

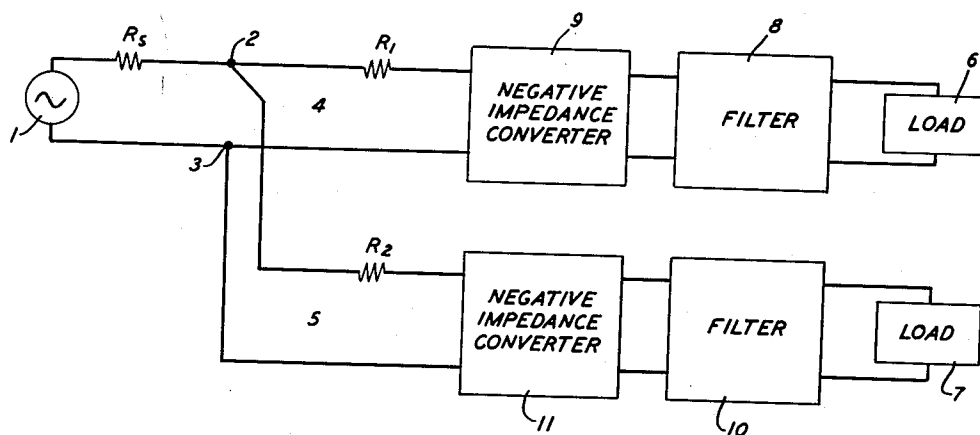
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WAVE TRANSMISSION BRANCHING ARRANGEMENT

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This invention relates to wave transmission systems and more particularly to a branching arrangement for a multi-channel system.

The object of the invention is to increase the discrimination between channels in a multichannel wave transmission system. Related objects are to decrease the complexity and reduce the cost of the wave filters required at a branching point in such a system.

In carrier telephone and other wave transmission systems it is necessary at certain points to separate a multi-frequency signal into individual channels on the basis of frequency. This may be done by connecting the channels to the branching point in parallel and providing in the various channels filters which have mutually exclusive pass bands. If these pass bands are located close together, the filter structures must be quite complex in order to provide the required discrimination between channels.

In the branching arrangement of the present invention, the discrimination between channels is greatly increased, or, alternatively, the complexity and cost of the filters are reduced, by adding a negative impedance converter and a resistor to each branch. In the illustrative embodiment shown, each branch comprises a band-pass wave filter, a negative impedance converter connected in tandem between the filter and the branching point, and a series resistance connected between the converter and the branching point. The filter has an image impedance which is resistive and preferably uniform over the major portion of the transmission band. The converter has an impedance conversion ratio so chosen that the impedance of the filter in the band, as seen through the converter, is approximately equal to the negative of the associated series resistance. The series resistances in the various branches are preferably, but not necessarily, approximately equal. In order to stabilize the operation of the converters, the impedance of the multifrequency signal source must be resistive in the pass bands of the filters, and is preferably approximately equal to the added series resistance in one of the branches.

The combination of the negative resistance presented by the converter and the associated series resistance provides at the branching point a substantially zero impedance, over the pass band, looking into the appropriate channel. This greatly increases the discrimination between channels obtainable with given passive filter structures, or provides the same discrimination with simpler and less expensive structures.

The nature of the invention and its various objects, features and advantages will appear more fully in the following detailed description of a typical embodiment illustrated in the accompanying drawing, the single figure of which is a schematic diagram of a two-channel branching arrangement in accordance with the invention.

A multifrequency source of alternating current signals 1 is shown connected to a pair of terminals 2 and 3 which constitute a branching point. The source preferably has a resistive impedance, as indicated by the series resistance of value R_s . At the point 2-3 the signals are separated,

on the basis of frequency, into the two transmission branches 4 and 5, which are terminated, respectively, in the matching loads 6 and 7. Between the load 6 and the point 2-3, the branch 4 comprises, in the order named, a band-pass wave filter 8, a negative impedance converter 9 connected in tandem therewith, and a series resistor of value R_1 . A filter 10, a negative impedance converter 11 and a series resistor of value R_2 are similarly disposed in the branch 5. The resistances R_1 and R_2 are preferably, but not necessarily, equal. It is to be understood that any required number of additional branches may be connected at the point 2-3. The filters 8 and 10 have mutually exclusive transmission bands. Each has an image impedance which is resistive and preferably substantially constant over at least most of the pass band, and is a comparatively high reactance outside of this band. If the image impedance is not constant over the band, it is preferable that the impedance-frequency characteristic be concave downward, that is, that it has its maximum value at the mid-band frequency and falls to zero at the band limits. A suitable characteristic is obtainable, for example, with a constant- k type of filter with a mid-series termination. A concave-downward type of characteristic results in more stable operation of the converter than if a concave-upward characteristic is employed. The image impedance of the filter at midband is preferably approximately equal to the associated resistance R_1 or R_2 .

The converters 9 and 10 may, for example, be of the type disclosed in Patent 2,726,370, to R. L. Wallace, Jr., and the present applicant, issued December 6, 1955. Each converter has an impedance conversion ratio such that the impedance at the midband frequency of the associated filter, as seen through the converter, is approximately equal to the negative of the associated series resistance R_1 or R_2 . Thus, if the image impedance in the band of the filter 8 is substantially constant and approximately equal to R_1 , the converter 9 is designed to have an impedance conversion ratio of -1 . Of course, the filter 8 may have an image impedance at midband which is either larger or smaller than R_1 , in which case the converter 9 will have the appropriate inverse impedance conversion ratio. If the filter 8 has a concave-downward characteristic in the band, it will be advantageous to make its value at midband slightly greater than R_1 . Then, the impedance seen at the left looking into the converter 9, with an impedance conversion ratio of -1 , will be equal to $-R_1$ at two frequencies, one on either side of midband, instead of only at the midband frequency.

It is thus apparent that, in the pass band of the filter 8, the branch 4 presents at the branching point 2-3 an impedance which is approximately equal to $R_1 - R_1$, and is very nearly zero. Similarly, in the band of the filter 10, the branch 5 has an input impedance approximately equal to $R_2 - R_2$, which is also nearly zero. Outside of the pass band, each of the branches 4 and 5 has an impedance which is high compared to the impedance at midband. Therefore, signal currents from the source 1 in the frequency range of the filter 8, when they arrive at the branching point 2-3, select the low-impedance shunt path presented by the branch 4, and very little of this energy reaches the branch 5. Similarly, substantially all of the signal currents falling in the pass band of the filter 10 enter the branch 5 in preference to the branch 4. Thus, the discrimination between channels provided by the filters 8 and 10 is greatly augmented by that due to the addition of the converters 9 and 11 and the resistors R_1 and R_2 . In a two-channel branching arrangement which has been successfully operated, this latter factor improved the discrimination by about 30 decibels.

In order to stabilize the operation of the converters 9 and 11, the signal source 1 should present a resistive

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impedance, shown as R_s , to the branching point 2—3. The resistance R_s is preferably approximately equal to R_1 or R_2 when the latter are approximately equal, or to the average of R_1 and R_2 if they differ considerably. If the internal resistance of the source 1 is less than the desired value R_s , it may be built out by the addition of an external series resistance of proper magnitude.

It is to be understood that the above-described arrangement is illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. In a wave transmission system, a branching point and a plurality of transmission branches connected in parallel at said point, each of said branches comprising a wave filter having a resistive image impedance in the transmission band, a negative impedance converter connected between said filter and said point, and a resistor connected in series between said converter and said point, said converter having an impedance conversion ratio so chosen that the impedance of said filter as viewed through said converter is approximately equal to the negative of the resistance of said resistor at a frequency in said band.

2. A system in accordance with claim 1 in which the resistors in said branches are approximately equal in resistance.

3. A system in accordance with claim 1 in which the resistance of said resistor is approximately equal to said image impedance at the midband frequency of said band and said ratio is approximately equal to -1 .

4. A system in accordance with claim 1 in which said image impedance is substantially constant over the major portion of said band.

5. A system in accordance with claim 1 in which the frequency characteristic of said image impedance is concave downward in said band.

6. A system in accordance with claim 5 in which said ratio is so chosen that the maximum value of the impedance of said filter in said band as seen through said converter is slightly greater than the resistance of said resistor.

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7. A system in accordance with claim 1 which includes a resistive source of multifrequency signals connected to said branching point.

8. A system in accordance with claim 7 in which the impedance of said source is approximately equal to the resistance of one of said series resistors.

9. A system in accordance with claim 8 in which the resistors in said branches are approximately equal in resistance.

10. A system in accordance with claim 1 in which the filters in said branches have mutually exclusive transmission bands.

11. In a multichannel wave transmission system, a branching point, a source of multifrequency signals having a resistive impedance R_s connected to said point, and a plurality of branches connected in parallel at said point, each of said branches comprising a wave filter having an image impedance which is resistive and substantially constant over the major portion of the transmission band, a negative impedance converter connected in tandem between said filter and said point, and a resistor having a resistance approximately equal to R_s connected in series between said converter and said point, said converter having an impedance conversion ratio so chosen that the impedance of said filter as viewed through said converter is approximately equal to $-R_s$ at a frequency in said band.

12. A system in accordance with claim 11 in which said image impedance is approximately equal to R_s at the midband frequency of said filter and said ratio is approximately equal to -1 .

13. A system in accordance with claim 11 in which the frequency characteristic of said image impedance is concave downward in said band.

14. A system in accordance with claim 13 in which said ratio is so chosen that the maximum value of the impedance of said filter as viewed through said converter is slightly greater than R_s .

No references cited.