

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS CO., LTD. AND SAMSUNG ELECTRONICS
AMERICA, INC.,
Petitioner,

v.

GENGHISCOMM HOLDINGS LLC,
Patent Owner

Case: IPR2025-00899
U.S. Patent No. 11,431,386

**PETITION FOR *INTER PARTES* REVIEW OF CLAIMS 1-3, 5-8, 10-12,
14-17, 19-21, AND 23-26 OF U.S. PATENT NO. 11,431,386**

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United States Patent and Trademark Office
PO Box 1450
Alexandria, Virginia 22313-1450
Submitted Electronically via P-TACTS

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LISTING OF CLAIMS

Claim 1. [1Pre] A method for receiving an Orthogonal Frequency Division Multiplexing (OFDM) signal transmitted by a user device in a wireless network, the method comprising:

[1A] determining a plurality of subcarrier frequencies allocated to the user device;

[1B] converting the OFDM signal to a plurality of frequency-domain values corresponding to the plurality of subcarrier frequencies; and

[1C] decoding the plurality of frequency-domain values to recover a plurality of data symbols encoded by the user device on the plurality of subcarrier frequencies;

[1D] wherein decoding employs a plurality of codes that are inverse to, complex-conjugate of, or complementary to a set of complex-valued codes that the user device employs to shape the OFDM signal into a superposition of cyclic-shifted pulse waveforms that each has one of the plurality of data symbols modulated thereon.

Claim 2. The method of claim 1, wherein each of the plurality of codes employed for decoding comprises a different vector of linear phase offsets.

Claim 3. The method of claim 1, wherein the cyclic-shifted waveforms have cyclic shifts that cause the cyclic-shifted waveforms to be orthogonal, and each of

the plurality of codes employed for decoding comprises a set of linear phase offsets that corresponds to one of the cyclic shifts.

Claim 5. The method of claim 1, wherein the plurality of subcarrier frequencies has a frequency spacing f_s , and the plurality of cyclic-shifted waveforms are periodic over a symbol interval $T_s=1/f_s$.

Claim 6. The method of claim 1, wherein converting the OFDM signal to a plurality of frequency-domain values uses a discrete Fourier transform.

Claim 7. The method of claim 1, further comprising removing at least one of a guard interval, a cyclic prefix, and a cyclic postfix from the OFDM signal before converting the OFDM signal to the plurality of frequency-domain values.

Claim 8. The method of claim 1, wherein converting the OFDM signal to the plurality of frequency-domain values provides for orthogonal frequency division multiple access for the user device and at least one other user device.

Claim 10. [10Pre] An apparatus for receiving an Orthogonal Frequency Division Multiplexing (OFDM) signal transmitted by a user device in a wireless network, the apparatus comprising:

[10A] at least one processor; and

[10B] a non-transitory computer-readable memory communicatively coupled to the at least one processor, the non-transitory computer-readable memory

including a set of instructions stored thereon and executable by the at least one processor for:

[10Ci] determining a plurality of subcarrier frequencies allocated to the user device;

[10Cii] converting the OFDM signal to a plurality of frequency-domain values corresponding to the plurality of subcarrier frequencies; and

[10Ciii] decoding the plurality of frequency-domain values to recover a plurality of data symbols encoded by the user device on the plurality of subcarrier frequencies;

[10Civ] wherein decoding employs a plurality of codes that are inverse to, complex-conjugate of, or complementary to a set of complex-valued codes that the user device employs to shape the OFDM signal into a superposition of cyclic-shifted pulse waveforms that each has one of the plurality of data symbols modulated thereon.

Claim 11. The apparatus of claim 10, wherein each of the plurality of codes employed for decoding comprises a different vector of linear phase offsets.

Claim 12. The apparatus of claim 10, wherein the cyclic-shifted waveforms have cyclic shifts that cause the cyclic-shifted waveforms to be orthogonal, and each of the plurality of codes employed for decoding comprises a set of linear phase offsets that corresponds to one of the cyclic shifts.

Claim 14. The apparatus of claim 10, wherein the plurality of subcarrier frequencies has a frequency spacing f_s , and the plurality of cyclic-shifted waveforms are periodic over a symbol interval $T_s=1/f_s$.

Claim 15. The apparatus of claim 10, wherein converting the OFDM signal to a plurality of frequency-domain values uses a discrete Fourier transform.

Claim 16. The apparatus of claim 10, wherein the non-transitory computer-readable memory further includes instructions stored thereon and executable by the at least one processor for removing at least one of a guard interval, a cyclic prefix, and a cyclic postfix from the OFDM signal before converting the OFDM signal to the plurality of frequency-domain values.

Claim 17. The apparatus of claim 10, wherein converting the OFDM signal to the plurality of frequency-domain values provides for orthogonal frequency division multiple access for the user device and at least one other user device.

Claim 19. [19Pre] A computer program product for receiving an Orthogonal Frequency Division Multiplexing (OFDM) signal transmitted by a user device in a wireless network, the computer program product comprising a non-transitory computer readable storage device having computer readable program code stored therein, said program code containing instructions executable by one or more processors of a computer system for:

[19A] determining a plurality of subcarrier frequencies allocated to the user

device;

[19B] converting the OFDM signal to a plurality of frequency-domain values corresponding to the plurality of subcarrier frequencies; and

[19C] decoding the plurality of frequency-domain values to recover a plurality of data symbols encoded by the user device on the plurality of subcarrier frequencies;

[19D] wherein decoding employs a plurality of codes that are inverse to, complex-conjugate of, or complementary to a set of complex-valued codes that the user device employs to shape the OFDM signal into a superposition of cyclic-shifted pulse waveforms that each has one of the plurality of data symbols modulated thereon.

Claim 20. The computer program product of claim 19, wherein each of the plurality of codes employed for decoding comprises a different vector of linear phase offsets.

Claim 21. The computer program product of claim 19, wherein the cyclic-shifted waveforms have cyclic shifts that cause the cyclic-shifted waveforms to be orthogonal, and each of the plurality of codes employed for decoding comprises a set of linear phase offsets that corresponds to one of the cyclic shifts.

Claim 23. The computer program product of claim 19, wherein the plurality of subcarrier frequencies has a frequency spacing f_s , and the plurality of cyclic-

shifted waveforms are periodic over a symbol interval $T_s=1/f_s$.

Claim 24. The computer program product of claim 19, wherein converting the OFDM signal to a plurality of frequency-domain values uses a discrete Fourier transform.

Claim 25. The computer program product of claim 19, wherein the non-transitory computer-readable storage device further includes instructions stored therein and executable by the one or more processors for removing at least one of a guard interval, a cyclic prefix, and a cyclic postfix from the OFDM signal before converting the OFDM signal to the plurality of frequency-domain values.

Claim 26. The computer program product of claim 19, wherein converting the OFDM signal to the plurality of frequency-domain values provides for orthogonal frequency division multiple access for the user device and at least one other user device.

PETITIONER’S EXHIBIT LIST

Exhibit No.	Description
1001	U.S. Patent No. 11,431,386 (“’386 Patent” or “Challenged Patent”)
1002	Declaration of Harry Bims, Ph.D.
1003	RESERVED
1004	Dirk Galda & Hermann Rohling, <i>A Low Complexity Transmitter Structure for OFDM-FDMA Uplink Systems</i> , Vehicular Technology Conference. IEEE 55 th Vehicular Technology Conference, vol. 4, pp.1737-1741 (May 6, 2002) (“Galda”).
1005	RESERVED
1006	RESERVED
1007	Andres Bury & Jurgen Linder, <i>Comparison of Amplitude Distributions for Hadamard Spreading and Fourier Spreading in Multi-Carrier Code Division Multiplexing</i> , Globecom ’00-IEEE. Global Telecommunications Conference, Vol. 2, pp.857-860 (Nov. 27, 2000) (“Bury”)
1008	Kwang-Cheng Chen, et al., <i>A Programmable Architecture for OFDM-CDMA</i> , IEEE Communications Magazine, pp.76-82 (Nov. 1999) (“Chen”)
1009	RESERVED
1010	RESERVED
1011	U.S. Patent Application Publication No. 2003/0081538 to Walton et al.
1012	Declaration of Sylvia Hall-Ellis, Ph.D.
1013	Hermann Rohling, et al., <i>Broad-Band OFDM Radio Transmission for Multimedia Applications</i> , Proceedings of the IEEE, Vol. 87, No. 10, Oct. 1999 (“Rohling”)
1014	Stephen B. Weinstein, <i>The History of Orthogonal Frequency-</i>

Exhibit No.	Description
	<i>Division Multiplexing</i> , IEEE Communications Magazine, pp.26-35 (Nov. 2009).
1015	Richard van Nee & Ramjee Prasad, <i>OFDM for Wireless Multimedia Communications</i> (Artech House 2000).
1016	Karsten Brünighaus & Herman Rohling, <i>Multi-carrier spread spectrum and its relationship to single-carrier transmission</i> , Vehicular Technology Conference. IEEE 48 th Vehicular Technology Conference, vol. 3, pp.2329-2332 (May 18-21, 1998) (“Brünighaus”).
1017	RESERVED
1018	RESERVED
1019	RESERVED
1020	RESERVED
1021	File History of U.S. Patent Application No. 11/187,107 as obtained from Patent Center (excerpts).
1022	RESERVED
1023	RESERVED
1024	RESERVED
1025	RESERVED
1026	RESERVED
1027	RESERVED
1028	RESERVED
1029	RESERVED
1030	File History of U.S. Patent Application No. 14/727,769 as obtained from Patent Center (excerpts)
1031	File History of U.S. Patent Application No. 14/276,309 as obtained from Patent Center (excerpts)

Exhibit No.	Description
1032	File History of U.S. Patent Application No. 12/545,572 as obtained from Patent Center (excerpts)
1033	RESERVED
1034	RESERVED
1035	RESERVED
1036	RESERVED
1037	RESERVED
1038	RESERVED
1039	RESERVED
1040	RESERVED
1041	RESERVED
1042	U.S. Patent No. 6,597,745 to Dowling
1043	RESERVED
1044	RESERVED
1045	RESERVED
1046	RESERVED
1047	RESERVED
1048	RESERVED
1049	RESERVED
1050	RESERVED
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1052	RESERVED
1053	RESERVED
1054	RESERVED

Exhibit No.	Description
1055	RESERVED
1056	RESERVED
1057	RESERVED
1058	RESERVED
1059	Declaration of Gary Swatzell including Exhibits A-D
1060	RESERVED
1061	RESERVED
1062	RESERVED
1063	RESERVED
1064	RESERVED
1065	RESERVED
1066	RESERVED
1067	RESERVED
1068	RESERVED
1069	RESERVED
1070	RESERVED
1071	RESERVED
1072	RESERVED
1073	A. Gusmão, et al., <i>Comparison of Two Modulation Choices for Broadband Wireless Communications</i> , VTC2000-Spring. 2000 IEEE 51 st Vehicular Technology Conference Proceedings, Vol. 2, pp.1300-1305 (May 15, 2000).
1074	RESERVED
1075	U.S. Patent No. 11,700,162 to Shattil
1076	RESERVED

Exhibit No.	Description
1077	U.S. Patent No. 7,436,896
1078	RESERVED
1079	RESERVED
1080	RESERVED
1081	File History of U.S. Patent Application No. 16/940,383 as obtained from Patent Center.
1082	RESERVED
1083	RESERVED
1084	RESERVED
1085	RESERVED
1086	RESERVED
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1088	RESERVED
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1090	RESERVED
1091	RESERVED
1092	RESERVED
1093	RESERVED
1094	RESERVED
1095	RESERVED
1096	RESERVED
1097	RESERVED
1098	RESERVED
1099	International Application Publication No. WO 02/054537 to Shattil (“Shattil-537”).

Exhibit No.	Description
1100	Request for Certificate of Correction from U.S. Patent No. 10,673,758 (withdrawn after issuance)
1101	Request for Certificate of Correction from U.S. Patent No. 10,389,568
1102	Request for Certificate of Correction from U.S. Patent No. 10,778,492
1103	Request for Certificate of Correction for U.S. Patent No. 11,025,468
1104	RESERVED
1105	RESERVED
1106	RESERVED
1107	File History of U.S. Patent Application No. 17/015,576 as obtained from Patent Center (excerpts)
1108	Kjetil Jacobsen, <i>Ubiquitous Devices United: Enabling Distributed Computing Through Mobile Code</i> , 1999 ACM Symposium on Applied computing, pp.399-404 (Feb. 1999)
1109	Wolfram MathWorld, “Complex Conjugate” (Apr. 18, 2025)
1110	Michael D. Alder, <i>An Introduction to Complex Analysis for Engineers</i> (Jun. 3, 1997).

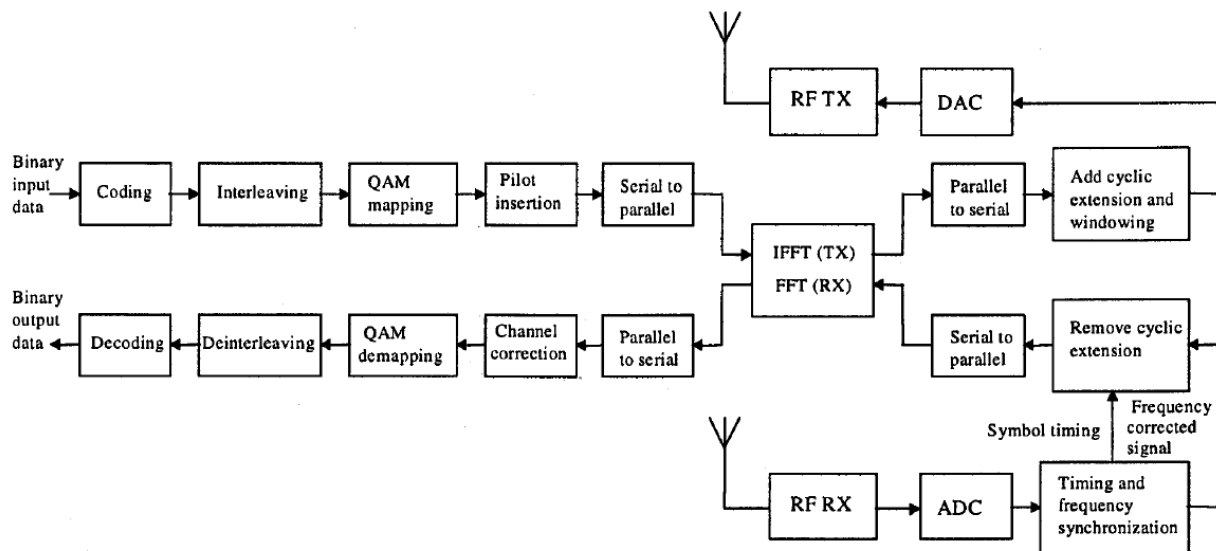
I. GROUNDS FOR STANDING

Petitioner has standing to bring this challenge because neither it nor any privy or real party-in-interest was served with a Complaint more than one year before the filing of this Petition and it is not estopped from bringing this challenge.

II. TECHNICAL OVERVIEW

The Challenged Patent relates to processes for use in orthogonal frequency division multiplexing (“OFDM”) wireless communications. OFDM has been studied for more than 50 years. EX1014, pp.26-28; EX1015, pp.20-24.

A textbook example of an OFDM transceiver is shown below.



EX1015, p.48. An OFDM signal is formed at the transmitter using an inverse Fourier transform, typically implemented using an inverse fast Fourier transform (“IFFT”).
Id., pp.42, 47-48. A guard interval including a cyclic prefix is added to minimize

intersymbol interference (“ISI”) and intercarrier interference (“ICI”). *Id.*, pp.39-40. At the receiver, “[a]n FFT is used to demodulate all subcarriers,” resulting in symbol values, which are ultimately mapped into binary values. *Id.*, p.48.

OFDM systems can exhibit high peak-to-average power ratios (“PAPR” or “PAR”). EX1013, p.1780; EX1014, pp.31-32. The Challenged Patent reduces PAPR in OFDM systems by spreading input data using complex-valued codes called “CI codes” or “orthogonal polyphase CI codes.” EX1001, 48:55-59, 49:3-8. Reducing PAPR in OFDM using complex-valued DFT spreading codes to generate a single carrier FDMA signal was not new. Various publications described using DFT spreading codes to reduce PAPR in OFDM systems before the earliest claimed effective filing date. For example, a 1998 article by Brüninghaus observes that when an “FFT matrix” is used “as a spreading matrix for OFDM-CDM” signals, this “leads to a single-carrier system with guard interval.” EX1016, p.2332. A 2000 article by Bury explains that “Fourier spreading” can be “implemented by a discrete Fourier transform (DFT) operation” and the resulting transmission can have a “much lower” PAPR. EX1007, p.857. A 2002 article by Galda “shows how an OFDM-FDMA uplink system can be combined with a user data spreading technique based on the DFT spreading matrix to reduce the PAR of the uplink signal without increasing the computational complexity of the transmitter.” EX1004, p.1738.

III. THE '386 PATENT

A. Overview of the Challenged Patent

The '386 Patent states that certain aspects of the disclosure relate to “a multicarrier protocol that controls interference relationships between” carriers allowing for “time domain signal shaping” and “adaptability to single-carrier waveforms.” EX1001, 48:55-58. “Disclosed aspects include Carrier Interferometry (CI).” *Id.*, 48:58-59. CI includes applying polyphase codes to each subcarrier “to control the time-domain characteristics of the superposition signal, as well as provide orthogonality between data symbols and/or other users.” *Id.*, 48:61-64.

An objective of the invention is to “provide[] frequency-diversity benefits of multicarrier modulation to single-carrier systems and provides the low-PAPR benefits of single-carrier modulation to multi-carrier communications systems....” EX1001, 49:3-8. Multiple CI waveforms are illustrated in FIG. 22A, in which “equally spaced carriers $f_1, f_2, \dots f_N$ are combined to generate ... pulses 2201 to 2209,” and “carrier phases 2211, 2212, ..., 2219” are “orthogonal polyphase CI code[s],” that are applied to the carriers. EX1001, 56:17-20.

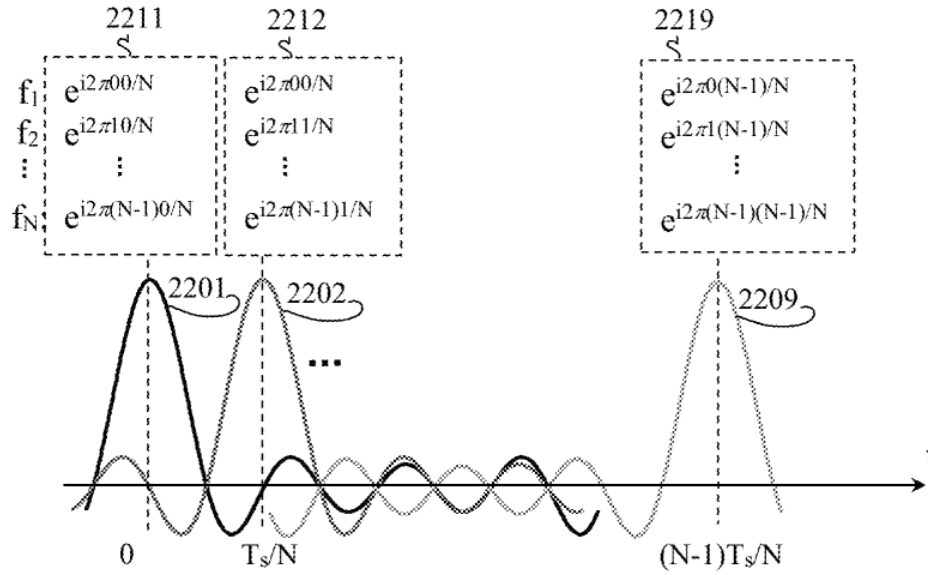


FIGURE 22A

EX1001, FIG. 22A. FIG. 29B similarly shows “CI subcarrier weights” (w_1 to w_N) generated from data symbols d_1 to d_N mapped to N orthogonal phase spaces where polyphase codes are provided by an $N \times N$ matrix. EX1001, 68:23-35.

	$d_1()$	$d_2()$	$d_3()$	$d_N()$
$w_1 = \Sigma():$	$e^{i2\pi(0)(0)/(N)}$	$e^{i2\pi(1)(0)/(N)}$	$e^{i2\pi(2)(0)/(N)}$	$e^{i2\pi(N-1)(0)/(N)}$
$w_2 = \Sigma():$	$e^{i2\pi(0)(1)/(N)}$	$e^{i2\pi(1)(1)/(N)}$	$e^{i2\pi(2)(1)/(N)}$	$e^{i2\pi(N-1)(1)/(N)}$
$w_3 = \Sigma():$	$e^{i2\pi(0)(2)/(N)}$	$e^{i2\pi(1)(2)/(N)}$	$e^{i2\pi(2)(2)/(N)}$	$e^{i2\pi(N-1)(2)/(N)}$
		$\vdots$		
$w_N = \Sigma():$	$e^{i2\pi(0)(N-1)/(N)}$	$e^{i2\pi(1)(N-1)/(N)}$	$e^{i2\pi(2)(N-1)/(N)}$	$e^{i2\pi(N-1)(N-1)/(N)}$

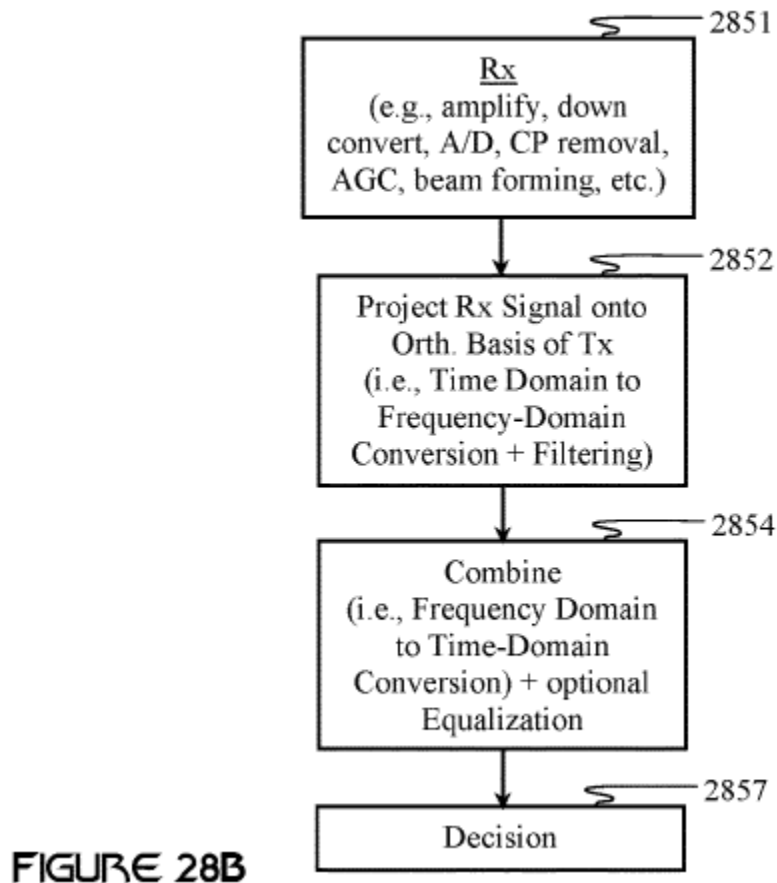
Figure 29B shows a matrix of CI subcarrier weights. The rows are labeled $w_1, w_2, w_3, \dots, w_N$ and the columns are labeled $d_1, d_2, d_3, \dots, d_N$. The elements are complex exponentials. A dashed box labeled 2951 encloses the first three columns. A dashed box labeled 2953 encloses the last column.

FIGURE 29B

EX1001, FIG. 29B. The rows and columns of the CI code matrix “resemble the

vectors of complex values used in DFTs.” *Id.*, 68:37-40.

A method of receiving is generally shown in FIG. 28B:



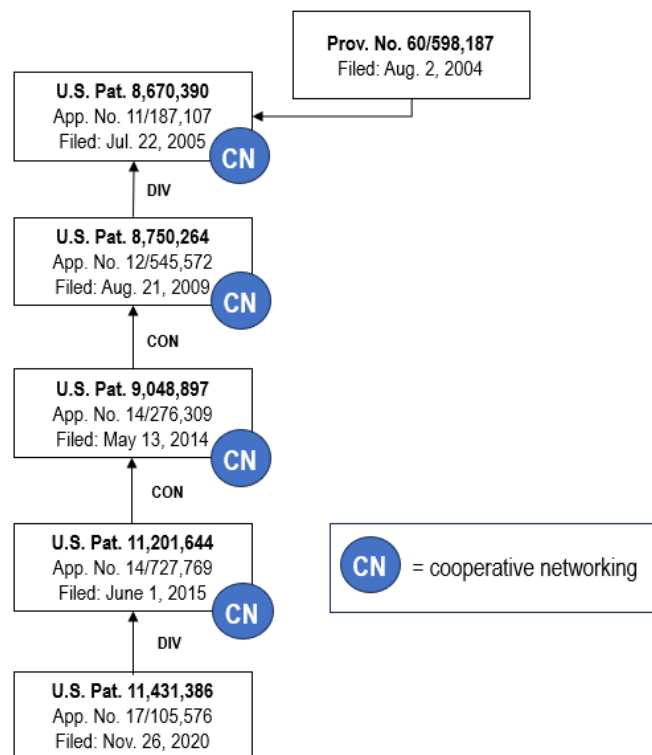
EX1001, FIG. 28B. This figure shows receiver processing, “time-domain to frequency-domain conversion,” “frequency-domain to time-domain conversion” and “equalization,” and a decision process, which includes “recovering symbols.”

EX1001, 67:27-48.

B. Prosecution History

The '386 Patent claims priority to four earlier-filed non-provisional applications and one provisional application. The '386 Patent purports to be a

“Divisional” of Application No. 14/727,769, but no restriction requirement was issued as to the subject matter recited in the ’386 Patent claims (the subject matter claimed in the ’386 Patent was not even described in the ’769 Application). The ’386 Patent family is outlined in the illustration below.



'386 Pat. Related U.S. Application Data

We omit a detailed discussion of the prosecution history of the applications identified with “CN” above because they pertain to materially different inventions from that of the ’386 Patent. They claim using multiple wireless terminals to cooperatively process or generate signals. *E.g.*, EX1021, p.76 (claiming

“cooperative beam-forming in the at least one group of wireless terminals”); EX1032, p.2 (claiming “a plurality of the mobile wireless terminals to perform cooperative subspace processing”).

1. Application No. 17/105,576 (Challenged Patent)

The application for the '386 Patent was filed on November 26, 2020. EX1001, cover. A preliminary amendment was filed shortly after the application was filed. EX1107, pp.175-294. In response to a second preliminary amendment, all claims were allowed. *Id.*, pp.6-9. In allowing the claims, the Examiner cited to U.S. Patent Application No. 2003/0161282 to Medvedev, et al. and U.S. Patent Application No. 2002/0193146 to Wallace et al. The Examiner stated that

The prior art alone or in combination with other references do not disclose or renders obvious claim limitation of a [sic] claim 1 including “determining a plurality of subcarrier frequencies allocated to the user device; converting the OFDM signal to a plurality of frequency-domain values corresponding to the plurality of subcarrier frequencies; and decoding the plurality of frequency-domain values to recover a plurality of data symbols encoded by the user device on the plurality of subcarrier frequencies; wherein decoding employs a plurality of codes that are inverse to, complex- conjugate of, or complementary to a set of complex-valued codes that the user device employed to shape the OFDM signal into a

superposition of cyclic-shifted pulse waveforms that each has one of the plurality of data symbols modulated thereon..[sic]”.

EX1107, pp.7-8.

None of the references raised in this Petition were applied in any rejection by the Office when it decided to issue the '386 Patent.

2. *U.S. Patent Application Nos. 14/727,769, 14/276,309, 12/545,572, 11/187,107*

These applications describe and claim aspects of cooperative networking involving multiple wireless terminals that cooperate in various ways to send and receive signals. They bear no material resemblance to the claims of the Challenged patent. EX1021, EX1030, EX1031, EX1032.

IV. EFFECTIVE FILING DATE; POST-AIA

The '386 Patent is not entitled to its claimed effective filing date of August 2, 2004. The '386 Patent is also not a pre-AIA patent. Petitioner has taken these positions in litigation. Nevertheless, for the challenges presented herein all references qualify as prior art under 35 U.S.C. §§102(b) or 102(a)(1), and as such they cannot be antedated. Thus, the correct effective filing date of the claimed subject matter is not material to the outcome of this proceeding and Petitioner does not elaborate further on the matter in this Petition while reserving its right to do so if necessary during trial.

V. IDENTIFICATION OF THE CHALLENGE

Petitioner challenges the following claims on the following grounds:

Ground	Claims	Challenge	Statute
1	1-3, 5-8, 10-12, 14-17, 19-21, 23-26	Anticipation by Shattil-537	Pre-AIA §102(b); Post-AIA §102(a)(1)
2	1-3, 5-8, 10-12, 14-17, 19-21, 23-26	Obviousness over Shattil-537	Post- or Pre-AIA §103
3	1, 6-8	Obviousness over Galda in view of Brüninghaus	Post- or Pre-AIA §103
4	10, 15-17, 19, 24-26	Obviousness over Galda in view of Brüninghaus and Dowling	Post- or Pre-AIA §103

VI. THE PERSON OF ORDINARY SKILL IN THE ART (“POSITA”)

Based on the '386 Patent, the prior art and other documentation cited herein, and on Dr. Bims's testimony a POSITA as of the earliest claimed effective filing date of August 2, 2004 would have had “either a Master's degree in electrical engineering or a related field, or a Bachelor's degree in electrical engineering or a related field with three years of experience in wireless communication systems, signal processing, and related technologies.” EX1002, ¶¶29-33, 62-65. A POSITA would have known that DFT spreading would reduce PAPR in OFDM systems and would have been familiar with hardware and software implementations of mobile device transmitters and base stations for receiving transmissions from mobile

terminals. *Id.* The level of skill possessed by a POSITA at a later filing date of, for example, November 26, 2020 would not have been materially different. EX1002, ¶65.

VII. CLAIM CONSTRUCTION

Petitioner submits that no formal claim constructions are necessary because “claim terms need only be construed to the extent necessary to resolve the controversy.” *Wellman, Inc. v. Eastman Chem. Co.*, 642 F.3d 1355, 1361 (Fed. Cir. 2011). Petitioner reserves the right to respond to any constructions offered by Patent Owner or adopted by the Board.

VIII. PRIOR ART STATUS OF THE REFERENCES; ANALOGOUS ART

Each reference relied upon in the challenges is analogous prior art. EX1002, ¶¶74-75, 79, 82, 85.

A. Shattil-537

Shattil-537 is an International Application Publication that was published on July 11, 2002. EX1099, cover. That makes it prior art under pre-AIA 35 U.S.C. §102(b) or post-AIA §102(a)(1).

Shattil-537 discloses a system and method for performing carrier interferometry using CI codes that “include families of orthogonal polyphase codes.” EX1099, Abstract; 1:6-8 (“The present invention relates to Carrier Interferometry

(CI). More specifically, the invention relates to applications of CI to multicarrier processing, such as Fourier transforms and coding.”). CI symbols can include codes derived from a Fourier transform. *Id.*, 24:15-20. Weights (also referred to as CI symbol values) can be applied to data symbols as shown in FIG. 22:¹

$$\begin{array}{c}
 \begin{array}{cccc}
 s_0 () & s_1 () & s_2 () & s_{N-1} ()
 \end{array} \\
 \begin{array}{l}
 w_1 = \Sigma () : \\
 w_2 = \Sigma () : \\
 w_3 = \Sigma () : \\
 \\
 w_N = \Sigma () :
 \end{array}
 \begin{array}{|c|c|c|c|}
 \hline
 e^{i2\pi(0)(0)/(N-1)} & e^{i2\pi(1)(0)/(N-1)} & e^{i2\pi(2)(0)/(N-1)} & e^{i2\pi(N-1)(0)/(N-1)} \\
 \hline
 e^{i2\pi(0)(1)/(N-1)} & e^{i2\pi(1)(1)/(N-1)} & e^{i2\pi(2)(1)/(N-1)} & e^{i2\pi(N-1)(1)/(N-1)} \\
 \hline
 e^{i2\pi(0)(2)/(N-1)} & e^{i2\pi(1)(2)/(N-1)} & e^{i2\pi(2)(2)/(N-1)} & e^{i2\pi(N-1)(2)/(N-1)} \\
 \hline
 e^{i2\pi(0)(N-1)/(N-1)} & e^{i2\pi(1)(N-1)/(N-1)} & e^{i2\pi(2)(N-1)/(N-1)} & e^{i2\pi(N-1)(N-1)/(N-1)} \\
 \hline
 \end{array}
 \end{array}$$

2201

2203

¹ This figure, which was present in at least some of the patents and applications that are related to the Challenged Patent, has an error in the denominator of the exponent term. Namely, “N-1” should be “N.” This was corrected in various issued patents, including several patents that could be considered cousins of the ’386 Patent, by certificate of correction. EX 1102, p.14; EX1100, p.7; EX1101, p.12; EX1103, p.3. Given Patent Owner’s representation that the changes are typographical and do not add new matter, this Figure should be interpreted as illustrating DFT coefficients (i.e., denominator “N” instead of “N-1”).

EX1099, FIG. 22.

Shattil-537 also describes applying various “CI Parameters” including “Carrier Selection,” and “Carrier Spacing” to the CI transceiver to adapt the operation of the transceiver. *Id.*, 19:20-24, 20:8-9. Shattil-537 speaks to the reasons for allowance as well by not only describing adjustable “Carrier Spacing,” but also explaining that carrier spacing relates to symbol duration. EX1099, 8:20, 10:8-10; *see also id.*, 8:12-14 (“A process for separating a received signal into orthogonal waveforms may utilize knowledge of carrier separations f_s (and, thus, $T_s = 1/f_s$) of a transmitted multicarrier signal.”), 11:15 (“the sampling period is $T_s = 1/f_s$.”), 14:29-30 (“In this case, the selector/accumulator 1004 may control symbol duration T_s (i.e., carrier separation f_s)”), cls. 1 (“ $T_s = 1/f_s$ ”), 9 (“ $T_s = 1/f_s$ ”), FIG. 14.

Shattil-537 discloses transceivers and receivers that can receive and process CI signals. One example of a CI transceiver is shown in FIG. 24:

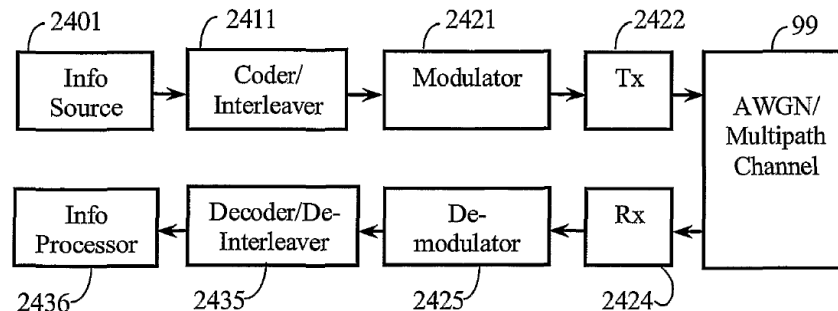


FIG. 24

EX1099, FIG. 24. Shattil-573 explains:

A receiver 2424 couples the transmitted signals from the channel 99. A demodulator 2425 retrieves symbols from the received signal. A CI decoder/de-interleaver 2435 decodes (and de-interleaves, if necessary) the received symbols into information symbols that are optionally processed in an information processor or sink 2436.

EX1099, 27:26-30.

Shattil-537 is analogous to the '386 Patent because both relate to "Carrier Interferometry," which includes the ability to select subcarriers to achieve a predetermined spectral response. EX1001, 48:55-61; EX1099, 1:6-8; EX1002, ¶¶68-75. Indeed, but for a typographical error and renaming of variables, Shattil-537 and the '386 Patent show how polyphase CI codes are applied to subcarriers to generate "weights" in the same way:

$$\begin{array}{c}
 \begin{array}{cccc}
 d_1() & d_2() & d_3() & d_N() \\
 \hline
 w_1 = \Sigma(): & e^{j2\pi(0)0/(N)} & e^{j2\pi(1)0/(N)} & e^{j2\pi(2)0/(N)} & e^{j2\pi(N-1)0/(N)} \\
 w_2 = \Sigma(): & e^{j2\pi(0)1/(N)} & e^{j2\pi(1)1/(N)} & e^{j2\pi(2)1/(N)} & \dots & e^{j2\pi(N-1)1/(N)} \\
 w_3 = \Sigma(): & e^{j2\pi(0)2/(N)} & e^{j2\pi(1)2/(N)} & e^{j2\pi(2)2/(N)} & \dots & e^{j2\pi(N-1)2/(N)} \\
 & & \vdots & & & \vdots \\
 w_N = \Sigma(): & e^{j2\pi(0)(N-1)/(N)} & e^{j2\pi(1)(N-1)/(N)} & e^{j2\pi(2)(N-1)/(N)} & \dots & e^{j2\pi(N-1)(N-1)/(N)}
 \end{array}
 \end{array}$$

FIGURE 29B

$$\begin{array}{c}
 \begin{array}{cccc}
 s_0() & s_1() & s_2() & s_{N-1}() \\
 \hline
 w_1 = \Sigma(): & e^{j2\pi(0)0/(N-1)} & e^{j2\pi(1)0/(N-1)} & e^{j2\pi(2)0/(N-1)} & e^{j2\pi(N-1)0/(N-1)} \\
 w_2 = \Sigma(): & e^{j2\pi(0)1/(N-1)} & e^{j2\pi(1)1/(N-1)} & e^{j2\pi(2)1/(N-1)} & \dots & e^{j2\pi(N-1)1/(N-1)} \\
 w_3 = \Sigma(): & e^{j2\pi(0)2/(N-1)} & e^{j2\pi(1)2/(N-1)} & e^{j2\pi(2)2/(N-1)} & \dots & e^{j2\pi(N-1)2/(N-1)} \\
 & & \vdots & & & \vdots \\
 w_N = \Sigma(): & e^{j2\pi(0)(N-1)/(N-1)} & e^{j2\pi(1)(N-1)/(N-1)} & e^{j2\pi(2)(N-1)/(N-1)} & \dots & e^{j2\pi(N-1)(N-1)/(N-1)}
 \end{array}
 \end{array}$$

FIG. 22

EX1001, FIG. 29B; EX1099, FIG. 22. Thus, Shattil-537 is in the same field as the '386 Patent and is reasonably pertinent to problems that the inventor was allegedly seeking to solve because it describes the use of the same techniques applied to

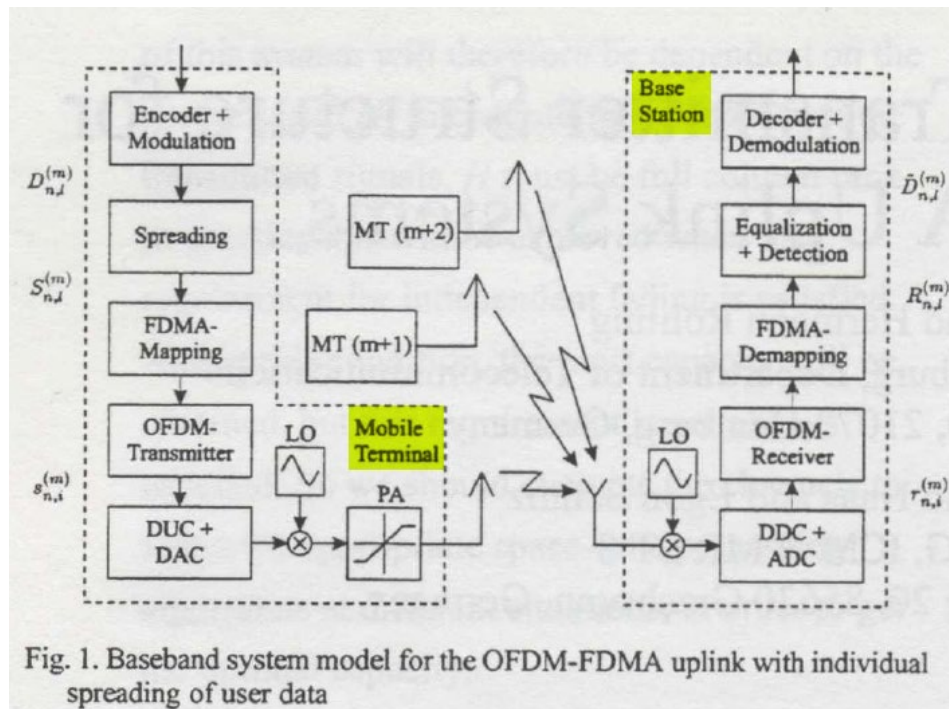
multicarrier signals. EX1002, ¶¶74-75.

B. Galda

Galda is a prior art printed publication because it was distributed and thus accessible to those skilled in the art between May 6th to 9th on CD to as many as 400 attendees at IEEE's 55th Vehicular Technology Conference in Birmingham, Alabama. EX1059, ¶¶4-10. The "main focus" of the conference was "voice and data wireless mobile communications," *Id.*, ¶6, and there were more than 100 presenters skilled in the field at the conference. *Id.* CDs were given to attendees when they checked in for the conference and included as part of the conference registration fee. *Id.*, ¶¶7-10, 11 (Exhibit D). The conference was open to the public, there were no confidentiality restrictions imposed on the conference proceedings, EX1059, ¶¶11-12, and it was expected that the proceedings would be shared widely as confirmed by the fact that the conference proceedings were cataloged into the Linda-Hall Library of Science, Engineering, and Technology less than two months later, then made available on the IEEE website by August 7, 2002. EX1012, ¶52; EX1002, ¶73. Galda is thus a prior art printed publication by at least May 6, 2002 and is prior art under pre-AIA §102(b) or post-AIA §102(a)(1). *E.g., GoPro, Inc. v. Contour Holding LLC*, 908 F.3d 690, 694-95 (Fed. Cir. 2018).

Galda teaches using "OFDM-FDMA multiple access ... combined with a data spreading technique based on a Discrete Fourier Transform." EX1004, p.1737.

Galda discloses a transmitter in a “Mobile Terminal” and a receiver in a “Base Station” as shown in the illustration below:



EX1004, p.1738 (Fig. 1). Galda explains that “an OFDM-FDMA uplink system can be combined with a user data spreading technique based on the DFT spreading matrix to reduce the PAR of the uplink signal without increasing the computational complexity of the transmitter.” EX1004, p.1738. In the receiver, “[a]fter calculating the FFT in the receiver which splits the received time signals into orthogonal sub-channel the same single- or multi-code detection techniques can be applied which are well known from OFDM-CDMA receiver structures.” *Id.*, p.1739.

Galda is analogous art to the '386 Patent because it describes techniques for receiving an OFDM signal transmitted by a mobile device in a wireless network that

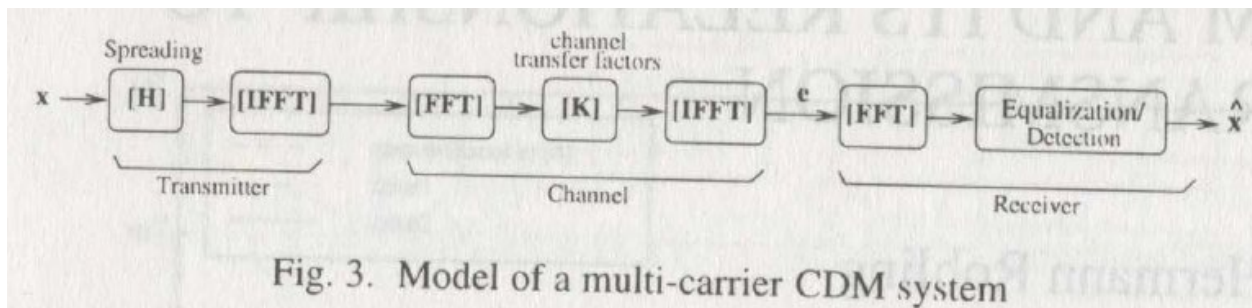
includes using “complex values used in DFTs” to spread the data symbols before OFDM modulation. EX1001, Abstract, 68:37-40; EX1004, pp.1737, 1738 (Fig. 1), 1739; EX1002, ¶¶76-79. Galda is also analogous art because a problem facing the inventor was bandwidth limitations, EX1001, 8:40-42, 9:29-34, and Galda seeks to solve that problem, EX1004, p.1737; EX1002, ¶79. Additionally, both Galda and the '386 Patent reduce PAPR by using DFT spreading codes. EX1001, 48:55-59; EX1004, pp.1737, 1738, 1741; EX1002, ¶¶77, 79.

C. Brüninghaus

Brüninghaus is a conference paper from the 48th IEEE Vehicular Technology Conference held in May 1998. EX1016, p.1. Exhibit 1016 was obtained from the Linda Hall Library. EX1012, ¶72. It was cataloged into that library as of July 16, 1998. EX1012, ¶75. It was cataloged by subject matter including “Mobile communication systems \$v Congresses,” which would have been sufficient to allow for a POSITA to locate Brüninghaus based on subject matter. EX1012, ¶77; EX1002, ¶80. As a further indication of its accessibility to those skilled in the art, Brüninghaus has been cited in other scholarly works. EX1073, p.1305 (reference [7]); EX1004, p.1741 (reference [3]); EX1007, p.860 (reference [4]). Brüninghaus is thus prior art under pre-AIA §102(b) or post-AIA §102(a)(1).

Brüninghaus describes that “[t]he combination of orthogonal frequency division multiplexing (OFDM) and code division multiplexing (CDM) has found

great interest during the last few years.” EX1016, p.2329. Brüninghaus also discloses that “[s]ince the single-carrier system which results from an OFDM-CDM system with Fourier spreading matrix is a special case of an OFDM-CDM system, the same detection algorithms can be applied and the same performance can be expected.” *Id.*, p.2330. “In case of a Fourier spreading matrix, despreading in the receiver is achieved by an inverse Fast-Fourier matrix, i.e. $[H]^H = [\text{IFFT}]$.” EX1016, p.2330. A model of the multi-carrier CDM system proposed by Brüninghaus is shown below:



EX1016, p.2330.

Brüninghaus is analogous to the '386 Patent because it describes techniques for receiving an OFDM signal transmitted by a mobile device in a wireless network that includes using “columns of a Fourier matrix” to spread the data symbols before OFDM modulation. EX1001, Abstract, 68:37-40; EX1016, pp.2329, 2332; EX1002, ¶¶81-82. Additionally, Brüninghaus is reasonably pertinent to a problem faced by the inventor, namely the reduction of PAPR in OFDM systems and both describe the use of DFT spreading codes for this purpose. EX1001, 48:55-59, 68:35-40; EX1016,

p.2330 (describing a problem in OFDM as being “a high dynamic which requires a linear power amplifier in the transmitter” and a solution being to “reduce the signal dynamic” using the “Fourier-matrix” for spreading); EX1002, ¶¶81-82.

D. Dowling

Dowling was filed on April 6, 1999 and issued July 22, 2003. EX1042, cover. Dowling is prior art under post-AIA §102(a)(1) or pre-AIA §102(b).

Dowling discloses multicarrier modulation and OFDM systems that may be implemented as software modules executing on programmable processors. Dowling’s transmitters, receivers, and precoders may be implemented in either hardware or software. EX1042, 3:46-50, 5:66-6:1.

Dowling is analogous to the ’386 Patent at least because it is in the same field of endeavor including multicarrier systems. EX1001, 48:55-60 (“[s]ome aspects provide a multicarrier protocol), 49:3-8 (“An objective may be to enable a communication protocol that provides frequency-diversity benefits of multicarrier modulation to single-carrier systems and provides the low-PAPR benefits of single-carrier modulation to multicarrier communication systems....”); EX1042, 1:6-12 (“field” relates to “data transmission,” more specifically to a “precoder” for multicarrier (e.g., OFDM) systems and “multi-carrier transmitter and receiver structures”), 21:62-64 (invention “applied to other FFT based multicarrier modulation and OFDM systems.”); EX1002, ¶85.

IX. DETAILED DISCUSSION

A. Grounds 1 and 2: Claims 1-3, 5-8, 10-12, 14-17, 19-21, and 23-26 are (Ground 1) anticipated by or (Ground 2) obvious over Shattil-537

1. Claim 1

a. [1Pre]: Method for receiving OFDM signal

Preambles are not generally limiting. *Arctic Cat Inc. v. GEP Power Prod., Inc.*, 919 F.3d 1320, 1327-28 (Fed. Cir. 2019). A preamble may be limiting if it “recites essential structure or steps, or if it is necessary to give life, meaning, and vitality to the claim.” *Id.* “When the limitations in the body of the claim rely upon and derive antecedent basis from the preamble, then the preamble may act as a necessary component of the claimed invention.” *Pacing Techs., LLC v. Garmin Int’l, Inc.*, 778 F.3d, 1021, 1024-25 (Fed. Cir. 2015).

Assuming claim 1’s preamble is limiting, Shattil-537 discloses and renders obvious a *method for receiving an Orthogonal Frequency Division Multiplexing (OFDM) signal transmitted by a user device in a wireless network*. EX1002, ¶¶86-89.

Shattil-537 describes a *method for receiving an OFDM signal*: “CI filtering may be performed by receivers designed for multicarrier transmission protocols, such as OFDM[.]” EX1099, 8:26-29; *see also id.*, 1:29 (“CI may also be applied to orthogonal frequency division multiplexing.”). Shattil-537 even claims “[a] method

of performing CI processing of at least one received single-carrier signal ... including ... providing for decomposition of the at least one received single-carrier signal into a plurality of CI components” EX1099, 36:17-21; *see also id.*, 5:16-18 (defining “CI Components” to be “CI carriers or CI symbol values,” the latter of which “are complex values (or weights) for a plurality of CI carriers”), 17:31-18:3 (“FIG. 15C illustrates a CI reception method.”), 21:20-21 (“CI codes may be applied to ... OFDM ...”), 21:29-31 (“Multicarrier signals may be defined by any set of substantially orthogonal diversity parameters” such as “frequency...”).

Shattil-537’s reception methods include receiving OFDM signals *transmitted by a user device in a wireless network* because Shattil-537 describes a “CI transmitter adapted to generate at least one CI-coded information signal,” that can then be “coupled to a transmission system 2102 that may include a pre-transmission processor (not shown),” EX1099, 24:30-34, and describes “the many wireless applications of the invention” as including “cellular communications,” which a POSITA would have understood to include transmitters on user cellular phones (i.e., *a user device in a wireless network*), *id.*, 2:20-21, EX1002, ¶87. At the very least, because cellular phones were so ubiquitous by the earliest claimed effective filing date of August 2004, it would have been obvious to implement the CI techniques described by Shattil-537 in a transmitter within a user device. EX1002, ¶88 (citing EX1108, p.399 (“cellular phones ... are becoming ubiquitous”)).

Thus, Shattil-537 discloses and renders obvious [1Pre].

b. [1A]: determining subcarrier frequencies

Shattil-537 discloses and renders obvious *determining a plurality of subcarrier frequencies allocated to the user device*. EX1002, ¶¶90-96.

Shattil-537 describes *determining a plurality of subcarrier frequencies* through a process called “[c]arrier selection.” EX1099, 5:8-10. “Carrier selection may include either or both transmit-side carrier selection with respect to one or more predetermined CI carrier parameters to generate at least one transmit signal and receive-side carrier selection to decompose at least one signal into CI components.” *Id.* Shattil-537 describes the process of “decomposing a single-carrier signal into a plurality of component values representing overlapping narrowband carrier signals” as including using a “predetermined time interval” called “ T_s ” (referred to as the “sample period” by Shattil-537) to specify—*determine*—“a set of orthogonal frequencies f_n .” EX1099, 16:25-31; *see also id.*, 9:32-33. This is an example of how Shattil-537 performs a step of *determining a plurality of subcarrier frequencies*. EX1002, ¶¶91-92.

As another example of Shattil-537’s disclosure of *determining a plurality of subcarrier frequencies*, Shattil-537 explains that

A received signal is decomposed 1504 into a plurality of CI carriers. Carrier properties, such as frequency selection,

frequency spacing, and complex weighting are selected, at least in part, with respect to the channel estimates.

EX1099, 17:17-19. Selection of carrier (sub-carrier) frequencies is another example of *determining a plurality of subcarrier frequencies*. EX1002, ¶93.

Shattil-537's determined subcarrier frequencies are *allocated to [a] user device* because both the transmitter and receiver identify “desirable and/or undesirable spectral regions,” EX1099, 17:6-7, 17:16-17, which includes “a spectral range 1412 allocated to another user, application, or system,” *id.*, 16:35-17:2. For example, Shattil-537 describes multicarrier transmission involving “phase-shift coding [that] may be accomplished” by modulating “[e]ach carrier ... with one or more CI code chip encoded subcarriers.” EX1099, 21:20-27. Thus, a POSITA would have understood that Shattil-537's determination of the subcarriers determines the subcarriers *allocated to a user device* because it includes techniques to avoid modulating subcarriers that are “allocated to another user, application, or system” at the receiver. EX1002, ¶¶94-95; EX1099, 16:35-17:2.

Accordingly, Shattil-537 discloses and renders obvious Limitation [1A].

c. [1B]: converting OFDM signal to frequency-domain

Shattil-537 discloses and renders obvious *converting the OFDM signal to a plurality of frequency-domain values corresponding to the plurality of subcarrier frequencies*. EX1002, ¶¶97-100.

Shattil-537 explains that “CI may also be applied to [OFDM]” and “N- point transforms used in OFDM, such as fast Fourier transforms (FFTs) and inverse FFTs (IFFTs), essentially map one set of data symbols onto another set of data symbols.” EX1099, 1:29-31. Thus, Shattil-537 explains that in OFDM a step of *converting the OFDM signal to a plurality of frequency-domain values* is performed. EX1002, ¶¶98-99. This is shown in further detail in connection with Shattil-537’s Figure 18, which shows “[r]eceived signals” (“Rx I&Q”) that “are separated into orthogonal components by an FFT processor 1821.” EX1099, 19:25-26.

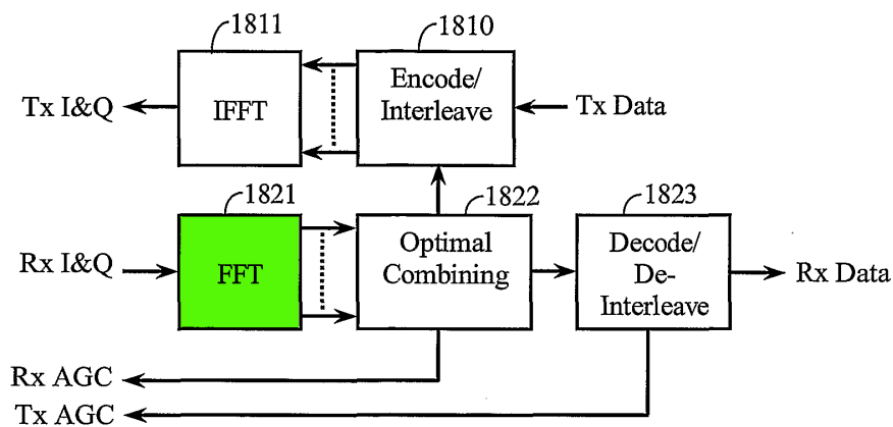


FIG. 18

EX1099, FIG. 18. As Shattil-537 itself recognizes, a FFT converts “a time-domain signal” $x(t)$ into a frequency-domain expression, $X(f_n)$. EX1099, 11:7-18; EX1002, ¶¶98-99. Shattil-537 further explains that “[w]hen a signal is decomposed into carrier components, each carrier frequency f_n is associated with a complex-valued symbol v_n Fourier transforms or equivalent operations may be performed.”

EX1099, 16:25-30. Thus, the OFDM signal is decomposed—*converted*—to a *plurality of frequency domain values* (“complex-valued symbol[s] v_n ”) that *correspond to the plurality of subcarrier frequencies* (“each carrier frequency f_n is associated with a complex-valued symbol v_n ”). EX1002, ¶99; EX1099, 16:25-30. These frequency domain values—i.e., complex-valued symbols (v_n)—are referred to as “CI symbol values,” which “are complex values (or weights)” and are sometimes abbreviated as “ w ” in Shattil-537’s description of CI coding processes. EX1099, 5:16-18; 25:18-36; EX1002, ¶99.

Thus, Shattil-537 discloses and renders obvious Limitation [1B].

d. [1C]: decoding frequency-domain values

Shattil-537 discloses and renders obvious *decoding the plurality of frequency-domain values to recover a plurality of data symbols encoded by the user device on the plurality of subcarrier frequencies*. EX1002, ¶¶101-107.

Shattil-537 explains that, in the context of OFDM, “[e]ach transform of a transform pair provides the basis for mixing symbols together to form a code that can be reversed by the complementary transform.” EX1099, 1:31-33. In one example, Shattil-537 includes an “Encoder/Interleaver software module 1810” on the transmit side and a complementary “Decoder/De-interleaver 1823” on the receiver side. EX1099, 19:25-31.

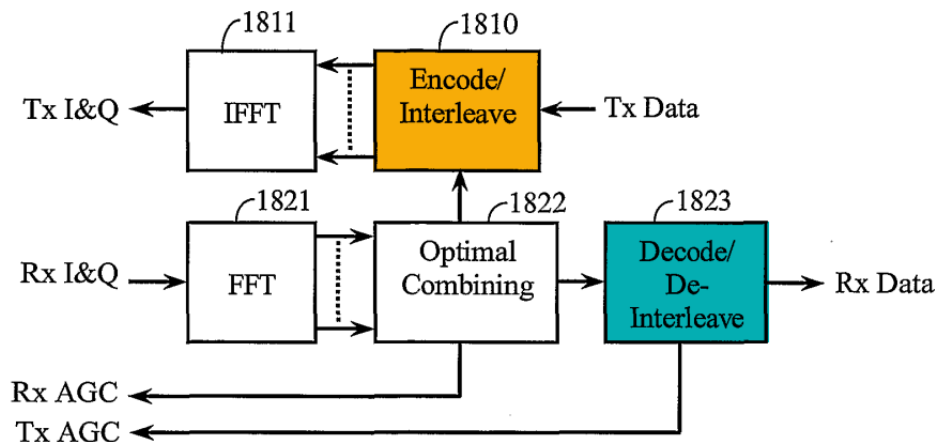


FIG. 18

EX1099, FIG. 18. Shattil-537’s decoder *decodes the plurality of frequency-domain values to recover a plurality of data symbols encoded by the user device on the plurality of subcarrier frequencies* because Shattil-537 explains that “CI-coded symbols may be decoded by correlating a coded signal with a complex-conjugate code.” EX1099, 22:23-24.

Shattil-537 describes the decoding process in more detail in connection with Figures 22 and 23. Figure 22 shows a “relationship between CI symbol values w_n and data symbols s_n .”²

² As discussed above in footnote 1, this figure has an error in the denominator of the exponent term, where “N-1” should be read as “N.” With this correction this Figure depicts DFT coefficients, which is consistent with the description. EX1099, 25:18; 24:18-20.

$$\begin{array}{c}
 \begin{array}{cccc}
 s_0() & s_1() & s_2() & s_{N-1}() \\
 \hline
 w_1 = \Sigma(): & e^{i2\pi(0)(0)/(N-1)} & e^{i2\pi(1)(0)/(N-1)} & e^{i2\pi(2)(0)/(N-1)} & e^{i2\pi(N-1)(0)/(N-1)} \\
 w_2 = \Sigma(): & e^{i2\pi(0)(1)/(N-1)} & e^{i2\pi(1)(1)/(N-1)} & e^{i2\pi(2)(1)/(N-1)} & e^{i2\pi(N-1)(1)/(N-1)} \\
 w_3 = \Sigma(): & e^{i2\pi(0)(2)/(N-1)} & e^{i2\pi(1)(2)/(N-1)} & e^{i2\pi(2)(2)/(N-1)} & e^{i2\pi(N-1)(2)/(N-1)} \\
 \vdots & \vdots & \vdots & \vdots & \vdots \\
 w_N = \Sigma(): & e^{i2\pi(0)(N-1)/(N-1)} & e^{i2\pi(1)(N-1)/(N-1)} & e^{i2\pi(2)(N-1)/(N-1)} & e^{i2\pi(N-1)(N-1)/(N-1)}
 \end{array}
 \end{array}
 \quad
 \begin{array}{l}
 \text{2201} \\
 \text{2203}
 \end{array}$$

EX1099, FIG. 22. This figure shows that CI symbols (weights w_n) are the combination of a CI code (e.g., “values derived from ... a Fourier transform”) and the data symbol s_n . EX1099, 25:18; 24:18-20; EX1002, ¶¶104-105. To decode the coded CI symbols, Shattil-537 explains:

Decoding may include any appropriate inverse of the coding operation represented by FIG. 22. For example, to extract an n^{th} data symbol value s_n , from a vector of received CI symbol values w , the complex conjugate of a vector of the n^{th} phase space (or CI code) values $\underline{w}_n$ may be correlated with the received CI symbol vector w .

EX1099, 25:33-36. Thus, Shattil-537 *decodes the plurality of frequency-domain values* (“CI symbol values w ,” which are also described as “complex values (or weights),” or more generically, “complex-valued symbol v_n ”) to *recover a plurality of data symbols* (“data symbol value[s] s_n ”) *encoded by the user device on the*

plurality of subcarrier frequencies (which are encoded using CI coding techniques at the transmitter and which are reversed by the receiver). EX1002, ¶106; *see also* EX1099, 26:4-19 (describing the process of processing “received CI symbols w'_n to produce data-symbol estimates 2301”).

Thus, Shattil-537 discloses and renders obvious Limitation [1C].

- e. [1D]: decoding employs codes inverse to set of codes that the user device employs to shape the OFDM signal into a superposition of cyclic-shifted pulse waveforms

Shattil-537 discloses and renders obvious *wherein decoding employs a plurality of codes that are inverse to, complex-conjugate of, or complementary to a set of complex-valued codes that the user device employs to shape the OFDM signal into a superposition of cyclic-shifted pulse waveforms that each has one of the plurality of data symbols modulated thereon*. EX1002, ¶¶108-120.

First, we address how Shattil-537’s *user device* transmitter uses *a set of complex-valued codes* to produce the claimed OFDM signal. Next, we address the *decoding* of the coded superposition signal, which inverts the process performed at the transmitter.

Shattil-537’s *user device*, which includes the transmitter that creates the single-carrier signal, *employs complex-valued codes* (e.g., “[a] basic CI code c_m ”) *to shape the OFDM signal into a superposition of cyclic-shifted pulse waveforms that each has one of the plurality of data symbols modulated thereon*. Shattil-537

explains that “[t]he basic family of CI codes is generated from an $M \times M$ matrix of elements having phases ϕ_{mn} ” and “[a] basic CI code c_m can include a row or column vector having terms defined by

$$c_m = e^{im\phi'} \sum_{n=0}^{N-1} e^{imn\phi} \hat{n}$$

where $\phi = 2\pi/M$ and $\phi' = 2\pi f_o/f_s M$.” EX1099, 20:17-30. The term $e^{imn\phi}$ can be expressed as $e^{\frac{i2\pi mn}{M}}$, which, but for the typographical error noted in footnote 1 above, resembles the “CI code chip values” provided in Shattil-537’s Figure 22:

	$s_0()$	$s_1()$	$s_2()$	$s_{N-1}()$
$w_1 = \Sigma():$	$e^{i2\pi(0)(0)/(N-1)}$	$e^{i2\pi(1)(0)/(N-1)}$	$e^{i2\pi(2)(0)/(N-1)}$	$e^{i2\pi(N-1)(0)/(N-1)}$
$w_2 = \Sigma():$	$e^{i2\pi(0)(1)/(N-1)}$	$e^{i2\pi(1)(1)/(N-1)}$	$e^{i2\pi(2)(1)/(N-1)}$	$e^{i2\pi(N-1)(1)/(N-1)}$
$w_3 = \Sigma():$	$e^{i2\pi(0)(2)/(N-1)}$	$e^{i2\pi(1)(2)/(N-1)}$	$e^{i2\pi(2)(2)/(N-1)}$	$e^{i2\pi(N-1)(2)/(N-1)}$
$w_N = \Sigma():$	$e^{i2\pi(0)(N-1)/(N-1)}$	$e^{i2\pi(1)(N-1)/(N-1)}$	$e^{i2\pi(2)(N-1)/(N-1)}$	$e^{i2\pi(N-1)(N-1)/(N-1)}$

EX1099, FIG. 22, 25:18-32. Each data symbol (e.g., $s_0()$) is multiplied by a vector of CI codes to generate weights w_1 to w_N (also referred to as “complex-valued symbol v_n ” or “CI symbol values”). Shattil-537 thus shows *complex-valued codes* because of the presence of i , which is the mathematical symbol for $\sqrt{-1}$, which makes the codes complex-valued. EX1002, ¶¶110-112.

Shattil-537's CI codes are used at the transmitter (*user device*) to *shape the OFDM signal into a superposition of cyclic-shifted pulse waveforms that each has one of the plurality of data symbols modulated thereon* because Shattil-537 explains that:

Each code chip value is analogous to a complex weight applied to a particular CI carrier. A superposition of these carriers produces a CI waveform bearing the data symbol value s_n , such as a particular pulse position.

A CI superposition waveform bearing multiple data-symbol/pulse-position characteristics can be created by applying weights to CI carriers that correspond to sums of carrier weights for each data-symbol/pulse-position."

EX1099, 25:24-29; FIG. 22. Thus, a pulse waveform is generated at "a particular pulse position" and the "pulse waveform" has one data symbol (s_n) *modulated thereon*. Indeed, Shattil-537's disclosure is consistent with the disclosure of the '386 Patent, which shows the following:

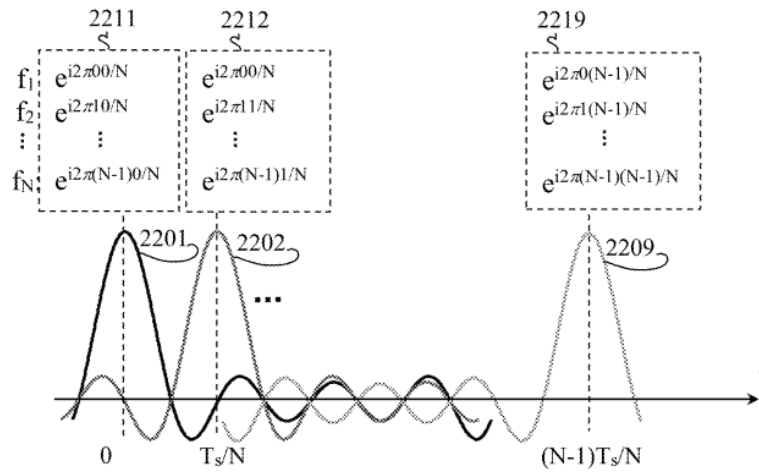


FIGURE 22A

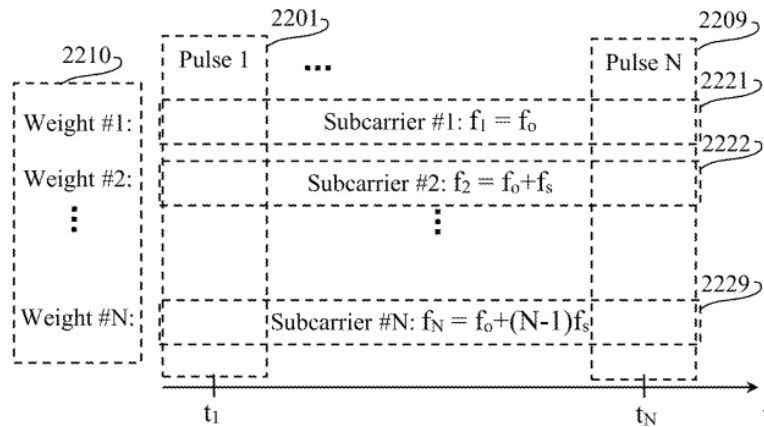


FIGURE 22B

EX1001, FIGS. 22A-22B; EX1002, ¶¶113-115. That the columns of CI code chips correspond to cyclic-shifted waveforms is echoed in Shattil-537 where it says that the “CI code chip values are arranged in columns with respect to phase spaces, such as phase space column (2201),” where the phase spaces are “analogous to a pulse position.” EX1099, 25:18-20. After the weights are produced, they are OFDM

modulated, such as by the “IFFT 1811” of Shattil-537’s Figure 18 or the IFFT 2703 of Figure 27A, ultimately resulting in the production of a superposition signal, which is transmitted over the air. EX1099, FIGS. 18, 27A, 19:20-24, 32:4-5; EX1002, ¶¶116-117. At the very least, that the generation of Shattil-537’s “CI symbols,” which may be “derived from at least one invertible transform function, such as a Fourier transform,” would obviously have produced *cyclic-shifted pulse waveforms that each has one of the plurality of data symbols modulated thereon* because that would have been understood to be the result of applying complex-valued polyphase codes derived from a Fourier transform to data symbols in the manner shown in Shattil-537. EX1002, ¶118.

At the receiver, the superposition signal is received and Shattil-537 explains that *decoding employs a plurality of codes that are inverse to, complex-conjugate of ... the complex-valued codes that the user device employs* because it teaches that decoding “may include any appropriate inverse of the coding operation. . . .” EX1099, 25:33. The inverse may include using complex-conjugate codes. For instance, “CI-coded symbols may be decoded by correlating a coded signal with a complex-conjugate code.” EX1099, 25:33; *see also id.* 22:23-24 (“CI-coded symbols may be decoded by correlating a coded signal with a complex-conjugate code.”). Shattil-537 further explains that “to extract an n^{th} data symbol value s_n , from a vector of received CI symbol values w , the complex conjugate of a vector of the n^{th} phase space (or CI

code) values w_n may be correlated with the received CI symbol vector w .” EX1099, 25:33-36. A POSITA thus would have understood that Shattil-537 is describing receipt of a CI-coded data symbol (or “weight” w) and the use of a complex-conjugate code to recover the data symbol value s_n , thereby decoding the frequency-domain values. EX1002, ¶119.

Thus, Shattil-537 discloses and renders obvious Limitation [1D] and claim 1.

2. *Claims 10 and 19*

a. [10Pre], [10A], [10B], [19Pre]: Apparatus for receiving OFDM signal and computer program product

Assuming the preambles are limiting, Shattil-537 discloses and renders obvious the following aspects of claim 10:

[10Pre] *[a]n apparatus for receiving an Orthogonal Frequency Division Multiplexing (OFDM) signal transmitted by a user device in a wireless network, the apparatus comprising: [10A] at least one processor; and [10B] a non-transitory computer-readable memory communicatively coupled to the at least one processor, the non-transitory computer-readable memory including a set of instructions stored thereon and executable by the at least one processor*

[19Pre] *A computer program product for receiving an Orthogonal Frequency Division Multiplexing (OFDM) signal transmitted by a user device in a wireless network,*

the computer program product comprising a non-transitory computer readable storage device having computer readable program code stored therein, said program code containing instructions executable by one or more processors of a computer system

EX1002, ¶¶122-128.

Shattil-537 describes a “software-controlled” transceiver that includes “an Encoder/Interleaver software module 1810 that generates weights provided to an IFFT processor 1811.” EX1099, 19:20-22; FIGS. 18 & 19. “The IFFT may be adaptable with respect to control signals provided by other software modules, such as the Encoder 1810.” *Id.*, 19:23-24. In addition, Shattil-537 explains that “[t]he IFFT 1811 may include a signal processing software module.” *Id.*, 19:22. Shattil-537 further discloses that physical layer properties of the transceiver can be controlled by “a software defined-controller 1901 that processes one or more system requirements 1911 and/or one or more channel characteristics 1912 to control one or more CI parameters 1902 in a radio transceiver 1903.” *Id.*, 20:3-5; FIG. 19.

Shattil-537 reveals that “physical-layer functions” are “performed via software-controlled processes, such as application programs residing in one or more memory spaces of one or more processing units.” EX1099, 19:11-19. Shattil-537’s “processing unit” refers to “a computer processing unit, such as a microprocessor device, a main frame, a work station, a computer network, and/or a stand-alone

computer.” *Id.*, 6:30-31. Likewise, Shattil-537’s reference to a “Memory space” means “a disk drive, tap drive, VD, DVD, flash memory, or any other data storage media or device.” *Id.*, 6:23-24.

Shattil-537’s “software-controlled transceiver” illustrated in Figure 18 and 19 is an *apparatus*. That apparatus is *for receiving an OFDM signal transmitted by a user device in a wireless network* because Shattil-537 explains that the invention has “many wireless applications” including “cellular communications,” EX1099, 2:20-21, and as explained above in connection with [1Pre], one of those applications is use in OFDM communications, *supra* §IX.A.1.a; EX1002, ¶¶87-88. And, that apparatus comprises *a non-transitory computer-readable memory storing one or more instructions* (e.g., Shattil-537’s application programs/software stored in memory spaces) because the various modules are described as being implemented in software modules, as explained above. EX1002, ¶¶123-126. Shattil-537’s software modules are instructions that are stored in “memory spaces”—i.e., *non-transitory computer-readable memory*—including, for example, “flash memory[] or any other data storage media or device.” EX1099, 6:23-24; EX1002, ¶¶124-126. And, the instructions defining the various modules are executed by *at least one processor* because Shattil-537 describes software executed by “processing unit” such as a “microprocessor device.” EX1099, 6:30-31; EX1002, ¶126. This is consistent with how a POSITA would have understood software-based radios such

as those described in Shattil-537 to operate. EX1002, ¶126.

As detailed below, the software-controlled transceiver's software instructions cause the functions of Limitations [10Ci]-[10Civ] to be performed. *Infra* §§IX.A.2b-IX.A.2e. Therefore, Shattil-537 discloses and renders obvious preambles [10Pre] and [19Pre] and limitations [10A] and [10B].

b. [10Ci], [19A]: determining subcarrier frequencies

Limitations [10Ci] and [19A] are the same as Limitation [1A], and thus are disclosed and rendered obvious for the same reasons as Limitation [1A]. *Supra* §IX.A.1.b; EX1002, ¶129.

c. [10Cii], [19B]: converting OFDM signal to frequency-domain

Limitations [10Cii] and [19B] are the same as Limitation [1B], and thus are disclosed and rendered obvious for the same reasons as Limitation [1B]. *Supra* §IX.A.1.c; EX1002, ¶130.

d. [10Ciii], [19C]: decoding frequency-domain values

Limitations [10Ciii] and [19C] are the same as Limitation [1C], and thus are disclosed and rendered obvious for the same reasons as Limitation [1C]. *Supra* §IX.A.1.d; EX1002, ¶131.

e. [10Civ], [19D]: decoding employs codes inverse to set of codes that the user device employs to shape the OFDM signal into a superposition of cyclic-shifted pulse waveforms

Limitations [10Civ] and [19D] are the same as Limitation [1D], and thus are disclosed and rendered obvious for the same reasons as Limitation [1D]. *Supra* §IX.A.1.e; EX1002, ¶132.

Thus, Shattil-537 discloses and renders obvious claims 10 and 19.

3. *Claims 2, 11, and 20*

Shattil-537 discloses and renders obvious *wherein each of the plurality of codes employed for decoding comprises a different vector of linear phase offsets*. EX1002, ¶¶134-140.

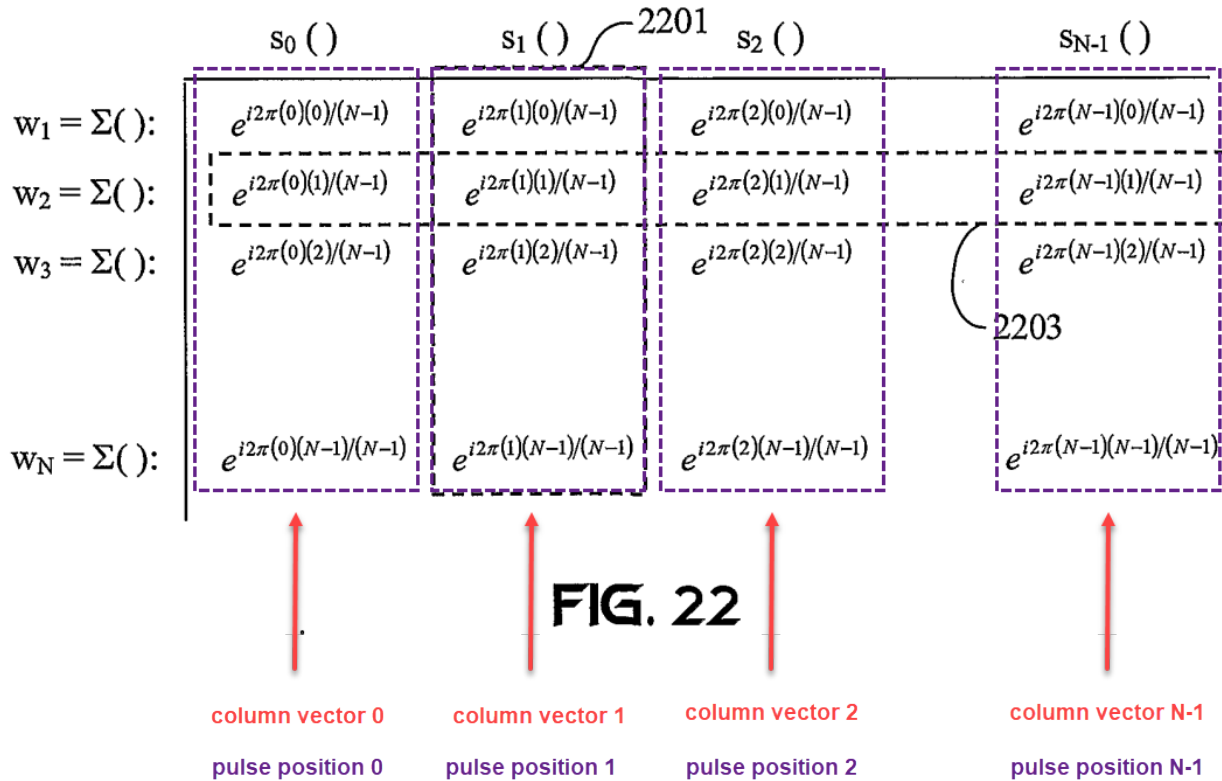
As explained in connection with Limitation [1D], Shattil-537 describes “[a] basic CI code c_m can include a row or column vector consisting of terms

$$c_m = e^{im\phi'} \sum_{n=0}^{N-1} e^{imn\phi} \hat{n}$$

where $\phi=2\pi/M$ and $\phi'=2\pi f_o/f_s M$.” EX1099, 20:17-30. Shattil-537 further teaches that “[t]he basic family of CI codes is generated from an $M \times M$ matrix of elements having phases ϕ_{mn} described by: $\phi_{mn}=2\pi mn/M + 2\pi f_o m/f_s M$, where m and n are row and column indices, respectively.” *Id.*, 20:22-26.

Shattil-537 explains that “CI code chip values are arranged in columns with respect to phase spaces, such as phase space (column) 2201,” and these phase spaces reflect “pulse positions.” EX1099, 25:18-21. As shown below (and with the correction to the DFT codes discussed in footnote 2, above) each column of “CI code

chip values”—i.e., each column vector of CI codes—used for encoding comprises a different vector of linear phase offsets because they shift the frequency components in time by the same amount. EX1002, ¶¶135-136.



EX1099, FIG. 22; EX1002, ¶136. Therefore, Shattil-537’s encoding/interleaving process includes using a *plurality of codes* that comprise *different vector[s] of linear phase offsets*. EX1002, ¶136.

As explained in connection with the discussion of Limitation [1D], above, Shattil-537’s decoding process employs the inverse of the encoding process, e.g., by using “complex conjugate” codes. EX1099, 25:33-36. The complex-conjugate of a

complex code flips the sign of the imaginary part (i.e., the complex-conjugate of $x + iy$ is equal to $x - iy$), or in matrix form, merely reflects the matrix around its principal diagonal. EX1002, ¶¶137-138; EX1110, p.22-23. When the complex-conjugate of the matrix values shown in FIG. 22 are taken, the *plurality of codes employed for decoding* (i.e., the complex conjugates of the codes used for encoding) *comprises a different vector of linear phase offsets* (i.e., also result in vectors of code values with linear phase offsets to recover the original data symbols). EX1002, ¶139.

Thus, Shattil-537 discloses and renders obvious claim 2, 11, and 20.

4. Claims 3, 12, and 21

Shattil-537 discloses and renders obvious *wherein the cyclic-shifted waveforms have cyclic shifts that cause the cyclic-shifted waveforms to be orthogonal, and each of the plurality of codes employed for decoding comprises a set of linear phase offsets that corresponds to one of the cyclic shifts*. EX1002, ¶¶141-149.

Shattil-537 teaches that *the cyclic-shifted waveforms have cyclic shifts that cause the cyclic-shifted waveforms to be orthogonal*. Shattil-537 teaches:

A sample period of $T_s = 1/f_s$ provides overlapping frequencies f_n (shown in FIG. 14B) that have an incremental frequency separation of f_s .

The sample period T_s is a predetermined time interval in which samples are collected and processed. Fourier

transforms or equivalent operations may be performed.

The period T_s specifies a set of orthogonal frequencies f_n .

EX1099, 16:27-31. The cyclic-shifts—also referred to as “phase space” or “pulse positions”—“may be orthogonal,” and the “superposition of carriers” to which code chips are applied “produces a CI waveform bearing the data symbol value s_n , such as at a particular pulse position.” EX1099, 25:18-26. Thus, the different cyclic shifts correspond to the symbol duration T_s , which because of its inverse relationship with the subcarrier spacing (f_s), make the waveforms *orthogonal* as claimed. EX1002, ¶143.

Additionally, Shattil-537 teaches that *each of the plurality of codes employed for decoding* (i.e., each column vector of polyphase Fourier codes, e.g., shown in FIG. 22) *comprises a set of linear phase offsets that corresponds to one of the cyclic shifts* because Shattil-537 explains that “CI code chip values are arranged in columns with respect to phase spaces, such as phase space (column) 2201,” and these phase spaces reflect “pulse positions.” EX1099, 25:18-21. Each column of “CI code chip values”—i.e., each column vector of CI codes—used for encoding comprises a different vector of linear phase offsets because they shift the frequency components in time by the same amount based on the equal spacing between the carriers (f_s) as shown, for example, in Shattil-537 FIGS. 14A-14B. EX1002, ¶¶144-145. Indeed, this is consistent with the ’386 Patent, which shows how the codes apply a linear

phase offset resulting in an uniform spacing of pulses in the time domain. EX1001, FIG. 22A; EX1002, ¶146. Therefore, Shattil-537's encoding/interleaving process includes using a *plurality of codes* that comprise *a set of linear phase offsets that corresponds to one of the cyclic shifts*. EX1002, ¶147.

And, as discussed with respect to Limitation [1D] and claim 2 above, Shattil-537's decoding process employs the inverse of the encoding process, e.g., by using "complex conjugate" codes. EX1099, 25:33-36. The complex-conjugate of a complex code flips the sign of the imaginary part (i.e., the complex-conjugate of $x+iy$ is equal to $x-iy$), or in matrix form, merely reflects the matrix around its principal diagonal. EX1002, ¶¶138, 148; EX1110, p.22-23. When the complex-conjugate of the matrix values shown in FIG. 22 are taken, the complex conjugate code vector also comprises *a set of linear phase offsets that corresponds to one of the cyclic shifts* (i.e., vectors of code values with linear phase offsets to recover the original data symbols). EX1002, ¶148; *see also supra* §IX.A.3. (claims 2, 11, and 20).

Thus, Shattil-537 discloses and renders obvious claims 3, 12, and 21.

5. *Claims 5, 14, and 23:*

Shattil-537 discloses and renders obvious *wherein the plurality of subcarrier frequencies has a frequency spacing f_s , and the plurality of cyclic-shifted waveforms are periodic over a symbol interval $T_s=1/f_s$* . EX1002, ¶¶150-152.

Shattil-537 explains that "[a] sample period of $T_s = 1/f_s$ provides overlapping

frequencies f_n (shown in FIG. 14B) that have an incremental frequency separation of f_s ” and “[t]he period T_s specifies a set of orthogonal frequencies f_n .” EX1099, 16:27-31. The plurality of cyclic shifted waveforms are orthogonal to one another as explained by Shattil-537. *Id.*, 25:20-21 (“The phase spaces (e.g., pulse positions) may be orthogonal”). Pulses are orthogonal when they are an integer multiple of $1/T_s$ as a POSITA would have understood. EX1002, ¶151; EX1015, p.22 (“[T]he carriers are linearly independent (i.e., orthogonal) if the carrier spacing is a multiple of $1/T$.”).

Thus, Shattil-537 discloses and renders obvious claims 5, 14, and 23.

6. *Claims 6, 15, and 24*

Shattil-537 discloses and renders obvious *wherein converting the OFDM signal to a plurality of frequency-domain values uses a discrete Fourier transform*. EX1002, ¶¶153-156.

Shattil-537 explains when CI is applied to OFDM “N- point transforms used in OFDM, such as fast Fourier transforms (FFTs) and inverse FFTs (IFFTs), essentially map one set of data symbols onto another set of data symbols.” EX1099, 1:29-31. Shattil-537’s Figure 18 shows “[r]eceived signals” (“Rx I&Q”) that “are separated into orthogonal components by an FFT processor 1821” as illustrated below:

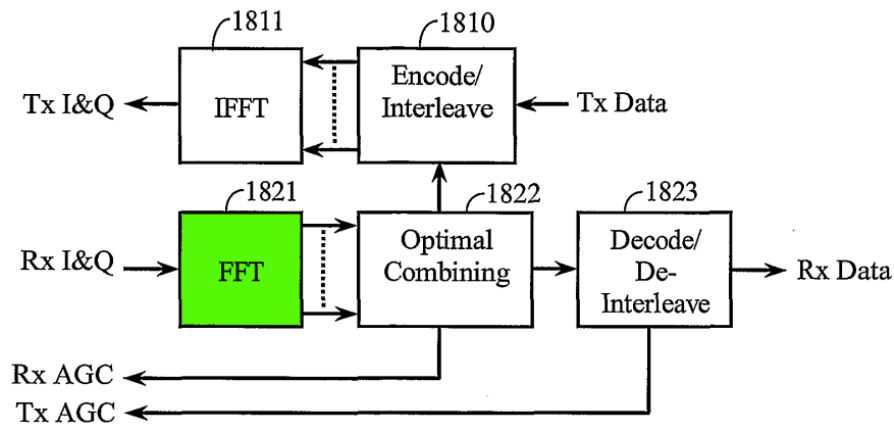


FIG. 18

EX1099, FIG. 18, 19:25-26. This FFT converts “a time-domain signal” $x(t)$ into a frequency-domain expression, $X(f_n)$. EX1099, 11:7-18; EX1002, ¶154. And, as explained in connection with Limitation [1B] the FFT shown in, for example, Figure 18 is used for *converting the OFDM signal to a plurality of frequency-domain values*. *Supra* §IX.A.1.c. A FFT, such as that shown in Shattil-537, is an example of a *discrete Fourier transform* as recognized by the ’386 Patent. EX1001, 60:60-63 (referring to “a DFT implemented with a fast transform algorithm, such as a fast Fourier transform”); EX1002, ¶155.

Thus, Shattil-537 discloses and renders obvious claims 6, 15, and 24.

7. Claims 7, 16, and 25

Shattil-537 discloses and renders obvious *further comprising removing at least one of a guard interval, a cyclic prefix, and a cyclic postfix from the OFDM signal before converting the OFDM signal to the plurality of frequency-domain*

values. EX1002, ¶¶157-160.

Shattil-537 explains that FIG. 27B shows “general steps of a reception process of the present invention,” which includes “various reception processes” including “but not limited to Cyclic prefix removal” EX1099, 32:15-19. This is illustrated below:

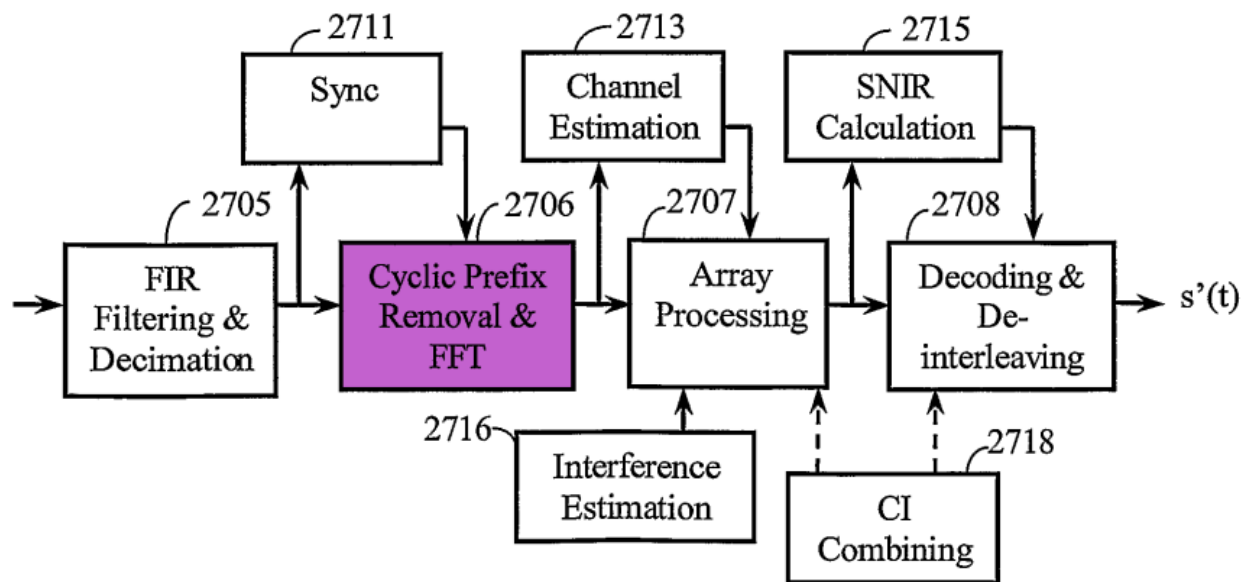


FIG. 27B

EX1099, FIG. 27B. This describes *removing a cyclic prefix from the OFDM signal*. The removal of the cyclic prefix would have been understood to come *before converting the OFDM signal to the plurality of frequency-domain values* because it is identified before the FFT, as would have been the familiar and understood operation of an OFDM receiver. EX1002, ¶158; EX1099, FIG. 27B, 32:15-19.

And, at the very least it would have been obvious to a POSITA that the cyclic

prefix needed to be removed before the signals are converted to frequency-domain values because the cyclic prefix is added to the coded data symbols after they are coded. EX1099, FIG. 27A, 32:5-7 (“Optionally, a cyclic prefix may be added to the coded data symbols.”). Thus to recover the coded data symbols, the cyclic prefix should first be removed. EX1002, ¶158. This is consistent with the general illustration of a textbook OFDM receiver as shown in the Prasad textbook and would have been appreciated by a POSITA.

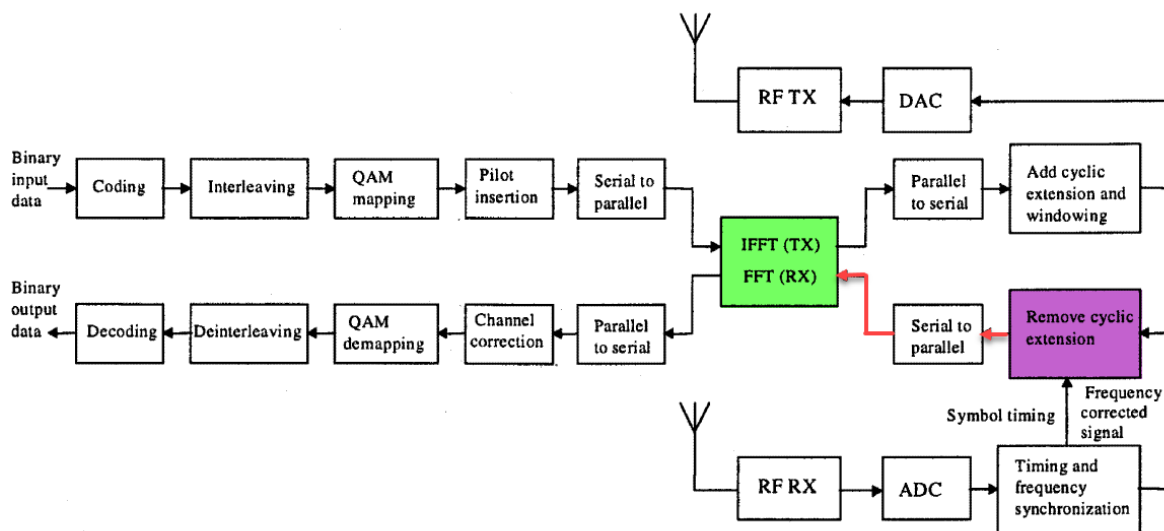


Figure 2.14 Block diagram of an OFDM transceiver.

EX1015, p.48; EX1002, ¶159.

Thus, Shattil-537 discloses and renders obvious claims 7, 16, and 25.

8. *Claims 8, 17, and 26*

Shattil-537 discloses and renders obvious *wherein converting the OFDM signal to the plurality of frequency-domain values provides for orthogonal frequency*

division multiple access for the user device and at least one other user device.

EX1002, ¶¶161-166.

As explained in connection with [1Pre], Shattil-537 describes receiving an OFDM signal because it explains, for example, “CI filtering may be performed by receivers designed for multicarrier transmission protocols, such as OFDM[.]” EX1099, 8:26-29; *see also id.*, 1:29 (“CI may also be applied to orthogonal frequency division multiplexing.”). Shattil-537 even claims “[a] method of performing CI processing of at least one received single-carrier signal ... including ... providing for decomposition of the at least one received single-carrier signal into a plurality of CI components” EX1099, 36:17-21; *see also id.*, 5:16-18 (defining “CI Components” to be “CI carriers or CI symbol values,” the latter of which “are complex values (or weights) for a plurality of CI carriers”), 17:31-18:3 (“FIG. 15C illustrates a CI reception method.”), 21:20-21 (“CI codes may be applied to ... OFDM”), 21:29-31 (“Multicarrier signals may be defined by any set of substantially orthogonal diversity parameters” such as “frequency....”). Thus, Shattil-537’s receiver converts *the OFDM signal into a plurality of frequency-domain values* as explained in further detail in connection with Limitation [1C]. *Supra* §IX.A.1.d; EX1002, ¶162.

As used in Shattil-537, “OFDM” refers to “orthogonal frequency division multiplexing.” EX1099, 1:29; EX1002, ¶163. In Shattil-537 OFDM provides for

multiple access. EX1002, ¶164. For instance, Shattil-537 describes an “Encoder/Interleaver software module 1810” on the transmit side and a complementary “Decoder/De-interleaver 1823” on the receiver side. EX1099, 19:25-31. “The CI decoder may perform ... multiple-access decoding....” EX1099, 31:15-17; *see also id.*, 32:33-34 (“Decoding may include ... multiple access ... and/or other decoding processes.”). Multiple access means that more than one user/device can access the shared spectrum. EX1002, ¶164. This is confirmed by Shattil-537’s statement that frequencies for user devices are chosen such that a spectral range “allocated to another user” is avoided. EX1099, 16:35-36. Thus, by ensuring that user devices use frequencies that are not allocated to other users and because decoding provides for “multiple access,” Shattil-537 discloses, or at the very least, renders obvious that the converting the *OFDM signal to the plurality of frequency-domain values provides for orthogonal frequency division multiple access for the user device* (i.e., the user device that avoids frequencies “allocated to other users” *and at least one other user device* (the “other users” that have frequencies allocated to them). EX1002, ¶165.

Additionally, a POSITA would have found it obvious to receive communications on Shattil-537’s multiple access OFDM system to provide for communications from multiple user devices because it would have readily expanded the usefulness of a system to allow more than one device to communicate using the

system and is expressly taught and suggested by Shattil-537 itself. EX1002, ¶165.

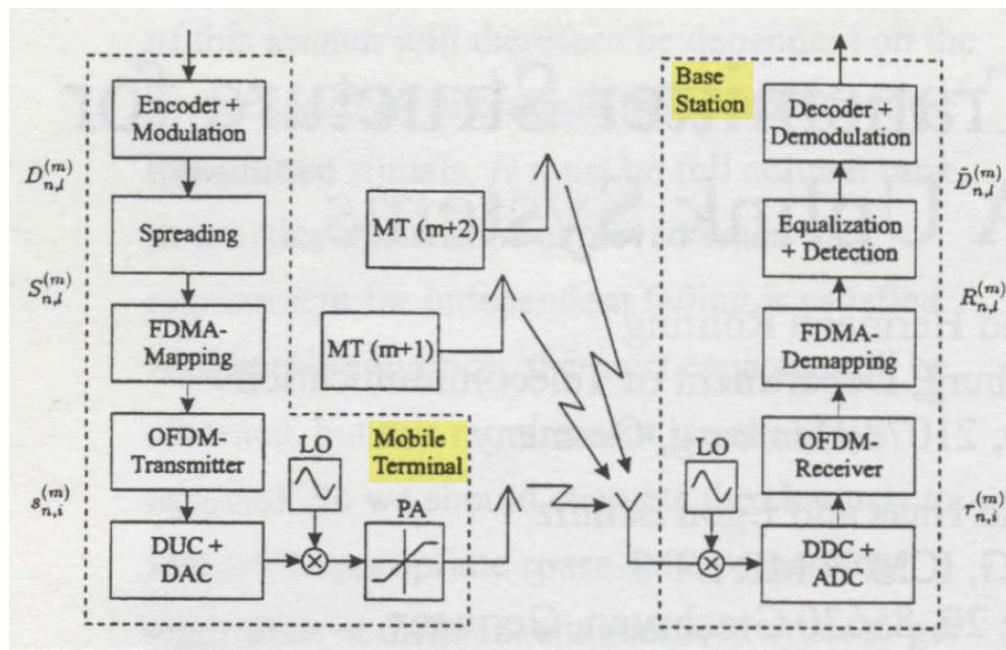
Thus, Shattil-537 discloses and renders obvious claims 8, 17, and 26.

B. Ground 3: Claims 1 and 6-8 are obvious over Galda in view of Brüninghaus

1. Overview of the combination; motivation to combine; expectation of success

Ground 3 addresses claims 1 and 6-8 and relies on Galda in view of Brüninghaus.

As explained in more detail below, Galda generally teaches an “[OFDM] transmission technique” that includes “a data spreading technique based on a [DFT] spreading matrix.” EX1004, p.1737, Abstract. Galda shows a “Mobile Terminal” with a transmitter communicating with a “Base Station” with a receiver:

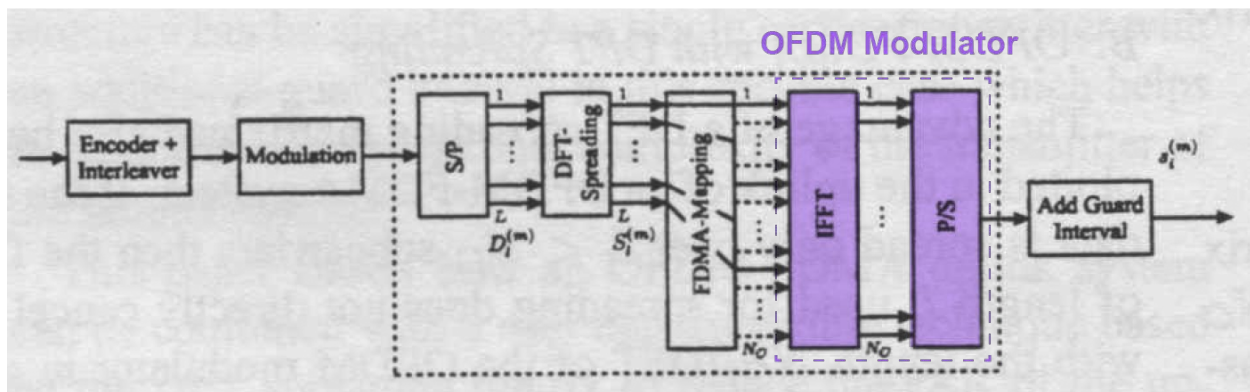


EX1004, p.1738 (Fig. 1); EX1002, ¶168.

The Mobile Terminal includes several modules for processing signals, including “Spreading,” “FDMA-Mapping,” and “OFDM-Transmitter” blocks.

Galda uses “the [DFT] matrix ... for spreading the vector $\vec{D}$ of length $L = N_C$ [and block $D_{n,l}^{(m)}$] over all subcarriers of an OFDM system.” *Id.*, p.1739. EX1004, pp.1738, 1740 (Fig. 6(a)); EX1002, ¶¶169-170. Galda’s DFT spreading uses a plurality of complex-valued codes (“ L orthogonal code vectors $\vec{C}_l$ ”) that shape the interference patterns of a superposition signal as discussed in detail in connection with Limitation [1D], below.

Galda uses an IFFT to modulate DFT spread data symbols onto the plurality of subcarriers (i.e., L subcarriers) and a parallel to serial converter to create a serialized time-domain waveform.

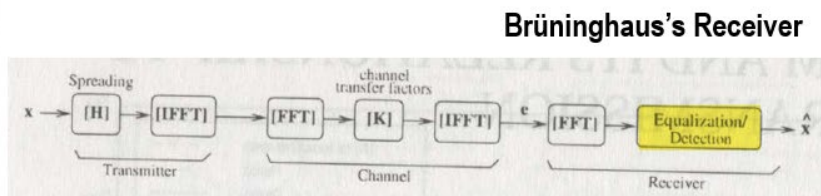
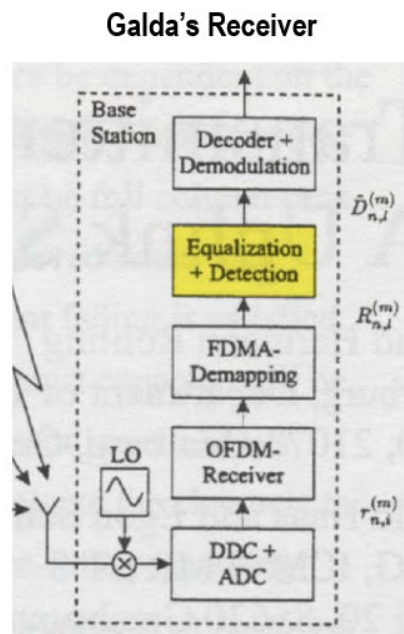


EX1004, p.1740 (Fig. 6(a)).

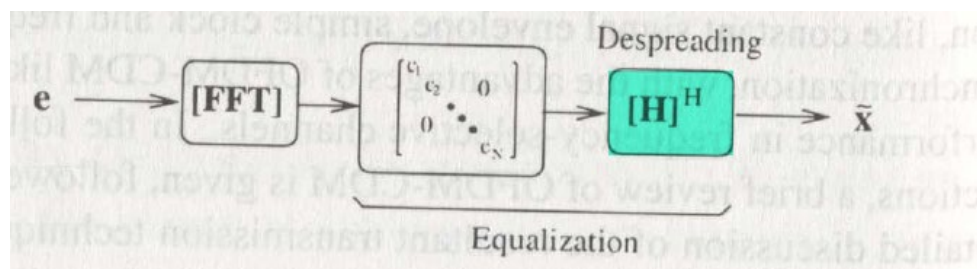
At the receiver, Galda processes “received time signal” “by ... calculating the Fourier transformation (FFT) which splits the time signal into the orthogonal

subcarrier channels and finally selecting the user specific complex valued symbols $R_l^{(m)}$ at the FFT output.” EX1004, p.1738. “An estimate of data symbols $\tilde{D}_l^{(m)}$ can then be calculated independently for each user by applying any single- or multi-code detection techniques.” EX1004, pp.1738-39. According to Galda, such techniques “are well known from OFDM-CDMA receiver structures.” EX1004, p.1739. Galda does not mention using *codes that are inverse to, complex-conjugate of, or complementary to* the DFT spreading codes used at the transmitter to decode the frequency domain values to recover the data symbols. However, using complex-conjugates of DFT spreading codes to recover data symbols from frequency-domain values was a known technique as shown by Brüninghaus.

Like Galda, Brüninghaus’s receiver includes a block called “Equalization/Detection” as shown below.



EX1004, p.1738; EX1016, p.2330. While Galda says that “any single- or multi-code detection techniques” can be used in the receiver, Galda does not show the implementation details for recovering the data symbols (i.e., $\tilde{D}_{n,l}^{(m)}$). Brüninghaus provides details of how to recover data symbols when DFT spreading is used in a transmitter. For example, Brüninghaus shows:



EX1016, p.2330. Here, Brüninghaus shows “despreading” by application of “an inverse Fast-Fourier matrix $[H]^H$.” EX1016, p.2329-30 (Figs. 3 & 4). Here, the superscript “ H ” represents the Hermitian transpose, which is also known as the

“conjugate transpose.” See EX1077, 2:2-3 (“The Hermitian transpose of a matrix A , denoted by A^H , is the complex conjugate transpose of A .”); EX1002, ¶¶174-176. Thus, Brüninghaus’s receiver employs *codes that are inverse to, complex-conjugate of, or complementary to* the DFT spreading codes $[H]$ because it uses the complex conjugate transpose of matrix $[H]$, i.e., $[H]^H$. EX1002, ¶176.

Thus, a POSITA considering Galda would have been motivated to look to other known solutions to reverse the spreading operation at Galda’s receiver and, at Galda’s recommendation, would have looked for “any [known] single- or multi-code detection techniques.” EX1004, p.1738-39. A POSITA would have appreciated that Brüninghaus is identified in Galda and provides a known detection technique to reverse the DFT spreading operation. EX1004, p.1741 (reference [3]); EX1016, p.2330; EX1002, ¶177. A POSITA would have been motivated to use Brüninghaus’s complex conjugate transpose of matrix $[H]$, i.e., $[H]^H$ in Galda’s “Equalization + Detection” block to reverse the spreading operation in the receiver and recover the data symbols. EX1002, ¶177.

A POSITA would have merely combined prior art elements (Galda’s “Equalization + Detection” receiver block and Brüninghaus’s despreading block) according to known methods of using inverse, complex-conjugate codes of the codes used during Galda’s spreading in Galda’s “Equalization” block as shown in, and suggested by, Brüninghaus to yield predictable results of recovering an estimate of

the original data symbol ($\tilde{D}_{n,l}^{(m)}$). EX1002, ¶178. Additionally, a POSITA would have found it obvious to apply Brüninghaus's known technique of using the inverse, complex-conjugate to the DFT matrix used at the transmitter (i.e., using the "an inverse Fast-Fourier matrix [$\mathbf{H}$]^H") to despread the data in an equalization block of a receiver to Galda's known receiver and more specifically Galda's "Equalization + Detection" receiver block to provide for a technique to despread the data and recover the original data symbol ($\tilde{D}_{n,l}^{(m)}$). EX1002, ¶179. Using Brüninghaus's inverse Fast-Fourier matrix would have allowed the spread data symbols to be despread and thus recovered, thus providing predictable results. EX1002, ¶179.

A POSITA would have had a reasonable expectation of success in including Brüninghaus's complex-conjugate inverse Fast-Fourier matrix in Galda's "Equalization + Detection" receiver block because using inverse (complex-conjugate) codes to reverse encoding of data symbols in wireless communications was a known mathematical technique available to a POSITA. EX1004, p.1739 ("single- or multi-code detection techniques can be applied which are well known from OFDM-CDMA receiver structures"); EX1016, pp.2329-30 ("In case of a Fourier spreading matrix, despreading in the receiver is achieved by an inverse Fast-Fourier matrix."); EX1002, ¶180. Indeed, implementing inverse codes of the spreading codes used in the transmitter to recover data symbols was a common

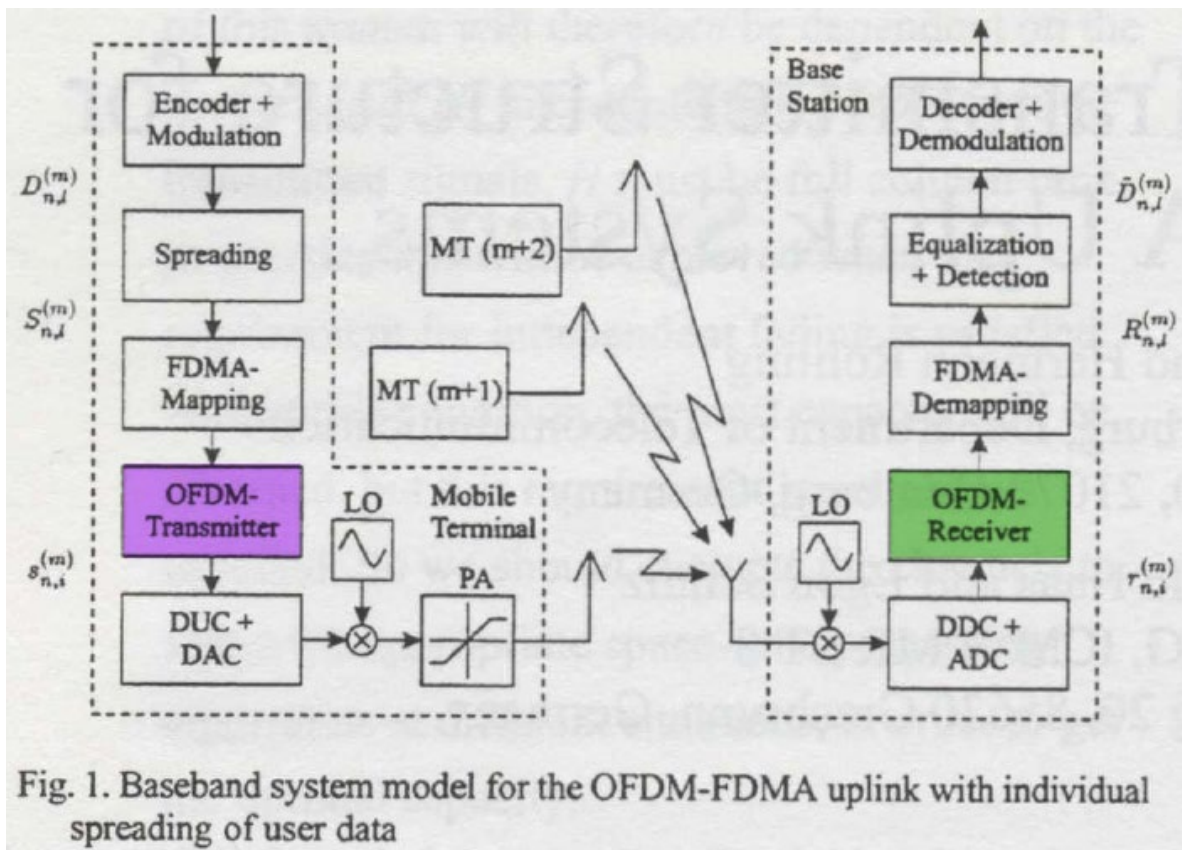
technique used to invert operations performed using coefficients of a matrix in communications. EX1002, ¶180.

2. *Claim 1*

a. [1Pre]: Method for receiving OFDM signal

Assuming the preamble is limiting, Galda in view of Brüninghaus renders obvious *a method for receiving an Orthogonal Frequency Division Multiplexing (OFDM) signal transmitted by a user device in a wireless network*. EX1002, ¶¶181-183.

Galda's Fig. 1 shows a baseband system model "for the OFDM-FDMA uplink with individual spreading of user data" in which an "OFDM-Transmitter" is involved with the sending of *an OFDM signal by a user device in a wireless network* (i.e., Galda's "Mobile Terminal" transmitter) and an "OFDM receiver" is *for receiving an OFDM signal* (i.e., Galda's "Base Station" receiver) transmitted by the Mobile Terminal in the network.



EX1004, p.1738 (Fig. 1); EX1002, ¶182.

Thus, Galda in view of Brüninghaus renders obvious [1Pre].

b. [1A]: determining subcarrier frequencies

Galda and Brüninghaus render obvious *determining a plurality of subcarrier frequencies allocated to the user device*. EX1002, ¶¶184-190.

On the transmitter/*user device* side, Galda teaches an “OFDM-FDMA multiple access scheme” can be “combined with a data spreading technique based on a Discrete Fourier Transform (DFT) spreading matrix using only the user specific subcarriers.” EX1004, p.1738. “By allocating distinct sets of subcarriers to different

users the available bandwidth can be flexibly shared between different mobile terminals....” *Id.* Moreover, “[i]f channel state information is not available the performance can be increased using an additional spreading over the subcarriers assigned to one user.” *Id.* In one example, “ M different users are considered and each user allocates L different subcarrier[s] exclusively. The total number of subcarrier[s] in the considered transmission system is $N_C = L \cdot M$.” *Id.* at p.1738. Thus, in the transmitter of Galda, each user signal is transformed and split (“spread”) into a set of subcarriers. EX1002, ¶¶185-186.

On the receiver side, Galda teaches receiving, at a base station, a time signal from a “user m ” and:

calculating the Fourier transformation (FFT) which splits the time signal into the orthogonal subcarrier channels and finally selecting the user specific complex valued symbols $R_l^{(m)}$ at the FFT output. The user specific subcarrier set is located at subcarrier $k = m, m + M, \dots, m + (L - 1)M$ for user m .

EX1004, pp.1738-39.

Accordingly, by explaining that (1) subcarriers are uniquely allocated to users, (2) that the FFT in the receiver “splits the time signal into the orthogonal subcarrier channels,” and (3) spread symbols $R_l^{(m)}$ are selected, Galda is teaching *determining a plurality of subcarrier frequencies* (“orthogonal subcarrier channels” and “user

specific subcarrier set”) *allocated to the user device* (device corresponding to “user m ”) to thus allow for the FFT to be performed and the FDMA-Demapping to generate spread data symbols $R_{n,l}^{(m)}$ before despreading them. EX1002, ¶¶187-188. Indeed, the use of the FFT to determine the subcarriers allocated to a user is the same purpose it is used for in a receiver disclosed in the ’386 Patent. EX1001, 67:52-55 (DFT, such as an FFT or “other types of filters” are used to “select one or more subcarrier components allocated to a particular user”).

Thus, Galda in view of Brüninghaus renders obvious Limitation [1A].

c. [1B]: converting OFDM signal to frequency-domain

Galda in view of Brüninghaus renders obvious *converting the OFDM signal to a plurality of frequency-domain values corresponding to the plurality of subcarrier frequencies*. EX1002, ¶¶191-193.

Galda’s “OFDM time signal of user m ” is transmitted to the receiver where an FFT “splits the time signal into the orthogonal subcarrier channels.” EX1004, p.1738. This splitting converts *the OFDM time signal* (i.e., the “OFDM time signal of user m ”) *to a plurality of frequency-domain values* (“user specific complex valued symbols $R_l^{(m)}$ at the FFT output,” which correspond *to the plurality of subcarrier frequencies* (“orthogonal subcarrier channels”). *Id.*; EX1002, ¶192. These subcarrier frequencies are the frequencies allocated to user m . EX1004, p.1738 (“The user

specific subcarrier set is located at subcarrier $k = m, m + M, \dots, m + (L - 1)M$ for user m .”).

Thus, Galda in view of Brüninghaus renders obvious Limitation [1B].

d. [1C]: decoding frequency-domain values

Galda in view of Brüninghaus renders obvious *decoding the plurality of frequency-domain values* (“complex valued symbols $R_l^{(m)}$ ”) *to recover a plurality of data symbols* (“data symbols $\tilde{D}_l^{(m)}$ ”) *encoded by the user device on the plurality of subcarrier frequencies*. EX1002, ¶¶194-198.

As explained above, Galda’s transmitter uses DFT spreading to encode data symbols on subcarriers. *Supra* §IX.B.2.b. For example, Galda generates “ L complex transmit symbols $S_l^{(m)}$ ” by spreading “ L complex modulation symbols $D_l^{(m)}$, $l=0, \dots, L-1$ ” “over the L user-specifically allocated subcarrier” using a “unitary spreading matrix $[C]$ ” that includes “the elements of the discrete Fourier matrix.” EX1004, pp.1738-39. Galda thus describes *encod[ing] data symbols by the user device on the plurality of subcarrier frequencies*. EX1002, ¶196

After discussing the use of FFT in the receiver to convert the received OFDM signal into frequency-domain values (“complex valued symbols $R_l^{(m)}$ ”), Galda teaches that “[a]n estimate of data symbols $\tilde{D}_l^{(m)}$ can then be calculated independently for each user by applying any single- or multi-code detection

techniques.” EX1004, pp.1738-39. Thus, Galda describes *decoding the plurality of frequency-domain values* (“complex valued symbols $R_l^{(m)}$ ”) *to recover a plurality of data symbols* (“data symbols $\tilde{D}_l^{(m)}$ ”). EX1002, ¶197.

Thus, Galda in view of Brüninghaus renders obvious Limitation [1C].

- e. [1D]: decoding employs codes inverse to set of codes that the user device employs to shape the OFDM signal into a superposition of cyclic-shifted pulse waveforms

Galda in view of Brüninghaus renders obvious *wherein decoding employs a plurality of codes that are inverse to, complex-conjugate of, or complementary to a set of complex-valued codes that the user device employs to shape the OFDM signal into a superposition of cyclic-shifted pulse waveforms that each has one of the plurality of data symbols modulated thereon*. EX1002, ¶¶199-215.

First, we address how Galda’s *user device* (“Mobile Terminal”) *employs a set of complex-valued codes* to produce the claimed OFDM signal. Next, we address the *decoding* of the coded superposition signal, which uses—or obviously would have used—the inverse of the encoding operations performed by Galda’s transmitter.

Galda’s *user device* (“Mobile Terminal”) *employs a set of complex-valued codes* to spread data symbols. EX1002, ¶¶201-203. Galda describes the “unitary spreading matrix” $[C]$ that has “elements of the discrete Fourier matrix” defined as:

$C_{i,j} = \frac{1}{\sqrt{L}} e^{j2\pi ij/L}$. EX1004, pp.1738, 1739. The matrix $[C]$ includes “ L orthogonal

code vectors $\vec{C}_l = (C_{l,0}, C_{l,1}, \dots, C_{l,L})$ with $l = 0, \dots, L - 1$.” *Id.*, p.1738. Thus, “the elements of the discrete Fourier matrix” can be expressed as: $\vec{C}_l = \frac{1}{\sqrt{L}}(e^{j2\pi l 0/L}, e^{j2\pi l 1/L}, \dots, e^{j2\pi l (L-1)/L})$ for $l=0$ to $l=L-1$. EX1002, ¶¶201-202; EX1004, pp.1738-1739. Thus, Galda’s Mobile Terminal *employs a set of complex-valued codes* $\vec{C}_l$ to spread data symbols (i.e., “ L user modulation symbols $D_l^{(m)}$ ”). EX1002, ¶203.

The application of Galda’s *set of complex-valued codes* to the “ L user modulation symbols $D_l^{(m)}$ ” to produce “transmit symbols $S_l^{(m)}$ ” which are then input into an IFFT to generate “OFDM time signal of user m ” that is expressed as

$$S_i^{(m)} = e^{j2\pi i m/N_C} \frac{1}{\sqrt{L}} \sum_{l=0}^{L-1} S_l^{(m)} e^{-j2\pi i l/L} \quad (3)$$

$$\text{for } i = -N_G, \dots, 0, \dots, N_C,$$

where the summation of subcarriers from $l = 0$ to L represents *a superposition* of the subcarriers modulated by the set of subcarrier values $S_l^{(m)}$ where l ranges from 0 to $L-1$.³ EX1004, pp.1738, 1739; EX1002, ¶203.

³ Galda provides another expression for the OFDM time-domain waveform that substitutes in the DFT matrix coefficients and the “complex modulation symbols”:

Galda's *set of complex-valued codes* $\vec{C}_l$ impart a cyclic shift to the encoded data symbols (i.e., " L complex transmit symbols $S_l^{(m)}$ ") and thus the resulting *superposition of cyclic-shifted pulse waveforms*. For example, in a situation in which $L=4$, Galda's DFT spreading matrix takes on the following values:

$$[C] = \begin{bmatrix} C_{0,0} & C_{0,1} & C_{0,2} & C_{0,3} \\ C_{1,0} & C_{1,1} & C_{1,2} & C_{1,3} \\ C_{2,0} & C_{2,1} & C_{2,2} & C_{2,3} \\ C_{3,0} & C_{3,1} & C_{3,2} & C_{3,3} \end{bmatrix} = \begin{bmatrix} \frac{1}{2}e^{j\frac{2\pi(0)(0)}{4}} & \frac{1}{2}e^{j\frac{2\pi(0)(1)}{4}} & \frac{1}{2}e^{j\frac{2\pi(0)(2)}{4}} & \frac{1}{2}e^{j\frac{2\pi(0)(3)}{4}} \\ \frac{1}{2}e^{j\frac{2\pi(1)(0)}{4}} & \frac{1}{2}e^{j\frac{2\pi(1)(1)}{4}} & \frac{1}{2}e^{j\frac{2\pi(1)(2)}{4}} & \frac{1}{2}e^{j\frac{2\pi(1)(3)}{4}} \\ \frac{1}{2}e^{j\frac{2\pi(2)(0)}{4}} & \frac{1}{2}e^{j\frac{2\pi(2)(1)}{4}} & \frac{1}{2}e^{j\frac{2\pi(2)(2)}{4}} & \frac{1}{2}e^{j\frac{2\pi(2)(3)}{4}} \\ \frac{1}{2}e^{j\frac{2\pi(3)(0)}{4}} & \frac{1}{2}e^{j\frac{2\pi(3)(1)}{4}} & \frac{1}{2}e^{j\frac{2\pi(3)(2)}{4}} & \frac{1}{2}e^{j\frac{2\pi(3)(3)}{4}} \end{bmatrix}$$

EX1002, ¶203. These codes apply a set of carrier phases when producing Galda's subcarrier values $S_l^{(m)}$ where l ranges from 0 to $L-1$, such that when the subcarrier values are modulated onto the subcarriers the resulting subcarriers also exhibit the phase shift imparted by the code. EX1002, ¶203.

When the resulting phase-shifted subcarriers undergo the OFDM modulation process via Galda's IFFT, this results in shaping of the *OFDM signal into a superposition of cyclic-shifted pulse waveforms* defined by $s_i^{(m)}$ where each shifted waveform has *one of the plurality of data symbols modulated thereon*. EX1002,

$$S_i^{(m)} = e^{j2\pi im/N_c} \cdot \frac{1}{\sqrt{L}} \cdot \sum_{l=0}^{L-1} \sum_{v=0}^{L-1} C_{l,v} D_v^{(m)} e^{-j2\pi il/L}. \text{ EX1004, p.1739.}$$

¶¶204. As Galda explains:

The transmit time signal $s_i^{(m)}$ of user m in an OFDM-FDMA uplink using DFT spreading matrix and an equidistant subcarrier allocation results therefore in a periodic repetition of the complex user data symbol $D_t^{(m)}$ sequence including an added guard interval as cyclic prefix, shown in Fig. 5. This periodic data sequence is multiplied by a user specific complex signal $e^{j2\pi im/N_C}$ due to the user individual frequency shift by m subcarriers of the complete allocated subcarrier set. The number of periods inside a single OFDM symbol is equal to the spacing M of the subcarriers allocated to user m .

EX1004, pp.1739-1740.

This is demonstrated in Galda's mathematical expressions for the case of equally spaced subcarriers:

$$\begin{aligned}
 s_i^{(m)} &= e^{j2\pi im/N_C} \cdot \frac{1}{\sqrt{L}} \cdot \sum_{l=0}^{L-1} \sum_{v=0}^{L-1} c_{lv} D_v^{(m)} e^{-j2\pi il/L} \\
 &= e^{j2\pi im/N_C} \cdot \frac{1}{L} \sum_{v=0}^{L-1} D_v^{(m)} \underbrace{\sum_{l=0}^{L-1} e^{j2\pi(v-i)l/L}}_{= L\delta_L(v-i)} \\
 &= e^{j2\pi im/N_C} \cdot \sum_{v=0}^{L-1} D_v^{(m)} \delta_L(v-i) \\
 s_i^{(m)} &= e^{j2\pi im/N_C} \cdot D_{i \bmod L}^{(m)} \quad (7)
 \end{aligned}$$

EX1004, p.1739. Here, the *set of complex-valued codes* $\vec{C}_l$ (represented by their elements “ $C_{l,v}$ ” and highlighted blue) shape the OFDM signal into a superposition of cyclic-shifted pulse waveforms (highlighted yellow) to produce a plurality of cyclic-shifted waveforms (each represented by “the periodic dirac pulse sequence $\delta_L()$ ” and highlighted green) that each have one of the data symbols (represented by “ $D_v^{(m)}$ ” and highlighted pink) modulated thereon. EX1002, ¶¶205-206. In the second line of expression 7 of Galda,

$$L \delta_L(v-i) = \sum_{l=0}^{L-1} e^{j2\pi(v-i)l/L},$$

where

- $\delta_L(v-i)$ represents L *cyclic-shifted pulse waveforms* that result in the *superposition* of such *waveforms* when summed as reflected in the expression: $\sum_{l=0}^{L-1} e^{j2\pi(v-i)l/L}$ and
- $\sum_{l=0}^{L-1} e^{j2\pi(v-i)l/L}$ is a restructuring of $\sum_{l=0}^{L-1} C_{l,v} e^{-j2\pi il/L}$ shown in the first line of expression 7 that represents how the *set of complex-valued codes* $\vec{C}_l$ shape the *OFDM signal into a superposition of the L cyclic-shifted pulse waveforms*

$$\sum_{l=0}^{L-1} \underbrace{e^{j2\pi lv/L}}_{C_{l,v} = \vec{C}_l} \cdot e^{-j2\pi il/L} = \sum_{l=0}^{L-1} e^{j2\pi(v-i)l/L} = L \delta_L(v-i).$$

EX1002, ¶206; EX1004, p.1739.

As Dr. Bims explains, $\delta_L(v - i)$ represents *L cyclic-shifted pulse waveforms* defined as:

$$\delta_L(v - i) = \begin{cases} 1, & \text{for } v \bmod L = i \bmod L \\ 0, & \text{otherwise} \end{cases}$$

where v identifies a particular one of the L cyclic-shifted waveforms having a unique shift v , where $v = 0, \dots, L - 1$, i indexes the waveform samples, and L defines each cyclic-shifted waveform's cyclic nature. EX1002, ¶207. For example, $\delta_L(0 - i)$ represents a first *cyclic-shifted pulse waveform* that is equal to 1 whenever $i \bmod L = 0$, and $\delta_L(1 - i)$ represents a second *cyclic-shifted pulse waveform* that is equal to 1 whenever $i \bmod L = 1$. *Id.*

When $N_C = 8$, $M = 4$, and $L = 2$ as in the example illustrated in Fig. 5 of Galda, $\delta_L(v - i)$ becomes $\delta_2(v - i)$ and $s_i^{(m)}$ may be expressed as

$$\begin{aligned} s_i^{(m)} &= e^{j2\pi im/8} \cdot \sum_{v=0}^{2-1} D_v^{(m)} \delta_2(v - i) \\ &= e^{j2\pi im/8} \left(D_0^{(m)} \delta_2(0 - i) + D_1^{(m)} \delta_2(1 - i) \right) \end{aligned}$$

where $\delta_2(0 - i)$ is a first of a plurality of cyclic-shifted pulse waveforms that has a first one of the data symbols $D_0^{(m)}$ modulated thereon, and $\delta_2(1 - i)$ is a second of the plurality of cyclic-shifted pulse waveforms that has a second one of the data

symbols $D_1^{(m)}$ modulated thereon. EX1002, ¶¶208; EX1004, p.1739. In this example, $\delta_2(0 - i)$ is a cyclic-shifted pulse waveform that is equal to 1 whenever $i \bmod 2 = 0$ (i.e., when $i = -2, 0, 2, 4, \text{ or } 6$), and $\delta_2(1 - i)$ is a cyclic-shifted waveform that is equal to 1 when $i \bmod 2 = 1$ (i.e., when $i = -1, 1, 3, 5, \text{ or } 7$) as shown below:

i		-2	-1	0	1	2	3	4	5	6	7	
$\delta_2(0 - i)$		1	0	1	0	1	0	1	0	1	0	
$\delta_2(1 - i)$		0	1	0	1	0	1	0	1	0	1	

EX1002, ¶208.

Thus, $D_0^{(m)}\delta_2(0 - i)$ and $D_1^{(m)}\delta_2(1 - i)$ may be illustrated as:

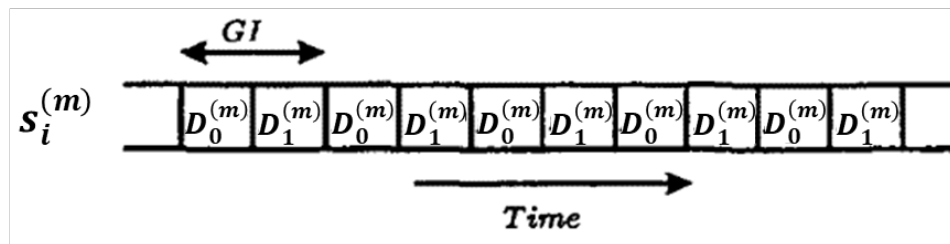
$D_0^{(m)}\delta_2(0 - i)$		$D_0^{(m)}$		$D_0^{(m)}$		$D_0^{(m)}$		$D_0^{(m)}$		$D_0^{(m)}$		
$D_1^{(m)}\delta_2(1 - i)$			$D_1^{(m)}$		$D_1^{(m)}$		$D_1^{(m)}$		$D_1^{(m)}$		$D_1^{(m)}$	

and

$$s_i^{(m)} = e^{j2\pi im/8} \left(D_0^{(m)}\delta_2(0 - i) + D_1^{(m)}\delta_2(1 - i) \right)$$

may be illustrated in a simplified form like that shown in Fig. 5 of Galda⁴ as

⁴ A POSITA would understand that Galda's Fig. 5 simplifies expression 7 and omits

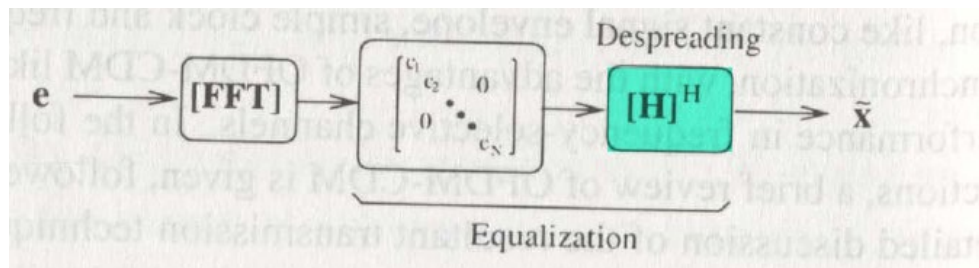


EX1002, ¶¶208-209.

Turning to the receiver side of things, while Galda explains that “data symbols $\tilde{D}_l^{(m)}$ ” can be recovered “for each user by applying any single- or multi-code detection techniques,” and indicates that the recovery of the data symbols is performed by the “Equalization + Detection” block, Galda does not describe a step of decoding that *employs a plurality of codes that are inverse to, complex-conjugate of, or complementary to a set of complex-valued codes*. Brüninghaus describes this. For example, Brüninghaus provides details of how to recover data symbols when

the term “ $e^{j2\pi lm/8}$ ” to illustrate the periodic repetition of the complex user data symbol $D_l^{(m)}$ sequence. EX1002, ¶210. A POSITA would also have understood that the indices of the complex user data symbol $D_l^{(m)}$ sequence used in Galda’s Fig. 5 is one-based indexing (i.e., ranges from 1 to L), rather than the zero-based indexing (i.e., ranges from 0 to $L-1$) as used in expression 7 and Petitioner’s example. *Id.* This change in nomenclature has no bearing on the resulting mathematics nor how Galda meets the claims. *Id.*

DFT spreading is used in a transmitter. For example, Brüninghaus shows:



EX1016, p.2330. Brüninghaus's "despreading" uses "an inverse Fast-Fourier matrix $[H]^H$." EX1016, pp.2329-30 (Figs. 3 & 4). As explained above the superscript " H " represents the Hermitian transpose, which is also known as the "conjugate transpose" or the "complex conjugate transpose." See EX1077, 2:2-3 ("The Hermitian transpose of a matrix A , denoted by A^H , is the complex conjugate transpose of A ."); EX1002, ¶¶211-213. Thus, Brüninghaus's receiver employs *codes that are inverse to, complex-conjugate of, or complementary to* the DFT spreading codes $[H]$ because it uses the complex conjugate transpose of matrix $[H]$, i.e., $[H]^H$. EX1002, ¶¶213-214. It would have been obvious to implement Brüninghaus's complex-conjugate codes in Galda's "Equalization + Detection" block to recover the original data symbols in the received information signals for the reasons explained above. *Supra* §IX.B.1.

Thus, Galda in view of Brüninghaus renders obvious Limitation **[1D]** and claim 1.

3. *Claim 6*

Galda in view of Brüninghaus renders obvious *wherein converting the OFDM signal to a plurality of frequency-domain values uses a discrete Fourier transform*. EX1002, ¶¶217-220.

Galda teaches performing a fast Fourier transform (FFT) on an OFDM time signal to “split[] the time signal into the orthogonal subcarrier channels,” as discussed above with reference to Limitation [1B]. EX1004, p.1738; *supra*, §IX.B.2.c. An FFT is a type of discrete Fourier transform as the '386 Patent recognizes. EX1001, 60:60-63 (referring to “a DFT implemented with a fast transform algorithm, such as a fast Fourier transform”); EX1002, ¶¶218-219.

Thus, Galda in view of Brüninghaus renders obvious claim 6.

4. *Claim 7*

Galda in view of Brüninghaus renders obvious *further comprising removing at least one of a guard interval, a cyclic prefix, and a cyclic postfix from the OFDM signal before converting the OFDM signal to the plurality of frequency-domain values*. EX1002, ¶¶221-224.

Galda teaches that its transmitter inserts a “guard interval ... into the transmit time signal.” EX1004, p. 1738. The receiver processes this OFDM time signal “by removing the guard interval, [and] calculating the Fourier transformation (FFT) which splits the time signal into the orthogonal subcarrier channels....” *Id.* As

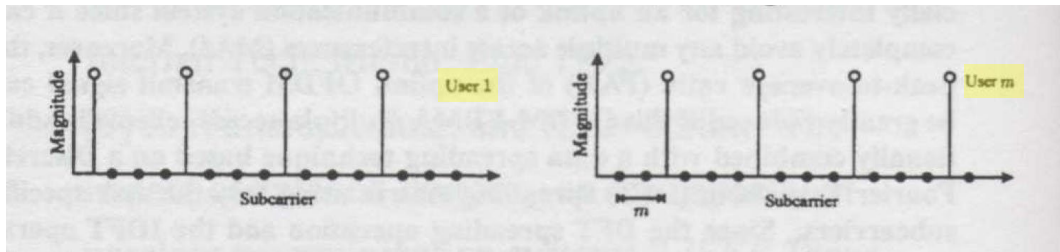
discussed above with reference to Limitation **[1B]** (*supra*, §IX.B.2.c), Galda's calculation of the FFT to split the time signal into the orthogonal subcarrier channels is a process of *converting the OFDM signal to the plurality of frequency-domain values*. EX1002, ¶¶222-223. Accordingly, Galda teaches *removing ... a guard interval* ("removing the guard interval") *... from the OFDM signal* (the "OFDM time signal") *before converting the OFDM signal to the plurality of frequency-domain values* ("calculating the [FFT] which splits the time signal into the orthogonal subcarrier channels").

Thus, Galda in view of Brüninghaus renders obvious claim 7.

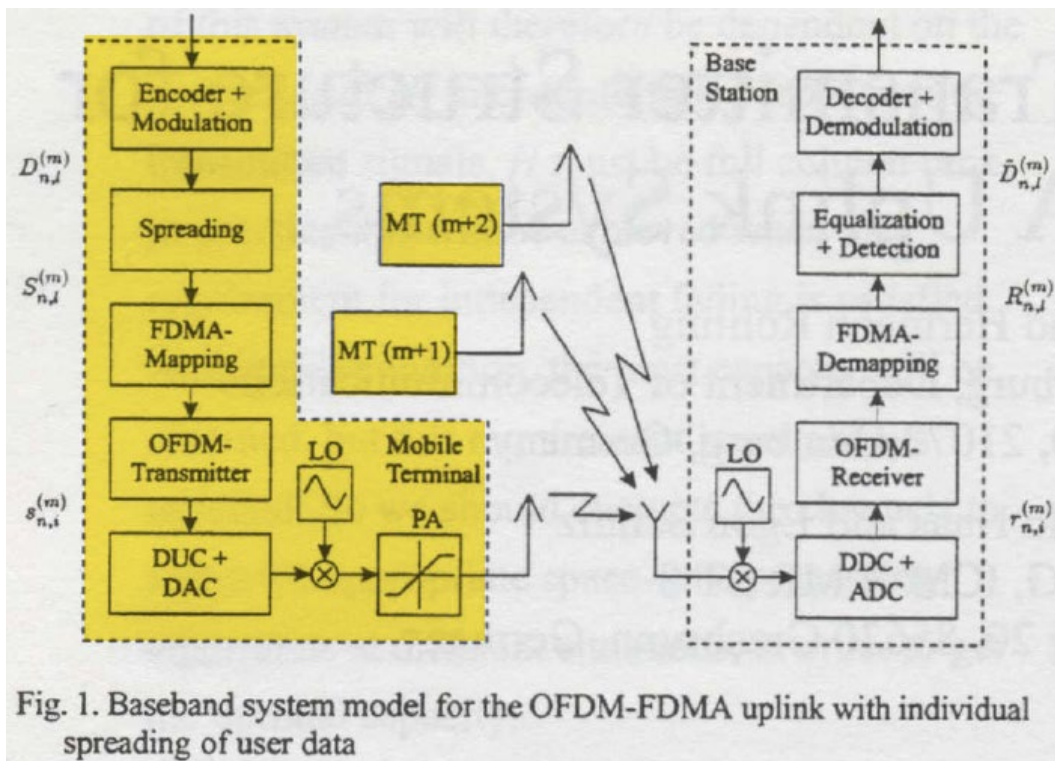
5. *Claim 8*

Galda in view of Brüninghaus renders obvious *wherein converting the OFDM signal to the plurality of frequency-domain values provides for orthogonal frequency division multiple access for the user device and at least one other user device*. EX1002, ¶¶225-229.

On the transmitter side, Galda explains that the system can include a total of N_C subcarriers, of which L subcarriers are allocated to a particular user. EX1004, p.1738 ("In principle, the set of subcarrier[s] assigned to each user can be composed of any L out of N_C subcarrier that have not been assigned to another user."). Galda gives an example of selecting the set of subcarriers *for the user device* (e.g., of "User 1") *and at least one other user device* ("User m") as shown below:



EX1004, p.1738; EX1002, ¶226. This is the point of Galda’s “OFDM-FDMA” system, which stands for “orthogonal frequency division-frequency division multiple access.” EX1004, p.1737 (referring to scheme as a “OFDM-FDMA multiple access scheme”); EX1002, ¶227. Galda’s receiver performs *converting the OFDM signal* from the transmitter by implementing the opposite or inverse function as the transmitter. EX1004, p.1738; EX1002, ¶¶227-228. Galda’s Figure 1 shows the receiver (“Base Station” and “OFDM-Receiver” thereof) processing signals from multiple users (“Mobile Terminal,” “MT (m+1),” and “MT (m+2)”):



EX1004, p.1738 (Fig. 1); EX1002, ¶228.

Thus, Galda in view of Brüninghaus renders obvious claim 8.

C. Ground 4: Claims 10, 15-17, 19, and 24-26 are obvious over Galda in view of Brüninghaus and further in view of Dowling

1. Overview of the combination; motivation to combine; expectation of success

Ground 4 relies on Galda in view of Brüninghaus and further in view of Dowling and addresses claims 10, 15-17, 19, and 24-26. Claims 10 and 15-17 require “at least one processor” [10A] and “a non-transitory computer-readable memory communicatively coupled to the at least one processor, the non-transitory computer-readable memory including a set of instructions stored thereon and executable by the at least one processor” [10B]. Similarly, claims 19 and 24-26 require “a non-

transitory computer readable storage device having computer readable program code stored therein, said program code containing instructions executable by one or more processors of a computer system for” [19Pre]. Otherwise, these claims correspond to claims 1 and 6-8, as shown above in the Listing of Claims and further below.

While these claims require computer instructions stored in memory, Galda and Brüninghaus do not explicitly state whether the disclosed systems are implemented in hardware or a combination of hardware and software. EX1002, ¶¶230-236. Nevertheless, a POSITA would have understood that Galda in view of Brüninghaus would have needed to be implemented using at least one of these technologies. *Id.* A POSITA would have found it obvious to implement Galda in view of Brüninghaus in software stored in memory coupled to a processor such that the software is executed by the processor. *Id.*

A POSITA knew that receivers could be implemented in hardware or software. For example, Dowling explains that various aspects of an OFDM receiver including its modulation techniques “may be implemented as software modules which execute on a programmable processor architecture.” EX1042, 3:46-50 (disclosing that “any of the units and/or modules” disclosed in Dowling, including receivers, “may be implemented as software modules which execute on a programmable processor architecture”); *see id.* at 5:66-6:1 (disclosing that the

“transmitter, receiver and precoder may be implemented in hardware or software”); 21:62-64 (disclosing that the “present invention” is applicable to “FFT based multicarrier modulation and OFDM systems”). In a software implementation, software is stored in some form of memory and is provided from memory to a processor for execution as was well known to a POSITA. EX1002, ¶233. Indeed, those skilled in the art were aware of “software radios” that used code in memory and processors to execute that code to provide flexibility in design and updating, as opposed to hardware which was significantly more difficult to upgrade because it is fixed in silicon. EX1002, ¶233; EX1008 (describing OFDM-CDMA software radio); EX1011, ¶¶[0124]-[0125] (noting that modulation “and other techniques” can be implemented in “hardware, software, or a combination thereof”).

A POSITA would have been motivated to implement the claimed receiving techniques as reflected in the combined teachings of Galda in view of Brüninghaus as discussed in connection with Ground 3 in a software radio (including code in memory and a processor coupled to memory to execute the code) rather than in specialized hardware because doing so would have involved (a) the simple substitution of one known element (a software-based receiver) for another (hardware implementation of same) to obtain predictable results (the same functionality performed in software rather than hardware), (b) the predictable use of prior art elements (software-based receiver components) according to their established

functions (i.e., performing the same functions taught by the combined teachings of Galda and Brüninghaus), and (c) applying a known technique (software implementation) to a known device (the Galda-Brüninghaus receiver) ready for improvement—e.g., in need of implementation details—to yield predictable results (a receiver using complex-conjugate of the DFT spreading codes used in a transmitter as reflected by the combined teachings of Galda and Brüninghaus where the operations are implemented in software). EX1002, ¶¶234-235.

A POSITA also would have expected to succeed in making this combination. Galda in view of Brüninghaus discloses an OFDM receiver with the claimed features and defines the various mathematical operations for each of the components. Implementing these mathematical operations in software would have required only routine knowledge because software is especially well-suited for performing mathematical operations. EX1002, ¶236. Given numerous disclosures indicating that those in the field were aware that various transceiver (transmitter and receiver) functions were able to be implemented in either hardware or software—two known alternatives—a POSITA would have reasonably expected success in achieving a software implementation using instructions stored on a memory for execution by a processor. *Id.*

2. Claims 10 and 19

Galda in view of Brüninghaus and further in view of Dowling renders obvious

the following aspects of claims 10 and 19:

[10Pre] *An apparatus for receiving an Orthogonal Frequency Division Multiplexing (OFDM) signal transmitted by a user device in a wireless network, the apparatus comprising: [10A] at least one processor; and [10B] a non-transitory computer-readable memory communicatively coupled to the at least one processor, the non-transitory computer-readable memory including a set of instructions stored thereon and executable by the at least one processor for:*

[19Pre] *A computer program product for receiving an Orthogonal Frequency Division Multiplexing (OFDM) signal transmitted by a user device in a wireless network, the computer program product comprising a non-transitory computer readable storage device having computer readable program code stored therein, said program code containing instructions executable by one or more processors of a computer system for:*

EX1002, ¶¶237-241.

As discussed above (*supra*, §§IX.B.2, IX.C.1), Galda and Brüninghaus both disclose OFDM systems including receivers, but these references do not explicitly state whether the OFDM procedures are performed with hardware or software.

Dowling explains that various aspects of an OFDM receiver including its modulation techniques “may be implemented as software modules which execute on

a programmable processor architecture.” EX1042, 3:46-50; *see id.*, 5:66-6:1 (disclosing that the “transmitter, receiver and precoder may be implemented in hardware or software”); 21:62-64 (disclosing that the “present invention” is applicable to “FFT based multicarrier modulation and OFDM systems”). In a software implementation, software is stored in *memory*, and is provided from memory to a *processor* for execution. EX1002, ¶¶239-240. This software is *computer-readable program code* and the memory is a *computer-readable memory* because it can be read by a *processor* to obtain the software code for execution. A POSITA knew about “software radios” with code in memory and processors to execute that code to provide flexibility in design and updating, as opposed to hardware which was significantly more difficult to upgrade because it is fixed in silicon. EX1002, ¶240; EX1008 (describing OFDM-CDMA software radio); EX1011, ¶¶[0124]-[0125] (modulation can be implemented in “hardware, software, or a combination thereof”). For the reasons already explained above, a POSITA would have found it obvious to implement the combined Galda-Brüninghaus receiver in software stored on memory for execution by a processor coupled to the memory as recited in claims 10 and 19. *Supra* §IX.C.1.

Thus, Galda in view of Brüninghaus and further in view of Dowling discloses and renders obvious limitations [10Pre], [10A], [10B], [19Pre].

a. [10Ci], [19A]: determining subcarrier frequencies

Limitations [10Ci] and [19A] are the same as Limitation [1A]. *Supra* §IX.B.2.b; EX1002, ¶242. Limitations [10Ci] and [19A] are rendered obvious by Galda in view of Brüninghaus for the same reasons as Limitation [1A]. *Id.* It would be obvious to implement the functionality recited in this limitation in software stored in memory for execution by a processor for the reasons provided above based on Galda in view of Brüninghaus and further in view of Dowling. *Supra* §IX.C.1.

b. [10Cii], [19B]: converting OFDM signal to frequency-domain

Limitations [10Cii] and [19B] are the same as Limitation [1B]. *Supra* §IX.B.2.c; EX1002, ¶243. Limitations [10Cii] and [19B] are rendered obvious by Galda in view of Brüninghaus for the same reasons as Limitation [1B]. *Id.* It would be obvious to implement the functionality recited in this limitation in software stored in memory for execution by a processor for the reasons provided above based on Galda in view of Brüninghaus and further in view of Dowling. *Supra* §IX.C.1.

c. [10Ciii], [19C]: decoding frequency-domain values

Limitations [10Ciii] and [19C] are the same as Limitation [1C]. *Supra* §IX.B.2.d; EX1002, ¶244. Limitations [10Ciii] and [19C] are rendered obvious by Galda in view of Brüninghaus for the same reasons as Limitation [1C]. *Id.* It would be obvious to implement the functionality recited in this limitation in software stored in memory for execution by a processor for the reasons provided above based

on Galda in view of Brüninghaus and further in view of Dowling. *Supra* §IX.C.1.

- d. [10Civ], [19D]: decoding employs codes inverse to set of codes that the user device employs to shape the OFDM signal into a superposition of cyclic-shifted pulse waveforms

Limitations [10Civ] and [19D] are the same as Limitation [1D]. *Supra* §IX.B.2.e; EX1002, ¶245. Limitations [10Civ] and [19D] are rendered obvious by Galda in view of Brüninghaus for the same reasons as Limitation [1D]. *Id.* It would be obvious to implement the functionality recited in this limitation in software stored in memory for execution by a processor for the reasons provided above based on Galda in view of Brüninghaus and further in view of Dowling. *Supra* §IX.C.1.

Thus, Galda in view of Brüninghaus and further in view of Dowling renders obvious claims 10 and 19.

3. *Claims 15 and 24*

Claims 15 and 24 are the same as claim 6. *Supra* §IX.B.3; EX1002, ¶¶247-248. Accordingly, Galda in view of Brüninghaus renders obvious the functionality recited in claims 15 and 24 for the same reasons provided with respect to claim 6. *Supra* §IX.B.3. Galda in view of Brüninghaus and further in view of Dowling thus renders obvious the software implementation recited in claims 15 and 24 for the reasons discussed above. *Supra* §IX.C.1.

4. *Claims 16 and 25*

Claims 16 and 25 are the same as claim 7. *Supra* §IX.B.4; EX1002, ¶¶249-

250. Accordingly, Galda in view of Brüninghaus renders obvious the functionality recited in claims 16 and 25 for the same reasons provided with respect to claim 7. *Supra* §IX.B.4. Galda in view of Brüninghaus and further in view of Dowling thus renders obvious the software implementation recited in claims 16 and 25 for the reasons discussed above. *Supra* §IX.C.1.

5. *Claims 17 and 26*

Claims 17 and 26 are the same as claim 8. *Supra* §IX.B.5; EX1002, ¶¶251-252. Accordingly, Galda in view of Brüninghaus renders obvious the functionality recited in claims 17 and 26 for the same reasons provided with respect to claim 8. *Supra* §IX.B.5. Galda in view of Brüninghaus and further in view of Dowling thus renders obvious the software implementation recited in claims 17 and 26 for the reasons discussed above. *Supra* §IX.C.1.

X. DISCRETIONARY DENIAL

In accordance with the recent guidance from the Office, Petitioner reserves any arguments about discretionary denial to address arguments that may be presented by Patent Owner in its discretionary denial briefing. Nevertheless, Petitioner hereby stipulates that it will not attempt to prove unpatentability or invalidity on any prior art that it could have reasonably presented in this proceeding in accordance with *Sotera Wireless, Inc. v. Masimo Corporation*, IPR2020-01019, Paper 12 at 13-14 (PTAB Dec. 1, 2020).

XI. MANDATORY NOTICES

A. Real Party-In-Interest

Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc. are the real parties-in-interest.

B. Related Matters

The '386 Patent is asserted in the following litigation: *GenghisComm Holdings, LLC v. Samsung Electronics America, Inc.*, No. 2:24-cv-901-RWS-RSP (E.D. Tex.).

Eight patents that are in the same or related patent families and which name the same inventor are asserted in the following litigation: *GenghisComm Holdings, LLC v. Samsung Electronics America, Inc. f/k/a Samsung Telecommunications America LLC*, No. 24-cv-00242. Those eight patents are also the subject of the following post-grant challenges:

- **U.S. Patent No. 9,768,842:** *Samsung Electronics Co., Ltd. v. GenghisComm Holdings, LLC*, IPR2025-00780.
- **U.S. Patent No. 10,200,227:** U.S. Reexamination Control No. 90/019,411; *Samsung Electronics Co., Ltd. v. GenghisComm Holdings, LLC*, IPR2025-00781.
- **U.S. Patent No. 10,389,568:** *Samsung Electronics Co., Ltd. v. GenghisComm Holdings, LLC*, IPR2025-00788.

- **U.S. Patent No. 11,075,786:** *Samsung Electronics Co., Ltd. v. GenghisComm Holdings, LLC*, IPR2025-00789; Petitioner also anticipates filing a request for reexamination as to this patent to raise grounds that cannot be raised in this proceeding.
- **U.S. Patent No. 11,223,508:** *Samsung Electronics Co., Ltd. v. GenghisComm Holdings, LLC*, IPR2025-00790; Petitioner also anticipates filing a request for reexamination as to this patent to raise grounds that cannot be raised in this proceeding.
- **U.S. Patent No. 11,252,005:** U.S. Reexamination Control No. 90/019,847; *Samsung Electronics Co., Ltd. v. GenghisComm Holdings, LLC*, IPR2025-00791.
- **U.S. Patent No. 11,381,285:** *Samsung Electronics Co., Ltd. v. GenghisComm Holdings, LLC*, IPR2025-00792; Petitioner also anticipates filing a request for reexamination as to this patent to raise grounds that cannot be raised in this proceeding.
- **U.S. Patent No. 11,424,792:** *Samsung Electronics Co., Ltd. v. GenghisComm Holdings, LLC*, IPR2025-00793; U.S. Reexamination Control No. 90/019,848.

C. Lead and Back-Up Counsel

Petitioner designates the following lead and back-up counsel:

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D. Service

Petitioner consents to service by email on the following email address:

GT-Genghiscomm-IPR@gtlaw.com.

XII. FEES

The required fee is being paid electronically through P-TACTS.

Dated: April 28, 2025

Respectfully Submitted,

/Andrew R. Sommer/

Andrew R. Sommer
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CERTIFICATE OF COMPLIANCE

This petition complies with the word count limits set forth in 37 C.F.R. § 42.24(a)(i), effective May 2, 2016, because this Petition contains 13,357 words, excluding the parts of the petition exempted by 37 C.F.R. § 42.24(a), as determined using the word count provided by Microsoft Word, which was used to prepare this Petition.

Dated: April 28, 2025

Respectfully Submitted,

/Andrew R. Sommer/

Andrew R. Sommer
Reg. No. 53,932

CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. §§ 42.6(e) and 42.105(a), the undersigned certifies that on April 28, 2025, I caused a true and correct copy of **PETITION FOR *INTER PARTES* REVIEW OF CLAIMS 1-3, 5-8, 10-12, 14-17, 19-21, AND 23-26 OF U.S. PATENT NO. 11,431,386, PETITIONER’S POWER OF ATTORNEY BY SAMSUNG ELECTRONICS CO., LTD., PETITIONER’S POWER OF ATTORNEY BY SAMSUNG ELECTRONICS AMERICA, INC., AND EXHIBIT NOS. 1001-1002, 1004, 1007-1008, 1011-1016, 1021, 1030-1032, 1042, 1059, 1073, 1075, 1077, 1081, 1099-1103, AND 1107-1110** by EXPRESS MAIL on the Patent Owner at the correspondence address of record for U.S. Patent No. 11,431,386 as follows:

Mr. Steven J Shattil
P.O. Box 17355
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UNITED STATES

I further certify that a courtesy copy of the above-identified materials were served on litigation counsel by electronic means upon the foregoing individuals:

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/Andrew R. Sommer/

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