

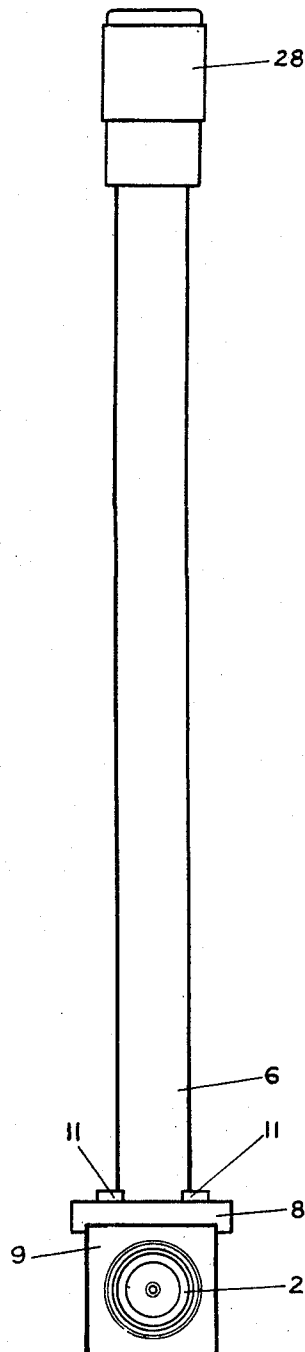
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ELECTRIC FILTER CIRCUITS

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ELECTRIC FILTER CIRCUITS

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The present invention relates to electric filter circuits. In frequency-discriminative circuits it is known to connect a stub line across a main transmission line. Such a stub line, which may for example be a co-axial line of suitable length, may be either short-circuited or open-circuited at the end thereof remote from the main transmission line. If the stub is short-circuited, it presents a substantially infinite impedance to the main transmission line when its electrical length is one quarter wave or an odd integral multiple of quarter waves at that frequency, while, if the stub is open-circuited, it presents a substantially infinite impedance when its electrical length is one half wave or an integral multiple of half waves. In general, a stub line presents a finite impedance to the main transmission line at all other frequencies except that at frequencies at which the electrical length of the stub line is one half wave or an integral multiple of half waves, if it is short-circuited, or an even integral multiple of quarter waves, if it is open-circuited, the stub line presents zero reactance to the main transmission line. At these last mentioned frequencies the filter circuit thus presents high attenuation to electric energy passing along the main transmission line whereas at the previously mentioned frequency there is substantially no such attenuation. These frequencies at which the stub line presents substantially infinite and substantially zero impedance to the main transmission line may, therefore, be termed pass frequencies and rejection frequencies of the stub line respectively.

In order to reduce the physical length of stub lines it has been proposed in British patent specification No. 659,812 that the stub line should be made up of sections of transmission line having different characteristic impedances.

According to the present invention, an electric filter circuit comprises a main transmission line and a stub line which comprises a plurality of sections of transmission line connected in series across the main transmission line, a group of at least three adjacent sections of the stub line having two different characteristic impedances which occur alternately throughout the group while the next section adjacent to the said group between that group and the main transmission line has a characteristic impedance which is different to the characteristic impedance of any of the sections of the said group so that the stub line presents a lower impedance to the main transmission line at frequencies in the region of the pass frequency or rejection frequency of the stub line than if the said next section had had the same characteristic impedance as the section of the said group which is next but one to it.

Preferably the characteristic impedance of the said next section is less than the characteristic impedance of any of the sections of the said group and each section of the stub line other than the end section remote from the main transmission line has an electrical length that is an integral odd number, preferably one, of quarter waves at the pass or rejection frequency of the stub line. That

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end section may also have an electrical length of one quarter wave if it is short- or open-circuited but, if not, the length of the end section is then such that it is equivalent to an open- or short-circuited section having an electrical length of an integral number of quarter waves. If the filter circuit has a band-pass characteristic and the stub line has an even number of sections of which the end one is effectively an open-circuited quarter wave section, the end of the said next section remote from the said group of sections may be connected directly to the main transmission line. The main transmission line and the stub line may both be of the co-axial type, the inner and outer conductors of the said group of sections of the stub line being uniform along the group and alternate sections of the group having air as dielectric while the remaining sections of the group have as dielectric a material having a dielectric constant greater than unity. The mean of the characteristic impedances of the transmission lines forming the said group may be equal to the characteristic impedance of the main transmission line.

One construction of a band-pass filter circuit in accordance with the present invention will now be described by way of example with reference to the two figures of the accompanying drawings. In the drawings, Figure 1 shows a sectional elevation of the filter circuit while Figure 2 shows a view in the direction of the arrow II in Figure 1.

The filter circuit has a pass band of frequencies in the region of 2,000 megacycles per second and, referring to the drawings, it comprises a main transmission line 1 of co-axial construction having connectors 2 and 3 at its two ends. Two stub lines 4 and 5 which are similar to one another and are both of co-axial construction are connected across the transmission line 1 and are spaced apart by an electrical length of the order of one quarter wave at the mid-frequency of the pass band. The actual spacing of the stub lines 4 and 5 determines the attenuation/frequency characteristic of the filter circuit.

Considering now the stub line 4 in detail, it comprises a tube 6 which forms the outer conductor of the co-axial line and a rod 7 which forms the inner conductor. The tube 6 is secured, for example by soldering, to a flange member 8. This flange member 8 is located in a recess in a block 9 which forms the outer conductor of the transmission line 1 and is held in position by means of screws 11.

The stub line 4 is in fact made up of six sections 12 to 17. The sections 12 to 16 have electrical lengths equal to one quarter wave at the mid frequency of the pass band while the section 17 has a capacity termination, as hereinafter described, so as to be equivalent to an open-circuited section having an electrical length of one quarter wave. Although theoretically the sections 12 to 16 should have electrical lengths of exactly a quarter wave, it is found that these lengths are not critical. The sections 12, 13, 15 and 17 have air as the dielectric material between the inner and outer conductors while the sections 14 and 16 have polyethylene as the dielectric material. The section 12 differs from the sections 13, 15 and 17 in that the inner conductor thereof is of increased cross-section so that the characteristic impedance of said section 12 is less than that of the sections 14 and 16. The part 18 of the rod 7 which constitutes the inner conductor of the section 12 is cylindrical and at the end thereof remote from the section 13 carries a screw thread (not shown) which is screwed into a cylindrical member 19 which is secured, for example by soldering, to the inner conductor 21 of the main transmission line 1. The member 19 is of the same cross-section as the part 18 and thus effectively forms a continuation of that part.

A metal bushing 22 is secured in the open end of the

tube 6 and a metal slug 23 is screwed into this bushing 22. This slug 23 has a cylindrical opening 24 in its end into which projects the end of the rod 7. It will be appreciated that the slug 23 is electrically connected to the end of the tube 6 and accordingly the capacity between the rod 7 and the wall 25 of the opening 24 forms the termination of the stub line 4. This capacity may be varied by turning the slug 23 in the bushing 22 so as to cause it to move axially relative to the rod 7. A lock-nut 26 is threaded onto the slug 23 while a spring washer 27 is located between the bushing 22 and the lock-nut 26. A protective cover 28 is screwed over the bushing 22.

It will be appreciated that since the stub lines 4 and 5 are each effectively open-circuited and have an electrical length of six quarter waves at the mid-frequency of the pass band, they each present a substantially infinite impedance to the transmission line 1 at that frequency. At that frequency the characteristic impedance of the transmission line forming the section 12 of the stub line 4 has no effect but at other frequencies in the region of that frequency the impedance presented by the stub line 4 is considerably less than if the section 12 had had the same characteristic impedance as the sections 14 or 16, that is to say if the stub line 4 had been made up of alternate quarter wave sections having air and polyethylene as the dielectric material. This has the effect of making the attenuation/frequency characteristic of the filter circuit more steep on either side of the pass band.

The pass band of the filter circuit may be considered as those frequencies at which the circuit has an attenuation less than some predetermined small value. In the arrangement being described in which the mid-band frequency is of the order of 2,000 megacycles per second, the pass band may be 10 megacycles per second on either side of that frequency. The number of sections 13 to 17 of each stub line 4 and 5 affects the width of the pass band and the slope of the attenuation/frequency characteristic but with a given number of sections some control of the filter characteristic is possible by choosing the characteristic impedance of the section 12 which effectively is an impedance transformer.

The filter circuit described above may be modified by the addition of a third stub line, the three stub lines being spaced apart along the transmission line 1 by distances of the order of a quarter wave at the mid-frequency of the pass band. The two outer stub lines would then be of identical construction while the centre stub line would have similar sections 13 to 17 although the part corresponding to the part 18 would be of increased cross-section so that the characteristic impedance of the transmission line forming the section corresponding to the section 12 would have half the characteristic impedance of the transmission line forming the section 12.

The stub lines of a filter circuit in accordance with the present invention may form part of stub devices in a filter circuit as described in British patent specifications No. 659,811 or No. 659,863.

In a band-stop filter circuit of similar construction to the band-pass filter circuit described above, only five quarter wave sections are required. Thus the section 12 may then be omitted and the section 14 modified in accordance with the present invention to decrease its characteristic impedance by increasing the diameter of the rod 7 over that section.

The invention has been described with particular reference to transmission lines of the co-axial type. It is equally applicable to other forms of transmission line, including waveguides, of the kind in which (using the terminology of British patent specification No. 659,812) the impedance characteristic can be expressed in the form $Z = jZ_0 \tan \theta$ or $Z = -jZ_0 \cot \theta$.

I claim:

1. A frequency-discriminating electric filter circuit comprising a main transmission line and a stub line which

comprises a plurality of sections of transmission line connected in series with each other, said plurality of sections being connected in parallel with the main transmission line, each of said sections except the end section remote from the main transmission line having an electrical length which is an integral number of quarter waves at the mid-frequency of the filter a group of at least three adjacent sections of the stub line having two different characteristic impedances which occur alternately throughout the group while the next section adjacent to the said group between that group and the main transmission line has a characteristic impedance which is less than the characteristic impedance of any of the sections of the said group so that the stub line presents a lower impedance to the main transmission line at frequencies in the region of the mid-frequency of the stub line than if the said next section had had the same characteristic impedance as the section of the said group that is next but one to it.

2. A frequency-discriminating electric filter circuit according to claim 1 wherein each section of the stub line other than the end section remote from the main transmission line has an electrical length that is an integral odd number of quarter waves at the mid-frequency of the stub line.

3. A frequency-discriminating electric filter circuit according to claim 2 wherein each section of the stub line other than the said end section has an electrical length of one quarter wave at the mid-frequency of the stub line.

4. A frequency-discriminating electric filter circuit according to claim 2 and which has a band-pass characteristic wherein the stub line has an even number of sections of which the said end one is effectively an open-circuited quarter wave section and the end of the said next section remote from the said group of sections is connected directly to the main transmission line.

5. A frequency-discriminating electric filter circuit comprising a main co-axial transmission line and a co-axial stub line connected across the main transmission line, the stub line having inner and outer conductors and being divided along its length into at least four sections, whereby said sections are in series with each other and all of said sections are in parallel with the main transmission line, the lengths of said sections except the end section remote from the main transmission line being an integral number of quarter waves at the mid-frequency of the filter, the diameter of the outer conductor being uniform all along the stub line and the diameter of the inner conductor of the section of the stub line connected to the main transmission line being greater than that of the remaining sections of the stub line which have a uniform diameter of inner conductor while the said section nearest to the main transmission line has air as dielectric between the inner and outer conductors and the said remaining sections have as dielectric between the inner and outer conductors alternately air and a material that has a dielectric constant greater than unity, the diameters of the inner conductor of the said sections which have as a dielectric a material that has a dielectric constant greater than unity being such that the characteristic impedance of the section of the stub line connected to the main transmission line is less than that of the sections having the said material as a dielectric.

6. A frequency-discriminating electric filter circuit according to claim 5 wherein all the said sections of the stub line other than the end section remote from the main transmission line have the same electrical length.

7. A frequency-discriminating electric filter circuit according to claim 5 wherein the said material is polyethylene.

2,790,959

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References Cited in the file of this patent

UNITED STATES PATENTS

2,317,439 Buchholtz ----- Apr. 27, 1943
2,421,033 Mason ----- May 27, 1947
2,438,367 Keister ----- Mar. 23, 1948

2,438,913
2,588,226
2,713,152

5

659,812

6

Hansen ----- Apr. 6, 1948
Fox ----- Mar. 4, 1952
Brown ----- July 12, 1955

FOREIGN PATENTS

Great Britain ----- Oct. 31, 1951