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(54) **Title**: RECEIVER ARRANGEMENT AND METHOD OF CONTROLLING A RECEIVER

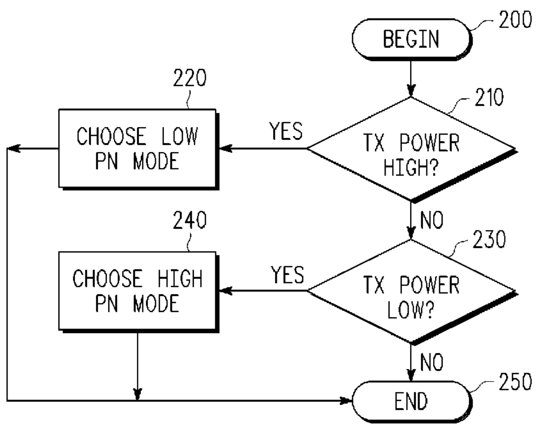


*FIG. 4*

(57) **Abstract**: A receiver arrangement, operable in the presence of an interference signal, comprises a receiver (120), arranged to generate a mixing signal comprising a main component at a predetermined frequency; and a phase noise component, and a controller (124), coupled to the receiver and being arranged to adjust the ratio of the phase noise component level to the main component level of the mixing signal on the basis of the interference signal. In an embodiment, the controller (124) is arranged to control the ratio of the phase noise component level to the main component level on the basis of the transmission power of the interference signal. The receiver arrangement may be part of a transceiver arrangement (100). In this embodiment, the interference signal comprises the transmission signal generated by the transmitter (130) in the transceiver arrangement (100).

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# RECEIVER ARRANGEMENT AND METHOD OF CONTROLLING A RECEIVER

## Field of the Invention

This invention relates to a receiver arrangement and a method of controlling a receiver.

## Background of the Invention

When a transmitter and a receiver are operating simultaneously near-by, for instance, when they form part of a transceiver arrangement, some of the power generated by the transmitter may be received at the receiver as interference. For example, in transceivers for Third Generation Cellular systems, even though the transmitter operates at a different frequency from that at which the receiver operates, such interference is still a significant problem.

Referring first to FIG. 1, there is shown an exemplary transceiver for use in a Third Generation Cellular system, according to existing technology. The transceiver comprises an antenna 10, which is coupled to duplexer 20. Duplexer 20 couples the antenna 10 to a transmitter 30 and a receiver 40. Signals received by the antenna 10 are coupled to the duplexer 20 which feeds them to the receiver 40. Conversely, signals generated by the transmitter 30 are sent to the duplexer 20, which feeds them to the antenna 10. However, some of the power of these transmitted signals is fed from the duplexer 20 to the receiver 40.

As an example, the power of the signals generated by the transmitter may be +27.6dBm (dB over 1mW). The duplexer 20 and associated front-end circuitry may have a combined insertion loss of 2.6dB, such that the power transmitted by antenna 10 is 25dBm. Typically, the duplexer may have transmitter to receiver isolation of at least 51dB, such that the power received at receiver 40 that was generated by transmitter 30 may be as high as -23.4dBm. The power of the wanted signal received by antenna 10, at the receiver 40, may be as low as -100dBm. Hence, the transmitter 30 may cause significant interference to the receiver 40.

Referring now to FIG. 2A, there is shown a frequency spectrum for the signals received at the receiver 40. A portion of the transmitted signal 50, which arrives at the receiver through the duplexer 20 is at a different frequency from the signal 60 that is received from the antenna 10.

Referring to FIG. 2B, there is shown the frequency spectrum of the RF carrier signal 70 generated in the receiver 40. The carrier signal has a main component at a predetermined frequency and a noise component. The carrier signal is mixed with the signals 50 and 60 at the receiver 40, and therefore the carrier signal may be referred to as the mixing signal.

Referring now to FIG. 2C, there is shown the products of mixing the RF carrier signal 70 with the signals 50, 60 received at receiver 40. Signal 80 is the received signal 60 moved to baseband. Signal 90 is the product of mixing the received signal 50, which originates from the transmitter 30, with the phase noise comprised in the RF carrier signal 70.

In view of the high power of the signal 50 generated by the transmitter and despite the low power of the phase noise, signal 90 is also of relatively high power. It therefore causes significant interference at the receiver 40.

Existing technologies seek to reduce this interference by reducing the power of the generated transmission signal that the duplexer 20 feeds to the receiver 40, such as by increasing the isolation loss. However, this is still insufficient to mitigate the interference. Surface Acoustic Wave (SAW) filters are therefore also placed between each stage of the transceiver. Since these are electromechanical devices they can significantly increase the size and cost of the transceiver.

## Summary of the Invention

In accordance with the present invention, there is provided a receiver arrangement, as claimed in the accompanying claims.

In accordance with another aspect of the present invention, there is provided a method of controlling a receiver, as claimed in the accompanying claims.

## Brief Description of the Drawings

A receiver arrangement, and a method of controlling a receiver will now be described, by way of example only, with reference to the accompanying drawings in which:

FIG. 1 is an exemplary transceiver for use in a Third Generation cellular system, according to existing technology;

FIG. 2A shows a frequency spectrum for the signals received at the receiver shown in FIG. 1;

FIG. 2B shows the frequency spectrum of the RF carrier signal generated in the receiver of FIG. 1;

FIG. 2C shows the products of mixing the RF carrier signal of FIG. 2B with the signals received at the receiver shown in FIG. 2A;

FIG. 3 is a block diagram of a transceiver arrangement in accordance with an embodiment of the disclosure;

FIG. 4 is a flow diagram, showing a method for controlling receiver operation in a transceiver, in accordance with an embodiment of the disclosure; and

FIG. 5 is a block diagram of a transceiver arrangement in accordance with a second embodiment of the disclosure.

## Detailed Description of the Drawings

The present disclosure will be described with reference to a third generation cellular communication system, but it will be appreciated that the present disclosure may apply to different communication systems, which may be selected from, for example: private mobile radio (PMR); the Global System for Mobile Communication (GSM); Enhanced Data rates for GSM Evolution

(EDGE); General Packet Radio System (GPRS); Wideband Code Division Multiple Access (WCDMA) or Universal Mobile Telecommunications System (UMTS); Third Generation Long Term Evolution (LTE); Wireless Local Area Networks (WLAN); Worldwide Interoperability for Microwave Access (WIMAX); Bluetooth; or the like. Because the apparatus implementing the present invention is, for the most part, composed of electronic components and circuits known to those skilled in the art, circuit details will not be explained in any greater extent than that considered necessary as illustrated above, for the understanding and appreciation of the underlying concepts of the present invention and in order not to obfuscate or distract from the teachings of the present invention.

FIG. 3 is a block diagram of a transceiver arrangement in accordance with an embodiment of the disclosure. The transceiver arrangement 100 may form part of a portable or mobile telephone, a personal digital assistant (PDA), a wireless video or multimedia device, a portable computer, or similar wireless communication device. The transceiver arrangement comprises an antenna 101 connected to an RF block 102, which is coupled to a duplexer 110. The duplexer 110 has two further connections. A first connection 112 provides signals to a receiver 120 and a second connection 114 receives signals generated by a transmitter 130.

The receiver 120 comprises amplifier 121 and mixer 122, which form a Low Noise Module (LNM). Local oscillator 123 generates a signal at a predetermined carrier frequency. Mixer 122 mixes the output of amplifier of 121 with the signal generated by local oscillator 123. The frequency of the carrier signal generated by the local oscillator 123 is determined such that the desired signal at the input to the receiver, for example the signal 60 in FIG. 2A, is down-converted to baseband.

The generated baseband signal is processed by an analogue baseband processing module 125, the output of which is passed to Analogue to Digital Converter (ADC) 126. A controller 124 is provided, which controls the operation of the local oscillator 123. The output of ADC 126 is coupled to further digital signal processing circuits (not shown), as is well known in the art.

Transmitter 130 comprises a transmission signal generator 134 and a power amplifier 132. The transmission signal generator 134 may, for example, comprise one or more data encoding processors, a modulator, and pulse filtering and is coupled to receive the signal to be transmitted. Through the use of duplexer 110, the signal generated by the transmitter 130 is passed to duplexer port 114, which then passes it to antenna 101. At the same time, signals received at antenna 101, are passed through duplexer 110, to receiver 120. However, some of the signals generated by transmitter 130 are directed, through duplexer 110, to receiver 120. As explained above, this causes interference in the signal received at the receiver 120. The receiver controller 124 is adapted to reduce this interference level.

As explained above, local oscillator 123 generates a mixing signal. This mixing signal comprises a main component, which in this embodiment is at a carrier frequency, and a phase noise component. Local oscillator 123 has at least two operating modes. In a first operating mode, the power of the phase noise component with respect to that of the main component is high, but the current drawn by the local oscillator 123 is low. In a second operating mode, the current drawn by the local oscillator is high, but the power of the phase noise component generated by the local oscillator 123 with respect to that of the main component is low. The controller 124 is able to select the operating mode of the local oscillator.

The operating mode of the local oscillator may be adjusted by adjusting the oscillator bias currents used in generating the main component of the mixing signal. Increasing the currents would increase the power of the main component with respect to the phase noise. Hence, increasing the current would reduce the level of the phase noise with respect to that of the carrier signal. This would raise the main component level relative to the noise floor.

By operating the receiver 120 in the second operating mode with the local oscillator in the second operating mode, the immunity of the receiver to interference generated by the transmitter 130 will be increased. However, the penalty for this increased immunity is an increase in current consumption. When only limited power is available, for example, when the transceiver is powered by a battery, it is desirable to minimise, or at least reduce, current consumption.

Technologies exist for reducing current consumption in a receiver of a transceiver by reducing receiver linearity, based on the level of received interference. For example, US Patent Number 6,311,048, US Patent Number 6,801,760, and US Patent Number 6,876,635 all describe techniques for increasing the receiver linearity when increased interference is experienced. US Patent Number 6,876,635 recognises that the transmitter in the transceiver is a source of interference and adjusts the receiver linearity based on the transmitter power and the received signal strength. However, none of these techniques recognise the interference problem caused by phase noise.

Referring now to FIG. 4, there is shown a flow diagram, which shows the operation of the controller 124 according to an embodiment of the present invention. The flow diagram begins at step 200. At step 210, the controller determines whether the transmission power falls within a high range. If so, at step 220, the controller selects the low phase noise mode of the local oscillator 123, the second operating mode of the receiver. Then, the controller moves to the end step 250. The bounds of the high range can be fixed or variable.

If, at step 210, the controller determines that the transmission power is not in a high level band, the flow chart moves to step 230. At step 230, the controller determines if the transmission power is in a low range. If so, the flow chart moves to step 240, and selects the high phase noise mode for the local oscillator 123, the first mode of the receiver. The flow chart then moves to step 250 which ends. The bounds of the low range can also be fixed or variable. However, the low range and high range need not cover all possible levels for the transmission power.

For example, the high transmission power range might be greater than 12dBm and the low power range may be greater than zero and less than or equal to 12dBm.

If the transmission power is determined to be neither low nor high at step 230, then the controller does not make any selection on the receiver and simply goes to the end step 250. This may be the case, for example, when the transmitter and receiver are both off.

Although the embodiment described above comprises a single antenna, multiple antennas may be used. Multiple antennas may be used to provide diversity, for example. Even when multiple antennas may be used, the transceiver may be operable to connect to a single antenna connection. In any event, energy transfer may occur from one antenna to another, for example when the antennas are in physical proximity.

Referring now to FIG. 5, there is shown a block diagram of a transceiver arrangement in accordance with a second embodiment of the disclosure. A first antenna 201 is connected to a duplexer 204, which is connected to first receiver 206 and transmitter 208. A second antenna 202 is connected to second receiver 210 through a SAW filter 212.

Hence, the signal generated by the transmitter 208 can cause interference to the first receiver 206 through duplexer 206. The signal generated by the transmitter 208 can also cause interference to the second receiver 210 through pick-up by second antenna 202 of the signal emitted by first antenna 201.

First receiver 206 and second receiver 210 use a signal from phase-locked loop 215, which itself is a signal generated from the reference oscillator 217. Together, phase-locked loop 215 and reference oscillator 217 comprise a local oscillator, equivalent to local oscillator 123 in the embodiment shown in FIG. 3. Phase-locked loop 215 generates a mixing signal to be used in first receiver 206 and second receiver 210. A second phase-locked loop (not shown) may be used to provide a frequency reference for the transmitter 208. This may be desirable where the transmitter 208 and the first receiver 206 and second receiver 210 operate at different frequencies.

Phase-locked loop 215 is controlled by processor 218 and provides outputs to interface 219 and Digital Base-Band (DBB) interface 220.

In this embodiment, processor 218 can control phase-locked loop 215 to adjust the ratio of the phase noise power with respect to carrier signal power, dependent on the transmitter power level.

In an example a receiver arrangement, operable in the presence of an interference signal, may comprise: a receiver, arranged to generate a mixing signal comprising: a main component at a predetermined frequency; and a phase noise component; a controller, coupled to the receiver and being arranged to adjust the ratio of the phase noise component level to the main component level of the mixing signal on the basis of the interference signal.

In an example, a method of controlling a receiver, operable in the presence of an interference signal, may comprise: generating a mixing signal for use in the receiver, the mixing signal comprising: a main component at a predetermined frequency; and a phase noise component; and adjusting the ratio of the phase noise component level to the main component level of the mixing signal on the basis of the interference signal.

Reducing the ratio of the level of the phase noise with respect to the level of the carrier generated by the receiver reduces the level of interference. As the transmission power increases, reducing this ratio reduces the level of interference caused by the transmitter to the receiver. This obviates the need for large and expensive filters, such as SAW filters.

By only reducing the relative level of the phase noise when the transmission power is at higher level, the current drain of the receiver can be reduced, which reduces the overall power consumption of the transceiver arrangement. This is important in communication devices, such as Third Generation cellular communication devices. For such devices, it is desirable that they are always in operation. Power consumption is then an important consideration and is particularly relevant where such devices are powered by a limited power resource such as batteries.

In an interference-limited cellular system such as Third Generation WCDMA, the network endeavours to keep all users at the minimum transmitting power so that the interference from one user to other users is minimised. This means that each user will spend most of the time transmitting at lower power levels. Hence, it is desirable for the system to be dynamically controlled to balance current consumption against transmitted power, as opposed to using additional hardware which will be a fixed cost at all transmitted powers.

In the foregoing specification, the invention has been described with reference to specific examples of embodiments of the invention. It will, however, be evident that various modifications and changes may be made therein without departing from the broader spirit and scope of the invention as set forth in the appended claims. For example, the connections may be an type of connection suitable to transfer signals from or to the respective nodes, units or devices, for example via intermediate devices. Accordingly, unless implied or stated otherwise the connections may for example be direct connections or indirect connections.

. Also, although the examples of embodiments of the present invention described above use only two receiver modes and two power levels, more than two receiver levels and more than two power levels may be used by the controller. Indeed, the controller 124 may alternatively adjust the relative level of the phase noise generated by the receiver over a continuous range. The use of more than two power ranges advantageously allows the current to be reduced in closer correlation with any reduction in transmission power.

Furthermore, although specific embodiments have been described above with relation to a direct conversion receiver, it may be alternatively be implemented using other receiver designs, for example a super-heterodyne receiver. In such a receiver, more than one local oscillator may be used, and the frequency of the carrier signal generated by the local oscillator is different from the frequency at which the received signal is modulated.

The embodiment described herein uses fixed high transmission power and low transmission power ranges. However, it is also possible that these ranges may be dynamically varied.

Moreover hysteresis might be added to the process of changing between receiver operating modes. An example of this may be as follows. If the receiver is operating in the first mode, since the transmission power is in the high level range, and the transmission power decreases to below a first threshold, the receiver is then operated in the second operating mode. The transmission power then increases again. However, the receiver does not change from the second mode back to the first mode until the transmission power increases above a second threshold, higher than the first threshold. This hysteresis mitigates the problem of repeated changes between the two transmission power ranges causing too frequent changes in the control of the receiver.

Whilst the embodiment described herein changes the level of the main component in the mixing signal, any method that adjusts the power of the phase noise component of the mixing signal with respect to the main component of the mixing signal could also be used to control the operating mode of the receiver.

Iin embodiments described herein, the transmitter and receiver are connected to antennas that are in close proximity. Alternatively, the transmitter and receiver may be in close proximity and the antennas may be far apart. Nevertheless, in that case also, a signal generated by the transmitter may be received at the receiver.

aAlthough the embodiments described above adjust the ratio of the phase noise component with respect to the main component of the mixing signal on the basis of the transmission power, it may be adjusted on the basis of other factors in the transmission signal, which might affect the level of interference caused. For example, these factors might include transmission signal modulation mode, modulation depth, bandwidth, or other relevant factors.

Whilst the above embodiments relate to a transceiver arrangement, the skilled person will recognise that the interference signal received by the receiver need not originate from the transmitter of a transceiver arrangement, but rather could originate from a near-by transmitter. The power of such an interference signal may be large, and possibly of comparable size to the power of a transmission signal from a transmitter in a transceiver arrangement.

However, other modifications, variations and alternatives are also possible. The specifications and drawings are, accordingly, to be regarded in an illustrative rather than in a restrictive sense.

In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. The word ‘comprising’ does not exclude the presence of other elements or steps then those listed in a claim. Furthermore, Furthermore, the terms “a” or “an,” as used herein, are defined as one or more than one. Also, the use of introductory phrases such as “at least one” and “one or more” in the claims should not be construed to imply that the introduction of another claim element by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim element to inventions containing only one such element, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an." The same holds true for the use of definite articles. Unless stated otherwise, terms such as “first” and “second” are used to arbitrarily distinguish between the elements such terms describe. Thus, these terms are not necessarily intended to indicate temporal or other prioritization of such elements The mere fact that certain measures are recited in mutually different claims does not indicate that a combination of these measures cannot be used to advantage.

CLAIMS:

1. A receiver arrangement, operable in the presence of an interference signal, comprising:

a receiver (120), arranged to generate a mixing signal comprising: a main component at a predetermined frequency; and a phase noise component;

a controller (124), coupled to the receiver and being arranged to adjust the ratio of the phase noise component level to the main component level of the mixing signal on the basis of the interference signal.

2. The receiver of claim 1, wherein the controller (124) is arranged to control the ratio of the phase noise component level to the main component level on the basis of the transmission power of the interference signal.

3. The receiver of claim 2, wherein the controller (124) is arranged to control the ratio of the phase noise component level to the main component level on the basis of the power of the interference signal received at the receiver (120).

4. The receiver arrangement of any preceding claim, wherein the receiver (120) comprises:

a local oscillator (123), arranged to generate the mixing signal; and

a mixer (122), arranged to mix a reception signal with the mixing signal.

5. The receiver arrangement of claim 4, wherein the local oscillator (123) comprises a phase-locked loop (215).

6. The receiver arrangement of claim 4 or claim 5, wherein the controller (124) is arranged to control the ratio of the phase noise component level to the main component level by adjusting the current drawn by the local oscillator (123).

7. A transceiver arrangement (100), comprising:

a receiver arrangement, according to any preceding claim; and

a transmitter (130), arranged to generate a transmission signal with a variable power; and

wherein the interference signal comprises the generated transmission signal.

8. The transceiver arrangement claim 7, wherein the receiver (120) is further configured to operate in one of: a first mode, wherein the signal generator is arranged to generate the mixing signal with a first ratio of the phase noise component level to the main component level; or a second mode, wherein the receiver is arranged to generate the mixing signal with a second ratio of the phase noise component level to the main component level, the second ratio being lower than the first ratio, and wherein the controller (124) is arranged to control the operating mode of the receiver on the basis of the generated transmission signal.

9. The transceiver arrangement of claim 8, wherein the controller (124) is arranged to control the receiver (120) to operate in the first mode when the power of the generated transmission signal is below a first threshold level, and to control the receiver to operate in the second mode when the power of the generated transmission signal is above a second threshold level.

10. The transceiver arrangement of claim 9, wherein the first threshold level and second threshold level are the same.

11. The transceiver arrangement of claim 8, wherein the controller (124) is arranged to control the receiver (120) to operate in the first mode when the receiver (120) is operating in the second mode and the power of the generated transmission signal falls below a first threshold level, and to control the receiver to operate in the second mode when the receiver (120) is operating in the first mode and the power of the generated transmission signal rises above a second threshold level.

12. The transceiver arrangement of claim 8 when dependent on claim 4, wherein the local oscillator (123) draws a first current when the receiver (120) is operating in the first mode and a second current when the receiver (120) is operating in the second mode, the second current being higher than the first current.

13. The transceiver arrangement of any one of claims 9 to 12, wherein the first threshold level and second threshold level are dynamically adjusted.

14. The transceiver arrangement of any one of claims 7 to 13, further comprising:

a duplexer (110), having a connector for coupling to an antenna (101), and being arranged to provide a signal from the connector to the receiver (120) and to provide a signal from the transmitter (130) to the connector.

15. The transceiver arrangement of any one of claims 7 to 14, wherein the receiver is arranged to operate in one of: a first mode having a first ratio of the phase noise component level to the main component level; or a second mode having a second ratio of the phase noise component level to the main component level; or a third mode having a third ratio of the phase noise component level to the main component level, the third ratio being lower than the second ratio and the second ratio being lower than the first ratio.

16. The transceiver arrangement of claim 15, when dependent on claim 9, wherein the controller (124) is arranged to control the receiver (120) to operate in the third mode when the power of the generated transmission signal is above a third threshold level.

17. The transceiver arrangement of any one of claims 7 to 16, wherein the transmitter (130) is operable at a first frequency and the receiver is operable at a second frequency, different to said first frequency.

18. A method of controlling a receiver (120), operable in the presence of an interference signal, the method comprising:

generating a mixing signal for use in the receiver, the mixing signal comprising: a main component at a predetermined frequency; and a phase noise component; and

adjusting the ratio of the phase noise component level to the main component level of the mixing signal on the basis of the interference signal.

19. The method of any one of claim 18, wherein the receiver forms part of a transceiver arrangement (100), the transceiver arrangement further comprising a transmitter (130), and the method further comprising:

generating a transmission signal from the transmitter; and

wherein the interference signal comprises the generated transmission signal.

20. A wireless communication device including a receiver or transceiver arrangement according to any one of the preceding claims.

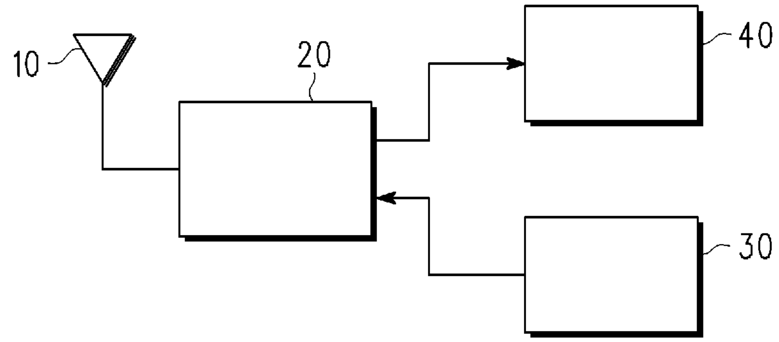



FIG. 1
–PRIOR ART–

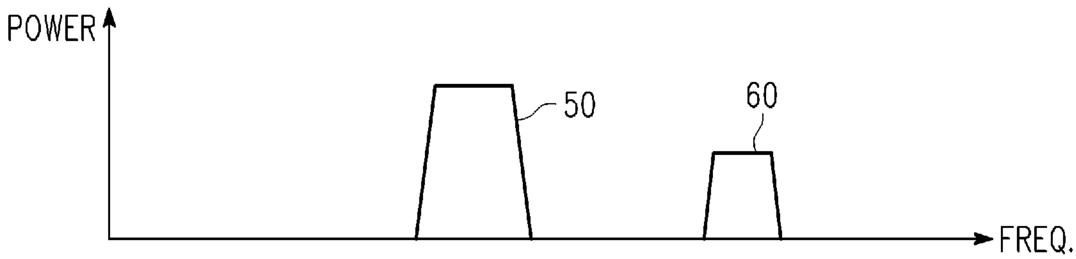



FIG. 2A


FIG. 2B

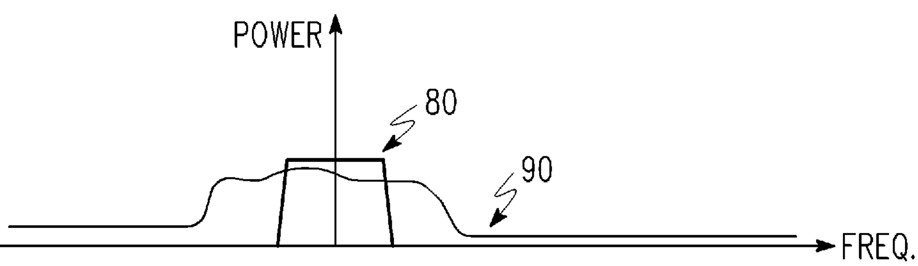
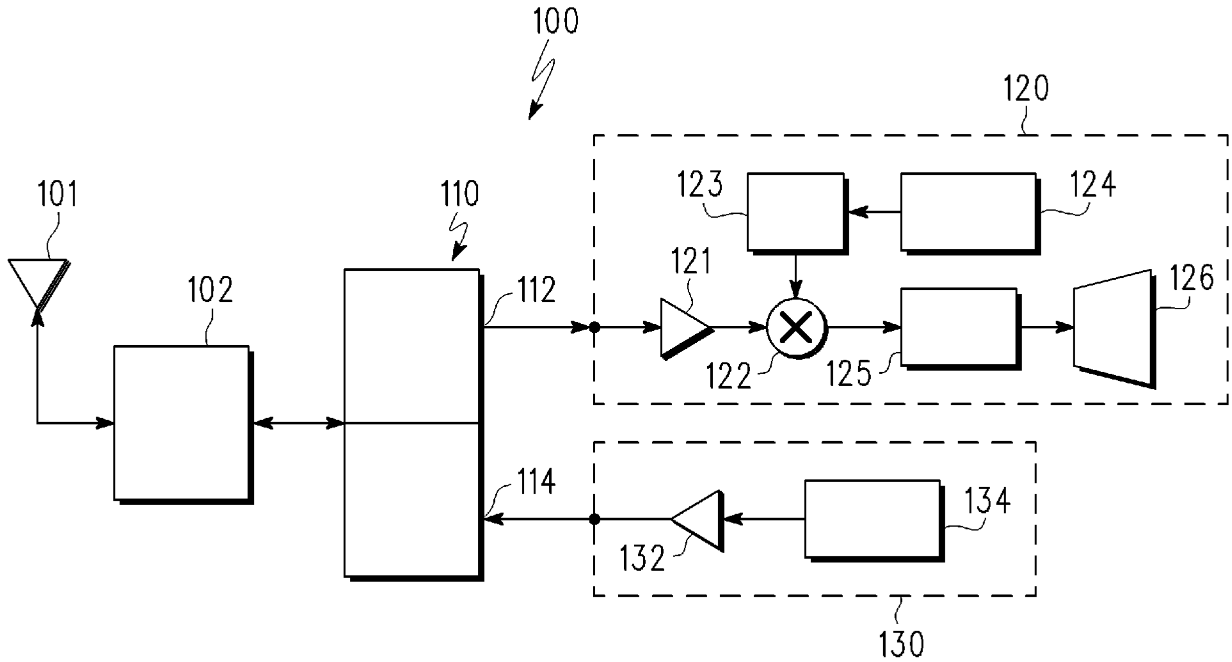



FIG. 2C


100
120
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124
121
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122
125
114
134
132
130

*FIG. 3*

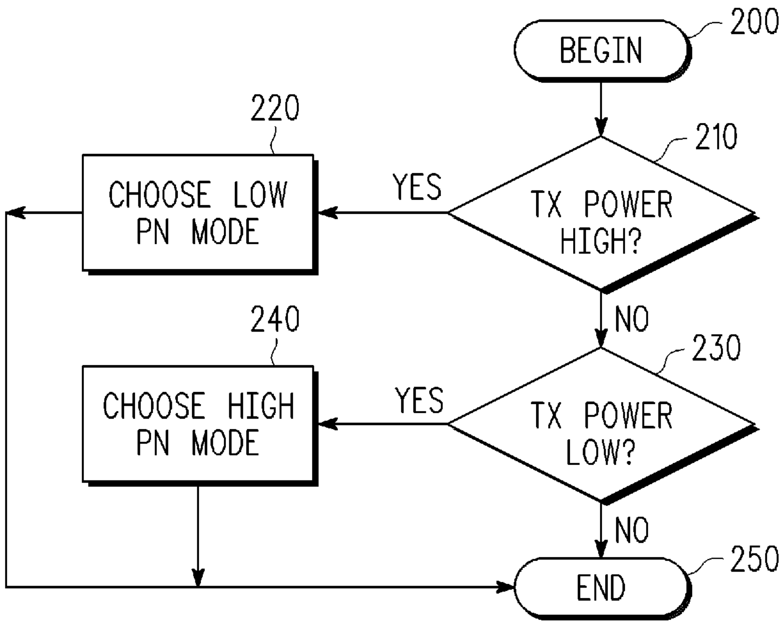
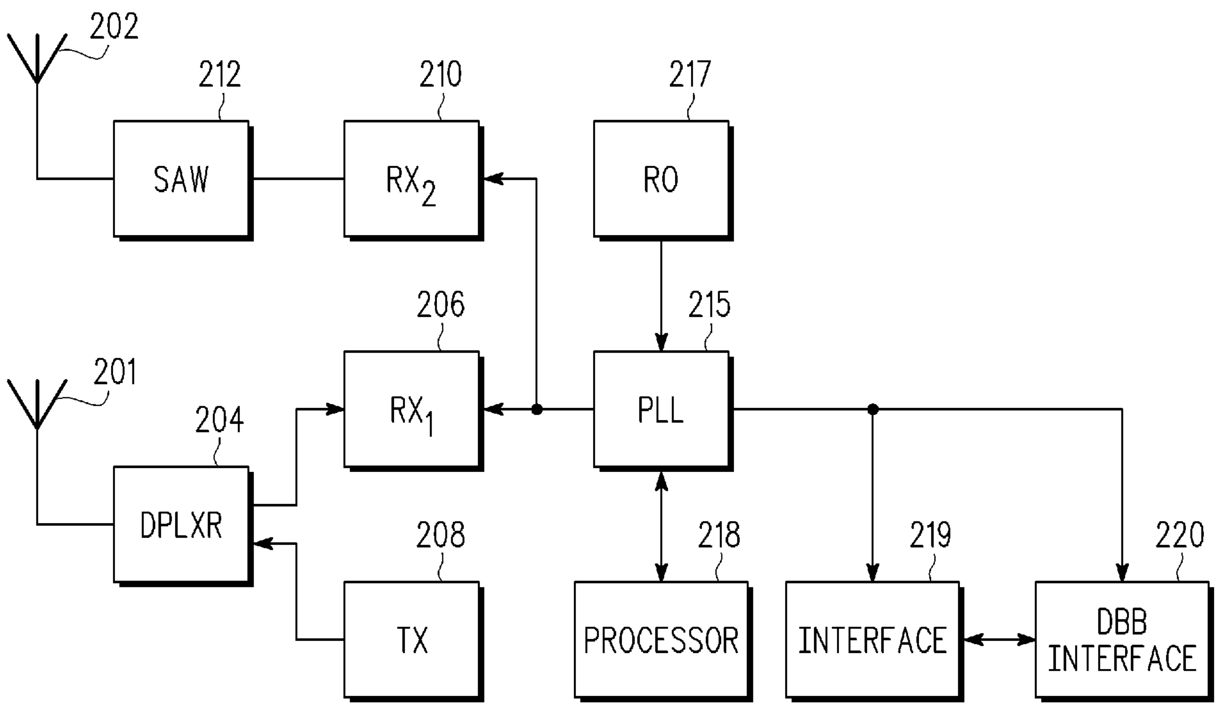

BEGIN
200
220
210
CHOOSE LOW PN MODE
YES
TX POWER HIGH?
NO
240
230
CHOOSE HIGH PN MODE
YES
TX POWER LOW?
NO
END
250

*FIG. 4*


202
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SAW
$RX_2$
RO
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215
201
204
$RX_1$
PLL
DPLXR
208
218
219
220
TX
PROCESSOR
INTERFACE
DBB
INTERFACE

FIG. 5

## INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2008/050694

**A. CLASSIFICATION OF SUBJECT MATTER**
INV. H04B1/10 H04B1/52

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, INSPEC

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | WO 2005/099109 A (QUALCOMM INC [US]; PERSICO CHARLES J [US]; VLADIMIR APARIN [US]; WU YU) 20 October 2005 (2005-10-20) paragraph [0029] - paragraph [0034]; figures 1,2,3a,3b,3c | 1-20 |
| X | WO 2006/055792 A (QUALCOMM INC [US]; GOLDBLATT JEREMY MARK [US]; AHN HEE TAE [US]; CICCA) 26 May 2006 (2006-05-26) paragraph [0006] - paragraph [0010] paragraph [0034] - paragraph [0041]; figures 1-3 | 1-20 |
| X | US 6 298 221 B1 (NGUYEN DIEN M [US]) 2 October 2001 (2001-10-02) column 2, line 22 - column 3, line 39; claim 1 | 1-20 |

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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