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A TRANSISTORIZED DIRECTIONAL COUPLER

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In this paper is described a directional coupler in which the analogical reconstruction of the backward wave is obtained by means of a transistor. The use of an active element has allowed one to obtain at the same time a broad band, a high directivity and a tight coupling.

The use of such a coupler in a bidirectional broad band amplifier is also proposed.

Active Directional Couplers (^)

In a transmission line the amplitude of the backward wave voltage (V^-) is related, at any point, to the total current (I) and voltage (V) and to the characteristic impedance (Z) of the line by the following relationship:

$$V^- = (V - ZI)/2 \qquad (1)$$

According to eq.(1) the reconstruction of V^- can be made by picking-up both V and I and by performing operations appearing in eq.(1) in an analogic way. For the analogical reconstruction we propose the use of a junction transistor as shown in the schematic diagram of Fig.1.
When $Z_E/(1-\alpha_o) \gg |Z|_I$ and $|Z_E| \gg 1/g_m$, the circuit of Fig.1 gives an output voltage proportional to V^- if:

$$Z_V Z_I / Z_E = Z \qquad (2)$$

In particular, the output voltage is equal to V^- if

$$Z_L = Z + Z_V \qquad (3)$$

If we denote by ΔZ_I, ΔZ_V, ΔZ_E and ΔZ the amount by which Z_I, Z_V, Z_E and Z differ from a set of values that satisfies eq.(2), we obtain the following expression for the directivity at low frequency (D_o):

$$D_o = 2/(\Delta Z_E/Z_E + \Delta Z/Z - \Delta Z_I/Z_I - \Delta Z_V/Z_V) \qquad (4)$$

The expressions of the coupling factor (C) and of the directivity (D) versus frequency are given by:

$$C = 1/(1+j\omega/\omega_c) \qquad (5)$$

$$D = D_o/[1-D_o(\omega/\omega_d)^2] \qquad (6)$$

where ω_c and ω_d are cut off frequencies, functions of the circuit parameters (°).

Bidirectional Amplifiers

The described directional coupler can be used in a bidirectional amplifier in a conventional way. In this use it is very important to mantain a high directivity against variations of circuit parameters. This can be achieved by supplying the system with a control signal (°). A phase detector at the output of the directional coupler gives a signal by which the value of one of the Z's appearing in eq.(4) can be controlled. We propose the use of a FET connected at the Z_I-terminals, as appears in Fig.2.

Experimental Results

An active directional coupler has been realized according to the electric diagram of Fig.2. A theoretic analysis of the circuit (°) shows that the performances can be improved by using a capacitor of proper value connected as C_c in Fig.2.

In Fig.3 are plotted C and D versus frequency. It can be seen that the experimental measurements agree quite well with the theoretic curves.

Fig.1

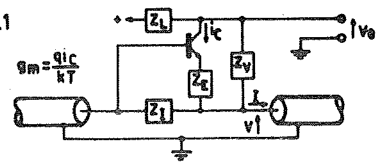
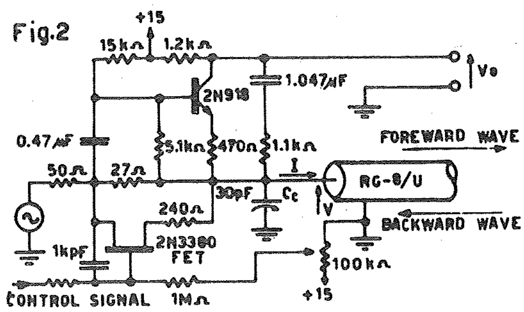
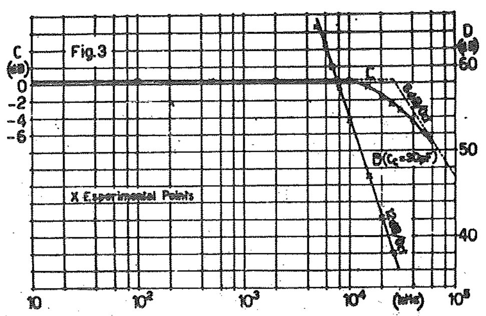


Fig.2





(^) Pending patent by B.Pellegrini
(°) Internal Report of CSCE and CSET.