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U.S. Patent 9,106,486

U.S. Patent 9,106,486 ("*Redwood*" or the "patent-at-issue") was filed on September 13, 2012 and claims an earliest priority date of July 28, 1999. The patent is directed to a transmission apparatus, reception apparatus and digital radio communication method capable of flexibly improving the data transmission efficiency and the quality of data. The invention describes a method by which the interval of inserting a known pilot symbol and the modulation system of information symbols are changed according to the communication situation such as fluctuations in the transmission path and the level of a reception signal.

The primary reference, U.S. Patent 8,687,677 ("*Sun Patent*"), was filed on May 9, 2013 and claims an earliest priority date of January 19, 1999. The patent is directed to a method for digital wireless communications using a multivalue modulation type. In a multivalue modulation type with one pilot symbol inserted for every 3 or more symbols, signal points of each one symbol immediately before and after a pilot symbol are modulated using a modulation type different from that for pilot symbols. In this way, it is possible to suppress deterioration of the accuracy in estimating the reference phase and amount of frequency offset by pilot symbols and improve the bit error rate characteristic in the signal to noise ratio in quasi-coherent detection with symbols whose symbol synchronization is not completely established.

The secondary reference, U.S. Patent 7,362,824 ("*Panasonic*"), was filed on February 1, 1999 and claims an earliest priority date of the January 30, 1998. The patent is directed to a modulation relating to a radio communication system. The modulation method according to the invention can prevent the occurrence of a decrease in an information transmission rate. An aspect of this invention provides a method of modulation which comprises the steps of periodically and alternately subjecting an input digital signal to first modulation and second modulation to convert the input digital signal into a pair of a baseband I signal and a baseband Q signal, the first modulation and the second modulation being different from each other; and outputting the pair of the baseband I signal and the baseband Q signal.

Patent Owner is now on notice that claims of this patent are invalid; as a result, any new or continued assertion of this patent may be considered meritless or brought in bad faith. *Octane Fitness, LLC v. ICON Health & Fitness, Inc.*, 572 U.S. 545, 554 (2014). Such considerations are relevant to whether a case is deemed "exceptional" for purposes of awarding attorneys' fees. 35 U.S.C. § 285; *see, e.g.*, *WPEM, LLC v. SOTI Inc.*, 2020 WL 555545, at *7 (E.D. Tex. Feb. 4, 2020), *aff'd*, 837 F. App'x 773 (Fed. Cir. 2020) (awarding fees for an exceptional case where plaintiff "failed to conduct an invalidity and enforceability pre-filing investigation"); *Energy Heating, LLC v. Heat On-The-Fly, LLC*, 15 F.4th 1378, 1383 (Fed. Cir. 2021) (affirming award of fees where, *inter alia*, the plaintiff knew "that its patent was invalid").

A sample claim chart comparing claim 1 of *Redwood* to *Sun Patent* and *Panasonic* is provided below.

US9106486 ("*Redwood*")	**A. US8687677** (*"Sun Patent"*) **B. US7362824** *("Panasonic")*
1. **A transmission method comprising**: **generating first symbols for transmitting data, a signal point of each of the first symbols on an in-phase and quadrature-phase plane comprising an in-phase component and a quadrature-phase component, a first symbol being a quadrature baseband signal**;	**A. US8687677** 1. A wireless communications apparatus comprising: a **transmitter** comprising a first modulator configured to modulate a first pilot symbol according to a first modulation scheme, a second modulator configured to **modulate specific first symbols according to a second modulation scheme** different from the first modulation scheme, and. . . .**modulated specific first symbols are inserted before and after associated modulated first pilot symbols**; and. . . . *Sun Patent*, claim 1 6. The wireless communications apparatus according to claim 1 wherein the first and **second modulation schemes are selected from** a group of a 64QAM modulation scheme, a 32QAM modulation scheme, a 16QAM modulation scheme, a 8PSK modulation scheme, **a QPSK modulation scheme**, a 16APSK modulation scheme, and a π/4-shift DQPSK modulation scheme. *Sun Patent*, claim 6 "On the **transmitter** side shown in FIG. 4, **transmission data** are sent to quadrature baseband signal generating section (for multivalue modulation type) 101 and quadrature baseband signal generating section (for modulation type for symbols immediately before and after PL) 102." *Sun Patent*, col. 4:58-62 "**Quadrature baseband signal generating section (for modulation type for symbols immediately before and after PL) 102** receives transmission data and a frame timing signal as inputs and if the frame timing signal **indicates a symbol immediately before or after the pilot symbol, quadrature baseband signal generating section (for modulation type for symbols immediately before and after PL) 102 outputs the I component of the quadrature baseband signal for the modulation type for symbols immediately before and after PL to I component switching section 104 and outputs the Q component of the quadrature baseband signal** for the modulation type for symbols immediately before and after PL to Q component switching section 105." *Sun Patent*, col. 5:14-26

(cont.) 1. **A transmission method comprising**: **generating first symbols for transmitting data, a signal point of each of the first symbols on an in-phase and quadrature-phase plane comprising an in-phase component and a quadrature-phase component, a first symbol being a quadrature baseband signal;**	**B. US7362824** "It is a first object of this invention to provide **a modulation method** which can prevent the occurrence of a decrease in an **information transmission** rate." *Panasonic*, col. 1:26-28 "FIG. 1 shows a **transmitter** 10 in a radio communication system according to a first embodiment of this invention. With reference to FIG. 1, the transmitter 10 includes a modulator 12 and an RF (radio frequency) portion 15. The modulator 12 is defined and referred to as the quadrature baseband modulator 12. A digital signal to be transmitted (that is, an input digital signal or main information to be transmitted) is fed to the quadrature baseband modulator 12. The device 12 subjects **the input digital signal to quadrature baseband modulation, thereby converting the input digital signal into a pair of modulation-resultant baseband signals, that is, a baseband I (in-phase) signal and a baseband Q (quadrature) signal.** The quadrature baseband modulator 12 outputs the baseband I signal and the baseband Q signal to the RF portion 15. As is well known in the art, a pair of modulated baseband I and Q signals is composed of (or contains) a stream of modulated symbols. According to the invention, the **quadrature baseband modulator 12 outputs the baseband I and Q signals composed of a stream of modulated symbols** as shown in FIG. 7. . . In FIG. 7, the symbol stream is basically composed of **first symbols having been subjected to a first modulation scheme** (16 APSK in the specific example of FIG. 7). . . ." *Panasonic*, col. 8:62 through col. 9:20
generating a second symbol, the second symbol being a pilot symbol and a second quadrature baseband signal;	**A. US8687677** 1. A wireless communications apparatus comprising: a transmitter comprising a first modulator configured to **modulate a first pilot symbol according to a first modulation scheme**, a second modulator configured to modulate specific first symbols according to a second modulation scheme different from the first modulation scheme, and. . . . *Sun Patent*, claim 1 6. The wireless communications apparatus according to claim 1 wherein the **first** and second **modulation schemes are selected from** a group of a 64QAM modulation scheme, a 32QAM modulation scheme, a 16QAM modulation scheme, a

(cont.) **generating a second symbol, the second symbol being a pilot symbol and a second quadrature baseband signal;**	8PSK modulation scheme, **a QPSK modulation scheme,** a 16APSK modulation scheme, and a π/4-shift DQPSK modulation scheme. *Sun Patent*, claim 1 "That is, the **modulation type that modulates pilot symbols is different** from the modulation type that modulates symbol 301 immediately before the pilot symbol and symbol 302 immediately after the pilot symbol." *Sun Patent*, col. 6:50-54 "**Quadrature baseband signal generating section (for PL) 103** receives a frame timing signal as an input and if the frame timing signal **indicates a pilot symbol, quadrature baseband signal generating section (for PL) 103 outputs the I component of the pilot symbol quadrature baseband signal to I component switching section 104 and outputs the Q component of the pilot symbol quadrature baseband signal** to Q component switching section 105." *Sun Patent*, col. 5:27-34 "For example, as shown in FIG. 6B and FIG. 6C, if **the modulation type of pilot symbol** 305 **is QPSK modulation** and the modulation type of symbol 306 immediately before and after the pilot symbol is 16QAM, when a time offset (jitter) from ideal judgment time 303 occurs (time 304), errors (amplitude errors) YI and YQ from the signal point occur because of the time offset." *Sun Patent* at col. 6:59-65 **B. US7362824** "In FIG. 7, the symbol stream is basically composed of first symbols having been subjected to a first modulation scheme (16 APSK in the specific example of FIG. 7) and periodically includes **second symbols having been subjected to a second modulation scheme** (QPSK in the specific example of FIG. 7) **which is different from the first modulation scheme.** This enables a receiver to use each of the **second symbols as a pilot symbol** from which the amplitude distortion and the phase distortion can be estimated for use in demodulation of the second symbols following the first symbol." *Panasonic*, col. 9:17-28

determining an interval of symbol insertion, outputting a signal indicating the determined interval, and selecting an insertion pattern of the second symbol, from a plurality of predetermined insertion patterns;	**A. US8687677** 1. . . . a **timing controller cooperating with said first and second modulators so that modulated specific first symbols are inserted before and after associated modulated first pilot symbols**; and. . . . *Sun Patent*, claim 1 2. The wireless communications apparatus according to claim 1 wherein said **timing controller is configured so that the modulated specific first symbols are inserted immediately before and after the associated modulated first pilot symbols.** *Sun Patent*, claim 2 "This objective is achieved by a digital wireless communication apparatus that uses a modulation type including QPSK modulation and modulates the signal points of each one symbol immediately before and after a pilot symbol using a modulation type different from the modulation type for the pilot symbol in **a frame configuration with one pilot symbol inserted for every 3 or more symbols**." *Sun Patent*, col. 2:22-28 "By the way, the **locations of the pilot symbol signal point and signal points of each one symbol immediately before and after the pilot symbol** on the in-phase I-quadrature Q plane **are not limited** to FIG. 7. The frame configuration is not limited to FIG. 8, either. The present embodiment explains the case where the multivalue modulation type with 8 or more values is a 16APSK modulation type, but the multivalue modulation type with 8 or more values is not limited to this." *Sun Patent*, col. 7:64 through 8:4 "On the transmitter side shown in FIG. 4, transmission data are sent to quadrature baseband signal generating section (for multivalue modulation type) 101 and quadrature baseband signal generating section (for modulation type for symbols immediately before and after PL) 102. **Frame timing signal generating section** 108 **generates a frame timing signal at timing indicating a frame configuration** shown in FIG. 6A and outputs the frame timing signal to quadrature baseband signal generating section (for multivalue modulation type) 101, quadrature baseband signal generating section (for modulation type for symbols immediately before and after PL) 102 and quadrature baseband signal generating section (for PL) 103. . . Quadrature baseband signal generating section (for modulation

(cont.) **determining an interval of symbol insertion, outputting a signal indicating the determined interval, and selecting an insertion pattern of the second symbol, from a plurality of predetermined insertion patterns;**	type for symbols immediately before and after PL) 102 **receives** transmission data and **a frame timing signal as inputs and if the frame timing signal indicates a symbol immediately before or after the pilot symbol,** quadrature baseband signal generating section (for modulation type for symbols immediately before and after PL) 102 outputs the I component of the quadrature baseband signal for the modulation type for symbols immediately before and after PL to I component switching section 104 and outputs the Q component of the quadrature baseband signal for the modulation type for symbols immediately before and after PL to Q component switching section 105. Quadrature baseband signal generating section (for PL) 103 **receives a frame timing signal as an input and if the frame timing signal indicates a pilot symbol**, quadrature baseband signal generating section (for PL) 103 outputs the I component of the pilot symbol quadrature baseband signal to I component switching section 104 and outputs the Q component of the pilot symbol quadrature baseband signal to Q component switching section 105." *Sun Patent*, col. 5:27-34 **B. US7362824** "According to the invention, the quadrature baseband modulator 12 outputs the **baseband I and Q signals composed of a stream of modulated symbols** as shown in FIG. 7. FIG. 7 shows **an arrangement of a symbol stream** according to the base concept of the invention. In FIG. 7, **the symbol stream is basically composed of first symbols** having been subjected to a first modulation scheme (16 APSK in the specific example of FIG. 7) **and periodically includes second symbols** having been subjected to a second modulation scheme (QPSK in the specific example of FIG. 7) which is different from the first modulation scheme. This enables a receiver to use each of the second symbols as a pilot symbol from which the amplitude distortion and the phase distortion can be estimated for use in demodulation of the second symbols following the first symbol. Many widely different embodiments of the quadrature baseband modulator 12 can be constructed. Some embodiments will be described in the followings." *Panasonic*, col. 9:12-30 "With reference to FIG. 7, **a pair of the I signal and the Q signal outputted from the quadrature baseband modulator** 12 in the transmitter 10, or the RF signal outputted from the RF portion 15 in the transmitter 10 is composed of **a stream of**

(cont.) **determining an interval of symbol insertion, outputting a signal indicating the determined interval, and selecting an insertion pattern of the second symbol, from a plurality of predetermined insertion patterns;**	**frames each having N successive symbols. Here, N denotes a predetermined natural number.** In every frame, the first symbol results from the QPSK modulation, and the second and later symbols result from the 16-value APSK modulation." *Panasonic*, col. 12:48-56 "Simulation was executed by a computer. During the simulation, normal symbols were made on the basis of 16-value QAM while pilot symbols were made on the basis of QPSK modulation according to this invention. The **normal symbols and the pilot symbols were combined into a symbol stream** in a way based on this invention. **In the symbol stream, the number of normal symbols between pilot symbols (that is, a data symbol length) was equal to a given natural number "n" while each of the separate pilot symbols was equal to "1" in length. The given natural number "n" was "1", "7", or "15"**." *Panasonic*, col. 47:21-31
inserting the second symbol in the first symbols based on the selected insertion pattern to generate a transmission signal; and	**A. US8687677** 1. . . . a transmitter comprising. . . a timing controller cooperating with said first and second modulators so that **modulated specific first symbols are inserted before and after associated modulated first pilot symbols**; and. . . . *Sun Patent*, claim 1 "Quadrature baseband signal generating section (for modulation type for symbols immediately before and after PL) 102 receives transmission data and a frame timing signal as inputs and if the frame timing signal indicates a symbol immediately before or after the pilot symbol, **quadrature baseband signal generating section (for modulation type for symbols immediately before and after PL) 102 outputs the I component of the quadrature baseband signal for the modulation type for symbols immediately before and after PL to I component switching section 104 and outputs the Q component of the quadrature baseband signal** for the modulation type for symbols immediately before and after PL to Q component switching section 105." *Sun Patent*, col. 5:14-26 "Quadrature baseband signal generating section (for PL) 103 receives a frame timing signal as an input and if the frame timing signal indicates **a pilot symbol, quadrature baseband**

(cont.)
inserting the second symbol in the first symbols based on the selected insertion pattern to generate a transmission signal; and

signal generating section (for PL) 103 outputs the I component of the pilot symbol quadrature baseband signal to I component switching section 104 and outputs the Q component of the pilot symbol quadrature baseband signal to Q component switching section 105." *Sun Patent*, col. 5:27-34

"Radio section 106 **receives the I component and Q component of the transmission quadrature baseband signal as inputs, carries out predetermined radio processing on the baseband signal and then outputs a transmission signal**. This transmission signal is amplified by power amplifier 107 and the amplified transmission signal is output from transmission antenna 109." *Sun Patent*, col. 5:61-67

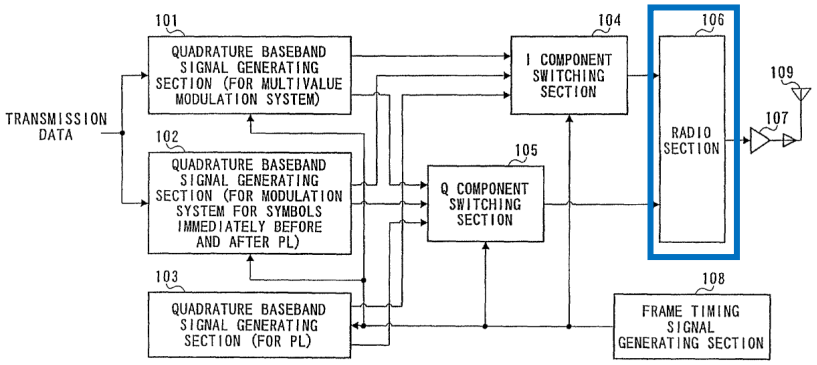

FIG. 4

B. US7362824

"According to the invention, the quadrature baseband modulator 12 outputs the **baseband I and Q signals composed of a stream of modulated symbols** as shown in FIG. 7. FIG. 7 shows **an arrangement of a symbol stream** according to the base concept of the invention. In FIG. 7, the **symbol stream is basically composed of first symbols** having been subjected to a first modulation scheme (16 APSK in the specific example of FIG. 7) **and periodically includes second symbols** having been subjected to a second modulation scheme (QPSK in the specific example of FIG. 7) which is different from the first modulation scheme. This enables a receiver to use each of the second symbols as a pilot symbol from which the amplitude distortion and the phase distortion can be estimated for use in demodulation of the second symbols following the first symbol. Many widely different embodiments of the quadrature baseband modulator 12 can be constructed. Some embodiments will be described in the

(cont.) **inserting the second symbol in the first symbols based on the selected insertion pattern to generate a transmission signal; and**	followings. The RF portion 15 **converts the baseband I signal and the baseband Q signal into an RF signal** through frequency conversion which may include RF modulation. The RF portion 15 feeds the RF signal to an antenna 17. The RF signal is radiated by the antenna 17." *Panasonic*, col. 9:12-35
transmitting the transmission signal, wherein the first symbols are generated using a modulation scheme selected from a plurality of modulation schemes.	**A. US8687677** 1. A wireless communications apparatus comprising: a **transmitter** comprising a first modulator configured to modulate a first pilot symbol according to a first modulation scheme, a second modulator configured to **modulate specific first symbols according to a second modulation scheme** different from the first modulation scheme, and. . . . *Sun Patent*, claim 1 6. The wireless communications apparatus according to claim 1 wherein the first and **second modulation schemes are selected from a group of a 64QAM modulation scheme, a 32QAM modulation scheme, a 16QAM modulation scheme, a 8PSK modulation scheme, a QPSK modulation scheme, a 16APSK modulation scheme, and a π/4-shift DQPSK modulation scheme.** *Sun Patent*, claim 6 "Radio section 106 receives the I component and Q component of the transmission quadrature baseband signal as inputs, carries out predetermined radio processing on the baseband signal and then outputs a transmission signal. This transmission signal is amplified by power amplifier 107 and the **amplified transmission signal is output from transmission antenna** 109." *Sun Patent*, col. 5:61-67 **B. US7362824** "According to the invention, the **quadrature baseband modulator 12 outputs the baseband I and Q signals composed of a stream of modulated symbols** as shown in FIG. 7. FIG. 7 shows an arrangement of a symbol stream according to the base concept of the invention. In FIG. 7, the symbol stream is basically composed of **first symbols having been subjected to a first modulation scheme** (16 APSK in the specific example of FIG. 7) and periodically includes second symbols having been subjected to a second modulation scheme (QPSK in the specific example of FIG. 7) which is different from the first modulation scheme. This enables a

(cont.) **transmitting the transmission signal, wherein the first symbols are generated using a modulation scheme selected from a plurality of modulation schemes**.	receiver to use each of the second symbols as a pilot symbol from which the amplitude distortion and the phase distortion can be estimated for use in demodulation of the second symbols following the first symbol. Many widely different embodiments of the quadrature baseband modulator 12 can be constructed. Some embodiments will be described in the followings. The **RF portion** 15 **converts the baseband I signal and the baseband Q signal into an RF signal** through frequency conversion which may include RF modulation. **The RF portion** 15 **feeds the RF signal to an antenna** 17**. The RF signal is radiated by the antenna** 17. As shown in FIG. 2, the **quadrature baseband modulator 12 includes a 16-value APSK (amplitude phase shift keying) modulator 12A, a QPSK (quadrature phase shift keying) modulator 12B**, a reference signal generator 12C, and switches 12D and 12E." *Panasonic*, col. 9:12-40 "With reference to FIG. 7, a pair of the I signal and the Q signal outputted from the quadrature baseband modulator 12 in the transmitter 10, or the **RF signal outputted from the RF portion 15 in the transmitter** 10 is composed of a stream of frames each having N successive symbols." *Panasonic*, col. 12:48-52