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TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A SUBMISSION UNDER 35 U.S.C. 371

Attorney Docket No.	U.S. Application No. (if known, see 37 CFR 1.5)
8241P074	

International Application No.	International Filing Date	Priority Date Claimed
PCT/US2012/060115	12 October 2012 (12.10.2012)	27 July 2012 (27.07.2012)

Title of Invention
MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER

First Named Inventor
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Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information.

1. ☑ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). NOTE: The express request under 35 U.S.C. 371(f) will not be effective unless the requirements under 35 U.S.C. 371(c)(1), (2), and (4) for payment of the basic national fee, copy of the International Application and English translation thereof (if required), and the oath or declaration of the inventor(s) have been received.
2. ☑ A copy of the International Application (35 U.S.C. 371(c)(2)) is attached hereto (not required if the International Application was previously communicated by the International Bureau or was filed in the United States Receiving Office (RO/US)).
3. An English language translation of the International Application (35 U.S.C. 371(c)(2))
   a. ☐ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
4. An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4))
   a. ☐ is attached.
   b. ☐ was previously filed in the international phase under PCT Rule 4.17(iv).

Items 5 to 8 below concern amendments made in the international phase.

PCT Article 19 and 34 amendments

5. ☐ Amendments to the claims under PCT Article 19 are attached (not required if communicated by the International Bureau) (35 U.S.C. 371(c)(3)).
6. ☐ English translation of the PCT Article 19 amendment is attached (35 U.S.C. 371(c)(3)).
7. ☐ English translation of annexes (Article 19 and/or 34 amendments only) of the International Preliminary Examination Report is attached (35 U.S.C. 371(c)(5)).

Cancellation of amendments made in the international phase

8a. ☐ Do not enter the amendment made in the international phase under PCT Article 19.

8b. ☐ Do not enter the amendment made in the international phase under PCT Article 34.

NOTE: A proper amendment made in English under Article 19 or 34 will be entered in the U.S. national phase application absent a clear instruction from applicant not to enter the amendment(s).

The following items 9 to 17 concern a document(s) or information included.

9. ☑ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
10. ☑ A preliminary amendment.
11. ☑ An Application Data Sheet under 37 CFR 1.76.
12. ☐ A substitute specification. NOTE: A substitute specification cannot include claims. See 37 CFR 1.125(b).
13. ☐ A power of attorney and/or change of address letter.
14. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13*ter*.3 and 37 CFR 1.821-1.825.
15. ☐ Assignment papers *(cover sheet and document(s))*. Name of Assignee: _____
16. ☐ 37 CFR 3.73(c) Statement *(when there is an Assignee)*.

This collection of information is required by 37 CFR 1.414 and 1.491-1.492. The information is required to obtain or retain a benefit by the public, which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 15 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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17. ☐ Other items or information:

The following fees have been submitted.	CALCULATIONS	PTO USE ONLY
18. ☑ Basic national fee (37 CFR 1.492(a)) **$280**	$ 280	
19. ☑ Examination fee (37 CFR 1.492(c)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** All other situations **$720**	$ 720	
20. ☑ Search fee (37 CFR 1.492(b)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** Search fee (37 CFR 1.445(a)(2)) has been paid on the international application to the USPTO as an International Searching Authority ..... **$120** International Search Report prepared by an ISA other than the US and provided to the Office or previously communicated to the US by the IB ..... **$480** All other situations **$600**	480 $	
TOTAL OF 18, 19, and 20 =	$ 1,480	
☐ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing in compliance with 37 CFR 1.821(c) or (e) in an electronic medium or computer program listing in an electronic medium) (37 CFR 1.492(j)). Fee for each additional 50 sheets of paper or fraction thereof **$400**		

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CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	40 - 20 =	20	x **$80**	$ 1,600	
Independent claims	4 - 3 =	1	x **$420**	$ 420	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			**+ $780**	$	
Processing fee of **$140.00** for furnishing the English translation later than 30 months from the earliest claimed priority date (37 CFR 1.492(i)). **+**				$	
TOTAL OF ABOVE CALCULATIONS =				$ 3,500	
☐ **Applicant asserts small entity status.** See 37 CFR 1.27. Fees above are reduced by ½.					
☐ **Applicant certifies micro entity status.** See 37 CFR 1.29. Fees above are reduced by ¾. Applicant must attach form PTO/SB/15A or B or equivalent.					
TOTAL NATIONAL FEE =				$ 3,500	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property. **+**				$	
TOTAL FEES ENCLOSED =				$ 3,500	
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a. ☐ A check in the amount of $_____ to cover the above fees is enclosed.

b. ☑ Please charge my Deposit Account No. 02-2666 in the amount of $ 3,500.00 to cover the above fees.

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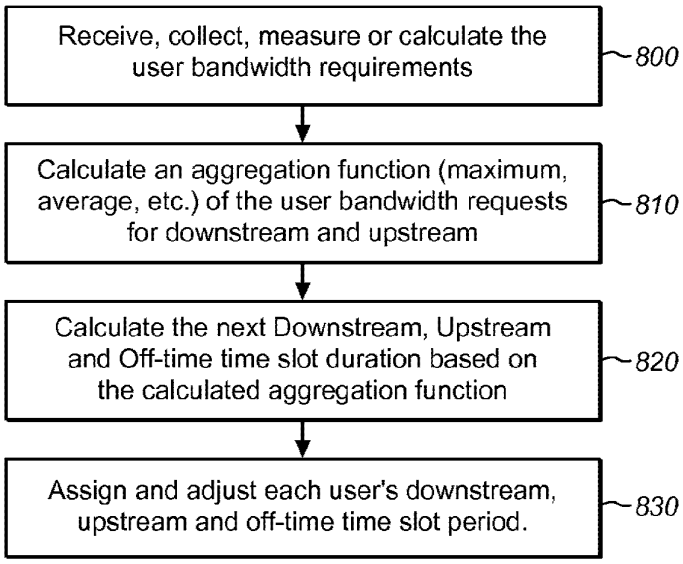
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(54) Title: MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER

(57) Abstract: Time division duplex transmission over copper physical channels is managed. In one example, upstream time slots for upstream transmission in a first physical channel are scheduled. Downstream time slots for downstream transmission in a second physical channel are scheduled. Transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots.

FIG. 8



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MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER

FIELD

The present description relates to the field of data transmission in channels subject to crosstalk and, in particular, to scheduling time slot allocations for such channels.

BACKGROUND

TDD (Time Division Duplex) systems transmit downstream (network to subscriber) data and upstream (subscriber to network) data in distinct time slots of the same physical channel. Additionally, there is often a small guard-time between distinct time slots to ensure that data does not overlap. One new TDD system is called 'G.fast,' which is currently in the process of standardization by the ITU-T (International Telecommunication Union - Telecommunication Standardization Sector). G.fast is to transmit over relatively short (< 250 m) copper telephone loops and premises wiring.

Figure 1 is a diagram of slots on a horizontal time axis for a classic TDD system, alternately transmitting downstream from the network toward the subscriber and upstream from the subscriber toward the network in different Down and Up TDD time slots. There is a downstream slot 12, and an upstream slot 14. This is followed by another downstream slot 16 and then an upstream slot 18. The cycle is repeated along the horizontal time axis. The "asymmetry ratio" is the ratio of the size of the Down slot compared to the size of the Up slot. There is usually also a small guard-time (not shown) between each time slot. Each repetition of the two slots may be referred to as a frame. Alternatively, a frame may have multiple repetitions of the two slots.

To reduce power consumption and interference on nearby lines, a power saving TDD system is shown in Figure 2. Figure 2 is a diagram of slots on a horizontal axis for the power saving TDD system. Broadband data communication systems are often idle or highly underutilized, and current practice is generally to send idle codes at full power when there is no data traffic. A power saving alternative is to suppress transmission when there is no user data traffic. As shown in Figure 2, there are two frames 21, 22, TDD frame$_1$, TDD frame $_2$, each having a downstream slot, 23, 27, followed by an upstream slot, 25, 29. In addition, a portion of the downstream slot, in this case the later portion, is an off portion, D_off 24, 28, during which transmission is suppressed. During the off portion, neither data nor idle bits are sent. Similarly the upstream slot, Up, has an off portion U_off 26, 30 at the end of each slot, during which

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neither data, nor idle bits are sent. Sending no power, during off times "D_off" and "U_off" can provide significant power savings. "D_off" and "U_off" may also be combined into a single off portion.

In many TDD systems, there are multiple physical channels. If these channels are close together in location and overlap in frequency, then they may interfere with each other. Figure 3 is a diagram of a TDD system with two channels 31, 32. In this example, each channel uses a twisted pair of copper cables and both channels are in the same cable or cable binder. As illustrated in Figure 3, systems transmitting in multi-pair copper cables can generate crosstalk into each other, Near-End Crosstalk (NEXT) 33 and Far-End Crosstalk (FEXT) 34 are generated by each channel and directed at least in part into the nearby channel.

Each channel is connected between a network-end Transmission Unit-Office (TU-O) 35, 36 and a subscriber-end Transmission Unit-Remote (TU-R) transceiver 37, 38. While each channel is shown as connecting a different TU-O to its own TU-R, a single TU-O can connect to a single TU-R using both of the two channels. This allows more data to be sent to the one TU-R. A single TU-O may also connect to multiple TU-Rs, which is sometimes called "bonding."

NEXT can be very powerful and debilitate high speed transmissions. ADSL (Asymmetric Digital Subscriber Line) and VDSL (Very high bit rate Digital Subscriber Line) use Frequency-Division Multiplexing (FDM) to avoid self-NEXT. Self-NEXT 33 is the crosstalk that is created into neighboring channels as shown in Figure 3.

SUMMARY

In one example, a method for managing multiple physical channels in a data communications system that are subject to crosstalk is described. The method includes scheduling time slot allocations for the physical channels so that upstream transmissions do not occur at the same time as downstream transmissions. In another example, the method is implemented by a machine operating on a machine-readable medium having stored instructions. In another example, a time slot management system manages multiple physical channels in a data communications system that are subject to crosstalk. The system has a process for determining time slot allocations for the physical channels so that upstream transmissions do not occur at the same time as downstream transmissions and a communications interface to make assignments to transmitters of the physical channels.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

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Embodiments are illustrated by way of example, and not by way of limitation, and will be more fully understood with reference to the following detailed description when considered in connection with the figures in which:

Figure 1 is a diagram of slots on a horizontal time axis for a classic TDD system;

Figure 2 is a diagram of slots on a horizontal axis for a power saving TDD system;

Figure 3 is a diagram of two related physical channels connected to end nodes in a TDD system;

Figure 4 is a diagram of slot assignments for two related physical channels according to an embodiment of the invention;

Figure 5 is a diagram of alternative slot assignments for two related physical channels according to an embodiment of the invention;

Figure 6 is a diagram of further alternative slot assignments for two related physical channels according to an embodiment of the invention;

Figure 7 is a diagram of a twisted pair having at least two related physical channels connected between a central office and an end node;

Figure 8 is a process flow diagram of an example of computing TDD slot times and off times according to an embodiment of the invention;

Figure 9 is a process flow diagram of computing start and end times of time slots according to an embodiment of the invention;

Figure 10 is a diagram of multiple TDD groups that have crosstalk coupling between some of their lines including autonomous TDD management according to an embodiment of the invention;

Figure 11 is a process flow diagram of another example of computing TDD slot times according to an embodiment of the invention; and

Figure 12 is a block diagram of a TDD management system according to an embodiment of the invention.

DETAILED DESCRIPTION

Embodiments of the invention may provide a management system for systems that transmit over wires using Time-Division Duplex (TDD). The management system receives input

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data about service levels, traffic, power and other requirements. It then determines an assignment of TDD time slots, off times, and asymmetry; for optimal performance, minimal traffic delays, and minimal power usage. The TDD frames are flexible and need not follow a fixed pattern.

One way to avoid self-NEXT is to synchronize the transmissions on the two lines so that one line does not transmit downstream while another line transmits upstream. This is particularly important with TDD systems that have channels that use the same multi-pair cable binder.

Figure 4. is a diagram showing TDD frames, $frame_1$, $frame_2$, on two different channels, $Line_1$, $Line_2$, which are close enough to cause NEXT 41, 42 in the other line. The frames are shown as aligned across a horizontal time axis. Each frame for each channel has a downstream slot, 43-1, 43-2, 44-1, 44-2, and an upstream slot, 45-1, 46-2, 45-2, 46-2. Even though the TDD frames are aligned, in this case the slots are not. $Line_1$, the upper line, is transmitting predominately in the upstream direction while $Line_2$ is transmitting predominately in the downstream direction. The downstream and upstream misalignment causes NEXT 41, 42 in the nearby line. As shown, the $Line_1$ $frame_1$ upstream slot 45-1 begins before the $Line_2$ $frame_2$ downstream slot 43-2 completes. During this overlap, NEXT 41 is much higher. After the $Line_2$ $frame_2$ downstream slot 43-2 ends and the upstream slot 45-2 begin, NEXT 41 is greatly reduced. A similar overlap occurs in $frame_2$.

One way of avoiding NEXT is to align all the TDD frames, the downstream and upstream time slots, and the off times, as shown for example in Figure 5. As in Figure 4, the frame structure $frame_1$, $frame_2$ for two nearby channels $Line_1$, $Line_2$ are shown aligned on a horizontal time axis. Both the upper line, $Line_1$ and the lower line, $Line_2$, have downstream 53-1, 54-1, 53-2, 54-2 and upstream slots 55-1, 56-1, 55-2, 56-2 which are aligned with respect to time. As a result, the two channels will be carrying downstream data at the same time and upstream data at the same time. Since no downstream transmission occurs during an upstream transmission, NEXT is minimized.

In addition, the two frames also have off portions, D_off 57-1, 58-1, 57-2, 58-2, in each downstream slot of each frame and U_off 51-1, 52-1, 51-2, 52-2 in each upstream slot of each frame. Part of each upstream and each downstream slot is shown as being off to save power. The off portions are also aligned.

A more flexible way of avoiding NEXT, instead of enforcing perfect alignment of each slot in each frame as in Figure 5, is to enforce sufficient alignment to avoid transmitting

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upstream and downstream at the same time on any line. This has the advantage that one line can transmit more data than other lines if it has high demand, while the other lines can be quiet and save power. Further, the frame times can be varied. This, however, has the disadvantage that it requires a high level of control and coordination. Figure 6 shows an example of this.

Figure 6 shows two channels an upper, $Line_1$, and a lower, $Line_2$, aligned on a horizontal time axis. The downstream 63-1, 64-1, 63-2, 64-2 and upstream 65-1, 66-1, 65-2, 66-2 portions of these two channels are aligned as in Figure 5. However, the off portions, the downstream off portions D_off 67-1, 68-1, 67-2, 68-2, and U_off, the upstream off portions 61-1, 66-1, 61-2, 66-2 are not aligned. In order to eliminate NEXT, the off portions do not need to be aligned. When a channel is off, then it is not generating any interference. Each of these off periods do not need to be aligned for all lines in all TDD groups of a multiple channel binder. Embodiments of the invention help to control the off periods and determine how to adapt the off periods for each channel to avoid NEXT and to minimize power usage.

A further method of mitigating NEXT is to employ active NEXT cancellation at the network end of the lines, where the TU-Os are located. This is generally feasible among TU-Os that are in the same equipment chassis, or at least in the same location. In such a case, transmitted data signals, received upstream signals plus NEXT, and the associated error signals are available to a cancellation system or filter, which subtracts estimates of the NEXT from the received signals in real-time. The NEXT canceller may have a zero-forcing structure, a minimum-mean square error (MMSE) structure, a decision-feedback equalizer (DFE) structure, or any other cancellation filter structure. The cancellation coefficients may be calculated at start-up, and may be adapted using error signals while the lines are active.

NEXT cancellation eliminates most of the NEXT from downstream signals into upstream signals, allowing some overlap between downstream and upstream time slots. NEXT from upstream signals into downstream signals occurs primarily at the subscriber ends of the lines where the upstream signals are strongest. The amplitude of this NEXT may be low enough to be ignored due to the attenuation that occurs on drop and inside wires. Transmitting upstream and downstream simultaneously in the same frequencies is known as full-duplex operation, and generally also requires line hybrids and echo cancellers. Compatibility with VDSL2 may be enabled by using NEXT cancellation at the TU-O end of the lines and by not allowing upstream transmission in the VDSL2 downstream frequency bands unless the NEXT is low at the subscriber end of the lines. Different bit loadings may be used when transmitting upstream and downstream simultaneously, and when transmitting in only one direction.

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With NEXT cancellation, management of the TDD system proceeds as described elsewhere here, except that some overlap between downstream and upstream time slots may be allowed in some cases or in some time slots. The combination of time slot and frequency-band allocations can be dynamically adjusted for each environment.

Several network-end transmission units (TU-O) are often in a single access node. One example of a single access node is a Digital Subscriber Line Access Multiplexer (DSLAM). Referring to Figure 7, a central office (CO) or exchange 71 is coupled through a feeder 72 to one or more crossboxes or splice points 73, although only one is shown. The crossbox is coupled through a distribution line 74 to one or more drop wire interfaces 75, although only one is shown. The drop wire interface is coupled though one or more drops or drop wires 76 to one or more TU-Rs 77, although only one is shown. Depending on the system implementation, the crossbox 73 may be replaced with or in the form of, for example, a feeder distribution interface (FDI), a serving area interface (SAI), a junction wire interface (JWI), or a sub-loop distribution frame (SDF). The drop wire interface 75 may be replaced with or in the form of a distribution terminal or a deployment point (dP).

The access node or DSLAM (not shown) can be located in the distribution terminal or it can be located somewhere else in the distribution plant, and usually it is fed with optical fiber from the Central Office (CO) or exchange. Downstream of the access node, toward the TU-Rs, crosstalk may be only between lines from a single access node, or there may be crosstalk between lines from multiple access nodes. A set of lines using TDD that all originate at the same access node will be referred to herein as a TDD group.

The invention may be embodied by a TDD management system that coordinates the TDD slot times and the off times of different channels to maximize the transmission of user data traffic while minimizing power. On and off times may be selected to ensure there is no possibility of creating NEXT between lines in a TDD group, or between lines in different TDD groups that have crosstalk coupling into each other. The on and off times may also be chosen to maximize traffic throughput to meet user demands, and to also minimize power consumption by being off when possible.

The TDD management system receives input on the traffic levels, traffic types, and traffic patterns that should be provided on the lines under its control. This input may include one or more of the following:

a) static (time-invariant) data about service subscription levels and their traffic requirements, e.g. a "traffic descriptor;

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b) service layer information from a policy manager which provides high-level estimates of data rate requirements based on service requests;

c) data on the behavior of different traffic types, different users, e.g. bit rate variations, traffic behavior, or burstiness;

d) time series data from long term traffic monitoring which is analyzed to determine the traffic demands as a function of time-of-day or time-of-week;

e) instantaneous feedback based on current traffic demands or queue lengths (Queue lengths or traffic requests can be sent from the customer end up to the network-end for input to the TDD management system);

f) upstream and downstream traffic asymmetry patterns; and

g) traffic requests or reports.

The traffic can further be classified according to priority level, service type, QoS (Quality of Service), tagging, stream type, protocol type, etc., and this classification information can be input to TDD scheduling algorithms.

The TDD management system uses this input to calculate TDD slot times and off times. The slot times are arranged in such a way as to avoid or reduce NEXT when possible, for example as shown in Figure 6. Ideally, no two lines that have significant crosstalk coupling into each other can transmit upstream and downstream at the same time. The slot times and off times may also be calculated to satisfy the traffic requested by subscribers, and can further minimize power usage by maximizing off times.

Figure 8 is a process flow diagram of an example of computing TDD slot times and off times as described above. At 800, the bandwidth requirements or requests of the users are received, collected, calculated, or measured. The information may be based on the input received by the TDD management system as described above. This information may include any number of different factors including the type of traffic (for example fixed, variable), and the amount of bandwidth requested (for example in Bytes or microseconds). The bandwidth requirements of some users may be fixed over time, such as for streaming video, while the bandwidth of others may vary.

At 810, an aggregation function (maximum, average, etc.) of the user bandwidth requests for downstream and upstream is calculated for different types of traffic. For example, the function could be the maximum of all users' downstream fixed bandwidth requests. Further examples are provided in the next section.

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At 820, the next downstream, upstream and off time time slot periods are calculated based on the calculated aggregation function. For example, the next downstream time slot duration could be equal to the sum of the maximum downstream requests for all types of traffic. In such a case, for instance it is guaranteed that no user's bandwidth request would exceed the time slot duration allocated for that type of traffic. Further examples are provided below.

At 830, each user's downstream, upstream and off time time slot periods are assigned and then, if need be, they are adjusted. If the conditions of previous operations are properly satisfied, then each user should be able to receive its requested bandwidth, given limitations or requirements of its traffic type. It is also possible that, for example, the assignments could provide excess bandwidth for certain users. In such cases, adjustments may be made to utilize this excess capacity, for example by assigning variable bit rate traffic to excess fixed bandwidth time slots, or by assigning off time for power savings. Further examples are provided below. The assignment of time slots may be internal to a transceiver, or it may be transmitted from the TDD management system down to the transceiver.

The following provides an example of the process above, for assigning bandwidth at a single access node with mixtures of delay-sensitive fixed bandwidth assignments (e.g., video, voice) and delay-insensitive real-time bandwidth assignments (e.g., data). This example assumes bandwidth requests were converted into time slot requests in microseconds. If user i has a data rate of Z Mbps, and is requesting B bits of traffic, the request equals B/Z microseconds in the next frame.

1) The receive, collect, measure, or calculate operation at 800 may be performed as receiving bandwidth request data input for each user. This data may, for example, include any of the following:

a) Fixed upstream bandwidth requests, e.g. UXi microseconds dedicated for each user i;

b) Real-time upstream bandwidth requests, e.g. UYi microseconds in the next time slot for user i;

c) Fixed downstream bandwidth requests, e.g. DXi microseconds dedicated for each user i; and

d) Real-time downstream bandwidth requests, e.g. DYi microseconds in the next time slot for user i.

2) The calculation of the aggregated function at 810 may be performed in several steps. First, the maximum requested bandwidth of each type in the next frame is calculated. These can be defined, for example, as follows:

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a) Maximum fixed upstream bandwidth request e.g. MaxUX = max over i (UXi);

b) Maximum real-time upstream bandwidth request e.g. MaxUY = max over i (UYi);

c) Maximum fixed downstream bandwidth request e.g. MaxDX = max over i (DXi); and

d) Maximum real-time downstream bandwidth request e.g. MaxDY = max over i (DYi)

3) The time duration of the next frame may be named TF. The time slot durations can be determined at 820 using different criteria depending on the particular subscriber and system architecture circumstances. Some examples are provided below, where it is assumed that fixed bandwidth requests have strict priority over real-time bandwidth requests.

4) If TF >= MaxUX + MaxUY + MaxDX + MaxDY, then the next upstream time slot duration is MaxUX + MaxUY, the next downstream time slot duration is MaxDX + MaxDY, and the off time in the next TDD frame is TF – (MaxUX + MaxUY + MaxDX + MaxDY).

5) Otherwise, if MaxUX + MaxUY + MaxDX + MaxDY > TF > MaxUX + MaxDX, then the fixed bandwidth requests will be completely satisfied and the real-time bandwidth requests will be partially satisfied. One way of doing this is to divide the real-time bandwidth proportional to the maximum requested real-time bandwidth so that the next upstream time slot duration is

MaxUX + (TF – MaxUX - MaxDX) * (MaxUY/(MaxUY + MaxDY),

the next downstream time slot duration is

MaxDX + (TF – MaxUX - MaxDX)*(MaxDY/(MaxUY + Max DY),

and there is no off time in the next time slot.

6) Otherwise, if TF = MaxUX + MaxDX, then the next upstream time slot duration is MaxUX and the next downstream time slot duration is MaxDX.

7) Otherwise, if MaxUX + MaxDX > TF, then the fixed bandwidth requests are partially satisfied and the real-time bandwidth requests are not satisfied at all. One way of doing this is to divide the fixed bandwidth proportional to the maximum requested fixed bandwidth so that the next upstream time slot duration is TF*(MaxUX/(MaxUX + MaxDX)), the next downstream time slot duration is TF*(MaxDX/(MaxUX + MaxDX)), and there is no off time in the next time slot.

8) Having calculated the functions and the time slot durations, the operations at 830 are performed: assign and adjust each user's downstream, upstream and off time time slot period.

There are many variations to the example process described above, depending on the particular application and system architecture, for example the bandwidth may be divided

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proportional to average upstream and downstream requests instead of maximum, or the bandwidth may simply be split in half, or the bandwidth may be divided along a sliding window that accounts for bandwidth requests in multiple time slots, or the bandwidth may be assigned according to a fairness criteria, or the bandwidth may be assigned according to subscription level, etc. The processes may also be extended to more than two different traffic types. The process may operate on multiple TDD frames at a time.

In the example of using the maximum requested bandwidth as described above, the time slot dedicated to one or more users could exceed the required bandwidth requested by those users. In some cases, the required bandwidth for a user could be significantly less than the assigned time slot. For example, MaxUX+MaxUY could be much larger than the UXi+UYi or MaxDX+MaxDY could be much larger than DXi+DYi for a specific user i. In such cases, the adjustment stated as step 7 above can be utilized.

As one example, the extra bandwidth may be utilized for either saving power or improving latency or some combination of both. The TDD management, as an example may extend the off period for those users, to reduce their power consumption. Alternatively, the TDD management system may accommodate the available extra bandwidth to be used for variable upstream or downstream traffic for those users to allow newly arriving traffic to be transmitted immediately. Conversely, when using the average requested bandwidth in the above algorithm, some user requests might not get satisfied. For example, the fixed bandwidth requests could be partially satisfied. In such cases, steps 5-7 of the above 8-step process for calculating an aggregate function could be modified, where instead of Max; the Average function is used. Other functions may alternatively be used to suit different implementations and different traffic management goals.

After the time slot durations are calculated, the start and end times of each time slot in the next TDD frame are calculated. This may be a simple assignment anchored at a fixed time such as the beginning or end of a TDD frame. Or it may involve a more involved solution, such as an iterative solution. Figure 9 is a process flow diagram of an example of computing the start and end times of each time slot in a next or subsequent TDD frame.

At 900, the next downstream (DS) time slot, the next upstream (US) time slot, and the next off time locations are assigned to arbitrary locations in the next TDD frame.

At 910, it is checked whether the downstream time slot is overlapping with another upstream time slot, or vice versa, whether the upstream time slot is overlapping with another

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downstream time slot. If there is no overlap, then the allocations in step 900 are accepted, and no further action is needed.

If there is an overlap, then at 920, the entire downstream time slot assignment or the entire upstream time slot assignment is moved forward or backward in time, by a predetermined amount or by a random amount. The choice of DS or US is based on whether the overlapping time slot is a DS slot or a US slot from 910.

After this adjustment, the operations at 910 are repeated, and if there are no more overlaps, then no further action is required. However, if there still is an overlap, either with the downstream time slot or with the upstream time slot, then the operations at 920 are repeated. If after the adjustments the non-overlapping conditions cannot be met, then the DS or the US time slot durations are decreased (depending on which one had the overlapping issue), and the initial assignment at 900 is repeated.

A more specific example of the operations in the process flow diagram of Figure 9 is provided below. As in Figure 9, this is an example of the above process for computing the start and end times of each time slot in a next TDD frame. In the following example it is assumed that the previous process of Figure 8 has already been performed, and therefore the next downstream time slot DS duration, the next upstream time slot US duration, and the next off time D_off, U_off duration, have already been determined.

1) As an example of the operations at 900, assign the next downstream time slot, the next upstream time slot, and the next off time(s) to arbitrary locations in the next TDD frame. For example, the next TDD frame may begin with the downstream time slot, then have the next slot be downstream off time D_off, then have the upstream time slot, and then have the next upstream slot be upstream off time U_off. Alternately, the off time may be contiguous and in the beginning, middle, or end of the TDD frame.

2) If the downstream time slot does not overlap with any other upstream time slot of any other TDD system that crosstalks into or from this TDD system, then the process is finished until the next time the slots are adjusted based on new parameters. This is the test at 910.

3) Otherwise, move the entire downstream time slot assignment by x microseconds either forward or backward in time. This corresponds to the operation at 920.

4) Repeat step 4, varying x, until the condition of non-overlap in step 3 is achieved in the downstream direction. x may be varied randomly or it may vary in predetermined steps.

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5) If the condition of step 3 cannot be achieved, then decrease the downstream time slot duration and repeat steps 1 through 4.

6) If the upstream time slot does not overlap with the downstream time slot, nor with any other upstream time slot of any other TDD system that crosstalks with this TDD system, then the process if finished.

7) Otherwise, move the entire upstream time slot assignment by y microseconds either forward or backward in time.

8) Repeat step 7, varying y, until the condition of non-overlap in step 6 is achieved in the upstream direction. y may be varied randomly or it may vary in predetermined steps.

9) If the condition of step 7 cannot be achieved, then decrease the upstream time slot duration and repeat steps 6 through 8.

10) Assign the off time. For example, the off time may be contiguous and in the beginning, middle, or end of the TDD frame; or it may be split into two times before or after the upstream and downstream time slots such that it fits in the TDD frame.

11) This procedure may be repeated to assign off times to each line, or each line may autonomously assign off times.

12) Set the times for the next slots, either internally or by communicating with external equipment. If the transceivers are external to the management system, then the management system notifies the transceivers of one or more of the future assignments: beginning of the upstream time slot(s), ending of the upstream time slot(s), duration of the upstream time slot(s), the beginning of the downstream time slot(s), ending of the downstream time slot(s), duration of the downstream time slot(s), the beginning of the off time slot(s), ending of the off time slot(s), duration of the off time slot(s),

The calculation of TDD slot times and off times may also be performed in various other ways, by a direct calculation that maximizes the projection of user demands on the achievable space, by iteratively adjusting the slot boundaries from frame-to-frame, via heuristics, by selecting from among a stored set of timings, a generalized algorithm that uses several of these approaches, etc. In addition, the frame length can be variable, the time slot start and end times need not be periodic, and these need not be aligned. Frame lengths can be varied to meet delay requirements, e.g., a short frame when low-delay applications are used. The calculation may simultaneously be applied to multiple TDD frames.All of this may be determined by the TDD management system.

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The TDD management system may be made to be capable of converting high-level requests for traffic and power consumption into low-level TDD scheduling. High-level requests may be e.g. an outline of traffic and power requirements, or a general indication of the trade-off between traffic delay and power usage. The TDD management system may also coordinate power savings that are achieved by entering, exiting, or transitioning between multiple power line states. In addition to TDD off times, these power line states can save power by transmitting a lower bit rate with a lower bit loading using a lower transmit spectrum.

Part of each frame time may be reserved on a long-term basis for down and up time slots, with an additional part dynamically varied as traffic comes and goes. The TDD management system then optimizes time slot assignment using both long-term and short-term variations.

TDD up and down time slots and the asymmetry ratio can be varied to minimize average traffic delays and maximize average throughput across all lines in the TDD group. The asymmetry ratio can be defined in terms of time for each slot or in terms of the number of DMT (Discrete Multi-Tone) symbol positions used by a particular user in upstream or downstream. Alternatively, the performance of some set of premium services can be maximized. As a further alternative, the worst-case performance can be maximized. As a further alternative, a more general fairness criterion, such as "alpha-fairness" can be applied to maximize any arbitrarily weighted combination of different user traffic demands.

The TU-Rs are often synchronized to the timing of the TU-O. This timing can be assisted by regularly sending a "synch symbol" downstream that the TU-Rs can lock on to maintain a level of timing synchronization. The TDD management system can determine the times to send synch symbols and the synch symbol durations. When there is very little traffic, the line could be off during an entire down or up time slot, or during an entire TDD frame, or even during multiple TDD frames. Then, the TDD management system can schedule the VTU-O to send enough synch symbols, with enough duration, so that the TU-R maintains or regains synchronization. These synch symbols may be sent in only some time slots, in only some TDD frames, and even using only some subcarriers. The synch symbols can use a low-level modulation for robustness. This enables an inactive TU-R to maintain TDD frame timing so that the TU-R can transmit during an upstream time slot when it wakes up.

A transceiver, such as a TU-R or TU-O may stay in receive-only mode, with the transmitter turned off. This allows power savings by turning off the transmitter. In this mode, the transceiver may also listen to regularly-occurring receptions to maintain synchronization and to hear traffic or instructions to wake up.

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An alternative wake-up procedure is for a TU-R to listen to the noise on the line, and determine when there is NEXT by reading regularly-occurring high-power noise once every TDD frame or at any other suitable interval. The TU-R transmits start-up signals when it estimates that this NEXT is active, which should be during an upstream time slot.

There may be a two step process for TU-R wake-up:

1: The TU-R stays approximately synchronized through slow periodic keep alives from the TU-O;

2: When the TU-R wants to start transmitting after some time period of upstream and downstream inactivity (and hence synchronization is only approximate):

a) The TU-R sends a short sync request in what it thinks is the middle of the upstream frame period (sending the short message in the middle ensures that the transmission is entirely within the upstream period);

b) The TU-O responds with a transmission that the TU-R can use for recovering synchronization;

c) Transmission proceeds normally.

Transmission systems adapt to the noise environment on the line, and the described techniques may ensure that adaptation is performed while crosstalking lines are actively creating crosstalk and not during quiet times.

Vectoring technology, as exemplified in the ITU-T G.993.5 standard, is used to cancel at least some FEXT. In order for vectoring to be effective, if it is applied to a TDD group, NEXT should be kept low. So the avoidance of NEXT also allows vectoring to function better. The described techniques can coordinate the TDD timing with the vectoring engine. The TDD management system can reassign vectoring resources in real-time when the TDD asymmetry ratio changes.

The TDD management system can also schedule when to send retransmission units. Retransmission units may be sent at any time. In some embodiments, retransmission units are sent at times that don't cause NEXT problems in a part of what would have been an off time, or retransmission units are sent with multiple retransmissions at other frame times. Retransmissions can be incremental, with all or part of the original data retransmitted, or by sending additional parity bits. Multiple retransmissions can be scheduled, and a block of original data can be retransmitted in one or more blocks of data or parity. Acknowledgements (ACKs) or negative acknowledgements (NACKs) related to retransmission can also be scheduled by the invention.

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The avoidance of NEXT between lines in a single TDD group is relatively straight-forward compared to avoiding NEXT with multiple lines. The TDD coordination simply needs to enforce this among the lines from a single access node, which all originate in the same location and so are relatively easy to jointly control.

Figure 10 is a diagram of a more complex system implementation in which there are multiple TDD groups that have crosstalk coupling between some of their lines, for example between the two TDD groups in a Shared Cable 3 in Figure 10. In this case the TDD management may span multiple access nodes, either explicitly with a centralized management element, or autonomously by detecting crosstalk.

Centralized TDD management allows multiple TDD groups to be coordinated directly. Centralized TDD management can use explicit timing information and feedback from access nodes, EMS, or other network elements to then centrally optimize all interacting TDD groups.

As shown in Figure 10, centralized TDD management 111 may be coupled through a network 112 to multiple access nodes 113-1, 113-2. While only two are shown, there may be many more. The centralized TDD management receives traffic data as described above, performs the assignments and then sends time slot assignments to the access nodes. The access nodes are coupled through communications channels to one or more end nodes or TU-Rs 116-1, 116-2, 116-3, 116-4. The communications channels may be in the form of twisted pair wiring 117-1, 117-2, 117-3, 117-4, or in any other form and may be in one or more binders 115-1, 115-2, 115-3. The binders may be in the form of a shared multiple conductor cable with lines for four or for hundreds of channels.

Figure 10 illustrates that two channels 117-1, 117-2 that initially are in a common binder or cable and that may generate cross-talk with each other may later be separated and combined with other channels in other binders. As shown, the second twisted pair 117-2 is separated from the first twisted pair 117-1 and later combined with a third twisted pair 117-3 in a third binder 115-3. These two lines now generate crosstalk with each other. This third twisted pair originated with a second binder 115-2. The second and third lines may also be routed to a common or to different end stations 116-2 116-3. The crosstalk generated at any one point between two nearby channels may propagate along any one channel and affect other channels. As an example, the crosstalk generated by the first line 117-1 and received by the second line 117-2 may be coupled to the third line 117-3 in the third shared cable. The third line 117-3 may couple that same crosstalk from the first line 117-1 into a fourth line 117-4.

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The connections between lines in different cables or binders may occur in switches, junctions, crossboxes, distribution frames, pedestals, or other types of terminals including network-end terminal, such as TU-R's, or in splice points. In these locations channels can be separated from their original binders and then recombined into different binders or combined at a termination point. TDD systems may alternately not be assigned to separate binders at all, in which case crosstalk will usually arise between them resulting in essentially the same configuration as in Figure 10.

Autonomous TDD management 114-1, 114-2 at each access node 113-1, 113-2 or at any other point in the system can coordinate multiple TDD groups even though it reads data from, and controls, only a single TDD group. Synchronization may also be performed by measuring the time series of time-varying crosstalk and synchronizing to its patterns. As another alternative, synchronization is performed by measuring the time series of error events and synchronizing to its patterns. This may be done by reading in the time-varying pattern of noise or errors on the lines in the TDD group. Crosstalk from another "alien" TDD system, such as that from a different access node, creates a regularly-occurring pattern of noise as it alternately transmits in both directions, first in one direction, then in the other. This crosstalk can be measured by reading the noise on the lines, or by reading the time-series of error patterns. These can be analyzed on both ends of the line to identify the pattern of the alien TDD groups' up and down time slots. For example, errors occurring in one direction once each millisecond indicate that crosstalk is being generated once each millisecond from the alien TDD groups. The TDD management system can then synchronize its own transmissions to this crosstalk.

Figures 3, 7, and 10 all show different perspectives of the same communication system. While the time slot assignment may be performed at any of a variety of different locations, in each case, the transmissions are either controlled directly or the controller sends assignments to the appropriate transmitter. The assignments may be sent, e.g., to a transceiver unit (TU), to a crossbox, to a switch, to a junction, to a pedestal or to another type of transmitter whether it is an original signal source or a repeater at any point in the channel. Similarly, the controller can provide synchronization signals that allow the upstream and downstream signals to be coordinated. Synchronization can also be based on signals from a vectoring unit, from an access node, a crossbox, or some other junction point or from an external clock or synchronization source. In one example, synchronization symbols are sent to the sources of upstream transmissions, such as TU-R's.

TDD management may more generally be split between centralized and autonomous methods, using traffic data and TDD synchronization information from:

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a) Explicit use of management data and synchronization data from DSLAMs, EMS, OSS or other network elements;

b) Global synchronization data using Global Positioning Satellite (GPS) data or network timing protocols;

c) Autonomous estimation using monitoring data on crosstalk patterns or by reading time-varying noise or error counts;

d) Explicit estimates of crosstalk couplings between lines can be input, for example vectored lines can provide such data as reported Xlin values.

The TDD management system may adjust one or more of the following quantities or other quantities not listed for one or more lines:

a) asymmetry ratio,

b) up and down slot times,

c) off times; and

d) use of low-power or quiescent states;

with the objective of meeting bit-rate requirements and requests, and optionally minimizing power. These can also be set indirectly through higher-level or lower-level control specifications. These can be controlled by slowly changing them as scheduled or as needed after a traffic threshold is crossed; or they can vary in real time. Dynamic Bandwidth Allocation (DBA) or Dynamic Resource Allocation (DRA) can also be all or part of this control. The TDD management system may also interface with, or contain, a Timing Control Entity (TCE).

The TDD management system's capability to detect and adapt to TDD crosstalk can assist in enabling spectral compatibility of TDD systems with FDM (Frequency Division Multiplexed) systems such as VDSL2 (Very high bit rate Digital Subscriber Line, version 2). This can be done by using automated crosstalk identification, coordinating TDD timings, and Dynamic Spectrum Management (DSM) to enable the TDD system to be compatible with VDSL2. Frequency band assignments may further be coordinated to enable spectral compatibility.

Figure 11 is a process flow diagram of scheduling upstream and downstream time slots according to another embodiment. The process flow is specifically intended for use in managing multiple time division physical channels that are subject to crosstalk, however, the invention is not so limited. The scheduling is described here in the context of two physical channels that are subject to crosstalk, however there may be many more than two channels.

At 1104, the TDD management system receives input about traffic objectives for the scheduling of the time slots. This operation is optional. The input is typically received from an

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external controller, although the TDD management system may be able to monitor the channels or use preset parameters instead of any received input. In a typical DSL system external controllers already generate Operations Support System (OSS) data and Management Information Database (MIB) parameters. This information may be provided to the TDD management system for it use in assigning time slots. Other types of information may also be used. The received input may be of a variety of different types and may include desired traffic levels, static subscription data, service layer information from a policy manager, behavior data for traffic types and users of the physical channels, long term traffic behavior data as a function of time, current traffic demands, queue lengths, traffic requests, upstream/downstream asymmetry, and traffic descriptors. The received input may also include transmission requests from network elements at the network end or the remote end.

At 1106, the TDD management system schedules upstream time slots for upstream transmission in one or more physical channels. AT 1108, the TDD management system schedules downstream time slots for downstream transmission in one or more physical channels. This may be the same channels as the upstream channels or different channels, depending on the nature of the TDD system and the assignment of channels. The upstream channels may be assigned before or after or at the same time as the downstream channels. In these assignments transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots. To make these assignments, all or some of various types of information in the received input can be used. These can be combined in different ways. In one example, optimization criteria are used that weigh different factors.

There are additional factors that may also be considered in the scheduling such as power usage, or a target upstream/downstream asymmetry ratio of data throughput. The data throughput can be defined or measured as an average throughput across all lines, a traffic demand match, a minimum throughput for each physical channel, a perceived quality of experience, an average delay, or a minimum delay.

As mentioned previously, the scheduling may allow some simultaneous transmission in the upstream and downstream time slots. The NEXT that may be caused by the simultaneous transmission may be ignored or the TDD system may also use active NEXT cancellation to cancel NEXT at the network end of the channels.

As a part of the scheduling, the TDD management system will typically send time slot assignments to a corresponding network element. At 1110, the TDD management system may also optionally synchronize times slot among different transmitters. The TDD management

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system may send synch symbols to source of upstream or downstream transmissions. It may also measure a time series of time-varying crosstalk and then synchronize the time slots to the measured time-varying patterns. Instead of crosstalk patterns, a time series of error events may be measured and used to synchronize.

At 1112, the TDD management system may optionally adjust the scheduling of upstream and downstream time slots. The adjustment may be applied to the next frame or frames, or to the current assignments. The adjustment may accommodate delay requirements for an upstream or downstream traffic source. Many different adjustments may be made such as moving the upstream and downstream time slots in time to reduce simultaneous upstream and downstream transmission, moving only if upstream transmissions overlap downstream transmissions in time, and reducing the duration of at least one downstream time slot to reduce simultaneous upstream and downstream transmission.

Figure 12 is a block diagram of a TDD management system 1200 in one example. The system 1200 includes a memory 1295 coupled directly or through a bus to a processor or processors 1296. The memory may be a hard drive, non-volatile memory, solid state memory, or a combination of different memory types for different purposes. The processor may also include its own internal memory. The memory may, for example, store instructions to be executed and the processor may execute the stored instructions. The processor may also implement or execute implementing logic 1260 having logic to implement the methodologies discussed herein. System 1200 includes one or more communications buses 1215 to connect the various illustrated components and to transfer transactions, instructions, requests, and data within the system among the components and other peripheral devices. The system further includes a management interface 1225 coupled to the bus and to external management devices, for example, to receive requests, return responses, and otherwise interface with network elements located separately from the system. This information may include Operations Support System (OSS) data and Management Information Database (MIB) parameters. These network elements may include access nodes, a central office, vectoring units, crossboxes, TU-Rs, and TU-Os.

The system further includes a LAN (Local Area Network) interface 1230 coupled to the bus and externally to communicate information via a LAN based connection, including collecting network information, reporting information and diagnostics to other entities within the network, and for initiating instructions and commands over the network. The system further includes a WAN (Wide Area Network) interface 1235 coupled to the bus and to an external WAN, to communicate information via a WAN based connection for similar purposes and to reach other more remote devices.

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In some embodiments, the management interface 1225 communicates information via an out-of-band connection separate from LAN and/or WAN based communications, where "in-band" communications are communications that traverse the same communication means as payload data (e.g., content) being exchanged between networked devices and where "out-of-band" communications are communications that traverse an isolated communication means, separate from the mechanism for communicating the payload data. An out-of-band connection may serve as a redundant or backup interface over which to communicate control data between a management device 1201 and other networked devices or between the management device and a third party service provider.

The system further includes stored historical information 1250 which may be stored within the memory 1295 or as a separate component coupled to the memory or to the bus. The historical information may be analyzed or referenced when conducting long term trending analysis for scheduling time slots and for reporting. Similarly management events 1255 may be stored within the memory or as a separate component coupled to the bus or to the memory. The management events may be initiated responsive to the identification of an operational condition. For example, corrective actions, additional diagnostics, information probes, configuration change requests, local commands, remote execution commands, and the like may be specified by and triggered as a management event 1255. Similarly, operational reports, configuration reports, network activity reports and diagnostic reports may be generated and sent in accordance with stored management events 1255.

A management device 1201 coupled to the bus includes a collection module 1270, analysis module 1275, diagnostics module 1280, and implementation module 1285. Management Device 1201 may be installed and configured in a compatible system 1200 as is depicted by Figure 12A, or provided separately so as to operate in conjunction with appropriate implementing logic 1260 or other software.

The collection module 1270 collects information from available sources, such as management information, LAN information and WAN information via the external interfaces. The scheduling module 1275 analyzes the information retrieved by the collection module and generates upstream and downstream time slot schedules including, as appropriate, off times and active transmission times. The scheduling module may further perform long term trending analysis based on stored historical information 1250 or conduct neighborhood analysis based on aggregation data yielded from multiple separate and distinct reports, or conduct other joint analysis based on collected information. The adjusting module 1280 adjusts the schedules to better suit the collected information and internal parameters, such as power usage and

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asymmetry ratio objectives. The results from the adjusting module may be supplied back to the scheduling module, depending on the embodiment. The synchronizing module 1285 synchronizes the scheduled time slots through the external connections 1225, 1230, 1235 so that all of the access nodes, transmitting units, or other components transmit at appropriate times.

The modules of the management device 1201 may be provided as separate components coupled to the bus 1215 as shown or may be incorporated into the processor or memory or another component. The management device may include its own processing and memory resources that interact with the processor and the external interfaces. The management device may include more or fewer modules than those shown. The TDD management system of Figure 12 is provided only as an example and may be modified to suit different implementations. It may also be incorporated into another component such as an access node, or a TU-O. In one embodiment, the management system is provided as a card in a system rack with a backplane interface to communicate with local and remote network elements.

There are a number of optional and additional advantages and features to the described techniques and systems above. These can be understood in the statements below, among others which may be combined in any of a variety of different ways.

A system has been described above for managing multiple TDD lines, in part, by determining time slot boundaries. The system provides sufficient coordination to avoid NEXT by ensuring that two lines with significant crosstalk coupling do not transmit downstream and upstream at the same time. The system further assigns slot-times and the downstream/upstream asymmetry ratio to maximize a measure of throughput. The maximized measure of throughput is one or more of: the maximum average or minimum average across all lines; chosen to best match traffic demands; chosen to provide a minimum service level to all lines; chosen to ensure user-perceived quality of experience; chosen to minimize average or maximum delays; or chosen to meet any fairness criteria. Other measures of throughput may be used as alternatives or additions, depending on the implementation. The assignment of time slots may be internal to a transceiver, or it may be transmitted from the TDD management system into a transceiver. The TDD management system can further perform Dynamic Bandwidth Allocation (DBA) or Dynamic Resource Allocation (DRA).

The TDD management system can further optimize the scheduling of off time slots to minimize power usage. The TDD management system can further schedule off times during low traffic that suppress transmission for the duration of entire time slot, TDD-frame, or multiple TDD frames. It may save power by controlling entries, exits, and transitions between low-power

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states. Low-power states save power by transmitting a lower bit rate with a lower bit-loading using a lower transmit spectrum.

The TDD management system can calculate an optimal set of up and down slot times and off times according to an optimization criteria, this criteria can flexibly weigh different tradeoffs between different users, tradeoffs between different services, and tradeoffs between performance and power savings.

The TDD management system adjusts one or more of the following or other quantities for one or more lines: a) asymmetry ratio, b) up and down slot durations, c) up and down slot times, and d) off times. The TDD management system controls the TDD time slot boundaries and off times. This can be a fixed assignment, a slowly varying assignment based on time-of-day, or an assignment that is varied in real time. One or more control parameters such as any one slot time start or end point, slot lengths, asymmetry, up slot time, down slot time, a single off time, and total off time, can be varied while other parameters remain fixed. The TDD management system may employ flexible slot-time boundaries, with variable-length frames, up slot-times, and down slot-times.

The TDD management system receives input on the traffic levels that need to be provided on the lines under its control. This input may include one or more of the following: static (time-invariant) data about service subscription levels and their traffic requirements; service layer information from a policy manager which provides high-level estimates of data rate requirements based on service requests; data on the behavior of different traffic types e.g., burstiness, for different users; time-series data from long-term traffic monitoring which is analyzed to determine the traffic demands as a function of time-of-day or time-of-week; instantaneous feedback based on current traffic demands or queue lengths; and traffic requests or reports sent from the customer end.

The TDD management system can be further controlled by external Operations Support Systems (OSS) or by reading and writing Management Information Database (MIB) parameters. A single TDD group can be managed or multiple TDD groups can be managed. The TDD management system may be a centralized controller that controls multiple lines, and/or multiple TDD groups. Alternatively, the TDD management system may be distributed among multiple pieces of equipment.

The TDD management system can control synchronization of a TDD group. This synchronization can be assisted by using one or more of the following input data: explicit use of management data and synchronization data from DSLAMs, EMS (Element Management

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Systems), OSS (Operations Support Systems) or other network elements; global synchronization data using Global Positioning Satellite (GPS) data or network timing protocols; autonomous estimation reading time-varying noise that contains crosstalk patterns or by using monitoring data such as error counts.

The timing reference can be further used to control the synchronization of multiple TDD groups. The TDD management system can provide information to assist the synchronization of multiple lines and/or multiple TDD groups.

The TDD management system can determine the times to send synch symbols and the synch symbol durations. The TDD management system can schedule the VTU-O to send synch symbols sufficiently often and with sufficient duration, for the VTU-R(s) to maintain synchronization with the VTU-O. These synch symbols may be sent only in some time slots, in some TDD frames, and only using some subcarriers. The synch symbols can use a low-level modulation for robustness. Long synch symbols can be scheduled to be sent from the VTU-O to recover synchronization after long off times. The TDD management system may further coordinate off times by instructing one or more transceiver(s) to be in receive-only mode, with the transmitter turned off for some time period, or until it receives a signal, or until traffic in a queue crosses a threshold.

An inactive TU-R can listen to the noise on the line, and determine when there is NEXT by reading regularly-occurring high-power noise once every TDD frame. The TU-R then transmits start-up signals when it estimates that this NEXT is active, which should be during an upstream time slot.

The TDD management system may use multiple, distributed components, each operating autonomously. The autonomous TDD system can further read in crosstalk coupling data. The crosstalk data can be used to determine which TDD groups and which lines to coordinate. A combination of centralized and autonomous TDD management can be supported.

The TDD management system can further control FEXT cancellation using, for example, vectoring. Vectoring resources can be re-assigned in real-time when the TDD asymmetry ratio changes. The TDD management system can adapt to satisfy varying delay requirements for different lines, subscribers, services, and at different times. The TDD management system can assist compatibility with FDM systems (e.g., G.fast and VDSL2), use crosstalk identification and "fingerprinting" of FDM and TDD crosstalk. The TDD management system can control retransmission, assign retransmission time slots, coordinate Hybrid retransmission that can re-send multiple parts of a block of data and/or multiple parity bits.

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The TDD management system can manage allocation of time slots for acknowledgement messages (ACKs) and/or negative acknowledgement messages (NACKs). The TDD management system can further coordinate TDD groups that have NEXT cancellation or partial NEXT cancellation, thereby allowing some overlap between down and up time slots that have such cancellation.

In this description, numerous specific details such as logic implementations, opcodes, means to specify operands, resource partitioning/sharing/duplication implementations, types and interrelationships of system components, and logic partitioning/integration choices are set forth. It will be appreciated, however, by one skilled in the art that the different implementations may be practiced without such specific details. In other instances, control structures, gate level circuits and full software instruction sequences have not been shown in detail in order not to obscure the description.

References in the specification to "one embodiment," "an embodiment," "an example embodiment," etc., indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to effect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

In this description and claims, the terms "coupled" and "connected," along with their derivatives, may be used. It should be understood that these terms are not intended as synonyms for each other. "Coupled" is used to indicate that two or more elements, which may or may not be in direct physical or electrical contact with each other, co-operate or interact with each other. "Connected" is used to indicate the establishment of communication between two or more elements that are coupled with each other. The operations of the flow and signaling diagrams are described with reference to exemplary embodiments. However, it should be understood that the operations of the flow diagrams can be performed by variations other than those discussed with reference to these other diagrams, and the variations discussed with reference to these other diagrams can perform operations different than those discussed with reference to the flow diagrams.

As described herein, instructions may refer to specific configurations of hardware such as application specific integrated circuits (ASICs) configured to perform certain operations or

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having a predetermined functionality or software instructions stored in memory embodied in a non-transitory computer readable medium. Thus, the techniques shown in the figures can be implemented using code and data stored and executed on one or more electronic devices (e.g., a UE, an eNB, etc.). Such electronic devices store and communicate (internally and/or with other electronic devices over a network) code and data using machine-readable media, such as non-transitory machine-readable storage media (e.g., magnetic disks; optical disks; random access memory; read only memory; flash memory devices; phase-change memory) and transitory machine-readable communication media (e.g., electrical, optical, acoustical or other form of propagated signals – such as carrier waves, infrared signals, digital signals, etc.).

In addition, such electronic devices typically include a set of one or more processors coupled to one or more other components, such as one or more storage devices (non-transitory machine-readable storage media), user input/output devices (e.g., a keyboard, a touchscreen, and/or a display), and network connections. The coupling of the set of processors and other components is typically through one or more busses and bridges (also termed as bus controllers). Thus, the storage device of a given electronic device typically stores code and/or data for execution on the set of one or more processors of that electronic device. Of course, one or more parts of an embodiment of the invention may be implemented using different combinations of software, firmware, and/or hardware

While the flow diagrams in the figures show a particular order of operations performed by certain embodiments of the invention, it should be understood that such order is exemplary (e.g., alternative embodiments may perform the operations in a different order,

While the invention has been described in terms of several embodiments, those skilled in the art will recognize that the invention is not limited to the embodiments described, can be practiced with modification and alteration. The description is thus to be regarded as illustrative instead of limiting.

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CLAIMS

1. A method in a data communications system for managing multiple time division physical channels that are subject to crosstalk, the method comprising

scheduling upstream time slots for upstream transmission in a first physical channel; and

scheduling downstream time slots for downstream transmission in a second physical channel,

wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots.

2. The method of Claim 1, wherein scheduling downstream time slots comprises allowing some simultaneous transmission in the upstream and downstream time slots, the method further comprising cancelling near-end crosstalk (NEXT) from downstream into upstream transmission at a network end of the channels.

3. The method of Claim 1, wherein the upstream and downstream time slots have an active portion during which signals are transmitted and an off portion during which no signals are transmitted and wherein the active portions of the upstream time slots are substantially not simultaneous with the active portions of the downstream time slots.

4. The method of Claim 1, wherein scheduling upstream and downstream time slots comprises scheduling upstream and downstream time slot boundaries.

5. The method of Claim 4, wherein the time slot boundaries are flexible.

6. The method of Claim 5, wherein the time slot boundaries have one or more of: variable-length frames; variable upstream time slot lengths; and variable downstream time slot-lengths.

7. The method of Claim 1, further comprising assigning time slots to a network element based on the scheduling and transmitting the assignments from a management system to a network element.

8. The method of Claim 1, further comprising adapting scheduling at least one of upstream and downstream time slots to accommodate delay requirements for the other of a downstream and upstream traffic source.

9. The method of Claim 1, further comprising receiving input on desired traffic levels for the first and second physical channels and wherein scheduling upstream and downstream time slots is performed based on the received input.

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10. The method of Claim 9, wherein a portion of a downstream time slot is invariant and a portion of a downstream time slot varies in real-time.

11. The method of Claim 9, wherein the received input comprises at least one of static subscription data, service layer information from a policy manager, behavior data for traffic types and users of the physical channels, long term traffic behavior data as a function of time, current traffic demands, queue lengths, traffic requests, upstream/downstream asymmetry, and traffic descriptors.

12. The method of Claim 9, wherein scheduling upstream and downstream time slots comprises assigning time slots to achieve a target upstream/downstream asymmetry ratio of data throughput.

13. The method of Claim 12, wherein the upstream/downstream asymmetry ratio is defined in numbers of discrete multi-tone symbol positions

14. The method of Claim 12, wherein the measure of throughput is at least one of an average throughput across all lines, a traffic demand match, a minimum throughput for each physical channel, a perceived quality of experience, an average delay, and a minimum delay.

15. The method of Claim 1, wherein scheduling upstream and downstream time slots comprises assigning time slots based at least in part on power usage.

16. The method of Claim 15, wherein assigning time slots based on power usage comprises assigning by scheduling entries, exits, and transitions between low-power link states and off states.

17. The method of Claim 15, wherein assigning time slots based on power usage includes assigning at least one network element to a receive-only mode, with a transmitter of the network element turned off.

18. The method of Claim 10, wherein scheduling upstream and downstream time slots comprises assigning time slots using an optimization criteria that weights different factors.

19. The method of Claim 18, wherein receiving input comprises receiving input from an external controller.

20. The method of Claim 19, wherein the received input comprises at least one of Operations Support System (OSS) data, Element Management System (EMS) data, and Management Information Database (MIB) parameters.

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21. The method of Claim 10, wherein the time slots are defined within a time division frame, wherein receiving input comprises receiving input during a frame, and wherein scheduling upstream and downstream time slots comprises scheduling upstream and downstream time slots of an immediately subsequent frame.

22. The method of Claim 1, further comprising receiving requests for upstream and downstream transmission and wherein scheduling upstream time slots is based on the received upstream transmission requests.

23. The method of Claim 1, wherein the transmission in the upstream time slots is from a plurality of different network-end transmission sources.

24. The method of Claim 23, further comprising synchronizing upstream transmission and downstream transmission among a plurality of different network-end transmission sources.

25. The method of Claim 24, wherein synchronizing comprises sending synch symbols to a source of upstream transmissions.

26. The method of Claim 24, wherein synchronizing comprises measuring a time series of time-varying crosstalk and synchronizing to time-varying patterns of the crosstalk.

27. The method of Claim 24, wherein synchronizing is performed by measuring a time series of error events and synchronizing to time-varying patterns of the error events.

28. The method of Claim 1, wherein scheduling upstream and downstream time slots comprises determining a duration of the upstream and downstream time slots and moving the upstream and downstream time slot start times to reduce simultaneous upstream and downstream transmission.

29. The method of Claim 28, wherein determining a duration comprises adjusting a default duration based on bandwidth requests.

30. The method of Claim 28, wherein moving comprises moving only if upstream transmissions overlap downstream transmissions in time.

31. The method of Claim 28, further comprising reducing the duration of at least one downstream time slot to reduce simultaneous upstream and downstream transmission.

32. The method of Claim 1, wherein the scheduling upstream and downstream time slot is further performed to minimize crosstalk on nearby VDSL2 lines.

33. The method of Claim 1, further comprising receiving input on desired traffic levels for the first and second physical channels and wherein scheduling upstream and

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downstream time slots is performed based on the received input and at least in part on power usage.

34. A machine-readable medium having instructions that when operated on by the machine cause the machine to perform operations comprising:

scheduling upstream time slots for upstream transmission in a first physical channel of multiple time division physical channels in a data communication system in which the physical channels are subject to crosstalk; and

scheduling downstream time slots for downstream transmission in a second physical channel subject to crosstalk from the upstream time slots,

wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots.

35. The medium of Claim 34, the operations further comprising receiving input on desired traffic levels for the first and second physical channels and wherein scheduling upstream and downstream time slots is performed based on the received input.

36. The medium of Claim 34, wherein scheduling upstream and downstream time slots comprises assigning time slots to achieve a target upstream/downstream asymmetry ratio of data throughput.

37. An apparatus for managing multiple time division physical channels in a data communications system that are subject to crosstalk, the apparatus comprising

means for scheduling upstream time slots for upstream transmission in a first physical channel; and

means for scheduling downstream time slots for downstream transmission in a second physical channel subject to crosstalk from the upstream time slots,

wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots.

38. The apparatus of Claim 37, further comprising means for assigning at least one network element to a receive-only mode, with a transmitter of the network element turned off.

39. The apparatus of Claim 37, further comprising means for receiving requests for upstream and downstream transmission for use by the means for scheduling.

40. A system with multiple physical channels in a data communications system transmitting point-to-multipoint over multiple copper wires that are subject to crosstalk, wherein

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the system allows full-duplex operation by using line hybrids and echo cancellation to separate upstream transmission from downstream transmission, and

near-end crosstalk (NEXT) is cancelled only at the network-end of the channels, from downstream into upstream transmission,

wherein transmission in the upstream time slots may occur simultaneous with transmission in the downstream time slots.

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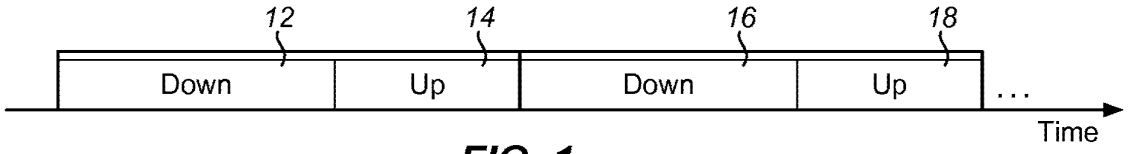


FIG. 1

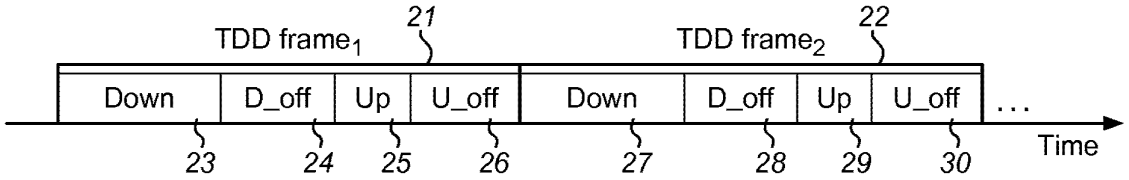


FIG. 2

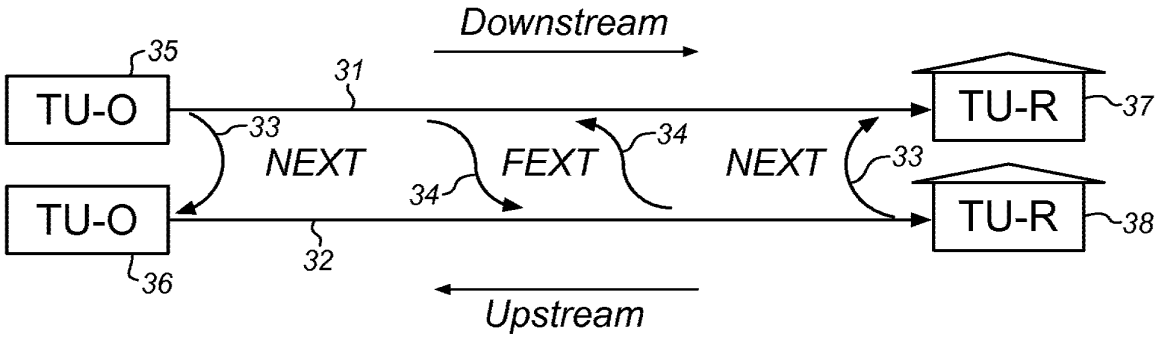


FIG. 3

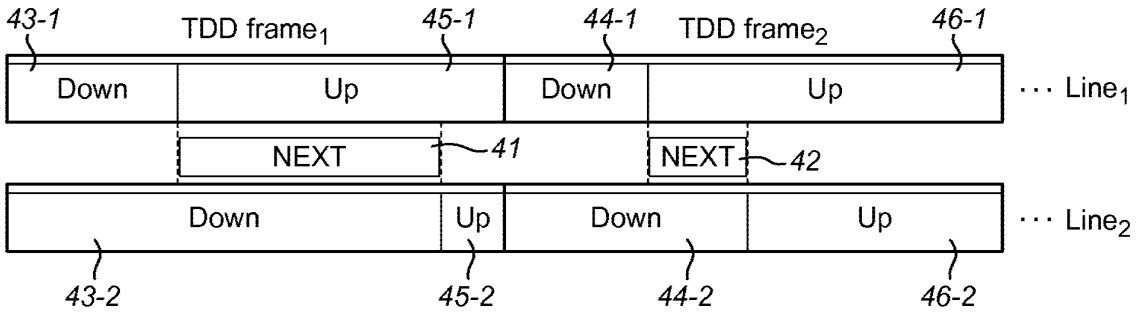


FIG. 4

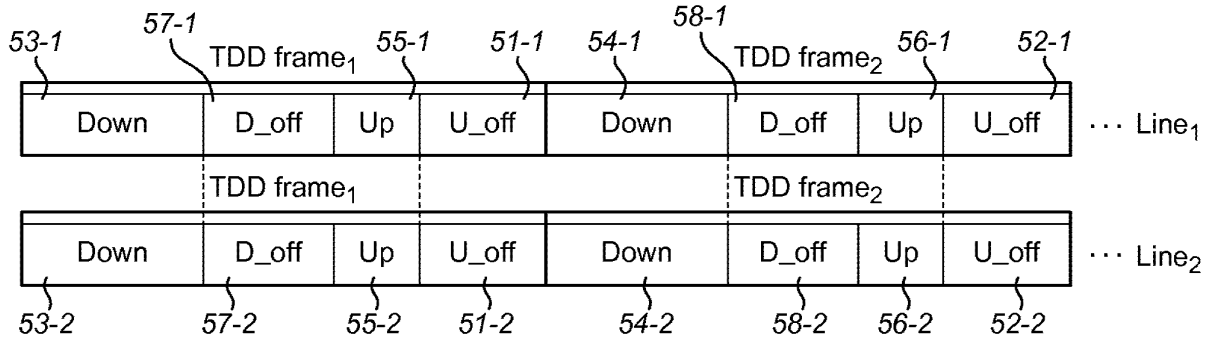


FIG. 5

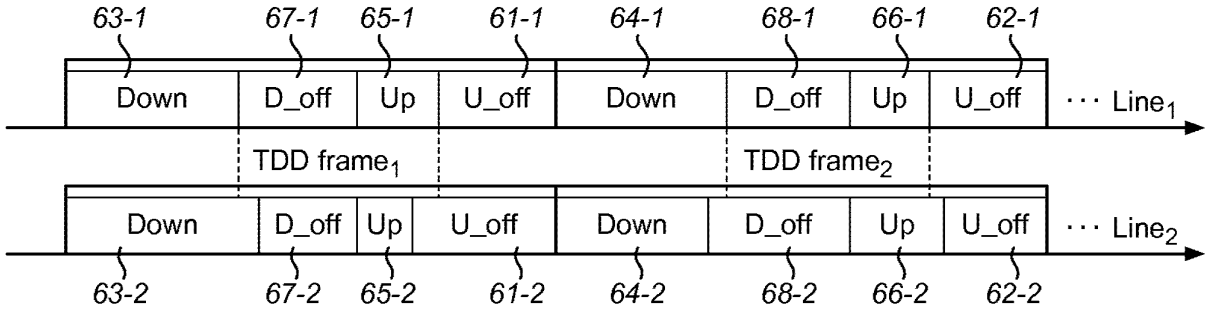


FIG. 6

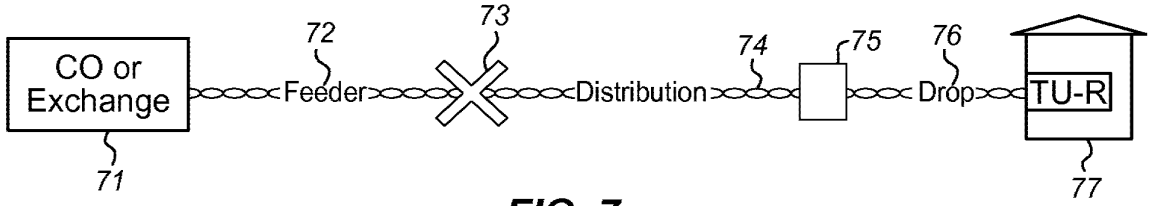


FIG. 7

FIG. 8

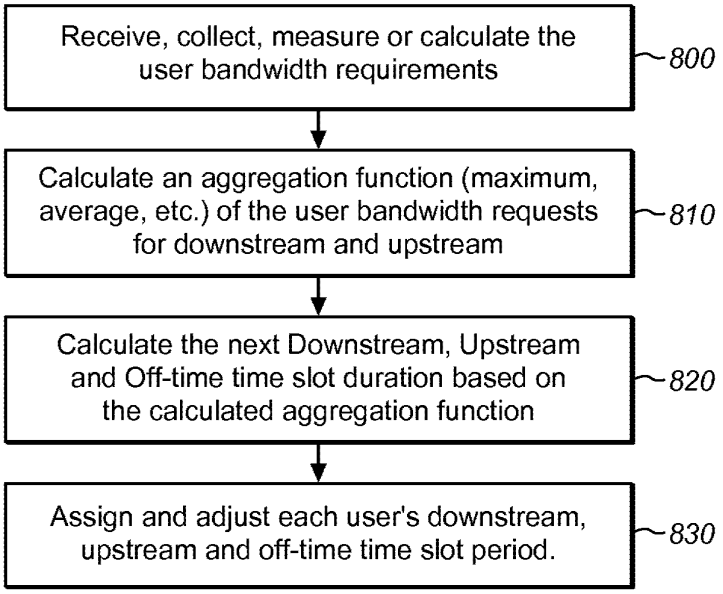
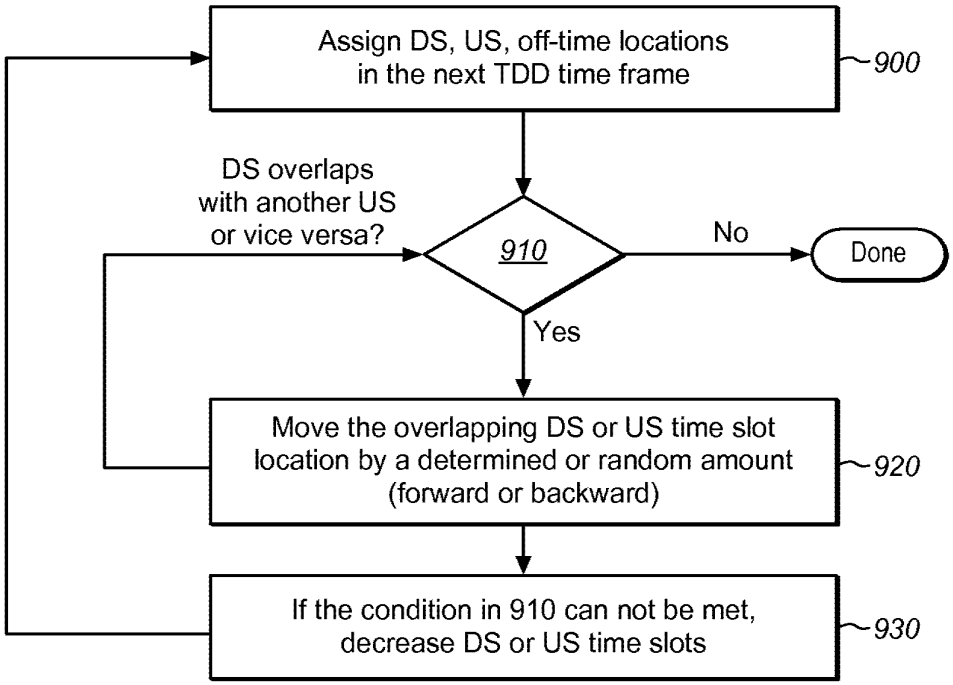

Receive, collect, measure or calculate the user bandwidth requirements
800
Calculate an aggregation function (maximum, average, etc.) of the user bandwidth requests for downstream and upstream
810
Calculate the next Downstream, Upstream and Off-time time slot duration based on the calculated aggregation function
820
Assign and adjust each user's downstream, upstream and off-time time slot period.
830

FIG. 9


Assign DS, US, off-time locations in the next TDD time frame
900
DS overlaps with another US or vice versa?
910
No
Done
Yes
Move the overlapping DS or US time slot location by a determined or random amount (forward or backward)
920
If the condition in 910 can not be met, decrease DS or US time slots
930

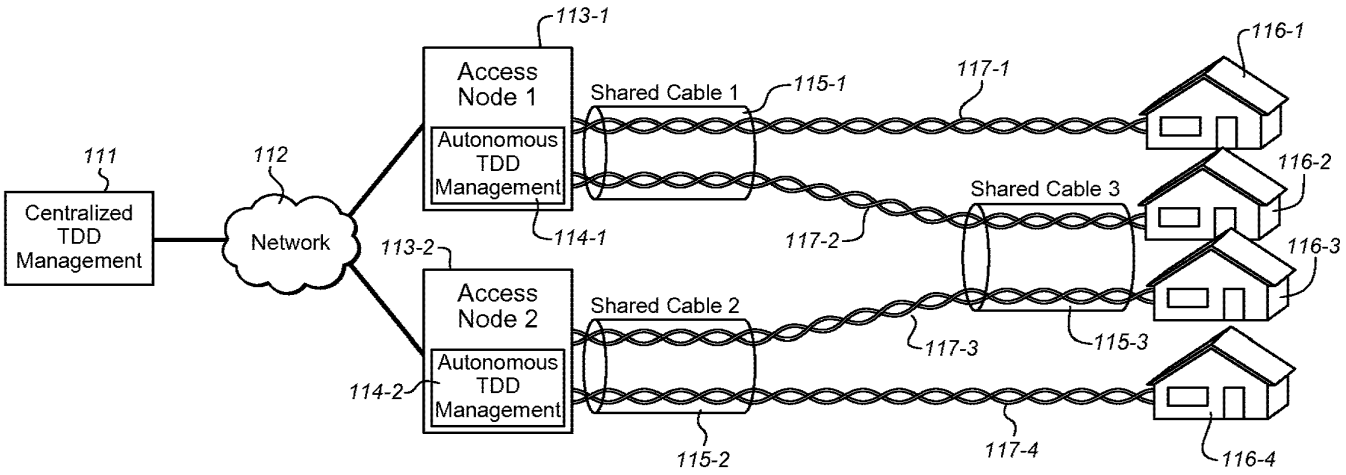
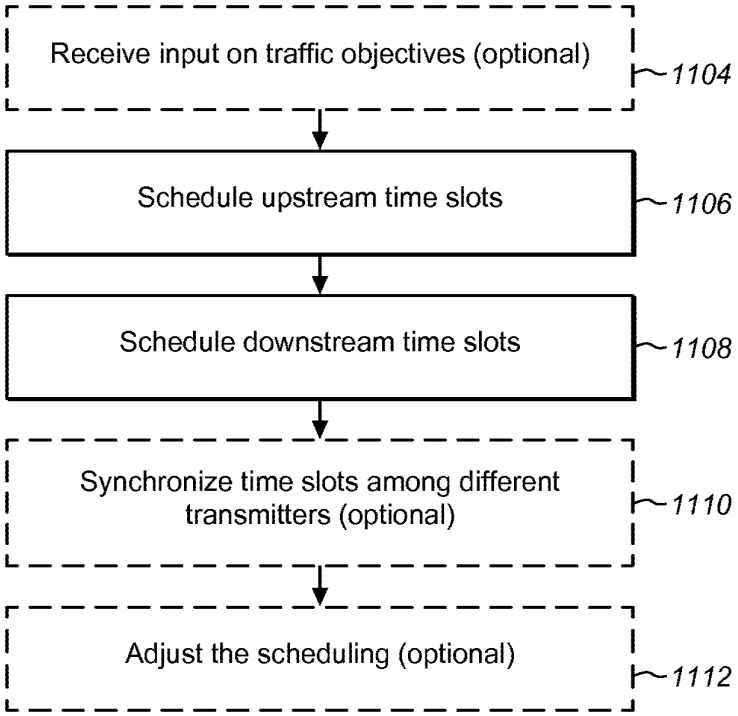

113-1
Access Node 1
Autonomous TDD Management
114-1
Shared Cable 1
115-1
117-1
116-1
111
Centralized TDD Management
112
Network
113-2
Access Node 2
Autonomous TDD Management
114-2
Shared Cable 2
115-2
117-2
Shared Cable 3
116-2
116-3
117-3
115-3
117-4
116-4

FIG. 10

FIG. 11


Receive input on traffic objectives (optional)
1104
Schedule upstream time slots
1106
Schedule downstream time slots
1108
Synchronize time slots among different transmitters (optional)
1110
Adjust the scheduling (optional)
1112

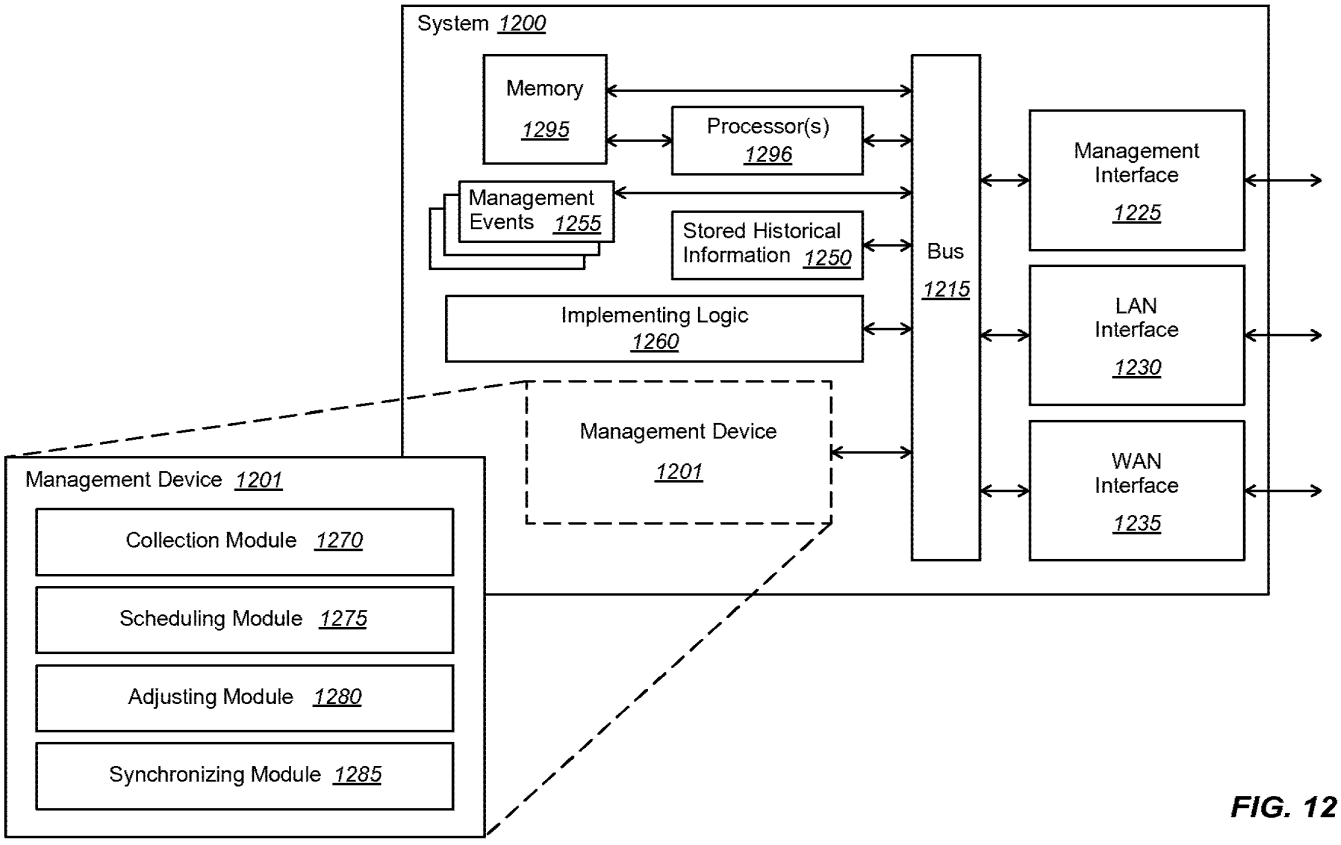

System 1200
Memory 1295
Processor(s) 1296
Management Events 1255
Stored Historical Information 1250
Implementing Logic 1260
Management Device 1201
Bus 1215
Management Interface 1225
LAN Interface 1230
WAN Interface 1235
Management Device 1201
Collection Module 1270
Scheduling Module 1275
Adjusting Module 1280
Synchronizing Module 1285

FIG. 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/060115

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04M11/06 H04B3/46
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B H04M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CA 2 254 807 A1 (AMATI COMM CORP [US]) 30 May 2000 (2000-05-30) abstract; figures 2-4,5B,11 page 6, line 7 - page 9, line 27 page 13, line 1 - line 3 page 14, line 7 - line 31 page 16, line 22 - line 29 page 20, line 29 - line 33 page 21, line 34 - line 36 page 23, line 1 - line 2 page 27, line 8 - line 14 -----	1-40
X	US 6 480 475 B1 (MODLIN CORY S [US] ET AL) 12 November 2002 (2002-11-12) abstract; figures 2A,2B,4 column 3, line 54 - column 8, line 8 column 10, line 54 - column 11, line 67 ----- -/--	1-40

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 April 2013	02/05/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Ohanovici, Z

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/060115

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 2003/086362 A1 (HASEGAWA KAZUTOMO [JP] ET AL) 8 May 2003 (2003-05-08) abstract; claims 1-7; figures 1A,2,5 paragraph [0009] - paragraph [0019] paragraph [0033] - paragraph [0035] -----	1,2,32, 40 3-31, 33-39
A	EP 1 011 206 A2 (NORTEL NETWORKS CORP [CA] NORTEL NETWORKS LTD [CA]) 21 June 2000 (2000-06-21) abstract paragraph [0006] paragraph [0020] - paragraph [0025] paragraph [0041] - paragraph [0043] -----	15-17
X A	US 2009/082064 A1 (LI QINGHUA [US] ET AL) 26 March 2009 (2009-03-26) abstract; figures 1,2A,2B,4 paragraph [0019] - paragraph [0021] paragraphs [0027], [0033], [0040] -----	1-3,34, 37 4-33,35, 36,38-40
X A	US 2005/122999 A1 (SCHERZER SHIMON B [US] ET AL) 9 June 2005 (2005-06-09) abstract; figures 1,3,6,8,9,12 paragraph [0009] - paragraph [0015] paragraphs [0045], [0047], [0063] paragraph [0086] - paragraph [0088] -----	1,4-7, 9-21, 28-31, 34,37 2,3,8, 22-27, 32,33, 35,36, 38-40

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2012/060115

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			DE	69829725 T2	09-02-2006
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			US	2008227401 A1	18-09-2008
			WO	2005057944 A2	23-06-2005

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Attorney Docket No.: 8241P074

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	
Kenneth Kerpez et al.	Examiner:
Application No.:	Art Group:
Filed:	Confirmation No.:
For: MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	

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Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

PRELIMINARY AMENDMENT

Prior to examination, please amend the above-identified application as follows:

Amendments to the Specification begin on page **2** of this paper.

Remarks/Arguments begin on page **3** of this paper.

Conclusion begins on page **4** of this paper.

SPECIFICATION

Please add the following heading and new paragraph at page 1, after the title of the application:

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is the U.S. National Phase of International Application No. PCT/US2012/060115, filed October 12, 2012, and claims the benefit of U.S. Provisional Application No. 61/676,862, filed July 27, 2012, the disclosures of both of which are incorporated herein by reference in their entirety.

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Page 46 of 511

REMARKS

The specification has been amended to add a priority claim. No new matter has been added.

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Page 47 of 511

CONCLUSION

The Examiner is respectfully requested to contact the undersigned by telephone if such contact would further the examination of the present application.

Please charge any shortages and credit any overcharges to our Deposit Account number 02-2666.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN, LLP

Date: January 26, 2015

/Gregory D. Caldwell/

Gregory D. Caldwell
Reg. No. 39,926
Attorney for Applicants

1279 Oakmead Parkway
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(503) 439-8778

I hereby certify that this correspondence is being submitted electronically via EFS Web on the date shown below.

January 26, 2015
Date

/Lisa Bennett/
Lisa Bennett

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Petitioners' Exhibit 1002
Page 48 of 511

PTO/SB/14 (11-08)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	8241P074
	Application Number	
Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Applicant Information:

Applicant 1 Remove

Applicant Authority ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
	Kenneth		Kerpez	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Longvalley	State/Province	NJ	Country of Residence[i]	US

Citizenship under 37 CFR 1.41(b)[i]: US

Mailing Address of Applicant:

Address 1	150 Old Farmers Road		
Address 2			
City	Longvalley	State/Province	NJ
Postal Code	07853	Country[i]	US

Applicant 2 Remove

Applicant Authority ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
	George		Ginis	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	San Mateo	State/Province	CA	Country of Residence[i]	US

Citizenship under 37 CFR 1.41(b)[i]: GR

Mailing Address of Applicant:

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Address 2			
City	San Mateo	State/Province	CA
Postal Code	94402	Country[i]	US

Applicant 3 Remove

Applicant Authority ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
	Marc		Goldburg	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Redwood City	State/Province	CA	Country of Residence[i]	US

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	8241P074
	Application Number	
Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	

Citizenship under 37 CFR 1.41(b) i	US				
Mailing Address of Applicant:					
Address 1	226 Hillsdale Way				
Address 2					
City	Redwood City	**State/Province**	CA		
Postal Code	94062	**Country**i	US		

Applicant 4 Remove

Applicant Authority (•) Inventor ( ) Legal Representative under 35 U.S.C. 117 ( ) Party of Interest under 35 U.S.C. 118

Prefix	**Given Name**	**Middle Name**	**Family Name**	**Suffix**
	Ardavan	Maleki	Tehrani	

Residence Information (Select One) (•) US Residency ( ) Non US Residency ( ) Active US Military Service

City	Menlo Park	**State/Province**	CA	**Country of Residence** i	US
Citizenship under 37 CFR 1.41(b) i	US				
Mailing Address of Applicant:					
Address 1	350 Sharon Park Drive, R-24				
Address 2					
City	Menlo Park	**State/Province**	CA		
Postal Code	94025	**Country**i	US		

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	08791		
Email Address		Add Email	Remove Email

Application Information:

Title of the Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER		
Attorney Docket Number	8241P074	**Small Entity Status Claimed**	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		**Sub Class (if any)**	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)	6	**Suggested Figure for Publication (if any)**	

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	8241P074
	Application Number	
Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Enter either Customer Number or complete the Representative Name section below. If both sections are completed the Customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	08791		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	a 371 of international	PCT/US2012/060115	2012-10-12
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
PCT/US2012/060115	non provisional of	61676862	2012-07-27

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

Remove

Application Number	Country [i]	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
			◉ Yes ○ No

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	8241P074
	Application Number	
Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	

Assignee Information:

Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office.

Assignee 1 Remove

If the Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information:

Address 1			
Address 2			
City		**State/Province**	
Country [i]		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee Data may be generated within this form by selecting the **Add** button. Add

Signature:

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature.

Signature	/Gregory D. Caldwell/			Date (YYYY-MM-DD)	2015-01-26
First Name	Gregory D.	Last Name	Caldwell	Registration Number	39926

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The information provided by you in this form will be subject to the following routine uses:

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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application No.	
Filing Date	
First Inventor	Kenneth Kerpez, et al.
Art Unit	
Examiner Name	
Attorney Docket No.	8241P074 Conf. No.

DUTY OF DISCLOSURE STATEMENT

In accordance with the duty of disclosure, enclosed is a copy of an Information Disclosure Statement (IDS) Citation Form PTO/SB/08 or PTO-1449, together with copies of the documents cited on that form, except for copies not required to be submitted (e.g., copies of U.S. patents and U.S. published patent applications need not be enclosed). This IDS and IDS Citation Form are being submitted concurrently with the US National Stage Application of PCT. It is respectfully requested that the cited references be considered and that the enclosed copy of PTO/SB/08 be initialed by the Examiner to indicate such consideration and a copy thereof returned to applicant(s).

The submission of this Information Disclosure Statement is not to be construed as a representation that a search has been made in the subject application and is not to be construed as an admission that the information cited in this statement is material to patentability.

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

OR

☒ None

☐ The IDS Filing Fee in the amount of $180.00 as set forth in 37 CFR 1.17(p) has been submitted herewith.

☒ It is requested that any requisite fees be debited from Deposit Account 02-2666.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of signature.

Signature	/Gregory D. Caldwell/	Date (MM-DD-YYYY)	01-26-2015
Name/Print	Gregory D. Caldwell	Registration Number	39,926

I hereby certify that this correspondence is being submitted electronically via EFS Web on the date shown below.

/Lisa Bennett/

Lisa Bennett *Date* *01-26-15*

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Substitute for form 1449A/PTO	*Complete if Known*	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(Use as many sheets as necessary)*	**Application Number**	
	Filing Date	
	First Named Inventor	Kenneth Kerpez
	Group Art Unit	
	Examiner Name	
Sheet 1 of 1	Attorney Docket No: 8241P074	

US PATENT DOCUMENTS					
Examiner Initial *	**Cite No [1]**	**USP Document Number**	**Publication or Issue Date MM-DD-YYYY**	**Name of Patentee or Applicant of cited Document**	**Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear**
		US-2009/0082064	03-26-2009	LI et al.	
		US-2005/0122999	06-09-2005	SCHERZER et al.	
		US-2003/0086362	05-08-2003	HASEGAWA et al.	
		US-6,480,475	11-12-2002	MODLIN et al.	

FOREIGN PATENT DOCUMENTS						
Examiner Initials*	**Cite No [1]**	**Foreign Patent Document** Country Code/Number/Kind Code (if known)	**Publication Date MM-DD-YYYY**	**Name of Patentee or Applicant of cited Document**	**Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear**	**T [2]**
		CA-2254807	05-30-2000	AMATI COMMUNICATIONS CORPORATION		
		EP-1011206	06-21-2000	NORTEL NETWORKS CORPORATION		

OTHER DOCUMENTS -- NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	**Cite No [1]**	**Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.**	**T [2]**
		International Search Report for International Patent Application No. PCT/US2012/060115 (Attorney Docket No. 8241P074PCT), mailed May 2, 2013.	

EXAMINER **DATE CONSIDERED**

Based on PTO/SB/08A(09-06) - Substitute Disclosure Statement Form (PTO-1449) as modified by BSTZ 03/26/07

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1] Applicant's unique citation designation number (optional) [2] Applicant is to place a check mark here if English language Translation is attached

(19) Canadian Intellectual Property Office
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Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

(11) CA 2 254 807 (13) A1
(43) 30.05.2000

(12)

(21) 2 254 807
(22) 30.11.1998

(51) Int. Cl.[6]: H04L 005/14, G11B 023/00, H04L 007/027

(71) AMATI COMMUNICATIONS CORPORATION, 2043 Samaritan Drive, SAN JOSE, XX (US).

(72) BINGHAM, John A. C. (US).
SANDS, Nicholas P. (US).

(74) KIRBY EADES GALE BAKER

(54) METHODE ET SYSTEME DE SYNCHRONISATION D'EMETTEURS-RECEPTEURS A DUPLEXAGE PAR REPARTITION DANS LE TEMPS

(54) METHOD AND SYSTEM FOR SYNCHRONIZING TIME-DIVISION-DUPLEXED TRANSCEIVERS

(57)

Improved techniques for synchronizing transmissions and receptions of a data transmission system utilizing time division duplexing is disclosed. The improved synchronization techniques utilize the time-varying nature of the energy of the received data to obtain synchronization. In one embodiment, an improved synchronization processing (500) measures energy (502) in n consecutive frames of received data. An alignment error estimate is then computed (504) based on the measured energy values for the n consecutive frames. In another embodiment, the improved synchronization technique uses the output signals from a multicarrier modulation unit (FFT unit) and thus provides the ability to avoid frequency tones that are susceptible to RF interference. The improved synchronization techniques can also utilize crosstalk interference levels to obtain synchronization. Remote receivers in the data transmission system are able to synchronize to central transmitters, central receivers in the data transmission system are able to synchronize to remote transmitters, and central transmitters are able to synchronize with one another.

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(12) (19) (CA) **Demande-Application**

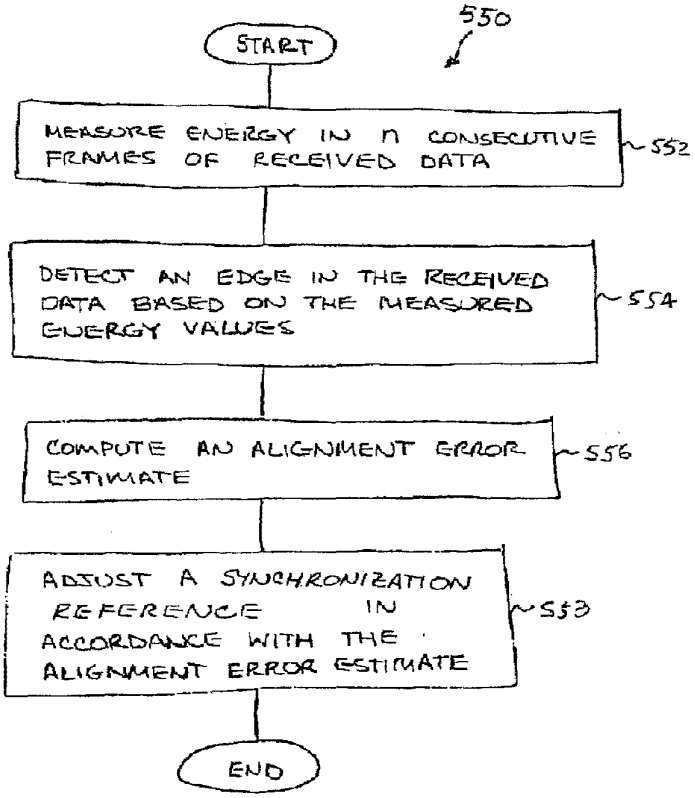
(21) (A1) **2,254,807**
(22) 1998/11/30
(43) 2000/05/30

(72) SANDS, Nicholas P., US
(72) BINGHAM, John A. C., US
(71) AMATI COMMUNICATIONS CORPORATION, US

(51) Int.Cl.[6] H04L 5/14, H04L 7/027, G11B 23/00

(54) **METHODE ET SYSTEME DE SYNCHRONISATION D'EMETTEURS-RECEPTEURS A DUPLEXAGE PAR REPARTITION DANS LE TEMPS**

(54) **METHOD AND SYSTEM FOR SYNCHRONIZING TIME-DIVISION-DUPLEXED TRANSCEIVERS**



(57) Improved techniques for synchronizing transmissions and receptions of a data transmission system utilizing time division duplexing is disclosed. The improved synchronization techniques utilize the time-varying nature of the energy of the received data to obtain synchronization. In one embodiment, an improved synchronization processing (500) measures energy (502) in n consecutive frames of received data. An alignment error estimate is then computed (504) based on the measured energy values for the n consecutive frames. In another embodiment, the improved synchronization technique uses the output signals from a multicarrier modulation unit (FFT unit) and thus provides the ability to avoid frequency tones that are susceptible to RF interference. The improved synchronization techniques can also utilize crosstalk interference levels to obtain synchronization. Remote receivers in the data transmission system are able to synchronize to central transmitters, central receivers in the data transmission system are able to synchronize to remote transmitters, and central transmitters are able to synchronize with one another.

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METHOD AND SYSTEM FOR SYNCHRONIZING TIME-DIVISION-DUPLEX TRANSCEIVERS

ABSTRACT OF THE DISCLOSURE

Improved techniques for synchronizing transmissions and receptions of a data transmission system utilizing time division duplexing is disclosed. The improved synchronization techniques utilize the time-varying nature of the energy of the received data to obtain synchronization. In one embodiment, an improved synchronization processing (500) measures energy (502) in *n* consecutive frames of received data. An alignment error estimate is then computed (504) based on the measured energy values for the *n* consecutive frames. In another embodiment, the improved synchronization technique uses the output signals from a multicarrier modulation unit (FFT unit) and thus provides the ability to avoid frequency tones that are susceptible to RF interference. The improved synchronization techniques can also utilize crosstalk interference levels to obtain synchronization. Remote receivers in the data transmission system are able to synchronize to central transmitters, central receivers in the data transmission system are able to synchronize to remote transmitters, and central transmitters are able to synchronize with one another.

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Petitioners' Exhibit 1002
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METHOD AND SYSTEM FOR SYNCHRONIZING TIME-DIVISION-DUPLEXED TRANSCEIVERS

CROSS-REFERENCE TO RELATED APPLICATION

This application is related to (i) U.S. Application Serial No. 08/707,322 which is entitled "METHOD AND APPARATUS FOR CROSSTALK CANCELLATION" and (ii) U.S. Application Serial No. 08/501,250 which is entitled "TIME DIVISION DUPLEXED HIGH SPEED DATA TRANSMISSION SYSTEM AND METHOD," and both of which are hereby incorporated by reference for all purposes.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to data transmission systems, and more particularly, to data transmission systems utilizing time-division duplexing.

2. Description of the Related Art

Bi-directional digital data transmission systems are presently being developed for high-speed data communications. One standard for high-speed data communications over twisted-pair phone lines that has developed is known as Asymmetric Digital Subscriber Lines (ADSL). Another standard for high-speed data communications over twisted-pair phone lines that is presently proposed is known as Very High Speed Digital Subscriber Lines (VDSL).

The Alliance For Telecommunications Information Solutions (ATIS), which is a group accredited by the ANSI (American National Standard Institute) Standard Group, has finalized a discrete multi tone based approach for the transmission of digital data over twisted-pair phone lines. The standard, known as ADSL, is intended primarily for transmitting video data and fast Internet access over ordinary telephone lines, although it may be used in a variety of other applications as well. The North American Standard is referred to as the ANSI T1.413 ADSL Standard (hereinafter ADSL standard), and is hereby incorporated by reference. Transmission rates under the ADSL standard are intended to facilitate the transmission of information at rates of up to 8 million bits per second (Mbits/s) over twisted-pair phone lines. The standardized system defines the use of a discrete multi tone (DMT) system that uses 256 "tones" or "sub-channels" that are each 4.3125 kHz wide in the forward

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(downstream) direction. In the context of a phone system, the downstream direction is defined as transmissions from the central office (typically owned by the telephone company) to a remote location that may be an end-user (i.e., a residence or business user). In other systems, the number of tones used may be widely varied.

The ADSL standard also defines the use of reverse transmissions at a data rate in the range of 16 to 800 Kbit/s. The reverse transmissions follow an upstream direction, as for example, from the remote location to the central office. Thus, the term ADSL comes from the fact that the data transmission rate is substantially higher in the downstream direction than in the upstream direction. This is particularly useful in systems that are intended to transmit video programming or video conferencing information to a remote location over telephone lines.

Because both downstream and upstream signals travel on the same pair of wires (that is, they are duplexed) they must be separated from each other in some way. The method of duplexing used in the ADSL standard is Frequency Division Duplexing (FDD) or echo canceling. In frequency division duplexed systems, the upstream and downstream signals occupy different frequency bands and are separated at the transmitters and receivers by filters. In echo cancel systems, the upstream and downstream signals occupy the same frequency bands and are separated by signal processing.

ANSI is producing another standard for subscriber line based transmission system, which is referred to as the VDSL standard. The VDSL standard is intended to facilitate transmission rates of at least about 6 Mbit/s and up to about 52 Mbit/s or greater in the downstream direction. Simultaneously, the Digital, Audio and Video Council (DAVIC) is working on a similar system, which is referred to as Fiber To The Curb (FTTC). The transmission medium from the "curb" to the customer is standard unshielded twisted-pair (UTP) telephone lines.

A number of modulation schemes have been proposed for use in the VDSL and FTTC standards (hereinafter VDSL/FTTC). For example, some of the possible VDSL/FTTC modulation schemes include multi-carrier transmission schemes such as Discrete Multi-Tone modulation (DMT) or Discrete Wavelet Multi-Tone modulation (DWMT), as well as single carrier transmission schemes such as Quadrature Amplitude Modulation (QAM), Carrierless Amplitude and Phase modulation (CAP), Quadrature Phase Shift Keying (QPSK), or vestigial sideband modulation.

Additionally, multicarrier modulation transmission schemes have been receiving a large amount of attention due to the high data transmission rates they offer. FIG. 1A is a simplified block diagram of a conventional transmitter 100 for a multicarrier modulation system. The conventional transmitter 100 is, for example, suitable for DMT modulation in

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ADSL or VDSL systems. The transmitter 100 receives data signals to be transmitted at a buffer 102. The data signals are then supplied from the buffer 102 to a forward error correction (FEC) unit 104. The FEC unit 104 compensates for errors that are due to crosstalk noise, impulse noise, channel distortion, etc. The signals output by the FEC unit 104 are supplied to a data symbol encoder 106. The data symbol encoder 106 operates to encode the signals for a plurality of frequency tones associated with the multicarrier modulation. In assigning the data, or bits of the data, to each of the frequency tones, the data symbol encoder 106 utilizes data stored in a transmit bit allocation table 108 and a transmit energy allocation table 110. The transmit bit allocation table 108 includes an integer value for each of the carriers (frequency tones) of the multicarrier modulation. The integer value indicates the number of bits that are to be allocated to the particular frequency tone. The value stored in the transmit energy allocation table 110 is used to effectively provide fractional number of bits of resolution via different allocation of energy levels to the frequency tones of the multicarrier modulation. In any case, after the data symbol encoder 106 has encoded the data onto each of the frequency tones, an Inverse Fast Fourier Transform (IFFT) unit 112 modulates the frequency domain data supplied by the data symbol encoder 106 and produces time domain signals to be transmitted. The time domain signals are then supplied to a digital-to-analog converter (DAC) 114 where the digital signals are converted to analog signals. Thereafter, the analog signals are transmitted over a channel to one or more remote receivers.

FIG. 1B is a simplified block diagram of a conventional remote receiver 150 for a multicarrier modulation system. The conventional remote receiver 150 is, for example, suitable for DMT demodulation in ADSL or VDSL systems. The remote receiver 150 receives analog signals that have been transmitted over a channel by a transmitter. The received analog signals are supplied to an analog-to-digital converter (ADC) 152. The ADC 152 converts the received analog signals to digital signals. The digital signals are then supplied to a Fast Fourier Transform (FFT) unit 154 that demodulates the digital signals while converting the digital signals from a time domain to a frequency domain. The demodulated digital signals are then supplied to a frequency domain equalizer (FEQ) unit 156. The FEQ unit 156 performs an equalization on the digital signals so the attenuation and phase are equalized over the various frequency tones. Then, a data symbol decoder 158 receives the equalized digital signals. The data symbol decoder 158 operates to decode the equalized digital signals to recover the data, or bits of data, transmitted on each of the carriers (frequency tones). In decoding the equalized digital signals, the data symbol decoder 158 needs access to the bit allocation information and the energy allocation information that were used to transmit the data. Hence, the data symbol decoder 158 is coupled to a received bit allocation table 162 and a received energy allocation table 160 which respectively store the bit allocation information and the energy allocation information that were used to transmit

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the data. The data obtained from each of the frequency tones is then forwarded to the forward error correction (FEC) unit 164. The FEC unit 164 performs error correction of the data to produce corrected data. The corrected data is then stored in a buffer 166. Thereafter, the data may be retrieved from the buffer 166 and further processed by the receiver 150. Alternatively, the received energy allocation table 160 could be supplied to and utilized by the FEQ unit 166.

The bit allocation tables and the energy allocation tables utilized in the conventional transmitter 100 can be implemented as a single table or as individual tables. Likewise, the bit allocation tables and the energy allocation tables utilized in the remote receiver 150 can be implemented as a single table or as individual tables. Also, the transmitter 100 is normally controlled by a controller, and the remote receiver 150 is normally controlled by a controller. Typically, the controllers are programmable controllers.

The transmitter 100 and the remote receiver 150 illustrated in FIGs. 1A and 1B, respectively, optionally include other components. For example, the transmitter 100 could add a cyclic prefix to symbols after the IFFT unit 112, and the remote receiver 150 can then remove the cyclic prefix before the FFT unit 154. Also, the remote receiver 150 can provide a time domain equalizer (TEQ) unit between the ADC 152 and the FFT unit 154.

Most of the proposed VDSL/FTTC transmission schemes utilize frequency division duplexing (FDD) of the upstream and downstream signals. On the other hand, one particular proposed VDSL/FTTC transmission scheme uses time division duplexing (TDD) of the upstream and downstream signals. More particularly, the time division duplexing is synchronized in this case such that periodic synchronized upstream and downstream communication periods do not overlap with one another. That is, the upstream and downstream communication periods for all of the wires that share a binder are synchronized. With this arrangement, all the very high speed transmissions within the same binder are synchronized and time division duplexed such that downstream communications are not transmitted at times that overlap with the transmission of upstream communications. This is also referred to as a (i.e. "ping pong") based data transmission scheme. Quiet periods, during which no data is transmitted in either direction, separate the upstream and downstream communication periods. When the synchronized time division duplexed approach is used with DMT it is often referred to as synchronized DMT (SDMT).

A common feature of the above-mentioned transmission systems is that twisted-pair phone lines are used as at least a part of the transmission medium that connects a central office (e.g., telephone company) to users (e.g., residence or business). Even though fiber optics may be available from a central office to the curb near a user's residence, twisted-pair phone lines are used to bring in the signals from the curb into the user's home or business.

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The twisted-pair phone lines are grouped in a binder. While the twisted-pair phone lines are within the binder, the binder provides reasonably good protection against external electromagnetic interference. However, within the binder, the twisted-pair phone lines induce electromagnetic interference on each other. This type of electromagnetic interference is generally known as crosstalk interference which includes near-end crosstalk (NEXT) interference and far-end crosstalk (FEXT) interference. As the frequency of transmission increases, the crosstalk interference (NEXT interference) becomes substantial. As a result, the data signals being transmitted over the twisted-pair phone lines at high speeds can be significantly degraded by the crosstalk interference caused by other twisted-pair phone lines in the binder. As the speed of the data transmission increases, the problem worsens. The advantage of the synchronized TDD (such as SDMT) based data transmission is that crosstalk interference (NEXT interference) from other lines in a binder is essentially eliminated, provided all the lines transmit for the same duration (i.e., same superframe format).

A data transmission system normally includes a central office and a plurality of remote units. Each remote unit communicates with the central office over a data link (i.e., channel) that is established between the central office and the particular remote unit. To establish such a data link, initialization processing is performed to initialize communications between the central office and each of the remote units. For purposes of the discussion to follow, a central office includes a central modem (or central unit) and a remote unit includes a remote modem. These modems are transceivers that facilitate data transmission between the central office and the remote unit. The central office thus normally includes a plurality of central side transceivers, each of which has a central side transmitter and a central side receiver, and the remote unit normally includes a remote side transceiver having a remote side transmitter and a remote side receiver.

One conventional frame synchronization technique required the transmission of a predetermined sequence of data which was received by a receiver and then correlated with a predetermined stored sequence of data to determine the adjustment required in order to yield synchronization. U.S. Patent No. 5,627,863 describes a frame synchronization approach suitable for systems (e.g., ADSL) using frequency division duplexing (FDD) or echo cancelling to provide duplexed operation. This frame synchronization technique requires a special start-up training sequence to obtain the frame synchronization. However, the described frame synchronization approach is not suitable for systems (e.g., synchronized TDD or SDMT) using time division duplexing because synchronization in time is not necessary for FDD or echo cancelling as it is with TDD in order to reduce crosstalk.

When a data transmission system is operating in a time-division duplexed (TDD) manner, the transmitters and receivers of the central office and remote units must be

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synchronized in time so that transmission and reception do not overlap in time. In a data transmission system, downstream transmissions are from a central side transmitter to one or more remote side receivers and upstream transmissions are from one or more remote side transmitters to a central side receiver. The central side transmitter and receiver can be combined as a central side transceiver, and the remote side transmitter and receiver can be combined as a remote side transceiver.

Generally speaking, in a time division duplexed system, upstream signals are alternated with downstream signals. Typically, the upstream transmissions and the downstream transmissions are separated by a guard interval or a quiet period. The guard interval is provided to enable the transmission system to reverse the direction in which data is being transmitted so that a transmission can be received before the transmission in the opposite direction occurs. Some transmission schemes divide upstream and downstream transmissions into smaller units referred to as frames. These frames may also be grouped into superframes that include a series of downstream frames and a series of upstream frames, as well as guard intervals between the two.

Time-division duplexing is a simple method to share a channel (medium) between two or more transceivers. Each transceiver is assigned a time slot during which it may transmit, and there are quiet periods (guard intervals) during which no unit must transmit. On channels subject to crosstalk (NEXT interference) between multiple connections, if time-division duplexing is used, synchronization must be established and maintained among all units so affected. An example is the VDSL service that uses the existing twisted pair telephone loop plant to transport up to 13-52 Mb/s on loops up to 1.5 km. Pairs destined for subscribers are bundled together in a cable consisting of 25-100 pairs. The proximity and the high frequency use (0.2-11 MHz signal bandwidth) leads to significant crosstalk between adjacent pairs in a binder. To get the desired data rate on loops up to 1.5 km long, DMT is a suitable multicarrier modulation scheme. This scheme makes excellent use of time-division duplexing since a single FFT unit can be used during transmission and reception and avoids the need for two such FFT units, and other savings in the analog circuitry.

Conventional frame synchronization techniques are not only not well suited for synchronized TDD but also are unreliable when RF interference is present. Due to the potential for significant RF interference due to amateur radio frequency bands, the RF interference might have a signal power equal to, or perhaps greater than, the desired receive signal power under some conditions. However, in a synchronized TDD system, it is important that synchronization be established and maintained so that crosstalk is mitigated and controlled and/or received data is accurately recovered.

Accordingly, there is a need for improved synchronization techniques for time-division duplexed systems.

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SUMMARY OF THE INVENTION

Broadly speaking, the invention relates to improved techniques for synchronizing transmissions and receptions of a data transmission system utilizing time division duplexing. According to one aspect of the invention, the improved synchronization techniques utilize the time-varying nature of the energy of the received data to obtain synchronization. In one embodiment, the improved synchronization technique uses the output signals from a multicarrier modulation unit (e.g., FFT unit) and thus provides the ability to avoid frequency tones that are susceptible to RF interference. According to another aspect of the invention, the improved synchronization techniques utilize crosstalk interference levels to obtain synchronization. With the improved synchronization techniques, remote receivers in the data transmission system are able to synchronize to central transmitters, central receivers in the data transmission system are able to synchronize to remote transmitters, and central transmitters are able to synchronize with one another.

The invention can be implemented in numerous ways, including as an apparatus, system, method, or computer readable media. Several embodiments of the invention are discussed below.

As a method for adjusting an alignment for a first transceiver to receive frames of data transmitted from a second transceiver over a transmission medium to the first transceiver, where the first transceiver and the second transceiver are associated with a data transmission system providing two-way data communication using time division duplexing, an embodiment of the invention includes the operations of: measuring an energy amount for each of a plurality of consecutive frames of received data; detecting an edge in the plurality of consecutive frames of the received data based on the measured energy amounts; and computing an alignment error estimate using the edge detected in the plurality of consecutive frames. Additionally, the synchronization may thereafter be adjusted in accordance with the alignment error estimate. Optionally, the data transmission system transmits data using a superframe structure having a plurality of frames, a first set of the frames in the superframe transmit data in a first direction, and a second set of the frames in the superframe transmit data in a second direction.

As a computer readable medium containing program instructions for adjusting an alignment for a first transceiver to receive frames of data transmitted from a second transceiver over a transmission medium to the first transceiver, the first transceiver and the second transceiver being associated with a data transmission system providing two-way data communication using time division duplexing, an embodiment of the invention includes: first computer readable code devices for measuring an energy amount for each of a plurality of

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consecutive frames of received data; second computer readable code devices for detecting an edge in the plurality of consecutive frames of the received data based on the measured energy amounts; and third computer readable code devices for computing an alignment error estimate using the edge detected in the plurality of consecutive frames.

As a receiver for a data transmission system using time division duplexing to alternate between transmission and reception of data, an embodiment of the invention includes: an analog-to-digital converter, the analog-to-digital converter receives analog data that has been transmitted over a channel to the receiver and converts the received analog signals into received digital signals; an input buffer for temporarily storing the received digital signals; a multicarrier demodulation unit, the multicarrier demodulation unit demodulates the received digital signals from the input buffer to frequency domain data for a plurality of different carrier frequencies; a frame synchronization unit, the frame synchronization unit synchronizes a receive frame boundary for the multicarrier demodulation unit based on the time-varying nature of the energy of the frequency domain data produced by the multicarrier demodulation unit; a bit allocation table, the allocation table stores bit allocation information used in transmitting data being received at the receiver; a data symbol decoder, the data symbol decoder receives the frequency domain data and decodes bits associated with the frequency domain data from the carrier frequencies based on the bit allocation information stored in the bit allocation table; and an output buffer for storing the decoded bits as recovered data. Preferably, the data transmission system is a synchronized DMT system, and wherein the multicarrier demodulation unit includes a FFT unit.

As a receiver for a data transmission system using time division duplexing to alternate between transmission and reception of data, another embodiment of the invention includes: an analog-to-digital converter, the analog-to-digital converter receives analog data that has been transmitted over a channel to the receiver and converts the received analog signals into received digital signals; an input buffer for temporarily storing the received digital signals; a multicarrier demodulation unit, the multicarrier demodulation unit demodulates the received digital signals from the input buffer to frequency domain data for a plurality of different carrier frequencies; frame synchronization means for synchronizing a receive frame boundary for the multicarrier demodulation unit based on the time-varying nature of the energy of the frequency domain data produced by the multicarrier demodulation unit; a bit allocation table, the allocation table stores bit allocation information used in transmitting data being received at the receiver; a data symbol decoder, the data symbol decoder receives the frequency domain data and decodes bits associated with the frequency domain data from the carrier frequencies based on the bit allocation information stored in the bit allocation table; and an output buffer for storing the decoded bits as recovered data.

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For a data transmission system having a plurality of transmitters at a central site where an external clock signal is unavailable for synchronizing the transmitters, the transmitters transmit data in accordance with a superframe format including at least one quiet period, a method for synchronizing data transmissions by a given transmitter to other of the transmitters at the central site according to an embodiment of the invention includes the acts of: measuring the energy in the quiet period associated with the given transmitter due to data transmissions from the other of the transmitters at the central site; comparing the measured energy with a threshold amount; and modifying the synchronization for the transmissions by the given transmitter when the comparing indicates that the measured energy exceeds the threshold amount.

As a computer readable medium containing program instructions for synchronizing data transmissions in a data transmission system having a plurality of transmitters at a central site where an external clock signal is unavailable for synchronizing the transmitters, the transmitters transmit data in accordance with a superframe format including at least one quiet period, an embodiment of the invention includes: first computer readable code devices for measuring the energy in the quiet period associated with a given transmitter due to data transmissions from other of the transmitters at the central site; second computer readable code devices for comparing the measured energy with a threshold amount; and third computer readable code devices for modifying the synchronization for the transmissions by the given transmitter when the comparing indicates that the measured energy exceeds the threshold amount.

The advantages of the invention are numerous. One advantage of the invention is that synchronization can be achieved even in the presence of radio frequency (RF) interference, such as due to amateur radio users. Another advantage of the invention is that it is well suited for data transmission systems utilizing time division duplexing such as synchronized DMT or synchronized VDSL. Yet another advantage of the invention is that it is relatively insensitive to noise in the data transmission system.

Other aspects and advantages of the invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be readily understood by the following detailed description in conjunction with the accompanying drawings, wherein like reference numerals designate like structural elements, and in which:

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FIG. 1A is a simplified block diagram of a conventional transmitter for a multicarrier modulation system;

FIG. 1B is a simplified block diagram of a conventional remote receiver for a conventional multicarrier modulation system;

FIG. 2 is a block diagram of an exemplary telecommunications network suitable for implementing the invention;

FIG. 3 is a block diagram of a processing and distribution unit 300 according to an embodiment of the invention;

FIG. 4 is a diagram illustrating an exemplary superframe format in which a certain level of service is provided;

FIG. 5A is a flow diagram of synchronization processing according to a basic embodiment of the invention;

FIG. 5B is a flow diagram of synchronization processing according to an embodiment of the invention;

FIGs. 6A and 6B are flow diagrams of synchronization processing according to a more detailed embodiment of the invention;

FIG. 7 is a flow diagram of edge detection processing according to an embodiment of the invention;

FIG. 8 is a flow diagram of alignment error estimation processing according to an embodiment of the invention;

FIGs. 9A and 9B represent diagrams of energy values and energy difference values for received data over a sequence of twenty frames;

FIGs. 10A and 10B represent energy values and energy difference values for received data over a series of twenty frames for the example illustrated in FIGs. 9A and 9B after an alignment adjustment has been made in accordance with the invention;

FIG. 11 is a block diagram of a receiver according to one embodiment of the invention; and

FIG. 12 is a flow diagram of a synchronization processing for synchronizing adjacent transmitters to compensate for small synchronization differences.

DETAILED DESCRIPTION OF THE INVENTION

The invention relates to improved techniques for synchronizing transmissions and receptions by a data transmission system utilizing time division duplexing. In one aspect of

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the invention, the improved synchronization techniques utilize the time-varying nature of the energy of the received data to obtain synchronization. In another aspect of the invention, the improved synchronization techniques utilize crosstalk interference levels to obtain synchronization. With the improved synchronization techniques, remote receivers in the data transmission system are able to synchronize to central transmitters, central receivers in the data transmission system are able to synchronize to remote transmitters, and central transmitters are able to synchronize with one another.

The synchronization required in a time-division duplex system requires that transmissions be synchronized with a superframe structure. Conventional time-domain methods which tend to correlate samples, such as first and last samples in a frame to detect a cyclic prefix, are not reliable because of the likely presence of RF interference in the receive signals which can be of equal power to be desired signals. However, the invention provides accurate techniques to synchronize transmissions in a time-division duplex system even when RF interference renders the time domain signal unreliable. The frequency domain approach to synchronization provided by the invention is able to obtain significant immunity from RF interference. In one embodiment, the improved synchronization technique preferably uses the output signals from a multicarrier modulation unit (FFT unit) and thus provides the ability to avoid frequency tones that are susceptible to radio frequency (RF) interference.

Embodiments of the invention are discussed below with reference to FIGs. 1A-12. However, those skilled in the art will readily appreciate that the detailed description given herein with respect to these figures is for explanatory purposes as the invention extends beyond these limited embodiments.

FIG. 2 is a block diagram of an exemplary telecommunications network 200 suitable for implementing the invention. The telecommunications network 200 includes a central office 202. The central office 202 services a plurality of distribution posts to provide data transmission to and from the central office 202 to various remote units. In this exemplary embodiment, each of the distribution posts is a processing and distribution unit 204 (node). The processing and distribution unit 204 is coupled to the central office 202 by a high speed, multiplexed transmission line 206 that may take the form of a fiber optic line. Typically, when the transmission line 206 is a fiber optic line, the processing and distribution unit 204 is referred to as an optical network unit (ONU). The central office 202 also usually interacts with and couples to other processing and distribution units (not shown) through high speed, multiplexed transmission lines 208 and 210, but only the operation of the processing and distribution unit 204 is discussed below. In one embodiment, the processing and distribution unit 204 includes one or more modems (central modems).

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The processing and distribution unit 204 services a multiplicity of discrete subscriber lines 212-1 through 212-n. Each subscriber line 212 typically services a single end user. The end user has a remote unit suitable for communicating with the processing and distribution unit 204 at very high data rates. More particularly, a remote unit 214 of a first end user 216 is coupled to the processing and distribution unit 204 by the subscriber line 212-1, and a remote unit 218 of a second end user 220 is coupled to the processing and distribution unit 204 by the subscriber line 212-n. The remote units 214 and 218 include a data communications system capable of transmitting data to and receiving data from the processing and distribution unit 204. In one embodiment, the data communication systems are modems. The remote units 214 and 218 can be incorporated within a variety of different devices, including for example, a telephone, a television, a monitor, a computer, a conferencing unit, etc. Although FIG. 2 illustrates only a single remote unit coupled to a respective subscriber line, it should be recognized that a plurality of remote units can be coupled to a single subscriber line. Moreover, although FIG. 2 illustrates the processing and distribution unit 204 as being centralized processing, it should be recognized that the processing need not be centralized and could be performed independently for each of the subscriber lines 212.

The subscriber lines 212 serviced by the processing and distribution unit 204 are bundled in a shielded binder 222 as the subscriber lines 212 leave the processing and distribution unit 204. The shielding provided by the shielded binder 222 generally serves as a good insulator against the emission (egress) and reception (ingress) of electromagnetic interference. However, the last segment of these subscriber lines, commonly referred to as a "drop" branches off from the shielded binder 222 and is coupled directly or indirectly to the end user's remote units. The "drop" portion of the subscriber line between the respective remote unit and the shielded binder 222 is normally an unshielded, twisted-pair wire. In most applications the length of the drop is not more than about 30 meters.

Crosstalk interference, including near-end crosstalk (NEXT) and far-end crosstalk (FEXT), primarily occurs in the shielded binder 222 where the subscriber lines 212 are tightly bundled. Hence, when data is transmitted on some of the subscriber lines 212 while other subscriber lines are receiving data as is common when multiple levels of service are being provided, the crosstalk inference induced becomes a substantial impairment to proper reception of data. Hence, to overcome this problem, data is transmitted using a superframe structure over which bits of data to be transmitted are allocated. The telecommunications network 200, for example, is particularly well suited for a synchronized TDD transmission system (e.g., synchronized VDSL or SDMT) offering different levels of service.

Hence, referring to the SDMT transmission system shown in FIG. 2, data transmissions over all lines 212 in the shielded binder 222 associated with the processing and

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distribution unit 204 need to be synchronized. As such, all active lines emanating from the processing and distribution unit 204 could be transmitting in the same direction (i.e., downstream or upstream) so as to substantially eliminate NEXT interference.

FIG. 3 is a block diagram of a processing and distribution unit 300 according to an embodiment of the invention. For example, the data processing and distribution unit 300 is a detailed implementation of the processing and distribution unit 204 illustrated in FIG. 2.

The data processing and distribution unit 300 includes a processing unit 302 that receives data and sends data over a data link 304. The data link 304 could, for example, be coupled to a fiber optic cable of a telephone network or a cable network. The processing unit 302 needs to operate to synchronize the various processed transmissions and receptions of the processing unit 302. The data processing and distribution unit 300 further includes a bus arrangement 308 and a plurality of analog cards 310. The output of the processing unit 302 is coupled to the bus arrangement 308. The bus arrangement 308 together with the processing unit 302 thus direct output data from the processing unit 302 to the appropriate analog cards 310 as well as direct input from the analog cards 310 to the processing unit 302. The analog cards 310 provide analog circuitry utilized by the processing and distribution unit 300 that is typically more efficiently performed with analog components than using digital processing by the processing unit 302. For example, the analog circuitry can include filters, transformers, analog-to-digital converters or digital-to-analog converters. Each of the analog cards 310 are coupled to a different line. Typically, all the lines for a given data transmission system 300 are bundled into a binder including about fifty (50) lines (LINE-1 through LINE-50). Hence, in such an embodiment, there are fifty (50) analog cards 310 respectively coupled to the fifty (50) lines. In one embodiment, the lines are twisted-pair wires. The processing unit 302 may be a general-purpose computing device such as a digital signal processor (DSP) or a dedicated special purpose device. The bus arrangement 308 may take many arrangements and forms. The analog cards 310 need not be designed for individual lines, but could instead be a single card or circuitry that supports multiple lines.

In a case where the processing is not centralized, the processing unit 302 in FIG. 3 can be replaced by modems for each of the lines. The processing for each of the lines can then be performed independently for each of the lines. In this case, the modem may be placed on a single card along with the analog circuitry.

The NEXT interference problem occurs on the lines proximate to the output of the processing and distribution unit 300. With respect to the block diagram illustrated in FIG. 3, the NEXT interference is most prevalent near the outputs of the analog cards 310 because this is where the lines are closest to one another and have their largest power differential (between transmitted and received signals). In other words, from the output of the processing and distribution unit 300 the lines travel towards the remote units. Usually, most of the distance

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is within a shielded binder that would, for example, hold fifty (50) twisted-pair wires, and the remaining distance is over single unshielded twisted-pair wires. Because all these lines (e.g., twisted-pair wires) are held in close proximity in the binder and individually offer little shielding against electromagnetic coupling from other of the lines in the binder, crosstalk interference (namely NEXT interference and FEXT interference) between the lines within the binder is problematic.

Depending on the level of service being provided, data transmission implemented with SDMT can be symmetric or asymmetric with respect to upstream and downstream transmissions. With symmetric transmission, DMT symbols tend to be transmitted in alternating directions for equal durations. In other words, the duration in which DMT symbols are transmitted downstream is the same as the duration in which DMT symbols are transmitted upstream. With asymmetric transmission, DMT symbols tend to be transmitted downstream for a longer duration than upstream.

In VDSL it has been proposed to have a superframe structure including a fixed number (e.g., 20) frames, with each frame being associated with a DMT symbol. With such a frame format, the number of frames being used for downstream transmissions and the number of frames being used for upstream transmissions can vary. As a result, there are several different superframe formats that can occur. Typically, a superframe consists of a downstream burst of several frames and an upstream burst of several frames. Quiet frames are inserted between the upstream and the downstream bursts to allow the channel to settle before the direction of transmission is changed.

FIG. 4 is a diagram illustrating an exemplary superframe format 400 in which a certain level of service is provided. The superframe format 400 is an asymmetric frame that includes a downstream portion 402, a quiet portion 404, an upstream portion 406, and a quiet portion 408. The quiet portions (quiet periods) 404 and 408 are positioned between the downstream and upstream transmissions. With this asymmetric superframe format 400, the downstream portion 402 is substantially larger (e.g., longer burst) than the upstream portion 406. Such a superframe format is useful for situations in which downstream traffic is significantly greater than the upstream traffic. As an example, with respect to FIG. 2, the superframe format 400 can include 16 symbols downstream; 1 quiet period; 2 symbols upstream; and 1 quiet period.

With proper synchronization at a central unit (processing and distribution unit 204 or processing unit 302) and uniform superframe formats, synchronized transmissions of equal duration are provided for all lines within a binder. Accordingly, the NEXT interference problem is effectively eliminated. The synchronization of the central unit and the remote units is also important for accurate data recovery. These synchronizations are needed in

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synchronized VDSL and SDMT systems. According to the invention, improved synchronization techniques are described below with respect to FIGs. 5-12.

FIG. 5A is a flow diagram of synchronization processing 500 according to a basic embodiment of the invention. Initially, the synchronization processing 500 measures 502 energy in n consecutive frames of received data. An alignment error estimate is then computed 504 based on the measured energy values for the n consecutive frames. Following block 504, the synchronization processing 500 is complete and ends.

FIG. 5B is a flow diagram of synchronization processing 550 according to an embodiment of the invention. Initially, the synchronization processing 550 measures 552 energy in n consecutive frames of received data. Next, an edge is detected 554 in the received data based on the measured energy values for the n consecutive frames. An alignment error estimate is then computed 556 from the position of the edge that has been detected. Thereafter, the synchronization processing 550 is able to adjust 558 its synchronization reference in accordance with the alignment error estimate. Following block 558, the synchronization processing 550 is complete and ends.

By determining and adjusting synchronization of receivers of the remote units to transmissions from a central unit in accordance with the synchronization processing 500 or 550, the remote units are able to establish synchronization with the central unit. Once synchronized the central unit and the remote units are able to share a channel (transmission line) in a time-division duplexed manner. Also, the synchronization processing 500 or 550 is suitable for determining and adjusting synchronization of receivers at the central unit with transmissions from the remote units.

FIGs. 6A and 6B are flow diagrams of synchronization processing 600 according to a more detailed embodiment of the invention. Once the synchronization processing 600 is initiated, FFT outputs are obtained 602 for n consecutive frames of received data. Typically, a receiver side of a transceiver will receive data from a transmission line and forward the received data to an analog-to-digital converter and then to a FFT unit, such as illustrated in FIG. 1B. Hence, the FFT outputs may be obtained from the output of the FFT unit. The FFT outputs are frequency domain signals.

Next, the FFT outputs that are susceptible to RF interference are dropped 604. The remaining FFT outputs are then used for subsequent processing. Typically, a frame includes a plurality of different frequency tones. Each of the frequency tones is capable of having data encoded thereon for transmission. However, certain of the frequency tones are more susceptible to RF interference than others. In the case where the RF interference is caused by amateur radio users, it is usually known which frequency tones of the frame are likely subjected to the RF interference due to amateur radio users. In the case of a remote unit of a

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synchronized multicarrier VDSL system, where a frame has 256 frequency tones, frequency tones 6 through 40 are generally free from RF interference due to amateur radio users, less attenuated because lower frequency tones have less attenuation, and therefore sufficient to obtain a reliable synchronization result. Hence, in one embodiment, frequency tones 6 through 40 from each of n consecutive frames are used for subsequent processing.

Next, energy values for the n consecutive frames of the remaining FFT outputs are determined 606. As an example, if the frequency tones 6 through 40 are being utilized, then the corresponding outputs from the FFT unit are obtained and then converted to energy values and summed together so as to produce a single energy value for the frame. Preferably, the energy values are power values for the frames. As an example, the single energy value for a frame can be obtained by summing the squared moduli of all outputs of the FFT unit that are in use. Alternatively, the energy values could be obtained by summing the energies of time domain samples, after having filtered out those time domain samples that are subjected to substantial amounts of RF interference.

Once the energy values for the n consecutive frames have been determined 606, the synchronization processing 600 detects 608 a burst edge within the received data based on the determined energy values. By detecting the burst edge, a receiver is able to identify when the received data burst from a transmitter begins. The burst edge thus identifies the beginning (or end) of a received transmission from the transmitter and additionally identifies a synchronization for the frame. A trailing edge within the received data and/or characteristics of the superframe (superframe information) can also be detected.

Next, an alignment error estimate for a frame boundary setting is determined 610 with respect to the detected burst edge. Here, using the burst edge that has been detected 608, the alignment error estimate can be determined 610 for a frame boundary setting. In particular, from the determined energy values in the burst edge, the remote unit synchronization processing 600 is able to determine the alignment error for a frame (i.e., error in frame synchronization). Typically, the alignment error is estimated as a fraction of a frame. Thereafter, the frame boundary can be adjusted 612 in accordance with the alignment error estimate.

Once adjusted 612, the frame synchronization should be established. However, preferably, the synchronization processing 600 continues to confirm that the synchronization has been achieved. Specifically, following block 612, a decision block 614 determines whether the absolute value of the alignment error estimate is less than a predetermined threshold. If the alignment error estimate is not less than a predetermined threshold, then the synchronization processing 600 returns to repeat block 602 and subsequent blocks so as to iteratively reduce the magnitude of the error. On the other hand, when the decision block 614 determines that the alignment error estimate is less than the predetermined threshold, then the

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superframe information is output 616. As an example, the superframe information can indicate the beginning of the received transmission and the end of the received transmission and/or the number of frames in the burst. Following block 616, the synchronization processing 600 is complete and ends.

Normally, when the frame synchronization is adjusted 612 by a significant amount, the alignment error estimate is greater then the predetermined threshold. Hence, the synchronization processing 600 will repeat and should produce a small alignment error amount which is less than the predetermined threshold. Then, the synchronization processing 600 is able to proceed to block 616. Alternatively, the decision block 614 can be eliminated when the alignment error estimate is produced accurately with a high degree of confidence.

FIG. 7 is a flow diagram of edge detection processing 700 according to an embodiment of the invention. The edge detection processing 700 describes additional details on the block 608 in FIG. 6A where the burst edge is detected. The edge detection processing 700 initially computes 702 successive energy differences for the n determined energy values. These successive energy differences may be indexed from 1 to i. Next, the largest energy difference and its index (j) are determined 704. The energy differences at indices (j-1) and (j+1) are then stored 706 for later retrieval. Following block 706, the edge detection processing 700 is complete and the processing returns to block 610 of the synchronization processing 600.

FIG. 8 is a flow diagram of alignment error estimation processing 800 according to an embodiment of the invention. The alignment error estimation processing 800 describes additional details on the block 610 in FIG. 6A where an alignment error estimate is determined. The alignment error estimation processing 800 initially determines 802 a difference amount from the energy values at indices (j+1) and (j-1). The energy values at indices (j+1) and (j-1) are the energy values immediately proceeding and immediately following the largest energy difference at index (j). The energy values can, for example, be power values. Next, the difference amount is normalized 804 to produce the alignment error estimate. In this embodiment, the alignment error estimate represents a fractional part of a frame. Accordingly, the synchronization of the receiver to the data transmission unit would be off by this fractional part of the frame. Following block 804, the alignment error estimation processing 800 is complete and the processing returns to block 612 of the synchronization processing 600.

FIGs. 9A and 9B represent diagrams of energy values (e) and energy difference values (Δe) for received data over a sequence of twenty frames. In FIG. 9A, a diagram 900 plots the energy values (e) for the twenty frames shows a burst of data in the vicinity of frames 6 through 15. As an example, the energy values (e) are produced by block 606 in FIG. 6A. In FIG. 9B, a diagram 902 plots successive energy difference values (Δe) for the

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determined energy values. The successive energy difference values (Δe) identify regions associated with edges or transition points in the received data. A first edge represents an initial edge or the start of a burst of data and is somewhere within a region 904, and a second edge 906 represents a trailing edge, or an end of a burst of data, and is somewhere within a region 906. As an example, the energy difference values (Δe) are determined by block 702 in FIG. 7.

As seen in FIGs. 9A and 9B, the receiver is not properly synchronized with the incoming transmitted data from a remotely located transmitter. In particular, the beginning of the burst of data received from the transmitter begins somewhere within frame 6. To be properly synchronized, the burst of data from the transmitter would begin exactly at the beginning of frame 6 in this example. By using the energy difference values (Δe), the technique achieves substantial immunity to noise levels on the received data. The diagram 902 shows that the initial edge of the burst of data is within the region 904, *i.e.*, somewhere within frame 6, and that the trailing edge of the burst of data is within the region 906, *i.e.*, somewhere within frame 14.

FIGs. 10A and 10B represent energy values (e) and energy difference values (Δe) for received data over a series of twenty frames for the example illustrated in FIGs. 9A and 9B after an alignment adjustment has been made in accordance with the invention, that is, with proper synchronization. In FIG. 10A a diagram 1000 indicates a burst of data between frames 6 and 14 with an initial edge 1002 at the beginning of frame 6 and a trailing edge 1004 at the end of frame 14. In FIG. 10B, a diagram 1006 illustrates the successive energy difference values (Δe) over the twenty frames, including an initial maximum point 1008 and a trailing maximum point 1010. The initial edge (frame 6) of the burst of data indicates the starting frame of the received burst of data, while the negative edge (frame 15) indicates the frame following the end of the burst of data. From this information, the received burst length can be inferred (9 frames), and the superframe format can be identified (9-1-9-1).

During synchronization the successive differences in the energy values observed in each frame of the superframe will show a positive and negative peak. The positive peak indicates the leading edge of a burst, while the negative edge indicates the end of a burst. According to one embodiment of the invention, the edge detection processing adjusts the frame alignment so that the maximum difference is increased, the right-hand neighboring energy difference is forced to zero. When synchronization has been obtained, the result is as shown in FIG. 10B. Note that the edge detection processing is relatively insensitive to the absolute amplitudes being observed. The successive differences approach requires only that the energy in the "quiet" frames (which are not truly quiet due to noise) be smaller than the energy in the active frames and that the energy be approximately constant for each type of frame.

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When the data transmission system operates to delete a cyclic prefix at the receiver, a dead-zone may be created in the frame/superframe alignment that is the width of the cyclic prefix because the removal of the cyclic prefix drops samples useful for frame synchronization but thus unavailable from the FFT unit. One technique to resolve this dead-zone where the frame has 512 samples and the cyclic prefix has 40 samples is to use energy estimates from samples 41 through 552 as well as using samples 1 to 512, and then take the mean of these energy estimates to get a combined energy estimate which is then used in the burst detection processing.

The synchronization processing discussed above is generally applicable to remote side and central side synchronization. For synchronization processing at a remote unit, a receiver at the remote unit acquires and maintains synchronization with data transmissions (bursts) with a transmitter of the central unit. As for synchronization processing at a central unit, a receiver at the central unit acquires and maintains synchronization with data transmissions (bursts) with a transmitter of a remote unit. In one embodiment, the synchronization is managed by setting or adjusting receive frame alignment for the recovery of data transmissions (bursts) at a receiver.

Due to the round-trip delay of a line (or channel), the time at which an upstream transmission from a remote unit reaches a central unit will vary and will appear to be late by the by the length of the round-trip delay if no correction is made. Accordingly, the central unit needs to adjust its receive frame alignment so that the correct receive samples are used in the receiver at the central unit. The processing carried out at the central unit to adjust its receive frame alignment is similar to the synchronization processing discussed above for the remote unit. Generally, the energy in upstream frames being received is measured over a number of frames corresponding to the length of the upstream transmission burst from the remote unit. These energy values are used to identify the start of the upstream transmission burst and then determines an alignment correction to align the receive frame boundary pointer with the frames of data received from the remote unit.

FIG. 11 is a block diagram of a receiver 1100 according to one embodiment of the invention. The receiver 1100 is part of a time domain duplexed transmission system. The construction of the receiver 1100 illustrated in FIG. 11 may be used in either or both of the central office transceiver and the remote unit transceiver.

The receiver 1100 receives analog signals 1102 that have been transmitted over a channel from a transmitter (e.g., a central office transmitter). The received analog signals are then supplied to an analog-to-digital (ADC) 1104 which converts the received analog signals to digital signals. The digital signals are then supplied to an input buffer 1106 that temporarily stores the digital signals. The FFT unit 1108 retrieves a frame of data from the

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input buffer 1106 in accordance with a receive frame boundary pointer 1110, and then produces frequency domain signals.

In accordance with the invention, the FFT unit 1108 outputs the frequency domain signals 1112 to a frame synchronization unit 1114. The frame synchronization unit 1114 operates to perform the synchronization processing discussed above with reference to FIGs. 5-10B. The frame synchronization unit 1114 outputs an alignment error estimate 1116 to a controller 1118. The controller 1118 then adjusts the receive frame boundary pointer 1110 for accessing the received data from the input buffer 1106. Hence, the frame synchronization unit 1114 provides for frame synchronization in the time domain duplexed transmission system in a manner that is substantially immune from RF interference (e.g., such as from amateur radio users). The controller 1118 also controls the overall operation of the receiver 1100. The controller 1118, for example, controls the receiver 1100 to perform the initialization processing and to monitor steady-state data transmission. For example, the controller 1118 can be implemented by a digital signal processor, a microprocessor or microcontroller, or specialized circuitry. In the case where the receiver 1100 forms part of a transceiver, the controller 1118 can be used by both transmit and receive sides of the transceiver, shared among a plurality of transceivers, or individually provided for each transmitter and receiver. Likewise, the frame synchronization unit 1114 can be implemented by a digital signal processor, a microprocessor or microcontroller, or specialized circuitry.

Returning to the receive data path the frequency domain signals 1112 output by the FFT unit 1108 are then equalized by the FEQ unit 1120. The equalized signals are then supplied to a data symbol decoder 1122. The data symbol decoder 1122 operates to decode the equalized signals to recover data that has been transmitted on each of the frequency tones of the symbol being received. The decoding by the data symbol decoder 1122 is performed based on bit allocation information stored in a receive bit and energy allocation table 1124. The decoded data is then supplied to the FEC unit 1126 and then stored in an output buffer 1128. Thereafter, recovered data 1130 (stored decoded data) may be retrieved from the output buffer 1128 as needed.

The receiver 1100 illustrated in FIG. 11 optionally includes other components. For example, when a corresponding transmitter adds a cyclic prefix to symbols after an IFFT unit, the receiver 1100 can remove the cyclic prefix before the FFT unit 1108. Also, the receiver 1100 can provide a time domain equalizer (TEQ) unit between the ADC 1104 and the FFT unit 1106. Additional details on TEQ units are contained in U.S. Patent No. 5,285,474 and U.S. Application Serial No. 60/046,244 (Att.Dkt.No.: AMATP021+), filed May 12, 1997 and entitled POLY-PATH TIME DOMAIN EQUALIZATION, which are hereby incorporated by reference.

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Moreover, the invention provides techniques to synchronize transmissions at a central side (i.e., central unit). With synchronized transmissions at the central side, the NEXT interference is substantially eliminated, provided all lines of a binder offer the same level of service (i.e., superframe format). However, if the transmissions from the central side over lines in a binder are not properly synchronized, the NEXT interference is a substantial impediment to efficient and accurate operation of the data transmission system. Hence, the invention also pertains to techniques to adjust a transmit frame boundary at a central side transmitter of data transmission system. The general principle is to use NEXT interference from other central side transmissions. If the NEXT interference is not strong enough to be detected for synchronization purposes, then it will be assumed to be insignificant during reception, and therefore synchronization is not necessary.

Conventionally, the various transmitters at the central side can synchronize with one another by all using a common master clock supplied to the central side. However, sometimes such a master clock is not available for one reason or another. Also, even though available, the various transmitters could be positioned at slightly greater positions from the master clock source so as to cause small synchronization differences between the various transmissions. Hence, the synchronization techniques according to the invention can also be used to synchronize various transmissions at the central side.

FIG. 12 is a flow diagram of a synchronization processing 1200 for synchronizing adjacent transmitters to compensate for small synchronization differences. If these small synchronization differences were to go uncorrected, over time the degree of the lack of synchronization worsens. The synchronization processing 1200 initially measures 1202 energy received from other transmitters at the central side. Here, during quiet periods (or guard periods), energy being received from other transmitters at the central side is measured by the receivers associated with the transmitters (i.e., transceivers). The transmissions from the various transmitters all follow the same superframe format. Preferably, the second quiet period (i.e., after the upstream transmission) is used to measure the energy because there tends to be less echo present. Next, a decision block 1204 determines whether the measured energy is greater than a predetermined threshold amount. If the measured energy during the quiet period is determined to be greater than the predetermined threshold amount, then the presence of NEXT interference is detected. Since NEXT interference is detected, it is known that the transmitters at the central side are not synchronized. Hence, the timing alignment at the transmitter is modified 1202 in order to synchronize its alignment with respect to the other transmitters at the central side. For example, the timing alignment could be modified by altering an oscillator frequency or changing (increase or decrease) the length of the superframe. On the other hand, when the measured energy is determined to be less than the predetermined threshold amount, then the transmitters at the central side are deemed to be

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sufficiently aligned and thus block 1206 is bypassed. Following block 1206 or following block 1204 when the predetermined threshold is not exceeded, the synchronization processing 1200 is complete and ends.

The synchronization processing 1200 is performed by all the transceivers at the central side. By repeating the synchronization processing 1200, gradually the alignment will reach a more less steady state, particularly if adjustments to alignment are made in only one direction.

Recall, as illustrated in FIG. 4, the superframe format has two quiet periods 404 and 408. The synchronization processing 1200 uses one of the two quiet periods 404 and 408. When a receiver at the central side hears the NEXT interference during the quiet period 408, it means that this transceiver is late and should transmit earlier. Alternatively, if the receiver at the central side uses the quiet period 404 and hears the NEXT interference during the quiet period 404, it means that this transceiver is early and should transmit later. However, before the transceiver adjust its timing alignment at the central side, it may inform the corresponding remote unit of the change so that it also modifies its timing alignment. This notification to the remote can, for example, be performed over an overhead channel.

The synchronization technique needs to distinguish downstream NEXT interference from upstream FEXT interference. This can be achieved a number of different ways. One way to distinguish upstream transmissions from downstream transmissions, in the case of VDSL using DMT frames with 256 tones, is to use tone 128 which is Nyquist/2 only with downstream transmissions. As noted above, the quiet period is used to measure the interference from adjacent downstream transmissions. If the downstream distinguishing feature is detected (greater than some threshold) it means that the clock in this unit is running faster than the interfering transmitter's clock.

The adjustment to the synchronization can be to modify the clock frequency of the particular transceiver's clock, such as with a voltage controlled oscillator. Alternatively, an extra cycle can be inserted into the superframe structure. In VDSL, if the central side transceiver's clocks are within 100 ppm of each other, then insertion of 1 sample per superframe (11,040 samples) will be sufficient to monitor synchronization. If the central side transceivers can only insert, the central side transceivers will reach a consensus at the lowest clock frequency of the group (that has significant NEXT).

For example, the energy of tone 128 can be measured with a special single-tone DFT:

$$|z_{128}|^2 = \left[\sum_{k=0}^{255} x_{2k}(-1)^k\right]^2 + \left[\sum_{k=0}^{255} x_{2k+1}(-1)^{k+1}\right]^2$$

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If the measured energy is larger than a predetermined threshold, then insert a sample (extra cycle) in the subsequent downstream transmission.

The advantages of the invention are numerous. One advantage of the invention is that synchronization can be achieved even in the presence of radio frequency (RF) interference, such as due to amateur radio signals. Another advantage of the invention is that it is well suited for data transmission systems utilizing time division duplexing such as synchronized DMT or synchronized VDSL. Yet another advantage of the invention is that it is relatively insensitive to background or receiver noise.

Thus, the present invention includes a method for adjusting an alignment for a first transceiver to receive frames of data transmitted from a second transceiver over a transmission medium to the first transceiver, the first transceiver and the second transceiver being associated with a data transmission system providing two-way data communication using time division duplexing the method comprising the acts of: (a) measuring an energy amount for each of a plurality of consecutive frames of received data; and (b) computing an alignment error estimate based on the measured energy amounts.

Also included is the method as recited hereinabove, wherein the alignment error estimate is an estimated alignment error as a fraction of a frame.

Also included is the method as recited hereinabove, wherein the data transmission system transmits data using a superframe structure having a plurality of frames, a first set of the frames in the superframe transmit data in a first direction, and a second set of the frames in the superframe transmit data in a second direction.

Also included is the method as recited hereinabove, wherein the first transceiver uses a frame boundary pointer to identify a beginning of a frame in the superframe being received, and wherein the method further comprises: (c) adjusting the frame boundary pointer in accordance with the alignment error estimate.

Also included is the method as recited hereinabove, wherein the alignment error estimate is an estimated alignment error as a fraction of a frame.

Also included is the method as recited hereinabove, wherein the method further comprises: (d) comparing the alignment error estimate with a threshold amount; (e) repeating steps (a) - (d) until the comparing (d) indicates that the alignment error estimate is less than the threshold amount.

Also included is the method as recited hereinabove, wherein the method further comprises: (f) outputting superframe identification information.

Also included is the method as recited hereinabove, wherein the computing (b) comprises: detecting an edge in the plurality of consecutive frames of the received data based

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on the measured energy amounts; and determining the alignment error estimate using the edge detected in the plurality of consecutive frames.

Also included is the method as recited hereinabove, wherein the edge detected is a burst edge.

Also included is the method as recited hereinabove, wherein the detecting comprises: computing successive energy differences in the plurality of the measured energy amounts; and identifying a largest one of the successive energy differences, the largest one of the successive energy difference corresponding to the burst edge.

Also included is the method as recited hereinabove, wherein the computing (b) comprises: identifying a prior energy difference and a subsequent energy difference, the prior energy difference being the one of the successive differences immediately preceding the largest one of the successive energy differences, and the subsequent energy difference being the one of the successive differences immediately following the largest one of the successive energy differences; and determining the alignment error estimate based on the prior energy difference and the subsequent energy difference.

Also included is the method as recited hereinabove, wherein the determining of the alignment error estimate computes a difference amount between the subsequent energy difference and the prior energy difference.

Also included is the method as recited hereinabove, wherein the determining of the alignment error estimate computes a difference amount between the subsequent energy difference and the prior energy difference, and then normalizes the difference amount to produce the alignment error estimate.

Also included is a method as recited hereinabove, wherein the first transceiver uses a frame boundary pointer to identify a beginning of a frame in the superframe being received, and wherein the method further comprises: (c) adjusting the frame boundary pointer in accordance with the alignment error estimate.

Also included is a method as recited hereinabove, wherein the alignment error estimate is an estimated alignment error as a fraction of a frame.

Also included is a method as recited hereinabove, wherein the method further comprises: (d) comparing the alignment error estimate with a threshold amount; (e) repeating (a) - (d) until the comparing (d) indicates that the alignment error estimate is less than the threshold amount.

Also included is a method as recited hereinabove, wherein the method further comprises: (f) outputting superframe identification information.

Also included is a method as recited hereinabove, wherein the first transceiver is a remote unit and the second transceiver is a central unit.

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Also included is a method as recited hereinabove, wherein the second transceiver is a remote unit and the first transceiver is a central unit.

Also included is a method as recited hereinabove, wherein the energy amount is a power amount.

Also included is a method as recited hereinabove, wherein the data transmission system transmits data using a superframe structure having a plurality of frames, some of the frames transmit data in a first direction, some of the frames transmit data in a second direction, and some of the frames contain a cyclic prefix for the superframe structure, and

wherein the measuring (a) of the energy amounts comprises: measuring energy amounts of a first set of consecutive frames of received data for the superframe structure; measuring energy amounts of a second set of consecutive frames of received data for the superframe structure, the second set of the consecutive frames being offset from and overlapped with the first set of the consecutive frames; and combining together the energy amounts from respective consecutive frames from the first and second sets of the consecutive frames to produce the energy amounts for the computing (b).

Also included is the method as recited hereinabove, wherein the number of frames in the first and second sets of the consecutive frames is equal to the length of the superframe structure less the length of the cyclic prefix.

Also included is the method as recited hereinabove, wherein the combining determines mean energy amounts for each of the frames of the superframe structure including the cyclic prefix.

Also included is a computer readable medium containing program instructions for adjusting an alignment for a first transceiver to receive frames of data transmitted from a second transceiver over a transmission medium to the first transceiver, the first transceiver and the second transceiver being associated with a data transmission system providing two-way data communication using time division duplexing, the computer readable medium comprising: first computer readable code devices for measuring an energy amount for each of a plurality of consecutive frames of received data; and second computer readable code devices for computing an alignment error estimate based on the measured energy amounts.

Also included is the computer readable medium as recited hereinabove, wherein the second computer readable medium comprises: computer readable code devices for detecting an edge in the plurality of consecutive frames of the received data based on the measured energy amounts; and computer readable code devices for determining the alignment error estimate using the edge detected in the plurality of consecutive frames.

Also included is the computer readable medium as recited hereinabove, wherein the second computer readable medium further comprises: computer readable code devices for computing successive energy differences in the plurality of the measured energy amounts;

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and computer readable code devices for identifying a largest one of the successive energy differences, the largest one of the successive energy difference corresponding to a burst edge.

Also included is the computer readable medium as recited hereinabove, wherein the second computer readable medium comprises: computer readable code devices for identifying a prior energy difference and a subsequent energy difference, the prior energy difference being the one of the successive differences immediately preceding the largest one of the successive energy differences, and the subsequent energy difference being the one of the successive differences immediately following the largest one of the successive energy differences; computer readable code devices for determining the alignment error estimate based on the prior energy difference and the subsequent energy difference.

Also included is the computer readable medium as recited hereinabove, wherein the data transmission system transmits data using a superframe structure having a plurality of frames, some of the frames transmit data in a first direction, some of the frames transmit data in a second direction, and some of the frames contain a cyclic prefix for the superframe structure, and wherein the first computer readable code devices for measuring of the energy amounts comprises: computer readable code for measuring energy amounts of a first set of consecutive frames of received data for the superframe structure; computer readable code for measuring energy amounts of a second set of consecutive frames of received data for the superframe structure, the second set of the consecutive frames being offset from and overlapped with the first set of the consecutive frames; and computer readable code for combining together the energy amounts from respective consecutive frames from the first and second sets of the consecutive frames to produce the energy amounts for the second computer readable code devices.

Also included is the computer readable medium as recited hereinabove, wherein the combining determines mean energy amounts for each of the frames of the superframe structure including the cyclic prefix.

Also included is the computer readable medium as recited hereinabove, wherein the number of frames in the first and second sets of the consecutive frames is equal to the length of the superframe structure less the length of the cyclic prefix.

Also included is a receiver for a data transmission system using time division duplexing to alternate between transmission and reception of data, the receiver comprising: an analog-to-digital converter, the analog-to-digital converter receives analog data that has been transmitted over a channel to the receiver and converts the received analog signals into received digital signals; an input buffer for temporarily storing the received digital signals; a multicarrier demodulation unit, the multicarrier demodulation unit demodulates the received digital signals from the input buffer to frequency domain data for a plurality of different carrier frequencies; a frame synchronization unit, the frame synchronization unit synchronizes a receive frame boundary for the multicarrier demodulation unit based on the

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time-varying nature of the energy of the frequency domain data produced by the multicarrier demodulation unit; a bit allocation table, the allocation table stores bit allocation information used in transmitting data being received at the receiver; a data symbol decoder, the data symbol decoder receives the frequency domain data and decodes bits associated with the frequency domain data from the carrier frequencies based on the bit allocation information stored in the bit allocation table; and an output buffer for storing the decoded bits as recovered data.

Also included is the receiver as recited hereinabove, wherein the frame synchronization unit determines an alignment adjustment amount, wherein the receiver further comprises a controller for controlling overall operation of the receiver, the controller receives the alignment adjustment amount from the frame synchronization unit and accordingly adjusts a receive frame boundary pointer for the input buffer.

Also included is the receiver as recited hereinabove, wherein at least one of the frame synchronization unit and the controller are implemented by a processor.

Also included is the receiver as recited hereinabove, wherein the frame synchronization unit is a processor.

Also included is the receiver as recited hereinabove, wherein the received data signals undesirably include radio frequency interference, and wherein the frame synchronization unit ignores the portion of the frequency domain data that overlaps with frequency ranges of the radio frequency interference.

Also included is the receiver as recited hereinabove, wherein the data transmission system is a synchronized DMT system, and wherein the multicarrier demodulation unit includes a FFT unit.

Also included is a receiver for a data transmission system using time division duplexing to alternate between transmission and reception of data, the receiver comprising: an analog-to-digital converter, the analog-to-digital converter receives analog data that has been transmitted over a channel to the receiver and converts the received analog signals into received digital signals; an input buffer for temporarily storing the received digital signals; a multicarrier demodulation unit, the multicarrier demodulation unit demodulates the received digital signals from the input buffer to frequency domain data for a plurality of different carrier frequencies; frame synchronization means for synchronizing a frame boundary for the multicarrier demodulation unit based on the time-varying nature of the energy of the frequency domain data produced by the multicarrier demodulation unit; a bit allocation table, the allocation table stores bit allocation information used in transmitting data being received at the receiver; a data symbol decoder, the data symbol decoder receives the frequency domain data and decodes bits associated with the frequency domain data from the carrier frequencies based on the bit allocation information stored in the bit allocation table; and an output buffer for storing the decoded bits as recovered data.

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Also included is, in a data transmission systems having a plurality of transmitters at a central site, the transmitters transmiting data in accordance with a superframe format including at least one quiet period, a method for synchronizing data transmissions by a given transmitter to other of the transmitters at the central site, the method comprises the acts of: (a) measuring the energy in the quiet period associated with the given transmitter due to data transmissions from the other of the transmitters at the central site; (b) comparing the measured energy with a threshold amount; and (c) modifying the synchronization for the transmissions by the given transmitter when the comparing (b) indicates that the measured energy exceeds the threshold amount.

Also included is the method as recited hereinabove, wherein the data transmission system transmits data using time division duplexing, and wherein the transmitters are part of transceivers at the central site.

Also included is the method as recited hereinabove, wherein the data transmission system is a multicarrier data transmission system.

Also included is the method as recited hereinabove, wherein the modifying (c) comprises adjusting timing alignment to reduce crosstalk interference.

Also included is the method as recited hereinabove, wherein the adjusting increases or decreases the length of the superframe format.

Also included is the method as recited hereinabove, wherein the adjusting alters the frequency of a local clock for the given transmitter.

Also included is the method as recited hereinabove, wherein the data transmission system is a multicarrier data transmission system, and wherein an external clock signal is unavailable for synchronizing the transmitters, and wherein the modifying (c) comprises adjusting timing alignment to reduce crosstalk interference.

Also included is the method as recited hereinabove, the measuring (a) of the energy in the quiet period associated with the given transmitter due to the data transmissions from the other of the transmitters at the central site operates to distinguish between outgoing data transmissions from the other of the transmitters and incoming data receptions, so that the measuring (a) measures the energy in the quiet period due to the outgoing data transmissions from the other of the transmitters and not due to the incoming data receptions.

Also included is a computer readable medium containing program instructions for synchronizing data transmissions in a data transmission systems having a plurality of transmitters at a central site where an external clock signal is unavailable for synchronizing the transmitters, the transmitters transmit data in accordance with a superframe format including at least one quiet period, the computer readable medium comprising: first computer readable code devices for measuring the energy in the quiet period associated with a given transmitter due to data transmissions from other of the transmitters at the central site; second computer readable code devices for comparing the measured energy with a threshold amount;

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and third computer readable code devices for modifying the synchronization for the transmissions by the given transmitter when the comparing indicates that the measured energy exceeds the threshold amount.

Also included is the computer readable medium as recited hereinabove, wherein the data transmission system is a multicarrier data transmission system that transmits data uses time division duplexing, and the transmitters are part of transceivers at the central site, and wherein the third computer readable code devices operates to adjust timing alignment to reduce crosstalk interference.

The many features and advantages of the present invention are apparent from the written description, and thus, it is intended by the appended claims to cover all such features and advantages of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation as illustrated and described. Hence, all suitable modifications and equivalents may be resorted to as falling within the scope of the invention.

What is claimed is:

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CLAIMS

1. A method for adjusting an alignment for a first transceiver to receive frames of data transmitted from a second transceiver over a transmission medium to the first transceiver, the first transceiver and the second transceiver being associated with a data transmission system providing two-way data communication using time division duplexing, said method comprising the acts of:

(a) measuring an energy amount for each of a plurality of consecutive frames of received data;

(b) computing an alignment error estimate based on the measured energy amounts.

2. A method as recited in claim 1, wherein the alignment error estimate is an estimated alignment error as a fraction of a frame.

3. A method as recited in claim 1, wherein the data transmission system transmits data using a superframe structure having a plurality of frames, a first set of the frames in the superframe transmit data in a first direction, and a second set of the frames in the superframe transmit data in a second direction.

4. A method as recited in claim 3, wherein the first transceiver uses a frame boundary pointer to identify a beginning of a frame in the superframe being received, and

wherein said method further comprises:

(c) adjusting the frame boundary pointer in accordance with the alignment error estimate.

5. A method as recited in claim 4, wherein the alignment error estimate is an estimated alignment error as a fraction of a frame.

6. A method as recited in claim 4, wherein said method further comprises:

(d) comparing the alignment error estimate with a threshold amount;

(e) repeating (a) - (d) until said comparing (d) indicates that the alignment error estimate is less than the threshold amount.

7. A computer readable medium containing program instructions for adjusting an alignment for a first transceiver to receive frames of data transmitted from a second transceiver over a transmission medium to the first transceiver, the first transceiver and the second transceiver being associated with a data transmission system providing two-way data communication using time division duplexing, said computer readable medium comprising:

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first computer readable code devices for measuring an energy amount for each of a plurality of consecutive frames of received data; and

second computer readable code devices for computing an alignment error estimate based on the measured energy amounts.

8. A receiver for a data transmission system using time division duplexing to alternate between transmission and reception of data, said receiver comprising:

an analog-to-digital converter, said analog-to-digital converter receives analog data that has been transmitted over a channel to said receiver and converts the received analog signals into received digital signals;

an input buffer for temporarily storing the received digital signals;

a multicarrier demodulation unit, said multicarrier demodulation unit demodulates the received digital signals from said input buffer to frequency domain data for a plurality of different carrier frequencies;

a frame synchronization unit, said frame synchronization unit synchronizes a receive frame boundary for said multicarrier demodulation unit based on the time-varying nature of the energy of the frequency domain data produced by said multicarrier demodulation unit;

a bit allocation table, said allocation table stores bit allocation information used in transmitting data being received at said receiver;

a data symbol decoder, said data symbol decoder receives the frequency domain data and decodes bits associated with the frequency domain data from the carrier frequencies based on the bit allocation information stored in said bit allocation table; and

an output buffer for storing the decoded bits as recovered data.

9. In a data transmission systems having a plurality of transmitters at a central site, the transmitters transmit data in accordance with a superframe format including at least one quiet period, a method for synchronizing data transmissions by a given transmitter to other of the transmitters at the central site, said method comprises the acts of:

(a) measuring the energy in the quiet period associated with the given transmitter due to data transmissions from the other of the transmitters at the central site;

(b) comparing the measured energy with a threshold amount; and

(c) modifying the synchronization for the transmissions by the given transmitter when said comparing (b) indicates that the measured energy exceeds the threshold amount.

10. A computer readable medium containing program instructions for synchronizing data transmissions in a data transmission systems having a plurality of transmitters at a central site where an external clock signal is unavailable for synchronizing the transmitters, the

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transmitters transmit data in accordance with a superframe format including at least one quiet period, said computer readable medium comprising:

first computer readable code devices for measuring the energy in the quiet period associated with a given transmitter due to data transmissions from other of the transmitters at the central site;

second computer readable code devices for comparing the measured energy with a threshold amount; and

third computer readable code devices for modifying the synchronization for the transmissions by the given transmitter when said comparing indicates that the measured energy exceeds the threshold amount.

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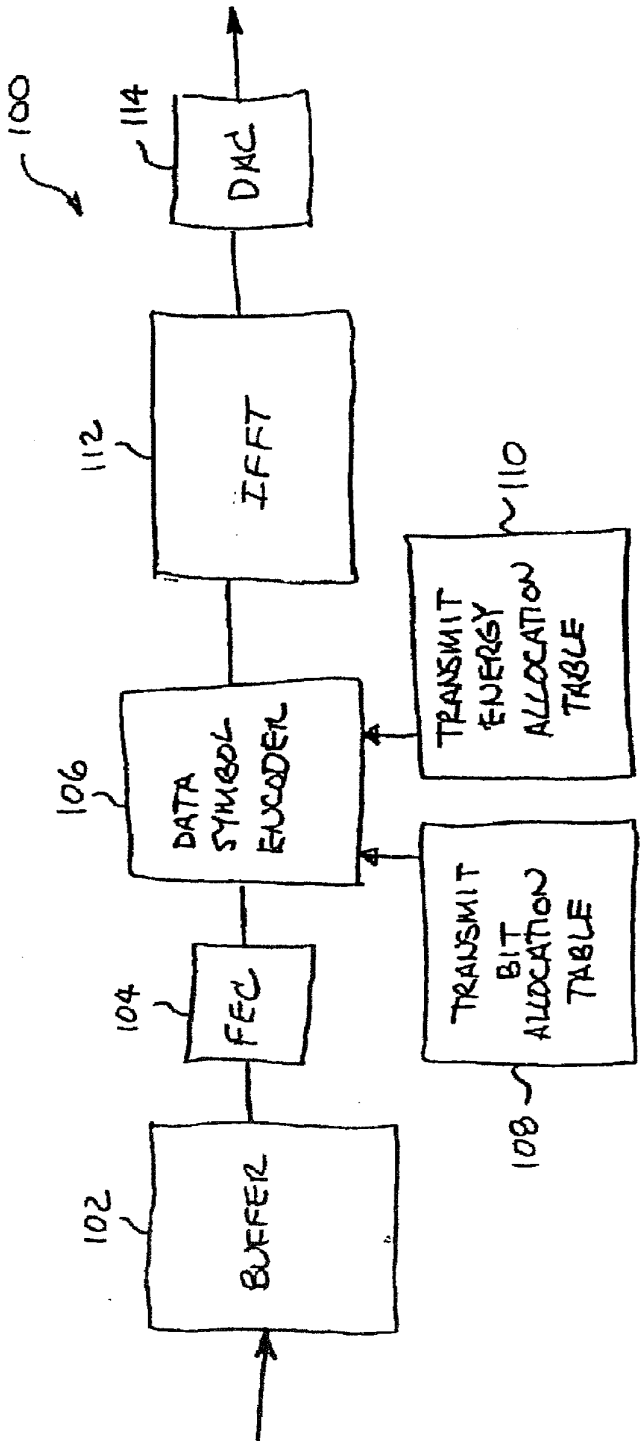


FIG. 1A (PRIOR ART)

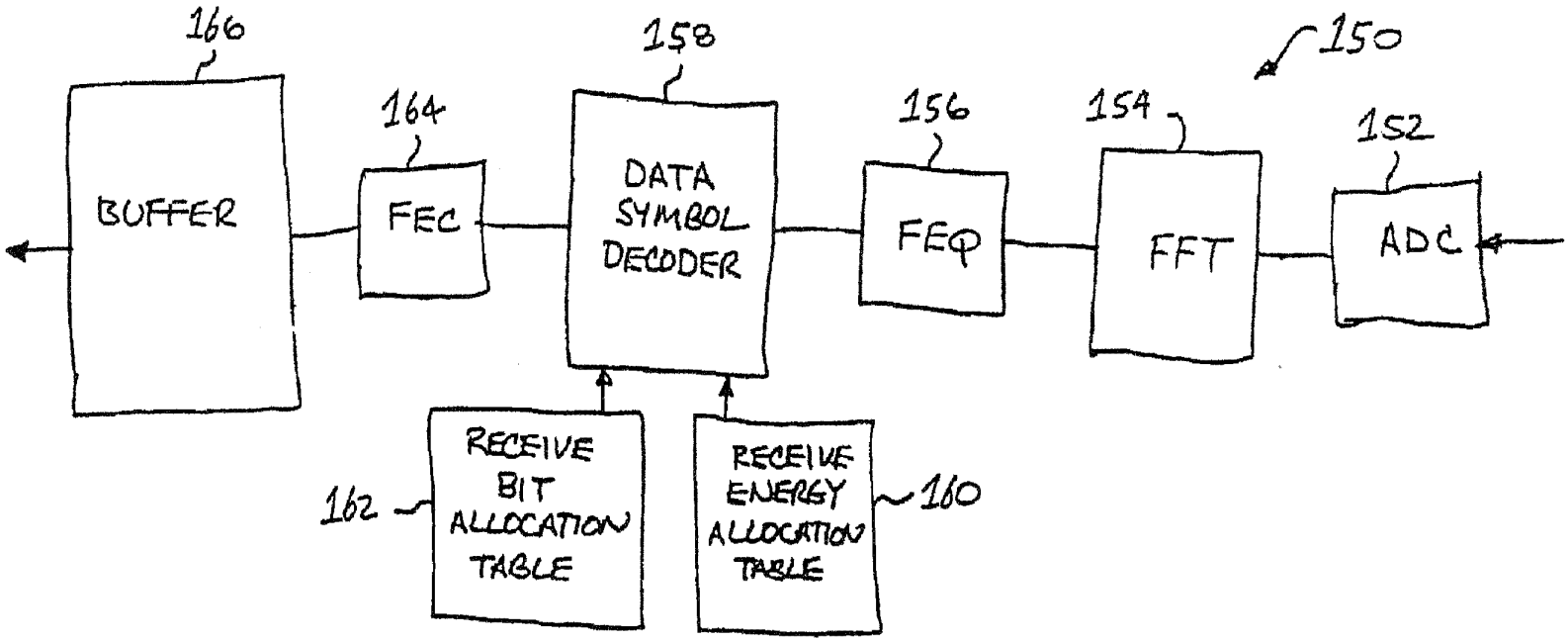


FIG. 1B (PRIOR ART)

CA 02254807 2000-02-28

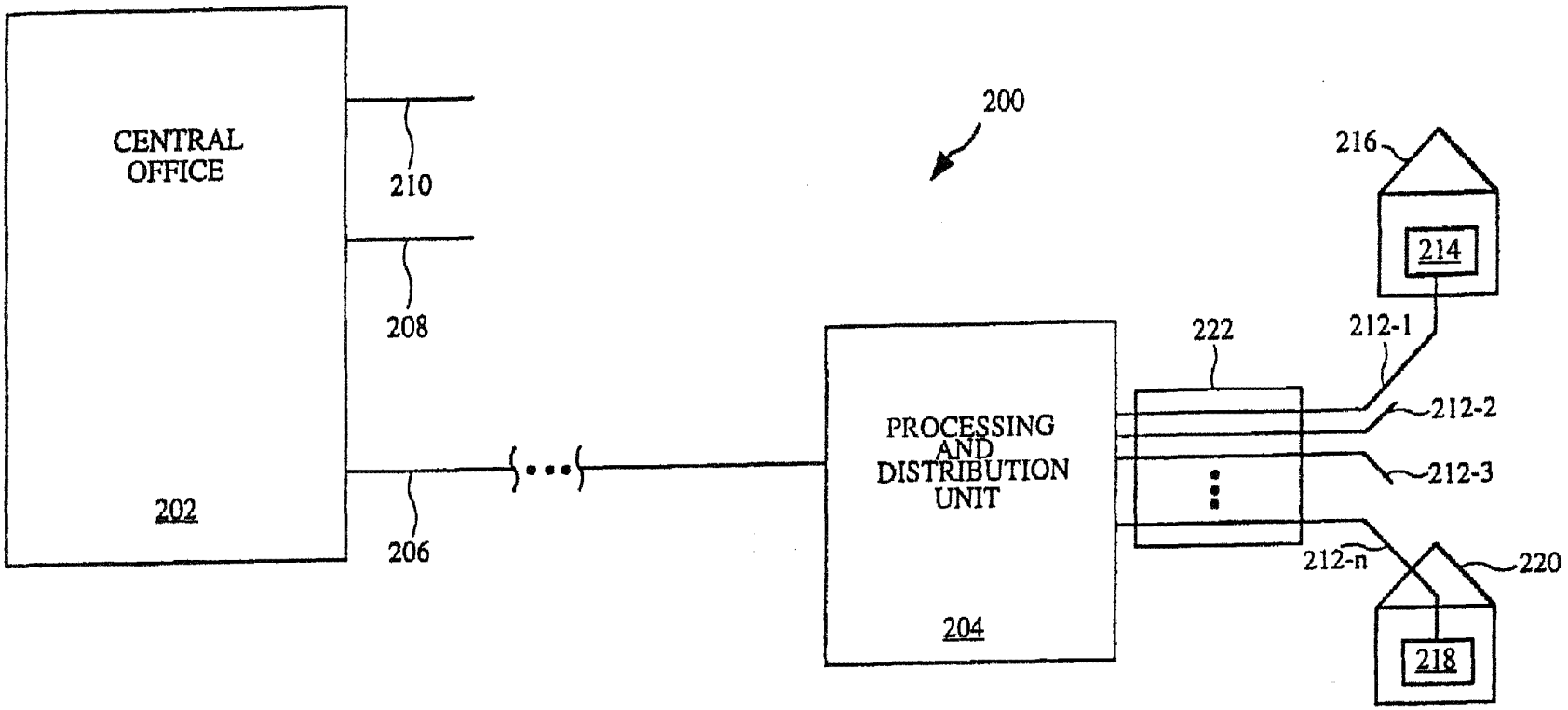


FIG. 2

CA 02254807 2000-02-28

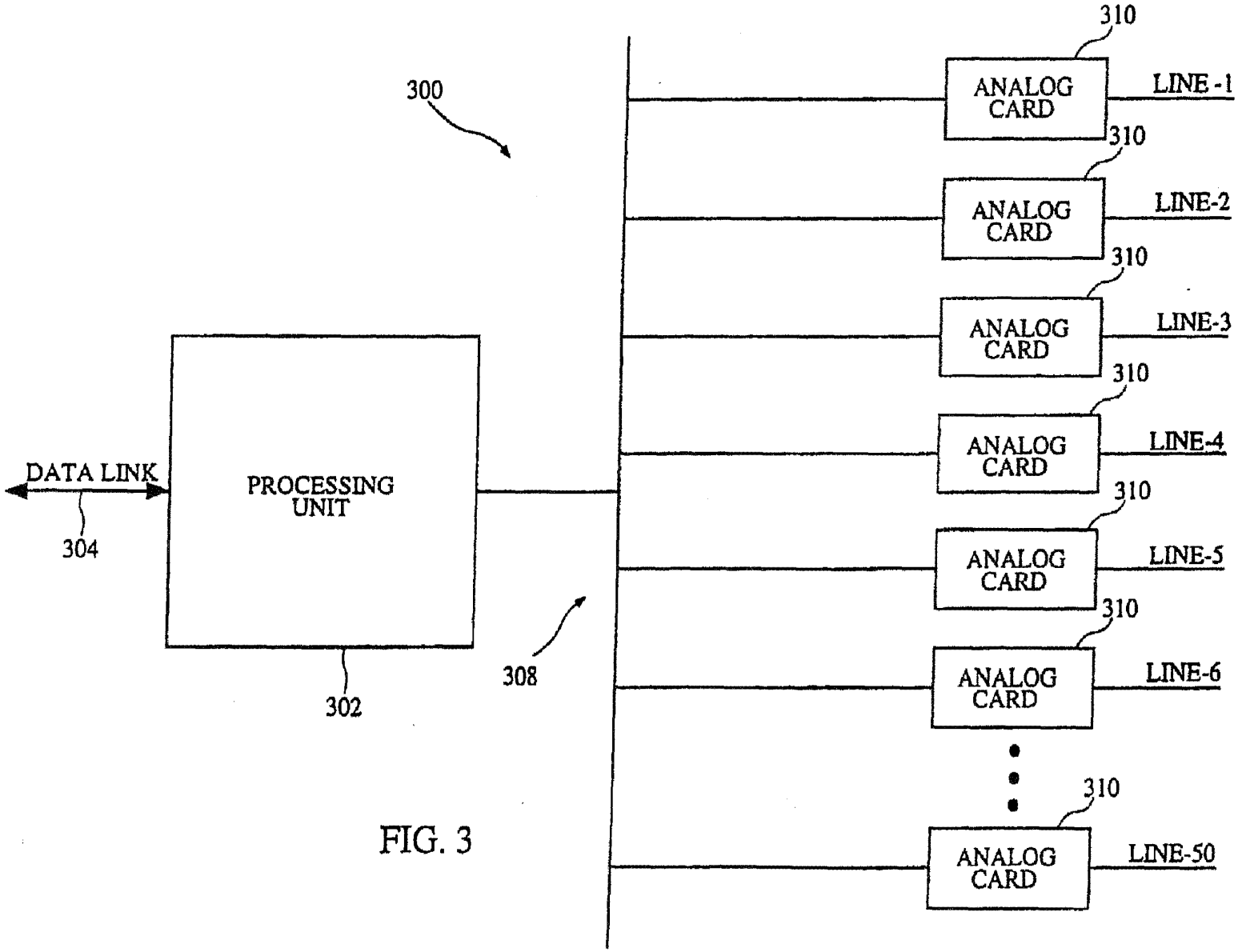


FIG. 3

CA 02254807 2000-02-28

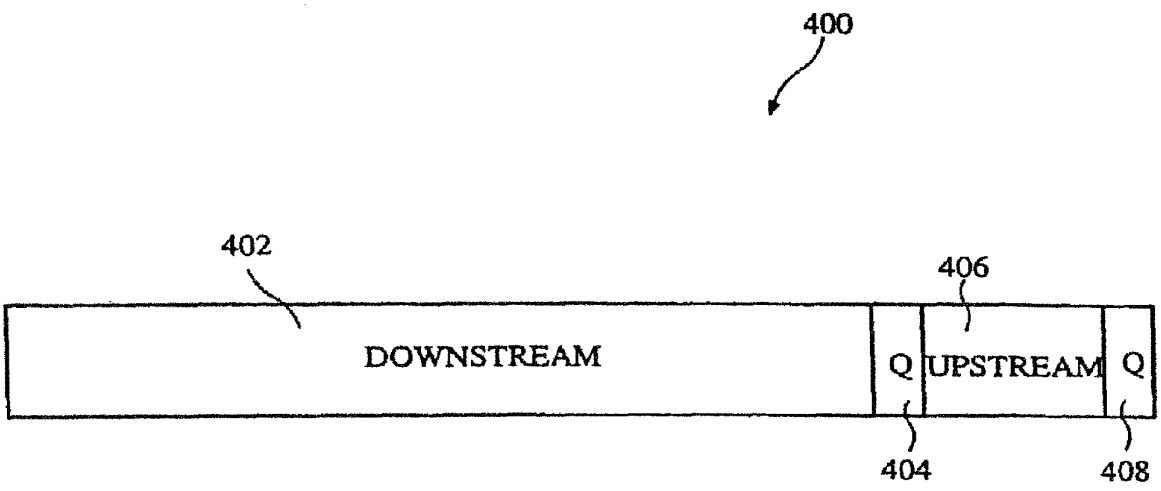


FIG. 4

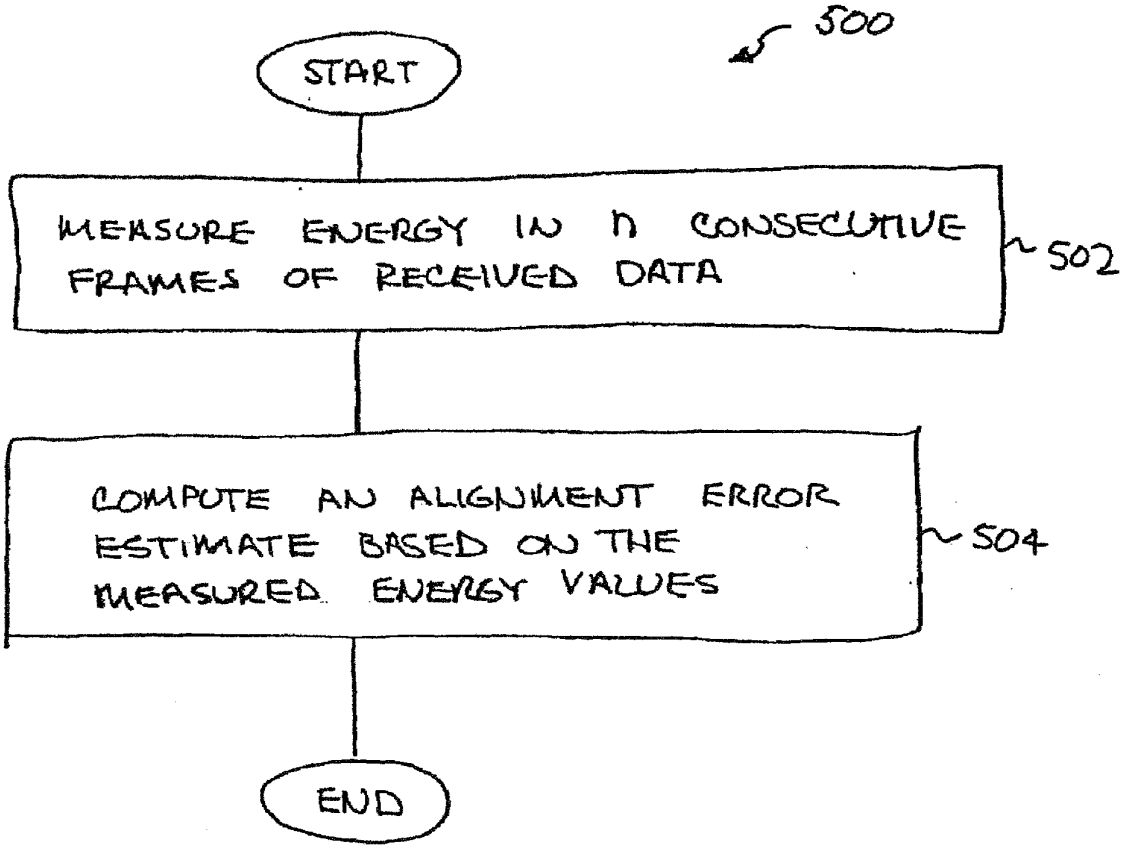

500
START
MEASURE ENERGY IN N CONSECUTIVE FRAMES OF RECEIVED DATA
502
COMPUTE AN ALIGNMENT ERROR ESTIMATE BASED ON THE MEASURED ENERGY VALUES
504
END

FIG. 5A

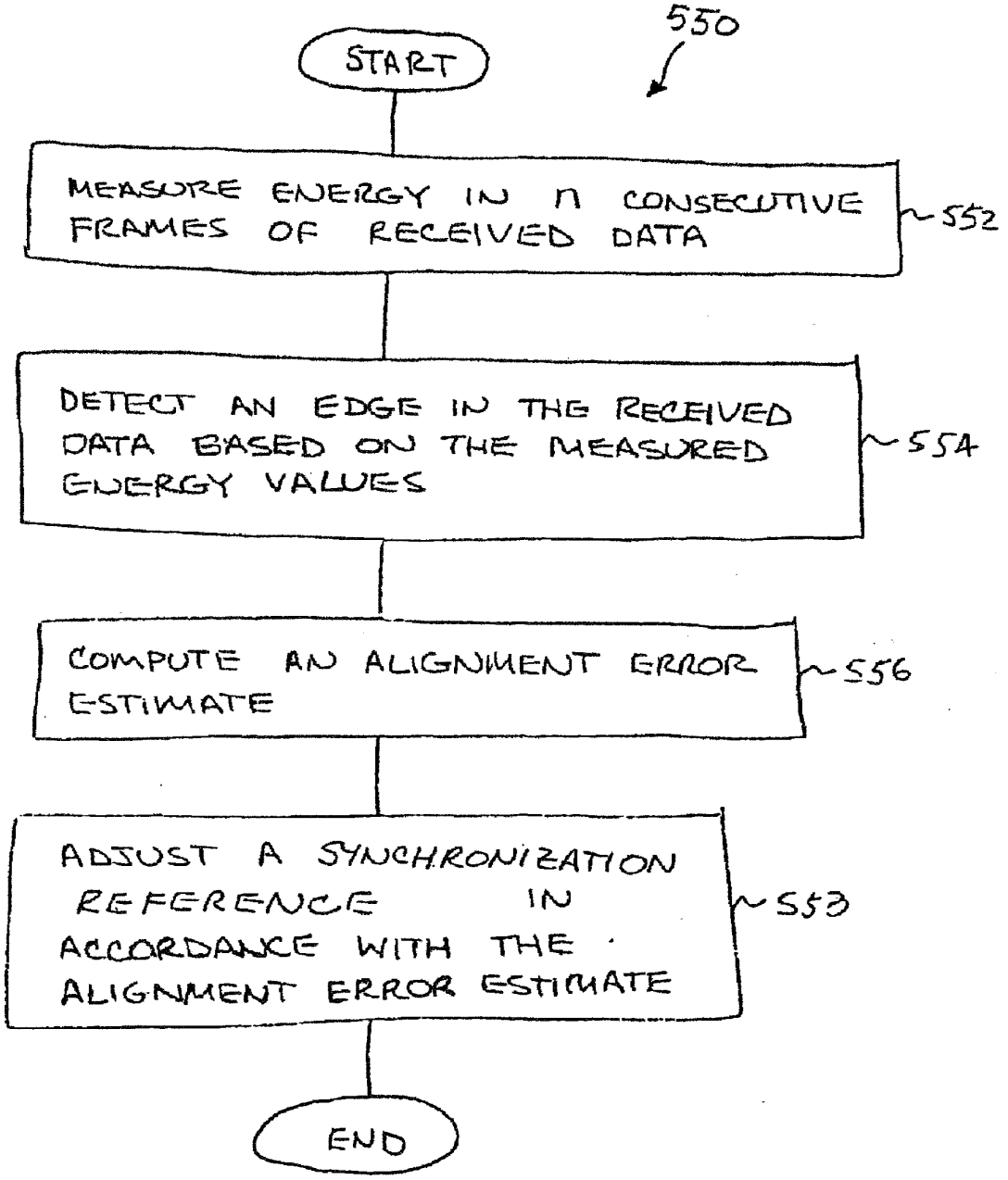

550
START
MEASURE ENERGY IN N CONSECUTIVE FRAMES OF RECEIVED DATA
552
DETECT AN EDGE IN THE RECEIVED DATA BASED ON THE MEASURED ENERGY VALUES
554
COMPUTE AN ALIGNMENT ERROR ESTIMATE
556
ADJUST A SYNCHRONIZATION REFERENCE IN ACCORDANCE WITH THE ALIGNMENT ERROR ESTIMATE
553
END

FIG. 5B

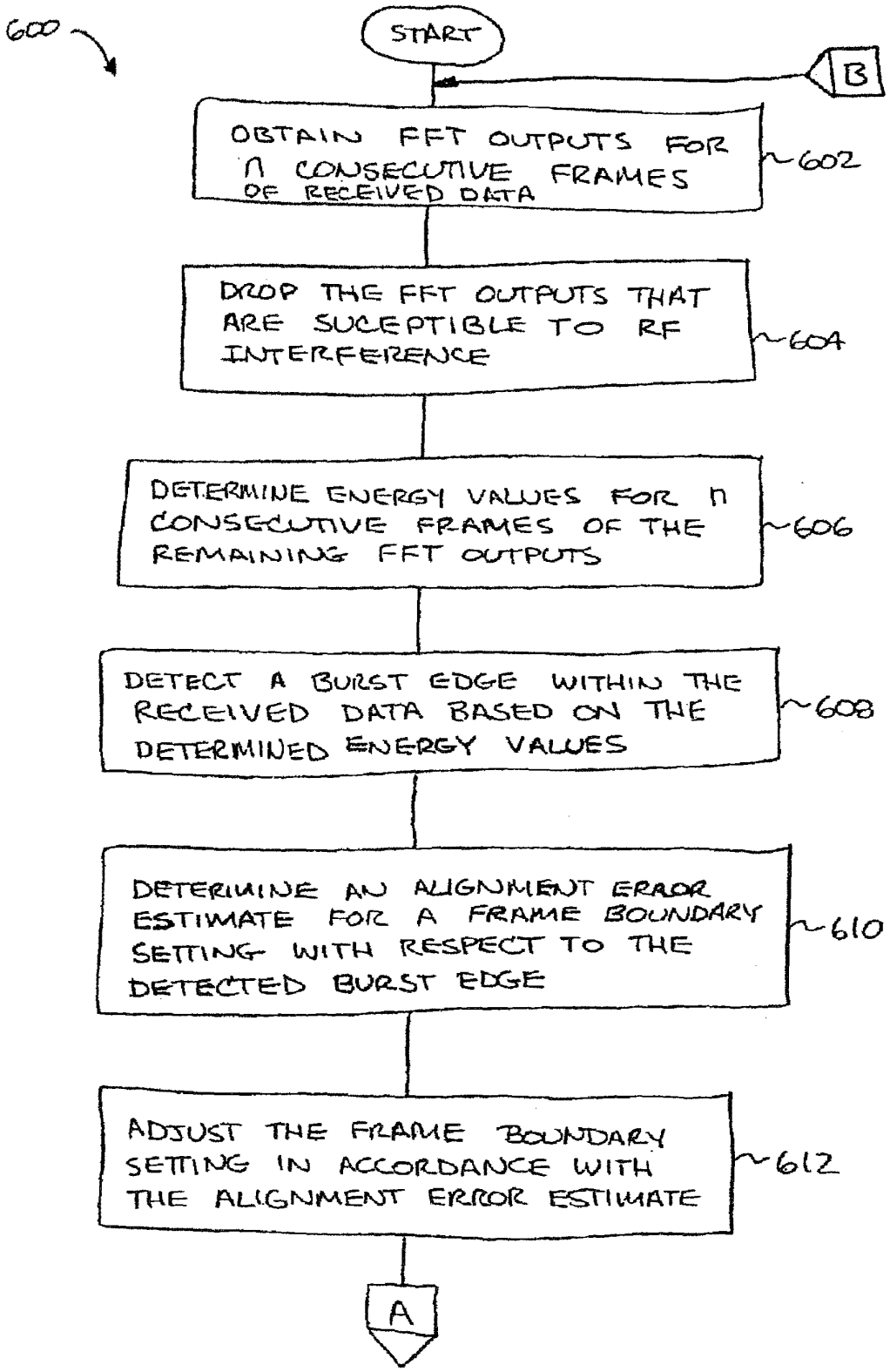


FIG. 6A

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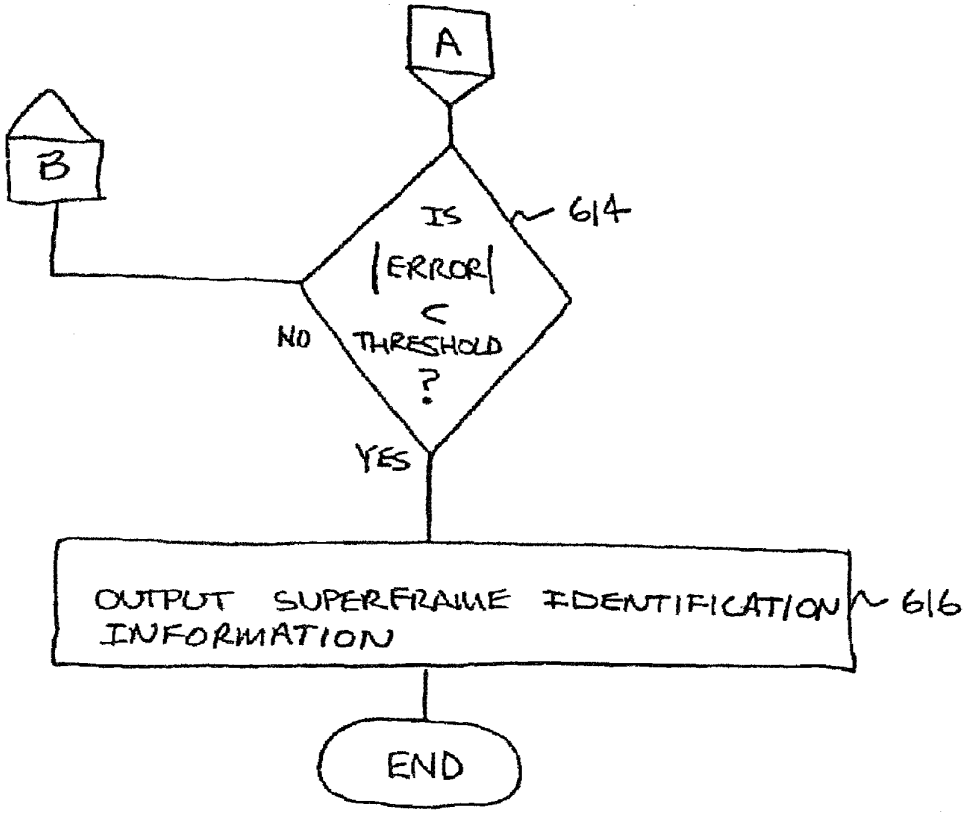

A
B
IS
|ERROR|
<
THRESHOLD
?
614
NO
YES
OUTPUT SUPERFRAME IDENTIFICATION INFORMATION
616
END

FIG. 6B

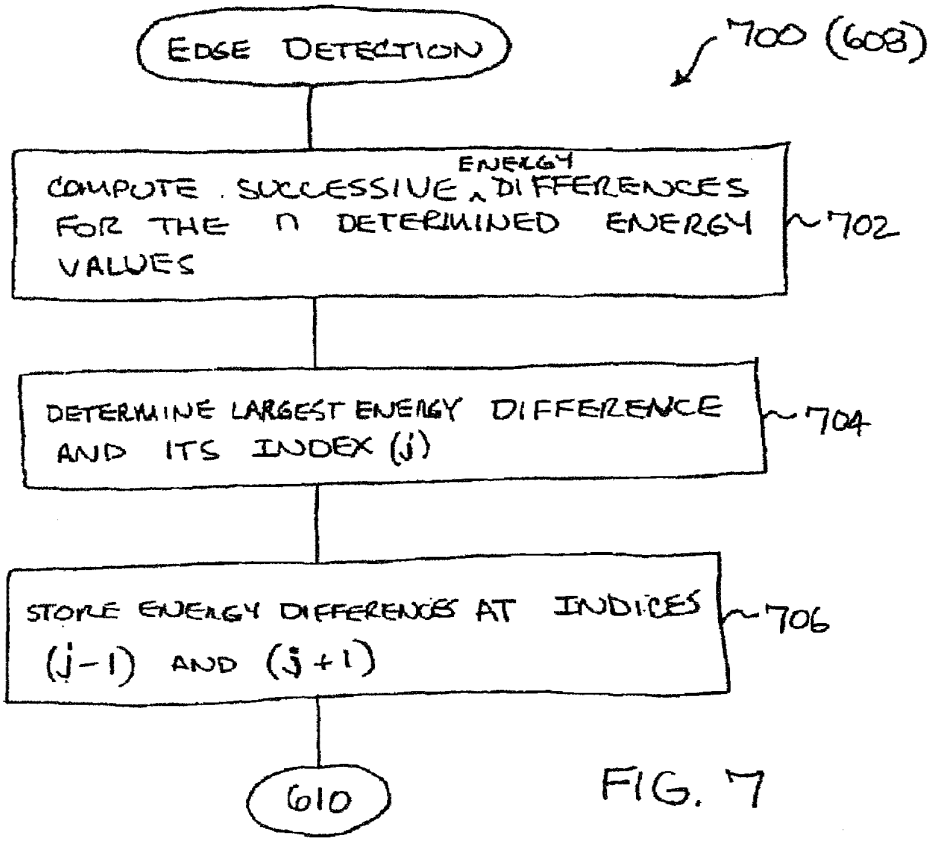

EDGE DETECTION
700 (608)
COMPUTE SUCCESSIVE ENERGY DIFFERENCES FOR THE n DETERMINED ENERGY VALUES
702
DETERMINE LARGEST ENERGY DIFFERENCE AND ITS INDEX (j)
704
STORE ENERGY DIFFERENCES AT INDICES (j-1) AND (j+1)
706
610

FIG. 7

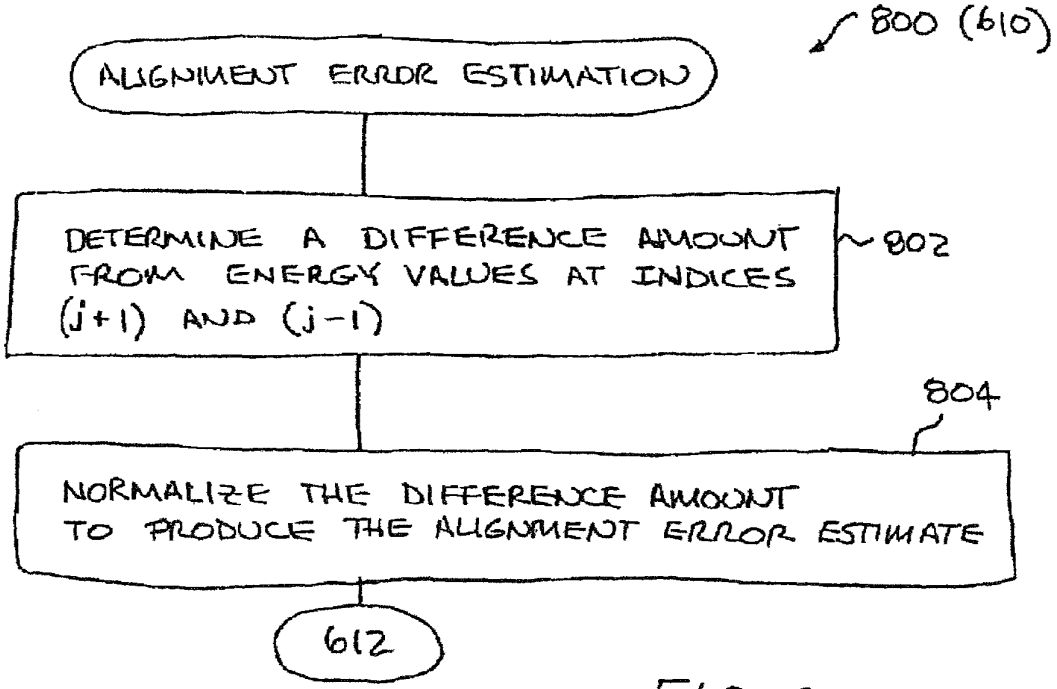

800 (610)
ALIGNMENT ERROR ESTIMATION
DETERMINE A DIFFERENCE AMOUNT FROM ENERGY VALUES AT INDICES (j+1) AND (j-1)
802
804
NORMALIZE THE DIFFERENCE AMOUNT TO PRODUCE THE ALIGNMENT ERROR ESTIMATE
612

FIG. 8

FIG. 9A

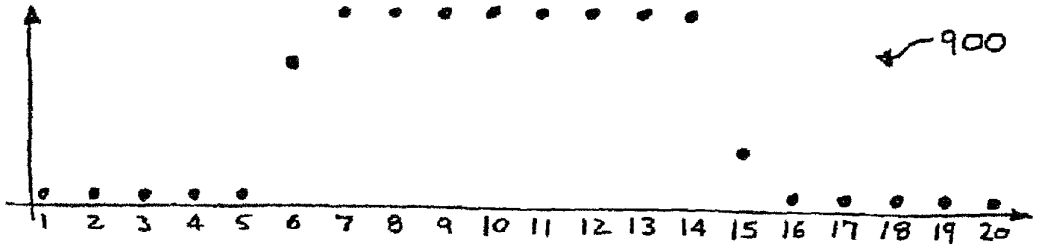
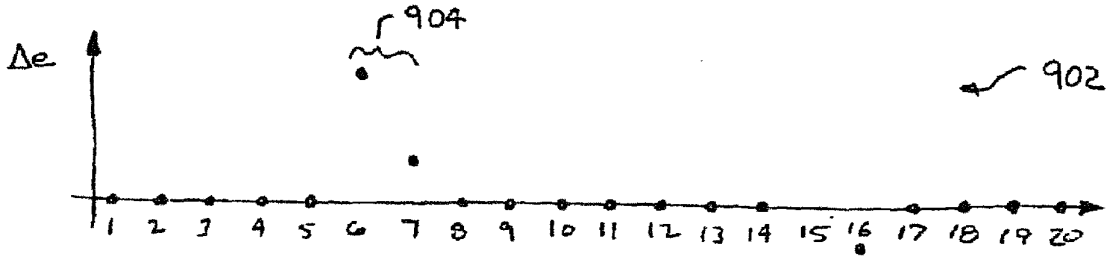


FIG. 9B



906

FIG. 10A

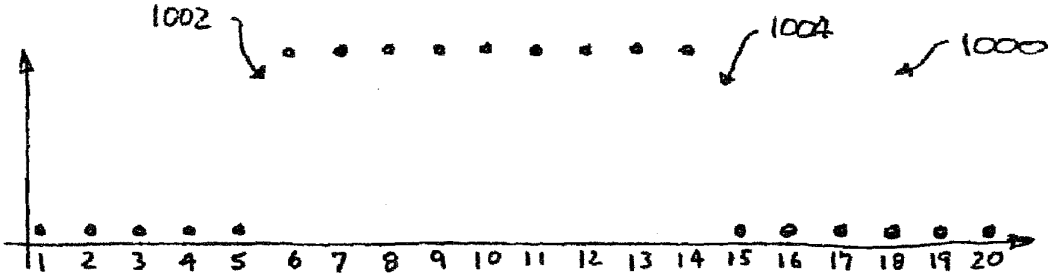
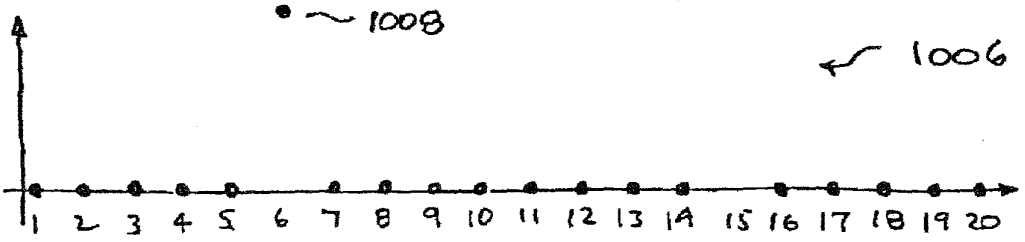


FIG. 10B



1010

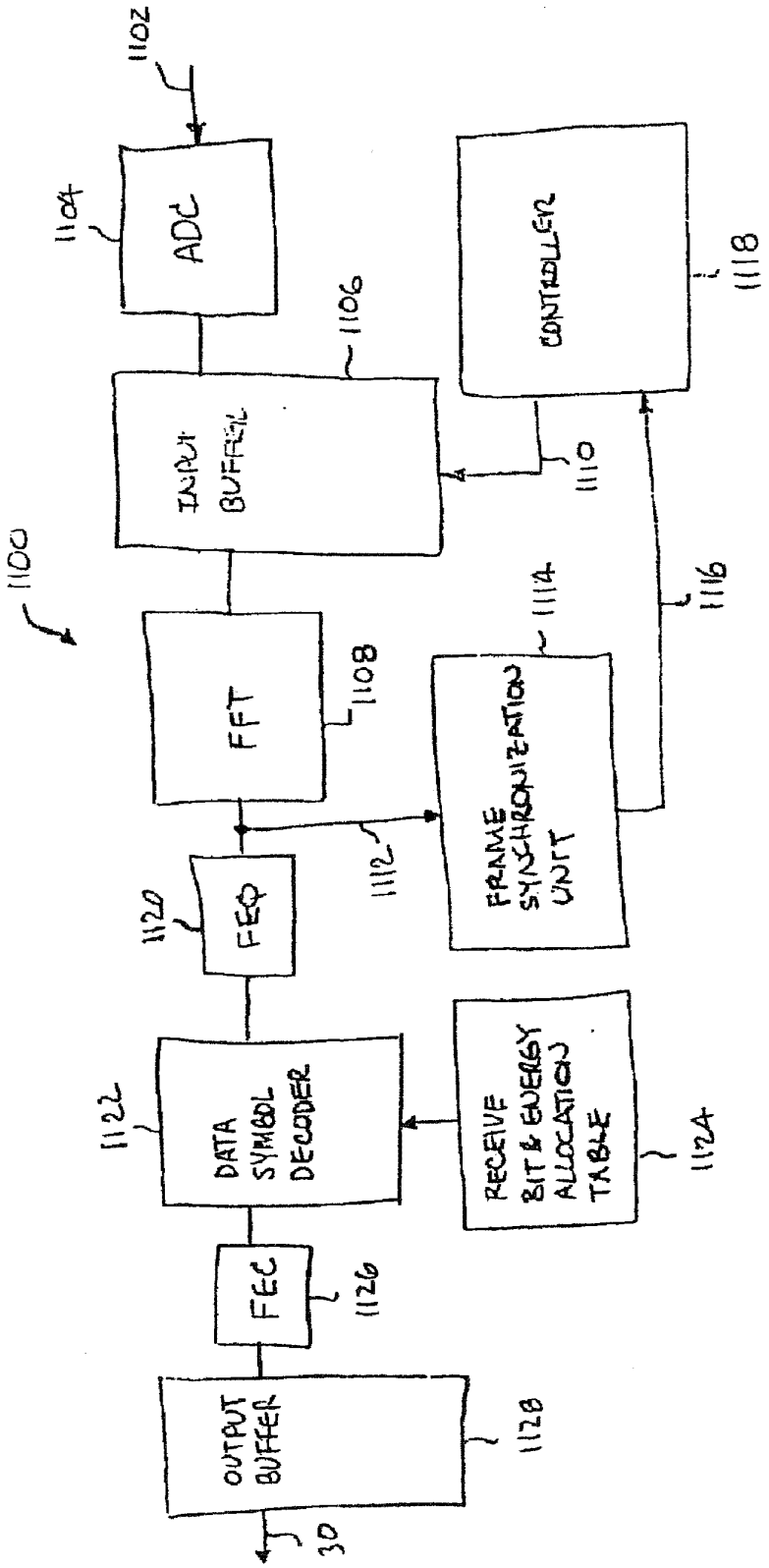

1102
ADC
1104
INPUT BUFFER
1106
CONTROLLER
1118
1110
1100
FFT
1108
1114
1116
FRAME SYNCHRONIZATION UNIT
1112
FEQ
1120
DATA SYMBOL DECODER
1122
RECEIVE BIT & ENERGY ALLOCATION TABLE
1124
FEC
1126
OUTPUT BUFFER
1128
30

FIG. 11

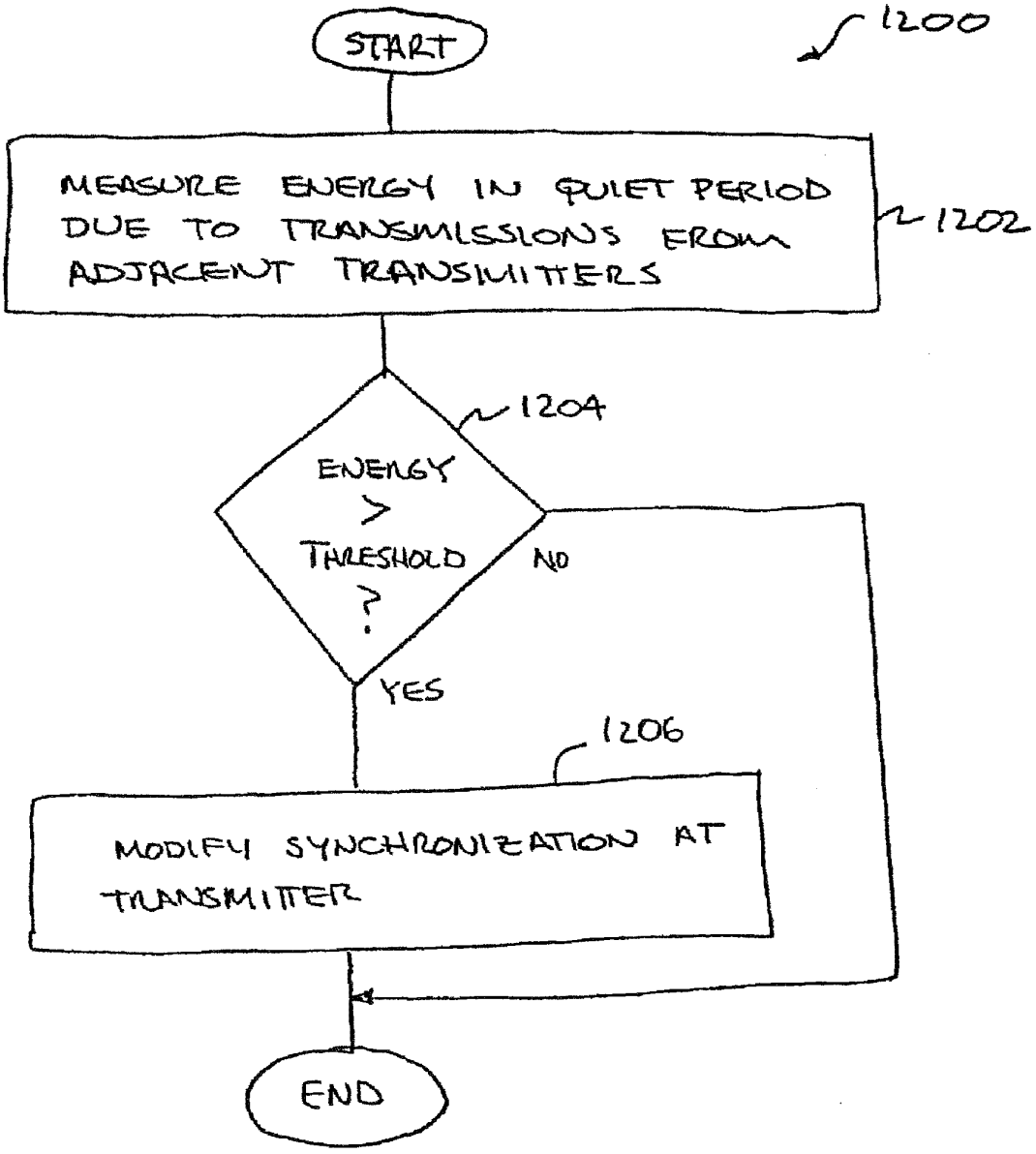

1200
START
MEASURE ENERGY IN QUIET PERIOD DUE TO TRANSMISSIONS FROM ADJACENT TRANSMITTERS
1202
1204
ENERGY > THRESHOLD ?
NO
YES
1206
MODIFY SYNCHRONIZATION AT TRANSMITTER
END

FIG. 12

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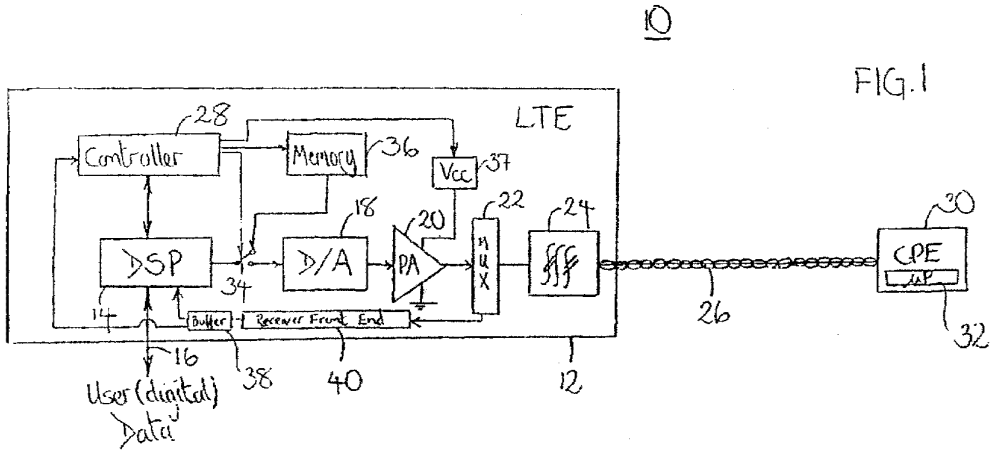
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(54) Apparatus, method and system having reduced power consumption in a multi-carrier wireline environment

(57) To reduce power consumption and associated heating in a line card of line termination equipment (LTE, 12) employing multiple sub-channel carriers to communicate broadband information to customer premise equipment (CPE, 30) down a wireline communication resource (26), sub-channel carrier transmissions are restricted (58) during periods of CPE inactivity. Power supplies to a power amplifier (30) associated with the line card and wireline resource (26) are reduced, with digital signal processing capabilities of the LTE (12) further restricted (64). When the CPE wishes to re-start communication, the CPE (30) locks (68) to a correct alignment in a transmission scheme using a pilot tone that is transmitted within a simple pattern sent during reduced sub-channel carrier transmissions. Alternatively, should all transmission from the LTE cease during CPE inactivity, then the CPE monitors (80) the transmission environment and sends (82) a wake-up call to the LTE between boundaries of an uplink slot. The LTE (12) re-establishes pilot tone transmissions (86), with synchronisation and lock (88) subsequently achievable by the CPE (30); this is illustrated in FIG. 2.



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Description

Background to the Invention

[0001] This invention relates, in general, to an apparatus, method and system arranged to minimise power consumption in a wireline environment, and is especially (but not exclusively) applicable to a wireline communication system that communicates relatively high frequency broadband signals over relatively low frequency voiceband signals, e.g. by using digital subscriber line (xDSL) communication protocols in bi-directional twisted-pair systems.

Summary of the Prior Art

[0002] Telecommunication systems that interconnect wireline subscriber terminals are being developed to support broadband data communication. More particularly, recent developments in broadband communication protocols allow broadband data to be overlaid on narrowband voice or integrated service digital network (ISDN) traffic. Specifically, the interconnection of broadband modems located at the subscriber terminal and at an exchange allow current broadband access systems to communicate on spare spectrum (i.e. spare frequency channels) of a twisted pair communication resource; the spare frequency channels being isolated from conventionally encoded voice signals by a suitable filter. In this respect, and depending upon the complexity of the xDSL coding scheme, overlaid broadband systems can support data rates in excess of two Megabits per second (Mbps), although this rate is dependent upon the physical parameters of the connection, e.g. the overall length of the twisted pair and its composition and configuration.

[0003] Asymmetric Digital Subscriber Line (ADSL) and High-speed Digital Subscriber Line (HDSL) protocols, for example, can support data rates of 2Mbps over distances of approximately three kilometres, while more complex schemes (such as VDSL) can support data rates of 8Mbps and above over distances of, typically, less than two kilometres. Protocols such as Very high-speed Digital Subscriber Line (VDSL) utilise multiple sub-channel carriers, e.g. in a discrete multi-tone (DMT) environment, to provide an adaptive system that mitigates the effects of cross-talk by selectively ignoring noise-effected sub-channel carriers or reducing the number of bits supported on each sub-channel. As will be appreciated, DMT provides a comb of frequency carriers that are each separated modulated and then combined to generate a composite signal envelope. As such, information (both control information and traffic) is distributed across a number of different frequency carriers.

[0004] DMT schemes for supporting, for example, VDSL are often realised in a time division duplex (TDD) transmission environment in which a single communication resource, i.e. a frequency band, supports both up-link and down-link transmissions using the same frequencies. In other words, there is a sharing in time of the bandwidth provided by the extended spectrum. The use of guard periods between adjacent groups of time-slots within a TDD frame ensures that rogue overlapping transmissions within the up-link and down-link do not occur, and hence eliminates the likelihood of near-end cross talk (NEXT). In more detail, the guard periods provide a period in which a power amplifier can power-up and power-down, and also allow for some adjustment (i.e. alignment) of the frame with respect to a selected pilot tone on a designated sub-channel carrier of a DMT scheme.

[0005] In relation to bundles of wireline communication resources, it is also important to understand the potentially undesirable effects associated with cross-talk interference. Specifically, with bi-directional communication, the relative location of the lines, for example, between twisted copper-pair causes cross-talk interference to be induced into proximately located wireline communication resources (principally by the mechanisms of capacitive and inductive coupling and by radiation arising from the imperfect nature and performance of the cabling). Moreover, where symmetrical and asymmetrical service are simultaneously required on pairs in the same bundle, cross-talk becomes a significant problem, as will readily be appreciated.

[0006] For completeness, it will be understood that near-end cross-talk (NEXT) occurs when electromagnetic interference is induced into a wireline resource that is communicating information in an opposing direction, e.g. down-link (or downstream) information appears as noise in an up-link (or upstream) path. NEXT is undesirable because near-end generated interference is at a level that can potentially swamp data signals received from a remote terminal, which data signals have previously been subjected to attenuation through the transmission path. Furthermore, NEXT increases significantly at the higher frequency components and so is even more undesirable in high frequency data-over-voice wireline systems, such as VDSL. To avoid the harmful effects of Near-End Cross-Talk (NEXT) in a TDD system, an ensemble of collated communication resources must have synchronised and aligned transmissions. However, in a mixed symmetrical/asymmetrical system, NEXT often occurs where the two opposing schemes have either different frequency allocations (in frequency division duplex, FDD) or different time slot allocations (in TDD).

[0007] With regard to Far End Cross-Talk (FEXT), this form of cross-talk affects non-addressed ports of a remote terminal. In other words, FEXT occurs when electromagnetic interference (i.e. noise) is induced into a wireline resource that is communicating information in a similar direction, e.g. upstream (or up-link) information appears as noise in another upstream wireline resource to an extent that performance on a given pair is limited.

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The effects of FEXT are correspondingly reduced by the attenuation path of the wireline resource. However, when multiple separate modem links exist (as supported by a multiplicity of different copper pairs proximally located towards the exchange LTE as a bundle of pairs in the access network and then fanned out to individual drops serving particular CPEs), crosstalk between the numerous signals at (or towards) the exchange presently generates noise that limits the data-rate performance of both a given pair and the entire wireline system, in general. In synchronised systems, FEXT is inherent.

[0008] FEXT on adjacent pairs can be severely exacerbated from increased signal strengths at a receiver modem of the exchange LTE for the pair causing the FEXT. More especially, where these adjacent pairs have shorter reaches (i.e. shorter cable lengths), the attenuation of the signal in the wireline resource from such relatively closely located modems (as opposed to remotely located modems) is relatively little and, correspondingly, FEXT induced into adjacent wireline resources can be relatively large. In other words, in instances when FEXT from a relatively closely located modem is introduced into a wireline resource serving a distantly located modem, the FEXT interference effects can be catastrophic and corruption of the data from the distant modem absolute. For this reason, it is accepted that there is a need to "back-off" the power transmitted by the transmitting (CPE) modem in the upstream direction for all but the longest lines. Unfortunately, the necessity for back-off results in inefficient utilisation of the spectrum as a consequence of CPEs served by short loop distances having to forego the benefits of better signal to noise ratios (SNR) and therefore to restrict channel throughput by reducing power and lowering the bit transmission rate. In summary, FEXT is particularly problematic in the uplink at the LTE and limits spectral capacity generally.

[0009] The term "self-FEXT" will be understood to mean FEXT arising from use of the same time-slot and/or the same frequency for a common form of service (as opposed to differing services on a common wireline resource, such as a combination of ADSL and VDSL).

[0010] In order to establish effective end-to-end communication in a communication system, it is necessary for synchronisation between a transmitting unit and an interconnected receiving unit to occur; this is true for both a radio frequency environment and a wireline environment, such a VDSL system employed over a twisted pair. More specifically, synchronisation is required to demodulate encoded signals that are addressed to the receiver. In this respect and in relation to a DMT system (or the like, such as an orthogonal frequency division multiplexed OFDM scheme), a pilot carrier or tone is used in a training sequence on a dedicated (pre-allocated) sub-channel. Initially, upon receipt of the pilot tone, the receiver acquires frequency lock and then establishes phase lock.

[0011] Another concern in relation to the implementation of wide bandwidth applications (required multi-carrier schemes) arises from the fact that the frequency spectrum seldom provides a homogeneous transmission environment and usually exhibits significant variations in its signal to noise (S:N) ratio across its bandwidth. In fact, portions of the spectrum are often unusable as a consequence of the presence of interference, such as noise and intermodulation products. To avoid these poor spectral regions, modems associated with the transmitter and receiver negotiate for the best sub-channel carriers during training and reject those sub-channel carriers that have a performance below a predetermined and acceptable threshold.

[0012] Another significant problem in a multi-carrier environment pertains to the peak power of the composite envelope formed by a summation of the individual sub-channel carriers. While techniques have been developed to restrict these peaks, there is still a general requirement for DMT equipment to support a wide (large) dynamic range.

[0013] In relation to a typical (although simplified) model of a wireline transmission path, line termination equipment (LTE) typically has an interface for receiving user data, which user data is subsequently applied to a digital signal processor (DSP). As will readily be appreciated, the DSP is configured to perform many signal processing tasks, including DMT encoding.

[0014] Following DMT encoding of the data, resultant signals are converted into the analog domain (in a digital-to-analog converter, DAC) before being applied to a power amplifier that is required to ensure that there is sufficient power to drive the wireline communication resource and therefore to ensure reception of the signals at the addressed customer premise equipment (CPE). As will be understood, a passive filter is generally included in the path between the power amplifier and the wireline, with a line impedance of the wireline having a nominal impedance value of approximately 100 (with the actual value being country specific). In other words, the power amplifier is required by virtue of the fact that copper pairs have low impedance and DAC operation is subject to restricted operational parameters.

[0015] In relation to the aforementioned transmission path, it will be appreciated that the functional elements are attributable to individual line cards of telecommunication exchanges, such as private branch exchanges (PBXs) and infrastructure nodes that integrate with ancillary services, e.g. Internet servers.

[0016] Unfortunately, the power amplifier is responsible for dissipating approximately half of the total power of the line card and so its inclusion and operation generates significant heat (that must effectively be channelled away from temperature sensitive integrated circuits) whilst also placing significant demands on power supplies within the exchange. Consequently, systems and schemes that reduce total power consumption in line cards are very desirable.

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Summary of the Invention

[0017] According to a first aspect of the present invention there is provided a wireline communication system comprising line termination equipment coupled to customer premise equipment through a wireline communication resource supporting a multi-carrier transmission scheme between the LTE and the CPE, the wireline communication system comprising: means for indicating activity of the CPE; and a controller, responsive to the means for indicating activity, for selecting sub-channel carriers of the multi-carrier transmission scheme on which information is modulated for transmission to the CPE over the wireline resource, wherein the controller is arranged to limit a number of sub-channel carriers utilised by the LTE in response to the means for indicating activity identifying that the CPE is inactive.

[0018] The LTE typically comprises a line driver coupled to a voltage supply and arranged to amplify signals to be applied to the wireline communication resource, the voltage supply being operationally responsive to the controller and wherein the controller is arranged to reduce a voltage applied to power the line driver in response to the means for indicating activity identifying that the CPE is inactive.

[0019] In a preferred embodiment, the LTE comprises a signal processor operationally responsive to the controller, the controller arranged to at least partially disable operationally functionality of the signal processor in response to the means for indicating activity identifying that the CPE is inactive.

[0020] In another embodiment, the wireline communication system comprises a memory containing at least one pattern having relatively few sub-channel carriers in relation to a number of sub-channel carriers utilised during information transfer in a data path between the LTE and CPE, the LTE further comprising a switch operationally responsive to the controller and configured to couple one of the data path and the memory to the wireline communication resource, the controller further arranged to cause the at least one pattern to be applied to the wireline communication resource in response to the means for indicating activity identifying that the CPE is inactive.

[0021] The controller (28) maintains at least one sub-channel carrier in response to the means for indicating activity identifying that the CPE is inactive; this ensures that the CPE maintains synchronisation and reasonable lock.

[0022] In another aspect of the present invention there is provided a line card for coupling to customer premises equipment through a wireline communication resource supporting a multi-carrier transmission scheme, the line card comprising: means of establishing a presence of CPE activity; and a controller, responsive to the means of establishing a presence of CPE activity, for selecting sub-channel carriers of the multi-carrier transmission scheme on which information is modulated for transmission to the CPE over the wireline resource, wherein the controller is arranged to limit a number of sub-channel carriers utilised by the LTE in response to the means for indicating activity identifying that the CPE is inactive.

[0023] In yet another aspect of the present invention there is provided a method of reducing power consumption in line termination equipment coupled to customer premise equipment through a wireline communication resource supporting a multi-carrier transmission between the LTE and the CPE, the method comprising the steps of: determining activity of the CPE; and assigning a relatively large number of sub-channel carriers to support information modulation onto the wireline communication resource in a multi-carrier transmission; and utilising a reduced number of sub-channel carriers for transmissions from the LTE in response to the step of determining activity of the CPE identifying that the CPE is inactive.

[0024] In still yet another aspect of the present invention there is provided a method of establishing a multi-carrier transmission between a line card of an exchange and customer premise equipment through a dedicated wireline communication resource, the exchange coupled to a plurality of CPEs through a plurality of wireline resources in which cross-talk is experienced, the method comprising the steps of: at the CPE, monitoring a cross-talk environment to identify an uplink transmission slot to the LTE; transmitting a wake-up message to the CPE within the uplink transmission slot; at the LTE, receiving the wake-up message and sending to the CPE at least one pilot tone; and at the CPE, receiving the at least one pilot tone and acquiring synchronisation and lock therefrom.

[0025] Advantageously, therefore, the present invention reduces power consumption within a line card and line termination equipment (at an exchange, for example). Moreover, by virtue of the fact that the line driver or power amplifier can be backed-off, heat generation within the line card is reduced. Beneficially, with reduced power consumption and reduced heat generation, temperature regulation devices (such as heat sinks and fans) can be scaled down within exchanges which simplifies exchange construction and reduces manufacturing costs. Furthermore, with battery powered equipment (e.g. required when the mains supply is interrupted), prolonged operational life is obtained through lower power consumption.

Brief Description of the Drawings

[0026] Exemplary embodiments of the present invention will now be described with reference to the accompanying drawings, in which:

FIG. 1 is a block diagram of a wireline system employing various preferred embodiments of the present invention;

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FIG. 2 is a flow diagram illustrating the steps employed in the wireline system of FIG. 1 to reduce power consumption (principally) in line termination equipment (LTE).

Detailed Description of a Preferred Embodiment

[0027] FIG. 1 shows an enhanced wireline system 10 employing various preferred embodiments of the present invention. A transmission path of LTE 12 contains a DSP 14 responsive to user data 16. The DSP 14 is coupled through a D/A converter 18 to a power amplifier or line driver (PA) 20 which is, in turn, coupled to a multiplexer/demultiplexer (MUX) 22 that therefore supports bi-directional communication within the LTE 12. A filter 24 is disposed intermediate between the MUX 22 and a wireline resource 26, such as a twisted copper pair. Operation of the LTE is controlled by a controller 28, although this function could be integrated into the DSP 14.

[0028] It will be appreciated that, generically, an exchange will contain a plurality of line cards and hence serve a plurality of CPEs through individual wireline resources, such as twisted copper pair. Moreover, the multiplicity of wireline resources will, to some extent, generally be bundled together before branching to a specific CPE. The exchange per se and the numerous CPEs have been omitted from FIG. 1 for the sake of clarity

[0029] In an uplink direction to the LTE, the MUX 22 functions to route encoded (and modulated) signals to a receiver front end and then to the DSP 14 for signal processing.

[0030] The wireline resource 26 is connected to customer premise equipment (CPE) 30 that contains transmission and/or reception circuitry (as will readily be appreciate). Operational control of the CPE 30 is typically overseen by a microprocessor 32 or the like, with the functionality in the CPE 30 complementary to that provided in the LTE 12.

[0031] The structure of the LTE 12 (and for that matter the system as a whole) to this point corresponds to that in existing LTEs (systems).

[0032] Intermediate between the DSP 14 and the D/A 18 is a switch 34 that is operationally responsive to the controller 28. The switch 34 selectively isolates the DSP 14 from a transmit path in the LTE 12 and, in this position, couples a memory 36 to the transmit path. The content of the memory 36 will be described subsequently, with it presently suffice to say that the memory 36 can be accessed and controlled by the controller 28.

[0033] In order to appreciate fully the present invention, it is necessary to realise that the LTE 12 can deduce (or can be informed about) the absence of CPE activity, e.g. the CPE is either switched-off or has otherwise ceased to function. The CPE 30 can notify the LTE 12 of its intention to go off-line by sending an appropriate control message to the LTE on a dedicated control channel. Alternatively, the LTE 12 can deduce that the CPE is off-line through an increased bit error rate (BER) in the decoded data, i.e. random noise is decoded by the LTE with output values therefore containing invalid codewords. The LTE 12 can also determine CPE inactivity by virtue of the relatively low level of received power at the LTE, with the power being attributable merely to the energy of noise rather than in relation to transmitted symbols.

[0034] Irrespective of the reason for CPE inactivity, it is still essential that the LTE 12 regularly transmits synchronisation and timing information to the CPE 30; this ensures that the CPE 30 can come back on-line and acquire lock/synchronisation and correct alignment with respect to a transmission scheme adopted for a bundle of wireline resources. As previously indicated, it is beneficial to have synchronised transmissions from the LTEs and CPEs to avoid cross-talk. Ideally, re-establishment of the CPE into the system should be immediate.

[0035] The preferred embodiments of the present invention all operate to reduce power consumption and hence reduce heat generation during idle periods of CPE inactivity. There are several mechanisms that are employed that can be used independently or in combination to provide enhanced effects and improved reliability/performance.

[0036] Usually, when the wireline system is active, i.e. transmissions are occurring between a dedicated line card and its associated CPE, many hundreds of sub-channel carriers are used to relay information symbols. All these sub-channel carriers contribute to form a composite signal envelope in which there are significant power excursions from a nominal mean or root-mean-square (rms) level. It has been identified that, during idle periods, many of these sub-channel carriers become overhead, i.e. they are redundant since they do not communicate meaningful information in the form of encoded symbols. Consequently, the controller 28 of the LTE 12 can effectively reduce the number of sub-channel carriers used to form the composite signal envelope when the CPE is off-line. In fact, it is possible to reduce the number of sub-channel carriers to only that number required to ensure/allow the CPE to detect the presence of the LTE and then to respond to register its own existence. For example, an on-going call could require four hundred sub-channel carriers, whereas a CPE idle condition may reduce this number to, perhaps, four or so. As will be appreciated, the reduction in the number of sub-channel carriers reduces the amplitude excursions in the composite signal envelope, i.e. the peak-to-peak level (as presented to the PA 20) is reduced significantly. Consequently, it is possible for the controller 28 to reduce a voltage supply V_{cc} 37 (or its functional equivalent) applied to the line amplifier (i.e. the PA 20) in the transmit path and hence to cut both the power consumed and the heat generated by the PA 20. In other words, class A power dissipation in the PA 20 is reduced.

[0037] In relation to those sub-channel carriers that

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are kept live during periods of CPE inactivity, it is preferably that these be associated with pilot tones used by the multi-carrier transmission scheme. Moreover, it is preferable that the reduced number of sub-channel carriers form a fixed pattern, which pattern may be unique to a particular line card-CPE association. The number of sub-channel carriers selected may also be subject to quality of the link to the CPE, while it is also envisaged that the pattern could, if desired, be randomly or sequentially rotated to mitigate interference problems, although at least one sub-channel carrier associated with a pilot tone must be maintained in the pattern.

[0038] In relation to FIG. 1, once the controller 28 has identified an idle CPE, the controller isolates the DSP 14 by re-routing the transmission path from the memory 36. The memory 36 therefore contains the fixed pattern, whilst the controller 28 causes the fixed pattern to be sent for modulation, amplification and eventual transmission from the LTE 12 to the addressed (but idle) CPE 30. In relation to a rotating pattern, the controller 28 may generate a pseudo-random sequence to effect rotation or may rely upon a prestored sequence in memory 36.

[0039] In a preferred embodiment of this first aspect of the present invention, use of the simple pattern of fewer sub-channel carriers allows DSP functionality to be temporarily reduced. Therefore, current drawn (and hence powered consumed) by the DSP 14 can be scaled down to reflect the lower number of operational sub-channel carriers.

[0040] If all processing capabilities of the DSP 14 are disabled, e.g. the DSP is turned-off entirely, then this potentially presents a problem when the CPE 30 comes back on-line and attempts to re-establish effective communication. In other words, the DSP cannot initially process information, and it is unaware when meaningful information in once again being transmitted from the CPE 30. This can be overcome by providing at least one of two mechanisms. First, to allow information received from the CPE to be subsequently processed, the system 10 of FIG. 1 can be adapted to include a buffer 38 (such as a random access memory, RAM) in-line with receiver front end equipment 40 that is fed from the MUX 22. The buffer 38 need only store a few symbols of analog samples, with DSP functionality re-stored by virtue of the controller 28 analysing the status of the buffer 38. In relation to the buffering of data, it will be appreciated that the DSP processing in the LTE does take some time to establish and that, as such, there may be a necessity to continue buffering until a natural break in transmission from the CPE occurs; the buffer therefore acts in a "first in first out" (FIFO) capacity and so data is sequenced through the buffer during processing. Alternatively or additionally, DSP functionality and power can be restored by the controller 28 in response to the detection of an increased level of received signal strength. In this latter respect, receiver front end equipment 40 may contain a suitable received signal strength indicator (RSSI) circuit or a software algorithm can be stored in memory 36 and accessed by the controller 28 in relation to all incoming data (whether spurious noise-related or legitimate information).

[0041] In order to further reduce transmissions from the LTE during CPE inactivity and therefore to further reduce power dissipation and heat generation associated with the PA 20, a further embodiment contemplates restricting downlink transmissions; this can be implemented in association with the simple pattern of fewer sub-channel carriers, or may be independently actioned with all sub-channel carriers. Specifically, once the LTE 12 has identified a CPE as being in an idle mode, the periodicity of downlink transmission from the LTE is decreased. In other words, a superframe structure is established with only one frame in N containing any form of donwlink transmissions from the LTE to a specifically addressed but idle CPE 30. This system, whilst still further reducing power consumption in the line card, is a compromise inasmuch a CPE going back on-line is denied uplink communication capacity until such time as it receives the pilot tones and it also achieves lock acquisition.

[0042] Yet another embodiment of the present invention proposes that downlink transmission in a superframe environment be offset between the various wireline resources within a bundle of twisted pairs, for example. By moving to a burst transmission environment with respect to idle CPEs, cross-talk between collocated wireline resources is reduced since there is no simultaneous transmission.

[0043] In another embodiment, the LTE 12 firstly determines inactivity at the CPE 30 and then enters a dormant transmission mode to the CPE by disabling its DSP 14 and suspending sub-channel carrier transmissions to the CPE 30. In this instance, both the CPE and LTE are unaware of each other's mutual existence. Once the CPE requires service, the CPE powers-up and has its microprocessor 32 monitor the cross-talk environment to identify a nominal uplink slot, e.g. a TDD slot. This system is immediately effective in relation to an asymmetric transmission scheme in which uplink and downlink transmission having different durations. However, in an equally split duty cycle environment, it is necessary for the microprocessor 32 of the CPE 30 to analyse the frequency characteristics of the cross-talk to differentiate FEXT-related and NEXT related transmission. For example, the CPE 30 may seek to identify coherent pilot tones that are entirely indicative of downlink transmissions. In other multi-carrier environments, different line codes are used for each of the uplink and downlink paths and so the CPE 30 is able to identify the uplink from the downlink by virtue of the fact that each line coc has a distinct frequency characteristic. As will be appreciated, the microprocessor (or its equivalent) includes suitable control algorithms that can assess spectral characteristics and regulate transmission from the CPE.

[0044] The CPE 30, once armed with approximate

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timing information concerning transmission direction boundaries, sends a wake-up transmission to the LTE 12 in ab the centre of the uplink slot (but certainly within the guard bands associated with the uplink slot). More specifically, the CPE 30 sends a wake-up message on a small number of sub-channel carriers to limit interference on adjacent lines. The LTE 12, using the RSSI or buffering techniques mentioned above, re-enables its dormant DSP 14 and line driver (i.e. PA 20) and then transmits its normal training sequence back to the CPE 30 to effect accurate synchronisation and lock. Full-blown communication can then commence, although it will be appreciated that there is a finite delay before the CPE is serviceable.

[0045] The mechanism by which power consumption in the LTE 12 is reduced is summarised in FIG. 2. Assuming that the default (start) position 50 is that the LTE 12 is fully operational and configured to transmit a multi-carrier signal, monitoring 52 of CPE activity precedes a determination 54 of CPE activity. Should the CPE be active, then there is conventional communication 56 of multi-carrier data, and the process basically loops back to the monitoring and subsequent determination of CPE activity. In the negative, i.e. the CPE is determined to be idle, then flow proceeds to step 58 where the LTE (or line card) reduces the number of sub-channel carriers used in transmission; this could be to zero or to the simple pattern that preferably includes at least one pilot tone.

[0046] Contemporaneously with the reduction in the number of sub-channel carriers, the controller 28 of the LTE can reduce 60 the voltage/power consumption to/ of the PA 30. If desired, the functionality of the DSP can be restricted 62 by the controller 28. The LTE is then arranged to send 64 a simple pattern (which can be sequenced or time delayed to 1 frame in N). Of course, in the limit, all transmission to a dormant CPE could cease. In the case of a limited sub-channel pattern, the LTE may co-ordinate its 1 in N frame transmission such as to offset 66 bursts between idle lines in a bundle.

[0047] Depending on whether or not the LTE 12 maintains some form of limited transmission to the CPE during CPE idling determines the route taken when the CPE comes back on-line. If the LTE transmits the simple pattern, flow proceeds to step 68 in which the CPE locks to correct alignment in transmission scheme, whereafter multi-carrier communication can re-commence from the CPE; flow returns to step 56. However, the LTE may have to have its DSP functionality restored and so a test is made to this extent at step 70. If LTE DSP functionality is fully enabled then effective decoding can take place immediately. However, if the operational capacity of the LTE DSP 14 has been scaled down or disabled in its entirety then incident multi-carrier data transmitted by the CPE must be buffered 72. The controller 28 of the LTE, using either an RSSI circuit or a buffer flag associated with data in the buffer 38, identifies 74 the presence of the buffered data and then re-establishes 76 necessary DSP functionality. The LTE (and particularly the DSP 14) is then able to process 78 the buffered data to recover user data.

[0048] If the LTE 12 has ceased transmission and the CPE wishes to come back on-line, the CPE monitors 80 the cross-talk environment to identify an uplink transmission slot. The CPE 30 then transmits 82 a wake-up message to the LTE 12, but ensures that this wake-up message is confined within the boundaries of the uplink slot. The controller 28, in response to the wake-up message from the CPE (typically transmitted on a selected and limited number of sub-channel carriers assigned as control channels) wakes-up/powers-up 84 from its dormant transmission state. The LTE 12 then transmits 86 pilots downlink to the CPE, which pilot are used by the CPE 30 to acquire 88 synchronisation and lock before multi-carrier communication is established 56.

[0049] Of course, whenever the CPE goes off-line, power consumption (and associatec' heating) in the CPE is also reduced. Clearly, in a battery-driven environment, CPE inactivity can enhance battery life.

[0050] It will, of course, be appreciated that the above description has been given by way of example only and that modification in detail may be made within the scope of the present invention. The preferred embodiments of the present invention are applicable to frequency division multiplexing (FDM) techniques and time division multiplexing (TDM) techniques such as (particularly) TDD. For example, the preferred embodiment of the present invention is generally concerned with re-establishment of a multi-carrier communication, although the principle of having the CPE monitor the cross-talk environment (steps 80 to 88 of FIG. 2) can be independently employed with respect to a CPE wanting to establish a communication connection with the LTE.

[0051] The system of FIG. 1 shares many common features with prior art configurations. Consequently, prior art systems may be easily up-graded to accommodate the inventive concepts of the present invention, with such easy migration therefore encouraging deployment of the preferred embodiments to achieve improved operational performance at relatively little expense.

[0052] The term "line termination equipment (LTE)" generally suggest a high level entity, although in the context of the present invention this term should not be considered to be restrictive and should be considered to include a solitary line card that is uniquely assigned to serve associated customer premise equipment (such as a modem or a computer) through a dedicated wireline communication resource. Indeed, it will be appreciated that a line card will generally include some signal processing capability (which could be pooled, although it is usually a dedicated DSP), a line driver, a D/A converter and some form of modulator. Of course, the line card typically further includes an analog-to-digital (A/D) converter and a demodulator in a receive path thereof to enable bi-directional communication.

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Claims

1. A wireline communication system comprising line termination equipment coupled to customer premise equipment through a wireline communication resource supporting a multi-carrier transmission scheme between the LTE and the CPE, the wireline communication system comprising:

   means for indicating activity of the CPE; and

   a controller, responsive to the means for indicating activity, for selecting sub-channel carriers of the multi-carrier transmission scheme on which information is modulated for transmission to the CPE over the wireline resource, wherein the controller is arranged to limit a number of sub-channel carriers utilised by the LTE in response to the means for indicating activity identifying that the CPE is inactive.

2. The wireline communication system of claim 1, wherein the LTE comprises a line driver coupled to a voltage supply and arranged to amplify signals to be applied to the wireline communication resource, the voltage supply being operationally responsive to the controller and wherein the controller is arranged to reduce a voltage applied to power the line driver in response to the means for indicating activity identifying that the CPE is inactive.

3. The wireline communication system of claim 1, wherein the LTE comprises a signal processor operationally responsive to the controller, the controller arranged to at least partially disable operational functionality of the signal processor in response to the means for indicating activity identifying that the CPE is inactive.

4. The wireline communication system of claim 1, further comprising a memory containing at least one pattern having relatively few sub-channel carriers in relation to a number of sub-channel carriers utilised during information transfer in a data path between the LTE and CPE, the LTE further comprising a switch operationally responsive to the controller and configured to couple one of the data path and the memory to the wireline communication resource, the controller further arranged to cause the at least one pattern to be applied to the wireline communication resource in response to the means for indicating activity identifying that the CPE is inactive.

5. The wireline communication system of claim 1, wherein the controller maintains at least one sub-channel carrier in response to the means for indicating activity identifying that the CPE is inactive.

6. The wireline communication system of claim 1, wherein the at least one sub-channel carrier includes a pilot tone.

7. The wireline communication system of claim 4, wherein the at least one pattern is associated with a plurality of sub-channel carriers.

8. The wireline communication system of claim 4, wherein the controller is arranged to sequence an application of a plurality of patterns stored in the memory onto the wireline communication resource.

9. The wireline communication system of claim 8, wherein each of the plurality of patterns contains at least one pilot tone.

10. The wireline communication system of claim 9, wherein sequencing by the controller is random.

11. The wireline communication system of claim 9, wherein sequencing by the controller is delayed to produce a multi-carrier transmission on a limited number of sub-channel carriers on a one-in-N frame basis.

12. The wireline communication system of claim 1, wherein the controller disables the transmission of the multi-carrier transmission scheme in response to the means for indicating activity identifying that the CPE is inactive.

13. The wireline communication system of claim 2, wherein the voltage applied to power the line driver is reduced to substantially zero.

14. The wireline communication system of claim 1, wherein the multi-carrier transmission scheme supports a digital subscriber line (xDSL) communication protocol.

15. The wireline communication system of claim 14, wherein the multi-carrier transmission scheme overlays relatively low frequency voiceband transmissions.

16. The wireline communication system of claim 1, wherein the line termination equipment is a line card.

17. A line card for coupling to customer premise equipment through a wireline communication resource supporting a multi-carrier transmission scheme, the line card comprising:

   means of establishing a presence of CPE activity; and

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a controller, responsive to the means of establishing a presence of CPE activity for selecting sub-channel carriers of the multi-carrier transmission scheme on which information is modulated for transmission to the CPE over the wireline resource, wherein the controller is arranged to limit a number of sub-channel carriers utilised by the LTE in response to the means for indicating activity identifying that the CPE is inactive.

18. The line card of claim 17, further comprising a line driver coupled to a voltage supply and arranged to amplify signals to be applied to the wireline communication resource, the voltage supply operationally responsive to the controller and wherein the controller is arranged to reduce a voltage applied to power the line driver in response to the means for indicating activity identifying that the CPE is inactive.

19. The line card of claim 17, further comprising a signal processor operationally responsive to the controller, the controller arranged to at least partially disable operational functionality of the signal processor in response to the means for indicating activity identifying that the CPE is inactive.

20. The line card of claim 17, further comprising a memory containing at least one pattern having relatively few sub-channel carriers in relation to a number of sub-channel carriers utilised during information transfer in a data path between the line card and CPE, the line card further comprising a switch operationally responsive to the controller and configured to couple one of the data path and the memory to the wireline communication resource, the controller further arranged to cause the at least one pattern to be applied to the wireline communication resource in response to the means for indicating activity identifying that the CPE is inactive.

21. The line card of claim 17, wherein the controller maintains at least one sub-channel carrier in response to the means for indicating activity identifying that the CPE is inactive.

22. The line card of claim 21, wherein the at least one sub-channel carrier includes a pilot tone.

23. The line card of claim 21, wherein the at least one pattern is associated with a plurality of sub-channel carriers.

24. The line card of claim 20, wherein the controller is arranged to sequence an application of a plurality of patterns stored in the memory onto the wireline communication resource.

25. A method of reducing power consumption in line termination equipment coupled to customer premise equipment through a wireline communication resource supporting a multi-carrier transmission between the LTE and the CPE, the method comprising the steps of:

determining activity of the CPE; and

assigning a relatively large number of sub-channel carriers to support information modulation onto the wireline communication resource in a multi-carrier transmission; and

utilising a reduced number of sub-channel carriers for transmissions from the LTE in response to the step of determining activity of the CPE identifying that the CPE is inactive.

26. The method of reducing power consumption according to claim 25, wherein the LTE comprises a line driver, coupled to a voltage supply, arranged to amplifier signals to be applied to the wireline communication resource, the method further comprising the steps of:

reducing a voltage applied to power the line driver in response to the step of determining activity of the CPE identifying that the CPE is inactive.

27. The method of reducing power consumption according to claim 25, wherein the LTE comprises a signal processor and the method comprises the step of at least partially disabling operational functionality of the signal processor in response to the step of determining activity of the CPE identifying that the CPE is inactive.

28. The method of reducing power consumption according to claim 25, the LTE further comprising a memory and a switch, the method further comprising the steps of:

storing in the memory at least one pattern identifying relatively few sub-channel carriers with respect to a number of sub-channel carriers used during information transfer in a data path between the LTE and CPE;

in response to the step of determining activity of the CPE, using the switch selectively to isolate one of the data path and the memory with respect to the wireline communication resource; and

in response to the step of determining activity identifying that the CPE is inactive, isolating the data path and causing the at least one pattern to be applied to the wireline communication re-

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source.

29. The method of reducing power consumption according to claim 25, further comprising the step of maintaining transmission of at least one sub-channel carrier in response to the step of determining activity identifying that the CPE is inactive.

30. The method of reducing power consumption according to claim 29, wherein the at least one sub-channel carrier includes a pilot tone.

31. The method of reducing power consumption according to claim 28, wherein the at least one pattern is associated with a plurality of sub-channel carriers.

32. The method of reducing power consumption according to claim 28, further comprising the steps of:

storing a plurality of patterns in the memory (36); and

sequentially applying the plurality of patterns onto the wireline communication resource.

33. The method of reducing power consumption according to claim 32, wherein each of the plurality of patterns contains at least one pilot tone.

34. The method of reducing power consumption according to claim 32, wherein sequencing is random.

35. The method of reducing power consumption according to claim 32, wherein sequencing is delayed to produce a multi-carrier transmission on a limited number of sub-channel carriers on a one-in-N frame basis.

36. The method of reducing power consumption according to claim 25, further comprising the step of disabling transmissions by the LTE to the CPE in response to the step of determining activity of the CPE identifying that the CPE is inactive.

37. The method of reducing power consumption according to claim 26, further comprising the step of reducing to substantially zero a voltage applied to power the line driver.

38. The method of reducing power consumption according to claim 25, wherein the multi-carrier transmission scheme supports a digital subscriber line (xDSL) communication protocol.

39. The method of reducing power consumption according to claim 38, wherein the multi-carrier transmission scheme overlays relatively low frequency voiceband transmissions.

40. The method of reducing power consumption according to claim 29, further comprising the step of re-establishing multi-carrier transmission between the LTE and the CPE, the step of re-establishing further comprising the steps of:

at the CPE, locking to correct alignment in the transmission scheme using the at least one sub-channel carrier.

41. The method of reducing power consumption according to claim 36, further comprising the step of re-establishing multi-carrier transmission between the LTE and the CPE, the step of re-establishing further comprising the steps of:

at the CPE, monitoring a cross-talk environment to identify an uplink transmission slot to the LTE;

transmitting a wake-up message to the CPE within the uplink transmission slot;

at the LTE, receiving the wake-up message and sending to the CPE at least one pilot tone; and

at the CPE, receiving the at least one pilot tone and acquiring synchronisation and lock therefrom.

42. A method of establishing a multi-carrier transmission between a line carp of an exchange and customer premise equipment (CPE30) through a dedicated wireline communication resource, the exchange coupled to a plurality of CPEs through a plurality of wireline resources in which cross-talk is experienced, the method comprising the steps of:

at the CPE, monitoring a cross-talk environment to identify an uplink transmission slot to the LTE;

transmitting a wake-up message to the CPE within the uplink transmission slot;

at the LTE, receiving the wake-up message and sending to the CPE at least one pilot tone; and

at the CPE, receiving the at least one pilot tone and acquiring synchronisation and lock therefrom.

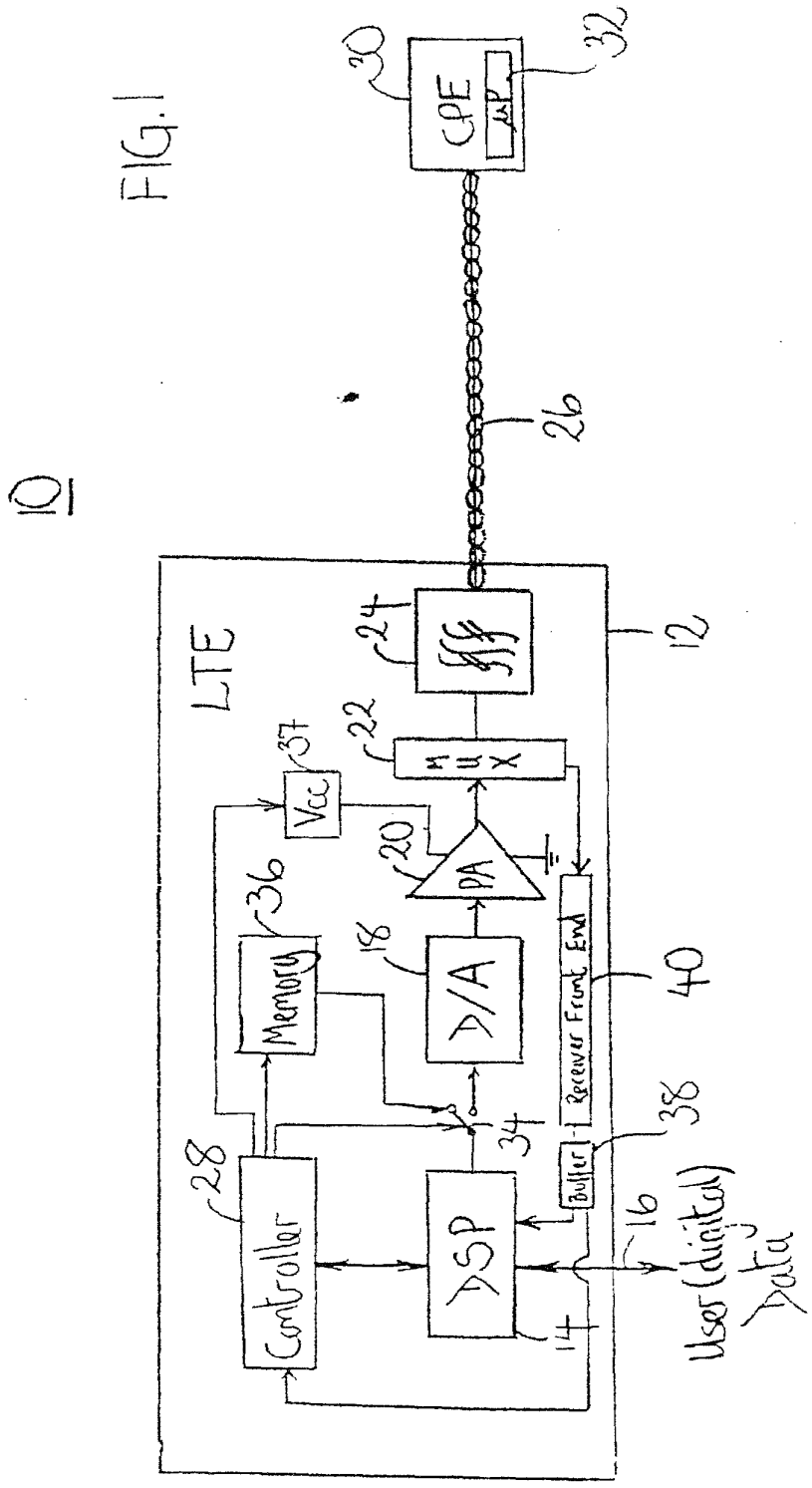
43. A method of establishing a multi-carrier transmission between a line card of an exchange and customer premise equipment (CPE30) according to claim 42, wherein the step of transmitting the wake-up message further comprises the step of:

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ensuring that the transmission occurs within boundaries of the uplink transmission slot.

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FIG. 1



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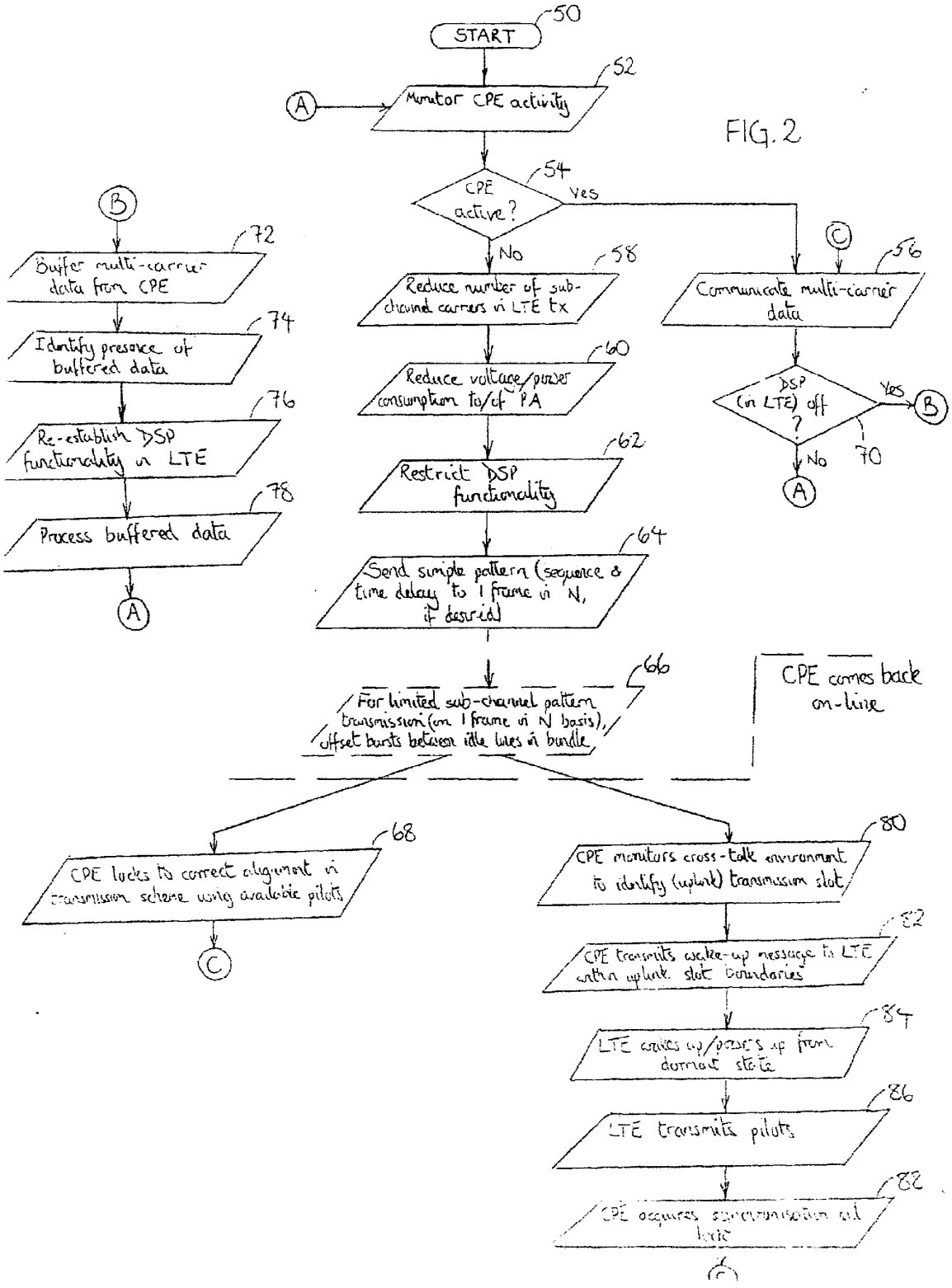


FIG. 2

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(54) Apparatus, method and system having reduced power consumption in a multi-carrier wireline environment

(57) To reduce power consumption and associated heating in a line card of line termination equipment (LTE, 12) employing multiple sub-channel carriers to communicate broadband information to customer premise equipment (CPE, 30) down a wireline communication resource (26), sub-channel carrier transmissions are restricted (58) during periods of CPE inactivity. Power supplies to a power amplifier (30) associated with the line card and wireline resource (26) are reduced, with digital signal processing capabilities of the LTE (12) further restricted (64). When the CPE wishes to re-start communication, the CPE (30) locks (68) to a correct alignment in a transmission scheme using a pilot tone that is transmitted within a simple pattern sent during reduced sub-channel carrier transmissions. Alternatively, should all transmission from the LTE cease during CPE inactivity, then the CPE monitors (80) the transmission environment and sends (82) a wake-up call to the LTE between boundaries of an uplink slot. The LTE (12) re-establishes pilot tone transmissions (86), with synchronisation and lock (88) subsequently achievable by the CPE (30); this is illustrated in FIG. 2.

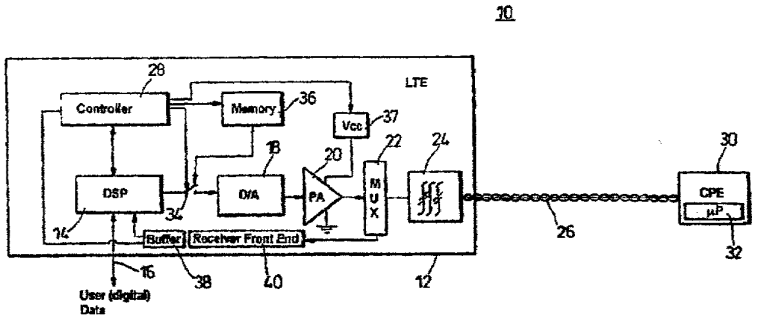


Fig. 1

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EP 1 011 206 A3

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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 30 7866

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	US 5 668 857 A (MCHALE JOHN F) 16 September 1997 (1997-09-16) * column 14, line 61 - column 14, line 47; figures 1,4,9 * * abstract *	1-41	H04B3/00 H04B15/00
A	US 5 832 387 A (BAE HEE-MOON ET AL) 3 November 1998 (1998-11-03) * abstract; figure 5 *	1-41	
A	EP 0 753 948 A (ALCATEL BELL NV) 15 January 1997 (1997-01-15) * abstract; figure 2 * * page 5, line 38 - page 7, line 53 *	1-41	
A	US 5 479 447 A (CIOFFI JOHN M ET AL) 26 December 1995 (1995-12-26) * abstract; figure 9 *	1-41	
A	EP 0 753 947 A (ALCATEL BELL NV) 15 January 1997 (1997-01-15) * abstract; figures 3,4 *	1-41	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7) H04B H04L

~~The present search report has been drawn up for all claims~~

Place of search	Date of completion of the search	Examiner
MUNICH	14 August 2003	Ciccarese, C

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

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European Patent Office

Application Number
EP 99 30 7866

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1-41

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European Patent Office

LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 99 30 7866

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims: 1-41

System, apparatus and method for reducing power consumption in a multicarrier wireline environment.

Common features (steps or means for performing the step) of invention:

1.1 establishing presence of Customer Premise Equipment activity
1.2 selecting sub-channel carriers
1.3 limiting sub-channel carriers for transmission to CPE over wireline IF CPE IS INACTIVE

2. Claims: 42-43

Method of establishing transmission between a line card of an exchange and a Customer Premise Equipment through a dedicated wireline, the exchange coupled to a plurality of CPEs, comprising the steps of:

2.1 monitoring cross-talk environment to identify an uplink transmission slot to the LTE;
2.2 transmitting wake-up message to CPE;
2.3.1 receiving wake-up message at LTE
2.3.2 sending pilot tone to CPE
2.4.1 receiving pilot tone
2.4.2 synchronising

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 99 30 7866

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

14-08-2003

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5668857 A	16-09-1997	AU 2426997 A	22-10-1997
		CA 2250487 A1	09-10-1997
		EP 0890254 A2	13-01-1999
		US 2001043568 A1	22-11-2001
		US 6282273 B1	28-08-2001
		WO 9737458 A2	09-10-1997
		US 6169788 B1	02-01-2001
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		JP 8307385 A	22-11-1996
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		AU 701040 B2	21-01-1999
		AU 5832696 A	23-01-1997
		CA 2180973 A1	12-01-1997
		DE 69528974 D1	09-01-2003
		DE 69528974 T2	28-08-2003
		ES 2185681 T3	01-05-2003
		IL 118676 A	22-09-1999
		US 5812599 A	22-09-1998

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
8241P074PCT		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/US2012/060115	12/10/2012	27/07/2012
Applicant		
ASSIA, INC.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 4 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language,** the international search was carried out on the basis of:
      [X] the international application in the language in which it was filed
      [ ] a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. [ ] This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. [ ] With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. [ ] **Certain claims were found unsearchable** (See Box No. II)

3. [ ] **Unity of invention is lacking** (see Box No III)

4. With regard to the **title,**
   [X] the text is approved as submitted by the applicant
   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**
   [X] the text is approved as submitted by the applicant
   [ ] the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority

6. With regard to the **drawings,**
   a. the figure of the **drawings** to be published with the abstract is Figure No. 8
      [X] as suggested by the applicant
      [ ] as selected by this Authority, because the applicant failed to suggest a figure
      [ ] as selected by this Authority, because this figure better characterizes the invention
   b. [ ] none of the figures is to be published with the abstract

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/060115

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04M11/06 H04B3/46
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B H04M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CA 2 254 807 A1 (AMATI COMM CORP [US]) 30 May 2000 (2000-05-30) abstract; figures 2-4,5B,11 page 6, line 7 - page 9, line 27 page 13, line 1 - line 3 page 14, line 7 - line 31 page 16, line 22 - line 29 page 20, line 29 - line 33 page 21, line 34 - line 36 page 23, line 1 - line 2 page 27, line 8 - line 14 -----	1-40
X	US 6 480 475 B1 (MODLIN CORY S [US] ET AL) 12 November 2002 (2002-11-12) abstract; figures 2A,2B,4 column 3, line 54 - column 8, line 8 column 10, line 54 - column 11, line 67 ----- -/--	1-40

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 April 2013	02/05/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Ohanovici, Z

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Form PCT/ISA/210 (second sheet) (April 2005)

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/060115

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 2003/086362 A1 (HASEGAWA KAZUTOMO [JP] ET AL) 8 May 2003 (2003-05-08) abstract; claims 1-7; figures 1A,2,5 paragraph [0009] - paragraph [0019] paragraph [0033] - paragraph [0035] -----	1,2,32, 40 3-31, 33-39
A	EP 1 011 206 A2 (NORTEL NETWORKS CORP [CA] NORTEL NETWORKS LTD [CA]) 21 June 2000 (2000-06-21) abstract paragraph [0006] paragraph [0020] - paragraph [0025] paragraph [0041] - paragraph [0043] -----	15-17
X A	US 2009/082064 A1 (LI QINGHUA [US] ET AL) 26 March 2009 (2009-03-26) abstract; figures 1,2A,2B,4 paragraph [0019] - paragraph [0021] paragraphs [0027], [0033], [0040] -----	1-3,34, 37 4-33,35, 36,38-40
X A	US 2005/122999 A1 (SCHERZER SHIMON B [US] ET AL) 9 June 2005 (2005-06-09) abstract; figures 1,3,6,8,9,12 paragraph [0009] - paragraph [0015] paragraphs [0045], [0047], [0063] paragraph [0086] - paragraph [0088] -----	1,4-7, 9-21, 28-31, 34,37 2,3,8, 22-27, 32,33, 35,36, 38-40

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2012/060115

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CA 2254807 A1	30-05-2000	CA 2254807 A1	30-05-2000
		DE 69829725 D1	19-05-2005
		DE 69829725 T2	09-02-2006
US 6480475 B1	12-11-2002	JP H11313044 A	09-11-1999
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		WO 2005057944 A2	23-06-2005

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Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
First Named Inventor/Applicant Name:	Kenneth Kerpez
Filer:	Gregory D. Caldwell/Lisa Bennett
Attorney Docket Number:	8241P074

Filed as Large Entity

Filing Fees for U.S. National Stage under 35 USC 371

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
National Stage Fee	1631	1	280	280
Natl Stage Search Fee - Report provided	1642	1	480	480
National Stage Exam - all other cases	1633	1	720	720
Pages:				
Claims:				
Claims in excess of 20	1615	20	80	1600
Independent claims in excess of 3	1614	1	420	420
Miscellaneous-Filing:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**3500**

Electronic Acknowledgement Receipt

EFS ID:	21313455
Application Number:	14417544
International Application Number:	PCT/US2012/060115
Confirmation Number:	8970
Title of Invention:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
First Named Inventor/Applicant Name:	Kenneth Kerpez
Customer Number:	8791
Filer:	Gregory D. Caldwell/Lisa Bennett
Filer Authorized By:	Gregory D. Caldwell
Attorney Docket Number:	8241P074
Receipt Date:	26-JAN-2015
Filing Date:	
Time Stamp:	19:30:12
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$3500
RAM confirmation Number	6407
Deposit Account	022666
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. 1.492 (National application filing, search, and examination fees)

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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal of New Application	8241P074_1390.pdf	44142 9f0c0c388f51a92b20c1f614a0d6585202f3cf60	no	3
Warnings:					
Information:					
2	Documents submitted with 371 Applications	8241P074PCT_PCTPub.pdf	1916158 694cda3e0f2f5165d0cb224a86d9fc5ebf2ac2a2	no	41
Warnings:					
Information:					
3		8241P074_PreAmend.pdf	76704 d945464984dada529ad208a2e50b186356a10fe2	yes	4

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Preliminary Amendment	1	1
	Specification	2	2
	Applicant Arguments/Remarks Made in an Amendment	3	4

Warnings:					
Information:					
4	Application Data Sheet	8241P074_ADS.pdf	1743579 c86ba0fcb04d4470dd6ca50eab8a748a0526efe0	no	5
Warnings:					
Information:					
5		8241P074_IDS_1449.pdf	126263 1cd18d061e9947b44be1755779abdf2ebabc274c	yes	2

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Transmittal Letter	1	1

	Information Disclosure Statement (IDS) Form (SB08)		2	2	
Warnings:					
Information:					
6	Foreign Reference	CA2254807.pdf	5861466 4cf584e3e291a74861cb7143cba1246f6859564a	no	48
Warnings:					
Information:					
7	Foreign Reference	EP1011206.pdf	2057662 e24786f5c63f9a8c0b5b12544b6c1220c3dea3c9	no	20
Warnings:					
Information:					
8	Other Reference-Patent/App/Search documents	8241P074PCT_ISR.pdf	132091 fb80024f61232f8fea7dbe038d497344e34343dd	no	4
Warnings:					
Information:					
9	Fee Worksheet (SB06)	fee-info.pdf	38640 c09ec30c49312c74354145a2a8301f926c6cf48b	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	11996705		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

496068

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

October 21, 2012

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE.

APPLICATION NUMBER: *61/676,862*
FILING DATE: *July 27, 2012*
RELATED PCT APPLICATION NUMBER: *PCT/US12/60115*

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS *US61/676,862*

Certified by

David J. Kappos

Under Secretary of Commerce
for Intellectual Property
and Director of the United States
Patent and Trademark Office

TITLE

MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER

Inventors

KENNETH KERPEZ
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(303) 740-1980

CERTIFICATE OF EFS Web

I hereby certify that this correspondence is being submitted electronically via EFS Web on the date shown below to the United States Patent and Trademark Office.

Date of Deposit: July 27, 2012
Name of Person Mailing Correspondence: Debbie Casias
/Debbie Casias/ / July 27, 2012/
Signature Date

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Background

[0001] TDD (Time Division Duplex) systems transmit downstream (network to subscriber) data and upstream (subscriber to network) data in distinct time-slots of the same physical channel. Additionally, there is often a small guard-time between distinct time slots to ensure that data does not overlap. One new TDD system is called 'G.fast,' which is currently in the process of standardization by the ITU-T. G.fast is to transmit over relatively short (< 250 m) copper telephone loops and premises wiring.

[0002] Error! Reference source not found. is a diagram of slots on a horizontal time axis for a classic TDD system, alternately transmitting downstream from the network toward the subscriber and upstream from the subscriber toward the network in different Down and Up TDD time slots. There is a downstream slot, Down, and an upstream slot, Up. This is followed by another downstream slot and then an upstream slot. The cycle is repeated along the horizontal time axis. The "asymmetry ratio" is the ratio of time in the Down slot compared to the Up slot. There is usually also a small guard-time (not shown) between each time-slot. Each repetition of the two slots may be referred to as a frame. Alternatively, a frame may have multiple repetitions of the two slots.

[0003] To reduce power consumption and interference on nearby lines, a power saving TDD system is shown in Figure 2. Figure 2 is a diagram of slots on a horizontal axis for the power saving TDD system. Broadband data communication systems are often idle or highly underutilized, and current practice is generally to send idle codes at full power when there is no data traffic. A power saving alternative is to suppress transmission when there is no user data traffic. As shown in **Error! Reference source not found.**, there are two frames, TDD frame$_1$, TDD frame $_2$, each having a downstream slot, Down, followed by an upstream slot, Up. In addition, a portion of the downstream slot is an off portion, D_off, during which transmission is suppressed. During the off portion, neither data nor idle bits are sent. Similarly the upstream slot, Up, has a off portion U_off, during which neither data, nor idle bits are sent. Sending no power, during off-times "D_off" and "U_off" can provide significant power savings.

[0004] In many TDD systems, there are multiple physical channels. If these channels are close together in location or in frequency, then they may interfere with each other. Figure 3 is a diagram of a TDD system with two channels. In this example, each channel uses a twisted pair of copper cables and both channels are in the same binder. As illustrated in **Error! Reference source not found.**, systems transmitting in multi-pair copper cables can generate crosstalk into each other, Near-End Crosstalk (NEXT) and Far-End Crosstalk (FEXT) are generated by each channel and directed at least in part into the nearby channel.

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[0005] Each channel is connected between a network-end Transmission Unit-Office (TU-O) and a subscriber-end Transmission Unit-Remote (TU-R) transceiver. While each channel is shown as connected a different TU-O its own TU-R, a single TU-O can connect to a single TU-R using both of the two channels. This allows more date to be sent to the one TU-R. A single TU-O may also connect to multiple TU-Rs.

[0006] NEXT can be very powerful and debilitate high speed transmissions. ADSL (Assymetric Digital Subscriber Line) and VDSL (Very high bit rate Digital Subscriber Line) use Frequency-Division Multiplexing (FDM) to avoid self-NEXT. Self-NEXT is the crosstalk that is created into neighboring channels as shown in Figure 3.

DETAILED DESCRIPTION

[0007] Embodiments of the invention may provide a management system for systems that transmit over wires using Time-Division Duplex (TDD). The management system receives input data about service levels, traffic, power and other requirements. It then determines an assignment of TDD time-slots, off times, and asymmetry; for optimal performance, minimal traffic delays, and minimal power usage. The TDD frames are flexible and need not follow a fixed pattern.

[0008] One way to avoid self-NEXT is to synchronize the transmissions on the two lines so that one line does not transmit downstream while another line transmits upstream. This is particularly important with TDD systems that have channels that use the same multi-pair cable binder.

[0009] Error! Reference source not found. is a diagram showing TDD frames on two different channels which are close enough to cause NEXT in the other line. The frames are shown as aligned across a horizontal time axis. Each frame for each channel has a downstream slot, Down, and an upstream slot, Up. Even though the TDD frames are aligned the slots are not. $Line_1$, the upper line is transmitting predominately in the upstream direction while $line_2$ is transmitting predominately in the downstream direction. The downstream and upstream mis-alignment cause NEXT in the nearby line.

[0010] One way of avoiding NEXT is to align all the TDD frames, the downstream and upstream time-slots, and the off times, as shown for example in Figure 5. As in Figure 4, the frame structure for two nearby channels are shown aligned on a horizontal time axis. Both the upper line, $line_1$ and the lower line, $line_2$, have downstream and upstream slots, which are aligned with respect to time. As a result, the two channels will be carrying downstream data at the same time and upstream data at the same time.

[0011] In addition, the two frames also have off portions, D_off, U_off, in each slot. Part of each upstream and each downstream slot is shown as being off to save power. The off portions are also aligned.

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[0012] Figure 6 shows two channels an upper, $line_1$, and a lower, $line_2$, aligned on horizontal time axis. The downstream and upstream portions of these two channels are aligned as in Figure 5. However, the off portions, D_off, U_off are not aligned. In order to eliminate NEXT, the off portions do not need to be aligned. When a channel is off, then it is not generating any interference. Each of these off periods do not need to be aligned for all lines in all TDD groups of a multiple channel binder. Embodiments of the invention help to control the off periods and determining how to adapt the off periods for each channel.

[0013] A more flexible way of avoiding NEXT is to enforce sufficient alignment to avoid transmitting upstream and downstream at the same time on any line. This has the advantage that one line can transmit more data than other lines if it has high demand, while the other lines can be quiet and save power. Further, the frame times can be varied. This, however, has the disadvantage that it requires a high level of control and coordination.

[0014] Several network-end transmission units (TU-O) are often in a Digital Subscriber Line Access Multiplexer (DSLAM) or access node. Referring to **Error! Reference source not found.**, a central office (CO) or exchange is coupled through a feeder to one or more crossboxes, although only one is shown. The crossbox is coupled through a distribution line to one or more drop wire interfaces, although only one is shown. The drop wire interface is coupled though one or more drops or drop wires to one or more TU-Rs, although only one is shown. Depending on the system implementation, the crossbox may be replaced with or in the form of, for example, a feeder distribution interface (FDI), a serving area interface (SAI), a junction wire interface (JWI), or a sub-loop distribution frame (SDF). The drop wire interface may be replaced with or in the form of a distribution terminal or a terminal deployment point (DP).

[0015] The access node or DSLAM (not shown) can be located in the distribution terminal or it can be located somewhere else in the distribution plant, and usually it is fed with fiber from the Central Office (CO) or exchange. Downstream of the access node, toward the TU-Rs, crosstalk may be only between lines from a single access node, or there may be crosstalk between lines from multiple access nodes. A set of lines using TDD that all originate at the same access node will be referred to herein as TDD group.

[0016] Embodiments of the invention may be embodied by a TDD management system that coordinates the TDD slot times and the off times of different channels to maximize the transmission of user data traffic while minimizing power. On and off times may be pre-selected to ensure there is no possibility of creating NEXT between lines in a TDD group, or between lines in different TDD groups that have crosstalk coupling into each other. The on and off times may also be chosen to maximize traffic throughput to meet user demands, and can also minimize power consumption by being off when possible.

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[0017] The TDD management system receives input on the traffic levels, traffic types, and traffic patterns that need to be provided on the lines under its control. This input may include one or more of the following:

[0018] Static (time-invariant) data about service subscription levels and their traffic requirements;

[0019] Service layer information from a policy manager which provides high-level estimates of data rate requirements based on service requests;

[0020] Data on the behavior of different traffic types, different users, e.g., burstiness;

[0021] Time-series data from long-term traffic monitoring which is analyzed to determine the traffic demands as a function of time-of-day or time-of-week;

[0022] Instantaneous feedback based on current traffic demands or queue lengths (Queue lengths or traffic requests can be sent from the customer end up to the network-end for input to the TDD management system).

[0023] The traffic can further be classified according to priority level, service type, QoS (Quality of Service), tagging, stream type, protocol type, etc., and this classification information can be input to a TDD scheduling algorithms.

[0024] The TDD management system uses this input to calculate TDD slot times and off times. The slot times are arranged in such a way as to avoid or reduce NEXT when possible, for example as shown in **Error! Reference source not found.**. Ideally, no two lines that have crosstalk coupling into each other can transmit upstream and downstream at the same time. The slot times and off times may also be calculated to satisfy the traffic requested by subscribers, and can further minimize power usage by maximizing off times.

[0025] Figure 8 is a process flow diagram of an example algorithm for computing TDD time slots and off times as described above. At 800, the bandwidth requirements or requests of the users are received, collected, calculated or measured. The information may be based on the input received by the TDD management system as described above. This information may include any number of different factors including the type of traffic (for example fixed, variable), and the amount of bandwidth requested (for example in Bytes or microseconds).

[0026] At 810, an aggregation function (maximum, average, etc.) of the user bandwidth requests for downstream and upstream is calculated for different types of traffic. For example, the function could be the maximum of all user's downstream fixed bandwidth requests. Further examples are provided in the next section.

[0027] At 820, the next downstream, upstream and off-time time-slot periods are calculated based on the calculated aggregation function. For example, the next

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downstream time-slot duration could be equal to the sum of the maximum downstream requests for all types of traffic. In such a case, for instance it is guaranteed that no user's bandwidth request would exceed the time slot duration allocated for that type of traffic. Further examples are provided below.

[0028] At 830, each user's downstream, upstream and off-time time slot periods are assigned and then, if need be, they are adjusted. If the conditions of previous operations are properly satisfied, then each user should be able to receive its requested bandwidth, given limitations or requirements of its traffic type. It is also possible that, for example, the assignments could provide excess bandwidth for certain users. In such cases, adjustments may be made to utilize this excess capacity, for example by assigning variable bit rate traffic to excess fixed bandwidth time slots, or by assigning off time for power savings. Further examples are provided below.

[0029] The following provides an example of the process above, for assigning bandwidth at a single access node with mixtures of delay-sensitive fixed bandwidth assignments (e.g., video, voice) and delay-insensitive real-time bandwidth assignments (e.g., data). This example assumes bandwidth requests were converted into time-slot requests in microseconds. If user i has a data rate of Z Mbps, and is requesting B bits of traffic, the request equals B/Z microseconds.

1) The receive collect measure or calculate operation at 800 may be performed as receiving bandwidth request data input for each user. This data may include any of the following:

a) Fixed upstream bandwidth requests, e.g. UXi microseconds dedicated for each user i;

b) Real-time upstream bandwidth requests, e.g. UYi microseconds in the next time-slot for user i;

c) Fixed downstream bandwidth requests, e.g. DXi microseconds dedicated for each user i; and

d) Real-time downstream bandwidth requests, e.g. DYi microseconds in the next time-slot for user i.

2) The calculation of the aggregated function at 810 may be perfomed in several steps. First, the maximum requested bandwidth of each type in the next time slot is calculated. These can be defined as follows:

a) Maximum fixed upstream bandwidth request e.g. MaxUX = max over i (UXi);

b) Maximum real-time upstream bandwidth request e.g. MaxUY = max over i (UYi);

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c) Maximum fixed downstream bandwidth request e.g. MaxDX = max over i (DXi); and

d) Maximum real-time downstream bandwidth request e.g. MaxDY = max over i (DYi)

3) The time duration of the next time slot may be named TD.

[0030] The time slot durations can be determined at 820 using different criteria depending on the particular subscriber and system architecture circumstances. Some examples are provided below.

[0031] 4) If TD >= MaxUX + MaxUY + MaxDX + MaxDY, then the next upstream time-slot duration is MaxUX + MaxUY, the next downstream time slot duration is MaxDX + MaxDY, and the off-time in the next TDD frame is TD – (MaxUX + MaxUY + MaxDX + MaxDY).

[0032] 5) Otherwise, if MaxUX + MaxUY + MaxDX + MaxDY > TD > MaxUX + MaxDX, then the fixed bandwidth requests are completely satisfied and the real-time bandwidth requests are partially satisfied. One way of doing this is to divide the real-time bandwidth proportional to the maximum requested real-time bandwidth so that the next upstream time-slot duration is MaxUX + (TD – MaxUX - MaxDX)*(MaxUY/(MaxUY + MaxDY), the next downstream time slot duration is MaxDX + (TD – MaxUX - MaxDX)*(MaxDY/(MaxUY + Max DY), and there is no off time in the next time-slot.

[0033] 6) Otherwise, if TD = MaxUX + MaxDX, then the next upstream time-slot duration is MaxUX and the next downstream time-slot duration is MaxDX.

[0034] 7) Otherwise, if MaxUX + MaxDX > TD, then the fixed bandwidth requests are partially satisfied and the real-time bandwidth requests are not satisfied at all. One way of doing this is to divide the fixed bandwidth proportional to the maximum requested fixed bandwidth so that the next upstream time-slot duration is TD*(MaxUX/(MaxUX + MaxDX)), the next downstream time slot duration is TD*(MaxDX/(MaxUX + MaxDX)), and there is no off time in the next time-slot.

[0035] 8) Having calculated the functions and the time-slot durations, the operations at 830 are performed, assign and adjust each user's downstream, upstream and off-time time slot period.

[0036] There are many variations to the example process described above, depending on the particular application and system architecture, for example the bandwidth may be divided proportional to average upstream and downstream requests instead of maximum, or the bandwidth may simply be split in half, or the bandwidth may be divided along a sliding window that accounts for bandwidth requests in multiple time-slots, or the bandwidth may be assigned according to a fairness criteria, or the bandwidth may be assigned according to subscription level, etc.

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[0037] In the example of using the maximum requested bandwidth as described above, the time slot dedicated to one or more users could exceed the required bandwidth requested by those users. In some cases, the required bandwidth for a user could be significantly less than the assigned time slot. For example, MaxUX+MaxUY could be much larger than the UXi+UYi or MaxDX+MaxDY could be much larger than DXi+DYi for a specific user i. In such cases, the adjustment stated as step 7 above can be utilized.

[0038] As one example, the extra bandwidth may be utilized for either saving power or improving latency. The TDD management, as an example may extend the off period for those users, to reduce their power consumption. Alternatively, the TDD management system could accommodate the available extra bandwidth to be used for variable upstream or downstream traffic for those users to allow newly arriving traffic to be transmitted immediately. Conversely, when using the average requested bandwidth in the above algorithm, some user requests might not get satisfied. For example, the fixed bandwidth requests could be partially satisfied. In such cases, steps 5-7 of the above process, could be modified, where instead of Max; the Average function is used.

[0039] After the time-slot durations are calculated, the start and end times of each time-slot in the next TDD frame are calculated. Figure 9 is a process flow diagram for computing the start and end times of each time-slot in a next or subsequent TDD frame**Error! Reference source not found.**.

[0040] At 900, the next downstream (DS) time-slot, the next upstream (US) time-slot, and the next off-time locations are assigned to arbitrary locations in the next TDD frame.

[0041] At 910, it is checked whether the downstream time slot is overlapping with another upstream time slot, or vice versa, whether the upstream time slot is overlapping with another downstream time slot. If there is no overlap, then the allocations in step 900 are accepted, and no further action is needed.

[0042] If there is an overlap, then at 920, the entire downstream time-slot assignment or the entire upstream time-slot assignment is moved forward or backward in time, by a pre-determined amount or by a random amount. The choice of DS or US is based on the whether the overlapping time slot is a DS slot or an US slot from 910.

[0043] After this adjustment, the oerations at 910 are repeated, and if there are no more overlaps, then no further action is required. However, if there still is an overlap, either with the downstream time slot or with the upstream time slot, then the operations at 920 are repeated. If after the adjustments the non-overlapping conditions cannot be met, then the DS or the US time slot durations are decreased (depending on which one had the overlapping issue), and the initial assignment at 900 is repeated.

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[0044] A more specific example of the operations in the process flow diagram of Figure 9 is provided below. As in Figure 9, this is an example of the above process for computing the start and end times of each time-slot in a next TDD frame.

[0045] In the following example it is assumed that the previous process of **Error! Reference source not found.** has already been performed, and therefore the next downstream time-slot DS duration, the next upstream time-slot US duration, and the next off-time OS duration, have already been determined.

[0046] 1) As an example of the operations at 900, assign the next downstream time-slot, the next upstream time-slot, and the next off-time(s) to arbitrary locations in the next TDD frame. For example, the next TDD frame may begin with the downstream time-slot, then have half of the off time in the next slot, then have the upstream time-slot, and then have half of the off time in the next slot. Alternately, the off time may be contiguous and in the beginning, middle, or end of the TDD frame.

[0047] 2) If the downstream time slot does not overlap with any other upstream time slot of any other TDD system that crosstalks into or from this TDD system, then the process is finished until the next time the slots are adjusted based on new parameters. This is the test at 910.

[0048] 3) Otherwise, move the entire downstream time-slot assignment by x microseconds either forward or backward in time. This corresponds to the operation at 920.

[0049] 4) Repeat step 4, varying x, until the condition of non-overlap in step 3 is achieved in the downstream direction. x may be varied randomly or it may vary in pre-determined steps.

[0050] 5) If the condition of step 3 cannot be achieved, then decrease the downstream time slot duration and repeat steps 1 through 4.

[0051] 6) If the upstream time slot does not overlap with the downstream time slot, nor with any other upstream time slot of any other TDD system that crosstalks with this TDD system, then the process if finished.

[0052] 7) Otherwise, move the entire upstream time-slot assignment by y microseconds either forward or backward in time.

[0053] 8) Repeat step 7, varying y, until the condition of non-overlap in step 6 is achieved in the upstream direction. y may be varied randomly or it may vary in pre-determined steps.

[0054] 9) If the condition of step 7 cannot be achieved, then decrease the upstream time slot duration and repeat steps 6 through 8.

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[0055] 10) Assign the off-time. For example, the off time may be contiguous and in the beginning, middle, or end of the TDD frame; or it may be split into two times before or after the upstream and downstream time slots such that it fits in the TDD frame.

[0056] The calculation of TDD slot times and off times may also be performed in various other ways, by a direct calculation that maximizes the projection of user demands on the achievable space, by iteratively adjusting the slot boundaries from frame-to-frame, via heuristics, by selecting from among a stored set of timings, a generalized algorithm that uses several of these approaches, etc. In addition, the frame length can be variable, the time slot start and end times need not be periodic, and they need not be aligned. Frame lengths can be varied to meet delay requirements (e.g., short frame when low-delay applications are used.) All of this may be determined by the TDD management system.

[0057] The TDD management system may be made to be capable of converting high-level requests for traffic and power consumption (e.g. as an outline of traffic and power requirements, or a general indication of the trade-off between traffic delay and power usage) into low-level TDD scheduling.

[0058] Part of each frame time may be reserved on a long-term basis for Down and Up time-slots, with an additional part dynamically varied as traffic comes and goes. The TDD management system then optimizes time-slot assignment using both long-term and short-term variations.

[0059] TDD Up and Down time-slots and the asymmetry ratio can be varied to minimize average traffic delays and maximize average throughput across all lines in the TDD group. Or, the performance of some set of premium services can be maximized. Or, the worst-case performance can be maximized. Or, a more general fairness criteria, such as "alpha-fairness" can be applied to maximize any arbitrarily weighted combination of different user traffic demands.

[0060] The TU-Rs are often synchronized to the timing of the TU-O. This timing can be assisted by regularly sending a "synch symbol" downstream that the TU-Rs can lock on to maintain a level of timing synchronization. The TDD management system can determine the times to send synch symbols and the synch symbol durations. When there is very little traffic, the line could be off during an entire Down or Up time-slot, or during an entire TDD frame, or even during multiple TDD frames. Then, the TDD management system can schedule the VTU-O to send enough synch symbols, with enough duration, so that the VTU-R maintains synchronization. These synch symbols may be sent only in some time-slots, in some TDD frames, and even only using some subcarriers. The synch symbols can use a low-level modulation for robustness. This enables an inactive TU-R to maintain TDD frame timing so it can transmit during an upstream time-slot when it wakes up.

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[0061] An alternative wake-up procedure is for a TU-R to listen to the noise on the line, and determine when there is NEXT by reading regularly-occurring high-power noise once every TDD frame. The TU-R transmits start-up signals when it estimates that this NEXT is active, which should be during an upstream time slot.

[0062] There may be a two step process for TU-R wake-up:

1: The TU-R stays approximately synchronized through slow periodic keep alives from the TU-O.

2: When the TU-R wants to start transmitting after some time period of upstream and downstream inactivity (and hence synchronization is only approximate):

a) The TU-R sends a short sync request in what it thinks is the middle of the upstream frame period (sending the short message in the middle ensures that the transmission is entirely within the upstream period);

b) The TU-O responds with a transmission that the TU-R can use for recovering synchronization;

c) Upstream transmission proceeds normally.

[0063] Transmission systems adapt to the noise environment on the line, and the described techniques may ensure that adaptation is performed while crosstalking lines are actively creating crosstalk and not during quiet times.

[0064] Vectoring technology, as exemplified in the ITU-T G.993.5 standard, cancels FEXT. In order for vectoring to be effective, if it is applied to a TDD group, NEXT should be kept low. So the avoidance of NEXT also allows vectoring to function better. The described techniques can coordinate the TDD timing with the vectoring engine. The system can reassign vectoring resources in real-time when the TDD asymmetry ratio changes.

[0065] The TDD management system can also schedule when to send retransmission frames, at times that don't cause NEXT problems in a part of what would have been an off time, or with multiple retransmissions at other frame times. Retransmissions can be incremental, with all or part of the original data retransmitted, or by sending additional parity bits. Multiple retransmissions can be scheduled, and a block of original data can be retransmitted in one or more blocks of data or parity. Acknowledgements (ACKs) or negative acknowledgements (NACKs) related to retransmission can also be scheduled by the invention.

[0066] The avoidance of NEXT between lines in a single TDD group is relatively straight-forward. The TDD coordination simply needs to enforce this among the lines from a single access node, which all originate in the same location and so are easy to jointly control.

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[0067] Figure 10 is a diagram of a more complex system implementation in which there are multiple TDD groups that have crosstalk coupling between some of their lines, for example between the two TDD groups in a Shared Cable 3 in **Error! Reference source not found.**. In this case the TDD management may span multiple access nodes, either explicitly with a centralized management element, or autonomously by detecting crosstalk.

[0068] Centralized TDD management directly coordinates multiple TDD groups. Centralized TDD management can use explicit timing information and feedback from access nodes, EMS, or other network elements to then centrally optimize all interacting TDD groups.

[0069] Autonomous TDD management can coordinate multiple TDD groups even though it reads data from, and controls, only a single TDD group. This may be done by reading in the time-varying pattern of noise or errors on the lines in the TDD group. Crosstalk from another "alien" TDD system creates a regularly-occurring pattern of noise as it alternately transmits in both directions. This crosstalk can be measured by reading the noise on the lines, or by reading the time-series of error patterns. These can be analyzed on both ends of the line to identify the pattern of the alien TDD groups Up and Down time-slots. For example, errors occurring in one direction once each millisecond indicate that crosstalk is being generated once each millisecond from the alien TDD groups. The TDD management system can then synchronize its own transmissions to this crosstalk.

[0070] TDD management may more generally be split between centralized and autonomous methods, using traffic data and TDD synchronization information from:

a) Explicit use of management data and synchronization data from DSLAMs, EMS, OSS or other network elements;

b) Global synchronization data using Global Positioning Satellite (GPS) data or network timing protocols;

c) Autonomous estimation using monitoring data on crosstalk patterns or by reading time-varying noise or error counts;

d) Explicit estimates of crosstalk couplings between lines can be input, for example vectored lines can provide such data as reported Xlin values.

[0071] The TDD management system may adjusts the following quantities for one or more lines: a) asymmetry ratio, b) Up and Down slot times, and c) off times; with the objective of meeting bit-rate requirements and requests, and optionally minimizing power. These can also be set indirectly through higher-level or lower-level control specifications. These can be controlled by slowly changing them as scheduled or as needed after a traffic threshold is crossed; or they can vary in real time. Dynamic

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Bandwidth Allocation (DBA) can also be used to control these. The TDD management system may interface with, or contain, a Timing Control Entity.

[0072] The TDD management system's capability to detect and adapt to TDD crosstalk can assist in enabling spectral compatibility of TDD systems with FDM (Frequency Division Multiplexed) systems such as VDSL2. This can be done by using automated crosstalk identification, coordinating TDD timings, and using Dynamic Spectrum Management (DSM) to enable the TDD system to be compatible with VDSL2.

[0073] There are a number of optional and additional advantages and features to the described techniques and systems above. These can be understood in the statements below, among others which may be combined in any of a variety of different ways.

[0074] A system for managing multiple TDD lines that determines time slot boundaries. The system provides sufficient coordination to avoid NEXT, by ensuring that two lines with significant crosstalk coupling do not transmit downstream and upstream at the same time. The system further assigns slot-times and the downstream/upstream asymmetry ratio to maximize a measure of throughput. The maximized measure of throughput is one or more of the average across all lines, chosen to best match traffic demands, provide a minimum service level to all lines, ensure user-perceived quality of experience, minimize average or maximum delays, or meet any fairness criteria.

[0075] The TDD management system can further optimize the scheduling of off time-slots to minimize power usage. The TDD management system can further schedule off times during low traffic that suppress transmission for the duration of entire time-slot, TDD-frame, or multiple TDD frames.

[0076] The TDD management system can calculate an optimal set of Up and Down slot times and off times according to an optimization criteria, this criteria can flexibly weight different tradeoffs between different users, tradeoffs between different services, and tradeoffs between performance and power savings.

[0077] The TDD management system adjusts the following quantities for one or more lines: a) asymmetry ratio, b) Up and Down slot times, and c) off times. for one or more lines. The TDD management system controls the TDD time slot boundaries and off times. This can be a fixed assignment, slowly varying based on time-of-day, or varied in real time. One or more control parameters such as any one time point, slot lengths, asymmetry, Up slot time, Down slot time, a single off time, total off time, can be varied while other parameters remain fixed. The TDD management system may employ flexible slot-time boundaries, with variable-length frames, Up time-slot lengths, and Down slot-times.

[0078 The TDD management system receives input on the traffic levels that need to be provided on the lines under its control. This input may include one or more of the following: Static (time-invariant) data about service subscription levels and their traffic

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requirements; Service layer information from a policy manager which provides high-level estimates of data rate requirements based on service requests; Data on the behavior of different traffic types, different users, e.g., burstiness; Time-series data from long-term traffic monitoring which is analyzed to determine the traffic demands as a function of time-of-day or time-of-week; Instantaneous feedback based on current traffic demands or queue lengths; Traffic requests or reports sent from the customer end.

[0079] The TDD management system can be further controlled by external Operations Support Systems (OSS) or by reading and writing Management Information Database (MIB) parameters. A single TDD group can be managed or multiple TDD groups can be managed. The TDD management system may be a centralized controller that controls multiple lines, and/or multiple TDD groups.

[0080] The TDD management system can control synchronization of a TDD group. This synchronization can be assisted by using one or more of the following input data: Explicit use of management data and synchronization data from DSLAMs, EMS, OSS or other network elements; Global synchronization data using Global Positioning Satellite (GPS) data or network timing protocols; Autonomous estimation using monitoring data on crosstalk patterns or by reading time-varying noise or error counts.

[0081] The timing reference can be further used to control the synchronization of multiple TDD groups. The TDD management system can provide information to assist the synchronization of multiple lines and/or multiple TDD groups.

[0082] The TDD management system can determine the times to send synch symbols and the synch symbol durations. The TDD management system can schedule the VTU-O to send synch symbols sufficiently often and with sufficient duration, for the VTU-R(s) to maintain synchronization with the VTU-O. These synch symbols may be sent only in some time-slots, in some TDD frames, and even only using some subcarriers. The synch symbols can use a low-level modulation for robustness. Long synch symbols can be scheduled to be sent from the VTU-O to recover synchronization after long off times.

[0083] An inactive TU-R can listen to the noise on the line, and determines when there is NEXT by reading regularly-occurring high-power noise once every TDD frame. The TU-R then transmits start-up signals when it estimates that this NEXT is active, which should be during an upstream time slot.

[0084] The TDD management system may use multiple, distributed components, each operating autonomously. The autonomous TDD system can further read in crosstalk coupling data. The crosstalk data can be used to determine which TDD groups and which lines to coordinate. A combination of centralized and autonomous TDD management can be supported.

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[0085] The TDD management system can further control FEXT cancellation (vectoring). Vectoring resources can be re-assigned in real-time when the TDD asymmetry ratio changes. The TDD management system can adapt to satisfy varying delay requirements for different lines, subscribers, services, and at different times. The TDD management system can assist compatibility with FDM systems (e.g., G.fast and VDSL2), use crosstalk identification and "fingerprinting" of FDM and TDD crosstalk. The TDD management system can control retransmission, assign retransmission time slots, coordinate Hybrid retransmission that can re-send multiple parts of a block of data and/or multiple parity bits.

[0086] The TDD management system can manage allocation of time-slots for acknowledge messages (ACKs) and/or negative acknowledgement messages (NACKs). The TDD management system can further coordinate TDD groups that have NEXT cancellation or partial NEXT cancellation, thereby allowing some overlap between Down and Up time-slots that have such cancellation.

[0087] In the this description, numerous specific details such as logic implementations, opcodes, means to specify operands, resource partitioning/sharing/duplication implementations, types and interrelationships of system components, and logic partitioning/integration choices are set forth. It will be appreciated, however, by one skilled in the art that the different implementations may be practiced without such specific details. In other instances, control structures, gate level circuits and full software instruction sequences have not been shown in detail in order not to obscure the description.

[0088] References in the specification to "one embodiment," "an embodiment," "an example embodiment," etc., indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to effect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0089] In this description and claims, the terms "coupled" and "connected," along with their derivatives, may be used. It should be understood that these terms are not intended as synonyms for each other. "Coupled" is used to indicate that two or more elements, which may or may not be in direct physical or electrical contact with each other, co-operate or interact with each other. "Connected" is used to indicate the establishment of communication between two or more elements that are coupled with each other. The operations of the flow and signaling diagrams are described with reference to exemplary embodiments. However, it should be understood that the operations of the flow diagrams can be performed by variations other than those

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discussed with reference to these other diagrams, and the variations discussed with reference to these other diagrams can perform operations different than those discussed with reference to the flow diagrams.

[0090] As described herein, instructions may refer to specific configurations of hardware such as application specific integrated circuits (ASICs) configured to perform certain operations or having a predetermined functionality or software instructions stored in memory embodied in a non-transitory computer readable medium. Thus, the techniques shown in the figures can be implemented using code and data stored and executed on one or more electronic devices (e.g., a UE, an eNB, etc.). Such electronic devices store and communicate (internally and/or with other electronic devices over a network) code and data using machine-readable media, such as non-transitory machine-readable storage media (e.g., magnetic disks; optical disks; random access memory; read only memory; flash memory devices; phase-change memory) and transitory machine-readable communication media (e.g., electrical, optical, acoustical or other form of propagated signals – such as carrier waves, infrared signals, digital signals, etc.).

[0091] In addition, such electronic devices typically include a set of one or more processors coupled to one or more other components, such as one or more storage devices (non-transitory machine-readable storage media), user input/output devices (e.g., a keyboard, a touchscreen, and/or a display), and network connections. The coupling of the set of processors and other components is typically through one or more busses and bridges (also termed as bus controllers). Thus, the storage device of a given electronic device typically stores code and/or data for execution on the set of one or more processors of that electronic device. Of course, one or more parts of an embodiment of the invention may be implemented using different combinations of software, firmware, and/or hardware

[0092] While the flow diagrams in the figures show a particular order of operations performed by certain embodiments of the invention, it should be understood that such order is exemplary (e.g., alternative embodiments may perform the operations in a different order,

[0093] While the invention has been described in terms of several embodiments, those skilled in the art will recognize that the invention is not limited to the embodiments described, can be practiced with modification and alteration. The description is thus to be regarded as illustrative instead of limiting

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CLAIMS

1. A method for managing multiple physical channels in a data communications system that are subject to cross talk, the method comprising scheduling time slot allocations for the physical channels so that upstream transmissions do not occur at the same time as downstream transmissions.

2. A machine-readable medium having instructions that when operated on by the machine cause the machine to schedule time slot allocations for a physical channels of a data communication system so that upstream transmissions do not occur at the same time as downstream transmissions.

3. A time slot management system to manage multiple physical channels in a data communications system that are subject to cross talk, the system having a process for determining time slot allocations for the physical channels so that upstream transmissions do not occur at the same time as downstream transmissions and a communications interface to make assignments to transmitters of the physical channels.

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Petitioners' Exhibit 1002
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Figures



Figure 1. Classic TDD System.

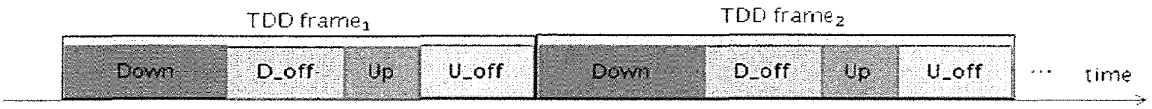


Figure 2. Power-Saving TDD System.

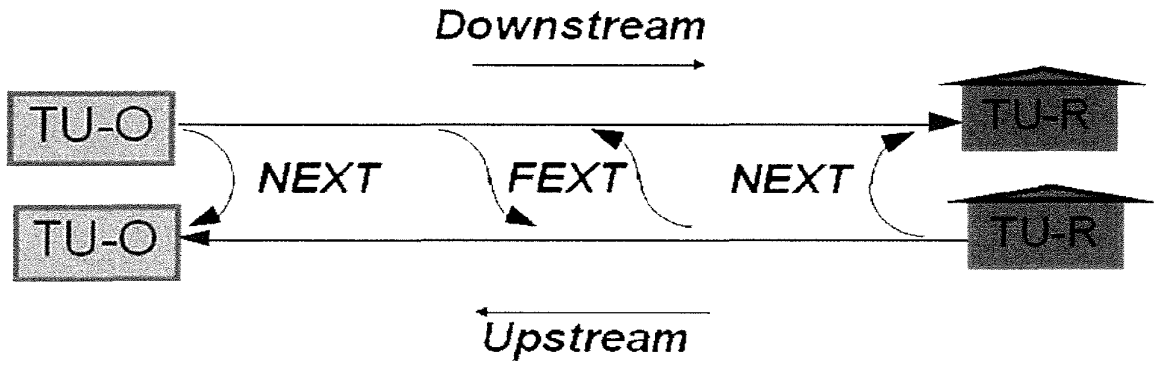


Figure 3. Crosstalk.

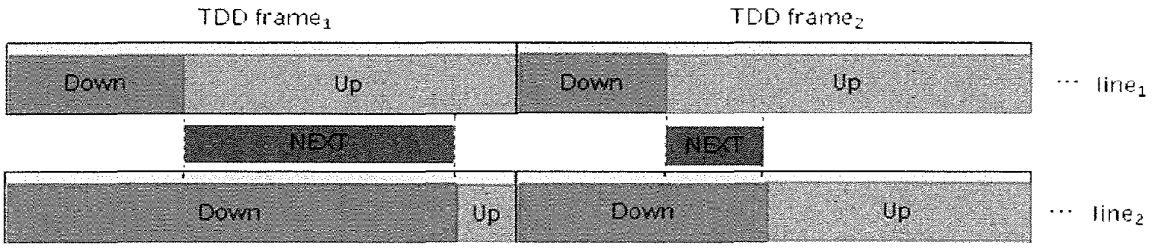


Figure 4. Mis-aligned TDD experiences NEXT.

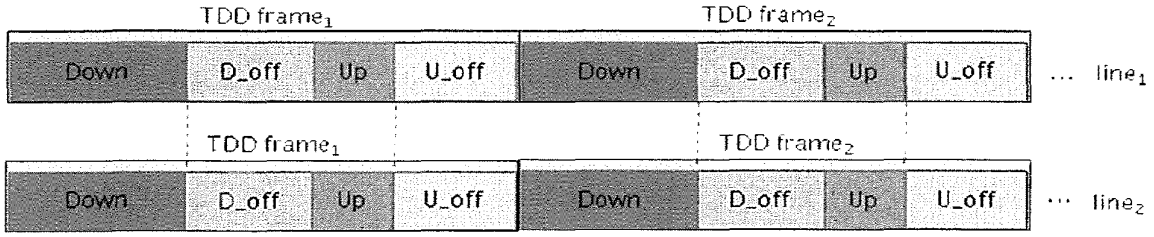


Figure 5. Aligned TDD frames, downstream and upstream time-slots, and off times.

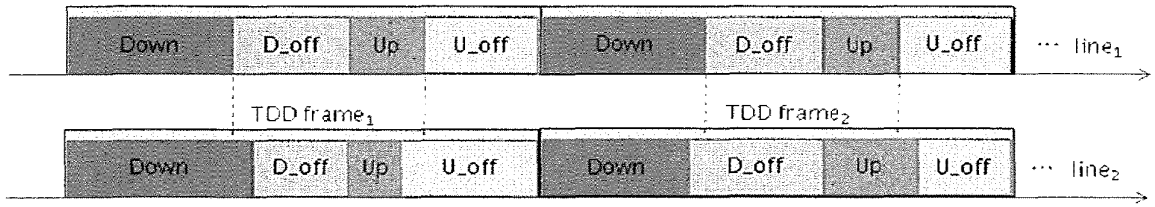


Figure 6. Sufficient alignment to avoid NEXT.

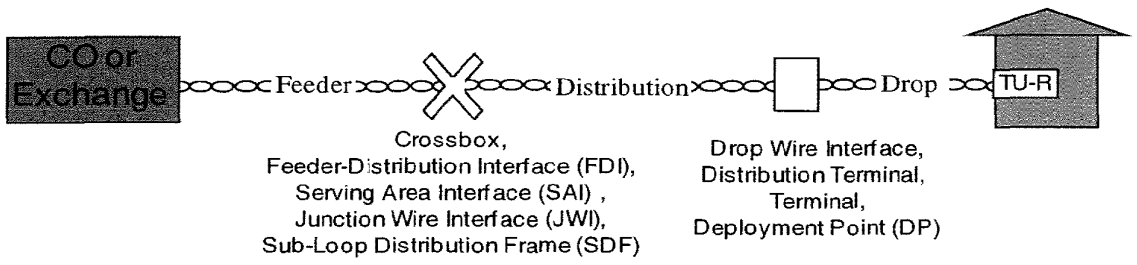


Figure 7. Telephone Loop Plant.

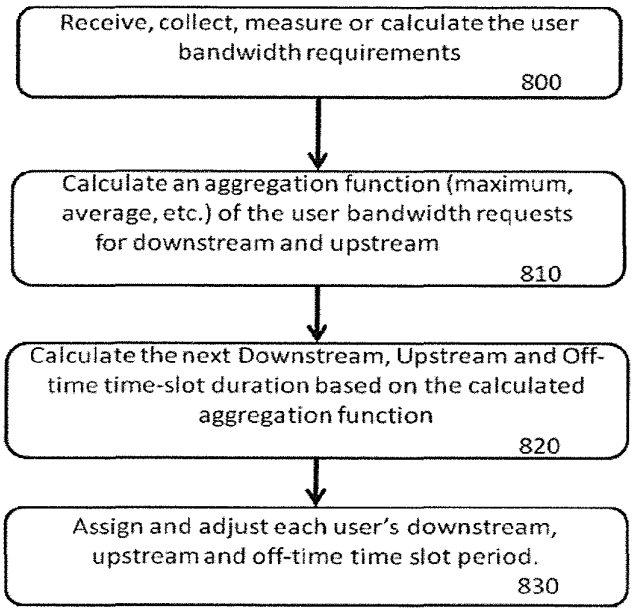


Figure 8

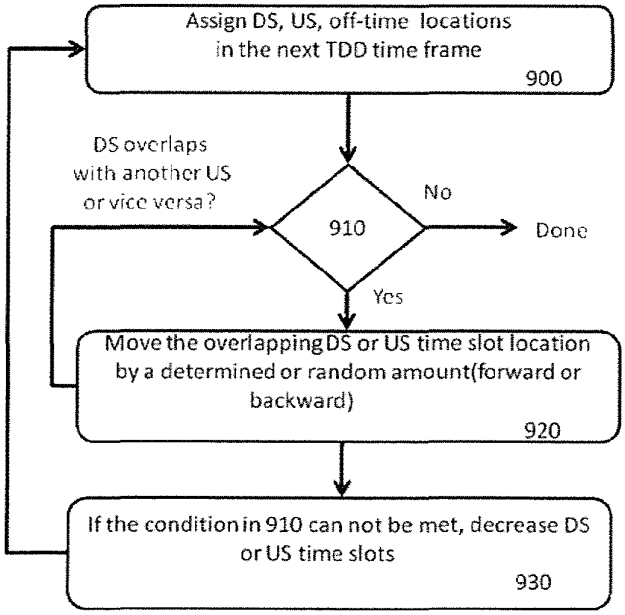


Figure 9

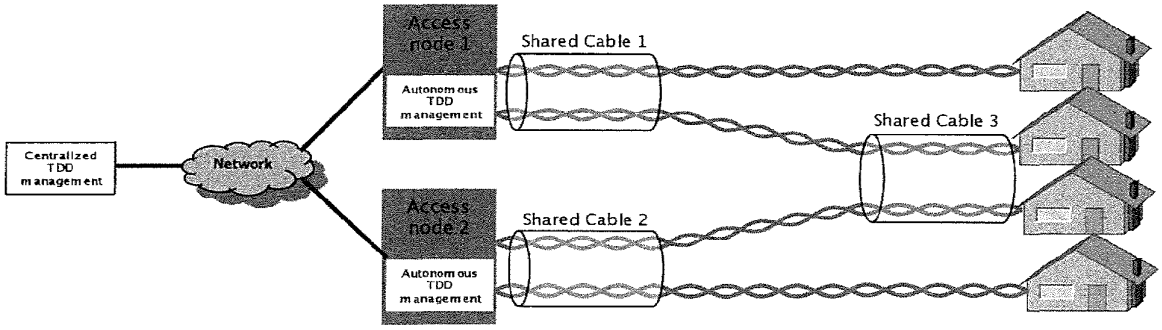


Figure 10. TDD points of interaction and management.

PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

Express Mail Label No.

INVENTOR(S)

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☒ *Additional Inventors are being named on the 1 separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max)

Management System and Methods of Managing Time-Division Duplex (TDD) Transmission over Copper

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

☒ Customer Number 08791

OR

☐ Firm *or* Individual Name	Blakely, Sokoloff, Taylor & Zafman LLP				
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Address					
City	Sunnyvale	State	California	ZIP	94085-4040
Country		Telephone	(303) 740-1980	Fax	(303) 740-6962

ENCLOSED APPLICATION PARTS *(check all that apply)*

☒ Application Data Sheet. See 37 CFR 1.76

☒ Specification *Number of Pages* 17

☒ Drawing(s) *Number of Sheets* 4

☐ CD(s), Number _____

☐ Other (specify) _____

Fees Due: Filing fee of $250 ($125 for small entity). If the specification and drawings exceed 100 sheets of paper, an additional size fee is also due, which is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

METHOD OF PAYMENT OF THE FILING FEE AND APPLICATION SIZE FEE FOR THIS PROVISIONAL APPLICATION FOR PATENT

☐ Applicant claims small entity status. See 37 CFR 1.27.

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$250.00

TOTAL FEE AMOUNT ($)

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No

☐ Yes, the name of the U.S. Government agency and the Government contract number are:

_____

Respectfully submitted,

SIGNATURE /Gordon R. Lindeen III/ Date 7/27/2012

TYPED or PRINTED NAME Gordon R. Lindeen III REGISTRATION NO. *(if appropriate)* 33192

TELEPHONE (303) 740-1980 Docket Number: 8241P074

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

Based on PTO/SB/16 (10-07) as modified by Blakely, Sokoloff, Taylor & Zafman (wlr) 10/04/2007.
SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450

PROVISIONAL APPLICATION COVER SHEET

Additional Page

Docket Number	8241P074

INVENTOR(S)/APPLICANT(S)		
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Ardavan Maleki	Tehrani	Menlo Park, CA US

Number 1 of 1

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Electronic Acknowledgement Receipt

EFS ID:	13364889
Application Number:	61676862
International Application Number:	
Confirmation Number:	3908
Title of Invention:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
First Named Inventor/Applicant Name:	KENNETH KERPEZ
Customer Number:	8791
Filer:	Gordon R. Lindeen/Debbie Casias
Filer Authorized By:	Gordon R. Lindeen
Attorney Docket Number:	8241P074Z
Receipt Date:	27-JUL-2012
Filing Date:	
Time Stamp:	20:54:05
Application Type:	Provisional

Payment information:

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Payment Type	Deposit Account
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RAM confirmation Number	8800
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1		8241P074SPEC.pdf	94943 702acee49c322bdb8f5363b61ccdeaea3476278f	yes	17

Multipart Description/PDF files in .zip description		
Document Description	**Start**	**End**
Specification	1	16
Claims	17	17

Warnings:					
Information:					
2	Drawings-only black and white line drawings	8241P074FIGS.pdf	485289 f6182faae7f48ed6c18a86f3cc3005640ca34366	no	4
Warnings:					
Information:					
3	Provisional Cover Sheet (SB16)	8241P074Provcover.pdf	256035 31d2fe715dc160c53c1eda2b9416c29e9a981303	no	2
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International application number:		**PCT/US2012/060115**
International filing date:		**12 October 2012 (12.10.2012)**
Document type:		**Certified copy of priority document**
Document details:	Country/Office:	**US**
	Number:	**61/676,862**
	Filing date:	**27 July 2012 (27.07.2012)**
Date of receipt at the International Bureau:		**22 October 2012 (22.10.2012)**

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a),(b) or (b-*bis*)

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PCT REQUEST

Original (for **SUBMISSION**)

0	**For receiving Office use only**	
0-1	International Application No.	PCT/US12/60115
0-2	International Filing Date	12 OCT 2012 (12.10.12)
0-3	Name of receiving Office and "PCT International Application"	PCT INTERNATIONAL APPLICATION RO/US

0-4	**Form PCT/RO/101 PCT Request**	
0-4-1	Prepared Using	PCT-SAFE [EASY/EFS-Web mode] Version 3.51.056.232 MT/FOP 20121001/0.20.5.19
0-5	**Petition** The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	**Receiving Office (specified by the applicant)**	United States Patent and Trademark Office (USPTO) (RO/US)
0-7	**Applicant's or agent's file reference**	8241P074PCT
I	**Title of Invention**	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
II	**Applicant**	
II-1	This person is	Applicant only
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II-7	State of residence	US
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III-2-7	State of residence	US
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III-3-7	State of residence	US
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III-4-6	State of nationality	US
III-4-7	State of residence	US

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	The person identified below is hereby/ has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	Agent
IV-1-1	Name (LAST, First)	VINCENT, Lester J.
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IV-1-3	Telephone No.	408-720-8300
IV-1-4	Facsimile No.	408-720-8383
IV-1-5	e-mail	mail@bstz.com
IV-1-5(a)	E-mail authorization The receiving Office, the International Searching Authority, the International Bureau and the International Preliminary Examining Authority are authorized to use this e-mail address, if the Office or Authority so wishes, to send notifications issued in respect of this international application:	as advance copies followed by paper notifications
IV-1-6	Agent's registration No.	31,460
IV-2	**Additional agent(s)**	additional agent(s) with same address as first named agent
IV-2-1	Name(s)	LINDEEN, Gordon(33,192); MALLIE, Michael J.(36,591); NICHOLSON, David F.(62,888)
V	**DESIGNATIONS**	
V-1	**The filing of this request constitutes under Rule 4.9(a), the designation of all Contracting States bound by the PCT on the international filing date, for the grant of every kind of protection available and, where applicable, for the grant of both regional and national patents.**	
VI-1	**Priority claim of earlier national application**	
VI-1-1	Filing date	27 July 2012 (27.07.2012)
VI-1-2	Number	61/676,862
VI-1-3	Country	US
VI-2	**Priority document request**	
	The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s):	VI-1

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Original (for **SUBMISSION**)

VI-3	**Incorporation by reference :** where an element of the international application referred to in Article 11(1)(iii)(d) or (e) or a part of the description, claims or drawings referred to in Rule 20.5(a) is not otherwise contained in this international application but is completely contained in an earlier application whose priority is claimed on the date on which one or more elements referred to in Article 11(1)(iii) were first received by the receiving Office, that element or part is, subject to confirmation under Rule 20.6, incorporated by reference in this international application for the purposes of Rule 20.6.		
VII-1	**International Searching Authority Chosen**	European Patent Office (EPO) (ISA/EP)	
VIII	**Declarations**	Number of declarations	
VIII-1	Declaration as to the identity of the inventor	–	
VIII-2	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	–	
VIII-3	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	–	
VIII-4	Declaration of inventorship (only for the purposes of the designation of the United States of America)	–	
VIII-5	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	–	
IX	**Check list**	Number of sheets	Electronic file(s) attached
IX-1	Request (including declaration sheets)	5	✓
IX-2	Description	25	–
IX-3	Claims	5	–
IX-4	Abstract	1	✓
IX-5	Drawings	6	–
IX-7	TOTAL	42	
	Accompanying Items	Paper document(s) attached	Electronic file(s) attached
IX-8	Fee calculation sheet	✓	–
IX-19	Other	PCT-TRANSMITTAL	
IX-20	**Figure of the drawings which should accompany the abstract**	8	
IX-21	**Language of filing of the international application**	English	

PCT REQUEST

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X-1	**Signature of applicant, agent or common representative**	/Lester J. Vincent, Reg No. 31,460/
X-1-1	Name (LAST, First)	VINCENT, Lester J.
X-1-2	Name of signatory	
X-1-3	Capacity (if such capacity is not obvious from reading the request)	

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10-1	**Date of actual receipt of the purported international application**	12 OCT 2012 (12.10.12)
10-2	**Drawings:**	
10-2-1	Received	
10-2-2	Not received	
10-3	**Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application**	
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10-5	**International Searching Authority**	ISA/EP
10-6	**Transmittal of search copy delayed until search fee is paid**	

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(74) Agents: **VINCENT, Lester J.** et al.; Blakely Sokoloff Taylor & Zafman LLP, 1279 Oakmead Parkway, Sunnyvale, California 94085 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

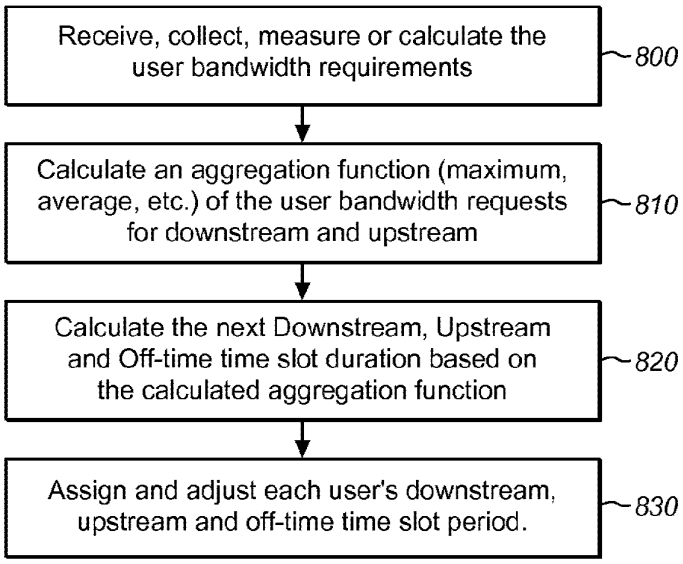
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[Continued on next page]

(54) Title: MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER

(57) Abstract: Time division duplex transmission over copper physical channels is managed. In one example, upstream time slots for upstream transmission in a first physical channel are scheduled. Downstream time slots for downstream transmission in a second physical channel are scheduled. Transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots.

FIG. 8



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TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER

FIELD

The present description relates to the field of data transmission in channels subject to crosstalk and, in particular, to scheduling time slot allocations for such channels.

BACKGROUND

TDD (Time Division Duplex) systems transmit downstream (network to subscriber) data and upstream (subscriber to network) data in distinct time slots of the same physical channel. Additionally, there is often a small guard-time between distinct time slots to ensure that data does not overlap. One new TDD system is called 'G.fast,' which is currently in the process of standardization by the ITU-T (International Telecommunication Union - Telecommunication Standardization Sector). G.fast is to transmit over relatively short (< 250 m) copper telephone loops and premises wiring.

Figure 1 is a diagram of slots on a horizontal time axis for a classic TDD system, alternately transmitting downstream from the network toward the subscriber and upstream from the subscriber toward the network in different Down and Up TDD time slots. There is a downstream slot 12, and an upstream slot 14. This is followed by another downstream slot 16 and then an upstream slot 18. The cycle is repeated along the horizontal time axis. The "asymmetry ratio" is the ratio of the size of the Down slot compared to the size of the Up slot. There is usually also a small guard-time (not shown) between each time slot. Each repetition of the two slots may be referred to as a frame. Alternatively, a frame may have multiple repetitions of the two slots.

To reduce power consumption and interference on nearby lines, a power saving TDD system is shown in Figure 2. Figure 2 is a diagram of slots on a horizontal axis for the power saving TDD system. Broadband data communication systems are often idle or highly underutilized, and current practice is generally to send idle codes at full power when there is no data traffic. A power saving alternative is to suppress transmission when there is no user data traffic. As shown in Figure 2, there are two frames 21, 22, TDD frame$_1$, TDD frame $_2$, each having a downstream slot, 23, 27, followed by an upstream slot, 25, 29. In addition, a portion of the downstream slot, in this case the later portion, is an off portion, D_off 24, 28, during which transmission is suppressed. During the off portion, neither data nor idle bits are sent. Similarly the upstream slot, Up, has an off portion U_off 26, 30 at the end of each slot, during which

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neither data, nor idle bits are sent. Sending no power, during off times "D_off" and "U_off" can provide significant power savings. "D_off" and "U_off" may also be combined into a single off portion.

In many TDD systems, there are multiple physical channels. If these channels are close together in location and overlap in frequency, then they may interfere with each other. Figure 3 is a diagram of a TDD system with two channels 31, 32. In this example, each channel uses a twisted pair of copper cables and both channels are in the same cable or cable binder. As illustrated in Figure 3, systems transmitting in multi-pair copper cables can generate crosstalk into each other, Near-End Crosstalk (NEXT) 33 and Far-End Crosstalk (FEXT) 34 are generated by each channel and directed at least in part into the nearby channel.

Each channel is connected between a network-end Transmission Unit-Office (TU-O) 35, 36 and a subscriber-end Transmission Unit-Remote (TU-R) transceiver 37, 38. While each channel is shown as connecting a different TU-O to its own TU-R, a single TU-O can connect to a single TU-R using both of the two channels. This allows more data to be sent to the one TU-R. A single TU-O may also connect to multiple TU-Rs, which is sometimes called "bonding."

NEXT can be very powerful and debilitate high speed transmissions. ADSL (Asymmetric Digital Subscriber Line) and VDSL (Very high bit rate Digital Subscriber Line) use Frequency-Division Multiplexing (FDM) to avoid self-NEXT. Self-NEXT 33 is the crosstalk that is created into neighboring channels as shown in Figure 3.

SUMMARY

In one example, a method for managing multiple physical channels in a data communications system that are subject to crosstalk is described. The method includes scheduling time slot allocations for the physical channels so that upstream transmissions do not occur at the same time as downstream transmissions. In another example, the method is implemented by a machine operating on a machine-readable medium having stored instructions. In another example, a time slot management system manages multiple physical channels in a data communications system that are subject to crosstalk. The system has a process for determining time slot allocations for the physical channels so that upstream transmissions do not occur at the same time as downstream transmissions and a communications interface to make assignments to transmitters of the physical channels.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

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Embodiments are illustrated by way of example, and not by way of limitation, and will be more fully understood with reference to the following detailed description when considered in connection with the figures in which:

Figure 1 is a diagram of slots on a horizontal time axis for a classic TDD system;

Figure 2 is a diagram of slots on a horizontal axis for a power saving TDD system;

Figure 3 is a diagram of two related physical channels connected to end nodes in a TDD system;

Figure 4 is a diagram of slot assignments for two related physical channels according to an embodiment of the invention;

Figure 5 is a diagram of alternative slot assignments for two related physical channels according to an embodiment of the invention;

Figure 6 is a diagram of further alternative slot assignments for two related physical channels according to an embodiment of the invention;

Figure 7 is a diagram of a twisted pair having at least two related physical channels connected between a central office and an end node;

Figure 8 is a process flow diagram of an example of computing TDD slot times and off times according to an embodiment of the invention;

Figure 9 is a process flow diagram of computing start and end times of time slots according to an embodiment of the invention;

Figure 10 is a diagram of multiple TDD groups that have crosstalk coupling between some of their lines including autonomous TDD management according to an embodiment of the invention;

Figure 11 is a process flow diagram of another example of computing TDD slot times according to an embodiment of the invention; and

Figure 12 is a block diagram of a TDD management system according to an embodiment of the invention.

DETAILED DESCRIPTION

Embodiments of the invention may provide a management system for systems that transmit over wires using Time-Division Duplex (TDD). The management system receives input

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data about service levels, traffic, power and other requirements. It then determines an assignment of TDD time slots, off times, and asymmetry; for optimal performance, minimal traffic delays, and minimal power usage. The TDD frames are flexible and need not follow a fixed pattern.

One way to avoid self-NEXT is to synchronize the transmissions on the two lines so that one line does not transmit downstream while another line transmits upstream. This is particularly important with TDD systems that have channels that use the same multi-pair cable binder.

Figure 4. is a diagram showing TDD frames, $frame_1$, $frame_2$, on two different channels, $Line_1$, $Line_2$, which are close enough to cause NEXT 41, 42 in the other line. The frames are shown as aligned across a horizontal time axis. Each frame for each channel has a downstream slot, 43-1, 43-2, 44-1, 44-2, and an upstream slot, 45-1, 46-2, 45-2, 46-2. Even though the TDD frames are aligned, in this case the slots are not. $Line_1$, the upper line, is transmitting predominately in the upstream direction while $Line_2$ is transmitting predominately in the downstream direction. The downstream and upstream misalignment causes NEXT 41, 42 in the nearby line. As shown, the $Line_1$ $frame_1$ upstream slot 45-1 begins before the $Line_2$ $frame_2$ downstream slot 43-2 completes. During this overlap, NEXT 41 is much higher. After the $Line_2$ $frame_2$ downstream slot 43-2 ends and the upstream slot 45-2 begin, NEXT 41 is greatly reduced. A similar overlap occurs in $frame_2$.

One way of avoiding NEXT is to align all the TDD frames, the downstream and upstream time slots, and the off times, as shown for example in Figure 5. As in Figure 4, the frame structure $frame_1$, $frame_2$ for two nearby channels $Line_1$, $Line_2$ are shown aligned on a horizontal time axis. Both the upper line, $Line_1$ and the lower line, $Line_2$, have downstream 53-1, 54-1, 53-2, 54-2 and upstream slots 55-1, 56-1, 55-2, 56-2 which are aligned with respect to time. As a result, the two channels will be carrying downstream data at the same time and upstream data at the same time. Since no downstream transmission occurs during an upstream transmission, NEXT is minimized.

In addition, the two frames also have off portions, D_off 57-1, 58-1, 57-2, 58-2, in each downstream slot of each frame and U_off 51-1, 52-1, 51-2, 52-2 in each upstream slot of each frame. Part of each upstream and each downstream slot is shown as being off to save power. The off portions are also aligned.

A more flexible way of avoiding NEXT, instead of enforcing perfect alignment of each slot in each frame as in Figure 5, is to enforce sufficient alignment to avoid transmitting

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upstream and downstream at the same time on any line. This has the advantage that one line can transmit more data than other lines if it has high demand, while the other lines can be quiet and save power. Further, the frame times can be varied. This, however, has the disadvantage that it requires a high level of control and coordination. Figure 6 shows an example of this.

Figure 6 shows two channels an upper, $Line_1$, and a lower, $Line_2$, aligned on a horizontal time axis. The downstream 63-1, 64-1, 63-2, 64-2 and upstream 65-1, 66-1, 65-2, 66-2 portions of these two channels are aligned as in Figure 5. However, the off portions, the downstream off portions D_off 67-1, 68-1, 67-2, 68-2, and U_off, the upstream off portions 61-1, 66-1, 61-2, 66-2 are not aligned. In order to eliminate NEXT, the off portions do not need to be aligned. When a channel is off, then it is not generating any interference. Each of these off periods do not need to be aligned for all lines in all TDD groups of a multiple channel binder. Embodiments of the invention help to control the off periods and determine how to adapt the off periods for each channel to avoid NEXT and to minimize power usage.

A further method of mitigating NEXT is to employ active NEXT cancellation at the network end of the lines, where the TU-Os are located. This is generally feasible among TU-Os that are in the same equipment chassis, or at least in the same location. In such a case, transmitted data signals, received upstream signals plus NEXT, and the associated error signals are available to a cancellation system or filter, which subtracts estimates of the NEXT from the received signals in real-time. The NEXT canceller may have a zero-forcing structure, a minimum-mean square error (MMSE) structure, a decision-feedback equalizer (DFE) structure, or any other cancellation filter structure. The cancellation coefficients may be calculated at start-up, and may be adapted using error signals while the lines are active.

NEXT cancellation eliminates most of the NEXT from downstream signals into upstream signals, allowing some overlap between downstream and upstream time slots. NEXT from upstream signals into downstream signals occurs primarily at the subscriber ends of the lines where the upstream signals are strongest. The amplitude of this NEXT may be low enough to be ignored due to the attenuation that occurs on drop and inside wires. Transmitting upstream and downstream simultaneously in the same frequencies is known as full-duplex operation, and generally also requires line hybrids and echo cancellers. Compatibility with VDSL2 may be enabled by using NEXT cancellation at the TU-O end of the lines and by not allowing upstream transmission in the VDSL2 downstream frequency bands unless the NEXT is low at the subscriber end of the lines. Different bit loadings may be used when transmitting upstream and downstream simultaneously, and when transmitting in only one direction.

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With NEXT cancellation, management of the TDD system proceeds as described elsewhere here, except that some overlap between downstream and upstream time slots may be allowed in some cases or in some time slots. The combination of time slot and frequency-band allocations can be dynamically adjusted for each environment.

Several network-end transmission units (TU-O) are often in a single access node. One example of a single access node is a Digital Subscriber Line Access Multiplexer (DSLAM). Referring to Figure 7, a central office (CO) or exchange 71 is coupled through a feeder 72 to one or more crossboxes or splice points 73, although only one is shown. The crossbox is coupled through a distribution line 74 to one or more drop wire interfaces 75, although only one is shown. The drop wire interface is coupled though one or more drops or drop wires 76 to one or more TU-Rs 77, although only one is shown. Depending on the system implementation, the crossbox 73 may be replaced with or in the form of, for example, a feeder distribution interface (FDI), a serving area interface (SAI), a junction wire interface (JWI), or a sub-loop distribution frame (SDF). The drop wire interface 75 may be replaced with or in the form of a distribution terminal or a deployment point (dP).

The access node or DSLAM (not shown) can be located in the distribution terminal or it can be located somewhere else in the distribution plant, and usually it is fed with optical fiber from the Central Office (CO) or exchange. Downstream of the access node, toward the TU-Rs, crosstalk may be only between lines from a single access node, or there may be crosstalk between lines from multiple access nodes. A set of lines using TDD that all originate at the same access node will be referred to herein as a TDD group.

The invention may be embodied by a TDD management system that coordinates the TDD slot times and the off times of different channels to maximize the transmission of user data traffic while minimizing power. On and off times may be selected to ensure there is no possibility of creating NEXT between lines in a TDD group, or between lines in different TDD groups that have crosstalk coupling into each other. The on and off times may also be chosen to maximize traffic throughput to meet user demands, and to also minimize power consumption by being off when possible.

The TDD management system receives input on the traffic levels, traffic types, and traffic patterns that should be provided on the lines under its control. This input may include one or more of the following:

a) static (time-invariant) data about service subscription levels and their traffic requirements, e.g. a "traffic descriptor;

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b) service layer information from a policy manager which provides high-level estimates of data rate requirements based on service requests;

c) data on the behavior of different traffic types, different users, e.g. bit rate variations, traffic behavior, or burstiness;

d) time series data from long term traffic monitoring which is analyzed to determine the traffic demands as a function of time-of-day or time-of-week;

e) instantaneous feedback based on current traffic demands or queue lengths (Queue lengths or traffic requests can be sent from the customer end up to the network-end for input to the TDD management system);

f) upstream and downstream traffic asymmetry patterns; and

g) traffic requests or reports.

The traffic can further be classified according to priority level, service type, QoS (Quality of Service), tagging, stream type, protocol type, etc., and this classification information can be input to TDD scheduling algorithms.

The TDD management system uses this input to calculate TDD slot times and off times. The slot times are arranged in such a way as to avoid or reduce NEXT when possible, for example as shown in Figure 6. Ideally, no two lines that have significant crosstalk coupling into each other can transmit upstream and downstream at the same time. The slot times and off times may also be calculated to satisfy the traffic requested by subscribers, and can further minimize power usage by maximizing off times.

Figure 8 is a process flow diagram of an example of computing TDD slot times and off times as described above. At 800, the bandwidth requirements or requests of the users are received, collected, calculated, or measured. The information may be based on the input received by the TDD management system as described above. This information may include any number of different factors including the type of traffic (for example fixed, variable), and the amount of bandwidth requested (for example in Bytes or microseconds). The bandwidth requirements of some users may be fixed over time, such as for streaming video, while the bandwidth of others may vary.

At 810, an aggregation function (maximum, average, etc.) of the user bandwidth requests for downstream and upstream is calculated for different types of traffic. For example, the function could be the maximum of all users' downstream fixed bandwidth requests. Further examples are provided in the next section.

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At 820, the next downstream, upstream and off time time slot periods are calculated based on the calculated aggregation function. For example, the next downstream time slot duration could be equal to the sum of the maximum downstream requests for all types of traffic. In such a case, for instance it is guaranteed that no user's bandwidth request would exceed the time slot duration allocated for that type of traffic. Further examples are provided below.

At 830, each user's downstream, upstream and off time time slot periods are assigned and then, if need be, they are adjusted. If the conditions of previous operations are properly satisfied, then each user should be able to receive its requested bandwidth, given limitations or requirements of its traffic type. It is also possible that, for example, the assignments could provide excess bandwidth for certain users. In such cases, adjustments may be made to utilize this excess capacity, for example by assigning variable bit rate traffic to excess fixed bandwidth time slots, or by assigning off time for power savings. Further examples are provided below. The assignment of time slots may be internal to a transceiver, or it may be transmitted from the TDD management system down to the transceiver.

The following provides an example of the process above, for assigning bandwidth at a single access node with mixtures of delay-sensitive fixed bandwidth assignments (e.g., video, voice) and delay-insensitive real-time bandwidth assignments (e.g., data). This example assumes bandwidth requests were converted into time slot requests in microseconds. If user i has a data rate of Z Mbps, and is requesting B bits of traffic, the request equals B/Z microseconds in the next frame.

1) The receive, collect, measure, or calculate operation at 800 may be performed as receiving bandwidth request data input for each user. This data may, for example, include any of the following:

a) Fixed upstream bandwidth requests, e.g. UXi microseconds dedicated for each user i;

b) Real-time upstream bandwidth requests, e.g. UYi microseconds in the next time slot for user i;

c) Fixed downstream bandwidth requests, e.g. DXi microseconds dedicated for each user i; and

d) Real-time downstream bandwidth requests, e.g. DYi microseconds in the next time slot for user i.

2) The calculation of the aggregated function at 810 may be performed in several steps. First, the maximum requested bandwidth of each type in the next frame is calculated. These can be defined, for example, as follows:

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a) Maximum fixed upstream bandwidth request e.g. MaxUX = max over i (UXi);

b) Maximum real-time upstream bandwidth request e.g. MaxUY = max over i (UYi);

c) Maximum fixed downstream bandwidth request e.g. MaxDX = max over i (DXi); and

d) Maximum real-time downstream bandwidth request e.g. MaxDY = max over i (DYi)

3) The time duration of the next frame may be named TF. The time slot durations can be determined at 820 using different criteria depending on the particular subscriber and system architecture circumstances. Some examples are provided below, where it is assumed that fixed bandwidth requests have strict priority over real-time bandwidth requests.

4) If TF >= MaxUX + MaxUY + MaxDX + MaxDY, then the next upstream time slot duration is MaxUX + MaxUY, the next downstream time slot duration is MaxDX + MaxDY, and the off time in the next TDD frame is TF – (MaxUX + MaxUY + MaxDX + MaxDY).

5) Otherwise, if MaxUX + MaxUY + MaxDX + MaxDY > TF > MaxUX + MaxDX, then the fixed bandwidth requests will be completely satisfied and the real-time bandwidth requests will be partially satisfied. One way of doing this is to divide the real-time bandwidth proportional to the maximum requested real-time bandwidth so that the next upstream time slot duration is

MaxUX + (TF – MaxUX - MaxDX) * (MaxUY/(MaxUY + MaxDY),

the next downstream time slot duration is

MaxDX + (TF – MaxUX - MaxDX)*(MaxDY/(MaxUY + Max DY),

and there is no off time in the next time slot.

6) Otherwise, if TF = MaxUX + MaxDX, then the next upstream time slot duration is MaxUX and the next downstream time slot duration is MaxDX.

7) Otherwise, if MaxUX + MaxDX > TF, then the fixed bandwidth requests are partially satisfied and the real-time bandwidth requests are not satisfied at all. One way of doing this is to divide the fixed bandwidth proportional to the maximum requested fixed bandwidth so that the next upstream time slot duration is TF*(MaxUX/(MaxUX + MaxDX)), the next downstream time slot duration is TF*(MaxDX/(MaxUX + MaxDX)), and there is no off time in the next time slot.

8) Having calculated the functions and the time slot durations, the operations at 830 are performed: assign and adjust each user's downstream, upstream and off time time slot period.

There are many variations to the example process described above, depending on the particular application and system architecture, for example the bandwidth may be divided

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proportional to average upstream and downstream requests instead of maximum, or the bandwidth may simply be split in half, or the bandwidth may be divided along a sliding window that accounts for bandwidth requests in multiple time slots, or the bandwidth may be assigned according to a fairness criteria, or the bandwidth may be assigned according to subscription level, etc. The processes may also be extended to more than two different traffic types. The process may operate on multiple TDD frames at a time.

In the example of using the maximum requested bandwidth as described above, the time slot dedicated to one or more users could exceed the required bandwidth requested by those users. In some cases, the required bandwidth for a user could be significantly less than the assigned time slot. For example, MaxUX+MaxUY could be much larger than the UXi+UYi or MaxDX+MaxDY could be much larger than DXi+DYi for a specific user i. In such cases, the adjustment stated as step 7 above can be utilized.

As one example, the extra bandwidth may be utilized for either saving power or improving latency or some combination of both. The TDD management, as an example may extend the off period for those users, to reduce their power consumption. Alternatively, the TDD management system may accommodate the available extra bandwidth to be used for variable upstream or downstream traffic for those users to allow newly arriving traffic to be transmitted immediately. Conversely, when using the average requested bandwidth in the above algorithm, some user requests might not get satisfied. For example, the fixed bandwidth requests could be partially satisfied. In such cases, steps 5-7 of the above 8-step process for calculating an aggregate function could be modified, where instead of Max; the Average function is used. Other functions may alternatively be used to suit different implementations and different traffic management goals.

After the time slot durations are calculated, the start and end times of each time slot in the next TDD frame are calculated. This may be a simple assignment anchored at a fixed time such as the beginning or end of a TDD frame. Or it may involve a more involved solution, such as an iterative solution. Figure 9 is a process flow diagram of an example of computing the start and end times of each time slot in a next or subsequent TDD frame.

At 900, the next downstream (DS) time slot, the next upstream (US) time slot, and the next off time locations are assigned to arbitrary locations in the next TDD frame.

At 910, it is checked whether the downstream time slot is overlapping with another upstream time slot, or vice versa, whether the upstream time slot is overlapping with another

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downstream time slot. If there is no overlap, then the allocations in step 900 are accepted, and no further action is needed.

If there is an overlap, then at 920, the entire downstream time slot assignment or the entire upstream time slot assignment is moved forward or backward in time, by a predetermined amount or by a random amount. The choice of DS or US is based on whether the overlapping time slot is a DS slot or a US slot from 910.

After this adjustment, the operations at 910 are repeated, and if there are no more overlaps, then no further action is required. However, if there still is an overlap, either with the downstream time slot or with the upstream time slot, then the operations at 920 are repeated. If after the adjustments the non-overlapping conditions cannot be met, then the DS or the US time slot durations are decreased (depending on which one had the overlapping issue), and the initial assignment at 900 is repeated.

A more specific example of the operations in the process flow diagram of Figure 9 is provided below. As in Figure 9, this is an example of the above process for computing the start and end times of each time slot in a next TDD frame. In the following example it is assumed that the previous process of Figure 8 has already been performed, and therefore the next downstream time slot DS duration, the next upstream time slot US duration, and the next off time D_off, U_off duration, have already been determined.

1) As an example of the operations at 900, assign the next downstream time slot, the next upstream time slot, and the next off time(s) to arbitrary locations in the next TDD frame. For example, the next TDD frame may begin with the downstream time slot, then have the next slot be downstream off time D_off, then have the upstream time slot, and then have the next upstream slot be upstream off time U_off. Alternately, the off time may be contiguous and in the beginning, middle, or end of the TDD frame.

2) If the downstream time slot does not overlap with any other upstream time slot of any other TDD system that crosstalks into or from this TDD system, then the process is finished until the next time the slots are adjusted based on new parameters. This is the test at 910.

3) Otherwise, move the entire downstream time slot assignment by x microseconds either forward or backward in time. This corresponds to the operation at 920.

4) Repeat step 4, varying x, until the condition of non-overlap in step 3 is achieved in the downstream direction. x may be varied randomly or it may vary in predetermined steps.

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5) If the condition of step 3 cannot be achieved, then decrease the downstream time slot duration and repeat steps 1 through 4.

6) If the upstream time slot does not overlap with the downstream time slot, nor with any other upstream time slot of any other TDD system that crosstalks with this TDD system, then the process if finished.

7) Otherwise, move the entire upstream time slot assignment by y microseconds either forward or backward in time.

8) Repeat step 7, varying y, until the condition of non-overlap in step 6 is achieved in the upstream direction. y may be varied randomly or it may vary in predetermined steps.

9) If the condition of step 7 cannot be achieved, then decrease the upstream time slot duration and repeat steps 6 through 8.

10) Assign the off time. For example, the off time may be contiguous and in the beginning, middle, or end of the TDD frame; or it may be split into two times before or after the upstream and downstream time slots such that it fits in the TDD frame.

11) This procedure may be repeated to assign off times to each line, or each line may autonomously assign off times.

12) Set the times for the next slots, either internally or by communicating with external equipment. If the transceivers are external to the management system, then the management system notifies the transceivers of one or more of the future assignments: beginning of the upstream time slot(s), ending of the upstream time slot(s), duration of the upstream time slot(s), the beginning of the downstream time slot(s), ending of the downstream time slot(s), duration of the downstream time slot(s), the beginning of the off time slot(s), ending of the off time slot(s), duration of the off time slot(s),

The calculation of TDD slot times and off times may also be performed in various other ways, by a direct calculation that maximizes the projection of user demands on the achievable space, by iteratively adjusting the slot boundaries from frame-to-frame, via heuristics, by selecting from among a stored set of timings, a generalized algorithm that uses several of these approaches, etc. In addition, the frame length can be variable, the time slot start and end times need not be periodic, and these need not be aligned. Frame lengths can be varied to meet delay requirements, e.g., a short frame when low-delay applications are used. The calculation may simultaneously be applied to multiple TDD frames.All of this may be determined by the TDD management system.

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The TDD management system may be made to be capable of converting high-level requests for traffic and power consumption into low-level TDD scheduling. High-level requests may be e.g. an outline of traffic and power requirements, or a general indication of the trade-off between traffic delay and power usage. The TDD management system may also coordinate power savings that are achieved by entering, exiting, or transitioning between multiple power line states. In addition to TDD off times, these power line states can save power by transmitting a lower bit rate with a lower bit loading using a lower transmit spectrum.

Part of each frame time may be reserved on a long-term basis for down and up time slots, with an additional part dynamically varied as traffic comes and goes. The TDD management system then optimizes time slot assignment using both long-term and short-term variations.

TDD up and down time slots and the asymmetry ratio can be varied to minimize average traffic delays and maximize average throughput across all lines in the TDD group. The asymmetry ratio can be defined in terms of time for each slot or in terms of the number of DMT (Discrete Multi-Tone) symbol positions used by a particular user in upstream or downstream. Alternatively, the performance of some set of premium services can be maximized. As a further alternative, the worst-case performance can be maximized. As a further alternative, a more general fairness criterion, such as "alpha-fairness" can be applied to maximize any arbitrarily weighted combination of different user traffic demands.

The TU-Rs are often synchronized to the timing of the TU-O. This timing can be assisted by regularly sending a "synch symbol" downstream that the TU-Rs can lock on to maintain a level of timing synchronization. The TDD management system can determine the times to send synch symbols and the synch symbol durations. When there is very little traffic, the line could be off during an entire down or up time slot, or during an entire TDD frame, or even during multiple TDD frames. Then, the TDD management system can schedule the VTU-O to send enough synch symbols, with enough duration, so that the TU-R maintains or regains synchronization. These synch symbols may be sent in only some time slots, in only some TDD frames, and even using only some subcarriers. The synch symbols can use a low-level modulation for robustness. This enables an inactive TU-R to maintain TDD frame timing so that the TU-R can transmit during an upstream time slot when it wakes up.

A transceiver, such as a TU-R or TU-O may stay in receive-only mode, with the transmitter turned off. This allows power savings by turning off the transmitter. In this mode, the transceiver may also listen to regularly-occurring receptions to maintain synchronization and to hear traffic or instructions to wake up.

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An alternative wake-up procedure is for a TU-R to listen to the noise on the line, and determine when there is NEXT by reading regularly-occurring high-power noise once every TDD frame or at any other suitable interval. The TU-R transmits start-up signals when it estimates that this NEXT is active, which should be during an upstream time slot.

There may be a two step process for TU-R wake-up:

1: The TU-R stays approximately synchronized through slow periodic keep alives from the TU-O;

2: When the TU-R wants to start transmitting after some time period of upstream and downstream inactivity (and hence synchronization is only approximate):

a) The TU-R sends a short sync request in what it thinks is the middle of the upstream frame period (sending the short message in the middle ensures that the transmission is entirely within the upstream period);

b) The TU-O responds with a transmission that the TU-R can use for recovering synchronization;

c) Transmission proceeds normally.

Transmission systems adapt to the noise environment on the line, and the described techniques may ensure that adaptation is performed while crosstalking lines are actively creating crosstalk and not during quiet times.

Vectoring technology, as exemplified in the ITU-T G.993.5 standard, is used to cancel at least some FEXT. In order for vectoring to be effective, if it is applied to a TDD group, NEXT should be kept low. So the avoidance of NEXT also allows vectoring to function better. The described techniques can coordinate the TDD timing with the vectoring engine. The TDD management system can reassign vectoring resources in real-time when the TDD asymmetry ratio changes.

The TDD management system can also schedule when to send retransmission units. Retransmission units may be sent at any time. In some embodiments, retransmission units are sent at times that don't cause NEXT problems in a part of what would have been an off time, or retransmission units are sent with multiple retransmissions at other frame times. Retransmissions can be incremental, with all or part of the original data retransmitted, or by sending additional parity bits. Multiple retransmissions can be scheduled, and a block of original data can be retransmitted in one or more blocks of data or parity. Acknowledgements (ACKs) or negative acknowledgements (NACKs) related to retransmission can also be scheduled by the invention.

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The avoidance of NEXT between lines in a single TDD group is relatively straight-forward compared to avoiding NEXT with multiple lines. The TDD coordination simply needs to enforce this among the lines from a single access node, which all originate in the same location and so are relatively easy to jointly control.

Figure 10 is a diagram of a more complex system implementation in which there are multiple TDD groups that have crosstalk coupling between some of their lines, for example between the two TDD groups in a Shared Cable 3 in Figure 10. In this case the TDD management may span multiple access nodes, either explicitly with a centralized management element, or autonomously by detecting crosstalk.

Centralized TDD management allows multiple TDD groups to be coordinated directly. Centralized TDD management can use explicit timing information and feedback from access nodes, EMS, or other network elements to then centrally optimize all interacting TDD groups.

As shown in Figure 10, centralized TDD management 111 may be coupled through a network 112 to multiple access nodes 113-1, 113-2. While only two are shown, there may be many more. The centralized TDD management receives traffic data as described above, performs the assignments and then sends time slot assignments to the access nodes. The access nodes are coupled through communications channels to one or more end nodes or TU-Rs 116-1, 116-2, 116-3, 116-4. The communications channels may be in the form of twisted pair wiring 117-1, 117-2, 117-3, 117-4, or in any other form and may be in one or more binders 115-1, 115-2, 115-3. The binders may be in the form of a shared multiple conductor cable with lines for four or for hundreds of channels.

Figure 10 illustrates that two channels 117-1, 117-2 that initially are in a common binder or cable and that may generate cross-talk with each other may later be separated and combined with other channels in other binders. As shown, the second twisted pair 117-2 is separated from the first twisted pair 117-1 and later combined with a third twisted pair 117-3 in a third binder 115-3. These two lines now generate crosstalk with each other. This third twisted pair originated with a second binder 115-2. The second and third lines may also be routed to a common or to different end stations 116-2 116-3. The crosstalk generated at any one point between two nearby channels may propagate along any one channel and affect other channels. As an example, the crosstalk generated by the first line 117-1 and received by the second line 117-2 may be coupled to the third line 117-3 in the third shared cable. The third line 117-3 may couple that same crosstalk from the first line 117-1 into a fourth line 117-4.

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The connections between lines in different cables or binders may occur in switches, junctions, crossboxes, distribution frames, pedestals, or other types of terminals including network-end terminal, such as TU-R's, or in splice points. In these locations channels can be separated from their original binders and then recombined into different binders or combined at a termination point. TDD systems may alternately not be assigned to separate binders at all, in which case crosstalk will usually arise between them resulting in essentially the same configuration as in Figure 10.

Autonomous TDD management 114-1, 114-2 at each access node 113-1, 113-2 or at any other point in the system can coordinate multiple TDD groups even though it reads data from, and controls, only a single TDD group. Synchronization may also be performed by measuring the time series of time-varying crosstalk and synchronizing to its patterns. As another alternative, synchronization is performed by measuring the time series of error events and synchronizing to its patterns. This may be done by reading in the time-varying pattern of noise or errors on the lines in the TDD group. Crosstalk from another "alien" TDD system, such as that from a different access node, creates a regularly-occurring pattern of noise as it alternately transmits in both directions, first in one direction, then in the other. This crosstalk can be measured by reading the noise on the lines, or by reading the time-series of error patterns. These can be analyzed on both ends of the line to identify the pattern of the alien TDD groups' up and down time slots. For example, errors occurring in one direction once each millisecond indicate that crosstalk is being generated once each millisecond from the alien TDD groups. The TDD management system can then synchronize its own transmissions to this crosstalk.

Figures 3, 7, and 10 all show different perspectives of the same communication system. While the time slot assignment may be performed at any of a variety of different locations, in each case, the transmissions are either controlled directly or the controller sends assignments to the appropriate transmitter. The assignments may be sent, e.g., to a transceiver unit (TU), to a crossbox, to a switch, to a junction, to a pedestal or to another type of transmitter whether it is an original signal source or a repeater at any point in the channel. Similarly, the controller can provide synchronization signals that allow the upstream and downstream signals to be coordinated. Synchronization can also be based on signals from a vectoring unit, from an access node, a crossbox, or some other junction point or from an external clock or synchronization source. In one example, synchronization symbols are sent to the sources of upstream transmissions, such as TU-R's.

TDD management may more generally be split between centralized and autonomous methods, using traffic data and TDD synchronization information from:

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a) Explicit use of management data and synchronization data from DSLAMs, EMS, OSS or other network elements;

b) Global synchronization data using Global Positioning Satellite (GPS) data or network timing protocols;

c) Autonomous estimation using monitoring data on crosstalk patterns or by reading time-varying noise or error counts;

d) Explicit estimates of crosstalk couplings between lines can be input, for example vectored lines can provide such data as reported Xlin values.

The TDD management system may adjust one or more of the following quantities or other quantities not listed for one or more lines:

a) asymmetry ratio,

b) up and down slot times,

c) off times; and

d) use of low-power or quiescent states;

with the objective of meeting bit-rate requirements and requests, and optionally minimizing power. These can also be set indirectly through higher-level or lower-level control specifications. These can be controlled by slowly changing them as scheduled or as needed after a traffic threshold is crossed; or they can vary in real time. Dynamic Bandwidth Allocation (DBA) or Dynamic Resource Allocation (DRA) can also be all or part of this control. The TDD management system may also interface with, or contain, a Timing Control Entity (TCE).

The TDD management system's capability to detect and adapt to TDD crosstalk can assist in enabling spectral compatibility of TDD systems with FDM (Frequency Division Multiplexed) systems such as VDSL2 (Very high bit rate Digital Subscriber Line, version 2). This can be done by using automated crosstalk identification, coordinating TDD timings, and Dynamic Spectrum Management (DSM) to enable the TDD system to be compatible with VDSL2. Frequency band assignments may further be coordinated to enable spectral compatibility.

Figure 11 is a process flow diagram of scheduling upstream and downstream time slots according to another embodiment. The process flow is specifically intended for use in managing multiple time division physical channels that are subject to crosstalk, however, the invention is not so limited. The scheduling is described here in the context of two physical channels that are subject to crosstalk, however there may be many more than two channels.

At 1104, the TDD management system receives input about traffic objectives for the scheduling of the time slots. This operation is optional. The input is typically received from an

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external controller, although the TDD management system may be able to monitor the channels or use preset parameters instead of any received input. In a typical DSL system external controllers already generate Operations Support System (OSS) data and Management Information Database (MIB) parameters. This information may be provided to the TDD management system for it use in assigning time slots. Other types of information may also be used. The received input may be of a variety of different types and may include desired traffic levels, static subscription data, service layer information from a policy manager, behavior data for traffic types and users of the physical channels, long term traffic behavior data as a function of time, current traffic demands, queue lengths, traffic requests, upstream/downstream asymmetry, and traffic descriptors. The received input may also include transmission requests from network elements at the network end or the remote end.

At 1106, the TDD management system schedules upstream time slots for upstream transmission in one or more physical channels. AT 1108, the TDD management system schedules downstream time slots for downstream transmission in one or more physical channels. This may be the same channels as the upstream channels or different channels, depending on the nature of the TDD system and the assignment of channels. The upstream channels may be assigned before or after or at the same time as the downstream channels. In these assignments transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots. To make these assignments, all or some of various types of information in the received input can be used. These can be combined in different ways. In one example, optimization criteria are used that weigh different factors.

There are additional factors that may also be considered in the scheduling such as power usage, or a target upstream/downstream asymmetry ratio of data throughput. The data throughput can be defined or measured as an average throughput across all lines, a traffic demand match, a minimum throughput for each physical channel, a perceived quality of experience, an average delay, or a minimum delay.

As mentioned previously, the scheduling may allow some simultaneous transmission in the upstream and downstream time slots. The NEXT that may be caused by the simultaneous transmission may be ignored or the TDD system may also use active NEXT cancellation to cancel NEXT at the network end of the channels.

As a part of the scheduling, the TDD management system will typically send time slot assignments to a corresponding network element. At 1110, the TDD management system may also optionally synchronize times slot among different transmitters. The TDD management

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system may send synch symbols to source of upstream or downstream transmissions. It may also measure a time series of time-varying crosstalk and then synchronize the time slots to the measured time-varying patterns. Instead of crosstalk patterns, a time series of error events may be measured and used to synchronize.

At 1112, the TDD management system may optionally adjust the scheduling of upstream and downstream time slots. The adjustment may be applied to the next frame or frames, or to the current assignments. The adjustment may accommodate delay requirements for an upstream or downstream traffic source. Many different adjustments may be made such as moving the upstream and downstream time slots in time to reduce simultaneous upstream and downstream transmission, moving only if upstream transmissions overlap downstream transmissions in time, and reducing the duration of at least one downstream time slot to reduce simultaneous upstream and downstream transmission.

Figure 12 is a block diagram of a TDD management system 1200 in one example. The system 1200 includes a memory 1295 coupled directly or through a bus to a processor or processors 1296. The memory may be a hard drive, non-volatile memory, solid state memory, or a combination of different memory types for different purposes. The processor may also include its own internal memory. The memory may, for example, store instructions to be executed and the processor may execute the stored instructions. The processor may also implement or execute implementing logic 1260 having logic to implement the methodologies discussed herein. System 1200 includes one or more communications buses 1215 to connect the various illustrated components and to transfer transactions, instructions, requests, and data within the system among the components and other peripheral devices. The system further includes a management interface 1225 coupled to the bus and to external management devices, for example, to receive requests, return responses, and otherwise interface with network elements located separately from the system. This information may include Operations Support System (OSS) data and Management Information Database (MIB) parameters. These network elements may include access nodes, a central office, vectoring units, crossboxes, TU-Rs, and TU-Os.

The system further includes a LAN (Local Area Network) interface 1230 coupled to the bus and externally to communicate information via a LAN based connection, including collecting network information, reporting information and diagnostics to other entities within the network, and for initiating instructions and commands over the network. The system further includes a WAN (Wide Area Network) interface 1235 coupled to the bus and to an external WAN, to communicate information via a WAN based connection for similar purposes and to reach other more remote devices.

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In some embodiments, the management interface 1225 communicates information via an out-of-band connection separate from LAN and/or WAN based communications, where "in-band" communications are communications that traverse the same communication means as payload data (e.g., content) being exchanged between networked devices and where "out-of-band" communications are communications that traverse an isolated communication means, separate from the mechanism for communicating the payload data. An out-of-band connection may serve as a redundant or backup interface over which to communicate control data between a management device 1201 and other networked devices or between the management device and a third party service provider.

The system further includes stored historical information 1250 which may be stored within the memory 1295 or as a separate component coupled to the memory or to the bus. The historical information may be analyzed or referenced when conducting long term trending analysis for scheduling time slots and for reporting. Similarly management events 1255 may be stored within the memory or as a separate component coupled to the bus or to the memory. The management events may be initiated responsive to the identification of an operational condition. For example, corrective actions, additional diagnostics, information probes, configuration change requests, local commands, remote execution commands, and the like may be specified by and triggered as a management event 1255. Similarly, operational reports, configuration reports, network activity reports and diagnostic reports may be generated and sent in accordance with stored management events 1255.

A management device 1201 coupled to the bus includes a collection module 1270, analysis module 1275, diagnostics module 1280, and implementation module 1285. Management Device 1201 may be installed and configured in a compatible system 1200 as is depicted by Figure 12A, or provided separately so as to operate in conjunction with appropriate implementing logic 1260 or other software.

The collection module 1270 collects information from available sources, such as management information, LAN information and WAN information via the external interfaces. The scheduling module 1275 analyzes the information retrieved by the collection module and generates upstream and downstream time slot schedules including, as appropriate, off times and active transmission times. The scheduling module may further perform long term trending analysis based on stored historical information 1250 or conduct neighborhood analysis based on aggregation data yielded from multiple separate and distinct reports, or conduct other joint analysis based on collected information. The adjusting module 1280 adjusts the schedules to better suit the collected information and internal parameters, such as power usage and

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asymmetry ratio objectives. The results from the adjusting module may be supplied back to the scheduling module, depending on the embodiment. The synchronizing module 1285 synchronizes the scheduled time slots through the external connections 1225, 1230, 1235 so that all of the access nodes, transmitting units, or other components transmit at appropriate times.

The modules of the management device 1201 may be provided as separate components coupled to the bus 1215 as shown or may be incorporated into the processor or memory or another component. The management device may include its own processing and memory resources that interact with the processor and the external interfaces. The management device may include more or fewer modules than those shown. The TDD management system of Figure 12 is provided only as an example and may be modified to suit different implementations. It may also be incorporated into another component such as an access node, or a TU-O. In one embodiment, the management system is provided as a card in a system rack with a backplane interface to communicate with local and remote network elements.

There are a number of optional and additional advantages and features to the described techniques and systems above. These can be understood in the statements below, among others which may be combined in any of a variety of different ways.

A system has been described above for managing multiple TDD lines, in part, by determining time slot boundaries. The system provides sufficient coordination to avoid NEXT by ensuring that two lines with significant crosstalk coupling do not transmit downstream and upstream at the same time. The system further assigns slot-times and the downstream/upstream asymmetry ratio to maximize a measure of throughput. The maximized measure of throughput is one or more of: the maximum average or minimum average across all lines; chosen to best match traffic demands; chosen to provide a minimum service level to all lines; chosen to ensure user-perceived quality of experience; chosen to minimize average or maximum delays; or chosen to meet any fairness criteria. Other measures of throughput may be used as alternatives or additions, depending on the implementation. The assignment of time slots may be internal to a transceiver, or it may be transmitted from the TDD management system into a transceiver. The TDD management system can further perform Dynamic Bandwidth Allocation (DBA) or Dynamic Resource Allocation (DRA).

The TDD management system can further optimize the scheduling of off time slots to minimize power usage. The TDD management system can further schedule off times during low traffic that suppress transmission for the duration of entire time slot, TDD-frame, or multiple TDD frames. It may save power by controlling entries, exits, and transitions between low-power

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states. Low-power states save power by transmitting a lower bit rate with a lower bit-loading using a lower transmit spectrum.

The TDD management system can calculate an optimal set of up and down slot times and off times according to an optimization criteria, this criteria can flexibly weigh different tradeoffs between different users, tradeoffs between different services, and tradeoffs between performance and power savings.

The TDD management system adjusts one or more of the following or other quantities for one or more lines: a) asymmetry ratio, b) up and down slot durations, c) up and down slot times, and d) off times. The TDD management system controls the TDD time slot boundaries and off times. This can be a fixed assignment, a slowly varying assignment based on time-of-day, or an assignment that is varied in real time. One or more control parameters such as any one slot time start or end point, slot lengths, asymmetry, up slot time, down slot time, a single off time, and total off time, can be varied while other parameters remain fixed. The TDD management system may employ flexible slot-time boundaries, with variable-length frames, up slot-times, and down slot-times.

The TDD management system receives input on the traffic levels that need to be provided on the lines under its control. This input may include one or more of the following: static (time-invariant) data about service subscription levels and their traffic requirements; service layer information from a policy manager which provides high-level estimates of data rate requirements based on service requests; data on the behavior of different traffic types e.g., burstiness, for different users; time-series data from long-term traffic monitoring which is analyzed to determine the traffic demands as a function of time-of-day or time-of-week; instantaneous feedback based on current traffic demands or queue lengths; and traffic requests or reports sent from the customer end.

The TDD management system can be further controlled by external Operations Support Systems (OSS) or by reading and writing Management Information Database (MIB) parameters. A single TDD group can be managed or multiple TDD groups can be managed. The TDD management system may be a centralized controller that controls multiple lines, and/or multiple TDD groups. Alternatively, the TDD management system may be distributed among multiple pieces of equipment.

The TDD management system can control synchronization of a TDD group. This synchronization can be assisted by using one or more of the following input data: explicit use of management data and synchronization data from DSLAMs, EMS (Element Management

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Systems), OSS (Operations Support Systems) or other network elements; global synchronization data using Global Positioning Satellite (GPS) data or network timing protocols; autonomous estimation reading time-varying noise that contains crosstalk patterns or by using monitoring data such as error counts.

The timing reference can be further used to control the synchronization of multiple TDD groups. The TDD management system can provide information to assist the synchronization of multiple lines and/or multiple TDD groups.

The TDD management system can determine the times to send synch symbols and the synch symbol durations. The TDD management system can schedule the VTU-O to send synch symbols sufficiently often and with sufficient duration, for the VTU-R(s) to maintain synchronization with the VTU-O. These synch symbols may be sent only in some time slots, in some TDD frames, and only using some subcarriers. The synch symbols can use a low-level modulation for robustness. Long synch symbols can be scheduled to be sent from the VTU-O to recover synchronization after long off times. The TDD management system may further coordinate off times by instructing one or more transceiver(s) to be in receive-only mode, with the transmitter turned off for some time period, or until it receives a signal, or until traffic in a queue crosses a threshold.

An inactive TU-R can listen to the noise on the line, and determine when there is NEXT by reading regularly-occurring high-power noise once every TDD frame. The TU-R then transmits start-up signals when it estimates that this NEXT is active, which should be during an upstream time slot.

The TDD management system may use multiple, distributed components, each operating autonomously. The autonomous TDD system can further read in crosstalk coupling data. The crosstalk data can be used to determine which TDD groups and which lines to coordinate. A combination of centralized and autonomous TDD management can be supported.

The TDD management system can further control FEXT cancellation using, for example, vectoring. Vectoring resources can be re-assigned in real-time when the TDD asymmetry ratio changes. The TDD management system can adapt to satisfy varying delay requirements for different lines, subscribers, services, and at different times. The TDD management system can assist compatibility with FDM systems (e.g., G.fast and VDSL2), use crosstalk identification and "fingerprinting" of FDM and TDD crosstalk. The TDD management system can control retransmission, assign retransmission time slots, coordinate Hybrid retransmission that can re-send multiple parts of a block of data and/or multiple parity bits.

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The TDD management system can manage allocation of time slots for acknowledgement messages (ACKs) and/or negative acknowledgement messages (NACKs). The TDD management system can further coordinate TDD groups that have NEXT cancellation or partial NEXT cancellation, thereby allowing some overlap between down and up time slots that have such cancellation.

In this description, numerous specific details such as logic implementations, opcodes, means to specify operands, resource partitioning/sharing/duplication implementations, types and interrelationships of system components, and logic partitioning/integration choices are set forth. It will be appreciated, however, by one skilled in the art that the different implementations may be practiced without such specific details. In other instances, control structures, gate level circuits and full software instruction sequences have not been shown in detail in order not to obscure the description.

References in the specification to "one embodiment," "an embodiment," "an example embodiment," etc., indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to effect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

In this description and claims, the terms "coupled" and "connected," along with their derivatives, may be used. It should be understood that these terms are not intended as synonyms for each other. "Coupled" is used to indicate that two or more elements, which may or may not be in direct physical or electrical contact with each other, co-operate or interact with each other. "Connected" is used to indicate the establishment of communication between two or more elements that are coupled with each other. The operations of the flow and signaling diagrams are described with reference to exemplary embodiments. However, it should be understood that the operations of the flow diagrams can be performed by variations other than those discussed with reference to these other diagrams, and the variations discussed with reference to these other diagrams can perform operations different than those discussed with reference to the flow diagrams.

As described herein, instructions may refer to specific configurations of hardware such as application specific integrated circuits (ASICs) configured to perform certain operations or

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having a predetermined functionality or software instructions stored in memory embodied in a non-transitory computer readable medium. Thus, the techniques shown in the figures can be implemented using code and data stored and executed on one or more electronic devices (e.g., a UE, an eNB, etc.). Such electronic devices store and communicate (internally and/or with other electronic devices over a network) code and data using machine-readable media, such as non-transitory machine-readable storage media (e.g., magnetic disks; optical disks; random access memory; read only memory; flash memory devices; phase-change memory) and transitory machine-readable communication media (e.g., electrical, optical, acoustical or other form of propagated signals – such as carrier waves, infrared signals, digital signals, etc.).

In addition, such electronic devices typically include a set of one or more processors coupled to one or more other components, such as one or more storage devices (non-transitory machine-readable storage media), user input/output devices (e.g., a keyboard, a touchscreen, and/or a display), and network connections. The coupling of the set of processors and other components is typically through one or more busses and bridges (also termed as bus controllers). Thus, the storage device of a given electronic device typically stores code and/or data for execution on the set of one or more processors of that electronic device. Of course, one or more parts of an embodiment of the invention may be implemented using different combinations of software, firmware, and/or hardware

While the flow diagrams in the figures show a particular order of operations performed by certain embodiments of the invention, it should be understood that such order is exemplary (e.g., alternative embodiments may perform the operations in a different order,

While the invention has been described in terms of several embodiments, those skilled in the art will recognize that the invention is not limited to the embodiments described, can be practiced with modification and alteration. The description is thus to be regarded as illustrative instead of limiting.

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CLAIMS

1. A method in a data communications system for managing multiple time division physical channels that are subject to crosstalk, the method comprising

scheduling upstream time slots for upstream transmission in a first physical channel; and

scheduling downstream time slots for downstream transmission in a second physical channel,

wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots.

2. The method of Claim 1, wherein scheduling downstream time slots comprises allowing some simultaneous transmission in the upstream and downstream time slots, the method further comprising cancelling near-end crosstalk (NEXT) from downstream into upstream transmission at a network end of the channels.

3. The method of Claim 1, wherein the upstream and downstream time slots have an active portion during which signals are transmitted and an off portion during which no signals are transmitted and wherein the active portions of the upstream time slots are substantially not simultaneous with the active portions of the downstream time slots.

4. The method of Claim 1, wherein scheduling upstream and downstream time slots comprises scheduling upstream and downstream time slot boundaries.

5. The method of Claim 4, wherein the time slot boundaries are flexible.

6. The method of Claim 5, wherein the time slot boundaries have one or more of: variable-length frames; variable upstream time slot lengths; and variable downstream time slot-lengths.

7. The method of Claim 1, further comprising assigning time slots to a network element based on the scheduling and transmitting the assignments from a management system to a network element.

8. The method of Claim 1, further comprising adapting scheduling at least one of upstream and downstream time slots to accommodate delay requirements for the other of a downstream and upstream traffic source.

9. The method of Claim 1, further comprising receiving input on desired traffic levels for the first and second physical channels and wherein scheduling upstream and downstream time slots is performed based on the received input.

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10. The method of Claim 9, wherein a portion of a downstream time slot is invariant and a portion of a downstream time slot varies in real-time.

11. The method of Claim 9, wherein the received input comprises at least one of static subscription data, service layer information from a policy manager, behavior data for traffic types and users of the physical channels, long term traffic behavior data as a function of time, current traffic demands, queue lengths, traffic requests, upstream/downstream asymmetry, and traffic descriptors.

12. The method of Claim 9, wherein scheduling upstream and downstream time slots comprises assigning time slots to achieve a target upstream/downstream asymmetry ratio of data throughput.

13. The method of Claim 12, wherein the upstream/downstream asymmetry ratio is defined in numbers of discrete multi-tone symbol positions

14. The method of Claim 12, wherein the measure of throughput is at least one of an average throughput across all lines, a traffic demand match, a minimum throughput for each physical channel, a perceived quality of experience, an average delay, and a minimum delay.

15. The method of Claim 1, wherein scheduling upstream and downstream time slots comprises assigning time slots based at least in part on power usage.

16. The method of Claim 15, wherein assigning time slots based on power usage comprises assigning by scheduling entries, exits, and transitions between low-power link states and off states.

17. The method of Claim 15, wherein assigning time slots based on power usage includes assigning at least one network element to a receive-only mode, with a transmitter of the network element turned off.

18. The method of Claim 10, wherein scheduling upstream and downstream time slots comprises assigning time slots using an optimization criteria that weights different factors.

19. The method of Claim 18, wherein receiving input comprises receiving input from an external controller.

20. The method of Claim 19, wherein the received input comprises at least one of Operations Support System (OSS) data, Element Management System (EMS) data, and Management Information Database (MIB) parameters.

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21. The method of Claim 10, wherein the time slots are defined within a time division frame, wherein receiving input comprises receiving input during a frame, and wherein scheduling upstream and downstream time slots comprises scheduling upstream and downstream time slots of an immediately subsequent frame.

22. The method of Claim 1, further comprising receiving requests for upstream and downstream transmission and wherein scheduling upstream time slots is based on the received upstream transmission requests.

23. The method of Claim 1, wherein the transmission in the upstream time slots is from a plurality of different network-end transmission sources.

24. The method of Claim 23, further comprising synchronizing upstream transmission and downstream transmission among a plurality of different network-end transmission sources.

25. The method of Claim 24, wherein synchronizing comprises sending synch symbols to a source of upstream transmissions.

26. The method of Claim 24, wherein synchronizing comprises measuring a time series of time-varying crosstalk and synchronizing to time-varying patterns of the crosstalk.

27. The method of Claim 24, wherein synchronizing is performed by measuring a time series of error events and synchronizing to time-varying patterns of the error events.

28. The method of Claim 1, wherein scheduling upstream and downstream time slots comprises determining a duration of the upstream and downstream time slots and moving the upstream and downstream time slot start times to reduce simultaneous upstream and downstream transmission.

29. The method of Claim 28, wherein determining a duration comprises adjusting a default duration based on bandwidth requests.

30. The method of Claim 28, wherein moving comprises moving only if upstream transmissions overlap downstream transmissions in time.

31. The method of Claim 28, further comprising reducing the duration of at least one downstream time slot to reduce simultaneous upstream and downstream transmission.

32. The method of Claim 1, wherein the scheduling upstream and downstream time slot is further performed to minimize crosstalk on nearby VDSL2 lines.

33. The method of Claim 1, further comprising receiving input on desired traffic levels for the first and second physical channels and wherein scheduling upstream and

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downstream time slots is performed based on the received input and at least in part on power usage.

34. A machine-readable medium having instructions that when operated on by the machine cause the machine to perform operations comprising:

scheduling upstream time slots for upstream transmission in a first physical channel of multiple time division physical channels in a data communication system in which the physical channels are subject to crosstalk; and

scheduling downstream time slots for downstream transmission in a second physical channel subject to crosstalk from the upstream time slots,

wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots.

35. The medium of Claim 34, the operations further comprising receiving input on desired traffic levels for the first and second physical channels and wherein scheduling upstream and downstream time slots is performed based on the received input.

36. The medium of Claim 34, wherein scheduling upstream and downstream time slots comprises assigning time slots to achieve a target upstream/downstream asymmetry ratio of data throughput.

37. An apparatus for managing multiple time division physical channels in a data communications system that are subject to crosstalk, the apparatus comprising

means for scheduling upstream time slots for upstream transmission in a first physical channel; and

means for scheduling downstream time slots for downstream transmission in a second physical channel subject to crosstalk from the upstream time slots,

wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots.

38. The apparatus of Claim 37, further comprising means for assigning at least one network element to a receive-only mode, with a transmitter of the network element turned off.

39. The apparatus of Claim 37, further comprising means for receiving requests for upstream and downstream transmission for use by the means for scheduling.

40. A system with multiple physical channels in a data communications system transmitting point-to-multipoint over multiple copper wires that are subject to crosstalk, wherein

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the system allows full-duplex operation by using line hybrids and echo cancellation to separate upstream transmission from downstream transmission, and

near-end crosstalk (NEXT) is cancelled only at the network-end of the channels, from downstream into upstream transmission,

wherein transmission in the upstream time slots may occur simultaneous with transmission in the downstream time slots.

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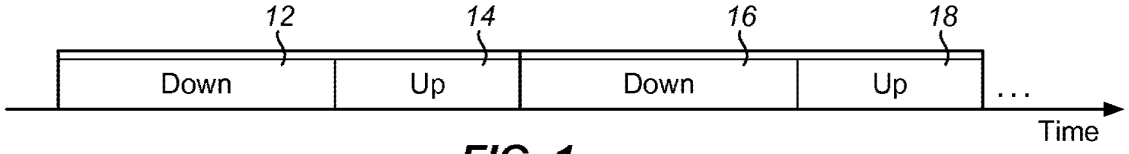


FIG. 1

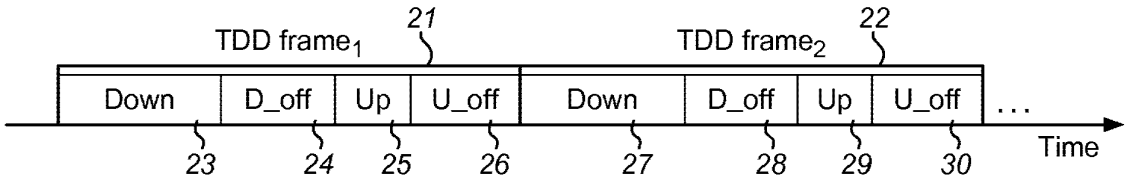


FIG. 2

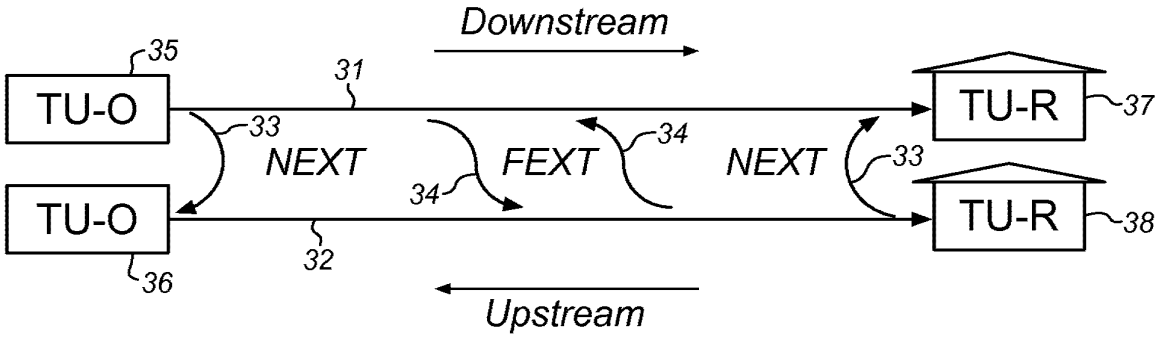


FIG. 3

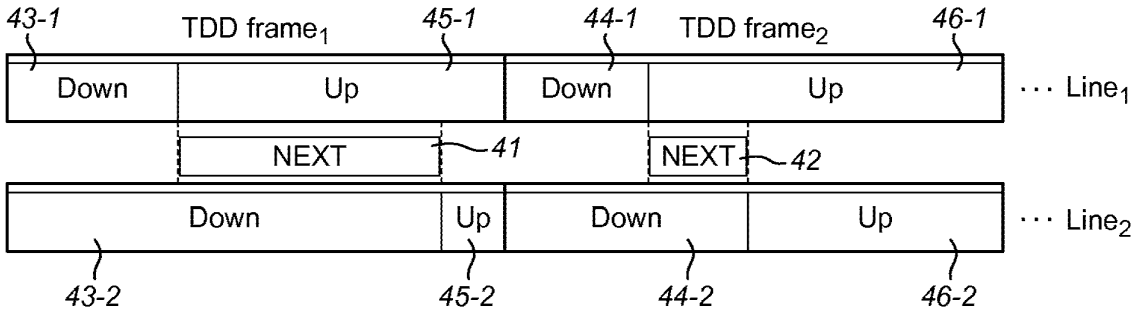


FIG. 4

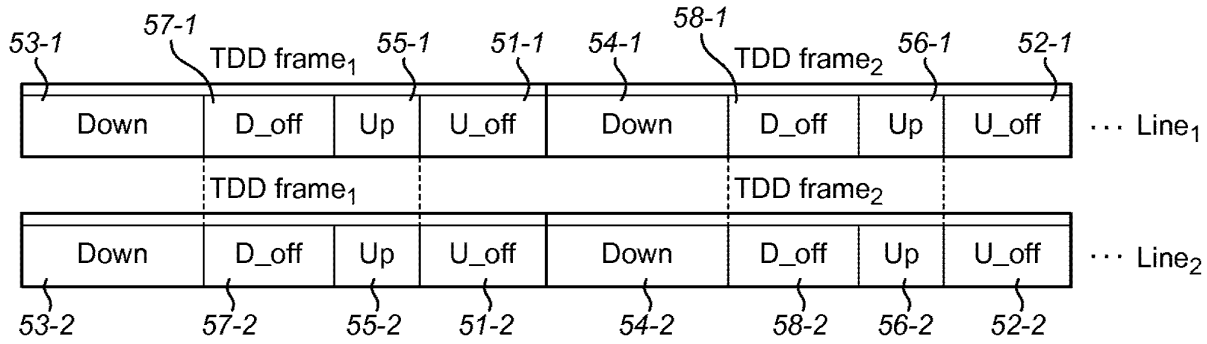


FIG. 5

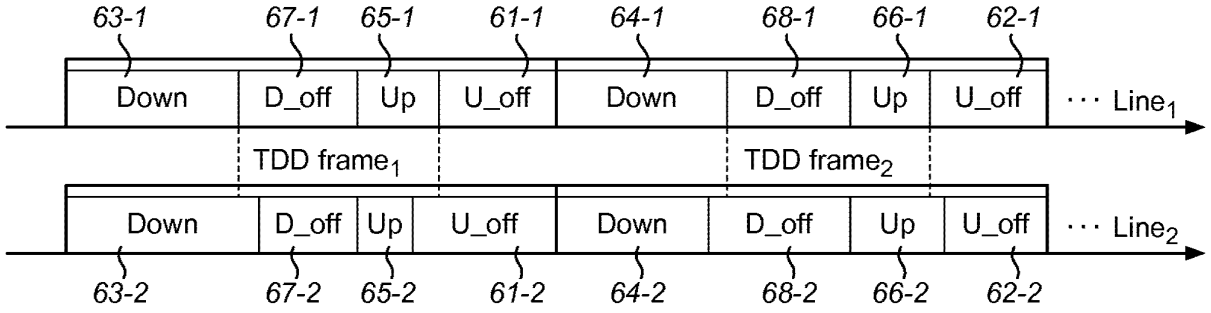


FIG. 6

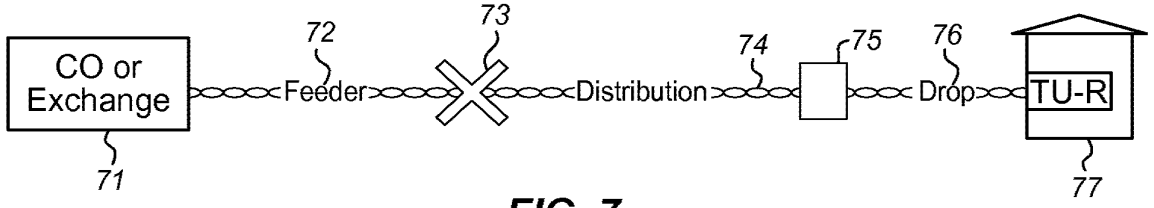


FIG. 7

FIG. 8

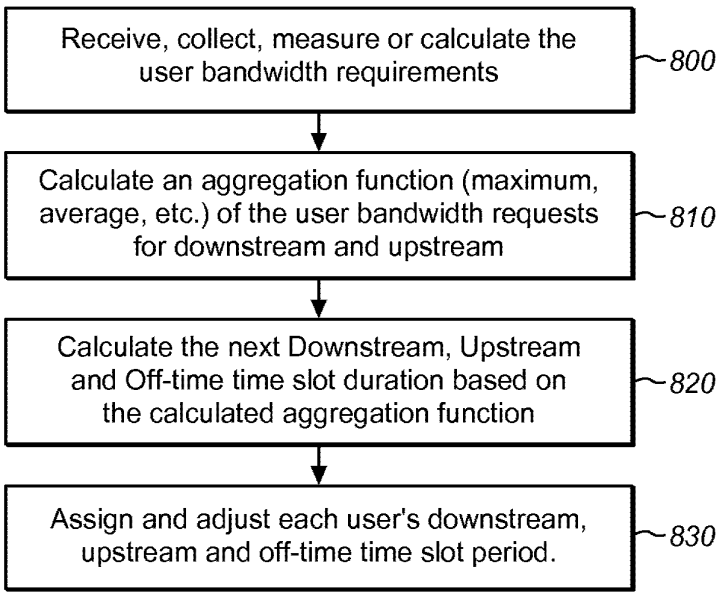
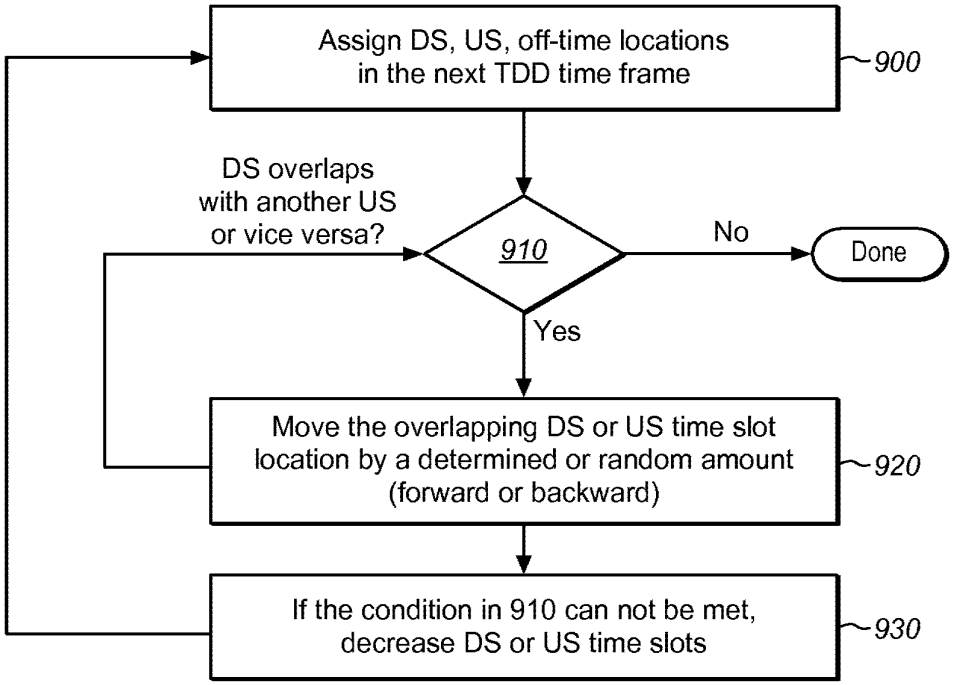

Receive, collect, measure or calculate the user bandwidth requirements
800
Calculate an aggregation function (maximum, average, etc.) of the user bandwidth requests for downstream and upstream
810
Calculate the next Downstream, Upstream and Off-time time slot duration based on the calculated aggregation function
820
Assign and adjust each user's downstream, upstream and off-time time slot period.
830

FIG. 9


Assign DS, US, off-time locations in the next TDD time frame
900
DS overlaps with another US or vice versa?
910
No
Done
Yes
Move the overlapping DS or US time slot location by a determined or random amount (forward or backward)
920
If the condition in 910 can not be met, decrease DS or US time slots
930

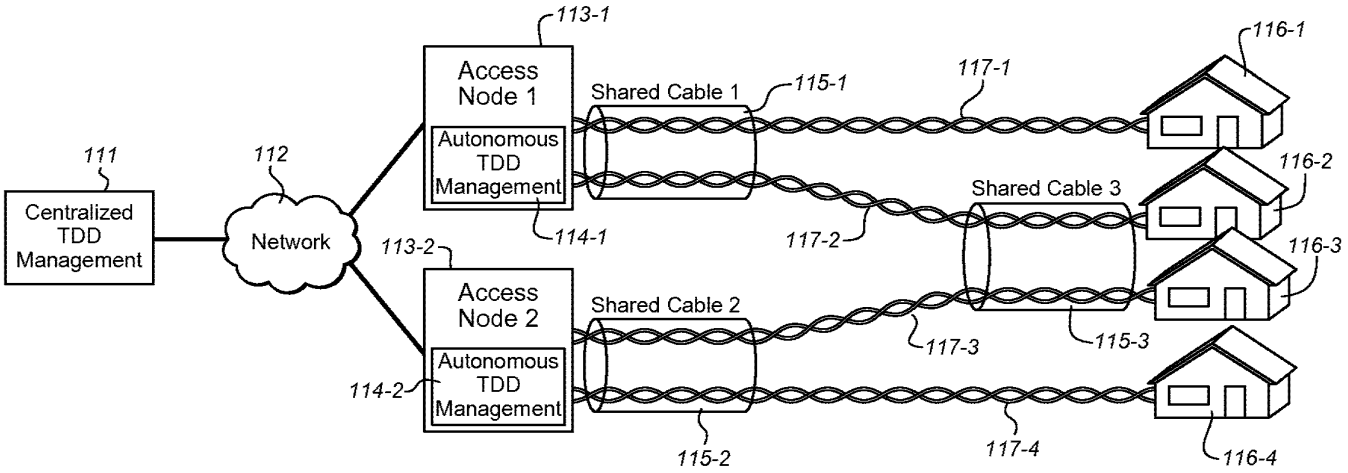
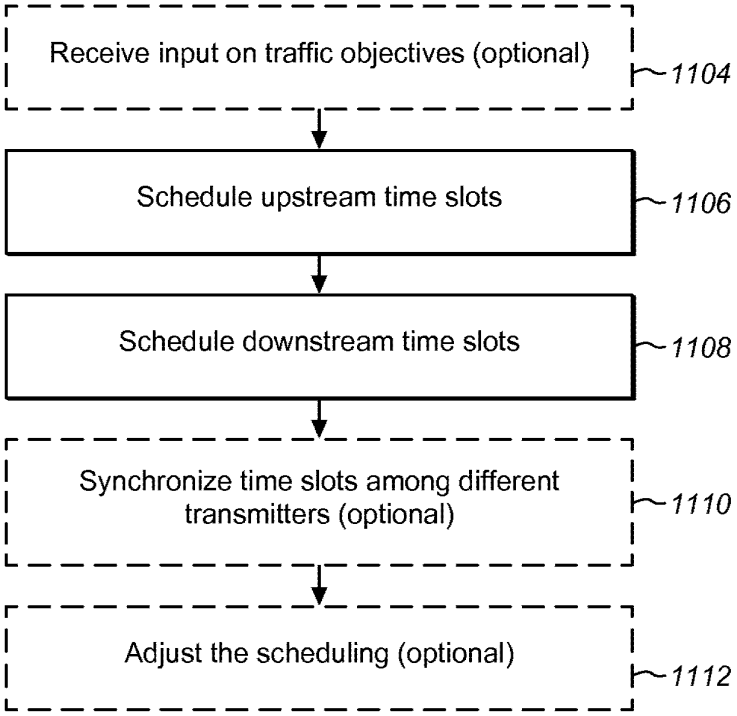

113-1
Access Node 1
Autonomous TDD Management
114-1
Shared Cable 1
115-1
117-1
116-1
111
Centralized TDD Management
112
Network
113-2
Access Node 2
Autonomous TDD Management
114-2
Shared Cable 2
115-2
117-2
Shared Cable 3
116-2
116-3
117-3
115-3
117-4
116-4

FIG. 10

FIG. 11


Receive input on traffic objectives (optional)
1104
Schedule upstream time slots
1106
Schedule downstream time slots
1108
Synchronize time slots among different transmitters (optional)
1110
Adjust the scheduling (optional)
1112

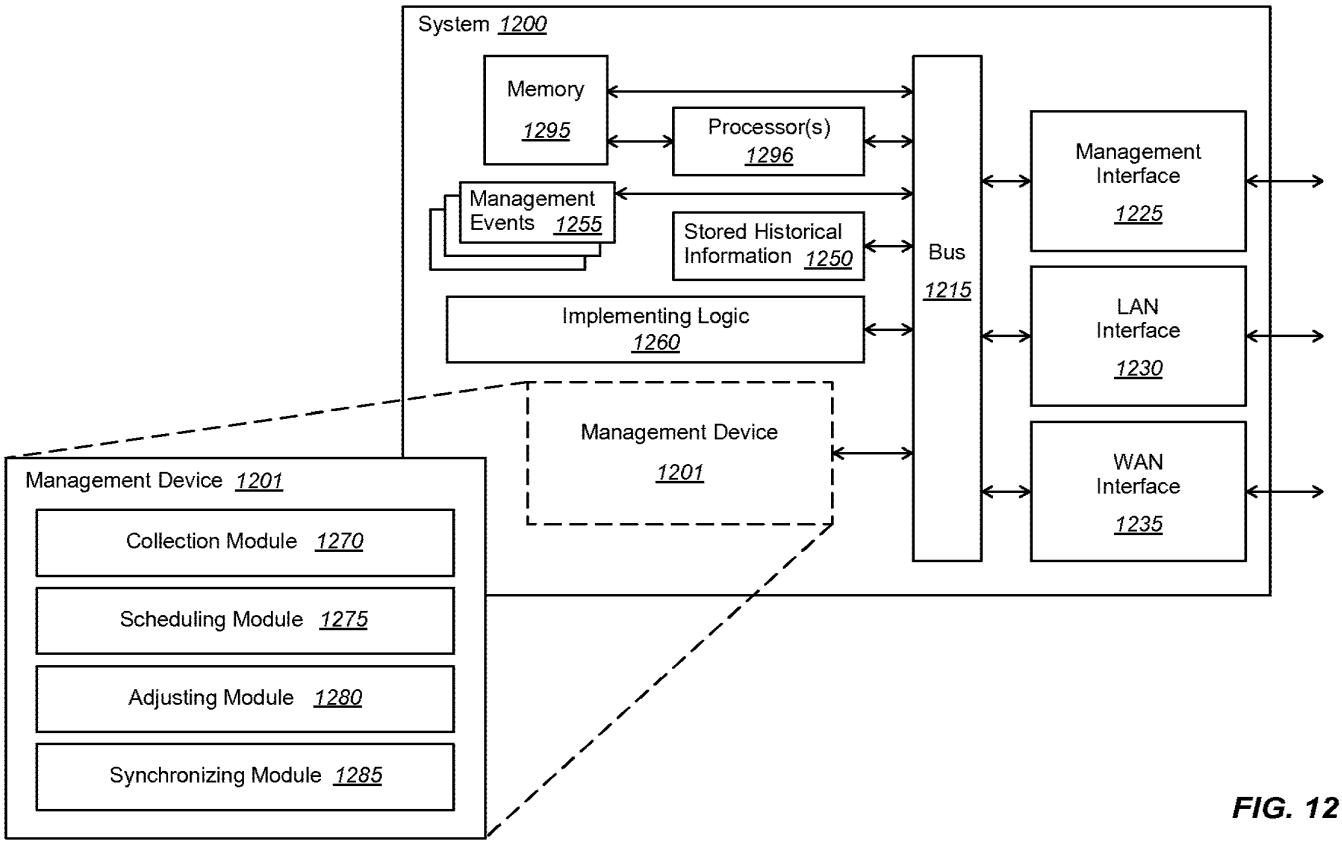

System 1200
Memory 1295
Processor(s) 1296
Management Events 1255
Stored Historical Information 1250
Implementing Logic 1260
Management Device 1201
Bus 1215
Management Interface 1225
LAN Interface 1230
WAN Interface 1235
Management Device 1201
Collection Module 1270
Scheduling Module 1275
Adjusting Module 1280
Synchronizing Module 1285

FIG. 12

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

U.S. APPLICATION NUMBER NO.	FIRST NAMED INVENTOR	ATTY. DOCKET NO.
14/417,544	Kenneth Kerpez	8241P074

8791
BLAKELY SOKOLOFF TAYLOR & ZAFMAN
1279 Oakmead Parkway
Sunnyvale, CA 94085-4040

INTERNATIONAL APPLICATION NO.	
PCT/US12/60115	
I.A. FILING DATE	PRIORITY DATE
10/12/2012	07/27/2012

CONFIRMATION NO. 8970
371 ACCEPTANCE LETTER



Date Mailed: 04/21/2015

NOTICE OF ACCEPTANCE OF APPLICATION UNDER 35 U.S.C 371 AND 37 CFR 1.495

The applicant is hereby advised that the United States Patent and Trademark Office, in its capacity as a Designated / Elected Office (37 CFR 1.495), has ACCEPTED the above identified international application for national patentability examination in the United States Patent and Trademark Office.

The United States Application Number assigned to the application is shown above. A Filing Receipt will be issued for the present application in due course. **THE DATE APPEARING ON THE FILING RECEIPT AS THE "FILING DATE or 371(c) DATE" IS THE DATE ON WHICH THE LAST OF THE 35 U.S.C. 371 (c)(1) and (c)(2) REQUIREMENTS HAS BEEN RECEIVED IN THE OFFICE. THIS DATE IS SHOWN BELOW.** The filing date of the above identified application is the international filing date of the international application (Article 11(3) and 35 U.S.C. 363)

01/26/2015
DATE OF RECEIPT OF 35 U.S.C.
371(c)(1) and (c)(2) REQUIREMENTS

The following items have been received:

- Copy of the International Application filed on 01/26/2015
- Copy of the International Search Report filed on 01/26/2015
- Copy of IPE Report filed on 01/26/2015
- Preliminary Amendments filed on 01/26/2015
- Information Disclosure Statements filed on 01/26/2015
- Request for Immediate Examination filed on 01/26/2015
- U.S. Basic National Fees filed on 01/26/2015
- Priority Documents filed on 01/26/2015
- Application Data Sheet (37 CFR 1.76) filed on 01/26/2015

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.495(c).

- Properly executed inventor's oath or declaration for the following inventor(s) has not been submitted: **Kenneth Kerpez**, **George Ginis**, **Marc Goldburg**, and **Ardavan Maleki Tehrani**

IPR2025-00451
Petitioners' Exhibit 1002
Page 204 of 511

Applicant is reminded that any communications to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above (37 CFR 1.5)

SHELBY J MILLER

Telephone: (571) 272-0384

IPR2025-00451
Petitioners' Exhibit 1002
Page 205 of 511

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
14/417,544	01/26/2015		3640	8241P074	40	4

CONFIRMATION NO. 8970

8791
BLAKELY SOKOLOFF TAYLOR & ZAFMAN
1279 Oakmead Parkway
Sunnyvale, CA 94085-4040

FILING RECEIPT

OC000000074646229

Date Mailed: 04/21/2015

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Kenneth Kerpez, Longvalley, NJ;
George Ginis, San Mateo, CA;
Marc Goldburg, Redwood City, CA;
Ardavan Maleki Tehrani, Menlo Park, CA;

Applicant(s)

ASSIA, INC., Redwood City, CA

Power of Attorney: The patent practitioners associated with Customer Number 08791

Domestic Priority data as claimed by applicant

This application is a 371 of PCT/US12/60115 10/12/2012
which claims benefit of 61/676,862 07/27/2012

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

If Required, Foreign Filing License Granted: 04/15/2015

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 14/417,544**

Projected Publication Date: 07/30/2015

Non-Publication Request: No

Early Publication Request: No

IPR2025-00451
Petitioners' Exhibit 1002
Page 206 of 511

Title

MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

IPR2025-00451
Petitioners' Exhibit 1002
Page 207 of 511

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 14/417,544

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	280
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	480
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	720
TOTAL CLAIMS (37 CFR 1.16(i))	40 minus 20 =	* 20			OR	x 80 =	1600
INDEPENDENT CLAIMS (37 CFR 1.16(h))	4 minus 3 =	* 1				x 420 =	420
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	3500

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

MULTIPLE DEPENDENT CLAIM FEE CALCULATION SHEET

Substitute for Form PTO-1360
(For use with Form PTO/SB/06)

Application Number	Filing Date
14417544	

Applicant(s) Kenneth Kerpez

* May be used for additional claims or amendments

CLAIMS	AS FILED		AFTER FIRST AMENDMENT		AFTER SECOND AMENDMENT	
	Indep	Depend	Indep	Depend	Indep	Depend
1	1					
2		1				
3		1				
4		1				
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50						
Total Indep	4		0		0	
Total Depend	36	↵	0	↵	0	↵
Total Claims	40		0		0	

	*		*		*	
	Indep	Depend	Indep	Depend	Indep	Depend
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PCT

Power of Attorney

(for an international application filed under the Patent Cooperation Treaty)

(PCT Rule 90.4)

The undersigned applicant(s) (Names should be indicated as they appear in the Request Form (PCT/RO/101):

1.	KERPEZ Kenneth	7.	
2.	GINIS George	8.	
3.	GOLDBURG Marc	9.	
4.	TEHRANI Ardavan Maleki	10.	
5.		11.	
6.		12.	

hereby appoints (appoint) the following person as: ☒ agent ☐ common representative

Name and Address

(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

Gregory D. Caldwell, Reg. No. 39926; Spencer K. Hunter, Reg. No. 67337

Blakely Sokoloff Taylor and Zafman LLP
1279 Oakmead Parkway
Sunnyvale, CA 94086
United States of America

to represent the undersigned before

☒ all the competent International Authorities

☐ the International Searching Authority only

☐ the Authority specified for supplementary search only
(please indicate the Authority(ies) specfied for supplementary search)

☐ the International Preliminary Examining Authority only

in connection with the international application identified below:

Title of the Invention: MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER

Applicant's or agent's file reference: 8241P074PCT

International application number (if already available): PCT/US2012/060115

filed with the following Office United States of America (US) as receiving Office and to make or receive payments on behalf of the undersigned.

Signature of the applicant(s) *(where there are several applicants, each of them must sign: next to each signature, indicate the name of the person sign and the capacity in which the person signs, if such capacity is not obvious from reading the request or this power):*

1. KERPEZ Kenneth	2. GINIS George	3. GOLDBURG Marc	4. TEHRANI Ardavan Maleki
5.	6.	7.	8.
9.	10.	11.	12.

Date: _____

PCT

Power of Attorney

(for an international application filed under the Patent Cooperation Treaty)
(PCT Rule 90.4)

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1.	KERPEZ Kenneth	7.	
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4.	TEHRANI Ardavan Maleki	10.	
5.		11.	
6.		12.	

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Name and Address
(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

Gregory D. Caldwell, Reg. No. 39926; Spencer K. Hunter, Reg. No. 67337

Blakely Sokoloff Taylor and Zafman LLP
1279 Oakmead Parkway
Sunnyvale, CA 94086
United States of America

to represent the undersigned before

- ☒ all the competent International Authorities
- ☐ the International Searching Authority only
- ☐ the Authority specified for supplementary search only
  (please indicate the Authority(ies) specfied for supplementary search)
- ☐ the International Preliminary Examining Authority only

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1. _____ KERPEZ Kenneth	2. G. Ginis GINIS George	3. _____ GOLDBURG Marc	4. Ardavan Maleki Tehrani TEHRANI Ardavan Maleki
5. _____	6. _____	7. _____	8. _____
9. _____	10. _____	11. _____	12. _____

Date: 4/14/15

PCT

Power of Attorney

(for an international application filed under the Patent Cooperation Treaty)

(PCT Rule 90.4)

The undersigned applicant(s) (Names should be indicated as they appear in the Request Form (PCT/RO/101):

1.	KERPEZ Kenneth	7.	
2.	GINIS George	8.	
3.	GOLDBURG Marc	9.	
4.	TEHRANI Ardavan Maleki	10.	
5.		11.	
6.		12.	

hereby appoints (appoint) the following person as: ☒ agent ☐ common representative

Name and Address

(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

Gregory D. Caldwell, Reg. No. 39926; Spencer K. Hunter, Reg. No. 67337

Blakely Sokoloff Taylor and Zafman LLP
1279 Oakmead Parkway
Sunnyvale, CA 94086
United States of America

to represent the undersigned before

☒ all the competent International Authorities

☐ the International Searching Authority only

☐ the Authority specified for supplementary search only
(please indicate the Authority(ies) specfied for supplementary search)

☐ the International Preliminary Examining Authority only

in connection with the international application identified below:

Title of the Invention: MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER

Applicant's or agent's file reference: 8241P074PCT

International application number (if already available): PCT/US2012/060115

filed with the following Office United States of America (US) as receiving Office and to make or receive payments on behalf of the undersigned.

Signature of the applicant(s) *(where there are several applicants, each of them must sign; next to each signature, indicate the name of the person sign and the capacity in which the person signs, if such capacity is not obvious from reading the request or this power):*

1. _____ KERPEZ Kenneth	2. _____ GINIS George	3. _____ GOLDBURG Marc	4. _____ TEHRANI Ardavan Maleki
5. _____	6. _____	7. _____	8. _____
9. _____	10. _____	11. _____	12. _____

Date: _____

Electronic Acknowledgement Receipt

EFS ID:	22882960
Application Number:	14417544
International Application Number:	
Confirmation Number:	8970
Title of Invention:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
First Named Inventor/Applicant Name:	Kenneth Kerpez
Customer Number:	8791
Filer:	Gregory D. Caldwell/Lisa Bennett
Filer Authorized By:	Gregory D. Caldwell
Attorney Docket Number:	8241P074
Receipt Date:	10-JUL-2015
Filing Date:	26-JAN-2015
Time Stamp:	16:31:10
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Oath or Declaration filed	8241P074_Declarations_Signed.pdf	411344 9094078d27773eeeee4e52054d0f79298eb5feeb	no	4

Warnings:	
Information:	

2	Power of Attorney	8241P074_POA_Signed.pdf	196151 fc18bb751b1c5e6f28c445a953a36fba31a98b9a	no	3

Warnings:	
Information:	
Total Files Size (in bytes):	607495

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER

As the below named inventor, I hereby declare that:

This declaration is directed to:

☐ The attached application, or

☒ United States application or PCT international application number **PCT/US2012/060115** filed on **10/12/2012**.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

WARNING:

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

LEGAL NAME OF INVENTOR

Inventor: **Kenneth KERPEZ** Date (Optional): MARCH 26, 2015

Signature: _____

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
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Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER

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This declaration is directed to:

☐ The attached application, or

☒ United States application or PCT international application number **PCT/US2012/060115** filed on **10/12/2012**.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

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LEGAL NAME OF INVENTOR

Inventor: **George GINIS** Date (Optional): 4/13/2015

Signature: G. Ginis

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

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☐ The attached application, or

☒ United States application or PCT international application number **PCT/US2012/060115** filed on **10/12/2012**.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

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LEGAL NAME OF INVENTOR

Inventor: **Marc GOLDBURG** Date (Optional): 26 March 2015

Signature:

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER

As the below named inventor, I hereby declare that:

This declaration is directed to:

☐ The attached application, or

☒ United States application or PCT international application number **PCT/US2012/060115** filed on **10/12/2012**.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

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LEGAL NAME OF INVENTOR

Inventor: **Ardavan Maleki TEHRANI** Date (Optional): 4/14/15

Signature: Ardavan Maleki Teh

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/417,544	01/26/2015	Kenneth Kerpez	8241P074

CONFIRMATION NO. 8970

IMPROPER CPOA LETTER

8791
BLAKELY SOKOLOFF TAYLOR & ZAFMAN
1279 Oakmead Parkway
Sunnyvale, CA 94085-4040

OC000000076391609

Date Mailed: 07/20/2015

NOTICE REGARDING POWER OF ATTORNEY

This is in response to the power of attorney filed 07/10/2015. The power of attorney in this application is not accepted for the reason(s) listed below:

- The power of attorney from the inventors has not been accepted because the power of attorney must be signed by the applicant for patent. See 37 CFR 1.32(b)(4).

/dtdinh/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

IPR2025-00451
Petitioners' Exhibit 1002
Page 220 of 511

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14/417,544	01/26/2015	Kenneth Kerpez	8241P074

CONFIRMATION NO. 8970

8791
BLAKELY SOKOLOFF TAYLOR & ZAFMAN
1279 Oakmead Parkway
Sunnyvale, CA 94085-4040

PUBLICATION NOTICE

OC000000076584459

Title:MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER

Publication No.US-2015-0215059-A1
Publication Date:07/30/2015

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

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IPR2025-00451
Petitioners' Exhibit 1002
Page 221 of 511

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POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

■ Practitioners associated with Customer Number: 08791

OR

☐ Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

■ The address associated with Customer Number: 08791

OR

☐	Firm or Individual Name			
	Address			
	City		State	Zip
	Country			
	Telephone		Email	

Assignee Name and Address: Adaptive Spectrum and Signal Alignment, Inc.
333 Twin Dolphin Drive
Redwood City, CA 94065

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be Filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of The practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature	Ardavan Maleki Tehrani	Date	6/29/2015
Name	Ardavan Maleki Tehrani	Telephone	
Title	SVP Technology Strategy		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: Adaptive Spectrum and Signal Alignment, Inc.

Application No./Patent No.: 14/417,544 Filed/Issue Date: 01/26/2015

Titled: MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER

Adaptive Spectrum and Signal Alignment, Inc., a corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.

2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):

   ☐ The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

   ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

A. ☑ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel 036060, Frame 0589, or for which a copy thereof is attached.

B. ☐ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: _____ To: _____

   The document was recorded in the United States Patent and Trademark Office at

   Reel _____, Frame _____, or for which a copy thereof is attached.

2. From: _____ To: _____

   The document was recorded in the United States Patent and Trademark Office at

   Reel _____, Frame _____, or for which a copy thereof is attached.

This collection of information is required by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450**.

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STATEMENT UNDER 37 CFR 3.73(c)

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5. From: _____ To: _____

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The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☑ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Gregory D. Caldwell/	October 2, 2015
Signature	Date
Gregory D. Caldwell	39,926
Printed or Typed Name	Title or Registration Number

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	8241P074
	Application Number	
Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Kenneth		Kerpez	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Longvalley	State/Province	NJ	Country of Residence	US

Mailing Address of Inventor:

Address 1	150 Old Farmers Road		
Address 2			
City	Longvalley	State/Province	NJ
Postal Code	07853	Country	US

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	George		Ginis	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	San Mateo	State/Province	CA	Country of Residence	US

Mailing Address of Inventor:

Address 1	735 Folkstone Avenue		
Address 2			
City	San Mateo	State/Province	CA
Postal Code	94402	Country	US

Inventor 3 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Marc		Goldburg	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	8241P074
	Application Number	
Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	

City	Redwood City	State/Province	CA	Country of Residence	US

Mailing Address of Inventor:

Address 1	226 Hillsdale Way		
Address 2			
City	Redwood City	State/Province	CA
Postal Code	94062	Country	US

Inventor 4 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Ardavan	Maleki	Tehrani	

Residence Information (Select One) (•) US Residency ( ) Non US Residency ( ) Active US Military Service

City	~~Menlo Park~~ **Stanford**	State/Province	CA	Country of Residence	US

Mailing Address of Inventor:

Address 1	~~350 Sharon Park Drive, R 24~~ **P.O. Box 19677**		
Address 2			
City	~~Menlo Park~~ **Stanford**	State/Province	CA
Postal Code	~~94025~~ **94309**	Country	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	08791		
Email Address		Add Email	Remove Email

Application Information:

Title of the Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER		
Attorney Docket Number	8241P074	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	6	Suggested Figure for Publication (if any)	

Filing By Reference :

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	8241P074
	Application Number	
Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	08791		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the application number blank.

Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	a 371 of international	PCT/US2012/060115	2012-10-12
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
PCT/US2012/060115	Claims benefit of provisional	61676862	2012-07-27

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

PTO/AIA/14 (12-13)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	8241P074
	Application Number	
Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(d). When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(h)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Authorization to Permit Access:

☒ Authorization to Permit Access to the Instant Application by the Participating Offices

PTO/AIA/14 (12-13)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	8241P074
	Application Number	
Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	

If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the instant patent application is filed access to the instant patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the instant patent application is filed to have access to the instant patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date o f filing this Authorization.

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

◉ Assignee	○ Legal Representative under 35 U.S.C. 117	○ Joint Inventor
○ Person to whom the inventor is obligated to assign.	○ Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor :

If the Applicant is an Organization check here. ☒

Organization Name	Adaptive Spectrum and Signal Alignment, Inc.

Mailing Address Information For Applicant:

Address 1	~~ASSIA, INC.~~ Adaptive Spectrum and Signal Alignment, Inc.		
Address 2			
City	Redwood City	**State/Province**	CA
Country	US	Postal Code	94065-1417
Phone Number		Fax Number	

IPR2025-00451
Petitioners' Exhibit 1002

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	8241P074
	Application Number	
Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	

Email Address	

Additional Applicant Data may be generated within this form by selecting the Add button.

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not subsitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication . An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.

Signature:

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Signature	/Gregory D. Caldwell/			Date (YYYY-MM-DD)	2015-10-02
First Name	Gregory D.	Last Name	Caldwell	Registration Number	39926

Additional Signature may be generated within this form by selecting the Add button.

PTO/AIA/14 (12-13)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	8241P074
	Application Number	
Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Electronic Acknowledgement Receipt

EFS ID:	23682013
Application Number:	14417544
International Application Number:	
Confirmation Number:	8970
Title of Invention:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
First Named Inventor/Applicant Name:	Kenneth Kerpez
Customer Number:	8791
Filer:	Gregory D. Caldwell/Lisa Bennett
Filer Authorized By:	Gregory D. Caldwell
Attorney Docket Number:	8241P074
Receipt Date:	02-OCT-2015
Filing Date:	26-JAN-2015
Time Stamp:	17:45:16
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	8241P074_POA.pdf	89045 3fabab137613760b5481af322cca6bf59f447db6	no	1

Warnings:	
Information:	

2	Assignee showing of ownership per 37 CFR 3.73	8241P074_373c.pdf	41665 2c4dec643bd80a352c04d7627d3dd55021e7832c	no	2
Warnings:					
Information:					
3	Application Data Sheet	8241P074_ADS.pdf	60252 36c63c16925b38f680ff806ba534b0916467b295	no	7
Warnings:					
Information:					
This is not an USPTO supplied ADS fillable form					
			Total Files Size (in bytes):	190962	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/417,544	01/26/2015	Kenneth Kerpez	8241P074

CONFIRMATION NO. 8970

POWER OF ATTORNEY NOTICE

8791
BLAKELY SOKOLOFF TAYLOR & ZAFMAN
1279 Oakmead Parkway
Sunnyvale, CA 94085-4040

OC00000078084344

Date Mailed: 10/16/2015

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 10/02/2015.

- The Power of Attorney to you in this application has been revoked by the applicant. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/vvan/

IPR2025-00451
Petitioners' Exhibit 1002
Page 234 of 511

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/417,544	01/26/2015	Kenneth Kerpez	8241P074

CONFIRMATION NO. 8970

POA ACCEPTANCE LETTER

8791
BLAKELY SOKOLOFF TAYLOR & ZAFMAN
1279 Oakmead Parkway
Sunnyvale, CA 94085-4040

OC00000078084412

Date Mailed: 10/16/2015

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 10/02/2015.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/vvan/

IPR2025-00451
Petitioners' Exhibit 1002
Page 235 of 511

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
14/417,544	01/26/2015	2653	3640	8241P074	40	4

CONFIRMATION NO. 8970

REPLACEMENT FILING RECEIPT

8791
BLAKELY SOKOLOFF TAYLOR & ZAFMAN
1279 Oakmead Parkway
Sunnyvale, CA 94085-4040

OC000000078086308

Date Mailed: 10/16/2015

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Kenneth Kerpez, Longvalley, NJ;
George Ginis, San Mateo, CA;
Marc Goldburg, Redwood City, CA;
Ardavan Maleki Tehrani, Stanford, CA;

Applicant(s)

Adaptive Spectrum and Signal Alignment, Inc., Redwood City, CA;

Power of Attorney: The patent practitioners associated with Customer Number 08791

Domestic Priority data as claimed by applicant

This application is a 371 of PCT/US12/60115 10/12/2012
which claims benefit of 61/676,862 07/27/2012

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

If Required, Foreign Filing License Granted: 04/15/2015

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 14/417,544**

Projected Publication Date: Not Applicable

Non-Publication Request: No

Early Publication Request: No

IPR2025-00451
Petitioners' Exhibit 1002
Page 236 of 511

Title

MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER

Preliminary Class

379

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

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Petitioners' Exhibit 1002
Page 237 of 511

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

Doc Code: PET.POA.WDRW
Document Description: Petition to withdraw attorney or agent (SB83)

PTO/AIA/83 (04-13)
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REQUEST FOR WITHDRAWAL AS ATTORNEY OR AGENT AND CHANGE OF CORRESPONDENCE ADDRESS

Application Number	14/417,544
Filing Date	01-26-2015
First Named Inventor	Kenneth Kerpez
Art Unit	2653
Examiner Name	BEZUAYEHU, SOLOMON G.
Practitioner Docket Number	8241P074

To: Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Please withdraw me as attorney or agent for the above-identified patent application, and

- ☐ all the practitioners of record;
- ☐ the practitioners (with registration numbers) of record listed on the attached paper(s); or
- ☑ the practitioners of record associated with Customer Number: 08791

NOTE: The immediately preceding box should only be marked when the practitioners were appointed using the listed Customer Number.

The reason(s) for this request are those described in 37 CFR:

☐ 11.116(a)(1)	☐ 11.116(a)(2)	☐ 11.116(a)(3)
☐ 11.116(b)(1)	☐ 11.116(b)(2)	☐ 11.116(b)(3)
☐ 11.116(b)(4)	☑ 11.116(b)(5)	☑ 11.116(b)(6)

☐ 11. 116(b)(7) Please explain below:

Certifications

Check each box below that is factually correct. WARNING: If a box is left unchecked, the request will likely not be approved.

1. ☑ I/We have given reasonable notice to the client, prior to the expiration of the response period, that the practitioner(s) intend to withdraw from employment.
2. ☑ I/We have delivered to the client or a duly authorized representative of the client all papers and property (including funds) to which the client is entitled.
3. ☑ I/We have notified the client of any responses that may be due and the time frame within which the client must respond.

Please provide an explanation, if necessary:

This collection of information is required by 37 CFR 1.36. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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REQUEST FOR WITHDRAWAL AS ATTORNEY OR AGENT AND CHANGE OF CORRESPONDENCE ADDRESS

Complete the following section only when the correspondence address will change. *Changes of address will only be accepted to an applicant.*

Change the correspondence address and direct all future correspondence to:

A. ☐ The address of the applicant associated with Customer Number: _____

OR

B. ☑ Applicant

Address Adaptive Spectrum and Signal Alignment, Inc., 333 Twin Dolphin Drive

City	State	Zip	Country
Redwood City	CA	94065-1417	US

Telephone 650-654-3400 | Email

I am authorized to sign on behalf of myself and all withdrawing practitioners.

Signature /Gregory D. Caldwell/

Name Gregory D. Caldwell | Registration No. 39,926

Address 1279 Oakmead Parkway

City	State	Zip	Country
Sunnyvale	CA	94085-4040	US

Date November 18, 2015 | Telephone No. 503-439-8778

NOTE: Withdrawal is effective when approved rather than when received.

This collection of information is required by 37 CFR 1.36. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Electronic Acknowledgement Receipt

EFS ID:	24124968
Application Number:	14417544
International Application Number:	
Confirmation Number:	8970
Title of Invention:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
First Named Inventor/Applicant Name:	Kenneth Kerpez
Customer Number:	8791
Filer:	Gregory D. Caldwell/Lisa Bennett
Filer Authorized By:	Gregory D. Caldwell
Attorney Docket Number:	8241P074
Receipt Date:	18-NOV-2015
Filing Date:	26-JAN-2015
Time Stamp:	20:03:07
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Petition to withdraw attorney or agent (SB83)	8241P074_RFW.pdf	59666 42a1fcdf4f82482106a88cb6e57425812667b58d	no	2

Warnings:	
Information:	

Total Files Size (in bytes):	59666

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/AIA/80 (07-12)
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U.S. Patent and Trademark Office; U.S DEPARTMENT OF COMMERCE
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POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

☒ Practitioners associated with Customer Number: 136402

OR

☐ Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number

Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

☑ The address associated with Customer Number: 136402

OR

☐	Firm or Individual Name			
	Address			
	City		State	Zip
	Country			
	Telephone		Email	

Assignee Name and Address: Adaptive Spectrum and Signal Alignment, Inc.
333 Twin Dolphin Drive
Redwood City, CA 94065 US

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be Filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of The practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature	Ardavan M. Tehrani	Date	Nov. 4, 2015
Name	Ardavan Maleki Tehrani	Telephone	650-264-2629
Title	CTO		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Electronic Acknowledgement Receipt

EFS ID:	24707147
Application Number:	14417544
International Application Number:	
Confirmation Number:	8970
Title of Invention:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
First Named Inventor/Applicant Name:	Kenneth Kerpez
Customer Number:	8791
Filer:	Usman Mughal/Katherine Campbell
Filer Authorized By:	Usman Mughal
Attorney Docket Number:	8241P074
Receipt Date:	25-JAN-2016
Filing Date:	26-JAN-2015
Time Stamp:	16:02:14
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	03P074US_SADS.pdf	458914 8796893a098bc63f32a8c2f90eca3e031f657802	no	7

Warnings:	
Information:	

This is not an USPTO supplied ADS fillable form					
2	Power of Attorney	3_ASSIA_GHM_POA.pdf	1877487 e96df65000bb11516069106fa44f49e961505bb1	no	1
Warnings:					
Information:					
			Total Files Size (in bytes):	2336401	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	[8241P074]] 03.P074US
	Application Number	14/417,544
Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Kenneth		Kerpez	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Longvalley	State/Province	NJ	Country of Residence	US

Mailing Address of Inventor:

Address 1	150 Old Farmers Road		
Address 2			
City	Longvalley	State/Province	NJ
Postal Code	07853	Country	US

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	George		Ginis	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	San Mateo	State/Province	CA	Country of Residence	US

Mailing Address of Inventor:

Address 1	735 Folkstone Avenue		
Address 2			
City	San Mateo	State/Province	CA
Postal Code	94402	Country	US

Inventor 3 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Marc		Goldburg	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	[[8241P074]] 03.P074US
	Application Number	14/417,544
Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	

City	Redwood City	State/Province	CA	Country of Residence	US

Mailing Address of Inventor:

Address 1	226 Hillsdale Way		
Address 2			
City	Redwood City	State/Province	CA
Postal Code	94062	Country	US

Inventor 4 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Ardavan	Maleki	Tehrani	

Residence Information (Select One) (•) US Residency ( ) Non US Residency ( ) Active US Military Service

City	Stanford	State/Province	CA	Country of Residence	US

Mailing Address of Inventor:

Address 1	P.O. Box 19677		
Address 2			
City	Stanford	State/Province	CA
Postal Code	94309	Country	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	[[08791]] 136402		
Email Address	docketing@ghmip.com	Add Email	Remove Email

Application Information:

Title of the Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER		
Attorney Docket Number	[[8241P074]] 03.P074US	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	6	Suggested Figure for Publication (if any)	

Filing By Reference :

PTO/AIA/14 (12-13)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	[[8241P074]] 03.P074US
	Application Number	14/417,544
Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	[[08791]] 136402		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the application number blank.

Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
14/417,544	a 371 of international	PCT/US2012/060115	2012-10-12
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
PCT/US2012/060115	Claims benefit of provisional	61676862	2012-07-27

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	[8241P074]] 03.P074US
	Application Number	14/417,544
Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(d). When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(h)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Authorization to Permit Access:

☒ Authorization to Permit Access to the Instant Application by the Participating Offices

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	[8241P074]] 03.P074US
	Application Number	14/417,544
Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	

If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the instant patent application is filed access to the instant patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the instant patent application is filed to have access to the instant patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date o f filing this Authorization.

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

◉ Assignee	○ Legal Representative under 35 U.S.C. 117	○ Joint Inventor
○ Person to whom the inventor is obligated to assign.	○ Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor :

If the Applicant is an Organization check here. ☒

Organization Name	Adaptive Spectrum and Signal Alignment, Inc.

Mailing Address Information For Applicant:

Address 1	Adaptive Spectrum and Signal Alignment, Inc.		
Address 2			
City	Redwood City	**State/Province**	CA
Country	US	Postal Code	94065-1417
Phone Number		Fax Number	

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	[[8241P074]] 03.P074US
	Application Number	14/417,544
Title of Invention	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	

Email Address	

Additional Applicant Data may be generated within this form by selecting the Add button.

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not subsitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication . An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.

Signature:

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Signature	/Usman A. Mughal/			Date (YYYY-MM-DD)	2015-01-23
First Name	Usman	Last Name	Mughal	Registration Number	62887

Additional Signature may be generated within this form by selecting the Add button.

PTO/AIA/14 (12-13)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	[8241P074]] 03.P074US
	Application Number	14/417,544
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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/417,544	01/26/2015	Kenneth Kerpez	03.P074US

CONFIRMATION NO. 8970

POA ACCEPTANCE LETTER

136402
Green, Howard, & Mughal LLP
5 Centerpointe Dr.
Suite 400
LAKE OSWEGO, OR 97035

OC000000080373406

Date Mailed: 02/08/2016

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 01/25/2016.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/zabraha/

IPR2025-00451
Petitioners' Exhibit 1002
Page 253 of 511

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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P.O. Box 1450
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/417,544	01/26/2015	Kenneth Kerpez	8241P074

CONFIRMATION NO. 8970

POWER OF ATTORNEY NOTICE

8791
BLAKELY SOKOLOFF TAYLOR & ZAFMAN
1279 Oakmead Parkway
Sunnyvale, CA 94085-4040

OC000000080373354

Date Mailed: 02/08/2016

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 01/25/2016.

- The Power of Attorney to you in this application has been revoked by the applicant. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

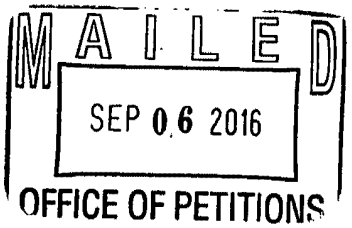
/zabraha/

IPR2025-00451
Petitioners' Exhibit 1002
Page 254 of 511

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BLAKELY SOKOLOFF TAYLOR & ZAFMAN
1279 OAKMEAD PARKWAY
SUNNYVALE, CA 94085-4040



In re Application of :
Kenneth KERPEZ et al. :
Application No. 14/417,544 : DECISION ON PETITION
Filing Date: January 26, 2015 : TO WITHDRAW
Attorney Docket No. 03.P074US FROM RECORD
:

This is a decision on the Request to Withdraw as attorney or agent under 37 C.F.R. § 1.36(b) or 37 C.F.R. § 10.40 filed November 18, 2015.

The request is **NOT APPROVED** as moot.

A review of the file record indicates that the power of attorney to Blakely Sokoloff Taylor & Zafman has been revoked by the applicant of the patent application on January 25, 2016. Accordingly, the request to withdraw under 37 C.F.R. § 1.36(b) is moot.

Telephone inquiries concerning this decision should be directed to the undersigned at 571-272-4231.

/Michelle R. Eason/
Michelle R. Eason
Paralegal Specialist
Office of Petitions

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/417,544	01/26/2015	Kenneth Kerpez	03.P074US	8970

136402 7590 09/12/2016

Green, Howard, & Mughal LLP
5 Centerpointe Dr.
Suite 400
LAKE OSWEGO, OR 97035

EXAMINER	
BEZUAYEHU, SOLOMON G	

ART UNIT	PAPER NUMBER
2653	

NOTIFICATION DATE	DELIVERY MODE
09/12/2016	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

docketing@ghmip.com

Office Action Summary	Application No. 14/417,544	Applicant(s) KERPEZ ET AL.	
	Examiner SOLOMON BEZUAYEHU	Art Unit 2653	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 2 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *01/26/2016*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *1-40* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☐ Claim(s) _____ is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☒ Claim(s) *1-40* are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

Detail action

Election/Restrictions

1. Restriction to one of the following inventions is required under 35 U.S.C. 121:

I. Claims 1-39, drawn to *scheduling different upstream and downstream time slots for different channels,* classified in class 379, subclass 406.01.

II. Claim 40 drawn to *full duplex where upstream and downstream time slots occurs at the same time,* classified in class 379, subclass 406.01.

2. Inventions group I and II are related as subcombinations disclosed as usable together in a single combination. The subcombinations are distinct if they do not overlap in scope and are not obvious variants, and if it is shown that at least one subcombination is separately usable. In the instant case, subcombination group I has separate utility such as *different time slot different channels* and subcombination group II has a separate utility such as *same time slots same channels*. See MPEP § 806.05(d).

The examiner has required restriction between subcombinations usable together. Where applicant elects a subcombination and claims thereto are

subsequently found allowable, any claim(s) depending from or otherwise requiring all the limitations of the allowable subcombination will be examined for patentability in accordance with 37 CFR 1.104. See MPEP § 821.04(a). Applicant is advised that if any claim presented in a continuation or divisional application is anticipated by, or includes all the limitations of, a claim that is allowable in the present application, such claim may be subject to provisional statutory and/or nonstatutory double patenting rejections over the claims of the instant application.

3. Restriction for examination purposes as indicated is proper because all these inventions listed in this action are independent or distinct for the reasons given above and there would be a serious search and examination burden if restriction were not required because one or more of the following reasons apply:

(a) the inventions have acquired a separate status in the art in view of their different classification;

(b) the inventions have acquired a separate status in the art due to their recognized divergent subject matter;

(c) the inventions require a different field of search (for example, searching different classes/subclasses or electronic resources, or employing different search queries);

(d) the prior art applicable to one invention would not likely be applicable to another invention;

(e) the inventions are likely to raise different non-prior art issues under 35 U.S.C. 101 and/or 35 U.S.C. 112, first paragraph.

Applicant is advised that the reply to this requirement to be complete must include (i) an election of a invention to be examined even though the requirement may be traversed (37 CFR 1.143) **and (ii) identification of the claims encompassing the elected invention**.

The election of an invention may be made with or without traverse. To reserve a right to petition, the election must be made with traverse. If the reply does not distinctly and specifically point out supposed errors in the restriction requirement, the election shall be treated as an election without traverse. Traversal must be presented at the time of election in order to be considered timely. Failure to timely traverse the requirement will result in the loss of right to petition under 37 CFR 1.144. If claims are added after the election,

applicant must indicate which of these claims are readable on the elected invention.

If claims are added after the election, applicant must indicate which of these claims are readable upon the elected invention.

Should applicant traverse on the ground that the inventions are not patentably distinct, applicant should submit evidence or identify such evidence now of record showing the inventions to be obvious variants or clearly admit on the record that this is the case. In either instance, if the examiner finds one of the inventions unpatentable over the prior art, the evidence or admission may be used in a rejection under 35 U.S.C. 103(a) of the other invention.

4. A telephone call was made to applicant's representative, Ardavan Tehrani, of record to request an oral election to the above restriction requirement, but did not result in an election being made.

Conclusion

5. Any inquiry concerning this communication or earlier communications from the examiner should be directed to SOLOMON BEZUAYEHU whose telephone number is (571)270-7452. The examiner can normally be reached on Monday through Friday 9 a.m-4 p.m.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, FAN TSANG can be reached on 571-272-7547. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/SOLOMON BEZUAYEHU/
Examiner, Art Unit 2614

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14/417,544
	Filing Date	Jan 26, 2015
	First Named Inventor	Kenneth Kerpez
	Art Unit	2653
	Examiner Name	BEZUAYEHU, SOLOMON G
	Attorney Docket Number	03.P074US

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		6480475		2002-11-12	MODLIN et al.	

U.S.PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		2003086362		2003- 05-08	HASEGAWA et al.	
		2005122999		2005-06-09	SCHERZER et al.	
		2009082064		2009-03-26	LI et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
		2254807	CA		2000- 05-30	BINGHAM et al.		
		1011206	EP		2000-06-21	NORTEL NETWORKS CORP		

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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	Application Number	14/417,544
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	First Named Inventor	Kenneth Kerpez
	Art Unit	2653
	Examiner Name	BEZUAYEHU, SOLOMON G
	Attorney Docket Number	03.P074US

NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
		Examination Report, mailed 07/17/15, for Australian Patent Application No. 2012385953 (Attorney Docket No. 01.P074AU).	
		International Preliminary Report on Patentability, mailed 07/27/12, for PCT Patent Application No. PCT/US12/60115 (Attorney Docket No. 03.P074PCT).	
		International Search Report and Written Opinion, mailed 05/02/13, for PCT Patent Application No. PCT/US12/60115 (Attorney Docket No. 03.P074PCT).	
		Reasons for Rejection, mailed 01/05/16, for JP Patent Application No. 2015-52424 (Attorney Docket No. 03.P074JP), no translation available.	

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document.
[4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14/417,544
	Filing Date	Jan 26, 2015
	First Named Inventor	Kenneth Kerpez
	Art Unit	2653
	Examiner Name	BEZUAYEHU, SOLOMON G
	Attorney Docket Number	03.P074US

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e) (1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e) (2).

☐ See attached certification statement.

X Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Usman A. Mughal/	Date (YYYY-MM-DD)	2016-11-14
Name/Print	Usman Mughal	Registration Number	62887

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor: **Kenneth Kerpez**	Examiner: **BEZUAYEHU, SOLOMON G**
Application No.: 14/417,544	Art Group: 2653
Filed: 26 January 2015	Confirmation No.: 8970
For: MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	Docket No.: 03.P074US

Mail Stop
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

RESPONSE TO RESTRICTION REQUIREMENT

Dear Examiner:

This Amendment is in response to the Restriction Requirement of 12 September 2016. Applicants respectfully request the Examiner to enter this Amendment and consider the following remarks.

LISTING OF CLAIMS

1. (Original) A method in a data communications system for managing multiple time division physical channels that are subject to crosstalk, the method comprising scheduling upstream time slots for upstream transmission in a first physical channel; and scheduling downstream time slots for downstream transmission in a second physical channel, wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots.

2. (Original) The method of Claim 1, wherein scheduling downstream time slots comprises allowing some simultaneous transmission in the upstream and downstream time slots, the method further comprising cancelling near-end crosstalk (NEXT) from downstream into upstream transmission at a network end of the channels.

3. (Original) The method of Claim 1, wherein the upstream and downstream time slots have an active portion during which signals are transmitted and an off portion during which no signals are transmitted and wherein the active portions of the upstream time slots are substantially not simultaneous with the active portions of the downstream time slots.

4. (Original) The method of Claim 1, wherein scheduling upstream and downstream time slots comprises scheduling upstream and downstream time slot boundaries.

5. (Original) The method of Claim 4, wherein the time slot boundaries are flexible. 6. The method of Claim 5, wherein the time slot boundaries have one or more of: variable-length frames; variable upstream time slot lengths; and variable downstream time slot- lengths.

7. (Original) The method of Claim 1, further comprising assigning time slots to a network element based on the scheduling and transmitting the assignments from a management system to a network element.

8. (Original) The method of Claim 1, further comprising adapting scheduling at least one of upstream and downstream time slots to accommodate delay requirements for the other of a downstream and upstream traffic source.

9. (Original) The method of Claim 1, further comprising receiving input on desired traffic levels for the first and second physical channels and wherein scheduling upstream and downstream time slots is performed based on the received input.

10. (Original) The method of Claim 9, wherein a portion of a downstream time slot is invariant and a portion of a downstream time slot varies in real-time.

11. (Original) The method of Claim 9, wherein the received input comprises at least one of static subscription data, service layer information from a policy manager, behavior data for traffic types and users of the physical channels, long term traffic behavior data as a function of time, current traffic demands, queue lengths, traffic requests, upstream/downstream asymmetry, and traffic descriptors.

12. (Original) The method of Claim 9, wherein scheduling upstream and downstream time slots comprises assigning time slots to achieve a target upstream/downstream asymmetry ratio of data throughput.

13. (Original) The method of Claim 12, wherein the upstream/downstream asymmetry ratio is defined in numbers of discrete multi-tone symbol positions

14. (Original) The method of Claim 12, wherein the measure of throughput is at least one of an average throughput across all lines, a traffic demand match, a minimum throughput for each physical channel, a perceived quality of experience, an average delay, and a minimum delay.

15. (Original) The method of Claim 1, wherein scheduling upstream and downstream time slots comprises assigning time slots based at least in part on power usage.

16. (Original) The method of Claim 15, wherein assigning time slots based on power usage comprises assigning by scheduling entries, exits, and transitions between low-power link states and off states.

17. (Original) The method of Claim 15, wherein assigning time slots based on power usage includes assigning at least one network element to a receive-only mode, with a transmitter of the network element turned off.

18. (Original) The method of Claim 10, wherein scheduling upstream and downstream time slots comprises assigning time slots using an optimization criteria that weights different factors.

19. (Original) The method of Claim 18, wherein receiving input comprises receiving input from an external controller.

20. (Original) The method of Claim 19, wherein the received input comprises at least one of Operations Support System (OSS) data, Element Management System (EMS) data, and Management Information Database (MIB) parameters.

21. (Original) The method of Claim 10, wherein the time slots are defined within a time division frame, wherein receiving input comprises receiving input during a frame, and wherein scheduling upstream and downstream time slots comprises scheduling upstream and downstream time slots of an immediately subsequent frame.

22. (Original) The method of Claim 1, further comprising receiving requests for upstream and downstream transmission and wherein scheduling upstream time slots is based on the received upstream transmission requests.

23. (Original) The method of Claim 1, wherein the transmission in the upstream time slots is from a plurality of different network-end transmission sources.

24. (Original) The method of Claim 23, further comprising synchronizing upstream transmission and downstream transmission among a plurality of different network-end transmission sources.

25. (Original) The method of Claim 24, wherein synchronizing comprises sending synch symbols to a source of upstream transmissions.

26. (Original) The method of Claim 24, wherein synchronizing comprises measuring a time series of time-varying crosstalk and synchronizing to time-varying patterns of the crosstalk.

27. (Original) The method of Claim 24, wherein synchronizing is performed by measuring a time series of error events and synchronizing to time-varying patterns of the error events.

28. (Original) The method of Claim 1, wherein scheduling upstream and downstream time slots comprises determining a duration of the upstream and downstream time slots and moving the upstream and downstream time slot start times to reduce simultaneous upstream and downstream transmission.

29. (Original) The method of Claim 28, wherein determining a duration comprises adjusting a default duration based on bandwidth requests.

30. (Original) The method of Claim 28, wherein moving comprises moving only if upstream transmissions overlap downstream transmissions in time.

31. (Original) The method of Claim 28, further comprising reducing the duration of at least one downstream time slot to reduce simultaneous upstream and downstream transmission.

32. (Original) The method of Claim 1, wherein the scheduling upstream and downstream time slot is further performed to minimize crosstalk on nearby VDSL2 lines.

33. (Original) The method of Claim 1, further comprising receiving input on desired traffic levels for the first and second physical channels and wherein scheduling upstream and downstream time slots is performed based on the received input and at least in part on power usage.

34. (Original) A machine-readable medium having instructions that when operated on by the machine cause the machine to perform operations comprising: scheduling upstream time slots for upstream transmission in a first physical channel of multiple time division physical channels in a data communication system in which the physical channels are subject to crosstalk; and

scheduling downstream time slots for downstream transmission in a second physical channel subject to crosstalk from the upstream time slots, wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots.

35. (Original) The medium of Claim 34, the operations further comprising receiving input on desired traffic levels for the first and second physical channels and wherein scheduling upstream and downstream time slots is performed based on the received input.

36. (Original) The medium of Claim 34, wherein scheduling upstream and downstream time slots comprises assigning time slots to achieve a target upstream/downstream asymmetry ratio of data throughput.

37. (Original) An apparatus for managing multiple time division physical channels in a data communications system that are subject to crosstalk, the apparatus comprising means for scheduling upstream time slots for upstream transmission in a first physical channel; and means for scheduling downstream time slots for downstream transmission in a second physical channel subject to crosstalk from the upstream time slots, wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots.

38. (Original) The apparatus of Claim 37, further comprising means for assigning at least one network element to a receive-only mode, with a transmitter of the network element turned off.

39. (Original) The apparatus of Claim 37, further comprising means for receiving requests for upstream and downstream transmission for use by the means for scheduling.

40. (Withdrawn) A system with multiple physical channels in a data communications system transmitting point-to-multipoint over multiple copper wires that are subject to crosstalk, wherein the system allows full-duplex operation by using line hybrids and echo cancellation to separate upstream transmission from downstream transmission, and near-end crosstalk (NEXT) is cancelled only at the network-end of the channels, from downstream into upstream transmission, wherein transmission in the upstream time slots may occur simultaneous with transmission in the downstream time slots.

REMARKS

In the Office Action mailed July 22, 2014, the Examiner has required that Applicants elect one of the following groups for examination:

I. Group I. Claims 1-39 which are allegedly drawn to scheduling different upstream and downstream time slots for different channels, classified in class 379, subclass 406.01; and

II. Group II. Claim 40 which is allegedly drawn to full duplex where upstream and downstream time slots occurs at the same time, classified in class 379, subclass 406.01.

ELECTION WITHOUT TRAVERSE

Applicants elect without traverse, to prosecute the claims of **Group I**, which corresponds to **Claims 1-39**. Applicants have withdrawn the remaining claim 40 corresponding to Group II.

CONCLUSION

Applicants submit that they have overcome Examiner's objections to and rejections of the claims and that they have the right to claim the invention as listed in the listing of claims. Examiner is respectfully requested to contact the undersigned by telephone if it is believed that such contact would further the examination of the present application.

Pursuant to 37 C.F.R. § 1.136(a)(3), Applicants request and authorize the U.S. Patent and Trademark Office to (1) treat any concurrent or future reply that requires a petition for extension of time as incorporating a petition for extension of time for the appropriate length of time and (2) charge all required fees, including extension of time fees and fees under 37 C.F.R. § 1.16 and § 1.17, to Deposit Account No. 50-6925.

Respectfully submitted,
GREEN, HOWARD, & MUGHAL, LLP

14 November 2016
Date

/Usman A. Mughal/
Usman A. Mughal
Reg. No. 62,887
Attorney for Applicants

5 Centerpointe Drive, Suite 400
Lake Oswego, OR 97035
(503) 968-8233
docketing@ghmip.com

Electronic Patent Application Fee Transmittal

Application Number:	14417544
Filing Date:	26-Jan-2015
Title of Invention:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
First Named Inventor/Applicant Name:	Kenneth Kerpez
Filer:	Usman Mughal/Katherine Campbell
Attorney Docket Number:	03.P074US

Filed as Large Entity

Filing Fees for U.S. National Stage under 35 USC 371

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt

EFS ID:	27494088
Application Number:	14417544
International Application Number:	
Confirmation Number:	8970
Title of Invention:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
First Named Inventor/Applicant Name:	Kenneth Kerpez
Customer Number:	136402
Filer:	Usman Mughal/Katherine Campbell
Filer Authorized By:	Usman Mughal
Attorney Docket Number:	03.P074US
Receipt Date:	14-NOV-2016
Filing Date:	26-JAN-2015
Time Stamp:	20:50:28
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$180
RAM confirmation Number	111516INTEFSW20513500
Deposit Account	
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Non Patent Literature	03P074AU_ExamRpt.pdf	992968 bc61c108e455047bc394ca32e1132fb839028965	no	3
Warnings:					
Information:					
2	Non Patent Literature	03P074JP_OA_01_05_16.pdf	940781 4662800ad5e6a43b2a648fa8baa12e9f389e2001	no	4
Warnings:					
Information:					
3	Non Patent Literature	03P074PCT_IPRP.pdf	1896559 5a049995aee8728659471e39afcbc63b75ce7d64	no	6
Warnings:					
Information:					
4	Non Patent Literature	03P074PCT_ISRWO.pdf	2305862 2cb7ddd354ecbb9b16394e040f20379167f50729	no	9
Warnings:					
Information:					
5	Foreign Reference	CA2254807A1.pdf	2040924 6b03ed4d63b87d984f7802a32f43acea5c4e67bc	no	48
Warnings:					
Information:					
6	Foreign Reference	EP1011206A2.pdf	880469 d2694cb64abfb101f637955a8c65c7c335504818	no	13
Warnings:					
Information:					

7	Information Disclosure Statement (IDS) Form (SB08)	03P074US_IDS.pdf	182044 b809c9d73546fc7b8585cffe6f911de715b86607	no	3
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
8		03P074US_RRR.pdf	118722 fb84f1bf1f8a2c356a63ebbcaf553994f6b9dd9d	yes	8

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Response to Election / Restriction Filed	1	1
	Claims	2	6
	Applicant Arguments/Remarks Made in an Amendment	7	8

Warnings:					
Information:					
9	Fee Worksheet (SB06)	fee-info.pdf	31061 29d8515de427ea7b6968848d28c0dab624d0a075	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	9389390	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT COOPERATION TREATY

ADVANCE E-MAIL

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING TRANSMITTAL OF COPY OF INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY (CHAPTER I OF THE PATENT COOPERATION TREATY)
(PCT Rule 44bis.1(c))

To:

VINCENT, Lester J.
Blakely Sokoloff Taylor & Zafman LLP
1279 Oakmead Parkway
Sunnyvale, California 94085
ETATS-UNIS D'AMERIQUE

Date of mailing *(day/month/year)*	
05 February 2015 (05.02.2015)	
Applicant's or agent's file reference	IMPORTANT NOTICE
8241P074PCT	

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2012/060115	12 October 2012 (12.10.2012)	27 July 2012 (27.07.2012)

Applicant
ADAPTIVE SPECTRUM AND SIGNAL ALIGNMENT, INC. et al

The International Bureau transmits herewith a copy of the international preliminary report on patentability (Chapter I of the Patent Cooperation Treaty)

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FEB 05 2015
BLAKELY SOKOLOFF TAYLOR ZAFMAN
SUNNYVALE

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FEB 05 2015
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FEB 05 2015
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Entered into FIP
By:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. +41 22 338 82 70

Authorized officer
Philippe Bécamel

e-mail: pt03.pct@wipo.int

IPR2025-00451
Petitioners' Exhibit 1002
Page 279 of 511

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter I of the Patent Cooperation Treaty)

(PCT Rule 44*bis*)

Applicant's or agent's file reference 8241P074PCT	**FOR FURTHER ACTION**	See item 4 below
International application No. PCT/US2012/060115	International filing date *(day/month/year)* 12 October 2012 (12.10.2012)	Priority date *(day/month/year)* 27 July 2012 (27.07.2012)
International Patent Classification (8th edition unless older edition indicated) See relevant information in Form PCT/ISA/237		
Applicant ADAPTIVE SPECTRUM AND SIGNAL ALIGNMENT, INC.		

1. This international preliminary report on patentability (Chapter I) is issued by the International Bureau on behalf of the International Searching Authority under Rule 44 *bis*.1(a).

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   In the attached sheets, any reference to the written opinion of the International Searching Authority should be read as a reference to the international preliminary report on patentability (Chapter I) instead.

3. This report contains indications relating to the following items:

☒	Box No. I	Basis of the report
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application

4. The International Bureau will communicate this report to designated Offices in accordance with Rules 44*bis*.3(c) and 93*bis*.1 but not, except where the applicant makes an express request under Article 23(2), before the expiration of 30 months from the priority date (Rule 44*bis* .2).

	Date of issuance of this report 27 January 2015 (27.01.2015)
The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. +41 22 338 82 70	Authorized officer Philippe Bécamel e-mail: pt03.pct@wipo.int

Form PCT/IB/373 (January 2004)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:

see form PCT/ISA/220

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY
(PCT Rule 43*bis*.1)

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2012/060115	12.10.2012	27.07.2012

International Patent Classification (IPC) or both national classification and IPC
INV. H04M11/06 H04B3/46

Applicant
ASSIA, INC.

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA:	Date of completion of this opinion	Authorized Officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Fax: +49 89 2399 - 4465	see form PCT/ISA/210	Ohanovici, Z Telephone No. +49 89 2399-8035

Form PCT/ISA/237 (Cover Sheet) (July 2009)

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43bis.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing filed or furnished:

   a. (means)

      ☐ on paper

      ☐ in electronic form

   b. (time)

      ☐ in the international application as filed

      ☐ together with the international application in electronic form

      ☐ subsequently to this Authority for the purposes of search

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	8, 22, 33, 35, 36, 38, 39
	No:	Claims	1-7, 9-21, 23-32, 34, 37, 40
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-40
Industrial applicability (IA)	Yes:	Claims	1-40
	No:	Claims	

2. Citations and explanations

see separate sheet

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Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 Reference is made to the following document:

D1 CA 2 254 807 A1 (AMATI COMM CORP [US]) 30 May 2000 (2000-05-30)

D2 US 6 480 475 B1 (MODLIN CORY S [US] ET AL) 12 November 2002 (2002-11-12)

D3 US 2003/086362 A1 (HASEGAWA KAZUTOMO [JP] ET AL) 8 May 2003 (2003-05-08)

D4 EP 1 011 206 A2 (NORTEL NETWORKS CORP [CA] NORTEL NETWORKS LTD [CA]) 21 June 2000 (2000-06-21)

D5 US 2009/082064 A1 (LI QINGHUA [US] ET AL) 26 March 2009 (2009-03-26)

D6 US 2005/122999 A1 (SCHERZER SHIMON B [US] ET AL) 9 June 2005 (2005-06-09)

2 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 1 is not new in the sense of Article 33(2) PCT.

D1 discloses a method in a data communications system for managing multiple time division physical channels (page 6, lines 7-9: "time division duplexed system") that are subject to crosstalk, the method comprising

scheduling upstream time slots for upstream transmission in a first physical channel (page 6, line 7-9: "upstream signals are alternated with downstream signals"); and

scheduling downstream time slots for downstream transmission in a second physical channel (page 6, lines 7-9: "share a channel... between two or more transceivers"),

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Petitioners' Exhibit 1002
Page 283 of 511

wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots (page 6, lines 33-35: "in a synchronized TDD system, it is important that synchronization be established and maintained so that crosstalk is mitigated", page 6, lines 7-9: "the upstream and the downstream transmissions are separated by a guard period").

3 The same reasoning applies, mutatis mutandis, to the subject-matter of the corresponding independent claims 34 and 37, which therefore are also considered not new (Articles 33(1) and 33(2) PCT).

4 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 40 is not new in the sense of Article 33(2) PCT.

D3 discloses a system with multiple physical channels (figure 2: Channel 270 (1)...270(h+L)) in a data communications system transmitting point-to-multipoint (paragraph [0037]: "Vectored-DMT") over multiple copper wires that are subject to crosstalk, wherein the system allows full-duplex operation by using line hybrids and echo cancellation to separate upstream transmission from downstream transmission (claim 1: "synchronized TDD DSL system"), and

near-end crosstalk is cancelled only at the network-end of the channels, from downstream into upstream transmission (claim 1: "removing NEXT interference in the primary signal") ,

wherein transmission in the upstream time slots may occur simultaneous with transmission in the downstream time slots (paragraph [0034]: "received SSDSL signal can be affected by NEXT from one or more ADSL or VDSL transmit signals").

5 Dependent claims 2-33, 35, 36 and 38-39 do not seem to introduce any inventive features (Articles 33(1) and 33(3) PCT). The features introduced by this claims are merely one of several straightforward possibilities, known from the documents cited in the search report, from which the skilled person would select, in accordance with circumstances, without the exercise of inventive skill, in order to solve the problem posed.

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Petitioners' Exhibit 1002
Page 284 of 511

PATENT COOPERATION TREATY

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MAY 03 2013
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From the INTERNATIONAL SEARCHING AUTHORITY

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

To:
Vincent, Lester J.
BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP
1279 Oakmead Parkway
Sunnyvale CA 94085-4040
ETATS-UNIS D'AMERIQUE

Date of mailing *(day/month/year)*: 2 May 2013 (02-05-2013)

Applicant's or agent's file reference: 8241P074PCT

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SUNNYVALE
MAY 0 9 2013
BLAKELY SOKOLOFF
TAYLOR & ZAFMAN

FOR FURTHER ACTION See paragraphs 1 and 4 below

International application No.: PCT/US2012/060115

International filing date *(day/month/year)*: 12 October 2012 (12-10-2012)

Applicant: ASSIA, INC.

1. [X] The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

   Filing of amendments and statement under Article 19:
   The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

   When? The time limit for filing such amendments is normally two months from the date of transmittal of the International Search Report.

   Where? Directly to the International Bureau of WIPO, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Fascimile No.: (41-22) 338.82.70

   For more detailed instructions, see *PCT Applicant's Guide*, International Phase, paragraphs 9.004 - 9.011.

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02 2013
FIP DEPT.

2. [ ] The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

Entered into FII
By:

3. [ ] **With regard to any protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

   [ ] the protest together with the decision thereon has been transmitted to the International Bureau together with any request to forward the texts of both the protest and the decision thereon to the designated Offices.

   [ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. Following the expiration of 30 months from the priority date, these comments will also be made available to the public.

Shortly after the expiration of **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before completion of the technical preparations for international publication (Rules 90*bis*.1 and 90*bis*.3).

Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices.

In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months.

For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the *PCT Applicant's Guide*, National Chapters.

Name and mailing address of the International Searching Authority:
European Patent Office, P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk
Tel. (+31-70) 340-2040
Fax: (+31-70) 340-3016

Authorized officer:
MEISTER, Pia
Tel: +49 (0)89 2399-5356

Form PCT/ISA/220 (July 2010)

Reported by agp 5/8/13
Entered refs 5/8/13 (agp)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
8241P074PCT		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/US2012/060115	12/10/2012	27/07/2012
Applicant		
ASSIA, INC.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 4 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of:

[X] the international application in the language in which it was filed

[ ] a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

b. [ ] This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).

c. [ ] With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. [ ] **Certain claims were found unsearchable** (See Box No. II)

3. [ ] **Unity of invention is lacking** (see Box No III)

4. With regard to the **title,**

[X] the text is approved as submitted by the applicant

[ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

[X] the text is approved as submitted by the applicant

[ ] the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority

6. With regard to the **drawings,**

a. the figure of the **drawings** to be published with the abstract is Figure No. 8

[X] as suggested by the applicant

[ ] as selected by this Authority, because the applicant failed to suggest a figure

[ ] as selected by this Authority, because this figure better characterizes the invention

b. [ ] none of the figures is to be published with the abstract

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Petitioners' Exhibit 1002
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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/060115

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04M11/06 H04B3/46
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B H04M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CA 2 254 807 A1 (AMATI COMM CORP [US]) 30 May 2000 (2000-05-30) abstract; figures 2-4,5B,11 page 6, line 7 - page 9, line 27 page 13, line 1 - line 3 page 14, line 7 - line 31 page 16, line 22 - line 29 page 20, line 29 - line 33 page 21, line 34 - line 36 page 23, line 1 - line 2 page 27, line 8 - line 14 -----	1-40
X	US 6 480 475 B1 (MODLIN CORY S [US] ET AL) 12 November 2002 (2002-11-12) abstract; figures 2A,2B,4 column 3, line 54 - column 8, line 8 column 10, line 54 - column 11, line 67 ----- -/--	1-40

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 April 2013	02/05/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Ohanovici, Z

2

Form PCT/ISA/210 (second sheet) (April 2005)

IPR2025-00451
Petitioners' Exhibit 1002
Page 287 of 511

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/060115

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003/086362 A1 (HASEGAWA KAZUTOMO [JP] ET AL) 8 May 2003 (2003-05-08)	1,2,32, 40
A	abstract; claims 1-7; figures 1A,2,5 paragraph [0009] - paragraph [0019] paragraph [0033] - paragraph [0035]	3-31, 33-39
A	EP 1 011 206 A2 (NORTEL NETWORKS CORP [CA] NORTEL NETWORKS LTD [CA]) 21 June 2000 (2000-06-21) abstract paragraph [0006] paragraph [0020] - paragraph [0025] paragraph [0041] - paragraph [0043]	15-17
X	US 2009/082064 A1 (LI QINGHUA [US] ET AL) 26 March 2009 (2009-03-26)	1-3,34, 37
A	abstract; figures 1,2A,2B,4 paragraph [0019] - paragraph [0021] paragraphs [0027], [0033], [0040]	4-33,35, 36,38-40
X	US 2005/122999 A1 (SCHERZER SHIMON B [US] ET AL) 9 June 2005 (2005-06-09)	1,4-7, 9-21, 28-31, 34,37
A	abstract; figures 1,3,6,8,9,12 paragraph [0009] - paragraph [0015] paragraphs [0045], [0047], [0063] paragraph [0086] - paragraph [0088]	2,3,8, 22-27, 32,33, 35,36, 38-40

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

IPR2025-00451
Petitioners' Exhibit 1002
Page 288 of 511

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2012/060115

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CA 2254807 A1	30-05-2000	CA 2254807 A1	30-05-2000
		DE 69829725 D1	19-05-2005
		DE 69829725 T2	09-02-2006
US 6480475 B1	12-11-2002	JP H11313044 A	09-11-1999
		US 6480475 B1	12-11-2002
US 2003086362 A1	08-05-2003	JP 2003174386 A	20-06-2003
		US 2003086362 A1	08-05-2003
EP 1011206 A2	21-06-2000	CA 2286541 A1	15-06-2000
		EP 1011206 A2	21-06-2000
		US 6353628 B1	05-03-2002
US 2009082064 A1	26-03-2009	NONE	
US 2005122999 A1	09-06-2005	CA 2548998 A1	23-06-2005
		US 2005122999 A1	09-06-2005
		US 2008227401 A1	18-09-2008
		WO 2005057944 A2	23-06-2005

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:

see form PCT/ISA/220

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY
(PCT Rule 43*bis*.1)

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2012/060115	12.10.2012	27.07.2012

International Patent Classification (IPC) or both national classification and IPC
INV. H04M11/06 H04B3/46

Applicant
ASSIA, INC.

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA:	Date of completion of this opinion	Authorized Officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Fax: +49 89 2399 - 4465	see form PCT/ISA/210	Ohanovici, Z Telephone No. +49 89 2399-8035

Form PCT/ISA/237 (Cover Sheet) (July 2009)

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43bis.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing filed or furnished:

   a. (means)

      ☐ on paper

      ☐ in electronic form

   b. (time)

      ☐ in the international application as filed

      ☐ together with the international application in electronic form

      ☐ subsequently to this Authority for the purposes of search

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	8, 22, 33, 35, 36, 38, 39
	No:	Claims	1-7, 9-21, 23-32, 34, 37, 40
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-40
Industrial applicability (IA)	Yes:	Claims	1-40
	No:	Claims	

2. Citations and explanations

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 Reference is made to the following document:

D1 CA 2 254 807 A1 (AMATI COMM CORP [US]) 30 May 2000 (2000-05-30)

D2 US 6 480 475 B1 (MODLIN CORY S [US] ET AL) 12 November 2002 (2002-11-12)

D3 US 2003/086362 A1 (HASEGAWA KAZUTOMO [JP] ET AL) 8 May 2003 (2003-05-08)

D4 EP 1 011 206 A2 (NORTEL NETWORKS CORP [CA] NORTEL NETWORKS LTD [CA]) 21 June 2000 (2000-06-21)

D5 US 2009/082064 A1 (LI QINGHUA [US] ET AL) 26 March 2009 (2009-03-26)

D6 US 2005/122999 A1 (SCHERZER SHIMON B [US] ET AL) 9 June 2005 (2005-06-09)

2 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 1 is not new in the sense of Article 33(2) PCT.

D1 discloses a method in a data communications system for managing multiple time division physical channels (page 6, lines 7-9: "time division duplexed system") that are subject to crosstalk, the method comprising

scheduling upstream time slots for upstream transmission in a first physical channel (page 6, line 7-9: "upstream signals are alternated with downstream signals"); and

scheduling downstream time slots for downstream transmission in a second physical channel (page 6, lines 7-9: "share a channel... between two or more transceivers"),

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wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots (page 6, lines 33-35: "in a synchronized TDD system, it is important that synchronization be established and maintained so that crosstalk is mitigated", page 6, lines 7-9: "the upstream and the downstream transmissions are separated by a guard period").

3 The same reasoning applies, mutatis mutandis, to the subject-matter of the corresponding independent claims 34 and 37, which therefore are also considered not new (Articles 33(1) and 33(2) PCT).

4 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 40 is not new in the sense of Article 33(2) PCT.

D3 discloses a system with multiple physical channels (figure 2: Channel 270 (1)...270(h+L)) in a data communications system transmitting point-to-multipoint (paragraph [0037]: "Vectored-DMT") over multiple copper wires that are subject to crosstalk, wherein the system allows full-duplex operation by using line hybrids and echo cancellation to separate upstream transmission from downstream transmission (claim 1: "synchronized TDD DSL system"), and

near-end crosstalk is cancelled only at the network-end of the channels, from downstream into upstream transmission (claim 1: "removing NEXT interference in the primary signal") ,

wherein transmission in the upstream time slots may occur simultaneous with transmission in the downstream time slots (paragraph [0034]: "received SSDSL signal can be affected by NEXT from one or more ADSL or VDSL transmit signals").

5 Dependent claims 2-33, 35, 36 and 38-39 do not seem to introduce any inventive features (Articles 33(1) and 33(3) PCT). The features introduced by this claims are merely one of several straightforward possibilities, known from the documents cited in the search report, from which the skilled person would select, in accordance with circumstances, without the exercise of inventive skill, in order to solve the problem posed.

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(19) Canadian Intellectual Property Office
An Agency of Industry Canada

Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

(11) CA 2 254 807 (13) A1

(43) 30.05.2000

(12)

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(51) Int. Cl.[6]: H04L 005/14, G11B 023/00, H04L 007/027

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(54) METHODE ET SYSTEME DE SYNCHRONISATION D'EMETTEURS-RECEPTEURS A DUPLEXAGE PAR REPARTITION DANS LE TEMPS

(54) METHOD AND SYSTEM FOR SYNCHRONIZING TIME-DIVISION-DUPLEXED TRANSCEIVERS

(57)

Improved techniques for synchronizing transmissions and receptions of a data transmission system utilizing time division duplexing is disclosed. The improved synchronization techniques utilize the time-varying nature of the energy of the received data to obtain synchronization. In one embodiment, an improved synchronization processing (500) measures energy (502) in n consecutive frames of received data. An alignment error estimate is then computed (504) based on the measured energy values for the n consecutive frames. In another embodiment, the improved synchronization technique uses the output signals from a multicarrier modulation unit (FFT unit) and thus provides the ability to avoid frequency tones that are susceptible to RF interference. The improved synchronization techniques can also utilize crosstalk interference levels to obtain synchronization. Remote receivers in the data transmission system are able to synchronize to central transmitters, central receivers in the data transmission system are able to synchronize to remote transmitters, and central transmitters are able to synchronize with one another.

OPIC
Office de la propriété intellectuelle du Canada

CIPO
Canadian Intellectual Property Office

(12) (19) (CA) **Demande-Application**

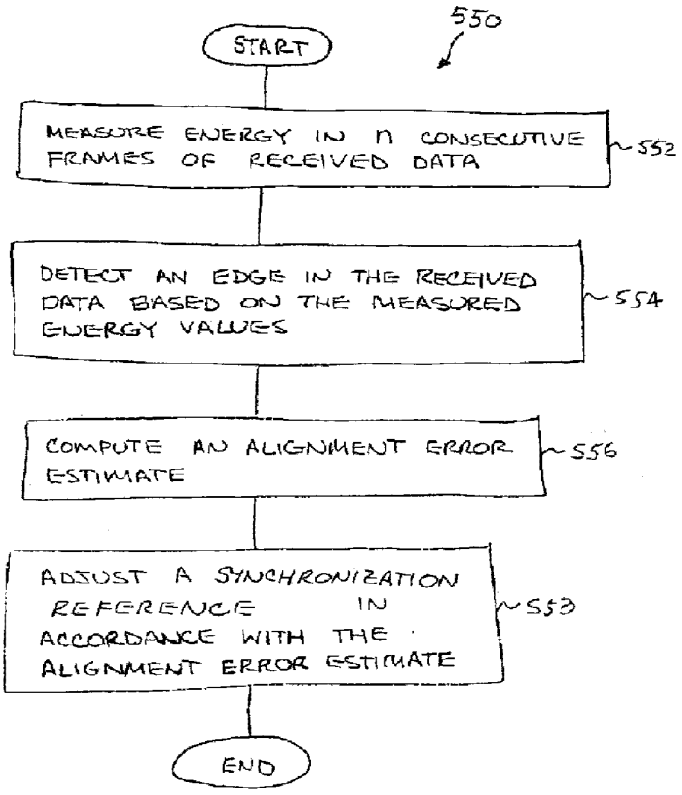
(21) (A1) **2,254,807**
(22) 1998/11/30
(43) 2000/05/30

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(54) **METHODE ET SYSTEME DE SYNCHRONISATION D'EMETTEURS-RECEPTEURS A DUPLEXAGE PAR REPARTITION DANS LE TEMPS**

(54) **METHOD AND SYSTEM FOR SYNCHRONIZING TIME-DIVISION-DUPLEXED TRANSCEIVERS**



(57) Improved techniques for synchronizing transmissions and receptions of a data transmission system utilizing time division duplexing is disclosed. The improved synchronization techniques utilize the time-varying nature of the energy of the received data to obtain synchronization. In one embodiment, an improved synchronization processing (500) measures energy (502) in n consecutive frames of received data. An alignment error estimate is then computed (504) based on the measured energy values for the n consecutive frames. In another embodiment, the improved synchronization technique uses the output signals from a multicarrier modulation unit (FFT unit) and thus provides the ability to avoid frequency tones that are susceptible to RF interference. The improved synchronization techniques can also utilize crosstalk interference levels to obtain synchronization. Remote receivers in the data transmission system are able to synchronize to central transmitters, central receivers in the data transmission system are able to synchronize to remote transmitters, and central transmitters are able to synchronize with one another.

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METHOD AND SYSTEM FOR SYNCHRONIZING TIME-DIVISION-DUPLEX TRANSCEIVERS

ABSTRACT OF THE DISCLOSURE

Improved techniques for synchronizing transmissions and receptions of a data transmission system utilizing time division duplexing is disclosed. The improved synchronization techniques utilize the time-varying nature of the energy of the received data to obtain synchronization. In one embodiment, an improved synchronization processing (500) measures energy (502) in *n* consecutive frames of received data. An alignment error estimate is then computed (504) based on the measured energy values for the *n* consecutive frames. In another embodiment, the improved synchronization technique uses the output signals from a multicarrier modulation unit (FFT unit) and thus provides the ability to avoid frequency tones that are susceptible to RF interference. The improved synchronization techniques can also utilize crosstalk interference levels to obtain synchronization. Remote receivers in the data transmission system are able to synchronize to central transmitters, central receivers in the data transmission system are able to synchronize to remote transmitters, and central transmitters are able to synchronize with one another.

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METHOD AND SYSTEM FOR SYNCHRONIZING TIME-DIVISION-DUPLEXED TRANSCEIVERS

CROSS-REFERENCE TO RELATED APPLICATION

This application is related to (i) U.S. Application Serial No. 08/707,322 which is entitled "METHOD AND APPARATUS FOR CROSSTALK CANCELLATION" and (ii) U.S. Application Serial No. 08/501,250 which is entitled "TIME DIVISION DUPLEXED HIGH SPEED DATA TRANSMISSION SYSTEM AND METHOD," and both of which are hereby incorporated by reference for all purposes.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to data transmission systems, and more particularly, to data transmission systems utilizing time-division duplexing.

2. Description of the Related Art

Bi-directional digital data transmission systems are presently being developed for high-speed data communications. One standard for high-speed data communications over twisted-pair phone lines that has developed is known as Asymmetric Digital Subscriber Lines (ADSL). Another standard for high-speed data communications over twisted-pair phone lines that is presently proposed is known as Very High Speed Digital Subscriber Lines (VDSL).

The Alliance For Telecommunications Information Solutions (ATIS), which is a group accredited by the ANSI (American National Standard Institute) Standard Group, has finalized a discrete multi tone based approach for the transmission of digital data over twisted-pair phone lines. The standard, known as ADSL, is intended primarily for transmitting video data and fast Internet access over ordinary telephone lines, although it may be used in a variety of other applications as well. The North American Standard is referred to as the ANSI T1.413 ADSL Standard (hereinafter ADSL standard), and is hereby incorporated by reference. Transmission rates under the ADSL standard are intended to facilitate the transmission of information at rates of up to 8 million bits per second (Mbits/s) over twisted-pair phone lines. The standardized system defines the use of a discrete multi tone (DMT) system that uses 256 "tones" or "sub-channels" that are each 4.3125 kHz wide in the forward

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(downstream) direction. In the context of a phone system, the downstream direction is defined as transmissions from the central office (typically owned by the telephone company) to a remote location that may be an end-user (i.e., a residence or business user). In other systems, the number of tones used may be widely varied.

The ADSL standard also defines the use of reverse transmissions at a data rate in the range of 16 to 800 Kbit/s. The reverse transmissions follow an upstream direction, as for example, from the remote location to the central office. Thus, the term ADSL comes from the fact that the data transmission rate is substantially higher in the downstream direction than in the upstream direction. This is particularly useful in systems that are intended to transmit video programming or video conferencing information to a remote location over telephone lines.

Because both downstream and upstream signals travel on the same pair of wires (that is, they are duplexed) they must be separated from each other in some way. The method of duplexing used in the ADSL standard is Frequency Division Duplexing (FDD) or echo canceling. In frequency division duplexed systems, the upstream and downstream signals occupy different frequency bands and are separated at the transmitters and receivers by filters. In echo cancel systems, the upstream and downstream signals occupy the same frequency bands and are separated by signal processing.

ANSI is producing another standard for subscriber line based transmission system, which is referred to as the VDSL standard. The VDSL standard is intended to facilitate transmission rates of at least about 6 Mbit/s and up to about 52 Mbit/s or greater in the downstream direction. Simultaneously, the Digital, Audio and Video Council (DAVIC) is working on a similar system, which is referred to as Fiber To The Curb (FTTC). The transmission medium from the "curb" to the customer is standard unshielded twisted-pair (UTP) telephone lines.

A number of modulation schemes have been proposed for use in the VDSL and FTTC standards (hereinafter VDSL/FTTC). For example, some of the possible VDSL/FTTC modulation schemes include multi-carrier transmission schemes such as Discrete Multi-Tone modulation (DMT) or Discrete Wavelet Multi-Tone modulation (DWMT), as well as single carrier transmission schemes such as Quadrature Amplitude Modulation (QAM), Carrierless Amplitude and Phase modulation (CAP), Quadrature Phase Shift Keying (QPSK), or vestigial sideband modulation.

Additionally, multicarrier modulation transmission schemes have been receiving a large amount of attention due to the high data transmission rates they offer. FIG. 1A is a simplified block diagram of a conventional transmitter 100 for a multicarrier modulation system. The conventional transmitter 100 is, for example, suitable for DMT modulation in

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ADSL or VDSL systems. The transmitter 100 receives data signals to be transmitted at a buffer 102. The data signals are then supplied from the buffer 102 to a forward error correction (FEC) unit 104. The FEC unit 104 compensates for errors that are due to crosstalk noise, impulse noise, channel distortion, etc. The signals output by the FEC unit 104 are supplied to a data symbol encoder 106. The data symbol encoder 106 operates to encode the signals for a plurality of frequency tones associated with the multicarrier modulation. In assigning the data, or bits of the data, to each of the frequency tones, the data symbol encoder 106 utilizes data stored in a transmit bit allocation table 108 and a transmit energy allocation table 110. The transmit bit allocation table 108 includes an integer value for each of the carriers (frequency tones) of the multicarrier modulation. The integer value indicates the number of bits that are to be allocated to the particular frequency tone. The value stored in the transmit energy allocation table 110 is used to effectively provide fractional number of bits of resolution via different allocation of energy levels to the frequency tones of the multicarrier modulation. In any case, after the data symbol encoder 106 has encoded the data onto each of the frequency tones, an Inverse Fast Fourier Transform (IFFT) unit 112 modulates the frequency domain data supplied by the data symbol encoder 106 and produces time domain signals to be transmitted. The time domain signals are then supplied to a digital-to-analog converter (DAC) 114 where the digital signals are converted to analog signals. Thereafter, the analog signals are transmitted over a channel to one or more remote receivers.

FIG. 1B is a simplified block diagram of a conventional remote receiver 150 for a multicarrier modulation system. The conventional remote receiver 150 is, for example, suitable for DMT demodulation in ADSL or VDSL systems. The remote receiver 150 receives analog signals that have been transmitted over a channel by a transmitter. The received analog signals are supplied to an analog-to-digital converter (ADC) 152. The ADC 152 converts the received analog signals to digital signals. The digital signals are then supplied to a Fast Fourier Transform (FFT) unit 154 that demodulates the digital signals while converting the digital signals from a time domain to a frequency domain. The demodulated digital signals are then supplied to a frequency domain equalizer (FEQ) unit 156. The FEQ unit 156 performs an equalization on the digital signals so the attenuation and phase are equalized over the various frequency tones. Then, a data symbol decoder 158 receives the equalized digital signals. The data symbol decoder 158 operates to decode the equalized digital signals to recover the data, or bits of data, transmitted on each of the carriers (frequency tones). In decoding the equalized digital signals, the data symbol decoder 158 needs access to the bit allocation information and the energy allocation information that were used to transmit the data. Hence, the data symbol decoder 158 is coupled to a received bit allocation table 162 and a received energy allocation table 160 which respectively store the bit allocation information and the energy allocation information that were used to transmit

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the data. The data obtained from each of the frequency tones is then forwarded to the forward error correction (FEC) unit 164. The FEC unit 164 performs error correction of the data to produce corrected data. The corrected data is then stored in a buffer 166. Thereafter, the data may be retrieved from the buffer 166 and further processed by the receiver 150. Alternatively, the received energy allocation table 160 could be supplied to and utilized by the FEQ unit 166.

The bit allocation tables and the energy allocation tables utilized in the conventional transmitter 100 can be implemented as a single table or as individual tables. Likewise, the bit allocation tables and the energy allocation tables utilized in the remote receiver 150 can be implemented as a single table or as individual tables. Also, the transmitter 100 is normally controlled by a controller, and the remote receiver 150 is normally controlled by a controller. Typically, the controllers are programmable controllers.

The transmitter 100 and the remote receiver 150 illustrated in FIGs. 1A and 1B, respectively, optionally include other components. For example, the transmitter 100 could add a cyclic prefix to symbols after the IFFT unit 112, and the remote receiver 150 can then remove the cyclic prefix before the FFT unit 154. Also, the remote receiver 150 can provide a time domain equalizer (TEQ) unit between the ADC 152 and the FFT unit 154.

Most of the proposed VDSL/FTTC transmission schemes utilize frequency division duplexing (FDD) of the upstream and downstream signals. On the other hand, one particular proposed VDSL/FTTC transmission scheme uses time division duplexing (TDD) of the upstream and downstream signals. More particularly, the time division duplexing is synchronized in this case such that periodic synchronized upstream and downstream communication periods do not overlap with one another. That is, the upstream and downstream communication periods for all of the wires that share a binder are synchronized. With this arrangement, all the very high speed transmissions within the same binder are synchronized and time division duplexed such that downstream communications are not transmitted at times that overlap with the transmission of upstream communications. This is also referred to as a (i.e. "ping pong") based data transmission scheme. Quiet periods, during which no data is transmitted in either direction, separate the upstream and downstream communication periods. When the synchronized time division duplexed approach is used with DMT it is often referred to as synchronized DMT (SDMT).

A common feature of the above-mentioned transmission systems is that twisted-pair phone lines are used as at least a part of the transmission medium that connects a central office (e.g., telephone company) to users (e.g., residence or business). Even though fiber optics may be available from a central office to the curb near a user's residence, twisted-pair phone lines are used to bring in the signals from the curb into the user's home or business.

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The twisted-pair phone lines are grouped in a binder. While the twisted-pair phone lines are within the binder, the binder provides reasonably good protection against external electromagnetic interference. However, within the binder, the twisted-pair phone lines induce electromagnetic interference on each other. This type of electromagnetic interference is generally known as crosstalk interference which includes near-end crosstalk (NEXT) interference and far-end crosstalk (FEXT) interference. As the frequency of transmission increases, the crosstalk interference (NEXT interference) becomes substantial. As a result, the data signals being transmitted over the twisted-pair phone lines at high speeds can be significantly degraded by the crosstalk interference caused by other twisted-pair phone lines in the binder. As the speed of the data transmission increases, the problem worsens. The advantage of the synchronized TDD (such as SDMT) based data transmission is that crosstalk interference (NEXT interference) from other lines in a binder is essentially eliminated, provided all the lines transmit for the same duration (i.e., same superframe format).

A data transmission system normally includes a central office and a plurality of remote units. Each remote unit communicates with the central office over a data link (i.e., channel) that is established between the central office and the particular remote unit. To establish such a data link, initialization processing is performed to initialize communications between the central office and each of the remote units. For purposes of the discussion to follow, a central office includes a central modem (or central unit) and a remote unit includes a remote modem. These modems are transceivers that facilitate data transmission between the central office and the remote unit. The central office thus normally includes a plurality of central side transceivers, each of which has a central side transmitter and a central side receiver, and the remote unit normally includes a remote side transceiver having a remote side transmitter and a remote side receiver.

One conventional frame synchronization technique required the transmission of a predetermined sequence of data which was received by a receiver and then correlated with a predetermined stored sequence of data to determine the adjustment required in order to yield synchronization. U.S. Patent No. 5,627,863 describes a frame synchronization approach suitable for systems (e.g., ADSL) using frequency division duplexing (FDD) or echo cancelling to provide duplexed operation. This frame synchronization technique requires a special start-up training sequence to obtain the frame synchronization. However, the described frame synchronization approach is not suitable for systems (e.g., synchronized TDD or SDMT) using time division duplexing because synchronization in time is not necessary for FDD or echo cancelling as it is with TDD in order to reduce crosstalk.

When a data transmission system is operating in a time-division duplexed (TDD) manner, the transmitters and receivers of the central office and remote units must be

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synchronized in time so that transmission and reception do not overlap in time. In a data transmission system, downstream transmissions are from a central side transmitter to one or more remote side receivers and upstream transmissions are from one or more remote side transmitters to a central side receiver. The central side transmitter and receiver can be combined as a central side transceiver, and the remote side transmitter and receiver can be combined as a remote side transceiver.

Generally speaking, in a time division duplexed system, upstream signals are alternated with downstream signals. Typically, the upstream transmissions and the downstream transmissions are separated by a guard interval or a quiet period. The guard interval is provided to enable the transmission system to reverse the direction in which data is being transmitted so that a transmission can be received before the transmission in the opposite direction occurs. Some transmission schemes divide upstream and downstream transmissions into smaller units referred to as frames. These frames may also be grouped into superframes that include a series of downstream frames and a series of upstream frames, as well as guard intervals between the two.

Time-division duplexing is a simple method to share a channel (medium) between two or more transceivers. Each transceiver is assigned a time slot during which it may transmit, and there are quiet periods (guard intervals) during which no unit must transmit. On channels subject to crosstalk (NEXT interference) between multiple connections, if time-division duplexing is used, synchronization must be established and maintained among all units so affected. An example is the VDSL service that uses the existing twisted pair telephone loop plant to transport up to 13-52 Mb/s on loops up to 1.5 km. Pairs destined for subscribers are bundled together in a cable consisting of 25-100 pairs. The proximity and the high frequency use (0.2-11 MHz signal bandwidth) leads to significant crosstalk between adjacent pairs in a binder. To get the desired data rate on loops up to 1.5 km long, DMT is a suitable multicarrier modulation scheme. This scheme makes excellent use of time-division duplexing since a single FFT unit can be used during transmission and reception and avoids the need for two such FFT units, and other savings in the analog circuitry.

Conventional frame synchronization techniques are not only not well suited for synchronized TDD but also are unreliable when RF interference is present. Due to the potential for significant RF interference due to amateur radio frequency bands, the RF interference might have a signal power equal to, or perhaps greater than, the desired receive signal power under some conditions. However, in a synchronized TDD system, it is important that synchronization be established and maintained so that crosstalk is mitigated and controlled and/or received data is accurately recovered.

Accordingly, there is a need for improved synchronization techniques for time-division duplexed systems.

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SUMMARY OF THE INVENTION

Broadly speaking, the invention relates to improved techniques for synchronizing transmissions and receptions of a data transmission system utilizing time division duplexing. According to one aspect of the invention, the improved synchronization techniques utilize the time-varying nature of the energy of the received data to obtain synchronization. In one embodiment, the improved synchronization technique uses the output signals from a multicarrier modulation unit (e.g., FFT unit) and thus provides the ability to avoid frequency tones that are susceptible to RF interference. According to another aspect of the invention, the improved synchronization techniques utilize crosstalk interference levels to obtain synchronization. With the improved synchronization techniques, remote receivers in the data transmission system are able to synchronize to central transmitters, central receivers in the data transmission system are able to synchronize to remote transmitters, and central transmitters are able to synchronize with one another.

The invention can be implemented in numerous ways, including as an apparatus, system, method, or computer readable media. Several embodiments of the invention are discussed below.

As a method for adjusting an alignment for a first transceiver to receive frames of data transmitted from a second transceiver over a transmission medium to the first transceiver, where the first transceiver and the second transceiver are associated with a data transmission system providing two-way data communication using time division duplexing, an embodiment of the invention includes the operations of: measuring an energy amount for each of a plurality of consecutive frames of received data; detecting an edge in the plurality of consecutive frames of the received data based on the measured energy amounts; and computing an alignment error estimate using the edge detected in the plurality of consecutive frames. Additionally, the synchronization may thereafter be adjusted in accordance with the alignment error estimate. Optionally, the data transmission system transmits data using a superframe structure having a plurality of frames, a first set of the frames in the superframe transmit data in a first direction, and a second set of the frames in the superframe transmit data in a second direction.

As a computer readable medium containing program instructions for adjusting an alignment for a first transceiver to receive frames of data transmitted from a second transceiver over a transmission medium to the first transceiver, the first transceiver and the second transceiver being associated with a data transmission system providing two-way data communication using time division duplexing, an embodiment of the invention includes: first computer readable code devices for measuring an energy amount for each of a plurality of

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consecutive frames of received data; second computer readable code devices for detecting an edge in the plurality of consecutive frames of the received data based on the measured energy amounts; and third computer readable code devices for computing an alignment error estimate using the edge detected in the plurality of consecutive frames.

As a receiver for a data transmission system using time division duplexing to alternate between transmission and reception of data, an embodiment of the invention includes: an analog-to-digital converter, the analog-to-digital converter receives analog data that has been transmitted over a channel to the receiver and converts the received analog signals into received digital signals; an input buffer for temporarily storing the received digital signals; a multicarrier demodulation unit, the multicarrier demodulation unit demodulates the received digital signals from the input buffer to frequency domain data for a plurality of different carrier frequencies; a frame synchronization unit, the frame synchronization unit synchronizes a receive frame boundary for the multicarrier demodulation unit based on the time-varying nature of the energy of the frequency domain data produced by the multicarrier demodulation unit; a bit allocation table, the allocation table stores bit allocation information used in transmitting data being received at the receiver; a data symbol decoder, the data symbol decoder receives the frequency domain data and decodes bits associated with the frequency domain data from the carrier frequencies based on the bit allocation information stored in the bit allocation table; and an output buffer for storing the decoded bits as recovered data. Preferably, the data transmission system is a synchronized DMT system, and wherein the multicarrier demodulation unit includes a FFT unit.

As a receiver for a data transmission system using time division duplexing to alternate between transmission and reception of data, another embodiment of the invention includes: an analog-to-digital converter, the analog-to-digital converter receives analog data that has been transmitted over a channel to the receiver and converts the received analog signals into received digital signals; an input buffer for temporarily storing the received digital signals; a multicarrier demodulation unit, the multicarrier demodulation unit demodulates the received digital signals from the input buffer to frequency domain data for a plurality of different carrier frequencies; frame synchronization means for synchronizing a receive frame boundary for the multicarrier demodulation unit based on the time-varying nature of the energy of the frequency domain data produced by the multicarrier demodulation unit; a bit allocation table, the allocation table stores bit allocation information used in transmitting data being received at the receiver; a data symbol decoder, the data symbol decoder receives the frequency domain data and decodes bits associated with the frequency domain data from the carrier frequencies based on the bit allocation information stored in the bit allocation table; and an output buffer for storing the decoded bits as recovered data.

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For a data transmission system having a plurality of transmitters at a central site where an external clock signal is unavailable for synchronizing the transmitters, the transmitters transmit data in accordance with a superframe format including at least one quiet period, a method for synchronizing data transmissions by a given transmitter to other of the transmitters at the central site according to an embodiment of the invention includes the acts of: measuring the energy in the quiet period associated with the given transmitter due to data transmissions from the other of the transmitters at the central site; comparing the measured energy with a threshold amount; and modifying the synchronization for the transmissions by the given transmitter when the comparing indicates that the measured energy exceeds the threshold amount.

As a computer readable medium containing program instructions for synchronizing data transmissions in a data transmission system having a plurality of transmitters at a central site where an external clock signal is unavailable for synchronizing the transmitters, the transmitters transmit data in accordance with a superframe format including at least one quiet period, an embodiment of the invention includes: first computer readable code devices for measuring the energy in the quiet period associated with a given transmitter due to data transmissions from other of the transmitters at the central site; second computer readable code devices for comparing the measured energy with a threshold amount; and third computer readable code devices for modifying the synchronization for the transmissions by the given transmitter when the comparing indicates that the measured energy exceeds the threshold amount.

The advantages of the invention are numerous. One advantage of the invention is that synchronization can be achieved even in the presence of radio frequency (RF) interference, such as due to amateur radio users. Another advantage of the invention is that it is well suited for data transmission systems utilizing time division duplexing such as synchronized DMT or synchronized VDSL. Yet another advantage of the invention is that it is relatively insensitive to noise in the data transmission system.

Other aspects and advantages of the invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be readily understood by the following detailed description in conjunction with the accompanying drawings, wherein like reference numerals designate like structural elements, and in which:

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FIG. 1A is a simplified block diagram of a conventional transmitter for a multicarrier modulation system;

FIG. 1B is a simplified block diagram of a conventional remote receiver for a conventional multicarrier modulation system;

FIG. 2 is a block diagram of an exemplary telecommunications network suitable for implementing the invention;

FIG. 3 is a block diagram of a processing and distribution unit 300 according to an embodiment of the invention;

FIG. 4 is a diagram illustrating an exemplary superframe format in which a certain level of service is provided;

FIG. 5A is a flow diagram of synchronization processing according to a basic embodiment of the invention;

FIG. 5B is a flow diagram of synchronization processing according to an embodiment of the invention;

FIGs. 6A and 6B are flow diagrams of synchronization processing according to a more detailed embodiment of the invention;

FIG. 7 is a flow diagram of edge detection processing according to an embodiment of the invention;

FIG. 8 is a flow diagram of alignment error estimation processing according to an embodiment of the invention;

FIGs. 9A and 9B represent diagrams of energy values and energy difference values for received data over a sequence of twenty frames;

FIGs. 10A and 10B represent energy values and energy difference values for received data over a series of twenty frames for the example illustrated in FIGs. 9A and 9B after an alignment adjustment has been made in accordance with the invention;

FIG. 11 is a block diagram of a receiver according to one embodiment of the invention; and

FIG. 12 is a flow diagram of a synchronization processing for synchronizing adjacent transmitters to compensate for small synchronization differences.

DETAILED DESCRIPTION OF THE INVENTION

The invention relates to improved techniques for synchronizing transmissions and receptions by a data transmission system utilizing time division duplexing. In one aspect of

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the invention, the improved synchronization techniques utilize the time-varying nature of the energy of the received data to obtain synchronization. In another aspect of the invention, the improved synchronization techniques utilize crosstalk interference levels to obtain synchronization. With the improved synchronization techniques, remote receivers in the data transmission system are able to synchronize to central transmitters, central receivers in the data transmission system are able to synchronize to remote transmitters, and central transmitters are able to synchronize with one another.

The synchronization required in a time-division duplex system requires that transmissions be synchronized with a superframe structure. Conventional time-domain methods which tend to correlate samples, such as first and last samples in a frame to detect a cyclic prefix, are not reliable because of the likely presence of RF interference in the receive signals which can be of equal power to be desired signals. However, the invention provides accurate techniques to synchronize transmissions in a time-division duplex system even when RF interference renders the time domain signal unreliable. The frequency domain approach to synchronization provided by the invention is able to obtain significant immunity from RF interference. In one embodiment, the improved synchronization technique preferably uses the output signals from a multicarrier modulation unit (FFT unit) and thus provides the ability to avoid frequency tones that are susceptible to radio frequency (RF) interference.

Embodiments of the invention are discussed below with reference to FIGs. 1A-12. However, those skilled in the art will readily appreciate that the detailed description given herein with respect to these figures is for explanatory purposes as the invention extends beyond these limited embodiments.

FIG. 2 is a block diagram of an exemplary telecommunications network 200 suitable for implementing the invention. The telecommunications network 200 includes a central office 202. The central office 202 services a plurality of distribution posts to provide data transmission to and from the central office 202 to various remote units. In this exemplary embodiment, each of the distribution posts is a processing and distribution unit 204 (node). The processing and distribution unit 204 is coupled to the central office 202 by a high speed, multiplexed transmission line 206 that may take the form of a fiber optic line. Typically, when the transmission line 206 is a fiber optic line, the processing and distribution unit 204 is referred to as an optical network unit (ONU). The central office 202 also usually interacts with and couples to other processing and distribution units (not shown) through high speed, multiplexed transmission lines 208 and 210, but only the operation of the processing and distribution unit 204 is discussed below. In one embodiment, the processing and distribution unit 204 includes one or more modems (central modems).

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The processing and distribution unit 204 services a multiplicity of discrete subscriber lines 212-1 through 212-n. Each subscriber line 212 typically services a single end user. The end user has a remote unit suitable for communicating with the processing and distribution unit 204 at very high data rates. More particularly, a remote unit 214 of a first end user 216 is coupled to the processing and distribution unit 204 by the subscriber line 212-1, and a remote unit 218 of a second end user 220 is coupled to the processing and distribution unit 204 by the subscriber line 212-n. The remote units 214 and 218 include a data communications system capable of transmitting data to and receiving data from the processing and distribution unit 204. In one embodiment, the data communication systems are modems. The remote units 214 and 218 can be incorporated within a variety of different devices, including for example, a telephone, a television, a monitor, a computer, a conferencing unit, etc. Although FIG. 2 illustrates only a single remote unit coupled to a respective subscriber line, it should be recognized that a plurality of remote units can be coupled to a single subscriber line. Moreover, although FIG. 2 illustrates the processing and distribution unit 204 as being centralized processing, it should be recognized that the processing need not be centralized and could be performed independently for each of the subscriber lines 212.

The subscriber lines 212 serviced by the processing and distribution unit 204 are bundled in a shielded binder 222 as the subscriber lines 212 leave the processing and distribution unit 204. The shielding provided by the shielded binder 222 generally serves as a good insulator against the emission (egress) and reception (ingress) of electromagnetic interference. However, the last segment of these subscriber lines, commonly referred to as a "drop" branches off from the shielded binder 222 and is coupled directly or indirectly to the end user's remote units. The "drop" portion of the subscriber line between the respective remote unit and the shielded binder 222 is normally an unshielded, twisted-pair wire. In most applications the length of the drop is not more than about 30 meters.

Crosstalk interference, including near-end crosstalk (NEXT) and far-end crosstalk (FEXT), primarily occurs in the shielded binder 222 where the subscriber lines 212 are tightly bundled. Hence, when data is transmitted on some of the subscriber lines 212 while other subscriber lines are receiving data as is common when multiple levels of service are being provided, the crosstalk inference induced becomes a substantial impairment to proper reception of data. Hence, to overcome this problem, data is transmitted using a superframe structure over which bits of data to be transmitted are allocated. The telecommunications network 200, for example, is particularly well suited for a synchronized TDD transmission system (e.g., synchronized VDSL or SDMT) offering different levels of service.

Hence, referring to the SDMT transmission system shown in FIG. 2, data transmissions over all lines 212 in the shielded binder 222 associated with the processing and

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distribution unit 204 need to be synchronized. As such, all active lines emanating from the processing and distribution unit 204 could be transmitting in the same direction (i.e., downstream or upstream) so as to substantially eliminate NEXT interference.

FIG. 3 is a block diagram of a processing and distribution unit 300 according to an embodiment of the invention. For example, the data processing and distribution unit 300 is a detailed implementation of the processing and distribution unit 204 illustrated in FIG. 2.

The data processing and distribution unit 300 includes a processing unit 302 that receives data and sends data over a data link 304. The data link 304 could, for example, be coupled to a fiber optic cable of a telephone network or a cable network. The processing unit 302 needs to operate to synchronize the various processed transmissions and receptions of the processing unit 302. The data processing and distribution unit 300 further includes a bus arrangement 308 and a plurality of analog cards 310. The output of the processing unit 302 is coupled to the bus arrangement 308. The bus arrangement 308 together with the processing unit 302 thus direct output data from the processing unit 302 to the appropriate analog cards 310 as well as direct input from the analog cards 310 to the processing unit 302. The analog cards 310 provide analog circuitry utilized by the processing and distribution unit 300 that is typically more efficiently performed with analog components than using digital processing by the processing unit 302. For example, the analog circuitry can include filters, transformers, analog-to-digital converters or digital-to-analog converters. Each of the analog cards 310 are coupled to a different line. Typically, all the lines for a given data transmission system 300 are bundled into a binder including about fifty (50) lines (LINE-1 through LINE-50). Hence, in such an embodiment, there are fifty (50) analog cards 310 respectively coupled to the fifty (50) lines. In one embodiment, the lines are twisted-pair wires. The processing unit 302 may be a general-purpose computing device such as a digital signal processor (DSP) or a dedicated special purpose device. The bus arrangement 308 may take many arrangements and forms. The analog cards 310 need not be designed for individual lines, but could instead be a single card or circuitry that supports multiple lines.

In a case where the processing is not centralized, the processing unit 302 in FIG. 3 can be replaced by modems for each of the lines. The processing for each of the lines can then be performed independently for each of the lines. In this case, the modem may be placed on a single card along with the analog circuitry.

The NEXT interference problem occurs on the lines proximate to the output of the processing and distribution unit 300. With respect to the block diagram illustrated in FIG. 3, the NEXT interference is most prevalent near the outputs of the analog cards 310 because this is where the lines are closest to one another and have their largest power differential (between transmitted and received signals). In other words, from the output of the processing and distribution unit 300 the lines travel towards the remote units. Usually, most of the distance

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is within a shielded binder that would, for example, hold fifty (50) twisted-pair wires, and the remaining distance is over single unshielded twisted-pair wires. Because all these lines (e.g., twisted-pair wires) are held in close proximity in the binder and individually offer little shielding against electromagnetic coupling from other of the lines in the binder, crosstalk interference (namely NEXT interference and FEXT interference) between the lines within the binder is problematic.

Depending on the level of service being provided, data transmission implemented with SDMT can be symmetric or asymmetric with respect to upstream and downstream transmissions. With symmetric transmission, DMT symbols tend to be transmitted in alternating directions for equal durations. In other words, the duration in which DMT symbols are transmitted downstream is the same as the duration in which DMT symbols are transmitted upstream. With asymmetric transmission, DMT symbols tend to be transmitted downstream for a longer duration than upstream.

In VDSL it has been proposed to have a superframe structure including a fixed number (e.g., 20) frames, with each frame being associated with a DMT symbol. With such a frame format, the number of frames being used for downstream transmissions and the number of frames being used for upstream transmissions can vary. As a result, there are several different superframe formats that can occur. Typically, a superframe consists of a downstream burst of several frames and an upstream burst of several frames. Quiet frames are inserted between the upstream and the downstream bursts to allow the channel to settle before the direction of transmission is changed.

FIG. 4 is a diagram illustrating an exemplary superframe format 400 in which a certain level of service is provided. The superframe format 400 is an asymmetric frame that includes a downstream portion 402, a quiet portion 404, an upstream portion 406, and a quiet portion 408. The quiet portions (quiet periods) 404 and 408 are positioned between the downstream and upstream transmissions. With this asymmetric superframe format 400, the downstream portion 402 is substantially larger (e.g., longer burst) than the upstream portion 406. Such a superframe format is useful for situations in which downstream traffic is significantly greater than the upstream traffic. As an example, with respect to FIG. 2, the superframe format 400 can include 16 symbols downstream; 1 quiet period; 2 symbols upstream; and 1 quiet period.

With proper synchronization at a central unit (processing and distribution unit 204 or processing unit 302) and uniform superframe formats, synchronized transmissions of equal duration are provided for all lines within a binder. Accordingly, the NEXT interference problem is effectively eliminated. The synchronization of the central unit and the remote units is also important for accurate data recovery. These synchronizations are needed in

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synchronized VDSL and SDMT systems. According to the invention, improved synchronization techniques are described below with respect to FIGs. 5-12.

FIG. 5A is a flow diagram of synchronization processing 500 according to a basic embodiment of the invention. Initially, the synchronization processing 500 measures 502 energy in n consecutive frames of received data. An alignment error estimate is then computed 504 based on the measured energy values for the n consecutive frames. Following block 504, the synchronization processing 500 is complete and ends.

FIG. 5B is a flow diagram of synchronization processing 550 according to an embodiment of the invention. Initially, the synchronization processing 550 measures 552 energy in n consecutive frames of received data. Next, an edge is detected 554 in the received data based on the measured energy values for the n consecutive frames. An alignment error estimate is then computed 556 from the position of the edge that has been detected. Thereafter, the synchronization processing 550 is able to adjust 558 its synchronization reference in accordance with the alignment error estimate. Following block 558, the synchronization processing 550 is complete and ends.

By determining and adjusting synchronization of receivers of the remote units to transmissions from a central unit in accordance with the synchronization processing 500 or 550, the remote units are able to establish synchronization with the central unit. Once synchronized the central unit and the remote units are able to share a channel (transmission line) in a time-division duplexed manner. Also, the synchronization processing 500 or 550 is suitable for determining and adjusting synchronization of receivers at the central unit with transmissions from the remote units.

FIGs. 6A and 6B are flow diagrams of synchronization processing 600 according to a more detailed embodiment of the invention. Once the synchronization processing 600 is initiated, FFT outputs are obtained 602 for n consecutive frames of received data. Typically, a receiver side of a transceiver will receive data from a transmission line and forward the received data to an analog-to-digital converter and then to a FFT unit, such as illustrated in FIG. 1B. Hence, the FFT outputs may be obtained from the output of the FFT unit. The FFT outputs are frequency domain signals.

Next, the FFT outputs that are susceptible to RF interference are dropped 604. The remaining FFT outputs are then used for subsequent processing. Typically, a frame includes a plurality of different frequency tones. Each of the frequency tones is capable of having data encoded thereon for transmission. However, certain of the frequency tones are more susceptible to RF interference than others. In the case where the RF interference is caused by amateur radio users, it is usually known which frequency tones of the frame are likely subjected to the RF interference due to amateur radio users. In the case of a remote unit of a

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synchronized multicarrier VDSL system, where a frame has 256 frequency tones, frequency tones 6 through 40 are generally free from RF interference due to amateur radio users, less attenuated because lower frequency tones have less attenuation, and therefore sufficient to obtain a reliable synchronization result. Hence, in one embodiment, frequency tones 6 through 40 from each of n consecutive frames are used for subsequent processing.

Next, energy values for the n consecutive frames of the remaining FFT outputs are determined 606. As an example, if the frequency tones 6 through 40 are being utilized, then the corresponding outputs from the FFT unit are obtained and then converted to energy values and summed together so as to produce a single energy value for the frame. Preferably, the energy values are power values for the frames. As an example, the single energy value for a frame can be obtained by summing the squared moduli of all outputs of the FFT unit that are in use. Alternatively, the energy values could be obtained by summing the energies of time domain samples, after having filtered out those time domain samples that are subjected to substantial amounts of RF interference.

Once the energy values for the n consecutive frames have been determined 606, the synchronization processing 600 detects 608 a burst edge within the received data based on the determined energy values. By detecting the burst edge, a receiver is able to identify when the received data burst from a transmitter begins. The burst edge thus identifies the beginning (or end) of a received transmission from the transmitter and additionally identifies a synchronization for the frame. A trailing edge within the received data and/or characteristics of the superframe (superframe information) can also be detected.

Next, an alignment error estimate for a frame boundary setting is determined 610 with respect to the detected burst edge. Here, using the burst edge that has been detected 608, the alignment error estimate can be determined 610 for a frame boundary setting. In particular, from the determined energy values in the burst edge, the remote unit synchronization processing 600 is able to determine the alignment error for a frame (i.e., error in frame synchronization). Typically, the alignment error is estimated as a fraction of a frame. Thereafter, the frame boundary can be adjusted 612 in accordance with the alignment error estimate.

Once adjusted 612, the frame synchronization should be established. However, preferably, the synchronization processing 600 continues to confirm that the synchronization has been achieved. Specifically, following block 612, a decision block 614 determines whether the absolute value of the alignment error estimate is less than a predetermined threshold. If the alignment error estimate is not less than a predetermined threshold, then the synchronization processing 600 returns to repeat block 602 and subsequent blocks so as to iteratively reduce the magnitude of the error. On the other hand, when the decision block 614 determines that the alignment error estimate is less than the predetermined threshold, then the

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superframe information is output 616. As an example, the superframe information can indicate the beginning of the received transmission and the end of the received transmission and/or the number of frames in the burst. Following block 616, the synchronization processing 600 is complete and ends.

Normally, when the frame synchronization is adjusted 612 by a significant amount, the alignment error estimate is greater then the predetermined threshold. Hence, the synchronization processing 600 will repeat and should produce a small alignment error amount which is less than the predetermined threshold. Then, the synchronization processing 600 is able to proceed to block 616. Alternatively, the decision block 614 can be eliminated when the alignment error estimate is produced accurately with a high degree of confidence.

FIG. 7 is a flow diagram of edge detection processing 700 according to an embodiment of the invention. The edge detection processing 700 describes additional details on the block 608 in FIG. 6A where the burst edge is detected. The edge detection processing 700 initially computes 702 successive energy differences for the *n* determined energy values. These successive energy differences may be indexed from 1 to i. Next, the largest energy difference and its index (j) are determined 704. The energy differences at indices (j-1) and (j+1) are then stored 706 for later retrieval. Following block 706, the edge detection processing 700 is complete and the processing returns to block 610 of the synchronization processing 600.

FIG. 8 is a flow diagram of alignment error estimation processing 800 according to an embodiment of the invention. The alignment error estimation processing 800 describes additional details on the block 610 in FIG. 6A where an alignment error estimate is determined. The alignment error estimation processing 800 initially determines 802 a difference amount from the energy values at indices (j+1) and (j-1). The energy values at indices (j+1) and (j-1) are the energy values immediately proceeding and immediately following the largest energy difference at index (j). The energy values can, for example, be power values. Next, the difference amount is normalized 804 to produce the alignment error estimate. In this embodiment, the alignment error estimate represents a fractional part of a frame. Accordingly, the synchronization of the receiver to the data transmission unit would be off by this fractional part of the frame. Following block 804, the alignment error estimation processing 800 is complete and the processing returns to block 612 of the synchronization processing 600.

FIGs. 9A and 9B represent diagrams of energy values (e) and energy difference values (Δe) for received data over a sequence of twenty frames. In FIG. 9A, a diagram 900 plots the energy values (e) for the twenty frames shows a burst of data in the vicinity of frames 6 through 15. As an example, the energy values (e) are produced by block 606 in FIG. 6A. In FIG. 9B, a diagram 902 plots successive energy difference values (Δe) for the

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determined energy values. The successive energy difference values (Δe) identify regions associated with edges or transition points in the received data. A first edge represents an initial edge or the start of a burst of data and is somewhere within a region 904, and a second edge 906 represents a trailing edge, or an end of a burst of data, and is somewhere within a region 906. As an example, the energy difference values (Δe) are determined by block 702 in FIG. 7.

As seen in FIGs. 9A and 9B, the receiver is not properly synchronized with the incoming transmitted data from a remotely located transmitter. In particular, the beginning of the burst of data received from the transmitter begins somewhere within frame 6. To be properly synchronized, the burst of data from the transmitter would begin exactly at the beginning of frame 6 in this example. By using the energy difference values (Δe), the technique achieves substantial immunity to noise levels on the received data. The diagram 902 shows that the initial edge of the burst of data is within the region 904, *i.e.*, somewhere within frame 6, and that the trailing edge of the burst of data is within the region 906, *i.e.*, somewhere within frame 14.

FIGs. 10A and 10B represent energy values (e) and energy difference values (Δe) for received data over a series of twenty frames for the example illustrated in FIGs. 9A and 9B after an alignment adjustment has been made in accordance with the invention, that is, with proper synchronization. In FIG. 10A a diagram 1000 indicates a burst of data between frames 6 and 14 with an initial edge 1002 at the beginning of frame 6 and a trailing edge 1004 at the end of frame 14. In FIG. 10B, a diagram 1006 illustrates the successive energy difference values (Δe) over the twenty frames, including an initial maximum point 1008 and a trailing maximum point 1010. The initial edge (frame 6) of the burst of data indicates the starting frame of the received burst of data, while the negative edge (frame 15) indicates the frame following the end of the burst of data. From this information, the received burst length can be inferred (9 frames), and the superframe format can be identified (9-1-9-1).

During synchronization the successive differences in the energy values observed in each frame of the superframe will show a positive and negative peak. The positive peak indicates the leading edge of a burst, while the negative edge indicates the end of a burst. According to one embodiment of the invention, the edge detection processing adjusts the frame alignment so that the maximum difference is increased, the right-hand neighboring energy difference is forced to zero. When synchronization has been obtained, the result is as shown in FIG. 10B. Note that the edge detection processing is relatively insensitive to the absolute amplitudes being observed. The successive differences approach requires only that the energy in the "quiet" frames (which are not truly quiet due to noise) be smaller than the energy in the active frames and that the energy be approximately constant for each type of frame.

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When the data transmission system operates to delete a cyclic prefix at the receiver, a dead-zone may be created in the frame/superframe alignment that is the width of the cyclic prefix because the removal of the cyclic prefix drops samples useful for frame synchronization but thus unavailable from the FFT unit. One technique to resolve this dead-zone where the frame has 512 samples and the cyclic prefix has 40 samples is to use energy estimates from samples 41 through 552 as well as using samples 1 to 512, and then take the mean of these energy estimates to get a combined energy estimate which is then used in the burst detection processing.

The synchronization processing discussed above is generally applicable to remote side and central side synchronization. For synchronization processing at a remote unit, a receiver at the remote unit acquires and maintains synchronization with data transmissions (bursts) with a transmitter of the central unit. As for synchronization processing at a central unit, a receiver at the central unit acquires and maintains synchronization with data transmissions (bursts) with a transmitter of a remote unit. In one embodiment, the synchronization is managed by setting or adjusting receive frame alignment for the recovery of data transmissions (bursts) at a receiver.

Due to the round-trip delay of a line (or channel), the time at which an upstream transmission from a remote unit reaches a central unit will vary and will appear to be late by the by the length of the round-trip delay if no correction is made. Accordingly, the central unit needs to adjust its receive frame alignment so that the correct receive samples are used in the receiver at the central unit. The processing carried out at the central unit to adjust its receive frame alignment is similar to the synchronization processing discussed above for the remote unit. Generally, the energy in upstream frames being received is measured over a number of frames corresponding to the length of the upstream transmission burst from the remote unit. These energy values are used to identify the start of the upstream transmission burst and then determines an alignment correction to align the receive frame boundary pointer with the frames of data received from the remote unit.

FIG. 11 is a block diagram of a receiver 1100 according to one embodiment of the invention. The receiver 1100 is part of a time domain duplexed transmission system. The construction of the receiver 1100 illustrated in FIG. 11 may be used in either or both of the central office transceiver and the remote unit transceiver.

The receiver 1100 receives analog signals 1102 that have been transmitted over a channel from a transmitter (e.g., a central office transmitter). The received analog signals are then supplied to an analog-to-digital (ADC) 1104 which converts the received analog signals to digital signals. The digital signals are then supplied to an input buffer 1106 that temporarily stores the digital signals. The FFT unit 1108 retrieves a frame of data from the

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input buffer 1106 in accordance with a receive frame boundary pointer 1110, and then produces frequency domain signals.

In accordance with the invention, the FFT unit 1108 outputs the frequency domain signals 1112 to a frame synchronization unit 1114. The frame synchronization unit 1114 operates to perform the synchronization processing discussed above with reference to FIGs. 5-10B. The frame synchronization unit 1114 outputs an alignment error estimate 1116 to a controller 1118. The controller 1118 then adjusts the receive frame boundary pointer 1110 for accessing the received data from the input buffer 1106. Hence, the frame synchronization unit 1114 provides for frame synchronization in the time domain duplexed transmission system in a manner that is substantially immune from RF interference (e.g., such as from amateur radio users). The controller 1118 also controls the overall operation of the receiver 1100. The controller 1118, for example, controls the receiver 1100 to perform the initialization processing and to monitor steady-state data transmission. For example, the controller 1118 can be implemented by a digital signal processor, a microprocessor or microcontroller, or specialized circuitry. In the case where the receiver 1100 forms part of a transceiver, the controller 1118 can be used by both transmit and receive sides of the transceiver, shared among a plurality of transceivers, or individually provided for each transmitter and receiver. Likewise, the frame synchronization unit 1114 can be implemented by a digital signal processor, a microprocessor or microcontroller, or specialized circuitry.

Returning to the receive data path the frequency domain signals 1112 output by the FFT unit 1108 are then equalized by the FEQ unit 1120. The equalized signals are then supplied to a data symbol decoder 1122. The data symbol decoder 1122 operates to decode the equalized signals to recover data that has been transmitted on each of the frequency tones of the symbol being received. The decoding by the data symbol decoder 1122 is performed based on bit allocation information stored in a receive bit and energy allocation table 1124. The decoded data is then supplied to the FEC unit 1126 and then stored in an output buffer 1128. Thereafter, recovered data 1130 (stored decoded data) may be retrieved from the output buffer 1128 as needed.

The receiver 1100 illustrated in FIG. 11 optionally includes other components. For example, when a corresponding transmitter adds a cyclic prefix to symbols after an IFFT unit, the receiver 1100 can remove the cyclic prefix before the FFT unit 1108. Also, the receiver 1100 can provide a time domain equalizer (TEQ) unit between the ADC 1104 and the FFT unit 1106. Additional details on TEQ units are contained in U.S. Patent No. 5,285,474 and U.S. Application Serial No. 60/046,244 (Att.Dkt.No.: AMATP021+), filed May 12, 1997 and entitled POLY-PATH TIME DOMAIN EQUALIZATION, which are hereby incorporated by reference.

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Moreover, the invention provides techniques to synchronize transmissions at a central side (i.e., central unit). With synchronized transmissions at the central side, the NEXT interference is substantially eliminated, provided all lines of a binder offer the same level of service (i.e., superframe format). However, if the transmissions from the central side over lines in a binder are not properly synchronized, the NEXT interference is a substantial impediment to efficient and accurate operation of the data transmission system. Hence, the invention also pertains to techniques to adjust a transmit frame boundary at a central side transmitter of data transmission system. The general principle is to use NEXT interference from other central side transmissions. If the NEXT interference is not strong enough to be detected for synchronization purposes, then it will be assumed to be insignificant during reception, and therefore synchronization is not necessary.

Conventionally, the various transmitters at the central side can synchronize with one another by all using a common master clock supplied to the central side. However, sometimes such a master clock is not available for one reason or another. Also, even though available, the various transmitters could be positioned at slightly greater positions from the master clock source so as to cause small synchronization differences between the various transmissions. Hence, the synchronization techniques according to the invention can also be used to synchronize various transmissions at the central side.

FIG. 12 is a flow diagram of a synchronization processing 1200 for synchronizing adjacent transmitters to compensate for small synchronization differences. If these small synchronization differences were to go uncorrected, over time the degree of the lack of synchronization worsens. The synchronization processing 1200 initially measures 1202 energy received from other transmitters at the central side. Here, during quiet periods (or guard periods), energy being received from other transmitters at the central side is measured by the receivers associated with the transmitters (i.e., transceivers). The transmissions from the various transmitters all follow the same superframe format. Preferably, the second quiet period (i.e., after the upstream transmission) is used to measure the energy because there tends to be less echo present. Next, a decision block 1204 determines whether the measured energy is greater than a predetermined threshold amount. If the measured energy during the quiet period is determined to be greater than the predetermined threshold amount, then the presence of NEXT interference is detected. Since NEXT interference is detected, it is known that the transmitters at the central side are not synchronized. Hence, the timing alignment at the transmitter is modified 1202 in order to synchronize its alignment with respect to the other transmitters at the central side. For example, the timing alignment could be modified by altering an oscillator frequency or changing (increase or decrease) the length of the superframe. On the other hand, when the measured energy is determined to be less than the predetermined threshold amount, then the transmitters at the central side are deemed to be

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sufficiently aligned and thus block 1206 is bypassed. Following block 1206 or following block 1204 when the predetermined threshold is not exceeded, the synchronization processing 1200 is complete and ends.

The synchronization processing 1200 is performed by all the transceivers at the central side. By repeating the synchronization processing 1200, gradually the alignment will reach a more less steady state, particularly if adjustments to alignment are made in only one direction.

Recall, as illustrated in FIG. 4, the superframe format has two quiet periods 404 and 408. The synchronization processing 1200 uses one of the two quiet periods 404 and 408. When a receiver at the central side hears the NEXT interference during the quiet period 408, it means that this transceiver is late and should transmit earlier. Alternatively, if the receiver at the central side uses the quiet period 404 and hears the NEXT interference during the quiet period 404, it means that this transceiver is early and should transmit later. However, before the transceiver adjust its timing alignment at the central side, it may inform the corresponding remote unit of the change so that it also modifies its timing alignment. This notification to the remote can, for example, be performed over an overhead channel.

The synchronization technique needs to distinguish downstream NEXT interference from upstream FEXT interference. This can be achieved a number of different ways. One way to distinguish upstream transmissions from downstream transmissions, in the case of VDSL using DMT frames with 256 tones, is to use tone 128 which is Nyquist/2 only with downstream transmissions. As noted above, the quiet period is used to measure the interference from adjacent downstream transmissions. If the downstream distinguishing feature is detected (greater than some threshold) it means that the clock in this unit is running faster than the interfering transmitter's clock.

The adjustment to the synchronization can be to modify the clock frequency of the particular transceiver's clock, such as with a voltage controlled oscillator. Alternatively, an extra cycle can be inserted into the superframe structure. In VDSL, if the central side transceiver's clocks are within 100 ppm of each other, then insertion of 1 sample per superframe (11,040 samples) will be sufficient to monitor synchronization. If the central side transceivers can only insert, the central side transceivers will reach a consensus at the lowest clock frequency of the group (that has significant NEXT).

For example, the energy of tone 128 can be measured with a special single-tone DFT:

$$|z_{128}|^2 = \left[\sum_{k=0}^{255} x_{2k}(-1)^k\right]^2 + \left[\sum_{k=0}^{255} x_{2k+1}(-1)^{k+1}\right]^2$$

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If the measured energy is larger than a predetermined threshold, then insert a sample (extra cycle) in the subsequent downstream transmission.

The advantages of the invention are numerous. One advantage of the invention is that synchronization can be achieved even in the presence of radio frequency (RF) interference, such as due to amateur radio signals. Another advantage of the invention is that it is well suited for data transmission systems utilizing time division duplexing such as synchronized DMT or synchronized VDSL. Yet another advantage of the invention is that it is relatively insensitive to background or receiver noise.

Thus, the present invention includes a method for adjusting an alignment for a first transceiver to receive frames of data transmitted from a second transceiver over a transmission medium to the first transceiver, the first transceiver and the second transceiver being associated with a data transmission system providing two-way data communication using time division duplexing the method comprising the acts of: (a) measuring an energy amount for each of a plurality of consecutive frames of received data; and (b) computing an alignment error estimate based on the measured energy amounts.

Also included is the method as recited hereinabove, wherein the alignment error estimate is an estimated alignment error as a fraction of a frame.

Also included is the method as recited hereinabove, wherein the data transmission system transmits data using a superframe structure having a plurality of frames, a first set of the frames in the superframe transmit data in a first direction, and a second set of the frames in the superframe transmit data in a second direction.

Also included is the method as recited hereinabove, wherein the first transceiver uses a frame boundary pointer to identify a beginning of a frame in the superframe being received, and wherein the method further comprises: (c) adjusting the frame boundary pointer in accordance with the alignment error estimate.

Also included is the method as recited hereinabove, wherein the alignment error estimate is an estimated alignment error as a fraction of a frame.

Also included is the method as recited hereinabove, wherein the method further comprises: (d) comparing the alignment error estimate with a threshold amount; (e) repeating steps (a) - (d) until the comparing (d) indicates that the alignment error estimate is less than the threshold amount.

Also included is the method as recited hereinabove, wherein the method further comprises: (f) outputting superframe identification information.

Also included is the method as recited hereinabove, wherein the computing (b) comprises: detecting an edge in the plurality of consecutive frames of the received data based

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on the measured energy amounts; and determining the alignment error estimate using the edge detected in the plurality of consecutive frames.

Also included is the method as recited hereinabove, wherein the edge detected is a burst edge.

Also included is the method as recited hereinabove, wherein the detecting comprises: computing successive energy differences in the plurality of the measured energy amounts; and identifying a largest one of the successive energy differences, the largest one of the successive energy difference corresponding to the burst edge.

Also included is the method as recited hereinabove, wherein the computing (b) comprises: identifying a prior energy difference and a subsequent energy difference, the prior energy difference being the one of the successive differences immediately preceding the largest one of the successive energy differences, and the subsequent energy difference being the one of the successive differences immediately following the largest one of the successive energy differences; and determining the alignment error estimate based on the prior energy difference and the subsequent energy difference.

Also included is the method as recited hereinabove, wherein the determining of the alignment error estimate computes a difference amount between the subsequent energy difference and the prior energy difference.

Also included is the method as recited hereinabove, wherein the determining of the alignment error estimate computes a difference amount between the subsequent energy difference and the prior energy difference, and then normalizes the difference amount to produce the alignment error estimate.

Also included is a method as recited hereinabove, wherein the first transceiver uses a frame boundary pointer to identify a beginning of a frame in the superframe being received, and wherein the method further comprises: (c) adjusting the frame boundary pointer in accordance with the alignment error estimate.

Also included is a method as recited hereinabove, wherein the alignment error estimate is an estimated alignment error as a fraction of a frame.

Also included is a method as recited hereinabove, wherein the method further comprises: (d) comparing the alignment error estimate with a threshold amount; (e) repeating (a) - (d) until the comparing (d) indicates that the alignment error estimate is less than the threshold amount.

Also included is a method as recited hereinabove, wherein the method further comprises: (f) outputting superframe identification information.

Also included is a method as recited hereinabove, wherein the first transceiver is a remote unit and the second transceiver is a central unit.

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Also included is a method as recited hereinabove, wherein the second transceiver is a remote unit and the first transceiver is a central unit.

Also included is a method as recited hereinabove, wherein the energy amount is a power amount.

Also included is a method as recited hereinabove, wherein the data transmission system transmits data using a superframe structure having a plurality of frames, some of the frames transmit data in a first direction, some of the frames transmit data in a second direction, and some of the frames contain a cyclic prefix for the superframe structure, and

wherein the measuring (a) of the energy amounts comprises: measuring energy amounts of a first set of consecutive frames of received data for the superframe structure; measuring energy amounts of a second set of consecutive frames of received data for the superframe structure, the second set of the consecutive frames being offset from and overlapped with the first set of the consecutive frames; and combining together the energy amounts from respective consecutive frames from the first and second sets of the consecutive frames to produce the energy amounts for the computing (b).

Also included is the method as recited hereinabove, wherein the number of frames in the first and second sets of the consecutive frames is equal to the length of the superframe structure less the length of the cyclic prefix.

Also included is the method as recited hereinabove, wherein the combining determines mean energy amounts for each of the frames of the superframe structure including the cyclic prefix.

Also included is a computer readable medium containing program instructions for adjusting an alignment for a first transceiver to receive frames of data transmitted from a second transceiver over a transmission medium to the first transceiver, the first transceiver and the second transceiver being associated with a data transmission system providing two-way data communication using time division duplexing, the computer readable medium comprising: first computer readable code devices for measuring an energy amount for each of a plurality of consecutive frames of received data; and second computer readable code devices for computing an alignment error estimate based on the measured energy amounts.

Also included is the computer readable medium as recited hereinabove, wherein the second computer readable medium comprises: computer readable code devices for detecting an edge in the plurality of consecutive frames of the received data based on the measured energy amounts; and computer readable code devices for determining the alignment error estimate using the edge detected in the plurality of consecutive frames.

Also included is the computer readable medium as recited hereinabove, wherein the second computer readable medium further comprises: computer readable code devices for computing successive energy differences in the plurality of the measured energy amounts;

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and computer readable code devices for identifying a largest one of the successive energy differences, the largest one of the successive energy difference corresponding to a burst edge.

Also included is the computer readable medium as recited hereinabove, wherein the second computer readable medium comprises: computer readable code devices for identifying a prior energy difference and a subsequent energy difference, the prior energy difference being the one of the successive differences immediately preceding the largest one of the successive energy differences, and the subsequent energy difference being the one of the successive differences immediately following the largest one of the successive energy differences; computer readable code devices for determining the alignment error estimate based on the prior energy difference and the subsequent energy difference.

Also included is the computer readable medium as recited hereinabove, wherein the data transmission system transmits data using a superframe structure having a plurality of frames, some of the frames transmit data in a first direction, some of the frames transmit data in a second direction, and some of the frames contain a cyclic prefix for the superframe structure, and wherein the first computer readable code devices for measuring of the energy amounts comprises: computer readable code for measuring energy amounts of a first set of consecutive frames of received data for the superframe structure; computer readable code for measuring energy amounts of a second set of consecutive frames of received data for the superframe structure, the second set of the consecutive frames being offset from and overlapped with the first set of the consecutive frames; and computer readable code for combining together the energy amounts from respective consecutive frames from the first and second sets of the consecutive frames to produce the energy amounts for the second computer readable code devices.

Also included is the computer readable medium as recited hereinabove, wherein the combining determines mean energy amounts for each of the frames of the superframe structure including the cyclic prefix.

Also included is the computer readable medium as recited hereinabove, wherein the number of frames in the first and second sets of the consecutive frames is equal to the length of the superframe structure less the length of the cyclic prefix.

Also included is a receiver for a data transmission system using time division duplexing to alternate between transmission and reception of data, the receiver comprising: an analog-to-digital converter, the analog-to-digital converter receives analog data that has been transmitted over a channel to the receiver and converts the received analog signals into received digital signals; an input buffer for temporarily storing the received digital signals; a multicarrier demodulation unit, the multicarrier demodulation unit demodulates the received digital signals from the input buffer to frequency domain data for a plurality of different carrier frequencies; a frame synchronization unit, the frame synchronization unit synchronizes a receive frame boundary for the multicarrier demodulation unit based on the

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time-varying nature of the energy of the frequency domain data produced by the multicarrier demodulation unit; a bit allocation table, the allocation table stores bit allocation information used in transmitting data being received at the receiver; a data symbol decoder, the data symbol decoder receives the frequency domain data and decodes bits associated with the frequency domain data from the carrier frequencies based on the bit allocation information stored in the bit allocation table; and an output buffer for storing the decoded bits as recovered data.

Also included is the receiver as recited hereinabove, wherein the frame synchronization unit determines an alignment adjustment amount, wherein the receiver further comprises a controller for controlling overall operation of the receiver, the controller receives the alignment adjustment amount from the frame synchronization unit and accordingly adjusts a receive frame boundary pointer for the input buffer.

Also included is the receiver as recited hereinabove, wherein at least one of the frame synchronization unit and the controller are implemented by a processor.

Also included is the receiver as recited hereinabove, wherein the frame synchronization unit is a processor.

Also included is the receiver as recited hereinabove, wherein the received data signals undesirably include radio frequency interference, and wherein the frame synchronization unit ignores the portion of the frequency domain data that overlaps with frequency ranges of the radio frequency interference.

Also included is the receiver as recited hereinabove, wherein the data transmission system is a synchronized DMT system, and wherein the multicarrier demodulation unit includes a FFT unit.

Also included is a receiver for a data transmission system using time division duplexing to alternate between transmission and reception of data, the receiver comprising: an analog-to-digital converter, the analog-to-digital converter receives analog data that has been transmitted over a channel to the receiver and converts the received analog signals into received digital signals; an input buffer for temporarily storing the received digital signals; a multicarrier demodulation unit, the multicarrier demodulation unit demodulates the received digital signals from the input buffer to frequency domain data for a plurality of different carrier frequencies; frame synchronization means for synchronizing a frame boundary for the multicarrier demodulation unit based on the time-varying nature of the energy of the frequency domain data produced by the multicarrier demodulation unit; a bit allocation table, the allocation table stores bit allocation information used in transmitting data being received at the receiver; a data symbol decoder, the data symbol decoder receives the frequency domain data and decodes bits associated with the frequency domain data from the carrier frequencies based on the bit allocation information stored in the bit allocation table; and an output buffer for storing the decoded bits as recovered data.

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Also included is, in a data transmission systems having a plurality of transmitters at a central site, the transmitters transmiting data in accordance with a superframe format including at least one quiet period, a method for synchronizing data transmissions by a given transmitter to other of the transmitters at the central site, the method comprises the acts of: (a) measuring the energy in the quiet period associated with the given transmitter due to data transmissions from the other of the transmitters at the central site; (b) comparing the measured energy with a threshold amount; and (c) modifying the synchronization for the transmissions by the given transmitter when the comparing (b) indicates that the measured energy exceeds the threshold amount.

Also included is the method as recited hereinabove, wherein the data transmission system transmits data using time division duplexing, and wherein the transmitters are part of transceivers at the central site.

Also included is the method as recited hereinabove, wherein the data transmission system is a multicarrier data transmission system.

Also included is the method as recited hereinabove, wherein the modifying (c) comprises adjusting timing alignment to reduce crosstalk interference.

Also included is the method as recited hereinabove, wherein the adjusting increases or decreases the length of the superframe format.

Also included is the method as recited hereinabove, wherein the adjusting alters the frequency of a local clock for the given transmitter.

Also included is the method as recited hereinabove, wherein the data transmission system is a multicarrier data transmission system, and wherein an external clock signal is unavailable for synchronizing the transmitters, and wherein the modifying (c) comprises adjusting timing alignment to reduce crosstalk interference.

Also included is the method as recited hereinabove, the measuring (a) of the energy in the quiet period associated with the given transmitter due to the data transmissions from the other of the transmitters at the central site operates to distinguish between outgoing data transmissions from the other of the transmitters and incoming data receptions, so that the measuring (a) measures the energy in the quiet period due to the outgoing data transmissions from the other of the transmitters and not due to the incoming data receptions.

Also included is a computer readable medium containing program instructions for synchronizing data transmissions in a data transmission systems having a plurality of transmitters at a central site where an external clock signal is unavailable for synchronizing the transmitters, the transmitters transmit data in accordance with a superframe format including at least one quiet period, the computer readable medium comprising: first computer readable code devices for measuring the energy in the quiet period associated with a given transmitter due to data transmissions from other of the transmitters at the central site; second computer readable code devices for comparing the measured energy with a threshold amount;

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and third computer readable code devices for modifying the synchronization for the transmissions by the given transmitter when the comparing indicates that the measured energy exceeds the threshold amount.

Also included is the computer readable medium as recited hereinabove, wherein the data transmission system is a multicarrier data transmission system that transmits data uses time division duplexing, and the transmitters are part of transceivers at the central site, and wherein the third computer readable code devices operates to adjust timing alignment to reduce crosstalk interference.

The many features and advantages of the present invention are apparent from the written description, and thus, it is intended by the appended claims to cover all such features and advantages of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation as illustrated and described. Hence, all suitable modifications and equivalents may be resorted to as falling within the scope of the invention.

What is claimed is:

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CLAIMS

1. A method for adjusting an alignment for a first transceiver to receive frames of data transmitted from a second transceiver over a transmission medium to the first transceiver, the first transceiver and the second transceiver being associated with a data transmission system providing two-way data communication using time division duplexing, said method comprising the acts of:

(a) measuring an energy amount for each of a plurality of consecutive frames of received data;

(b) computing an alignment error estimate based on the measured energy amounts.

2. A method as recited in claim 1, wherein the alignment error estimate is an estimated alignment error as a fraction of a frame.

3. A method as recited in claim 1, wherein the data transmission system transmits data using a superframe structure having a plurality of frames, a first set of the frames in the superframe transmit data in a first direction, and a second set of the frames in the superframe transmit data in a second direction.

4. A method as recited in claim 3, wherein the first transceiver uses a frame boundary pointer to identify a beginning of a frame in the superframe being received, and

wherein said method further comprises:

(c) adjusting the frame boundary pointer in accordance with the alignment error estimate.

5. A method as recited in claim 4, wherein the alignment error estimate is an estimated alignment error as a fraction of a frame.

6. A method as recited in claim 4, wherein said method further comprises:

(d) comparing the alignment error estimate with a threshold amount;

(e) repeating (a) - (d) until said comparing (d) indicates that the alignment error estimate is less than the threshold amount.

7. A computer readable medium containing program instructions for adjusting an alignment for a first transceiver to receive frames of data transmitted from a second transceiver over a transmission medium to the first transceiver, the first transceiver and the second transceiver being associated with a data transmission system providing two-way data communication using time division duplexing, said computer readable medium comprising:

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first computer readable code devices for measuring an energy amount for each of a plurality of consecutive frames of received data; and

second computer readable code devices for computing an alignment error estimate based on the measured energy amounts.

8. A receiver for a data transmission system using time division duplexing to alternate between transmission and reception of data, said receiver comprising:

an analog-to-digital converter, said analog-to-digital converter receives analog data that has been transmitted over a channel to said receiver and converts the received analog signals into received digital signals;

an input buffer for temporarily storing the received digital signals;

a multicarrier demodulation unit, said multicarrier demodulation unit demodulates the received digital signals from said input buffer to frequency domain data for a plurality of different carrier frequencies;

a frame synchronization unit, said frame synchronization unit synchronizes a receive frame boundary for said multicarrier demodulation unit based on the time-varying nature of the energy of the frequency domain data produced by said multicarrier demodulation unit;

a bit allocation table, said allocation table stores bit allocation information used in transmitting data being received at said receiver;

a data symbol decoder, said data symbol decoder receives the frequency domain data and decodes bits associated with the frequency domain data from the carrier frequencies based on the bit allocation information stored in said bit allocation table; and

an output buffer for storing the decoded bits as recovered data.

9. In a data transmission systems having a plurality of transmitters at a central site, the transmitters transmit data in accordance with a superframe format including at least one quiet period, a method for synchronizing data transmissions by a given transmitter to other of the transmitters at the central site, said method comprises the acts of:

(a) measuring the energy in the quiet period associated with the given transmitter due to data transmissions from the other of the transmitters at the central site;

(b) comparing the measured energy with a threshold amount; and

(c) modifying the synchronization for the transmissions by the given transmitter when said comparing (b) indicates that the measured energy exceeds the threshold amount.

10. A computer readable medium containing program instructions for synchronizing data transmissions in a data transmission systems having a plurality of transmitters at a central site where an external clock signal is unavailable for synchronizing the transmitters, the

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transmitters transmit data in accordance with a superframe format including at least one quiet period, said computer readable medium comprising:

first computer readable code devices for measuring the energy in the quiet period associated with a given transmitter due to data transmissions from other of the transmitters at the central site;

second computer readable code devices for comparing the measured energy with a threshold amount; and

third computer readable code devices for modifying the synchronization for the transmissions by the given transmitter when said comparing indicates that the measured energy exceeds the threshold amount.

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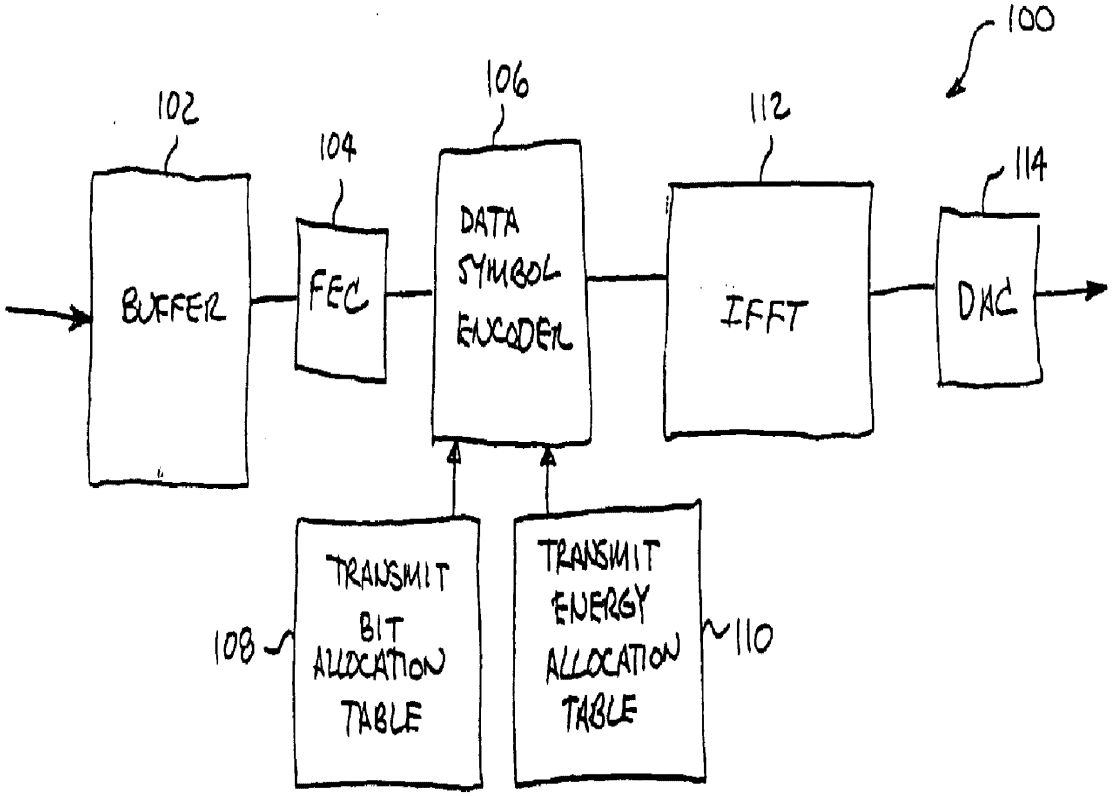


FIG. 1A (PRIOR ART)

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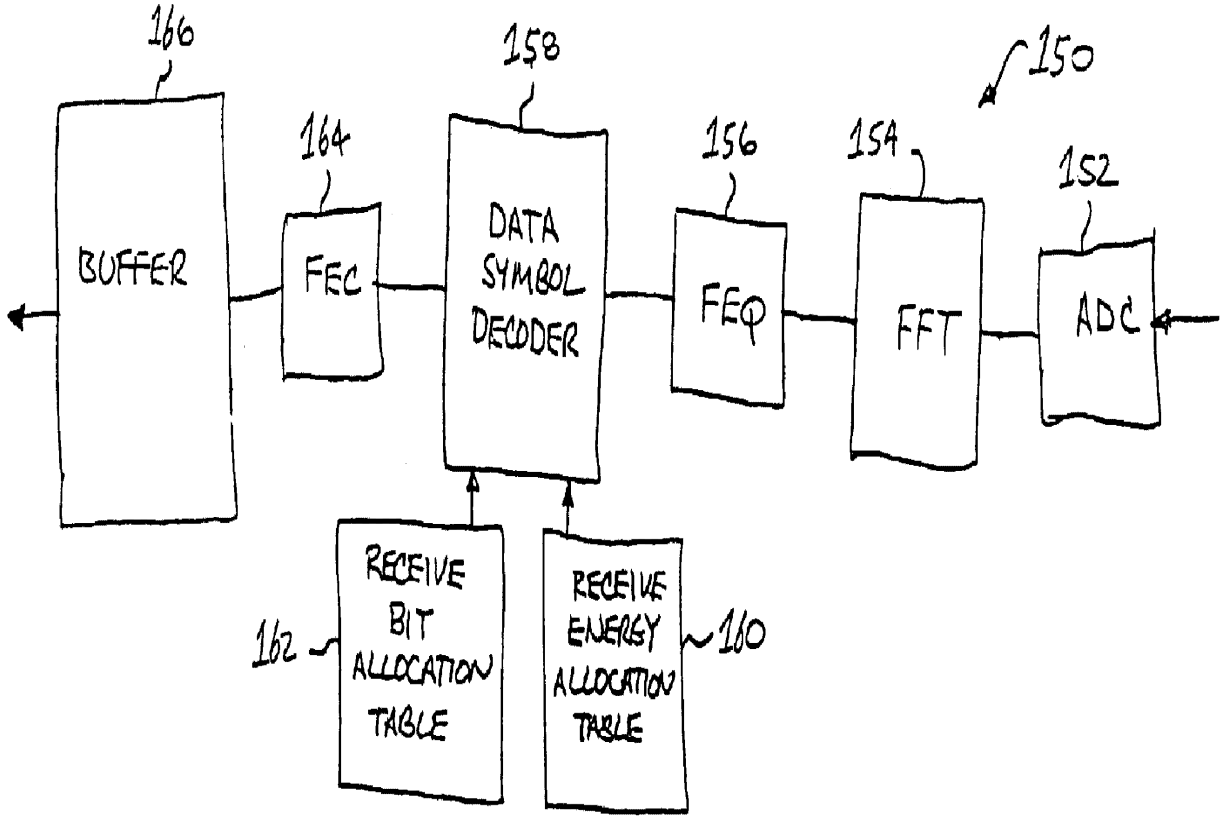


FIG. 1B (PRIOR ART)

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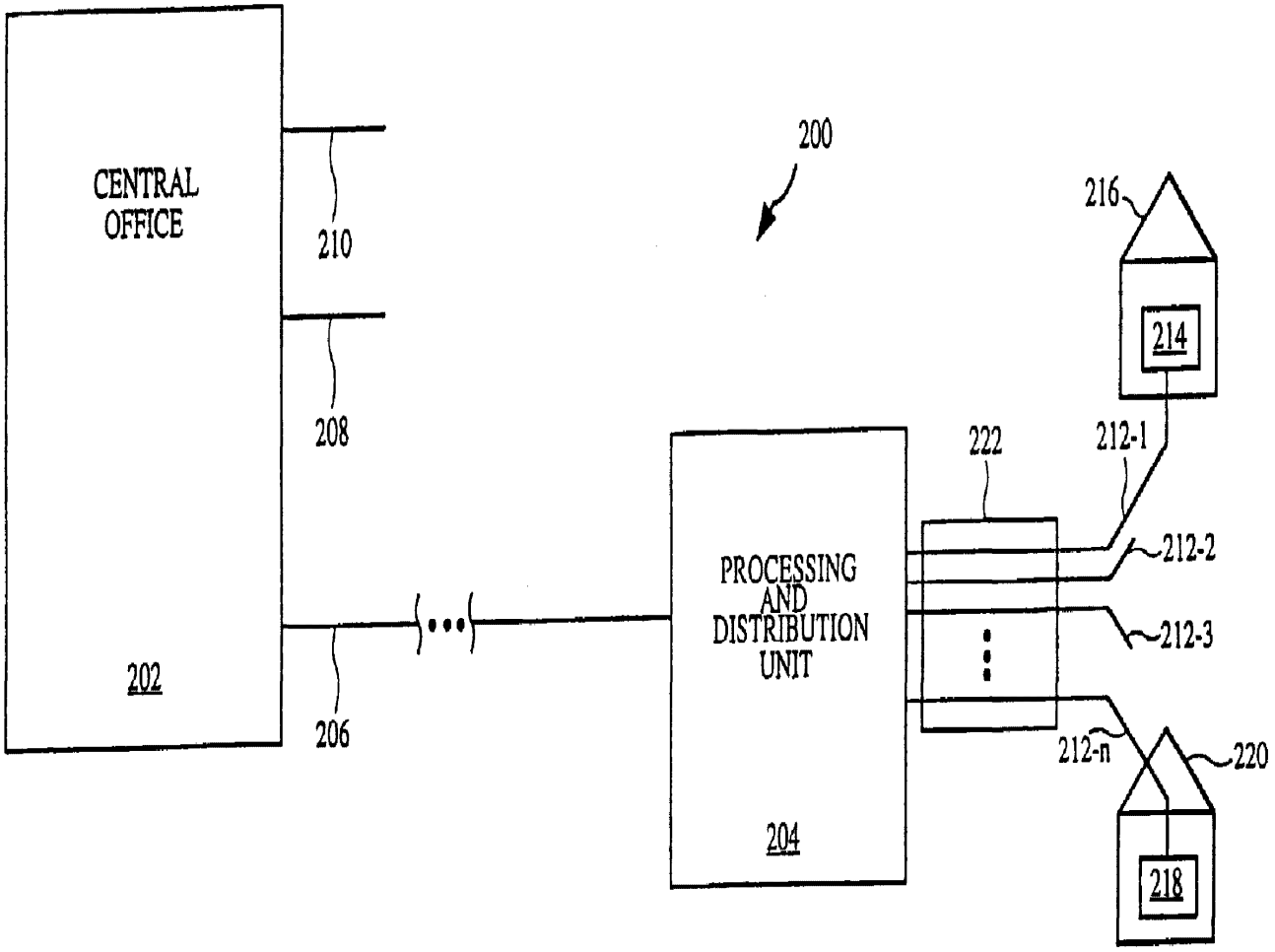


FIG. 2

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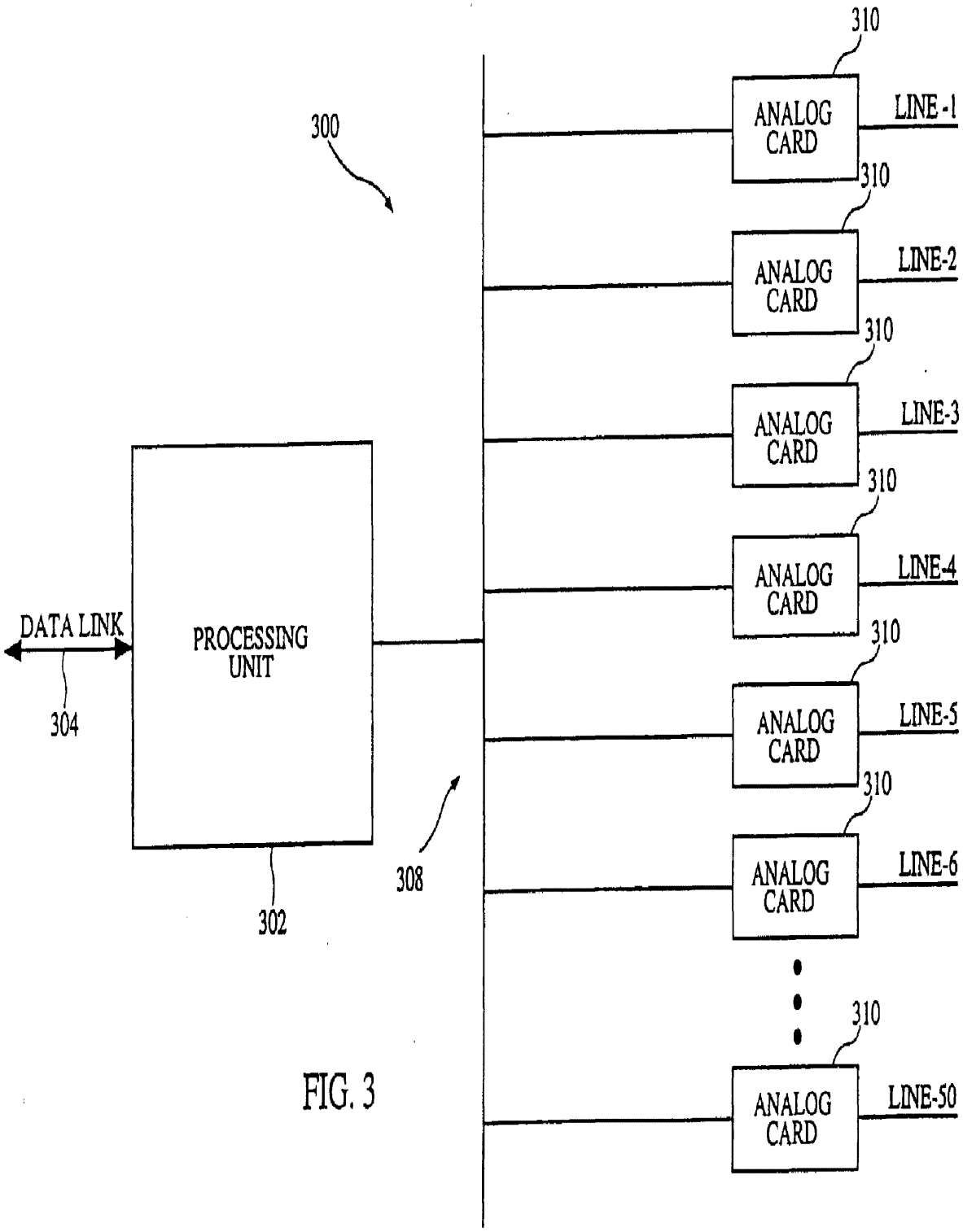


FIG. 3

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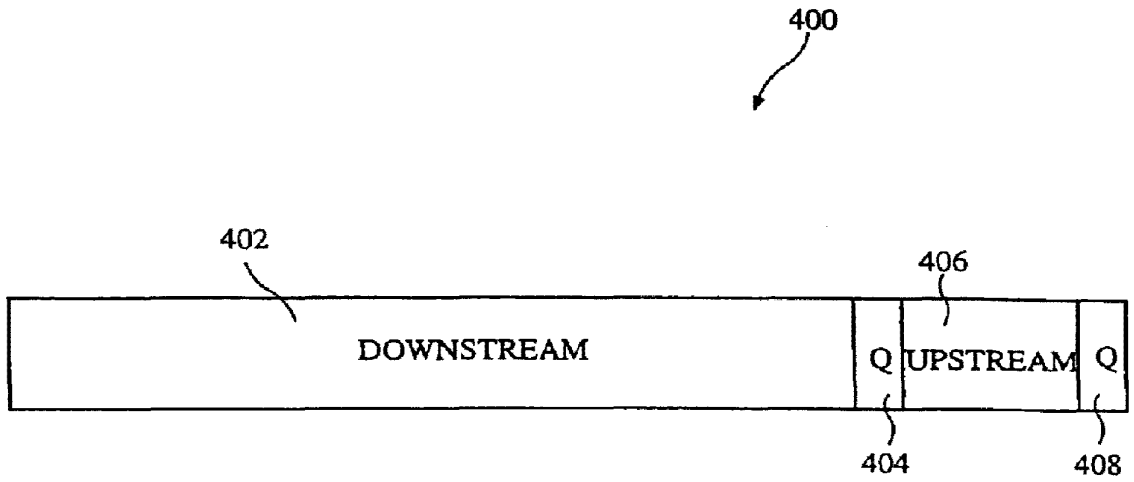


FIG. 4

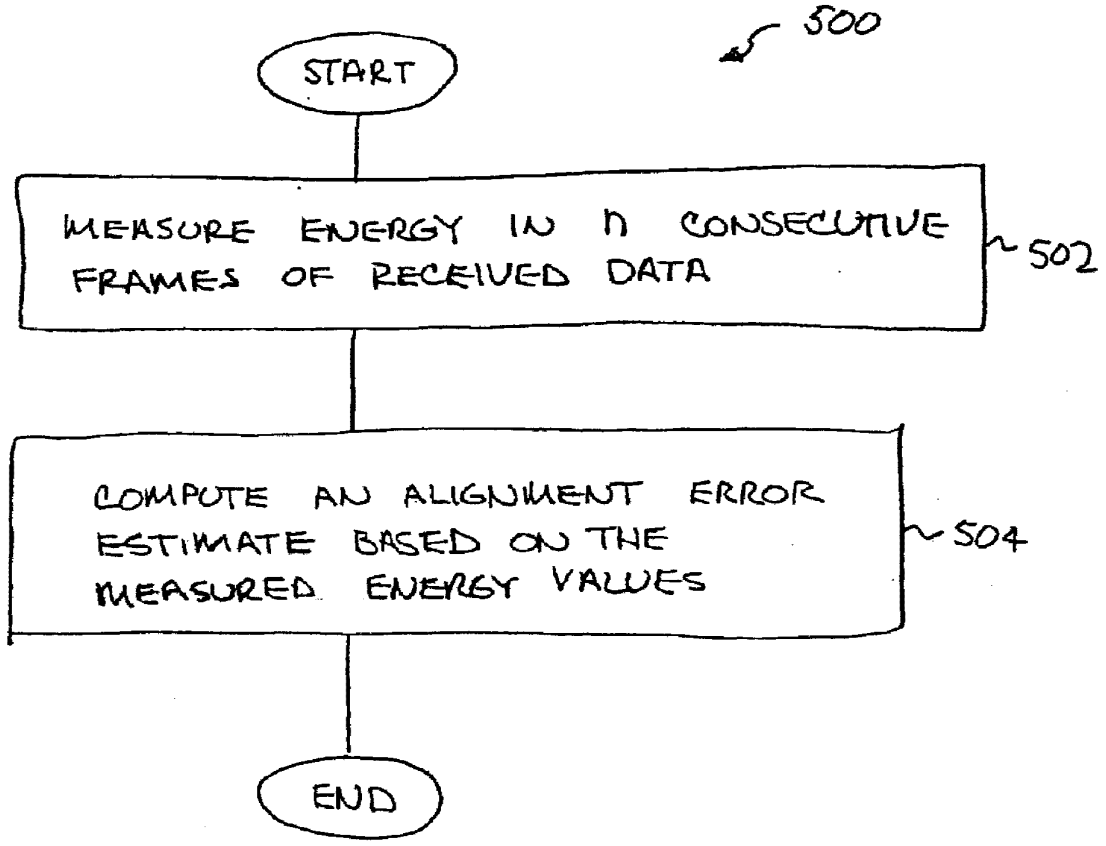

500
START
MEASURE ENERGY IN n CONSECUTIVE FRAMES OF RECEIVED DATA
502
COMPUTE AN ALIGNMENT ERROR ESTIMATE BASED ON THE MEASURED ENERGY VALUES
504
END

FIG. 5A

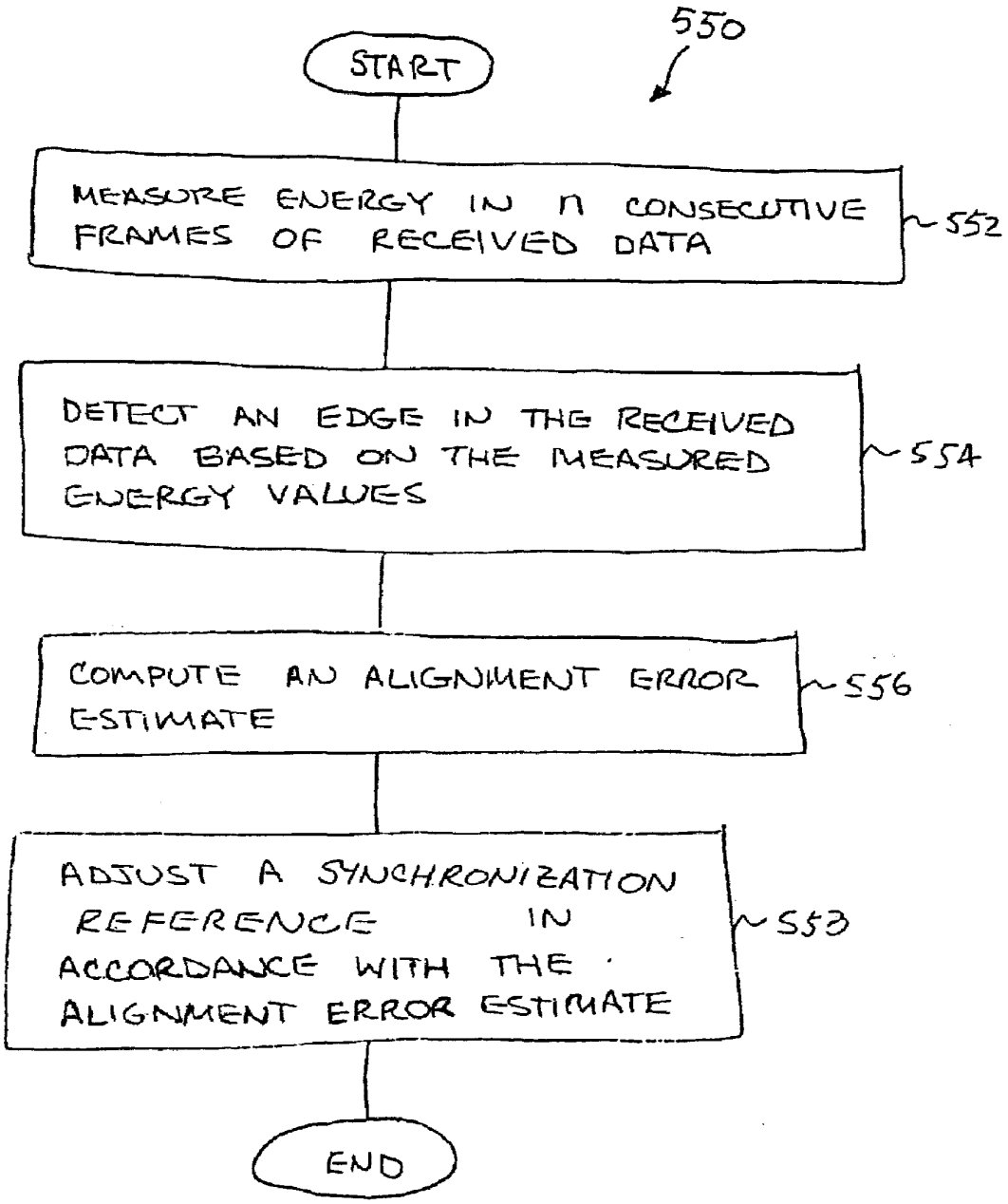

550
START
MEASURE ENERGY IN N CONSECUTIVE FRAMES OF RECEIVED DATA
552
DETECT AN EDGE IN THE RECEIVED DATA BASED ON THE MEASURED ENERGY VALUES
554
COMPUTE AN ALIGNMENT ERROR ESTIMATE
556
ADJUST A SYNCHRONIZATION REFERENCE IN ACCORDANCE WITH THE ALIGNMENT ERROR ESTIMATE
553
END

FIG. 5B

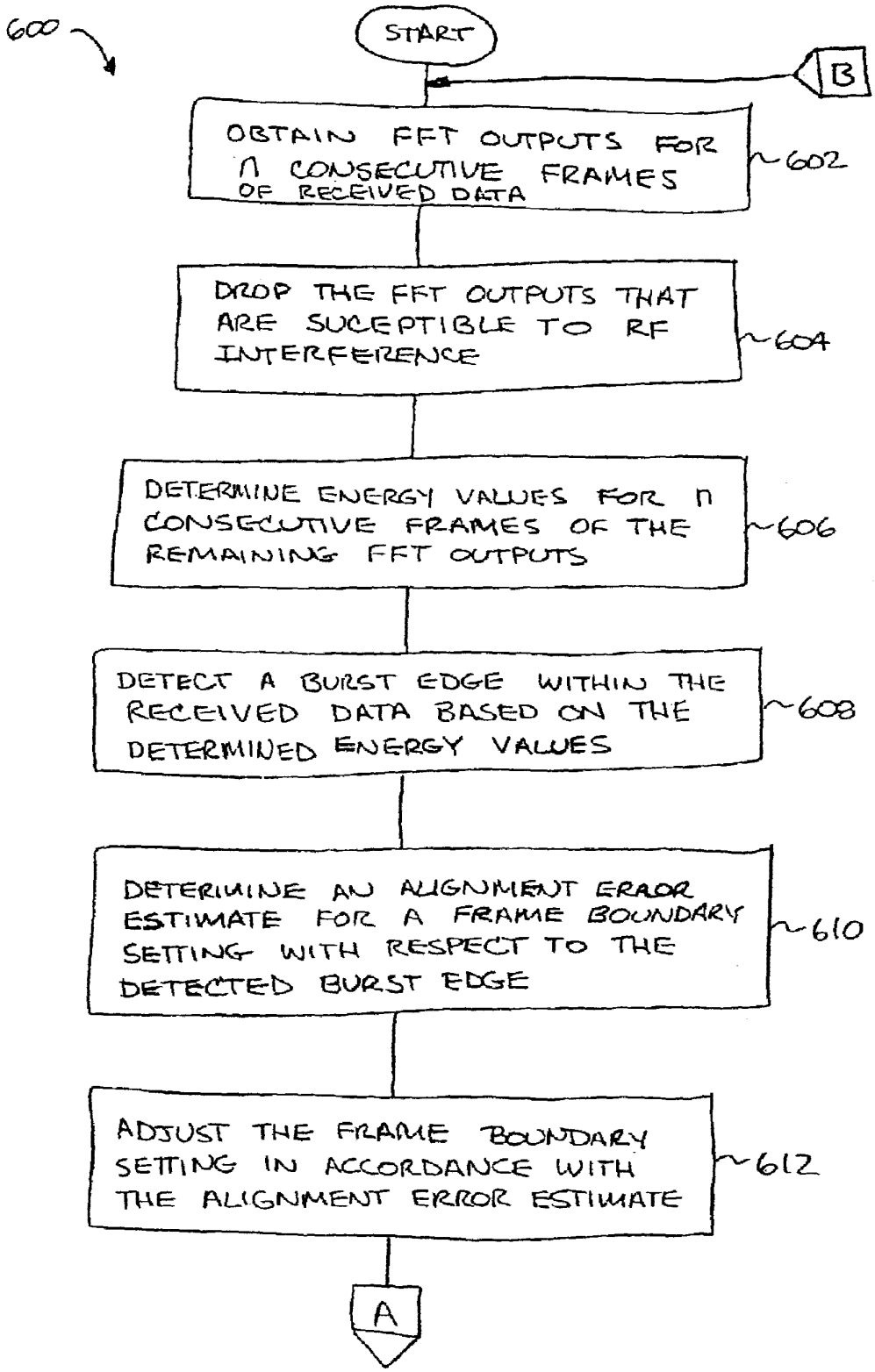

600
START
B
OBTAIN FFT OUTPUTS FOR n CONSECUTIVE FRAMES OF RECEIVED DATA
602
DROP THE FFT OUTPUTS THAT ARE SUCEPTIBLE TO RF INTERFERENCE
604
DETERMINE ENERGY VALUES FOR n CONSECUTIVE FRAMES OF THE REMAINING FFT OUTPUTS
606
DETECT A BURST EDGE WITHIN THE RECEIVED DATA BASED ON THE DETERMINED ENERGY VALUES
608
DETERMINE AN ALIGNMENT ERROR ESTIMATE FOR A FRAME BOUNDARY SETTING WITH RESPECT TO THE DETECTED BURST EDGE
610
ADJUST THE FRAME BOUNDARY SETTING IN ACCORDANCE WITH THE ALIGNMENT ERROR ESTIMATE
612
A

FIG. 6A

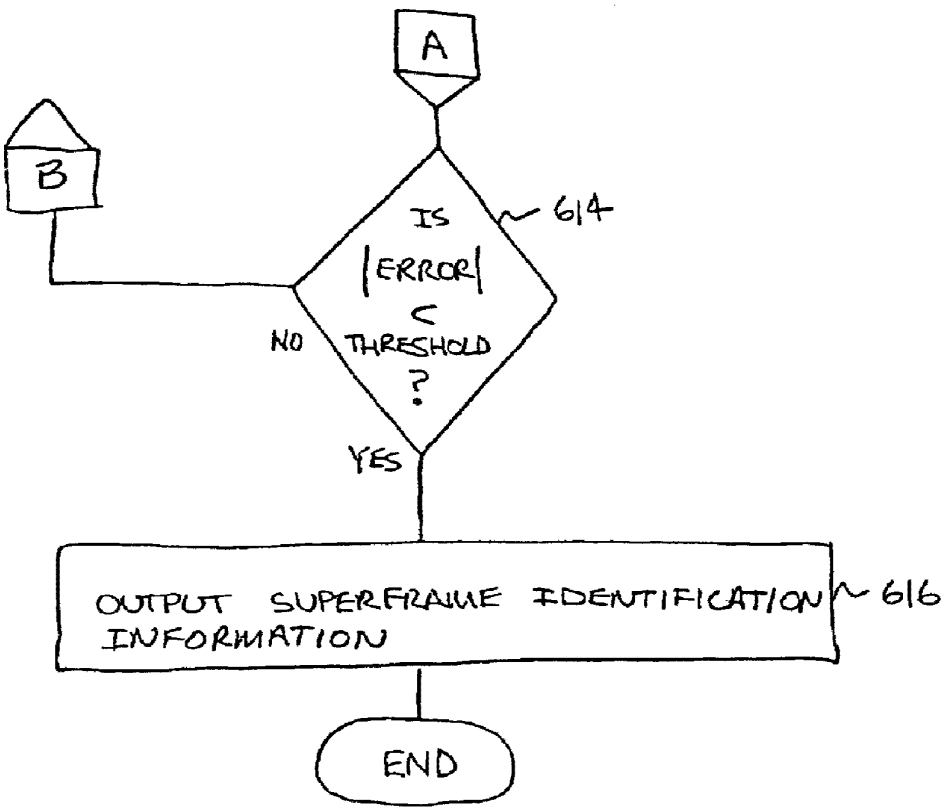

A
B
IS |ERROR| < THRESHOLD ?
614
NO
YES
OUTPUT SUPERFRAME IDENTIFICATION INFORMATION
616
END

FIG. 6B

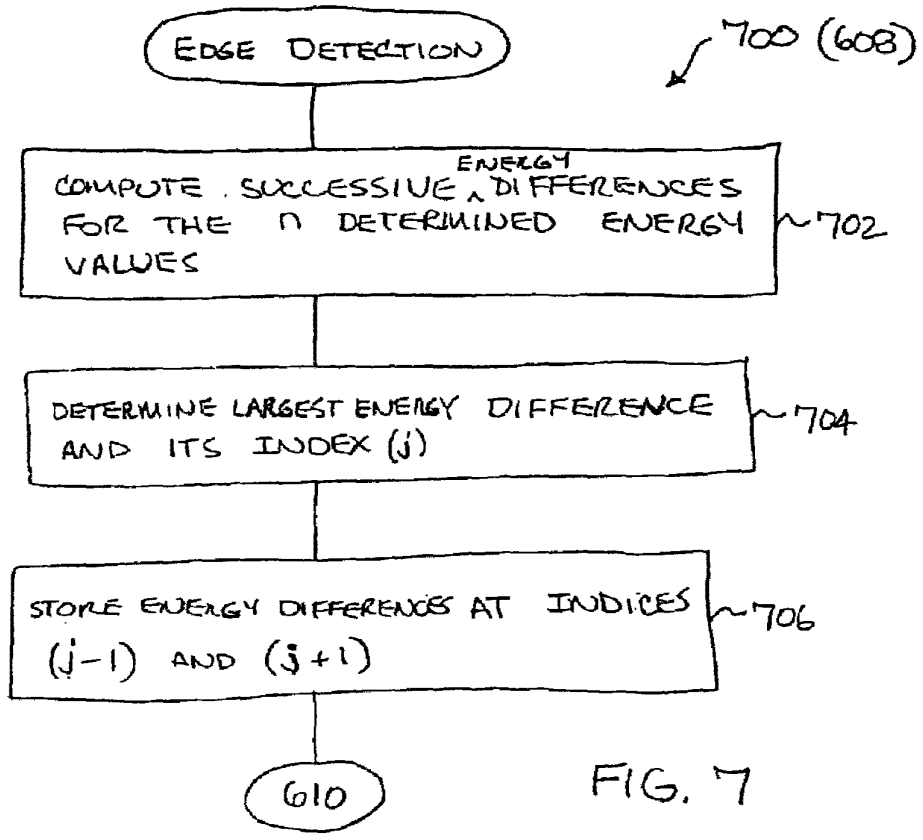

EDGE DETECTION
700 (608)
COMPUTE SUCCESSIVE ENERGY DIFFERENCES FOR THE N DETERMINED ENERGY VALUES
702
DETERMINE LARGEST ENERGY DIFFERENCE AND ITS INDEX (j)
704
STORE ENERGY DIFFERENCES AT INDICES (j-1) AND (j+1)
706
610

FIG. 7

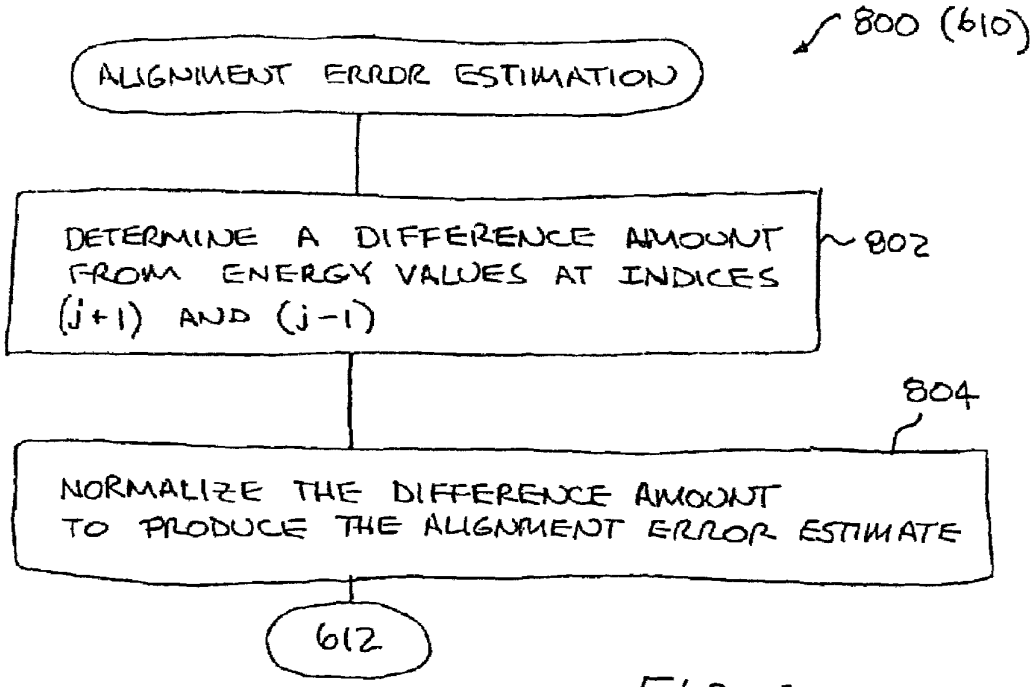

800 (610)
ALIGNMENT ERROR ESTIMATION
DETERMINE A DIFFERENCE AMOUNT FROM ENERGY VALUES AT INDICES (j+1) AND (j-1)
802
804
NORMALIZE THE DIFFERENCE AMOUNT TO PRODUCE THE ALIGNMENT ERROR ESTIMATE
612

FIG. 8

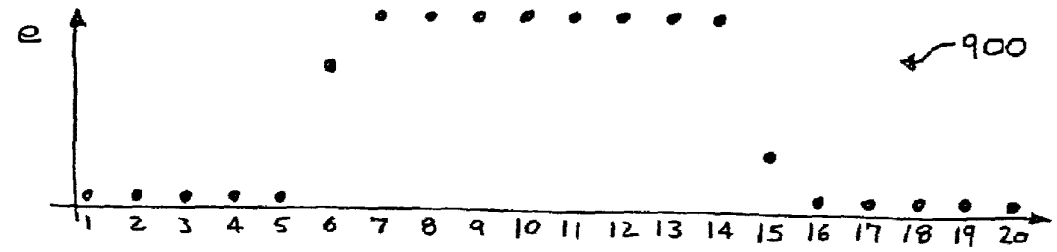


FIG. 9A

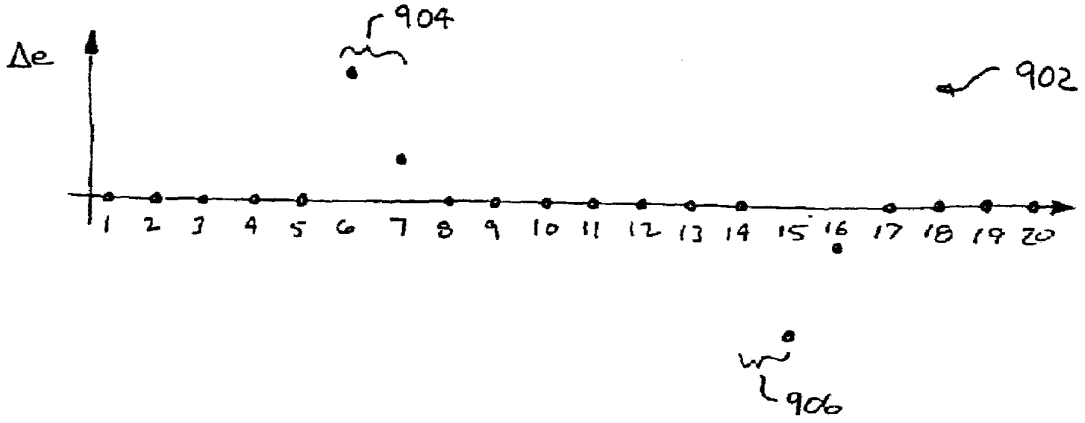


FIG. 9B

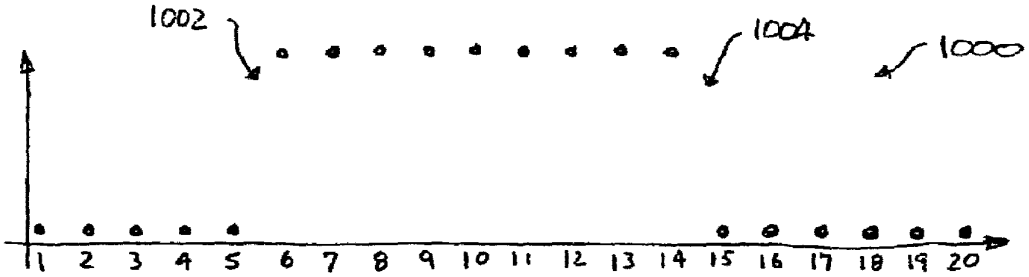


FIG. 10A

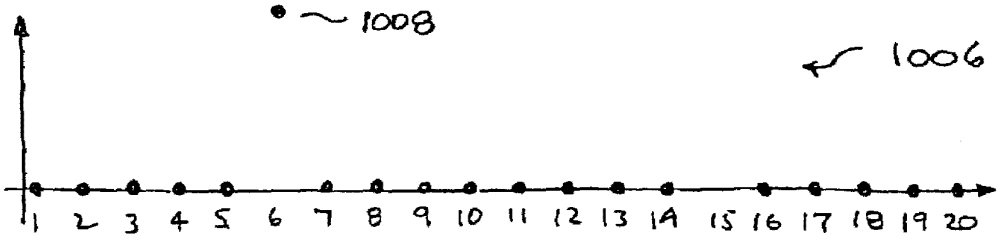


FIG. 10B

1010

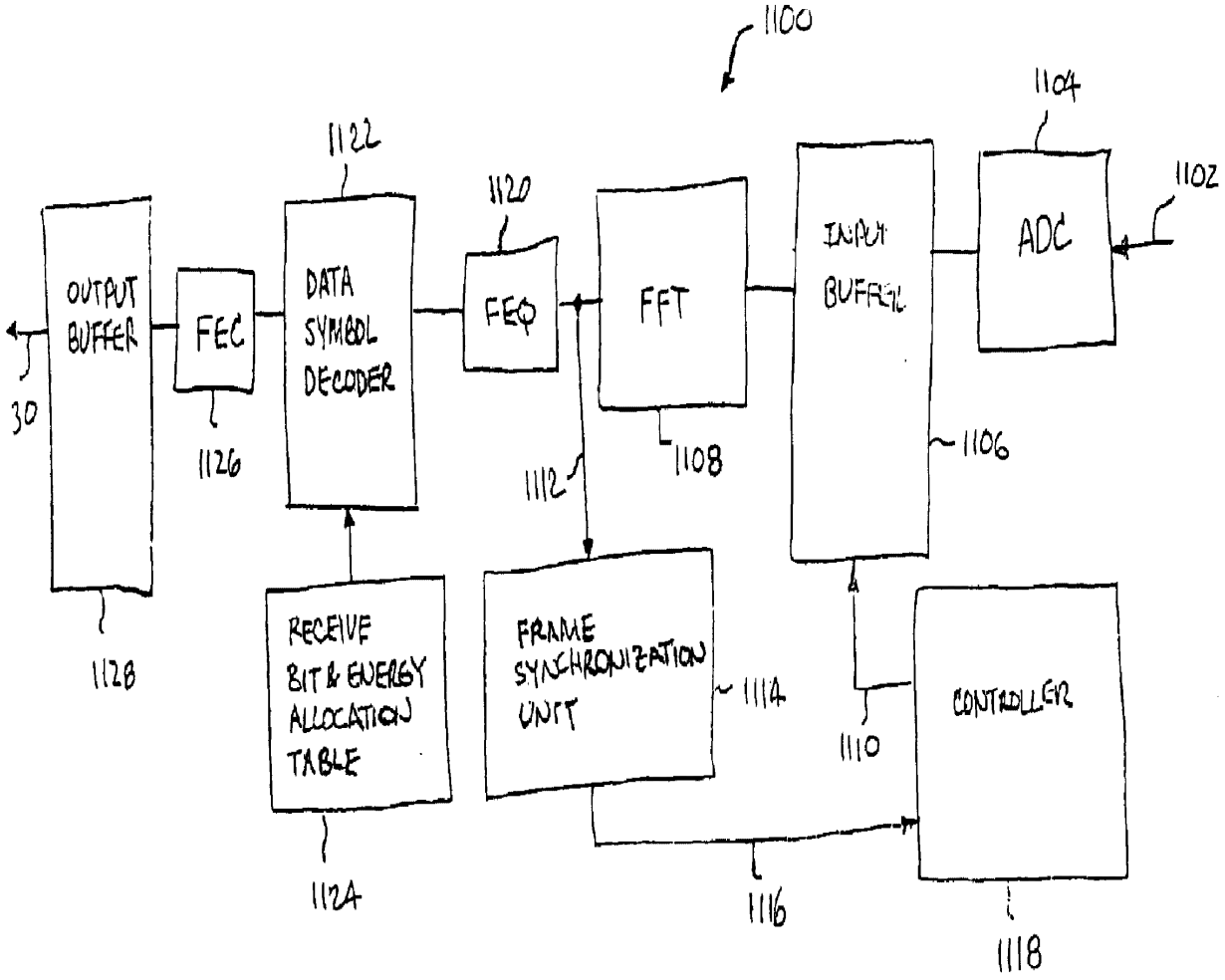


FIG. 11

CA 02254807 2000-02-28

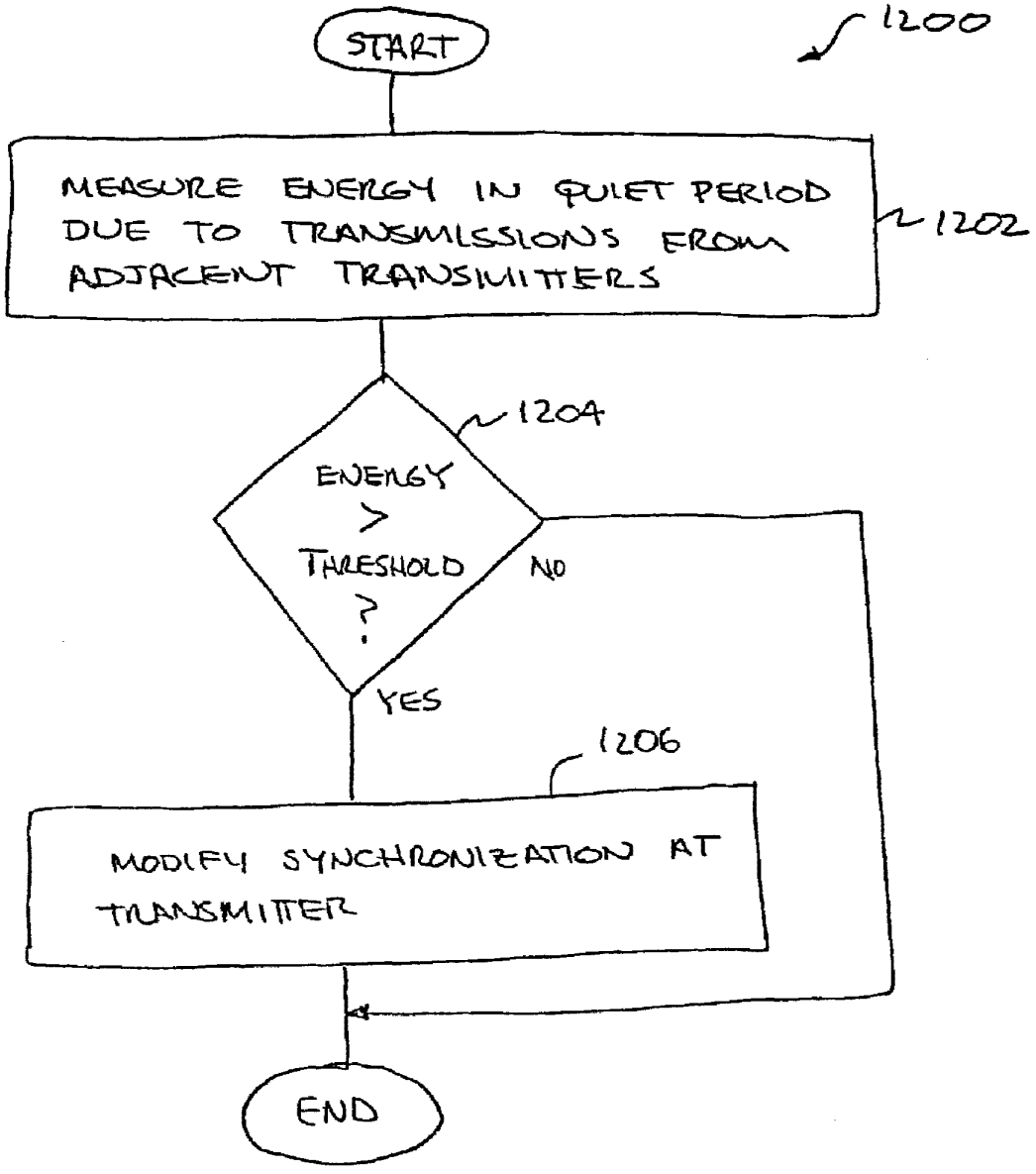

START
1200
MEASURE ENERGY IN QUIET PERIOD DUE TO TRANSMISSIONS FROM ADJACENT TRANSMITTERS
1202
ENERGY > THRESHOLD ?
1204
NO
YES
MODIFY SYNCHRONIZATION AT TRANSMITTER
1206
END

FIG. 12

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(54) Apparatus, method and system having reduced power consumption in a multi-carrier wireline environment

(57) To reduce power consumption and associated heating in a line card of line termination equipment (LTE, 12) employing multiple sub-channel carriers to communicate broadband information to customer premise equipment (CPE, 30) down a wireline communication resource (26), sub-channel carrier transmissions are restricted (58) during periods of CPE inactivity. Power supplies to a power amplifier (30) associated with the line card and wireline resource (26) are reduced, with digital signal processing capabilities of the LTE (12) further restricted (64). When the CPE wishes to re-start communication, the CPE (30) locks (68) to a correct alignment in a transmission scheme using a pilot tone that is transmitted within a simple pattern sent during reduced sub-channel carrier transmissions. Alternatively, should all transmission from the LTE cease during CPE inactivity, then the CPE monitors (80) the transmission environment and sends (82) a wake-up call to the LTE between boundaries of an uplink slot. The LTE (12) re-establishes pilot tone transmissions (86), with synchronisation and lock (88) subsequently achievable by the CPE (30); this is illustrated in FIG. 2.

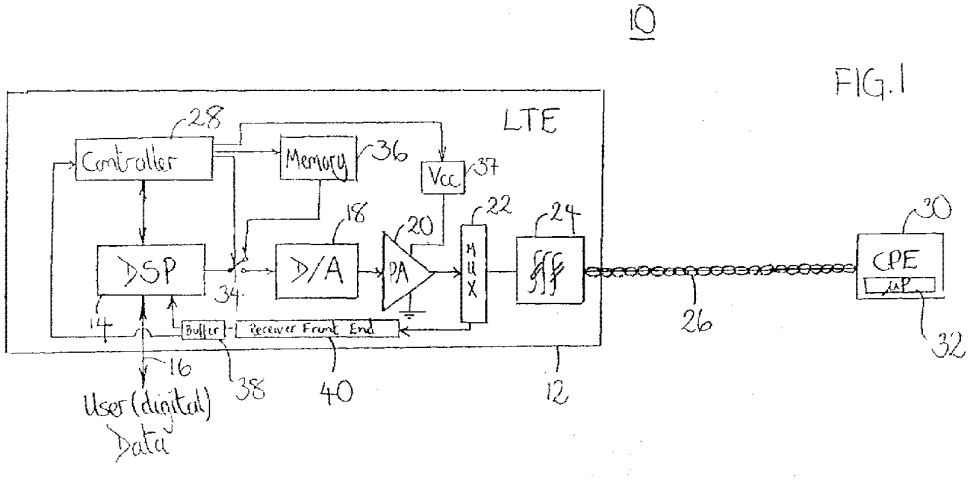


FIG. 1

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Description

Background to the Invention

[0001] This invention relates, in general, to an apparatus, method and system arranged to minimise power consumption in a wireline environment, and is especially (but not exclusively) applicable to a wireline communication system that communicates relatively high frequency broadband signals over relatively low frequency voiceband signals, e.g. by using digital subscriber line (xDSL) communication protocols in bi-directional twisted-pair systems.

Summary of the Prior Art

[0002] Telecommunication systems that interconnect wireline subscriber terminals are being developed to support broadband data communication. More particularly, recent developments in broadband communication protocols allow broadband data to be overlaid on narrowband voice or integrated service digital network (ISDN) traffic. Specifically, the interconnection of broadband modems located at the subscriber terminal and at an exchange allow current broadband access systems to communicate on spare spectrum (i.e. spare frequency channels) of a twisted pair communication resource; the spare frequency channels being isolated from conventionally encoded voice signals by a suitable filter. In this respect, and depending upon the complexity of the xDSL coding scheme, overlaid broadband systems can support data rates in excess of two Megabits per second (Mbps), although this rate is dependent upon the physical parameters of the connection, e.g. the overall length of the twisted pair and its composition and configuration.

[0003] Asymmetric Digital Subscriber Line (ADSL) and High-speed Digital Subscriber Line (HDSL) protocols, for example, can support data rates of 2Mbps over distances of approximately three kilometres, while more complex schemes (such as VDSL) can support data rates of 8Mbps and above over distances of, typically, less than two kilometres. Protocols such as Very high-speed Digital Subscriber Line (VDSL) utilise multiple sub-channel carriers, e.g. in a discrete multi-tone (DMT) environment, to provide an adaptive system that mitigates the effects of cross-talk by selectively ignoring noise-effected sub-channel carriers or reducing the number of bits supported on each sub-channel. As will be appreciated, DMT provides a comb of frequency carriers that are each separated modulated and then combined to generate a composite signal envelope. As such, information (both control information and traffic) is distributed across a number of different frequency carriers.

[0004] DMT schemes for supporting, for example, VDSL are often realised in a time division duplex (TDD) transmission environment in which a single communication resource, i.e. a frequency band, supports both up-link and down-link transmissions using the same frequencies. In other words, there is a sharing in time of the bandwidth provided by the extended spectrum. The use of guard periods between adjacent groups of time-slots within a TDD frame ensures that rogue overlapping transmissions within the up-link and down-link do not occur, and hence eliminates the likelihood of near-end cross talk (NEXT). In more detail, the guard periods provide a period in which a power amplifier can power-up and power-down, and also allow for some adjustment (i.e. alignment) of the frame with respect to a selected pilot tone on a designated sub-channel carrier of a DMT scheme.

[0005] In relation to bundles of wireline communication resources, it is also important to understand the potentially undesirable effects associated with cross-talk interference. Specifically, with bi-directional communication, the relative location of the lines, for example, between twisted copper-pair causes cross-talk interference to be induced into proximately located wireline communication resources (principally by the mechanisms of capacitive and inductive coupling and by radiation arising from the imperfect nature and performance of the cabling). Moreover, where symmetrical and asymmetrical service are simultaneously required on pairs in the same bundle, cross-talk becomes a significant problem, as will readily be appreciated.

[0006] For completeness, it will be understood that near-end cross-talk (NEXT) occurs when electromagnetic interference is induced into a wireline resource that is communicating information in an opposing direction, e.g. down-link (or downstream) information appears as noise in an up-link (or upstream) path. NEXT is undesirable because near-end generated interference is at a level that can potentially swamp data signals received from a remote terminal, which data signals have previously been subjected to attenuation through the transmission path. Furthermore, NEXT increases significantly at the higher frequency components and so is even more undesirable in high frequency data-over-voice wireline systems, such as VDSL. To avoid the harmful effects of Near-End Cross-Talk (NEXT) in a TDD system, an ensemble of collated communication resources must have synchronised and aligned transmissions. However, in a mixed symmetrical/asymmetrical system, NEXT often occurs where the two opposing schemes have either different frequency allocations (in frequency division duplex, FDD) or different time slot allocations (in TDD).

[0007] With regard to Far End Cross-Talk (FEXT), this form of cross-talk affects non-addressed ports of a remote terminal. In other words, FEXT occurs when electromagnetic interference (i.e. noise) is induced into a wireline resource that is communicating information in a similar direction, e.g. upstream (or up-link) information appears as noise in another upstream wireline resource to an extent that performance on a given pair is limited.

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The effects of FEXT are correspondingly reduced by the attenuation path of the wireline resource. However, when multiple separate modem links exist (as supported by a multiplicity of different copper pairs proximally located towards the exchange LTE as a bundle of pairs in the access network and then fanned out to individual drops serving particular CPEs), crosstalk between the numerous signals at (or towards) the exchange presently generates noise that limits the data-rate performance of both a given pair and the entire wireline system, in general. In synchronised systems, FEXT is inherent.

[0008] FEXT on adjacent pairs can be severely exacerbated from increased signal strengths at a receiver modem of the exchange LTE for the pair causing the FEXT. More especially, where these adjacent pairs have shorter reaches (i.e. shorter cable lengths), the attenuation of the signal in the wireline resource from such relatively closely located modems (as opposed to remotely located modems) is relatively little and, correspondingly, FEXT induced into adjacent wireline resources can be relatively large. In other words, in instances when FEXT from a relatively closely located modem is introduced into a wireline resource serving a distantly located modem, the FEXT interference effects can be catastrophic and corruption of the data from the distant modem absolute. For this reason, it is accepted that there is a need to "back-off" the power transmitted by the transmitting (CPE) modem in the upstream direction for all but the longest lines. Unfortunately, the necessity for back-off results in inefficient utilisation of the spectrum as a consequence of CPEs served by short loop distances having to forego the benefits of better signal to noise ratios (SNR) and therefore to restrict channel throughput by reducing power and lowering the bit transmission rate. In summary, FEXT is particularly problematic in the uplink at the LTE and limits spectral capacity generally.

[0009] The term "self-FEXT" will be understood to mean FEXT arising from use of the same time-slot and/or the same frequency for a common form of service (as opposed to differing services on a common wireline resource, such as a combination of ADSL and VDSL).

[0010] In order to establish effective end-to-end communication in a communication system, it is necessary for synchronisation between a transmitting unit and an interconnected receiving unit to occur; this is true for both a radio frequency environment and a wireline environment, such a VDSL system employed over a twisted pair. More specifically, synchronisation is required to demodulate encoded signals that are addressed to the receiver. In this respect and in relation to a DMT system (or the like, such as an orthogonal frequency division multiplexed OFDM scheme), a pilot carrier or tone is used in a training sequence on a dedicated (pre-allocated) sub-channel. Initially, upon receipt of the pilot tone, the receiver acquires frequency lock and then establishes phase lock.

[0011] Another concern in relation to the implementation of wide bandwidth applications (required multi-carrier schemes) arises from the fact that the frequency spectrum seldom provides a homogeneous transmission environment and usually exhibits significant variations in its signal to noise (S:N) ratio across its bandwidth. In fact, portions of the spectrum are often unusable as a consequence of the presence of interference, such as noise and intermodulation products. To avoid these poor spectral regions, modems associated with the transmitter and receiver negotiate for the best sub-channel carriers during training and reject those sub-channel carriers that have a performance below a predetermined and acceptable threshold.

[0012] Another significant problem in a multi-carrier environment pertains to the peak power of the composite envelope formed by a summation of the individual sub-channel carriers. While techniques have been developed to restrict these peaks, there is still a general requirement for DMT equipment to support a wide (large) dynamic range.

[0013] In relation to a typical (although simplified) model of a wireline transmission path, line termination equipment (LTE) typically has an interface for receiving user data, which user data is subsequently applied to a digital signal processor (DSP). As will readily be appreciated, the DSP is configured to perform many signal processing tasks, including DMT encoding.

[0014] Following DMT encoding of the data, resultant signals are converted into the analog domain (in a digital-to-analog converter, DAC) before being applied to a power amplifier that is required to ensure that there is sufficient power to drive the wireline communication resource and therefore to ensure reception of the signals at the addressed customer premise equipment (CPE). As will be understood, a passive filter is generally included in the path between the power amplifier and the wireline, with a line impedance of the wireline having a nominal impedance value of approximately 100 (with the actual value being country specific). In other words, the power amplifier is required by virtue of the fact that copper pairs have low impedance and DAC operation is subject to restricted operational parameters.

[0015] In relation to the aforementioned transmission path, it will be appreciated that the functional elements are attributable to individual line cards of telecommunication exchanges, such as private branch exchanges (PBXs) and infrastructure nodes that integrate with ancillary services, e.g. Internet servers.

[0016] Unfortunately, the power amplifier is responsible for dissipating approximately half of the total power of the line card and so its inclusion and operation generates significant heat (that must effectively be channelled away from temperature sensitive integrated circuits) whilst also placing significant demands on power supplies within the exchange. Consequently, systems and schemes that reduce total power consumption in line cards are very desirable.

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Summary of the Invention

[0017] According to a first aspect of the present invention there is provided a wireline communication system comprising line termination equipment coupled to customer premise equipment through a wireline communication resource supporting a multi-carrier transmission scheme between the LTE and the CPE, the wireline communication system comprising: means for indicating activity of the CPE; and a controller, responsive to the means for indicating activity, for selecting sub-channel carriers of the multi-carrier transmission scheme on which information is modulated for transmission to the CPE over the wireline resource, wherein the controller is arranged to limit a number of sub-channel carriers utilised by the LTE in response to the means for indicating activity identifying that the CPE is inactive.

[0018] The LTE typically comprises a line driver coupled to a voltage supply and arranged to amplify signals to be applied to the wireline communication resource, the voltage supply being operationally responsive to the controller and wherein the controller is arranged to reduce a voltage applied to power the line driver in response to the means for indicating activity identifying that the CPE is inactive.

[0019] In a preferred embodiment, the LTE comprises a signal processor operationally responsive to the controller, the controller arranged to at least partially disable operationally functionality of the signal processor in response to the means for indicating activity identifying that the CPE is inactive.

[0020] In another embodiment, the wireline communication system comprises a memory containing at least one pattern having relatively few sub-channel carriers in relation to a number of sub-channel carriers utilised during information transfer in a data path between the LTE and CPE, the LTE further comprising a switch operationally responsive to the controller and configured to couple one of the data path and the memory to the wireline communication resource, the controller further arranged to cause the at least one pattern to be applied to the wireline communication resource in response to the means for indicating activity identifying that the CPE is inactive.

[0021] The controller (28) maintains at least one sub-channel carrier in response to the means for indicating activity identifying that the CPE is inactive; this ensures that the CPE maintains synchronisation and reasonable lock.

[0022] In another aspect of the present invention there is provided a line card for coupling to customer premises equipment through a wireline communication resource supporting a multi-carrier transmission scheme, the line card comprising: means of establishing a presence of CPE activity; and a controller, responsive to the means of establishing a presence of CPE activity, for selecting sub-channel carriers of the multi-carrier transmission scheme on which information is modulated for transmission to the CPE over the wireline resource, wherein the controller is arranged to limit a number of sub-channel carriers utilised by the LTE in response to the means for indicating activity identifying that the CPE is inactive.

[0023] In yet another aspect of the present invention there is provided a method of reducing power consumption in line termination equipment coupled to customer premise equipment through a wireline communication resource supporting a multi-carrier transmission between the LTE and the CPE, the method comprising the steps of: determining activity of the CPE; and assigning a relatively large number of sub-channel carriers to support information modulation onto the wireline communication resource in a multi-carrier transmission; and utilising a reduced number of sub-channel carriers for transmissions from the LTE in response to the step of determining activity of the CPE identifying that the CPE is inactive.

[0024] In still yet another aspect of the present invention there is provided a method of establishing a multi-carrier transmission between a line card of an exchange and customer premise equipment through a dedicated wireline communication resource, the exchange coupled to a plurality of CPEs through a plurality of wireline resources in which cross-talk is experienced, the method comprising the steps of: at the CPE, monitoring a cross-talk environment to identify an uplink transmission slot to the LTE; transmitting a wake-up message to the CPE within the uplink transmission slot; at the LTE, receiving the wake-up message and sending to the CPE at least one pilot tone; and at the CPE, receiving the at least one pilot tone and acquiring synchronisation and lock therefrom.

[0025] Advantageously, therefore, the present invention reduces power consumption within a line card and line termination equipment (at an exchange, for example). Moreover, by virtue of the fact that the line driver or power amplifier can be backed-off, heat generation within the line card is reduced. Beneficially, with reduced power consumption and reduced heat generation, temperature regulation devices (such as heat sinks and fans) can be scaled down within exchanges which simplifies exchange construction and reduces manufacturing costs. Furthermore, with battery powered equipment (e.g. required when the mains supply is interrupted), prolonged operational life is obtained through lower power consumption.

Brief Description of the Drawings

[0026] Exemplary embodiments of the present invention will now be described with reference to the accompanying drawings, in which:

FIG. 1 is a block diagram of a wireline system employing various preferred embodiments of the present invention;

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FIG. 2 is a flow diagram illustrating the steps employed in the wireline system of FIG. 1 to reduce power consumption (principally) in line termination equipment (LTE).

Detailed Description of a Preferred Embodiment

[0027] FIG. 1 shows an enhanced wireline system 10 employing various preferred embodiments of the present invention. A transmission path of LTE 12 contains a DSP 14 responsive to user data 16. The DSP 14 is coupled through a D/A converter 18 to a power amplifier or line driver (PA) 20 which is, in turn, coupled to a multiplexer/demultiplexer (MUX) 22 that therefore supports bi-directional communication within the LTE 12. A filter 24 is disposed intermediate between the MUX 22 and a wireline resource 26, such as a twisted copper pair. Operation of the LTE is controlled by a controller 28, although this function could be integrated into the DSP 14.

[0028] It will be appreciated that, generically, an exchange will contain a plurality of line cards and hence serve a plurality of CPEs through individual wireline resources, such as twisted copper pair. Moreover, the multiplicity of wireline resources will, to some extent, generally be bundled together before branching to a specific CPE. The exchange per se and the numerous CPEs have been omitted from FIG. 1 for the sake of clarity

[0029] In an uplink direction to the LTE, the MUX 22 functions to route encoded (and modulated) signals to a receiver front end and then to the DSP 14 for signal processing.

[0030] The wireline resource 26 is connected to customer premise equipment (CPE) 30 that contains transmission and/or reception circuitry (as will readily be appreciate). Operational control of the CPE 30 is typically overseen by a microprocessor 32 or the like, with the functionality in the CPE 30 complementary to that provided in the LTE 12.

[0031] The structure of the LTE 12 (and for that matter the system as a whole) to this point corresponds to that in existing LTEs (systems).

[0032] Intermediate between the DSP 14 and the D/A 18 is a switch 34 that is operationally responsive to the controller 28. The switch 34 selectively isolates the DSP 14 from a transmit path in the LTE 12 and, in this position, couples a memory 36 to the transmit path. The content of the memory 36 will be described subsequently, with it presently suffice to say that the memory 36 can be accessed and controlled by the controller 28.

[0033] In order to appreciate fully the present invention, it is necessary to realise that the LTE 12 can deduce (or can be informed about) the absence of CPE activity, e.g. the CPE is either switched-off or has otherwise ceased to function. The CPE 30 can notify the LTE 12 of its intention to go off-line by sending an appropriate control message to the LTE on a dedicated control channel. Alternatively, the LTE 12 can deduce that the CPE is off-line through an increased bit error rate (BER) in the decoded data, i.e. random noise is decoded by the LTE with output values therefore containing invalid codewords. The LTE 12 can also determine CPE inactivity by virtue of the relatively low level of received power at the LTE, with the power being attributable merely to the energy of noise rather than in relation to transmitted symbols.

[0034] Irrespective of the reason for CPE inactivity, it is still essential that the LTE 12 regularly transmits synchronisation and timing information to the CPE 30; this ensures that the CPE 30 can come back on-line and acquire lock/synchronisation and correct alignment with respect to a transmission scheme adopted for a bundle of wireline resources. As previously indicated, it is beneficial to have synchronised transmissions from the LTEs and CPEs to avoid cross-talk. Ideally, re-establishment of the CPE into the system should be immediate.

[0035] The preferred embodiments of the present invention all operate to reduce power consumption and hence reduce heat generation during idle periods of CPE inactivity. There are several mechanisms that are employed that can be used independently or in combination to provide enhanced effects and improved reliability/performance.

[0036] Usually, when the wireline system is active, i.e. transmissions are occurring between a dedicated line card and its associated CPE, many hundreds of sub-channel carriers are used to relay information symbols. All these sub-channel carriers contribute to form a composite signal envelope in which there are significant power excursions from a nominal mean or root-mean-square (rms) level. It has been identified that, during idle periods, many of these sub-channel carriers become overhead, i.e. they are redundant since they do not communicate meaningful information in the form of encoded symbols. Consequently, the controller 28 of the LTE 12 can effectively reduce the number of sub-channel carriers used to form the composite signal envelope when the CPE is off-line. In fact, it is possible to reduce the number of sub-channel carriers to only that number required to ensure/allow the CPE to detect the presence of the LTE and then to respond to register its own existence. For example, an on-going call could require four hundred sub-channel carriers, whereas a CPE idle condition may reduce this number to, perhaps, four or so. As will be appreciated, the reduction in the number of sub-channel carriers reduces the amplitude excursions in the composite signal envelope, i.e. the peak-to-peak level (as presented to the PA 20) is reduced significantly. Consequently, it is possible for the controller 28 to reduce a voltage supply V_{cc} 37 (or its functional equivalent) applied to the line amplifier (i.e. the PA 20) in the transmit path and hence to cut both the power consumed and the heat generated by the PA 20. In other words, class A power dissipation in the PA 20 is reduced.

[0037] In relation to those sub-channel carriers that

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are kept live during periods of CPE inactivity, it is preferably that these be associated with pilot tones used by the multi-carrier transmission scheme. Moreover, it is preferable that the reduced number of sub-channel carriers form a fixed pattern, which pattern may be unique to a particular line card-CPE association. The number of sub-channel carriers selected may also be subject to quality of the link to the CPE, while it is also envisaged that the pattern could, if desired, be randomly or sequentially rotated to mitigate interference problems, although at least one sub-channel carrier associated with a pilot tone must be maintained in the pattern.

[0038] In relation to FIG. 1, once the controller 28 has identified an idle CPE, the controller isolates the DSP 14 by re-routing the transmission path from the memory 36. The memory 36 therefore contains the fixed pattern, whilst the controller 28 causes the fixed pattern to be sent for modulation, amplification and eventual transmission from the LTE 12 to the addressed (but idle) CPE 30. In relation to a rotating pattern, the controller 28 may generate a pseudo-random sequence to effect rotation or may rely upon a prestored sequence in memory 36.

[0039] In a preferred embodiment of this first aspect of the present invention, use of the simple pattern of fewer sub-channel carriers allows DSP functionality to be temporarily reduced. Therefore, current drawn (and hence powered consumed) by the DSP 14 can be scaled down to reflect the lower number of operational sub-channel carriers.

[0040] If all processing capabilities of the DSP 14 are disabled, e.g. the DSP is turned-off entirely, then this potentially presents a problem when the CPE 30 comes back on-line and attempts to re-establish effective communication. In other words, the DSP cannot initially process information, and it is unaware when meaningful information in once again being transmitted from the CPE 30. This can be overcome by providing at least one of two mechanisms. First, to allow information received from the CPE to be subsequently processed, the system 10 of FIG. 1 can be adapted to include a buffer 38 (such as a random access memory, RAM) in-line with receiver front end equipment 40 that is fed from the MUX 22. The buffer 38 need only store a few symbols of analog samples, with DSP functionality re-stored by virtue of the controller 28 analysing the status of the buffer 38. In relation to the buffering of data, it will be appreciated that the DSP processing in the LTE does take some time to establish and that, as such, there may be a necessity to continue buffering until a natural break in transmission from the CPE occurs; the buffer therefore acts in a "first in first out" (FIFO) capacity and so data is sequenced through the buffer during processing. Alternatively or additionally, DSP functionality and power can be restored by the controller 28 in response to the detection of an increased level of received signal strength. In this latter respect, receiver front end equipment 40 may contain a suitable received signal strength indicator (RSSI) circuit or a software algorithm can be stored in memory 36 and accessed by the controller 28 in relation to all incoming data (whether spurious noise-related or legitimate information).

[0041] In order to further reduce transmissions from the LTE during CPE inactivity and therefore to further reduce power dissipation and heat generation associated with the PA 20, a further embodiment contemplates restricting downlink transmissions; this can be implemented in association with the simple pattern of fewer sub-channel carriers, or may be independently actioned with all sub-channel carriers. Specifically, once the LTE 12 has identified a CPE as being in an idle mode, the periodicity of downlink transmission from the LTE is decreased. In other words, a superframe structure is established with only one frame in N containing any form of donwlink transmissions from the LTE to a specifically addressed but idle CPE 30. This system, whilst still further reducing power consumption in the line card, is a compromise inasmuch a CPE going back on-line is denied uplink communication capacity until such time as it receives the pilot tones and it also achieves lock acquisition.

[0042] Yet another embodiment of the present invention proposes that downlink transmission in a superframe environment be offset between the various wireline resources within a bundle of twisted pairs, for example. By moving to a burst transmission environment with respect to idle CPEs, cross-talk between collocated wireline resources is reduced since there is no simultaneous transmission.

[0043] In another embodiment, the LTE 12 firstly determines inactivity at the CPE 30 and then enters a dormant transmission mode to the CPE by disabling its DSP 14 and suspending sub-channel carrier transmissions to the CPE 30. In this instance, both the CPE and LTE are unaware of each other's mutual existence. Once the CPE requires service, the CPE powers-up and has its microprocessor 32 monitor the cross-talk environment to identify a nominal uplink slot, e.g. a TDD slot. This system is immediately effective in relation to an asymmetric transmission scheme in which uplink and downlink transmission having different durations. However, in an equally split duty cycle environment, it is necessary for the microprocessor 32 of the CPE 30 to analyse the frequency characteristics of the cross-talk to differentiate FEXT-related and NEXT related transmission. For example, the CPE 30 may seek to identify coherent pilot tones that are entirely indicative of downlink transmissions. In other multi-carrier environments, different line codes are used for each of the uplink and downlink paths and so the CPF 30 is able to identify the uplink from the downlink by virtue of the fact that each line coc has a distinct frequency characteristic. As will be appreciated, the microprocessor (or its equivalent) includes suitable control algorithms that can assess spectral characteristics and regulate transmission from the CPE.

[0044] The CPE 30, once armed with approximate

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timing information concerning transmission direction boundaries, sends a wake-up transmission to the LTE 12 in ab the centre of the uplink slot (but certainly within the guard bands associated with the uplink slot). More specifically, the CPE 30 sends a wake-up message on a small number of sub-channel carriers to limit interference on adjacent lines. The LTE 12, using the RSSI or buffering techniques mentioned above, re-enables its dormant DSP 14 and line driver (i.e. PA 20) and then transmits its normal training sequence back to the CPE 30 to effect accurate synchronisation and lock. Full-blown communication can then commence, although it will be appreciated that there is a finite delay before the CPE is serviceable.

[0045] The mechanism by which power consumption in the LTE 12 is reduced is summarised in FIG. 2. Assuming that the default (start) position 50 is that the LTE 12 is fully operational and configured to transmit a multi-carrier signal, monitoring 52 of CPE activity precedes a determination 54 of CPE activity. Should the CPE be active, then there is conventional communication 56 of multi-carrier data, and the process basically loops back to the monitoring and subsequent determination of CPE activity. In the negative, i.e. the CPE is determined to be idle, then flow proceeds to step 58 where the LTE (or line card) reduces the number of sub-channel carriers used in transmission; this could be to zero or to the simple pattern that preferably includes at least one pilot tone.

[0046] Contemporaneously with the reduction in the number of sub-channel carriers, the controller 28 of the LTE can reduce 60 the voltage/power consumption to/ of the PA 30. If desired, the functionality of the DSP can be restricted 62 by the controller 28. The LTE is then arranged to send 64 a simple pattern (which can be sequenced or time delayed to 1 frame in N). Of course, in the limit, all transmission to a dormant CPE could cease. In the case of a limited sub-channel pattern, the LTE may co-ordinate its 1 in N frame transmission such as to offset 66 bursts between idle lines in a bundle.

[0047] Depending on whether or not the LTE 12 maintains some form of limited transmission to the CPE during CPE idling determines the route taken when the CPE comes back on-line. If the LTE transmits the simple pattern, flow proceeds to step 68 in which the CPE locks to correct alignment in transmission scheme, whereafter multi-carrier communication can re-commence from the CPE; flow returns to step 56. However, the LTE may have to have its DSP functionality restored and so a test is made to this extent at step 70. If LTE DSP functionality is fully enabled then effective decoding can take place immediately. However, if the operational capacity of the LTE DSP 14 has been scaled down or disabled in its entirety then incident multi-carrier data transmitted by the CPE must be buffered 72. The controller 28 of the LTE, using either an RSSI circuit or a buffer flag associated with data in the buffer 38, identifies 74 the presence of the buffered data and then re-establishes 76 necessary DSP functionality. The LTE (and particularly the DSP 14) is then able to process 78 the buffered data to recover user data.

[0048] If the LTE 12 has ceased transmission and the CPE wishes to come back on-line, the CPE monitors 80 the cross-talk environment to identify an uplink transmission slot. The CPE 30 then transmits 82 a wake-up message to the LTE 12, but ensures that this wake-up message is confined within the boundaries of the uplink slot. The controller 28, in response to the wake-up message from the CPE (typically transmitted on a selected and limited number of sub-channel carriers assigned as control channels) wakes-up/powers-up 84 from its dormant transmission state. The LTE 12 then transmits 86 pilots downlink to the CPE, which pilot are used by the CPE 30 to acquire 88 synchronisation and lock before multi-carrier communication is established 56.

[0049] Of course, whenever the CPE goes off-line, power consumption (and associatec' heating) in the CPE is also reduced. Clearly, in a battery-driven environment, CPE inactivity can enhance battery life.

[0050] It will, of course, be appreciated that the above description has been given by way of example only and that modification in detail may be made within the scope of the present invention. The preferred embodiments of the present invention are applicable to frequency division multiplexing (FDM) techniques and time division multiplexing (TDM) techniques such as (particularly) TDD. For example, the preferred embodiment of the present invention is generally concerned with re-establishment of a multi-carrier communication, although the principle of having the CPE monitor the cross-talk environment (steps 80 to 88 of FIG. 2) can be independently employed with respect to a CPE wanting to establish a communication connection with the LTE.

[0051] The system of FIG. 1 shares many common features with prior art configurations. Consequently, prior art systems may be easily up-graded to accommodate the inventive concepts of the present invention, with such easy migration therefore encouraging deployment of the preferred embodiments to achieve improved operational performance at relatively little expense.

[0052] The term "line termination equipment (LTE)" generally suggest a high level entity, although in the context of the present invention this term should not be considered to be restrictive and should be considered to include a solitary line card that is uniquely assigned to serve associated customer premise equipment (such as a modem or a computer) through a dedicated wireline communication resource. Indeed, it will be appreciated that a line card will generally include some signal processing capability (which could be pooled, although it is usually a dedicated DSP), a line driver, a D/A converter and some form of modulator. Of course, the line card typically further includes an analog-to-digital (A/D) converter and a demodulator in a receive path thereof to enable bi-directional communication.

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Claims

1. A wireline communication system comprising line termination equipment coupled to customer premise equipment through a wireline communication resource supporting a multi-carrier transmission scheme between the LTE and the CPE, the wireline communication system comprising:

   means for indicating activity of the CPE; and

   a controller, responsive to the means for indicating activity, for selecting sub-channel carriers of the multi-carrier transmission scheme on which information is modulated for transmission to the CPE over the wireline resource, wherein the controller is arranged to limit a number of sub-channel carriers utilised by the LTE in response to the means for indicating activity identifying that the CPE is inactive.

2. The wireline communication system of claim 1, wherein the LTE comprises a line driver coupled to a voltage supply and arranged to amplify signals to be applied to the wireline communication resource, the voltage supply being operationally responsive to the controller and wherein the controller is arranged to reduce a voltage applied to power the line driver in response to the means for indicating activity identifying that the CPE is inactive.

3. The wireline communication system of claim 1, wherein the LTE comprises a signal processor operationally responsive to the controller, the controller arranged to at least partially disable operational functionality of the signal processor in response to the means for indicating activity identifying that the CPE is inactive.

4. The wireline communication system of claim 1, further comprising a memory containing at least one pattern having relatively few sub-channel carriers in relation to a number of sub-channel carriers utilised during information transfer in a data path between the LTE and CPE, the LTE further comprising a switch operationally responsive to the controller and configured to couple one of the data path and the memory to the wireline communication resource, the controller further arranged to cause the at least one pattern to be applied to the wireline communication resource in response to the means for indicating activity identifying that the CPE is inactive.

5. The wireline communication system of claim 1, wherein the controller maintains at least one sub-channel carrier in response to the means for indicating activity identifying that the CPE is inactive.

6. The wireline communication system of claim 1, wherein the at least one sub-channel carrier includes a pilot tone.

7. The wireline communication system of claim 4, wherein the at least one pattern is associated with a plurality of sub-channel carriers.

8. The wireline communication system of claim 4, wherein the controller is arranged to sequence an application of a plurality of patterns stored in the memory onto the wireline communication resource.

9. The wireline communication system of claim 8, wherein each of the plurality of patterns contains at least one pilot tone.

10. The wireline communication system of claim 9, wherein sequencing by the controller is random.

11. The wireline communication system of claim 9, wherein sequencing by the controller is delayed to produce a multi-carrier transmission on a limited number of sub-channel carriers on a one-in-N frame basis.

12. The wireline communication system of claim 1, wherein the controller disables the transmission of the multi-carrier transmission scheme in response to the means for indicating activity identifying that the CPE is inactive.

13. The wireline communication system of claim 2, wherein the voltage applied to power the line driver is reduced to substantially zero.

14. The wireline communication system of claim 1, wherein the multi-carrier transmission scheme supports a digital subscriber line (xDSL) communication protocol.

15. The wireline communication system of claim 14, wherein the multi-carrier transmission scheme overlays relatively low frequency voiceband transmissions.

16. The wireline communication system of claim 1, wherein the line termination equipment is a line card.

17. A line card for coupling to customer premise equipment through a wireline communication resource supporting a multi-carrier transmission scheme, the line card comprising:

   means of establishing a presence of CPE activity; and

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a controller, responsive to the means of establishing a presence of CPE activity for selecting sub-channel carriers of the multi-carrier transmission scheme on which information is modulated for transmission to the CPE over the wireline resource, wherein the controller is arranged to limit a number of sub-channel carriers utilised by the LTE in response to the means for indicating activity identifying that the CPE is inactive.

18. The line card of claim 17, further comprising a line driver coupled to a voltage supply and arranged to amplify signals to be applied to the wireline communication resource, the voltage supply operationally responsive to the controller and wherein the controller is arranged to reduce a voltage applied to power the line driver in response to the means for indicating activity identifying that the CPE is inactive.

19. The line card of claim 17, further comprising a signal processor operationally responsive to the controller, the controller arranged to at least partially disable operational functionality of the signal processor in response to the means for indicating activity identifying that the CPE is inactive.

20. The line card of claim 17, further comprising a memory containing at least one pattern having relatively few sub-channel carriers in relation to a number of sub-channel carriers utilised during information transfer in a data path between the line card and CPE, the line card further comprising a switch operationally responsive to the controller and configured to couple one of the data path and the memory to the wireline communication resource, the controller further arranged to cause the at least one pattern to be applied to the wireline communication resource in response to the means for indicating activity identifying that the CPE is inactive.

21. The line card of claim 17, wherein the controller maintains at least one sub-channel carrier in response to the means for indicating activity identifying that the CPE is inactive.

22. The line card of claim 21, wherein the at least one sub-channel carrier includes a pilot tone.

23. The line card of claim 21, wherein the at least one pattern is associated with a plurality of sub-channel carriers.

24. The line card of claim 20, wherein the controller is arranged to sequence an application of a plurality of patterns stored in the memory onto the wireline communication resource.

25. A method of reducing power consumption in line termination equipment coupled to customer premise equipment through a wireline communication resource supporting a multi-carrier transmission between the LTE and the CPE, the method comprising the steps of:

determining activity of the CPE; and

assigning a relatively large number of sub-channel carriers to support information modulation onto the wireline communication resource in a multi-carrier transmission; and

utilising a reduced number of sub-channel carriers for transmissions from the LTE in response to the step of determining activity of the CPE identifying that the CPE is inactive.

26. The method of reducing power consumption according to claim 25, wherein the LTE comprises a line driver, coupled to a voltage supply, arranged to amplifier signals to be applied to the wireline communication resource, the method further comprising the steps of:

reducing a voltage applied to power the line driver in response to the step of determining activity of the CPE identifying that the CPE is inactive.

27. The method of reducing power consumption according to claim 25, wherein the LTE comprises a signal processor and the method comprises the step of at least partially disabling operational functionality of the signal processor in response to the step of determining activity of the CPE identifying that the CPE is inactive.

28. The method of reducing power consumption according to claim 25, the LTE further comprising a memory and a switch, the method further comprising the steps of:

storing in the memory at least one pattern identifying relatively few sub-channel carriers with respect to a number of sub-channel carriers used during information transfer in a data path between the LTE and CPE;

in response to the step of determining activity of the CPE, using the switch selectively to isolate one of the data path and the memory with respect to the wireline communication resource; and

in response to the step of determining activity identifying that the CPE is inactive, isolating the data path and causing the at least one pattern to be applied to the wireline communication re-

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source.

29. The method of reducing power consumption according to claim 25, further comprising the step of maintaining transmission of at least one sub-channel carrier in response to the step of determining activity identifying that the CPE is inactive.

30. The method of reducing power consumption according to claim 29, wherein the at least one sub-channel carrier includes a pilot tone.

31. The method of reducing power consumption according to claim 28, wherein the at least one pattern is associated with a plurality of sub-channel carriers.

32. The method of reducing power consumption according to claim 28, further comprising the steps of:

storing a plurality of patterns in the memory (36); and

sequentially applying the plurality of patterns onto the wireline communication resource.

33. The method of reducing power consumption according to claim 32, wherein each of the plurality of patterns contains at least one pilot tone.

34. The method of reducing power consumption according to claim 32, wherein sequencing is random.

35. The method of reducing power consumption according to claim 32, wherein sequencing is delayed to produce a multi-carrier transmission on a limited number of sub-channel carriers on a one-in-N frame basis.

36. The method of reducing power consumption according to claim 25, further comprising the step of disabling transmissions by the LTE to the CPE in response to the step of determining activity of the CPE identifying that the CPE is inactive.

37. The method of reducing power consumption according to claim 26, further comprising the step of reducing to substantially zero a voltage applied to power the line driver.

38. The method of reducing power consumption according to claim 25, wherein the multi-carrier transmission scheme supports a digital subscriber line (xDSL) communication protocol.

39. The method of reducing power consumption according to claim 38, wherein the multi-carrier transmission scheme overlays relatively low frequency voiceband transmissions.

40. The method of reducing power consumption according to claim 29, further comprising the step of re-establishing multi-carrier transmission between the LTE and the CPE, the step of re-establishing further comprising the steps of:

at the CPE, locking to correct alignment in the transmission scheme using the at least one sub-channel carrier.

41. The method of reducing power consumption according to claim 36, further comprising the step of re-establishing multi-carrier transmission between the LTE and the CPE, the step of re-establishing further comprising the steps of:

at the CPE, monitoring a cross-talk environment to identify an uplink transmission slot to the LTE;

transmitting a wake-up message to the CPE within the uplink transmission slot;

at the LTE, receiving the wake-up message and sending to the CPE at least one pilot tone; and

at the CPE, receiving the at least one pilot tone and acquiring synchronisation and lock therefrom.

42. A method of establishing a multi-carrier transmission between a line carp of an exchange and customer premise equipment (CPE30) through a dedicated wireline communication resource, the exchange coupled to a plurality of CPEs through a plurality of wireline resources in which cross-talk is experienced, the method comprising the steps of:

at the CPE, monitoring a cross-talk environment to identify an uplink transmission slot to the LTE;

transmitting a wake-up message to the CPE within the uplink transmission slot;

at the LTE, receiving the wake-up message and sending to the CPE at least one pilot tone; and

at the CPE, receiving the at least one pilot tone and acquiring synchronisation and lock therefrom.

43. A method of establishing a multi-carrier transmission between a line card of an exchange and customer premise equipment (CPE30) according to claim 42, wherein the step of transmitting the wake-up message further comprises the step of:

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ensuring that the transmission occurs within boundaries of the uplink transmission slot.

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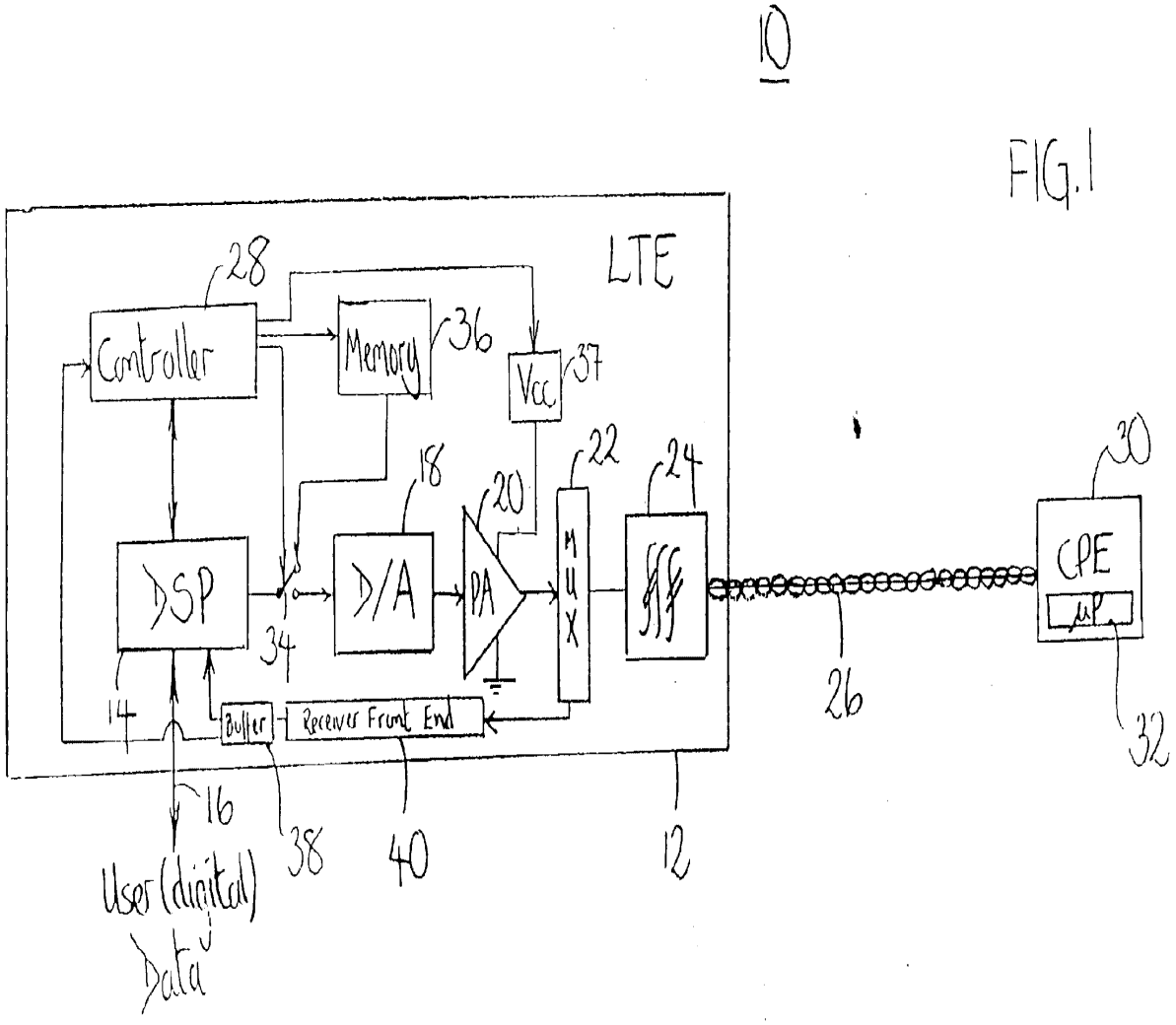


FIG. 1

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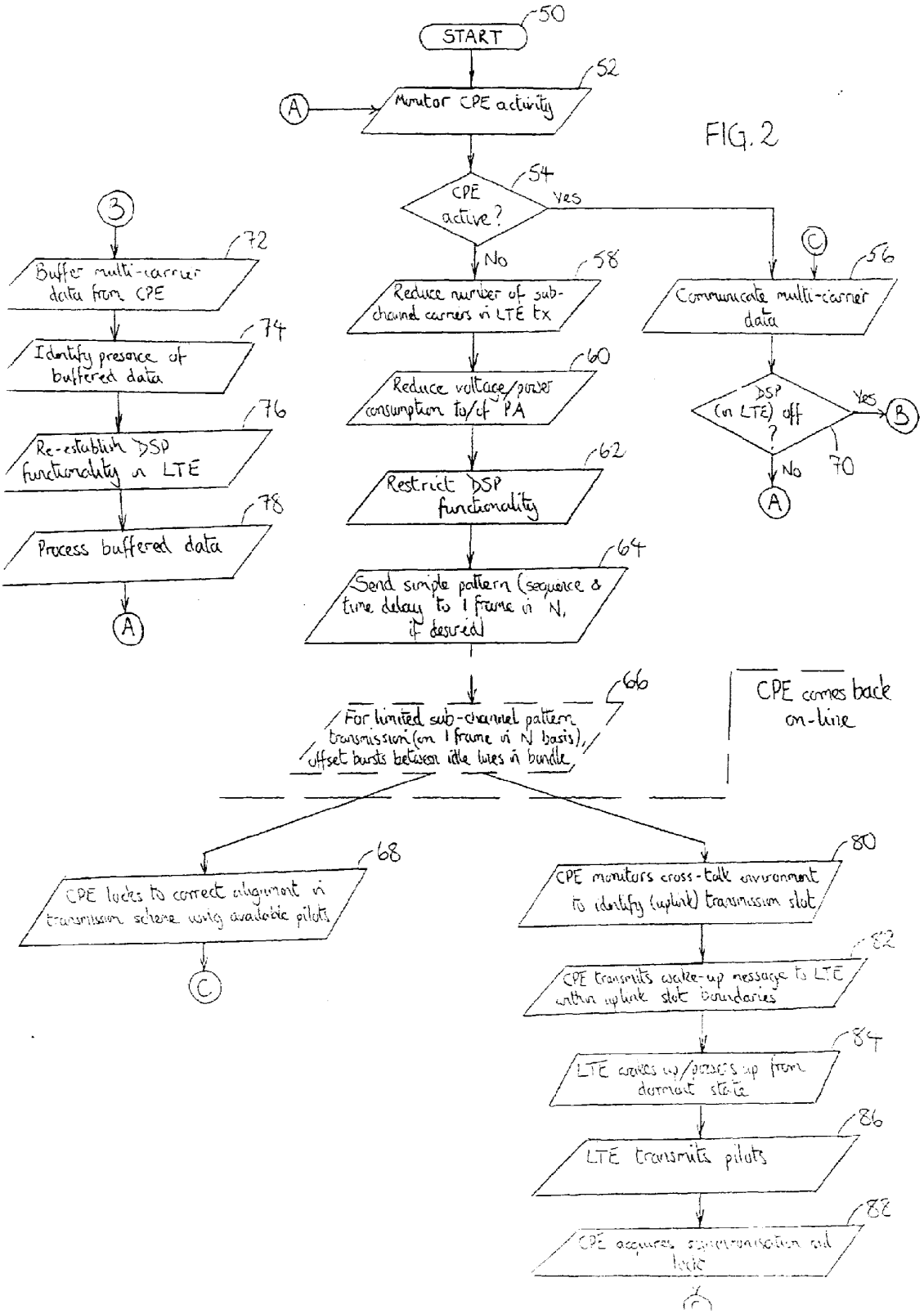


FIG. 2

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PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 14/417,544	Filing Date 01/26/2015	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT **11/14/2016**

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 40	Minus	** 40	= 0	X $80 =	0
Independent (37 CFR 1.16(h))	* 4	Minus	***4	= 0	X $420 =	0
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	0

AMENDMENT

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/GAIL WOOTEN/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/417,544	01/26/2015	Kenneth Kerpez	03.P074US	8970

136402 7590 12/23/2016

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EXAMINER	
BEZUAYEHU, SOLOMON G	

ART UNIT	PAPER NUMBER
2653	

NOTIFICATION DATE	DELIVERY MODE
12/23/2016	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

docketing@ghmip.com

Office Action Summary	Application No. 14/417,544	Applicant(s) KERPEZ ET AL.	
	Examiner SOLOMON BEZUAYEHU	Art Unit 2653	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *11/14/2016*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *1-39* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-39* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☒ The drawing(s) filed on *1/26/2015* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☒ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date *11/14/2016, 1/26/2015*.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 103

1. The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

2. Claims 1-39 is/are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Williams et al. (Pub. No. US 20140003307) further in view of Cioffi (Patent No. 5,887,032).

Regarding claims 1, 34, and 37, Williams teaches a method in a data communications system for managing multiple time division physical channels, the method comprising scheduling upstream time slots for upstream transmission in a physical channel [Para. 17, 18, Claim 1, 2, 11]; and scheduling downstream time slots for downstream transmission in a physical channel, wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots [Para. 17, 18, Claim 1, 2, and 11].

However, Williams doesn't explicitly teach about a first and second physical channels that are subjected to crosstalk.

Cioffi teaches first physical channel (line) for downstream and second physical channel for upstream that are subjected to crosstalk [fig. 6 and related description].

It would have been obvious to one of ordinary skill in the art, at the time of this invention was made, to modify Williams to schedule transmission for first and second physical channel subjected to crosstalk, feature as taught by Cioffi; because the modification enable system removes crosstalk interference from received signals on a given line by adaptively estimating the crosstalk interference induced by certain other of the lines having interfering transmissions.

Regarding claim 2, Williams teaches wherein scheduling downstream time slots comprises allowing some simultaneous transmission in the upstream and downstream time slots, the method further comprising cancelling near-end crosstalk (NEXT) from downstream into upstream transmission at a network end of the channels [fig. 1-3 and related description].

Regarding claim 3, Williams teaches wherein the upstream and downstream time slots have an active portion during which signals are transmitted and an off portion during which no signals are transmitted and wherein the active portions of the upstream time slots are substantially not simultaneous with the active portions of the downstream time slots [fig. 1-3 and related description].

Regarding claim 4, Williams teaches wherein scheduling upstream and downstream time slots comprises scheduling upstream and downstream time slot boundaries [fig. 1-3 and related description].

Regarding claim 5, Williams teaches wherein the time slot boundaries are flexible [fig. 1-3 and related description].

Regarding claim 6, Williams teaches wherein the time slot boundaries have one or more of: variable-length frames; variable upstream time slot lengths; and variable downstream time slot- lengths [fig. 1-3 and related description].

Regarding claim 7, Williams teaches further comprising assigning time slots to a network element based on the scheduling and transmitting the assignments from a management system to a network element [fig. 1-3 and related description].

Regarding claim 8, Williams teaches further comprising adapting scheduling at least one of upstream and downstream time slots to accommodate delay requirements for the other of a downstream and upstream traffic source [fig. 1-3 and related description].

Regarding claims 9, 35, Williams teaches further comprising receiving input on desired traffic levels for the first and second physical channels and wherein scheduling upstream and downstream time slots is performed based on the received input [fig. 1-3 and related description].

Regarding claim 10, Williams teaches wherein a portion of a downstream time slot is invariant and a portion of a downstream time slot varies in real-time [fig. 1-3 and related description].

Regarding claim 11, Williams teaches wherein the received input comprises at least one of static subscription data, service layer information from a policy manager, behavior data for traffic types and users of the physical channels, long term traffic behavior data as a function of time, current traffic demands, queue lengths, traffic requests, upstream/downstream asymmetry, and traffic descriptors [fig. 1-3 and related description].

Regarding claims 12 and 36, Williams teaches, wherein scheduling upstream and downstream time slots comprises assigning time slots to achieve a target upstream/downstream asymmetry ratio of data throughput [fig. 1-3 and related description].

Regarding claim 13, Williams teaches, wherein the upstream/downstream asymmetry ratio is defined in numbers of discrete multi-tone symbol positions [fig. 1-3 and related description].

Regarding claim 14, Williams teaches, wherein the measure of throughput is at least one of an average throughput across all lines, a traffic demand match, a minimum throughput for each physical channel, a perceived quality of experience, an average delay, and a minimum delay [fig. 1-3 and related description].

Regarding claim 15, Williams teaches wherein scheduling upstream and downstream time slots comprises assigning time slots based at least in part on power usage [fig. 1-3 and related description].

Regarding claim 16, Williams teaches wherein assigning time slots based on power usage comprises assigning by scheduling entries, exits, and transitions between low-power link states and off states [fig. 1-3 and related description].

Regarding claims 17 and 38, Williams teaches wherein assigning time slots based on power usage includes assigning at least one network element to a receive-only mode, with a transmitter of the network element turned off [fig. 1-3 and related description].

Regarding claim 18, Williams teaches wherein scheduling upstream and downstream time slots comprises assigning time slots using an optimization criteria that weights different factors [fig. 1-3 and related description].

Regarding claim 19, Williams teaches wherein receiving input comprises receiving input from an external controller [fig. 1-3 and related description].

Regarding claim 20, Williams teaches wherein the received input comprises at least one of Operations Support System (OSS) data, Element Management System (EMS) data, and Management Information Database (MIB) parameters [fig. 1-3 and related description].

Regarding claim 21, Williams teaches wherein the time slots are defined within a time division frame, wherein receiving input comprises receiving input during a frame, and wherein scheduling upstream and downstream time slots comprises scheduling upstream and downstream time slots of an immediately subsequent frame [fig. 1-3 and related description].

Regarding claim 22 , Williams teaches further comprising receiving requests for upstream and downstream transmission and wherein scheduling upstream time slots is based on the received upstream transmission requests [fig. 1-3 and related description].

Regarding claim 23, Williams teaches wherein the transmission in the upstream time slots is from a plurality of different network-end transmission sources [fig. 1-3 and related description].

Regarding claim 24, Williams teaches further comprising synchronizing upstream transmission and downstream transmission among a plurality of different network-end transmission sources [fig. 1-3 and related description].

Regarding claim 25, Williams teaches wherein synchronizing comprises sending synch symbols to a source of upstream transmissions [fig. 1-3 and related description].

Regarding claim 26, Williams teaches wherein synchronizing comprises measuring a time series of time-varying crosstalk and synchronizing to time-varying patterns of the crosstalk [fig. 1-3 and related description].

Regarding claim 27, Williams teaches, wherein synchronizing is performed by measuring a time series of error events and synchronizing to time-varying patterns of the error events [fig. 1-3 and related description].

Regarding claim 28, Williams teaches wherein scheduling upstream and downstream time slots comprises determining a duration of the upstream and downstream time slots and moving the upstream and downstream time slot start times to reduce simultaneous upstream and downstream transmission [fig. 1-3 and related description].

Regarding claim 29, Williams teaches wherein determining a duration comprises adjusting a default duration based on bandwidth requests [fig. 1-3 and related description].

Regarding claim 30, Williams teaches wherein moving comprises moving only if upstream transmissions overlap downstream transmissions in time [fig. 1-3 and related description].

Regarding claim 31, Williams teaches further comprising reducing the duration of at least one downstream time slot to reduce simultaneous upstream and downstream transmission [fig. 1-3 and related description].

Regarding claim 32, Williams teaches wherein the scheduling upstream and downstream time slot is further performed to minimize crosstalk on nearby VDSL2 lines [fig. 1-3 and related description].

Regarding claim 33, Williams teaches further comprising receiving input on desired traffic levels for the first and second physical channels and wherein scheduling upstream and downstream time slots is performed based on the received input and at least in part on power usage [fig. 1-3 and related description].

Regarding claim 39, Williams further comprising means for receiving requests for upstream and downstream transmission for use by the means for scheduling [fig. 1-3 and related description].

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to SOLOMON BEZUAYEHU whose telephone number is (571)270-7452. The examiner can normally be reached on Monday through Friday 9 a.m-4 p.m.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, FAN TSANG can be reached on 571-272-7547. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/SOLOMON BEZUAYEHU/

Primary Examiner, Art Unit 2653

Notice of References Cited	Application/Control No. 14/417,544	Applicant(s)/Patent Under Reexamination KERPEZ ET AL.	
	Examiner SOLOMON BEZUAYEHU	Art Unit 2653	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-5,887,032 A	03-1999	Cioffi; John M.	H04L27/2647	370/201
*	B	US-2014/0003307 A1	01-2014	Williams; Thomas H.	H04L49/10	370/294
	C	US-				
	D	US-				
	E	US-				
	F	US-				
	G	US-				
	H	US-				
	I	US-				
	J	US-				
	K	US-				
	L	US-				
	M	US-				

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14/417,544
	Filing Date	Jan 26, 2015
	First Named Inventor	Kenneth Kerpez
	Art Unit	2653
	Examiner Name	BEZUAYEHU, SOLOMON G
	Attorney Docket Number	03.P074US

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		6480475		2002-11-12	MODLIN et al.	

U.S.PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		2003086362		2003- 05-08	HASEGAWA et al.	
		2005122999		2005-06-09	SCHERZER et al.	
		2009082064		2009-03-26	LI et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
		2254807	CA		2000- 05-30	BINGHAM et al.		
		1011206	EP		2000-06-21	NORTEL NETWORKS CORP		

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /S.G.B/

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	First Named Inventor	Kenneth Kerpez
	Art Unit	2653
	Examiner Name	BEZUAYEHU, SOLOMON G
	Attorney Docket Number	03.P074US

NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
		Examination Report, mailed 07/17/15, for Australian Patent Application No. 2012385953 (Attorney Docket No. 01.P074AU).	
		International Preliminary Report on Patentability, mailed 07/27/12, for PCT Patent Application No. PCT/US12/60115 (Attorney Docket No. 03.P074PCT).	
		International Search Report and Written Opinion, mailed 05/02/13, for PCT Patent Application No. PCT/US12/60115 (Attorney Docket No. 03.P074PCT).	
		Reasons for Rejection, mailed 01/05/16, for JP Patent Application No. 2015-52424 (Attorney Docket No. 03.P074JP), no translation available.	

EXAMINER SIGNATURE

Examiner Signature	/SOLOMON G BEZUAYEHU/	Date Considered	12/06/2016

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document.
[4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /S.G.B/

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14/417,544
	Filing Date	Jan 26, 2015
	First Named Inventor	Kenneth Kerpez
	Art Unit	2653
	Examiner Name	BEZUAYEHU, SOLOMON G
	Attorney Docket Number	03.P074US

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e) (1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e) (2).

☐ See attached certification statement.

X Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Usman A. Mughal/	Date (YYYY-MM-DD)	2016-11-14
Name/Print	Usman Mughal	Registration Number	62887

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /S.G.B/

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14417544	KERPEZ ET AL.
	Examiner	Art Unit
	SOLOMON BEZUAYEHU	2653

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/07/2016								
	1	✓								
	2	✓								
	3	✓								
	4	✓								
	5	✓								
	6	✓								
	7	✓								
	8	✓								
	9	✓								
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	32	✓								
	33	✓								
	34	✓								
	35	✓								
	36	✓								

IPR2025-00451
Petitioners' Exhibit 1002
Page 372 of 511

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14417544	KERPEZ ET AL.
	Examiner	**Art Unit**
	SOLOMON BEZUAYEHU	2653

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/07/2016								
	37	✓								
	38	✓								
	39	✓								
	40	N								

IPR2025-00451
Petitioners' Exhibit 1002
Page 373 of 511

Substitute for form 1449A/PTO	Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(Use as many sheets as necessary)*	**Application Number**	14417544
	Filing Date	
	First Named Inventor	Kenneth Kerpez
	Group Art Unit	
	Examiner Name	
Sheet 1 of 1	Attorney Docket No: 8241P074	

US PATENT DOCUMENTS					
Examiner Initial *	**Cite No [1]**	**USP Document Number**	**Publication or Issue Date MM-DD-YYYY**	**Name of Patentee or Applicant of cited Document**	**Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear**
		US-2009/0082064	03-26-2009	LI et al.	
		US-2005/0122999	06-09-2005	SCHERZER et al.	
		US-2003/0086362	05-08-2003	HASEGAWA et al.	
		US-6,480,475	11-12-2002	MODLIN et al.	

FOREIGN PATENT DOCUMENTS						
Examiner Initials*	**Cite No [1]**	**Foreign Patent Document** Country Code/Number/Kind Code (if known)	**Publication Date MM-DD-YYYY**	**Name of Patentee or Applicant of cited Document**	**Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear**	**T [2]**
		CA-2254807	05-30-2000	AMATI COMMUNICATIONS CORPORATION		
		EP-1011206	06-21-2000	NORTEL NETWORKS CORPORATION		

OTHER DOCUMENTS -- NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	**Cite No [1]**	**Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.**	**T [2]**
		International Search Report for International Patent Application No. PCT/US2012/060115 (Attorney Docket No. 8241P074PCT), mailed May 2, 2013.	

EXAMINER	/SOLOMON G BEZUAYEHU/	**DATE CONSIDERED**	12/07/2016

Based on PTO/SB/08A(09-06) - Substitute Disclosure Statement Form (PTO-1449) as modified by BSTZ 03/26/07

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1] Applicant's unique citation designation number (optional) [2] Applicant is to place a check mark here if English language Translation is attached

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /S.G.B/

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	34896	(379/88.01-88.19 or 370/351-365).ccls.	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/07 06:47
L2	6460	((upstream$3 or up$load$$) same (down$load$6 or down$stream)) near4 (time)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/07 06:59
L3	69	1 and L2	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/07 06:59
L5	55	2 AND ((H04L49/10 OR H04L5/14 OR H04N21/2408 OR H04N21/61 OR H04W72/0406).CPC.)	US-PGPUB	ADJ	ON	2016/12/07 07:08
S2	285	((upstream$3 or up$load$$) same (down$load$6 or down$stream)) adj (time)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/09/06 13:03
S3	6312	((upstream$3 or up$load$$) same (down$load$6 or down$stream)) near4 (time)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/09/06 13:03
S4	33	(((upstream$3 or up$load$$) same (down$load$6 or down$stream)) near4 (time)) near4 schedul$3	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/09/06 13:04
S6	14	(((upstream$3) same (down$load$6)) near4 (time))	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/09/06 13:19
S7	13	S6 and (@ad<"20120727" or @rlad<"20120727" or @ptad<"20120727")	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/09/06 13:20
S8	432	((upstream$3) same (down$stream)) near4 schedul$5	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/11/28 05:58
S9	1045	((upstream$3) with (down$stream)) with schedul$5	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/11/28 05:59
S10	292	S9 and (time division)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/11/28 05:59
S11	251	S10 and (@ad<"20120727" or @rlad<"20120727" or @ptad<"20120727")	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/11/28 06:00
S12	6	S9 same simultan$5	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/11/28 06:01
S13	5	S12 and (@ad<"20120727" or @rlad<"20120727" or @ptad<"20120727")	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/11/28 06:02
S14	1045	((upstream$3) with (down$stream)) with schedul$5	US-PGPUB; USPAT;	ADJ	ON	2016/11/28 08:11

			EPO; JPO			
S15	439	S14 and (time (division or slot))	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/11/28 08:11
S16	379	S15 and (@ad<"20120727" or @rlad<"20120727" or @ptad<"20120727")	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/11/28 08:11
S17	218	S16 and (prevent$6 or simultan$5)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/11/28 08:13
S18	102	S16 and (simultan$5)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/11/28 08:13
S19	11	S16 and (cross$talk)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/11/28 09:20
S20	23	S14 and (cross$talk)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/11/28 09:36
S21	14	S20 and (@ad<"20120727" or @rlad<"20120727" or @ptad<"20120727")	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/11/28 09:36
S22	3	S21 not S19	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/11/28 09:36
S23	1003	((upstream$3) with (down$stream)) same (cross$talk)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/11/28 09:48
S24	291	((upstream$3) same (down$stream)) same (cross$talk) same (time or period or time$slot)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/11/28 09:48
S25	107	((upstream$3) same (down$stream)) same (cross$talk) same (time or period or time$slot) same channel	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/11/28 10:18
S26	90	S25 and (@ad<"20120727" or @rlad<"20120727" or @ptad<"20120727")	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/11/28 10:18
S30	4060	(alternate or alternating or schedul$5) near5 (transmi$5 or upload$3 or down$load$3) near5 line	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/05 20:28
S31	922	(aalternating or schedul$5) near5 (transmi$5 or upload$3 or down$load$3) near5 line	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/05 20:28
S32	23	S30 same (crosstalk)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/05 20:29
S33	15	S32 and (@ad<"20120727" or @rlad<"20120727" or @ptad<"20120727")	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/05 20:29
S34	4008	(transmi$5) with line with cross$talk	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/05 20:33
S35	147	S34 and (tme$5 or schedul$5)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/05 20:34
S36	4	S34 same (tme$5 or schedul$5)	US-PGPUB; USPAT;	ADJ	ON	2016/12/05 20:34

			EPO; JPO			
S37	860	S34 same (time$4 or schedul$4)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/05 20:34
S38	748	S37 and (@ad<"20120727" or @rlad<"20120727" or @ptad<"20120727")	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/05 20:35
S39	580	(cross$talk).bsum. and S38	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/05 20:35
S40	161	(cross$talk).ti. and S38	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/05 20:35
S41	161	S40 and (@ad<"20120727" or @rlad<"20120727" or @ptad<"20120727")	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/05 20:35
S42	6038	((transmit or transmission or transmitting) with line) same cross$talk	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/05 20:39
S43	602	((transmit or transmission or transmitting) with time with line) same cross$talk	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/05 20:39
S44	110	(cross$talk).ti. and S43	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/05 20:40
S45	92	S44 and (@ad<"20120727" or @rlad<"20120727" or @ptad<"20120727")	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/05 20:40
S46	10147	simultaneous$3 same cross$talk	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/06 05:32
S47	2792	S46 same (schedul$5 or time or time$line)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/06 05:33
S48	172	(cross$talk).ti. and S47	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/06 05:33
S49	140	S48 and (@ad<"20120727" or @rlad<"20120727" or @ptad<"20120727")	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/06 05:33
S50	577	S46 same (schedul$5 or time or time$line) same line	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/06 05:33
S51	500	S50 and (@ad<"20120727" or @rlad<"20120727" or @ptad<"20120727")	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/06 05:34
S52	38	(cross$talk).ti. and S51	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/06 05:34
S53	62	simultaneous$3 same cross$talk same schedul$3	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/06 05:37
S54	35	S53 and (@ad<"20120727" or @rlad<"20120727" or @ptad<"20120727")	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/06 05:37
S55	311	cross$talk same schedul$3	US-PGPUB; USPAT;	ADJ	ON	2016/12/06 05:40

			EPO; JPO			
S56	234	S55 and (@ad<"20120727" or @rlad<"20120727" or @ptad<"20120727")	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/06 05:40
S57	199	S56 not S54	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/06 05:40
S58	126	S57 and (wire or cable or dsl)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/06 06:09
S59	383	cross$talk same2 ((first and second) line)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/06 08:39
S60	311	S59 and (@ad<"20120727" or @rlad<"20120727" or @ptad<"20120727")	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/06 08:41
S61	243	cross$talk.bsum. and S60	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/06 08:41
S62	442	(upstream$3 same down$stream$3) same (first line) same (second line)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/06 10:29
S63	11	S62 and cross$talk	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/06 10:31
S64	10	S63 and (@ad<"20120727" or @rlad<"20120727" or @ptad<"20120727")	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2016/12/06 10:31

EAST Search History (Interference)

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12/7/2016 7:09:48 AM
C:\Users\sbezuayehu\Documents\EAST\Workspaces\14417544.wsp

IPR2025-00451
Petitioners' Exhibit 1002
Page 378 of 511

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14417544	KERPEZ ET AL.
	Examiner	Art Unit
	SOLOMON BEZUAYEHU	2653

CPC- SEARCHED		
Symbol	Date	Examiner
(H04L49/10 OR H04L5/14 OR H04N21/2408 OR H04N21/61 OR H04W72/0406).CPC.	12/7/2016	bezuayehu

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
379	88.01-88.19	12/7/2016	bezuayehu
370	351-365	12/7/2016	bezuayehu

SEARCH NOTES		
Search Notes	Date	Examiner
PGPUB;EPO;JPO;USPAT	12/7/2016	bezuayehu

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

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Courtesy Reminder for
Application Serial No: 14/417,544

Attorney Docket No: 03.P074US
Customer Number: 136402
Date of Electronic Notification: 12/23/2016

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor: **Kenneth Kerpez**	Examiner: **Solomon G. Bezuayehu**
Application No.: 14/417,544	Art Group: 2653
Filed: January 26, 2015	Confirmation No.: 8970
For: MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	Docket No.: 03.P074US

Mail Stop **Amendment**
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

AMENDMENT UNDER 37 C.F.R. § 1.111

Dear Examiner:

This Amendment is in response to the Non-Final Office Action notified December 23, 2016. Applicants respectfully request the Examiner to enter this Amendment and consider the following remarks.

LISTING OF CLAIMS

1. **(Currently Amended)** A method in a data communications system for managing multiple time division physical channels that are subject to crosstalk, the method comprising:

scheduling upstream time slots for upstream transmission in a first physical channel; and

scheduling downstream time slots for downstream transmission in a second physical channel, wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots.

2. (Previously Presented) The method of Claim 1, wherein scheduling downstream time slots comprises allowing some simultaneous transmission in the upstream and downstream time slots, the method further comprising cancelling near-end crosstalk (NEXT) from downstream into upstream transmission at a network end of the channels.

3. **(Currently Amended)** The method of Claim 1, wherein the upstream and downstream time slots have an active portion during which signals are transmitted and an off portion during which no signals are transmitted, and wherein the active portions of the upstream time slots are substantially not simultaneous with the active portions of the downstream time slots.

4. (Previously Presented) The method of Claim 1, wherein scheduling upstream and downstream time slots comprises scheduling upstream and downstream time slot boundaries.

5. (Previously Presented) The method of Claim 4, wherein the time slot boundaries are flexible.

6. **(Currently Amended)** The method of Claim 5, wherein the time slot boundaries have one or more of: variable-length frames; variable upstream time slot lengths; [[and]]or variable downstream time slot- lengths.

7. (Previously Presented) The method of Claim 1, further comprising assigning time slots to a network element based on the scheduling and transmitting the assignments from a management system to a network element.

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8. (Previously Presented) The method of Claim 1, further comprising adapting scheduling at least one of upstream and downstream time slots to accommodate delay requirements for the other of a downstream and upstream traffic source.

9. (**Currently Amended**) The method of Claim 1, further comprising receiving input on desired traffic levels for the first and second physical channels, and wherein scheduling upstream and downstream time slots is performed based on the received input.

10. (Previously Presented) The method of Claim 9, wherein a portion of a downstream time slot is invariant and a portion of a downstream time slot varies in real-time.

11. (**Currently Amended**) The method of Claim 9, wherein the received input comprises at least one of static subscription data, service layer information from a policy manager, behavior data for traffic types and users of the physical channels, long term traffic behavior data as a function of time, current traffic demands, queue lengths, traffic requests, upstream/downstream asymmetry, [[and]]or traffic descriptors.

12. (Previously Presented) The method of Claim 9, wherein scheduling upstream and downstream time slots comprises assigning time slots to achieve a target upstream/downstream asymmetry ratio of data throughput.

13. (Previously Presented) The method of Claim 12, wherein the upstream/downstream asymmetry ratio is defined in numbers of discrete multi-tone symbol positions

14. (**Currently Amended**) The method of Claim 12, wherein the measure of throughput is at least one of an average throughput across all lines, a traffic demand match, a minimum throughput for each physical channel, a perceived quality of experience, an average delay, [[and]]or a minimum delay.

15. (Previously Presented) The method of Claim 1, wherein scheduling upstream and downstream time slots comprises assigning time slots based at least in part on power usage.

16. (Previously Presented) The method of Claim 15, wherein assigning time slots based on power usage comprises assigning by scheduling entries, exits, and transitions between low-power link states and off states.

17. (Previously Presented) The method of Claim 15, wherein assigning time slots based on power usage includes assigning at least one network element to a receive-only mode, with a transmitter of the network element turned off.

18. (Previously Presented) The method of Claim 10, wherein scheduling upstream and downstream time slots comprises assigning time slots using an optimization criteria that weights different factors.

19. (Previously Presented) The method of Claim 18, wherein receiving input comprises receiving input from an external controller.

20. (**Currently Amended**) The method of Claim 19, wherein the received input comprises at least one of: Operations Support System (OSS) data, Element Management System (EMS) data, [[and]]or Management Information Database (MIB) parameters.

21. (Previously Presented) The method of Claim 10, wherein the time slots are defined within a time division frame, wherein receiving input comprises receiving input during a frame, and wherein scheduling upstream and downstream time slots comprises scheduling upstream and downstream time slots of an immediately subsequent frame.

22. (Previously Presented) The method of Claim 1, further comprising receiving requests for upstream and downstream transmission and wherein scheduling upstream time slots is based on the received upstream transmission requests.

23. (Previously Presented) The method of Claim 1, wherein the transmission in the upstream time slots is from a plurality of different network-end transmission sources.

24. (Previously Presented) The method of Claim 23, further comprising synchronizing upstream transmission and downstream transmission among a plurality of different network-end transmission sources.

25. (Previously Presented) The method of Claim 24, wherein synchronizing comprises sending synch symbols to a source of upstream transmissions.

26. (Previously Presented) The method of Claim 24, wherein synchronizing comprises measuring a time series of time-varying crosstalk and synchronizing to time-varying patterns of the crosstalk.

27. (Previously Presented) The method of Claim 24, wherein synchronizing is performed by measuring a time series of error events and synchronizing to time-varying patterns of the error events.

28. (Previously Presented) The method of Claim 1, wherein scheduling upstream and downstream time slots comprises determining a duration of the upstream and downstream time slots and moving the upstream and downstream time slot start times to reduce simultaneous upstream and downstream transmission.

29. (Previously Presented) The method of Claim 28, wherein determining a duration comprises adjusting a default duration based on bandwidth requests.

30. (**Currently Amended**) The method of Claim 28, wherein moving comprises moving [[only]] if upstream transmissions overlap downstream transmissions in time.

31. (Previously Presented) The method of Claim 28, further comprising reducing the duration of at least one downstream time slot to reduce simultaneous upstream and downstream

transmission.

32. (Previously Presented) The method of Claim 1, wherein the scheduling upstream and downstream time slot is further performed to minimize crosstalk on nearby VDSL2 lines.

33. (Previously Presented) The method of Claim 1, further comprising receiving input on desired traffic levels for the first and second physical channels and wherein scheduling upstream and downstream time slots is performed based on the received input and at least in part on power usage.

34. (Previously Presented) A machine-readable medium having instructions that when operated on by the machine cause the machine to perform operations comprising:

scheduling upstream time slots for upstream transmission in a first physical channel of multiple time division physical channels in a data communication system in which the physical channels are subject to crosstalk; and

scheduling downstream time slots for downstream transmission in a second physical channel subject to crosstalk from the upstream time slots, wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots.

35. (Previously Presented) The medium of Claim 34, the operations further comprising receiving input on desired traffic levels for the first and second physical channels and wherein scheduling upstream and downstream time slots is performed based on the received input.

36. (Previously Presented) The medium of Claim 34, wherein scheduling upstream and downstream time slots comprises assigning time slots to achieve a target upstream/downstream asymmetry ratio of data throughput.

37. (Previously Presented) An apparatus for managing multiple time division physical channels in a data communications system that are subject to crosstalk, the apparatus comprising:

means for scheduling upstream time slots for upstream transmission in a first physical channel; and

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means for scheduling downstream time slots for downstream transmission in a second physical channel subject to crosstalk from the upstream time slots, wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots.

38. (Previously Presented) The apparatus of Claim 37, further comprising means for assigning at least one network element to a receive-only mode, with a transmitter of the network element turned off.

39. (Previously Presented) The apparatus of Claim 37, further comprising means for receiving requests for upstream and downstream transmission for use by the means for scheduling.

40. (Previously Withdrawn) A system with multiple physical channels in a data communications system transmitting point-to-multipoint over multiple copper wires that are subject to crosstalk, wherein the system allows full-duplex operation by using line hybrids and echo cancellation to separate upstream transmission from downstream transmission, and near-end crosstalk (NEXT) is cancelled only at the network-end of the channels, from downstream into upstream transmission, wherein transmission in the upstream time slots may occur simultaneous with transmission in the downstream time slots.

REMARKS

This listing of claims will replace all prior versions and listings of claims in the application. Claims 1, 3, 6, 9, 11, 20, and 30 are amended. No claims are added. No claims are cancelled in this response. Hence, claims 1-39 are pending. Applicants respectfully request reconsideration of claims in view of the amendments and arguments.

REJECTION UNDER 35 U.S.C. § 103

Claims 1-39 stand rejected under pre-AIA 35 U.S.C. § 103(a) for allegedly being unpatentable over U.S. Patent Publication No. 2014/0003307 of Williams et al. (hereinafter "Williams") in view of U.S. Patent No. 5,887,032 of Cioffi (hereinafter "Cioffi"). Office Action, p. 2, item 2.

The following arguments are presented with reference to claim 1. The same arguments are applicable to other independent claims.

M.P.E.P. § 2143 states that "[t]he key to supporting any rejection under 35 U.S.C. 103 is the **clear articulation** of the reason(s) why the claimed invention would have been obvious. The Supreme Court in *KSR* noted that the analysis supporting a rejection under 35 U.S.C. 103 should be **made explicit**" (emphasis added). According to M.P.E.P. § 2143, rationales that may support a conclusion of obviousness include:

> (A) Combining prior art elements according to known methods to yield predictable results;
> (B) Simple substitution of one known element for another to obtain predictable results;
> (C) Use of known technique to improve similar devices (methods, or products) in the same way;
> (D) Applying a known technique to a known device (method, or product) ready for improvement to yield predictable results;
> (E) "Obvious to try" - choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;
> (F) Known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art;
> (G) Some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

While the above list is not an exclusive list, the MPEP requires that some rationale be provided in order to support a conclusion of obviousness.

Here, not only has the Office Action failed to present one or more of the above-listed rationales, the Office Action has failed to present **any** type of reasonable rationale. Specifically, the Office Action lacks a **clear articulation** of the reasons why these features would allegedly have been obvious. As such, the rejection cannot be supported per the requirements set forth by the United States Supreme Court in the *KSR* decision.

The Office Action merely appends a citation to the end of each paragraph of the claims with no reasoning or association with the claimed features. As such, Applicants cannot reasonably determine which "element" of the claim is believed to correspond with which section, figure or feature cited in the rejection. In other words, Applicants are not put on any reasonable notice as to the rationale behind the rejection and cannot adequately determine whether such basis is proper.

Further, failure to specifically identify which features of Williams and Cioffi are believed to disclose each element of the claims likely renders the Office Action "arbitrary and capricious", and therefore invalid, under the Administrative Procedure Act (5 U.S.C. § 706), a standard to which all Actions by the USPTO must adhere (see *Dickenson v. Zurko*, 527 U.S. 150 (1999)). Without proper guidance as to which "element" of the claim is believed to correspond with which section cited in the rejection, Applicants are forced to guess which features in the cited art the Examiner believed to disclose each of the claimed features.

Thus, it is respectfully submitted that the rejection is improper and must be withdrawn. Further, because the Office Action failed to establish a *prima facie* case of obviousness, any rejection in a subsequent Office Action providing adequate reasoning(s) would be presented for the first time on the record, and, as such, a subsequent Office Action cannot be made final.

Despite the above deficiencies in the Office Action, Applicants also contend that Williams teaches away from having a first physical channel for downstream and a second physical channel for upstream that are subjected to crosstalk. For example, Williams states in

paragraph [0008] that "SW1, SW2, SW3 to prevent or ameliorate interference ingresses, i.e., one or more of the switches SW0, SW1, SW2, SW3 may be controllably closed to prevent interference from a corresponding portion of the system 10, and oscillation in the case of amplifiers" which strongly suggests that the channel used in Williams is not subject to crosstalk.

Further, there are no separate physical channels for downstream and upstream in Williams. Instead, both upstream and downstream transmission is on the same channel which is time multiplexed by the switches SW0, SW1, SW2, SW3. This deficiency is not cured by Cioffi.

Cioffi allegedly discloses a data transmission system that mitigates crosstalk interference by adaptively estimating the crosstalk from received signals on a given line by adaptively estimating the crosstalk interference induced by certain other of the lines having interfering transmission and by cancelling the crosstalk interference using the estimated crosstalk interference from the certain other of the lines. Cioffi "Summary of the Invention." However, Cioffi does not disclose having separate channels for upstream and downstream. Instead, the alleged lines Cioffi appear to be bi-directional. Therefore, Cioffi does not have the need for having separate channels for upstream and downstream. As such, Cioffi and Williams together or alone do not disclose a method in a data communications system for managing multiple time division physical channels that are subject to crosstalk, the method comprising: scheduling upstream time slots for upstream transmission in a first physical channel; and scheduling downstream time slots for downstream transmission in a second physical channel, wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots.

Additionally, since both upstream and downstream transmission in Williams are on the same channel which is time multiplexed by the switches SW0, SW1, SW2, SW3, it means any combination of a reference that teaches separate physical channels for downstream and upstream will change the principle of operation of Williams because the purpose of the switches will be meaningless.

M.P.E.P. § 2143.01(V) states "[i]f proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, then there is **no suggestion or**

motivation to make the proposed modification. *In re Gordon*, 733 F.2d 900, 221 USPQ 1125 (Fed. Cir. 1984)" (emphasis added). "If the proposed modification or combination of the prior art would change the principle of operation of the prior art invention being modified, then the teachings of the references are **not sufficient** to render the claims *prima facie* obvious. *In re Ratti*, 270 F.2d 810, 123 USPQ 349 (CCPA 1959)" (emphasis added).

As discussed above, if the different "lines" of Cioffi are combined with the alleged scheduling of Williams, then the purpose of the switches of Williams will be meaningless because they are used for a single channel for upstream and downstream. As such, the combination of Cioffi with Williams would change the principle of operation of Williams. See. M.P.E.P. § 2143.01(V).

Applicants also contend that Examiner's reliance on the claims 1, 2 and 11 of Williams is improper because they are not enabled. For example, the term "prohibited" does not appear in the Specification of Williams and it is not clear what that term means in context of simultaneous transmissions.

Based on the above arguments, claim 1 is not obvious by the cited references. The same arguments apply to other independent claims. "If an independent claim is nonobvious under 35 U.S.C. 103, then any claim depending therefrom is nonobvious." M.P.E.P. § 2143.03.

Accordingly, Applicants respectfully request reconsideration of pending claims in view of the amendments.

Note that merely because Applicants do not specifically argue that certain limitations of a claim are not in the references is not a concession that a reference or combination of references includes the limitations. That Applicants do not contradict a particular statement made in the Office action is not a concession that Applicants agree with it. Further, merely because Applicants do not separately argue the patentability of every dependent claim is not a concession that there are not additional reasons for patentability of these dependent claims.

Applicants believe every assertion by the Office Action has been addressed. However, in the interest of clarity and brevity, Applicants may not have asserted every available argument for each assertion made in the Office Action. Applicants' silence regarding any such assertion does not constitute any admission or acquiescence. Applicants reserve all rights not exercised in connection with this response, such as the right to challenge or rebut any tacit or explicit characterization of any reference or of any of the present claims, the right to challenge or rebut any asserted factual or legal basis of any of the rejections, the right to swear behind any cited reference such as provided under 37 C.F.R. § 1.131 or otherwise, or the right to assert co-ownership of any cited reference.

Applicants do not admit that any of the cited references or any other references of record is relevant to the present claims, or that they constitute prior art. To the extent that any rejection or assertion is based upon the Examiner's personal knowledge, rather than any objection evidence of record as manifested by a cited prior art reference, Applicants timely object to such reliance on Official Notice, and reserve all rights to request that the Examiner provide a reference or affidavit in support of such assertion, as required by M.P.E.P. § 2144.03. Applicants reserve all rights to pursue any cancelled claims in a subsequent patent application claiming the benefit of priority of the present patent application, and to request rejoinder of any withdrawn claim, as required by M.P.E.P. § 821.04.

Based on the amendments and arguments, Applicants respectfully request the Examiner to allow all pending claims.

CONCLUSION

Applicants submit that they have overcome Examiner's objections to and rejections of the claims and that they have the right to claim the invention as listed in the listing of claims. Examiner is respectfully requested to contact the undersigned by telephone if it is believed that such contact would further the examination of the present application.

Pursuant to 37 C.F.R. § 1.136(a)(3), Applicants request and authorize the U.S. Patent and Trademark Office to (1) treat any concurrent or future reply that requires a petition for extension of time as incorporating a petition for extension of time for the appropriate length of time and (2) charge all required fees, including extension of time fees and fees under 37 C.F.R. § 1.16 and § 1.17, to Deposit Account No. 50-6925.

Respectfully submitted,
GREEN, HOWARD, & MUGHAL, LLP

03/16/17
Date

/Usman A. Mughal/
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PTO/SB/08a (01-10)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14/417,544
	Filing Date	Jan 26, 2015
	First Named Inventor	Kenneth Kerpez
	Art Unit	2653
	Examiner Name	Solomon G. Bezuayehu
	Attorney Docket Number	03.P074US

U.S. PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear

U.S. PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		20040076174		2004-04-22	BAUM et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]

NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
		Office Action for Canadian Patent Application No. 2,80,267, mailed February 25, 2016 (Attorney Docket No. 03.074CA)	
		Office Action for Korean Patent Application No. 10-2015-7004853 (Attorney Docket No. 03.P074KR) mailed March 2, 2017	

PTO/SB/08a (01-10)
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	Examiner Name	Solomon G. Bezuayehu
	Attorney Docket Number	03.P074US

		Office Action Mailed February 5, 2016 for Koren Patent Application No. 1020157004853 (Attorney Docket No. 03.P074KR)	

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document.
[4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e) (1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e) (2).

☐ See attached certification statement.

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	Art Unit	2653
	Examiner Name	Solomon G. Bezuayehu
	Attorney Docket Number	03.P074US

☒ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Usman Mughal/	Date (YYYY-MM-DD)	2017-03-16
Name/Print	Usman Mughal	Registration Number	62887

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Electronic Patent Application Fee Transmittal

Application Number:	14417544
Filing Date:	26-Jan-2015
Title of Invention:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
First Named Inventor/Applicant Name:	Kenneth Kerpez
Filer:	Usman Mughal/Michelle Murray-Hitchcock
Attorney Docket Number:	03.P074US

Filed as Small Entity

Filing Fees for U.S. National Stage under 35 USC 371

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
SUBMISSION- INFORMATION DISCLOSURE STMT	2806	1	90	90
		Total in USD ($)		**90**

Electronic Acknowledgement Receipt

EFS ID:	28648979
Application Number:	14417544
International Application Number:	
Confirmation Number:	8970
Title of Invention:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
First Named Inventor/Applicant Name:	Kenneth Kerpez
Customer Number:	136402
Filer:	Usman Mughal/Michelle Murray-Hitchcock
Filer Authorized By:	Usman Mughal
Attorney Docket Number:	03.P074US
Receipt Date:	16-MAR-2017
Filing Date:	26-JAN-2015
Time Stamp:	17:19:11
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

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Payment Type	CARD
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Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		03P074US_ROA.pdf	535766 436467ce26b39223ce5a5690646277961df5ccc9	yes	13
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Amendment/Req. Reconsideration-After Non-Final Reject		1	1	
	Claims		2	7	
	Applicant Arguments/Remarks Made in an Amendment		8	13	
Warnings:					
Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	03P074US_IDS.pdf	562609 3965242a416866ced4dd14732744aaf8fa8ce8e6	no	3
Warnings:					
Information:					
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3	Non Patent Literature	CA_Office_Action_02_25_2016.PDF	99166 e8d533e20ce95e96e3d2b4bd5c349bf63ca7544a	no	4
Warnings:					
Information:					
4	Non Patent Literature	KR_Office_Action_02_05_2016.pdf	435541 d61f7643a37ff90bf5b098fd1c1faecc6d9b98ad	no	13
Warnings:					
Information:					

5	Non Patent Literature	KR_Office_Action_03_02_2017.pdf	2572914 0483709bb07d55074b8945fcfb01be143a99398d	no	7
Warnings:					
Information:					
6	Fee Worksheet (SB06)	fee-info.pdf	31198 f9f4ba7ce45a06ba047a2bddbc896df718238cc7	no	2
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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/AIA/82A (07-13)
Approved for use through 11/30/2014. OMB 0651-0051
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TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	14/417,544
Filing Date	2015-01-26
First Named Inventor	Kenneth Kerpez
Title	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
Art Unit	2653
Examiner Name	Solomon G. Bezuayehu
Attorney Docket Number	20145-074US

SIGNATURE of Applicant or Patent Practitioner

Signature	/Michael V. North/	Date (Optional)	2017-03-14
Name	Michael V. North	Registration Number	46963
Title (if Applicant is a juristic entity)	Attorney		
Applicant Name (if Applicant is a juristic entity)	Adaptive Spectrum and Signal Alignment, Inc.		

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ *Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Document Description: Power of Attorney

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POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

✓ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above:

OR

146571

I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

✓ The address associated with the above-mentioned Customer Number

OR

The address associated with Customer Number:

OR

Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

Adaptive Spectrum and Signal Alignment, Inc.

Inventor or Joint Inventor (title not required below)

Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

✓ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature	Mary Fuller	Date (Optional)	2/24/2014
Name	Mary Fuller		
Title	General Counsel and Corporate Secretary		

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

✓ Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Electronic Acknowledgement Receipt

EFS ID:	28626886
Application Number:	14417544
International Application Number:	
Confirmation Number:	8970
Title of Invention:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
First Named Inventor/Applicant Name:	Kenneth Kerpez
Customer Number:	136402
Filer:	Michael V. North
Filer Authorized By:	
Attorney Docket Number:	03.P074US
Receipt Date:	16-MAR-2017
Filing Date:	26-JAN-2015
Time Stamp:	19:02:30
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	074US_POA.pdf	1872517 5f83478c72f480a967717fd1f1e9038bd25d1298	no	2

Warnings:

Information:	
Total Files Size (in bytes):	1872517

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 14/417,544	Filing Date 01/26/2015	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT **03/16/2017**

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 40	Minus	** 40	= 0	X $80 =	0
Independent (37 CFR 1.16(h))	* 4	Minus	***4	= 0	X $420 =	0
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	0

AMENDMENT

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
Frederick Briscoe

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/417,544	01/26/2015	Kenneth Kerpez	03.P074US

CONFIRMATION NO. 8970

POWER OF ATTORNEY NOTICE

136402
Green, Howard, & Mughal LLP
5 Centerpointe Dr.
Suite 400
LAKE OSWEGO, OR 97035

OC000000090046008

Date Mailed: 03/21/2017

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 03/16/2017.

- The Power of Attorney to you in this application has been revoked by the applicant. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/fstephanos/

IPR2025-00451
Petitioners' Exhibit 1002
Page 407 of 511

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/417,544	01/26/2015	Kenneth Kerpez	20145-074US

CONFIRMATION NO. 8970

POA ACCEPTANCE LETTER

146571
North Weber & Baugh LLP - ASSIA
3260 Hillview Avenue
Palo Alto, CA 94304

OC00000090046015

Date Mailed: 03/21/2017

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 03/16/2017.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/fstephanos/

IPR2025-00451
Petitioners' Exhibit 1002
Page 408 of 511

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/417,544	01/26/2015	Kenneth Kerpez	20145-074US	8970

146571 7590 05/30/2017

North Weber & Baugh LLP - ASSIA
3260 Hillview Avenue
Palo Alto, CA 94304

EXAMINER
BEZUAYEHU, SOLOMON G

ART UNIT	PAPER NUMBER
2653	

MAIL DATE	DELIVERY MODE
05/30/2017	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 14/417,544	Applicant(s) KERPEZ ET AL.	
	Examiner SOLOMON BEZUAYEHU	Art Unit 2653	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *3/16/2017*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *1-39* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-39* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☒ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date *3/16/2017*.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

DETAILED ACTION

1. Applicant's arguments, see Page 10, filed 3/16/2017, with respect to *Cioffi teaching not having upstream and downstream physical channel* have been fully considered and are persuasive. The previous rejection has been withdrawn.

Claim Rejections - 35 USC § 103

2. The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

3. Claims 1-39 is/are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Williams et al. (Pub. No. US 20140003307) further in view of Liu et al. (Patent No. US 6754261).

Regarding claims 1, 34, and 37, Williams teaches a method in a data communications system for managing multiple time division physical channels, the method comprising scheduling upstream time slots for upstream transmission in a physical channel [Claim 1, 2, 11, Para. 17, 18]; and scheduling downstream time slots for downstream transmission in a physical channel, wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots [Claim 1, 2, and 11, Para. 17, 18].

Williams teaches that the present invention could be configured for use with any coaxial line, however, Williams doesn't explicitly teach having a first physical channel for upstream and second physical channel for downstream transmission.

Liu teaches having first physical channel for downstream and second physical channel for upstream that are subjected to crosstalk [Col. 1 line 51-61, Col. 2 lines 45-50, fig. 1].

It would have been obvious to one of ordinary skill in the art, at the time of this invention was made, to modify Williams to schedule transmission for first and second physical channel, feature as taught by Liu; because the modification enable system equalize time-domain in communication channel to reduce signal distortion.

Regarding claim 2, Williams teaches wherein scheduling downstream time slots comprises allowing some simultaneous transmission in the upstream and downstream time slots, the method further comprising cancelling near-end crosstalk (NEXT) from downstream into upstream transmission at a network end of the channels [fig. 1-3 and related description].

Regarding claim 3, Williams teaches wherein the upstream and downstream time slots have an active portion during which signals are transmitted and an off portion during which no signals are transmitted and wherein the active portions of the upstream

time slots are substantially not simultaneous with the active portions of the downstream time slots [fig. 1-3 and related description].

Regarding claim 4, Williams teaches wherein scheduling upstream and downstream time slots comprises scheduling upstream and downstream time slot boundaries [fig. 1-3 and related description].

Regarding claim 5, Williams teaches wherein the time slot boundaries are flexible [fig. 1-3 and related description].

Regarding claim 6, Williams teaches wherein the time slot boundaries have one or more of: variable-length frames; variable upstream time slot lengths; and variable downstream time slot- lengths [fig. 1-3 and related description].

Regarding claim 7, Williams teaches further comprising assigning time slots to a network element based on the scheduling and transmitting the assignments from a management system to a network element [fig. 1-3 and related description].

Regarding claim 8, Williams teaches further comprising adapting scheduling at least one of upstream and downstream time slots to accommodate delay requirements for the other of a downstream and upstream traffic source [fig. 1-3 and related description].

Regarding claims 9, 35, Williams teaches further comprising receiving input on desired traffic levels for the first and second physical channels and wherein scheduling upstream and downstream time slots is performed based on the received input [fig. 1-3 and related description].

Regarding claim 10, Williams teaches wherein a portion of a downstream time slot is invariant and a portion of a downstream time slot varies in real-time [fig. 1-3 and related description].

Regarding claim 11, Williams teaches wherein the received input comprises at least one of static subscription data, service layer information from a policy manager, behavior data for traffic types and users of the physical channels, long term traffic behavior data as a function of time, current traffic demands, queue lengths, traffic requests, upstream/downstream asymmetry, and traffic descriptors [fig. 1-3 and related description].

Regarding claims 12 and 36, Williams teaches, wherein scheduling upstream and downstream time slots comprises assigning time slots to achieve a target upstream/downstream asymmetry ratio of data throughput [fig. 1-3 and related description].

Regarding claim 13, Williams teaches, wherein the upstream/downstream asymmetry ratio is defined in numbers of discrete multi-tone symbol positions [fig. 1-3 and related description].

Regarding claim 14, Williams teaches, wherein the measure of throughput is at least one of an average throughput across all lines, a traffic demand match, a minimum throughput for each physical channel, a perceived quality of experience, an average delay, and a minimum delay [fig. 1-3 and related description].

Regarding claim 15, Williams teaches wherein scheduling upstream and downstream time slots comprises assigning time slots based at least in part on power usage [fig. 1-3 and related description].

Regarding claim 16, Williams teaches wherein assigning time slots based on power usage comprises assigning by scheduling entries, exits, and transitions between low-power link states and off states [fig. 1-3 and related description].

Regarding claims 17 and 38, Williams teaches wherein assigning time slots based on power usage includes assigning at least one network element to a receive-only mode, with a transmitter of the network element turned off [fig. 1-3 and related description].

Regarding claim 18, Williams teaches wherein scheduling upstream and downstream time slots comprises assigning time slots using an optimization criteria that weights different factors [fig. 1-3 and related description].

Regarding claim 19, Williams teaches wherein receiving input comprises receiving input from an external controller [fig. 1-3 and related description].

Regarding claim 20, Williams teaches wherein the received input comprises at least one of Operations Support System (OSS) data, Element Management System (EMS) data, and Management Information Database (MIB) parameters [fig. 1-3 and related description].

Regarding claim 21, Williams teaches wherein the time slots are defined within a time division frame, wherein receiving input comprises receiving input during a frame, and wherein scheduling upstream and downstream time slots comprises scheduling upstream and downstream time slots of an immediately subsequent frame [fig. 1-3 and related description].

Regarding claim 22 , Williams teaches further comprising receiving requests for upstream and downstream transmission and wherein scheduling upstream time slots is based on the received upstream transmission requests [fig. 1-3 and related description].

Regarding claim 23, Williams teaches wherein the transmission in the upstream time slots is from a plurality of different network-end transmission sources [fig. 1-3 and related description].

Regarding claim 24, Williams teaches further comprising synchronizing upstream transmission and downstream transmission among a plurality of different network-end transmission sources [fig. 1-3 and related description].

Regarding claim 25, Williams teaches wherein synchronizing comprises sending synch symbols to a source of upstream transmissions [fig. 1-3 and related description].

Regarding claim 26, Williams teaches wherein synchronizing comprises measuring a time series of time-varying crosstalk and synchronizing to time-varying patterns of the crosstalk [fig. 1-3 and related description].

Regarding claim 27, Williams teaches, wherein synchronizing is performed by measuring a time series of error events and synchronizing to time-varying patterns of the error events [fig. 1-3 and related description].

Regarding claim 28, Williams teaches wherein scheduling upstream and downstream time slots comprises determining a duration of the upstream and downstream

time slots and moving the upstream and downstream time slot start times to reduce simultaneous upstream and downstream transmission [fig. 1-3 and related description].

Regarding claim 29, Williams teaches wherein determining a duration comprises adjusting a default duration based on bandwidth requests [fig. 1-3 and related description].

Regarding claim 30, Williams teaches wherein moving comprises moving only if upstream transmissions overlap downstream transmissions in time [fig. 1-3 and related description].

Regarding claim 31, Williams teaches further comprising reducing the duration of at least one downstream time slot to reduce simultaneous upstream and downstream transmission [fig. 1-3 and related description].

Regarding claim 32, Williams teaches wherein the scheduling upstream and downstream time slot is further performed to minimize crosstalk on nearby VDSL2 lines [fig. 1-3 and related description].

Regarding claim 33, Williams teaches further comprising receiving input on desired traffic levels for the first and second physical channels and wherein scheduling

upstream and downstream time slots is performed based on the received input and at least in part on power usage [fig. 1-3 and related description].

Regarding claim 39, Williams further comprising means for receiving requests for upstream and downstream transmission for use by the means for scheduling [fig. 1-3 and related description].

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to SOLOMON BEZUAYEHU whose telephone number is (571)270-7452. The examiner can normally be reached on Monday through Friday 9 a.m-4 p.m.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, FAN TSANG can be reached on 571-272-7547. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/SOLOMON BEZUAYEHU/

Primary Examiner, Art Unit 2653

Notice of References Cited	Application/Control No. 14/417,544	Applicant(s)/Patent Under Reexamination KERPEZ ET AL.	
	Examiner SOLOMON BEZUAYEHU	Art Unit 2653	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-6,819,716 B1	11-2004	Purkovic; Aleksander	H04L25/03012	348/E5.084
	B	US-				
	C	US-				
	D	US-				
	E	US-				
	F	US-				
	G	US-				
	H	US-				
	I	US-				
	J	US-				
	K	US-				
	L	US-				
	M	US-				

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S78	1615	upstream with down$stream with ((separat$2 or different) near2 (line or channel))	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2017/05/25 06:25
S79	958	upstream with down$stream with ((separat$2 or different) adj2 (line or channel))	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2017/05/25 06:26
S80	22	S79 same (cross$talk)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2017/05/25 06:26
S81	19	S80 and (@ad<"20120727" or @rlad<"20120727" or @ptad<"20120727")	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2017/05/25 06:26
S82	109	upstream with down$stream with ((separat$2 or different) with physical with (line or channel))	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2017/05/25 06:28
S83	100	S82 and (@ad<"20120727" or @rlad<"20120727" or @ptad<"20120727")	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2017/05/25 06:28
S84	7	S83 and cross$talk	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2017/05/25 06:28

EAST Search History (Interference)

<This search history is empty>

5/25/2017 10:37:34 AM
C:\Users\sbezuayehu\Documents\EAST\Workspaces\14417544.wsp

IPR2025-00451
Petitioners' Exhibit 1002
Page 422 of 511

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14417544	KERPEZ ET AL.
	Examiner	Art Unit
	SOLOMON BEZUAYEHU	2653

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/07/2016	05/25/2017							
	1	✓	✓							
	2	✓	✓							
	3	✓	✓							
	4	✓	✓							
	5	✓	✓							
	6	✓	✓							
	7	✓	✓							
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	33	✓	✓							
	34	✓	✓							
	35	✓	✓							
	36	✓	✓							

IPR2025-00451
Petitioners' Exhibit 1002
Page 423 of 511

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14417544	KERPEZ ET AL.
	Examiner	**Art Unit**
	SOLOMON BEZUAYEHU	2653

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/07/2016	05/25/2017							
	37	✓	✓							
	38	✓	✓							
	39	✓	✓							
	40	N	N							

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14417544	KERPEZ ET AL.
	Examiner	Art Unit
	SOLOMON BEZUAYEHU	2653

CPC- SEARCHED		
Symbol	Date	Examiner
(H04L49/10 OR H04L5/14 OR H04N21/2408 OR H04N21/61 OR H04W72/0406).CPC.	5/25/2017	bezuayehu

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
379	88.01-88.19	5/25/2017	bezuayehu
370	351-365	5/25/2017	bezuayehu

SEARCH NOTES		
Search Notes	Date	Examiner
PGPUB;EPO;JPO;USPAT	5/25/2017	bezuayehu

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

IPR2025-00451
Petitioners' Exhibit 1002
Page 425 of 511

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Field

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14/417,544
	Filing Date	Jan 26, 2015
	First Named Inventor	Kenneth Kerpez
	Art Unit	2653
	Examiner Name	Solomon G. Bezuayehu
	Attorney Docket Number	03.P074US

U.S. PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear

U.S. PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		20040076174		2004-04-22	BAUM et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]

NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
		Office Action for Canadian Patent Application No. 2,80,267, mailed February 25, 2016 (Attorney Docket No. 03.074CA)	
		Office Action for Korean Patent Application No. 10-2015-7004853 (Attorney Docket No. 03.P074KR) mailed March 2, 2017	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /S.G.B/

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Field

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	Application Number	14/417,544
	Filing Date	Jan 26, 2015
	First Named Inventor	Kenneth Kerpez
	Art Unit	2653
	Examiner Name	Solomon G. Bezuayehu
	Attorney Docket Number	03.P074US

		Office Action Mailed February 5, 2016 for Koren Patent Application No. 1020157004853 (Attorney Docket No. 03.P074KR)	

EXAMINER SIGNATURE

Examiner Signature	/SOLOMON G BEZUAYEHU/	Date Considered	05/25/2017

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document.
[4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

CERTIFICATION STATEMENT

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OR

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☐ See attached certification statement.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /S.G.B/

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Field

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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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	Filing Date	Jan 26, 2015
	First Named Inventor	Kenneth Kerpez
	Art Unit	2653
	Examiner Name	Solomon G. Bezuayehu
	Attorney Docket Number	03.P074US

☒ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Usman Mughal/	Date (YYYY-MM-DD)	2017-03-16
Name/Print	Usman Mughal	Registration Number	62887

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	14417544
Filing Date	2015-01-26
First Named Inventor	Kenneth Kerpezt et al.
Art Unit	2653
Examiner Name	BEZUAYEHU, SOLOMON G
Attorney Docket Number	20145-074US

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6480475	B1	2002-11-12	Cory S. Modlin et al.	

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U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20030086362	A1	2003-05-08	Kazutomo Hasegawa, et al.	
	2	20150215000	A1	2015-07-30	Santiago Vicent Colonques, et al.	
	3	20040076174	A1	2004-04-22	David Baum, et al.	

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	2254807	CA	C	2000-05-30	Bingham, et al.		

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14417544
	Filing Date	2015-01-26
	First Named Inventor	Kenneth Kerpezt et al.
	Art Unit	2653
	Examiner Name	BEZUAYEHU, SOLOMON G
	Attorney Docket Number	20145-074US

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NON-PATENT LITERATURE DOCUMENTS [Remove]

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	Office Action dated October 11, 2016, in Chinese Patent Application No. 201280075697.8 (22 pgs).	
	2	Notice of Allowance dated July 1, 2017, in Korean Patent Application No. 10-2017-7009038 (3 pgs).	
	3	Notice of Final Rejection dated November 8, 2016, in Korean Patent Application No. 10-2015-7004853 (6 pgs).	X

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	14417544
Filing Date	2015-01-26
First Named Inventor	Kenneth Kerpezt et al.
Art Unit	2653
Examiner Name	BEZUAYEHU, SOLOMON G
Attorney Docket Number	20145-074US

CERTIFICATION STATEMENT

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See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Michael North/	Date (YYYY-MM-DD)	2017-07-18
Name/Print	Michael North	Registration Number	46963

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

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9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal

Application Number:	14417544
Filing Date:	26-Jan-2015
Title of Invention:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
First Named Inventor/Applicant Name:	Kenneth Kerpez
Filer:	Michael V. North/Domarina Alkhas
Attorney Docket Number:	20145-074US

Filed as Large Entity

Filing Fees for U.S. National Stage under 35 USC 371

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt

EFS ID:	29821467
Application Number:	14417544
International Application Number:	
Confirmation Number:	8970
Title of Invention:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
First Named Inventor/Applicant Name:	Kenneth Kerpez
Customer Number:	146571
Filer:	Michael V. North/Domarina Alkhas
Filer Authorized By:	Michael V. North
Attorney Docket Number:	20145-074US
Receipt Date:	18-JUL-2017
Filing Date:	26-JAN-2015
Time Stamp:	20:30:04
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$180
RAM confirmation Number	071917INTEFSW20340200
Deposit Account	
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Foreign Reference	074US_SIDS_FR1.pdf	6942 1ad28ddeba2a9794fbda1c7f460a4f5c38510074	no	2
Warnings:					
Information:					
2	Non Patent Literature	074US_SIDS_NPL1.pdf	271963 509254033637f68a238d71489389a7b23216a23d	no	22
Warnings:					
Information:					
3	Non Patent Literature	074US_SIDS_NPL2.pdf	2010988 9a32391f156b7d7125d82a108e1a0e8633236b1b	no	3
Warnings:					
Information:					
4	Non Patent Literature	074US_SIDS_NPL3.pdf	5377188 fbb844a9317742b2484389 7f019edd42b648cf22	no	6
Warnings:					
Information:					
5	Transmittal Letter	074US_SIDS_Trans.pdf	27920 4aa537fcd1e4aa004a7f3fd9af90e0592fe6ede6	no	3
Warnings:					
Information:					
6	Information Disclosure Statement (IDS) Form (SB08)	074US_SIDS_SB08a.pdf	612542 5fe99c6379509ff357e9b310fe21443f9e05ff3a	no	4
Warnings:					
Information:					

7	Fee Worksheet (SB06)	fee-info.pdf	31020 8e16c641c543ffa6475f2f02e1bffb2417265266	no	2

Warnings:	
Information:	
Total Files Size (in bytes):	8338563

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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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ERROR: undefined
OFFENDING COMMAND: eexec

STACK:

/quit
-dictionary-
-mark-
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s)	:	Kenneth Kerpezt et al.	Confirmation No.	: 8970
Appl. No.	:	14/417,544		
Filing Date	:	January 26, 2015		
Title	:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER		
Art Unit	:	2653		
Examiner	:	BEZUAYEHU, SOLOMON G		
Docket No.	:	20145-074US		

CERTIFICATE OF MAILING (37 CFR §1.8)

I hereby certify, pursuant to 37 CFR §1.8, that this correspondence is being electronically transmitted via EFS-Web addressed to Mail Stop RCE, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on the date shown below:

Date: 2017-07-18 By: /Domarina Alkhas/
Domarina Alkhas

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Examiner Mr. BEZUAYEHU:

Filed herewith, in accordance with the provisions of 37 CFR §§ 1.56 and 1.97–1.98, listing various references for consideration by the Examiner, is an Information Disclosure Statement ("IDS").

The filing of this IDS shall not be construed as a representation that a search has been made, or regarding the completeness of the list of references, or that no other material information exists. Furthermore, the filing of this IDS shall not be construed as a representation that inclusion of a reference in this list is an admission that it is prior art or is pertinent to this application, or as an admission that the information listed is, or may be considered to be, material to the patentability of the above referenced application. The filing of this IDS shall not be construed in any manner as an admission against interest.

This IDS is being filed:

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Page 440 of 511

☐ within three months of the filing date of a national application, other than a continued prosecution application under § 1.53(d);

☐ within three months of the date of entry of the national stage as set forth in § 1.491 in an international application;

☐ before the mailing of a first Office Action on the merits;

☐ before the mailing of a first Office Action after the filing of a request for continued examination under § 1.114;

☒ after three months of the filing date or entry into the national stage or after the mailing of a first Office action on the merits, but before the mailing date of any final action under § 1.113, a notice of allowance under §1.311, or an action that otherwise closes prosecution in the application;

AND

☒ enclosed herein is the fee set forth in 37 CFR § 1.17(p);

OR

☐ Applicant certifies pursuant to 37 CFR § 1.97(e):

☐ That each item of information contained in the information disclosure statement was first cited in a communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this information disclosure statement;

OR

☐ That no item of information contained in this information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing this certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in § 1.56(c) more than three months prior to the filing of this information disclosure statement.

☐ on or before the payment of the issue fee but after the mailing of a final action under § 1.113, a notice of allowance under §1.311, or an action that otherwise closes prosecution in the application;

AND

☐ enclosed herein is the fee set forth in 37 CFR § 1.17(p);

AND

☐ Applicant certifies pursuant to 37 CFR § 1.97(e):

☐ That each item of information contained in the information disclosure statement was first cited in a communication from a foreign patent office in a counterpart foreign application

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Petitioners' Exhibit 1002
Page 441 of 511

not more than three months prior to the filing of this information disclosure statement;

OR

☐ That no item of information contained in this information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing this certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in § 1.56(c) more than three months prior to the filing of this information disclosure statement.

☐ Applicant submits that the enclosed Information Disclosure Statement is timely; therefore, no fee is required.

☒ Except as provided for under 37 CFR § 1.98(a)(2), Applicant has enclosed a copy of each listed reference.

☐ The above referenced application relies upon Application No. _____, filed _____ for an earlier effective filing date under 35 U.S.C. 120. Although, pursuant to 37 CFR § 1.98(d), the references submitted herein are not required to be submitted for the Examiner to consider them, Applicant submits the references herein so that the information will be printed on the patent issuing from this application.

☐ Pursuant to 37 CFR § 1.704(d), Applicant certifies that each of the references cited herein were first cited in a communication from a foreign patent office in a counterpart application and that this communication was not received by any individual designated in 37 CFR § 1.56(c) more than thirty days prior to the filing of this Information Disclosure Statement.

Consideration of the listed references and favorable action are requested. If any additional fees are due in connection with the filing of this Information Disclosure Statement, the Commissioner is hereby authorized to charge such fees to Deposit Account 50-6925.

Respectfully submitted,

Date: 2017-07-18

By: /Michael V. North/
Michael V. North
Reg. No. 46963

Customer No.
146571
UNITED STATES PATENT AND TRADEMARK OFFICE

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Petitioners' Exhibit 1002
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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s)	:	Kenneth Kerpez *et al.*	Confirmation No.: 8970
Appl. No.	:	14/417,544	
Filed	:	January 26, 2015	
Title	:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER	
Examiner	:	Solomon G. Bezuayehu	
Art Unit	:	2653	
Docket No.	:	20145-074US	

CERTIFICATE OF MAILING (37 CFR §1.8)

I hereby certify, pursuant to 37 CFR §1.8, that this correspondence is being electronically transmitted via EFS-Web addressed to: Mail Stop Amendment, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on the date shown below:

Date: 2017-08-29 By: /Nita Miller/
Nita Miller

RESPONSE TO NON-FINAL OFFICE ACTION

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Examiner Bezuayehu:

This paper is responsive to the Non-Final Office Action mailed May 30, 2017, and having a shortened statutory period ending August 30, 2017. Accordingly, this paper is timely filed. Reconsideration is respectfully requested in view of the Amendments and Remarks below.

Amendments to the Claims appear in the complete Listing of Claims which may be found beginning at page **2** of this paper.

Remarks/Arguments may be found at page **9** of this paper.

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AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in the application, and reflects the Examiner's renumbering:

Listing of Claims:

1. (Previously presented) A method in a data communications system for managing multiple time division physical channels that are subject to crosstalk, the method comprising:

scheduling upstream time slots for upstream transmission in a first physical channel; and

scheduling downstream time slots for downstream transmission in a second physical channel, wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots.

2. (Previously pesented) The method of Claim 1, wherein scheduling downstream time slots comprises allowing some simultaneous transmission in the upstream and downstream time slots, the method further comprising cancelling near-end crosstalk (NEXT) from downstream into upstream transmission at a network end of the channels.

3. (Previously presented) The method of Claim 1, wherein the upstream and downstream time slots have an active portion during which signals are transmitted and an off portion during which no signals are transmitted, and wherein the active portions of the upstream time slots are substantially not simultaneous with the active portions of the downstream time slots.

4. (Previously presented) The method of Claim 1, wherein scheduling upstream and downstream time slots comprises scheduling upstream and downstream time slot boundaries.

5. (Previously presented) The method of Claim 4, wherein the time slot boundaries are flexible.

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6. (Previously presented) The method of Claim 5, wherein the time slot boundaries have one or more of: variable-length frames; variable upstream time slot lengths; or variable downstream time slot- lengths.

7. (Previously presented) The method of Claim 1, further comprising assigning time slots to a network element based on the scheduling and transmitting the assignments from a management system to a network element.

8. (Previously presented) The method of Claim 1, further comprising adapting scheduling at least one of upstream and downstream time slots to accommodate delay requirements for the other of a downstream and upstream traffic source.

9. (Previously presented) The method of Claim 1, further comprising receiving input on desired traffic levels for the first and second physical channels, and wherein scheduling upstream and downstream time slots is performed based on the received input.

10. (Previously presented) The method of Claim 9, wherein a portion of a downstream time slot is invariant and a portion of a downstream time slot varies in real-time.

11. (Previously presented) The method of Claim 9, wherein the received input comprises at least one of static subscription data, service layer information from a policy manager, behavior data for traffic types and users of the physical channels, long term traffic behavior data as a function of time, current traffic demands, queue lengths, traffic requests, upstream/downstream asymmetry, or traffic descriptors.

12. (Previously presented) The method of Claim 9, wherein scheduling upstream and downstream time slots comprises assigning time slots to achieve a target upstream/downstream asymmetry ratio of data throughput.

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13. (Previously presented) The method of Claim 12, wherein the upstream/downstream asymmetry ratio is defined in numbers of discrete multi-tone symbol positions.

14. (Previously presented) The method of Claim 12, wherein the measure of throughput is at least one of an average throughput across all lines, a traffic demand match, a minimum throughput for each physical channel, a perceived quality of experience, an average delay, or a minimum delay.

15. (Previously presented) The method of Claim 1, wherein scheduling upstream and downstream time slots comprises assigning time slots based at least in part on power usage.

16. (Previously presented) The method of Claim 15, wherein assigning time slots based on power usage comprises assigning by scheduling entries, exits, and transitions between low-power link states and off states.

17. (Previously presented) The method of Claim 15, wherein assigning time slots based on power usage includes assigning at least one network element to a receive-only mode, with a transmitter of the network element turned off.

18. (Previously presented) The method of Claim 10, wherein scheduling upstream and downstream time slots comprises assigning time slots using an optimization criteria that weights different factors.

19. (Previously presented) The method of Claim 18, wherein receiving input comprises receiving input from an external controller.

20. (Previously presented) The method of Claim 19, wherein the received input comprises at least one of: Operations Support System (OSS) data, Element Management System (EMS) data, or Management Information Database (MIB) parameters.

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21. (Previously presented) The method of Claim 10, wherein the time slots are defined within a time division frame, wherein receiving input comprises receiving input during a frame, and wherein scheduling upstream and downstream time slots comprises scheduling upstream and downstream time slots of an immediately subsequent frame.

22. (Previously presented) The method of Claim 1, further comprising receiving requests for upstream and downstream transmission and wherein scheduling upstream time slots is based on the received upstream transmission requests.

23. (Previously presented) The method of Claim 1, wherein the transmission in the upstream time slots is from a plurality of different network-end transmission sources.

24. (Previously presented) The method of Claim 23, further comprising synchronizing upstream transmission and downstream transmission among a plurality of different network-end transmission sources.

25. (Previously presented) The method of Claim 24, wherein synchronizing comprises sending synch symbols to a source of upstream transmissions.

26. (Previously presented) The method of Claim 24, wherein synchronizing comprises measuring a time series of time-varying crosstalk and synchronizing to time-varying patterns of the crosstalk.

27. (Previously presented) The method of Claim 24, wherein synchronizing is performed by measuring a time series of error events and synchronizing to time-varying patterns of the error events.

28. (Previously presented) The method of Claim 1, wherein scheduling upstream and downstream time slots comprises determining a duration of the upstream and downstream time

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slots and moving the upstream and downstream time slot start times to reduce simultaneous upstream and downstream transmission.

29. (Previously presented) The method of Claim 28, wherein determining a duration comprises adjusting a default duration based on bandwidth requests.

30. (Previously presented) The method of Claim 28, wherein moving comprises moving if upstream transmissions overlap downstream transmissions in time.

31. (Previously presented) The method of Claim 28, further comprising reducing the duration of at least one downstream time slot to reduce simultaneous upstream and downstream transmission.

32. (Previously presented) The method of Claim 1, wherein the scheduling upstream and downstream time slot is further performed to minimize crosstalk on nearby VDSL2 lines.

33. (Previously presented) The method of Claim 1, further comprising receiving input on desired traffic levels for the first and second physical channels and wherein scheduling upstream and downstream time slots is performed based on the received input and at least in part on power usage.

34. (Previously presented) A machine-readable medium having instructions that when operated on by the machine cause the machine to perform operations comprising:

scheduling upstream time slots for upstream transmission in a first physical channel of multiple time division physical channels in a data communication system in which the physical channels are subject to crosstalk; and

scheduling downstream time slots for downstream transmission in a second physical channel subject to crosstalk from the upstream time slots, wherein transmission in

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the upstream time slots is substantially not simultaneous with transmission in the downstream time slots.

35. (Previously presented) The medium of Claim 34, the operations further comprising receiving input on desired traffic levels for the first and second physical channels and wherein scheduling upstream and downstream time slots is performed based on the received input.

36. (Previously presented) The medium of Claim 34, wherein scheduling upstream and downstream time slots comprises assigning time slots to achieve a target upstream/downstream asymmetry ratio of data throughput.

37. (Previously presented) An apparatus for managing multiple time division physical channels in a data communications system that are subject to crosstalk, the apparatus comprising:

means for scheduling upstream time slots for upstream transmission in a first physical channel; and

means for scheduling downstream time slots for downstream transmission in a second physical channel subject to crosstalk from the upstream time slots, wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots.

38. (Previously presented) The apparatus of Claim 37, further comprising means for assigning at least one network element to a receive-only mode, with a transmitter of the network element turned off.

39. (Previously presented) The apparatus of Claim 37, further comprising means for receiving requests for upstream and downstream transmission for use by the means for scheduling.

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40. (Withdrawn) A system with multiple physical channels in a data communications system transmitting point-to-multipoint over multiple copper wires that are subject to crosstalk, wherein the system allows full-duplex operation by using line hybrids and echo cancellation to separate upstream transmission from downstream transmission, and near-end crosstalk (NEXT) is cancelled only at the network-end of the channels, from downstream into upstream transmission, wherein transmission in the upstream time slots may occur simultaneous with transmission in the downstream time slots.

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REMARKS/ARGUMENTS

In the Non-Final Office Action (hereinafter, "Office Action"), mailed May 30, 2017, the Examiner rejected all pending claims. By this response, claims 1-39 are re-submitted, no claims are cancelled and no claims are added. Following entry of this response, claims 1-29, will be pending in the application.

Claim Amendments

Independent claims 1, 16 and 23 are amended with incorporation of limitation "the one or more packets are transmitted in a continuous stream".

The amendment is fully support by the specification. For example, [0028] discloses that "*In one embodiment, an agent issues latency test commands successively without a wait time between them. The successive latency test commands result in a continuous stream of packets and prevent the target communication device from going into a sleep state.*" (underline added for emphasis)

Therefore, the amendment is enabled and no new matter is added.

Claim Rejections

I. Rejection of Claims 1-39 under pre-AIA 35 U.S.C. § 103

Applicant respectfully makes reference to MPEP §§ 2142, which state in part:

> **The key to supporting any rejection under 35 U.S.C. 103 is the clear articulation of the reason(s) why the claimed invention would have been obvious. The Supreme Court in KSR International Co. v. Teleflex Inc., 550 U.S. [398 (2007)], 82 USPQ2d 1385, 1396 (2007) noted that the analysis supporting a rejection under 35 U.S.C. 103 should be made explicit. The Federal Circuit has stated that 'rejections on obviousness cannot be sustained with mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness. In re Kahn, 441 F.3d 977, 988, 78 USPQ2d 1329, 1336 (Fed. Cir. 2006). See also KSR, 550 U.S. at [418], 82 USPQ2d at 1396 (quoting Federal Circuit statement with approval). (MPEP § 2142.)**

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The Examiner rejected claims 1-39 under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent Publication No. 2014/0003307 to Williams *et al.* (hereinafter, "Williams") in view of U.S. Patent No. 6,574,261 to Liu *et al.* (hereinafter, "Liu"). Applicant respectfully disagrees.

Claim 1 states (*emphasis added*):

"A method in a data communications system for managing multiple time division physical channels that are subject to crosstalk, the method comprising:

scheduling upstream time slots for upstream transmission in a first physical channel; and

scheduling downstream time slots for downstream transmission in a second physical channel, wherein transmission in the upstream time slots is substantially not simultaneous with transmission in the downstream time slots."

In the Office Action, the Examiner notes on page 3 that

> "*Williams teaches that the present invention could be configured for use with any coaxial line, however, Williams doesn't explicitly teach having a first physical channel for upstream and second physical channel for downstream transmission.*
>
> *Liu teaches having first physical channel for downstream and second physical channel for upstream that are subjected to crosstalk [Col. l line 51-61, Col. 2 lines 45-50, fig. l].*
>
> *It would have been obvious to one of ordinary skill in the art, at the time of this invention was made, to modify Williams to schedule transmission for first and second physical channel, feature as taught by Liu; because the modification enable system equalize time-domain in communication channel to reduce signal distortion.*"

Applicant respectfully asserts that there is no rational to modify Williams with teaching of Liu.

First, Applicant respectfully points out that in Williams' disclosure, the upstream transmission and downstream transmission are on the same channel which is time multiplexed by the switches SW0, SW1, SW2, SW3. Therefore, any combination of a reference that teaches separate physical channels for downstream and upstream will change the principle of operation of Williams because the purpose of the switches will be meaningless. MPEP § 2143.01(V) states "If proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, then there is **no suggestion or motivation** to make the proposed modification. *In re Gordon*, 733 F.2d 900, 221 USPQ 1125 (Fed. Cir. 1984)" (emphasis added).

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Second, Liu's disclosure is focused on determining sampling time for a time-domain equalizer divides an over-sampled sequence into a plurality of individual Nyquist rate sequences (abstract, and summary of invention). While on the other hand, the current patent application is related to managing time division duplex transmission over copper physical channels. Although Liu only mentioned briefly and once in background section that "*The upstream channel and the downstream channel may share the same physical communication link or occupy different physical communication links*", Liu is not at the same field of endeavor as the claimed invention, nor reasonably pertinent to the problem faced by the inventor. MEPE § 2141.01 states that "*In order for a reference to be proper for use in an obviousness rejection under 35 U.S.C. 103 , the* ***reference must be analogous art to the claimed invention*****.....** *a reference is analogous art to the claimed invention if: (1) the reference is from the same field of endeavor as the claimed invention (even if it addresses a different problem); or (2) the reference is reasonably pertinent to the problem faced by the inventor (even if it is not in the same field of endeavor as the claimed invention).*" (*emphasis added*)

Third, the Examiner states that "*It would have been obvious to one of ordinary skill in the art, at the time of this invention was made, to modify Williams to schedule transmission for first and second physical channel, feature as taught by Liu; because the modification enable system equalize time-domain in communication channel to reduce signal distortion*". However, there is no place in Liu to explicitly disclose or suggest scheduling upstream transmission for first and downstream transmission for second physical channel to reduce signal distortion. Therefore, the combining reason stated by the Examiner is not supported or suggested.

Therefore, based on at least the above remarks, Applicant respectfully asserts that claim 1 is patentable over Williams in view of Liu.

The above mentioned remarks in regarding to independent claim 1 are also applicable to independent claims 34 and 37. Therefore, independent claims 34 and 37 are also patentable over Williams in view of Liu.

Dependent claims 2-33, 35-36, and 38-39 depend from independent claims 1, 34, and 37 respectively, and thus follow the allowability of independent claims 1, 34, or 37.

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Therefore, Applicant respectfully requests withdrawn of rejections on claims 1-39.

CONCLUSION

In view of the above arguments, Applicant believes that pending claims 1-26, are allowable and respectfully requests that a Notice of Allowance be issued for this application in its current state. Should the Examiner believe that a telephone conference would expedite the prosecution of this application, the undersigned may be reached by telephone at 520-288-8876.

If any fees are due in connection with this filing the Commissioner is authorized to charge such fees to Deposit Account 50-2776.

Respectfully submitted,

Date: 2017-08-29

By: /Xin Dai/
Xin Dai, Ph.D.
Reg. No. 72,098

Customer No.
146571
UNITED STATES PATENT & TRADEMARK OFFICE

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Electronic Acknowledgement Receipt

EFS ID:	30214489
Application Number:	14417544
International Application Number:	
Confirmation Number:	8970
Title of Invention:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
First Named Inventor/Applicant Name:	Kenneth Kerpez
Customer Number:	146571
Filer:	Michael V. North/Nita Miller
Filer Authorized By:	Michael V. North
Attorney Docket Number:	20145-074US
Receipt Date:	29-AUG-2017
Filing Date:	26-JAN-2015
Time Stamp:	15:32:24
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		074US_RNFOA.pdf	80522 639c87e10efbc4ee2896bf4655bcbf36de820a72	yes	12

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
	Claims	2	8
	Applicant Arguments/Remarks Made in an Amendment	9	12
Warnings:			
Information:			
	Total Files Size (in bytes):	80522	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 14/417,544	Filing Date 01/26/2015	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT **08/29/2017**

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 40	Minus	** 40	= 0	X $80 =	0
Independent (37 CFR 1.16(h))	* 4	Minus	***4	= 0	X $420 =	0
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	0

AMENDMENT

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

SLIE
TONYA MCBRIDE

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	14417544
Filing Date	2012-07-27
First Named Inventor	Kenneth Kerpez
Art Unit	2653
Examiner Name	Solomon G. Bezuayehu
Attorney Docket Number	20145-074US

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20040165547	A1	2004-08-26	Luis Lopes	

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	Attorney Docket Number	20145-074US

	1	Office Action dated 2017-09-26, in Chinese Patent Application No. 201280075697.8.	X

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14417544
	Filing Date	2012-07-27
	First Named Inventor	Kenneth Kerpez
	Art Unit	2653
	Examiner Name	Solomon G. Bezuayehu
	Attorney Docket Number	20145-074US

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Michael North/	Date (YYYY-MM-DD)	2017-11-28
Name/Print	Michael North	Registration Number	46963

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	31064364
Application Number:	14417544
International Application Number:	
Confirmation Number:	8970
Title of Invention:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
First Named Inventor/Applicant Name:	Kenneth Kerpez
Customer Number:	146571
Filer:	Michael V. North/Nita Miller
Filer Authorized By:	Michael V. North
Attorney Docket Number:	20145-074US
Receipt Date:	28-NOV-2017
Filing Date:	26-JAN-2015
Time Stamp:	16:10:56
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	074US_SIDS_Trans.pdf	29861 5a7e2123e7ea8f44a89cd501b73eb60670ab6a71	no	3

Warnings:

Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	074US_SIDS_SB08.pdf	612268 e39af57a67cbb06c5e0f60aa72b73046e414a69d	no	4
Warnings:					
Information:					
3	Non Patent Literature	074US_SIDS_NPL1.pdf	2531128 808da86b23ff2ca412d0d7d34e95a0a5b808fed5	no	33
Warnings:					
Information:					
			Total Files Size (in bytes):	3173257	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s)	:	Kenneth Kerpezt *et al.*	Confirmation No.	: 8970
Appl. No.	:	14/417,544		
Filing Date	:	January 26, 2015		
Title	:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER		
Art Unit	:	2653		
Examiner	:	Solomon G. Bezuayehu		
Docket No.	:	20145-074US		

CERTIFICATE OF MAILING (37 CFR §1.8)

I hereby certify, pursuant to 37 CFR §1.8, that this correspondence is being electronically transmitted via EFS-Web addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on the date shown below:

Date: 2017-11-28 By: /Nita Miller/
Nita Miller

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Examiner Bezuayehu:

Filed herewith, in accordance with the provisions of 37 CFR §§ 1.56 and 1.97–1.98, listing various references for consideration by the Examiner, is an Information Disclosure Statement ("IDS").

The filing of this IDS shall not be construed as a representation that a search has been made, or regarding the completeness of the list of references, or that no other material information exists. Furthermore, the filing of this IDS shall not be construed as a representation that inclusion of a reference in this list is an admission that it is prior art or is pertinent to this application, or as an admission that the information listed is, or may be considered to be, material to the patentability of the above referenced application. The filing of this IDS shall not be construed in any manner as an admission against interest.

This IDS is being filed:

IPR2025-00451
Petitioners' Exhibit 1002
Page 464 of 511

☐ within three months of the filing date of a national application, other than a continued prosecution application under § 1.53(d);

☐ within three months of the date of entry of the national stage as set forth in § 1.491 in an international application;

☐ before the mailing of a first Office Action on the merits;

☐ before the mailing of a first Office Action after the filing of a request for continued examination under § 1.114;

☒ after three months of the filing date or entry into the national stage or after the mailing of a first Office action on the merits, but before the mailing date of any final action under § 1.113, a notice of allowance under §1.311, or an action that otherwise closes prosecution in the application;

AND

☐ enclosed herein is the fee set forth in 37 CFR § 1.17(p);

OR

☒ Applicant certifies pursuant to 37 CFR § 1.97(e):

☒ That each item of information contained in the information disclosure statement was first cited in a communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this information disclosure statement;

OR

☐ That no item of information contained in this information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing this certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in § 1.56(c) more than three months prior to the filing of this information disclosure statement.

☐ on or before the payment of the issue fee but after the mailing of a final action under § 1.113, a notice of allowance under §1.311, or an action that otherwise closes prosecution in the application;

AND

☐ enclosed herein is the fee set forth in 37 CFR § 1.17(p);

AND

☐ Applicant certifies pursuant to 37 CFR § 1.97(e):

☐ That each item of information contained in the information disclosure statement was first cited in a communication from a foreign patent office in a counterpart foreign application

IPR2025-00451
Petitioners' Exhibit 1002
Page 465 of 511

not more than three months prior to the filing of this information disclosure statement;

OR

☐ That no item of information contained in this information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing this certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in § 1.56(c) more than three months prior to the filing of this information disclosure statement.

☒ Applicant submits that the enclosed Information Disclosure Statement is timely; therefore, no fee is required.

☒ Except as provided for under 37 CFR § 1.98(a)(2), Applicant has enclosed a copy of each listed reference.

☐ The above referenced application relies upon Application No. _____, filed _____ for an earlier effective filing date under 35 U.S.C. 120. Although, pursuant to 37 CFR § 1.98(d), the references submitted herein are not required to be submitted for the Examiner to consider them, Applicant submits the references herein so that the information will be printed on the patent issuing from this application.

☐ Pursuant to 37 CFR § 1.704(d), Applicant certifies that each of the references cited herein were first cited in a communication from a foreign patent office in a counterpart application and that this communication was not received by any individual designated in 37 CFR § 1.56(c) more than thirty days prior to the filing of this Information Disclosure Statement.

Consideration of the listed references and favorable action are requested. If any additional fees are due in connection with the filing of this Information Disclosure Statement, the Commissioner is hereby authorized to charge such fees to Deposit Account 50-6925.

Respectfully submitted,

Date: 2017-11-28

By: /Michael V. North/
Michael V. North
Reg. No. 46963

Customer No.
146571
UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

146571 7590 12/15/2017
North Weber & Baugh LLP - ASSIA
3260 Hillview Avenue, 1st Floor
Palo Alto, CA 94304

EXAMINER
BEZUAYEHU, SOLOMON G

ART UNIT	PAPER NUMBER
2666	

DATE MAILED: 12/15/2017

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/417,544	01/26/2015	Kenneth Kerpez	20145-074US	8970

TITLE OF INVENTION: MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	03/15/2018

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

146571 7590 12/15/2017
North Weber & Baugh LLP - ASSIA
3260 Hillview Avenue, 1st Floor
Palo Alto, CA 94304

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/417,544	01/26/2015	Kenneth Kerpez	20145-074US	8970

TITLE OF INVENTION: MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	03/15/2018

EXAMINER	ART UNIT	CLASS-SUBCLASS
BEZUAYEHU, SOLOMON G	2666	379-406010

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ Applicant certifying micro entity status. See 37 CFR 1.29 — NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
- ❑ Applicant asserting small entity status. See 37 CFR 1.27 — NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
- ❑ Applicant changing to regular undiscounted fee status. — NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

IPR2025-00451
Petitioners' Exhibit 1002
Page 468 of 511

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/417,544	01/26/2015	Kenneth Kerpez	20145-074US	8970

146571 7590 12/15/2017
North Weber & Baugh LLP - ASSIA
3260 Hillview Avenue, 1st Floor
Palo Alto, CA 94304

EXAMINER	
BEZUAYEHU, SOLOMON G	
ART UNIT	PAPER NUMBER
2666	

DATE MAILED: 12/15/2017

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
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6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 14/417,544	Applicant(s) KERPEZ ET AL.	
	Examiner SOLOMON BEZUAYEHU	Art Unit 2653	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *8/29/2017*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *1-39*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892)
2. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date See Continuation Sheet
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☒ Interview Summary (PTO-413), Paper No./Mail Date *12/6/2017* .
5. ☒ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/SOLOMON BEZUAYEHU/
Primary Examiner, Art Unit 2653

Continuation of Attachment(s) 2. Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date: 7/18/2017, 11/28/2017.

IPR2025-00451
Petitioners' Exhibit 1002
Page 472 of 511

DETAILED ACTION

Response to Arguments

1. Applicant's arguments filed on 8/29/2017 have been fully considered and are persuasive. The rejection of claim 1-20 has been withdrawn.

EXAMINER'S AMENDMENT

2. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in a telephone interview with Dai Xin on 12/6/2017.

The application has been amended as follows:

- Claim 40 is cancelled.

Allowable Subject Matter

3. Claims 1-39 are allowed.

4. Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance".

Conclusion

5. Any inquiry concerning this communication or earlier communications from the examiner should be directed to SOLOMON BEZUAYEHU whose telephone number is (571)270-7452. The examiner can normally be reached on Monday through Friday 9 a.m-4 p.m.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, FAN TSANG can be reached on 571-272-7547. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/SOLOMON BEZUAYEHU/

Examiner, Art Unit 2653

Examiner-Initiated Interview Summary	Application No.	Applicant(s)	
	14/417,544	KERPEZ ET AL.	
	Examiner	Art Unit	
	SOLOMON BEZUAYEHU	2653	

All participants (applicant, applicant's representative, PTO personnel):

(1) *SOLOMON BEZUAYEHU*. (3)_____.

(2) *Dai Xin*. (4)_____.

Date of Interview: *06 December 2017*.

Type: ☒ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☒ No.
If Yes, brief description: _____.

Issues Discussed ☐101 ☐112 ☐102 ☐103 ☒Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: *40*.

Identification of prior art discussed: *N/A*.

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

Applicant representative agreed to cancel claim 40 in order to place the application in good condition for allowance .

Applicant recordation instructions: It is not necessary for applicant to provide a separate record of the substance of interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/SOLOMON BEZUAYEHU/ Primary Examiner, Art Unit 2653	

IPR2025-00451
Petitioners' Exhibit 1002
Page 475 of 511

Notice of References Cited	Application/Control No. 14/417,544	Applicant(s)/Patent Under Reexamination KERPEZ ET AL.	
	Examiner SOLOMON BEZUAYEHU	Art Unit 2653	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-6,819,716 B1	11-2004	Purkovic; Aleksander	H04L25/03012	348/E5.084
	B	US-				
	C	US-				
	D	US-				
	E	US-				
	F	US-				
	G	US-				
	H	US-				
	I	US-				
	J	US-				
	K	US-				
	L	US-				
	M	US-				

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	14417544
Filing Date	2012-07-27
First Named Inventor	Kenneth Kerpez
Art Unit	2653
Examiner Name	Solomon G. Bezuayehu
Attorney Docket Number	20145-074US

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20040165547	A1	2004-08-26	Luis Lopes	

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							

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NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /S.G.B/

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Art Unit	2653
Examiner Name	Solomon G. Bezuayehu
Attorney Docket Number	20145-074US

	1	Office Action dated 2017-09-26, in Chinese Patent Application No. 201280075697.8.	X

If you wish to add additional non-patent literature document citation information please click the Add button [Add]

EXAMINER SIGNATURE

Examiner Signature	/SOLOMON G BEZUAYEHU/	Date Considered	12/06/2017

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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Examiner Name	Solomon G. Bezuayehu
Attorney Docket Number	20145-074US

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Michael North/	Date (YYYY-MM-DD)	2017-11-28
Name/Print	Michael North	Registration Number	46963

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
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First Named Inventor	Kenneth Kerpezt et al.
Art Unit	2653
Examiner Name	BEZUAYEHU, SOLOMON G
Attorney Docket Number	20145-074US

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6480475	B1	2002-11-12	Cory S. Modlin et al.	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20030086362	A1	2003-05-08	Kazutomo Hasegawa, et al.	
	2	20150215000	A1	2015-07-30	Santiago Vicent Colonques, et al.	
	3	20040076174	A1	2004-04-22	David Baum, et al.	

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	2254807	CA	C	2000-05-30	Bingham, et al.		

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Attorney Docket Number	20145-074US

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NON-PATENT LITERATURE DOCUMENTS [Remove]

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	Office Action dated October 11, 2016, in Chinese Patent Application No. 201280075697.8 (22 pgs).	
	2	Notice of Allowance dated July 1, 2017, in Korean Patent Application No. 10-2017-7009038 (3 pgs).	
	3	Notice of Final Rejection dated November 8, 2016, in Korean Patent Application No. 10-2015-7004853 (6 pgs).	X

If you wish to add additional non-patent literature document citation information please click the Add button [Add]

EXAMINER SIGNATURE

Examiner Signature	/SOLOMON G BEZUAYEHU/	Date Considered	12/06/2017

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

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Signature	/Michael North/	Date (YYYY-MM-DD)	2017-07-18
Name/Print	Michael North	Registration Number	46963

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /S.G.B/

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /S.G.B/

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14417544	KERPEZ ET AL.
	Examiner	**Art Unit**
	SOLOMON BEZUAYEHU	2653

CPC								
Symbol							**Type**	**Version**
H04J		3	/	10			F	2013-01-01
H04M		11	/	062			I	2013-01-01
H04B		3	/	32			I	2013-01-01
H04B		3	/	487			A	2015-01-15
H04L		5	/	14			I	2013-01-01
			/					
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CPC Combination Sets								
Symbol							**Type**	**Set**	**Ranking**	**Version**
			/							
			/							

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	39	
/S.B./ Primary Examiner.Art Unit 2653	12/06/2017	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14417544	KERPEZ ET AL.
	Examiner	**Art Unit**
	SOLOMON BEZUAYEHU	2653

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION									
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED				
379	406.01	H	0	4	M	9 / 08 (2006.01.01)	H	0	4	M	1 / 64 (2006.01.01)
CROSS REFERENCE(S)											
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)										
379	88.01										

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 39	
/S.B./ Primary Examiner.Art Unit 2653 (Primary Examiner)	12/06/2017 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14417544	KERPEZ ET AL.
	Examiner	**Art Unit**
	SOLOMON BEZUAYEHU	2653

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	17	17	33	33										
2	2	18	18	34	34										
3	3	19	19	35	35										
4	4	20	20	36	36										
5	5	21	21	37	37										
6	6	22	22	38	38										
7	7	23	23	39	39										
8	8	24	24												
9	9	25	25												
10	10	26	26												
11	11	27	27												
12	12	28	28												
13	13	29	29												
14	14	30	30												
15	15	31	31												
16	16	32	32												

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	39	
/S.B./ Primary Examiner.Art Unit 2653	12/06/2017	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14417544	KERPEZ ET AL.
	Examiner	Art Unit
	SOLOMON BEZUAYEHU	2653

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/07/2016	05/25/2017	12/06/2017						
	1	✓	✓	=						
	2	✓	✓	=						
	3	✓	✓	=						
	4	✓	✓	=						
	5	✓	✓	=						
	6	✓	✓	=						
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	34	✓	✓	=						
	35	✓	✓	=						
	36	✓	✓	=						

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Petitioners' Exhibit 1002
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Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14417544	KERPEZ ET AL.
	Examiner	**Art Unit**
	SOLOMON BEZUAYEHU	2653

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/07/2016	05/25/2017	12/06/2017						
	37	✓	✓	=						
	38	✓	✓	=						
	39	✓	✓	=						
	40	N	N	-						

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	498	(upstream$3 same down$stream$3) same (first line) same (second line)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2017/12/06 22:05
L2	12	L1 and cross$talk	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2017/12/06 22:05
L10	227	(cross$talk same ((first and second) line))	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2017/12/06 22:14
L11	182	10 and (time or time$line)	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2017/12/06 22:27
L12	77	11 and (simultan$5 or ("same" time))	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2017/12/06 22:27
L13	56	12 and (@ad<"20120727" or @rlad<"20120727" or @ptad<"20120727")	US-PGPUB; USPAT; EPO; JPO	ADJ	ON	2017/12/06 22:27

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L3	99	((upstream$3 same down$stream$3) same (first line) same (second line)).clm.	USPAT	ADJ	ON	2017/12/06 22:07
L4	7	3 same (time).clm.	USPAT	ADJ	ON	2017/12/06 22:08
L5	1	((uplink$3 same down$link$3) same (first line) same (second line)).clm.	USPAT	ADJ	ON	2017/12/06 22:09
L7	46	(cross$talk same ((first and second) line)).clm.	USPAT	ADJ	ON	2017/12/06 22:10
L8	39	7 and time	USPAT	ADJ	ON	2017/12/06 22:13
L9	17	7 and (time).clm.	USPAT	ADJ	ON	2017/12/06 22:13

12/6/2017 10:28:03 PM
C:\Users\sbezuayehu\Documents\EAST\Workspaces\14417544.wsp

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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14417544	KERPEZ ET AL.
	Examiner	Art Unit
	SOLOMON BEZUAYEHU	2653

CPC- SEARCHED		
Symbol	Date	Examiner
(H04L49/10 OR H04L5/14 OR H04N21/2408 OR H04N21/61 OR H04W72/0406).CPC.	5/25/2017	bezuayehu

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
379	88.01-88.19 , 406.01	5/25/2017	bezuayehu
370	351-365	5/25/2017	bezuayehu

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

SEARCH NOTES		
Search Notes	Date	Examiner
PGPUB;EPO;JPO;USPAT	5/25/2017	bezuayehu

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
379	88.01-88.19	12/6/2017	sb

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United States Patent and Trademark Office
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www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/417,544	01/26/2015	Kenneth Kerpez	20145-074US	8970

146571 7590 01/29/2018
North Weber & Baugh LLP - ASSIA
3260 Hillview Avenue, 1st Floor
Palo Alto, CA 94304

EXAMINER
BEZUAYEHU, SOLOMON G

ART UNIT	PAPER NUMBER
2666	

NOTIFICATION DATE	DELIVERY MODE
01/29/2018	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

docket1@northweber.com

Examiner-Initiated Interview Summary	Application No.	Applicant(s)	
	14/417,544	KERPEZ ET AL.	
	Examiner	Art Unit	
	SOLOMON BEZUAYEHU	2666	

All participants (applicant, applicant's representative, PTO personnel):

(1) *SOLOMON BEZUAYEHU*. (3)_____.

(2) *Xin Dai*. (4)_____.

Date of Interview: *24 January 2018*.

Type: ☒ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☒ No.
If Yes, brief description: _____.

Issues Discussed ☒101 ☐112 ☐102 ☐103 ☐Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: *34*.

Identification of prior art discussed: *N/A*.

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

Applicant representative agreed to add "non-transitory" in claim 34 in order to overcome 101 issue .

Applicant recordation instructions: It is not necessary for applicant to provide a separate record of the substance of interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/SOLOMON BEZUAYEHU/ Primary Examiner, Art Unit 2666	

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Petitioners' Exhibit 1002
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Corrected Notice of Allowability	Application No. 14/417,544	Applicant(s) KERPEZ ET AL.	
	Examiner SOLOMON BEZUAYEHU	Art Unit 2666	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *8/29/2017*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *1-39*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892)
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☒ Interview Summary (PTO-413), Paper No./Mail Date *1/24/2018* .
5. ☒ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/SOLOMON BEZUAYEHU/
Primary Examiner, Art Unit 2666

DETAILED ACTION

Response to Arguments

1. Applicant's arguments filed on 8/29/2017 have been fully considered and are persuasive. The rejection of claim 1-20 has been withdrawn.

EXAMINER'S AMENDMENT

2. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in a telephone interview with Dai Xin on 1/24/2018.

The application has been amended as follows:

- Claim 40 is cancelled.
- Claim 34, in line 1, add "non-transitory" before "machine-readable"

Allowable Subject Matter

3. Claims 1-39 are allowed.

4. Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance".

Conclusion

5. Any inquiry concerning this communication or earlier communications from the examiner should be directed to SOLOMON BEZUAYEHU whose telephone number is (571)270-7452. The examiner can normally be reached on Monday through Friday 9 a.m-4 p.m.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, FAN TSANG can be reached on 571-272-7547. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/SOLOMON BEZUAYEHU/

Examiner, Art Unit 2653

Examiner-Initiated Interview Summary	Application No.	Applicant(s)	
	14/417,544	KERPEZ ET AL.	
	Examiner	Art Unit	
	SOLOMON BEZUAYEHU	2666	

All participants (applicant, applicant's representative, PTO personnel):

(1) *SOLOMON BEZUAYEHU*. (3)_____.

(2) *Xin Dai*. (4)_____.

Date of Interview: *24 January 2018*.

Type: ☒ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☒ No.
If Yes, brief description: _____.

Issues Discussed ☒101 ☐112 ☐102 ☐103 ☐Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

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Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

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☐ Attachment

/SOLOMON BEZUAYEHU/ Primary Examiner, Art Unit 2666	

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Notice of References Cited	Application/Control No. 14/417,544	Applicant(s)/Patent Under Reexamination KERPEZ ET AL.	
	Examiner SOLOMON BEZUAYEHU	Art Unit 2666	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-6,819,716 B1	11-2004	Purkovic; Aleksander	H04L25/03012	348/E5.084
	B	US-				
	C	US-				
	D	US-				
	E	US-				
	F	US-				
	G	US-				
	H	US-				
	I	US-				
	J	US-				
	K	US-				
	L	US-				
	M	US-				

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14417544	KERPEZ ET AL.
	Examiner	Art Unit
	SOLOMON BEZUAYEHU	2653

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
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	1	✓	✓	=						
	2	✓	✓	=						
	3	✓	✓	=						
	4	✓	✓	=						
	5	✓	✓	=						
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	34	✓	✓	=						
	35	✓	✓	=						
	36	✓	✓	=						

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CLAIM		DATE								
Final	Original	12/07/2016	05/25/2017	01/24/2018						
	37	✓	✓	=						
	38	✓	✓	=						
	39	✓	✓	=						
	40	N	N	-						

IPR2025-00451
Petitioners' Exhibit 1002
Page 501 of 511

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	Examiner	**Art Unit**
	SOLOMON BEZUAYEHU	2653

CPC						
Symbol					**Type**	**Version**
H04J		3	/	10	F	2013-01-01
H04M		11	/	062	I	2013-01-01
H04B		3	/	32	I	2013-01-01
H04B		3	/	487	A	2015-01-15
H04L		5	/	14	I	2013-01-01
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CPC Combination Sets							
Symbol					**Type**	**Set**	**Ranking**	**Version**
			/					
			/					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	39	
/SOLOMON BEZUAYEHU/ Primary Examiner.Art Unit 2666	01/24/2018	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14417544	KERPEZ ET AL.
	Examiner	**Art Unit**
	SOLOMON BEZUAYEHU	2653

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION									
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED				
379	406.01	H	0	4	M	9 / 08 (2006.0)	H	0	4	M	1 / 64 (2006.0)

CROSS REFERENCE(S)					
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
379	88.01				

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	39	
/SOLOMON BEZUAYEHU/ Primary Examiner.Art Unit 2666	01/24/2018	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14417544	KERPEZ ET AL.
	Examiner	**Art Unit**
	SOLOMON BEZUAYEHU	2653

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	17	17	33	33										
2	2	18	18	34	34										
3	3	19	19	35	35										
4	4	20	20	36	36										
5	5	21	21	37	37										
6	6	22	22	38	38										
7	7	23	23	39	39										
8	8	24	24												
9	9	25	25												
10	10	26	26												
11	11	27	27												
12	12	28	28												
13	13	29	29												
14	14	30	30												
15	15	31	31												
16	16	32	32												

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 39	
/SOLOMON BEZUAYEHU/ Primary Examiner.Art Unit 2666 (Primary Examiner)	01/24/2018 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14417544	KERPEZ ET AL.
	Examiner	Art Unit
	SOLOMON BEZUAYEHU	2653

CPC- SEARCHED		
Symbol	Date	Examiner
(H04L49/10 OR H04L5/14 OR H04N21/2408 OR H04N21/61 OR H04W72/0406).CPC.	5/25/2017	bezuayehu

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
379	88.01-88.19 , 406.01	5/25/2017	bezuayehu
370	351-365	5/25/2017	bezuayehu

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

SEARCH NOTES		
Search Notes	Date	Examiner
PGPUB;EPO;JPO;USPAT	5/25/2017	bezuayehu

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
379	88.01-88.19	12/6/2017	sb

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

146571 7590 12/15/2017
North Weber & Baugh LLP - ASSIA
3260 Hillview Avenue, 1st Floor
Palo Alto, CA 94304

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/417,544	01/26/2015	Kenneth Kerpez	20145-074US	8970

TITLE OF INVENTION: MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	03/15/2018

EXAMINER	ART UNIT	CLASS-SUBCLASS
BEZUAYEHU, SOLOMON G	2666	379-406010

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 North Weber & Baugh LLP
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
- ☒ Issue Fee
- ☐ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ☐ A check is enclosed.
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- ☒ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number 50-2776 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ☐ Applicant certifying micro entity status. See 37 CFR 1.29
  NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
- ☐ Applicant asserting small entity status. See 37 CFR 1.27
  NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
- ☐ Applicant changing to regular undiscounted fee status.
  NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date 3/9/18

Typed or printed name Michael V. North Registration No. 46963

IPR2025-00451
Petitioners' Exhibit 1002
Page 506 of 511

Electronic Patent Application Fee Transmittal

Application Number:	14417544
Filing Date:	26-Jan-2015
Title of Invention:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
First Named Inventor/Applicant Name:	Kenneth Kerpez
Filer:	Michael V. North/Nita Miller
Attorney Docket Number:	20145-074US

Filed as Large Entity

Filing Fees for U.S. National Stage under 35 USC 371

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
UTILITY APPL ISSUE FEE	1501	1	960	960

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**960**

Electronic Acknowledgement Receipt

EFS ID:	32014579
Application Number:	14417544
International Application Number:	
Confirmation Number:	8970
Title of Invention:	MANAGEMENT SYSTEM AND METHODS OF MANAGING TIME-DIVISION DUPLEX (TDD) TRANSMISSION OVER COPPER
First Named Inventor/Applicant Name:	Kenneth Kerpez
Customer Number:	146571
Filer:	Michael V. North/Nita Miller
Filer Authorized By:	Michael V. North
Attorney Docket Number:	20145-074US
Receipt Date:	09-MAR-2018
Filing Date:	26-JAN-2015
Time Stamp:	18:46:39
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$960
RAM confirmation Number	031218INTEFSW18472900
Deposit Account	502776
Authorized User	Nita Miller

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

37 CFR 1.492 (National application filing, search, and examination fees)

37 CFR 1.492(a) (Basic national fee only)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	074US_PTOL85.pdf	665824 3b837cf05eabea9fb34d3294c07d611c41a454a8	no	1
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30701 536af34de2482c0c2d271669919fc3e9e8f67b41	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	696525		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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United States Patent and Trademark Office
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www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/417,544	04/24/2018	9954631	20145-074US	8970

146571 7590 04/04/2018

North Weber & Baugh LLP - ASSIA
3260 Hillview Avenue, 1st Floor
Palo Alto, CA 94304

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 167 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Kenneth Kerpez, Longvalley, NJ;
Adaptive Spectrum and Signal Alignment, Inc., Redwood City, CA;
George Ginis, San Mateo, CA;
Marc Goldburg, Redwood City, CA;
Ardavan Maleki Tehrani, Stanford, CA;

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