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(54) **Ceramic filter**

Keramisches Filter

Filtre céramique

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Description

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 bandpass 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.

JP-A-2094901 discloses a filter in accordance with the pre-characterising part of Claim 1.

According to the present invention there is provided a filter including three or more dielectric resonator blocks, each dielectric resonator block respectively comprising one or more transmission line resonators, characterised in that the filter comprises a housing within which the dielectric resonator blocks are encapsulated and the dielectric resonator blocks have substantially the same physical length to reduce wasted space within the housing.

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.

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 duplex 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 duplex filter would either have to be stepped or would have considerable interior dead space.

Figure 2 shows a duplex filter 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 indi-

vidual 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 $\text{Ba}_2\text{Ti}_9\text{O}_{20}$ ($\epsilon = 37$) and $\text{Ba}(\text{Sm}, \text{Nd})_2\text{Ti}_5\text{O}_{14}$ ($\epsilon = 78$), 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 three or more dielectric resonator blocks (32,34,42,44), each dielectric resonator block respectively comprising one or more transmission line resonators, wherein at least one resonator block is made of a dielectric material having a dielectric constant different to that of the other resonator blocks characterised in that

(i) the filter comprises a housing within which the dielectric resonator blocks are encapsulated; and

(ii) the dielectric resonator blocks (32,34,42,44) have substantially the same physical length to reduce wasted space within the housing.

2. A filter as claimed in any of the preceding claims wherein, at least one of the dielectric resonator blocks (32,34,42,44) comprises a single transmission line resonator.
3. A filter as claimed in any preceding claims, wherein at least one of the resonator blocks comprises plural transmission line resonators.
4. A filter as claimed in any of the preceding claims, wherein the resonator blocks are disposed in contiguous relationship.
5. A filter as claimed in any of the preceding claims, wherein the resonator blocks (32,34,42,44) comprise ceramic material.
6. 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.
7. A filter as claimed in any of the preceding claims, wherein the filter is a duplex filter.

Patentansprüche

1. Filter mit drei oder mehreren dielektrischen Resonatorblöcken (32, 34, 42, 44), wobei jeder einzelne dielektrische Resonatorblock jeweils einen oder mehrere Übertragungsleitungsresonatoren enthält, und mindestens ein Resonatorblock aus einem dielektrischen Material hergestellt ist, dessen Dielektrizitätskonstante zu denen der anderen Resonatorblöcke verschieden ist, **dadurch gekennzeichnet**, daß

(i) das Filter ein Gehäuse aufweist, in dem die dielektrischen Resonatoren eingekapselt sind; und

(ii) die Resonatorblöcke (32, 34, 42, 44) im wesentlichen dieselbe physikalische Länge aufweisen, damit kein unnötiger Platz im Gehäuse verschwendet wird.

2. Filter nach Anspruch 1, bei dem zumindest einer der dielektrischen Resonatorblöcke (32, 34, 42, 44) einen einzelnen Übertragungsleitungsresonator enthält.
3. Filter nach irgendeinem vorangegangenen Anspruch, bei dem zumindest einer der Resonatorblöcke eine Vielzahl von Übertragungsleitungsresonatoren enthält.

4. Filter nach irgendeinem vorangegangenen Anspruch, bei dem die Resonatorblöcke aneinander-grenzend angeordnet sind. 5
5. Filter nach irgendeinem vorangegangenen Anspruch, bei dem die Resonatorblöcke (32, 34, 42, 44) keramisches Material enthalten. 5
6. Filter nach irgendeinem vorangegangenen Anspruch, bei dem zumindest einer der Resonatorblöcke eine auf Titanat basierende Verbindung enthält. 10
7. Filter nach irgendeinem vorangegangenen Anspruch, das als Duplexfilter ausgebildet ist. 15
7. Un filtre selon l'une quelconque des revendications précédentes, dans lequel le filtre est un filtre duplex. sur le titanate.

Revendications

1. Un filtre comportant trois ou plus de blocs de résonateurs diélectriques (32, 34, 42, 44), chaque bloc de résonateur diélectrique comportant respectivement un ou plusieurs résonateurs de lignes de transmission, dans lequel au moins un bloc de résonateur est fait d'un matériau diélectrique ayant une constante diélectrique différente des autres blocs de résonateurs caractérisé en ce que 20 25
- (i) le filtre comporte un boîtier à l'intérieur duquel les blocs de résonateurs diélectriques sont encapsulés et 30
- (ii) les blocs de résonateurs diélectriques (32, 34, 42, 44) ont essentiellement la même longueur physique pour réduire le volume perdu à l'intérieur du boîtier. 35
2. Un filtre selon la revendication 1, dans lequel au moins un des blocs de résonateurs diélectriques (32, 34, 42, 44) comporte un seul résonateur de ligne de transmission. 40
3. Un filtre selon l'une quelconque des revendications précédentes dans lequel au moins l'un des blocs résonateurs comporte plusieurs résonateurs de ligne de transmission. 45
4. Un filtre selon l'une quelconque des revendications précédentes, dans lequel les blocs de résonateurs sont disposés en contact contigu. 50
5. Un filtre selon l'une quelconque des revendications précédentes, dans lequel les blocs résonateurs (32, 34, 42, 44) comporte un matériau céramique. 55
6. Un filtre selon l'une quelconque des revendications précédentes, caractérisé en ce qu'au moins un des blocs résonateurs comporte un composant basé

Fig.1. (PRIOR ART)

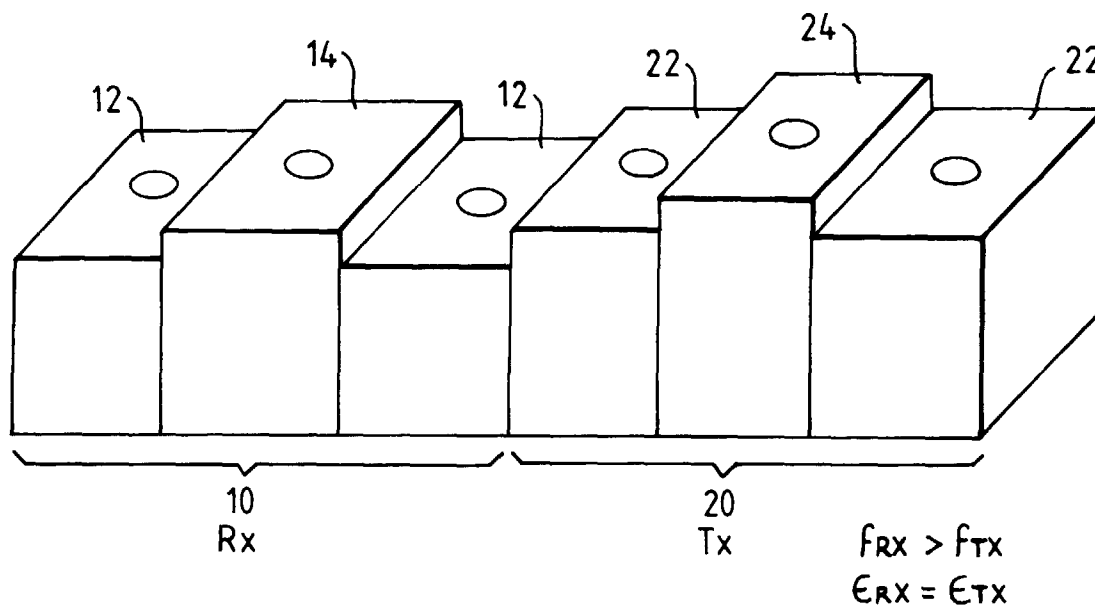


Fig.2.

