Bridged-T and Parallel-T Null Circuits for Measurements at Radio Frequencies

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Summary—Bridged-T and parallel-T null circuits may, under some circumstances, be preferable to bridge circuits for radio-frequency measurements as no transformer is required and the generator and detector can have a common grounded terminal. An analysis of the circuits can be made in terms of the transfer impedances of the various possible component T networks so that the nature of possible null conditions becomes evident by inspection. The circuits considered include arrangements suitable for the measurement of resistance, reactance, and frequency, and of the power factor of dielectrics. Some of the circuits, particularly suited to high-frequency work, employ neither coils nor capacitors.

INTRODUCTION

The bridged-T circuit is now widely employed in wave-filter design as it provides the equivalent of a symmetrical lattice or bridge network under certain limitations and under conditions where balanced-to-ground operation is not required. In common with the lattice, certain bridged-T structures permit a choice of element values to obtain perfect suppression of a single frequency, even when considerable dissipation is present in the components. This fact is evident from the equivalence relationships between lattice and bridged-T networks developed by Bartlett{1} taken with the familiar conditions of balance of a lattice or bridged network.

This property of true null balance of the bridged-T network has been employed by several investigators{2,4} to improve the rejection characteristics of wave filters, the result being usually accomplished by adding resistances to the filter without making other changes from the design on a pure reactance basis. Moreover, since it can be balanced to give a null indication, the bridged-T network can evidently be used in the same manner as a bridge for alternating-current measurements. The fact that one terminal is common to the input and output circuits is an important advantage, particularly at high frequencies, as no shielded transformer or Wagner ground connection is required.

These two applications of bridged-T null circuits are different in several important respects. In filter design, for example, the reactive elements must be proportioned in such a way as to give desired transmission characteristics over a band of frequencies which may be very wide. The requirements for null transmission at a single frequency, however, are all that need be considered when the network is used to replace a bridge for measurement purposes. In consequence, the networks which are preferable in the measurement field do not, as a rule, have transmission characteristics which are useful in wave filters. Some of the measuring circuits are essentially reactive networks but resemble compensated resonant circuits rather than compensated filter sections. Others of the circuits make a more fundamental use of resistance and are analogous to the bridge circuits of measuring technique which have one or more resistive arms, rather than to the lattice sections of filter theory. In view of differences of this kind, it seems desirable to examine in a general way from the measuring-circuit standpoint the possibilities of the bridged-T configuration and of the similar more general parallel-T arrangement in which two or more T-networks have their corresponding terminals connected in parallel.

Conditions for Zero Transmission

The network marked (a) in Fig. 1 comprises two T sections in parallel and includes as a special case the bridged-T circuit, indicated at (b). When the circuit is balanced to give zero transmission, each of the component T networks plays its part independently of the other, and the null condition is simply that corresponding to equal and opposite transmission through the two components. This is evident from the fact that, as in the case of a balanced bridge, neither the impedance of the generator ahead of the junction point nor that of the common output circuit can affect the balance conditions. At the input, the source impedance must affect equally the voltage applied to both T's, and at the output, no voltage can be developed across the output impedance because, at balance, no current flows through it. In computing the transmission of...