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(71) Applicant: **REALME MOBILE TELECOMMUNICATIONS (SHENZHEN) CO., LTD.**
Shenzhen, Guangdong 518052 (CN)

(72) Inventor: **PENG, Zhiyong**
Shenzhen, Guangdong 518052 (CN)

(74) Representative: **Novagraaf Technologies Bâtiment O2**
2, rue Sarah Bernhardt
CS90017
92665 Asnières-sur-Seine Cedex (FR)

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(54) **ELECTRONIC DEVICE**

(57) The present application provides an electronic device. The electronic device comprises a conductive frame and an antenna assembly; the conductive frame comprises a frame body, a first bezel and a second bezel; the first bezel and the second bezel are connected to the periphery of the frame body, and the first bezel and the second bezel bend to connect to each other, the length of the first bezel being longer than the length of the second bezel; the antenna assembly comprises a first antenna and a second antenna; the first antenna is a main transmitting antenna, and works in a first frequency band. The first antenna comprises a first radiating body, one end of the first radiating body being located at the end of the first bezel away from the second bezel; the second antenna is a diversity receiving antenna, and works in the first frequency band. The second antenna comprises a second radiating body, one end of the second radiating body being located at the end of the first bezel away from the first radiating body, and the other end of the second radiating body being located on the second bezel. The electronic device of the present application has relatively good communication performance.

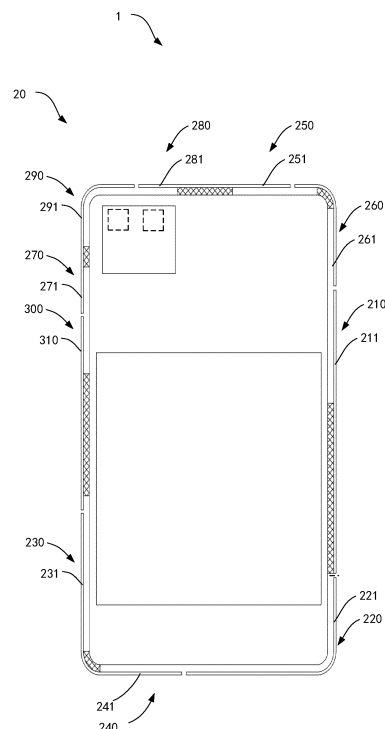


FIG. 2

Description

[0001] The present application claims priorities to Chinese Patent Application No. 202111602700.4, entitled "ELECTRONIC DEVICE", filed December 24, 2021, which is herein incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to the field of communication technologies, and in particular to an electronic device.

BACKGROUND

[0003] With the development of technology, popularity of electronic devices with communication functions, such as mobile phones, is increasing, and functions of the electronic devices are becoming more and more powerful. The electronic devices typically include antenna assemblies to achieve communication functions. However, the communication performance of the antenna assemblies of the electronic devices in related art are not good enough, and there is still room for improvement.

SUMMARY OF THE DISCLOSURE

[0004] An aspect of the present disclosure provides an electronic device. The electronic device includes a conductive frame and an antenna assembly.

[0005] The conductive frame includes a frame body, a first side frame, and a second side frame, the first side frame and the second side frame are connected to periphery of the frame body, the first side frame is bent and connected to the second side frame, and a length of the first side frame is greater than that of the second side frame.

[0006] The antenna assembly includes a first antenna and a second antenna.

[0007] The first antenna is a primary transmitting antenna and operates in a first frequency band, the first antenna includes a first radiator, and an end of the first radiator is located on an end of the first side frame away from the second side frame.

[0008] The second antenna is a diversity receiving antenna and operates in the first frequency band, the second antenna includes a second radiator, one end of the second radiator is located on an end of the first side frame away from the first radiator, and the other end of the second radiator is located on the second side frame.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] In order to more clearly illustrate the technical solutions in some embodiments of the present disclosure, hereinafter, a brief introduction will be given to the accompanying drawings that are used in the description of some embodiments. Obviously, the accompanying

drawings in the description below are merely some embodiments of the present disclosure. For those of ordinary skill in the art, other accompanying drawings may be obtained based on these accompanying drawings without any creative efforts.

FIG. 1 is an identification schematic view of a conductive frame of an electronic device in some embodiments of the present disclosure.

FIG. 2 is an identification schematic view of an antenna assembly of the electronic device of FIG. 1.

FIG. 3 is a schematic view illustrating various components of the electronic device of FIG. 1.

FIG. 4 is a schematic view of a first antenna of the electronic device of FIG. 1.

FIG. 5 is a circuit block view of the electronic device of FIG. 1.

FIG. 6 is a circuit block view of the first antenna of FIG. 5.

FIG. 7 is a schematic view of a second antenna of the electronic device in some embodiments of the present disclosure.

FIG. 8 is a circuit block view of a third antenna of the electronic device in some embodiments of the present disclosure.

FIG. 9 is a circuit block view of a fifth antenna in some embodiments of the present disclosure.

FIG. 10 is a directional pattern of a third antenna operating in a third frequency band.

FIG. 11 is a directional pattern of a ninth antenna operating in the third frequency band.

FIG. 12 is a directional pattern illustrating the third antenna and the ninth antenna that are combined and operate in the third frequency band.

FIG. 13 is a circuit block view of a tenth antenna in some embodiments of the present disclosure.

FIG. 14 is a three-dimensional structural schematic view of the electronic device in some embodiments of the present disclosure.

FIG. 15 is a cross-sectional structural schematic view of the electronic device of FIG. 14 in a I-I direction.

DETAILED DESCRIPTION

[0010] The present disclosure provides an electronic device. The electronic device includes a conductive frame and an antenna assembly.

[0011] The conductive frame includes a frame body, a first side frame, and a second side frame. The first side frame and the second side frame are connected to periphery of the frame body, the first side frame is bent and connected to the second side frame, and a length of the first side frame is greater than that of the second side frame.

[0012] The antenna assembly includes a first antenna and a second antenna.

[0013] The first antenna is a primary transmitting an-

tenna and operates in a first frequency band, the first antenna includes a first radiator, and an end of the first radiator is located on an end of the first side frame away from the second side frame.

[0014] The second antenna is a diversity receiving antenna and operates in the first frequency band, the second antenna includes a second radiator, one end of the second radiator is located on an end of the first side frame away from the first radiator, and the other end of the second radiator is located on the second side frame.

[0015] In some embodiments, the electronic device further includes a controller.

[0016] The controller is electrically connected to the first antenna and the second antenna, the controller is configured to use the second antenna as a transmitting antenna for currently transmitting electromagnetic wave signals in the first frequency band in response to transmission performance of the first antenna being poor.

[0017] In some embodiments the second antenna further includes a first capacitor.

[0018] One end of the first capacitor is electrically connected to the second radiator, the other end of the first capacitor is grounded, the first capacitor is configured to adjust resonant frequency point in the first frequency band supported by the second antenna, and the first capacitor is configured to make the second radiator serve as a SAR detection radiator.

[0019] In some embodiments the first antenna further includes a plurality of first matching circuits and a first switch.

[0020] The first switch is configured to switch a corresponding one of the plurality of first matching circuits electrically connected to the first radiator, so that the first antenna supports a first frequency sub-band, a second frequency sub-band, a third frequency sub-band, and a fourth frequency sub-band in the first frequency band.

[0021] In some embodiments the conductive frame further includes a third side frame.

[0022] The third side frame is opposite to the first side frame, the third side frame is bent and connected to the second side frame, and both the third side frame and the first side frame are disposed on a side of the second side frame.

[0023] The antenna assembly further includes a third antenna.

[0024] The third antenna operates in a second frequency band, the first frequency band, and a third frequency band, the third antenna includes a third radiator located on an end of the third side frame adjacent to the second side frame.

[0025] In some embodiments the third antenna further includes three first RF front-end circuits, a first combiner, and a second matching circuit.

[0026] The first combiner includes three first input ends and one first output end, each of the three first input ends is electrically connected to a corresponding one of the three first RF front-end circuits, and different first input ends are electrically connected to different first RF front-

end circuits.

[0027] One end of the second matching circuit is electrically connected to the first output end of the first combiner, and the other end of the second matching circuit is electrically connected to the third radiator.

[0028] In some embodiments the antenna assembly further includes a fourth antenna.

[0029] The fourth antenna is the primary transmitting antenna and operates in a fourth frequency band, the fourth antenna includes a fourth radiator, and the fourth radiator is located on an end of the second side frame away from the first side frame.

[0030] In some embodiments the conductive frame further includes a fourth side frame.

[0031] The fourth side frame is disposed opposite to the second side frame, the fourth side frame is bent and connected to the first side frame and the third side frame respectively.

[0032] The antenna assembly further includes a fifth antenna.

[0033] The fifth antenna is the diversity receiving antenna in the fourth frequency band and the primary transmitting antenna in a fifth frequency band; the fifth frequency band includes a fifth frequency sub-band, a sixth frequency sub-band, and a seventh frequency sub-band; the fifth antenna includes a fifth radiator, and the fifth radiator is located on an end of the fourth side frame adjacent to the first side frame.

[0034] In some embodiments the fifth antenna further includes a second capacitor and a third matching circuit.

[0035] The third matching circuit is connected in series with the second capacitor; excitation signals are coupled and fed to the fifth radiator through the second capacitor, so as to excite a 1/8 mode of the fifth radiator; and the 1/8 mode is configured to support the fourth frequency band, and a parasitic mode of the fifth radiator is configured to support the fifth frequency band.

[0036] In some embodiments the antenna assembly further includes a sixth antenna.

[0037] The sixth antenna is the primary transmitting antenna in the fourth frequency band and the diversity receiving antenna in the sixth frequency sub-band of the fifth frequency band, the sixth antenna includes a sixth radiator, and the sixth radiator is located on the first side frame and located on an end of the first radiator away from the second side frame.

[0038] In some embodiments the antenna assembly further includes a seventh antenna.

[0039] The seventh antenna is the diversity receiving antenna and configured to support the fourth frequency band and the sixth frequency sub-band of the fifth frequency band, the seventh antenna includes a seventh radiator, and the seventh radiator is disposed on an end of the third side frame away from the second side frame.

[0040] In some embodiments the fourth antenna, the fifth antenna, the sixth antenna, and the seventh antenna are configured to form a 4 * 4 MIMO antenna in the fourth frequency band.

[0041] In some embodiments the antenna assembly further includes an eighth antenna.

[0042] The eighth antenna is configured to support a sixth frequency band and the sixth frequency sub-band of the fifth frequency band, the eighth antenna includes an eighth radiator, and the eighth radiator is located on the fourth side frame and located on an end of the fifth radiator away from the first side frame.

[0043] In some embodiments the fifth antenna, the sixth antenna, the seventh antenna, and the eighth antenna are configured to form a 4 * 4 MIMO antenna in the sixth frequency sub-band. Alternatively, the fifth antenna, the sixth antenna, the seventh antenna, and the eighth antenna are configured to achieve 1T4R in the sixth frequency sub-band.

[0044] In some embodiments the antenna assembly further includes a ninth antenna.

[0045] The ninth antenna is configured to support the third frequency band and a seventh frequency band, the ninth antenna includes a ninth radiator, and a part of the ninth radiator is located on an end of the third side frame away from the third radiator.

[0046] In some embodiments the antenna assembly further includes a tenth antenna.

[0047] The tenth antenna is configured to support the sixth frequency band, the tenth antenna includes a tenth radiator, and the tenth radiator is located on the third side frame and between the third radiator and the seventh radiator.

[0048] In some embodiments a mode from a feeding point of the tenth radiator to an end of the tenth radiator is configured to support the sixth frequency band.

[0049] In some embodiments the tenth antenna includes two second RF front-end circuits, a second combiner, and a fourth matching circuit.

[0050] The second combiner includes two second input ends and one second output end, each of the two second input ends is electrically connected to a corresponding one of the two second RF front-end circuits, and different second input ends are electrically connected to different second RF front-end circuits.

[0051] One end of the fourth matching circuit is electrically connected to the second output end of the second combiner, and the other end of the fourth matching circuit is electrically connected to the tenth radiator, so as to support the second frequency band and the sixth frequency band.

[0052] In some embodiments the conductive frame is a middle frame of the electronic device, and a radiator of each antenna of the antenna assembly is a metal branch formed on a corresponding side frame.

[0053] In some embodiments a radiator of each antenna of the antenna assembly is electrically connected to a corresponding frame body through a conductive member for grounding.

[0054] The technical solutions in some embodiments of the present disclosure may be clearly and completely described in conjunction with accompanying drawings in

some embodiments of the present disclosure. Obviously, the described embodiments are only a part of the embodiments of the present disclosure, and not all embodiments. Based on the embodiments in the present disclosure, all other embodiments obtained by those of ordinary skill in the art without creative effort are within the scope of the present disclosure.

[0055] The reference to "embodiments" in the present disclosure means that, specific features, structures, or characteristics described in conjunction with some embodiments may be included in at least one embodiment of the present disclosure. The phrase appearing in various positions in the specification does not necessarily refer to the same embodiment, nor is it an independent or alternative embodiment that is mutually exclusive with other embodiments. Those of ordinary skill in the art explicitly and implicitly understand that the embodiments described in the present disclosure may be combined with other embodiments.

[0056] The present disclosure provides an electronic device 1. The electronic device 1 includes, but is not limited to, the electronic device 1 with a communication function, such as, a mobile phone, a mobile internet device (MID), an e-book, a play station portable (PSP), a personal digital assistant (PDA), or the like.

[0057] As illustrated in FIGS. 1 and 2, FIG. 1 is an identification schematic view of a conductive frame of an electronic device in some embodiments of the present disclosure, FIG. 2 is an identification schematic view of an antenna assembly of the electronic device of FIG. 1, and FIG. 3 is a schematic view illustrating various components of the electronic device of FIG. 1. The electronic device 1 includes a conductive frame 10 and an antenna assembly 20. The conductive frame 10 includes a frame body 110, a first side frame 120, and a second side frame 130. The first side frame 120 and the second side frame 130 are connected to periphery of the frame body 110, and the first side frame 120 is bent and connected to the second side frame 130. A length of the first side frame 120 is greater than that of the second side frame 130. The antenna assembly 20 includes a first antenna 210 and a second antenna 220. The first antenna 210 is a primary transmitting antenna (PRX) and operates in a first frequency band. The first antenna 210 includes a first radiator 211. An end of the first radiator 211 is located on an end of the first side frame 120 away from the second side frame 130. The second antenna 220 is a diversity receiving antenna (DRX) and operates in the first frequency band. The second antenna 220 includes a second radiator 221. One end of the second radiator 221 is located on an end of the first side frame 120 away from the first radiator 211, and the other end of the second radiator 221 is located on the second side frame 130.

[0058] The conductive frame 10 may be a middle frame 40 of the electronic device 1, or other frames, as long as the conductive frame 10 is conductive. In some embodiments, the conductive frame 10 being the middle frame 40 of the electronic device 1 is taken as an example for

illustration, which is not a limitation on the electronic device 1 in the present disclosure.

[0059] A material of the conductive frame 10 may be conductive, for example, the material of the conductive frame 10 is not limited to at least one or more of copper, aluminum, magnesium, gold, silver, and the like. In some embodiments, the conductive frame 10 may include a conductive material and a non-conductive material, as long as the conductive frame 10 includes the conductive materials. A shape of the frame body 110 may be, but is not limited to, a rectangular or quasi-rectangular shape. The frame body 110 may form a ground electrode of the electronic device 1. In response to a component of the electronic device 1 needing to be grounded, the component may be electrically connected to the frame body 110. In some embodiments, in response to a radiator of each antenna of the electronic device 1 needs to be grounded, the radiator may be electrically connected to the frame body 110 for grounding. The electronic device 1 further includes other ground electrodes, such as the ground electrode of a circuit board 60 (as illustrated in FIG. 3), or the ground electrode of a screen 50 (as illustrated in FIGS. 14 and 15). In response to the conductive frame 10 being not the middle frame 40, the ground electrode of the electronic device 1 further includes the middle frame 40. In the following embodiments, the conductive frame 10 being the middle frame 40 is taken as an example for illustration.

[0060] The first side frame 120 is connected to the periphery of the frame body 110. In some embodiments, the first side frame 120 is a side frame located on a right side of the frame body 110. A position of the first side frame 120 relative to the frame body 110 varies with a placement posture of the conductive frame body 10. The position of the first side frame 120 relative to the frame body 110 in the schematic views of some embodiments should not be understood as a limitation on the electronic device 1 in the present disclosure.

[0061] In some embodiments, the first side frame 120 protrudes from at least one of two opposite surfaces of the frame body 110, so as to cooperate with the frame body 110 to carry other components of the electronic device 1 (such as the screen 50, the circuit board 60, or the like). In some embodiments, the first side frame 120 is flush with the frame body 110, or even lower than at least one of the two opposite surfaces of the frame body 110, as long as the first side frame 120 is connected to the periphery of the frame body 110.

[0062] The second side frame 130 is connected to the periphery of the frame body 110. In some embodiments, the second side frame 130 is a side frame located on a lower side of the frame body 110. A position of the second side frame 130 relative to the frame body 110 varies with the placement posture of the conductive frame 10. The position of the second side frame 130 relative to the frame body 110 in the schematic views of some embodiments should not be understood as the limitation on the electronic device 1 in the present disclosure.

[0063] In some embodiments, the second side frame 130 protrudes from at least one of the two opposite surfaces of the frame body 110, so as to cooperate with the frame body 110 to carry other components of the electronic device 1 (such as the screen 50, the circuit board 60, or the like). In some embodiments, the second side frame 130 is flush with the frame body 110, or even lower than at least one of the two opposite surfaces of the frame body 110, as long as the second side frame 130 is connected to the periphery of the frame body 110.

[0064] The first side frame 120 is bent and connected to the second side frame 130, and a connection between the first side frame 120 and the second side frame 130 may be in the form of an arc, a right angle, an acute angle, an obtuse angle, or the like.

[0065] The length of the first side frame 120 is greater than that of the second side frame 130. Thus, the first side frame 120 is a long side frame of the conductive frame 10, and the second side frame 130 is a short side frame of the conductive frame 10.

[0066] The first antenna 210 is the primary transmitting antenna (PRX) and operates in the first frequency band. In some embodiments, the first frequency band being a low frequency band or a lower band (LB) is taken as an example for illustration. The first antenna 210 may support low frequency bands of 2G, 3G, 4G, and 5G. That is, a frequency range of the low frequency is from 703 MHz to 960 MHz, such as, a B28 frequency band, a B20 frequency band, a B5 frequency band, a B8 frequency band, or the like. In response to the first frequency band being the low frequency, a required length of the first radiator 211 is longer. The first radiator 211 is disposed on the longer first side frame 120, which may facilitate a layout of the first radiator 211.

[0067] In some embodiments, the first antenna 210 may be a flexible printed circuit (FPC) antenna, a laser direct structuring (LDS) antenna, a print direct structuring (PDS) antenna, or a metal branch antenna. Accordingly, the first radiator 211 may be a flexible printed circuit (FPC) antenna radiator, a laser direct structuring (LDS) antenna radiator, a print direct structuring (PDS) antenna radiator, or a metal branch. The first radiator 211 may be disposed on the first side frame 120, or directly formed on the first side frame 120. In response to the first radiator 211 being directly disposed on the first side frame 120, the first radiator 211 may be the FPC antenna radiator, the LDS antenna radiator, the PDS antenna radiator, or the metal branch. In response to the first radiator 211 being directly formed on the first side frame 120, the first radiator 211 may be the metal branch. In some embodiments, gaps may be defined on the first side frame 120, so as to form the metal branches of the frame body 110 spaced apart from each other through the gaps, and one of the metal branches is the first radiator 211.

[0068] In some embodiments, the first antenna 210 may be, but is not limited to, an inverted-F antenna (IFA), a loop antenna, or a monopole antenna.

[0069] In some embodiments, an end of the first radi-

ator 211 is located on an end of the first side frame 120 away from the second side frame 130. Thus, during using the electronic device 1, the end of the first radiator 211 is not easily obstructed by a user's hand holding the electronic device 1, thereby reducing performance degradation caused by the hand obstructing the end of the first radiator 211. In addition, the position of the first radiator 211 is disposed, so that electromagnetic wave signals in the first frequency band transmitted and received by the first antenna 210 are not easily obstructed by the user's head in response to the electronic device 1 being disposed adjacent to the head (such as answering a phone). Thus, the position setting of the first radiator 211 of the electronic device 1 in the present disclosure may improve the performance of the electronic device 1 that is held or disposed adjacent to the head. That is, the position setting of the first radiator 211 in the present disclosure enables the first antenna 210 to have good head to hand performance. Generally speaking, the first radiator 211 is disposed on the short side frame of a top, compared with unobstructed first radiator 211 (equivalent to being disposed in a free space), in response to the electronic device 1 being held or disposed adjacent to the user's head, the head to hand performance of the first antenna 210 may decrease by 7 dB - 8 dB. In the electronic device 1 in some embodiments of the present disclosure, compared with the unobstructed first radiator 211 (equivalent to being disposed in the free space), in response to the electronic device 1 being held or adjacent to the user's head, the head to hand performance of the first antenna 210 may decrease by 2 dB - 3 dB. Thus, the position setting of the first radiator 211 of the electronic device 1 in the present disclosure may enable the first antenna 210 to have good head to hand performance.

[0070] The second antenna 220 is the diversity receiving antenna (DRX) and operates in the first frequency band. The second antenna 220 and the first antenna 210 may support the first frequency band at the same time. Alternatively, one of the second antenna 220 and the first antenna 210 operates under control of a control signal at the same time. In some embodiments, the first frequency band being the low frequency band or the lower band is taken as an example for illustration. The second antenna 220 may support the low frequency bands of 2G, 3G, 4G, and 5G. That is, the frequency range of the low frequency ranges from 703 MHz to 960 MHz, such as, the B28 frequency band, the B20 frequency band, the B5 frequency band, the B8 frequency band, or the like. In response to the first frequency band being the low frequency, required length of the second radiator 221 is longer. One end of the second radiator 221 is located on the end of the first side frame 120 away from the first radiator 211, and the other end of the second radiator 221 is located on the second side frame 130, which facilitate the layout of the second radiator 221.

[0071] In some embodiments, the second antenna 220 may be the FPC antenna, the LDS antenna, the PDS antenna, or the metal branch antenna. Accordingly, the

second radiator 221 may be the FPC antenna radiator, the LDS antenna radiator, the PDS antenna radiator, or the metal branch. The second radiator 221 may be disposed on the second side frame 130, or directly formed on the second side frame 130. In response to the second radiator 221 being directly disposed on the second side frame 130, the second radiator 221 may be the FPC antenna radiator, the LDS antenna radiator, the PDS antenna radiator, or the metal branch. In response to the second radiator 221 being directly formed on the first side frame 120 and the second side frame 130, the second radiator 221 may be the metal branch. In some embodiments, gaps may be defined on the first side frame 120 and the second side frame 130, so as to form the metal branches of the frame body 110 spaced apart from each other through the gaps, and the second radiator 221 is the metal branch.

[0072] In some embodiments, the second antenna 220 may be, but is not limited to, the IFA, the loop antenna, or the monopole antenna.

[0073] In the electronic device 1 in some embodiments of the present disclosure, the position setting of the first radiator 211 and the second radiator 221 may enable the performance of the second antenna 220 to be higher (about 1.5 dB higher) than that of the first antenna 210 in the free space. When the electronic device 1 is disposed adjacent to the head or held, the performance of the first antenna 210 is better than that of the second antenna 220. That is, the position setting of the first radiator 211 and the second radiator 221 ensures that the second antenna 220 has low frequency performance in the free space. The first antenna 210 ensures the performance of the electronic device 1 during disposing the electronic device 1 adjacent to the head or holding the electronic device 1. In summary, in the electronic device 1 in some embodiments of the present disclosure, the position setting of the first radiator 211 and the second radiator 221 enables the electronic device 1 to have good communication performance during disposing the electronic device 1 in the free space, adjacent to the head, or holding the electronic device 1.

[0074] Due to the position setting of the second radiator 221, in response to the electronic device 1 being used in a portrait screen state, the second radiator 221 is far away from the user's head. Thus, a test card (also known as a Tx white card) that is configured for detecting a specific absorption rate (SAR) of electromagnetic wave energy of the electronic device 1 may be disposed adjacent to the second radiator 221, which may reduce SAR value of radiation to the user. The specific absorption rate of the electromagnetic wave energy, may also be called an absorption ratio of the electromagnetic wave energy, which refers to the electromagnetic wave power absorbed or consumed per unit mass of human tissue, and a unit is W/Kg. The larger the SAR value, the more the electromagnetic wave power absorbed or consumed per unit mass of the human tissue, and the greater the harm to the human body. Accordingly, the smaller the SAR

value, the smaller the electromagnetic wave power absorbed or consumed per unit mass of the human tissue, and the less the harm to the human body.

[0075] As illustrated in FIG. 4, FIG. 4 is a schematic view of a first antenna of the electronic device of FIG. 1. The first antenna 210 includes a first radiator 211, a plurality of first matching circuits 212, and a first switch 213. The first switch 213 is configured to switch the first matching circuits 212 electrically connected to the first radiator 211, so that the first antenna 210 supports a first frequency sub-band, a second frequency sub-band, a third frequency sub-band, and a fourth frequency sub-band in the first frequency band.

[0076] In some embodiments, the number of the first matching circuits 212 being four and the first switch 213 being a single pole four throw switch (SP4T) are taken as an example. In some embodiments, the number of the first matching circuits 212 may also be other numbers, such as N, wherein $N \geq 2$ and N is a positive integer. Accordingly, the first switch 213 is a single pole N-throw switch.

[0077] The first switch 213 includes a common end 2131, N ports 2132, and a switch port 2133. The common end 2131 is electrically connected to the first radiator 211. Each port 2132 of the N ports 2132 is electrically connected to a corresponding first matching circuit 212 to ground respectively, and different ports 2132 are electrically connected to different first matching circuits 212. The plurality of first matching circuits 212 are different from each other. The switch port 2133 is electrically connected to the common end 2131 and one of the N ports 2132, which is configured to make the first antenna 210 have different electrical lengths (i.e. switching different antenna apertures), achieving coverage of the first frequency sub-band, the second frequency sub-band, the third frequency sub-band, and the fourth frequency sub-band. In some embodiments, the first frequency sub-band is B28, the second frequency sub-band is B20, the third frequency sub-band is B5, and the fourth frequency sub-band is B8. In some embodiments, the first frequency sub-band, the second frequency sub-band, the third frequency sub-band, and the fourth frequency sub-band may be different frequency sub-bands with low frequencies. The first antenna 210 may only support one of the first frequency sub-band, the second frequency sub-band, the third frequency sub-band, and the fourth frequency sub-band at the same time, and cannot simultaneously support two or more frequency bands of the first frequency sub-band, the second frequency sub-band, the third frequency sub-band, and the fourth frequency sub-band.

[0078] In order to distinguish different ports 2132, the four ports 2132 are named 213a, 213b, 213c, and 213d respectively. In addition, in order to distinguish different first matching circuits 212, the four first matching circuits 212 are named 212a, 212b, 212c, and 212d respectively.

[0079] As illustrated in FIGS. 1, 2, 5, and 6, FIG. 5 is a circuit block view of the electronic device of FIG. 1, and

FIG. 6 is a circuit block view of the first antenna of FIG. 5. In some embodiments, the electronic device 1 further includes a controller 610. The controller 610 is electrically connected to the first antenna 210 and the second antenna 220. The controller 610 is configured to use the second antenna 220 as a transmitting antenna for currently transmitting the electromagnetic wave signals in the first frequency band in response to the transmission performance of the first antenna 210 being poor.

[0080] The controller 610 may be disposed on the circuit board 60. In some embodiments, the controller 610 judges the performance of the first antenna 210 based on a signal strength difference (received signal strength indicator, RSSI) between the first antenna 210 and the second antenna 220, or magnitude of a transmission power of a power amplifier 215 (PA) of the first antenna 210. In response to the signal strength difference between the first antenna 210 and the second antenna 220 being less than a preset strength difference, or in response to the power amplifier 215 being electrically connected to the first radiator 211 and the transmission power of the power amplifier 215 being greater than a preset power, it is judged that the performance of the first antenna 210 is not good. In response to the transmission performance of the first antenna 210 being poor, the controller 610 uses the second antenna 220 as the transmitting antenna for currently transmitting the electromagnetic wave signals in the first frequency band. That is, the controller 610 switches the antenna that transmits the electromagnetic wave signals in the first frequency band from the first antenna 210 to the second antenna 220. In some embodiments, the controller 610 may control the transmitting antenna that transmits the electromagnetic wave signals in the first frequency band by controlling a switching switch 620 (DPDT). In some embodiments, in response to the controller 610 switching configured for transmitting radio frequency signals in first frequency band to the first radiator 211 through the switching switch 620, the first antenna 210 serves as the transmitting antenna for currently transmitting the electromagnetic wave signals in the first frequency band. A radio frequency (RF) front-end module 214 is configured for transmitting the radio frequency signals in the first frequency band.

[0081] The first antenna 210 includes the RF front-end module 214, the power amplifier 215, and the first radiator 211. The RF front-end module 214 is configured to output the RF signals. An input end of the power amplifier 215 is electrically connected to the RF front-end module 214 and configured for amplifying the RF signals. The first radiator 211 is electrically connected to an output end of the power amplifier 215 and configured for receiving amplified RF signals output by the power amplifier 215, converting the amplified RF signals into the electromagnetic wave signals in the first frequency band, and radiating the electromagnetic wave signals out. In response to the first antenna 210 being obstructed, strengths of the electromagnetic wave signals in the first frequency band radiated by the first radiator 211 are poor. Thus, the con-

troller 610 controls the power amplifier 215 to increase the transmission power. The transmission power of the power amplifier 215 is greater than the preset power, which indicates that the first antenna 210 is obstructed more severely. Thus, in response to the power amplifier 215 being electrically connected to the first radiator 211 and the transmission power of the power amplifier 215 being greater than the preset power, the controller 610 controls the switching switch 620 to electrically connect the RF front-end module 214 to the second radiator 221, so as to use the second antenna 220 as the transmission antenna for currently transmitting the electromagnetic wave signals in the first frequency band.

[0082] As illustrated in FIG. 7, FIG. 7 is a schematic view of a second antenna of the electronic device in some embodiments of the present disclosure. In some embodiments, the second antenna 220 further includes a first capacitor 222. The second antenna 220 further includes the capacitor that may be combined with the electronic device 1 in any one of the above embodiments. In the schematic views of the present embodiment, the second antenna 220 further including the first capacitor 222 that is combined into the schematic view of any of the above embodiments is only taken as an example. One end of the first capacitor 222 is electrically connected to the second radiator 221, and the other end of the first capacitor 222 is grounded. The first capacitor 222 is configured to adjust resonant frequency point of the first frequency band supported by the second antenna 220, and the first capacitor 222 is configured to make the second radiator 221 serve as a SAR detection radiator.

[0083] One end of the first capacitor 222 is electrically connected to the second radiator 221, and the other end of the first capacitor 222 is grounded. That is, the second radiator 221 adopts a suspended design and is grounded through the first capacitor 222. Thus, the second radiator 221 further serves as the SAR detection radiator, thereby achieving multiplexing of the second antenna 220. That is, the second antenna 220 may not only serve as the diversity receiving antenna operating in the first frequency band, but also as the SAR detection antenna.

[0084] In some embodiments, a capacitance value C1 of the first capacitor 222 satisfies: $22\text{PF} \leq C1 \leq 68\text{PF}$. On the one hand, it may adjust the resonant frequency point of the first frequency band supported by the second antenna 220, and on the other hand, it may make the second radiator 221 have good detection effect in response to the second radiator 221 being used as the SAR detection radiator.

[0085] As illustrated in FIGS. 1 and 2, the conductive frame 10 further includes a third side frame 140. The third side frame 140 is disposed opposite to the first side frame 120. The third side frame 140 is bent and connected to the second side frame 130. Both the third side frame 140 and the first side frame 120 are disposed on a side of the second side frame 130. The antenna assembly 20 further includes a third antenna 230. The third antenna 230 operates in a second frequency band, the first frequency

band, and a third frequency band. The third antenna 230 includes a third radiator 231, and the third radiator 231 is located on an end of the third side frame 140 adjacent to the second side frame 130.

[0086] The antenna assembly 20 further includes the third antenna 230 that may be combined into the electronic device 1 in any one of the above embodiments. The electronic devices 1 illustrated in the schematic views of some embodiments should not be understood as limitations on the electronic devices 1 in some embodiments.

[0087] The third side frame 140 is connected to the periphery of the frame body 110. In some embodiments, the third side frame 140 is a side frame located on a left side of the frame body 110. A position of the third side frame 140 relative to the frame body 110 varies with the placement posture of the conductive frame 10. The position of the third side frame 140 relative to the frame body 110 in the schematic views of some embodiments should not be understood as a limitation on the electronic device 1 provided in the present disclosure.

[0088] In some embodiments, the third side frame 140 protrudes from at least one of the two opposite surfaces of the frame body 110, so as to cooperate with the frame body 110 to carry other components of the electronic device 1. In some embodiments, the third side frame 140 is flush with the frame body 110, or even lower than at least one of the two opposite surfaces of the frame body 110, as long as the third side frame 140 is connected to the periphery of the frame body 110.

[0089] The third side frame 140 is bent and connected to the second side frame 130. A connection between the third side frame 140 and the second side frame 130 may be in the form of the arc, the right angle, the acute angle, the obtuse angle, or the like.

[0090] A length of the third side frame 140 is greater than that of the second side frame 130. Thus, the third side frame 140 is also the long side frame of the conductive frame 10. The length of the third side frame 140 may be equal or unequal to that of the first side frame 120.

[0091] The third antenna 230 may support the first frequency band, the second frequency band, and the third frequency band at the same time. In some embodiments, the first frequency band is N28 in the low frequency band, the second frequency band may be GPS L5, and the third frequency band may be WiFi 2.4G. The first frequency band, the second frequency band, and the third frequency band are only examples of the three frequency bands supported by the third antenna 230, and should not be understood as a limitation on the third antenna 230.

[0092] The third radiator 231 is located on the end of the third side frame 140 adjacent to the second side frame 130, which may improve the performance of the second frequency band. In response to the third antenna 230 operating in the second frequency band, a proportion of upper hemisphere radiation may reach more than 80%. In some embodiments, the first frequency band supported by the third antenna 230 at the same time is N28 and

the second frequency band is GPS L5, which may allow the electronic device 1 to simultaneously meet the needs of GPS L5 in China and N28 in foreign countries. Thus, the design of the third antenna 230 may meet common needs of both China and foreign countries. In some embodiments, in response to the electronic device 1 being used domestically in China, the third antenna 230 may use GPS L5. In response to the electronic device 1 being used in foreign countries, the first antenna 210, the second antenna 220, and the third antenna 230 may be used as three low-frequency antennas, and the third antenna 230 may be used as the diversity receiving antenna (DRX).

[0093] In some embodiments, the third antenna 230 may be the FPC antenna, the LDS antenna, the PDS antenna, or the metal branch antenna. Accordingly, the third radiator 231 may be the FPC antenna radiator, the LDS antenna radiator, the PDS antenna radiator, or the metal branch.

[0094] In some embodiments, the third antenna 230 may be, but is not limited to, the IFA, the loop antenna, or the monopole antenna.

[0095] As illustrated in FIG. 8, FIG. 8 is a circuit block view of a third antenna of the electronic device in some embodiments of the present disclosure. The third antenna 230 includes a third radiator 231, three first RF front-end circuits 232, a first combiner 233, and a second matching circuit 234. The first combiner 233 includes three first input ends 2331 and one first output end 2332. Each of the three first input ends 2331 is electrically connected to a corresponding one of the three first RF front-end circuits 232, and different first input ends 2331 are electrically connected to different first RF front-end circuits 232. One end of the second matching circuit 234 is electrically connected to the first output end 2332 of the first combiner 233, and the other end of the second matching circuit 234 is electrically connected to the third radiator 231. The three first RF front-end circuits 232 are configured to generate different RF signals. The third radiator 231 supports the first frequency band based on one of the first RF front-end circuits 232 (named 232a for differentiation). The third radiator 231 supports the second frequency band based on another first RF front-end circuit 232 (named 232b for differentiation). The third radiator 231 supports the third frequency band based on yet another first RF front-end circuit 232 (named 232c for differentiation).

[0096] Thus, in some embodiments, the third antenna 230 only requires one third radiator 231, which may support the first frequency band, the second frequency band, and the third frequency band through the three first RF front-end circuits 232, the first combiner 233, and the second matching circuit 234. Since no switch is used, a structure of the third antenna 230 is relatively simple, and a volume of the third antenna 230 is relatively small.

[0097] In the schematic views of some embodiments, the antenna assembly 20 including the third antenna 230 is taken as an example. In some embodiments, the an-

tenna assembly 20 may not include the third antenna 230.

[0098] As illustrated in FIGS. 1 and 2, the antenna assembly 20 further includes a fourth antenna 240. The fourth antenna 240 is the primary transmitting antenna and operates in a fourth frequency band. The fourth antenna 240 includes a fourth radiator 241, and the fourth radiator 241 is located on an end of the second side frame 130 away from the first side frame 120.

[0099] The antenna assembly 20 further includes the fourth antenna 240 that may be combined into the electronic device 1 in any one of the above embodiments. The electronic devices 1 illustrated in the schematic views of some embodiments should not be understood as limitations on the electronic devices 1 in some embodiments of the present disclosure.

[0100] In some embodiments, the fourth antenna 240 may be the FPC antenna, the LDS antenna, the PDS antenna, or the metal branch antenna. Accordingly, the fourth radiator 241 may be the FPC antenna radiator, the LDS antenna radiator, the PDS antenna radiator, or the metal branch.

[0101] In some embodiments, the fourth antenna 240 may be, but is not limited to, the IFA, the loop antenna, or the monopole antenna.

[0102] The fourth radiator 241 of the fourth antenna 240 is located on the end of the second side frame 130 away from the first side frame 120. Thus, during using the electronic device 1 by the user, an end of the fourth radiator 241 is not easy to be held. Thus, the fourth radiator 241 of the fourth antenna 240 has a relatively good use environment and may be used as the primary transmitting antenna (PRX) in the fourth frequency band. In some embodiments, the fourth frequency band is a middle high band (MHB) frequency band, and the MHB frequency band ranges from 1000 MHz to 3000 MHz. The fourth antenna 240 may support the MHB of 2G, the MHB of 3G, the MHB of 4G, and the MHB of 5G. In some embodiments, the fourth antenna 240 may support a transmission (Tx) function during dual connecting MHB of LTE and MHB of NR.

[0103] In the schematic views of some embodiments, the antenna assembly 20 including the fourth antenna 240 is taken as an example. In some embodiments, the antenna assembly 20 may not include the fourth antenna 240.

[0104] As illustrated in FIGS. 1 and 2. The conductive frame 10 further includes a fourth side frame 150. The fourth side frame 150 is disposed opposite to the second side frame 130, and the fourth side frame 150 is bent and connected to the first side frame 120 and the third side frame 140, respectively. The antenna assembly 20 further includes a fifth antenna 250. The fifth antenna 250 is the diversity receiving antenna in the fourth frequency band and the primary transmitting antenna in the fifth frequency band. The fifth frequency band includes a fifth frequency sub-band, a sixth frequency sub-band, and a seventh frequency sub-band. The fifth antenna 250 includes a fifth radiator 251, and the fifth radiator 251 is

located on an end of the fourth side frame 150 adjacent to the first side frame 120.

[0105] The antenna assembly 20 further includes the fifth antenna 250 that may be combined into the electronic device 1 in any one of the above embodiments. The electronic devices 1 illustrated in the schematic views of some embodiments should not be understood as limitations on the electronic devices 1 in some embodiments.

[0106] The fourth side frame 150 is connected to the periphery of the frame body 110. In some embodiments, the fourth side frame 150 is a side frame located on the top of the frame body 110. A position of the fourth side frame 150 relative to the frame body 110 varies with the placement posture of the conductive frame 10. The position of the fourth side frame 150 relative to the frame body 110 in the schematic views of some embodiments should not be understood as a limitation on the electronic device 1 in the present disclosure.

[0107] In some embodiments, the fourth side frame 150 protrudes from at least one of the two opposite surfaces of the frame body 110, so as to cooperate with the frame body 110 to carry other components of the electronic device 1. In some embodiments, the fourth side frame 150 is flush with the frame body 110, or even lower than at least one of the two opposite surfaces of the frame body 110, as long as the fourth side frame 150 is connected to the periphery of the frame body 110.

[0108] The fourth side frame 150 is bent and connected to the first side frame 120 and the third side frame 140, respectively. A connection between the fourth side frame 150 and one of the first side frame 120 and the second side frame 130 may be in the form of the arc, the right angle, the acute angle, or the obtuse angle.

[0109] A length of the fourth side frame 150 is less than that of the first side frame 110, and the length of the fourth side frame 150 is less than that of the third side frame 140. Thus, the fourth side frame 150 is also the short side frame of the conductive frame 10. The length of the fourth side frame 150 may be equal or unequal to that of the second side frame 130.

[0110] The fifth radiator 251 of the fifth antenna 250 is located on an end of the fourth side frame 150 adjacent to the first side frame 120. Thus, during using the electronic device 1 by the user, the end of the fifth radiator 251 is not easy to be held. Thus, the use environment of the fifth radiator 251 of the fifth antenna 250 is relatively good, and the fifth antenna 250 may be used as the diversity receiving antenna in the fourth frequency band.

[0111] The fifth frequency band is a high band (HB) and an ultra-high band (UHB), and the HB and the UHB range from 3000 MHz to 6000 MHz.

[0112] In some embodiments, the fifth antenna 250 may be the FPC antenna, the LDS antenna, the PDS antenna, or the metal branch antenna. Accordingly, the fifth radiator 251 may be the FPC antenna radiator, the LDS antenna radiator, the PDS antenna radiator, or the metal branch.

[0113] In some embodiments, the fifth antenna 250

may be, but is not limited to, the IFA, the loop antenna, or the monopole antenna.

[0114] The fifth antenna 250 may support both the fourth frequency band and the fifth frequency bands at the same time. In response to the fifth antenna 250 supporting the fifth frequency band, the fifth antenna 250 may only support one of the fifth frequency sub-band, the sixth frequency sub-band, and the seventh frequency sub-band at the same time.

[0115] In some embodiments, the fifth frequency sub-band is N41, the sixth frequency sub-band is N78, and the seventh frequency sub-band is N79.

[0116] As illustrated in FIG. 9, FIG. 9 is a circuit block view of a fifth antenna in some embodiments of the present disclosure. The fifth antenna 250 includes the fifth radiator 251, a second capacitor 252, and a third matching circuit 253. The third matching circuit 253 is connected in series with the second capacitor 252, and exciting signals are coupled and fed to the fifth radiator 251 through the second capacitor 252, so as to excite a 1/8 mode of the fifth radiator 251. The 1/8 mode is configured to support the fourth frequency band, and a parasitic mode of the fifth radiator 251 is configured to support the fifth frequency band.

[0117] In some embodiments, a capacitance value of the second capacitor 252 is relatively small. In some embodiments, the capacitance value C2 of the second capacitor 252 satisfies: $0.3\text{PF} \leq C2 \leq 1.2\text{PF}$.

[0118] In some embodiments, the fifth antenna 250 may further include a second switch 254. The second switch 254 being the single pole four throw switch (SP4T) is taken as an example. The sub-matching circuit of the third matching circuit 253 loaded onto the fifth radiator 251 is adjusted through the second switch 254, thereby aperture tuning on the fifth antenna 250, so as to better support the fourth frequency band.

[0119] In the schematic views of some embodiments, the antenna assembly 20 including the fifth antenna 250 is taken as an example. In some embodiments, the antenna assembly 20 may also not include the fifth antenna 250.

[0120] As illustrated in FIGS. 1 and 2, the antenna assembly 20 further includes a sixth antenna 260. The sixth antenna 260 is the primary transmitting antenna in the fourth frequency band and the diversity receiving antenna in the sixth sub-frequency band of the fifth frequency band. The sixth antenna 260 includes a sixth radiator 261, and the sixth radiator 261 is located on the first side frame 120 and on an end of the first radiator 211 away from the second side frame 130.

[0121] The antenna assembly 20 further includes the sixth antenna 260 that may be combined into the electronic device 1 in any one of the above embodiments. The electronic devices 1 illustrated in the schematic views of some embodiments should not be understood as limitations on the electronic devices 1 in some embodiments.

[0122] In some embodiments, the sixth antenna 260

may be the FPC antenna, the LDS antenna, the PDS antenna, or the metal branch antenna. Accordingly, the sixth radiator 261 may be the FPC antenna radiator, the LDS antenna radiator, the PDS antenna radiator, or the metal branch.

[0123] In some embodiments, the sixth antenna 260 may be, but is not limited to, the IFA, the loop antenna, or the monopole antenna.

[0124] The sixth radiator 261 is located on the first side frame 120 and on the end of the first radiator 211 away from the second side frame 130. Thus, during using the electronic device 1 by the user, the end of the sixth radiator 261 is not easy to be held. Thus, the use environment of the sixth radiator 261 of the sixth antenna 260 is relatively good, and the sixth antenna 260 may be used as the primary transmitting antenna (PRX) in the fourth frequency band.

[0125] In some embodiments, in response to the electronic device 1 being held in a landscape state, the performance of the sixth antenna 260 decreases slightly. Thus, the performance of the electronic device 1 is better in the landscape state (such as playing games in the landscape state).

[0126] In some embodiments, the sixth antenna 260 may simultaneously support the fourth frequency band and the sixth frequency sub-band of the fifth frequency band at the same time.

[0127] In the schematic views of some embodiments, the antenna assembly 20 including the sixth antenna 260 is taken as an example. In some embodiments, the antenna assembly 20 may not include the sixth antenna 260.

[0128] As illustrated in FIGS. 1 and 2, the antenna assembly 20 further includes a seventh antenna 270. The seventh antenna 270 is the diversity receiving antenna, and configured to support the fourth frequency band and the sixth frequency sub-band of the fifth frequency band. The seventh antenna 270 includes a seventh radiator 271, and the seventh radiator 271 is located on an end of the third side frame 140 away from the second side frame 130.

[0129] The antenna assembly 20 further includes the seventh antenna 270 that may be combined into the electronic device 1 in any one of the above embodiments. The electronic devices 1 illustrated in the schematic views of some embodiments should not be understood as limitations on the electronic devices 1 in some embodiments.

[0130] In some embodiments, the seventh antenna 270 may be the FPC antenna, the LDS antenna, the PDS antenna, or the metal branch antenna. Accordingly, the seventh radiator 271 may be the FPC antenna radiator, the LDS antenna radiator, the PDS antenna radiator, or the metal branch.

[0131] In some embodiments, the seventh antenna 270 may be, but is not limited to, the IFA, the loop antenna, or the monopole antenna.

[0132] The seventh antenna 270 may support the

fourth frequency band and the sixth frequency sub-band of the fifth frequency band at the same time. The seventh antenna 270 is the diversity receiving antenna, which is disposed though considering a distance between the seventh radiator 271 and a rear camera 810 (as illustrated in FIGS. 2 and 3) of the electronic device 1 and a distance between the seventh radiator 271 and the RF module of the seventh antenna 270.

[0133] The seventh radiator 271 is usually located adjacent to the rear camera 810 of the electronic device 1, thus, the environment in which the seventh radiator 271 is located is relatively poor, which affects the efficiency of the seventh antenna 270. In addition, the distance between the seventh radiator 271 and the RF module of the seventh antenna 270 are relatively long, and loss of wiring between the seventh radiator 271 and the RF module of the seventh antenna 270 is relatively large, so that the performance of the antenna and transmission of board level data are relatively poor. Thus, the seventh antenna 270 is set as the diversity receiving antenna, so as to support the fourth frequency band and the sixth frequency sub-band of the fifth frequency band, which helps to fully utilize the position of the electronic device 1, even relatively unfriendly position to antenna environment of the electronic device 1. Thus, the electronic device 1 may be provided with more antennas, so that the electronic device 1 have good communication performance.

[0134] In some embodiments, in response to the electronic device 1 being held in the landscape state, the performance of the seventh antenna 270 decreases slightly. Thus, the performance of the electronic device 1 is better in the landscape state (such as playing games in the landscape state).

[0135] In the schematic views of some embodiments, the antenna assembly 20 including the seventh antenna 270 is taken as an example. In some embodiments, the antenna assembly 20 may not include the seventh antenna 270.

[0136] In response to the antenna assembly 20 including the fourth antenna 240, the fifth antenna 250, the sixth antenna 260, and the seventh antenna 270, the fourth antenna 240, the fifth antenna 250, the sixth antenna 260, and the seventh antenna 270 are configured to form a 4 * 4 multiple input multiple output (MIMO) antenna in the fourth frequency band.

[0137] The fourth antenna 240, the fifth antenna 250, the sixth antenna 260, and the seventh antenna 270 are configured to form the 4 * 4 MIMO antenna in the fourth frequency band, which may enable the antenna assembly 20 to have good communication performance in the fourth frequency band.

[0138] As illustrated in FIGS. 1 and 2, the antenna assembly 20 further includes an eighth antenna 280. The eighth antenna 280 is configured to support the sixth frequency band and the sixth frequency sub-band of the fifth frequency band. The eighth antenna 280 includes an eighth radiator 281, and the eighth radiator 281 is

located on the fourth side frame 150 and on an end of the fifth radiator 251 away from the first side frame 120.

[0139] The antenna assembly 20 further includes the eighth antenna 280 that may be combined into the electronic device 1 in any one of the above embodiments. The electronic devices 1 illustrated in the schematic views of some embodiments should not be understood as limitations on the electronic devices 1 in some embodiments.

[0140] In some embodiments, the eighth antenna 280 may be the FPC antenna, the LDS antenna, the PDS antenna, or the metal branch antenna. Accordingly, the eighth radiator 281 may be the FPC antenna radiator, the LDS antenna radiator, the PDS antenna radiator, or the metal branch.

[0141] In some embodiments, the eighth antenna 280 may be, but is not limited to, the IFA, the loop antenna, or the monopole antenna.

[0142] In some embodiments, the sixth frequency band is WiFi 5G, and the sixth frequency sub-band is N78. The eighth antenna 280 may simultaneously support the sixth frequency band and the sixth frequency sub-band at the same time.

[0143] A distance between the eighth radiator 281 and a proximity sensor 820 (as illustrated in FIGS. 2 and 3) of the electronic device 1 and a distance between the eighth radiator 281 and a light sensor 830 (as illustrated in FIGS. 2 and 3) of the electronic device 1 are relatively short. Thus, the eighth antenna 280 is set to support an ultra-high frequency with a low clearance requirement, and the ultra-high frequency includes WiFi 5G and N78. Thus, the electronic device 1 in the present disclosure may fully utilize the position of the electronic device 1, even relatively unfriendly position to the antenna environment of the electronic device 1. Thus, the electronic device 1 may be provided with more antennas, so that the electronic device 1 have good communication performance.

[0144] In the schematic views of some embodiments, the antenna assembly 20 including the eighth antenna 280 is taken as an example. In some embodiments, the antenna assembly 20 may not include the eighth antenna 280.

[0145] In response to the antenna assembly 20 including the fifth antenna 250, the sixth antenna 260, the seventh antenna 270, and the eighth antenna 280, the fifth antenna 250, the sixth antenna 260, the seventh antenna 270, and the eighth antenna 280 are configured to form the 4 * 4 MIMO antenna in the sixth frequency sub-band. Alternatively, the fifth antenna 250, the sixth antenna 260, the seventh antenna 270, and the eighth antenna 280 are configured to achieve 1T4R in the sixth frequency sub-band.

[0146] Since the fifth antenna 250, the sixth antenna 260, the seventh antenna 270, and the eighth antenna 280 all support the sixth frequency sub-band, the fifth antenna 250, the sixth antenna 260, the seventh antenna 270, and the eighth antenna 280 may form the 4 * 4 MIMO

antenna in the sixth frequency sub-band. Thus, the antenna assembly 20 has good communication performance in the sixth frequency sub-band.

[0147] In some embodiments, even if the fifth antenna 250, the sixth antenna 260, the seventh antenna 270, and the eighth antenna 280 do not form the 4 * 4 MIMO antenna, since the fifth antenna 250, the sixth antenna 260, the seventh antenna 270, and the eighth antenna 280 may all support the sixth frequency sub-band, there may still be unobstructed antennas. The unobstructed antennas support the transmission of the electromagnetic wave signals in the sixth frequency sub-band in response to the electronic device 1 being held in multiple poses, thereby maintaining the performance of the sixth frequency sub-band during holding the electronic device 1. That is, the fifth antenna 250, the sixth antenna 260, the seventh antenna 270, and the eighth antenna 280 may achieve the 1T4R in the sixth frequency sub-band.

[0148] As illustrated in FIGS. 1 and 2, in some embodiments, the antenna assembly 20 further includes a ninth antenna 290. The ninth antenna 290 is configured to support the third frequency band and the seventh frequency band. The ninth antenna 290 includes a ninth radiator 291, and a port of the ninth radiator 291 is located on an end of the third side frame 140 away from the third radiator 231.

[0149] The antenna assembly 20 further includes the ninth antenna 290 that may be combined into the electronic device 1 in any one of the above embodiments. The electronic devices 1 illustrated in the schematic views of some embodiments should not be understood as limitations on the electronic devices 1 in some embodiments.

[0150] In some embodiments, the ninth antenna 290 may be the FPC antenna, the LDS antenna, the PDS antenna, or the metal branch antenna. Accordingly, the ninth radiator 291 may be the FPC antenna radiator, the LDS antenna radiator, the PDS antenna radiator, or the metal branch.

[0151] In some embodiments, the ninth antenna 290 may be, but is not limited to, the IFA, the loop antenna, or the monopole antenna.

[0152] In some embodiments, the third frequency band is WiFi 2.4G, and the seventh frequency band is GPS L1. The ninth antenna 290 may support the third frequency band and the seventh frequency band at the same time.

[0153] A part of the ninth radiator 291 is located on the end of the third side frame 140 away from the third radiator 231, thus, the use environment of the ninth radiator 291 is better.

[0154] As illustrated in FIGS. 10, 11, and 12, FIG. 10 is a directional pattern of a third antenna operating in a third frequency band, FIG. 11 is a directional pattern of a ninth antenna operating in the third frequency band, and FIG. 12 is a directional pattern illustrating the third antenna and the ninth antenna that are combined and operate in the third frequency band. From FIGS. 10 to

12, it may be seen that the layouts of the ninth antenna 290 and the third antenna 230 may achieve complementation of the directional patterns in the third frequency band, thereby improving networking experience using the third frequency band.

[0155] In the schematic views of some embodiments, the antenna assembly 20 including the ninth antenna 290 is taken as an example. In some embodiments, the antenna assembly 20 may not include the ninth antenna 290.

[0156] As illustrated in FIGS. 1 and 2, the antenna assembly 20 further includes a tenth antenna 300. The tenth antenna 300 is configured to support the sixth frequency band. The tenth antenna 300 includes a tenth radiator 310, and the tenth radiator 310 is located on the third side frame 140 and between the third radiator 231 and the seventh radiator 271.

[0157] The antenna assembly 20 further includes the tenth antenna 300 that may be combined into the electronic device 1 in any one of the above embodiments. The electronic devices 1 illustrated in the schematic views of some embodiments should not be understood as limitations on the electronic devices 1 in some embodiments.

[0158] In some embodiments, the tenth antenna 300 may be the FPC antenna, the LDS antenna, the PDS antenna, or the metal branch antenna. Accordingly, the tenth radiator 310 may be the FPC antenna radiator, the LDS antenna radiator, the PDS antenna radiator, or the metal branch.

[0159] In some embodiments, the tenth antenna 300 may be, but is not limited to, the IFA, the loop antenna, or the monopole antenna.

[0160] A type of each antenna of the first antenna 210 to the tenth antenna 300 may be the same or different, which is not limited in the present disclosure.

[0161] The tenth antenna 300 and the eighth antenna 280 may support the sixth frequency band. Thus, the tenth antenna 300 and the eighth antenna 280 together improve non-circularity of the directional patterns in the sixth frequency band, so as to achieve complementation of the directional patterns, thereby enhancing the networking experience using the sixth frequency band.

[0162] In some embodiments, a mode from a feeding point of the tenth radiator 310 to an end of the tenth radiator 310 is configured to support the sixth frequency band.

[0163] As illustrated in FIGS. 1, 2, and 13, and FIG. 13 is a circuit block view of a tenth antenna in some embodiments of the present disclosure. The tenth antenna 300 includes the tenth radiator 310, two second RF front-end circuits 320, a second combiner 330, and a fourth matching circuit 340. The second combiner 330 includes two second input ends 331 and one second output end 332. Each of the two second input ends 331 is electrically connected to a corresponding one of the two second RF front-end circuits 320, and different second input ends 331 are electrically connected to different second RF

front-end circuits 320. One end of the fourth matching circuit 340 is electrically connected to the second output end 332 of the second combiner 330, and the other end of the fourth matching circuit 340 is electrically connected to the tenth radiator 310, so that the tenth radiator 310 supports the second frequency band and the sixth frequency band.

[0164] In order to distinguish the two second RF front-end circuits 320, the two second RF front-end circuits 320 are named as 321 and 322, respectively. In order to distinguish the two second input ends 331, the two second input ends 331 are named as 331a and 331b, respectively.

[0165] In the schematic views of some embodiments, the antenna assembly 20 including the tenth antenna 300 is taken as an example. In some embodiments, the antenna assembly 20 may not include the tenth antenna 300.

[0166] In some embodiments, a depth of a groove between the tenth radiator 310 of the tenth antenna 300 and the frame body 110 is greater than that of a groove between the tenth radiator 310 and the frame body 110 in FIG. 1. The electronic device 1 in some embodiments may enable the tenth radiator 310 to support the second frequency band and the sixth frequency band, thereby enabling the tenth antenna 300 to have the good communication performance. In some embodiments, the tenth radiator 310 may simultaneously support the second frequency band and the sixth frequency band at the same time.

[0167] The third antenna 230 supports the second frequency band (GPS-L5), the ninth antenna 290 supports the second frequency band (GPS-L5), and the ninth antenna 290 supports the seventh frequency band (GPS L1). During using the electronic device 1, the third antenna 230, the ninth antenna 290, and the eighth antenna 280 may be configured for positioning, thereby achieving more accurate positioning functions.

[0168] In summary, in the electronic device 1 in some embodiments, the first antenna 210, the second antenna 220, and the controller 610 are utilized to achieve two-way intelligent switching (two-way ASDiv) in the first frequency band (such as the LB) in a compact space. The fourth antenna 240, the fifth antenna 250, the sixth antenna 260, and the seventh antenna 270 are utilized to realize four-way reception and transmission in the fourth frequency band (such as the MHB). The fifth antenna 250, the sixth antenna 260, the seventh antenna 270, and the eighth antenna 280 are utilized to achieve the 1T4R in the sixth frequency sub-band (e.g., belonging to Sub 6G). Thus, the electronic device 1 in some embodiments may be provided with the antennas that support multiple frequency bands in the compact space, so that the electronic device 1 has good communication effects in the multiple frequency bands.

[0169] In some embodiments, the conductive frame 10 is the middle frame 40 of the electronic device 1, and the radiator of each antenna of the antenna assembly 20 is

the metal branch formed on a correspond side frame.

[0170] The conductive frame 10 is the middle frame 40 of the electronic device 1, and the radiator of each antenna of the antenna assembly 20 is the metal branch formed on the corresponding side frame, which may facilitate preparation of the radiator of each antenna. The antenna here refers to the first antenna 210 to the tenth antenna 300. The radiator is a corresponding radiator of each antenna, such as, a M-th radiator in a M-th antenna, wherein M is the positive integer greater than or equal to 1 and less than or equal to 10.

[0171] In some embodiments, the radiator of each antenna of the first antenna 210 to the tenth antenna 300 is electrically connected to the frame body 110 through a conductive member 20a for grounding. The conductive member 20a may be, but is not limited to, a conductive shrapnel, a connecting rib, a conductive adhesive, or the like.

[0172] As illustrated in FIGS. 1, 2, 14, and 15, FIG. 14 is a three-dimensional structural schematic view of the electronic device in some embodiments of the present disclosure, and FIG. 15 is a cross-sectional structural schematic view of the electronic device of FIG. 14 in a I-I direction. In some embodiments, the electronic device 1 includes the middle frame 40, the screen 50, the circuit board 60, and a battery cover 70. In some embodiments, the conductive frame 10 being the middle frame 40 is taken as an example to illustrate.

[0173] A material of the middle frame 40 is metal, such as aluminum magnesium alloy, which usually forms the ground electrode of the electronic device 1. In response to electronic components of the electronic device 1 need to be grounded, the electronic components may be connected to the middle frame 40 for grounding (GND). In addition, a ground system of the electronic device 1 includes not only the middle frame 40, but also the ground electrode of the circuit board 60 and the ground electrode of the screen 50.

[0174] The screen 50 may be a display screen with a display function or a screen that integrates the display function and a touch function. The screen 50 is configured to display information, such as text, images, videos, or the like. The screen 50 is carried on the middle frame 40 and is located on a side of the middle frame 40.

[0175] The circuit board 60 is usually also carried on the middle frame 40, and the circuit board 60 and the screen 50 are carried on two opposite sides to the middle frame 40 respectively. At least one or more of the signal sources of each antenna of the first antenna 210 to the tenth antenna 300 of the antenna assembly 20, and at least one or more of the matching circuits of each antenna of the first antenna 210 to the tenth antenna 300, may be disposed on the circuit board 60.

[0176] The battery cover 70 is located on a side of the circuit board 60 away from the middle frame 40. The battery cover 70, the middle frame 40, the circuit board 60, and the screen 50 cooperate with each other to assemble into the complete electronic device 1. The description of

the structure of the electronic device 1 is only a description of a form of the structure of the electronic device 1, should not be understood as the limitation on the electronic device 1, and should not be understood as the limitation on the antenna assembly 20.

[0177] Although the above embodiments of the present disclosure have been shown and described, the above embodiments are exemplary and cannot be understood as limitations to the present disclosure. Those of ordinary skill in the art may make changes, modifications, substitutions, and variations to the above embodiments in the scope of the present disclosure, and these improvements and embellishments are also considered in the protection scope of the present disclosure.

Claims

1. An electronic device, **characterized by** comprising:

a conductive frame, comprising a frame body, a first side frame, and a second side frame, wherein the first side frame and the second side frame are connected to periphery of the frame body, the first side frame is bent and connected to the second side frame, and a length of the first side frame is greater than that of the second side frame; and
an antenna assembly, comprising:

a first antenna, wherein the first antenna is a primary transmitting antenna and operates in a first frequency band, the first antenna comprises a first radiator, and an end of the first radiator is located on an end of the first side frame away from the second side frame; and
a second antenna, wherein the second antenna is a diversity receiving antenna and operates in the first frequency band, the second antenna comprises a second radiator, one end of the second radiator is located on an end of the first side frame away from the first radiator, and the other end of the second radiator is located on the second side frame.

2. The electronic device as claimed in claim 1, further comprising:

a controller, electrically connected to the first antenna and the second antenna, wherein the controller is configured to use the second antenna as a transmitting antenna for currently transmitting electromagnetic wave signals in the first frequency band in response to transmission performance of the first antenna being poor.

3. The electronic device as claimed in claim 1, wherein

the second antenna further comprises:

a first capacitor, wherein one end of the first capacitor is electrically connected to the second radiator, the other end of the first capacitor is grounded, the first capacitor is configured to adjust resonant frequency point in the first frequency band supported by the second antenna, and the first capacitor is configured to make the second radiator serve as a SAR detection radiator.

4. The electronic device as claimed in claim 1, wherein the first antenna further comprises:

a plurality of first matching circuits; and a first switch, configured to switch a corresponding one of the plurality of first matching circuits electrically connected to the first radiator, so that the first antenna supports a first frequency sub-band, a second frequency sub-band, a third frequency sub-band, and a fourth frequency sub-band in the first frequency band.

5. The electronic device as claimed in claim 1, wherein the conductive frame further comprises:

a third side frame, opposite to the first side frame, wherein the third side frame is bent and connected to the second side frame, and both the third side frame and the first side frame are disposed on a side of the second side frame; the antenna assembly further comprises: a third antenna, operating in a second frequency band, the first frequency band, and a third frequency band, wherein the third antenna comprises a third radiator located on an end of the third side frame adjacent to the second side frame.

6. The electronic device as claimed in claim 5, wherein the third antenna further comprises:

three first RF front-end circuits; a first combiner, comprising three first input ends and one first output end, wherein each of the three first input ends is electrically connected to a corresponding one of the three first RF front-end circuits, and different first input ends are electrically connected to different first RF front-end circuits; and a second matching circuit, wherein one end of the second matching circuit is electrically connected to the first output end of the first combiner, and the other end of the second matching circuit is electrically connected to the third radiator.

7. The electronic device as claimed in claim 5, wherein the antenna assembly further comprises:

a fourth antenna, wherein the fourth antenna is the primary transmitting antenna and operates in a fourth frequency band, the fourth antenna comprises a fourth radiator, and the fourth radiator is located on an end of the second side frame away from the first side frame.

8. The electronic device as claimed in claim 7, wherein the conductive frame further comprises:

a fourth side frame, disposed opposite to the second side frame, wherein the fourth side frame is bent and connected to the first side frame and the third side frame respectively; the antenna assembly further comprises: a fifth antenna, wherein the fifth antenna is the diversity receiving antenna in the fourth frequency band and the primary transmitting antenna in a fifth frequency band; the fifth frequency band comprises a fifth frequency sub-band, a sixth frequency sub-band, and a seventh frequency sub-band; the fifth antenna includes a fifth radiator, and the fifth radiator is located on an end of the fourth side frame adjacent to the first side frame.

9. The electronic device as claimed in claim 8, wherein the fifth antenna further comprises:

a second capacitor; and a third matching circuit, wherein the third matching circuit is connected in series with the second capacitor; excitation signals are coupled and fed to the fifth radiator through the second capacitor, so as to excite a 1/8 mode of the fifth radiator; and the 1/8 mode is configured to support the fourth frequency band, and a parasitic mode of the fifth radiator is configured to support the fifth frequency band.

10. The electronic device as claimed in claim 8, wherein the antenna assembly further comprises:

a sixth antenna, wherein the sixth antenna is the primary transmitting antenna in the fourth frequency band and the diversity receiving antenna in the sixth frequency sub-band of the fifth frequency band, the sixth antenna comprises a sixth radiator, and the sixth radiator is located on the first side frame and located on an end of the first radiator away from the second side frame.

11. The electronic device as claimed in claim 10, wherein the antenna assembly further comprises:

a seventh antenna, wherein the seventh antenna is the diversity receiving antenna and configured to support the fourth frequency band and the sixth frequency sub-band of the fifth frequency band, the seventh antenna comprises a seventh radiator, and the

seventh radiator is disposed on an end of the third side frame away from the second side frame.

12. The electronic device as claimed in claim 11, wherein the fourth antenna, the fifth antenna, the sixth antenna, and the seventh antenna are configured to form a 4 * 4 MIMO antenna in the fourth frequency band. 5
13. The electronic device as claimed in claim 11, wherein the antenna assembly further comprises: 10
an eighth antenna, configured to support a sixth frequency band and the sixth frequency sub-band of the fifth frequency band, the eighth antenna comprises an eighth radiator, and the eighth radiator is located on the fourth side frame and located on an end of the fifth radiator away from the first side frame. 15
14. The electronic device as claimed in claim 13, wherein the fifth antenna, the sixth antenna, the seventh antenna, and the eighth antenna are configured to form a 4 * 4 MIMO antenna in the sixth frequency sub-band; or 20
the fifth antenna, the sixth antenna, the seventh antenna, and the eighth antenna are configured to achieve 1T4R in the sixth frequency sub-band. 25
15. The electronic device as claimed in claim 5, wherein the antenna assembly further comprises: 30
a ninth antenna, configured to support the third frequency band and a seventh frequency band, wherein the ninth antenna comprises a ninth radiator, and a part of the ninth radiator is located on an end of the third side frame away from the third radiator.
16. The electronic device as claimed in claim 13, wherein the antenna assembly further comprises: 35
a tenth antenna, configured to support the sixth frequency band, wherein the tenth antenna comprises a tenth radiator, and the tenth radiator is located on the third side frame and between the third radiator and the seventh radiator. 40
17. The electronic device as claimed in claim 16, wherein a mode from a feeding point of the tenth radiator to an end of the tenth radiator is configured to support the sixth frequency band. 45
18. The electronic device as claimed in claim 16, wherein the tenth antenna comprises: 50
two second RF front-end circuits;
a second combiner, comprising two second input ends and one second output end, wherein each of the two second input ends is electrically connected to a corresponding one of the two second RF front-end circuits, and different second input ends are electrically connected to different second RF front-end circuits; and 55

a fourth matching circuit, wherein one end of the fourth matching circuit is electrically connected to the second output end of the second combiner, and the other end of the fourth matching circuit is electrically connected to the tenth radiator, so as to support the second frequency band and the sixth frequency band.

19. The electronic device as claimed in any one of claims 1 to 18, **characterized in that** the conductive frame is a middle frame of the electronic device, and a radiator of each antenna of the antenna assembly is a metal branch formed on a corresponding side frame.
20. The electronic device as claimed in any one of claims 1 to 18, **characterized in that** a radiator of each antenna of the antenna assembly is electrically connected to a corresponding frame body through a conductive member for grounding.

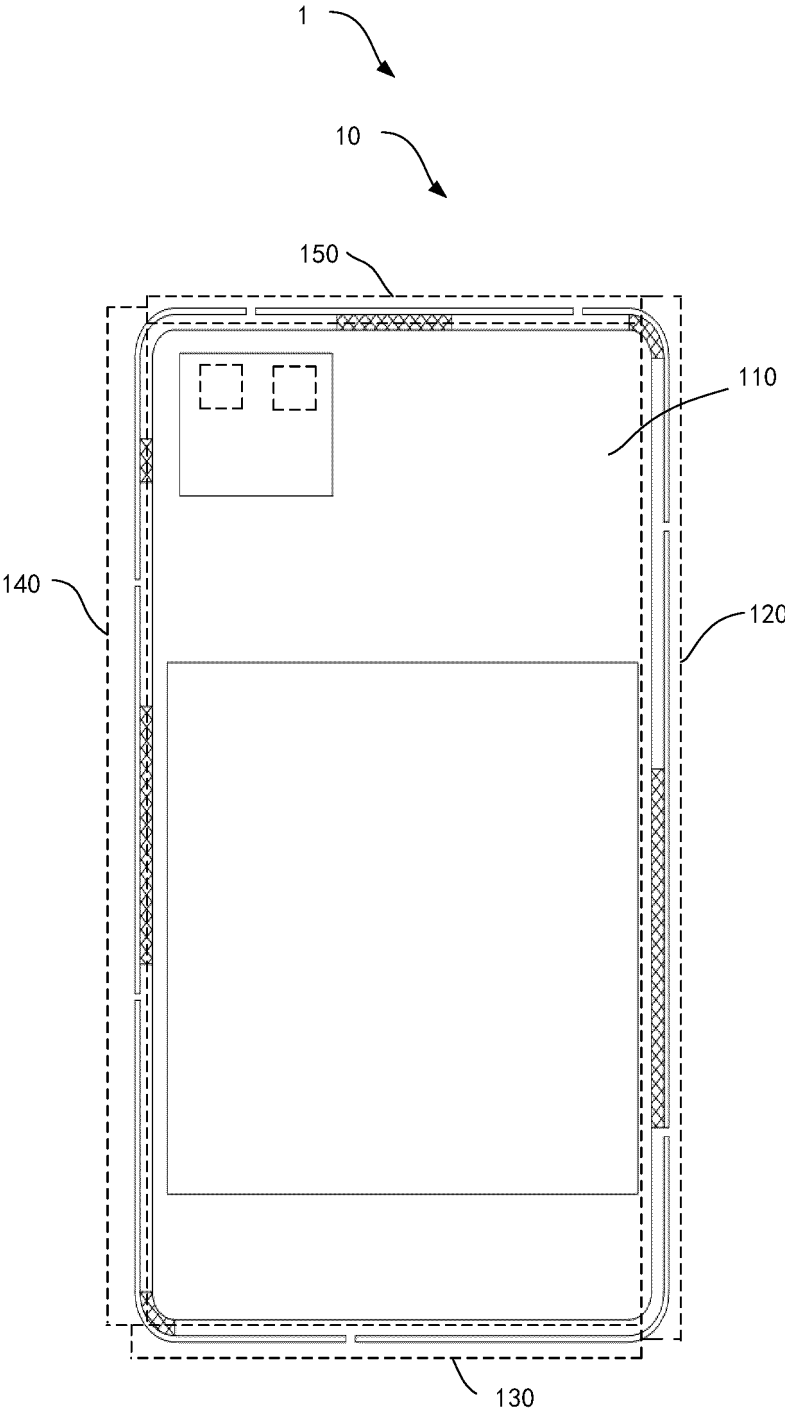


FIG. 1

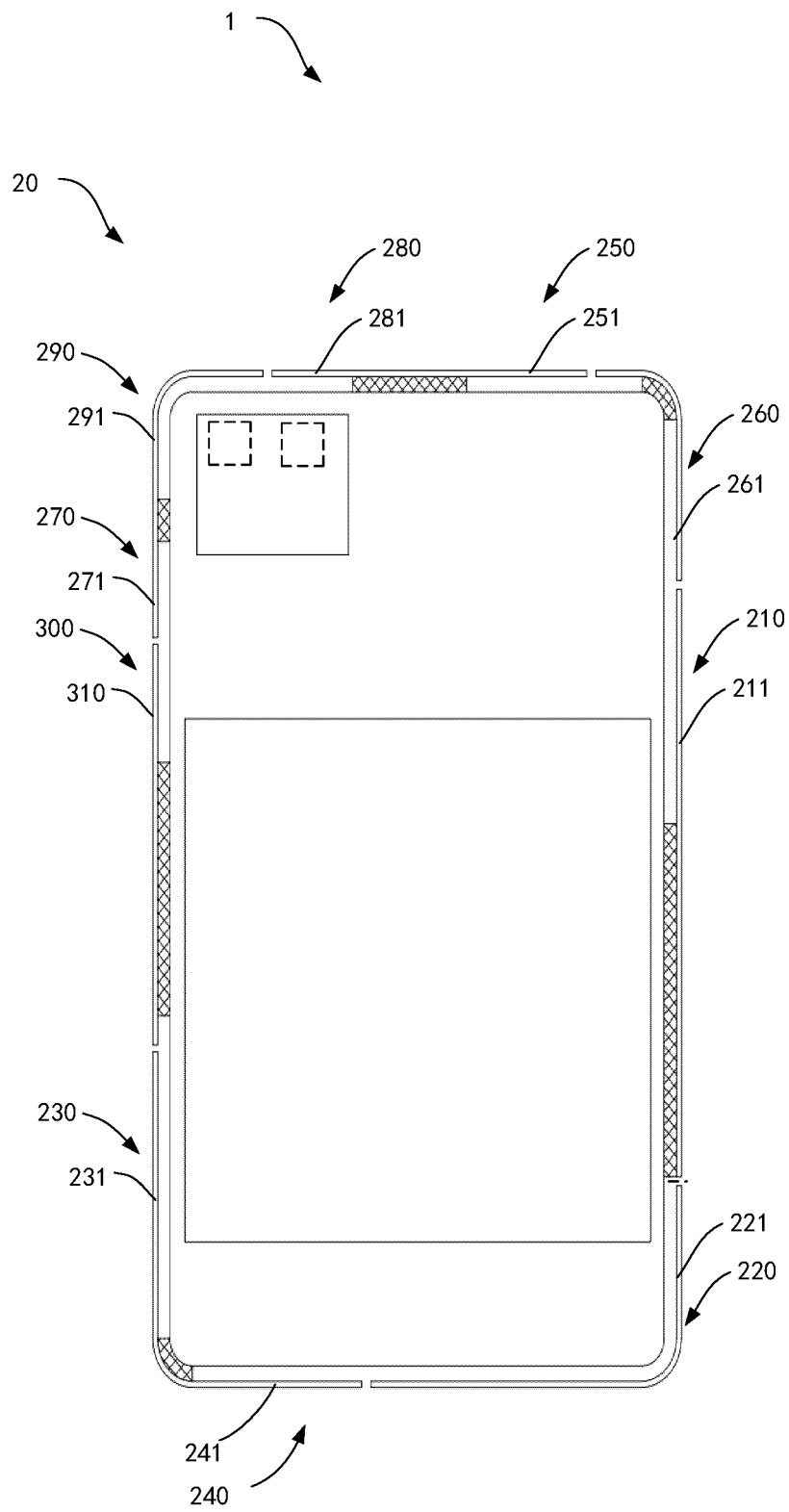


FIG. 2

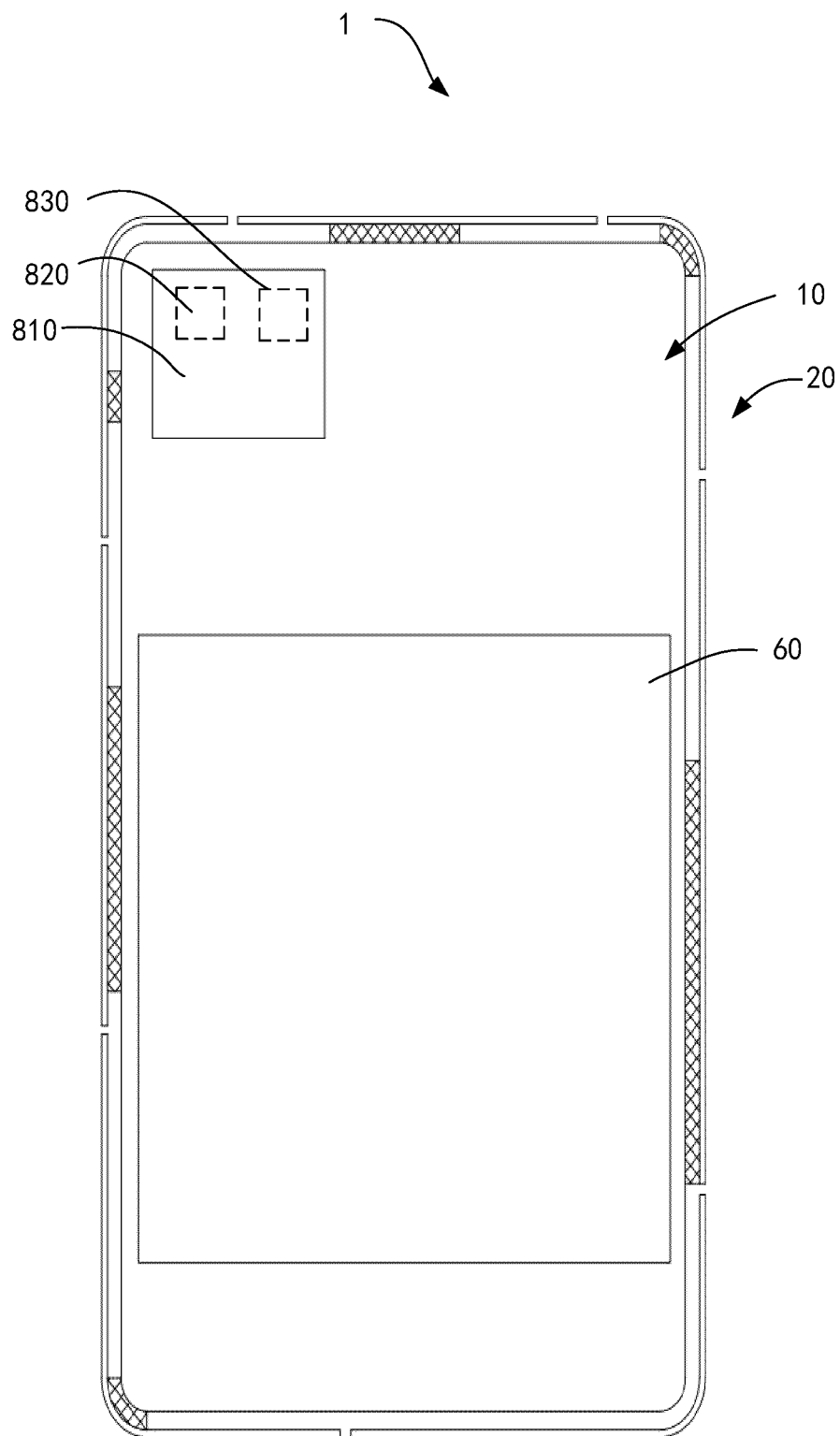


FIG. 3

210

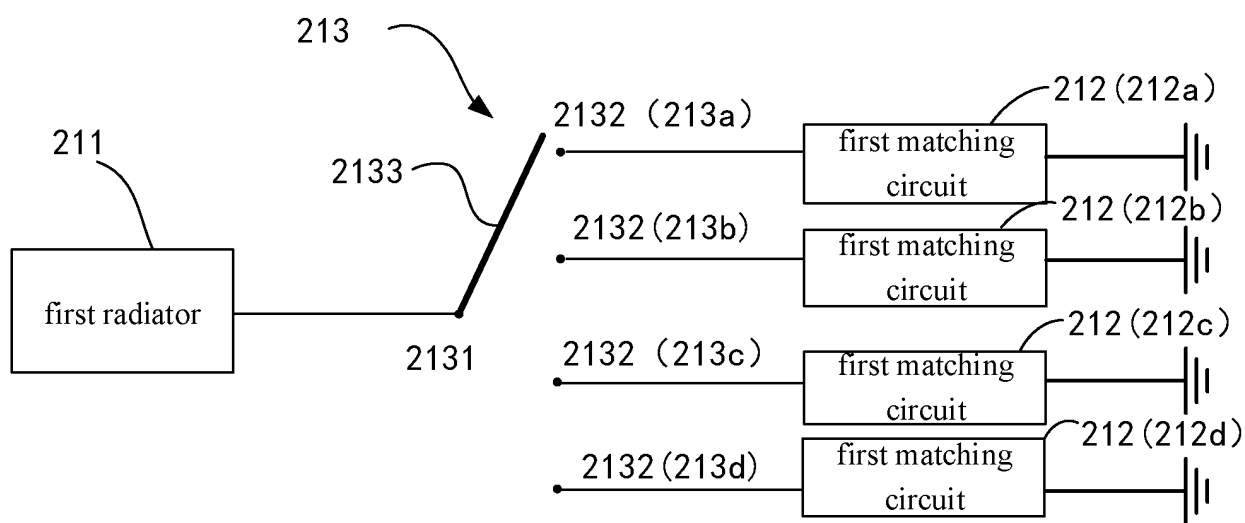


FIG. 4

1

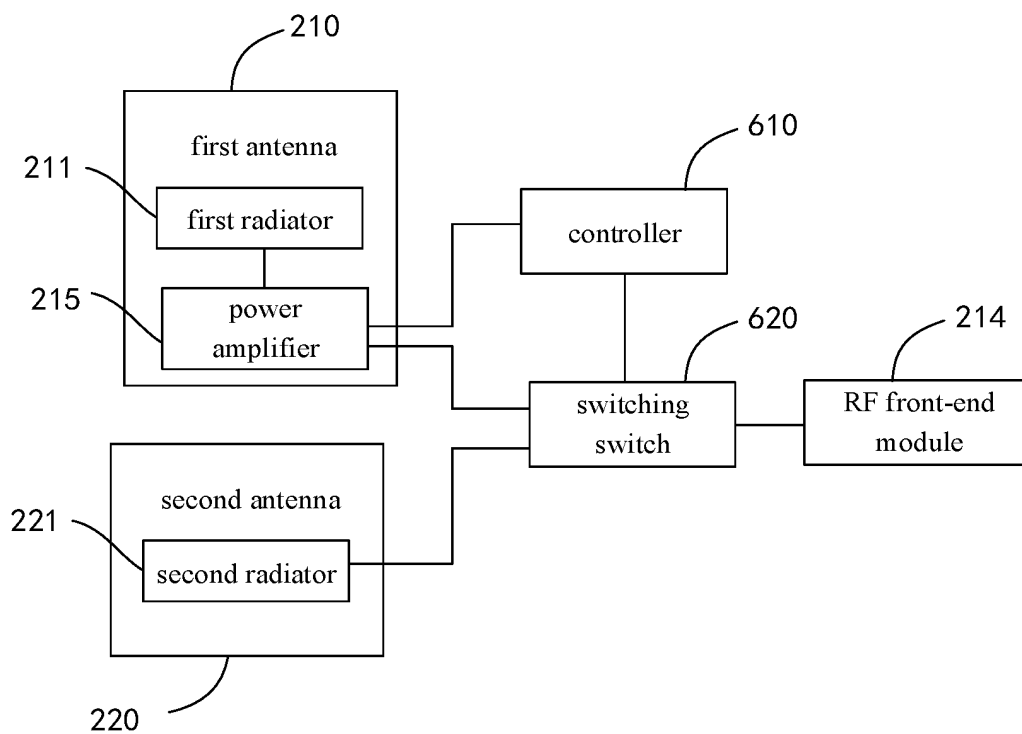


FIG. 5

210

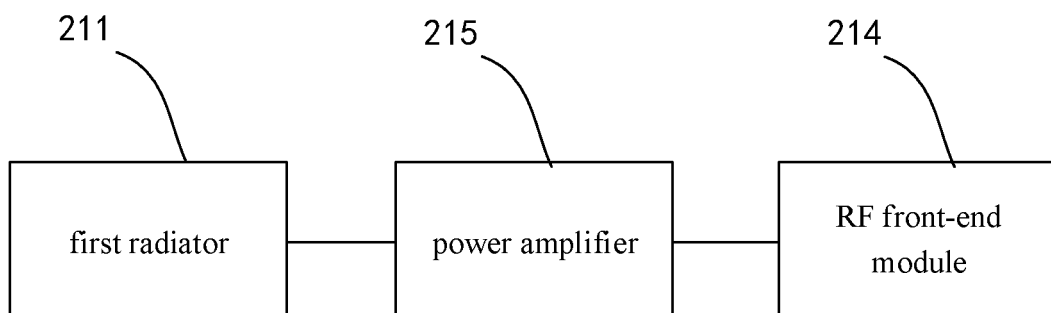


FIG. 6

220

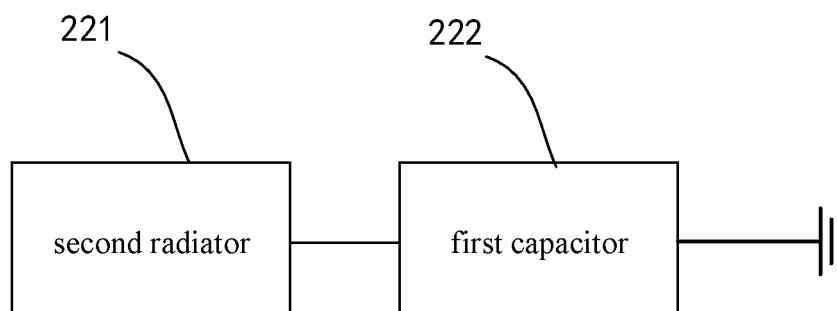


FIG. 7

230

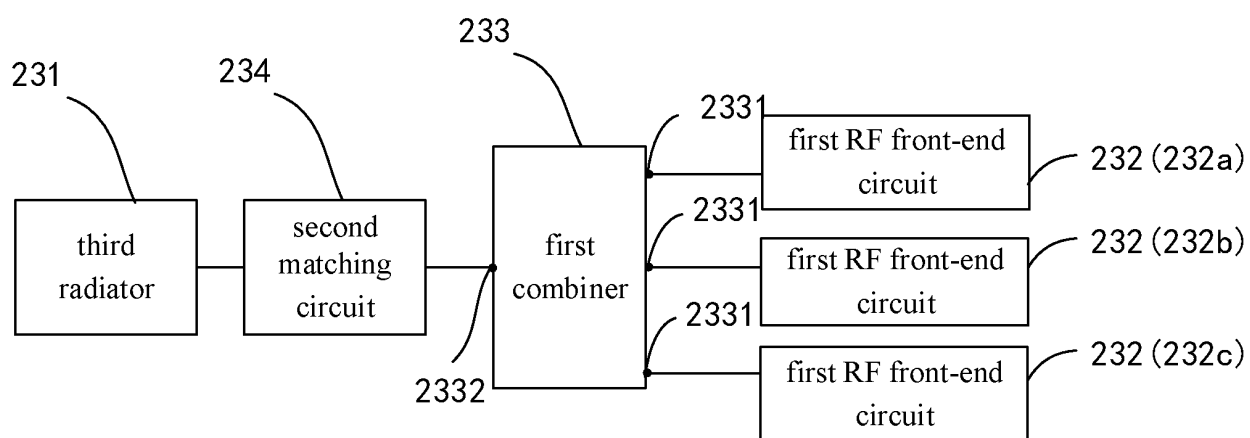


FIG. 8

250

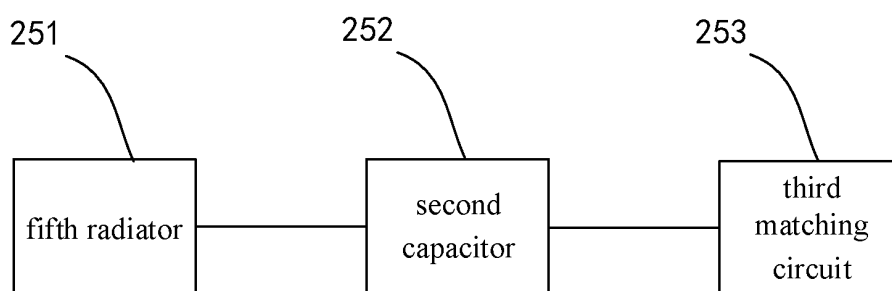


FIG. 9

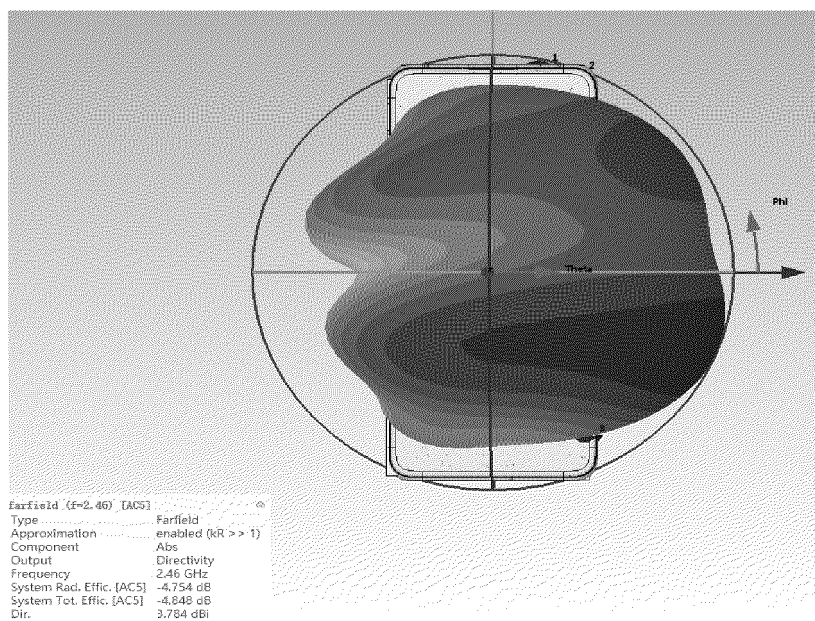


FIG. 10

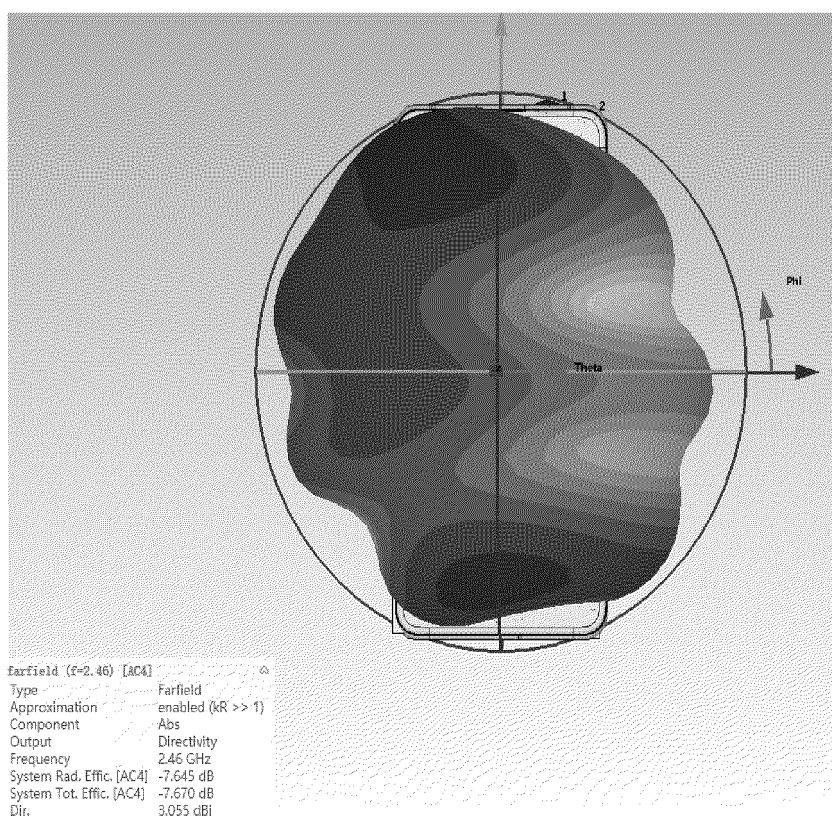


FIG. 11

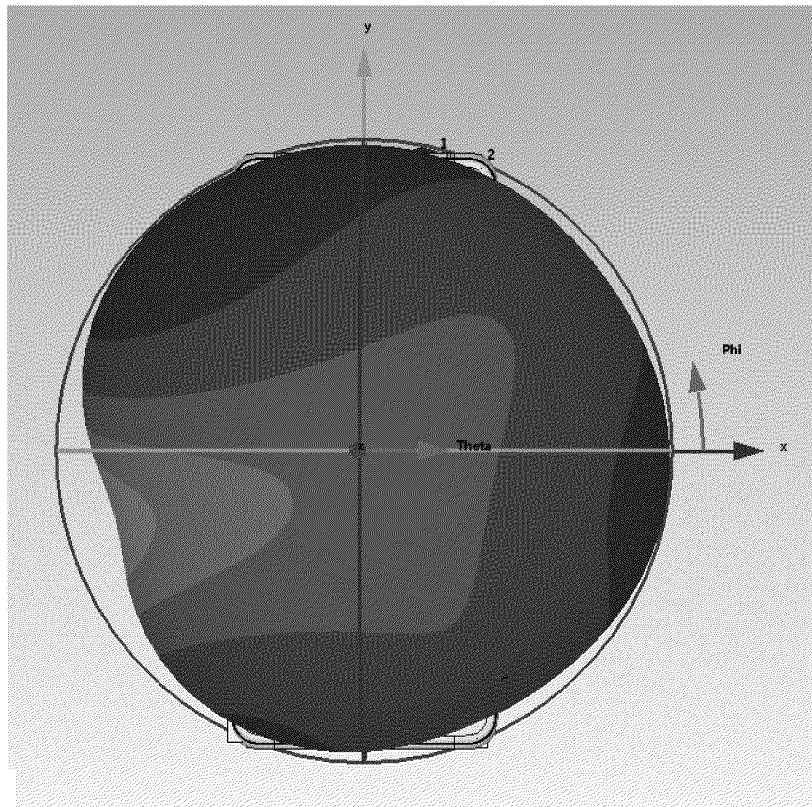


FIG. 12

300

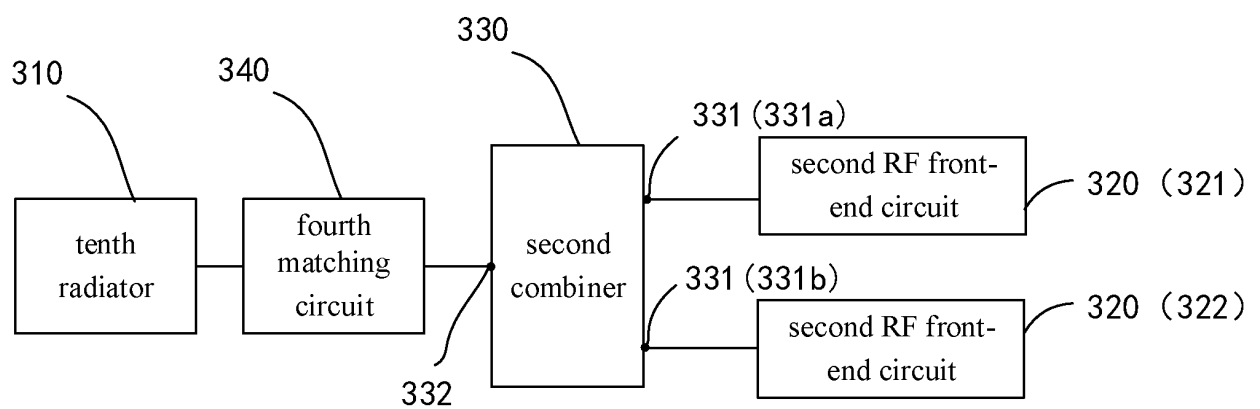


FIG. 13

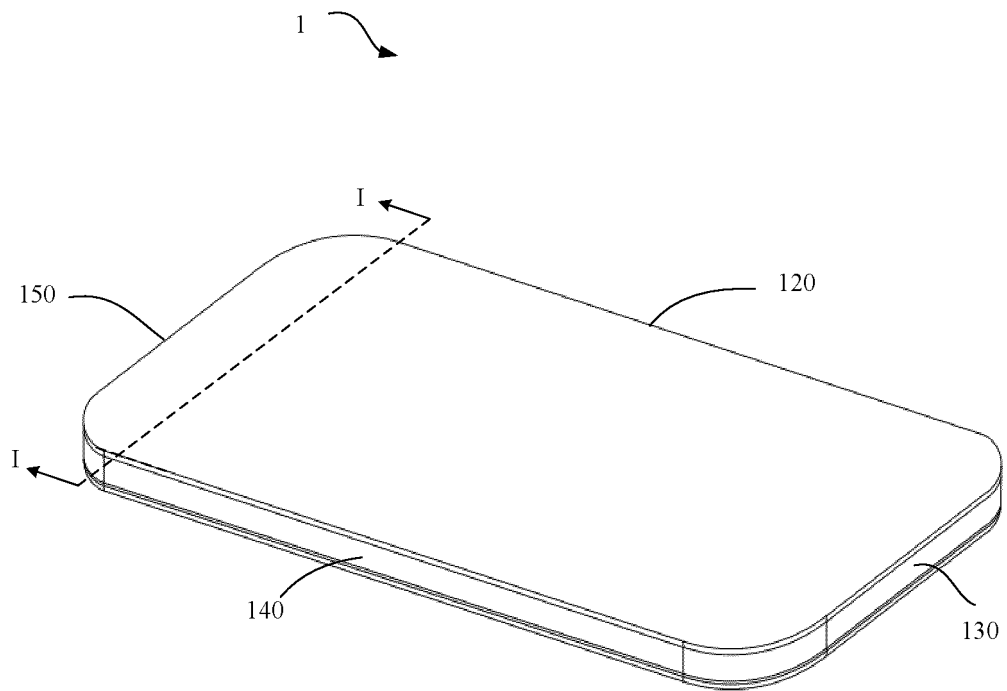


FIG. 14

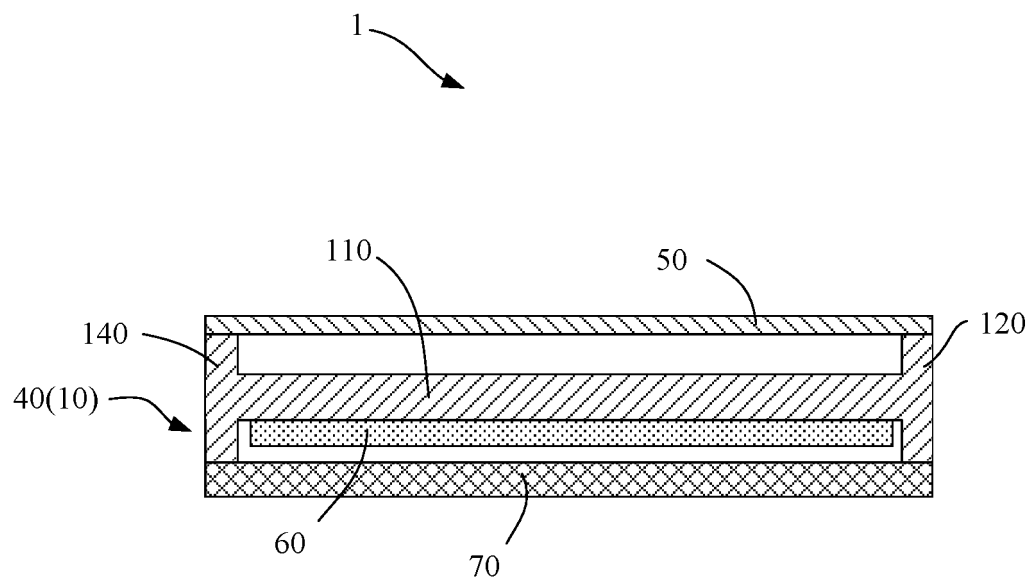


FIG. 15

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2022/134744

A. CLASSIFICATION OF SUBJECT MATTER

H01Q1/52 (2006.01)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)

IPC: H01Q

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

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

CNTXT, VEN, CNKI, DWPI, EPTXT, USTXT, WOTXT, IEEE: 天线, 边框, 发射, 分集, 发射, 接收, 频段, 射频, 同样; antenna, deversity, diversity, DRX, first, frame, main, radiator, second, receiv+, transmit+, frequency, band, same

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 114336009 A (REALME INC.) 12 April 2022 (2022-04-12) entire document	1-20
Y	CN 112086753 A (GUANGDONG OPPO MOBILE COMMUNICATIONS CO., LTD.) 15 December 2020 (2020-12-15) description, paragraphs 26-43	1-5
Y	CN 108963456 A (GUANGDONG OPPO MOBILE COMMUNICATIONS CO., LTD.) 07 December 2018 (2018-12-07) description, paragraphs 26-43	1-5
A	CN 110299604 A (REALME CHONGQING MOBILE TELECOMMUNICATIONS CORP., LTD.) 01 October 2019 (2019-10-01) entire document	1-20
A	CN 111193101 A (GUANGDONG OPPO MOBILE COMMUNICATIONS CO., LTD.) 22 May 2020 (2020-05-22) entire document	1-20
A	US 2019312336 A1 (SAMSUNG ELECTRONICS CO., LTD.) 10 October 2019 (2019-10-10) entire document	1-20

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

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“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

“&” document member of the same patent family

Date of the actual completion of the international search

28 August 2023

Date of mailing of the international search report

28 August 2023

Name and mailing address of the ISA/CN

China National Intellectual Property Administration (ISA/ CN)
China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088

Facsimile No. (86-10)62019451

Authorized officer

Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2022/134744

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
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A	US 2021359392 A1 (LG ELECTRONICS INC.) 18 November 2021 (2021-11-18) entire document	1-20
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

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		EP 3514982 A3	25 September 2019
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