ST. ANNE'S

COLLEGE OF ENGINEERING AND TECHNOLOGY

(Approved by AICTE, New Delhi. Affiliated to Anna University, Chennai)

(An ISO 9001 **:** 2015 Certified Institution)

ANGUCHETTYPALAYAM, PANRUTI – 607 110.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

EC8761 ADVANCED COMMUNICATION LABORATORY

NAME: ……………………………………………………………

REG.NO: …………………………………………………………

BATCH/YEAR: …………………………………………………

EC8761 ADVANCED COMMUNICATION LABORATORY   L T P C 0 0 4
LIST OF EXPERIMENTS

LIST OF OPTICAL EXPERIMENTS

1. Measurement of connector, bending and fiber attenuation losses.

2. Numerical Aperture and Mode Characteristics of Fibers.

3. DC Characteristics of LED and PIN Photo diode.

4. Fiber optic Analog and Digital Link Characterization - frequency response(analog), eye diagram and BER (digital)

LIST OF WIRELESS COMMUNICATION EXPERIMENTS

1. Wireless Channel Simulation including fading and Doppler effects

2. Simulation of Channel Estimation, Synchronization & Equalization techniques

3. Analysing Impact of Pulse Shaping and Matched Filtering using Software Defined Radios

4. OFDM Signal Transmission and Reception using Software Defined Radios
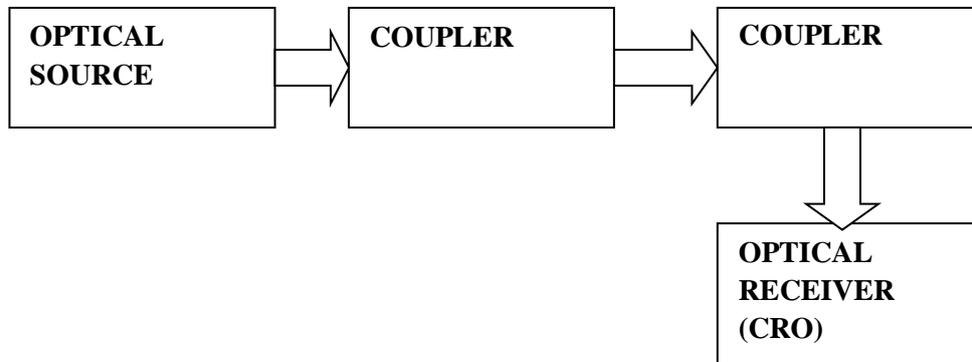
LIST OF MICROWAVE EXPERIMENTS

1. VSWR and Impedance Measurement and Impedance Matching

2. Characterization of Directional Couplers, Isolators, Circulators

3. Gunn Diode Characteristics

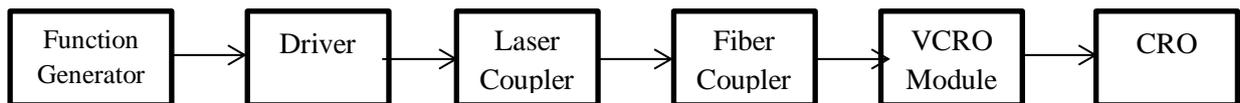4. Microwave IC – Filter Characteristics

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OPTICAL EXPERIMENTS

BLOCK DIAGRAM: (Coupling Loss)

```
┌──────────────┐      ┌──────────────┐      ┌──────────────┐
│ OPTICAL      │ ───▶ │ COUPLER      │ ───▶ │ COUPLER      │
│ SOURCE       │      │              │      │              │
└──────────────┘      └──────────────┘      └──────┬───────┘
                                                    │
                                                    ▼
                                             ┌──────────────┐
                                             │ OPTICAL      │
                                             │ RECEIVER     │
                                             │ (CRO)        │
                                             └──────────────┘
```

Without Coupler:

```
┌───────────┐   ┌────────┐   ┌─────────┐   ┌─────────┐   ┌─────────┐   ┌───────┐
│ Function  │─▶ │ Driver │─▶ │ Laser   │─▶ │ Fiber   │─▶ │ VCRO    │─▶ │ CRO   │
│ Generator │   │        │   │ Coupler │   │ Coupler │   │ Module  │   │       │
└───────────┘   └────────┘   └─────────┘   └─────────┘   └─────────┘   └───────┘
```

With Coupler:

```
┌───────────┐   ┌────────┐   ┌─────────┐   ┌─────────┐          ┌─────────┐   ┌───────┐
│ Function  │─▶ │ Driver │─▶ │ Laser   │─▶ │ Fiber   │─▶  ▮  ─▶ │ VCRO    │─▶ │ CRO   │
│ Generator │   │        │   │ Coupler │   │ Coupler │          │ Module  │   │       │
└───────────┘   └────────┘   └─────────┘   └─────────┘          └─────────┘   └───────┘
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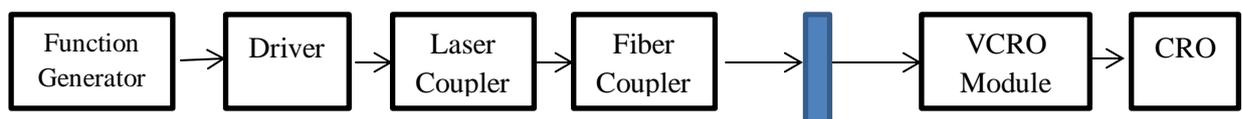
Formula Used:

$$\text{Gain} = -20 \log (V_0 / V_{in}) \text{ dB}$$

Exp. No: 1

Date:

MEASUREMENT OF COUPLING LOSS

UNIVERSITY QUESTION:

1.By conducting an experiment measure the coupling loss of the given optical fiber.

Aim:

To determine the coupling loss of multimode glass optical fiber.

Pre Lab Questions:

1. The loss in signal power as light travels down the fiber

    a) Attenuation   b) Scattering   c) Absorption.

2. Coupling loss in fiber optics refers to _____

    a) Power loss   b) Current loss   c) Voltage loss.

3. Coupling loss results because of _____ mismatch.

    a) Impedance   b) Inductance   c) Capacitance.

4. Coupling loss is expressed in _____ units.

    a) Watts   b) Decibels   c) both A and B

5. The coupling loss is to be calculated for____optical fiber.

    a)single mode b)multimode c) both A and B

Apparatus Required:

1. VLR.01 model.

2. Fiber coupler.

3. Multimode optical glass fiber.

4. CRO.

Tabulation:

S.No	Coupling	Length (m)	Input (V)	Output (V)	Gain= -20 log (V_0 / V_{in}) dB
1	Without Coupling				
2	With coupling				

Calculation:

Gain = -20 log (V_0 / V_{in}) dB

Theory:

Coupling loss, also known as connection loss, is the loss that occurs when energy is transferred from one circuit, circuit element, or medium to another. Coupling loss is usually expressed in the same units—such as watts or decibels—as in the originating circuit element or medium. Coupling loss in fiber optics refers to the power loss that occurs when coupling light from one optical device or medium to another.

Procedure:

1. Give the connections as per the block diagram.

2. Establish the analog link between the laser source and fiber coupling.

3. Connect a non coupled multimode fiber and measure the output voltage.

4. Then connect a coupled multimode fiber and measure the output voltage,.

5. Tabulate the reading and find the coupling loss by the efficiency.

Result:

Thus the coupling loss of a multimode glass optical fiber is determined.

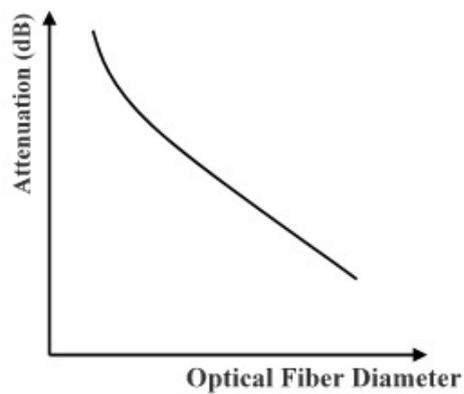**Block Diagram: Bending Loss:**
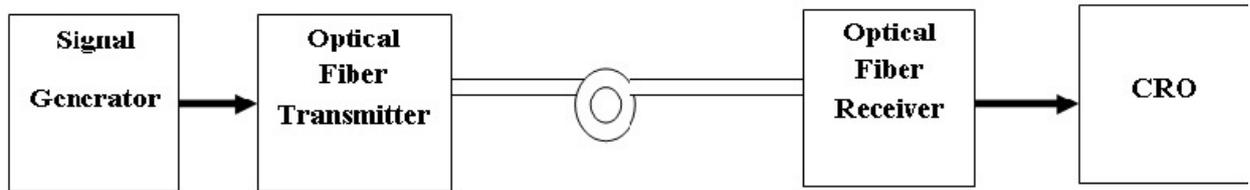
Tabulation:

Diameter	Input Voltage (V)	Output Voltage (V)	Gain = -20 log (V_0 / V_{in})

Model Graph:

Exp.No: 2

Date:

MEASUREMENT OF BENDING LOSS

UNIVERSITY QUESTION:

1.By conducting an experiment measure the bending loss of the given optical fiber.

Aim:

      To determine the bending losses in the analog communication link.

Pre Lab Questions:

1. _____ bend is normally used in communication.

   a) Macro bend b)sharp bend c) sharp edge bend

2. Large curvature loss is called as_____ loss.

   a) Micro bending   b) Macro bending   c) Coupling

3. Macro bending loss is also called as _____ loss.

   a) Bending   b) Coupling   c) Attenuation.

4. Small scale fluctuations is called as _____

   a) Micro bends   b) Macro bends   c) Bends.

5. The loss in signal power as light travels down a fiber is called_____

   a) Dispersion b) Scattering   c) Attenuation

Apparatus Required:

1. Signal generator.

2. Optical Transmitter.

3. Optical fiber.

4. Optical receiver.

5. CRO.

Calculation

$$GAIN = -20 \log \frac{Vo}{Vin}$$

Theory:

Radioactive losses occur whenever an optical fiber undergoes a bend of finite radius of curvature, the fiber can be subjected to the two types of bends namely Micro bends and Macro Bends.

Large curvature radiation loss is called as macrobends whereas the microbends are respective small scale fluctuations in the radius of curvature of the fiber axis.

Procedure:

1. Give the connections are per the block diagram.
2. Give the input signal to the kit and measure the amplitude and time period of the input signal.
3. Take a 1metre optical fiber and bend the fiber to measure the diameter and note down the output voltage.
4. Vary the diameter of the fiber bends and measure the output voltage.
5. Calculate the attenuation of fiber.

Result:

Thus the bending loss in the analog communication link has been determined.

Block Diagram: (Attenuation Loss):

Signal Generator → Optical Fiber Transmitter → Test Fiber → Optical Fiber Receiver → CRO
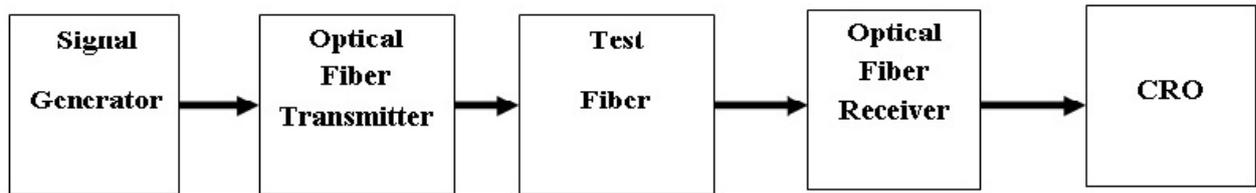
Tabulation:

S.No	Length (m)	Output voltage (V)	Gain = -20 log (V_0 / V_{in})
1			
2			
3			

Model Graph:
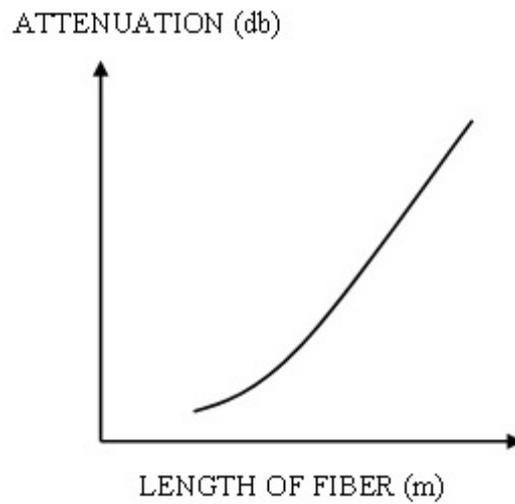
Exp. No: 3

Date:

MEASUREMENT OF ATTENUATION LOSS

UNIVERSITY QUESTION:

1.By conducting an experiment measure the attenuation loss of the given optical fiber.

Aim:

To determine the attenuation loss in fiber using single mode plastic fiber.

Pre Lab Questions:

1. Attenuation defines _____
   a) Decreasing the strength of signal b)increasing the strength of signal c) destroy signal
2. As signal propagated over a long distance _____ loss occurs.
   a) Attenuation   b) Bending   c) Coupling
3. The attenuation loss can be minimized by increasing _____
   a) Signal strength   b) Voltage   c) Current
4. The gain is calculated in _____
   a) Decibel   b) mm   c) no unit
5. The loss is due to _____
   a) Long distance transmission   b) small distance   c) very long distance.

Apparatus Required:

1. VLR.01 model.

2. Function generator.

3. Optical fiber.

4. CRO.

Theory:

Attenuation of a light signal as it propagates along a fiber in an important consideration in the design of an optical communication systems. Since it plays a major role in determining the maximum transmission distance between the transmitter and the receiver.

As light travels along the fiber, its power decreases exponentially and the signal may not be able to reach the receiver or the data received may be of noise corrupted or even undergoes data loss.

Procedure:

1. Give the connections as per the block diagram.
2. Switch the supply and establish an analog link between the laser source and fiber complex.
3. Measure the input voltage.
4. Connect the various lengths of fiber and measure the output voltage.
5. Calculate the gain using the formula.
6. Plot the graph.

Result:

Thus the attenuation loss of an optical fiber has been determined.

Circuit Diagram: (Numerical Aperture):
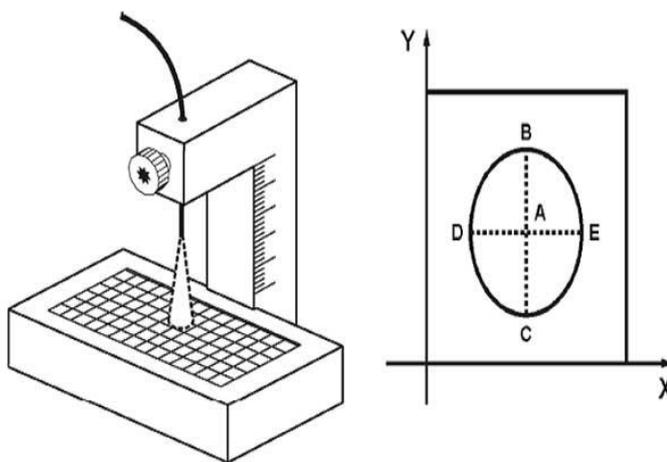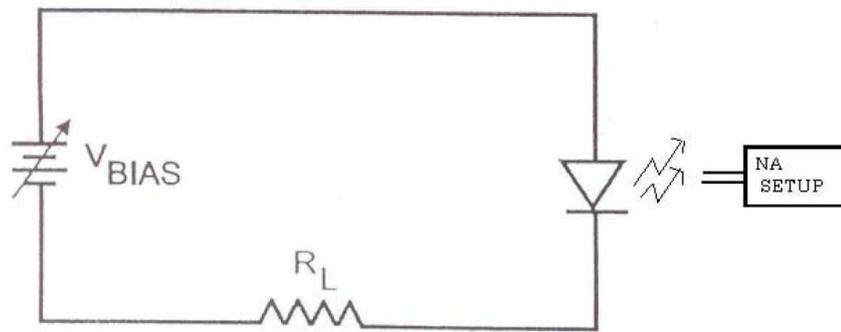
Tabulation:

Distance "d" (cm)	AB	CD	X=(AB+CD)/4	NA	ΘA

Exp. No: 4

Date:

DETERMINATION OF NUMERICAL APERTURE

UNIVERSITY QUESTION:

1.By conducting an experiment measure the Numerical Aperture of the given optical fiber.

Aim:

To determine the numerical aperture and number of modes of a fiber.

Pre Lab Questions:

1. Numerical aperture is _____ number.
   a) Dimensionless   b) Finite   c) Real
2. The Numerical Aperture (NA) is a measure of how much _____ can be collected by an optical system.
   a) light   b) sound   c) both
3. Half of the angular aperture is called as _____
   a) Acceptance angle   b) Angle of Incidence   c) Angle of Reflection.
4. Number of modes is depending on
   a) refractive index of core
   b) refractive index of cladding
   c) refractive index of core and cladding
5. Formula for modes_____

   a) $V = \dfrac{\pi d(NA)}{\lambda}$ b) d(NA)/4   c) NA/6

Apparatus Required:

1. Optical fiber.
2. Numerical aperture unit.
3. Off transmitter.

Theory:

Numerical aperture (NA) of a fiber is a measure of the acceptance angle of light in the fiber. Light which is launched at angles greater than this maximum acceptable angle does not get coupled to propagating modes in the fiber and therefore does not reach the receiver at the other end of the fiber. The Numerical aperture is useful in the computation of optical power coupled from an optical source to the fiber, from the fiber to a photo detector and between two fibers.

Formula Used:

1. Numerical Aperture (NA) = $NA = \dfrac{x}{\sqrt{x^2 + d^2}}$

2. Acceptance angle: $V = \dfrac{\pi d(NA)}{\lambda}$ $\theta_A = \sin^{-1}(NA)\deg ree$

3. Calculation of number of modes (M): $V = \dfrac{\pi d(NA)}{\lambda}$

Calculation:

Procedure:

1. Connect optical fiber to the optical tool kit.

2. Insert the optical fiber in a NA unit.

3. Connections are given as per block diagram.

4. Adjust the distance of the fiber from the screen as per the scale.

5. Observe the diameter at different distance and calculate numerical aperture using the formula given below:

$$NA = \frac{x}{\sqrt{x^2 + d^2}}$$

Result:

Thus the numerical aperture of the optical fiber is determined.

Numerical Aperture: _____

Block Diagram: (Mode Characteristics of Fiber)
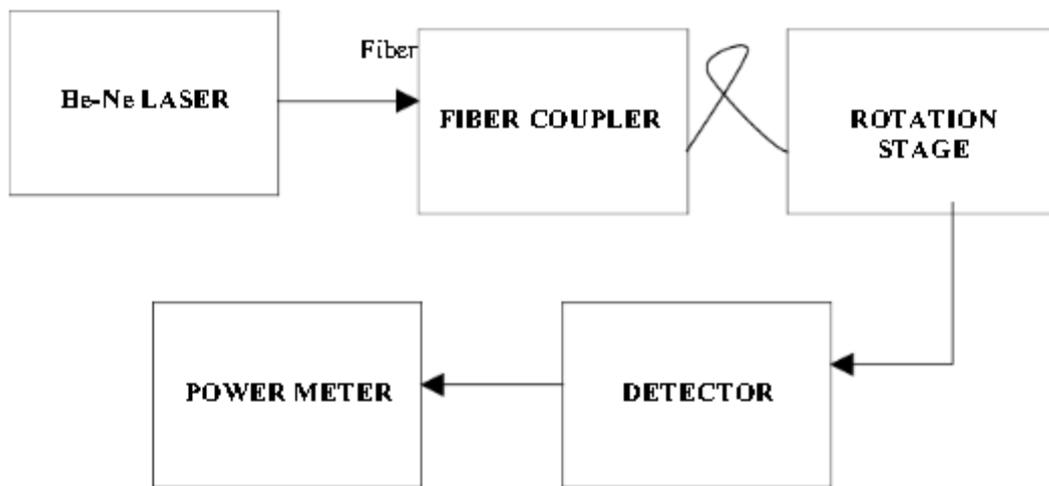
TABULATION:

Distance (cm)	Ab	cd	X=(ab+cd)/4	NA

Exp. No: 5

Date:

MODE CHARACTERISTICS OF SINGLE MODE FIBER

UNIVERSITY QUESTION:

1.By conducting an experiment obtain the mode characteristics of single mode fiber.

Aim:

To determine the mode characteristics of a single mode optical fiber.

Pre Lab Questions:

1. Fiber optic cable is for carrying information in the form of _____

   a) Light   b) Sound   c) Acoustic

2. The other modes have been avoided for _____

   a) Attenuated   B) Reflected   c) Refracted.

3. Which mode has been used in single mode fiber?

   a) Transverse mode   b) TE mode   c) TM mode

4. The core cladding difference varies between _____

   a) 0.2 to 1   b) 0.3 to 1   c) 0.5 to 1

5. The single mode fiber exhibits _____

   a) Modal dispersion   b) Modal reflection   c) Modal Refraction.

Apparatus Required:

1. Function Generator.

2. NA Unit.

3. Laser source.

Calculation:

$$X = \frac{0.1 + 0.1}{4} = 0.05$$

$$NA = \frac{X}{\left(X^2 + D^2\right)^{1/2}}$$

Theory:

In fiber-optic communication, a single-mode optical fiber (SMF) is an optical fiber designed to carry light only directly down the fibre - the transverse mode. Modes are the possible solutions of the Helmholtz equation for waves, which is obtained by combining Maxwell's equations and the boundary conditions. These modes define the way the wave travels through space, i.e. how the wave is distributed in space. Waves can have the same mode but have different frequencies.

Procedure:

1. Give the connections as per the block diagram.

2. Provide the electrical energy to drive through function generator.

3. Connect the optical fiber and project the optical signal to the numerical Aperture unit.

4. Calculate the diameter and the radius of the light signal which falls on the NA unit.

5. Calculate the numerical aperture.

Result:

Thus the mode characteristics of single mode fiber have been obtained successfully.

Circuit Diagram:
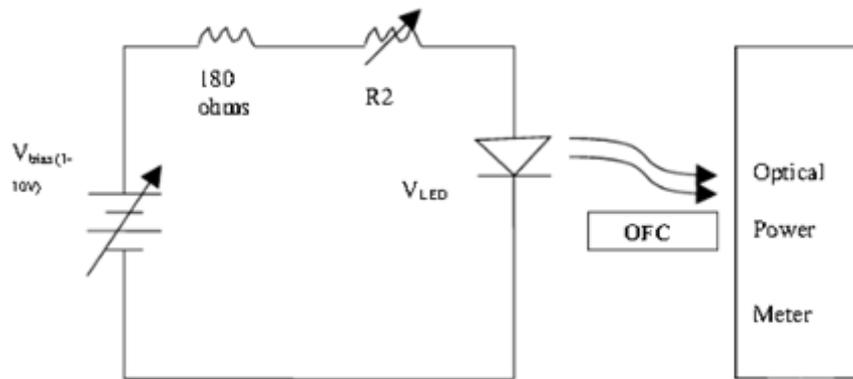
Model Graph:

- **PI Characteristics:**
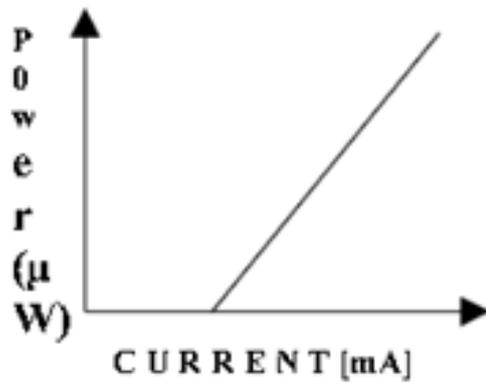
- **VI Characteristics:**
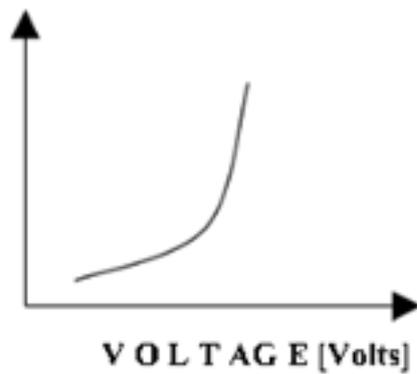
Exp.No.: 6

Date:

CHARACTERISTICS OF LED

UNIVERSITY QUESTION:

1.Obtain the characteristics of LED by conducting an experiment.

Aim:

      To study about the Power Current (PI) characteristics and Voltage Current (VI) characteristics of a Light Emitting Diode (LED).

Pre Lab Questions:

1) Light Emitting Diode is a _____ Device.
   a) Semiconductor   b) Conductor   c) Dielectric
2) LED release energy in the form of _____
   a) Protons   b) Electrons   c) Photons.
3) The working principle of LED is _____
   a) Electromagnetic   b) Electroluminescence   C) Electrostatic.
4) The colour of the LED depends on _____
   a) Bandgap   b) Energy gap   c) Forbidden energy gap.
5) LED is abbreviation of_____
   a) Light emitting diode   b) Light enter diode   C) Low emitting diode

 Apparatus Required:

1. RPS($\pm$12V)

2. Multimeter.

3. LED module.

Tabulation:

Voltage (V_{Bias})	$I_f = \dfrac{V_1}{R_1}\ (mA)$	V_{LED} (V)	P_0 (db)	$P = 10^{(P0/10)}$ (mw)

Theory:

A light-emitting diode (LED) is a two-lead semiconductor light source that resembles a basic P-junction diode, except that an LED also emits light. When an LED's anode lead has a voltage that is more positive than its cathode lead by at least the LED's forward voltage drop, current flows. Electrons are able to recombine with holes within the device, releasing energy in the form of photons.

Procedure:

1. Insert a 180Ω resistor in the port provided across V_1 (Voltage across the Resistor).

2. Measure the voltage V_1 across the 180Ω resistor and calculate the current through the LED.

3. Vary the input bias voltage $V_{Bias.}$ and measure the voltage V_{LED} across the LED.

4. Calculate the power by using the formula: $\mathbf{P=10^{(P0/10)}\ mw}$.

5. Plot the graph based on the observed values.

Result:

Thus the VI and PI characteristics of the LED have been studied and the graph was plotted successfully.

Circuit diagram (PIN Diode):
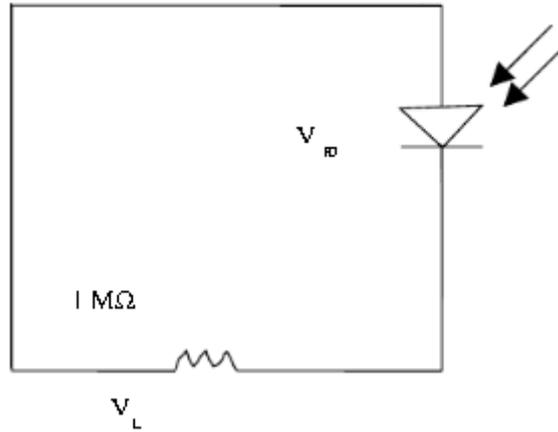
TABULATION: (Forward Bias)

PI CHARACTERISTICS: *V=*

Power (db)	V_L(V)	I_f(μA)

VI CHARACTERISTICS: *P=*

V_{bias} (V)	V_L(V)	I_f(μA)

Expt.No.: 7

Date:

CHARACTERISTICS OF PIN DIODE

UNIVERSITY QUESTION:

1.Obtain the VI characteristics of PIN diode by conducting an experiment.

Aim:

To determine the mode characteristics and to plot the VI and PI characteristics of PIN diode.

Pre Lab Questions:

1) PIN diode is a _____

   a) near Intrinsic Semi conductor   b) P type semiconductor   c) Conductor.

2) The p type and n type are _____ doped.

   a) Heavily   b) Lightly   c) Moderately

3) PIN diode has _____ reverse recovery time.

   a) Poor   b) High   c) moderate.

4) _____ helps in speeding up the operation of PIN diode.

   a) Electric Field   b) Magnetic field.   C) Electromagnetic field.

5) Pin diode act as _____ switching.

   a) Slow   b)Fast   c)Moderate

Apparatus Required:

1. Digital multimeter.

2. PD module.

3. Fiber optic power supply.

4. Photometer.

TABULATION: (Reverse Bias)

PI CHARACTERISTICS:

Power (db)	V_L(V)	I_f(µA)

VI CHARACTERISTICS:

V_{bias} (V)	V_L(V)	I_f(µA)

Formula Used :

1. $I_f = \dfrac{V_l}{R_1} (mA)$

Where; h= 6640x10^{-24}J.

e= 7.62x10^{-19}C.

Procedure:

1. Connect 1MΩ resistor across V.
2. Keep the module in forward bias and set the voltage.
3. Set V_{bias} as constant, and by varying the Input Power, measure the output voltage V_L.
4. Set the input Power as constant, and by varying the V_{bias}, measure the output voltage V_L.
5. Repeat the same process for the reverse bias.
6. Calculate I_F using the formula and plot the graph.
7. Now perform the same operation for reverse biasing condition.

Result:

Thus the characteristics of PIN diode is studied and the graph was plotted.

Block Diagram: (Analog Communication Link):
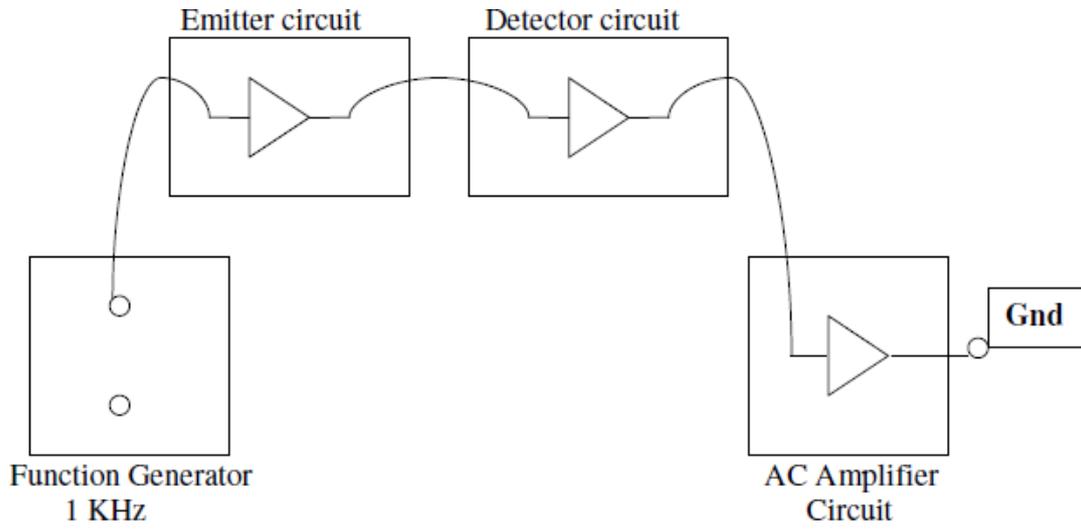
Tabulation:

Input Voltage (V)	Output Voltage (V)

Model Graph:
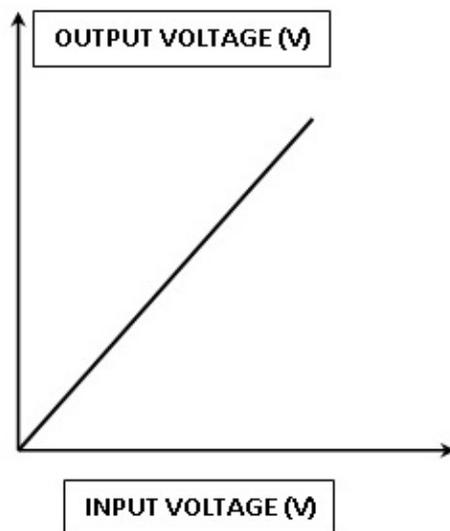
Exp. No: 8

Date:

ANALOG COMMUNICATION LINK

UNIVERSITY QUESTION:

1.Conduct an experiment to establish optic analog and digital link in a 650 nm fiber.

Aim:

To study the analog communication link and plot the voltage characteristics of a analog link.

Pre Lab Questions:

1. The source of analog link is _____

   a) LED   b) LCD   c) SCR

2. The analog signal is transmitted after _____ process.

   a) Modulation   b) Demodulation   c) Sampling

3. The information is transmitted directly in the _____

   a) Baseband   b) Broadband   c) Band pass

4. Converting data into signals by transforming and encoding the information to produce electromagnetic signals is the functionality of a _____

   a) Source   b) Transmitter   c) Receiver.

5. The signal is transmitted in _____

   a) Continuous   b) Discrete c) both A and B

Apparatus Required:

1. Fiber optic communication kit.

2. CRO

Theory:

In analog communication link, transmitter contains either an LED or a LASER source. The analog signal can be sent by one or more modulation techniques. The simplest method is the direct intensity modulation. The use of an optical amplifier in the link leads to the additional noise known as Amplified Spontaneous Emission (ASE)

Model graph:

Analog signal Waveform
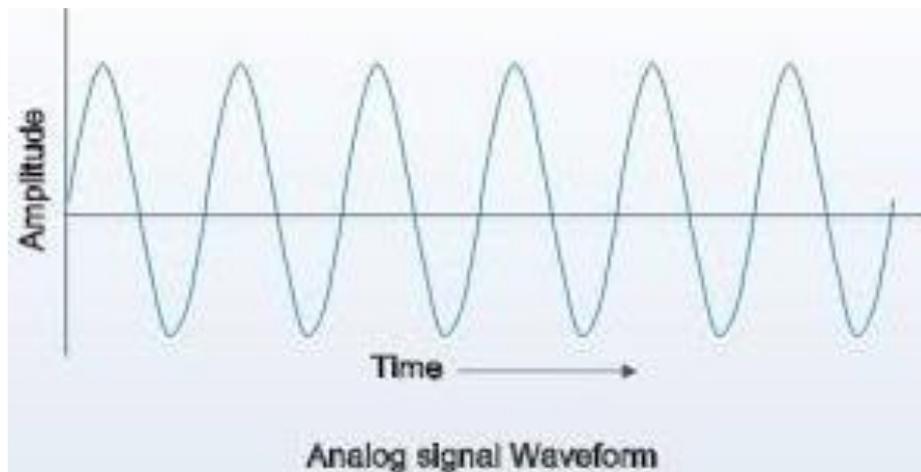
Tabulation:

Signal	Amplitude (V)	Time period (t)
Input Signal		
Output Signal		

Procedure:

1. Connections are given as per the circuit diagram.
2. Input wave is given from the source (Sinusoidal Wave).
3. Input and output voltages are noted and calculate the bit error rate.

Result:

The voltage characteristics of analog communication link have been determined.

Block Diagram: (Digital Communication Link):
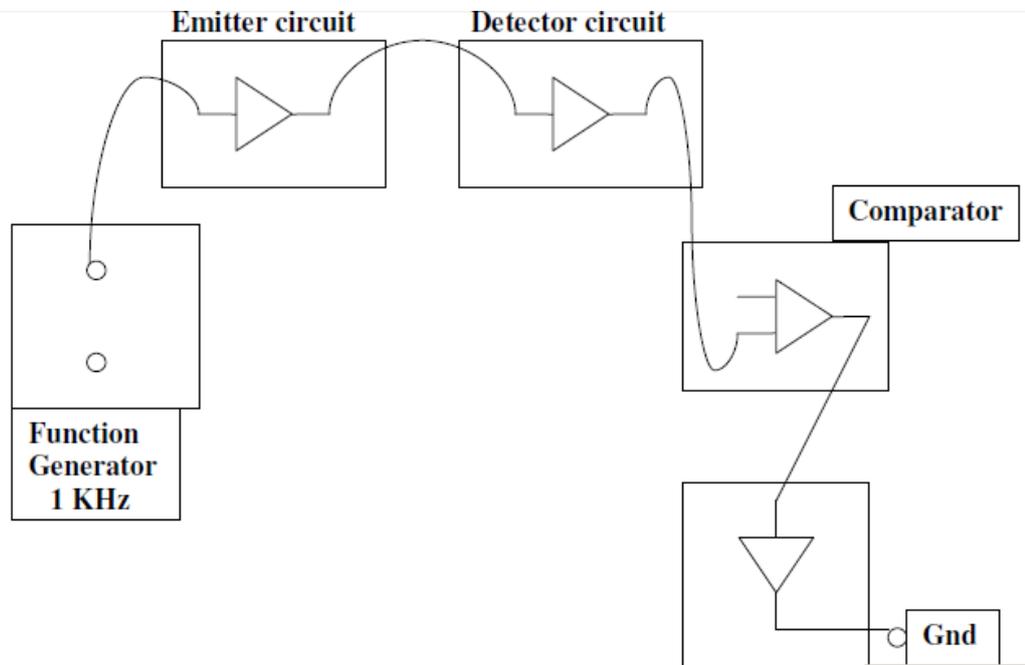
Tabulation:

Signal	Amplitude (V)	No of pulse	Time period (t)
Input Signal			
Output Signal			

Exp.No: 9

Date:

DIGITAL COMMUNICATION LINK

UNIVERSITY QUESTION:

1.Conduct an experiment to establish optic analog and digital link in a 650 nm fiber.

Aim:

To study the digital link and to determine the bit error rate in the digital link.

Pre Lab Questions:

1. TTL signal is built in digital circuits from _____

   a) BJT   b) UJT   c)both A and B

2. The modulation techniques followed in digital communication link_____

   a) Analog   b) digital   c) both A and B

3. Tran's impedance receiver is_____ sensitivity.

   A) High   b) low   c) normal

4.   The upper pulse rate and information carrying capacity of a cable is limited by_____

   a)Pulse shortening   b) Attenuation   c) Modal dispersion

5. Manchester coder is_____

   a) self-clocking b)external clocking c)no clock pulse

Apparatus Required:

1. Fiber optic communication trainer.

2. Optical fiber.

3. Cathode ray oscilloscope.

Model graph:
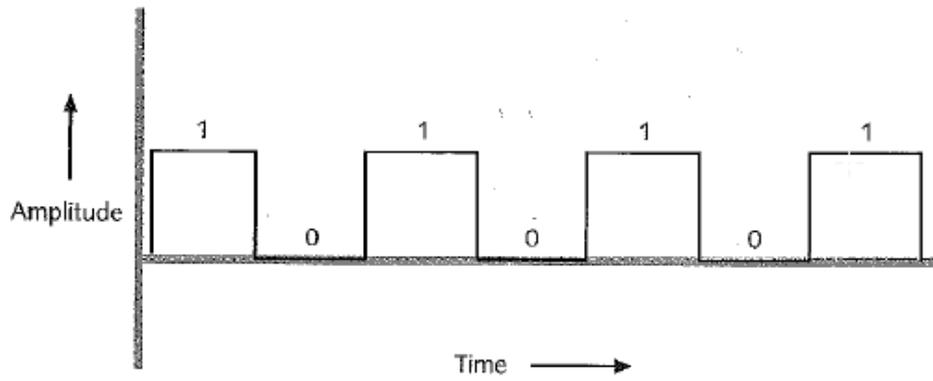
Calculation:

Bit rate =

Theory:

The OFT can be used to set up two fiber optic digital links, one at a wavelength of 650nm and the other at 850nm. Ledl, in the optical TXl block, is an 850nmLED, and LED2, in the optical TX2 block, is a 650nm LED.

PD1, in the optical Rxl block, is a PIN detector which gives a current proportional to the optical power falling on the detector. The received signal is amplified and converted to a TTL signal using a comparator. The GAIN control plays a crucial role in this conversion.

Procedure:

1. Give the connections as per the circuit diagram.
2. The input is given from the TTL link.
3. The Optical Fiber cable is connected between the transmitter and the receiver section.
4. Input and output voltages are noted.
5. Bit error rate is calculated by taking the time value of "t_{ON}" and "t_{OFF}".

Result:

Thus the characteristics of digital communication link have been determined and then its bit error rate has been calculated.

Bit Error Rate = _____

WIRELESS COMMUNICATION EXPERIMENTS

Rayleigh Fading channel with Doppler effect

```
clear;
clc;
N=5000;                                    %Number of paths
t=0.0001:10/N:10;                          %Time range
fc=900*10.^6;                              %Carrier frequency
wc=2*pi*fc;
v=30/3600;                                 %Receiver speed[km/h]
c=300*10^3;                                %Light speed
wm=wc*(v/c);
        %Maximum shift
fm=wm/(2*pi);                              %Doppler shift
for i=1:N
  A(i)=(2*pi/N)*i;                         %Azimuthal angles
  wn(i)=wm*cos(A(i));
  O(i)=(pi*i)/(N+1);
        xc(i)=2*cos(wn(i)*t(i)).*cos(O(i))+cos(wm*t(i));
 xs(i)=2*cos(wn(i)*t(i)).*sin(O(i));
 T(i)=(1/(2*N+1)^0.5).*(xc(i)+j*xs(i));%Complex envelope
 end
M=mean(abs(T));                            %Mean
MdB=20*log10(M);
TdB=floor(20*log10(abs(T)));               %Field [dB]
z1=hist(abs(T));
z=hist(TdB,9);
n=0;
for k=1:9
  n=n+z(k);
  end
        for j=1:9
            P(j)=z(j)/n;
                end
  f(1)=P(1);
                                for x=2:9
                                f(x)=f(x-1)+P(x);
                                F(10-x)=f(x);

    end
plot(z1)
        %Distribution chart
title('Rayleighs distribution');
pause
semilogy(t,abs(T)/max(abs(T)),'r') %Fading graphic
title('Received field');
ylabel(Fading);
xlabel('time');
```

EXP. NO: 10   Simulation of Wireless Channel with fading & Doppler effect
DATE :

AIM:
     To write a MATLAB program for fading and Doppler effect in wireless channel.

PRE-LAB QUESTIONS:
1. Which of the following is not a channel parameter?
a) Bandwidth
b) Coherence time
c) Rms delay spread
d) Doppler spread

2. _____ leads to time dispersion and frequency selective fading.
a) Doppler spread
b) Multipath delay spread
c) Time dispersive parameters
d) Frequency delay spread

3. Which of the following s not a characteristic of flat fading?
a) Mobile radio channel has constant gain
b) Linear phase response
c) Non linear phase response
d) Bandwidth is greater than the bandwidth of transmitted signal

4. Spectral characteristics of the channel changes with time in flat fading. State whether True or False.
a) True
b) False

5. Flat fading channel is also known as _____
a) Amplitude varying channel
b) Wideband channel
c) Phase varying channel
d) Frequency varying channel

THEORY:
Rayleigh fading is caused by multipath reception. The mobile antenna receives a large number, say N, reflected and scattered waves. Because of wave cancellation effects, the instantaneous received power seen by a moving antenna becomes a random variable, dependent on the location of the antenna.
A sample of a Rayleigh fading signal. Signal amplitude (in dB) versus time for an antenna moving at constant velocity. Notice the deep fades that occur occasionally. Although fading is a random process, deep fades have a tendency to occur approximately every half a wavelength of motion.

```
grid on
pause
loglog(100*F,'m');%Indicates the probability of exceed a given attenuation
title('Probability of exceed a given attenuation (%)');
```

Model Graph
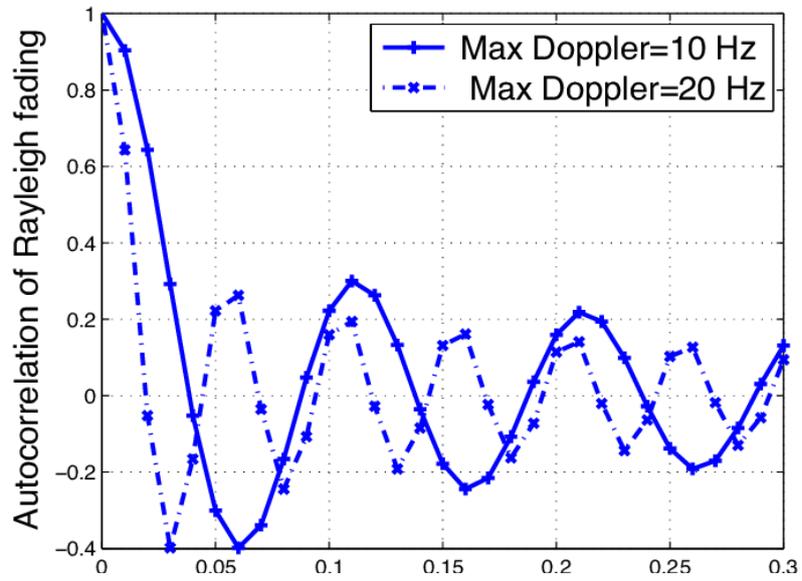
PROCEDURE:
1. Start the MATLAB software and create new M-file.
2. Type the program in the file.
3. Save & compile the program.
4. Give the input data.
5. Observe the output waveform.
6. Thus the graph is to be plotted.

POST-LAB QUESTIONS:
1. In a frequency selective fading, mobile radio channel possess a constant gain and a linear phase over bandwidth smaller than bandwidth of transmitted signal. State whether True or False.
a) True
b) False

2. Frequency selective fading channels are also known as _____
a) Narrowband channel
b) Wideband channel
c) Amplitude varying channel
d) Phase varying channel

3. Frequency selective fading does not induce intersymbol interference. State whether True or False.
a) True
b) False

4. For fast fading channel, the coherence time of the channel is smaller than _____ of transmitted signal.
a) Doppler spread
b) Bandwidth
c) Symbol period
d) Coherence bandwidth

5. In slow fading channel, Doppler spread of the channel is much less than the _____ of baseband signal.
a) Symbol period
b) Phase
c) Coherence time
d) Bandwidth

RESULT:
Thus a program and simulate the fading and Doppler effect in wireless channel was executes successfully and the performance was analyzed.

EQUALIZATION-ZERO FORCING AND LMS ALGORITHMS for Channel Estimation

PROGRAM

```
xlabel('taps' clc;
clear all;
close all;
%simulation length
N=1000;
%channel length
M=5;
%number of independent trials
T=10;
cascade_impulse_response=zeros(1,2*M-1);
for j=1:T
    %training signal
    u=randn(1,N);
    %channel to be equalized
    c=randn(M,1);
    c=c/norm(c);
    %channel output
    z=filter(c,1,u);
    %additive noise to the channel output
    SNR=30;
    var_v=var(z)*10^(-SNR/10);
    v=var_v^0.5*randn(1,N);
    %input to the equalizer
    x=z+v;
    %NLMS channel equalization
    w=zeros(M,1);
    x_regressor=zeros(1,M);
    step=0.1;
    epsilon=10^(-6);
    for k=4:N
        x_regressor=[x(k),x_regressor(1:M-1)]
        e=u(k-3)-x_regressor*w;
        w=w+step*x_regressor'*e/(x_regressor*x_regressor'+epsilon);
    end cascade_impulse_response=cascade_impulse_response+conv(w,c)';
    display(j);
end
figure;
stem(cascade_impulse_response/T);
title('cascade channel equalizer impulse response');
);
```

EXP. NO: 11   EQUALIZATION-ZERO FORCING AND LMS ALGORITHMS
DATE :   FOR CHANNEL ESTIMATION

AIM:

To write a MATLAB program for equalization & Least mean square algorithm for Channel estimation

PRE-LAB QUESTIONS:

1. Channel vocoder consists of both an _____and _____
    a) Analyzer, Synthesizer B) Linear, Nonlinear   C) Analyzer   D) All Of The Above

2. The process of conversion of continuous time signal into discrete time signal is known as.
    a)Aliasing B) Sampling C)Convolution D) None Of The Above

3. Transform coding is a _____domain technique
     a) frequency   b)time c)linear d) None of these

4. The antialiasing filter removes the possible ___effects.
     a) Sampling   B)Non Sampling C)Aliasing   D)Linear

5. High signal to noise ration limited only by the _____converter.
     a) ADC   b) DAC   c) Unstable   D) None of the above

ALGORITHM:
    1.   Start the program.
    2.   Get the N point values from the user.
    3.   Assign the range of the time axis.
    4.   Give the title for the x axis and y axis for the program.
    5.   Plot the data sequence as a discrete values or continuous as per our requirements.

THEORY:

An adaptive equalizer is an equalizer that automatically adapts to time-varying properties of the communication channel It is frequently used with coherent modulations such as phase shift keying, mitigating the effects of multipath propagation and Doppler spreading. Many adaptation strategies exist. They include:

LMS Note that the receiver does not have access to the transmitted signal x when it is not in training mode. If the probability that the equalizer makes a mistake is sufficiently small, the symbol decisions made by the equalizer may be substituted for x.

MODEL OUTPUT

cascade channel equalizer impulse response

PROCEDURE:

1. Start the MATLAB software and create new M-file.
2. Type the program in the file.
3. Save & compile the program.
4. Give the input data.
5. Observe the output waveform.
6. Thus the graph is to be plotted.

RESULT:

Thus a program to perform the Equalization using Zero forcing and LMS algorithms is executed successfully.

Pulse Shaping and Receive Filtering

Model Graph

EXP. NO: 12   SIMULATION OF PULSE SHAPING AND FILTERING IN
DATE :   SOFTWARE DEFINED RADIO

AIM:

To analyze the impact of pulse shaping and matched filtering in software defined radio.

PRE-LAB QUESTIONS:

1. Intersymbol interference (ISI) leads to _____ probability of the receiver for making an error in detecting the symbols.
a) Increased
b) Decreased
c) Zero
d) One

2. ISI is _____ by increasing channel bandwidth.
a) Maximized
b) Minimized
c) Zero
d) Infinite

3. Why is pulse shaping technique used?
a) To increase ISI
b) To increase spectral width of modulated signal
c) To reduce ISI
d) To reduce power spectral density

4. Who was the first to solve the problem of ISI?
a) Manchester
b) Faraday
c) Graham Bell
d) Nyquist

5. According to Nyquist, the impulse response of the overall communication system should have _____ decay with _____ magnitude for sample values not equal to zero.
a) Fast, small
b) Slow, small
c) Slow, large
d) Fast. Large

THEORY:

Pulse shaping is the process of changing the waveform of transmitted pulses. Its purpose is to make the transmitted signal better suited to its purpose or the communication channel, typically by limiting the effective bandwidth of the transmission. By filtering the transmitted pulses this way, the intersymbol interference caused by the channel can be kept in

control. In RF communication, pulse shaping is essential for making the signal fit in its frequency band.

PROCEDURE:

1. Start the MATLAB software and create new M-file.
2. Type the program in the file.
3. Save & compile the program.
4. Give the input data.
5. Observe the output waveform.
6. Thus the graph is to be plotted.

RESULT:

 Thus pulse shaping and filtering in software defined radio was executed.

OFDM Transeciver

```
clc;
clear all;
close all;
L=input('Length Of OFDM Data = ');
Ncp=L*0.0625
Tx_data=randi([0 15],L,Ncp);
mod_data=qammod(Tx_data,16);
s2p=mod_data.';
am=ifft(s2p);
p2s=am.';
CP_part=p2s(:,end-Ncp+1:end); %Cyclic Prefix part to be appended.
cp=[CP_part p2s];
SNRstart=0;
SNRincrement=1;
SNRend=25;
c=0;
r=zeros(size(SNRstart:SNRincrement:SNRend));
for snr=SNRstart:SNRincrement:SNRend
   c=c+1;
   noisy=awgn(cp,snr,'measured');
   cpr=noisy(:,Ncp+1:Ncp+Ncp); %remove the Cyclic prefix
   parallel=cpr.';
   amdemod=fft(parallel);
   rserial=amdemod.';
   Umap=qamdemod(rserial,16);
   [n, r(c)]=biterr(Tx_data,Umap);
end
snr=SNRstart:SNRincrement:SNRend;
semilogy(snr,r,'-ok');
grid;
title('OFDM Bit Error Rate .VS. Signal To Noise Ratio');
ylabel('BER');
xlabel('SNR [dB]');
```

EXP. NO: 13   OFDM SIGNAL TRANSEIVER USING SOFTWARE DEFINED RADIO

DATE :

AIM:

    To write a MATLAB program for OFDM signal transmission and reception using software defined radio.

PRE-LAB QUESTIONS:

1. OFDM is a technique of

1. encoding digital data   2. multiple carrier frequencies
 3. wide band digital communication   4. 4G mobile communication

a. 1,2 and 3 are correct
b. 2 and 3 are correct
c. 1, 2 and 4 are correct
d. All the four correct

2. Advantages of using OFDM include

1. Avoids complex equalizers   2. Low symbol rate and guard interval
3. Avoids ISI   4. Multiple users at same frequency

a. 1,2 and 3 are correct
b. 2 and 3 are correct
c. 1, 2 and 4 are correct
d. All the four correct

3. The troubles that OFDM faces over other spread spectrum techniques are

1. Sensitivity to Doppler shift   2. Frequency synchronization problems
3. Time synchronization problems   4. Low efficiency due to guard intervals

a. 1, 2 and 3 are correct
b. 2 and 3 are correct
c. 1, 2 and 4 are correct
d. All the four correct

4. The guard interval is provided in OFDM

a. To eliminate the need of pulse shaping filter   b. To eliminate ISI
c. High symbol rate   d. Both a) and b)

5. Which transmission scheme has the highest spectral efficiency?

a) Frequency Division Multiplexing (FDM)
b) Orthogonal Frequency Division Multiplexing (OFDM)
c) Orthogonal Frequency Division Multiple Access (OFDMA)
d) Uber Orthogonal Frequency Division Multiple Access (UOFDMA)

Model Graph :
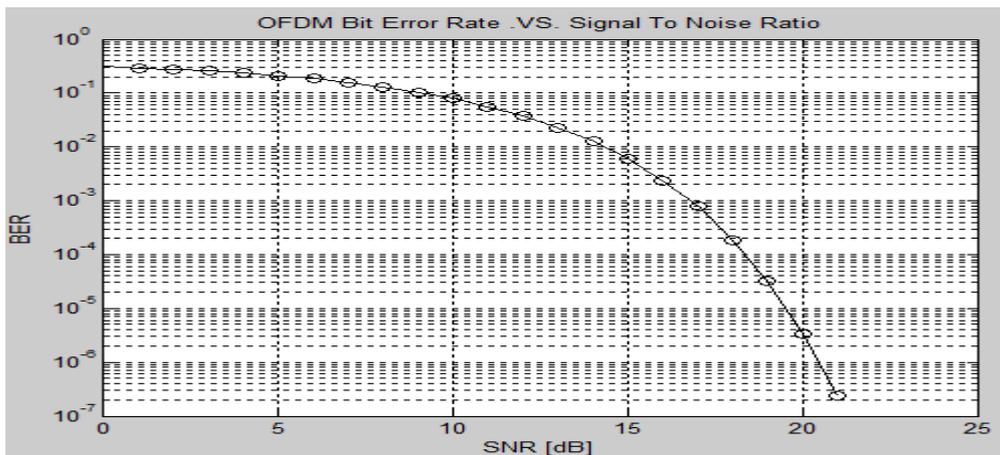
ALGORITHM:
1. Start the program.
2. Get the N point values from the user.
3. Assign the range of the time axis.
4. Give the title for the x axis and y axis for the program.
5. Plot the data sequence as a discrete values or continuous as per our requirements.

THEORY:
Orthogonal Frequency Division Multiplexing (OFDM) is a digital multi-carrier modulation scheme that extends the concept of single subcarrier modulation by using multiple subcarriers within the same single channel. Rather than transmit a high-rate stream of data with a single subcarrier, OFDM makes use of a large number of closely spaced orthogonal subcarriers that are transmitted in parallel. Each subcarrier is modulated with a conventional digital modulation scheme (such as QPSK, 16QAM, etc.) at low symbol rate. However, the combination of many subcarriers enables data rates similar to conventional single-carrier modulation schemes within equivalent bandwidths.

OFDM is based on the well-known technique of Frequency Division Multiplexing (FDM). In FDM different streams of information are mapped onto separate parallel frequency channels. Each FDM channel is separated from the others by a frequency guard band to reduce interference between adjacent channels.

PROCEDURE:
1. Start the MATLAB software and create new M-file.
2. Type the program in the file.
3. Save & compile the program.
4. Give the input data.
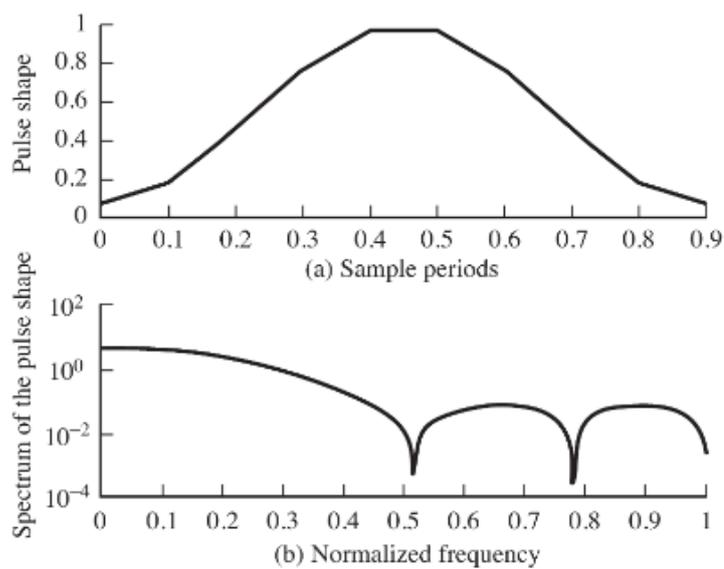5. Observe the output waveform.
6. Thus the graph is to be plotted

RESULT:
Thus a program to design OFDM transceiver was done and BER performance is executed successfully.

MICROWAVE EXPERIMENTS

Block Diagram: (VSWR meter):

```
┌──────────────┐      ┌──────────────┐                          ┌──────────────┐
│  Klystron    │◄─────│  Klystron    │                          │  V.S.W.R     │◄──────┐
│  Oscillator  │      │  Power       │                          │  Meter       │       │
│              │      │  Supply      │                          │              │       │
└──────┬───────┘      └──────────────┘                          └──────────────┘       │
       │                                                                          ┌─────┴────┐
       ▼                                                                          │          │
┌──────────┐    ┌──────────────┐    ┌──────────────┐    ┌──────────────┐          │  Probe   │
│ Isolator │───►│  Variable    │───►│  Frequency   │───►│  Slotted     │───►      │          │
│          │    │  Attenuator  │    │  Meter       │    │  Line        │          └──────────┘
└──────────┘    └──────────────┘    └──────────────┘    └──────┬───────┘
                                                               ▲
                                                        ┌──────┴───────┐
                                                        │  Matched     │
                                                        │  Termination │
                                                        └──────────────┘
```
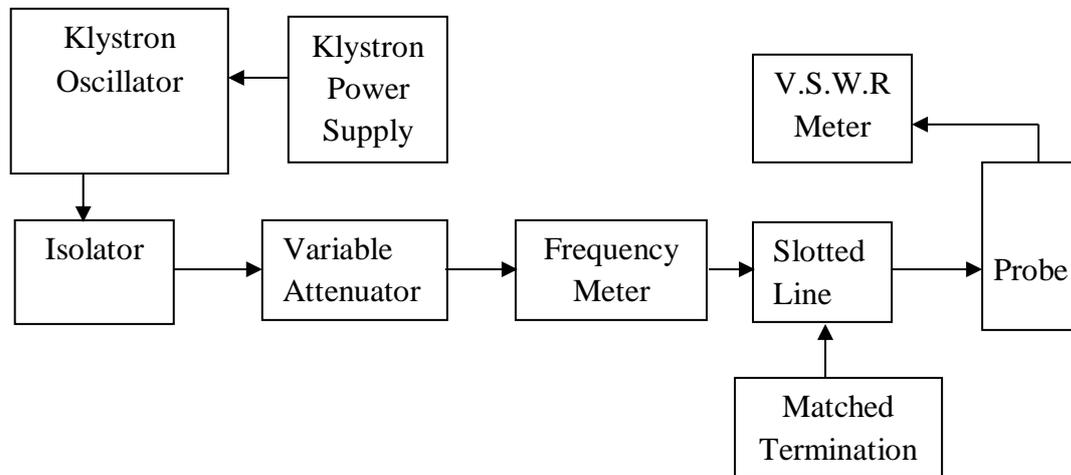
Tabulation:

Load	V_{max}	V_{min}	VSWR
Ss tuner			
Movable short			
Fixed short			
Detector mount			

Exp.No:14

Date:

VSWR MEASUREMENT

Aim:

To determine the voltage standing wave ratio using microwave bench setup.

Pre Lab Question:
1. What is the cause for the generation of standing wave?
   a) Load mismatch   b) Source mismatch   c) Impedance mismatch
2. How does the standing wave can be avoided to reach the source?
   a) Isolator   b) Circulator   c) Magic Tee
3. A SWR meter measures the _____ of the reflected wave.
   a) Magnitude   b) Frequency   c) Phase angle
4. Standing wave can be cleared by performing _____
   a) Impedance matching   b) Load matching   c) Source matching
5. The SWR depends on _____
   a) Reflection coefficient   b) Incident coefficient   c) Incident coefficient.

Apparatus Required:

Klystron power supply, klystron Tube, klystron mount, Isolator, Frequency meter, Variable attenuator, Slotted section, Tunable probe, Wave guide stands, Movable short load, BNC cable, V.S.W.R Meter.

Theory:

The SWR meter of VSWR meter measures the standing wave ratio in a transmission line. The meter can be used to indicate the degree of mismatch between the transmission line and its load, or evaluate the effectiveness of impedance matching efforts.

Calculation:

Voltage Standing Wave Ratio

$$VSWR = \frac{V_{max}}{V_{min}}$$

Where

V_{max} - Maximum Voltage

V_{min} - Minimum Voltage

1. **SS tuner**

2. **Movable Short**

3. **Fixed Short**

4. **Detector Mount**

Procedure:

- Set the equipments as figure – 5.
- Keep variable attenuator in the minimum attenuation position.
- Keep the control knob of vswr meter as below.
  - ➢ Range db   :   40 db to 50 db
  - ➢ Input switch   :   Low impedance
  - ➢ Meter switch   :   Normal position
  - ➢ Gain   :   Mid position
- Keep control knobs of klystron power supply as given below:
  - ➢ Beam Voltage   :   Off
  - ➢ Mod-switch   :   AM
  - ➢ Beam voltage knob   :   Full anticlockwise
  - ➢ Reflector voltage knob   :   Full clockwise
  - ➢ Am amplitude knob   :   Full clockwise
  - ➢ Am frequency & amplitude knob   :   Mid position
- Switch on the klystron power supply, vswr meter and cooling fan.
- Switch on the beam voltage switch and set beam voltage at 300V
- Rotate the reflector voltage knob to get deflection in vswr meter.
- Tune the output by tuning the reflector voltage, amplitude and frequency of am modulation.
- Tune plunger of klystron mount and probe for maximum deflection in vswr meter.
- If required change the range db switch variable attenuator position and gain control knob to get deflection in the scale of vswr meter.
- As we move probe along the slotted line, the deflection will change.

Result:

       Thus the VSWR of an unknown microwave signal has been measured successfully.

Block Diagram: (Determination Of Impedance Measurement And Impedance Matching)

Klystron Supply				CRO	Mount Detector
Klystron Oscillator	Isolator	Variable Attenuator	Frequency Modulator	Slotted Section	
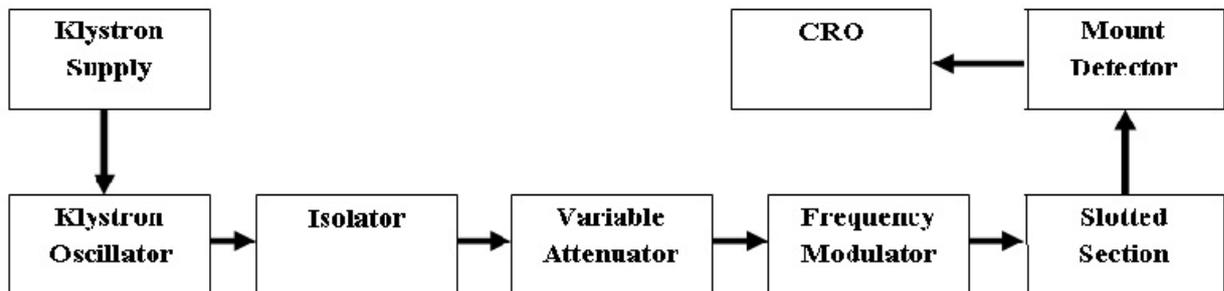
Practical frequency	Minimum value	Minimum value	λg	λc

Formula Used:

- $\lambda_C = 2.a$

- $\lambda_g = 2(\lambda_2 - \lambda_1)$

- $f = \dfrac{c}{\lambda_0}$

- $\dfrac{1}{\lambda_g^2} + \dfrac{1}{\lambda_c^2} = \dfrac{1}{\lambda_0^2}$

Exp.No: 15
Date:
DETERMINATION OF IMPEDANCE MEASUREMENT AND IMPEDANCE MATCHING

Aim:
      To determine the Impedance measurement and impedance matching of the microwave signal using microwave bench set up.

Pre Lab Question:
1. The frequency can be measured using _____ method.
   a) Single minima method   b) Double minima method   c)   Double   maxima method.
2. Mention a method to determine the frequency of a unknown signal.
   a) Wavemeter method   b) Wavelength method   c) Frequency method
3. Mention a method to determine the high frequency of a unknown signal.
   a) Slotted line method   b) Absorption method   c) Dispersion method
4. The frequency can be measured accurately by _____ method.
   a) Up conversion   b) Down conversion   c) Slotted line
5. The wavemeter method is also called as _____ type wavemeter.
   a) Absorption   b) Reflection   c) Incident

Apparatus Required:
- Klystron Power Supply.
- Klystron Oscillator.
- Slotted Line.
- CRO.

Theory:
      Microwave frequency can be measured either electric or by mechanical techniques. These two are the general and more accurate techniques but more expensive. Frequency counters and high frequency heterodyne system can be used for domain TE_{10} mode in rectangular waveguide

Procedure:

- Connect the components and equipment as shown in fig. 2
- Keep the control knob of klystron power supply as below:
  - ➢ Modulation selection   : AM
  - ➢ Beam voltage knob   : Fully anti-clockwise
  - ➢ Reflector voltage knob   : Fully clockwise

- ***Selector switch   : Beam voltage***
- Keep the AM modulation control knob of amplitude &frequency at mid position.
- Switch on the klystron power supply.

- Now vary the Beam voltage knob to 295V. Next change the selector knob to Beam Current. Observe the BEAM CURRENT.   [The beam current should not be more than 30 m amps].

Calculation:

$$F = \frac{C}{\lambda}$$

$$\lambda = \frac{1}{\sqrt{\dfrac{1}{\lambda_G^2} + \dfrac{1}{\lambda_C^2}}}$$

$$F = \frac{C}{1/\sqrt{\dfrac{1}{\lambda_G^2} + \dfrac{1}{\lambda_C^2}}}$$

$\lambda_g = 2d$

$d = d2 - d1$

- Now change the selector switch to Reflector voltage position.
- Now decrease the Reflector voltage to minimum position..
- Now observe the square wave form in CRO by varying either reflector voltage or adjusting the amplitude knob of AM.
- Next rotate the direct frequency meter in clock wise or anti clock wise direction and note down the dip which is displayed in the CRO as low amplitude output. Note down the frequency (**fc**) which is in giga Hertz.
- Next tabulate the Reflector, output voltage & frequency by gradual increase of reflector voltage and note down the corresponding output voltage.
- Now vary the slotted section left to right and observe the wave form in CRO same time tabulated in distance V_{max} (**d1**) & V_{max} (d2).
- Next calculate the guided wavelength (λ**g)**. Twice of the Difference between two minimum position or two maximum position (distance) is called Guided wavelength.
- Next calculate the cutoff wavelength (λ**c**).

Result:

Thus the frequency of the unknown microwave signal can be measured using frequency meter.

Block Diagram: (Directional Coupler)
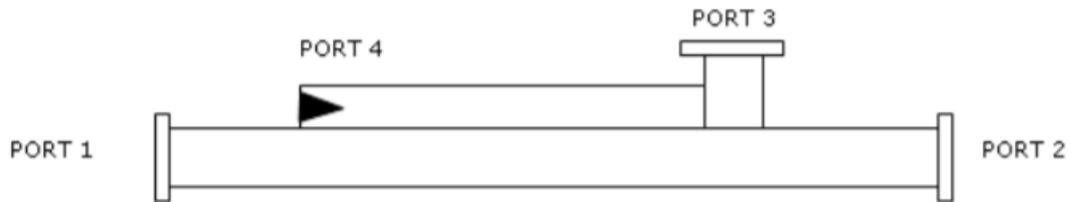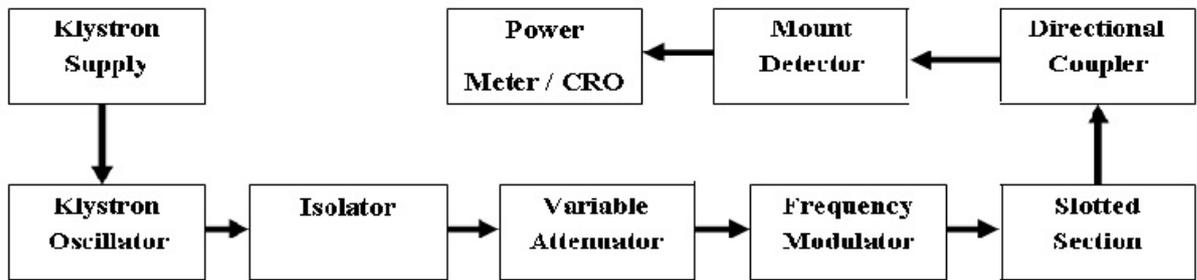
Initial Calibrations:

Beam Voltage: 295V.

Beam Current: 16A.

Repeller Voltage: 219V.

Tabulation:

S.No	Power at Port 1	Power at Port 2	Power at Port 3	Power at Port 4	Coupling Loss	Directivity

Exp.No: 16
Date:

DIRECTIONAL COUPLER

Aim:

To measure directivity, coupling coefficient and S parameter of the directional coupler.

Pre lab Question:
1. The directional coupler has _____ ports.
   a) 2   b) 3   c) 4
2. In a directional coupler, the Port 1 and port 3 are:
   a) Isolated   b) Connected   c) Phase shift by 90 degree
3. In a directional coupler, port 1 and port 2 are _____
   a) Isolated   b) Directly Connected   c) Phase shift by 90 degrees
4. In a directional coupler, port 2 and port 4 are _____
   a) Isolated   b) Connected   c) Phase shift by 90 degree
5. The directional coupler is a hybrid _____
   a) Waveguide junction   b) Waveguide bend   c) Waveguide connector

Apparatus Required:
- Microwave bench setup.
- Directional Coupler.
- Power meter.
- CRO.

Theory:

Power dividers (also power splitters and, when used in reverse, power combiners) and directional couplers are passive devices used in the field of radio technology. They couple a defined amount of the electromagnetic power in a transmission line to a port enabling the signal to be used in another circuit. An essential feature of directional couplers is that they only couple power flowing in one direction. Power entering the output port is coupled to the isolated port but not to the coupled port.

S parameter:

$$S = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44} \end{bmatrix}$$

Formula Used:
- Coupling Loss (dB) = $20 \log(V_1 / V_4)$
- Directivity = $20 \log (V_4 / V_3)$
- Transmission Loss (dB) = $10 \log(V_1 / V_2)$

Calculation:

Procedure:

➤ Connect the components and equipment as shown in fig. 2
➤ Keep the control knob of klystron power supply as below:
  ✓ Modulation selection   : AM
  ✓ Beam voltage knob   : Fully anti-clockwise
  ✓ Reflector voltage knob   : Fully clockwise
  ✓ Selector switch   : Beam voltage
➤ Keep the AM modulation control knob of amplitude &frequency at mid position.
➤ Switch on the klystron power supply.
➤ Now vary the Beam voltage knob to 295V. Next change the selector knob to Beam Current. Observe the BEAM CURRENT.   [The beam current should not be more than 30 m amps].
➤ Now change the selector switch to Reflector voltage position.
➤ Now decrease the Reflector voltage to minimum position.
➤ Now observe the square wave form in CRO by varying either reflector voltage or adjusting the amplitude knob of AM.
➤ Connect the slotted section output to detector mount, now measure the input Power (P1).
➤ Disconnect to setup as shown in fig 2.
➤ Now connect the slotted section output to directional coupler input (port1), connect the detector mount at port2, Terminate the port4 with matched termination.
➤ Now measure the Power (P2) at port 2.
➤ Then remove detector mount from port2 and connect to port 4 terminate port 2 with matched termination
➤ Now measure the power (P3) at port 3.

Result:

        Thus the S parameter, coupling coefficient and the directivity of the directional coupler have been determined successfully.
                Directivity   :

Block Diagram: (Isolator):

```
┌──────────┐                                                      ┌──────────┐
│ Klystron │                                                      │ V.S.W.R  │
│  Power   │                                                      │  Meter   │
│  Supply  │                                                      │          │
└────┬─────┘                                                      └────▲─────┘
     │                                                                 │
     ▼                                                                 │
┌──────────┐    ┌──────────┐   ┌──────────┐   ┌──────────┐   ┌──────────┐
│ Klystron │───▶│ Isolator │──▶│Attenuator│──▶│ Isolator │──▶│ Detector │
│  Mount   │    │          │   │          │   │          │   │  Mount   │
└──────────┘    └──────────┘   └──────────┘   └──────────┘   └──────────┘
```
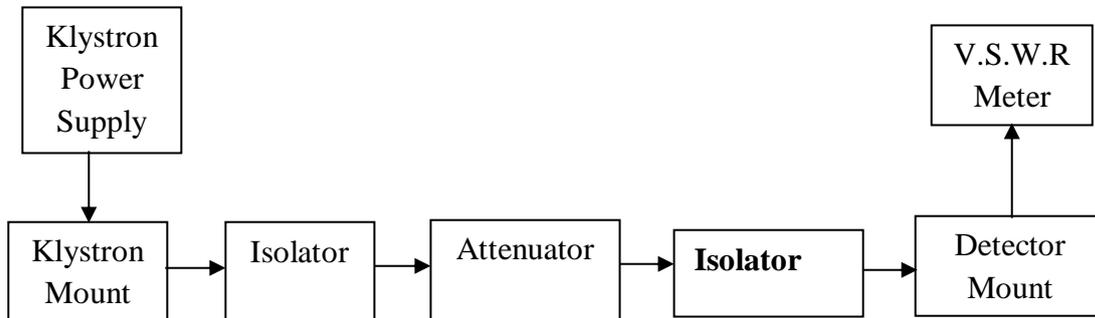
Tabulation:

Component	Input port	Output port		
		port	**Voltage**	
Isolator	**P1**	**P2**		
	P2	**P1**		

Exp.No : 17
Date:

S PARAMETER OF ISOLATOR AND CIRCULATOR

Aim:

To study operation of ferrite circulator, isolator and hence measure insertion loss and isolation offered by these devices.

Pre Lab Questions:
1. The Isolator is _____ port device.
   a) 2   b) 3   c) 4
2. The Circulator is a _____ port device.
   a) 1   b) 2   c) 3
3. The Isolator is a _____ device.
   a) Non Reciprocal   b) Reciprocal   c) Inverting.
4. What is the principle followed by the Circulator?
   a) Faraday Rotation   b) Faraday left hand   C) Faraday right hand.
5. The Circulators are used as a type of _____
   a) Duplexer   b) Transmitter   c) Antenna

Apparatus Required:
- Microwave bench setup.
- Isolator and Circulator
- Power meter.
- CRO.

Theory:
Isolator:

An isolator is a two-port device that transmits microwave or radio frequency power in one direction only. It is used to shield equipment on its input side, from the effects of conditions on its output side; for example, to prevent a microwave source being detuned by a mismatched load.

Procedure:

1. Connect the components and equipments as per the diagram.
2. Switch ON the power supply and beam voltage to 295V.
3. Now increase the reflected voltage to minimum position.
4. Observe the square wave form in CRO by varying wither reflector voltage or adjusting the amplitude knob of AM.
5. Remove the Isolator / Circulator from the slotted section and connect the slotted section output.

Result:

Thus the scattering parameter of the isolator and the circulator has been determined successfully.

Block Diagram: (Gunn Diode Characteristics):

Tabulation :

S.No	Gunn Bias Voltage (V)	Gunn Diode Current(I)

Expt. No: 18

Date:

GUNN DIODE CHARACTERISTICS

Aim:

To study and verify the VI characteristics of a Gunn diode and depth of modulation of a PIN diode.

Pre Lab Questions:

1. Gunn diode is a _____ electronic component.
   a) Semiconductor   b) Conductor   c) Intrinsic Semiconductor
2. How many regions are present in a Gunn diode?
   a) 3   b) 4   c) 2
3. The Gunn diode exhibits _____
   a) Negative resistance b) Positive resistance   c) Transferred electrons
4. The Gunn diode follows _____
   a) RWH Theory   b) Gunn Effect   c)Fermi level
5. If the number of electron in higher in conduction band , it _____
   a) forms Population inversion   b) does not forms inversion   c)   Neutral population.

Apparatus Required:

- Gunn Power supply.
- Gunn Diode oscillator.
- PIN modulator.
- CRO.

Theory:

A **Gunn diode**, also known as a **transferred electron device** (TED), is a form of diode, a semiconductor electronic component, used in high-frequency electronics. Its largest use is in electronic oscillators to generate microwaves, in applications such as radar speed guns and microwave relay transmitters. Its internal construction is unlike other diodes in that it consists only of N-doped semiconductor material, whereas most diodes consist of both P and N-doped regions. In the Gunn diode, three regions exist: two of them are heavily N-doped on each terminal, with a thin layer of lightly doped material in between. When a voltage is applied to the device, the electrical gradient will be largest across the thin middle layer. Conduction will take place as in any conductive material, with current being proportional to the applied voltage. Eventually, at higher field values, the conductive properties of the middle layer are altered, increasing its resistivity, preventing further conduction and current starts to fall. This means a Gunn diode has a region of negative differential resistance.

Model Graph:
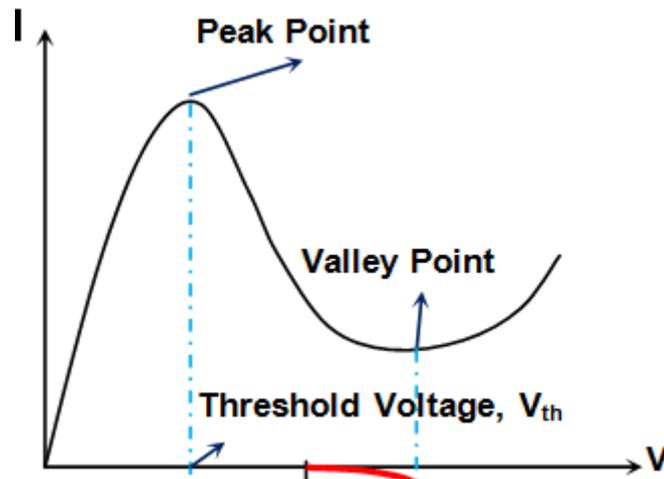
Procedure:
- Connect the components and equipment as shown in fig
- Keep the control knob of Gun power supply as below:
  Meter Switch   : 'OFF'
  Gun Bias   : Fully anti-clockwise
  Pin Bias (Amplitude)   : Mid Position
  Pin Modulation Frequency   : Mid Position
- Set micro meter of gun oscillator between 6-7mm for required frequency of operation.
- ON the gun power supply,& VSWR,Cooling fan.
- Set mode switch in internal mode.
- Now vary the gun bias voltage around 8 volts.
- Now change the meter switch to current position and noted.
- Gun bias voltage is varied current starts decreasing .this indicates negative resistance characteristics of gun diode..
- Now see the waveform in CRO.or VSWR meter.
- Adjust the square wave modulation frequency to approximately 1 KHz.
- Change the meter range if no deflection is observed.
- Tabulated the readings Gun bias voltage, current.

Result:

        Thus the VI characteristics of Gunn diode oscillator have been studied. From this study, we observed that the current output is increasing as the input voltage is increased. After the Threshold voltage, the Gunn diode is in negative resistance region and so the output current decreases.

                   Threshold Voltage = _____
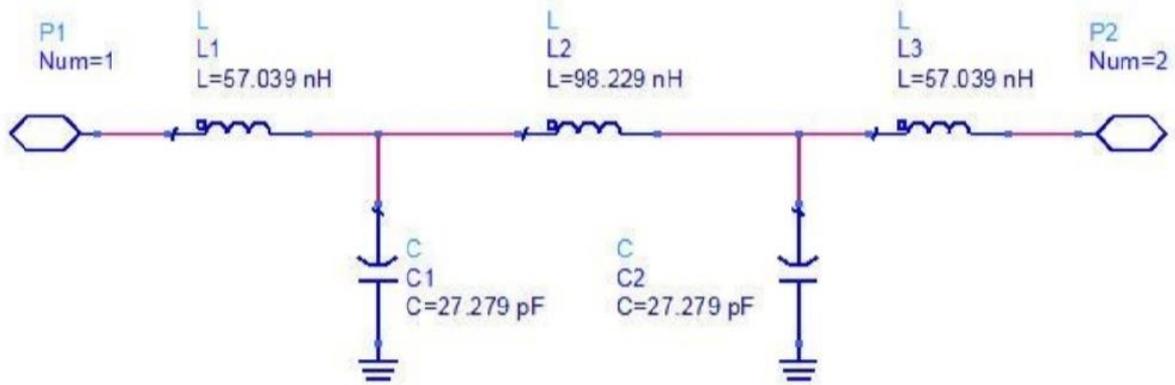
Circuit Diagram:
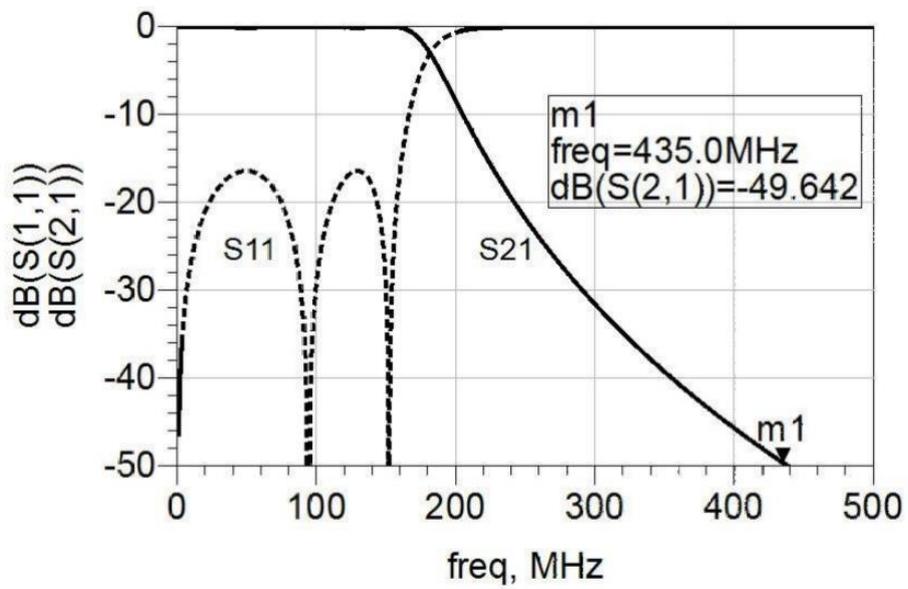
Low Pass Filter

Fig Low Pass Filter with N=5

Simulation Output:

Fig Response of Low Pass Filter

Expt. No: 19

Date:

MICROWAVE IC – FILTER CHARACTERISTICS

Aim:

        To design and analyze the characteristics of microwave signal for Low pass and High Pass filter

Pre lab questions:

1. What is an ideal value of attenuation for the frequencies in pass band especially for a cascade configuration?
   a. Zero   b. Unity   c. Infinity   d. Unpredictable
2. It is possible to overcome the drawback of m-derived filter by connecting number of sections in addition to prototype & m-derived sections with terminating _____
   a. One-fourth sections   b. Half sections
   c. Square of three-fourth sections   d. Full sections
3. Which value of 'm' is selected in a composite filter, while connecting the terminating sections in order to acquire proper impedance matching and constant characteristic impedance throughout the passband?
   a. 0.3 b. 0.6 c. 0.9 d. 0.12
4. In band elimination filter, the frequency of resonance of individual arms is geometric _____
   a. Mean of two cut-off frequencies   b. Difference of two cut-off frequencies
   c. Product of two cut-off frequencies   d. Division of two cut-off frequencies
5. What do the high pass filters generally comprise of?
   a. Capacitive series arm   b. Capacitive shunt arm
   c. Inductive series arm   d. Inductive shunt arm

Apparatus Required:

➢ PC
➢ ADS Software

Theory:

        Radio frequency (RF) and microwave filters represent a class of electronic filter, designed to operate on signals in the megahertz to gigahertz frequency ranges (medium frequency to extremely high frequency). This frequency range is the range used by most broadcast radio, television, wireless communication (cellphones, Wi-Fi, etc.), and thus most RF and microwave devices will include some kind of filtering on the signals transmitted or received. Such filters are commonly used as building blocks for duplexers and diplexers to combine or separate multiple frequency bands.

        Advanced Design System (ADS) is an automation software system produced by Keysight. It provides an integrated design environment to designers of RF electronic products such as mobile phones, pagers, wireless networks, satellite communications, radar systems, and high-speed data links. In this Software, we can simulation and synthesis package the microwave signal like tuning, optimization and statistical design support for RF, Microwave, MMIC and etc.
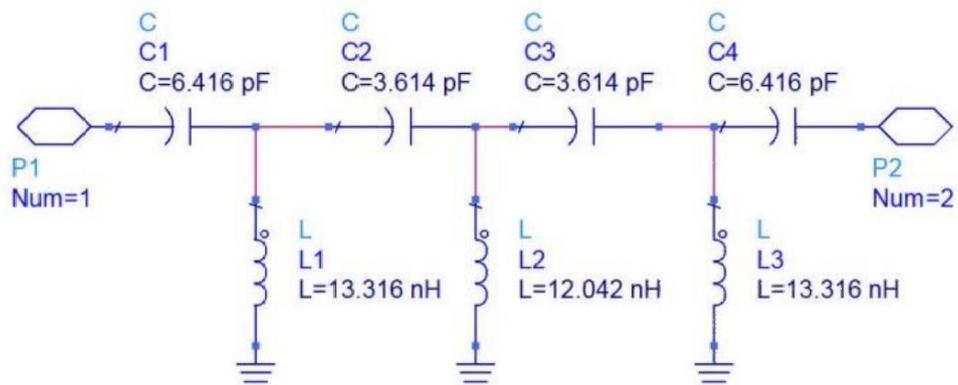
Circuit Diagram

High Pass Filter

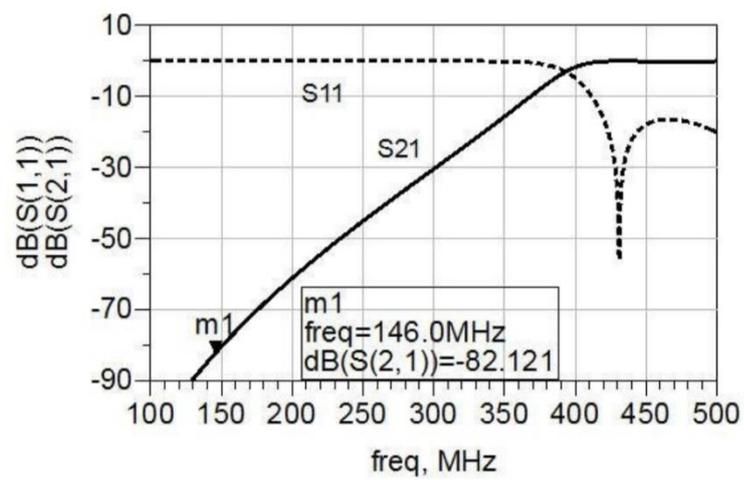**Fig High Pass filter with N=7**

Simulation Output:

Fig Response of High Pass Filter

Procedure:
- ➢ Open new file in ADS software
- ➢ Select microwave test bench in menu
- ➢ Select the required components in tools button
- ➢ Drag the components and draw the circuit diagram
- ➢ Simulate the diagram by selecting appropriate frequency
- ➢ Run the circuit Diagram

Result:

Thus the simulation of   microwave signal for low pass filter and high pass filter was analyzed and characteristics was observed using ADS software successfully.