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(54) **ANTENNA DEVICE**

(57) An antenna device is provided. The antenna device includes a first antenna, a second antenna, a first extension element, and a second extension element. The first antenna and the second antenna respectively operate in an operating frequency band. The first extension element is electrically connected to the first antenna and directed to the second antenna, so that the first antenna

generates a first resonant path. The second extension element is electrically connected to the second antenna and directed to the first antenna, so that the second antenna generates a second resonant path. The first extension element and the second extension element are located between the first antenna and the second antenna.

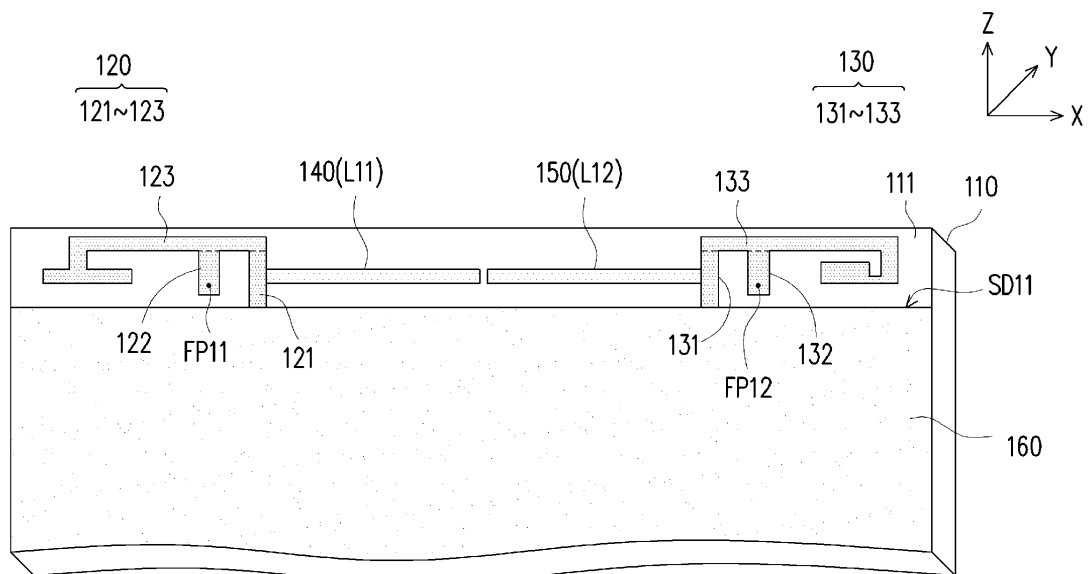


FIG. 1

Description**BACKGROUND OF THE INVENTION****FIELD OF THE INVENTION**

[0001] The invention relates to an antenna device, and particularly relates to an antenna device capable of improving isolation between two antennas.

DESCRIPTION OF RELATED ART

[0002] In recent years, a planar antenna, such as a planar printed antenna, has been broadly used in a network device such as a wireless access point (AP), a router, and a gateway, etc. Besides, in order to support a multi-input multi-output (MIMO) transmission mechanism, a plurality of planar antennas have to be built in the network device. However, the space available for disposing the planar antennas in the network device is limited. Thus, how to improve isolation between the planar antennas so that the plurality of planar antennas may be integrated in the limited space of the network device has become an important issue.

SUMMARY OF THE INVENTION

[0003] The invention provides an antenna device capable of improving isolation between a first antenna and a second antenna by a first resonant path and a second resonant path. The invention is defined in the independent claim. The dependent claims define preferred embodiments.

[0004] An antenna device according to an embodiment includes a first antenna, a second antenna, a first extension element, and a second extension element. The first antenna and a second antenna respectively operate in an operating frequency band. The first extension element is electrically connected to the first antenna and directed to the second antenna, so that the first antenna generates a first resonant path. The second extension element is electrically connected to the second antenna and directed to the first antenna, so that the second antenna generates a second resonant path. In addition, the first extension element and the second extension element are located between the first antenna and the second antenna.

[0005] Based on the above, the first extension element and the second extension element are disposed between the first antenna and the second antenna in the antenna device according to the embodiments of the invention, so that the first antenna and the second antenna may generate the first resonant path and the second resonant path. In addition, with the first resonant path and the second resonant path, the antenna device is able to improve isolation between the first antenna and the second antenna.

[0006] In order to make the aforementioned and other

features and advantages of the invention more comprehensible, embodiments accompanying figures are described in detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

FIG. 1 is a schematic view illustrating an antenna device according to an embodiment of the invention.

FIG. 2 is a diagram illustrating a radiation pattern of the first antenna according to an embodiment of the invention.

FIG. 3 is a graph illustrating a return loss of the first antenna according to an embodiment of the invention.

FIG. 4 is a graph illustrating a return loss of a second antenna according to an embodiment of the invention.

FIG. 5 is a graph illustrating the isolation between the first antenna and the second antenna according to an embodiment of the invention.

FIG. 6 is a schematic view illustrating an antenna device according to another embodiment of the invention.

FIG. 7 is a schematic view illustrating an antenna device according to yet another embodiment of the invention.

DESCRIPTION OF THE EMBODIMENTS

[0008] FIG. 1 is a schematic view illustrating an antenna device according to an embodiment of the invention. As shown in FIG. 1, an antenna device 100 includes a substrate 110, a first antenna 120, a second antenna 130, a first extension element 140, and a second extension element 150. The first antenna 120, the second antenna 130, the first extension element 140, and the second extension element 150 are disposed on the substrate 110. For example, the first antenna 120, the second antenna 130, the first extension element 140, and the second extension element 150 may be printed on a surface 111 of the substrate 110. In other words, the first antenna 120 and the second antenna 130 may respectively be a planar printed antenna.

[0009] The first extension element 140 and the second extension element 150 are located between the first an-

tenna 120 and the second antenna 130. Besides, the first extension element 140 is electrically connected to the first antenna 120, so that the first antenna 120 may generate a first resonant path. The second extension element 150 is electrically connected to the second antenna 130, so that the second antenna 130 may generate a second resonant path. The first extension element 140 and the second extension element 150 respectively have an open end, and the open end of the first extension element 140 faces an open end of the second extension element 150.

[0010] Namely, in an overall configuration, the open end of the first extension element 140 is toward (i.e., directed to) the second antenna 130 (i.e., in X-axis direction), and the open end of the second extension element 150 is toward (i.e., directed to) the first antenna 120 (i.e., in -X-axis direction). In operation, the first antenna 120 may receive a first feeding signal from a transceiver (not shown) through a feeding point FP11, and the second antenna 130 may receive a second feeding signal from the transceiver through a feeding point FP12. Accordingly, under the excitation of the first and the second feeding signals, the first antenna 120 and the second antenna 130 may respectively operate in an operating frequency band (e.g., 2.4 GHz band). Certainly, the operating frequency band may be one of a plurality of operating frequency bands covered by the first antenna 120 and/or the second antenna 130.

[0011] It should be noted that a length of the first resonant path is a quarter wavelength of a lowest frequency of the operating frequency band. Thus, the first antenna 120 may generate a resonant mode in the operating frequency band through the first resonant path, and a radiation pattern of the first antenna 120 may generate a null point in response to the resonant mode. Besides, the open end of the first extension element 140 is toward the second antenna 130 (i.e., X-axis direction), and therefore the null point generated by the first antenna 120 through the first resonant path may be toward the second antenna 130 (i.e., X-axis direction). For example, FIG. 2 is a diagram illustrating a radiation pattern of the first antenna according to an embodiment of the invention. As shown in FIG. 2, with the arrangement of the first extension element 140, the radiation pattern of the first antenna 120 has the null point in the X-axis direction. In other words, the radiation pattern of the first antenna 120 may generate a null point at a side toward the second antenna 130.

[0012] Similarly, a length of the second resonant path is also the quarter wavelength of the lowest frequency of the operating frequency band. Thus, the second antenna 130 may generate a resonant mode in the operating frequency band through the second resonant path, and a radiation pattern of the second antenna 130 may generate a null point in response to the resonant mode. Besides, the open end of the second extension element 150 is toward the first antenna 120 (i.e., -X-axis direction), so the null point generated by the second antenna 130 through the second resonant path is toward the first an-

tenna 120 (i.e., -X-axis direction).

[0013] In other words, with the arrangement of the first extension element 140 and the second extension element 150, the radiation pattern of the first antenna 120 may generate a null point at the side toward the second antenna 130, and the radiation pattern of the second antenna 130 may generate a null point at a side toward the first antenna 120. Thus, a coupling effect between the first antenna 120 and the second antenna 130 may be reduced, so as to effectively improve isolation between the first antenna 120 and the second antenna 130, thereby facilitating integration of the first antenna 120 and the second antenna 130 in a network device.

[0014] For example, FIG. 3 is a graph illustrating a return loss (S11) of the first antenna according to an embodiment of the invention, FIG. 4 is a graph illustrating a return loss (S22) of the second antenna according to an embodiment of the invention, and FIG. 5 is a graph illustrating the isolation (S21) between the first antenna and the second antenna according to an embodiment of the invention. In the embodiment shown in FIGs. 3 to 5, a distance between the open end of the first extension element 140 and the open end of the second extension element 150 is about 1 mm, and a distance between the feeding point FP11 of the first antenna 120 and the feeding point FP12 of the second antenna 130 is about 47 mm. As shown in FIGs. 3 and 4, a frequency range of the operating frequency band of the first antenna 120 and the second antenna 130 covers 2.4 GHz to 2.5 GHz. In addition, as shown in FIG. 5, isolation of the antenna device 100 within 2.4 GHz to 2.5 GHz is mostly lower than -20 dB.

[0015] It should be noted that the first antenna 120 and the second antenna 130 may respectively have an antenna structure of various types, such as an inverted-F antenna structure, a dipole antenna structure, or a monopole antenna structure, etc. For example, as shown in FIG. 1, the first antenna 120 and the second antenna 130 respectively have the inverted-F antenna structure. Specifically, the antenna device 100 further includes a ground plane 160 disposed on the substrate 110. The first antenna 120 includes a first shorting portion 121, a first feeding portion 122, and a first radiation portion 123, and the second antenna 130 includes a second shorting portion 131, a second feeding portion 132, and a second radiation portion 133.

[0016] For the first antenna 120, the first shorting portion 121 is electrically connected the first extension element 140 and the ground plane 160. The first feeding portion 122 has the feeding point FP11 for receiving a first feeding signal. The first radiation portion 123 is electrically connected the first shorting portion 121 and the first feeding portion 122. In addition, the first antenna 120 may operate in the operating frequency band through a resonant path formed by the first radiation portion 123 and the first shorting portion 121. Similarly, for the second antenna 130, the second shorting portion 131 is electrically connected the second extension element 150 and

the ground plane 160. The second feeding portion 132 has the feeding point FP12 for receiving a second feeding signal. The second radiation portion 133 is electrically connected the second shorting portion 131 and the second feeding portion 132. In addition, the second antenna 130 may operate in the operating frequency band through a resonant path formed by the second radiation portion 133 and the second shorting portion 131.

[0017] More specifically, the first shorting portion 121, the first extension element 140, the second extension element 150, and the second shorting portion 131 are sequentially arranged along an edge SD11 of the ground plane 160. In addition, the length of the first extension element 140 is equal to the length of the first resonant path, and the length of the second extension element 150 is equal to the length of the second resonant path. Moreover, the first extension element 140 may be formed of a metal line L11, and the second extension element 150 may be formed of a metal line L12. A first end of the metal line L11 is electrically connected to the first shorting portion 121, and a second end of the metal line L11 is configured to form the open end of the first extension element 140. A first end of the metal line L12 is electrically connected to the second shorting portion 131, and a second end of the metal line L12 is configured to form the open end of the second extension element 150.

[0018] FIG. 6 is a schematic view illustrating an antenna device according to another embodiment of the invention. As shown in FIG. 6, an antenna device 600 includes a substrate 610, a first antenna 620, a second antenna 630, a first extension element 640, and a second extension element 650. In addition, the first antenna 620, the second antenna 630, the first extension element 640, and the second extension element 650 are disposed on a surface 611 of the substrate 610. Besides, the first antenna 620 and the second antenna 630 shown in FIG. 6 respectively have a dipole antenna structure.

[0019] Specifically, the first antenna 620 includes a first radiation portion 661 and a third radiation portion 663 parallel to each other, and the second antenna 630 includes a second radiation portion 662 and a fourth radiation portion 664 parallel to each other. In addition, the first radiation portion 661 is parallel to the second radiation portion 662. The first radiation portion 661 has a first connection point P61. The first radiation portion 661 receives the first feeding signal from a signal source S61 or is coupled to a ground through the first connection point P61. The second radiation portion 662 has a second connection point P62. The second radiation portion 662 receives the second feeding signal from a signal source S62 or is coupled to the ground through the second connection point P62. The first antenna 620 and the second antenna 630 may respectively operate in an operating frequency band.

[0020] The first extension element 640 and the second extension element 650 are disposed between the first radiation portion 661 and the second radiation portion 662. The first extension element 640 is perpendicular to

the first radiation portion 661, and the second extension element 650 is perpendicular to the second radiation portion 662. Besides, the first extension element 640 is electrically connected to the first radiation portion 661 of the first antenna 620, so that the first antenna 620 may generate a first resonant path 601. In addition, the first resonant path 601 extends from the first connection point P61 to an open end of the first extension element 640, and the first resonant path 601 is a quarter wavelength of a lowest frequency of the operating frequency band.

[0021] The second extension element 650 is electrically connected to the second radiation portion 662 of the second antenna 630, so that the second antenna 630 may generate a second resonant path 602. In addition, the second resonant path 602 extends from the second connection point P62 to an open end of the second extension element 650. Besides, the open end of the first extension element 640 faces the open end of the second extension element 650. Accordingly, with the arrangement of the first extension element 640 and the second extension element 650, a radiation pattern of the first antenna 620 may generate a null point at a side toward the second antenna 630, and a radiation pattern of the second antenna 630 may generate a null point at a side toward the first antenna 620. Consequently, isolation between the first antenna 620 and the second antenna 630 may be effectively improved.

[0022] It is noteworthy that, based on the design, people having ordinary skill in the art may selectively remove the third radiation portion 663 of the first antenna 620 and the fourth radiation portion 664 of the second antenna 630 and dispose a ground plane below the first antenna 620 and the second antenna 630, so that the first antenna 620 and the second antenna 630 respectively have a monopole antenna structure. For example, FIG. 7 is a schematic view illustrating an antenna device according to yet another embodiment of the invention. In an antenna device 700 shown in FIG. 7, a first antenna 710 is formed by the first radiation portion 661, a second antenna 720 is formed by the second radiation portion 662, the antenna device 700 further includes a ground plane 730 disposed below the first antenna 710 and the second antenna 720.

[0023] In the embodiment shown in FIG. 7, the first antenna 710 receives the first feeding signal from the signal source S61 through the first connection point P61, and the second antenna 720 receives the second feeding signal from the signal source S62 through the second connection point P62. Consequently, the first antenna 710 and the second antenna 720 may respectively have a monopole antenna structure and respectively operate in the operating frequency band. Moreover, similar to the embodiment shown in FIG. 6, with the arrangement of the first extension element 640 and the second extension element 650, a radiation pattern of the first antenna 710 may generate a null point at a side toward the second antenna 720, and a radiation pattern of the second antenna 720 may generate a null point at a side toward the

first antenna 710. Consequently, isolation between the first antenna 710 and the second antenna 720 may be effectively improved. Details concerning the arrangement and operation of respective components in the embodiment shown in FIG. 7 have been described in the foregoing embodiments, and thus will not be repeated in the following.

[0024] In view of the foregoing, the first extension element and the second extension element are disposed between the first antenna and the second antenna in the antenna device according to the embodiments of the invention, so that the first antenna and the second antenna may generate the first resonant path and the second resonant path. Besides, the lengths of the first resonant path and the second resonant path are respectively a quarter wavelength of the lowest frequency of the operating frequency band. Accordingly, the first antenna and the second antenna may respectively generate the corresponding resonant mode in response to the first resonant path and the second resonant path, thereby effectively improving the isolation between the first antenna and the second antenna.

[0025] In summary, an antenna device is provided. The antenna device includes a first antenna, a second antenna, a first extension element, and a second extension element. The first antenna and the second antenna respectively operate in an operating frequency band. The first extension element is electrically connected to the first antenna and directed to the second antenna, so that the first antenna generates a first resonant path. The second extension element is electrically connected to the second antenna and directed to the first antenna, so that the second antenna generates a second resonant path. The first extension element and the second extension element are located between the first antenna and the second antenna.

Claims

1. An antenna device (100, 600, 700), comprising:

a first antenna (120, 620, 710) and a second antenna (130, 630, 720), respectively operating in an operating frequency band;
a first extension element (140, 640), electrically connected to the first antenna (120, 620, 710) and directed to the second antenna (130, 630, 720), so that the first antenna (120, 620, 710) generates a first resonant path; and
a second extension element (150, 650), electrically connected to the second antenna (130, 630, 720) and directed to the first antenna (120, 620, 710), so that the second antenna (130, 630, 720) generates a second resonant path, wherein the first extension element (140, 640) and the second extension element (150, 650) are located between the first antenna (120, 620, 710) and

the second antenna (130, 630, 720).

2. The antenna device as claimed in claim 1, wherein a length of the first resonant path and a length of the second resonant path are respectively a quarter wavelength of a lowest frequency of the operating frequency band, and an open end of the first extension element (140, 640) faces an open end of the second extension element (150, 650).
3. The antenna device as claimed in claim 2, further comprising a ground plane (160) disposed on a substrate (110), wherein the first antenna (120) comprises:

a first shorting portion (121), electrically connected to the first extension element (140) and the ground plane (160);
a first feeding portion (122), receiving a first feeding signal; and
a first radiation portion (123), electrically connected to the first shorting portion (121) and the first feeding portion (122), wherein a length of the first extension element (140) is equal to the length of the first resonant path; and
the second antenna (130) comprises:

a second shorting portion (131), electrically connected to the second extension element (150) and the ground plane (160);
a second feeding portion (132), receiving a second feeding signal; and
a second radiation portion (133), electrically connected to the second shorting portion (131) and the second feeding portion (132), wherein the first shorting portion (121), the first extension element (140), the second extension element (150), and the second shorting portion (131) are sequentially arranged along an edge (SD11) of the ground plane (160), and a length of the second extension element (150) is equal to the length of the second resonant path.

4. The antenna device as claimed in claim 3, wherein the first antenna (120) and the second antenna (130) respectively have an inverted-F antenna structure.
5. The antenna device as claimed in one of the preceding claims, wherein the first antenna (620, 710) comprises a first radiation portion (661) having a first connection point (P61), the first extension element (640) is electrically connected to the first radiation portion (661), so that the first resonant path (601) extends from the first connection point (P61) to an open end of the first extension element (640), the second antenna (630, 720) comprises a second radiation portion (662) having a second connection point (P62),

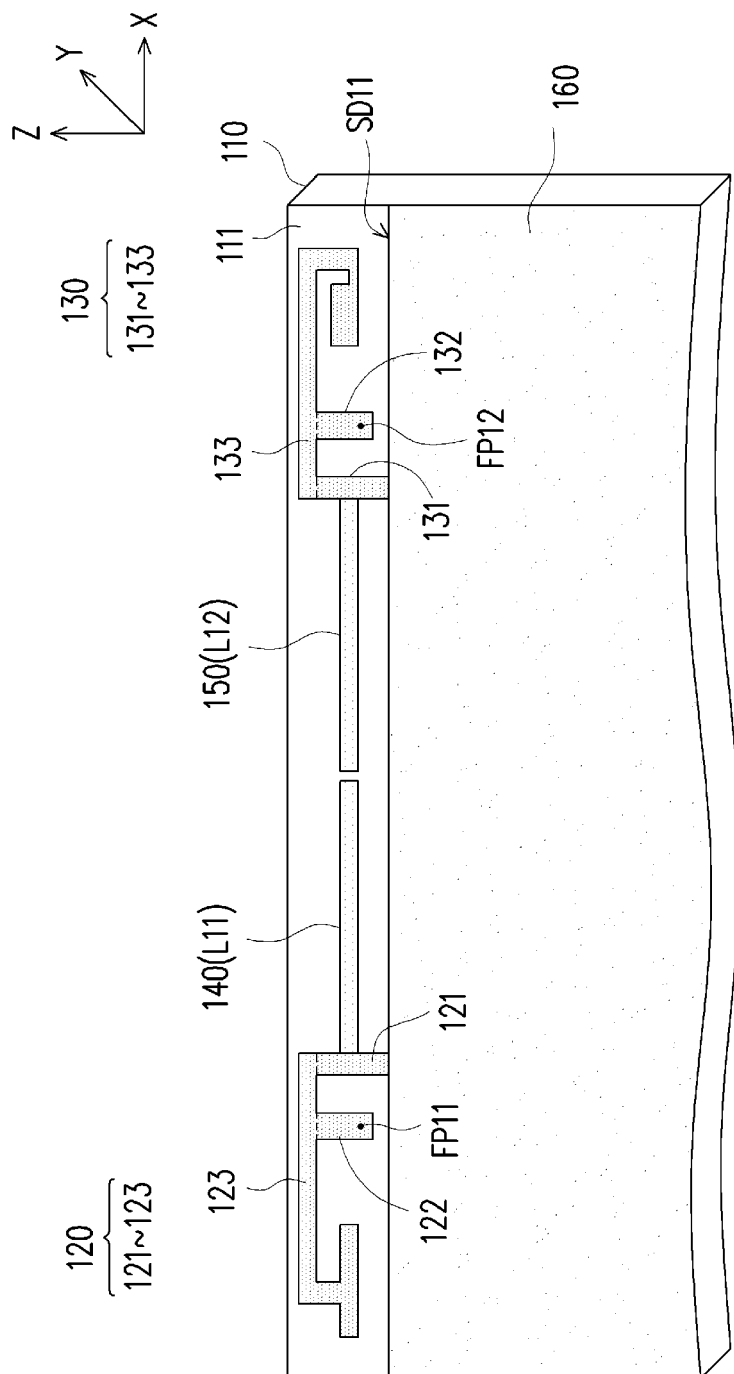
and the second extension element (650) is electrically connected to the second radiation portion (662), so that the second resonant path (602) extends from the second connection point (P62) to an open end of the second extension element (650).

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6. The antenna device as claimed in claim 5, wherein the first extension element (640) and the second extension element (650) are disposed between the first radiation portion (661) and the second radiation portion (662) parallel to each other, the first extension element (640) is perpendicular to the first radiation portion (661), and the second extension element (650) is perpendicular to the second radiation portion (662).
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7. The antenna device as claimed in claim 6, wherein the first antenna (710) and the second antenna (720) respectively have a monopole antenna structure, the first antenna (710) receives a first feeding signal through the first connection point (P61), and the second antenna (720) receives a second feeding signal through the second connection point (P62).
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8. The antenna device as claimed in claim 6, wherein the first antenna (620) further comprises a third radiation portion (663) parallel to the first radiation portion (661), and the first antenna (620) forms a dipole antenna structure through the first radiation portion (661) and the third radiation portion (663).
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9. The antenna device as claimed in claim 8, wherein the second antenna (630) further comprises a fourth radiation portion (664) parallel to the second radiation portion (662), and the second antenna (630) forms the dipole antenna structure through the second radiation portion (662) and the fourth radiation portion (664).
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10. The antenna device as claimed in in one of the preceding claims 1, wherein the first extension element (140) and the second extension element (150) are respectively formed of a metal line (L11, L12), and the first antenna (120), the second antenna (130), the first extension element (140), and the second extension element (150) are respectively printed on a substrate (110).
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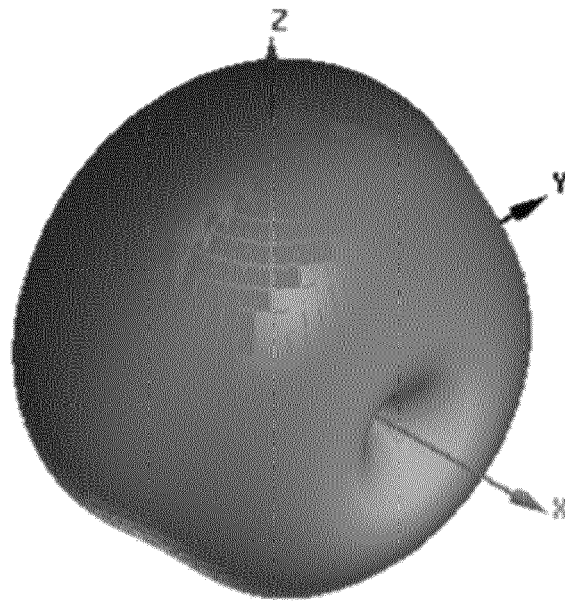


FIG. 2

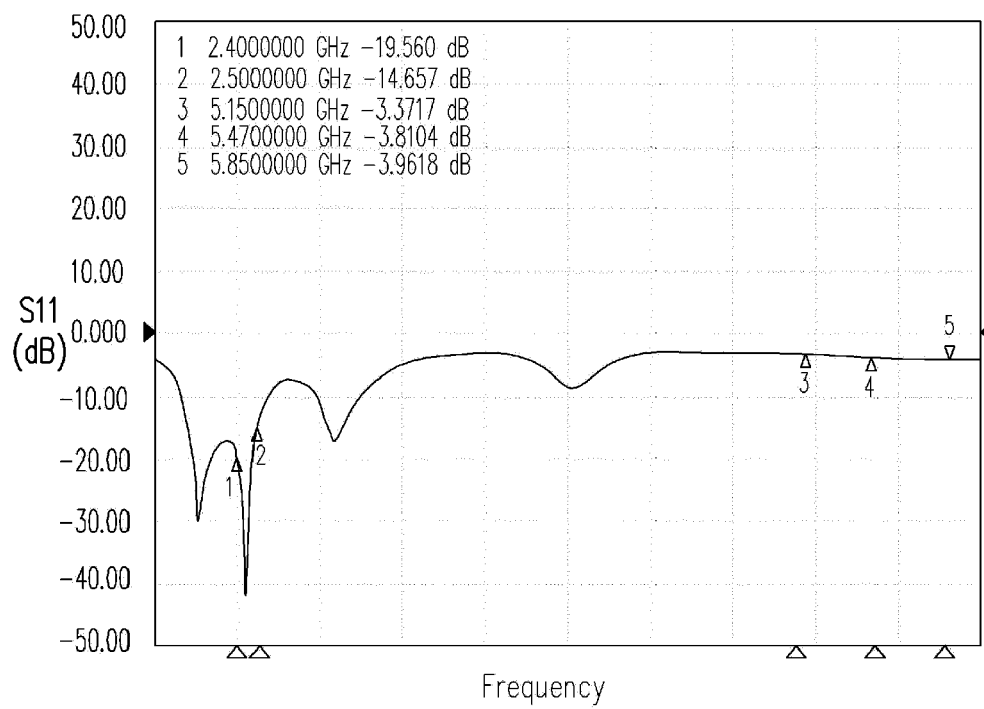


FIG. 3

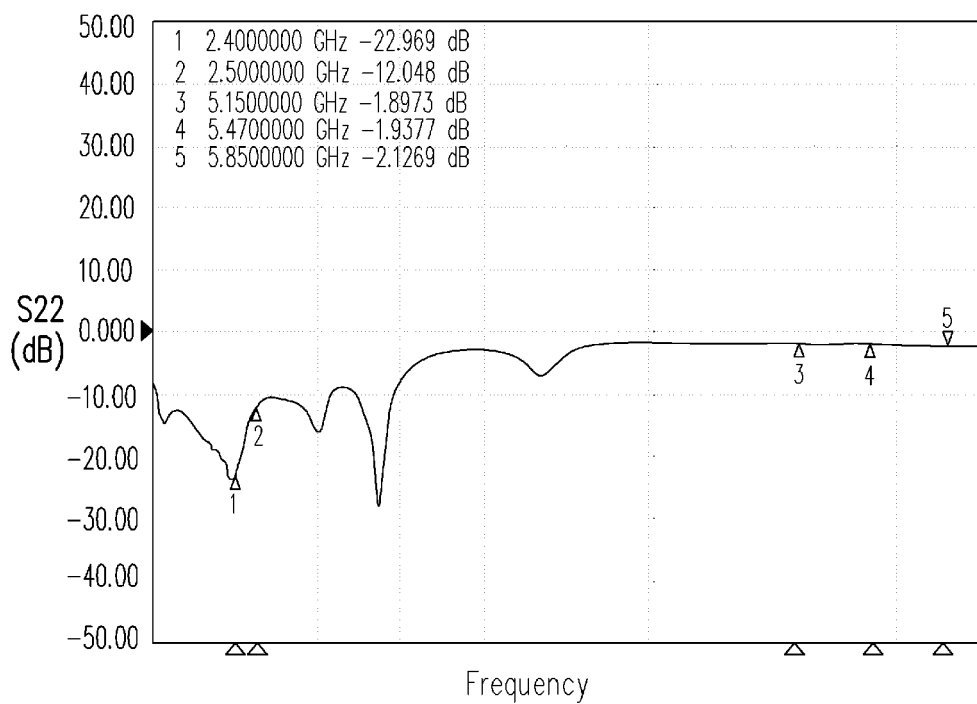


FIG. 4

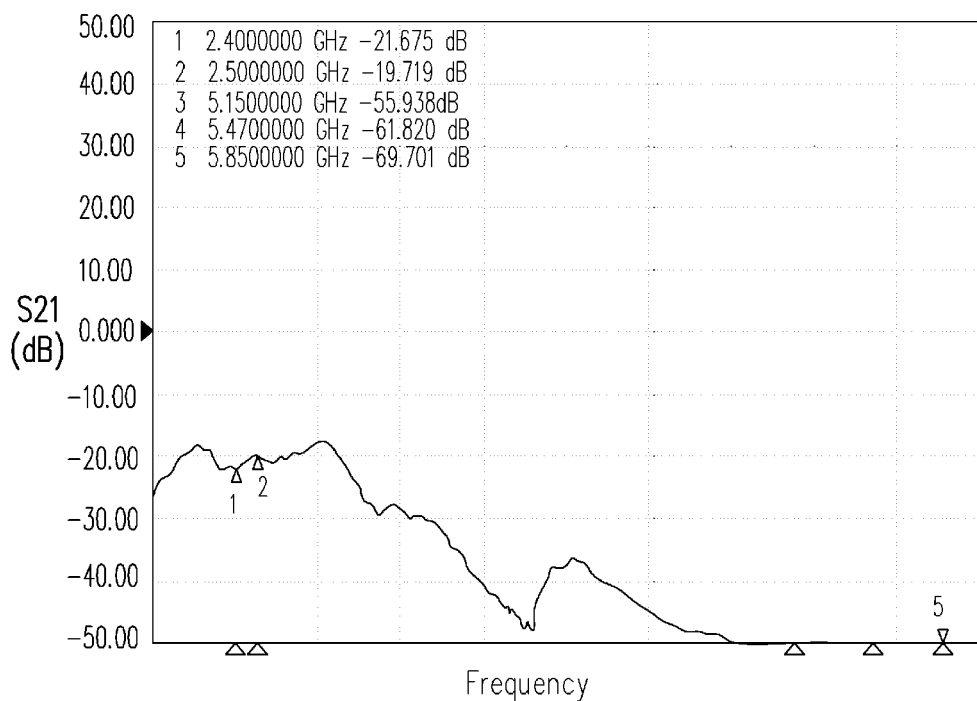


FIG. 5

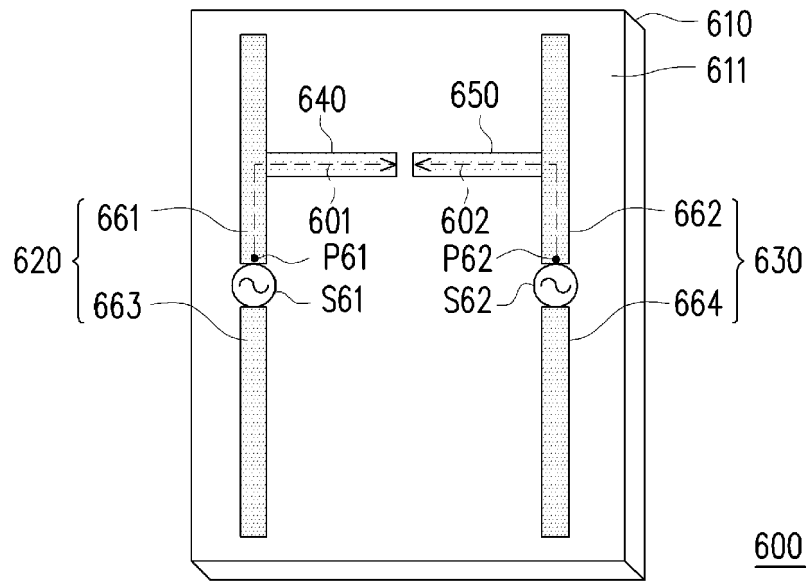


FIG. 6

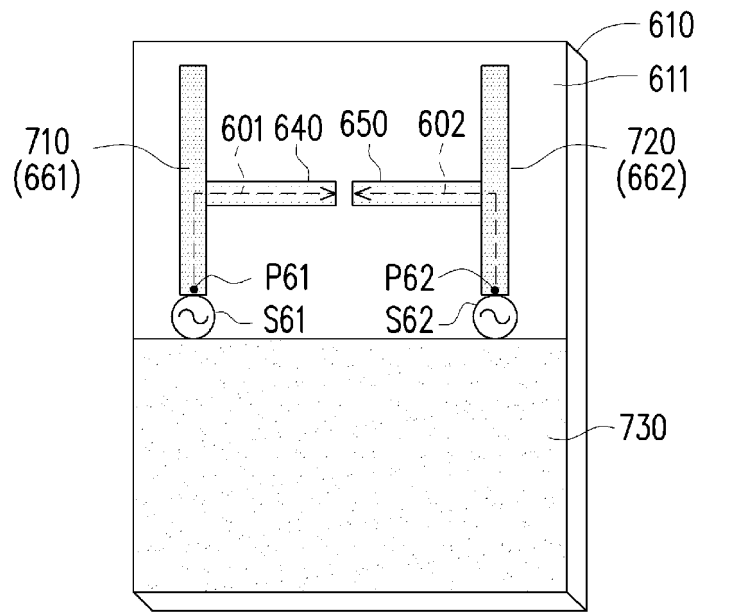


FIG. 7



EUROPEAN SEARCH REPORT

Application Number
EP 16 19 6287

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 10 May 2017	Examiner Wattiaux, Véronique
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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