Calculation of Band-Pass Filters Using Piezoelectric Crystals in Lattice Structures

By A. FROMAGEOT and M. A. LALANDE

Laboratoire Central de Télécommunications, Paris, France

There is presented, a method of calculating the components of lattice filters in which the opposite arms consist of identical dipoles. This method is based on the fact that the critical frequencies of the dipoles (series and parallel resonances) included in the transmitted and in the attenuated ranges are computed independently. The first are related to the image attenuation constant and the second to the image impedance. The image attenuation constant is determined by the lowest required values in the attenuated range, i.e., the attenuation required from the filter. The image impedance is fixed by the average value and the deviation allowed around this value in the transmitted range.

Examples include the calculation of elements for three types of filters, and curves are provided to show the attenuation characteristics of filters constructed in accordance with these designs.

1. General

The components of an electric band-pass filter must often be calculated on the basis of the impedance-matching conditions within the transmitted band and the attenuation requirements outside this band. This is commonly the case in the design of multichannel telephone systems based on frequency division, particularly with regard to filters for selecting pilot and carrier frequencies, telephone channels, and groups of channels. These filters must provide a high attenuation outside and maintain a fairly uniform response within the transmitted band.

The attenuation requirements, it should be remembered, are not uniform over all the attenuated frequency range. Attenuation must be high at frequencies where existing currents are translated to the transmitted range by the action of the various carriers. As a convenient basis for our calculations, the frequency spectrum of these unwanted currents can be drawn on a diagram to indicate the lower limits of attenuation that must be provided by the filter.

Concerning uniformity of response within the transmitted band, any difference between the image impedance of the filter and the terminal resistances, which establishes the impedance-matching conditions, can be expressed in a diagram similar to that for the attenuation requirements.

The design procedure to be described is based on conventional filter theory making use of image parameters, emphasizing particularly two theorems by H. W. Bode,1 and the attenuation-gage method by E. Rumpelt.2

1.1 Bode's Two Theorems

A. Cut-off frequencies and infinite-attenuation frequencies (or poles of attenuation) determine the image attenuation of a filter.

B. A filter consisting of n sections in tandem, all with the same cut-off frequencies and image impedances, is equivalent to a single lattice section, the cut-off frequencies and image impedance of which are the same as those of the n sections.

According to these theorems, one can replace n sections in tandem, each section having a single pole of attenuation, by a single lattice section with n poles of attenuation, and reciprocally.

In accordance with theorem B and for particular cases met in practice, expressions will be given relating the parameters of a single section with n poles of attenuation to the parameters of n sections each with a single pole of attenuation. The usefulness of these relations resides in the facility with which the parameters of a single-pole section may be calculated.
