(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
31 January 2002 (31.01.2002)

PCT

(10) International Publication Number
WO 02/09270 A2

(51) International Patent Classification[7]: H03D

(21) International Application Number: PCT/US01/22653

(22) International Filing Date: 18 July 2001 (18.07.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/621,407 21 July 2000 (21.07.2000) US

(71) Applicant: **CONEXANT SYSTEMS, INC.** [US/US]; 4311 Jamboree Road, Newport Beach, CA 92660-3095 (US).

(72) Inventors: **DOMINO, William, J.**; 4740 Via Corona, Yorba Linda, CA 92897 (US). **GRIFFITH, Scott, A.**; 705 Loma Adria, San Clemente, CA 92672 (US). **ROZENBLIT, DMITRIY (NMI)**; 32 Cedar Tree Lane, Irvine, CA 92612 (US).

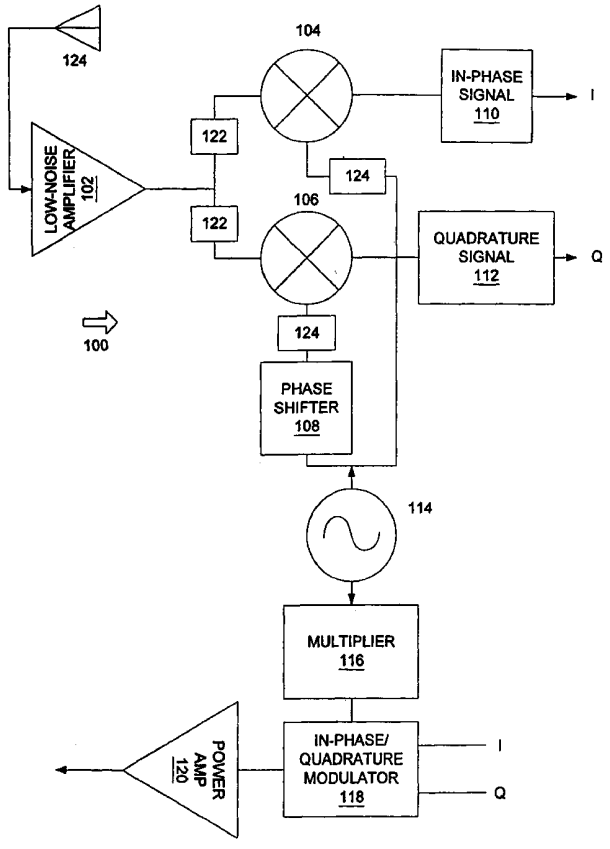
(74) Agent: **ROURK, Christopher, J.**; Akin, Gump, Strauss, Hauer & Feld, L.L.P., Suite 4100, 1700 Pacific Avenue, Dallas, TX 75201-4675 (US).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE,

[Continued on next page]

(54) Title: SYSTEM AND APPARATUS FOR A DIRECT CONVERSION RECEIVER AND TRANSMITTER



(57) Abstract: A system for transmitting and receiving data is provided. The system includes a direct-conversion receiver that receives a signal modulated on a carrier frequency signal. The direct-conversion receiver includes one or more subharmonic local oscillator mixers. A local oscillator is connected to the direct conversion receiver, and generates a signal having a frequency equal to a subharmonic of the carrier frequency signal. A transmitter is connected to the local oscillator, which uses the local oscillator signal to transmit outgoing data.

WO 02/09270 A2

IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
U.S. RECEIVING OFFICE

SPECIFICATION
accompanying

TITLE: SYSTEM AND APPARATUS FOR A DIRECT CONVERSION RECEIVER AND TRANSMITTER

FIELD OF THE INVENTION

The present invention pertains to the field of data transmission. More specifically, the invention relates to a system and apparatus for data transmission that allows a direct conversion receiver and transmitter to be used without the shielding or offset circuitry for a direct current component in the received signal that is normally required for such direct conversion receivers and transmitters.

RELATED CASES

This case is related to U.S. Patent Application serial number 09/260,919, "DIRECT CONVERSION RECEIVER," filed March 02, 1999, which is commonly owned and assigned with the present application and is incorporated by reference herein for all purposes.

BACKGROUND

Direct conversion receivers are known in the art. In a direct conversion receiver, the received carrier frequency signal with the data signal modulated on it is mixed with a signal from a local oscillator having the same frequency as the carrier frequency. The signal product of these two signals is a signal having components at the base band and at two times the carrier frequency. The high frequency component can be filtered using a low pass filter, such that the data signal remains in the base band signal. The base band signal is then processed to extract the data encoded in the transmitted signal.

One drawback of direct conversion receivers is that the local oscillator can radiate a leakage signal that may be stronger than the signal transmitted and received by the antenna. In this configuration, it is possible for the local oscillator signal to be received at the antenna of the direct conversion receiver or at intermediate points between the antenna and the mixer. If this condition occurs, the radiated local oscillator signal is received and mixed with the local oscillator signal that is provided directly at the input of the mixer, which creates a significant DC signal component in the output from the mixer.

In order to prevent the generation of a DC signal from such feedback, shielding or filtering can be performed. Likewise, it is also possible to offset the DC signal by applying a DC signal that is equal to that created by the leakage signal from the local oscillator and having a reverse polarity. Both shielding and offsetting the DC signal require additional costs, such as the cost and expense of shielding, the additional weight of shielding, the additional

power required to generate the DC offset, and other similar costs.

Thus, while direct conversion receivers have some utility, the additional costs required to shield the direct conversion receiver antenna from the local oscillator or to offset the DC signal can significantly increase the weight and costs of the direct conversion receiver. The increased weight and cost of the direct conversion receiver limits the types of applications in which the direct conversion receiver can be effectively used.

SUMMARY OF THE INVENTION

In accordance with the present invention, a system and method for a direct conversion receiver and transmitter are provided that overcome known problems with direct conversion receivers and transmitters.

In particular, a system and method for a direct conversion receiver and transmitter are provided that allow the local oscillator for a direct conversion receiver to also be used for an associated transmitter, thus reducing the number of components required to receive and transmit data.

In accordance with an exemplary embodiment of the present invention, a system for transmitting and receiving data is provided. The system includes a direct-conversion receiver that receives a signal modulated on a carrier frequency signal. The direct-conversion receiver includes one or more subharmonic local oscillator mixers. A local oscillator is connected to the direct conversion receiver, and generates a signal having a frequency equal to a subharmonic of the carrier frequency signal. A transmitter is connected to the local oscillator, which uses the local oscillator signal to transmit outgoing data.

The present invention provides many important technical advantages. One important technical advantage of the present invention is a system and method for receiving and transmitting data that uses a single local oscillator to both receive and transmit data. The present invention uses a subharmonic local oscillator to minimize the effect of leakage fields from the local oscillator on the received signal. In addition, the receiver and transmitter can, if the communications system requires it, both operate at the same frequency, such as by allocating time slots to the receive and transmit functions.

Those skilled in the art will further appreciate the advantages and superior features of the invention together with other important aspects thereof on reading the detailed description that follows in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a diagram of a system for providing a direct conversion receiver and transmitter in accordance with an exemplary embodiment of the present invention;

FIGURE 2 is a diagram of a direct conversion receiver in accordance with an exemplary embodiment of the present invention;

FIGURE 3 is a diagram of a transmitter for transmitting an outgoing data signal in accordance with an exemplary embodiment of the present invention;

FIGURE 4 is a diagram of a transmitter for transmitting a signal in accordance with an exemplary embodiment of the present invention;

FIGURE 5 is a diagram of a transmitter for transmitting a signal in accordance with an exemplary embodiment of the present invention;

FIGURE 6 is a diagram of a method for using a direct conversion receiver and transmitter in accordance with an exemplary embodiment of the present invention; and

FIGURE 7 is a diagram of a system in which systems and components interface via a direct conversion receiver and transmitter, in accordance with an exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

In the description that follows, like parts are marked throughout the specification and drawings with the same reference numerals, respectively. The drawing figures might not be to scale, and certain components can be shown in generalized or schematic form and identified by commercial designations in the interest of clarity and conciseness.

FIGURE 1 is a diagram of a system 100 for providing a direct conversion receiver and transmitter in accordance with an exemplary embodiment of the present invention. System 100 allows the local oscillator for a direct conversion receiver to also be used to modulate an outgoing signal to a transmission frequency, so as to reduce the number of components needed in a system for receiving and transmitting data. System 100 can be implemented in hardware or a suitable combination of hardware and software, and is preferably an integrated circuit that is on a single silicon wafer substrate.

System 100 includes low noise amplifier 102 that receives a carrier frequency signal from antenna 124. The carrier frequency signal includes a data signal that has been modulated onto the carrier frequency signal using a suitable modulation technique, such as quadrature phase shift keying, frequency modulation, or other suitable modulation. Low noise amplifier 102 is coupled to high-pass filters 122a and 122b. As used herein, the term "couple" and its cognate terms, such as "couples" and "coupled," can refer to a physical connection (such as through a copper conductor), a logical connection (such as through logical gates of a semiconducting circuit), a virtual connection (such as through randomly assigned memory locations of a data memory device), other suitable connections, or a

combination of such connections. In one exemplary embodiment, systems and components are coupled to other systems and components through intervening systems or components, such as through a conductive layer of a semiconducting circuit.

High pass filters 122a and 122b are used to minimize the amount of leakage signal that may be received from local oscillator 114 by antenna 124 and related circuitry of system 100. In one exemplary embodiment, local oscillator 114 generates a signal having a frequency that is one-half of the carrier signal frequency, such that high pass filters 122a and 122b reduce the magnitude of the leakage signal by a suitable amount, such as -30 decibels. In this manner, the effect of the leakage signal can be reduced to a level that does not interfere with the carrier frequency signal received by antenna 124.

Mixers 104 and 106 receive the amplified carrier frequency signal from low noise amplifier 102 and mix the amplified carrier frequency signal with a local oscillator signal from local oscillator 114. Band pass filters 124a and 124b are used to remove high frequency components from the signal received from local oscillator 114, such as leakage signal from other components of system 100. As such, band pass filters 124a and 124b allow signals having the frequency of local oscillator 114 to pass, and may either be low-pass filters that allow frequencies below those of local oscillator 114 to pass, or band-pass filters that block both high and low frequency signals.

Mixers 104 and 106 receive the signal from the local oscillator and multiply the signal by a numerical factor prior to mixing the signal with the carrier frequency signal. In one exemplary embodiment, the frequency of the

carrier signal, the local oscillator 114, and the multiplication factor of mixers 104 and 106 are related, such that local oscillator 114 generates a signal at a subharmonic frequency of the carrier frequency, and the mixers multiply the local oscillator signal by a factor equal to the inverse of the subharmonic prior to mixing the local oscillator signal with the carrier frequency signal. In this manner, mixers 104 and 106 multiply the frequency of the local oscillator 114 to that of the carrier frequency, such that the output of mixers 104 and 106 is a signal having a frequency distribution around the base band frequency and a frequency distribution around the frequency centered at two times the carrier frequency.

Mixer 106 receives the signal from local oscillator 114 through phase shifter 108 and low-pass filter 124b. Phase shifter 108 shifts the phase of the local oscillator signal by a predetermined amount so as to create an output from mixer 106 that is shifted by 90°. The degree of phase shift of phase shifter 108 is thus coordinated with the frequency of local oscillator 114 and the carrier signal frequency.

In one exemplary embodiment, mixer 106 is a one-half local oscillator mixer that receives a local oscillator signal that is one-half of the frequency of the carrier signal frequency. In this exemplary embodiment, phase shifter 108 shifts the phase of the signal received from local oscillator 114 by 45 degrees, such that the phase shift becomes 90 degrees after being multiplied by mixer 106. In this manner, the phase of the signals generated by mixer 104 and mixer 106 is separated by 90° so that quadrature phase shift keying modulation can be detected. Likewise, other suitable frequencies for phase shifter 108, local oscillator 114, mixer 104, and mixer 106 can be used.

For example, mixers 104 and 106 can be one-third local oscillator and mixers, where the frequency of local oscillator 114 is one-third of the frequency of the carrier signal frequency, and phase shifter 108 shifts the frequency of the signal from local oscillator 114 by 30°.

In-phase signal circuit 110 and quadrature phase signal circuit 112 are coupled to mixers 104 and 106, respectively. In-phase signal circuit 110 and quadrature phase signal circuit 112 are used to amplify and filter the in-phase and quadrature phase signals, which are used to detect quadrature phase shift keying or other suitable modulation from the signal encoded on the carrier signal received by low noise amplifier 102.

Local oscillator 114 is a suitable oscillator, such as a voltage-controlled oscillator, that generates an oscillator signal at a predetermined frequency. In one exemplary embodiment, local oscillator 114 generates a signal having a frequency that is a subharmonic of the carrier frequency signal that is received and amplified by low noise amplifier 102, such as a one-half harmonic, a one-third harmonic, a one-quarter harmonic or other suitable harmonics. In this manner, signals generated by local oscillator 114 that radiate to connector circuitry between local oscillator 114 and antenna 124 will not result in the generation of a DC signal at the output of mixers 104 and 106.

Frequency multiplier 116 is coupled to local oscillator 114 and multiplies the frequency of the signal generated by local oscillator 114 by a predetermined factor. In one exemplary embodiment, the transmitter of system 100 may transmit a signal at the same frequency as the carrier signal frequency during periods when the receiver is not

receiving the carrier signal. In this exemplary embodiment, frequency multiplier 116 multiplies the frequency of the signal output for mixer 114 by an amount corresponding to the inverse of the subharmonic of mixer 114. For example, if local oscillator 114 generates an oscillator signal having frequency that is one-half of the frequency of the carrier signal, frequency multiplier 116 multiplies this signal frequency by a factor of two. In another exemplary embodiment, if local oscillator 114 generates a signal having a frequency one-third of the carrier frequency, then frequency multiplier 116 multiplies the signal frequency by a factor of three. Other suitable factors may be used.

Frequency multiplier 116 can also be used to multiply the transmit carrier frequency to a level other than the receive carrier frequency. In this configuration, system 100 can simultaneously transmit and receive, and does not need to have the transmission periods coordinated with the reception periods. Likewise, frequency multiplier 116 can be excluded such that the transmit carrier frequency is equal to the local oscillator frequency.

In-phase/quadrature modulator 118 receives outgoing in-phase and quadrature signals and modulates the signals onto the carrier frequency received from frequency multiplier 116. For example, in-phase and quadrature signals can be used to perform quadrature phase shift keying on the signal received from frequency multiplier 116. This modulated signal is then provided to power amp 120 for transmission over an antenna.

In operation, system 100 is used to perform direct conversion reception of a carrier signal that has been modulated with encoded data, and further utilizes the same local oscillator frequency for transmission of a data signal

generated at system 100. In this manner, system 100 can be used to receive and transmit a signal using a subharmonic local oscillator in a manner that minimizes the potential for feedback, direct current generation, and other unwanted effects in the direct conversion receiver and transmitter of system 100.

FIGURE 2 is a diagram of a direct conversion receiver 200 in accordance with an exemplary embodiment of the present invention. Direct conversion receiver 200 can be implemented in hardware or a suitable combination of hardware and software, and can be a single circuit that is part of an integrated circuit receiver/transmitter circuit that is embodied on a single silicon wafer die.

Direct conversion receiver 200 includes a phase shifter 202 that is coupled between low-noise amplifier 102 and mixer 106. In this configuration, phase shifter 202 shifts the incoming modulated carrier signal in order to produce the quadrature signal 112. Thus, the effect of phase shifter 202 is not multiplied by mixer 106, as opposed to the configuration of system 100 where the amount of shift of the phase shifter on the subharmonic local oscillator signal is multiplied by the multiplication factor of mixer 106. Thus, phase shifter 202 can be used to shift the phase of the amplified carrier signal by 90 degrees instead of a fraction corresponding to the frequency of the local oscillator. In addition, suitable frequency filters, such as high-pass filters 122a and 122b, and low-pass filters 124a and 124b, can be also be used to reduce signal components created in the carrier frequency signal through leakage from the local oscillator or other system components.

In operation, direct conversion receiver 200 allows a carrier signal that is modulated with a data signal to be directly converted to the base band signal in a manner that reduces the amount of shielding required and the amount of D.C. offset generated. Direct conversion receiver 200 can be combined with a transmitter that uses the same local oscillator as that used by direct conversion receiver 200, so as to reduce the number of components required and to allow a receiver and transmitter circuit to be fabricated on a single silicon wafer die.

FIGURE 3 is a diagram of a transmitter 300 for transmitting an outgoing data signal in accordance with an exemplary embodiment of the present invention. Transmitter 300 can be implemented in hardware or a suitable combination of software and hardware, and can be a single circuit that is part of an integrated circuit receiver/transmitter circuit that is embodied on a single silicon wafer die.

Transmitter 300 receives a signal from a local oscillator at in-phase/quadrature modulator 118, which also receives data encoded in a quadrature phase shift keyed signal or other suitable modulation. In-phase/quadrature modulator then modulates the signal received from the local oscillator with the quadrature phase shift keyed or otherwise modulated signal to generate an outgoing data signal. The frequency of the outgoing data signal is then multiplied by multiplier 302, and is subsequently amplified by power amp 120. Thus, the outgoing carrier signal carrying the encoded outgoing data signal is multiplied after the local oscillator signal is modulated with the data signal. As a result, the quadrature phase sift keyed or otherwise modulated signal that is encoded onto the local oscillator signal must have a phase shift corresponding to

the inverse of the multiplication factor applied at in-phase/quadrature modulator 118 in order to properly decode the encoded data. The outgoing data signal can also be transmitted after modulation without frequency multiplication.

In one exemplary embodiment, a multiplication factor of two is applied by multiplier 302 to the local oscillator signal, such that the phase shift applied at in-phase/quadrature modulator 118 must be one-half of the phase shift that will be required by the signal receiver in order to properly decode the encoded data. Thus, if the transmitted data signal is to have a keyed phase shift of 90 degrees, then the phase shift applied at in-phase/quadrature modulator 118 would be 45 degrees in this exemplary embodiment.

In operation, transmitter 300 allows a single local oscillator to be used to modulate a carrier signal for a direct conversion receiver and to transmit an outgoing data signal. Modulation of the outgoing data signal by transmitter 300 is performed prior to multiplication of the signal up to the outgoing carrier frequency. Transmitter 300 allows a receiver and transmitter circuit to be fabricated on a single silicon wafer die.

FIGURE 4 is a diagram of a transmitter 400 for transmitting a signal in accordance with an exemplary embodiment of the present invention. Transmitter 400 can be implemented in hardware or a suitable combination of software and hardware, and can be a single circuit that is part of an integrated circuit receiver/transmitter circuit that is embodied on a single silicon wafer die.

Transmitter 400 includes frequency modulator 402 which is used to modulate an outgoing data signal onto the signal

generated by local oscillator 114. Switch 404 is coupled to frequency modulator 402 and phase locked loop 406, such that when switch 404 is closed, the circuit including frequency modulator 402 and switch 404 allows local oscillator 114 to be modulated with the signal of frequency modulator 402 without drifting from the desired local oscillator frequency for a short period of time. In this manner, frequency modulator 402 can be used to modulate the signal generated by local oscillator 114 during predetermined cycles. In one exemplary embodiment, a predetermined receive period and transmit period are used, such that a single carrier frequency can be used to receive and transmit data from the direct conversion receiver.

Switch 404 is used to allow transmitter 400 to transmit during the transmit period, and interrupts transmission during the receive period. In this exemplary embodiment, multiplier 408 and power amp 120 are on during transmit and off during receive. In one exemplary embodiment, switch 404 can detect the transmit and receive cycles, such as by receiving a local clock signal and the incoming data signal. In another exemplary embodiment, switch 404 receives a control signal from a controller that causes switch 404 to connect local oscillator 114 to the phase locked loop 406 during the receive cycle and to connect local oscillator 114 to the frequency modulator 402 during the transmit cycle. Other suitable configurations may be used.

Local oscillator 114 is coupled to multiplier 408, which multiplies the frequency of the modulated data signal received from local oscillator 114 by a predetermined multiple. Frequency modulator 402 modulates the local oscillator signal 114 at a predetermined inverse multiple of this multiplier frequency. In one exemplary embodiment,

where local oscillator 114 generates a signal that is one-half of the frequency of the carrier signal, then frequency modulator 402 modulates the frequency of local oscillator 114 at one-half of the transmitted modulation rate that will correspond to the data that is being encoded and transmitted.

In operation, transmitter 400 allows a single local oscillator to be used to modulate a carrier signal for a direct conversion receiver and to transmit an outgoing data signal. A phase-locked loop and switch are used by transmitter 400 to maintain the local oscillator at the desired frequency and to control transmission and reception periods, respectively. Transmitter 400 allows a receiver and transmitter circuit to be fabricated on a single silicon wafer die.

FIGURE 5 is a diagram of a transmitter 500 for transmitting a signal in accordance with an exemplary embodiment of the present invention. Transmitter 500 can be implemented in hardware or a suitable combination of software and hardware, and can be a single circuit that is part of an integrated circuit receiver/transmitter circuit that is embodied on a single silicon wafer die.

Transmitter 500 includes phase locked loop 502 which is coupled to local oscillator 114 and which maintains local oscillator 114 at a predetermined frequency. Frequency modulator 504 is coupled to local oscillator 114 and reference oscillator 506, and modulates an outgoing data signal onto the signal generated by local oscillator 114. Phase locked loop 502 remains locked during both transmit and receive cycles. During transmit, frequency modulator 504 applies modulation to local oscillator 114. Since phase locked loop 502 is locked, phase locked loop 502 will tend

to remove the low-frequency portion of the modulation. To prevent this, the modulation is also applied to the reference oscillator 506. The frequency of the signal output by local oscillator 114 with the modulated data signal is then multiplied by multiplier 508, and is then amplified to a transmission power level by power amp 120. The modulation frequency of frequency modulator 504 is therefore adjusted to compensate for the subsequent multiplication by multiplier 508, so as to result in a transmitted signal having a modulation that allows the encoded outgoing data signal to be detected and extracted.

In one exemplary embodiment, the outgoing data signal provided to frequency modulator is controlled so that no signal is provided during a receive cycle, and an outgoing data signal is provided during a transmit cycle. Other suitable configurations can also be used.

In operation, transmitter 500 allows a single local oscillator to be used to modulate a carrier signal for a direct conversion receiver and to transmit an outgoing data signal. Transmitter 500 allows a receiver and transmitter circuit to be fabricated on a single silicon wafer die.

FIGURE 6 is a diagram of a method 600 for using a direct conversion receiver and transmitter in accordance with an exemplary embodiment of the present invention. Method 600 allows a single local oscillator to be used to receive and transmit data, and reduces the effect of leakage fields from the local oscillator on the received signal.

Method 600 begins at 602 where a carrier signal having an encoded data signal is received. The carrier signal is transmitted at a predetermined frequency and includes an encoded data signal that is modulated onto the carrier signal using a suitable modulation technique, such as

quadrature phase shift keying. The method then proceeds to 604 where it is determined whether phase shift keying is being used. The method may also be implemented using a circuit in which phase shift keying is always used, or in which phase shift keying is not used, such that the process of determining whether phase shift keying is being used is not performed. If phase shift keying is not being used, the method proceeds directly to 610. Otherwise, method proceeds to 606.

At 606, the carrier signal is split into an in-phase and quadrature phase signal. The method then proceeds to 608 where the quadrature phase signal is phase shifted. In one exemplary embodiment, the quadrature phase signal is phase shifted by phase shifting the carrier signal by 90 degrees. In another exemplary embodiment, the quadrature phase signal is phase shifted by phase shifting a subharmonic local oscillator signal by a factor corresponding to the inverse of the subharmonic frequency, such that when the local oscillator signal is multiplied and mixed with the carrier signal, the phase shift factor is multiplied so as to equal 90 degrees. The method then proceeds to 610.

At 610, the carrier signal is mixed with the subharmonic local oscillator signal through a subharmonic mixer so as to generate a base band signal and a signal at two times the frequency of the carrier signal. In one exemplary embodiment, the carrier signal can be mixed with a one-half local oscillator signal using a one-half local oscillator mixer. The method then proceeds to 612 where the base band incoming signal is extracted. The base band incoming signal can be extracted as an in-phase component and a quadrature phase component, so as to facilitate

decoding of a quadrature phase shift keyed data signal. The method then proceeds to 614.

At 614, an outgoing data signal is received from a data source. The method then proceeds to 616 where the outgoing data signal is modulated using a subharmonic local oscillator signal. In one exemplary embodiment, an in-phase and quadrature phase modulator is used to modulate the outgoing data signal onto the local oscillator signal. In another exemplary embodiment, a frequency modulator is used to modulate the local oscillator signal with the outgoing data signal. The method then proceeds to 618 where the frequency of the modulated outgoing data signal is multiplied to the carrier frequency. The multiplication can be performed prior to modulation of the local oscillator signal. Likewise, the multiplication can be performed after modulation, where the outgoing data signal is modulated onto the local oscillator signal at a factor corresponding to the subharmonic frequency of the local oscillator. For example, if the subharmonic frequency of the local oscillator is one-half of the carrier frequency, then the data in the outgoing data signal is modulated at one-half of the frequency required for the data to be received and decoded by a receiver. Other suitable procedures can be used.

In operation, method 600 is used to receive an incoming data signal and to transmit an outgoing data signal using a direct conversion receiver or other suitable receiver and a local oscillator having a frequency that is a subharmonic of the carrier frequency. Method 600 thus allows direct conversion receivers or other suitable receivers to be used without shielding or DC offset compensation, and further allows the local oscillator to be used with the transmitter

to modulate the outgoing data stream to a carrier frequency or other suitable frequency for transmission.

FIGURE 7 is a diagram of a system 700 in which systems and components interface via a direct conversion receiver and transmitter, in accordance with an exemplary embodiment of the present invention. System 700 allows systems and components to interface via a wireless connection over short distances in a manner that is economical and lightweight.

System 700 includes direct conversion receiver and transmitters 702a through 702d, which can include features from systems 100 through 500 of the present invention, plus additional interface circuitry to allow digitally-encoded data in the incoming data signal to be extracted and provided to an attached system or component, and to receive an outgoing data stream from the attached system or component for transmission to other systems and components. In the exemplary embodiment shown in FIGURE 7, direct conversion receiver and transmitter 702a is coupled to local area network 704, direct conversion receiver and transmitter 702b is coupled to a telephone 706, and direct conversion receiver and transmitters 702c and 702d are coupled to laptop computers 706a and 706b. These components can send and receive data to the other components using the wireless connection provided by direct conversion receiver and transmitters 702a through 702d. The light weight and low cost of direct conversion receiver and transmitters 702a through 702d allow wireless connections to be inexpensively provided for many devices and in many situations where providing such wireless connectivity would otherwise be prohibitively expensive.

Although exemplary embodiments of a system and method for a direct conversion receiver and transmitter have been

described in detail herein, those skilled in the art will also recognize that various substitutions and modifications can be made to the systems and methods without departing from the scope and spirit of the appended claims.

WHAT IS CLAIMED IS

1. A system for transmitting and receiving data comprising:

a direct-conversion receiver receiving a signal modulated on a carrier frequency signal, the direct-conversion receiver further comprising one or more subharmonic local oscillator mixers;

a local oscillator coupled to the direct conversion receiver, the local oscillator generating a signal having a frequency equal to a subharmonic of the carrier frequency signal; and

a transmitter coupled to the local oscillator.

2. The system of claim 1 wherein the direct conversion receiver further comprises:

a phase shifter coupled to a first subharmonic local oscillator mixer, where the output of the first subharmonic local oscillator mixer is used to generate a quadrature signal of a phase shift keyed signal; and

a second subharmonic local oscillator mixer, where the output of the second subharmonic local oscillator mixer is used to generate an in-phase signal of a phase shift keyed signal.

3. The system of claim 2 wherein the phase shifter is further coupled to the local oscillator.

4. The system of claim 2 further comprising a low-noise amplifier coupled to the phase shifter, wherein the signal modulated on the carrier frequency signal is received by the low-noise amplifier and is transmitted to the phase shifter after being amplified.

5. The system of claim 1 further comprising a frequency multiplier coupled between the local oscillator and the transmitter, wherein the frequency multiplier increases the frequency of the oscillator.

6. The system of claim 5 wherein the frequency multiplier increases the frequency of the oscillator up to the frequency of the carrier signal.

7. The system of claim 1 wherein the transmitter comprises:

a frequency multiplier coupled to the local oscillator; and

an in-phase/quadrature modulator coupled to the frequency multiplier, receiving an in-phase modulation input signal and a quadrature modulation input signal, and outputting a quadrature phase shift keyed signal modulated at the multiplied local oscillator frequency.

8. The system of claim 1 wherein the transmitter comprises:

an in-phase/quadrature modulator coupled to the local oscillator, receiving an in-phase modulation input signal and a quadrature modulation input signal, and outputting a quadrature phase shift keyed signal modulated at the local oscillator frequency; and

a frequency multiplier coupled to the in-phase/quadrature modulator and multiplying the frequency of the quadrature phase shift keyed signal.

9. The system of claim 1 wherein the transmitter comprises:

a frequency modulator coupled to the local oscillator, wherein the local oscillator is modulated by the frequency modulator;

a phase locked loop coupled to the frequency modulator and the local oscillator; and

a switch coupled between the local oscillator and the phase locked loop, wherein the switch can couple the phase locked loop to the local oscillator during a transmit cycle and can decouple the phase locked loop from the local oscillator during a receive cycle.

10. The system of claim 1 wherein the transmitter comprises:

a frequency modulator coupled to the local oscillator, where the local oscillator is modulated by the frequency modulator;

a voltage-controlled reference oscillator coupled to the frequency modulator, where the voltage-controlled reference oscillator is modulated by the frequency modulator; and

a phase locked loop coupled to the local oscillator in a feedback loop, the phase locked loop further coupled to the voltage controlled oscillator.

11. A method for receiving and transmitting data comprising:

receiving a carrier signal modulated with a data signal;

mixing the carrier signal with a subharmonic local oscillator signal to extract a baseband signal; and

modulating an outgoing data signal with the subharmonic local oscillator signal.

12. The method of claim 11 wherein mixing the carrier signal with the subharmonic local oscillator signal to extract the baseband signal further comprises:

mixing the carrier signal with the subharmonic local oscillator signal to extract an in-phase signal;

phase-shifting the subharmonic local oscillator signal; and

mixing the carrier signal with the phase-shifted subharmonic local oscillator signal to extract a quadrature phase signal.

13. The method of claim 11 wherein mixing the carrier signal with the subharmonic local oscillator signal to extract the baseband signal further comprises:

mixing the carrier signal with the subharmonic local oscillator signal to extract an in-phase signal;

phase-shifting the carrier signal; and

mixing the phase-shifted carrier signal with the subharmonic local oscillator signal to extract a quadrature phase signal.

14. The method of claim 11 wherein modulating the outgoing data signal with the subharmonic local oscillator signal comprises:

multiplying the subharmonic local oscillator signal; and

modulating an outgoing in-phase data signal and an outgoing quadrature phase data signal with the multiplied subharmonic local oscillator signal.

15. The method of claim 11 wherein modulating the outgoing data signal with the subharmonic local oscillator signal comprises:

modulating an outgoing in-phase data signal and an outgoing quadrature phase data signal with the subharmonic local oscillator signal to generate a modulated outgoing data signal; and

multiplying the modulated outgoing data signal to generate the outgoing data signal.

16. The method of claim 11 wherein modulating the outgoing data signal with the subharmonic local oscillator signal comprises:

frequency modulating the subharmonic local oscillator signal during a transmit cycle; and

interrupting frequency modulation of the subharmonic local oscillator signal during a receive cycle.

17. The method of claim 16 further comprising opening a phase locked loop during the transmit cycle to lock the subharmonic local oscillator signal.

18. The method of claim 16 further comprising

frequency modulating a reference oscillator signal of a phase locked loop that locks the subharmonic local oscillator signal.

19. The method of claim 11 wherein modulating the outgoing data signal with the subharmonic local oscillator signal comprises:

modulating an outgoing in-phase data signal and an outgoing quadrature phase data signal with the subharmonic local oscillator signal at a subharmonic modulation index to generate a modulated outgoing data signal; and

multiplying the modulated outgoing data signal by an inverse subharmonic to generate the outgoing data signal.

20. A system for transmitting and receiving data comprising:

a low noise amplifier receiving a modulated incoming carrier signal having a carrier signal frequency;

a local oscillator generating a signal having a subharmonic frequency of the carrier signal;

a first mixer coupled to the low noise amplifier and the local oscillator, the first mixer receiving the modulated incoming carrier signal and generating an in-phase incoming data signal;

a second mixer coupled to the low noise amplifier and the local oscillator, the second mixer receiving the modulated incoming carrier signal and generating a quadrature phase incoming data signal;

a modulator coupled to the local oscillator, the modulator receiving an outgoing data signal and modulating the outgoing data signal onto the local oscillator signal to generate an outgoing modulated carrier signal; and

a transmit amplifier coupled to the modulator, the transmit amplifier amplifying the outgoing modulated carrier signal to a transmission power level.

21. The system of claim 20 further comprising a general purpose computing platform coupled to the first mixer, the second mixer, and the modulator, the general purpose computing platform decoding an incoming data signal from the in-phase incoming data signal and the quadrature phase incoming data signal, and generating the outgoing data signal.

22. The system of claim 20 further comprising a telephone handset coupled to the first mixer, the second mixer, and the modulator, the telephone handset decoding an incoming data signal from the in-phase incoming data signal and the quadrature phase incoming data signal, and generating the outgoing data signal.

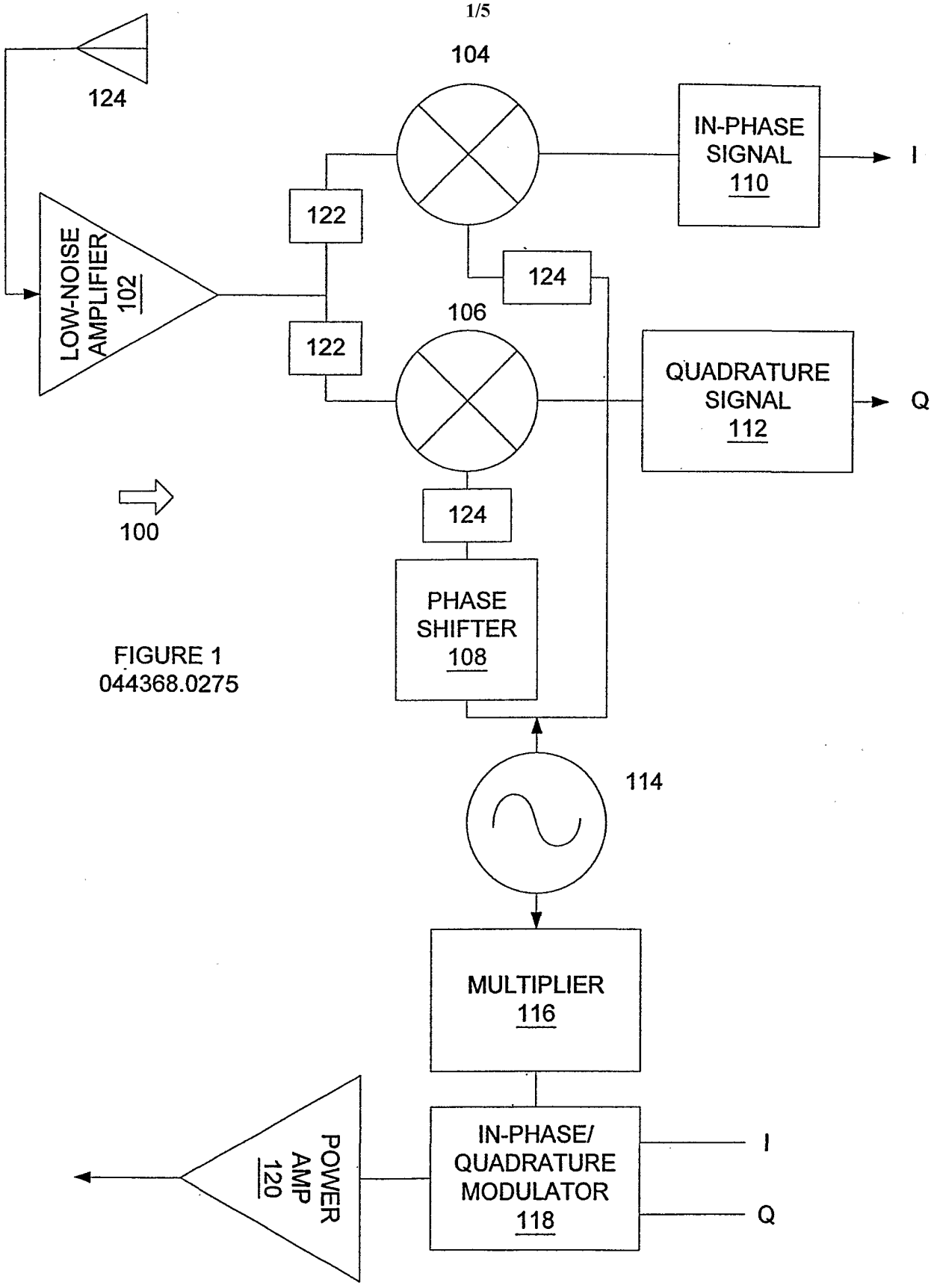


FIGURE 1
044368.0275

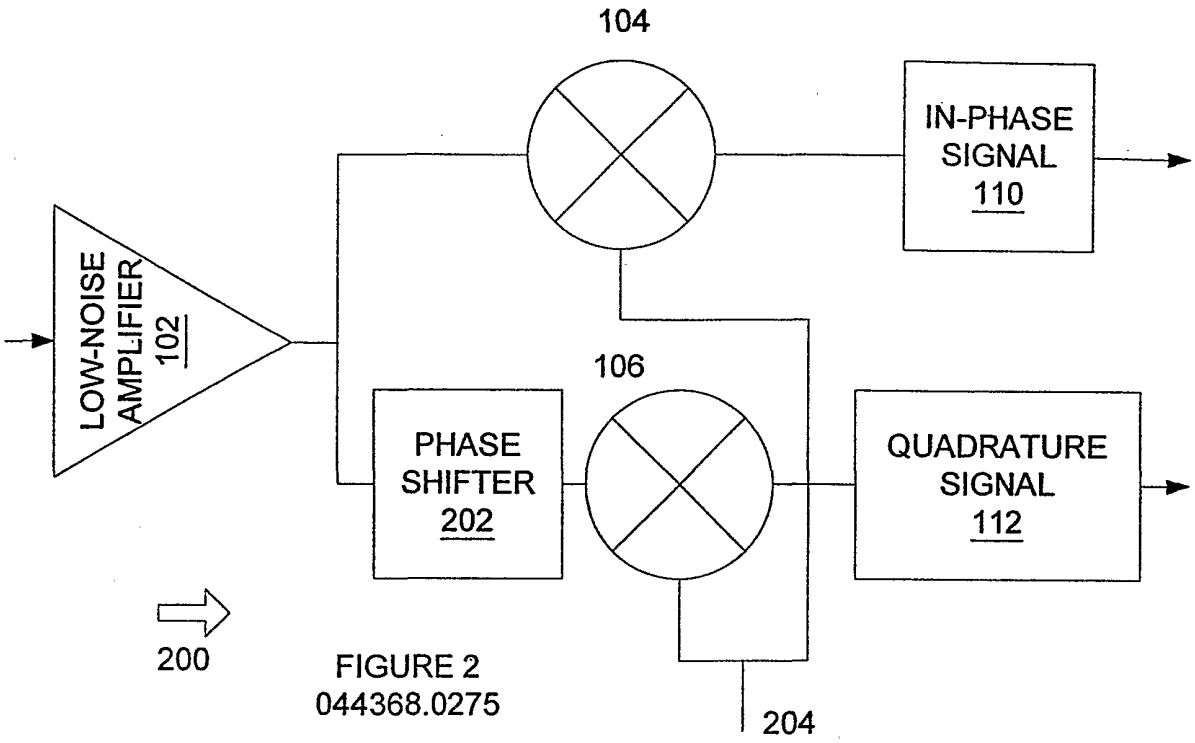


FIGURE 2
044368.0275

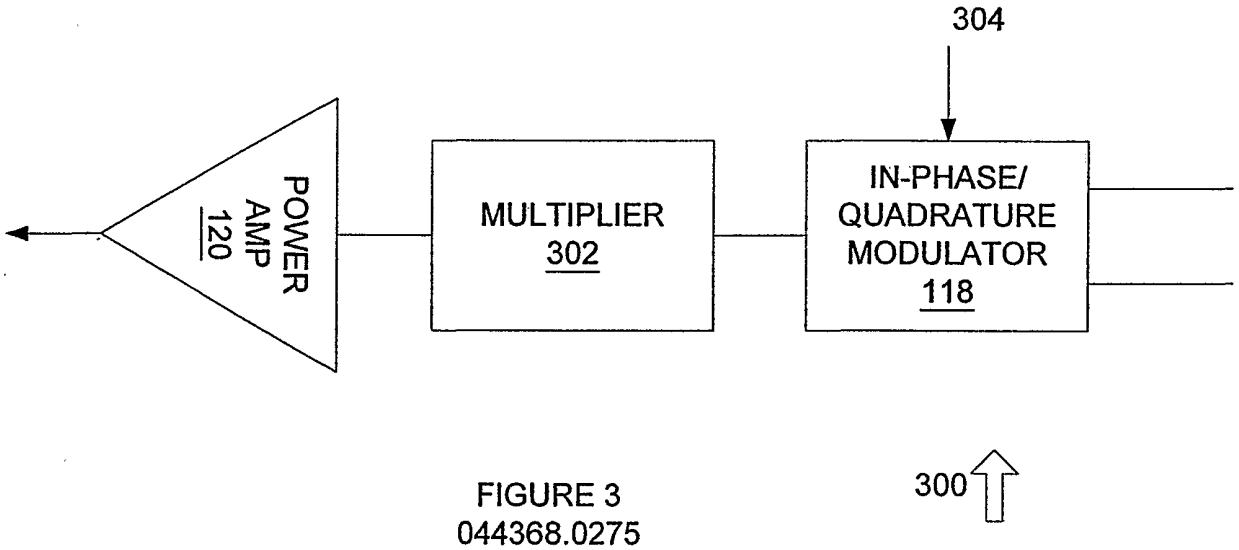


FIGURE 3
044368.0275

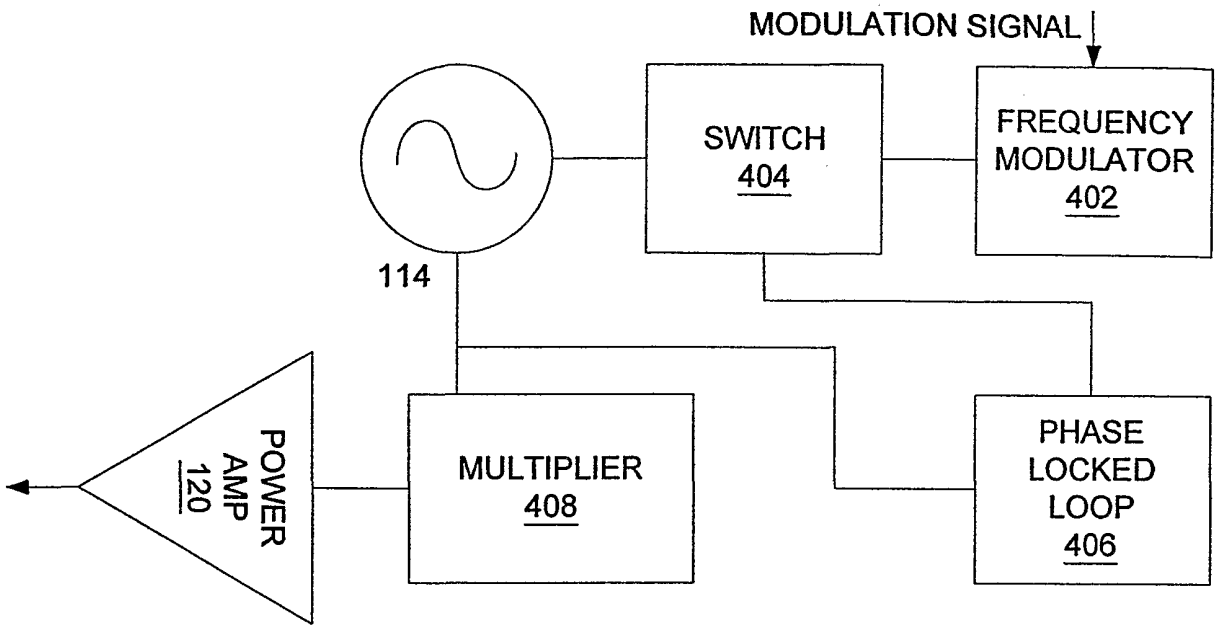


FIGURE 4
044368.0275

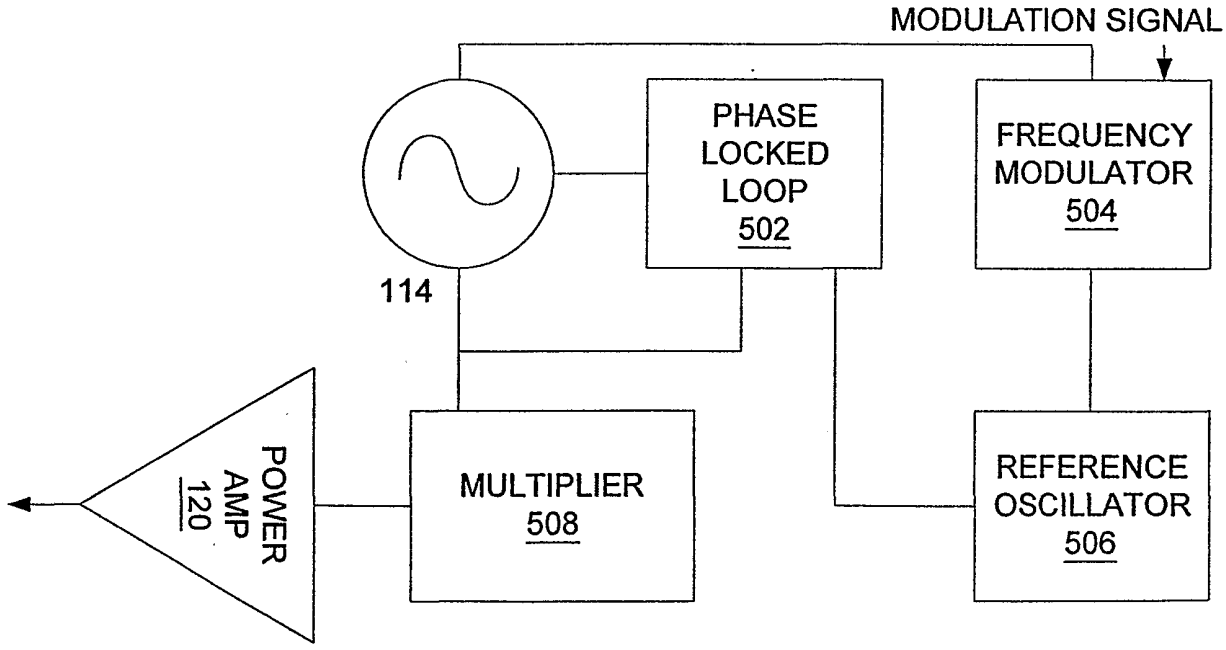


FIGURE 5
044368.0275

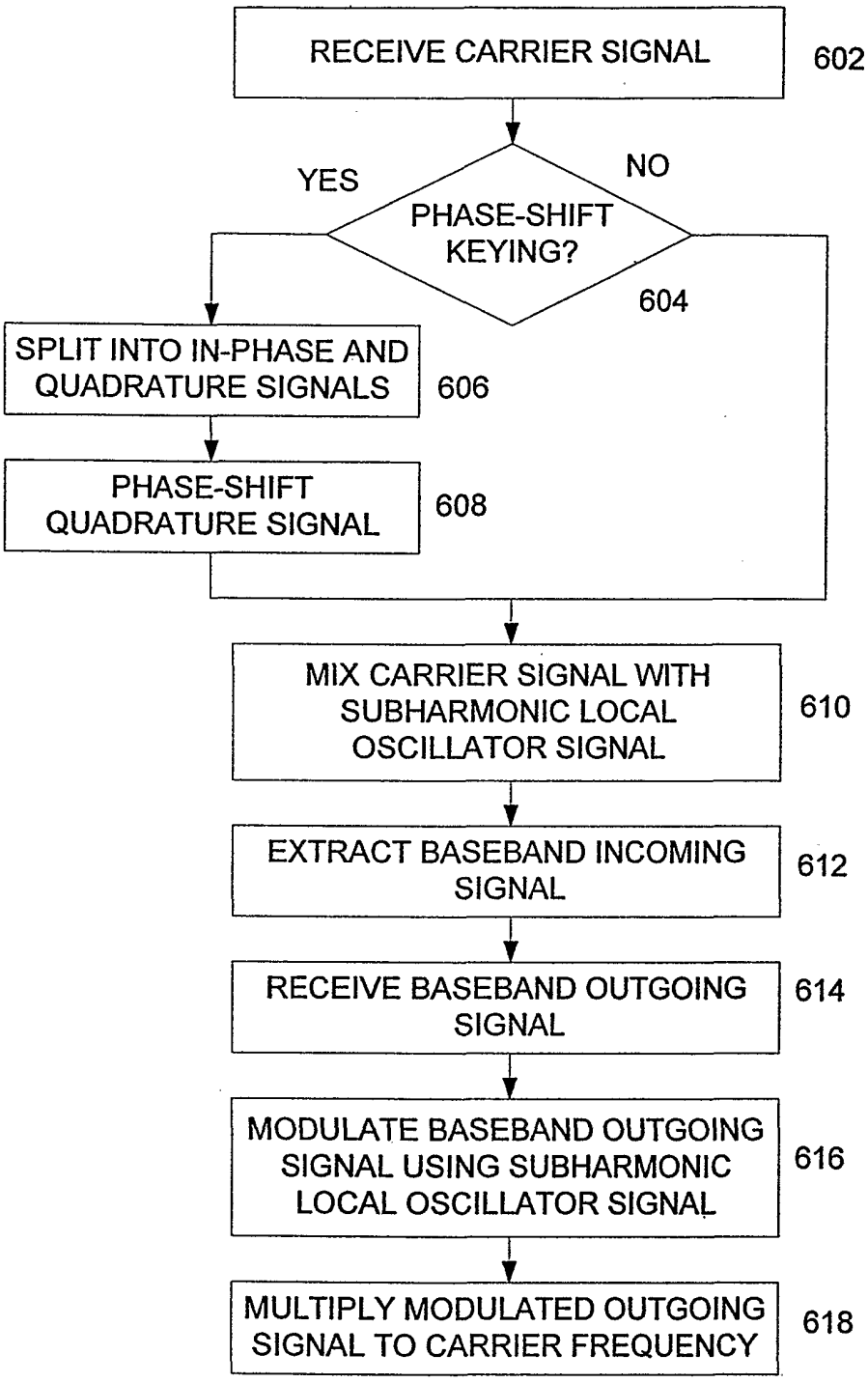


FIGURE 6
044368.0275

600

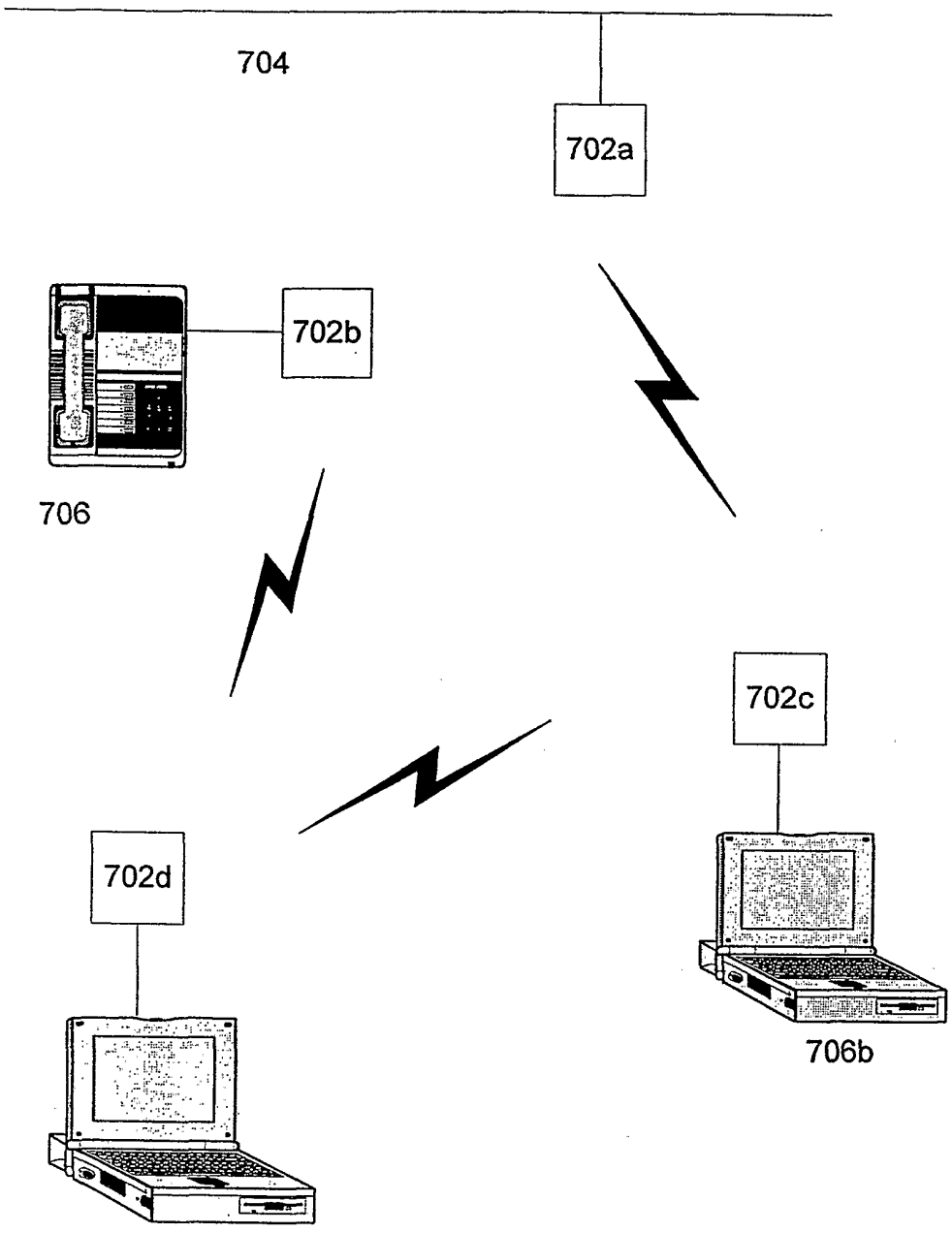


FIGURE 7
044368.0275

700