4 Description

4.1 Principle of Resistive Couplers

Wide-band reflectometer circuits cannot be realised by use of the common directional coupler, e.g. line coupler, since these only exhibit a bandwidth of a few octaves. In contrast, however, use of resistive couplers enable very wide bandwidths to be achieved. The specified frequency range of the SWR Bridge ZRB2 is, for instance, 5 MHz to 2.5 GHz corresponding to a bandwidth of nine octaves.

The basic circuit of resistive couplers (see Fig. 5) resembles the familiar Wheatstone bridge.

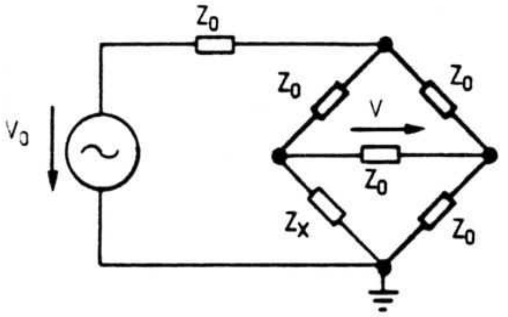

Fig. 5 Principle of resistive couplers

In this bridge circuit, the unknown impedance Z_x is compared with the reference impedance Z_0. Unlike the Wheatstone bridge circuit, the voltage V across the bridge diagonal is not adjusted to zero but it is measured and then evaluated. As can easily be shown, voltage V is given by equation (4).

$$V = \frac{1}{8} \cdot \frac{Z_x - Z_0}{Z_x + Z_0} . V_0 \tag{4}$$

As can be seen, voltage V is a measure of the magnitude and phase of the reflection coefficient:

$$r = \frac{Z_x - Z_0}{Z_x + Z_0}$$

where Z_x = impedance of device-under-test

4.2 Design of the SWR Bridge

The SWR Bridge ZRB2 consists of the three heavily outlined impedances Z_0 in Fig. 5. Impedance Z_0 in the bridge diagonal is the internal impedance of the indicator and not a component part of the bridge; the same applies to the internal impedance Z_0 of the source. The signal source, the indicator and the device-under-test are connected to the SWR bridge via N-series coaxial connectors. To prevent the arms of the bridge from being short circuited, the voltage across the bridge diagonal must be tapped symmetrically with respect to ground. This is achieved by the balun shown in Fig. 6. It consists of a coaxial cable whose inner conductor is connected to the left-hand junction of the bridge diagonal and whose outer conductor is connected to the right-hand junction.

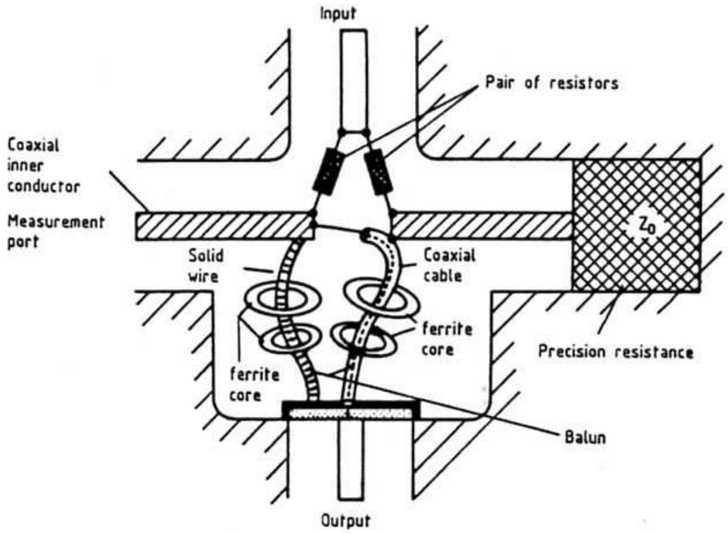

Fig. 6 Bridge schematic

The possibility of connecting the right-hand junction of the diagonal of the bridge to ground via the outer conductor of the coaxial cable is prevented by ferrite cores. These define the lower frequency limit of the SWR bridge. In order to achieve a wide bandwidth, two different types of ferrite cores are used in the SWR Bridge ZRB2. Nevertheless, the outer-conductor impedance of the coaxial cable is not infinitely high resulting in an unsymmetry of the bridge which brings about a deterioration of the directivity. To prevent this, the bridge must be made to balance. This is achieved by connecting a solid wire with ferrite cores to the left-hand junction of the bridge diagonal which "simulates" the outer-conductor impedance of the coaxial cable and tends to balance the bridge. The two ferrite cores on the simulated outer conductor are also of different type. To ensure that the quality of the SWR bridge is high, i.e. high directivity, the coaxial cable and the simulated outer conductor are constructed to be as mirror-symmetrical as possible.

A disadvantage is that the simulated outer conductor reduces the input impedance of the device-under-test connector. However, this can be compensated for by suitable selection of the heavily outlined impedances in Fig. 5. It can be shown that the three resistors need not have the value of Z_0. It is sufficient to have the upper pair as equal as possible and to use for the third impedance a precision resistance (see Fig. 6). In the SWR Bridge ZRB2, the value of the upper pair of resistors is selected to be greater than Z_0. In this way, the reduction in input impedance caused by the simulated outer conductor is compensated for and a good match of the device-under-test connector is achieved without influencing the directivity of the bridge. The precision resistance is a thin-film device. This allows the impedance of 50 Ω or 75 Ω to be as closely purely resistive as possible for the complete specified frequency range of the ZRB2.