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

(11) EP 1 544 938 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
22.06.2005 Bulletin 2005/25

(51) Int Cl.[7]: **H01P 1/205**, H01P 1/213

(21) Application number: **04029980.2**

(22) Date of filing: **17.12.2004**

(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 MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR LV MK YU

(30) Priority: **19.12.2003 EP 03029337**

(71) Applicant: **ALCATEL**
75008 Paris (FR)

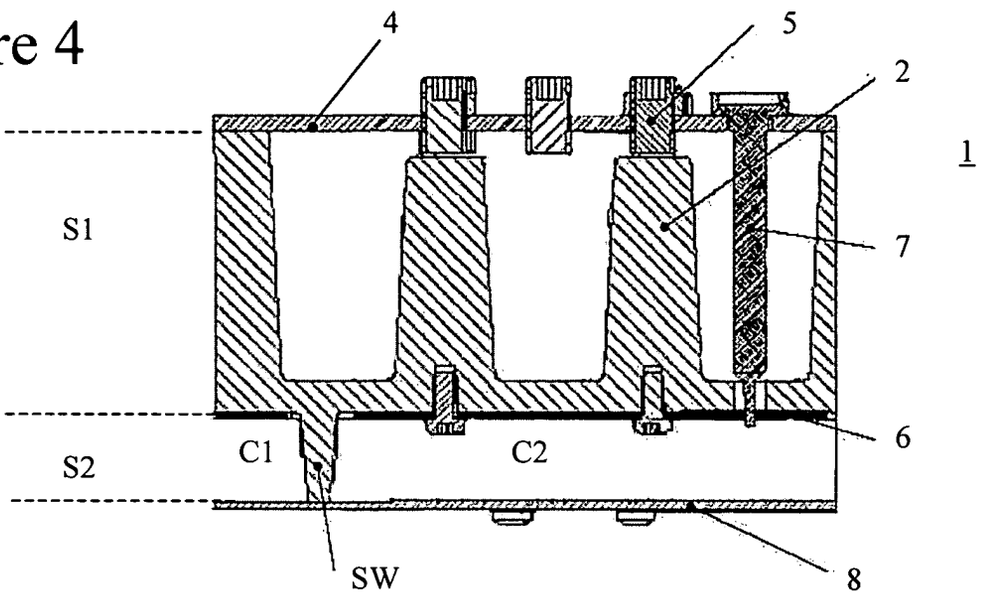
(72) Inventor: **Broholm, Niels**
2100 Copenhagen (DK)

(74) Representative: **Brose, Gerhard et al**
Alcatel,
Intellectual Property Group, Stuttgart
70430 Stuttgart (DE)

(54) Multiple cavity filter

(57) The invention relates to a multiple cavity filter (1) for use in tower mounted amplifier and transceiver front end applications comprising a duplexer or triplexer (T1) filter functionality implemented by means of coaxial resonator cavities, wherein the filter body housing (2) is made of a thermoplastic material; the filter body housing (2) is designed so that on a first side (S1), the side of the multiple cavity filters, it provides at least an extra duplexer or triplexer filter functionality (T2); the filter body housing (2) is designed so that on a second side (52), opposite to the side of the filter cavities, it provides at least two compartments (C1 to C3) separated by shielding walls (SW) for placement of a plurality of digital electronic circuitry for the more than one duplexer or triplexer filter functionality and system functioning monitoring; and the body housing (2) is plated with an electrical conductive material.

Figure 4



EP 1 544 938 A1

Description

[0001] The present invention relates generally to multiple cavity filters, and more particularly to a multiple cavity filter made of a polymeric material.

[0002] Many types of filters are used today in base stations for mobile telephony. Often these filters are formed from central conductors placed inside a cavity or a number of cavities known as coaxial cavity resonators. The walls of this cavity or cavities are conductive and usually formed by the inner surface of a filter-casing. A broadband filter comprising resonators having slightly different tuning frequencies in comb-line filters is disclosed in US Patent 5,963,854 for tower mounted amplifier (TMA) applications. Also a multi-cavity radio frequency (RF) filter having transmitting and receiving filter sections with a single input/output cavity is found in US Patent 6,392,506.

[0003] In order to make such filters lighter and easier to manufacture, it has been also proposed, in US Patents 3,955,161 and 5,329,687, to fabricate them using a moldable material, such as a plastic having predetermined thermal properties. The injection molded plastic structure of the filter is then plated with a conductive layer.

[0004] Usually, such filters, used for amplifier or transceiver applications in mobile communication systems, are part of a greater system structure in which a plurality of electronic circuits and filters are interconnected in order to obtain the desired overall system functionality. For example, in US Patent Application 2004/0198418 a conventional transceiver system is described which comprises receiving and transmitting filters connected to a plurality of other electronic equipment such as switches, high-frequency amplifiers, mixers, modulators, power amplifiers, etc. These transceiver systems occupy a lot of space because the RF components and the direct current (DC) supply components are implemented separately and the different electronic RF and DC equipment connected with coaxial and DC cables.

[0005] It is the object of the present invention to provide a novel and improved multiple cavity filter.

[0006] The object is achieved according to the invention by a multiple cavity filter for use in tower mounted amplifier and transceiver front end applications comprising a duplexer or triplexer filter functionality implemented by means of coaxial resonator cavities, wherein the filter body housing is made of a thermoplastic material; the filter body housing is designed so that on a first side, the side of the multiple cavity filters, it provides at least an extra duplexer or triplexer filter functionality; the filter body housing is further designed so that on a second side, opposite to the side of the filter cavities, it provides at least two compartments separated by shielding walls for placement of a plurality of digital electronic circuitry for the more than one duplexer or triplexer filter functionality and system functioning monitoring; and the filter body housing is plated with an electrical conductive material.

[0007] The object is also achieved according to the invention by a method for manufacturing a multiple cavity filter comprising the steps of: molding a filter body housing in thermoplastic material, the body housing having on a first side cavities implementing at least a double duplexer or triplexer filter functionality, and on a second side, opposite to the filter cavities, having at least two compartments separated by shielding walls for placement of a plurality of digital electronic circuitry for the more than one duplexer or triplexer filter functionality and system monitoring; coating the filter body housing with an electrical conductive material; and fitting a trimming plate and a shielding cover to cover the body housing.

[0008] In present times, there is an increasing industry pressure to reduce the cost and size of base station communications equipment. By developing the solution proposed by the invention a high level of integration can be achieved which substantially reduces space, weight and cost of base station equipment such as front end transceiver systems or tower mounted amplifiers. The lifetime of the filter is considerably higher compared with conventional machined or casted aluminum filters. The lifetime of the mould when injection molding thermoplastic material is used is at least ten times higher compared to die's used for pressure die-casting. Furthermore, the special way the RF and DC electronic functionality is placed and coupled to the filter allows shorter assembly times.

[0009] Other advantageous configurations of the invention emerge from the dependent claims, the following description and the drawings.

[0010] An embodiment example of the invention is now explained with the aid of Figures 1 to 5.

[0011] Fig. 1A, B show a simplified block diagram of a TMA comprising a multiple cavity filter according to the invention.

[0012] Fig. 2 shows a simplified block diagram of a transceiver front end (TFE) comprising a multiple cavity filter according to the invention.

[0013] Fig. 3 A, B show a perspective sectional top and back view of an exemplary embodiment of a multiple cavity filter according to the present invention.

[0014] Fig. 4 shows a sectional side view of an exemplary embodiment of a multiple cavity filter according to the invention.

[0015] Fig. 5 A, B show a perspective partial view of an exemplary embodiment of a multiple cavity filter with connectors mounted onto the housing according to the invention.

[0016] Figure 1A shows a simplified block diagram of a TMA 10 comprising, in the signal reception path, two reception filters RXF1 and RXF2 connected to a low noise amplifier LNA and, in the transmission path, a transmission filter TXF. The receive and transmission paths are combined in two output/input ports, one port AP for connection with a Tx/Rx antenna arrangement

ANT, and another port BP for connection with a mobile base station (not shown).

[0017] Figure 1B shows a typical duplex arrangement of a TMA 10. It is a paired configuration in which the functions are doubled. The TMA filter 1 comprises in this case a doubled triplexer filter functionality. Triple arrangements or any other multiple of the basic arrangement shown in figure 1A are also possible.

[0018] The TMA 10 comprises further digital electronic circuitry, such as DC supplies, Bias Tee circuits and switches, which is not shown in Figure 1, in order to develop the desired system function. It is also possible that the TMA 10 comprises also a digital control unit in order to monitor the functioning and performance of the whole TMA system and generate alarms in case of malfunction. A communication link and communication protocol unit or modem may also be incorporated for communication with the base station. All this electronic circuitry is coupled and placed on the TMA multiple cavity filter 1 according to the invention.

[0019] Figure 2 shows a simplified block diagram of a transceiver front end (TFE) in a duplex arrangement, with two RF modules M1 and M2 connected to a control and DC unit CDC. Each RF module M1, M2 comprises a Voltage Standing Wave Ratio (VSWR) detector VD, a Bias-Tee circuit BT, a duplexer filter functionality DT which is implemented with a multiple cavity filter according to the invention, two reception and transmission low pass filters RX LPF and TX LPF, a low noise amplifier LNA, power dividers PD and connections to an antenna and other base station systems. The control and DC unit CDC is in charge, for example, of controlling and monitoring the functionality of the VSWR detectors VD and the Bias-Tee circuits BT, providing DC/DC conversion and DC-supply functionality DCM, and signaling and interfacing means TSI, DEI between the TFE and another base station systems.

[0020] Figure 3A shows a perspective sectional top view of an exemplary embodiment of a filter 1 according to the present invention. The filter 1 is a coaxial cavity filter which implements a double triplexer filter functionality T1 and T2. For the sake of simplification we will explain here only one triplexer functionality T1, that is, implementation of two signal reception path filters RF1, RF2 and one transmission path filter TF.

[0021] The cavities are manufactured by moulding a filter body housing 2 in thermoplastic material. Customizable material properties, such as coefficient of thermal expansion and heat conductivity is achievable by controlling the content of glass-, mineral-fillers and additives of the thermoplastic material. The polymer filter is then coated with an electrical conductive material, such as for example copper or silver-plating. The plating process is usually made by electro-deposited silver on top of a thin layer of chemical copper and electrolytic copper.

[0022] The triplexer filter T1 of Figure 3A has two common resonators CR1, CR2 for the reception and transmission signal filter paths and the cavities implementing the reception and transmission filters RF1, RF2, TF are not aligned in a straight form in order to save space. Further, the housing comprises two coupling openings Ci, Co for coupling the filter functionality to other electronic digital functionality, RF and DC electronic circuitry, located at the back side of the filter housing 2, that is, on the side opposite to the cavities shown in Figure 3B.

[0023] The back side of the filter body housing 2 is designed so that it provides cavities or compartments C1 to C3 to mount said RF and DC electronic circuitry, e.g. DC supplies, reception and transmission combiners, Bias Tee circuits, low noise amplifiers, etc. directly on the filter body housing 2. It is also possible that said electronic circuitry is implemented on a printed circuit board (PCB) and placed on the body housing 2. The back side of the body housing 2 is further designed so that it allows the integration of such RF and DC electronic circuitry in a single PCB, avoiding having several PCB circuits connected with DC and coaxial cables as it is seen in another TFE or TMA systems. The different RF and DC electronic circuits are shielded by means of shielding walls SW molded on the filter body housing 2. For example, in a first compartment C1 at the back side of the filter body housing 2 a common DC supply and a monitoring digital control unit for the two triplexer filters T1 and T2 could be implemented, on a second compartment C2 a low noise amplifier and a reception combiner for the first triplexer T1 could be located and in a third compartment C3 a bias tee and a VSWR detector circuit could be placed. These circuits would be shielded with a plurality of shielding walls in order to avoid interferences between them. The back side of the body housing 2 can be completely plated or at least the shielding walls in order to effectively isolate the compartments.

[0024] Figure 4 shows a sectional side view of an exemplary embodiment of a multiple cavity filter 1. The filter body housing 2 is molded, according to the invention, so that on one side S1 it provides multiple cavity filter functionality e.g. duplexer or triplexer filter functionality, and on a second side S2, opposite to the side of the filter cavities S1, it provides at least two compartments C1, C2 separated by shielding walls SW for placement of a plurality of digital electronic circuitry on the surface 6 of said filter body housing side S2. The shielding walls integrated in the moulded filter housing prevent the RF signals to interfere with the digital electronic circuits. A coupling rod 7 is used for coupling the filter functionality to the electronic digital functionality (RF and DC electronic circuitry) through a hole or coupling opening in the filter cavity.

[0025] A shielding cover 8 is provided over the side S2 of the body housing in which the electronic circuitry is placed in order to avoid electro-magnetical interference.

[0026] The multiple cavity filter 1 comprises also a trimming plate 4 or cover of the body housing 2 multiple cavity filter functionality side S1 can be either manufac-

tured in coated/plated aluminum or moulded in the same thermoplastic material as the filter body 2 and then coated. The conventional aluminum trimming plate is normally secured to the filter body by mounting self tapping or self cutting screws into the filter body. If the trimming plate is made in thermoplastic, it can be joined to the filter body 2 by several methods as e.g. reflow soldering, conductive glue, laser welding, heat staking or ultrasonic welding.

[0027] Over each of the cavity resonators there is a thread in which a tuning screw 5 is mounted. By adjusting the screws 5 towards the top of the resonators, the filter is tuned to its frequency, attenuation specs, return loss and insertion loss. When the position of the screw is correct, it is secured by means of a counter nut.

[0028] Figures 5 A and B show a perspective partial view of an exemplary multiple cavity filter 1 with connectors 3 mounted onto the housing 2 according to the invention.

[0029] In a typical arrangement of a mobile network base station, the inner filter cavity resonators are coupled to external devices, for example an antenna, by means of a coaxial connector 3 mounted onto the housing 2 of the multiple cavity filter 1.

[0030] In figure 5A, the coaxial connectors 3 are mounted on the multiple cavity filter housing 2 by means of screws or by press-fit.

[0031] Alternatively, also according to the invention, the multiple cavity filter housing 2 can be moulded together with the connectors 3, as shown in figure 5B, so that the connectors 3 constitute an integrated part of the filter housing 2.

[0032] To mould the filter together with the connectors reduces overall equipment weight, cost, assembly time and optimizes passive intermodulation performance.

Claims

1. A multiple cavity filter (1) for use in tower mounted amplifier and transceiver front end applications comprising a duplexer or triplexer (T1) filter functionality implemented by means of coaxial resonator cavities,
   characterized in that
   the filter body housing (2) is made of a thermoplastic material;
   the filter body housing (2) is designed so that on a first side (S1), the side of the multiple cavity filters, it provides at least an extra duplexer or triplexer filter functionality (T2);
   the filter body housing (2) is designed so that on a second side (S2), opposite to the side of the filter cavities, it provides at least two compartments (C1 to C3) separated by shielding walls (SW) for placement of a plurality of digital electronic circuitry for the more than one duplexer or triplexer filter functionality and system functioning monitoring;
   the filter body housing (2) is plated with an electrical conductive material.

2. The multiple cavity filter (1) of claim 1 **characterized in that** the plurality of digital electronic circuitry is mounted directly onto said second side (S2) of the body housing (2).

3. The multiple cavity filter (1) of claim 1 **characterized in that** the plurality of digital electronic circuitry is mounted on a printed circuit board which is placed onto said second side (S2) of the body housing (2).

4. The multiple cavity filter (1) of claim 3 **characterized in that** the plurality of digital electronic circuitry is mounted on a single printed circuit board adapted to fit with the compartments (C1 to C3) and shielding walls of said second side (S2) of the body housing (2).

5. The multiple cavity filter (1) of claim 1 **characterized in that** said plurality of digital electronic circuitry placed on that second side (S2) of the body housing (2) is coupled to the cavity filter functionality of that first side (S1) by means of a coupling rod (7) through a hole or coupling opening (Ci, Co) in a filter cavity.

6. The multiple cavity filter (1) of claim 1 **characterized in that** the filter body housing (2) is further designed so that it provides at least a connector (3) as an integral part of the body housing (2).

7. The multiple cavity filter (1) of claim 1 **characterized in that** the filter body housing (2) is further designed so that the cavities implementing the filter functionality are arranged in a not-straight form in order to save space.

8. A method for manufacturing a multiple cavity filter (1) comprising the following steps:

   molding a filter body housing (2) in thermoplastic material, the body housing having on a first side (S1) cavities implementing at least a double duplexer or triplexer (T1, T2) filter functionality, and on a second side (S2), opposite to the filter cavities, having at least two compartments (C1 to C3) separated by shielding walls (SW) for placement of a plurality of digital electronic circuitry for the more than one duplexer or triplexer filter functionality and system monitoring;
   coating the filter body housing (2) with an electrical conductive material;
   fitting a trimming plate (4) and a shielding cover (8) to cover the body housing (2).

9. The method of claim 8 further molding the filter body housing (2) with at least a connector (3) as an integral part of the body housing.

10. The method of claim 8 **characterized in that** the trimming plate is moulded in the same thermoplastic material as the filter body (2) and mounted on it by any of the following methods: reflow soldering, gluing with conductive glue, laser welding, heat staking or ultrasonic welding.

Figure 1

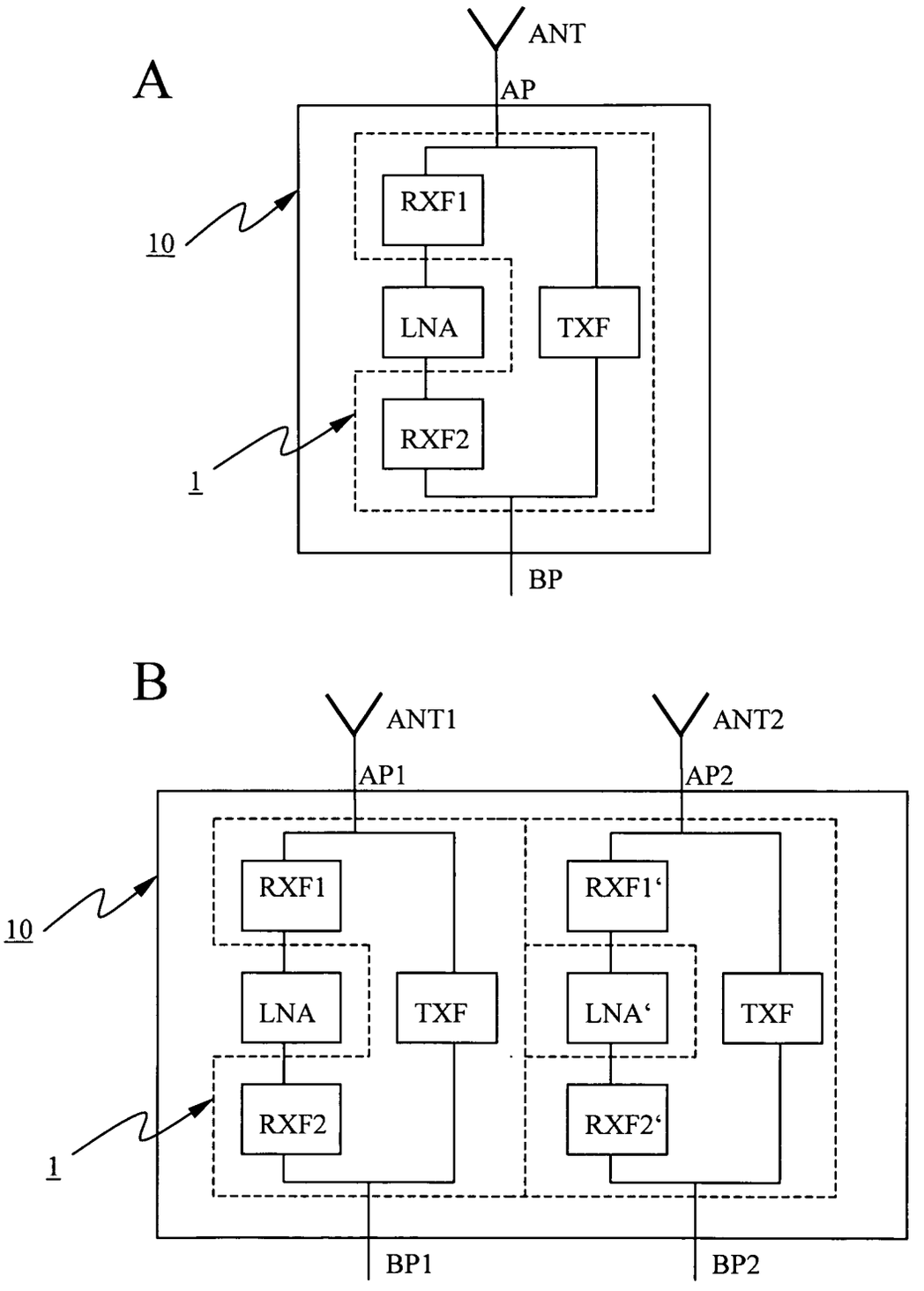

A
ANT
AP
RXF1
10
LNA
TXF
RXF2
1
BP
B
ANT1
ANT2
AP1
AP2
RXF1
RXF1'
10
LNA
TXF
LNA'
TXF
RXF2
RXF2'
1
BP1
BP2

Figure 2

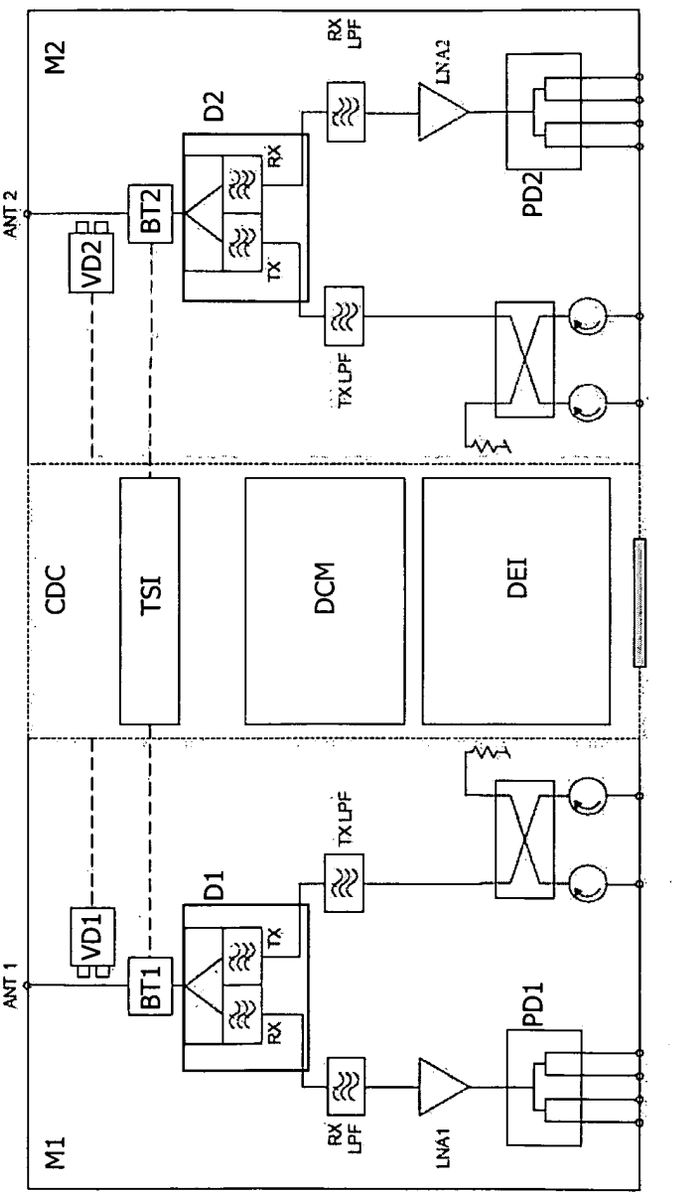

M2
RX LPF
LNA2
D2
RX
TX
PD2
ANT 2
VD2
BT2
TX LPF
CDC
TSI
DCM
DEI
M1
TX LPF
D1
TX
RX
PD1
ANT 1
VD1
BT1
RX LPF
LNA1

Figure 3

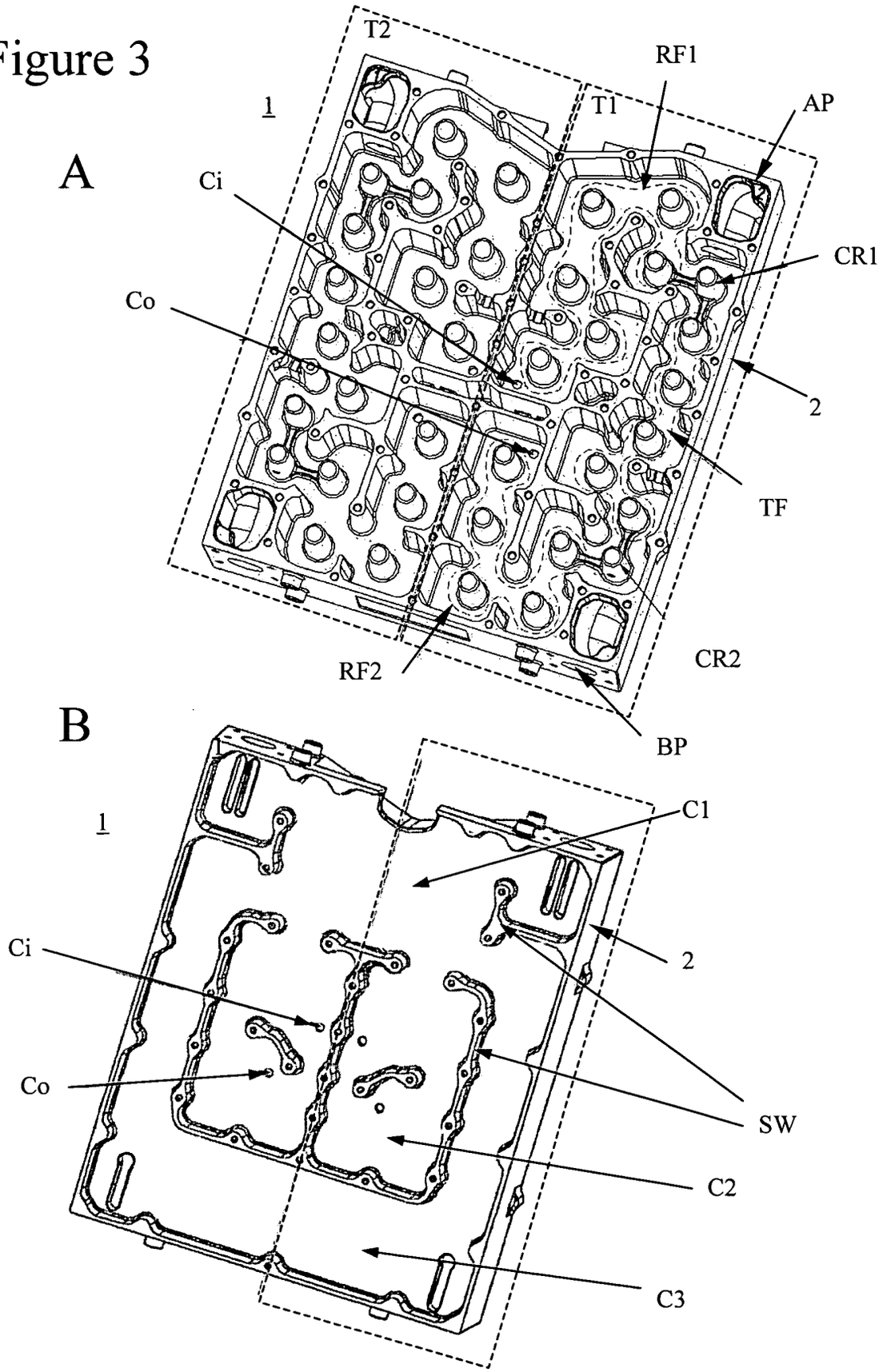


Figure 4

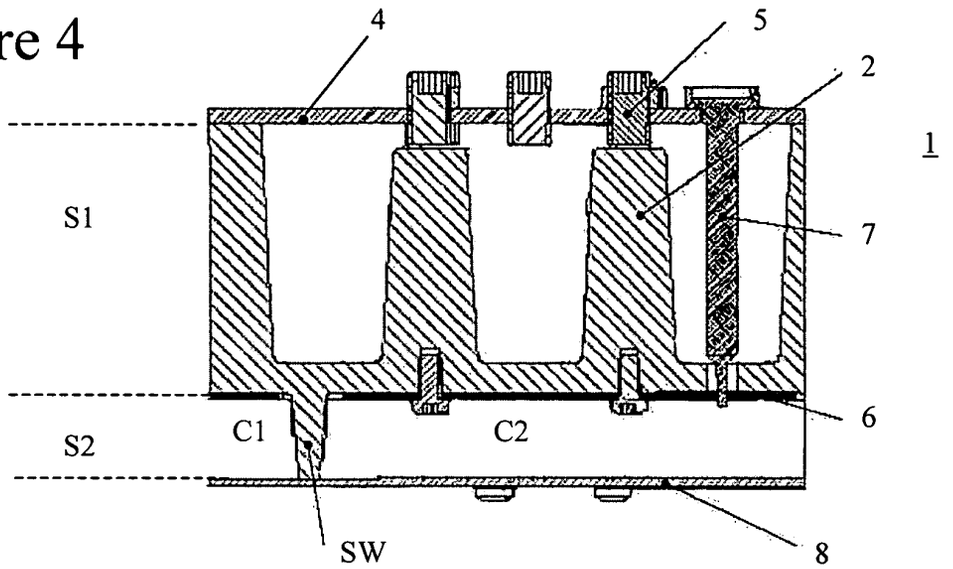
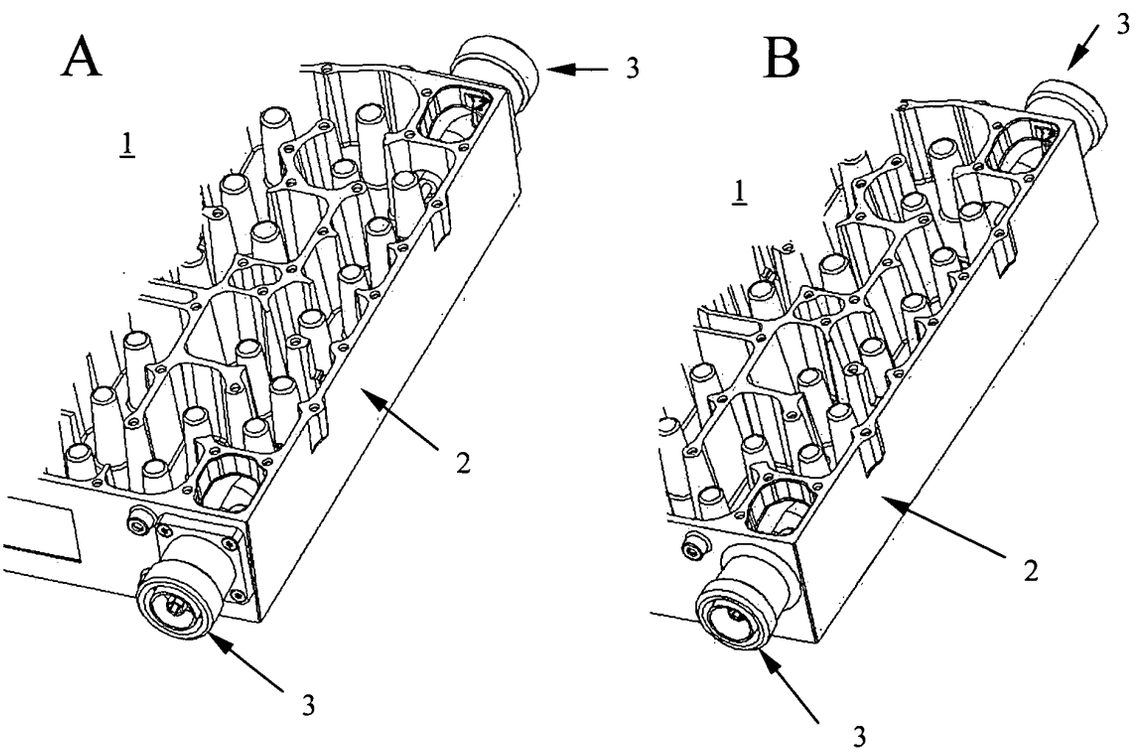


Figure 5



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 02 9980

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
D,Y	US 5 329 687 A (SCOTT ET AL) 19 July 1994 (1994-07-19) * column 2, line 15 - line 33 * * column 7, line 31 - line 38; figures 8a-8c,9a *	1-10	H01P1/205 H01P1/213
Y	US 2002/053956 A1 (HENNINGSSON UNO ET AL) 9 May 2002 (2002-05-09) * column 4, line 19 - line 29; figure 2 *	1-10	
Y	US 4 278 957 A (STARAI ET AL) 14 July 1981 (1981-07-14) * column 2, line 51 - column 3, line 23; figure 1 *	1-10	
A	US 5 428 325 A (JACHOWSKI ET AL) 27 June 1995 (1995-06-27) * column 7, line 32 - line 64; figure 5 *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

H01P

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	15 April 2005	Pastor Jiménez, J-V

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 04 02 9980

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.

15-04-2005

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5329687 A	19-07-1994	DE 4337079 A1	09-06-1994
		JP 7038307 A	07-02-1995
US 2002053956 A1	09-05-2002	SE 516242 C2	10-12-2001
		AU 3786801 A	12-09-2001
		SE 0000715 A	04-09-2001
		WO 0165632 A1	07-09-2001
US 4278957 A	14-07-1981	NONE	
US 5428325 A	27-06-1995	NONE	

EPO FORM P0459

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