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JAMMING SIGNAL REJECTION

Abstract

An apparatus, including: a first radio-frequency (RF) receive chain comprising a first input; a second RF receive chain comprising a second input; a jamming rejection filter circuit comprising a first node; and a control circuit configured to selectively couple, via a first switch, the first node of the jamming rejection filter circuit to the first input of the first RF receive chain or to the second input of the second RF receive chain.

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Background/Summary

FIELD

[0001] Aspects of the present disclosure relate generally to rejecting a radio frequency (RF) signal that may otherwise jam a receiver and, more particularly, to jamming signal rejection technology in a wireless communication user equipment.

BACKGROUND

[0002] Wireless communication networks may provide various communication services such as telephony, video, data, messaging, broadcasts, and so on. Such networks may be multiple access networks that support communication for multiple users (e.g., where a user uses a device such as a user equipment (UE)) by sharing the available network resources. For example, each UE operating in a network may communicate with one or more network entities (e.g., base stations, access points, etc.) in the network.

SUMMARY

[0003] The following presents a simplified summary of one or more implementations in order to provide a basic understanding of such implementations. This summary is not an extensive overview of all contemplated implementations, and is intended to neither identify key or critical elements of all implementations nor delineate the scope of any or all implementations. Its sole purpose is to present some concepts of one or more implementations in a simplified form as a prelude to the more detailed description that is presented later.

[0004] An aspect of the disclosure relates to an apparatus. The apparatus includes: a first radio-frequency (RF) receive chain comprising a first input; a second RF receive chain comprising a second input; a jamming rejection filter circuit comprising a first node; and a control circuit configured to selectively couple, via a first switch, the first node of the jamming rejection filter circuit to the first input of the first RF receive chain or to the second input of the second RF receive chain.

[0005] Another aspect of the disclosure relates to a method for communication at an apparatus. The method includes: selectively coupling a first node of a jamming rejection filter circuit to a first input of a first radio frequency (RF) receive chain of the apparatus or to a second input of a second RF receive chain of the apparatus; and receiving at least one of a first signal based on a first radio access technology (RAT) via the first RF receive chain or a second signal based on a second RAT via the first RF receive chain.

[0006] Another aspect of the disclosure relates to an apparatus. The apparatus includes: means for selectively coupling a first node of a jamming rejection filter circuit to a first input of a first radio frequency (RF) receive chain of the apparatus or to a second input of a second RF receive chain of the apparatus; and means for receiving at least one of a first signal based on a first radio access technology (RAT) via the first RF receive chain or a second signal based on a second RAT via the first RF receive chain.

[0007] To the accomplishment of the foregoing and related ends, the one or more implementations include the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed drawings set forth in detail certain illustrative aspects of the one or more implementations. These aspects are indicative, however, of but a few of the various ways in which the principles of various implementations may be employed and the description implementations are intended to include all such aspects and their equivalents.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** illustrates an example wireless communication system in accordance with an aspect of the disclosure.

[0009] FIG. **2** illustrates an example communication system in accordance with another aspect of the disclosure.

[0010] FIG. **3** illustrates an example of associated transmit and receive chains in accordance with another aspect of the disclosure.

[0011] FIG. **4** illustrates an example of jamming rejection filter related circuitry in accordance with another aspect of the disclosure.
[0012] FIG. **5** illustrates another example of jamming rejection filter related circuitry in accordance with another aspect of the disclosure.
[0013] FIG. **6** illustrates an example receive chain of a primary path in accordance with another aspect of the disclosure.
[0014] FIG. **7** illustrates an example receive chain of a secondary path in accordance with another aspect of the disclosure.
[0015] FIG. **8** illustrates an example of jamming rejection filter related circuitry implemented with the receive chains of FIGS. **6** and **7** in accordance with another aspect of the disclosure.
[0016] FIG. **9** illustrates a block diagram of an example user equipment in accordance with another aspect of the disclosure.
[0017] FIG. **10** illustrates a flow diagram of an example jamming rejection method in accordance with another aspect of the disclosure.
[0018] FIG. **11** illustrates a flow diagram of another example jamming rejection method in accordance with another aspect of the disclosure.

DETAILED DESCRIPTION

[0019] The detailed description set forth below, in connection with the appended drawings, is intended as a description of various configurations and is not intended to represent the only configurations in which the concepts described herein may be practiced. The detailed description includes specific details for the purpose of providing a thorough understanding of the various concepts. However, it will be apparent to those skilled in the art that these concepts may be practiced without these specific details. In some instances, well-known structures and components are shown in block diagram form in order to avoid obscuring such concepts.

[0020] Various aspects of the disclosure relate to jamming signal rejection. In some examples, a user equipment that is operable within a wireless communication system may include jamming signal rejection functionality.

[0021] FIG. **1** illustrates an example wireless communication system **100** in accordance with an aspect of the disclosure. The wireless communication system **100** includes three interacting domains: a core network **102**, a radio access network (RAN) **104**, and a user equipment (UE) **106**. By virtue of the wireless communication system **100**, the UE **106** may be enabled to carry out data communication with an external data network **110**, such as (but not limited to) the Internet.

[0022] The UE **106** includes multiple transmit/receive chains (not shown) whereby the UE **106** may concurrently communicate with different network entities via the different transmit/receive chains. If one of the transmit chains is transmitting a first radio frequency (RF) signal when one of the receive chains is attempting to receive a second RF signal, the first RF signal transmitted by the transmit chain may interfere with (e.g., jam) the reception of the second RF signal at the receive chain.

[0023] To address this issue, the UE **106** may include jamming rejection functionality **122** that can attenuate so-called jamming RF signals that may otherwise adversely affect the receipt of desired RF signals at a receive chain of the UE **106**. For example, the jamming rejection functionality **122** (e.g., including a jamming rejection filter) may be selectively coupled to an input of one or more of the receive chains to attenuate a jamming RF signal.

[0024] The RAN **104** may implement any suitable wireless communication technology or technologies to provide radio access to the UE **106**. As one example, the RAN **104** may operate according to the European telecommunications standards institute (ETSI) global system for mobile communications (GSM) specifications. As another example, the RAN **104** may operate according to 3rd Generation Partnership Project (3GPP) New Radio (NR) specifications, often referred to as 5G. As a further example, the RAN **104** may operate under a hybrid of 5G NR and Evolved Universal Terrestrial Radio Access Network (eUTRAN) standards, often referred to as Long-Term

Evolution (LTE). The 3GPP refers to this hybrid RAN as a next-generation RAN, or NG-RAN. In another example, the RAN **104** may operate according to both the LTE and 5G NR standards. Of course, many other examples may be utilized within the scope of the present disclosure.

[0025] As illustrated, the RAN **104** includes a plurality of base stations **108**. Broadly, a base station is a type of network entity in a radio access network that is responsible for radio transmission and reception in one or more cells to or from a UE. In different technologies, standards, or contexts, a base station may variously be referred to by those skilled in the art as a base transceiver station (BTS), a radio base station, a radio transceiver, a transceiver function, a basic service set (BSS), an extended service set (ESS), an access point (AP), a Node B (NB), an eNode B (eNB), a gNode B (gNB), a transmission and reception point (TRP), a disaggregated base station, or some other suitable terminology. In some examples, a base station may include two or more TRPs that may be collocated or non-collocated. Each TRP may communicate on the same or different carrier frequency within the same or different frequency band. In examples where the RAN **104** operates according to both the LTE and 5G NR standards, one of the base stations **108** may be an LTE base station, while another base station may be a 5G NR base station.

[0026] The radio access network **104** supports wireless communication for multiple UEs or other apparatuses. A UE may also be referred to by those skilled in the art as a mobile station (MS), a subscriber station, a mobile unit, a subscriber unit, a wireless unit, a remote unit, a mobile device, a wireless device, a wireless communications device, a remote device, a mobile subscriber station, an access terminal (AT), a mobile terminal, a wireless terminal, a remote terminal, a handset, a terminal, a user agent, a mobile client, a client, or some other suitable terminology.

[0027] The term UE broadly refers to a diverse array of devices and technologies. UEs may include a number of hardware structural components sized, shaped, and arranged to help in communication; such components can include antennas, antenna arrays, RF chains, amplifiers, one or more processors, etc., electrically coupled to each other. For example, some non-limiting examples of a mobile apparatus include a mobile, a cellular (cell) phone, a smart phone, a session initiation protocol (SIP) phone, a laptop, a personal computer (PC), a notebook, a netbook, a smartbook, a tablet, a personal digital assistant (PDA), and a broad array of embedded systems, e.g., corresponding to an Internet of Things (IoT).

[0028] A UE may additionally be incorporated into or include an automotive or other transportation vehicle, a remote sensor or actuator, a robot or robotics device, a satellite radio, a global positioning system (GPS) device, an object tracking device, a remote control device, a consumer and/or wearable device, such as eyewear, a wearable camera, a virtual reality device, a smart watch, a health or fitness tracker, a digital audio player (e.g., MP3 player), a camera, a game console, etc. A UE may additionally be a digital home or smart home device such as a home audio, video, and/or multimedia device, an appliance, a vending machine, intelligent lighting, a home security system, a smart meter, etc. A UE may additionally be a smart energy device, a security device, a solar panel or solar array, a municipal infrastructure device controlling electric power (e.g., a smart grid), lighting, water, etc., an industrial automation and enterprise device, a logistics controller, agricultural equipment, etc. Still further, a UE may provide for connected medicine or telemedicine support, i.e., health care at a distance. Telehealth devices may include telehealth monitoring devices and telehealth administration devices, whose communication may be given preferential treatment or prioritized access over other types of information, e.g., in terms of prioritized access for transport of critical service data, and/or relevant QoS for transport of critical service data.

[0029] Wireless communication between the RAN **104** and the UE **106** may be described as utilizing an air interface. Transmissions over the air interface from a base station (e.g., base station **108**) to one or more UEs (e.g., the UE **106**) may be referred to as downlink (DL) transmission. In some examples, the term downlink may refer to a point-to-multipoint transmission originating at a base station (e.g., base station **108**). Another way to describe this point-to-multipoint transmission scheme may be to use the term broadcast channel multiplexing. Transmissions from a UE (e.g., UE **106**) to a base station (e.g., base station **108**) may be referred to as uplink (UL) transmissions. In some examples, the term uplink may refer to a point-to-point transmission originating at a UE (e.g., UE **106**).

[0030] In some examples, access to the air interface may be scheduled, wherein a scheduling entity (e.g., a base station **108**) of some other type of network entity allocates resources for communication among some or all devices and equipment within its service area or cell. Within the present disclosure, as discussed further below, the scheduling entity may be responsible for scheduling, assigning, reconfiguring, and releasing resources for one or more scheduled entities (e.g., UEs). That is, for scheduled communication, a plurality of UEs **106**, which may be scheduled entities, may utilize resources allocated by a scheduling entity (e.g., a base station **108**).

[0031] Base stations **108** are not the only entities that may function as scheduling entities. That is, in some examples, a UE may function as a scheduling entity, scheduling resources for one or more scheduled entities (e.g., one or more other UEs). For example, UEs may communicate with other UEs in a peer-to-peer or device-to-device fashion and/or in a relay configuration.

[0032] As illustrated in FIG. **1**, a base station **108** may broadcast downlink traffic **112** to one or more UEs (e.g., a UE **106**). Broadly, the base station **108** may be a node or device responsible for scheduling traffic in a wireless communication network, including the downlink traffic **112** and, in some examples, uplink traffic **116** and/or uplink control information **118** from one or more scheduled entities to the scheduling entity. In addition, the base station **108** may be a node or device that receives downlink control information **114**, including but not limited to scheduling information (e.g., a grant), synchronization or timing information, or other control information from another entity in the wireless communication network such as the scheduling entity.

[0033] The uplink control information **118**, downlink control information **114**, downlink traffic **112**, and/or uplink traffic **116** may be time-divided into frames, subframes, slots, and/or symbols. As used herein, a symbol may refer to a unit of time that, in an orthogonal frequency division multiplexed (OFDM) waveform, carries one resource element (RE) per sub-carrier. A slot may carry a certain number of OFDM symbols in some examples.

[0034] A subframe may refer to a specified duration (e.g., 1 millisecond (ms)). Multiple subframes or slots may be grouped together to form a single frame or radio frame. Within the present disclosure, a frame may refer to a predetermined duration (e.g., 10 ms) for wireless transmissions, with each frame consisting of, for example, 10 subframes of 1 ms each. Of course, these definitions are not required, and any suitable scheme for organizing waveforms may be utilized, and various time divisions of the waveform may have any suitable duration.

[0035] In general, each base station **108** may include a backhaul interface for communication with a backhaul **120** of the wireless communication system. The backhaul **120** may provide a link between a base station **108** and the core network **102**. Further, in some examples, a backhaul network may provide interconnection between respective base stations **108**. Various types of backhaul interfaces may be employed, such as a direct physical connection, a virtual network, or the like using any suitable transport network.

[0036] The core network **102** may be a part of the wireless communication system **100**, and may be independent of the radio access technology used in the RAN **104**. In some examples, the core network **102** may be configured according to an ETSI standard, a 3GPP standard, or any other suitable standard or configuration.

[0037] FIG. **2** illustrates an example communication system **200** in accordance with another aspect of the disclosure. The communication system **200** includes a UE **202** that may communicate with one or more base stations **204** and/or one or more access points **206**. In some examples, each of the base stations **204** may support cellular communication using ETSI-defined technology, 3GPP-defined technology, or some other similar technology (e.g., as discussed above). In some examples, each of the access points **206** may support Wi-Fi communication using Institute of Electrical and

Electronics Engineers (IEEE) 802.11-based technology (e.g., 802.11a, 802.11b, 802.11g, 802.11n, etc.).
[0038] The UE **202** includes a first transmit/receive chain **208** and a second transmit/receive chain **210** that may operate concurrently. FIG. **3** illustrates an example of associated transmit and receive chains **300** in accordance with another aspect of the disclosure. Other types of transmit chains and/or receive chains may be used as well.
[0039] An RF transmit chain **302** includes a digital-to-analog converter (DAC) **304** that converts information to be transmitted to an analog signal. A filter **306** filters the analog signal to provide a filtered signal to a mixer **308**. The mixer **308** upconverts the filtered signal based on a signal **310** from a local oscillator (LO) **312**. An amplifier **314** amplifies the upconverted signal and provides an output signal to a radio frequency front end (RFFE) module (not shown) for transmission via an antenna (e.g., an antenna array, not shown).
[0040] An RF receive chain **316** includes a low-noise amplifier (LNA) **318** that amplifies a signal that was received by the RFFE module via the antenna. A mixer **320** down-converts the amplified signal based on a signal **322** from the local oscillator **312**. A low-pass filter **324** filters the down-converted signal and an analog-to-digital converter (ADC) **326** converts the analog filtered signal to a digital signal to enable further processing (e.g., decoding) of the received signal.
[0041] Referring again to FIG. **2**, in some examples, the UE **202** may be configured to communicate with different base stations (e.g., two of the base stations **204**) via a primary path and a secondary (e.g., diversity) path. In this case, the UE **202** may use the first transmit/receive chain **208** to communicate via the primary path and use the second transmit/receive chain **210** to communicate via the secondary path.
[0042] As another example, the UE **202** may be configured to communicate with a base station (e.g., one of the base stations **204**) via a cellular path and communicate with an access point (e.g., one of the access points **206**) via a Wi-Fi path. In this case, the UE **202** may use the first transmit/receive chain **208** to communicate via the Wi-Fi path and use the second transmit/receive chain **210** to communicate via the cellular path.
[0043] In some examples, the UE **202** may use Wi-Fi communication to supplement the services provided by cellular communication. For example, the UE **202** may use Wi-Fi communication to acquire over-the-air (OTA) updates, to transmit and/or receive data streams, to determine the position of the UE **202** or other devices, or for other purposes.
[0044] As a specific example, a UE implemented as an Internet of Things (IoT) device may use Wi-Fi communication to achieve sub-1 meter positioning accuracy.
[0045] Conventionally, UEs (e.g., cell phones, IoT devices, etc.) and base stations may use different radio frequency integrated circuits (RFICs) to provide OTA updates, data streaming, and positioning information than are used for cellular communication. The disclosure relates in some aspects to providing Wi-Fi and cellular functionality on the same RFIC (e.g., on the same integrated circuit die). In this way, material cost and/or device size may be reduced.
[0046] In an implementation where Wi-Fi functionality and cellular functionality are implemented on the same integrated circuit die (hereafter, simply die), the transmitter and receiver components of these different radio access technologies (RATs) may be relatively close to one another. In this case, Wi-Fi signal transmissions that occur when a cellular receiver is attempting to receive signals may interfere with the receive operations at the cellular receiver. Similarly, cellular signal transmissions that occur when a Wi-Fi receiver is attempting to receive signals may interfere with the receive operations at the Wi-Fi receiver.
[0047] Some wireless communication standards dictate that certain signal rejection requirements are to be met when cellular functionality and Wi-Fi functionality are implemented in proximity. For example, out-of-band (OOB) blocking test cases specified by 3GPP (e.g., TS 34.121 v6.3.0, section 6.5) define rejection requirements that may be used for cellular and Wi-Fi convergence.
[0048] The disclosure relates in some aspects to signal rejection techniques that may be used at one

or both of these receivers to mitigate interference from a nearby transmitter (e.g., and thereby meet any applicable rejection performance requirement). For example, a UE may apply signal rejection for Industrial, Scientific, and Medical (ISM) frequency bands in the range of 2.4 GHz-2.5 GHz and 5.725 GHz-5.875 GHz used for Wi-Fi communication since these frequencies are close to some of the bands used in cellular communication. A UE may apply signal rejection for other frequency ranges as well.

[0049] FIG. **4** illustrates an example of jamming rejection filter related circuitry **400** in accordance with another aspect of the disclosure. In FIG. **4**, a first receive chain **402** (e.g., an RF receive chain for a secondary path) receives an RF signal via a first input **404** and a second receive chain **406** (e.g., an RF receive chain for a primary path) receives an RF signal via a second input **408**.

[0050] A control circuit **410** controls (e.g., via a signal **412**) a first switch **414** (e.g., an RF switch matrix) to selectively couple a first node **416** of a jamming rejection filter circuit **418** to the first input **404** of the first receive chain **402** or to the second input **408** of the second receive chain **406**. Thus, in this case, the jamming rejection filter circuit **418** is shared between the first receive chain **402** and the second receive chain **406**. In some examples, this selective coupling is based on a condition (e.g., which transmit chain of a set of transmit chains is currently transmitting and/or which receive chain of a set of receive chains is currently receiving).

[0051] For example, when a first transmit chain (not shown) associated with the first receive chain **402** is transmitting a first RF signal (e.g., for cellular communication), the control circuit **410** controls the first switch **414** to couple, via a signal path **420**, the first node **416** of the jamming rejection filter circuit **418** to the second input **408** of the second receive chain **406**. In this case, the jamming rejection filter circuit **418** will attenuate the first RF signal at the second input **408**, thereby facilitating concurrent operation of the first transmit chain **402** (e.g., which may be transmitting a cellular signal) and the second receive chain **406** (e.g., which may be receiving a Wi-Fi signal).

[0052] Conversely, when a second transmit chain (not shown) associated with the second receive chain **406** is transmitting a second RF signal (e.g., for Wi-Fi communication), the control circuit **410** controls the first switch **414** to couple, via a signal path **422**, the first node **416** of the jamming rejection filter circuit **418** to the first input **404** of the first receive chain **402**. In this case, the jamming rejection filter circuit **418** will attenuate the second RF signal at the first input **404**, thereby facilitating concurrent operation of the second transmit chain **406** (e.g., which may be transmitting a Wi-Fi signal) and the first receive chain **402** (e.g., which may be receiving a cellular signal).

[0053] It should be appreciated that the control circuit **410** may dynamically control the first switch **414**. For example, for one period time, the control circuit **410** controls the first switch **414** to couple the first node **416** of the jamming rejection filter circuit **418** to the first input **404**, for another period of time, the control circuit **410** controls the first switch **414** to couple the first node **416** of the jamming rejection filter circuit **418** to the second input **408**, and so on.

[0054] In some examples, the selective coupling condition referred to above may relate to whether a jamming signal has been detected at an input of a receive chain. For example, the control circuit **410** may determine whether a jamming signal is present at an input of a receive chain based on signals received by that receive chain (e.g., based on ADC clipping of I,Q samples received by the receive chain). In the event a jamming signal is detected at a particular input, the control circuit **410** may control the first switch **414** to couple the first node **416** of the jamming rejection filter circuit **418** to that input.

[0055] Jamming rejection filter related circuitry may take different forms in different examples. Several examples of such circuitry are discussed in FIGS. **5-8** below. Other forms of jamming rejection filter related circuitry may be used in other examples.

[0056] FIG. **5** illustrates another example of jamming rejection filter related circuitry **500** in accordance with another aspect of the disclosure. The jamming rejection filter related circuitry **500** includes the jamming rejection filter related circuitry **400** of FIG. **4** as well as other circuitry for selectively coupling different local oscillators to the jamming rejection filter circuit **418**.

[0057] FIG. **5** also illustrates an example implementation of the jamming rejection filter circuit **418**. The jamming rejection filter circuit **418** may take different forms in other examples.

[0058] The jamming rejection filter circuit **418** includes a jamming rejection filter **502** and a coupler **504** for coupling an input signal to the jamming rejection filter **502**. The jamming rejection filter **502** includes a mixer **506** and a low pass filter **508** that will be shunted across a receive chain input when the first node **416** is coupled to that receive chain input.

[0059] The jamming rejection filter **502** provides a frequency response as shown in the graph **510**. As indicated, the jamming rejection filter **502** has a relatively high impedance (Z) at in-band (IB) frequencies **512** (e.g., frequencies corresponding to a frequency band allocated for communication signals such as a cellular signals or Wi-Fi signals that are to be received by the first receive chain **402** or the second receive chain **406**) and a relatively low impedance at out-of-band (OoB) frequencies **514** (e.g., frequencies that are higher or lower than the in-band frequencies). Consequently, when the first node **416** of the jamming rejection filter circuit **418** is coupled to an input of a receive chain, the jamming rejection filter **502** will have a negligible impact on IB signals at the input to the receive chain due to the high impedance shunted across the input at these IB frequencies. In contrast, the jamming rejection filter **502** will attenuate (reject) GoB signals at the input to the receive chain due to the low impedance shunted across the input at these OoB frequencies.

[0060] Typically, different types of RATs (e.g., cellular, Wi-Fi, etc.) will use different frequency bands. As discussed above, however, the frequency bands used by different RATs may be relatively close to one another in some cases, potentially resulting in jamming (e.g., in a cellular and Wi-Fi convergence scenario). To mitigate this jamming, the IB frequency range of the jamming rejection filter **502** may be set based on the IB frequency range of a receive chain that is subject to jamming. Here, the jamming rejection filter **502** will have negligible effect on signals at these IB frequencies (e.g., received signals associated with a first RAT) while attenuating signals at the OoB frequencies (e.g., transmitted signals associated with a second RAT).

[0061] In the example of FIG. **5**, the IB range of the jamming rejection filter **502** is set based on the frequency of a local oscillator used by the receive chain subject to jamming. The IB range of the jamming rejection filter **502** may be set in other ways in other examples.

[0062] When the control circuit **410** controls the first switch **414** to couple the first node **416** of the jamming rejection filter circuit **418** to the first input **404** (to mitigate jamming at the first receive chain **402**), the control circuit **410** also controls a second switch **516** (e.g., via a signal **518**) to couple a first local oscillator **520** of the first receive chain **402** to a second node **522** of the jamming rejection filter circuit **418**. As shown in FIG. **5**, the second node **522** is coupled to the mixer **506**. Thus, the frequency characteristics of the jamming rejection filter **502** will be based on the frequency of the first local oscillator **520**. The IB range of the jamming rejection filter **502** may thereby be configured to correspond to the IB range associated with the particular signal expected to be received by the first receive chain **402**. For example, the jamming rejection filter **502** may be calibrated for desired characteristics (e.g., IB flatness, gain, noise figure, residual sideband (RSB), linearity, etc.) at the corresponding IB frequencies currently being used by the first receive chain **402**.

[0063] Alternatively, when the control circuit **410** controls the first switch **414** to couple the first node **416** of the jamming rejection filter circuit **418** to the second input **408** (to mitigate jamming at the second receive chain **406**), the control circuit **410** also controls the second switch **516** (e.g., via the signal **518**) to couple a second local oscillator **524** of the second receive chain **406** to the second node **522** of the jamming rejection filter circuit **418**. Thus, the frequency characteristics of the jamming rejection filter **502** will be based on the frequency of the second local oscillator **524** in this case. The IB range of the jamming rejection filter **502** may thereby correspond to the IB range associated with the particular signal expected to be received by the second receive chain **406**. In this case, the jamming rejection filter **502** may be calibrated for desired characteristics (e.g., IB flatness, gain, noise figure, residual sideband (RSB), linearity, etc.) at the corresponding IB frequencies currently being used by the second receive chain **406**.

[0064] In some examples, a jamming rejection filter may be used in an apparatus that includes a primary path (including a first receive chain and a first transmit chain) and a secondary (e.g., diversity) path (including a second receive chain and a second transmit chain). Here, the secondary path may be used for cellular communication only, while the primary path may be used for cellular communication at some times and for Wi-Fi communication at other times. For example, in some scenarios, the primary path may be used for a cellular primary component carrier, while the secondary path may be used for a cellular secondary component carrier, where the two paths may operate concurrently. As another example, in some scenarios, the primary path may be used for Wi-Fi communication, while the secondary path may be used for cellular communication, where the two paths may operate concurrently.

[0065] FIG. **6** illustrates an example RF receive chain **600** of a primary path in accordance with another aspect of the disclosure. As mentioned above, the RF receive chain **600** may be used to receive cellular signals or Wi-Fi signals.

[0066] Similar to the RF receive chain **316** of FIG. **3**, the RF receive chain **600** includes an LNA **602** that amplifies a received signal, a mixer **604** that down-converts the amplified signal based on a signal from a local oscillator (LO) **606**, and low-pass filter circuitry **608** that filters the down-converted signal. As discussed above, the filtered signal is provided to an ADC (not shown in FIG. **6**) that converts the analog filtered signal to a digital signal to enable further processing (e.g., decoding) of the received signal.

[0067] FIG. **7** illustrates an example RF receive chain **700** of a secondary path in accordance with another aspect of the disclosure. As mentioned above, the RF receive chain **700** may be used to receive cellular signals.

[0068] The RF receive chain **700** includes a set of LNAs **702** for amplifying signals received on different frequency bands. A first LNA **704** is configured to amplify received low band (LB) signals (e.g., the output of the first LNA **704** corresponds to an LB path **706**). A second LNA **708** is configured to amplify received mid band (MB) signals (e.g., the output of the second LNA **708** corresponds to an MB path **710**). A third LNA **712** is configured to amplify received high band (HB) signals (e.g., the output of the third LNA **712** corresponds to an HB path **714**). A fourth LNA **716** is configured to amplify signals received on an unlicensed (UNA) band (e.g., the output of the fourth LNA **716** corresponds to a UNA path **718**).

[0069] The RF receive chain **700** also includes a set of switches **720** for coupling one of the LB path **706**, the MB path **710**, the HB path **714**, or the UNA path **718** to an input of a mixer circuit **724**. When the RF receive chain **700** is configured (e.g., by processing circuitry of a UE that includes the RF receive chain **700**) to process signals received on LB frequencies, a first switch **726** is closed to couple the output of the first LNA **704** to the mixer circuit **724**. When the RF receive chain **700** is configured to process signals received on MB frequencies, a second switch **728** is closed to couple the output of the second LNA **708** to the mixer circuit **724**. When the RF receive chain **700** is configured to process signals received on HB frequencies, a third switch **730** is closed to couple the output of the third LNA **712** to the mixer circuit **724**. When the RF receive chain **700** is configured to process signals received on unlicensed frequencies, a fourth switch **732** is closed to couple the output of the fourth LNA **716** to the mixer circuit **724**.

[0070] The mixer circuit **724** down-converts a received amplified signal based on signals from a local oscillator (LO) circuit **734**. In the example of FIG. **7**, the mixer circuit **724** receives a first LO signal **736** and a second LO signal **738** from the LO circuit **734**.

[0071] Low-pass filter circuitry **740** filters the down-converted signal output by the mixer circuit **724**. As discussed above, the filtered signal is provided to an ADC (not shown in FIG. **7**) that converts the analog filtered signal to a digital signal to enable further processing (e.g., decoding) of the received signal.

[0072] FIG. **8** illustrates an example of jamming rejection filter related circuitry implemented with the RF receive chain **600** of the primary path of FIG. **6** and the RF receive chain **700** of the secondary path of FIG. **7** in accordance with another aspect of the disclosure. Specifically, FIG. **8** illustrates a portion **600***a* of the RF receive chain **600**, a portion **700***a* of the RF receive chain **700**, along with a jamming rejection filter circuit **802**, a control circuit **804**, a first switch **806**, and a second switch **808**. The jamming rejection filter circuit **802** may correspond at least in some aspects to the jamming rejection filter circuit **418** of FIG. **5**. The jamming rejection filter circuit **802** includes a first node **810** (e.g., corresponding to the first node **416** of FIG. **5**) and a second node **812** (e.g., corresponding to the second node **522** of FIG. **5**). The control circuit **804** may correspond at least in some aspects to the control circuit **410** of FIG. **5**. The first switch **806** may correspond at least in some aspects to the first switch **414** of FIG. **5**. The second switch **808** may correspond at least in some aspects to the second switch **516** of FIG. **5**.

[0073] The jamming rejection filter circuit **802** is shared between the primary path and the secondary path (e.g., a diversity path), thereby reducing jamming interference when the primary path and the secondary path are operated simultaneously (e.g., for Wi-Fi communication and cellular communication concurrency).

[0074] Under the control of the control circuit **804**, the first switch **806** and the second switch **808** cause the jamming rejection filter circuit **802** to be coupled to either the primary path (e.g., Wi-Fi path) or the secondary (e.g., diversity) cellular path (e.g., based on operating conditions). As shown in FIG. **8**, the first switch (e.g., an RF switch matrix) is configurable to couple the first node **810** of the jamming rejection filter circuit **802** to the primary path or the second path. Specifically, the first switch is configurable to couple the first node **810** of the jamming rejection filter circuit **802** to the LB path **706** via connection A, to the MB path **710** via connection B, to the HB path **714** via connection C, to the UNA path **718** via connection D, or to the primary path via connection E. To reduce the complexity of FIG. **8**, only the endpoints of connections A, B, C, D, and E are illustrated.

[0075] When the control circuit **804** configures the first switch **806** to couple the first node **810** of the jamming rejection filter circuit **802** to the primary path (e.g., via connection E), the control circuit **804** may also configure the second switch **808** to couple the LO **606** of the primary path to the second node **812** of the jamming rejection filter circuit **802** (e.g., by closing switch SW**2**). Thus, the output of the LO **606** is provided to the mixer (not shown) of the jamming rejection filter circuit **802**.

[0076] When the control circuit **804** configures the first switch **806** to couple the first node **810** of the jamming rejection filter circuit **802** to the second path (e.g., via any one of connections A, B, C, or D), the control circuit **804** may also configure the second switch **808** to couple the LO circuit **734** of the secondary path to the second node **812** of the jamming rejection filter circuit **802** (e.g., by closing switch SW**1**). Thus, the output of the LO circuit **734** is provided to the mixer of the jamming rejection filter circuit **802**.

[0077] In view of the above, when the jamming rejection filter circuit **802** is coupled to an input of a receive chain, based on the frequency of the LO provided to the jamming rejection filter circuit **802**, the jamming rejection filter circuit **802** exhibits a band pass response since it provides a high impedance path to in-band frequencies and a low impedance path to out-of-band frequencies, thereby creating additional rejection at the front end of the receive chain for the unwanted out-of-band frequencies. In some examples, high bands such as cellular bands B7, 42, 41, 40 may particularly benefit from this rejection since these bands are close to the 2.4 GHz ISM band that may be used for Wi-Fi communication. Thus, in some aspects, this approach may be used for high band paths or other paths to relax the filter rejection requirements and enable the use of Wi-Fi RF circuitry and cellular RF circuitry on the same die.

[0078] As mentioned above, a control circuit may selectively invoke the coupling of a jamming filter rejection circuit to an input of a receive chain based on a condition. Several examples of such conditions follow. Other conditions may be used in other examples.
[0079] Some conditions may relate to a scenario where different transceivers that are implemented on the same die are operating concurrently. For example, a first transceiver may be transmitting and receiving Wi-Fi signals (e.g., via a primary path) while a second transceiver is also transmitting and receiving cellular signals (e.g., via a diversity path). Three examples of conditions that may apply in such a scenario follow.
[0080] A first condition involves the transmit chain of the first transceiver transmitting Wi-Fi signals at maximum power. In this case, the receive chain of the first transceiver may be idled (e.g., shut off). In addition, the control circuit may enable the jamming rejection filter circuitry for (e.g., couple the jamming rejection filter circuitry to) the receive chain of the second transceiver (cellular diversity RX). In some examples, the control circuit may enable the jamming rejection filter circuitry for the receive chain of the second transceiver after detecting jamming signals at the receive chain of the second transceiver (e.g., where the detection is based on clipping of received I,Q samples).
[0081] A second condition involves the transmit chain of the second transceiver transmitting cellular signals at maximum power. In this case, the control circuit may enable the jamming rejection filter circuitry for the receive chain of the first transceiver (Wi-Fi RX). In some examples, the control circuit may enable the jamming rejection filter circuitry for the receive chain of the first transceiver after detecting jamming signals at the receive chain of the first transceiver. For the second condition, the Wi-Fi TX power may also be reduced to mitigate interference at the receive chain of the second transceiver. For example, sensitivity at the cellular receive chain may be more important than throughput.
[0082] A third condition relates to a scenario where the transmit chains of both transceivers are initially configured to transmit at maximum power (maximum cellular TX power and maximum Wi-Fi TX power). In this case, cellular communication is given priority for enhanced performance. For example, since downloads can happen at reduced throughputs while a cellular call is ongoing, the Wi-Fi TX power is adjusted to avoid jamming the cellular receive chain.
[0083] Some conditions may relate to a scenario where only one transceiver is currently operating (e.g., transmitting and/or receiving). Two examples of conditions that may apply in such a scenario follow.
[0084] A first condition involves active Wi-Fi communication and no cellular communication. In this case, jamming rejection for the Wi-Fi path may be enabled to relax the front-end filter requirements for the Wi-Fi path.
[0085] A second condition involves active cellular communication and no Wi-Fi communication. In this case, jamming rejection for the cellular path may be enabled to relax the front-end filter requirements for the cellular path.
[0086] FIG. **9** illustrates a block diagram of an example user equipment **900** in accordance with another aspect of the disclosure. The user equipment **900** may be a device configured to wirelessly communicate in a network as discussed in FIGS. **1** and **2**. The user equipment **900** may correspond to any of the UEs (e.g., IoT devices, cell phones, etc.) described herein. The user equipment **900** may incorporate some or all of the functionality described above in connection with FIGS. **3-8**.
[0087] In accordance with various aspects of the disclosure, an element, or any portion of an element, or any combination of elements may be implemented with the processing system **914**. The processing system **914** may include one or more processors (referred to herein as the processor **904**, for convenience). Examples of processors **904** include microprocessors, microcontrollers, digital signal processors (DSPs), field programmable gate arrays (FPGAs), programmable logic devices (PLDs), state machines, gated logic, discrete hardware circuits, and other suitable hardware configured to perform the various functionality described throughout this disclosure. In various

examples, the user equipment **900** may be configured to perform any one or more of the functions described herein. That is, the processor **904**, as utilized in an user equipment **900**, may be used to implement any one or more of the processes and procedures described herein.

[0088] The processor **904** may in some instances be implemented via a baseband or modem chip and in other implementations, the processor **904** may itself include a number of devices distinct and different from a baseband or modem chip (e.g., in such scenarios these devices may work in concert to achieve examples discussed herein). And as mentioned above, various hardware arrangements and components outside of a baseband modem processor can be used in implementations, including RF-chains, power amplifiers, modulators, buffers, interleavers, adders/summers, etc.

[0089] In this example, the processing system **914** may be implemented with a bus architecture, represented generally by the bus **902**. The bus **902** may include any number of interconnecting buses and bridges depending on the specific application of the processing system **914** and the overall design constraints. The bus **902** communicatively couples together various circuits including one or more processors (represented generally by the processor **904**), one or more memories (referred to herein as the memory **905**, for convenience), and one or more computer-readable media (represented generally by the computer-readable medium **906**). The bus **902** may also link various other circuits such as timing sources, peripherals, voltage regulators, and power management circuits, which are well known in the art, and therefore, will not be described any further. A bus interface **908** provides an interface between the bus **902**, a transceiver **910** and an antenna array **920** and between the bus **902** and an interface **930**. The transceiver **910** provides a communication interface or means for communicating with various other apparatus over a wireless transmission medium. The interface **930** provides a communication interface or means of communicating with various other apparatuses and devices (e.g., other devices housed within the same apparatus as the user equipment **900** or other external apparatuses) over an internal bus or external transmission medium, such as an Ethernet cable. Depending upon the nature of the apparatus, the interface **930** may include a user interface (e.g., keypad, display, speaker, microphone, joystick). Of course, such a user interface is optional, and may be omitted in some examples, such as an IoT device.

[0090] As shown in FIG. **9**, the transceiver **910** may include multiple RF chains (e.g., each of which includes a transmit chain and a receive chain). For example, the transceiver **910** may include a primary chain **912** for a primary path and a secondary chain for a secondary path. In addition, the transceiver **910** may include shared jamming rejection circuitry **916** for selectively rejecting jamming signals at the receive chains of the primary chain **912** and the secondary chain **913**. In some examples, the primary chain **912**, the secondary chain **913**, and the jamming rejection circuitry **916** may be implemented on the same die.

[0091] In some examples, a first RF transmit chain is configured to transmit a first signal based on a first radio access technology (RAT) and an associated first RF receive chain is configured to receive a second signal based on the first RAT. In some examples, a second RF transmit chain is configured to transmit a third signal based on the second RAT and an associated second RF receive chain is configured to receive a fourth signal based on the second RAT. In some examples, the first RAT may be a cellular technology and the second RAT may be Wi-Fi technology.

[0092] The processor **904** is responsible for managing the bus **902** and general processing, including the execution of software stored on the computer-readable medium **906**. The software, when executed by the processor **904**, causes the processing system **914** to perform the various functions described below for any particular apparatus. The computer-readable medium **906** and the memory **905** may also be used for storing data that is manipulated by the processor **904** when executing software. For example, the memory **905** may store configuration information **915** (e.g., filter parameters) used by the processor **904** for the communication operations described herein.

[0093] One or more processors **904** in the processing system may execute software. Software shall be construed broadly to mean instructions, instruction sets, code, code segments, program code, programs, subprograms, software modules, applications, software applications, software packages, routines, subroutines, objects, executables, threads of execution, procedures, functions, etc., whether referred to as software, firmware, middleware, microcode, hardware description language, or otherwise. The software may reside on a computer-readable medium **906**.

[0094] The computer-readable medium **906** may be a non-transitory computer-readable medium. A non-transitory computer-readable medium includes, by way of example, a magnetic storage device (e.g., hard disk, floppy disk, magnetic strip), an optical disk (e.g., a compact disc (CD) or a digital versatile disc (DVD)), a smart card, a flash memory device (e.g., a card, a stick, or a key drive), a random access memory (RAM), a read only memory (ROM), a programmable ROM (PROM), an erasable PROM (EPROM), an electrically erasable PROM (EEPROM), a register, a removable disk, and any other suitable medium for storing software and/or instructions that may be accessed and read by a computer. The computer-readable medium **906** may reside in the processing system **914**, external to the processing system **914**, or distributed across multiple entities including the processing system **914**. The computer-readable medium **906** may be embodied in a computer program product. By way of example, a computer program product may include a computer-readable medium in packaging materials. Those skilled in the art will recognize how best to implement the described functionality presented throughout this disclosure depending on the particular application and the overall design constraints imposed on the overall system.

[0095] The user equipment **900** may be configured to perform one or more of the operations described herein (e.g., as described above in conjunction with FIGS. **1-8** and as described below in conjunction with FIGS. **10** and **11**). In some aspects of the disclosure, the processor **904**, as utilized in the user equipment **900**, may include circuitry configured for various functions.

[0096] In some aspects of the disclosure, the processor **904** may include communication and processing circuitry **941**. The communication and processing circuitry **941** may be configured to communicate with a network entity (e.g., a base station and/or an access point). The communication and processing circuitry **941** may include one or more hardware components that provide the physical structure that performs various processes related to communication (e.g., signal reception and/or signal transmission) as described herein. The communication and processing circuitry **941** may further include one or more hardware components that provide the physical structure that performs various processes related to signal processing (e.g., processing a received signal and/or processing a signal for transmission) as described herein. The communication and processing circuitry **941** may further be configured to execute communication and processing software **951** included on the computer-readable medium **906** to implement one or more functions described herein.

[0097] In some implementations where the communication involves receiving information, the communication and processing circuitry **941** may obtain information from a component of the user equipment **900** (e.g., from the transceiver **910** that receives the information via radio frequency signaling or some other type of signaling suitable for the applicable communication medium), process (e.g., decode) the information, and output the processed information. For example, the communication and processing circuitry **941** may output the information to another component of the processor **904**, to the memory **905**, or to the bus interface **908**. In some examples, the communication and processing circuitry **941** may receive one or more of signals, messages, other information, or any combination thereof. In some examples, the communication and processing circuitry **941** may receive information via one or more channels. In some examples, the communication and processing circuitry **941** may receive one or more of signals, messages, SCIs, feedback, other information, or any combination thereof. In some examples, the communication and processing circuitry **941** and/or the transceiver **910** may include functionality for a means for receiving. In some examples, the communication and processing circuitry **941** may include functionality for a means for decoding. In some examples, the communication and processing

circuitry **941** may include functionality for a means for receiving information from a network entity.
[0098] In some implementations where the communication involves sending (e.g., transmitting) information, the communication and processing circuitry **941** may obtain information (e.g., from another component of the processor **904**, the memory **905**, or the bus interface **908**), process (e.g., encode) the information, and output the processed information. For example, the communication and processing circuitry **941** may output the information to the transceiver **910** (e.g., that transmits the information via radio frequency signaling or some other type of signaling suitable for the applicable communication medium). In some examples, the communication and processing circuitry **941** may send one or more of signals, messages, other information, or any combination thereof. In some examples, the communication and processing circuitry **941** may send information via one or more channels. In some examples, the communication and processing circuitry **941** may send one or more of signals, messages, SCIs, feedback, other information, or any combination thereof. In some examples, the communication and processing circuitry **941** and/or the transceiver **910** may include functionality for a means for transmitting. In some examples, the communication and processing circuitry **941** may include functionality for a means for encoding. In some examples, the communication and processing circuitry **941** may include functionality for a means for transmitting information to a network entity.
[0099] The processor **904** may include jamming rejection configuration circuitry **942** configured to perform jamming rejection configuration-related operations as discussed herein. The jamming rejection configuration circuitry **942** may be configured to execute jamming rejection configuration software **952** included on the computer-readable medium **906** to implement one or more functions described herein.
[0100] The jamming rejection configuration circuitry **942** may include functionality for a means for configuring a jamming rejection filter. For example, the jamming rejection configuration circuitry **942** may configure operating characteristics of a jamming rejection filter.
[0101] The processor **904** may include jamming rejection control circuitry **943** configured to perform jamming rejection control-related operations as discussed herein. The jamming rejection control circuitry **943** may be configured to execute jamming rejection control software **953** included on the computer-readable medium **906** to implement one or more functions described herein. In some examples, the jamming rejection control circuitry **943** may provide at least some of the functionality of the control circuit **410** of FIG. **4** and/or the control circuit **804** of FIG. **8**.
[0102] The jamming rejection control circuitry **943** may include functionality for a means for performing a jamming rejection control operation. For example, the jamming rejection control circuitry **943** may include functionality for a means for controlling at least one switch (e.g., generating signals to control a first switch and a second switch).
[0103] The jamming rejection control circuitry **943** may include functionality for a means for performing selectively coupling. For example, the jamming rejection control circuitry **943** may be configured to selectively couple, via a first switch, the first node of the jamming rejection filter to the first input of the first RF receive chain or to the second input of the second RF receive chain. As another example, the jamming rejection control circuitry **943** may be configured to selectively couple, via a second switch, a second node of the jamming rejection filter to the first oscillator or to the second oscillator.
[0104] The jamming rejection control circuitry **943** may include functionality for a means for detecting a condition. For example, the jamming rejection control circuitry **943** may include a means for detecting that is configured to process received signal data to determine whether jamming signals are present at an input of a receive chain.
[0105] FIG. **10** illustrates a flow diagram of an example method in accordance with another aspect of the disclosure. As described below, some or all illustrated features may be omitted in a particular implementation within the scope of the present disclosure, and some illustrated features may not be

required for implementation of all examples. In some examples, the method **1000** (e.g., a method for wireless communication) may be carried out by the user equipment **900** illustrated in FIG. **9**, or another wireless communication device. In some examples, the method **1000** may be carried out by any suitable apparatus or means for carrying out the functions or algorithm described herein.

[0106] At block **1002**, an apparatus (e.g., the user equipment **900** or another apparatus) may selectively couple a first node of a jamming rejection filter to a first input of a first radio frequency (RF) receive chain of the apparatus or to a second input of a second RF receive chain of the apparatus. Example means for selectively coupling may include any of the control circuits, switches, or related circuitry described herein. For example, the jamming rejection control circuitry **943** may control a switch to selectively couple a first node of a jamming rejection filter to a first input of a first radio frequency (RF) receive chain of the apparatus or to a second input of a second RF receive chain of the apparatus.

[0107] At block **1004**, the apparatus may receive at least one of a first signal based on a first radio access technology (RAT) via the first RF receive chain or a second signal based on a second RAT via the first RF receive chain. Example means for receiving may include any of the receive chains, receive paths, RF circuitry, or related circuitry described herein. For example, the communication and processing circuitry **941** and/or the transceiver **910** may receive at least one of a first signal based on a first radio access technology (RAT) via the first RF receive chain or a second signal based on a second RAT via the first RF receive chain.

[0108] In some examples, the apparatus may include a first oscillator associated with the first RF receive chain and a second oscillator associated with the second RF receive chain. In some examples, the apparatus may selectively couple, via a second switch, a second node of the jamming rejection filter to the first oscillator or to the second oscillator.

[0109] In some examples, the apparatus may couple the first node of the jamming rejection filter circuit to the first input of the first RF receive chain and couple a second node of the jamming rejection filter circuit to the first oscillator when a first jamming signal is detected at the first input. In some examples, the apparatus may couple the first node of the jamming rejection filter circuit to the second input of the second RF receive chain and couple the second node of the jamming rejection filter circuit to the second oscillator when a second jamming signal is detected at the second input.

[0110] In some examples, when the second node of the jamming rejection filter circuit is coupled to the first oscillator, the jamming rejection filter circuit has a first impedance characteristic at in-band frequencies associated with the first receive chain and a second impedance characteristic at out-of-band frequencies associated with the first receive chain. In some examples, the first impedance characteristic corresponds to higher impedances than the second impedance characteristic.

[0111] In some examples, when the second node of the jamming rejection filter circuit is coupled to the second oscillator, the jamming rejection filter circuit has a first impedance characteristic at in-band frequencies associated with the second receive chain and a second impedance characteristic at out-of-band frequencies associated with the second receive chain. In some examples, the first impedance characteristic corresponds to higher impedances than the second impedance characteristic.

[0112] In some examples, a first RF transmit chain associated with the first RF receive chain, wherein the first RF transmit chain is configured to transmit a first signal based on a first radio access technology (RAT) and the first RF receive chain is configured to receive a second signal based on the first RAT. In some examples, a second RF transmit chain associated with the second RF receive chain, wherein the second RF transmit chain is configured to transmit a third signal based on the second RAT and the second RF receive chain is configured to receive a fourth signal based on the second RAT. In some examples, the first RAT may be a cellular technology. In some examples, the second RAT may be a Wi-Fi technology.

[0113] In some examples, the apparatus may couple the first node of the jamming rejection filter circuit to the first input of the first RF receive chain when the first RF receive chain is receiving the second signal based on the first RAT, and the second RF transmit chain is transmitting the third signal based on the second RAT at a maximum transmit power (e.g., a currently applicable maximum transmit power, a maximum transmit power as limited by hardware, etc.).

[0114] In some examples, the apparatus may couple the first node of the jamming rejection filter circuit to the second input of the second RF receive chain when the second RF receive chain is receiving the fourth signal based on the second RAT and the first RF transmit chain is transmitting the first signal based on the first RAT at a maximum transmit power.

[0115] In some examples, the apparatus may couple the first node of the jamming rejection filter circuit to the second input of the second RF receive chain when the second RF transmit chain is transmitting the third signal based on the second RAT and the first RF transmit chain is idle.

[0116] In some examples, the apparatus may couple the first node of the jamming rejection filter circuit to the first input of the first RF receive chain when the first RF transmit chain is transmitting the first signal based on the first RAT and the second RF transmit chain is idle.

[0117] In some examples, the jamming rejection filter circuit may include a mixer coupled to the first node and a low pass filter coupled to the mixer.

[0118] In some examples, the apparatus may selectively couple the first node of the jamming rejection filter to the first input of the first RF receive chain, at least one other input of the first RF receive chain, or the second input of the second RF receive chain. In some examples, the at least one other input of the first RF receive chain is associated with at least one of a first RF frequency band, a second RF frequency band that is higher than the first RF frequency band, a third RF frequency band that is higher than the second RF frequency band, or an unlicensed RF frequency band.

[0119] In some examples, the apparatus is configured as a user equipment for cellular communication.

[0120] FIG. **11** illustrates a flow diagram of another example method in accordance with another aspect of the disclosure. As described below, some or all illustrated features may be omitted in a particular implementation within the scope of the present disclosure, and some illustrated features may not be required for implementation of all examples. In some examples, the method **1100** (e.g., a method for wireless communication) may be carried out by the user equipment **900** illustrated in FIG. **9**, or another wireless communication device. In some examples, the method **1100** may be carried out by any suitable apparatus or means for carrying out the functions or algorithm described herein.

[0121] At block **1102**, an apparatus (e.g., the user equipment **900** or another apparatus) may couple the first node of the jamming rejection filter to the first input of the first RF receive chain and couple a second node of the jamming rejection filter to the first oscillator when a first jamming signal is detected at the first input. Example means for coupling may include any of the control circuits, switches, or related circuitry described herein. For example, the jamming rejection control circuitry **943** may control a switch to couple the first node of the jamming rejection filter to the first input of the first RF receive chain and couple a second node of the jamming rejection filter to the first oscillator when a first jamming signal is detected at the first input.

[0122] At block **1104**, the apparatus may couple the first node of the jamming rejection filter to the second input of the second RF receive chain and couple the second node of the jamming rejection filter to the second oscillator when a second jamming signal is detected at the second input. Example means for coupling may include any of the control circuits, switches, or related circuitry described herein. For example, the jamming rejection control circuitry **943** may control a switch to couple the first node of the jamming rejection filter to the second input of the second RF receive chain and couple the second node of the jamming rejection filter to the second oscillator when a second jamming signal is detected at the second input.

[0123] Referring again to FIG. **9**, in one configuration, the user equipment **900** includes means for selectively coupling a first node of a jamming rejection filter to a first input of a first radio frequency (RF) receive chain of the apparatus or to a second input of a second RF receive chain of the apparatus, and means for receiving at least one of a first signal based on a first radio access technology (RAT) via the first RF receive chain or a second signal based on a second RAT via the first RF receive chain. In one aspect, the aforementioned means may be the processor **904** shown in FIG. **9** configured to perform the functions recited by the aforementioned means (e.g., as discussed above). In another aspect, the aforementioned means may be a circuit or any apparatus configured to perform the functions recited by the aforementioned means (e.g., as described herein in conjunction with FIGS. **1-8**, **10**, and **11**).

[0124] The following provides an overview of aspects of the present disclosure:

[0125] Aspect 1: An apparatus, comprising: a first radio-frequency (RF) receive chain comprising a first input; a second RF receive chain comprising a second input; a jamming rejection filter circuit comprising a first node; and a control circuit configured to selectively couple, via a first switch, the first node of the jamming rejection filter circuit to the first input of the first RF receive chain or to the second input of the second RF receive chain.

[0126] Aspect 2: The apparatus of aspect 1, further comprising: a first oscillator associated with the first RF receive chain; and a second oscillator associated with the second RF receive chain, wherein the control circuit is further configured to selectively couple, via a second switch, a second node of the jamming rejection filter circuit to the first oscillator or to the second oscillator.

[0127] Aspect 3: The apparatus of aspect 2, wherein the control circuit is further configured to: couple the first node of the jamming rejection filter circuit to the first input of the first RF receive chain and couple the second node of the jamming rejection filter circuit to the first oscillator when a first jamming signal is detected at the first input; and couple the first node of the jamming rejection filter circuit to the second input of the second RF receive chain and couple the second node of the jamming rejection filter circuit to the second oscillator when a second jamming signal is detected at the second input.

[0128] Aspect 4: The apparatus of aspect 3, wherein: wherein: when the second node of the jamming rejection filter circuit is coupled to the first oscillator, the jamming rejection filter circuit has a first impedance characteristic at in-band frequencies associated with the first receive chain and a second impedance characteristic at out-of-band frequencies associated with the first receive chain; and the first impedance characteristic corresponds to higher impedances than the second impedance characteristic.

[0129] Aspect 5: The apparatus of aspect 3, wherein: when the second node of the jamming rejection filter circuit is coupled to the second oscillator, the jamming rejection filter circuit has a first impedance characteristic at in-band frequencies associated with the second receive chain and a second impedance characteristic at out-of-band frequencies associated with the second receive chain; and the first impedance characteristic corresponds to higher impedances than the second impedance characteristic.

[0130] Aspect 6: The apparatus of any one of aspects 1-5, further comprising: a first RF transmit chain associated with the first RF receive chain, wherein the first RF transmit chain is configured to transmit a first signal based on a first radio access technology (RAT) and the first RF receive chain is configured to receive a second signal based on the first RAT; and a second RF transmit chain associated with the second RF receive chain, wherein the second RF transmit chain is configured to transmit a third signal based on the second RAT and the second RF receive chain is configured to receive a fourth signal based on the second RAT.

[0131] Aspect 7: The apparatus of aspect 6, wherein: the first RAT comprises a cellular technology; and the second RAT comprises a Wi-Fi technology.

[0132] Aspect 8: The apparatus of any one of aspects 6-7, wherein the control circuit is further configured to couple the first node of the jamming rejection filter circuit to the first input of the first RF receive chain when: the first RF receive chain is receiving the second signal based on the first RAT; and the second RF transmit chain is transmitting the third signal based on the second RAT at a maximum transmit power.

[0133] Aspect 9: The apparatus of any one of aspects 6-7, wherein the control circuit is further configured to couple the first node of the jamming rejection filter circuit to the second input of the second RF receive chain when: the second RF receive chain is receiving the fourth signal based on the second RAT; and the first RF transmit chain is transmitting the first signal based on the first RAT at a maximum transmit power.

[0134] Aspect 10: The apparatus of any one of aspects 6-7, wherein the control circuit is further configured to couple the first node of the jamming rejection filter circuit to the second input of the second RF receive chain when: the second RF transmit chain is transmitting the third signal based on the second RAT; and the first RF transmit chain is idle.

[0135] Aspect 11: The apparatus of any one of aspects 6-7, wherein the control circuit is further configured to couple the first node of the jamming rejection filter circuit to the first input of the first RF receive chain when: the first RF transmit chain is transmitting the first signal based on the first RAT; and the second RF transmit chain is idle.

[0136] Aspect 12: The apparatus of any one of aspects 1-11, further comprising an integrated circuit die, wherein the first RF receive chain, a first RF transmit chain associated with the first RF receive chain, the second RF receive chain, a second RF transmit chain associated with the second RF receive chain, and the jamming rejection filter circuit are implemented on the integrated circuit die.

[0137] Aspect 13: The apparatus of any one of aspects 1-12, wherein the jamming rejection filter circuit comprises: a mixer coupled to the first node; and a low pass filter coupled to the mixer.

[0138] Aspect 14: The apparatus of any one of aspects 1-13, wherein the first switch comprises a switch matrix configurable to selectively couple the first node of the jamming rejection filter circuit to: the first input of the first RF receive chain; at least one other input of the first RF receive chain; or the second input of the second RF receive chain.

[0139] Aspect 15: The apparatus of aspect 14, wherein the at least one other input of the first RF receive chain is associated with at least one of: a first RF frequency band; a second RF frequency band that is higher than the first RF frequency band; a third RF frequency band that is higher than the second RF frequency band; or an unlicensed RF frequency band.

[0140] Aspect 16: The apparatus of any one of aspects 1-15, wherein the apparatus is configured as a user equipment for cellular communication.

[0141] Aspect 17: A method, comprising: selectively coupling a first node of a jamming rejection filter circuit to a first input of a first radio frequency (RF) receive chain of the apparatus or to a second input of a second RF receive chain of the apparatus; and receiving at least one of a first signal based on a first radio access technology (RAT) via the first RF receive chain or a second signal based on a second RAT via the first RF receive chain.

[0142] Aspect 18: The method of aspect 17, wherein the selectively coupling comprises: coupling the first node of the jamming rejection filter circuit to the first input of the first RF receive chain when a first jamming signal is detected at the first input; and coupling the first node of the jamming rejection filter circuit to the second input of the second RF receive chain when a second jamming signal is detected at the second input.

[0143] Aspect 19: The method of any one of aspects 17-18, further comprising: selectively coupling a second node of the jamming rejection filter circuit to a first oscillator associated with the first RF receive chain or to a second oscillator associated with the second RF receive chain.

[0144] Aspect 20: An apparatus, comprising: means for selectively coupling a first node of a jamming rejection filter circuit to a first input of a first radio frequency (RF) receive chain of the apparatus or to a second input of a second RF receive chain of the apparatus; and means for receiving at least one of a first signal based on a first radio access technology (RAT) via the first RF receive chain or a second signal based on a second RAT via the first RF receive chain.

[0145] The previous description of the disclosure is provided to enable any person skilled in the art to make or use the disclosure. Various modifications to the disclosure will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other variations without departing from the spirit or scope of the disclosure. Thus, the disclosure is not intended to be limited to the examples described herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

Claims

1. An apparatus, comprising: a first radio-frequency (RF) receive chain comprising a first input; a second RF receive chain comprising a second input; a jamming rejection filter circuit comprising a first node; and a control circuit configured to selectively couple, via a first switch, the first node of the jamming rejection filter circuit to the first input of the first RF receive chain or to the second input of the second RF receive chain.
2. The apparatus of claim 1, further comprising: a first oscillator associated with the first RF receive chain; and a second oscillator associated with the second RF receive chain, wherein the control circuit is further configured to selectively couple, via a second switch, a second node of the jamming rejection filter circuit to the first oscillator or to the second oscillator.
3. The apparatus of claim 2, wherein the control circuit is further configured to: couple the first node of the jamming rejection filter circuit to the first input of the first RF receive chain and couple the second node of the jamming rejection filter circuit to the first oscillator when a first jamming signal is detected at the first input; and couple the first node of the jamming rejection filter circuit to the second input of the second RF receive chain and couple the second node of the jamming rejection filter circuit to the second oscillator when a second jamming signal is detected at the second input.
4. The apparatus of claim 3, wherein: when the second node of the jamming rejection filter circuit is coupled to the first oscillator, the jamming rejection filter circuit has a first impedance characteristic at in-band frequencies associated with the first RF receive chain and a second impedance characteristic at out-of-band frequencies associated with the first RF receive chain; and the first impedance characteristic corresponds to higher impedances than the second impedance characteristic.
5. The apparatus of claim 3, wherein: when the second node of the jamming rejection filter circuit is coupled to the second oscillator, the jamming rejection filter circuit has a first impedance characteristic at in-band frequencies associated with the second RF receive chain and a second impedance characteristic at out-of-band frequencies associated with the second RF receive chain; and the first impedance characteristic corresponds to higher impedances than the second impedance characteristic.
6. The apparatus of claim 1, further comprising: a first RF transmit chain associated with the first RF receive chain, wherein the first RF transmit chain is configured to transmit a first signal based on a first radio access technology (RAT) and the first RF receive chain is configured to receive a second signal based on the first RAT; and a second RF transmit chain associated with the second RF receive chain, wherein the second RF transmit chain is configured to transmit a third signal based on a second RAT and the second RF receive chain is configured to receive a fourth signal based on the second RAT.
7. The apparatus of claim 6, wherein: the first RAT comprises a cellular technology; and the second RAT comprises a Wi-Fi technology.
8. The apparatus of claim 6, wherein the control circuit is further configured to couple the first node of the jamming rejection filter circuit to the first input of the first RF receive chain when: the first RF receive chain is receiving the second signal based on the first RAT; and the second RF transmit chain is transmitting the third signal based on the second RAT at a maximum transmit

power.

9. The apparatus of claim 6, wherein the control circuit is further configured to couple the first node of the jamming rejection filter circuit to the second input of the second RF receive chain when: the second RF receive chain is receiving the fourth signal based on the second RAT; and the first RF transmit chain is transmitting the first signal based on the first RAT at a maximum transmit power.

10. The apparatus of claim 6, wherein the control circuit is further configured to couple the first node of the jamming rejection filter circuit to the second input of the second RF receive chain when: the second RF transmit chain is transmitting the third signal based on the second RAT; and the first RF transmit chain is idle.

11. The apparatus of claim 6, wherein the control circuit is further configured to couple the first node of the jamming rejection filter circuit to the first input of the first RF receive chain when: the first RF transmit chain is transmitting the first signal based on the first RAT; and the second RF transmit chain is idle.

12. The apparatus of claim 1, further comprising an integrated circuit die, wherein the first RF receive chain, a first RF transmit chain associated with the first RF receive chain, the second RF receive chain, a second RF transmit chain associated with the second RF receive chain, and the jamming rejection filter circuit are implemented on the integrated circuit die.

13. The apparatus of claim 1, wherein the jamming rejection filter circuit comprises: a mixer coupled to the first node; and a low pass filter coupled to the mixer.

14. The apparatus of claim 1, wherein the first switch comprises a switch matrix configurable to selectively couple the first node of the jamming rejection filter circuit to: the first input of the first RF receive chain; at least one other input of the first RF receive chain; or the second input of the second RF receive chain.

15. The apparatus of claim 14, wherein the at least one other input of the first RF receive chain is associated with at least one of: a first RF frequency band; a second RF frequency band that is higher than the first RF frequency band; a third RF frequency band that is higher than the second RF frequency band; or an unlicensed RF frequency band.

16. The apparatus of claim 1, wherein the apparatus is configured as a user equipment for cellular communication.

17. A method for communication at an apparatus, comprising: selectively coupling a first node of a jamming rejection filter circuit to a first input of a first radio frequency (RF) receive chain of the apparatus or to a second input of a second RF receive chain of the apparatus; and receiving at least one of a first signal based on a first radio access technology (RAT) via the first RF receive chain or a second signal based on a second RAT via the first RF receive chain.

18. The method of claim 17, wherein the selectively coupling comprises: coupling the first node of the jamming rejection filter circuit to the first input of the first RF receive chain when a first jamming signal is detected at the first input; and coupling the first node of the jamming rejection filter circuit to the second input of the second RF receive chain when a second jamming signal is detected at the second input.

19. The method of claim 18, further comprising: selectively coupling a second node of the jamming rejection filter circuit to a first oscillator associated with the first RF receive chain or to a second oscillator associated with the second RF receive chain.

20. An apparatus, comprising: means for selectively coupling a first node of a jamming rejection filter circuit to a first input of a first radio frequency (RF) receive chain of the apparatus or to a second input of a second RF receive chain of the apparatus; and means for receiving at least one of a first signal based on a first radio access technology (RAT) via the first RF receive chain or a second signal based on a second RAT via the first RF receive chain.