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FILTER ARRANGEMENT CONSISTING OF A LADDER NETWORK OF REACTANCES AND A TERMINATING RESISTANCE AND SIGNAL SOURCES CONNECTED TO A SERIES ELEMENT ON THE INPUT SIDE OF THE FILTER AND TO ONE OR MORE SHUNT ELEMENTS IN SAID LADDER NETWORK

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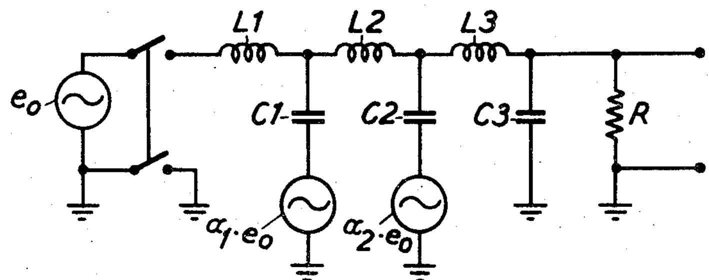

Fig. 1

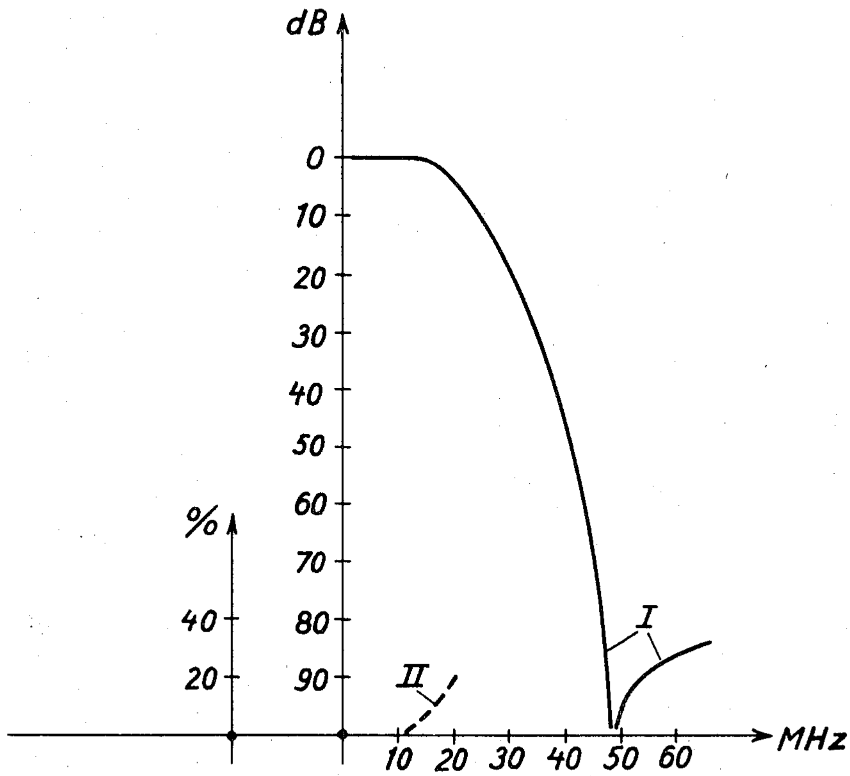

Fig. 2

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ABSTRACT OF THE DISCLOSURE

A filter comprises a ladder network of reactances connected between a signal input and a terminating resistor. One type of reactance serially connects the signal input to the terminating resistor, the second type extends from the junctions of serially connected reactances. A portion of the input signal is fed to the free end of at least some of the reactances of the second type. The magnitudes of the reactances and the required portions of the input signal are chosen in accordance with the desired transfer characteristic.

Simple types of filter arrangements have a transfer function F of for example the form

$$F=\frac{k}{s^5+k_4s^4+\cdots+k_0}$$

i.e. with a constant in the numerator and a polynomial in the complex variable $\sigma=j\omega$ in the denominator. These filters can in a known way consist of for example ladder networks with inductances and capacitances, which networks in one end are terminated by a resistance and in the other end are fed from a voltage generator with a very low output impedance or a current generator with a very high output impedance. In such filters the number of reactances, i.e. inductances and capacitances, is equal to the degree of the denominator polynomial. Filters with a transfer function F with a polynomial also in the numerator can by means of conventional methods be constructed so that the ladder network is provided with certain parallel resonance circuits instead of the corresponding simple series elements or so that the ladder network besides simple inductances is provided also with mutual inductances, which are necessary when the numerator polynomial has roots in the right half of the complex frequency plane. In these filters additional reactances are thus required on account of the numerator polynomial. This need for additional reactances and particularly for mutual inductances must be regarded as a great disadvantage, and the purpose of the present invention is to eliminate this disadvantage.

A filter arrangement according to the invention is of the kind characterized in accordance with the terminating claim following after the description.

The invention will be more fully described in connection with the accompanying drawing, where FIG. 1 schematically shows a filter arrangement according to the invention and FIG. 2 shows the attenuation of the filter arrangement and the time delay deviation as a function of the frequency.

The filter arrangement consists of a ladder network with series inductances L1, L2, L3 and shunt capacitances C1, C2, C3. The right end of the ladder network is terminated by a resistance R and the left end is intended to be connected to an input signal source e_0. The

capacitor C1 is in one end connected to the connecting point between the inductances L1 and L2 and in its other end it is connected to a signal source α_1e_0. The capacitor C2 is in one end connected to the connecting point between the inductances L2 and L3 and in its other end it is connected to a signal source α_2e_0. The capacitor C3 is in one end connected to the connecting point between the inductance L3 and the resistance R and in its other end it is connected to ground.

It is intended that the filter arrangement according to FIG. 1 shall be used in a telecommunication application requiring a transfer function F which in FIG. 2 is shown in the form of a curve by the attenuation curve I and the time delay deviation II as a function of the frequency

$$f=\frac{\omega}{2\pi}$$

This function F can be given in an analytic form with $s=\beta+j\omega$ as the complex angular frequency and in the present case the transfer function F will be of the following kind:

$$F=\frac{2.45s^4+503s^2+10395}{s^6+21s^5+210s^4+1260s^3+4725s^2+10395s+10395}$$

From the function F given in this way its transmission poles (= the roots of the denominator polynomial) and transmission zeros (= the roots of the numerator polynomial) can be calculated, and from such calculated poles the ladder network of the filter arrangement is determined in detail, i.e. y_p as well as y_{21} are then known, where y_p is the admittance of a shunt element p of the total number n of shunt elements of the ladder network, and y_{21} is a portion of the transfer admittance of the ladder network, which portion is situated between the input terminal of the filter arrangement (to the left in FIG. 1) and the shunt element y_p. From the different values of the admittance portion y_{21}, which values are obtained for different integer values of p within the interval $1\leqq p\leqq n$, and by the known transmission zeros for the transfer function the different values for the quantity α_k are obtained, which is the relation to magnitude and sign between on one hand a signal supplied to a shunt element k from a connected signal source, and on the other hand a signal supplied from the input signal source to the series elements of the filter arrangement on the input side during operation. Thus k has different integral numbers within the interval $1\leqq k\leqq m$, where m is the number of shunt elements to which signal sources are connected. Generally the transfer function F for a filter arrangement according to the invention can be written in the form:

$$F=\frac{1+\sum_{k=1}^{k=m}\alpha_k y_k\frac{1}{(-y_{21})_k}}{1+\sum_{p=1}^{p=n}y_p\frac{1}{(-y_{21})_p}}$$

For the arrangement according to FIG. 1 obviously $m=2$ and $n=3$. The different components in the arrangement have the following values: L1=22.3 μh.; L2=12 μh.; L3=5.6 μh.; C1=15.3 pf.; C2=9 pf.; C3=1.9 pf.; $\alpha_1=-0.46$; $\alpha_2=-0.0037$; R=1000Ω.

The invention is of course not limited to the embodiment shown in FIG. 1 with inductances in the series branches and capacitances in the shunt branches. Which kind of reactances that is required, the number of reactances, and the number of signal sources is determined completely by the transfer function that is desired to be realized. In for example filter arrangements of the band pass type the series elements will consist of series resonance circuits and the shunt elements of parallel resonance circuits. Furthermore the signal sources need not be separate units but they can for example consist of portions of a voltage divider supplied from or controlled by the input signal source.

I claim:

1. Filter arrangement consisting of a ladder network of reactances and a terminating resistance, the type and magnitude of these reactances being determined by the transmission poles of the transfer function F of the filter arrangement determined beforehand, signal sources being connected to one or more shunt elements in said ladder network and one series element in the input side of the filter being intended to be connected to an input signal source, characterized in that the ladder network and the signal sources are dimensioned so that the admittance of the ladder network and the indicated signals of the signal sources with respect to magnitude and sign satisfy the wanted transfer function F of the filter arrangement according to the relation:

$$F=\frac{1+\sum_{k=1}^{k=m}\alpha_k y_k \frac{1}{(-y_{21})_k}}{1+\sum_{p=1}^{p=n} y_p \frac{1}{(-y_{21})_p}}$$

where:

y_p is the admittance of a shunt element p of the total number n shunt elements of the ladder network;

y_k is the admittance of a shunt element k of the m shunt elements of the ladder network to which shunt elements signal sources are connected;

$(y_{21})_p$ is a portion of the transfer admittance of the ladder network, which portion is situated between the input of the filter arrangement and the shunt element p;

$(y_{21})_k$ is a portion of the transfer admittance of the ladder network, which portion is situated between the input of the filter arrangement and the shunt element k;

α_k is the relation with respect to magnitude and sign between on one hand a signal supplied to the shunt element k from the connected signal source and on the other hand a signal supplied from the input signal source to the series elements of the filter arrangement on the input side during operation; and

k, p, m, n are integers which satisfy the relations:

$$1\leqq k\leqq m;\ 1\leqq p\leqq n;\ m\leqq n$$

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U.S. Cl. X.R.

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