Lab-1

RF equipment Fundamentals

Microwave Design and Measurements (EERF 6396)
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Submitted By

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1. Introduction

Objectives:

- To measure the insertion loss of passive components using scalar measurements.
- To calculate speed of light by measuring length of standing waves.

- The following equipment were used to perform the experiments:

a. Signal Generator (Agilent N5181A – 100kHz to 6GHz)
b. Power Meter (Agilent E4419B)
c. Power Sensor (Agilent E9301H: 10MHz – 6GHz, 10 nW – 1W)
d. N-type to SMA coaxial cable
e. SMA to N-type coaxial cable
f. SMA Attenuators: 3 dB, 6 dB, 10 dB, 20 dB
g. Band pass filter
h. Microwave oven
i. Chocolate bar

2. Procedure

Measurement of Speed of light:

1) Remove the turning plate from the microwave oven.
2) Place a food substance (chocolate bar was used) in the microwave oven.
3) Heat the chocolate for about 20 seconds until melting spots on the chocolate are observed.
4) Remove the chocolate bar from the microwave and measure the distance between the centers of the hot spots. ($d = \lambda/2$)
5) Calculate the speed of light c = 2 x d x 2.45 x 10^9 (frequency of microwave oven) m/s

Scalar Measurements:

1) Turn on Signal generator and power meter 20 minutes prior to the experiment to let them stabilize.
2) Perform zero check and power calibration of the power sensor. Turn RF off while not taking measurements.
3) Set Signal generator frequency to 3 GHz at 0.00 dBm power.
4) Connect power sensor to the output port of the signal generator and record the reading on the power meter.
5) Connect RF Coaxial cable between signal generator & power sensor and record the reading on the power meter.
6) Connect attenuators between the RF cable and the power sensor and record the corresponding power meter readings.
7) Measure transmitted power of filter at frequency range of 2 to 5 GHz in steps of 200MHz.

3. Data

3.1 Speed of light

c = 2 x d x 2.45 x 10^9 (frequency of microwave oven) m/s

c = 2 x 0.062 x 2.45 x 10^9 m/s

c = 3.038 * 10^(8) m/s.

Actual speed of light (c) = 299 792 458 m / s

Analysis: As we can see there is about +2.95% deviation from the actual speed of light.

3.2 Attenuators

Length of the cable =80 cm = 0.80m
Attenuation per unit length of cable (α) = -0.71 dBm/0.8m = -0.8875 dB/m

Following table shows Recorded Data and Insertion loss for each component:

Components	Power meter reading (dBm)	Power meter reading(mW)	Insertion loss (dB)	Percentage loss (%)
Signal generator to power meter	-0.16	0.963	-	
RF cable	-0.71	0.849	-	
3 dB Attenuator	-4.08	0.39	(-0.71) - (-4.08) = 3.37	12.33%
6 dB Attenuator	-7.0	0.199	(-0.71) - (-7) = 6.29	4.883%
10 dB Attenuator	-10.78	0.083	(-0.71) - (-10.78) = 10.07	0.7%
20 dB Attenuator	-20.70	0.0085	(-0.71) - (-20.70) = 19.99	0.05%

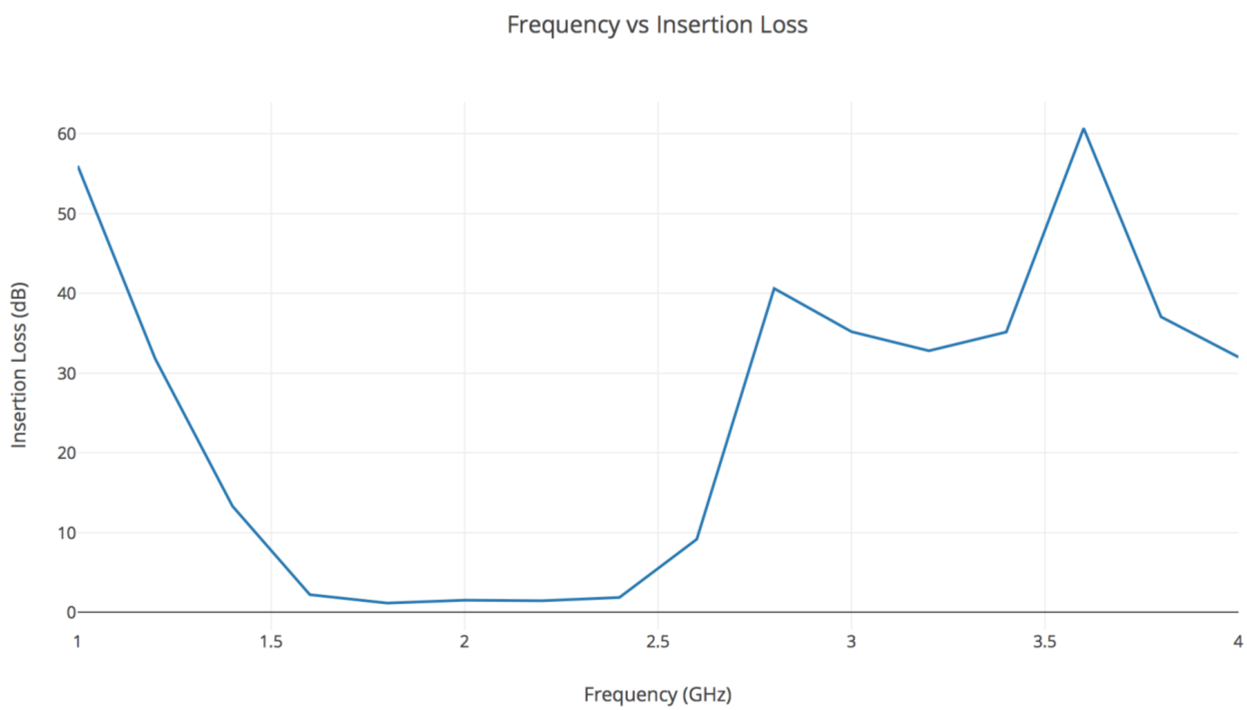
3.3 Band pass filter

Following table shows Insertion loss of filter from frequency range 1-4 GHz:

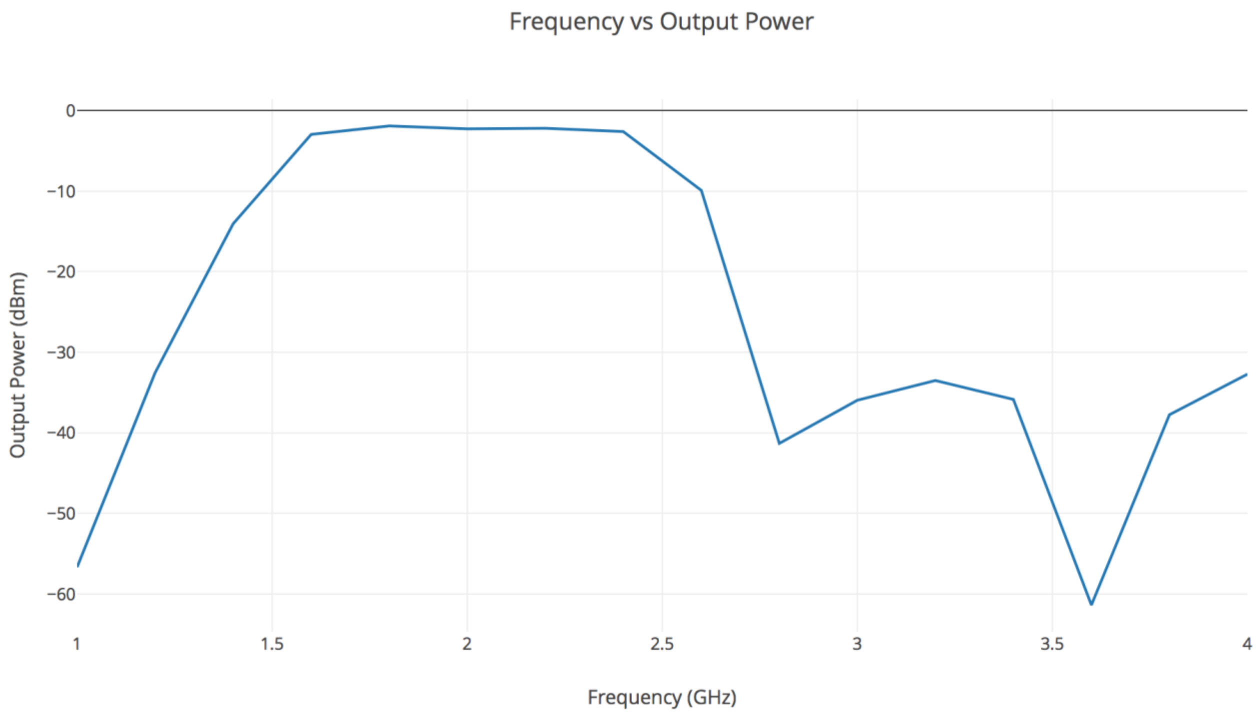
Frequency(GHz)	Output Power(dBm)	Insertion loss(dB)
1	-56.69	55.98
1.2	-32.54	31.83
1.4	-14.04	13.33
1.6	-2.94	2.23
1.8	-1.89	1.18

2	-2.25	1.54
2.2	-2.18	1.47
2.4	-2.59	1.88
2.6	-9.89	9.18
2.8	-41.32	40.61
3	-35.96	35.19
3.2	-33.51	32.8
3.4	-35.86	35.15
3.6	-61.40	60.69
3.8	-37.76	37.05
4	-32.72	32.01

Frequency vs Insertion loss plot:



Frequency vs Output Power plot:



1. Nominal Insertion loss of filter in its pass band: 1.18 dB at 1.8 GHz
2. Pass band: 1.6 GHz – 2.4 GHz.
3. 3dB cutoff frequencies: 1.7 GHz and 2.5 GHz

4. Summary

Speed of light Experiment:

- In this experiment, the wavelength of microwaves was measured by recording the distance between hot spots formed on chocolate bar due to interference between the reflected waves. The distance between the two hot spots is $\lambda/2$ and it was used to calculate speed of light.
- Deviation error of +2.95% was observed from actual speed of light value due to dissimilarity of the size and width of the melting spots.

Importance of Calibration:

- The power meter requires a reference power based on which it can measure the input power that is given. Therefore, it is required to set this power, which is done by calibration.
- Hence, calibration in necessary to ensure the reliability and consistency of the measurements.

Adverse Effects of Impedance Mismatch at DUT:

- Impedance mismatch will cause undesired power reflections from the DUT to the RF cable which leads to less efficiency.
- Impedance mismatch increases reflection power and decreases transmitted power.