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WAVE FILTER

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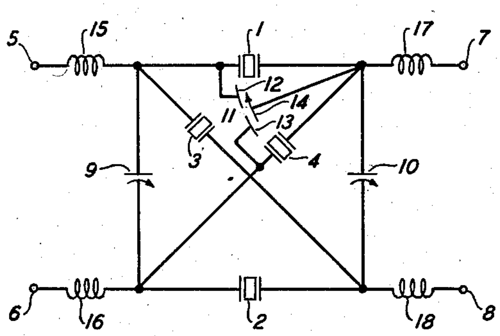

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WAVE FILTER

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9 Claims. (Cl. 178—44)

This invention relates to wave transmission networks and more particularly to wave filters of the lattice type.

An object of the invention is to reduce the number of component elements required to build wave filters of the lattice type, especially those using piezoelectric crystals.

Other objects are to reduce the manufacturing cost and the size of such filters.

Another object of the invention is to increase the stability of filters of this type.

It is known that two pairs of piezoelectric crystal impedances may be connected between a pair of input terminals and a pair of output terminals to form a lattice-type wave filter. Ordinarily each crystal impedance must be effectively shunted by a capacitance, and all of these capacitances will be of approximately the same value. Heretofore the practice has been to take part of each of these capacitances outside of the lattice and connect it in shunt at the ends of the network. The rest of the required capacitances are furnished by two fixed capacitors connected in shunt, respectively, with the crystal impedances of one pair, and two variable capacitors connected in shunt, respectively, with the crystal impedances of the other pair. Inductances may be added at the ends of the lattice to increase the width of the transmission band, if desired.

In accordance with the present invention all four of the capacitors within the lattice are replaced by a single differential capacitor which furnishes two variable capacitances, one of which increases in value as the other is decreased. One of these capacitances is connected in shunt with a crystal impedance in one of the pairs and the other capacitance is connected in shunt with a crystal impedance in the other pair. Adjustment of the differential capacitor permits a very accurate placement of the peaks of attenuation in the filter characteristic.

It will be apparent that in the filter structure of the invention a single differential capacitor replaces two fixed capacitors and two variable capacitors, thus reducing the cost and saving space. The time required for assembling and wiring the two fixed capacitors is also saved. Furthermore, time is saved in adjusting the filter, since only one differential capacitor need be adjusted instead of two variable capacitors, thus reducing the time during which an expensive testing circuit is in use. A further advantage of the filter over those of the prior art is that it is more stable. Since there are fewer capacitors within the lattice and since they are of the same type, the peaks of attenuation will change less from their adjusted locations due to changes in the values of the capacitances caused by aging and temperature cycles.

The nature of the invention will be more fully understood from the following detailed description and by reference to the accompanying drawing, the single figure of which is a schematic circuit showing a wave filter embodying the invention.

As shown in the drawing, the filter comprises a pair of piezoelectric crystal impedances 1, 2 and a second pair of piezoelectric crystal impedances 3, 4 arranged between a pair of input terminals 5, 6 and a pair of output terminals 7, 8 to form a symmetrical lattice network. The crystals in one of the pairs of impedances are resonant at a common frequency and antiresonant at a higher common frequency. The crystals in the other pair of impedances are antiresonant at or near the resonant frequency of the crystals in the one pair and resonant at a lower common frequency. Equal capacitors 9 and 10 are connected in shunt at the ends of the lattice. These are preferably made variable, as indicated, primarily to provide for an adjustment of the width of the transmission band. In order to widen the band four equal inductors 15, 16, 17 and 18 may be connected in series at the ends of the lattice. For a more detailed explanation of how the component elements of the filter are proportioned to provide the desired transmission characteristic, reference is hereby made to United States Patent 2,045,991 issued to the assignee of W. P. Mason, June 30, 1936.

To provide for adjustment of the location of the attenuation peaks additional variable capacitances are required. Theoretically, only two variable capacitors connected in shunt, respectively, with the crystals of one pair should be sufficient. In practice, however, it is often found that the required minimum capacitance of these capacitors is so small that it cannot be realized practically. Another difficulty has been that, due to manufacturing variations in the interelectrode capacitances of the crystals, it was not known in advance across which crystals to connect the capacitors. One solution of the problem has been to reduce the capacitance of each of the end capacitors 9 and 10 by a small amount C, connect fixed capacitors of capacitance C across each crytsal of a pair and connect variable capacitors with a range above and below C across the other two crystals. This, however, requires four capacitors within the lattice, two fixed and two variable.

In accordance with the invention all four of these last-mentioned capacitors are replaced by a single differential capacitor 11 comprising two fixed plates 12 and 13 and a movable plate 14. As the plate 14 is moved in the direction of the arrow, the capacitance between it and the plate 12 increases as the capacitance between it and the plate 13 is decreased. Each capacitance has a range above and below C. One of these variable capacitances is connected in shunt with a crystal impedance in one of the pairs and the other capacitance is connected in shunt with a crystal impedance in the other pair. As shown in the drawing, these crystal impedances are 1 and 4. They could as well be 1 and 3, 2 and 3 or 2 and 4. It is unnecessary to find by trial across which crystal impedance the capacitances should be connected.

By adjusting the one differential capacitor 11 the peaks of attenuation in the transmission characteristic of the filter may be accurately placed at the desired frequencies. By this procedure the lattice may be slightly unbalanced, since there is no corresponding adjustment of the capacitances associated with the other two crystal impedances. However, practical experience with the filter has shown that the height of the attenuation peaks is decreased by a negligible amount since, ordinarily, an adjustment of only a few micromicrofarads is involved. Material savings are effected in the number of component elements required, cost and size of the filter and adjusting time. In addition, the filter is more stable.

What is claimed is:

1. A wave filter comprising four impedance branches and a differential capacitor, each of said branches including a piezoelectric crystal impedance, said branches being arranged to form a lattice network, said capacitor providing two variable capacitances one of which increases in value as the other is decreased and said capacitances being associated, respectively, with two of said impedance branches which are adjacent to each other.

2. A filter in accordance with claim 1 in which each of said capacitances is connected in shunt with its associated impedance branch.

3. A wave filter comprising four piezoelectric crystal impedances arranged to form a lattice network, said filter including two variable capacitances connected, respectively, in parallel with two of said impedances which are in adjacent branches of said lattice network and one of said capacitances increasing in value as the other is decreased.

4. A wave filter of the lattice type comprising two series impedance branches and two diagonal impedance branches, each of said branches including a piezoelectric crystal impedance, said filter including a differential capacitor providing two variable capacitances one of which increases in value as the other is decreased, one of said capacitances being connected in parallel with one of said series branches and the other of said capacitances being connected in parallel with one of said diagonal branches.

5. A wave filter comprising two pairs of piezoelectric crystal impedances and a differential capacitor, said crystal impedances being connected to form a lattice network, said differential capacitor furnishing two variable capacitances one of which increases in value as the other is decreased, one of said capacitances being connected in shunt with a crystal impedance in one of said pairs and the other of said capacitances being connected in shunt with a crystal impedance in the other of said pairs.

6. A filter in accordance with claim 5 which includes variable capacitors connected in shunt at the ends of said lattice network.

7. A filter in accordance with claim 5 which includes inductors connected in series at the ends of said lattice network.

8. A filter in accordance with claim 5 which includes shunt capacitors and series inductors connected at the ends of said lattice network.

9. A wave filter comprising two pairs of terminals, four impedance branches and a differential capacitor, each of said branches comprising a piezoelectric crystal impedance, said branches being connected between said terminals to form a lattice network, said capacitor comprising two fixed plates and a movable plate, said movable plate being connected to a terminal in one of said pairs and said fixed plates being connected, respectively, to the terminals in the other of said pair.

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