

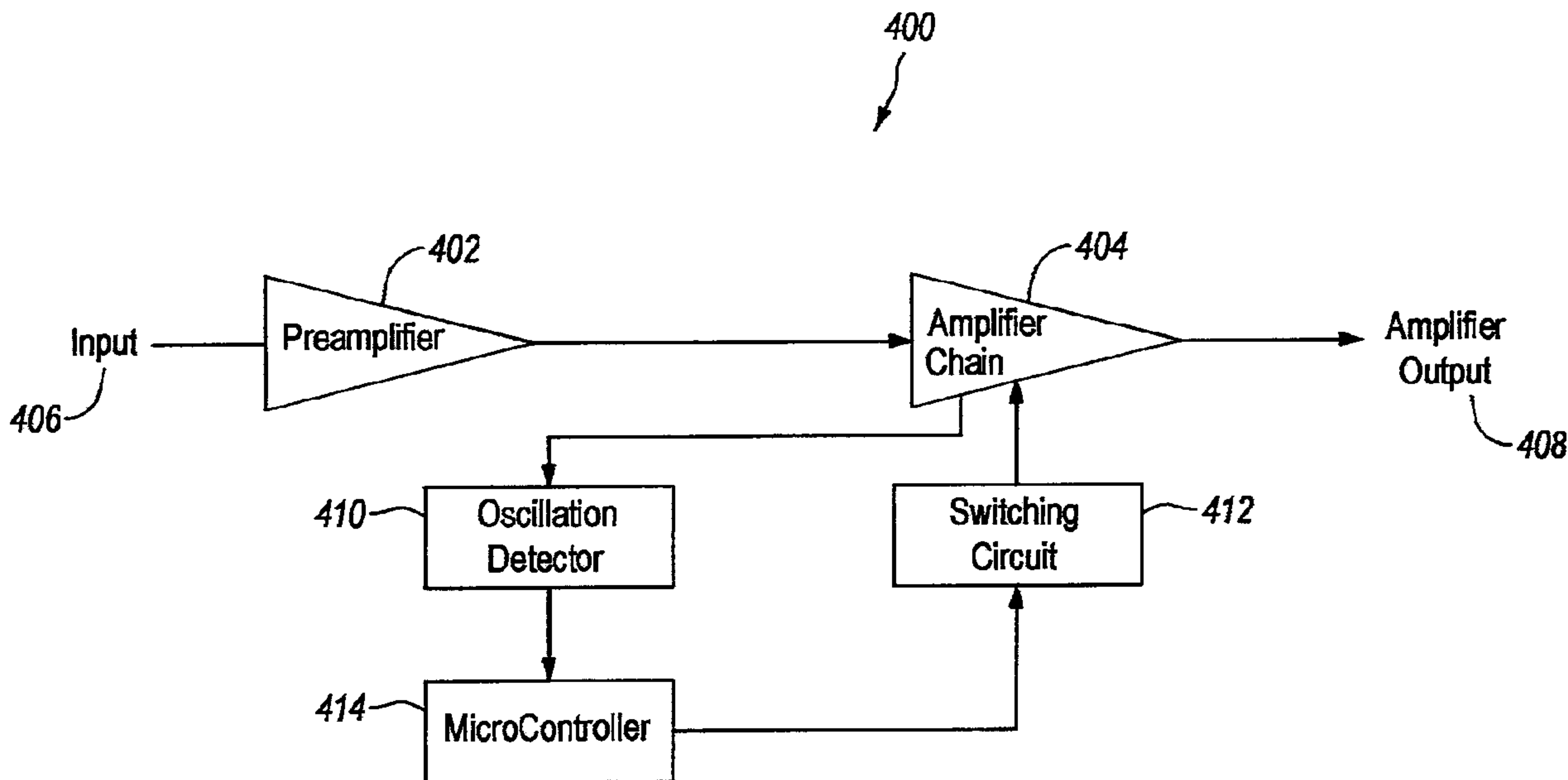


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(57) Abrégé/Abstract:

A method is provided for detecting and mitigating oscillation in an amplifier. The amplifier is configured to sample a signal being amplified to determine whether the amplifier is oscillating. In addition, the status of the amplifier can be verified based on the apparent signal levels of the signals being amplified. The gain of the amplifier is then adjusted in accordance with whether the amplifier is oscillating or as necessary to maintain gain that is compatible with the system within which the amplifier is operating.

Abstract

A method is provided for detecting and mitigating oscillation in an amplifier. The amplifier is configured to sample a signal being amplified to determine whether the amplifier is oscillating. In addition, the status of the amplifier can be verified based on the apparent signal levels of the signals being amplified. The gain of the amplifier is then adjusted in accordance with whether the amplifier is oscillating or as necessary to maintain gain that is compatible with the system within which the amplifier is operating.

VERIFYING OSCILLATION IN AMPLIFIERS AND THE MITIGATION THEREOF

BACKGROUND

5 Booster amplifiers are bi-directional amplifiers used for increasing the sensitivity and power output of cell phones and other devices that are communicating through them. The use of a booster amplifier, however, may disrupt cellular systems of both the network through which the device is communicating and other cellular networks that the device is not
10 communicating through.

 The adverse effects of a booster amplifier can result in a power overload situation, where excessive power overshadows other devices and causes them to be dropped or disconnected. A booster amplifier can also increase the noise floor, which decreases the sensitivity of a base station.
15 Increasing the noise floor often decreases the coverage area of a base station and impairs cellular service. In addition, a booster may begin to self-oscillate. A condition that results in noise and that can cause interference in the cellular system.

 In addition to the disruption of cellular systems, an improperly
20 functioning booster amplifier can cause a subscriber's signal, as received by base stations, to be weaker than necessary. This can result in poor reception of the subscriber's signal by base stations. Under certain conditions, this could even inhibit a subscriber from placing or receiving calls.

 With the introduction of newer cellular and wireless technologies,
25 there is a need to prevent devices operating in the various networks from interfering in those networks. At the same time, there is a need to enhance the ability of devices to effectively communicate in their respective networks.

5

BRIEF DESCRIPTION OF THE DRAWINGS

To further clarify at least some of the advantages and features of the present invention, a more particular description of the invention will be rendered by reference to specific embodiments thereof which are illustrated in the appended drawings. It is appreciated that these drawings depict only illustrated embodiments of the invention and are therefore not to be considered limiting of its scope. The invention will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

Figure 1 illustrates an example of an amplifier operating in a communication system;

Figure 2 illustrates a generalized amplifier with a control circuit that controls gain level.

Figure 3 illustrates an embodiment of a bidirectional amplifier configured to control the amplification of signals between at least two devices;

Figure 4 illustrates another embodiment of an amplifier;

Figure 5A-5E illustrate examples of methods for handling oscillation in an amplifier or for reducing oscillation in an amplifier;

Figure 6 illustrates an example of a method for determining an optimal gain for an amplifier;

Figure 7 illustrates an embodiment of a system and method for setting an optimum gain in an amplifier;

Figure 8 illustrates an example of a flow diagram for setting the gain of an amplifier operating in a network environment;

Figure 9 illustrates another example of a flow diagram for setting the gain of an amplifier; and

Figure 10 illustrates an embodiment of a system and method for implementing the flow diagrams illustrated in Figures 8 and/or 9.

30

5 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A properly functioning booster amplifier (also referred to herein as an amplifier) should be transparent to the cellular system such that base stations do not perceive any significant differences for either the case of a cell phone communicating by itself, or a cell phone communicating through the booster amplifier. Additionally,
10 any emissions from the booster amplifier should always be within limits acceptable to cellular systems, even without a cell phone communicating through the amplifier.

Embodiments of the invention may be discussed with reference to a cell phone or other wireless device operating in a cellular network or other wireless network. Exemplary devices include, by way of example only, cell phones, personal digital
15 assistants, smart phones, laptop computers, modems, or other network enabled devices. One of skill in the art can appreciate that embodiments of the invention can be applied to other wireless networks including those operating on various frequencies throughout the electromagnetic spectrum. Wireless networks include cellular networks as well as other wireless networks. References to cellular networks
20 and cellular systems are also applicable more generally to wireless networks and wireless systems.

“Cell site” and “base station” are used herein interchangeably. Cell site and base station are defined as the location where the wireless network antenna and communications equipment is placed. The wireless network typically has many base
25 stations in operation. A cell site or base station typically includes a transmitter/receiver, antenna tower, transmission radios and radio controllers for maintaining communications with mobile handsets such as a cell phone or other wireless devices within a given range. Similarly, base station or cell site can refer to one or more base stations. Cell phone may also be representative of other devices that
30 may communicate through the amplifier. Embodiments of the amplifier discussed herein, for example, may amplify signals for one or more cell phones or other devices in communication with one or more base stations.

The term “reverse link” refers to the transmission path of a signal being transmitted from a device to a base station. The term “forward link” refers to the
35 transmission path of a signal being transmitted from the base station to the device. The phrases “reverse link signal” and “forward link signal” are not limited to any

5 particular type of data that may be transmitted between a device and a base station, but instead are simply used to specify the direction in which a signal is being transmitted.

Embodiments of the invention relate to amplifiers, including booster amplifiers, that enhance the ability of a device such as a cellular telephone (or other
10 device configured to communicate over a wireless network) to communicate in a wireless network. Embodiments extend to an amplifier that adjusts the gain, dynamically in some embodiments, that is applied to a wireless signal. Embodiments further relate to systems and methods for managing at least one of base station overload, noise floor protection, and self-oscillation as they relate to amplifiers such
15 as booster amplifiers.

One embodiment of a booster amplifier variably adjusts its gain as needed. The ability to variably and/or automatically adjust the gain applied to a wireless signal can prevent the amplifier from generating emissions that may interfere with the operation of a wireless network within which the amplifier is operating, with other
20 cellular or wireless networks, or with the operation of the amplifier itself. Too much gain, for example, can cause the booster amplifier to oscillate, which may result in interference to the wireless network and may adversely impact users of the wireless network. Also, too much gain unnecessarily increases the amount of residual noise at the base stations. Too little gain may interfere with the ability of the wireless device
25 to communicate in the wireless network. As previously stated, embodiments of the invention protect against at least one of power overload oscillation, and/or excessive noise floor increase.

Embodiments of the invention consider parameters that may have an impact on the operation of the amplifier when setting the amplifier's gain. The amplifier
30 includes circuitry, modules and/or components (e.g., hardware, software, firmware, etc.) that determine an optimum gain under various circumstances based on these parameters. The amplifier can be configured to determine an optimum gain by mitigating the effect of specific issues individually and/or multiple issues at the same time. The amplifier can determine an optimum gain to mitigate each of the issues that
35 have been considered by the amplifier. In one example the amplifier generates potential gains for each issue. These potential gains can then be harmonized to

5 generate a final gain that may be optimum in light of all the issues that are being mitigated.

Embodiments of the amplifier can be integrated with wireless devices such as cellular telephones (or other devices) or connect with a wireless device either wirelessly or wired. The amplifier acts as an intermediary between a base station (or
10 other cell site) and a wireless device. Signals generated by the wireless device are amplified and retransmitted by the amplifier. The amplifier also receives signals from the base station and transmits the amplified signals to the wireless device after applying a gain to the received signals. In some examples, the gain may reduce the strength of the signal.

15 The booster amplifier receives a first wireless signal from a base station via a first antenna and a second wireless signal from a device via a second antenna. A control circuit analyzes the inputs and/or outputs of the amplifier and adjusts a gain (or an amplification factor) in a manner that accounts for the parameters sensed using various inputs to the amplifier.

20 The adjusted gain is applied to the first and/or second wireless signals, and the resulting wireless signals are retransmitted via the first and second antennas to the base station and the device, respectively. In some embodiments, the gain applied to the wireless signals in one direction (e.g., from the base station to the wireless device) may be different from the gain applied to the wireless signals in the other direction
25 (e.g., from the wireless device to the base station).

Figure 1 shows an exemplary communications system 100. The communications system 100 may be a cellular telephone wireless network or other wireless network. In this example, a booster amplifier 102 (also referred to as an amplifier) amplifies the signals transmitted between a base station 106 and a device
30 104. In a typical system, the booster amplifier 102 is located in close proximity to the device 104 in comparison to the distance between the booster amplifier 102 and the base station 106. The base station 106 transmits a signal 108 into the surrounding air, which is attenuated for various reasons known to one of skill in the art as it travels outward from the base station 106. An antenna 110 receives the signal 108 and
35 converts the radiated signal into a conducted electrical signal.

5 The booster amplifier 102 amplifies the electrical signal and communicates the amplified signal to the device 104. In one example, the booster amplifier 102 may retransmit the electrical signal from a second antenna 112 as an amplified RF signal 114 to the device 104. The amplified signal 114 is received by an antenna 116 of device 104, which processes the signal and ultimately communicates the appropriate
10 content to a user of device 104.

 As previously indicated, the booster amplifier 102 may be an integral part of, or separate from, the device 104. The booster amplifier 102 may also be implemented in a cradle configured to hold the device 104. For example, the cradle may be mounted on a dash of a car and the device 104 may be placed in the cradle. The
15 communication between the cradle, which may include the booster amplifier 102, may be wired and/or wireless. In addition, signals to and from the device 104 may be communicated with the amplifier 102 using a wired cable 118 and/or the antenna 112. More generally, the booster amplifier 102 may be included in a different form. When the booster amplifier 102 is used, for example, in a building or other area, the form
20 may be adapted or configured for placement or mounting as appropriate for the location.

 Similarly, the device 104 may communicate content to the booster amplifier 102 by transmitting an RF signal from the antenna 116, which is ultimately received by the antenna 112. The booster amplifier 102 amplifies the received signal and
25 retransmits the signal using the antenna 110. The transmitted signal is received by the base station 106, which may perform a number of operations on the signal, as determined by the wireless service provider.

 During operation, the amplifier 102 can dynamically amplify signals transmitted to the base station 106 as well as signals received from the base station
30 106. The gain applied to the signals being amplified can be dynamically adjusted over time and in accordance with various factors. For example, the gain may be set to account for or to mitigate potential issues that may arise in the wireless environment. The amplifier 102 may be configured to prevent the amplifier itself from interfering with the operation of the wireless system 100 or of the base station 106 or of other
35 devices operating in the system 100 or with other wireless systems that may be in operation.

5 For example, embodiments of the invention consider parameters that may have an impact on the operation of the amplifier 102 when setting the amplifier's gain. In particular, the operation of the amplifier 102 is monitored to ensure that the amplifier 102 does not oscillate. If oscillation is detected in the amplifier 102, then the gain of the amplifier 102 is reduced or the amplifier 102 is turned off in order to
10 eliminate the oscillation and reduce the adverse effects of the oscillation.

Because it may be possible to confuse oscillation with valid amplification, embodiments of the invention also distinguish between oscillation and valid amplification. By way of example only, a desirable signal may be present when the device 104 is used to communicate in the system 100 or transmit/receive signals (e.g.,
15 a cellular phone call, Internet access, etc., are examples of when a desirable signal is present). When the device 104 is idle or not being used, a desirable signal may not be present at the input to the booster amplifier 102. It may also be possible for oscillation to occur when amplifying a valid signal.

The amplifier includes circuitry, modules and/or components (e.g., hardware,
20 software, firmware, etc.) that determine an optimum gain or optimum configuration (including off) under various circumstances including oscillation. The amplifier 102 can be configured, for example, to reduce, change, or eliminate the gain applied by the amplifier 102 when oscillation is detected or when other issues are detected.

Figure 2 illustrates a generalized directional amplifier 202 (an example of the
25 booster amplifier 102) configured for producing an optimal gain level. The booster amplifier 202 is unidirectional in this example in the sense that gain is only controlled in the reverse link direction or in the forward link direction. The amplifier 202 is connected to an antenna 210, which is configured to receive a signal. The antenna 210 converts the received signal into an electrical signal. The electrical signal is
30 received by a variable gain module (VGM) 216, which applies an amplification factor to the electrical signal. In one embodiment, the electrical signal is communicated via a second antenna 212, which transmits the adjusted electrical signal as an RF signal, to be received by one or more devices, which may include handsets.

The variable gain module 216 is controlled by a control circuit 214. The
35 control circuit 214 receives the electrical signal from the antenna 210, and based on, by way of example, the properties of the electrical signal and/or other parameters,

5 determines an optimal amplification factor that should be applied to the electrical signal. The control circuit 214 provides a control signal to the variable gain module 216. The control signal instructs the gain module 216 as to the amplification factor that should be applied to the electrical signal.

10 Many factors or parameters may be accounted for when calculating the required amplification factor. Factors include, by way of example and not limitation, the level or strength of the electrical signal and whether there is any indication that the booster amplifier 202 is oscillating or overloading the cellular network in any way or affecting other wireless networks.

15 The amplification factor, in one embodiment, can be a multiplier that is applied to the electrical signal. The amplification factor can result in either an amplified or attenuated output signal. In other words, where the absolute value of the amplification factor is less than one, the amplified adjusted signal will have lower amplitude than the original electrical signal. Conversely, when the absolute value of the amplification factor is greater than one, the amplified adjusted signal will have
20 greater amplitude than the original electrical signal.

The control circuit 214 is an example of a processor that can be used for processing inputs. As described in more detail below, the control circuit 214 may also receive other inputs, which are examples of factors or parameters, that are used when setting the gain to be applied to the electrical signal. The inputs can be derived from
25 the input signal or received from other sources.

Figure 3 illustrates one embodiment of a bidirectional amplifier 302 (an example of the booster amplifier 102) configured to control the amplification of wireless signals being transmitted between a base station and a device (or other wireless signals transmitted between two devices or apparatus). In the amplifier 302,
30 a cellular signal is received from a base station at the antenna 310 and is passed to both a control circuit 314 and a variable gain module 316. Control circuit 314 controls the amplification factor of the variable gain module 316. The amplified signal may be connected to a second antenna 312, which transmits a cellular signal to at least one handset.

35 Bidirectional cellular amplifier 302 is also configured to receive signals from one or more devices (e.g., cellular devices), amplify those signals, and retransmit the

5 amplified signals to a base station. A signal from a handset may be received by antenna 312. The signal is routed to a second variable gain module 304, which applies an amplification factor to the signal. The amplification factor is determined and controlled by control circuitry 314.

10 In order to allow antennas 310 and 312 to simultaneously transmit and receive signals, duplexers (DUP) 306 and 308 are provided by way of example. A duplexer is defined as an automatic electrical routing device that permits simultaneous transmitting and receiving through a common point. More generally, a duplexer is a three port device with one common port "A" and two independent ports "B" and "C". Ideally, signals are passed from A to B and from C to A, but not between B and C.
15 For example, the duplexer 306 receives an RF signal from a base station and converts the signal into a first electrical signal, which is routed to the inputs of the variable gain device 316 and the control circuitry 314. The duplexer 306 simultaneously receives a second electrical signal from the output of the variable gain module 304, and causes this signal to be transmitted as an RF signal via the antenna 310.

20 The control circuitry 314 may be configured to accomplish various objectives when determining the amplification factors to be applied to the variable gain modules 304 and 316. Exemplary objectives include, but are not limited to, i) setting the power level at which the signals are transmitted at a sufficient level to ensure that the signals reach a target destination; and ii) ensuring that the signals transmitted from the
25 booster amplifier are transmitted at a power level that substantially eliminates the interference that would otherwise be introduced into the surrounding cellular network.

First, the control circuitry 314 establishes the amplification factors of the variable gain modules 304 and 316 so that the resultant signals are transmitted with sufficient power to adequately reach a target destination, such as a device or a base
30 station while not exceeding regulatory or other (e.g. industry) established power limitations. Where the wireless signal received at the antenna 310 has undergone significant attenuation, e.g., when the target destination is located a long distance away from the booster amplifier 302, the amplification factor is increased. Conversely, where the wireless signal received at the antenna 310 is at a sufficiently
35 high level, a lower amplification may be established for variable gain modules 316

5 and 304. Thus, the amplification factor or gain for various conditions can be determined by considering these parameters.

Second, the control circuitry 314 ensures that the signals transmitted from the booster amplifier 302 are transmitted at a power level that substantially eliminates the interference that would otherwise be introduced into the surrounding cellular network. Many cellular networks, such as CDMA systems, are configured such that the power level transmitted by each handset in the network is determined by the base station. When communication between a device and a base station is initiated, a "handshake" occurs between the device and base station, and the base station instructs the device as to the power at which the device should transmit. If the base station determines that the signal from the device is too strong, it will instruct the device to reduce the power level of the transmitted signal. The CDMA system is designed so that all of the signals coming into the base station are of approximately the same power. If one signal arrives at the base station at a power level that is significantly higher than the others, it can potentially overpower the base station and cause interference with the other devices in communication with the base station.

Therefore, the control circuitry 314 may determine the maximum amplitude or power level that can be transmitted by antenna 310 to substantially eliminate interference. Interference is considered to be substantially eliminated, in one example, when signals are transmitted from the booster amplifier 302 without causing harmful effects to the surrounding cellular network. For example, interference is substantially eliminated where the signals are transmitted without overpowering the base station, or otherwise interfering with other devices within the wireless network in a way that degrades their performance. The control circuitry 314 may establish the amplification factors applied to variable gain modules to either attenuate or amplify the electrical signals in order to achieve this objective.

The determination of the amplification factor values may be dependent on whether the signals received from the base station via antenna 310 exceed a threshold (also referred to herein as a threshold level or threshold value). The threshold value may be a predetermined set value, or may be a variable that is not established until the control circuitry 314 makes a determination. For example, if after analyzing the strength of the signals received via antenna 310, the control circuitry 314 determines

5 that the signal attenuation between cellular booster amplifier 302 and the target base station or handset is substantial, the control circuitry 314 may establish higher threshold values than if the base station signal was less attenuated. The higher threshold values would allow a greater amplification factor to be applied to the signals so that the transmitted signals will reach their target destination. Because of the
10 substantial distance over which the signals must traverse, the signals will arrive at the target destination (e.g., a base station) without exceeding an appropriate power level, and will therefore not overpower the base station or cause substantial interference with signals transmitted from other handsets.

In the embodiment of Figure 3, the amplification factors applied to the
15 variable gain modules 316 and 304 may both be determined based on the attributes of the signal received from a base station via the antenna 310. The input signal from the base station is received by the control circuitry 314 from the antenna 310 at the connection 318, and radiated to a device via antenna 312. The control circuitry 314 can make a number of determinations based on the attributes of the base station
20 signal. First, the control circuitry 314 can determine the amplitude level of the signal from the base station. Based on the amplitude, the control circuitry can determine an adequate amplification factor for the variable gain module 316 to enable communication of the received signal to a device. Second, the amplitude of the signal received from the base station is also an indicator of the amplitude required to
25 successfully transmit a signal back to the base station via the antenna 310. For example, if the control circuitry 314 measures low amplitude of the first electrical signal, it is likely that the signal transmitted by the base station has been substantially attenuated between the base station and the booster amplifier 302. Therefore, it can determine the amplification factor required by the variable gain module 304 so that
30 the second electrical signal originating from the device is retransmitted with sufficient power to reach the base station (within allowable regulatory and/or other established power limitations)..

The control circuit 314 may also receive additional input. The control circuit may receive an input signal from the connections 320, 322, and 324 which
35 correspond, respectively, to the input signal from the handset (which may be received wirelessly), the output signal of the VGM 316, and the output signal of the VGM 304.

5 Figure 4 generally illustrates another embodiment of a booster amplifier 400, which is an example of the amplifier 102, 202, and/or 302. Figure 4 illustrates an example of the booster amplifier 400 in the context of detecting oscillation and is used to illustrate aspects of oscillation mitigation in the amplifier 400.

10 The amplifier 400 may include one or more stages (including a final power stage and one or more preceding stages) and may be configured to amplify signals transmitted to the base station as well as received from the base station. When embodiments of the invention operate in the reverse link path and the forward link path, the circuitry can be adapted to account for the signal path. For example, one amplifier (or chain of amplifiers) may amplify in the reverse link direction while
15 another amplifier (or chain of amplifiers) may be used to amplify in the other direction. Some components can be shared, such as a microcontroller 414 (which is an example of the control circuit 314). The microcontroller 414 may have the ability to control amplification in either direction. Suitable hardware may be provided in order to route these signals as necessary within the amplifier 400. Alternatively, the
20 microcontroller is an example of control circuitry. The operations of the microcontroller 414 can be implemented in hardware and/or software.

 In this example, an input 406 (e.g., a signal from a base station or from a wireless device) is provided to a preamplifier 402. An output of the preamplifier 402 usually contains amplified input signals (examples of desired signals) and amplified
25 thermal noise such as amplified broadband thermal noise. By way of example only, in the 800 MHz Cellular band, the reverse link bandwidth could be from 824 to 849 MHz, and in the 1900 MHz PCS band, the reverse link bandwidth could be from 1850 to 1910 MHz.

 The output of the preamplifier 402 is provided to the amplifier chain 404. The
30 oscillation detector 410 is configured to detect or sample an output of the amplifier chain 404. Alternatively, the oscillation detector 410 can sample the signal at any point in the amplification chain 404 including before and/or after the signal is operated on by the amplifier chain 404. In this example, the oscillation detector 410 may sample the output of the amplifier chain 404, although the oscillation detector
35 410 may also sample the signals received and/or transmitted by the amplifier 400 at other locations or at other times as previously stated. In addition, the oscillation

5 detector 410 may be configured to operate with specific frequencies (e.g., the cellular band). Further, the preamplifier 402 may include a filter that restricts or controls which frequencies or bands are passed.

During oscillation detection, the oscillation detector 410 may sample the output of the amplifier chain 404 a multitude of times over a predetermined time
10 period. By way of example, the output may be sampled about 100 times over a short period of time such as 3 milliseconds. One of skill in the art, with the benefit of the present disclosure, can appreciate that the different numbers of samples can vary and can be taken over different periods. For example, approximately 100 samples can be taken over 5 milliseconds. The number of samples and the time over which the
15 samples are taken can vary. In addition, the samples can be taken continuously or at predetermined intervals. In one embodiment, samples are taken continuously and a time window can be applied to the samples for evaluating the samples. A 3 millisecond window, by way of example, can be applied to the samples taken by the oscillation detector 410. By continuously taking and evaluating samples, the status
20 (e.g., oscillating or not oscillating) of the amplifier 400 can be repeatedly evaluated.

The samples taken by the oscillation detector 410 may be provided to the microcontroller 414. The microcontroller 414 can then evaluate the samples to determine the status of the amplifier 400.

In many wireless networks (e.g., CDMA, GSM, LTE, WiMAX), there is a
25 high peak to average power ratio (PAPR) (e.g., 5 to 10 dB in some examples). Oscillation, in contrast, in the amplifier 410 has a substantially lower peak to average power ratio value because oscillation saturates the amplifier and compresses the signal. In this case, the PAPR may be closer to 0 dB, which may indicate a carrier or oscillation.

30 Thus, the microcontroller 414 can determine the PAPR and determine whether the amplifier 400 may be oscillating using samples of the signal over a certain time period. In one example, if the PAPR exceeds a threshold level, then the microcontroller 414 determines that the amplifier 400 is not oscillating. If the PAPR is below the threshold value, then the amplifier 400 may be oscillating. In some
35 examples, additional processes may be performed to verify the oscillation status before the gain is actually reduced or before the amplifier 400 is shut down. These

5 processes may be performed in order to prevent any use of the device from being unnecessarily interrupted. In other words, the gain may be reduced first when a desirable signal is being amplified and oscillation is detected.

When oscillation is detected, the gain of the amplifier 400 is reduced or the amplifier 400 is turned off using a switching circuit 412. The microcontroller 414
10 communicates with the switching circuit 412 to control the gain of the amplifier 400 as necessary to eliminate the oscillation. The gain can be gradually reduced, reduced in steps, or the like. If oscillation is not present, normal operation may the amplifier 400 to dynamically adjust the gain. In one embodiment, the ability of other the amplifier 400 to dynamically adjust the gain may be restricted or reduced when the
15 output of the switching circuit 412 indicates that the amplifier 404 is off or has reduced gain. The switching circuit 412, in other words, may have control that supersedes other components of the amplifier 400. The ability to dynamically adjust the gain, along with other methods disclosed herein, may be implemented in hardware, software, firmware, or any combination thereof.

20 Embodiments of the invention can reduce the effect of oscillation. The amplifier is controlled by determining whether oscillation is present. When the amplifier is being used to amplify a desirable signal, the amplifier is enabled to operate normally. If oscillation is detected even when amplifying a desirable signal, the gain may be reduced as discussed herein.

25 The proper gain of the amplifier can be achieved gradually, for example when oscillation is detected, by a variable attenuator or by changing a bias voltage to the amplifier (e.g., to an amplifier chain in the amplifier).

Figure 5A illustrates an exemplary method for handling or detecting oscillation in a booster amplifier, such as the amplifier 102, 202, 302, and/or 400.
30 The method 500 may also be used as a precursor to identify a potential oscillation that is then verified in another manner. This can eliminate false positives that may occur when the status of the amplifier is either based on signal samples taken over a short time frame, or based upon a signal with a low PAPR. The methods of Figure 5A (as well as the methods of Figure 5B-5E) may be performed by the oscillation detector
35 410 and/or the microcontroller 414. In some examples, an output of the oscillation detector 410 is provided to the microcontroller 414 for further consideration. An

5 amplification factor can then be applied to the amplifier chain 404 (or to any amplifier therein).

A method 500 for reducing amplifier noise may begin by sampling 502 a signal being amplified in an amplifier. The sampling may be continuous in one example or may occur periodically. The samples can be taken at any point in the
10 amplifier chain.

The method then analyzes 504 the samples over a predetermined time period. This can be done by applying a time window to the samples, which may be stored in memory. The samples can be stored, for example, in a rotating buffer. The samples are analyzed to determine at least a PAPR. The method then determines 506 a status
15 of the amplifier. If the PAPR is below a threshold, the microcontroller determines 508 that oscillation may be occurring in the amplifier and the amplifier's gain may be adjusted accordingly. For example, the control circuitry may reduce the gain, reduce the gain in stages, turn the amplifier off (or any stages thereof) or the like. If the microcontroller determines 508 that oscillation is not occurring when the PAPR
20 exceeds a threshold value, then the amplifier may be allowed to operate normally. Often, when oscillation is determined to be occurring, the gain is reduced until the effects of oscillation are removed at which point the amplifier may be allowed to resume normal operation at reduced gain.

When determining 506 the status of the amplifier, a certain number of samples
25 within a predetermined amount of time are averaged in one example. The peak value of the samples can be identified from the samples and the average of all the samples is then determined. The resulting PAPR is then compared to a threshold value to determine the status of the amplifier. The status of the amplifier may be oscillation when the PAPR is less than the threshold value and the status is normal when the
30 PAPR exceeds the threshold value.

The samples in a given window or predetermined amount of time may be used to determine one or more signal ratios or power ratios including, by way of example only, a PAPR, a peak to peak power ratio, or a change in sample power levels.

More generally and by way of example and not limitation, examples of signal
35 or power ratios include peak to average power ratio, a change in sample power levels for a signal, and a peak to minimum power ratio, or peak to average power ratio. One

5 or more of these power ratios can be used to determine the status of the amplifier. For example, each ratio can be compared to a threshold or predetermined value (this may be a different predetermined value for different power ratios). The result of the comparison can indicate whether the status of the amplifier is oscillation or normal. In one example, the status may be verified by another procedure.

10 In determining the peak to peak power ratio, the ratio may be determined from samples that may include adjacent peaks, multiple pairs of adjacent peaks, an average determined from multiple pairs of adjacent peaks, non-adjacent peaks, or the like or any combination thereof. A change in sample power levels may be determined from the samples. A peak to minimum power ratio can be determined from samples that
15 include various combinations of peaks and minimum values. The signal ratio in this example may include an analysis of multiple pairs of adjacent samples and the change in power levels from the multiple pairs of samples can be averaged.

The status, determined in block 506, may be determined using one or more of the signal ratios. Of course, the status can be determined using only one of the signal
20 ratios and there is no requirement that more than one signal ratio be used to determine the status of the amplifier.

The relationship between the signal ratio and a threshold or a predetermined value can be used by the controller to determine whether oscillation is occurring in the amplifier. One of skill in the art can appreciate that the predetermined value can be
25 selected such that oscillation can be determined with the signal ratio is less than, greater than, equal to or greater than, equal to or less than, or the like, than the predetermined value.

For example, if the controller determines that oscillation is occurring (the status is oscillation) when the signal ratio is below a predetermined value or threshold,
30 then the controller may reduce the gain, turn the amplifier off (or any one of the stages), or the like. Often, the gain is controlled until the effects of oscillation are removed at which point the amplifier may be allowed to resume normal operation. In this context, the signal ratio is continually reevaluated in order to determine when the oscillation has been eliminated or controlled. Monitoring the signal ratio (or the
35 signal ratios) provides an effective means to determine when the amplifier is allowed to resume normal operation.

5 When determining the status of the amplifier, a certain number of samples within a predetermined amount of time may be averaged. The peak value of the samples can be identified and the average of all the samples can also be determined when the signal ratio is the PAPR. The resulting PAPR is then compared to a threshold or predetermined value to determine the status of the amplifier. The status
10 is oscillation when the PAPR is less than the threshold value and normal when the PAPR is equal to or exceeds the threshold value. Alternatively, an average PAPR that is obtained by averaging the PAPRs associated with multiple windows may also be used in determining the status of the amplifier.

 Similarly, other signal ratios can be used to determine the status of the
15 amplifier. The peak to peak power ratio for samples in at least one window or the change in sample power levels in at least one window are also signal ratios that can be used to determine the status of the amplifier as illustrated in Figure 5.

 During operation (or at another time such as evaluation or testing), the gain of the amplifier may be increased to a level above the current operating gain where such
20 an increased level is where oscillation begins. This enables a margin between the operating gain and the oscillation point to be determined. In addition, this may be useful during operation of the device since the amplifier may be able to estimate how much gain can be increased before oscillation occurs in the amplifier. If the margin varies in operation due to actual operating conditions, embodiments of the invention
25 may determine the status of the amplifier independently of using the margin.

 During operation (or at another time such as during evaluation or testing), the gain of the amplifier may be increased to a level above the current operating gain to a level where oscillation begins. This enables determining a margin between the
30 operating gain and the oscillation point. In addition, this may be useful during operation of the device since the amplifier may be able to estimate how much the gain can be increased before oscillation occurs in the amplifier. If the margin varies in operation due to actual operating conditions, embodiments of the invention may determine the status of the amplifier independently of using the margin.

 When it is determined that the amplifier is oscillating or that the status is
35 oscillation at 508, some embodiments of the invention may perform further routines to confirm that the amplifier is oscillating. For example, a short time window of

5 samples may indicate that the amplifier is oscillating when in fact, the amplifier is not oscillating. In other words, the amplifier may or may not be treated as oscillatory when the status is determined at 508 when the PAPR is less than the threshold value.

Figures 5B-5E illustrate further examples of methods for reducing oscillation in an amplifier. The methods illustrated in Figures 5B-5E, or portions thereof, can also be combined with the method of Figure 5A to stop an amplifier from oscillating or to prevent oscillation in the amplifier. Some of the elements illustrates in Figures 5B-5E may occur prior to, during, and/or after the elements illustrated in Figure 5A. For example, receiving a downlink signal, receiving an uplink signal, and measuring aspects of these signals (e.g., input power) may be performed continuously or repeatedly by the amplifier. These values or measurements may be used in determining the status of the amplifier.

Figure 5B illustrates a flow diagram for a method 520 of reducing oscillation in an amplifier. An amplifier may include one or more antennas. A first antenna may be configured to communicate with a device and a second device is configured for communication with a base station.

Method 520 includes receiving 522 a downlink signal at the amplifier from a base station via a first antenna, and receiving 524 an uplink signal from a device via a second antenna. The downlink and/or uplink signals are analyzed 526 to determine the presence of or confirm an oscillation created by the amplifier. As previously stated, this determination may be confirmed after the status of oscillation is determined based on the PAPR.

If an oscillation is detected, the amplification factor may be adjusted 528 in a manner that substantially reduces the presence of the oscillation. Control circuitry (such as control circuit 314) performs the analysis of the cellular signals and the adjustment of the amplification factor. In one embodiment, oscillation is considered to be substantially reduced when the presence of oscillation is reduced to a level that does not introduce interference into the surrounding cellular network.

In one embodiment, the step of analyzing 526 the cellular signals includes measuring a signal level (e.g., input power) of the downlink and/or uplink signals. The measured signal levels may be compared to predetermined values. The predetermined values may be selected based on values that, if exceeded by the

5 downlink and/or uplink cellular signals, is likely to be indicative of an oscillating condition within the amplifier.

In one embodiment, where the predetermined value is exceeded, the amplification factor is reduced by an amount necessary to substantially reduce the oscillation. For example, the amplification factor may be incrementally reduced until
10 the downlink and/or uplink signals fall below the predetermined value. The downlink and uplink signals may be associated with different predetermined values.

Alternatively, the amplification factor may be automatically reduced to a zero value in the event that the signal level of the downlink and/or uplink signals exceeds the predetermined value. On the other hand, if the predetermined value is not
15 exceeded, the amplification factor may be established so as to produce first and second amplified cellular signals that are strong enough to be successfully transmitted to the cellular telephone and the base station, without increasing noise at either the base station or the device beyond a tolerable limit. In other words, the amplification factor may be increased to a value that allows signals to be transmitted between the
20 device and the base station without poor reception or dropped calls.

Method 520 further includes applying 530 the adjusted amplification factor to the uplink and downlink signals. The adjusted amplification factor may be applied to the signals using variable gain modules. As described above, the amplification factor may actually include a first and second amplification factor, where the first
25 amplification factor is applied to the downlink signal, and the second amplification factor is applied to the second cellular signal.

Method 520 also includes transmitting 532 the first amplified cellular signal to the base station via the first antenna, and the second amplified cellular signal to the device via the second antenna.

30 Figure 5C illustrates a flow diagram for a method 540 performed by a control circuit for use in an amplifier. The amplifier includes first and second antennas and at least one variable gain module. As described herein, the amplifier is configured for the amplification and transmission of cellular or other wireless signals between a device and a base station. The method 540 includes analyzing 542 the cellular signals
35 to determine the presence and/or degree of oscillation within the amplifier. Based on

5 this analysis, the control circuit makes the determination 544 of whether an oscillation is detected at a degree that exceeds a predetermined value.

The predetermined value may be selected to represent a degree of oscillation that if exceeded, produces a level of interference into a surrounding cellular or wireless network. If it is determined that the degree of oscillation exceeds the
10 predetermined value (i.e., the degree of oscillation is likely to generate sufficiently adverse interference), the amplification factor may immediately set 546 to a zero value. If, on the other hand, it is determined that the degree of oscillation is detected at a degree that does not exceed the predetermined value (i.e., the degree of oscillation is either negligible or relatively minor, thus causing no interference or relatively mild
15 interference), the amplification factor may be repeatedly decremented 548 until the oscillation is substantially reduced.

Finally the control circuit instructs 550 at least one variable gain module to apply the resultant amplification factor to the cellular signals. The control circuit may instruct variable gain modules as to what amplification factor to apply to the cellular
20 signals.

In one embodiment, if it is determined that the amplifier does not have any significant degree of oscillation, method 540 may further include establishing the amplification factor so that the retransmission of the cellular signals has sufficient power to be transmitted to the base station and/or device.

25 Figure 5D illustrates one embodiment of a method 560 for detecting and substantially reducing oscillation in an amplifier. A cellular (or wireless) signal is received 562 by a first antenna. The cellular signal is amplified 564 by an amount determined by a first amplification factor. The resultant amplified cellular signal is transmitted via a second antenna to a target destination, such as a device or base
30 station.

After the cellular signal is received 562 by the first antenna and while the first amplification factor is being applied to the cellular signal, the level of the cellular signal is measured 566, thereby acquiring a first signal level. The first signal level is recorded, and then a second amplification factor, which is less than the first
35 amplification factor, is applied 568 to the cellular signal. In one embodiment, the

5 second amplification factor is approximately a zero value (i.e., the power amplifier amplifying the cellular signal may be turned off).

While the second amplification factor is being applied to the cellular signal, the level of the cellular signal is measured again 570, thereby acquiring a second signal level. The second signal level is compared 572 to the first signal level. If the
10 second signal level is significantly less than the first signal level, then it is determined that the use of the first amplification factor is likely causing an oscillating condition to occur. Therefore, the first amplification factor is reduced 576 by a predetermined amount, and the process may be repeated until the first amplification factor is reduced by a sufficient amount to eliminate the oscillating condition. However, if the second
15 signal level is not significantly less than the first signal level, it is likely that an oscillating condition does not exist while first amplification factor is applied to the cellular signal. Therefore, the first amplification factor remains unchanged 574, and the process may be repeated.

Figure 5E illustrates another method 580 for detecting and substantially
20 reducing an oscillating condition within an amplifier. In general, the method 580 includes the process of measuring 582 and 588 a cellular signal level and comparing 584 and 590 the signal level to one or more threshold values. The amplification factor applied to the cellular signal is adjusted 586 and 592 based on the results of the comparisons. The results of multiple comparisons are analyzed 594 in order to detect
25 a pattern that indicates that the presence of an oscillation is likely, and the amplification factor applied to the cellular signal is adjusted 596 in order to eliminate the oscillating condition.

In particular, and in one exemplary embodiment, after a cellular signal is received via an antenna and an amplification factor is applied to the cellular signal,
30 the level of the cellular signal is measured 582 in order to determine 584 whether the cellular signal exceeds a predefined maximum threshold value. If the signal level of the cellular signal does not exceed the maximum threshold value, the method 580 continues measuring 582 the cellular signal and comparing 584 the signal to the maximum threshold value.

35 In the event that the signal level of the cellular signal exceeds the maximum threshold value, the method 580 reduces 586 the amplification factor applied to the

5 cellular signal. Following the reduction of the amplification factor, the method 580
again measures 588 the signal level of the cellular signal. The method 580 then
compares 590 the new signal level to the maximum threshold value and to a
predetermined minimum threshold value. If the signal level still exceeds the
maximum threshold value, the method 580 will continue to reduce 586 amplification
10 factor applied to the cellular signal until the signal level no longer exceeds the
maximum threshold value. If the signal level measured at 588 falls between the
maximum threshold value and the minimum threshold value, the method repeats
itself, starting with the measurement at 582. However, if the signal level measured at
588 falls below the minimum threshold value, the amplification factor applied to the
15 cellular signal is increased by a predetermined amount.

Finally, the results of the comparisons and/or the adjustments made to the
amplification factor are analyzed 594 in order to determine if an oscillating condition
likely exists. In one embodiment, the measured signal levels are analyzed in order to
detect a pattern that may indicate the presence of an oscillation.

20 For example, in one exemplary embodiment, the measured signal levels are
analyzed in order to detect an alternating pattern, where the measurements of the
signal levels alternate between exceeding the maximum threshold level and falling
below the minimum threshold level. Therefore, an oscillation is identified if the
signal level recorded during a first measurement exceeds the maximum threshold
25 level, the signal level recorded during a second measurement falls below the
minimum threshold level, and the signal level recorded during a third measurement
exceeds the maximum threshold level. Likewise, an oscillation is also identified if the
signal level recorded during a first measurement falls below the minimum threshold
level, the signal level recorded during a second measurement exceeds the maximum
30 threshold level, and the signal level recorded during a third measurement falls below
the minimum threshold level.

The control circuit 314 can also implement additional gain control based on
other parameters. Figure 6 illustrates an example of a method 600 for determining an
optimal gain for an amplifier such as the amplifiers discussed herein. The method
35 600, or a portion thereof, can also be combined with the methods of Figure 5A-5E to
stop an amplifier from oscillating.

5 The inputs 602 can be received by the control circuit 314. At least some of the inputs 602 can be measured by the control circuit, stored in memory and accessed when needed, updated regularly by the amplifier, and the like.

 The inputs 602 correspond to possible external parameters that may relate to issues that should be mitigated when setting the gain of the amplifier. Embodiments
10 of the invention may only use some of the inputs and can be configured to accept additional inputs. Examples of the parameters that serve as the inputs 602 include, by way of example only:

 Input to the amplifier received from a cell phone (or cell phones) or other device(s);

15 Output from the amplifier to a cell phone (or cell phones) or other device(s);

 Input to the amplifier received from a cellular system base station (or base stations) and/or other wireless networks;

20 Output from the amplifier to a cellular system base station (or base stations) and/or other wireless network components;

 Power/Current supplied to the booster amplifier from the power source (e.g. battery, power supply, etc.); and/or

25 Indication of a distance between cell phone(s) or other device(s) and the amplifier or its accessories (e.g. cradle for holding a cell phone, antennas, etc.).

 As a result of any of the above inputs 602, and/or in consideration of relevant technical requirements, the method determines the control of the amplifier's circuitry such that optimum gain is obtained in both directions of amplification, i.e. from the base station(s) to the cell phone(s) or other device(s), and from the cell phone(s) or
30 other device(s) to the base station(s).

 Figure 6 illustrates, in this example, a plurality of subroutines 604 that can be performed, for instance, by the control circuit 314 or other processor or controller. The subroutines 604 determine potential gains based on the corresponding input(s). More specifically, the subroutines 604a, 604b, ... 604m determine optimum gains for
35 the respective inputs 602a, 602b, ... 602m or a combination of one or more of the inputs 602a, 602b, ... 602m. The subroutines 604 may include subroutines that

5 accept one or more of the inputs 602. As a result, the number of inputs is not necessarily the same as the number of the subroutines 604. In some examples, a particular subroutine may receive multiple inputs and be able to identify gains for multiple combinations of the inputs.

For example, the subroutine 604a may determine potential gain based upon the
10 input 602a. Each of the subroutines 604 may be configured to mitigate a particular issue (e.g., power level, oscillation, distance from base station, distance from cell phone, power/current from power source, etc.). When determining a potential gain to mitigate an issue, each subroutine may use more than one of the inputs 602.

In the context of detecting oscillation, one of the inputs may be the status
15 determined from comparing the PAPR to a threshold. The status, normal or oscillation, may be used by the subroutines in either confirming oscillation and/or mitigating the detected oscillation of the amplifier.

The subroutines 604 are not limited to a particular input. For example, the
20 optimum gain to mitigate the distance between the amplifier and the base station may use the power/current drawn by the amplifier as well as the input from the base station.

In another example, the subroutines 604 can determine a potential gain
according to the power level of the signals received from the base station. When setting the gain in consideration of this issue, the amplifier may i) consider setting the
25 power level at which the signals are transmitted at a sufficient level to ensure that the signals reach a target destination; and ii) ensure that the signals transmitted from the booster amplifier are transmitted at a power level that substantially eliminates interference.

After the subroutines 604 have identified potential gains to mitigate for
30 various issues, the control circuit determines 606 the optimum gain $G_{Optimum}$ based on the potential gains (G_{1-m}) produced by the subroutines 604. The control circuit may then set 608 the amplifier gain equal to the optimum gain $G_{Optimum}$. The amplifier gain may be different for reverse link signals than for forward link signals.

The performance of the booster amplifier is thus compatible with the cellular
35 system and provides maximum gain/performance to the subscriber using the amplifier. This is done, in one embodiment, by implementing two or more

5 subroutines. Each subroutine establishes the optimum gain allowable in consideration of the issues that the subroutines mitigate. In some instances, the subroutines can mitigate different issues using the same input(s). Embodiments generate an optimum or a preferred gain by encompassing several (two or more) subroutines each of which ameliorates a specific problem. The amplifier determines the optimum gain allowable
10 for the amplifier in consideration of the potential gains generated by at least some of the subroutines. The amplifier is configured with structure and architecture that is amenable to adding additional subroutines for which the need becomes apparent. As additional problems are identified, additional subroutines can be included and used in determining the optimal gain for the amplifier.

15 Figure 7 illustrates an embodiment of a system and method for setting an optimum gain. Inputs 702 and 704 can be sensors/detectors that develop electrical output signals that are a function of Forward Link and Reverse Link power inputs to an amplifier, such as the amplifiers discussed herein. The Forward Link power input 704 is the power that is received from the base station and the Reverse Link power
20 input 702 is the power received from the cell phone(s) and or other device(s). The amplifier may use a single input 702 for all cell phones or multiple inputs 702. These electrical signals generated by the inputs 702 and 704 are processed by a processor, such as the control circuit 314 or other micro-processor/controller, using three unique subroutines in this example.

25 The first subroutine 706 determines the optimum Gain G1 in consideration of self-oscillation. The first subroutine 706 may be combined with the method in Figure 5 to more definitively determine that the amplifier is oscillating before determining the optimum Gain G1. The second subroutine 708 determines the optimum Gain G2 considering the requirements of an industry standard, (e.g., TIA-98-F-1 and/or other
30 standards). The third subroutine 710 determines the optimum Gain G3 in consideration of the maximum allowable noise increase in a base station's receiver or in the base station. Such noise can potentially interfere with the proper performance of base stations, and can be reduced to an acceptable level by controlling the gain of the booster amplifier.

35 The first subroutine 706 can determine a maximum gain G1 to account for oscillation in the amplifier or for oscillation protection. For example, the first

5 subroutine 706 analyzes the inputs (e.g., the cellular signals) in one example to detect the presence of an oscillation in the amplifier. This subroutine may be preceded, as previously stated, by the method of Figure 5 that determines a status of the amplifier based on the PAPR. Where an oscillation is detected or confirmed, the control circuit adjusts the gain G1 in a manner that stops the oscillating condition. The gain G1 can
10 be determined by measuring the apparent signal level of the cellular signal received from the device and/or from the base station. If one or both of the signals exceed a predetermined signal value, an oscillatory condition likely exists, and the amplification factor of gain G1 is then reduced by a predefined amount.

In another embodiment, the amplifier is simply shut off when an oscillation is
15 detected. Alternatively, the value of the amplification factor may be incrementally reduced until the oscillation is eliminated. One embodiment of the invention combines both of the above aspects, and automatically shuts off the amplification when a severe oscillation is detected, but may alternatively incrementally reduce the amplification until a less severe oscillation is stopped.

20 In one example, a method for mitigating oscillation includes sampling a signal multiple times during a predetermined period. A peak to average power ratio is determined for the signals based on the samples. Then, a preliminary status of the amplifier is determined. The amplifier is determined to be oscillating when the PAPR is below a threshold and determined to be operating normally when the PAPR is
25 above the threshold.

If the status is oscillation, then the method continues by measuring the apparent signal level of the cellular signal received from the device and/or from the base station. If one or both of these signals exceeds a predetermined signal value, an oscillatory condition likely exists and the gain G1 is set accordingly. In other words,
30 the oscillation preliminarily detected by evaluating the PAPR is verified or confirmed by measuring the signal levels of the signals received from the device and/or the base station.

In one example when the status is oscillation the gain is reduced immediately when oscillation is detected. The gain in either the reverse link and/or the forward
35 link can be reduced or shut off. While reducing the gain or when shutting the amplifier off, the reverse link power input from the device may still be sampled.

5 As previously described, embodiments of the amplifier disclosed here can
amplify both forward link and reverse link signals. The amplification factors applied
to the uplink and/or downlink signals can be adjusted when oscillation is detected.
The second subroutine 708 determines a maximum gain G2. Cell phones may have a
built-in power control algorithm that adjusts their power output based upon the power
10 that they receive from base stations. This built-in power control algorithm is in
accordance with the requirements of relevant industry standards. For example, for
CDMA phones, the standard is "Recommended Minimum Performance Standards for
cdma2000® Spread Spectrum Mobile Stations – Addendum, TIA-98-F-1", published
by the Telecommunications Industry Association. The initial power transmitted by
15 the cell phone to a base station (i.e. before being in closed loop wherein the base
station controls the cell phone's transmitted power) is a function of the power
received from the base station. This cell phone reverse link (output) power should be
maintained within close tolerances in order to preclude interfering with the base
station and/or jeopardizing the communicability of the cell phone. With some
20 exceptions that will be described, this is expressed, mathematically, by the above
mentioned standard as:

$$P_{out} = -P_{in} - K$$

Where:

P_{out} is the (reverse link) output power of the cell phone in dBm;

25 P_{in} is the (forward link) power that the cell phone receives from a
base station in dBm; and

K is a constant depending upon the frequency band and other
factors and is most commonly equal to 73 dB for the 824-894 MHz band
and 76 dB for the 1850-1910 MHz band.

30 Exceptions in one embodiment:

Maximum power may never exceed 30 dBm even when the
formula implies a greater value;

Whenever the base station commands a cell phone to transmit
Minimum Power, the cell phone's power must be -50 dBm or less; and

5 Whenever the base station commands a cell phone to transmit
Maximum Power, the cell phone's power must be at least 23 dBm, but not
more than 30 dBm.

There may be two inputs to subroutine 708. The first is indicative of the
reverse link power input received by the amplifier from a cell phone, and the second
10 is indicative of the forward link power received by the amplifier from a base station in
one example. At any instant, knowing the reverse link power from the cell phone and
the forward link power from the base station enables the subroutine to determine the
gain of the amplifier so that it is compliant with the above formula (e.g., $P_{out} = -P_{in} - K$)
and exceptions identified above. The second subroutine 708 determines a
15 maximum value for G2 that is the largest value possible in accordance with the above
formula and special cases (exceptions).

The third subroutine 710 determines a gain for noise floor protection. In
general, an amplifier transmits thermal noise that is inherently present at its input.
The noise power output from any amplifier can be calculated using, by way of
20 example and not limitation, the formula:

$N_{out} = FGkTB$, where N_{out} = noise power output in watts, F =
"noise factor" of the amplifier (this is a measure of the noise internally
generated by the amplifier), G = gain of the amplifier, k = Boltzmann's
constant ($1.38e-23$ watts/Hz-K), T = temperature (degrees Kelvin), and B
25 = bandwidth (Hz).

By knowing the Forward Link power received from the base station, and
additional factors which will be described, the third subroutine is able to establish a
maximum value for gain G3 for the third subroutine 710.

The additional factors may include:

30 The equivalent radiated power of the base stations transmitter (i.e.
transmitter power output increased by transmitting antenna gain and less
losses such as those from cables, connectors, etc.);

 The maximum allowable increase in noise that is permitted in the
base station receiver, which is more commonly referred to as "allowable
35 noise floor increase";

 The gain of the base station's receiving antenna;

5 The gain of the amplifier's antenna;
 The amplifier's gain; and
 The amplifier's noise figure.

 The parameters of the base station (e.g. equivalent radiated power, permitted
increase in noise, gain of receiving antenna) may be set to be typical values that are
10 generally known, or they may be set to be specifically required values when
necessary, or some may be typical values and others can be set to specifically required
values.

 At any instant, based upon the received Forward Link power, the third
subroutine 710 takes into account at least some of the above mentioned additional
15 factors and determines the maximum gain G_3 such that the noise power transmitted
by the amplifier will not cause the noise floor in the base station's receiver to increase
by more than the allowable amount.

 The gains G_1 , G_2 , and G_3 of the subroutines 706, 708, and 710, respectively,
are resolved to determine the optimal gain 712 by considering all of the gains
20 generated by the subroutines 706, 708, and 710 for the booster amplifier 714 (which is
an example of the amplifiers discussed herein). The optimal gain can be resolved, for
example, by averaging, by weighted averaging, and the like. The optimal gain may be
set to one of the potential gains generated by the subroutines. Alternatively, the
optimal gain may be set to lowest potential gain (lowest value of G_1 , G_2 , G_3). In
25 some instances, the gain from one subroutine may be given preference or may act as a
limit to the optimal gain.

 For example, if the subroutine 706 determines a gain that is associated with
oscillation, the potential gain determined by the first subroutine 706 may limit the
optimal gain. In addition, the optimal gain can be updated repeatedly or continually.
30 As the inputs to the subroutines change, the optimal gain is likely to change as well.
Thus, embodiments of the invention can dynamically adapt to changes in the inputs
that may impact the optimal gain of the amplifier in either the reverse link and/or
forward link direction.

 The microprocessor or control circuitry, with suitable interface circuitry, then
35 sends an electrical signal to the gain control (e.g., a variable attenuator or other VGM)

5 of booster amplifier 714 that sets the booster amplifier's gain to be the optimal value that was determined as described herein.

Before an actual ("closed loop") connection is made between a base station and a wireless device (e.g., a cell phone), the cell phone is unconnected ("open loop") and attempts to make a connection by setting its initial output power based upon the
10 received power from the base station that it intends to connect with. After making the connection with a base station, the base station controls the power transmitted by the cell phone, thereafter making continuous corrections to the cell phone's power output as may be necessary. However, if the unconnected ("open loop") transmitted power from a cell phone is not within established tolerances, it may not be possible for the
15 cell phone to connect with the base station. Cell phones have a built-in power control algorithm that adjusts their initial output power according to the power that they receive from base stations. The cell phone's built-in power control algorithm is in accordance with the requirements of relevant industry standards. Embodiments of the booster amplifier disclosed herein ensure that the amplifier does not interfere with
20 either the closed loop and/or open loop algorithms.

Embodiments of the invention ensure that the booster amplifier will not increase the Noise Floor of nearby off-channel Base Stations beyond an acceptable amount.

The power transmitted by the booster amplifier, such as the booster amplifier
25 102 (with the attached cell phone, PDA, etc.), meets the requirements of the cellular system, as defined herein or as defined by the cellular system operator, industry standards, or government regulations. This ensures that base stations will not be overloaded by an excessively strong signal and also ensures optimum gain of the base station's forward link signal (received by the cell phone) thereby giving maximum
30 benefit to subscribers without harming the cellular system.

Figure 8 illustrates a flow diagram for setting the gain of a booster amplifier or other device operating in a network environment. Figure 9 illustrates another example of a flow diagram for setting the gain of a booster amplifier or other device. Figure 10 shows an illustrative embodiment of an amplifier that implements the logic
35 shown in Figures 8 and 9. In addition, Figures 8, 9 and 10 illustrate an example of the subroutines (e.g., the subroutines 706, 708, and/or 710) illustrated in Figure 7.

5 The method 800 often begins by sensing 802 inputs. The inputs include, by way of example and not limitation: (i) power input to the booster received from a cell phone (or cell phones) or other device(s) (those knowledgeable in the art commonly refer to this as “reverse link” input) and (ii) power input to the booster received from a base station (or base stations) (those knowledgeable in the art commonly refer to this
10 as “forward link” input).

 Knowing the reverse link power from the cell phone and the forward link power from base stations enables determination of the gain of the booster amplifier that gives maximum benefit to the subscriber while maintaining compliance with the requirements of cellular systems as explained herein.

15 Embodiments also substantially mitigate interference to nearby base stations, which are not in communications with the subscriber. This is often referred to in the technical literature as the “Near/Far” problem. It occurs when a device is communicating through a distant (“far”) base station while, at the same time, the device is physically located very close to a “near” base station that the device is not
20 communicating through. As a result, the power output of the subscriber’s cell phone (or other device) will be maximum in order to enable communicating with the far base station. But, such maximum power will be excessive to the near base station thereby causing interference, which could be extremely harmful to the near base station’s operation.

25 Thus, the method 800 often begins by measuring or determining 802 the forward link and reverse link power levels. At block 804, the forward link input power is compared to a noise floor threshold level (threshold 1). The threshold level is the input that corresponds to a distance where noise floor interference is possible. If the forward link input power exceeds the noise floor threshold level, then the gain
30 of the amplifier is set 812 to be the gain in a lookup table stored in the booster amplifier. When the input power does not exceed the noise floor threshold level, the forward link input power is compared 806 to a power overload threshold level to determine if there is a potential problem of power overload to nearby base stations. At block 806, a measurement is made that determines whether or not the forward link
35 input power is greater than the power overload threshold level (threshold 2). When the forward link input power is less than the power overload threshold level, the gain

5 of the booster amplifier may be set in box 810 to be the Maximum Gain (Gmax).
When the forward link input power is greater than the power overload threshold level,
then the reverse link input power is examined and compared in box 808 to a second
power overload threshold level (threshold 3). If the second power overload threshold
level is exceeded, then the amplifier's gain is set in box 810 to be the Maximum Gain
10 (Gmax). If, however, the second power overload threshold level is not exceeded, then
the amplifier's gain is set in box 812 to a value determined by the lookup table. After
setting the gain of the amplifier to be either Gmax or to a value from the Lookup
Table, the method returns to the initial measurement in block 802, and thereafter
proceeds as previously described. This repetitive process continues as long as the
15 booster amplifier is turned on.

In this way, the booster amplifier can dynamically determine the maximum
gain for noise floor protection and/or for power overload protection.

One of skill in the art can appreciate that Figure 8 illustrates examples and
comparisons, which are performed in blocks 804, 806, and 808, to set the gain of the
20 amplifier. The tests or comparisons in blocks 804, 806, and 808, however can be
performed in a different order and/or with different dependencies. These tests or
comparisons can also be performed independently. The gain of the amplifier can be
set on the basis of a single comparison or on the basis of multiple comparisons. In
addition, the comparisons used to set a particular gain can vary over time.

25 For example, the gain of the booster amplifier could be set based on a single
comparison, any pair of comparisons, or any group of comparisons. In another
example, the result of the comparison performed in block 806 may be used to trigger
the comparison in block 804 and/or block 808.

Figure 9 illustrates another example of a method 900 for setting the gain of an
30 amplifier such as a booster amplifier or other device. In one example, the method 900
(similar to other apparatus and methods disclosed herein) may operate to address
problems such as amplifier oscillation, overload issues, and noise floor problems.
Often, the gain set or determined in the method 900 (and other methods disclosed
herein) is a maximum gain in the sense that it should not be exceeded based on
35 current conditions. As discussed herein, this gain may be reduced or altered based on
other conditions such as maintaining the linearity of the amplifier.

5 The method 900 begins in box 902 by sampling an input to an amplifier such as the amplifier 302. The input may include the forward link input power, the reverse link input power, or other inputs or signals as discussed herein.

 In box 904, comparisons are performed between the input and thresholds. For example, the forward link input power may be compared to one or more threshold
10 values or levels. Similarly, the reverse link input power may be compared to one or more threshold values or levels.

 The thresholds may include thresholds that are related to various issues that the amplifier may encounter. One of the thresholds may relate to a noise floor. Another threshold may relate to power overload protection. In some instances, the
15 threshold for noise floor or power overload protection may be different for different inputs. As described herein, the comparisons can be performed in any order.

 In box 906, outputs are generated from the comparisons performed in box 904 (examples of the comparisons are discussed herein and shown by way of example only in Figure 8). The gain of the amplifier is set based on the outputs in box 910.
20 When setting the gain, by way of example, the amplifier may use one or more of the outputs. The outputs can be selectively evaluated such that the gain to which the amplifier is set may be based on any combination of the outputs. Each of the various outputs, for example, may be ranked or prioritized in some examples. The rank or prioritization of the outputs may change, however, based on conditions experienced
25 by the cell phone, amplifier, base station, or the like. In addition, the gain can be dynamically adjusted over time as the outputs of the comparisons change.

 In addition, the amplifier may also apply automatic gain control in box 908. Automatic gain control may be applied to the amplifier, for example, to maintain linearity of the amplifier. As a result, the gain determined by the outputs of the
30 comparisons may be further altered by applying automatic gain control. For example, if the outputs of the comparisons suggest that the amplifier should be set at maximum gain, automatic gain control may reduce the gain, for example, to maintain linearity. Automatic gain control can be applied in both the forward link and reverse link directions and the gain may be different in the forward link and the reverse link
35 directions.

5 In one example, a lookup table, such as illustrated in Figure 10, may be used when setting the gain or when setting the amplification factors. When the lookup table is used to set the gain, the lookup table may be accessed, by way of example only, based on whether the various input signal levels are greater than or less than the various thresholds, based on one or more of the inputs to the amplifier, based on what
10 type of issues is being mitigated, or the like or any combination thereof. For example, when the lookup table is used to set the gain, the lookup table may be accessed according to the forward link input power, the reverse link input power, or the like.

 In another example, multiple lookup tables may be present. In this case, the lookup tables may be accessed based on one or more of the inputs (e.g., the forward
15 or reverse link input power) and the type of issue being mitigated. As a result, the gain of the amplifier can be optimized using the lookup tables. Figure 10 illustrates an example of a booster amplifier. In Figure 10, a sample relative to the power level of the forward link signal from the Base Station is detected to determine whether the signal is above or below either Threshold 1 or Threshold 2. The sample 1002 is
20 provided to a detector 1006 and a detector 1008. The detector 1006 can determine whether the sample 1002 exceeds the threshold 1 and the detector 1008 can determine whether the sample 1002 exceeds the threshold 2. Similarly, a sample 1004 relative to the power level of the reverse link signal from the subscriber's cell phone, PDA, etc. is detected to determine whether the signal is above or below Threshold 3 using a
25 detector 1010. The samples may be provided as a voltage and the comparisons of the samples 1002 and 1004 to the relevant thresholds can be achieved using a voltage comparison circuit (which may be included in the processor 1014). The samples can be converted to digital values before comparison to the relevant threshold values.

 The outputs from the three threshold detectors 1006, 1008, and 1010 are
30 provided to the processor 1014. The processor 1014 may be a microprocessor, or a simple transistor or other logic circuit. The processor is also connected to a lookup table 1012 that could be an integral part of the processor 1014 or may be located in memory that is external to the processor. The processor 1014 examines the outputs of the detectors 1006, 1008, and 1010 and also examines the Lookup Table 1012 (as
35 needed) in order to determine the required gain of the bi-directional booster amplifier 1020 as described with reference to Figures 8 and 9. After the required or optimal

5 gain is determined, the processor 1014 originates a signal that feeds the gain control interface 1018. The gain control interface 1018 gives the correct drive (or signal) to the device(s) that actually adjust(s) the gain of the bi-directional booster amplifier 1020. As previously stated, the gain control interface 1018 may also apply automatic gain control to the amplifier, which may change or reduce the optimal gain, for
10 various reasons, such as to maintain linearity of the amplifier 1000.

There are several types of devices that could enable adjustable gain. Some examples are: pin-diode attenuators and active gain devices whose gain depends upon a DC control voltage, etc. The gain of the amplifier 1020 may or may not be equal in forward link and reverse link directions depending upon the characteristics of the
15 signals being amplified by the amplifier 1020. The threshold detectors 1006, 1008, and 1010, the processor 1014, lookup table 1012, and gain control interface 1018 could be included in one hardware device (e.g. a PIC).

The lookup table(s) may include values that are determined according to characteristics of the amplifier, base stations, and cell phone(s). For instance, the
20 maximum gain of the booster amplifier and the noise figure of the booster amplifier may influence the values in the lookup table. The allowable increase in the base station noise floor, and equivalent isotropic radiated power of the base station, the forward link power received at the antenna input of the booster amplifier, the maximum cell phone radiated power, the gain of the base station receive antenna, the
25 path loss between the booster amplifier and the base station, and the path loss between the booster amplifier and cell phone(s), are additional examples of values that may influence the parameters set in the lookup table.

The following paragraphs assume the following values:

Maximum Gain of booster amplifier = 38 dB
30 Noise figure of booster amplifier = 6 dB
Allowable increase in base station noise floor = 0.06 dB
Base Station Output Power = 30 dBm
Forward Link Power received at booster's outside antenna input = -28.9
dBm
35 Maximum Cell Phone Radiated Power = 23 dBm
Path Loss between booster and base station = 77.6 dB

5 Path Loss between booster and cell phone = 17 dB

In this example, the above parameter values may be for a specific booster and typical base station characteristics. One of skill in the art can appreciate the determination of other values based on the booster and/or base station characteristics and/or path losses. In addition, changes to these values may require changing the
10 lookup tables used to set the gain in the booster amplifier.

As previously stated, some of the values may be determined according to the characteristics of the amplifier. For example, to protect the base station noise floor when the forward link input power is equal to -27 dBm, the maximum allowable reverse link gain plus noise figure of the amplifier is 38dB. The amplifier should
15 lower its gain to this level even if this results in shutting the amplifier off. This is an example of the gain of the booster amplifier for the first threshold, for example, at 804 in Figure 8.

For the second threshold and to protect against base station overload, for example at 806 in Figure 8, when the forward link input power is -38 dBm the
20 maximum allowable reverse link gain of the amplifier is 21 dB.

For the third threshold and to protect from base station overload, for example at 808 in Figure 8, when the reverse link input power is +8 dBm the maximum allowable reverse link gain of the amplifier is 22 dB. The level of the reverse and forward link input powers allows the amplifier to determine whether the cell phone is
25 communicating with a near or far base station in order to optimize gain.

In one example, a gain in an amplifier is set by initially measuring a forward link input power and/or a reverse link input power. The forward link input power is compared to a noise floor threshold level. A gain of the amplifier is set to a value in a
30 lookup table when the forward link input power exceeds the noise floor threshold level.

If necessary, the forward link input power is compared to a first power overload protection threshold level when the forward link input power does not exceed the noise floor threshold level and the gain is set to a maximum gain when the forward link input power does not exceed the first power overload protection
35 threshold level.

5 If necessary, the reverse link input power is compared to a second power
overload protection threshold level when the forward link input power exceeds the
first power overload protection threshold level. The gain is set to the maximum gain
when the reverse link input power exceeds the second power overload protection
threshold level. Alternatively, the gain is set according to a value in the lookup table
10 when the reverse link input power does not exceed the second power overload
protection threshold level.

The embodiments of the present invention may comprise a special purpose or
general-purpose computing device including various computer hardware. The control
circuit or other processor included in embodiments of the amplifier are examples of a
15 computing device.

Embodiments within the scope of the present invention also include computer-
readable media for carrying or having computer-executable instructions or data
structures stored thereon. Such computer-readable media can be any available media
that can be accessed by a general purpose or special purpose computer. By way of
20 example, and not limitation, such computer-readable media can comprise RAM,
ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or
other magnetic storage devices, or any other medium which can be used to carry or
store desired program code means in the form of computer-executable instructions or
data structures and which can be accessed by a general purpose or special purpose
25 computer. Combinations of the above should also be included within the scope of
computer-readable media. Computer-executable instructions comprise, for example,
instructions and data which cause a general purpose computer, special purpose
computer, or special purpose processing device to perform a certain function or group
of functions.

30 The following discussion is intended to provide a brief, general description of
a suitable computing environment in which the invention may be implemented.
Although not required, the invention will be described in the general context of
computer-executable instructions, such as program modules, being executed by
computers in network environments. Generally, program modules include routines,
35 programs, objects, components, data structures, etc. that perform particular tasks or
implement particular abstract data types. Computer-executable instructions,

5 associated data structures, and program modules represent examples of the program code means for executing steps of the methods disclosed herein. The particular sequence of such executable instructions or associated data structures represents examples of corresponding acts for implementing the functions described in such steps.

10 Those skilled in the art will appreciate that the invention may be practiced in network computing environments with many types of computer system configurations, including personal computers, hand-held devices, multi-processor systems, microprocessor-based or programmable consumer electronics, network PCs, minicomputers, mainframe computers, and the like. The invention may also be
15 practiced in distributed computing environments where tasks are performed by local and remote processing devices that are linked (either by hardwired links, wireless links, or by a combination of hardwired or wireless links) through a communications network. In a distributed computing environment, program modules may be located in both local and remote memory storage devices.

20 The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of
25 equivalency of the claims are to be embraced within their scope.

CLAIMS

1. A method, comprising:
 - sampling a signal in a booster amplifier a plurality of times to obtain a plurality of samples of the signal, the booster amplifier configured to apply a gain to the signal and to operate in a wireless network;
 - determining a signal power ratio for the signal based on the plurality of samples;
 - comparing the signal power ratio to a threshold, wherein the threshold is based on power ratio values of a compressed signal output by self-oscillating amplifiers in the wireless network; and
 - determining that an amplifier within the booster amplifier is self-oscillating in response to the signal power ratio being below the threshold.
2. The method of claim 1, wherein the signal power ratio is a peak-to-average power ratio, a peak-to-peak power ratio, a peak-to-minimum power ratio, or a change in sample power levels.
3. The method of claim 1, wherein the method further comprises:
 - taking a second sample of the signal in the booster amplifier when the amplifier has a reduced gain;
 - determining a difference between one of the plurality of samples and the second sample; and
 - verifying that the amplifier is self-oscillating based on the difference.
4. The method of claim 3, wherein the gain of the amplifier is reduced by turning the amplifier off, by reducing the gain gradually, or by reducing the gain by steps.
5. The method of claim 3, wherein the amplifier includes an amplifier chain, wherein the gain of the amplifier chain is reduced by adjusting a bias voltage applied to the amplifier or adjusting a variable attenuator included in the amplifier chain.

6. The method of claim 1, further comprising determining a margin between an operating gain of the amplifier and a gain of the amplifier at which self-oscillation of the amplifier begins.

7. A method, comprising:

sampling a signal in a booster amplifier a plurality of times to obtain a plurality of samples of the signal, the booster amplifier configured to apply a gain to the signal;

determining, from the samples, one or more power ratios including a peak-to-average power ratio for the signal, a change in sample power levels for the signal, and a peak-to-minimum power ratio for the signal;

determining a status of the booster amplifier based on one or more of the power ratios;

in response to determining the status of the booster amplifier, reducing the gain applied to the signal;

sampling the signal in the booster amplifier at the reduced gain to obtain a second sample of the signal; and

verifying the status of the booster amplifier when a signal level of the second sample is less than a signal level of one of the plurality of samples.

8. A booster amplifier, comprising:

an amplifier that receives a signal and provides an output that is based on a first amplification of the signal;

a sampler circuit that obtains a plurality of samples of the signal;

a control circuit that determines a signal power ratio based on the plurality of samples and that compares the signal power ratio to a threshold to determine whether the amplifier is self-oscillating, wherein the threshold is based on power ratio values of a compressed signal output by self-oscillating amplifiers in a wireless network in which the booster amplifier operates; and

a gain control circuit that adjusts the amplification of the signal in response to the self-oscillation of the amplifier.

9. The booster amplifier of claim 8, wherein the amplifier is self-oscillating when the signal power ratio is below the threshold.

10. The booster amplifier of claim 8, wherein when the amplifier is self-oscillating the control circuit verifies the self-oscillation of the amplifier by:

comparing a second sample of the signal taken by the sampler circuit to one or more of the plurality of the samples of the signal, the second sample taken when the amplifier has a second amplification that is less than the first amplification; and

verifying the self-oscillation of the amplifier when a signal level of the second sample is less than the signal level of the one or more of the plurality of samples.

11. The booster amplifier of claim 10, wherein the gain control circuit adjusts the first amplification of the amplifier in response to the self-oscillation of the amplifier and in response to results of one or more additional subroutines, wherein each of the one or more additional subroutines are configured to generate a potential amplification to mitigate a particular issue.

12. The booster amplifier of claim 11, wherein one of the one or more additional subroutines mitigates noise floor control and another of the one or more additional subroutines mitigates base station overload.

13. A method, comprising:

sampling a signal in a booster amplifier a plurality of times to generate a plurality of samples of the signal;

determining a signal power ratio for the signal based on the plurality of samples;

determining an amplifier in the booster amplifier is self-oscillating in response to the signal power ratio being below a first threshold, wherein the first threshold is based on power ratio values of a compressed signal output by self-oscillating amplifiers in a wireless network;

after determining that the amplifier is self-oscillating, measuring signal levels of wireless signal received from the wireless network; and

confirming the self-oscillation of the amplifier when the wireless signal exceeds a second threshold.

14. The method of claim 13, further comprising mitigating a gain applied to the signal by the booster amplifier by reducing the gain gradually or reducing the gain in steps.

15. The method of claim 14, further comprising adjusting the gain in accordance with other issues being mitigated by other subroutines operating in the amplifier.

16. The method of claim 13, further comprising determining a margin between an operating gain of the amplifier and a gain of the amplifier at which self-oscillation of the amplifier begins.

17. The method of claim 13, wherein the signal is sampled the plurality of times over a predetermined time period.

18. The method of claim 17, wherein the samples are stored in a rotating buffer and a window is applied to the samples to determine the signal power ratio within the window.

19. The method of claim 13, wherein the amplifier includes an amplifier chain, wherein the signal is sampled at an input to the amplifier chain, at an output of the amplifier chain, or at a stage within the amplifier chain.

20. The method of claim 13, wherein the signal power ratio is a peak-to-average power ratio, a peak-to-peak power ratio, a peak-to-minimum power ratio, or a change in sample power levels.

21. A method for handling parasitic oscillation in an amplifier operating in a wireless network, the method comprising:

sampling a signal amplified in an amplifier operating in a wireless network a plurality of times to obtain a plurality of samples;

determining a signal ratio for the signal based on the plurality of samples;
determining whether a parasitic oscillation is occurring in the amplifier based on the signal ratio; and
mitigating the parasitic oscillation occurring in the amplifier.

22. The method of claim 21, wherein determining a signal ratio further includes at least one of:

determining a peak to average power ratio for the signal based on the plurality of samples; and

determining a peak to peak power ratio for the signal based on the plurality of samples.

23. The method of claim 21, wherein: the parasitic oscillation is determined to be occurring in the amplifier when the signal ratio is less than a first predetermined value and the parasitic oscillation is determined to not be occurring in the amplifier when the signal ratio equals or exceeds the first predetermined value.

24. The method of claim 21, wherein mitigating the parasitic oscillation occurring in the amplifier includes adjusting a gain of the amplifier by turning the amplifier off or by reducing the gain gradually or by steps.

25. The method of claim 24, further comprising:
continuing to monitor the signal ratio for the signal;
determining that the parasitic oscillation is not occurring in the amplifier based on the signal ratio; and
increasing the gain of the amplifier when the parasitic oscillation is not occurring in the amplifier.

26. The method of claim 21, further comprising determining a margin between an operating gain and a gain at which parasitic oscillation begins.

27. The method of claim 26, further comprising determining the operating gain based on determining that the parasitic oscillation of the amplifier is not occurring and the margin, wherein the gain of the amplifier is changed by increasing the gain less than the margin or by reducing the gain.

28. The method of claim 21, wherein sampling a signal amplified in the amplifier a plurality of times includes sampling an output of a preamplifier or an output of an amplifier chain.

29. The method of claim 21, wherein determining a signal ratio for the signal based on the plurality of samples comprises applying a window to the plurality of samples, wherein the signal ratio is determined from the samples in the window.

30. The method of claim 29, further comprising determining more than one signal ratio using more than one window, wherein each of the more than one window includes different samples.

31. The method of claim 30, wherein the more than one signal ratio includes a peak to average power ratio and a peak to peak power ratio.

32. The method of claim 21, wherein the plurality of samples are stored in a memory.

33. An amplifier comprising:

an amplifier chain that receives a signal for amplification; a signal detector that samples the signal in the amplifier chain;

a controller connected with the signal detector, the controller configured: to analyze the samples of the signal taken by the signal detector, to determine a signal ratio of the signal based on the analyzed samples, and to determine whether a parasitic oscillation is occurring in the amplifier chain based on the signal ratio; and

a switching circuit configured to adjust a gain of the amplifier chain when the parasitic oscillation is determined to be occurring in the amplifier chain by the controller.

34. The amplifier of claim 33, wherein: the parasitic oscillation is determined to be occurring in the amplifier when the signal ratio of the samples is less than a first predetermined value and the parasitic oscillation is determined to not be occurring in the amplifier when the signal ratio equals or exceeds the first predetermined value.

35. The amplifier of claim 33, wherein the switching circuit adjusts the gain by adjusting a gain of one or more amplifiers included in the amplifier chain.

36. The amplifier of claim 35, wherein the gain is reduced when the parasitic oscillation is determined to be occurring in amplifier chain.

37. The amplifier of claim 36, wherein the gain is reduced by turning at least one of the one or more amplifiers off or reducing the gain gradually or in steps.

38. The amplifier of claim 33, further comprising a preamplifier to preamplify the signal, wherein an output of the preamplifier is received by the amplifier chain.

39. The amplifier of claim 38, wherein the preamplifier includes a filter configured to pass a particular band of frequencies.

40. The amplifier of claim 33, further comprising a memory for storing the samples, wherein the controller is configured to apply a plurality of windows to the samples to obtain a plurality of signal ratios that include the signal ratio, wherein the parasitic oscillation is determined to be occurring in the amplifier chain based on an average of the plurality of signal ratios being less than a predetermined value.

41. The amplifier of claim 40, wherein the signal ratios include one or more of a peak to average power ratio, a peak to peak power ratio, and a change in sample power levels.

42. The amplifier of claim 33, wherein to determine the signal ratio further includes at least one of: determining a peak to average power ratio for the signal; and determining a peak to peak power ratio for the signal.

43. The amplifier of claim 42, wherein the controller determines the peak to average power ratio and the peak to peak power ratio by applying a window to the samples, wherein the window includes a certain number of the samples over a certain time period.

44. A method for handling oscillation in an amplifier operating in a wireless network, the method comprising:

sampling a signal amplified in the amplifier a plurality of times to obtain a plurality of samples;

determining a signal ratio for the signal based on the plurality of samples by determining one of: a peak to average power ratio based on samples in a window applied to the plurality of samples, a peak to peak power ratio based on the samples in the window,

determining whether a parasitic oscillation is occurring in the amplifier based on the signal ratio; and

mitigating the parasitic oscillation occurring in of the amplifier.

1 / 13

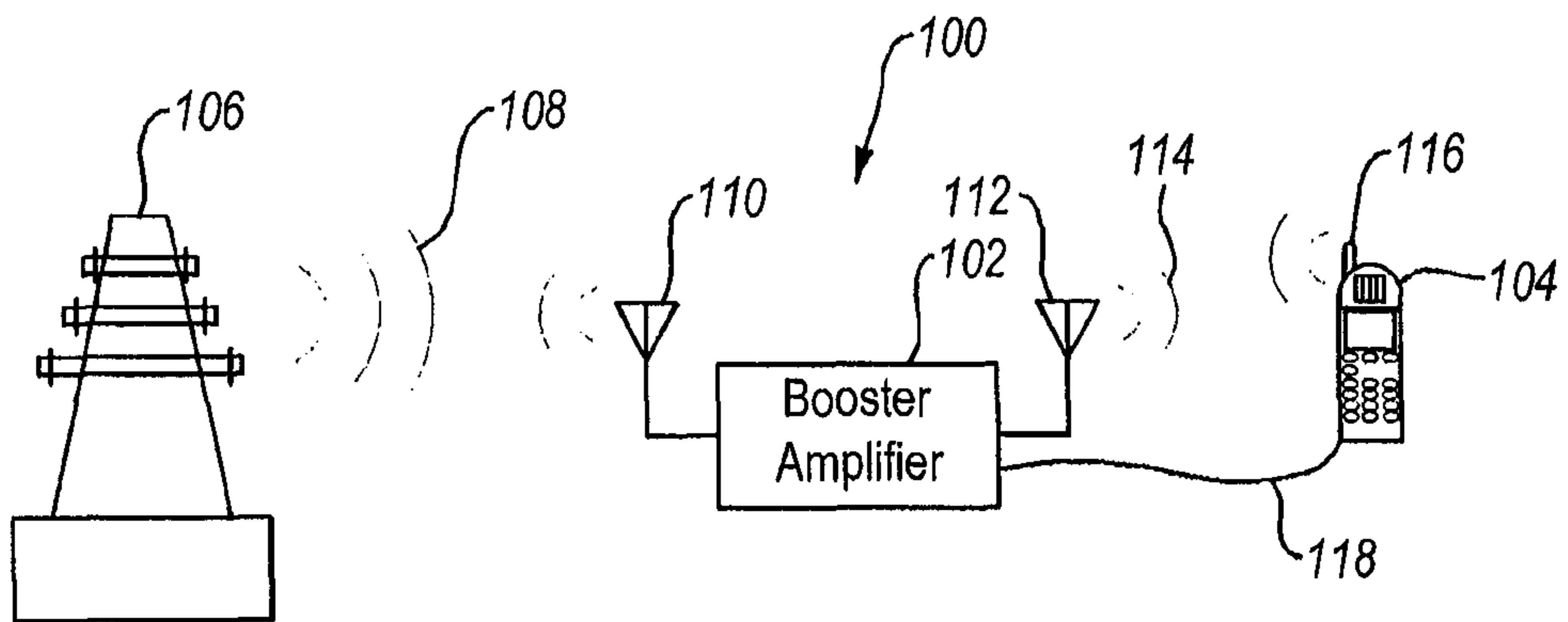


Fig. 1

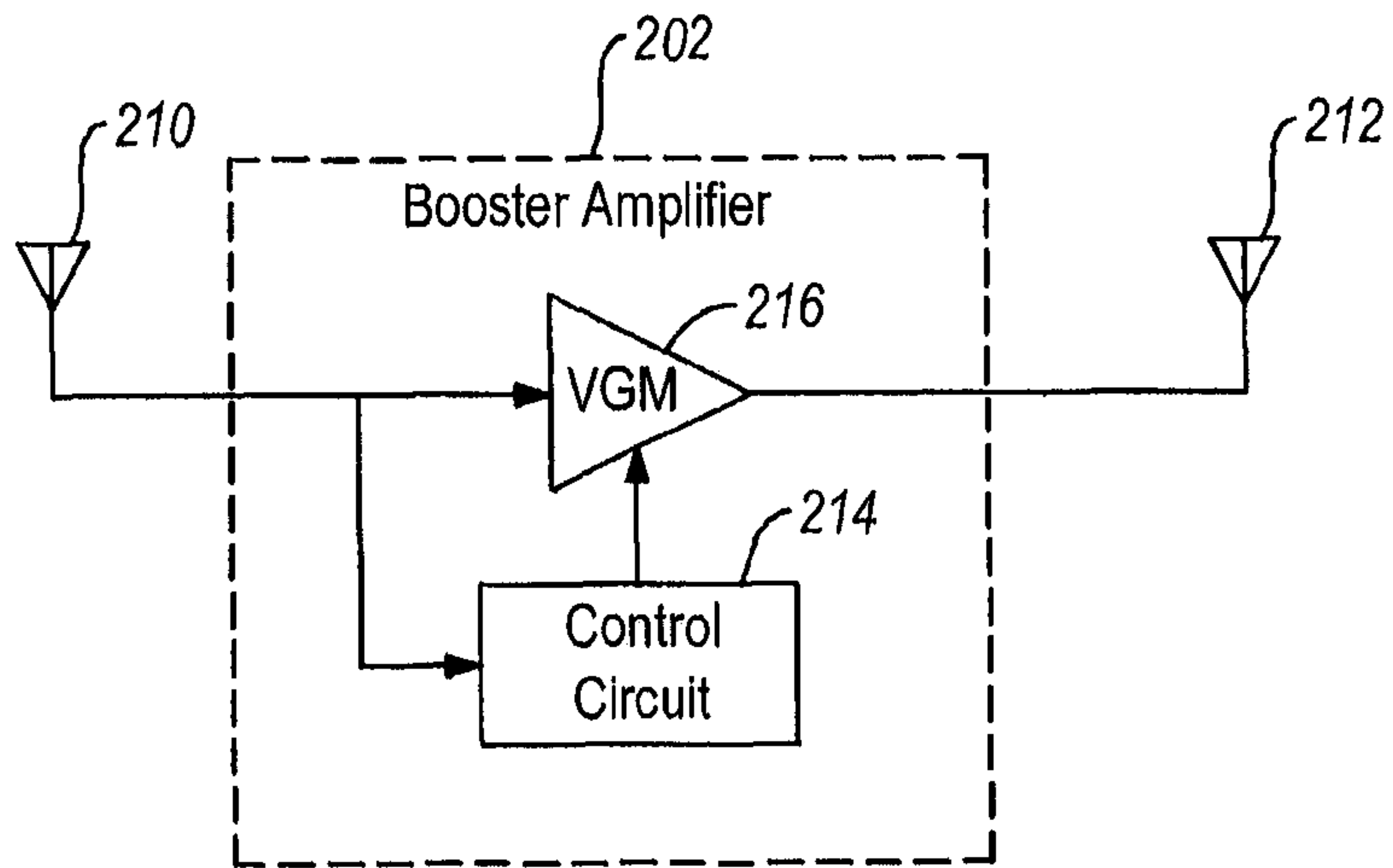
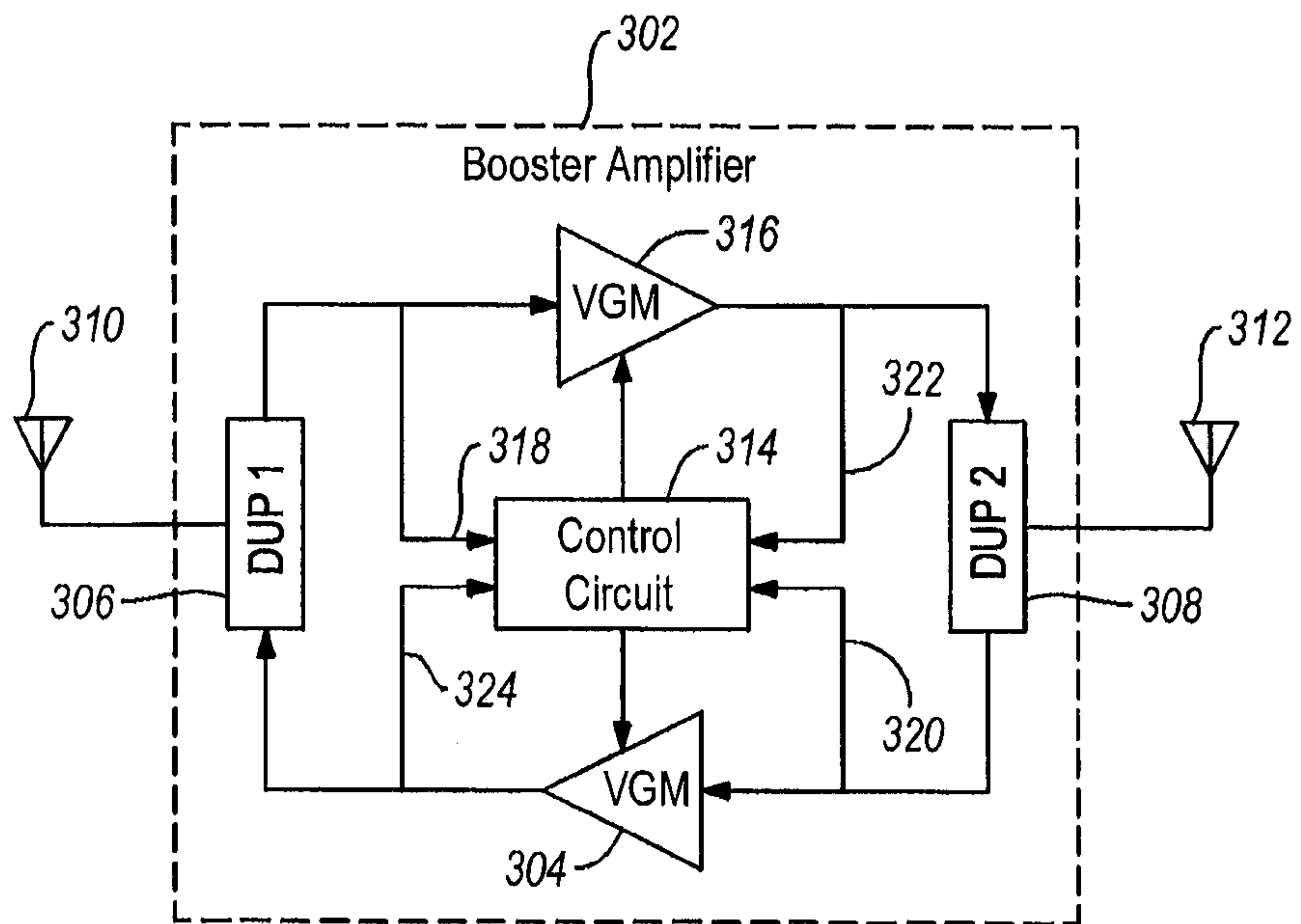


Fig. 2

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**Fig. 3**

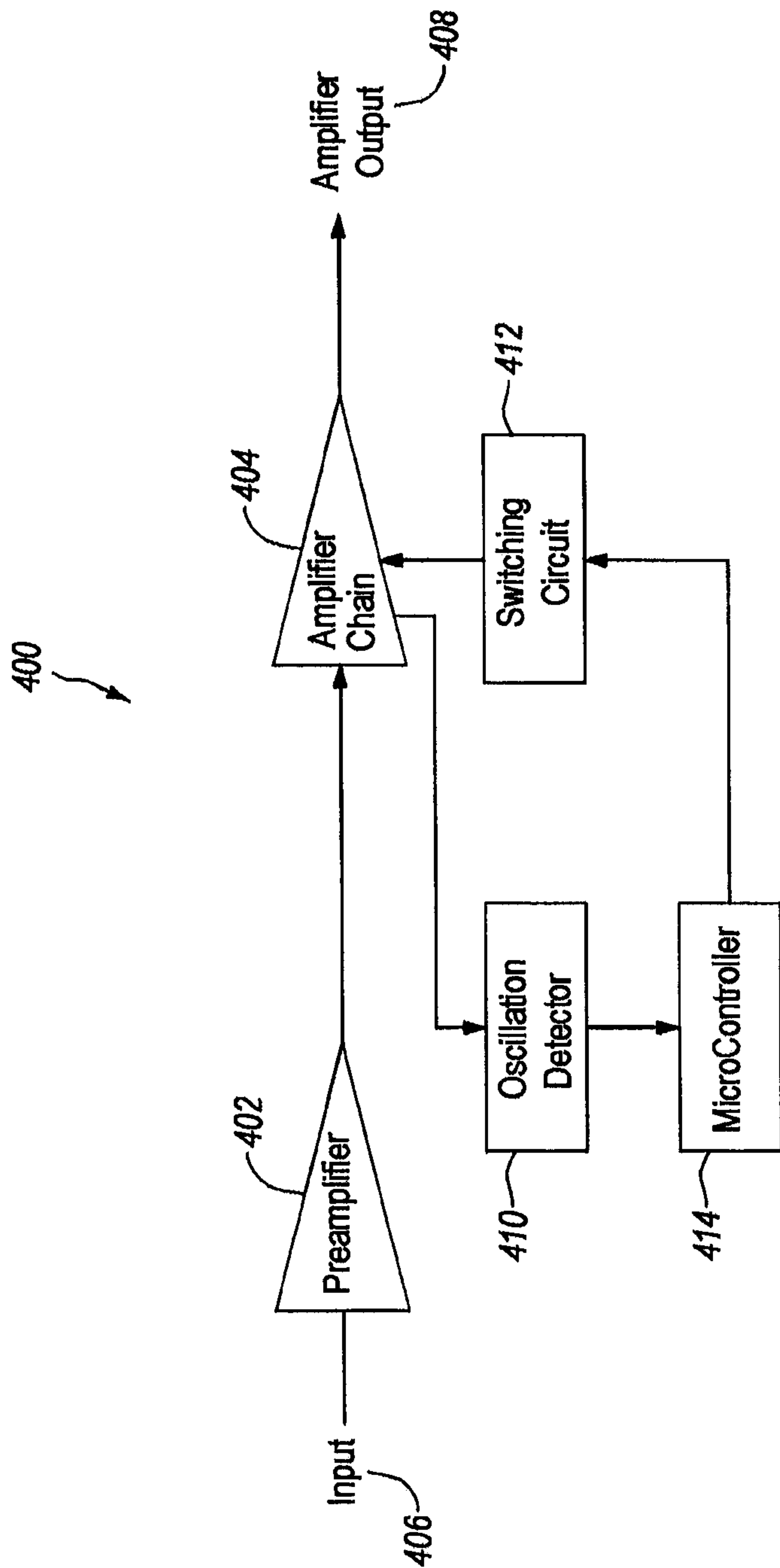


Fig. 4

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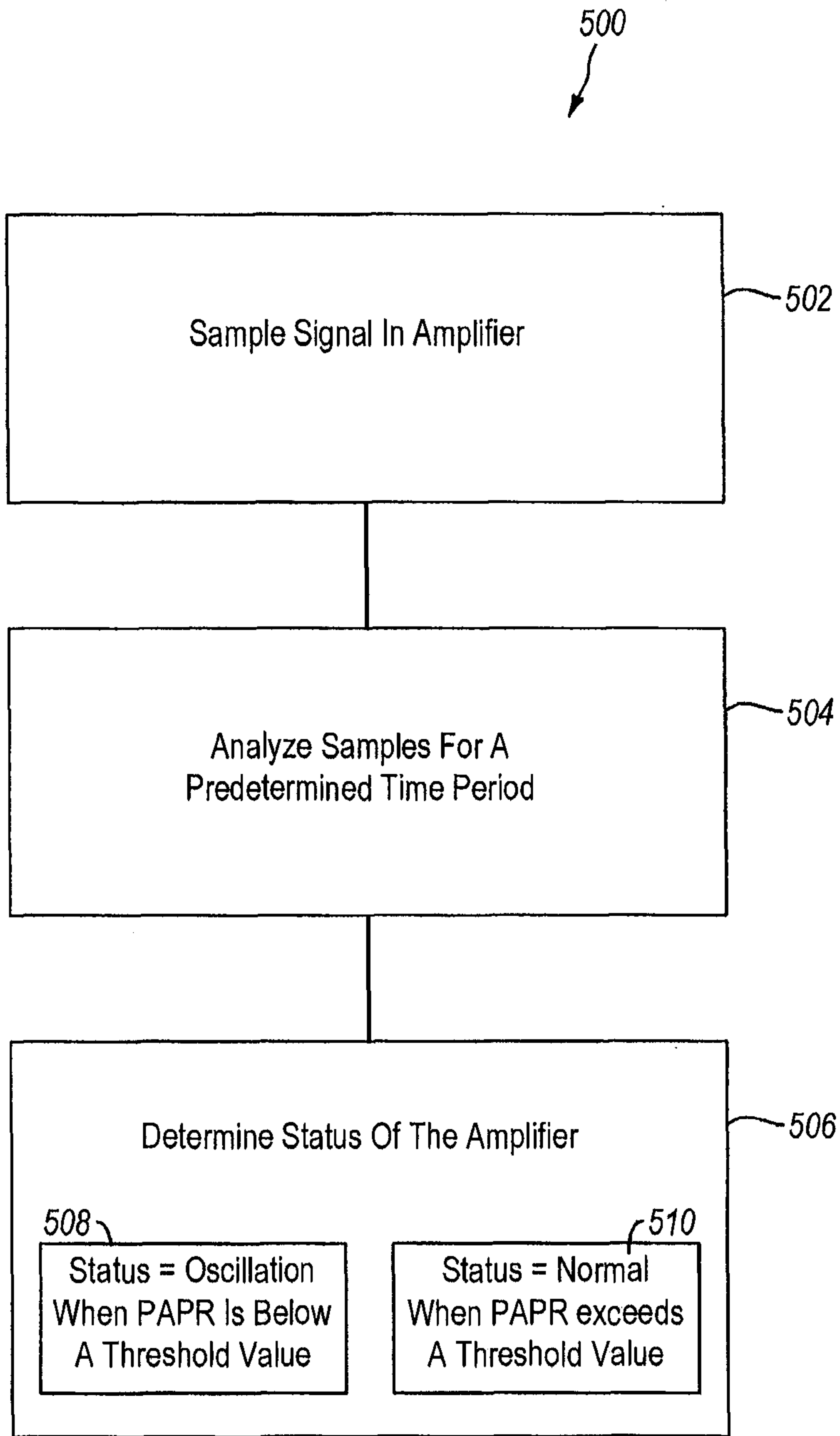


Fig. 5A

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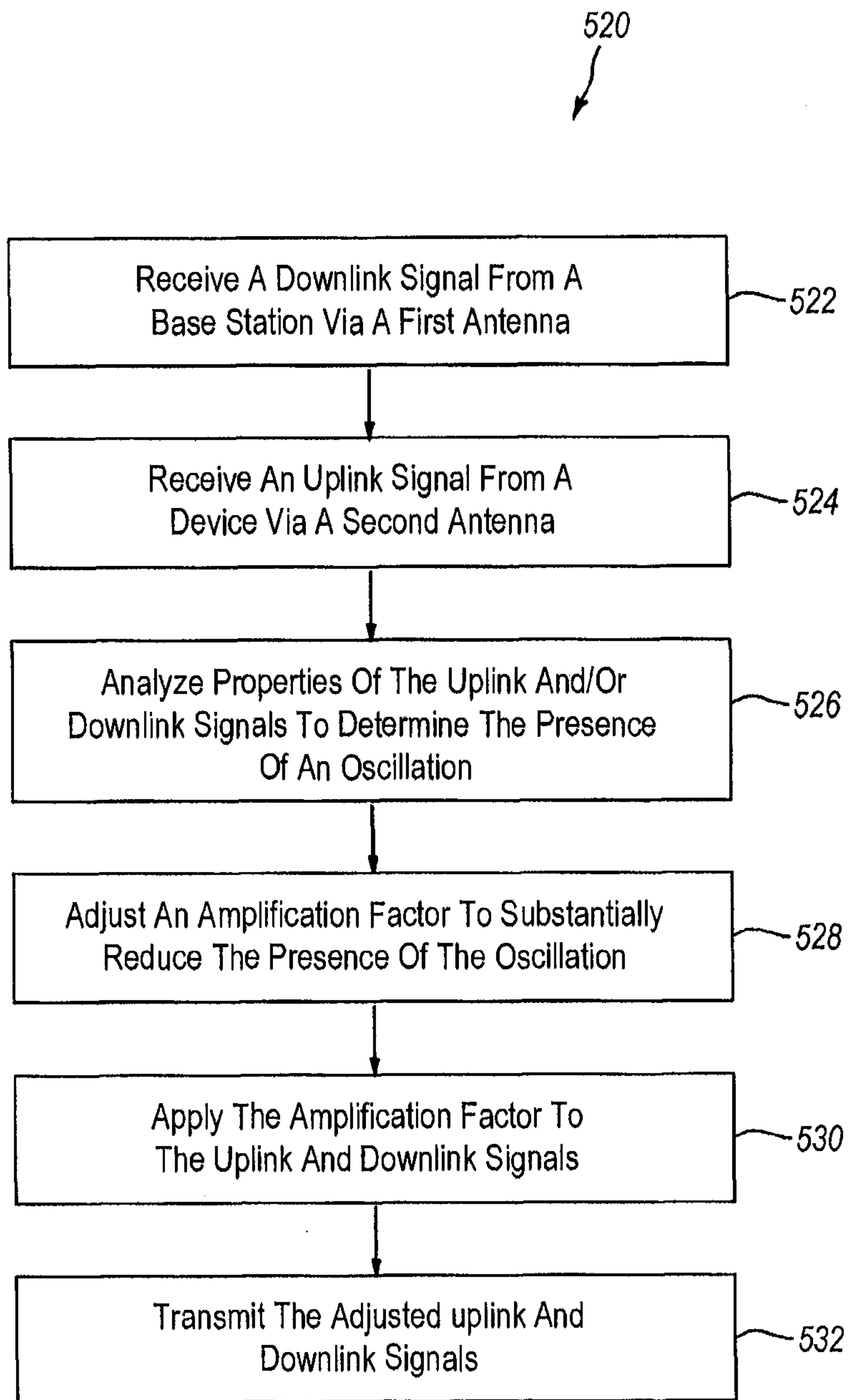


Fig. 5B

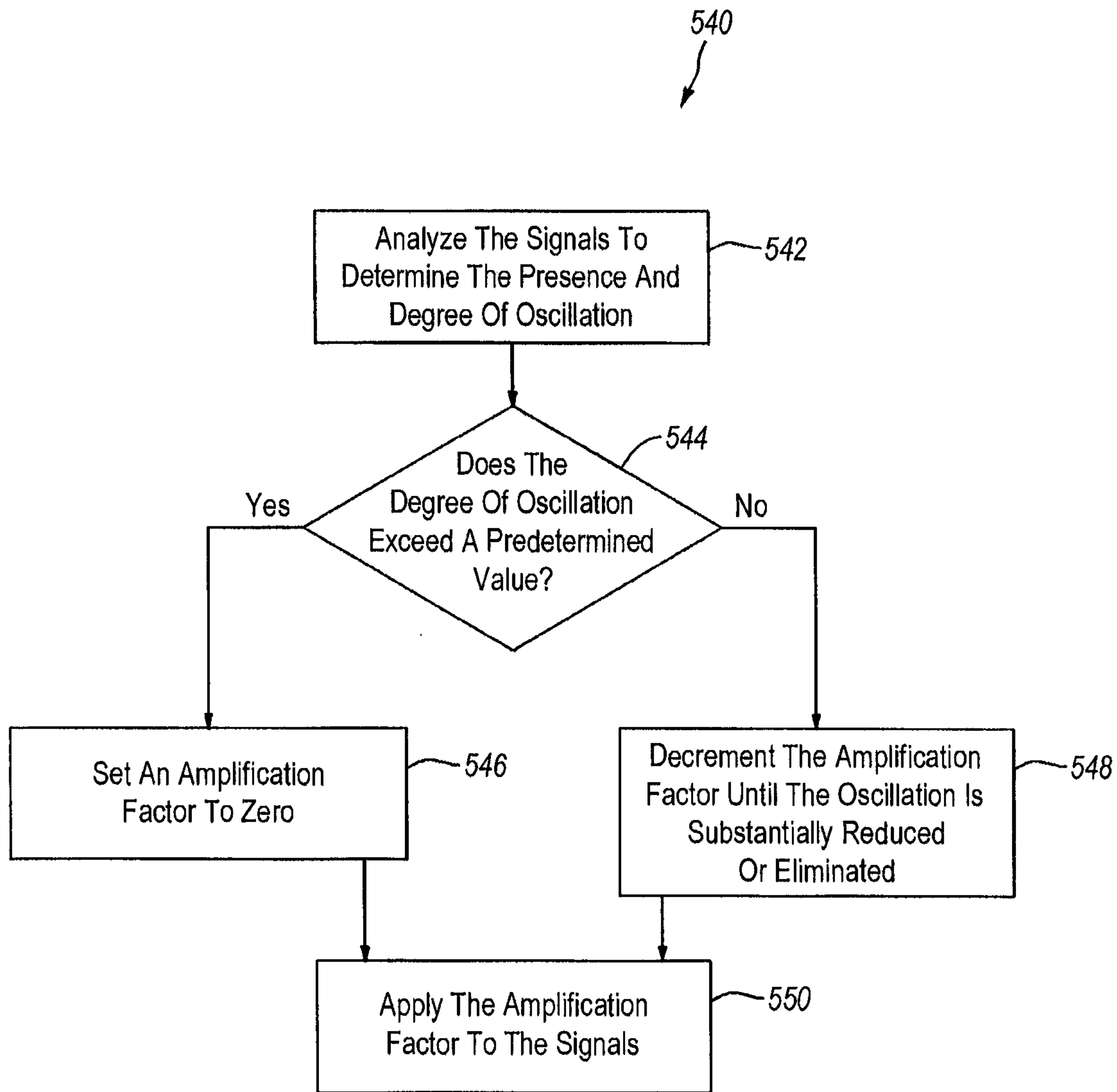


Fig. 5C

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560

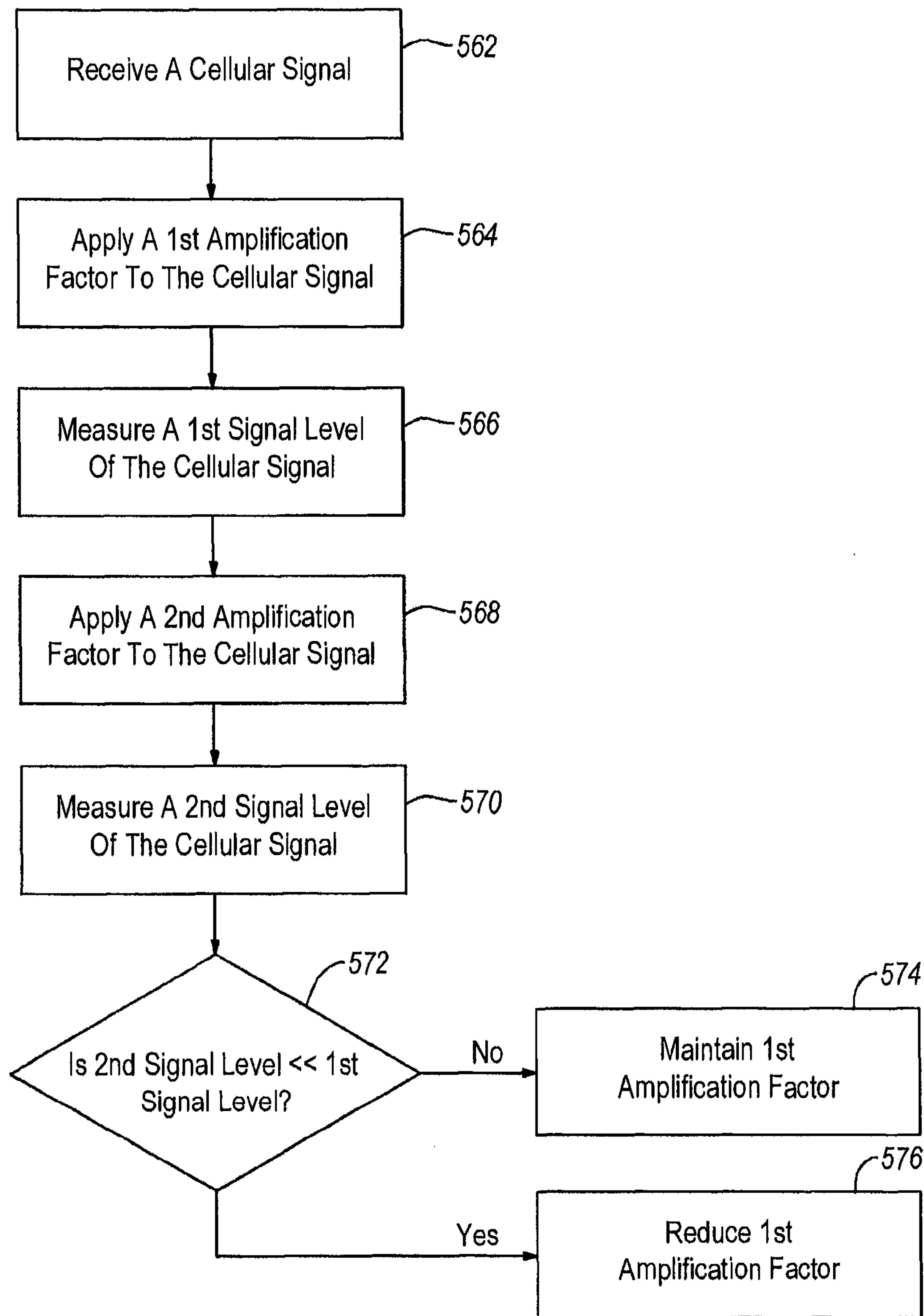


Fig. 5D

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580

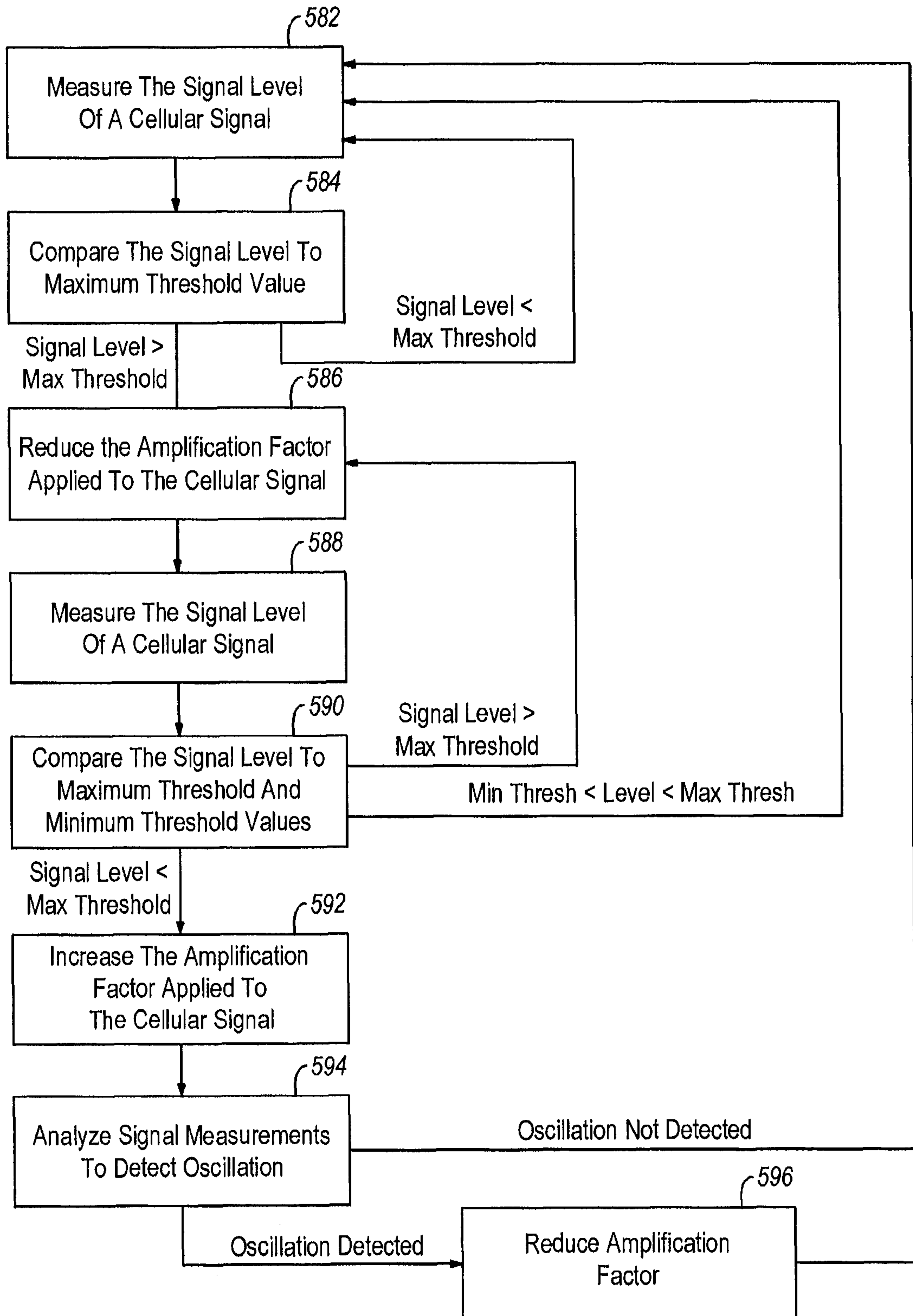


Fig. 5E

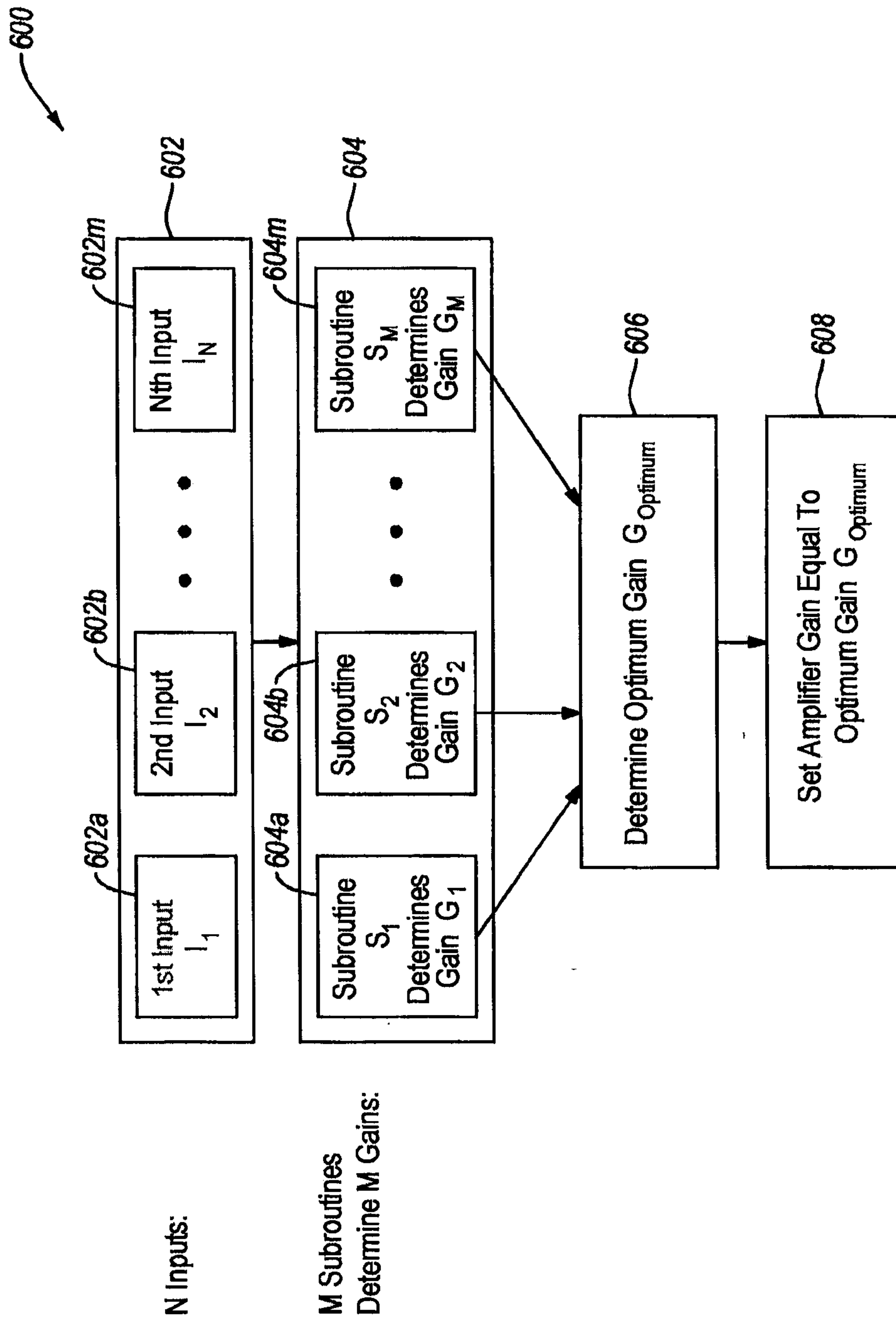
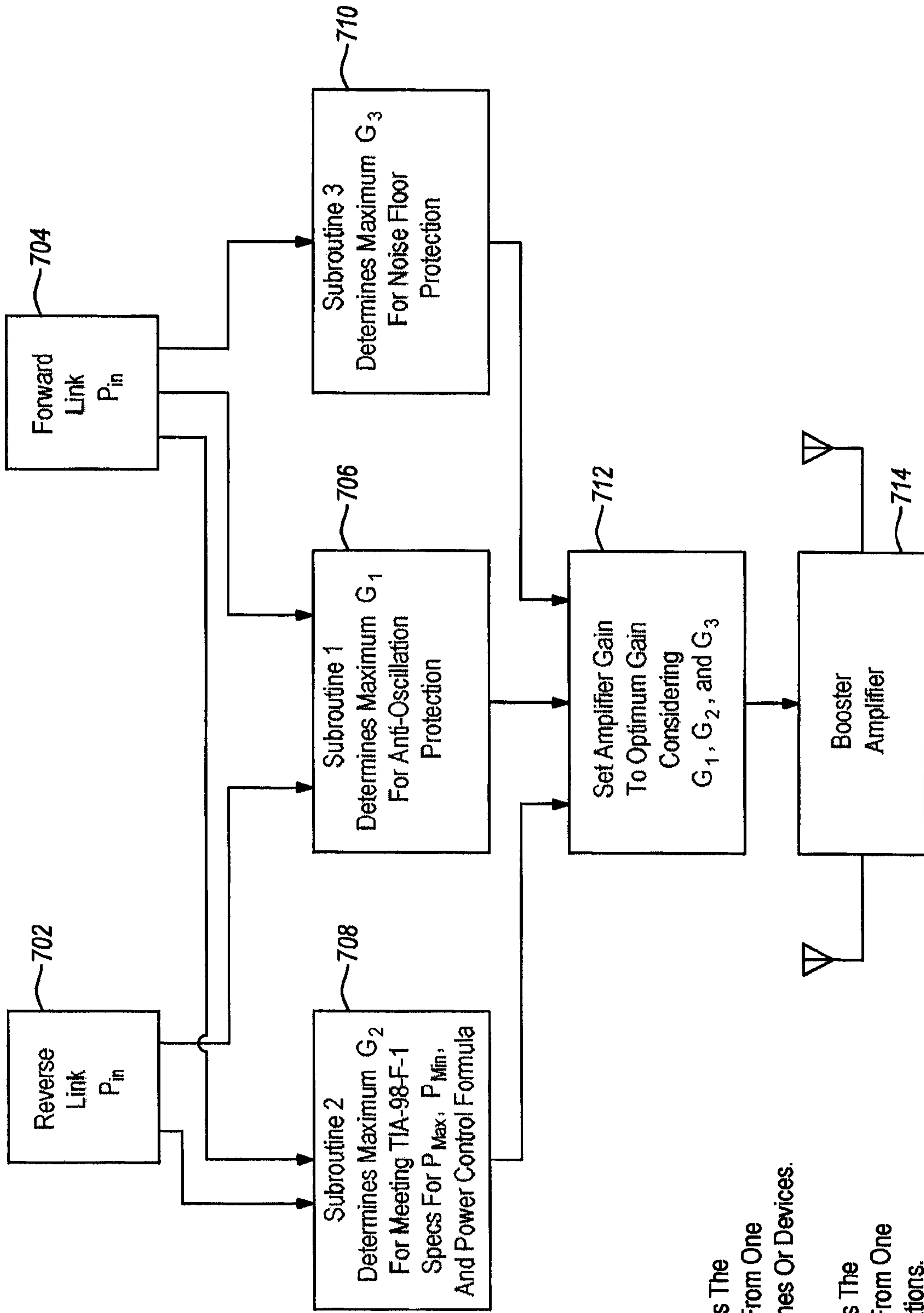


Fig. 6



1) Reverse Link P_{in} Is The Power Received From One Or More Cell Phones Or Devices.

2) Forward Link P_{in} Is The Power Received From One Or More Base Stations.

Fig. 7

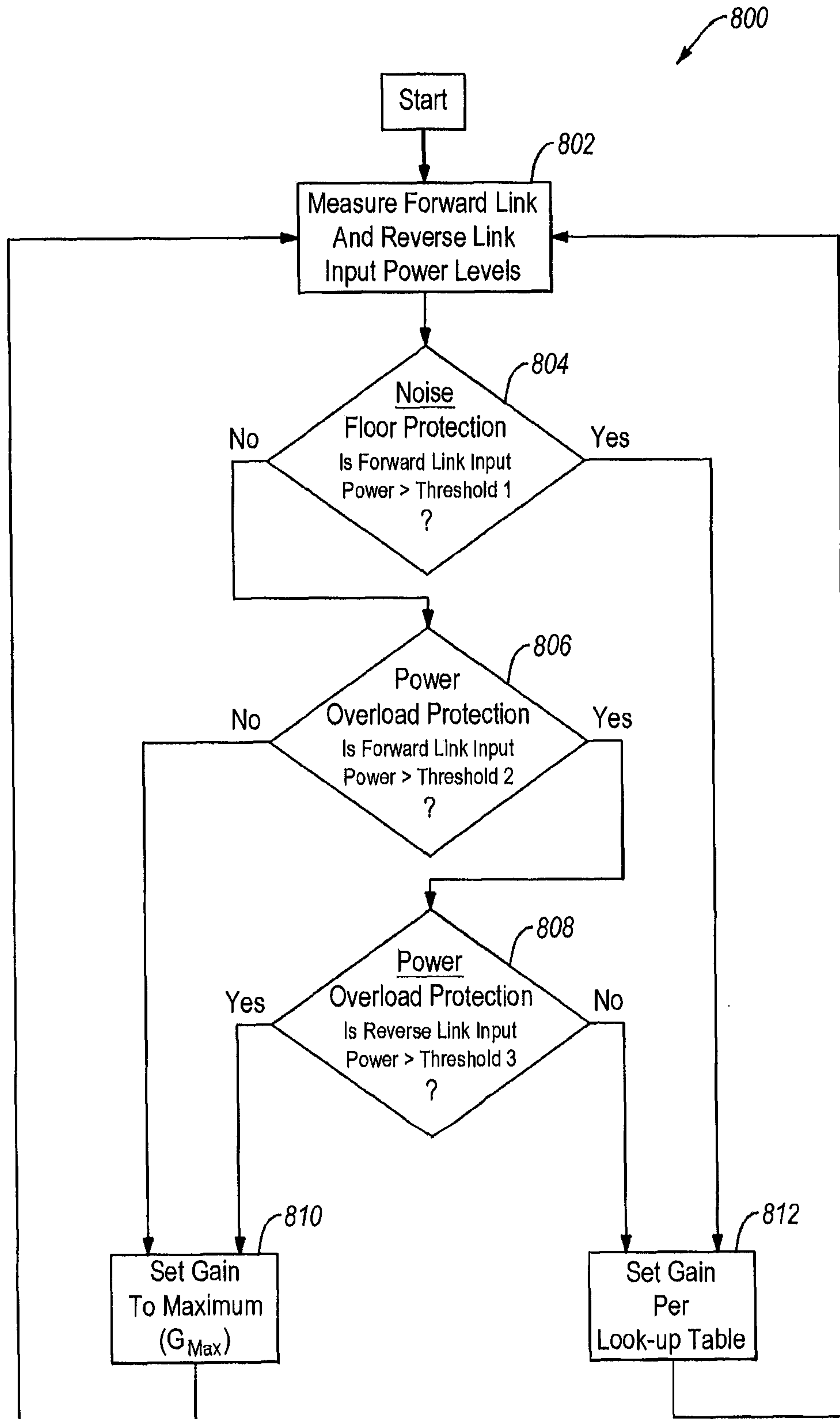


Fig. 8

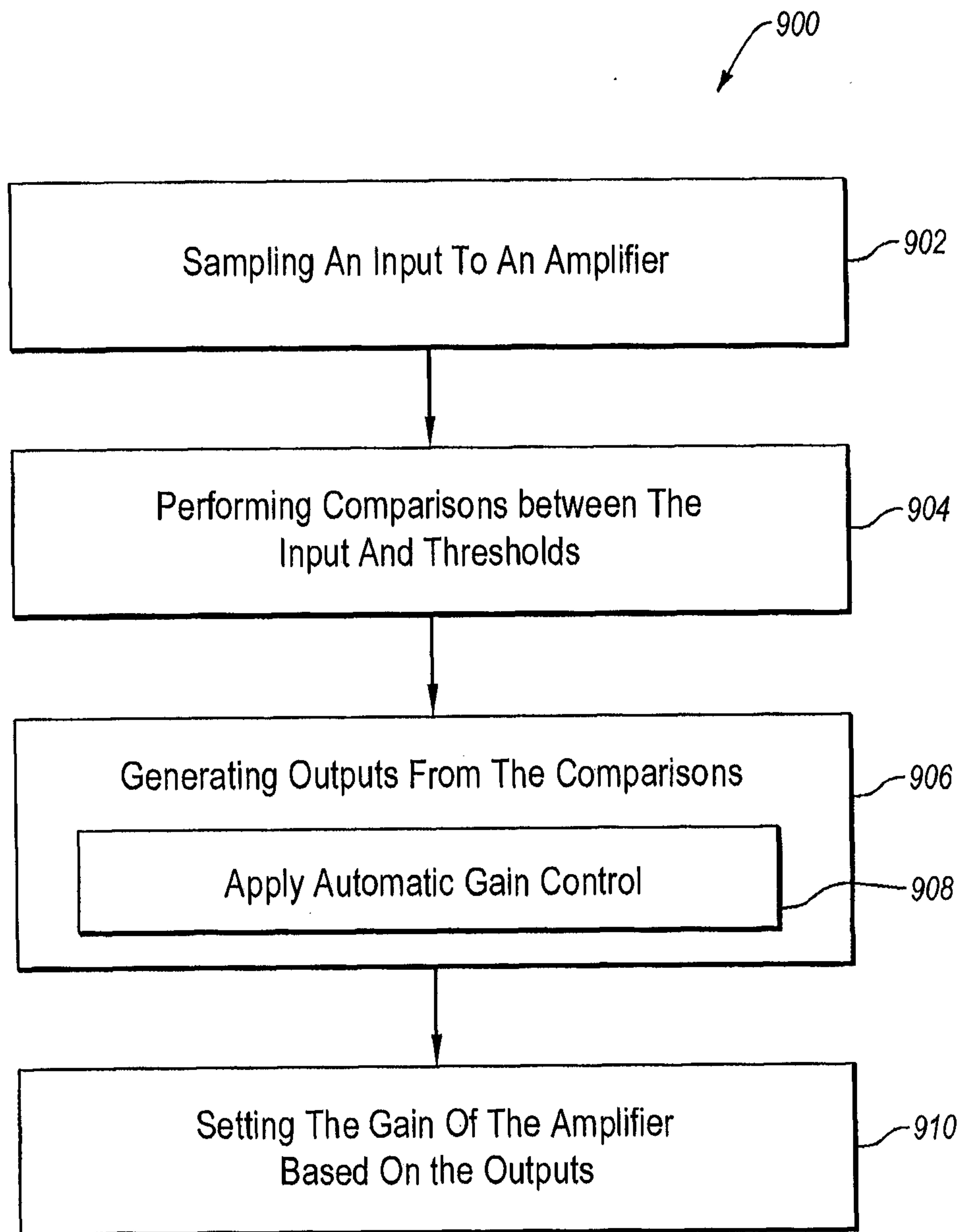


Fig. 9

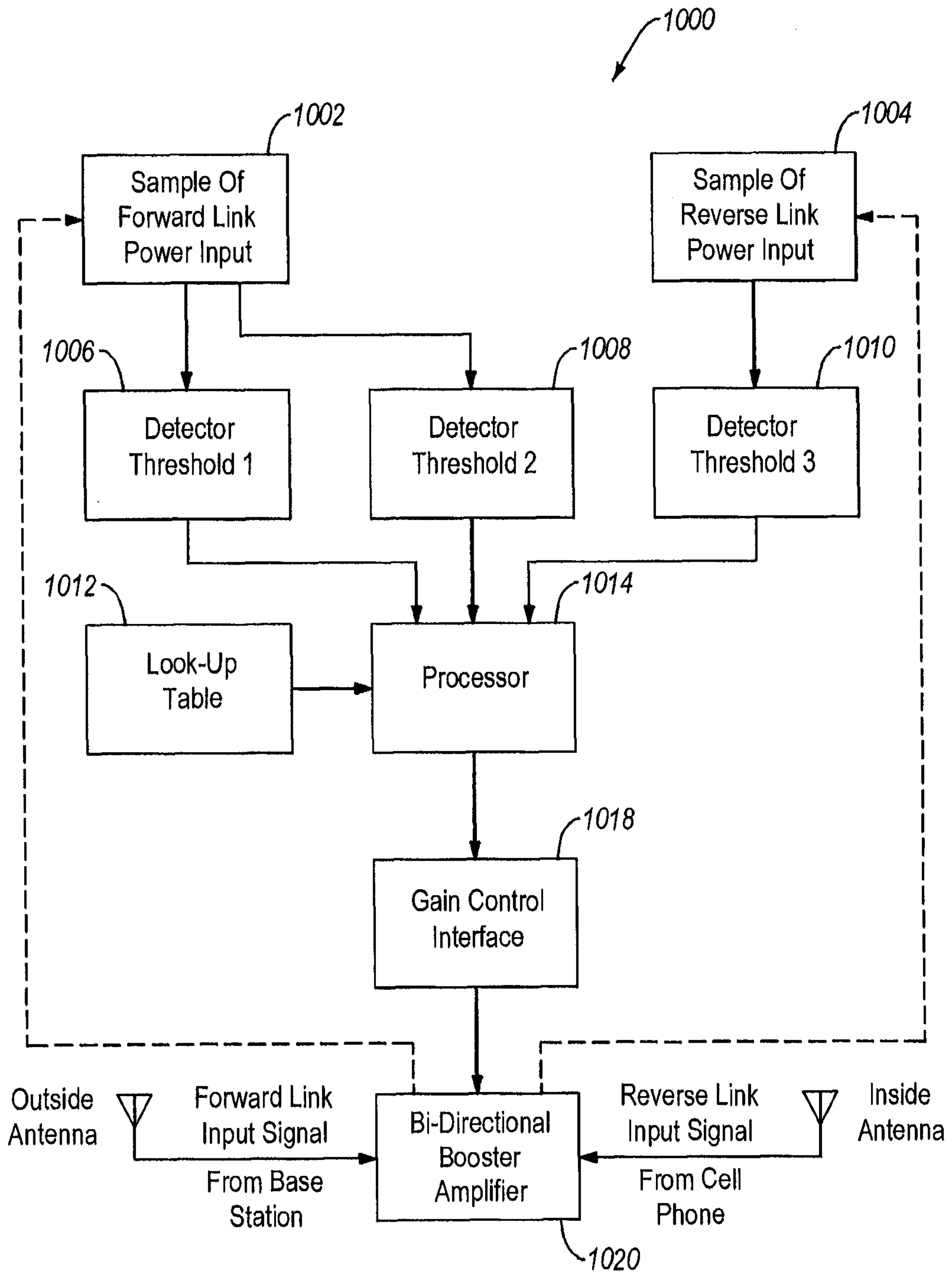


Fig. 10

400

