**Dr. Mahalingam College of Engineering and Technology: Pollachi**

**Department of Electronics and Communication Engineering**

# Record Note Book

## 19ECCN3701-RF and Microwave Laboratory

| | |
|---|---|
| **Name** | |
| **Roll No** | |
| **Branch** | |
| **Class & Section** | |

## *Dr. Mahalingam College of Engineering and Technology, Pollachi*

## *Record Note Book*

### 19ECCN3701-RF and Microwave Laboratory

***Name*** : ______________________________

***Roll. No*** : ______________________________

***Branch*** : ______________________________

*Certified that this is the bonafide record of work done by the above student for ______________________Year B.E Degree during 20_____to 20 __*

____________________ ____________

*Head of the Department* *Faculty In-charge*

| End Semester Practical Examinations | |
|---|---|
| Submitted to the Autonomous Cycle Test Practical Examination held on __________ | |
| Examiner 1 | |
| Examiner 2 | |

# INDEX

| S.No | Date | Name of the Experiment | Page No. | Marks Out of 75 | Signature of Faculty with Date |
|---|---|---|---|---|---|
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| | | | | | |
| | | | Average Marks | | |

| Course Code: 19ECCN3701 | Course Title: RF and Microwave Laboratory | | |
|---|---|---|---|
| Course Category: Professional Core | | Course Level: Mastery | |
| L:T:P (Hours/Week) 0 :0: 3 | Credits:1.5 | Total Contact Hours: 45 | Max Marks:100 |

**Pre-requisites**

- 19PHBC2001 - Physics for Electrical Sciences
- 19ECCN2301-Transmission Lines and Wave Guides
- 19ECEN1003 -Antenna and Wave Propagation

**Course Objectives**

The course is intended to:

1. Measure the losses in optical fibre and its numerical aperture
2. Examine the characteristics of optical sources
3. Analyze the working Principle of Microwave sources
4. Analyze the characteristics of optical fibre.
5. Measure the performance parameters of microwave components and devices

**LIST OF EXPERIMENTS**

1. Measurement of Numerical Aperture and bending losses in Optical Fiber.
2. Measurement of Power Distribution in directional coupler and Magic Tee.
3. VI characteristics of LED and LASER Diode.
4. Characteristics of Gunn Diode Oscillator
5. Characteristics of Reflex Klystron Oscillator
6. Measurement of Antenna parameters and RF passive component characteristics using Vector Network Analyzer
7. Radiation pattern measurement of Horn Antenna.
8. Optical Time Domain Reflect meter
9. Design of low pass and high pass filters using ADS
10. Discover the source of EMI emissions in with near-field probes

| Course Outcomes | Cognitive Level |
|---|---|
| At the end of this course, students will be able to: | |
| CO1: Measure the losses in optical fibre and its numerical aperture | Analyze |
| CO2: Examine the characteristics of optical sources used in optical communication systems | Analyze |
| CO3: Analyze the working Principle of Microwave sources with its design Mechanism | Analyze |
| CO4: Analyze the Charecteristics if optical fibre using OTDR | Analyze |
| CO5: Measure the performance parameters of microwave components and devices using an appropriate equipment | Analyze |

**References :**

Lab manual prepared by the department.

**Course Articulation matrix**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 2 | 3 | - | - | 2 | 3 | 2 | - | 2 | 2 | - |
| CO2 | 3 | 3 | 2 | 2 | 3 | - | - | 2 | 3 | 2 | - | 2 | 2 | - |
| CO3 | 3 | 3 | 2 | 2 | 3 | - | - | 2 | 3 | 2 | - | 2 | 2 | - |
| CO4 | 3 | 3 | 2 | 2 | 3 | - | - | 2 | 3 | 2 | - | 2 | 2 | - |
| CO5 | 3 | 3 | 2 | 2 | 3 | - | - | 2 | 3 | 2 | - | 2 | 2 | - |

High-3; Medium-2;Low-1

**Assessment pattern**

| Type | Assessment Component | CO. No. | Marks | Total |
|---|---|---|---|---|
| **Internal Assessment** | Observation and record | 1,2,3,4,5 | 75 | 75 |
| **End Semester Examination** | Cycle Tests | 1,2,3,4,5 | 50 | 25 |
| | | | | 100 |

**Rubrics for Record Evaluation**

## Rubrics for Observation (out of 55):

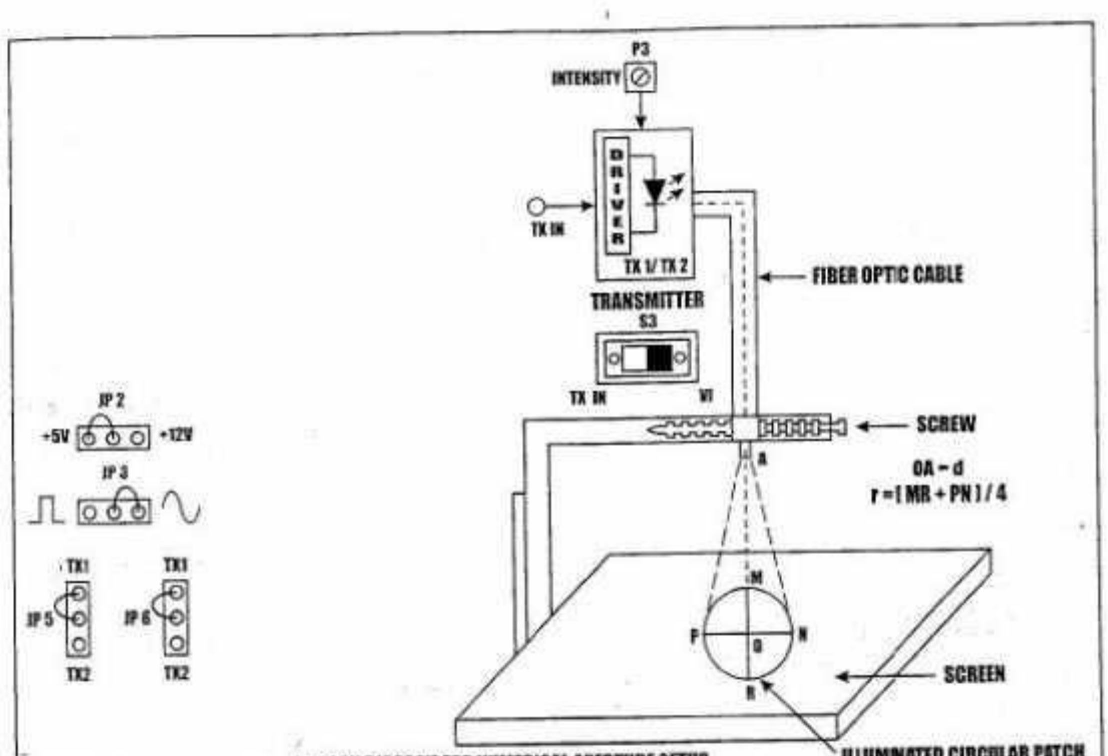
| Criteria | Level of performance | | | |
|---|---|---|---|---|
| | Excellent | Good | Satisfactory | Needs Improvement |
| Preparation | 20 | 17 | 14 | 10 |
| | Student has very clearly understood the concepts and reflected fully in the responses for pre viva. | Student has very clearly understood the concepts and reflected most of the questions in the responses for pre viva. | Student has clearly understood the concepts and reflected very few of the questions in the responses for pre viva. | Student has not understood the concepts and reflected none of the questions in the responses for pre viva. |
| Observation & Results | 25 | 22 | 19 | 15 |
| | Student demonstrates sound knowledge of lab procedures.<br><br>Student has written all the results and inferences neatly and completely. | Student Demonstrates good knowledge of the lab procedures.<br><br>Student has written most of the results and inferences neatly and completely. | Student requires help from teacher with some steps in procedures.<br><br>Student has written part of the results and inferences neatly and completely. | Student often requires help from the teacher to even complete basic procedures.<br><br>Student has written few of the results and inferences neatly and completely. |
| Viva Voce | 10 | 8 | 6 | 5 |
| | The student responded for all questions. | The student responded for most of the questions. | The student responded for part of the questions. | The student responded for few of the questions. |

| OBSERVATION Criteria | Excellent | Good | Satisfactory | Needs Improvement |
|---|---|---|---|---|
| Preparation | 20 | 17 | 14 | 10 |
| Observation & Results | 25 | 22 | 19 | 15 |
| Viva Voce | 10 | 8 | 6 | 5 |
| Total | /55 | | | |

**Rubrics for Record (Out of 20 ):**

| Criteria | Level of performance | | | |
|---|---|---|---|---|
| | Excellent | Good | Satisfactory | Needs Improvement |
| Neatness | 10 | 8 | 6 | 5 |
| | In all the entries in the record, the student has clearly written. | In most of the entries in the record, the student has clearly written. | In some of the entries in the record, the student has clearly written. | In a very few of the entries in the record, the student has clearly written |
| Submission on time | 10 | 8 | 6 | 5 |
| | The student brings the record and gets sign in time. | The student brings the record and gets sign ONE DAY late. | The student brings the record and gets sign THREE DAYS late. | The student brings the record and gets sign a WEEK later. |

| RECORD Criteria | Excellent | Good | Satisfactory | Needs Improvement |
|---|---|---|---|---|
| Neatness | 10 | 8 | 6 | 5 |
| Submission on time | 10 | 8 | 6 | 5 |
| Total | /20 | | | |



BLOCK DIAGRAM FOR NUMERICAL APERTURE SETUP

**TABULATION:**

| S.NO | PN (cm) | MR(cm) | RADIUS (cm) | DISTANCE (cm) | NA | Ømax |
|---|---|---|---|---|---|---|
| | | | | | | |

# MEASUREMENT OF NUMERICAL APERTURE AND BENDING LOSSES IN OPTICAL FIBER

**EXP No:** **DATE:**

**AIM:**

The objective of this experiment is to measure the numerical aperture and bending loss of the optical fiber.

**APPARATUS REQUIRED:**

- Experimenter kit 4
- 1 meter fiber cable
- Fiber holding fixture
- Ruler

**THEORY:**

Numerical aperture refers to the maximum angle at which the light incident on the fiber end is totally internally reflected and is transmitted properly along the fiber. The cone formed by the rotation of this angle along the axis of the fiber is the cone of acceptance of the fiber. The light ray should strike the fiber end within its cone of acceptance; else it is refracted out of the fiber core.

**Consideration in NA measurement:**

- It is very important that the optical source should be properly aligned with the cable & the distance from the launched point & the cable be properly selected to ensure that the maximum amount of optical power is transferred to the cable.
- This experiment is best performed in a less illuminated room.

**PROCEDURE:**

1. Slightly unscrew the cap of LED SFH756V. Do not remove the cap from the connector. Once the cap is loosened, insert the fiber into the cap. Now tighten the cap by screwing it back.
2. Now short the jumper as shown in the jumper diagram.
3. Connect the power cord to the kit & switch on the power supply.
4. Apply TTL high input to the LED from EXT-TTL terminal.
5. Insert the other end of the fiber into the numerical aperture measurement. Hold the white sheet facing the fiber. Adjust the fiber such that its cut face is perpendicular to the axis of the fiber.
6. Keep the distance of about 10-mm between the fiber tip and the screen. Gently tighten the screw and thus fix the fiber in the place.
7. Now observe the illuminated circular patch of light on the screen.

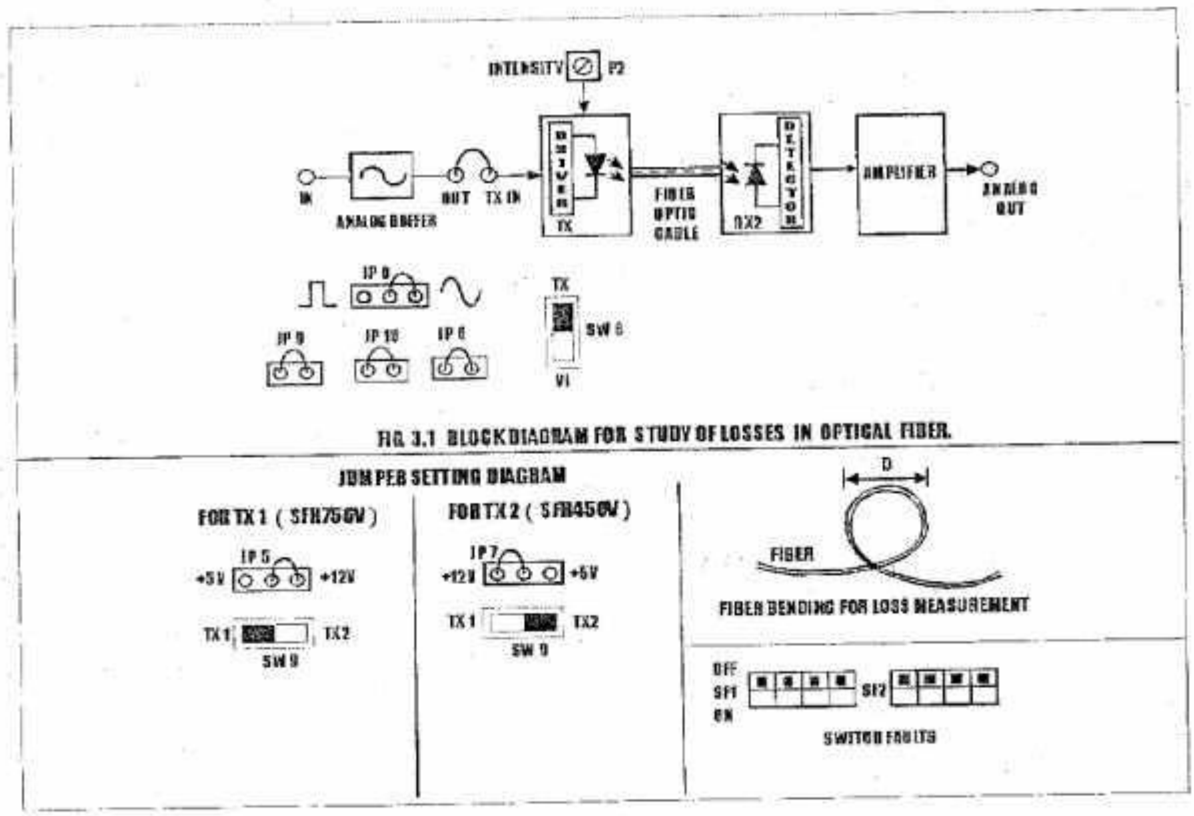



FIG 3.1 BLOCK DIAGRAM FOR STUDY OF LOSSES IN OPTICAL FIBER.

**TABULATION:**

| 1m Fiber | | 3m Fiber | |
|---|---|---|---|
| **Diameter** | **Voltage** | **Diameter** | **Voltage** |
| | | | |
| | | | |
| | | | |
| | | | |

8. Measure exactly the distance d and also the vertical and horizontal diameters MR and PN as indicated in the fig.
9. Mean radius is calculated using the following formula r= (MR+PN)/4
10. Find the numerical aperture of the fiber using the formula

    $NA= \sin\theta_{max}= r / \sqrt{d^2+ r^2}$

    Where $\theta_{max}$ is the maximum angle at which the light incident is properly transmitted through the fiber.

## MEASUREMENT OF BENDING LOSSES:

1. Slightly unscrew the cap of IR LED SFH 450V from Kit 1. Do not remove the cap from the connector. Once the cap is loosened, insert the fiber into the cap and assure that the fiber is properly fixed. Now tighten the cap by screwing it back.
2. Connect the power supply cables with proper polarity to kit 1 and kit 2. While connecting this, ensure that the power supply is OFF.
3. Connect the signal generator between the AMP I/P and GND posts in kit 1 to feed the analog signal to the pre-amplifier.
4. Keep the signal generator in sine wave mode and select the frequency = 1 kHz with amplitude = 2 Up-p (Max input level is 4 Vp-p)
5. Switches on the power supply and signal generator.
6. Check the output signal of the pre-amplifier at the post AMP O/P in kit1.
7. Now rotate the Optical Power Control Pot P1 located below power supply connector in kit 1 in anticlock wise direction. This ensures minimum current flow through LED.
8. Short the following posts in Kit 1 with the links provided.
9. +9V and +9V - This ensures supply to the transmitter.
10. AMP O/P and TRANSMITTER I/P.
11. Connect the other end of the fiber to detector FH 250V in kit 2 very carefully as per the instructions in step 1.
12. Repeat all the steps from 1 to 11 as above.
13. Bend the fiber in a loop. (As shown in fig.) Measure the amplitude of the received signal.
14. Keep reducing the diameter to about 2-cm & take corresponding output voltage readings. (Do not reduce loop diameter less than 2 cm.)
15. Plot a graph of the received signal amplitude versus the loop diameter.

## RESULT:

Thus the numerical aperture and bending loss have been measured

| | |
|---|---|
| Preparation | /20 |
| Observation & Results | /25 |
| Viva Voce | /10 |
| Record | /20 |
| Total | /75 |
| Signature of faculty with date | |

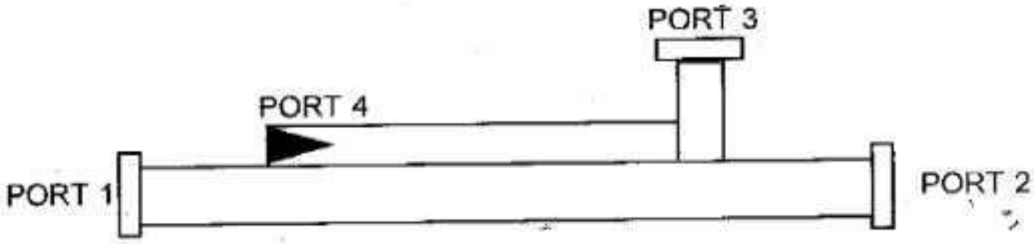



**FIG.1 DIRECTIONAL COUPLER**

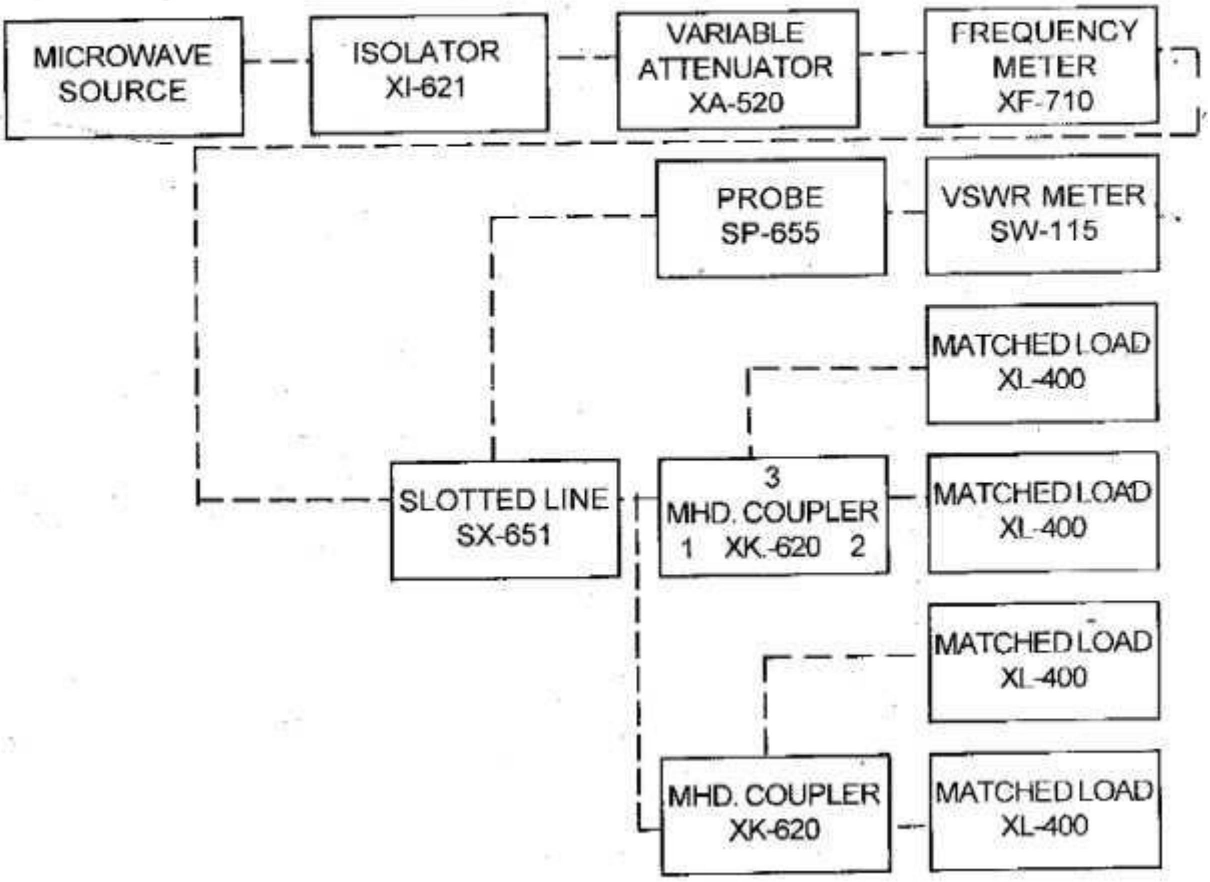



**FIG.2 MEASUREMENT OF VSWR OF MHD. COUPLER**

## MEASUREMENT OF POWER DISTRIBUTION IN DIRECTIONAL COUPLER

**EXP No:** **DATE:**

**AIM:**

To study 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

**APPARATUS REQUIRED:**

1. Microwave source (Klystron or Gunn diode)
2. Isolator
3. Frequency meter
4. Variable attenuator
5. Slotted line Tunable probe
6. Detector mount matched termination
7. MHD Coupler
8. Waveguide stand
9. Cables and Accessories
10. VSWR meter.

**THEORY:**

A directional coupler is a device with which it is possible to measure the incident and reflected wave separately. It consist of two transmission lines the main arm and auxiliary arm, electromagnetically coupled to each other Ref to the Fig.1 The power entering, in the main-arm gets divided between port 2 and port 3, and almost no power comes out in port (4) power entering at port is divided between port 1 and 4.

The coupling factor is defined as

Coupling (dB) = $10 \log_{10}[P_1 / P_3]$ Where $P_2$ is terminated.

Isolation (dB) = $10 \log_{10}[P_2 / P_3]$ Where $P_1$ is matched.

With built-in termination and power entering at port 1, the directivity of the coupler is a measure of separation between incident wave and the reflected wave. Directivity is measured indirectly as follows:

Hence Directivity D(dB) = I-C $= 10 \log_{10}[P_2 / P_1]$

Main line VSWR is SWR measured in to the main-line input terminal when the matched loads are placed at all other ports.

Auxiliary live VSWR is SWR measured in the auxiliary line looking in to the output terminal when the matched loads are placed on other terminals.

Main line insertion loss is the attenuation introduced in the transmission line by insertion of coupler, it is defined as:

$$\text{Insertion loss (dB)} = 10 \log_{10}[P_1 / P_2]$$

**PROCEDURE**

**A. Main line SWR Measurement**

1. Set up the equipment as shown in the 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.

**B. Auxiliary line SWR measurement:**

1. Set up the components and equipments as shown in the fig 2.
2. Energize the microwave source for particular frequency of operation as described in the 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.

**C. Measurement of coupling factor, Insertion loss, Isolation & Directivity.**

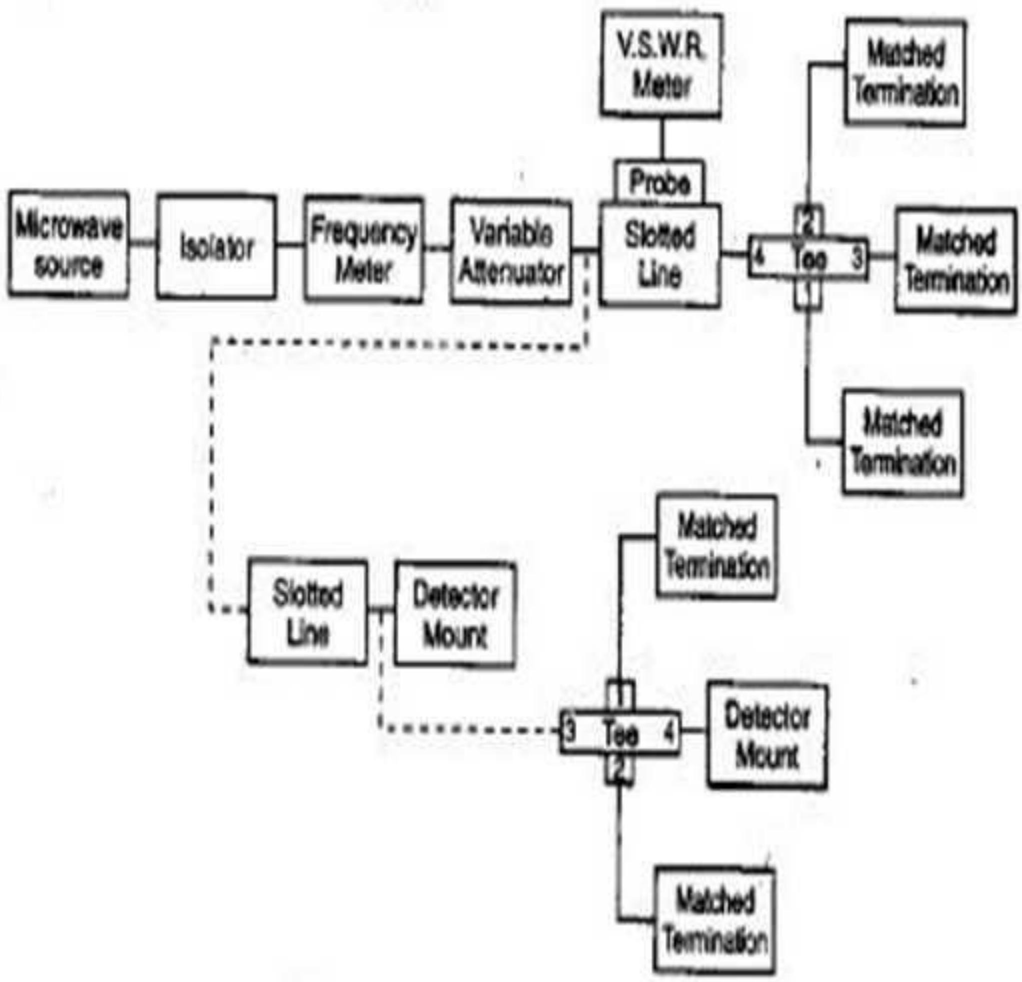
1. Set up the components and equipments as shown in the fig 2.
2. Energize the microwave source for particular frequency of operation.
3. Remove the multihole direction coupler and connect the detector mount to the frequency meter. Tune the detector for maximum output
4. Set any reference level of power on VSWR meter with the help of variable attenuator, gain control knob of VSWR meter, and note down the reading (reference level let X ).
5. Insert the direction coupler as shown in the fig 1 with detector to the auxiliary port 3 and matched termination to port 2, 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 port 3 and match termination from 2 without disturbing the set-up.
9. Connect the matched termination to the auxiliary port 3 and 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 direction coupler in the reverse direction, i.e. port 2 to frequency meter side. Matched termination to port 1 and detector mount to port 3. 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 $Y_d$. $X-Y_d$ gives isolation I (db).
14. Compute the directivity as $Y-Y_d = I-C$
15. Repeat the same for other frequencies.

**RESULT**

Thus mainline, auxiliary line VSWR, coupling factor, insertion loss, Isolation loss & directivity are measured.

| | |
|---|---|
| Preparation | /20 |
| Observation & Results | /25 |
| Viva Voce | /10 |
| Record | /20 |
| Total | /75 |
| Signature of faculty with date | |




Study of magic tee

# MEASUREMENT OF POWER DIDTRIBUTION IN MAGIC TEE

**EXP No:** **DATE:**

## AIM

Study of the power division in a magic tee

## EQUIPMENT REQUIRED

Microwave source, Isolator, Variable attenuator, Frequency meter, Slotted line, Tunable probe, Magic Tee, Matched terminations, Waveguide stand, Detector mount, VSWR Meter and Accessories.

## THEORY

The device magic tee is a combination of the E and H plane Tee. Arm 3, the H- Arm forms an H plane Tee and arm 4, the E –arm, forms an E plane Tee in combination of arm 1 and 2 as side or collinear arms. If the power is fed into arm 3(H- arm), the electric field divides equally between arm 1 and arm 2 with the same phase, and no electric field exists in arm 4. Reciprocity demands no coupling in part 3,(H-arm);If power is fed in arm 4(E- arm),it divides equally into arm 1 and 2 but out of phase with no power to arm 3.Further,if the power is fed from arm 1 and 2,it is added in arm 3(H-arm),and it is subtracted in E-arm ,i.e., arm 4.

**The basic parameters to be measured for magic Tee and defined below:**

a. INPUT VSWR: \alue of SWR corresponding to each port, as a load to the line while other ports are terminated in matched load.
b. ISOLATION: The isolation between E and H arms is defined as the ratio of the powers supplied by the generator connected to the E-arm (port 4) to the power at H-Arm (port 3) when side arms 1 and 2 are terminated in matched load.

   Hence,

$$Isolation(dB) = 10\ log_{10}\frac{P_4}{P_3}$$

c. Coupling coefficient: It is defined as $C_{ij}$=10-a/20

   where

   a is attenuation / isolation in dB when it is input arm and j is output arm.

$$a = 10\ log_{10}\frac{P_4}{P_3}$$

Where, $P_3$ is the power delivered to i arm

$P_4$ is the power detected at j arm

**PROCEDURE:**

a. VSWR Measurement of the Ports

1. Set up the components and equipments as shown in the figure. Keeping E arm towards, Slotted line and matched termination to other ports.
2. Energize the microwave source for the particular frequency of operation.
3. Measure the VSWR of the E arm as described in measurement of SWR low and medium value.
4. Connect another arm to slotted line and terminate the other port with the matched termination. Measure the VSWR as above. As above, VSWR of any port can be measured.

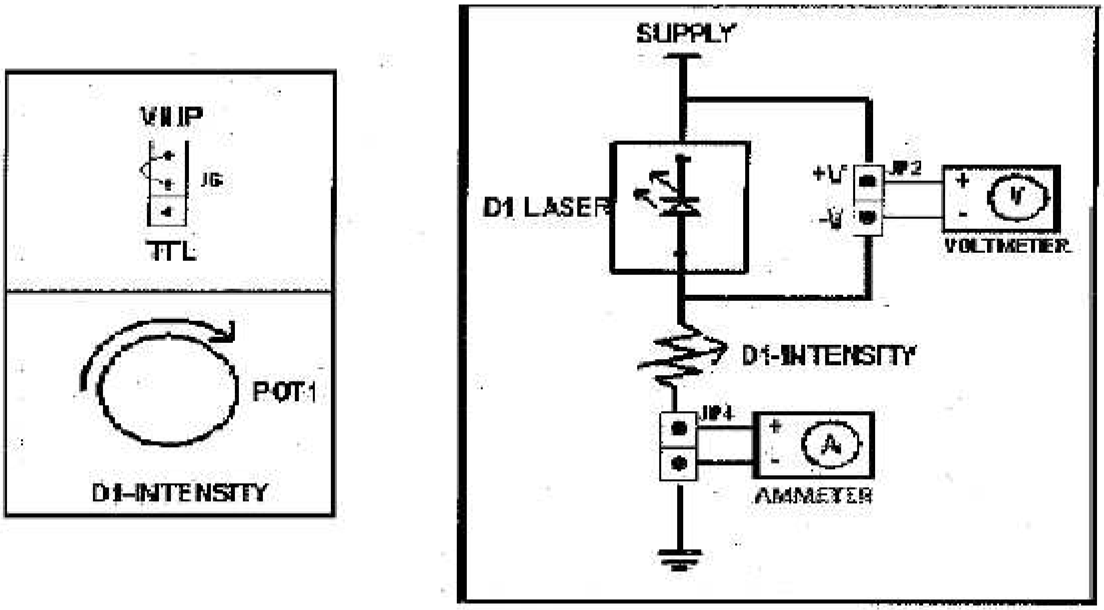
**b. Measurement of Isolation and Coupling Co-efficient**

1. Remove the Tunable probe and magic Tee from the slotted line and connect the detector mount to slotted line.
2. Energies the microwave source for particular frequency of operation and tune the detector mount for maximum output.
3. With the help of variable attenuator and gain control knob of VSWR meter, set any power level in the VSWR meter and note down. Let it be $P_3$.
4. Without disturbing the position of variable attenuator and gain control knob, carefully place the magic Tee after slotted line keeping H-arm to slotted line, detector to E-arm and matched termination to arm 1 and 2. Note down the reading of VSWR meter. Let it be P4.
5. Determine the isolation between port 3 and port 4 as $P_3$-$P_4$ in db.
6. Determine the coupling coefficient from equation given in the theory part.
7. The same experiment may be repeated for other ports also.
8. Repeat the above experiments for other frequencies.

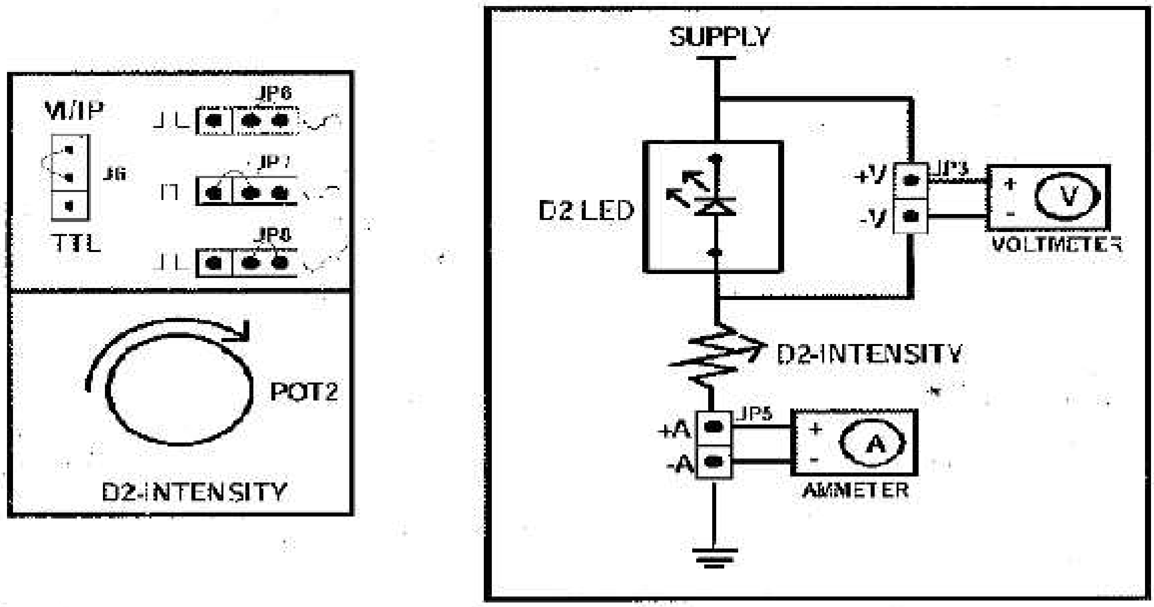
**RESULT**

Thus the power division in Magic Tee is studied.

| | |
|---|---|
| Preparation | /20 |
| Observation & Results | /25 |
| Viva Voce | /10 |
| Record | /20 |
| Total | /75 |
| Signature of faculty with date | |




EXPERIMENTAL SETUP FOR VI CHARACTERISTIC OF LASER DIODE.




EXPERIMENTAL SETUP FOR VI CHARACTERISTIC OF 660nm LED.

# VI CHARACTERISTICS OF LED AND LASER DIODE

**EXP No:** **DATE:**

**AIM:**

To study the IV characteristics of LED and LASER diode

**THEORY:**

In optical fiber communication system, electrical signal is first converted in to optical signal with the help of E / O conversion device as LED. After this optical signal is transmitted through optical fiber, it is retrieved in its original electrical form with the help O/E conversion device as photo detector.

Different technologies employed in chip fabrication lead to significant variation in parameters for the various emitter diodes. All the emitters distinguish themselves in offering high output power coupled in the plastic fiber. Data sheets for LEDs usually specify electrical and optical characteristics, out of which are important peak wavelength of emission, conversion efficiency (usually specified in terms of power launched in optical fiber for specified forward current) optical rise and fall times which put the limitation on operating frequency, maximum forward current through LED and typical forward voltage across LED.

Photo detectors usually come in variety of forms like photoconductive, photovoltaic, transistor type output and diode type output. Here also characteristics to be taken into account are response time of the detector which puts the limitation on the operating frequency, wavelength sensitivity and responsively.

**PROCEDURE:**

1. Confirm that the power switch is in OFF position
2. Make the jumper settings as shown in the jumper diagram
3. Insert the jumper connecting wires (provide along with the kit) in jumpers JP 17 and JP 16 at positions shown in the diagram.
4. Connect the ammeter and voltmeter with the jumper wires connected to JP17 and JP16 as shown in the diagram.
5. Keep the potentiometer Pr10 in its maximum position (anti-clockwise rotation) and Pr9 in its minimum position (clockwise rotation). Pr 10 is used to control current flowing through the LED and Pr9 is used to vary the amplitude of the received signal at phototransistor.

**TABULATION -1**

**CHARACTERISTICS OF LED**

| S. No. | VOLTAGE (V) | CURRENT(mA) | POWER (mw) |
|---|---|---|---|
| | | | |

**TABULATION -2**

**CHARACTERISTICS OF LASER DIODE**

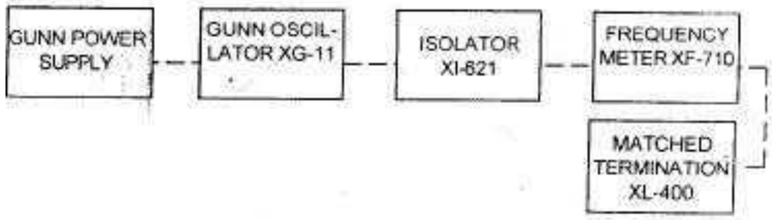
| S. No. | VOLTAGE (V) | CURRENT(mA) | POWER (mw) |
|---|---|---|---|
| | | | |

6. To get the IV characteristics of LED, rotate Pr 10 slowly and measure forward current and corresponding forward voltage. Take number of such readings for various current values and plot IV characteristics graph for the LED
7. For each reading taken above, find out the power which is product of me and V. This is the electrical power supplied to the LED. Data sheets for the LED specify optical power coupled into plastic fiber when forward current was 10 mA as 200μW. This means that the electrical power at 10 mA current is converted into 200 W of optical energy. Hence the efficiency of the LED comes out to be approx. 1.15%
8. With this efficiency assumed, find out optical power coupled into plastic optical fiber for each of reading in step 7. Plot the graph of forward current V/S output optical power of the LED.
9. Repeat the above procedure using the LASER diode.

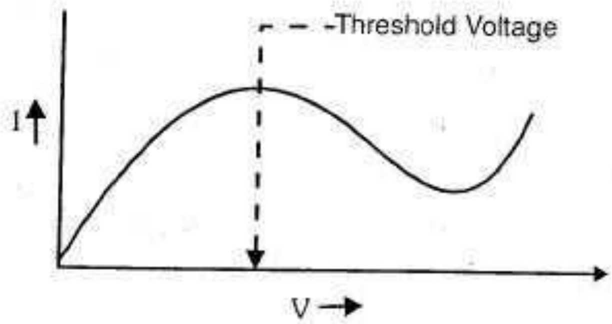
**RESULT:**

Thus, the VI characteristic of LED and LASER diode are drawn and studied.

| | |
|---|---|
| Preparation | /20 |
| Observation & Results | /25 |
| Viva Voce | /10 |
| Record | /20 |
| Total | /75 |
| Signature of faculty with date | |




**SET UP FOR THE STUDY OF DC V-I CHARCTERISTICS OF GUNN OSCILLATOR**




**I-V CHARACTERISTICS OF GUNN OSCILLATOR**

## CHARACTERISTICS OF GUNN DIODE OSCILLATOR

**EXP No:** **DATE:**

**AIM:**

To study the VI characteristics of GUNN diode.

**APPARATUS REQUIRED:**

1. GUNN diode
2. GUNN Oscillator
3. Isolator
4. Frequency meter
5. Matched termination
6. Gunn Power Supply

**THEORY:**

The GUNN oscillator is based on negative differential conductivity effect in bulk semiconductors which has two conduction bands separated by an energy gap (greater than thermal energies).A disturbance at the cathode gives rise to high field region which travels towards the anode. When this field domain reaches the anode, it disappears & another domain is formed at the cathode & starts moving towards anode & so on. The time required for domain to travel from cathode to anode (transit time) gives oscillation frequency. In a GUNN oscillator, the GUNN diode is placed in a resonant cavity. The oscillation frequency is determined by cavity dimensions.

Although GUNN oscillator can be amplitude modulated with the bias voltage, we have used a PIN modulator for square wave modulation of the signal coming from GUNN diode .A measure of the square wave modulation capability is the modulation depth i.e. the output ratio between „ON‟‟ and „OFF‟‟ state.

**PROCEDURE**:

1. Set the components as shown in the SETUP diagram
2. Keep the control knobs of GUNN power supply as below:

   Meter Switch - „OFF‟‟

   GUNN bias knob – fully anticlockwise

   PIN bias knob – fully anticlockwise

   PIN mode freq. - Any position

3. Set the micrometre of GUNN oscillator for required freq. of operation

**TABULATION**

**CHARACTERISTICS OF GUNN OSCILLATOR**

| SL.NO | VOLTAGE (V) | CURRENT (mA) |
|---|---|---|
| | | |

4. Switch “ON” the GUNN power supply.
5. Measure the GUNN diode current corresponding to the various GUNN bias Value through the digital panel meter & meter switch. Do not exceed the bias Voltage above 10 volts.
6. Plot the voltage and current readings to get VI Characteristic curve.
7. Measure the threshold voltage which corresponds to maximum current.

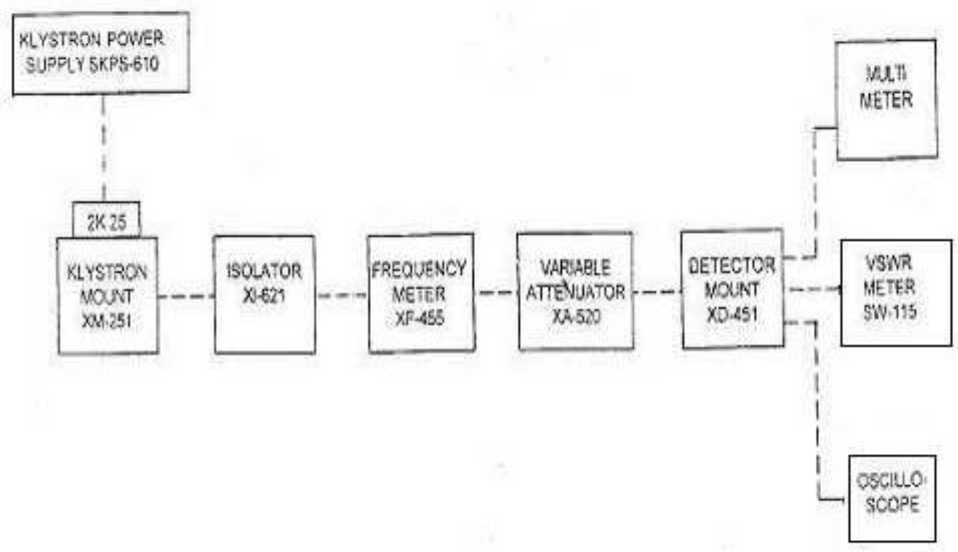
**MODEL GRAPH:**

Plot a graph keeping voltage in X-axis and Current in Y-axis

**RESULT:**

Thus the VI characteristics of GUNN diode oscillator is studied.

| | |
|---|---|
| Preparation | /20 |
| Observation & Results | /25 |
| Viva Voce | /10 |
| Record | /20 |
| Total | /75 |
| Signature of faculty with date | |




SET UP FOR STUDY OF KLYSTRON TUBE

# CHARACTERISTICS OF REFLEX KLYSTRON OSCILLATOR

**EXP No:** **DATE:**

**AIM:**

To determine the characteristics of the Reflex klystron

**APPARATUS REQUIRED:**

- Klystron power supply
- Klystron tube and klystron mount
- Isolator
- Frequency meter
- Variable attenuator
- Detector mount
- Waveguide stand
- VSWR meter
- Oscilloscope & BNC cable

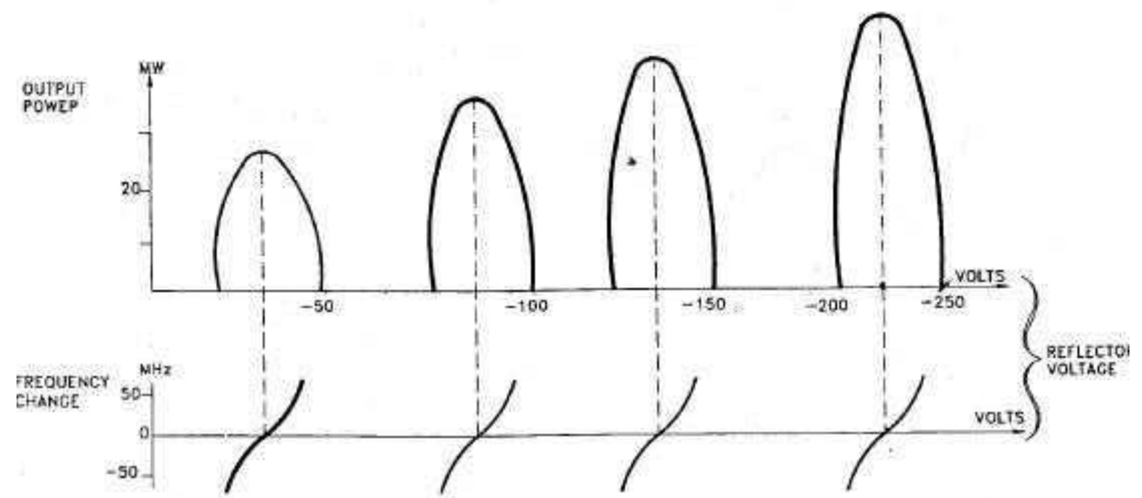
**THEORY:**

The Reflex klystron makes the use of the velocity modulation to transform a continuous electron beam into microwave power. Electrons emitted from the cathode are accelerated & passed through the positive resonator towards negative reflector, which retards and finally reflects the electrons and the electrons turn back through the resonator.

Suppose an RF field exists between the resonators, electrons traveling will be accelerated or retarded, as the voltage at the resonator changes in amplitude. The accelerated electron leaves at the reduced velocity

The electrons leaving the resonator will need different time to return, due to changes in velocities. As a result, returning electrons group together in bunches, as the electron bunches pass through resonator, they interact with voltage at resonator grids. If the bunches, pass the grid at such time that the electrons are slowed down by the voltage then energy will be delivered to the resonator and klystron will oscillate.

The frequency is primarily determined by the dimensions of resonating cavity. Hence, by changing the volume of resonator, mechanical tuning of klystron is possible. Also a small frequency change can be obtained by adjusting the reflector. This is called Electronic Tuning.




**MODES OF 2K25**

**PROCEDURE:**

**A. CARRIER WAVE OPERATION**

1. Set up the equipment as shown in the SETUP diagram.
2. Set the variable attenuator at the minimum at position.
3. Set the mod switch of klystron power supply at CW position, beam voltage control knob to fully anticlockwise and reflector voltage control knob to fully clockwise and meter switch to OFF position.
4. Rotate the knob of frequency meter at one side fully
5. Connect the D.C microampere meter at one side fully
6. Switch on the klystron power supply, VSMR meter and cooling fan for the klystron tube.
7. Put on beam voltage switch and rotate the beam voltage knob clockwise slowly pit to 300 volt meter reading and observe beam current position.
8. Change the reflector voltage slowly and watch the current meter set the voltage for the maximum deflection in the meter.
9. Tune the plunger of the 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 two, horizontal line and vertical marker. 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 & frequency for each reflector voltage.

**B. AM WAVE OPERATION**

1. Setup the equipment as shown in the SETUP diagram
2. Set micrometer of variable attenuator around some position.
3. Set the range switch of VSWR meter at 40 dB position, input selector switch to crystal impedance, meter switch to narrow position.
4. Switch on the klystron power supply, VSWR meter and cooling fan for the klystron tube.
5. Put on beam voltage switch and rotate the beam voltage knob clockwise slowly put to 300 voltmeter reading & observe beam current position.
6. Keep the AM-MOD amplitude knob and AM-FRE knob at the mid position.

**TABULATION:**

| S.No | Minimum Voltage | Maximum Voltage | Minimum Voltage | Amplitude | Frequency | Power |
|---|---|---|---|---|---|---|
| | | | | | | |

7. Rotate the reflector voltage knob to get reflection and rotate the AM-MOD amplitude knob to get maximum output in VSWR meter.

8. Maximize the deflection with frequency knob to get the maximum output in VSWR meter.

9. If necessary, change the range switch of VSWR meter 30dB to 50 dB if the deflection in VSWR meter is out of scale or less than normal scale respectively. Further the output can also reduced by variable attenuator for setting the output for any particular position.

### C. <u>FM WAVE OPERATION</u>

1. Set up the equipment as shown in the SETUP diagram

2. Keep the position of the variable attenuator at the minimum attenuation position.

3. Set the mode switch of klystron power supply at CW position, beam voltage control knob to fully anticlockwise and reflector voltage control knob to fully clockwise and meter switch to OFF position.

4. Keep the time\division scale of oscilloscope around 100 Hz frequency measurement and volt\div.to lower scale.

5. Switch ON klystron power supply and oscilloscope.

6. Keep amplitude knob of FM modulator to maximum position and rotate the reflector voltage anticlockwise to get the mode. The horizontal axis represents the reflector voltage axis and vertical axis represents output power.

7. By changing the reflector voltage and amplitude of FM modulation, any mode of of klystron tube can been seen an oscilloscope.

## RESULT:

Thus the characteristics of reflex klystron was determined and plotted.

| | |
|---|---|
| Preparation | /20 |
| Observation & Results | /25 |
| Viva Voce | /10 |
| Record | /20 |
| Total | /75 |
| Signature of faculty with date | |

## MEASUREMENT OF ANTENNA PARAMETERS AND RF PASSIVE COMPONENT CHARECTEISTICS USING VECTOR NETWORK ANALYZER

**EXP No:** **DATE:**

**AIM**

To estimate S parameter of microwave devices (Circulator and Isolator) and Antenna

**REQUIREMENTS**

| 1 | DUT, Equipments and Accessories | Model Name | Quantity |
|---|---|---|---|
| 2 | Circulator | CIRCULATOR | 1 |
| 3 | Vector network analyzer/ Spectrum Analyzer | Obzor 1300 or any components | 1 |
| 4 | Matched termination | 50Ω with SMA (male) connector | 1 |
| 5 | Measuring coaxial cable | Standard 50Ω type N male to SMA female | 2 |

**THEORY**

The circulator is defined as a passive device with three or more ports, where is transferred from one port to next in a prescribed order i.e., for a three port circulator (fig. a) power entering port three leaves port one where port two is decoupled. AS three port ferrite junction circulator, usually called Y-junction circulator is mostly commonly used. They are available in either rectangular waveguide or strip line form. The signal flow in the three port circulator is assumes as 1 to 2, 2 to 3, & 3 to 1.As shown in the figure if one port of a circulator is loaded, it becomes an isolator, i.e., power will pass from ports 1 to 2 but power reflected back from port 2 will go to the load at port 3versus going back to port 1.

The isolator is defined as a passive two port, where a power is transmitted in direction and reflected in another direction, i.e., power entering port 1 leaves port 2, but power entering port 2 is absorbed. An isolator can be a specially designed item. But we can get an isolator if we connect a matched load to port 3 of a 3 port circulator. Circulator and isolators are non-reciprocal devices, means their behaviour in one direction is very different from another direction.

**SET UP AND PROCEDURE USING VECTOR NETWORN ANALYZER**

1. Connect 50Ω standard coaxial cables to the port of the vector network analyzer and perform the calibration described or refer to the test and measure instrument user manual for details.
2. Perform the VNA calibration for the following settings before starting with the experiment and observations.

   Frequency range: 700MHz to 103GHz
   No. of points: 401 or higher
   Power level: 0 dBm or lower
   IF Bandwidth: 10 KHz

**MEASUREMENT OF INPUT RETURN LOSS CHARACTERISTICS**

1. Connect the output of the network analyzer (port 1) to the port 1 of the circulator module (ie. signal of VNA is applied as the input to the circulator).

2. Connect the port 2 of the circulator module to the network analyzer port 2( ie., output from the circulator is applied to the VNA for data display).
3. Connect 50Ω termination (load) to port 3 of the circulator module.
4. To observe S11 perform the following settings in “RESPONSE” menu of VNA.

    Measurement: S11 Format: Log
    magnitude

5. Apply markers and note down the readings for the frequency specified in the observation table. Save trace data for post processing and save trace image.
6. Similarly the return loss characteristics of the other ports can be observed.

**CIRCULATOR CHARACTERISTICS**

1. Connect the output of the network analyzer (port 1) to the port 1 of the circulator module (ie., signal of VNA is applied as the input to the circulator).
2. Connect the port 2 of the circulator module to the network analyzer port 2( i.e., output from the circulator is applied to the VNA for data display).
3. Connect 50Ω termination (load) to port 3 of the circulator module.
4. To observe the circulator action from port 1 to 2 perform the following settings in “RESPONSE” menu of VNA.

    Measurement: S12 Format: Log
    magnitude

5. Apply markers and note down the readings for the frequency specified in the observation table. Save trace data for post processing and save trace image.
6. Repeat the procedure for port 2 to port 3 and port 3 to port 1.

**ISOLATOR CHARACTERISTICS:**

1. Connect 50Ω standard coaxial cables to the port of the vector network analyzer and perform the calibration.
2. Perform the VNA calibration for the following settings before starting with the experiment and observations.

    Frequency range: 700MHz to 103GHz No. of points:
    401 or higher Power level: 0
    dBm or lower
    IF Bandwidth: 10 KHz

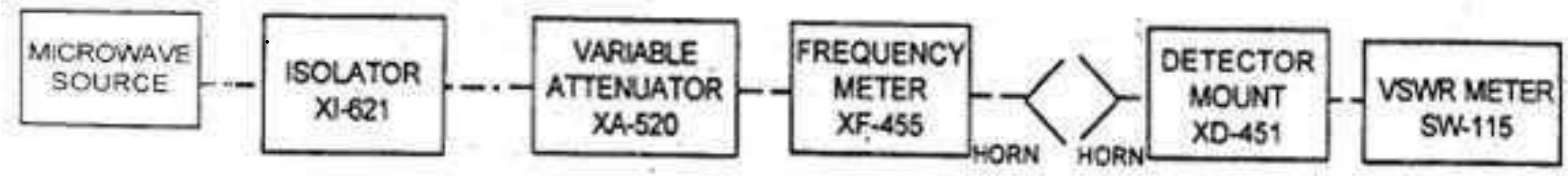
**ISOLATOR ACTION**

1. Repeat the steps of circulator characteristics until step 5 and follow the procedure given below.
2. Keeping the settings unchanged, now connect the output of the network analyzer (P1) to the P2 of the circulator module and connect the port 1 of the circulator module to network analyzer port2.
3. The data trace displayed on the network analyzer screen is for isolator action for signal going from P2 to P1.
4. Apply markers and note down the readings for the frequencies specified in the observation table. Save the trace data for post processing and save the trace image.

**RESULT**

Thus the “S” parameter of the microwave devices (circulator and isolator) and antenna has been estimated
.

| | |
|---|---|
| Preparation | /20 |
| Observation & Results | /25 |
| Viva Voce | /10 |
| Record | /20 |
| Total | /75 |
| Signature of faculty with date | |




*Setup for Radiation Pattern Measurement*

# RADIATION PATTERN MEASUREMENT OF HORN ANTENNA

**EXP No:** **DATE:**

**AIM:**

To plot radiation pattern and to obtain the beam width of the Horn antenna

**APPARATUS REQUIRED:**

1. Klystron power supply, Klystron Oscillator
2. Isolator
3. Variable attenuator.
4. Horn antenna.
5. Detector mount
6. VSWR meter/ Power meter

**THEORY**

If a transmission line, propagating energy is left open at one end, there will be radiation from this end. In case of a rectangular wave guide this antenna presents a mismatch of about 2 and it radiates in many directions. This match will improve if the open wave guide is a horn shape.

The Radiation pattern of an antenna is a plot of field strength of the power intensity as a function of the aspect angle at a constant distance from the radiating antenna. An antenna pattern is of course three dimensional, consisting of several lobes, the main lobe, side lobe and the back lobe. The major power is concentrated in the main lobe .It is required to keep power as low as possible in the other lobes. The power intensity at the maximum in the main lobe is compared to the power intensity achieved from an imaginary Omni-directional antenna with the same power fed to the antenna is defined as the Gain of the antenna

**TABULATION – 1**

**ANTENNA MEASUREMENT (HORN)**

| SL.NO | ANGLE (ϕ) | POWER (MW) |
|---|---|---|
| | | |

**3dB BEAMWIDTH:**

This is the angle between the two points on the main lobe where the power intensity is half the maximum power intensity. The antenna pattern measurement is always done in far field region. Far field pattern is achieved at a minimum distance of $2D^2 / \lambda_0$ (for rectangular Horn antenna) , where D is the size of the broad wall of horn aperture. One method to find the gain of the antenna is to compare the unknown antenna with the standard gain antenna with known gain. Another one is to use two antennas, one as a transmitter and other as a receiver. Now gain can be calculated as

$$P_r = P_t \lambda_0 \, G1G2 / (4\Pi S)^2$$

Where, $P_t$ is transmitted power, $P_r$ is the received power.G1, G2 gain of Transmitting and receiving antennas, S is the radial distance between two antennas. $\lambda_o$ is the free space wave length. If both transmitting and receiving antennas are identical having gain G then,

$$G = 4\Pi S / \sqrt{I_o} (P_r / P_t)$$

**PROCEDURE:**

2. Step up the equipments as shown in the figure. Keeping the axis of both the horn antenna in the same line.
3. Energize the Klystron Oscillator for maximum output at desired frequency with square wave modulation by tuning square wave amplitude and frequency of the modulating signal.
4. Obtain full wave deflection on normal db scale at any convenient range switch position of the VSWR meter by gain control knob or by variable attenuator.
5. Tune receiving horn to the left in 2 or 5 degree steps and note the corresponding VSWR db reading in normal db range.( If power meter is used, take the readings of the power meter)
6. Repeat the above step but this time turns the receiving horn to the right and note down the readings.

.

**RESULT**

Thus the radiation pattern of horn antenna is plotted and bandwidth is obtained.

| | |
|---|---|
| Preparation | /20 |
| Observation & Results | /25 |
| Viva Voce | /10 |
| Record | /20 |
| Total | /75 |
| Signature of faculty with date | |

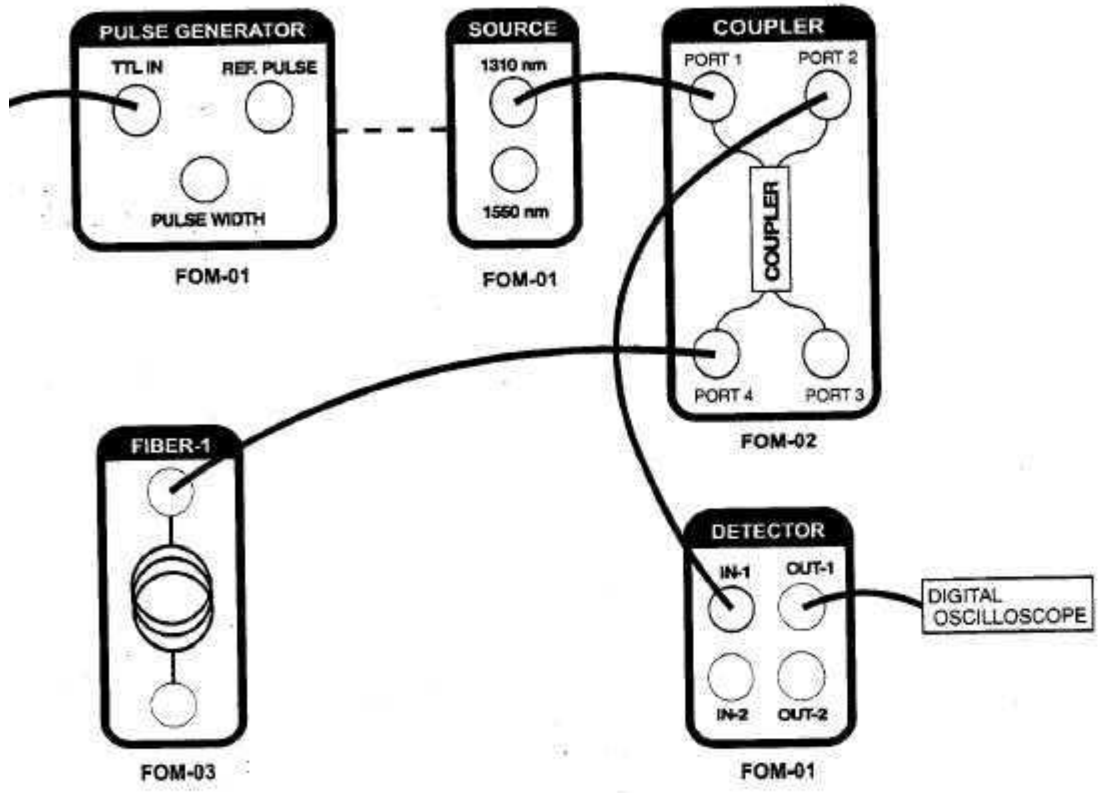



FIG.1 OPTICAL TIME DOMAIN REFLECTOMETRY

# OPTICAL TIME DOMAIN REFLECTOMETER

**EXP No:** **DATE:**

**AIM**

To study the operation of OTDR using the source of 1310 nm LASER diode.

**APPARATUS REQUIRED**

- FOM-01, FOM-02 & FOM-03
- 1 meter ST-ST glass fiber cables – 05
- Dual Channel Digital Storage Oscilloscope (DOS) 100 MHz
- Function Generator 1 MHz

**THEORY**

**BASIC WORKING PRINCIPLE**

More accurate measurements can be made by means of an Optical Time Domain Reflectometer. The main characteristic of making this instrument so versatile and used is its capability of measuring fiber local properties. The OTDR can measure not only fiber attenuation; it can give the trend of distributed losses along the fiber link.

For such reason, OTDR is used in

- Loss fiber coefficient
- Splices and connectors losses
- Splices and connectors spatial position
- To find out the fiber link length(or two subsections)
- To recognize fiber defects or damages

The OTDR is based on the Rayleigh scattering taking place in the optical fiber

1. An optical laser source reduces a pulse that is launched into the optical fiber through a directional coupler.
2. During the propagation, a portion of the pulse power is back –reflected due to Rayleigh scattering and is collected by a detector through the directional coupler.
3. At the time $\tau$ detector receives reflector pulse power coming from a distance.

$$R= c\ \Delta$$

t\2n Where n is the fiber refractive index

$\Delta$ t= time difference between reference pulse and back reflected pulse.

**RELATIVE THEORY**

OTDR is the detection and analysis, in relation to time of the retro diffused light by an optical fiber.in relation to time relation expresses

t: $P_r(t) = 1/2 P_o \tau V_g \alpha_d S^{-2\alpha V g t}$

Where $P_o$ is the average power injected into the fiber $\tau$ is pulse length

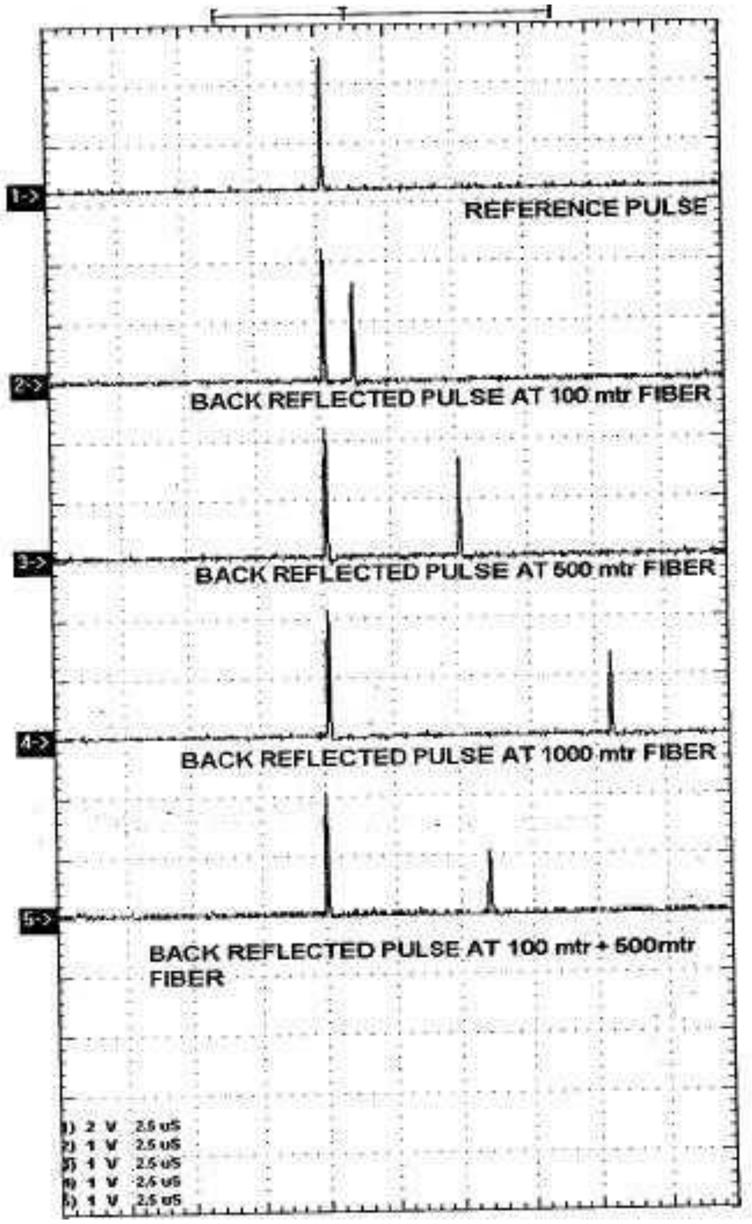
$V_g$ ~c/n1= group velocity

$\alpha_d$= Rayleigh diffusion coefficient

S= retro diffusion factor

$\alpha$ = linear attenuation of the fiber

**OUPUT WAVEFORM:**



The curve representing 10 log $P_r/P_o$ in relation to Z= $V_g$t (Z expressed in Km) is a straight line, whose slope is equal to 2 $A_{dB}$. Where $A_{dB}$ is lineic attenuation of the fiber expressed in dB/Km. The spatial resolution of the OTDR is related to the width of the pulse by relation

$$R= c\ \Delta\ t\backslash 2n$$

Where c= $3*10^8$m/s is the light in the vacuum and n effective index of a mode. Δ t= time difference between reference pulse and back reflected pulse. n= Refractive index of material of fiber core (for glass, n=1.5).

## PROCEDURE

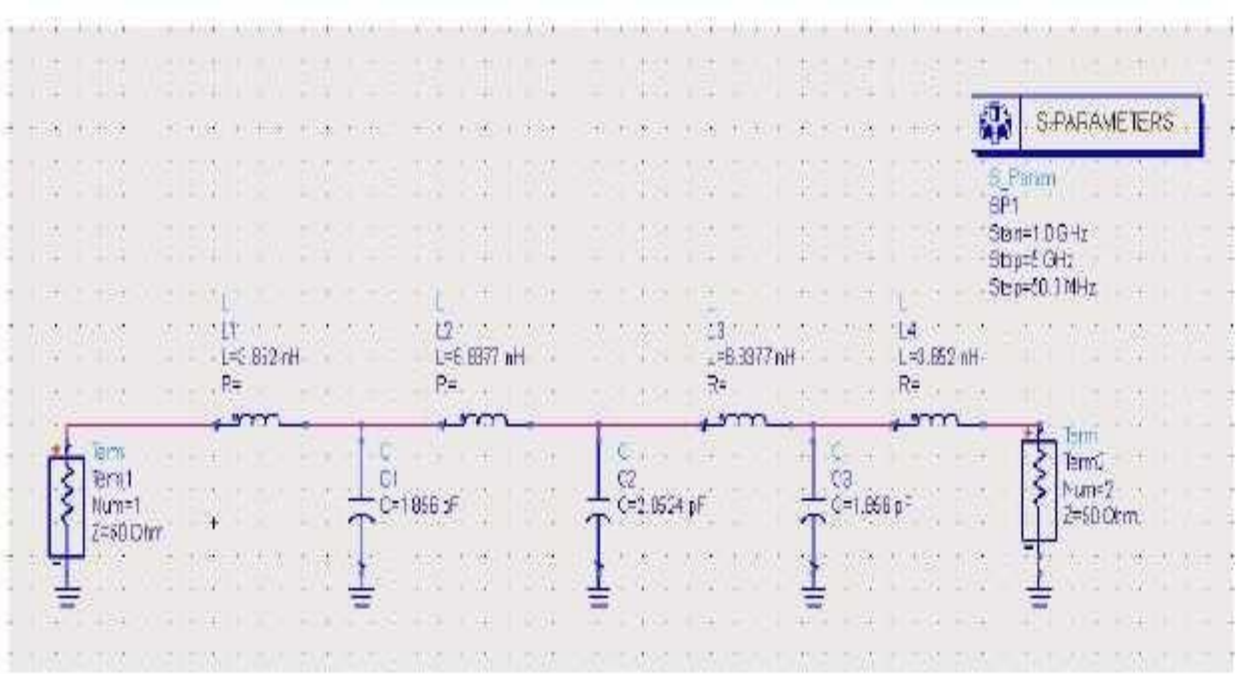
2. Refer to fig 1.connect function generator to TTL IN post of FOM -01 using BNC connector
3. Connect 1310nm post (FOM-01 module) to port -1 of coupler (FOM-02 module) using ST_ST 1 meter SM patch cord provided with modules.
4. Connect IN-1 post (FOM-01 module) to port -2 of coupler (FOM-02 module) using ST_ST 1 meter SM patch cord provided with modules and other end of fiber keep as it is.
5. Connect port-4 of coupler(FOM-01 module) to one end of fiber -1(FOM-03 module) using ST – ST 1 meter SM patch cord provided with modules and other end of fiber keep as it is.
6. Connect CH1 of DSO to REF PULSE post (FOM-01 module) as a ref pulse to be transmitted.
7. Connect CH2 of DSO to OUT-1 post (FOM-01 module) as a output from detector.
8. Connect the power supply to FOM-01 module. While connecting this ensure that the power supply is OFF.
9. Keep pulse width pot on minimum position i.e. anticlockwise direction.
10. Set external function generator to 1 kHz TTL input and connects to TTL IN of FOM_01.
11. Now switch ON the power supply of module FOM-01s, function generator and Digital Storage Oscilloscope.
12. Check ref pulse at REF>PULSE test point on front panel of module FOM_01.set the ref. pulse to 100 ns using PULSE WIDTH pot.
13. Observe output at OUT-1 post on front panel of module FOM-01 using DSO. Note down time Δ t between two pulses. Find the length of fiber.
14. Repeat the procedure using fiber-02 and observe the waveform using DSO. Note down time Δ t between two pulses. Find the length of fiber.
15. Repeat the procedure using fiber-3 and observe the waveform using DSO. Note down the time Δ t between two pulses. Find the length of fiber.

## RESULT

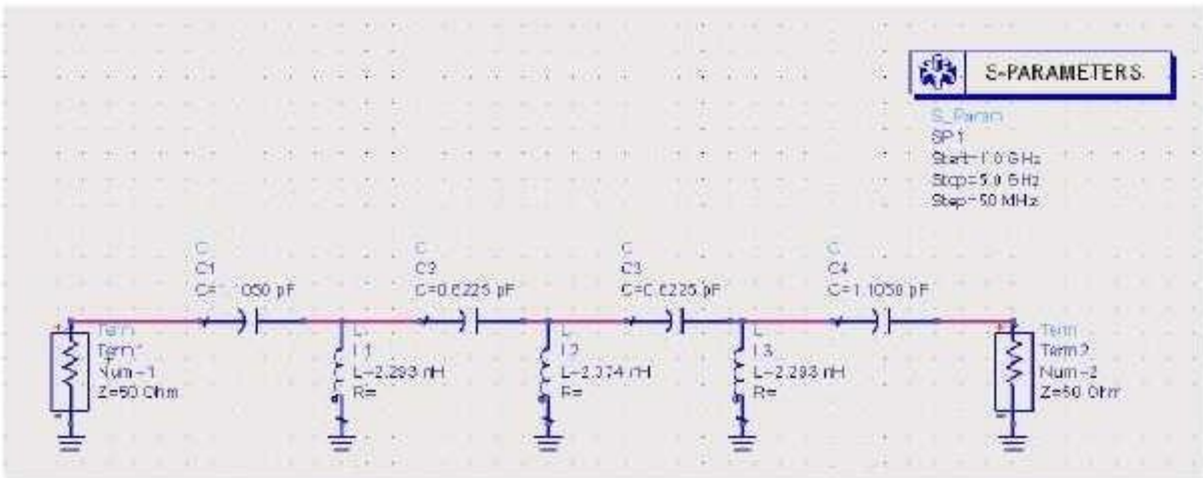
The operation of OTDR using the source of 1310 nm LASER is studied.

| | |
|---|---|
| Preparation | /20 |
| Observation & Results | /25 |
| Viva Voce | /10 |
| Record | /20 |
| Total | /75 |
| Signature of faculty with date | |

**LOW PASS FILTER:**




**HIGH PASS FILTER:**



# DESIGN OF LOW PASS AND HIGH PASS FILTER USING ADS

**EXP No:** **DATE:**

**AIM**

To design a micro strip low pass, high pass filter with cutoff frequency 2.44GHz 20db attenuation at the frequency 3GHz for chebyshev approximation response with 0.1 dB ripple.

**APPARATUS REQUIRED:**

PC with ADS software installed

**FILTERS:**

A filter is a network that provide perfect transmission for signal with frequencies in certain pass band region and infinite attenuation in the stop band regions" such ideal characteristics cannot be attained and the goal of filter design is to approximate the ideal requirements to with an acceptable tolerance filters are used to all frequency range and are categorized into four main groups

**LPF:**

Low pass filter that transmits all signal between dc and some other upper limit and attenuate all signals with frequency above cutoff frequency.

**HPF:**

High pass filter that pass all signals with frequencies above the cutoff value used and reject signals with frequencies below cutoff frequency.

**REALIZATION OF FILTERS:**

There were essentially two low frequency synthesizers" techniques for filters in use they are: image parameter method and insertion loss method. The image parameter method provides a relatively simple filter design approach but has the disadvantage that an arbitrary frequency response can't be incorporated in design. Insertion loss design procedure is based on attenuation response or insertion loss of a filter.

$P_{IL}$=Power available from source/power delivered to load

Designing a filter using the insertion loss approach begins by designing a normalized low pass prototype. The network consists of reactive elements forming a ladder usually known as a ladder network. The order of the network corresponds to the number of reactive elements. Impedance transformation and frequency scaling are then applied to the transform the network to no unity cut-off frequency, non-unity source/load resistance and to other type of filters such as high pass, band stop or band pass.

**PROCEDURE**:

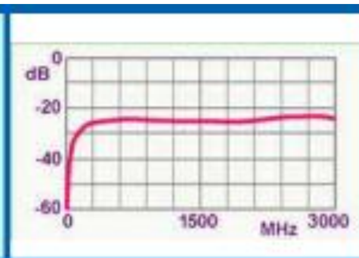
1. Log into the workstation
2. Run the ADS Software
3. Form the main window of ADS , create a new project folder name filters
4. The new schematic window will be created by clicking the new schematic button on the menu bar
5. From the component palette drop down list select the component pallete

   "lumped components" draw the schematic shown in fig(6) of low pass filter
6. Now change the component palette to Simulation S parameter", and the termination network "TERM" into the schematic. The termination network components TERM1 &TERM2. The S parameter simulation control SP1 determines the start, stop, and frequency.
7. Set the parameter SP1 to start, stop, and step

**RESULT:**

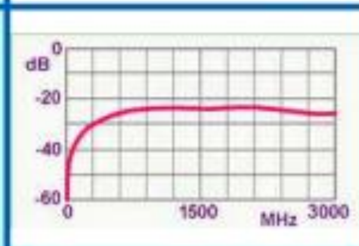
Thus the design of filter is simulated using ADS.

| | |
|---|---|
| Preparation | /20 |
| Observation & Results | /25 |
| Viva Voce | /10 |
| Record | /20 |
| Total | /75 |
| Signature of faculty with date | |

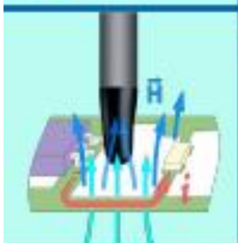

This large-diameter close field probe is the most sensitive and therefore has the lowest resolution. It can be used at distances up to 10 cm from units.

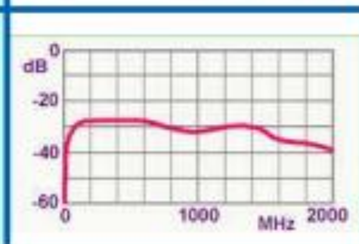
Frequency: 30 MHz to 3 GHz
Diameter: Approx. 25 mm


With a higher resolution and a lower sensitivity than the N9311X-100-1, this probe is suitable for measurements up to 3 cm from units.

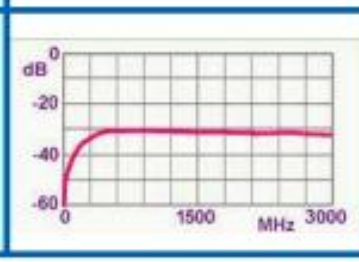
Frequency: 30 MHz to 2 GHz
Diameter: Approx. 10 mm




Designed for detecting magnetic fields emitting vertically from the surface area of flat units. The probe enables the measurement of obstructed parts of the printed circuit board.

Frequency: 30 MHz to 3 GHz
Resolution Approx. 2 mm


Designed for detecting surface and circular magnetic fields on conducting paths, metalized surfaces, plug and socket connectors, cables and component connections.

Frequency: 30 MHz to 2 GHz
Resolution approx. 5 mm

**DISCOVER THE SOURCES OF EMI EMISSIONS WITH NEAR FIELD PROBES**

**EXP No:** **DATE**

**AIM**:

To discover the EMI emissions in RF PCB board using near field probe

**APPARATUS REQUIRED:**

- Spectrum analyzer
- Near filed probe
- RF PCB board

**THEORY:**

An electromagnetic field is a combination of the electro field (E-field) and the magnetic field (H-field). Various probes are used to detect emissions in each field type.

**H-Field Probes**

Typically the H-field emission source stems from chipset pins, PCB traces, power or signal cables, or metal closures that are not well grounded. Appropriately, the sensing element of an H-field probe is a simple coil that is inductively coupled to the emitting trace or wire. The H-field probe provides the maximum output voltage of the spectrum analyzer when its loop is aligned with the current-carrying wire. When troubleshooting EMI, engineers need to rotate and move the probe over the DUT's surface to locate the maximum power readout and ensure an important emission source is not overlooked.

**E-field probes**

E-fields can be generated by un-terminated cables and wires, and printed circuit board traces leading to high-impedance logic, which can be high-impedance inputs or tri-state outputs of logic-integrated circuits. The simplest E-field probe is essentially a small antenna. The E-field probe easily detects over-the-air signals, like cellular downlink signals. These higher level over-the-air signals may require an increase in attenuation to prevent the spectrum analyzer from becoming over loaded. However, the attenuation increase will degrade the sensitivity of the spectrum analyzer.

**PROCEDURE:**

1. Connect the spectrum analyzer probe with near filed probe
2. Move the tip of near filed H/E probe along the PCB board
3. EMI Emissions are indicted by raising signal in the spectrum
4. The result can be viewed in Signal software with PC
5. Mark the amplitude and frequency of the RF emission
6. Compare with the approved standards of EMI emissions
7. Repeat for different RF boards and identify the interference source

**RESULT:**

Thus various EMI emissions are identified in RF PCB board and compared with existing standard.

| | |
|---|---|
| Preparation | /20 |
| Observation & Results | /25 |
| Viva Voce | /10 |
| Record | /20 |
| Total | /75 |
| Signature of faculty with date | |