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KULLIYYAH OF ENGINEERING

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

MICROWAVE LABORATORY
ECE 3203

EXPERIMENT NO.6

(Series, Shunt and Hybrid T Junctions)

CONTENT

The properties and applications of three important waveguide junctions: the H plane, the E-plane and hybrid Tees, are investigated.

EQUIPMENT REQUIRED

Qty	Identifying Letter	Description
1	-	Control console
1	A	Variable attenuator
1	B	Slotted line
1	S	Probe diode-detector unit
1	P	X-band oscillator
1	M	Waveguide mounted diode detector
1	K	Resistive termination
1	E	H plane or shunt Tee
1	G	E plane or series Tee
1	H	Hybrid Tee
2	N	Horn antennas

OBJECTIVES

When you have completed this assignment you will

- Appreciate the properties and applications of the three basic wavegeuide junctions: shunt, series and hybrid Tees
- Have investigated experimentally their power dividing properties

KNOWLEDGE LEVEL

Before your start this assignment it would be an advantage

- To be familiar with the operation of the microwave bench by at least having completed Assignments 1 and 2
- To know that microwave signals can be detected using a diode detector
- To know how VSWR may be measured using a slotted line

INTRODUCTION

In many microwave system applications it is required to divide a waveguide into two branches or conversely combine two waveguides into a single line.

This may be accomplished in rectangular waveguide by using either a shunt-type H-plane or series-type E-plane Tee junction; the form of the junctions and their equivalent circuits are shown in Figure 2-7-1. The H-plane junction is so called because all 3 branches are in the plane of the magnetic field of the H_{10} mode; the E-plane since the 3 branches lie in the electric field of the H_{10} mode.

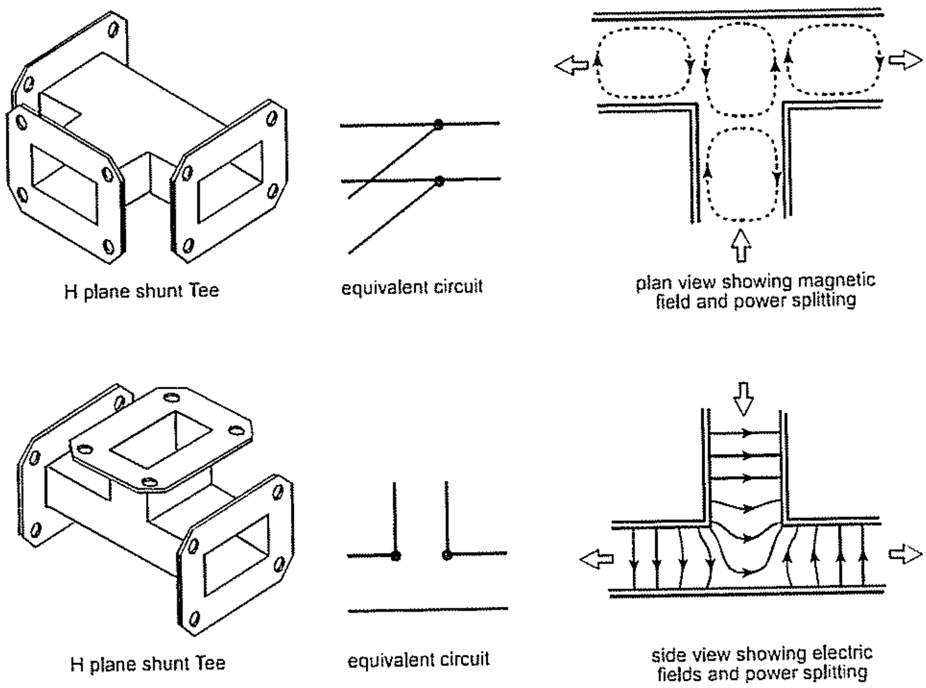

Figure 2-7-1

Power incident in the single line branch divides equally between the other two branches with waves in-phase in the case of the H-plane Tee but in anti-phase for the E-plane Tee. The two shunt lines present impedances in parallel at the junction which combine to give an impedance one-half the single guide impedance. In the E-plane case the input impedance at the junction seen by the single line is two impedances in series. Thus there will be a mismatch for both types of junction and in practice these are compensated by matching elements.

In addition to power splitting/power dividing applications, Tee junctions are used as shunt and series stub matching elements and in radar applications as microwave switches.

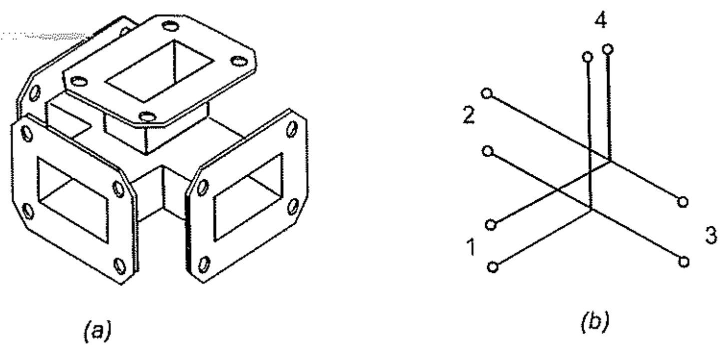

Figure 2-7-2

The hybrid-Tee junction shown in Figure 2-7-2 is essentially a combination of a shunt and series Tee junctions. The hybrid-Tee, assuming each branch is matched, has the property that power incident in any branch divides equally between the two adjacent branches but with no power coupled to the opposite branch. For example, referring to the hybrid-Tee diagram of Figure 2-7-2(b):

(i) power incident at 1 divides equally to 2 and 3; no power to 4

(ii) power incident at 4 divides equally to 2 and 3; no power to 1

(iii) power incident at 2 divides equally to 3 and 4; no power to 2

The hybrid-Tee finds important application as a duplexer for common use of a single antenna in radars, as a balanced mixer in receivers and as a bridge in microwave measurements.

EXPERIMENTAL PROCEDURE

> WARNING:
>
> Microwave radiation can be harmful, especially to eyes. NEVER look into an energised waveguide.

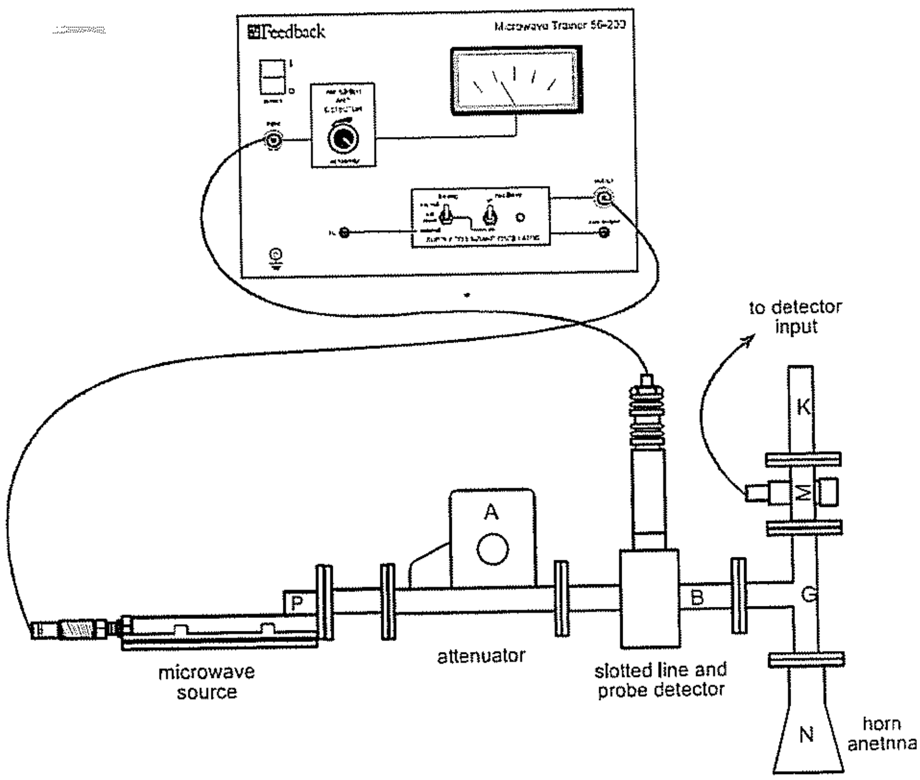

Figure 2-7-3

E- and H-plane investigations

1. Connect up the equipment as shown in Figure 2-7-3. The slotted line and probe-diode detector is to be used to measure the VSWR in the input waveguide to the Tee, the horn antenna is connected in one Tee arm to act as a good-quality load whilst the power in the other Tee arm is monitored by the diode-detector terminated in the resistive load.

2. Set the attenuator to approximately 60° (low attenuation), switch the X-band source to internal keying and meter to detector output. Switch on the console power supply and X-band oscillator source.

3. First measure the VSWR in the input line to the Tee using the slotted line and with the probe detector unit output connected to the console detector input. Move the probe diode-detector unit to locate a maximum of electric field. Adjust the detector-amplifier sensitivity on the console to obtain a mid-to-full scale reading. Record the meter current I_{max}. Next locate an electric field minimum and record the detect current I_{min}.

4. Disconnect the lead from the slotted line probe detector and connect to the waveguide diode detector in the left-hand Tee arm. Measure the detector current and record its value I_{LH}.

5. Interchange positions of horn antenna and diode-detector plus resistive termination and record the detector current I_{RH}.

6. Assuming the detector to be operating in its square-law range, I_{LH} and I_{RH} are directly proportional to the power flowing in the left-hand and right-hand arms of the junction. Thus the tracking performance of the Tee junction can be evaluated. Tracking in this context means the degree in which power splits equally into the two arms.

7. Repeat for the second Tee junction. Results for both Tees can be recorded in a table similar to that given in Figure 2-7-4.

8. Evaluate for each Tee:

   Voltage standing rations (VSWR);

   Reflection coefficient, Γ;

   Tracking ratio: power LH arm/power RH arm

Measurement Results	E-plane	H-plane
VSWR measurements detector current at		
maximum I_{max}		
minimum I_{min}		
VSWR, $S = \sqrt{\frac{I_{max}}{I_{min}}}$		
reflection coefficient, Γ = S - 1/S + 1		
Tracking: detector current		
Left-hand arm I_{LH}		
Right-hand arm I_{RH} Ratio of powers I_{LH}/I_{RH}		

Figure 2-7-4 Table for Recording Results of E- and H-Plane Tees

HYBRID-TEE INVESTIGATED

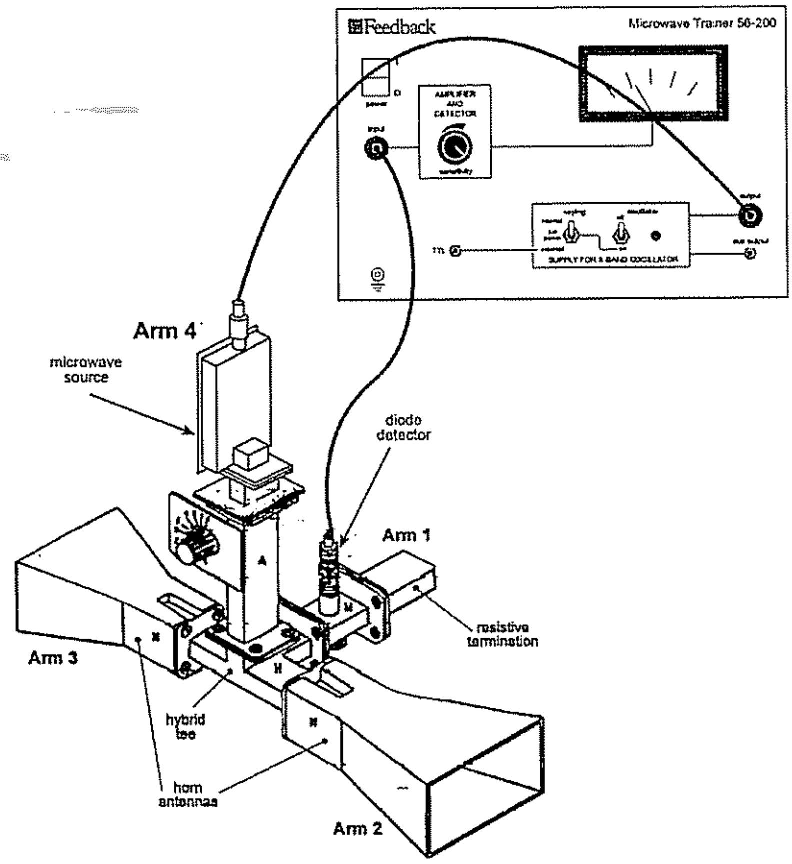

Figure 2-7-5

1. Set up the equipment as shown in Figure 2-7-5 with the attenuation set at about 60° producing low attenuation. Switch to internal keying if not already set and switch on power supply and the X-band oscillator source.

2. Measure the detector current in the position shown. Note this will be zero or very close to zero since the detector is located in the isolated arm of the hybrid-Tee, that is the supply ARM 4 and ARM 1 containing the detector are decoupled.

3. Next investigate the power supplied to ARMS 2 and 3 which currently supply the two horn loads. Disconnect the horn in ARM 2 and interchange with the detector and resistive termination so in the new set-up ARM 2 is terminated in a horn and ARM 2 has the detector to measure power. Record the detector output current I_2, which assuming square-law detecting operation will proportional to the power P_2 in ARM 2.

4. Interchange detector in ARM 2 and horn in ARM 3 to measure detector current I_3, which is directly proportional to the power in ARM 3, P_3.

5. Return system to the original set-up with the horns termination ARMS 2 and 3 and insert the slotted line and diode-probe detector unit in ARM 4. Measure the VSWR by recording detector current at positions of an electric field maximum and minimum.

SUMMARY

Three basic waveguide junctions; shunt, series and hybrid Tees have been investigated experimentally,. The shunt H-plane and series E-plane junctions have been shown to divide input equally to the two output branches.

The properties of the hybrid-Tee in dividing power and in presenting isolation between two branches are also confirmed.