A wireless device configured for simultaneous voice and data communications is described. The wireless device includes a voice and data transceiver. The voice and data transceiver includes data path circuitry, voice path circuitry, a first multiplexer and a second multiplexer. The first multiplexer sends a primary data receive signal to the data path circuitry and receives a data transmit signal from the data path circuitry. The second multiplexer sends a diversity data receive signal to the data path circuitry, sends a voice receive signal to the voice path circuitry and receives a voice transmit signal from the voice path circuitry.

The wireless device also includes a first antenna coupled to the first multiplexer. The wireless device further includes a second antenna coupled to the second multiplexer.
before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))
SIMULTANEOUS VOICE AND DATA COMMUNICATION

RELATED APPLICATIONS
[0001] This application is related to and claims priority from U.S. Provisional Patent Application Serial No. 61/407,266 filed October 27, 2010, for "SYSTEM AND METHODS TO IMPLEMENT SIMULTANEOUS VOICE AND DATA."

TECHNICAL FIELD
[0002] The present disclosure relates generally to electronic devices for communication systems. More specifically, the present disclosure relates to systems and methods for simultaneous voice and data communication.

BACKGROUND
[0003] Electronic devices (cellular telephones, wireless modems, computers, digital music players, Global Positioning System units, Personal Digital Assistants, gaming devices, etc.) have become a part of everyday life. Small computing devices are now placed in everything from automobiles to housing locks. The complexity of electronic devices has increased dramatically in the last few years. For example, many electronic devices have one or more processors that help control the device, as well as a number of digital circuits to support the processor and other parts of the device.
[0004] These electronic devices may communicate wireless with each other and with a network. Electronic devices may provide many different types of communication. For example, some electronic devices provide voice communication while other electronic devices provide data communication. Some electronic devices now provide both voice communication and data communication. Benefits may be realized by providing improved systems and methods to implement simultaneous voice and data communications for electronic devices.

SUMMARY
[0005] A wireless device configured for simultaneous voice and data communications is described. The wireless device includes a voice and data transceiver. The voice and data transceiver includes data path circuitry, voice path circuitry, a first
diplexer and a second diplexer. The first diplexer sends a primary data receive signal to the data path circuitry and receives a data transmit signal from the data path circuitry. The second diplexer sends a diversity data receive signal to the data path circuitry, sends a voice receive signal to the voice path circuitry and receives a voice transmit signal from the voice path circuitry. The wireless device also includes a first antenna coupled to the first diplexer and a second antenna coupled to the second diplexer.

[0006] The first diplexer and the second diplexer may reduce third order intermodulation interference introduced in the voice and data transceiver. The wireless device may be a wireless communication device configured to operate using a Long Term Evolution standard. The data path circuitry may include a primary data receive chain, a data transmit chain and a diversity data receive chain. The voice path circuitry may include a voice receive chain and a voice transmit chain.

[0007] A wireless device configured for simultaneous voice and data communications is also described. The wireless device includes a voice and data transceiver. The voice and data transceiver includes data path circuitry, voice path circuitry, a first diplexer and a second diplexer. The first diplexer sends a primary data receive signal to the data path circuitry, receives a data transmit signal from the data path circuitry and sends a voice receive signal to the voice path circuitry. The second diplexer sends a diversity data receive signal to the data path circuitry and receives a voice transmit signal from the voice path circuitry. The wireless device also includes a first antenna coupled to the first diplexer and a second antenna coupled to the second diplexer.

[0008] A wireless device configured for simultaneous voice and data communications is described. The wireless device includes a voice and data transceiver. The voice and data transceiver includes data path circuitry, voice path circuitry, a first diplexer and a second diplexer. The first diplexer sends a diversity data receive signal to the data path circuitry, receives a data transmit signal from the data path circuitry and sends a voice receive signal to the voice path circuitry. The second diplexer sends a primary data receive signal to the data path circuitry and receives a voice transmit signal from the voice path circuitry. The wireless device also includes a first antenna coupled to the first diplexer and a second antenna coupled to the second diplexer.

[0009] A method for simultaneous voice and data communication is described. A voice signal is communicated. A data signal is also communicated. Third order
intermodulation interference generated by simultaneously communicating the voice signal and the data signal is minimized.

[0010] The voice signal may be communicated using a first antenna and a first duplexer. The data signal may be communicated using the first antenna, the first duplexer, a second antenna and a second duplexer. Communicating the voice signal may include transmitting the voice signal. Communicating the data signal may include transmitting the data signal. The voice signal and the data signal may be transmitted simultaneously.

[0011] Communicating the voice signal may include receiving the voice signal. Communicating the data signal may include receiving the data signal. The voice signal and the data signal may be received simultaneously. The method may be performed by a wireless communication device.

[0012] A wireless device configured for simultaneous voice and data communications is also described. The wireless device includes a voice and data transceiver. The voice and data transceiver includes data path circuitry, voice path circuitry, a first diplexer and a second diplexer. The first diplexer sends a primary data receive signal to the data path circuitry, receives a voice transmit signal from the voice path circuitry and receives a data transmit signal from the data path circuitry. The second diplexer sends a diversity data receive signal to the data path circuitry and sends a voice receive signal to the voice path circuitry. The voice and data transceiver also includes a duplexer that is coupled between the second diplexer and a data modem. The voice and data transceiver further includes a resistor that is coupled between the duplexer and ground. The wireless device also includes a first antenna coupled to the first diplexer and a second antenna coupled to the second diplexer.

[0013] The configuration of the duplexer and the resistor may be such that the duplexer is used as a diversity receive signal filter. The data transmit signal may be terminated at the resistor such that it does not reflect back to the duplexer to generate third order intermodulation interference with the voice transmit signal. The resistor may be a 50 ohm resistor.

[0014] An apparatus for simultaneous voice and data communication is also described. The apparatus includes means for communicating a voice signal. The apparatus also includes means for communicating a data signal. The apparatus further
includes means for minimizing third order intermodulation interference generated by simultaneously communicating the voice signal and the data signal.

[0015] The means for communicating the voice signal may include using a first antenna and a first diplexer. The means for communicating the data signal may include the first antenna, the first diplexer, a second antenna and a second diplexer. Communicating the voice signal may include transmitting the voice signal. Communicating the data signal may include transmitting the data signal. The voice signal and the data signal may be transmitted simultaneously.

[0016] Communicating the voice signal may include receiving the voice signal. Communicating the data signal may include receiving the data signal. The voice signal and the data signal may be received simultaneously. The apparatus may be a wireless communication device.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0017] Figure 1 shows a wireless communication system 100 with multiple wireless devices;

[0018] Figure 2 is a block diagram illustrating a simultaneous voice and data (SVD) transceiver for use in the present systems and methods;

[0019] Figure 3 is a block diagram illustrating another simultaneous voice and data (SVD) transceiver for use in the present systems and methods;

[0020] Figure 4 is a block diagram illustrating a front-end architecture of a simultaneous voice and data (SVD) transceiver;

[0021] Figure 5 is a flow diagram of a method for simultaneous voice and data communication with reduced third order intermodulation (IM3) interference;

[0022] Figure 6 is a flow diagram of a method for receiving and transmitting voice signals and data signals simultaneously;

[0023] Figure 7 illustrates the desensitization that may occur during simultaneous voice and data (SVD) communications;

[0024] Figure 8 illustrates the proposed radio frequency (RF) front-end architecture to mitigate the third order intermodulation (IM3) interference issue; and

[0025] Figure 9 illustrates certain components that may be included within a wireless communication device.
DETAILED DESCRIPTION

[0026] The 3rd Generation Partnership Project (3GPP) is a collaboration between groups of telecommunications associations that aims to define a globally applicable 3rd generation (3G) mobile phone specification. 3GPP Long Term Evolution (LTE) is a 3GPP project aimed at improving the Universal Mobile Telecommunications System (UMTS) mobile phone standard. The 3GPP may define specifications for the next generation of mobile networks, mobile systems and mobile devices. In 3GPP LTE, a mobile station or device may be referred to as a "user equipment" (UE).

[0027] 3GPP specifications are based on evolved Global System for Mobile Communications (GSM) specifications, which are generally known as the Universal Mobile Telecommunications System (UMTS). 3GPP standards are structured as releases. Discussion of 3GPP thus frequently refers to the functionality in one release or another. For example, Release 99 specifies the first UMTS third generation (3G) networks, incorporating a CDMA air interface. Release 6 integrates operation with wireless local area networks (LAN) networks and adds High Speed Uplink Packet Access (HSUPA). Release 8 introduces dual downlink carriers and Release 9 extends dual carrier operation to uplink for UMTS.

[0028] CDMA2000 is a family of third generation (3G) technology standards that use code division multiple access (CDMA) to send voice, data and signaling between wireless devices. CDMA2000 may include CDMA2000 IX, CDMA2000 EV-DO Rev. 0, CDMA2000 EV-DO Rev. A and CDMA2000 EV-DO Rev. B. 1x or 1xRTT refers to the core CDMA2000 wireless air interface standard, 1x more specifically refers to 1 times Radio Transmission Technology and indicates the same radio frequency (RF) bandwidth as used in IS-95. 1xRTT adds 64 additional traffic channels to the forward link. EV-DO refers to Evolution-Data Optimized. EV-DO is a telecommunications standard for the wireless transmission of data through radio signals.

[0029] Figure 1 shows a wireless communication system 100 with multiple wireless devices. A wireless device may be a base station 102, a wireless communication device 104, a controller, or the like. A base station 102 is a station that communicates with one or more wireless communication devices 104. A base station 102 may also be referred to as, and may include some or all of the functionality of, an access point, a broadcast transmitter, a Node B, an evolved Node B, etc. Each base station 102 provides
communication coverage for a particular geographic area. A base station 102 may provide communication coverage for one or more wireless communication devices 104. The term "cell" can refer to a base station 102 and/or its coverage area depending on the context in which the term is used. Each cell may be further divided into sectors. A base station 102 may thus cover multiple sectors.

A wireless communication device 104 may also be referred to as, and may include some or all of the functionality of, a terminal, an access terminal, a user equipment (UE), a subscriber unit, a station, etc. A wireless communication device 104 may be a cellular phone, a personal digital assistant (PDA), a wireless device, a wireless modem, a handheld device, a laptop computer, a PC card, compact flash, an external or internal modem, a wireline phone, etc. A wireless communication device 104 may be mobile or stationary. A wireless communication device 104 may communicate with zero, one or multiple base stations 102 on a downlink 106 and/or an uplink 108 at any given moment. The downlink 106 (or forward link) refers to the communication link from a base station 102 to a wireless communication device 104, and the uplink 108 (or reverse link) refers to the communication link from a wireless communication device 104 to a base station 102. Uplink 108 and downlink 106 may refer to the communication link or to the carriers used for the communication link.

The wireless communication system 100 may be a multiple-access system capable of supporting communication with multiple wireless communication devices 104 by sharing the available system resources (e.g., bandwidth and transmit power). Examples of such multiple-access systems include code division multiple access (CDMA) systems, wideband code division multiple access (W-CDMA) systems, time division multiple access (TDMA) systems, frequency division multiple access (FDMA) systems, orthogonal frequency division multiple access (OFDMA) systems and spatial division multiple access (SDMA) systems.

A wireless communication network 100 may provide communication for a number of wireless communication devices 104, each of which may be serviced by a base station 102. Wireless communication networks 100 that use CDMA2000 for voice and Data Optimized (DO) for data may be unable to provide simultaneous voice and data (SVD) to consumers. For example, a base station 102 may be unable to provide both data and voice services simultaneously to a wireless communication device 104.
One main reason for this inability is the large amounts of interference that may occur during simultaneous voice and data (SVD) transmission.

In order to obtain simultaneous voice and data (SVD) services, a wireless communication device 104 may need a simultaneous voice and data (SVD) transceiver 110. In order to properly transmit and receive simultaneous voice and data (SVD), the design of the simultaneous voice and data (SVD) transceiver 110 may be such that third order intermodulation (IM3) interference reduction is needed. The simultaneous voice and data (SVD) transceiver 110 may be designed to minimize the third order intermodulation (IM3) interference generated without increasing the number of antennas on the wireless communication device 104. In LTE, a wireless communication device 104 may have two antennas; thus, it may be desirable to provide simultaneous voice and data (SVD) for LTE with two antennas. Examples of simultaneous voice and data (SVD) systems include lxCdMA voice + LTE/DO/TDSCDMA data, GSM voice + LTE/WCDMA/TDS CDMA data and UMTS voice + LTE/TDS CDMA data.

Typically, the data transmit signal (Tx1), the primary data receive signal (PRx), the voice transmit signal (Tx2) and the voice receive signal (Rx) use a first antenna while the diversity data receive signal (DRx) uses a second antenna. In this system, the third order intermodulation (EVI3) interference for data $I_{IM3(data)}$ is illustrated in Equation (1):

$$I_{IM3(data)} \propto \left(Tx1\right)^2 \ast Tx2.$$  \hspace{1cm} (1)

The third order intermodulation (EVI3) interference for voice $I_{IM3(voice)}$ is illustrated in Equation (2):

$$I_{IM3(voice)} \propto Tx1 \ast \left(Tx2\right)^2.$$  \hspace{1cm} (2)

The use of one antenna to transmit both data and voice may result in challenges to meet the Federal Communication Commission (FCC) Specific Absorption Rate (SAR) requirements. In addition, the third-order intermodulation (IM3) interference level is the strongest with both data and voice transmitted signals are at or
near their maximum. By using a simultaneous voice and data (SVD) transceiver 110 (with reduced third order intermodulation (IM3) interference), the third order intermodulation (IM3) interference for data $I_{IM3}(data)$ and the third order intermodulation (IM3) interference for voice $I_{IM3}(voice)$ may be reduced.

[0037] Figure 2 is a block diagram illustrating a simultaneous voice and data (SVD) transceiver 210 for use in the present systems and methods. The simultaneous voice and data (SVD) transceiver 210 of Figure 2 may be one configuration of the simultaneous voice and data (SVD) transceiver 110 of Figure 1. The simultaneous voice and data (SVD) transceiver 210 may be designed such that there is reduced third order intermodulation (IM3) interference. The simultaneous voice and data (SVD) transceiver 210 may be located on a wireless communication device 104 with a first antenna 214a and a second antenna 214b. The simultaneous voice and data (SVD) transceiver 210 may be coupled to both the first antenna 214a and the second antenna 214b.

[0038] The simultaneous voice and data (SVD) transceiver 210 may include data path circuitry 226 and voice path circuitry 228. Both data signals and voice signals may be input and output from the data path circuitry 226. Also, both data and voice signals may be input and output from the voice path circuitry 228. The data path circuitry 226 may be coupled to a first multiplexer 216a. A multiplexer 216 may be a passive device that implements frequency domain multiplexing. In one configuration, the multiplexers 216 used herein may be diplexers. The first multiplexer 216a may be coupled to the first antenna 214a. Signals between the data path circuitry 226 and the first multiplexer 216a may include a primary data receive signal (PRx) 241 and a data transmit signal (Txl) 242. In wireless communication devices 104 that make use of antenna diversity, one or more additional antennas 214 may be used to improve the quality and reliability of a wireless link. For example, the wireless communication device 104 may receive a data signal over each antenna 214. One of these data signals may be a primary data signal while the other is a diversity data signal. In one configuration, the primary data receive signal (PRx) 241 may be the data signal that has the highest signal-to-noise ratio (SNR) (compared to the diversity data receive signal (DRx) 222). In another configuration, the primary data receive signal (PRx) 241 may be the data signal that is received by the primary antenna 214 (i.e., the first antenna 214a) and the diversity data receive signal (DRx) 222 may be the data signal received by a secondary antenna 214.
The data path circuitry 226 may also be coupled to a second multiplexer 216b. The second multiplexer 216b may be coupled to the second antenna 214b. Signals between the data path circuitry 226 and the second multiplexer 216b may include a diversity data receive signal (DRx) 222.

The voice path circuitry 228 may be coupled to the second multiplexer 216b. Signals between the voice path circuitry 228 and the second multiplexer 216b may include a voice receive signal (Rx) 220 and a voice transmit signal (Tx2) 224.

If the first antenna 214a is assigned the primary data receive signal (PRx) 241 and the data transmit signal (Tx1) 242 and the second antenna 214b is assigned the diversity data receive signal (DRx) 222, the voice receive signal (Rx) 220 and the voice transmit signal (Tx2) 224, the third order intermodulation (IM3) interference for data $I_{IM3(data)}$ is illustrated in Equation (3):

$$I_{IM3(data)} \propto (Tx1)^2 * (\alpha *Tx2).$$  \hspace{1cm} (3)

The third order intermodulation (IM3) interference for voice $I_{IM3(voice)}$ may be illustrated using Equation (4):

$$I_{IM3(voice)} \propto (\alpha *Tx1) * (Tx2)^2.$$  \hspace{1cm} (4)

In Equation (3) and Equation (4), $\alpha$ is the antenna-to-antenna isolation. Equation (3) and Equation (4) represent a reduction in the baseline third order intermodulation (IM3) interference (i.e., the third order intermodulation (IM3) interference from Equation (1) and Equation (2) above) of $\alpha$, which is around -10 decibels (dB) for practical designs.

The data path circuitry 226 may receive data for transmission 230. The data path circuitry 226 may forward received data 232 for use by the wireless communication device 104. Likewise, the voice path circuitry 228 may receive voice for transmission 234. The voice path circuitry 228 may forward received voice 236 for use by the wireless communication device 104.
Figure 3 is a block diagram illustrating another simultaneous voice and data (SVD) transceiver 310 for use in the present systems and methods. The simultaneous voice and data (SVD) transceiver 310 of Figure 3 may be one configuration of the simultaneous voice and data (SVD) transceiver 110 of Figure 1. The simultaneous voice and data (SVD) transceiver 310 may be designed such that there is further reduced third order intermodulation (IM3) interference in comparison to previous configurations. The simultaneous voice and data (SVD) transceiver 310 may be located on a wireless communication device 104 with a first antenna 314a and a second antenna 314b. The simultaneous voice and data (SVD) transceiver 310 may be coupled to both the first antenna 314a and the second antenna 314b.

The simultaneous voice and data (SVD) transceiver 310 may include data path circuitry 326 and voice path circuitry 328. Both data signals and voice signals may be input and output from the data path circuitry 326. Also, both data and voice signals may be input and output from the voice path circuitry 328. The data path circuitry 326 may be coupled to a first multiplexer 316a. The first multiplexer 316a may be coupled to the first antenna 314a. Signals between the data path circuitry 326 and the first multiplexer 316a may include a primary data receive signal (PRx) 341 and a data transmit signal (Tx) 342. The data path circuitry 326 may also be coupled to a second multiplexer 316b. The second multiplexer 316b may be coupled to the second antenna 314b. Signals between the data path circuitry 326 and the second multiplexer 316b may include a diversity data receive signal (DRx) 322.

The voice path circuitry 328 may be coupled to both the first multiplexer 316a and the second multiplexer 316b. Signals between the voice path circuitry 328 and the first multiplexer 316a may include a voice receive signal (Rx) 320. Signals between the voice path circuitry 328 and the second multiplexer 316b may include a voice transmit signal (Tx) 324.

If the first antenna 314a is assigned the primary data receive signal (PRx) 341, the data transmit signal (Tx) 342 and the voice receive (Rx) signal 320 and the second antenna 314b is assigned the diversity data receive signal (DRx) 322 and the voice transmit signal (Tx) 324, the third order intermodulation (IM3) interference for voice $I_{IM3}^{(voice)}$ may be illustrated using Equation (5):
Thus, Equation (5) represents a reduction in the baseline third order intermodulation (IM3) interference (i.e., the third order intermodulation (IM3) interference from Equation (1)) of $2\alpha^2$, which is -17 dB. The third order intermodulation (IM3) interference for data for the primary data receive signal (PRx) 341 has a reduction factor of $(\alpha + \alpha^3) \approx a$, which is -10 dB.

The data path circuitry 326 may receive data for transmission 330. The data path circuitry 326 may forward received data 332 for use by the wireless communication device 104. Likewise, the voice path circuitry 328 may receive voice for transmission 334. The voice path circuitry 328 may forward received voice 336 for use by the wireless communication device 104.

Figure 4 is a block diagram illustrating a front-end architecture of a simultaneous voice and data (SVD) transceiver 510. The simultaneous voice and data (SVD) transceiver 510 of Figure 4 may be one configuration of the simultaneous voice and data (SVD) transceiver 110 of Figure 1. The simultaneous voice and data (SVD) transceiver 510 may be designed such that there is reduced third order intermodulation (IM3) interference. A first antenna 514a may be coupled to a first multiplexer 516a. In one configuration, the first multiplexer 516a may be a diplexer. The first antenna 514a may be used for a primary data receive (PRx) chain 543, a data transmit (Tx1) chain 546 and a voice receive (Rx) chain 552. A second antenna 514b may be coupled to a second multiplexer 516b. In one configuration, the second multiplexer 516b may be a diplexer. The second antenna 514b may be used for a diversity data receive (DRx) 549 chain and a voice transmit (Tx2) chain 555.

The primary data receive (PRx) chain 543, data transmit (Tx1) 546 chain and diversity data receive (DRx) chain 549 may each be a part of a data path circuitry 526. The primary data receive (PRx) chain 543 may include a receiver 544 and a demodulator 545. In one configuration, the demodulator 545 may be part of a modem. The data transmit (Tx1) chain 546 may include a transmitter 547 and a modulator 548. In one configuration, the modulator 548 may be part of a modem. The diversity data
receive (DRx) chain 549 may include a receiver 550 and a demodulator 551. The
demodulator 551 may be part of a modem.

[0052] The voice receive (Rx) chain 552 and the voice transmit (Tx2) chain 555
may be part of a voice path circuitry 528. The voice receive (Rx) chain 552 may include
a receiver 553 and a demodulator 554. The demodulator 554 may be part of a modem.
The voice transmit (Tx2) chain 555 may include a transmitter 556 and a modulator 557.
The modulator 557 may be part of a modem.

[0053] The first multiplexer 516a may send a primary data receive signal (PRx) 541
to the primary data receive (PRx) chain 543 in the data path circuitry 526. The first
multiplexer 516a may also send a voice receive signal (Rx) 520 to the voice receive
(Rx) chain 552 in the voice path circuitry 528. The first multiplexer 516a may receive a
data transmit signal (TxI) 542 from the data transmit (TxI) chain 546.

[0054] The second multiplexer 516b may send a diversity data receive signal (DRx)
522 to the diversity data receive (DRx) chain 549 in the data path circuitry 526. The
second multiplexer 516b may receive a voice transmit signal (Tx2) 524 from the voice
transmit (Tx2) chain 555 in the voice path circuitry 528.

[0055] A signal between the first antenna 514a and the first multiplexer 516a may
be a first composite signal 521a that includes at least one of the primary data receive
signal (PRx) 541, the data transmit signal (TxI) 542 and the voice receive signal (Rx)
520. A signal between the second antenna 514b and the second multiplexer 516b may
be a second composite signal 521b that includes at least one of the diversity data receive
signal (DRx) 522 and the voice transmit signal (Tx2) 524.

[0056] Figure 5 is a flow diagram of a method 600 for simultaneous voice and data
communication with reduced third order intermodulation (IM3) interference. The
method 600 may be performed by a wireless communication device 104. The wireless
communication device 104 may communicate 602 a voice signal. In one configuration,
the wireless communication device 104 may communicate 602 the voice signal using a
first multiplexer 316a, a first antenna 314a coupled to the first multiplexer 316a, a
second multiplexer 316b and a second antenna 314b coupled to the second multiplexer
316b. In another configuration, the wireless communication device 104 may
communicate 602 the voice signal using only a multiplexer 216b and an antenna 214b
coupled to the multiplexer 216b. Communicating 602 a voice signal may include both
receiving a voice receive signal (Rx) 220 and transmitting a voice transmit signal (Tx2)
224. In one configuration, communicating 602 a voice signal may include receiving a voice receive signal (Rx) 220 while simultaneously transmitting a voice transmit signal (Tx2) 224.

[0057] The wireless communication device 104 may also communicate 604 a data signal. In one configuration, the wireless communication device 104 may communicate a data signal using a first multiplexer 216a, a first antenna 214a coupled to the first multiplexer 216a, a second multiplexer 216b and a second antenna 214b coupled to the second multiplexer 216b. Communicating 604 a data signal may include receiving a primary data receive signal (PRx) 241, receiving a diversity data receive signal (DRx) 222 and sending a data transmit signal (Tx1) 242. In one configuration, communicating 604 a data signal may include receiving a primary data receive signal (PRx) 241 and a diversity data receive signal (DRx) 222 while simultaneously transmitting a data transmit signal (Tx1) 242.

[0058] The wireless communication device 104 may communicate 602 the voice signal while simultaneously communicating 604 the data signal. For example, the wireless communication device 104 may receive a primary data receive signal (PRx) 241, a diversity data receive signal (DRx) 222 and a voice receive signal (Rx) 220 while simultaneously transmitting a data transmit signal (Tx1) 242 and a voice transmit signal (Tx2) 224. The wireless communication device 104 may minimize 606 third order intermodulation (IM3) interference generated by simultaneously communicating the voice signal and the data signal. In one configuration, the design of the wireless communication device 104 may minimize 606 third order intermodulation (IM3) interference.

[0059] Figure 6 is a flow diagram of a method 700 for receiving and transmitting voice signals and data signals simultaneously. The method 700 may be performed by a wireless communication device 104. The wireless communication device 104 may include a simultaneous voice and data (SVD) transceiver 310 (with reduced third order intermodulation (IM3) interference). The wireless communication device 104 may receive 702 a diversity data receive signal (DRx) 322 using a first antenna 314a and a first multiplexer 316a. The wireless communication device 104 may also receive 704 a voice receive signal (Rx) using the first multiplexer 316a and the first antenna 314a.

[0060] The wireless communication device 104 may further receive 706 a primary data receive signal (PRx) 341 using a second multiplexer 316b and a second antenna
314b. The wireless communication device 104 may transmit 708 a data transmit signal (Tx1) 342 using the first multiplexer 316a and the first antenna 314a. The wireless communication device 104 may also transmit 710 a voice transmit signal (Tx2) 324 using the second multiplexer 316b and the second antenna 314b. The configuration of the first multiplexer 316a and the second multiplexer 316b may be such that third order intermodulation (IM3) interference introduced is reduced when compared to traditional configurations. In one configuration, the third order intermodulation (IM3) interference introduced may be reduced by -17 dB for the voice and -17 dB for the data compared to traditional configurations.

[0061] Figure 7 illustrates the desensitization that may occur during simultaneous voice and data (SVD) communications. A graph of frequency versus signal strength is shown. It is not certain when Voice over Internet Protocol (VOIP) will become ubiquitous. Thus, a dedicated chain for data (LTE, DO, WLAN, etc.) may be used along with a second chain for voice to cope with issues arising from dual transmissions. Intermodulation between the two transmission chains (the data transmission chain and the voice transmission chain) can lead to performance degradation (e.g., sensitivity, spurious emissions). This can result in challenges to meet the Federal Communication Commission (FCC) specific absorption rate (SAR) requirements.

[0062] Verizon Wireless Simultaneous Voice Long Term Evolution (SVLTE) uses the Band 13 (B13) for LTE and the Band 0 (BC0) for voice. The first 300 cellular channels are subject to desensitization because the B13 transmit signals intermodulate with the BC0 transmit signals and a third order intermodulation (IM3) product falls on the BC0 receive band. This desensitization occurs when both the Long Term Evolution (LTE) transmit signals 759 and the BC0 transmit signals (cell transmission (Tx) signal 760) are at or near maximum power, making it difficult to pass carrier certification testing.

[0063] In the past, the same antenna has been used for voice and data. The maximum transmit power for the data may be reduced at the expense of throughput. This is undesirable. Another solution was to dedicate two antennas for data and a third antenna for voice. However, the antenna-to-antenna isolation goes down as the number of antennas goes up, which is self-defeating in terms of dealing with the intermodulation (IM) problem. Furthermore, it is costly to increase the number of antennas in
commercial handsets. Also, form factor limits the number of antennas that can be placed on commercial handsets.

[0064] Wideband Code Division Multiple Access (WCDMA) embeds data and voice in the same waveform to support simultaneous voice and data (SVD). There is no flexibility to utilize two physical channels for voice and data. The use of LTE offers the next highest data rate, far beyond WCDMA or data optimized (DO). VOIP will take time to mature and reach the same network coverage as existing voice networks.

[0065] The third order intermodulation (EV13) interference 762 may dominate the cell receive (Rx) signal 761 when using simultaneous voice and data communications, limiting the effectiveness of simultaneous voice and data (SVD) communications. However, by using a simultaneous voice and data (SVD) transceiver 110 (with reduced third order intermodulation (EV13) interference), only a reduced third order intermodulation (IM3) interference 763 is seen on the cell receive (Rx) signal 761, allowing for the use of simultaneous voice and data (SVD) communications. The long term evolution (LTE) receive (Rx) signal 758 may be unaffected by third order intermodulation (IM3).

[0066] The frequencies and relative signal strengths of the Long Term Evolution (LTE) receive (Rx) signal 758, the Long Term Evolution (LTE) transmission (Tx) signal 759, the cell transmission (Tx) signal 760 and the cell receive (Rx) signal 761 are shown. The frequencies and signal strengths are not drawn to scale and are illustrated only to show where the third order intermodulation (IM3) interference 762 falls on the frequency spectrum (and how this third order intermodulation (IM3) interference 762 is reduced).

[0067] Figure 8 illustrates the proposed radio frequency (RF) front-end architecture to mitigate the third order intermodulation (IM3) interference issue. A first antenna 814a may be used for the primary data receive (PRx) chain 543, the data transmit (Tx1) chain 546 and the voice receive (Rx) chain 552. A second antenna 814b may be used for the voice transmit (Tx2) chain 555 and the diversity data receive (DRx) chain 549.

[0068] A first multiplexer 816a may be coupled to the first antenna 814a. The first multiplexer 816a may be coupled to a first duplexer 864a and a second duplexer 864b. A duplexer 864 is a device that allows bi-directional communication over a single channel. The first duplexer 864a may output a primary data receive signal (PRx) 841 to a data modem 868. The second duplexer 864b may receive a data optimized (DO)
transmit signal (Txl) 842 from the data modem 868. The second duplexer 864b may also output a voice receive signal (Rx) 820 via a switch 867a to a voice and global positioning system (GPS) modem 870.

[0069] The first multiplexer 816a may also be coupled to a third duplexer 864c. The third duplexer 864c may receive a data optimized (DO) transmit signal from the data modem 868 and generate a personal communications system (PCS) receive signal (Rx). The personal communications system (PCS) receive signal (Rx) may be output to a switch 867b that then outputs either a data optimized (DO) receive signal to the data modem 868 or a 1x receive signal (Rx) to the voice and global positioning system (GPS) modem 870. Signals for transmission may be passed through power amplifiers 866a-e.

[0070] A second multiplexer 816b may be coupled to the second antenna 814b. The second multiplexer 816b may be coupled to a fourth duplexer 864d and a fifth duplexer 864e. The fourth duplexer 864d may output a long term evolution (LTE) diversity data receive signal (DRx) 822 to the data modem 868. The fifth duplexer 864e may receive a 1x voice transmit signal (Tx2) 824 from the voice and global positioning system (GPS) modem 870. The second multiplexer 816b may also be coupled to a sixth duplexer 864f for personal communications service (PCS). The voice and global positioning system (GPS) modem 870 may also be coupled to a global positioning system (GPS) antenna 814c.

[0071] The fourth duplexer 864d may be coupled to ground using a 50 Ohm resistor. The 50 Ohm resistor is used to terminate the data duplexer transmit signal (Txl) so that the fourth duplexer 864d is used as a diversity Rx filter. This results in reduced third order intermodulation (IM3) interference generated by the fourth duplexer 864d for voice because the data Tx coupling from the first antenna 814a will contribute less to the generation of third order intermodulation (IM3) interference. This is because the data transmit signal (Tx) find a 50 Ohm termination so that it does not reflect back to the voice duplexer to generate third order intermodulation (IM3) distortion with the voice transmit signal (Tx).

[0072] If a data transmit signal (Txl) 242 and a voice transmit (Tx) signal 224 are combined in the same antenna, then the third order intermodulation (IM3) interference ~ Txl * (Tx2)^2. If antenna-to-antenna isolation is a, the IM3i (the third order intermodulation (IM3) interference due to the circuitry for the first antenna 814a) ~ Txl (a*Tx2)^2 because Tx2 is in the second antenna 814b. Similarly, IM3i (the third order
intermodulation (EV13) interference due to the circuitry for the second antenna 814b) because Txl needs to be coupled to the second antenna 814b to generate IM3 2. Since the voice receive (Rx) signal 820 uses the first antenna 814a, the total third order intermodulation (EV13) interference that contributes to desensitization is EV13i+ a *IM3 2 = 2* a * (a *Txl)*(Tx2) 2.

[0073] Thus, separating Txl and Tx2 in two antennas 814 (the voice receive signal (Rx) 820 and Tx2 are in the same antenna 814) provides an improvement factor of a (10 dB) over the combining of Txl and Tx2 in the same antenna 814. This allows for a better use of the available spectrum and increased flexibility in spectrum planning. It also allows for concurrency of voice and data that the current standard does not support (e.g., SVLTE and SVDO). More security can be imposed on a chosen channel.

[0074] By separating Txl and Tx2 in two antennas 814 (and placing the voice receive signal (Rx) 820 in the same antenna 814 as Txl), an improvement of 2(a) 2 (17 dB) may be obtained. The data requires a primary data receive signal (PRx) 841 and a diversity data receive signal (DRx) 822 to benefit from spatial diversity gain. The voice transmit signal (Tx2) 824 may be allocated to the same antenna 814 as the diversity data receive signal (DRx) 822. The voice receive signal (Rx) 820 may be allocated to the same antenna 814 as the primary data receive signal (PRx) 841. This mitigates intermodulation issues between the data transmit signal (Txl) 842 and the voice transmit signal (Tx2) 824 by taking advantages of the antenna-to-antenna isolation (>10 dB). Specific absorption rate (SAR) hot spots from the two antennas 814 are not likely to coincide, improving the dual transmit SAR performance in comparison to a single antenna 814. It also allows for design trade-off to dedicate the better performing antenna 814 to the most important voice aspect. It further eases antenna 814 design constraints by not simultaneously supporting voice and data in one antenna 814. Finally, the isolation between the voice transmit signal (Tx2) 824 and the voice receive signal (Rx) 820 due to antenna-to-antenna isolation plus duplexer isolation would lead to improved single tone desensitization performance.

[0075] The data modem 868 and the voice and global positioning system (GPS) modem 870 may use a high-speed universal asynchronous receiver/transmitter (HS-UART) 871 to communicate with each other. The data modem 868 and the voice and global positioning system (GPS) modem 870 may also use a Secure Digital Input Output (SDIO) 872 to communicate with each other.
Figure 9 illustrates certain components that may be included within a wireless communication device 904. The wireless communication device 904 may be an access terminal, a mobile station, a user equipment (UE), etc. The wireless communication device 904 includes a processor 903. The processor 903 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 903 may be referred to as a central processing unit (CPU). Although just a single processor 903 is shown in the wireless communication device 904 of Figure 9, in an alternative configuration, a combination of processors (e.g., an ARM and DSP) could be used.

The wireless communication device 904 also includes memory 905. The memory 905 may be any electronic component capable of storing electronic information. The memory 905 may be embodied as 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 907a and instructions 909a may be stored in the memory 905. The instructions 909a may be executable by the processor 903 to implement the methods disclosed herein. Executing the instructions 909a may involve the use of the data 907a that is stored in the memory 905. When the processor 903 executes the instructions 909, various portions of the instructions 909b may be loaded onto the processor 903, and various pieces of data 907b may be loaded onto the processor 903.

The wireless communication device 904 may also include a transmitter 911 and a receiver 913 to allow transmission and reception of signals to and from the wireless communication device 904 via a first antenna 917a and a second antenna 917b. The transmitter 911 and receiver 913 may be collectively referred to as a transceiver 915. The wireless communication device 904 may also include (not shown) multiple transmitters, additional antennas, multiple receivers and/or multiple transceivers.

The wireless communication device 904 may include a digital signal processor (DSP) 921. The wireless communication device 904 may also include a communications interface 923. The communications interface 923 may allow a user to interact with the wireless communication device 904.
The various components of the wireless communication device 904 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 Figure 9 as a bus system 919.

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 hardware, software, firmware, or any combination thereof. If implemented in software, 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 available medium that can be accessed by a computer. 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 can be used to 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.

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 Figures 5 and 6, 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.

[0091] 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.

[0092] What is claimed is:
CLAIMS

1. A wireless device configured for simultaneous voice and data communications, comprising:
   a voice and data transceiver comprising:
   data path circuitry;
   voice path circuitry;
   a first multiplexer, wherein the first multiplexer sends a primary data receive signal to the data path circuitry and receives a data transmit signal from the data path circuitry;
   a second multiplexer, wherein the second multiplexer sends a diversity data receive signal to the data path circuitry, sends a voice receive signal to the voice path circuitry and receives a voice transmit signal from the voice path circuitry;
   a first antenna coupled to the first multiplexer; and
   a second antenna coupled to the second multiplexer.

2. The wireless device of claim 1, wherein a configuration of the first multiplexer and the second multiplexer reduces third order intermodulation interference introduced in the voice and data transceiver.

3. The wireless device of claim 1, wherein the wireless device is a wireless communication device configured to operate using a Long Term Evolution standard.

4. The wireless device of claim 1, wherein the data path circuitry comprises:
   a primary data receive chain that receives the primary data receive signal from the first multiplexer;
   a data transmit chain that sends the data transmit signal to the first multiplexer; and
   a diversity data receive chain that receives the diversity data receive signal from the second multiplexer, and wherein the voice path circuitry comprises:
   a voice receive chain that receives the voice receive signal from the second multiplexer; and
5. The wireless device of claim 1, wherein the first multiplexer is a diplexer, and wherein the second multiplexer is a diplexer.

6. A wireless device configured for simultaneous voice and data communications, comprising:
   a voice and data transceiver comprising:
   data path circuitry;
   voice path circuitry;
   a first multiplexer, wherein the first multiplexer sends a primary data receive signal to the data path circuitry, receives a data transmit signal from the data path circuitry and sends a voice receive signal to the voice path circuitry;
   a second multiplexer, wherein the second multiplexer sends a diversity data receive signal to the data path circuitry and receives a voice transmit signal from the voice path circuitry;
   a first antenna coupled to the first multiplexer; and
   a second antenna coupled to the second multiplexer.

7. The wireless device of claim 6, wherein a configuration of the first multiplexer and the second multiplexer reduces third order intermodulation interference introduced in the voice and data transceiver.

8. The wireless device of claim 6, wherein the wireless device is a wireless communication device configured to operate using a Long Term Evolution standard.

9. The wireless device of claim 6, wherein the data path circuitry comprises:
   a primary data receive chain that receives the primary data receive signal from the first multiplexer;
   a data transmit chain that sends the data transmit signal to the first multiplexer; and
a diversity data receive chain that receives the diversity data receive signal from
the second multiplexer, and wherein the voice path circuitry comprises:
a voice receive chain that receives the voice receive signal from the first
multiplexer; and
a voice transmit chain that sends the voice transmit signal to the second
multiplexer.

10. The wireless device of claim 6, wherein the first multiplexer is a diplexer, and
wherein the second multiplexer is a diplexer.

11. A wireless device configured for simultaneous voice and data communications,
comprising:
   a voice and data transceiver comprising:
   data path circuitry;
   voice path circuitry;
   a first multiplexer, wherein the first multiplexer sends a diversity data
   receive signal to the data path circuitry, receives a data transmit
   signal from the data path circuitry and sends a voice receive
   signal to the voice path circuitry;
   a second multiplexer, wherein the second multiplexer sends a primary
   data receive signal to the data path circuitry and receives a voice
   transmit signal from the voice path circuitry;
   a first antenna coupled to the first multiplexer; and
   a second antenna coupled to the second multiplexer.

12. The wireless device of claim 11, wherein a configuration of the first multiplexer
and the second multiplexer reduces third order intermodulation interference introduced
in the voice and data transceiver.

13. The wireless device of claim 11, wherein the wireless device is a wireless
communication device configured to operate using a Long Term Evolution standard.

14. The wireless device of claim 11, wherein the data path circuitry comprises:
a primary data receive chain that receives the primary data receive signal from
the second multiplexer;
a data transmit chain that sends the data transmit signal to the first multiplexer;
and
a diversity data receive chain that receives the diversity data receive signal from
the first multiplexer, and wherein the voice path circuitry comprises:
a voice receive chain that receives the voice receive signal from the first
multiplexer; and
a voice transmit chain that sends the voice transmit signal to the second
multiplexer.

15. The wireless device of claim 11, wherein the first multiplexer is a diplexer, and
wherein the second multiplexer is a diplexer.

16. A method for simultaneous voice and data communication, comprising:
communicating a voice signal;
communicating a data signal; and
minimizing third order intermodulation interference generated by simultaneously
communicating the voice signal and the data signal.

17. The method of claim 16, wherein the voice signal is communicated using a first
antenna and a first multiplexer, and wherein the data signal is communicated using the
first antenna, the first multiplexer, a second antenna and a second multiplexer.

18. The method of claim 17, wherein the first multiplexer is a diplexer, and wherein
the second multiplexer is a diplexer.

19. The method of claim 16, wherein communicating the voice signal comprises
transmitting the voice signal, and wherein communicating the data signal comprises
transmitting the data signal.

20. The method of claim 19, wherein the voice signal and the data signal are
transmitted simultaneously.
21. The method of claim 16, wherein communicating the voice signal comprises receiving the voice signal, and wherein communicating the data signal comprises receiving the data signal.

22. The method of claim 21, wherein the voice signal and the data signal are received simultaneously.

23. The method of claim 16, wherein the method is performed by a wireless communication device.

24. The method of claim 16, wherein communicating the voice signal comprises receiving the voice signal while simultaneously transmitting the voice signal.

25. The method of claim 16, wherein communicating the data signal comprises transmitting the data transmit signal while simultaneously receiving the primary data receive signal and the diversity data receive signal.

26. A wireless device configured for simultaneous voice and data communications, comprising:
   a voice and data transceiver comprising:
   data path circuitry;
   voice path circuitry;
   a first multiplexer, wherein the first multiplexer sends a primary data receive signal to the data path circuitry, receives a voice transmit signal from the voice path circuitry and receives a data transmit signal from the data path circuitry;
   a second multiplexer, wherein the second multiplexer sends a diversity data receive signal to the data path circuitry and sends a voice receive signal to the voice path circuitry;
   a duplexer, wherein the duplexer is coupled between the second multiplexer and a data modem; and
   a resistor, wherein the resistor is coupled between the duplexer and ground;
27. The wireless device of claim 26, wherein the configuration of the duplexer and the resistor is such that the duplexer is used as a diversity receive signal filter.

28. The wireless device of claim 27, wherein the data transmit signal is terminated at the resistor such that it does not reflect back to the duplexer to generate third order intermodulation interference with the voice transmit signal.

29. The wireless device of claim 26, wherein the resistor is a 50 ohm resistor.

30. The wireless device of claim 26, wherein the first multiplexer is a diplexer, and wherein the second multiplexer is a diplexer.

31. An apparatus for simultaneous voice and data communication, comprising:
    means for communicating a voice signal;
    means for communicating a data signal; and
    means for minimizing third order intermodulation interference generated by simultaneously communicating the voice signal and the data signal.

32. The apparatus of claim 31, wherein the means for communicating the voice signal comprise using a first antenna and a first multiplexer, and wherein the means for communicating the data signal comprise the first antenna, the first multiplexer, a second antenna and a second multiplexer.

33. The apparatus of claim 32, wherein the first multiplexer is a diplexer, and wherein the second multiplexer is a diplexer.

34. The apparatus of claim 31, wherein communicating the voice signal comprises transmitting the voice signal, and wherein communicating the data signal comprises transmitting the data signal.
35. The apparatus of claim 34, wherein the voice signal and the data signal are transmitted simultaneously.

36. The apparatus of claim 31, wherein communicating the voice signal comprises receiving the voice signal, and wherein communicating the data signal comprises receiving the data signal.

37. The apparatus of claim 36, wherein the voice signal and the data signal are received simultaneously.

38. The apparatus of claim 31, wherein the apparatus is a wireless communication device.

39. The apparatus of claim 31, wherein communicating the voice signal comprises receiving the voice signal while simultaneously transmitting the voice signal.

40. The apparatus of claim 31, wherein communicating the data signal comprises transmitting the data transmit signal while simultaneously receiving the primary data receive signal and the diversity data receive signal.
Simultaneous Voice and Data (SVD) Transceiver
(with reduced Third Order Intermodulation (IM3) interference)

Data for Transmission 330

Received Data 332

Voice for Transmission 334

Received Voice 336

Data Path Circuitry 326

Voice Path Circuitry 328

Multiplexer 316a

Multiplexer 316b

Primary Data Receive Signal (PRx) 341

Data Transmit Signal (Tx1) 342

Voice Receive Signal (Rx) 320

Diversity Data Receive Signal (DRx) 322

Voice Transmit Signal (Tx2) 324

First Antenna 314a

Second Antenna 314b

FIG. 3
FIG. 5

Communicate a voice signal

Communicate a data signal

Minimize third order intermodulation (IM3) interference generated by simultaneously communicating the voice signal and the data signal.
FIG. 6

1. Receive a diversity data receive signal (DRx) using a first multiplexer and a first antenna
2. Receive a voice receive signal (Rx) using the first multiplexer and the first antenna
3. Receive a primary data receive signal (PRx) using a second multiplexer and a second antenna
4. Transmit a data transmit signal (Tx1) using the first multiplexer and the first antenna
5. Transmit a voice transmit signal (Tx2) using the second multiplexer and the second antenna
**INTERNATIONAL SEARCH REPORT**

**International application No**
PCT/US2011/05815O

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. H04B1/40 H04B1/52

**ADDITIONAL INFORMATION**

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

H04B

**Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched**

**Electronic data base consulted during the international search (name of data base and, where practical, search terms used)**

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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* Further documents are listed in the continuation of Box C. [See patent family annex.]

**Document definitions:**

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "A" document member of the same patent family

**Date of the actual completion of the international search**
28 February 2012

**Date of mailing of the international search report**
06/03/2012

**Name and mailing address of the ISA/ISB**
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016

**Authorized officer**
Marques, Gabriela
This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. □ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. □ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. □ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. □ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. X As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. □ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. □ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 

Remark on Protest

- The additional search fees were accompanied by the applicant’s protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant’s protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.
This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-40

   Simultaneous transmission of voice and data

   1.1. claims: 1-15, 26-30

   Transmission of voice and data by means of multiplexing

   1.2. claims: 16-25, 31-40

   Transmission of voice and data while minimizing intermodulation

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