A Laboratory Manual for

MICROWAVE & RADAR

(22535)

Semester- V

Scheme- I

Diploma in Electronics Engineering Group

(EJ)

Bharati Vidyapeeth Institute of Technology,

Navi Mumbai.

Bharati Vidyapeeth Institute of Technology

Navi Mumbai

Certificate

This is to certify that, Mr./ Ms. ………………………………………………….

Roll No. …………….. of Fifth Semester of Diploma in Electronics Engineering Group of Bharati Vidyapeeth Institute of Technology, Navi Mumbai (Inst. code: 0027) has satisfactorily completed the term work in the subject **MICROWAVE & RADAR (22535)** for the academic year 20…….to 20……. as prescribed in the MSBTE curriculum.

Place: ……………………...   Enrollment No. : …………………

Date: ……………………….   Exam. Seat No. : ………………….

Subject Teacher	**Head of the Department**	**Principal**

Sign:

Name:

Seal of Institution

LIST OF EXPERIMENTS AND PROGRESSIVE ASSESSMENT FOR TERM WORK D-3

ACADEMIC YEAR 20 - 20

Course Code :- Sub & Code :

Name of Candidate : Enrollment No : Roll No :

Marks : Max : Min : Name of Staff-

Sr. No	Title of Experiment	Page No	Date of Performance	Date of Submission	Assessment Marks	Dated Sign of teacher with Remark
1	Use the frequency meter with microwave test bench setup to determine the frequency and wavelength of waveguide for TE10	1				
2	Use the microwave test bench setup to ensure power division in microwave tees E- plane, H- plane and E-H plane.	8				
3	Determine coupling factor and insertion loss for the given circulator.	12				
4	Measure VSWR for the given microwave load.	16				
5	Measure attenuation of the given attenuator.	20				
6	Determine the directivity, insertion loss and coupling factor for the given Multi- Hole Directivity Coupler.	24				
7	Use given Microwave test bench setup to measure the gain of the Horn antenna.	28				
8	Use given Microwave test bench setup to test the performance of the given Reflex Klystron tube.	32				
9	Test the performance of Gunn Diode for the following aspects i. V-I characteristics ii. Output power and frequency as a function of voltage.	35				
10	Use Doppler RADAR to detect the maximum range.	39				

11	Determine the velocity of the moving objects with the help of RADAR range.	42				
12	Use RADAR system to measure the distance traveled by any object.	48				
					Total marks out of 120	
					Marks out of 25	

Name and Signature of Student **Name and Signature of Staff**

Assessment Scheme

	Performance Indicators	**Weightage in %**
a.	Preparation of experiments set up	**20**
b.	Setting and operation	20
c.	Safety measures	10
d.	Observation and Recording	**10**
e.	Interpretation of result and conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
	Total	**100**

Experiment No. : 1

Title: Use the frequency meter with microwave test bench setup to determine the frequency and wavelength of waveguide for TE10

EQUIPMENTS:

Klystron Power supply, klystron mount isolator, frequency meter, variable attenuator, slotted section, tunable probe, VSWR meter, Waveguide stand, movable short/matched termination.

EXPERIMENTAL SET UP:

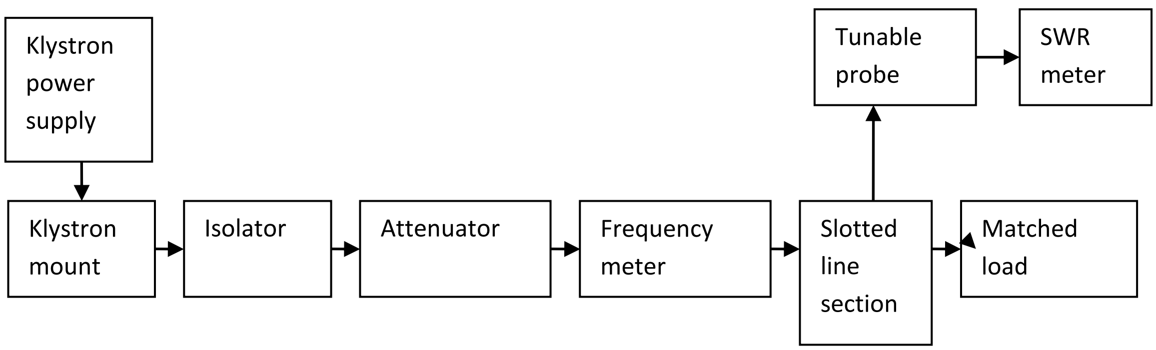


Fig 1.Set up for frequency and wavelength measurement.

THEORY:

The cut-off frequency relationship shows that the physical size of the wave guide will determine the propagation of the particular modes of specific orders determined by values of m and n. The minimum cut-off frequency is obtained for a rectangular wave guide having dimension a>b, for values of m=1, n=0, i.e. TE10 mode is the dominant mode since for TMmn modes, n#0 or n#0 the lowest-order mode possible is TE10, called the dominant mode in a rectangular wave guide

For dominant TE10 mode rectangular wave guide λo, λg and λc are related as below. $1/\lambda o^2 = 1/\lambda g^2 + 1/\lambda c^2$

Where λo is free space wave length

λg is guide wave length

λc is cut off wave length

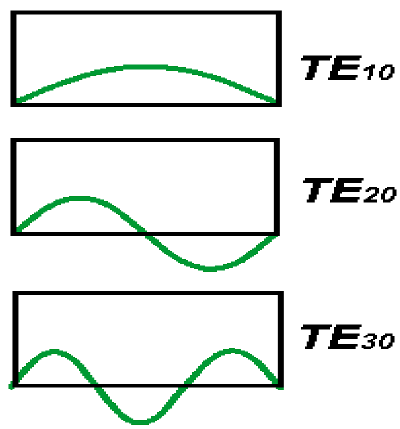
For TE10 mode λc – 2a where 'a' is broad dimension of wave guide.

What is waveguide cutoff frequency? - the concept

Although the exact mechanics for the cutoff frequency of a waveguide vary according to whether it is rectangular, circular, etc, a good visualization can be gained from the example of a rectangular waveguide. This is also the most widely used form.

Signals can progress along a waveguide using a number of modes. However the dominant mode is the one that has the lowest cutoff frequency. For a rectangular waveguide, this is the TE10 mode.

The TE means transverse electric and indicates that the electric field is transverse to the direction of propagation.



TE modes for a rectangular waveguide

The diagram shows the electric field across the cross section of the waveguide. The lowest frequency that can be propagated by a mode equates to that were the wave can "fit into" the waveguide.

As seen by the diagram, it is possible for a number of modes to be active and this can cause significant problems and issues. All the modes propagate in slightly different ways and therefore if a number of modes are active, signal issues occur.

It is therefore best to select the waveguide dimensions so that, for a given input signal, only the energy of the dominant mode can be transmitted by the waveguide. For example: for a given frequency, the width of a rectangular guide may be too large: this would cause the TE20 mode to propagate.

As a result, for low aspect ratio rectangular waveguides the TE20 mode is the next higher order mode and it is harmonically related to the cutoff frequency of the TE10 mode. This relationship and attenuation and propagation characteristics that determine the normal operating frequency range of rectangular waveguide.

Rectangular waveguide cutoff frequency

Although waveguides can support many modes of transmission, the one that is used, virtually exclusively is the TE10 mode. If this assumption is made, then the calculation for the lower cutoff point becomes very simple:

$$f_{c} = C/2a$$

Where:

fc = rectangular waveguide cutoff frequency in Hz

c = speed of light within the waveguide in metres per second

a = the large internal dimension of the waveguide in metres

It is worth noting that the cutoff frequency is independent of the other dimension of the waveguide. This is because the major dimension governs the lowest frequency at which the waveguide can propagate a signal.

Mode represents in wave guides as either **TE m, n/ TM m, n**

Where

TE – Transverse electric,

TM – Transverse magnetic

m – Number of half wave length variation in broader direction.

n – Number of half wave length variation in shorter direction

PROCEDURE:

1. Set up the components and equipment as shown in figure.
2. Set up variable attenuator at minimum attenuation position.
3. Keep the control knobs of klystron power supply as below:

    Beam voltage – OFF

    Mod-switch – AM

    Beam voltage knob – Fully anti clock wise

    Repeller voltage – Fully clock wise

    AM – Amplitude knob – Around fully clock wise

    AM – Frequency knob – Around mid position

4. Switch ‘ON’ the klystron power supply, CRO and cooling fan switch.
5. Switch ’ON’ the beam voltage switch and set beam voltage at 300V with help of beam voltage knob.
6. Adjust the repeller voltage to get the maximum amplitude in CRO
7. Maximize the amplitude with AM amplitude and frequency control knob of power supply.
8. Tune the plunger of klystron mount for maximum Amplitude.
9. Tune the repeller voltage knob for maximum Amplitude.

10. Tune the frequency meter knob to get a ‘dip’ on the CRO and note down the frequency from frequency meter.

11. Replace the termination with movable short, and detune the frequency meter.

12. Move the probe along with slotted line. The amplitude in CRO will vary .Note and record the probe position, Let it be d1.

13. Move the probe to next minimum position and record the probe position again, Let it be d2.

14. Calculate the guide wave length as twice the distance between two successive minimum positions obtained as above.

15. Measure the wave guide inner board dimension ‘a’ which will be around 22.86mm for x-band.

16. Calculate the frequency by following equation.

17. Verify with frequency obtained by frequency modes

18. Above experiment can be verified at different frequencies.

$f_o = C/\lambda_o$ => C => 3x108 m/s (i.e., velocity of light)

$$1/\lambda_o^2 = 1/\lambda_g^2 + 1/\lambda_c^2$$

$$\lambda_g = 2x\ \Delta d$$

For TE10 mode => $\lambda_c = 2a$

a□wave guide inner broad dimension

a = 2.286cm” (given in manual)

$$\lambda_c = 4.6\text{cm}$$

OBSERVATION TABLE:

Sr.No	Beam Voltage	Repeller Voltage	Frequency	1st d1	2nd d2	Difference	λg

CALCULATIONS:

$$\lambda g = 2\ (d1-d2)$$

$$\lambda c = 2a$$

$$1/\lambda o^2 = 1/\lambda g^2 + 1/\lambda c^2$$

$$C \Rightarrow 3x108\ m/s$$

RESULT:

Wavelength = _____

CONCLUSION:

In this way wavelength is measured in a rectangular wave guide working in TE10 mode.

Questions:

1. Compare waveguide with two wire transmission line.
2. What is waveguide?
3. Define i) Cut-off frequency ii) Phase velocity iii) Group velocity.
4. Explain wave propagation in rectangular waveguide. What is dominant mode?

Space for Answers

Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

Experiment No. : 2

Title: Use the microwave test bench setup to ensure power division in microwave tees E- plane, H- plane and E-H plane..

Apparatus: Klystron power supply, Klystron mount, Isolator, Attenuator, frequency meter, magic tee and matched terminator, VSWR meter/CRO

EXPERIMENTAL SET UP:

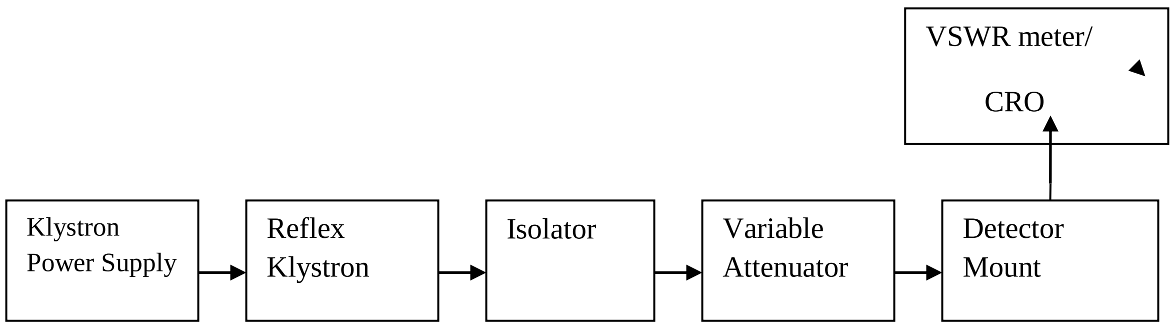


Fig. 1 Input Power Measurement

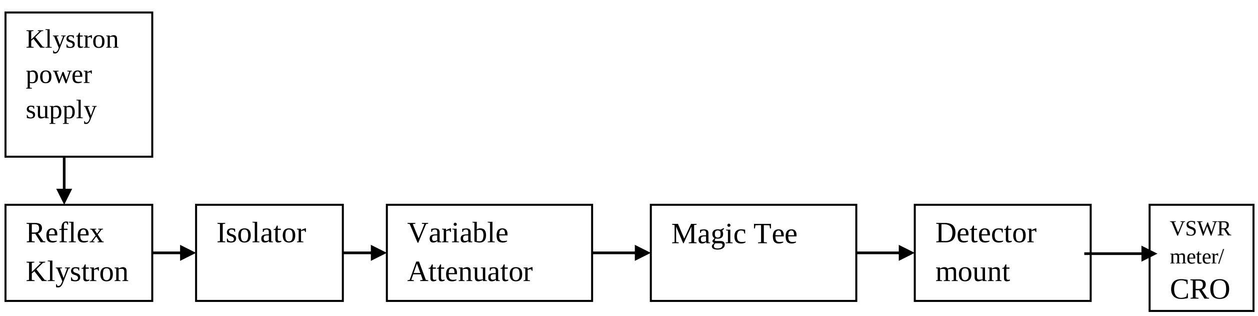


Fig. 2 Coupled/Isolator Power Measurement

Stepwise Procedure:

Part A: General setup:

1. Setup the equipment's as indicated in fig.
2. Keep the control knob of klystron power supply as mentioned below.

Mode switch : AM

Beam voltage knob : Fully anticlockwise

Repeller voltage knob : Fully clockwise

Meter switch : Cathode voltage position

3. Measurements or isolation between E and H arms.
   i) Set the attenuator around 20dB. Let this settings be A1 dB.
   ii) Obtain reference readings on VSWR meter.
   Preferable in the 40 dB range of VSWR meter.
   iii) Disconnected and setup all the instruments as shown in fig.
   iv) Reduce the attenuation till the VSWR meter reads the value obtained in step ii).
   Note attenuation setting A2 dB . The difference in the attenuator (A1 – A2) dB given the isolation in dB.

Part B : Experimental setup for demonstrating the 3 dB power division in collinear arms:

1. Apply the power input to either at E or H arm.
2. Set the attenuator to get reference readings on VSWR meter without the components under test. Note the attenuator settings A1 dB.
3. Connect Magic tee.
4. Reduced attenuation to get the reference reading obtained in step ii) (step 3.ii) from part 1).
5. Note down the attenuator setting A2 dB.

The difference in the attenuator setting given the ratio of power coupled to collinear arm to that main arm, in dB . This value should be around 3 dB>

Observations

1. Isolator Measurement

Attenuator setting when measuring input to E-arm A1(dB)	Attenuator setting when measuring input to H-arm A2(dB)

2. Isolator Measurement

Attenuator setting when measuring input to E/H-arm A1(dB)	Attenuator setting when measuring power collinear arm A2(dB)

Calculation:

Isolation between E and H arms dB = (A1-A2)dB

Coupling between Collinear arms and E/H arms dB = (A1-A2)dB

CONCLUSION:

Questions:

1. Draw the field pattern for TE10,TE11 and TE20 mode.
2. Define TE, TM & TEM.

Space for Answer

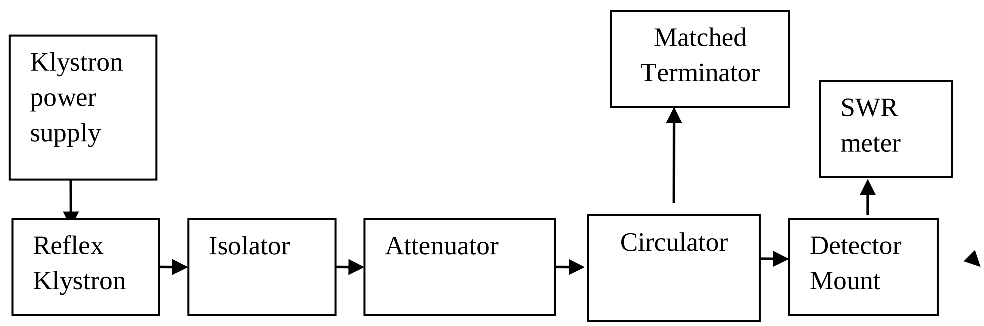
<table>
<tr><td colspan="3">Marks obtained</td><td>Dated sign. Of Teacher</td></tr>
<tr><td>Process Related(10)</td><td>Product Related(15)</td><td>Total(25)</td><td rowspan="2"></td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

Experiment No. : 3

Title: Determine coupling factor and insertion loss for the given circulator.

Apparatus: Microwave test bench, Circulator, VSWR meter, CRO

EXPERIMENTAL SET UP:



Circulator:

The circulator is a multi port junction that permits transmission in certain ways. A circulator is a passive non-reciprocal three- or four-port device, in which a microwave or radio frequency signal entering any port is transmitted to the next port in rotation (only). A wave incident in port A is coupled to port B only; a wave incident at port B is coupled to port C only and so on.

Insertion Loss (Forward Loss):

It is defined as the ratio of power supplied by a source to the input port to the power detected by a detector in the coupling arm, i.e., output arm with other port terminated in a matched load.

Stepwise Procedure:

1. Setup the microwave test bench as shown in diagram (initially without circulator) i.e. directly connect detector with VSWR in order to measure input A1.
2. Set the variable attenuator at maximum position.

3. Keep the control knob of Klystron power supply as mentioned below

   Mode Switch : AM

   Beam voltage knob : Fully anti-clockwise

   Repeller voltage knob : Fully clockwise

   Meter switch : Cathode voltage function.

4. Keep the control knob of VSWR meter as below

   Range dB : 50 dB position

   Input switch : Crystal low impedance.

   Meter switch : Normal position.

   Gain (course fine) : Mid position.

5. Switch 'ON' the klystron power supply.

6. Switch 'ON' the VSWR Meter.

7. Switch 'ON' the cooling fan.

8. Set some reference reading in VSWR meter by adjusting the variable attenuator. Note this attenuator setting as A1 dB.

9. Carefully remove the detector setup and insert circulator as in the setup diagram with power fed to port 1.

10. Measure output at port 2 with terminated in matched load.

11. Reduce the attenuation to get the reference reading in VSWR/CRO as per setup 6. Note down attenuator setting as (A2) dB.

12. Interchange the position of detector setup and matched load between ports 2 and ports 3. Adjust attenuator setting to get reference reading. Note this attenuator setting as A21 dB.

Observations:

Measure Power:

A1(dB)	A2(dB)	A3(dB)

Calculations:

Isolation loss dB = (A1-A2)dB

Insertion dB = (A1-A3)Db

CONCLUSION:

Questions:

1. Compare rectangular waveguide and circular.
2. State two advantages and two applications of circular waveguide.

Space for Answer

Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

Experiment No. : 4

Title: Measure VSWR for the given microwave load.

Apparatus: Klystron tube, klystron power supply**,** D.C mill voltmeter, isolator, frequency meter, Variable attenuator, slotted line tunable probe, Waveguide stand, movable short/Termination or any unknown load & BNC cable's Tuner

EXPERIMENTAL SET UP:

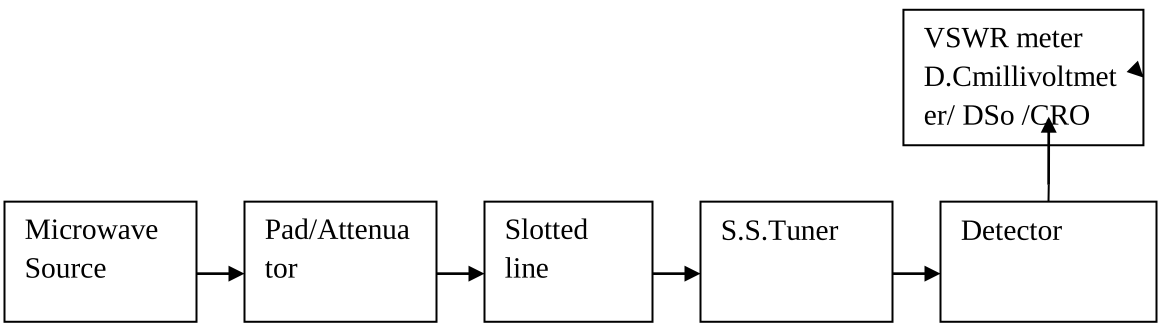


Fig 1.Set up for VSWR measurement

THEORY:

The electromagnetic field at any point of transmission line, may be considered as sum of two traveling waves the incident wave and reflected wave . The reflected wave is set up by reflection of incident wave from the load impedance the presence of two traveling waves. Give rise to standing wave along the line. The maximum field strength is found where two waves are in phase & minimum where two waves add in opposite phase the distance between two successive minimum (or maximum) is half the guide wavelength on the line The ratio of electrical field is called reflection Co- efficient. The voltage standing wave ratio (VSWR) is defined as ratio between maximum & minimum field strength along the line

Hence VSWR , S = E_{max} / E_{min}

Reflection Co- efficient , $\rho = Er/Ei$

The above equation gives following Eq

$| \rho | \quad = |S-1/S+1|$

PROCEDURE:

1. Set up the equipment as shown in circuit diagram.
2. Keep variable attenuator at maximum position .
3. Keep control knobs of klystron power supply as below:-

Meter switch - off

Mod switch - 'AM'

Beam voltage knob – fully anticlockwise

Reflector voltage knob – fully clockwise

AM frequency & amplitude knob – Mid position

4. 'ON' the klystron power supply, VSWR meter & cooling fan.
5. Turn the meter switch of klystron power supply to beam voltage at 300V.
6. Rotate reflector knob to get reading in D C mill voltmeter.
7. Tune the output by tuning the reflector voltage, amplitude & frequency of AM modulation.
8. Move the probe along with slotted line to change the reading in DC -Mill voltmeter to get maximum reading i.e. E_{max}.
9. Keep all control knob as it is , move the probe to next minimum position note the voltage i.e. E_{min}.
10. Repeat the above steps for change of SS tuner probe depth & record corresponding SWR.
11. Set the SS tuner on 9mm and get the deflection on VSWR meter. Set the VSWR meter to 1 by course and fine and gain knob adjustment.
12. Move on the slotted line to get Emin note the VSWR from the meter.
13. Change SS tuner probe depth and measure VSWR .

Observation Table/Results

S S tuner position	E_{max}	E_{Min}	VSWR S= E_{max}/E_{min}	VSWR from meter	Reflection coefficient
2mm					
4mm					
6mm					
8mm					
10mm					
12mm					
14mm					
16mm					

CONCLUSION:

Questions:

1. Explain the working principle of H-plane- plane Tee with constructional sketch.
   Sketch one application of each
2. Draw the neat sketch of hybrid junction illustrates its properties.

Space for Answer

<table>
<tr><td colspan="3">Marks obtained</td><td>Dated sign. Of Teacher</td></tr>
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<tr><td></td><td></td><td></td></tr>
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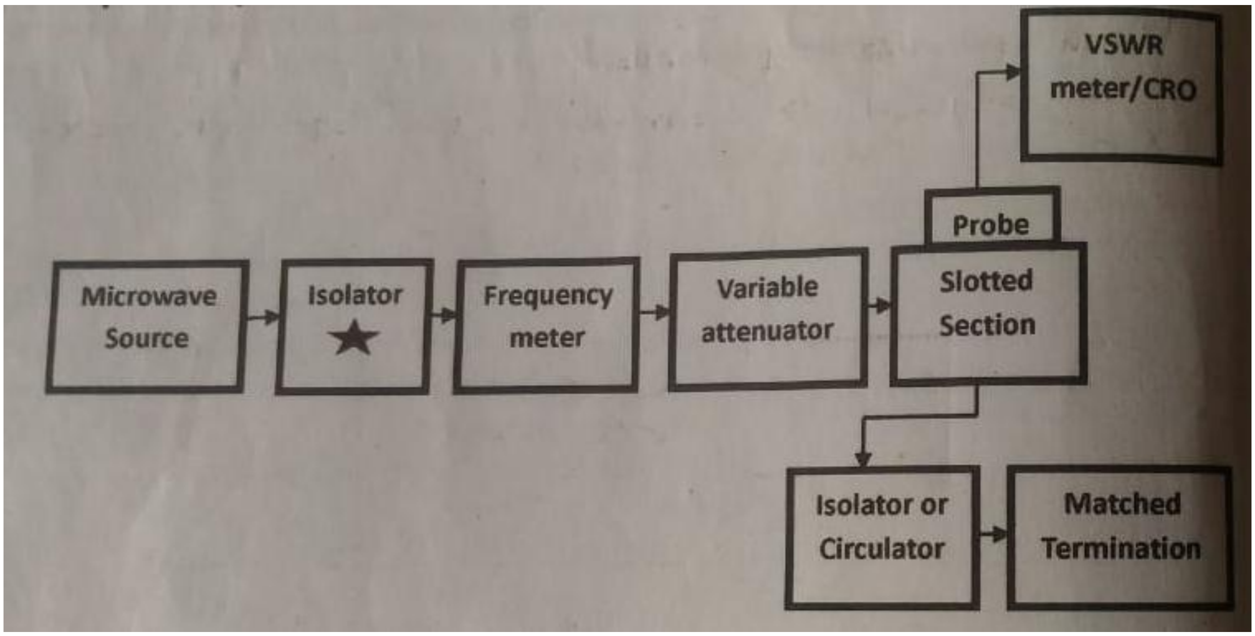
Experiment No. : 5

Title: Measure attenuation of the given attenuator.

Apparatus: Microwave test bench, Klystron power supply, VSWR meter, CRO

EXPERIMENTAL SET UP:



THEORY:

Isolator: It is a two-port device that transmits microwave or radio frequency power in one direction only. It is to shield equipment on its input side, from the effects of conditions on its output side. The isolator is a two-port device with small insertion loss in forward direction and a large in reverse attenuation.

Insertion loss: The ratio of power supplied by a source to the input port to the power detected by a detector in the coupling arm, i.e., output arm with other port terminated in the matched load, is defined as insertion loss or forward loss.

Isolation: it is the ratio of power fed to input arm to the input power detected at not coupled port with other port terminated in the matched load.

Stepwise Procedure:

Note: In experiment setup diagram “two isolator” are shown. The isolator indicated by “ ★ “ is by default and is essential in the setup. Another isolator (indicated with reverse video effect) is connected to study isolator function.

1. In the setup shown in fig., do not connected isolator under study (indicated with reverse video effect). Connect attenuator output of directly to the input of detector.
2. Switch on the power supply.
3. keep the control knob of klystron power supply as mentioned below

   Mode switch : AM

   Beam voltage : Fully anti-clockwise

   Repeller voltage knob : Fully clockwise

   Meter switch : Cathode voltage position.
4. Keep the control knob of VSWR meter as below

   Range dB : 50 dB position

   Input switch : Crystal low impedance

   Meter switch : Normal position.

   Gain (course fine) : Mid position
5. Switch ‘ON’ the klystron power supply.
6. Switch ‘ON’ the VSWR meter.
7. Switch ‘ON’ the cooling fan.
8. Set some reference reading in VSWR meter by adjusting the variable attenuator. Note this

   attenuator setting as A1 dB.
9. Take three different readings
10. Insert isolator with input power fed to port 1.
11. Measure output at port 2; adjust the attenuator to get reference reading in indicating meter. Note this attenuator setting as A21 dB.

Observations:

Sr. No	Power measured without isolator-B A1(dB)	Power measured with insertion of isolator –B at port A12(dB)	Power measured by interchanging ports of isolator –B at port A12(dB)

Calculations:

Insertion loss dB = (A1-A12)dB

Isolation provided by isolator = (A1-A3)dB

Conclusion:

Questions:

1. Draw labeled sketch of reflex Klystron and explain. List its two applications.

2. Explain the working principle of travelling wave tube with neat diagram.

Space for Answer

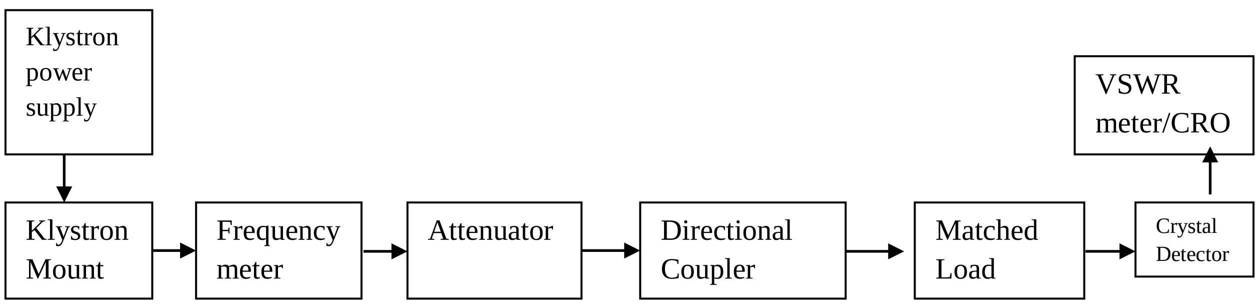
Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

Experiment No. : 6

Title: Determine the directivity, insertion loss and coupling factor for the given Multi- Hole Directivity Coupler.

Apparatus: Klystron power supply, Klystron mount, Isolator, Attenuator, frequency meter, matched termination, crystal detector, directional coupler, VSWR meter/CRO

EXPERIMENTAL SET UP:



Directional couplers:

They are most frequently constructed from two coupled transmission lines set close enough together such that energy passing through one is coupled to the other. Directional couplers and power dividers have many applications, these include:

1. Providing a signal sample for measurement or monitoring, feedback
2. Combining feeds to and from antenna.
3. Antenna beam forming, providing taps for cable distributed systems such as cable TV.
4. Separating transmitted and received signals on telephone lines.

Stepwise Procedure:

1. Setup the equipment as indicated in the diagram but without directional coupler i.e, directly connected the crystal detector to VSWR meter (or CRO).
2. Set the variable attenuator at maximum position.
3. Keep the control knob of VSWR meter as below

Range dB : 50 dB position

Input switch : Crystal low impedance

Meter switch : Normal position

Gain (course & fine) : Mid position

4. Keep the control knob of Klystron power supply as mentioned below

Mode switch : AM

Beam voltage knob : Fully anti-clockwise

Repeller voltage knob : Fully clockwise

Meter switch : Cathode voltage position.

5. Switch 'ON' the Klystron power supply, VSWR meter and cooling fan.

6. Turn the meter switch of supply beam voltage position and beam voltage at 300 volts with the help of beam voltage knob.

7. Adjust the reflector voltage to set Klystron for maximum mode of operation. Get some deflection in VSWR meter.

8. Maximize the deflection with AM amplitude and frequency control knob of power and some reference reading in VSWR meter. Note and record this attenuator setting as A1 dB.

9. Insert multi-hole directional coupler as shown in diagram of experimental setup, Feed the power through port 1 and measure output at port 2 by termination.

10. Reduce the attenuator to get the reference reading in step 8. Note and record the attenuator setting as A2 dB.

11. Terminate port 2 with matched load and measure output at port 3. Reduce the attenuation to get reference reading obtained in step 8. Note and record this attenuator setting as A3 dB.

12. Reserve the direction coupler and feed power through port 2 and measure the power at port 3. Note and record this attenuator setting as A4 dB.

13. Calculate directivity, coupling , isolation and insertion loss.

Observations:

Frequency (Ghz)	A1(dB)	A2(dB)	A3(dB)	A4(dB)

Calculation:

Coupling dB = (A1-A3)dB

Directivity dB = (A3-A4)dB

Isolation dB = (A1-A4)dB

Insertion dB = (A1-A2)dB

CONCLUSION:

Questions:

1. Draw constructional details of magnetron and explain its working. List its applications.

2. Explain working principle of PIN diode.

Space for Answer

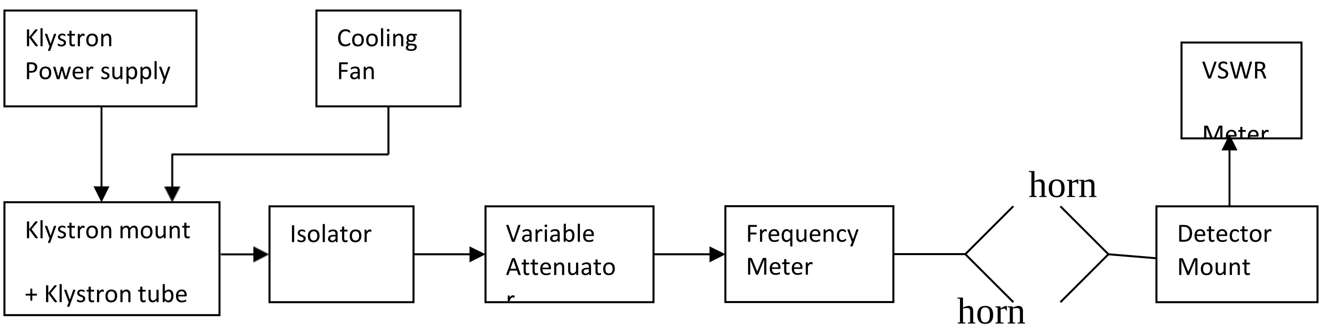
Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

Experiment No. : 7

Title: Use given Microwave test bench setup to measure the gain of the Horn antenna.

Apparatus: Microwave source, Frequency meter, Isolator, Variable attenuator, Detector mount, two horn antenna, Turn table, VSWR meter and Accessories.

EXPERIMENTAL SET UP:



<u>THEORY</u>: - If a transmission line propagating energy is left open at one end, there will be radiation from this end. In case of a rectangular waveguide this antenna presents a mismatch of about 2 : 1 and it radiates in many directions. The match will improve if the open waveguide is a horn shape.The radiation pattern of an antenna is a diagram of field strength or more often the power intensity as a function of the aspect angle at a constant distance from the radiating antenna. The power intensity at the maximum of the main lobe compared to the power intensity achieved from an imaginary Omni directional antenna (radiating equally in all direction) with the same power fed to the antenna is defined as in gain of the antenna.

3 db Beam Width

The angle between the two points on a main lobe where the power intensity is half the maximum power intensity.When measuring an antenna pattern, it is normally most interesting to plot the pattern far from the antenna.

Far field pattern is achieved at a minimum distance of $\frac{2D^2}{\lambda_0}$ (for rectangular Horn Antenna)

where D is size of the broad wall of horn aperture in free space wave length. It is also very important to avoid disturbing reflection. Antenna measurement are normally made at outdoor rangers or in so called anechoic chambers made of absorbing materials. Antenna measurements are mostly made with unknown antenna as receiver. There are several methods to measure the gain of antenna. One method is to compare the unknown antenna with a standard gain antenna with known gain. An another method is to use two identical antennas, as transmitter and other as receiver from following formula the gain can be calculated.

$$P_r = \frac{P_t \lambda_0 G_1 G_2}{(4 \pi S)^2}$$

Where, P_t = transmitted power

P_r = received power

G_1 , G_2 = gain of transmitting and receiving antenna,

S =radial distance between two antenna

λ_0 = free space wave length.

If both transmitting and receiving antennas are identical having gain G, then

$$P_r = \frac{P_t \lambda_0 G^2}{(4 \pi S)^2}$$

$$G = 4 \frac{\pi S}{\lambda} \sqrt{P_r / P_t}$$

In the above equation P_t , P_r , S and λ_0 can be measured and gain can be computed. As from the above equation it is not necessary to know the absolute value of P_t and P_r only ratio is required, which can be measured by VSWR meters.

Stepwise Procedure:

GAIN MEASUREMENT

1. Set up the equipment's as shown in Fig. Both horns should be in line.
2. Keep the range db switch of VSWR meter at 50 db position with gain control full.
3. Energize the Gunn Oscillator for maximum output at desired frequency with modulating amplitude and frequency of Gunn Power Supply and by tuning of detector.
4. Obtain full scale deflection in VSWR meter with variable attenuator.
5. Replace the transmitting horn by detector mount and change the appropriate range db position to get the deflection on Scale (do not touch the gain control knob). Note and record the range db position and deflection of VSWR meter.
6. Calculate the difference in db between the power measured in step 4 and 5.
7. Convert G into db in above example

   G db = 10 log 318 = 15.02 db

8. The same set up can be used for other frequency of operation.

<u>OBSERVATIONS</u>

<u>CALCULATIONS:</u>

Questions:

1.
2.
3.

Space for Answer

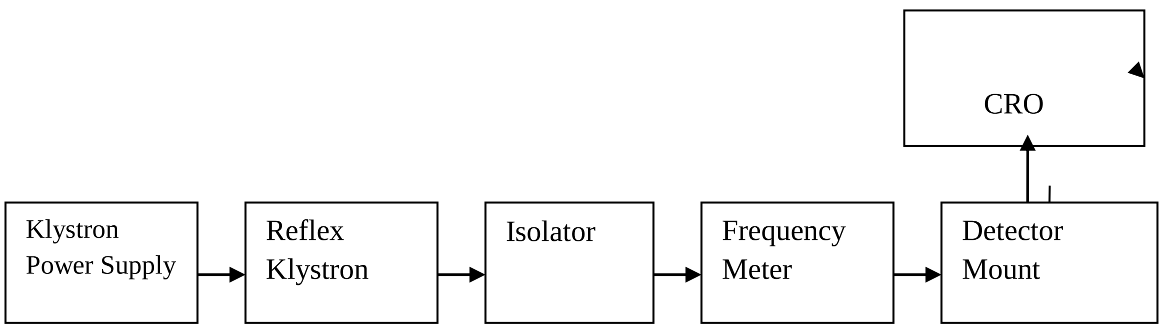
Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

Experiment No. : 8

Title: Use given Microwave test bench setup to test the performance of the given Reflex Klystron tube.

Apparatus: Microwave test bench setup, CRO, Reflex Klystron.

EXPERIMENTAL SET UP:



Stepwise Procedure:

1. Connect the equipment's /instruments as indicated in setup diagram
2. Keep the control knob of Klystron power supply as mentioned below:

   Mode switch : CW

   Beam voltage knob : Fully anticlockwise

   Repeller voltage knob : Cathode voltage position

3. Rotate the frequency meter at one side.
4. Switch ON the klystron power supply and cooling fan for the klystron tube.
5. Wait for 1-2 minutes for the Klystron to respond.
6. Cathode voltage knob at minimum position gives a beam voltage of 235V.
7. Observed the beam current on the meter by changing meter switch to beam current position.
8. Change the meter switch to repeller voltage position.

9. Select proper range for the power meter so that power output of maximum mode will not exceed the meter range.
10. Record output power and frequency by decreasing the reflector voltage.
11. To measure frequency switch the mode switch of klystron to AM mode and observe output on CRO. By matching the detector with tuning posts adjust for maximum output. Use AM amplitude, frequency controls and controls on CRO front panel. Try to get clear display on CRO. Observed for the dip in output and note corresponding frequency.
12. Plot power/relative frequency versus repeller voltage to get mode curves,

Observation Table:

Power and relative frequency with repeller voltage

Sr. No.	Repeller voltage(Volts)	Output power/ voltage(Mw/volts)	Frequency meter reading(GHz)
1			
2			
3			

CONCLUSION:

Questions:

1. Draw neat constructional diagram of IMPATT diode. Describe it’s working.

2.

Space for Answer

Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

Experiment No. : 9

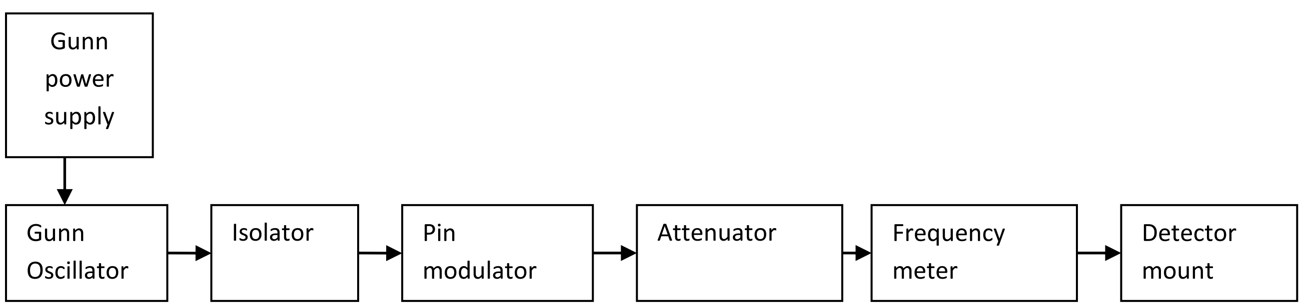
Title: Test the performance of Gunn Diode for the following aspects

i. V-I characteristics
ii. Output power and frequency as a function of voltage.

Apparatus: Gunn power supply, Gunn oscillator, PIN Modulator, Isolator, Frequency Meter, Variable attenuator, Slotted line ,Detector mount and CRO.

THEORY:

Gunn diode oscillator normally consist of a resonant cavity, an arrangement for coupling diode to the cavity a circuit for biasing the diode and a mechanism to couple the RF power from cavity to external circuit load. A co-axial cavity or a rectangular wave guide cavity is commonly used. The circuit using co-axial cavity has the Gunn diode at one end at one end of cavity along with the central conductor of the co-axial line. The O/P is taken using a inductively or coactively coupled probe. The length of the cavity determines the frequency of oscillation. The location of the coupling loop or probe within the resonator determines the load impedance presented to the Gunn diode. Heat sink conducts away the heat due to power dissipation of the device.



V) PROCEDURE:

1. Set the components and equipments as shown in Figure.

2. Initially set the variable attenuator for minimum attenuation.

3. Keep the control knobs of Gunn power supply as below

Meter switch – “OFF”

Gunn bias knob – Fully anti clock wise

PIN bias knob – Fully anti clock wise

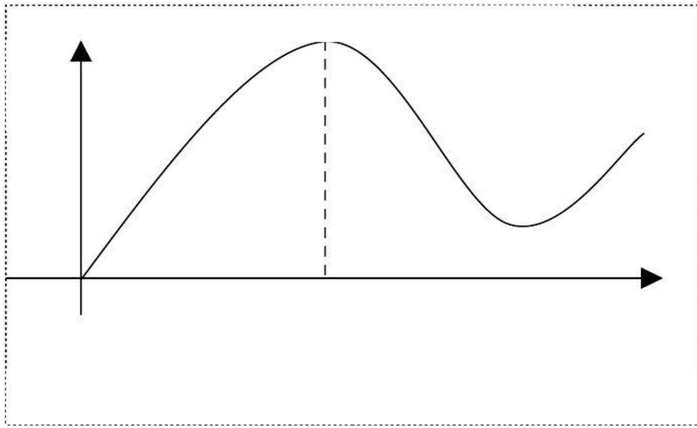
PIN mode frequency – any position

4. Set the micrometer of Gunn oscillator for required frequency of operation.
5. Switch “ON” the Gunn power supply.
6. Measure the Gunn diode current to corresponding to the various Gunn bias voltages through the digital panel meter and meter switch. Do not exceed the bias voltage above 10 volts.
7. Plot the voltage and current readings on the graph.
8. Measure the threshold voltage which corresponding to max current.

Note: Do not keep Gunn bias knob position at threshold position for more than 10-15 sec. readings should be obtained as fast as possible. Otherwise due to excessive heating Gunn diode may burn

VI) OBSERVATION TABLE:

Sr.No	Gunn bias voltage (v)	Gunn diode current (mA)



CONCLUSION:

In this way we obtain V – I characteristics of diode, when the voltage greater than threshold voltage current will be decreases

Questions:

1.
2.

Space for Answer

Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

Experiment No. : 10

Title: Use Doppler RADAR to detect the maximum range.

Apparatus: Matlab Software

Theory:

The radar equation relates the range of radar to the characteristics of the transmitter, receiver, antenna, target, and environment. **I f** the power of the radar transmitter is denoted by P, and if an isotropic antenna is used (one which radiates uniformly in all directions), the ***power*** density (watts per unit area) at a distance ***R*** from the radar is equal to the transmitter power divided by the surface area ***4nR2*** of an imaginary sphere of radius R, or

Power density from isotropic antenna = $\frac{\mathbf{Pt}}{\mathbf{4\pi R^2}}$

Radars employ directive antennas to channel, or direct, the radiated power ***Pt*** into some particular direction. The ***gain*** G of an antenna is a measure of the increased power radiated in the direction of the target as compared with the power that would have been radiated from an isotropic antenna. It may be defined as the ratio of the maximum radiation intensity from the subject antenna to the radiation intensity from a lossless, isotropic antenna with the same power input. (The radiation intensity is the power radiated per unit solid angle in a given direction.) The power density at the target from an antenna with a transmitting gain G is

Power density from directive antenna = $\frac{\mathbf{PtG}}{\mathbf{4\pi R^2}}$

The target intercepts a portion of the incident power and reradiates it in various directions. The measure of the amount of incident power intercepted by the target and reradiated back in the direction of the radar is denoted as the radar cross section a, and is defined by the relation

Power density of echo signal at radar= $\frac{PtG}{4\pi R^2}\frac{\sigma}{4\pi R^2}$

The radar cross section a has units of area. It is a characteristic of the particular target and is a measure of its size as seen by the radar. The radar antenna captures a portion of the echo power. If the effective area of the receiving antenna is denoted ***A.,*** the power *P,* received by the radar is

$$= \frac{PtG}{4\pi R^2}\frac{\sigma Ae}{4\pi R^2} = \frac{PtGAe\sigma}{(4\pi)^2\, R^4}$$

The maximum radar range ***Rmax*** is the distance beyond which the target cannot be detected. It occurs when the received echo signal power *P,* just equals the minimum detectable signal ***S,*** . Therefore

$$Rmax = \left[\frac{PtGAe\sigma}{(4\pi)^2\ Smin}\right]^{1/4}$$

Result

Conclusion-

Questions:

1. Draw block diagram of Radar system and explain it.
2. Give RADAR range equation .Discuss the factors influencing maximum range.
3. Explain antenna scanning methods.

Space for Answers

Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

Experiment No. : 11

Title: Determine the velocity of the moving objects with the help of RADAR range
OBJECTIVE:

- To Measure the angular position of stationary target.
- To Measure the speed of a fan.

EQUIPMENTS:

Doppler Radar, PC with multimedia, Doppler power supply, fan, Connecting cables

THEORY:

At one point or another, we have all experienced the phenomenon known as the Doppler effect. The text defines the Doppler effect as a shift in the frequency of a wave caused by the relative motion of the transmitting source, the reflecting object, or the receiving system The Doppler effect (or Doppler shift as it is sometimes referred to) can be described mathematically in the case of the Doppler radar by Eq. 1.

fd = 2u / lambda * cos(q)

where fd is the change in frequency (Doppler frequency), u is the velocity of the relative motion, lambda is the wavelength of the transmitted waves, and (q) is the angle between In our case the wavelength corresponds to free space wavelength of the 10.525 In our case the wavelength corresponds to free space wavelength of the 10.525 GHz CW signal generated by the radar. Since Speed of light = frequency X wavelength

Hence 3X10^8 m/s = 24 X 10^9 X wavelength

wavelength = 0.8 X 10^-2 m So fd = 2 X u / 0.8 X 10^-2 Hz

where u is in m/s. fd = 250 X u Hz

Which means that a relative velocity of 1m/s produces a Doppler shift of 250? Hz for a carrier frequency of 24 GHz. Which for velocity in Km/hr becomes 250 X 5 /18 = 69.44 Hz/Km/hr. Which means that Doppler speed constant is 69.44 for speed in km/hr. Or in other words a speed of 1000 km/hr produces a Doppler shift of 69.44 KHz at 24 GHz.

PROCEDURE:

1 Fix the Doppler radar on a Tripod with the help of connector pre-fitted under

the Radar L clamp.

2 Switch On the Target Emulator at a distance of 1m in front of radar in any direction.

3 Turn the pot (frequency variable) at the back panel of Target Emulator, clockwise so that you can receive sine waves through radar on PC.

4 Now, slide the Doppler feed in front of parabolic reflector backward and forward to achieve the maximum signal level. Also rotate the feed left or right, slightly, to achieve maximum sensitivity.

5 As the radar is transmitting at 24 GHz and receiving the same, so lambda /4 is 3.1mm. As at every lambda/4 maxima and minima of signal will be formed due to formation of standing waves, hence slight movement of radar feed will cause considerable change in received signal.

6 Further the radar feed phase center has to be placed at the focus of the parabolic dish for best gain from antenna. And this adjustment is very critical here since the dish f/d is close to 0.25 because the dish is so small.

7 Avoid even the slightest movement around radar. This is very important in Order to take correct readings. Hence take measurements once you have set up everything, stop any possible movement and then take readings by changing angular positions of the transmitting antenna.

8 Preferably switch off any ceiling fans, as they are a major source of Microwave churning.

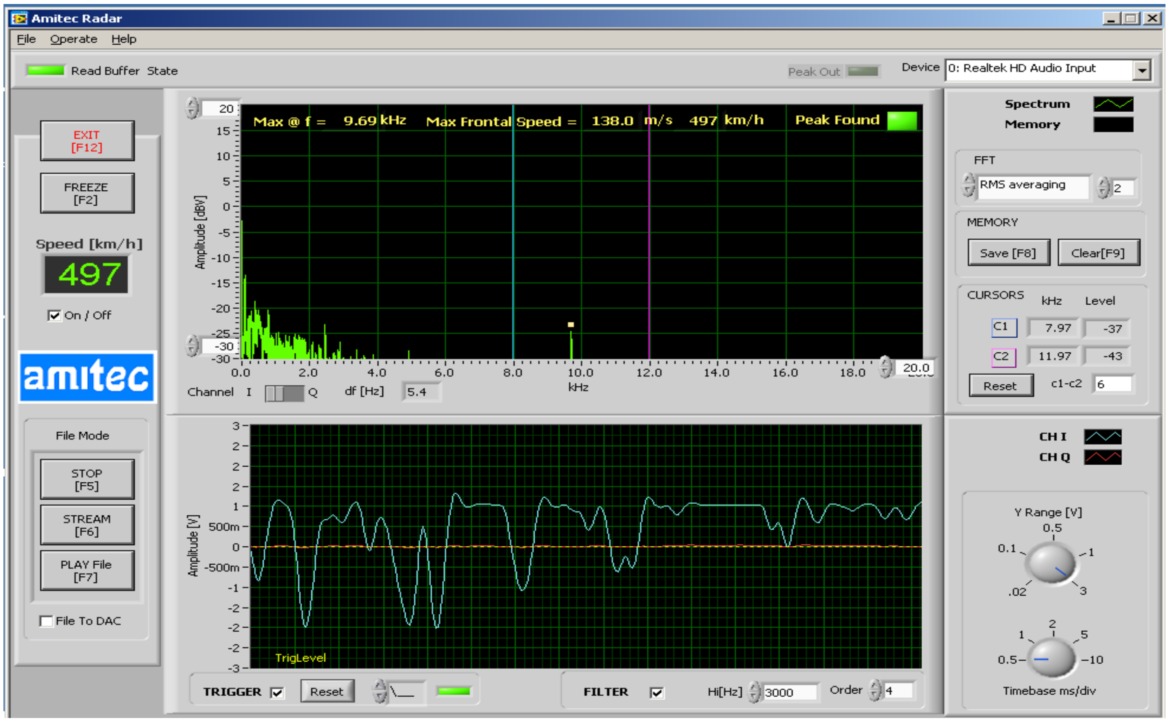
9 Connect the Power Supply adaptor supplied, to the Doppler radar and the LED will glow on the back panel of radar.

10 Point the antenna of radar towards the fan.

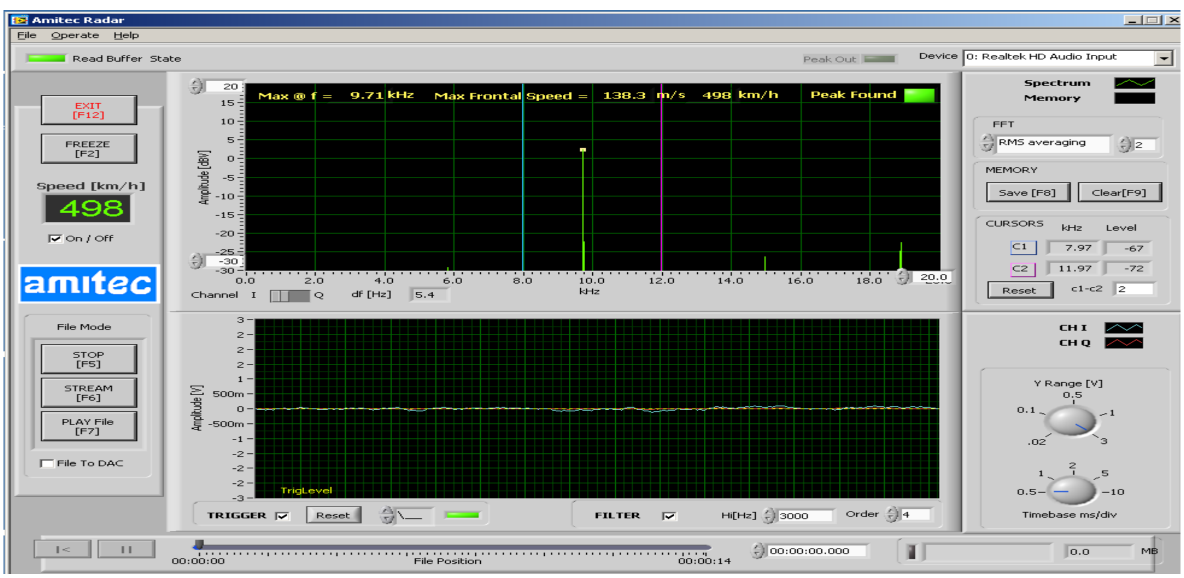
11 Measure the rpm of fan as indicated on the radar software control panel.

12 Switch off the fan and count the number of blades and divide the rpm of the fan indicated by software by the number of fins that is say 7.

Results : Doppler radar receiving signal from Target Emulator before adjustment

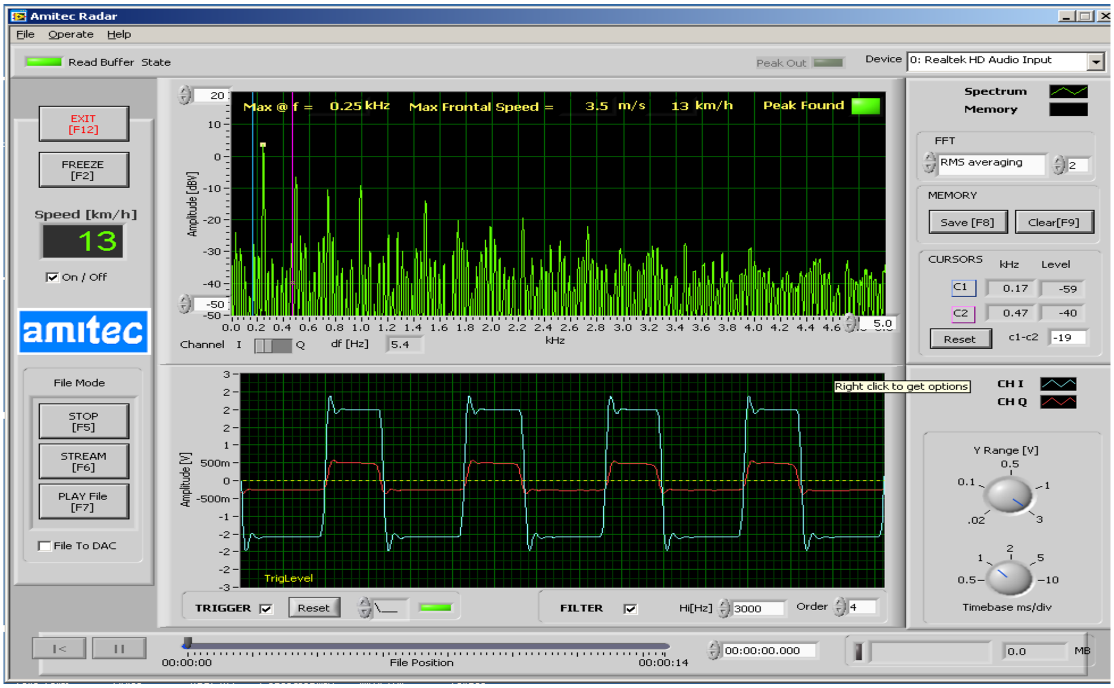


Doppler radar receiving signal from Target Emulator after adjustment.
A DJUSTMENT IS CRUCIAL.

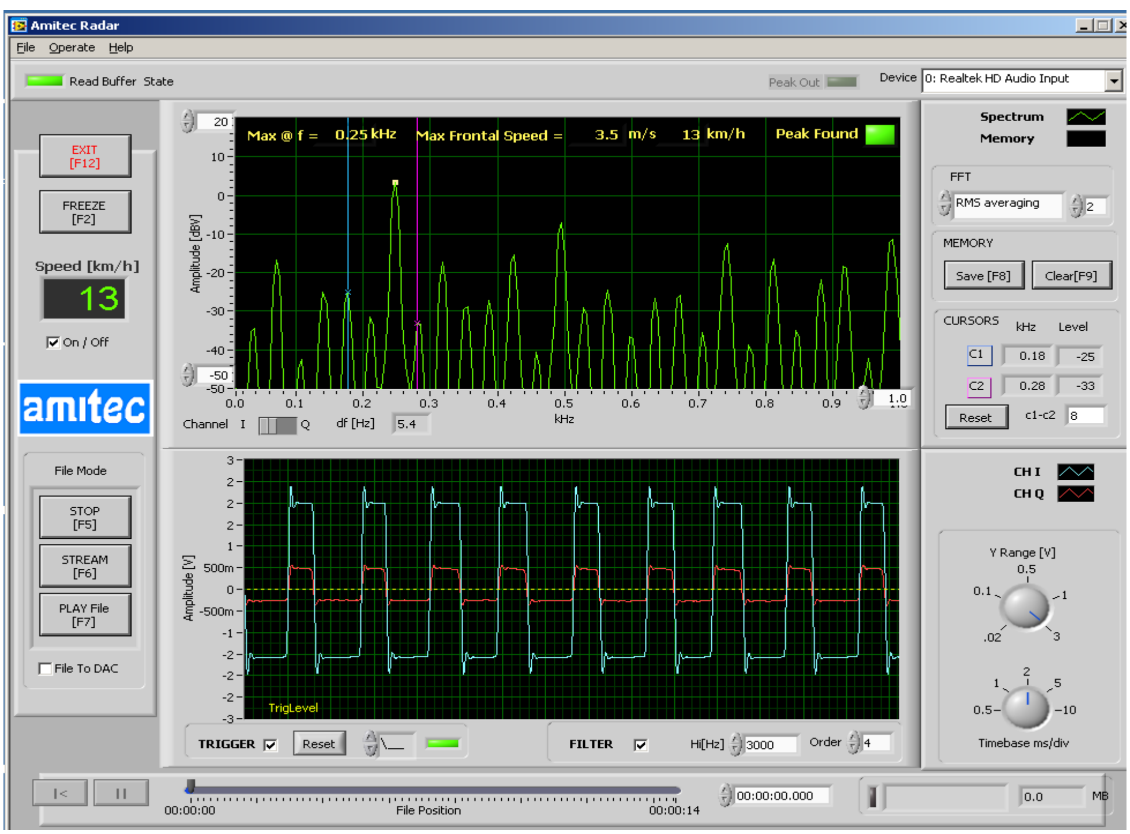


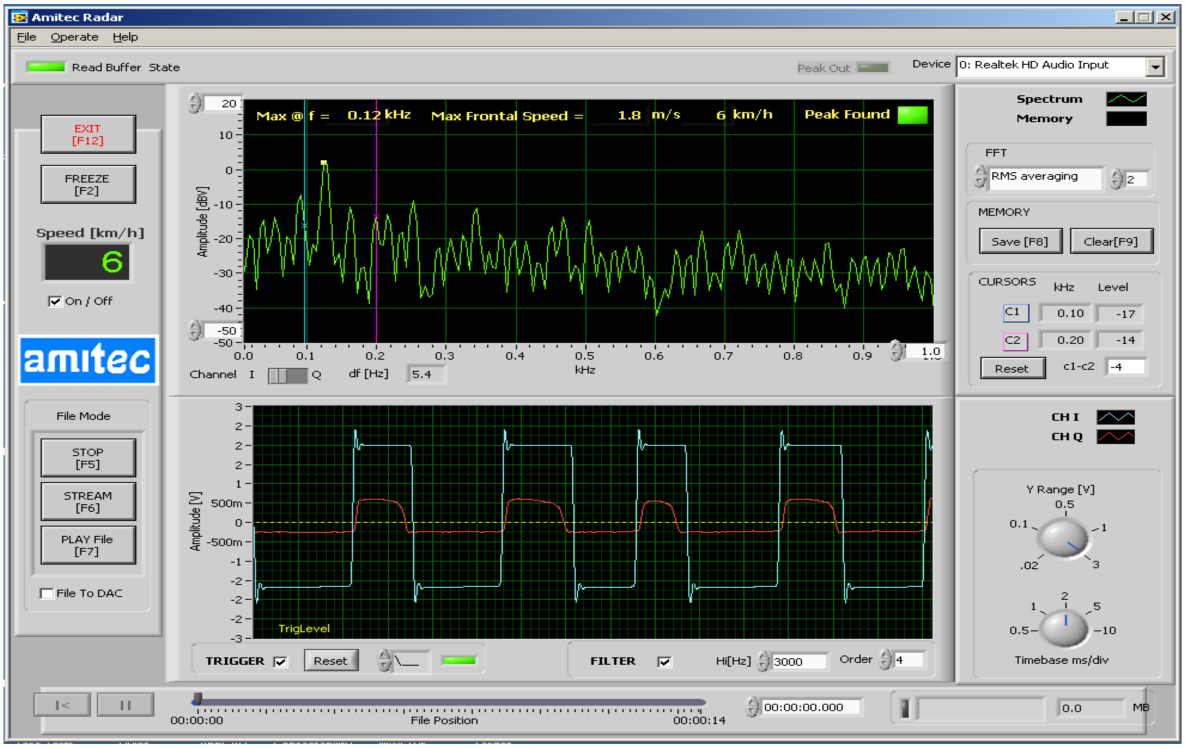
The fan rpm could be measured by using the Doppler radar.

Observe that the rps being measured is 0.25 KHz or 250 rps. In rpm, it is equal to 250 X 60= 15,000 rpm. Further see that the fan has 7 blades and the radar sees all of them so actual speed of fan is 15,000/7 = 2143 rpm.



Rotating blades.





Rotating Blades at low speed

CONCLUSION:

Questions:

1. List different display methods used in Radar. Explain any one.

2. Q. Daw the block diagram of MTI radar.

3. Describe the principle of Doppler Effect used in Radar system.

Space for Answers

Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

Experiment No. : 12

Title: Use RADAR system to measure the distance traveled by any object.

EQUIPMENTS:

Doppler Radar, PC with multimedia, Doppler power supply, fan, Connecting cables

THEORY:

At one point or another, we have all experienced the phenomenon known as the Doppler effect. The text defines the Doppler effect as a shift in the frequency of a wave caused by the relative motion of the transmitting source, the reflecting object, or the receiving system The Doppler effect (or Doppler shift as it is sometimes referred to) can be described mathematically in the case of the Doppler radar by Eq. 1.

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15 Connect the Power Supply adaptor supplied, to the Doppler radar and the LED will glow on the back panel of radar.

CONCLUSION:

Questions:

1.

2.

.

Space for Answers

Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	