$$Isolation\ (port\,2\ to\ port\,3) \qquad S_{32}\,(dB) = -20\log_{10}|S_{32}| \qquad (9.22)$$

$$Return\ loss\,(port\,1) \qquad S_{11}\,(dB) = -20\log_{10}|S_{11}| \qquad (9.23)$$

This power divider offers a theoretical bandwidth of approximately 1.44:1 for input VSWR of 1.22 and an isolation of 20 dB between the two output ports.

9.3 Experiment 3 - Measurement of Power Division, Isolation and Return Loss Characteristics

Experiment

To measure the power division, isolation and return loss characteristics of a matched 3 dB power divider in the frequency range 2 to 3 GHz.

A. Transmission Loss Measurement using Test Bench Set up

Measurement of Power Division and Isolation as a function of frequency

Equipment/Components

Microwave signal source (2 –3 GHz) with modulation (1 KHz)
Attenuator pad
VSWR meter
Frequency meter

Items from the Kit -

Matched power divider (DUT)♦
Stripline directional coupler
Detector
Matched loads
Cables and adapters

♦ The microstrip power divider provided in the Kit is of the 3 dB Wilkinson type described in section 9.2. The impedance of the input/output lines is 50Ω and the isolation resistor connected between the two output lines has a value of 100Ω. Measuring the power division property involves measuring the transmission response between the input port (port1) and the two output ports (ports 2 and 3). While measuring the transmission response between any two ports, the third port has to be terminated in a matched load. Measuring the isolation property involves measuring the transmission response between ports 2 and 3 by terminating port 1 in a matched load.

Read **Note** under Experiment 1(Chapter 7) for precautions, alternate measurement set up using the power meter and sensor, and measurement using the Network Analyzer.

Procedure

1. Assemble the set up as shown in Fig. 7.1. Connect the output of the frequency meter directly to the stripline directional coupler (connect P to Q directly).
2. Switch on the source and the VSWR meter. Before switching on the source, ensure that there is sufficient attenuation to keep the RF power output low.
3. Set the frequency of the source to 2 GHz. Adjust the power output of the source for a reasonable power indication on the VSWR meter. Note the reading of the VSWR meter. Increase the frequency of the source in steps of 0.1 GHz to 3 GHz and note the corresponding readings of the VSWR meter. Record the frequencies in column 1 and VSWR meter readings as P_{in} dB in column 2 of Table 9.1. This is the reference input power.
4. Insert the power divider (DUT) between P and Q with input port (port1) connected to P and one of the output ports (port 2) to Q. Terminate port 3 of the power divider in matched load. Record the readings of the VSWR meter at the above frequencies as $P_{2\ out}$ dB in column 3 of Table.9.1
5. Interchange ports 2 and 3. That is, connect port 3 to Q and terminate port 2 in matched load. Record the readings of the VSWR meter at the same frequencies as $P_{3\ out}$ dB in column 4 of the Table.
6. In order to determine the isolation between the two output ports, remove the power divider and reconnect with port 2 at the input end (at P) and port 3 at the output end (at Q). Terminate port 1 in matched load. Record the readings of the VSWR meter at the same frequencies as $P_{32\ out}$ dB in column 5 of the Table.

Power Division

Power loss from port 1 to port 2 = P_{in} (dB) - $P_{2\ out}$ (dB) = - 20 $\log_{10}|S_{21}|$. Denote this loss as S_{21}(dB) and enter at column 6 of the Table.

Power loss from port 1 to port 3 = P_{in} (dB) - $P_{3,out}$ (dB) = - 20 $\log_{10}|S_{31}|$. Denote this loss as S_{31}(dB) and enter at column 7 of the Table.

Isolation

Isolation between ports 2 and 3 = P_{in} (dB) - $P_{32\text{ out}}$ (dB) = - 20 $\log_{10}|S_{32}|$. Denote this isolation as S_{32}(dB) and enter at column 8 of the Table.

TABLE 9.1

Power Division and Isolation Characteristics of Matched Power Divider

Freq. f(GHz)	VSWR meter readings (dB)				Power division Port1 to 2 S_{21}(dB)	Power division Port1 to 3 S_{31}(dB)	Isolation Port 2 to 3 S_{32}(dB)
	P_{in}	$P_{2\text{ out}}$ or P_{21}	$P_{3\text{ out}}$ or P_{31}	$P_{32\text{ out}}$			
2.0							
2.1							
:							
:							
:							
:							
3.0							

A. Reflection Loss Measurement Using Test Bench Set up

Measurement of Return Loss as a function of frequency

Equipment/Components

Microwave signal source (2-3 GHz) with modulation (1 KHz)
Attenuator pad
VSWR meter
Frequency meter

Items from the Kit -

Power divider (DUT)
Stripline directional coupler
Detector
Matched loads (50Ω)
Short
Cables and adapters

Procedure

1. Assemble the set up as shown in Fig. 7.2.
2. Terminate the output port of the coupler directly in a short circuit termination.
3. Switch on the source and the VSWR meter. (Before switching on the source, ensure that there is sufficient attenuation to keep the RF output low.)
4. Set the frequency of the source to 2 GHz). Adjust the power output of the source for a reasonable power indication on the VSWR meter. Note the reading of the VSWR meter. Increase the frequency of the source in steps of 0.1 GHz to 3 GHz and note the corresponding readings of the VSWR meter. Record the frequencies in column 1 and VSWR meter readings as P_{sh} dB in the column 2 of Table 9.2.
5. Remove the short and connect the input port (port 1) of the power divider (DUT) to the output port of the coupler. Terminate the other two ports in 50Ω matched loads. Record the readings of the VSWR meter at the above frequencies as P_{r1} dB in column 3 of Table 9.2.
6. The reflection loss (return loss) of the device is (P_{sh} - P_{r1}) dB = -20 $\log_{10}|S_{11}|$. Enter this as S_{11}dB at column 4. Calculate the reflection coefficient $|S_{11}|$ and enter at column 5.

TABLE 9.2

Measurement of Return Loss Characteristic of Power Divider

Freq. f(GHz)	VSWR meter readings (dB)		Return Loss S_{11}(dB)	Reflection Coefficient $\lvert S_{11}\rvert$
	P_{sh}	P_{r1}		
2.0				
:				
:				
:				
:				
:				
:				
3.0				

Analysis of Results

1. Plot power division S_{21} and S_{31} in dB as a function of frequency. Ideally the values of both these should be 3 dB at the centre frequency. In the actual device, because of the losses in the connectors and in the microstrip line, the measured loss will be around 3.5 dB. Compare the variation in the loss characteristic with the ideal response given in Fig. 9.7

2. Plot isolation S_{32} in dB as a function of frequency. Compare with the ideal response and explain the difference.

3. Plot return loss S_{11} in dB as a function of frequency. Compare with the ideal response and explain the difference.

4. Calculate the magnitudes of the scattering parameters from the measured loss at the centre frequency. Compare with the theoretical values.