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

(11) EP 1 988 597 A2

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 158(3) EPC

(43) Date of publication:
05.11.2008 Bulletin 2008/45

(21) Application number: **07712549.0**

(22) Date of filing: **01.02.2007**

(51) Int Cl.:
H01P 1/203 *(2006.01)* ***H01P 7/08*** *(2006.01)*

(86) International application number:
PCT/ES2007/000055

(87) International publication number:
WO 2007/088230 (09.08.2007 Gazette 2007/32)

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR

(30) Priority: **01.02.2006 ES 200600214 U**

(71) Applicant: **MARCOTEGUI ITURMENDI, José Antonio**
31195 Aizoain (ES)

(72) Inventors:
- **ILLESCAS OTERMIN, Jésus Miguel**
  E-45600 Talavera de la Reina (Toledo) (ES)
- **JARAUTA AYENSA, Eduardo José**
  E-31522 Monteagudo (Navarra) (ES)
- **FALCONE LANAS, Francisco Javier**
  E-31016 Pamplona (Navarra) (ES)

(74) Representative: **Cabinet Plasseraud**
52 rue de la Victoire
75440 Paris Cedex 09 (FR)

(54) MICROWAVE AND MILLIMETER WAVE FILTER

(57) The invention relates to a microwave and millimeter wave filter formed by a strip conductor (1) defining steps (3) of coupled lines and a segment (4) including at least one resonator (5) comprising complementary open rings with a capacitive gap therein.

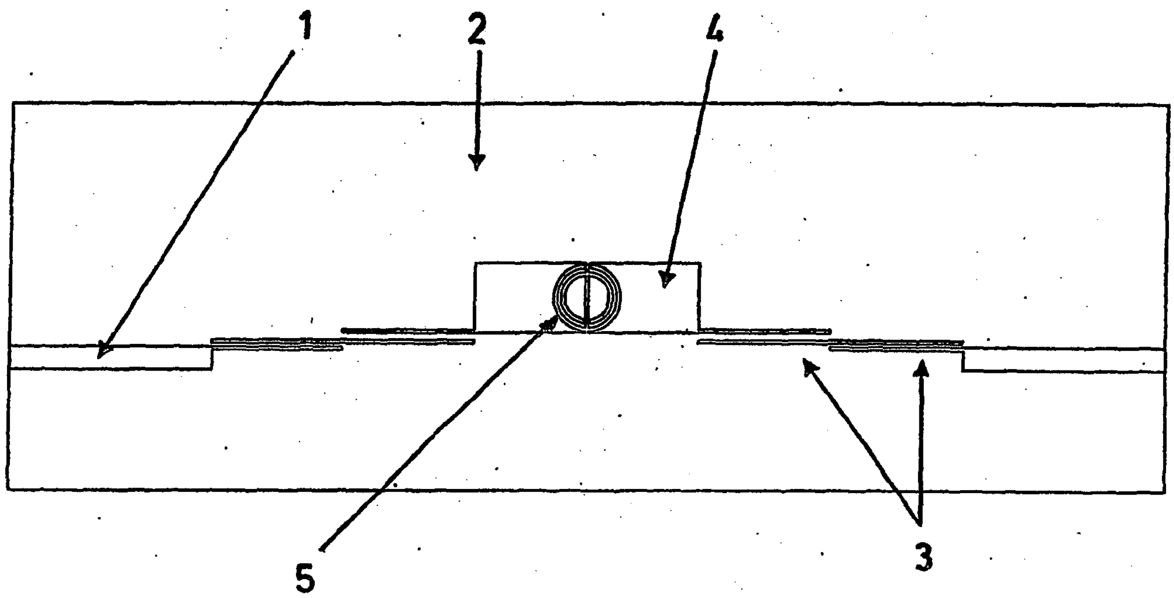

Fig.1A

Printed by Jouve, 75001 PARIS (FR)

Description

Field of the Art

[0001] The present invention relates to structures based on transmission lines with resonators, in planar technology, proposing a microwave and millimeter wave filter, which is implemented without modifying the ground plane, with a design by means of transmission lines containing resonator pairs based on complementary open rings, coupled by means of a capacitive gap, and resonator pairs with steps of coupled lines.

State of the Art

[0002] Microwaves and millimeter waves are waves with a high frequency, between 1 GHz and 300 GHz, which makes the way of treating them different from the treatment of signals with greater amplitude.

[0003] The electronic mediums necessary for treating these waves are generally formed by a base or substrate on which metal sheets are inserted, forming a structure used for transporting the signal, there being able to be several heights of metal depending on the complexity of the element.

[0004] In addition, according to the geometry of the metal sheets, different structures are achieved which modify the signal adapting it to the generated needs.

[0005] Filters are structures limiting the passage of a certain part of the signal, allowing the passage of the rest of the signal, depending on which there are high-pass, low-pass, band-pass, and band-reject filters.

[0006] High-pass filters are those filters limiting the passage of the signal above a specific frequency value, whereas low-pass filters allow the passage of the signal below a specific frequency value.

[0007] Band-pass filters allow, where applicable, the passage of the signal the frequency of which is between two specific values; and band-reject filers allow passing the signal which has a value less than a specific value or greater than another value greater than the first.

[0008] Structures based on distributed resonators for designing said microwave and millimeter wave filters, with a response in the desired frequency, are in turn known.

[0009] Said structures are based on the property that, for certain frequencies, dynamic resonances, i.e., depending on their physical dimensions, occur which allow obtaining the desired frequency responses by suitably coupling the different resonators forming the device.

[0010] As has been mentioned, the final responses and resonances in these devices depend on the dimensions of the different components forming the structure: line impedance, line length, etc., and due to the relationship between the wave length and the frequency, the responses have a periodic frequency performance, therefore unwanted frequency bands, commonly called spurious frequency bands, can be obtained in bands of interest.

[0011] Frequency filtering structures are also known based on transmission lines and on concentrated resonators, such as resonators with open rings or resonators comprising complementary open rings and topologies derived therefrom.

[0012] In such structures, the resonators with open rings, or the resonators comprising complementary open rings, are arranged such that a certain magnetic and/or electric coupling occurs between said resonators and the transmission lines, such that pass or reject bands occur near the resonance frequency of the mentioned resonators, it being necessary in this latter case to also introduce additional elements, such as capacitive gaps, in a series configuration with the transmission line and/or metal junctions between the central strip conductor and the ground plane.

[0013] Said capacitive gaps are gaps made in the transmission line, demarcating the two faces of a capacitor, between which the direct transmission of the signal is interrupted, at the same time that alterations occur therein.

[0014] Solutions based on complementary open rings engraved in the ground plane, coupling steps in the strip conductor, metal elements or stubs by way of inductions between the strip conductor and the ground plane, and routes connecting the strip conductor with the ground plane are known for controlling the bandwidth in these structures.

[0015] A limitation of the mentioned structures based on distributed resonators for their use as filters, is the fact that their dimensions can be considerable insofar as they depend on the wavelength at the typical frequency of the filter. Furthermore, in such structures spurious frequency bands are produced, which can occur at frequencies relatively close to the bands of interest.

[0016] A limitation of the structures based on complementary open rings lies in the fact that the modification of the ground plane prevents integrating these devices into chip technology structures (PCB) for their industrial production, also limiting the possible shielding from the devices generated from these structures.

Object of the invention

[0017] The purpose of the present invention is to solve the mentioned drawbacks of the structures based on transmission lines and resonators which require modifying the ground plane or establishing connections therewith, developing a filter operating at microwaves and millimeter wave frequencies, based on resonators without the alteration of the ground plane, and in which the bandwidth, the frequency response and the rejection levels can be controlled, being able to be implemented in planar technology, either in low-loss microwave or millimeter wave substrates, in multilayer substrates, or by means of microelectronic manufacturing technologies.

[0018] According to this objective, the filter of the invention is characterized by the fact of being included in a planar transmission medium, or transmission line, comprising a strip conductor, a metal ground plane (which by no means is altered), and a dielectric substrate; by the fact that it comprises at least one resonator based on complementary open rings, modified in order to include therein a capacitive coupling gap (which forms part of the construction); and by the fact that the band rejection level can optionally be controlled by providing one or more steps of coupled lines, which in such case forms part of the filter.

[0019] These features allow making a filter with reduced dimensions without modifying the ground plane, due to the fact that the dimensions of the resonators with open rings are smaller than the wavelength at the resonance frequency thereof and to the fact that the construction is completely defined in the strip conductor. Furthermore, as a result of the combination of the mentioned resonators comprising complementary open rings, modified with a capacitive gap with additional elements, such as steps of coupled lines, the rejection level of the filter is controlled by increasing it, with the added advantage that the capacitive gap forming part of the complementary resonator allows having control over the bandwidth of the filter.

[0020] Insofar as the dielectrics and metals used for its manufacture have low loss levels and resistivity, respectively, this filter of the invention also has low insertion losses in the pass-band, its design is simple and its manufacturing process is compatible with the technologies for manufacturing integrated and printed circuits.

[0021] The resonators comprising complementary open rings, modified in order to include the capacitive gap, are engraved in the transmission line, being able to generally have polyhedral or circular geometry, and can have one or more cuts in each ring of the pair.

[0022] The resonators can alternatively be implemented by means of complementary spirals, and the construction furthermore does not have to be symmetrical with respect to the axis of the gap, such that the complementary open half-rings which are at both sides of the gap can be off-centered, and between them not only can they have different geometric centers, but their geometry can also differ, which geometry can generally be circular or polyhedral, with one or more different cuts in each ring of the pair formed at each side of the gap; and optionally one or both sides of the resonator around the gap can be implemented by means of spirals.

[0023] In addition to the degree of freedom provided by having two half-resonators within the same construction, the capacitive gap itself provides in such case an effective control of the bandwidth.

[0024] According to another embodiment, one or more steps, not necessarily identical, of resonators comprising complementary open rings, modified in order to include a capacitive gap therein, appear interacting with one or more steps, not necessarily identical, of coupled lines, which provides a greater rejection level and a control thereof by means of the design of the coupled lines and with the number of steps of coupled lines included.

[0025] Each of the steps of coupled lines used forms a magnetic-inductive coupling between two separated conductor tracks having a certain coupling length along any path, both tracks not having to be identical, and being able to be engraved therein or in different metallization levels.

[0026] One and the same conductor track can also form part of more than one step of coupled lines, and each of the conductor tracks along the coupling, within one and the same step, can have any type of profile.

[0027] The planar transmission line is preferably of the microstrip, coplanar, belt type, or variants thereof, as a result of which the filter can be implemented in any type of planar technology compatible with the processes for manufacturing integrated or printed circuits, the belt transmission line being known as a stripline.

[0028] The filter of the present invention advantageously allows synthesizing responses with ultra wide pass-bands, with significant rejection levels, and with the presence of spurious frequency bands far from the frequency band of interest. Another great advantage is obtaining these results without modifying the ground plane, which is especially convenient for working with microstrip and stripline type transmission lines, facilitating their integration in PCB chips.

[0029] Resonators with cut rings or resonators with complementary cut rings can be additionally added in the input and/or output steps of the filter for eliminating spurious frequency bands.

Description of the Drawings

[0030]

Figure 1A shows an embodiment of a band-pass filter according to the invention.

Figure 1B is an enlarged detail of the central area of the filter of previous figure.

Figure 1C shows the response in measured frequency of the previous filter.

Figure 2A shows another configuration of a band-pass filter.

Figure 2B depicts the response in obtained frequency by means of simulating the filter shown in the previous figure.

Figure 3A shows another possible implementation of the filter of the invention.

Figure 3B depicts the response in obtained frequency by means of simulating the filter of the previous figure.

Detailed Description of the Invention

[0031] The object of the invention consists of a band-pass filter implemented in microstrip technology, which can have an undetermined number of steps (3) both at the input and at the output, comprising an upper metallization (1) located on a dielectric substrate (2) which is in turn arranged on another metallization (not shown).

[0032] Figures 1A and 1B show an embodiment of the proposed filter, comprising four steps (3) of coupled lines, two at the input and two a the output; whereas Figure 2A depicts another example of the filter, under the same concept of the invention, with a step (3) at the input and another one at the output.

[0033] A resonator (5) formed by open rings is determined in the central segment (4) of the conductive metal part (1), which resonator has been modified in order to include a capacitive gap (6) therein. One or more segments (4) with one or more resonators (5) formed by complementary open rings, modified or not, with different radiuses, shapes, and even off-centered from the central capacitive gap (6), can alternatively be implemented.

[0034] The resonators (5) formed by complementary open rings, modified in order to include a coupling capacitive gap (6) therein, can also have polyhedral geometry and/or can have more than one opening and/or can be made in a spiral configuration with different morphologies.

[0035] The steps (3) of coupled lines of the input or of the output, as well as its morphology, in addition to varying in number, can also be replaced by a transmission line.

[0036] Resonators with open rings (10), as shown in Figure 3A, can also be circumstantially placed close to the sections of coupled lines, or in other places of the chip for the purpose of eliminating spurious frequency bands.

[0037] In any case the filter can be implemented by means of any other type of planar transmission medium, or in multilayer structures.

[0038] The frequency response of the output signal (7) of each filter is the product of being able to minimize the value of the signal in the frequencies outside the pass-band (9) determined by the filter in the input signal and maintain the unitary gain in the range of frequencies belonging to said pass-band (9). Similarly, a signal can be obtained with the components of the input signal, outside the range frequencies (8) demarcated by the filter, which is reflected, therefore those values are cancelled out in the output signal (7).

[0039] Although three embodiments of the filter of the invention have been shown, such embodiments have a nonlimiting character, since with the same concept and without departing from the scope of the invention other technically equivalent forms of the filter can be adopted in order to fulfill the same function.

Claims

1. A microwave and millimeter wave filter comprising a planar transmission medium based on conventional transmission lines, including a strip conductor (1), an unaltered metal ground plane and a dielectric substrate (2), **characterized by** the fact of having in the strip conductor (1) one or more steps (3), not necessarily identical, of coupled lines and a segment (4) including at least one resonator (5) comprising complementary open rings, modified in order to include a capacitive gap (6) therein.

2. The microwave and millimeter wave filter according to claim 1, **characterized by** the fact that one or more segments (4) with one or more resonators (5) comprising complementary open rings, modified in order to include a capacitive gap (6) therein, can be implemented.

3. The microwave and millimeter wave filter according to claims 1 and 2, **characterized by** the fact that the resonators (5) comprising complementary open rings, modified in order to include a capacitive gap (6) therein, have a polyhedral or circular geometry, having a plurality of openings and/or metal elements engraved in one or more metal levels.

4. The microwave and millimeter wave filter according to claims 1 to 3, **characterized by** the fact that the construction of the resonators (5) with complementary open rings, modified in order to include a capacitive gap (6) therein, can have or not have asymmetries with respect to the axis of the corresponding gap.

5. The microwave and millimeter wave filter according to claim 4, **characterized by** the fact that the complementary open half-rings which are at the sides of the capacitive gap (6) of each resonator (5), can have different geometric centers.

6. The microwave and millimeter wave filter according to claims 1 to 3, **characterized by** the fact that in each resonator (5) the complementary open half-rings which are at the sides of the corresponding gap (6), can be or not be symmetric with respect to the axis of the capacitive gap (6), being able to have different or identical geometries, and a different or identical number of openings and/or metal elements engraved in one or more metal levels.

7. The microwave and millimeter wave filter according to claims 1 to 3, **characterized by** the fact that in each resonator (5) the complementary open half-rings of each side of the corresponding capacitive gap (6) can be formed with openings arranged in any position, defined between metal arcs determining a spiral configuration.

8. The microwave and millimeter wave filter according to claim 1, **characterized by** comprising one or more steps with resonators (5) comprising complementary

open rings, modified in order to include a capacitive gap (6) therein, which steps can be engraved in one or more metallization levels, each of them including one or more steps (3) of coupled lines which can have any configuration.

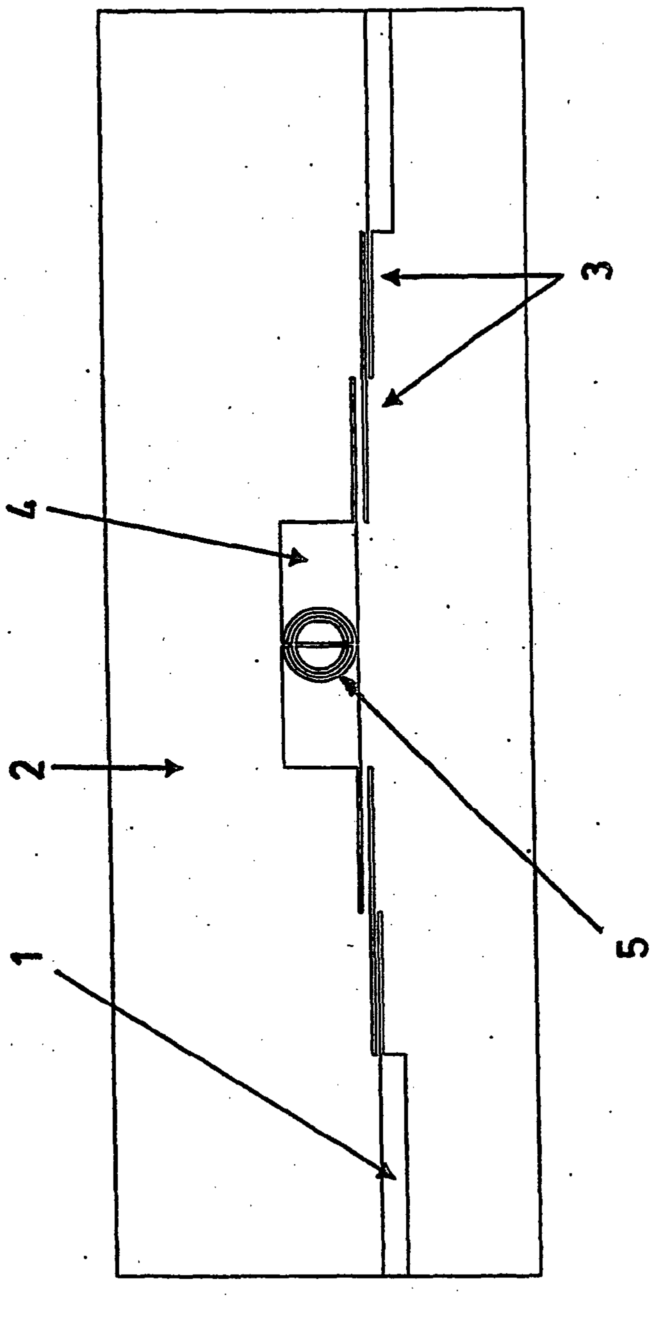

Fig.1A

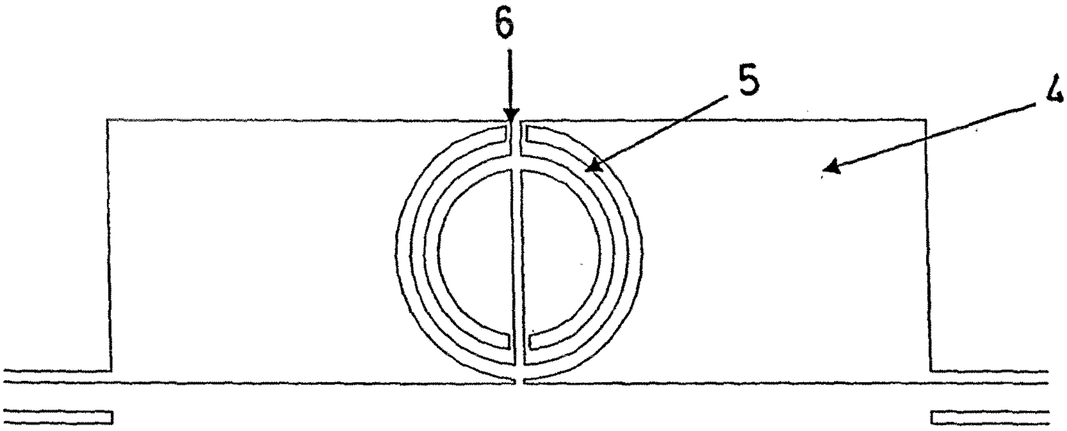

Fig.1B

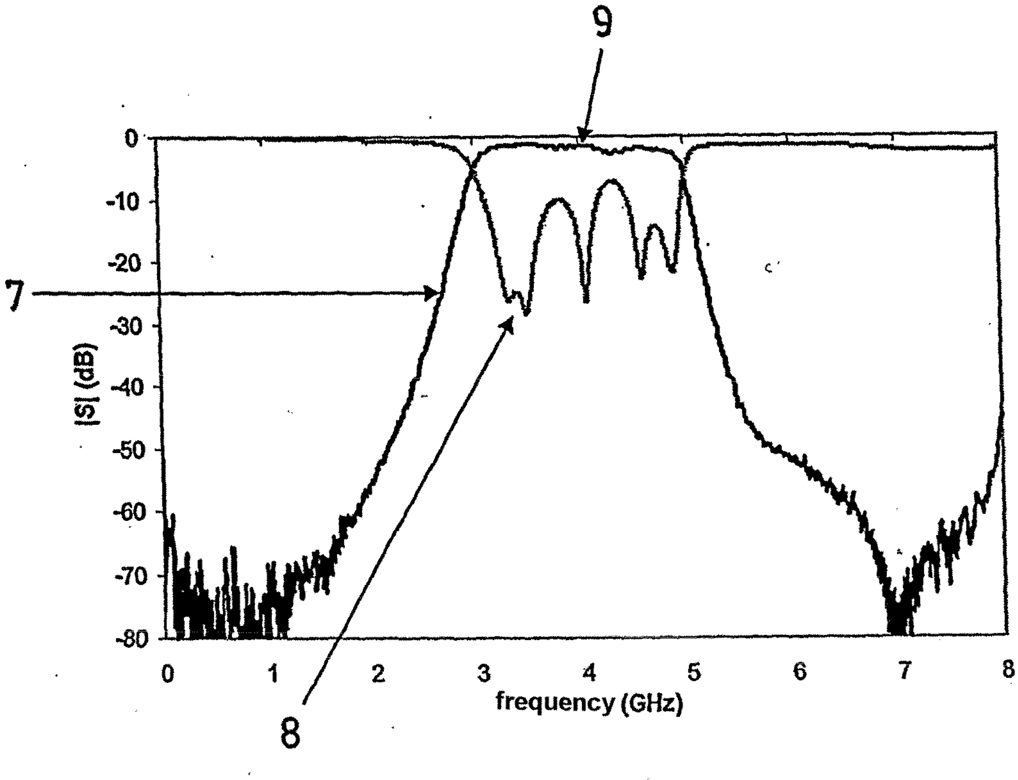

Fig.1C

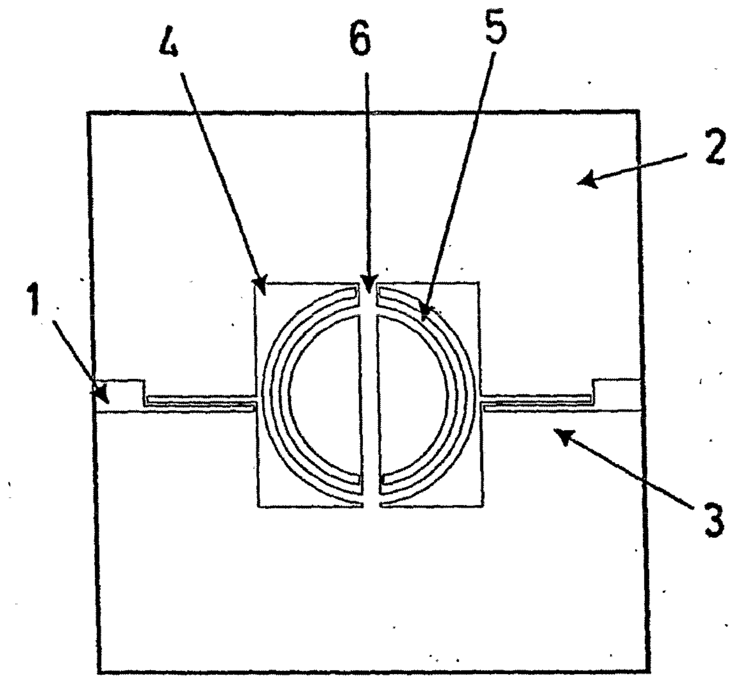

Fig.2A

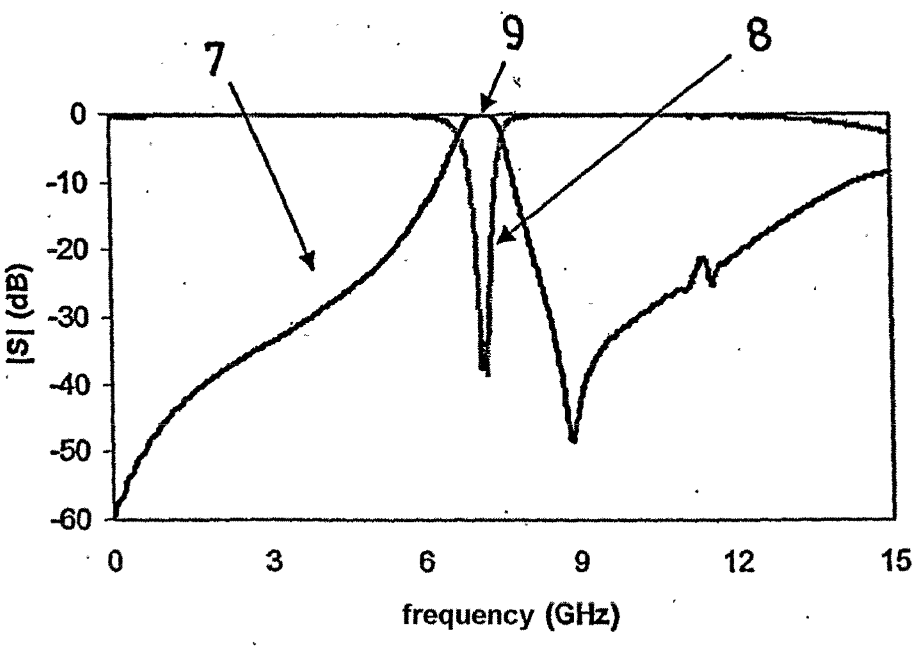

Fig.2B

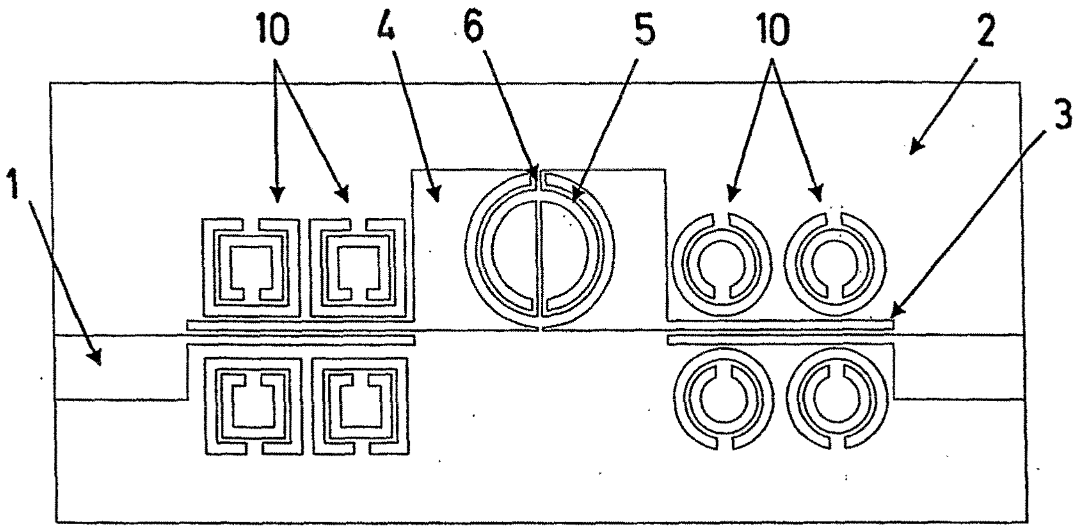
10
4
6
5
10
2
3
1

Fig.3A

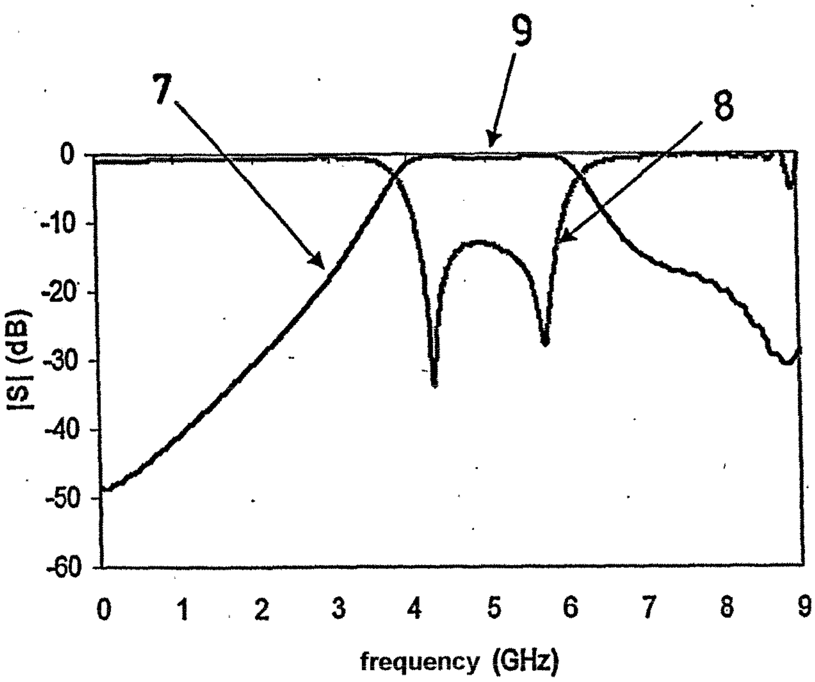
9
7
8
0
-10
-20
-30
-40
-50
-60
|S| (dB)
0
1
2
3
4
5
6
7
8
9
frequency (GHz)

Fig.3B