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(54) Microwave filters including a capacitive coupling element

(57) The invention relates to a microwave filter comprising a plurality of coaxial resonators, at least two adjacent coaxial resonators being electrically coupled by a capacitive coupling element (6) having-an elongated portion (5) and, at each end thereof, an enlarged diameter end portion (4), the elongated portion being held by a dielectric mounting (7) which is placed in a coupling opening which is cut out from one end of the side wall separating the cavities. According to the invention the dielectric mounting (7) is a cylindrical body (7) formed in one piece of elastic material and having a bore (9) perpendicular to its cylinder axis for holding at least part of the elongated portion (5) of the coupling element (6), the cylindrical body having a cut (8) leading from one of its end faces to the bore and opening into the bore (9), wherein the cylindrical body (7), with the coupling element (6) inserted into the bore (9), is received in the coupling opening (10) which is of complementary shape to the cylindrical body to engage the latter along its length in a press-fitting manner between two opposing side walls of the coupling opening.

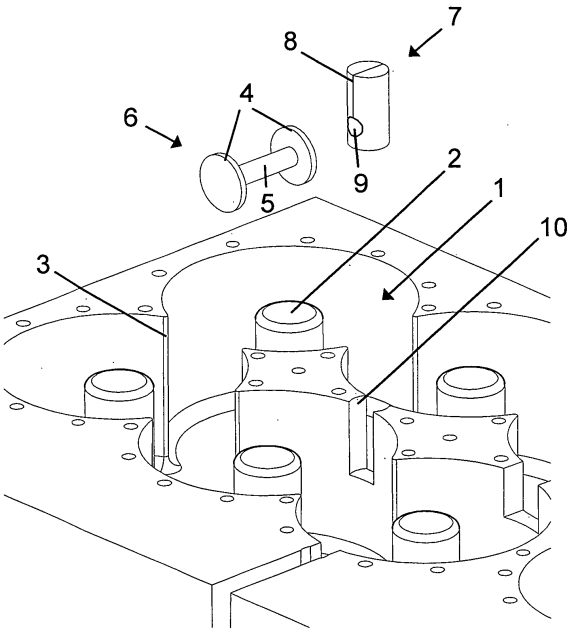

Fig. 1

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Description

[0001] The present invention relates to a microwave filter comprising a plurality of coaxial resonators, at least two adjacent coaxial resonators being electrically coupled by a capacitive coupling element having an elongated portion and, at each end thereof, an enlarged diameter portion, the elongated portion being held by a dielectric mounting element which is placed in an opening cut out from an end of the wall separating the cavities of the two resonators, the elongated portion of the capacitive coupling element projecting into both cavities.

[0002] The microwave region of the electromagnetic spectrum finds widespread use in various fields of technology. Exemplary applications include wireless communication systems, such as mobile communication and satellite communication systems, as well as navigation and radar technology. The growing number of microwave applications increases the possibility of interference occurring within a system or between different systems. Therefore, the microwave region is divided into a plurality of distinct frequency bands. To ensure, that a particular device only communicates within the frequency band assigned to this device, microwave filters are utilized to perform band-pass and band reject functions during transmission and/or reception. Accordingly, the filters are used to separate the different frequency bands and to discriminate between wanted and unwanted signal frequencies so that the quality of the received and of the transmitted signals is largely governed by the characteristics of the filters. Commonly, the filters have to provide for a small bandwidth and a high filter quality.

[0003] Commonly, microwave filters include a plurality of resonators which are coupled together in various configurations. Each resonator usually comprises a space contained within a closed or substantially closed conducting surface. Upon suitable external excitation, an oscillating electromagnetic field may be maintained within this space or cavity. The resonators exhibit marked resonance effects and are characterized by the respective resonant frequency and band-width.

[0004] One particular type of resonator regularly used to build microwave filters is known as coaxial resonator. This resonator structure is short-circuited at one end and open circuited at the other end, i.e. comprises a housing defining a cavity and having a longitudinal axis, and a coaxial inner conductor electrically connected to the housing at only one end. The housing comprises a base, from which the inner conductor extends upwardly, and a side wall extending upwardly from the base, and in a certain distance above the open end of the inner conductor, the housing is enclosed by a cover so that a gap exists between one end of the inner conductor and the inner surface of the cover. Such coaxial resonators are also referred to as combline resonators, and can essentially be regarded as a section of coaxial transmission line that is short-circuited at one end and capacitively loaded (open) at the other end. Microwave energy may be coupled into the cavity by a magnetic loop antenna located near the inner conductor at the short-circuited end of the transmission line. The free space between the top of the inner conductor and the cover is referred to as the capacitive gap.

[0005] The easiest way to achieve coupling between the resonators is the provision of a larger aperture in the wall between adjacent resonators which leads to magnetic coupling between these resonators. Therefore, the main way of coupling between the resonators is preferably realized as magnetic coupling. Nevertheless, there are also applications in which besides magnetic coupling also electric coupling is helpful. Such cross-coupling is helpful for improvement of the filter characteristic. The required electric coupling between two coaxial resonators is achieved by provision of a capacitive coupling element which may comprise an elongated portion or pin. The coupling element is held in a dielectric mounting to avoid contact with the conductive walls of the cavities. The mounting is placed in an opening cut out from an end of the side wall separating the two adjacent resonators. The elongated portion or pin extends into both cavities and provides an electric coupling. Such arrangement is for example described in DE 196 02 815 A1. A similar arrangement is described in EP 0 525 416 B1.

[0006] If an increased capacitive coupling strength is desired, the coupling element is provided with enlarged diameter end portions or disks at both ends of the elongated pin portion. Such coupling elements are for example disclosed in DE 21 61 792 A1 on which the preamble of claim 1 is based.

[0007] In order install such coupling elements with enlarged diameter disks at its ends, it is known in the prior art to assemble two dielectric mounting parts around at least part of the elongated portion of the coupling element. The two pieces when put together form a bore in which the elongated portion of the coupling element is received. The assembled two pieces with the coupling element received therein are then inserted in an opening cut out in one of the walls separating the two adjacent resonators to be coupled. Such arrangement is shown in Figures 3 and 4. The outer dimensions of the mounting pieces 2, 4 are such that they may be press-fitted in the cut-out opening. It is disadvantageous that two pieces 2, 4 need to be assembled in order to form a mounting for the coupling element 3. Furthermore, it is very difficult to adjust the capacitive coupling strength after the coupling element is mounted and the cover (not shown) of the microwave filter 1 is closed.

[0008] It is an object of the present invention to provide a microwave filter with at least two coaxial resonators electrically coupled, wherein the electrical coupling arrangement is simplified and easier to manufacture.

[0009] It is a further object of the present invention to provide an microwave filter with at least two coaxial resonators which are electrically coupled which simplifies the adjustment of the capacitive coupling strength.

[0010] According to the present invention the dielectric

mounting of the coupling element is a cylindrical body formed in one piece of elastic material. This cylindrical body is provided with a bore perpendicular to its longitudinal axis which bore is dimensioned to receive the elongated portion of the coupling element therein. The cylindrical body has a cut leading from one of its end faces to the bore and merging with the bore.

[0011] Because of this cut the elongated portion of the coupling member may be pressed into and slid through the cut. When the coupling element is pressed into the cut, the cut is enlarged to a gap by elastic deformation of the cylindrical body. Once the elongated portion of the coupling element has been slid through the cut it is received in the bore, i.e. the axis of the bore lies in the plane of the cut. Then the elastic body snaps back once the elongated portion left the cut area, and the cut is essentially closed again.

[0012] The cylindrical mounting body, with the coupling element inserted into the bore, is received in the coupling opening in the side wall separating the two resonators to be coupled. This coupling opening is of complementary shape to the cylindrical body so that it may receive the cylindrical body in a press'-fitting manner. The opposing surfaces of the cut-out opening in the side wall thus have the shape of cylinder surface segments. The cylindrical body is closely fitting into this cylinder segment opening. Due to the press-fit of the cylindrical body in the cylinder segment opening, the opposing portions of the cylinder adjacent to the cut are pressed together so that the coupling element is secured in the bore.

[0013] Furthermore, due to the cylindrical shape of the mounting and its cylindrical seat, it is possible to alter or to adjust the alignment of the coupling element by slightly turning the cylindrical body in its press-fitting seat. This turning of the cylindrical body results in a corresponding turning of the coupling element and thus changes the location of the enlarged diameter disks within the respective cavities, so that the capacitive coupling strength may be varied in this manner. In a particular advantageous embodiment the cover of the microwave filter which covers the resonator cavities has an opening in the area in which the free end face of the cylindrical body in the coupling opening is situated. This allows to engage the cylindrical body, while the cover of the microwave filter is in its closed stage, and to vary capacitive coupling strength by slightly turning the cylindrical body in its seat as described above.

[0014] This is a particular advantage since this modification of the capacitive strength may be performed in the completely assembled state of the microwave filter, i.e. with the cover closed, whereas in the prior art the cover had to be opened in order to allow to adjust or modify any of the capacitive couplings.

[0015] The cylindrical mounting body may for example be made of PTFE (polytetrafluor ethylene), polyethylene, FEP (fluorinated ethylene-propylene), or PEEK (polyether etherketone). The mounting body is simple to manufacture, because it may be cut from a rod to the desired length, whereafter the bore is formed and a cut is applied running from one of the end faces to the bore.

[0016] The invention is in the following described by way of examples with reference to an embodiment shown in the drawings in which

Figure 1 is a perspective explosive view of an open microwave filter with the mounting and coupling element removed from its seat;

Figure 2 is a view corresponding to Figure 1 with the mounting and the inserted coupling element fitted into the coupling opening;

Figures 3 and 4 show views corresponding to Figures 1 and 2 of an arrangement of the prior art.

[0017] Figure 1 shows a perspective view of a portion of a microwave filter comprising a plurality of coaxial resonators, one of the resonator cavities being indicated by 1 and its inner conductor by 2. Each resonator comprises an essentially circular cavity. The main couplings between the coaxial resonators are achieved by large apertures 3 or cut-outs in the side walls between adjacent cavities.

[0018] The electric coupling arrangement of the microwave filter of the present invention is achieved by a cylindrical mounting body 7 which has a bore 9 through the cylinder body extending perpendicular to the cylinder axis. This bore 9 is dimensioned to receive the elongated or pin portion 5 of a capacitive coupling element 6. The cylindrical mounting body 7 further has a cut 8 which leads from one of its end faces and merges into the bore 9. This allows that, by stretching away the two cylinder portions separated by the cut, a gap is formed which is sufficiently large to allow the pin portion 5 of the coupling element 6 to be slid through the cut 8 into the bore 9, whereafter the elastic deformation forming the gap is released and the cut is closed. In this state, the mounting body 7 with the inserted coupling element 6 is fitted into the coupling opening 10 which is cut out from the upper end of the side wall separating the adjacent cavities to be coupled. The opposing surfaces of the cut-out in the side walls are adapted to conform to the surface of the cylindrical mounting body 7 and are dimensioned to receive this cylindrical mounting body 7 in a press fitting manner. This ensures that the capacitive coupling element 6 is securely held in place once the mounting is in its press-fitting seat in the coupling opening 10. This state is shown in Figure 2.

[0019] The cylindrical shape of the mounting body 7 together with the cylinder segment shape of the opposing surfaces of the opening 10 with complementary shape provides for a press-fitting seat of the mounting body 7. Nevertheless, it is possible to turn the mounting body 7 inside the opening 10 in order to alter the direction of the coupling element 6. Since this also alters the locations of the enlarged diameter coupling disks 4, the capacitive

coupling strength may be altered. This can also be achieved if the cover (not shown) is already closed and fixed, if an opening is provided in the cover in the area over the mounting body 7.

[0020] A further advantage of the cylindrical mounting body 7 is that it can be received in openings which are formed in side walls of different thicknesses. In a side wall of greater thickness a larger part of the cylinder surface is surrounded by the opposing surfaces of the opening in the side wall, whereas in thinner side walls only a relatively small part of the cylinder surface is engaged by the opposing surfaces of the opening, whereas the radius of curvature of the opposing surfaces of the opening in the side wall is always the same and equal to the radius of the cylinder.

Claims

1. Microwave filter comprising a plurality of coaxial resonators, at least two adjacent coaxial resonators being electrically coupled by a capacitive coupling element (6) having an elongated portion (5) and, at each end thereof, an enlarged diameter end portion (4), the elongated portion being held by a dielectric mounting (7) which is placed in a coupling opening which is cut out from one end of the side wall separating the cavities of the two resonators, the elongated portion of the capacitive coupling element projecting into both cavities, **characterized in that** the dielectric mounting (7) is a cylindrical body (7) formed in one piece of elastic material and having a bore (9) perpendicular to its cylinder axis for holding at least part of the elongated portion (5) of the coupling element (6), the cylindrical body having a cut (8) leading from one of its end faces to the bore and opening into the bore (9), wherein the cylindrical body (7), with the coupling element (6) inserted into the bore (9), is received in the coupling opening (10) which is of complementary shape to the cylindrical body to engage the latter along its length in a press-fitting manner between two opposing side walls of the coupling opening.

2. Microwave filter according to claim 1, **characterized in that** the cover covering the resonators has, in the area above the opening (10) between the two electrically coupled resonators, an opening which allows to engage the end face of the cylindrical body (7) in order to turn the cylindrical body inside its seat in the opening around its longitudinal axis, to thereby modify the capacitive coupling strength provided by the capacitive coupling element.

3. Microwave filter according to claim 1 or 2, **characterized in that** the cylindrical body is made of an elastic material selected from the group consisting of PTFE (polytetrafluor ethylene), Polyethylene, FEP (fluorinated ethylene-propylene), PEEK (polyether etherketone).

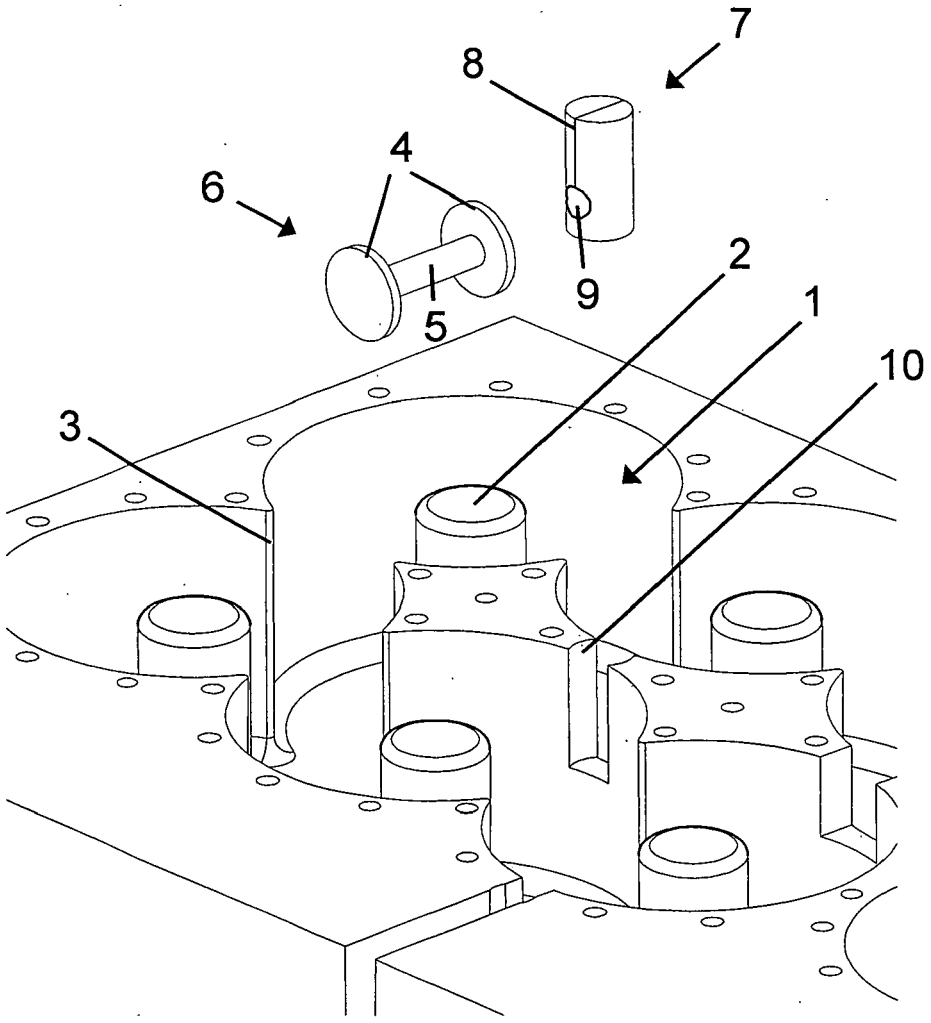

Fig. 1

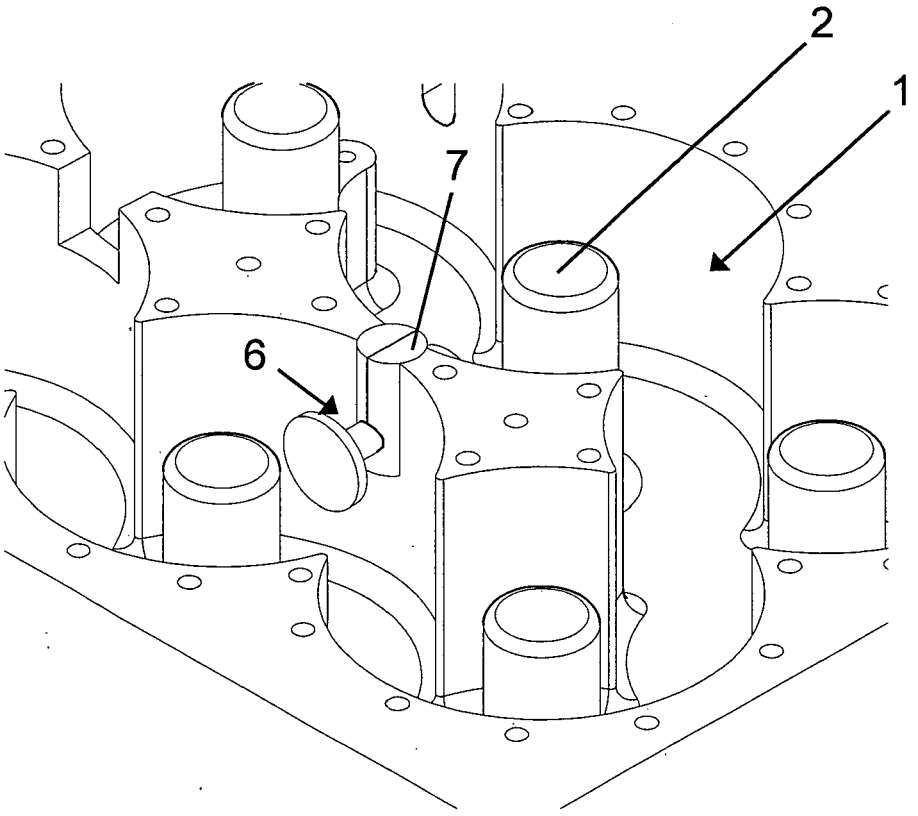

Fig. 2

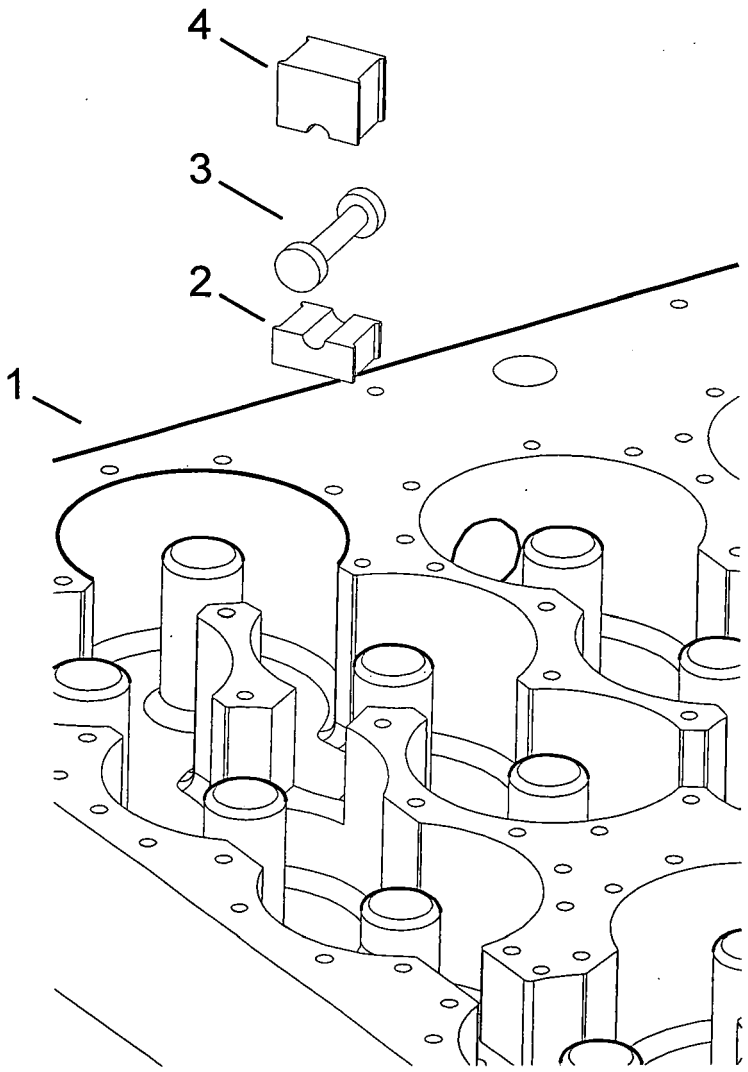

Fig. 3

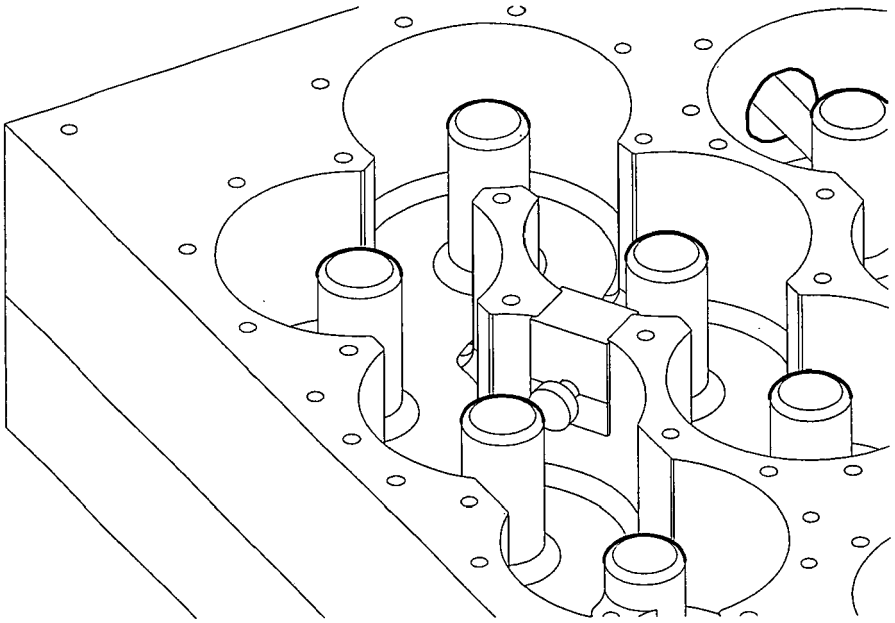

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 05 02 5887

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A	DE 26 40 210 A1 (SIEMENS AG; SIEMENS AG, 1000 BERLIN UND 8000 MUENCHEN) 9 March 1978 (1978-03-09) * page 7, line 10 - line 21; figure 1 *	1-3	INV. H01P1/205
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	24 April 2006	Pastor Jiménez, J-V

CATEGORY OF CITED DOCUMENTS

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REFERENCES CITED IN THE DESCRIPTION

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