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U.S. Patent 7,917,102

U.S. Patent 7,917,102 ("*Redwood" or* the "patent-at-issue") was filed on November 8, 2007. The patent-at-issue is a continuation application of Ser. No. 10/566,682 and claims an earliest priority date of August 7, 2003. Claim 1 of the patent-at-issue is directed to a radio transmitting method transmitting a modulated signal comprising a transmission frame. The transmission frame includes frequency offset estimation signal, channel fluctuation estimation signal, and gain control signals. A first gain control signal is arranged prior to the frequency offset signal and a second gain control signal following the frequency offset signal and prior to the channel fluctuation signal.

The primary reference, U.S. Patent 6,768,728 ("*Samsung*"), was filed on March 15, 1999 and claims an earliest priority date on March 14, 1998. The patent is directed to a method for exchanging frame messages having multiple lengths in a Code Division Multiple Access (CDMA) communication system. The method includes generating a shorter message during the transmission of longer frame message and when interrupted, the shorter frame message is transmitted in place of a portion of the longer frame message.

The secondary reference, U.S. Patent 9,131,029 ("*Cisco*"), was filed on April 7, 2014 and claims an earliest priority date on July 22, 2003. The patent is directed to a method for operating an access point in a Multiple Input Multiple Output (MIMO) wireless communication system. The method includes transmitting a first packet to a first subscriber unit via a first spatial subchannel and sending a second packet to a second subscriber unit via a second subchannel. The second packet has greater data length than first packet and the first and second subchannels occupy the same bandwidth.

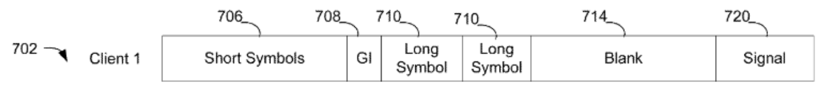
The secondary reference, U.S. Patent 7,190,748 ("*DSP*"), was filed on May 10, 2002 and claims an earliest priority date on August 17, 2001. The patent is directed to a digital front-end for a wireless communication system where the digital front-end includes gain control, signal detection, frame synchronization, and carrier frequency offset estimation. The patent also describes a method of measuring power levels, identifying the largest power level, selecting an amplifier gain based on the largest power level, applying the gain to each of the observed wireless signals.

The secondary reference, U.S. Pat. App. 2004/0004934 ("*Wipro*"), was filed on March 27, 2003 and claims a priority on on July 3, 2002. The patent application is directed to a frequency offset estimation apparatus for an Orthogonal Frequency Division Multiplexed receiver which determines the correlation of received preamble samples. The apparatus also determines the signal power of the symbol samples and identifies the threshold from the signal power.

A sample claim chart comparing claim 1 of *Redwood* to *Samsung*, *Cisco*, *DSP*, and *Wipro* is provided below.

US7917102 (“*Redwood*”)	**A. US6768728** (*“Samsung”*) **B. US9131029** (*“Cisco”*) **C. US7190748** (*“DSP”*) **D. US20040004934** (*“Wipro”*)
1.pre. A **radio transmission method** for **transmitting a modulated signal**, said method comprising:	**A. US6768728** “14. A **data transmission method in a wireless communication system**, comprising the steps of: . . . .” *Samsung* at claim 14 “A serial-to-parallel (S/P) converter 529 multiplexes input signals so as to 20 propagate the control signals output from the gain controllers 527 and 528 through a multicarrier signal. An orthogonal code modulator 533 generates an orthogonal code according to the orthogonal code number and length of the allocated channel and **orthogonally modulates the frame message by multiplying the frame message by the generated orthogonal code**.” *Samsung* at col. 13:19-26 **B. US9131029** “FIG. 3 depicts **an SDMA transmitter system** 300 according to one embodiment of the present invention.” *Cisco* at col. 5:49-50 “Data from the MAC layer processor is first scrambled, encoded, and interleaved in an encoding block 302 as defined by the IEEE 802.11a standard. **Modulators** 304 **translate the coded data bits into complex values to be assigned to OFDM subcarriers in accordance with the currently selected modulation scheme** (4-QAM, 16-QAM, etc.) A pilot tone insertion block 306 inserts pilot tones at subcarrier positions defined by the IEEE 802.11a standard to support phase offset synchronization at the receiver. IFFT blocks 308 convert groups of 64 subcarrier values from the frequency domain to the time domain. The **output is a succession of OFDM symbols** carrying payload data.” *Cisco* at col. 5:59-67 through col. 6:1-3 **C. US7190748** “FIG. 2 is a block diagram illustrating a wireless communication device 16 in further detail. As shown in FIG. 2, **wireless communication device** 16 **may include one or more radio frequency (RF) antennas** 18A, 18B (hereinafter

(cont.) 1.pre. A **radio transmission method** for **transmitting a modulated signal**, said method comprising:	18), **a transmit antenna** 20, a radio 22, a modem 24, a media access controller (MAC) 26 and host processor 28." *DSP* at col. 3:49-54 "FIG. 3 is a diagram of **an OFDM frame, or "packet," transmitted** according to the IEEE 802.11a standard. As shown in FIG. 4, the OFDM frame includes a physical layer convergence procedure (PLCP) preamble 30 that contains a short preamble 32, a guard interval 34 and a long preamble 36." *DSP* at col. 4:47-52 **D. US20040004934** "Since the **radio environment** in which the wireless LANs operate is usually adverse, the transmitted signal is distorted by multipath fading, collapsed with thermal noise, or interfered by other signals." *Wipro* at par. 0090 "Conventionally the first 7 short symbols are used for signal detection and AGC. The control gain is applied to both the symbols for synchronization and the symbols carrying data. The **preambles modulated by QPSK require less accurate control gain than the data symbols, especially those modulated by 64QAM**. To meet the requirement of all kinds of symbols, conventional AGC needs a long period to achieve an accurate control gain." *Wipro* at par. 0108
1.a. **forming a transmission frame** which includes **a frequency offset estimation signal for estimating frequency offset of the modulated signal** at a receiving apparatus, **a channel fluctuation estimation signal for estimating channel fluctuation of the modulated signal** at the receiving apparatus and **a gain control signal for performing gain control of the modulated signal** at the receiving apparatus; and	**A. US6768728** "Thus, channel transceiver devices for the base station and the mobile station in the present embodiment each include transceiver circuitry for transmitting and/or receiving the following information in the respective channels: 1) **pilot channel information used for estimating the channel gain** and phase and performing cell acquisition and handoff; . . . ." *Samsung* at col. 4:8-13 "That is, the **gain controllers** 527 and 528 **output the input signals, as they are, in response to the first gain control signal, increase the gains of the input signals to increase the transmission power in response to the second gain control signal**, and decrease the gains of the input signals to zero to discontinue an output of the dedicated control channel in response to the third gain control signal." *Samsung* at col. 12:63-67 through col. 13:1-3

(cont.) 1.a. **forming a transmission frame** which includes **a frequency offset estimation signal for estimating frequency offset of the modulated signal** at a receiving apparatus, **a channel fluctuation estimation signal for estimating channel fluctuation of the modulated signal** at the receiving apparatus and **a gain control signal for performing gain control of the modulated signal** at the receiving apparatus; and	**B. US9131029** "The IEEE 802.11a standard also provides for the use of a preamble including special symbols for use in synchronization and carrier estimation. In **a transmitted frame or packet**, this preamble precedes the data-carrying OFDM symbols. The preamble includes so-called short and long symbols and is modified in accordance with embodiments of the present invention." *Cisco* at col. 6:4-10  Figure 7, *Cisco* at p. 7 "**Preamble** 702 **begins with 10 short symbols** 706 that are specified by the 802.11a standard and **that are used for** signal detection, **automatic gain control**, and **frequency offset estimation**. Each short symbol is specified to be 0.8 microseconds long. Following the short symbols 706, there is a guard interval 708 followed by a channel training period where two long symbols 710 are transmitted. The **long symbols** are specified by the 802.11a standard and **are used for channel estimation**." *Cisco* at col. 9:4-12 **C. US7190748** "FIG. 4 is another diagram of **an OFDM frame** as shown in FIG. 3, illustrating the start and end of **a transmitted frame**. Burst communications are characterized by the transmission and reception of data packets or frames separated by a null signal period. Accordingly, as shown in FIG. 4, **each OFDM frame is transmitted** as a burst and therefore is typically preceded and followed by null signal periods 42, 44, respectively. During null signal periods 42, 44, **antennas** 18 **receives a relatively low power signal characterized by channel noise**. As will be described, signal detection techniques typically rely on identification of a transition point between the null signal period 42 and the onset of short preamble 32." *DSP* at col. 5:9-21 "FIG. 10 is a diagram of **a carrier frequency offset (CFO) estimation** and correction circuit forming part of the digital front-end of FIG. 6." *DSP* at col. 3:1-3 "**CFO estimator unit** 66 **monitors the signals applied to FFT units** 54A, 54B **to estimate the carrier frequency**

(cont.) 1.a. **forming a transmission frame** which includes **a frequency offset estimation signal for estimating frequency offset of the modulated signal** at a receiving apparatus, **a channel fluctuation estimation signal for estimating channel fluctuation of the modulated signal** at the receiving apparatus and **a gain control signal for performing gain control of the modulated signal** at the receiving apparatus; and	**difference between the transmitter and receiver in each signal**. Based on the **estimated CFO**, **CFO estimator** 66 **generates a control signal** that is applied to CFO correction units 68A, 68B." *DSP* at col. 6:32-36 "FIG. 7 is a diagram of gain control unit 60. In general, gain control unit 60 operates in such a way that the typical assumption of white channel noise used in receiver design need not be disturbed by the gain control. In operation, the arrival of the transmitted signal at the receiver is detected by signal detection unit 62 at the beginning of the short preamble and notified to gain control unit 60 to start the **amplifier gain adjustment procedure**. By measuring the signal power, **the gain of the amplifier is adjusted by gain control unit** 60 so that the observed signal power can meet a certain target." *DSP* at col. 6:49-59 **D. US20040004934** "7. A method of **estimating the frequency offset** for an OFDM receiver, the method comprising: . . . ." *Wipro* at claim 7 "Prior art units 1 detect a signal by measuring the correlation of incoming signals. Consider two repeated **training symbols** as shown in FIG. 5 **that are identical to each other at the receiver except for a phase shift caused by the carrier frequency offset**. If the conjugate of a sample from the first symbol is multiplied by the corresponding sample from the second (delay time T_d=T_{short} later), the effect of the channel should be cancelled and the products of each of these pairs of samples will have approximately the same phase." *Wipro* at par. 0091 "For an OFDM-based wireless receiver, the following issues are significant: signal detection, **AGC (automatic control gain)**, carrier recovery, Symbol timing, frequency timing, and channel estimation." *Wipro* at par. 0003 "Conventionally the above operations are done one at a time using separate preamble symbols. For example the **first seven short training symbols are used for** signal detection and **AGC**. The remaining three short training symbols are then used for coarse frequency offset estimation and symbol timing. Then the **two long training symbols in the preamble are used for fine frequency offset estimation and channel estimation**." *Wipro* at par. 0087

1.b. **transmitting the transmission frame**, wherein:	**A. US6768728** "2. The transmission device as claimed in claim 1, wherein **the first frame message and the second frame message are multiplexed when the first frame message is generated during transmission of the second frame message**." *Samsung* at claim 2 **B. US9131029** "The IEEE 802.11a standard also provides for the use of a preamble including special symbols for use in synchronization and carrier estimation. In **a transmitted frame** or packet, this preamble precedes the data-carrying OFDM symbols. The preamble includes so-called short and long symbols and is modified in accordance with embodiments of the present invention." *Cisco* at col. 6:4-10 "FIG. 7 depicts **preambles** 702 and 704 as **may be simultaneously transmitted** either by two simultaneously transmitting subscriber units or by a single access point according to one embodiment of the present invention." *Cisco* at col. 9:1-4 **C. US7190748** "FIG. 4 is another diagram of **an OFDM frame** as shown in FIG. 3, illustrating the start and end of **a transmitted frame**. Burst communications are characterized by the **transmission** and reception **of** data packets or **frames** separated by a null signal period." *DSP* at col. 5:9-13 **D. US20040004934** "Since the radio environment in which the wireless LANs operate is usually adverse, **the transmitted signal** is distorted by multipath fading, collapsed with thermal noise, or interfered by other signals." *Wipro* at par. 0090
1.c. the **transmission frame includes a first gain control signal** and **a second gain control signal**;	**A. US6768728** "In addition, the modem controller 513 generates **a first gain control signal in the event that a 20 ms or 5 ms frame message is present to be transmitted**. However, **in the event that the 5 ms frame message is intermixed with the 20 ms frame message, the modem controller** 513 **generates a second gain control signal** for increasing the transmission power for the remaining portion of the 20 ms frame message following the duration where the frame messages are intermixed." *Samsung* at col. 10:67 through col. 11:1-8

(cont.) 1.c. the **transmission frame includes a first gain control signal** and **a second gain control signal**;	**B. US9131029** "**Preamble** 702 **begins with 10 short symbols** 706 that are specified by the 802.11a standard and **that are used for** signal detection, **automatic gain control**, and frequency offset estimation." *Cisco* at col. 9:4-7 "Grouping is also helpful in ensuring that both transmissions are received at comparable power levels, even before **application of automatic gain control**, and thus can be simultaneously received within receiver dynamic range." *Cisco* at col. 7:33-37 **C. US7190748** "Gain control unit 60 detects the levels of the outputs from ADCs 50A, 50B, respectively, and **generates a digital gain control signal**. A digital-to-analog converter (DAC) 70 converts the gain control signal to an analog signal that is applied to amplifiers 58A, 58B to selectively control the gain applied to the incoming baseband signals." *DSP* at col. 6:7-12 "**Short preamble** 32 **carries a repetition of 10 short symbols**, each of which is 16 samples in length. Long preamble 36 carries two repeated symbols that are each 64 samples in length. Unlike short preamble 32, long preamble 36 is preceded by guard interval 34, which contains a cycle prefix that is 32 samples in length. The cycle prefix is a replica of the last 32 samples of a long symbol from long preamble 36. **In general, the techniques described herein for gain control**, signal detection, frame synchronization **make use of the repeating characteristics of short preamble** 32." *DSP* at col. 4:60-67 through col. 5:1-2 **D. US20040004934** "In the embodiment, AGC operation is divided into two stages. **At the first stage, coarse AGC is done when the signal is detected. The coarse control gain is used to adjust the subsequent short symbols until the symbol timing and coarse frequency offset estimate is obtained**. **At the second stage, fine AGC is done following symbol timing. The fine control gain is used to adjust the subsequent second preamble and data symbols**." *Wipro* at par. 0109

1.d. the **first gain control signal is arranged prior to the frequency offset estimation signal**; and	**A. US6768728** "In addition, the modem controller 513 generates **a first gain control signal** in the event that a 20 ms or 5 ms frame message is present to be transmitted." *Samsung* at col. 10:67 through col. 11:1-3 **B. US9131029** "**Preamble** 702 **begins with 10 short symbols** 706 that are specified by the 802.11a standard and **that are used for** signal detection, **automatic gain control**, and frequency offset estimation." *Cisco* at col. 9:4-7 "Grouping is also helpful in ensuring that both transmissions are received at comparable power levels, even before **application of automatic gain control**, and thus can be simultaneously received within receiver dynamic range." *Cisco* at col. 7:33-37 **C. US7190748** "42. The method of claim 40, further comprising: **adjusting the amplifier gain applied to each of the observations at the beginning of the short preamble**; and . . . ." *DSP* at claim 42 "**Short preamble** 32 **carries a repetition of 10 short symbols**, each of which is 16 samples in length. Long preamble 36 carries two repeated symbols that are each 64 samples in length. Unlike short preamble 32, long preamble 36 is preceded by guard interval 34, which contains a cycle prefix that is 32 samples in length. The cycle prefix is a replica of the last 32 samples of a long symbol from long preamble 36. **In general, the techniques described herein for gain control**, signal detection, frame synchronization **make use of the repeating characteristics of short preamble** 32." *DSP* at col. 4:60-67 through col. 5:1-2 **D. US20040004934** "In the embodiment, AGC operation is divided into two stages. **At the first stage, coarse AGC is done** when the signal is detected. The **coarse control gain is used to adjust the subsequent short symbols until the symbol timing and coarse frequency offset estimate is obtained**." *Wipro* at par. 0109 "In the first step of AGC, **one** or preferably two **short symbols of the first preamble is measured to obtain an AGC gain**

(cont.) 1.d. the **first gain control signal is arranged prior to the frequency offset estimation signal**; and	and then the amplifier 16 before the ADC (22,23) is adjusted. During the second step of AGC, the following short symbols are measured to update the AGC gain to a more accurate value. If signal detection occurs after two short symbols, coarse AGC after a further one short symbol, then fine AGC will utilise 7 short symbols as shown in FIG. 8a." *Wipro* at par. 0112
1.e. the **second gain control signal is arranged subsequent to the frequency offset estimation signal and prior to the channel fluctuation estimation signal**.	**A. US6768728** "Also, the modem controller 513 generates the second frame select signal and the **second gain control signal**, to output the second length frame data at the second output terminal 542." *Samsung* at col. 11:14-16 **B. US9131029** "**Preamble** 702 **begins with 10 short symbols** 706 that are specified by the 802.11a standard and **that are used for** signal detection, **automatic gain control**, and frequency offset estimation." *Cisco* at col. 9:4-7 "Grouping is also helpful in ensuring that both transmissions are received at comparable power levels, even before **application of automatic gain control**, and thus can be simultaneously received within receiver dynamic range." *Cisco* at col. 7:33-37 **C. US7190748** "**Short preamble** 32 **carries a repetition of 10 short symbols**, each of which is 16 samples in length. Long preamble 36 carries two repeated symbols that are each 64 samples in length. Unlike short preamble 32, long preamble 36 is preceded by guard interval 34, which contains a cycle prefix that is 32 samples in length. The cycle prefix is a replica of the last 32 samples of a long symbol from long preamble 36. **In general, the techniques described herein for gain control**, signal detection, frame synchronization **make use of the repeating characteristics of short preamble** 32." *DSP* at col. 4:60-67 through col. 5:1-2 **D. US20040004934** "**During the second step of AGC, typically the following seven short symbols are measured to update the AGC gain to a more accurate value**. The variable gain amplifier 16 is then adjusted again to provide a constant gain for the following incoming signals for one frame. Note the **second AGC adjustment is triggered by the symbol timing function**

(cont.) 1.e. the **second gain control signal is arranged subsequent to the frequency offset estimation signal and prior to the channel fluctuation estimation signal**.	(described below). When correct symbol timing is determined usually after the remaining seven short symbols, AGC gain for the second AGC adjustment is completed and the variable gain amplifier adjusted accordingly." *Wipro* at par. 0113