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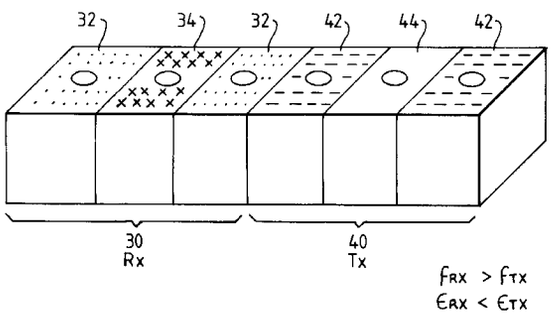
(54) Ceramic filter.

(57) A dielectric filter comprises several ceramic resonator blocks (30,40) in contiguous relationship. The individual resonator blocks are made of different ceramic materials having respectively different dielectric constants. Consequently, the resonator blocks may all have the same physical height, while having different resonant frequencies. Thus an optimum physical size may be selected for the resonator blocks, particularly with regard to packing density.

Fig. 2.



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The present invention relates to a dielectric filter comprising at least two dielectric, e.g. ceramic resonator blocks.

It is known that one way of shortening a quarter wavelength coaxial-cavity resonator is to fill the cavity between its coaxial conductors with a dielectric. Dielectric filters are used for applications in the microwave range, as in radiotelephone duplex filters and in receiver front-end filters. Small size, low loss and excellent stability are known advantages of such ceramic filters.

Prior art dielectric filters comprise one or more dielectric block resonators. A filter may be an assembly of several discrete resonators, each formed by a piece of dielectric, usually ceramic, material coated with conducting material and provided with a hole. The coating and the electrical interfaces are such that a transmission line resonator is formed with a natural frequency determined by the physical length or "height" of the resonator in the direction of the hole. The electrical length of the resonator is usually the length of a quarterwave, and so the device is called a $\lambda/4$-resonator. A desired number of resonator blocks may be coupled in contiguous relationship, whereby a filter with a desired bandwidth is obtained, e.g. a band-stop filter. It is also possible to use a monolithic block of ceramic material containing a required number of holes coated with conductive material, forming a corresponding number of transmission line resonators. In a single block it is easy to realize e.g. a band-pass filter. A duplex filter may be formed with two such filters. In this case the two separate filter blocks may be mechanically joined, i.e. by soldering into a common frame or housing.

As mentioned above, resonators are usually made as quarter-wave resonators, and the length of the resonator hole, i.e. the height of the ceramic part, is determined by the resonance frequency. Because the wave velocity in a dielectric material having a dielectric constant ε_x is equal to the wave velocity in air divided by the square root of the dielectric constant, very small sized filters are obtained due to the high ε_x values of ceramic materials. As a natural consequence of the fact that the wave velocity in a dielectric material depends on its dielectric constant, the resonance frequency of the resonator varies depending on the physical length ("height") of the ceramic block using the same material.

If a filter is formed by several separate resonator blocks coupled mechanically side by side to form a long bar, its profile seen from one side may resemble a staircase, where the difference between the shortest and tallest resonator blocks could be considerable. When a filter comprising resonators with different heights is encapsulated, the housing will contain much "wasted space" in the height direction, because the tallest resonator will determine the size of the filter. The same applies for a duplex filter. Because the center frequency of the filter in the receiver branch differs considerably from the center frequency of the filter in the transmitter branch, there is a perceivable height difference between these filter blocks, which is a drawback when the device is encapsulated. Because all resonator blocks typically are made of the same material, the shorter resonators may be made of a material having a better quality than is required, because a material with an unnecessary high dielectric constant is used for the required height. The price of the ceramic material tends to increase steeply when the dielectric constant increases.

According to the present invention there is provided a dielectric ceramic filter including two or more ceramic resonator blocks, each ceramic resonator block respectively comprising one or more transmission line resonators, characterized in that the dielectric constant of the material in at least one ceramic block is different from the dielectric constant of at least one of the other ceramic blocks.

A dielectric ceramic filter in accordance with the invention relies on the fact that a resonator with a given height can be made for different frequencies by selecting a ceramic material having a dielectric constant suited for the purpose and providing the required resonance frequency at the given dimensions. Thus it is possible to select the material according to the use and to optimize the material costs. It is also possible, by selecting a suitable ceramic material, to select for the resonators an optimal physical size regarding the encapsulation. In particular the material may be chosen so that each of the individual resonator blocks has substantially the same physical length.

An embodiment of the invention will now be described, by way of example, with reference to the accompanying drawing in which:

Figure 1 is a perspective view of the resonators of a prior art filter; and

Figure 2 is a perspective view of the resonators of a filter in accordance with the invention.

The filter of Figure 1 is a prior art duplexer filter made of a single dielectric material. The filter has, as an example, a three resonator receiver section 10 and a three resonator transmitter section 20, the exposed sides, except for the top, being coated by a conductive material. The height of the resonators in the receiver section are generally lower than those in the transmitter section, which indicates that the receiver pass band is at a higher frequency than the transmitter pass band. Also, the endmost resonators 12 in the receiver section and the endmost resonators 22 in the transmitter section are shorter than the respective center resonator 14,24. As a result of these differences in height, the case for the duplexer would either have to be stepped or would have considerable interior dead space.

Figure 2 shows a duplexer in accordance with the present invention. In this regard it should be noticed

that in comparison to the filter of Figure 1, all the resonators are of a substantially uniform height. However, the individual resonators are made of materials having different dielectric constants. In particular, the material of the resonators in the receiver section 30 are made of a material with a generally lower dielectric constant than the resonators of the transmitter section 40. In effect, the higher dielectric constant allows the normally longer lower frequency transmitter resonators to be made as small as the higher frequency receiver resonators. Similarly, the endmost resonators 32 of the receiver section are made of a material (shown as a dotted pattern) with a lower dielectric constant than the center lower frequency resonator 34 (shown with an x pattern). Likewise, the transmitter endmost resonators 42 are made with a material (shown in dash line) with a lower dielectric constant than the center resonator 44.

Several different ceramic materials are known in the art having different dielectric constants for use in filters

These known ceramic materials may be used to make a filter in accordance with the invention, wherein the individual resonator blocks can be made equally high. A suitable height for a resonator can be calculated by a person skilled in the art in a known way, using the frequency and the dielectric constant of the dielectric material. In a filter according to the invention feasible ceramic materials are for example ceramic compounds based on titanate, such as $Ba_2Ti_9O_{20}$ (ε = 37) and $Ba(Sm,Nd)_2Ti_5O_{14}$ (ε = 78), but a suitable material will be selected case by case, considering the desired frequency and filter size.

In view of the foregoing description it will be evident to a person skilled in the art that various filter configurations are possible within the scope of the present invention. For example, one or more of the dielectric blocks may comprise two or more holes, i.e. resonators, in the same block. Moreover, the filter may comprise three or more discrete dielectric block resonators made of ceramic materials with different dielectric constants. In this case of a multi-block filter each block may be made of a material having a different dielectric constant.

Alternatively, some of the blocks may be made of a material having the same dielectric constant, but in this case at least one other block in the filter is made of a material having a different dielectric constant.

Claims

1. A filter including two or more dielectric resonator blocks, each dielectric resonator block respectively comprising one or more transmission line resonators, characterized in that the dielectric constant of the material in at least one dielectric block is different from the dielectric constant of at least one of the other dielectric blocks.

2. A filter as claimed in claim 1 characterised in that the dielectric block resonators have substantially the same physical length.

3. A filter as claimed in claim 1 or claim 2, comprising three or more dielectric resonator blocks, wherein each resonator block is made of a dielectric material having a dielectric constant different to that of the other resonator blocks.

4. A filter as claimed in claim 1 or claim 2, comprising three or more dielectric resonator blocks, wherein at least one of the resonator blocks is made of a material having substantially the same dielectric constant as one of the other resonator blocks.

5. A filter as claimed in any of the preceding claims wherein, at least one of the dielectric resonator blocks comprises a single transmission line resonator.

6. A filter as claimed in any of claims 1 to 4, wherein at least one of the resonator blocks comprises plural transmission line resonators.

7. A filter as claimed in any of the preceding claims, wherein the resonator blocks are disposed in contiguous relationship.

8. A filter as claimed in any of the preceding claims, wherein the resonator blocks comprise ceramic material.

9. A filter as claimed in any of the preceding claims, characterised in that at least one of the resonator blocks comprises a titanate based compound.

Fig.1. (PRIOR ART)

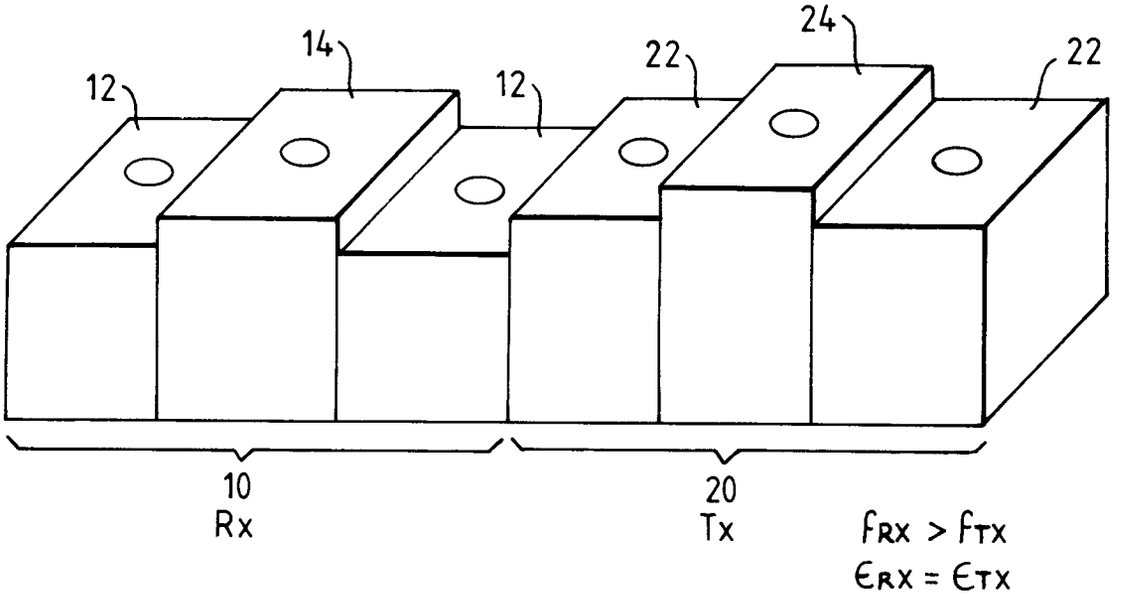
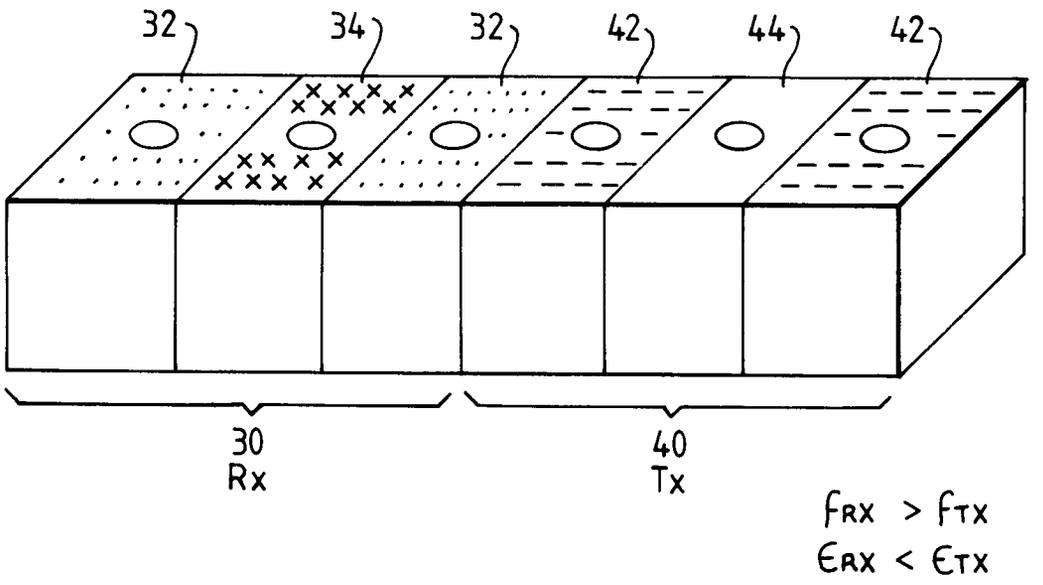


Fig. 2.



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EUROPEAN SEARCH REPORT

Application Number

EP 92 30 3227

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.5)
X Y	PATENT ABSTRACTS OF JAPAN vol. 14, no. 297 (E-945)27 June 1990 & JP-A-2 094 901 (TOKO INC) 5 April 1990 * abstract *	1,2,4,5, 8,9 6,7	H01P1/205 H01P1/213
Y	PATENT ABSTRACTS OF JAPAN vol. 7, no. 292 (E-219)(1437) 27 December 1983 & JP-A-58 168 302 (FUJITSU K.K.) 4 October 1983 * abstract *	6,7	
A	PATENT ABSTRACTS OF JAPAN vol. 5, no. 11 (E-42)(683) 23 January 1981 & JP-A-55 141 802 (ALPS DENKI K.K.) 6 November 1980 * abstract *	1-3	
A	US-A-4 829 274 (GREEN ET AL.) * column 5, line 59 - column 6, line 49; figure 10 *	1,8	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	GB-A-2 236 432 (KYOCERA CORP) * page 15, line 14 - page 17, line 5; figures 4,5 *	1	H01P
A	PATENT ABSTRACTS OF JAPAN vol. 12, no. 106 (E-596)(2953) 6 April 1988 & JP-A-62 235 801 (FUJI ELECTROCHEM CO LTD) 16 October 1987 * abstract *	1,6,7	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	13 JULY 1992	DEN OTTER A.M.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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