MICROWAVE LAB - Antenna measurement

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Introduction

This experiment was to measure the radiation pattern of two types of antenna, namely the Horn antenna and the Parabolic Antenna. Gunn oscillator is used to generate microwaves. The field strngth or power is measured at different angles and a constant radius in the far field zone. The 3-dB width of the pattern was also calculated from the plots. Gain of the two antennae were calculated.

General Measurements

The frequency of the microwave was found to be 9.03 GHz. It uses the principle of resonance and standing waves for the measurement of frequency i.e. at the frequency of the waves power transmitted is minimum because energy is accumulated in the standing waves. The wavelength of the microwaves was found to be$3.2222cm$ in free space. In order to apply the far field approximation, the distance between the two antennae needs to be greater than $\frac{2D^2}{\lambda}$.

$$\begin{aligned} D =& 0.1m \\ \lambda =& 0.032222m \\ \Rightarrow R \geq& 0.602m \end{aligned}$$

The actual value we have used in our experiment was $80cm$ and so it obeyed far-field approximation criteria. The experiment uses a Gunn diode to set up the microwave in the cavity. In the Gunn diode, three regions exist: two of them are heavily N-doped on each terminal, with a thin layer of lightly doped material in between. When a voltage is applied to the device, the electrical gradient will be largest across the thin middle layer. If the voltage is increased, the current through the layer will first increase, but eventually, at higher field values, the conductive properties of the middle layer are altered, increasing its resistivity, causing current to fall. This means a Gunn diode has a region of negative differential resistance in its current-voltage characteristic curve, in which an increase of voltage across it causes a decrease in current.

The voltage vs current characteristics of the gunn diode:

V (in Volts)	I (in Amps)	V (in Volts)	I (in Amps)
0	0	5.5	1.2
0.5	0.4	6	1.1
1	0.6	6.5	1.1
1.5	0.9	7	1.1
2	1.2	7.5	1.1
2.5	1.3	8	1.1
3	1.4	8.5	1.0
3.5	1.4	9	1.0
4	1.3	9.5	1.0
4.5	1.2	10	1.0
5	1.2		

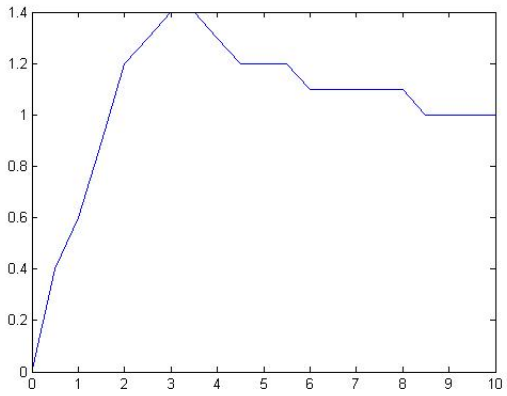

Figure 1: Voltage vs Current Characteristics of a gunn diode

An isolator is used in the equipment in order to allow the propogation of energy in only one direction. That is to avoid reflection of waves in the cable and thus maintaining an impedence match.

Horn Antenna

The angle vs the received power for a horn antenna in far-field.

Angle	Power (in mW)	Angle	Power (in mW)
0	1.7	0	1.7
2	1.65	-2	1.65
4	1.65	-4	1.65
6	1.60	-6	1.60
8	1.5	-8	1.5
10	1.4	-10	1.4
12	1.25	-12	1.25
14	1.05	-14	1.05
16	0.9	-16	0.9
18	0.75	-18	0.75
20	0.55	-20	0.55
22	0.4	-22	0.4
24	0.28	-24	0.28
26	0.18	-26	0.18
28	0.12	-28	0.12
30	0.08	-30	0.08

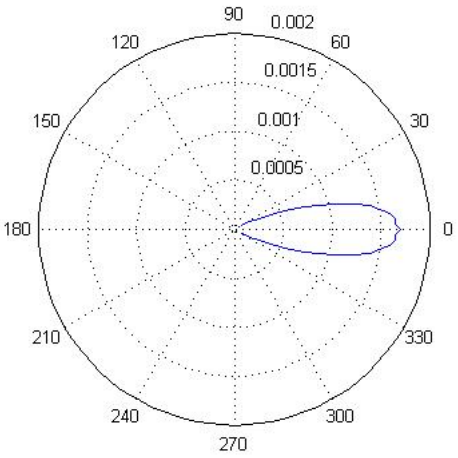

Figure 2: Polar plot of the radiation pattern of a horn antenna

The 3 dB width of the horn antenna was found to be 17°
Gain of the antenna was found to be

$$\begin{aligned} P_t &= 40mW \\ P_r &= 1.7mW \\ Gain &= \frac{4\pi R}{\lambda}\sqrt{\frac{P_r}{P_t}} \\ &= 62.175(or)17.94dB \end{aligned}$$

Parabolic Antenna

The angle vs the received power for a parabolic antenna.

Angle	Power (in mW)	Angle	Power (in mW)
0	3.8	0	3.8
2	3.4	-2	3.4
4	2.8	-4	2.8
6	2.2	-6	2.2
8	1.4	-8	1.4
10	1.0	-10	1.0
12	0.6	-12	0.6
14	0.52	-14	0.52
16	0.42	-16	0.42
18	0.2	-18	0.2
20	0.1	-20	0.1
22	0.065	-22	0.065
24	0.040	-24	0.040
26	0.015	-26	0.015
28	0.008	-28	0.008
30	0.0014	-30	0.0014

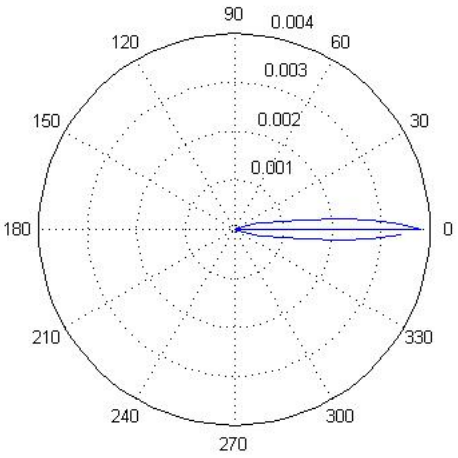

Figure 3: Polar plot of the radiation pattern of a parabolic antenna

The 3 dB width of the parabolic antenna was found to be 7°
Gain of the antenna was found to be

$$\begin{aligned} P_t &= 40mW \\ P_r &= 3.8mW \\ Gain &= \frac{(4\pi R)^2}{G_H \lambda^2} \sqrt{\frac{P_r}{P_t}} \\ &= 139(or)17.94dB \end{aligned}$$