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

(11) EP 2 166 612 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
24.03.2010 Bulletin 2010/12

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

(21) Application number: **08290907.8**

(22) Date of filing: **19.09.2008**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA MK RS

(71) Applicant: **Alcatel Lucent**
75008 Paris (FR)

(72) Inventors:
- **Geelani, Shaik**
  80798 München (DE)
- **Schenkel, Horst**
  90542 Eckental (DE)

(74) Representative: **Kohler Schmid Möbus**
Patentanwälte
Ruppmannstraße 27
70565 Stuttgart (DE)

(54) Metafilter with asymmetric structure

(57) A radio frequency band-pass filter device (31), comprising
- a grounded frame structure (34),
- a dielectric substrate (32) suspended within the frame structure (34),
- and a microstrip conductor structure (1; 21; 33) located on top of the dielectric substrate (32),
wherein the microstrip conductor structure (1; 21; 33) comprises

- an input conductor part (2),
- a plurality of identical unit cell conductor parts (4a-4e),
- and an output conductor part (3), with these conductor parts (2, 4a-4e, 3) arranged in a straight line (L),
wherein the unit cell conductor parts (4a-4e) are asymmetric with respect to a mirror plane (M) perpendicular to the substrate (32) and running along the straight line (L) of conductor parts (2, 4a-4e, 3),
and wherein the unit-cell conductor parts (4a-4e) are separated by gaps (5a, 5b) of equal width. The invention provides an improved RF band-pass filter device which is less expensive in production, and allows the exploitation of a CRLH behaviour of the filter device.

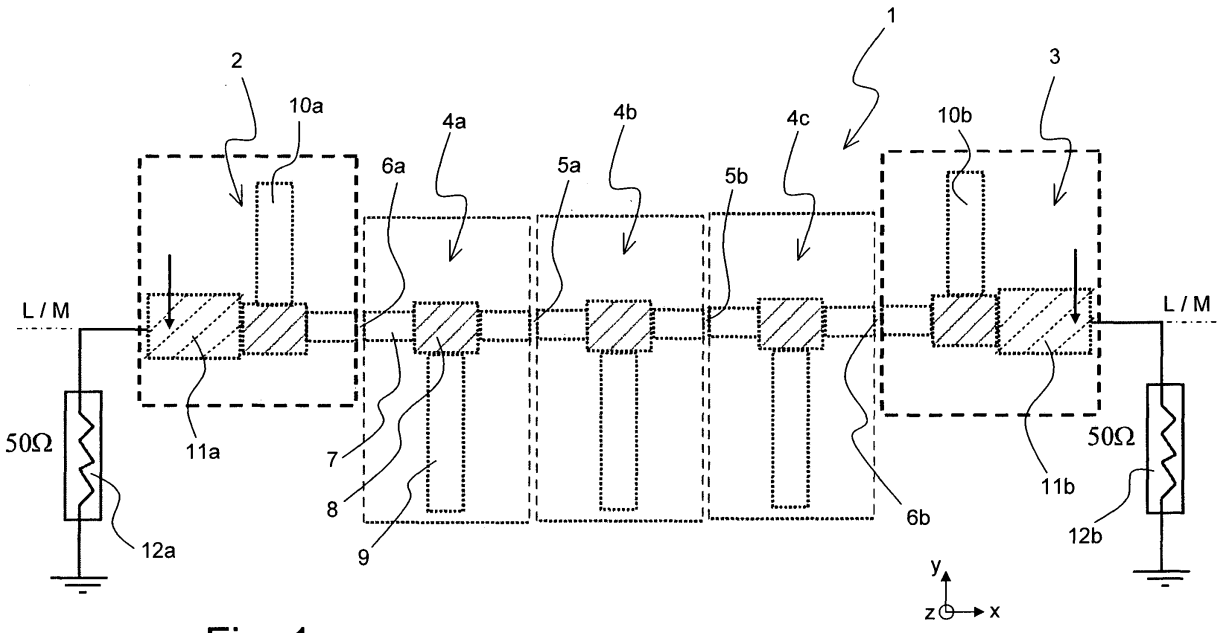

Fig. 1

EP 2 166 612 A1

Description

Background of the invention

[0001] The invention relates to a radio frequency (=RF) band-pass filter device, in particular for use in a mobile base station.

[0002] Such filter devices are, for example, known from Kathrein-Werke KG, Rosenheim, DE, technical data sheet of Duplexer Type Nos. 78210168 through 78210172, available on Sept. 9th, 2008 via http://www.kathrein.de/de/fil/index.htm, via item "Produkte A-Z", item "790-2500 MHz, Duplexers"

[0003] Mobile telephony and other mobile data transmission services apply radio transmissions in the radio frequency range. To adequately operate for example mobile base transceiver stations, band-pass filter devices are necessary.

[0004] Filter devices used inside mobile base transceiver stations for various standards, such as GSM, CDMA, UMTS or WiMAX, in the state of the art, are of the cavity duplex type, compare the Kathrein-Werke filters above. This type comprises a profile machined out of cast iron (or a comparable metal construction), comprising a plurality of tube-like metal resonators extending from the bottom of the profile, and metal bolts projecting into the resonators, with the metal bolts extending from a metal cover plate. Although the design details depend on the filter specification, the size and weight of such cavity duplex type filters are generally rather large. In particular, the lower the specified frequency range of the filter, the bigger must be the cavity duplex type filter.

[0005] For the reasons above, cavity duplex type filters are particularly expensive in production. Attempts to reduce the costs for cavity duplex type filters were mainly based on the relaxation of margins of these filters, but this decreases the filter efficiency.

[0006] In recent years, the theory of so called "meta-materials" has been discussed. Meta-materials exhibit a "left-handed" behaviour resulting from a negative relative magnetic permeability. Although materials exhibiting a left-handed behaviour do not exist in nature, some device structures have been found which exhibit a "mixed behaviour" as if the device was composed of both some material of conventional right-handed behaviour and some material of left-handed behaviour, compare C. Caloz and T. Itoh in 2003 IEEE MTT-S Digest, pages 195-198. The behaviour of such structures has become known as "composite right/left handed" (CRLH).

[0007] CRLH behaviour results in RF device characteristics different from and often superior to conventional RF devices. However, only few device structures exhibiting a CRLH behaviour have been found so far, with equally few practical implementations.

Object of the invention

[0008] It is the object of the invention to introduce an improved RF band-pass filter device which is less expensive in production than known RF band-pass filter devices, in particular wherein a CRLH behaviour of the filter device can be exploited.

Short description of the invention

[0009] This object is achieved, in accordance with the invention, by a radio frequency band-pass filter device, comprising

- a grounded frame structure,
- a dielectric substrate suspended within the frame structure,
- and a microstrip conductor structure located on top of the dielectric substrate, wherein the microstrip conductor structure comprises
- an input conductor part,
- a plurality of identical unit cell conductor parts,
- and an output conductor part,

with these conductor parts arranged in a straight line, wherein the unit cell conductor parts are asymmetric with respect to a mirror plane perpendicular to the substrate and running along the straight line of conductor parts, and wherein the unit-cell conductor parts are separated by gaps of equal width.

[0010] The inventive filter device is based on a suspended stripline circuit design with microstrip gaps, with an asymmetric structure. The asymmetric structure is typically achieved by open stubs protruding to one side of the strung unit cell conductor parts. The inventive design reliably results in composite right/left handed (=CRLH) behaviour of the filter device, and allows a better RF band-pass filter performance than known conventional filter devices, and also a better performance than known CRLH behaving devices with symmetric structures.

[0011] The straight line of the conductor parts of the microstrip conductor structure, with a sequence of input conductor part - unit cell conductor parts - output conductor part, results in a serial capacity and shunt inductivity. The serial capacity is represented by the microstrip gaps between the unit cell conductor parts (and typically in addition an input gap and an output gap, see below), and shunt inductivity is represented by the section of each unit cell conductor part introducing the asymmetry, such as open stubs. By reducing the capacity in the serial branch, the distance between resonances in the frequency domain can be reduced. The width of the gaps steers the bandwidth of the filter device. The smaller the capacity (i.e. the wider slot), the narrower is the band-pass.

[0012] Insertion losses of the filter are mainly due to the substrate. In order to keep its influence low, shielded suspended substrate technology is applied. By this means, the electromagnetic field may be concentrated outside the substrate, i.e. in the free space (typically air-filled) above and below the substrate within the shielding.

Thin substrates also help reduce insertion losses and improve the filter efficiency (Q-factor).

[0013] It is noted that the inventive design can be optimized with respect to a specific, desired filter performance by adapting, in particular,

- the width of the gaps,
- the amount of unit cell conductor parts,
- the properties of the substrate (in particular its electric susceptibility ε and/or the permeability μ, by choosing a corresponding substrate material),
- the gap-to-gap distance (i.e. the length of a unit cell conductor part in the direction of the straight line of conductor parts),
- the design of the unit cell parts, in particular with respect to its sections(s) establishing the asymmetry with respect to the mirror plane,
- and/or the distance between the microstrip conductor structure and the shielding (i.e. the grounded frame structure).

[0014] It is noted that the input conductor part and the output conductor part may have a special form (in particular comprising asymmetric sections with respect to the mirror plane, for example of open stub-like type) in order to adapt to the impedance level in the area of the unit cell conductor parts. In addition, impedance transformers can be used to match in particular a 50 Ohms input/output impedance. Note that the inventive filter device is contacted via the input conductor part and the output conductor part, typically with an input contact line and an output contact leading through an opening of the grounded frame structure (shielding) each.

[0015] By means of the invention, RF band-pass filter devices can be designed which are smaller in size and weight and less expensive to produce, as compared to conventional filter designs, with the same filter performance. In particular, depositing a microstrip conductor structure on a substrate (i.e. manufacturing a printed circuit board) and introducing the substrate into the grounded frame structure is much cheaper than machining a profile out of cast iron. The invention offers a new design approach for RF band-pass filters that can be used in mobile base stations, namely with input power levels in the range of 50 W to 1000 W. This new design approach does not have the strict reciprocal correlation between filter frequency and filter size that conventional cavity duplex filters exhibit, thus granting particular benefits when the filter frequency is relatively low.

Preferred variants of the invention

[0016] In a highly preferred embodiment of the inventive filter device, the unit cell conductor parts comprise an open stub each. Open stubs, as a section of the unit cell conductor parts introducing an asymmetry with respect to the mirror plane, are simple to produce and have shown good results in practice. Typically, only one open stub on one side of a unit cell conductor part is provided.

[0017] In an advantageous embodiment, the asymmetric unit cell conductor parts are all oriented to the same side of the straight line of conductor parts. By this means, a particularly compact design can be achieved.

[0018] Alternatively, the asymmetric unit cell conductor parts are oriented to different sides of the straight line of the conductor parts, in particular wherein the asymmetric unit cell conductor parts have an alternating orientation along the straight line of the conductor parts. This design allows more adaptation to required filter characteristics.

[0019] A particularly preferred embodiment of the inventive filter device is **characterized in that** the unit-cell conductor parts comprise a mircrostrip conductor element with a width B, wherein the microstrip conductor element comprises a central section broadened with respect to the width B, and that an open stub extends from one side of the central section of each unit-cell conductor part in a direction perpendicular to the straight line of the conductor parts. This relatively simple design has shown particularly good filter performance in practice.

[0020] Further, in a preferred embodiment, the input conductor part and a neighbouring first unit-cell conductor part are separated by an input gap, and/or a last unit-cell conductor part and the neighbouring output conductor part are separated by an output gap. The input gap and output gap may help to achieve a good matching with the (internal) impedance level of the unit cell conductor parts. However, it is noted that an input gap and output gap might be omitted when choosing the form of the input and output conductor part according to the impedance matching demands.

[0021] In a further development of this embodiment, the gaps between unit-cell conductor parts on the one hand, and the input gap and/or the output gap on the other hand have an identical width. This simple design has shown good filter performance in practice.

[0022] Preferred is also an embodiment of the inventive filter device, wherein the microstrip conductor structure has a uniform height on the substrate. Such a microstrip conductor structure is particularly simple to deposit on the substrate, e.g. by lithographic means.

[0023] In an advantageous embodiment, the input conductor part and/or the output conductor part are connected to an impedance transformer, in particular wherein the impedance transformer matches to 50 Ohms. This simplifies the cooperation of the filter device with equipment connected to it.

[0024] In a particularly preferred embodiment, the filter device exhibits characteristics corresponding to a composite right/left handed (CRLH) material. This gives access to improved filter performance as compared to conventional filter types.

[0025] Further preferred is an embodiment, wherein the number of unit cell conductor parts is between 3 and 11. With such a number of unit cells (or filter stages), both low input losses and good edge steepness can be

achieved. It is noted that the number of unit cell parts depends, in particular, on the desired filter characteristics and the desired frequency range. It is also noted that due to the identity of the unit cell conductor parts in an inventive filter device, each filter stage has an identical center frequency, in contrast to conventional filter stages which are out of tune to a small degree with respect to each other.

[0026] In another preferred embodiment, the frequency range of the filter device is in the range of 700 MHz to 2100 MHz, with a band width in the range of 25 MHz to 75 MHz. In these ranges, which are of particular relevance in numerous commercial applications, good filter performance can be achieved by means of the invention.

[0027] Finally, an advantageous embodiment is **characterized in that** the grounded frame structure is box-shaped. In this design, suspending the substrate is simple, and the separation of the microstrip conductor structure from the shielding can be well-controlled. The box-shaped frame structure is typically made of sheet metal. Alternatively, the frame structure may for example be round in cross-section perpendicular to the straight line of conductor parts.

[0028] In the scope of the present invention is also the use of an inventive filter device for filtering of transmit signals of a mobile base station. In mobile base (transceiver) stations, the inventive advantages in size, weight and filter performance are of particular relevance.

[0029] Further advantages can be extracted from the description and the enclosed drawing. The features mentioned above and below can be used in accordance with the invention either individually or collectively in any combination. The embodiments mentioned are not to be understood as exhaustive enumeration but rather have exemplary character for the description of the invention.

Drawing and detailed description of the invention

[0030] The invention is shown in the drawing.

Fig. 1 shows a schematic top view on the microstrip conductor structure of a first embodiment of an inventive RF band-pass filter device, comprising three unit cell conductor parts;

Fig. 2 shows a schematic top view on the microstrip conductor structure of a second embodiment of an inventive RF band-pass filter device, comprising five unit cell conductor parts;

Fig. 3 shows a third embodiment of an inventive RF band-pass filter device, comprising three unit cell conductor parts, in a schematic 3D view;

Fig. 4 shows schematically a cross-sectional view through an inventive RF band-pass filter device.

[0031] **Fig. 1** illustrates a top view onto the microstrip conductor structure 1 of a first embodiment of an inventive RF band-pass filter device. The microstrip conductor structure 1 is deposited on top of a flat, dielectric substrate (not shown). The microstrip conductor structure 1 comprises an input conductor part 2 (marked with a dashed box), a plurality of identical unit cell conductor parts 4a, 4b, 4c, here with three unit cell conductor parts (all marked with an own dashed box), and an output conductor part 3 (also marked with a dashed box).

[0032] The conductor parts 2, 4a-4c, 3 are arranged in a straight line, in Fig. 1 from left to right (in parallel to the x direction). Said straight line is indicated schematically with a dashed line marked L. The fist unit cell conductor part 4a is separated from the second unit cell conductor part 4b by a gap 5a, and the second unit cell conductor part 4b is separated from the third unit cell conductor part 4c by another gap 5b. Further, in the example shown, the input conductor part 2 is separated from the first unit cell conductor part 4a by an input gap 6a, and the last unit cell conductor part 4c is separated from the output conductor part 3 by an output gap 6b. In the example shown, the gap width of all gaps 5a, 5b, 6a, 6b in the x direction is identical.

[0033] The unit cell conductor parts 4a-4c are now described in detail by way of example with the first unit cell conductor part 4a. The unit cell conductor part 4a comprises a microstrip element 7, which basically establishes the connection to the neighboring conductor parts 2, 4b along the straight line L of conductor parts. The microstrip element 7 has a rectangular, central section 8, which is broader in y-direction as compared to the remaining microstrip element 7 in before and after it (where its width is B). On the right hand side of the central section 8 (seen in the direction along the straight line L of conductor parts, from the input to the output conductor part, in Fig. 1 on the bottom side) protrudes an open stub 9. The open stub 9 is rectangular in shape here, and the open stub 9 is oriented perpendicular to the straight line L. By means of the open stub 9, the unit cell conductor part 4a is asymmetric with respect to a mirror plane M running along straight line L and extending perpendicular to the substrate plane, which corresponds to the plane of the drawing here. For the open stub 9 on the right hand side, there is no corresponding section of the unit cell conductor part 4a on the left hand side (in Fig. 1 on the top side).

[0034] In other words, seen in the direction of the current path from the input conductor part to the output conductor part (with the mirror plane M running through the center of said current path), there is at least one section (here the open stub 9) of the unit cell conductor part 4a at one side on the substrate surface, which has no corresponding section of the unit cell conductor part 4a on the other side on the substrate surface. Therefore, the design of the unit cell conductor part is considered asymmetric. The inventors have found out that using such an asymmetric design of the unit cell conductor parts allows establishing a CRLH behaviour of the inventive filter device in a simple way.

[0035] The input conductor part 2, as well as the output conductor part 3, comprise several sections each, here also including an asymmetric section 10a, 10b each. The overall forms of the input and output conductor parts 2, 3, together with the input and output gaps 6a, 6b, are designed to adapt to an internal impedance level within the plurality of the unit cell conductor parts 4a-4c. The outermost sections 11 a, 11 b of the input and output conductor parts 2, 3 may be used to connect to lines leading to external systems (equipment) which use the inventive RF band-pass filter device. The contacting lines are indicated by arrows.

[0036] The input conductor part 2 and the output conductor part 3 (here there outermost elements 11 a, 11 b) are moreover connected to impedance transformers 12a, 12b, for matching the inventive band-pass filter device to (here) 50 Ohms.

[0037] **Fig. 2** illustrates a microstrip conductor structure 21 of another embodiment of an inventive RF band-pass filter device, similar to the one shown in Fig. 1. For simplicity, only the deviations are discussed in the following.

[0038] The microstrip conductor structure 21 here comprises five identical unit cell conductor parts 4a-4e. However, the unit cell conductor parts 4a-4e have an alternating orientation. The open stubs 9 of unit cell conductor parts 4b, 4d protrude to the left hand side (in Fig. 2 to the top), and the open stubs of unit cell conductor parts 4a, 4c and 4e protrude to the right hand side (in Fig. 2 to the bottom).

[0039] **Fig. 3** shows in a schematic 3D view an inventive radio frequency (RF) band-pass filter device 31. On the top surface of a dielectric substrate 32, a microstrip conductor structure 33 is deposited, here comprising three unit cell conductor parts with a relatively long open stub 9 each. The substrate 32 is suspended within a box-shaped grounded frame structure 34 (indicated by lines showing the internal boundaries). Note that the suspension can be accomplished for example by means of bearings fixed on the bottom of the frame structure 34. The grounded frame structure 34 entirely encapsulates the substrate 32 and the microstrip conductor structure 33, for the purpose of electromagnetic shielding. Accordingly, above and below the substrate 32, and above the microstrip conductor structure 33, there is some empty space (typically filled with air).

[0040] The frame structure 34 is typically made of steel or another electrically highly conducting metal. The microstrip conductor structure 33 is typically made of copper, and typically exhibits a uniform height (in the z direction perpendicular to the substrate 32).

[0041] **Fig. 4** illustrates a cross-sectional view in the y-z plane through an inventive RF band-pass filter device 31 similar to the one shown in Fig. 3. Within a box-shaped (and in the cross-section rectangular shaped) grounded frame structure 34, here comprising a removable cover 34a for mounting purposes, a dielectric substrate 32 is suspended. On top of the substrate 32, there is deposited a microstrip conductor structure 33.

Detailed example

[0042] In experiments performed by the inventors, which exhibited good filter performance, a separation S (see Fig. 4) of the substrate with respect to the bottom and top of the frame structure of 20 mm was used. A typical width W of microstrip elements in y direction was 3 mm. A typical length of unit cell conductor parts in x direction was 14 mm, and a gap spacing (gap width) in x direction used was 0.15 mm. Open stubs with width (in x direction) of 5 mm and a length (in y direction) between 1.2 mm and 274 mm were used. A substrate material used with the invention was Rogers4003 (with $\varepsilon_r = 3.38$, and $\tan \delta = 0.002$ rad). A substrate thickness T (see Fig. 4) of 0.5 mm exhibited sufficient mechanical stability for the purposes of the invention.

Claims

1. A radio frequency band-pass filter device (31), comprising

   - a grounded frame structure (34),
   - a dielectric substrate (32) suspended within the frame structure (34),
   - and a microstrip conductor structure (1; 21; 33) located on top of the dielectric substrate (32),

   wherein the microstrip conductor structure (1; 21; 33) comprises

   - an input conductor part (2),
   - a plurality of identical unit cell conductor parts (4a-4e),
   - and an output conductor part (3),

   with these conductor parts (2, 4a-4e, 3) arranged in a straight line (L), wherein the unit cell conductor parts (4a-4e) are asymmetric with respect to a mirror plane (M) perpendicular to the substrate (32) and running along the straight line (L) of conductor parts (2, 4a-4e, 3),
   and wherein the unit-cell conductor parts (4a-4e) are separated by gaps (5a, 5b) of equal width.

2. A filter device (31) according to claim 1, **characterized in that** the unit cell conductor parts (4a-4e) comprise an open stub (9) each.

3. A filter device (31) according to claim 1, **characterized in that** the asymmetric unit cell conductor parts (4a-4e) all oriented to the same side of the straight line (L) of conductor parts (2, 4a-4e, 3).

4. A filter device (31) according to claim 1, **character-**

ized in that the asymmetric unit cell conductor parts (4a-4e) are oriented to different sides of the straight line (L) of the conductor parts (2, 4a-4e, 3), in particular wherein the asymmetric unit cell conductor parts (4a-4e) have an alternating orientation along the straight line (L) of the conductor parts (2, 4a-4e, 3).

5. A filter device (31) according to claim 1, **characterized in that** the unit-cell conductor parts (4a-4e) comprise a mircrostrip conductor element (7) with a width B, wherein the microstrip conductor element (7) comprises a central section (8) broadened with respect to the width B, and that an open stub (9) extends from one side of the central section (8) of each unit-cell conductor part (4a-4e) in a direction perpendicular to the straight line (L) of the conductor parts (2, 4a-4e, 3).

6. A filter device (31) according to claim 1, **characterized in that** the input conductor part (2) and a neighbouring first unit-cell conductor part (4a) are separated by an input gap (6a), and/or a last unit-cell conductor part (4c; 4e) and the neighbouring output conductor part (3) are separated by an output gap (6b).

7. A filter device (31) according to claim 6, **characterized in that** the gaps (5a, 5b) between unit-cell conductor parts (4a-4e) on the one hand, and the input gap (6a) and/or the output gap (6b) on the other hand have an identical width.

8. A filter device (31) according to claim 1, **characterized in that** the microstrip conductor structure (1; 21; 33) has a uniform height on the substrate (32).

9. A filter device (31) according to claim 1, **characterized in that** the input conductor part (2) and/or the output conductor part (3) are connected to an impedance transformer (12a, 12b), in particular wherein the impedance transformer (12a, 12b) matches to 50 Ohms.

10. A filter device (31) according to claim 1, **characterized in that** the filter device (31) exhibits characteristics corresponding to a composite right/left-handed (CRLH) material.

11. A filter device (31) according to claim 1, **characterized in that** the number of unit cell conductor parts (4a-4e) is between 3 and 11.

12. A filter device (31) according to claim 1, **characterized in that** the frequency range of the filter device (31) is in the range of 700 MHz to 2100 MHz, with a band width in the range of 25 MHz to 75 MHz.

13. A filter device (31) according to claim 1, **characterized in that** the grounded frame structure (34) is box-shaped.

14. Use of a filter device (31) according to claim 1 for filtering of transmit signals of a mobile base station.

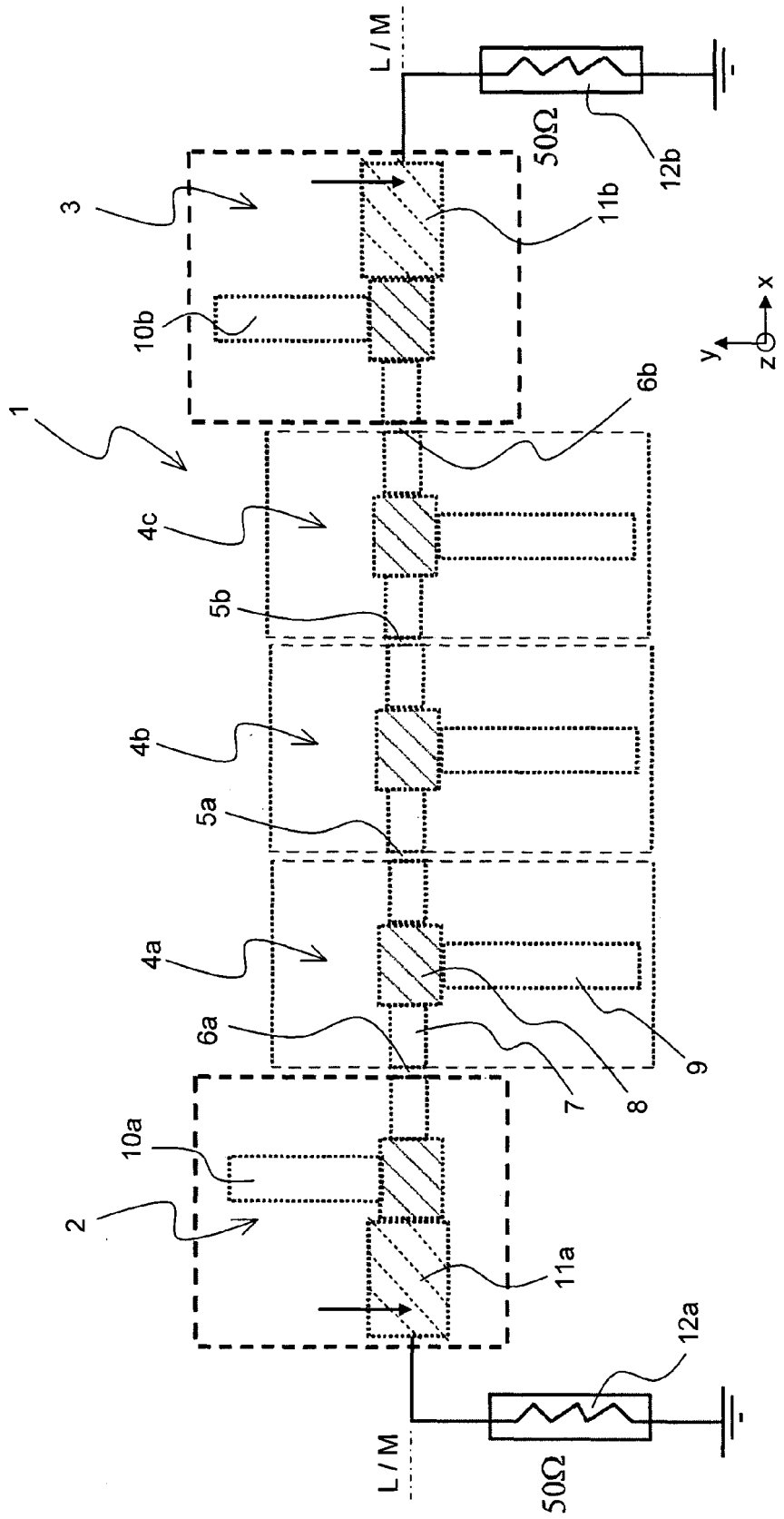
L / M
50Ω
12b
11b
3
10b
y
x
z
1
6b
4c
5b
4b
5a
4a
6a
7
8
9
10a
2
11a
12a
L / M
50Ω

Fig. 1

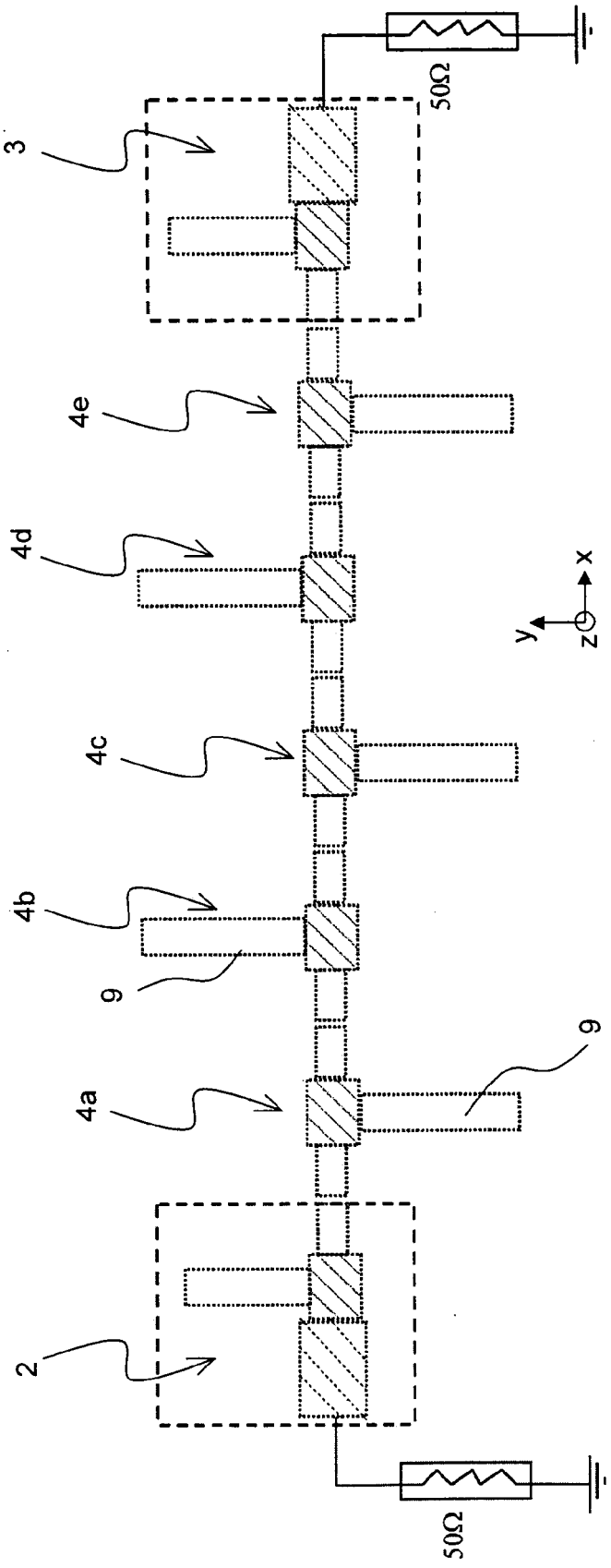

Fig. 2

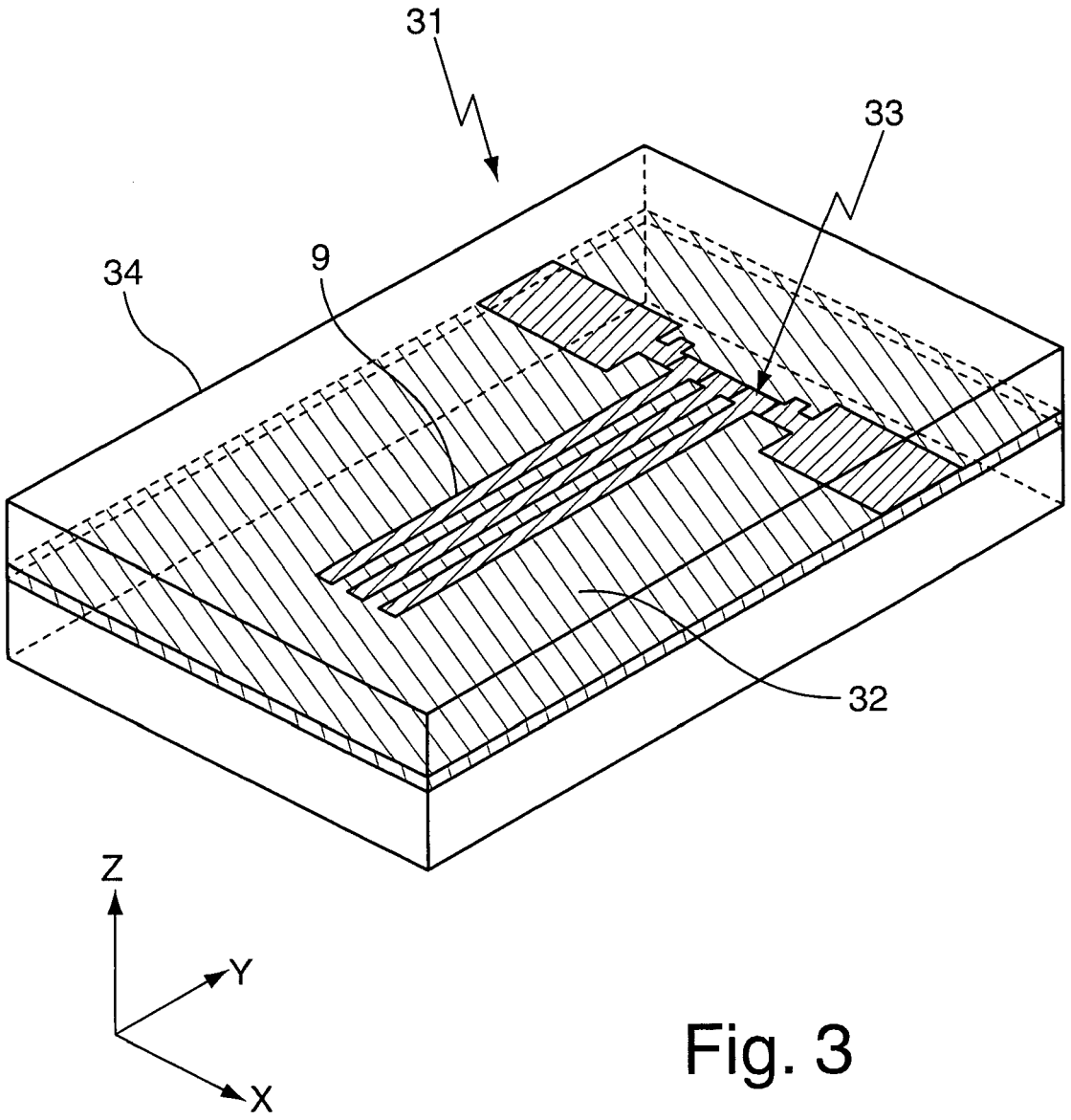

Fig. 3

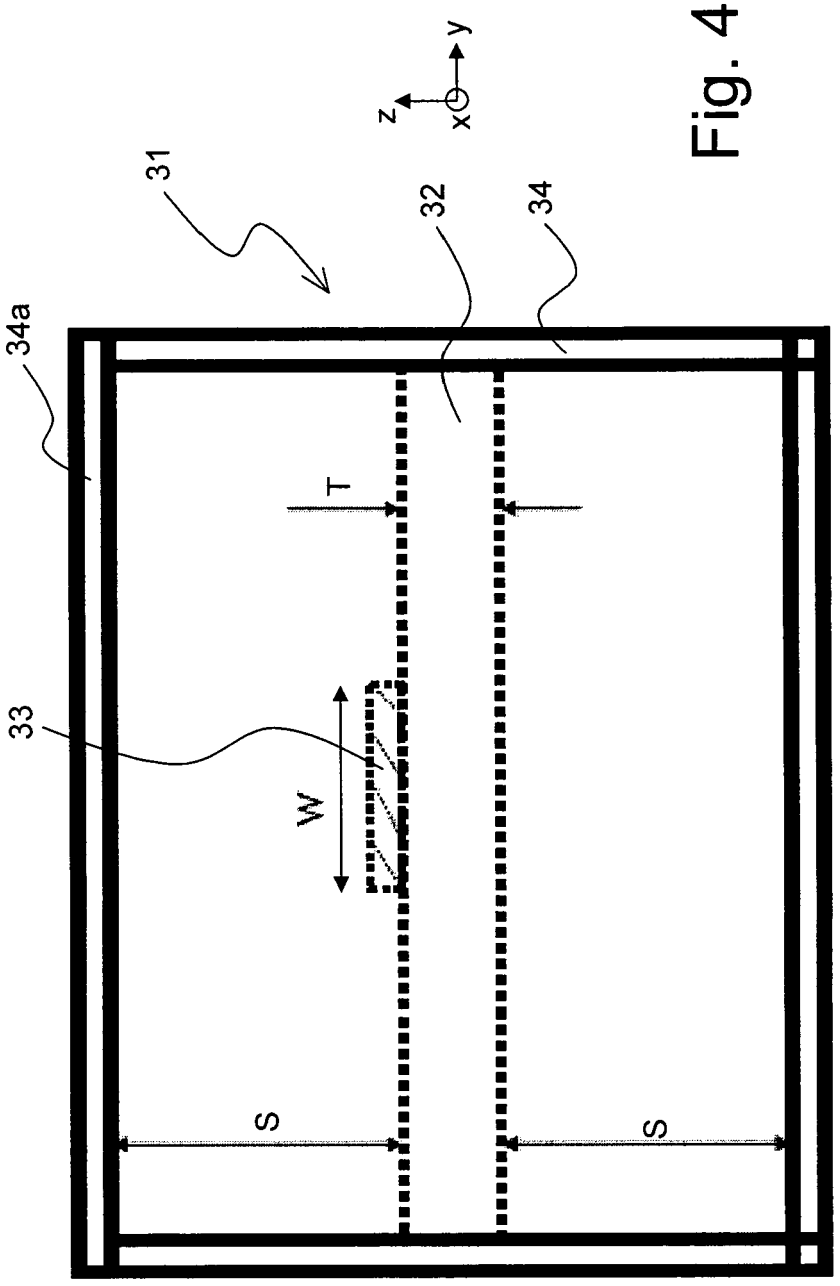

Fig. 4

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 08 29 0907

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 0 858 121 A (COM DEV LTD [CA]) 12 August 1998 (1998-08-12) * column 2, line 54 - column 3, line 16 * * column 5, lines 29-54 * * column 6, lines 51-54; figures 1,7 *	1,4,6,8, 10,11,13	INV. H01P1/203
Y		2,7,9,12	
Y	US 2006/125578 A1 (AKALE TAMRAT [US] ET AL) 15 June 2006 (2006-06-15) * paragraphs [0013] - [0015], [0021]; figure 1 *	2,7,12	
Y	US 2004/257173 A1 (LUQUE NORMAN A [US]) 23 December 2004 (2004-12-23) * paragraph [0054]; figure 7 *	9	
X	WO 2007/100324 A (LUCENT TECHNOLOGIES INC [US]; ADAMIUK GRZEGORZ [DE]; FISCHER GEORG [DE) 7 September 2007 (2007-09-07) * page 1, line 10 - page 2, line 10 * * page 8, line 23 - page 10, line 11; figures 5A-C *	1,3,14	TECHNICAL FIELDS SEARCHED (IPC) H01P
A	HAN W J ET AL: "Bandpass filters utilizing simplified left-handed transmission line structure" MICROWAVE AND MILLIMETER WAVE TECHNOLOGY, 2008. ICMMT 2008. INTERNATIONAL CONFERENCE ON, IEEE, PISCATAWAY, NJ, USA, 21 April 2008 (2008-04-21), pages 62-65, XP031270407 ISBN: 978-1-4244-1879-4 * figure 3 *	1	
A	GB 2 382 233 A (KONINKL PHILIPS ELECTRONICS NV [NL]) 21 May 2003 (2003-05-21) * page 1, lines 22-25; figure 3 *	1	
	-/--		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	18 December 2008	Den Otter, Adrianus

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

6

EPO FORM 1503 03.82 (P04C01)

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 08 29 0907

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	J.LI: "Novel filter using composite right/left-handed transmission line" MICROWAVE AND OPTICAL TECHNOLOGY LETTERS, vol. 48, no. 10, October 2006 (2006-10), pages 2013-2015, XP002508431 * figure 3 *	1	
A	US 3 668 569 A (HERRING FREDERICK G) 6 June 1972 (1972-06-06) * figures 1b,c *	1	
A	G. DEHM-ANDONE ET AL.: "Using metamaterial structures with frequency agile basestations" GERMAN MICROWAVE CONFERENCE - GEMIC 2006, 28 March 2006 (2006-03-28), - 30 March 2006 (2006-03-30) pages 1-8, XP002508440 * figure 18 *	1	
			TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	18 December 2008	Den Otter, Adrianus

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 08 29 0907

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

18-12-2008

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0858121 A	12-08-1998	CA 2197253 A1	11-08-1998
		US 5990765 A	23-11-1999
US 2006125578 A1	15-06-2006	EP 1831954 A1	12-09-2007
		JP 2008524926 T	10-07-2008
		KR 20070088697 A	29-08-2007
		WO 2006065384 A1	22-06-2006
US 2004257173 A1	23-12-2004	NONE	
WO 2007100324 A	07-09-2007	EP 1989753 A1	12-11-2008
GB 2382233 A	21-05-2003	NONE	
US 3668569 A	06-06-1972	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Non-patent literature cited in the description

- **C. Caloz ; T. Itoh.** *IEEE MTT-S Digest,* 2003, 195-198 **[0006]**