ATRIA INSTITUTE OF TECHNOLOGY

(Affiliated To Visvesvaraya Technological University, Belgaum)

Anandanagar, Bangalore-24

DEPARTMENT OF ELECTRONICS AND COMMUNICATION

COMMUNICATION LAB MANUAL

6th SEMESTER ELECTRONICS AND COMMUNICATION ENGINEERING

SUBJECT CODE: 18ECL67

Academic year 2020-2021

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COMMUNICATION LAB MANUAL

Communication Lab manual pertaining sixth 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.

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Atria IT

COMMUNICATION LAB

SYLLABUS

B.E., VI Semester, Electronics & Communication Engineering
[As per Choice Based Credit System (CBCS) scheme]

Subject Code 18ECL67   IA Marks 40
Number of Lecture Hours/Week 02Hr Tutorial (Instructions) + 02 Hours Laboratory = 04
Exam Marks 60
RBT Levels L1, L2, L3   Exam Hours 03

CREDITS – 02

Course objectives: This course will enable students to:
• Design and test the communication circuits for different analog modulation schemes.
• 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.
• Understand the probability of error computations of coherent digital modulation schemes.

Laboratory Experiments

PART-A: Following Experiments No. 1 to 5 has to be performed using discrete Components.

1. Amplitude Modulation and Demodulation: i) Standard AM, ii)DSBSC (LM741 and LF398 ICs can be used)
2. Frequency modulation and demodulation (IC 8038/2206 can be used)
3. Pulse sampling, flat top sampling and reconstruction
4. Time Division Multiplexing and Demultiplexing of two bandlimited signals.
5. FSK and PSK generation and detection
6. Measurement of frequency, guide wavelength, power, VSWR and attenuation in microwave test bench.
7. Obtain the Radiation Pattern and Measurement of directivity and gain of microstrip dipole and Yagi antennas.
8. 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.

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. Pulse code modulation and demodulation system.

3. Computations of the Probability of bit error for coherent binary ASK, FSK and
PSK for an AWGN Channel and Compare them with their Performance curves.
4. Digital Modulation Schemes i) DPSK Transmitter and receiver, ii) QPSK Transmitter and
Receiver.

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. Amplitude Modulation and Demodulation: i) Standard AM, ii)DSBSC (LM741 and LF398
ICs can be used)
2. Frequency modulation and demodulation (IC 8038/2206 can be used)
3. Pulse sampling, flat top sampling and reconstruction
4. Time Division Multiplexing and Demultiplexing of two bandlimited signals.
5. FSK and PSK generation and detection

CYCLE-II
6. Measurement of frequency, guide wavelength, power, VSWR and attenuation in microwave
test bench.
7. Obtain the Radiation Pattern and Measurement of directivity and gain of microstrip dipole and
Yagi antennas.
8. 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.

CYCLE-III
1. Simulate NRZ, RZ, half-sinusoid and raised cosine pulses and generate eye diagram for binary
polar signaling.
2. Pulse code modulation and demodulation system.
3. Computations of the Probability of bit error for coherent binary ASK, FSK and
PSK for an AWGN Channel and Compare them with their Performance curves.
4. Digital Modulation Schemes i) DPSK Transmitter and receiver, ii) QPSK Transmitter and
Receiver.

CYCLE - I

EXPERIMENT NO. 1

(i)   AMPLITUDE MODULATION & DEMODULATION

Aim:

1.   To generate amplitude modulated wave and determine the percentage modulation.

2.   To Demodulate the modulated wave using envelope detector.

Apparatus Required:

Name of the Component/Equipment	Specifications/Range		Quantity
Transistor (BC 107)	Ft=300MHz Pd =1W Ic (max)=100mA		1
Diode (0A79)	Max Current 35mA		1
Resistors	1KΩ, 2KΩ, 6.8KΩ, 10KΩ, 22KΩ		1 each
Capacitors	0.01µF, 2 µF		1 each
Inductor	130mH		1
CRO	20MHz		1
Function Generator	1MHz		2
Regulated Power Supply	0-30V, 1A		1

Theory:

Amplitude Modulation is defined as a process in which the amplitude of the carrier wave c (t) is varied linearly with the instantaneous amplitude of the message signal m(t). The standard form of amplitude modulated (AM) wave is defined by

$$s(t) = Ac \, (1 + Kam(t)) \cos(2\pi fct)$$

Where K_a- Amplitude sensitivity of the modulator $S(t)$ –Modulated signal, Ac- carrier signal m(t) modulating signal

The demodulation circuit is used to recover the message signal from the incoming AM wave at the receiver. An envelope detector is a simple and yet highly effective device that is well suited for the demodulation of AM wave, for which the percentage modulation is less then 100%. Ideally, an envelope detector produces an output

signal that follows the envelop of the input signal wave form exactly; hence, the name. Same version of this circuit is used in almost all commercial AM radio receivers.

The Modulation Index is defined as Emax-Emin/ Emax + Emin

Or percentage modulation = (Emax - Emin/ Vmax + Emin) ×100

Where E_{max} and E_{min} are the maximum and minimum amplitudes of the modulated wave.

The carrier frequency fc is much greater than the highest frequency component ω of the message signal m(t),that is fc >>W

Where W is the message bandwidth.

If the condition is not satisfied, and envelope cannot be visualized satisfactorily. The trainer kit has a carrier generator, which can generate the carrier wave of 100 KHz when the trainer is switched on.

The circuit's carrier generator, modulator and demodulator are provided with the built in supplies, no supply connections are to be given externally.
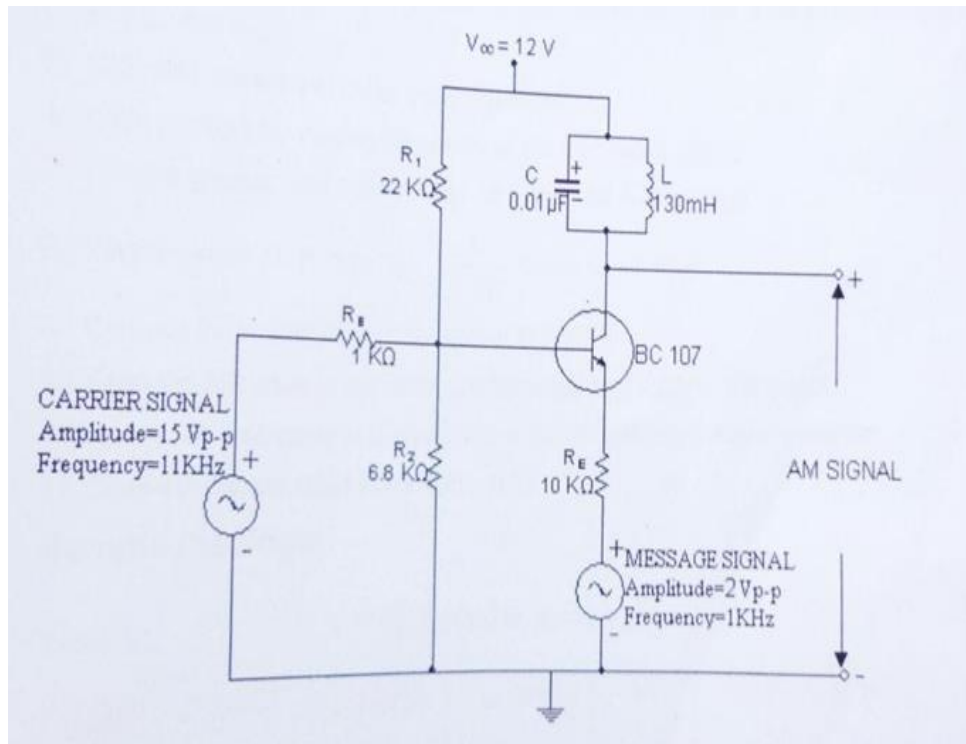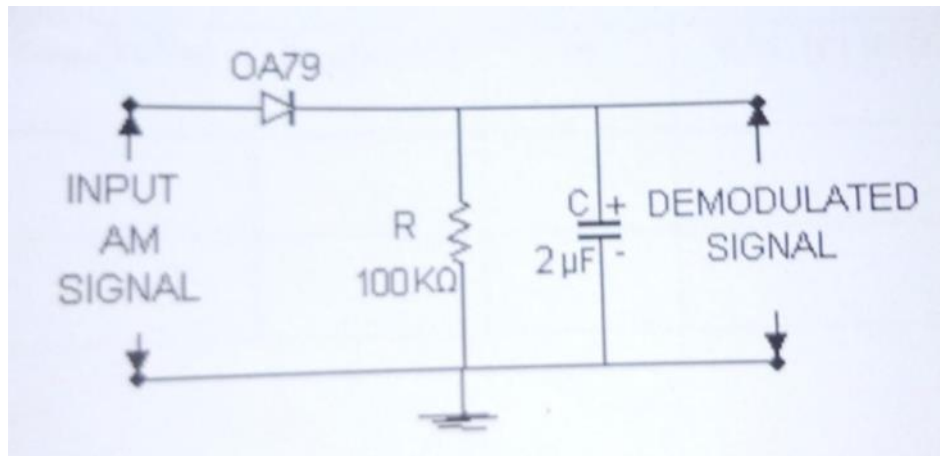
Circuit Diagrams:

For Modulation:

Fig: 1. AM Modulator

Procedure:

1. The circuit is connected as per the circuit diagram shown in Fig.1.
2. Switch on =12V V_{cc} supply
3. Apply sinusoidal signal of 1KHz frequency and amplitude 2 V_{p-p} as modulating signal, and carrier signal of frequency 11 KHz and amplitude 15 V_{p-p}.
4. Now slowly increase the amplitude of the modulating signal up to 7V and note down values of E_{max} and E_{min}.
5. Calculate modulation index using equation
6. Repeat step 5 by varying frequency of the modulating signal.
7. Plot the graphs: Modulation index vs Amplitude & Frequency
8. Find the value of R from $f_m = 1/2RC$, taking C=0.01 µF
9. Connect the circuit diagram as shown in Fig.2.
10. Feed the AM wave to the demodulator circuit and observe the output.
11. Note down frequency and amplitude of the demodulated output waveform.
12. Draw the demodulated wave form. m=1.

Sample Readings:
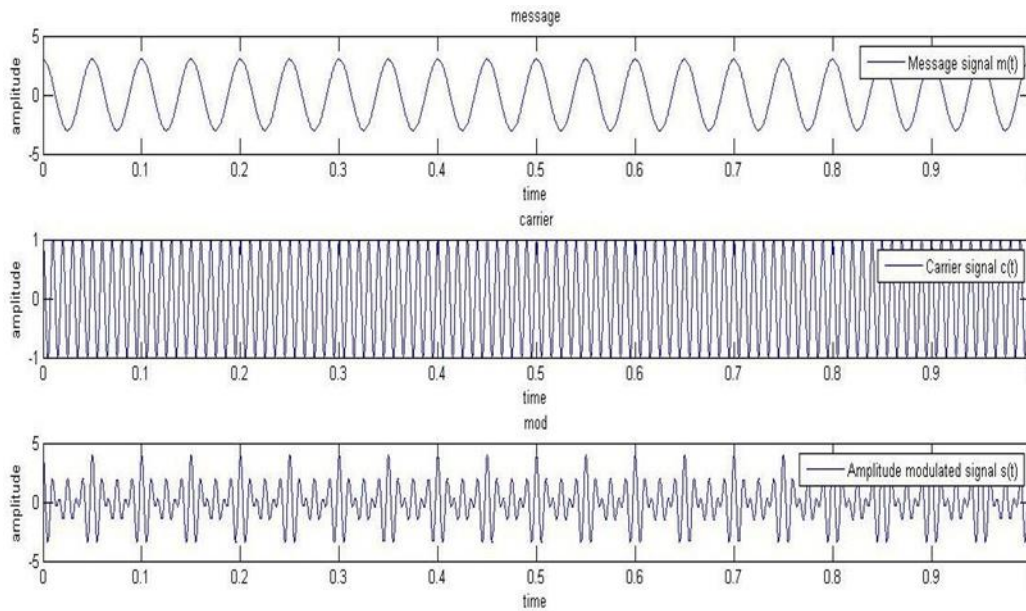
Table 1: f_m=1 KHz, f_c=11 KHz, A_c=15V_{p-p}.

S.NO.	V_m (Volts)	E_{max}(Volts)	E_{min}(Volts)	m	%m(mx100

Table 2: A_m=4V_{p-p}, f_c=11KHz, A_c=15V_{p-p}.

S.NO.	f_m(KHz)	E_{max}(Volts)	E_{min}(Volts)	m	%m(mx100

Precautions:

1. Check the connections before giving the power supply
2. Observations should be done carefully.

Model wave forms:

Result:

APPLICATIONS:

1. Tele communications.
2. TV Transmitters.

QUESTIONS:

3. Define AM and draw its spectrum?
4. Draw the phase representation of an amplitude modulated wave?
5. Give the significance of modulation index?
6. What is the different degree of modulation?
7. What are the limitations of square law modulator?
8. Compare linear and nonlinear modulators?
9. Compare base modulation and emitter modulation?
10. Explain how AM wave is detected?
11. Define detection process?
12. What are the different types of distortions that occur in an envelop detector? How can they be eliminated?

EXPERIMENT NO. 1(ii)

DSB-SC MODULATION AND DEMODULATION

Aim: To generate AM-Double Side Band Suppressed Carrier (DSB-SC) signal.

Pre-Lab Work:

1. Basic theory of DSB-SC modulation using balanced modulator and synchronous detection techniques.
2. Time and Frequency analysis of DSB-SC waves.
3. Understanding the circuit diagrams of DSB-SC generation using balanced modulator and envelope detection.
4. Understanding the data sheets of components used in the experiment.

Apparatus Required:

| Name of the Component/Equipment	Specifications /Range	Quantity
IC LM 741	Std. Op-amp (General Purpose)	1
IC LF 398	Monolithic Sample and Hold Circuit (10-µs acquisition, 7-mV offset)	1
Diode (0A79)	Max Current 35mA	1
Resistors	47KΩ 22KΩ 3.9KΩ 6.8KΩ 1KΩ,	1 1 1 1 3
Capacitors	0.1µF 0.01µF	2 1
Variable Resistor (Linear Pot)	0-50KΩ	1
CRO	100MHz	1
Function Generator	1MHz	2
Regulated Power Supply	0-30V, 1A	1

Circuit Diagram:
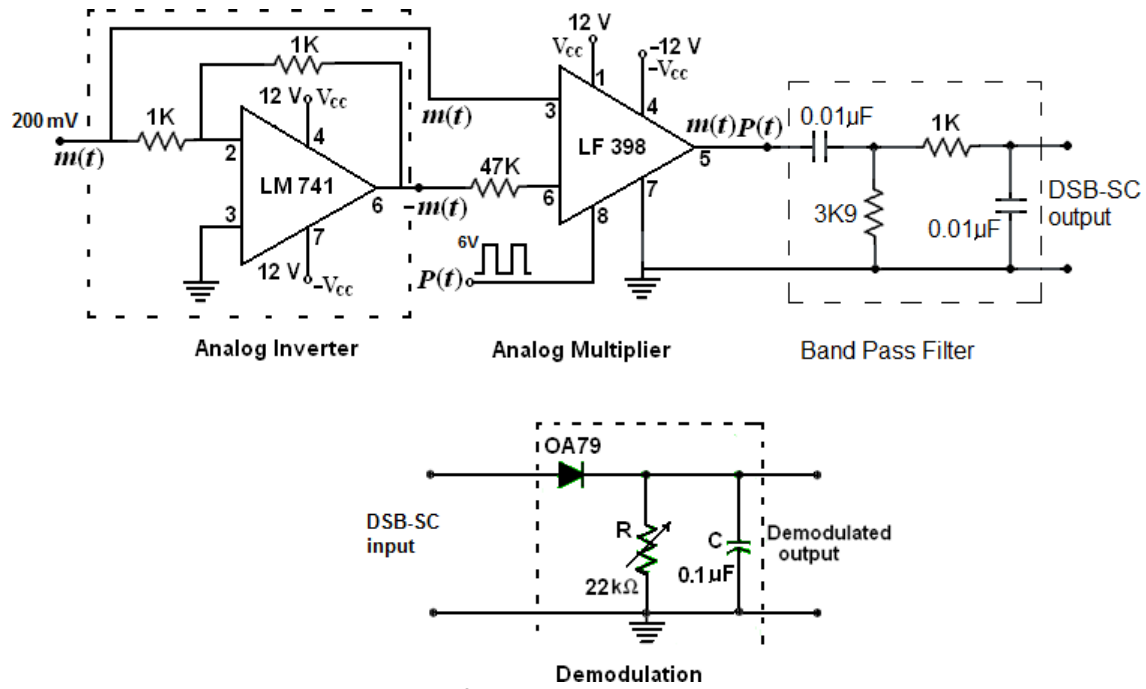
Fig 1. Circuit diagram of DSB-SC Modulation and Demodulation

Basic Theory: The block diagram of DSB-SC modulator is shown in Fig 2. A balanced modulator consists of two standard AM modulators arranged in a balanced configuration to suppress the carrier wave. We assume that the two modulators are identical except for the signal reversal of the modulating wave applied to the input of one of them. Thus the outputs of the two modulators are expressed as follows:

$$s_1(t) = Ac[1+ kam(t)]\cos 2\pi f_c t \quad and \quad s_2(t) = Ac[1- kam(t)]\cos 2\pi f_c t$$

By subtracting $s_2(t)$ from $s_1(t)$, we obtain $s(t) = s_1(t) - s_2(t) = [2kam(t)Ac \cos 2\pi f_c t]m(t)$.

Hence except for the the balanced modulator output is equal to the scaling factor 2ka product of the modulating wave and carrier as required. An envelope detector is used for demodulation purpose.
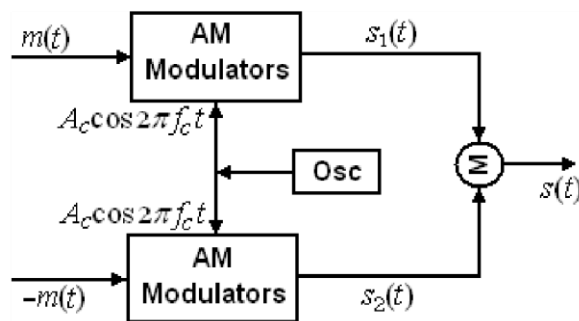

Fig. 2 Block diagram of Balanced Modulator

Procedure:

DSB-SC Modulation:

Analog Inverter:

1. Initially wire the circuit for analog inverter circuit as shown in Fig.1.
2. Set audio signal generator (modulating signal) to 1 kHz sine wave with 200 mV peak.
3. Now observe the output wave form at the output of analog inverter (pin No6 of LM 741). This waveform should be inversion of the input sine wave.

Analog Multiplier:

4. Now wire the analog multiplier circuit as shown in Fig.1.
5. A square wave of 10 kHz with 6 Vpp is connected to the Pin. No.8 of LF 398.
6. Observe the DSB-SC output at Pin No. 5 of LF 398.
7. Now slightly increase and decrease the modulating signal and note how the DSB-SC modulation changes.

Demodulation:

8. Now the demodulation circuit is connected across the output of DSB-SC modulator circuit.
9. By varying the "R" observe the demodulated signal.
10. By varying the modulating voltage in the DSB-SC modulation circuit, observe the demodulated signal.
11. Similarly, by varying the modulating signal frequency in the modulation circuit, observe the demodulated signal.
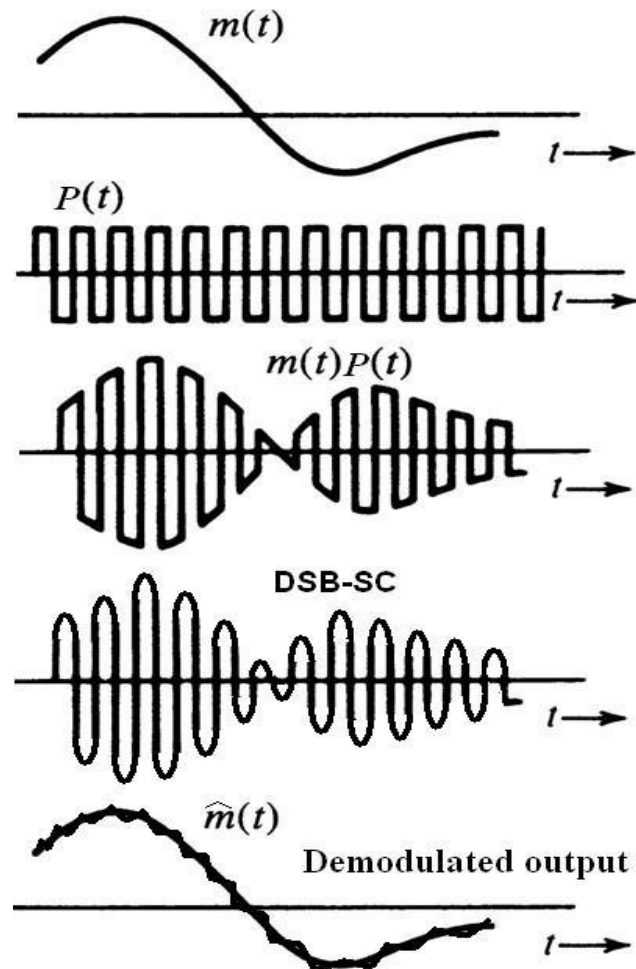
Observations:

Model Wave Forms:

Fig 3. DSB-SC Modulation waveforms and Envelope detector output waveforms

Precautions:

1. Check the connections before switching ON the power supply.

2. The components must be properly doped into the bread board.

3. Observations should be done carefully.

Results:

Post-Lab Requirements:
1. Create the illustration for Amplitude Modulation.
2. Compare the results are obtained in hardware lab with that of computer simulations.
3. Submit your illustration to the lab instructor at next week's lab.

Viva Questions:
1. What are discrete frequencies in DSB-SC?
2. What is the advantage of DSB-SC over AM?
3. Mention the names of methods for DSB-SC generation?
4. What do you mean by coherence detection and non-coherent detection?
5. How a message signal recovered from DSBSC wave?
6. What is the disadvantage of DSB-SC?
7. What is the bandwidth of DSB-SC?
8. Why DSB-SC is not used for commercial broad casting?
9. Mention few applications for DSB-SC.

EXPERIMENT NO.2

Frequency Modulation Using 8038

Aim: To obtain frequency modulator using IC 8038.

Components required: IC-8038, Resistor, Capacitor, Fixed Power

supply +12V, 0, - 12V, Signal generator, CRO

Theory:

In Frequency Modulation frequency of the carrier signal varies in accordance with the instantaneous amplitude of the modulating signal. Hence, in frequency modulation, the amplitude and the phase of the carrier signal remains constant. The frequency of the modulated wave increases, when the amplitude of the modulating or message signal increases. Similarly, the frequency of the modulated wave decreases, when the amplitude of the modulating signal decreases. Note that, the frequency of the modulated wave remains constant and it is equal to the frequency of the carrier signal, when the amplitude of the modulating signal is zero.

The equation for instantaneous frequency fifi in FM modulation is

$$f_i = f_c + k_f\, m(t)$$

where fc=carrier frequency, m(t)=message signal, kf=frequency sensitivity

FM wave Equation

$$s(t) = A_c \cos\left(2\pi f_c t + 2\pi\, k_f \int m(t)dt\right)$$

If the modulating signal is m(t)=Am cos (2πfm t), then the equation of FM wave will be

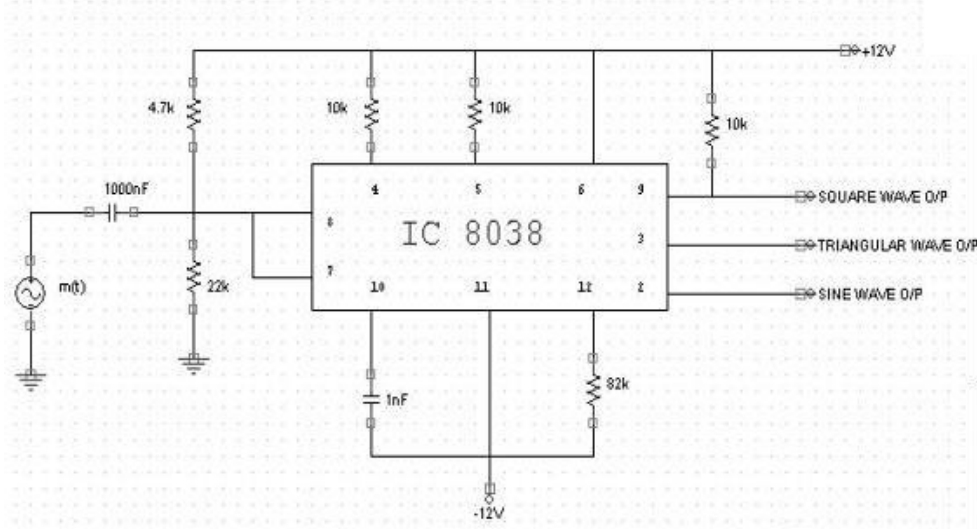$$s(t) = A_c \cos\left(2\pi f_c\, t + \beta \sin\left(2\pi f_m\, t\right)\right)$$

Where,

β= **modulation index** $= \Delta f/f_m = k_f\, A_m/\, f_m$

Transmission Bandwidth

$$\beta_T = 2(\Delta f + f_m)$$

Circuit Diagram:

Design:

Let R=R_A=R_B =10K, f_C=33 KHz

$$Fc= \cfrac{1}{5/3\, R_A\, C \left[1+ \cfrac{R_B}{2\,R_A - R_B} \right]}$$

$$= \frac{0.3}{RC}$$

Then C=1000pF   choose 0.001µF

Procedure:

1. Given ±12V as Vcc to IC 8038 and shorting pin numbers 7 and 8 observe the outputs at 9 and 3 and 2 on CRO i.e., square, triangular and sine wave respectively.
2. Measure the sine wave amplitude and frequency at pin no.2, which forms the carrier wave.
3. Connect modulating signal of Vm = 3Vpp and frequency of 80 Hz to 1.5kHz between pin numbers 7 and 8 through Rc as shown in diagram.
4. Observe the FM output at pin 2.
5. Draw the output waveform and note down fmax and fmin.

1. Calculate modulator index β and bandwidth B_T.

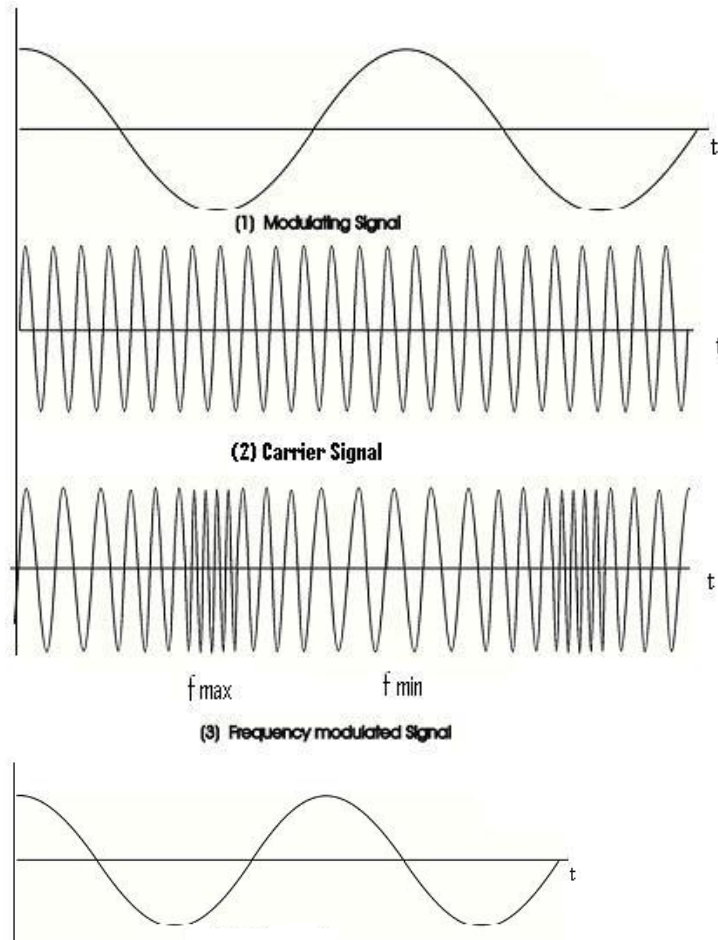   I.   To calculate modulator index β

$$\Delta f = f_{max} - f_{min}$$

$$\beta = \frac{\Delta f}{f_m}$$

     II.   Transmission Bandwidth

$$\beta_T = 2(\Delta f + f_m)$$
$$\beta_T =$$

Waveforms:

(1) Modulating Signal

(2) Carrier Signal

f max   f min

(3) Frequency modulated Signal

Experiment 2
Frequency demodulation: Frequency synthesis using PLL
Aim: To study phase lock loop and its capture range, lock range and free running VCO

Theory: PLL has emerged as one of the fundamental building block in electronic technology. It is used for the frequency multiplication, FM stereo detector, FM demodulator, frequency shift keying decoders, local oscillator in TV and FM tuner. It consists of a phase detector, a LPF and a voltage-controlled oscillator (VCO) connected together in the form of a feedback system. The VCO is a sinusoidal generator whose frequency is determined by a voltage applied to it from an external source. In effect, any frequency modulator may serve as a VCO. The phase detector or comparator compares the input frequency, fin, with feedback frequency, f out, (output frequency). The output of the phase detector is proportional to the phase difference between f in, and f out, . The output voltage of the phase detector is a DC voltage and therefore m is often referring to as error voltage. The output of the phase detector is then applied to the LPF, which removes the high frequency noise and produces a DC lend. The DC level, in term is the input to the VCO. The output frequency of the VCO is directly proportional to the input DC level. The VCO frequency is compared with the input frequencies and adjusted until it is equal to the input frequency. In short, PLL keeps its output frequency constant at the input frequency.

Thus, the PLL goes through 3 states.

1. Free running state.

2. Capture range / mode

3. Phase lock state.

Before input is applied, the PLL is in the free running state. Once the input frequency is applied, the VCO frequency starts to change and the PLL is said to be the capture range/mode. The VCO frequency continues to change (output frequency) until it equals the input frequency and the PLL is then in the phase locked state. When phase is locked, the loop tracks any change in the input frequency through its repetitive action.

Lock Range or Tracking Range: It is the range of frequencies in the vicinity

of f_O over which the VCO, once locked to the input signal, will remain locked

Capture Range: (f C): Is the range of frequencies in the vicinity of 'f_O' over which the loop will acquire lock with an input signal initially starting out of lock.

Circuit:
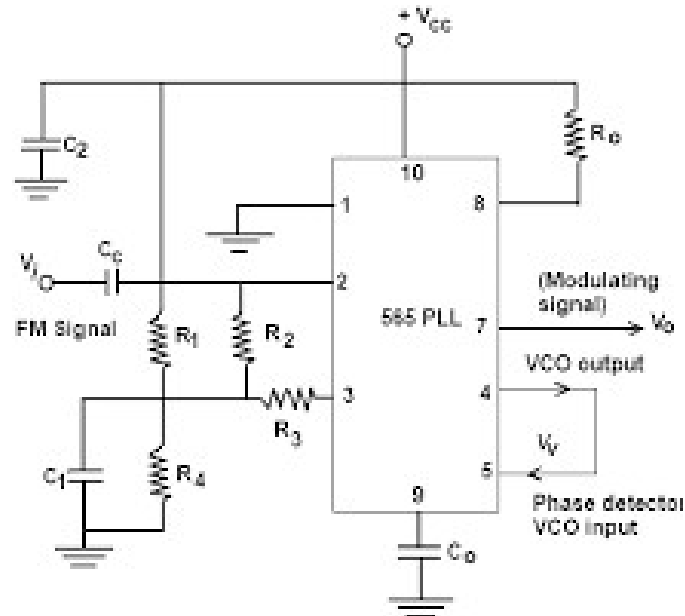
Procedure:

1. Connect + 5V to pin 10 of LM 565.

2. Connect -5V to pin 1.

3. Connect 10k resistor from pin 8 to + 5V

4. Connect 0.01 µf capacitor from pin 9 to – 5V

5. Short pin 4 to pin 5.

6. Without giving input measure (f_O) free running frequency.

7. Connect pin 2 to oscillator or function generator through a 1µf capacitor, adjust the amplitude aroung 2Vpp.

8. Connect 0.1 µf capacitor between pin 7 and + 5V (C2)

9. Connect output to the second channel is of CRO.

10. Connect output to the second channel of the CRO.

11. By varying the frequency in different steps observe that of one frequency the wave form will be phase locked.

12. Change R-C components to shift VCO center frequency and see how lock range of the input varies.
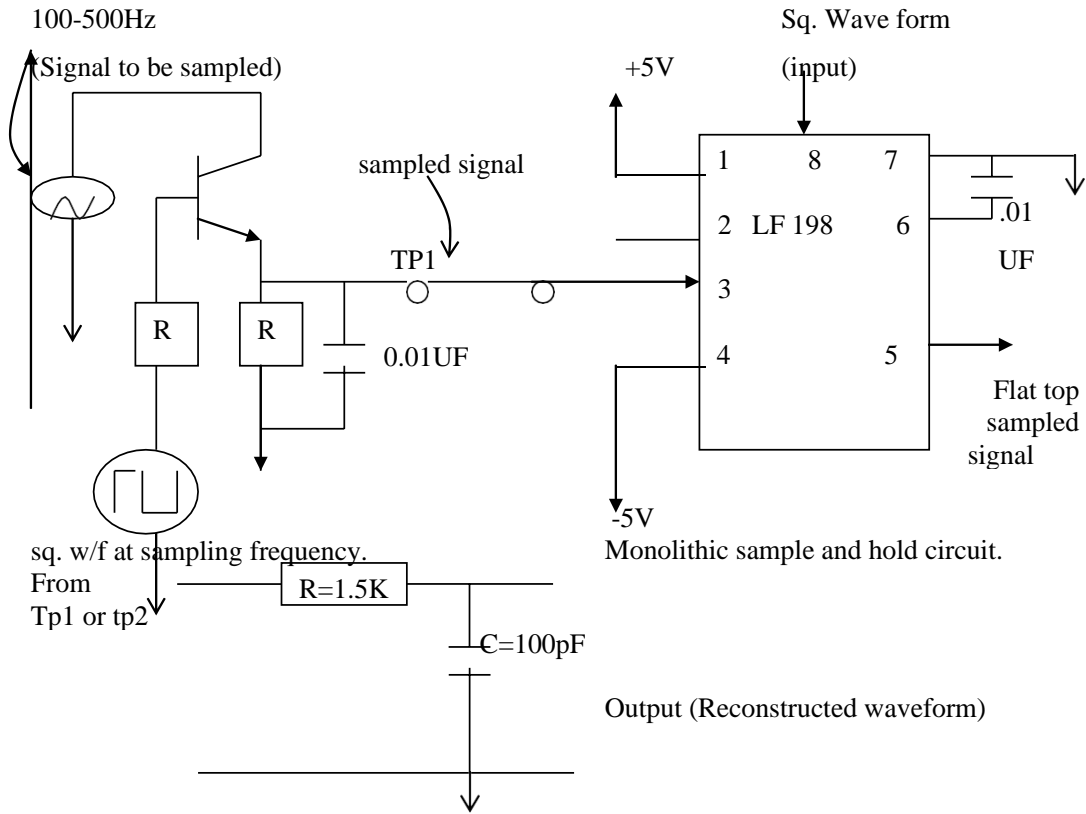
Result:
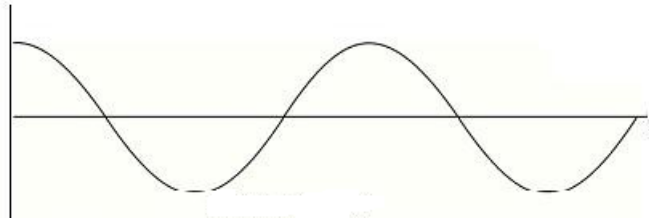
Questions:
1. Define Frequency modulation and draw its waveforms.
2. Define frequency deviation, carrier swing of FM signal
3. Give merits and demerits of FM
4. **What is the difference between detector and demodulator?**
5. **Explain Carson's rule with equation.**
6. **List out the applications of FM?**
7. **List out Narrow band, Wide Band Characteristics of FM**
8. How FM signal is better than AM signal
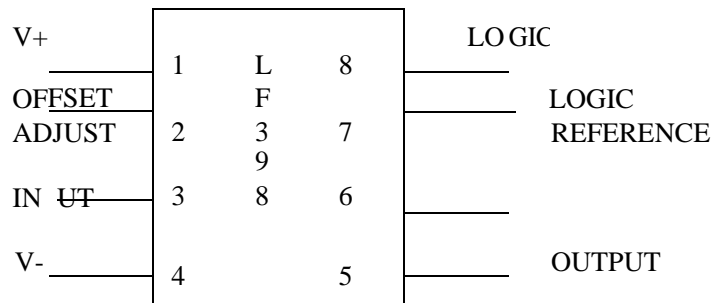
EXPERIMENT NO.3

VERIFICATION OF SAMPLING THEOREM USING FLAT TOP SAMPLES

Aim   : Verification of sampling theorem using flat top samples.

**Circuit diagram for sample and hold flat top sampling.**

100-500Hz   Sq. Wave form

(Signal to be sampled)   +5V   (input)

sampled signal

TP1

R   R

0.01UF

1   8   7

2   LF 198   6   .01

3   UF

4   5

Flat top
sampled
signal

-5V

sq. w/f at sampling frequency.   Monolithic sample and hold circuit.
From
Tp1 or tp2

R=1.5K

C=100pF

Output (Reconstructed waveform)

Demodulator Reconstructed filter.

V+   LOGIC

1   L   8

OFFSET   F   LOGIC
ADJUST   2   3   7   REFERENCE
                      9

IN UT   3   8   6

V-   4   5   OUTPUT

Procedure:

1. Rig up the circuit as shown in figure below.

1. Feed the modulating signal m(t) of 100 to 500 Hz sine wave of amplitude 5 to 10V peak to peak.
2. Feed a square wave of amplitude 10 to 15 V peak to peak of frequency 1 to 5 K Hz as carrier frequency as carrier signal c(t).
3. Set the carrier frequency fc to a value less than, equal to twice and more than the modulating signal frequency and observe the sampled waveforms at test points 1 and 2 in each case. Record the wave forms.
4. Wire the demodulator circuit with sampled signal as input from test point 1 and again from test point 2 and observe the reconstructed waveforms in each case. Record the result for various values of sampling frequency as stated in step 4 above.

Wave forms:

Fc <2fm   t

fc > 2fm

flat top samples

t

sampled signals at TP2.
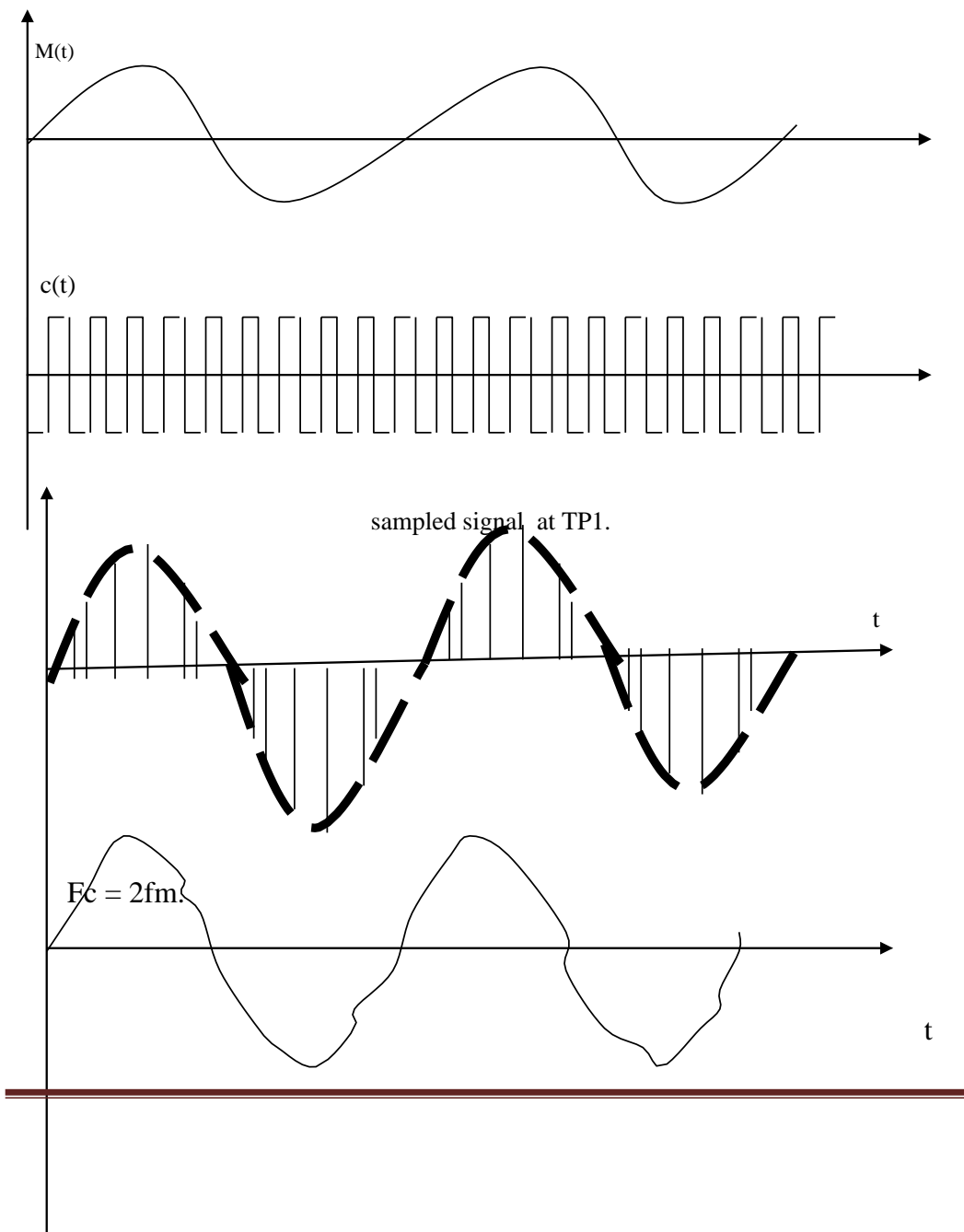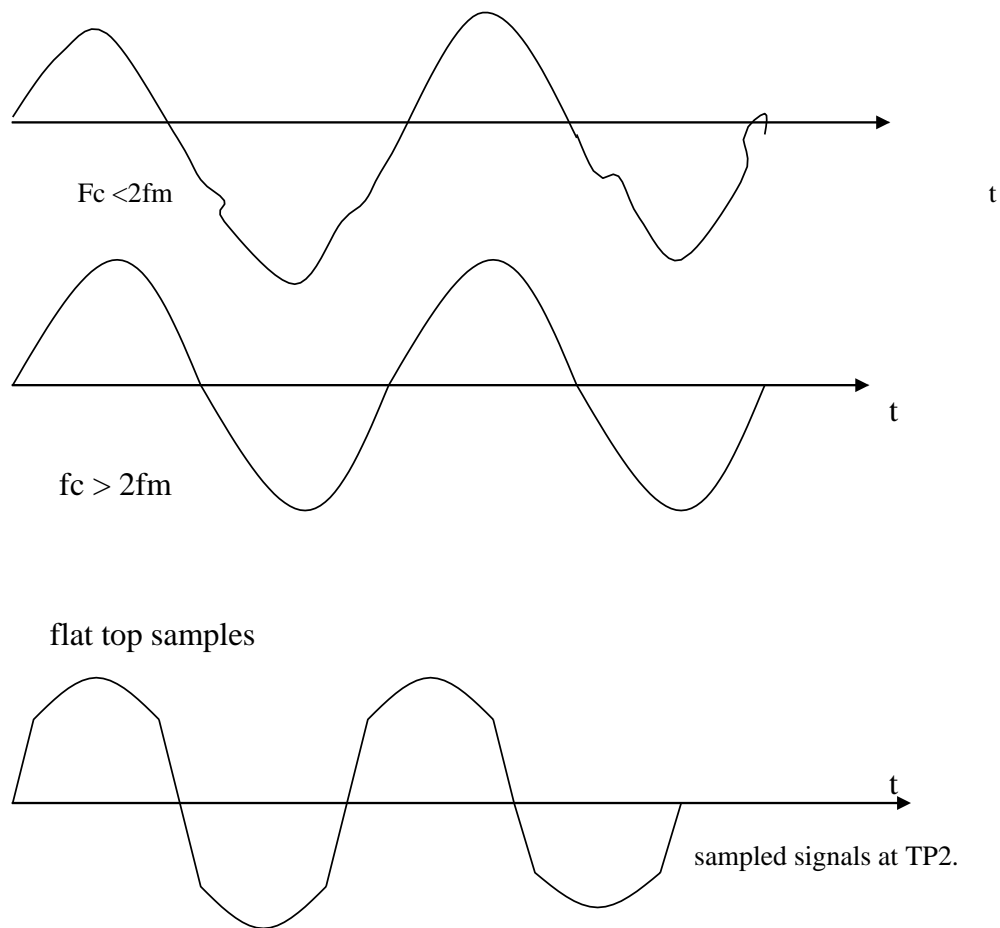
Theory: Sampling theorem for strictly band limited signals of finite energy into two equivalent parts:

- A band limited signal of finite energy, which only has frequency components less than **W** Hertz, is completely described by specifying the values of the signal at instants of time separated by **1/2W** seconds

- A band limited signal of finite energy which only has frequency components less than **W** Hertz , may be completely recovered from a knowledge of its sample taken at the rate of **2W** samples per second.

In flat top sampling, the top of the samples remains constant and equal to the instantaneous value of the modulating signal at the start of the sampling. Thus, the amplitude of the pulse after sampling is kept constant and the top of the sampled pulse do not follow the contour of the modulating signal unlike Natural sampling. The duration of each sample is τ and the sampling rate is fs=1/Ts. Therefore, Ts=1/fs Sample and hold circuit is used for the generation of the sampled signal to attain flat top sampling. Natural sampling is little complex whereas flat top sampling is quite easy.

Viva Questions:

What is Sampling process?

CYCLE 1

EXPERIMENT NO. 4

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.
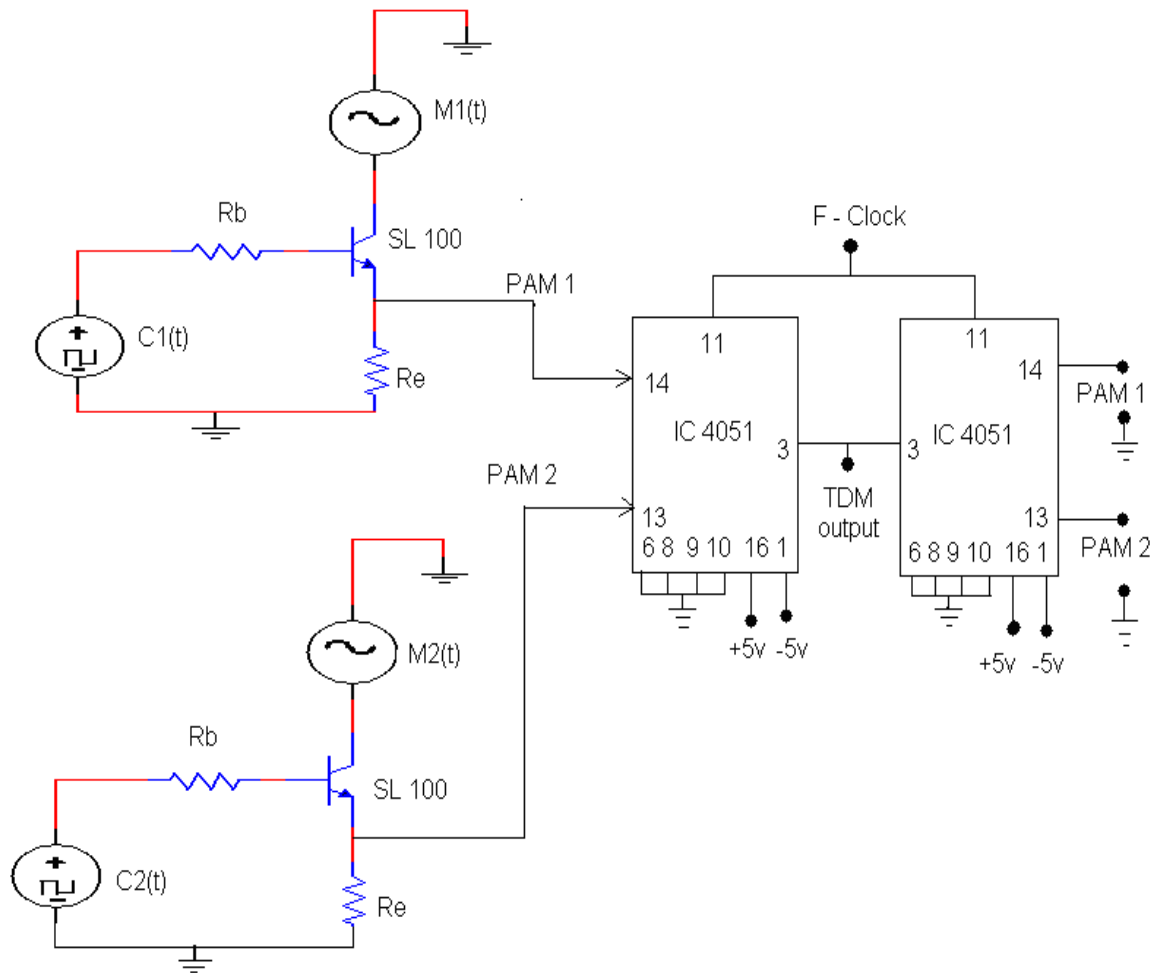
Equipments & Components required: Transistor - SL100,

Resistors - 1KΩ, 10KΩ, 2.7KΩ, 67KΩ

Multiplexer / Demultiplexer - IC4051.

Function generators, Power supplies, Oscilloscope.

CIRCUIT DIAGRAM:

DESIGN:

PAM 1

fm = 500Hz,   fc = 3 KHz

Given: Vc = 4Vpp, Vm = 3Vp-p, hfe = 30, V_{BESAT} = 0.7V, V_{CESAT} = 0.3V, Ic = 1mA

Appling KVL at the output side:

$Vm = V_{CE} + I_E R_E$

$1.5 = 0.3 + 1*(10^{-3)} R_E$

$R_E = 1 K\Omega$

Appling KVL at the input side;

$Vc = I_B R_B + V_{BE} + I_E R_E,$

$I_B = I_c / hfe$

$2 = R_B * 1m / 30 + 0.7 + 1m* 1K$

$R_B = 9K\Omega$ (choose $10K\Omega$)

Similarly,

PAM 2

Given: $Vc = 8Vpp, Vm = 6Vpp, hfe = 30, V_{BE(SAT)} = 0.7V, V_{CE(SAT)} = 0.3V, Ic = 1mA$

$fm = 1 KHz, \quad fc = 5 KHz$

Appling KVL at the output side,

$Vm = V_{CE} + I_E R_E$

$3 = 0.3 + 1*(10^{-3)} R_E$

$RE = 2.7 K\Omega$

Appling KVL at the input side,

$Vc = I_B R_B + V_{BE} + I_E R_E$

$I_B = I_{c/} / h_{fe}$

$4 = R_B * 1m / 30 + 0.7 + 1m* 1K$

$R_B = 69K\Omega$ (choose $67K\Omega$)

PROCEDURE:

1. Connect the two PAM circuits and check for the clear PAM output with different frequencies of m(t) and c(t).

2. Give the output of two PAM signals to IC 4051 multiplexer to get multiplexed output (with proper clock pulse).

3. Now connect the multiplexed output to next IC 4051 which acts as demultiplexer to get back the original PAM signals at pin number 13 and 14.

4. Record the results by tracing the waveforms obtained.

Tabulation:

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

WAVEFORMS:
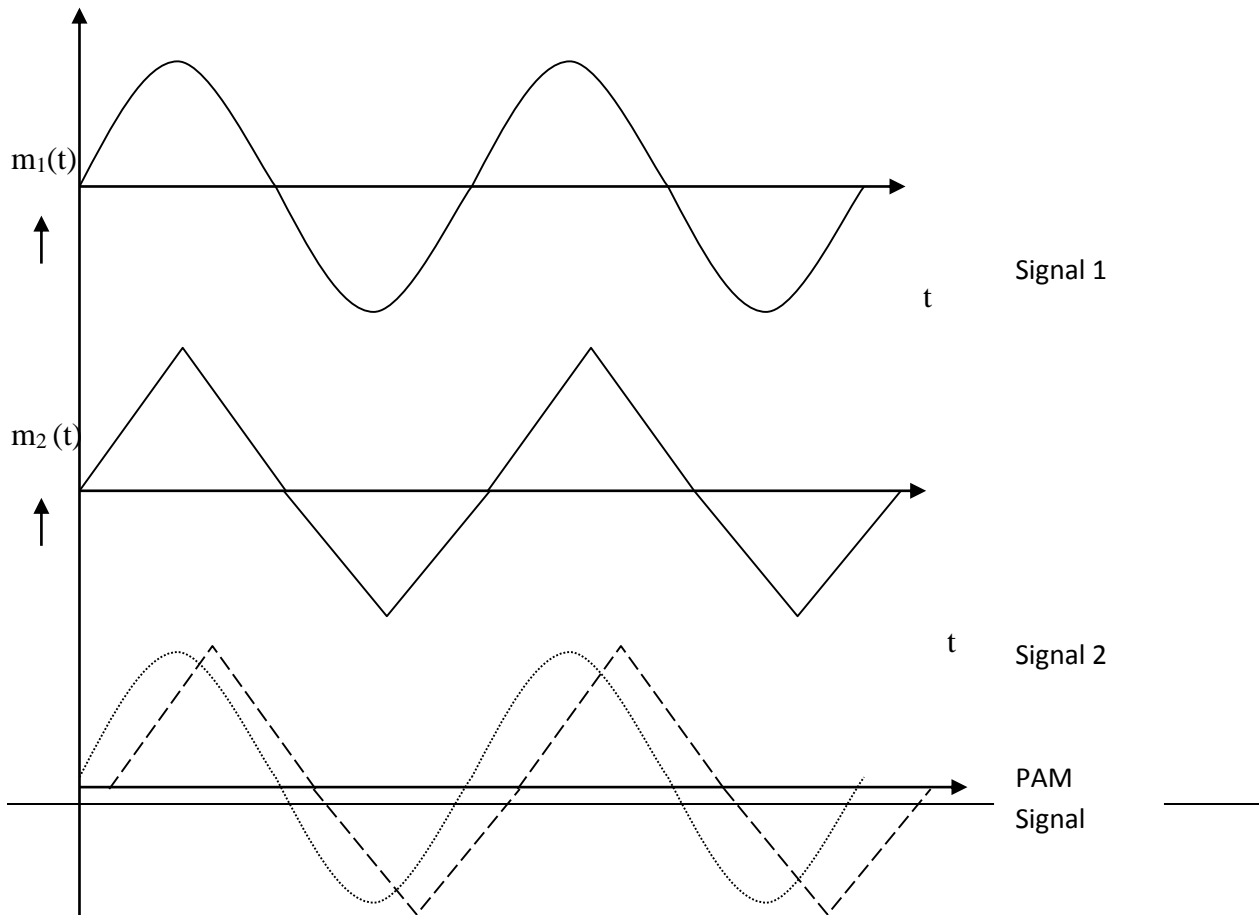
EXPERIMEMT NO. 5

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.
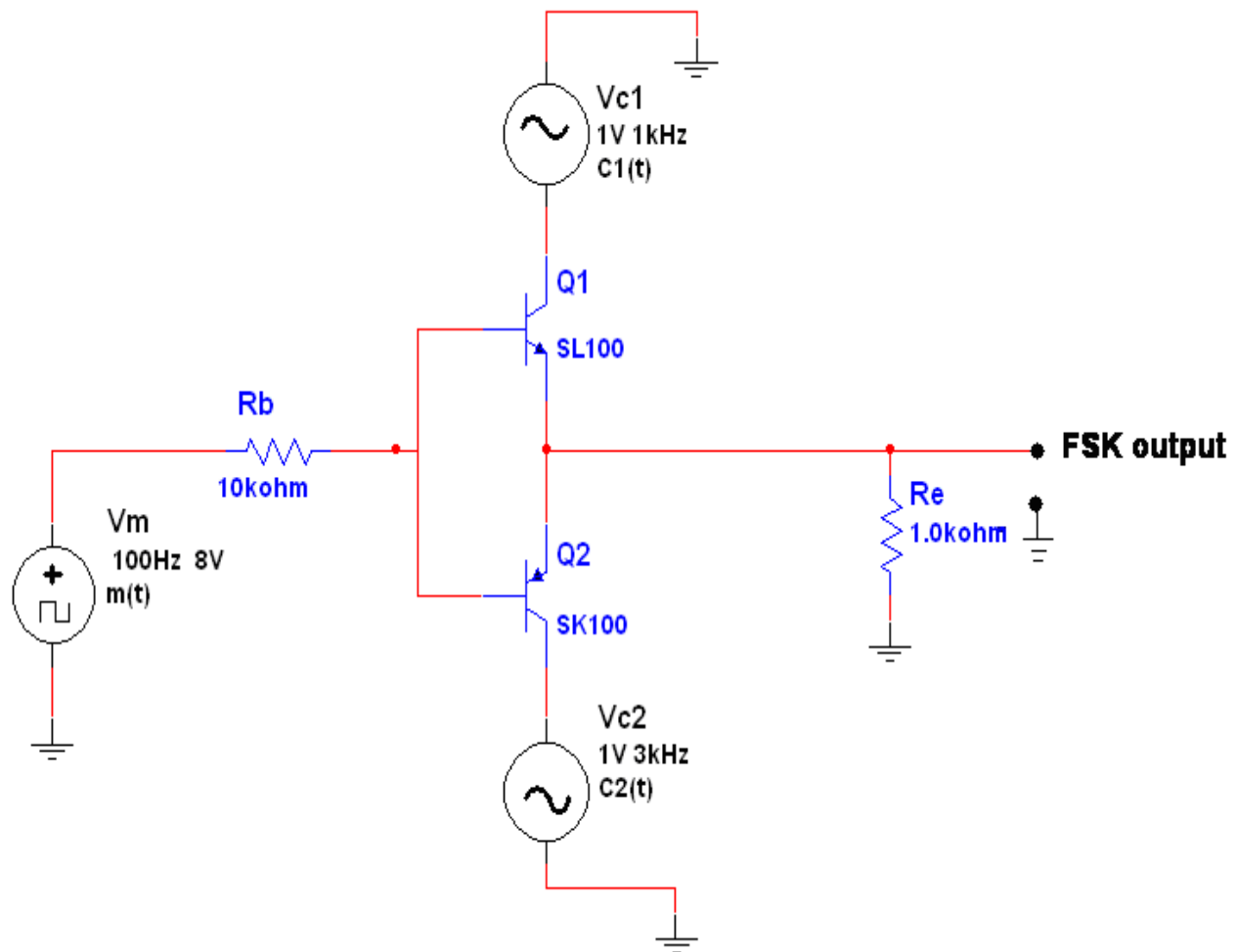
Equipments & Components: Transistor SL100 and SK100,

Resistors -1KΩ, 10KΩ, 5.6KΩ, 560Ω

Capacitors – 0.1μF - 2 Nos.

Op amp - μA741

Diode - 0A79

Function generators, Power supply, Oscilloscope.

CIRCUIT DIAGRAM:

FSK MODULATOR:

DESIGN:

Ic = Ic = 2.5mA, h_{fe} =100, V_{RE} = 2.5V

Then, R_E = V_{RE} / I_E = 2.5 / 2.5mA = R_E = 1KΩ

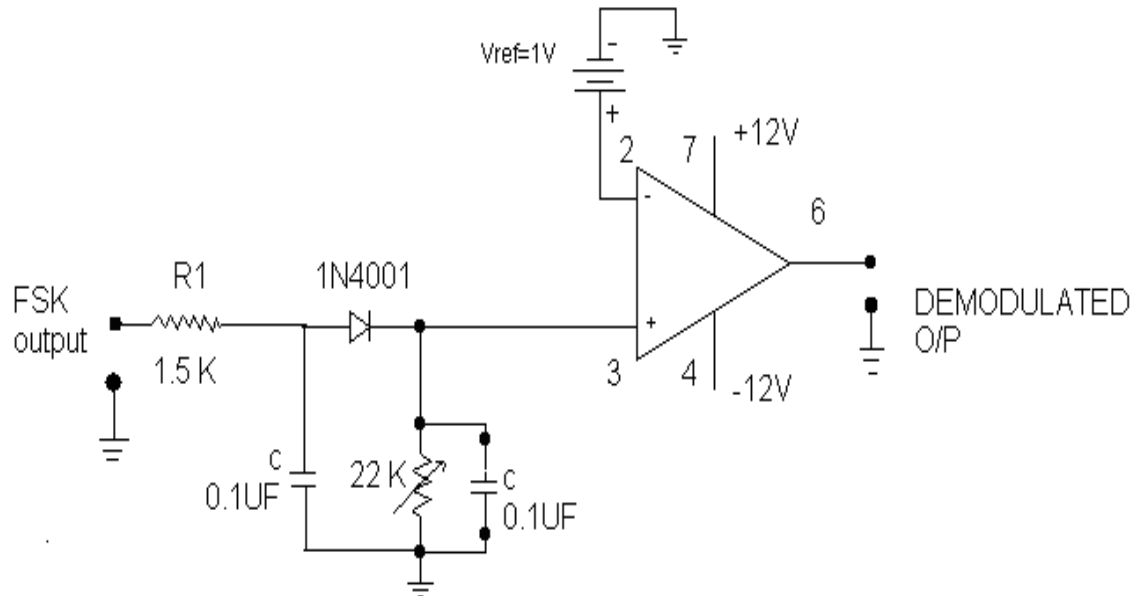V_{RB} = $V_m(t)$p-p / 2 − $V_{BE(sat)}$ − $V_{RE(sat)}$

       = 3.5 – 0.7 – 2.5

V_{RB} = 0.3V

I_B = Ic / hfe = 2.5 / 100 = 2.5μA

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

$I_{B(SAT)}$ = 30μA

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

FSK DEMODULATOR:

$fm = 1 / 2\Pi RC$

Assuming $C = 0.1\mu F$

$R = 15.9K\Omega$

$fm = 100Hz$

$f_{c1} = 1 / 2\Pi R1C1$

$f_{c1} = 1$ KHz

$R_1 = 1.59$ KΩ

$C_1 = 0.1\mu F$

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.
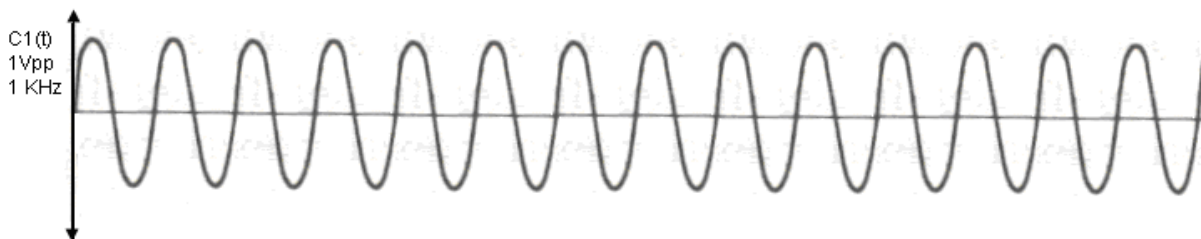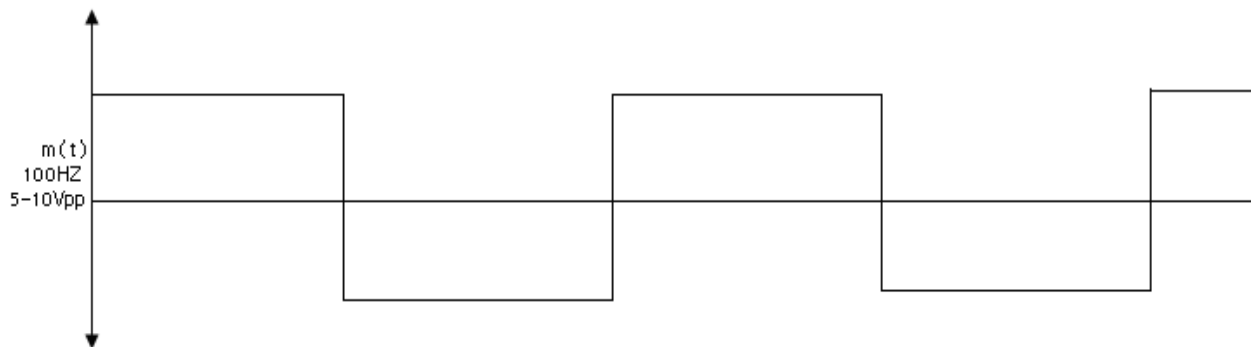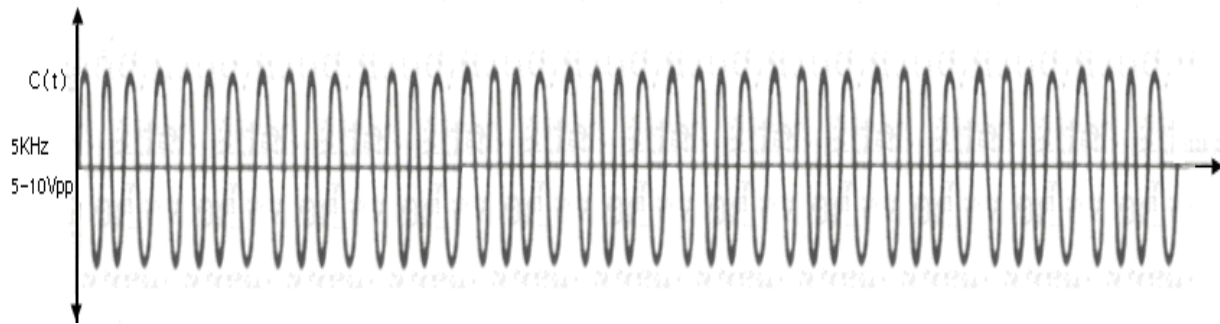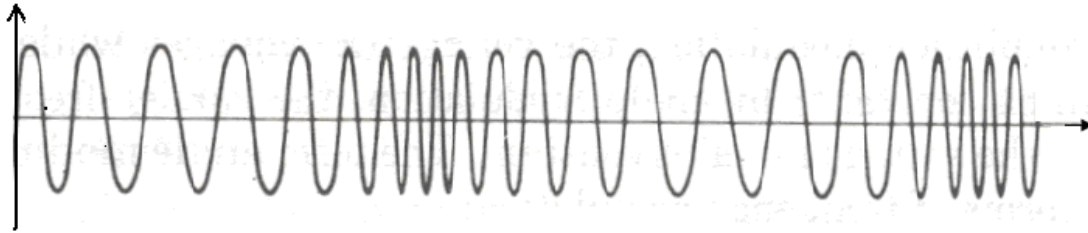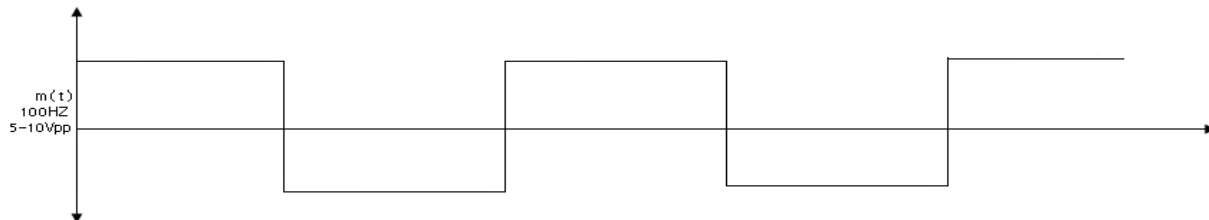
Detection:

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 in terms 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:

C(t)
5KHz
5-10Vpp

MODULATION WAVEFORMS:

DEMODULATION WAVEFORMS:

m(t)
100HZ
5-10Vpp

EXPERIMENT NO. 5

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.

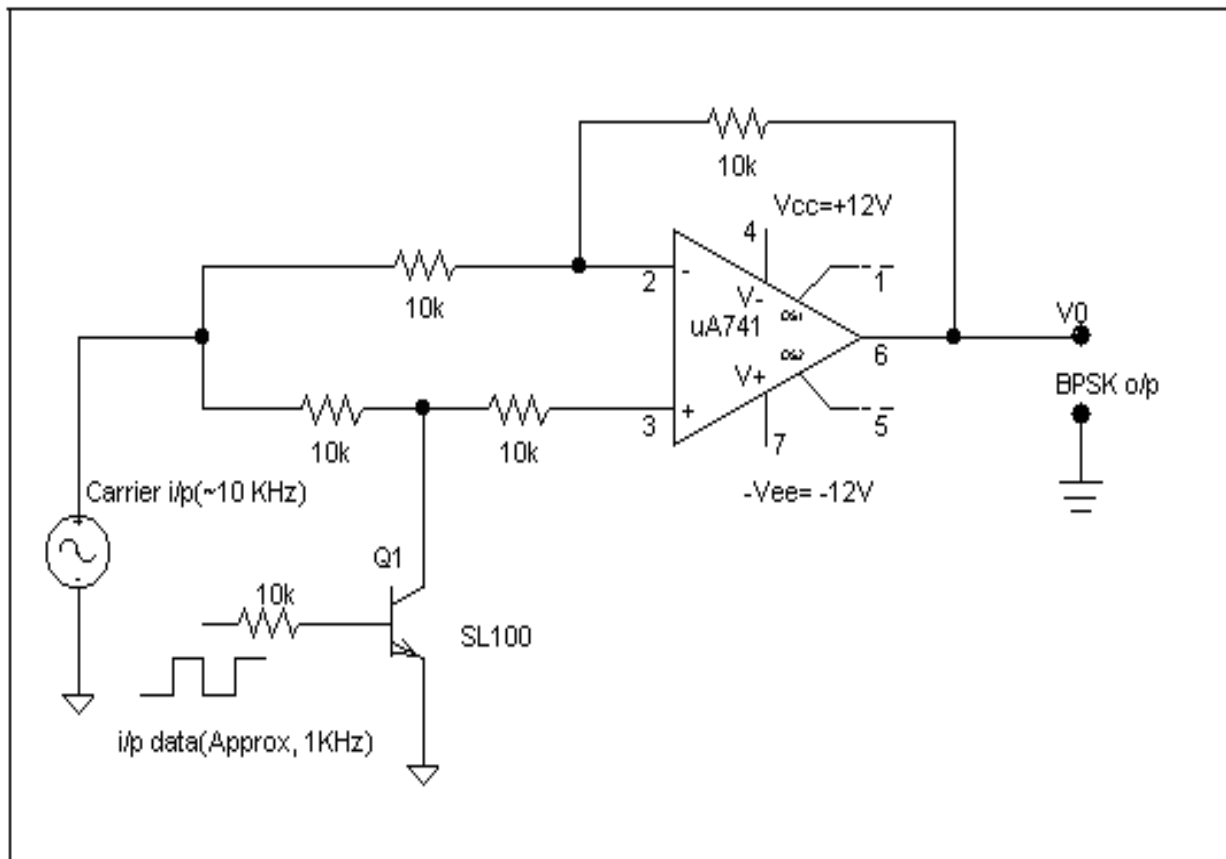**Equipments & Components required:** Transistor SL100, SK100

   Resistor – 1KΩ, 100KΩ, 5.6 KΩ

   Capacitor – 0.1μF

   OP Amp - μA741,

   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 interms of frequency but not in amplitude.

PSK DEMODULATOR:

PSK Demodulation

Waveforms

t
Message Signal

t
Carrier Signal

t
**BPSK Output**

t
**Demodulated
Output**
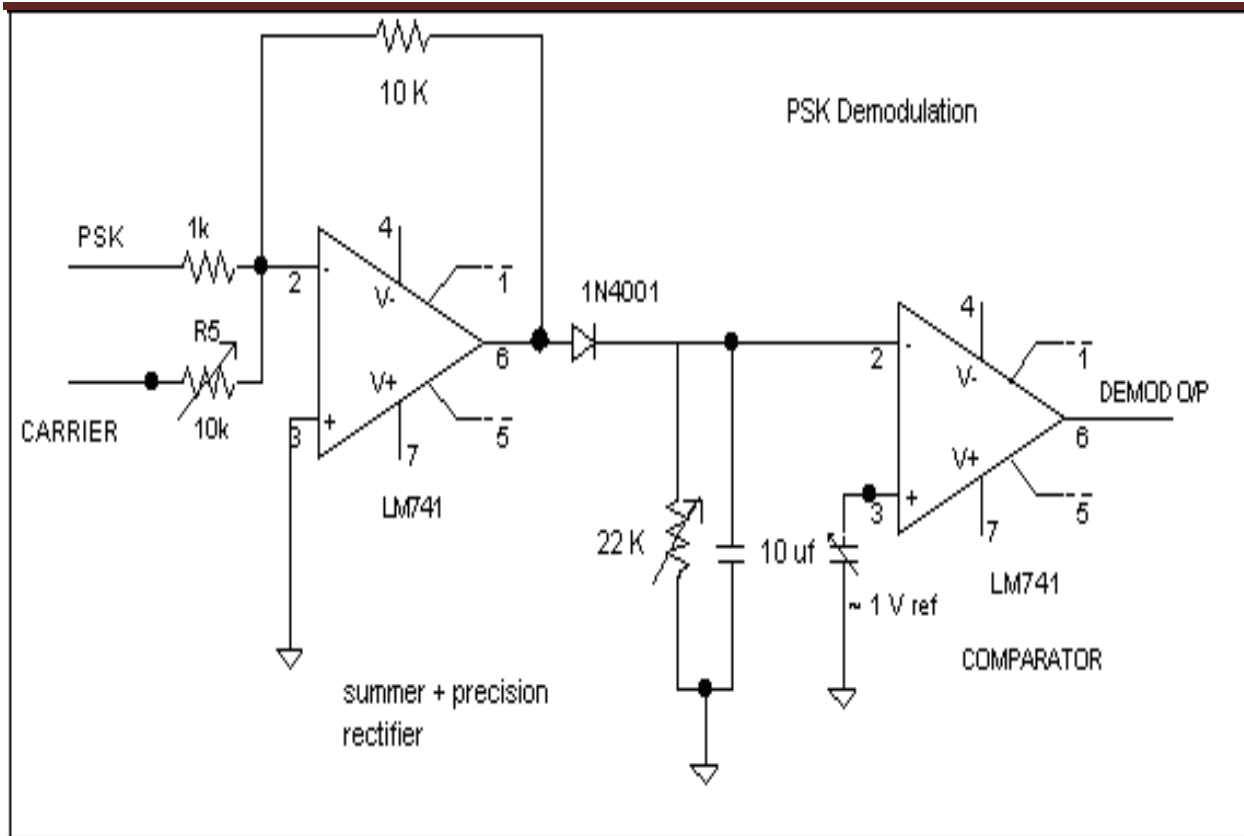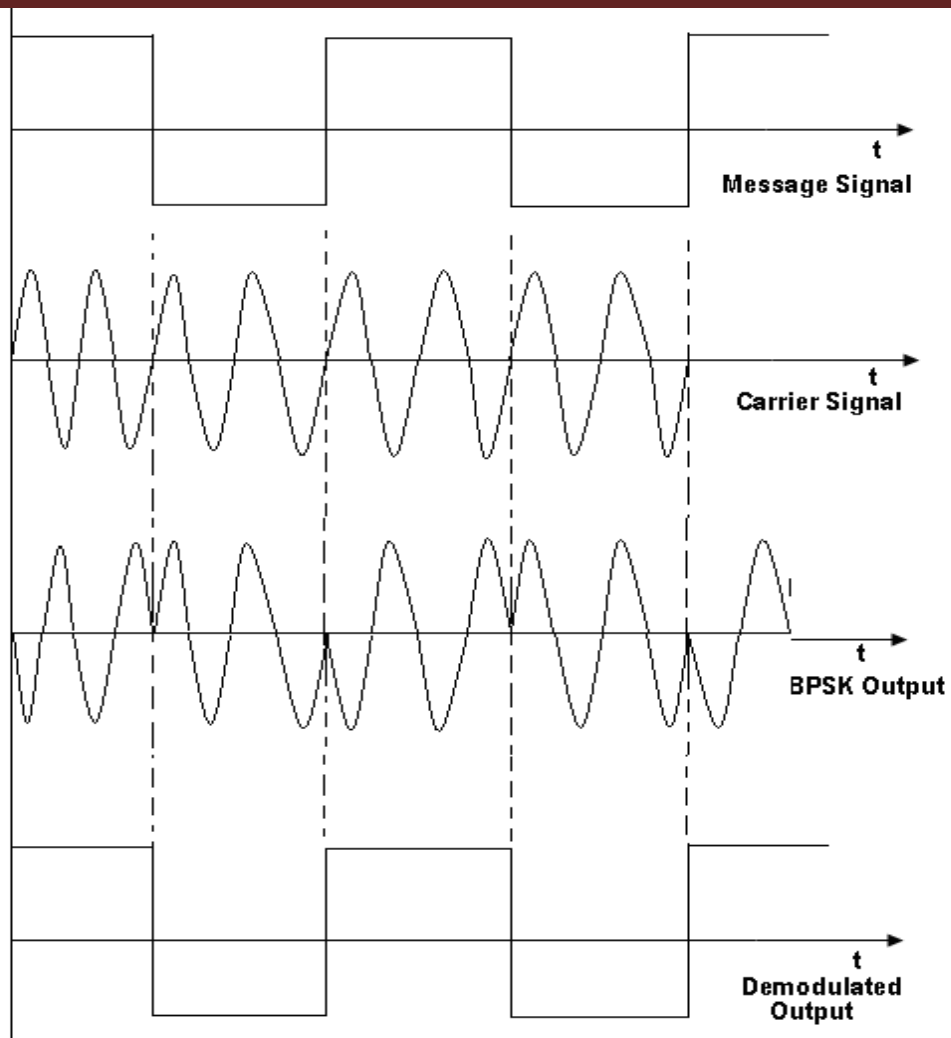
EXPERIMENT NO. 6

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:
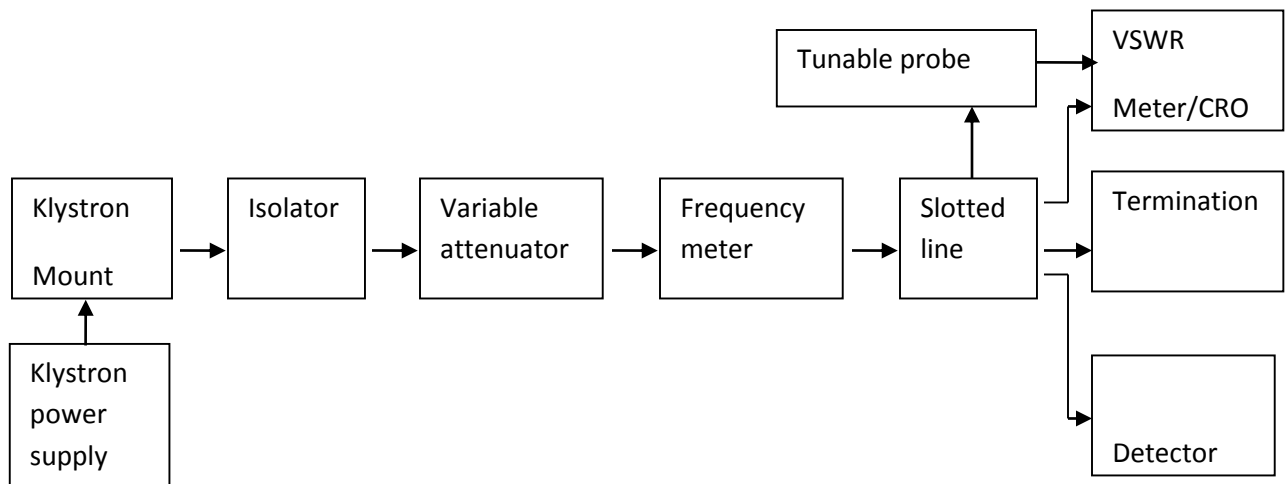
PROCEDURE:

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= $3* 10^8$ 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) $\lambda g_1 = 2(\,dmin\ 1 \approx dmin\ 2)$

(ii) $\lambda g_2 = 2(\,dmin\ 1 \approx dmin\ 2)$

VSWR:

(i) $VSWR_1 = Vmax\ /\ Vmin$

(ii) $VSWR_2 = Vmax\ /\ Vmin$

Frequency:

$$F = C/\lambda = C * \frac{\sqrt{\lambda g^2 + \lambda c^2}}{\lambda g\,\lambda c}$$

Where, $C = 3 * 10^8$ meter / sec

$$\lambda o = \frac{\lambda g\,\lambda c}{\sqrt{\lambda g^2 + \lambda c^2}}$$

For dominnant TE10 mode rectangular wave guide λo, λg, λc are related as below:

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

Where λo is free space wavelength

λg is guide wavelength

λc is cutoff wavelength

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

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

   o Yagi Antenna (Dielectric Constant: 4.7) - 2 no.
   o Dipole Antenna (Dielectric Constant: 4.7) - 1 no.
   o 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 arid 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

λo 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 λo 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
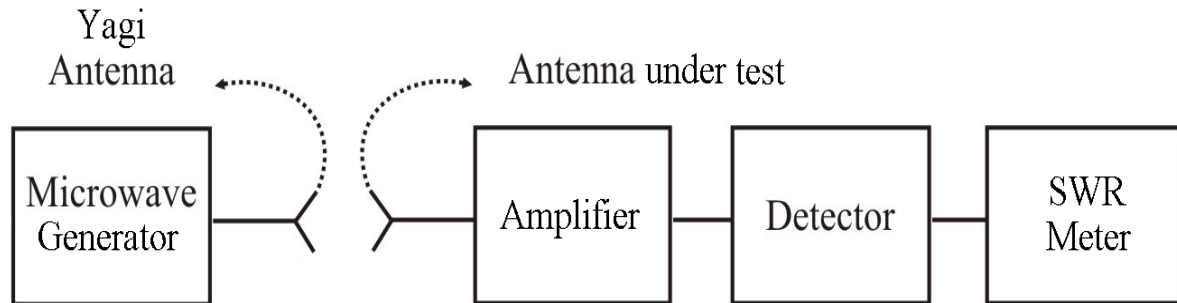
PROCEDURE:
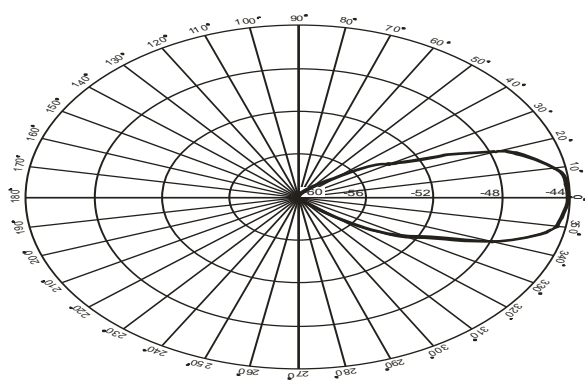
Directivity Measurement:

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.
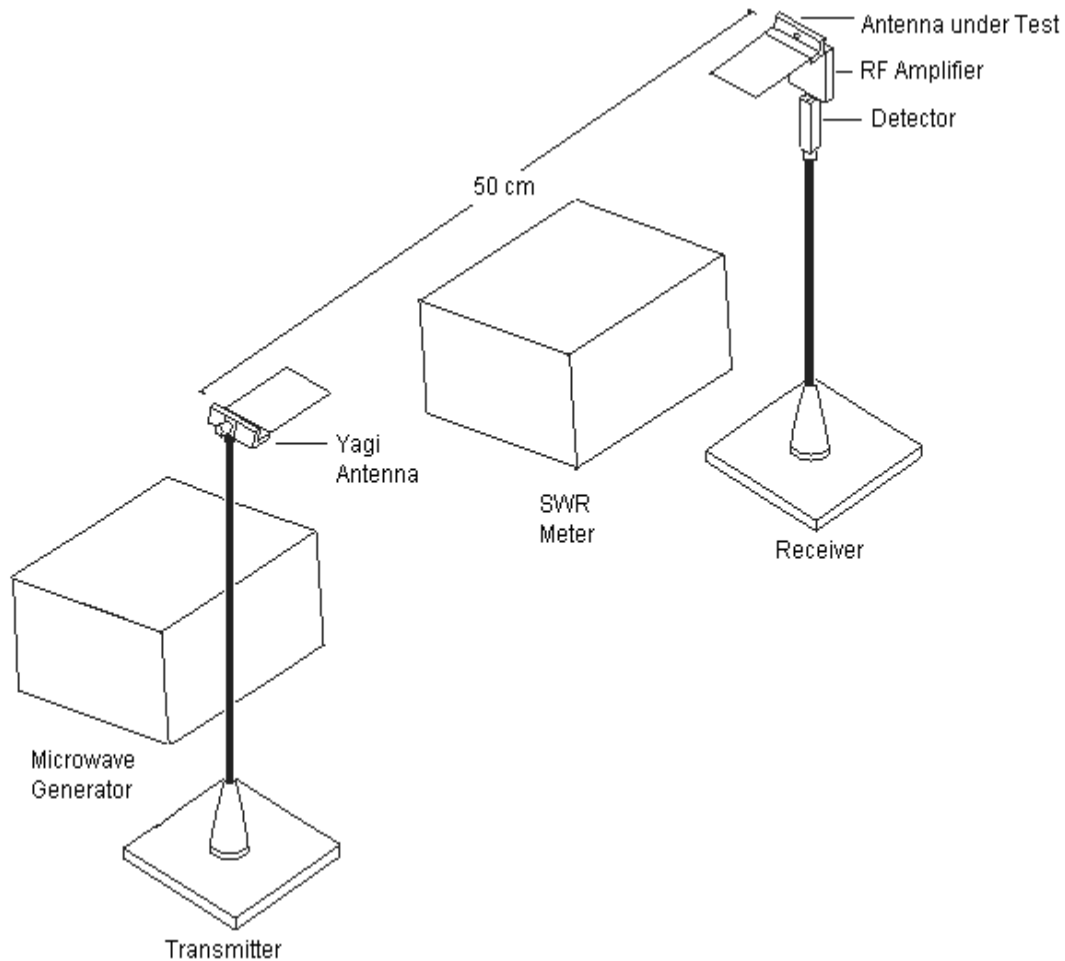
9. Now set the receiving antenna at zero degree (in line of Transmitter) and Switch on the power supply for Microwave Generator, SWR Meter. Also connect DC Adapter of RF Amplifier to the mains.

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 -

   o   Frequency of the Microwave Generator.

   o   Modulation frequency adjustment.

   o   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/ (θE x θH) Determining the directive gain of the antenna. Where θ_E is the E plane 3db beam 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 be ....dB at ....Degree.

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.
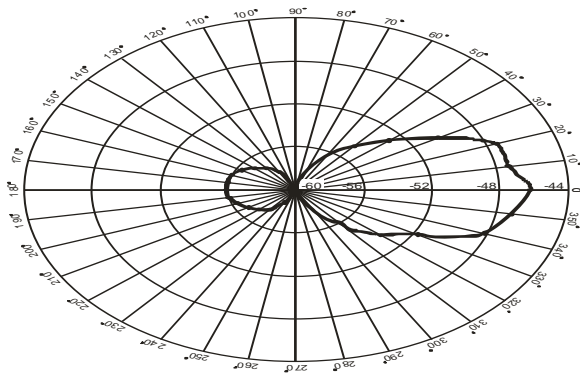
Radiation Patterns of Different Antennas:

Yagi Antenna
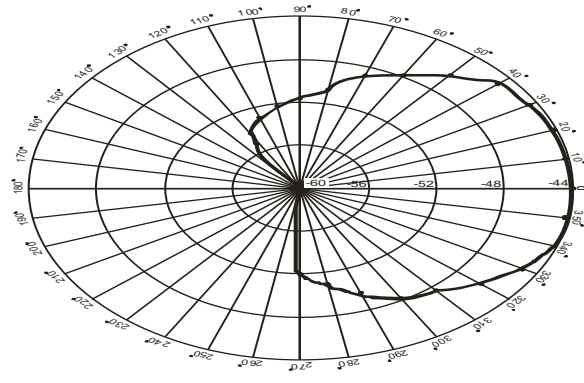
Patch Antenna

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 -

    o   Frequency of the Microwave Generator.

    o   Modulation frequency adjustment.

    o   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 Pt.

$$Pt = ...dB$$

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

$$Pt/Pr = ...$$

$$Pr/Pt = ...$$

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(a)

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 input port. 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:
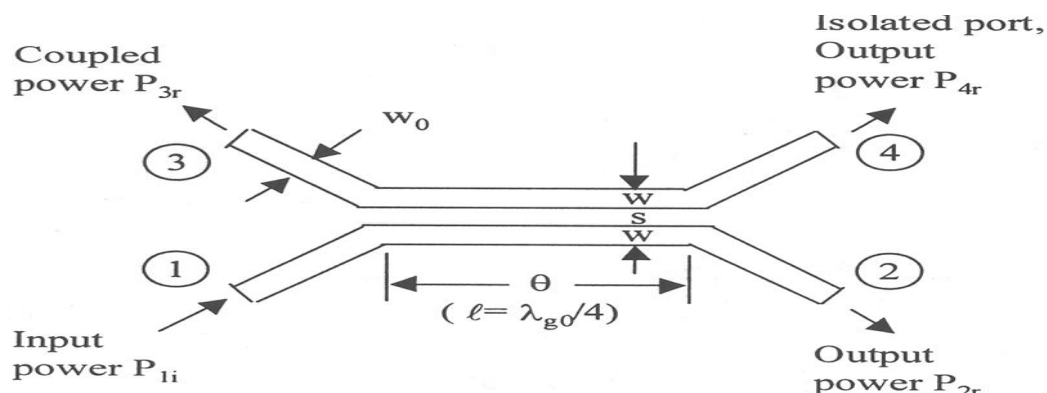
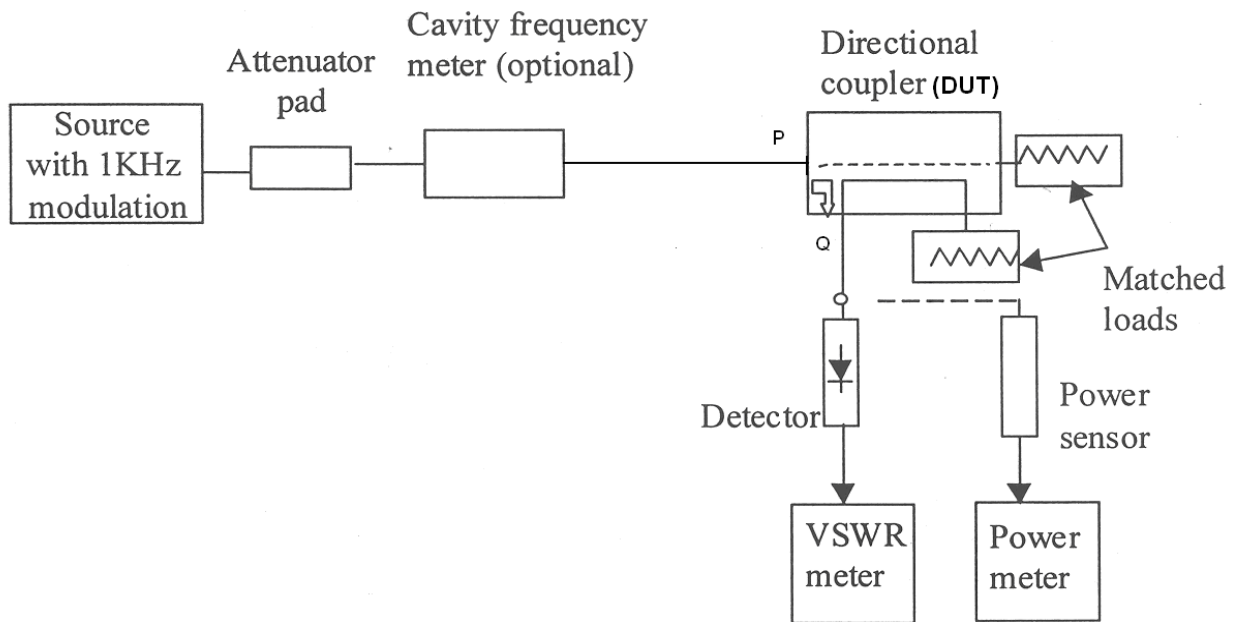**TEST BENCH SET UP FOR MEASURING THE TRANSMISSION LOSS OF DUT**

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.
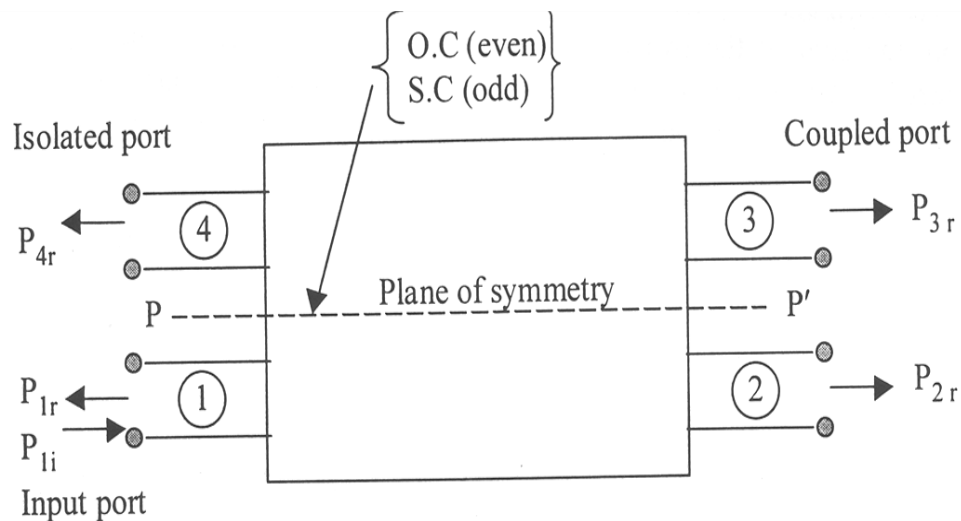
Coupling and Isolation

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

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

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

Directivity D (dB) = P_{30ut} (dB) - P_{4out} (dB). Denote this as S_{43} (dB) and enter at column 9 of the

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

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

EXPERIMENT NO. 8(b)

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.

$$2\pi r_0 = n\lambda = \frac{n v_0}{f_0 \sqrt{\varepsilon_{ef}}}, \qquad \text{For n = 1, 2, 3.......}$$

Where r_0 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.
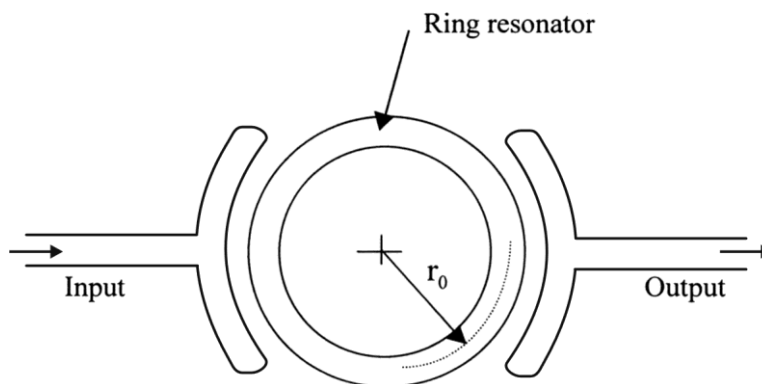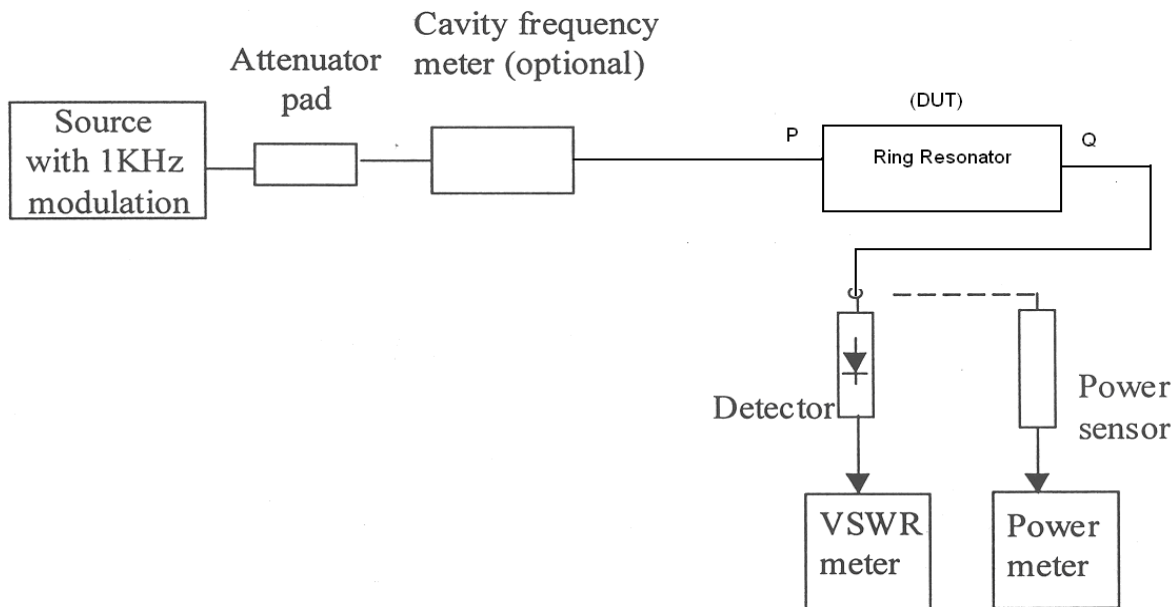

Layout with curved input and output feed line

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.

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

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

Which can be verified practically using the expression given below.

$$2\pi r_0 = n\lambda = \frac{n v_0}{f_0 \sqrt{\varepsilon_{ef}}}, \qquad \text{for n = 1, 2,3…..}$$

Table: VSWR meter readings

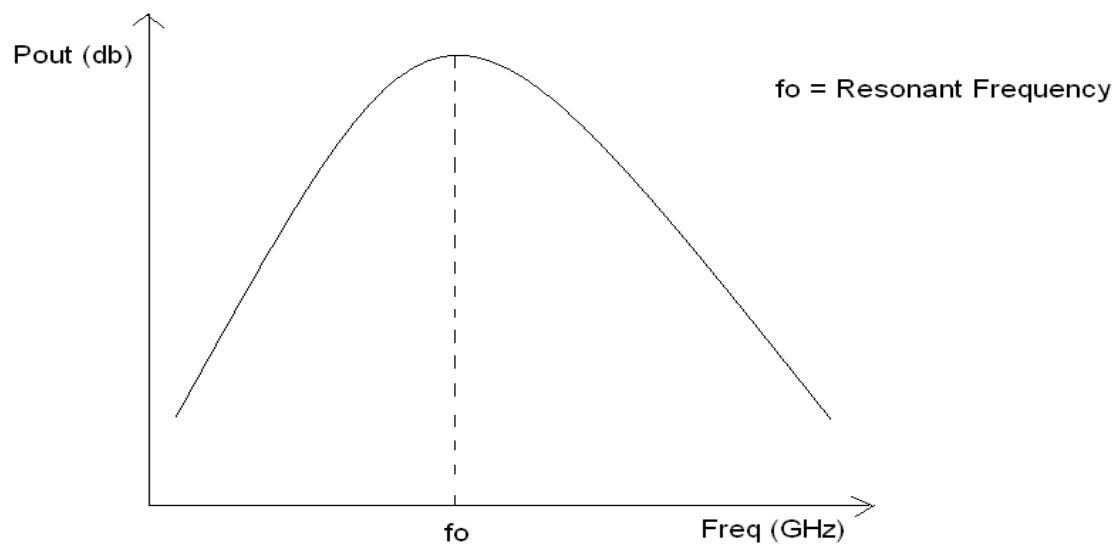| Frequency f (GHz)	VSWR meter reading without DUT P_{in} (dB)	VSWR meter reading with DUT P_{out}(dB)
2.0		
2.1		
:		
3.0		

Figure 1: Plot output power and resonant frequency

EXPERIMENT NO. 8 (c)

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 ($S_{11} = 0$).
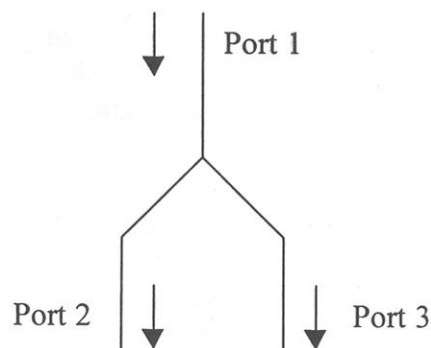

Figure 2: Schematic of a Y - junction power divider

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).
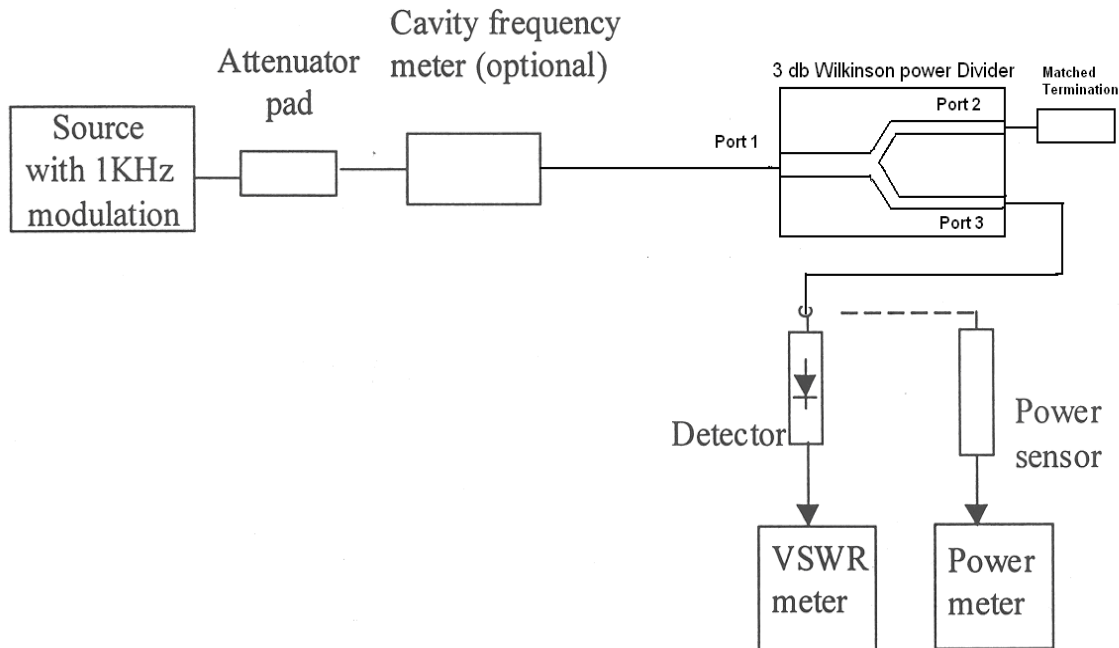

Figure. 3

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 $\log10*S_{31}*$. 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} (dB) - P_{32out} (dB) = - 20 $\log_{10}*S_{32}*$. Denote this isolation as S_{32} (dB) and enter at column 8 of the Table 1.

| Freq. $f(GHz)$	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}	$P_{2\ out}$	$P_{3\ out}$	$P_{32\ out}$			
2.0 2.1 : : : 3.0							

Table.1

CYCLE-III

Part-B: Simulation Experiments using Matlab

Experiment No. 1

Simulate 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
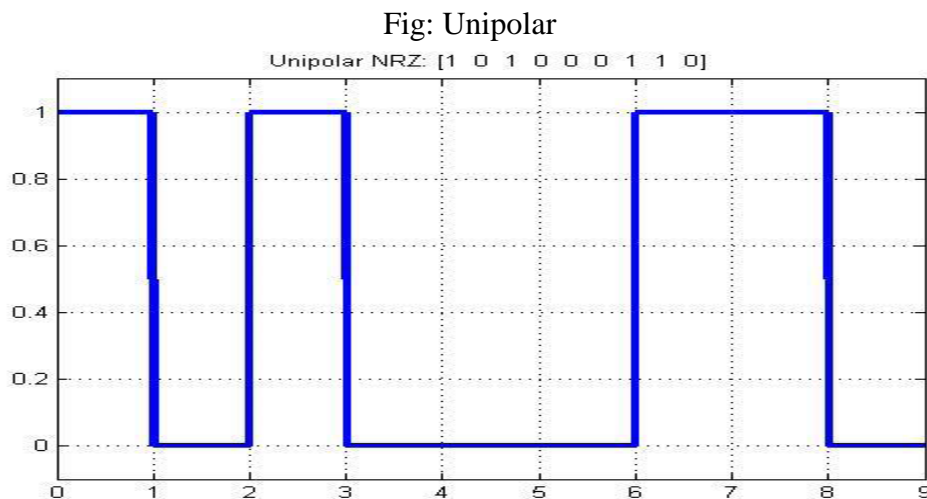
Fig: Unipolar

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) ']']);
```
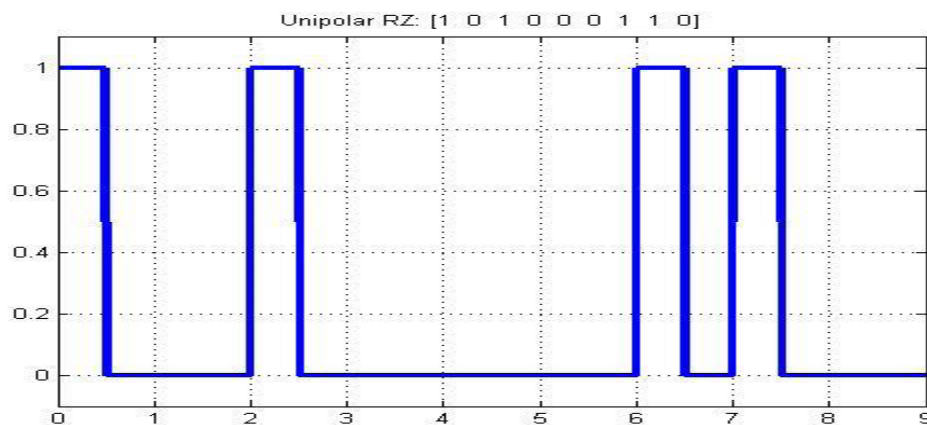
Output:

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 Pluse 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

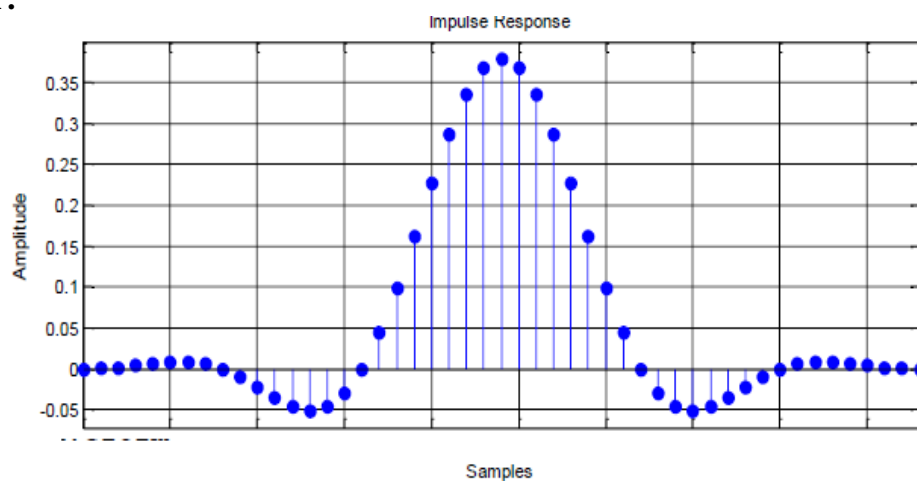fvtool(rctFilt, 'Analysis', 'impulse')

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=rcosfir(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)];
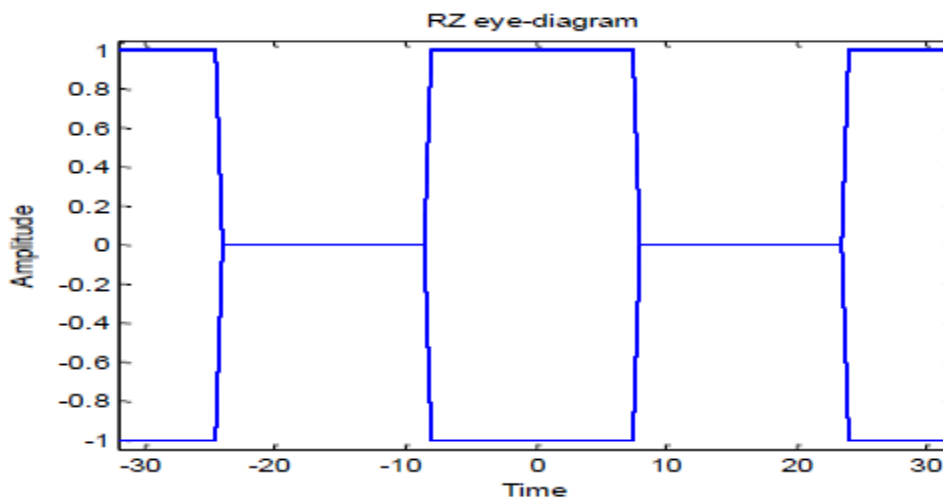
end

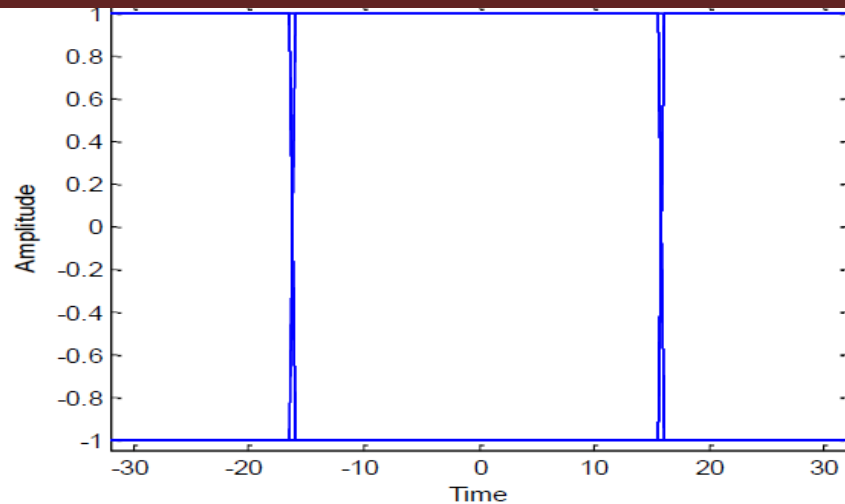 **Output:**

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 as a filtering effect on the data, restricting its spectrum.

Program:

```
close all;

clear all;

clc;

f = 50; % Frequency asumption

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
```
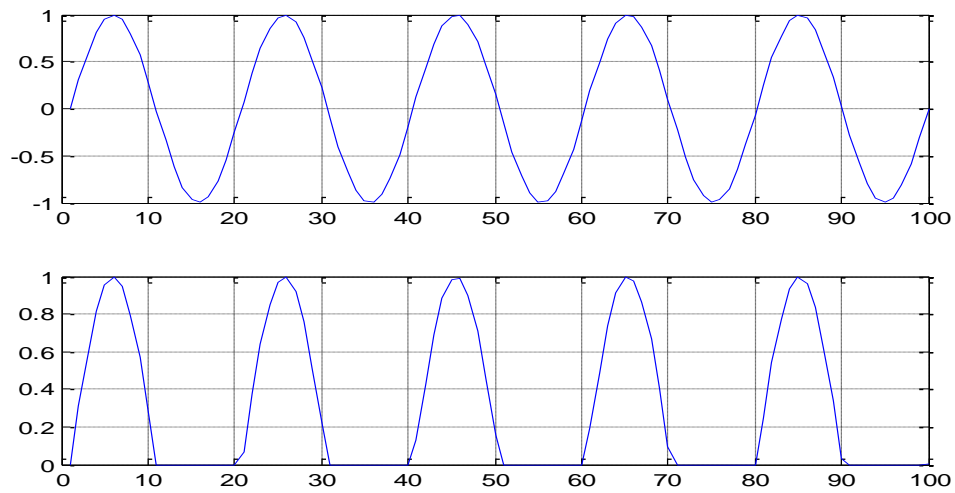
subplot(212)

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 essential a 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 Sinal'); 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 valuses
[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
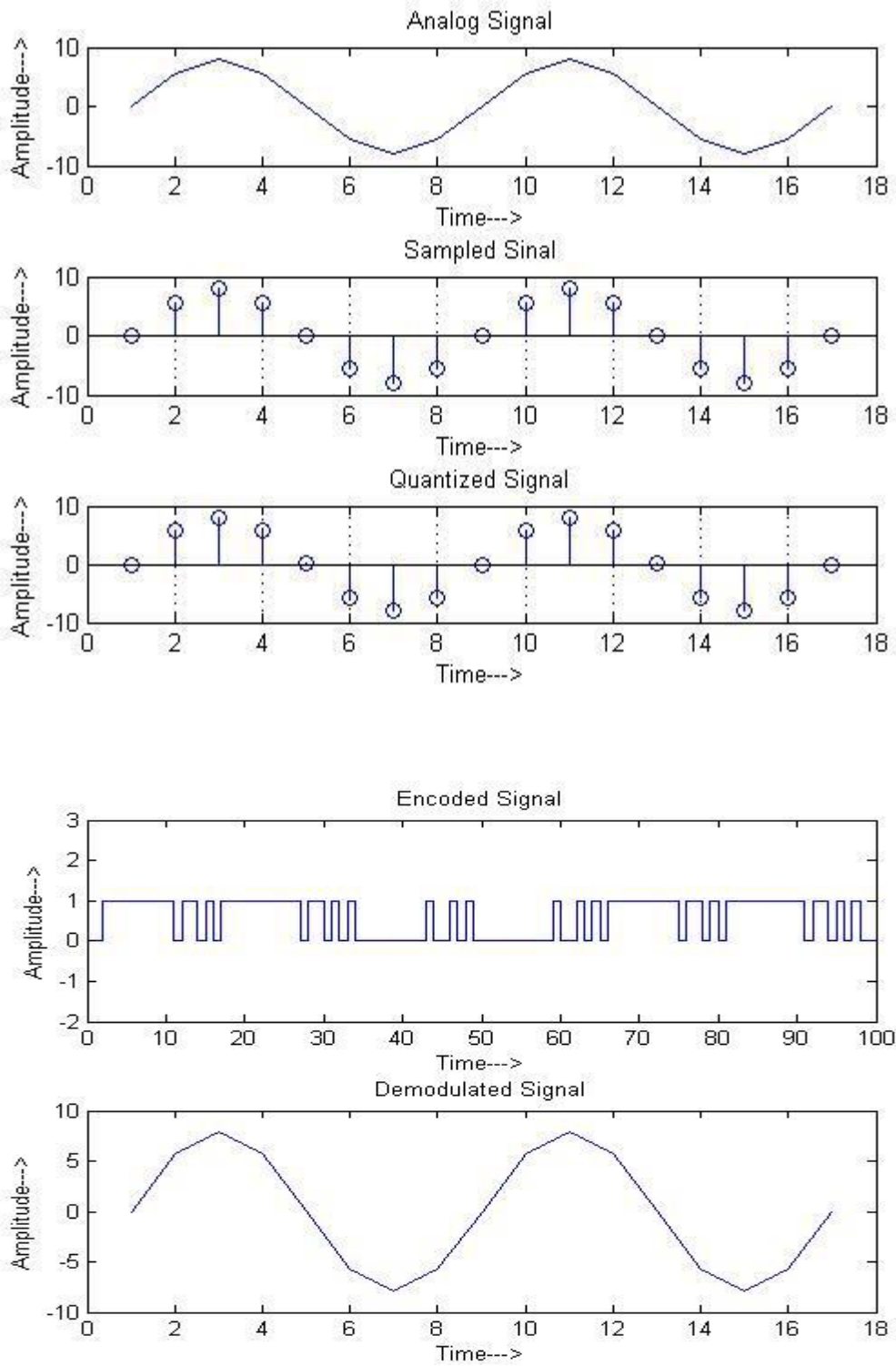
CYCLE-III

PART-B: EXPERIMENT NO. 3

Computation of Probability of Bit Error for Coherent Binary ASK, FSK and PSK for an AWGN Channel and Compare them with their Performance Curves.

BPSK transmission over AWGN channel

```
close all;
clear all;
clc;
SNRdB=1:1:10;                    % Signal to Noise Ratio in dB
SNR=10.^(SNRdB/10);              % Signal to Noise Ratio in Linear Scale
Bit_Length=10^6;                 % No. of Bits Transmitted
BER_Simulated=zeros(1, length(SNRdB));    % Simulated Bit Error Rate %Detection
Scheme:(Soft Detection) %+1 if o/p >=0 %-1 if o/p<0 % Error if input and output are of
different signs % BPSK Transmission over AWGN channel
for k=1: length(SNR);
    x= (2*floor(2*rand(1, Bit_Length)))-1;  %BPSK modulation
    y=(sqrt(SNR(k))*x) + randn(1,Bit_Length);  %received signal with noise
    BER_Simulated(k) = length(find((y.*x)<0));  %Total number of bits in error
end
BER_Simulated=BER_Simulated/Bit_Length;
semilogy(SNRdB,BER_Simulated,'m-<', 'linewidth' ,2.0);
hold on;
grid on;
semilogy(SNRdB,qfunc(sqrt(SNR)),'b-','linewidth',2.0);    %Theoretical Bit Error Rate
title('BPSK over AWGN Simulation');
xlabel('SNR in dB');
ylabel('BER');
legend('BER(Simulated)', 'BER(Theoretical)'


clc;
clear all;
close all;
num_bit = 100000;                % number of bit
data = floor(2*rand(1,num_bit)); %random bit generation (1 or 0)
SNRdB = 0:10;                     % SNR in dB
SNR= 10.^(SNRdB/10);             % SNR in ratio
for  (k=1:length(SNRdB))          % BER (error/bit) calculation for different SNR%
   y = awgn(complex(data), SNRdB(k));
   error = 0;
   R = 0;
   M = [];
   for(c=1:1:num_bit)
     if (y(c)>.5 && data(c) == 0) || (y(c)<.5 && data(c) == 1) %logic according to BASK
        error=error + 1;
        M = [M ~data(c)];
     else
```

```
        M = [M data(c)];
    end
  end
  error = error/num_bit;    %Calculate error/bit
  m(k) = error;
end
semilogy(SNRdB,m, 'o' , 'linewidth' , 2.0); % Simulated BER
grid on;
hold on;
BER_th = (1/2)*erfc(.5*sqrt(SNR));  % Theoritical Bit Error Rate
semilogy(SNRdB, BER_th, 'r' , 'linewidth' ,2.0);
title('curve for Bit Error Rate verses  SNR for Binary ASK modulation');
xlabel('SNR(dB)');
ylabel('BER');
legend('simulation', 'theoretical')
axis([0 10 10^-3 1]);




clear all;
close all;
clc;
num_bit = 10000;              % Signal length
max_run = 20;                 % Maximum number of iterations for a single SNR
Eb = 1;                       % Bit energy
SNRdB = 0:1:10;                % Signal to Noise Ratio (in dB)
SNR=10.^(SNRdB/10);    % Signal to Noise Ratio
for count=1:length(SNR)  % Beginning of loop for different SNR
   avgError = 0;
   No=Eb/SNR(count);       % Calculate noise power from SNR
   for run_time = 1:max_run % Beginning of loop for different runs
      Error=0;
      data=randi([0 1],1,num_bit);     % Generate binary data source
      s = data+j*(~data);              % Baseband BFSK modulation
      NI = sqrt(No/2)*randn(1,num_bit); % Real part of AWGN noise
      NQ = sqrt(No/2)*randn(1,num_bit);  % Imaz. part of AWGN noise
      N=NI + j*NQ;                   % Generate complex AWGN
      Y = s+N;                       % Received Signal
      for k=1:num_bit                % Decision device taking hard decision and deciding error
         Z(k) = real(Y(k))-imag(Y(k));
         if ((Z(k)>0 && data(k) == 0) || (Z(k)<0 && data(k) == 1))
            Error=Error+1;
         end
      end
      Error = Error/num_bit;           % Calculate error/bit
      avgError = avgError+Error;        % Calculate error/bit for different runs
   end                                 %Termination of loop for different runs
   BER_sim(count) = avgError/max_run; %Calculate BER for a particular SNR
end                                    %Termination of loop for different SNR
BER_th =  (1/2)*erfc(sqrt(SNR/2));    %Calculate analytical BER
semilogy(SNRdB,BER_th, 'k');           %Plot BER
```

```
hold on;
grid on;
title('Bit Error Rate vs Eb/No for Orthogonal MFSK');
xlabel('Eb/No(dB)'),
ylabel('Bit Error Probability');
semilogy(SNRdB, BER_sim, 'r-*' );
legend('BER Theory' , 'BER Simulation')
axis([0 10 10^(-4) 1]);
```

EXPERIMENT 4(a)

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 simulate simulating non-coherent detection of binary DPSK using Mat lab.

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 Transmiting ');
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 convertion 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(volt0');
```
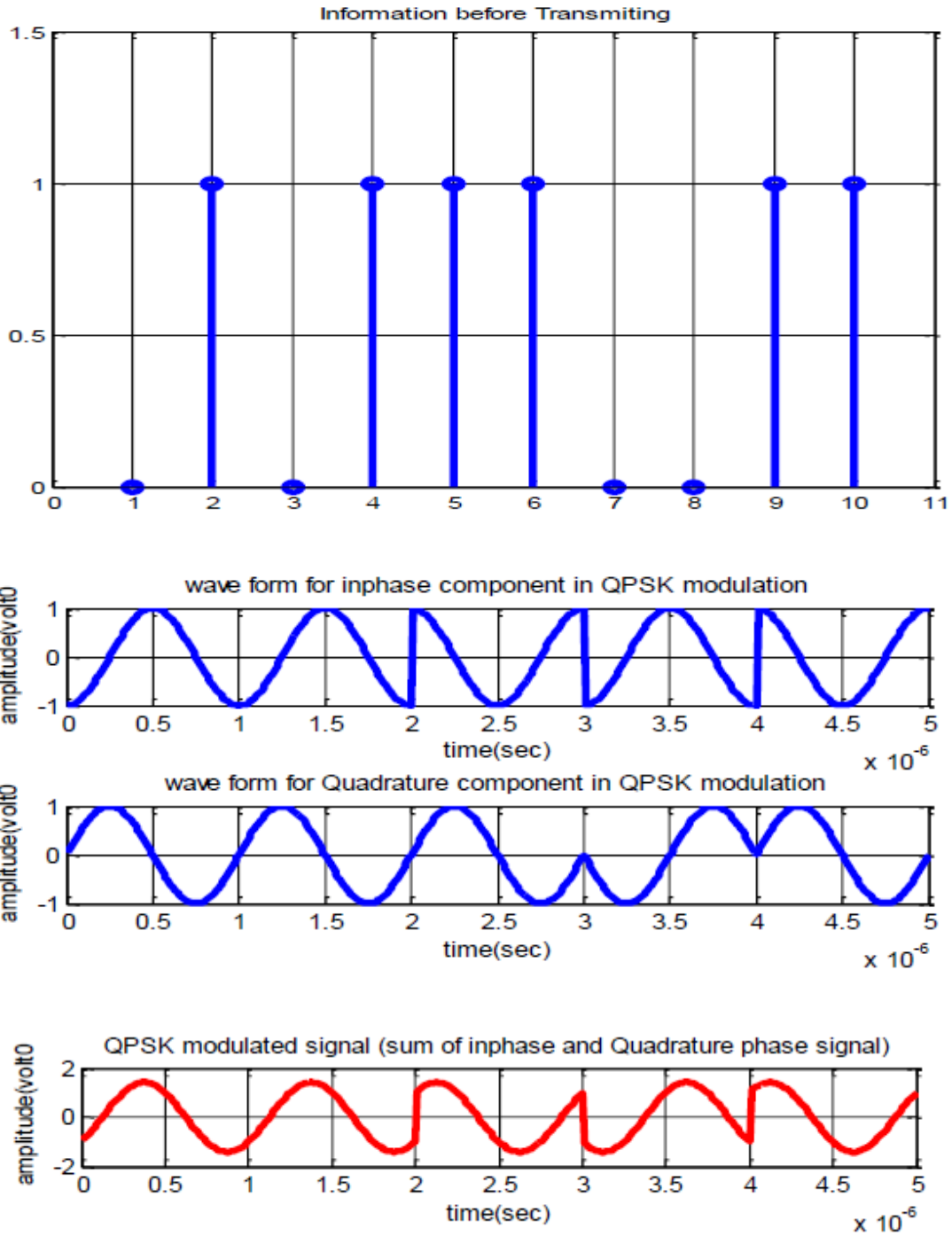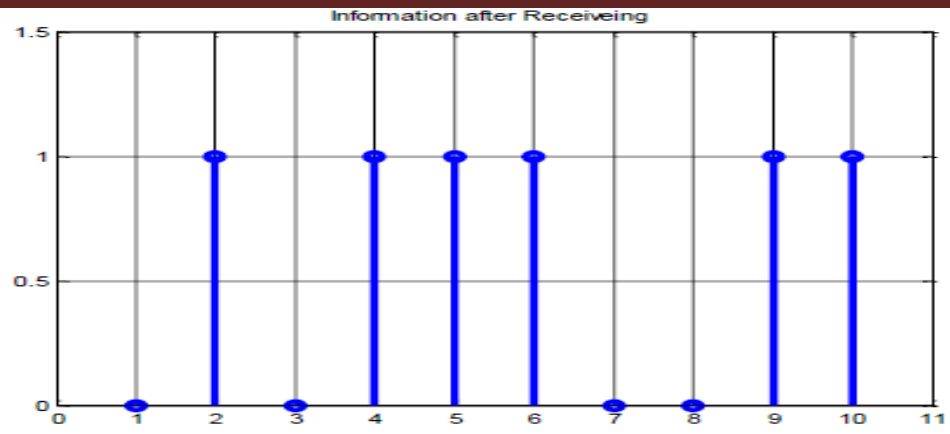
```
subplot(3,1,3);
plot(tt,Tx_sig,'r','linewidth',3), grid on;
title('QPSK modulated signal (sum of inphase and Quadrature phase signal)');
xlabel('time(sec)');
ylabel(' amplitude(volt0');
% QPSK demodulation
Rx_data=[];
Rx_sig=Tx_sig; % Received signal
for(i=1:1:length(data)/2)
%%XXXXXX inphase coherent dector XXXXXXX
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

Information before Transmiting

wave form for inphase component in QPSK modulation

wave form for Quadrature component in QPSK modulation

QPSK modulated signal (sum of inphase and Quadrature phase signal)

Information after Receiveing

EXPERIMENT 4(b)

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 Mat lab.

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 Qudrature 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:
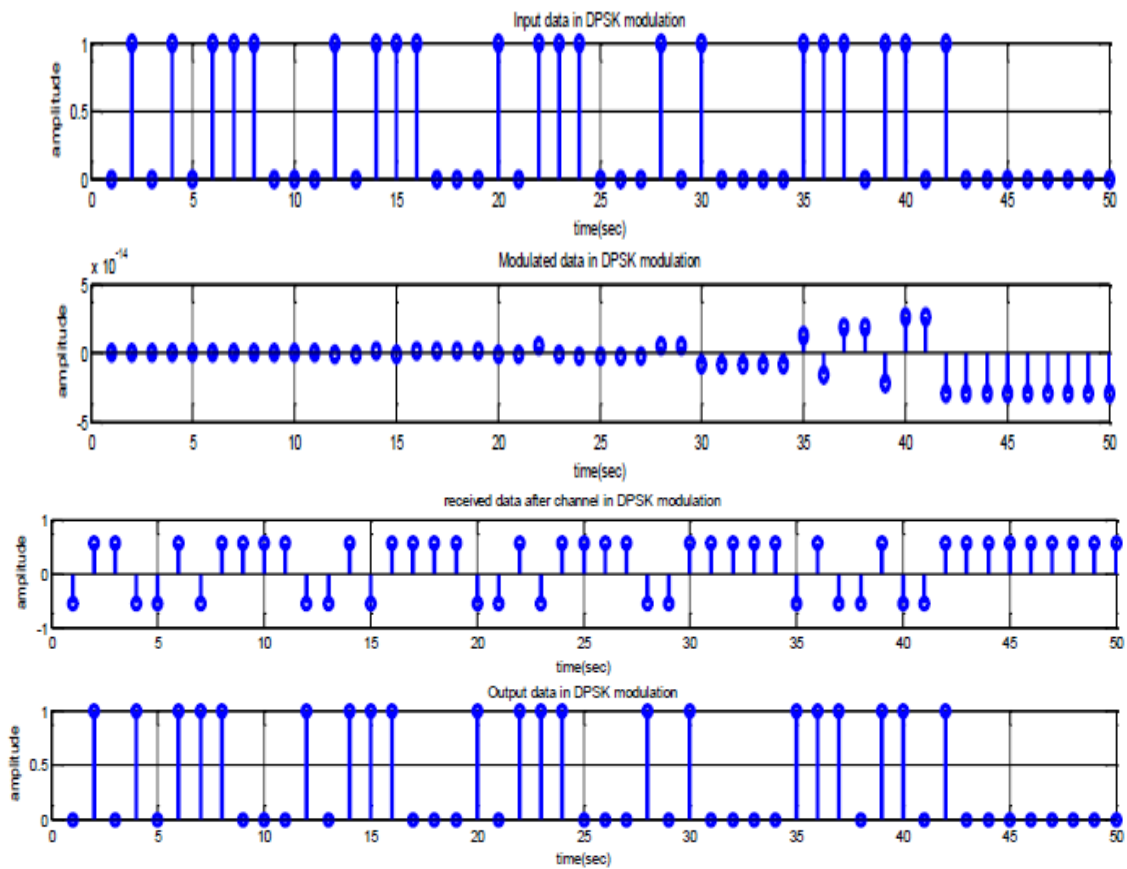
Question Bank

Subject code- 18ECL67

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.