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MICROWAVE AND OPTICAL COMMUNICATIONS

LABORATORY MANUAL

DEPARTMENT

OF

ELECTRONICS & COMMUNICATION ENGINEERING

JULY-2012

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JAWARHARLAL NEHRU TECHNOLOGICAL UNIVERSITY

IV Year B.Tech ECE- I SEM

MICROWAVE AND OPTICAL COMMUNICATIONS LAB

PART-A

CYCLE 1

1. Gunn Diode Characteristics
2. Reflex klystron characteristics
3. Attenuation measurement
4. VSWR Measurement
5. VSWR and Reflection coefficient Measurement
6. Directional coupler characteristics
7. Scattering Parameters Of Magic Tee

PART-B

CYCLE 2

8. Fiber optic Digital link
9. Attenuation measurement in a given optical fiber
10. LED characteristics

ADDITIONAL EXPERIMENTS

11. Impedance and frequency measurement in a wave guide
12. Radiation pattern of Horn antenna

EXPERIMENT-1

STUDY OF I-V CHARACTERISTICS OF GUNN DIODE

Objective: To study the characteristics of the Reflex Klystron tube and to determine its electronic tuning range.

Equipments Required:

Gunn Power Supply-GS-610,Gunn Oscillator XG-11, Isolator XI -621, Frequency Meter XF-710, PIN Modulator XM-55, BNC Cable.

Procedure:

1. Set the components as shown in fig.1.
2. Keep the control knob of GUNN Power Supply as below:

Meter Switch	-	OFF
Gunn bias knob	-	Fully anticlockwise
PIN bias knob	-	Fully clockwise
PIN Mode frequency	-	Any position

3. Set the micrometer of Gunn Oscillator for required frequency of operation.
4. Switch 'ON' the Gunn Power Supply.
5. Measure the Gunn diode current corresponding to the various Gunn bias voltage through panel meter and meter switch. Do not exceed the bias voltage above 10 Volts.
6. Plot the voltage and current reading on the graph as shown in fig.2.
7. Measure the Threshold voltage which corresponds to maximum current.

NOTE:

DO NOT KEEP GUNN BIAS KNOB POSITION AT THRESHOLD POSITION FOR MORE THAN 10 SECONDS READING SHOULD BE OBTAINED AS FAST AS POSSIBLE OTHERWISE EXCESSIVE HEATING, GUNNDIODE MAY BURN.

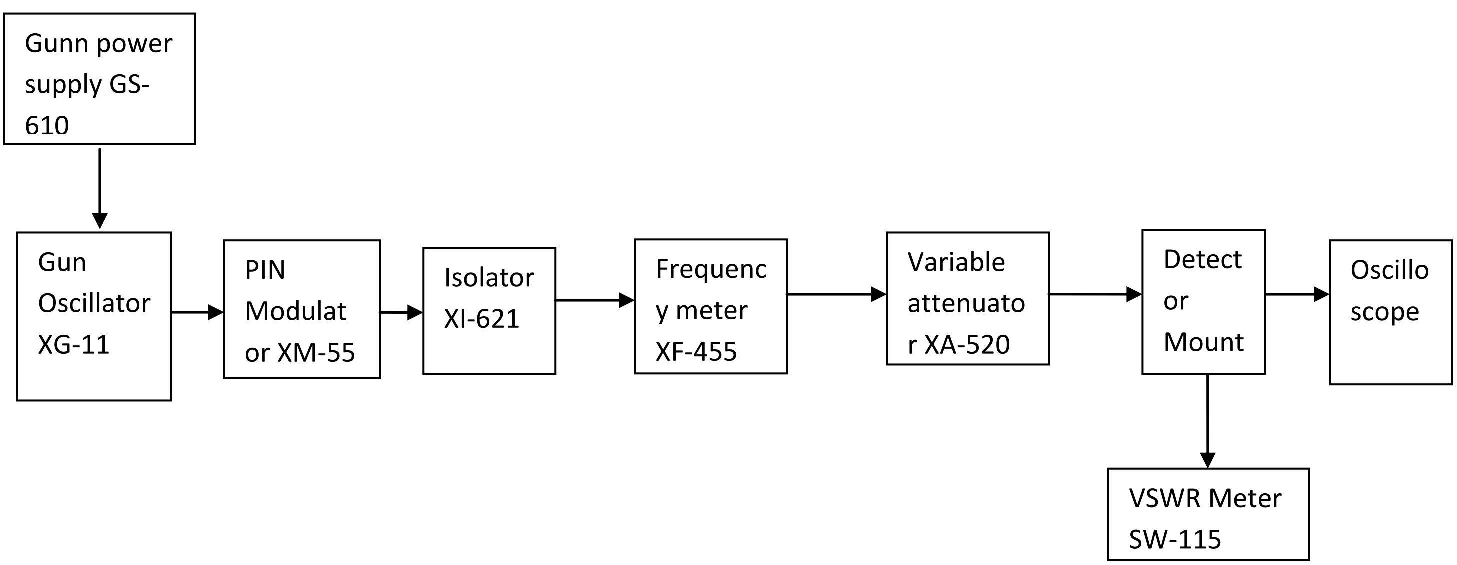

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Fig. **STUDY OF I-V CHARACTERISTICS OF GUNN DIODE**

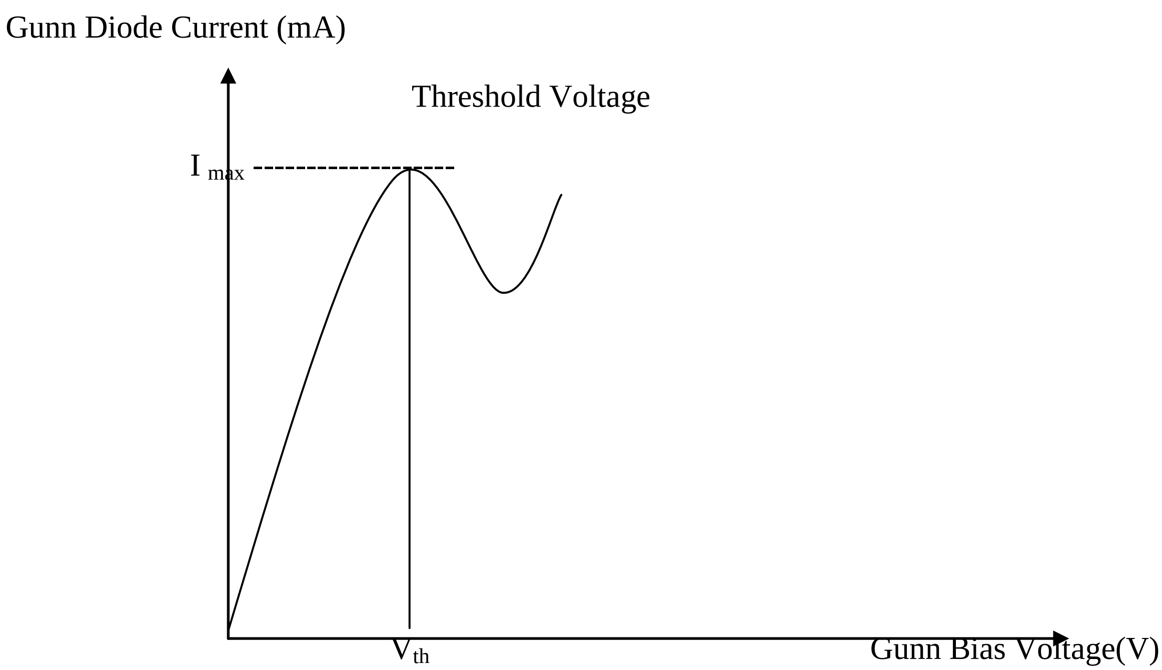

Fig. **I-V CHARACTERISTICS OF GUNN DIODE**

Observations:

Gunn Bias Voltage(Volts)	Gunn Diode Current(mA)
0	0
.	.
.	.
.	.
.	.
.	.
V_{th}	I_{max}
.	.
.	.
.	.

Threshold Voltage V_{th} = ------ V

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EXPERIMENT-2

STUDY OF REFLEX KLYSTON CHARACTERISTICS

Objective: To study the characteristics of the Reflex Klystron tube and to determine its electronic tuning range.

Equipments Required:

Klystron Power Supply(SKPS-610),Klystron Tube (2K-25) with Klystron Mount (XM 25), Isolator (XI -621), Frequency Meter (XF- 710), Variable Attenuator (XA 520), Detector Mount (XD-451), Wave Guide Stand (XU-535), VSWR Meter (SW-115), Oscilloscope , BNC Cable.

Procedure:

A. Carrier Wave Operation:

1. Connect the components and equipments as shown in fig.1.

2. Set the variable attenuator at the minimum position.

3. Set the Mod-Switch of Klystron Power Supply at CW position, Beam Voltage control knob to Anti-clock wise and Reflector Voltage control knob to fully Clock wise and the Meter Switch to position.

4. Rotate the knob of Frequency meter at one side fully.

5. Connect the DC Microampere meter with Detector.

6. Switch ON the Klystron Power Supply, VSWR meter and Cooling Fan for the Klystron Tube.

7. Put ON Beam voltage switch and rotate the Beam voltage knob clock wise slowly up to 300V meter reading and observe Beam current position, " The Beam current should not increase more than 30mV.

8. Change the Reflector voltage slowly and watch Current Meter, set the voltage for maximum deflection in the meter.

9. Tune the plunger of Klystron Mount for the maximum output.

10. Rotate the knob of Frequency meter slowly and stop at that position, where there is lowest output current on multimeter. Read directly the frequency meter between to horizontal lines and vertical mark. If micrometer type frequency meter is used read the micrometer reading and use the frequency chart.

11. Change the reflector voltage and read the current and frequency for each reflector voltage.

B. Square Wave Operation:

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1. Connect the components and equipments as shown in fig.1.
2. Set Micrometer of variable Attenuator around some position.
3. Set the range switch of VSWR Meter at 40db position , input selector switch to crystal impedance position, meter switch to narrow position.
4. Set the MOD-Switch of Klystron Power Supply at AM position, beam voltage control knob to fully anti- clock wise position.
5. Switch ON the Klystron Power Supply, VSWR meter and Cooling Fan for the Klystron Tube.
6. Put ON Beam voltage switch and rotate the Beam voltage knob clock wise slowly up to 300V deflection in meter.
7. Keep the AM – MOD amplitude knob and AM – FRE knob at the mid position.
8. Rotate the reflector voltage knob to get the deflection in VSWR meter.
9. Rotate the AM-MOD amplitude knob to get the maximum output in VSWR meter.
10. Maximize the deflection with frequency knob to get the maximum output in VSWR meter.
11. If necessary, change the range switch of VSWR meter 30db to 50db if the deflection in VSWR meter is out of scale or less than normal scale respectively. Further the output can be also reduced by Variable Attenuator for setting the output for any particular position.

Find the oscillator frequency by Frequency Meter as described in the earlier setup.

C. Mode study on Oscilloscope

1. Set up the components and equipments as shown in fig.1.
2. Keep Position of variable attenuator at min. attenuation position.
3. Set mode selector switch to FM-MOD position, FM amplitude and FM frequency knob at mid position, keep beam voltage knob fully anti-clock wise and reflector voltage knob to fully clock wise and Beam switch to OFF position.
4. Keep the time/division scale of oscilloscope around 100Hz frequency measurement and volt/div. to lower scale.
5. Switch “ON” the Klystron Power Supply and Oscilloscope.
6. Switch “ON” Beam voltage switch and set beam voltage to 300v by beam voltage control knob.
7. Keep amplitude knob of FM modulator to maximum position and rotate the reflector voltage anti-clock wise to get modes as shown in figure.4, on the oscilloscope. The horizontal axis represents reflector voltage axis and vertical represents output power.
8. By changing the reflector voltage and amplitude of FM modulation, any mode of Klystron tube can be seen on oscilloscope.

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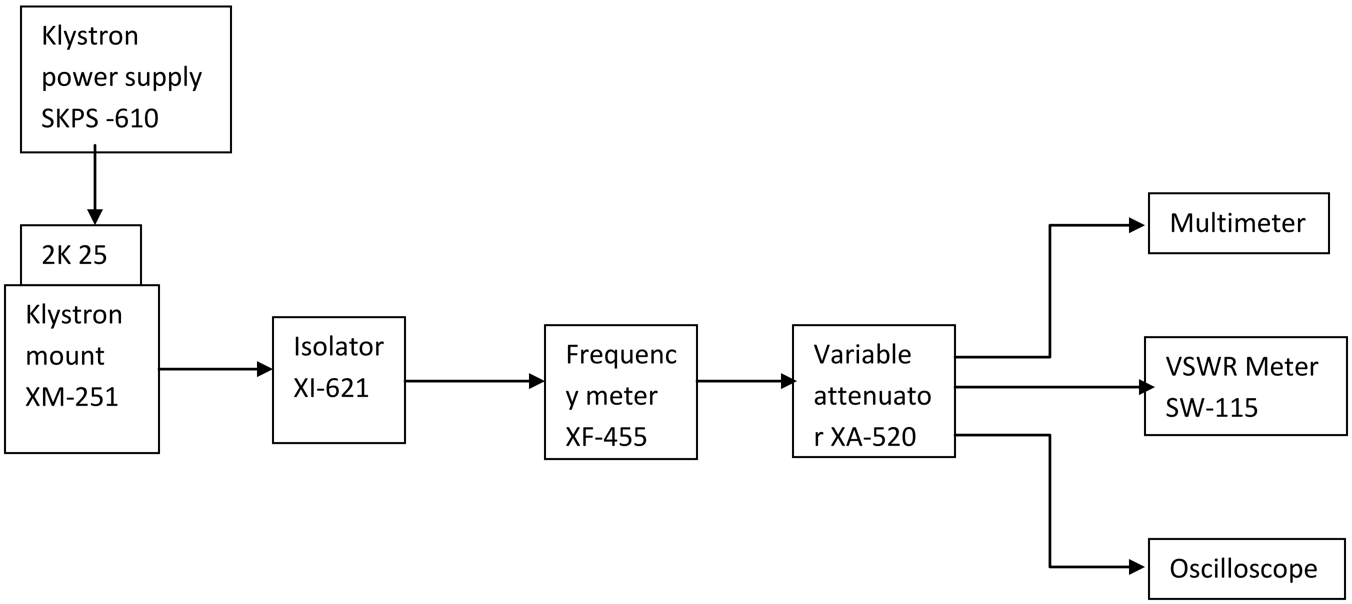
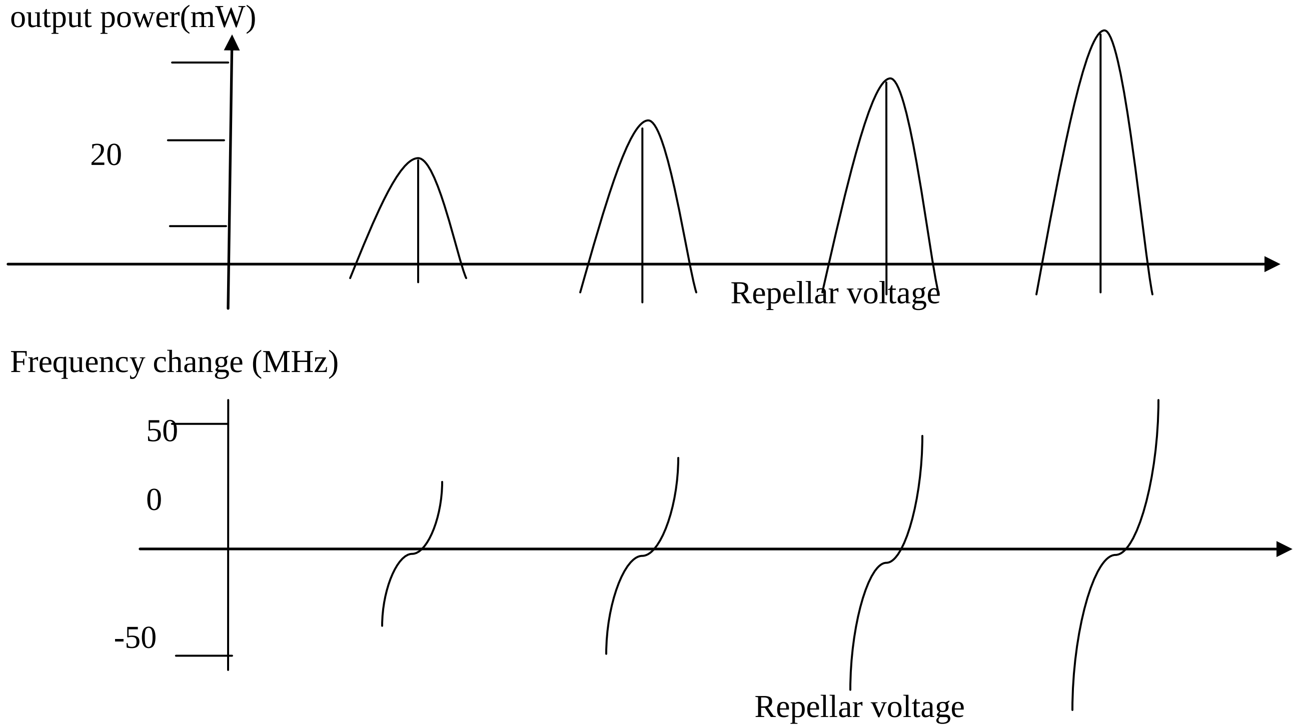


Fig. 1. Set up of study of Klystron tube

Output Waveforms:



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Observations: **Beam Voltage = ----------- V**

Repellar Voltage (V)	Beam Current (mA)	Frequency (GHz)	Output Current(mA)
MODE 1		f 1	0 . max . 0
MODE 2		f 2	0 . max . 0
MODE 3		f 3	0 . max . 0

Experiment-3

ATTENUATION MEASUREMENT

OBJECTIVE:

To measure the attenuation of the attenuator.

Equipment Required:

1. Microwave source
   a. Gunn oscillator - XG-11
   b. Klystron Tube - 2K25
2. Isolator - X1-21
3. Frequency meter - XF-10
4. Variable Attenuator - XA-520
5. Slotted line - XS-651
6. Tunable probe - XP-655
7. Detector mount - XD-451
8. Matched Termination - XL-400
9. Test attenuator
   a. Fixed
   b. Variable
10. Gunn Power Supply PIN Modulator/Klystron Power Supply + Klystron Mount.
11. Cooling Fan.
12. BNC- BNC cable and TNC-TNC cable.

Procedure:

A. <u>Input VSWR Measurement</u>

1. Connect the equipments as shown in the fig.
2. Energize the microwave source for maximum power at any frequency of operation.
3. Measure the VSWR with the help of tunable probe, slotted line and VSWR meter as described in experiment of measurement of low and medium VSWR.
4. Repeat the above step for other frequencies if required.

B. <u>Insertion Loss/Attenuation Measurement</u>

1. Remove the tunable probe, attenuator and matched termination from the slotted section in the above setup.
2. Connect the detector mount to the slotted line, and tune the detector mount also for maximum deflection on VAWR meter (Detector mount's output should be connected to VSWR meter).
3. Set any reference level on the VSWR meter with the help of variable attenuator (not test attenuator) and gain control knob of VSWR meter. Let it be P1.

4. Carefully disconnect the detector mount from the slotted line with out disturbing any position on the setup. Place the test variable attenuator to the slotted line and detector mount to other port of test variable attenuator. Keep the micrometer reading of test variable attenuator to zero and record the reading of VSWR meter. Let it be P2 then the insertion loss of test attenuator will be p1-p2db.
5. For measurement of attenuation of fixed and variable attenuator. Place the test attenuator to the slotted line and detector mount at the other port of test attenuator. Record the reading of VSWR meter. Let it be P3 then the attenuation value of variable attenuator for particular position of micrometer reading of will be P1-P3db.
6. In case the variable attenuator, change the micrometer reading and record the VSWR meter reading. Find out attenuation value for different position of micrometer reading and plot a graph.
7. Now change the operating frequency and all steps should be repeated for finding frequency sensitivity of fixed and variable attenuator.

Note:

For measuring frequency sensitivity of variable attenuator the position of micrometer reading of the variable attenuator should be same for all frequencies of operation.

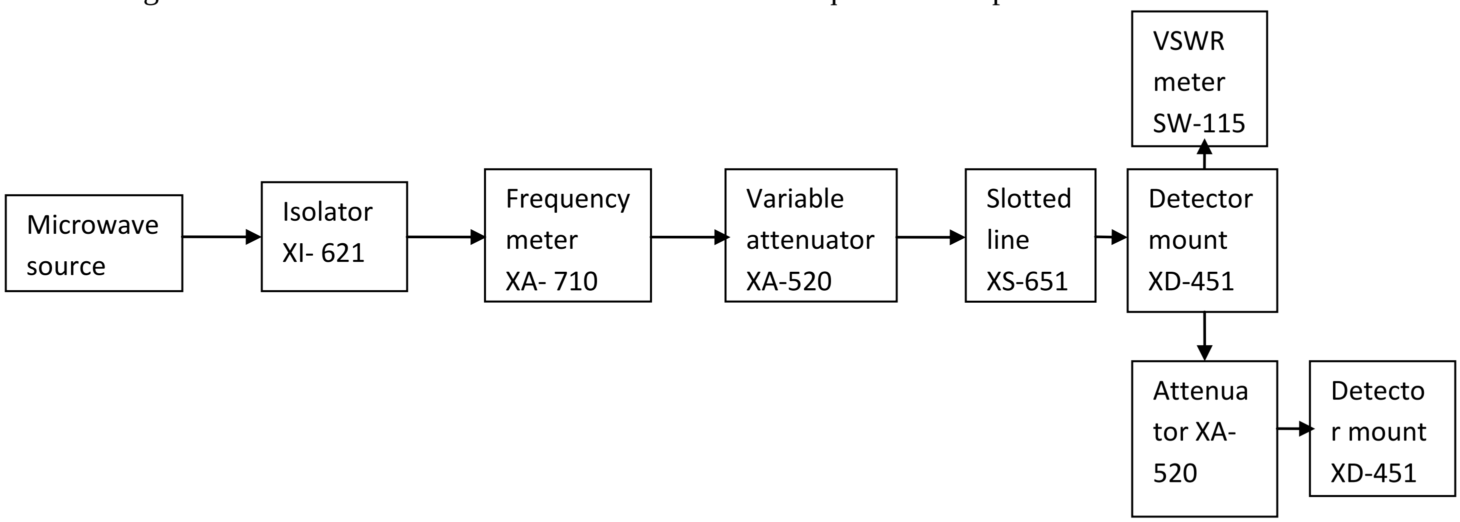

Fig.1 **INSERTION LOSS AND ATTENUATION MEASUREMENT**

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OBSERVATIONS:

Beam voltage = 230 V

Beam current = 11 mA

Repeller voltage = --------- V

Power without attenuator P1 = ---------------- dB

Power with variable attenuator with attenuation at 7 mm P2= ------------------ dB

Power with variable attenuator with attenuation at 5 mm P3= ------------------- dB

Insertion loss or Attenuation with 7 mm = P1 – P2 dB

Insertion loss or Attenuation with 5 mm = P1 – P3 dB

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Experiment-4

Determination of VSWR & Reflection Coefficient

OBJECTIVE: To determine the standing-wave ratio and reflection coefficient.

EQUIPMENTS:

Klystron Power Supply(SKPS-610), Klystron Tube(2K-25) with Klystron Mount(XM-25), Isolator (XI -621), Frequency Meter (XF- 710), Variable Attenuator (XA-520), Slotted line (X 565), Tunable probe (XP-655), Detector Mount(XD-451), Wave Guide Stand (XU-535), VSWR Meter (SW-115), Movable short/ Termination (XL 400) or any unknown load, BNC Cable.

PROCEDURE:

1. Set up the equipment as shown in the figure.
2. Keep the variable attenuator in the minimum attenuation position.
3. Keep the control knobs of VSWR as below:
   Range db - 40db/50 db
   Input Switch - Low Impedance
   Meter Switch - Normal
   Gain (Coarse-Fine) - Mid position approx.
4. Keep the control knobs of the Klystron power supply as below:
   Beam voltage - OFF
   Mod-switch - AM
   Beam voltage knob - Fully anticlockwise direction
   Reflector Voltage knob - Fully clockwise direction
   AM-amplitude knob - Around fully clockwise
   AM-frequency
   & amplitude knob - Mid position
5. Switch 'ON' the Klystron Power Supply, VSWR Meter and cooling fan.
6. Switch 'ON' the Beam voltage switch position and set beam voltage at 300V.
7. Rotate the reflector voltage knob to get deflection in VSWR Meter.
8. Tune the output by tuning the reflector voltage, amplitude and frequency of AM Modulation.
9. Tune the plunger of Klystron Mount and probe for maximum deflection in VSWR meter.
10. If required, change the range db-switch variable attenuator position and gain control knob to get deflection in the scale of VSWR meter.
11. As you move probe along the slotted line, the deflection will change.

A. <u>MEASUREMENT OF LOW AND MEDIUM VSWR:</u>

1. Move the probe along the slotted line to get maximum deflection in VSWR Meter.
2. Adjust the VSWR meter gain control knob or variable attenuator until the meter indicates '1.0' on normal VSWR scale.

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3. Keep all the control knobs as it is, move the probe to next minimum position. Read the VSWR on scale.
4. Repeat the above step for change of S.S. tuner probe depth and record the corresponding SWR.
5. If the VSWR is between 3.2 and 10, change the range db switch to next higher position and read the VSWR on second scale of 3 to 10.

B. MEASUREMENT OF HIGH VSWR:

1. Set the depth of S.S.Tuner slightly more for maximum VSWR.
2. Move the probe along with slotted line until a minimum is indicated.
3. Adjust the VSWR meter gain control knob and variable attenuator to obtain a reading og 3 db in the normal db scale (0 to 10 db) of VSWR Meter.
4. Move the probe to left on slotted line until full scale deflection is obtained on 0-10 db scale. Note and record the probe position on slotted line let it be d1.
5. Repeat the step 3 and then move the probe right along the slotted line until full scale deflection is obtained on 0-10 db normal db scale. Let it be d2.
6. Replace the S>S. tuner and termination by movable short.
7. Measure the distance between two successive minima positions of the probe. Twice this distance is guide wavelength λg.
8. Compute SWR from the following equation:

$$SWR = \frac{\lambda g}{\pi\,(d1-d2)}$$

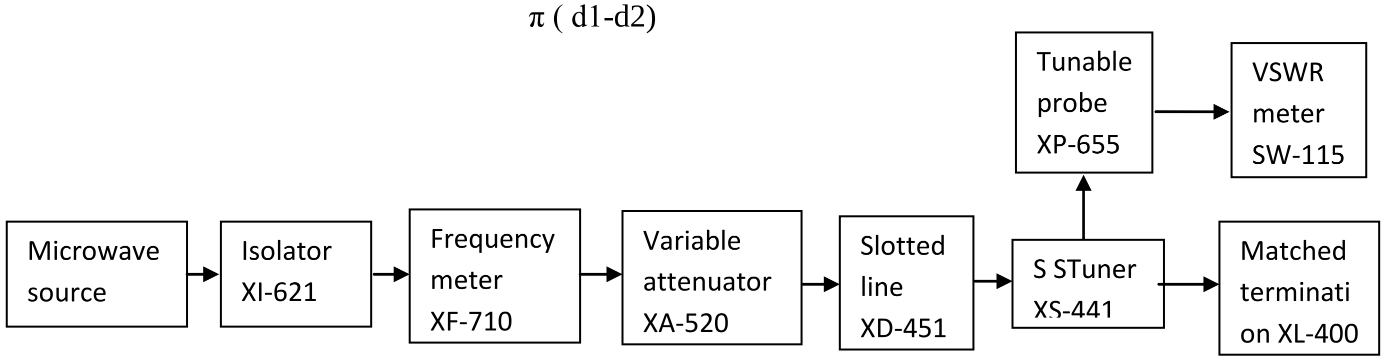

FIG.1 SET UP FOR VSWR MEASUREMENT

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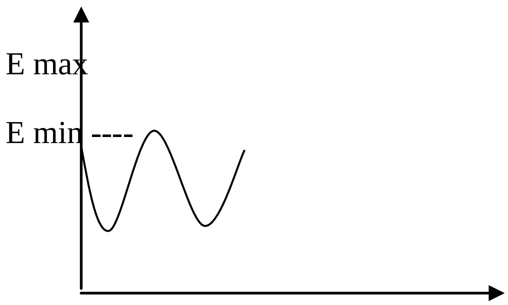

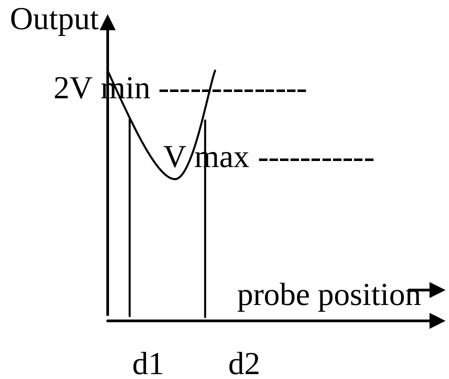

Fig.2(a)**STANDING WAVE** Fig.2(b)**DOUBLE**
MINIMA METHOD

Calculations:

d 1 =

d 2 =

λ g= 2(d1 – d2)

Low and medium VSWR= S =

Reflection coefficient (for low VSWR) = S-1/S+1

High VSWR:

d 3 =

d 4 =

High VSWR= S =

Reflection coefficient (for high VSWR) = S -1/S +1

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Experiment-5

Waveguide Parameters

Objective: To determine the frequency and wave length in a rectangular waveguide working in TE10 mode.

Equipment Required:

Klystron Tube 2K25, Klystron Power Supply 5KPS-610,Klystron Mount XM-251, Isolator XI-621, Frequency Meter X F710, Variable Attenuator XA-520, Slotted Section XS-651, Tunable probe XP-655, VSWR Meter SW-115, Waveguide Stand XU-535, Movable Short XT-481/Matched termination XL-400.

Procedure:

1. Set up the components and equipments as shown in fig.
2. Set up variable attenuator at minimum attenuation position.
3. Keep the control knobs of VSWR Meter as below:
   Range - 50db
   Input Switch - Crystal low impedance
   Meter Switch - Normal position
   Gain (Coarse & Fine) - Mid position.
4. Keep the Control Knobs of Klystron power supply as below
   Beam voltage - OFF
   Mod-switch - AM
   Beam Voltage knob - Fully anticlockwise
   Reflector Voltage - Fully clockwise
   AM-Amplitude Knob - Around fully clockwise
   AM-Frequency Knob - Around Mid position.
5. Switch 'ON' the Klystron power supply, VSWR Meter and Cooling Fan Switch.
6. Switch 'ON' the beam voltage switch and set beam voltage at 300v at with help of beam voltage knob.
7. Adjust the reflector voltage to get some deflection in VSWR Meter.
8. Maximize the deflection with AM amplitude and frequency control knob of power supply.
9. Tune the plunger of Klystron Mount for maximum deflection.
10. Tune the reflector voltage knob for maximum deflection.
11. Tune the probe for maximum deflection in VSWR Meter.
12. Tune the frequency meter knob to get a 'dip' on the VSWR scale
and note down the frequency directly from frequency meter.
13. Replace the termination with movable short, and detune the frequency meter.

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14. Move the probe along the slotted line. The deflection in VSWR meter will vary. Move the probe to a minimum deflection position, to get accurate reading. If necessary increase to VSWR meter range db switch to higher position. Note and record the probe position.
15. Move the probe to next minimum position and record the probe position again.
16. Calculate the guide wavelength as twice the distance between two successive minimum position obtained as above.
17. Measure the waveguide inner broad dimension 'a' which will be around 22.86 mm for X-band.
18. Calculate the frequency by following equation.

$$f = c/\lambda = \sqrt{1/\lambda g2 + 1/\lambda c2}$$

19. Verify with frequency obtained by frequency meter.
20. Above experiment can be verified at different frequencies.

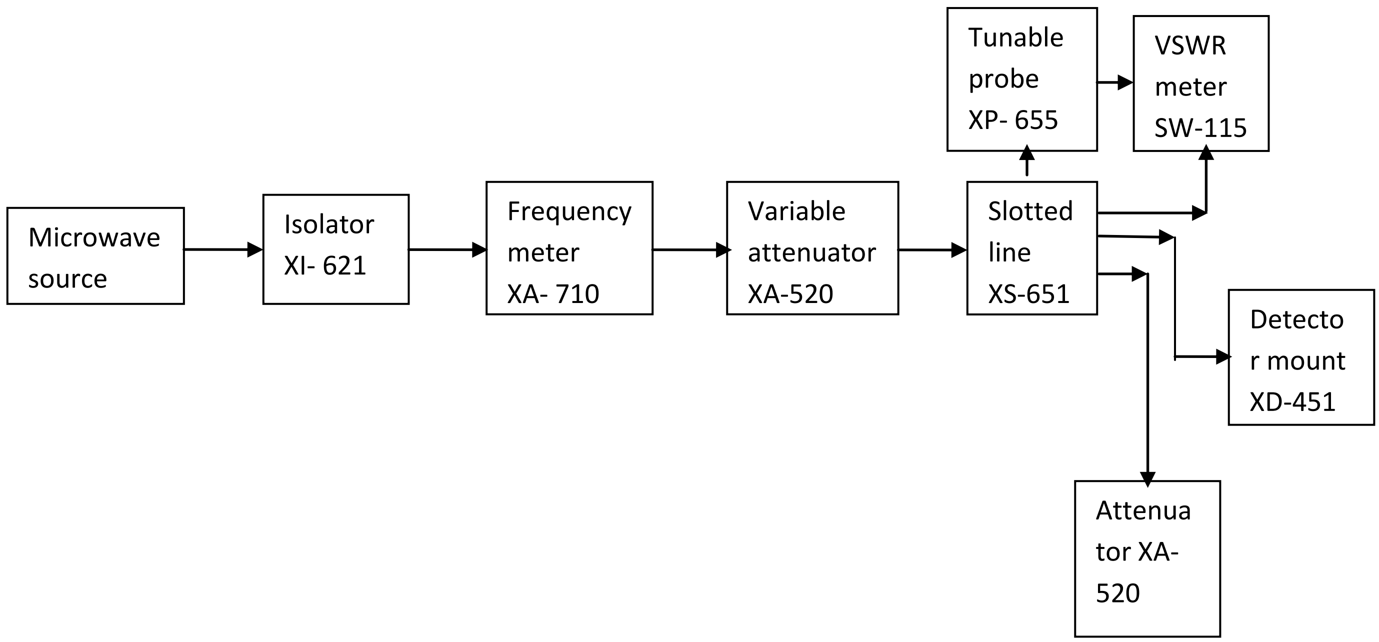

Fig. **SET UP FOR FREQUENCY & WAVE-LENGTH MEASUREMENT**

Calculations:

d 1 = ----------- cm

d 2 = ------------ cm

$\lambda_g = 2(d_1 - d_2)$ cm

$\lambda_c = 2.a$ (where a = 2.286 cm i.e broader dimension of wave guide)

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

λ_o = ---------- cm

Theoretical frequency $f = C/\lambda_o$ (G Hz)

Practical frequency = ---------- G Hz

EXPERIMENT-6

Directional Coupler

OBJECTIVE: To study the function of multihole directional coupler by measuring the following parameters

1. Mainline and auxiliary-line VSWR.
2. The coupling factor and directivity of the coupler.

EQUIPMENTS:

Microwave Source (Klystron or Gunn diode), Isolator, Frequency Meter, variable attenuator, slotted line, tunable probe, Detector mount matched termination, MHD Coupler, Waveguide stand, Cables and Accessories, VSWR meter.

PROCEDURE:

1. **<u>Main Line SWR Measurement</u>**
    1. Set up the equipments as shown in fig.
    2. Energize the microwave source for particular frequency of operation as described in the procedures given in the operation of Klystron tube/Gunn Oscillator.
    3. Follow the procedure as described for VSWR measurement (low and medium SWR measurement).
    4. Repeat the same for other frequencies.
2. **<u>Auxiliary Line SWR Measurement</u>**
    1. Set up the components and equipments as shown in fig.
    2. Energize the microwave source for particular frequency of operation as described in the operation of Klystron tube/Gunn Oscillator.
    3. Measure SWR as described in the experiment of SWR measurement (low and medium SWR measurement).
    4. Repeat the same for other frequencies.

3. **<u>Measurement of Coupling Factor, Insertion loss, Isolation & Directivity</u>**
    1. Set up the components and equipments as shown in the fig.
    2. Energize the microwave source for particular frequency of operation.

3. Remove the multi-hole directional coupler and contact the detector mount to the frequency meter. Tune the detector for maximum output.
4. Set any reference level of power on VSWR meter, and note down the reading (reference level let X).
5. Insert the directional coupler as shown in second fig. with detector to the auxiliary port3 and matched termination to port2, without changing the position of variable attenuator and gain control knob of VSWR meter.
6. Note down the reading on VSWR meter on the scale with the help of range-db switch if required. Let it be Y.
7. Calculate coupling factor which will be X-Y= C(dB).
8. Now carefully disconnect the detector from the auxiliary port3and match termination from port2 without disturbing the set-up.
9. Connect the matched termination to the auxiliary port3 and the detector to port 2 and measure the reading on VSWR meter. Suppose it is Z.
10. Compute insertion loss X-Z in db.
11. Repeat the steps from 1 to 4.
12. Connect the directional coupler in the reverse direction, i.e. port2 to frequency meter side. Matched termination to port1 and detector mount port3 without disturbing the position of the variable attenuator and gain control knob of VSWR meter.
13. Measure and note down the reading on VSWR meter. Let it be Yd. X-Yd gives Isolation 1(dB).
14. Compute the directivity as Y-Yd=I-C
15. Repeat the same for other frequencies.

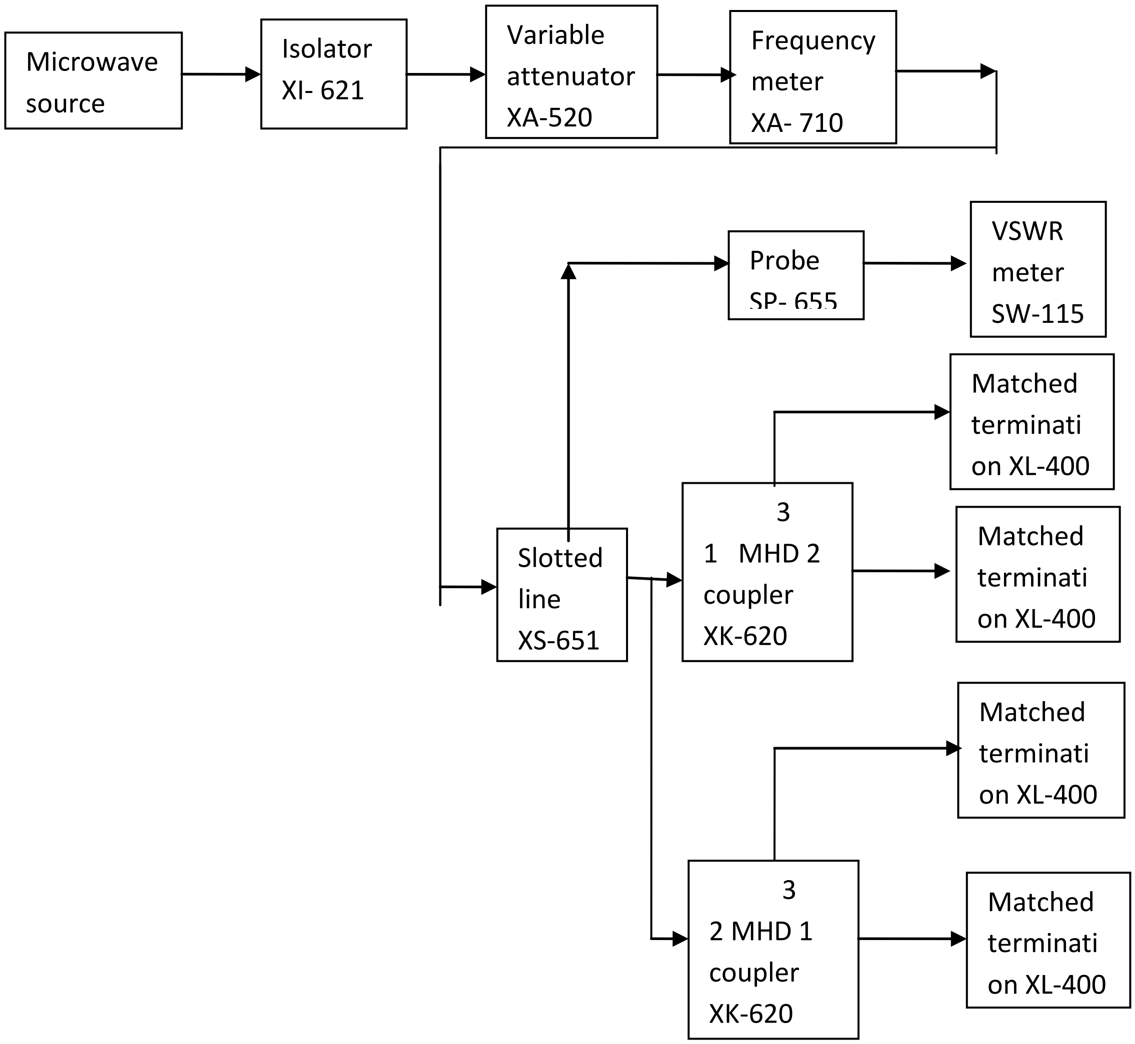

Fig. **SET UP FOR MULTI-HOLE DIRECTIONAL COUPLER**

Observations:

Beam voltage = 230 V

Beam current = 11 mA

Repeller voltage = ---------- V

Power without Directional coupler P1 = -------- dB

Power at Port 2 of D.C(Port 1 is connected and Port 3 is terminated), P2= ------- dB

Power at Port 3 of D.C(Port 1 is connected and Port 2 is terminated), P3= ------- dB

Power at Port 3 of D.C(Port 2 is connected and Port 1 is terminated), P4= ------- dB

Coupling factor C= P1- P3(dB)

Insertion loss I_l = P1 – P2 (dB)

Isolation I = P1 – P4 (dB)

Directivity (theoretical) D = I - C (dB)

Directivity (practical) D = P3 – P4 (dB)

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Experiment- 7

Study of Magic Tee

Objective: Study of Magic Tee

Equipments Required:

Micro wave source, Isolator, Variable attenuator, frequency meter, slotted line, tunable probe, magic tee, matched terminations, waveguide stand, detector mount, VSWR meter and accessories.

Procedure:

1. Remove the tunable probe and magic tee from slotted line and connect the detector mount to the slotted line.
2. Connect all the components as shown in experimental set up.
3. Energize the microwave source for particular frequency of operation.
4. With the help of variable attenuator and gain control knob of VSWR meter set any power level in the VSWR meter let it be P1.
5. Without changing the attenuation level measure the power at port 3 of the magic tee let it be P3. Now the insertion loss = P1-P3 (db).
6. Now measure the power at port2. E-arm by shorting port3 & port4. Let it be P2. Then coupling factor of E-arm = p1-P2 (db).
7. Similarly measure power at port4 (H-arm) by shorting port2 & port3. Then coupling factor of H-arm = P1-P4 (db).
8. Now connect H-arm to the slotted line and measure power at port2. Isolation = P4-P2 (db).

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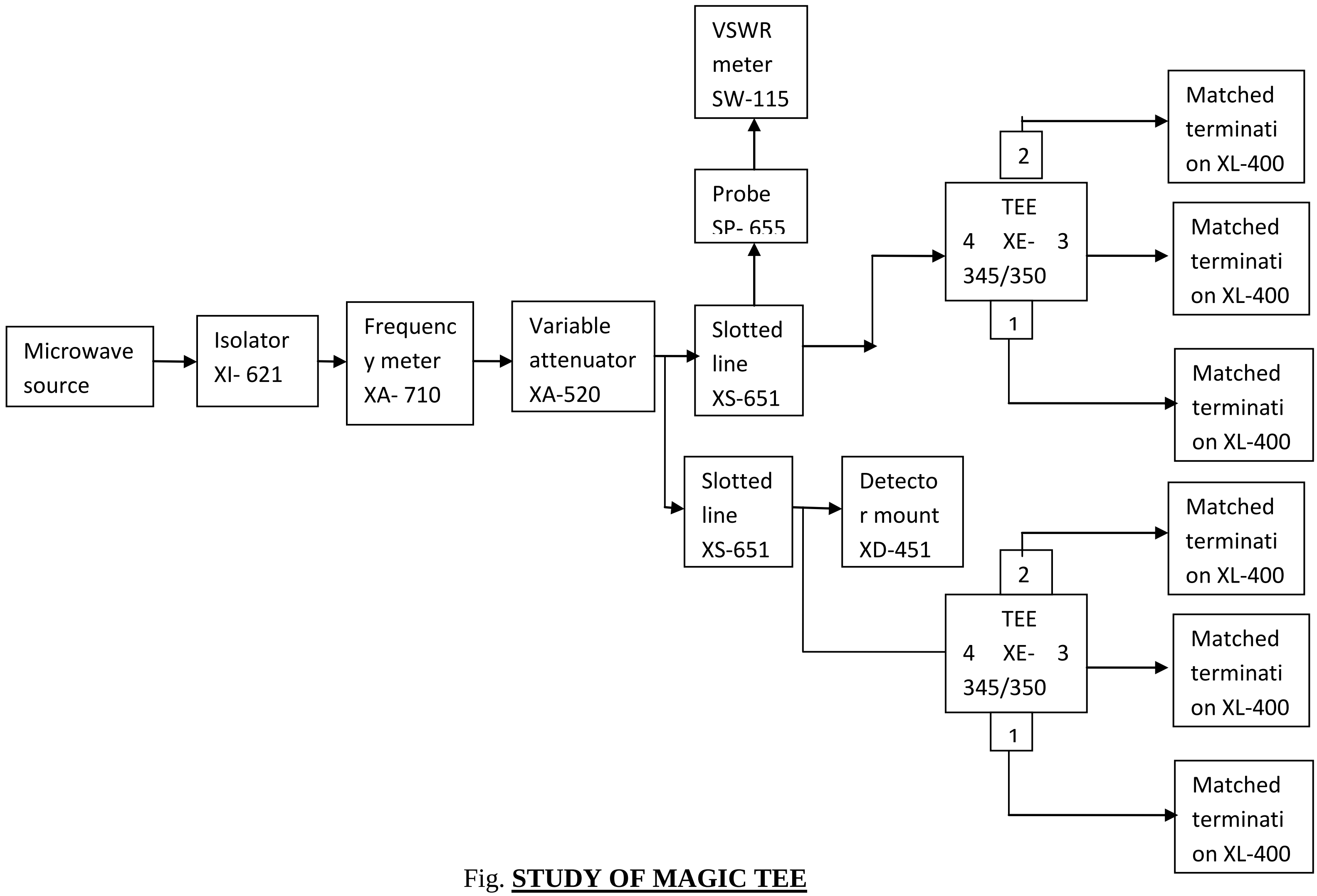

Fig. **STUDY OF MAGIC TEE**

Observations:

Beam voltage = v

Beam current= ma

Repeller voltage= v

Power at port1 P1= (P2 & P4 are matched termination)

Power at port2 (E-arm) P2= (P1 & P4 are matched termination)

Power at port3 P3=

Power at port4 (H-arm) P4= (P1 & P2 are matched termination)

Insertion loss = P1-P3 (db) = P2-P3 =

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Coupling Factor of E-arm = P2-P4 (db) =

Or

Coupling Factor of H-arm = P1-P4 (db) =

Isolation =P3-P4 (db) =

Max Power = (Only matched termination without magic tee).

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CYCLE 2

Experiment-8

Fiber Optic Digital Link

Objective: To design the fiber optic digital link for the transmission of digital signals.

Equipments required:

Optical fiber communication trainer, Power supply, connecting wires, fiber optic cable.

Procedure:

1. Connect 4 kHz digital source (A4) FO-Led (A).
2. Connect photo transistor output (c) to digital Rx4(R1)
3. Terminate the fiber optic cable both at source (or) detector.
4. Adjust FO led current to maximum.

Observations:

1. Observe an Oscilloscope signal source A4 & digital receiver output digital receiver output will inverse of signal source observe for distortion on raising edge of the pulse.
2. Observe pulse shaper output (E) & source (A4). It can be observed that both signals are identical except for switching characteristics of photo transistor
3. Repeat the experiment for other signal sources 8 kHz, 32 kHz, 64 kHz.
4. It can be observed that source frequency is increased the photo transistor switching times are pronounced.
5. Observe the change in photo transmitter switching times as Fo-Led current is reduced.

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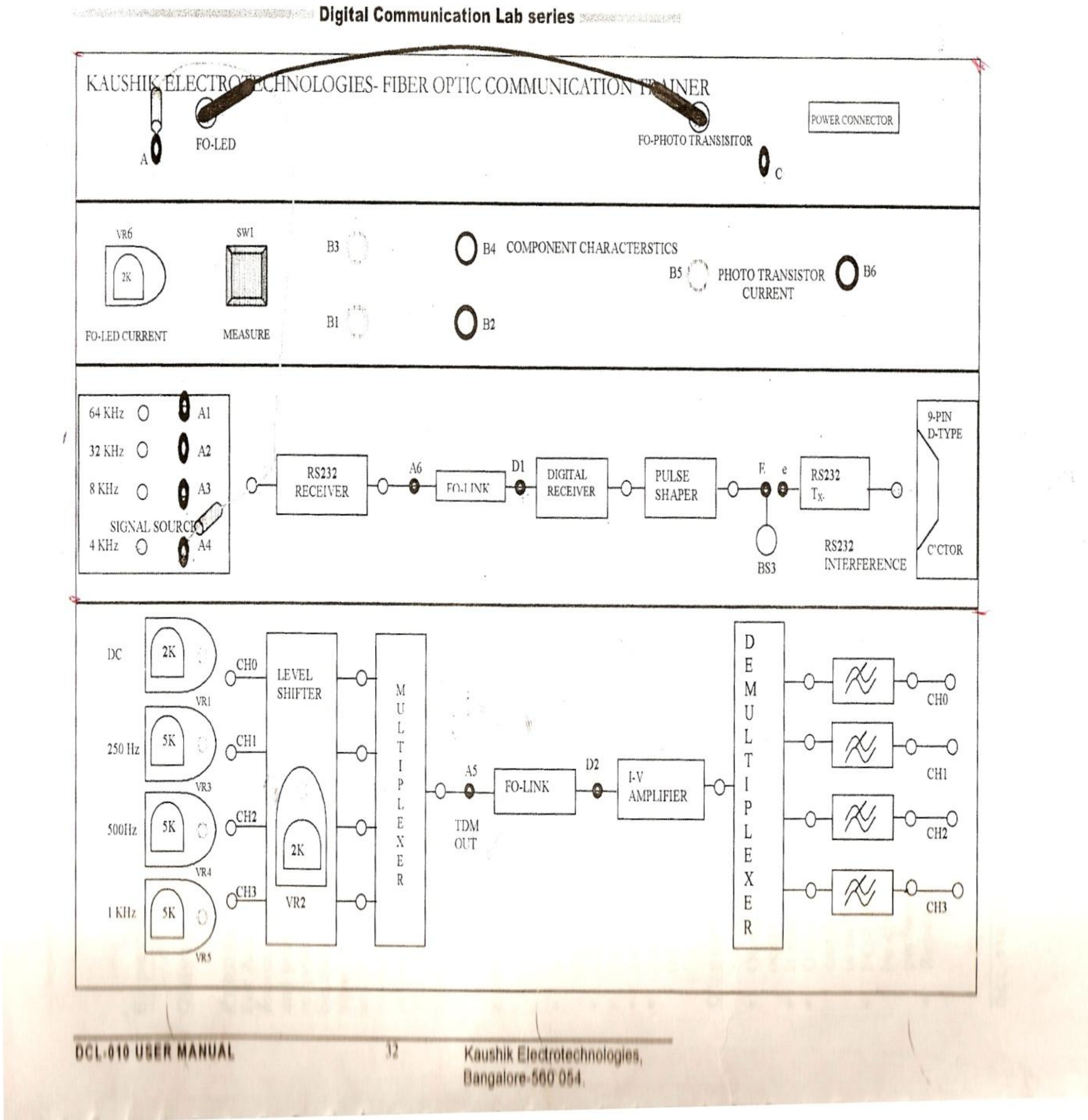
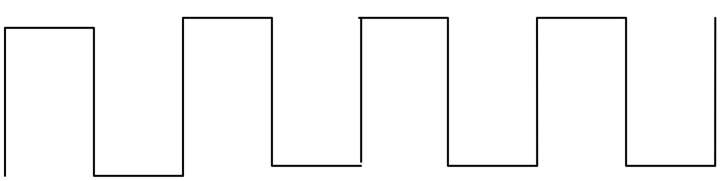


Fig. **FIBER OPTIC KIT FOR DIGITAL TRANSMISSION OF DATA**

Waveforms:



T= 0.015625 mS

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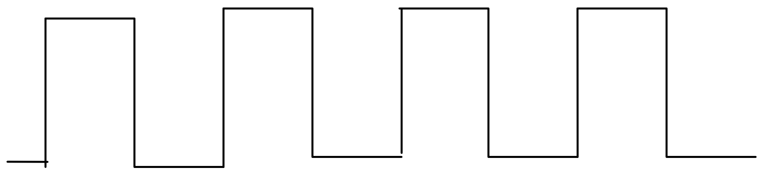
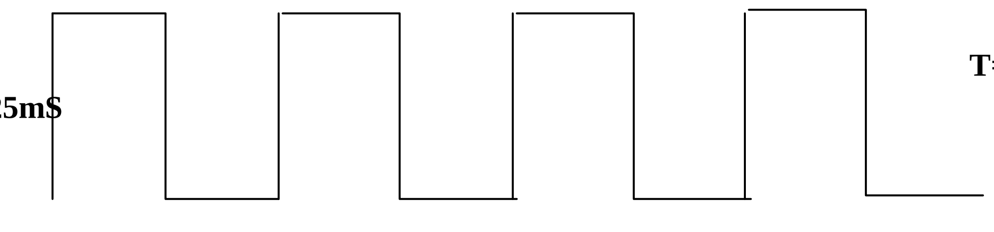
64 K Hz Input Signal

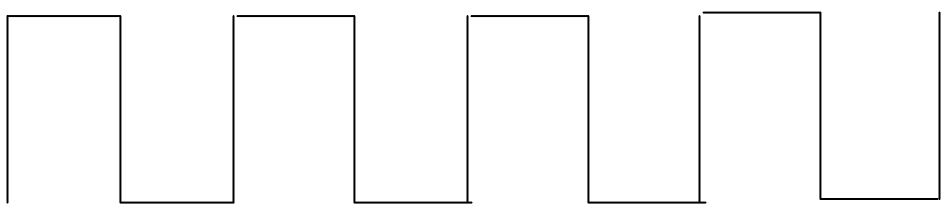


64 K Hz Output Signal

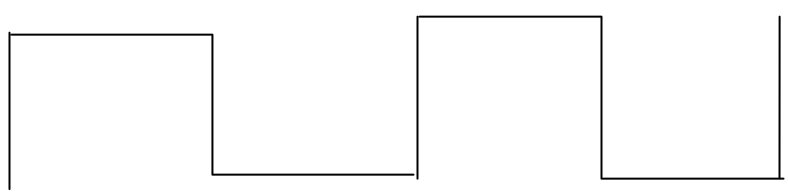


T= 0.03125mS

32 K Hz Input Signal

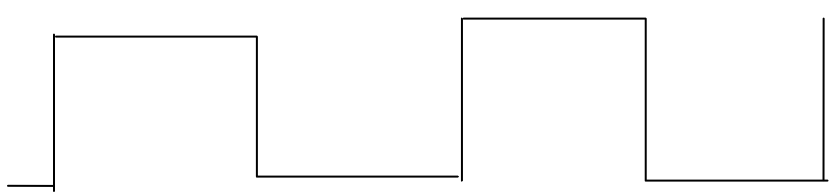


32 K Hz Output Signal



T=0.125mS

8 K Hz Input Signal



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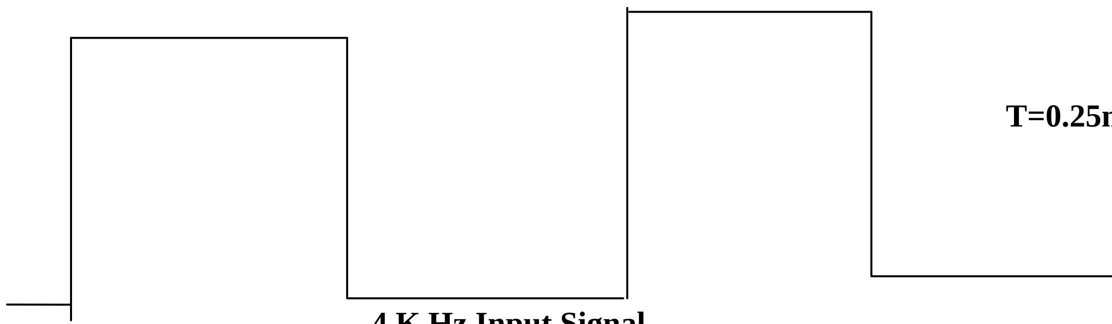
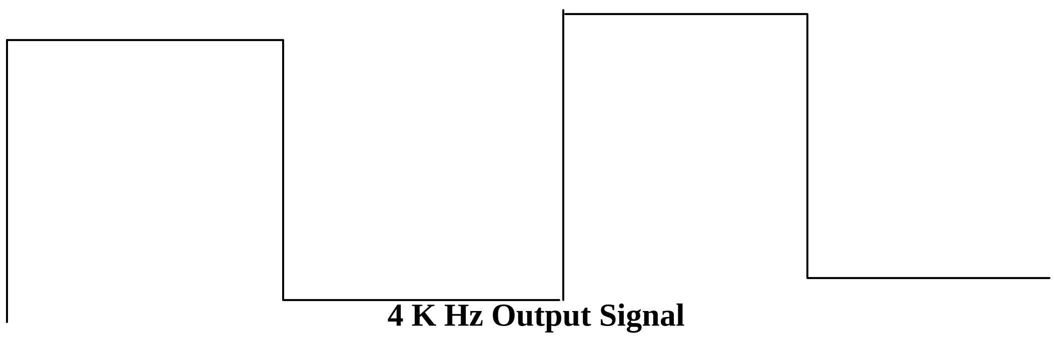
8 K Hz Output Signal



T=0.25mS

4 K Hz Input Signal



4 K Hz Output Signal

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Experiment-9

Attenuation measurement in given Optical fiber

Objective: To study the attenuation in the given fibre optic cable

Preparatory information:

Theoretically, a pulse of light with a given width and amplitude is transmitted into one end of a fiber should arrive at the far end of that fiber with its shape and length unchanged and only its amplitude reduced by losses. If the losses get too large, the pulse amplitude at the receiver will be too small to be detected, and a repeater will have to be included to boost the signal level entering the next section. Pulses of light transmitted into a fiber encounter several dispersion effects, which act to spread the pulse out in the time domain, changing its shape so that it may merge into the previous and succeeding pulses. The pulses can be separated by spacing them out at the transmitter, but this means reducing the maximum bit rate.

Experimental set_up:

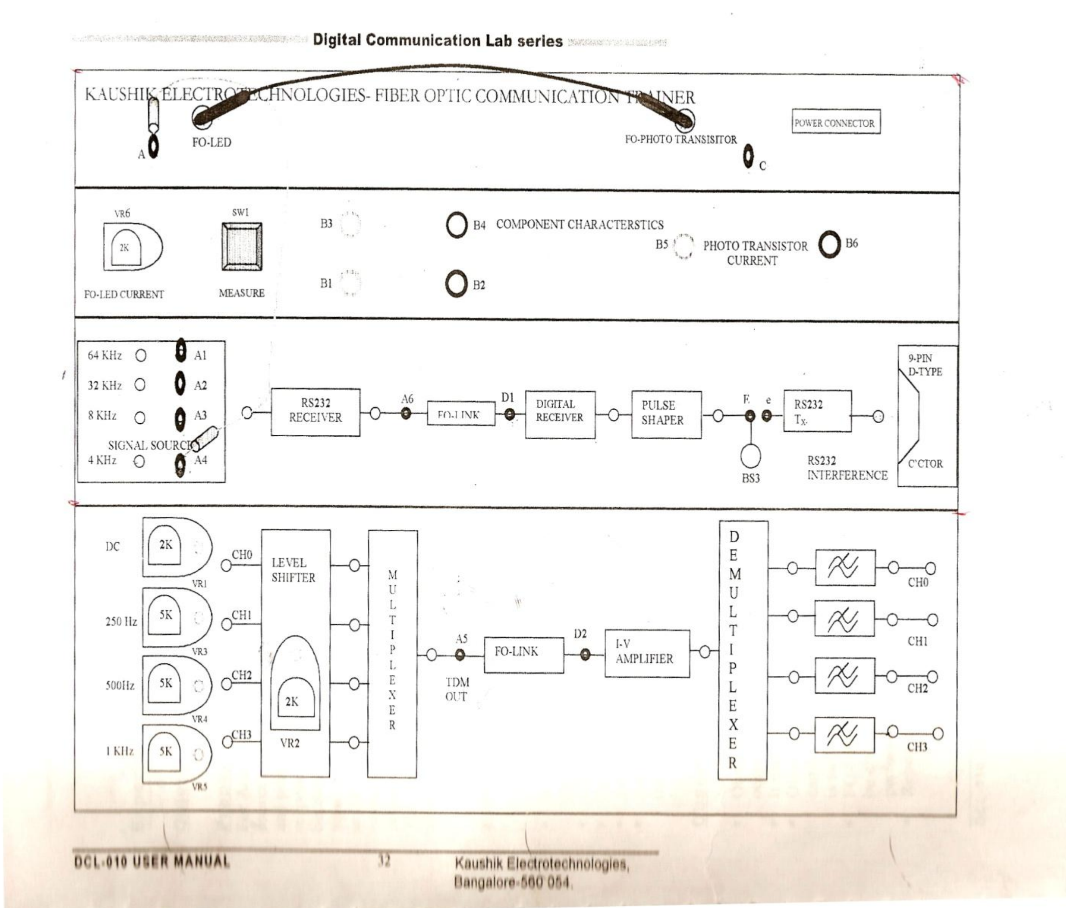


Fig: set up for attenuation measurement in optical fiber

Experimental procedure:

1. Connect 0-20 mA DC ammeter between B1 to B2
2. Connect 0-200 mA DC ammeter between B5-B6
3. Terminate the fiber optic cable both at source and detector
4. Push the measure switch SW1
5. Adjust FO-LED current to 10 mA by VR6
6. Note photo transistor current by pushing switch SW1
7. Convert PHOTO TRANSISTOR current to irradiated optical poer Pout. Typically 50 µA will be transistor current per micro watt of optical power
8. The ratio of $\mathbf{P_{out}}$ of $\mathbf{P_{in}}$ of a cable is calculated

Observations & Measurements

Photo transistor current= 10mA

Pin= Txd optical power = 30 µW at 10 mA

Pout= Rxd optical power = _____

Typically 1 µW for every 50µA of photo transistor current

Cable attenuation= $\mathbf{20 \log10(P_{out}/P_{in})}$

Experiment-10

Characteristics of LED

Objective:

a) To plot the volt-ampere characteristics of a LED.
b) To determine the cut-in voltage, dynamic & static forward bias resistance.

Equipment required:

Semiconductor trainer module containing bread board, LED CQ124, 1KΩ - resistor – 1no.

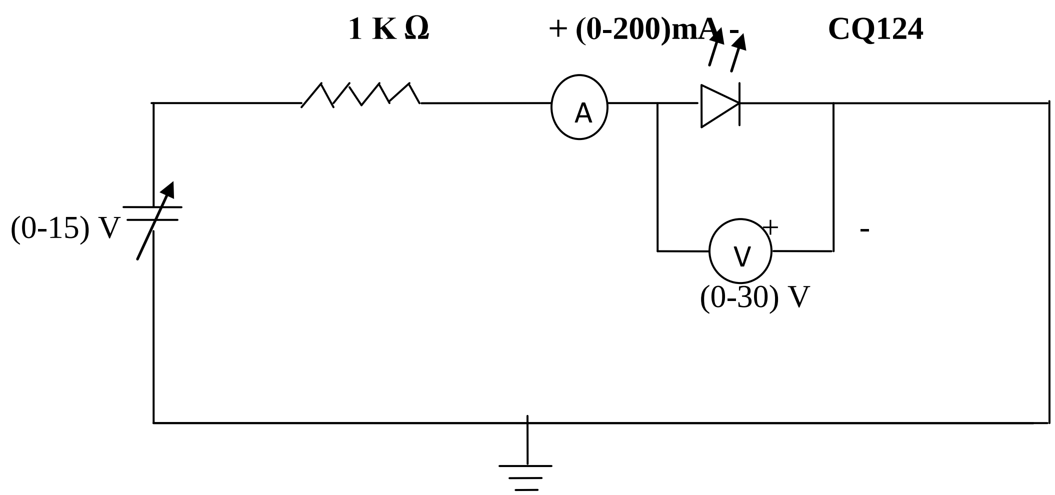
Procedure:

1. Connect the equipment as shown in fig.
2. Use CQ124 LED and make it forward bias connection.
3. Increases the voltage applied to diode gradually in steps and note the ammeter and voltmeter readings and plot is drawn.

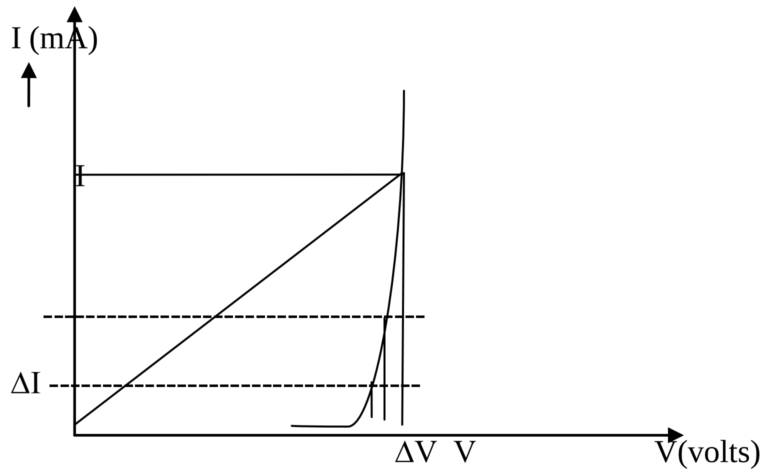
Precautions:

1. Do not connect the ammeter across the supply (or) to diode.
2. Do not connect the voltmeter in series with the diode.
3. Select the meters of proper range which are somewhat greater than required ratings.

Circuit Diagram:



Graph:



Dynamic resistance = Δ V/ ΔI Ohms

Static resistance = V/ I Ohms

Tabular column:

Voltage (volts)	Current (mA)

Cut-in voltage of LED= ------ volts

ADDITIONAL EXPERIMENT

EXPERIMENT-11

Impedance and Frequency Measurement

Objective: To measure an unknown Impedance using the smith chart.

Equipments Required:

Klystron Tube 2K25,Klystron Power supply SKPS-610,Klystron Mount XM-251,Isolator XF62, Frequency Meter XF710, Variable Attenuator XA-520, Slotted Line XS565,Tunable Probe XP655,VSWR Meter, Waveguide stand SU535, SS Tuner (XT441), Movable Short/Termination, etc.

Procedure:

1. Set up the equipments as shown in the fig.
2. Set the variable attenuator at minimum position.
3. Keep the control knobs of VSWR Meter as below:

Range	-	50 db position
Input Switch	-	Crystal Low Impedance
Meter Switch	-	Normal position
Gain (Coarse-Fine)	-	Mid Position

4. Keep the control knobs of Klystron power supply as below:

Beam voltage switch	-	'OFF'
Mod switch	-	AM
Beam voltage knob	-	Fully anticlockwise
Reflector voltage	-	Fully clockwise
AM- Amplitude	-	Around fully clockwise
AM-Frequency knob	-	Around Mid position

5. Switch 'ON' the Klystron power supply, VSWR meter and cooling fan.
6. Switch 'ON' the Beam Voltage Switch Position and set beam voltage at 300V with help of beam voltage knob.
7. Adjust the reflector voltage knob to get some deflection in VSWR meter.
8. Maximize the deflection with AM amplitude and frequency control knob of power supply.
9. Tune the Plunger of Klystron Mount for maximum deflection.
10. Tune the reflector voltage knob for maximum deflection.

11. Tune the probe for maximum deflection in VSWR meter.
12. Tune the frequency meter knob to get a ‘dip’ on the VSWR scale, and note down the frequency directly from frequency meter.
13. Keep the depth of pin of S.S. Tuner to around 3-4 mm and lock it.
14. Move the probe along the slotted line to get maximum deflection.
15. Adjust VSWR meter gain control knob and variable attenuator until the meter indicates 1.0 on the normal db SWR scale.
16. Move the probe to next minima position and note down the SWR So on the scale. Also note down the probe position, let it be d.
17. Remove the S.S. Tuner and Matched termination and place movable short at slotted line. The plunger of short should be at zero.
18. Note the position of two successive minima position. Let it be d1 and d2 Hence $\lambda g = 2(d1\text{-}d2)$.
19. Calculate

$$d / \lambda g$$

20. Find out the normalized impedance as described in the theory section.
21. Repeat the same experiment for other frequency if required.

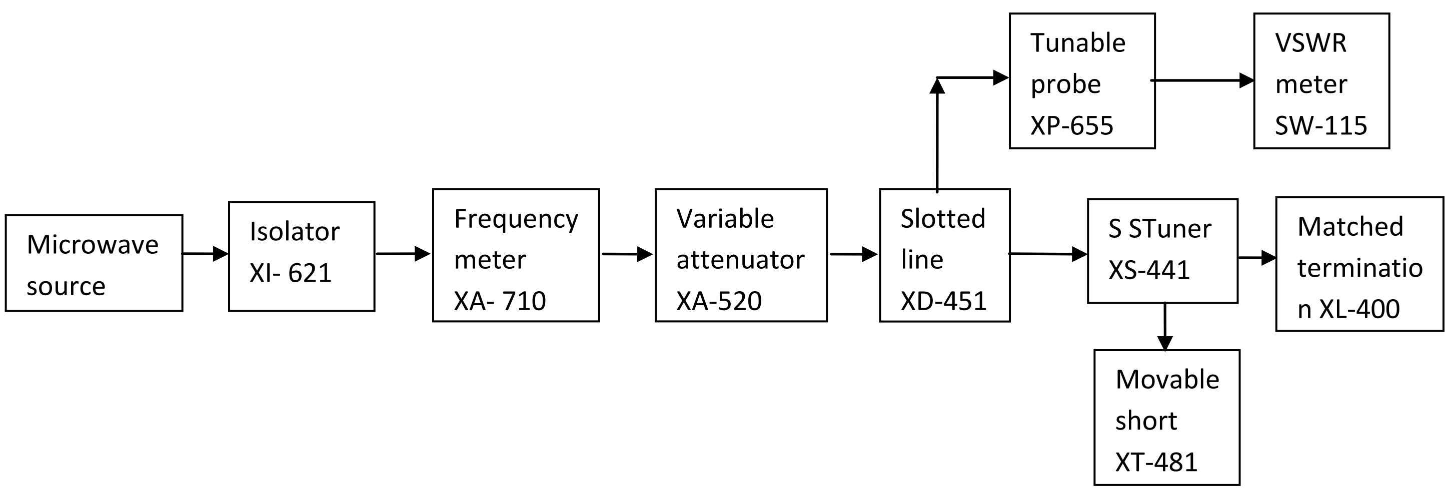


Fig.1 **SET UP FOR IMPEDANCE MEASUREMENT**

CALCULATIONS:

d 1= -------- cm

d 2 = -------- cm

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$\lambda g = 2 (d 2- d 1)$ cm

d 3 = --------- cm

d 4 = --------- cm

Low and medium SWR =

d = (d 3 – d 4) cm

$d / \lambda g$ =

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Experiment-12

Radiation Pattern of Horn Antenna

Objective: To measure the radiation pattern of pyramidal horn antenna.

Equipments Required:

S No	Components & Equipments	Model No
1.	Gunn Power supply	GS-610
2.	Gunn Oscillator	XG-11
3.	PIN modulator	XM-55
4.	Isolator	XI-621
5.	Variable attenuator	XA-520
6.	Detector mount	XD-451
7.	VSWR Meter	SW-115
8.	Radiation Pattern or Microprocessor Controlled Twin Table	XTB-105
9.	Pyramidal Horn Antenna	XH-541
10.	E-plane bend	XB-771
11.	Wave guide stand	XU-535
12.	Frequency Meter	XF-710
	Accessories	
1.	Cooling fan	CF-205
2.	BNC cable	
3.	TNC cable	

(Gunn source, Isolator, Transmitting Antenna, Receiving Antenna, DC Ammeter.)

Procedure:

A. Antenna Radiation Pattern:

1. Set up the equipment as shown in fig.1.Keeping the axis of both the antennas in same line.
2. Make sure no objects are closed. The propagation path and the distance between the Transmitting antenna & the antenna at receiving end is much greater than 2d2/λ where d is the size of broad wall of the transmitting antenna 'λ' is wavelength.
3. Energize the Gunn Oscillator for maximum output at desired frequency with square wave modulation by tuning square wave amplitude and frequency of modulating signal of Gunn power supply and by tuning the detector.
4. Also tune the S.S. Tuner, in the line for maximum output (if S.S. Tuner is in the set up).
5. Obtain full scale deflection (0 db) on normal db scale (0-10 db) at any convenient range switch position of the VSWR Meter by gain control knob of VSWR meter or by variable attenuator.

6. Tune the receiving horn to the left in 2^0- 5^0 steps up to 4^0-5^0 and note the corresponding VSWR db reading in normal db range. When necessary, change switch to next higher range and add 10 db to the observed value.
7. Plot a relative power pattern i.e. output Vs. Angle.
8. From diagram determine 3 db-width (beak width) of the horn Antenna.

B. GAIN MEASUREMENT:

1. Set up the equipment as shown in the figure.1
2. Keep the range db switch meter at 50 db position with gain control full.
3. Energize the Gunn Oscillator for maximum output at desired frequency with square wave modulation by tuning square wave amplitude and frequency of modulating signal of Gunn power supply and by tuning the detector.
4. Obtain full scale deflection in VSWR meter with variable attenuator
5. Replace the transmitting horn antenna 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 in step 4 and 5.

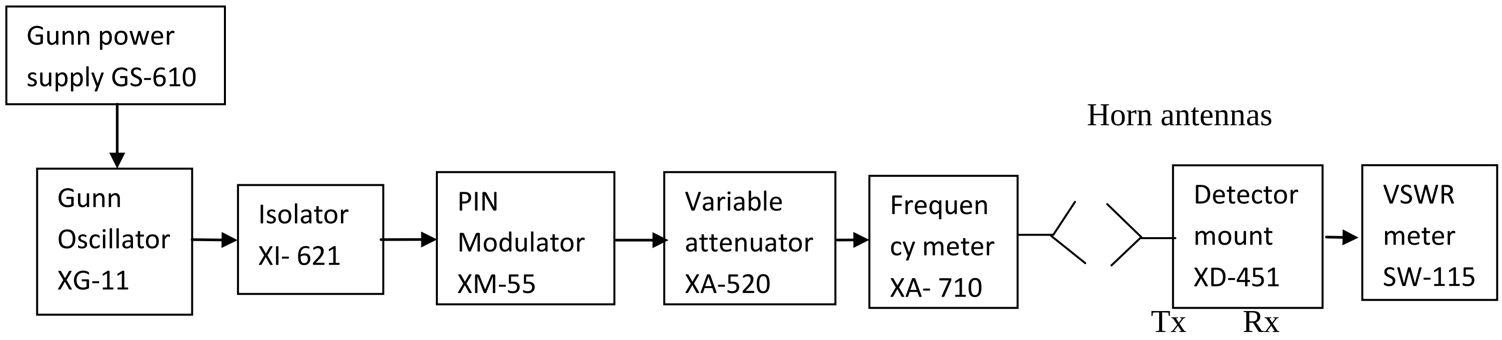

Fig. **SET UP FOR THE ANTENNA GAIN & PATTERN MEASUREMENT**

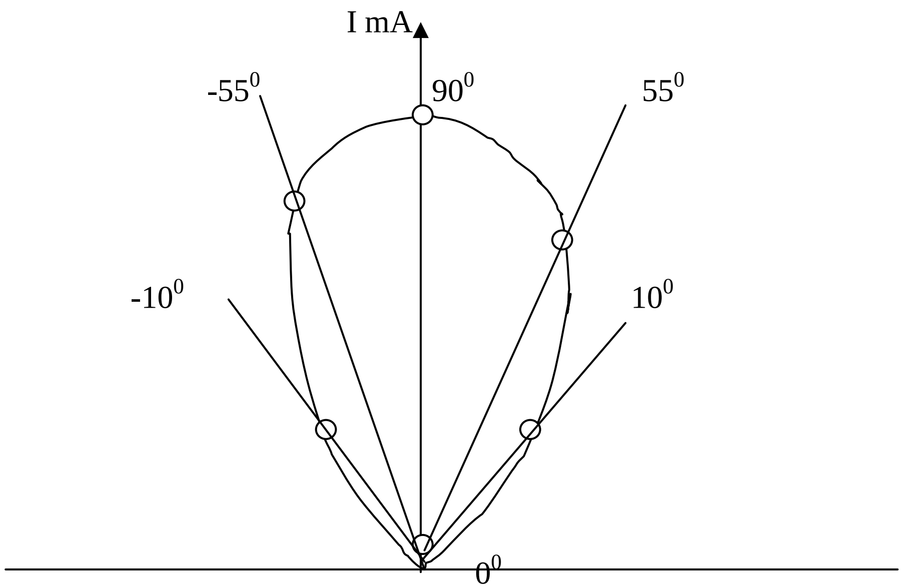

Fig.**RADIATION PATTERN OF HORN ANTENNA**

Observations:

Angle of rotation (90 + or 90-) Degrees	H-plan current(mA)
0^0	--
$+10^0$	--
.	--
.	--
.	--
$+60^0$	--
-10^0	--
-20^0	--
.	--
.	--
-60	--

Radial Distance between horns $S = 2 D^2 / \lambda$

Where D= 10.2 cm

And $\lambda = C / f$ where $C=3*10^8$ m/s & f= 9.3 G Hz

Gain ,

$$G = \frac{4\pi S}{\lambda 0}\sqrt{Pr/Pt}$$

Where Pr and Pt are receiving and transmitting powers.