Introduction to Digital Communications:

Data transmission, **digital transmission** or **digital communications** is the physical transfer of data (a digital bit stream) over a point-to-point or point-to-multipoint transmission medium. Examples of such media are copper wires, optical fibers, wireless communication media, and storage media. The data is often represented as an electro-magnetic signal, such as an electrical voltage signal, a radio-wave or microwave signal or an infra-red signal.

While analog communications is the transfer of continuously varying information signal, digital communications is the transfer of discrete messages. The messages are either represented by a sequence of pulses by means of a line code (*base band transmission*), or by a limited set of continuously varying wave forms (*pass band transmission*), using a digital modulation method. According to the most common definition of digital signal, both base band and pass band signals representing bit-streams are considered as digital transmission, while an alternative definition only considers the baseband signal as digital, and the pass band transmission as a form of digital-to-analog conversion.

Data transmitted may be digital messages originating from a data source, for example a computer or a keyboard. It may also be an analog signal such as a phone call or a video signal, digitized into a bit-stream for example using pulse-code modulation (PCM) or more advanced source coding (data compression) schemes. This source coding and decoding is carried out by codec equipment. This Digital Communications laboratory is an introduction to the basic theory and practice of Digital Communication; in particular it deals with the applications of electronic techniques for Digital Modulation Techniques. It is also intended for practicing engineers who wish to acquaint themselves with the recent developments in the area.

Introduction to Microwave Communications:

The range of the electromagnetic spectrum from 300 MHz to 300 GHz is commonly referred to as the microwave range. For applications with wavelengths from 1 meter to 1millimeter, low frequency circuit analysis techniques can not be used; we must use transmission-line theory. In transmission-line theory, the voltage and current along a transmission line can vary in magnitude and phase as a function of position.

Many different types of microwave transmission lines have been developed over the years. In an evolutionary sequence from rigid rectangular and circular waveguide, to flexible coaxial cable, to planar strip line to microstrip line, microwave transmission lines have been reduced in size and complexity

The purpose of this Lab is to acquaint the student with microwave measurement parameters and techniques necessary to understand the expanding area of Microwave Engineering.

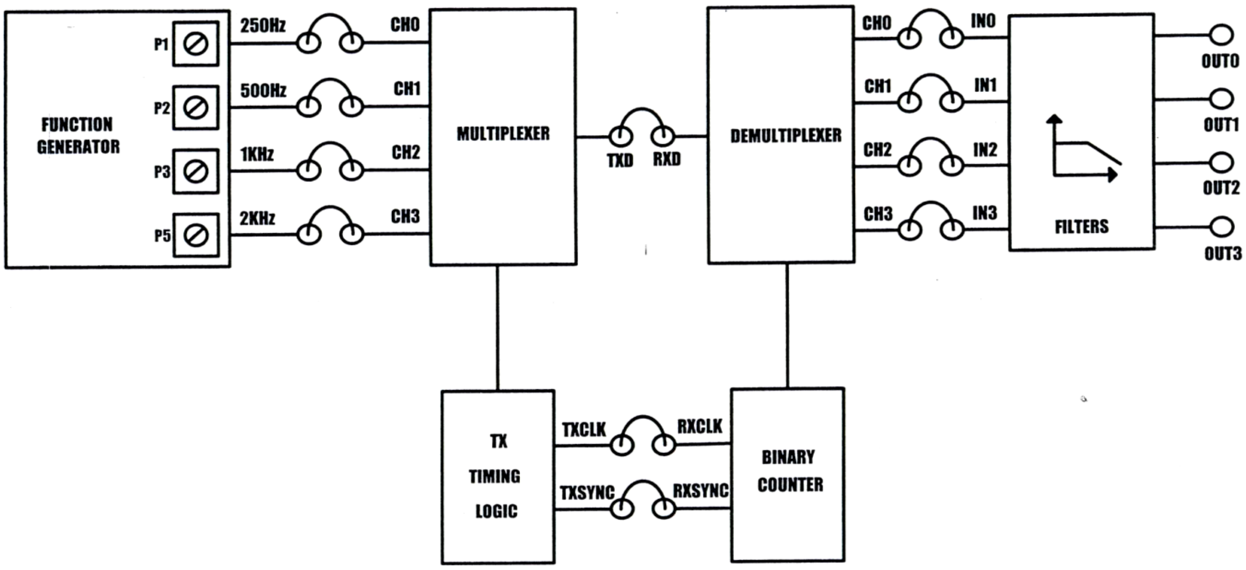
PART-A

1. TIME DIVISION MULTIPLEXING (TDM)

AIM: To study Time Division Multiplexing for 4 waves.

THEORY: Refer "Digital Communications", 8th edition, Simon Haykin, Page 162

BLOCK DIAGRAM:



PROCEDURE:

1 Refer to the Block Diagram (Fig. 1) & Carry out the following connections and switch settings.
2 Connect power supply in proper polarity to the kit DCL-02 & switch it on.
3 Connect 250Hz, 500Hz, 1KHz, and 2KHz sine wave signal from the Function Generator to the multiplexer input channel CHO, CH1, CH2, CH3 by means of the connecting chords provided.
4 Connect the multiplexer output TXD of the transmitter section to the demultiplexer input RXD of the receiver section.
5 Connect the output of the receiver section CHO, CH1, CH2, CH3 to the IN0, IN1, IN2, IN3 of the filter section.
6 Connect the sampling clock TX CLK and Channel Identification Clock TXSYNC.of the transmitter section to the corresponding RX CLK and RX SYNC of the receiver section respectively.
7 Set the amplitude of the input sine wave as desired.
8 Take observations as mentioned below.

OBSERVATION:

Observe the following waveforms on oscilloscope and plot it on the paper

a. Input channel CH0, CH1, CH2, CH3.
b. Channel Selection Signal
c. TX CLK and RX CLK
d. Channel Identification signal TX SYNC and RX SYNC
e. Multiplexer Output TXD
f. Demultiplexer Input RXD
g. Demultiplexer output CH0, CH1, CH2,CH3
h. Reconstructed signal OUT0, OUT1, OUT2, OUT3

SWITCH FAULTS:

Note: Keep the connections as per the procedure. Now switch corresponding fault switch button in ON condition & observe the different effect on the output. The faults are normally used one at a time.

1 Put switch 1 of SF1 in Switch Fault section to ON position. This will short circuit 250Hz & 500Hz sine waves. We will get mixing of both the signals.
2 Put switch 4 of SF1 in Switch Fault section to ON position. This will short MSB of ladder network used for 500Hz sine wave generation. Shape of this sine wave changes.
3 Put switch 5 of SF2 in Switch Fault section to ON position. This will remove TXCHO signal. This will remove all receiver-decoding pulses. Receiver outputs are disturbed.
4 Put switch 6 of SF2 in Switch Fault section to ON position. This will remove control signal of first channel in demultiplexer section. Output for Channel Zero is mixing of all signals.
5 Put switch 8 of SF2 in Switch Fault section to ON position. This will remove bypass capacitor from filter of third channel. Distorted output at channel three.

INFERENCE: ____

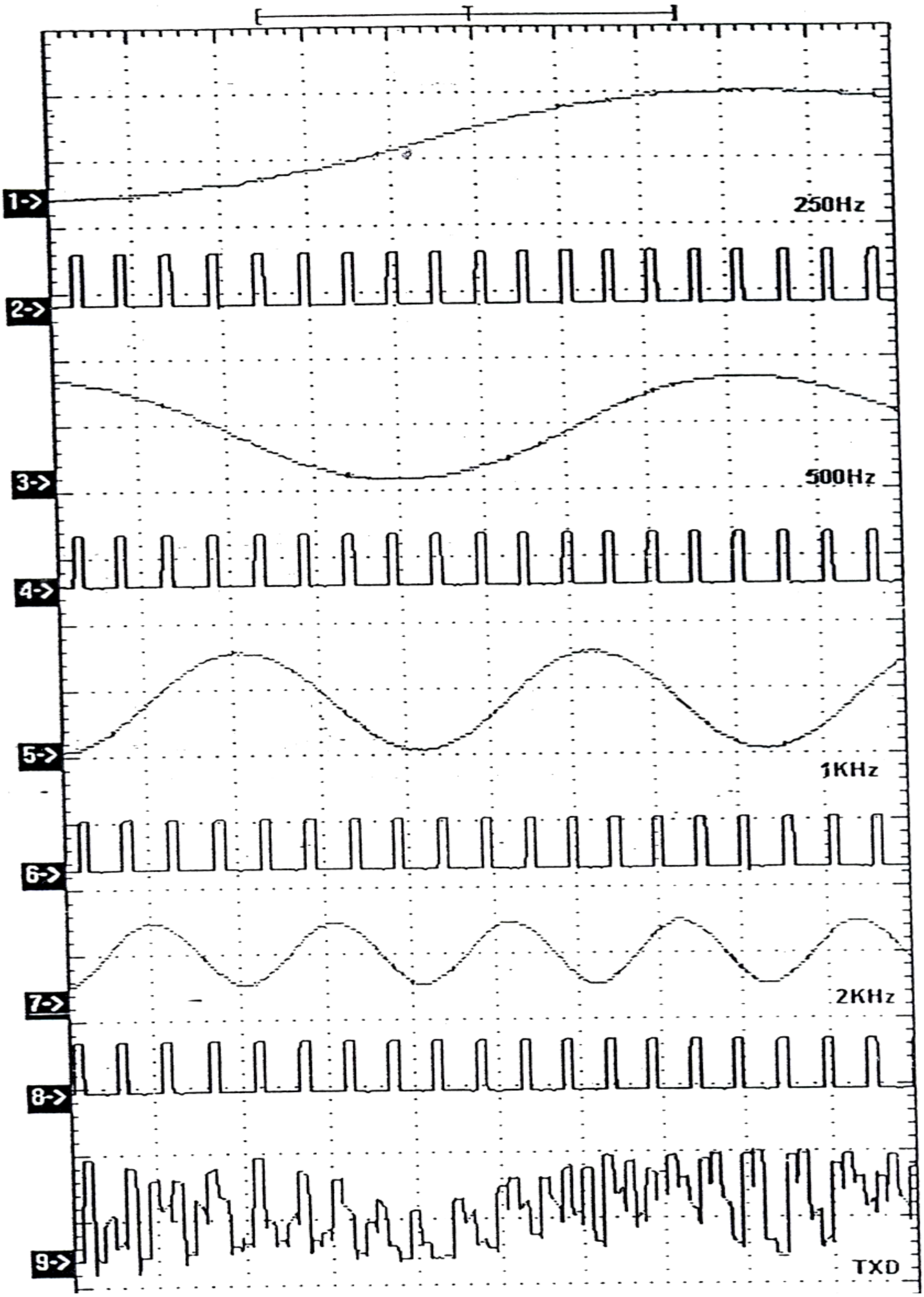
CONCLUSION:

In this experiment, the transmitter clock and the channel identification clock (Sync) are directly linked to the receiver section. Hence transmitter and receiver are synchronized and proper reconstruction of the signal is achieved.

VIVA QUESTIONS:

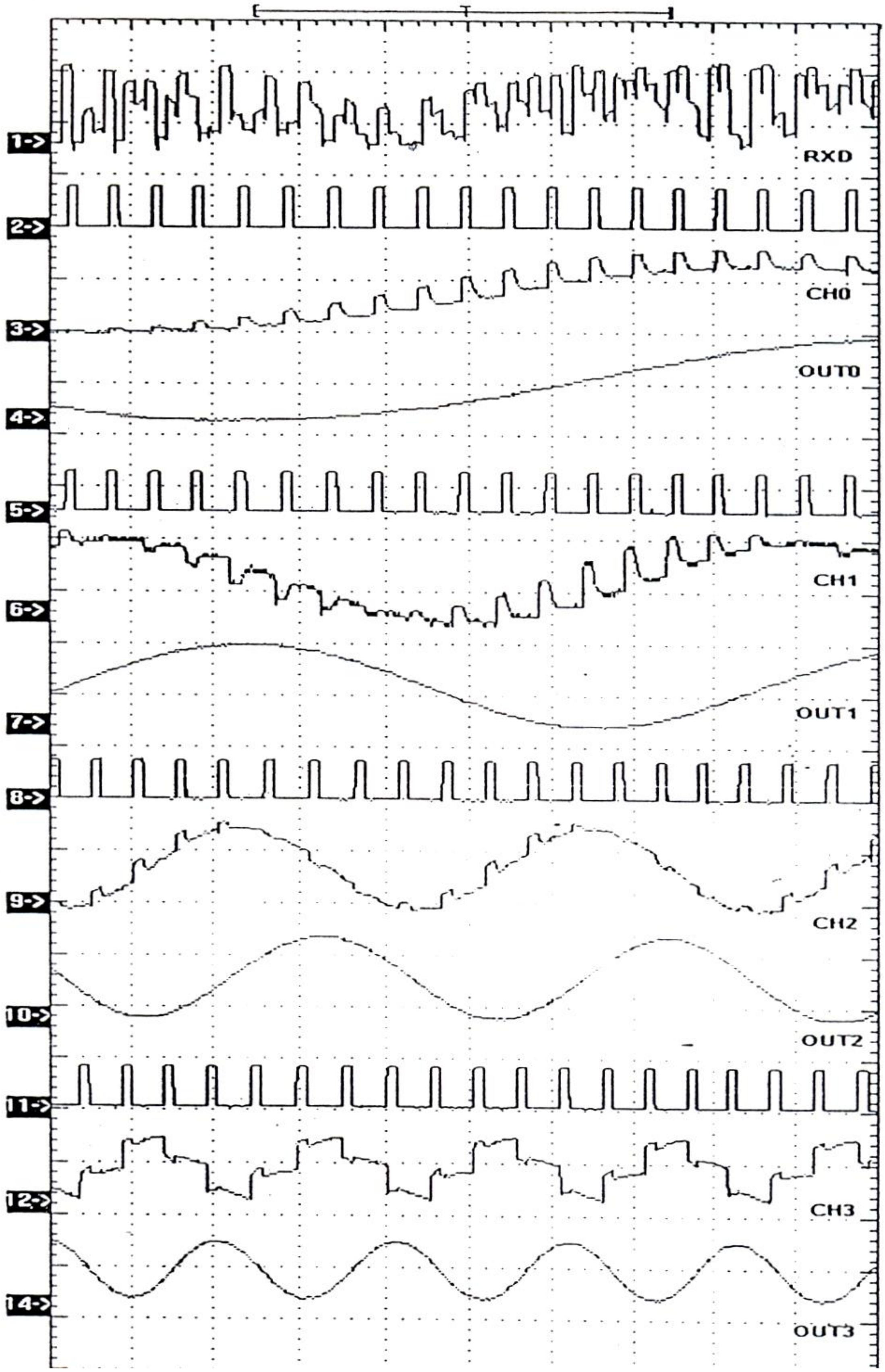
1. What is TDM?
2. What is FDM?
3. Compare TDM and FDM?
4. What are the applications of TDM?

TDM TX WAVEFORMS



TD

M RX
WAVEFORMS

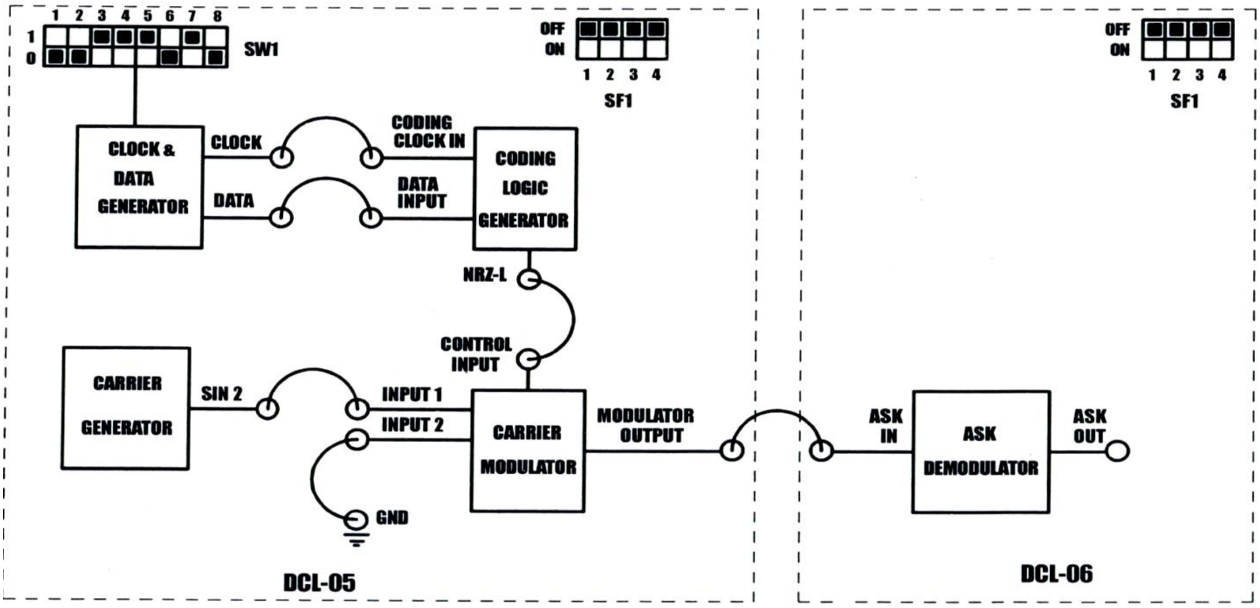


2. AMPLITUDE SHIFT KEYING

AIM: To generate ASK signal and to demodulate the ASK signal.

THEORY: Refer "Digital Communications", 8th edition, Simon Haykin, Page 273

BLOCK DIAGRAM:



PROCEDURE:

1 Refer to the block diagram and carry out the following connections and switch settings.
2 Connect power supply in proper polarity to the kits DCL-05 and DCL-06 and switch it on.
3 Connect CLOCK and DATA generated on DCL-05 to CODING CLOCK IN and DATA INPUT respectively by means of the patch-chords provided.
4 Connect the NRZ-L data input to the CONTROL INPUT of the Carrier Modulator logic.
5 Connect carrier component SIN2 to INPUT1 and GROUND to INPUT2 of the Carrier Modulator Logic.
6 Connect ASK modulated signal MODULATOR OUTPUT on DCL-05 to the ASK IN of the ASK DEMODULATOR on DCL-06.
7 Observe various waveforms as mentioned below.

OBSERVATION:

Observe the following waveforms on oscilloscope and plot it on the paper.

ON KIT DCL-05

1 Input NRZ-L Data at CONTROL INPUT.
2 Carrier frequency SIN 2.
3 ASK modulated signal at MODULATOR OUTPUT.

ON KIT DCL-06

1 ASK Modulated signal at ASK IN.
2 ASK Demodulated signal at ASK OUT.

SWITCH FAULTS:

Note: Keep the connections as per the procedure. Now switch corresponding fault switch button in ON condition & observe the different effect on the output. The faults are normally used one at a time.

1 Put switch 2 of SF1 (DCL-05) in Switch Fault section to ON position. This will disable channel selection signal going to Modulator IC. Modulator output contains only single channel (INPUT 1) data.

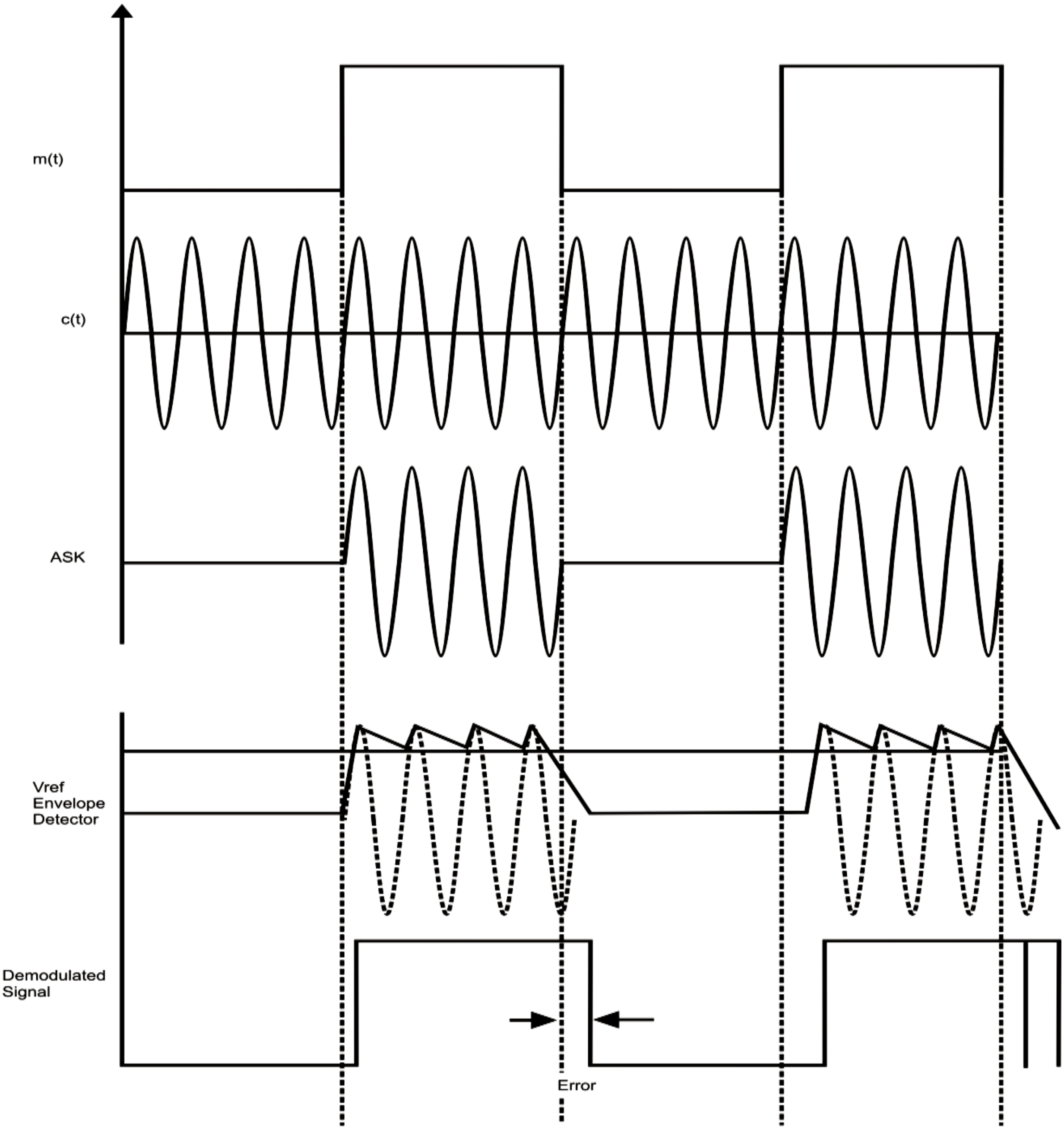
INFERENCE: ____

CONCLUSION:
It has been observed that a very small-time lag between the modulating data and the recovered data.

VIVA Questions:

1. State the difference between Analog systems and digital systems.
2. Explain why digital systems are considered superior than Analog systems.
3. Mention the disadvantages of Analog communication.
4. Explain the basic steps involved in digitizing a signal.
5. Explain ASK operation

WAVE FORMS:



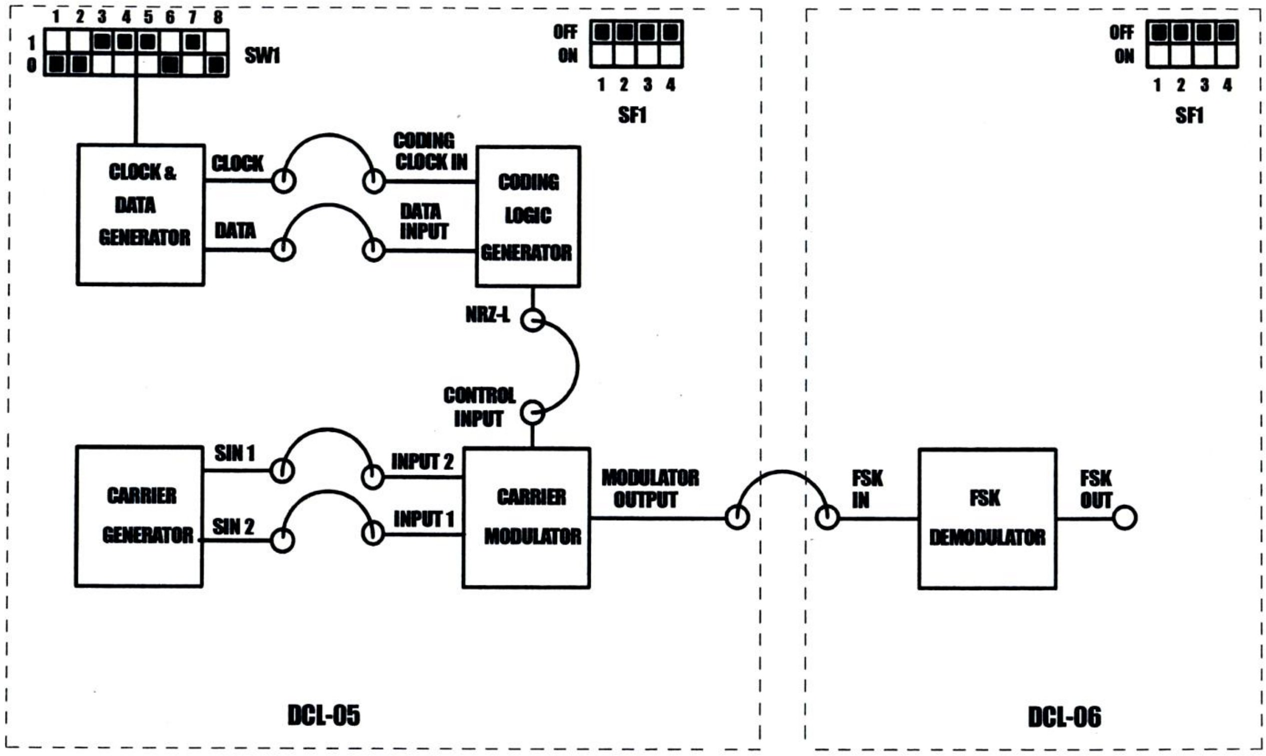
ASK Modulation and Demodulation Waveforms

3. FREQUENCY SHIFT KEYING (FSK)

AIM: To generate FSK signal and to demodulate the FSK signal.

THEORY: Refer "Digital Communications", 8th edition, Simon Haykin, Page 273

BLOCK DIAGRAM:



PROCEDURE:

1. Refer to the block diagram and carry out the following connections and switch settings.
2. Connect power supply in proper polarity to the kits **DCL-05** and **DCL-06** and switch it on.
3. Connect **CLOCK** and **DATA** generated on **DCL-05** to **CODING CLOCK IN** and **DATA INPUT** respectively by means of the patch-chords provided.
4. Connect the **NRZ-L** data input to the **CONTROL INPUT** of the Carrier Modulator logic
5. Connect carrier component **SIN1** to **INPUT2** and **SIN2** to **INPUT1** of the Carrier Modulator Logic
6. Connect FSK modulated signal **MODULATOR OUTPUT** on **DCL-05** to the **FSK IN** of the FSK DEMODULATOR on **DCL-06**
7. Observe the waveforms

OBSERVATION:
Observe the following waveforms on oscilloscope and plot it on the paper.

ON KIT DCL-05

1. Input NRZ-L Data at CONTROL INPUT.
2 Carrier frequency SIN 1 and SIN 2.
3 FSK modulated signal at MODULATOR OUTPUT.

ON KIT DCL-06

1. FSK Modulated signal at FSK IN.
2. FSK Demodulated signal at FSK OUT.
3. Observe output of PHASE DETECTOR. LPF, VCO on test points provided.

NOTE:
In FSK demodulator PLL circuit used is very sensitive to input voltage level, because of which you may get blurred output signal if input power varies slightly. To get clear signal at the output tune pot P3 in FSK Demodulator section. To get better results set the following bit pattern for INPUT DATA:

10101010
10101110
111010 10
00111010
11001100

SWITCH FAULTS:

Note: Keep the connections as per the procedure. Now switch corresponding fault switch button in ON condition & observe the different effect on the output. The faults are normally used one at a time.

1. Put switch 1 of SF1 (DCL-05) in Switch Fault section to ON position. This will open capacitor for filtering of SIN 1 signal. Sine wave SIN 1 will be distorted and its amplitude gets reduced.
2. Put switch 2 of SF1 (DCL-05) in Switch Fault section to ON position. This will disable channel selection signal going to Modulator IC. Modulator output contains only single channel (INPUT 1) data.
3. Put switch 2 of SF1 (DCL-06) in Switch Fault section to ON position. This will remove resistor connected to PLL in FSK demodulator. Center frequency of PLL changes and output of FSK demodulator gets distorted.

INFERENCE: ____

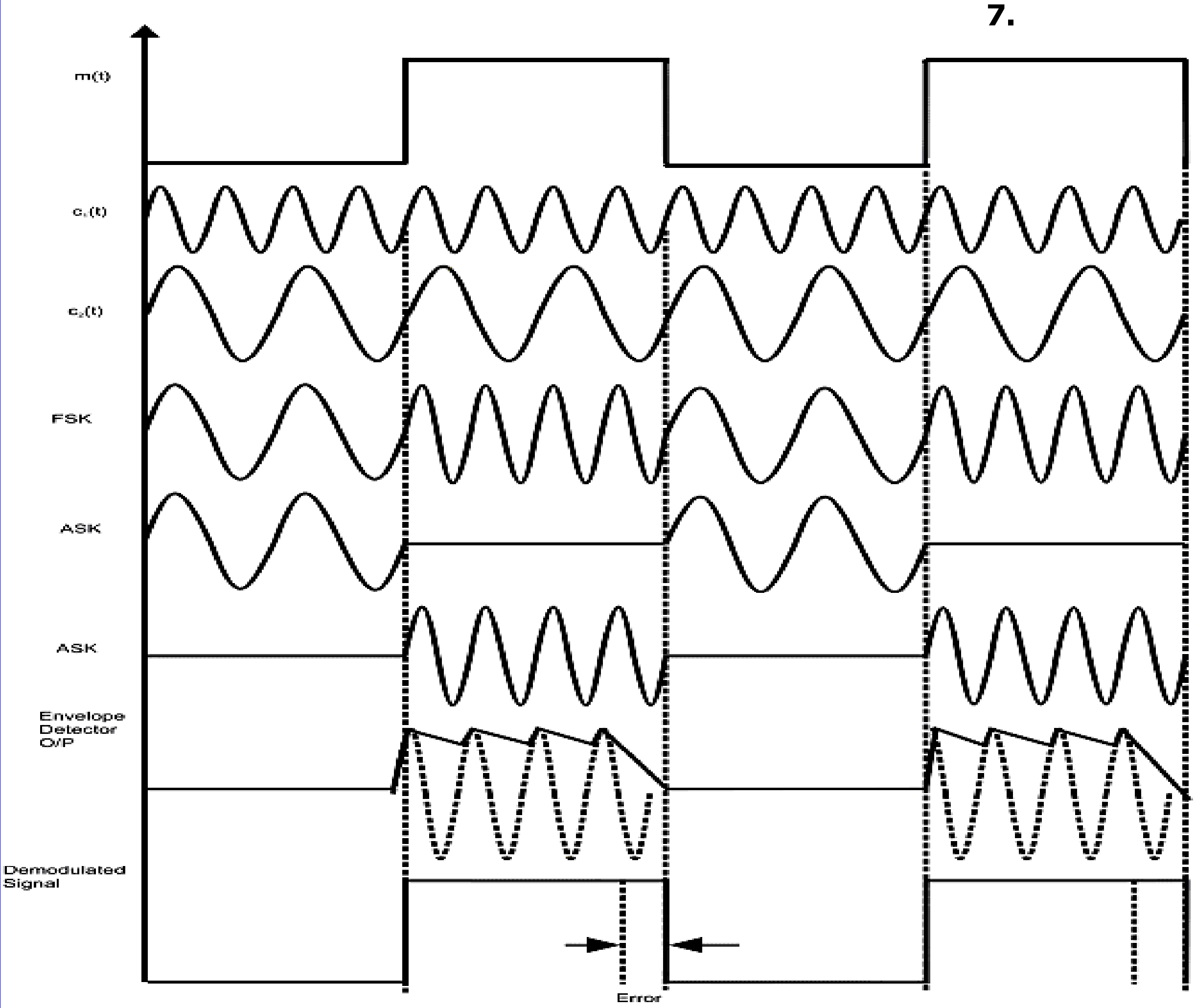
CONCLUSION:
A small phase lag exists between the modulating data and the recovered data because of the limitation of tracking ability and the time response of PLL.

VIVA QUESTIONS:

1. State the difference between discrete and digital signals.
2. Define Quantizing.
3. Define Encoding.
4. Explain PCM encoding.
5. State the difference between pulse modulation and digital modulation.
6. Explain FSK circuit operation.

WAVE FORMS:

7.

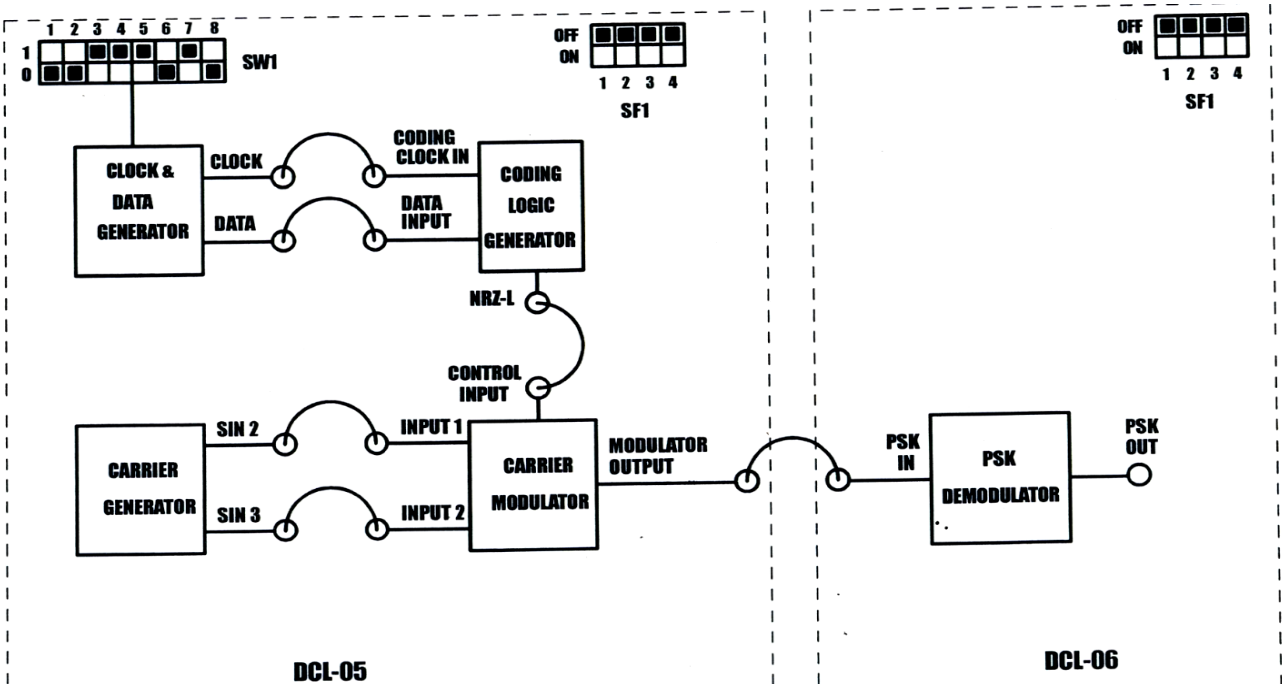


4. Phase Shift Keying

AIM: To generate PSK signal and to demodulate the PSK signal.

THEORY: Refer "Digital Communications", 8th edition, Simon Haykin, Page 273

BLOCK DIAGRAM:



PROCEDURE:

1. Refer to the block diagram and carry out the following connections and switch settings.
2. Connect power supply in proper polarity to the kits **DCL-05** and **DCL-06** and switch it on.
3. Connect **CLOCK** and **DATA** generated on **DCL-05** to **CODING CLOCK IN** and **DATA INPUT** respectively by means of the patch-chords provided.
4. Connect the **NRZ-L** data input to the **CONTROL INPUT** of the Carrier Modulator logic
5. Connect carrier component **SIN2** to **INPUT1** and **SIN3** to **INPUT2** of the Carrier Modulator Logic
6. Connect PSK modulated signal **MODULATOR OUTPUT** on **DCL-05** to the **PSK IN** of the PSK DEMODULATOR on **DCL-06**
7. Observe the waveforms

OBSERVATION:

Observe the following waveforms on oscilloscope and plot it on the paper.

ON KIT DCL-05

1. Input NRZ-L Data at CONTROL INPUT.
2. Carrier frequency SIN 2 and SIN 3.
3. PSK modulated signal at MODULATOR OUTPUT.

ON KIT DCL-06

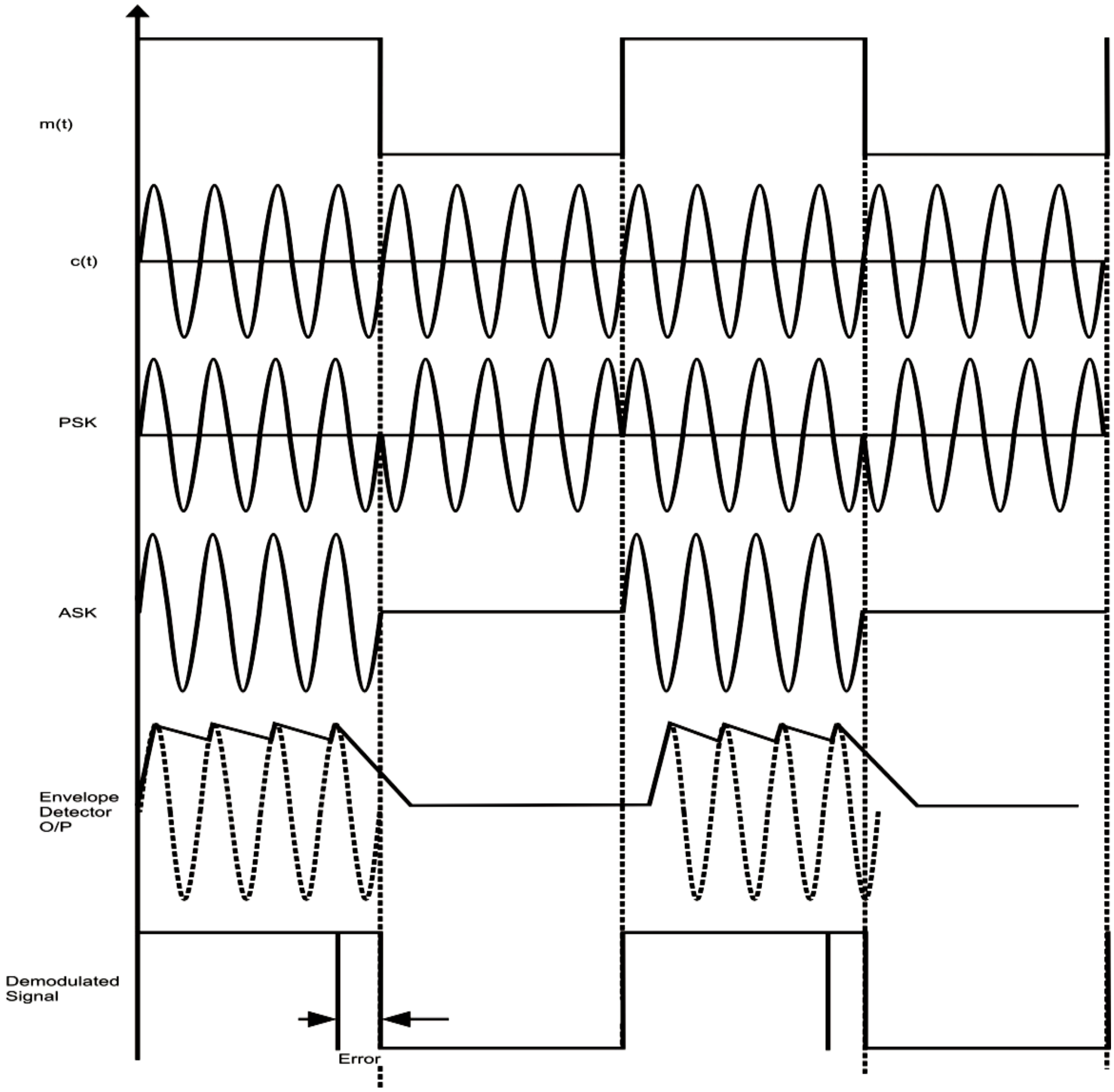
1. PSK Modulated signal at PSK IN.
2. PSK Demodulated signal at PSK OUT.
3. Observe output of SINE TO SQUEARE CONVERTOR, SQUARING LOOP, DIVIDE BY 2 on test points provided.

SWITCH FAULTS:

Note: Keep the connections as per the procedure. Now switch corresponding fault switch button in ON condition & observe the different effect on the output. The faults are normally used one at a time.

1. Put switch 1 of SF1 (DCL-05) in Switch Fault section to ON position. This will open capacitor for filtering of SIN 1 signal. Sine wave SIN 1 will be distorted and its amplitude gets reduced.
2. Put switch 2 of SF1 (DCL-05) in Switch Fault section to ON position. This will disable channel selection signal going to Modulator IC. Modulator output contains only single channel (INPUT 1) data.
3. Put switch 1 of SF1 (DCL-06) in Switch Fault section to ON position. This will remove connection for signal generator for PLL input. PLL input signal frequency reduces to half. Output of PSK demodulator gets distorted.

WAVE FORMS:



INFERENCE: ____

CONCLUSION:

It is observed that the successful operation of the PSK detector is fully dependent on the phase components of the transmitted modulated carrier. If the phase reversal of the modulated carrier along with the rising and falling edges of the data are not proper, then the efficient detection of data from PSK modulated carrier becomes impossible.

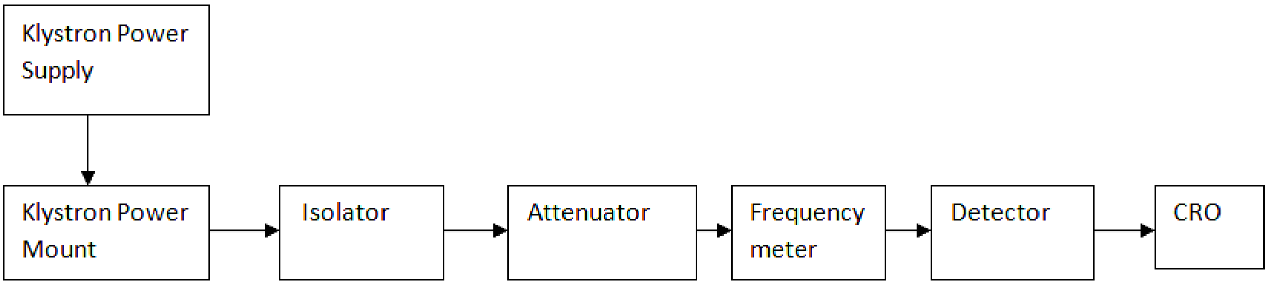
5. Study of Microwave Test Bench

EXP: 5A

AIM: To measure the operating frequency and attenuation in a microwave test bench

THEORY: Refer Microwave devices and circuits: by *LIAO*

BLOCK DIAGRAM:



PROCEDURE:

Part-1: Frequency Measurement

1) Set the cooling fan to blow air across the tube.
    - Set beam voltage control knob fully anti-clockwise(off)
    - Repeller voltage to ¾ clockwise
    - Set modulation selector switch to AM-MOD position
    - Keep AM-MODE amplitude knob and AM-FREQUENCY knob at midposition
    - HT/LT switch to LT position
    - Volt/Current switch of the display to current position
    - Set display to read beam current
2) Switch on the supply. Set HT/LT switch to HT
3) Wait for some 10 seconds. Let the tube warm up and power supply get properly stabilized.
4) Slowly vary the beam voltage knob clockwise and set beam current to 10 or 15mA. The corresponding beam voltage would be around +200v.
5) Observe the demodulated square wave available at the detector output using a CRO.

- Now the system is ready for conduction of experiment. Always ensure that the beam current is steady at 10 to 15mA. Do not apply more than20mA as it would bring down the life of tube
- In klystron, the repeller plate does not carry any current and it should not. If it does so, it may severely be damaged by electron bombardment. Therefore do not reduce the negative supply of the repeller below say -75 or -50v
- During switch off or power failure, bring down the beam current to 0 and follow step 1& 2 in the reverse order.
- The frequency is measured by tuning the frequency meter to have a dip in the o/p signal.
- Note down the frequency from the frequency meter

(Do not allow the freq meter to continue in the 'dip' as it absorbs microwave power during 'dip' detune the freq meter towards higher freq side each time after recording the readings. If not, when the repeller voltages is decreased further, the generated freq is also decreasing and might be trapped in the detuned position of the meter giving rise to a dip at low freq side of the meter This is known as direct frequency measurement)

Part-2: Attenuation measurement

Rotate down the variable attenuator, observe the wave form in the CRO and note down the amplitude of signal

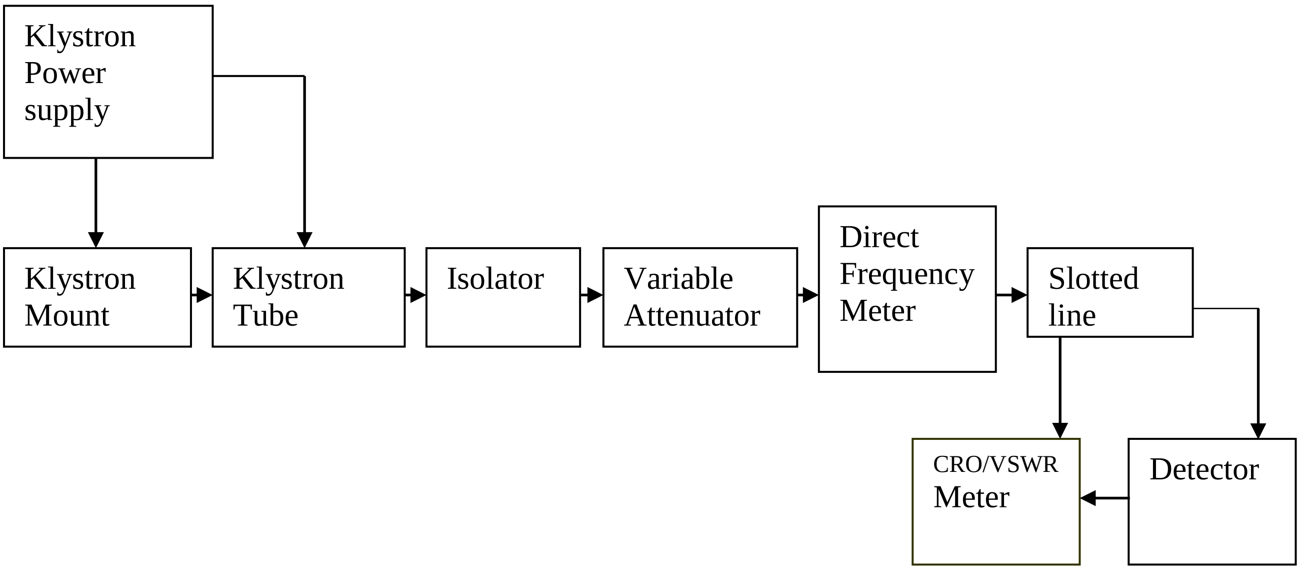
INFERENCE: ____

EXP 5B:

AIM: To determine guide wavelength and VSWR in a microwave test bench

THEORY: Microwave devices and circuits: by LIAO

BLOCK DIAGRAM:



Guide wavelength measurement

1. Connect the CRO to the detector of the slotted line.
2. Move the probe carriage along the slotted line horizontally to get a maximum signal o/p on the CRO. Record the probe position as D1 in Cms. Read the Cms scale against the 0 marking of the movable carriage this is the position of one of the maximas.
3. Move the probe in the same direction to get another maximum after crossing minima. Record this position as D2
4. Guide wavelength λ_g is twice the difference of D1 and D2. That is $\lambda_g = 2(D2-D1)$
5. Measure the waveguide inner broad dimension as 'a' cms. Obtain frequency as follows. (This is known as indirect frequency measurement)

Calculation:

$\lambda_c = 2a$, $1/\lambda_0^2 = 1/\lambda_g^2 + 1/\lambda_c^2$

λ_o = ------------- cm.

So, $f_o = C/\lambda_o$ = -------------- GHz

VSWR measurement

Direct method

1. Set the gunn diode in the negative resistance region
2. Locate any Maxima in the slotted line V_{max}.
3. Adjust the gain control knob of VSWR meter so that the pointer reads VSWR=1dB
4. Move the carriage to V_{min} position
5. Move the slotted line section in any direction until the pointer deflects suddenly kicks back from the value which is the VSWR.
6. The VSWR meter reading at the kick back point gives the VSWR.

Double Minima method:-

1.Measure λ_g following appropriate procedure.
2.Locate any minima and note down the corresponding power in db.
3.Move the slotted line section to the right till power increases by 3 dB(D_1) and bring it back.
4.Move slotted line section to the left till power decreases by 3 dB (D_2)
5.If distance between two points is d , then VSWR= $\lambda_g/ \pi d$, where d=(D_2 –D_1) .

INFERENCE: ____

6. Measurement of Directivity and Gain of Antenna YAGI Antenna

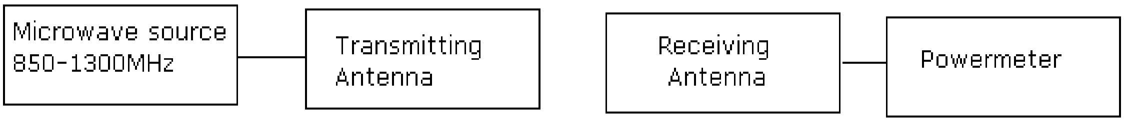
AIM: To measure the directivity and gain of the Yagi antenna

COMPONENTS REQUIRED:

Microwave source, Power meter, Transmitting and receiving antenna

THEORY: Refer "Antenna and propagation", by J.D.Krauss

Block Diagram



Procedure

1. Set up the system as shown in the block diagram
2. Keeping at the resonant frequency 1.25 MHz calculate and keep the minimum distance for field between the transmitting and receiving antenna using the formula $S = 2d^2/\lambda$

   Where, $\lambda = c/f = (3x10^8)/(1.25x10^6) = 240m$

   D = length of the antenna

3. Keep the line of sight properly
4. Note the readings on the power meter.
5. Rotate the turned table on clockwise and anticlockwise for different angles note down the corresponding reading of power meter.
6. Plot the graph from tabulated values
7. Find the HPBW from the points where the power is half of the maximum values or <3dB

   Directivity = $41253/(\theta_E \times \theta_H)$

   Gain = $(4\pi S / \lambda) \times (V_r/V_t)$

   θ_E=HPBW in E-plane

   θ_H= HPBW in H-plane

   V_r = received power/voltage

   sV_t = transmitted power/voltage

TABULAR COLUMN

For θ_E in degree

Angle θ		Power P	
+	-	+	-

For θ_H

Angle θ		Power P	
+	-	+	-

VIVA QUESTIONS:

1. Define basic antenna parameter.
2. Define directivity, power gain of an antenna
3. Define Aperture of an antenna
4. Define Broad side array and end fire array system.

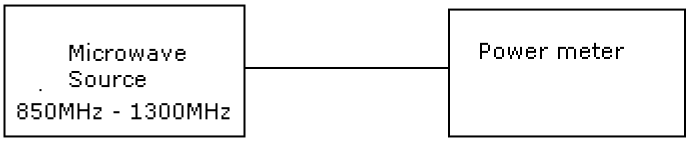
7A. Determination of coupling isolation Characteristics of a Microstrip Directional coupler

Aim: To study the coupling factor isolation loss and directivity of Microstrip directional coupler.

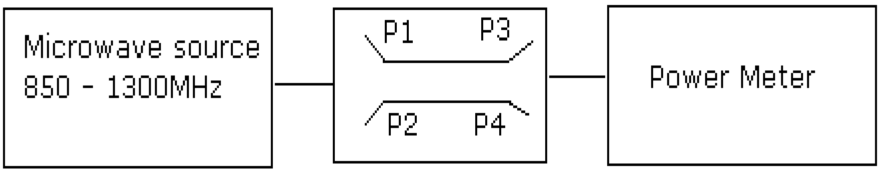
Components required: Microstrip directional coupler, attenuator, power meter, 50Ω terminator (2 no's), SMA connector

Theory: "Microwave Engineering" by Annapurna Das,

Block Diagram



Direct connection to get transmitted power



Directional coupler

Procedure:

To find coupling characteristic

1. Set up the system as shown in the block diagram

2. Connect one cable to the output and the other is to be connected via the attenuator pad to the input. Directly connect the input and output via the SMA adapter provided.

3. Take reading from 900MHz to 1200MHz every 10MHz.record this as P0

4. Remove SMA adaptor insert Directional coupler between input and output

5. Connect input at port1 and output at port 3. Terminate open port with 50 Ω terminations

6. Take readings from 900MHz to 1200MHz and record this as P3

7. Determine coupling factor by using the formula P0-P3

To find Isolation Characteristics

1. Connect input at port 1 and output is taken from port 4
2. Open ports are terminated with 50 Ω termination.
3. Take readings from 900MHz to 1200MHz record them as P4
4. Isolation is determined by using the formula P0-P4
5. Calculate directivity by using the formula

   Directivity = Isolation – Coupling factor

CALCULATION:

Insertion loss =Power at Port 1 – Power at Port 2

Coupling factor = Power at Port 1 – Power at Port 3

Isolation Factor = Power at Port1 – Power at Port4

Directivity = isolation – coupling factor

TABULATION:

I/P at port 1	O/P at port 2	O/P at port 3	O/P at port 4	Insertion loss	Isolation	Coupling factor	directivity

VIVA QUESTIONS

1. What is Directional coupler?
2. Define Isolation and coupling factor.
3. What is attenuator?
4. What is the type of detector used?
5. What is microstrip?
6. What is microwave signal? Which band of frequency you are using?

7B. RING RESONATOR

AIM: To conduct an experiment to measure resonance characteristics of a micro strip ring resonator and to determine the dielectric constant of the substrate.

COMPONENTS REQUIRED:
Power supply, VCO, 50Ω transmission line, Ring resonator,50Ω terminations, cables with SMA connector, oscilloscope / VSWR meter.

THEORY:" Microwave Engineering" by Annapurna Das , Page 260 to 272

BLOCK DIAGRAM

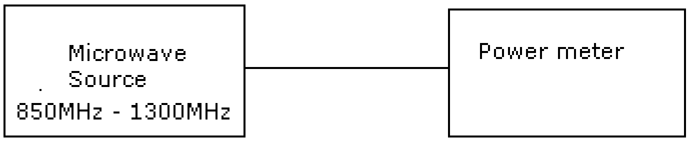


Fig 1. Direct connection to get transmitted power

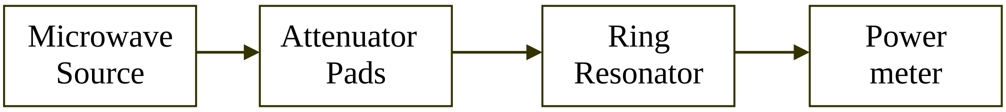


Fig 2. Connection to get resonator characteristics

PROCEDURE:

1. Set up the system as shown in figure
2. Keeping the voltage at minimum, switch on the power supply.
3. Insert a 50Ω transmission line and check for the output at the end of the system using a CRO/ VSWR meter
4. Replace the 50 Ω transmission lines with ring resonator.
5. Vary the supply frequency and tabulate frequency and out put
6. Plot the graph of frequency Vs output and find the resonant frequency
7. The calculation of dielectric constant can be done as follows

The value of µr can be found from these formulas

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}[1 + \frac{12h}{w}]^{-\frac{1}{2}} \quad \text{(1)}$$

$$\Delta L = \frac{h}{\varepsilon_{eff}} \quad \text{(2)}$$

$$L_{eff} = L + 4\Delta L \quad \text{(3)}$$

$$L_{eff} = \frac{c}{f\sqrt{\varepsilon_{eff}}} \quad \text{(4)}$$

or

$$f = \frac{c}{L_{eff}\sqrt{\varepsilon_{eff}}} \quad \text{(5)}$$

Here L=mean perimeter of the ring =4x39.5 =158mm
h= thickness of substrate =1.6mm
w = width of square ring = 1.5 mm
Measured frequency f = 1.050 GHz

We can solve closed form formulas by assuming

$\varepsilon_r = 4.0$

Using equation 1 ε_{eff} **= 2.90**
Using equation 2 ”L =0.94
Using equation 3 Leff =161.76
Using equation 5 f = 1.089 GHz

Which is more than the measured value , so in the next trial we increase the value to

$\varepsilon_r = 4.4$

= 3.16
”L=0.90
Leff =161.6
f= 1.044 GHz

Which is close to 1.050 GHz Hence the correct value of dieclectric constant is approx. 4.4.
Therefore we can calculate dielectric constant from the measured resonant frequency of a ring resonator.

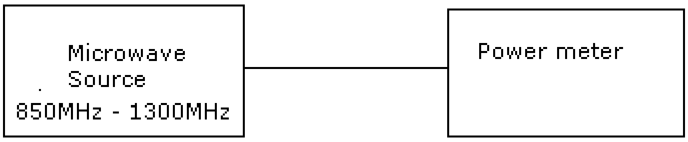
7C. POWER DIVIDER

AIM: To conduct an experiment to measure power division and isolation characteristics of micro strip 3dB power divider.

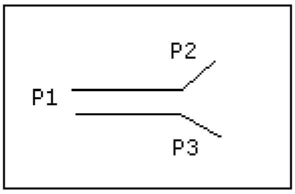
COMPONENTS REQUIRED:
Power supply, VCO, 50Ω transmission line, power divider, 50Ω terminations, cables with SMA connector, oscilloscope / VSWR meter.

THEORY:" Microwave Engineering" by Annapurna Das, Page 175,181

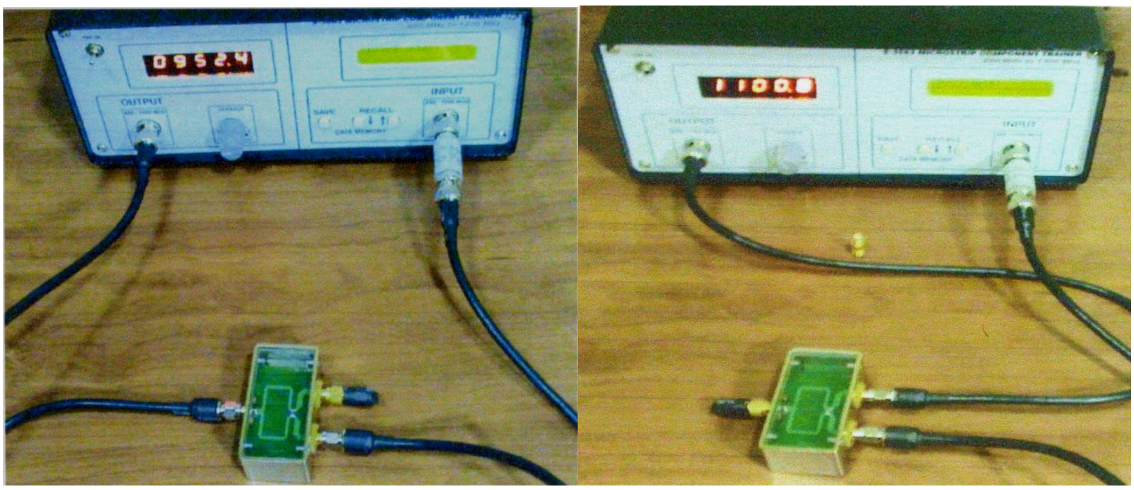
Block Diagram



Direct connection to get transmitted power



Power Divider



PROCEDURE:

To find Power division

1. Connect one cable to the output and the other is to be connected via the attenuator pad to the input.
2. Directly connect the input and output via the SMA adapter provided.
3. Take reading from 900MHz to 1200MHz and record this as P0.
4. Remove direct connection, insert power divider between input and output
5. Connect input port 1 and output port P2 to output and terminate open port.
6. Vary frequency from 900MHz to 1200MHz record this as P2
7. find power division by using the formula

Power division= P0-P2 in dB

To find Isolation Characteristic

1. Connect input at Port 2 and output at port 3 and terminate Port 1 with 50 Ω termination.
2. Take readings from 900MHz to 1200MHz and record them as P3
3. Isolation is determined by using the formula

Isolation = P2 – P3 in dB

CALCULATION:

Power division = P0-P2 in dB

Isolation Characteristic = P2 – P3 in dB

Power division

Freq	P0 I/P	P2 O/P	P3 O/P

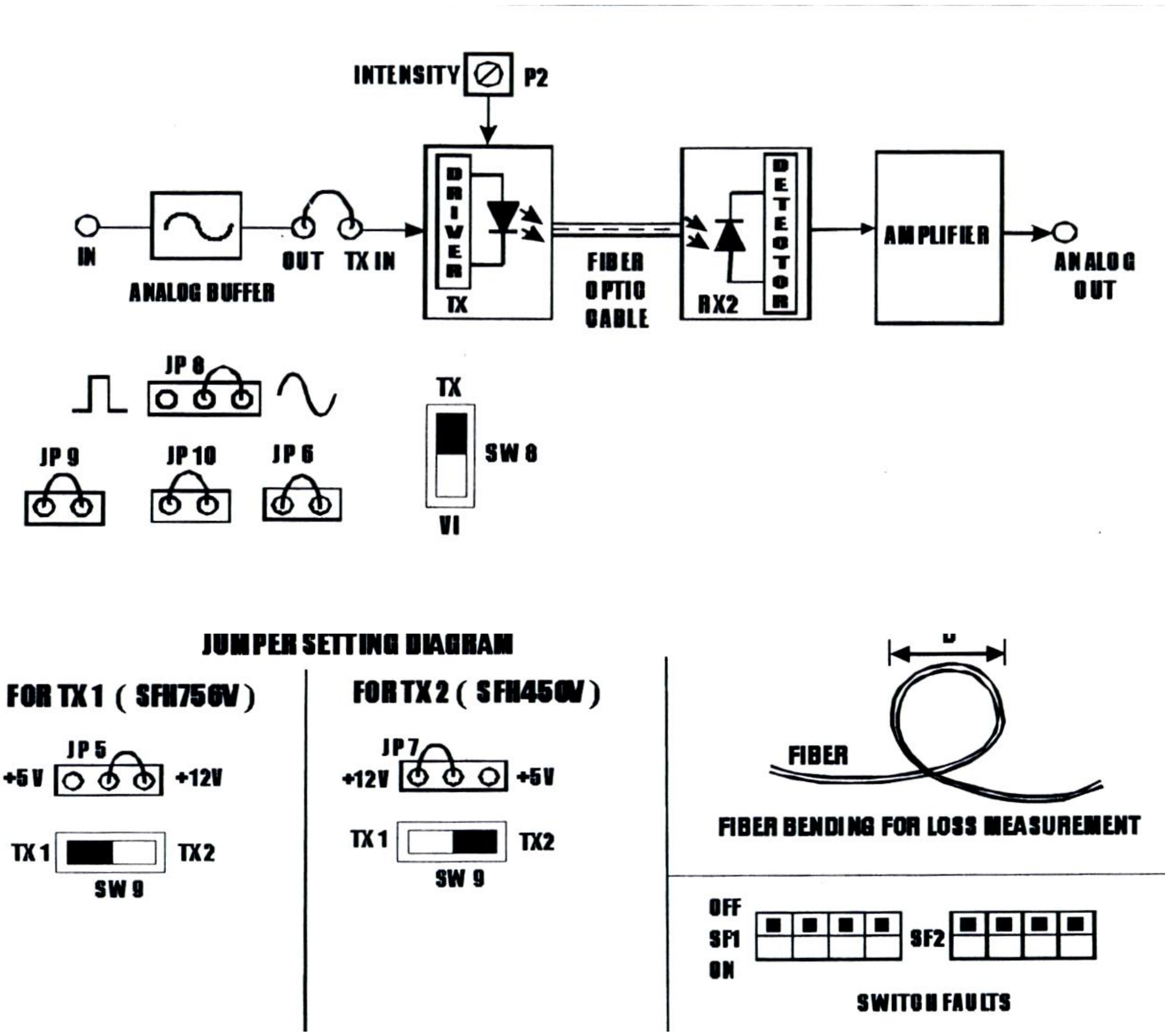
Power Isolation

Freq	P2 O/P	P3 O/P

8. LOSSES IN OPTICAL FIBER AND NUMERICAL APERATURE

AIM: Measurement of losses in a given optical fiber (propagation loss, bending loss) and numerical aperture.

BLOCK DIAGRAM:



PROCEDURE TO MEASURE ATTENUATION LOSS:

1. Make Connections as shown in block diagram.
2. Connect the power supply cables with proper polarity to link-B Kit. While connecting this, ensure that the power supply is off.
3. Keep SW9 towards Tx1 position for SFH756
4. Keep jumpers and SW8 positions as shown in block diagram.
5. Keep Intensity control pot P2 towards minimum position.
6. Feed about 2Vp-p sinusoidal signal of 1 KHz from the function generator to the IN post of Analog Buffer.

7. Connect the output post of Analog Buffer to the post TX In of Transmitter.
8. Connect the other end of the fiber to detector SFH350V.
9. Observe the detected output on the Oscilloscope.
10. Measure the Peak value of the received signal. Let this value be V1.
11. Now replace 1 meter fiber by 3 meter fiber between same LED and detector. Do not disturb any settings. Again take the peak voltage reading and let it be V2.
12. Calculate Attenuation factor α using the formula

$\alpha = 10/[L1-L2]) \log_{10} V_2/V_1$

Where α =…..db/km, L1=1m and L2=3 m.

PROCEDURE TO MEASURE BENDING LOSS:

1. Make Connections as shown in block diagram.
2. Make the following connection (as shown in diagram).
   a) Function generators 1 KHz sine wave output to input socket of emitter circuit via 4mm lead.
   b) Connect 1m optic fiber between emitter output and detectors input.
   c) Connect detector output to amplifier input socket via 4mm lead.
3. Switch ON the power supply.
4. Observe the output signal from detector (TP8) on CRO.
5. Adjust the amplitude of the received signal as that of transmitted one with the help of adjusts pot in AC amplifier block. Note this amplitude and name it V_1.

Wind the fiber optic cable on the mandrel and observe the corresponding AC amplifier output on CRO, it will be gradually reducing showing loss due to bends.

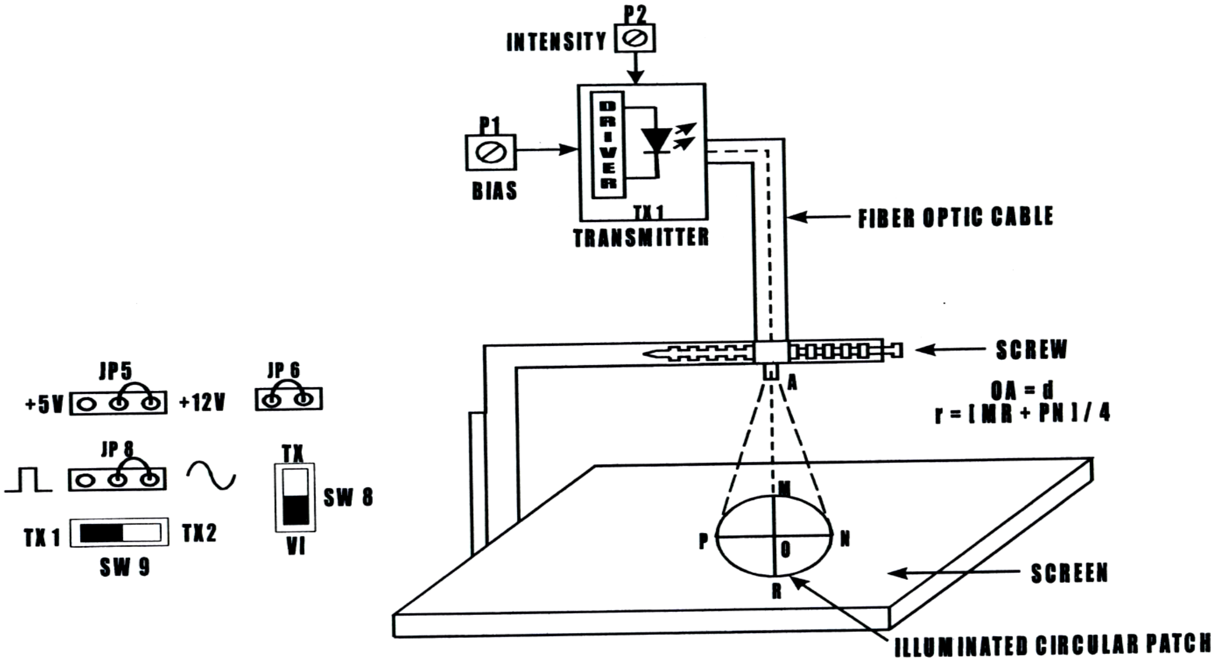
RESULT:

Attenuation Loss:

Bending Loss:

NUMERICAL APERTURE OF OPTICAL FIBER

BLOCK DIAGRAM:



PROCEDURE TO MEASURE NUMERICAL APERTURE:

1. Make Connections as shown in block diagram.
2. Keep Intensity Knob to towards Minimum position.
3. Connect the frequency generator's 1KHz sine wave output to input of emitter circuit. Adjust its amplitude at 5V p-p.
4. Connect one end of fiber cable to the output socket of emitter 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.
5. Record the distances of screen from fiber end d and note the diameters MN and PN as indicated.
6. Mean Radius is calculated using the following formula.

r= (MN+PN)/4.

7. Find the Numerical aperture of the fiber using the formula
8. $$NA = \sin\theta_{max} = \frac{r}{\sqrt{d^2 + r^2}}$$

Where θ_{max} is the maximum angle at which the light incident is properly transmitted through the filter.

RESULT:

Numerical Aperture:

Note: The N.A. recorded in the manufacturers data sheet is 0.5 typical.

Part -B Simulation Experiments using MATLAB

1. Simulate NRZ, RZ, half-sinusoid and raised cosine pulses

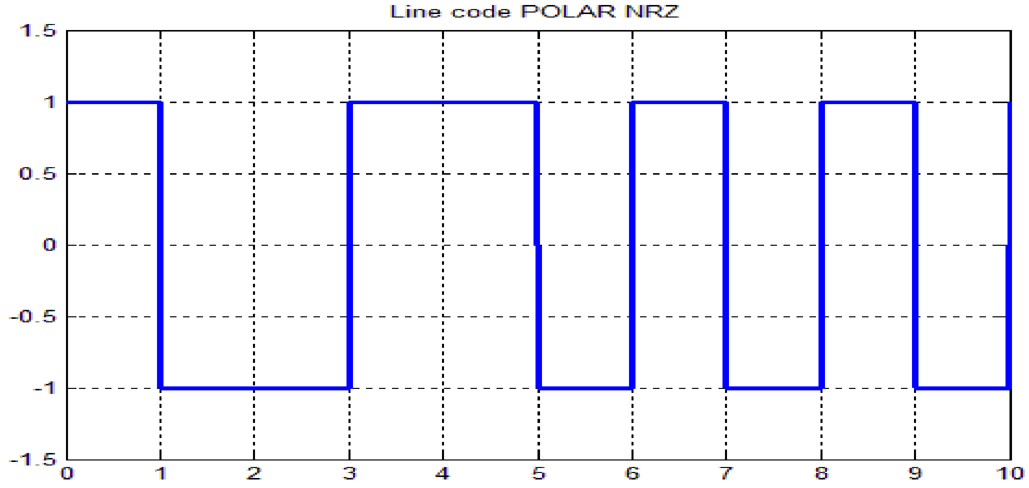
AIM: To Simulate NRZ, RZ, half-sinusoid and raised cosine pulses and generate eye diagram for binary polar signaling.

A. NRZ CODING

Program:

```
%h=[1 0 0 1 1 0 1 0 1 0];
%PNRZ(h)
clf;
n=1;
l=length(h);
h(l+1)=1;
while n<=length(h)-1;
    t=n-1:0.001:n;
if h(n) == 0
    if h(n+1)==0
        y=-(t<n)-(t==n);
    else
        y=-(t<n)+(t==n);
    end
    d=plot(t,y);grid on;
    title('Line code POLAR NRZ');
    set(d,'LineWidth',2.5);
    hold on;
    axis([0 length(h)-1 -1.5 1.5]);
    disp('zero');
else
    if h(n+1)==0
        y=(t<n)-1*(t==n);
    else
        y=(t<n)+1*(t==n);
    end
    d=plot(t,y);grid on;
    title('Line code POLAR NRZ');
    set(d,'LineWidth',2.5);
    hold on;
    axis([0 length(h)-1 -1.5 1.5]);
    disp('one');
end
n=n+1;
%pause;
end
```

Waveforms:



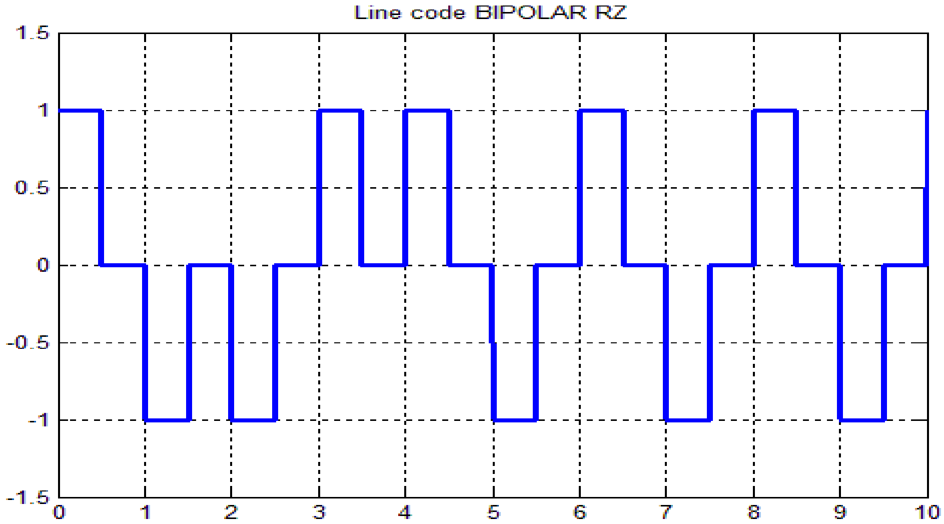
B.RZ CODING

Program:

```
function BRZ(h)
%Line code BIPOLAR RZ.

%h=[1 0 0 1 1 0 1 0 1 0];
%BRZ(h)
clf;
n=1;
l=length(h);
h(l+1)=1;
while n<=length(h)-1;
    t=n-1:0.001:n;
if h(n) == 0
    if h(n+1)==0
        y=-(t<n-0.5)-(t==n);
    else
        y=-(t<n-0.5)+(t==n);
    end
    d=plot(t,y);grid on;
    title('Line code BIPOLAR RZ');
    set(d,'LineWidth',2.5);
    hold on;
    axis([0 length(h)-1 -1.5 1.5]);
    disp('zero');
else
    if h(n+1)==0
        %y=(t>n-1)-2*(t==n);
        y=(t<n-0.5)-1*(t==n);
    else
        %y=(t>n-1)+(t==n-1);
        y=(t<n-0.5)+1*(t==n);
    end
    %y=(t>n-1)+(t==n-1);
    d=plot(t,y);grid on;
```

```
     title('Line code BIPOLAR RZ');
    set(d,'LineWidth',2.5);
    hold on;
    axis([0 length(h)-1 -1.5 1.5]);
    disp('one');
end
n=n+1;
%pause;
End
```

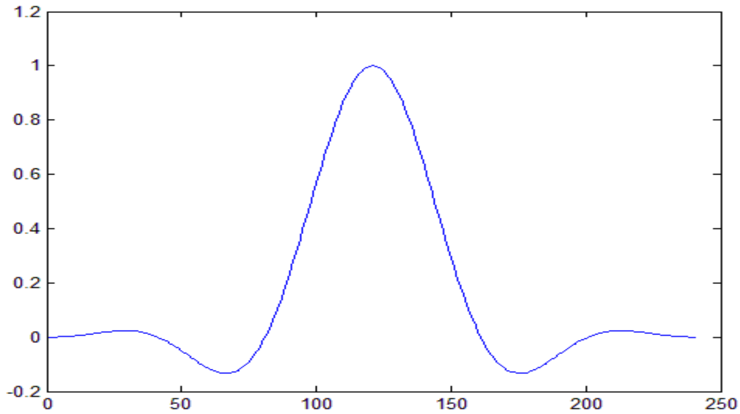
Waveforms:



C. SIMULATE RAISED COSINE PULSE

```
clear all;
close all;
fs=200;
fd=5;
y=rcosine(fd,fs);
figure(1)
plot(y)
```

Waveforms:



D. EYE DIAGRAM FOR BINARY POLAR SIGNALING.

```
% (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(1,400)); % 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);
ysine=conv(dataup,psine(Tau)); % half sinusoid polar
ysine=ysine(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');
eye3=eyediagram(ysine,2*Tau,Tau,Tau/2);title('Half-sine eye-diagram');
eye4=eyediagram(yrcos,2*Tau,Tau);title('Raised-cosine eye-diagram');
```

INFERENCE: ____

2.Pulse Code Modulation

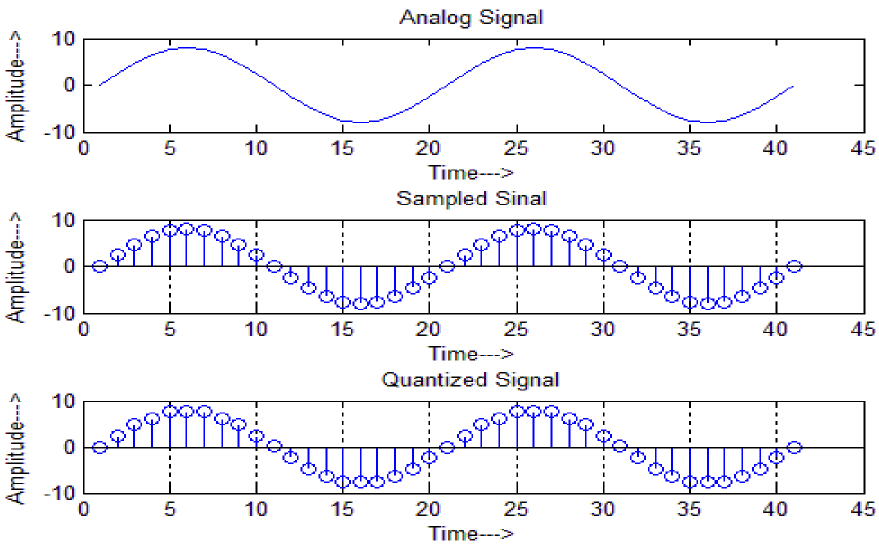
AIM: Simulate the Pulse code modulation and demodulation system and display the waveforms.

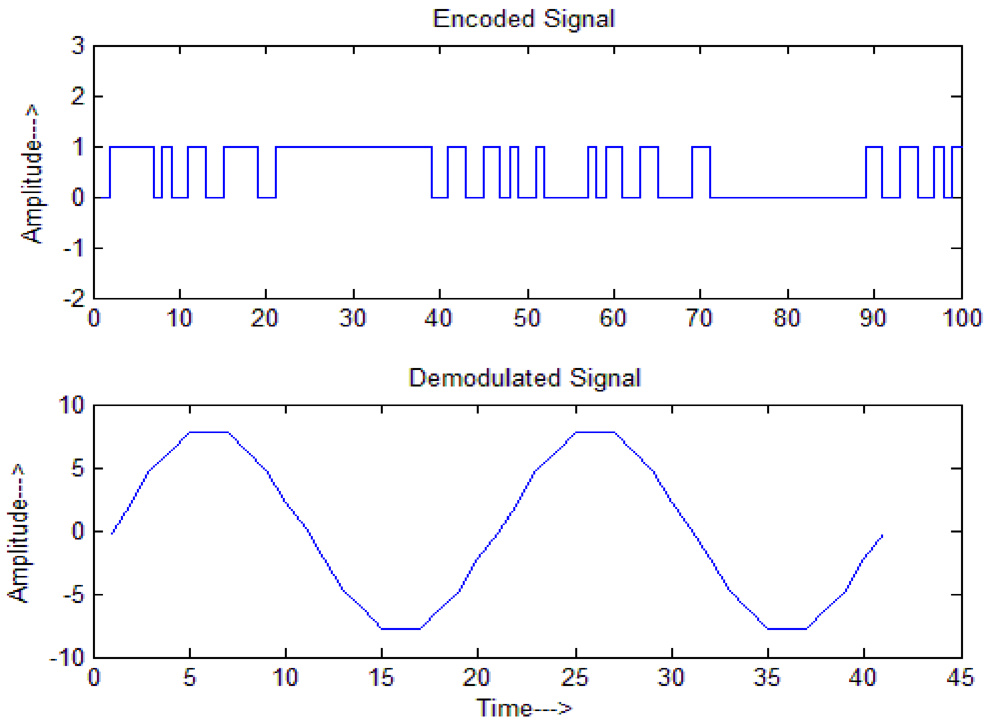
CODE:

```
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 nuber of samples have tobe 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);        % Contaion 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--->');

 %   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--->');
```

Waveforms:




Encoded Signal
Amplitude--->
3
2
1
0
-1
-2
0 10 20 30 40 50 60 70 80 90 100
Demodulated Signal
Amplitude--->
10
5
0
-5
-10
0 5 10 15 20 25 30 35 40 45
Time--->

INFERENCE: ____

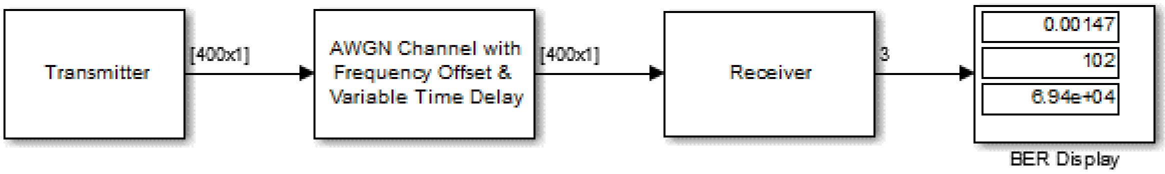
3. QUADRATURE PHASE SHIFT KEYING (QPSK)

AIM: Simulate the QPSK transmitter and receiver. Plot the signals and its constellation diagram.

COMPONENTS REQUIRED: QPSK Simulation

THEORY: Refer "Digital Communications", 8th edition, Simon Haykin, Page 284.

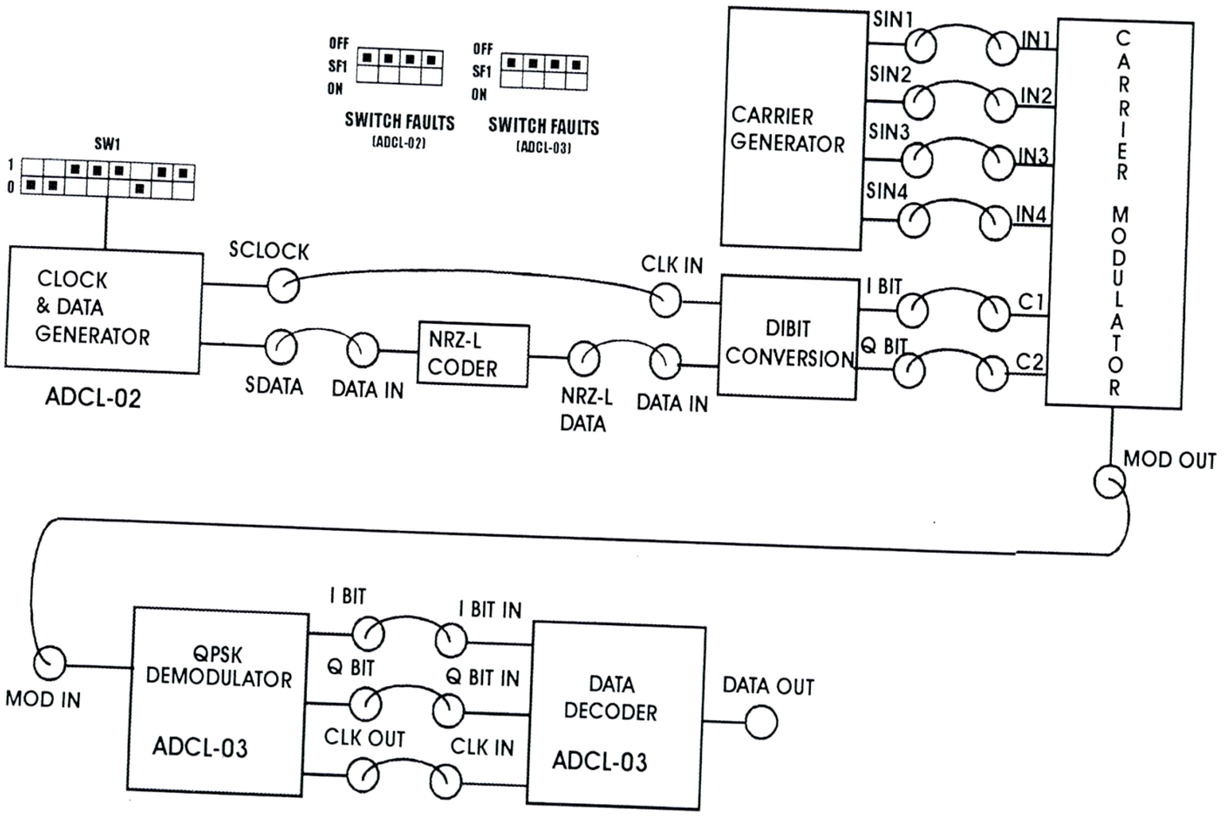
BLOCK DIAGRAM:

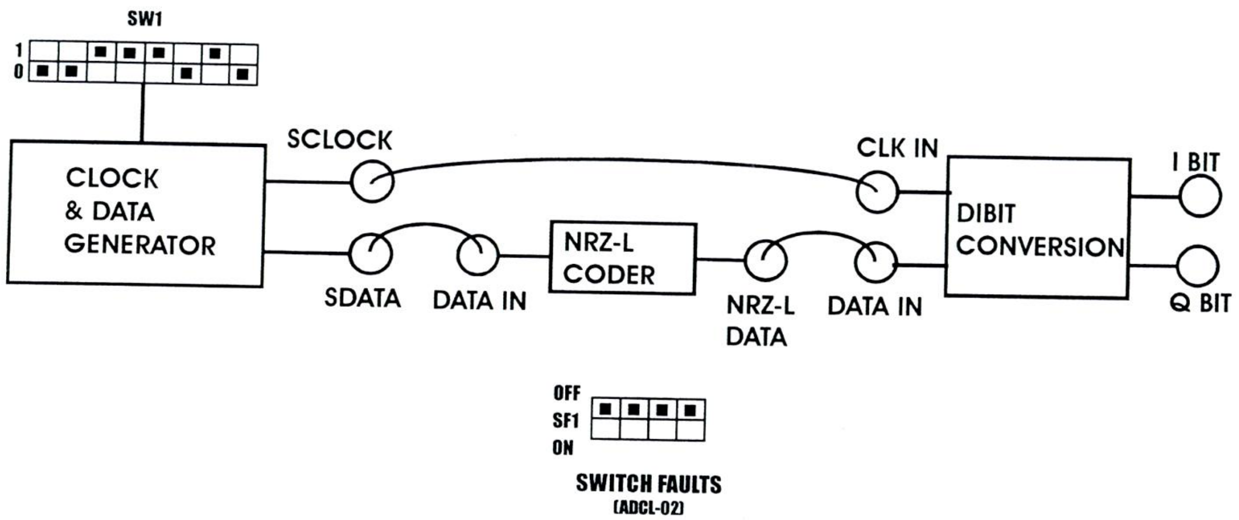


Code:

```
prmQPSKTxRx = commqpsktxrx_init % QPSK system parameters

useScopes = true; % true if scopes are to be used
printReceivedData = false; %true if the received data is to be printed
compileIt = false; % true if code is to be compiled
useCodegen = false; % true to run the generated mex file


if compileIt
    codegen -report runQPSKSystemUnderTest.m -args
{coder.Constant(prmQPSKTxRx),coder.Constant(useScopes),coder.Constant(printReceiv
edData)} %#ok
end
if useCodegen
   BER = runQPSKSystemUnderTest_mex(prmQPSKTxRx, useScopes);  %#ok
else
   BER = runQPSKSystemUnderTest(prmQPSKTxRx, useScopes, printReceivedData);
end
fprintf('Error rate = %f.\n',BER(1));
fprintf('Number of detected errors = %d.\n',BER(2));
fprintf('Total number of compared samples = %d.\n',BER(3));


displayEndOfDemoMessage(mfilename)
```

Block Diagram Kit:





PROCEDURE:

1. Refer to the block diagram (Fig.4.1) and carry out the following connections and switch settings.
2. Connect power supply in proper polarity to the kits ADCL-02 and ADCL-03 and switch it on.
3. Select Data pattern of simulated data using switch SW1.
4. Connect SDATA generated to DATA IN of the NRZ-L CODER.

5. Connect NRZ-L DATA to DATA IN of the DIBIT CONVERSION.
6. Connect SCLOCK to CLK IN of the DIBIT CONVERSION.
7. Connect the dibit data I & Q bit to control input C1 and C2 of CARRIER MODULATOR respectively. NOTE: Adjust I & Q bit as shown in Fig.4.2A by operating RST Switch on ADCL-02 before connecting it to C1 &C2 .
8. Connect carrier component to input of CARRIER MODULATOR as follows:
   a. SIN 1 to IN 1
   b. SIN 2 to IN 2
   c. SIN 3 to IN 3
   d. SIN 4 to IN 4
9. Connect QPSK modulated signal MOD OUT on ADCL-02 to the MOD IN of the QPSK DEMODULATOR on ADCL-03. NOTE: Adjust Recovered I & Q bit on ADCL-03 as per ADCL-02 by RST Switch on ADCL-03.
10. Connect I BIT, Q BIT & CLK OUT outputs of QPSK Demodulator to I BIT IN, Q BIT IN & CLK IN posts of Data Decoder respectively.
11. Observe various waveforms as mentioned below (Fig. 4.2).
    NOTE: If there is mismatch in input & Recovered Data, then adjust that Data by RST Switch on ADCL-03.

1. Four sampling clocks at the output of SAMPLING CLOCK GENERATOR.
2. Two adder outputs at the output of ADDER.
3. Recovered data bits (I & Q bits) at the output of ENVELOP DETECTORS.
4. Recovered NRZ-L data from I& Q bits at the output of DATA DECODER.

SWITCH FAULTS:

Note: Keep the connections as per the procedure. Now switch corresponding fault switch button in ON condition & observe the different effect on the output. The faults are normally used one at a time.

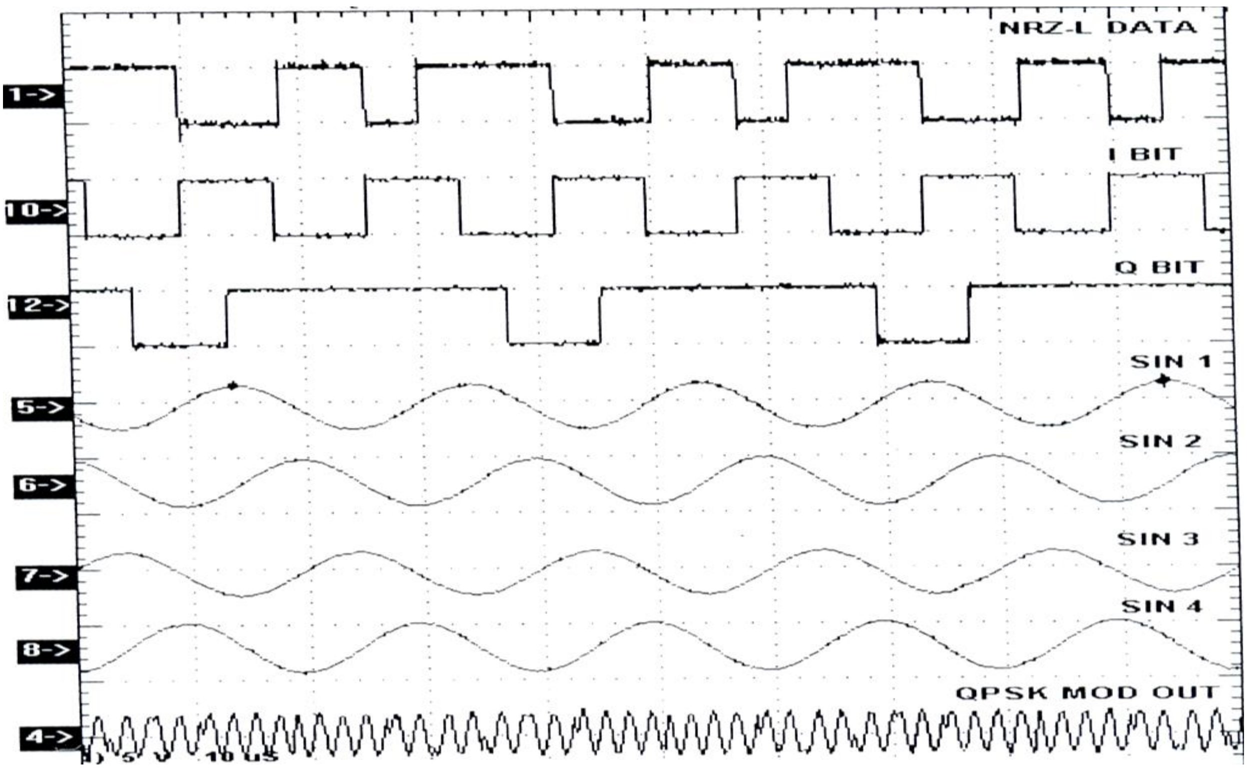
1. Put switch 1 of SF1 (ADCL-02) in Switch Fault section to ON position. This will open capacitor for filtering of SIN 1. Thus amplitude of SIN 1 and SIN 3 gets reduced.
2. Put switch 2 of SF1 (ADCL-02) in Switch Fault section to ON position. This will disable control signal C1 going to Modulator IC. Modulator will not able to modulate the signal properly.
3. Put switch 3 of SF1 (ADCL-02) in Switch Fault section to ON position. This will open the input of EX OR gate used in differential encoder 1. Due to this random data is generated at the output of differential encoder 1.
4. Put switch 4 of SF1 (ADCL-02) in Switch Fault section to ON position. This will remove the clock signal (125 KHz-180 deg.) in the generation of Q bit data. This disable the generation of Q bit data at the output of dibit conversion.

5. Put switch 2 of SF1 (ADCL-03) in Switch Fault section to ON position. This will remove Pull up resistor from envelope detector of I-Bit. I-Bit generation gets disabled.
6. Put switch 3 of SF1 (ADCL-03) in Switch Fault section to ON position. This will remove one of the sampling clocks to sampler. Thus QPSK signal doesn't get sampled properly and due to this QPSK demodulated data also gets disturbed.
7. Put switch 4 of SF1 (ADCL-03) in Switch Fault section to ON position. This will remove the sampling input of sample. So I bit can not be observed and recovered data also gets disturbed.

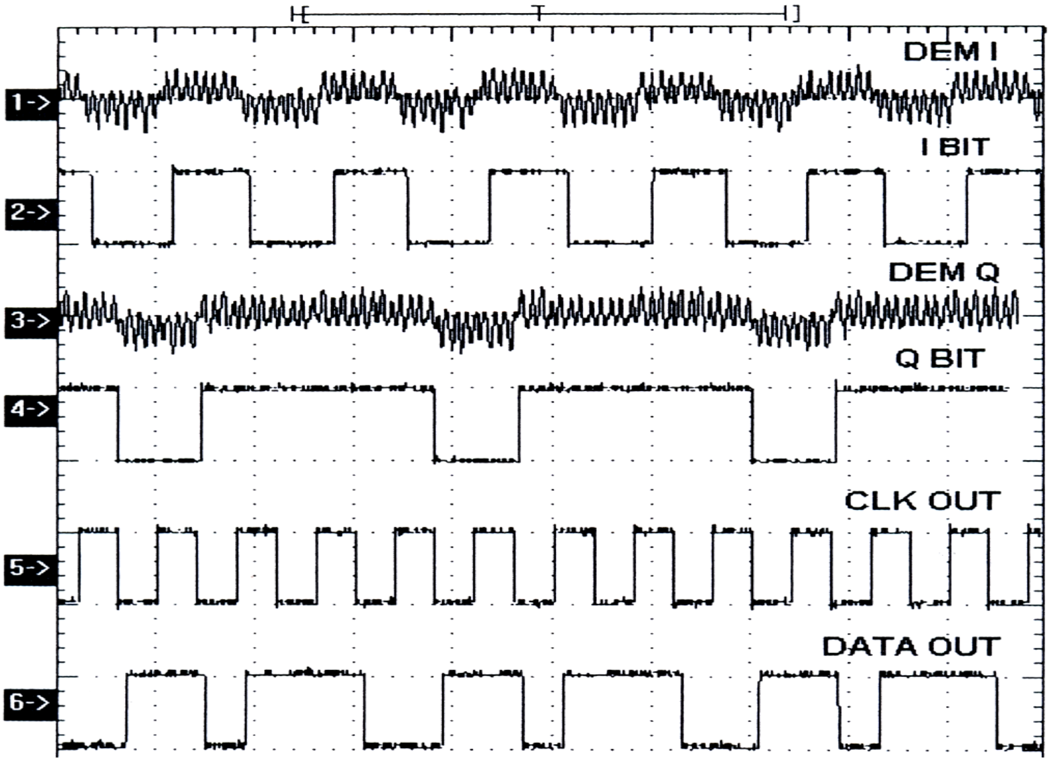
CONCLUSION:

In BPSK we deal individually with each bit of duration Tb. In QPSK we lump two bits together to form a SYMBOL. The symbol can have any one of four possible values corresponding to two-bit sequence 00, 01, 10, and 11. We therefore arrange to make available for transmission four distinct signals. At the receiver each signals represents one symbol and correspondingly, two bits. When bits are transmitted, as in BPSK.the signal changes occur at the bit rate When symbols are transmitted the changes occur at the symbol rate which is one-half the bit rate. [Thus the symbol time is Ts = 2Tb.

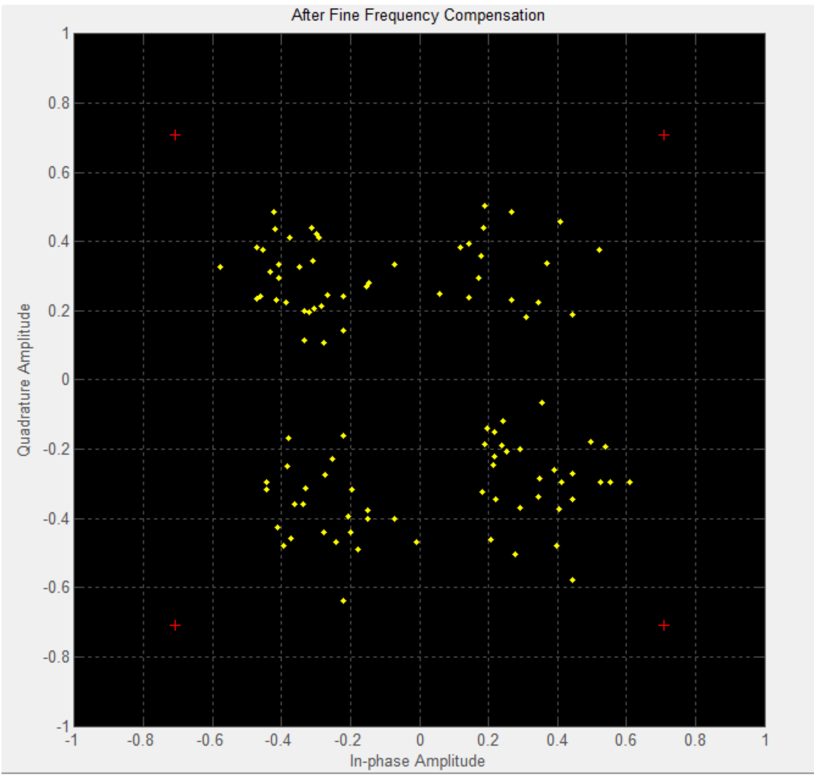
MODULATION WAVEFORMS:



DEMODULATION WAVEFORMS:



QPSK CONSTELLATION DIAGRAM:



4. DIFFERENTIAL PHASE SHIFT KEYING (DPSK)

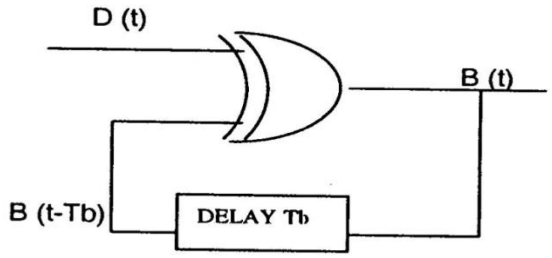
AIM: Test the performance of a binary differential phase shift keying system by simulating the non-coherent detection of binary DPSK**.**

COMPONENTS REQUIRED: DPSK Simulation

THEORY: Refer "Digital Communications", 8th edition, Simon Haykin, Page 307

Differential encoding logic:

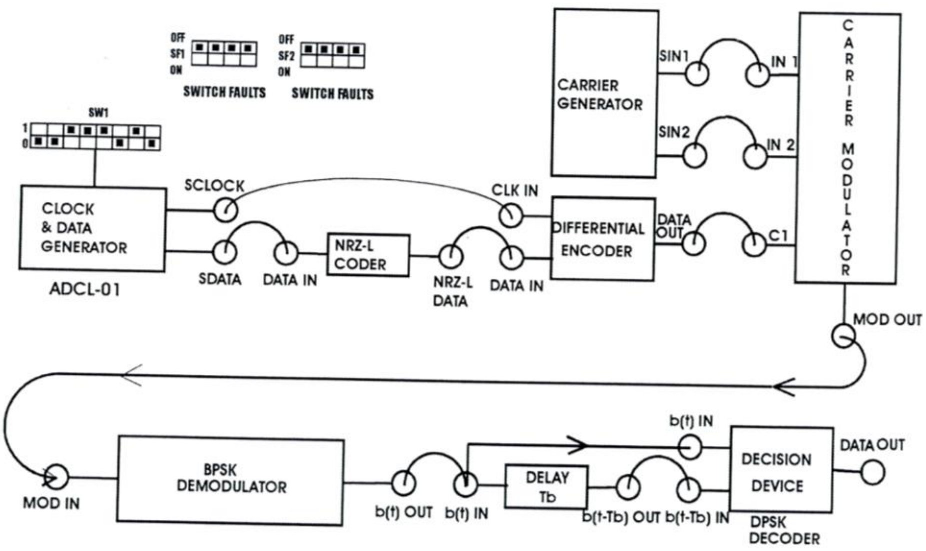
A means of generating a differentially encoded data is shown in fig. 2. 2. The data stream to be transmitted, d (t), is applied to one input of an exclusive-OR logic gate. To the other gate input is applied the output of the exclusive-OR gate b (t) delayed by the time Tb allocated to one bit. This second input is then b (t-Tb).



Code:

```
s = RandStream.create('mt19937ar', 'seed',131)
prevStream = RandStream.setGlobalStream(s); % seed for repeatability
M = 4; % Use DQPSK in this example, so M is 4.
x = randi([0 M-1],500,1); % Random data
y = dpskmod(x,M,pi/8); % Modulate using a nonzero initial phase.
plot(y) % Plot all points, using lines to connect them.
```

BLOCK DIAGRAM:



PROCEDURE:

DIFFERENTIAL ENCODING OF NRZ-L DATA.

1. Refer to the block diagram (Fig 2.1) and carry out the following connections and switch settings
2. Connect power supply in proper polarity to the kit ADCL-01 and switch it on.
3. Select Data pattern ol simulated data using switch SW1.
4. Connect SDATA generated to DATA IN of NRZ-L CODER.
5. Connect the coded data NRZ-L DATA to the DATA IN of the DIFFERENTIAL ENCODER.
6. Connect the clock generated SCLOCK to the CLK IN of the DIFFERENTIAL ENCODER
7. Observe the input data and the differentially encoded data on test points provided.

SWITCH FAULTS:

Note: Keep the connections as per the procedure. Now switch corresponding fault switch button in ON condition & observe the different effect on the output. The faults are normally used one at a time.

5. Put switch 1 of SF1 (ADCL-01) in Switch Fault section to ON position. This will open the MSB bit of the data. Due to this MSB bit of data remains high (logic 1) irrespective to its switch position of SW1.
6. Put switch 4 of SF1 (ADCL-01) in Switch Fault section to ON position This will open input of the EX-OP. used in Differential encoder section due to this we does not get proper encoded signal at the output of DIFFERENTIAL ENCODER.

PROCEDURE TO GET DPSK OUTPUT:

1. Refer to the block diagram (Fig.3.1) and carry out the following connections and switch settings.
2. Connect power supply in proper polarity to the kit ADCL-01 and switch it on.
3. Select Data pattern of simulated data using switch SW1.
4. Connect SDATA generated to DATA IN of NRZ-L CODER.
5. Connect the NRZ-L DATA output to the DATA IN of the DIFFERENTIAL ENCODER.
6. Connect the clock generated SCLOCK to CLK IN of the DIFFERENTIAL ENCODER.
7. Connect differentially encoded data to control input CI of CARRIER MODULATOR.
8. Connect carrier component SIN 1 to IN1 and SIN 2 to IN2 of the Carrier Modulator Logic.
9. Connect DPSK modulated signal MOD OUT to MOD IN of the BPSK DEMODULATOR.
10. Connect output of BPSK demodulator b (t) OUT to input of DELAY SECTION b(t) IN and one input b(t) IN of decision device.

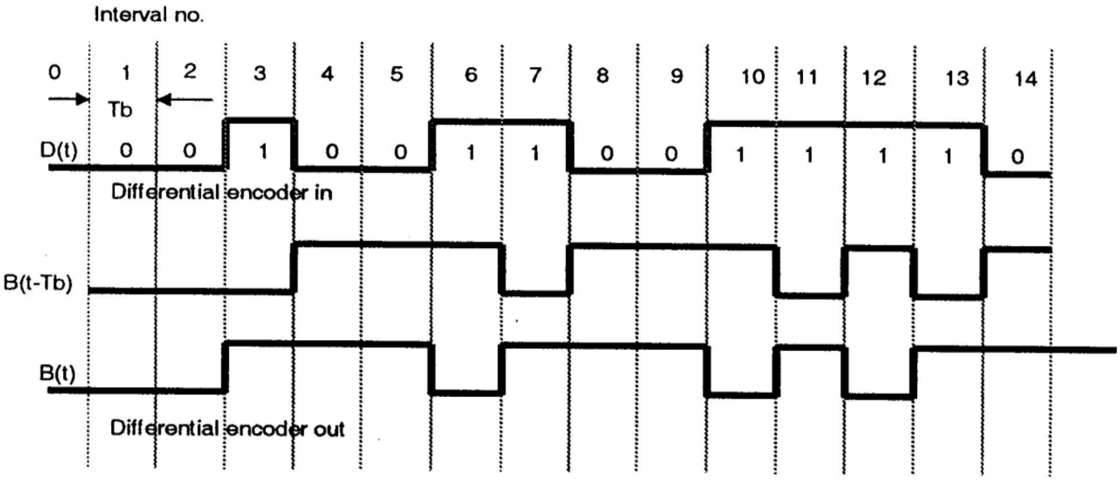
11. Connect the output of delay section b(t -Tb) OUT to the input b(t-Tb) IN of decision device.
12. Compare the DPSK decoded data at DATA OUT with respect to input SDATA.
13. Observe various waveforms as mentioned below (Fig. 3.3), If recovered data mismatches with respect to the transmitter data, then use RESET switch for clear observation of data output.

SWITCH FAULTS:

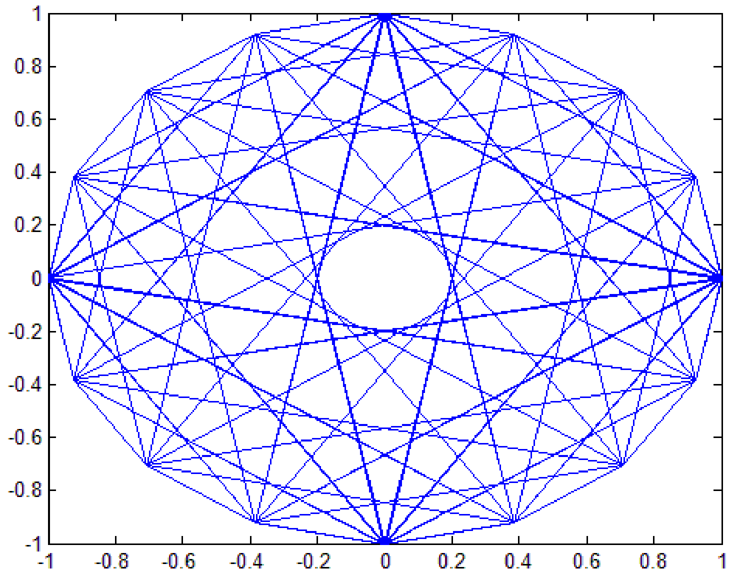
Note: Keep the connections as per the procedure. Now switch corresponding fault switch button in ON condition & observe the different effect on the output. The faults are normally used one at a time.

1. Put switch 1 of SF1 (ADCL-01) in Switch Fault section to ON position. This will open the MSB bit of the data Due to this MSB bit of data remains high (logic 1) irrespective to its switch position of SW1.
2. Put switch 2 of SF1 (ADCL-01) in Switch Fault section to ON position. This will open capacitor for filtering of carrier signal. Due to this amplitude of SIN 1 and SIN 2 gets reduced.
3. Put switch 3 of SF1 (ADCL-01) in Switch Fault section to ON position. This will open capacitor used to get 180 deg. Phase shift between SIN 1 & SIN 2. Due to this there is no 180 deg phase shift obtained.
4. Put switch 4 of SF1 (ADCL-01) in Switch Fault section to ON position. This will open input of the EX-OP. used in Differential encoder section, due to this we does not get proper encoded signal at the output of DIFFERENTIAL ENCODER.
5. Put switch 5 of SF2 (ADCL-01) in Switch Fault section to ON position. This will disable control signal C1 going to Modulator IC. Modulator will not able to modulate the signal properly.
6. Put switch 6 of SF2 (ADCL-01) in Switch Fault section to ON position. This will remove the connection for PLL input. Due to this PLL gets mistuned and BPSK/DPSK/DEPSK output gets disturbed.
7. Put switch 7 of SF2 (ADCL-01) in Switch Fault section to ON position. This will open the data input to the D-F/F in DELAY SECTION. Thus, output of the delay section gets disabled.
8. Put switch 8 of SF2 (ADCL-01) in Switch Fault section to ON position. This will remove one of the inputs in the DPSK decoder section. Due to this the decoded data having different pattern with respect to the transmitted data.

Waveforms of differential encoding data:



Constellation Diagram: for M=4



CONCLUSION:

The differential coding of data to be transmitted makes the bit "1" to be transformed into carrier phase variation. In this way the receiver recognizes one bit "1"at a time which detects a phase shift of the modulated carrier, independently from its absolute phase. In this way the BPSK modulation which can take to the inversion of the demodulated data, is overcome.

VIVA QUESTIONS:

1) Explain DPSK modulator and Demodulator.
2) Mention the difference between BPSK and DPSK