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(54) METHOD AND SYSTEM FOR SINGLE SIDEBAND MIXING RECEIVER ARCHITECTURE FOR IMPROVING SIGNAL QUALITY

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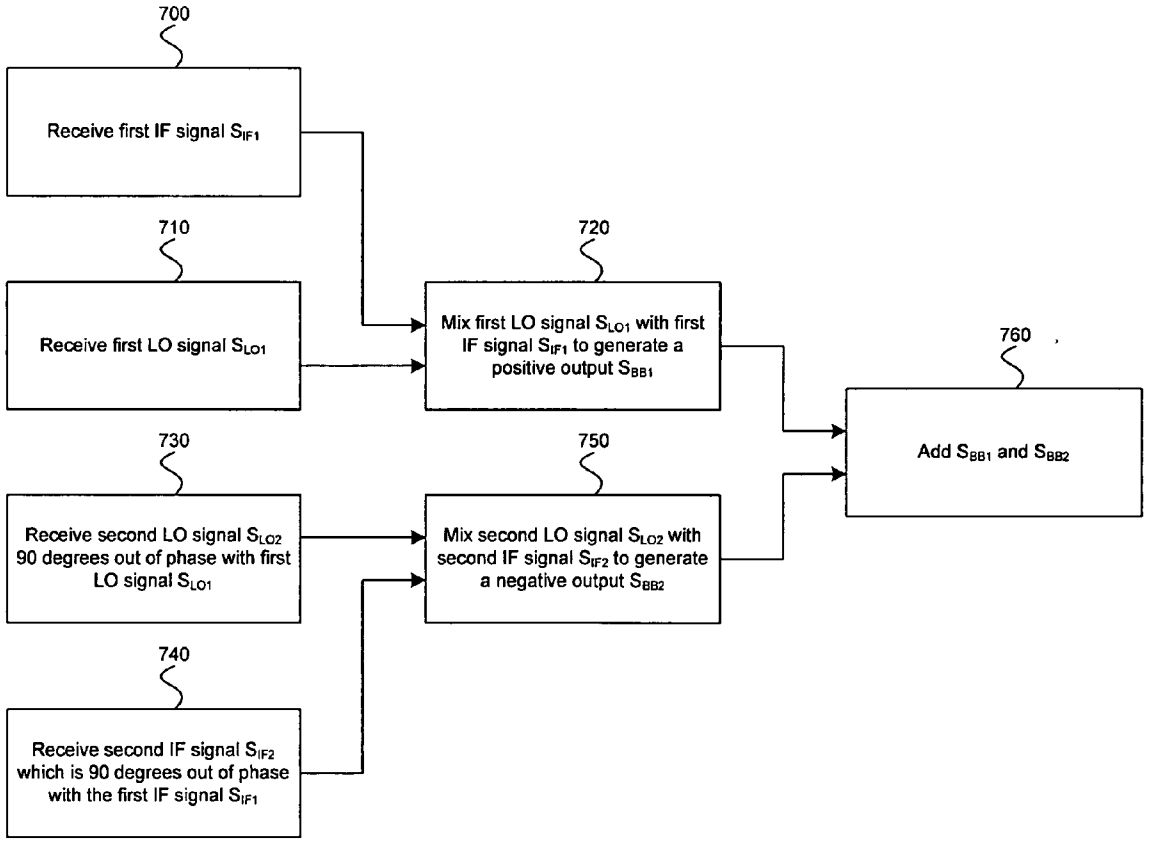
(57) **ABSTRACT**

Certain embodiments of the invention may be found in a method and system for single sideband mixing receiver architecture for improving signal quality in an RF communication system. An embodiment of the invention may mix a first input signal with a first local oscillator signal, via a first mixer, to generate a first mixed output signal. It may also mix a second input signal with a second local oscillator signal, via a second mixer, to generate a second mixed output signal. It may then generate a single sideband signal by adding the first mixed output signal and the second mixed output signal. The removal of one of two sidebands may reduce noise at the desired signal, since the removed sideband may have been at the same frequency as the desired signal.



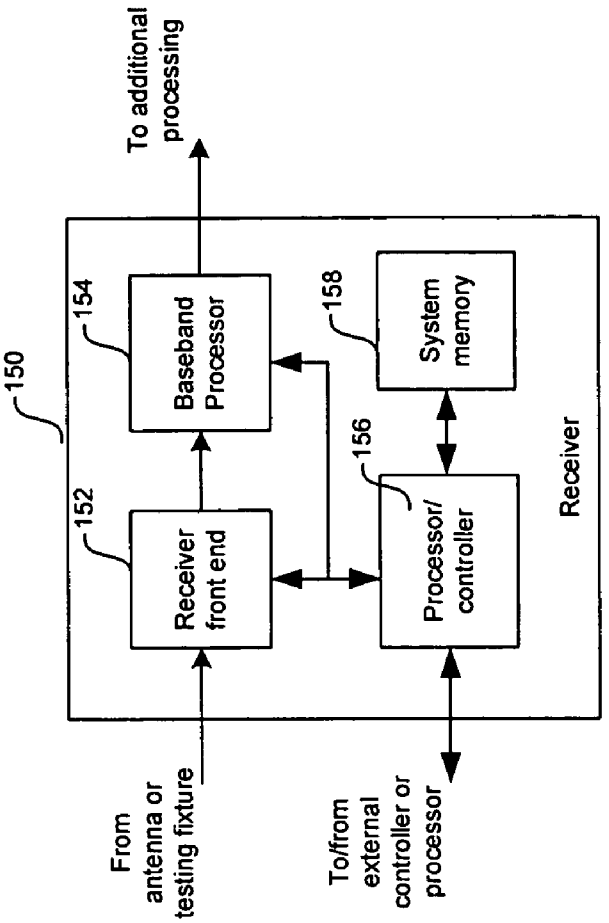

To additional processing
150
154
Baseband Processor
158
System memory
156
152
Receiver front end
Processor/ controller
Receiver
From antenna or testing fixture
To/from external controller or processor

FIG. 1b

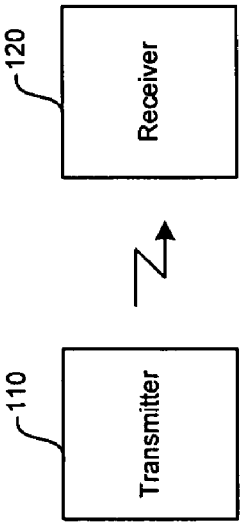

120
Receiver
110
Transmitter

FIG. 1a

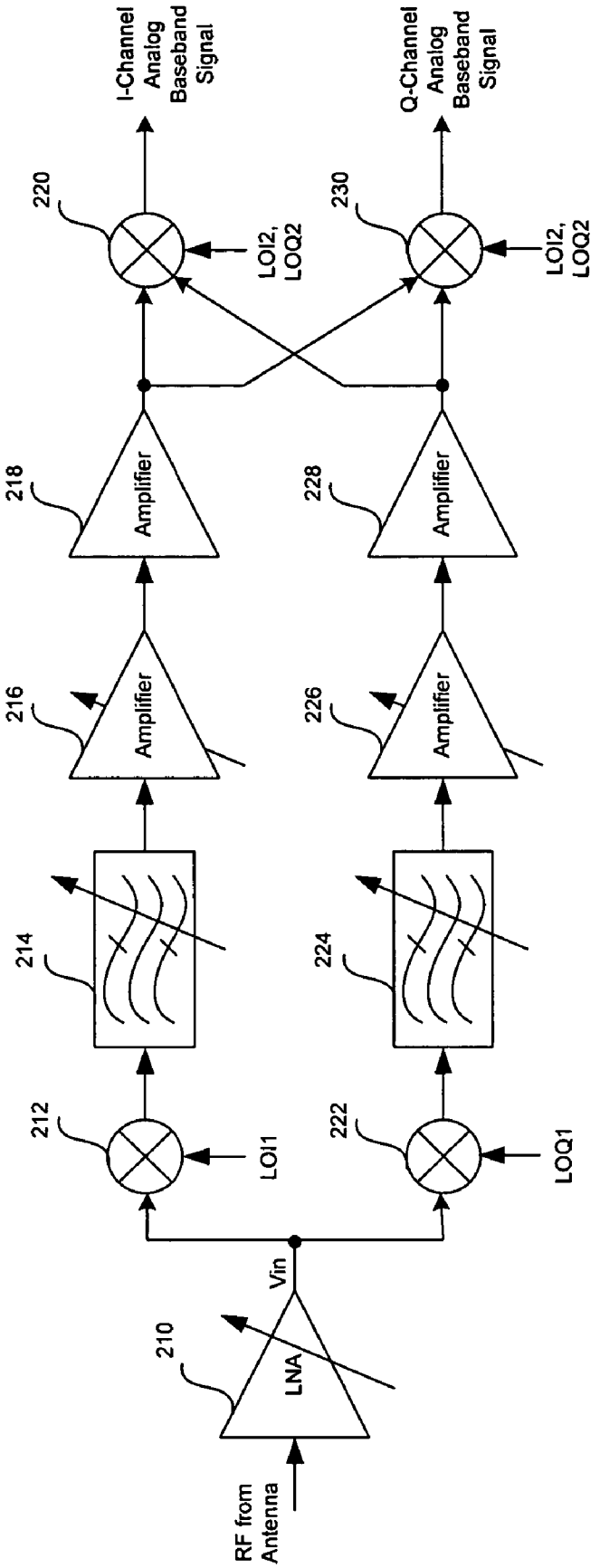

I-Channel Analog Baseband Signal
Q-Channel Analog Baseband Signal
220
230
LOI2, LOQ2
LOI2, LOQ2
218
228
Amplifier
Amplifier
216
226
Amplifier
Amplifier
214
224
212
222
LOI1
LOQ1
Vin
210
LNA
RF from Antenna

FIG. 2

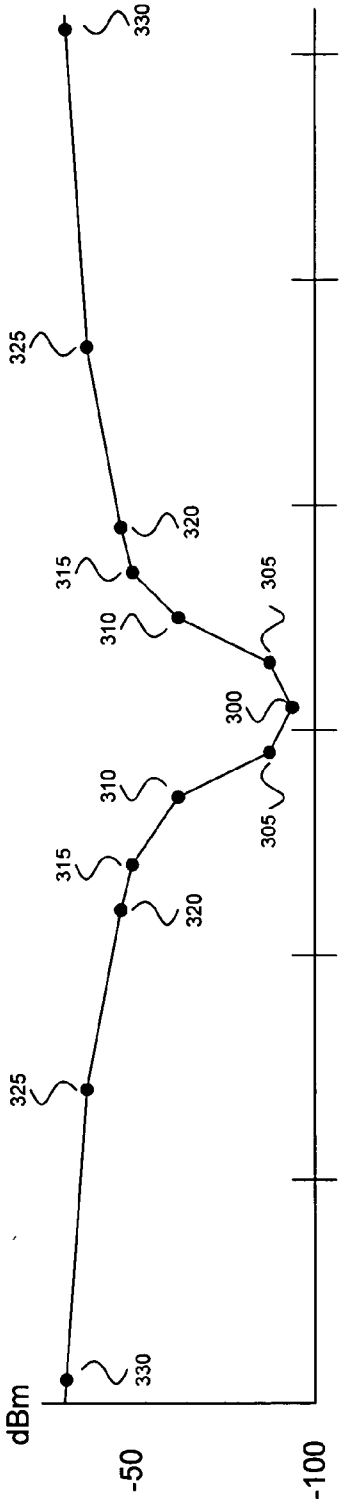

dBm
-50
-100
330
325
320
315
310
305
300
310
315
320
325
330

FIG. 3a

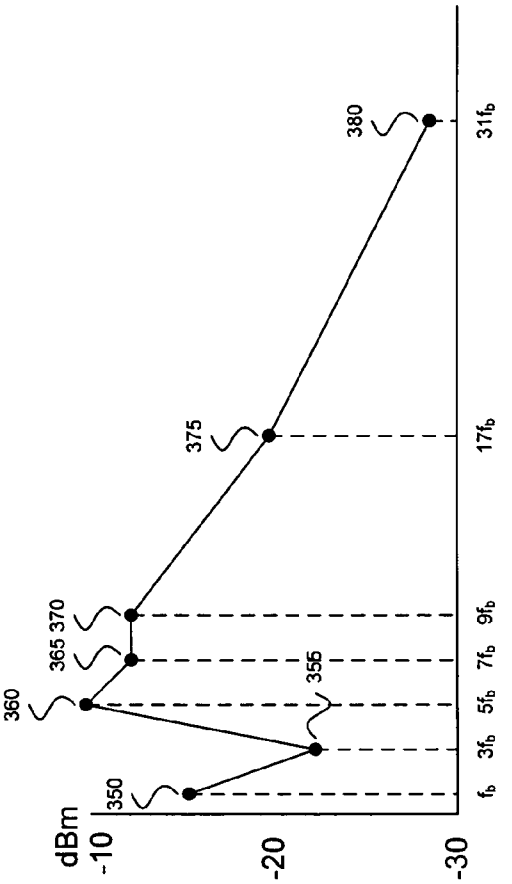

dBm
-10
-20
-30
350
360
365
370
375
380
f_b
$3f_b$
$5f_b$
$7f_b$
$9f_b$
$17f_b$
$31f_b$
356

FIG. 3b

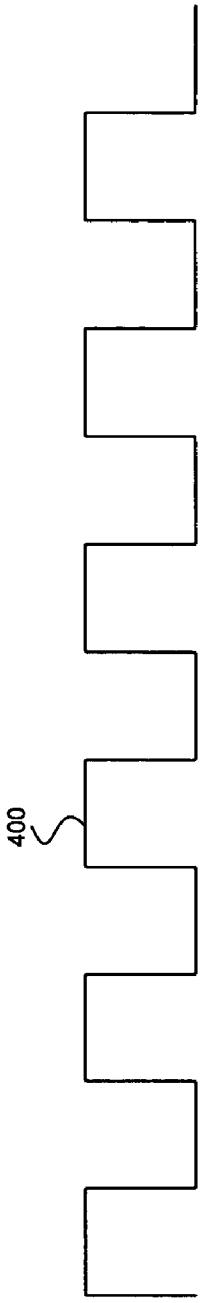

Local Oscillator Signal
400

FIG. 4a

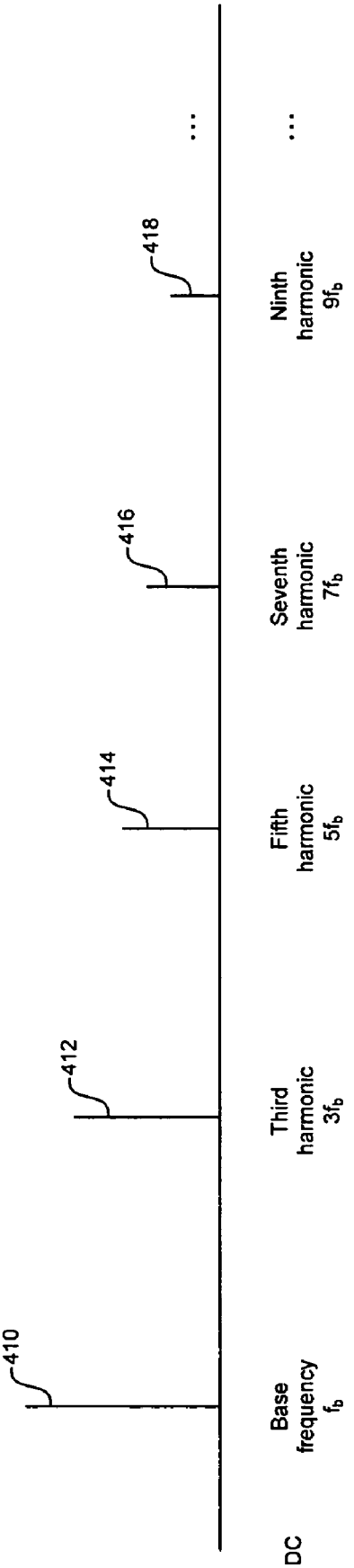

DC
Base frequency f_b
Third harmonic $3f_b$
Fifth harmonic $5f_b$
Seventh harmonic $7f_b$
Ninth harmonic $9f_b$
410
412
414
416
418
...
...

FIG. 4b

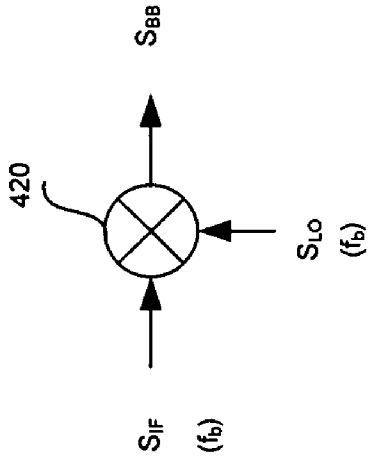

420
S_{BB}
S_{LO}
(f_b)
S_{IF}
(f_b)

FIG. 4c

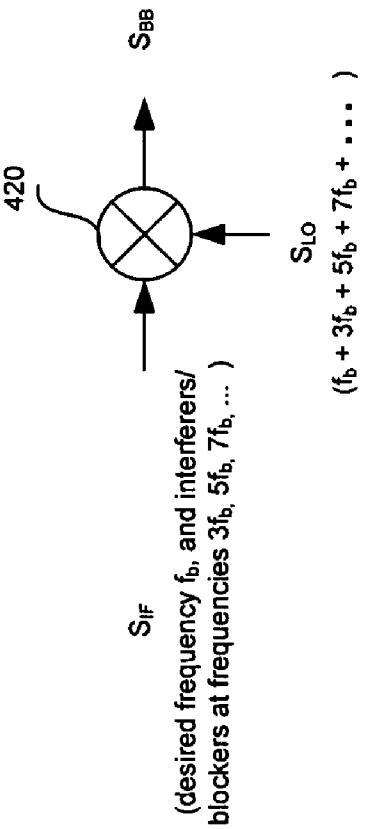

420
S_{BB}
S_{LO}
($f_b + 3f_b + 5f_b + 7f_b + \ldots$)
S_{IF}
(desired frequency f_b, and interferers/ blockers at frequencies $3f_b$, $5f_b$, $7f_b$, ...)

FIG. 4d

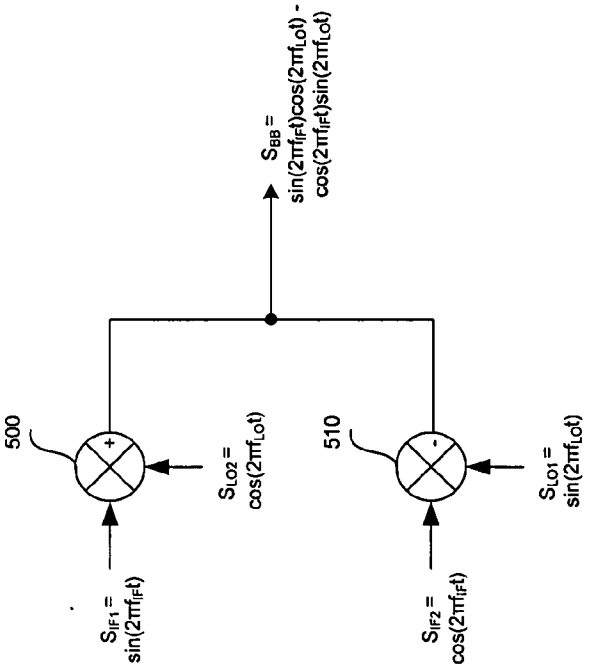


FIG. 5b

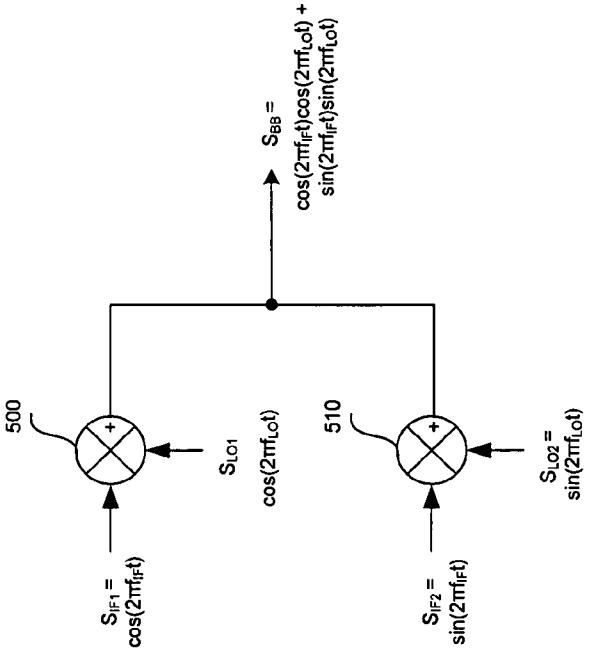


FIG. 5a

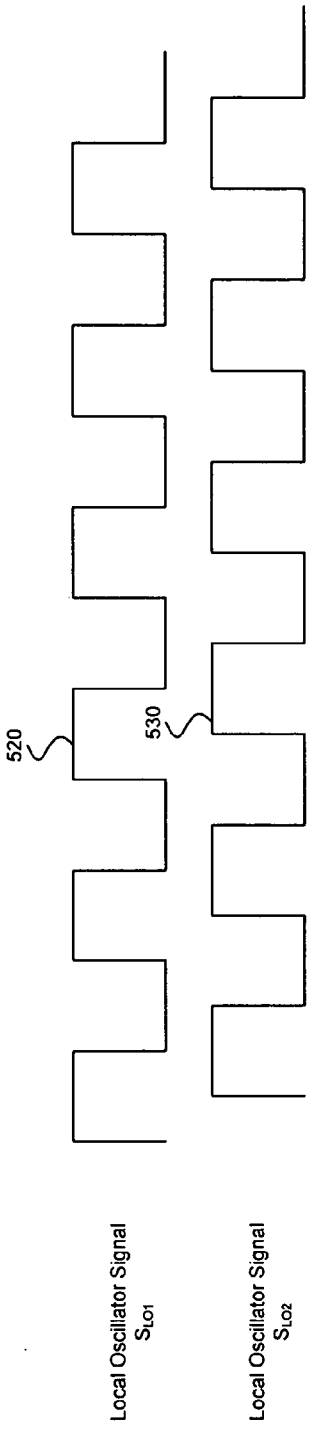


FIG. 5c

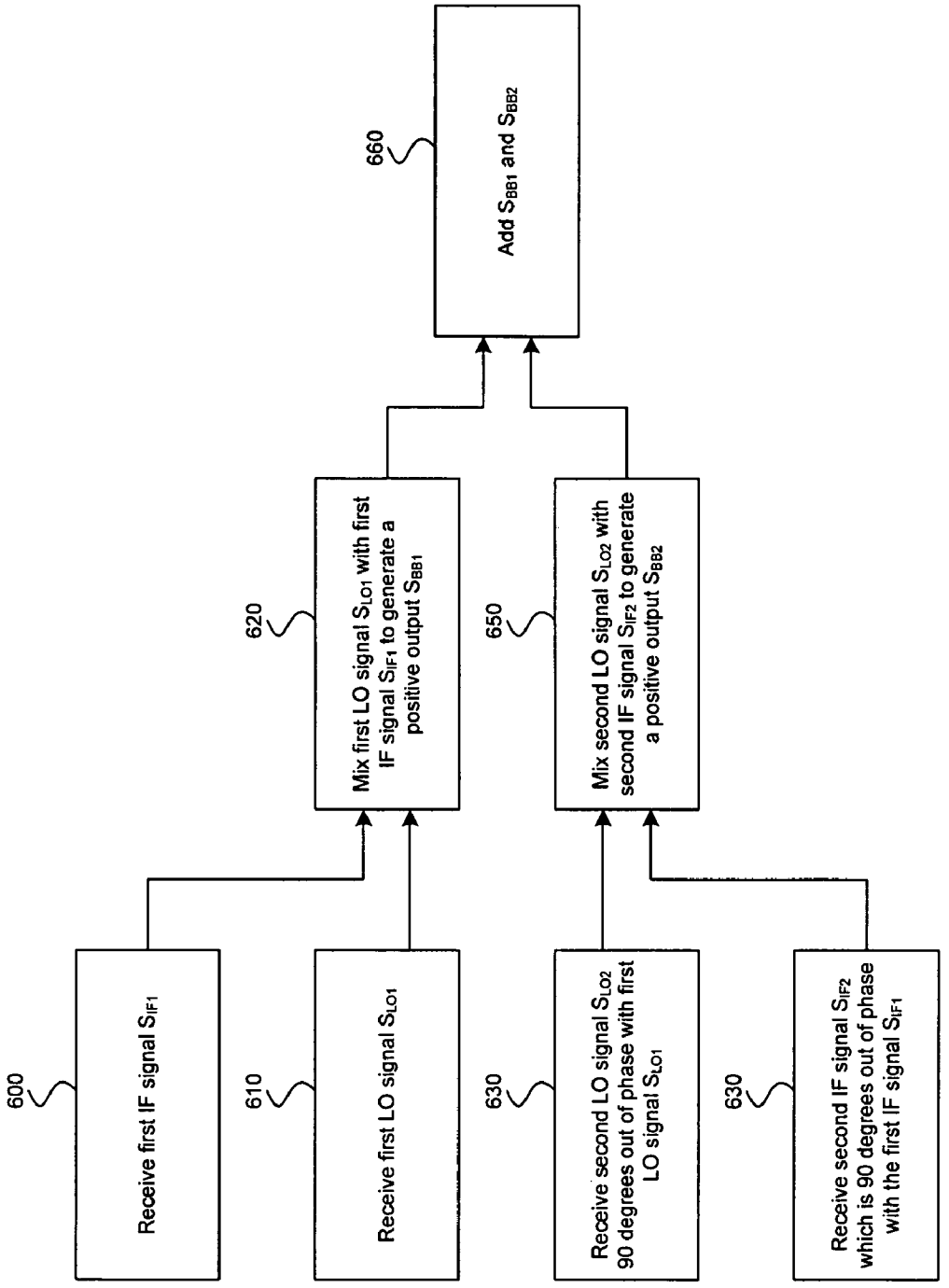

600
Receive first IF signal S_{IF1}
610
Receive first LO signal S_{LO1}
630
Receive second LO signal S_{LO2} 90 degrees out of phase with first LO signal S_{LO1}
630
Receive second IF signal S_{IF2} which is 90 degrees out of phase with the first IF signal S_{IF1}
620
Mix first LO signal S_{LO1} with first IF signal S_{IF1} to generate a positive output S_{BB1}
650
Mix second LO signal S_{LO2} with second IF signal S_{IF2} to generate a positive output S_{BB2}
660
Add S_{BB1} and S_{BB2}

FIG. 6

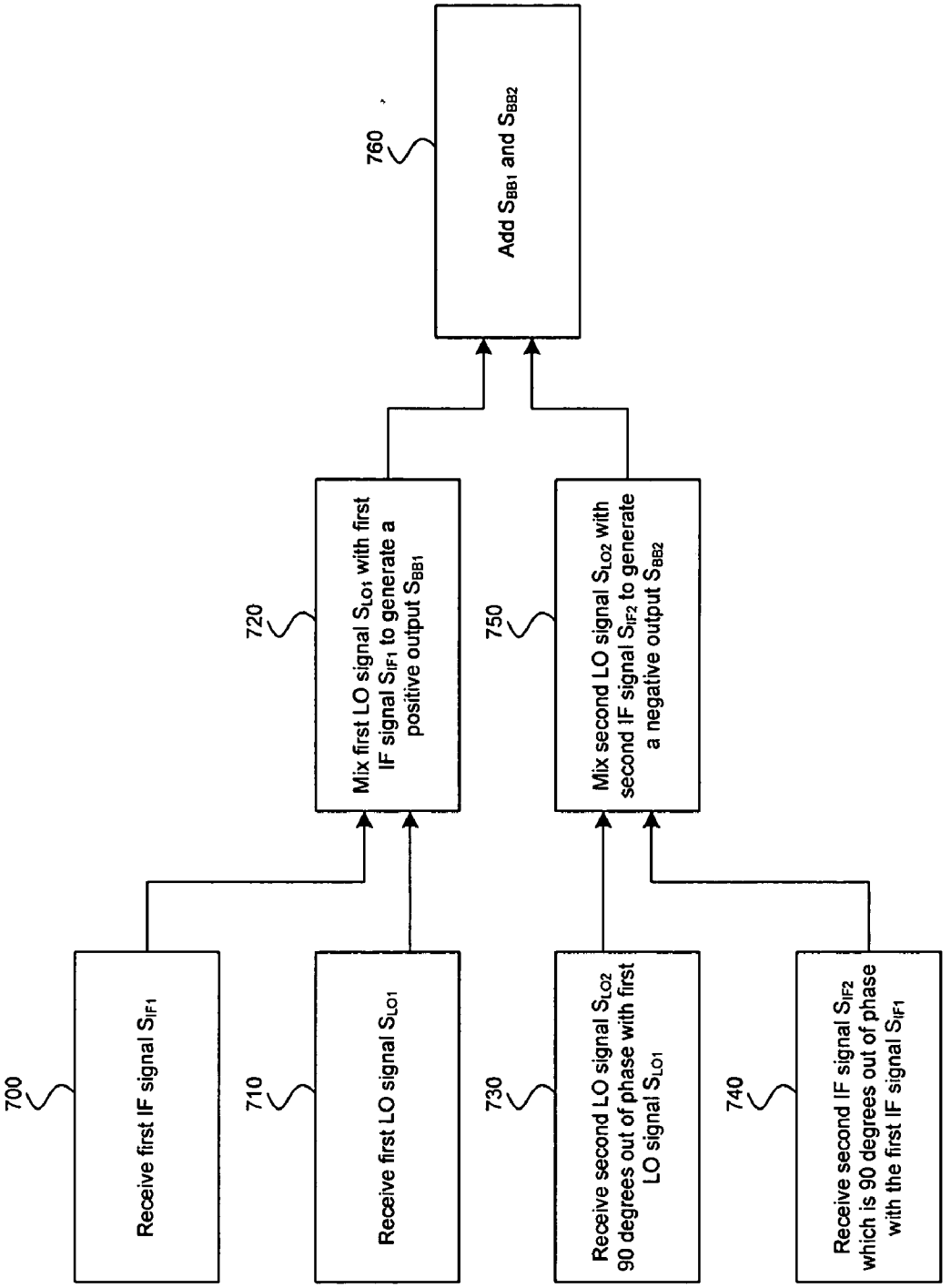

700
Receive first IF signal S_{IF1}
710
Receive first LO signal S_{LO1}
730
Receive second LO signal S_{LO2} 90 degrees out of phase with first LO signal S_{LO1}
740
Receive second IF signal S_{IF2} which is 90 degrees out of phase with the first IF signal S_{IF1}
720
Mix first LO signal S_{LO1} with first IF signal S_{IF1} to generate a positive output S_{BB1}
750
Mix second LO signal S_{LO2} with second IF signal S_{IF2} to generate a negative output S_{BB2}
760
Add S_{BB1} and S_{BB2}

FIG. 7

METHOD AND SYSTEM FOR SINGLE SIDEBAND MIXING RECEIVER ARCHITECTURE FOR IMPROVING SIGNAL QUALITY

CROSS-REFERENCE TO RELATED APPLICATIONS/INCORPORATION BY REFERENCE

[0001] This application is related to the following applications, each of which is incorporated herein by reference in its entirety for all purposes:

[0002] U.S. patent application Ser. No. _____ (Attorney Docket No. 16149US01) filed _____, **2004**;

[0003] U.S. patent application Ser. No. _____ (Attorney Docket No. 16150US01) filed _____, 2004;

[0004] U.S. patent application Ser. No. _____ (Attorney Docket No. 16151 US01) filed _____, 2004;

[0005] U.S. patent application Ser. No. _____ (Attorney Docket No. 16152US01) filed _____, 2004;

[0006] U.S. patent application Ser. No. _____ (Attorney Docket No. 16153US01) filed _____, 2004;

[0007] U.S. patent application Ser. No. _____ (Attorney Docket No. 16154US01) filed _____, 2004;

[0008] U.S. patent application Ser. No. _____ (Attorney Docket No. 16155US01) filed _____, 2004;

[0009] U.S. patent application Ser. No. _____ (Attorney Docket No. 16156US01) filed _____, 2004;

[0010] U.S. patent application Ser. No. _____ (Attorney Docket No. 16157US01) filed _____, 2004;

[0011] U.S. patent application Ser. No. _____ (Attorney Docket No. 16158US01) filed _____, 2004;

[0012] U.S. patent application Ser. No. _____ (Attorney Docket No. 16162US01) filed _____, 2004;

[0013] U.S. patent application Ser. No. _____ (Attorney Docket No. 16228US01) filed _____, 2004;

[0014] U.S. patent application Ser. No. _____ (Attorney Docket No. 16229US01) filed _____, 2004;

[0015] U.S. patent application Ser. No. _____ (Attorney Docket No. 16230US01) filed _____, 2004;

[0016] U.S. patent application Ser. No. _____ (Attorney Docket No. 16236US01) filed _____, 2004; and

[0017] U.S. patent application Ser. No. _____ (Attorney Docket No. 16237US01) filed _____, 2004.

FIELD OF THE INVENTION

[0018] Certain embodiments of the invention relate to receiving RF signals. More specifically, certain embodiments of the invention relate to a method and system for single sideband mixing receiver architecture for improving signal quality.

BACKGROUND OF THE INVENTION

[0019] In some conventional systems, a radio frequency (RF) signal may be converted to an intermediate frequency (IF), and then from IF to a baseband signal, where the IF may be in the megahertz range. Generally, the RF signal may be mixed with a local oscillator signal that results in two sideband signals that are the sum of the frequencies of the two signals and the difference of the frequencies of the two signals. One of the two sideband signals may be chosen as an IF signal, and this IF signal may be the same for all received RF signals. Therefore, a radio that may receive a plurality of channels, such as an AM or FM radio, may tune to a particular station by changing the local oscillator signal frequency such that the IF remains constant. With a constant IF, most of the receive path may be common in the receiver.

[0020] Today, much of radio receiver development may be driven mostly by a great demand for mobile wireless communication devices, including handsets. With the ever-decreasing size of mobile handsets, capacities of smaller batteries may be an issue. As most of these handsets may utilize complementary metal-oxide semiconductor (CMOS) technology for analog-to-digital conversion, and for much of the processing of voice and data signals, a very important factor to consider is that it may be advantageous for CMOS devices to operate at lower frequencies. This may be crucial since CMOS devices have power dissipation directly related to the speed at which the CMOS devices switch. The faster the frequencies, the faster the CMOS device switching speed, and therefore, the greater the amount of power consumed. Therefore, receivers may be designed to down-convert the high frequency RF, which may be in gigahertz range, to a lower frequency, preferably to a baseband frequency, as quickly as possible.

[0021] As a result, some receivers may utilize chips for digitally processing baseband signals, and may expect to receive the baseband signal, rather than an IF signal. To meet this need, some receiver architectures, for example, direct-conversion receivers, attempt to eliminate IF by converting directly from RF to baseband. This method of direct conversion reduces power consumption by not processing IF signals, and also reduces cost by not having to provide circuitry for processing the IF signals. However, with direct-conversion receivers, the reduced power consumption may be offset by strong drawbacks, such as DC-offset generation, 1/f noise, I/Q mismatch, excessive flicker noise in the baseband, and local oscillator (LO) leakage. In addition, a digital signal processor (DSP) may be required to perform complex digital processing of the digital signal for filtering and downconverting from the RF frequency.

[0022] If a measured signal-to-noise ratio (SNR) is less than a desired SNR, the DSP may need to perform, for example, distortion cancellation or other SNR reduction or mitigation function. Additionally, during direct conversion a majority of gain and filtering may be performed in a frequency band from DC to the signal bandwidth. In this process, a signal path's intrinsic DC offsets may be amplified. The dynamic range of the circuit may thereby be degraded. In addition, a DC offset may be created if the LO signal leaks to the RF front end and self-mixes. Some systems, for example, GSM systems, may use modulation and system synchronization techniques that require DC information, therefore, it may not be feasible to simply remove the DC component. Rather, complex DSP processing may be required to reduce the DC offset while still keeping the information present in the DC signal.

[0023] Although direct conversion receivers may attempt to reduce component count and power consumption, addi-

tional complex digital signal processing, and its accompanying cost is required. Simply reducing component count as with direct conversion, because system design complexity may increase, as well as cost, may not be the desired route. Furthermore, the digital baseband signal may have to be converted to an analog signal for some baseband processors.

[0024] Further limitations and disadvantages of conventional and traditional approaches will become apparent to one of skill in the art, through comparison of such systems with some aspects of the present invention as set forth in the remainder of the present application with reference to the drawings.

BRIEF SUMMARY OF THE INVENTION

[0025] Certain embodiments of the invention may be found in a method and system for single sideband mixing receiver architecture for improving signal quality. Aspects of the method may comprise mixing a first input signal with a first local oscillator signal, via a first mixer, to generate a first mixed output signal, mixing a second input signal with a second local oscillator signal, via a second mixer, to generate a second mixed output signal, and generating a single sideband signal by adding the first mixed output signal and the second mixed output signal.

[0026] The second input signal may be 90° out of phase with the first input signal. Accordingly, the first input signal may comprise an I-channel intermediate frequency signal and the second input signal may comprise a Q-channel intermediate frequency signal. Alternatively, the first input signal may comprise a Q-channel intermediate frequency signal and the second input signal may comprise an I-channel intermediate frequency signal. The second oscillator signal may be 90° out of phase with the first oscillator signal.

[0027] The first input signal may be defined by $\cos(2\pi f_{in}t)$, in which f_{in} is a base frequency of the first input signal, and the first local oscillator signal may be defined by $\cos(2\pi f_{lo}t)$, wherein f_{in} may be a base frequency of the first local oscillator signal. The first mixed output signal may then be defined by $\cos(2\pi f_{in}t)\cos(2\pi f_{lo}t)$. Similarly, the second input signal may be defined by $\sin(2\pi f_{in}t)$, wherein f_{in} may be a base frequency of the second input signal. The second local oscillator signal may be defined by $\sin(2\pi f_{lo}t)$, wherein f_{lo}, which may be the base frequency of the first local oscillator signal, may also be a base frequency of the second local oscillator signal. The second mixed output signal may then be defined by $\sin(2\pi f_{in}t)\sin(2\pi f_{lo}t)$.

[0028] The two output signals may be added together, and the resulting single sideband signal may be defined by $\cos(2\pi f_{in}t)\cos(2\pi f_{lo}t)+\sin(2\pi f_{in}t)\sin(2\pi f_{lo}t)=\cos(2\pi(f_{in}-f_{lo})t)$.

[0029] Alternatively, the first input signal may be defined by $\sin(2\pi f_{in}t)$, wherein f_{in} is a base frequency of the first input signal, and the first local oscillator signal may be defined by $\cos(2\pi f_{lo}t)$, wherein f_{lo} may be a base frequency of the first local oscillator signal. The first mixed output signal may be defined by $\sin(2\pi f_{in}t)\cos(2\pi f_{lo}t)$. Similarly, the second input signal may be defined by $\cos(2\pi f_{in}t)$, wherein f_{in} may be a base frequency of the second input signal. The second local oscillator signal may be defined by $\sin(2\pi f_{lo}t)$, wherein f_{lo}, which may be the base frequency of the first local oscillator signal, may also be a base frequency of the second local oscillator signal. The second mixed output signal may be defined by $-\sin(2\pi f_{in}t)\cos(2\pi f_{lo}t)$.

[0030] The two output signals may be added together, and the resulting single sideband signal may be defined by $\sin(2\pi f_{in}t)-\cos(2\pi f_{lo}t)-\cos(2\pi f_{in}t)\sin(2\pi f_{lo}t)=\sin(2\pi(f_{in}-f_{lo})t)$.

[0031] Aspects of the system may comprise a first mixer to mix a first input signal with a first local oscillator signal to generate a first mixed output signal, and a second mixer to mix a second input signal with a second local oscillator signal to generate a second mixed output signal. A single sideband signal may be the result of adding the first mixed output signal and the second mixed output signal.

[0032] The second input signal may be 90° out of phase with the first input signal. Accordingly, the first input signal may comprise an I-channel intermediate frequency signal and the second input signal may comprise a Q-channel intermediate frequency signal. Alternatively, the first input signal may comprise a Q-channel intermediate frequency signal and the second input signal may comprise an I-channel intermediate frequency signal. The second oscillator signal may be 90° out of phase with the first oscillator signal.

[0033] The first input signal may be defined by $\cos(2\pi f_{in}t)$, in which f_{in} is a base frequency of the first input signal, and the first local oscillator signal may be defined by $\cos(2\pi f_{lo}t)$, wherein f_{lo} may be a base frequency of the first local oscillator signal. The first mixed output signal may then be defined by $\cos(2\pi f_{in}t)\cos(2\pi f_{lo}t)$. Similarly, the second input signal may be defined by $\sin(2\pi f_{in}t)$, wherein f_{in} may be a base frequency of the second input signal. The second local oscillator signal may be defined by $\sin(2\pi f_{lo}t)$, wherein f_{lo}, which may be the base frequency of the first local oscillator signal, may also be a base frequency of the second local oscillator signal. The second mixed output signal may then be defined by $\sin(2\pi f_{in}t)\sin(2\pi f_{lo}t)$.

[0034] The two output signals may be added together, and the resulting single sideband signal may be defined by $\cos(2\pi f_{in}t)\cos(2\pi f_{lo}t)+\sin(2\pi f_{in}t)\sin(2f_{lo}t)=\cos(2\pi(f_{in}-f_{lo})t)$.

[0035] Alternatively, the first input signal may be defined by $\sin(2\pi f_{in}t)$, wherein f_{in} is a base frequency of the first input signal, and the first local oscillator signal may be defined by $\cos(2\pi f_{lo}t)$, wherein f_{lo} may be a base frequency of the first local oscillator signal. The first mixed output signal may be defined by $\sin(2\pi f_{in}t)\cos(2\pi f_{lo}t)$. Similarly, the second input signal may be defined by $\cos(2\pi f_{in}t)$, wherein f_{in} may be a base frequency of the second input signal. The second local oscillator signal may be defined by $\sin(2\pi f_{lo}t)$, wherein f_{lo}, which may be the base frequency of the first local oscillator signal, may also be a base frequency of the second local oscillator signal. The second mixed output signal may be defined by $-\sin(2\pi f_{in}t)\cos(2\pi f_{lo}t)$.

[0036] The two output signals may be added together, and the resulting single sideband signal may be defined by $\sin(2\pi f_{in}t)\cos(2\pi f_{lo}t)-\cos(2\pi f_{in}t)\sin(2\pi f_{lo}t)=\sin(2\pi(f_{in}-f_{lo})t)$.

[0037] These and other advantages, aspects and novel features of the present invention, as well as details of an illustrated embodiment thereof, will be more fully understood from the following description and drawings.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

[0038] **FIG. 1***a* is a block diagram of an exemplary transmitter system and a receiver system that may be utilized in connection with an embodiment of the invention.

[0039] **FIG. 1***b* is a block diagram of an exemplary RF receiver system that may be utilized in connection with an embodiment of the invention.

[0040] **FIG. 2** is a block diagram illustrating an exemplary RF receiver front end using a single sideband receiver architecture to extract an analog baseband signal, in accordance with an embodiment of the invention.

[0041] **FIG. 3***a* is a graph illustrating strengths of exemplary desired signal and undesired interferers/blockers received by a receiving antenna, in connection with an embodiment of the invention.

[0042] **FIG. 3***b* is a graph illustrating strengths of exemplary desired signal and undesired interferers/blockers, for example, of **FIG. 3***a*, after being downconverted to IF, filtered and amplified, in connection with an embodiment of the invention.

[0043] **FIG. 4***a* is a timing diagram illustrating an exemplary local oscillator signal, which may be utilized in connection with an embodiment of the invention.

[0044] **FIG. 4***b* is a graph illustrating frequency components of an exemplary local oscillator signal of **FIG. 4***a*, for example, which may be utilized in connection with an embodiment of the invention.

[0045] **FIG. 4***c* is a block diagram illustrating an exemplary mixer mixing a single frequency input IF signal with a single frequency local oscillator signal, which may be utilized in connection with an embodiment of the invention.

[0046] **FIG. 4***d* is a block diagram illustrating an exemplary mixer mixing an exemplary input IF signal of **FIG. 3***b*, for example, with an exemplary local oscillator signal of **FIG. 4***b*, for example, which may be utilized in connection with an embodiment of the invention.

[0047] **FIG. 5***a* is a block diagram illustrating an exemplary single sideband mixing circuit, in accordance with an embodiment of the invention.

[0048] **FIG. 5***b* is a block diagram illustrating an alternate exemplary single sideband mixing circuit, in accordance with an embodiment of the invention.

[0049] **FIG. 5***c* is a timing diagram illustrating exemplary local oscillator signals out of phase by 90° with each other, in accordance with an embodiment of the invention.

[0050] **FIG. 6** is an exemplary flow diagram of an exemplary single sideband mixing circuit used to extract a single sideband I channel baseband signal, in accordance with an embodiment of the invention.

[0051] **FIG. 7** is an exemplary flow diagram of an exemplary single sideband mixing circuit used to extract a single sideband Q channel baseband signal, in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0052] Certain embodiments of the invention may be found in an analog zero-IF interface for GSM receivers. Various aspects of the invention may be utilized in, for example, a GSM receiver, which may be adapted to receive RF signals and downconvert the received RF signals to a very low intermediate frequency (VLIF) signal. The VLIF signal may be further downconverted to a baseband signal. Aspects of the invention may comprise amplifying the received RF signal, mixing the amplified RF signal down to a VLIF signal, filtering the VLIF signal, amplifying the VLIF signal, mixing the filtered VLIF signal to a baseband signal, and filtering the baseband signal.

[0053] **FIG. 1***a* is a block diagram of an exemplary transmitter system and a receiver system. Referring to **FIG. 1***a*, there is shown a transmitter block **110** and a receiver block **120**. The transmitter block **110** may comprise suitable logic, circuitry, and/or code that may be adapted to filter and modulate a baseband signal to an RF signal, and transmit the RF signal. The receiver block **120** may comprise suitable logic, circuitry, and/or code that may be adapted to demodulate the RF signal to the baseband signal.

[0054] In operation, the transmission block **110** may be adapted to transmit RF signals over a wired or wireless medium. The receiver block **120** may be adapted to receive the RF signals and process it to a baseband signal that may be suitable for further processing, for example, as data or voice.

[0055] **FIG. 1***b* is a block diagram of an exemplary RF receiver system, in accordance with an embodiment of the invention. Referring to **FIG. 1***b*, the RF receiver system **150** may comprise a receiver front end **152**, a baseband processor **154**, a controller/processor **156**, and a system memory **158**. The receiver front end **152** may comprise suitable logic, circuitry, and/or code that may be adapted to receive an RF signal. The receiver front end **152** may be coupled to an external antenna for signal reception. The receiver front end **152** may demodulate a received signal before further processing. Moreover, the receiver front end **152** may comprise other functions, for example, filtering the received signal, amplifying the received signal, and/or downconverting the received signal to very low intermediate frequency (VLIF) signal and/or baseband signal. The receiver front end **152** may comprise a IF processor which may digitize an IF signal, and digitally process the digitized IF signal to filter and/or downconvert the digitized IF signal to a digital baseband signal. The IF processor may then convert the digitized baseband signal to an analog baseband signal.

[0056] The baseband processor **154** may comprise suitable logic, circuitry, and/or code that may be adapted to process analog baseband signals generated from the receiver front end (RFE) **152**. The controller/processor **156** may comprise suitable logic, circuitry, and/or code that may be adapted to control the operations of the receiver front end **152** and/or the baseband processor **154**. For example, the controller/processor **156** may be utilized to update and/or modify programmable parameters and/or values in a plurality of components, devices, and/or processing elements in the receiver front end **152** and/or the baseband processor **154**. Control and/or data information may be transferred from at least one controller and/or processor external to the RF receiver system **100** (**FIG. 1***a*) to the controller/processor **156**. Similarly, the controller/processor **156** may transfer control and/or data information to at least one controller and/or processor external to the RF receiver system **100**.

[0057] The controller/processor **156** may utilize the received control and/or data information to determine the mode of operation of the RFE **152**. For example, the controller/processor **156** may select a specific frequency for a local oscillator, or a specific gain for a variable gain amplifier. Moreover, the specific frequency selected and/or parameters needed to calculate the specific frequency, and/or the specific gain value and/or the parameters needed to calculate the specific gain, may be stored in the system memory **158** via the controller/processor **156**. This information stored in system memory **158** may be transferred to the RFE **152** from the system memory **158** via the controller/processor **156**. The system memory **158** may comprise suitable logic, circuitry, and/or code that may be adapted to store a plurality of control and/or data information, including parameters needed to calculate frequencies and/or gain, and/or the frequency value and/or gain value.

[0058] **FIG. 2** is a block diagram illustrating an exemplary RF receiver front end using a single sideband receiver architecture to extract an analog baseband signal, in accordance with an embodiment of the invention. Referring to **FIG. 2**, there is shown a low noise amplifier (LNA) **210**, mixers **212**, **222**, **220** and **230**, bandpass filters **214** and **224**, programmable gain amplifiers (PGA) **216** and **226**, and amplifiers **218** and **228**. The LNA **210** may comprise suitable logic, circuitry, and/or code that may be adapted to amplify input signals and output the amplified signals. The LNA **210** may be utilized in instances where the signal to noise ratio (SNR) may be relatively low, such as, for example, RF signals received by an antenna.

[0059] The mixers **212** and **222** may comprise suitable logic, circuitry, and/or code that may be adapted to have as inputs two signals, and generate an output signal, which may be a difference of the frequencies of the two input signals and/or a sum of the frequencies of the two input signals.

[0060] The bandpass filters **214** and **224** may comprise suitable logic, circuitry, and/or code that may be adapted to selectively pass signals within a certain bandwidth while attenuating signals outside that bandwidth. The bandpass filters **214** and **224** may further comprise an amplifier circuit that may amplify the bandpass filtered signal, and the gain of the amplifier circuit may be controlled by a processor, such as, for example, a baseband processor **154** or a processor/controller **156**.

[0061] The PGAs **216** and **226** may comprise suitable logic, circuitry, and/or code that may be adapted to amplify input signals and output the amplified signals. The gain of the amplifiers **216** and **226** may be controlled by a processor, such as, for example, a baseband processor **154** (**FIG. 1***b*) or a processor/controller **156** (**FIG. 1***b*). The gain of the PGAs **216** and **226** may be as high as, for example, 30 dB.

[0062] The amplifiers **218** and **228** may comprise suitable logic, circuitry, and/or code that may be adapted to amplify input signals and output the amplified signals. The gain of the amplifiers **216** and **226** may be amplify input signals and output the amplified signals. The amplifiers **218** and **228** may be fixed gain amplifiers, and the gain may be fixed, for example, at 15 dB.

[0063] The mixers **220** and **230** may comprise suitable logic, circuitry, and/or code that may be adapted to mix two input signals with two local oscillator input signals to produce an output signal that may be a difference of the frequencies of the two input signals and/or a sum of the frequencies of the two input signals. Additionally, the mixers **220** and **230** may reduce interferers/blockers around a desired bandwidth of the output signal by utilizing phase shifted input signals and phase shifted local oscillator signals. Interferers/blockers may be undesired signals that may interfere with and/or block a desired signal.

[0064] In operation, the RF signal, which may have a carrier frequency f_{RF}, may be received by an antenna and communicated to the LNA **210**, where the RF signal may be amplified by the LNA **210**. The amplified RF signal may be communicated to an input of the mixers **212** and **222**. The mixers **212** and **222** may mix this amplified signal with local oscillator signals LOI**1** and LOQ**1**, respectively. The outputs of the mixers **212** and **222** may be IF I and Q signals, respectively, and these signals may be at an intermediate frequency (IF).

[0065] The IF I and Q signals may be communicated to a bandpass filters **214** and **224**, which may be adapted to pass the desired bandwidth of signals about the IF frequency, while attenuating the undesired frequencies in the IF signal, and may also amplify the desired bandwidth of signals. The filtered and amplified IF I and Q signals may be communicated to PGAs **216** and **226**, and these signals may be amplified. The gain of the amplifier may be controlled by a processor, for example, a baseband processor **154** or a processor/controller **156**. The amplified output signals IF I and IF Q of the bandpass filters **214** and **224** may be communicated to the amplifiers **218** and **228**. The IF I and Q signals may be further amplified. The IF I signal generated at the output of the amplifier **218** may be communicated to an input of the mixers **220** and **230**, and the IF Q signal at the output of the amplifier **228** may be communicated to another input of the mixers **220** and **230**.

[0066] The mixers **220** and **230** may also be adapted to receive as inputs two local oscillator signals LOI**2** and LOQ**2**. The four inputs at each mixer **220** and **230** may be mixed and combined by the mixers **220** and **230**, respectively, to result in baseband I and Q signals, respectively, and these baseband signals may have less interferers/blockers at the desired bandwidth than if generated from a mixer similar to, for example, mixer **212** or **222**.

[0067] **FIG. 3***a* is a graph illustrating strengths of exemplary desired signal and undesired interferers/blockers as received by a receiving antenna, in connection with an embodiment of the invention. Referring to **FIG. 3***a*, there is shown signals **300**, **305**, **310**, **315**, **320**, **325**, and **330**. The signal **300** may be the desired signal and the other signals may be interferers/blockers that need to be attenuated. For example, the interferers/blockers **305**, **310**, **315**, **320**, **325** and **330** may be at harmonic frequencies of the desired signal **300**.

[0068] **FIG. 3***b* is a graph illustrating strengths of exemplary desired signal and undesired interferers/blockers, for example, of **FIG. 3***a*, after being downconverted to IF, filtered and amplified, in connection with an embodiment of the invention. Referring to **FIG. 3***b*, there is shown signals **300**, **305**, **310**, **315**, **320**, **325**, and **330**, which may have been bandpass filtered and amplified. The signal **300** may be the desired signal and the other signals may be the undesired interferers/blockers that need to be attenuated.

[0069] Ideally, a bandpass filter may be adapted to pass unattenuated only the frequencies that lie within a pass band and reject all other frequencies outside the pass band. However, normally, the bandpass filter passes the frequencies with some attenuation in the pass band and gradually attenuates the frequencies outside the pass band, with the frequencies farthest from the pass band being attenuated most. The desired signal **300** may have been passed by the bandpass filter, and amplified from −99 dBm (decibel-milliwatt) to −15 dBm, for a total gain of 84 dB. The undesired interferer/blocker **305** may have been attenuated by the bandpass filter such that when it was further amplified the resulting signal may have been amplified from −90 dBm to −24 dBm. Therefore, the total gain by the interferer/blocker **305** may be 66 dB.

[0070] Similarly, the interferer/blocker **310** may have been amplified from −58 dBm to −10 dBm for a 48 dB gain, and the interferer/blocker **315** may have been amplified from −50 dBm to −12 dBm for a 38 dB gain. The remaining interferers/blockers **320**, **325** and **330** may have been amplified from −50 dBm to −13 dBm for a 37 dB gain, from −33 dBm to −21 dBm for 12 dB gain, and from −23 dBm to −28 dBm for a 5 dB attenuation.

[0071] **FIG. 4***a* is a timing diagram illustrating an exemplary local oscillator signal **400**, in connection with an embodiment of the invention. Referring to **FIG. 4***a*, there is shown a diagram illustrating a shape of the local oscillator signal, which may be a waveform in which there may be two states—a high state and a low state. The high state may represent a logic 1 and the low state may represent a logic 0, for example. The local oscillator signal may be an input to a mixer in which the mixer may mix the local oscillator signal with an input signal, for example, the signal illustrated in **FIG. 3***b*.

[0072] **FIG. 4***b* is a graph illustrating frequency components of an exemplary local oscillator signal of **FIG. 4***a*, for example, in connection with an embodiment of the invention. Referring to **FIG. 4***b*, there is shown a graph of the exemplary local oscillator signal with the base frequency **410** and odd harmonics of the base frequency **412**, **414**, **416**, **418**, . . . , that may be characteristic of the local oscillator signal illustrated in **FIG. 4***a*. The signal strength of the odd harmonics **412**, **414**, **416**, **418**, . . . , may decrease as the frequency increases. Therefore, although it may be desirable to remove all odd harmonics, removing and/or attenuating those closest to the base frequency **410** may be most important.

[0073] **FIG. 4***c* is a block diagram illustrating an exemplary mixer mixing a single frequency input IF signal with a single frequency local oscillator signal, in connection with an embodiment of the invention. Referring to **FIG. 4***c*, there is shown a mixer **420** that may comprise suitable logic, circuitry and/or code that may be adapted mix two input signals and generate an output signal that may comprise frequencies that may be represented as a sum and a difference of frequencies of signals that are communicated to two inputs of the mixer **420**.

[0074] An IF signal S_{IF} may be communicated to one of the two inputs, and a local oscillator (LO) signal S_{LO} may be communicated to the other of the two inputs, and an output signal S_{BB} may be the output of the mixer **420**. The IF signal S_{IF} may comprise a single frequency f_b, and the LO signal S_{LO} may also comprise a single frequency f_b. The base frequency of f_b may be chosen for the LO signal S_{LO} such that a DC baseband frequency may be generated when the desired base frequency f_b of the IF signals S_{IF1} and S_{IF2} is mixed with the base frequency f_b of the LO signal S_{LO}. The frequency f_b may also be referred to as fin. The output signal S_{BB} may comprise frequencies that may be represented as a sum and a difference of the frequencies of the two signals S_{IF} and S_{LO}. Therefore, the output signal S_{BB} may comprise a signal at DC, the difference of the two frequencies, and a signal at $2f_b$, the sum of the two frequencies.

[0075] This may be illustrated by using cosine notation to represent the two signals S_1 and S_2, and mixing the two signals may be represented by multiplying the two signals

$$S_1=\cos(2\pi f_1 t)$$

$$S_2=\cos(2\pi f_2 t)$$

$$\cos(2\pi f_1 t)\times\cos(2\pi f_2 t)=0.5\cos(2\pi(f_1-f_2)t)+0.5\cos(2\pi(f_1+f_2)t)$$

[0076] **FIG. 4***d* is a block diagram illustrating an exemplary mixer mixing an exemplary input IF signal of **FIG. 3***b*, for example, with an exemplary local oscillator signal of **FIG. 4***b*, for example, in connection with an embodiment of the invention. Referring to **FIG. 4***d*, there is shown a mixer **420** that may comprise suitable logic, circuitry and/or code that may be adapted mix two input signals and output a signal that may comprise frequencies that may be a sum and difference of frequencies of the two input signals.

[0077] An IF signal S_{IF} may be communicated to a first of the two inputs, and a local oscillator (LO) signal S_{LO} may be communicated to a second of the two inputs, and an output signal S_{BB} may be generated by the mixer **420**, in which an output baseband signal S_{BB}' may be the desired component. The IF signal S_{IF} may comprise a plurality of frequencies including a baseband frequency f_b and interferers/blockers at various frequencies, for example, $3f_b$, $5f_b$, $7f_b$, $9f_b$, $17f_b$, $31f_b$. The LO signal S_{LO} may comprise a plurality of frequencies, for example, a base frequency f_b and odd harmonics of the base frequency f_b. For the base frequency of f_b, the third harmonic frequency may be $3f_b$, the fifth harmonic frequency may be $5f_b$, the seventh harmonic frequency may be $7f_b$, etc. The mixer may output a signal that may comprise a sum and a difference of component frequencies of the IF signal S_{IF} and the plurality of frequencies of the LO signal S_{LO}. Therefore, the output signal S_{BB} may comprise a plurality of frequencies due to two signal components resulting from mixing of each frequency of the IF signal S_{IF} with each frequency of the LO signal S_{LO}, in which a DC baseband signal of the output signal S_{BB} may be desired to be further processed.

[0078] For example, the frequency components due to the baseband frequency f_b of the IF signal S_{IF} mixed with the base frequency f_b in the LO signal S_{LO} may be DC and $2f_b$. Similarly, mixing the baseband frequency f_b of the IF signal S_{IF} with the harmonics of the LO signal S_{LO} may result in frequency components at $2f_b$ and $4f_b$ for the third harmonic, frequency components at $4f_b$ and $6f_b$ for the fifth harmonic, frequency components at $6f_b$ and $8f_b$ for the seventh harmonic, frequency components at $8f_b$ and $10f_b$ for the ninth harmonic, etc.

[0079] Similarly, the interferer/blocker at frequency $3f_b$ of the IF signal S_{IF} may be mixed with the LO signal S_{LO} to

result in frequency components at $2f_b$ and $4f_b$ for the base frequency f_b in the LO signal S_{LO}, at DC and $6f_b$ for the third harmonic in the LO signal S_{LO}, at $2f_b$ and $8f_b$ for the fifth harmonic in the LO signal S_{LO}, at $4f_b$ and $10f_b$ for the seventh harmonic in the LO signal S_{LO}, etc.

[0080] The interferer/blocker at frequency $5f_b$ of the IF signal S_{IF} may be mixed with the LO signal S_{LO} to result in frequency components at $4f_b$ and $6f_b$ for the base frequency f_b in the LO signal S_{LO}, at $2f_b$ and $8f_b$ for the third harmonic in the LO signal S_{LO}, at DC and $10f_b$ for the fifth harmonic in the LO signal S_{LO}, at $2f_b$ and $12f_b$ for the seventh harmonic in the LO signal S_{LO}, etc.

[0081] Accordingly, there may be a DC component in the output signal S_{BB} due to each odd harmonic of the LO signal S_{LO}. These interfering components at the DC baseband may distort the information in the output baseband signal S_{BB}'.

[0082] **FIG. 5***a* is a block diagram illustrating an exemplary single sideband mixing circuit, in accordance with an embodiment of the invention. Referring to **FIG. 5***a*, there is shown two mixers **500** and **510** that may comprise suitable logic, circuitry and/or code that may be adapted mix two input signals and generate an output signal that may comprise frequencies that may be represented as a sum and a difference of frequencies of the two signals.

[0083] An IF signal S_{IF1} may be communicated to a first of the two inputs of the mixer **500**, and a local oscillator (LO) signal S_{LO1} may be communicated to a second of the two inputs of the mixer **500**. An IF signal S_{IF2} that may be 90° out of phase with the IF signal S_{IF1} may be communicated to a first of the two inputs of the mixer **510**, and a local oscillator (LO) signal S_{LO2} that may be 90° out of phase with the local oscillator (LO) signal S_{LO1} may be communicated to a second of the two inputs of the mixer **510**. The outputs of the mixers **500** and **510** may be coupled together, and the output signals of the mixers **500** and **510** may add together to form the output signal S_{BB}, in which an output baseband signal S_{BB}' may be the desired component.

[0084] The IF signals S_{IF1} and S_{IF2} and the LO signals S_{LO1} and S_{LO2} may be represented by using sine and cosine notations to represent the two signals, and mixing the two signals may be represented by multiplying the two signals. Therefore, the IF signal S_{IF1} may be represented as

$$S_{IF1}=\cos(2\pi f_b t)$$

and since the IF signal S_{IF2} may be 90°, or $\pi/2$ radians, out of phase with the IF signal S_{IF1}, the IF signal may be represented as

$$S_{IF2}=\cos(2\pi f_b t-\pi/2)=\sin(2\pi f_b t).$$

Similarly, the LO signals S_{LO1} and S_{LO2} may be represented as

$$S_{LO1}=\cos(2\pi f_{LO} t)$$

$$S_{LO2}=\cos(2\pi f_{LO} t-\pi/2)=\sin(2\pi f_{LO} t).$$

The output signals of the mixers **500** and **510** may then be represented as $\cos(2\pi f_b t)\cos(2\pi f_{LO} t)$ and $\sin(2\pi f_b t)\sin(2\pi f_{LO} t)$, respectively. Therefore, the output of the mixer **500** added to the output of the mixer **510** may be represented as

$$S_{BB}=\cos(2\pi f_b t)\cos(2\pi f_{LO} t)+\sin(2\pi f_b t)\sin(2\pi f_{LO} t)=\cos(2\pi(f_b-f_{LO})t)$$

When the output signals of the two mixers **500** and **510** are added together, the result may be that only one sideband is generated, rather than two sidebands that may result from the output of one mixer as illustrated, for example, in **FIG. 4***c*.

[0085] The IF signals S_{IF1} and S_{IF2} may comprise a plurality of frequencies including a desired base frequency f_b and undesired interferers/blockers at various frequencies, for example, $3f_b$, $5f_b$, $7f_b$, $9f_b$, $17f_b$, $31f_b$. The LO signals S_{LO1} and S_{LO2} may also comprise a plurality of frequencies, for example, a base frequency f_b and odd harmonics of the base frequency f_b. The base frequency of f_b may be chosen for the LO signals S_{LO1} and S_{LO2} such that a DC baseband frequency may be generated when the desired base frequency f_b of the IF signals S_{IF1} and S_{IF2} is mixed with the base frequency f_b of the LO signals S_{LO1} and S_{LO2}. For the base frequency of f_b of the LO signals S_{LO1} and S_{LO2}, the third harmonic frequency may be $3f_b$, the fifth harmonic frequency may be $5f_b$, the seventh harmonic frequency may be $7f_b$, etc. Therefore, the output signal S_{BB} may comprise a plurality of frequencies due to mixing of each frequency of the IF signal S_{IF} with each frequency of the LO signal S_{LO}, in which a DC baseband signal of the output signal S_{BB} may be desired to be further processed.

[0086] Since mixing of the IF signal S_{IF} with the base frequency f_b of the LO signal S_{LO} may be represented as $S_{BB}=\cos(2\pi(f_b-f_{LO})t)$, the frequencies generated may be $f_b-f_b=0$ or DC, $4f_b$, $6f_b$, etc. However, when the harmonics of the LO signal S_{LO} are considered, additional phase differences must be taken in to account. Since the frequency of the third harmonic of the LO signal S_{LO} is tripled, the phase difference of the third harmonic is also tripled with respect to the base frequency of the LO signal S_{LO}. Therefore, the third harmonic may be described by

$$\sin(2\pi(3f_b t)+\pi)=-\sin(2\pi(3f_b t)).$$

[0087] The addition of π, which is equivalent to 180°, is because the third harmonic has a phase difference of 270° versus the phase difference of 90° for the base frequency. The third harmonic has an extra phase difference of 180°. Therefore, the equation describing the sum of the outputs of the two mixers may then be

$$S_{BB}=\cos(2f_b t)\cos(2f_{LO} t)-\sin(2f_b t)\sin(2\pi f_{LO} t)=\cos(2\pi(f_b+f_{LO})t)$$

[0088] The frequencies generated due to the third harmonic of the LO signal S_{LO} may be a sum of the two frequencies of the IF signal S_{IF} and the LO signal S_{LO}. Similarly, the fifth harmonic of the LO signal S_{LO} may be subtracted from the frequencies of the IF signal S_{IF}, the seventh harmonic of the LO signal S_{LO} may be added to the frequencies of the IF signal S_{IF}, etc.

[0089] Therefore, the frequencies generated due to the IF signal S_{IF} mixed with the third harmonic frequency $3f_b$ of the LO signal S_{LO} may be $4f_b$, $6f_b$, $8f_b$, etc. The frequencies generated due to the IF signal S_{IF} mixed with the fifth harmonic frequency $5f_b$ of the LO signal S_{LO} may be $4f_b$, $2f_b$, DC, $2f_b$, $4f_b$, etc. Accordingly, where there may be at least one DC component in the output signal S_{BB} from each odd harmonic of the LO signal S_{LO} in the single mixer implementation illustration of **FIG. 4***d*, only every other odd harmonic of the LO signal S_{LO} may contribute a DC component to the output signal S_{BB}. Therefore, the interfer-

ing components at the DC baseband that may distort the information in the output baseband signal S_{BB}' may have been reduced by half.

[0090] **FIG. 5***b* is a block diagram illustrating an alternate exemplary single sideband mixing circuit, in accordance with an embodiment of the invention. Referring to **FIG. 5***b*, there is shown two mixers **500** and **510** that may comprise suitable logic, circuitry and/or code that may be adapted mix two input signals and output a signal that may comprise frequencies that may be represented as a sum and a difference of frequencies of the two signals.

[0091] An IF signal S_{IF1} may be communicated to a first of the two inputs of the mixer **500**, and a local oscillator (LO) signal S_{LO1} may be communicated to a second of the two inputs of the mixer **500**. An IF signal S_{IF2} that may be 90° out of phase with the IF signal S_{IF1} may be communicated to a first of the two inputs of the mixer **510**, and a local oscillator (LO) signal S_{LO2} that may be 90° out of phase with the local oscillator (LO) signal S_{LO1} may be communicated to a second of the two inputs of the mixer **510**. The outputs of the mixers **500** and **510** may be coupled together, and the output signals of the mixers **500** and **510** may add together to form the output signal S_{BB}, in which an output baseband signal S_{BB}' may be the desired component.

[0092] The IF signals S_{IF1} and S_{IF2} and the LO signals S_{LO1} and S_{LO2} may be represented by using sine and cosine notations to represent the two signals, and mixing the two signals may be represented by multiplying the two signals. As an alternative to **FIG. 5***a*, however, the IF signal S_{IF1} may be represented by a sine function

$$S_{IF1}=\sin(2\pi f_b t)$$

and since the IF signal S_{IF2} may be 90° (or π/2 radians) out of phase with the IF signal S_{IF1}, the IF signal may be represented as

$$S_{IF2}=\sin(2\pi f_b t+\pi/2)=\cos(2\pi f_b t).$$

[0093] The LO signals S_{LO1} and S_{LO2} may be represented as in **FIG. 5***a*

$$S_{LO1}=\cos(2\pi f_{LO} t)$$

$$S_{LO2}=\cos(2\pi f_{LO} t-\pi/2)=\sin(2\pi f_{LO} t).$$

[0094] The outputs of the mixers **500** and **510** may then be $\sin(2\pi f_b t)\cos(2\pi f_{LO} t)$ and $\cos(2\pi f_b t)\sin(2\pi f_{LO} t)$, respectively. Therefore, the output of the mixer **500** may be added to the negative output of the mixer **510** and the result may be represented as

$$S_{BB}=\sin(2\pi f_b t)\cos(2\pi f_{LO} t)-\cos(2\pi f_b t)\sin(2\pi f_{LO} t)=\sin(2\pi(f_b-f_{LO})t)$$

[0095] When the positive output of the mixer **500** is added to the negative output of the mixer **510**, the result is that only one sideband is generated, rather than two sidebands that are generated from the output of one mixer as illustrated, for example, in **FIG. 4***c*. Therefore, similarly as illustrated in **FIG. 5***b*, only every other odd harmonic of the LO signal S_{LO} may contribute a DC component to the output signal S_{BB}. This may result in the number of interfering components at the DC baseband, which may distort the information in the output baseband signal S_{BB}', being reduced by half.

[0096] **FIG. 5***c* is a timing diagram illustrating exemplary local oscillator signals out of phase by 90° with each other, in accordance with an embodiment of the invention. Referring to **FIG. 5***c*, there is shown local oscillator (LO) signals S_{LO1} **520** and S_{LO2} **530**. LO signal S_{LO1} **520** may be a waveform in which there may be two states—a high state and a low state. The high state may represent a logic 1 and the low state may represent a logic 0, for example. The LO signal S_{LO2} **530** may be 90° out of phase with respect to the LO signal S_{LO1} **520**. One method of generating the LO signal S_{LO2} **530** may comprise delaying the LO signal S_{LO1} **520** by one clock cycle, for example, by utilizing a flip-flop, in which the clock signal to the flip-flop may have a frequency that may be four times the frequency of the LO signal S_{LO1} **520**.

[0097] **FIG. 6** is an exemplary flow diagram of an exemplary single sideband mixing circuit used to extract an I channel baseband signal, in accordance with an embodiment of the invention. Referring to **FIG. 6**, there is shown a plurality of steps **600** to **660** that may be utilized to demodulate a received I channel IF signal to a single sideband I channel baseband signal. In step **600**, a first IF signal S_{IF1}, which may be represented as $\cos(2\pi f_b t)$, may be received at a first mixer. In step **610**, a first local oscillator (LO) signal S_{LO1}, which may be represented as $\cos(2\pi f_{LO} t)$, may be received at the first mixer. In step **620**, the two signals may be mixed in the first mixer, and the output of the mixer may be $\cos(2\pi f_b t)\cos(2\pi f_{LO} t)$.

[0098] In step **630**, a second IF signal S_{IF2} may be received at a second mixer, and the second IF signal S_{IF2} may be 90°, or π/2 radians, out of phase with respect to the first IF signal S_{IF1}. The second IF signal S_{IF2} may be represented as $\cos(2\pi f_b t-\pi/2)=\sin(2\pi f_b t)$. In step **640**, a second local oscillator (LO) signal S_{LO2} may be received at the first mixer, which may be 90° out of phase with respect to the first local oscillator signal S_{LO1}, and may be similarly represented as $\sin(2\pi f_{LO} t)$. Step **650** may mix the two signals in the second mixer, and the output may be $\sin(2\pi f_b t)\sin(2\pi f_{LO} t)$. In step **660**, the outputs of the first mixer and the second mixer may be added together, and the resulting output may be a single sideband I channel baseband signal represented by $\cos(2\pi f_b t)\cos(2\pi f_{LO} t)+\sin(2\pi f_b t)\sin(2\pi f_{LO} t)=\cos(2\pi(f_b-f_{LO})t)$.

[0099] **FIG. 7** is an exemplary flow diagram of an exemplary single sideband mixing circuit used to extract a Q channel baseband signal, in accordance with an embodiment of the invention. Referring to **FIG. 7**, there is shown a plurality of steps **700** to **760** that may be utilized to demodulate a received Q channel IF signal to a single sideband Q channel baseband signal. In step **700** a first IF signal S_{IF1} may be received at a first mixer, and it may be represented as $\sin(2\pi f_b t)$. In step **710**, a first local oscillator (LO) signal S_{LO1} may be received at the first mixer, and it may be represented as $\cos(2\pi f_{LO} t)$. In step **720**, the two signals may be mixed in the first mixer and the resulting output may be $\sin(2\pi f_b t)\cos(2\pi f_{LO} t)$.

[0100] In step **730**, a second IF signal S_{IF2} may be received at a second mixer, and it may be 90°, or π/2 radians, out of phase with respect to the first IF signal S_{IF1}. The second IF signal S_{IF2} may be represented as $\sin(2\pi f_b t+\pi/2)=\cos(2\pi f_b t)$. In step **740**, a second local oscillator (LO) signal S_{LO2} may be received at the second mixer, which may be 90° out of phase with respect to the first local oscillator signal S_{LO1}, and may be represented as $\cos(2\pi f_{LO} t-\pi/2)=\sin(2\pi f_{LO} t)$. In step **750** the two signals may be mixed in the second mixer,

and a negative output may be $-\cos(2\pi f_b t)\sin(2\pi f_{LO} t)$. In step **760**, the outputs of the first mixer and the second mixer may be added together, and the resulting output may be a single sideband Q channel baseband signal represented by $\sin(2\pi f_b t)\cos(2\pi f_{LO} t)-\cos(2\pi f_b t)\sin(2\pi f_{LO} t)=\sin(2\pi(f_b-f_{LO})t)$.

[**0101**] The exemplary mixer circuit illustrated in **FIG. 5***a* and corresponding inputs may be representative of mixer **220** (**FIG. 2**) used for the I channel path. Similarly, the exemplary mixer circuit illustrated in **FIG. 5***b*, and corresponding inputs, may be the mixer **230** (**FIG. 2**) used for the Q channel path. Although, the illustrations in **FIG. 2**, **FIG. 5***a*, **FIG. 5***b*, **FIG. 6** and **FIG. 7** may show specific implementations, the invention need not be so limited.

[**0102**] Accordingly, the present invention may be realized in hardware, software, or a combination of hardware and software. The present invention may be realized in a centralized fashion in at least one computer system, or in a distributed fashion where different elements are spread across several interconnected computer systems. Any kind of computer system or other apparatus adapted for carrying out the methods described herein is suited. A typical combination of hardware and software may be a general-purpose computer system with a computer program that, when being loaded and executed, controls the computer system such that it carries out the methods described herein.

[**0103**] The present invention may also be embedded in a computer program product, which comprises all the features enabling the implementation of the methods described herein, and which when loaded in a computer system is able to carry out these methods. Computer program in the present context means any expression, in any language, code or notation, of a set of instructions intended to cause a system having an information processing capability to perform a particular function either directly or after either or both of the following: a) conversion to another language, code or notation; b) reproduction in a different material form.

[**0104**] While the present invention has been described with reference to certain embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the present invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present invention without departing from its scope. Therefore, it is intended that the present invention not be limited to the particular embodiment disclosed, but that the present invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. A method for reducing interference in a signal, the method comprising:

mixing a first input signal with a first local oscillator signal, via a first mixer, to generate a first mixed output signal;

mixing a second input signal with a second local oscillator signal, via a second mixer, to generate a second mixed output signal; and

generating only a single sideband signal by adding said first mixed output signal and said second mixed output signal.

2. The method according to claim 1, wherein said second input signal is 90° out of phase with said first input signal.

3. The method according to claim 1, wherein said first input signal comprises an I-channel intermediate frequency signal.

4. The method according to claim 1, wherein said second input signal comprises a Q-channel intermediate frequency signal.

5. The method according to claim 1, wherein said first input signal comprises a Q-channel intermediate frequency signal.

6. The method according to claim 1, wherein said second input signal comprises an I-channel intermediate frequency signal.

7. The method according to claim 1, wherein said first input signal is defined by $\cos(2\pi f_{in} t)$, wherein f_{in} is a base frequency of said first input signal.

8. The method according to claim 7, wherein said first local oscillator signal is defined by $\cos(2\pi f_{lo} t)$, wherein f_{lo} is a base frequency of said first local oscillator signal.

9. The method according to claim 8, wherein said first mixed output signal is defined by $\cos(2\pi f_{in} t)\cos(2\pi f_{lo} t)$.

10. The method according to claim 9, wherein said second input signal is defined by $\sin(2\pi f_{in} t)$, wherein f_{in} is a base frequency of said second input signal.

11. The method according to claim 10, wherein said second local oscillator signal is defined by $\sin(2\pi f_{lo} t)$, wherein f_{lo}, which is said base frequency of said first local oscillator signal, is a base frequency of said second local oscillator signal.

12. The method according to claim 11, wherein said second mixed output signal is defined by $\sin(2\pi f_{in} t)\sin(2\pi f_{lo} t)$.

13. The method according to claim 12, wherein said single sideband signal is defined by $\cos(2\pi f_{in} t)\cos(2\pi f_{lo} t)+\sin(2\pi f_{in} t)\sin(2\pi f_{lo} t)=\cos(2\pi(f_{in}-f_{lo})t)$.

14. The method according to claim 1, wherein said first input signal is defined by $\sin(2\pi f_{in} t)$, wherein f_{in} is a base frequency of said first input signal.

15. The method according to claim 14, wherein said first local oscillator signal is defined by $\cos(2\pi f_{lo} t)$, wherein f_{lo} is a base frequency of said first local oscillator signal.

16. The method according to claim 15, wherein said first mixed output signal is defined by $\sin(2\pi f_{in} t)\cos(2\pi f_{lo} t)$.

17. The method according to claim 16, wherein said second input signal is defined by $\cos(2\pi f_{in} t)$, wherein f_{in} is a base frequency of said second input signal.

18. The method according to claim 17, wherein said second local oscillator signal is defined by $\sin(2\pi f_{lo} t)$, wherein f_{lo}, which is said base frequency of said first local oscillator signal, is a base frequency of said second local oscillator signal.

19. The method according to claim 18, wherein said second mixed output signal is defined by $-\sin(2\pi f_{in} t)\cos(2\pi f_{lo} t)$.

20. The method according to claim 19, wherein said single sideband signal is defined by $\sin(2\pi f_{in} t)\cos(2\pi f_{lo} t)-\cos(2\pi f_{in} t)\mathrm{Sin}(2\pi f_{lo} t)=\sin(2\pi(f_{in}-f_{lo})t)$.

21. The method according to claim 1, wherein said second oscillator signal is 90° out of phase with respect to said first oscillator signal.

22. A system for reducing interference in a signal, the method comprising:

a first mixer that generates a first mixed output signal by mixing a first input signal with a first local oscillator signal; and

a second mixer that generates a second mixed output signal by mixing a second input signal with a second local oscillator signal, wherein only a single sideband signal is generated by adding said first mixed output signal and said second mixed output signal.

23. The system according to claim 22, wherein said second input signal is 90° out of phase with said first input signal.

24. The system according to claim 22, wherein said first input signal comprises an I-channel intermediate frequency signal.

25. The system according to claim 22, wherein said second input signal comprises a Q-channel intermediate frequency signal.

26. The system according to claim 22, wherein said first input signal comprises a Q-channel intermediate frequency signal.

27. The system according to claim 22, wherein said second input signal comprises an I-channel intermediate frequency signal.

28. The system according to claim 22, wherein said first input signal is defined by $\cos(2\pi f_{in}t)$, wherein f_{in} is a base frequency of said first input signal.

29. The system according to claim 28, wherein said first local oscillator signal is defined by $\cos(2\pi f_{lo}t)$, wherein f_{lo} is a base frequency of said first local oscillator signal.

30. The system according to claim 29, wherein said first mixed output signal is defined by $\cos(2\pi f_{in}t)\cos(2\pi f_{lo}t)$.

31. The system according to claim 30, wherein said second input signal is defined by $\sin(2\pi f_{in}t)$, wherein f_{in} is a base frequency of said second input signal.

32. The system according to claim 31, wherein said second local oscillator signal is defined by $\sin(2\pi f_{lo}t)$, wherein f_{lo}, which is said base frequency of said first local oscillator signal, is a base frequency of said second local oscillator signal.

33. The system according to claim 32, wherein said second mixed output signal is defined by $\sin(2\pi f_{in}t)\sin(2\pi f_{lo}t)$.

34. The system according to claim 33, wherein said single sideband signal is defined by $\cos(2\pi f_{in}t)\cos(2\pi f_{lo}t)+\sin(2\pi f_{in}t)\sin(2\pi f_{lo}t)=\cos(2\pi(f_{in}-f_{lo})t)$.

35. The system according to claim 32, wherein said first input signal is defined by $\sin(2\pi f_{in}t)$, wherein f_{in} is a base frequency of said first input signal.

36. The system according to claim 35, wherein said first local oscillator signal is defined by $\cos(2\pi f_{lo}t)$, wherein f_{lo} is a base frequency of said first local oscillator signal.

37. The system according to claim 36, wherein said first mixed output signal is defined by $\sin(2\pi f_{in}t)\cos(2\pi f_{lo}t)$.

38. The system according to claim 37, wherein said second input signal is defined by $\cos(2\pi f_{in}t)$, wherein f_{in} is a base frequency of said second input signal.

39. The system according to claim 38, wherein said second local oscillator signal is defined by $\sin(2\pi f_{lo}t)$, wherein f_{lo} which is said base frequency of said first local oscillator signal, is a base frequency of said second local oscillator signal.

40. The system according to claim 39, wherein said second mixed output signal is defined by $-\sin(2\pi f_{in}t)\cos(2\pi f_{lo}t)$.

41. The system according to claim 40, wherein said single sideband signal is defined by $\sin(2\pi f_{in}t)\cos(2\pi f_{lo}t)-\cos(2\pi f_{in}t)\sin(2\pi f_{lo}t)=\sin(2\pi(f_{in}-f_{lo})t)$.

42. The system according to claim 22, wherein said second oscillator signal is a 90° out of phase with respect to said first oscillator signal.

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