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

(11) **EP 3 319 166 A1**

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

(43) Date of publication:
09.05.2018 Bulletin 2018/19

(21) Application number: **15909085.1**

(22) Date of filing: **27.11.2015**

(51) Int Cl.:
***H01P 1/207** (2006.01)* ***H01P 1/208** (2006.01)*
***H01P 5/00** (2006.01)*

(86) International application number:
PCT/CN2015/095791

(87) International publication number:
WO 2017/088174 (01.06.2017 Gazette 2017/22)

(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
Designated Validation States:
MA MD

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(54) **DIELECTRIC FILTER, TRANSCEIVER AND BASE STATION**

(57) Embodiments of the present invention provide a dielectric filter, and relate to the technical field of communication device components, to provide a novel dielectric filter structure for implementing cross coupling. The dielectric filter provided in the embodiments of the present invention includes at least three resonant cavities, each resonant cavity includes a debug hole, the debug hole is disposed in a body, each debug hole and the surrounding body of the debug hole form a resonant cavity, a blind hole is disposed between two resonant cavities that are not adjacent to each other, and the blind hole is configured to implement cross coupling. The dielectric resonator provided in the embodiments of the present invention simplifies a structure for implementing capacitive coupling and further enhances structure miniaturization.

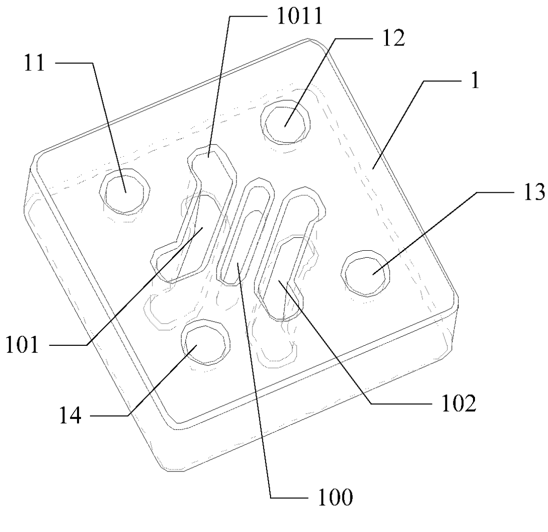

FIG. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to a communication device component, and in particular, to a dielectric filter, a transceiver, and a base station.

BACKGROUND

[0002] A dielectric filter has become an indispensable part in a modern mobile communications technology, and is widely applied to various mobile communications systems, to filter out a noise wave or an interference signal other than a communication signal frequency.

[0003] Like a metal filter, the dielectric filter needs to use cross coupling to implement high selectivity of the dielectric filter. Cross coupling has two forms: capacitive coupling and inductive coupling. In capacitive coupling, a transmission zero is formed at a low end of a dielectric filter response, so as to form high selectivity at the low end of the dielectric filter. In inductive coupling, a transmission zero is formed at a high end of a dielectric filter response, so as to form high selectivity at the high end of the dielectric filter. At present, in a dielectric filter commonly used in the industry, a transmission zero of the dielectric filter usually can implement only inductive coupling. To implement capacitive coupling of the dielectric filter, an additional structure such as a PCB or a cable needs to be bridged to a dielectric, or a near-cavity structure of non-cross coupling needs to be used. These additional structures bring inconvenience to processing, assembly, and tuning of the dielectric filter.

[0004] In addition, ever-increasing development of wireless communications technologies requires miniaturization of both a base station and a dielectric filter in the base station. However, an additional structure needs to be cascaded to an existing dielectric filter to implement capacitive coupling. As a result, the existing dielectric filter cannot meet the base station miniaturization requirement in the existing communications technologies.

SUMMARY

[0005] Embodiments of the present invention provide a dielectric filter, to resolve a prior-art problem that an existing dielectric filter that can implement capacitive coupling occupies large space.

[0006] According to a first aspect, an embodiment of this application provides a dielectric filter, including a body and at least three resonant cavities, where each resonant cavity includes a debug hole, the debug hole is disposed in the body, each debug hole and the surrounding body of the debug hole form a single resonant cavity, a blind hole is disposed between two resonant cavities that are not adjacent to each other, the blind hole is not connected to the debug hole, and the blind hole is configured to implement cross coupling. A conducting layer is attached to a surface of the surrounding body of the resonant cavity.

[0007] In a possible design, a depth of the blind hole is related to a transmission zero of the dielectric filter.

[0008] In a possible design, the depth of the blind hole may determine a polarity of cross coupling of the dielectric filter, and the polarity of the cross coupling includes inductive coupling or capacitive coupling.

[0009] In a possible design, the depth of the blind hole may determine a degree of the cross coupling of the dielectric filter.

[0010] In a possible design, the depth of the blind hole is related to the polarity of the cross coupling, and when the depth of the blind hole increases, the polarity of the cross coupling may correspondingly change from inductive coupling to capacitive coupling.

[0011] In a possible design, the blind hole is in one of the following shapes: a cylindrical shape, a groove shape, a strip shape, or a hole shape.

[0012] In a possible design, a width of the blind hole is related to the transmission zero. Specifically, a larger width of the blind hole indicates a smaller relative location of the transmission zero, and the relative location of the transmission zero to a location of a central frequency of the dielectric filter is greater than 1.

[0013] In a possible design, a depth of the debug hole may be used to determine a resonance frequency of a resonant cavity corresponding to the debug hole. The debug holes may have depths different from one another, so that a separate resonance frequency may be set for a corresponding resonant cavity of each debug hole according to a specific scenario, or all resonance frequencies may be the same.

[0014] According to another aspect, an embodiment of the present invention provides a transceiver, including the dielectric filter described in any one of the foregoing possible designs.

[0015] According to another aspect, an embodiment of the present invention further provides a base station, including the transceiver described above.

[0016] New structures inside the dielectric filter, the transceiver, and the base station provided in the embodiments of the present invention are used to implement capacitive coupling. This simplifies a manufacturing process, and further minimizes a structure of the dielectric filter.

BRIEF DESCRIPTION OF DRAWINGS

[0017] 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.

FIG. 1 is a perspective view of a dielectric filter structure according to an embodiment of the present invention;

FIG. 2 is a top view of a dielectric filter structure according to an embodiment of the present invention;

FIG. 3 is a bottom view of a dielectric filter structure according to an embodiment of the present invention;

FIG. 4 is a simulation diagram of inductive coupling of a dielectric filter according to an embodiment of the present invention;

FIG. 5 is a simulation diagram of capacitive coupling of a dielectric filter according to an embodiment of the present invention;

FIG. 6 is a perspective view of a dielectric filter structure according to an embodiment of the present invention; and

FIG. 7 is a perspective view of a dielectric filter structure according to an embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0018] The technical solutions according to embodiments of the present invention are clearly and completely described in the following with reference to the accompanying drawings. 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.

[0019] Structures and application scenarios described in the embodiments of the present invention are intended to describe the technical solutions in the embodiments of the present invention more clearly, and do not constitute limitation on the technical solutions provided in the embodiments of the present invention. A person of ordinary skill in the art can know that with development of the communications technologies, the technical solutions provided in the embodiments of the present invention are also applicable to a similar technical problem.

[0020] To resolve the problem of an existing dielectric filter mentioned in the Background, the embodiments of the present invention creatively propose a novel structure of a dielectric filter, to implement capacitive coupling without cascading an additional structure to a dielectric. The embodiments of the present invention are described in detail below with reference to the accompanying drawings. It should be noted that the accompanying drawings provided in the embodiments of the present invention are merely examples used to describe the embodiments of the present invention, and are not intended to limit the protection scope of the present invention.

[0021] As shown in FIG. 1, the dielectric filter includes at least three resonant cavities. In an embodiment of the present invention, for example, a dielectric filter includes four resonant cavities. A main structure of a dielectric resonator includes a body (1). Four debug holes (11, 12, 13, and 14) are respectively disposed in four corners of the body (1). Through holes (101 and 102) are disposed between adjacent debug holes. The through hole is disposed through an upper surface and a lower surface of the body (1). In this embodiment, both the through holes (101 and 102) are designed to be of a strip shape, and two ends of the through hole are respectively bent towards somewhere between two adjacent debug holes. The through hole (101) is used as an example. The through hole (101) is of a strip shape, and disposed through the upper surface and the lower surface of the body (1). One end (1011) of the strip shape of the through hole (101) is bent towards somewhere between the debug hole (11) and the debug hole (12), and the other end is bent towards somewhere between the debug hole (11) and the debug hole (14). The through hole (101) separates the debug hole (11) from another debug hole (such as 12 and 14), so that a resonant cavity is formed around the debug hole (11). Similarly, the through hole (101) and the through hole (102) together separate the four debug holes, so that a single resonant cavity is separately formed around each debug hole. Therefore, the dielectric resonator shown in FIG. 1 includes four resonant cavities. One end of each debug hole is disposed through the upper surface of the body (1), and the other end goes deep into the body (1), so as to form a concavity. A depth of the debug hole may be designed and manufactured according to a need, and different resonance frequencies can be obtained in formed resonant cavities by setting different depths for the debug holes. Depths of the debug holes may all be set according to a specific application scenario, and the depths may be set to be the same or different.

[0022] As shown in FIG. 1, a resonant cavity formed around the debug hole (12) and a resonant cavity formed around the debug hole (14) are not adjacent to each other. For these two resonant cavities that are not adjacent to each other, a blind hole (100) is disposed at a location shown in FIG. 1: the blind hole (100) is disposed between the debug hole (12) and the debug hole (14). The blind hole (100) in this embodiment is designed to be of a strip shape. An upper end of the blind hole (100) is disposed through the upper surface of the body (1), and a lower end of the blind hole may be set according to a required depth. One end of the blind hole (100) is near to the resonant cavity formed by the debug hole (12), and the other end is near to the resonant cavity formed by the debug hole (14). Neither of the two ends of the blind hole (100) communicates with the debug hole (12) and the debug hole (14). The blind hole (100) communicates with neither of the through holes (101 and 102) that are located on two sides of the blind hole (100).

[0023] The through hole, the debug hole, and the blind hole in this embodiment of the present invention may be of a square shape, a circular shape, a strip shape, an oval shape, or another shape in plane. This is not limited in this embodiment of the present invention.

[0024] The body (1) is generally made of a solid dielectric material, preferentially ceramics. With a relatively high dielectric constant, relatively excellent hardness and heat resistance, the ceramics have become a common solid dielectric material in the field of dielectric filters. Certainly, another material such as glass and an electrical-insulating macromolecular polymer known to a person skilled in the art may alternatively be selected as a dielectric material.

[0025] During designing and manufacturing, the dielectric filter may be obtained in the following manner: forming the all-in-one body (1) with the debug hole, the through hole, and the blind hole; and then performing surface metallization such as surface plating on the body. In this way, the body of the dielectric resonator included in the dielectric filter is continuous. When the dielectric filter is obtained in the integrated forming manner, a manufacturing process of the dielectric filter can be simpler.

[0026] A dielectric filter with more cavities is shown in FIG. 7. The dielectric filter with more resonant cavities may be formed by means of cascading to a fixed structure with three cavities (as shown in FIG. 6) or four cavities. For the dielectric filter with more cavities, a blind hole is disposed between non-adjacent resonant cavities, to implement cross coupling. Refer to the foregoing embodiment for the structure implementation of the dielectric filter including three or more resonant cavities, and details are not repeated herein.

[0027] The blind hole (100) is related to coupling of the dielectric filter. A cross coupling form of the dielectric filter may be determined by determining a depth of the blind hole (100). The depth of the blind hole herein is a depth that the blind hole reaches into the inside of the body (1) of the dielectric filter from the upper surface of the dielectric filter. When the depth of the blind hole increases, polarity of cross coupling of the dielectric filter can change from inductive coupling to capacitive coupling. The depth of the blind hole may be set according to a need in an actual application scenario, so that a degree of cross coupling varies.

[0028] During designing and manufacturing, the depth of the blind hole is usually fixed after the depth of the blind hole is determined according to a need in an actual application scenario. Specifically, the depth of the blind hole is fixed after a corresponding depth of the blind hole is determined according to a desired cross coupling characteristic of the dielectric filter, such as a corresponding desired degree of inductive coupling. Correspondingly, the depth of the blind hole may alternatively be fixed after a corresponding desired degree of capacitive coupling is determined. The implementation of a fixed blind hole depth can ensure quality during manufacture, and can keep the quality stable in subsequent use as no parameter deviates. In implementation, the depth of the blind hole of the dielectric filter may alternatively be designed to be tunable to adapt to application scenarios that require different parameters.

[0029] The depth of the blind hole may be set according to a need in an actual application scenario, such as a frequency of a transmission zero or a desired degree of inductive coupling or capacitive coupling. This is not limited herein.

[0030] In FIG. 1, there is one blind hole (100) between two non-adjacent resonant cavities, but more blind holes may alternatively be designed. A blind hole quantity, position, depth, and the like may be determined according to an actually required transmission zero quantity and/or frequency.

[0031] A width of the blind hole (100) is related to the transmission zero. Specifically, a larger width of the blind hole indicates a smaller relative location of the transmission zero, and the relative location of the transmission zero to a location of a central frequency of the dielectric filter is greater than 1.

[0032] The blind hole itself also has a resonance frequency. The resonance frequency of the blind hole is usually not used for resonance of a passband of the body of the filter. That is, the resonance frequency of the blind hole may be higher than a resonance frequency of the passband of the filter, or may be lower than a resonance frequency of the passband of the filter. When the resonance frequency of the blind hole is higher than the resonance frequency of the passband of the dielectric filter, cross coupling is inductive coupling. When the resonance frequency of the blind hole is lower than the resonance frequency of the passband of the dielectric filter, cross coupling is capacitive coupling. The resonance frequency of the blind hole may be determined by the depth of the blind hole. As the depth of the blind hole increases, the resonance frequency of the blind hole gradually decreases. When the frequency drops from a high end to a low end of the passband of the filter, cross coupling switches from inductive coupling to capacitive coupling. In specific implementation, in a dielectric filter including four resonant cavities, when a depth of a blind hole is 2/5 of a total height of the dielectric filter, cross coupling is inductive coupling, and a transmission zero is on the right side of a passband, as shown in FIG. 4. When the depth of the blind hole changes to 3/5 of the total height, cross coupling is capacitive coupling, and the transmission zero is on the left side of the passband, as shown in FIG. 5.

[0033] A conducting layer is attached to the surface of the dielectric resonator, and conducting layers may also be attached to concave surfaces of the blind hole, the through hole, and the debug hole.

[0034] In the dielectric filter provided in this embodiment of the present invention, the blind hole is disposed between the non-adjacent resonant cavities. In this way, capacitive coupling can be implemented inside the dielectric resonator without cascading an additional external structure, so that miniaturization of the dielectric filter is implemented. In addition, compared with a dielectric filter that implements capacitive coupling by cascading an additional external structure, this solution simplifies a manufacturing process of a structure that implements cross coupling.

[0035] The dielectric filter provided in this embodiment of the present invention is mainly applied to a radio frequency front end of a high-power wireless communications base station.

[0036] An embodiment of the present invention further provides a transceiver. The dielectric filter provided in the foregoing embodiment is used in the transceiver. The dielectric filter may be configured to filter a radio frequency signal.

[0037] An embodiment of the present invention further provides a base station. The transceiver provided in the foregoing embodiment is used in the base station.

[0038] The objectives, technical solutions, and benefits of the present invention are further described in detail in the foregoing specific implementations. It should be understood that the foregoing descriptions are merely specific implementations of the present invention, but are not intended to limit the protection scope of the present invention. Any modification, equivalent replacement, or improvement made within the spirit and principle of the present invention shall fall within the protection scope of the present invention.

Claims

1. A dielectric filter, comprising a body, wherein the dielectric filter further comprises:
at least three resonant cavities, wherein each resonant cavity comprises a debug hole, the debug hole is disposed in the body, each debug hole and the surrounding body of the debug hole form a single resonant cavity, a blind hole is disposed between the two resonant cavities that are not adjacent to each other, the blind hole is not connected to the debug hole, and the blind hole is configured to implement cross coupling.

2. The dielectric filter according to claim 1, wherein a depth of the blind hole is related to a transmission zero of the dielectric filter.

3. The dielectric filter according to claim 1 or 2, wherein the depth of the blind hole determines a polarity of cross coupling of the dielectric filter, and the polarity of the cross coupling comprises inductive coupling or capacitive coupling.

4. The dielectric filter according to claim 3, wherein the depth of the blind hole determines a degree of the cross coupling of the dielectric filter.

5. The dielectric filter according to any one of claims 1 to 4, wherein the depth of the blind hole is related to the polarity of the cross coupling, and when the depth of the blind hole increases, the polarity of the cross coupling changes from inductive coupling to capacitive coupling.

6. The dielectric filter according to any one of claims 1 to 5, wherein the blind hole is in one of the following shapes: a cylindrical shape, a groove shape, a strip shape, or a hole shape.

7. The dielectric filter according to any one of claims 1 to 6, wherein a width of the blind hole is related to the transmission zero.

8. The dielectric filter according to claim 7, wherein that a width of the blind hole is related to the transmission zero comprises:
a larger width of the blind hole indicates a smaller relative location of the transmission zero, and the relative location of the transmission zero to a location of a central frequency of the dielectric filter is greater than 1.

9. The dielectric filter according to any one of claims 1 to 8, wherein a depth of the debug hole is used to determine a resonance frequency of a resonant cavity corresponding to the debug hole.

10. A transceiver, comprising the dielectric filter according to any one of claims 1 to 9.

11. Abase station, comprising the transceiver according to claim 10.

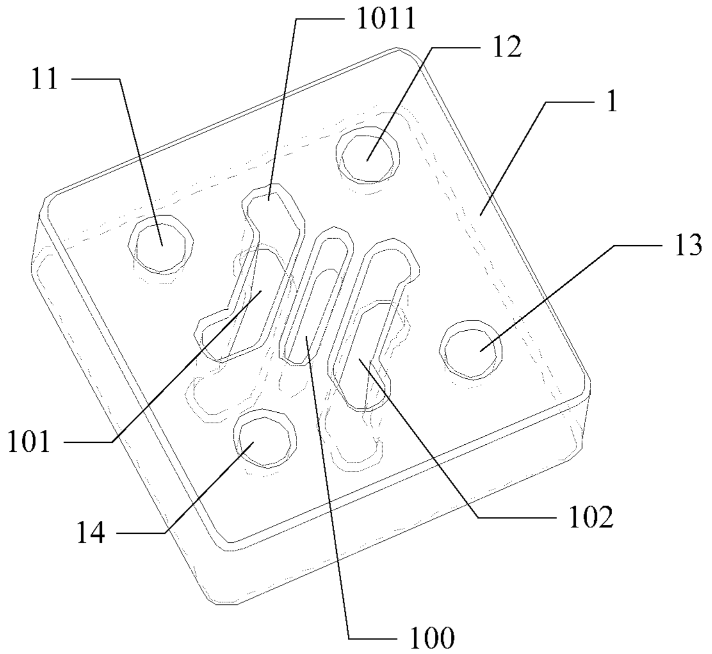


FIG. 1

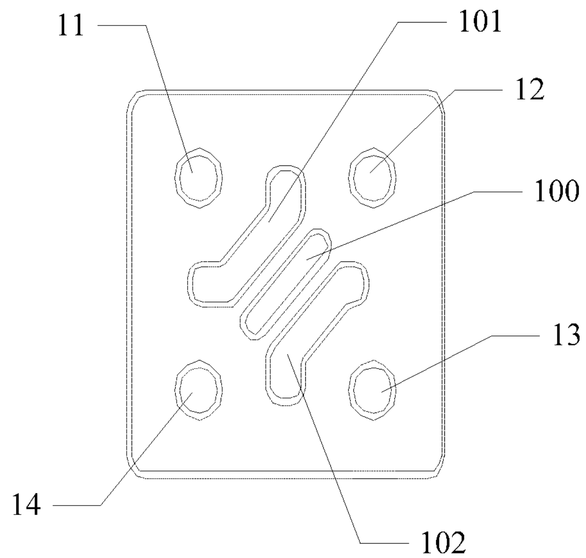


FIG. 2

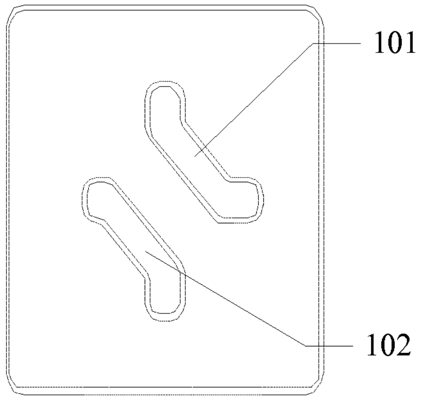


FIG. 3

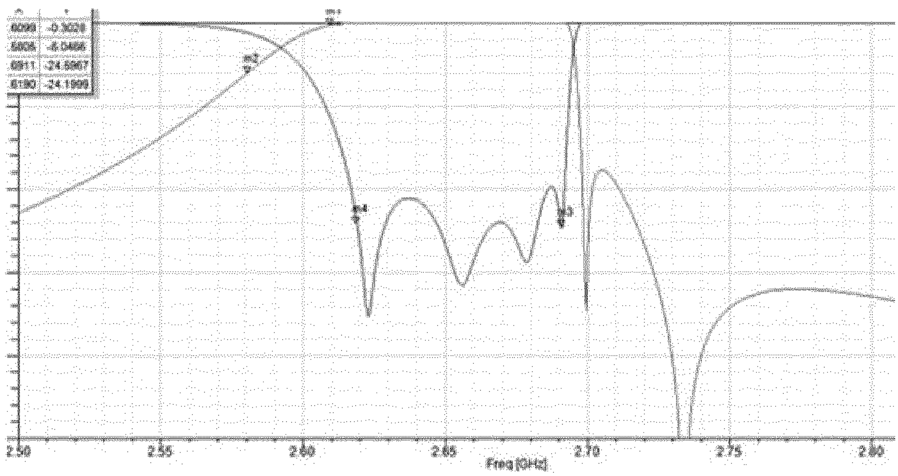
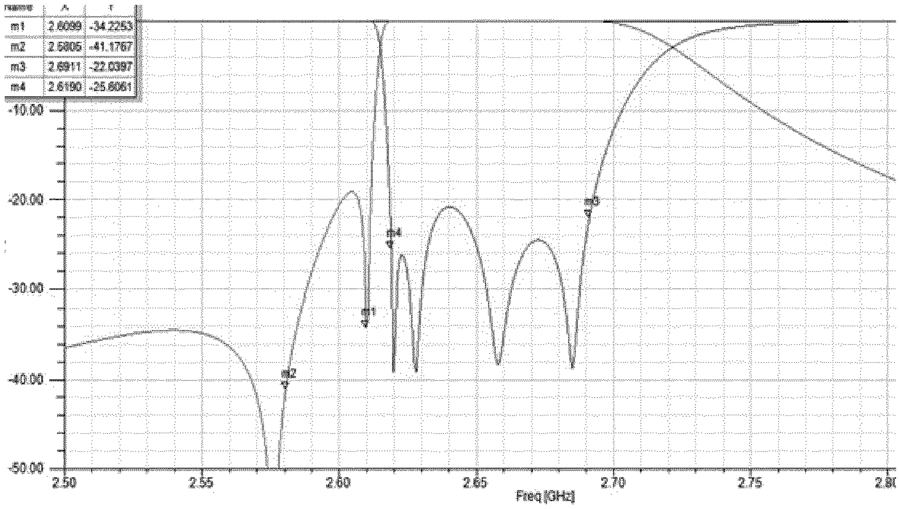


FIG. 4



m1 2.6099 -34.2253
m2 2.5805 -41.1767
m3 2.6911 -22.0397
m4 2.6190 -25.6061
-10.00
-20.00
-30.00
-40.00
-50.00
2.50
2.55
2.60
2.65
2.70
2.75
Freq [GHz]
m1
m2
m3
m4

FIG. 5

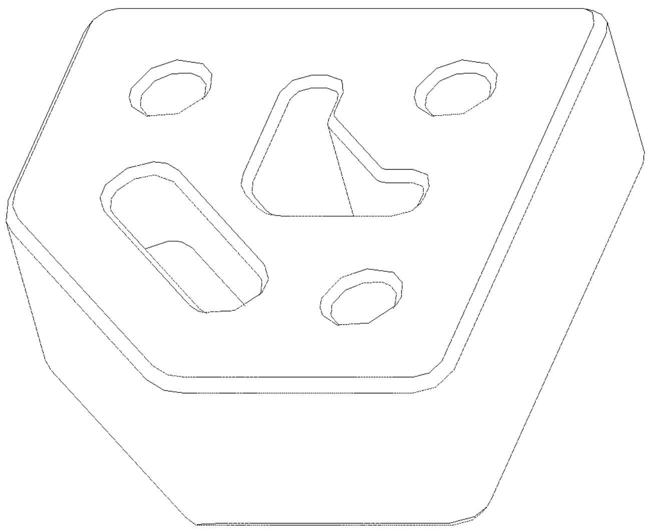


FIG. 6

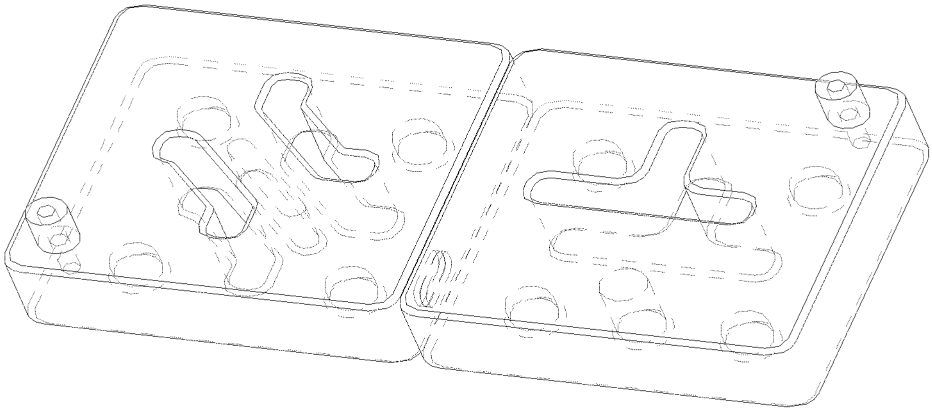


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No. **PCT/CN2015/095791**

A. CLASSIFICATION OF SUBJECT MATTER

H01P 1/207 (2006.01) i; H01P 1/208 (2006.01) i; H01P 5/00 (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)

H01P

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, WPI, EPODOC, CNKI: cross coupling, capacitive coupling, resonant cavity, seam, dielectric resonator, dielectric filter, blind hole, blind via, conducting layer, slot, aperture, couple, frequency, zero

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 102544658 A (SHENZHEN TAT FOOK TECHNOLOGY CO., LTD.), 04 July 2012 (04.07.2012), abstract, description, paragraphs [0005]-[0033], and figure 2	1-11
X	CN 202474159 U (SHENZHEN TAT FOOK TECHNOLOGY CO., LTD.), 03 October 2012 (03.10.2012), abstract, description, paragraphs [0005]-[0033], and figure 2	1-11
A	CN 104900951 A (HUAWEI TECHNOLOGIES CO., LTD.), 09 September 2015 (09.09.2015), the whole document	1-11
A	CN 202797211 U (WUHAN FINGU ELECTRONIC TECHNOLOGY CO., LTD.), 13 March 2013 (13.03.2013), the whole document	1-11
A	US 2009231064 A1 (DIELECTRIC LABORATORIES, INC.), 17 September 2009 (17.09.2009), the whole document	1-11
A	WO 2014190536 A1 (HUAWEI TECHNOLOGIES CO., LTD.), 04 December 2014 (04.12.2014), the whole 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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"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
31 July 2016 (31.07.2016)	**22 August 2016 (22.08.2016)**

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Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/095791

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 102544658 A	04 July 2012	None	
CN 202474159 U	03 October 2012	None	
CN 104900951 A	09 September 2015	None	
CN 202797211 U	13 March 2013	None	
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		US 2016094265 A1	31 March 2016
		EP 3007267 A1	13 April 2016

Form PCT/ISA/210 (patent family annex) (July 2009)