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(54) **REDUCING POWER CONSUMPTION ON A RECEIVER**

(71) Applicant: **QUALCOMM Incorporated**, San Diego, CA (US)

(72) Inventors: **Li Liu**, San Diego, CA (US); **Steven C Ciccarelli**, San Diego, CA (US); **Shrenik Patel**, San Diego, CA (US); **Prasad Srinivasa Siva Gudem**, San Diego, CA (US); **Zixiang Yang**, San Diego, CA (US); **Frederic Bossu**, San Diego, CA (US); **Wu-Hsin Chen**, San Diego, CA (US); **Chiewcharn Narathong**, San Diego, CA (US)

(73) Assignee: **QUALCOMM, Incorporated**, San Diego, CA (US)

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H04W 52/02 (2009.01)

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CPC *H04W 52/0238* (2013.01)
USPC **455/245.1**; 455/254; 455/296; 455/307

(58) **Field of Classification Search**
USPC 455/63.1, 67.11, 226.1, 234.1, 245.1, 455/254, 296, 307, 334; 375/346, 349
See application file for complete search history.

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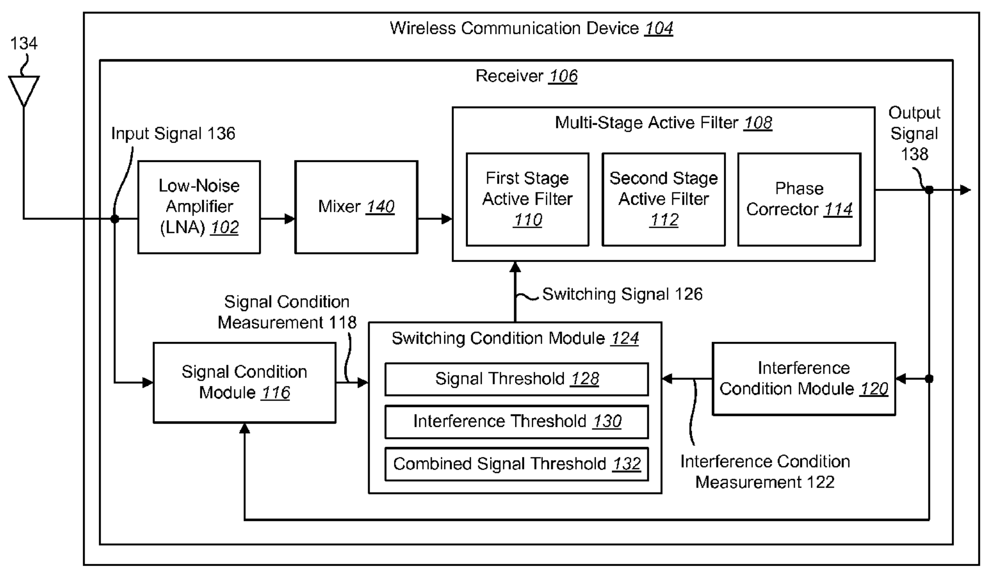
Primary Examiner — Thanh Le

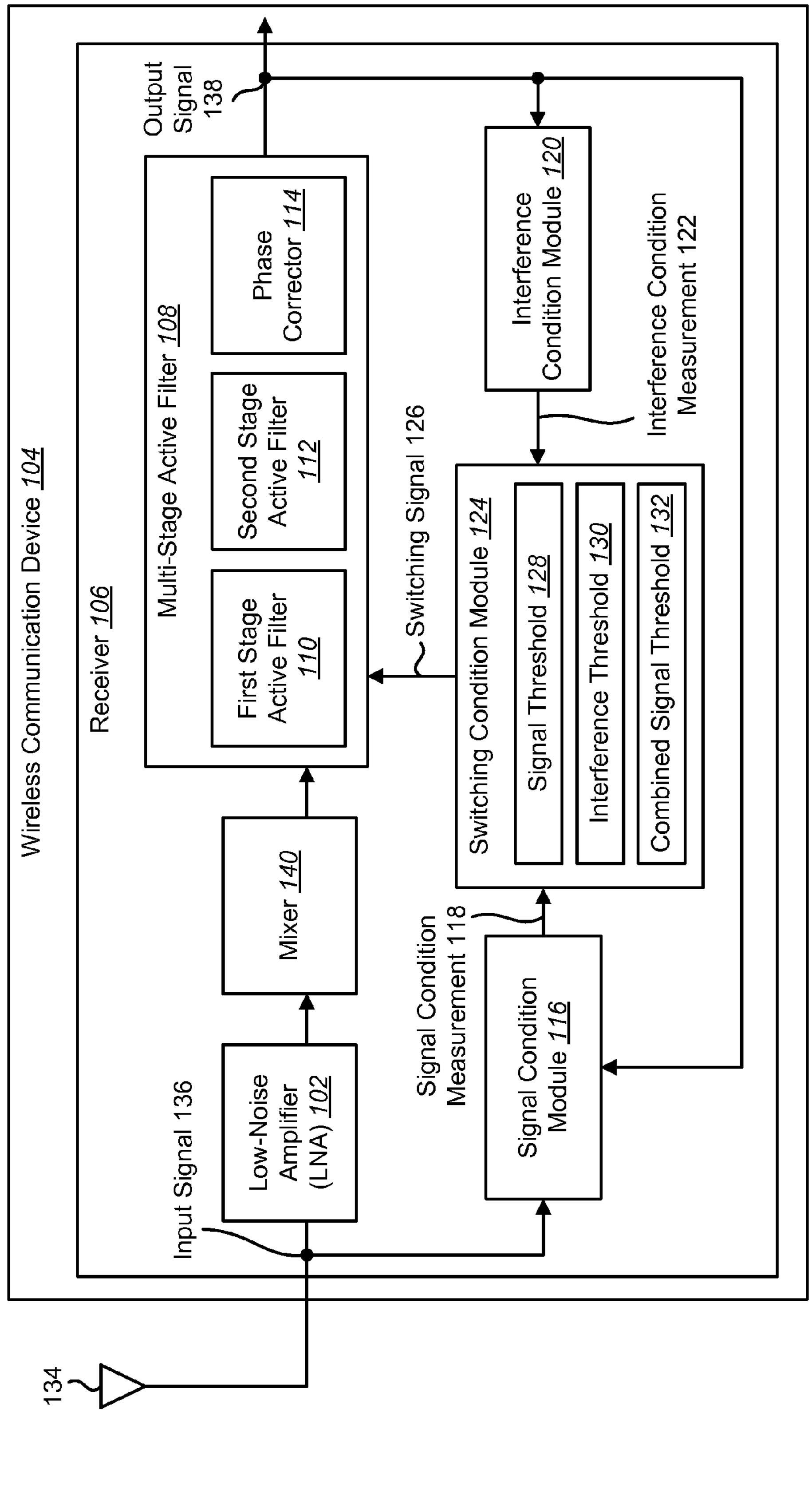
(74) *Attorney, Agent, or Firm* — Fountainhead Law Group P.C.

(57) **ABSTRACT**

A method for reducing power consumption on a wireless communication device is described. The wireless communication device includes a first stage active filter and a second stage active filter. A condition measurement is obtained that includes a signal measurement condition. If it is determined that the condition measurement is above a threshold, the second stage active filter is bypassed.

48 Claims, 11 Drawing Sheets

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Receiver 106
Multi-Stage Active Filter 108
First Stage Active Filter 110
Second Stage Active Filter 112
Phase Corrector 114
Output Signal 138
Input Signal 136
Low-Noise Amplifier (LNA) 102
Mixer 140
Switching Signal 126
Interference Condition Module 120
Interference Condition Measurement 122
Switching Condition Module 124
Signal Threshold 128
Interference Threshold 130
Combined Signal Threshold 132
Signal Condition Measurement 118
Signal Condition Module 116
134

FIG. 1

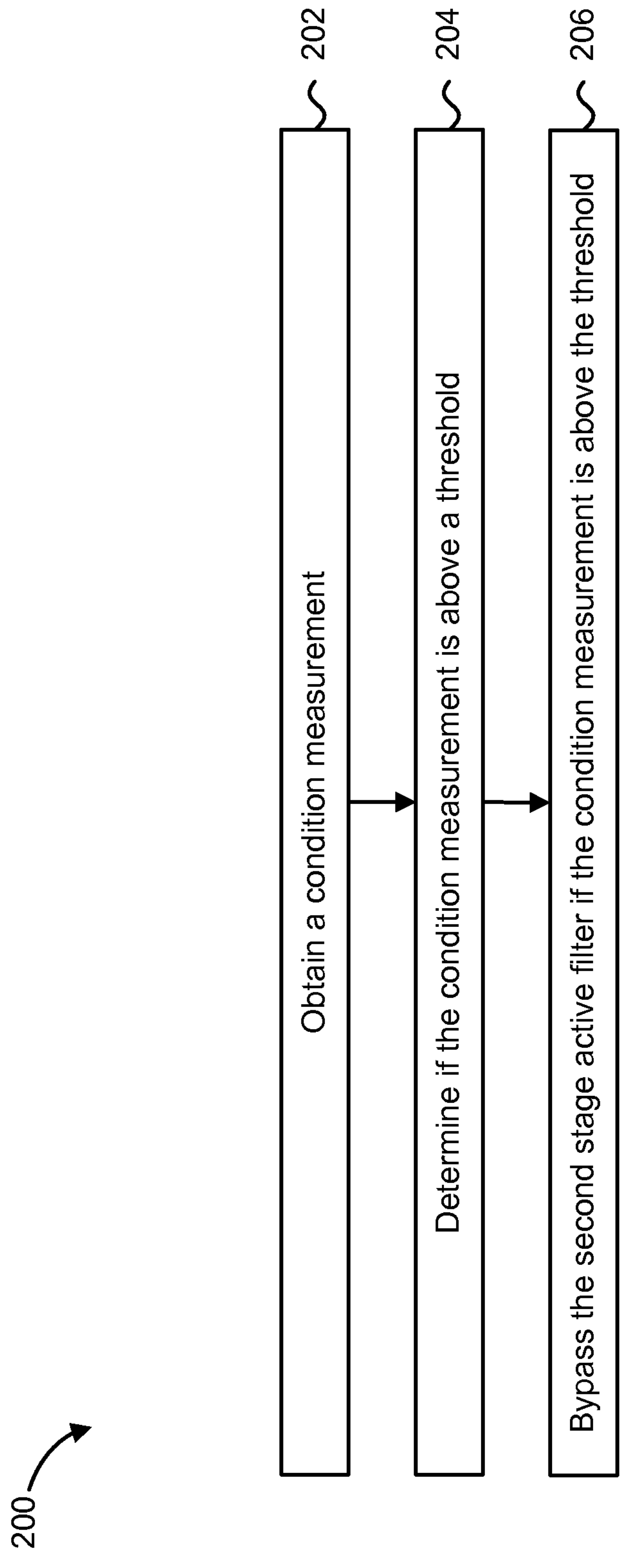

202
204
206
Obtain a condition measurement
Determine if the condition measurement is above a threshold
Bypass the second stage active filter if the condition measurement is above the threshold
200

FIG. 2

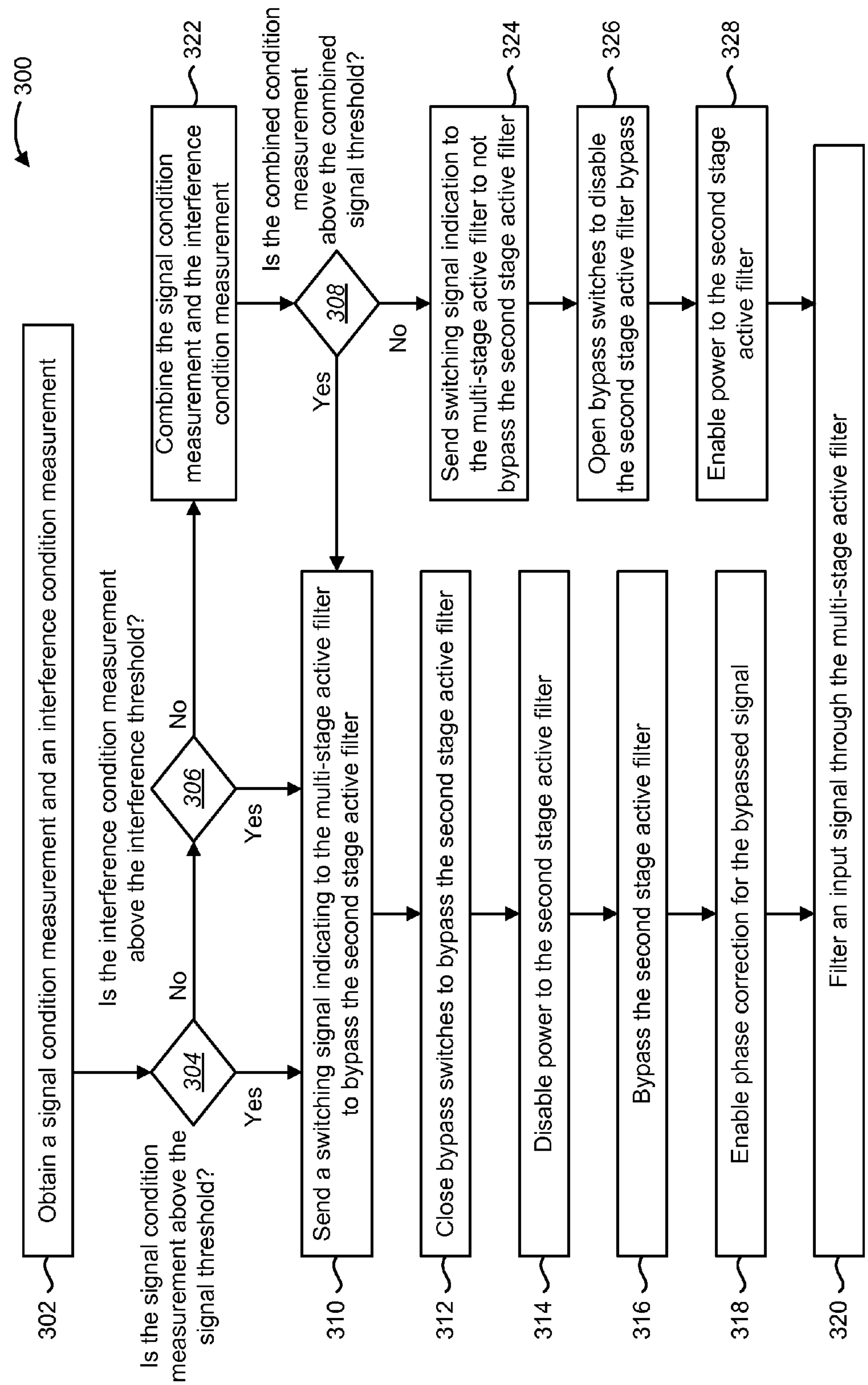

300
302
Obtain a signal condition measurement and an interference condition measurement
304
Is the signal condition measurement above the signal threshold?
Yes
No
306
Is the interference condition measurement above the interference threshold?
Yes
No
322
Combine the signal condition measurement and the interference condition measurement
308
Is the combined condition measurement above the combined signal threshold?
Yes
No
310
Send a switching signal indicating to the multi-stage active filter to bypass the second stage active filter
312
Close bypass switches to bypass the second stage active filter
314
Disable power to the second stage active filter
316
Bypass the second stage active filter
318
Enable phase correction for the bypassed signal
324
Send switching signal indication to the multi-stage active filter to not bypass the second stage active filter
326
Open bypass switches to disable the second stage active filter bypass
328
Enable power to the second stage active filter
320
Filter an input signal through the multi-stage active filter

FIG. 3

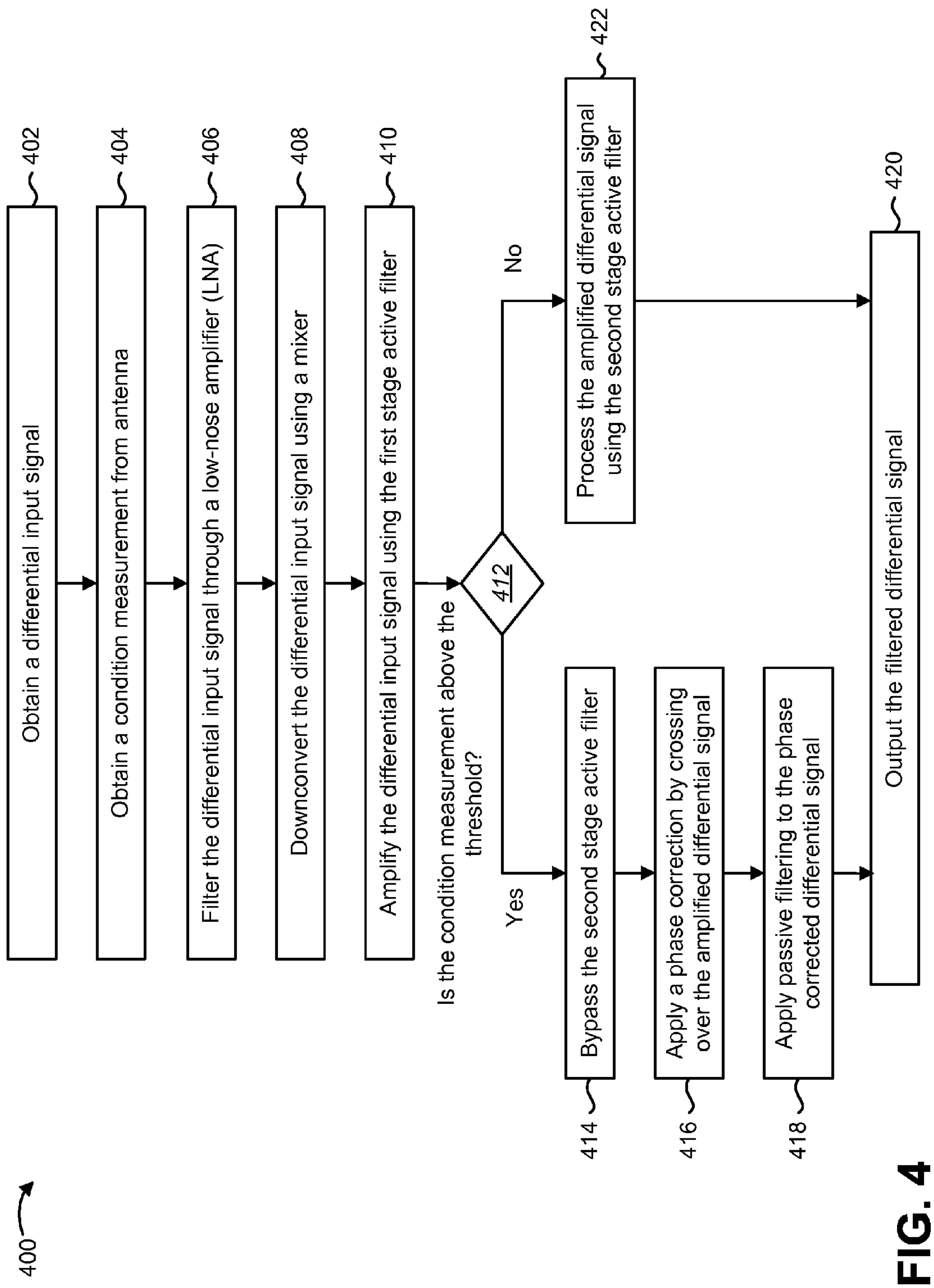

400
Obtain a differential input signal
402
Obtain a condition measurement from antenna
404
Filter the differential input signal through a low-nose amplifier (LNA)
406
Downconvert the differential input signal using a mixer
408
Amplify the differential input signal using the first stage active filter
410
Is the condition measurement above the threshold?
412
Yes
No
Process the amplified differential signal using the second stage active filter
422
Bypass the second stage active filter
414
Apply a phase correction by crossing over the amplified differential signal
416
Apply passive filtering to the phase corrected differential signal
418
Output the filtered differential signal
420

FIG. 4

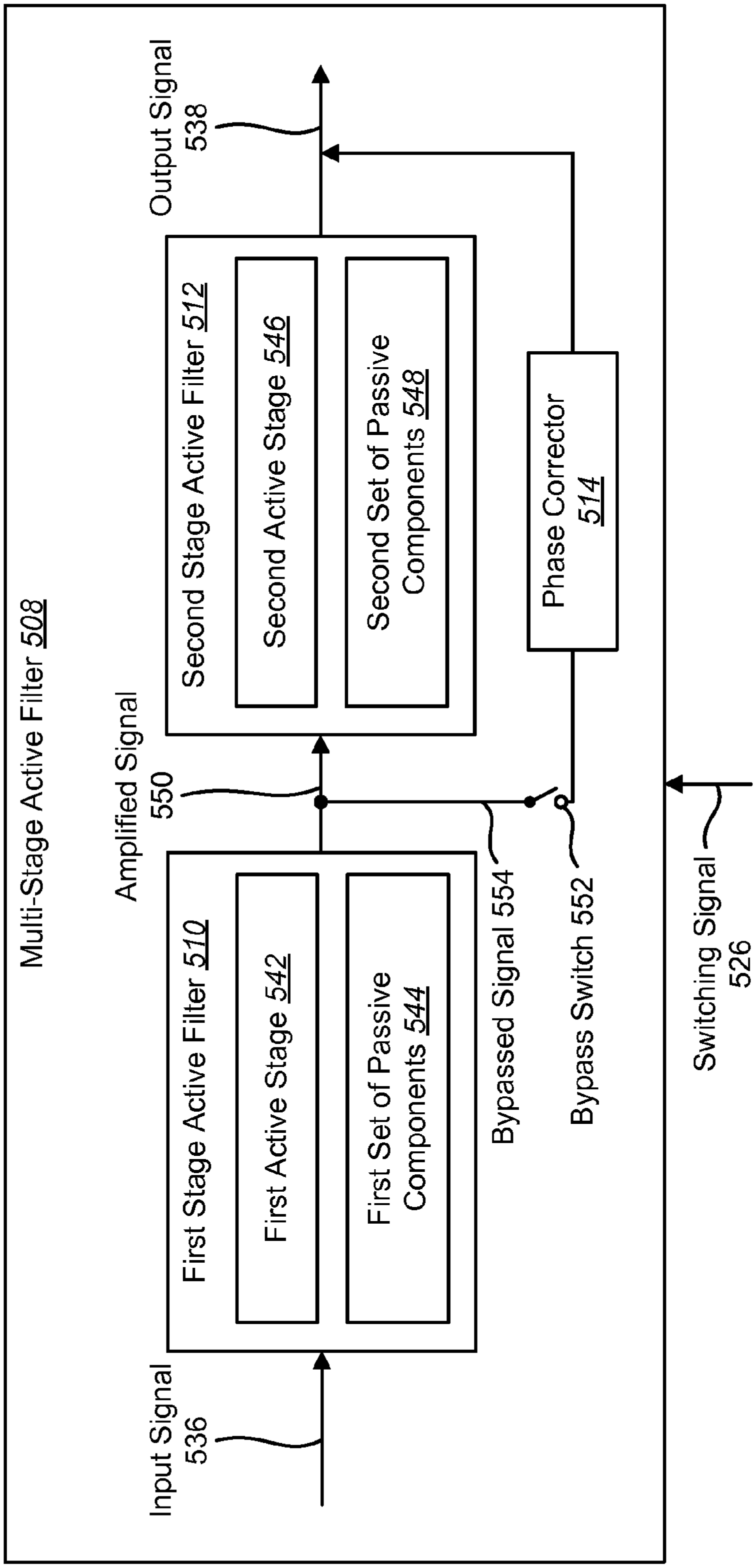

Multi-Stage Active Filter 508
Input Signal 536
First Stage Active Filter 510
First Active Stage 542
First Set of Passive Components 544
Amplified Signal 550
Second Stage Active Filter 512
Second Active Stage 546
Second Set of Passive Components 548
Output Signal 538
Phase Corrector 514
Bypassed Signal 554
Bypass Switch 552
Switching Signal 526

FIG. 5

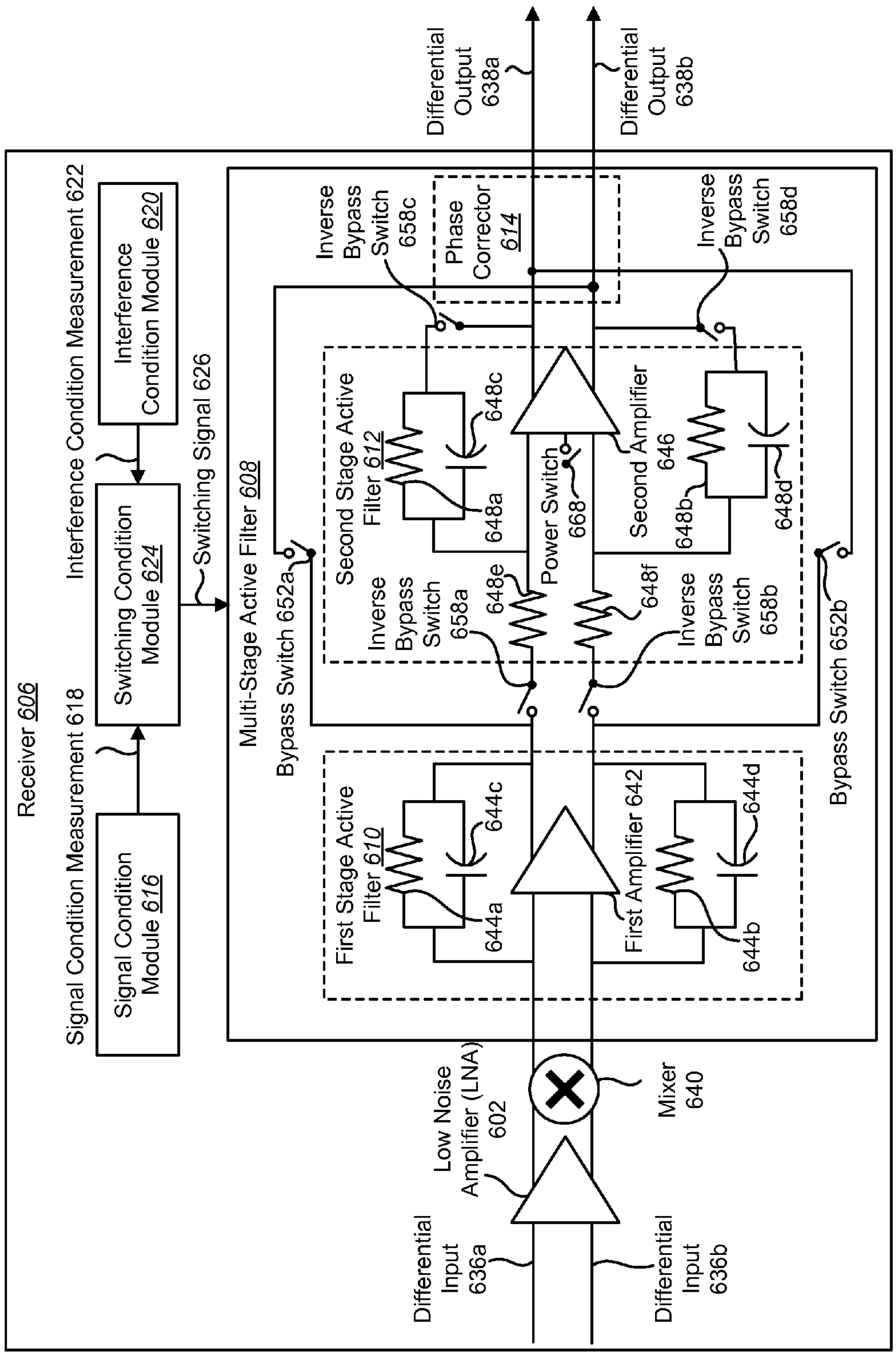

Receiver 606
Signal Condition Measurement 618
Signal Condition Module 616
Interference Condition Measurement 622
Interference Condition Module 620
Switching Condition Module 624
Switching Signal 626
Multi-Stage Active Filter 608
Bypass Switch 652a
Bypass Switch 652b
First Stage Active Filter 610
644a
644b
644c
644d
First Amplifier 642
Second Stage Active Filter 612
648a
648b
648c
648d
648e
648f
Second Amplifier 646
Power Switch 668
Inverse Bypass Switch 658a
Inverse Bypass Switch 658b
Inverse Bypass Switch 658c
Inverse Bypass Switch 658d
Phase Corrector 614
Differential Output 638a
Differential Output 638b
Differential Input 636a
Differential Input 636b
Low Noise Amplifier (LNA) 602
Mixer 640

FIG. 6

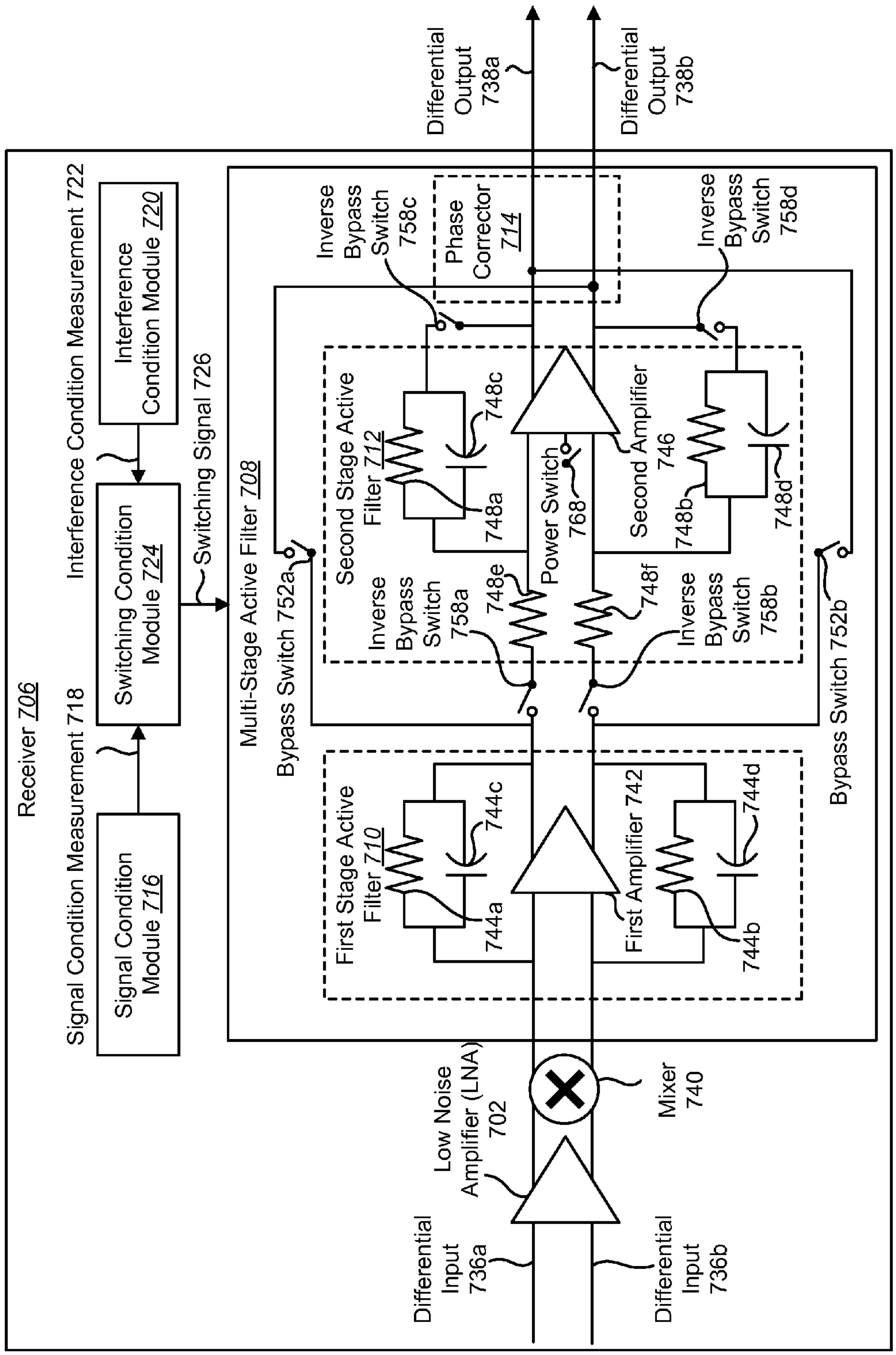
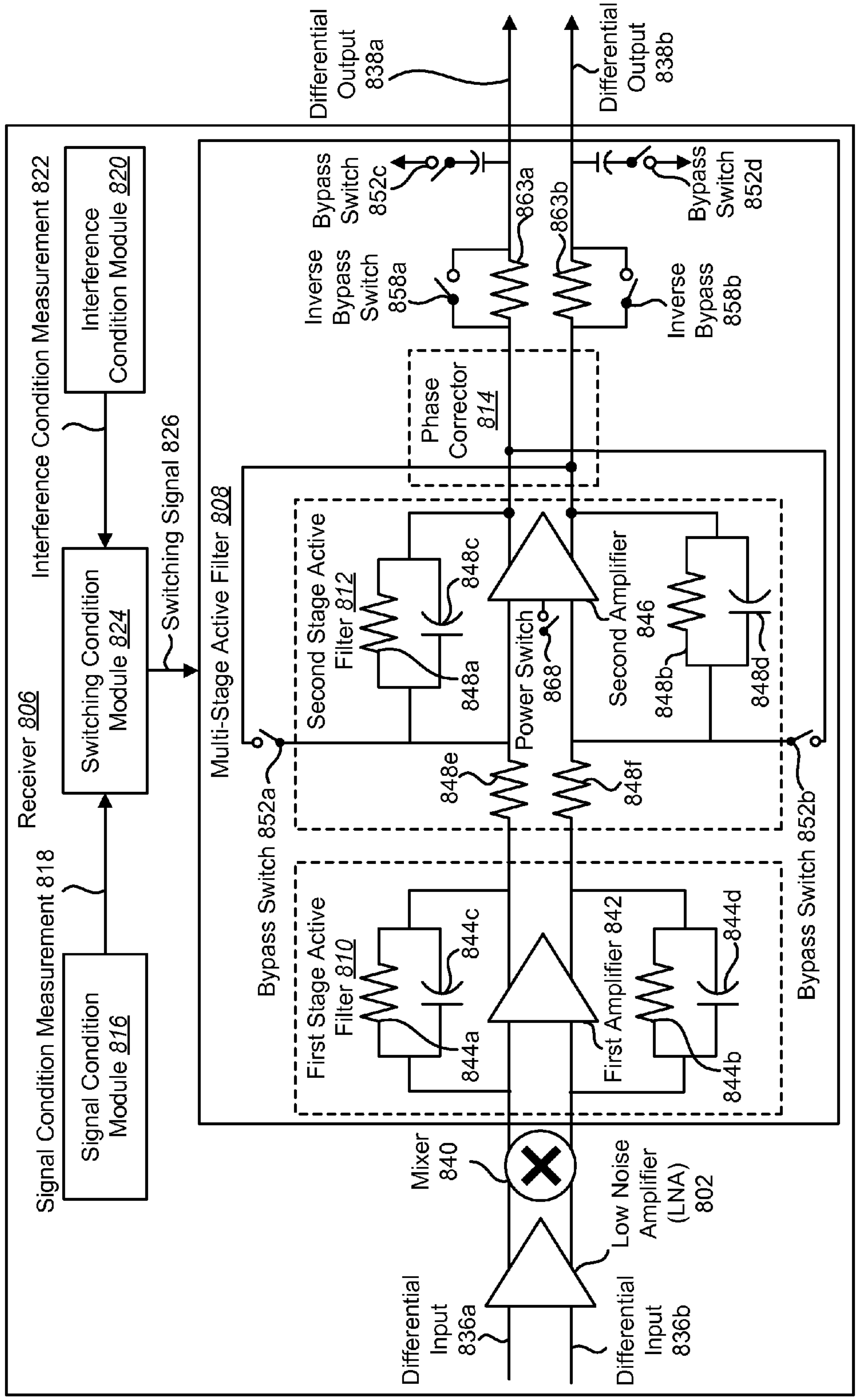

Receiver 706
Signal Condition Module 716
Signal Condition Measurement 718
Switching Condition Module 724
Interference Condition Module 720
Interference Condition Measurement 722
Switching Signal 726
Multi-Stage Active Filter 708
First Stage Active Filter 710
744a
744b
744c
744d
First Amplifier 742
Second Stage Active Filter 712
748a
748b
748c
748d
748e
748f
Second Amplifier 746
Power Switch 768
Bypass Switch 752a
Bypass Switch 752b
Inverse Bypass Switch 758a
Inverse Bypass Switch 758b
Inverse Bypass Switch 758c
Inverse Bypass Switch 758d
Phase Corrector 714
Differential Input 736a
Differential Input 736b
Low Noise Amplifier (LNA) 702
Mixer 740
Differential Output 738a
Differential Output 738b

FIG. 7



Receiver 806
Signal Condition Measurement 818
Signal Condition Module 816
Switching Condition Module 824
Interference Condition Measurement 822
Interference Condition Module 820
Switching Signal 826
Multi-Stage Active Filter 808
First Stage Active Filter 810
Second Stage Active Filter 812
Phase Corrector 814
First Amplifier 842
Second Amplifier 846
Power Switch 868
844a
844b
844c
844d
848a
848b
848c
848d
848e
848f
Bypass Switch 852a
Bypass Switch 852b
Bypass Switch 852c
Bypass Switch 852d
Inverse Bypass Switch 858a
Inverse Bypass 858b
863a
863b
Differential Output 838a
Differential Output 838b
Differential Input 836a
Differential Input 836b
Mixer 840
Low Noise Amplifier (LNA) 802

FIG. 8

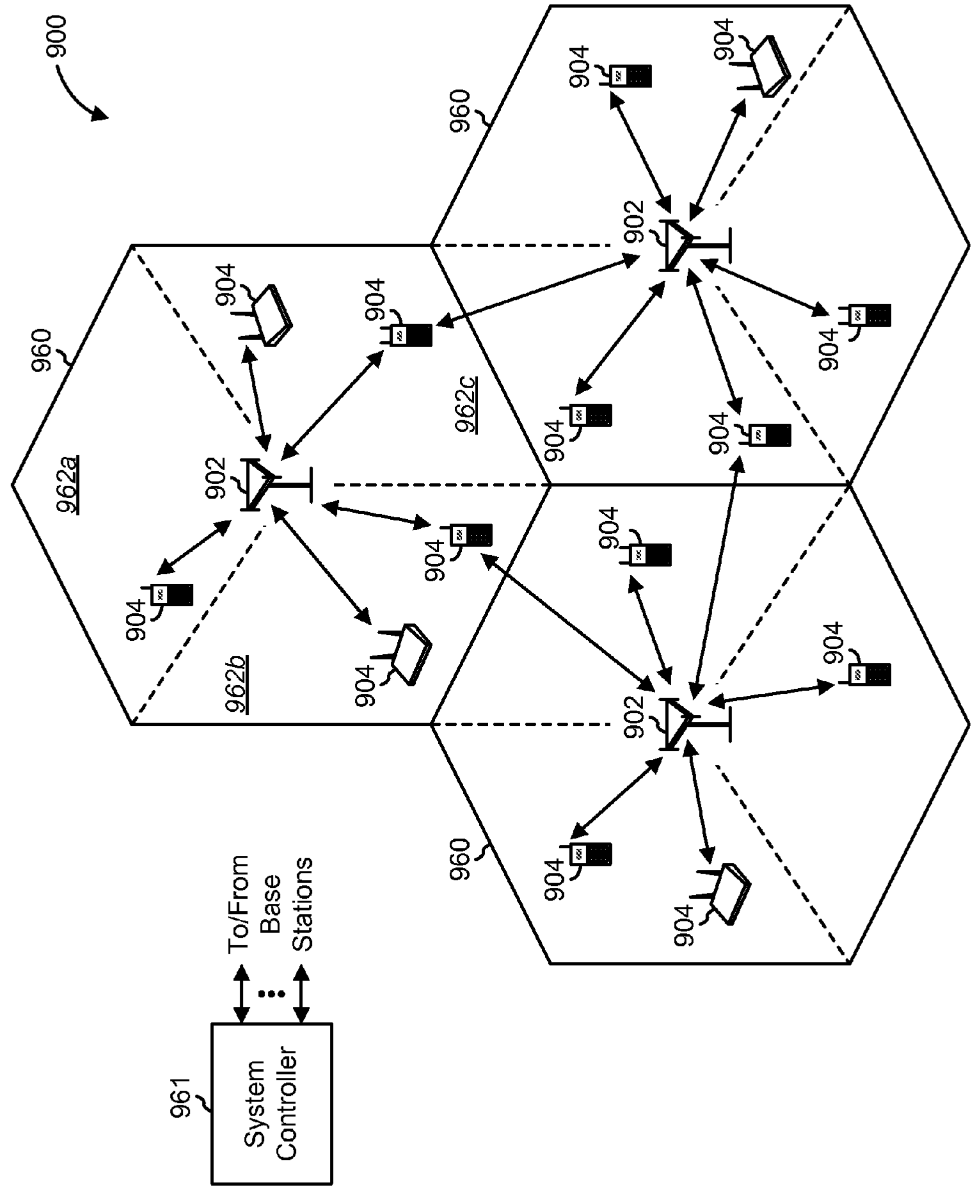

900
960
960
960
962a
962b
962c
902
902
902
904
961
System Controller
To/From Base Stations

FIG. 9

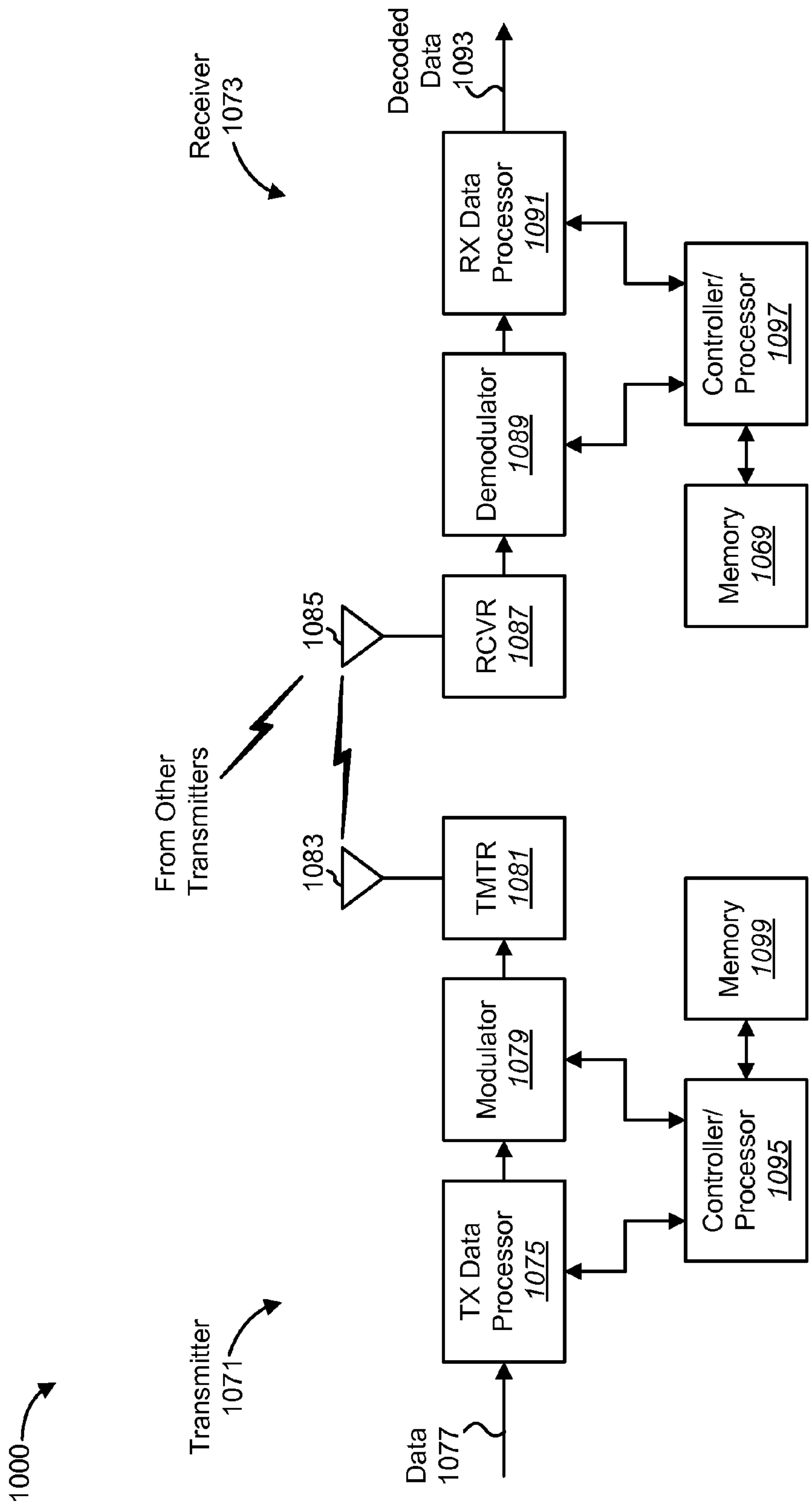

1000
Transmitter 1071
Receiver 1073
Data 1077
TX Data Processor 1075
Modulator 1079
TMTR 1081
1083
From Other Transmitters
1085
RCVR 1087
Demodulator 1089
RX Data Processor 1091
Decoded Data 1093
Controller/ Processor 1095
Memory 1099
Memory 1069
Controller/ Processor 1097

FIG. 10

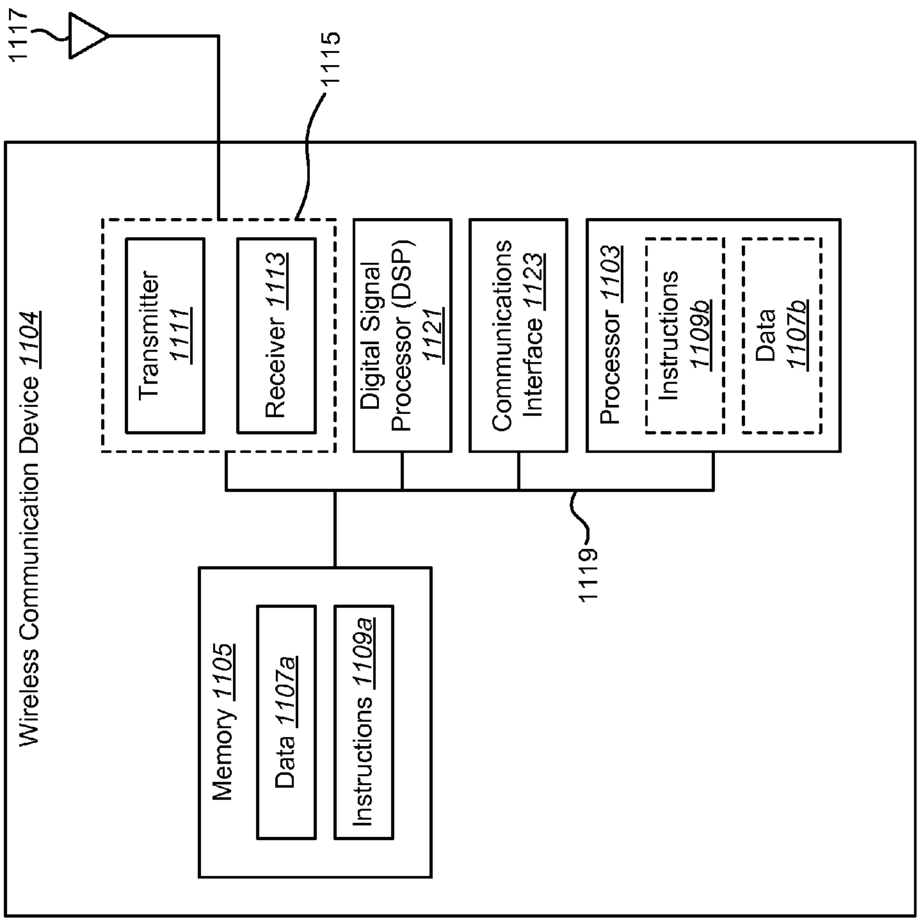

1117
1115
Wireless Communication Device 1104
Transmitter 1111
Receiver 1113
Digital Signal Processor (DSP) 1121
Communications Interface 1123
Processor 1103
Instructions 1109b
Data 1107b
1119
Memory 1105
Data 1107a
Instructions 1109a

FIG. 11

REDUCING POWER CONSUMPTION ON A RECEIVER

TECHNICAL FIELD

The present disclosure relates generally to communication systems. More specifically, the present disclosure relates to systems and methods for reducing power consumption on a receiver.

BACKGROUND

Wireless communication systems are widely deployed to provide various types of communication content such as voice, video, data and so on. These systems may be multiple-access systems capable of supporting simultaneous communication of multiple mobile devices with one or more base stations.

A subscriber station may include one or more integrated circuits. These integrated circuits may include analog and digital circuitry necessary for wireless communication. Power is consumed when the circuitry is employed. However, there may be instances when circuitry is used when it is not necessary. Thus, unnecessary power is consumed. Therefore, benefits may be realized by more efficiently managing circuit components.

SUMMARY OF THE INVENTION

A method for reducing power consumption on a wireless communication device is described. The wireless communication device includes a first stage active filter and a second stage active filter. A condition measurement is obtained that includes a signal measurement condition. If it is determined that the condition measurement is above a threshold, the second stage active filter is bypassed.

The signal condition measurement may be a wideband signal condition measurement. The condition measurement may be an interference condition measurement. The condition measurement may be a combined condition measurement based on a signal condition measurement and an interference condition measurement. The threshold may be a signal threshold, an interference threshold or a combined signal threshold.

The second stage active filter may include an active stage. Bypassing the second stage active filter may further include disabling power to the active stage and opening a bypass circuit path to bypass the second stage active filter. Opening the bypass circuit path may include closing at least one bypass switch.

An input signal may also be obtained. The input signal may be amplified at the first stage active filter. A filtered signal may be outputted. The input signal may be a differential input signal with an inverted signal and a non-inverted signal. A phase correction may be applied to the input signal if the condition measurement is above the threshold. The phase correction may include crossing over the inverted signal to be the non-inverted signal and crossing over the non-inverted signal to be the inverted signal. At least one additional active filter may be bypassed and have its power disabled if the condition measurement is above the threshold. The input signal may be amplified using a low-noise amplifier. The input signal may be down-converted using a mixer.

A passive filter may be applied after the second stage active filter if the condition measurement is above the threshold. The passive filter may reject out-of-band signals. The condition measurement may be obtained, in part, from an antenna.

A wireless device for reducing power consumption on a wireless communication device is also described. The wireless device includes a first stage active filter and a second stage active filter. The wireless device includes a processor and executable instructions stored in memory that is in electronic communication with the processor. The wireless device obtains a condition measurement that includes a signal condition measurement. The wireless device also determines if the condition measurement is above a threshold. The wireless device further bypasses the second stage active filter if the condition measurement is above the threshold.

A computer-program product for reducing power consumption on a wireless communication device is also described. The computer-program product includes a non-transitory computer-readable medium with instructions thereon. The computer-program product includes instructions to obtain a condition measurement that includes a signal condition measurement. The computer-program product also includes code to determine if the condition measurement is above a threshold. The computer-program product further includes code to bypass a second stage active filter if the condition measurement is above the threshold.

An apparatus for reducing power consumption on a wireless communication device is also described. The apparatus includes means for obtaining a condition measurement that includes a signal condition measurement. The apparatus also includes means for determining if the condition measurement is above a threshold. The apparatus further includes means for bypassing a second stage active filter if the condition measurement is above the threshold.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates an example of a wireless communication device in which the systems and methods disclosed herein may be utilized;

FIG. **2** is a flow diagram of a method for reducing power consumption on a wireless communication device;

FIG. **3** is a flow diagram of a more detailed method for reducing power consumption on a wireless communication device;

FIG. **4** is a flow diagram of another method for reducing power consumption on a wireless communication device;

FIG. **5** is a block diagram illustrating a multi-stage active filter on a wireless communication device;

FIG. **6** is a block diagram illustrating one configuration of a receiver on a wireless communication device;

FIG. **7** is a block diagram illustrating another configuration of a receiver on a wireless communication device;

FIG. **8** is a block diagram illustrating yet another receiver on a wireless communication device;

FIG. **9** illustrates an example of a wireless communication system in which the systems and methods disclosed herein may be utilized;

FIG. **10** illustrates a block diagram of a transmitter and a receiver in a wireless communication system; and

FIG. **11** illustrates certain components that may be included within a wireless communication device.

DETAILED DESCRIPTION

FIG. **1** illustrates an example of a wireless communication device **104** in which the systems and methods disclosed herein may be utilized. The wireless communication device **104** includes a receiver **106** and an antenna **134**. The receiver **106** may be configured to reduce the power consumption of the wireless communication device **104**. The wireless communication device **104** may be designed to implement one or more standards such as Long Term Evolution (LTE), wideband code division multiple access (W-CDMA) and/or other standards. It should be appreciated that while the presents systems and methods described herein relate to a Long Term Evolution (LTE) wireless communication device **104**, corresponding systems and methods may also be practiced in other wireless communication systems, such as Global System for Mobile Communications (GSM) systems, Enhanced Data Rates for GSM Evolution (EDGE) systems, Code Division Multiple Access (CDMA) systems, etc.

As used herein, the term "wireless communication device" refers to an electronic device that may be used for voice and/or data communication over a wireless communication system. Examples of wireless communication devices **104** include cellular phones, personal digital assistants (PDAs), handheld devices, wireless modems, laptop computers, personal computers, machine type communication (MTC) devices, machine-to-machine (M2M) devices and sensor devices (including, for example, so-called "smart-meters," alarms and health monitoring devices). A wireless communication device **104** may alternatively be referred to as an access terminal, a mobile terminal, a mobile station, a remote station, a user terminal, a terminal, a subscriber unit, a subscriber station, a mobile device, a wireless device, user equipment (UE), an MTC device or an M2M device, or some other similar terminology.

While only a single receiver **106** is illustrated herein, it should be appreciated that multiple receivers may be employed in the wireless communication device **104**. For example, the wireless communication device **104** may include both a primary receiver (PRx) and a diversity receiver (DRx).

As discussed above, the receiver **106** may be configured to reduce the power consumption of the wireless communication device **104**. The receiver **106** may include a multi-stage active filter **108** and a switching condition module **124**. The switching condition module **124** may reduce the power consumption of the multi-stage active filter **108** when the wireless communication device **104** is receiving a strong input signal **136** by turning off one or more components within the multi-stage active filter **108**. For example, the switching signal **126** may shut off an amplifier within a filter in the multi-stage active filter **108** when conditions warrant it.

The multi-stage active filter **108** may be part of a baseband filter (BBF). The multi-stage active filter **108** may provide high gain for the desired signal and provide high anti-aliasing filtering for an analog-to-digital converter (ADC) (not shown) located in the wireless communication device **104**.

When the wireless communication device **104** receives an input signal **136**, the input signal **136** may include the desired signal and/or interference. Either the desired signal and/or the interference of the input signal **136** may range from a low (i.e., weak) signal to a high (i.e., strong) signal. Typically, signal conditions and/or interference conditions (i.e., the interference level) do not affect the active filtering process of the multi-stage active filter **108**. In other words, every component in the multi-stage active filter **108** is typically always turned on to accommodate poor desired signal and interference conditions, regardless of the real signal conditions and/or the interference conditions. In this manner, unnecessary power is wasted. By turning off one or more components within the multi-stage active filter **108** during strong signal and/or low interference conditions, the power consumption of the wireless communication device **104** may be reduced.

If the input signal **136** has a low signal strength, every component in the multi-stage active filter **108** may be needed to properly amplify the desired signal and filter the unwanted interference input signal **136**. However, if the input signal **136** is strong (e.g., the receive power level is high), the receiver **106** may reduce gain as well as the amount of active filtering that occurs. For example, the receiver **106** may reduce power or power down one or more active filter stages within the multi-stage active filter **108** to conserve power on the wireless communication device **104**. Similarly, power conservation may also be achieved through measuring interference conditions and reducing one or more active filter stages when interference levels are low.

The receiver **106** may include a low noise amplifier (LNA) **102** and a mixer **140**. An input signal **136** may be input in to the low noise amplifier (LNA) **102**. The input signal **136** may be obtained from the antenna **134**. In some configurations, the input signal **136** may be a differential signal. In other words, the input signal **136** may be separated into two signals. The differential signals may correspond to each other. For example, the differential signals may include similar signals that are out of phase with each other. In one configuration, one differential signal may be positive and the other differential signal may be negative. As another example, one differential signal may be an inverted signal and the other differential signal may be a non-inverted signal. As yet another example, the input signal may include an inphase (I) signal and a quadrature (Q) signal.

The multi-stage active filter **108** on the receiver **106** may provide filtering to the input signal **136**, such as gain (e.g., amplification) and rejection (e.g., out-of-band signal and/or noise filtering). Providing gain and rejection generally involves a multi-stage active filter **108** design, such as a two-stage active filter. The multi-stage active filter **108** may include a first stage active filter **110** and a second stage active filter **112**. For example, the first stage active filter **110** may provide gain and the second stage active filter **112** may provide out-of-band rejection and some level of amplification or attenuation. The second stage active filter **112** may be bypassed and powered down based on signal conditions and interference levels.

It should be appreciated that while the multi-stage active filter **108** illustrates a first stage active filter **110** and a second stage active filter **112**, additional active filters and/or other active components may be employed within the multi-stage active filter **108**. The additional active filters and/or other active components may also be bypassed and powered down based on signal conditions and interference levels.

It should also be appreciated that in some configurations, the second stage active filter **112** may be located before the first stage active filter **110** in a signal path. Thus, the input signal **136** may be sent past the bypassed second stage active filter **112** and processed at the first stage active filter **110**. Additionally, while the first stage active filter **110** may provide gain and the second stage active filter **112** may reject out-out-band signals and/or noise, the first stage active filter **110** and the second stage active filter **112** are not limited to such functions. For example, the second stage active filter **112** may provide gain and the first stage active filter **110** may reject out-out-band signals. As another example, the first stage active filter **110** and the second stage active filter **112** may both provide gain and/or reject out-out-band signals.

When the input signal **136** has a good signal connection, such as a strong power level of a signal and/or low interference, the rejection/anti-aliasing stage of the multi-stage active filter **108** may be relaxed or waived without affecting performance. For example, the second stage active filter **112** in the multi-stage active filter **108** may be bypassed and powered down to conserve power. For instance, a wireless communication device **104** in Long Term Evolution (LTE) mode may save 7 milliamps (mA) of battery current by bypassing the second stage active filter **112** active filter. In this instance, the power savings may be a combination of the power saved on both the primary receiver and the diversity receiver.

A strong signal and/or low interference levels may be common in wideband applications, such as in Long Term Evolution (LTE) wireless communication devices **104**. In other words, power consumption may be conserved in Long Term Evolution (LTE) wideband mode by bypassing one or more active filters.

In the case of additional active filters (not shown) in the multi-stage active filter **108**, the additional active filters may be bypassed and powered down to conserve additional power. Improving battery savings may result in additional battery life and additional talk or data time for the wireless communication device **104**.

The multi-stage active filter **108** may also include a phase corrector **114**. The phase corrector **114** may adjust the phase of one or more bypassed signals in the multi-stage active filter **108**. For example, the phase corrector **114** may shift the phase of a bypassed signal **180** degrees. In the case of differential signals, the phase corrector **114** may cross over the two differential signals that have bypassed the second stage active filter **112** to compensate for phase flip. Additional details regarding the phase corrector **114** will be given below in connection with FIG. **6**.

The low noise amplifier (LNA) **102** may amplify the input signal **136**. The low noise amplifier (LNA) **102** may output an amplified signal to the mixer **140**. The mixer **140** may downconvert the amplified signal. The mixer **140** may output a downconverted signal to the multi-stage active filter **108**.

The receiver **106** may also include a signal condition module **116**, an interference condition module **120** and a switching condition module **124**. The signal condition module **116** may obtain a portion of the input signal **136**, which is received at the antenna **134**. The signal condition module **116** may also obtain a portion of the output signal **138** from the output of the multi-stage active filter **108**. In other words, the signal condition module **116** may receive the input signal **136** and/or the output signal **138**.

The signal condition module **116** may measure the signal level of received signals (i.e., the input signal **136**) at (i.e. from) the antenna **134** as a signal condition measurement **118**. The signal condition measurement **118** may be a power level signal (e.g., measured as a power ratio in decibels (dB) relative to one milliwatt (dBm)), a Boolean value, a range of values or another set of values. In some configurations, the signal condition measurement **118** may be a wideband signal condition measurement, for example, as employed in Long Term Evolution (LTE) networks. The signal condition module **116** may provide the signal condition measurement **118** to the switching condition module **124**. In some configurations, the signal condition module **116** may be located within or may be part of the switching condition module **124**.

The switching condition module **124** may determine if the signal condition measurement **118** is at or above a signal threshold **128**. The signal threshold **128** may be a value corresponding to the signal condition measurement **118**, such as a decibel value. For example, the signal threshold **128** may be −55 dBm. The signal threshold **128** may include multiple values and may rank the signal condition measurement **118** from high to low, or according to some other range.

The interference condition module **120** may measure levels of interference at the receiver **106** similar to how the signal condition module **116** measures signal strength and signal condition. The interference condition module **120** may receive the input signal **136** and/or the output signal **138**. In some configurations, the interference condition module **120** may receive a signal from a component or subcomponent located between the input signal **136** and the output signal **138**.

The interference condition module **120** may measure the strength of the interference in either the analog domain or the digital domain. In the analog domain, filters may be employed to select the interference, which may then be processed by analog comparators. In the digital domain, a fast Fourier transform (FFT) may be employed to determine the interference frequency and strength.

The interference condition module **120** may provide an interference condition measurement **122** to the switching condition module **124**. The interference condition measurement **122** may reflect the measured interference. The interference condition measurement **122** may be a power level signal (e.g., measured in dBm), a Boolean value, a range of values or another set of values. In some configurations, the interference condition module **120** may be part of the switching condition module **124**.

The switching condition module **124** may obtain the signal condition measurement **118**. The switching condition module **124** may compare the signal condition measurement **118** to the signal threshold **128**. If the signal condition measurement **118** is at or above the signal threshold **128**, the switching condition module **124** may adjust a switching signal **126** to the multi-stage active filter **108**, causing the multi-stage active filter **108** to bypass and power down second stage active filter **112**.

The switching condition module **124** may also obtain the interference condition measurement **122**. The switching condition module **124** may compare the interference condition measurement **122** to the interference threshold **130**. The interference threshold **130** may be −44 dBm as required by Long Term Evolution (LTE) receiver blocking tests, for example. If the interference condition measurement **122** is at or above the interference threshold **130**, the switching condition module **124** may adjust the switching signal **126** to the multi-stage active filter **108**, causing the multi-stage active filter **108** to bypass and power down the second stage active filter **112**. Thus, either the signal condition measurement **118** or the interference condition measurement **122** may trigger the switching condition module **124** to adjust the switching signal **126** to the multi-stage active filter **108**, causing the multi-stage active filter **108** to bypass and power down the second stage active filter **112**.

In one configuration, the signal condition measurement **118** may be combined with the interference condition measurement **122** and may be compared to a combined signal threshold **132**. If the combined signal condition measurement **118** and interference condition measurement **122** is above the combined signal threshold **132**, the switching condition module **124** may adjust the switching signal **126** to the multi-stage active filter **108**, causing the multi-stage active filter **108** to bypass and power down the second stage active filter **112**. When the second stage active filter **112** (or other additional filters) on the multi-stage active filter **108** is bypassed, power may be conserved on the wireless communication device **104**.

The multi-stage active filter **108** may output an output signal **138**. Depending on the switching signal **126**, the multi-stage active filter **108** may be instructed to bypass and power down the second stage active filter **112** (and/or additional active filters). If the signal power level is strong and the interference level is low, then the multi-stage active filter **108** may be instructed to bypass and power down the second stage active filter **112**. Under these conditions, the second stage active filter **112** may be bypassed with negligible signal degradation. In addition, the wireless communication device **104** may have an increase in power savings as the power to the second stage active filter **112** is conserved.

In some configurations, the receiver **106** may be employed in wideband Long Term Evolution (LTE) mode. Long Term Evolution (LTE) is a standard for providing voice, data and signaling services to and from wireless communication devices. A Long Term Evolution (LTE) network employs Orthogonal Frequency Division Multiple Access (OFDMA) and an Evolved Packet System (EPS). An OFDMA network may implement a radio technology such as Evolved Universal Terrestrial Radio Access UTRA (E-UTRA), IEEE 802.11, IEEE 802.16, IEEE 802.20, Flash-OFDMA, etc. Long Term Evolution (LTE) is a release of UMTS that uses E-UTRA.

In some configurations, the receiver **106** may be employed in CDMA mode or a TDMA mode. A CDMA network may implement a radio technology such as Universal Terrestrial Radio Access (UTRA), CDMA2000, etc. UTRA includes W-CDMA and Low Chip Rate (LCR). A TDMA network may implement a radio technology such as Global System for Mobile Communications (GSM). UTRA, E-UTRA and Global System for Mobile Communications (GSM) are part of Universal Mobile Telecommunication System (UMTS). UTRA, E-UTRA, GSM, UMTS and Long Term Evolution (LTE) are described in documents from an organization named “3rd Generation Partnership Project” (3GPP).

FIG. **2** is a flow diagram of a method **200** for reducing power consumption on a wireless communication device **104**. The method **200** may be performed by a wireless communication device **104**. The wireless communication device **104** may include a multi-stage active filter **108** that includes a first stage active filter **110** and a second stage active filter **112**.

The wireless communication device **104** may obtain **202** a condition measurement. The condition measurement may be based on a signal condition measurement **118** and/or an interference condition measurement **122**. In one configuration, the condition measurement may be the signal condition measurement **118**. In another configuration, the condition measurement may be the interference condition measurement **122**. In yet another configuration, the condition measurement may be a combination of the signal condition measurement **118** and the interference condition measurement **122**.

The wireless communication device **104** may determine **204** if the condition measurement is above a threshold. For example, if the condition measurement is a signal condition measurement **118**, the wireless communication device **104** may determine if the signal condition measurement **118** is above the signal threshold **128**. If the condition measurement is an interference condition measurement **122**, the wireless communication device **104** may determine if the interference condition measurement **122** is above the interference threshold **130**. If the condition measurement is a combined condition measurement, the wireless communication device **104** may determine if the combined condition measurement is above the combined signal threshold **132**.

The wireless communication device may bypass **206** the second stage active filter **112** if the condition measurement is above the threshold. For example, if the condition measurement is above a corresponding threshold, as described above, the switching control module **124** may adjust a switching signal **126** to indicate that the second stage active filter **112** should be bypassed. In some configurations, bypassing the second stage active filter **112** may also include disabling power to the second stage active filter **112**.

FIG. **3** is a flow diagram of a more detailed method **300** for reducing power consumption on a wireless communication device **104**. The method **300** may be performed by a wireless communication device **104**. The wireless communication device **104** may include a multi-stage active filter **108** that includes a first stage active filter **110** and a second stage active filter **112**.

The wireless communication device **104** may obtain **302** a signal condition measurement **118** and an interference condition measurement **122**. Both the signal condition measurement **118** and the interference condition measurement **122** may be measured in the digital baseband by processing the output signal **138**. For example, the signal condition module **116**, the switching condition module **124** and the interference condition module **120** may each be part of the digital baseband. Alternatively, the signal condition measurement **118** may be measured in the digital baseband and the interference condition measurement **122** may be measured in the analog domain, as described previously.

The wireless communication device **104** may determine **304** if the signal condition measurement **118** is above the signal threshold **128**. If it is determined **304** that the signal condition measurement **118** is above the signal threshold **128**, the wireless communication device may send **310** a switching signal **126** indicating to the multi-stage active filter **108** to bypass and power down the second stage active filter **112**.

Sending **310** a switching signal **126** indicating to the multi-stage active filter **108** to bypass and power down the second stage active filter **112** may trigger the wireless communication device **104** to perform additional actions. For example, the wireless communication device **104** may close **312** bypass switches to the second stage active filter **112**. Closing **312** one or more bypass switches may allow the second stage active filter **112** to be bypassed. For example, closing **312** the one or more bypass switches may allow for the second stage active filter **112** to be bypassed. Additional detail regarding bypass switches will be provided below in FIG. **6**.

The wireless communication device **104** may disable **314** power to the second stage active filter **112**. Because the second stage active filter **112** is bypassed, the second stage active filter **112** is not used for signal processing. Thus, the second stage active filter **112** may be powered down. In some instances, the second stage active filter **112** may reduce power consumption rather than powering down. By disabling **314** power to the second stage active filter **112**, the wireless communication device **104** may conserve power, extend battery life and extend talk time.

In some configurations, the multi-stage active filter **108** may need to correct the phase of the output signal **138** when an active filter is bypassed. Thus, if the signal bypasses the second stage active filter **112**, the phase of the output signal may need correction. For example, the phase may need to be shifted or flipped 180 degrees. In these configurations, the wireless communication device **104** may enable **318** phase correction for the bypassed signal. Thus, if a signal, such as the input signal **136**, bypasses the second stage active filter **112**, then a phase correction may be applied to compensate for phase mismatches. The wireless communication device **104** may then filter **320** an input signal **136** through the multi-stage active filter **108**.

If the second stage active filter **112** is bypassed **316**, then only the first stage active filter **110** may be employed (while the second stage active filter **112** is powered down). In this manner, power may be conserved and battery life may be extended without signal degradation.

If it is determined **304** that the signal condition measurement **118** is not above the signal threshold **128**, the wireless communication device **104** may determine **306** if the interference condition measurement **122** is above the interference threshold **130**. If it is determined **306** that the interference condition measurement **122** is above the interference threshold **130**, the wireless communication device may send **310** a switching signal **126** indicating to the multi-stage active filter **108** to bypass and power down the second stage active filter **112**.

If it is determined **306** that the interference condition measurement **122** is not above the interference threshold **130**, the wireless communication device **104** may combine **322** the signal condition measurement **118** and the interference condition measurement **122**. The wireless communication device **104** may then determine **308** whether the combined signal condition measurement **118** and interference condition measurement **122** is above the combined signal threshold **132**.

If it is determined **308** that the combined signal condition measurement **118** and interference condition measurement **122** is not above the combined signal threshold **132**, the wireless communication device may send **324** a switching signal **126** indicating to the multi-stage active filter **108** not to bypass the second stage active filter **112**. In this instance, the wireless communication device **104** may open **326** bypass switches to disable bypassing of the second stage active filter **112**. The wireless communication device **104** may also enable **328** power to the second stage active filter **112**. The wireless communication device **104** may then filter **320** an input signal **136** through the multi-stage active filter **108**.

In this instance, the signal condition measurement **118** is not above the signal threshold **128**, the interference condition measurement **122** is not above the interference threshold **130** and the combined signal condition measurement **118** and interference condition measurement **122** is not above the combined signal threshold **132**. Thus, the wireless communication device **104** does not bypass the second stage active filter **112** in the multi-stage active filter **108** and the multi-stage active filter **108** employs both the first stage active filter **110** and the second stage active filter **112**.

FIG. **4** is a flow diagram of another method **400** for reducing power consumption on a wireless communication device **104**. The method **400** may be performed by a wireless communication device **104**. For example, the wireless communication device **104** may include a multi-stage active filter **108** that includes a first stage active filter **110** and a second stage active filter **112**.

The wireless communication device **104** may obtain **402** a differential input signal. For example, the differential input signal may be obtained from the input signal **136**. For instance, the input signal **136** may be separated into in-phase (I) and quadrature (Q) components to form the differential signal.

The wireless communication device **104** may obtain **404** a condition measurement from the antenna **134**. For example, the condition measurement may be obtained based on a signal condition measurement **118** and/or an interference condition measurement **122**. The wireless communication device **104** may filter **406** the differential input signal through a low noise amplifier (LNA) **102**. The wireless communication device **104** may downconvert **408** the differential input signal using a mixer **140**.

The wireless communication device **104** may amplify **410** the differential input signal using the first stage active filter **110**. For example, the differential input signal may be provided to the multi-stage active filter **108**. The multi-stage active filter **108** may include a first stage active filter **110**, a second stage active filter **112**, additional active filters (not shown) and/or other active components (not shown). Amplifying **410** the differential input signal may result in an amplified differential signal.

The wireless communication device **104** may determine **412** if the condition measurement is above a threshold. This may be accomplished as described in FIG. **3** above. If it is determined **412** that the condition measurement is above the threshold, the wireless communication device **104** may bypass **414** the second stage active filter **112**. As an example, the threshold may be the signal threshold **128**, the interference threshold **130** or the combined signal threshold **132**.

The wireless communication device **104** may apply **416** a phase correction by crossing over the amplified differential signal. For example, if a set of differential signals includes an I portion and a Q portion, the two portions may be crossed to correct for the 180 degrees phase flip that resulted when the second stage active filter **112** was bypassed. An example of crossing to correct the 180 degrees phase flip and/or phase mismatch is illustrated in FIG. **6** below. Applying **416** the phase correction in the amplified differential signal may result in a phase corrected differential signal.

The wireless communication device **104** may apply **418** passive filtering to the phase corrected differential signal. Passive filtering may assist the multi-stage active filter **108** by reducing/rejecting out-of-band signals without requiring power to operate the passive elements. Passive elements may include resistors, capacitors, etc. Applying **418** passive filtering to the phase corrected differential signal may result in a filtered differential signal.

The wireless communication device **104** may output **420** the filtered differential signal. The filtered differential signal may be one example of an output signal **138**. The filtered differential signal may be outputted from the receiver **106** to other circuitry within the wireless communication device **104** (such as a modem or an analog-to-digital converter (ADC)). In some configurations, the filtered differential signal may be output to a separate device.

If it is determined **412** that the condition measurement is not above, or does not meet, the threshold, the wireless communication device **104** may process **422** the amplified differential signal using the second stage active filter **112**. In some configurations, the second stage active filter **112** may amplify the amplified differential signal. In some configurations, the second stage active filter **112** may filter the amplified differential signal. In this case, processing **422** the amplified differential signal using the second stage active filter **112** may result in filtered differential signal. The wireless communication device **104** may then output **420** the filtered differential signal.

FIG. **5** is a block diagram illustrating a multi-stage active filter **508** on a wireless communication device **104**. The multi-stage active filter **508** may be one configuration of the multi-stage active filter **108** described above in connection with FIG. **1**. The multi-stage active filter **508** may be part of the receiver **106** and/or the wireless communication device **104**.

The multi-stage active filter **508** may include a first stage active filter **510** and a second stage active filter **512**. In some configurations, additional active filters may be included. The first stage active filter **510** may include a first active stage **542** and a first set of passive components **544**. The first active stage **542** may employ one or more active components, such as amplifiers. In one configuration, the first active stage **542** may include an operational transconductance amplifier (OTA). An operational transconductance amplifier (OTA) may receive one or more voltage inputs and may output differential currents. In other words, an OTA may be a voltage controlled current source (VCCS). The first set of passive components **544** may include resistors, capacitors, inductors and/or transformers.

The second stage active filter **512** may include a second active stage **546** and a second set of passive components **548**. The second active stage **546** and the second set of passive components **548** may be similar to the first active stage **542** and the first set of passive components **544**. For example, the second set of passive components **548** may include one or more resistors, capacitors, inductors and/or transformers.

The multi-stage active filter **508** may also include a bypass switch **552** and a phase corrector **514**. The phase corrector **514** may correct phase mismatches that occur when the second stage active filter **512** is bypassed. The bypass switch **552** may control whether the second stage active filter **512** is to be bypassed. While only one bypass switch **552** is illustrated, multiple bypass switches **552** may be employed. For example, in the case of differential input signals, multiple parallel bypass switches **552** may be employed for each input signal path. Closing the one or more bypass switches **552** may allow for a bypass circuit path that allows a bypassed signal **554** to bypass the second stage active filter **512**.

The state of the bypass switch **552** (e.g., open or closed) may be based on the switching signal **526**. For example, if the switching signal **526** indicates that the second stage active filter **512** is to be bypassed, the bypass switch **552** may close and complete the circuit to bypass the second stage active filter **512**.

The switching signal **526** may also indicate whether to disable power to the second stage active filter **512**. For example, the switching signal **526** may indicate that power to the second stage active filter **512** is to be disabled or enabled.

The multi-stage active filter **508** may receive an input signal **536**. For example, the input signal **536** may be from an antenna **134** or received from another part of the receiver **106** and/or wireless communication device **104**. The first stage active filter **510** may process the input signal **536**. For example, the input signal **536** may pass through the first active stage **542** and the first set of passive components **544**. The first stage active filter **510** may provide gain to the input signal **536** and generate an amplified signal **550**.

The first stage active filter **510** may output the amplified signal **550**. The amplified signal **550** may either pass through the second stage active filter **512** or bypass the second stage active filter **512**, depending on the signal condition measurement **118** and/or the interference condition measurement **122**.

As described above, the switching signal **526** may indicate to the multi-stage active filter **508** whether to bypass and disable power to the second stage active filter **512**. The switching signal **526** may be based on the signal condition measurement **118** and/or the interference condition measurement **122** and whether the signal threshold **128**, the interference threshold **130** or the combined signal threshold **132** is met and/or exceeded.

If the switching signal **526** indicates to the multi-stage active filter **508** to bypass and power down the second stage active filter **512**, the bypass switch **552** may close (e.g., complete the bypass circuit), the amplified signal **550** may bypass the second stage active filter **512** and power to the second stage active filter **512** may be disabled. In this instance, the amplified signal **550** may become a bypassed signal **554**. The bypassed signal **554** may pass through the phase corrector **514** and be output as an output signal **538**.

If the switching signal **526** indicates to the multi-stage active filter **508** to not bypass the second stage active filter **512**, the bypass switch **552** may open (e.g., disable the bypass circuit), power may be enabled at the second stage active filter **512** and the amplified signal **550** may pass through the second stage active filter **512**.

The second stage active filter **512** may process the amplified signal **550**. For example, the second stage active filter **512** may filter the amplified signal **550**. The second stage active filter **512** may output an output signal **538**.

FIG. **6** is a block diagram illustrating one configuration of a receiver **606** on a wireless communication device **104**. The receiver **606** may be one configuration of the receiver **106** described above in connection with FIG. **1**. For example, the receiver **606** may be part of the wireless communication device **104**.

The receiver **606** may include a low noise amplifier (LNA) **602**, a mixer **640**, a signal condition module **616** that generates a signal condition measurement **618**, an interference condition module **620** that generates an interference condition measurement **622**, a switching condition module **624** and a switching signal **626**. The receiver **606** may also include a multi-stage active filter **608**. The multi-stage active filter **608** may include a first stage active filter **610** and a second stage active filter **612**. In some configurations, additional active filters may be included.

The first stage active filter **610** may include a first amplifier **642** (e.g., a first active stage **542**) and a first set of passive components **644***a-d*. For example, the first amplifier **642** may be an operational transconductance amplifier (OTA). The first set of passive components **644***a-d* may include resistors **644***a-b* and capacitors **644***c-d*.

The second stage active filter **612** may include a second amplifier **646** (e.g., a second active stage **546**) and a second set of passive components **648***a-d*. The second amplifier **646** may be an operational transconductance amplifier (OTA) and the second set of passive components **648***a-d* may include resistors **648***a-b* and capacitors **648***c-d*.

The receiver **606** may include bypass switches **652***a-b* and corresponding inverse bypass switches **658***a-d*. The bypass switches **652***a-b* and corresponding inverse bypass switches **658***a-d* may control whether the second stage active filter **612** is bypassed. The state of the bypass switches **652***a-b* (e.g., open or closed) and corresponding inverse bypass switches **658***a-d* (e.g., closed or open, respectively) may be based on the switching signal **626**, as described above. The inverse bypass switches **658***a-d* may be opened when the bypass switches **652***a-b* are closed. Likewise, the inverse bypass switches **658***a-d* may be closed when the bypass switches **652***a-b* are open. One bypass switch **652**, along with corresponding inverse bypass switches **658**, may be employed for each signal path of differential input signals **636***a-b*. For example, bypass switch **652***a* and inverse bypass switches **658***a*, **658***c*, may be used for the signal path corresponding differential input signals **636***a*. The multiple bypass switches **652***a-b* may be in parallel with each other.

Changing the state of the bypass switches **652** from open to closed or from closed to open may take micro seconds (μsec). In this manner, the multi-stage active filter **608** may bypass and power down the second stage active filter **612** in a matter of micro seconds (μsec). This is an improvement over other known approaches, such as linearity state machines that control bias current with jammer detectors and hardware interrupts, which take milliseconds (msec) to change states.

The receiver **606** may include a phase corrector **614**. The phase corrector **614** may correct phase mismatches caused when the second stage active filter **612** is bypassed. The phase corrector **614** may cross over the two differential inputs **636** that have bypassed the second stage active filter **612** to compensate for phase flip and/or phase mismatch. For example, the differential input signal **636***a* may cross over at the phase corrector **614** and may become the differential output signal **638***b*. Similarly, the differential input signal **636***b* may cross over at the phase corrector **614** and may become the differential output signal **638***a*. Is should be appreciated that the differential input signals **636***a-b* and differential output signals **638***a-b* may correspond to plus/minus or inverted/non-inverted differential signals.

The receiver **606** may include a power switch **668**. The power switch **668** may be a second amplifier **646** power switch **668**. The power switch **668** may disable power to the second amplifier **646** based on the switching signal **626**. For example, the switching signal **626** may indicate to enable or disable power to the second amplifier **646**. Disabling power to the second amplifier **646** may result in power savings to the receiver **606** and the wireless communication device **104**.

The differential input signals **636***a-b* may be filtered at the first stage active filter **610**. For example, the differential input signals **636***a-b* may pass through the first amplifier **642** and the first set of passive components **644***a-d*. The differential input signals **636***a-b* may or may not bypass the second amplifier **646** and the second set of passive components **648***a-d*, depending on the switching signal **626**. If the second stage active filter **612** is bypassed, the differential input signals **636***a-b* may cross over in the phase corrector **614** to correct phase flip. The differential input signals **636***a-b* may be output from the receiver **606** as differential output signals **638***a-b*.

FIG. **7** is a block diagram illustrating another configuration of a receiver **706** on a wireless communication device **104**. The receiver **706** may be one configuration of the receiver **106** described above in connection with FIG. **1**. For example, the receiver **706** may be part of the wireless communication device **104**.

The receiver **706** may include a low noise amplifier (LNA) **702**, a mixer **740**, a signal condition module **716** that generates a signal condition measurement **718**, an interference condition module **720** that generates an interference condition measurement **722**, a switching condition module **724** and a switching signal **726**. The receiver **706** may also include a multi-stage active filter **708**. The multi-stage active filter **708** may include a first stage active filter **710** and a second stage active filter **712**.

The first stage active filter **710** may include a first amplifier **742** (e.g., a first active stage **542**) and a first set of passive components **744***a-d*. For example, the first amplifier **742** may be an operational transconductance amplifier (OTA). The first set of passive components **744***a-d* may include resistors **744***a-b* and capacitors **744***c-d*.

The second stage active filter **712** may include a second amplifier **746** (e.g., a second active stage **546**) and a second set of passive components **748***a-f*. The second amplifier **746** may be an operational transconductance amplifier (OTA) and the second set of passive components **748***a-e* may include resistors **748***a-b*, **748***e-f*, and capacitors **748***c-d*.

The receiver **706** may include bypass switches **752***a-b* and corresponding inverse bypass switches **758***a-d*. The bypass switches **752***a-b* and corresponding inverse bypass switches **758***a-d* may control whether the second stage active filter **712** is bypassed. The state of the bypass switches **752***a-b* (e.g., open or closed) may be based on the switching signal **726**, as described above. The inverse bypass switches **758***a-d* may be opened when the bypass switches **752***a-b* are closed. Likewise, the inverse bypass switches **758***a-d* may be closed when the bypass switches **752***a-b* are open. In this manner, the second stage active filter may be completely bypassed when the bypass switches **752***a-b* are closed, thus conserving battery by not sending power to bypassed components.

Bypassing the second stage active filter **712** does not require changes in linearity state, hardware interrupts or the use of a jammer detector. Additionally, linearity in the multi-stage active filter **708** remains constant regardless of whether the second stage active filter **712** is bypassed or not.

The receiver **706** may include a phase corrector **714**. The phase corrector **714** may correct phase mismatches caused when the second stage active filter **712** is bypassed. The phase corrector **714** may cross over the two differential inputs **736***a-b* that have bypassed the second stage active filter **712** to compensate for phase flip and/or phase mismatch.

The receiver **706** may include a power switch **768**. The power switch **768** may be a second amplifier **746** power switch **768**. The power switch **768** may disable power to the second amplifier **746** based on the switching signal **726**. For example, the switching signal **726** may indicate to enable or disable power to the second amplifier **746**. Disabling power to the second amplifier **746** may result in power savings to the receiver **706** and the wireless communication device **104**.

The differential input signals **736***a-b* may be filtered at the first stage active filter **710**. For example, the differential input signals **736***a-b* may pass through the first amplifier **742** and the first set of passive components **744***a-d*. The differential input signals **736***a-b* may or may not bypass the second amplifier **746** and the second set of passive components **748***a-e*, depending on the switching signal **726**. If the second stage active filter **712** is bypassed, the differential input signals **736***a-b* may cross over in the phase corrector **714** to correct phase flip. The differential input signals **736***a-b* may be output from the receiver **706** as differential output signals **738***a-b*.

FIG. **8** is a block diagram illustrating yet another receiver **806** on a wireless communication device **104**. The receiver **806** may be one configuration of the receiver **106** described above in connection with FIG. **1**. For example, the receiver **806** may be part of the wireless communication device **104**.

The receiver **806** may include a low noise amplifier (LNA) **802**, a mixer **840**, a signal condition module **816** that generates a signal condition measurement **818**, an interference condition module **820** that generates an interference condition measurement **822**, a switching condition module **824** and a switching signal **826**. The receiver **806** may also include a multi-stage active filter **808** including a first stage active filter **810** and a second stage active filter **812**, bypass switches **852***a-b* and a power switch **868** (e.g., second amplifier power switch). In some configurations, additional active filters may be included.

The first stage active filter **810** may include a first amplifier **842** (e.g., a first active stage **542**) and a first set of passive components **844***a-d*. The second stage active filter **812** may include a second amplifier **846** (e.g., a second active stage **546**) and a second set of passive components **848***a-f*. The first stage active filter **810**, the second stage active filter **812**, bypass switches **852** and power switch **868** may be similar to corresponding elements **610**, **612** and **652**, **668** described in connection with FIG. **6**.

In some configurations, the receiver **806** may include additional bypass switches **852***c-d*, inverse bypass switches **858***a-b* and additional passive components **863***a-b*. For example, the additional passive components **863***a-b* may be resistors used to reject out-of-band signals and noise. The additional passive components **863***a-b* may be employed without required additional power at the receiver **806**.

When the switching signal **826** indicates to the multi-stage active filter **808** to bypass the second stage active filter **812**, the bypasses switches **852** may close to bypass the second stage active filter **812**. At the same time, the inverse bypass switches **858** may open. Similarly, when the switching signal **826** indicates to the multi-stage active filter **808** to not bypass the second stage active filter **812**, the bypasses switches **852** may open and the inverse bypass switches **858** may close. In this manner, the bypass switches **852** and the inverse bypass switches **858** remain in opposite states.

When the inverse bypass switches **858** are open (e.g., the second stage active filter **812** is bypassed), the differential signals may pass through the additional passive components **863***a-b*. When the inverse bypass switches **858** are closed (e.g., the second stage active filter **812** is not bypassed), the differential signals may bypass the additional passive components **863***a-b*. In this manner, additional passive filtering may be performed only when the second stage active filter **812** is bypassed.

In FIG. **8**, differential input signals **836***a-b* may pass through the low noise amplifier (LNA) **802** and the mixer **840**. The differential input signals **836***a-b* may be filtered at the first stage active filter **810**. For example, the differential input signals **836***a-b* may pass through the first amplifier **842** and the first set of passive components **844***a-d*. The differential input signals **836***a-b* may or may not bypass the second amplifier **846** and the second set of passive components **848***a-f*, depending on the switching signal **826**.

If the second stage active filter **812** is bypassed, the differential signals may cross over in the phase corrector **814** to correct phase flip. The differential signals may be filtered by the additional passive components **863** before being output from the receiver **806** as differential output signals **838***a-b*. In this manner, power may be conserved. For example, in Long Term Evolution (LTE) mode, 8 milliamps (mA) of battery current may be conserved at a wireless communication device **104** employing a primary receiver (PRx) and a secondary receiver (SRx).

If the second stage active filter **812** is not bypassed, the differential input signals **836***a-b* may be amplified/filtered by the second amplifier **846** and second set of passive components **848**. The differential signals may then bypass the additional passive components **863** via the inverse bypass switches **858***a-b* and may be output from the receiver **806** as differential output signals **838***a-b*.

FIG. **9** illustrates an example of a wireless communication system **900** in which the systems and methods disclosed herein may be utilized. The wireless communication system **900** includes multiple base stations **902** and multiple wireless communication devices **904**. Each base station **902** provides communication coverage for a particular geographic area **960**. The term "cell" can refer to a base station **902** and/or its coverage area **960**, depending on the context in which the term is used.

As used herein, the term "base station" refers to a wireless communication station that is used to communicate with wireless communication devices **904**. A base station **902** may alternatively be referred to as an access point (including nano-, pico- and femto-cells), a Node B, an evolved Node B, a Home Node B or some other similar terminology.

To improve system capacity, a base station coverage area **960** may be partitioned into plural smaller areas, e.g., three smaller areas **962***a*, **962***b*, and **962***c*. Each smaller area **962***a*, **962***b*, **962***c*, may be served by a respective base transceiver station (BTS). The term "sector" can refer to a BTS and/or its coverage area **962**, depending on the context in which the term is used. For a sectorized cell, the BTSs for all sectors of that cell are typically co-located within the base station **902** for the cell.

Wireless communication devices **904** are typically dispersed throughout the wireless communication system **900**. A wireless communication device **904** may communicate with one or more base stations **902** on the downlink and/or uplink at any given moment. The downlink (or forward link) refers to the communication link from a base station **902** to a wireless communication device **904**, and the uplink (or reverse link) refers to the communication link from a wireless communication device **904** to a base station **902**. Uplink and downlink may refer to the communication link or to the carriers used for the communication link.

For a centralized architecture, a system controller **961** may couple to the base stations **902** and provide coordination and control for the base stations **902**. The system controller **961** may be a single network entity or a collection of network entities. For a distributed architecture, base stations **902** may communicate with one another as needed.

FIG. **10** illustrates a block diagram of a transmitter **1071** and a receiver **1073** in a wireless communication system **1000**. For the downlink, the transmitter **1071** may be part of a base station **102** and the receiver **1073** may be part of a wireless communication device **104**. For the uplink, the transmitter **1071** may be part of a wireless communication device **104** and the receiver **1073** may be part of a base station **102**.

At the transmitter **1071**, a transmit (TX) data processor **1075** receives and processes (e.g., formats, encodes, and interleaves) data **1077** and provides coded data. A modulator **1079** performs modulation on the coded data and provides a modulated signal. The modulator **1079** may perform Gaussian minimum shift keying (GMSK) for GSM, 8-ary phase shift keying (8-PSK) for Enhanced Data rates for Global Evolution (EDGE), etc. GMSK is a continuous phase modulation protocol, whereas 8-PSK is a digital modulation protocol. A transmitter unit (TMTR) **1081** conditions (e.g., filters, amplifies, and upconverts) the modulated signal and generates an RF-modulated signal, which is transmitted via an antenna **1083**.

At the receiver **1073**, an antenna **1085** receives RF-modulated signals from the transmitter **1071** and other transmitters. The antenna **1085** provides a received radio frequency (RF) signal to a receiver unit (RCVR) **1087**. The receiver unit **1087** conditions (e.g., filters, amplifies, and downconverts) the received RF signal, digitizes the conditioned signal, and provides samples. A demodulator **1089** processes the samples as described below and provides demodulated data. A receive (RX) data processor **1091** processes (e.g., deinterleaves and decodes) the demodulated data and provides decoded data **1093**. In general, the processing by demodulator **1089** and RX data processor **1091** is complementary to the processing by the modulator **1079** and the TX data processor **1075**, respectively, at the transmitter **1071**.

Controllers/processors **1095** and **1097** direct operation at the transmitter **1071** and receiver **1073**, respectively. Memories **1099** and **1069** store program codes in the form of computer software and data used by the transmitter **1071** and receiver **1073**, respectively.

FIG. **11** illustrates certain components that may be included within a wireless communication device **1104**. The wireless communication device **1104** may be an access terminal, a mobile station, a user equipment (UE), etc. The wireless communication device **1104** includes a processor **1103**. The processor **1103** may be a general purpose single- or multi-chip microprocessor (e.g., an ARM), a special purpose microprocessor (e.g., a digital signal processor (DSP)), a microcontroller, a programmable gate array, etc. The processor **1103** may be referred to as a central processing unit (CPU). Although just a single processor **1103** is shown in the wireless communication device **1104** of FIG. **11**, in an alternative configuration, a combination of processors (e.g., an ARM and DSP) could be used.

The wireless communication device **1104** also includes memory **1105**. The memory **1105** may be any electronic component capable of storing electronic information. The memory **1105** may be random access memory (RAM), read-only memory (ROM), magnetic disk storage media, optical storage media, flash memory devices in RAM, on-board memory included with the processor, EPROM memory, EEPROM memory, registers and so forth, including combinations thereof.

Data **1107***a* and instructions **1109***a* may be stored in the memory **1105**. The instructions **1109***a* may be executable by the processor **1103** to implement the methods disclosed herein. Executing the instructions **1109***a* may involve the use of the data **1107***a* that is stored in the memory **1105**. When the processor **1103** executes the instructions **1109**, various portions of the instructions **1109***b* may be loaded onto the processor **1103**, and various pieces of data **1107***b* may be loaded onto the processor **1103**.

The wireless communication device **1104** may also include a transmitter **1111** and a receiver **1113** to allow transmission and reception of signals to and from the wireless communication device **1104** via an antenna **1117**. The transmitter **1111** and receiver **1113** may be collectively referred to as a transceiver **1115**. The wireless communication device **1104** may also include (not shown) multiple transmitters, multiple antennas, multiple receivers, and/or multiple transceivers.

The wireless communication device **1104** may include a digital signal processor (DSP) **1121**. The wireless communication device **1104** may also include a communications interface **1123**. The communications interface **1123** may allow a user to interact with the wireless communication device **1104**.

The various components of the wireless communication device **1104** may be coupled together by one or more buses, which may include a power bus, a control signal bus, a status signal bus, a data bus, etc. For the sake of clarity, the various buses are illustrated in FIG. **11** as a bus system **1119**.

The techniques described herein may be used for various communication systems, including communication systems that are based on an orthogonal multiplexing scheme. Examples of such communication systems include Orthogonal Frequency Division Multiple Access (OFDMA) systems, Single-Carrier Frequency Division Multiple Access (SC-FDMA) systems, and so forth. An OFDMA system utilizes orthogonal frequency division multiplexing (OFDM), which is a modulation technique that partitions the overall system bandwidth into multiple orthogonal sub-carriers. These sub-carriers may also be called tones, bins, etc. With OFDM, each sub-carrier may be independently modulated with data. An SC-FDMA system may utilize interleaved FDMA (IFDMA) to transmit on sub-carriers that are distributed across the system bandwidth, localized FDMA (LFDMA) to transmit on a block of adjacent sub-carriers, or enhanced FDMA (EFDMA) to transmit on multiple blocks of adjacent sub-carriers. In general, modulation symbols are sent in the frequency domain with OFDM and in the time domain with SC-FDMA.

In the above description, reference numbers have sometimes been used in connection with various terms. Where a term is used in connection with a reference number, this is meant to refer to a specific element that is shown in one or more of the figures. Where a term is used without a reference number, this is meant to refer generally to the term without limitation to any particular figure.

The term "determining" encompasses a wide variety of actions and, therefore, "determining" can include calculating, computing, processing, deriving, investigating, looking up (e.g., looking up in a table, a database or another data structure), ascertaining and the like. Also, "determining" can include receiving (e.g., receiving information), accessing (e.g., accessing data in a memory) and the like. Also, "determining" can include resolving, selecting, choosing, establishing and the like.

The phrase "based on" does not mean "based only on," unless expressly specified otherwise. In other words, the phrase "based on" describes both "based only on" and "based at least on."

The term "processor" should be interpreted broadly to encompass a general purpose processor, a central processing unit (CPU), a microprocessor, a digital signal processor (DSP), a controller, a microcontroller, a state machine, and so forth. Under some circumstances, a "processor" may refer to an application specific integrated circuit (ASIC), a programmable logic device (PLD), a field programmable gate array (FPGA), etc. The term "processor" may refer to a combination of processing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

The term "memory" should be interpreted broadly to encompass any electronic component capable of storing electronic information. The term memory may refer to various types of processor-readable media such as random access memory (RAM), read-only memory (ROM), non-volatile random access memory (NVRAM), programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), electrically erasable PROM (EEPROM), flash memory, magnetic or optical data storage, registers, etc. Memory is said to be in electronic communication with a processor if the processor can read information from and/or write information to the memory. Memory that is integral to a processor is in electronic communication with the processor.

The terms "instructions" and "code" should be interpreted broadly to include any type of computer-readable statement(s). For example, the terms "instructions" and "code" may refer to one or more programs, routines, sub-routines, functions, procedures, etc. "Instructions" and "code" may comprise a single computer-readable statement or many computer-readable statements.

The functions described herein may be implemented in software or firmware being executed by hardware. The functions may be stored as one or more instructions on a computer-readable medium. The terms "computer-readable medium" or "computer-program product" refers to any tangible storage medium that can be accessed by a computer or a processor. By way of example, and not limitation, a computer-readable medium may comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that may carry or store desired program code in the form of instructions or data structures and that can be accessed by a computer. Disk and disc, as used herein, includes compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk and Blu-ray® disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. It should be noted that a computer-readable medium may be tangible and non-transitory. The term "computer-program product" refers to a computing device or processor in combination with code or instructions (e.g., a "program") that may be executed, processed or computed by the computing device or processor. As used herein, the term "code" may refer to software, instructions, code or data that is/are executable by a computing device or processor.

Software or instructions may also be transmitted over a transmission medium. For example, if the software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of transmission medium.

The methods disclosed herein comprise one or more steps or actions for achieving the described method. The method steps and/or actions may be interchanged with one another without departing from the scope of the claims. In other words, unless a specific order of steps or actions is required for proper operation of the method that is being described, the order and/or use of specific steps and/or actions may be modified without departing from the scope of the claims.

Further, it should be appreciated that modules and/or other appropriate means for performing the methods and techniques described herein, such as those illustrated by FIGS. **2-4**, can be downloaded and/or otherwise obtained by a device. For example, a device may be coupled to a server to facilitate the transfer of means for performing the methods described herein. Alternatively, various methods described herein can be provided via a storage means (e.g., random access memory (RAM), read-only memory (ROM), a physical storage medium such as a compact disc (CD) or floppy disk, etc.), such that a device may obtain the various methods upon coupling or providing the storage means to the device. Moreover, any other suitable technique for providing the methods and techniques described herein to a device can be utilized.

It is to be understood that the claims are not limited to the precise configuration and components illustrated above. Various modifications, changes and variations may be made in the arrangement, operation, and details of the systems, methods and apparatus described herein without departing from the scope of the claims.

What is claimed is:

1. A method for reducing power consumption on a wireless communication device, wherein the wireless communication device comprises a first stage active filter and a second stage active filter, the method comprising:
- obtaining a condition measurement that comprises a signal condition measurement;
- determining if the condition measurement is above a threshold;
- bypassing the second stage active filter if the condition measurement is above the threshold; and
- applying a passive filter after the second stage active filter if the condition measurement is above the threshold.

2. The method of claim **1**, wherein the signal condition measurement is a wideband signal condition measurement.

3. The method of claim **1**, wherein the condition measurement further comprises an interference condition measurement.

4. The method of claim **1**, wherein the condition measurement is a combined condition measurement based on a signal condition measurement and an interference condition measurement.

5. The method of claim **1**, wherein the threshold is one of a signal threshold, an interference threshold, and a combined signal threshold.

6. The method of claim **1**, wherein the second stage active filter comprises an active stage.

7. The method of claim **6**, wherein bypassing the second stage active filter further comprises:
- disabling power to the active stage; and
- opening a bypass circuit path to bypass the second stage active filter.

8. The method of claim **7**, wherein opening the bypass circuit path comprises closing at least one bypass switch.

9. The method of claim **1**, further comprising:
- obtaining an input signal;
- amplifying the input signal at the first stage active filter; and
- outputting a filtered signal.

10. The method of claim **9**, wherein the input signal is a differential input signal with an inverted signal and a non-inverted signal.

11. The method of claim **10**, further comprising applying a phase correction to the input signal if the condition measurement is above the threshold.

12. The method of claim **11**, wherein applying the phase correction comprises crossing over the inverted signal to be the non-inverted signal and crossing over the non-inverted signal to be the inverted signal.

13. The method of claim **9**, further comprising bypassing and disabling power to at least one additional active filter if the condition measurement is above the threshold.

14. The method of claim **9**, further comprising:
- amplifying the input signal using a low-noise amplifier; and
- downconverting the input signal using a mixer.

15. The method of claim **1**, wherein the passive filter rejects out-of-band signals.

16. The method of claim **1**, wherein the condition measurement is obtained, in part, from an antenna.

17. A wireless device for reducing power consumption on a wireless communication device, wherein the wireless device comprises a first stage active filter and a second stage active filter, the wireless device comprising:
- a processor;
- memory in electronic communication with the processor; and
- instructions stored in the memory, the instructions being executable by the processor to:
- obtain a condition measurement that comprises a signal condition measurement;
- determine if the condition measurement is above a threshold;
- bypass the second stage active filter if the condition measurement is above the threshold; and
- apply a passive filter after the second stage active filter if the condition measurement is above the threshold.

18. The wireless device of claim **17**, wherein the signal condition measurement is a wideband signal condition measurement.

19. The wireless device of claim **17**, wherein the condition measurement is an interference condition measurement.

20. The wireless device of claim **17**, wherein the condition measurement is a combined condition measurement based on a signal condition measurement and an interference condition measurement.

21. The wireless device of claim **17**, wherein the threshold is one of a signal threshold, an interference threshold, and a combined signal threshold.

22. The wireless device of claim **17**, wherein the second stage active filter comprises an active stage.

23. The wireless device of claim 22, wherein the instructions to bypass the second stage active filter further comprise instructions executable to:

disable power to the active stage; and

open a bypass circuit path to bypass the second stage active filter.

24. The wireless device of claim 23, wherein the instructions to open the bypass circuit path comprise instructions executable to close at least one bypass switch.

25. The wireless device of claim 17, further comprising instructions executable to:

obtain an input signal;

amplify the input signal at the first stage active filter; and

output a filtered signal.

26. The wireless device of claim 25, wherein the input signal is a differential input signal with an inverted signal and a non-inverted signal.

27. The wireless device of claim 26, further comprising instructions executable to apply a phase correction to the input signal if the condition measurement is above the threshold.

28. The wireless device of claim 27, wherein the instructions to apply the phase correction comprise instructions executable to cross over the inverted signal to be the non-inverted signal and cross over the non-inverted signal to be the inverted signal.

29. The wireless device of claim 25, further comprising instructions executable to bypass and disable power to at least one additional active filter if the condition measurement is above the threshold.

30. The wireless device of claim 25, further comprising instructions executable to:

amplify the input signal using a low-noise amplifier; and

downconvert the input signal using a mixer.

31. The wireless device of claim 17, wherein the passive filter rejects out-of-band signals.

32. The wireless device of claim 17, wherein the condition measurement is obtained, in part, from an antenna.

33. A non-transitory computer readable medium for reducing power consumption on a wireless communication device, wherein the wireless communication device comprises a first stage active filter and a second stage active filter, the computer-program product comprising a non-transitory computer-readable medium having instructions thereon, the instructions comprising:

code for causing a wireless communication device to obtain a condition measurement that comprises a signal condition measurement;

code for causing the wireless communication device to determine if the condition measurement is above a threshold;

code for causing the wireless communication device to bypass the second stage active filter if the condition measurement is above the threshold; and

code for causing the wireless communication device to apply a passive filter after the second stage active filter if the condition measurement is above the threshold.

34. The non-transitory computer readable medium of claim 33, wherein the second stage active filter comprises an active stage.

35. The non-transitory computer readable medium of claim 33, wherein the instructions for causing the wireless communication device to bypass the second stage active filter further comprise instructions for causing the wireless communication device to:

disable power to the active stage; and

open a bypass circuit path to bypass the second stage active filter.

36. The non-transitory computer readable medium of claim 35, wherein the instructions for causing the wireless communication device to open the bypass circuit path comprise instructions for causing the wireless communication device to close at least one bypass switch.

37. The non-transitory computer readable medium of claim 33, further comprising instructions for causing the wireless communication device to:

obtain an input signal;

amplify the input signal at the first stage active filter; and

output a filtered signal.

38. The non-transitory computer readable medium of claim 37, wherein the input signal is a differential input signal with an inverted signal and a non-inverted signal.

39. The non-transitory computer readable medium of claim 38, further comprising instructions for causing the wireless communication device to apply a phase correction to the input signal if the condition measurement is above the threshold.

40. The non-transitory computer readable medium of claim 39, wherein the instructions for causing the wireless communication device to apply the phase correction comprise instructions for causing the wireless communication device to cross over the inverted signal to be the non-inverted signal, and cross over the non-inverted signal to be the inverted signal.

41. An apparatus for reducing power consumption on a wireless communication device, wherein the wireless communication device comprises a first stage active filter and a second stage active filter, the apparatus comprising:

means for obtaining a condition measurement that comprises a signal condition measurement;

means for determining if the condition measurement is above a threshold;

means for bypassing the second stage active filter if the condition measurement is above the threshold; and

means for applying a passive filter after the second stage active filter if the condition measurement is above the threshold.

42. The apparatus of claim 41, wherein the second stage active filter comprises an active stage.

43. The apparatus of claim 41, wherein the means for bypassing the second stage active filter further comprise:

means for disabling power to the active stage; and

means for opening a bypass circuit path to bypass the second stage active filter.

44. The apparatus of claim 43, wherein the means for opening the bypass circuit path comprise means for closing at least one bypass switch.

45. The apparatus of claim 41, further comprising:

means for obtaining an input signal;

means for amplifying the input signal at the first stage active filter; and

means for outputting a filtered signal.

46. The apparatus of claim 45, wherein the input signal is a differential input signal with an inverted signal and a non-inverted signal.

47. The apparatus of claim 46, further comprising means for applying a phase correction to the input signal if the condition measurement is above the threshold.

48. The apparatus of claim 47, wherein the means for applying the phase correction comprise:

means for crossing over the inverted signal to be the non-inverted signal; and means for crossing over the non-inverted signal to be the inverted signal.

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