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# (54) RADIATION ENHANCER OF WIRELESS APPARATUS, RADIATION SYSTEM AND WIRELESS APPARATUS

(57) Disclosed in the present application are a radiation enhancer of a wireless apparatus, a radiation system of the wireless apparatus and the wireless apparatus. The radiation enhancer comprises: a dielectric substrate; a first conductive element, which is mounted on a first side surface of the dielectric substrate; and a second conductive element, which is mounted on a second side surface of the dielectric substrate opposite to the first side surface; wherein the thickness between the first side surface and the second side surface of the dielectric substrate is such that a non-contact and electromagnetic coupling connection of the first conductive element and the second conductive element is enabled. The present radiation enhancer has a simple structure and is easy to process and fabricate. By means of the present application, radiation efficiency is met while simultaneously effectively lowering costs.

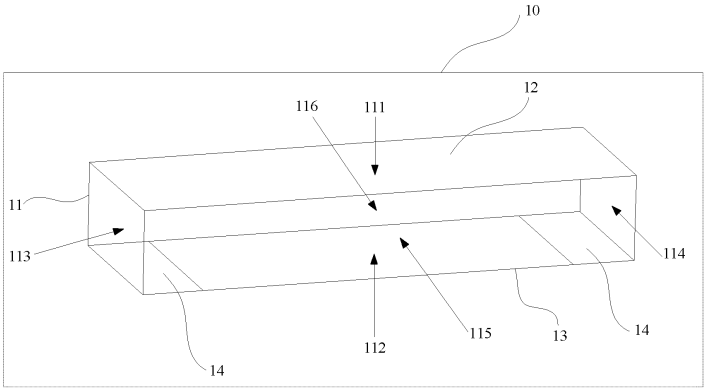


**Fig. 2**

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## Description

**[0001]** The present application claims the priority to a Chinese patent application No. 201920013046.5 filed with the China National Intellectual Property Administration on January 4, 2019 and entitled "Radiation Enhancer of Wireless Apparatus, Radiation System of Wireless Apparatus, and Wireless Apparatus", which is incorporated herein by reference in its entirety.

## Technical field

**[0002]** The present application relates to the field of wireless communication technologies, and in particular, to a radiation enhancer of a wireless apparatus, a radiation system of the wireless apparatus and the wireless apparatus.

## Background

**[0003]** The radiation enhancer in the wireless apparatus plays a crucial role in the operational performance of the wireless apparatus. In the prior art, as shown in Fig. 1, the current radiation enhancer 10' includes a dielectric substrate 11', a top layer conductive element 12', a bottom layer conductive element 13', and a metalized through hole 14' electrically connecting the top layer conductive element 12' and the bottom layer conductive element 13', the metalized through hole 14' penetrates the dielectric substrate 11'.

**[0004]** The radiation enhancer 10' with this structure needs to be provided with the metalized through hole 14' on the dielectric substrate 11' to ensure the electric connection between the top layer conductive element 12 ' and the bottom layer conductive element 13', which is difficult to process, complicated to manufacture, and high in cost.

**[0005]** Accordingly, it is one of the technical problems that need to be solved urgently for those skilled in the art to provide a radiation enhancer which has a simple and compact structure, is easy to process and fabricate, capable of fully ensuring radiation efficiency.

## Summary

**[0006]** The application provides a radiation enhancer of a wireless apparatus, which has a simple structure, is easy to process and fabricate, meets radiation efficiency while simultaneously effectively lowers the costs. The application also provides a radiation system and a wireless apparatus applying the radiation enhancer.

**[0007]** An embodiment of the present application provides a radiation enhancer of a wireless apparatus, wherein the radiation enhancer includes:

a dielectric substrate;

a first conductive element, which is mounted on a first side surface of the dielectric substrate;

a second conductive element, which is mounted on a second side surface of the dielectric substrate opposite to the first side surface;

wherein the thickness between the first side surface and the second side surface of the dielectric substrate is such that a non-contact and electromagnetic coupling connection of the first conductive element and the second conductive element is enabled.

**[0008]** Optionally, the first conductive element or the second conductive element is provided with two internal connection ports.

**[0009]** Optionally, the two internal connection ports are disposed symmetrically with respect to a center line of the first conductive element or the second conductive element.

**[0010]** Optionally, the first conductive element and the second conductive element overlap corresponding side surfaces of the dielectric substrate, and the two internal connection ports are disposed at ends of the first conductive element or the second conductive element.

**[0011]** Optionally, one of the internal connection ports is configured for electrically connecting to a radio frequency module of the wireless apparatus, and the other of internal connection ports is configured for fixedly connecting to a mainboard of the wireless apparatus.

**[0012]** Optionally, a distance between the first side surface and the second side surface of the dielectric substrate is less than one twentieth of a wavelength propagating in an air medium corresponding to a lowest resonant frequency point of a radiation enhancer of the wireless apparatus.

**[0013]** Optionally, the dielectric substrate is provided in a cubic shape, and a maximum side length of the dielectric substrate is less than one twentieth of a wavelength propagating in an air medium corresponding to a lowest resonant frequency point of a radiation enhancer of the wireless apparatus.

**[0014]** Optionally, the lowest resonance frequency point is within an operating frequency range of 698MHz to 960 MHz.

**[0015]** The present application further provides a radiation system of a wireless apparatus, the radiation system includes a radiation structure, a radio frequency module and an external port, the radiation structure includes the radiation enhancer described above, and the radiation enhancer and the external port are electrically connected to the radio frequency module, respectively.

**[0016]** Optionally, the radiation structure further includes a grounding plane layer electrically connecting the radiation enhancer and the radio frequency module.

**[0017]** The present application further provides a wireless apparatus including a radiation system, a matching system and a transmission cable, wherein a radiation structure in the radiation system includes the radiation

enhancer described above, and the transmission cable electrically connects the matching system and a radio frequency module in the radiation system.

**[0018]** In view of the above, based on the above embodiments, the present application provides a radiation enhancer of a wireless apparatus, the radiation enhancer includes a dielectric substrate, a first conductive element, and a second conductive element. The dielectric substrate has a first side surface and a second side surface disposed opposite to each other, the first conductive element is mounted on the first side surface, and the second conductive element is mounted on the second side surface. The thickness between the first side surface and the second side surface is such that an electromagnetic coupling connection of the first conductive element and the second conductive element is enabled, and the first conductive element and the second conductive element are not in contact, namely, the first conductive element and the second conductive element are not electrically connected. By such arrangement, a complex process of providing the metalized through hole on the dielectric substrate in the prior art is avoided, and the processing efficiency is improved; in addition, compared with the electrical connection mode in the prior art, the first conductive element and the second conductive element in the radiation enhancer according to the embodiment of the application are electromagnetically coupled to form an electromagnetic field, which can be sufficiently extended the current path between the first conductive element and the second conductive element while reducing the size of the dielectric substrate to ensure the radiation efficiency of the wireless apparatus.

## Brief Description of the Drawings

**[0019]** In order to illustrate the embodiments of the present application and the technical solutions of the prior art more clearly, the drawings used in the embodiments and the prior art are briefly described below. Obviously, the drawings in the following description are only some embodiments of the present application, and it is obvious for those skilled in the art that other drawings can be obtained according to the drawings without creative efforts.

Fig. 1 is a schematic structural diagram of a radiation enhancer in the prior art;

Fig. 2 is a schematic structural diagram of a radiation enhancer according to an embodiment of the present application;

Fig. 3 is a schematic structural diagram of a wireless apparatus according to an embodiment of the present application;

Fig. 4 is a diagram of passive performance-S parameter of an antenna of a wireless apparatus according to an embodiment of the present application.

**[0020]** Reference List:
In Fig. 1:

| | |
|---|---|
| 10’ | radiation enhancer; |
| 11’ | dielectric substrate; |
| 12’ | top layer conductive element; |
| 13’ | bottom layer conductive element; |
| 14’ | metalized through hole. |

**[0021]** In Fig. 2 and Fig. 3:

| | |
|---|---|
| 10 | radiation enhancer; |
| 11 | dielectric substrate; |
| 111 | first side surface; |
| 112 | second side surface; |
| 113 | third side surface; |
| 114 | fourth side surface; |
| 115 | fifth side surface; |
| 116 | sixth side surface; |
| 12 | first conductive element; |
| 13 | second conductive element; |
| 14 | internal connection port; |
| 20 | radio frequency module; |
| 30 | grounding plane layer; |
| 40 | matching system; |
| 50 | mainboard. |

## Detailed Description

**[0022]** In order to make the objects, technical solutions and advantages of the present application more clearer, the following further describes the present application in detail with reference to the accompanying drawings and embodiments. Obviously, the described embodiments are only a part of the embodiments of the present application, rather than all the embodiments. Based on the embodiments in the present application, all other embodiments obtained by those ordinary skill skilled in the art without creative work shall fall within the protection scope of the present application.

**[0023]** To illustrate in detail the structure and principles of the radiation enhancer of the wireless apparatus provided herein, the radiation enhancer is described in detail below with reference to the drawings.

**[0024]** As shown in Fig. 2 and Fig. 3, Fig. 2 is a schematic structural diagram of a radiation enhancer according to an embodiment of the present application; Fig. 3 is a schematic structural diagram of a wireless apparatus according to an embodiment of the present application.

**[0025]** It should be noted that, the terms "first, second, third, fourth, fifth and sixth" appearing herein are only used for distinguishing the same components and clearly expressing technical solutions, and do not limit the major and minor parts, importance and orders of the components, that is, do not limit the technical solutions of the present application.

**[0026]** As shown in Fig. 2, an embodiment of the present application provides a radiation enhancer 10 of a wireless apparatus, wherein the radiation enhancer 10 includes a dielectric substrate 11, a first conductive element 12, and a second conductive element 13. The dielectric substrate 11 has a first side surface 111 and a second side surface 112 disposed opposite to each other. The first conductive element 12 is arranged on the first side surface 111, and the second conductive element 13 is arranged on the second side surface 112. There is a thickness between the first side surface 111 and the second side surface 112 that enables the electromagnetic coupling connection of the first conductive element 12 and the second conductive element 13, and the first conductive element 12 and the second conductive element 13 are not in contact, that is, the first conductive element 12 and the second conductive element 13 are not electrically connected. This arrangement avoids a complex process of forming the metalized through hole on the dielectric substrate 11 in the prior art, and the processing efficiency is improved.

**[0027]** In an embodiment, the radiation enhancer 10 may further have a third side surface 113 and a fourth side surface 114 disposed opposite to each other, and a fifth side surface 115 and a sixth side surface 116 disposed opposite to each other.

**[0028]** As shown in Fig. 2, in the embodiment of the present application, the dielectric substrate 11 is a solid dielectric body. Of course, the dielectric substrate 11 is not limited to a solid dielectric body, and may be hollow, or the dielectric substrate 11 may be provided with a through hole. The structure and shape of the dielectric substrate 11 is not limited in the embodiment of the present application, and it is only necessary that the first conductive element 12 and the second conductive element 13 are not in contact, and the electromagnetic coupling connection of the first conductive element 12 and the second conductive element 13 can be realized.

**[0029]** Referring to Fig. 1, in a radiation enhancer 10' in the prior art, a through hole needs to be additionally formed, and metallization needs to be performed on a surface of a hole wall of the through hole to electrically connect a top layer conductive element 12' and a bottom layer conductive element 13' so that a wireless apparatus can have an antenna function, which is difficult in process and high in cost. Referring to Fig. 2, the dielectric substrate 11 of the radiation enhancer 10 according to the embodiment of the present application has a thickness such that the first conductive element 12 and the second conductive element 13 are not in contact, and enables the electromagnetic coupling connection of the first conductive element 12 and the second conductive element 13, so that an electromagnetic field is formed by electromagnetic coupling, and a current path between the first conductive element 12 and the second conductive element 13 can be sufficiently extended to ensure the radiation efficiency of the wireless apparatus, compared with an electrical connection of the first conductive element 12 and the second conductive element 13 by metalizing the through hole.

**[0030]** In an embodiment, the first conductive element 12 or the second conductive element 13 is provided with two internal connection ports 14, that is, the two internal connection ports 14 are disposed on the same conductive element. Referring to Fig. 2, in the embodiment of the present application, two internal connection ports 14 may be provided on the second conductive element 13, and the two internal connection ports 14 are disposed symmetrically with respect to the center line of the second conductive element 13.

**[0031]** The above internal connection port 14 is configured for connecting the first conductive element 12 or the second conductive element 13 to other elements. For example, the internal connection port 14 may be a pad.

**[0032]** In an embodiment, the two internal connection ports 14 may also be disposed on the first conductive element 12, in which case the two internal connection ports 14 are disposed symmetrically with respect to the center line of the first conductive element 12.

**[0033]** In an embodiment, the first conductive element 12 and the second conductive element 13 overlap the corresponding side surfaces of the dielectric substrate 11, that is, the first conductive element 12 may overlap the first side surface 111, and the second conductive element may overlap the second side surface 112.

**[0034]** In an embodiment, if two internal connection ports 14 are provided on the second conductive element 13, the two internal connection ports 14 may be arranged at the ends of the second conductive element 13.

**[0035]** In an embodiment, if two internal connection ports 14 are provided on the first conductive element 12, the two internal connection ports 14 may be arranged at the ends of the first conductive element 12.

**[0036]** In an embodiment, one internal connection port 14 is configured for electrically connecting to a radio frequency module for the wireless apparatus and the other internal connection port 14 is configured for fixedly connecting to a mainboard of the wireless apparatus. For example, one internal connection port 14 may be electrically connected to a TX (Transmit)/RX (Receive) port of the radio frequency module, and the radiation enhancer 10 may be soldered and fixed to the mainboard through the other internal connection port 14.

**[0037]** In an embodiment, the two internal connection ports 14 may be provided in a square shape.

**[0038]** In an embodiment, the distance between the first side surface 111 and the second side surface 112 of the dielectric substrate 11, that is, the distance between the surface where the first conductive element 12 is located and the surface where the second conductive element 13 is located in Fig. 2, is less than one twentieth of a wavelength propagating in the air medium corresponding to the lowest resonant frequency point of the radiation enhancer 10, so that the size of the radiation enhancer 10 can be effectively reduced, and further, the size of a wireless apparatus including the radiation en-

hancer 10 can be reduced to further meets the miniaturization design requirement for the wireless apparatus.

**[0039]** In an embodiment, the dielectric substrate 11 may be provided in a cubic shape, for example, the dielectric substrate 11 may be a rectangular parallelepiped, or the dielectric substrate 11 may also be a hexahedron, but is not limited thereto.

**[0040]** In an embodiment, the dielectric substrate 11 may have side length in three directions: length, width and height, and the distance between the first side surface 111 and the second side surface 112 may be considered as the same as the dimension of a side length of the dielectric substrate 11 in the height direction. For the dielectric substrate 11 provided in a cubic shape, the maximum side length of the dielectric substrate 11, that is, the side length having the largest dimension in the three directions of the length, the width, and the height, is less than one twentieth of the wavelength propagating in the air medium corresponding to the lowest resonance frequency point of the radiation enhancer 10 of the wireless apparatus, and thus the size of the radiation enhancer 10 is reduced, and further the size of the wireless apparatus including the radiation enhancer 10 can be reduced to further meets the miniaturization design requirement for the wireless apparatus.

**[0041]** In an embodiment, the lowest resonant frequency point of the radiation enhancer 10 may be within the operating frequency range of 698MHz to 960 MHz.

**[0042]** Based on the electromagnetic coupling connection arrangement of the first conductive element 12 and the second conductive element 13 in the radiation enhancer 10 provided by the present application, the size of the radiation enhancer 10 can be reduced, and further, the size of a wireless apparatus including the radiation enhancer 10 can be sufficiently reduced to further optimize the structural size of the wireless apparatus, and thereby the design requirements of miniaturization and light weight are realized.

**[0043]** In addition to the radiation enhancer 10 of the wireless apparatus described above, further with reference to Fig. 3, an embodiment of the present application also provides a radiation system, which includes a radiation structure, a radio frequency module 20 and an external port.

**[0044]** The radiation structure includes the radiation enhancer 10 in the above embodiments, and the radiation enhancer 10 and the external port are electrically connected to the radio frequency module 20, respectively.

**[0045]** In an embodiment, a grounding plane layer 30 in the radiation structure electrically connects the radiation enhancer 10 and the radio frequency module 20.

**[0046]** The grounding plane layer 30 may be a single layer conductor for connecting the radiation enhancer 10 and the radio frequency module 20.

**[0047]** In an embodiment, one end of the grounding plane layer 30 may be electrically connected to one of the internal connection ports 14 in the radiation enhancer 10, the other end of the grounding plane layer 30 is electrically connected to the radio frequency module 20, and the external port of the radiation system may be understood as one end of the grounding plane layer 30 that is electrically connected to the radio frequency module 20.

**[0048]** The application also provides a wireless apparatus including a radiation system, a matching system 40 and a transmission cable. As shown in Fig. 3, the radiation structure in the radiation system include the radiation enhancer 10, the transmission cable thereof electrically connecting the matching system 40 and the radio frequency module 20 in the radiation system.

**[0049]** The matching system 40 may include a plurality of circuits, and the matching system 40 is configured for adjusting the signal generated by the radio frequency module 20 to be in a preset frequency band.

**[0050]** In an embodiment, the radiation system in the wireless apparatus may include the radiation structure, the radio frequency module 20, and the external port in the above embodiments.

**[0051]** One end of the transmission cable may be electrically connected to the radio frequency module 20 in the radiation system, and the other end of the transmission cable may be electrically connected to the matching system 40.

**[0052]** The wireless apparatus uses the radiation enhancer 10, the radiation current of the grounding plane layer 30 is excited through the electromagnetic coupling connection of the first conductive element 12 and the second conductive element 13, the transmission cable and the matching system 40, the signal generated by the radio frequency module 20 is adjusted based on the matching system 40, single-band, dual-band, and multi-band electromagnetic energy radiation can be completed, which effectively improves the radiation efficiency of the wireless apparatus.

**[0053]** Referring to Fig. 4, which is a diagram of passive performance-S parameter of an antenna of the wireless apparatus according to an embodiment of the present application.

**[0054]** In Fig. 4, the abscissa represents the frequency of a signal generated by the wireless apparatus, and the ordinate represents the return loss. Among M1 (824 MHz, -8.13 dB), M2 (960 MHz, -7.61 dB), M3 (1710 MHz, -7.45 dB), M4 (2170 MHz, -7.35 dB), M5 (2300 MHz, -10.37 dB), and M6 (2700 MHz, -15.42 dB) in Fig. 4 the frequency band corresponding to M1 to M2, namely 824 MHz-960 MHz, may represent a low frequency band in 2G communication; the frequency band corresponding to M3-M4, namely 1710 MHz-2170 MHz, may represent a frequency band in 3G communication; the frequency band corresponding to M5-M6, namely 2300 MHz-2700 MHz, may represent a high frequency band in 4G communication, these three frequency bands can cover a plurality of currently used communication modes such as GSM (Global System for Mobile Communications) 850, GSM900, GSM1800, GSM1900, WCDMA (Wideband Code Division Multiple Access) 1900,

WCDMA2100, TD-SCDMA (Time Division-Synchronous Code Division Multiple Access), CDMA (Code Division Multiple Access), LTE (Long Term Evolution) 1, LTE3, LTE5, LTE8, LTE38, LTE39, LTE40, LTE41, WIFI 2.4-2.5G, and the return loss of these three frequency bands is all below -5 dB, that is, in the frequency bands of 2G, 3G and 4G communication, the radiation enhancer according to the embodiments of the present application can effectively improve the working performance of the wireless apparatus.

**[0055]** The above embodiments are only the preferred embodiments of the present application and are not intended to limit the present application. Any modifications, equivalents, improvements and the like made within the spirit and principle of the present application should be included in the protection scope of the present application.

## Claims

1. A radiation enhancer of a wireless apparatus, wherein the radiation enhancer comprises:

   a dielectric substrate;
   a first conductive element, which is mounted on a first side surface of the dielectric substrate;
   a second conductive element, which is mounted on a second side surface of the dielectric substrate opposite to the first side surface;
   wherein the thickness between the first side surface and the second side surface of the dielectric substrate is such that a non-contact and electromagnetic coupling connection of the first conductive element and the second conductive element is enabled.

2. The radiation enhancer of claim 1, wherein the first conductive element or the second conductive element is provided with two internal connection ports.

3. The radiation enhancer of claim 2, wherein the two internal connection ports are disposed symmetrically with respect to a center line of the first conductive element or the second conductive element.

4. The radiation enhancer of claim 3, wherein the first conductive element and the second conductive element overlap corresponding side surfaces of the dielectric substrate, and the two internal connection ports are disposed at ends of the first conductive element or the second conductive element.

5. The radiation enhancer of claim 2, wherein one of the internal connection ports is configured for electrically connecting to a radio frequency module of the wireless apparatus, and the other of the internal connection ports is configured for fixedly connecting to a mainboard of the wireless apparatus.

6. The radiation enhancer of claim 1, wherein a distance between the first side surface and the second side surface is less than one twentieth of a wavelength propagating in an air medium corresponding to a lowest resonant frequency point of the radiation enhancer.

7. The radiation enhancer of claim 1, wherein the dielectric substrate is provided in a cubic shape, and a maximum side length of the dielectric substrate is less than one twentieth of a wavelength propagating in the air medium corresponding to a lowest resonant frequency point of the radiation enhancer.

8. The radiation enhancer of claim 6 or 7, wherein the lowest resonant frequency point is within a frequency band of 698 MHz-960 MHz.

9. A radiation system of a wireless apparatus, wherein the radiation system comprises a radiation structure, a radio frequency module and an external port, wherein the radiation structure comprises the radiation enhancer of any one of claims 1-8, and wherein the radiation enhancer and the external port are electrically connected to the radio frequency module, respectively.

10. The radiation system of claim 9, wherein the radiation structure further comprises a grounding plane layer electrically connecting the radiation enhancer and the radio frequency module.

11. A wireless apparatus, wherein the wireless apparatus comprises a radiation system, a matching system, and a transmission cable, wherein a radiation structure in the radiation system comprises the radiation enhancer of any one of claims 1-8, and wherein the transmission cable electrically connects the matching system and a radio frequency module in the radiation system.

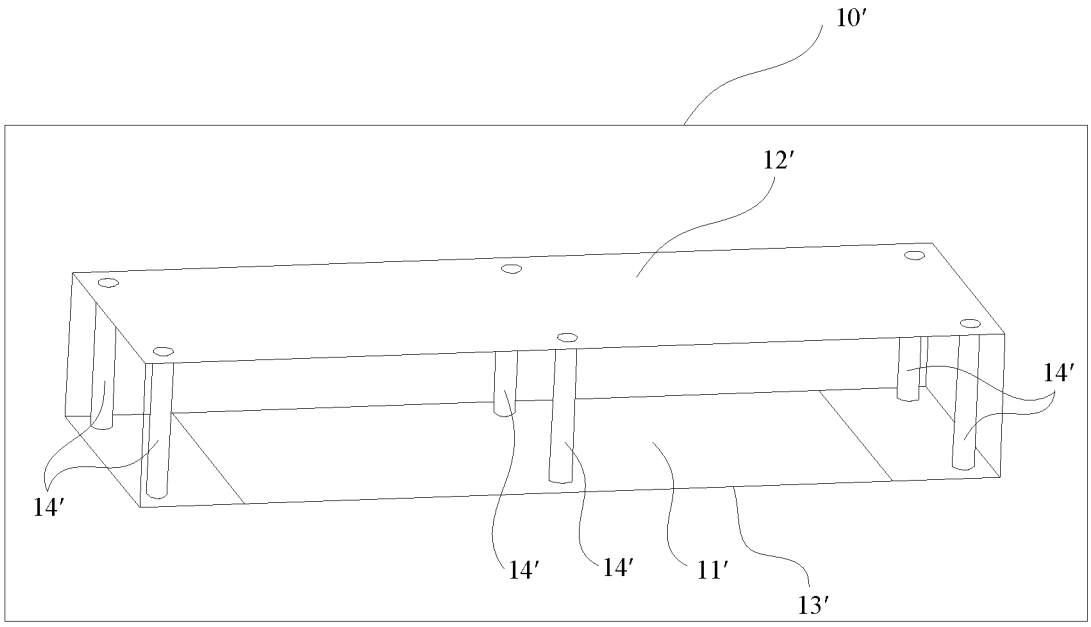


Fig. 1

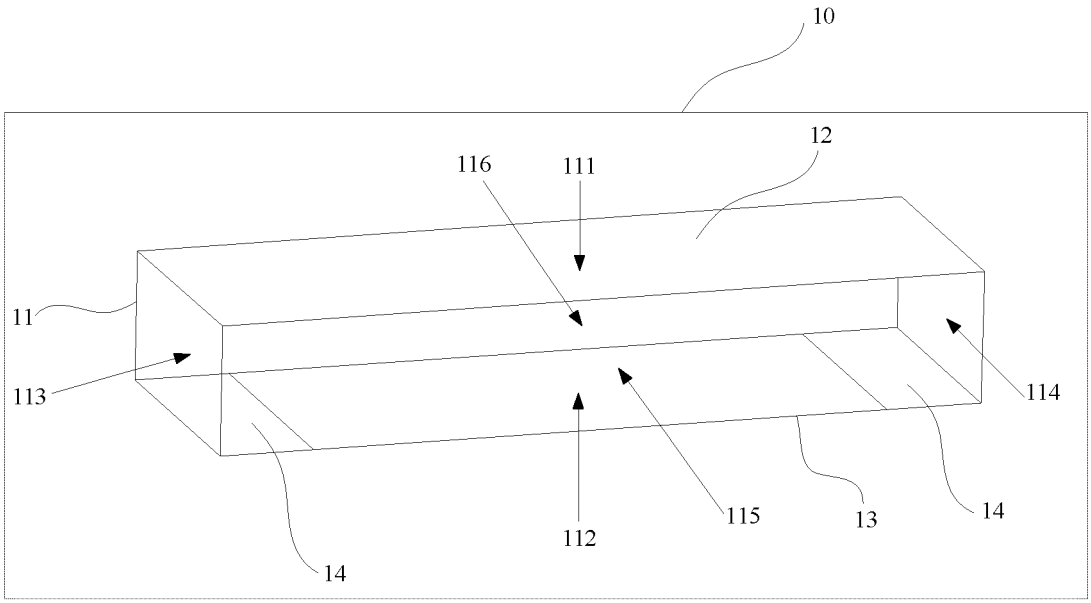


Fig. 2

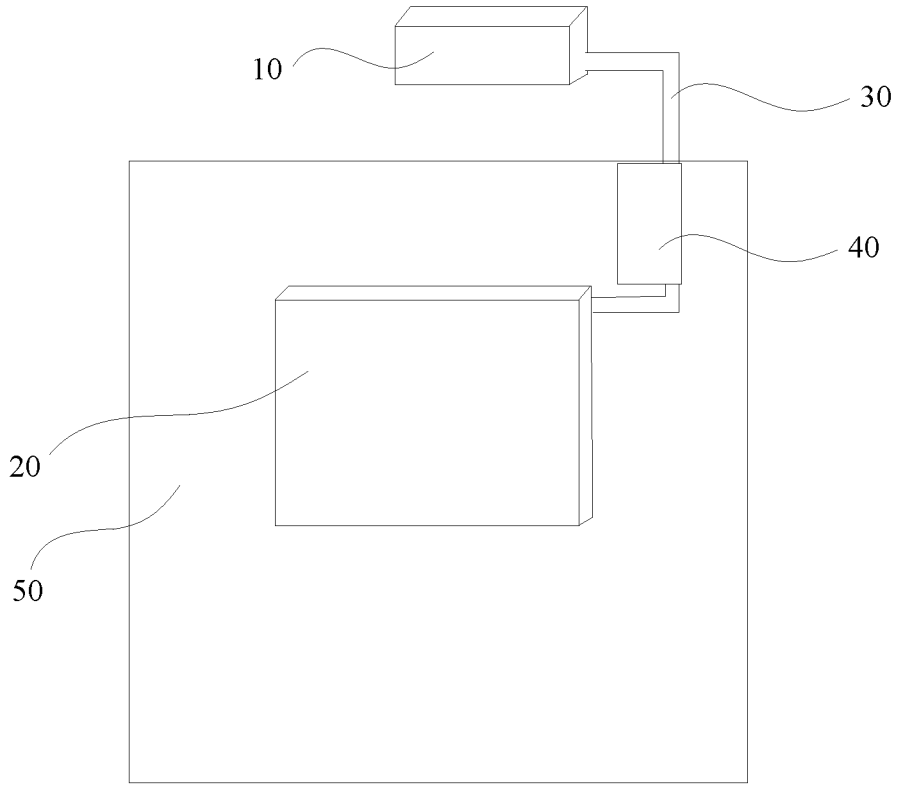
10
30
40
20
50

Fig. 3

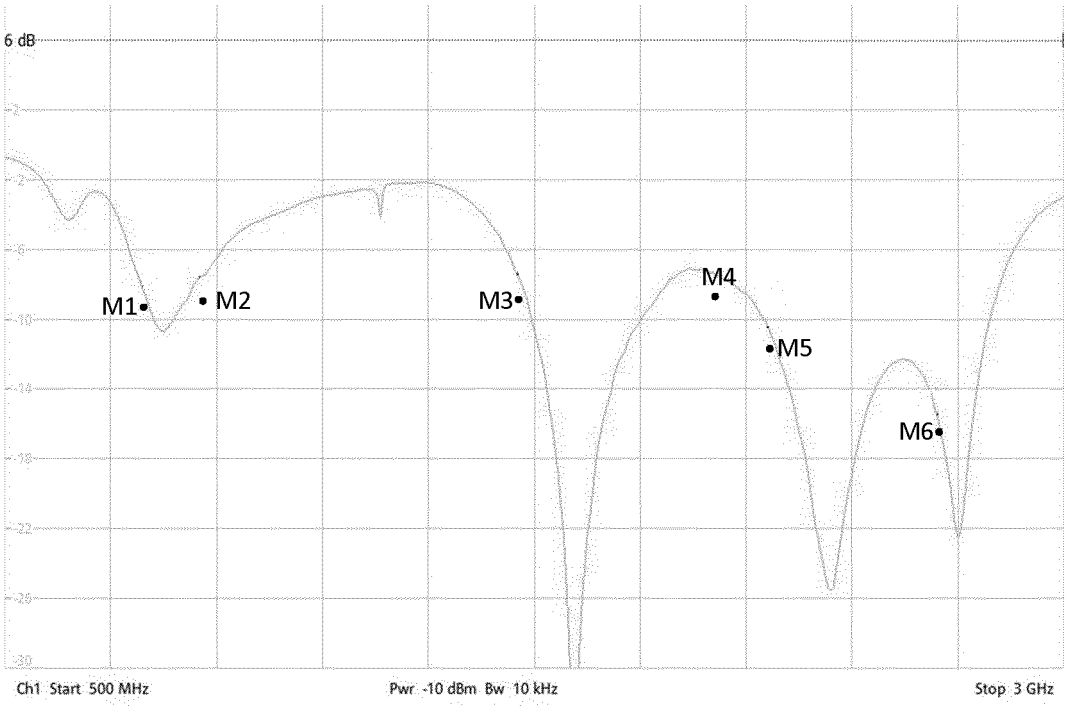
6 dB
M1
M2
M3
M4
M5
M6
Ch1 Start 500 MHz
Pwr -10 dBm Bw 10 kHz
Stop 3 GHz

Fig. 4

## INTERNATIONAL SEARCH REPORT

International application No.
**PCT/CN2019/128758**

**A. CLASSIFICATION OF SUBJECT MATTER**

H01Q 19/00(2006.01)i; H01Q 1/38(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)

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)

CNABS; CNKI; CNTXT; VEN; IEEE; WEB OF SCIENCE; USTXT; EPTXT; WOTXT: 寄生, 耦合, 介质, parasit+, coupl+, substrate

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| PX | CN 209607916 U (HANGZHOU HIKVISION DIGITAL TECTECHNOLOGY CO., LTD.) 08 November 2019 (2019-11-08)<br>claims 1-11 | 1-11 |
| X | CN 1501586 A (MURATA MANUFACTURING CO., LTD.) 02 June 2004 (2004-06-02)<br>description, pages 11-16, and figures 11-12B | 1-11 |
| A | CN 102694245 A (MURATA MANUFACTURING CO., LTD.) 26 September 2012 (2012-09-26)<br>entire document | 1-11 |

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

* Special categories of cited documents:
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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| **14 February 2020** | **17 March 2020** |

| Name and mailing address of the ISA/CN | Authorized officer |
|---|---|
| **China National Intellectual Property Administration (ISA/CN)**<br>**No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088**<br>**China** | |
| Facsimile No. **(86-10)62019451** | Telephone No. |

Form PCT/ISA/210 (second sheet) (January 2015)

**INTERNATIONAL SEARCH REPORT**
**Information on patent family members**

International application No.
**PCT/CN2019/128758**

| Patent document cited in search report | | | Publication date (day/month/year) | Patent family member(s) | | | Publication date (day/month/year) |
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Form PCT/ISA/210 (patent family annex) (January 2015)

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