

[54] **MONOLITHIC COUPLED CRYSTAL
RESONATOR FILTER HAVING CROSS
IMPEDANCE ADJUSTING MEANS**

[72] Inventor: Frank K. Priebe, Fair Haven, N.J.

[73] Assignee: The United States of America as
represented by the Secretary of the
Army

[22] Filed: Oct. 8, 1970

[21] Appl. No.: 79,105

[52] U.S. Cl. 333/71, 333/72

[51] Int. Cl. H03h 7/02, H03h 9/18

[58] Field of Search 333/72, 30, 71; 310/8.2

[56] **References Cited**

UNITED STATES PATENTS

3,564,463	6/1966	Beaver.....	333/72
3,518,573	6/1970	Smith	331/116
3,437,848	4/1969	Borner.....	333/72
3,222,622	12/1965	Curran	333/72

2,271,870	2/1942	Mason.....	333/72
2,248,776	7/1941	Och.....	333/72

Primary Examiner—Paul L. Gensler

Attorney—Harry M. Saragovitz, Edward J. Kelly, Herbert Berl and Jeremiah G. Murray

[57] **ABSTRACT**

A monolithic coupled resonator bandpass filter having pairs of input and output electrodes mounted on a crystal resonator such as quartz. A generator is coupled to the high potential side of the input electrodes via an adjustable input impedance. The high potential side of the output electrodes is coupled to a load via an adjustable output impedance. The low potential sides of the input and output electrodes are coupled to ground via adjustable base impedances. The frequency transfer response of the filter may be adjusted by proper adjustment of the various adjustable impedances. Proper adjustment of the base impedances can adjust the symmetry and ripple of the transfer response curve.

4 Claims, 2 Drawing Figures

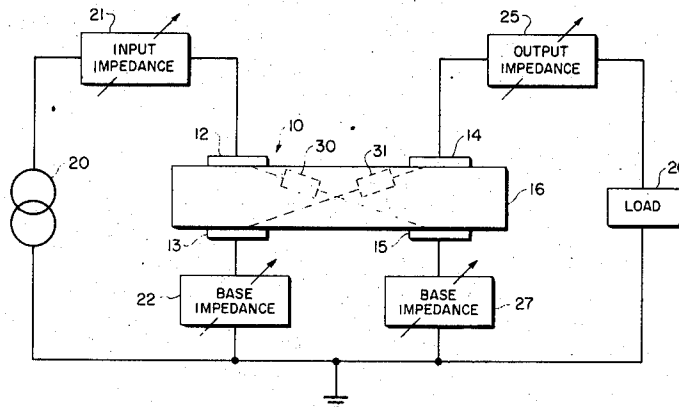


FIG. 1

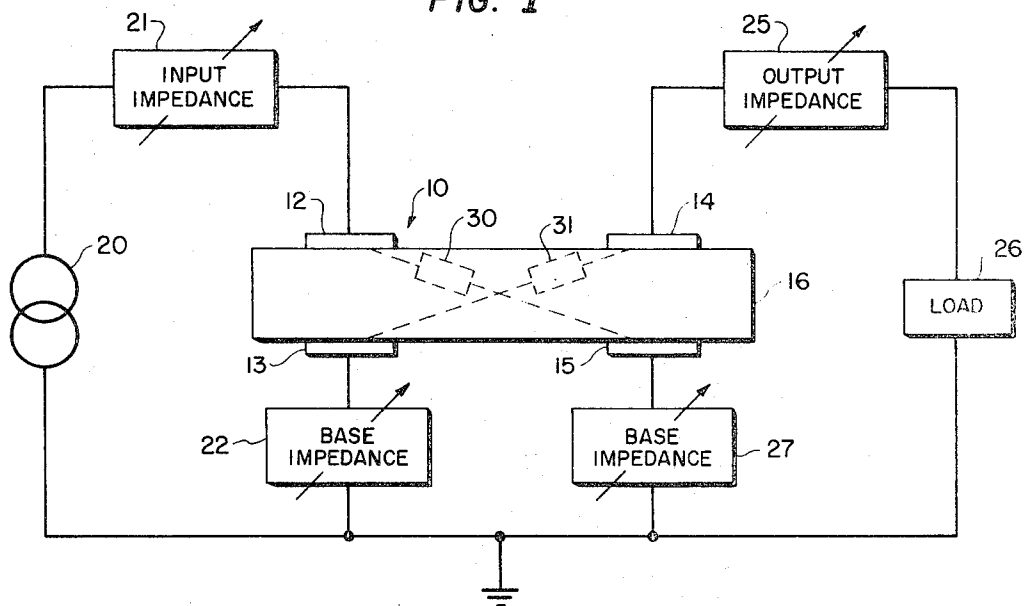
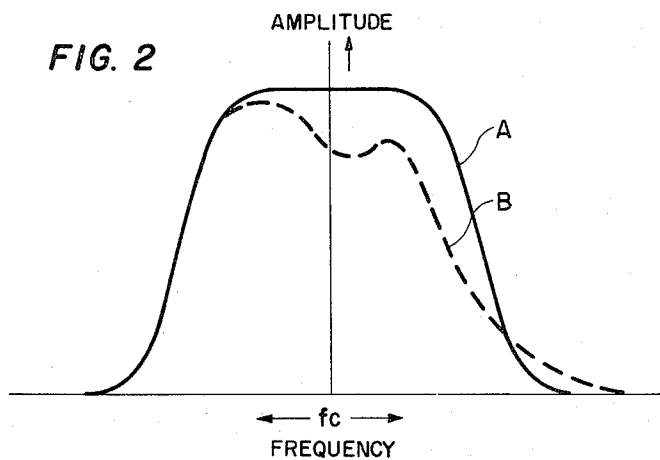


FIG. 2



INVENTOR,
FRANK K. PRIEBE

BY: *Jeremiah G. Munro* AGENT
Henry M. Snagovitz,
Edward J. Kelly ATTORNEYS
Robert B. Bell

MONOLITHIC COUPLED CRYSTAL RESONATOR FILTER HAVING CROSS IMPEDANCE ADJUSTING MEANS

The invention described herein may be manufactured, used, and licensed by or for the Government for governmental purposes without the payment to me of any royalty thereon.

The present invention relates to crystal filters and more particularly to improvements in monolithic coupled resonator bandpass filters.

In the field of solid-state bandpass filters, monolithic coupled filters have found widespread use. Those concerned with the design of such filters have long recognized the importance of maintaining extremely close tolerances in the manufacture thereof and in particular the placing of the electrodes on the crystal. As is well known in monolithic filter design, strict requirements are placed on the shape, size, and thickness of the electrodes and on the separation of the electrode pairs. These physical parameters govern the bandwidth of the filters, the ripple in the passband, the magnitude of the unwanted responses and the characteristic impedances required for optimum power transfer. For example, if the electrodes are not maintained exactly alike in size and shape, and are not deposited symmetrically on the crystal, then an asymmetric frequency transfer response curve may result. Correction of the symmetry of the transfer response curve is then normally accomplished by scraping away portions of the electrodes or depositing additional electrode material where necessary, an obviously laborious and time consuming process. Standard techniques for terminating such filters consists of input and output impedances attached to the high potential electrodes and a common grounding point which connects directly together all of the low potential electrodes. These input and output impedances are provided so that the effective impedance of the input may be matched to the effective impedance of the output for maximum power transfer. However, adjustments of these input and output impedances will have no substantial effect on the general symmetry and shape of the transfer response curve.

The general purpose of this invention is to provide a means of improving the transfer response curves of monolithic coupled filters without requiring extremely high manufacturing tolerances in electrode deposition. Also, adjustment of the shape of such transfer response curves may also be affected electrically. To attain this, the present invention contemplates a unique filter wherein the low potential sides are not directly connected together but are coupled to adjustable impedance devices so that the specific shape of the transfer response curves may be adjusted thereby.

Therefore, the primary object of the present invention is the provision of monolithic resonating filters having means for electrically adjusting the transfer response curves thereof.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. 1 is a schematic diagram of a preferred embodiment of the invention; and

FIG. 2 are frequency response curves helpful in understanding the device of FIG. 1.

Referring now to the drawing there is shown in FIG. 1 monolithic resonating bandpass filter 10 comprising a crystal resonator 16, such as quartz, having a pair of input electrodes 12 and 13 and a pair of output electrodes 14 and 15 respectively mounted thereon. A signal generator 20 is coupled to electrode 12 of the high potential side of filter 10 via an adjustable input impedance 21. The electrode 14 of the high potential side of filter 10 is coupled to a load 26 via an adjustable output impedance 25. The low potential or base electrodes 13 and 15 are coupled to ground via adjustable base impedances 22 and 27 respectively.

In the manufacture of the filter 10 the input electrodes 12 and 13 are mounted or deposited some predetermined distance from the output electrodes 14 and 15, so that the effective cross impedances 30 and 31 will assume the values necessary for filter operation. Great care is normally taken to insure that the capacitive components, for example, of the cross impedances 30 and 31 are of the proper value with respect to the effective inductance presented by the crystal 16 so that resonance will occur in the intended passband.

If the transfer response curve of filter 10 is to be symmetrical, then the effective cross impedances 30 and 31 should also be symmetrical. Adjustment of the values of the effective impedances 30 and 31 may be accomplished, as mentioned earlier, by adjusting during manufacture the size, shape, spacing, etc. of the electrodes 12, 13, 14 and 15. However, adjustment of the effective cross impedances 30 and 31 may be effected by adjusting the base impedances 22 and 27.

Therefore, besides being able to electrically adjust the effective input and output impedances via adjustable impedances 21 and 25, the effective cross impedances 30 and 31 of the input and output electrodes may now be electrically adjusted via adjustable base impedances 22 and 27.

For example, if it is desirable that the filter 10 have a symmetrical transfer response curve, as shown by the solid line A in FIG. 2, but during manufacture the size, shape and spacing of the electrodes 12, 13, 14 and 15 is not exactly symmetric such that the transfer response looks like the dotted line B in FIG. 2, then adjustment of the response may be accomplished by properly adjusting the base impedances 22 and 27. Adjustment of the input and output impedances 21 and 25 will simply move the curve A or B up and down, but will have substantially no effect on the shape of these curves.

Of course, it is also pointed out that an asymmetrical curve may also be produced, if desirable. Further, the use of more than one pair of output electrodes or a multiplicity of coupling electrode pairs on the crystal 16 would be an obvious extension of the inventive concept. Obviously many other modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A monolithic bandpass filter comprising a crystal resonator characterized by a lattice equivalent network, said network having effective cross impedance; a first pair of electrodes mounted on said crystal resonator; a second pair of electrodes mounted on said crystal

3

4

resonator; a signal input means having one side thereof connected via an input impedance means to one of said first pair of electrodes; a signal output means having one side thereof connected via an output impedance means to one of said second pair of electrodes; the other sides of said signal input and output means connected in common; and a cross impedance adjusting means connected between the other electrodes of said pairs of electrodes and said common connection for adjusting with respect to each other the relative values of the effective cross impedances between said first and second pairs of electrodes.

2. The device according to claim 1 and wherein said cross impedance adjusting means includes an impedance device connected between one of said other electrodes and said common connection.

5 3. The device according to claim 1 and wherein said cross impedance adjusting means includes impedance devices connected between each of said other electrodes and said common connection.

10 4. The device according to claim 3 and wherein each said impedance device of said cross impedance adjusting means is adjustable.

* * * * *

15

20

25

30

35

40

45

50

55

60

65