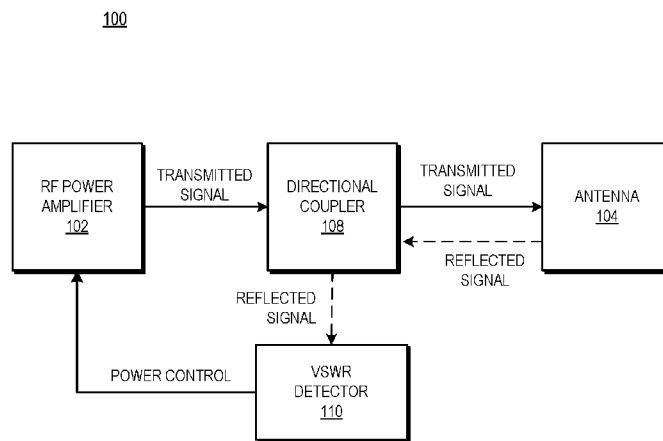




- (51) International Patent Classification:  
*H04B 1/04* (2006.01)      *H04B 17/309* (2014.01)
- (21) International Application Number:  
PCT/US2019/042184
- (22) International Filing Date:  
17 July 2019 (17.07.2019)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
16/050,984      31 July 2018 (31.07.2018)      US
- (71) Applicant: **ADVANCED MICRO DEVICES, INC.**  
[US/US]; 2485 Augustine Drive, Santa Clara, California 95054 (US).
- (72) Inventors: **BOLOGNA, Benny Joseph**; 2485 Augustine Drive, Santa Clara, California 95054 (US). **STEIGER-WALD, Todd W.**; 2485 Augustine Drive, Santa Clara, Cal-

- ifornia 95054 (US). **SKAFIDAS, Efstratios**; 2485 Augustine Drive, Santa Clara, California 95054 (US).
- (74) Agent: **SHEEHAN, Adam D.**; Davidson Sheehan LLP, 6836 Austin Center Blvd., Suite 320, Austin, Texas 78731 (US).
- (81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ,

(54) Title: TRANSMITTER DYNAMIC RF POWER CONTROL VIA VSWR DETECTION FOR WIRELESS RADIOS



**FIG. 1**

(57) Abstract: An electronic device [100] includes a power amplifier [102] that sets the power of a transmit signal that is transmitted via an antenna [104] of the device, and further includes a VSWR detector [110] to identify the VSWR at a signal path between the antenna and the power amplifier. As a person (e.g., a user) moves in close proximity to the antenna, the amount of reflected energy along the signal path increases, thereby increasing the VSWR. A power controller of the electronic device sets a gain of the power amplifier based on the VSWR to ensure that the SAR exposure to the person is maintained below a specified threshold.



UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

**Published:**

— *with international search report (Art. 21(3))*

## TRANSMITTER DYNAMIC RF POWER CONTROL VIA VSWR DETECTION FOR WIRELESS RADIOS

### BACKGROUND

#### Description of the Related Art

5           Hand-held and other electronic devices that transmit radio frequency (RF) signals are known to emit radiation that can be absorbed by persons in close proximity to the electronic device. Exposure to such radiation is sometimes referred to as Specific Absorption Rate (SAR) exposure. To reduce potential health risks from SAR exposure, the Federal Communications Commission mandates requirements for

10 the level of SAR exposure that can be generated by specified devices, such as cell phones. Because the amount of radiation generated by an electronic device is proportional to the amount of power used to generate the corresponding transmitted RF signal (the transmit power), the FCC requirements can be met by placing a limit on the maximum transmit power for the device. However, limiting the transmit power

15 of the device in this way can undesirably reduce the transmit range and reliability for the device. Some devices employ a dynamic power control scheme, wherein dedicated proximity sensors detect the presence of a person near the device, and in response temporarily reduce the transmit power. However, conventional dynamic power control schemes are difficult to implement, requiring additional hardware, such

20 as proximity sensors, and/or complex software development.

### BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure may be better understood, and its numerous features and advantages made apparent to those skilled in the art by referencing the accompanying drawings. The use of the same reference symbols in different

25 drawings indicates similar or identical items.

FIG. 1 is a block diagram of an electronic device that controls transmit RF power based on monitoring a voltage standing wave ratio (VSWR) on a signal path between a power amplifier and an antenna in accordance with some embodiments.

FIG. 2 is a circuit diagram illustrating a power control feedback loop of the electronic device of FIG. 1 in accordance with some embodiments.

FIG. 3 is a diagram illustrating an example of transmit power control based on user proximity to the electronic device of FIG. 1 in accordance with some  
5 embodiments.

FIG. 4 is a flow diagram of a method of controlling transmit power at an electronic device based on monitoring VSWR in accordance with some embodiments.

#### DETAILED DESCRIPTION

10 FIGS. 1-4 illustrate techniques for controlling transmit RF power at an electronic device based on monitoring a voltage standing wave ratio (VSWR). The electronic device includes a power amplifier that sets the power of a transmit signal that is transmitted via an antenna of the device, and further includes a VSWR detector to identify the VSWR at a signal path between the antenna and the power amplifier. As  
15 a person (e.g., a user) moves in close proximity to the antenna, the amount of reflected energy along the signal path increases, thereby increasing the VSWR. A power controller of the electronic device sets a gain of the power amplifier based on the VSWR to ensure that the SAR exposure to the person is maintained below a specified threshold. By detecting proximity using VSWR, SAR exposure is  
20 maintained below the threshold without the use of additional proximity sensors or placing a fixed limit on transmit power, thereby simplifying device design and implementation while maintaining a satisfactory user experience.

FIG. 1 illustrates a block diagram of an electronic device 100 that controls transmit power based on monitoring VSWR in accordance with some embodiments.  
25 The electronic device 100 is any device that transmits signals and whose proximity to a user or other person varies during normal use. Thus, in various embodiments the electronic device 100 is a handheld device such as a cell phone or a tablet, a laptop or desktop computer, a server, a game console, and the like. In some embodiments, the electronic device 100 includes modules and circuits not specifically illustrated at  
30 FIG. 1, such as one or more processing units (e.g. CPUs and GPUs) configured to

execute instructions to perform operations on behalf of the electronic device 100. As part of these operations, the processing units generate data for transmission via a wireless transceiver of the electronic device 100. The wireless transceiver is generally configured to transmit data according to one or more corresponding  
5 wireless communication standards, such as one or more Bluetooth, wireless local area network (WLAN), and wireless wide area network (WWAN) standards.

FIG. 1 illustrates portions of the above-referenced wireless transceiver, including a power amplifier 102 and an antenna 104. The power amplifier 102 is generally configured to receive an input signal representing data to be transmitted and to  
10 amplify a magnitude of the input signal based on the gain of the power amplifier 102. In the embodiment of FIG. 1, the gain of the power amplifier 102 is an adjustable value that is controlled by a signal designated POWER CONTROL. As described further herein, the electronic device 100 is configured to adjust the POWER CONTROL signal, and therefore the gain of the power amplifier 102 to maintain SAR  
15 exposure associated with the electronic device 100 within acceptable limits.

The antenna 104 is generally configured to receive the output signal (that is, the amplified input signal) of the power amplifier 102 via a signal path and to wirelessly transmit the received signal. In some embodiments, the signal path is a transmission  
20 line, metal wire or other conductor that transfers signals from the power amplifier 102 to the antenna 104. In other embodiments, the signal path can include one or more modules not specifically illustrated at FIG. 1, such as one or more filters, couplers, diodes, and the like to support good signal fidelity and other specified requirements for the transferred signal.

In some scenarios, a user or other person in proximity to the electronic device  
25 100 is exposed to near field RF radiation as a result of the antenna 104 transmitting RF signals. To ensure that SAR exposure resulting from the RF radiation is maintained below specified limits (e.g., the limits set by the FCC), the electronic device 100 employs a directional coupler 108 to provide a reflected signal from the antenna 104 to a VSWR detector 110, which detects increased reflection from the  
30 antenna caused by the close near field proximity of a person to the antenna 104 and adjusts the POWER CONTROL signal based on the detected proximity. For example, in response to detecting that a person is within a threshold distance to the

antenna 104 as indicated by an increase in the magnitude of the reflected signal, the VSWR detector 110 adjusts the POWER CONTROL signal to reduce the gain of the power amplifier 102. This in turn reduces the transmit power for the signal transmitted by the antenna 104, thereby reducing the level of RF radiation and therefore the SAR exposure level. In response to the VSWR detector 110 identifying that a person is no longer within the threshold distance, the VSWR detector 110 adjusts the POWER CONTROL signal to increase the gain of the power amplifier 102, thereby increasing the transmit power for the signal transmitted by the antenna 104. Thus, the VSWR detector 110 dynamically adjusts the transmit power of the electronic device 100 based on a person's proximity to the antenna 104, thereby maintaining SAR exposure below the specified limit while supporting sufficient transmit power for a satisfactory user experience.

To detect the person's proximity to the antenna 104, the VSWR detector 110 identifies the VSWR along the signal path. Close proximity to the antenna refers to the near field region of the antenna that is susceptible to impedance changes, thus increasing the magnitude of reflected signal in the intended frequency band when loaded by a human body. In some embodiments, the VSWR detector 110 identifies the VSWR by monitoring a power level, referred to as reflected power, of a reflected signal transmitted along the signal path, and calculates the VSWR according to the following formula:

$$VSWR = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

where  $\Gamma$  is the reflection coefficient calculated according to the following formula:

$$\Gamma = \frac{V_r}{V_t}$$

where  $V_t$  is the voltage magnitude of the signal provided by the power amplifier 102 along the signal path and  $V_r$  is the voltage magnitude of the reflected signal along the signal path.

In operation, in the absence of a person in relatively close proximity to the antenna 104,  $V_r$  is relatively low, and therefore the VSWR value is also relatively low.

As the person moves in close proximity to the antenna 104,  $V_r$  increases as signals are reflected by the person to the antenna 104 and the signal path. The increase in  $V_r$  results in an increase in the VSWR value. In response to the increase in the VSWR value, the VSWR detector adjusts the POWER CONTROL signal to reduce the gain of the power amplifier, thus reducing the SAR exposure level when the person moves in close proximity to the antenna 104.

In some embodiments, the VSWR detector 110 is configured to adjust the POWER CONTROL signal based on the relationship of the VSWR value to one or more threshold values. Thus, for example, in some embodiments the VSWR detector 110 compares the VSWR level to a threshold value corresponding to a specified proximity of a person to the antenna 104. In response to the VSWR value exceeding the threshold, the VSWR detector 110 adjusts the gain of the power amplifier 102, using the POWER CONTROL signal, by a specified amount. In other embodiments, the VSWR detector 110 adjusts the POWER CONTROL signal to maintain a specified relationship, such as a specified linear relationship or other specified mathematical relationship, between the VSWR level and the gain of the power amplifier 102. In some embodiments, to allow the electronic device 100 to be used in a variety of environments and applications, the one or more thresholds or the mathematical relationship that govern modification of the gain of the power amplifier 102 are, or are based on, programmable values that are set by a programmer of the electronic device 100.

FIG. 2 illustrates a circuit diagram of a circuit 200 including a feedback control loop that adjusts a gain of a power amplifier based on a measured VSWR in accordance with some embodiments. In some embodiments, the circuit 200 is employed at the electronic device 100 and forms at least a portion of the VSWR detector 110. The circuit 200 includes a power amplifier 202 (corresponding in some embodiments to the power amplifier 102 of FIG. 1), an antenna 204 (corresponding in some embodiments to the antenna 104 of FIG. 1), a filter 206, a directional coupler 208, a resistor 214, an RF detector 217 including a diode 212 and a driver 216, and a control module 218. The power amplifier 202 includes an input to receive an input signal and an output. The filter 206 includes an input connected to the output of the power amplifier 202 and an output.

The directional coupler 208 includes a terminal connected to the output of the filter 206, a terminal connected to the antenna 204, a terminal connected to a terminal of the RF detector 217, and a terminal connected to a terminal of the resistor 214. The resistor 214 includes another terminal connected to a ground reference voltage. The control module 218 includes an input connected to the output of the RF detector 217 and an output to provide the POWER CONTROL signal to the power amplifier 202.

In at least one embodiment, the directional coupler 208 is generally arranged so that the input port is connected to the output of the filter 206, transmitted port is coupled to the antenna 204, the coupled port is connected to the resistor 214, and the isolated port is connected to the input of RF detector 217. The directional coupler 208 is thus connected, and the resistor 214 sized, so that in the absence of a presence near the antenna 204, and assuming the power amplifier 202 is providing the output signal at a nominal power level, the amount of reflected power at the isolated port (and therefore at the input of the RF detector 217) is relatively low. When a person moves to within a threshold proximity of the antenna 204, the effective impedance of the antenna 204 is altered, so that the amount of reflected power at the negative input of the detector circuit increases.

The control module 218 is generally configured to measure the signal provided by the RF detector 217 and based on the measured signal generate VSWR values for the signal provided to the antenna 204. The control module 218 is further configured to compare the measured VSWR value to a programmable control threshold and, in response to determining that the VSWR value exceeds the threshold, sets the POWER CONTROL to reduce the gain of the power amplifier 202, reducing the power of the output signal provided to the antenna 204, thereby reducing SAR radiation levels to within a specified tolerance. The control module 218 continues to measure the reflected power from the antenna 204 and, in response to the VSWR value falling below the threshold (indicating that the person is no longer within the threshold proximity of the antenna 204) sets the POWER control signal to return the power of the output signal to the nominal power level.

FIG. 3 illustrates a diagrams 330, 331, and 332 that together illustrate an example of transmit power control based on user proximity to the electronic device

100 of FIG. 1 in accordance with some embodiments. The x axes of each of the diagrams 330, 331, and 332 each represent time, while the y-axis of the diagram 330 represents the VSWR measured by the VSWR detector 110, the y-axis of the diagram 331 represents the RF power of the output signal of the power amplifier 102,  
5 and the y-axis of the diagram 332 represents the level of SAR radiation emitted by the antenna 104.

In the depicted example, prior to a time 335, a human body is not within a threshold proximity to the antenna 104. Accordingly, the VSWR detected by the VSWR detector 110 is below a threshold level 336. The VSWR detector 110 thereby  
10 sets the POWER CONTROL signal to set the power output of the power amplifier 102 to a maximum level. Therefore, prior to the time 335 the level of SAR radiation is above a threshold set by the FCC, as illustrated by diagram 332. At time 335, a human body moves within a threshold proximity to the antenna 104, thereby increasing the VSWR above the threshold level 336. In response, the VSWR  
15 detector 110 adjusts the POWER CONTROL signal to reduce the power of the output signal of the power amplifier 102, as illustrated by diagram 331. The adjustment in the POWER CONTROL signal causes the level of SAR radiation to fall below the FCC threshold, as illustrated by diagram 332.

FIG. 4 illustrates a flow diagram of a method 400 of controlling transmit power at  
20 an electronic device based on monitoring VSWR in accordance with some embodiments. For purposes of description, the method 400 is described with respect to an example implementation at the electronic device 100 of FIG. 1. At block 402, the electronic device 100 is turned on or reset. At this point, the proximity of a person to the antenna 104 is unknown. Accordingly, to ensure that SAR exposure is  
25 maintained within specified limits, the electronic device 100 initializes the power amplifier 102 to have a relatively low gain.

At block 404, the VSWR detector 110 measures the VSWR along the signal path and compares the VSWR to a threshold value. If the VSWR is below the threshold value, the method flow moves to block 406 and the VSWR detector 110  
30 sets the POWER CONTROL signal to increase the gain of the power amplifier 102 to a full, nominal level. The method flow returns to block 404 and the VSWR detector 110 continues to monitor the VSWR along the signal path.

At block 404, in response to the VSWR detector 110 determining that the VSWR is above the threshold value, the method flow moves to block 408 and the VSWR detector detects the amount of reflected power along the signal path. Based on the reflected power, the VSWR detector sets the POWER CONTROL signal to reduce the gain of the power amplifier 102. At block 410, based on the adjusted POWER CONTROL signal, the gain of the power amplifier 102 is reduced, thereby reducing SAR exposure to any person in proximity to the antenna 104.

As disclosed herein, in some embodiments a method includes: identifying a voltage standing-wave ratio (VSWR) for a voltage provided by a power amplifier to an antenna; and adjusting the power amplifier in response to the VSWR indicating a human body presence in near field proximity to the antenna. In one aspect, identifying the VSWR includes: detecting a reflected signal on a signal path between the power amplifier and the antenna; and identifying the VSWR based on the reflected signal. In another aspect, identifying VSWR includes: identifying a reflection coefficient based on the reflected signal and a signal transmitted to the antenna along the signal path; and identifying the VSWR based on the reflection coefficient.

In one aspect, detecting the reflected signal includes: detecting the reflected signal at a directional coupler in the signal path, and using an RF detector to rectify the reflected signal. In another aspect, adjusting the power amplifier includes: reducing a power output of the power amplifier in response to the VSWR exceeding a threshold. In yet another aspect, the threshold is a programmable value. In still another aspect, adjusting the power amplifier includes: reducing a power output of the power amplifier by an adjustment amount, the adjustment amount based on the VSWR.

As disclosed herein, in some embodiments, a method includes: identifying a proximity of a human body presence to an antenna of a device based on a voltage standing-wave ratio (VSWR) for a voltage provided by a power amplifier to the antenna; and adjusting the power amplifier based on the identified proximity. In one aspect, adjusting the power amplifier includes: adjusting a power supplied to the power amplifier by a first amount in response to identifying the proximity is within a first threshold; and adjusting the power supplied to the power amplifier by a second amount in response to identifying the proximity is within a second threshold. In

another aspect, adjusting the power amplifier includes: adjusting a power supplied to the power amplifier to a pre-calibrated level in response to identifying the proximity is within a threshold. In yet another aspect, the threshold is a programmable value. In still another aspect, the method includes: detecting a reflected signal on a signal path  
5 between the power amplifier and the antenna; and identifying the VSWR based on the reflected signal. In still another aspect, identifying VSWR includes: identifying a reflection coefficient based on the reflected signal and a signal transmitted to the antenna along the signal path; and identifying the VSWR based on the reflection coefficient.

10 As disclosed herein, in some embodiments a device includes: a power amplifier; an antenna coupled to the power amplifier via a signal path or transmission line; a voltage standing-wave ratio (VSWR) detector configured to identify a VSWR for a voltage provided by a power amplifier to the antenna; and a power control module configured to adjust the power amplifier in response to the VSWR indicating a human  
15 body presence in proximity to the antenna. In one aspect, the VSWR module identifies the VSWR by: detecting a reflected signal on a signal path between the power amplifier and the antenna; and identifying the VSWR based on the reflected signal.

In one aspect, the VSWR module identifies the VSWR by: identifying a reflection  
20 coefficient based on the reflected signal and a signal transmitted to the antenna along the signal path; and identifying the VSWR based on the reflection coefficient. In another aspect, the device includes a directional coupler, and wherein the VSWR detector detects the reflected signal at a directional coupler in the signal path. In still another aspect, the power control module is to adjust the power amplifier by:  
25 reducing a power output of the power amplifier in response to the VSWR exceeding a threshold. In yet another aspect, the threshold is a programmable value. In still another aspect, the power control module is to adjust the power amplifier by: reducing a power output of the power amplifier by an adjustment amount, the adjustment amount based on the magnitude of RF reflections from the antenna.

30 A computer readable storage medium may include any non-transitory storage medium, or combination of non-transitory storage media, accessible by a computer system during use to provide instructions and/or data to the computer system. Such

storage media can include, but is not limited to, optical media (e.g., compact disc (CD), digital versatile disc (DVD), Blu-Ray disc), magnetic media (e.g., floppy disc, magnetic tape, or magnetic hard drive), volatile memory (e.g., random access memory (RAM) or cache), non-volatile memory (e.g., read-only memory (ROM) or Flash memory), or microelectromechanical systems (MEMS)-based storage media. The computer readable storage medium may be embedded in the computing system (e.g., system RAM or ROM), fixedly attached to the computing system (e.g., a magnetic hard drive), removably attached to the computing system (e.g., an optical disc or Universal Serial Bus (USB)-based Flash memory), or coupled to the computer system via a wired or wireless network (e.g., network accessible storage (NAS)).

In some embodiments, certain aspects of the techniques described above may be implemented by one or more processors of a processing system executing software. The software comprises one or more sets of executable instructions stored or otherwise tangibly embodied on a non-transitory computer readable storage medium. The software can include the instructions and certain data that, when executed by the one or more processors, manipulate the one or more processors to perform one or more aspects of the techniques described above. The non-transitory computer readable storage medium can include, for example, a magnetic or optical disk storage device, solid state storage devices such as Flash memory, a cache, random access memory (RAM) or other non-volatile memory device or devices, and the like. The executable instructions stored on the non-transitory computer readable storage medium may be in source code, assembly language code, object code, or other instruction format that is interpreted or otherwise executable by one or more processors.

Note that not all of the activities or elements described above in the general description are required, that a portion of a specific activity or device may not be required, and that one or more further activities may be performed, or elements included, in addition to those described. Still further, the order in which activities are listed are not necessarily the order in which they are performed. Also, the concepts have been described with reference to specific embodiments. However, one of ordinary skill in the art appreciates that various modifications and changes can be made without departing from the scope of the present disclosure as set forth in the

claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of the present disclosure.

Benefits, other advantages, and solutions to problems have been described  
5 above with regard to specific embodiments. However, the benefits, advantages,  
solutions to problems, and any feature(s) that may cause any benefit, advantage, or  
solution to occur or become more pronounced are not to be construed as a critical,  
required, or essential feature of any or all the claims. Moreover, the particular  
embodiments disclosed above are illustrative only, as the disclosed subject matter  
10 may be modified and practiced in different but equivalent manners apparent to those  
skilled in the art having the benefit of the teachings herein. No limitations are  
intended to the details of construction or design herein shown, other than as  
described in the claims below. It is therefore evident that the particular embodiments  
disclosed above may be altered or modified and all such variations are considered  
15 within the scope of the disclosed subject matter. Accordingly, the protection sought  
herein is as set forth in the claims below.

## WHAT IS CLAIMED IS:

1. A method comprising:
  - identifying a voltage standing-wave ratio (VSWR) for a voltage provided by a power amplifier [102] to an antenna [104]; and
  - adjusting the power amplifier in response to the VSWR indicating a human body presence in near field proximity to the antenna [335].
2. The method of claim 1, wherein identifying the VSWR comprises:
  - detecting a reflected signal on a signal path between the power amplifier and the antenna; and
  - identifying the VSWR based on the reflected signal.
3. The method of claim 2, wherein identifying VSWR comprises:
  - identifying a reflection coefficient based on the reflected signal and a signal transmitted to the antenna along the signal path; and
  - identifying the VSWR based on the reflection coefficient.
4. The method of claim 3, wherein detecting the reflected signal comprises:
  - detecting the reflected signal at a directional coupler [108] in the signal path, and using an RF detector [217] to rectify the reflected signal.
5. The method of claim 1, wherein adjusting the power amplifier comprises:
  - reducing a power output of the power amplifier in response to the VSWR exceeding a threshold [336].
6. The method of claim 5, wherein the threshold is a programmable value.
7. The method of claim 1, wherein adjusting the power amplifier comprises:
  - reducing a power output of the power amplifier by an adjustment amount, the adjustment amount based on the VSWR.

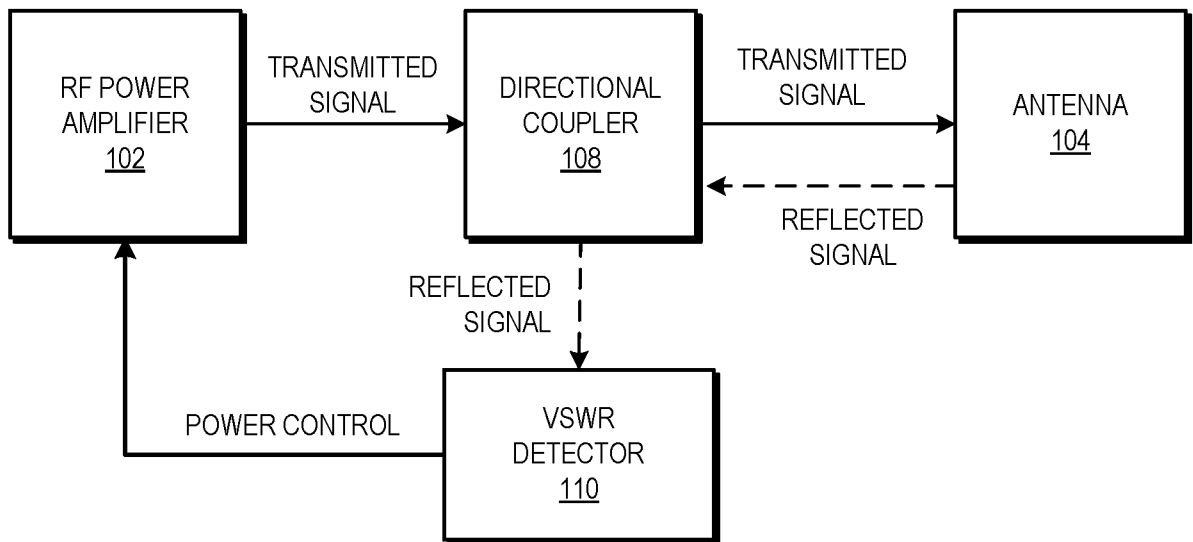
8. A method comprising:  
identifying a proximity of a human body presence to an antenna [104] of a  
device [100] based on a voltage standing-wave ratio (VSWR) for a  
voltage provided by a power amplifier [102] to the antenna; and  
5 adjusting the power amplifier based on the identified proximity.
9. The method of claim 8, wherein adjusting the power amplifier comprises:  
adjusting a power supplied to the power amplifier by a first amount in response  
to identifying the proximity is within a first threshold; and  
adjusting the power supplied the power amplifier by a second amount in  
10 response to identifying the proximity is within a second threshold.
10. The method of claim 8, wherein adjusting the power amplifier comprises:  
adjusting a power supplied to the power amplifier to a pre-calibrated level in  
response to identifying the proximity is within a threshold.
11. The method of claim 10, wherein the threshold is a programmable value.
- 15 12. The method of claim 8, further comprising:  
detecting a reflected signal on a signal path between the power amplifier and  
the antenna; and  
identifying the VSWR based on the reflected signal.
13. The method of claim 12, wherein identifying VSWR comprises:  
20 identifying a reflection coefficient based on the reflected signal and a signal  
transmitted to the antenna along the signal path; and  
identifying the VSWR based on the reflection coefficient.
14. A device [100], comprising:  
a power amplifier [102];  
25 an antenna [104] coupled to the power amplifier via a signal path;  
a voltage standing-wave ratio (VSWR) detector [110] configured to identify a  
VSWR for a voltage provided by a power amplifier to the antenna; and

a power control module [218] configured to adjust the power amplifier in response to the VSWR indicating a human body presence in proximity to the antenna.

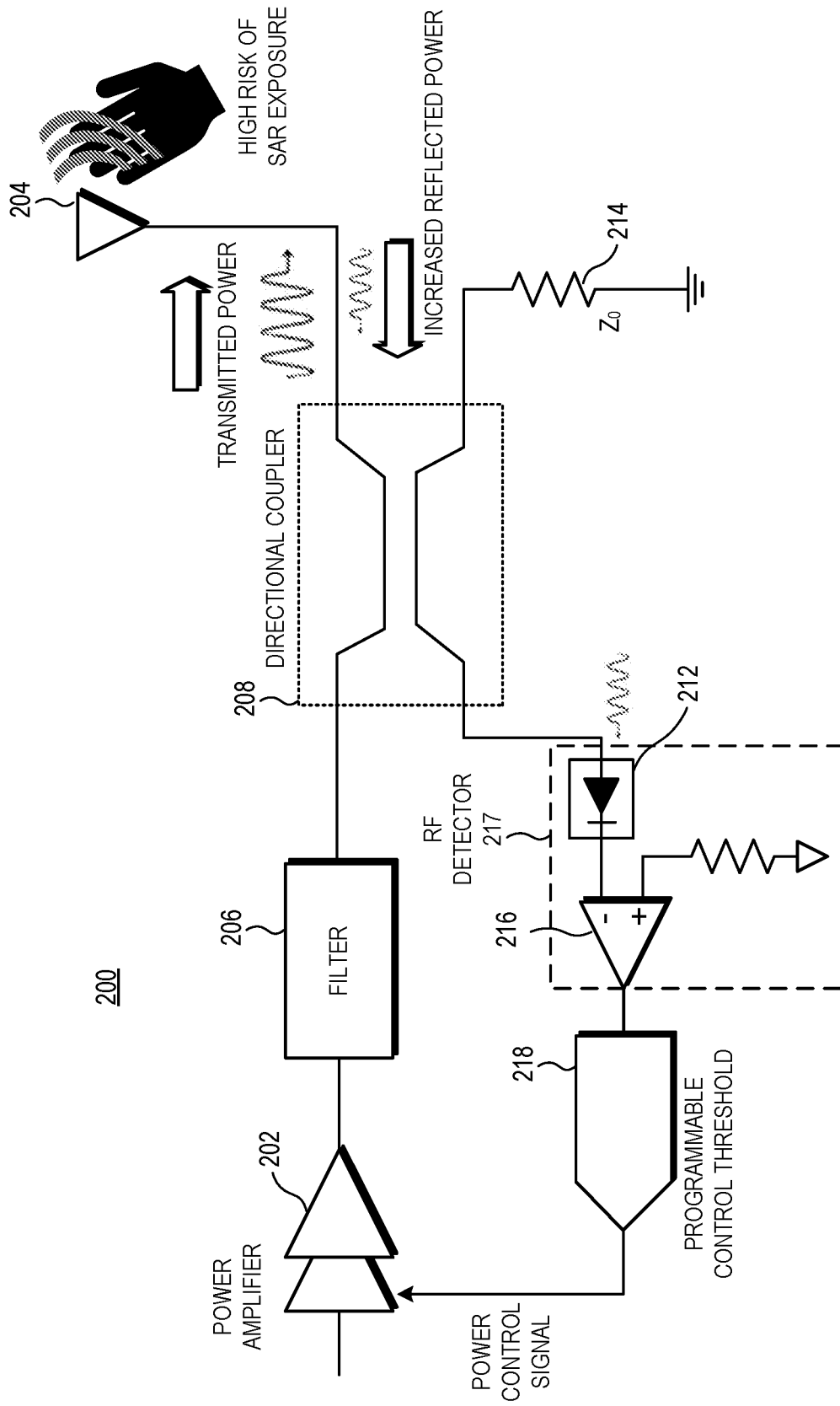
15. The device of claim 14, wherein the VSWR module identifies the VSWR by:  
5 detecting a reflected signal on a signal path between the power amplifier and the antenna; and  
identifying the VSWR based on the reflected signal.
16. The device of claim 15, wherein the VSWR module identifies the VSWR by:  
10 identifying a reflection coefficient based on the reflected signal and a signal transmitted to the antenna along the signal path; and  
identifying the VSWR based on the reflection coefficient.
17. The device of claim 16, further comprising a directional coupler [108], and wherein the VSWR detector detects the reflected signal at a directional coupler in the signal path.
- 15 18. The device of claim 14, wherein the power control module is to adjust the power amplifier by:  
reducing a power output of the power amplifier in response to the VSWR exceeding a threshold.
19. The device of claim 18, wherein the threshold is a programmable value.
- 20 20. The device of claim 14, wherein the power control module is to adjust the power amplifier by:  
reducing a power output of the power amplifier by an adjustment amount, the adjustment amount based on the magnitude of RF reflections from the antenna.

1/4

100



**FIG. 1**



**FIG. 2**

3/4

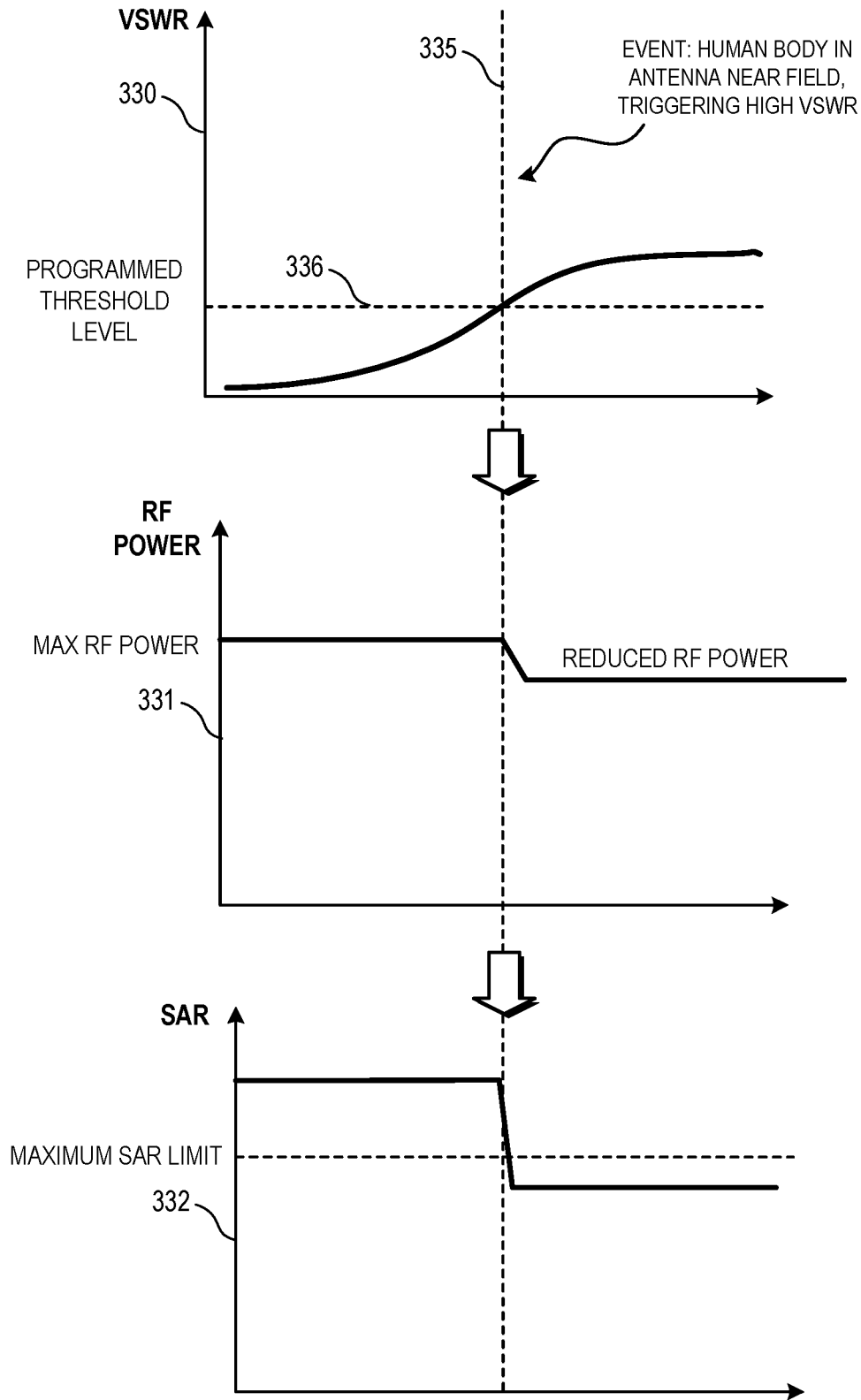
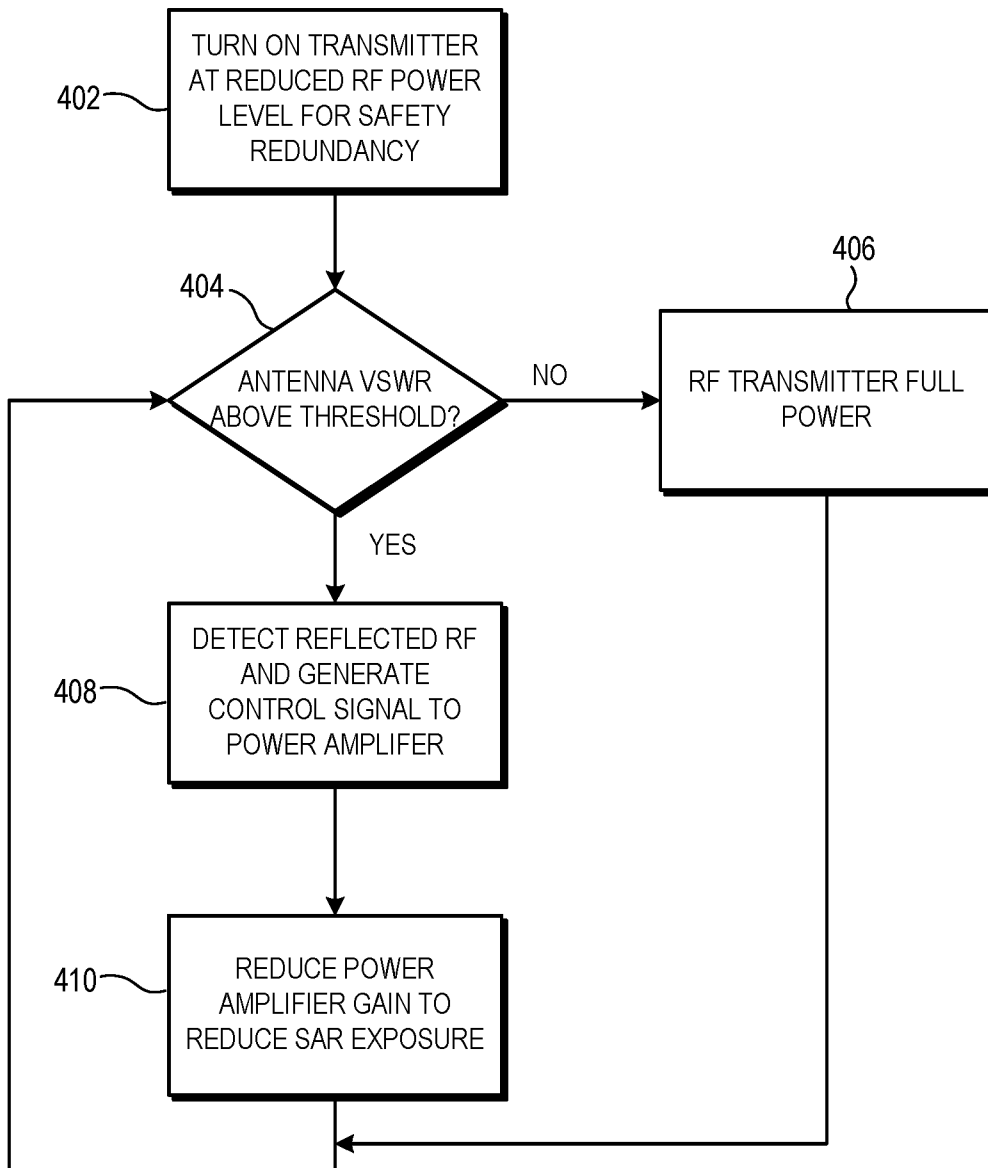


FIG. 3

4/4



400

**FIG. 4**

**A. CLASSIFICATION OF SUBJECT MATTER****H04B 1/04(2006.01)i, H04B 17/309(2014.01)i**

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

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

H04B 1/04; G01R 27/06; H01Q 11/12; H04B 1/00; H04B 1/18; H04B 1/3827; H04B 17/00; H04B 17/10; H04W 52/18; H04B 17/309

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) &amp; Keywords: voltage standing-wave ratio (VSWR), power amplifier, antenna, human body, presence

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2016-0211928 A1 (VIASAT, INC.) 21 July 2016 See paragraphs [0010], [0022], [0035]-[0044], [0057]-[0058], [0084], [0092]; and figure 1.	1-20
Y	US 2015-0162944 A1 (MICROCHIP TECHNOLOGY INCORPORATED) 11 June 2015 See paragraphs [0004], [0008], [0023]-[0029], [0035]; and figure 1.	1-20
A	US 2008-0026710 A1 (RICHARD JAMES BUCKLEY) 31 January 2008 See paragraphs [0005], [0013]-[0014], [0019]-[0020]; and figure 1.	1-20
A	KR 10-2016-0027415 A (KMW INC.) 10 March 2016 See paragraphs [0019]-[0031]; and figure 1.	1-20
A	CN 103609026 A (DMARC BROADCASTING, INC.) 26 February 2014 See paragraphs [0008], [0023], [0027]; and figure 1.	1-20

 Further documents are listed in the continuation of Box C. See patent family annex.

\* Special categories of cited documents:

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

"D" document cited by the applicant in the international application

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

06 November 2019 (06.11.2019)

Date of mailing of the international search report

**06 November 2019 (06.11.2019)**

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

YANG, Jeong Rok

Telephone No. +82-42-481-5709



**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No.

**PCT/US2019/042184**

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2016-0211928 A1	21/07/2016	US 9461755 B2	04/10/2016
US 2015-0162944 A1	11/06/2015	CN 104170265 A	26/11/2014
		CN 104170265 B	28/07/2017
		EP 2815512 A2	24/12/2014
		EP 2815512 B1	03/04/2019
		KR 10-2014-0124803 A	27/10/2014
		KR 10-2019-0030771 A	22/03/2019
		TW 201338272 A	16/09/2013
		US 2013-0210477 A1	15/08/2013
		US 2015-0162943 A1	11/06/2015
		US 9144051 B2	22/09/2015
		US 9197271 B2	24/11/2015
		US 9258027 B2	09/02/2016
		WO 2013-123155 A2	22/08/2013
		WO 2013-123155 A3	28/11/2013
US 2008-0026710 A1	31/01/2008	AT 455398 T	15/01/2010
		EP 2070195 A1	17/06/2009
		EP 2070195 B1	13/01/2010
		IL 196686 A	28/06/2012
		JP 2009-545250 A	17/12/2009
		KR 10-2009-0037476 A	15/04/2009
		NO 20090784 A	27/04/2009
		TW 200818746 A	16/04/2008
		US 7590395 B2	15/09/2009
		WO 2008-014210 A1	31/01/2008
KR 10-2016-0027415 A	10/03/2016	WO 2016-032114 A1	03/03/2016
CN 103609026 A	26/02/2014	CN 103609026 B	21/09/2016
		EP 2724469 A2	30/04/2014
		EP 2724469 A4	11/03/2015
		EP 2724469 B1	14/02/2018
		US 2014-0125546 A1	08/05/2014
		US 9525203 B2	20/12/2016
		WO 2012-177939 A2	27/12/2012
		WO 2012-177939 A3	21/02/2013