

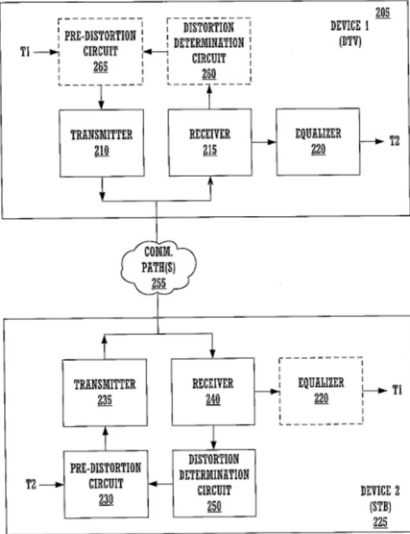
DEFENDANTS' INVALIDITY CONTENTIONS FOR U.S. PAT. 8,891,347

EXHIBIT A4: US20100159855A1 ("Hardacker")

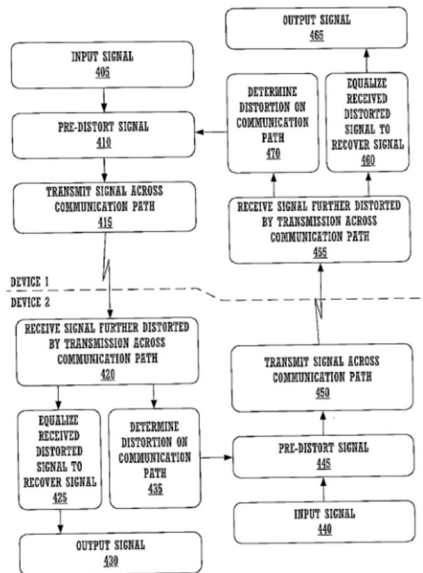
As demonstrated in the claim charts below, the claims of U.S. Patent No. 8,891,347 ("the '347 patent") are invalid (a) under one or more sections of 35 U.S.C. § 102 as anticipated by Hardacker and (b) under 35 U.S.C. § 103(a) as obvious over Hardacker standing alone and as set forth herein, and/or combined with the knowledge of a person of ordinary skill in the art, Applicant's Admitted Prior Art, and/or the additional prior art identified in Defendant's Preliminary Invalidity Contentions, the contents of which are hereby incorporated by reference into this chart. One of ordinary skill in the art, as of the priority date of the '347 patent, would have known to combine the prior art elements disclosed by the foregoing references using known methods, and to use these elements according to their established functions in order to achieve a known and predictable result.

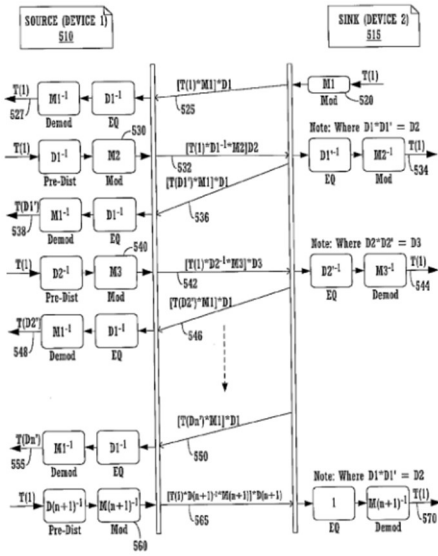
Defendant has conducted the invalidity analysis herein based at least in part and in some instance entirely upon Plaintiff's apparent application of the claims of the '347 patent. By charting the prior art against the claims and elements herein, Defendant is not admitting or agreeing to Plaintiff's application of the claims at issue in this case, and these charts should not be interpreted as an admission or concession by Defendant that any particular construction or application of any claim element by Plaintiff is correct or proper. Additionally, these charts provide representative examples of portions of the charted references that disclose the indicated elements of the claims; additional portions of these references other than the representative examples provided herein may also disclose the indicated element(s). For example, where a particular figure is cited, the citation should be understood to encompass the caption and description of the figure as well as any text relating to or describing the figure. Conversely, where particular text referring to a figure is cited, the citation should be understood to include the figure as well.

Claim Element	Exemplary Citations to Hardacker
19[pre] A wireless device for performing wireless communication with a base station with a transmitter via a plurality of propagation paths, the wireless device comprising:	By providing this disclosure, Defendant does not take a position on whether the preamble is a claim limitation. Hardacker discloses or renders obvious "[a] wireless device for performing wireless communication with a base station with a transmitter via a plurality of propagation paths." For example: Hardacker at Abstract Techniques for sending and receiving signals include pre-distorting signals before transmission across a communication path. The signals are pre-distorted as a function of a distortion on the communication path. In one embodiments, transmitter a broadcasts to receiver b and there is also a transmitter b broadcasting to receiver a. This return channel enables both transmitters a and b to have a priori information regarding the transmission medium and path the signal takes. In this way, the nature of the distortion or interference is known to the transmitter, therefore, it pre-distorts the transmitted signal to compensate for the receiver exceeding its capabilities in recovering signal.

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 2  FIGURE 2

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 3 <pre> graph TD subgraph Device_1 [DEVICE 1] 305[INPUT SIGNAL 305] --> 310[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 310] 345[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 345] --> 350[OUTPUT SIGNAL 350] end subgraph Device_2 [DEVICE 2] 315[RECEIVE SIGNAL DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 315] --> 320[DETERMINE DISTORTION ON COMMUNICATION PATH 320] 320 --> 330[PRE-DISTORT SIGNAL 330] 330 --> 335[TRANSMIT PRE-DISTORTED SIGNAL ACROSS COMMUNICATION PATH 335] end 310 -.-> 315 335 -.-> 345 </pre> FIGURE 3

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 4  <pre> graph TD subgraph Device_1 [DEVICE 1] 405[INPUT SIGNAL 405] --> 410[PRE-DISTORT SIGNAL 410] 410 --> 415[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 415] 470[DETERMINE DISTORTION ON COMMUNICATION PATH 470] 460[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 460] 455[RECEIVE SIGNAL FURTHER DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 455] 450[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 450] 406[OUTPUT SIGNAL 406] end subgraph Device_2 [DEVICE 2] 420[RECEIVE SIGNAL FURTHER DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 420] 425[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 425] 435[DETERMINE DISTORTION ON COMMUNICATION PATH 435] 440[INPUT SIGNAL 440] 445[PRE-DISTORT SIGNAL 445] 430[OUTPUT SIGNAL 430] end 415 -.-> 420 425 --> 430 435 --> 470 470 --> 460 460 --> 455 440 --> 445 445 --> 450 450 --> 455 455 --> 406 </pre> FIGURE 4

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 5  FIGURE 5 Hardacker at [0001] Radio frequency (RF) receivers are typically more difficult to construct than RF transmitters. Hardacker at [0002] FIG. 1 shows a communication system according to the conventional art. The communication system 100 includes a transmitter 110, a communication path 120, a receiver 130 and an equalizer 140. The transmitter 110 transmits a signal $[T]$ across the communication path 120. The receiver 130 receives a distorted signal $[T]*[D]$ after transmission across the communication path 120. The equalizer 140 equalizes $[D-1]$ the distorted signal $[T]*[D]$. If the distortion on the communication channel 120 is less than the recovery capability $[D-1]$ of the equalizer 140, the recovered signal will be substantially equal to the transmitted signal $[T]$. However, if the distortion on the communication channel 120 is greater than the recovery capability of the equalizer 140, the recovered signal $[T']$ will not be equal to the transmitted signal $[T]$. Hardacker at [0004] In another embodiment, a system for sending and receiving signals includes one or more devices coupled to one or more communication paths. At least one device includes a transceiver coupled to the

Claim Element	Exemplary Citations to Hardacker
	communication path and a pre-distortion circuit coupled to the transceiver. The pre-distortion circuit pre-distorts the signals to be transmitted by the transceiver of the given device as a function of the distortion on the communication path. When the signal is transmitted, the distortion on the communication path is at least partially compensated for by the pre-distortion introduced by the pre-distortion circuit. Hardacker at [0005] In one embodiment of the present invention, a first transmitter (a) broadcasts to first receiver (b) and there is also a second transmitter (of b) broadcasting to second receiver (of a). This return channel enables both transmitters (a) and (b) to have a priori information regarding the transmission medium and path the signal takes. In this way, the nature of the distortion or interference is known to the transmitter, therefore, it pre-distorts the transmitted signal to compensate for the receiver exceeding its capabilities in recovering signal. This functionality, in accordance with embodiments of the present invention, reduces the complexity of the receiver by placing some of the burden on the transmitter. The back channel enables optimization of the original signal for the current state of the communications channel. Hardacker at [0006] In another embodiment, a communication methodology is employed in an asymmetric system where complex modulation can be employed while using equalizers and recovery circuits having only limited complexity. In this embodiment, a training signal is sent from a sink device to a source device using a simple modulation M1. The source device, knowing the training signal, determines an equalization $D1^{-1}$ that is able to recover the training signal wherein D1 is the channel distortion for M1. The source then pre-distorts the training signal with the computed $D1^{-1}$ and communicates this back to the sink using a second order modulation M2. The sink then knowing the training signal employs a simple equalization circuit to determine another distortion amount $D1'$ required to recover the training signal from the pre-distorted transmission, where $D1' \cdot D1$ equals D2 (the channel distortion of the M2 modulated signal). Advantageously, the sink then uses M1 to transmit back to the source the computed $D1'$ and upon which the source can compute D2 since it knows D1. Here, the source advantageously uses a simple equalization circuit and simple modulation circuit. Knowing D2, the source can use M2 to communicate large amounts of data to the sink device (as pre-distorted by D2) even though the sink device has a relatively simple equalization circuit and also a simple modulator. Alternatively, the above iterative methodology can be repeated for higher order modulations, e.g., M3, etc. Although equalization is described above, this discussion is merely exemplary. This embodiment operates equally well employing other distortion types, e.g., multi-path, amplitude, frequency, phase and other well known types. Hardacker at [0014] Referring now to FIG. 2, an exemplary system for transmitting and receiving signals, in accordance with

Claim Element	Exemplary Citations to Hardacker
	embodiments of the present technology, is shown. In one embodiment, the system includes a plurality of devices 205 and 225 communicatively coupled by a communication network. A first device 205 may include a transmitter 210, a receiver 215 and optionally an equalizer 220. A second device 225 may include a pre-distortion circuit 230, a transmitter 235, a receiver 240, a distortion determination circuit 250 and optionally an equalizer 245. The first and second devices 205 and 225 transmit and receive signals across one or more communication paths 255 of the communication network. Hardacker at [0015] The communication paths may be wired links, wireless links or a combination thereof. In one exemplary implementation, the devices may be consumer electronic devices and the network may be a home multimedia network. Hardacker at [0016] With respect to FIG. 2 and FIG. 3, at 305, a first input signal [T(1)] is presented to the transmitter 210 of the first device 205 for transmission. Alternatively, the first input signal [T(1)] may be generated internally by the transmitter 210. The first input signal [T(1)] may be any signal to be transmitted by the first device 205 across the communication path 255. In one implementation, the first input signal [T(1)] is a training or configuration signal specifically utilized to determine the nature of the distortion or interference on the communication path 255. In another implementation, the first input signal [T(1)] may be a predetermined control signal or general data signal that facilitates the determination of the nature of the distortion or interference on the communication path 255. For example, the signal may be a predictable control signal transmitted from the first device 205 to the second device 225 Hardacker at [0017] At 310, the first input signal [T(1)] is transmitted across the communication path 255 by the transmitter 210. At 315, the first input signal distorted by channel distortion D(1) due to transmission across the communication path. The transmitted signal is represented here as a convolution product, $[T(1)]*[D(1)]$, and is received by the receiver 240 of the second device 225. At 320, the distortion [D(1)] introduced by the communication path 255 is automatically determined by the distortion determination circuit 250 since the training signal T(1) is a known signal. Hardacker at [0018] In accordance with embodiments of the present invention, the nature of the distortion or interference may then be used to pre-distort signals transmitted from the second device 225 to the first device 205 or optionally vice-versa. For example, the pre-distortion circuit 230 of the second device 225 may receive a second signal [T(2)], for transmission to device 205 at 325. At 330, the second signal [T(2)] is pre-

Claim Element	Exemplary Citations to Hardacker
	distorted by $[D(1)-1]$ at the pre-distortion circuit 230. The pre-distortion $[D(1)-1]$ is a function of the distortion on the communication path 255 determined at process 320. At 335, the transmitter 235 in the second device 225 transmits the pre-distorted signal $[T(2)]*[D(1)-1]$ across the communication path 255 which introduces a determined amount of distortion $[D(2)]$. The distortion $[D(2)]$ from the communication path 255 and the pre-distortion $[D(1)-1]$ introduced by the pre-distortion circuit 230 of the second device 225 produce convolved distortion $[D(2)]*[D(1)-1]$. If this convolution product=1, the recovered signal $T(2)$ will be correct and the pre-distortion introduced by device 225 enables recovery of signal $T(2)$ at device 205. Hardacker at [0019] At 340, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)]*[D(1)-1]$ further distorted by $[D(2)]$ after transmission across the communication path 255. If the product of $[D(2)]*[D(1)-1] \neq 1$ at 345, the equalizer 220 in the first device equalizes, or performs some amount of signal recovery on the pre-distorted signal further distorted $[T(2)]*[D(1)-1]*[D(2)]$ by transmission across the communication path to recover the second signal $[T(2)]$. The convolved distortion $[D(2)]*[D(1)-1]$ is recoverable by the equalization function $[D(n)-1]$ of the equalizer 220. At 350, the recovered second signal $[T(2)]$ is output by the equalizer 220 for use by other circuits of the first device 205. It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0021] In one embodiment, a given application may only need pre-distortion for communication in one direction. For example, a DTV may only transmit control signals requiring a relatively low transmission rate to one or more content sources such as a set top box (STB). However, in the other direction, the set top box transmits a large amount of image data that requires a high transmission rate, which may experience high bit error rates when the distortion and/or interference on the communication path 255 is greater than a particular level. Therefore, implementing pre-distortion in the set top box may be sufficient for such a configuration. In other embodiments it may be desirable to implement pre-distortion in both devices. Therefore, the first device 205 may also include a distortion determination circuit 260 and a pre-distortion circuit 265 in the first device 205 for determining the distortion $[D(1)]$ introduced by the communication path 255 and pre-distorting signals transmitted by the first device 205. Likewise, the second device 225 may include an equalizer 245 to recover pre-distorted signals transmitted by the first device 205.

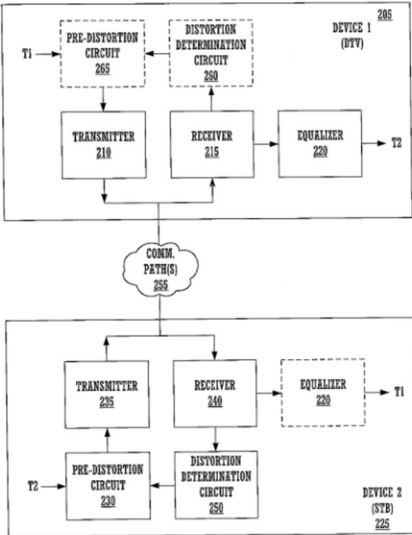
Claim Element	Exemplary Citations to Hardacker
	Hardacker at [0022] Referring now to FIG. 4, a method of transmitting and receiving signals, in accordance with other embodiments of the present technology, is shown. The system implementing the method of FIG. 4 may be the communications system of FIG. 2, for instance. At least one transmitter, e.g., of device 205 contains a distortion determination circuit 260 and a pre-distortion circuit 265. A back channel exists between the transmitter 235 of device 225 and the receiver 215 of device 205. Hardacker at [0023] Regarding FIG. 4, at 405, there is a first input signal $[T(1)]$ to be transmitted by the first device 205 across the communication path 255. The first signal $[T(1)]$ is pre-distorted by $[D(1)]$ by the pre-distortion circuit 265, at 410. The first input signal $[T(1)]$ may be distorted based upon the nature of the distortion or interference on the communication path 255 as previously determined by the distortion determination circuit 260 during receipt of a previous signal (e.g., during process 460 described below). At 515, the pre-distorted signal $[T(1)]*[D(1)-1]$ is transmitted by the transmitter 210 across the communication path 255. Hardacker at [0024] At 420, the receiver 240 of the second device 225 receives the pre-distorted signal $[T(1)]*[D(1)-1]$ further distorted by $[D(1)]$ after transmission across the communication path 255. The received pre-distorted signal is represented as $[[T(1)]*[D(1)-1]]*D(1)$. At 425, the equalizer 245 of the second device 225 equalizes the received pre-distorted signal by $D(1)-1$ to recover the first signal $[T(1)]$. At 430, the recovered signal $[T(1)]$ is output from the equalizer 245 for use by other circuits of the second device 225. In addition, the distortion determination circuit 250 determines the distortion $[D(1)]$ on the communication path 255, at 435. The distortion $[D(1)]$ may be used by the pre-distortion circuit 230 to pre-distort signals (e.g., during process 445 described below). It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0025] At 440, there is a second input signal $[T(2)]$ to be transmitted by the second device 225 across the communication path 255 to device 205. The second signal $[T(2)]$ is pre-distorted $[D(1)-1]$ by the pre-distortion circuit 230, at 445. The second input signal $[T(2)]$ may be distorted based upon the nature of the distortion or interference on the communication path 255 as determined by the distortion determination circuit 230 during receipt of a previous signal (e.g., during process 435 described above). At 450, the pre-distorted signal $[T(2)]*[D(1)-1]$ is transmitted by the transmitter 235 across the communication path 255.

Claim Element	Exemplary Citations to Hardacker
	Hardacker at [0026] At 455, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)]*[D(1)-1]$ further distorted by $[D(2)]$ after transmission across the communication path 255. At 460, the equalizer 220 equalizes the received pre-distorted signal $[[T(2)]*[D(1)-1]]*[D(2)]$ to recover the first signal $[T(2)]$. At 465, the recovered signal $[T(2)]$ is output from the equalizer 220 for use by other circuits of the first device 205. In addition, the distortion determination circuit 260 determines the distortion $[D(1)]$ on the communication path 255. The nature of the distortion or interference determined by the distortion determination circuit 260 is used at process 410 to apply an appropriate amount of pre-distortion $[D(1)-1]$. Again, the distortion $[D(1)]$ on the communication path 255 may be determined for each signal received by the receiver 215 or periodically when the distortion changes over time. Hardacker at [0027] The above described embodiments are intended for use when the distortion on the communication path 255 is substantially the same when signals are transmitted from the first device 205 to the second device 225 and from the second device 225 to the first device 205. However, in other circumstances the distortion on the communication path is not the same in both directions between two devices and may also differ between different devices. Therefore, in another embodiment (as shown in FIG. 5), data indicating the distortion determined at process 435 is transmitted from the second device 225 back to the first device 205 and used by the pre-distortion circuit 260 of the first device 205 to pre-distort the signal $(T(1))$ transmitted from the first device 205 to the second device 225 at process 410. Similarly, data indicating the distortion determined at process 470 is transmitted from the first device 205 back to the second device and used by the pre-distortion circuit 230 of the second device 225 to pre-distort the signal $(T(2))$ at process 445. Hardacker at [0028] In another embodiment, a signal is transmitted from the first device 205 to the second device 225. The signal is re-transmitted (e.g., reflected back) by the second device 205 to the first device 225 pre-distorted $[D(1)-1]$ by the second device 225 as a verification that the pre-distortion substantially compensates for the distortion introduced by the communication path 255. In yet another embodiment, an iterative method might include using simple robust training signals that gradually increase in complexity while pre-distortion and equalization circuits keep correcting such that a complex modulation scheme (e.g., conveying higher data rates) can be possible with the dual efforts of the pre-distortion circuits and equalizer, see FIG. 5. Hardacker at [0030] The signals are pre-distorted so that the distortion does not exceed the capabilities of the receiver at the

Claim Element	Exemplary Citations to Hardacker
	other end of the channel. The techniques advantageously reduce the complexity of the receiver by placing some of the burden (e.g., circuit complexity) on the transmitter. The back channel can be exploited to compensate the original signal for the current state of the communication channel. This can result in improved performance, such as fewer bit errors and/or greater link distances, when compared to substantially similar systems without the pre-distortion modulation under substantially the same environmental factors. Hardacker at [0031] FIG. 5 illustrates a communication methodology in an asymmetric system where complex modulation can be employed while using equalizers and recovery circuits having only reduced complexity. The asymmetric system includes a source device 510 and a sink device 515. The source 510 is capable of pre-distortion and equalization. Hardacker at [0034] In accordance with FIG. 5, the sink device 515 sends a training signal or data packet T(1) to the source device 510 using a simple modulation M1520. The training signal is known to the source device 510. The transmit signal is represented at 525 as $[T(1)*M1]*D1$ where D1 is the distortion of the communication channel as seen using modulation M1. Channel distortion can have phase, amplitude and multipath distortion characteristics which may all be non-linear. Herein, a distortion description, Dx, is valid for a single type of modulation, Mx, but may not be accurate for more advanced modulations, e.g., M(x+1). The source device 510 receives the signal 525 and equalizes the signal and demodulates the signal until the known training data packet T(1) is recovered at 527. Since the source device 510 knows the modulation M1 used, the equalizer is varied in a feedback loop fashion until the known training signal T(1) is recovered. When recovered, the equalizer located a good first order approximation of the channel distortion, or D1-1. This first order approximation is good enough for the simple modulation M1. Hardacker at [0035] The source 510 then sends “known” training signal or data packet T(1) using a more complex modulation M2530 to the sink 515 and using pre-distortion D1-1 at 532. That is, the signal transmitted by the source 510 is pre-distorted by D1-1. This transmission is also distorted by channel distortion D2 when recovered by the sink device 515. The sink device 515 equalizes this slightly by D1’ until the training signal is recovered at 534. Hardacker at [0036] At this point, the sink device 515 communicates D1’ to the source device 510 using the simple modulation M1. Specifically, the sink device uses simple modulation M1 to transmit D1’ to the source device at 536.

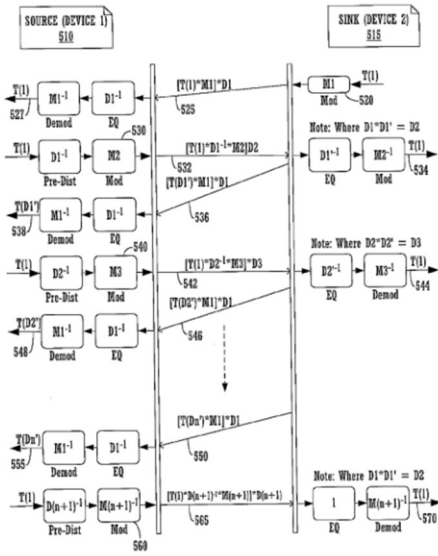
Claim Element	Exemplary Citations to Hardacker
	This transmission 536 experiences channel distortion D1. The source device 510 already knows the channel distortion approximation D1-1 and the modulation scheme M1, so the data packet D1' is readily recovered at 538. Since the source device knows D1' and D1, it can advantageously compute D2, a second order approximation of the channel distortion for modulation M2. Source 510 now sends T(1) again by transmission 542 but using a more complex modulation scheme, M3540, with the transmitted signal pre-distorted by the second order pre-distortion, D2-1. The sink 515 again has to equalize the recovered signal slightly because the D2-1 pre-distortion is good enough for M2, but not quite good enough for M3. Equalization continues until the training signal is recovered at 544. This leads to distortion approximation D2'(D3=D2*D2'). Again, the sink 515 sends back to the source 510 (using M1) the additional equalization T(D2') necessary to decode T(1) when modulated with M3. This is shown as 546. Hardacker at [0037] The source device 510 already knows the channel distortion approximation D1-1 and the modulation scheme M1, so the data packet D2' is readily recovered at 538. Since the source device knows D2' and D2, it can advantageously compute D3, a third order approximation of the channel distortion for M3. This third order channel distortion D3 can be used by the source device 510 to communicate large amounts of data to the sink device 515 using pre-distortion D3-1 and modulation M3, as shown in general terms by transmission 565. The above process is iterative, with each group of communications providing for more complex modulation while using limited equalization. The number of iterations is variable depending on the modulation required and the particular number of iterations shown in FIG. 5 is exemplary. Hardacker at claim 1 1. A method comprising:determining a distortion on a communication path between a first device and a second device;pre-distorting a signal to be transmitted as a function of the distortion determined on the communication path to produce a pre-distorted signal; andtransmitting the pre-distorted signal on the communication path wherein said transmitting is performed by the first device of said two devices. Hardacker at claim 2 2. The method according to claim 1, further comprising receiving the pre-distorted signal after transmission across the communication path wherein said receiving is performed by the second device of said two devices. Hardacker at claim 4 4. A method comprising:transmitting a first signal from a first device to a second device wherein said first signal is a known signal;at said second device, determining a first distortion amount in recovering said first signal wherein said first distortion amount represents channel distortion of a communication channel

Claim Element	Exemplary Citations to Hardacker
	between said first device and said second device;pre-distorting a second signal at said second device and transmitting a pre-distorted version of said second signal to said first device; andsaid first device performing a signal recovery process on said pre-distorted version of said second signal to recover said second signal. Hardacker at claims 8–10 8. A system for communicating over a communication path, said system comprising:a first device comprising:a first pre-distortion circuit for pre-distortion a first signal as a function of a distortion introduced on the communication path from the first device to a second device;a first transmitter coupled to the first pre-distortion circuit for transmitting the first signal on the communication path; andthe second device comprising a first receiver communicatively coupled to the communication path for receiving the pre-distorted first signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the first pre-distortion circuit.9. The system of claim 8, wherein:the second device further comprises:a first distortion determination circuit coupled to the first receiver for determining the distortion on the communication path from a training signal after transmission across the communication path from the first device to the second device; anda second transmitter coupled to the first distortion determination circuit for transmitting data to the first device indicating the distortion on the communication path from the first device to the second device; andwherein the first device further comprises:a second receiver communicatively coupled to the communication path for receiving the data indicating the distortion on the communication path from the first device to the second device.10. The system of claim 9, wherein:the second device further comprises a second pre-distortion circuit for pre-distorting a second signal as a function of a distortion introduced on the communication path from the second device to the first device;wherein the second transmitter is for further transmitting the second signal on the communication path; andwherein further the second receiver is communicatively coupled to the communication path for receiving the pre-distorted second signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the second pre-distortion circuit. To the extent this element is not disclosed by Hardacker, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Hardacker, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
[19.a] a receiver;	Hardacker discloses or renders obvious “a receiver.” For example:

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	Hardacker at Abstract Techniques for sending and receiving signals include pre-distorting signals before transmission across a communication path. The signals are pre-distorted as a function of a distortion on the communication path. In one embodiments, transmitter a broadcasts to receiver b and there is also a transmitter b broadcasting to receiver a. This return channel enables both transmitters a and b to have a priori information regarding the transmission medium and path the signal takes. In this way, the nature of the distortion or interference is known to the transmitter, therefore, it pre-distorts the transmitted signal to compensate for the receiver exceeding its capabilities in recovering signal. Hardacker at Figure 2  FIGURE 2

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 3 <pre> graph TD subgraph Device_1 [DEVICE 1] 305[INPUT SIGNAL 305] --> 310[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 310] 345[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 345] --> 350[OUTPUT SIGNAL 350] end subgraph Device_2 [DEVICE 2] 315[RECEIVE SIGNAL DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 315] --> 320[DETERMINE DISTORTION ON COMMUNICATION PATH 320] 320 --> 330[PRE-DISTORT SIGNAL 330] 330 --> 335[TRANSMIT PRE-DISTORTED SIGNAL ACROSS COMMUNICATION PATH 335] end 310 -.-> 315 335 -.-> 345 315 --> 320 </pre> FIGURE 3

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 4 <pre> graph TD subgraph Device_1 [DEVICE 1] 405[INPUT SIGNAL 405] --> 410[PRE-DISTORT SIGNAL 410] 410 --> 415[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 415] 415 --> 425[RECEIVE SIGNAL FURTHER DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 425] 425 --> 470[DETERMINE DISTORTION ON COMMUNICATION PATH 470] 470 --> 480[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 480] 480 --> 485[OUTPUT SIGNAL 485] end subgraph Device_2 [DEVICE 2] 440[INPUT SIGNAL 440] --> 445[PRE-DISTORT SIGNAL 445] 445 --> 450[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 450] 450 --> 465[RECEIVE SIGNAL FURTHER DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 465] 465 --> 435[DETERMINE DISTORTION ON COMMUNICATION PATH 435] 435 --> 425[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 425] 425 --> 460[OUTPUT SIGNAL 460] end 415 -.-> 420[RECEIVE SIGNAL FURTHER DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 420] 420 -.-> 425 450 -.-> 425 425 -.-> 470 </pre> FIGURE 4

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 5  FIGURE 5 Hardacker at [0001] Radio frequency (RF) receivers are typically more difficult to construct than RF transmitters. Hardacker at [0002] FIG. 1 shows a communication system according to the conventional art. The communication system 100 includes a transmitter 110, a communication path 120, a receiver 130 and an equalizer 140. The transmitter 110 transmits a signal $[T]$ across the communication path 120. The receiver 130 receives a distorted signal $[T]*[D]$ after transmission across the communication path 120. The equalizer 140 equalizes $[D-1]$ the distorted signal $[T]*[D]$. If the distortion on the communication channel 120 is less than the recovery capability $[D-1]$ of the equalizer 140, the recovered signal will be substantially equal to the transmitted signal $[T]$. However, if the distortion on the communication channel 120 is greater than the recovery capability of the equalizer 140, the recovered signal $[T']$ will not be equal to the transmitted signal $[T]$. Hardacker at [0005] In one embodiment of the present invention, a first transmitter (a) broadcasts to first receiver (b) and there is also a second transmitter (of b) broadcasting to second receiver (of a). This return channel enables both

Claim Element	Exemplary Citations to Hardacker
	transmitters (a) and (b) to have a priori information regarding the transmission medium and path the signal takes. In this way, the nature of the distortion or interference is known to the transmitter, therefore, it pre-distorts the transmitted signal to compensate for the receiver exceeding its capabilities in recovering signal. This functionality, in accordance with embodiments of the present invention, reduces the complexity of the receiver by placing some of the burden on the transmitter. The back channel enables optimization of the original signal for the current state of the communications channel. Hardacker at [0006] In another embodiment, a communication methodology is employed in an asymmetric system where complex modulation can be employed while using equalizers and recovery circuits having only limited complexity. In this embodiment, a training signal is sent from a sink device to a source device using a simple modulation M1. The source device, knowing the training signal, determines an equalization $D1^{-1}$ that is able to recover the training signal wherein D1 is the channel distortion for M1. The source then pre-distorts the training signal with the computed $D1^{-1}$ and communicates this back to the sink using a second order modulation M2. The sink then knowing the training signal employs a simple equalization circuit to determine another distortion amount $D1'$ required to recover the training signal from the pre-distorted transmission, where $D1' * D1$ equals D2 (the channel distortion of the M2 modulated signal). Advantageously, the sink then uses M1 to transmit back to the source the computed $D1'$ and upon which the source can compute D2 since it knows D1. Here, the source advantageously uses a simple equalization circuit and simple modulation circuit. Knowing D2, the source can use M2 to communicate large amounts of data to the sink device (as pre-distorted by D2) even though the sink device has a relatively simple equalization circuit and also a simple modulator. Alternatively, the above iterative methodology can be repeated for higher order modulations, e.g., M3, etc. Although equalization is described above, this discussion is merely exemplary. This embodiment operates equally well employing other distortion types, e.g., multi-path, amplitude, frequency, phase and other well known types. Hardacker at [0014] Referring now to FIG. 2, an exemplary system for transmitting and receiving signals, in accordance with embodiments of the present technology, is shown. In one embodiment, the system includes a plurality of devices 205 and 225 communicatively coupled by a communication network. A first device 205 may include a transmitter 210, a receiver 215 and optionally an equalizer 220. A second device 225 may include a pre-distortion circuit 230, a transmitter 235, a receiver 240, a distortion determination circuit 250 and optionally an equalizer 245. The first and second devices 205 and 225 transmit and receive signals across one or more communication paths 255 of the communication network.

Claim Element	Exemplary Citations to Hardacker
	Hardacker at [0016] With respect to FIG. 2 and FIG. 3, at 305, a first input signal $[T(1)]$ is presented to the transmitter 210 of the first device 205 for transmission. Alternatively, the first input signal $[T(1)]$ may be generated internally by the transmitter 210. The first input signal $[T(1)]$ may be any signal to be transmitted by the first device 205 across the communication path 255. In one implementation, the first input signal $[T(1)]$ is a training or configuration signal specifically utilized to determine the nature of the distortion or interference on the communication path 255. In another implementation, the first input signal $[T(1)]$ may be a predetermined control signal or general data signal that facilitates the determination of the nature of the distortion or interference on the communication path 255. For example, the signal may be a predictable control signal transmitted from the first device 205 to the second device 225 Hardacker at [0017] At 310, the first input signal $[T(1)]$ is transmitted across the communication path 255 by the transmitter 210. At 315, the first input signal distorted by channel distortion $D(1)$ due to transmission across the communication path. The transmitted signal is represented here as a convolution product, $[T(1)]*[D(1)]$, and is received by the receiver 240 of the second device 225. At 320, the distortion $[D(1)]$ introduced by the communication path 255 is automatically determined by the distortion determination circuit 250 since the training signal $T(1)$ is a known signal. Hardacker at [0018] In accordance with embodiments of the present invention, the nature of the distortion or interference may then be used to pre-distort signals transmitted from the second device 225 to the first device 205 or optionally vice-versa. For example, the pre-distortion circuit 230 of the second device 225 may receive a second signal $[T(2)]$, for transmission to device 205 at 325. At 330, the second signal $[T(2)]$ is pre-distorted by $[D(1)-1]$ at the pre-distortion circuit 230. The pre-distortion $[D(1)-1]$ is a function of the distortion on the communication path 255 determined at process 320. At 335, the transmitter 235 in the second device 225 transmits the pre-distorted signal $[T(2)]*[D(1)-1]$ across the communication path 255 which introduces a determined amount of distortion $[D(2)]$. The distortion $[D(2)]$ from the communication path 255 and the pre-distortion $[D(1)-1]$ introduced by the pre-distortion circuit 230 of the second device 225 produce convolved distortion $[D(2)]*[D(1)-1]$. If this convolution product=1, the recovered signal $T(2)$ will be correct and the pre-distortion introduced by device 225 enables recovery of signal $T(2)$ at device 205. Hardacker at [0019] At 340, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)]*[D(1)-1]$ further distorted by $[D(2)]$ after transmission across the communication path 255. If the product of

Claim Element	Exemplary Citations to Hardacker
	[D(2)]*[D(1)−1]≠1 at 345, the equalizer 220 in the first device equalizes, or performs some amount of signal recovery on the pre-distorted signal further distorted [T(2)]*[D(1)−1]*[D(2)] by transmission across the communication path to recover the second signal [T(2)]. The convolved distortion [D(2)]*[D(1)−1] is recoverable by the equalization function [D(n)−1] of the equalizer 220. At 350, the recovered second signal [T(2)] is output by the equalizer 220 for use by other circuits of the first device 205. It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0021] In one embodiment, a given application may only need pre-distortion for communication in one direction. For example, a DTV may only transmit control signals requiring a relatively low transmission rate to one or more content sources such as a set top box (STB). However, in the other direction, the set top box transmits a large amount of image data that requires a high transmission rate, which may experience high bit error rates when the distortion and/or interference on the communication path 255 is greater than a particular level. Therefore, implementing pre-distortion in the set top box may be sufficient for such a configuration. In other embodiments it may be desirable to implement pre-distortion in both devices. Therefore, the first device 205 may also include a distortion determination circuit 260 and a pre-distortion circuit 265 in the first device 205 for determining the distortion [D(1)] introduced by the communication path 255 and pre-distorting signals transmitted by the first device 205. Likewise, the second device 225 may include an equalizer 245 to recover pre-distorted signals transmitted by the first device 205. Hardacker at [0022] Referring now to FIG. 4, a method of transmitting and receiving signals, in accordance with other embodiments of the present technology, is shown. The system implementing the method of FIG. 4 may be the communications system of FIG. 2, for instance. At least one transmitter, e.g., of device 205 contains a distortion determination circuit 260 and a pre-distortion circuit 265. A back channel exists between the transmitter 235 of device 225 and the receiver 215 of device 205. Hardacker at [0023] Regarding FIG. 4, at 405, there is a first input signal [T(1)] to be transmitted by the first device 205 across the communication path 255. The first signal [T(1)] is pre-distorted by [D(1)] by the pre-distortion circuit 265, at 410. The first input signal [T(1)] may be distorted based upon the nature of the distortion or interference on the communication path 255 as previously determined by the distortion determination

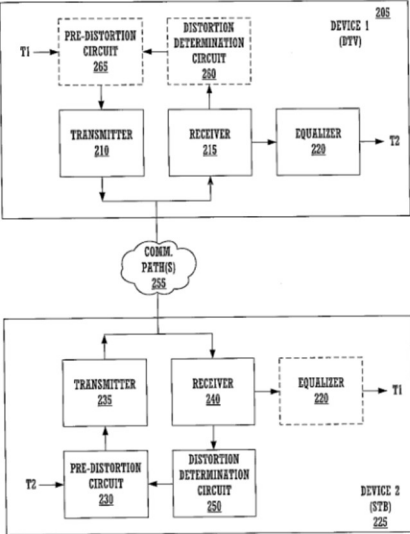
Claim Element	Exemplary Citations to Hardacker
	circuit 260 during receipt of a previous signal (e.g., during process 460 described below). At 515, the pre-distorted signal $[T(1)]*[D(1)-1]$ is transmitted by the transmitter 210 across the communication path 255. Hardacker at [0024] At 420, the receiver 240 of the second device 225 receives the pre-distorted signal $[T(1)]*[D(1)-1]$ further distorted by $[D(1)]$ after transmission across the communication path 255. The received pre-distorted signal is represented as $[[T(1)]*[D(1)-1]]*D(1)$. At 425, the equalizer 245 of the second device 225 equalizes the received pre-distorted signal by $D(1)-1$ to recover the first signal $[T(1)]$. At 430, the recovered signal $[T(1)]$ is output from the equalizer 245 for use by other circuits of the second device 225. In addition, the distortion determination circuit 250 determines the distortion $[D(1)]$ on the communication path 255, at 435. The distortion $[D(1)]$ may be used by the pre-distortion circuit 230 to pre-distort signals (e.g., during process 445 described below). It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0025] At 440, there is a second input signal $[T(2)]$ to be transmitted by the second device 225 across the communication path 255 to device 205. The second signal $[T(2)]$ is pre-distorted $[D(1)-1]$ by the pre-distortion circuit 230, at 445. The second input signal $[T(2)]$ may be distorted based upon the nature of the distortion or interference on the communication path 255 as determined by the distortion determination circuit 230 during receipt of a previous signal (e.g., during process 435 described above). At 450, the pre-distorted signal $[T(2)]*[D(1)-1]$ is transmitted by the transmitter 235 across the communication path 255. Hardacker at [0026] At 455, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)]*[D(1)-1]$ further distorted by $[D(2)]$ after transmission across the communication path 255. At 460, the equalizer 220 equalizes the received pre-distorted signal $[[T(2)]*[D(1)-1]]*[D(2)]$ to recover the first signal $[T(2)]$. At 465, the recovered signal $[T(2)]$ is output from the equalizer 220 for use by other circuits of the first device 205. In addition, the distortion determination circuit 260 determines the distortion $[D(1)]$ on the communication path 255. The nature of the distortion or interference determined by the distortion determination circuit 260 is used at process 410 to apply an appropriate amount of pre-distortion $[D(1)-1]$. Again, the distortion $[D(1)]$ on the communication path 255 may be determined for each signal received by the receiver 215 or periodically when the distortion changes over time.

Claim Element	Exemplary Citations to Hardacker
	Hardacker at [0027] The above described embodiments are intended for use when the distortion on the communication path 255 is substantially the same when signals are transmitted from the first device 205 to the second device 225 and from the second device 225 to the first device 205. However, in other circumstances the distortion on the communication path is not the same in both directions between two devices and may also differ between different devices. Therefore, in another embodiment (as shown in FIG. 5), data indicating the distortion determined at process 435 is transmitted from the second device 225 back to the first device 205 and used by the pre-distortion circuit 260 of the first device 205 to pre-distort the signal (T(1)) transmitted from the first device 205 to the second device 225 at process 410. Similarly, data indicating the distortion determined at process 470 is transmitted from the first device 205 back to the second device and used by the pre-distortion circuit 230 of the second device 225 to pre-distort the signal (T(2)) at process 445. Hardacker at [0028] In another embodiment, a signal is transmitted from the first device 205 to the second device 225. The signal is re-transmitted (e.g., reflected back) by the second device 205 to the first device 225 pre-distorted [D(1)–1] by the second device 225 as a verification that the pre-distortion substantially compensates for the distortion introduced by the communication path 255. In yet another embodiment, an iterative method might include using simple robust training signals that gradually increase in complexity while pre-distortion and equalization circuits keep correcting such that a complex modulation scheme (e.g., conveying higher data rates) can be possible with the dual efforts of the pre-distortion circuits and equalizer, see FIG. 5. Hardacker at [0030] The signals are pre-distorted so that the distortion does not exceed the capabilities of the receiver at the other end of the channel. The techniques advantageously reduce the complexity of the receiver by placing some of the burden (e.g., circuit complexity) on the transmitter. The back channel can be exploited to compensate the original signal for the current state of the communication channel. This can result in improved performance, such as fewer bit errors and/or greater link distances, when compared to substantially similar systems without the pre-distortion modulation under substantially the same environmental factors. Hardacker at [0031] FIG. 5 illustrates a communication methodology in an asymmetric system where complex modulation can be employed while using equalizers and recovery circuits having only reduced complexity. The

Claim Element	Exemplary Citations to Hardacker
	asymmetric system includes a source device 510 and a sink device 515. The source 510 is capable of pre-distortion and equalization. Hardacker at [0034] In accordance with FIG. 5, the sink device 515 sends a training signal or data packet T(1) to the source device 510 using a simple modulation M1520. The training signal is known to the source device 510. The transmit signal is represented at 525 as $[T(1)*M1]*D1$ where D1 is the distortion of the communication channel as seen using modulation M1. Channel distortion can have phase, amplitude and multipath distortion characteristics which may all be non-linear. Herein, a distortion description, Dx, is valid for a single type of modulation, Mx, but may not be accurate for more advanced modulations, e.g., M(x+1). The source device 510 receives the signal 525 and equalizes the signal and demodulates the signal until the known training data packet T(1) is recovered at 527. Since the source device 510 knows the modulation M1 used, the equalizer is varied in a feedback loop fashion until the known training signal T(1) is recovered. When recovered, the equalizer located a good first order approximation of the channel distortion, or D1-1. This first order approximation is good enough for the simple modulation M1. Hardacker at [0035] The source 510 then sends “known” training signal or data packet T(1) using a more complex modulation M2530 to the sink 515 and using pre-distortion D1-1 at 532. That is, the signal transmitted by the source 510 is pre-distorted by D1-1. This transmission is also distorted by channel distortion D2 when recovered by the sink device 515. The sink device 515 equalizes this slightly by D1' until the training signal is recovered at 534. Hardacker at [0036] At this point, the sink device 515 communicates D1' to the source device 510 using the simple modulation M1. Specifically, the sink device uses simple modulation M1 to transmit D1' to the source device at 536. This transmission 536 experiences channel distortion D1. The source device 510 already knows the channel distortion approximation D1-1 and the modulation scheme M1, so the data packet D1' is readily recovered at 538. Since the source device knows D1' and D1, it can advantageously compute D2, a second order approximation of the channel distortion for modulation M2. Source 510 now sends T(1) again by transmission 542 but using a more complex modulation scheme, M3540, with the transmitted signal pre-distorted by the second order pre-distortion, D2-1. The sink 515 again has to equalize the recovered signal slightly because the D2-1 pre-distortion is good enough for M2, but not quite good enough for M3. Equalization continues until the training signal is recovered at 544. This leads to distortion approximation

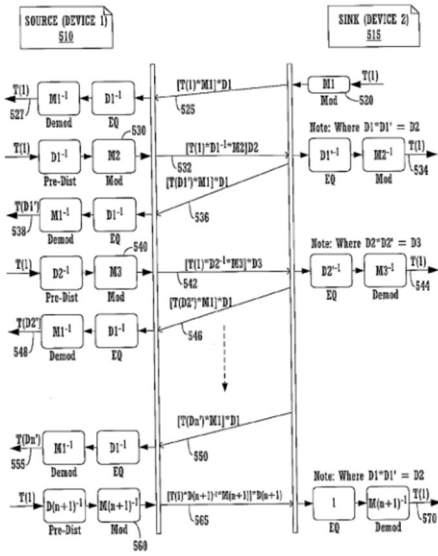
Claim Element	Exemplary Citations to Hardacker
	D2'(D3=D2*D2'). Again, the sink 515 sends back to the source 510 (using M1) the additional equalization T(D2') necessary to decode T(1) when modulated with M3. This is shown as 546. Hardacker at [0037] The source device 510 already knows the channel distortion approximation D1-1 and the modulation scheme M1, so the data packet D2' is readily recovered at 538. Since the source device knows D2' and D2, it can advantageously compute D3, a third order approximation of the channel distortion for M3. This third order channel distortion D3 can be used by the source device 510 to communicate large amounts of data to the sink device 515 using pre-distortion D3-1 and modulation M3, as shown in general terms by transmission 565. The above process is iterative, with each group of communications providing for more complex modulation while using limited equalization. The number of iterations is variable depending on the modulation required and the particular number of iterations shown in FIG. 5 is exemplary. Hardacker at claim 1 1. A method comprising:determining a distortion on a communication path between a first device and a second device;pre-distorting a signal to be transmitted as a function of the distortion determined on the communication path to produce a pre-distorted signal; andtransmitting the pre-distorted signal on the communication path wherein said transmitting is performed by the first device of said two devices. Hardacker at claim 2 2. The method according to claim 1, further comprising receiving the pre-distorted signal after transmission across the communication path wherein said receiving is performed by the second device of said two devices. Hardacker at claim 4 4. A method comprising:transmitting a first signal from a first device to a second device wherein said first signal is a known signal;at said second device, determining a first distortion amount in recovering said first signal wherein said first distortion amount represents channel distortion of a communication channel between said first device and said second device;pre-distorting a second signal at said second device and transmitting a pre-distorted version of said second signal to said first device; andsaid first device performing a signal recovery process on said pre-distorted version of said second signal to recover said second signal. Hardacker at claims 8-10 8. A system for communicating over a communication path, said system comprising:a first device comprising:a first pre-distortion circuit for pre-distortion a first signal as a function of a distortion introduced on the communication path from the first device to a second device;a first transmitter coupled

Claim Element	Exemplary Citations to Hardacker
	to the first pre-distortion circuit for transmitting the first signal on the communication path; and the second device comprising a first receiver communicatively coupled to the communication path for receiving the pre-distorted first signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the first pre-distortion circuit.9. The system of claim 8, wherein: the second device further comprises: a first distortion determination circuit coupled to the first receiver for determining the distortion on the communication path from a training signal after transmission across the communication path from the first device to the second device; and a second transmitter coupled to the first distortion determination circuit for transmitting data to the first device indicating the distortion on the communication path from the first device to the second device; and wherein the first device further comprises: a second receiver communicatively coupled to the communication path for receiving the data indicating the distortion on the communication path from the first device to the second device.10. The system of claim 9, wherein: the second device further comprises a second pre-distortion circuit for pre-distorting a second signal as a function of a distortion introduced on the communication path from the second device to the first device; wherein the second transmitter is for further transmitting the second signal on the communication path; and wherein further the second receiver is communicatively coupled to the communication path for receiving the pre-distorted second signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the second pre-distortion circuit. To the extent this element is not disclosed by Hardacker, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Hardacker, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
[19b] a computing device; and	Hardacker discloses or renders obvious “a computing device.” For example:

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 2  FIGURE 2

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 3 <pre> graph TD subgraph Device_1 [DEVICE 1] 305[INPUT SIGNAL 305] --> 310[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 310] 345[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 345] --> 350[OUTPUT SIGNAL 350] end subgraph Device_2 [DEVICE 2] 315[RECEIVE SIGNAL DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 315] --> 320[DETERMINE DISTORTION ON COMMUNICATION PATH 320] 320 --> 330[PRE-DISTORT SIGNAL 330] 330 --> 335[TRANSMIT PRE-DISTORTED SIGNAL ACROSS COMMUNICATION PATH 335] end 310 -.-> 315 335 -.-> 345 315 --> 320 </pre> FIGURE 3

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 4 <pre> graph TD subgraph Device_1 [DEVICE 1] 405[INPUT SIGNAL 405] --> 410[PRE-DISTORT SIGNAL 410] 410 --> 412[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 412] 470[DETERMINE DISTORTION ON COMMUNICATION PATH 470] 460[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 460] 465[RECOVER SIGNAL 465] end subgraph Device_2 [DEVICE 2] 420[RECEIVE SIGNAL FURTHER DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 420] 425[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 425] 430[OUTPUT SIGNAL 430] 455[RECEIVE SIGNAL FURTHER DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 455] 456[DETERMINE DISTORTION ON COMMUNICATION PATH 456] 445[PRE-DISTORT SIGNAL 445] 440[INPUT SIGNAL 440] end 412 -.-> 420 420 --> 425 425 --> 430 425 --> 470 470 --> 460 460 --> 465 465 --> 410 412 -.-> 455 455 --> 456 456 --> 445 445 --> 440 </pre> FIGURE 4

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 5  FIGURE 5 Hardacker at [0002] FIG. 1 shows a communication system according to the conventional art. The communication system 100 includes a transmitter 110, a communication path 120, a receiver 130 and an equalizer 140. The transmitter 110 transmits a signal $[T]$ across the communication path 120. The receiver 130 receives a distorted signal $[T]*[D]$ after transmission across the communication path 120. The equalizer 140 equalizes $[D^{-1}]$ the distorted signal $[T]*[D]$. If the distortion on the communication channel 120 is less than the recovery capability $[D^{-1}]$ of the equalizer 140, the recovered signal will be substantially equal to the transmitted signal $[T]$. However, if the distortion on the communication channel 120 is greater than the recovery capability of the equalizer 140, the recovered signal $[T']$ will not be equal to the transmitted signal $[T]$. Hardacker at [0006] In another embodiment, a communication methodology is employed in an asymmetric system where complex modulation can be employed while using equalizers and recovery circuits having only limited complexity. In this embodiment, a training signal is sent from a sink device to a source device using a simple modulation $M1$. The source device, knowing the training signal, determines an equalization $D1^{-1}$ that is able to recover the training signal wherein $D1$ is the channel distortion for $M1$. The source then

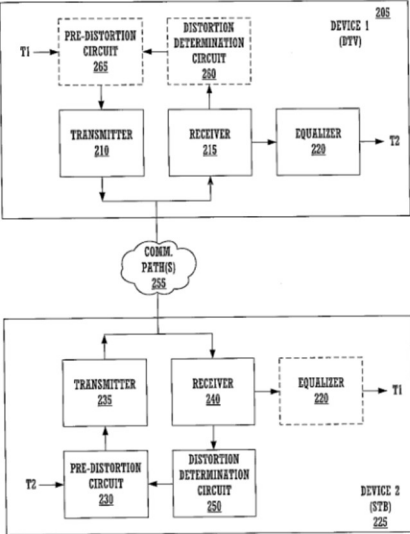
Claim Element	Exemplary Citations to Hardacker
	pre-distorts the training signal with the computed $D1-1$ and communicates this back to the sink using a second order modulation $M2$. The sink then knowing the training signal employs a simple equalization circuit to determine another distortion amount $D1'$ required to recover the training signal from the pre-distorted transmission, where $D1' \cdot D1$ equals $D2$ (the channel distortion of the $M2$ modulated signal). Advantageously, the sink then uses $M1$ to transmit back to the source the computed $D1'$ and upon which the source can compute $D2$ since it knows $D1$. Here, the source advantageously uses a simple equalization circuit and simple modulation circuit. Knowing $D2$, the source can use $M2$ to communicate large amounts of data to the sink device (as pre-distorted by $D2$) even though the sink device has a relatively simple equalization circuit and also a simple modulator. Alternatively, the above iterative methodology can be repeated for higher order modulations, e.g., $M3$, etc. Although equalization is described above, this discussion is merely exemplary. This embodiment operates equally well employing other distortion types, e.g., multi-path, amplitude, frequency, phase and other well known types. Hardacker at [0018] In accordance with embodiments of the present invention, the nature of the distortion or interference may then be used to pre-distort signals transmitted from the second device 225 to the first device 205 or optionally vice-versa. For example, the pre-distortion circuit 230 of the second device 225 may receive a second signal $[T(2)]$, for transmission to device 205 at 325. At 330, the second signal $[T(2)]$ is pre-distorted by $[D(1)-1]$ at the pre-distortion circuit 230. The pre-distortion $[D(1)-1]$ is a function of the distortion on the communication path 255 determined at process 320. At 335, the transmitter 235 in the second device 225 transmits the pre-distorted signal $[T(2)] \cdot [D(1)-1]$ across the communication path 255 which introduces a determined amount of distortion $[D(2)]$. The distortion $[D(2)]$ from the communication path 255 and the pre-distortion $[D(1)-1]$ introduced by the pre-distortion circuit 230 of the second device 225 produce convolved distortion $[D(2)] \cdot [D(1)-1]$. If this convolution product=1, the recovered signal $T(2)$ will be correct and the pre-distortion introduced by device 225 enables recovery of signal $T(2)$ at device 205. Hardacker at [0019] At 340, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)] \cdot [D(1)-1]$ further distorted by $[D(2)]$ after transmission across the communication path 255. If the product of $[D(2)] \cdot [D(1)-1] \neq 1$ at 345, the equalizer 220 in the first device equalizes, or performs some amount of signal recovery on the pre-distorted signal further distorted $[T(2)] \cdot [D(1)-1] \cdot [D(2)]$ by transmission across the communication path to recover the second signal $[T(2)]$. The convolved distortion $[D(2)] \cdot [D(1)-1]$ is recoverable by the equalization function $[D(n)-1]$ of the equalizer 220. At 350, the recovered second signal $[T(2)]$ is output by the equalizer 220 for use by other circuits of the first device

Claim Element	Exemplary Citations to Hardacker
	205. It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0021] In one embodiment, a given application may only need pre-distortion for communication in one direction. For example, a DTV may only transmit control signals requiring a relatively low transmission rate to one or more content sources such as a set top box (STB). However, in the other direction, the set top box transmits a large amount of image data that requires a high transmission rate, which may experience high bit error rates when the distortion and/or interference on the communication path 255 is greater than a particular level. Therefore, implementing pre-distortion in the set top box may be sufficient for such a configuration. In other embodiments it may be desirable to implement pre-distortion in both devices. Therefore, the first device 205 may also include a distortion determination circuit 260 and a pre-distortion circuit 265 in the first device 205 for determining the distortion $[D(1)]$ introduced by the communication path 255 and pre-distorting signals transmitted by the first device 205. Likewise, the second device 225 may include an equalizer 245 to recover pre-distorted signals transmitted by the first device 205. Hardacker at [0024] At 420, the receiver 240 of the second device 225 receives the pre-distorted signal $[T(1)]*[D(1)-1]$ further distorted by $[D(1)]$ after transmission across the communication path 255. The received pre-distorted signal is represented as $[[T(1)]*[D(1)-1]]*D(1)$. At 425, the equalizer 245 of the second device 225 equalizes the received pre-distorted signal by $D(1)-1$ to recover the first signal $[T(1)]$. At 430, the recovered signal $[T(1)]$ is output from the equalizer 245 for use by other circuits of the second device 225. In addition, the distortion determination circuit 250 determines the distortion $[D(1)]$ on the communication path 255, at 435. The distortion $[D(1)]$ may be used by the pre-distortion circuit 230 to pre-distort signals (e.g., during process 445 described below). It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0025] At 440, there is a second input signal $[T(2)]$ to be transmitted by the second device 225 across the communication path 255 to device 205. The second signal $[T(2)]$ is pre-distorted $[D(1)-1]$ by the pre-distortion circuit 230, at 445. The second input signal $[T(2)]$ may be distorted based upon the nature of the distortion or interference on the communication path 255 as determined by the distortion determination

Claim Element	Exemplary Citations to Hardacker
	circuit 230 during receipt of a previous signal (e.g., during process 435 described above). At 450, the pre-distorted signal $[T(2)]*[D(1)-1]$ is transmitted by the transmitter 235 across the communication path 255. Hardacker at [0028] In another embodiment, a signal is transmitted from the first device 205 to the second device 225. The signal is re-transmitted (e.g., reflected back) by the second device 205 to the first device 225 pre-distorted $[D(1)-1]$ by the second device 225 as a verification that the pre-distortion substantially compensates for the distortion introduced by the communication path 255. In yet another embodiment, an iterative method might include using simple robust training signals that gradually increase in complexity while pre-distortion and equalization circuits keep correcting such that a complex modulation scheme (e.g., conveying higher data rates) can be possible with the dual efforts of the pre-distortion circuits and equalizer, see FIG. 5. Hardacker at [0034] In accordance with FIG. 5, the sink device 515 sends a training signal or data packet T(1) to the source device 510 using a simple modulation M1 520. The training signal is known to the source device 510. The transmit signal is represented at 525 as $[T(1)*M1]*D1$ where D1 is the distortion of the communication channel as seen using modulation M1. Channel distortion can have phase, amplitude and multipath distortion characteristics which may all be non-linear. Herein, a distortion description, Dx, is valid for a single type of modulation, Mx, but may not be accurate for more advanced modulations, e.g., M(x+1). The source device 510 receives the signal 525 and equalizes the signal and demodulates the signal until the known training data packet T(1) is recovered at 527. Since the source device 510 knows the modulation M1 used, the equalizer is varied in a feedback loop fashion until the known training signal T(1) is recovered. When recovered, the equalizer located a good first order approximation of the channel distortion, or D1-1. This first order approximation is good enough for the simple modulation M1. Hardacker at [0036] At this point, the sink device 515 communicates D1' to the source device 510 using the simple modulation M1. Specifically, the sink device uses simple modulation M1 to transmit D1' to the source device at 536. This transmission 536 experiences channel distortion D1. The source device 510 already knows the channel distortion approximation D1-1 and the modulation scheme M1, so the data packet D1' is readily recovered at 538. Since the source device knows D1' and D1, it can advantageously compute D2, a second order approximation of the channel distortion for modulation M2. Source 510 now sends T(1) again by transmission 542 but using a more complex modulation scheme, M3 540, with the transmitted signal pre-distorted by the second order pre-distortion, D2-1. The sink 515 again has to equalize the recovered signal slightly because the D2-1 pre-distortion is good enough for M2, but not quite good enough for M3.

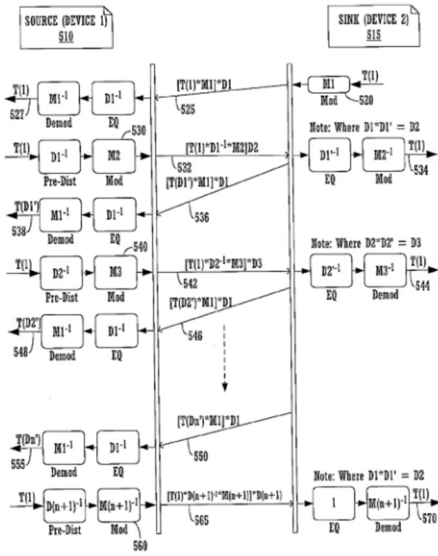
Claim Element	Exemplary Citations to Hardacker
	Equalization continues until the training signal is recovered at 544. This leads to distortion approximation $D2'(D3=D2*D2')$. Again, the sink 515 sends back to the source 510 (using M1) the additional equalization $T(D2')$ necessary to decode $T(1)$ when modulated with M3. This is shown as 546. Hardacker at claim 4 4. A method comprising:transmitting a first signal from a first device to a second device wherein said first signal is a known signal;at said second device, determining a first distortion amount in recovering said first signal wherein said first distortion amount represents channel distortion of a communication channel between said first device and said second device;pre-distorting a second signal at said second device and transmitting a pre-distorted version of said second signal to said first device; andsaid first device performing a signal recovery process on said pre-distorted version of said second signal to recover said second signal. Hardacker at claims 8–10 8. A system for communicating over a communication path, said system comprising:a first device comprising:a first pre-distortion circuit for pre-distortion a first signal as a function of a distortion introduced on the communication path from the first device to a second device;a first transmitter coupled to the first pre-distortion circuit for transmitting the first signal on the communication path; andthe second device comprising a first receiver communicatively coupled to the communication path for receiving the pre-distorted first signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the first pre-distortion circuit.9. The system of claim 8, wherein:the second device further comprises:a first distortion determination circuit coupled to the first receiver for determining the distortion on the communication path from a training signal after transmission across the communication path from the first device to the second device; anda second transmitter coupled to the first distortion determination circuit for transmitting data to the first device indicating the distortion on the communication path from the first device to the second device; andwherein the first device further comprises:a second receiver communicatively coupled to the communication path for receiving the data indicating the distortion on the communication path from the first device to the second device.10. The system of claim 9, wherein:the second device further comprises a second pre-distortion circuit for pre-distorting a second signal as a function of a distortion introduced on the communication path from the second device to the first device;wherein the second transmitter is for further transmitting the second signal on the communication path; andwherein further the second receiver is communicatively coupled to the communication path for receiving the pre-distorted second signal further distorted by transmission across the communication path,

Claim Element	Exemplary Citations to Hardacker
	wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the second pre-distortion circuit. To the extent this element is not disclosed by Hardacker, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Hardacker, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
[19c] a computer-readable storage medium having computer-executable instructions stored thereon that are executable by the computing device to perform operations comprising:	Hardacker discloses or renders obvious “a computer-readable storage medium having computer-executable instructions stored thereon that are executable by the computing device to perform operations.” For example: To the extent this element is not disclosed by Hardacker, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Hardacker, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
[19d] receiving a first signal at the receiver via a first propagation path of the plurality of propagation paths;	Hardacker discloses or renders obvious “receiving a first signal at the receiver via a first propagation path of the plurality of propagation paths.” For example: Hardacker at Abstract Techniques for sending and receiving signals include pre-distorting signals before transmission across a communication path. The signals are pre-distorted as a function of a distortion on the communication path. In one embodiments, transmitter a broadcasts to receiver b and there is also a transmitter b broadcasting to receiver a. This return channel enables both transmitters a and b to have a priori information regarding the transmission medium and path the signal takes. In this way, the nature of the distortion or interference is known to the transmitter, therefore, it pre-distorts the transmitted signal to compensate for the receiver exceeding its capabilities in recovering signal.

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 2  FIGURE 2

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 3 <pre> graph TD subgraph Device_1 [DEVICE 1] 305[INPUT SIGNAL 305] --> 310[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 310] 345[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 345] --> 350[OUTPUT SIGNAL 350] end subgraph Device_2 [DEVICE 2] 315[RECEIVE SIGNAL DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 315] --> 320[DETERMINE DISTORTION ON COMMUNICATION PATH 320] 320 --> 330[PRE-DISTORT SIGNAL 330] 330 --> 335[TRANSMIT PRE-DISTORTED SIGNAL ACROSS COMMUNICATION PATH 335] end 310 -.-> 315 335 -.-> 345 </pre> FIGURE 3

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 4 <pre> graph TD subgraph Device_1 [DEVICE 1] 405[INPUT SIGNAL 405] --> 410[PRE-DISTORT SIGNAL 410] 410 --> 415[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 415] 470[DETERMINE DISTORTION ON COMMUNICATION PATH 470] 460[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 460] end subgraph Device_2 [DEVICE 2] 440[INPUT SIGNAL 440] --> 455[PRE-DISTORT SIGNAL 455] 455 --> 450[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 450] 420[RECEIVE SIGNAL FURTHER DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 420] 425[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 425] 430[OUTPUT SIGNAL 430] end 415 --> 420 420 --> 425 425 --> 430 430 --> 460 460 --> 470 470 --> 455 </pre> FIGURE 4

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 5  FIGURE 5 Hardacker at [0001] Radio frequency (RF) receivers are typically more difficult to construct than RF transmitters. Hardacker at [0002] FIG. 1 shows a communication system according to the conventional art. The communication system 100 includes a transmitter 110, a communication path 120, a receiver 130 and an equalizer 140. The transmitter 110 transmits a signal $[T]$ across the communication path 120. The receiver 130 receives a distorted signal $[T] \cdot [D]$ after transmission across the communication path 120. The equalizer 140 equalizes $[D^{-1}]$ the distorted signal $[T] \cdot [D]$. If the distortion on the communication channel 120 is less than the recovery capability $[D^{-1}]$ of the equalizer 140, the recovered signal will be substantially equal to the transmitted signal $[T]$. However, if the distortion on the communication channel 120 is greater than the recovery capability of the equalizer 140, the recovered signal $[T']$ will not be equal to the transmitted signal $[T]$. Hardacker at [0003] Embodiments of the present technology are directed toward techniques for pre-distorting signals. In one embodiment, a method of sending and receiving signals includes determining the nature of the distortion

Claim Element	Exemplary Citations to Hardacker
	and/or interference on a communication path. Thereafter, signals to be transmitted on the communication path are pre-distorted as a function of the determined distortion. The pre-distortion may be accomplished using various types of distortion including equalization, multi-path, amplitude, frequency, phase and other well known types. Hardacker at [0004] In another embodiment, a system for sending and receiving signals includes one or more devices coupled to one or more communication paths. At least one device includes a transceiver coupled to the communication path and a pre-distortion circuit coupled to the transceiver. The pre-distortion circuit pre-distorts the signals to be transmitted by the transceiver of the given device as a function of the distortion on the communication path. When the signal is transmitted, the distortion on the communication path is at least partially compensated for by the pre-distortion introduced by the pre-distortion circuit. Hardacker at [0005] In one embodiment of the present invention, a first transmitter (a) broadcasts to first receiver (b) and there is also a second transmitter (of b) broadcasting to second receiver (of a). This return channel enables both transmitters (a) and (b) to have a priori information regarding the transmission medium and path the signal takes. In this way, the nature of the distortion or interference is known to the transmitter, therefore, it pre-distorts the transmitted signal to compensate for the receiver exceeding its capabilities in recovering signal. This functionality, in accordance with embodiments of the present invention, reduces the complexity of the receiver by placing some of the burden on the transmitter. The back channel enables optimization of the original signal for the current state of the communications channel. Hardacker at [0006] In another embodiment, a communication methodology is employed in an asymmetric system where complex modulation can be employed while using equalizers and recovery circuits having only limited complexity. In this embodiment, a training signal is sent from a sink device to a source device using a simple modulation M1. The source device, knowing the training signal, determines an equalization $D1^{-1}$ that is able to recover the training signal wherein D1 is the channel distortion for M1. The source then pre-distorts the training signal with the computed $D1^{-1}$ and communicates this back to the sink using a second order modulation M2. The sink then knowing the training signal employs a simple equalization circuit to determine another distortion amount $D1'$ required to recover the training signal from the pre-distorted transmission, where $D1' * D1$ equals D2 (the channel distortion of the M2 modulated signal). Advantageously, the sink then uses M1 to transmit back to the source the computed $D1'$ and upon which the source can compute D2 since it knows D1. Here, the source advantageously uses a simple equalization circuit and simple modulation circuit. Knowing D2, the source can use M2 to communicate large amounts

Claim Element	Exemplary Citations to Hardacker
	of data to the sink device (as pre-distorted by D2) even though the sink device has a relatively simple equalization circuit and also a simple modulator. Alternatively, the above iterative methodology can be repeated for higher order modulations, e.g., M3, etc. Although equalization is described above, this discussion is merely exemplary. This embodiment operates equally well employing other distortion types, e.g., multi-path, amplitude, frequency, phase and other well known types. Hardacker at [0014] Referring now to FIG. 2, an exemplary system for transmitting and receiving signals, in accordance with embodiments of the present technology, is shown. In one embodiment, the system includes a plurality of devices 205 and 225 communicatively coupled by a communication network. A first device 205 may include a transmitter 210, a receiver 215 and optionally an equalizer 220. A second device 225 may include a pre-distortion circuit 230, a transmitter 235, a receiver 240, a distortion determination circuit 250 and optionally an equalizer 245. The first and second devices 205 and 225 transmit and receive signals across one or more communication paths 255 of the communication network. Hardacker at [0016] With respect to FIG. 2 and FIG. 3, at 305, a first input signal [T(1)] is presented to the transmitter 210 of the first device 205 for transmission. Alternatively, the first input signal [T(1)] may be generated internally by the transmitter 210. The first input signal [T(1)] may be any signal to be transmitted by the first device 205 across the communication path 255. In one implementation, the first input signal [T(1)] is a training or configuration signal specifically utilized to determine the nature of the distortion or interference on the communication path 255. In another implementation, the first input signal [T(1)] may be a predetermined control signal or general data signal that facilitates the determination of the nature of the distortion or interference on the communication path 255. For example, the signal may be a predictable control signal transmitted from the first device 205 to the second device 225 Hardacker at [0017] At 310, the first input signal [T(1)] is transmitted across the communication path 255 by the transmitter 210. At 315, the first input signal distorted by channel distortion D(1) due to transmission across the communication path. The transmitted signal is represented here as a convolution product, $[T(1)] * [D(1)]$, and is received by the receiver 240 of the second device 225. At 320, the distortion [D(1)] introduced by the communication path 255 is automatically determined by the distortion determination circuit 250 since the training signal T(1) is a known signal. Hardacker at [0018] In accordance with embodiments of the present invention, the nature of the distortion or interference may

Claim Element	Exemplary Citations to Hardacker
	then be used to pre-distort signals transmitted from the second device 225 to the first device 205 or optionally vice-versa. For example, the pre-distortion circuit 230 of the second device 225 may receive a second signal $[T(2)]$, for transmission to device 205 at 325. At 330, the second signal $[T(2)]$ is pre-distorted by $[D(1)-1]$ at the pre-distortion circuit 230. The pre-distortion $[D(1)-1]$ is a function of the distortion on the communication path 255 determined at process 320. At 335, the transmitter 235 in the second device 225 transmits the pre-distorted signal $[T(2)]*[D(1)-1]$ across the communication path 255 which introduces a determined amount of distortion $[D(2)]$. The distortion $[D(2)]$ from the communication path 255 and the pre-distortion $[D(1)-1]$ introduced by the pre-distortion circuit 230 of the second device 225 produce convolved distortion $[D(2)]*[D(1)-1]$. If this convolution product=1, the recovered signal $T(2)$ will be correct and the pre-distortion introduced by device 225 enables recovery of signal $T(2)$ at device 205. Hardacker at [0019] At 340, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)]*[D(1)-1]$ further distorted by $[D(2)]$ after transmission across the communication path 255. If the product of $[D(2)]*[D(1)-1] \neq 1$ at 345, the equalizer 220 in the first device equalizes, or performs some amount of signal recovery on the pre-distorted signal further distorted $[T(2)]*[D(1)-1]*[D(2)]$ by transmission across the communication path to recover the second signal $[T(2)]$. The convolved distortion $[D(2)]*[D(1)-1]$ is recoverable by the equalization function $[D(n)-1]$ of the equalizer 220. At 350, the recovered second signal $[T(2)]$ is output by the equalizer 220 for use by other circuits of the first device 205. It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0021] In one embodiment, a given application may only need pre-distortion for communication in one direction. For example, a DTV may only transmit control signals requiring a relatively low transmission rate to one or more content sources such as a set top box (STB). However, in the other direction, the set top box transmits a large amount of image data that requires a high transmission rate, which may experience high bit error rates when the distortion and/or interference on the communication path 255 is greater than a particular level. Therefore, implementing pre-distortion in the set top box may be sufficient for such a configuration. In other embodiments it may be desirable to implement pre-distortion in both devices. Therefore, the first device 205 may also include a distortion determination circuit 260 and a pre-distortion circuit 265 in the first device 205 for determining the distortion $[D(1)]$ introduced by the communication

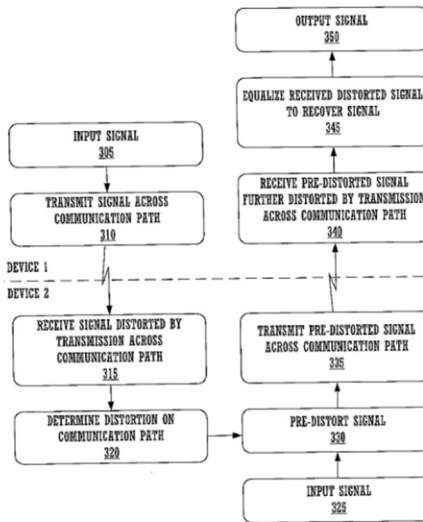
Claim Element	Exemplary Citations to Hardacker
	path 255 and pre-distorting signals transmitted by the first device 205. Likewise, the second device 225 may include an equalizer 245 to recover pre-distorted signals transmitted by the first device 205. Hardacker at [0022] Referring now to FIG. 4, a method of transmitting and receiving signals, in accordance with other embodiments of the present technology, is shown. The system implementing the method of FIG. 4 may be the communications system of FIG. 2, for instance. At least one transmitter, e.g., of device 205 contains a distortion determination circuit 260 and a pre-distortion circuit 265. A back channel exists between the transmitter 235 of device 225 and the receiver 215 of device 205. Hardacker at [0023] Regarding FIG. 4, at 405, there is a first input signal $[T(1)]$ to be transmitted by the first device 205 across the communication path 255. The first signal $[T(1)]$ is pre-distorted by $[D(1)]$ by the pre-distortion circuit 265, at 410. The first input signal $[T(1)]$ may be distorted based upon the nature of the distortion or interference on the communication path 255 as previously determined by the distortion determination circuit 260 during receipt of a previous signal (e.g., during process 460 described below). At 515, the pre-distorted signal $[T(1)]*[D(1)-1]$ is transmitted by the transmitter 210 across the communication path 255. Hardacker at [0024] At 420, the receiver 240 of the second device 225 receives the pre-distorted signal $[T(1)]*[D(1)-1]$ further distorted by $[D(1)]$ after transmission across the communication path 255. The received pre-distorted signal is represented as $[[T(1)]*[D(1)-1]]*D(1)$. At 425, the equalizer 245 of the second device 225 equalizes the received pre-distorted signal by $D(1)-1$ to recover the first signal $[T(1)]$. At 430, the recovered signal $[T(1)]$ is output from the equalizer 245 for use by other circuits of the second device 225. In addition, the distortion determination circuit 250 determines the distortion $[D(1)]$ on the communication path 255, at 435. The distortion $[D(1)]$ may be used by the pre-distortion circuit 230 to pre-distort signals (e.g., during process 445 described below). It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0025] At 440, there is a second input signal $[T(2)]$ to be transmitted by the second device 225 across the communication path 255 to device 205. The second signal $[T(2)]$ is pre-distorted $[D(1)-1]$ by the pre-distortion circuit 230, at 445. The second input signal $[T(2)]$ may be distorted based upon the nature of the distortion or interference on the communication path 255 as determined by the distortion determination

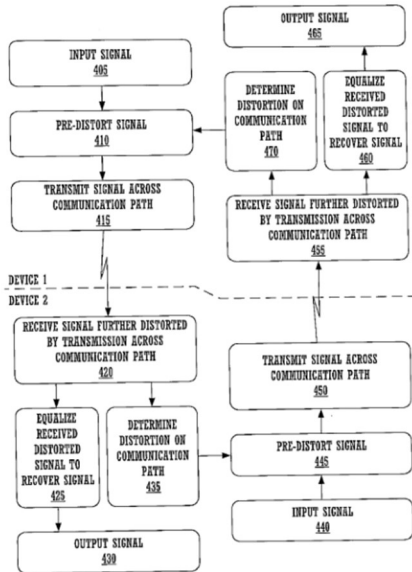
Claim Element	Exemplary Citations to Hardacker
	circuit 230 during receipt of a previous signal (e.g., during process 435 described above). At 450, the pre-distorted signal $[T(2)]*[D(1)-1]$ is transmitted by the transmitter 235 across the communication path 255. Hardacker at [0026] At 455, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)]*[D(1)-1]$ further distorted by $[D(2)]$ after transmission across the communication path 255. At 460, the equalizer 220 equalizes the received pre-distorted signal $[[T(2)]*[D(1)-1]]*[D(2)]$ to recover the first signal $[T(2)]$. At 465, the recovered signal $[T(2)]$ is output from the equalizer 220 for use by other circuits of the first device 205. In addition, the distortion determination circuit 260 determines the distortion $[D(1)]$ on the communication path 255. The nature of the distortion or interference determined by the distortion determination circuit 260 is used at process 410 to apply an appropriate amount of pre-distortion $[D(1)-1]$. Again, the distortion $[D(1)]$ on the communication path 255 may be determined for each signal received by the receiver 215 or periodically when the distortion changes over time. Hardacker at [0027] The above described embodiments are intended for use when the distortion on the communication path 255 is substantially the same when signals are transmitted from the first device 205 to the second device 225 and from the second device 225 to the first device 205. However, in other circumstances the distortion on the communication path is not the same in both directions between two devices and may also differ between different devices. Therefore, in another embodiment (as shown in FIG. 5), data indicating the distortion determined at process 435 is transmitted from the second device 225 back to the first device 205 and used by the pre-distortion circuit 260 of the first device 205 to pre-distort the signal $(T(1))$ transmitted from the first device 205 to the second device 225 at process 410. Similarly, data indicating the distortion determined at process 470 is transmitted from the first device 205 back to the second device and used by the pre-distortion circuit 230 of the second device 225 to pre-distort the signal $(T(2))$ at process 445. Hardacker at [0028] In another embodiment, a signal is transmitted from the first device 205 to the second device 225. The signal is re-transmitted (e.g., reflected back) by the second device 205 to the first device 225 pre-distorted $[D(1)-1]$ by the second device 225 as a verification that the pre-distortion substantially compensates for the distortion introduced by the communication path 255. In yet another embodiment, an iterative method might include using simple robust training signals that gradually increase in complexity while pre-distortion and equalization circuits keep correcting such that a complex modulation scheme (e.g.,

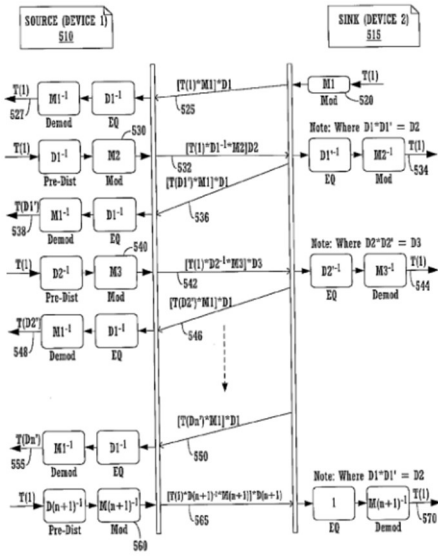
Claim Element	Exemplary Citations to Hardacker
	conveying higher data rates) can be possible with the dual efforts of the pre-distortion circuits and equalizer, see FIG. 5. Hardacker at [0030] The signals are pre-distorted so that the distortion does not exceed the capabilities of the receiver at the other end of the channel. The techniques advantageously reduce the complexity of the receiver by placing some of the burden (e.g., circuit complexity) on the transmitter. The back channel can be exploited to compensate the original signal for the current state of the communication channel. This can result in improved performance, such as fewer bit errors and/or greater link distances, when compared to substantially similar systems without the pre-distortion modulation under substantially the same environmental factors. Hardacker at [0031] FIG. 5 illustrates a communication methodology in an asymmetric system where complex modulation can be employed while using equalizers and recovery circuits having only reduced complexity. The asymmetric system includes a source device 510 and a sink device 515. The source 510 is capable of pre-distortion and equalization. Hardacker at [0034] In accordance with FIG. 5, the sink device 515 sends a training signal or data packet T(1) to the source device 510 using a simple modulation M1520. The training signal is known to the source device 510. The transmit signal is represented at 525 as $[T(1)*M1]*D1$ where D1 is the distortion of the communication channel as seen using modulation M1. Channel distortion can have phase, amplitude and multipath distortion characteristics which may all be non-linear. Herein, a distortion description, Dx, is valid for a single type of modulation, Mx, but may not be accurate for more advanced modulations, e.g., M(x+1). The source device 510 receives the signal 525 and equalizes the signal and demodulates the signal until the known training data packet T(1) is recovered at 527. Since the source device 510 knows the modulation M1 used, the equalizer is varied in a feedback loop fashion until the known training signal T(1) is recovered. When recovered, the equalizer located a good first order approximation of the channel distortion, or D1-1. This first order approximation is good enough for the simple modulation M1. Hardacker at [0035] The source 510 then sends “known” training signal or data packet T(1) using a more complex modulation M2530 to the sink 515 and using pre-distortion D1-1 at 532. That is, the signal transmitted by the source 510 is pre-distorted by D1-1. This transmission is also distorted by channel distortion D2 when recovered

Claim Element	Exemplary Citations to Hardacker
	by the sink device 515. The sink device 515 equalizes this slightly by D1' until the training signal is recovered at 534. Hardacker at [0036] At this point, the sink device 515 communicates D1' to the source device 510 using the simple modulation M1. Specifically, the sink device uses simple modulation M1 to transmit D1' to the source device at 536. This transmission 536 experiences channel distortion D1. The source device 510 already knows the channel distortion approximation D1-1 and the modulation scheme M1, so the data packet D1' is readily recovered at 538. Since the source device knows D1' and D1, it can advantageously compute D2, a second order approximation of the channel distortion for modulation M2. Source 510 now sends T(1) again by transmission 542 but using a more complex modulation scheme, M3540, with the transmitted signal pre-distorted by the second order pre-distortion, D2-1. The sink 515 again has to equalize the recovered signal slightly because the D2-1 pre-distortion is good enough for M2, but not quite good enough for M3. Equalization continues until the training signal is recovered at 544. This leads to distortion approximation D2'(D3=D2*D2'). Again, the sink 515 sends back to the source 510 (using M1) the additional equalization T(D2') necessary to decode T(1) when modulated with M3. This is shown as 546. Hardacker at [0037] The source device 510 already knows the channel distortion approximation D1-1 and the modulation scheme M1, so the data packet D2' is readily recovered at 538. Since the source device knows D2' and D2, it can advantageously compute D3, a third order approximation of the channel distortion for M3. This third order channel distortion D3 can be used by the source device 510 to communicate large amounts of data to the sink device 515 using pre-distortion D3-1 and modulation M3, as shown in general terms by transmission 565. The above process is iterative, with each group of communications providing for more complex modulation while using limited equalization. The number of iterations is variable depending on the modulation required and the particular number of iterations shown in FIG. 5 is exemplary. Hardacker at claim 1 1. A method comprising:determining a distortion on a communication path between a first device and a second device;pre-distorting a signal to be transmitted as a function of the distortion determined on the communication path to produce a pre-distorted signal; andtransmitting the pre-distorted signal on the communication path wherein said transmitting is performed by the first device of said two devices. Hardacker at claim 2 2. The method according to claim 1, further comprising receiving the pre-distorted signal after

Claim Element	Exemplary Citations to Hardacker
	transmission across the communication path wherein said receiving is performed by the second device of said two devices. Hardacker at claim 4 4. A method comprising:transmitting a first signal from a first device to a second device wherein said first signal is a known signal;at said second device, determining a first distortion amount in recovering said first signal wherein said first distortion amount represents channel distortion of a communication channel between said first device and said second device;pre-distorting a second signal at said second device and transmitting a pre-distorted version of said second signal to said first device; andsaid first device performing a signal recovery process on said pre-distorted version of said second signal to recover said second signal. Hardacker at claims 8–10 8. A system for communicating over a communication path, said system comprising:a first device comprising:a first pre-distortion circuit for pre-distortion a first signal as a function of a distortion introduced on the communication path from the first device to a second device;a first transmitter coupled to the first pre-distortion circuit for transmitting the first signal on the communication path; andthe second device comprising a first receiver communicatively coupled to the communication path for receiving the pre-distorted first signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the first pre-distortion circuit.9. The system of claim 8, wherein:the second device further comprises:a first distortion determination circuit coupled to the first receiver for determining the distortion on the communication path from a training signal after transmission across the communication path from the first device to the second device; anda second transmitter coupled to the first distortion determination circuit for transmitting data to the first device indicating the distortion on the communication path from the first device to the second device; andwherein the first device further comprises:a second receiver communicatively coupled to the communication path for receiving the data indicating the distortion on the communication path from the first device to the second device.10. The system of claim 9, wherein:the second device further comprises a second pre-distortion circuit for pre-distorting a second signal as a function of a distortion introduced on the communication path from the second device to the first device;wherein the second transmitter is for further transmitting the second signal on the communication path; andwherein further the second receiver is communicatively coupled to the communication path for receiving the pre-distorted second signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the second pre-distortion circuit.

Claim Element	Exemplary Citations to Hardacker
	To the extent this element is not disclosed by Hardacker, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Hardacker, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
[19e] performing a channel estimation based on the first signal to obtain path parameter information of the first propagation path;	Hardacker discloses or renders obvious “performing a channel estimation based on the first signal to obtain path parameter information of the first propagation path.” For example: Hardacker at Figure 3  FIGURE 3

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 4  <pre> graph TD subgraph Device_1 [DEVICE 1] 405[INPUT SIGNAL 405] --> 410[PRE-DISTORT SIGNAL 410] 410 --> 412[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 412] 470[DETERMINE DISTORTION ON COMMUNICATION PATH 470] 460[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 460] 465[OUTPUT SIGNAL 465] end subgraph Device_2 [DEVICE 2] 440[INPUT SIGNAL 440] --> 445[PRE-DISTORT SIGNAL 445] 445 --> 450[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 450] 420[RECEIVE SIGNAL FURTHER DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 420] 425[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 425] 430[OUTPUT SIGNAL 430] end 412 --> 420 450 --> 470 470 --> 410 425 --> 430 460 --> 470 465 --> 460 </pre> FIGURE 4

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 5  FIGURE 5 Hardacker at [0006] In another embodiment, a communication methodology is employed in an asymmetric system where complex modulation can be employed while using equalizers and recovery circuits having only limited complexity. In this embodiment, a training signal is sent from a sink device to a source device using a simple modulation M1. The source device, knowing the training signal, determines an equalization D1–1 that is able to recover the training signal wherein D1 is the channel distortion for M1. The source then pre-distorts the training signal with the computed D1–1 and communicates this back to the sink using a second order modulation M2. The sink then knowing the training signal employs a simple equalization circuit to determine another distortion amount D1' required to recover the training signal from the pre-distorted transmission, where D1'*D1 equals D2 (the channel distortion of the M2 modulated signal). Advantageously, the sink then uses M1 to transmit back to the source the computed D1' and upon which the source can compute D2 since it knows D1. Here, the source advantageously uses a simple equalization circuit and simple modulation circuit. Knowing D2, the source can use M2 to communicate large amounts of data to the sink device (as pre-distorted by D2) even though the sink device has a relatively simple equalization circuit and also a simple modulator. Alternatively, the above iterative methodology can be repeated for higher order modulations, e.g., M3, etc. Although equalization is described above, this

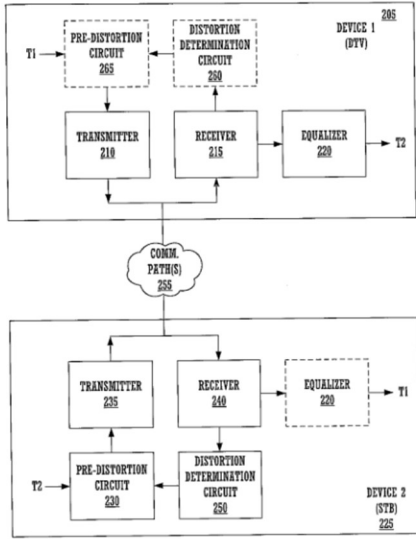
Claim Element	Exemplary Citations to Hardacker
	discussion is merely exemplary. This embodiment operates equally well employing other distortion types, e.g., multi-path, amplitude, frequency, phase and other well known types. Hardacker at [0017] At 310, the first input signal $[T(1)]$ is transmitted across the communication path 255 by the transmitter 210. At 315, the first input signal distorted by channel distortion $D(1)$ due to transmission across the communication path. The transmitted signal is represented here as a convolution product, $[T(1)]*[D(1)]$, and is received by the receiver 240 of the second device 225. At 320, the distortion $[D(1)]$ introduced by the communication path 255 is automatically determined by the distortion determination circuit 250 since the training signal $T(1)$ is a known signal. Hardacker at [0018] In accordance with embodiments of the present invention, the nature of the distortion or interference may then be used to pre-distort signals transmitted from the second device 225 to the first device 205 or optionally vice-versa. For example, the pre-distortion circuit 230 of the second device 225 may receive a second signal $[T(2)]$, for transmission to device 205 at 325. At 330, the second signal $[T(2)]$ is pre-distorted by $[D(1)-1]$ at the pre-distortion circuit 230. The pre-distortion $[D(1)-1]$ is a function of the distortion on the communication path 255 determined at process 320. At 335, the transmitter 235 in the second device 225 transmits the pre-distorted signal $[T(2)]*[D(1)-1]$ across the communication path 255 which introduces a determined amount of distortion $[D(2)]$. The distortion $[D(2)]$ from the communication path 255 and the pre-distortion $[D(1)-1]$ introduced by the pre-distortion circuit 230 of the second device 225 produce convolved distortion $[D(2)]*[D(1)-1]$. If this convolution product=1, the recovered signal $T(2)$ will be correct and the pre-distortion introduced by device 225 enables recovery of signal $T(2)$ at device 205. Hardacker at [0019] At 340, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)]*[D(1)-1]$ further distorted by $[D(2)]$ after transmission across the communication path 255. If the product of $[D(2)]*[D(1)-1] \neq 1$ at 345, the equalizer 220 in the first device equalizes, or performs some amount of signal recovery on the pre-distorted signal further distorted $[T(2)]*[D(1)-1]*[D(2)]$ by transmission across the communication path to recover the second signal $[T(2)]$. The convolved distortion $[D(2)]*[D(1)-1]$ is recoverable by the equalization function $[D(n)-1]$ of the equalizer 220. At 350, the recovered second signal $[T(2)]$ is output by the equalizer 220 for use by other circuits of the first device 205. It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal

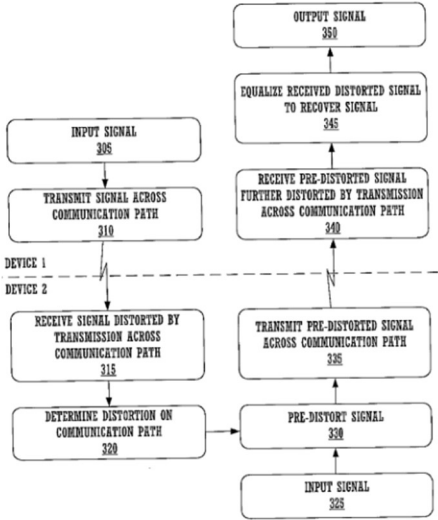
Claim Element	Exemplary Citations to Hardacker
	recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0021] In one embodiment, a given application may only need pre-distortion for communication in one direction. For example, a DTV may only transmit control signals requiring a relatively low transmission rate to one or more content sources such as a set top box (STB). However, in the other direction, the set top box transmits a large amount of image data that requires a high transmission rate, which may experience high bit error rates when the distortion and/or interference on the communication path 255 is greater than a particular level. Therefore, implementing pre-distortion in the set top box may be sufficient for such a configuration. In other embodiments it may be desirable to implement pre-distortion in both devices. Therefore, the first device 205 may also include a distortion determination circuit 260 and a pre-distortion circuit 265 in the first device 205 for determining the distortion $[D(1)]$ introduced by the communication path 255 and pre-distorting signals transmitted by the first device 205. Likewise, the second device 225 may include an equalizer 245 to recover pre-distorted signals transmitted by the first device 205. Hardacker at [0024] At 420, the receiver 240 of the second device 225 receives the pre-distorted signal $[T(1)]*[D(1)-1]$ further distorted by $[D(1)]$ after transmission across the communication path 255. The received pre-distorted signal is represented as $[[T(1)]*[D(1)-1]]*D(1)$. At 425, the equalizer 245 of the second device 225 equalizes the received pre-distorted signal by $D(1)-1$ to recover the first signal $[T(1)]$. At 430, the recovered signal $[T(1)]$ is output from the equalizer 245 for use by other circuits of the second device 225. In addition, the distortion determination circuit 250 determines the distortion $[D(1)]$ on the communication path 255, at 435. The distortion $[D(1)]$ may be used by the pre-distortion circuit 230 to pre-distort signals (e.g., during process 445 described below). It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0025] At 440, there is a second input signal $[T(2)]$ to be transmitted by the second device 225 across the communication path 255 to device 205. The second signal $[T(2)]$ is pre-distorted $[D(1)-1]$ by the pre-distortion circuit 230, at 445. The second input signal $[T(2)]$ may be distorted based upon the nature of the distortion or interference on the communication path 255 as determined by the distortion determination

Claim Element	Exemplary Citations to Hardacker
	circuit 230 during receipt of a previous signal (e.g., during process 435 described above). At 450, the pre-distorted signal $[T(2)]*[D(1)-1]$ is transmitted by the transmitter 235 across the communication path 255. Hardacker at [0026] At 455, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)]*[D(1)-1]$ further distorted by $[D(2)]$ after transmission across the communication path 255. At 460, the equalizer 220 equalizes the received pre-distorted signal $[[T(2)]*[D(1)-1]]*[D(2)]$ to recover the first signal $[T(2)]$. At 465, the recovered signal $[T(2)]$ is output from the equalizer 220 for use by other circuits of the first device 205. In addition, the distortion determination circuit 260 determines the distortion $[D(1)]$ on the communication path 255. The nature of the distortion or interference determined by the distortion determination circuit 260 is used at process 410 to apply an appropriate amount of pre-distortion $[D(1)-1]$. Again, the distortion $[D(1)]$ on the communication path 255 may be determined for each signal received by the receiver 215 or periodically when the distortion changes over time. Hardacker at [0027] The above described embodiments are intended for use when the distortion on the communication path 255 is substantially the same when signals are transmitted from the first device 205 to the second device 225 and from the second device 225 to the first device 205. However, in other circumstances the distortion on the communication path is not the same in both directions between two devices and may also differ between different devices. Therefore, in another embodiment (as shown in FIG. 5), data indicating the distortion determined at process 435 is transmitted from the second device 225 back to the first device 205 and used by the pre-distortion circuit 260 of the first device 205 to pre-distort the signal $(T(1))$ transmitted from the first device 205 to the second device 225 at process 410. Similarly, data indicating the distortion determined at process 470 is transmitted from the first device 205 back to the second device and used by the pre-distortion circuit 230 of the second device 225 to pre-distort the signal $(T(2))$ at process 445. Hardacker at [0029] In one implementation, the channel frequency response is determined. The inverse of the channel frequency response may then be used by the pre-distortion circuit 430 to pre-distort signals. In another implementation, the amount of pre-distortion applied by the pre-distortion circuit 430 may be a function of the impulse response of the communication path 445. Hardacker at [0034] In accordance with FIG. 5, the sink device 515 sends a training signal or data packet $T(1)$ to the source device 510 using a simple modulation $M1520$. The training signal is known to the source device 510. The

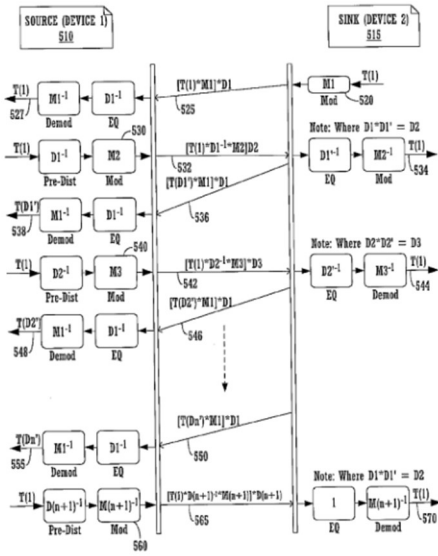
Claim Element	Exemplary Citations to Hardacker
	transmit signal is represented at 525 as $[T(1)*M1]*D1$ where D1 is the distortion of the communication channel as seen using modulation M1. Channel distortion can have phase, amplitude and multipath distortion characteristics which may all be non-linear. Herein, a distortion description, Dx, is valid for a single type of modulation, Mx, but may not be accurate for more advanced modulations, e.g., $M(x+1)$. The source device 510 receives the signal 525 and equalizes the signal and demodulates the signal until the known training data packet T(1) is recovered at 527. Since the source device 510 knows the modulation M1 used, the equalizer is varied in a feedback loop fashion until the known training signal T(1) is recovered. When recovered, the equalizer located a good first order approximation of the channel distortion, or $D1-1$. This first order approximation is good enough for the simple modulation M1. Hardacker at [0036] At this point, the sink device 515 communicates $D1'$ to the source device 510 using the simple modulation M1. Specifically, the sink device uses simple modulation M1 to transmit $D1'$ to the source device at 536. This transmission 536 experiences channel distortion D1. The source device 510 already knows the channel distortion approximation $D1-1$ and the modulation scheme M1, so the data packet $D1'$ is readily recovered at 538. Since the source device knows $D1'$ and D1, it can advantageously compute D2, a second order approximation of the channel distortion for modulation M2. Source 510 now sends T(1) again by transmission 542 but using a more complex modulation scheme, M3540, with the transmitted signal pre-distorted by the second order pre-distortion, $D2-1$. The sink 515 again has to equalize the recovered signal slightly because the $D2-1$ pre-distortion is good enough for M2, but not quite good enough for M3. Equalization continues until the training signal is recovered at 544. This leads to distortion approximation $D2'(D3=D2*D2')$. Again, the sink 515 sends back to the source 510 (using M1) the additional equalization T($D2'$) necessary to decode T(1) when modulated with M3. This is shown as 546. Hardacker at [0037] The source device 510 already knows the channel distortion approximation $D1-1$ and the modulation scheme M1, so the data packet $D2'$ is readily recovered at 538. Since the source device knows $D2'$ and D2, it can advantageously compute D3, a third order approximation of the channel distortion for M3. This third order channel distortion D3 can be used by the source device 510 to communicate large amounts of data to the sink device 515 using pre-distortion $D3-1$ and modulation M3, as shown in general terms by transmission 565. The above process is iterative, with each group of communications providing for more complex modulation while using limited equalization. The number of iterations is variable depending on the modulation required and the particular number of iterations shown in FIG. 5 is exemplary. Hardacker at claims 8–10 8. A system for communicating over a communication path, said system comprising:a first device

Claim Element	Exemplary Citations to Hardacker
	comprising: a first pre-distortion circuit for pre-distorting a first signal as a function of a distortion introduced on the communication path from the first device to a second device; a first transmitter coupled to the first pre-distortion circuit for transmitting the first signal on the communication path; and the second device comprising a first receiver communicatively coupled to the communication path for receiving the pre-distorted first signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the first pre-distortion circuit. 9. The system of claim 8, wherein: the second device further comprises: a first distortion determination circuit coupled to the first receiver for determining the distortion on the communication path from a training signal after transmission across the communication path from the first device to the second device; and a second transmitter coupled to the first distortion determination circuit for transmitting data to the first device indicating the distortion on the communication path from the first device to the second device; and wherein the first device further comprises: a second receiver communicatively coupled to the communication path for receiving the data indicating the distortion on the communication path from the first device to the second device. 10. The system of claim 9, wherein: the second device further comprises a second pre-distortion circuit for pre-distorting a second signal as a function of a distortion introduced on the communication path from the second device to the first device; wherein the second transmitter is for further transmitting the second signal on the communication path; and wherein further the second receiver is communicatively coupled to the communication path for receiving the pre-distorted second signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the second pre-distortion circuit. To the extent this element is not disclosed by Hardacker, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Hardacker, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
[19f] sending the channel estimation that includes the path parameter information to the transmitter; and	Hardacker discloses or renders obvious “sending the channel estimation that includes the path parameter information to the transmitter.” For example: Hardacker at Abstract Techniques for sending and receiving signals include pre-distorting signals before transmission across a communication path. The signals are pre-distorted as a function of a distortion on the communication path. In one embodiment, transmitter a broadcasts to receiver b and there is also a transmitter b broadcasting to receiver a. This return channel enables both transmitters a and b to have a priori information regarding the transmission medium and path the signal takes. In this way, the nature of the

Claim Element	Exemplary Citations to Hardacker
	distortion or interference is known to the transmitter, therefore, it pre-distorts the transmitted signal to compensate for the receiver exceeding its capabilities in recovering signal. Hardacker at Figure 2  FIGURE 2

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 3  <pre> graph TD subgraph Device_1 [DEVICE 1] 305[INPUT SIGNAL 305] --> 310[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 310] 345[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 345] --> 350[OUTPUT SIGNAL 350] end subgraph Device_2 [DEVICE 2] 315[RECEIVE SIGNAL DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 315] --> 320[DETERMINE DISTORTION ON COMMUNICATION PATH 320] 320 --> 330[PRE-DISTORT SIGNAL 330] 330 --> 335[TRANSMIT PRE-DISTORTED SIGNAL ACROSS COMMUNICATION PATH 335] end 310 -.-> 315 335 -.-> 345 </pre> FIGURE 3

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 4 <pre> graph TD subgraph Device_1 [DEVICE 1] 405[INPUT SIGNAL 405] --> 410[PRE-DISTORT SIGNAL 410] 410 --> 412[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 412] 470[DETERMINE DISTORTION ON COMMUNICATION PATH 470] 460[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 460] 465[RECOVER SIGNAL 465] end subgraph Device_2 [DEVICE 2] 420[RECEIVE SIGNAL FURTHER DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 420] 425[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 425] 430[OUTPUT SIGNAL 430] 450[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 450] 455[PRE-DISTORT SIGNAL 455] 440[INPUT SIGNAL 440] end 412 --> 420 420 --> 425 425 --> 430 440 --> 455 455 --> 450 450 --> 460 460 --> 470 470 --> 410 465 --> 410 </pre> FIGURE 4

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 5  FIGURE 5 Hardacker at [0001] Radio frequency (RF) receivers are typically more difficult to construct than RF transmitters. Hardacker at [0002] FIG. 1 shows a communication system according to the conventional art. The communication system 100 includes a transmitter 110, a communication path 120, a receiver 130 and an equalizer 140. The transmitter 110 transmits a signal $[T]$ across the communication path 120. The receiver 130 receives a distorted signal $[T]*[D]$ after transmission across the communication path 120. The equalizer 140 equalizes $[D-1]$ the distorted signal $[T]*[D]$. If the distortion on the communication channel 120 is less than the recovery capability $[D-1]$ of the equalizer 140, the recovered signal will be substantially equal to the transmitted signal $[T]$. However, if the distortion on the communication channel 120 is greater than the recovery capability of the equalizer 140, the recovered signal $[T']$ will not be equal to the transmitted signal $[T]$. Hardacker at [0004] In another embodiment, a system for sending and receiving signals includes one or more devices coupled to one or more communication paths. At least one device includes a transceiver coupled to the

Claim Element	Exemplary Citations to Hardacker
	communication path and a pre-distortion circuit coupled to the transceiver. The pre-distortion circuit pre-distorts the signals to be transmitted by the transceiver of the given device as a function of the distortion on the communication path. When the signal is transmitted, the distortion on the communication path is at least partially compensated for by the pre-distortion introduced by the pre-distortion circuit. Hardacker at [0005] In one embodiment of the present invention, a first transmitter (a) broadcasts to first receiver (b) and there is also a second transmitter (of b) broadcasting to second receiver (of a). This return channel enables both transmitters (a) and (b) to have a priori information regarding the transmission medium and path the signal takes. In this way, the nature of the distortion or interference is known to the transmitter, therefore, it pre-distorts the transmitted signal to compensate for the receiver exceeding its capabilities in recovering signal. This functionality, in accordance with embodiments of the present invention, reduces the complexity of the receiver by placing some of the burden on the transmitter. The back channel enables optimization of the original signal for the current state of the communications channel. Hardacker at [0006] In another embodiment, a communication methodology is employed in an asymmetric system where complex modulation can be employed while using equalizers and recovery circuits having only limited complexity. In this embodiment, a training signal is sent from a sink device to a source device using a simple modulation M1. The source device, knowing the training signal, determines an equalization $D1^{-1}$ that is able to recover the training signal wherein D1 is the channel distortion for M1. The source then pre-distorts the training signal with the computed $D1^{-1}$ and communicates this back to the sink using a second order modulation M2. The sink then knowing the training signal employs a simple equalization circuit to determine another distortion amount $D1'$ required to recover the training signal from the pre-distorted transmission, where $D1' \cdot D1$ equals D2 (the channel distortion of the M2 modulated signal). Advantageously, the sink then uses M1 to transmit back to the source the computed $D1'$ and upon which the source can compute D2 since it knows D1. Here, the source advantageously uses a simple equalization circuit and simple modulation circuit. Knowing D2, the source can use M2 to communicate large amounts of data to the sink device (as pre-distorted by D2) even though the sink device has a relatively simple equalization circuit and also a simple modulator. Alternatively, the above iterative methodology can be repeated for higher order modulations, e.g., M3, etc. Although equalization is described above, this discussion is merely exemplary. This embodiment operates equally well employing other distortion types, e.g., multi-path, amplitude, frequency, phase and other well known types. Hardacker at [0014] Referring now to FIG. 2, an exemplary system for transmitting and receiving signals, in accordance with

Claim Element	Exemplary Citations to Hardacker
	embodiments of the present technology, is shown. In one embodiment, the system includes a plurality of devices 205 and 225 communicatively coupled by a communication network. A first device 205 may include a transmitter 210, a receiver 215 and optionally an equalizer 220. A second device 225 may include a pre-distortion circuit 230, a transmitter 235, a receiver 240, a distortion determination circuit 250 and optionally an equalizer 245. The first and second devices 205 and 225 transmit and receive signals across one or more communication paths 255 of the communication network. Hardacker at [0016] With respect to FIG. 2 and FIG. 3, at 305, a first input signal [T(1)] is presented to the transmitter 210 of the first device 205 for transmission. Alternatively, the first input signal [T(1)] may be generated internally by the transmitter 210. The first input signal [T(1)] may be any signal to be transmitted by the first device 205 across the communication path 255. In one implementation, the first input signal [T(1)] is a training or configuration signal specifically utilized to determine the nature of the distortion or interference on the communication path 255. In another implementation, the first input signal [T(1)] may be a predetermined control signal or general data signal that facilitates the determination of the nature of the distortion or interference on the communication path 255. For example, the signal may be a predictable control signal transmitted from the first device 205 to the second device 225 Hardacker at [0017] At 310, the first input signal [T(1)] is transmitted across the communication path 255 by the transmitter 210. At 315, the first input signal distorted by channel distortion D(1) due to transmission across the communication path. The transmitted signal is represented here as a convolution product, $[T(1)] * [D(1)]$, and is received by the receiver 240 of the second device 225. At 320, the distortion [D(1)] introduced by the communication path 255 is automatically determined by the distortion determination circuit 250 since the training signal T(1) is a known signal. Hardacker at [0018] In accordance with embodiments of the present invention, the nature of the distortion or interference may then be used to pre-distort signals transmitted from the second device 225 to the first device 205 or optionally vice-versa. For example, the pre-distortion circuit 230 of the second device 225 may receive a second signal [T(2)], for transmission to device 205 at 325. At 330, the second signal [T(2)] is pre-distorted by $[D(1)-1]$ at the pre-distortion circuit 230. The pre-distortion $[D(1)-1]$ is a function of the distortion on the communication path 255 determined at process 320. At 335, the transmitter 235 in the second device 225 transmits the pre-distorted signal $[T(2)] * [D(1)-1]$ across the communication path 255 which introduces a determined amount of distortion [D(2)]. The distortion [D(2)] from the communication path 255 and the pre-distortion $[D(1)-1]$ introduced by the pre-distortion circuit 230 of the second device

Claim Element	Exemplary Citations to Hardacker
	225 produce convolved distortion $[D(2)]*[D(1)-1]$. If this convolution product=1, the recovered signal $T(2)$ will be correct and the pre-distortion introduced by device 225 enables recovery of signal $T(2)$ at device 205. Hardacker at [0019] At 340, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)]*[D(1)-1]$ further distorted by $[D(2)]$ after transmission across the communication path 255. If the product of $[D(2)]*[D(1)-1] \neq 1$ at 345, the equalizer 220 in the first device equalizes, or performs some amount of signal recovery on the pre-distorted signal further distorted $[T(2)]*[D(1)-1]*[D(2)]$ by transmission across the communication path to recover the second signal $[T(2)]$. The convolved distortion $[D(2)]*[D(1)-1]$ is recoverable by the equalization function $[D(n)-1]$ of the equalizer 220. At 350, the recovered second signal $[T(2)]$ is output by the equalizer 220 for use by other circuits of the first device 205. It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0021] In one embodiment, a given application may only need pre-distortion for communication in one direction. For example, a DTV may only transmit control signals requiring a relatively low transmission rate to one or more content sources such as a set top box (STB). However, in the other direction, the set top box transmits a large amount of image data that requires a high transmission rate, which may experience high bit error rates when the distortion and/or interference on the communication path 255 is greater than a particular level. Therefore, implementing pre-distortion in the set top box may be sufficient for such a configuration. In other embodiments it may be desirable to implement pre-distortion in both devices. Therefore, the first device 205 may also include a distortion determination circuit 260 and a pre-distortion circuit 265 in the first device 205 for determining the distortion $[D(1)]$ introduced by the communication path 255 and pre-distorting signals transmitted by the first device 205. Likewise, the second device 225 may include an equalizer 245 to recover pre-distorted signals transmitted by the first device 205. Hardacker at [0022] Referring now to FIG. 4, a method of transmitting and receiving signals, in accordance with other embodiments of the present technology, is shown. The system implementing the method of FIG. 4 may be the communications system of FIG. 2, for instance. At least one transmitter, e.g., of device 205 contains a

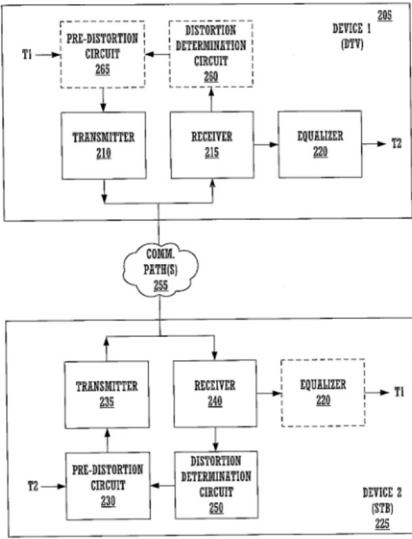
Claim Element	Exemplary Citations to Hardacker
	distortion determination circuit 260 and a pre-distortion circuit 265. A back channel exists between the transmitter 235 of device 225 and the receiver 215 of device 205. Hardacker at [0023] Regarding FIG. 4, at 405, there is a first input signal $[T(1)]$ to be transmitted by the first device 205 across the communication path 255. The first signal $[T(1)]$ is pre-distorted by $[D(1)]$ by the pre-distortion circuit 265, at 410. The first input signal $[T(1)]$ may be distorted based upon the nature of the distortion or interference on the communication path 255 as previously determined by the distortion determination circuit 260 during receipt of a previous signal (e.g., during process 460 described below). At 515, the pre-distorted signal $[T(1)]*[D(1)-1]$ is transmitted by the transmitter 210 across the communication path 255. Hardacker at [0024] At 420, the receiver 240 of the second device 225 receives the pre-distorted signal $[T(1)]*[D(1)-1]$ further distorted by $[D(1)]$ after transmission across the communication path 255. The received pre-distorted signal is represented as $[[T(1)]*[D(1)-1]]*D(1)$. At 425, the equalizer 245 of the second device 225 equalizes the received pre-distorted signal by $D(1)-1$ to recover the first signal $[T(1)]$. At 430, the recovered signal $[T(1)]$ is output from the equalizer 245 for use by other circuits of the second device 225. In addition, the distortion determination circuit 250 determines the distortion $[D(1)]$ on the communication path 255, at 435. The distortion $[D(1)]$ may be used by the pre-distortion circuit 230 to pre-distort signals (e.g., during process 445 described below). It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0025] At 440, there is a second input signal $[T(2)]$ to be transmitted by the second device 225 across the communication path 255 to device 205. The second signal $[T(2)]$ is pre-distorted $[D(1)-1]$ by the pre-distortion circuit 230, at 445. The second input signal $[T(2)]$ may be distorted based upon the nature of the distortion or interference on the communication path 255 as determined by the distortion determination circuit 230 during receipt of a previous signal (e.g., during process 435 described above). At 450, the pre-distorted signal $[T(2)]*[D(1)-1]$ is transmitted by the transmitter 235 across the communication path 255. Hardacker at [0026] At 455, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)]*[D(1)-1]$ further distorted by $[D(2)]$ after transmission across the communication path 255. At 460, the equalizer 220 equalizes the received pre-distorted signal $[[T(2)]*[D(1)-1]]*[D(2)]$ to recover the first signal $[T(2)]$. At

Claim Element	Exemplary Citations to Hardacker
	465, the recovered signal [T(2)] is output from the equalizer 220 for use by other circuits of the first device 205. In addition, the distortion determination circuit 260 determines the distortion [D(1)] on the communication path 255. The nature of the distortion or interference determined by the distortion determination circuit 260 is used at process 410 to apply an appropriate amount of pre-distortion [D(1)–1]. Again, the distortion [D(1)] on the communication path 255 may be determined for each signal received by the receiver 215 or periodically when the distortion changes over time. Hardacker at [0027] The above described embodiments are intended for use when the distortion on the communication path 255 is substantially the same when signals are transmitted from the first device 205 to the second device 225 and from the second device 225 to the first device 205. However, in other circumstances the distortion on the communication path is not the same in both directions between two devices and may also differ between different devices. Therefore, in another embodiment (as shown in FIG. 5), data indicating the distortion determined at process 435 is transmitted from the second device 225 back to the first device 205 and used by the pre-distortion circuit 260 of the first device 205 to pre-distort the signal (T(1)) transmitted from the first device 205 to the second device 225 at process 410. Similarly, data indicating the distortion determined at process 470 is transmitted from the first device 205 back to the second device and used by the pre-distortion circuit 230 of the second device 225 to pre-distort the signal (T(2)) at process 445. Hardacker at [0028] In another embodiment, a signal is transmitted from the first device 205 to the second device 225. The signal is re-transmitted (e.g., reflected back) by the second device 205 to the first device 225 pre-distorted [D(1)–1] by the second device 225 as a verification that the pre-distortion substantially compensates for the distortion introduced by the communication path 255. In yet another embodiment, an iterative method might include using simple robust training signals that gradually increase in complexity while pre-distortion and equalization circuits keep correcting such that a complex modulation scheme (e.g., conveying higher data rates) can be possible with the dual efforts of the pre-distortion circuits and equalizer, see FIG. 5. Hardacker at [0029] In one implementation, the channel frequency response is determined. The inverse of the channel frequency response may then be used by the pre-distortion circuit 430 to pre-distort signals. In another implementation, the amount of pre-distortion applied by the pre-distortion circuit 430 may be a function of the impulse response of the communication path 445.

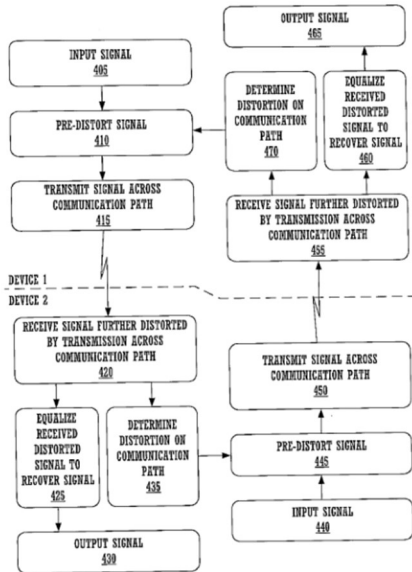
Claim Element	Exemplary Citations to Hardacker
	Hardacker at [0030] The signals are pre-distorted so that the distortion does not exceed the capabilities of the receiver at the other end of the channel. The techniques advantageously reduce the complexity of the receiver by placing some of the burden (e.g., circuit complexity) on the transmitter. The back channel can be exploited to compensate the original signal for the current state of the communication channel. This can result in improved performance, such as fewer bit errors and/or greater link distances, when compared to substantially similar systems without the pre-distortion modulation under substantially the same environmental factors. Hardacker at [0031] FIG. 5 illustrates a communication methodology in an asymmetric system where complex modulation can be employed while using equalizers and recovery circuits having only reduced complexity. The asymmetric system includes a source device 510 and a sink device 515. The source 510 is capable of pre-distortion and equalization. Hardacker at [0034] In accordance with FIG. 5, the sink device 515 sends a training signal or data packet T(1) to the source device 510 using a simple modulation M1520. The training signal is known to the source device 510. The transmit signal is represented at 525 as $[T(1)*M1]*D1$ where D1 is the distortion of the communication channel as seen using modulation M1. Channel distortion can have phase, amplitude and multipath distortion characteristics which may all be non-linear. Herein, a distortion description, Dx, is valid for a single type of modulation, Mx, but may not be accurate for more advanced modulations, e.g., M(x+1). The source device 510 receives the signal 525 and equalizes the signal and demodulates the signal until the known training data packet T(1) is recovered at 527. Since the source device 510 knows the modulation M1 used, the equalizer is varied in a feedback loop fashion until the known training signal T(1) is recovered. When recovered, the equalizer located a good first order approximation of the channel distortion, or D1-1. This first order approximation is good enough for the simple modulation M1. Hardacker at [0035] The source 510 then sends “known” training signal or data packet T(1) using a more complex modulation M2530 to the sink 515 and using pre-distortion D1-1 at 532. That is, the signal transmitted by the source 510 is pre-distorted by D1-1. This transmission is also distorted by channel distortion D2 when recovered by the sink device 515. The sink device 515 equalizes this slightly by D1’ until the training signal is recovered at 534.

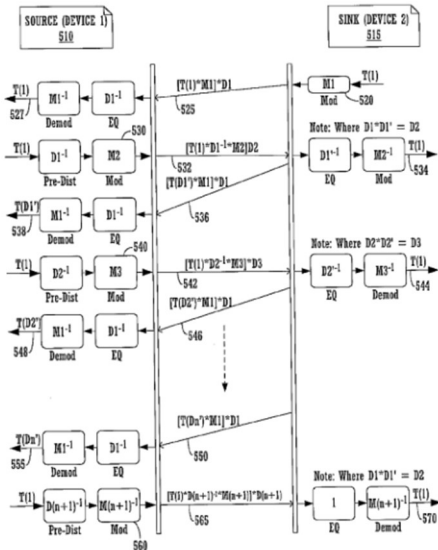
Claim Element	Exemplary Citations to Hardacker
	Hardacker at [0036] At this point, the sink device 515 communicates D1' to the source device 510 using the simple modulation M1. Specifically, the sink device uses simple modulation M1 to transmit D1' to the source device at 536. This transmission 536 experiences channel distortion D1. The source device 510 already knows the channel distortion approximation D1-1 and the modulation scheme M1, so the data packet D1' is readily recovered at 538. Since the source device knows D1' and D1, it can advantageously compute D2, a second order approximation of the channel distortion for modulation M2. Source 510 now sends T(1) again by transmission 542 but using a more complex modulation scheme, M3540, with the transmitted signal pre-distorted by the second order pre-distortion, D2-1. The sink 515 again has to equalize the recovered signal slightly because the D2-1 pre-distortion is good enough for M2, but not quite good enough for M3. Equalization continues until the training signal is recovered at 544. This leads to distortion approximation D2'(D3=D2*D2'). Again, the sink 515 sends back to the source 510 (using M1) the additional equalization T(D2') necessary to decode T(1) when modulated with M3. This is shown as 546. Hardacker at [0037] The source device 510 already knows the channel distortion approximation D1-1 and the modulation scheme M1, so the data packet D2' is readily recovered at 538. Since the source device knows D2' and D2, it can advantageously compute D3, a third order approximation of the channel distortion for M3. This third order channel distortion D3 can be used by the source device 510 to communicate large amounts of data to the sink device 515 using pre-distortion D3-1 and modulation M3, as shown in general terms by transmission 565. The above process is iterative, with each group of communications providing for more complex modulation while using limited equalization. The number of iterations is variable depending on the modulation required and the particular number of iterations shown in FIG. 5 is exemplary. Hardacker at claim 1 1. A method comprising:determining a distortion on a communication path between a first device and a second device;pre-distorting a signal to be transmitted as a function of the distortion determined on the communication path to produce a pre-distorted signal; andtransmitting the pre-distorted signal on the communication path wherein said transmitting is performed by the first device of said two devices. Hardacker at claim 2 2. The method according to claim 1, further comprising receiving the pre-distorted signal after transmission across the communication path wherein said receiving is performed by the second device of said two devices.

Claim Element	Exemplary Citations to Hardacker
	Hardacker at claim 4 4. A method comprising:transmitting a first signal from a first device to a second device wherein said first signal is a known signal;at said second device, determining a first distortion amount in recovering said first signal wherein said first distortion amount represents channel distortion of a communication channel between said first device and said second device;pre-distorting a second signal at said second device and transmitting a pre-distorted version of said second signal to said first device; andsaid first device performing a signal recovery process on said pre-distorted version of said second signal to recover said second signal. Hardacker at claims 8–10 8. A system for communicating over a communication path, said system comprising:a first device comprising:a first pre-distortion circuit for pre-distortion a first signal as a function of a distortion introduced on the communication path from the first device to a second device;a first transmitter coupled to the first pre-distortion circuit for transmitting the first signal on the communication path; andthe second device comprising a first receiver communicatively coupled to the communication path for receiving the pre-distorted first signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the first pre-distortion circuit.9. The system of claim 8, wherein:the second device further comprises:a first distortion determination circuit coupled to the first receiver for determining the distortion on the communication path from a training signal after transmission across the communication path from the first device to the second device; anda second transmitter coupled to the first distortion determination circuit for transmitting data to the first device indicating the distortion on the communication path from the first device to the second device; andwherein the first device further comprises:a second receiver communicatively coupled to the communication path for receiving the data indicating the distortion on the communication path from the first device to the second device.10. The system of claim 9, wherein:the second device further comprises a second pre-distortion circuit for pre-distorting a second signal as a function of a distortion introduced on the communication path from the second device to the first device;wherein the second transmitter is for further transmitting the second signal on the communication path; andwherein further the second receiver is communicatively coupled to the communication path for receiving the pre-distorted second signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the second pre-distortion circuit.

Claim Element	Exemplary Citations to Hardacker
	To the extent this element is not disclosed by Hardacker, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Hardacker, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
[19g] receiving a second signal via the first propagation path, the second signal predistorted in a time domain, a frequency domain, and a spatial domain according to the channel estimation based on the first signal.	Hardacker discloses or renders obvious “receiving a second signal via the first propagation path, the second signal predistorted in a time domain, a frequency domain, and a spatial domain according to the channel estimation based on the first signal.” For example: Hardacker at Abstract Techniques for sending and receiving signals include pre-distorting signals before transmission across a communication path. The signals are pre-distorted as a function of a distortion on the communication path. In one embodiments, transmitter a broadcasts to receiver b and there is also a transmitter b broadcasting to receiver a. This return channel enables both transmitters a and b to have a priori information regarding the transmission medium and path the signal takes. In this way, the nature of the distortion or interference is known to the transmitter, therefore, it pre-distorts the transmitted signal to compensate for the receiver exceeding its capabilities in recovering signal. Hardacker at Figure 2  FIGURE 2

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 3 <pre> graph TD subgraph Device_1 [DEVICE 1] 305[INPUT SIGNAL 305] --> 310[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 310] 345[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 345] --> 350[OUTPUT SIGNAL 350] end subgraph Device_2 [DEVICE 2] 315[RECEIVE SIGNAL DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 315] --> 320[DETERMINE DISTORTION ON COMMUNICATION PATH 320] 320 --> 330[PRE-DISTORT SIGNAL 330] 330 --> 335[TRANSMIT PRE-DISTORTED SIGNAL ACROSS COMMUNICATION PATH 335] end 310 -.-> 315 335 -.-> 345 </pre> FIGURE 3

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 4  <pre> graph TD subgraph Device_1 [DEVICE 1] 405[INPUT SIGNAL 405] --> 410[PRE-DISTORT SIGNAL 410] 410 --> 412[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 412] 470[DETERMINE DISTORTION ON COMMUNICATION PATH 470] 460[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 460] end subgraph Device_2 [DEVICE 2] 440[INPUT SIGNAL 440] --> 445[PRE-DISTORT SIGNAL 445] 445 --> 450[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 450] 420[RECEIVE SIGNAL FURTHER DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 420] 425[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 425] 430[OUTPUT SIGNAL 430] end 412 --> 420 450 --> 470 470 --> 410 420 --> 425 425 --> 430 430 --> 460 460 --> 470 </pre> FIGURE 4

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 5  FIGURE 5 Hardacker at [0002] FIG. 1 shows a communication system according to the conventional art. The communication system 100 includes a transmitter 110, a communication path 120, a receiver 130 and an equalizer 140. The transmitter 110 transmits a signal $[T]$ across the communication path 120. The receiver 130 receives a distorted signal $[T]*[D]$ after transmission across the communication path 120. The equalizer 140 equalizes $[D^{-1}]$ the distorted signal $[T]*[D]$. If the distortion on the communication channel 120 is less than the recovery capability $[D^{-1}]$ of the equalizer 140, the recovered signal will be substantially equal to the transmitted signal $[T]$. However, if the distortion on the communication channel 120 is greater than the recovery capability of the equalizer 140, the recovered signal $[T']$ will not be equal to the transmitted signal $[T]$. Hardacker at [0003] Embodiments of the present technology are directed toward techniques for pre-distorting signals. In one embodiment, a method of sending and receiving signals includes determining the nature of the distortion and/or interference on a communication path. Thereafter, signals to be transmitted on the communication path are pre-distorted as a function of the determined distortion. The pre-distortion may be accomplished

Claim Element	Exemplary Citations to Hardacker
	using various types of distortion including equalization, multi-path, amplitude, frequency, phase and other well known types. Hardacker at [0004] In another embodiment, a system for sending and receiving signals includes one or more devices coupled to one or more communication paths. At least one device includes a transceiver coupled to the communication path and a pre-distortion circuit coupled to the transceiver. The pre-distortion circuit pre-distorts the signals to be transmitted by the transceiver of the given device as a function of the distortion on the communication path. When the signal is transmitted, the distortion on the communication path is at least partially compensated for by the pre-distortion introduced by the pre-distortion circuit. Hardacker at [0005] In one embodiment of the present invention, a first transmitter (a) broadcasts to first receiver (b) and there is also a second transmitter (of b) broadcasting to second receiver (of a). This return channel enables both transmitters (a) and (b) to have a priori information regarding the transmission medium and path the signal takes. In this way, the nature of the distortion or interference is known to the transmitter, therefore, it pre-distorts the transmitted signal to compensate for the receiver exceeding its capabilities in recovering signal. This functionality, in accordance with embodiments of the present invention, reduces the complexity of the receiver by placing some of the burden on the transmitter. The back channel enables optimization of the original signal for the current state of the communications channel. Hardacker at [0006] In another embodiment, a communication methodology is employed in an asymmetric system where complex modulation can be employed while using equalizers and recovery circuits having only limited complexity. In this embodiment, a training signal is sent from a sink device to a source device using a simple modulation M1. The source device, knowing the training signal, determines an equalization $D1^{-1}$ that is able to recover the training signal wherein D1 is the channel distortion for M1. The source then pre-distorts the training signal with the computed $D1^{-1}$ and communicates this back to the sink using a second order modulation M2. The sink then knowing the training signal employs a simple equalization circuit to determine another distortion amount $D1'$ required to recover the training signal from the pre-distorted transmission, where $D1' \cdot D1$ equals D2 (the channel distortion of the M2 modulated signal). Advantageously, the sink then uses M1 to transmit back to the source the computed $D1'$ and upon which the source can compute D2 since it knows D1. Here, the source advantageously uses a simple equalization circuit and simple modulation circuit. Knowing D2, the source can use M2 to communicate large amounts of data to the sink device (as pre-distorted by D2) even though the sink device has a relatively simple equalization circuit and also a simple modulator. Alternatively, the above iterative methodology can be

Claim Element	Exemplary Citations to Hardacker
	repeated for higher order modulations, e.g., M3, etc. Although equalization is described above, this discussion is merely exemplary. This embodiment operates equally well employing other distortion types, e.g., multi-path, amplitude, frequency, phase and other well known types. Hardacker at [0014] Referring now to FIG. 2, an exemplary system for transmitting and receiving signals, in accordance with embodiments of the present technology, is shown. In one embodiment, the system includes a plurality of devices 205 and 225 communicatively coupled by a communication network. A first device 205 may include a transmitter 210, a receiver 215 and optionally an equalizer 220. A second device 225 may include a pre-distortion circuit 230, a transmitter 235, a receiver 240, a distortion determination circuit 250 and optionally an equalizer 245. The first and second devices 205 and 225 transmit and receive signals across one or more communication paths 255 of the communication network. Hardacker at [0016] With respect to FIG. 2 and FIG. 3, at 305, a first input signal $[T(1)]$ is presented to the transmitter 210 of the first device 205 for transmission. Alternatively, the first input signal $[T(1)]$ may be generated internally by the transmitter 210. The first input signal $[T(1)]$ may be any signal to be transmitted by the first device 205 across the communication path 255. In one implementation, the first input signal $[T(1)]$ is a training or configuration signal specifically utilized to determine the nature of the distortion or interference on the communication path 255. In another implementation, the first input signal $[T(1)]$ may be a predetermined control signal or general data signal that facilitates the determination of the nature of the distortion or interference on the communication path 255. For example, the signal may be a predictable control signal transmitted from the first device 205 to the second device 225 Hardacker at [0017] At 310, the first input signal $[T(1)]$ is transmitted across the communication path 255 by the transmitter 210. At 315, the first input signal distorted by channel distortion $D(1)$ due to transmission across the communication path. The transmitted signal is represented here as a convolution product, $[T(1)]*[D(1)]$, and is received by the receiver 240 of the second device 225. At 320, the distortion $[D(1)]$ introduced by the communication path 255 is automatically determined by the distortion determination circuit 250 since the training signal $T(1)$ is a known signal. Hardacker at [0018] In accordance with embodiments of the present invention, the nature of the distortion or interference may then be used to pre-distort signals transmitted from the second device 225 to the first device 205 or optionally vice-versa. For example, the pre-distortion circuit 230 of the second device 225 may receive a

Claim Element	Exemplary Citations to Hardacker
	second signal $[T(2)]$, for transmission to device 205 at 325. At 330, the second signal $[T(2)]$ is pre-distorted by $[D(1)-1]$ at the pre-distortion circuit 230. The pre-distortion $[D(1)-1]$ is a function of the distortion on the communication path 255 determined at process 320. At 335, the transmitter 235 in the second device 225 transmits the pre-distorted signal $[T(2)]*[D(1)-1]$ across the communication path 255 which introduces a determined amount of distortion $[D(2)]$. The distortion $[D(2)]$ from the communication path 255 and the pre-distortion $[D(1)-1]$ introduced by the pre-distortion circuit 230 of the second device 225 produce convolved distortion $[D(2)]*[D(1)-1]$. If this convolution product=1, the recovered signal $T(2)$ will be correct and the pre-distortion introduced by device 225 enables recovery of signal $T(2)$ at device 205. Hardacker at [0019] At 340, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)]*[D(1)-1]$ further distorted by $[D(2)]$ after transmission across the communication path 255. If the product of $[D(2)]*[D(1)-1] \neq 1$ at 345, the equalizer 220 in the first device equalizes, or performs some amount of signal recovery on the pre-distorted signal further distorted $[T(2)]*[D(1)-1]*[D(2)]$ by transmission across the communication path to recover the second signal $[T(2)]$. The convolved distortion $[D(2)]*[D(1)-1]$ is recoverable by the equalization function $[D(n)-1]$ of the equalizer 220. At 350, the recovered second signal $[T(2)]$ is output by the equalizer 220 for use by other circuits of the first device 205. It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0021] In one embodiment, a given application may only need pre-distortion for communication in one direction. For example, a DTV may only transmit control signals requiring a relatively low transmission rate to one or more content sources such as a set top box (STB). However, in the other direction, the set top box transmits a large amount of image data that requires a high transmission rate, which may experience high bit error rates when the distortion and/or interference on the communication path 255 is greater than a particular level. Therefore, implementing pre-distortion in the set top box may be sufficient for such a configuration. In other embodiments it may be desirable to implement pre-distortion in both devices. Therefore, the first device 205 may also include a distortion determination circuit 260 and a pre-distortion circuit 265 in the first device 205 for determining the distortion $[D(1)]$ introduced by the communication path 255 and pre-distorting signals transmitted by the first device 205. Likewise, the second device 225 may include an equalizer 245 to recover pre-distorted signals transmitted by the first device 205.

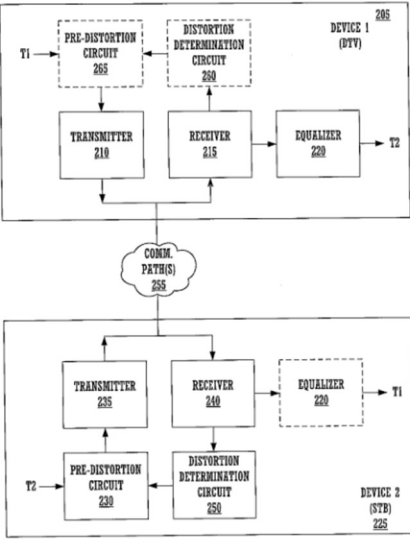
Claim Element	Exemplary Citations to Hardacker
	Hardacker at [0022] Referring now to FIG. 4, a method of transmitting and receiving signals, in accordance with other embodiments of the present technology, is shown. The system implementing the method of FIG. 4 may be the communications system of FIG. 2, for instance. At least one transmitter, e.g., of device 205 contains a distortion determination circuit 260 and a pre-distortion circuit 265. A back channel exists between the transmitter 235 of device 225 and the receiver 215 of device 205. Hardacker at [0023] Regarding FIG. 4, at 405, there is a first input signal $[T(1)]$ to be transmitted by the first device 205 across the communication path 255. The first signal $[T(1)]$ is pre-distorted by $[D(1)]$ by the pre-distortion circuit 265, at 410. The first input signal $[T(1)]$ may be distorted based upon the nature of the distortion or interference on the communication path 255 as previously determined by the distortion determination circuit 260 during receipt of a previous signal (e.g., during process 460 described below). At 515, the pre-distorted signal $[T(1)]*[D(1)-1]$ is transmitted by the transmitter 210 across the communication path 255. Hardacker at [0024] At 420, the receiver 240 of the second device 225 receives the pre-distorted signal $[T(1)]*[D(1)-1]$ further distorted by $[D(1)]$ after transmission across the communication path 255. The received pre-distorted signal is represented as $[[T(1)]*[D(1)-1]]*D(1)$. At 425, the equalizer 245 of the second device 225 equalizes the received pre-distorted signal by $D(1)-1$ to recover the first signal $[T(1)]$. At 430, the recovered signal $[T(1)]$ is output from the equalizer 245 for use by other circuits of the second device 225. In addition, the distortion determination circuit 250 determines the distortion $[D(1)]$ on the communication path 255, at 435. The distortion $[D(1)]$ may be used by the pre-distortion circuit 230 to pre-distort signals (e.g., during process 445 described below). It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0025] At 440, there is a second input signal $[T(2)]$ to be transmitted by the second device 225 across the communication path 255 to device 205. The second signal $[T(2)]$ is pre-distorted $[D(1)-1]$ by the pre-distortion circuit 230, at 445. The second input signal $[T(2)]$ may be distorted based upon the nature of the distortion or interference on the communication path 255 as determined by the distortion determination circuit 230 during receipt of a previous signal (e.g., during process 435 described above). At 450, the pre-distorted signal $[T(2)]*[D(1)-1]$ is transmitted by the transmitter 235 across the communication path 255.

Claim Element	Exemplary Citations to Hardacker
	Hardacker at [0026] At 455, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)]*[D(1)-1]$ further distorted by $[D(2)]$ after transmission across the communication path 255. At 460, the equalizer 220 equalizes the received pre-distorted signal $[[T(2)]*[D(1)-1]]*[D(2)]$ to recover the first signal $[T(2)]$. At 465, the recovered signal $[T(2)]$ is output from the equalizer 220 for use by other circuits of the first device 205. In addition, the distortion determination circuit 260 determines the distortion $[D(1)]$ on the communication path 255. The nature of the distortion or interference determined by the distortion determination circuit 260 is used at process 410 to apply an appropriate amount of pre-distortion $[D(1)-1]$. Again, the distortion $[D(1)]$ on the communication path 255 may be determined for each signal received by the receiver 215 or periodically when the distortion changes over time. Hardacker at [0027] The above described embodiments are intended for use when the distortion on the communication path 255 is substantially the same when signals are transmitted from the first device 205 to the second device 225 and from the second device 225 to the first device 205. However, in other circumstances the distortion on the communication path is not the same in both directions between two devices and may also differ between different devices. Therefore, in another embodiment (as shown in FIG. 5), data indicating the distortion determined at process 435 is transmitted from the second device 225 back to the first device 205 and used by the pre-distortion circuit 260 of the first device 205 to pre-distort the signal $(T(1))$ transmitted from the first device 205 to the second device 225 at process 410. Similarly, data indicating the distortion determined at process 470 is transmitted from the first device 205 back to the second device and used by the pre-distortion circuit 230 of the second device 225 to pre-distort the signal $(T(2))$ at process 445. Hardacker at [0028] In another embodiment, a signal is transmitted from the first device 205 to the second device 225. The signal is re-transmitted (e.g., reflected back) by the second device 205 to the first device 225 pre-distorted $[D(1)-1]$ by the second device 225 as a verification that the pre-distortion substantially compensates for the distortion introduced by the communication path 255. In yet another embodiment, an iterative method might include using simple robust training signals that gradually increase in complexity while pre-distortion and equalization circuits keep correcting such that a complex modulation scheme (e.g., conveying higher data rates) can be possible with the dual efforts of the pre-distortion circuits and equalizer, see FIG. 5. Hardacker at [0029] In one implementation, the channel frequency response is determined. The inverse of the channel

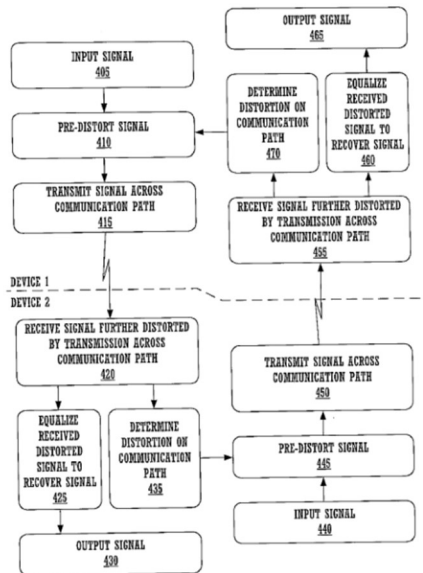
Claim Element	Exemplary Citations to Hardacker
	frequency response may then be used by the pre-distortion circuit 430 to pre-distort signals. In another implementation, the amount of pre-distortion applied by the pre-distortion circuit 430 may be a function of the impulse response of the communication path 445. Hardacker at [0030] The signals are pre-distorted so that the distortion does not exceed the capabilities of the receiver at the other end of the channel. The techniques advantageously reduce the complexity of the receiver by placing some of the burden (e.g., circuit complexity) on the transmitter. The back channel can be exploited to compensate the original signal for the current state of the communication channel. This can result in improved performance, such as fewer bit errors and/or greater link distances, when compared to substantially similar systems without the pre-distortion modulation under substantially the same environmental factors. Hardacker at [0034] In accordance with FIG. 5, the sink device 515 sends a training signal or data packet T(1) to the source device 510 using a simple modulation M1 520. The training signal is known to the source device 510. The transmit signal is represented at 525 as $[T(1)*M1]*D1$ where D1 is the distortion of the communication channel as seen using modulation M1. Channel distortion can have phase, amplitude and multipath distortion characteristics which may all be non-linear. Herein, a distortion description, Dx, is valid for a single type of modulation, Mx, but may not be accurate for more advanced modulations, e.g., M(x+1). The source device 510 receives the signal 525 and equalizes the signal and demodulates the signal until the known training data packet T(1) is recovered at 527. Since the source device 510 knows the modulation M1 used, the equalizer is varied in a feedback loop fashion until the known training signal T(1) is recovered. When recovered, the equalizer located a good first order approximation of the channel distortion, or D1-1. This first order approximation is good enough for the simple modulation M1. Hardacker at [0036] At this point, the sink device 515 communicates D1' to the source device 510 using the simple modulation M1. Specifically, the sink device uses simple modulation M1 to transmit D1' to the source device at 536. This transmission 536 experiences channel distortion D1. The source device 510 already knows the channel distortion approximation D1-1 and the modulation scheme M1, so the data packet D1' is readily recovered at 538. Since the source device knows D1' and D1, it can advantageously compute D2, a second order approximation of the channel distortion for modulation M2. Source 510 now sends T(1) again by transmission 542 but using a more complex modulation scheme, M3 540, with the transmitted signal pre-distorted by the second order pre-distortion, D2-1. The sink 515 again has to equalize the recovered signal slightly because the D2-1 pre-distortion is good enough for M2, but not quite good enough for M3.

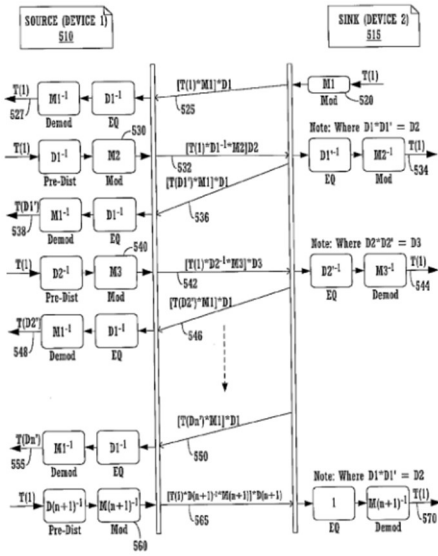
Claim Element	Exemplary Citations to Hardacker
	Equalization continues until the training signal is recovered at 544. This leads to distortion approximation $D2'(D3=D2*D2')$. Again, the sink 515 sends back to the source 510 (using M1) the additional equalization $T(D2')$ necessary to decode $T(1)$ when modulated with M3. This is shown as 546. Hardacker at [0037] The source device 510 already knows the channel distortion approximation $D1-1$ and the modulation scheme M1, so the data packet $D2'$ is readily recovered at 538. Since the source device knows $D2'$ and $D2$, it can advantageously compute $D3$, a third order approximation of the channel distortion for M3. This third order channel distortion $D3$ can be used by the source device 510 to communicate large amounts of data to the sink device 515 using pre-distortion $D3-1$ and modulation M3, as shown in general terms by transmission 565. The above process is iterative, with each group of communications providing for more complex modulation while using limited equalization. The number of iterations is variable depending on the modulation required and the particular number of iterations shown in FIG. 5 is exemplary. Hardacker at claim 1 1. A method comprising:determining a distortion on a communication path between a first device and a second device;pre-distorting a signal to be transmitted as a function of the distortion determined on the communication path to produce a pre-distorted signal; andtransmitting the pre-distorted signal on the communication path wherein said transmitting is performed by the first device of said two devices. Hardacker at claim 2 2. The method according to claim 1, further comprising receiving the pre-distorted signal after transmission across the communication path wherein said receiving is performed by the second device of said two devices. Hardacker at claim 4 4. A method comprising:transmitting a first signal from a first device to a second device wherein said first signal is a known signal;at said second device, determining a first distortion amount in recovering said first signal wherein said first distortion amount represents channel distortion of a communication channel between said first device and said second device;pre-distorting a second signal at said second device and transmitting a pre-distorted version of said second signal to said first device; andsaid first device performing a signal recovery process on said pre-distorted version of said second signal to recover said second signal. Hardacker at claims 8–10 8. A system for communicating over a communication path, said system comprising:a first device comprising:a first pre-distortion circuit for pre-distortion a first signal as a function of a distortion

Claim Element	Exemplary Citations to Hardacker
	introduced on the communication path from the first device to a second device;a first transmitter coupled to the first pre-distortion circuit for transmitting the first signal on the communication path; andthe second device comprising a first receiver communicatively coupled to the communication path for receiving the pre-distorted first signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the first pre-distortion circuit.9. The system of claim 8, wherein:the second device further comprises:a first distortion determination circuit coupled to the first receiver for determining the distortion on the communication path from a training signal after transmission across the communication path from the first device to the second device; anda second transmitter coupled to the first distortion determination circuit for transmitting data to the first device indicating the distortion on the communication path from the first device to the second device; andwherein the first device further comprises:a second receiver communicatively coupled to the communication path for receiving the data indicating the distortion on the communication path from the first device to the second device.10. The system of claim 9, wherein:the second device further comprises a second pre-distortion circuit for pre-distorting a second signal as a function of a distortion introduced on the communication path from the second device to the first device;wherein the second transmitter is for further transmitting the second signal on the communication path; andwherein further the second receiver is communicatively coupled to the communication path for receiving the pre-distorted second signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the second pre-distortion circuit. To the extent this element is not disclosed by Hardacker, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Hardacker, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
20. The wireless device of claim 19, wherein the path parameter information of the first propagation path includes at least one of an estimation of a delay, an estimation of a Doppler frequency, an estimation of a direction of arrival, an estimation of a direction of departure, and an estimation of	Hardacker discloses or renders obvious “[t]he wireless device of claim 19, wherein the path parameter information of the first propagation path includes at least one of an estimation of a delay, an estimation of a Doppler frequency, an estimation of a direction of arrival, an estimation of a direction of departure, and an estimation of a complex amplitude of the first propagation path.” For example: Hardacker at Abstract Techniques for sending and receiving signals include pre-distorting signals before transmission across a communication path. The signals are pre-distorted as a function of a distortion on the communication path. In one embodiments, transmitter a broadcasts to receiver b and there is also a transmitter b broadcasting to receiver a. This return channel enables both transmitters a and b to have a priori information regarding the transmission medium and path the signal takes. In this way, the nature of the

Claim Element	Exemplary Citations to Hardacker
a complex amplitude of the first propagation path.	distortion or interference is known to the transmitter, therefore, it pre-distorts the transmitted signal to compensate for the receiver exceeding its capabilities in recovering signal. Hardacker at Figure 2  FIGURE 2

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 3 <pre> graph TD subgraph Device_1 [DEVICE 1] 305[INPUT SIGNAL 305] --> 310[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 310] 345[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 345] --> 350[OUTPUT SIGNAL 350] end subgraph Device_2 [DEVICE 2] 315[RECEIVE SIGNAL DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 315] --> 320[DETERMINE DISTORTION ON COMMUNICATION PATH 320] 320 --> 330[PRE-DISTORT SIGNAL 330] 330 --> 335[TRANSMIT PRE-DISTORTED SIGNAL ACROSS COMMUNICATION PATH 335] end 310 -.-> 315 335 -.-> 345 315 --> 320 </pre> FIGURE 3

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 4  <pre> graph TD subgraph Device_1 [DEVICE 1] 405[INPUT SIGNAL 405] --> 410[PRE-DISTORT SIGNAL 410] 410 --> 415[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 415] 470[DETERMINE DISTORTION ON COMMUNICATION PATH 470] --> 480[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 480] 480 --> 485[OUTPUT SIGNAL 485] end subgraph Device_2 [DEVICE 2] 420[RECEIVE SIGNAL FURTHER DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 420] --> 425[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 425] 425 --> 430[OUTPUT SIGNAL 430] 450[PRE-DISTORT SIGNAL 450] --> 455[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 455] 455 --> 465[RECEIVE SIGNAL FURTHER DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 465] 465 --> 470 end 415 -.-> 420 455 -.-> 465 </pre> FIGURE 4

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 5  FIGURE 5 Hardacker at [0002] FIG. 1 shows a communication system according to the conventional art. The communication system 100 includes a transmitter 110, a communication path 120, a receiver 130 and an equalizer 140. The transmitter 110 transmits a signal $[T]$ across the communication path 120. The receiver 130 receives a distorted signal $[T]*[D]$ after transmission across the communication path 120. The equalizer 140 equalizes $[D^{-1}]$ the distorted signal $[T]*[D]$. If the distortion on the communication channel 120 is less than the recovery capability $[D^{-1}]$ of the equalizer 140, the recovered signal will be substantially equal to the transmitted signal $[T]$. However, if the distortion on the communication channel 120 is greater than the recovery capability of the equalizer 140, the recovered signal $[T']$ will not be equal to the transmitted signal $[T]$. Hardacker at [0003] Embodiments of the present technology are directed toward techniques for pre-distorting signals. In one embodiment, a method of sending and receiving signals includes determining the nature of the distortion and/or interference on a communication path. Thereafter, signals to be transmitted on the communication path are pre-distorted as a function of the determined distortion. The pre-distortion may be accomplished

Claim Element	Exemplary Citations to Hardacker
	using various types of distortion including equalization, multi-path, amplitude, frequency, phase and other well known types. Hardacker at [0004] In another embodiment, a system for sending and receiving signals includes one or more devices coupled to one or more communication paths. At least one device includes a transceiver coupled to the communication path and a pre-distortion circuit coupled to the transceiver. The pre-distortion circuit pre-distorts the signals to be transmitted by the transceiver of the given device as a function of the distortion on the communication path. When the signal is transmitted, the distortion on the communication path is at least partially compensated for by the pre-distortion introduced by the pre-distortion circuit. Hardacker at [0005] In one embodiment of the present invention, a first transmitter (a) broadcasts to first receiver (b) and there is also a second transmitter (of b) broadcasting to second receiver (of a). This return channel enables both transmitters (a) and (b) to have a priori information regarding the transmission medium and path the signal takes. In this way, the nature of the distortion or interference is known to the transmitter, therefore, it pre-distorts the transmitted signal to compensate for the receiver exceeding its capabilities in recovering signal. This functionality, in accordance with embodiments of the present invention, reduces the complexity of the receiver by placing some of the burden on the transmitter. The back channel enables optimization of the original signal for the current state of the communications channel. Hardacker at [0006] In another embodiment, a communication methodology is employed in an asymmetric system where complex modulation can be employed while using equalizers and recovery circuits having only limited complexity. In this embodiment, a training signal is sent from a sink device to a source device using a simple modulation M1. The source device, knowing the training signal, determines an equalization $D1^{-1}$ that is able to recover the training signal wherein D1 is the channel distortion for M1. The source then pre-distorts the training signal with the computed $D1^{-1}$ and communicates this back to the sink using a second order modulation M2. The sink then knowing the training signal employs a simple equalization circuit to determine another distortion amount $D1'$ required to recover the training signal from the pre-distorted transmission, where $D1' \cdot D1$ equals D2 (the channel distortion of the M2 modulated signal). Advantageously, the sink then uses M1 to transmit back to the source the computed $D1'$ and upon which the source can compute D2 since it knows D1. Here, the source advantageously uses a simple equalization circuit and simple modulation circuit. Knowing D2, the source can use M2 to communicate large amounts of data to the sink device (as pre-distorted by D2) even though the sink device has a relatively simple equalization circuit and also a simple modulator. Alternatively, the above iterative methodology can be

Claim Element	Exemplary Citations to Hardacker
	repeated for higher order modulations, e.g., M3, etc. Although equalization is described above, this discussion is merely exemplary. This embodiment operates equally well employing other distortion types, e.g., multi-path, amplitude, frequency, phase and other well known types. Hardacker at [0016] With respect to FIG. 2 and FIG. 3, at 305, a first input signal [T(1)] is presented to the transmitter 210 of the first device 205 for transmission. Alternatively, the first input signal [T(1)] may be generated internally by the transmitter 210. The first input signal [T(1)] may be any signal to be transmitted by the first device 205 across the communication path 255. In one implementation, the first input signal [T(1)] is a training or configuration signal specifically utilized to determine the nature of the distortion or interference on the communication path 255. In another implementation, the first input signal [T(1)] may be a predetermined control signal or general data signal that facilitates the determination of the nature of the distortion or interference on the communication path 255. For example, the signal may be a predictable control signal transmitted from the first device 205 to the second device 225 Hardacker at [0017] At 310, the first input signal [T(1)] is transmitted across the communication path 255 by the transmitter 210. At 315, the first input signal distorted by channel distortion D(1) due to transmission across the communication path. The transmitted signal is represented here as a convolution product, $[T(1)]*[D(1)]$, and is received by the receiver 240 of the second device 225. At 320, the distortion [D(1)] introduced by the communication path 255 is automatically determined by the distortion determination circuit 250 since the training signal T(1) is a known signal. Hardacker at [0019] At 340, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)]*[D(1)-1]$ further distorted by [D(2)] after transmission across the communication path 255. If the product of $[D(2)]*[D(1)-1] \neq 1$ at 345, the equalizer 220 in the first device equalizes, or performs some amount of signal recovery on the pre-distorted signal further distorted $[T(2)]*[D(1)-1]*[D(2)]$ by transmission across the communication path to recover the second signal [T(2)]. The convolved distortion $[D(2)]*[D(1)-1]$ is recoverable by the equalization function $[D(n)-1]$ of the equalizer 220. At 350, the recovered second signal [T(2)] is output by the equalizer 220 for use by other circuits of the first device 205. It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization.

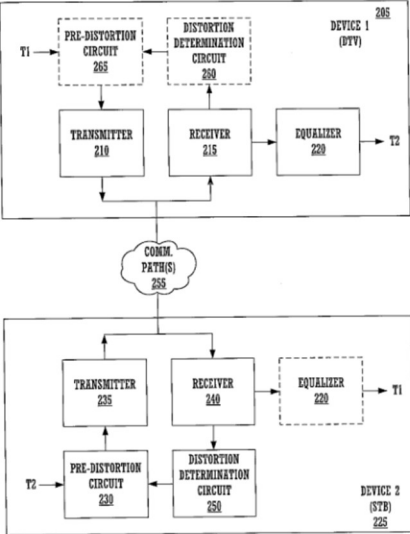
Claim Element	Exemplary Citations to Hardacker
	Hardacker at [0021] In one embodiment, a given application may only need pre-distortion for communication in one direction. For example, a DTV may only transmit control signals requiring a relatively low transmission rate to one or more content sources such as a set top box (STB). However, in the other direction, the set top box transmits a large amount of image data that requires a high transmission rate, which may experience high bit error rates when the distortion and/or interference on the communication path 255 is greater than a particular level. Therefore, implementing pre-distortion in the set top box may be sufficient for such a configuration. In other embodiments it may be desirable to implement pre-distortion in both devices. Therefore, the first device 205 may also include a distortion determination circuit 260 and a pre-distortion circuit 265 in the first device 205 for determining the distortion $[D(1)]$ introduced by the communication path 255 and pre-distorting signals transmitted by the first device 205. Likewise, the second device 225 may include an equalizer 245 to recover pre-distorted signals transmitted by the first device 205. Hardacker at [0022] Referring now to FIG. 4, a method of transmitting and receiving signals, in accordance with other embodiments of the present technology, is shown. The system implementing the method of FIG. 4 may be the communications system of FIG. 2, for instance. At least one transmitter, e.g., of device 205 contains a distortion determination circuit 260 and a pre-distortion circuit 265. A back channel exists between the transmitter 235 of device 225 and the receiver 215 of device 205. Hardacker at [0023] Regarding FIG. 4, at 405, there is a first input signal $[T(1)]$ to be transmitted by the first device 205 across the communication path 255. The first signal $[T(1)]$ is pre-distorted by $[D(1)]$ by the pre-distortion circuit 265, at 410. The first input signal $[T(1)]$ may be distorted based upon the nature of the distortion or interference on the communication path 255 as previously determined by the distortion determination circuit 260 during receipt of a previous signal (e.g., during process 460 described below). At 515, the pre-distorted signal $[T(1)]*[D(1)-1]$ is transmitted by the transmitter 210 across the communication path 255. Hardacker at [0024] At 420, the receiver 240 of the second device 225 receives the pre-distorted signal $[T(1)]*[D(1)-1]$ further distorted by $[D(1)]$ after transmission across the communication path 255. The received pre-distorted signal is represented as $[[T(1)]*[D(1)-1]]*D(1)$. At 425, the equalizer 245 of the second device 225 equalizes the received pre-distorted signal by $D(1)-1$ to recover the first signal $[T(1)]$. At 430, the recovered signal $[T(1)]$ is output from the equalizer 245 for use by other circuits of the second device 225. In addition, the distortion determination circuit 250 determines the distortion $[D(1)]$ on the communication path 255, at 435. The distortion $[D(1)]$ may be used by the pre-distortion circuit 230 to

Claim Element	Exemplary Citations to Hardacker
	pre-distort signals (e.g., during process 445 described below). It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0025] At 440, there is a second input signal $[T(2)]$ to be transmitted by the second device 225 across the communication path 255 to device 205. The second signal $[T(2)]$ is pre-distorted $[D(1)-1]$ by the pre-distortion circuit 230, at 445. The second input signal $[T(2)]$ may be distorted based upon the nature of the distortion or interference on the communication path 255 as determined by the distortion determination circuit 230 during receipt of a previous signal (e.g., during process 435 described above). At 450, the pre-distorted signal $[T(2)]*[D(1)-1]$ is transmitted by the transmitter 235 across the communication path 255. Hardacker at [0026] At 455, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)]*[D(1)-1]$ further distorted by $[D(2)]$ after transmission across the communication path 255. At 460, the equalizer 220 equalizes the received pre-distorted signal $[[T(2)]*[D(1)-1]]*[D(2)]$ to recover the first signal $[T(2)]$. At 465, the recovered signal $[T(2)]$ is output from the equalizer 220 for use by other circuits of the first device 205. In addition, the distortion determination circuit 260 determines the distortion $[D(1)]$ on the communication path 255. The nature of the distortion or interference determined by the distortion determination circuit 260 is used at process 410 to apply an appropriate amount of pre-distortion $[D(1)-1]$. Again, the distortion $[D(1)]$ on the communication path 255 may be determined for each signal received by the receiver 215 or periodically when the distortion changes over time. Hardacker at [0027] The above described embodiments are intended for use when the distortion on the communication path 255 is substantially the same when signals are transmitted from the first device 205 to the second device 225 and from the second device 225 to the first device 205. However, in other circumstances the distortion on the communication path is not the same in both directions between two devices and may also differ between different devices. Therefore, in another embodiment (as shown in FIG. 5), data indicating the distortion determined at process 435 is transmitted from the second device 225 back to the first device 205 and used by the pre-distortion circuit 260 of the first device 205 to pre-distort the signal $(T(1))$ transmitted from the first device 205 to the second device 225 at process 410. Similarly, data indicating the distortion determined at process 470 is transmitted from the first device 205 back to the second device

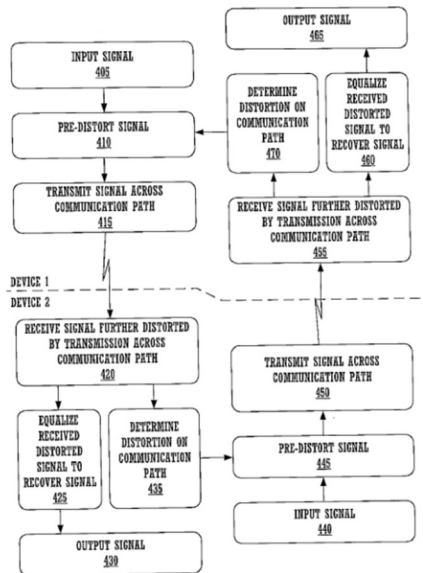
Claim Element	Exemplary Citations to Hardacker
	and used by the pre-distortion circuit 230 of the second device 225 to pre-distort the signal (T(2)) at process 445. Hardacker at [0029] In one implementation, the channel frequency response is determined. The inverse of the channel frequency response may then be used by the pre-distortion circuit 430 to pre-distort signals. In another implementation, the amount of pre-distortion applied by the pre-distortion circuit 430 may be a function of the impulse response of the communication path 445. Hardacker at [0034] In accordance with FIG. 5, the sink device 515 sends a training signal or data packet T(1) to the source device 510 using a simple modulation M1520. The training signal is known to the source device 510. The transmit signal is represented at 525 as $[T(1)*M1]*D1$ where D1 is the distortion of the communication channel as seen using modulation M1. Channel distortion can have phase, amplitude and multipath distortion characteristics which may all be non-linear. Herein, a distortion description, Dx, is valid for a single type of modulation, Mx, but may not be accurate for more advanced modulations, e.g., M(x+1). The source device 510 receives the signal 525 and equalizes the signal and demodulates the signal until the known training data packet T(1) is recovered at 527. Since the source device 510 knows the modulation M1 used, the equalizer is varied in a feedback loop fashion until the known training signal T(1) is recovered. When recovered, the equalizer located a good first order approximation of the channel distortion, or D1-1. This first order approximation is good enough for the simple modulation M1. Hardacker at [0036] At this point, the sink device 515 communicates D1' to the source device 510 using the simple modulation M1. Specifically, the sink device uses simple modulation M1 to transmit D1' to the source device at 536. This transmission 536 experiences channel distortion D1. The source device 510 already knows the channel distortion approximation D1-1 and the modulation scheme M1, so the data packet D1' is readily recovered at 538. Since the source device knows D1' and D1, it can advantageously compute D2, a second order approximation of the channel distortion for modulation M2. Source 510 now sends T(1) again by transmission 542 but using a more complex modulation scheme, M3540, with the transmitted signal pre-distorted by the second order pre-distortion, D2-1. The sink 515 again has to equalize the recovered signal slightly because the D2-1 pre-distortion is good enough for M2, but not quite good enough for M3. Equalization continues until the training signal is recovered at 544. This leads to distortion approximation D2'(D3=D2*D2'). Again, the sink 515 sends back to the source 510 (using M1) the additional equalization T(D2') necessary to decode T(1) when modulated with M3. This is shown as 546.

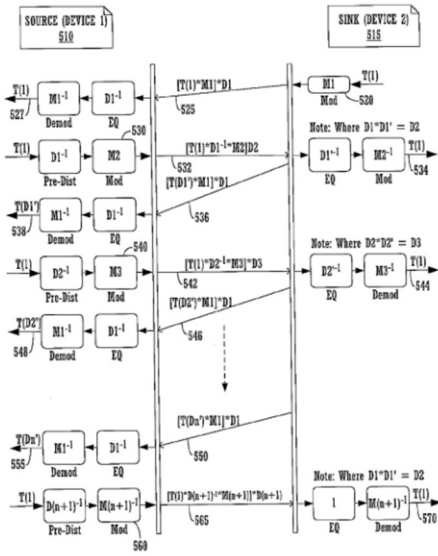
Claim Element	Exemplary Citations to Hardacker
	Hardacker at [0037] The source device 510 already knows the channel distortion approximation D1–1 and the modulation scheme M1, so the data packet D2' is readily recovered at 538. Since the source device knows D2' and D2, it can advantageously compute D3, a third order approximation of the channel distortion for M3. This third order channel distortion D3 can be used by the source device 510 to communicate large amounts of data to the sink device 515 using pre-distortion D3–1 and modulation M3, as shown in general terms by transmission 565. The above process is iterative, with each group of communications providing for more complex modulation while using limited equalization. The number of iterations is variable depending on the modulation required and the particular number of iterations shown in FIG. 5 is exemplary. Hardacker at claim 1 1. A method comprising:determining a distortion on a communication path between a first device and a second device;pre-distorting a signal to be transmitted as a function of the distortion determined on the communication path to produce a pre-distorted signal; andtransmitting the pre-distorted signal on the communication path wherein said transmitting is performed by the first device of said two devices. Hardacker at claim 2 2. The method according to claim 1, further comprising receiving the pre-distorted signal after transmission across the communication path wherein said receiving is performed by the second device of said two devices. Hardacker at claim 4 4. A method comprising:transmitting a first signal from a first device to a second device wherein said first signal is a known signal;at said second device, determining a first distortion amount in recovering said first signal wherein said first distortion amount represents channel distortion of a communication channel between said first device and said second device;pre-distorting a second signal at said second device and transmitting a pre-distorted version of said second signal to said first device; andsaid first device performing a signal recovery process on said pre-distorted version of said second signal to recover said second signal. Hardacker at claims 8–10 8. A system for communicating over a communication path, said system comprising:a first device comprising:a first pre-distortion circuit for pre-distortion a first signal as a function of a distortion introduced on the communication path from the first device to a second device;a first transmitter coupled to the first pre-distortion circuit for transmitting the first signal on the communication path; andthe second device comprising a first receiver communicatively coupled to the communication path for receiving the

Claim Element	Exemplary Citations to Hardacker
	pre-distorted first signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the first pre-distortion circuit.9. The system of claim 8, wherein:the second device further comprises:a first distortion determination circuit coupled to the first receiver for determining the distortion on the communication path from a training signal after transmission across the communication path from the first device to the second device; anda second transmitter coupled to the first distortion determination circuit for transmitting data to the first device indicating the distortion on the communication path from the first device to the second device; andwherein the first device further comprises:a second receiver communicatively coupled to the communication path for receiving the data indicating the distortion on the communication path from the first device to the second device.10. The system of claim 9, wherein:the second device further comprises a second pre-distortion circuit for pre-distorting a second signal as a function of a distortion introduced on the communication path from the second device to the first device;wherein the second transmitter is for further transmitting the second signal on the communication path; andwherein further the second receiver is communicatively coupled to the communication path for receiving the pre-distorted second signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the second pre-distortion circuit. To the extent this element is not disclosed by Hardacker, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Hardacker, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
21. The wireless device of claim 20, wherein the path parameter information of the first propagation path further includes an estimation of a polarization status of the first propagation path.	Hardacker discloses or renders obvious “[t]he wireless device of claim 20, wherein the path parameter information of the first propagation path further includes an estimation of a polarization status of the first propagation path.” For example: Hardacker at Abstract Techniques for sending and receiving signals include pre-distorting signals before transmission across a communication path. The signals are pre-distorted as a function of a distortion on the communication path. In one embodiments, transmitter a broadcasts to receiver b and there is also a transmitter b broadcasting to receiver a. This return channel enables both transmitters a and b to have a priori information regarding the transmission medium and path the signal takes. In this way, the nature of the distortion or interference is known to the transmitter, therefore, it pre-distorts the transmitted signal to compensate for the receiver exceeding its capabilities in recovering signal.

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 2  FIGURE 2

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 3 <pre> graph TD subgraph Device_1 [DEVICE 1] 305[INPUT SIGNAL 305] --> 310[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 310] 345[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 345] --> 350[OUTPUT SIGNAL 350] end subgraph Device_2 [DEVICE 2] 315[RECEIVE SIGNAL DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 315] --> 320[DETERMINE DISTORTION ON COMMUNICATION PATH 320] 320 --> 330[PRE-DISTORT SIGNAL 330] 330 --> 335[TRANSMIT PRE-DISTORTED SIGNAL ACROSS COMMUNICATION PATH 335] end 310 -.-> 315 335 -.-> 345 315 --> 320 </pre> FIGURE 3

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 4  <pre> graph TD subgraph Device_1 [DEVICE 1] 405[INPUT SIGNAL 405] --> 410[PRE-DISTORT SIGNAL 410] 410 --> 415[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 415] 470[DETERMINE DISTORTION ON COMMUNICATION PATH 470] 460[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 460] 465[OUTPUT SIGNAL 465] end subgraph Device_2 [DEVICE 2] 420[RECEIVE SIGNAL FURTHER DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 420] 425[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 425] 435[DETERMINE DISTORTION ON COMMUNICATION PATH 435] 430[OUTPUT SIGNAL 430] 440[INPUT SIGNAL 440] 445[PRE-DISTORT SIGNAL 445] 450[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 450] end 415 -.-> 420 425 --> 430 435 --> 445 445 --> 450 450 -.-> 460 460 --> 465 470 --> 410 470 --> 460 </pre> FIGURE 4

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 5  FIGURE 5 Hardacker at [0002] FIG. 1 shows a communication system according to the conventional art. The communication system 100 includes a transmitter 110, a communication path 120, a receiver 130 and an equalizer 140. The transmitter 110 transmits a signal $[T]$ across the communication path 120. The receiver 130 receives a distorted signal $[T]*[D]$ after transmission across the communication path 120. The equalizer 140 equalizes $[D-1]$ the distorted signal $[T]*[D]$. If the distortion on the communication channel 120 is less than the recovery capability $[D-1]$ of the equalizer 140, the recovered signal will be substantially equal to the transmitted signal $[T]$. However, if the distortion on the communication channel 120 is greater than the recovery capability of the equalizer 140, the recovered signal $[T']$ will not be equal to the transmitted signal $[T]$. Hardacker at [0003] Embodiments of the present technology are directed toward techniques for pre-distorting signals. In one embodiment, a method of sending and receiving signals includes determining the nature of the distortion and/or interference on a communication path. Thereafter, signals to be transmitted on the communication path are pre-distorted as a function of the determined distortion. The pre-distortion may be accomplished

Claim Element	Exemplary Citations to Hardacker
	using various types of distortion including equalization, multi-path, amplitude, frequency, phase and other well known types. Hardacker at [0004] In another embodiment, a system for sending and receiving signals includes one or more devices coupled to one or more communication paths. At least one device includes a transceiver coupled to the communication path and a pre-distortion circuit coupled to the transceiver. The pre-distortion circuit pre-distorts the signals to be transmitted by the transceiver of the given device as a function of the distortion on the communication path. When the signal is transmitted, the distortion on the communication path is at least partially compensated for by the pre-distortion introduced by the pre-distortion circuit. Hardacker at [0005] In one embodiment of the present invention, a first transmitter (a) broadcasts to first receiver (b) and there is also a second transmitter (of b) broadcasting to second receiver (of a). This return channel enables both transmitters (a) and (b) to have a priori information regarding the transmission medium and path the signal takes. In this way, the nature of the distortion or interference is known to the transmitter, therefore, it pre-distorts the transmitted signal to compensate for the receiver exceeding its capabilities in recovering signal. This functionality, in accordance with embodiments of the present invention, reduces the complexity of the receiver by placing some of the burden on the transmitter. The back channel enables optimization of the original signal for the current state of the communications channel. Hardacker at [0006] In another embodiment, a communication methodology is employed in an asymmetric system where complex modulation can be employed while using equalizers and recovery circuits having only limited complexity. In this embodiment, a training signal is sent from a sink device to a source device using a simple modulation M1. The source device, knowing the training signal, determines an equalization $D1^{-1}$ that is able to recover the training signal wherein D1 is the channel distortion for M1. The source then pre-distorts the training signal with the computed $D1^{-1}$ and communicates this back to the sink using a second order modulation M2. The sink then knowing the training signal employs a simple equalization circuit to determine another distortion amount $D1'$ required to recover the training signal from the pre-distorted transmission, where $D1' \cdot D1$ equals D2 (the channel distortion of the M2 modulated signal). Advantageously, the sink then uses M1 to transmit back to the source the computed $D1'$ and upon which the source can compute D2 since it knows D1. Here, the source advantageously uses a simple equalization circuit and simple modulation circuit. Knowing D2, the source can use M2 to communicate large amounts of data to the sink device (as pre-distorted by D2) even though the sink device has a relatively simple equalization circuit and also a simple modulator. Alternatively, the above iterative methodology can be

Claim Element	Exemplary Citations to Hardacker
	repeated for higher order modulations, e.g., M3, etc. Although equalization is described above, this discussion is merely exemplary. This embodiment operates equally well employing other distortion types, e.g., multi-path, amplitude, frequency, phase and other well known types. Hardacker at [0016] With respect to FIG. 2 and FIG. 3, at 305, a first input signal [T(1)] is presented to the transmitter 210 of the first device 205 for transmission. Alternatively, the first input signal [T(1)] may be generated internally by the transmitter 210. The first input signal [T(1)] may be any signal to be transmitted by the first device 205 across the communication path 255. In one implementation, the first input signal [T(1)] is a training or configuration signal specifically utilized to determine the nature of the distortion or interference on the communication path 255. In another implementation, the first input signal [T(1)] may be a predetermined control signal or general data signal that facilitates the determination of the nature of the distortion or interference on the communication path 255. For example, the signal may be a predictable control signal transmitted from the first device 205 to the second device 225 Hardacker at [0017] At 310, the first input signal [T(1)] is transmitted across the communication path 255 by the transmitter 210. At 315, the first input signal distorted by channel distortion D(1) due to transmission across the communication path. The transmitted signal is represented here as a convolution product, $[T(1)] * [D(1)]$, and is received by the receiver 240 of the second device 225. At 320, the distortion [D(1)] introduced by the communication path 255 is automatically determined by the distortion determination circuit 250 since the training signal T(1) is a known signal. Hardacker at [0019] At 340, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)] * [D(1)-1]$ further distorted by [D(2)] after transmission across the communication path 255. If the product of $[D(2)] * [D(1)-1] \neq 1$ at 345, the equalizer 220 in the first device equalizes, or performs some amount of signal recovery on the pre-distorted signal further distorted $[T(2)] * [D(1)-1] * [D(2)]$ by transmission across the communication path to recover the second signal [T(2)]. The convolved distortion $[D(2)] * [D(1)-1]$ is recoverable by the equalization function $[D(n)-1]$ of the equalizer 220. At 350, the recovered second signal [T(2)] is output by the equalizer 220 for use by other circuits of the first device 205. It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization.

Claim Element	Exemplary Citations to Hardacker
	Hardacker at [0021] In one embodiment, a given application may only need pre-distortion for communication in one direction. For example, a DTV may only transmit control signals requiring a relatively low transmission rate to one or more content sources such as a set top box (STB). However, in the other direction, the set top box transmits a large amount of image data that requires a high transmission rate, which may experience high bit error rates when the distortion and/or interference on the communication path 255 is greater than a particular level. Therefore, implementing pre-distortion in the set top box may be sufficient for such a configuration. In other embodiments it may be desirable to implement pre-distortion in both devices. Therefore, the first device 205 may also include a distortion determination circuit 260 and a pre-distortion circuit 265 in the first device 205 for determining the distortion [D(1)] introduced by the communication path 255 and pre-distorting signals transmitted by the first device 205. Likewise, the second device 225 may include an equalizer 245 to recover pre-distorted signals transmitted by the first device 205. Hardacker at [0022] Referring now to FIG. 4, a method of transmitting and receiving signals, in accordance with other embodiments of the present technology, is shown. The system implementing the method of FIG. 4 may be the communications system of FIG. 2, for instance. At least one transmitter, e.g., of device 205 contains a distortion determination circuit 260 and a pre-distortion circuit 265. A back channel exists between the transmitter 235 of device 225 and the receiver 215 of device 205. Hardacker at [0023] Regarding FIG. 4, at 405, there is a first input signal [T(1)] to be transmitted by the first device 205 across the communication path 255. The first signal [T(1)] is pre-distorted by [D(1)] by the pre-distortion circuit 265, at 410. The first input signal [T(1)] may be distorted based upon the nature of the distortion or interference on the communication path 255 as previously determined by the distortion determination circuit 260 during receipt of a previous signal (e.g., during process 460 described below). At 515, the pre-distorted signal $[T(1)]*[D(1)-1]$ is transmitted by the transmitter 210 across the communication path 255. Hardacker at [0024] At 420, the receiver 240 of the second device 225 receives the pre-distorted signal $[T(1)]*[D(1)-1]$ further distorted by [D(1)] after transmission across the communication path 255. The received pre-distorted signal is represented as $[[T(1)]*[D(1)-1]]*D(1)$. At 425, the equalizer 245 of the second device 225 equalizes the received pre-distorted signal by $D(1)-1$ to recover the first signal [T(1)]. At 430, the recovered signal [T(1)] is output from the equalizer 245 for use by other circuits of the second device 225. In addition, the distortion determination circuit 250 determines the distortion [D(1)] on the communication path 255, at 435. The distortion [D(1)] may be used by the pre-distortion circuit 230 to

Claim Element	Exemplary Citations to Hardacker
	pre-distort signals (e.g., during process 445 described below). It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0025] At 440, there is a second input signal $[T(2)]$ to be transmitted by the second device 225 across the communication path 255 to device 205. The second signal $[T(2)]$ is pre-distorted $[D(1)-1]$ by the pre-distortion circuit 230, at 445. The second input signal $[T(2)]$ may be distorted based upon the nature of the distortion or interference on the communication path 255 as determined by the distortion determination circuit 230 during receipt of a previous signal (e.g., during process 435 described above). At 450, the pre-distorted signal $[T(2)]*[D(1)-1]$ is transmitted by the transmitter 235 across the communication path 255. Hardacker at [0026] At 455, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)]*[D(1)-1]$ further distorted by $[D(2)]$ after transmission across the communication path 255. At 460, the equalizer 220 equalizes the received pre-distorted signal $[[T(2)]*[D(1)-1]]*[D(2)]$ to recover the first signal $[T(2)]$. At 465, the recovered signal $[T(2)]$ is output from the equalizer 220 for use by other circuits of the first device 205. In addition, the distortion determination circuit 260 determines the distortion $[D(1)]$ on the communication path 255. The nature of the distortion or interference determined by the distortion determination circuit 260 is used at process 410 to apply an appropriate amount of pre-distortion $[D(1)-1]$. Again, the distortion $[D(1)]$ on the communication path 255 may be determined for each signal received by the receiver 215 or periodically when the distortion changes over time. Hardacker at [0027] The above described embodiments are intended for use when the distortion on the communication path 255 is substantially the same when signals are transmitted from the first device 205 to the second device 225 and from the second device 225 to the first device 205. However, in other circumstances the distortion on the communication path is not the same in both directions between two devices and may also differ between different devices. Therefore, in another embodiment (as shown in FIG. 5), data indicating the distortion determined at process 435 is transmitted from the second device 225 back to the first device 205 and used by the pre-distortion circuit 260 of the first device 205 to pre-distort the signal $(T(1))$ transmitted from the first device 205 to the second device 225 at process 410. Similarly, data indicating the distortion determined at process 470 is transmitted from the first device 205 back to the second device

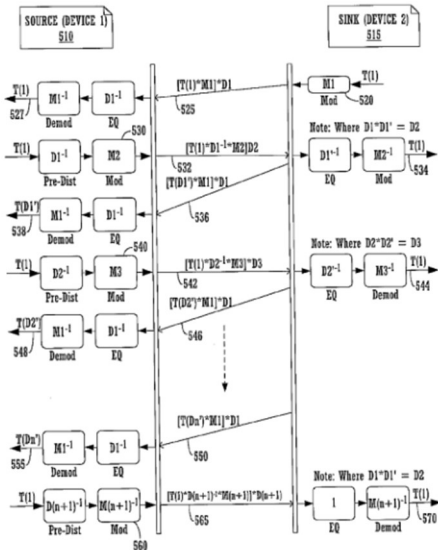
Claim Element	Exemplary Citations to Hardacker
	and used by the pre-distortion circuit 230 of the second device 225 to pre-distort the signal (T(2)) at process 445. Hardacker at [0029] In one implementation, the channel frequency response is determined. The inverse of the channel frequency response may then be used by the pre-distortion circuit 430 to pre-distort signals. In another implementation, the amount of pre-distortion applied by the pre-distortion circuit 430 may be a function of the impulse response of the communication path 445. Hardacker at [0034] In accordance with FIG. 5, the sink device 515 sends a training signal or data packet T(1) to the source device 510 using a simple modulation M1 520. The training signal is known to the source device 510. The transmit signal is represented at 525 as $[T(1)*M1]*D1$ where D1 is the distortion of the communication channel as seen using modulation M1. Channel distortion can have phase, amplitude and multipath distortion characteristics which may all be non-linear. Herein, a distortion description, Dx, is valid for a single type of modulation, Mx, but may not be accurate for more advanced modulations, e.g., M(x+1). The source device 510 receives the signal 525 and equalizes the signal and demodulates the signal until the known training data packet T(1) is recovered at 527. Since the source device 510 knows the modulation M1 used, the equalizer is varied in a feedback loop fashion until the known training signal T(1) is recovered. When recovered, the equalizer located a good first order approximation of the channel distortion, or D1-1. This first order approximation is good enough for the simple modulation M1. Hardacker at [0036] At this point, the sink device 515 communicates D1' to the source device 510 using the simple modulation M1. Specifically, the sink device uses simple modulation M1 to transmit D1' to the source device at 536. This transmission 536 experiences channel distortion D1. The source device 510 already knows the channel distortion approximation D1-1 and the modulation scheme M1, so the data packet D1' is readily recovered at 538. Since the source device knows D1' and D1, it can advantageously compute D2, a second order approximation of the channel distortion for modulation M2. Source 510 now sends T(1) again by transmission 542 but using a more complex modulation scheme, M3 540, with the transmitted signal pre-distorted by the second order pre-distortion, D2-1. The sink 515 again has to equalize the recovered signal slightly because the D2-1 pre-distortion is good enough for M2, but not quite good enough for M3. Equalization continues until the training signal is recovered at 544. This leads to distortion approximation D2'(D3=D2*D2'). Again, the sink 515 sends back to the source 510 (using M1) the additional equalization T(D2') necessary to decode T(1) when modulated with M3. This is shown as 546.

Claim Element	Exemplary Citations to Hardacker
	Hardacker at [0037] The source device 510 already knows the channel distortion approximation D1–1 and the modulation scheme M1, so the data packet D2' is readily recovered at 538. Since the source device knows D2' and D2, it can advantageously compute D3, a third order approximation of the channel distortion for M3. This third order channel distortion D3 can be used by the source device 510 to communicate large amounts of data to the sink device 515 using pre-distortion D3–1 and modulation M3, as shown in general terms by transmission 565. The above process is iterative, with each group of communications providing for more complex modulation while using limited equalization. The number of iterations is variable depending on the modulation required and the particular number of iterations shown in FIG. 5 is exemplary. Hardacker at claim 1 1. A method comprising:determining a distortion on a communication path between a first device and a second device;pre-distorting a signal to be transmitted as a function of the distortion determined on the communication path to produce a pre-distorted signal; andtransmitting the pre-distorted signal on the communication path wherein said transmitting is performed by the first device of said two devices. Hardacker at claim 2 2. The method according to claim 1, further comprising receiving the pre-distorted signal after transmission across the communication path wherein said receiving is performed by the second device of said two devices. Hardacker at claim 4 4. A method comprising:transmitting a first signal from a first device to a second device wherein said first signal is a known signal;at said second device, determining a first distortion amount in recovering said first signal wherein said first distortion amount represents channel distortion of a communication channel between said first device and said second device;pre-distorting a second signal at said second device and transmitting a pre-distorted version of said second signal to said first device; andsaid first device performing a signal recovery process on said pre-distorted version of said second signal to recover said second signal. Hardacker at claims 8–10 8. A system for communicating over a communication path, said system comprising:a first device comprising:a first pre-distortion circuit for pre-distortion a first signal as a function of a distortion introduced on the communication path from the first device to a second device;a first transmitter coupled to the first pre-distortion circuit for transmitting the first signal on the communication path; andthe second device comprising a first receiver communicatively coupled to the communication path for receiving the

Claim Element	Exemplary Citations to Hardacker
	pre-distorted first signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the first pre-distortion circuit.9. The system of claim 8, wherein:the second device further comprises:a first distortion determination circuit coupled to the first receiver for determining the distortion on the communication path from a training signal after transmission across the communication path from the first device to the second device; anda second transmitter coupled to the first distortion determination circuit for transmitting data to the first device indicating the distortion on the communication path from the first device to the second device; andwherein the first device further comprises:a second receiver communicatively coupled to the communication path for receiving the data indicating the distortion on the communication path from the first device to the second device.10. The system of claim 9, wherein:the second device further comprises a second pre-distortion circuit for pre-distorting a second signal as a function of a distortion introduced on the communication path from the second device to the first device;wherein the second transmitter is for further transmitting the second signal on the communication path; andwherein further the second receiver is communicatively coupled to the communication path for receiving the pre-distorted second signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the second pre-distortion circuit. To the extent this element is not disclosed by Hardacker, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Hardacker, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
22. The wireless device of claim 19, wherein the path parameter information is obtained by at least one estimation technique of the group consisting of a maximum likelihood estimation algorithm, periodogram, correlatorgram, spectral-based methods, Bartlett beamformers, Capon beamformers, subspace-based techniques, MUSIC (Multiple Signal Classification), ESPRIT (Estimation of Signal Parameters via Rotational Invariance Techniques), approximation of the maximum-likelihood method based on iterative schemes, SAGE (Space-Alternating Generalized Expectation-maximization), RiMAX (Richter's Maximum Likelihood method), maximum-a-posteriori based methods, Evidence Framework, Bayesian techniques, tracking algorithms, Kalman filtering techniques, enhanced Kalman filtering techniques, particle filtering techniques, and least-square-error methods.” For example:	Hardacker discloses or renders obvious “[t]he wireless device of claim 19, wherein the path parameter information is obtained by at least one estimation technique of the group consisting of a maximum likelihood estimation algorithm, periodogram, correlatorgram, spectral-based methods, Bartlett beamformers, Capon beamformers, subspace-based techniques, MUSIC (Multiple Signal Classification), ESPRIT (Estimation of Signal Parameters via Rotational Invariance Techniques), approximation of the maximum-likelihood method based on iterative schemes, SAGE (Space-Alternating Generalized Expectation-maximization), RiMAX (Richter's Maximum Likelihood method), maximum-a-posteriori based methods, Evidence Framework, Bayesian techniques, tracking algorithms, Kalman filtering techniques, enhanced Kalman filtering techniques, particle filtering techniques, and least-square-error methods.” For example:

Claim Element	Exemplary Citations to Hardacker
via Rotational Invariance Techniques), approximation of the maximum-likelihood method based on iterative schemes, SAGE (Space-Alternating Generalized Expectation-maximization), RiMAX (Richter's Maximum Likelihood method), maximum-a-posteriori based methods, Evidence Framework, Bayesian techniques, tracking algorithms, Kalman filtering techniques, enhanced Kalman filtering techniques, particle filtering techniques, and least-square-error methods.	Hardacker at Figure 3 <pre> graph TD subgraph Device_1 [DEVICE 1] 305[INPUT SIGNAL 305] --> 310[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 310] 315[RECEIVE SIGNAL DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 315] end subgraph Device_2 [DEVICE 2] 320[RECEIVE SIGNAL DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 320] 330[PRE-DISTORT SIGNAL 330] 335[TRANSMIT PRE-DISTORTED SIGNAL ACROSS COMMUNICATION PATH 335] 340[OUTPUT SIGNAL 340] end 310 --> 315 315 --> 320 320 --> 330 330 --> 335 335 --> 340 330 --> 315 340 --> 345[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 345] 345 --> 350[RECEIVE PRE-DISTORTED SIGNAL FURTHER DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 350] 350 --> 340 </pre> FIGURE 3

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 4 <pre> graph TD subgraph Device_1 [DEVICE 1] 405[INPUT SIGNAL 405] --> 410[PRE-DISTORT SIGNAL 410] 410 --> 415[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 415] 470[DETERMINE DISTORTION ON COMMUNICATION PATH 470] 460[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 460] 465[OUTPUT SIGNAL 465] end subgraph Device_2 [DEVICE 2] 420[RECEIVE SIGNAL FURTHER DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 420] 425[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 425] 435[DETERMINE DISTORTION ON COMMUNICATION PATH 435] 440[INPUT SIGNAL 440] 445[PRE-DISTORT SIGNAL 445] 450[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 450] 455[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 455] end 415 -.-> 420 425 --> 435 435 --> 445 445 --> 450 450 --> 455 455 --> 460 460 --> 470 470 --> 410 470 --> 460 460 --> 465 </pre> FIGURE 4

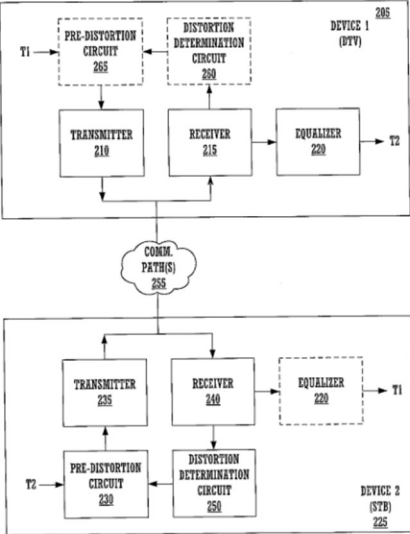
Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 5  FIGURE 5 Hardacker at [0006] In another embodiment, a communication methodology is employed in an asymmetric system where complex modulation can be employed while using equalizers and recovery circuits having only limited complexity. In this embodiment, a training signal is sent from a sink device to a source device using a simple modulation M1. The source device, knowing the training signal, determines an equalization D1–1 that is able to recover the training signal wherein D1 is the channel distortion for M1. The source then pre-distorts the training signal with the computed D1–1 and communicates this back to the sink using a second order modulation M2. The sink then knowing the training signal employs a simple equalization circuit to determine another distortion amount D1' required to recover the training signal from the pre-distorted transmission, where D1'*D1 equals D2 (the channel distortion of the M2 modulated signal). Advantageously, the sink then uses M1 to transmit back to the source the computed D1' and upon which the source can compute D2 since it knows D1. Here, the source advantageously uses a simple equalization circuit and simple modulation circuit. Knowing D2, the source can use M2 to communicate large amounts of data to the sink device (as pre-distorted by D2) even though the sink device has a relatively simple equalization circuit and also a simple modulator. Alternatively, the above iterative methodology can be repeated for higher order modulations, e.g., M3, etc. Although equalization is described above, this

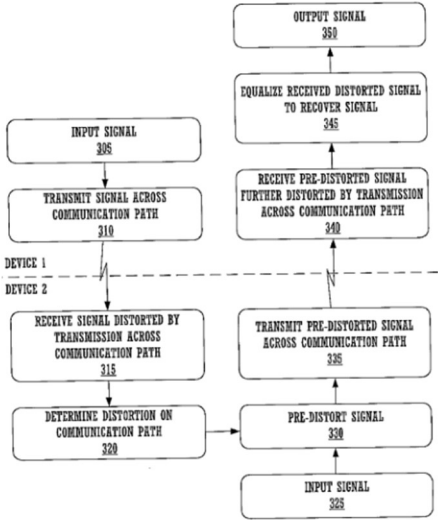
Claim Element	Exemplary Citations to Hardacker
	discussion is merely exemplary. This embodiment operates equally well employing other distortion types, e.g., multi-path, amplitude, frequency, phase and other well known types. Hardacker at [0019] At 340, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)]*[D(1)-1]$ further distorted by $[D(2)]$ after transmission across the communication path 255. If the product of $[D(2)]*[D(1)-1] \neq 1$ at 345, the equalizer 220 in the first device equalizes, or performs some amount of signal recovery on the pre-distorted signal further distorted $[T(2)]*[D(1)-1]*[D(2)]$ by transmission across the communication path to recover the second signal $[T(2)]$. The convolved distortion $[D(2)]*[D(1)-1]$ is recoverable by the equalization function $[D(n)-1]$ of the equalizer 220. At 350, the recovered second signal $[T(2)]$ is output by the equalizer 220 for use by other circuits of the first device 205. It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0021] In one embodiment, a given application may only need pre-distortion for communication in one direction. For example, a DTV may only transmit control signals requiring a relatively low transmission rate to one or more content sources such as a set top box (STB). However, in the other direction, the set top box transmits a large amount of image data that requires a high transmission rate, which may experience high bit error rates when the distortion and/or interference on the communication path 255 is greater than a particular level. Therefore, implementing pre-distortion in the set top box may be sufficient for such a configuration. In other embodiments it may be desirable to implement pre-distortion in both devices. Therefore, the first device 205 may also include a distortion determination circuit 260 and a pre-distortion circuit 265 in the first device 205 for determining the distortion $[D(1)]$ introduced by the communication path 255 and pre-distorting signals transmitted by the first device 205. Likewise, the second device 225 may include an equalizer 245 to recover pre-distorted signals transmitted by the first device 205. Hardacker at [0024] At 420, the receiver 240 of the second device 225 receives the pre-distorted signal $[T(1)]*[D(1)-1]$ further distorted by $[D(1)]$ after transmission across the communication path 255. The received pre-distorted signal is represented as $[[T(1)]*[D(1)-1]]*D(1)$. At 425, the equalizer 245 of the second device 225 equalizes the received pre-distorted signal by $D(1)-1$ to recover the first signal $[T(1)]$. At 430, the recovered signal $[T(1)]$ is output from the equalizer 245 for use by other circuits of the second device 225. In addition, the distortion determination circuit 250 determines the distortion $[D(1)]$ on the

Claim Element	Exemplary Citations to Hardacker
	communication path 255, at 435. The distortion [D(1)] may be used by the pre-distortion circuit 230 to pre-distort signals (e.g., during process 445 described below). It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0027] The above described embodiments are intended for use when the distortion on the communication path 255 is substantially the same when signals are transmitted from the first device 205 to the second device 225 and from the second device 225 to the first device 205. However, in other circumstances the distortion on the communication path is not the same in both directions between two devices and may also differ between different devices. Therefore, in another embodiment (as shown in FIG. 5), data indicating the distortion determined at process 435 is transmitted from the second device 225 back to the first device 205 and used by the pre-distortion circuit 260 of the first device 205 to pre-distort the signal (T(1)) transmitted from the first device 205 to the second device 225 at process 410. Similarly, data indicating the distortion determined at process 470 is transmitted from the first device 205 back to the second device 225 and used by the pre-distortion circuit 230 of the second device 225 to pre-distort the signal (T(2)) at process 445. Hardacker at [0029] In one implementation, the channel frequency response is determined. The inverse of the channel frequency response may then be used by the pre-distortion circuit 430 to pre-distort signals. In another implementation, the amount of pre-distortion applied by the pre-distortion circuit 430 may be a function of the impulse response of the communication path 445. Hardacker at [0034] In accordance with FIG. 5, the sink device 515 sends a training signal or data packet T(1) to the source device 510 using a simple modulation M1 520. The training signal is known to the source device 510. The transmit signal is represented at 525 as $[T(1)*M1]*D1$ where D1 is the distortion of the communication channel as seen using modulation M1. Channel distortion can have phase, amplitude and multipath distortion characteristics which may all be non-linear. Herein, a distortion description, Dx, is valid for a single type of modulation, Mx, but may not be accurate for more advanced modulations, e.g., M(x+1). The source device 510 receives the signal 525 and equalizes the signal and demodulates the signal until the known training data packet T(1) is recovered at 527. Since the source device 510 knows the modulation M1 used, the equalizer is varied in a feedback loop fashion until the known training signal

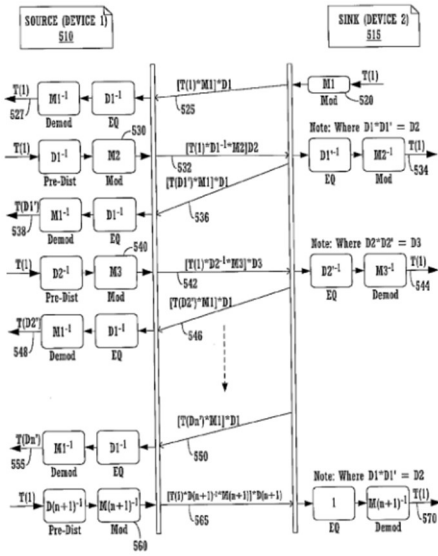
Claim Element	Exemplary Citations to Hardacker
	T(1) is recovered. When recovered, the equalizer located a good first order approximation of the channel distortion, or D1-1. This first order approximation is good enough for the simple modulation M1. Hardacker at [0036] At this point, the sink device 515 communicates D1' to the source device 510 using the simple modulation M1. Specifically, the sink device uses simple modulation M1 to transmit D1' to the source device at 536. This transmission 536 experiences channel distortion D1. The source device 510 already knows the channel distortion approximation D1-1 and the modulation scheme M1, so the data packet D1' is readily recovered at 538. Since the source device knows D1' and D1, it can advantageously compute D2, a second order approximation of the channel distortion for modulation M2. Source 510 now sends T(1) again by transmission 542 but using a more complex modulation scheme, M3540, with the transmitted signal pre-distorted by the second order pre-distortion, D2-1. The sink 515 again has to equalize the recovered signal slightly because the D2-1 pre-distortion is good enough for M2, but not quite good enough for M3. Equalization continues until the training signal is recovered at 544. This leads to distortion approximation D2'(D3=D2*D2'). Again, the sink 515 sends back to the source 510 (using M1) the additional equalization T(D2') necessary to decode T(1) when modulated with M3. This is shown as 546. Hardacker at [0037] The source device 510 already knows the channel distortion approximation D1-1 and the modulation scheme M1, so the data packet D2' is readily recovered at 538. Since the source device knows D2' and D2, it can advantageously compute D3, a third order approximation of the channel distortion for M3. This third order channel distortion D3 can be used by the source device 510 to communicate large amounts of data to the sink device 515 using pre-distortion D3-1 and modulation M3, as shown in general terms by transmission 565. The above process is iterative, with each group of communications providing for more complex modulation while using limited equalization. The number of iterations is variable depending on the modulation required and the particular number of iterations shown in FIG. 5 is exemplary. Hardacker at claims 8-10 8. A system for communicating over a communication path, said system comprising: a first device comprising: a first pre-distortion circuit for pre-distorting a first signal as a function of a distortion introduced on the communication path from the first device to a second device; a first transmitter coupled to the first pre-distortion circuit for transmitting the first signal on the communication path; and the second device comprising a first receiver communicatively coupled to the communication path for receiving the pre-distorted first signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the first pre-distortion circuit. 9. The system of claim 8, wherein: the second device further

Claim Element	Exemplary Citations to Hardacker
	comprises:a first distortion determination circuit coupled to the first receiver for determining the distortion on the communication path from a training signal after transmission across the communication path from the first device to the second device; anda second transmitter coupled to the first distortion determination circuit for transmitting data to the first device indicating the distortion on the communication path from the first device to the second device; andwherein the first device further comprises:a second receiver communicatively coupled to the communication path for receiving the data indicating the distortion on the communication path from the first device to the second device.10. The system of claim 9, wherein:the second device further comprises a second pre-distortion circuit for pre-distorting a second signal as a function of a distortion introduced on the communication path from the second device to the first device;wherein the second transmitter is for further transmitting the second signal on the communication path; andwherein further the second receiver is communicatively coupled to the communication path for receiving the pre-distorted second signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the second pre-distortion circuit. To the extent this element is not disclosed by Hardacker, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Hardacker, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
23. The wireless device of claim 19, wherein the receiver comprises multiple antennas in a multiple-input and multiple-output (MIMO) wireless communication system or a single antenna in a single-input and single-output (SISO) wireless communication system.	Hardacker discloses or renders obvious “[t]he wireless device of claim 19, wherein the receiver comprises multiple antennas in a multiple-input and multiple-output (MIMO) wireless communication system or a single antenna in a single-input and single-output (SISO) wireless communication system.” For example: Hardacker at Abstract Techniques for sending and receiving signals include pre-distorting signals before transmission across a communication path. The signals are pre-distorted as a function of a distortion on the communication path. In one embodiments, transmitter a broadcasts to receiver b and there is also a transmitter b broadcasting to receiver a. This return channel enables both transmitters a and b to have a priori information regarding the transmission medium and path the signal takes. In this way, the nature of the distortion or interference is known to the transmitter, therefore, it pre-distorts the transmitted signal to compensate for the receiver exceeding its capabilities in recovering signal.

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 2  FIGURE 2

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 3  <pre> graph TD subgraph Device_1 [DEVICE 1] 305[INPUT SIGNAL 305] --> 310[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 310] 345[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 345] --> 350[OUTPUT SIGNAL 350] end subgraph Device_2 [DEVICE 2] 315[RECEIVE SIGNAL DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 315] --> 320[DETERMINE DISTORTION ON COMMUNICATION PATH 320] 320 --> 330[PRE-DISTORT SIGNAL 330] 330 --> 335[TRANSMIT PRE-DISTORTED SIGNAL ACROSS COMMUNICATION PATH 335] end 310 -.-> 315 335 -.-> 345 315 --> 320 </pre> FIGURE 3

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 4 <pre> graph TD subgraph Device_1 [DEVICE 1] 405[INPUT SIGNAL 405] --> 410[PRE-DISTORT SIGNAL 410] 410 --> 415[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 415] 470[DETERMINE DISTORTION ON COMMUNICATION PATH 470] --> 410 460[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 460] --> 470 465[OUTPUT SIGNAL 465] --> 410 end subgraph Device_2 [DEVICE 2] 440[INPUT SIGNAL 440] --> 445[PRE-DISTORT SIGNAL 445] 445 --> 450[TRANSMIT SIGNAL ACROSS COMMUNICATION PATH 450] 450 --> 455[RECEIVE SIGNAL FURTHER DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 455] 455 --> 470 420[RECEIVE SIGNAL FURTHER DISTORTED BY TRANSMISSION ACROSS COMMUNICATION PATH 420] --> 425[EQUALIZE RECEIVED DISTORTED SIGNAL TO RECOVER SIGNAL 425] 425 --> 430[OUTPUT SIGNAL 430] end 415 -.-> 420 450 -.-> 415 </pre> FIGURE 4

Claim Element	Exemplary Citations to Hardacker
	Hardacker at Figure 5  FIGURE 5 Hardacker at [0001] Radio frequency (RF) receivers are typically more difficult to construct than RF transmitters. Hardacker at [0002] FIG. 1 shows a communication system according to the conventional art. The communication system 100 includes a transmitter 110, a communication path 120, a receiver 130 and an equalizer 140. The transmitter 110 transmits a signal $[T]$ across the communication path 120. The receiver 130 receives a distorted signal $[T]*[D]$ after transmission across the communication path 120. The equalizer 140 equalizes $[D-1]$ the distorted signal $[T]*[D]$. If the distortion on the communication channel 120 is less than the recovery capability $[D-1]$ of the equalizer 140, the recovered signal will be substantially equal to the transmitted signal $[T]$. However, if the distortion on the communication channel 120 is greater than the recovery capability of the equalizer 140, the recovered signal $[T']$ will not be equal to the transmitted signal $[T]$. Hardacker at [0005] In one embodiment of the present invention, a first transmitter (a) broadcasts to first receiver (b) and there is also a second transmitter (of b) broadcasting to second receiver (of a). This return channel enables both

Claim Element	Exemplary Citations to Hardacker
	transmitters (a) and (b) to have a priori information regarding the transmission medium and path the signal takes. In this way, the nature of the distortion or interference is known to the transmitter, therefore, it pre-distorts the transmitted signal to compensate for the receiver exceeding its capabilities in recovering signal. This functionality, in accordance with embodiments of the present invention, reduces the complexity of the receiver by placing some of the burden on the transmitter. The back channel enables optimization of the original signal for the current state of the communications channel. Hardacker at [0006] In another embodiment, a communication methodology is employed in an asymmetric system where complex modulation can be employed while using equalizers and recovery circuits having only limited complexity. In this embodiment, a training signal is sent from a sink device to a source device using a simple modulation M1. The source device, knowing the training signal, determines an equalization $D1^{-1}$ that is able to recover the training signal wherein D1 is the channel distortion for M1. The source then pre-distorts the training signal with the computed $D1^{-1}$ and communicates this back to the sink using a second order modulation M2. The sink then knowing the training signal employs a simple equalization circuit to determine another distortion amount $D1'$ required to recover the training signal from the pre-distorted transmission, where $D1' * D1$ equals D2 (the channel distortion of the M2 modulated signal). Advantageously, the sink then uses M1 to transmit back to the source the computed $D1'$ and upon which the source can compute D2 since it knows D1. Here, the source advantageously uses a simple equalization circuit and simple modulation circuit. Knowing D2, the source can use M2 to communicate large amounts of data to the sink device (as pre-distorted by D2) even though the sink device has a relatively simple equalization circuit and also a simple modulator. Alternatively, the above iterative methodology can be repeated for higher order modulations, e.g., M3, etc. Although equalization is described above, this discussion is merely exemplary. This embodiment operates equally well employing other distortion types, e.g., multi-path, amplitude, frequency, phase and other well known types. Hardacker at [0014] Referring now to FIG. 2, an exemplary system for transmitting and receiving signals, in accordance with embodiments of the present technology, is shown. In one embodiment, the system includes a plurality of devices 205 and 225 communicatively coupled by a communication network. A first device 205 may include a transmitter 210, a receiver 215 and optionally an equalizer 220. A second device 225 may include a pre-distortion circuit 230, a transmitter 235, a receiver 240, a distortion determination circuit 250 and optionally an equalizer 245. The first and second devices 205 and 225 transmit and receive signals across one or more communication paths 255 of the communication network.

Claim Element	Exemplary Citations to Hardacker
	Hardacker at [0016] With respect to FIG. 2 and FIG. 3, at 305, a first input signal $[T(1)]$ is presented to the transmitter 210 of the first device 205 for transmission. Alternatively, the first input signal $[T(1)]$ may be generated internally by the transmitter 210. The first input signal $[T(1)]$ may be any signal to be transmitted by the first device 205 across the communication path 255. In one implementation, the first input signal $[T(1)]$ is a training or configuration signal specifically utilized to determine the nature of the distortion or interference on the communication path 255. In another implementation, the first input signal $[T(1)]$ may be a predetermined control signal or general data signal that facilitates the determination of the nature of the distortion or interference on the communication path 255. For example, the signal may be a predictable control signal transmitted from the first device 205 to the second device 225 Hardacker at [0017] At 310, the first input signal $[T(1)]$ is transmitted across the communication path 255 by the transmitter 210. At 315, the first input signal distorted by channel distortion $D(1)$ due to transmission across the communication path. The transmitted signal is represented here as a convolution product, $[T(1)]*[D(1)]$, and is received by the receiver 240 of the second device 225. At 320, the distortion $[D(1)]$ introduced by the communication path 255 is automatically determined by the distortion determination circuit 250 since the training signal $T(1)$ is a known signal. Hardacker at [0018] In accordance with embodiments of the present invention, the nature of the distortion or interference may then be used to pre-distort signals transmitted from the second device 225 to the first device 205 or optionally vice-versa. For example, the pre-distortion circuit 230 of the second device 225 may receive a second signal $[T(2)]$, for transmission to device 205 at 325. At 330, the second signal $[T(2)]$ is pre-distorted by $[D(1)-1]$ at the pre-distortion circuit 230. The pre-distortion $[D(1)-1]$ is a function of the distortion on the communication path 255 determined at process 320. At 335, the transmitter 235 in the second device 225 transmits the pre-distorted signal $[T(2)]*[D(1)-1]$ across the communication path 255 which introduces a determined amount of distortion $[D(2)]$. The distortion $[D(2)]$ from the communication path 255 and the pre-distortion $[D(1)-1]$ introduced by the pre-distortion circuit 230 of the second device 225 produce convolved distortion $[D(2)]*[D(1)-1]$. If this convolution product=1, the recovered signal $T(2)$ will be correct and the pre-distortion introduced by device 225 enables recovery of signal $T(2)$ at device 205. Hardacker at [0019] At 340, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)]*[D(1)-1]$ further distorted by $[D(2)]$ after transmission across the communication path 255. If the product of

Claim Element	Exemplary Citations to Hardacker
	[D(2)]*[D(1)-1]≠1 at 345, the equalizer 220 in the first device equalizes, or performs some amount of signal recovery on the pre-distorted signal further distorted [T(2)]*[D(1)-1]*[D(2)] by transmission across the communication path to recover the second signal [T(2)]. The convolved distortion [D(2)]*[D(1)-1] is recoverable by the equalization function [D(n)-1] of the equalizer 220. At 350, the recovered second signal [T(2)] is output by the equalizer 220 for use by other circuits of the first device 205. It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0021] In one embodiment, a given application may only need pre-distortion for communication in one direction. For example, a DTV may only transmit control signals requiring a relatively low transmission rate to one or more content sources such as a set top box (STB). However, in the other direction, the set top box transmits a large amount of image data that requires a high transmission rate, which may experience high bit error rates when the distortion and/or interference on the communication path 255 is greater than a particular level. Therefore, implementing pre-distortion in the set top box may be sufficient for such a configuration. In other embodiments it may be desirable to implement pre-distortion in both devices. Therefore, the first device 205 may also include a distortion determination circuit 260 and a pre-distortion circuit 265 in the first device 205 for determining the distortion [D(1)] introduced by the communication path 255 and pre-distorting signals transmitted by the first device 205. Likewise, the second device 225 may include an equalizer 245 to recover pre-distorted signals transmitted by the first device 205. Hardacker at [0022] Referring now to FIG. 4, a method of transmitting and receiving signals, in accordance with other embodiments of the present technology, is shown. The system implementing the method of FIG. 4 may be the communications system of FIG. 2, for instance. At least one transmitter, e.g., of device 205 contains a distortion determination circuit 260 and a pre-distortion circuit 265. A back channel exists between the transmitter 235 of device 225 and the receiver 215 of device 205. Hardacker at [0023] Regarding FIG. 4, at 405, there is a first input signal [T(1)] to be transmitted by the first device 205 across the communication path 255. The first signal [T(1)] is pre-distorted by [D(1)] by the pre-distortion circuit 265, at 410. The first input signal [T(1)] may be distorted based upon the nature of the distortion or interference on the communication path 255 as previously determined by the distortion determination

Claim Element	Exemplary Citations to Hardacker
	circuit 260 during receipt of a previous signal (e.g., during process 460 described below). At 515, the pre-distorted signal $[T(1)]*[D(1)-1]$ is transmitted by the transmitter 210 across the communication path 255. Hardacker at [0024] At 420, the receiver 240 of the second device 225 receives the pre-distorted signal $[T(1)]*[D(1)-1]$ further distorted by $[D(1)]$ after transmission across the communication path 255. The received pre-distorted signal is represented as $[[T(1)]*[D(1)-1]]*D(1)$. At 425, the equalizer 245 of the second device 225 equalizes the received pre-distorted signal by $D(1)-1$ to recover the first signal $[T(1)]$. At 430, the recovered signal $[T(1)]$ is output from the equalizer 245 for use by other circuits of the second device 225. In addition, the distortion determination circuit 250 determines the distortion $[D(1)]$ on the communication path 255, at 435. The distortion $[D(1)]$ may be used by the pre-distortion circuit 230 to pre-distort signals (e.g., during process 445 described below). It is appreciated that equalization is discussed herein as an example of a signal recovery process that may be employed. However, this embodiment operates equally well employing other forms of signal recovery, e.g., multi-path, amplitude, frequency, phase and other well known types and is therefore not limited to equalization. Hardacker at [0025] At 440, there is a second input signal $[T(2)]$ to be transmitted by the second device 225 across the communication path 255 to device 205. The second signal $[T(2)]$ is pre-distorted $[D(1)-1]$ by the pre-distortion circuit 230, at 445. The second input signal $[T(2)]$ may be distorted based upon the nature of the distortion or interference on the communication path 255 as determined by the distortion determination circuit 230 during receipt of a previous signal (e.g., during process 435 described above). At 450, the pre-distorted signal $[T(2)]*[D(1)-1]$ is transmitted by the transmitter 235 across the communication path 255. Hardacker at [0026] At 455, the receiver 215 in the first device 205 receives the pre-distorted signal $[T(2)]*[D(1)-1]$ further distorted by $[D(2)]$ after transmission across the communication path 255. At 460, the equalizer 220 equalizes the received pre-distorted signal $[[T(2)]*[D(1)-1]]*[D(2)]$ to recover the first signal $[T(2)]$. At 465, the recovered signal $[T(2)]$ is output from the equalizer 220 for use by other circuits of the first device 205. In addition, the distortion determination circuit 260 determines the distortion $[D(1)]$ on the communication path 255. The nature of the distortion or interference determined by the distortion determination circuit 260 is used at process 410 to apply an appropriate amount of pre-distortion $[D(1)-1]$. Again, the distortion $[D(1)]$ on the communication path 255 may be determined for each signal received by the receiver 215 or periodically when the distortion changes over time.

Claim Element	Exemplary Citations to Hardacker
	Hardacker at [0027] The above described embodiments are intended for use when the distortion on the communication path 255 is substantially the same when signals are transmitted from the first device 205 to the second device 225 and from the second device 225 to the first device 205. However, in other circumstances the distortion on the communication path is not the same in both directions between two devices and may also differ between different devices. Therefore, in another embodiment (as shown in FIG. 5), data indicating the distortion determined at process 435 is transmitted from the second device 225 back to the first device 205 and used by the pre-distortion circuit 260 of the first device 205 to pre-distort the signal (T(1)) transmitted from the first device 205 to the second device 225 at process 410. Similarly, data indicating the distortion determined at process 470 is transmitted from the first device 205 back to the second device and used by the pre-distortion circuit 230 of the second device 225 to pre-distort the signal (T(2)) at process 445. Hardacker at [0028] In another embodiment, a signal is transmitted from the first device 205 to the second device 225. The signal is re-transmitted (e.g., reflected back) by the second device 205 to the first device 225 pre-distorted [D(1)–1] by the second device 225 as a verification that the pre-distortion substantially compensates for the distortion introduced by the communication path 255. In yet another embodiment, an iterative method might include using simple robust training signals that gradually increase in complexity while pre-distortion and equalization circuits keep correcting such that a complex modulation scheme (e.g., conveying higher data rates) can be possible with the dual efforts of the pre-distortion circuits and equalizer, see FIG. 5. Hardacker at [0030] The signals are pre-distorted so that the distortion does not exceed the capabilities of the receiver at the other end of the channel. The techniques advantageously reduce the complexity of the receiver by placing some of the burden (e.g., circuit complexity) on the transmitter. The back channel can be exploited to compensate the original signal for the current state of the communication channel. This can result in improved performance, such as fewer bit errors and/or greater link distances, when compared to substantially similar systems without the pre-distortion modulation under substantially the same environmental factors. Hardacker at [0031] FIG. 5 illustrates a communication methodology in an asymmetric system where complex modulation can be employed while using equalizers and recovery circuits having only reduced complexity. The

Claim Element	Exemplary Citations to Hardacker
	asymmetric system includes a source device 510 and a sink device 515. The source 510 is capable of pre-distortion and equalization. Hardacker at [0034] In accordance with FIG. 5, the sink device 515 sends a training signal or data packet T(1) to the source device 510 using a simple modulation M1520. The training signal is known to the source device 510. The transmit signal is represented at 525 as $[T(1)*M1]*D1$ where D1 is the distortion of the communication channel as seen using modulation M1. Channel distortion can have phase, amplitude and multipath distortion characteristics which may all be non-linear. Herein, a distortion description, Dx, is valid for a single type of modulation, Mx, but may not be accurate for more advanced modulations, e.g., M(x+1). The source device 510 receives the signal 525 and equalizes the signal and demodulates the signal until the known training data packet T(1) is recovered at 527. Since the source device 510 knows the modulation M1 used, the equalizer is varied in a feedback loop fashion until the known training signal T(1) is recovered. When recovered, the equalizer located a good first order approximation of the channel distortion, or D1-1. This first order approximation is good enough for the simple modulation M1. Hardacker at [0035] The source 510 then sends “known” training signal or data packet T(1) using a more complex modulation M2530 to the sink 515 and using pre-distortion D1-1 at 532. That is, the signal transmitted by the source 510 is pre-distorted by D1-1. This transmission is also distorted by channel distortion D2 when recovered by the sink device 515. The sink device 515 equalizes this slightly by D1’ until the training signal is recovered at 534. Hardacker at [0036] At this point, the sink device 515 communicates D1’ to the source device 510 using the simple modulation M1. Specifically, the sink device uses simple modulation M1 to transmit D1’ to the source device at 536. This transmission 536 experiences channel distortion D1. The source device 510 already knows the channel distortion approximation D1-1 and the modulation scheme M1, so the data packet D1’ is readily recovered at 538. Since the source device knows D1’ and D1, it can advantageously compute D2, a second order approximation of the channel distortion for modulation M2. Source 510 now sends T(1) again by transmission 542 but using a more complex modulation scheme, M3540, with the transmitted signal pre-distorted by the second order pre-distortion, D2-1. The sink 515 again has to equalize the recovered signal slightly because the D2-1 pre-distortion is good enough for M2, but not quite good enough for M3. Equalization continues until the training signal is recovered at 544. This leads to distortion approximation

Claim Element	Exemplary Citations to Hardacker
	D2'(D3=D2*D2'). Again, the sink 515 sends back to the source 510 (using M1) the additional equalization T(D2') necessary to decode T(1) when modulated with M3. This is shown as 546. Hardacker at [0037] The source device 510 already knows the channel distortion approximation D1-1 and the modulation scheme M1, so the data packet D2' is readily recovered at 538. Since the source device knows D2' and D2, it can advantageously compute D3, a third order approximation of the channel distortion for M3. This third order channel distortion D3 can be used by the source device 510 to communicate large amounts of data to the sink device 515 using pre-distortion D3-1 and modulation M3, as shown in general terms by transmission 565. The above process is iterative, with each group of communications providing for more complex modulation while using limited equalization. The number of iterations is variable depending on the modulation required and the particular number of iterations shown in FIG. 5 is exemplary. Hardacker at claim 1 1. A method comprising:determining a distortion on a communication path between a first device and a second device;pre-distorting a signal to be transmitted as a function of the distortion determined on the communication path to produce a pre-distorted signal; andtransmitting the pre-distorted signal on the communication path wherein said transmitting is performed by the first device of said two devices. Hardacker at claim 2 2. The method according to claim 1, further comprising receiving the pre-distorted signal after transmission across the communication path wherein said receiving is performed by the second device of said two devices. Hardacker at claim 4 4. A method comprising:transmitting a first signal from a first device to a second device wherein said first signal is a known signal;at said second device, determining a first distortion amount in recovering said first signal wherein said first distortion amount represents channel distortion of a communication channel between said first device and said second device;pre-distorting a second signal at said second device and transmitting a pre-distorted version of said second signal to said first device; andsaid first device performing a signal recovery process on said pre-distorted version of said second signal to recover said second signal. Hardacker at claims 8-10 8. A system for communicating over a communication path, said system comprising:a first device comprising:a first pre-distortion circuit for pre-distortion a first signal as a function of a distortion introduced on the communication path from the first device to a second device;a first transmitter coupled

Claim Element	Exemplary Citations to Hardacker
	to the first pre-distortion circuit for transmitting the first signal on the communication path; and the second device comprising a first receiver communicatively coupled to the communication path for receiving the pre-distorted first signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the first pre-distortion circuit.9. The system of claim 8, wherein: the second device further comprises: a first distortion determination circuit coupled to the first receiver for determining the distortion on the communication path from a training signal after transmission across the communication path from the first device to the second device; and a second transmitter coupled to the first distortion determination circuit for transmitting data to the first device indicating the distortion on the communication path from the first device to the second device; and wherein the first device further comprises: a second receiver communicatively coupled to the communication path for receiving the data indicating the distortion on the communication path from the first device to the second device.10. The system of claim 9, wherein: the second device further comprises a second pre-distortion circuit for pre-distorting a second signal as a function of a distortion introduced on the communication path from the second device to the first device; wherein the second transmitter is for further transmitting the second signal on the communication path; and wherein further the second receiver is communicatively coupled to the communication path for receiving the pre-distorted second signal further distorted by transmission across the communication path, wherein the distortion introduced by the communication path is partially compensated for by the pre-distortion introduced by the second pre-distortion circuit. To the extent this element is not disclosed by Hardacker, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Hardacker, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.