(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 073 575 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
28.09.2016 Bulletin 2016/39

(21) Application number: **13899614.5**

(22) Date of filing: **19.12.2013**

(51) Int Cl.:
H01Q 13/10 *(2006.01)*

(86) International application number:
PCT/CN2013/089972

(87) International publication number:
WO 2015/089792 (25.06.2015 Gazette 2015/25)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

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(54) MICRO-STRIP PATCH ANTENNA AND MULTIPLE-INPUT MULTIPLE-OUTPUT ANTENNA

(57) Embodiments of the present invention provide a microstrip patch antenna and a MIMO antenna, which are applied to the communications field and can reduce a power of a self-interference signal of the antenna. The microstrip patch antenna includes a microstrip patch, a grounding patch, and a dielectric layer located between the microstrip patch and the grounding patch; a first opening groove that runs through the grounding patch is disposed on the grounding patch, a shape of the first opening groove is a combination of a rectangle and an isosceles triangle, one side of the rectangle overlaps a base of the isosceles triangle; the microstrip patch is rectangular, and a symmetry axis that is of the microstrip patch and parallel to a length direction overlaps a symmetry axis of the isosceles triangle; and an overlapping area exists between a projection of the microstrip patch on the dielectric layer and a projection of an isosceles triangle part of the first opening groove on the dielectric layer. The microstrip patch antenna and the MIMO antenna provided in the embodiments of the present invention are applicable to a small cell.

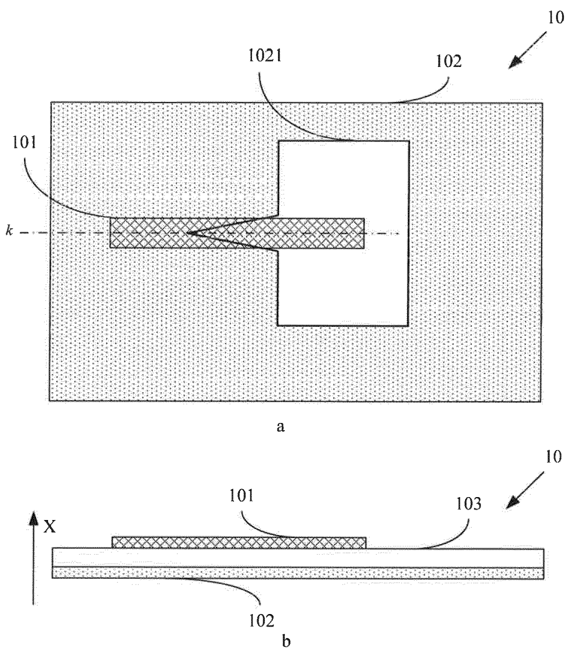

FIG. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to the communications field, and in particular, to a microstrip patch antenna and a MIMO (Multiple-Input Multiple-Output, multiple-input multiple-output) antenna.

BACKGROUND

[0002] In a wireless communications system such as a mobile cellular communications system, a WLAN (Wireless\ Local Area Network, wireless local area network), and FWA (Fixed Wireless Access, fixed wireless access), an antenna capable of transmitting a signal and receiving a signal is generally configured on a communications node such as a BS (Base Station, base station) or an AP (Access Point, access point), or an RS (Relay Station, relay station), or UE (User Equipment, user equipment). Attenuation of a wireless signal in a wireless channel is very great. Therefore, compared with a transmit signal of the antenna, a signal from another communications node is already very weak when arriving at the antenna. To ensure spectrum efficiency, a wireless full duplex technology is generally used in the communications system, namely, both sending of a signal and receiving of a signal are performed over the antenna. An antenna, a receive end, and a transmit end are generally configured on a small cell that uses the wireless full duplex technology. The antenna is generally a telescopic antenna or a rubber antenna. Assuming that the antenna of the small cell is a rubber antenna with a 2.4 GHz center frequency and an 80 MHz bandwidth, when the transmit end transmits signals over the antenna, some transmit signals enter the receive end due to reflection of the antenna, which generates self-interference signals. If a power of a transmit signal is approximately 0 dBm, a power of a self-interference signal generated due to reflection is approximately -15 dBm. Therefore, the power of the self-interference signal of a signal received by the small cell that uses the rubber antenna is relatively high.

SUMMARY

[0003] Embodiments of the present invention provide a microstrip patch antenna and a MIMO antenna, which can reduce a power of a self-interference signal of the antenna.

[0004] To achieve the foregoing objective, the following technical solutions are adopted in the embodiments of the present invention:

[0005] According to a first aspect, a microstrip patch antenna is provided, including a microstrip patch, a grounding patch, and a dielectric layer located between the microstrip patch and the grounding patch;

a first opening groove that runs through the grounding patch is disposed on the grounding patch, and is configured to perform coupling resonance on the microstrip patch, a shape of the first opening groove is a combination of a rectangle and an isosceles triangle, one side of the rectangle overlaps a base of the isosceles triangle, and a length of the overlapping side of the rectangle is greater than a length of the base of the isosceles triangle; the microstrip patch is rectangular, and a symmetry axis that is of the microstrip patch and parallel to a length direction overlaps a symmetry axis of the isosceles triangle; and

an overlapping area exists between a projection of the microstrip patch on the dielectric layer and a projection of an isosceles triangle part of the first opening groove on the dielectric layer.

[0006] With reference to the first aspect, in a first implementable manner, the base of the isosceles triangle is equal to a leg.

[0007] With reference to the first aspect or the first implementable manner, in a second implementable manner, the overlapping side of the rectangle is a long side of the rectangle.

[0008] With reference to the second implementable manner, in a third implementable manner, the microstrip patch antenna further includes:

> a microstrip feeder disposed on a same layer as the microstrip patch, where the microstrip feeder is electrically connected to a side that is near a vertex of the isosceles triangle and among sides parallel to a width direction on the microstrip patch, and a symmetry axis of the microstrip feeder overlaps the symmetry axis that is of the microstrip patch and parallel to the length direction.

[0009] With reference to the third implementable manner, in a fourth implementable manner, a length of a rectangle part of the first opening groove is $33\times(1\pm0.2)mm$, a width of the rectangle part of the first opening groove is $24\times(1\pm0.2)mm$, a length of the base of the isosceles triangle part of the first opening groove is $8\times(1\pm0.2)mm$, a height of the isosceles triangle part of the first opening groove is $16\times(1\pm0.2)mm$, a width of the microstrip patch is $6\times(1\pm0.2)mm$, a length of the microstrip patch is $38.8\times(1\pm0.2)mm$, a length of the microstrip feeder is $10\times(1\pm0.2)mm$, a width of the microstrip feeder is $3.38\times(1\pm0.2)mm$, a length of the grounding patch is $75\times(1\pm0.2)mm$, a width of the grounding patch is $60\times(1\pm0.2)mm$, a length of the dielectric layer is equal to the length of the grounding patch, a width of the dielectric layer is equal to the width of the grounding patch, and a thickness of the dielectric layer is 1.6*mm.*

[0010] With reference to the fourth implementable manner, in a fifth implementable manner, the length of the rectangle part of the first opening groove is 33*mm*, the width of the rectangle part of the first opening groove is 24*mm*, the length of the base of the isosceles triangle part of the first opening groove is 8*mm*, the height of the isosceles triangle part of the first opening groove is

16*mm*, the width of the microstrip patch is 6*mm,* the length of the microstrip patch is 38.8*mm*, the length of the microstrip feeder is 10*mm*, the width of the microstrip feeder is 3.38*mm*, the length of the grounding patch is 75*mm*, the width of the grounding patch is 60*mm*, the length of the dielectric layer is equal to the length of the grounding patch, the width of the dielectric layer is equal to the width of the grounding patch, and the thickness of the dielectric layer is 1.6*mm.*

[0011] With reference to the first aspect or any one implementable manner in the first to fifth implementable manners, in a sixth implementable manner, the dielectric layer is epoxy resin FR4 with a dielectric constant 4.4 and a loss angle tangent 0.02.

[0012] According to a second aspect, a MIMO antenna is provided, including a microstrip patch layer, a grounding patch layer, and a dielectric layer located between the microstrip patch layer and the grounding patch layer, where

the grounding patch layer includes N grounding patches, a first opening groove that runs through a grounding patch is disposed on each grounding patch, and is configured to perform coupling resonance on the microstrip patch, a shape of the first opening groove is a combination of a rectangle and an isosceles triangle, one side of the rectangle overlaps a base of the isosceles triangle, and a length of the overlapping side of the rectangle is greater than a length of the base of the isosceles triangle, where N is greater than or equal to 2;

each microstrip patch layer includes N microstrip patches, each microstrip patch corresponds to one grouping patch, the microstrip patch is rectangular, and a symmetry axis that is of the microstrip patch and parallel to a length direction overlaps a symmetry axis of the isosceles triangle;

an overlapping area exists between a projection of each microstrip patch on the dielectric layer and a projection of an isosceles triangle part of the first opening groove of each grounding patch on the dielectric layer; and

the MIMO antenna further includes a spacing unit on a same layer as the grounding patch of the antenna, where the spacing unit is located between every two adjacent grounding patches in the at least two grounding patches, and is used to increase isolation between antennas.

[0013] With reference to the second aspect, in a first implementable manner, the spacing unit includes a first spacer and a second spacer;

the first spacer comprises a first branch and a second branch that are perpendicular to each other and do not intersect, and a perpendicular foot of the second branch is located at a midpoint of the first branch;

the second spacer comprises a third branch, a fourth branch, and a fifth branch, the fourth branch and the fifth branch are parallel to a perpendicular bisector of the third branch separately and do not intersect the third branch, and the fourth branch is axially symmetric to the fifth branch against the perpendicular bisector of the third branch; and

the first branch, the second branch, the third branch, the fourth branch, and the fifth branch are all rectangular structures.

[0014] With reference to the first implementable manner, in a second implementable manner, the MIMO antenna further includes:

> a microstrip feeder set, where the microstrip feeder set includes N microstrip feeders that are disposed on a same layer as each microstrip patch, each microstrip feeder is electrically connected to a side that is near a vertex of the isosceles triangle and among sides parallel to a width direction on the microstrip patch,
>
> and a symmetry axis of each microstrip feeder overlaps the symmetry axis that is of the microstrip patch and parallel to the length direction.

[0015] With reference to the second implementable manner, in a third implementable manner, a length of each grounding patch is 75×(1±0.2)*mm*, a width of each grounding patch is 50×(1±0.2)*mm*, a length of a rectangle part of the first opening groove of each grounding patch is 33×(1±0.2)*mm*, a width of the rectangle part of the first opening groove is 24×(1±0.2)*mm*, a length of the base of the isosceles triangle part of the first opening groove is 8×(1±0.2)*mm*, a height of the isosceles triangle part of the first opening groove is 16×(1±0.2)*mm*, a width of each microstrip patch is 10×(1±0.2)*mm*, a length of each microstrip patch is 39x(1±0.2)*mm*, length of each microstrip feeder is 10x(1±0.2)*mm*, width of each microstrip feeder is 3.38×(1±0.2)*mm*, a space between two adjacent grounding patches is 40×(1±0.2)*mm*, a length of the first branch of the first spacer is 30×(1±0.2)*mm*, length of the second branch is 30×(1±0.2)*mm*, a length of the third branch of the second spacer is 30x(1±0.2)*mm*, a length of the fourth branch is 25×(1±0.2)*mm*, a length of the fifth branch is 25×(1±0.2)*mm*, widths of the first branch, the second branch, the third branch, the fourth branch, and the fifth branch are all 5×(1±0.2)*mm*, and a width of the dielectric layer is equal to the length of the grounding patch.

[0016] With reference to the third implementable manner, in a fourth implementable manner, the length of each grounding patch is 75*mm*, the width of each grounding patch is 50*mm*, the length of the rectangle part of the first opening groove of each grounding patch is 33*mm*, the width of the rectangle part of the first opening groove is 24*mm*, the length of the base of the isosceles triangle part of the first opening groove is 8*mm*, the height of the isosceles triangle part of the first opening groove is 16*mm*, the width of each microstrip patch is 10*mm*, the length of each microstrip patch is 39*mm*, the length of each microstrip feeder is 10*mm*, the width of each microstrip feeder is 3.38*mm*, the space between two adjacent grounding patches is 40*mm*, the length of the first branch of the first spacer is 30*mm*, the length of the second branch is 30*mm*, the length of the third branch of the second spacer is 30*mm*, the length of the fourth branch is 25*mm*, the length of the fifth branch is 25*mm*, the widths of the first branch, the second branch, the third branch, the fourth branch, and the fifth branch are all 5*mm*, and the width of the dielectric layer is equal to the length of the grounding patch.

[0017] The embodiments of the present invention provide the antenna and the MIMO, where the antenna includes a microstrip patch, a grounding patch that has a first opening groove, and a dielectric layer located between the microstrip patch and the grounding patch. Coupling resonance is generated between the microstrip patch and the grounding patch, and is used to receive and transmit a signal. Therefore, when a small cell that uses a microstrip patch antenna performs signal receiving and transmitting, a self-interference signal that enters a receive end because a transmit signal is reflected by the antenna is reduced, which can effectively reduce a power of the self-interference signal of the antenna.

BRIEF DESCRIPTION OF DRAWINGS

[0018] To describe the technical solutions in the embodiments of the present invention or in the prior art more clearly, the following briefly describes the accompanying drawings required for describing the embodiments or the prior art. Apparently, the accompanying drawings in the following description show merely some embodiments of the present invention, and a person of ordinary skill in the art may still derive other drawings from these accompanying drawings without creative efforts.

FIG. 1 is a schematic structural diagram of a microstrip patch antenna according to an embodiment of the present invention;

FIG. 2 is a schematic structural diagram of an opening groove of a grounding patch of a microstrip patch antenna according to an embodiment of the present invention;

FIG. 3 is a schematic diagram of a projection of an opening groove of a grounding patch of a microstrip patch antenna and a projection of a microstrip patch of the antenna according to an embodiment of the present invention;

FIG. 4 is a schematic structural diagram of another opening groove of a grounding patch of a microstrip patch antenna according to an embodiment of the present invention;

FIG. 5 is a schematic structural diagram of another microstrip patch antenna according to an embodiment of the present invention;

FIG. 6 is a schematic diagram of dimensions of a microstrip patch antenna according to an embodiment of the present invention;

FIG. 7 is a diagram of a self-interference power-frequency curve of a microstrip patch antenna according to an embodiment of the present invention;

FIG. 8 is a schematic structural diagram of a MIMO antenna according to an embodiment of the present invention;

FIG. 9 is a schematic structural diagram of another MIMO antenna according to an embodiment of the present invention;

FIG. 10 is a schematic structural diagram of still another MIMO antenna according to an embodiment of the present invention;

FIG. 11 is a schematic diagram of dimensions of a MIMO antenna according to an embodiment of the present invention; and

FIG. 12 is a diagram of a self-interference power-frequency curve of a MIMO antenna according to an embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0019] The following clearly and completely describes the technical solutions in the embodiments of the present invention with reference to the accompanying drawings in the embodiments of the present invention. Apparently, the described embodiments are merely some but not all of the embodiments of the present invention. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present invention without creative efforts shall fall within the protection scope of the present invention.

[0020] An embodiment of the present invention provides a microstrip patch antenna 10. As shown in FIG. 1-b, FIG. 1-b is a side view of the microstrip patch antenna 10, including a microstrip patch 101, a grounding patch 102, and a dielectric layer 103 located between the microstrip patch and the grounding patch. From FIG. 1-b, it can be learned that the grounding patch 102, the dielectric layer 103, and the microstrip patch 101 are disposed successively in bottom-up order when the microstrip patch antenna 10 works properly. In FIG. 1-b, a direction X denotes a bottom-up direction.

[0021] A top view of the microstrip patch antenna 10 may be shown in FIG. 1-a. A first opening groove 1021 that runs through the grounding patch 102 is disposed on the grounding patch 102, and is configured to perform coupling resonance on the microstrip patch 101. As shown in FIG. 2, a shape of the first opening groove 1021 is a combination of a rectangle 10211 and an isosceles triangle 10212, and one side of the rectangle 10211 overlaps a base of the isosceles triangle 10212. That is, a side AB of the rectangle 10211 in FIG. 2 overlaps a side CD of the isosceles triangle 10212. The overlapping side of the rectangle 10211 is the side AB in FIG. 2, and has a length l_1. The base of the isosceles triangle 10212 is the side CD in FIG. 2, and has a length l_2. A length of the overlapping side of the rectangle 10211 is greater than a length of the base of the isosceles triangle 10212, namely, $l1 > l_2$. In practical application, the overlapping side of the rectangle 10211 is generally a long side of the rectangle 10211.

[0022] The microstrip patch 101 is rectangular, and a symmetry axis that is of the microstrip patch 101 and parallel to a length direction overlaps a symmetry axis of the isosceles triangle. The overlapping symmetry axis is denoted by a straight line *k* in FIG. 1-a. In this way, when the microstrip patch antenna 10 is disposed in a normal working state, as described in FIG. 1-b, the microstrip patch 101 is located right above the isosceles triangle.

[0023] An overlapping area exists between a projection 1031 of the microstrip patch 101 on the dielectric layer 103 and a projection 1302 of an isosceles triangle part of the first opening groove 1021 on the dielectric layer 103. The projection 1031 of the microstrip patch 101 on the dielectric layer is a projection, of the microstrip patch 101, projected on the dielectric layer 103 in a direction parallel to the direction X. The projection 1032 of the isosceles triangle part of the first opening groove 1021 on the dielectric layer is a projection, of the isosceles triangle part of the first opening groove 1021, projected on the dielectric layer 103 in a direction parallel to the direction X. As shown in FIG. 3-a, the projection 1031 of the microstrip patch 101 on the dielectric layer 103 may fully cover the projection 1032 of the isosceles triangle part of the first opening groove 1021 on the dielectric layer 103. As shown in FIG. 3-b, the projection 1031 of the microstrip patch 101 on the dielectric layer may also cover only a central area of the projection 1032 of the isosceles triangle part of the first opening groove 1021 on the dielectric layer 103. The projection 1031 of the microstrip patch 101 on the dielectric layer 103 and the projection 1032 of the isosceles triangle part of the first opening groove 1021 on the dielectric layer 103 denote a size of the microstrip patch 101 and a size of the isosceles triangle part of the first opening groove 1021 respectively, center frequencies of different antennas including different sizes of microstrip patches 101 and different sizes of isosceles triangle parts of the first opening groove 1021 are different, and powers of generated self-interference signals are also different. Therefore, in practical application, a size of the overlapping area between the projection 1031 of the microstrip patch 101 on the dielectric layer 103 and the projection 1032 of the isosceles triangle part of the first opening groove 1021 on the dielectric layer 103 may be decided according to specific situations, which is not limited by this embodiment of the present invention.

[0024] In this way, coupling resonance is generated between the microstrip patch and the grounding patch, and is used to receive and transmit a signal. Therefore, when a small cell that uses the microstrip patch antenna performs signal receiving and transmitting, a self-interference signal that enters a receive end because a transmit signal is reflected by the antenna is reduced, which effectively reduces the power of the self-interference signal of the antenna in comparison with the prior art.

[0025] Further, as shown in FIG. 4, the isosceles triangle 10212 part of the first opening groove 1021 may be replaced with an equilateral triangle 10213. That is, the base of the isosceles triangle 10212 is equal to a leg. Therefore, any side of the equilateral triangle 10213 may be used as the base of the equilateral triangle 10213, and selection may be made depending on different application scenarios of the small cell with the microstrip patch antenna 10 and different parameter requirements on the microstrip patch antenna 10, which is not limited by this embodiment of the present invention.

[0026] Further, the microstrip patch antenna 10 further includes a microstrip feeder 104 disposed on a same layer as the microstrip patch 101. As shown in FIG. 5-a, the microstrip feeder 104 is electrically connected to a side that is near a vertex of the isosceles triangle and among sides parallel to a width direction on the microstrip patch 101. The side that is near the vertex of the isosceles triangle and among the sides parallel to the width direction on the microstrip patch 101 is denoted by CD in FIG. 5-a. A symmetry axis of the microstrip feeder 104 overlaps the symmetry axis that is of the microstrip patch 101 and parallel to the length direction. FIG. 5-b is a cross section chart, where a cross section is a plane in which the overlapping symmetry axis EF of the microstrip feeder 104 and the microstrip patch 101 in FIG. 5-a is located. The grounding patch 102, the dielectric layer 103, the microstrip patch 101, and the microstrip feeder 104 disposed on the same layer as the microstrip patch 101 are disposed successively in bottom-up order in FIG. 5-b. In FIG. 5-b, the direction X denotes a bottom-up direction. Feeding the microstrip patch 101 by using the microstrip feeder 104 is called microstrip feeding. Specifically, the microstrip patch 101 may be fed by using a 50-ohm microstrip feeder 104. In practical application, the microstrip patch 101 may be fed in a coaxial feeding manner. For example, the microstrip patch 101 may be fed by using a 50-ohm coaxial cable. A specific feeding manner may be selected according to specific situations, and is not limited by this embodiment of the present invention.

[0027] The microstrip patch antenna 10 provided in this embodiment of the present invention is generally used for a small cell. When a center frequency of the microstrip patch antenna 10 is 2.4 GHz and the microstrip patch antenna is used for WiFi (Wireless Fidelity, wireless fidelity), a dimensions range of the microstrip patch antenna 10 is: A length of a rectangle part of the first opening groove 1021 is $33\times(1\pm0.2)mm$, namely, the length of the rectangle part of the first opening groove 1021 is greater than or equal to $26.4mm$ and less than or equal to $39.6mm$, a width of the rectangle part of the first opening groove 1021 is $24\times(1\pm0.2)mm$, namely, the width of the rectangle part of the first opening groove 1021 is greater than or equal to $19.2mm$ and less than or equal to 28.8mm ; the length of the base of the isosceles triangle part of the first opening groove 1021 is $8\times(1\pm0.2)mm$ namely, the length of the base of the isosceles triangle part of the first opening groove 1021 is greater than or equal to $6.4mm$ and less than or equal to $9.6mm$; a height of the isosceles triangle part of the first opening groove 1021 is $16\times(1\pm0.2)mm$, namely, the height of the isosceles triangle part of the first opening groove 1021 is greater than or equal to 12.8 *mm* and less than or equal to 19.2*mm*; a width of the microstrip patch 101 is 6×(1±0.2)*mm*, namely, the width of the microstrip patch 101 is greater than or equal to 4.8*mm* and less than or equal to 7.2*mm*; a length of the microstrip patch 101 is 38.8×(1±0.2)*mm*, namely, the length of the microstrip patch 101 is greater than or equal to 31.04mm and less than or equal to 46-56*mm*; a length of the microstrip feeder 104 is 10×(1±0.2)*mm*, namely, the length of the microstrip feeder 104 is greater than or equal to 8*mm* and less than or equal to 12*mm*; a width of the microstrip feeder 104 is 3.38×(1±0.2)*mm*, namely, the width of the microstrip feeder 104 is greater than or equal to 2.7*mm* and less than or equal to 4.0*mm* ; a length of the grounding patch 102 is 75×(1±0.2)*mm*, namely, the length of the grounding patch 102 is greater than or equal to 60*mm* and less than or equal to 90*mm*; a width of the grounding patch 102 is 60×(1±0.2)*mm*, namely, the width of the grounding patch 102 is greater than or equal to 48*mm* and less than or equal to 72*mm*; and a length of the dielectric layer is equal to the length of the grounding patch, a width of the dielectric layer is equal to the width of the grounding patch, and a thickness of the dielectric layer is 1.6*mm*. By using the microstrip patch antenna 10 of the foregoing dimensions, reflection of a transmit signal can be reduced effectively, and therefore, self interference can further be reduced.

[0028] For example, by means of simulation on an ADS (Advanced Design System, advanced design system) platform, if the center frequency of the microstrip patch antenna 10 is 2.4 GHz and when the microstrip patch antenna 10 is used for WiFi (Wireless Fidelity, wireless fidelity), preferred dimensions of the microstrip patch antenna 10 are: As shown in FIG. 6-a, the length of the rectangle part of the first opening groove 1021 is 33*mm*, the width of the rectangle part of the first opening groove 1021 is 24*mm*, the length of the base of the isosceles triangle part of the first opening groove 1021 is 8*mm*, the height of the isosceles triangle part of the first opening groove 1021 is 16*mm*, the width of the microstrip patch 101 is 6*mm*, the length of the microstrip patch 101 is 38.8*mm*, the length of the microstrip feeder 104 is 10*mm*, the width of the microstrip feeder 104 is 3.38*mm*, the length of the grounding patch 102 is 75*mm*, the width of the grounding patch 102 is 60*mm*, the length of the medium layer is equal to the length of the grounding patch, and the width of the medium layer is equal to the width of the grounding patch; as shown in FIG. 6-b, the thickness of the medium layer is 1.6*mm*. When the dimensions of parts of the microstrip patch antenna 10 are the foregoing preferred dimensions and a 50-ohm microstrip feeder is used to feed the microstrip patch, a diagram of a frequency-self interference signal loss of the microstrip patch antenna 10 is shown in FIG. 7. In FIG. 7, a curve G denotes a power value of a self-interference signal of the microstrip patch antenna 10 under different operating frequencies. From the curve G, it can be seen that when the operating frequency is 2.4 GHz and the bandwidth is 80 MHz, the power of the self-interference signal of the microstrip patch antenna 10 is less than or equal to -27.5 dB, and the power of the self-interference signal on an antenna used by an existing small cell is less than or equal to -15 dB on a basis that a bandwidth of 80 MHz is met. When the power approaches -15 dB, it is possible that requirements of the small cell are already not met. Therefore, compared with the existing antenna, the microstrip patch antenna 10 in this embodiment of the present invention effectively reduces the power of the self-interference signal. If an application scenario of the small cell allows a return loss of a relatively great power, an operable bandwidth of the microstrip patch antenna 10 is 2.00 MHz, when the power of the self-interference signal is less than or equal to -15 dB. In comparison with the existing antenna, the operating bandwidth of the antenna is increased in a case in which the return loss is the same.

[0029] Specifically, in practical application, the dielectric layer 103 is generally epoxy resin FR4 with a dielectric constant 4.4 and a loss angle tangent 0.02, where FR4 is a model of epoxy resin; or may be a Rogers substrate, which may be selected according to specific situations and is not limited by this embodiment of the present invention.

[0030] The microstrip patch antenna provided in this embodiment of the present invention includes a rectangular microstrip patch, a grounding patch that has a first opening groove, and a dielectric layer located between the microstrip patch and the grounding patch. Coupling resonance is generated between the microstrip patch and the grounding patch, and is used to receive and transmit a signal. Therefore, when a small cell that uses the microstrip patch antenna performs signal receiving and transmitting, a self-interference signal that enters a receive end because a transmitted signal is reflected by the antenna is reduced, which effectively reduces a power of the self-interference signal of the antenna.

[0031] An embodiment of the present invention provides a MIMO antenna 80, which, as shown in FIG. 8-a, includes a microstrip patch layer 801, a grounding patch layer 802, and a dielectric layer 803 located between the microstrip patch layer 801 and the grounding patch layer 802. FIG. 6-b is a side view of the MIMO antenna 80. From FIG. 8-b, it can be learned that the grounding patch 802, the dielectric layer 803, and the microstrip patch 801 are disposed successively in bottom-up order when the MIMO antenna 80 work properly. In FIG. 8-b, a direction X denotes a bottom-up direction.

[0032] The grounding patch layer 802 includes N grounding patches 8021, where N is greater than or equal to 2. FIG. 8 uses two grounding patches 8021 for description. A first opening groove that runs through the grounding patch 8021 is disposed on the grounding patch 8021, and is configured to perform coupling resonance on the microstrip patch 8011, a shape of the first opening groove is a combination of a rectangle and an isosceles triangle, one side of the rectangle overlaps a base of the isosceles triangle, and a length of the overlapping side of the rectangle is greater than a length of the base of the isosceles triangle. Generally, the overlapping side of the rectangle is a side in a length direction of the rectangle. For detailed interpretation, refer to the description about FIG. 2 in the embodiments of the present invention, and details are not described herein again.

[0033] The microstrip patch layer 801 includes N microstrip patches 8011. A quantity of the microstrip patches 801 is the same as a quantity of the grounding patches 802. FIG. 8 uses two microstrip patches 801 for description. Each microstrip patch 8011 corresponds to one grounding patch 8021. That is, a one-to-one correspondence exists between the microstrip patch 8011 and the grounding patch 8021. The microstrip patch 8011 is rectangular, and a symmetry axis that is of the microstrip patch 8011 and parallel to a length direction overlaps a symmetry axis of the isosceles triangle. In this way, when the MIMO antenna 80 is disposed in a normal working state, as shown in FIG. 8-b, the microstrip patch 8011 is located right above the isosceles triangle.

[0034] An overlapping area exists between a projection of each microstrip patch 8011 on the dielectric layer and a projection of an isosceles triangle part of the first opening groove of each grounding patch 8021 on the dielectric layer, where the existence of the overlapping area denotes that the projection of the microstrip patch 8011 on the dielectric layer 803 may fully cover the projection of the isosceles triangle part of the first opening groove of the grounding patch 8021 on the dielectric layer 803, or may also cover only a central area of the projection of the isosceles triangle part of the first opening groove of the grounding patch 8021 on the dielectric layer 803. For detailed interpretation, refer to the interpretation and description about FIG. 3 in the embodiments of the present invention, and details are not described herein again. The projection of the microstrip patch 8011 on the dielectric layer 803 and the projection of the isosceles triangle part of the first opening groove of the grounding patch 8021 on the dielectric layer 803 denote a size of the microstrip patch 8011 and a size of the isosceles triangle part of the first opening groove of the grounding patch 8021, respectively, center frequencies of different antennas including different sizes of microstrip patches 8011 and different sizes of isosceles triangle parts of the first opening groove of the grounding patch 8021 are different, and powers of generated self-interference signals are also different. Therefore, in practical application, the overlapping area between the projection of the microstrip patch 8011 on the dielectric layer 803 and the projection of the isosceles triangle part of the first opening groove of the grounding patch 8021 on the medium layer 803 may be decided according to specific situations, which is not limited by this embodiment of the present invention.

[0035] As shown in FIG. 9, the MIMO antenna 80 further includes a spacing unit 804 disposed on a same layer as the grounding patch 8021 of the antenna. The spacing unit is located between every two adjacent grounding patches 8021 in the at least two grounding patches 8021, and is used to increase isolation between antennas.

[0036] Specifically, the spacing unit 804 may further include a first spacer 8041 and a second spacer 8042.

[0037] The first spacer 8041 includes a first branch and a second branch that are perpendicular to each other and do not intersect, and a perpendicular foot of the second branch is located at a midpoint of the first branch. The second spacer 8042 comprises a third branch, a fourth branch, and a fifth branch, the fourth branch and the fifth branch are parallel to a perpendicular bisector of the third branch separately and do not intersect the third branch, and the fourth branch is axially symmetric to the fifth branch against the perpendicular bisector of the third branch. The first branch, the second branch, the third branch, the fourth branch, and the fifth branch are all rectangular structures. Materials of the first spacer and the second spacer may he the same as a material of the grounding patch 8021, or may be different from the material of the grounding patch 8021, which is determined according to specific situations and is not limited by this embodiment of the present invention.

[0038] In this way, coupling resonance is generated between the microstrip patch and the grounding patch in the MIMO antenna, and is used to receive and transmit a signal. Therefore, when a small cell that uses the MIMO antenna performs signal receiving and transmitting, a self-interference signal that enters a receive end because a transmit signal is reflected by the antenna is reduced, which effectively reduces the power of the self-interference signal of the antenna in comparison with the prior art.

[0039] Further, as shown in FIG. 10, the MIMO antenna 80 further includes:

> a microstrip feeder set 805, where the microstrip feeder set 805 includes N microstrip feeders 8051 that are disposed on a same layer as each microstrip patch, each microstrip feeder 8051 is electrically connected to a side that is near a vertex of the isosceles triangle and among sides parallel to a width direction on the microstrip patch 8011, and a symmetry axis of each microstrip feeder 8051 overlaps the symmetry axis that is of the microstrip patch 8011 and parallel to the length direction. Specifically, a 50-ohm microstrip feeder 8051 may be used to feed the microstrip patch 8011. In practical application, the microstrip patch 8011 may be fed in a coaxial feeding manner. For example, the microstrip patch 101 may be fed by using a 50-ohm coaxial cable. A specific feeding manner may be selected according to specific situations, and is not limited by this embodiment of the present invention.

[0040] Specifically, the antenna 80 provided in this embodiment of the present invention is generally used for a small cell. When a center frequency of the MIMO antenna

80 is 2.4 GHz, a dimensions range of the MIMO antenna 80 is: A length of each grounding patch is 75×(1±0.2)*mm*, a width of each grounding patch is 50×(1±0.2)*mm*, a length of a rectangle part of the first opening groove of each grounding patch 8021 is 33×(1±0.2)*mm*, a width of the rectangle part of the first opening groove is 24×(1±0.2)*mm*, a length of a base of an isosceles triangle part of the first opening groove is 8×(1±0.2)mm, a height of the isosceles triangle part of the first opening groove is 16×(1±0.2)*mm*, a width of each microstrip patch 8011 is 10×(1±0.2)*mm*, a length of each microstrip patch 8011 is 39×(1±0.2)*mm*, a length of each microstrip feeder is 10×(1±0.2)*mm*, a width of each microstrip feeder is 3.38×(1±0.2)*mm*, a space between two adjacent grounding patches 8021 is 40×(1±0.2)*mm*, a length of the first branch of the first spacer 8041 is 30×(1±0.2)*mm*, a length of the second branch is 30×(1±0.2)*mm*, a length of the third branch of the second spacer 8042 is 30×(1±0.2)*mm*, a length of the fourth branch is 25×(1±0.2)*mm*, a length of the fifth branch is 25×(1±0.2)*mm*, widths of the first branch, the second branch, the third branch, the fourth branch, and the fifth branch are all 5×(1±0.2)*mm*, and a width of the dielectric layer is equal to the length of the grounding patch.

[0041] For example, as shown in FIG. 11, by means of simulation on an ADS platform, if the center frequency of the MIMO antenna 80 is 2.4 GHz, preferred dimensions of the MIMO antenna 80 are: The length of each grounding patch is 75*mm*, the width of each grounding patch is 50*mm*, the length of the rectangle part of the first opening groove of each grounding patch 8021 is 33*mm*, the width of the rectangle part of the first opening groove is 24*mm*, the length of the base of the isosceles triangle part of the first opening groove is 8*mm*, the height of the isosceles triangle part of the first opening groove is 16*mm*, the width of each microstrip patch 8011 is 10*mm*, the length of each microstrip patch 8011 is 39*mm*, the length of each microstrip feeder is 10*mm*, the width of each microstrip feeder is 3.38*mm*, the space between two adjacent grounding patches 8021 is 40*mm*, the length of the first branch of the first spacer 8041 is 30*mm*, the length of the second branch is 30*mm*, the length of the third branch of the second spacer 8042 is 30*mm*, the length of the fourth branch is 25*mm*, the length of the fifth branch is 25*mm*, the widths of the first branch, the second branch, the third branch, the fourth branch, and the fifth branch are all *5mm*, and the width of the dielectric layer is equal to the length of the grounding patch. When the dimensions of parts of the MIMO antenna 80 are the foregoing preferred dimensions and a 50-ohm microstrip feeder 8051 is used to feed the microstrip patch 8011, a diagram of a frequency-self interference signal loss of the MIMO antenna 80 is shown in FIG. 12. In FIG. 12, a curve H denotes a power value of the self-interference signal of the MIMO antenna 80 under different operating frequencies. From the curve H, it can be seen that when the operating frequency is 2.4 GHz and the bandwidth is 80 MHz, the power of the self-interference signal of the MIMO antenna 80 is less than or equal to -21.5 dB, and the power of the self-interference signal on the MIMO antenna used by an existing small cell is less than or equal to -15 dB on a basis that a bandwidth of 80 MHz is met. When the power approaches -15 dB, it is possible that requirements of the small cell are already not met. Therefore, compared with the existing MIMO antenna, the MIMO antenna 80 in this embodiment of the present invention effectively reduces the power of the self-interference signal. If an application scenario of the small cell allows a return loss of a relatively great power, an operable bandwidth of the MIMO antenna 80 is 200 MHz when the power of the self-interference signal is less than or equal to -15 dB. In comparison with the existing MIMO antenna, the operating bandwidth of the MIMO antenna is increased in a case in which the return loss is the same.

[0042] The MIMO antenna provided in this embodiment of the present invention includes a microstrip patch layer, a grounding patch layer, and a dielectric layer located between the microstrip patch layer and the grounding patch layer. The microstrip patch layer includes at least two microstrip patches, and the grounding patch layer includes at least two grounding patches. Coupling resonance is generated between the microstrip patch and the grounding patch, and is used to receive and transmit a signal. Therefore, when a small cell that uses the MIMO antenna performs signal receiving and transmitting, a self-interference signal that enters a receive end because a transmit signal is reflected by the antenna is reduced, which effectively reduces a power of the self-interference signal of the antenna.

[0043] The foregoing descriptions are merely specific implementation manners of the present invention, but are not intended to limit the protection scope of the present invention. Any variation or replacement readily figured out by a person skilled in the art within the technical scope disclosed in the present invention shall fall within the protection scope of the present invention. Therefore, the protection scope of the present invention shall be subject to the protection scope of the claims.

Claims

1. A microstrip patch antenna (10), comprising a microstrip patch (101), a grounding patch (102), and a dielectric layer (103) located between the microstrip patch and the grounding patch, wherein
a first opening groove (1021) that runs through the grounding patch (102) is disposed on the grounding patch (102), and is configured to perform coupling resonance on the microstrip patch (101), a shape of the first opening groove (1021) is a combination of a rectangle (10211) and an isosceles triangle (10212), one side of the rectangle (10211) overlaps a base of the isosceles triangle (10212), and a length of the overlapping side of the rectangle (10211) is

greater than a length of the base of the isosceles triangle (10212);
the microstrip patch (101) is rectangular, and a symmetry axis that is of the microstrip patch (101) and parallel to a length direction overlaps a symmetry axis of the isosceles triangle (10212); and
an overlapping area exists between a projection (1031) of the microstrip patch (101) on the dielectric layer (103) and a projection (1032) of an isosceles triangle (10212) part of the first opening groove (1021) on the dielectric layer (103).

2. The microstrip patch antenna (10) according to claim 1, wherein the base of the isosceles triangle (10212) is equal to a leg.

3. The microstrip patch antenna (10) according to claim 1 or 2, wherein the overlapping side of the rectangle (10211) is a long side of the rectangle (10211).

4. The microstrip patch antenna (10) according to claim 3, wherein the antenna (10) further comprises:

a microstrip feeder (104) disposed on a same layer as the microstrip patch (101), wherein the microstrip feeder (104) is electrically connected to a side that is near a vertex of the isosceles triangle (10212) and among sides parallel to a width direction on the microstrip patch (101), and a symmetry axis of the microstrip feeder (104) overlaps the symmetry axis that is of the microstrip patch (101) and parallel to the length direction.

5. The microstrip patch antenna (10) according to claim 4, wherein
a length of a rectangle (10211) part of the first opening groove (1021) is $33\times(1\pm0.2)mm$, a width of the rectangle (10211) part of the first opening groove (1021) is $24\times(1\pm0.2)mm$, a length of the base of the isosceles triangle (10212) part of the first opening groove (1021) is $8\times(1\pm0.2)mm$, a height of the isosceles triangle (10212) part of the first opening groove (1021) is $16\times(1\pm0.2)mm$, a width of the microstrip patch (101) is $6\times(1\pm0.2)mm$, a length of the microstrip patch (101) is $38.8\times(1\pm0.2)mm$, a length of the microstrip feeder (104) is $10\times(1\pm0.2)mm$, a width of the microstrip feeder (104) is $3.38\times(1\pm0.2)mm$, a length of the grounding patch (102) is $75\times(1\pm0.2)mm$, a width of the grounding patch (102) is $60\times(1\pm0.2)mm$, a length of the dielectric layer (103) is equal to the length of the grounding patch (102), a width of the dielectric layer (103) is equal to the width of the grounding patch (102), and a thickness of the dielectric layer (103) is 1.6*mm.*

6. The microstrip patch antenna (10) according to claim 5, wherein the length of the rectangle (10211) part of the first opening groove (1021) is 33*mm*, the width of the rectangle (10211) part of the first opening groove (1021) is 24*mm*, the length of the base of the isosceles triangle (10212) part of the first opening groove (1021) is 8*mm*, the height of the isosceles triangle (10212) part of the first opening groove (1021) is 16*mm*, the width of the microstrip patch (101) is 6*mm*, the length of the microstrip patch (101) is 38.8*mm*, the length of the microstrip feeder (104) is 10*mm*, the width of the microstrip feeder (104) is 3.38*mm*, the length of the grounding patch (102) is 75*mm*, the width of the grounding patch (102) is 60*mm*, the length of the dielectric layer (103) is equal to the length of the grounding patch (102), the width of the dielectric layer (103) is equal to the width of the grounding patch (102), and the thickness of the dielectric layer (103) is 1.6*mm*.

7. The microstrip patch antenna (10) according to any one of claims 1 to 6, wherein the dielectric layer (103) is epoxy resin FR4 with a dielectric constant 4.4 and a loss angle tangent 0.02.

8. A multiple-input multiple-output MIMO antenna (80), comprising: a microstrip patch layer (801), a grounding patch layer (802), and a dielectric layer (803) located between the microstrip patch layer (801) and the grounding patch layer (802), wherein
the grounding patch layer (802) comprises N grounding patches (8021), a first opening groove that runs through a grounding patch (8021) is disposed on each grounding patch (8021), and is configured to perform coupling resonance on the microstrip patch (8011), a shape of the first opening groove is a combination of a rectangle and an isosceles triangle, one side of the rectangle overlaps a base of the isosceles triangle, and a length of the overlapping side of the rectangle is greater than a length of the base of the isosceles triangle, wherein N is greater than or equal to 2;
each microstrip patch layer (801) comprises N microstrip patches (8011), each microstrip patch (8011) corresponds to one grouping patch (8021), the microstrip patch (8011) is rectangular, and a symmetry axis that is of the microstrip patch (8011) and parallel to a length direction overlaps a symmetry axis of the isosceles triangle;
an overlapping area exists between a projection of each microstrip patch (8011) on the dielectric layer (803) and a projection of an isosceles triangle part of the first opening groove of each grounding patch (8021) on the dielectric layer (803); and
the MIMO antenna (80) further comprises a spacing unit (804) on a same layer as the grounding patch (8021) of the antenna, wherein the spacing unit (804) is located between every two adjacent grounding patches (8021) in the at least two grounding patches (8021), and is used to increase isolation between

antennas.

9. The MIMO antenna (80) according to claim 8, wherein the spacing unit (804) comprises a first spacer (8041) and a second spacer (8042);
the first spacer (8041) comprises a first branch and a second branch that are perpendicular to each other and do not intersect, and a perpendicular foot of the second branch is located at a midpoint of the first branch;
the second spacer (8042) comprises a third branch, a fourth branch, and a fifth branch, the fourth branch and the fifth branch are parallel to a perpendicular bisector of the third branch separately and do not intersect the third branch, and the fourth branch is axially symmetric to the fifth branch against the perpendicular bisector of the third branch; and
the first branch, the second branch, the third branch, the fourth branch, and the fifth branch are all rectangular structures.

10. The MIMO antenna (80) according to claim 9, wherein the MIMO antenna (80) further comprises:

a microstrip feeder set (805), wherein the microstrip feeder set (805) comprises N microstrip feeders (8051) that are disposed on a same layer as each microstrip patch, each microstrip feeder (8051) is electrically connected to a side that is near a vertex of the isosceles triangle and among sides parallel to a width direction on the microstrip patch (8011), and a symmetry axis of each microstrip feeder (8051) overlaps the symmetry axis that is of the microstrip patch (8011) and parallel to the length direction.

11. The MIMO antenna (80) according to claim 10, wherein
a length of each grounding patch (8021) is 75×(1±0.2)*mm*, a width of each grounding patch (8021) is 50×(1±0.2)*mm*, length of a rectangle part of the first opening groove of each grounding patch (8021) is 33×(1±0.2)*mm*, a width of the rectangle part of the first opening groove is 24×(1±0.2)*mm*, a length of the base of the isosceles triangle part of the first opening groove is 8×(1±0.2)*mm*, a height of the isosceles triangle part of the first opening groove is 16×(1±0.2)*mm*, a width of each microstrip patch (8011) is 10×(1±0.2)*mm*, a length of each microstrip patch (8011) is 39×(1±0.2)*mm*, a length of each microstrip feeder (8051) is 10x(1±0.2)*mm*, a width of each microstrip feeder (8051) is 3.38×(1±0.2)*mm*, a space between two adjacent grounding patches (8021) is 40×(1±0.2)*mm*, a length of the first branch of the first spacer (8041) is 30×(1±0.2)*mm*, a length of the second branch is 30×(1±0.2)*mm*, a length of the third branch of the second spacer (8042) is 30×(1±0.2)*mm*, a length of the fourth branch is 25×(1±0.2)*mm*, a length of the fifth branch is 25×(1±0.2)*mm* widths of the first branch, the second branch, the third branch, the fourth branch, and the fifth branch are all 5×(1±0.2)*mm*, and a width of the dielectric layer (803) is equal to the length of the grounding patch (8021).

12. The MIMO antenna (80) according to claim 11, wherein
the length of each grounding patch (8021) is 75*mm*, the width of each grounding patch (8021) is 50*mm*, the length of the rectangle part of the first opening groove of each grounding patch (8021) is 33*mm*, the width of the rectangle part of the first opening groove is 24*mm*, the length of the base of the isosceles triangle part of the first opening groove is 8*mm*, the height of the isosceles triangle part of the first opening groove is 16*mm*, the width of each microstrip patch (8011) is 10*mm*, the length of each microstrip patch (8011) is 39*mm*, the length of each microstrip feeder (8051) is 10*mm*, the width of each microstrip feeder (8051) is 3.38*mm*, the space between two adjacent grounding patches (8021) is 40*mm*, the length of the first branch of the first spacer (8041) is 30*mm*, the length of the second branch is 30*mm*, the length of the third branch of the second spacer (8042) is 30*mm*, the length of the fourth branch is 25*mm*, the length of the fifth branch is 25*mm*, the widths of the first branch, the second branch, the third branch, the fourth branch, and the fifth branch are all 5*mm*, and the width of the dielectric layer (803) is equal to the length of the grounding patch (8021).

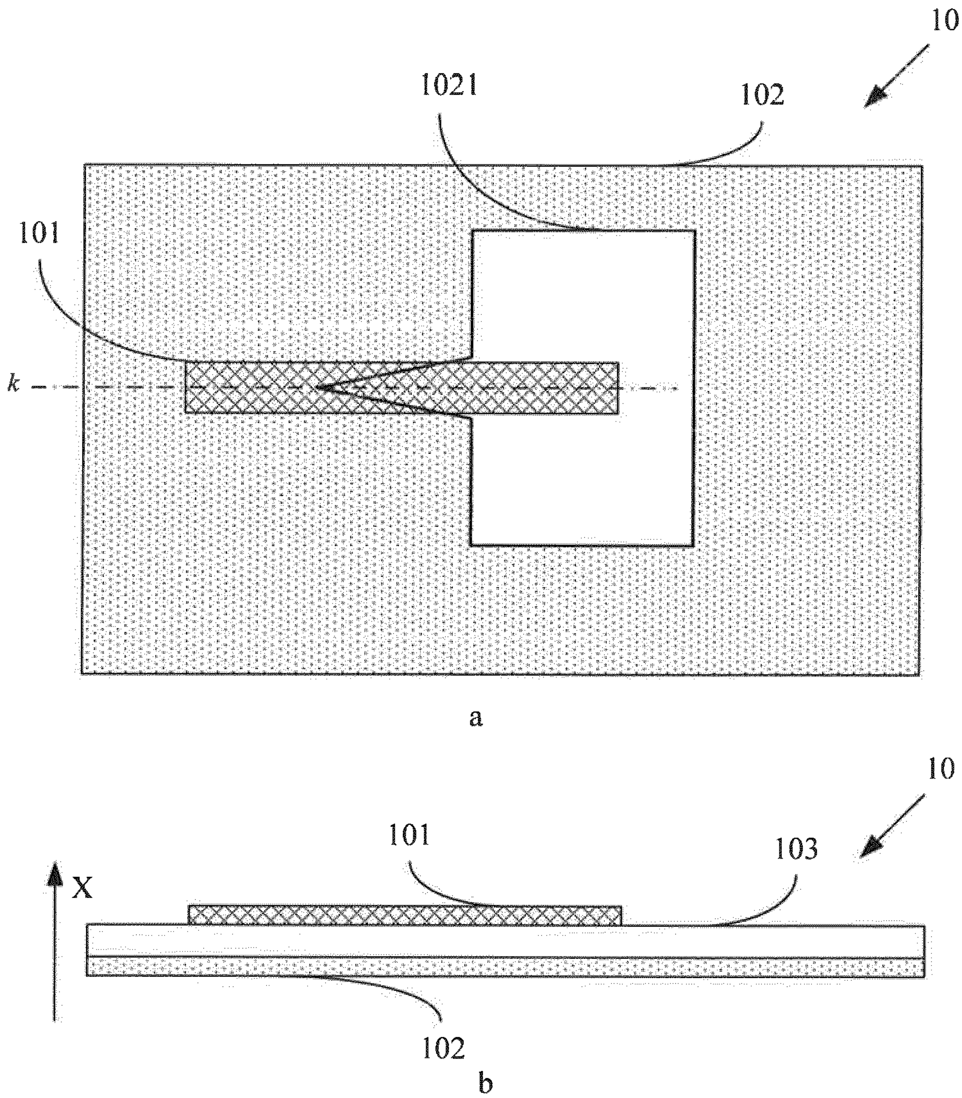


FIG. 1

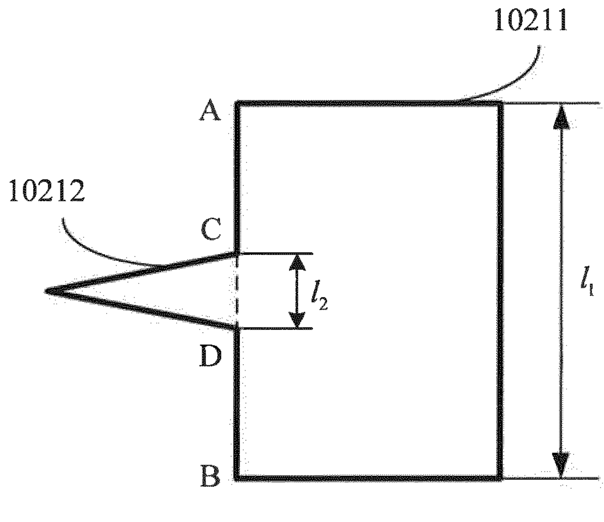


FIG. 2

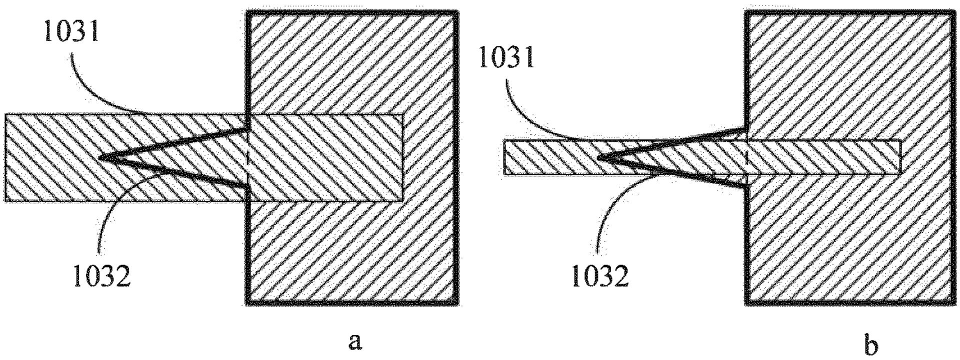


FIG. 3

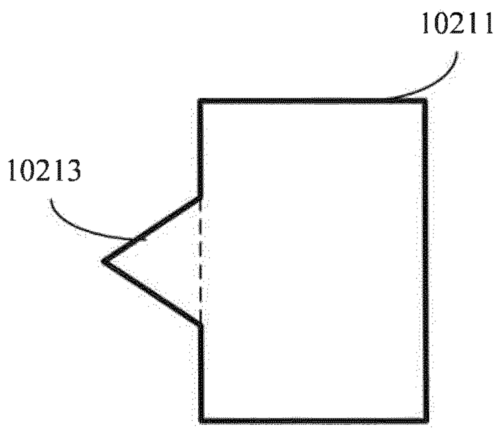
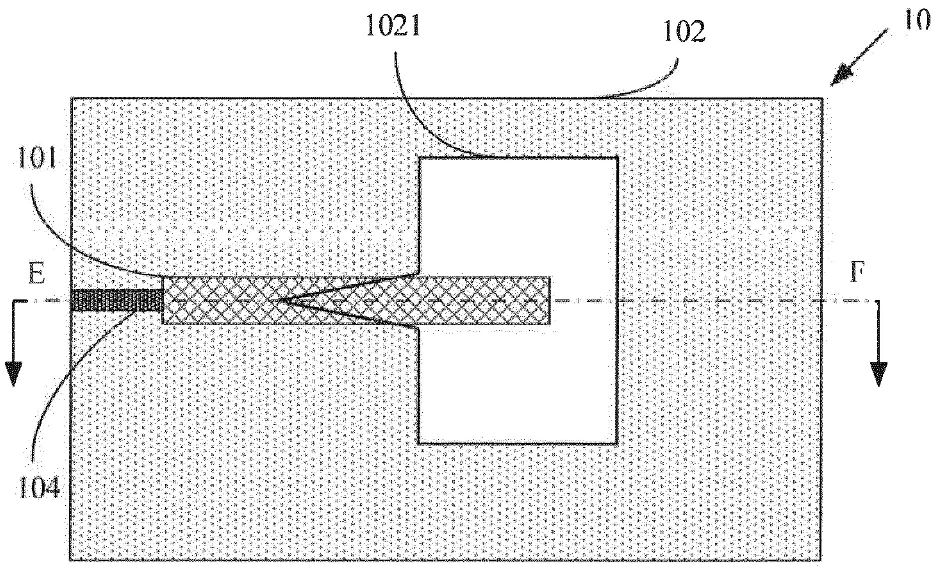
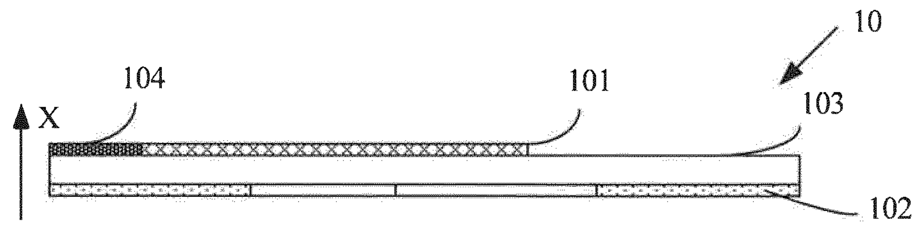


FIG. 4

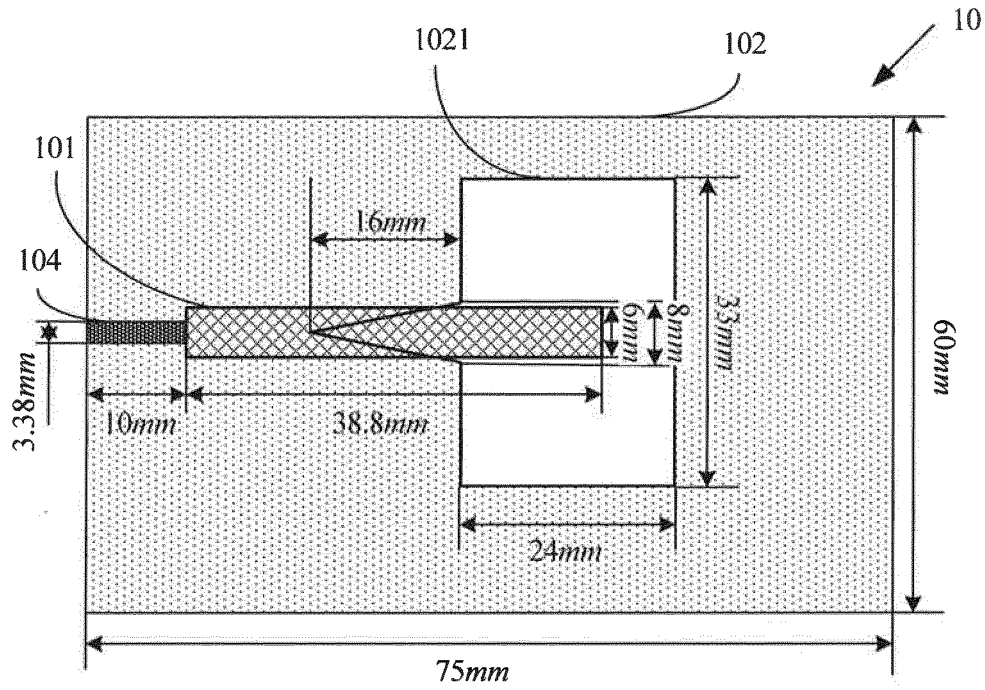


a

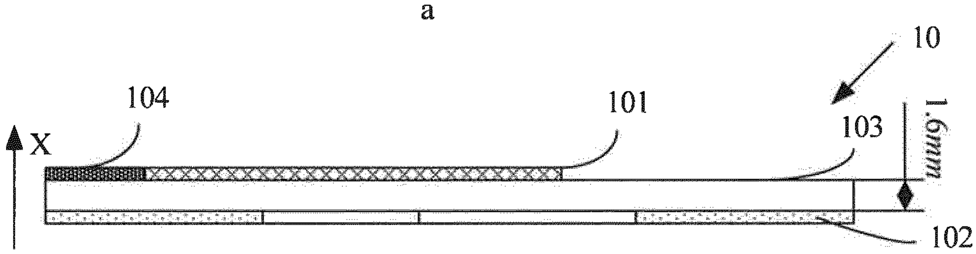


b

FIG. 5


10
1021
102
101
16mm
104
8mm
6mm
33mm
60mm
3.38mm
10mm
38.8mm
24mm
75mm

a


10
104
101
103
1.6mm
X
102

b

FIG. 6

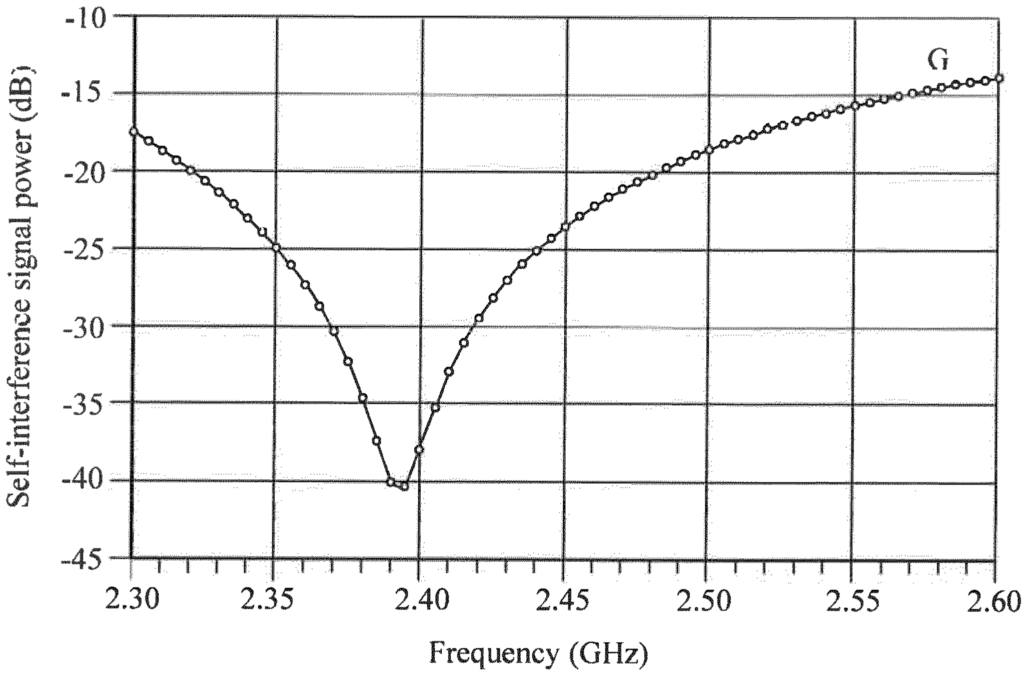

-10
-15
-20
-25
-30
-35
-40
-45
Self-interference signal power (dB)
G
2.30
2.35
2.40
2.45
2.50
2.55
2.60
Frequency (GHz)

FIG. 7

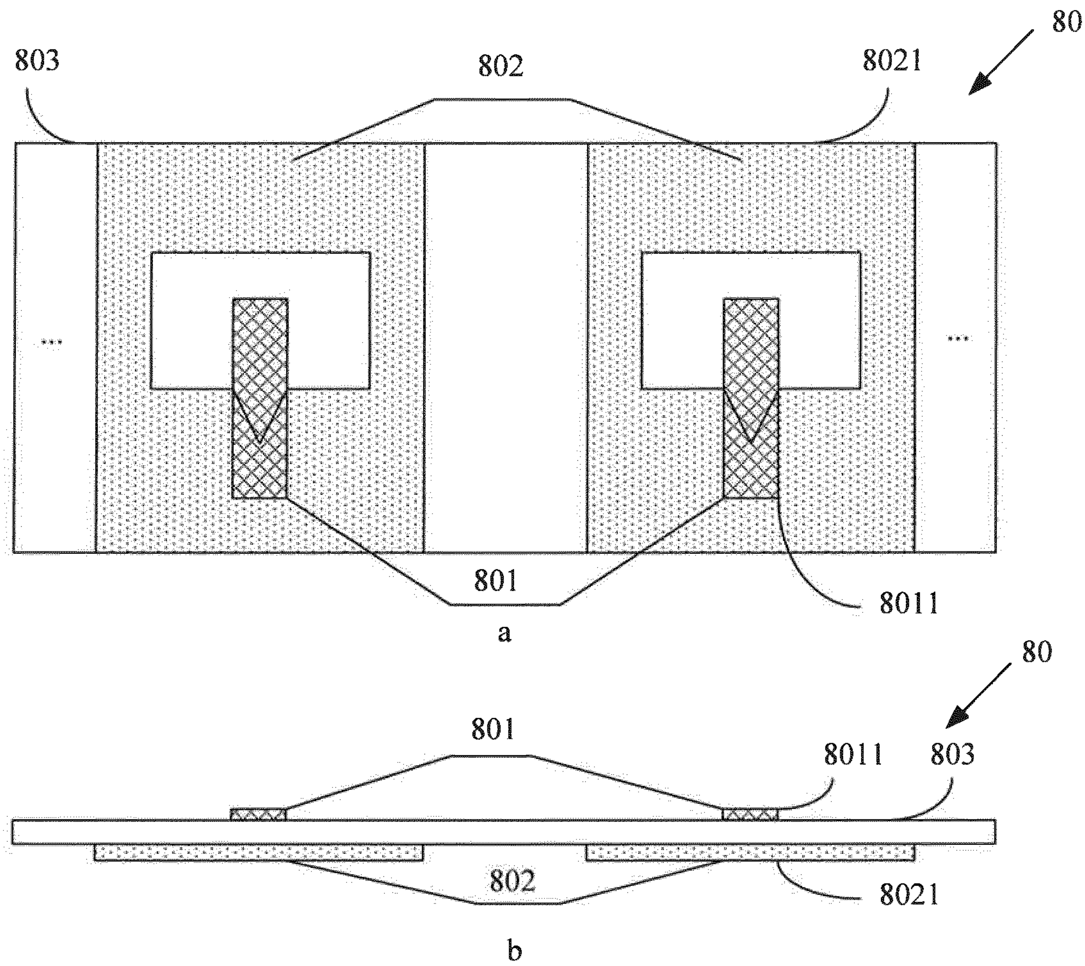


FIG. 8

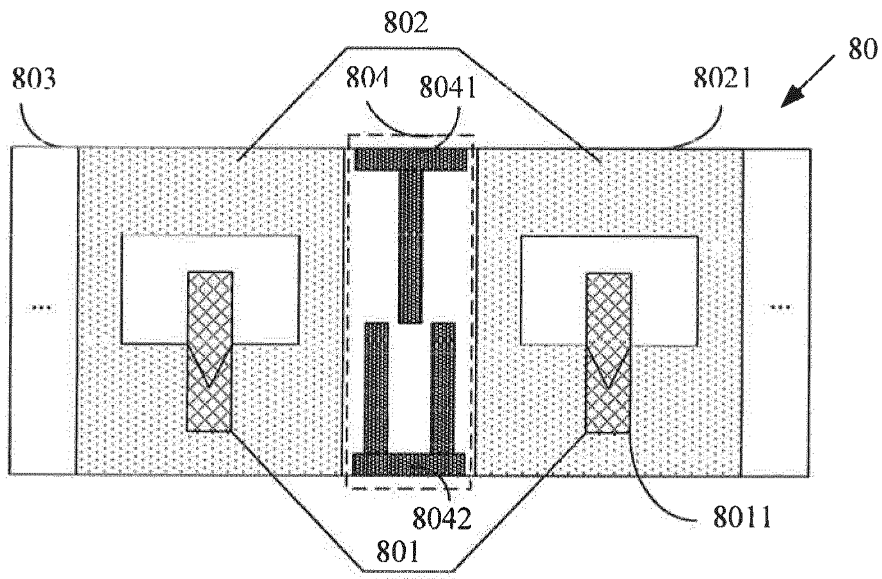

802
80
803
804
8041
8021
...
...
8042
8011
801

FIG. 9

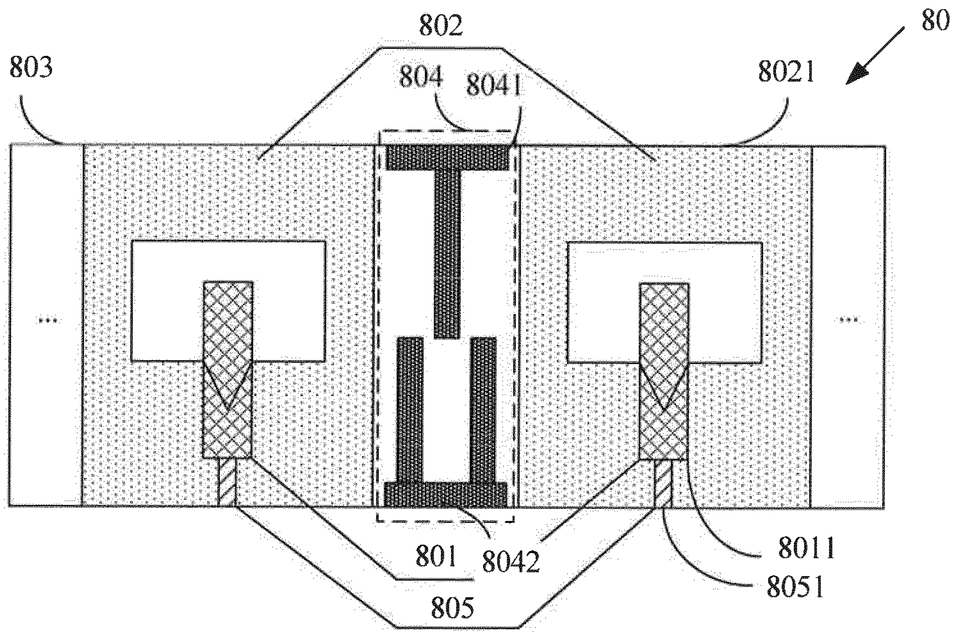

802
80
803
804
8041
8021
...
...
801
8042
8011
8051
805

FIG. 10

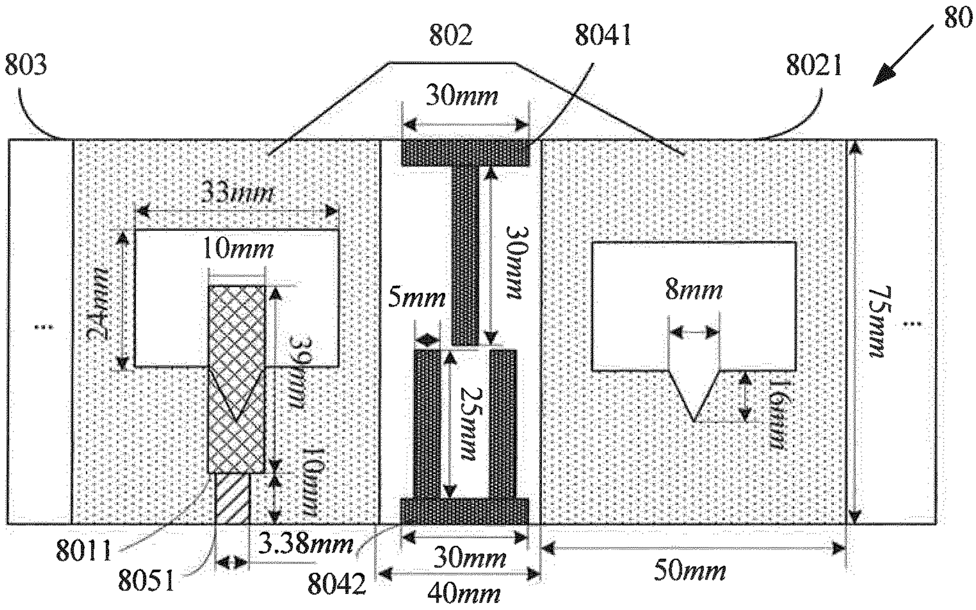

80
802
8041
803
8021
30mm
33mm
10mm
24mm
39mm
10mm
5mm
30mm
25mm
8mm
16mm
75mm
8011
8051
3.38mm
8042
30mm
40mm
50mm

FIG. 11

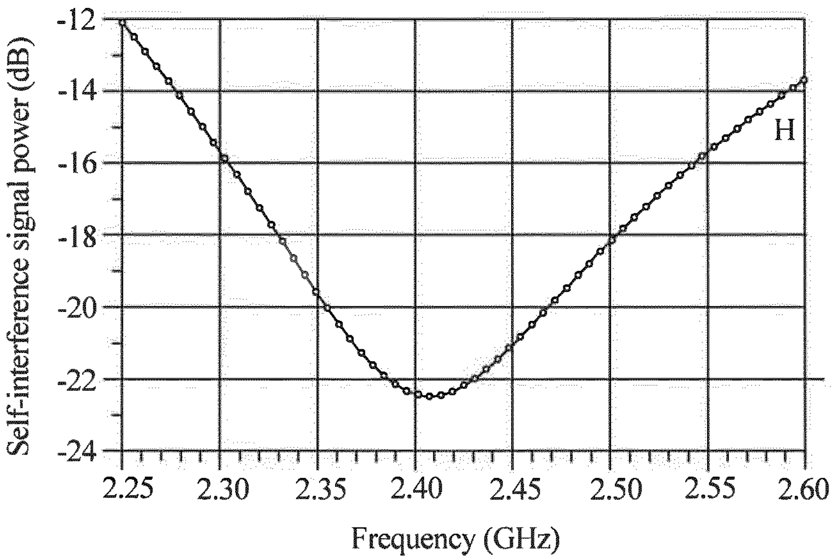

Self-interference signal power (dB)
-12
-14
-16
-18
-20
-22
-24
H
2.25
2.30
2.35
2.40
2.45
2.50
2.55
2.60
Frequency (GHz)

FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2013/089972

A. CLASSIFICATION OF SUBJECT MATTER

H01Q 13/10 (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)

CNPAT, CNABS, CNKI, CNTXT: micro-strip, antenna, patch, triangle, rectangle, interval, slot, ground, medium

VEN, WPI, EPODOC: microstrip, antenna, triangle, rectangle, interval, slot, ground, medium

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	TW 200723593 A (SOUTHERN TAIWAN UNIVERSITY OF SCIENCE AND TECHNOLOGY), 16 June 2007 (16.06.2007), description, page 7, line 20 to page 8, line 17, and page 9, lines 15-22, and figures 1, 2 and 20	1-12
A	CN 102439784 A (HUAWEI TECHNOLOGIES CO., LTD.), 02 May 2012 (02.05.2012), the whole document	1-12

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

* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 January 2014 (17.01.2014)	**27 March 2014 (27.03.2014)**

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INTERNATIONAL SEARCH REPORT
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International application No.
PCT/CN2013/089972

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