Karadeniz Technical University
Faculty of Engineering
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MULTI-PORT WAVEGUIDE COMPONENTS

Preliminary Information :

Directional Couplers : Directional couplers are components, typically consisting of two transmission lines (a main arm and an auxiliary arm), that enable the separate measurement of forward and reflected waves on a line. The main and auxiliary arms are electromagnetically coupled to each other.

Directional couplers can be realized using coaxial lines, microstrip lines, and waveguides. Figure 1 shows a 3-port directional coupler implemented with waveguides. In this coupler, a portion of the power P_1 entering through port 1 is coupled to port 3 as power P_3. The coupling and directivity of the coupler are calculated as follows:

$$\text{Coupling (C)} = 10\log\frac{P_1}{P_3} \text{ (dB)} \quad (1)$$

$$\text{Directivity (D)} = 10\log\frac{P_3}{P_4} \text{ (dB)} \quad (2)$$

The isolation between ports is:

$$\text{Isolation (I)} = 10\log\frac{P_1}{P_4} = \text{C+D (dB)} \quad (3)$$

Directional couplers are widely used in various applications such as measuring reflection coefficient and standing wave ratio, determining the S-parameters of microwave transistors, and as attenuators. The 4th port of the 3-port directional coupler to be used in the experiment has been terminated with a matched load during manufacturing.

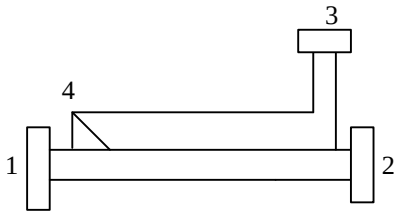

Figure 1: 3-port directional coupler

Ferrite Isolator : This component consists of a waveguide containing a piece of magnetized ferrite material adjacent to an ohmic metal sheet. Microwave power traveling in the forward direction experiences very little attenuation. However, power propagating in the reverse direction is absorbed by the ohmic sheet. Since the ferrite piece within the waveguide alters the field configuration in a unidirectional manner, it is also referred to as a field-displacement isolator.

Experimental Procedure:

1.1 Measurement of Coupling Value
1.1.1. Set up the experimental apparatus as shown in Figure 4 (at f=10 GHz). Set the rotary attenuator to 0 dB.
1.1.2. Take a reference reading on the DMM/meter.
1.1.3. Remove the directional coupler from the circuit and connect the detector in its place.
1.1.4. Increase the attenuation of the rotary attenuator until you obtain the reference value from step 1.1.2. The reading from the attenuator at this point is the coupling value.

1.2 Measurement of Directivity
1.2.1. In the setup from step 1.1.1, reverse the direction of the directional coupler. Set the rotary attenuator to 0 dB and take a new reference reading on the DMM/meter.
1.2.2. Return the coupler to its original orientation.
1.2.3. Increase the attenuation of the rotary attenuator until you obtain the reference value from step 1.2.1. The reading from the attenuator at this point is the directivity value.

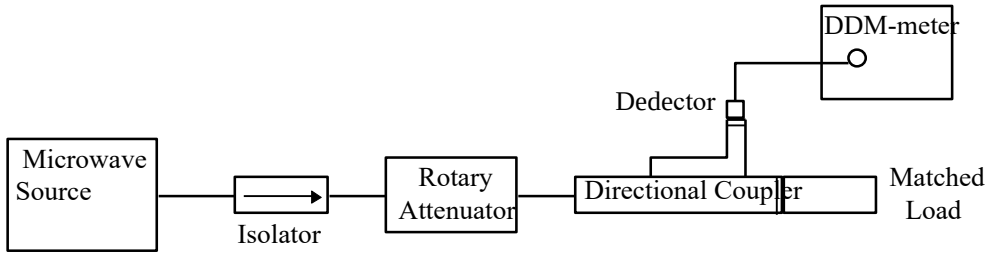

Figure 4: Experimental setup for measuring the coupling of a directional coupler

Questions

1. How would you measure both the transmitted and reflected power simultaneously using a 3-port directional coupler? Explain with a simple block diagram.