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

DIELEKTRISCHES FILTER, SENDE-EMPFÄNGER UND BASISSTATION

FILTRE DIÉLECTRIQUE, ÉMETTEUR-RÉCEPTEUR ET STATION DE BASE

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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.

[0005] CA 2914434 A1 discloses embodiments that relate to the technical field of communications device components, and provide a dielectric resonator and a dielectric filter, a transceiver and a base station using the same, which solve the problem that a loss indicator of existing dielectric resonators cannot meet filtering requirements of a base station. The dielectric resonator comprises a body made of a solid dielectric material, wherein a recess is arranged on the surface of the body, and the surface of the body and the surface of the recess are covered by a conductive layer. A dielectric filter comprises at least two of the dielectric resonators. Another dielectric filter comprises a body made of a solid dielectric material, wherein at least two recesses are arranged on the surface of the body, a hole and/or groove is arranged between two adjacent recesses, and the surface of the body is covered by a conductive layer. The transceiver com-

prises the dielectric filter. The base station comprises the transceiver.

[0006] WO 2014/190536 A1 discloses embodiments that provide a dielectric filter, which relates to the technical field of communication device assemblies and solves the problem that it is difficult for a solid dielectric filter to realize capacitive coupling. The dielectric filter provided in the embodiments of the disclosure comprises at least two dielectric resonators, and each dielectric resonator comprises a body made of a solid dielectric material and a debugging hole located on the surface of the body; the bodies of all the dielectric resonators included in the dielectric filter constitute a body of the dielectric filter, and the dielectric filter further comprises: at least one negative coupling hole, wherein each negative coupling hole is located on a position of the surface of the body where two dielectric resonators are connected, and the located position thereof is connected to the two dielectric resonators; and a conducting layer covering the surface of the body of the dielectric filter, the surface of the debugging hole and the surface of the negative coupling hole. The embodiments of the disclosure are mainly used for a radio frequency front end of a high-power wireless communication base station.

[0007] US 4,246,555 A discloses that multiple coupled high Q cavities are used to generate odd order elliptic function band-pass filters using a minimum number of cavities connected by simple and resonant coupling elements. A specific embodiment of a 3-pole, 20 MHz band-pass wave guide cavity filter centered at 3890 MHz is disclosed. Couplings between cavities may be either on the end walls or the side walls. The simple coupling elements may be simple coupling holes, and the resonant coupling elements may be a non-shorting screw in a window between cavities.

SUMMARY

[0008] 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.

[0009] According to a first aspect, an embodiment of this application provides a dielectric as defined in the appended claims.

[0010] 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

[0011] 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

[0012] 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.

[0013] 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.

[0014] 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.

[0015] 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.

[0016] 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).

[0017] The through hole and the debug 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.

[0018] 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.

[0019] 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.

[0020] 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.

[0021] 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.

[0022] 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.

[0023] 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.

[0024] 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.

[0025] 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.

[0026] 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 $\frac{2}{5}$ 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 $\frac{3}{5}$ 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.

[0027] 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.

[0028] 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 ad-

ditional external structure, this solution simplifies a manufacturing process of a structure that implements cross coupling.

[0029] 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.

[0030] 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.

[0031] An embodiment of the present invention further provides a base station. The transceiver provided in the foregoing embodiment is used in the base station.

[0032] 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 principle of the present invention shall fall within the protection scope of the present invention defined by the appended claims.

Claims

1. A dielectric filter, comprising a dielectric body (1), wherein the dielectric filter further comprises:

at least three resonant cavities bound by a surface of the body (1), wherein each resonant cavity comprises a debug hole (11-14), the debug hole is disposed in the body and a first end of the debug hole is disposed through an upper surface of the body, and a second end of the debug hole goes deep into the body, each debug hole and the surrounding body of the debug hole form a single resonant cavity, the dielectric filter further comprises a blind hole (100) 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, and the dielectric filter further comprises at least one through hole (101, 102),

characterized in that the blind hole is in a groove shape and the at least one through hole is of a strip shape, with two ends of the through hole bent towards somewhere between two adjacent debug holes.

2. The dielectric filter according to claim 1, wherein a depth of the blind hole (100) 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 (100) 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 (100) 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 (100) 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 a width of the blind hole (100) is related to the transmission zero.

7. The dielectric filter according to claim 6, wherein that a width of the blind hole (100) 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 location of the transmission zero relative to a central frequency of the dielectric filter is greater than 1.

8. The dielectric filter according to any one of claims 1 to 7, wherein a depth of the debug hole (11-14) determines a resonance frequency of a resonant cavity corresponding to the debug hole.

9. A transceiver, comprising the dielectric filter according to any one of claims 1 to 8.

10. A base station, comprising the transceiver according to claim 9.

Patentansprüche

1. Dielektrischer Filter, umfassend einen dielektrischen Körper (1), wobei der dielektrische Filter ferner Folgendes umfasst:

mindestens drei Resonanzhöhlräume, die durch eine Fläche des Körpers (1) gebunden sind,

wobei jeder Resonanzhohlraum ein Debug-Loch (11-14) umfasst, das Debug-Loch im Körper angeordnet ist und ein erstes Ende des Debug-Lochs durch eine obere Fläche des Körpers hindurch angeordnet ist, und ein zweites Ende des Debug-Lochs tief in den Körper hineinreicht, jedes Debug-Loch und der Hüllkörper des Debug-Lochs einen einzelnen Resonanzhohlraum

- bilden, der dielektrische Filter ferner ein Blindloch (100) umfasst, das zwischen zwei Resonanzhohlräumen angeordnet ist, die nicht aneinander angrenzen, das Blindloch nicht mit dem Debug-Loch verbunden ist und das Blindloch dazu konfiguriert ist, eine Kreuzkopplung zu implementieren, und der dielektrische Filter ferner mindestens ein Durchgangsloch (101, 102) umfasst,
- dadurch gekennzeichnet, dass** das Blindloch in Form einer Nut vorliegt und mindestens ein Durchgangsloch eine Streifenform aufweist, wobei beide Enden des Durchgangslochs in Richtung irgendeiner Stelle zwischen zwei benachbarten Debug-Löchern gebogen sind.
2. Dielektrischer Filter nach Anspruch 1, wobei eine Tiefe des Blindlochs (100) mit einer Übertragungsnullstelle des dielektrischen Filters zusammenhängt.
 3. Dielektrischer Filter nach Anspruch 1 oder 2, wobei die Tiefe des Blindlochs (100) eine Kreuzkopplungspolarität des dielektrischen Filters bestimmt und die Polarität der Kreuzkopplung eine induktive Kopplung oder eine kapazitive Kopplung umfasst.
 4. Dielektrischer Filter nach Anspruch 3, wobei die Tiefe des Blindlochs (100) einen Grad der Kreuzkopplung des dielektrischen Filters bestimmt.
 5. Dielektrischer Filter nach einem der Ansprüche 1 bis 4, wobei die Tiefe des Blindlochs (100) mit der Polarität der Kreuzkopplung zusammenhängt und, wenn die Tiefe des Blindlochs zunimmt, die Polarität der Kreuzkopplung von einer induktiven Kopplung zu einer kapazitiven Kopplung wechselt.
 6. Dielektrischer Filter nach einem der Ansprüche 1 bis 5, wobei eine Breite des Blindlochs (100) mit der Übertragungsnullstelle zusammenhängt.
 7. Dielektrischer Filter nach Anspruch 6, wobei der Umstand, dass eine Breite des Blindlochs (100) mit der Übertragungsnullstelle zusammenhängt, Folgendes umfasst:
eine größere Breite des Blindlochs zeigt eine kleinere relative Position der Übertragungsnullstelle an, und die Position der Übertragungsnullstelle in Bezug auf eine zentrale Frequenz des dielektrischen Filters ist größer als 1.
 8. Dielektrischer Filter nach einem der Ansprüche 1 bis 7, wobei eine Tiefe des Debug-Lochs (11-14) eine Resonanzfrequenz eines Resonanzhohlraums bestimmt, der dem Debug-Loch entspricht.
 9. Sendeempfänger, umfassend den dielektrischen

Filter nach einem der Ansprüche 1 bis 8.

10. Basisstation, umfassend den Sendeempfänger nach Anspruch 9.

Revendications

1. Filtre diélectrique, comprenant un corps diélectrique (1), dans lequel le filtre diélectrique comprend en outre :

au moins trois cavités résonantes liées par une surface du corps (1), dans lequel chaque cavité résonante comprend un trou de débogage (11 à 14), le trou de débogage est disposé dans le corps et une première extrémité du trou de débogage est disposée à travers une surface supérieure du corps, et une seconde extrémité du trou de débogage descend profondément dans le corps, chaque trou de débogage et le corps environnant du trou de débogage forment une seule cavité résonante, le filtre diélectrique comprend en outre un trou borgne (100) disposé entre deux cavités résonantes qui ne sont pas adjacentes l'une à l'autre, le trou borgne n'est pas raccordé au trou de débogage, et le trou borgne est conçu pour implémenter un couplage parasite, et le filtre diélectrique comprend en outre au moins un trou traversant (101, 102),
caractérisé en ce que le trou borgne est en forme de gorge et l'au moins un trou traversant est en forme de bande, avec deux extrémités du trou traversant courbé vers un endroit quelconque entre deux trous de débogage adjacents.

2. Filtre diélectrique selon la revendication 1, dans lequel une profondeur du trou borgne (100) est liée à un zéro de transmission du filtre diélectrique.
3. Filtre diélectrique selon la revendication 1 ou 2, dans lequel la profondeur du trou borgne (100) détermine une polarité de couplage parasite du filtre diélectrique, et la polarité du couplage parasite comprend un couplage inductif ou un couplage capacitif.
4. Filtre diélectrique selon la revendication 3, dans lequel la profondeur du trou borgne (100) détermine un degré du couplage parasite du filtre diélectrique.
5. Filtre diélectrique selon l'une quelconque des revendications 1 à 4, dans lequel la profondeur du trou borgne (100) est liée à la polarité du couplage parasite et lorsque la profondeur du trou borgne augmente, la polarité de couplage parasite change d'un couplage inductif à un couplage capacitif.

6. Filtre diélectrique selon l'une quelconque des revendications 1 à 5, dans lequel une largeur du trou borgne (100) est liée au zéro de transmission.
7. Filtre diélectrique selon la revendication 6, dans lequel le fait qu'une largeur du trou borgne (100) est liée au zéro de transmission comprend :
qu'une largeur plus grande du trou borgne indique un emplacement relatif plus petit du zéro de transmission, et que l'emplacement du zéro de transmission relatif à une fréquence centrale du filtre diélectrique est supérieur à 1.
8. Filtre diélectrique selon l'une quelconque des revendications 1 à 7, dans lequel une profondeur du trou de débogage (11 à 14) détermine une fréquence de résonance d'une cavité résonante correspondant au trou de débogage.
9. Emetteur-récepteur, comprenant le filtre diélectrique selon l'une quelconque des revendications 1 à 8.
10. Station de base, comprenant l'émetteur-récepteur selon la revendication 9.

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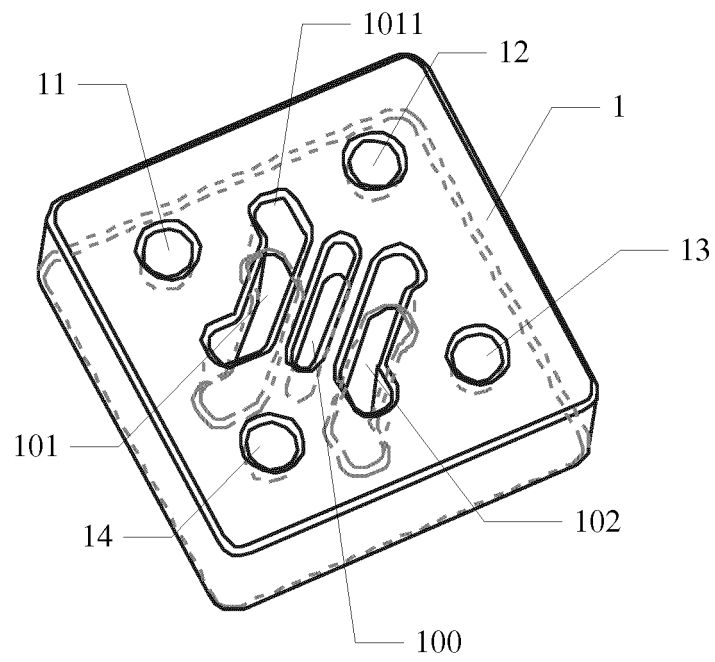


FIG. 1

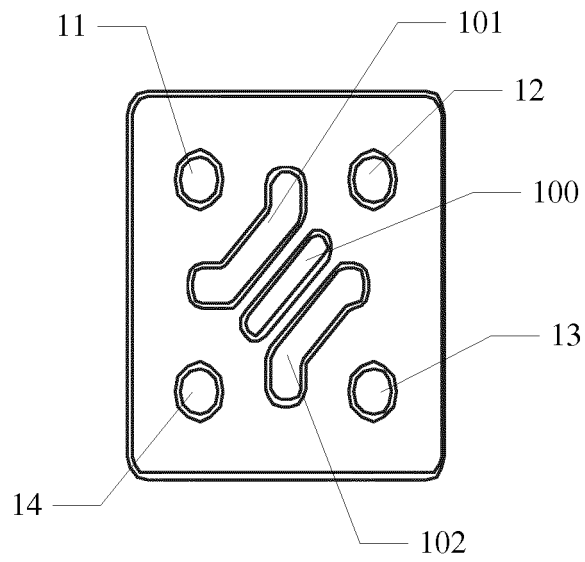


FIG. 2

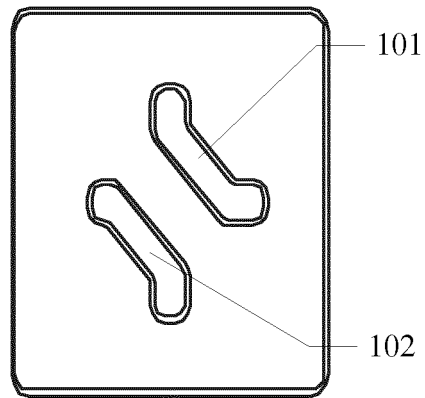


FIG. 3

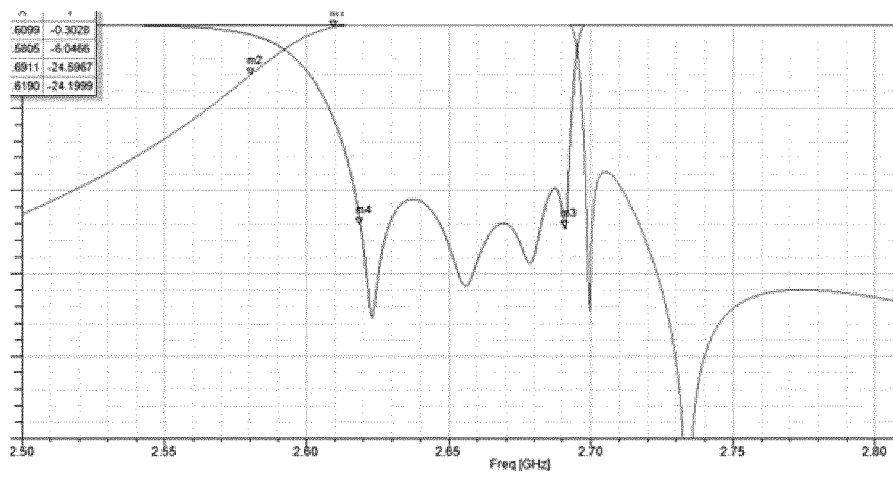


FIG. 4

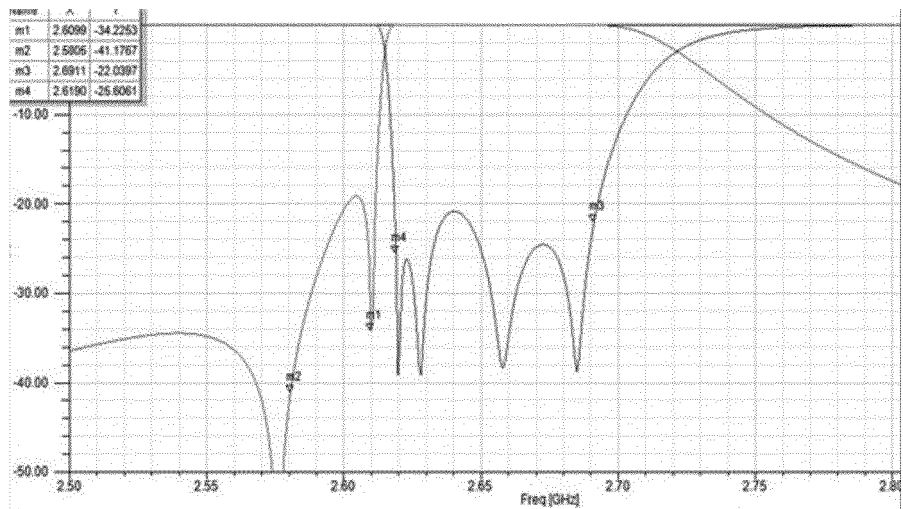


FIG. 5

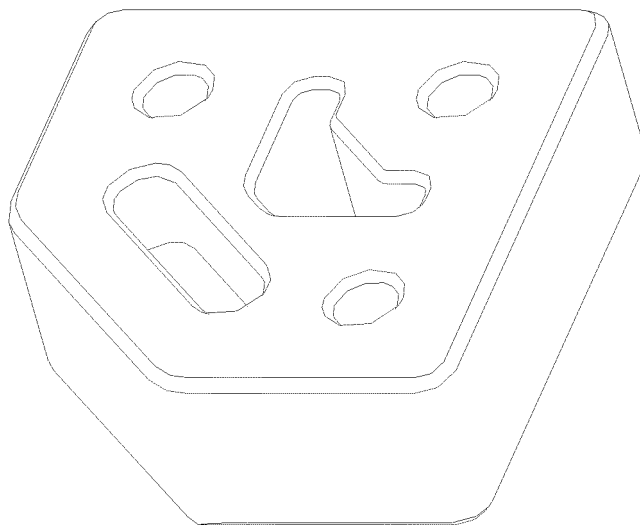


FIG. 6

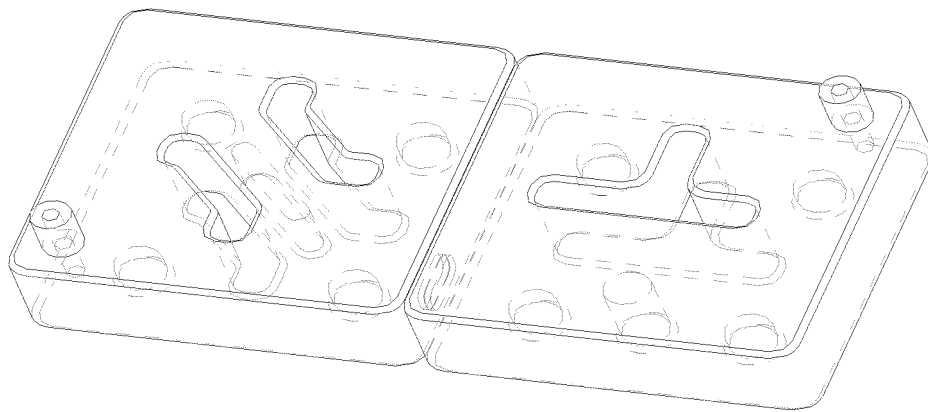


FIG. 7

REFERENCES CITED IN THE DESCRIPTION

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