

DEPARTMENT OF ELECTRONICS AND COMMUNICATION



ATRIA INSTITUTE OF TECHNOLOGY

(Affiliated To Visvesvaraya Technological University, Belgaum)

Anandanagar, Bangalore-24

ADVANCED COMMUNICATION LAB MANUAL

Advanced Communication Lab manual pertaining seventh Semester Electronics and Communication Engineering has been prepared as per the syllabus prescribed by Visvesvaraya Technological University. All the experiments given in the Lab Manual are conducted and verified as per the experiment list.

Prepared By:

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Dept. of ECE

Atria IT

ADVANCED COMMUNICATION LAB

SYLLABUS

B.E., VII Semester, Electronics & Communication Engineering

[As per Choice Based Credit System (CBCS) scheme]

Subject Code 17ECL76 IA Marks 40

Number of Lecture Hours/Week 01Hr Tutorial (Instructions) + 02 Hours Laboratory = 03

Exam Marks 60

RBT Levels L1, L2, L3

Exam Hours 03

CREDITS – 02

Course objectives: This course will enable students to:

- Design and demonstrate the digital modulation techniques
- Demonstrate and measure the wave propagation in microstrip antennas
- Characteristics of microstrip devices and measurement of its parameters.
- Model an optical communication system and study its characteristics.
- Simulate the digital communication concepts and compute and display various parameters along with plots/figures.

Laboratory Experiments

PART-A: Following Experiments No. 1 to 4 has to be performed using discrete components.

1. Time Division Multiplexing and Demultiplexing of two bandlimited signals.
2. ASK generation and detection
3. FSK generation and detection
4. PSK generation and detection
5. Measurement of frequency, guide wavelength, power, VSWR and attenuation in microwave test bench.
6. Measurement of directivity and gain of microstrip dipole and Yagi antennas.
7. Determination of
 - a. Coupling and isolation characteristics of microstrip directional coupler.
 - b. Resonance characteristics of microstrip ring resonator and computation of dielectric constant of the substrate.
 - c. Power division and isolation of microstrip power divider.
8. Measurement of propagation loss, bending loss and numerical aperture of an optical fiber.

PART-B:

Simulation Experiments using SCILAB/MATLAB/Simulink or LabView

1. Simulate NRZ, RZ, half-sinusoid and raised cosine pulses and generate eye diagram for binary polar signaling.
2. Simulate the Pulse code modulation and demodulation system and display the waveforms.
3. Simulate the QPSK transmitter and receiver. Plot the signals and its constellation diagram.
4. Test the performance of a binary differential phase shift keying system by simulating the non-coherent detection of binary DPSK.

Conduct of Practical Examination:

- All laboratory experiments are to be considered for practical examination.
- For examination one question from PART-A and one question from PART-B or only one question from PART-B experiments based on the complexity, to be set.
- Students are allowed to pick one experiment from the lot.
- Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
- Change of experiment is allowed only once and Marks allotted to the procedure part to be made zero.

CYCLE OF EXPERIMENTS

CYCLE I

1. TDM of two band limited signals.
2. ASK generation and detection.
3. FSK generation and detection.
4. PSK generation and detection.
5. Measurements of frequency, guide wavelength, power, VSWR and attenuation in a microwave test bench.

CYCLE-II

6. Measurements of directivity and gain of Microstrip dipole and Yagi antennas.
7. Determination of
 - a. Coupling and isolation characteristics of a Microstrip directional coupler.
 - b. Resonance characteristics of a Microstrip ring resonator and computation of dielectric constant of the substrate.
 - c. Power division and isolation of Microstrip power divider.
8. Measurement of losses in a given optical fiber (Propagation loss, bending loss) and numerical aperture.

CYCLE-III

1. Simulate NRZ, RZ, half-sinusoid and raised cosine pulses and generate eye diagram for binary polar signaling.
2. Simulate the Pulse Code modulation and demodulation system and display the waveforms.
3. Simulate the QPSK transmitter and receiver. Plot the signals and its constellation diagram.
4. Test the performance of a binary differential phase shift keying system by simulating the non-coherent detection of binary DPSK.

CYCLE - I

EXPERIMENT NO. 1

TIME DIVISION MULTIPLEXING OF TWO BAND LIMITED SIGNALS

AIM: Time division multiplexing and recovery of two band limited signals using PAM technique.

Preamble / Theory:

Time Division Multiplexing (TDM) is a type of digital or analog multiplexing in which two or more signals or bit streams are transmitted simultaneously as sub-channels in one communication channel, but are physically taking turns to ON the channel. It enables the joint use of a common transmission channel by plurality of independent message sources without mutual interference.

(or)

In Time Division Multiplexing (TDM), different time periods are allotted for different signals so that a common communication channel is utilized for transmission of these signals without interference. Thus in TDM all the samples obtained from different signals are accommodated on a time shared basis within one sampling interval T_s .

Each input message signal is first restricted in bandwidth by an LPF to remove the frequencies that are not essential to adequate signal transmission. The LPF outputs are then applied to a commutator that is usually implemented using electronic switching circuitry. Following the commutator process, the multiplexed signal into a form that is suitable for transmission over the common channel.

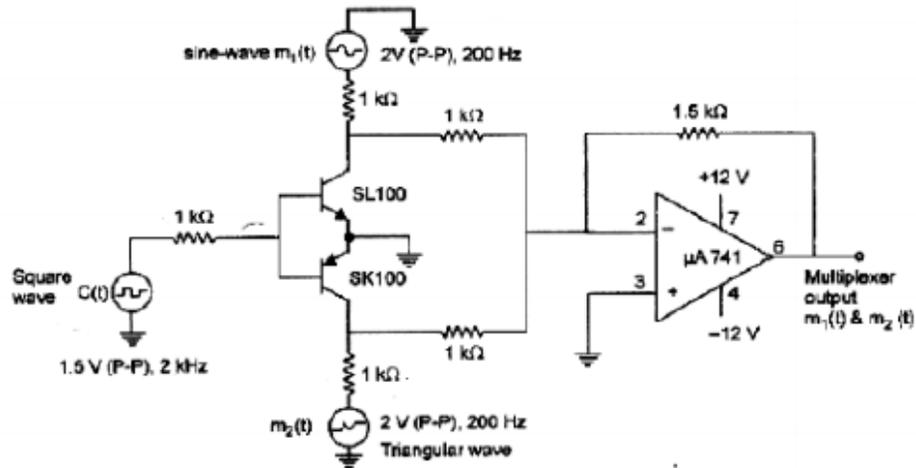
At the receiver end of the system, the received signal is applied to pulse demodulator, which performs the inverse operation of the pulse modulator. The narrow samples produced at the pulse demodulator are distributed to the appropriate low pass filters. By means of decommutator, reconstruction filters operates in synchronization with the commutator, since the synchronization is essential for satisfactory operation of the system.

Equipments & Components required: Transistor - SL100,SK100

Resistors - $1K\Omega$, $10K\Omega$, $1.5K\Omega$, $67K\Omega$

Function generators, Power supplies, Oscilloscope.

Circuit Diagram: Multiplexer



Demultiplexer

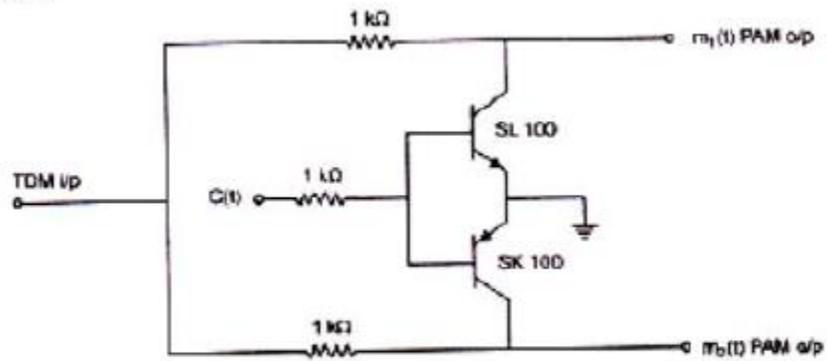


Fig 1. Circuit diagram of Multiplexer and Demultiplexer

DESIGN:

Calculations :

Modulation :

Triangular wave , $f = \frac{1}{1 \times 10^{-3}} = 1\text{KHz}$, 1 Vp-pSine wave , , $f = \frac{1}{3.8 \times 0.5 \times 10^{-3}} = 526\text{Hz}$, 4Vp-p

DeModulation :

Triangular wave , $f = \frac{1}{1 \times 10^{-3}} = 1\text{KHz}$ Sine wave , $f = \frac{1}{1.2 \times 1 \times 10^{-3}} = 833.3\text{ Hz}$ **Procedure:**

1. Rig up the circuit as shown in the circuit-diagram for multiplexer.
2. Feed the input message signals m1 and m2 of 2 volts P-P at 200 Hz.
3. Feed the high frequency carrier signal of 2V (P-P) at 2 kHz.
4. Observe the multiplexed output.
5. Rig up the circuit for demultiplexer.
6. Observe the demultiplexed output in the CRO.

WAVEFORMS:

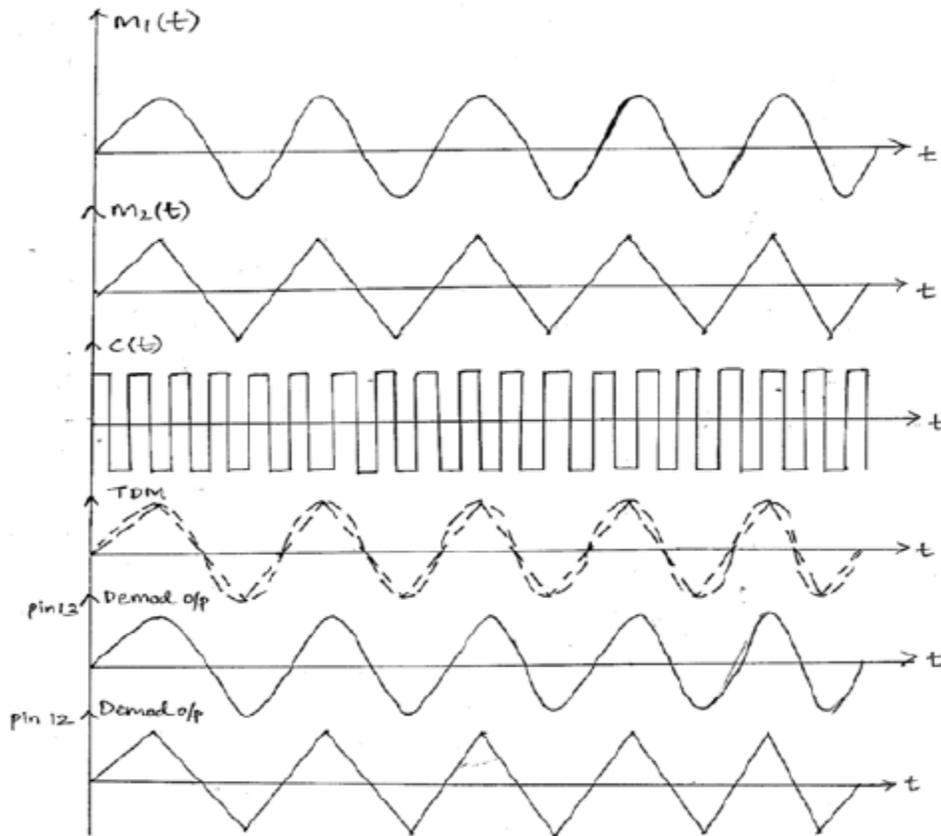


Fig 2. TDM waveforms

Tabulation:

| Measurement | C(t) | m1(t) | m2(t) | m'1(t) | m'2(t) |
|-------------|------|-------|-------|--------|--------|
| Amplitude | | | | | |
| Frequency | | | | | |

EXPERIMENT NO.2

AMPLITUDE SHIFT KEYING

AIM : To study the performance of the circuit that is used for generation and detection of Amplitude shift keying.

Preamble/Theory: Amplitude-shift keying (ASK) is a form of modulation that represents digital data as variations in the amplitude of a carrier wave. The amplitude of an analog carrier signal varies in accordance with the bit stream (modulating signal), keeping frequency and phase constant. The level of amplitude can be used to represent binary logic '0's and '1's. The carrier signal being switched by a ON or OFF switch. In the modulated signal logic '0' is represented by the absence of a carrier and logic '1' represents the presence of the carrier, thus giving OFF/ON keying operation and hence the name given.

The simplest and most common form of ASK operating as a switch is using the presence of a carrier wave to indicate a binary one and its absence to indicate a binary zero. This type of modulation is called ON-OFF keying.

Applications:

Its is used at radio frequencies to transmit MORSE code(referred to as continuous wave operation)In aviation to turn on runway lights.

Equipments & Components Required: Transistor - SL100,

Resistors - 2.2K, 67K, 33K, 200K, 100K potentiometer

Capacitor – 0.01 μ F

Op amp - μ A 741

Diode - 0A79

Function generators, Power supplies, Oscilloscope.

CIRCUIT DIAGRAM:

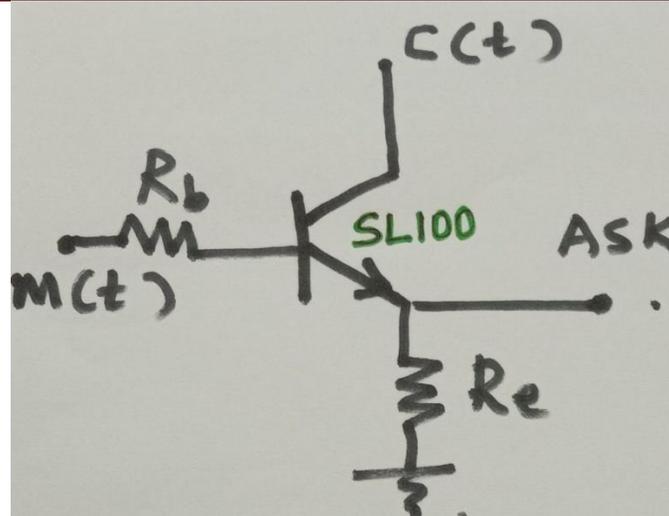


Figure.1: ASK Modulator circuit

DESIGN:

MODULATOR:

Given $I_E = I_C = 2.5\text{mA}$, $h_{fe} = 100$, $V_{RE} = 2.5\text{V}$,

Then, $R_E = V_{RE} / I_C = 1\text{K}\Omega$

Assuming peak to peak amplitude of message signal $V_{m(P-P)} = 7\text{V}$ & $f_m = 300\text{Hz}$,

Applying KVL across the Base-Emitter loop in circuit above we get,

$$\begin{aligned} V_{RB} &= V_{m(p-p)} - V_{BE} - V_{RE} \\ &= 3.5\text{V} - 0.7\text{V} - 2.5\text{V} = 0.3\text{V} \end{aligned}$$

$$I_B = I_C / h_{fe} = 25\mu\text{A}, \text{ therefore } I_{BSAT} = 1.2I_B = 30\mu\text{A}$$

$$R_B = V_{RB} / I_{BSAT} = 10\text{K}\Omega$$

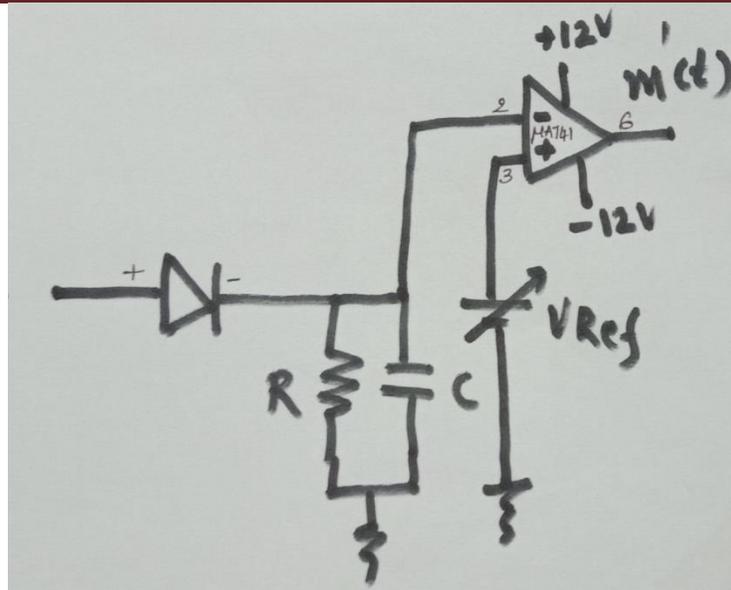


Figure.2: ASK Demodulator circuit

DEMODULATION:

Given $f_m = 300\text{Hz}$

$$f_m = 1/2\pi R_1 C_1$$

Assuming $C_1 = 0.1\mu\text{F}$ then

$$R_1 = 1/2\pi f_m C_1 = 1/2\pi * 300 * 0.1 * 10^{-6} = 5.6\text{K}\Omega$$

V_{ref} is varied from 0.5V to 2V

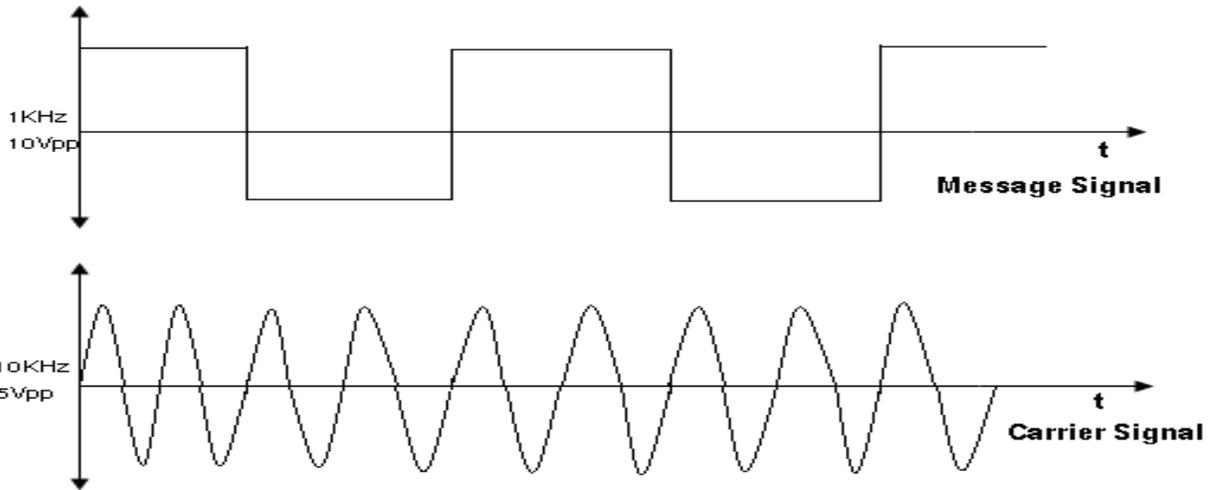
PROCEDURE:

1. Rig up the ASK modulation circuit as shown in circuit diagram(fig.1).
2. Check for the ASK signal across the emitter terminal of the transmitter
3. Feed the ASK input from the ASK modulator output to the OPAMP peak detector.
4. Adjust the reference voltage suitably (between 0 to 2 Volt) to get an undistorted demodulated output. Compare it with the message signal used in modulation.
5. Record all the waveforms as observed.

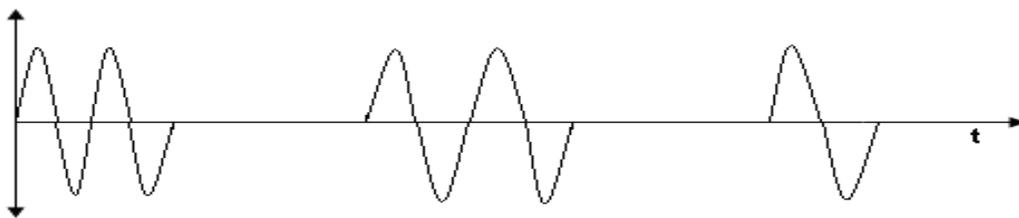
Tabulation:

| Measurement | $m(t)$ | $c(t)$ | ASK output | Envelop detector output | Reference DC | $m'(t)$ |
|-------------|--------|--------|------------|-------------------------|--------------|---------|
| Amplitude | | | | | | |
| Frequency | | | | | | |

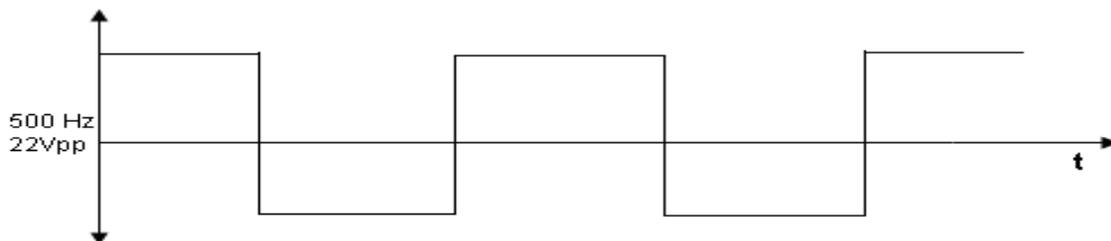
WAVE FORMS:



MODULATION WAVEFORMS: ASK output



DEMODULATION WAVEFORMS:



EXPERIMENT NO. 3

FREQUENCY SHIFT KEYING GENERATION AND DETECTION

AIM: To design an FSK modulator and demodulator and study the performance of the circuits.

Preamble / Theory:

Frequency Shift Keying (FSK) is a frequency modulation scheme in which digital information is transmitted through discrete frequency changes of carrier wave. The simplest FSK is binary FSK (BFSK). BFSK literally implies using a couple of discrete frequencies to transmit binary (0's and 1's) information. With this scheme, the "1" is called the mark frequency and "0" is called the space frequency.

Audio Frequency-shift keying (AFSK) is a modulation technique by which digital data is represented by the changes in the frequency(pitch) of an audio tone, yielding an encoded signal suitable for transmission via radio or telephone. Normally the transmitted audio alternates between two tones: one, the "mark", represents a binary one, the other the "space", represents a binary zero.

AFSK differs from regular frequency-shift keying in performing the modulation at baseband frequencies. In radio applications, the AFSK-modulated signal normally is being used to modulate an RF carrier for transmission.

AFSK is not always being used for high –speed data communication schemes. In addition to its simplicity AFSK has the advantage that encoded signals will pass through AC-coupled links, telephone links, including most equipment originally designed to carry music or speech.

The simplest and most common form of FSK operates as two switches, using the presence of one carrier wave to indicate a binary one and another one to indicate binary zero.

Equipments & Components: Transistor SL100 and SK100,

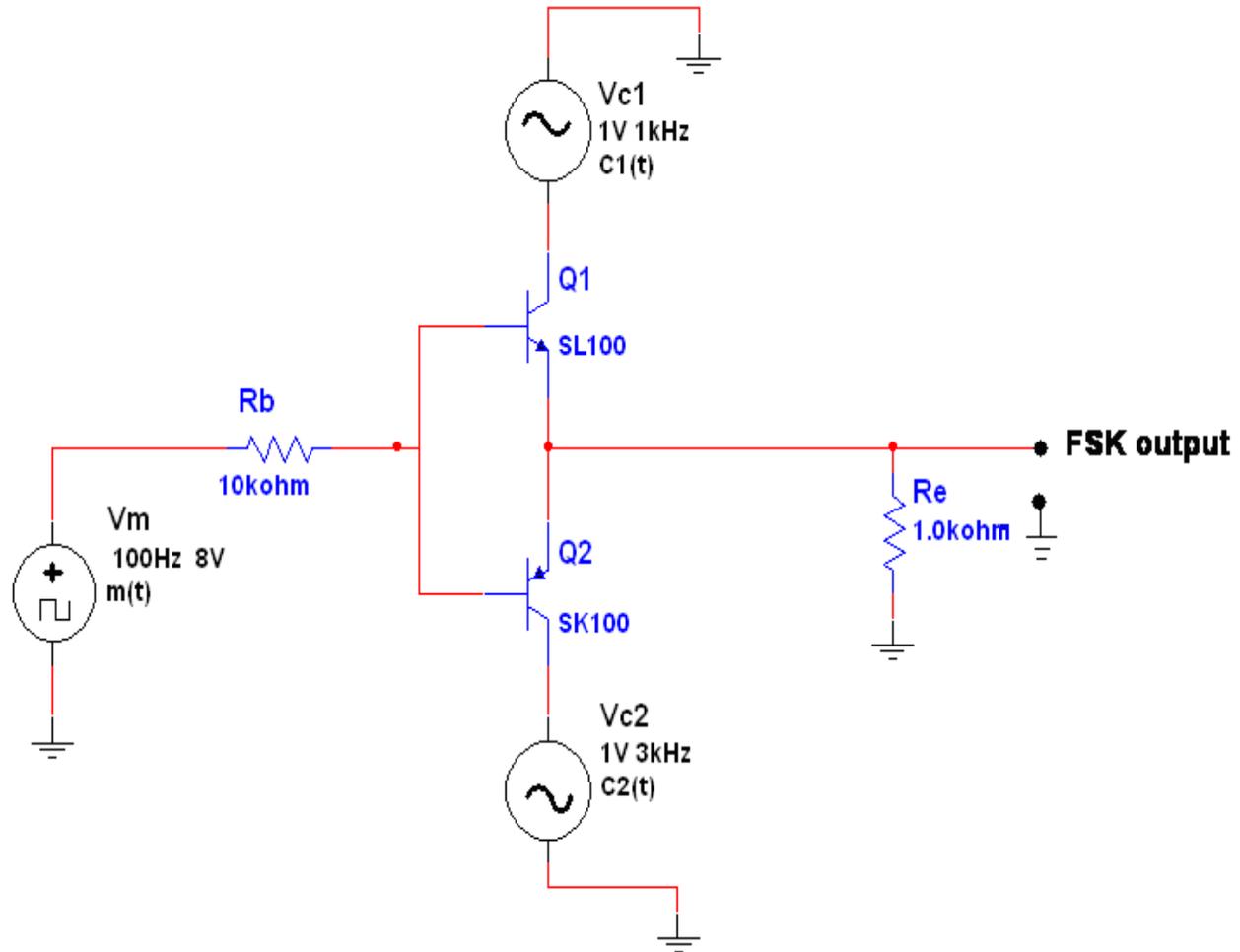
Resistors -1K Ω , 10K Ω , 5.6K Ω , 560 Ω

Capacitors – 0.1 μ F - 2 Nos.

Op amp - μ A741

Diode - 0A79

Function generators, Power supply, Oscilloscope.

CIRCUIT DIAGRAM:**FSK MODULATOR:****Figure.1: FSK Modulator circuit****DESIGN:**

$$I_c = I_e = 2.5\text{mA}, h_{fe} = 100, V_{RE} = 2.5\text{V}$$

$$\text{Then, } R_E = V_{RE} / I_E = 2.5 / 2.5\text{mA} = R_E = 1\text{K}\Omega$$

$$V_{RB} = V_m(t)_{p-p} / 2 - V_{BE}(\text{sat}) - V_{RE}(\text{sat})$$

$$= 3.5 - 0.7 - 2.5$$

$$V_{RB} = 0.3\text{V}$$

$$I_B = I_c / h_{fe} = 2.5 / 100 = 2.5\mu A$$

$$I_{B(SAT)} = 1.2I_B$$

$$I_{BSat} = 30\mu A$$

$$R_B = V_{RB} / I_{B(SAT)} = 0.3 / 30 = R_B = 10K\Omega$$

FSK DEMODULATOR:

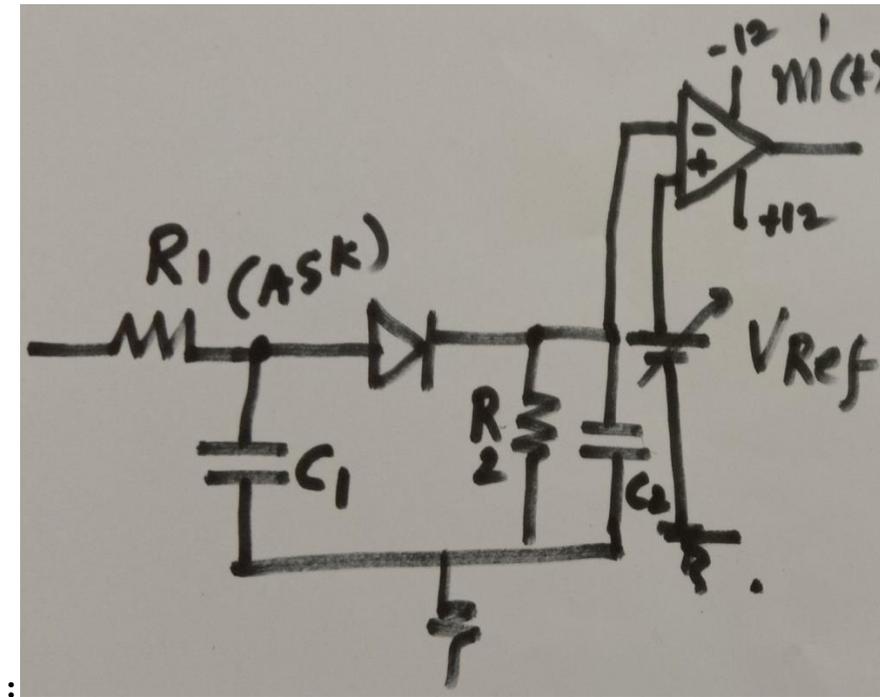


Figure.1: FSK Demodulator circuit

$$f_m = 1 / 2\pi RC$$

Assuming $C = 0.1\mu F$

$$R = 15.9K\Omega$$

$$f_m = 100Hz$$

$$f_{c1} = 1 / 2\pi R_1 C_1$$

$$f_{c1} = 1 KHz$$

$$R_1 = 1.59 K\Omega$$

$C1 = 0.1\mu\text{F}$

PROCEDURE:**Generation:**

1. Rig up the circuit as given in the circuit diagram for generation of FSK.
2. Apply $m(t) > 7V_{p-p}$, 300Hz square wave.
3. Apply $c_1(t) = 3V_{p-p}$, 2KHz and $c_2(t) = 3V_{p-p}$, 10KHz Sine wave.
4. Observe FSK output at the transmitter at the emitter of the transistor on an oscilloscope.

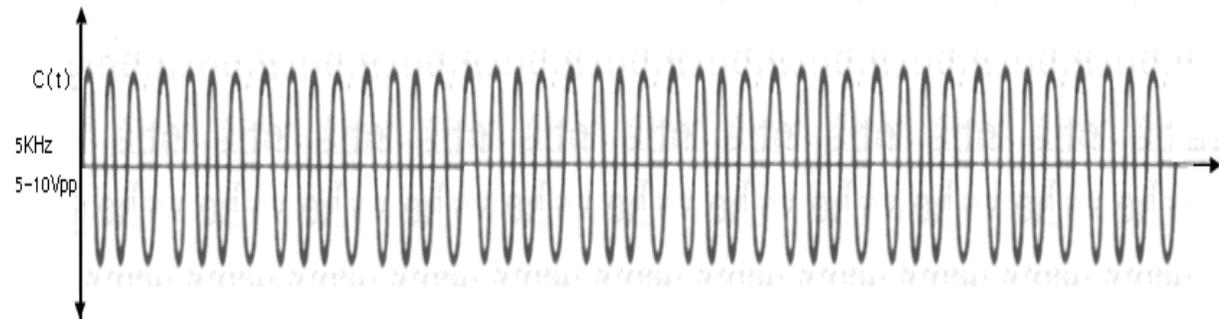
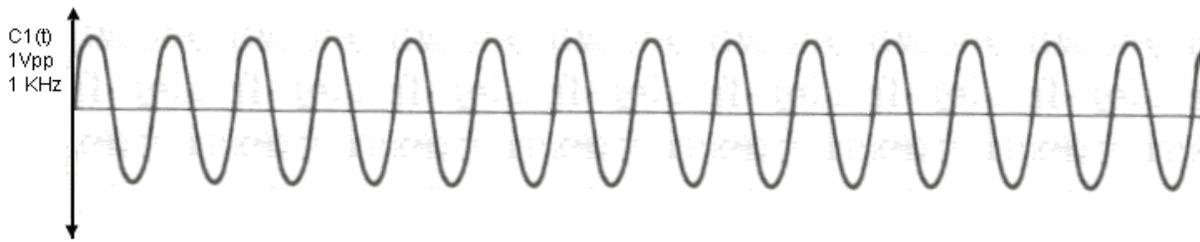
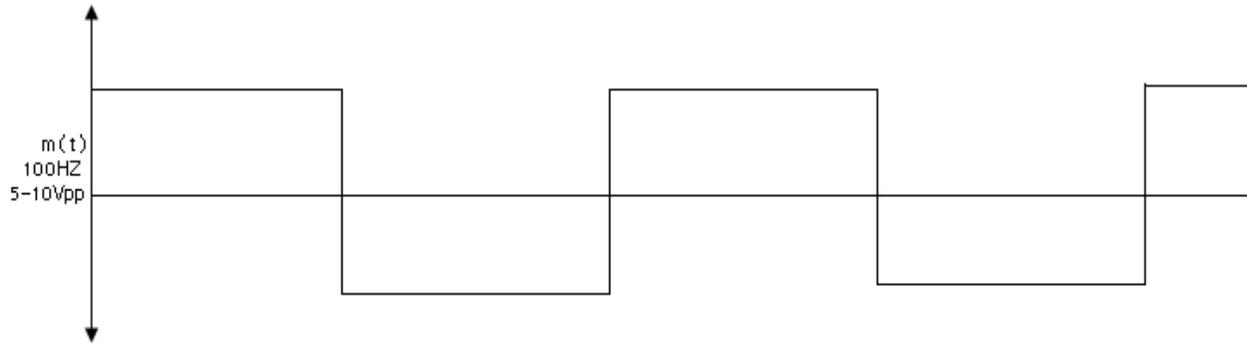
Detection:

1. Rig up the circuit as per the given circuit diagram.
2. It may be observed that after the first RC network, which is a low pass filter, the waveform becomes that of an ASK.
3. Observe the amplitude and waveform at pin no.3 of the op-Amp, which is the output of the envelop detector-RC combination, a ramp.
4. Since the Op-amp is working as a comparator, vary the reference dc voltage applied at pin no. 2 from 0V to a desired value such that a square waveform appears at the output.
5. It may be observed that the reproduced signal, $m'(t)$ matches with actual message signal interms of frequency but not in amplitude.

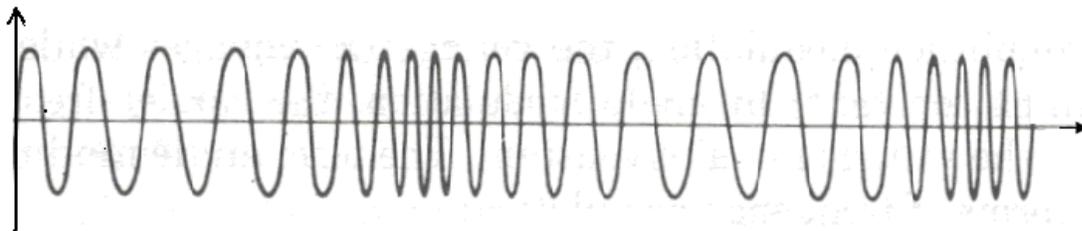
Tabulation:

| Measurement | $m(t)$ | $C_1(t)$ | $C_2(t)$ | FSK output | Envelop detector output | Reference DC | $m'(t)$ |
|-------------|--------|----------|----------|------------|-------------------------|--------------|---------|
| Amplitude | | | | | | | |
| Frequency | | | | | | | |

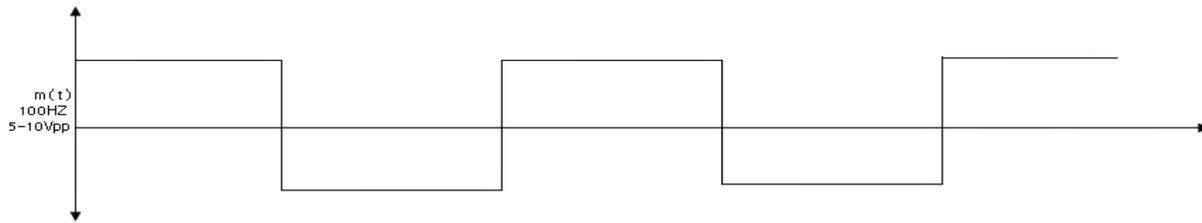
WAVE FORMS:



MODULATION WAVEFORMS:



DEMODULATION WAVEFORMS:



EXPERIMENT NO. 4

PHASE SHIFT KEYING GENERATION AND DETECTION

AIM: To design a Phase Shift keying (PSK) modulator and demodulator circuit, and study their performance.

Preamble / Theory

Phase-shift keying (PSK) is a digital modulation scheme that conveys data by changing, or modulating the phase of a reference signal (the carrier wave). Any digital modulation scheme uses a finite number of distinct signals to represent digital data. PSK uses a finite number of phases; each assigned a unique pattern of binary bits. Usually each phase encodes an equal number of bits. Each pattern of bits forms the symbol that is represented by the particular phase. The demodulator which is designed specifically for the symbol it represents thus recovering the original data. This requires the receiver to be able to compare the phase of the received signal to a reference signal- such a system is termed coherent PSK (CPSK).

BPSK or PRK (Phase Reversal Keying) is the simplest form of PSK. It uses two phases which are separated by 180 and so can also be termed as 2-PSK. It is however only able to modulate 1 bit/symbol and so it is unsuitable for high data-rate applications when bandwidth is limited.

Equipments & Components required: Transistor SL100, SK100

Resistor – $1K\Omega$, $100K\Omega$, $5.6 K\Omega$

Capacitor – $0.1\mu F$

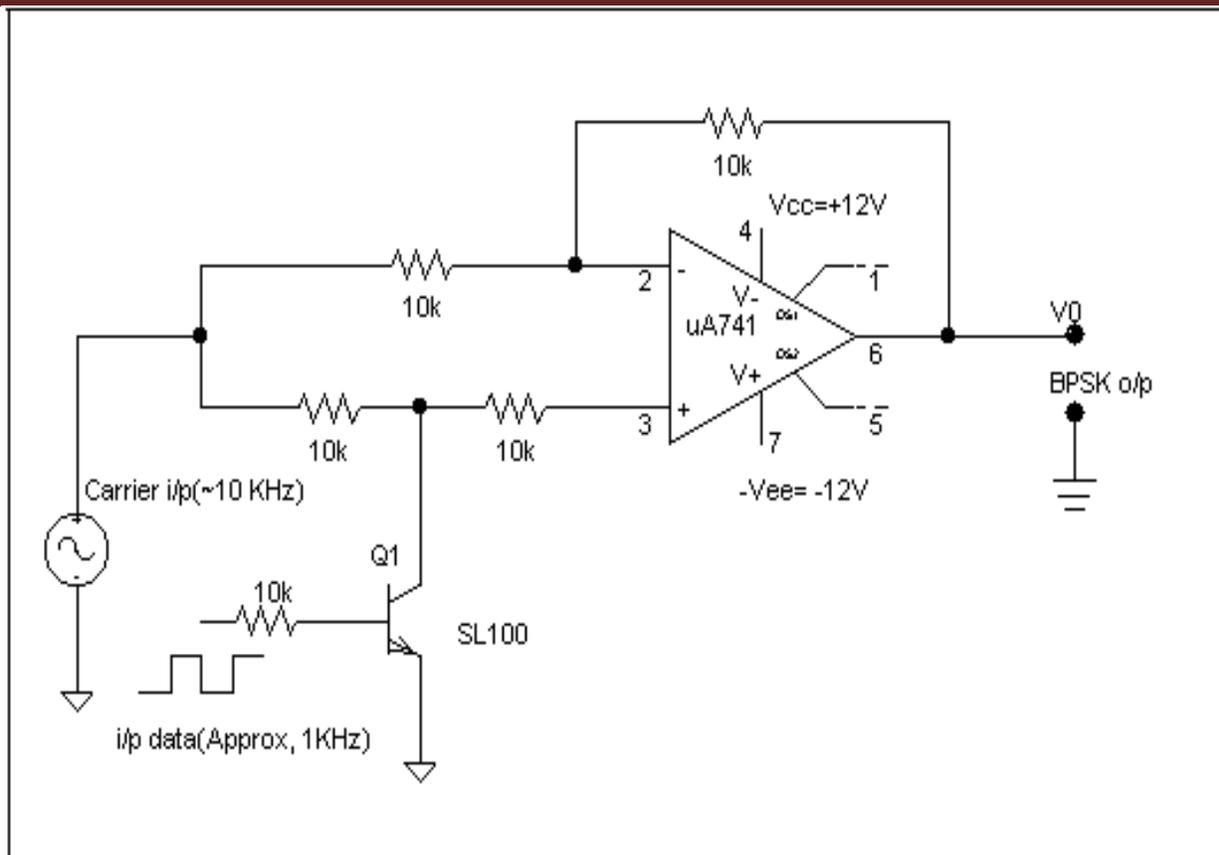
OP Amp - $\mu A741$,

Diode - 0A79

Signal generators, Power supplies, Oscilloscope.

CIRCUIT DIAGRAM:

PSK MODULATOR:



PROCEDURE:

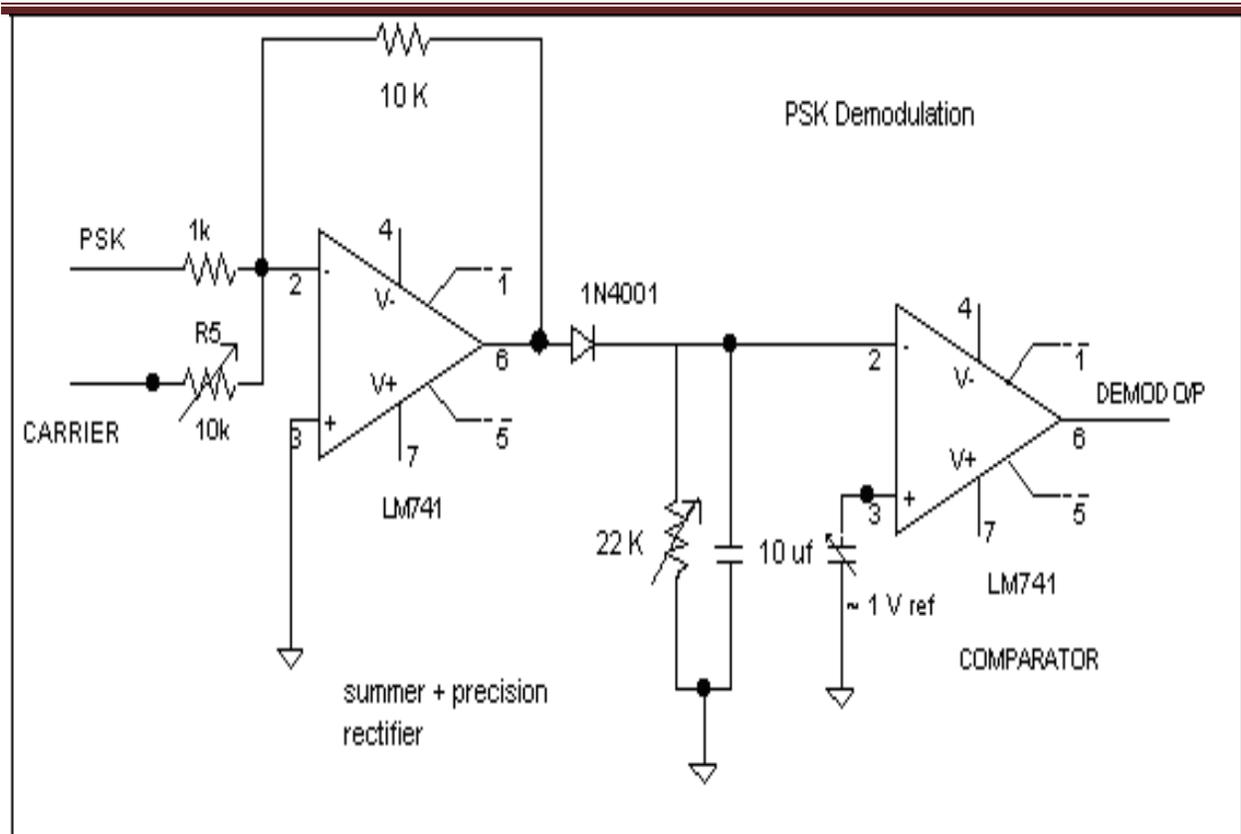
Generation:

5. Rig up the circuit as given in the circuit diagram for generation of FSK.
6. Apply $m(t) > 7V_{p-p}$, 300Hz square wave.
7. Apply $c_1(t) = 3V_{p-p}$, 2KHz and $c_2(t) = 3V_{p-p}$, 10KHz Sine wave.
8. Observe PSK output at the transmitter at the emitter of the transistor on an oscilloscope.

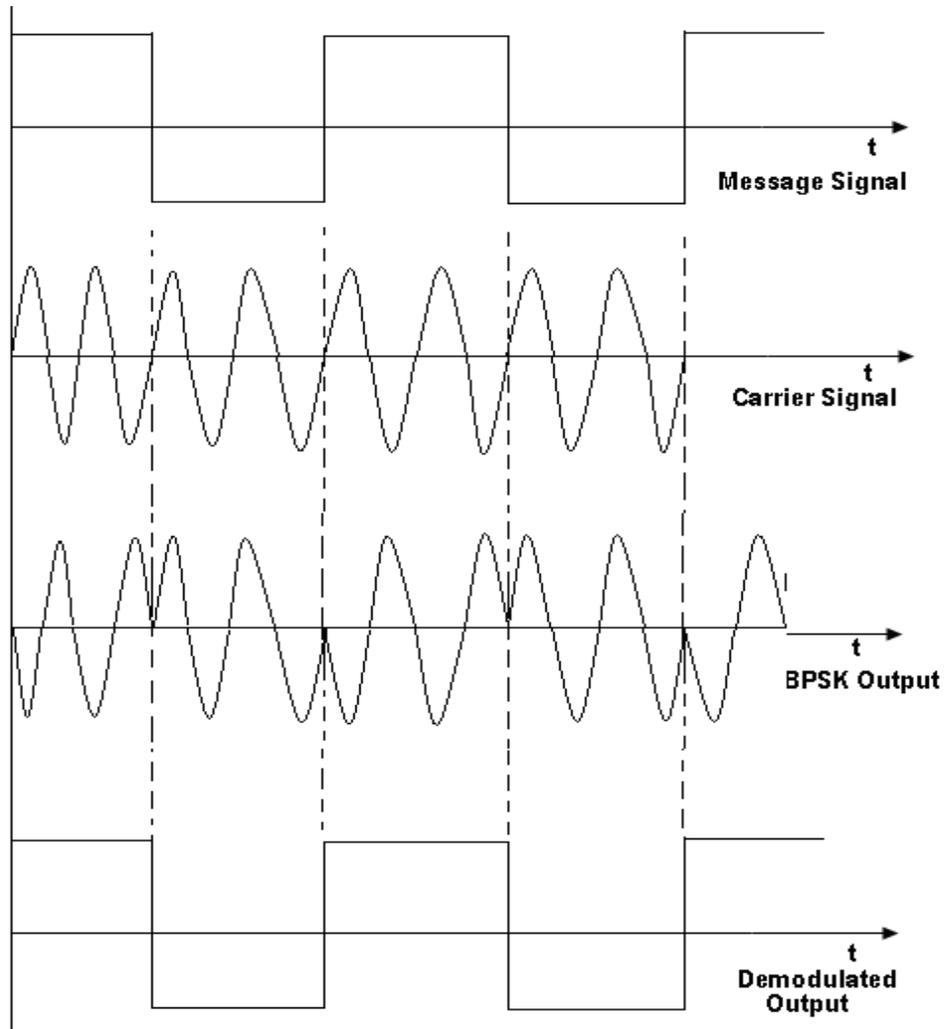
Detection:

6. Rig up the circuit as per the given circuit diagram.
7. It may be observed that after the first RC network, which is a low pass filter, the waveform becomes that of an ASK.
8. Observe the amplitude and waveform at pin no.3 of the op-Amp, which is the output of the envelop detector-RC combination, a ramp.
9. Since the Op-amp is working as a comparator, vary the reference dc voltage applied at pin no. 2 from 0V to a desired value such that a square waveform appears at the output.
10. It may be observed that the reproduced signal, $m'(t)$ matches with actual message signal in terms of frequency but not in amplitude.

PSK DEMODULATOR:



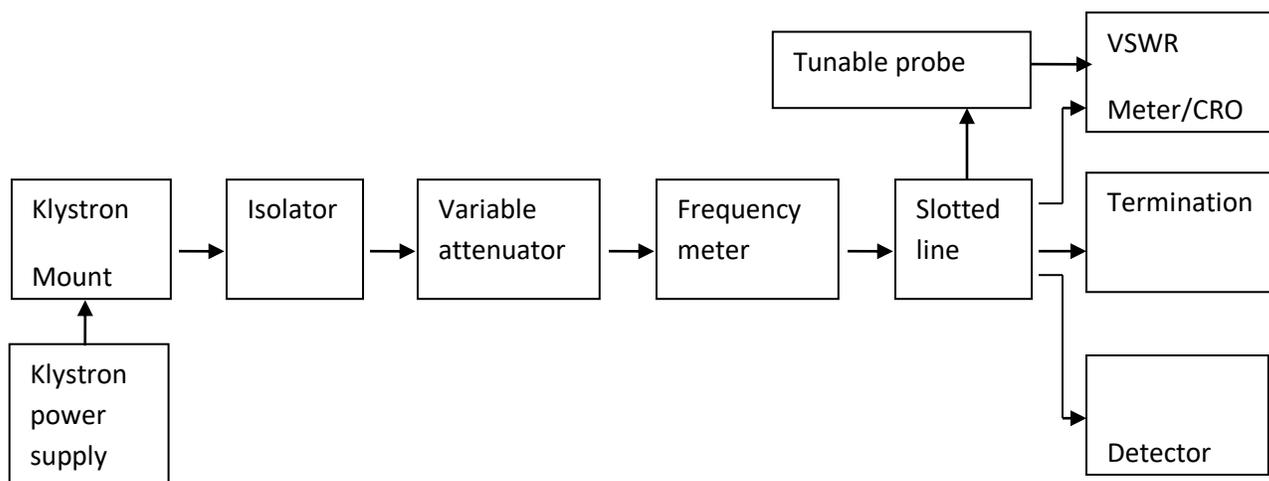
Waveforms



EXPERIMENT NO. 5**MEASUREMENTS OF FREQUENCY, GUIDE WAVELENGTH, POWER, VSWR AND ATTENUATION IN A MICROWAVE TEST BENCH.**

AIM: Measurements of Frequency, Guide Wavelength, Power, VSWR and Attenuation in a Microwave Test Bench

Equipments / Components required: Micro wave test bench, CRO, VSWR meter, Klystron power supply, cooling fan, wave guide stand, matched termination, detector mount, cables.

SET UP OF MICROWAVE TEST BENCH:**PROCEDURE:**

1. Set up the components and equipments as shown in figure.
2. Set up variable attenuator at minimum attenuation position.
3. Keep the control knobs of VSWR meter as given below:

Range : 50 db

Input switch : crystal low impedance

Meter switch : Normal position

Gain (coarse & fine) : mid position

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

Beam voltage : OFF

Mod – switch : AM

Beam voltage knob : fully anticlockwise

Reflector voltage : fully clockwise

AM – Amplitude knob : fully clockwise

AM –Frequency knob : fully clockwise

5. Switch ‘ON’ the Klystron power supply, VSWR meter, and cooling fan switch.
6. Switch ‘ON’ Beam voltage switch and set beam voltage at 300 V with help of beam voltage knob.
7. Adjust the reflector voltage to get some deflection in VSWR meter.
8. Maximize the deflection with AM amplitude and frequency control knob of power supply.
9. Tune the plunger of klystron mount for maximum deflection.
10. Tune the reflector voltage knob for maximum deflection.
11. Tune the probe for maximum deflection in VSWR meter.
12. Tune the frequency meter knob to get a ‘Dip’ on the VSWR scale and note down the frequency directly from the frequency meter.
13. Replace the termination with movable sort, and detune the frequency meter.
14. Move the probe along the slotted line. The deflection in VSWR meter will vary. Move the probe to minimum deflection position, to get accurate reading. If necessary increase the VSWR meter range db switch to higher position. Note and record the probe position.
15. Move the probe to next minimum position and record the probe position again.
16. Calculate the guide wavelength as twice the distance between two successive minimum positions obtained as above.
17. Measure the wave guide inner broad dimension, ‘a’ which will be around 22.86 mm for X- band.
18. Calculate the frequency by following equation.

$$F = C / \lambda$$

Where $C = 3 \times 10^8$ meter / sec. i.e. velocity of light and $1/\lambda_o^2 = 1/\lambda_g^2 + 1/\lambda_c^2$

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

CALCULATIONS:

Guide Wavelength:

(i) $\lambda_{g1} = 2(d_{min1} \approx d_{min2})$

(ii) $\lambda_{g2} = 2(d_{min1} \approx d_{min2})$

VSWR:

(i) $VSWR_1 = V_{max} / V_{min}$

(ii) $VSWR_2 = V_{max} / V_{min}$

Frequency:

$$F = C/\lambda = C * \frac{\sqrt{\lambda_g^2 + \lambda_c^2}}{\lambda_g \lambda_c}$$

Where,

$C = 3 \times 10^8$ meter / sec

$\lambda_o = \lambda_g \lambda_c$

$$\lambda_g^2 + \lambda_c^2$$

For dominant TE₁₀ mode rectangular wave guide $\lambda_o, \lambda_g, \lambda_c$ are related as below:

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

Where λ_o is free space wavelength

λ_g is guide wavelength

λ_c is cutoff wavelength

For TE₁₀ mode, $\lambda_c = 2a$ where 'a' is broad dimension of waveguide.

CYCLE – II**EXPERIMENT NO. 6****MEASUREMENT OF LOSSES IN A GIVEN OPTICAL FIBER (PROPAGATION LOSS, BENDING LOSS) AND NUMERICAL APERTURE.**

AIM: Study of different types of losses in optical fiber.

(a) To measure propagation or attenuation loss in optical fiber.

Preamble / Theory: Attenuation is loss of power. During transit light pulse lose some of their photons, thus reducing their amplitude. Attenuation for a fiber is usually specified in decibels per kilometer. For commercially available fibers attenuation ranges from 1 dB / km for premium small-core glass fibers to over 2000 dB / km for a large core plastic fiber. Loss is by definition negative decibels. In common usage, discussions of loss omit the negative sign. The basic measurement for loss in a fiber is made by taking the logarithmic ratio of the input power (Pi) to the output power (Po).

$$\alpha \text{ (dB)} = 10 \log_{10} \frac{P_i}{P_o}$$

Where α is Loss in dB / Meter

PROCEDURE:**Attenuation Loss or Propagation Loss**

1. Connect power supply to board
2. Make the following connections (as shown in figure 1).
 - a. Function generator's 1 KHz sine wave output to Input 1 socket of emitter 1 circuit via 4 mm lead.
 - b. Connect 0.5 m optic fiber between emitter 1 output and detector 1's input.
 - c. Connect detector 1 output to amplifier 1 input socket via 4mm lead.
3. Switch ON the power supply.

4. Set the oscilloscope channel 1 to 0.5 V / Div and adjust 4 - 6 div amplitude by using X 1 probe with the help of variable pot in function generator block at input 1 of Emitter 1. Observe the output signal from detector tp10 on CRO.
5. Observe the output signal from detector tp10 on CRO.
6. Adjust the amplitude of the received signal same as that of transmitted one with the help of gain adjust pot. In AC amplifier block. Note this amplitude and name it V1.
7. Now replace the previous FO cable with 1 m cable without disturbing any previous setting.
8. Measure the amplitude at the receiver side again at output of amplifier 1 socket tp 28. Note this value and name it V2. Calculate the propagation (attenuation) loss with the help of following formula.

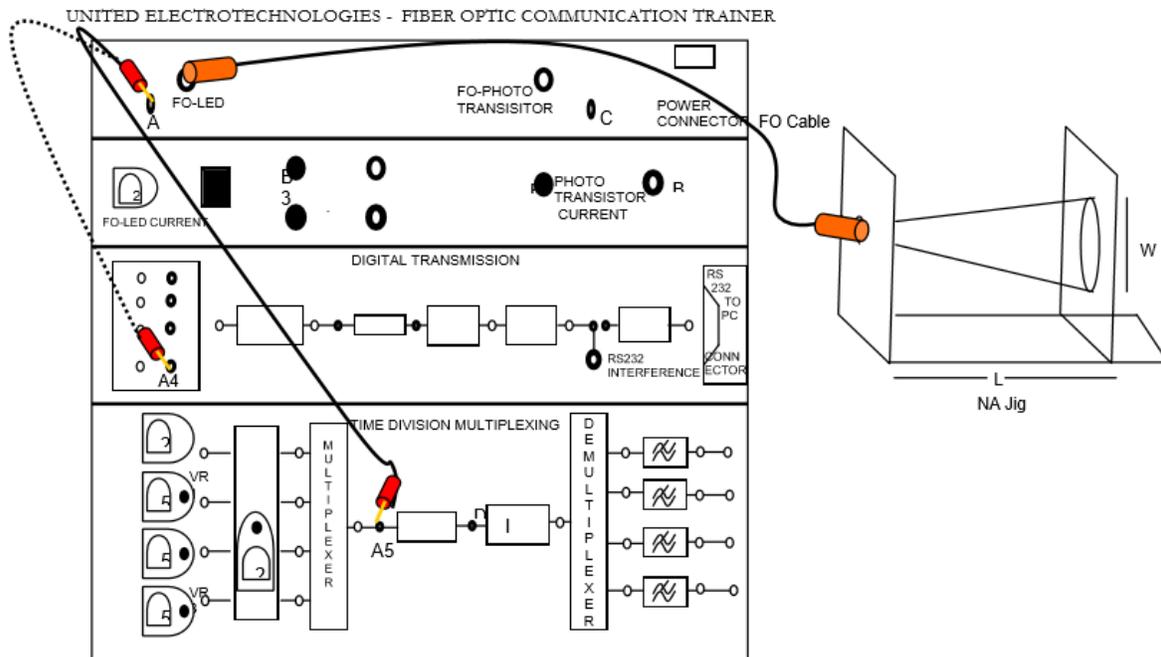
$$V1 / V2 = e^{-\alpha(L1 + L2)}$$

Where α is loss in nepers / meter

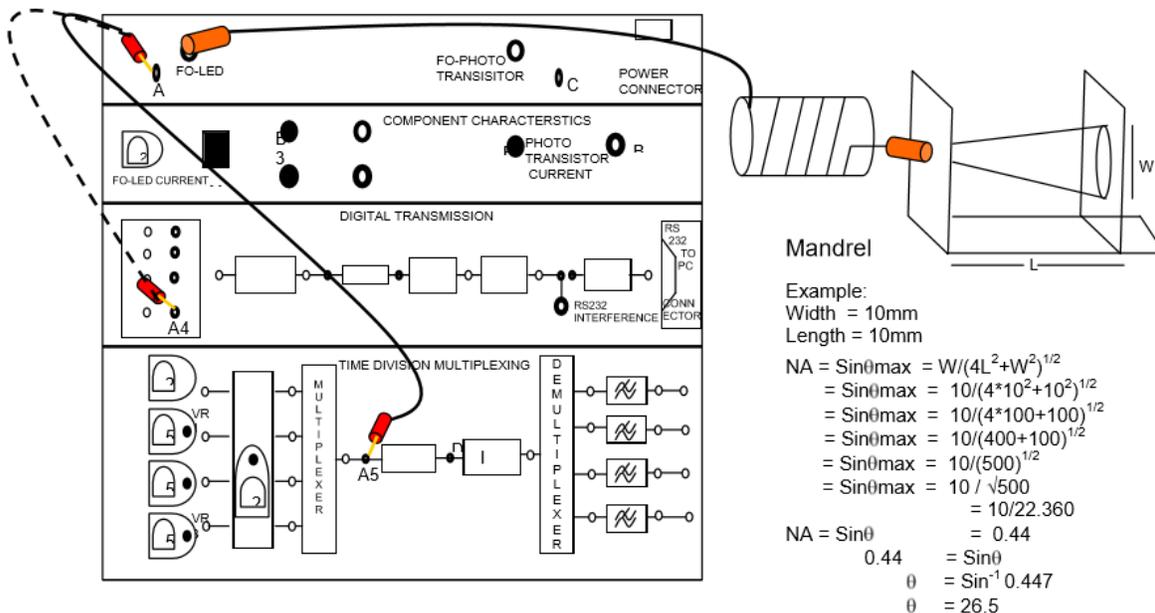
$$1 \text{ neper} = 8.686 \text{ dB}$$

L 1 = length of shorter cable (0.5 m)

L 2 = Length of longer cable (1 m)



NA Measurement Scheme

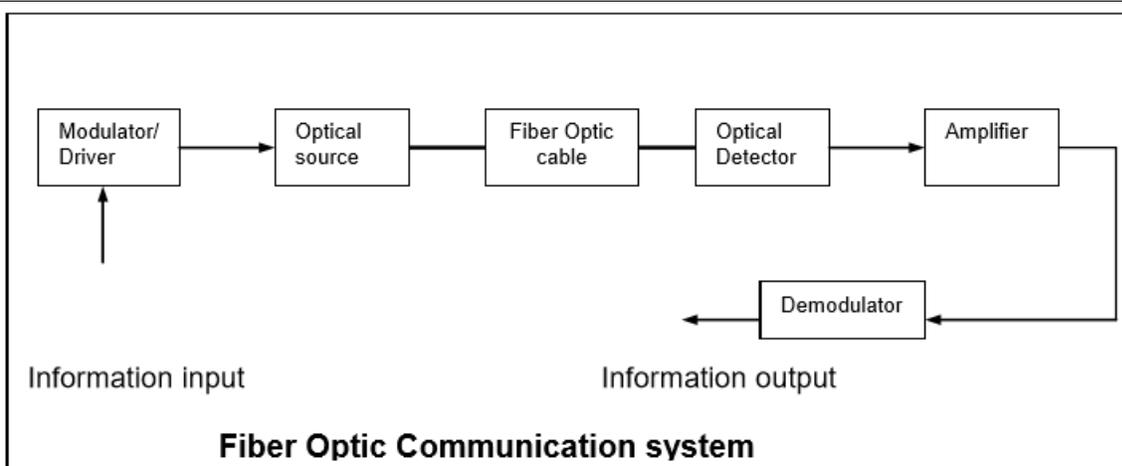


NA Measurement Scheme

Step 5: In case fibre is under filled, the intensity within the spot may not be evenly distributed. To ensure even distribution of light in the fibre, first remove twists on the fibre and then wind 5 turns of the fibre on to the mandrel as shown. Use an adhesive tape to hold the windings in position. Now view the spot. The intensity will be more evenly distributed within the core.

Table of Readings:

| Sl No | L (mm) | W(mm) | NA | θ (degrees) |
|-------|--------|-------|-------|-------------|
| 1 | 10 | 10 | 0.447 | 26.5 |
| 2 | 16 | 15 | 0.423 | 25.0 |
| 3 | 20 | 20 | 0.447 | 26.5 |
| 4 | 26 | 25 | 0.432 | 25.64 |
| 5 | 30 | - | | |



(b) Study of Bending Loss.

The objective of this experiment is to determine the bending loss in an optical fiber cable.

THEORY:

Whenever the condition for angle of incidence of the incident light is violated the losses are introduced due to refraction of light. This occurs when fiber is subjected to bending. Lower the radius of curvature more is the loss.

PROCEDURE:

1. Repeat all the steps from 1 to 6 of the previous experiment using 1m cable.
2. Wind the FO cable on the mandrel and observe the corresponding AC amplifier output on CRO. It will be gradually reducing showing loss due to bends.

STUDY OF NUMERICAL APERTURE OF OPTICAL FIBER:

AIM: The aim of this experiment is to measure the numerical aperture of the optical fiber provided with kit using 660nm wavelength LED.

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 rotating of this angle along the axis of the fiber is the cone of acceptance; else it is refracted out of the fiber core.

CONSIDERATIONS IN N.A. MEASUREMENT:

1. 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.
2. This experiment is best performed in a less illuminated room

EQUIPMENTS:

Experimenter kit, 1-meter fiber cable, Numerical Aperture measurement Jig.

PROCEDURE:

1. Connect power supply to the board
2. Connect the frequency generator's 1 KHz sine wave output to input of emitter 1 circuit. Adjust its amplitude at 5Vpp.

3. Connect one end of fiber cable to the output socket of emitter 1 circuit and the other end to the numerical aperture measurement jig. Hold the white screen facing the fiber such that its cut face is perpendicular to the axis of the fiber.
4. Hold the white screen with 4 concentric circles (10, 15, 20 & 25mm diameter) vertically at a suitable distance to make the red spot from the fiber coincide with 10 mm circle.

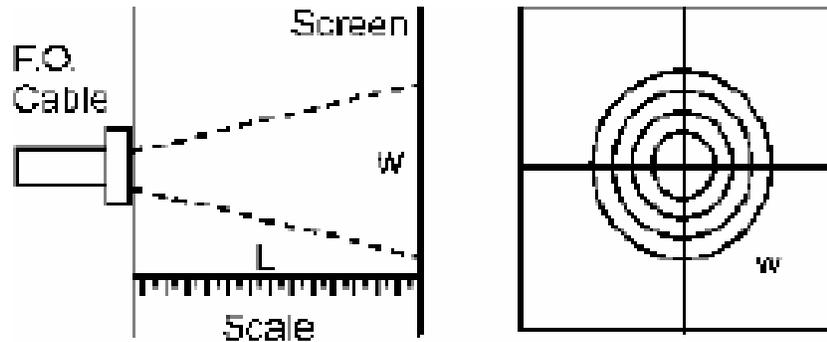
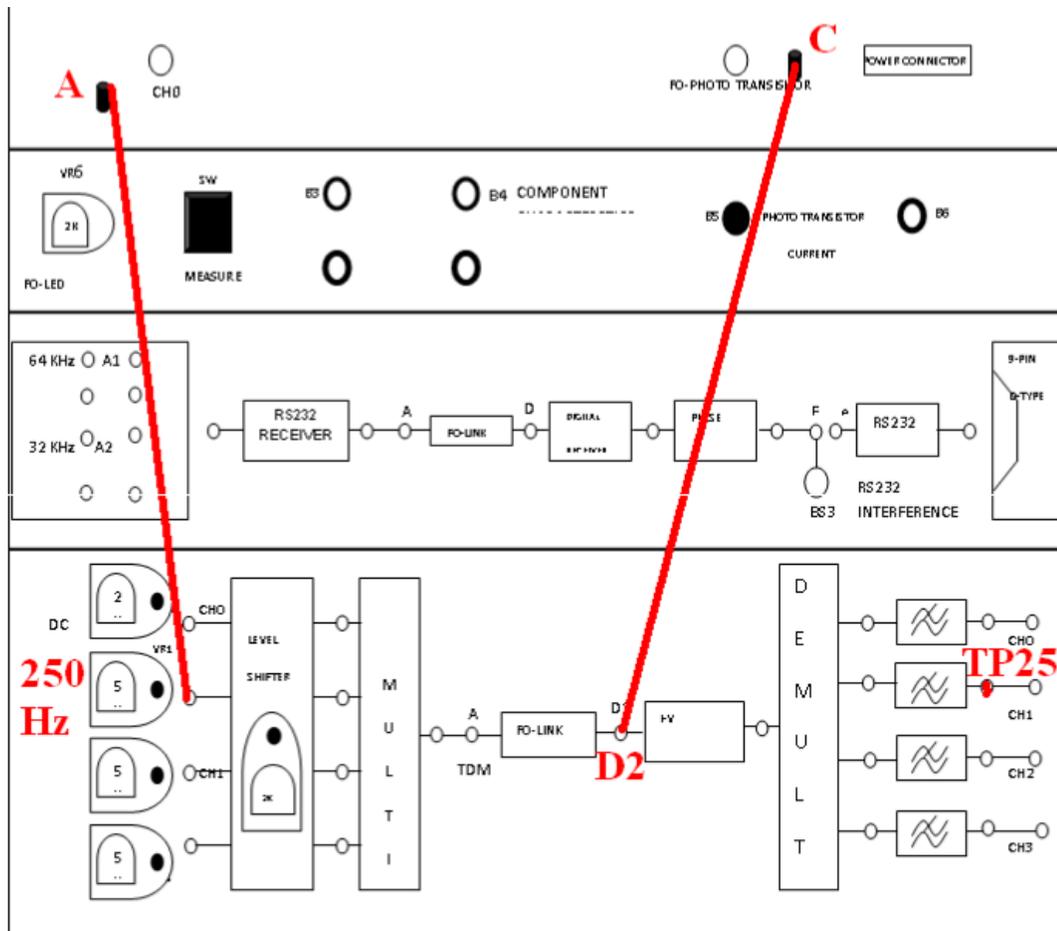


Figure. 4

1. Record the distance of screen from the fiber end L and note the diameter W of the spot.
2. Compute the numerical aperture from the formula given below

$$NA = \frac{W}{\sqrt{4L^2 + W^2}}$$
3. Vary the distance between in screen and fiber optic cable and make it coincide with one of the concentric circles. Note its distance
4. Tabulate the various distances and diameters of the circles made on the white screen and compute the numerical aperture from the formula given above.

Inferences: The N.A. recorded in the manufacturer's data sheet is 0.5 typical.

Propagation loss:**Experimental Procedure:**

1. Connect the Power Supply for Kit and turn on the supply in rare panel of Power supply
2. Connect Analog Signal 250 Hz (Sine Wave) to input terminal **A** Select Toggle Switch
3. Observe the Light on FO-LED
4. Now Connect the Smaller (consider this as L1) Fiber Optic Cable to between FO-LED and FO-Photo transistor
5. Now observe the output on **TP25** output post
6. Adjust the Level pots at 250Hz VR3 to get proper sine wave and adjust the level to 1Vpp (consider this as V1)
7. Now replace the optical fiber cable with longer (consider this as L2) and note down the output on TP25 (consider this as V2).
8. Calculate the Propagation Loss

| | |
|----------------------------|-----------------------|
| Optical fiber cable length | Output Voltage (Vpp) |
| L1 = | V1 = |
| L2 = | V2 = |

Propagation Loss

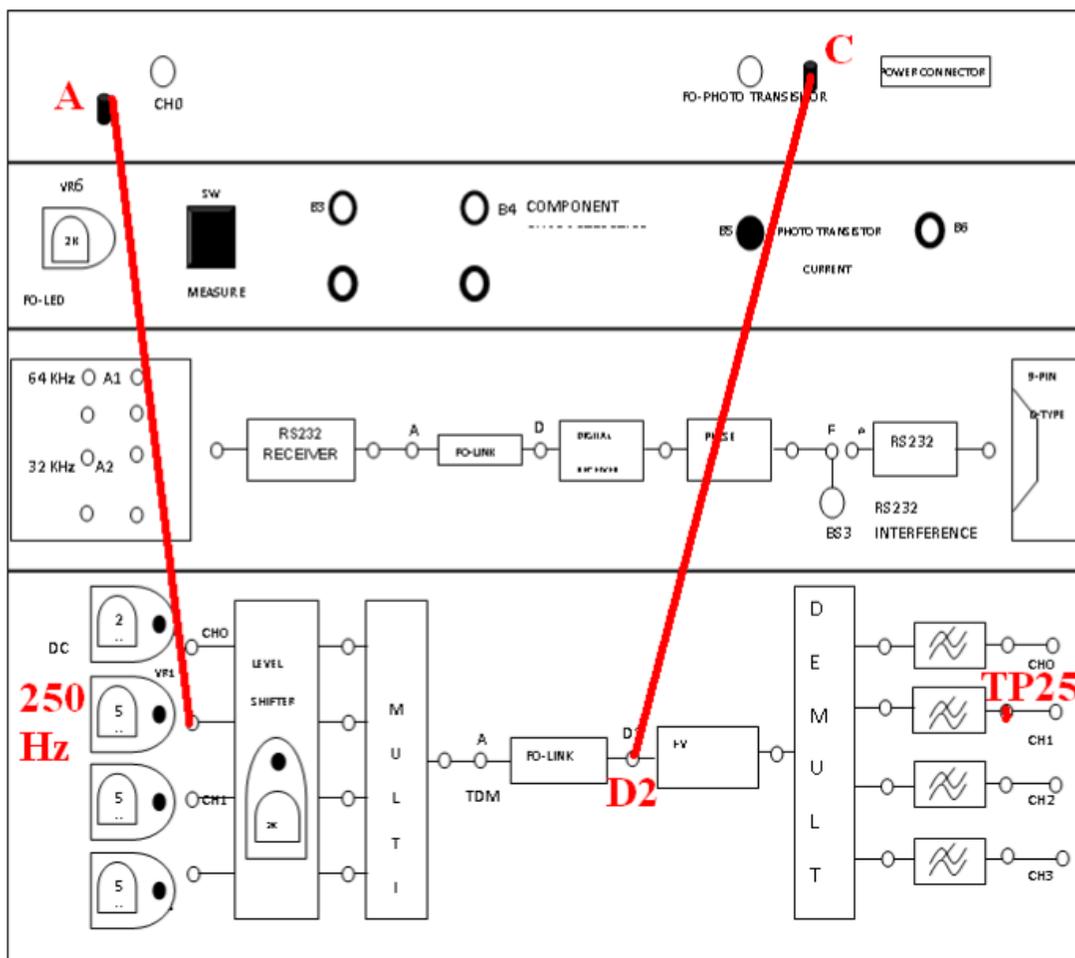
If α is the attenuation of the fiber then we have

$$\alpha_{dB} = \frac{10}{L1 - L2} \log_{10} \frac{V2}{V1}$$

Where α = dB/km

L1 = Fiber length for V1

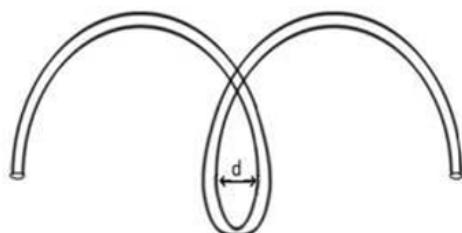
L2 = Fiber length for V2



Bending loss:

Experimental Procedure:

1. Connect the Power Supply for Kit and turn on the supply in rare panel of Power supply
2. Connect Analog Signal 250 Hz (Sine Wave) to input terminal **A** Select Toggle Switch
3. Observe the Light on FO-LED
4. Now Connect the Smaller (consider this as L1) Fiber Optic Cable to between FO-LED and FO-Photo transistor
5. Now observe the output on **TP25** output post
6. Adjust the Level pots at 250Hz VR3 to get proper sine wave and adjust the level to 1Vpp (consider this as V1)
7. Now bend the cable in circle shape and measure the diameter and note down the readings in bellow tabular Colum for different diameter
8. Calculate the Bending Loss



Tabula Column (Vin set to 1Vpp)

| Diameter of the circle (d) | Output Voltage (Vpp) | $10\text{Log} \frac{V_{out}}{V_{in}}$ |
|----------------------------|-----------------------|---------------------------------------|
| 10cm | | |
| 8cm | | |
| 6cm | | |
| 4cm | | |
| 2cm | | |

EXPERIMENT NO. 7

**MEASUREMENTS OF DIRECTIVITY AND GAIN OF ANTENNAS: STANDARD
DIPOLE (OR PRINTED DIPOLE) AND YAGI ANTENNA**

AIM:To find the directivity and gain of Antenna.

Equipments/Components required:

1. Microwave Generator
2. SWR Meter
3. Detector
4. RF Amplifier
5. Transmitter and receiving mast
6. Mains cord
7. Antennas
 - Yagi Antenna (Dielectric Constant: 4.7) - 2 no.
 - Dipole Antenna (Dielectric Constant: 4.7) - 1 no.
 - Patch Antenna (Dielectric Constant: 3.02) - 1 no.

THEORY:

If a transmission line propagating energy is left open at one end, there will be radiation from this end. The Radiation pattern of an antenna is a diagram of field strength or more often the power intensity as a function of the aspect angle at a constant distance from the radiating antenna. An antenna pattern is of course three dimensional but for practical reasons it is normally presented as a two dimensional pattern in one or several planes. An antenna pattern consists of several lobes, the main lobe, side lobes and the back lobe. The major power is concentrated in the main lobe and it is required to keep the power in the side lobes and back lobe as low as possible. The power intensity at the maximum of the main lobe compared to the power intensity achieved from an imaginary omni-directional antenna (radiating equally in all directions) with the same power fed to the antenna is defined as gain of the antenna.

As we know that the 3dB beam width is the angle between the two points on a main lobe where the power intensity is half the maximum power intensity. When measuring an antenna pattern, it

is normally most interesting to plot the pattern far from the antenna. It is also very important to avoid disturbing reflection. Antenna measurements are normally made at anechoic chambers made of absorbing materials. Antenna measurements are mostly made with unknown antenna as receiver. There are several methods to measure the gain of antenna. One method is to compare the unknown antenna with a standard gain antenna with known gain. Another method is to use two identical antennas, as transmitter and other as receiver. From following formula the gain can be calculated.

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

Where

P_t is transmitted power

P_r is received Power,

G_1, G_2 is gain of transmitting and receiving antenna

S is the radial distance between two antennas

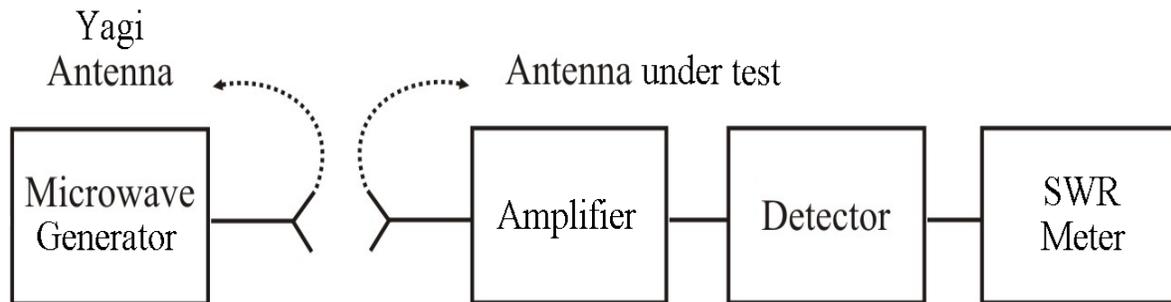
λ_0 is free space wave length.

If both, transmitting and receiving antenna are identical having gain G then above equation becomes.

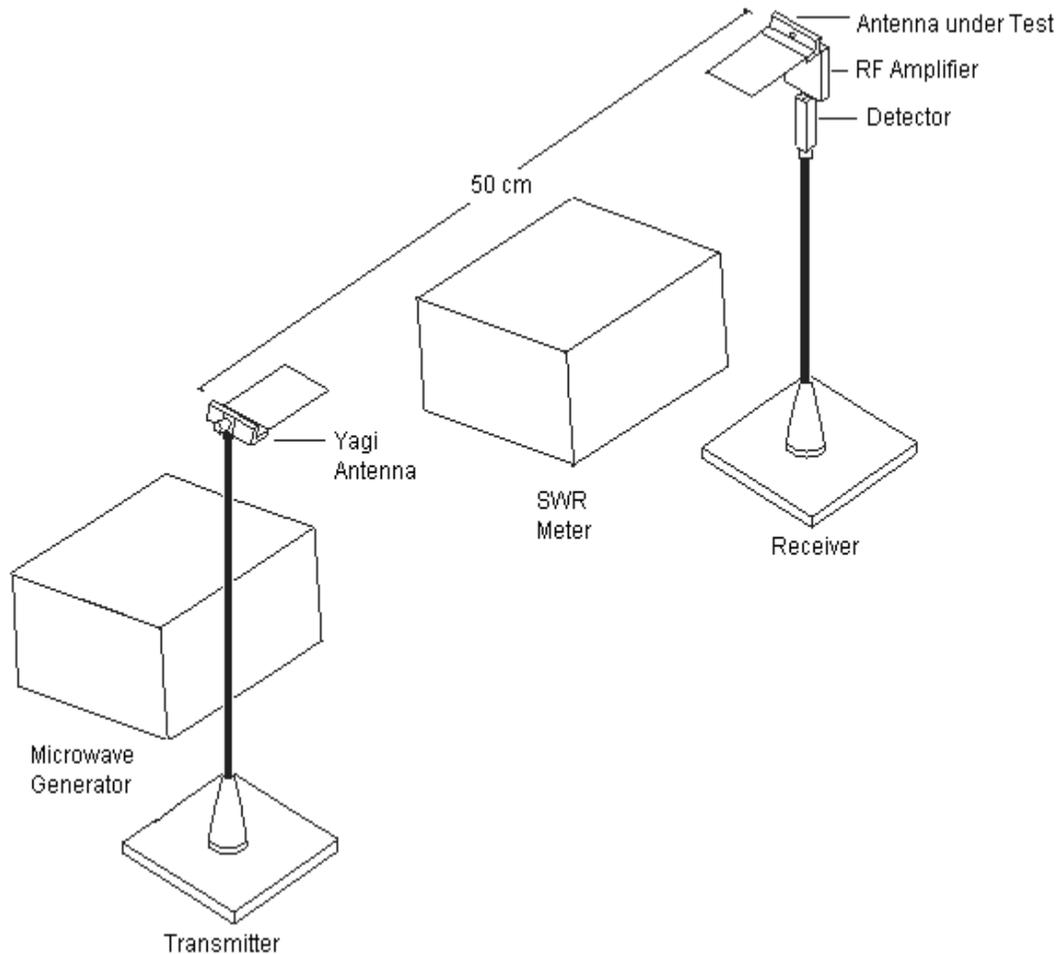
$$P_r = \frac{P_t \lambda_0^2 G^2}{(4\pi S)^2},$$

$$G = \frac{4\pi S}{\lambda_0} \sqrt{\frac{P_r}{P_t}}$$

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

SETUP FOR DIRECTIVITY MEASUREMENT**PROCEDURE:****Directivity Measurement:**

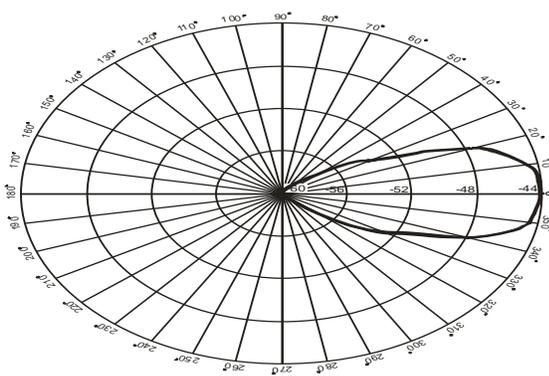
1. Connect a mains cord to the Microwave Generator and SWR Meter.
2. Now connect a Yagi antenna in horizontal plane to the transmitter mast and connect it to the RF Output of microwave generator using a cable (SMA to SMA).
3. Set both the potentiometer (Mod Freq & RF Level) at fully clockwise position.
4. Now take another Yagi antenna and RF Amplifier from the given suitcase.
5. Connect the input terminal of the Amplifier to the antenna in horizontal plane using an SMA (male) to SMA (female) L Connector.
6. Now connect the output of the Amplifier to the input of Detector and mount the detector at the Receiving mast.
7. Connect one end of the cable (BNC to BNC) to the bottom side of receiving mast, and another end to the input of SWR meter.
8. Now set the distance between Transmitter (feed point) and the receiver (receiving point) at half meter.



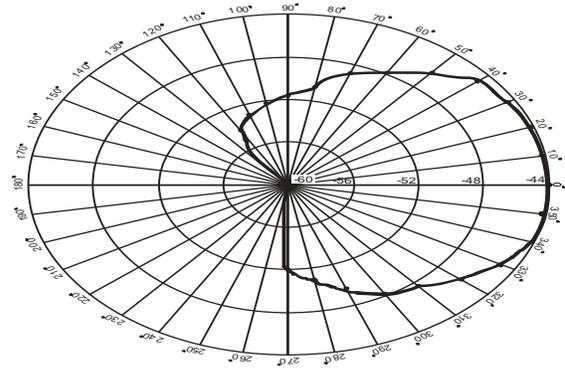
9. Now set the receiving antenna at zero degree (in line of Transmitter) and Switch on the power supply for Microwave Generator, SWR Meter. Also connect DC Adapter of RF Amplifier to the mains.
10. Select the transmitter for internal AM mode and press the switch “RF On”.
11. Select the range switch at SWR meter at – 40dB position with normal mode.
12. Set both the gain potentiometers (Coarse & Fine) at fully clockwise position and input select switch should be at 200 Ohm position. In case if reading is not available at – 40dB range then press 200 k ohm (Input Select) to get high gains reading.
13. Now set any value of received gain at – 40dB position with the help of -
 - Frequency of the Microwave Generator.
 - Modulation frequency adjustment.
 - Adjusting the distance between Transmitter and Receiver.

14. With these adjustments you can increase or decrease the gain.
15. Mark the obtained reading on the radiation pattern plot at zero degree position.
16. Now slowly move the receiver antenna in the steps of 10 degree and plot the corresponding readings.
17. Using the formula, Directivity = $41253 / (\theta_E \times \theta_H)$ Determining the directive gain of the antenna. Where θ_E is the E plane 3dbbeam width in degrees and θ_H in the H plane.
18. Directivity of the antenna is the measures of power density an actual antenna radiates in the direction of its strongest emission, so if the maximum power of antenna (in dB) is received at θ degree then directivity will bedB atDegree.
19. In the same way you can measure the directivity of the Dipole antenna.
20. For directivity measurement of the transformer fed Patch antenna connect transmitter Yagi antenna in the vertical plane (Patch Antenna is vertically polarized). Since it is comparatively low gain antenna distance can be reduced between transmitter and receiver.

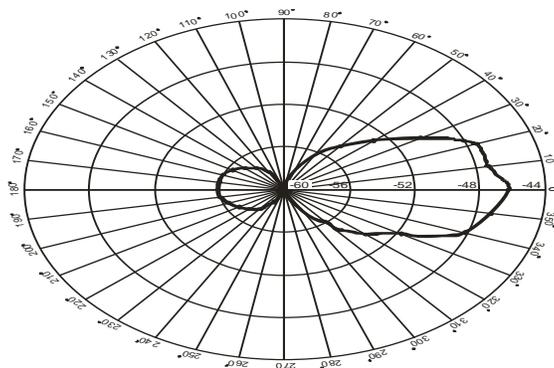
Radiation Patterns of Different Antennas:



Yagi Antenna



Patch Antenna



Dipole Antenna

Gain Measurement:

1. Connect a power cable to the Microwave Generator and SWR Meter.
2. Now connect a Yagi antenna in horizontal plane to the transmitter mast and connect it to the RF Output of microwave generator using a cable (SMA to SMA).
3. Set both the potentiometer (Mod Freq & RF Level) at fully clockwise position.
4. Now take another Yagi antenna from the given suitcase.
5. Connect this antenna to the detector with the help of SMA (male) to SMA (female) L Connector.
6. Connect detector to the receiving mast.
7. Connect one end of the cable (BNC to BNC) to the bottom side of receiving mast, and another end to the input of SWR meter.
8. Now set the distance between Transmitter (feed point) and the receiver (receiving point) at half meter.
9. Now set the receiving antenna at zero degree (in line of Transmitter) and Switch on the power from both Generator & SWR Meter.
10. Select the transmitter for internal AM mode and press the switch “RF On”.
11. Select the range switch at SWR meter at – 40dB position with normal mode.
12. Set both the gain potentiometers (Coarse & Fine) at fully clockwise position and input select switch should be at 200 Ohm position. In case if reading is not available at – 40dB range then press 200 kOhm (Input Select) to get high gain reading.
13. Now set the maximum gain in the meter with the help of following -
 - Frequency of the Microwave Generator.
 - Modulation frequency adjustment.
 - Adjusting the distance between Transmitter and Receiver.
14. Measure and record the received power in dB.

Pr =dB

15. Now remove the detector from the receiving end and also remove the transmitting Yagi antenna from RF output.

16. Now connect the RF output directly to detector without disturbing any setting of the transmitter (SMA-F to SMA-F connector can be used for this).

17. Observe the output of detector on SWR meter that will be the transmitting power P_t .

$$P_t = \dots\dots\dots\text{dB}$$

18. Calculate the difference in dB between the power measured in step 14 and 17 which will be the power ratio P_t/P_r .

$$P_t/P_r = \dots\dots\dots$$

$$P_r/P_t = \dots\dots\dots$$

19. Now we know that the formula for Gain of the antenna is:

$$G = \frac{4\pi S}{\lambda_0} \sqrt{\frac{P_r}{P_t}}$$

Where:

P_t is transmitted power

P_r is received Power,

G is gain of transmitting/receiving antenna (since we have used two identical antennas)

S is the radial distance between two antennas

λ_0 is free space wave length (approximately 12.5cm).

20. Now put the measured values in the above formula and measure the gain of the antenna which will be same for both the antennas. Now after this step you can connect one known gain antenna at transmitter end and the antenna under test at receiver end, to measure the gain of the antennas.

21. Gain can be measured with the help of absolute power meter also (Recommended Model NV105). For this, detector will not be used and directly the power sensor can be connected to both the ends as described earlier.

EXPERIMENT NO. 8

DETERMINATION OF COUPLING AND ISOLATION CHARACTERISTICS OF A STRIPLINE (OR MICROSTRIP) DIRECTIONAL COUPLER

AIM: determination of coupling and isolation characteristics of a stripline (or microstrip) directional coupler

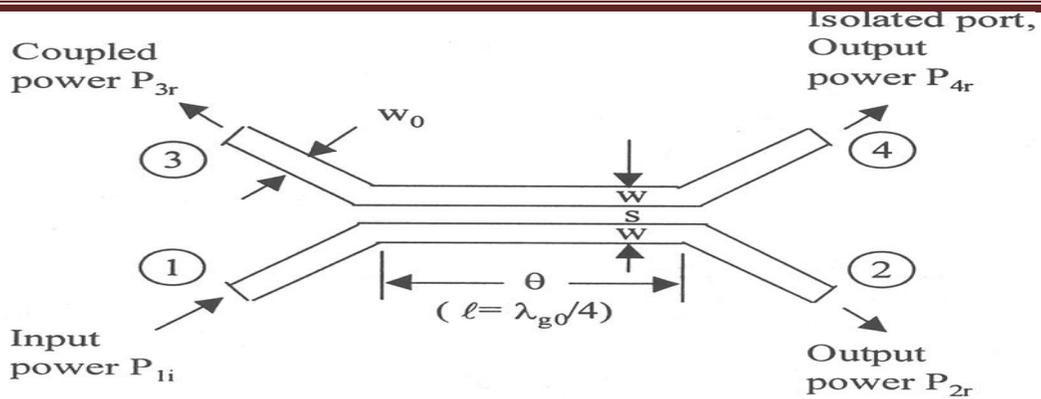
COMPONENTS:

1. Microwave signal source with modulation (1 KHz) and frequency (2 – 3 GHz)
2. VSWR meter
3. Parallel line microstrip directional coupler (DUT).
4. Detector
5. Matched loads
6. Cables and adapters

Provided in the Kit, is a parallel line (backward wave) directional coupler (15dB). The impedance of input/output lines is 50Ω . The length of the parallel coupled line region is quarter wavelength at the centre frequency (around 2.4 GHz). The ports are decoupled by bending the auxiliary line and main line at either ends of the parallel coupled section. For the experiment, anyone of the ports can be chosen as the inputport. With respect to this input port, identify the direct output port (port 2), the coupled port (port 3) and the isolated port (port 4). Measurement of coupling involves measuring the transmission response between the input port (port 1) and the coupled port (port 3). Similarly,

measurement of isolation of the coupler involves measuring the transmission response between the input port and the isolated port (port4). While making the measurement between any two ports, the remaining two ports will have to be terminated in matched loads.

LAYOUT OF A PARALLEL LINE (3db and 15 db) DIRECTIONAL COUPLER:



TEST BENCH SET UP FOR MEASURING THE TRANSMISSION LOSS OF DUT

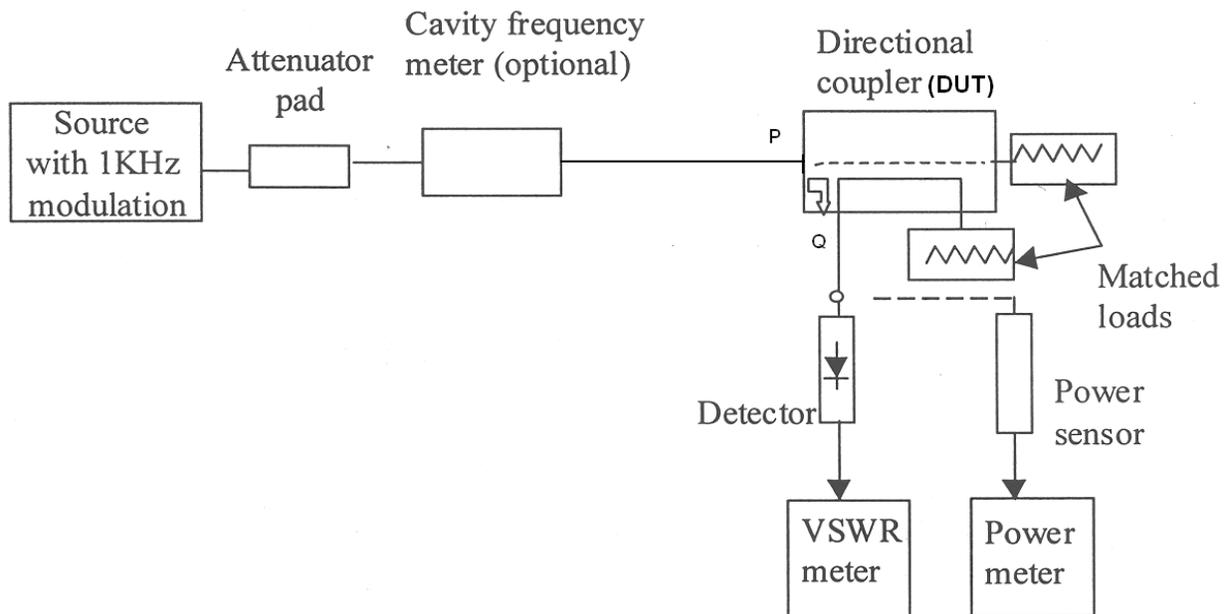


Figure. Test Bench Set up

PROCEDURE:

1. Assemble the set up shown in Fig. 1. Connect the output of the frequency meter directly to the directional coupler (connect P to Q directly).
2. Switch on the source and the VSWR meter. (Before switching on the source, ensure that there is sufficient attenuation to keep the RF output low) Set the frequency of the source to 2.2 GHz. Adjust the power output of the source for a reasonable power indication on the VSWR meter. Note the reading of the VSWR meter. Increase the frequency of the source in steps of 0.1 GHz to 3 GHz and note the corresponding readings of the VSWR meter.
3. Record the Frequencies in column 1 and VSWR meter readings (P_{in} dB) in column 2 of

Table 1. This is the reference input power.

4. Insert the parallel line coupler (DUT) between P and Q with input port (port 1) connected to P and the coupled port (port 3) to Q . Terminate ports 2 and 4 of the parallel line coupler in matched loads. Record the readings of the VSWR meter at the above frequencies as P_{3out} dB in column 3 of Table 1.
5. In order to determine the isolation property of the coupler, connect port 4 to the output end (at Q). Record the readings of the VSWR meter at the same frequencies as P_{4out} dB in column 4 of the following Table.

Table: Coupling, Isolation and Directivity of Parallel Line Microstrip Coupler

| Freq. f (GHz) | VSWR meter readings dB) | | | Coupling C (dB) = S_{31} (dB) | Isolation S_{41} (dB) | Directivity D (dB) = S_{43} (dB) |
|--------------------|-------------------------|------------|------------|---------------------------------------|----------------------------|--|
| | P_{in} | P_{3out} | P_{4out} | | | |
| 2.0 | | | | | | |
| 2.1 | | | | | | |
| : | | | | | | |
| : | | | | | | |
| 3.0 | | | | | | |

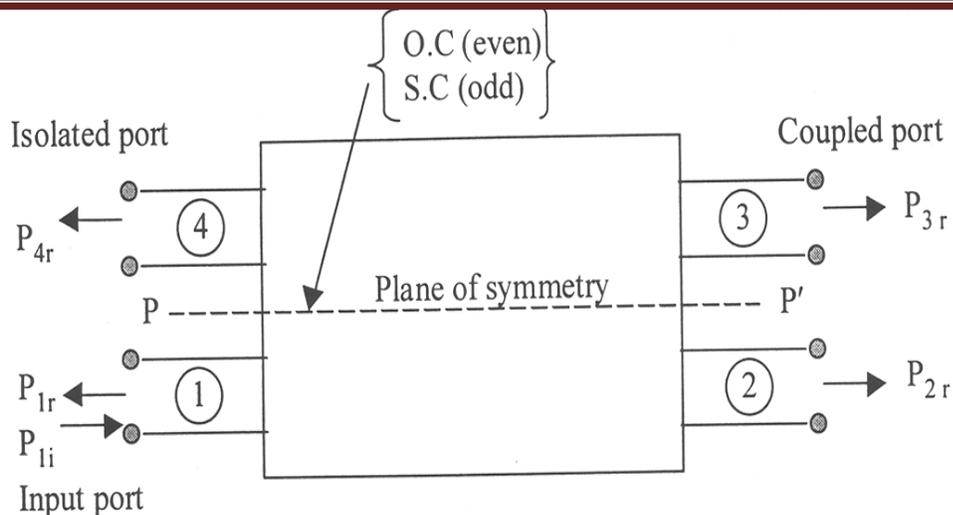
CALCULATIONS:

Coupling in dB = P_{in} (dB) - P_{3out} (dB). Denote this coupling as C (dB) = S_{31} (dB) and enter at column 5 of Table 1.

Isolation in dB = P_{in} (dB) - P_{4out} (dB). Denote this loss as S_{41} (dB) and enter at column 6 of the Table 1.

Directivity in dB = Isolation (dB) - Coupling (dB). Enter this as D (dB) = S_{43} (dB) at column 7 of the Table 1.

1. The above procedure can be repeated by using Branchline (3db) Directional Coupler and the readings are recorded in the table 2.



Coupling and Isolation

Power at direct output port in dB = $P_{in} \text{ (dB)} - P_{2out} \text{ (dB)}$. Denote this loss as $S_{21} \text{ (dB)}$ and enter at column 6 of Table 2.

Coupling $C \text{ (dB)} = P_{in} \text{ (dB)} - P_{3out} \text{ (dB)}$. Denote this coupling loss as $S_{31} \text{ (dB)}$ and enter at column 7 of Table 2.

Isolation in dB = $P_{in} \text{ (dB)} - P_{4out} \text{ (dB)}$. Denote this loss as $S_{41} \text{ (dB)}$ and enter at column 8 of the Table 2.

Directivity $D \text{ (dB)} = P_{3out} \text{ (dB)} - P_{4out} \text{ (dB)}$. Denote this as $S_{43} \text{ (dB)}$ and enter at column 9 of the

Table: Coupling, Isolation and Directivity of 3dB Branchline Coupler

| Freq. $f \text{ (GHz)}$ | VSWR meter readings (dB) | | | | Direct output $S_{21} \text{ (dB)}$ | Coupling $S_{31} \text{ (dB)}$ | Isolation $S_{41} \text{ (dB)}$ | Directivity $S_{43} \text{ (dB)}$ |
|----------------------------|--------------------------|------------|------------|------------|---|-----------------------------------|------------------------------------|--------------------------------------|
| | P_{in} | P_{2out} | P_{3out} | P_{4out} | | | | |
| 2.0 | | | | | | | | |
| 2.1 | | | | | | | | |
| : | | | | | | | | |
| : | | | | | | | | |
| : | | | | | | | | |
| 3.0 | | | | | | | | |

MEASUREMENTS OF RESONANCE CHARACTERISTICS OF A MICROSTRIP RING RESONATOR AND DETERMINATION OF DIELECTRIC CONSTANT OF THE SUBSTRATE

AIM: Measurement of Substrate Dielectric Constant using Ring Resonator and determine the relative dielectric constant ϵ_r of the substrate. The known parameters are,

Strip conductor width (in the ring) $w = 1.847$ mm

Height of the substrate $h = 0.762$ mm

Mean radius of the ring $r_o = 12.446$ mm

EQUIPMENT/COMPONENTS:

Microwave signal source (2.2 GHz) with modulation (1 KHz)

Attenuator pad

VSWR meter

Frequency meter

Items from the Kit

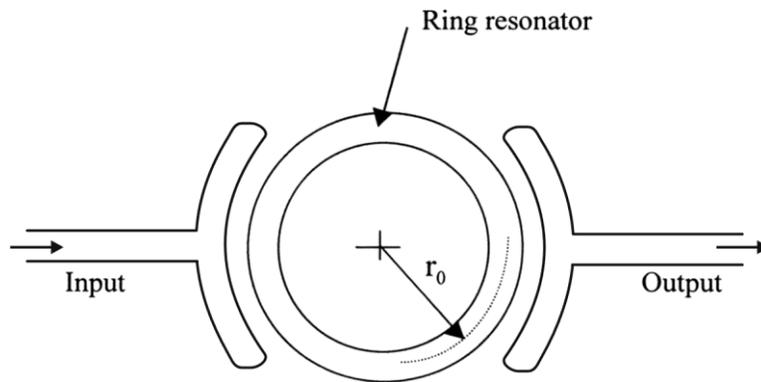
- Microstrip ring resonator (DUT).
- Detector
- Matched load
- Cables and adapters

THEORY OF RING RESONATOR:

The open-end effect encountered in a rectangular resonator at the feeding gaps can be minimized by forming the resonator as a closed loop. Such a resonator is called a ring resonator. The figure shown below is the layout of a ring resonator along with the input and output feed lines. Resonance is established when the mean circumference of the ring is equal to integral multiples of guide wavelength.

$$2\pi r_o = n\lambda = \frac{nv_o}{f_o \sqrt{\epsilon_{ef}}}, \quad \text{For } n = 1, 2, 3, \dots$$

Where r_o is the mean radius of the ring and n is the mode number. The microstrip ring resonator has the lowest order resonance for $n = 1$, for frequency range 2 - 3 GHz. For this mode, the field maxima occur at the two coupling gaps and nulls occur at 90° locations from the coupling gaps.



Layout with curved input and output feed line

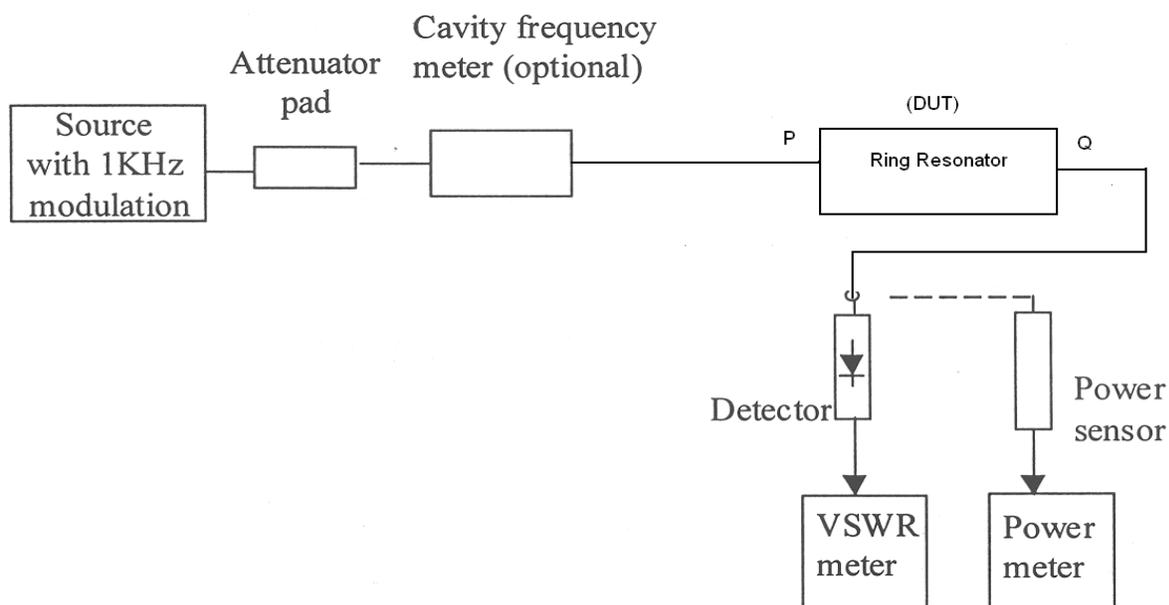


Figure. Test bench set up for measuring resonance characteristics of a micro strip ring resonator and determination of dielectric constant of the substrate

PROCEDURE:

1. The transmission loss response of the resonator can be measured using the Test Bench set up given at Fig. 1.
2. Tabulate the results as per Table 1 at frequencies from 2.2 to 3 GHz in steps of 0.1GHz.
3. Plot the transmission loss in dB as a function of frequency. Identify a smaller frequency span of about 200 MHz around the minimum transmission loss. In this frequency range, repeat the measurements in smaller frequency steps (steps of 20 MHz) and locate the

frequency at which the transmission loss reaches a minimum. This is the resonant frequency f_0 of the resonator as show in figure 2.

- An approximate expression for determining the effective dielectric constant of a Ring resonator theoretically is given by,

$$\epsilon_{ef} = \left(\frac{\epsilon_r + 1}{2} \right) + \left(\frac{\epsilon_r - 1}{2} \right) \left(1 + \frac{10h}{w} \right)^{-1/2}$$

Which can be verified practically using the expression given below.

$$2\pi r_0 = n\lambda = \frac{n v_0}{f_0 \sqrt{\epsilon_{ef}}}, \quad \text{for } n = 1, 2, 3, \dots$$

Table: VSWR meter readings

| Frequency f (GHz) | VSWR meter reading without DUT $P_{in}(dB)$ | VSWR meter reading with DUT $P_{out}(dB)$ |
|------------------------|---|---|
| 2.0 | | |
| 2.1 | | |
| : | | |
| 3.0 | | |

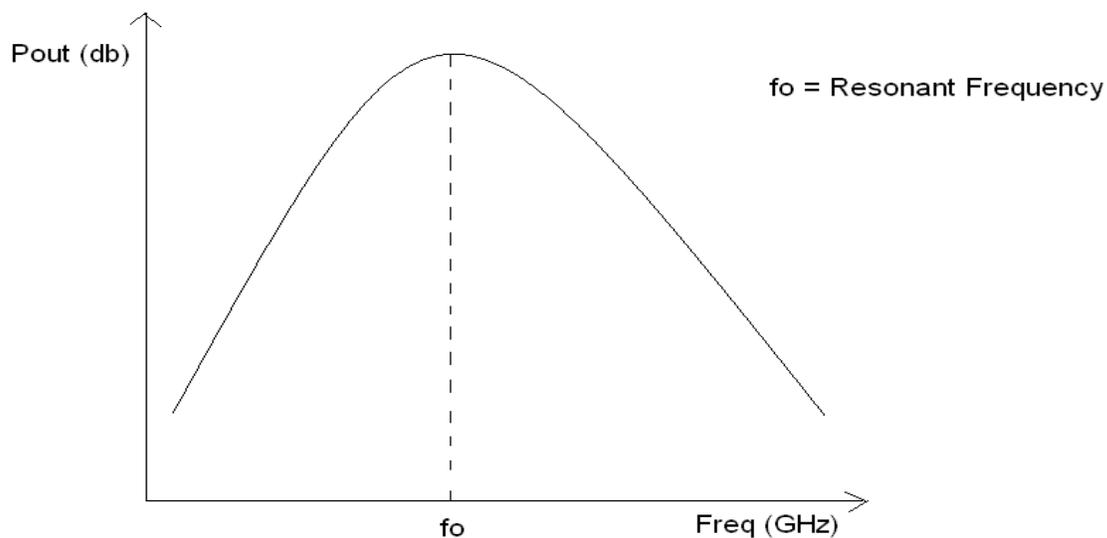


Figure 1: Plot output power and resonant frequency

EXPERIMENT NO. 8 (b)

Measurements of power division and isolation characteristics of a microstrip 3 db power divider

AIM: To measure the power division, isolation and return loss characteristics of a matched 3 dB power divider in the frequency range 2.2 to 3 GHz.

EQUIPMENT/COMPONENTS:

Microwave signal source with modulation (1 KHz)

Attenuator pad

VSWR meter

Frequency meter

Items from the Kit

- Matched power divider (DUT).
- Directional coupler
- Detector
- Matched loads
- Cables and adapters

THEORY:

The microstrip power divider provided is of the 3 dB Wilkinson type the impedance of the input/output lines is 50Ω and the isolation resistor connected between the two output lines has a value of 100Ω . Measuring the power division property involves measuring the transmission response between the input port (port 1) and the two output ports (ports 2 and 3). While measuring the transmission response between any two ports, the third port has to be terminated in a matched load. Measuring the isolation property involves measuring the transmission response between ports 2 and 3 by terminating port 1 in a matched load. Figure 1 shows the line diagram of Y- junction as a power divider. Let port 1 be the input port that is matched to the source ($S_{11} = 0$).

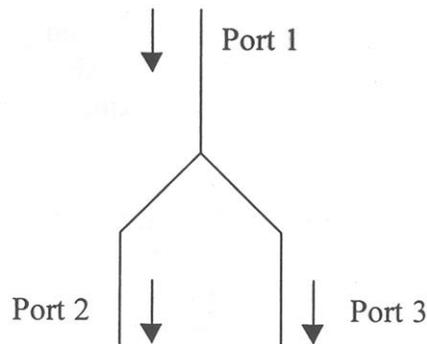


Figure 2: Schematic of a Y - junction power divider

As an equal-split power divider, power incident at port 1 gets divided equally between the two output ports 2 and 3. Equal power division implies $S_{21} = S_{31} = 1/\sqrt{2}$. The phase factors of S_{21} and S_{31} can be made equal to zero (multiples of 360°) by appropriately choosing the reference planes of ports 2 and 3 with respect to port 1.

Analysis and Design of Matched Power Divider

Figure 2 shows a matched power divider introduced by Wilkinson. Popularly known also as Wilkinson power divider, it uses an isolation resistor R of value $2Z_0$ between ports 2 and 3. The device is completely matched at all the three ports, and ports 2 and 3 are isolated from each other at the centre frequency (f_0).

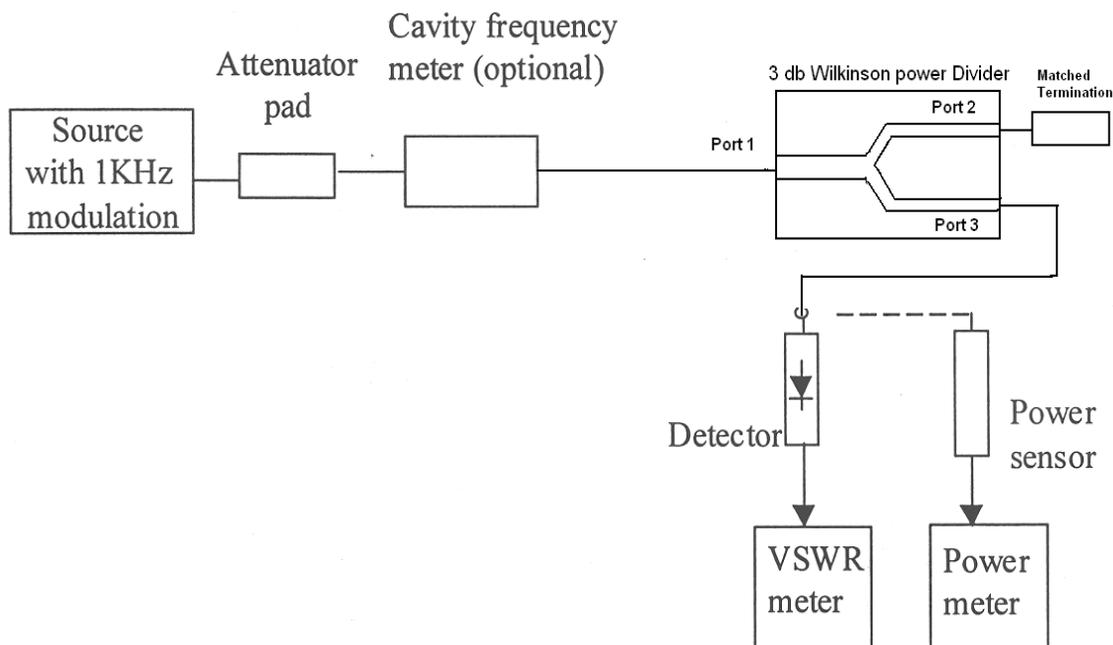


Figure. 3

PROCEDURE:

1. Assemble the set up as shown in figure 3.
2. Switch on the source and the VSWR meter. Before switching on the source, ensure that there is sufficient attenuation to keep the RF power output low.
3. Set the frequency of the source to 2.2 GHz. Adjust the power output of the source for a reasonable power indication on the VSWR meter. Note the reading of the VSWR meter as P_{in} dB in column 2 of Table 1. This is the reference input power.
4. Insert the power divider (DUT) with input port (port 1) and output ports (port 3) connected to detector and terminate port 2 of the power divider in matched load. Record the readings of the VSWR meter at the above frequencies as P_{2out} dB in column 3 of Table 1.
5. Interchange ports 2 and 3. That is, connect port 2 with a detector and terminate port 3 in matched load. Record the readings of the VSWR meter at the same frequencies as P_{3out} dB in column 4 of the Table.
6. In order to determine the isolation between the two output ports, remove the power divider and reconnect with port 2 at the input end and port 3 at the output end. Terminate port 1 in matched load. Record the readings of the VSWR meter at the same frequencies as P_{32out} dB in column 5 of the Table 1.

CALCULATIONS:**Power Division:**

Power loss from port 1 to port 2 = P_{in} (dB) - P_{2out} (dB) = $-20 \log_{10} S_{21}$. Denote this loss as S_{21} (dB) and enter at column 6 of the Table 1.

Power loss from port 1 to port 3 = P_{in} (dB) - P_{3out} (dB) = $-20 \log_{10} S_{31}$. Denote this loss as S_{31} (dB) and enter at column 7 of the Table 1.

Isolation:

Isolation between ports 2 and 3 = $P_{in} \text{ (dB)} - P_{32out} \text{ (dB)} = -20 \log_{10} S_{32}$. Denote this isolation as S_{32} (dB) and enter at column 8 of the Table 1.

| Freq. <i>f</i> (GHz) | VSWR meter readings (dB) | | | | Power division Port 1 to 2 S_{21} (dB) | Power division Port 1 to 3 S_{31} (dB) | Isolation Port 2 to 3 S_{32} (dB) |
|-------------------------|--------------------------|---------------------|---------------------|----------------------|---|---|---|
| | P_{in} | $P_{2 \text{ out}}$ | $P_{3 \text{ out}}$ | $P_{32 \text{ out}}$ | | | |
| 2.0 | | | | | | | |
| 2.1 | | | | | | | |
| : | | | | | | | |
| : | | | | | | | |
| : | | | | | | | |
| 3.0 | | | | | | | |

Table.1

CYCLE-III

Part-B: Simulation Experiments using Matlab

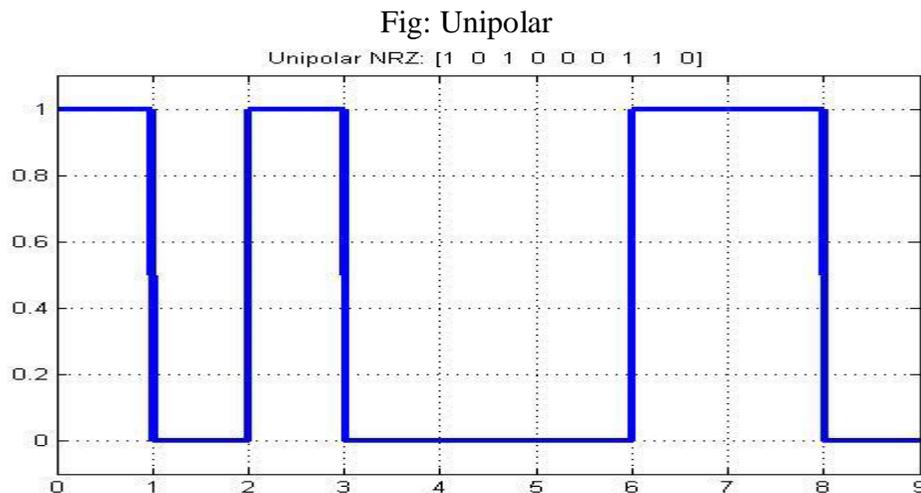
Experiment 1Simulate NRZ, RZ, Half-Sinusoid and raised Cosine pulses and generate eye diagram for Binary Polar Signaling.

Aim: To generate Unipolar NRZ sequence using Matlab

Preamble: Line code is the electrical representation of the encoded binary streams produced by baseband transmitters, so that these streams can be transmitted over communication channel. Basically there are two types of baseband signalling NRZ(Non Return to Zero) and RZ(Return to Zero) depending on the pulse duration and bit duration . Common Line codes used in digital communication are unipolar, polar, bipolar, Manchester, M-RY codes etc. Below given is the program for unipolar NRZ and RZ code.

1)a. Unipolar NRZ, RZ Matlab Code

```
bits = [1 0 1 0 0 0 1 1 0];
bitrate = 1;
figure;
[t,s] = unrz(bits,bitrate);
plot(t,s,'LineWidth',3);
axis([0 t(end) -0.1 1.1])
grid on;
title(['Unipolar NRZ: [' num2str(bits) ']']);
```

Output

1)b. Unipolar RZ Matlab Code

```

bits = [1 0 1 0 0 0 1 1 0];
bitrate = 1;
figure;
[t,s] = urz(bits,bitrate);
plot(t,s,'LineWidth',3);
axis([0 t(end) -0.1 1.1])
grid on;
title(['Unipolar RZ: [' num2str(bits) ']']);

```

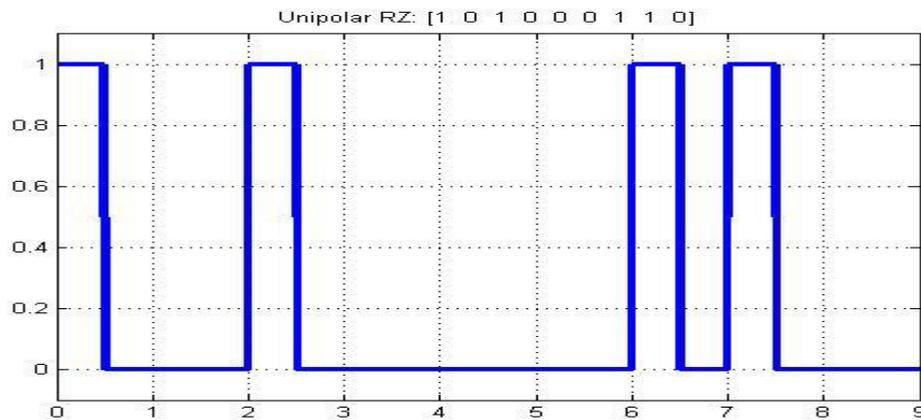
Output:

Fig: Unipolar RZ

1)c. Raised Cosine Matlab Code

Aim:To generate Raised Cosine Pulse Using Matlab

Preamble: when we transmit digital signals through a band limited channel it as a filtering effect on the data, restricting its spectrum. The residual effect due to occurrence of pluses before and after the sampling instant is called ISI(Inter Symbol Interference). Ideal Nyquist Pulse for distortionless baseband transmission is rectangular function. Raised Cosine spectrum overcome the practical difficulties encountered with the ideal Nyquist pulse by extending the bandwidth from the minimum value $W = R_b/2$ to an adjustable value between W and $2W$.

Program:

```

clc;

clear all;

close all;

Nsym = 6; % Filter span in symbol durations

```

```

beta = 0.5; % Roll-off factor

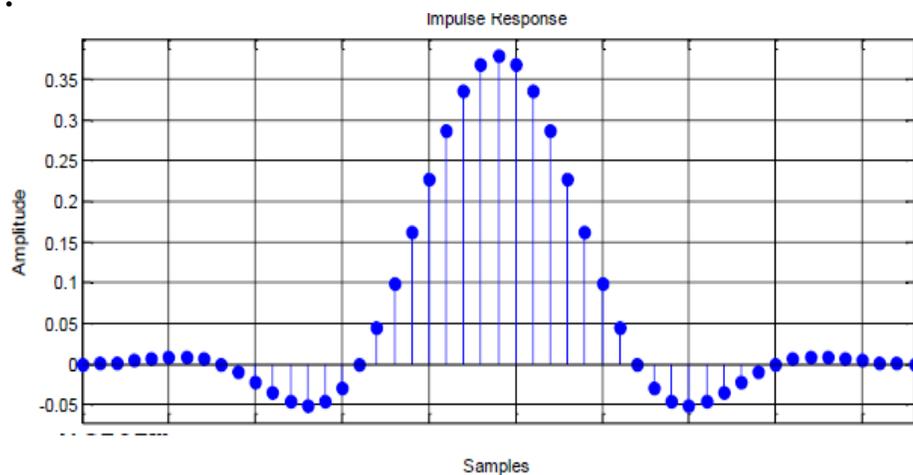
sampsPerSym = 8; % Upsampling factor

rctFilt = comm.RaisedCosineTransmitFilter(...
'Shape', 'Normal', ...
'RolloffFactor', beta, ...
'FilterSpanInSymbols', Nsym, ...
'OutputSamplesPerSymbol', sampsPerSym)

% Visualize the impulse response

fvtool(rctFilt, 'Analysis', 'impulse')

```

OUTPUT:**Fig: Raised Cosine****1)d. EYE DIAGRAM**

Aim: To generate an Eye Diagram for NRZ, RZ and Raised Cosine Matlab Code

Preamble: Eye pattern is a graphical representation to study ISI and signal degradations in baseband data transmission.

Main Program

```

% (binary_eye.m)

% this program uses the four different pulses to generate eye diagrams of

% binary polar signaling

clear all; close all; clc;

```

```

data=sign(randn(1,100)); % generate 400 random bits

Tau=64; % define the symbol period

for i=1:length(data)

dataup((i-1)*64+1:i*64)=[data(i),zeros(1,63)];% Generate impluse train

end

% dataup=upsample(date,Tau);% Generate impluse train

yrz=conv(dataup,prz(Tau));% Return to zero polar signal

yrz=yrz(1:end-Tau+1);

ynrz=conv(dataup,pnrz(Tau));% Non-return to zero polar

ynrz=ynrz(1:end-Tau+1);

Td=4; % truncating raised cosine to 4 periods

yrcos=conv(dataup,prcos(0.5,Td,Tau));% rolloff factor=0.5

yrcos=yrcos(2*Td*Tau:end-2*Td*Tau+1);% generating RC pulse train

eye1=eyediagram(yrz,2*Tau,Tau,Tau/2);title('RZ eye-diagram');

eye2=eyediagram(ynrz,2*Tau,Tau,Tau/2);title('NRZ eye-diagram');

eye4=eyediagram(yrcos,2*Tau,Tau);title('Raised-cosine eye-diagram');

```

Function files (Write each function file in separate script file)

Function File 1

```

% (pnrz.m)

% generating a rectangular pulse of width T

% usage function pout=pnrz(T);

function pout=pnrz(T);

pout=ones(1,T);

end

```

Function File 2

```

% (prcos.m)

% Usage y=prcos(rollfac,length, T)

function y=prcos(rollfac,length, T)

```

```
% rollfac = 0 to 1 is the rolloff factor
```

```
% length is the onesided pulse length in the number of Trcos
```

```
% length = 2T+1
```

```
% T is the oversampling rate
```

```
y=rcofir(rollfac, length, T, 1, 'normal');
```

```
end
```

Function File 3

```
% (prz.m)
```

```
% generating a rectangular pulse of wisth T/2
```

```
% usage function pout=prz(T);
```

```
function pout=prz(T);
```

```
pout=[zeros(1,T/4) ones(1,T/2) zeros(1,T/4)];
```

```
end
```

Output:

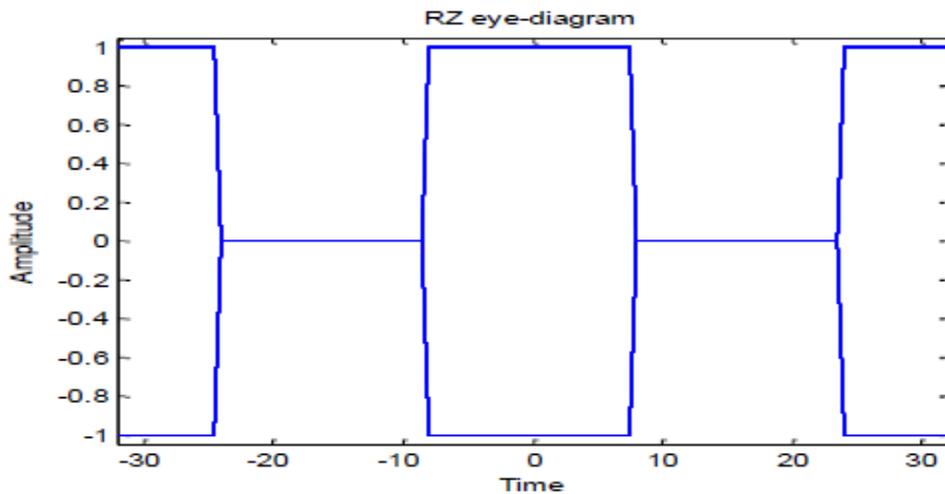


Fig: NRZ Eye diagram

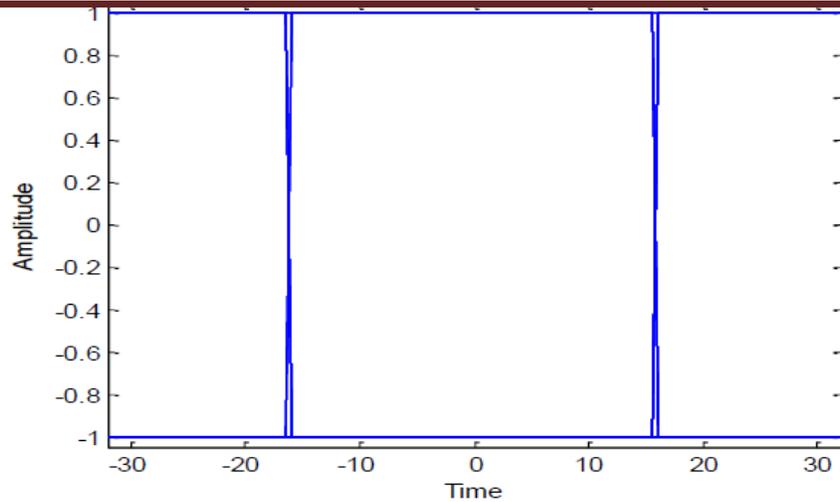


Fig: Raised Cosine Eye diagram

1)e. Half Sinusoid Matlab Code

Aim: To generate Raised Cosine Pulse Using Matlab

Preamble: when we transmit digital signals through a band limited channel it has a filtering effect on the data, restricting its spectrum.

Program:

```
close all;

clear all;

clc;

f = 50; % Frequency assumption
l=linspace(0,10,100); % time axis
sig=sin(2*pi*f*l); % sinusoidal signal
subplot(211) % Plot sinusoidal signal
plot(sig);
grid
hold on;
for t=1:100
    if sin(2*pi*50*l(t))<=0
        sig(t)=0;
    else
        sig(t) = sin(2*pi*50*l(t));
    end
end
end
```

```
subplot(212)
```

```
plot(sig);
```

```
grid
```

Output:

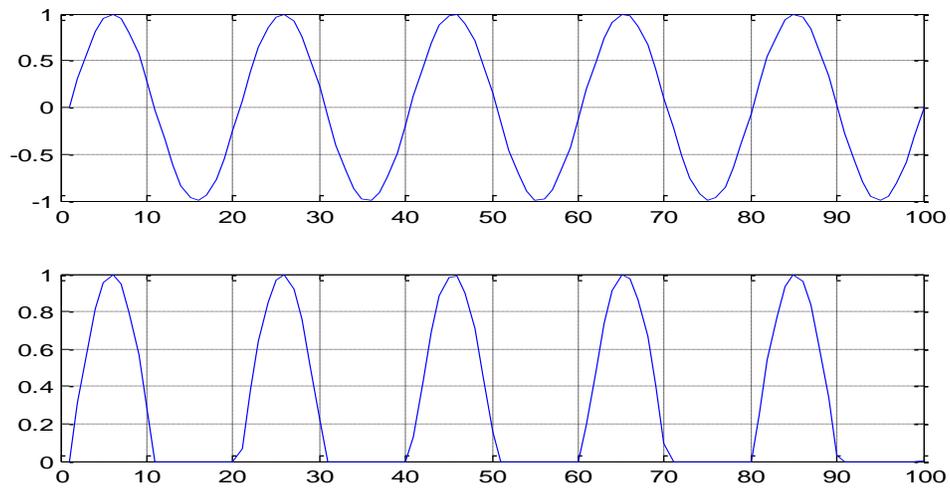


Figure: Generate sinusoid and half-sinusoid waveform

EXPERIMENT 2
SIMULATE THE PULSE CODE MODULATION AND DEMODULATION SYSTEM
AND DISPLAY THE WAVEFORMS

Aim: To generate Raised Cosine Pulse Using Matlab

Preamble: PCM is an essential analog to digital conversion, where analog signal samples are represented by digital words in a serial bit stream.

Program:

```

clc;
close all;
clear all;
n=input('Enter n value for n-bit PCM system : ');
n1=input('Enter number of samples in a period : ');
L=2^n;
% % Signal Generation
% x=0:1/100:4*pi;
% y=8*sin(x); % Amplitude Of signal is 8v
% subplot(2,2,1);
% plot(x,y);grid on;
% Sampling Operation
x=0:2*pi/n1:4*pi; % n1 number of samples have to be selected
s=8*sin(x);
subplot(3,1,1);
plot(s);
title('Analog Signal');
ylabel('Amplitude--->');
xlabel('Time--->');
subplot(3,1,2);
stem(s);grid on; title('Sampled Signal'); ylabel('Amplitude--->'); xlabel('Time--->');
% Quantization Process
vmax=8;
vmin=-vmax;
del=(vmax-vmin)/L;
part=vmin:del:vmax; % level are between vmin and vmax with difference of del
code=vmin-(del/2):del:vmax+(del/2); % Contain Quantized values
[ind,q]=quantiz(s,part,code); % Quantization process
% ind contain index number and q contain quantized values
l1=length(ind);
l2=length(q);
for i=1:l1
if(ind(i)~=0) % To make index as binary decimal so started from 0 to N

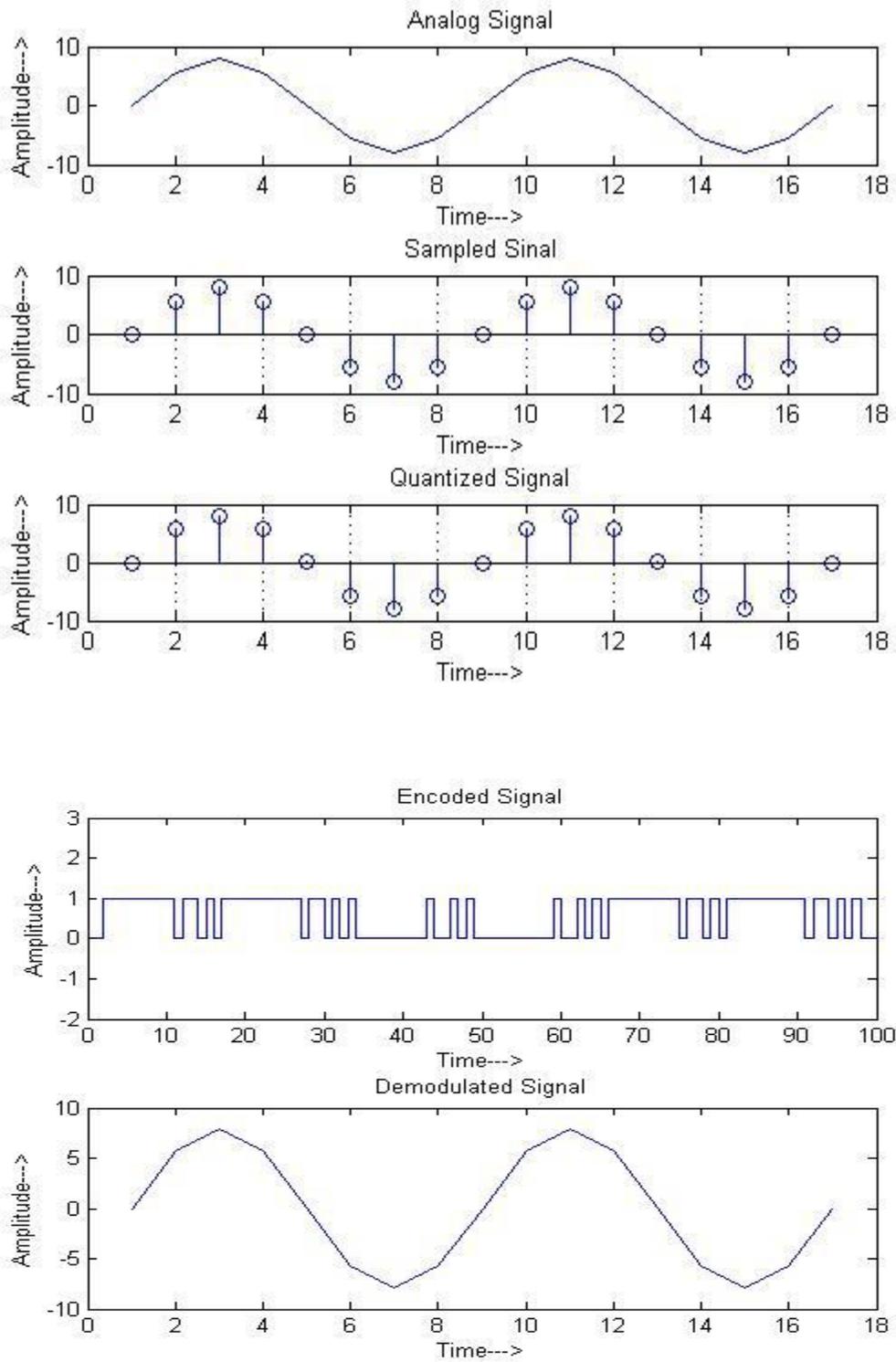
```

```

ind(i)=ind(i)-1;
end
i=i+1;
end
for i=1:l2
if(q(i)==vmin-(del/2)) % To make quantize value inbetween the levels
q(i)=vmin+(del/2);
end
end
subplot(3,1,3);
stem(q);grid on; % Display the Quantize values
title('Quantized Signal');
ylabel('Amplitude--->');
xlabel('Time--->');
% Encoding Process
figure
code=de2bi(ind,'left-msb'); % Cnvert the decimal to binary
k=1;
for i=1:l1
for j=1:n
coded(k)=code(i,j); % convert code matrix to a coded row vector
j=j+1;
k=k+1;
end
i=i+1;
end
subplot(2,1,1); grid on;
stairs(coded); % Display the encoded signal
axis([0 100 -2 3]); title('Encoded Signal');
ylabel('Amplitude--->');
xlabel('Time--->');
% Demodulation Of PCM signal
qunt=reshape(coded,n,length(coded)/n);
index=bi2de(qunt,'left-msb'); % Getback the index in decimal form
q=del*index+vmin+(del/2); % getback Quantized values
subplot(2,1,2); grid on;
plot(q); % Plot Demodulated signal
title('Demodulated Signal');
ylabel('Amplitude--->');
xlabel('Time--->');

```

Output:**Enter n value for n-bit PCM system : 8****Enter number of samples in a period : 8**



EXPERIMENT 3

SIMULATE THE QPSK TRANSMITTER AND RECEIVER, PLOT THE SIGNALS AND ITS CONSTELLATION DIAGRAM

Aim: To simulate QPSK Transmitter & Receiver signals and generate its its constellation diagram Using Matlab.

Preamble: QPSK is non-Coherent binary modulation, which is also a bandwidth modulation scheme, in this scheme for a given binary data rate there is a reduction in transmission bandwidth by a factor of two. The principle of QPSK is based on the property of Quadrature Multiplexing.

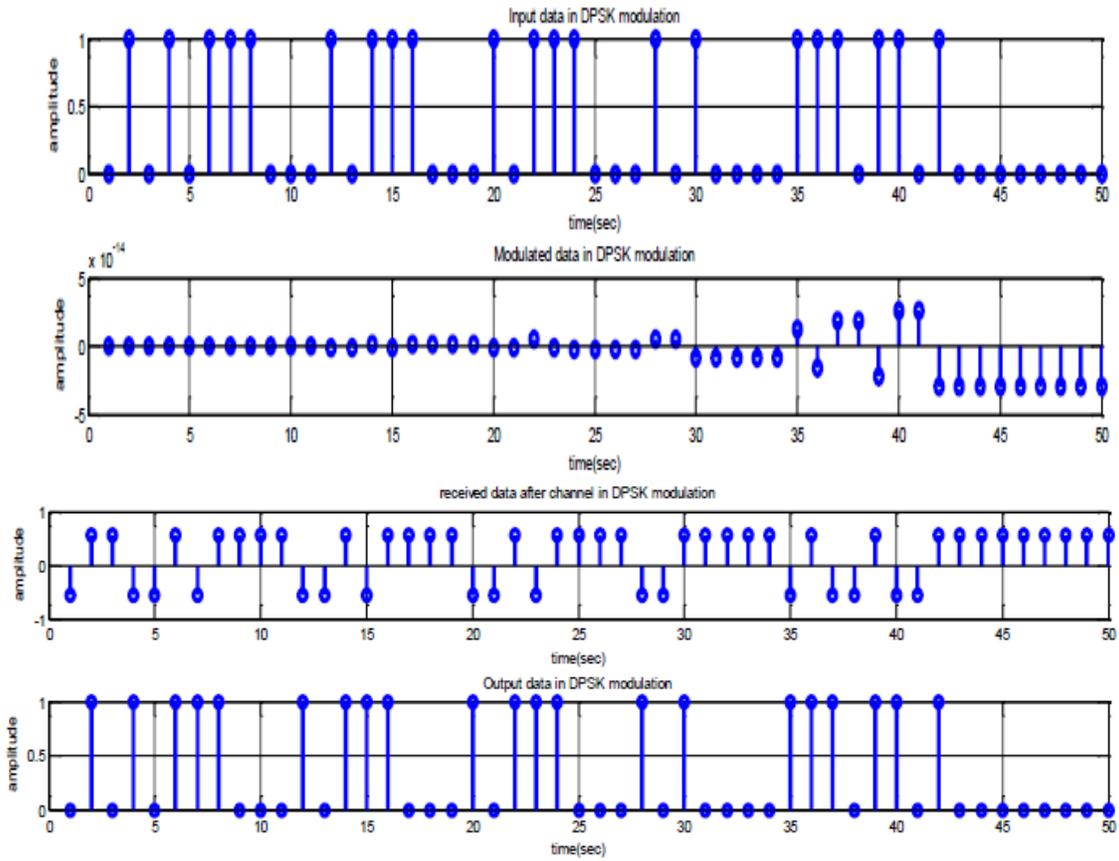
Program

```

clc;
close all;
clear all;
M = 2; % Alphabet size
dataIn = randi([0 M-1],50,1); % Random message
txSig = dpskmod(dataIn,M); % Modulate
rxSig = txSig*exp(2i*pi*rand());
dataOut = dpskdemod(rxSig,M);
errs = symerr(dataIn,dataOut)
errs = symerr(dataIn(2:end),dataIn(2:end))
subplot(4,1,1);
stem(dataIn,'linewidth',3), grid on;
title(' Input data in DPSK modulation ');
xlabel('time(sec)');
ylabel(' amplitude');
subplot(4,1,2);
stem(txSig,'linewidth',3), grid on;
title(' Modulated data in DPSK modulation ');
xlabel('time(sec)');
ylabel(' amplitude');
subplot(4,1,3);
stem(rxSig,'linewidth',3), grid on;
title(' received data after channel in DPSK modulation ');
xlabel('time(sec)');
ylabel(' amplitude');
subplot(4,1,4);
stem(dataOut,'linewidth',3), grid on;
title(' Output data in DPSK modulation ');
xlabel('time(sec)');
ylabel(' amplitude');

```

Output:



EXPERIMENT 4:**TEST THE PERFORMANCE OF A BINARY DIFFERENTIAL PHASE SHIFT KEYING SYSTEM BY SIMULATING THE NON-COHERENT DETECTION OF BINARY DPSK.**

Aim: To measure the performance of DPSK by simulating non-coherent detection of binary DPSK using Matlab.

Preamble: DPSK is NON-Coherent binary phase modulation technique, in which the binary samples are differentially encoded and then phase modulated.

Program:

```

clc;
clear all;
close all;
data=[0 1 0 1 1 1 0 0 1 1]; % information
%Number_of_bit=1024;
%data=randint(Number_of_bit,1);
figure(1)
stem(data, 'linewidth',3), grid on;
title(' Information before Transmitting ');
axis([ 0 11 0 1.5]);
data_NZR=2*data-1; % Data Represented at NZR form for QPSK modulation
s_p_data=reshape(data_NZR,2,length(data)/2); % S/P conversion of data
br=10.^6; %Let us transmission bit rate 1000000
f=br; % minimum carrier frequency
T=1/br; % bit duration
t=T/99:T/99:T; % Time vector for one bit information
% QPSK modulation
y=[];
y_in=[];
y_qd=[];
for(i=1:length(data)/2)
y1=s_p_data(1,i)*cos(2*pi*f*t); % inphase component
y2=s_p_data(2,i)*sin(2*pi*f*t); % Quadrature component
y_in=[y_in y1]; % inphase signal vector
y_qd=[y_qd y2]; % quadrature signal vector
y=[y y1+y2]; % modulated signal vector
end
Tx_sig=y; % transmitting signal after modulation
tt=T/99:T/99:(T*length(data))/2;
figure(2)
subplot(3,1,1);
plot(tt,y_in,'linewidth',3), grid on;
title(' wave form for inphase component in QPSK modulation ');
xlabel('time(sec)');
ylabel(' amplitude(volt0)');
subplot(3,1,2);
plot(tt,y_qd,'linewidth',3), grid on;

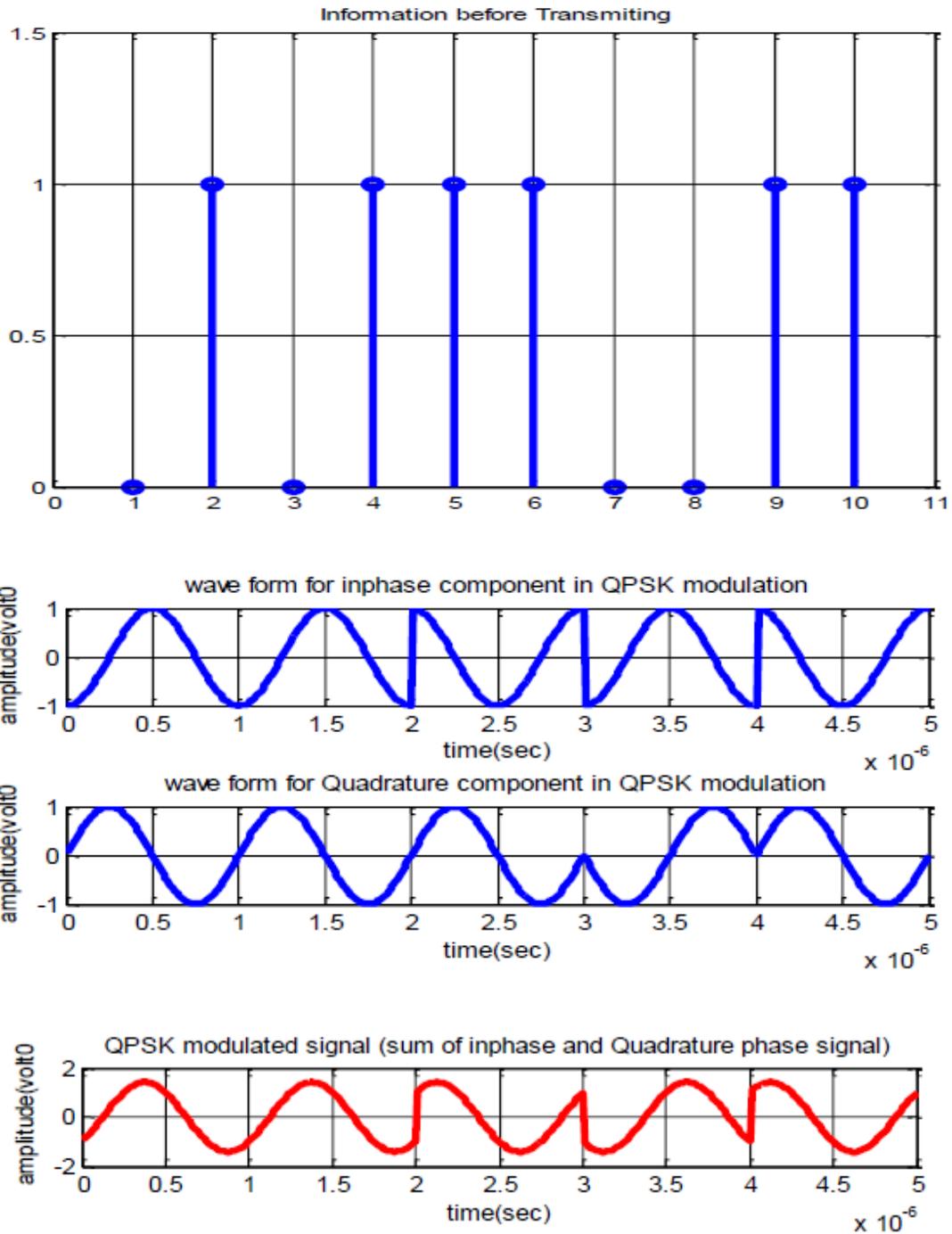
```

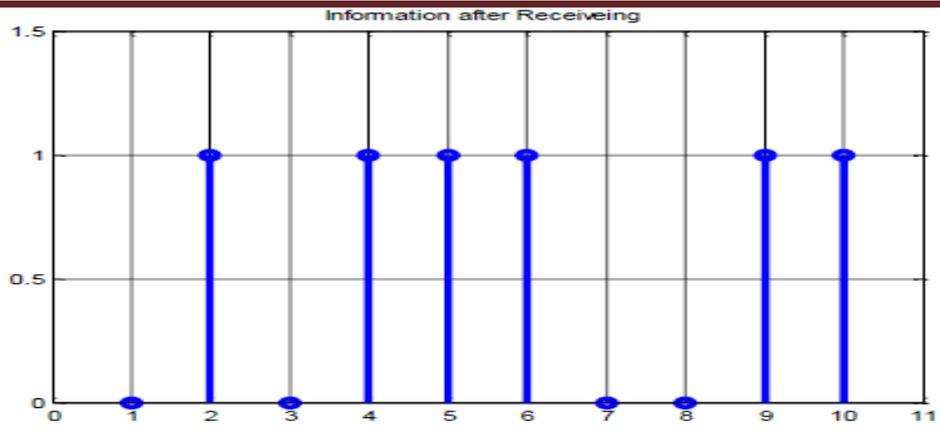
```

title(' wave form for Quadrature component in QPSK modulation ');
xlabel('time(sec)');
ylabel(' amplitude(volt)');
subplot(3,1,3);
plot(tt,Tx_sig,'r','linewidth',3), grid on;
title('QPSK modulated signal (sum of inphase and Quadrature phase signal)');
xlabel('time(sec)');
ylabel(' amplitude(volt)');
% QPSK demodulation
Rx_data=[];
Rx_sig=Tx_sig; % Received signal
for(i=1:1:length(data)/2)
%%XXXXXXXX inphase coherent dector XXXXXXXX
Z_in=Rx_sig((i-1)*length(t)+1:i*length(t)).*cos(2*pi*f*t);
% above line indicat multiplication of received & inphase carred signal
Z_in_intg=(trapz(t,Z_in))*(2/T);% integration using trapizodial rull
if(Z_in_intg>0) % Decession Maker
Rx_in_data=1;
else
Rx_in_data=0;
end
%Quadrature coherent dector
Z_qd=Rx_sig((i-1)*length(t)+1:i*length(t)).*sin(2*pi*f*t);
%above line indicat multiplication ofreceived & Quadphase carred signal
Z_qd_intg=(trapz(t,Z_qd))*(2/T);% integration using trapizodial rull
if (Z_qd_intg>0)% Decession Maker
Rx_qd_data=1;
else
Rx_qd_data=0;
end
Rx_data=[Rx_data Rx_in_data Rx_qd_data]; % Received Data vector
end
figure(3)
stem(Rx_data,'linewidth',3)
title('Information after Receiveing ');
axis([ 0 11 0 1.5]), grid on;

```

Output:





Question Bank

Subject code- 15ECL76

- 1). a) Design and Conduct a suitable Experiment to demonstrate the TDM of two band limited signals and demodulate the same.
b) Simulate NRZ, RZ signal and generate eye diagram for binary polar signaling.

- 2). a) Design and Conduct an experiment on ASK Modulation and Demodulation.
b) Simulate the pulse code modulation and demodulation system and display the waveform.

- 3). a) Design and Conduct an experiment on FSK Modulation and Demodulation.
b) Test the performance of BDPSK system by simulating the non-coherent detection of BDPSK.

- 4). a) Design and Conduct an experiment on PSK Modulation and Demodulation
b) Simulate NRZ, Raised cosine impulse signal and generate eye diagram for binary polar signaling.

- 5).a) Measure frequency, guide wavelength, VSWR in a microwave test bench
b) Simulate the pulse code modulation and demodulation system and display the waveform.

- 6). a) Conduct an Experiment to Measure directivity and gain of standard Yagi-Uda antenna. Plot the radiation pattern.
b) Test the performance of BDPSK system by simulating the non coherent detection of BDPSK.

- 7).a) Conduct an Experiment to Measure directivity and gain of standard dipole antenna. Plot the radiation pattern.
b) Simulate NRZ, RZ signal and generate eye diagram for binary polar signaling.

- 8). a) Determination of coupling and isolation characteristics of a micro strip directional coupler.

b) Test the performance of BDPSK system by simulating the non-coherent detection of BDPSK.

9). a) Conduct an experiment to Measure resonance characteristics of a micro strip ring resonator and determination of dielectric constant of the substrate

b) Simulate the pulse code modulation and demodulation system and display the waveform.

10).a) Conduct an experiment to Measure power division and isolation characteristics of a micro strip power divider.

b) Test the performance of BDPSK system by simulating the non-coherent detection of BDPSK.

11). a) Find the losses in a given optical fiber 1. Propagation loss 2. Bending loss and also find the numerical aperture

b) Simulate the pulse code modulation and demodulation system and display the waveform.

12). a) Find the losses in a given optical fiber 1. Propagation loss 2. Bending loss and also find the numerical aperture

b) Test the performance of BDPSK system by simulating the non-coherent detection of BDPSK.

SAMPLE VIVA QUESTIONS

1. What are the properties of Magic tee?
2. What are the applications of magic tee? Why it is called “magic tee”?
3. Give the scattering matrix of magic tee
4. Give the scattering matrix of directional coupler
5. Define : Coupling coefficient, directivity, insertion loss, isolation
6. Give the applications of directional coupler
7. How does an oscillation take place in reflex klystron?
8. Why can't we use conventional vacuum tubes at microwave frequencies?
9. Give the applications of reflex klystron
10. What is meant by ETR, ETS?
11. Define transit time modes.
12. Define LSA mode
13. How velocity modulation takes place in reflex klystron
20. Explain the modes of reflex klystron?
21. What is the difference between transmission lines and coaxial lines
22. Why cylindrical cavity resonators are not used with klystrons?

23. What are the advantages of directional couplers

24. What are waveguides?
25. What are cavity resonators? Mention its applications
26. By what method cavity resonators are tuned
27. What are the applications of circulators?
28. What is modulation? Mention different types of digital modulation techniques?
29. What is base band and band pass transmissions
30. Mention the two main resources available with communication channels
31. What are formatting blocks
32. What is sampling process?
33. State sampling theorem for low pass signals
34. Mention different types of sampling process?
35. What is aliasing ? Mention the conditions for aliasing to occur?
36. How can aliasing be reduced?
37. What is aperture effect? How it is reduced?
38. What is the minimum transmission bandwidth of transmission channel?
39. What are the requirements that a digital modulation scheme must satisfy
40. What is M-ary transmission?
41. What is demodulation and detection?

42. Define coherent and non-coherent detection?
 43. What is the drawback of BPSK?
 44. Mention the minimum transmission bandwidth of BPSK,DPSK,QPSK?
 45. Mention the advantages of DPSK? Also what are its disadvantages?
 46. What are the advantages and disadvantages of QPSK
 47. Differentiate ASK, FSK, PSK
-
48. Explain flat top sampling?
 49. What is antenna?
 50. What is radiation pattern
 51. What is directivity?
 52. Define antenna gain?
 53. Explain effective aperture of antenna
 54. Define bandwidth and beamwidth of antenna
 55. What is near field and far field of antenna
 56. What is polarization of antenna?
 57. Explain structure of optical fiber?
 58. What is refractive index?
 59. What is numerical aperture?
 60. What are the advantages and disadvantages of OFC?