[0001] POWER CONTROL IN ORTHOGONAL SUB-CHANNELS IN WIRELESS COMMUNICATIONS

[0002] FIELD OF INVENTION

[0003] The present application is related to wireless communications.

[0004] BACKGROUND

[0005] The concept of Orthogonal Sub-channels (OSCs) and how they can be used to increase the voice capacity of GSM EDGE Radio Access Network (GERAN) cells has been disclosed by others (GSM is Global System for Mobile; EDGE is Enhanced Data rates for Global Evolution). In an OSC scheme, the base station (BS) uses Quadrature Phase-Shift Keying (QPSK) modulation for downlink (DL), which multiplexes voice data from two users. The multiplexing is done such that legacy Mobile Stations (MSs) using Gaussian Minimum Shift Keying (GMSK) can receive their respective data.

[0006] As an example, Figure 1 shows a QPSK constellation chosen as a subset of an Eight Phase Shift Keying (8PSK) constellation. The most significant bit (MSB) and least significant bit (LSB) define two "orthogonal" sub-channels I and Q, wherein the bits are denoted as (OSC0, OSC1). Each sub-channel carries voice signals of two users in the DL direction. GMSK-only capable MSs are able to detect the individual sub-channels.

[0007] These prior OSC proposals also provide that downlink power control may use conditions of the weakest link as criteria. For example, in such an approach, if the weaker orthogonal sub-channel is I, the power control would be adjusted such that both sub-channels I and Q are equally increased until the sub-channel I attains the minimum acceptable power level. This approach would have the advantage of maintaining the shape of the QPSK constellation as circular, keeping all four constellation points equidistant, which provides maximum separation for best receiver decoding results. The disadvantage to this approach is that more power is used than is necessary on the sub-channel

that is not the weakest link, (i.e., sub-channel Q in this example). Consequently, the interference between the sub-channels will increase.

[0008] SUMMARY

[0009] A method and apparatus for multi-user communication includes independent power control to each sub-channel designated to a user. A modified QPSK modulation mapping is performed for two users, each user being assigned to an orthogonal sub-channel. The power control method minimizes transmitted power on each sub-channel and interference between each sub-channel.

[0010] BRIEF DESCRIPTION OF THE DRAWINGS

[0011] A more detailed understanding may be had from the following description of a preferred embodiment, given by way of example and to be understood in conjunction with the accompanying drawing, wherein:

[0012] Figure 1 shows a QPSK constellation chosen as a subset of an Eight Phase Shift Keying (8PSK) constellation and defining orthogonal sub-channels;

[0013] Figure 2 shows a block diagram of a wireless communication with orthogonal sub-channel power control of a downlink signal; and

[0014] Figures 3A and 3B show orthogonal sub-channel I and Q constellations for a modified QPSK modulation with independent power control.

[0015] DETAILED DESCRIPTION

[0016] When referred to hereafter, the terminology "wireless transmit/receive unit (WTRU)" includes but is not limited to a user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a computer, or any other type of user device capable of operating in a wireless environment. When referred to hereafter, the terminology "base station" includes but is not limited to a Node-B, a site controller, an access point (AP), or any other type of interfacing device capable of operating in a wireless environment.

[0017] Figure 2 shows a base station 201, comprising a processor 202 configured to perform a method of a first embodiment. The processor 202 processes data from users 251, 252 via the communication network 231, to be transmitted to a WTRU 211 and a WTRU 221 on a wireless downlink signal 215. In order to increase capacity on the downlink signal 215, a radio resource can be mapped by the processor 202 whereby voice or data signals from two users 251, 252 sent in the same time slot can be individually detected by the intended receivers WTRUs 211 and 221. A modified QPSK modulation is applied to the downlink signal 215 using orthogonal sub-channels I and Q.

[0018] Figures 3A and 3B show examples of constellations for mapping of the orthogonal sub-channels I and Q according to a modified QPSK modulation, where power control is adjusted independently on each sub-channel I and Q. In Figure 3A, a constellation 301 is rectangular along the Q axis, as a result of independent power adjustment upward on the sub-channel I, while applying zero power adjustment to sub-channel Q. Alternatively, there may also be some independent power control adjustment on the Q-sub-channel, so long as the relative increase in power control adjustment on the sub-channel I is greater than that on the sub-channel-Q.

[0019] Conversely in Figure 3B, a constellation 302 is rectangular along the I axis, which results when independent power control adjustment is increased more on the sub-channel Q than on the sub-channel I.

[0020] Alternatively, there may be a decrease in power control adjustment to either of the sub-channels I and Q.

[0021] Adaptive power control is independently applied on the sub-channels I and Q, such that the rectangular constellation of the modified QPSK modulation can vary according to an independent power control parameter α on the sub-channel I and an independent power control parameter β on the sub-channel Q. For example, the four constellation points for the modified QPSK according to this embodiment can be represented as shown in Table 1:

TABLE 1

(0,0)	(0,1)	(1,0)	(1,1)
α +jβ	α -jβ	-α + jβ	-α - jβ

The power control parameters α and β are constants set within the following limits:

$$0 < \alpha \leq 1;$$
$$0 < \beta \leq 1$$

where α and β are kept from approaching too close to 0. These parameters α and β represent the relative voltage amplitude for each of the two orthogonal sub-channel I and Q signals, where α is proportional to the square root of sub-channel I power P_I and β is proportional to the square root of sub-channel Q power P_Q. If the total power transmitted for the two sub-channels I and Q is equal to P, then the power P_I of the sub-channel I is as follows:

$$P_I = \alpha^2 P,$$

and the power P_Q of the sub-channel Q channel is:

$$P_Q = \beta^2 P.$$

[0022] Practical implementation issues may constrain the ratio of α / β to be within limits. For example, one range for the ratio may be:

$$0.5 < \frac{\alpha}{\beta} < 2,$$

which would represent a practical constraint that the relative power between the two sub-channels I and Q should not be greater than 4, or equivalently, 6 dB. The exact constraint will be a determined by practical implementation issues, including, but not limited to quantization resolution of the analog to digital process.

[0023] Thus, the example constellations shown in Figures 3A and 3B each depict one of many possible variations, depending on the power control parameter selected. The processor 202 determines the power control parameters α and β depending on detected received channel quality according to typical power control feedback schemes. One example includes the processor 212 of WTRU 211 determining that the multiple errors have been detected on received signal 215, and in response, a channel quality indicator (CQI) is reported back to the base station 201. Based on the CQI, the processor 202 of base station 201 will select a power control parameter α that will independently increase power on the sub-channel I, which was allocated for the WTRU 211.

[0024] Various power control techniques can be applied to the orthogonal sub-channels I and Q, including open-loop based or close-loop based schemes. Also, the time scale of the power control adaptation may be optimally chosen. The criteria for power control adaptation may include signal power, noise, or interference levels in any combination.

[0025] The criteria for power control adaptation also takes into account dynamic range issues. For example, measures are taken to ensure that the two sub-channels I and Q are sufficiently close in power level to prevent the well-known signal capture problems that can occur when a receiver, such as the WTRU 211, must process two signals arriving at significantly different power levels. In particular, the capture problems can occur at the WTRU 211 receiver during A/D conversion, where an A/D converter dynamic range can be impacted by a large power level offset between received sub-channels I and Q. Maintaining a proper balance of the power levels can be achieved by the following two techniques, either alone or in a combination thereof: (1) during a scheduling and channel assignment process, avoid assigning the two sub-channels I and Q to the WTRUs 211 and 221 with excessive differences in required transmit power level; and (2) set the individual target power levels to values that support a proper balance. Optionally, an additional, larger dynamic range can be achieved by specifying an increased dynamic range capability for the mobile terminals (i.e. more bits in the A/D converter).

[0026] As part of the OSC modulation applied by the base station 201, a link adaptation is performed for multiplexing the receivers WTRU 211 and WTRU 221, by which the base station 201, or a Base Station System (BSS) to which it belongs, can dynamically change the multiplexing based on current channel conditions. Take for example, a scenario in which the WTRU 211 is located very close to the base station 201, and the WTRU 221 is located relatively further away from the base station 201, and the sub-channels are multiplexed to the same time slot. Using internal thresholds and hysteresis, the base station 201 may elect to reassign the WTRU 221 information from the multiplexed time slot and instead multiplex the WTRU 211 information with information of another WTRU that is located closer to the base station 201. This can be achieved by simple Intra-Cell Handover procedures, taking advantage of procedures such as "Packing/Unpacking". As an alternative option, the base station 201 may elect to have the WTRU 221 as the sole user of another time slot.

[0027] The modified QPSK modulation method described above relates to the packet-switched (PS) domain as follows. In PS domain, data is exchanged on channels, such as a Packet Data Channel (PDCH). An example of a PDCH is a time slot in a single carrier. The timeslot carries a radio burst, which is made up of a number of modulated symbols, each of which carries one or more bits of data. All of these bits belong to the PDCH. In the present context, the bits associated with each symbol in the downlink are assigned to multiple users, such as the WTRU 211 and the WTRU 221. For example, the MSB and LSB of the modified QPSK (i.e., (MSB, LSB)) may be assigned as follows: MSB to the WTRU 211, LSB to the WTRU 221. Correspondingly, in the uplink, the WTRU 211 and the WTRU 212 transmit on the same time slot and the same carrier frequency, but using different (preferably orthogonal) training sequences. In this embodiment, the definition of the PDCH is extended to such orthogonal sub-channels, referred to herein as Orthogonal-PDCH (O-PDCH). In the above example, two O-PDCHs are defined in terms of the two orthogonal sub-channels in both the downlink and the uplink.

[0028] As an implementation of this embodiment, the WTRU 211 or the WTRU 221 may receive a Packet Timing Control Channel (PTCCH) using an orthogonal sub-channel I or Q in the downlink. One advantage to this is that there would be no need for the base station 201 to allocate a separate channel for the PTCCH, and delay transmission of PTCCH information until an opportunity is available for the PTCCH transmission. Instead, the PTCCH information can be conveyed immediately on the I and Q sub-channels and received by the WTRU 211, 221 without delay. For uplink transmissions by the WTRU 211 and 221, a normal PDCH may be used, (e.g., for case where WTRUs 211, 221 are legacy devices). Alternatively, an O-PDCH may be defined for the uplink, by which each of the sub-channels I and Q could carry a different data stream, or one sub-channel could carry data information and the other could carry voice or control information.

[0029] In an O-PDCH made up of more than one time slot, one or more time slots may carry orthogonal sub-channels I and Q, whereas other time slots support normal PDCH channels.

[0030] In order to uniquely identify the multiplexed WTRU 211 from the WTRU 221 in the downlink 215, the base station 201 can send two different blocks of information, using the sub-channels I and Q, respectively to the WTRU 211 and the WTRU 221. Within the same time slot, each block of information contains a Temporary Flow Identity (TFI) in the header that corresponds to the sub-channel I or Q.

[0031] Within an uplink 225 signal, the WTRU 211 can be uniquely identified from the WTRU 221 by scheduling of resources based on an uplink state flag (USF) parameter and/or the TFI. The scheduling of resources can be performed by the base station 201 using the orthogonal sub-channels I and Q to send two different USF values, one on each sub-channel, to the WTRU 211 and WTRU 221. When the WTRU 211 and WTRU 221 send information in the uplink, they are uniquely identified by a unique mapping of their corresponding TFI and the sub-channel number (e.g., 0 or 1). The base station processor 202 detects the

unique TFI and sub-channel number on the received uplink, enabling unique identification of the WTRU 211 and WTRU 221 signals.

[0032] Finally, link adaptation can be applied to each O-PDCH by changing adaptively among various modulation and coding scheme (MCS) classes. Automatic Repeat Request (ARQ) with and without incremental redundancy can be applied for reliable transmission of data.

[0033] While embodiments have been described in terms of QPSK modulation, other possible variations may apply higher order modulations including, but not limited to 8PSK, 16QAM and 32QAM, whereby the constellations may reflect independent power control of sub-channels according to power control parameter selection and adjustment.

[0034] Embodiments

1. A method implemented by a base station for power control in a wireless communication, comprising:

establishing at least two orthogonal sub-channels (OSCs) within a downlink channel for communication; and

controlling transmitted power in each sub-channel independently.

2. The method of embodiment 1, wherein the controlling transmitted power is performed adaptively.

3. The method of embodiment 1 or 2, wherein the step of controlling transmitted power is performed adaptively using criteria including at least one of a signal power level, a noise level, and an interference level.

4. The method as in any of embodiments 1-3, further comprising:

multiplexing information for a first wireless transmit/receive unit (WTRU) and information for a second WTRU on a common time slot of a downlink signal, where a first OSC is allocated to the first WTRU and a second OSC is allocated to the second WTRU;

monitoring channel conditions; and

reassigning the information for the second WTRU from the multiplexed common time slot to another time slot.

5. The method as in embodiment 4, wherein a third WTRU is located in closer proximity to the base station than the second WTRU, further comprising multiplexing information for the first WTRU with information for a third WTRU, following the reassigning of the information for the second WTRU.

6. The method as in any of embodiments 1-5, wherein an OSC is used for data exchange in a packet switched (PS) domain.

7. The method of embodiment 6, wherein the OSC is used as a Packet Data Channel (PDCH) and defined as an orthogonal packet data channel (O-PDCH).

8. The method of embodiment 6 or 7, wherein the PDCH comprises a timeslot in a single carrier.

9. The method as in any of embodiments 6-8, wherein an OSC is used as a packet timing control channel (PTCCH) in a downlink direction and the OSC is used as a PDCH in an uplink direction.

10. The method of embodiment 8, wherein an OSC is used as a packet timing control channel (PTCCH) in a downlink direction and a normal PDCH is used in an uplink direction.

11. The method as in any of embodiments 7-10, wherein the O-PDCH comprises more than one time slot, further comprising:

at least one time slot carrying orthogonal sub-channels I and Q and other time slots supporting PDCH channels.

12. A method implemented by a base station for uniquely identifying a first WTRU and a second WTRU in an uplink, comprising:

using orthogonal sub-channels I and Q in a downlink to send two different blocks of information to the first WTRU and the second WTRU, each block containing a corresponding Temporary Flow Identity (TFI); and

separately identifying each of the first and the second WTRU in the uplink by a unique mapping of a corresponding TFI with a number identifying the sub-channel allocated to the first WTRU and the second WTRU.

13. The method of embodiment 12, further comprising scheduling resources for the first WTRU and the second WTRU by sending two different values of an uplink state flag (USF) to the WTRUs by using orthogonal sub-channels in the downlink.

14. The method of embodiment 12 or 13, further comprising linking each PDCH by changing adaptively among various Modulation and Coding Scheme (MCS) classes.

15. A base station, comprising:

a processor configured to establish at least two orthogonal sub-channels (OSCs) within a channel for communication, whereby transmit power is controlled in each sub-channel independently.

16. The base station of embodiment 15, wherein the processor is configured to perform adaptive power control.

17. The base station of embodiment 15 or 16, wherein the adaptive power control is performed using criteria including at least one of a signal power level, a noise level, and an interference level.

18. The base station as in any of embodiments 15-17, wherein the processor is further configured to:

multiplex information for a first wireless transmit/receive unit (WTRU) and information for a second WTRU on a common time slot in a downlink signal where a first OSC is allocated to the first WTRU and a second OSC is allocated to the second WTRU;

monitor channel conditions;

reassign information for the second WTRU from the multiplexed common time slot to another time slot.

19. The base station as in embodiment 18, wherein the processor is configured to multiplex the first WTRU with a third WTRU on the downlink signal if the third WTRU is located in closer proximity to the base station than the second WTRU.

20. The base station as in any of embodiments 15-19, wherein an OSC is used for data exchange in a packet switched (PS) domain.

21. The base station of embodiment 20, wherein the OSC is used as a Packet Data Channel (PDCH) and defined as an orthogonal packet data channel (O-PDCH).

22. The base station of embodiment 20 or 21, wherein the PDCH comprises a timeslot in a single carrier.

23. The base station of embodiment 22, wherein the processor uses an OSC as a packet timing control channel (PTCCH) in a downlink direction and receives an OSC as a PDCH in an uplink direction.

24. The base station of embodiment 22, wherein the processor uses an OSC as a packet timing control channel (PTCCH) in an downlink direction and receives a PDCH in an uplink direction.

25. The base station as in any of embodiments 21-24, wherein the processor defines the O-PDCH to include more than one time slot, and defines at least one time slot for carrying orthogonal sub-channels I and Q while other time slots are defined to support normal PDCH channels.

26. A base station, comprising:

a processor configured for uniquely identifying a first WTRU and a second WTRU in both uplink (UL) and downlink (DL), whereby two different blocks of information are sent to the first and the second WTRU using an OSC in a downlink, each block containing a corresponding Temporary Flow Identity (TFI), such that the first WTRU and the second WTRU are uniquely identified in the uplink by a unique mapping of a corresponding TFI with a number identifying the sub-channel allocated to the first WTRU and the second WTRU.

27. The base station of embodiment 26, wherein the processor is configured to link each PDCH by changing adaptively among various Modulation and Coding Scheme (MCS) classes.

[0035] Although features and elements are described above in particular combinations, each feature or element can be used alone without the other features and elements or in various combinations with or without other features and elements. The methods or flow charts provided herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable storage medium for execution by a general purpose computer or a processor. Examples of computer-readable storage mediums include a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and

removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs).

[0036] Suitable processors include, by way of example, a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs) circuits, any other type of integrated circuit (IC), and/or a state machine.

[0037] A processor in association with software may be used to implement a radio frequency transceiver for use in a wireless transmit receive unit (WTRU), user equipment (UE), terminal, base station, radio network controller (RNC), or any host computer. The WTRU may be used in conjunction with modules, implemented in hardware and/or software, such as a camera, a video camera module, a videophone, a speakerphone, a vibration device, a speaker, a microphone, a television transceiver, a hands free headset, a keyboard, a Bluetooth® module, a frequency modulated (FM) radio unit, a liquid crystal display (LCD) display unit, an organic light-emitting diode (OLED) display unit, a digital music player, a media player, a video game player module, an Internet browser, and/or any wireless local area network (WLAN) or Ultra Wide Band (UWB) module.

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CLAIMS

1. A method for use in a base station, the method comprising:

establishing at least two orthogonal sub-channels (OSCs) within a channel for communication;

controlling transmit power in each OSC of the at least two OSCs independently;

multiplexing information for a first wireless transmit/receive unit (WTRU) and information for a second WTRU on a common time slot in a downlink signal where a first OSC of the at least two OSCs is allocated to the first WTRU and a second OSC of the at least two OSCs is allocated to the second WTRU;

monitoring channel conditions on the channel; and

reassigning information for the second WTRU from the multiplexed common time slot to another time slot in response to the monitored channel conditions.

2. The method of claim 1, further comprising:

performing adaptive power control on the first OSC or the second OSC.

3. The method of claim 2, wherein the performing adaptive power control is configured to perform the adaptive power control using criteria including at least one of a signal power level, a noise level, and an interference level.

4. The method of claim 1, further comprising:

multiplexing the first WTRU with a third WTRU on the downlink signal if the third WTRU is located in closer proximity to the base station than the second WTRU.

5. The method of claim 1, wherein the first OSC or the second OSC is used for data exchange in a packet switched (PS) domain.

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6. A base station, comprising:

a transmitter configured to establish at least two orthogonal sub-channels (OSCs) within a channel for communication;

a processor configured to control transmit power in each OSC of the at least two OSCs independently;

wherein the transmitter is configured to multiplex information for a first wireless transmit/receive unit (WTRU) and information for a second WTRU on a common time slot in a downlink signal where a first OSC of the at least two OSCs is allocated to the first WTRU and a second OSC of the at least two OSCs is allocated to the second WTRU;

wherein the processor is configured to monitor channel conditions on the channel; and

wherein the transmitter is configured to reassign information for the second WTRU from the multiplexed common time slot to another time slot based on the monitored channel conditions.

7. The base station of claim 6, wherein the processor is configured to perform adaptive power control on the first OSC or the second OSC.

8. The base station of claim 7, wherein the processor is configured to perform the adaptive power control using criteria including at least one of a signal power level, a noise level, and an interference level.

9. The base station of claim 6, wherein the transmitter is configured to multiplex the first WTRU with a third WTRU on the downlink signal if the third WTRU is located in closer proximity to the base station than the second WTRU.

10. The base station of claim 6, wherein the first OSC or the second OSC is used for data exchange in a packet switched (PS) domain.

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