7.2 Experiment 1 - Measurement of Transmission Loss and Reflection Loss

Experiment

To measure the transmission loss and return loss of a 50Ω microstrip line in the frequency range 2-3 GHz.

A. Transmission Loss Measurement using Test Bench Set up

Equipment/Components

Microwave signal source with modulation (1 KHz)
Attenuator pad
VSWR meter
Frequency meter (optional, see *Note* below (Item 3))

Items from the Kit -

50Ω microstrip line (DUT)
Stripline directional coupler
Detector
Matched load
Cables and adapters

Note

1. Before switching on the source, set the RF attenuation to maximum so that the detector (or the sensor) does not receive more than the maximum rated power. For the coaxial detector, the maximum power for operation in the square-law region is less than 1mW. This is an important precautionary measure. After switching on the source the power level can be increased gradually.

   When using the VSWR meter, the 1 KHz modulation on the source must be ***on*** and the frequency of modulation (1 KHz) must be adjusted precisely to maximize the output on the VSWR meter.

2. Power meter with sensor can be used in place of VSWR meter with detector. Modulation of the source is not required when using the power meter. In this case also, it is important to ensure that the power applied to the sensor does not exceed the maximum rated power.

3. If the source is not properly calibrated, use a cavity frequency meter to determine the frequency of the source. This is achieved by tuning the frequency meter and noting the frequency at which the VSWR meter (or power meter) shows a dip. After noting the frequency, always detune the frequency meter for taking the reading of power level.

4. While making measurements involving large transmission loss of the DUT (e.g. measurement of isolation in a coupler or large stop band loss in a filter), the power level at the detector (with DUT connected) may not be sufficient to give stable reading (above noise level) on the VSWR meter. In such cases, the directional coupler can be removed from the set-up (shown in Fig. 7.1) and the detector (or the power sensor) can be connected directly to point Q.

Procedure

1. Assemble the set up as shown in Fig. 7.1. Connect the output of the frequency meter directly to the 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 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 the first column and the VSWR meter readings as P_{in} dB in the second column of Table 7.1.
4. Now insert the 50Ω microstrip line (DUT) between *P* and *Q*. Record the readings of the VSWR meter at the above frequencies as P_{out} dB in the third column of Table 7.1.
5. The transmission (insertion) loss of the device is S_{21}(dB) = (P_{in}(dB)- P_{out}(dB)). Plot transmission loss versus frequency.

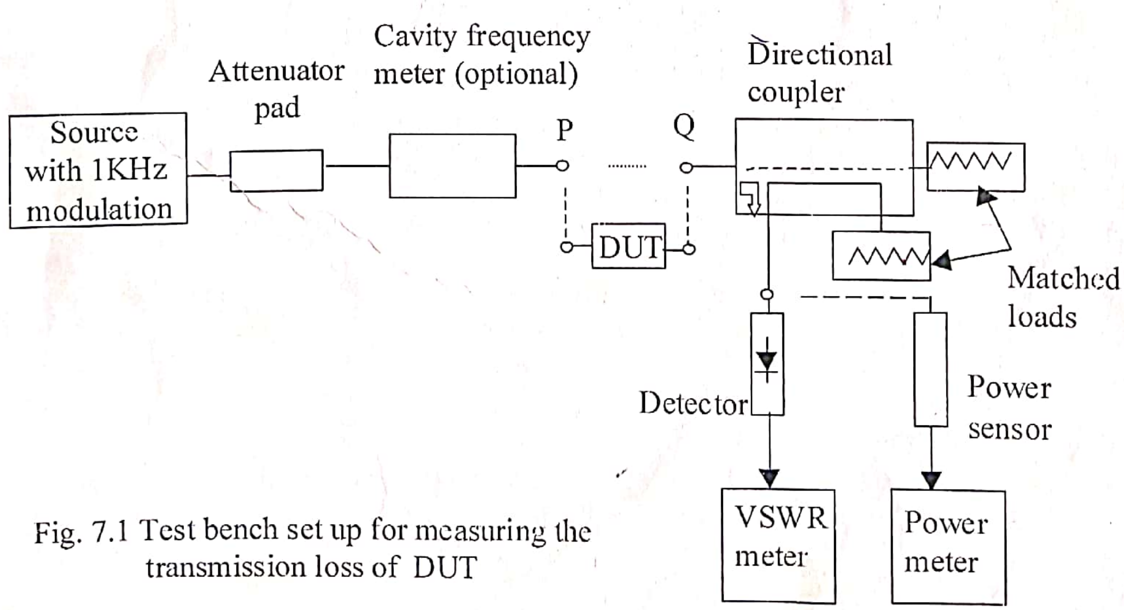

Fig. 7.1 Test bench set up for measuring the transmission loss of DUT

TABLE 7.1

Transmission loss of 50Ω line as a function of frequency

Frequency f (GHz)	VSWR meter reading without DUT P_{in} (dB)	VSWR meter reading with DUT P_{out} (dB)	Transmission loss S_{21}(dB)
2.0			
2.1			
:			
:			
3.0			

B. Reflection Loss Measurement using Test Bench Set-up

Equipment/Components

Microwave signal source with modulation (1 KHz)
Attenuator pad
VSWR meter
Frequency meter

Items from the Kit -

50Ω microstrip line(DUT)
Stripline directional coupler
Detector
Matched load (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 (terminal P) 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 the first column and the VSWR meter readings as P_{sh} dB in the second column of Table 7.2.
5. Now connect the 50Ω microstrip line (DUT) to P and terminate the microstrip line in a 50Ω matched load. Record the readings of the VSWR meter at the above frequencies as P_{out} dB in the third column of Table 7.2.
6. The reflection loss (also called return loss) of the device is S_{11}(dB) = P_{sh}(dB)-P_{out}(dB). Enter this at column 4.
7. Calculate reflection coefficient $|S_{11}|$ and also the input VSWR using the formulas given in Chapter 4 and enter at columns 5 and 6.
8. Plot return loss, reflection coefficient and VSWR as a function of frequency.

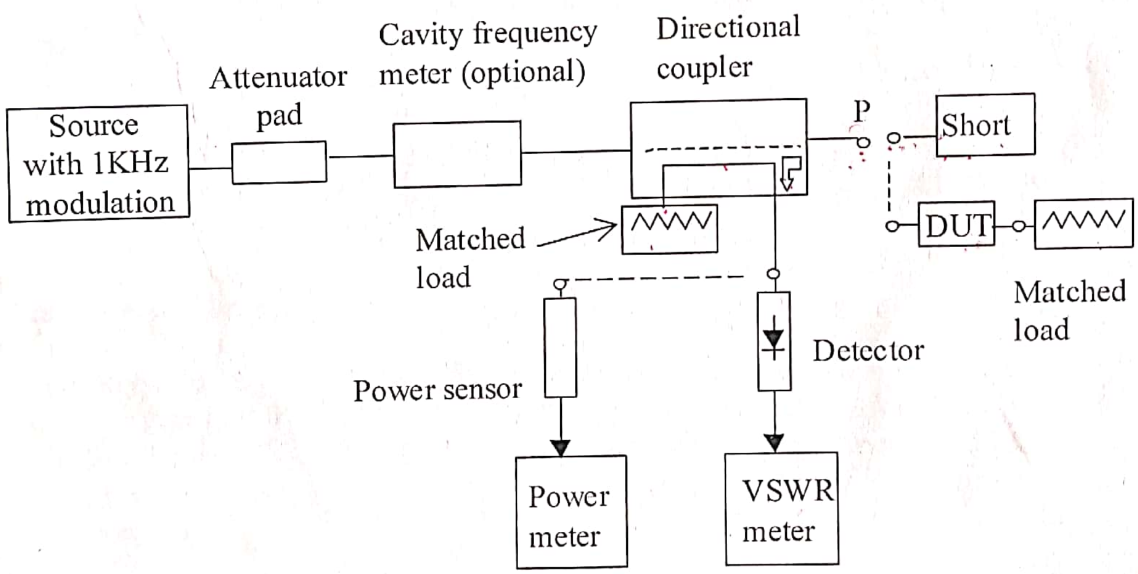

Fig. 7.2 Test bench set up for measuring the reflection loss of DUT

TABLE 7.2

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Reflection coefficient of 50Ω line as a function of frequency

Freq. f(GHz)	VSWR meter reading with short at P P_{sh} (dB)	VSWR meter reading with DUT and matched load P_{out} (dB)	Return loss S_{11}(dB)	Reflection coefficient $\lvert S_{11}\rvert$	VSWR
2.0	P_{in}	P_R	$P_{sh} - P_{out}$	P_{sh}/P_{out} $= -10\log\left(\frac{P_{out}}{P_{in}}\right)$	$\frac{1+\lvert S_{11}\rvert}{1-\lvert S_{11}\rvert}$
:					
3.0					

C. Measurement using Network Analyzer

1. Perform two-port calibration of the Network Analyzer from 2 to 3 GHz as per the instruction manual supplied with the instrument. (Procedure for Hp 8510A Vector Network Analyzer is summarized in Chapter 5).
2. Connect the 50Ω microstrip line (DUT) between the two reference planes at which the calibration is carried out.
3. Use *Dual Channel Display* to display the return loss (S_{11} dB at port 1 or S_{22} dB at port 2); and transmission loss (S_{21}dB from port 1 to port 2 or S_{12} dB from port 2 to port 1)

Analysis of Results

1. Ideally when a lossless transmission line is terminated in a matched load, the entire power gets absorbed in the load and the reflection coefficient of the transmission line should be zero (VSWR = 1). In this case, a 50Ω microstrip line is inserted in a 50Ω transmission line system. Explain the difference that you observe from the ideal response.

2. Calculate the loss for the 50Ω microstrip line supplied. The material of the strip conductor is copper with a flash of silver to prevent oxidation. Choose copper as the conductor and calculate α_c using equation (3.10) of Chapter 3. α_d may be neglected. Compare with the measured loss.

3. For the substrate $\varepsilon_r = 3.2$, $h = 0.76$ mm. Calculate the effective dielectric constant for a 50Ω line, and also the guide wavelength in the microstrip at 2.5 GHz.