DEPARTMENT
OF
ELECTRONICS & COMMUNICATION ENGINEERING
ADVANCED COMMUNICATION LABORATORY MANUAL
VI Semester (17EC6DLADC)
Autonomous Course

HOD
Dr. T.C. Manjunath
Lab In-Charge
Prof. Yamuna B J

Name of the Student	:	
Semester /Section	:	
USN	:	
Batch	:	

Dayananda Sagar College of Engineering
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(An Autonomous Institute Affiliated to VTU, Approved by AICTE & ISO 9001:2008 Certified)
(Accredited by NBA, National Assessment & Accreditation Council (NAAC) with 'A' grade)

Dayananda Sagar College of Engineering
Dept. of E & C Engg

Name of the Laboratory	**:**	Advanced Communication Laboratory (17EC6DLADC)
Semester/Year	**:**	VI/2019-20 (Autonomous)
No. of Students/Batch	**:**	20
No. of equipment's	**:**	20
Major Equipment's	**:**	Digital Storage Oscilloscope Function generator Power Supply Fixed Power Supply Communication Kits Microwave Test Bench Microstrip Setup Antenna Set up Dell Computers (Windows 8.1 Matlab 2014)
Area in square meters	**:**	109.44 Sq mts
Location	**:**	Room No.17209, 17202
Total Cost of Lab	**:**	₹ . 32,61,390
Staffs In-charge	**:**	Prof. Rajanish N R Prof. Yamuna B J Prof. Trupti Tagare Prof. Kumar P
Instructor	**:**	Mr. Ramamurthy N Mrs.Gayathri H N
HOD	**:**	Dr. T.C. Manjunath, Ph.D. (IIT Bombay)

About the college & the department

The Dayananda Sagar College of Engineering was established in 1979, was founded by Sri R. Dayananda Sagar and is run by the Mahatma Gandhi Vidya Peetha Trust (MGVP). The college offers undergraduate, post-graduates and doctoral programs under Visvesvaraya Technological University & is currently autonomous institution. MGVP Trust is an educational trust and was promoted by Late. Shri. R. Dayananda Sagar in 1960. The Trust manages 28 educational institutions in the name of "Dayananda Sagar Institutions" (DSI) and multi – Specialty hospitals in the name of Sagar Hospitals - Bangalore, India. Dayananda Sagar College of Engineering is approved by All India Council for Technical Education (AICTE), Govt. of India and affiliated to Visvesvaraya Technological University. It has widest choice of engineering branches having 16 Under Graduate courses & 17 Post Graduate courses. In addition, it has 21 Research Centers in different branches of Engineering catering to research scholars for obtaining Ph.D. under VTU. Various courses are accredited by NBA & the college has a NAAC with ISO certification. One of the vibrant & oldest dept is the ECE dept. & is the biggest in the DSI group with 70 staffs & 1200+ students with 10 Ph.D.'s & 30^+ staffs pursuing their research in various universities. At present, the department runs a UG course (BE) with an intake of 240 & 2 PG courses (M.Tech.), viz., VLSI Design Embedded Systems & Digital Electronics & Communications with an intake of 18 students each. The department has got an excellent infrastructure of 10 sophisticated labs & dozen class room, R & D center, etc…

Vision and Mission of the Institute:

Vision:

- To impart quality technical education with a focus on Research and Innovation emphasizing on Development of Sustainable and Inclusive Technology for the benefit of society.

Mission:

- To provide an environment that enhances creativity and Innovation in pursuit of Excellence.
- To nurture teamwork in order to transform individuals as responsible leaders and entrepreneurs.
- To train the students to the changing technical scenario and make them to understand the importance of sustainable and inclusive technologies.

Vision and Mission of the Department

Vision:

- To achieve continuous improvement in quality technical education for global competence with focus on industry, societal needs, research and professional success.

Mission:

- Offering quality education in Electronics and Communication Engineering with effective teaching learning process in multidisciplinary environment.
- Training the students to take-up projects in emerging technologies and work with team spirit.
- To imbibe professional ethics, development of skills and research culture for better placement opportunities.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs):

After four years, the students will be

PEO1: ready to apply the state-of-art technology in industry and meeting the societal needs with knowledge of Electronics and Communication Engineering due to strong academic culture.

PEO2: competent in technical and soft skills to be employed with capability of working in multidisciplinary domains.

PEO3: professionals, capable of pursuing higher studies in technical, research or management programs.

PROGRAM SPECIFIC OBJECTIVES(PSOs):

Students will be able to

PSO1 : Design, develop and integrate electronic circuits and systems using current practices and standards.

PSO2 : Apply knowledge of hardware and software in designing Embedded and Communication systems.

PROGRAM OUTCOMES (POs)

PO1: Engineering Knowledge.

PO2: Problem Analysis.

PO3: Design Development of solutions.

PO4: Conduct investigations on complex problems.

PO5: Modern tool usage.

PO6: The Engineer and Society.

PO7: Environment and Sustainability.

PO8: Ethics.

PO9: Individual and team work.

PO10: Communication.

PO11: Project management and finance.

PO12: Life Long learning.

Course Objectives

COURSE OBJECTIVES:

1. To understand and implement TDM, ASK, FSK, PSK .
2. To analyze QPSK, DPSK and PCM operation.
3. To measure the losses and to calculate the numerical aperture for an Analog Optical Fiber Link.
4. To learn the assembly of Microwave test bench and perform basic measurements.
5. To obtain radiation patterns of Patch, Yagi and Dipole antennas.
6. To measure the probability of error in coherent digital modulation schemes.

COURSE OUTCOMES:

At the end of the course, student will be able to

CO1	Apply the knowledge of signals and digital communication to Design and demonstrate the digital modulation techniques.
CO2	Analyze radiation patterns of basic micro strip antennas
CO3	Examine micro wave devices using Micro strip lines
CO4	Test the working of microwave communication system.
CO5	Relate the basic knowledge of optical fiber communication in determining numerical aperture and losses in an optical fiber system.
CO6	Understand the probability of error computations of coherent digital modulation schemes.

Mapping of Course outcomes to Program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	-	2	-	-	-	1	1	-	-
CO2	3	2	-	-	-	-	-	-	1	1	-	-
CO3	3	2	-	-	-	-	-	-	1	1	-	-
CO4	3	2	-	-	-	-	-	-	1	1	-	-
CO5	3	2	-	-	-	-	-	-	1	1	-	-
CO6	3	2	-	-	2	-	-	-	1	1	-	-

ADVANCED COMMUNICATION LAB

Course Code : 17EC6DLADC **Credits : 02**
L : P : T : S : 1 : 2 : 0 : 0 **CIE Marks : 50**
Exam Hours : 03 **SEE Marks : 50**
Total Hours : 26 **CIE + SEE : 100**

Module	Expt No.	Content of the Lab Module	Hours	Cos
Experiments Performed using discrete components & kit				
PART-A	1.	TDM of two band limited signals	**18**	CO1
	2.	ASK generation and detection		CO1
	3.	FSK generation and detection		CO1
	4.	PSK generation and detection		CO1
	5.	Analysis of PCM System		CO1
	6.	DPSK generation and detection using kit		CO1
	7.	QPSK generation and detection using kit		CO1
	8.	Determination of characteristics of a strip line (or Microstrip) directional coupler, Microstrip ring resonator, Microstrip 3 dB power divider.		CO3
	9.	Measurement of frequency, guide wavelength, power, VSWR and attenuation in a Microwave test bench.		CO4
	10.	Understanding the radiation pattern of Microstrip Dipole, Yagi, Patch antenna by Antenna setup/Simulation		CO2
	11.	Measurement of propagation loss, bending loss and numerical aperture for an Analog optical fiber link.		CO5
Simulation Experiments using SCILAB/MATLAB/Simulink or LabVIEW				
PART-B	12.	a)Simulate NRZ, RZ, half-sinusoid and raised cosine pulses b) Generate eye diagram for binary polar signaling.	**8**	CO1
	13.	Pulse code modulation and demodulation system.		CO1
	14.	Computations of the Probability of bit error for coherent binary ASK, FSK and PSK for an AWGN Channel and Compare Performance.		CO6
	15.	Digital Modulation Schemes i) DPSK Transmitter and receiver, ii) QPSK Transmitter and Receiver.		CO1

Cycle of experiments

Expt. No.	Title of the experiments	Hours	COs
Cycle-I			
1.	TDM of two band limited signals	02	CO1
2.	ASK generation and detection	02	CO1
3.	DPSK generation and detection using kit for the given sequence & simulation	02	CO1
4.	QPSK generation and detection using kit for the given sequence & simulation	02	CO1
5.	a)Determination of characteristics of a strip line (or Microstrip) and Microstrip ring resonator. b)Determination of characteristics of a directional coupler and Microstrip 3 dB power divider.	02	CO3,4
6.	Measurement of frequency, guide wavelength, power, VSWR and attenuation in a Microwave test bench.	02	CO4
7.	Simulate NRZ, RZ, half-sinusoid and raised cosine pulses and generate eye diagram for binary polar signaling.	02	CO1
Cycle-II			
1.	PSK generation and detection.	02	CO1
2.	FSK generation and detection.	02	CO1
3.	Analysis of PCM System	02	CO1
4.	Measurement of propagation loss, bending loss and numerical aperture for an Analog optical fiber link.	02	CO5
5.	Understanding the radiation pattern of Microstrip Dipole, Yagi, Patch antenna by Antenna setup/Simulation	02	CO2
6.	Pulse code modulation and demodulation system.	01	CO1
7.	Computations of the Probability of bit error for coherent binary ASK, FSK and PSK for an AWGN Channel and Compare Performance.	01	CO6

DO's

- Students should follow the dress code of the laboratory compulsorily.
- Keep your belongings in the corner of the laboratory.
- Students have to enter their name, USN, time in/out and signature in the log register maintained in the laboratory.
- Students are required to enter components in the components register related to the experiment and handle the equipment's smoothly.
- Check the components, range and polarities of the meters before connecting to the circuit.
- Come prepare for the experiment and background theory.
- Before connecting to the circuit refer the designed circuit diagram properly. Debug the circuit for proper output.
- Students should maintain discipline in the laboratory and keep the laboratory clean and tidy.
- Observation book and Record book should be complete in all respects and get it corrected by the staff members.
- Clarify the doubts with staff members and instructors.
- Experiment once conducted, in the next lab, the entire record should be complete in all respects, else the student will lose the marks.
- For programming lab, show the output to the concerned faculty.

DONT's

- Do not switch on the power supply before verification of the connected circuits by concerned staff.
- Do not feed higher voltages than rated to the device.
- Do not upload, delete or alter any software on the laboratory PC's.
- Do not write or mark on the equipment's.
- Usage of mobile phone is strictly prohibited.
- Ragging is punishable.
  - If student damages the equipment or any of the component in the lab, then he / she is solely responsible for replacing that entire amount of the equipment or else, replace the equipment.

Experiment No. : 1	Date : / / .

TIME DIVISION MULTIPLEXING

Aim: To study Time Division Multiplexing & De-multiplexing process for two message signals

Apparatus/Components required: Transistors SL-100, SK100, Diode OA79, Resistors 1kΩ, 1.5kΩ , IC µA741, Capacitors 0.1µF , Function generator, Operational power supply, Regulated Power Supply, Connecting wires, CRO, Bread board.

Theory:

According to sampling theorem a continuous band limited signal can be transmitted by using its samples at a rate slightly greater than Nyquist rate and at the receiver these samples can be recovered back and get back the original continuous signal passing these samples through LPF. That is for the transmission of a message signal the communication channel is engaged for only a fraction of sampling interval on a periodic basis. Hence the time interval between the adjacent samples can be utilized for the transmission of the samples of other independent message signals. Such a multiplexing, which is based on time-shared units, is called time division multiplexing (TDM).

The time allocated to one sample of one message is called a time slot. The time interval over which all message are sampled at least once is called a frame, the portion of the slot not used by any of the sample pulse is called the guard time. In a practical system, some time slots may be allocated to other functions like signaling, monitoring and synchronization etc. The concept of TDM is illustrated with the waveform below.

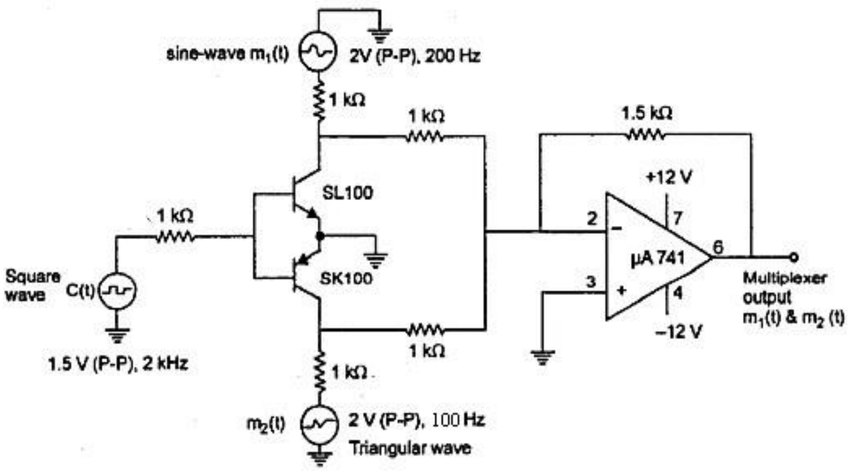
To maintain proper positions of sample pulses in the multiplexer, it is necessary to synchronize the sampling process, for which a clock pulse train is used as reference. At the receiver, there is a similar clock which helps in obtaining the synchronization.

Procedure:

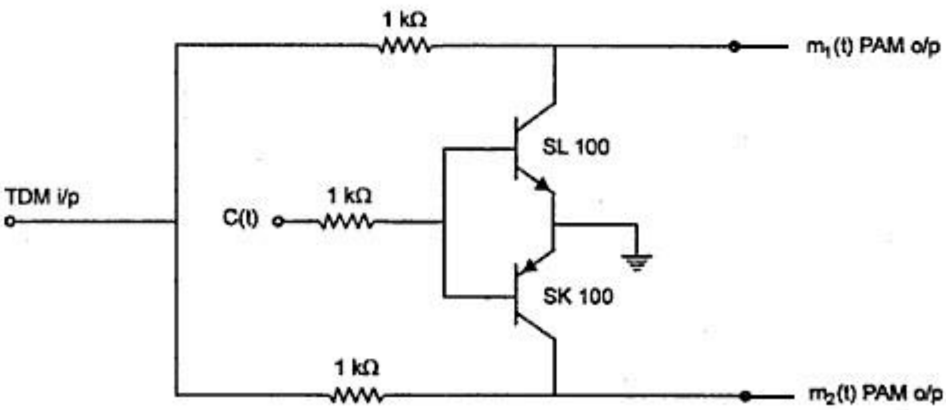
1. Rig up the circuit as shown in the circuit diagram for multiplexer.
2. Feed the input message signals m_1 and m_2 of 2 to 4V (p-p) at 200Hz and 100Hz.
3. Feed the high frequency sampling signal of 4 Vp-p at 2 kHz.
4. Observe the multiplexed output.
5. Rig up the circuit for demultiplexer.
6. Observe the demultiplexed output in the CRO.
7. Plot all signals on a graph sheet.

Circuit Diagram:

Multiplexer:

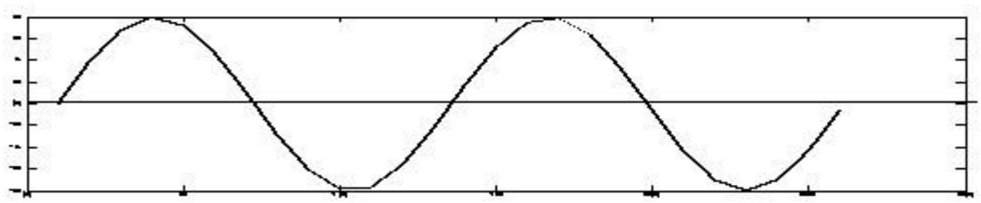


Demultiplexer:

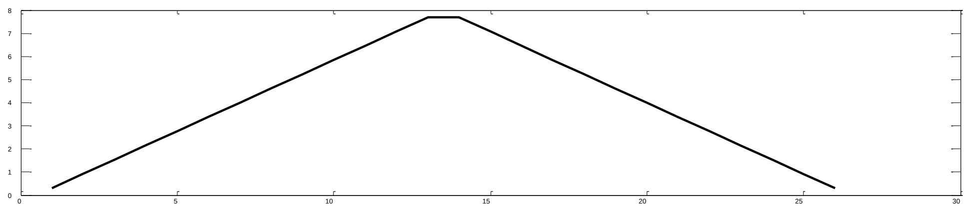


Nature of graph:

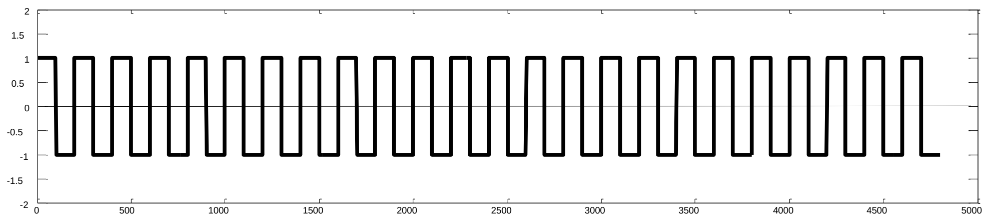
MULTIPLEXING:



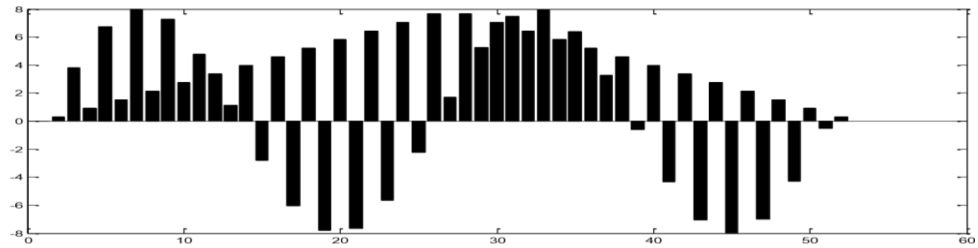
a. Message signal $m_1(t)$



b. Message signal $m_2(t)$

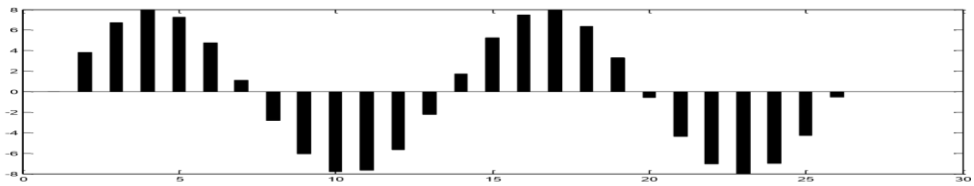


c. **Sampling signal C(t)**

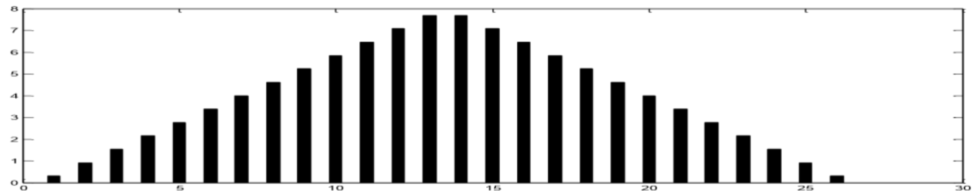


d. Sampled and multiplexed signal

DEMULTIPLEXING:

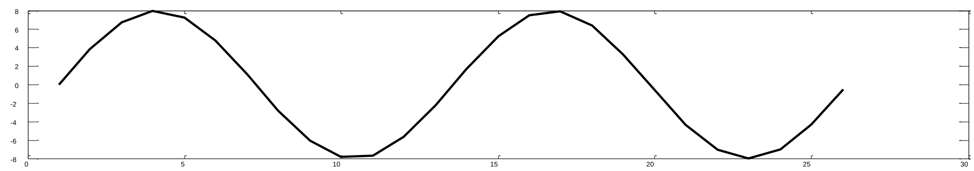


a. **m_1(t) PAM output**

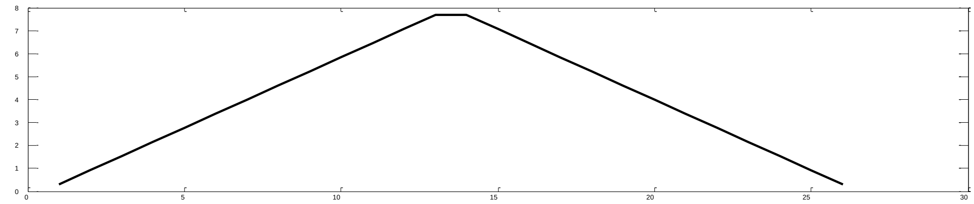


b. **m_2(t) PAM output**

By passing m1(t) and m_2(t) PAM signals through corresponding LPF we can obtain the reconstructed m_1(t) and m_2(t) as follows.



c. **Reconstructed m_1(t)**



d. **Reconstructed m_2(t)**

Results:

Applications:

Remarks :

Signature of Staff In charge with date

Probable viva questions:

1. What type of modulation is employed in TDM experiment?
2. What is multiplexing in the context of communication? What are different types of multiplexing?
3. What is multiplexer and demultiplexer?
4. What is TDM? How it is advantageous over FDM?
5. What is FDM? How it is different from TDM?
6. What is synchronization in TDM? Give its significance.
7. Give circuit diagram of TDM and explain its operation.
8. What is aliasing? How do you overcome this problem in practice?
9. What is multiple accesses? How it is different from multiplexing?

References:

1. An “**Introduction to Analog and Digital Communication”**, Simon Haykins, John Wiley India Pvt.Ltd., 2008

Experiment No. : 2	Date : / / .

AMPLITUDE SHIFT KEYING

Aim: To generate ASK signal and to detect the information signal from it.

Apparatus/Components required: Transistor SL- 100, Diode OA79, Resistors 4.7kΩ, 10kΩ, 22kΩ, IC μA741 , Capacitors 0.1 μF, Function generator, Operational power supply, Regulated Power Supply, Connecting wires, CRO, Bread board.

Theory:

Amplitude Shift keying is a form of digital modulation that represents digital data as variations in the amplitude of a carrier wave. The level of amplitude can be used to represent binary logic 0s and 1s. In the modulated signal, logic 0 is represented by the absence of the carrier and logic 1 is represented by the presence of the carrier, thus giving OFF/ON keying operation and hence the name On-Off Keying (OOK).

Like AM, ASK is also linear and sensitive to atmospheric noise, distortions, propagation conditions. Sharp discontinuities in the ASK waveform imply a wide bandwidth. But ASK modulation and demodulation processes are relatively inexpensive. The ASK technique is commonly used to transmit digital data over optical fiber.

Generation of ASK: ASK can be easily generated using transistor as a switch. Message, which is in the form of square wave, connected to base drives the transistor to saturation and cutoff alternatively. The carrier signal which is connected to collector will appear at the output when transistor is off, otherwise the output become zero as it get shorted to ground.

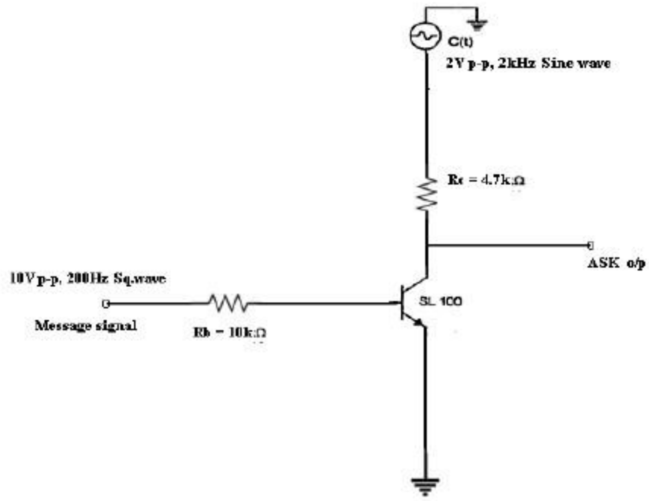
Demodulation: It is apparent that the ASK signal has a well-defined envelope. Thus it is amenable to demodulation by an envelope detector. Thus an envelope detector can be used as the first step in recovering the original sequence. Further processing can be employed to regenerate the true binary waveform.

Procedure:

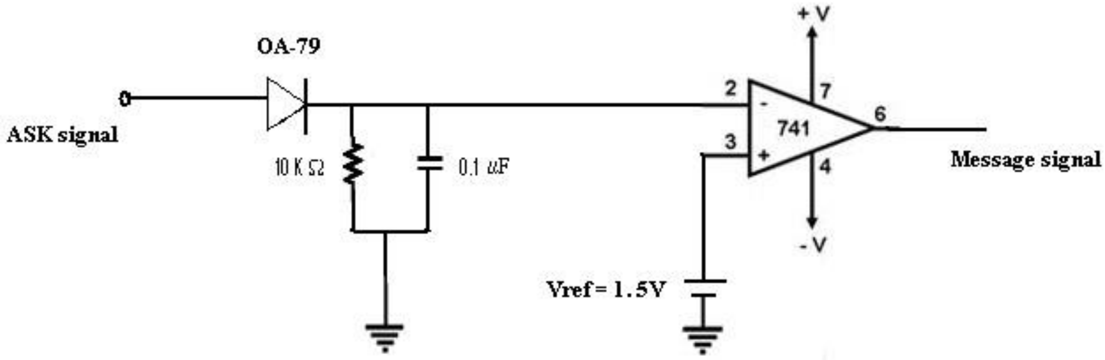
1. Rig up the circuit as shown in the circuit diagram
2. Feed the input message signal (square wave) of amplitude 10Vp-p and frequency 200Hz.
3. Feed the high frequency carrier signal of 2Vp-p and frequency 2 kHz.
4. Observe the ASK waveform at the collector of transistor.
5. Rig up the circuit for demodulation.
6. Feed output of ASK at the collector as the input to the demodulator circuit.
7. Observe the demodulated output.

Circuit Diagram:

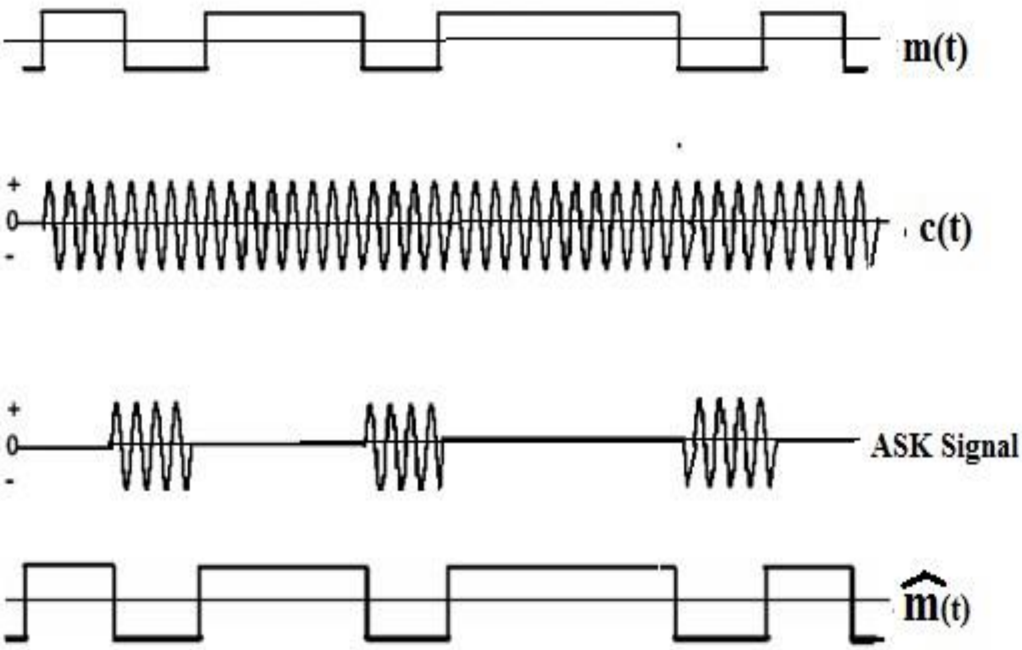
ASK modulator:



ASK demodulator:



Nature of graph:



Results:

Applications:

Remarks :

Signature of Staff Incharge with date:

Probable viva questions:

1. Give the significance of OA-79, IN-4001, BY-127?
2. What are the different types of digital modulation?
3. What is ASK? Explain the significance with practical applications?
4. Explain the operation of ASK modulator and demodulator circuits?
5. What is OOK? Give the difference between ASK and OOK
6. Differentiate coherent and non-coherent detection techniques?
7. Give the PSD plot for ASK and tell the BW requirement for ASK.
8. What are the disadvantages of ASK over other modulation schemes?

References:

1. Digital communications, Simon Haykin, John Wiley India Pvt. Ltd, 2008.
2. An introduction to Analog and Digital Communication, K. Sam Shanmugam, John Wiley India Pvt. Ltd, 2008.

Experiment No. : 3 Date : / / .

FREQUENCY SHIFT KEYING

Aim: To generate FSK signal and to detect the information signal from it.

Apparatus/Components required: Transistors SL-100, SK100, Diode OA79, Resistors 1kΩ, 10kΩ, 22kΩ , IC µA741, Capacitors 0.1µF, Function generator, CRO, Connecting wires, Bread board.

Theory:

FSK is a digital modulation technique wherein the frequency of the carrier signal is switched between two values. A frequency f_{c1} is used to represent symbol 1 and a frequency f_{c2} is used to represent symbol 0.

FSK modulated signal can be represented as

$S(t) = Ac\ COS\ (2\pi f_{c1}t)$ Symbol 1

$Ac\ COS(2\pi f_{c2}t)$ Symbol 0

FSK is a constant envelope modulation technique similar to FM. Hence it is insensitive to atmospheric noise, distortions and propagation conditions. Applications are in low speed digital data transmission systems. Its advantage is mainly due to hardware as we can use non coherent demodulation technique to get back the original signal. Probability of error is less compared to ASK but more compared to PSK. BW required is more compared to PSK. **Generation of FSK:** FSK can be generated using a PNP and NPN transistors as shown in circuit diagram. Transistors in this circuit acts as switches and connect either of the carrier signals to the output, as per the message signal.

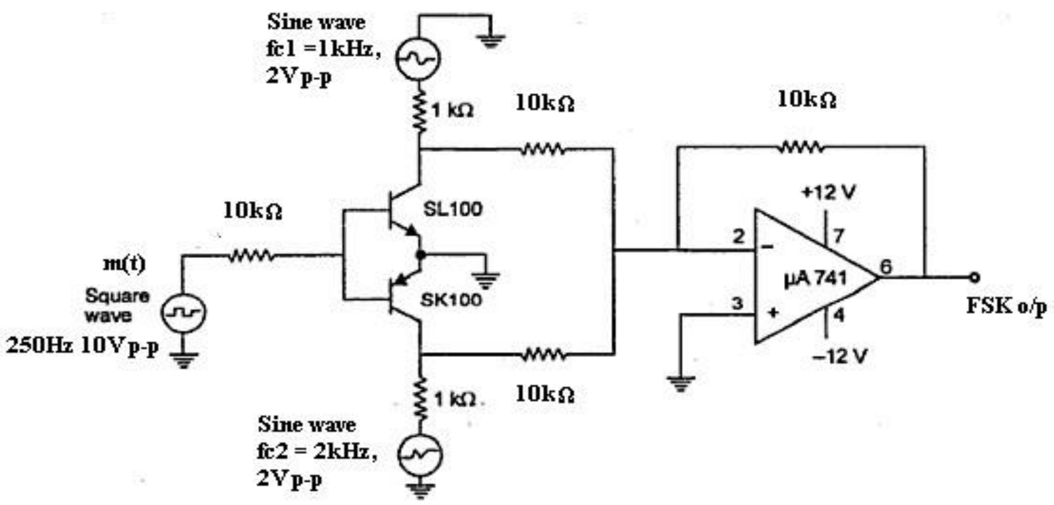
Demodulation: To detect message from FSK, first ASK is generated by subtracting one of the carrier from FSK signal. This ASK is then given to an envelope detector which can be further processed to regenerate the true binary waveform.

Procedure:

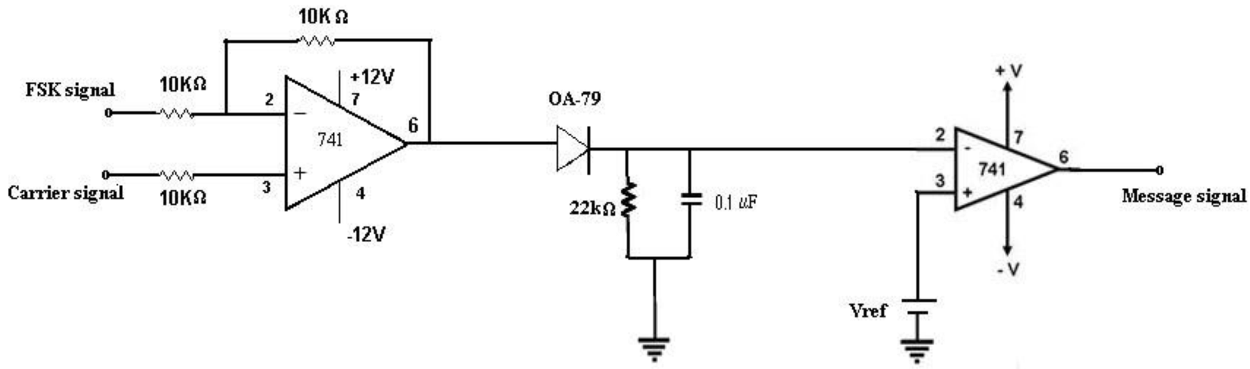
1. Connect the circuits as shown in fig, Apply carrier signal 1 of amplitude 2 Vp-p and frequency 1 kHz.
2. Apply carrier signal 2 of amplitude 2 Vp-p and frequency 2 kHz.
3. Apply message signal of amplitude 10 Vp-p and frequency 250Hz.
4. Observe the Amplitude shift keying outputs at each collector of transistor.
5. Finally observe the FSK output at pin 6 of operational amplifier.
6. Connect the demodulator circuit.
7. Give FSK as the input to the circuit.
8. Adjust Vref to get a proper square wave.
9. Observe the demodulated output

Circuit Diagram:

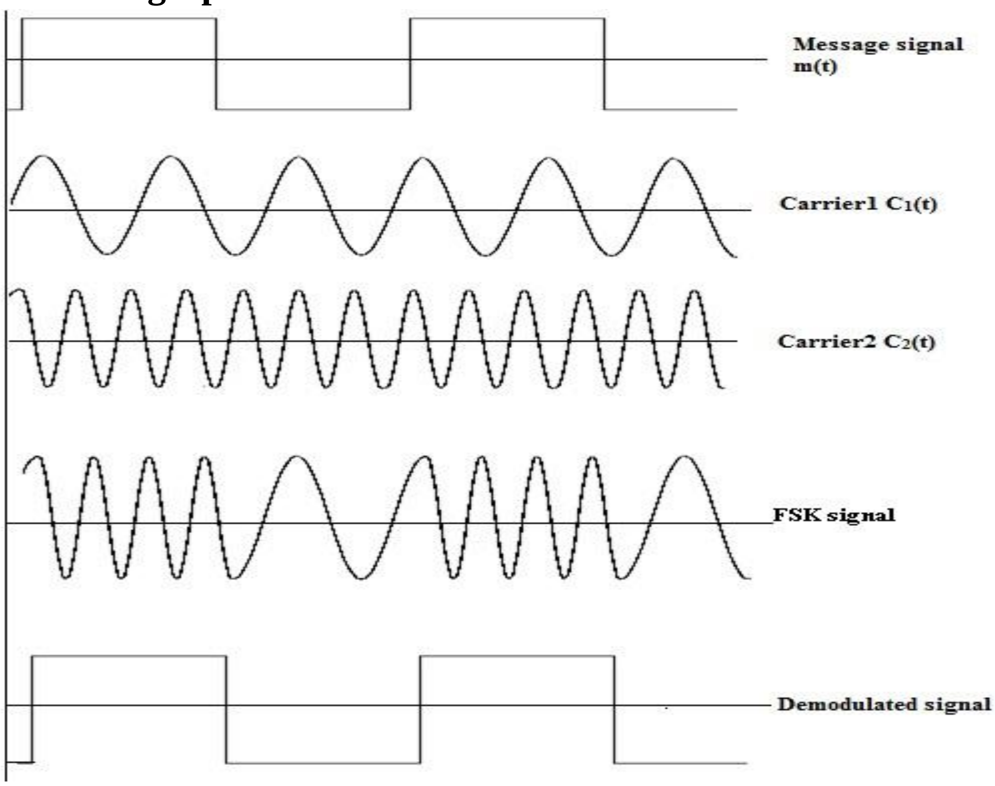
FSK Modulator:



FSK Demodulator:



Nature of graph:



Results:

Applications:

Remarks :

Signature of Staff Incharge with date:

Probable viva questions:

1. Explain the working of FSK modulator circuit?
2. What is the disadvantage of coherent FSK detection?
3. What are the advantages /disadvantages of FSK over ASK?
4. What is M-FSK? What are the advantages and disadvantages of M-FSK over binary modulation schemes?
5. What is MSK? How is it advantageous over FSK?
6. Give the PSD plot for FSK and tell the BW requirement for FSK

References:

1. Digital communications, Simon Haykin, John Wiley India Pvt. Ltd, 2008.
2. An introduction to Analog and Digital Communication, K. Sam Shanmugam, John Wiley India Pvt. Ltd, 2008.

Experiment No. : 4 Date : / / .

PHASE SHIFT KEYING (PSK)

Aim: To generate PSK signal and to detect the information signal from it

Apparatus/Components required:

Transistors	SL-100, SK100,
Diode	OA79
Resistors	1kΩ, 10kΩ,
IC	µA741
Capacitors	0.1µF

Function generator, Operational power supply, Regulated power supply, Connecting wires, CRO, Bread board.

Theory: Phase Shift Keying is a digital modulation technique where in phase angle of analog carrier signal is shifted between 0 and 180 degrees in accordance with input digital data. Since phase is shifting in accordance with input digital data we call it as Phase shift keying (PSK). PSK modulated waveforms can be represented as

$$S(t) = A_c \sin(2\pi ft) \quad \text{Symbol 1}$$
$$A_c \sin(2\pi ft + \pi) \quad \text{Symbol 0}$$

If the phase shifts occurs between two values it is called Binary phase shift keying (BPSK) This type of modulation will have least probability of error compared to other methods. Hence it is used for commercial mobile phone applications. It is also used in satellite communication.

Generation of PSK: To generate PSK, a PNP and NPN transistors are connected as shown in circuit diagram. Transistors are used as switches to connect the carrier to the inverting terminal of the OPAMP during negetive half cycle of the message signal and to the non-inverting terminal during positive half cycle of the message signal, thus generating BPSK signal.

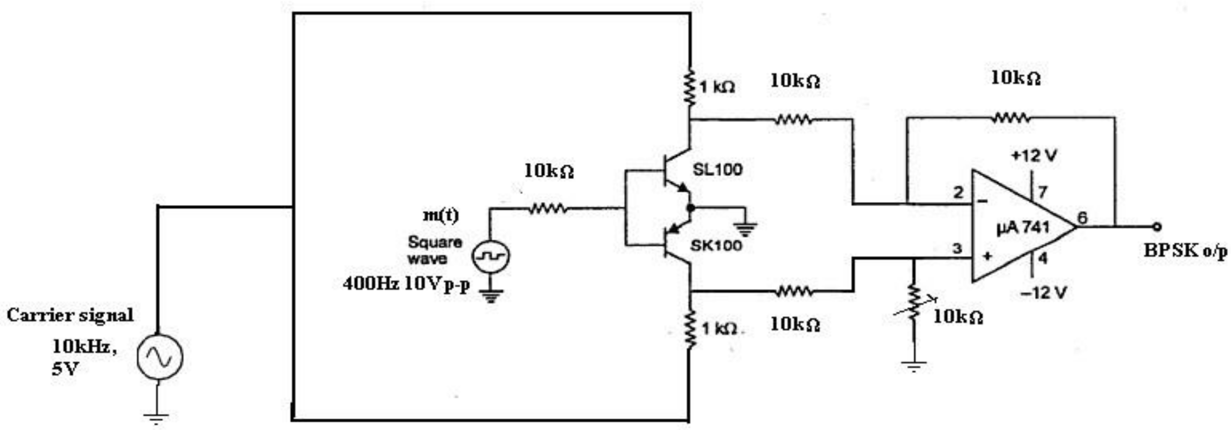
Demodulation: To detect message from PSK, first ASK is generated by subtracting one of the carrier from PSK signal. This ASKS is then given to an envelope detector which can be further processed to regenerate the true binary waveform.

Procedure:

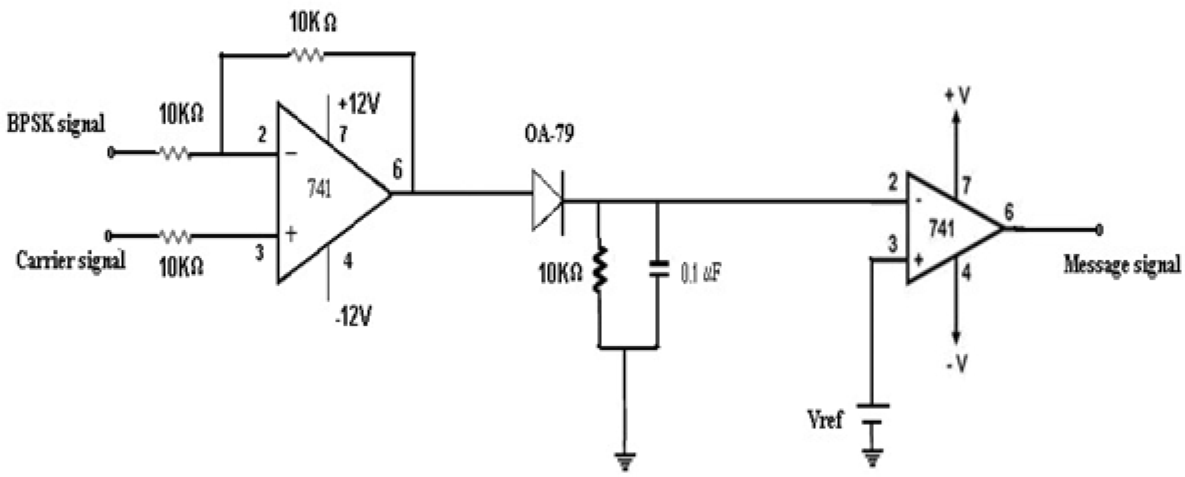
1. Connections are made as shown in figure.
2. Apply message signal of amplitude 10Vp-p and frequency 400Hz.
3. Apply carrier signal of amplitude 5Vp-p and frequency 10 kHz.
4. Observe the waveforms at collector of each transistor.
5. Observe the PSK output waveform at pin 6 of operational amplifier.
6. Now connect the demodulation circuit.
7. Give input as PSK signal to the demodulator circuit and observe the demodulated waveform.
8. Verify the signals.

Circuit Diagram:

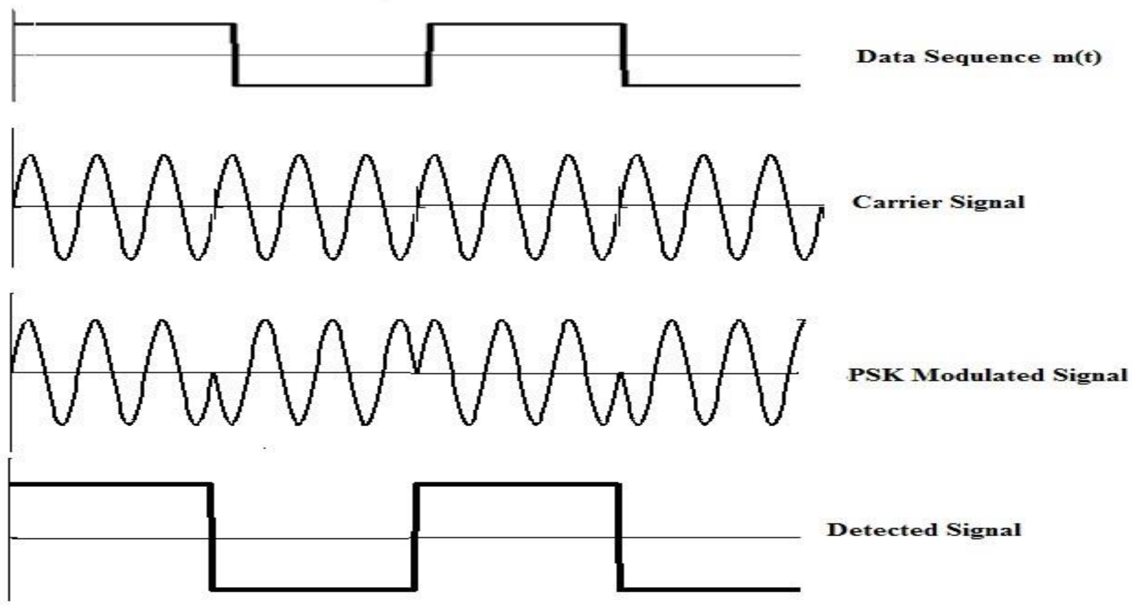
PSK Modulator



PSK Demodulator



Nature of graph:



Results:

Applications:

Remarks :

Signature of Staff Incharge with date:

Probable viva questions:

1. Explain the working of PSK modulator circuit?
2. What do you men by BPSK?
3. What are the advantages/disadvantages of PSK?
4. What type of detection technique is employed in PSK in your experiment?
5. Explain PSK with constellation diagram 6. Where do you find the application of PSK?
7. What do you mean by bit rate?
8. Compare PSK with ASK and FSK?
9. Name the hybrid modulation which combines FSK and PSK

References:

1. Digital communications, Simon Haykin, John Wiley India Pvt. Ltd, 2008.
2. An introduction to Analog and Digital Communication, K. Sam Shanmugam, John Wiley India Pvt. Ltd, 2008.

Experiment No. : 5 Date : / / .

PCM SYSTEM

Aim: To study the linearized A-law PCM coding. The analog to digital conversion as well as the reverse process.

Apparatus/Components required: Link-B Kit with power supply Patch chords,CRO

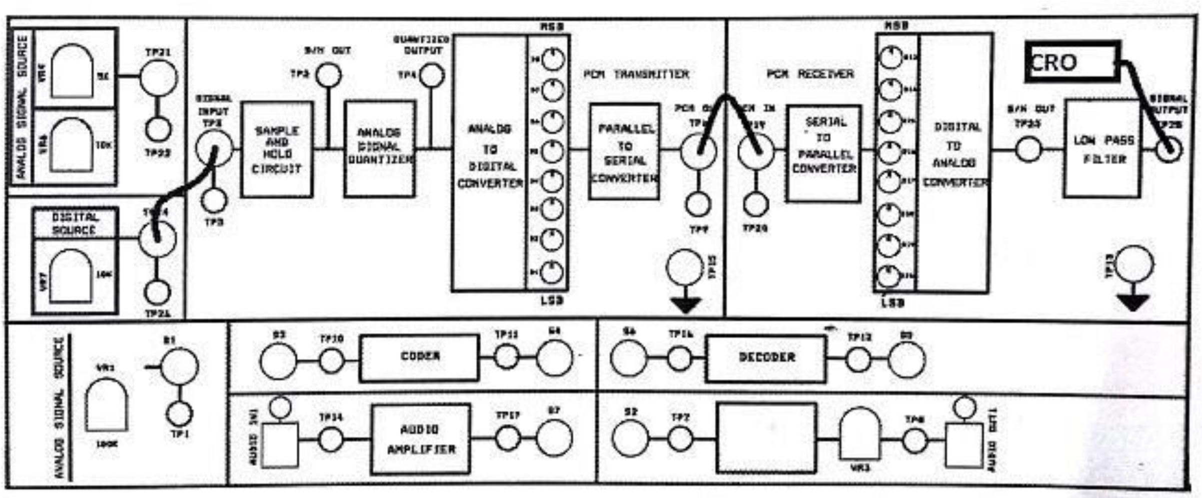
Theory: Present techniques of voice communication use standards such as A-law / µ – law companded PCM voice coding at 64 kbits/sec. When the analog speech signal is converted to pulse code modulation, it is first filtered using a low pass filter with a cut-off at about 3.4 KHz. The analog signal is sampled at 8 KHz as per the Nyquist Criteria. Each sample is quantized and coded into eight bits per sample. Actually the voice signal features something undesirable and that is its amplitude range varies greatly from one conversation to another. If the quantization levels are uniformly spaced then it certainly creates problems. If the amplitude of the signal is small, quantization levels have to be closely spaced. This gives proper resolution. But if the signal amplitude is large then this fine resolution will result in increasing the number of code bits. Hence, normally a technique of unequal spacing of quantization levels is used. In the Fiber Link B kit, the audio signal from the telephone handset is processed using telephone interface chip. It is then applied to voice coder. This chip actually performs analog to digital conversion and vice-versa. The digital data output is in pulse code modulated form. The CODEC chip used exhibits both A-law and u-law companding techniques. Here, we have selected ‘A’ law of companding. The digital output of CODEC is connected as i/p to the multiplexer. The received digital data is again converter into analog form by the chip.

Procedure:

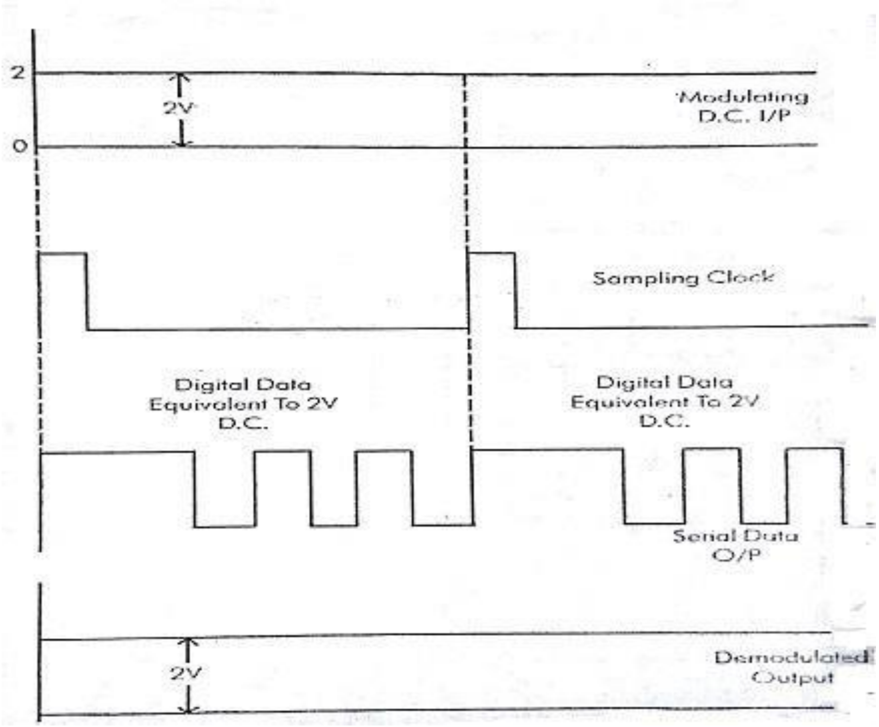
1. Connect the power supply cables with proper polarity to Link-B Kit and switch on the power supply.
2. Now connect analog input signal and note down its amplitude and frequency.
3. Observe the waveforms at outputs of sampler, Quantizer and Encoder and note down the outputs.
4. Now connect transmitter and receiver and note down the outputs at decoder and LPF outputs and note down the outputs.
5. Now connect DC input to the sampler.
6. Note down the amplitude of the input and observe the outpus at different parts and notedown.
7. Repeat for different DC voltages and tabulate voltage and corresponding code words at the encoder output.

Block Diagram of PCM

Connection diagram for DC input



Waveforms for DC input



Tabular Column:

(Note down Amplitude and Frequency of Analog Signal)

Note down different code words for different voltage levels when DC signal is connected

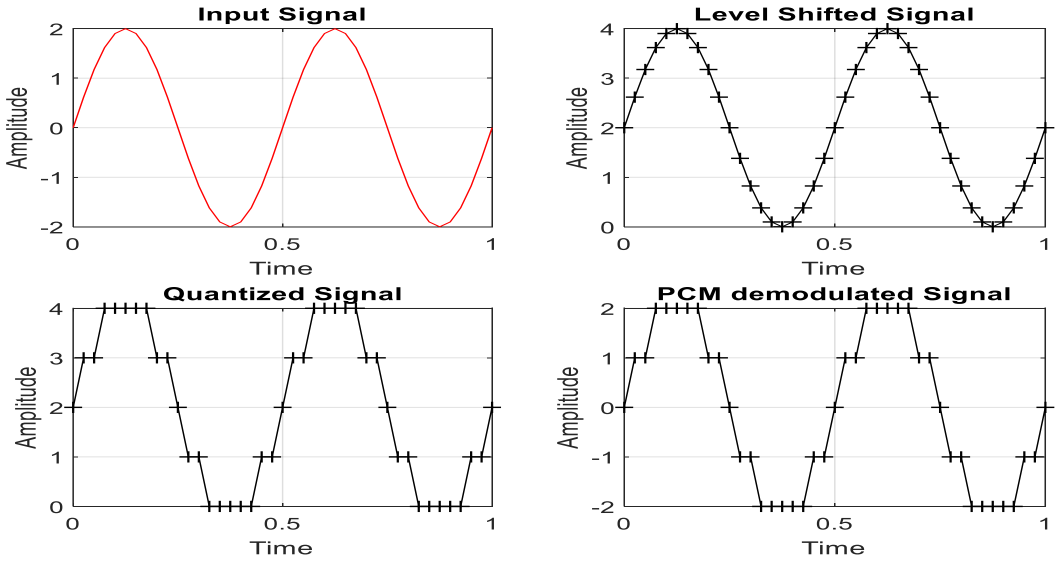
Sl.No.	Voltage	Code word

Results:

Experiment No. : 13. Simulate the Pulse code modulation and demodulation system and display the waveforms.

```
f=2; % freq of signal
fs=20*f; % Nyquist sampling
t=0:1/fs:1; % Time
a=2; % Amplitude

x=a*sin(2*pi*f*t); % input signal
figure;
subplot(2,2,1);
plot(t,x,'r-');
xlabel ('Time');
ylabel ('Amplitude');
title ('Input Signal');
grid on;

x1=x+a; % level shifting
subplot(2,2,2);
plot(t,x1,'k+-');
xlabel ('Time');
ylabel ('Amplitude');
title ('Level Shifted Signal');
grid on

q_op=round(x1);%quantization
subplot(2,2,3);
plot(t,q_op,'k+-');
xlabel ('Time');
ylabel ('Amplitude');
title ('Quantized Signal');
grid on;

enco=de2bi(q_op,'left-msb'); % decimal to binary
% pcm Rx
deco=bi2de(enco,'left-msb'); % binary to decimal

xr=deco-a; % level shifting back to original
subplot(2,2,4);
plot(t,xr,'k+-');
xlabel ('Time');
ylabel ('Amplitude');
title ('PCM demodulated Signal');
  grid on;
```

Results:



Applications:

Remarks :

Signature of Staff In charge with date:

Probable viva questions:

1. What is PCM?
2. Define terms sampling, Quantization and Encoding.
3. Is quantization a reversible process?
4. What is the relation between no. of quantization levels and no. of bits needed for encoding in PCM?
5. What is bandwidth of voice signal?

References:

1. Digital communications, Simon Haykin, John Wiley India Pvt. Ltd, 2008.
2. An introduction to Analog and Digital Communication, K. Sam Shanmugam, John Wiley India Pvt. Ltd, 2008.

Experiment No. : 6	Date : / / .

DIFFERENTIAL PHASE SHIFT KEYING (DPSK)

Aim: To generate Differential Phase Shift Keying signal and detect message signal from it.

Apparatus/Components required: DPSK modulator and demodulator trainer kit, Delay generator, Modulator, CRO, probes.

Theory:

Differential phase shift keying (DPSK) is the non-coherent version of Phase shift keying. It eliminates the need for a coherent reference signal at the receiver by combining two basic operations at the transmitter.

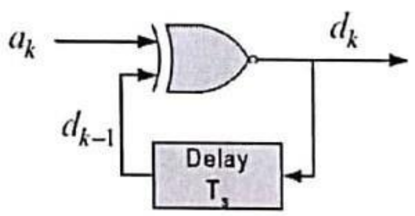
1) Differential encoding of the input binary wave and
2) Phase shift keying,

Hence, the name differential phase shift keying (DPSK).

In effect, to send symbol 1, phase advance the current signal waveform by 180^0, and to send symbol 0 leave the phase of the current signal waveform unchanged. The receiver is equipped with a storage capability, so that it can measure the relative phase difference between the waveforms received during two successive bit intervals provided that the unknown phase contained in the received wave varies slowly. The circuit complexity is less for DPSK compared to BPSK. The probability of error and noise interference is more in DPSK.

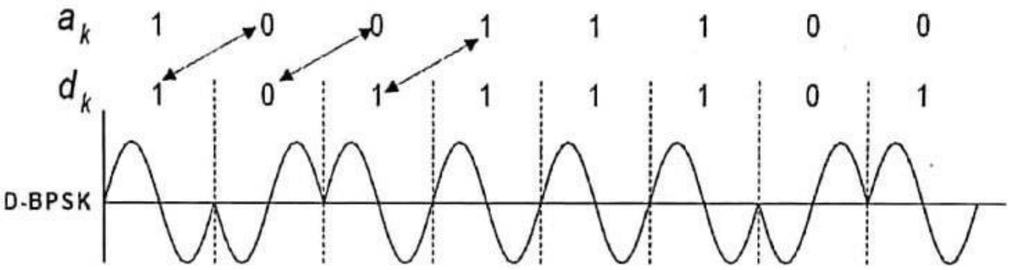
In the kit used to generate DPSK, differentially encoded signal is generated by converting unipolar NRZ data to polar NRZ-M waveform which is same as the differentially encoded data, assuming 0 as initial bit. This waveform is used as data input to PSK modulator to get DPSK output. To decode, first DPSK signal is converted to binary data which is in NRZ-M format and then decoded back to NRZ unipolar format.

Differential encoding with Ex-NOR logic (initial bit=1)



$$d_k = \begin{cases} \overline{d_{k-1}}, & a_k = 0 \\ d_{k-1}, & a_k = 1 \end{cases}$$

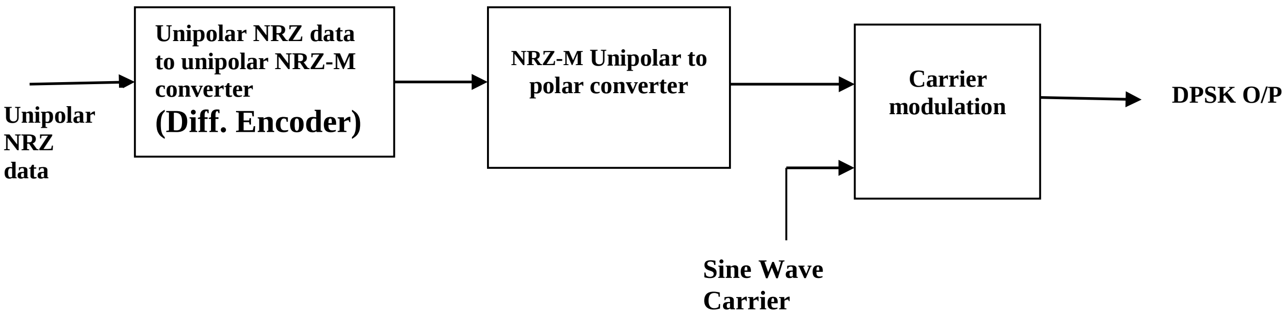
a_k	d_{k-1}	d_k
0	0	1
0	1	0
1	0	0
1	1	1



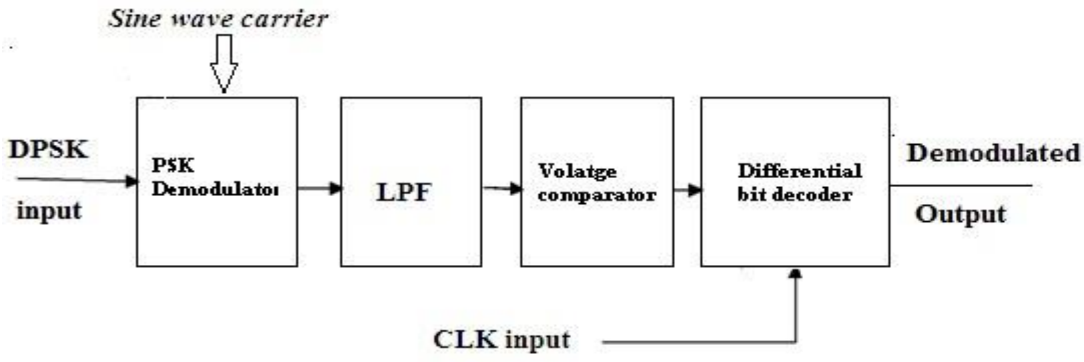
- The 1-bit delay can be realized very simply using a clocked shift register

Block Diagrams:

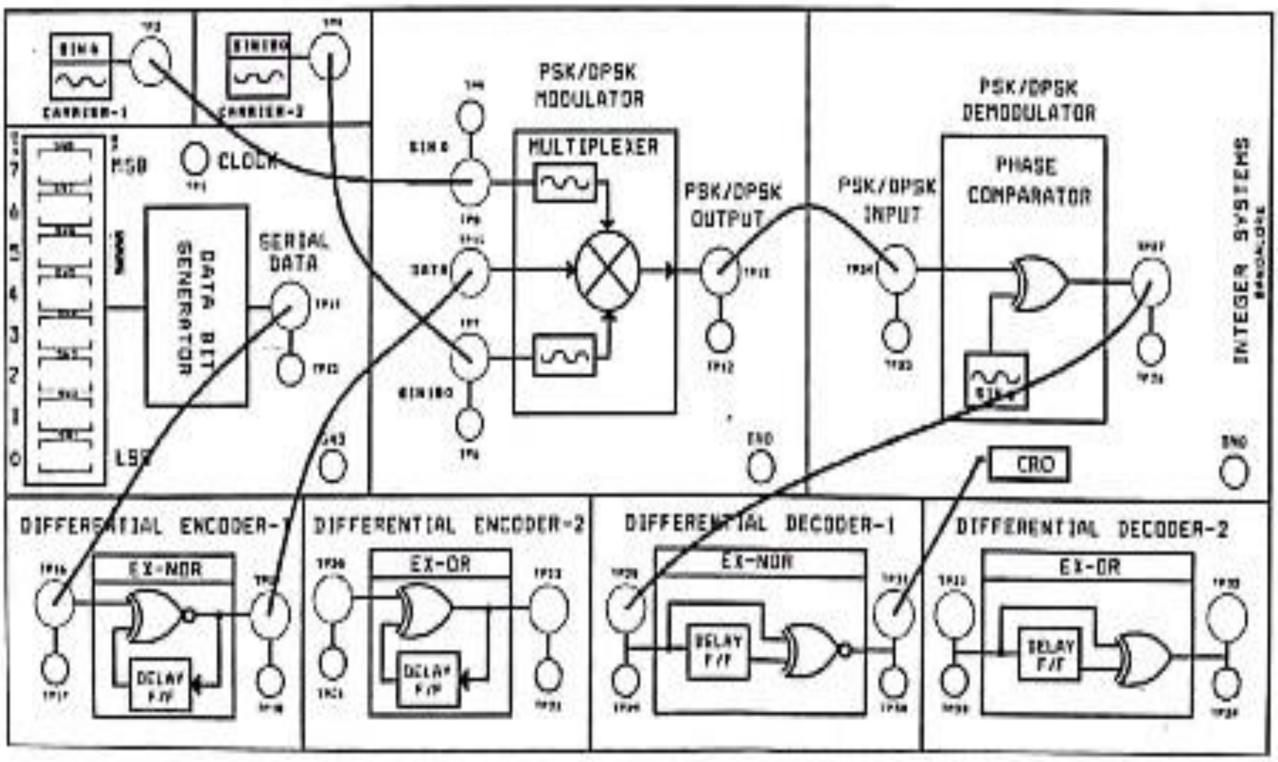
DPSK Modulator



DPSK Demodulator



Connection Diagram of DPSK Modulator and Demodulator with Ex-NOR Differential Encoding



Procedure:

MODULATION

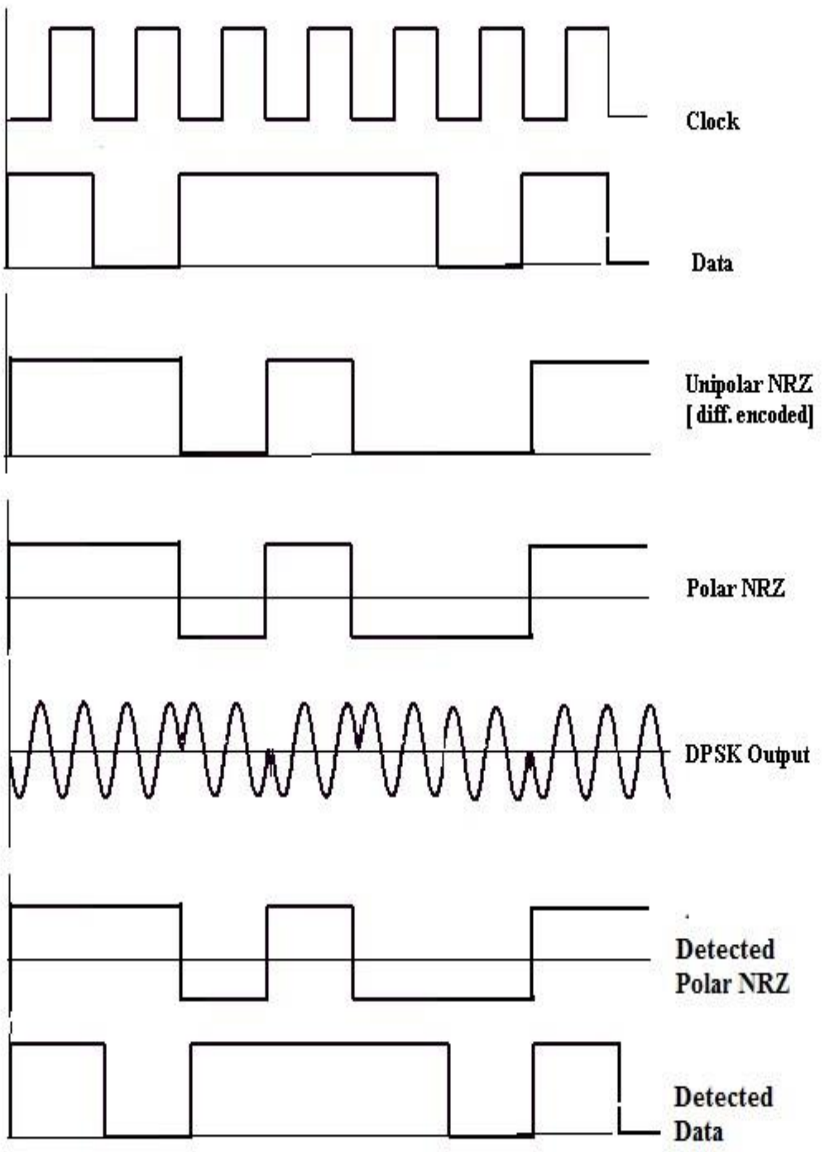
1. Connect the supply to the kit.
2. Select the input bit stream by the combination of DIP switches.
3. From these switches set 8 bit data.
4. Connect the patch cords as shown in the block diagram
5. DPSK data changes the phase of carrier when selected data bit=1 and remains in same phase when data bit is 0.

DEMODULATION:

1. Connect the demodulator as shown in the block diagram
2. Connect the DPSK input.
3. Observe the demodulated output.

Nature of graph:

Waveforms: For input data 10111010

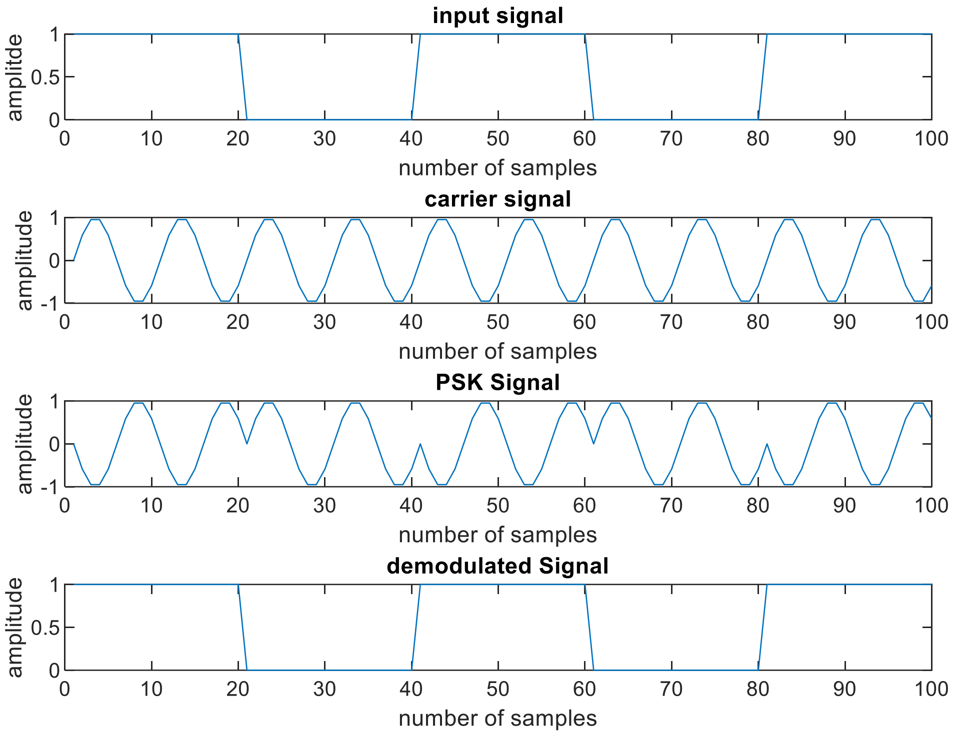


Results:

Experiment No. : 15 a Simulation of Digital Modulation DPSK

```
clc
clear all
close all
n=100
x=[ones(1,20) zeros(1,20) ones(1,20) zeros(1,20) ones(1,20)]
subplot(4,1,1);
plot(x)
title('input signal')
xlabel('number of samples')
ylabel('amplitde')
f=1*10^6;
fs=10*10^6;
for i=0:n-1
d(i+1)=sin(2*pi*(f/fs)*i);
end
subplot(4,1,2);
plot(d);
title('carrier signal');
xlabel('number of samples');
ylabel('amplitude');
for i=0:n-1
if(x(i+1)==0)
x(i+1)=sin(2*pi*(f/fs)*i);
else
x(i+1)=sin(2*pi*(f/fs)*i+pi);
end
end
subplot(4,1,3);
plot(x);
title('PSK Signal');
xlabel('number of samples');
ylabel('amplitude');
for i=0:n-1
if(x(i+1)==sin(2*pi*(f/fs)*i))
    x(i+1)=0;
else
x(i+1)=1;
end
end
subplot(4,1,4);
plot(x);
title('demodulated Signal');
xlabel('number of samples');
ylabel('amplitude');
```

Results:



Applications:

Remarks :

Signature of Staff Incharge with date:

Probable viva questions:

1. What is the bandwidth of DPSK Signal?
2. How noise excursions cancel in DPSK?
3. How the information is coded and decoded in DPSK?
4. What is the main disadvantage of DPSK and how it is rectified?
5. Explain DPSK with constellation diagram
6. What are the disadvantages of DPSK technique?
7. Give DPSK signal for the data 11001010111.

References:

1. Digital communications, Simon Haykin, John Wiley India Pvt. Ltd, 2008.
2. An introduction to Analog and Digital Communication, K. Sam Shanmugam, John Wiley India Pvt. Ltd, 2008.

Experiment No. : 7 Date : / / .

QUADRATURE PHASE SHIFT KEYING (QPSK)

Aim: To generate the QPSK waveform for a given binary digital signal and demodulate the same QPSK to get back the original signal.

Apparatus/Components required: QPSK modulator trainer kit, CRO, probes, connecting wires.

Theory:

The QPSK a multilevel shift keying technique where in M=4 and individual dibit is represented by different phase shifts. In particular, the phase of the carrier takes on one of the four equally spaced values such as Π/4, 3Π/4, 5Π /4 and 7Π /4. Each possible value of the phase corresponds to a unique pair of bits like 10, 00, 01 and 11 called dibit.

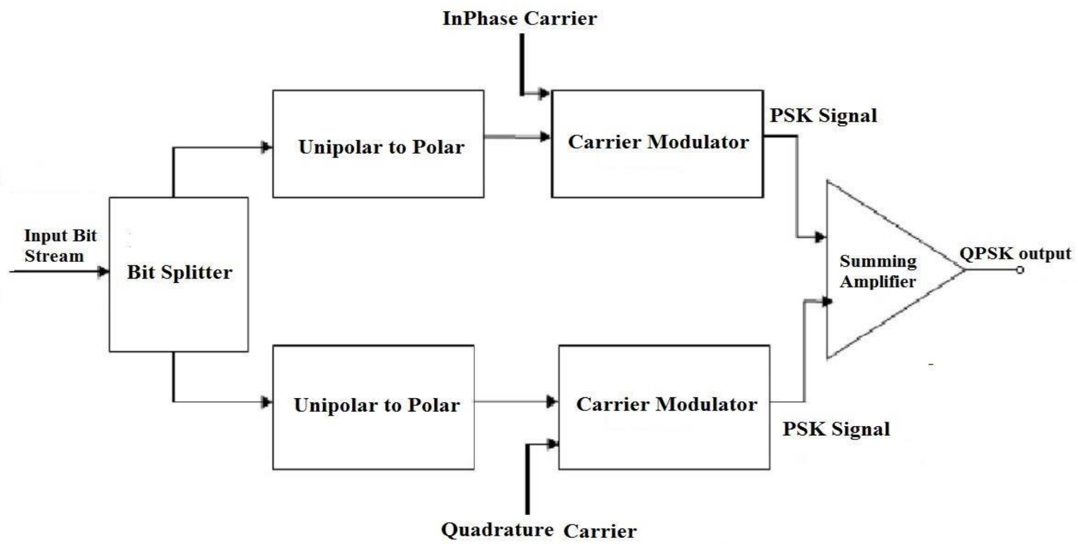
QPSK perform by changing the phase of the In-phase (I) carrier from 0° to 180° and the Quadrature-phase (Q) carrier between 90° and 270°. These two signals are added to get four phases to represent 4 states of a 2-bit binary code.

The QPSK waveform is widely used because it offers the best tradeoff between power and bandwidth requirements. Also, it provides very low probability of error. Some of the popular applications of QPSK include: CDMA Systems, Iridium (voice/data) Satellite Communication System, Digital Video Broadcasting Satellite (DVB-S), and satellite transmission of MPEG-2 video, Cable modems, Video conferencing, Cellular phone systems and other forms of digital communication over an RF carrier.

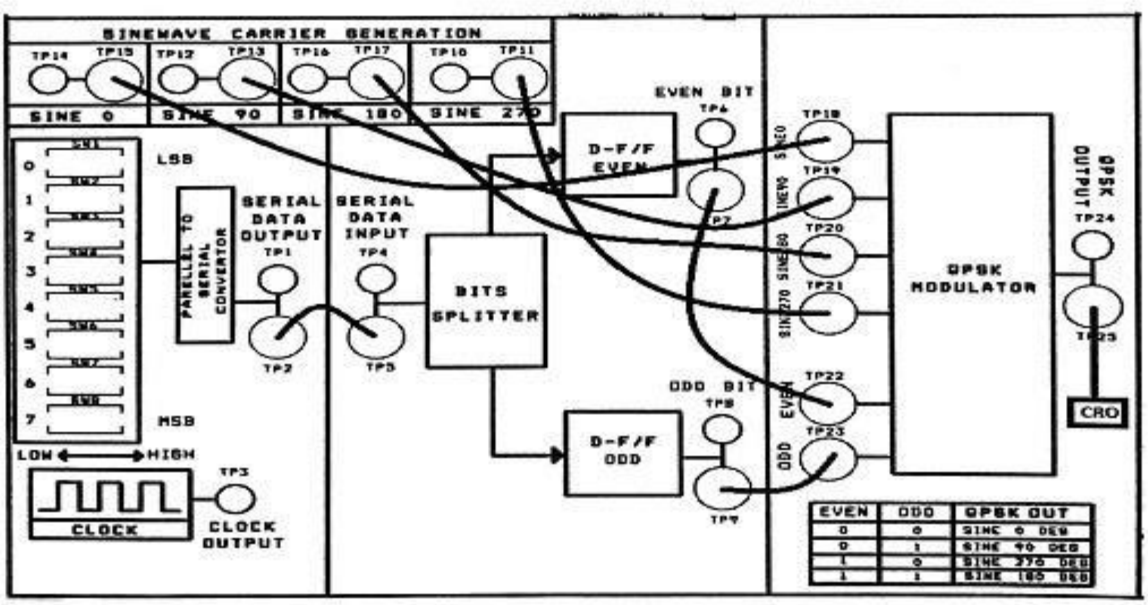
Procedure:

1. Connect sinusoidal signals with 4 phase shifts 0^0, 90^0, 180^0 and 270^0 as shown in the Kit connection diagram.
2. Take output from serial bit generator and give it to the serial data output of QPSK modulator.
3. Now observe the Even , Odd and QPSK waveform at the different output terminal.
4. Now feed QPSK signal to the input of the demodulator & observe binary output using CRO.

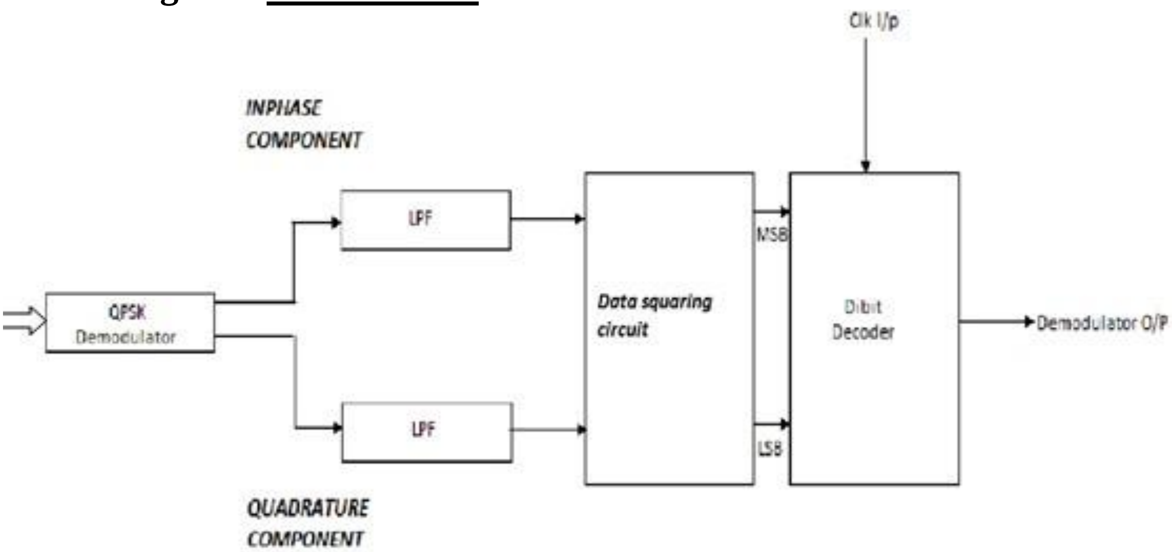
Block Diagram: Modulator:



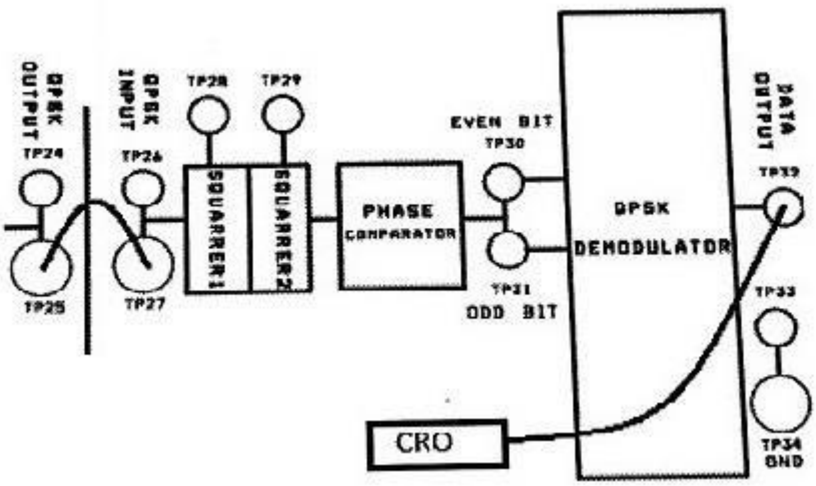
Kit Diagram



Block Diagram: <u>Demodulator</u>



Kit Diagram



Differential Phases for Sine signal

Dibits: **00 => 0^0** **01 => 90^0** **11=> 180^0** **10=> 270^0**

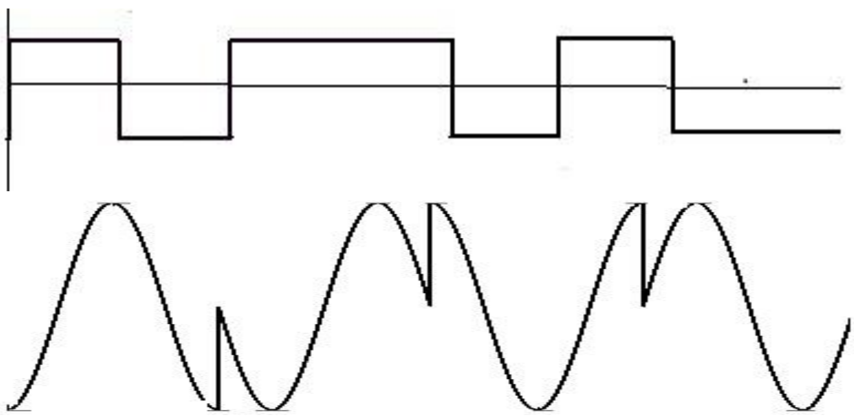
Tabular Column:
(Note down phase angles for di-bits from Kit)

For data 00101101

Keep 1 at LSB of kit and 0 at MSB while giving data

Even bits =	**1**	**1**	**0**	**0**
Odd bits =	**0**	**1**	**1**	**0**
Phase shifts	**270_0**	**180_0**	**90_0**	**0_0**

Even bits



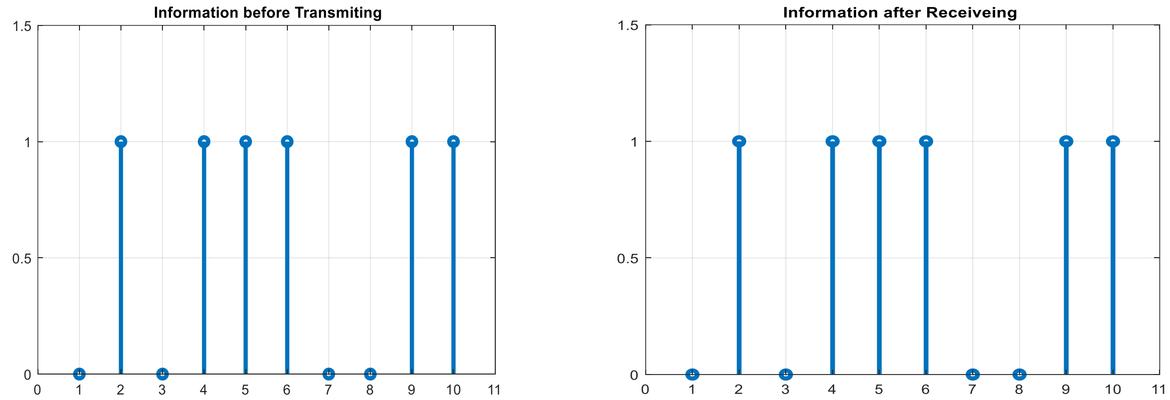
Results:
(Note down waveforms at different stages from kit)

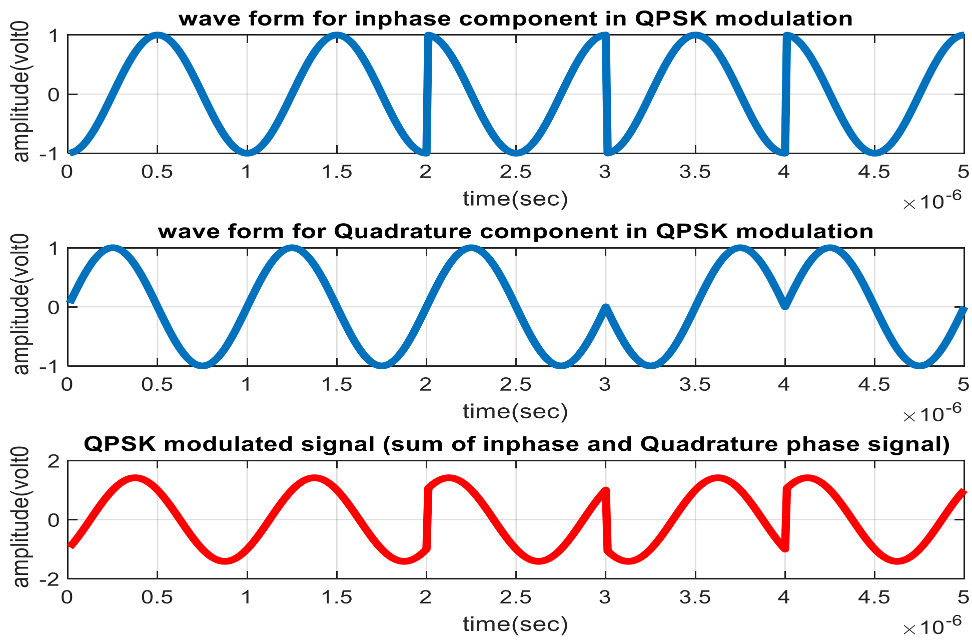
Experiment No. : 15b Simulation of Digital Modulation Scheme QPSK

```
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 modulatio
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)
    %% inphase coherent dector
    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 XXXXXX
    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;
```

Results:





Applications:

Remarks :

Signature of Staff In charge with date:

Probable viva questions:

1. Which are the two important band width conserving modulation schemes for transmission of binary data?
2. What is minimum shift-keying?
3. What is the bandwidth of QPSK SIGNAL?
4. How noise excursions cancel in QPSK?
5. How the information is coded and decoded in QPSK?
6. What is the main disadvantage of QPSK and how it is rectified?
7. Given the binary data 110110001011, give the phase changes in QPSK.
8. What is OQPSK? How it is different from ordinary QPSK?
9. What are the advantages of OQPSK
10. What is I-bit and Q-bit in QPSK?

References:

1. Digital communications, Simon Haykin, John Wiley India Pvt. Ltd, 2008.
2. An introduction to Analog and Digital Communication, K. Sam Shanmugam, John Wiley India Pvt. Ltd, 2008.

Experiment No. : 8	Date : / / .

MICROSTRIP RING RESONATOR

Aim: To Study of resonance characteristic of a micro strip ring resonator and determination of dielectric constant of the substrate.

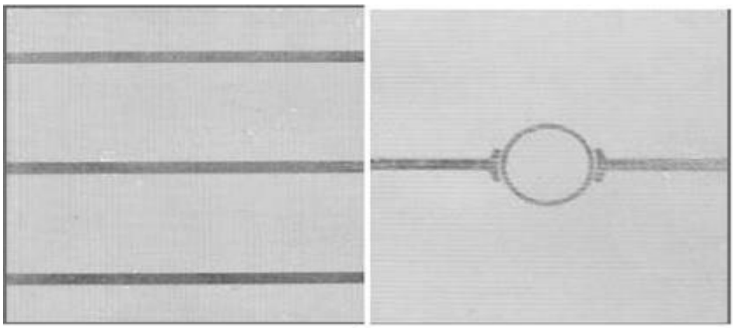
Apparatus/Components required:

Micro Strip Setup, (VCO, Test Gig, Detector, Filter, 50 Ohm Transmission line) Micro Strip Ring Resonator, Dielectric material, CRO/VSWR meter

Theory:

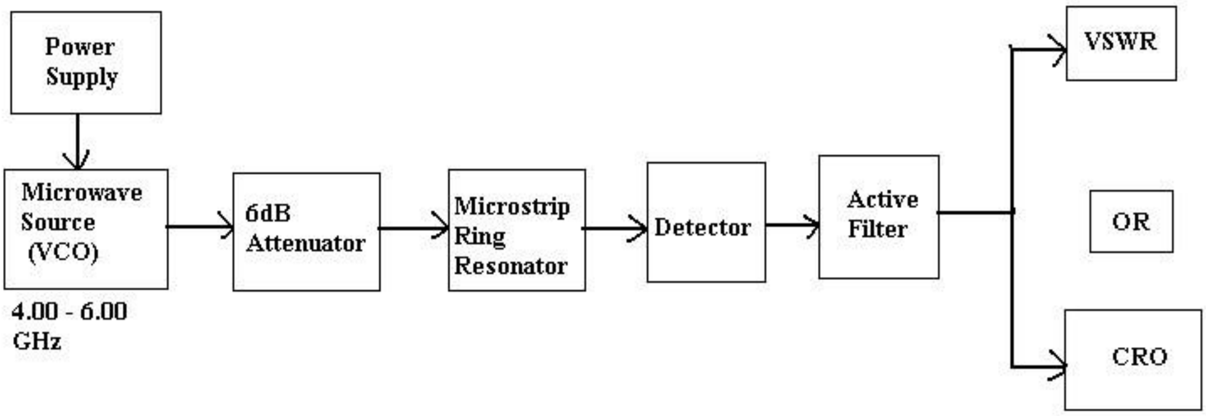
Micro strip ring resonators are widely used in many microwave devices, particularly in filters and mixers, Oscillators and couplers. An interest to these structures has recently increased due to the application of ferroelectric thin film structures and high temperature superconducting micro strip lines in ring resonator fabrication. The microwave components based on such structures have smaller size, lighter weight a higher Q-factor because of the super conductivity of micro strips and are tunable due to the sensitivity of the substrate changes in dc electric fields.

The ring resonator has one frequency called the resonant frequency at which the maximum value of the output is obtained. By using the ring resonator it is possible to find the dielectric constant of an unknown material. When the dielectric piece is placed on the resonator surface there is a change in the magnitude of the output and the frequency also changes accordingly.



(a) 50-ohm through Line and (b) Ring Resonator.

BLOCK DIAGRAM:



Procedure:

Part-A (Study of Transmission Line)

1. Set up the system as shown in the figure.
2. Keep the voltage at minimum ,switch on the power supply
3. Insert a 50 ohm transmission line and check for the output using a CRO.
4. Vary the power supply voltage and check the output for different VCO frequencies.
5. Find the resonant frequency that is the operating frequency.
6. Replace the 50 ohm transmission line with ring resonator.
7. Vary the power supply voltage and check the output for different VCO frequencies of the ring resonator.
8. Plot a graph frequency Vs output and find the resonant frequency.

50 ohm matched termination.

Frequency	Output voltage(in volts)

Part -B (Study of Ring Resonator)

1. Select a VCO frequency where there is a measurable output. Note down the magnitude of the output.
2. Place the unknown dielectric material on top of the ring resonator. Ensure that there is no air gap between the dielectric piece and resonator surface.
3. Observe the change in the magnitude at the output.
4. Now reduce the supply voltage till maximum power level is achieved. This is the new resonance condition due to the intersection of new dielectric material(Teflon)
5. Note down the VCO frequency (say f2).
6. Calculate the dielectric constant of the unknown material by using formula given.
7. Experiment may be repeated with different unknown material or with same material but do different height of the material**.**

Ring resonator (without Teflon):

Frequency	Output voltage(in volts)

Ring resonator (with Teflon):

Frequency	Output voltage(in volts)

CALCULATIONS: f_1 is the resonant frequency without teflon obtained from the graph.

f_2 is the resonant freqency with teflon obtained from the graph.

Find $\lambda_1 = (C/f_1)$……………. (1)

$\lambda_2 = (C/f_2)$……………. (2) where C=velocity of light **Tabulation of f and λ values**

f1	λ1	f2	λ2

Let ε_r=dielectric constant of known material (ε_r =3.2 for RT duroid) $\varepsilon 1= \varepsilon\ eff$ Effective dielectric constant of the known material which can be calculated using the formula

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[\left[1+\frac{12h}{w}\right]^{-1/2}\right]$$

--------------- (3)

Where, h=height of the known sample (substrate used for ring resonator) =0.762mm

w= width of the transmission line = 1.836mm

We need to calculate ε2, which is the Effective dielectric constant of the unknown material

$$\lambda_1 / \varepsilon_1 = \lambda_2 / \varepsilon_2$$

$$\varepsilon_2 = \varepsilon_1 * \lambda_2 / \lambda_1$$

-------- (4)

To calculate the dielectric constant ε_r of unknown material, substitute $\varepsilon 2= \varepsilon\ eff$ in formula(3)

Results:

Applications:

Remarks :

Signature of Staff In-charge with date:

Experiment No. : 8a	Date : / / .

MICROSTRIP DIRECTIONAL COUPLER

Aim: To determine the coupling & isolation characteristics of a micro-strip directional coupler.

Apparatus/Components required: Power supply, Microstrip Setup, Microstrip Directional Coupler, 50 ohm terminations cables with SMA connectors CRO/VSWR meter

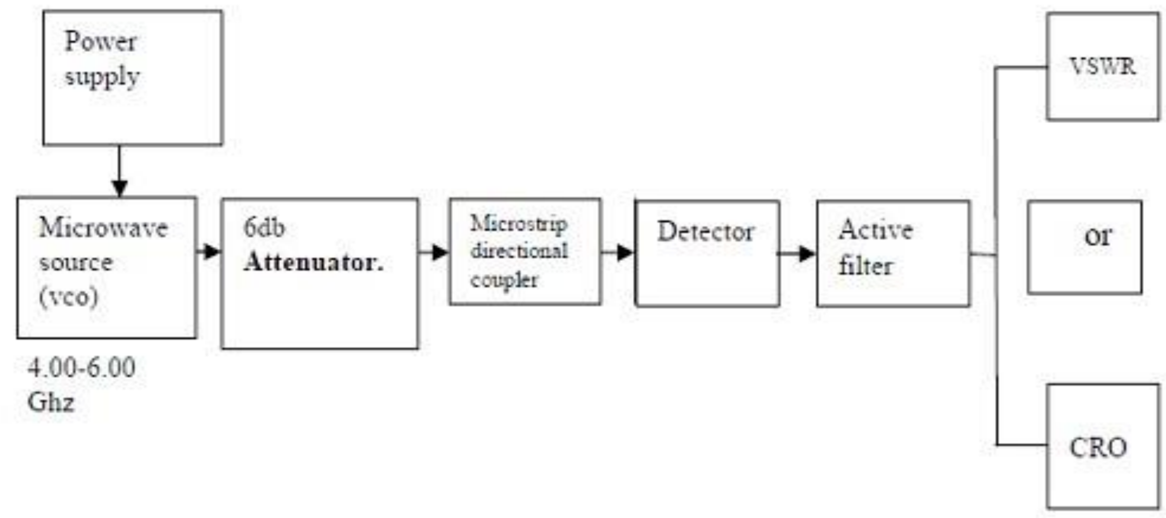
Theory:

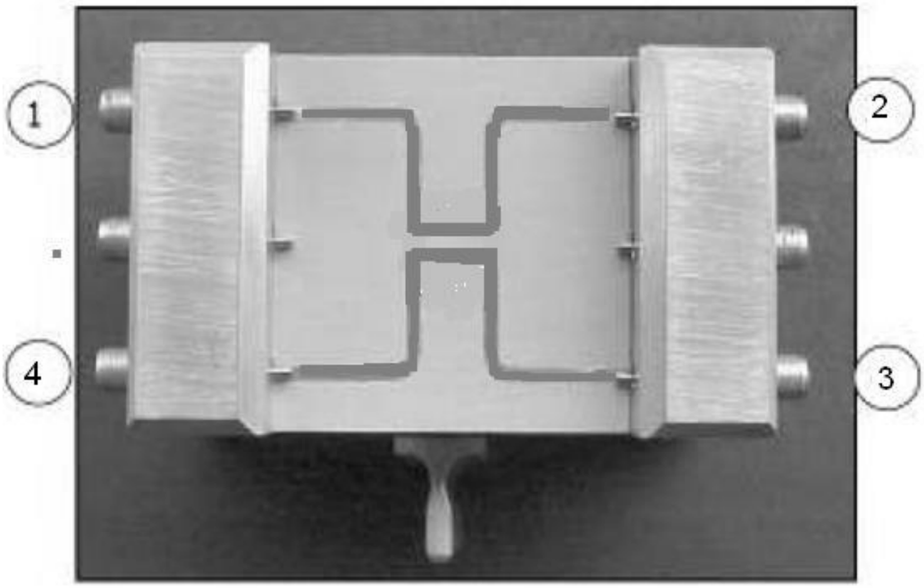
A directional coupler is a four port junction used for tapping main power flow in order to make some measurements on the signal characteristics. They are passive reciprocal networks having four ports. All four ports are (ideally) matched, and the circuit is (ideally) lossless. They are used for sampling a signal, sometimes both the incident and reflected waves It consists of a primary wave guide and a secondary wave guide. A main portion of the incident power (Pi) must be coupled to port 2. A small fraction of the incident power of port 1 must be coupled to port 3 so that measurement of power and signal characteristics is possible, the back power i.e. power at port 4 must ideally be equal to 0 (zero). Coupling factor is a measure of ratio of power levels in the primary and secondary lines. The directivity is a measure of how well the forward traveling wave in the primary wave guide couples only to a special port of the secondary wave guide. Coupling factor and directivity determine the characteristic of directional coupler. The directional couplers are of two types. Namely Forward wave couplers and backward wave couplers. Forward wave versus backward wave couplers Waveguide couplers couple in the forward direction (forward-wave couplers); Microstrip or stripline couplers are "backward wave" couplers. The coupled port on a microstrip or stripline directional coupler is closest to the input port because it is a backward wave coupler. On a waveguide broad wall directional coupler, the coupled port is closest to the output port because it is a forward wave coupler

Procedure:

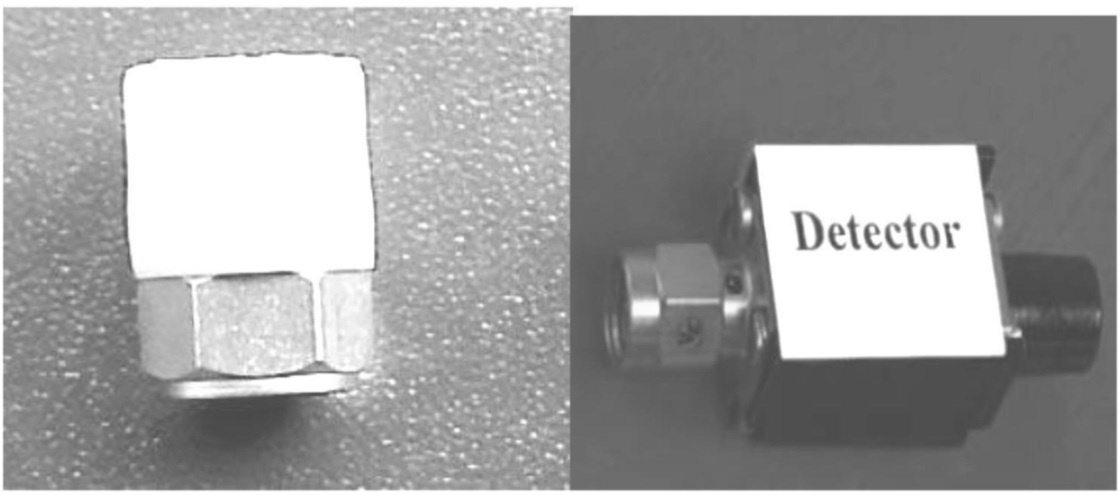
1. Setup the system as shown in the block diagram.
2. Keeping the voltage at minimum, switch ON the supply.
3. Insert 50 Ohm transmission line & check for the output at the end of the system using a CRO.
4. Vary the power supply voltage and note down the frequency at which the maximum output occurs. Note down V1(or P1)
5. Replace the 50 Ohm transmission line with strip line coupler.
6. Check the output at ports 2 (through output), 4 (coupled output), 3(isolated output).
7. Calculate insertion loss, coupling factor and isolation using the formulae given.

Block Diagram:





Strip line directional coupler



(a) Miniature SMA coaxial 50-ohm Matched Load (b) Detector.

Tabular Column:

CALCULATIONS:

V1=

V2=

V3=

V4=

With oscilloscope:

Insertion loss (dB) = Input/output=20 log (V1 / V2)

Coupling factor (dB) = Input/Coupled =20 log (V1 / V4)

Isolation (dB) = Input/Isolation =20 log (V1 / V3)

Directivity (dB) = Coupled/Isolation =20 log (V4 / V3)

Check for Isolation loss=Directivity + Coupling loss

With VSWR meter:

Insertion loss (dB) = P1-P2.

Coupling factor (dB) =P1-P4.

Isolation (dB) =P 1-P3.

Directivity (dB) =P4-P3.

Experiment No. : 8b Date : / / .

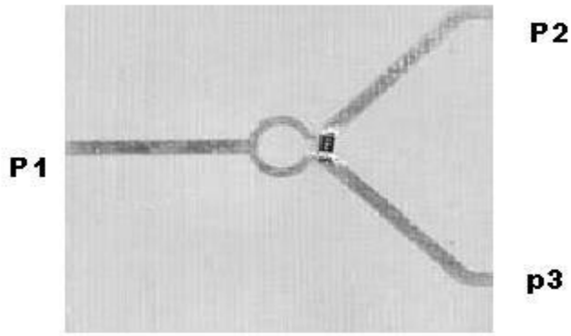
MICROSTRIP 3DB POWER DIVIDER

Aim: To determine the power division, coupling & isolation characteristics of a micro-strip 3DB Power Divider.

Apparatus/Components required: Power supply, Microstrip Setup, Microstrip transmission line, Micro strip 3dB power divider, 50 ohm terminations cables with SMA connectors CRO/VSWR meter

Theory:

Power divider is a three port junction. It is used for splitting the power .The input power at port1 divides equally between port 2 and port3.Thus the power divider is a -3dB splitter i.e the power comes out of port2 and port3 3dB down from port1.



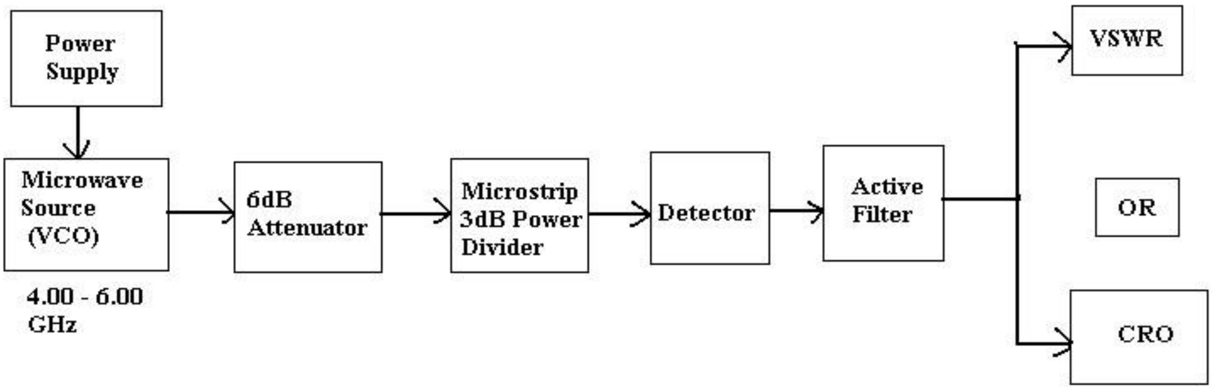
Microstrip Power Divider.

Procedure:

With RF Power meter:

1. Set up the system as shown in the block diagram.
2. Keeping the voltage minimum, switch on the power supply.
3. Insert the 50 ohm transmission line and check for the output using CRO.
4. Keep the VCO Frequency constant, note down the output. This value can be taken as the input to the power divider.
5. Replace the 50 ohm transmission line with the Wilkinson power divider.
6. Calculate the insertion loss and coupling factor in each coupled arm.
7. Calculate the isolation between ports 2 and port3 by feeding the input to port2 and measuring the output at port3 by terminating port1
8. Repeat the experiment for different VCO frequencies

Block Diagram:



Tabular Column:

Calculation:

Isolation loss (dB) = 10log (P_2/P_3)

Power division (dB) at arm 3= 10log ($P3/P_1$)

Power division (dB) at arm 2= 10log ($P2/P_1$)

With VSWR meter:

Isolation between port 2 and 3 = P_3-P_2 in dB.

Power division (dB) at arm 3= P_1-P_3 in dB.

Power division (dB) at arm 2= P_1-P_2 In dB.

With Oscilloscope:

Isolation between Port 2 and 3(dB) = 20log (V_3/V_2).

Coupling factor at arm 3 (dB) = 20log (V_3/V_1).

Coupling factor at arm 2 (dB) = 20log (V_2/V_1).

Results:

Applications:

Remarks:

Signature of Staff In-charge with date:

Probable viva questions:

1. What is a VSWR meter?
2. Which microwave frequency band is used in laboratories?
3. What is Transmission line?
4. What is ring resonator?
5. What do you mean by dielectric constant?
6. What is the difference between a microwave device and stripline device?
7. What is a microsrip ring resonator?
8. What are the applications of ring resonator?
9. What are the two ways of coupling in ring resonator?
10. How do you find dielectric constant of substrate with ring resonator?
11. Why RF source is used in microwave transmitter instead of microwave source?
12. What is dBm? How do you convert watts to dBm?
13. What is a power divider? What are its applications?
14. What is a directional coupler?
15. What are the types of directional couplers?
16. Give the applications of directional couplers?

References:

1. Microwave Devices and circuits- Samuel Liao / Pearson Education.
2. Microwave Engineering – Annapurna Das, Sisir K Das TMH Publication, 2nd , 2010.

Experiment No. : 9 Date : / / .

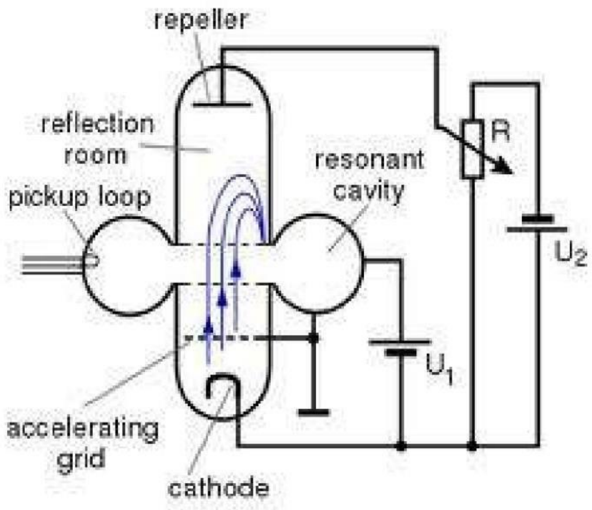
MICROWAVE EXPERIMENTS

General Information about Microwave Devices:

Microwaves are radio waves with wavelengths ranging from as long as one meter to as short as one millimeter, or equivalently, with frequencies between 300 MHz (0.3 GHz) and 300 GHz.

High power microwave sources use specialized vacuum tubes. These devices operate on different principles from low-frequency vacuum tubes, using the ballistic motion of electrons in a vacuum under the influence of controlling electric or magnetic fields, and include the magnetron (used in microwave ovens), klystron, traveling-wave tube (TWT), and gyrotron. These devices work in the density modulated mode, rather than the current modulated mode. This means that they work on the basis of clumps of electrons flying ballistically through them, rather than using a continuous stream of electrons. Low-power microwave sources use solidstate devices such as the field-effect transistor (at least at lower frequencies), tunnel diodes, Gunn diodes, and IMPATT diodes.

REFLEX KLYSTRON:

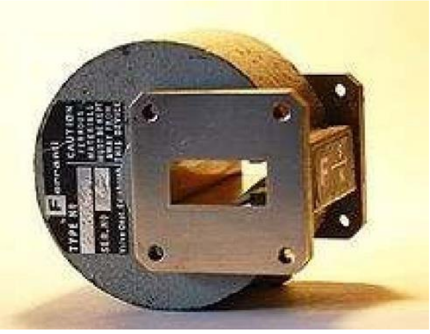


Reflex klystron is a device with which we can produce microwave frequency signal. In reflex klystron shown in the above figure, the electron beam passes through a single resonant cavity. The electrons are fired to one end of the tube by an electron gun. After passing through the resonant cavity they are reflected by the negatively charged electrode for another pass through the cavity where they are then collected. The electron beam is velocity modulated when it first passes through the cavity. The formation of electron bunches takes place in the drift space between the reflector and the cavity. The voltage on the reflector must be adjusted so that the bunching is maximum as the electron beam re-enters the cavity, thus ensuring a maximum of energy, and is transferred from the electron beam to the oscillator in the cavity. This tube is called a reflex klystron tube because it repells the input supply or performs the opposite function of a klystron.

The klystron oscillator generates frequencies in Ghz range which can not be measured in CRO. Hence the oscillator output is modulated with the lower modulating frequency signal, in KHz range and detected signal is displayed on CRO.

ISOLATOR:

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



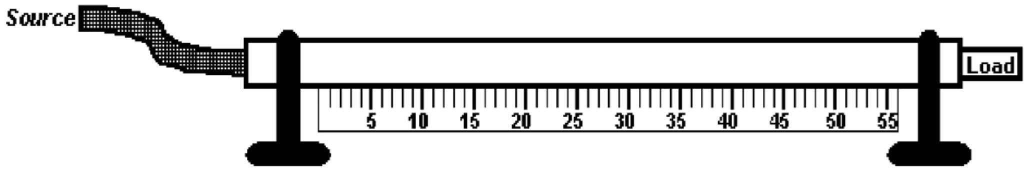
ATTENUATOR:

An attenuator is a device that passes an input signal while operating to reduce the signal by a precise amount. Microwave attenuators provide attenuation in either discrete step attenuation or continuously variable. Waveguide attenuators are generally constructed using lossy dielectric fins positioned to penetrate into a waveguide parallel to the electric fields to reduce the energy level of a signal at the output port.

FREQUENCY METER:

It gives direct frequency on the dial provided .These are recommended for quick determination of high signal frequency and easy read.

SLOTTED LINE:



Slotted line is a microwave transmission line, where we can tap the signal at any point of the line for study purpose with the help of a tunable probe without obstructing the signal from reaching the load.

CRYSTAL DETECTOR:

It detects the RF signal and gives the detected output to VSWR meter and CRO. The detected output is a square wave in Khz.

GENERAL INSTRUCTTIONS:

1. Cooling fan should be switched on before starting any experiment and it must remain on throughout the experiment.
2. Before the kystron power supply is switched on set the supply knobs as follows:
   i) Beam voltage at minimum
   ii) Repeller voltage at maximum
   iii) Amplitude and frequency knobs in mid position
   iv) Select Modulation to AM.
   v) Meter selection is kept at C.
3. Switch the klystron supply ON and turn ON the HT switch.
4. Wait for two to three minutes before starting the experiments for beam current to be constant.
5. During the experiment do not touch the klystron oscillator.
6. Attenuator gauge should be kept above 10 for minimum attenuation.
7. With load as crystal detector generate a square wave reducing the repeller voltage.
   Set the square wave to maximum amplitude to get a perfect square wave.
8. Note down the initial readings.
   Beam current – within 15 mA
   Beam voltage – within 200- 220 v
   Repeller voltage – within − 250v

MEASUREMENT USING MICROWAVE TEST BENCH

Aim: To measure a) Frequency, b) Guide wavelength, c) Power, d) VSWR e)Attenuation of a microwave signal.

Apparatus/Components required: Reflex Klystron , Isolator, Attenuator, Frequency Meter , Slotted Line, Crystal Detector, CRO,VSWR Meter.

Procedure:

Follow the general instruction to switch on microwave source. Set the initial readings of beam current, beam voltage and repeller voltage within the given limit and note down the readings

Beam current – -------------
------ Beam voltage – --------
------------- Repeller voltage
– ------------------

Frequency measurement

- Set up the system as shown in Fig1.
- Find the operating frequency at the dip position of the square wave by varying the frequency meter.
  (f will be in the range 8-10 Ghz.)
  Frequency measured=------------------

Power measurement

- Set up the system as shown in Fig3 Connect the crystal detector to VSWR meter Set the VSWR Meter as follows:
  Meter selection – normal, Range – dB position, Impedance selection – 200 ohms
  Fine : minimum position, Course: maximum position
- Read on dB scale, to get power in dBs
- Power measured = -----------------

Attenuation measurement:

- Keep attenuation gauge at 10 for min attenuation. Note down readings on VSWR meter Change the attenuation gauge reading to 5 and 0 and note down the power

.

Gauge at	Power in DB
10	
5	
0	

Guide wavelength measurement

- Set up the system as shown in Fig2
- Remove crystal detector, connect matched termination. Connect tunable probe to CRO
- **F**ind the distance between the two minima by varying the slotted line scale to find guide wavelength λg.

d_{Max}= Distance of first minima,

d_{Min}= Distance of second minima, .

Guide Wavelength $\lambda g = 2(d_{Max2} - d_{Max1})$

Width of the waveguide a=2.3cm.

Free space wavelength= $\lambda_0 = \frac{\lambda g}{\sqrt{1+(\lambda g / 2a)^2}}$

Calculated frequency $f = C/\lambda_0$

VSWR measurement:

- With the matched termination, connect CRO to slotted line probe.
- Measure the maximum and minimum voltage of the square wave.

Calculate **VSWR =Vmax/Vmin = --------**

Block Diagram:

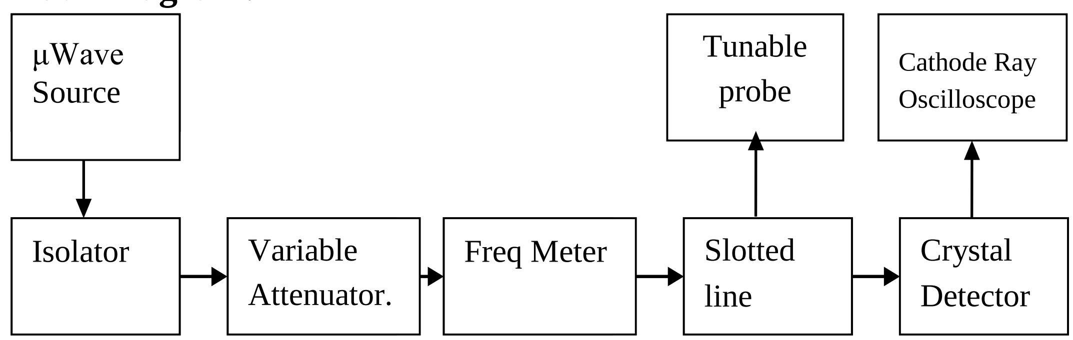


Fig1:Setup for frequency measurement

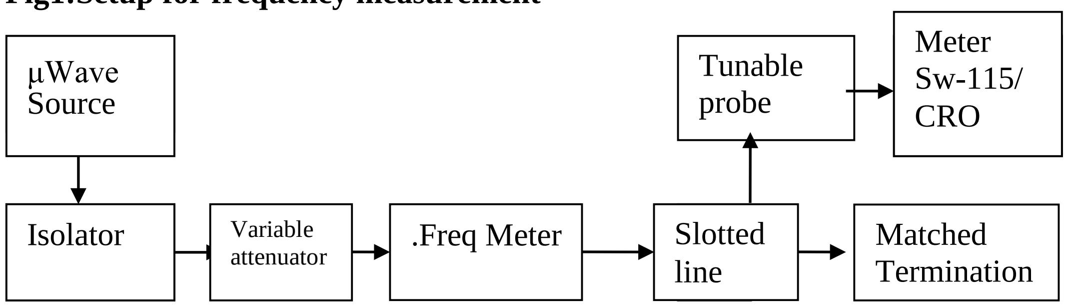


Fig2:Setup for VSWR and guide wavelength measurement

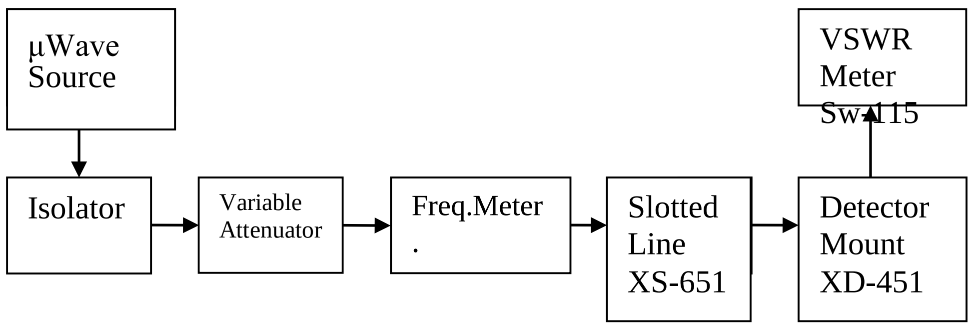


Fig3:Setup for Power and attenuation measurement

Results:

Applications:

Remarks :

Signature of Staff Incharge with date:

Probable viva questions:

1. What is the frequency range of microwave?
2. What are the different microwave sources?
3. What are the advantages and limitations of microwave communication?
4. What is Klystron? What are the different types of klystron?
5. What precautions you need to take before turning on klystron power supply?
6. What is isolator? Give the constructional features of isolator?
7. What is attenuator? Give the constructional features of attenuator?
8. What is a frequency meter? What are the different types of frequency meter?
9. What is the principle of operation of absorption type of frequency meter?
10. Explain the working of klystron oscillator?
11. What is velocity modulation?
12. Which microwave source is used in microwave oven?
13. What is a crystal detector?
14. What is VSWR? What is the significance of VSWR?
15. What are the different types of waveguides?
16. What are the different modes of transmission through waveguides?
17. What is a matched load? What is the value of VSWR when guide is terminated with matched load?
18. What is guide wavelength?

References:

1. Microwave Devices and circuits- Samuel Liao / Pearson Education.
2. Microwave Engineering – Annapurna Das, Sisir K Das TMH Publication, 2nd , 2010.

Experiment No. : 10	Date : / / .

MEASUREMENT OF DIRECTIVITY AND GAIN OF ANTENNA

Aim: To conduct an experiment to obtain radiation pattern and to measure the directivity and gain of the Dipole, Patch and Yagi Antenna (printed).

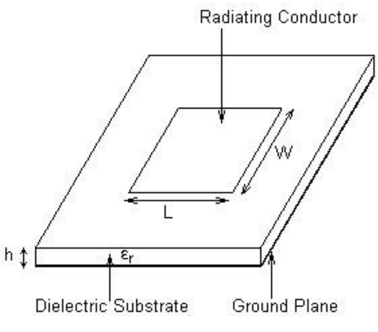
Apparatus required: The following Equipments, Devices, Components are required to conduct the experiment

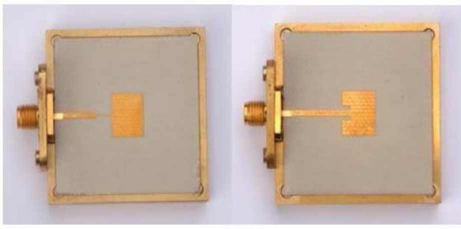
1. Microwave Signal Source (VCO)
2. Transmitting antenna turn table
3. Receiving antenna turn table
4. Transmitting Dipole antenna
5. Receiving Dipole antenna
6. RF Detector (Crystal Detector)
7. VSWR Meter/CRO/Power meter

Theory:

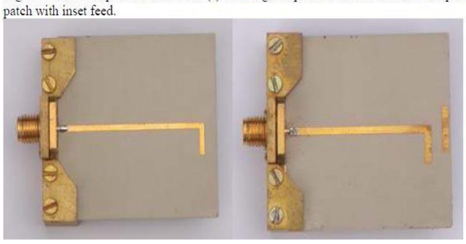
An antenna is a structure capable of radiating or receiving electromagnetic waves. Their function is to couple the transmitter or receiver to space. The most important parameters required to be measured to determine the performance characteristics of microwave antenna are radiation pattern, gain, directivity, efficiency, beam width and bandwidth.

A microstrip antenna is basically a conductor printed on top of a layer of substrate with a backing ground plane as shown in figure 8.*





Figures: Microstrip Patch Antennas (a) Rectangular patch with Transformer coupling. (b) Rectangular patch with inset feed.



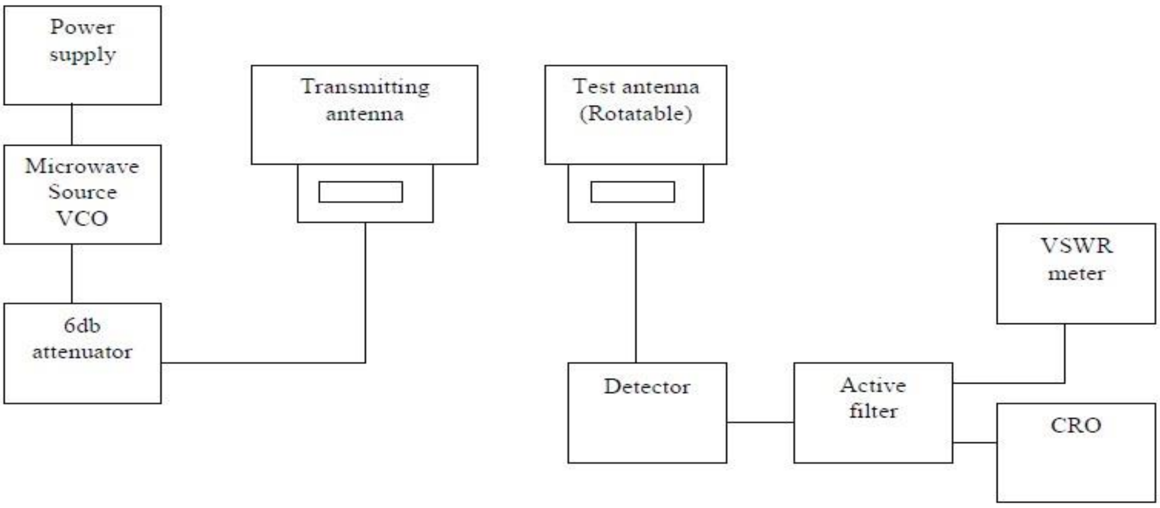
Figures: (a) Printed Dipole Antenna. (b) Printed Yagi-Uda Antenna

Figure 8 A typical microstrip antenna.

The length of the radiating conductor or patch is made approximately $\lambda_g/2$, so the patch starts to radiate. In this experiment the patch will be fed by a microstrip transmission line, which usually has a 50Ω impedance. The antenna is usually fed at the radiating edge along the width (W) as it gives good polarisation, however the disadvantages are the spurious radiation and the need for impedance matching. This is because the typical edge resistance of a microstrip antenna ranges from 150□ to 300□.

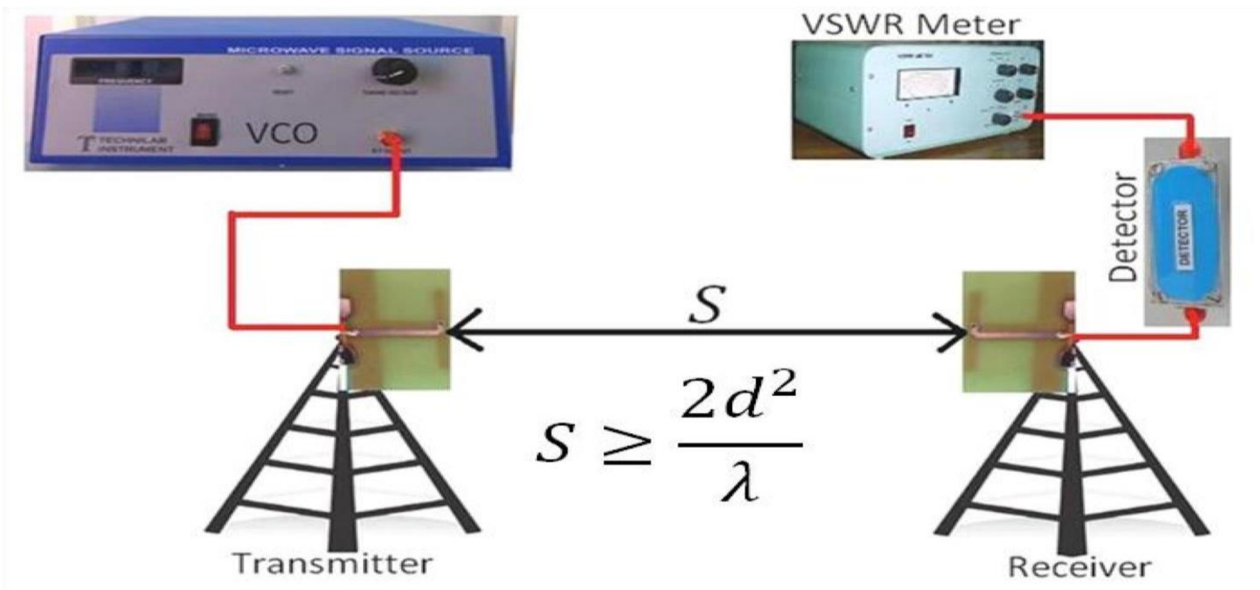
In most microstrip end fed antennas the feed line impedance (50Ω) is always not same as the radiation resistance at the edge of the patch, which is usually a few hundred ohms depending on the patch dimensions and the substrate used. As a result this input mismatch will affect the antenna performance because maximum power is not being transferred. When a matching network is implemented on the feed network this improves the performance of the antenna as there are less reflections. A typical method used to match the antenna is the use of an inset feed; because the resistance varies as a cosine squared function along the length of the patch, a 50Ω can be found. This distance from the edge of the patch is called the inset distance.

Block diagram:



Experimental Set up

Fig-1 Receiving power measurement set-up diagram



Procedure for Finding the Gain of antenna:

1. Set up the system as shown in Fig-1 for a receiving power measurement (Pr), red line in the diagram indicates the RF SMA (male) to SMA (male) cable connections.
2. Keeping the tuning voltage at minimum in the front panel of the VCO and switch on the VCO.
3. Select the Modulation Square wave by changing the toggle switch position in rare panel. When the power meter is used in the place of VSWR meter then select the CW mode.
4. Adjust the minimum distance between the transmitting and receiving antennas using the formula $S \geq 2\ d^2/\lambda$ where d is the broader dimension of the antenna.

Sample Calculation for Dipole antenna $S \geq \frac{2d^2}{\lambda}$ $S \geq \frac{2 \times (4.6cm)^2}{12cm}$ $S \geq 3.52$ cm (the minimum distance between Tx -Rx)	$\lambda = \frac{c}{f}$ $\lambda = \frac{3 \times 10^{10}}{2.5 \times 10^9}$ $\lambda = 12$cm

5. Vary the tuning voltage and check the output for different VCO frequencies. The frequency at which the output becomes maximum is the resonant frequency of the antenna.
6. Note down the frequency (RF) by reading the Display on front panel of VCO as an Operating frequency of RF signal.
7. Keeping both the antennas in line of sight and note down the Received power in VSWR meter directly in dBm (Pr-Receiving Power)
8. Now without disturbing the RF level and RF Frequency change the Setup as shown in the Fig-2 and use the same detector which is used in the measurement of Received power.

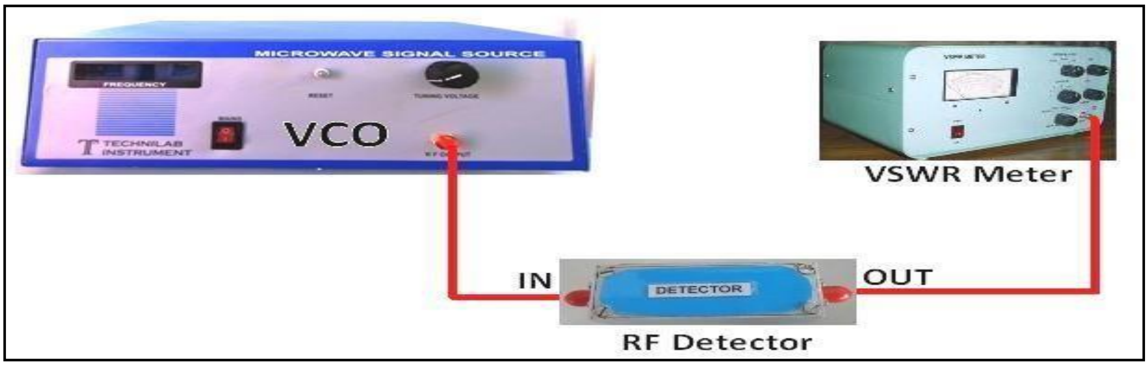


Fig.2 Transmitting power measurement set up diagram

9. After the completion of the setup note down the Transmitting power in VSWR meter directly in dBm (Pt-Transmitting power)
10. After noting down the Pr-Receiving Power, Pt-Transmitting power, f-operating Frequency, S-distance between Transmitting and receiving antenna calculate the Gain of the Antenna as follows.

Tabular column

Pr		dBm	Power measured at receiving end
Pt		dBm	Power measured at Source end
f		GHz	Operating frequency of RF signal
S		cm	Distance between Tx and Rx antennas

$$G = \frac{4\Pi s}{\lambda}\sqrt{\frac{Pr}{Pt}}$$

$$\frac{Pr}{Pt} = Antilog\ \frac{(Pr)dB - (Pt)dB}{10}$$

$$\lambda = \frac{c}{f}$$

Note: - **Where 'C' is velocity of light 3 x 10^{10} in cm and f in GHz**

Sample Calculation:-

Pr	-40	dBm	Power measured at receiving end
Pt	-10	dBm	Power measured at Source end
f	2.34	GHz	Operating frequency of RF signal
d	60	cm	Distance between Tx and Rx antennas

$$G = \frac{4\Pi d}{\lambda}\sqrt{\frac{Pr}{Pt}}$$

$$\lambda = \frac{c}{f}$$

$$\frac{Pr}{Pt} = Antilog\ \frac{(Pr)dB - (Pt)dB}{10}$$

$$\frac{Pr}{Pt} = Antilog\ \frac{-40-(-10)}{10}$$

$$\frac{Pr}{Pt} = 0.001$$

$$\lambda = \frac{c}{f}$$

$$\lambda = \frac{3 \times 10^{10}}{2.340 \times 10^{9}}$$

$$\lambda = 12.82cm$$

$$G = \frac{4\Pi d}{\lambda}\sqrt{\frac{Pr}{Pt}}$$

$$G = \frac{4 \times 3.14 \times 60cm}{12.82cm}\sqrt{0.001}$$

$$G = 1.76$$

$10log$ 1.76= 2.46dB

Gain of the antenna is 2.46dB

Procedure for Finding the Directivity of antenna:

1. Set up the system as shown in Fig-3, red line in the diagram indicates the RF SMA (male) to SMA (male) cable connections.

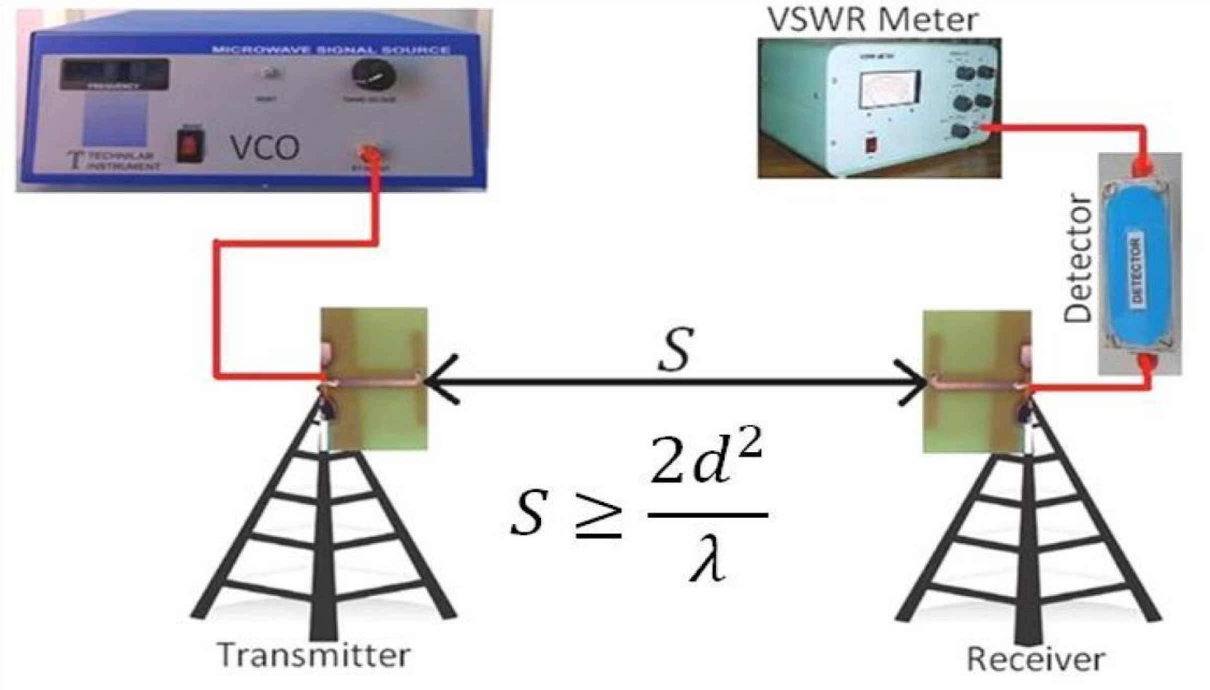


Fig-3 Basic antenna setup

2. Keeping the tuning voltage at minimum in the front panel of the VCO and switch on the VCO.
3. Select the Modulation Square wave by changing the toggle switch position in rare panel. When the power meter is used in the place of VSWR meter then select the CW mode.
4. Adjust the minimum distance between the transmitting and receiving antennas using the formula $S \geq \frac{2d^2}{\lambda}$ where d is the broader dimension of the antenna.
5. Vary the tuning voltage and check the output for different VCO frequencies. The frequency at which the output becomes maximum is the resonant frequency of the antenna.
6. Note down the frequency (RF) by reading the Display on front panel of VCO as an Operating frequency of RF signal.
7. Keeping both the antennas in line of sight and adjust the angle scale to zero by rotating the receiving antenna table.
8. Now, rotate the antenna clockwise in steps of 10° at a time (till 90°) and note the reading on the VSWR meter in dB scale,
9. Return to the 0° position. Repeat the measurements by rotating the antenna anticlockwise in 10° steps (till -90°) and record the VSWR meter readings at every step.
10. Now turn both dipole antennas by 90° in the vertical plane to get horizontal polarization. Align the antennas for maximum reading on the VSWR meter. Measure the pattern using the same procedure as given above (steps 8 and 9). This gives the E-plane pattern of the rotating dipole

Tabular Column:-

Angle (Right)	E-Plane	H-plane	θ	Angle (Left)	E-plane	H-plane
0°			HPBW by table θ_E=R+L θ_E=	0° (360°)		
10°				10°(350°)		
20°				20°(340°)		
30°				30°(330°)		
40°				40°(320°)		
50°				50°(310°)		
60°				60° (300°)		
70°				70°(290°)		
80°				80°(280°)		
90°				90°(270°)		

R/L= Right/Left Side angle where power is 3DB less than Max.Power in E-plane /H-Plane

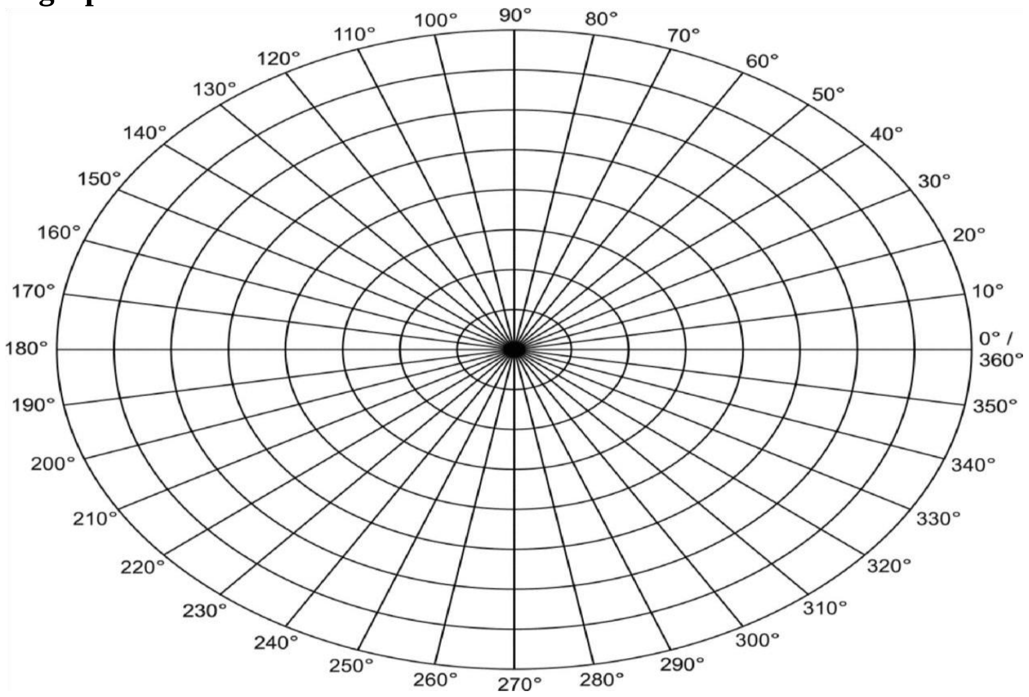
11. Plot a graph of angle vs. output. Find the half power beam width (HPBW) from the points where the power becomes half (3 dB points)
12. Calculate Directivity of the antenna by using the formula,

$$\boldsymbol{D = \frac{32400}{\theta_E \times \theta_H}}$$

D in DB=10Log (D) =5.85dB

13. Repeat for Yagi and Patch Antenna

Polar graph



Results:

Applications:

Remarks :

Signature of Staff Incharge with date:

Probable viva questions:

1. What is antenna? Why an oscillating dipole radiates electromagnetic energy in space isotropically?
2. Name the various types of antennas?
3. Why practical values of gain and bandwidth do not match with theoretical values?
4. Why is maximum signal detected when the transmitter and receiver are axially aligned?
5. When the reflector is employed in the radiation of the signals, how does it affect the VSWR at transmitter and signal at the detector?
6. What is radiation pattern, gain, bandwidth, directivity and beam width of an antenna?
7. What is near field and far field?
8. Where do you find application of yagi antenna?
9. Where do you find application of patch antenna?

References:

1. Antennas and Wave Propagation, John D. Krauss, 4^{th} Edn,McGraw-Hill International edition, 2010.
2. Antenna and Wavw Propagation,K D Prasad,Satya Prakashan,2^{nd} edition.

Experiment No. : 11 Date : / / .

OPTICAL FIBER EXPERIMENTS INTRODUCTION TO OPTICAL FIBER

HOW OPTICAL FIBER WORKS?

The principle of operation of Optical Fiber lies in the behavior of light. Light travels in straight line through most optical materials, but that, not necessarily the case at the junction (interface) of two materials of different refractive indices. Air & water are a case in point as shown in FIG(A). The light ray traveling through air actually is bent as it enters the water. The amount of bending depends on the refractive indices of the two materials involved & also on the angle of the incoming (incident) ray of light as it strikes the interface. The angle of the incident ray is measured from a line drawn perpendicular to the surface. The same is true for the angle of the outgoing (transmitted) ray of light after it has been bent.

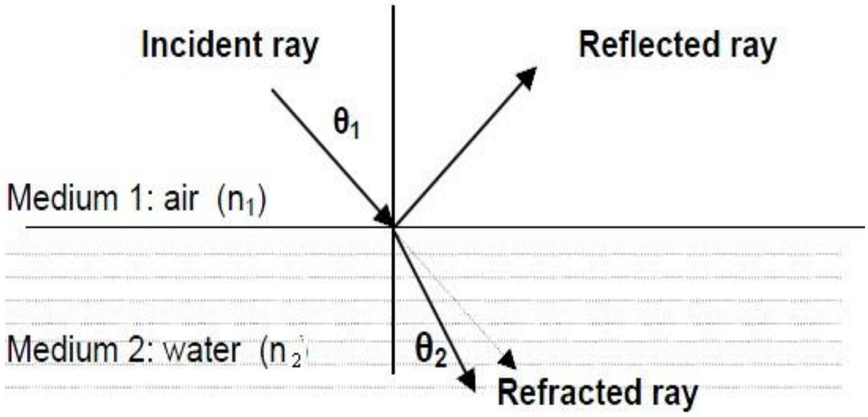


FIG. A: The different portions of a light ray at a material interface.

Snell’s Law explains the mathematical relationship between the incident ray & the refracted ray n1•Sine θ1 =n2•Sine θ2, in which n1 & n2 are the refractive indices of the initial and secondary materials respectively and θ1 and θ2 are the incident and transmitted angles. Snell’s Law says that refraction (bending) cannot take place when the angle of incidence grows too large (as when light travels from a material with a high refractive index to one with a low refractive index) If the angle of incidence exceeds a certain critical value (in which the product of n1 & the sine of the angle equals or exceeds one) light cannot exit. If light cannot exit the material, it is reflected. The angle that is reflected is equal to the angle of incidence. The phenomenon just described is called Total Internal Reflection & it is what keeps light inside an Optical Fiber.

TYPES OF OPTICAL FIBER

The simplest Fiber Optic cable consists of two concentric layers of transparent materials. The inner portion (the core) transports the light. The outer covering (the cladding) must have a lower refractive index than the core, so the two are made of different materials. Optical Fiber is generally made from either plastic or glass. This kit uses Plastic Fiber, which is very easy to terminate & does not require special tools. Plastic Fiber is generally limited to uses involving distance of less than 100 meters because of high attenuation (higher loss). Glass Fiber on other hand has very low attenuation (low Loss) & hard to cut, requires special end connections & is more expensive. The core of fiber is typically made of silica doped with impurities, which increases the refractive index relative to pure silica. The cladding, which surrounds the Fiber core & creates an optical interface, is typically made from pure silica. The outer buffer coating is plastic cover. The first type of Fiber Optic Cable put to use was called step index. In this design the cladding has a different index of refraction from the core. The light bounces off the sides & is reflected back into the Fiber core. The problem with this design is that the reflected light must travel a slightly longer distance than that which travels down the center of the fiber, thus limiting the max transmission rate. This design was improved with the use of Graded Index Fiber. In this design, the index of refraction decreases in proportion to the distance away from the center of the Fiber core. The light moves more quickly in the outer portion, thus compensating for the additional distance. The refractive index also has the effect of 'bending'. This change increases the transmission capacity. In the newest single Mode design, the diameter of the fiber core is made so small that all the light travels in a straight line.

SINGLEMODE V/S MULTIMODE

There are essentially two different types of Fiber Optic transmission schemes in use. Multimode Fiber Optic systems are typically used in short haul applications such as LANS & FDDI. Recent growth in multimode installations has been driven by LAN/FDDI applications. The term Multimode means that the diameter of the Fiber Optic core is large enough to propagate more than one mode (electromagnetic wave). Because of the multiple modes the pulse that is transmitted down the fiber tends to become stretched over distance, this is referred to as Modal Dispersion & has the effect of reducing available bandwidth.

Typical wavelengths used in multimode application are 850nm & 1300nm. There are other wavelengths used (e.g.660nm for plastic fiber, 820/870nm) in specialized applications such as the military. The vast majority of multimode applications are 850 or 1300nm wavelengths. Most multimode cables in use today are graded index in type with a cladding diameter of 125 microns & Fiber core diameter of 6.25 or 50 microns (Typically referred to as 62.5/125 or 50/125 Fiber). Single mode systems are generally used in long haul applications (10's or 100's Kilometers) & local loop applications. Some large utilities such as electrical power companies also utilize single mode fiber Optic backbones. As the name implies single mode Fiber is designed to propagate only one mode of light. It is therefore not affected by modal dispersion & has higher bandwidth capacity. It is considered to be higher quality transmission system. Wavelengths used in a single mode applications are 1300 & 1550nm. The majority of today's installed system uses 1300nm wavelength technology & is designed for higher speed applications. These systems are more sensitive to back reflections from connectors & sharp cable bends. Most single mode cables in use today are step index in type with cladding diameter or 125 micron & Fiber core diameter of 9 micron (Typically referred to as 9/125 Fiber).

ADVANTAGES OF FIBER OPTICS OVER CONVENTIONAL COPPER CABLES

- Much greater bandwidth (Several orders of magnitude are theoretically possible)
- Immunity to electrical disturbances, ground loops, cross talks etc, in addition, no EMI radiation is generated.

- Much lighter. A 3-inch bundle of 900 twisted copper pairs can carry about 21,000 channels of traffic & weighs about 25,000 pounds /mile. A ½ inch Fiber Link with 12
- Fiber stand can carry about 3,00,000 channels & weighs about 200 pounds/ mile. In addition less duct space is required to make the cable within building.
- Better in hostile environment, not affected as much by temperature, water etc.
- Lower transmission loss. Typical loss on a Fiber Link is 0.2 dB/Km. On a copper based facility,one can usually expect at least 5 dB/Km. For longer links, less repeaters are required.
- Better security as it is not possible to simply bridge onto the facility & monitor the traffic.

STUDY OF LOSSES IN OPTICAL FIBER

Aim: To measure propagation loss & bending losses for two different wavelengths in plastic Fiber provided with the kit.

Apparatus/Components required: FO Kit with power supply , Patch chords , 20MHz Dual Channel Oscilloscope , 1 Meter Fiber Cable

NOTE: KEEP ALL SWITCH FAULTS IN OFF POSITION.

Theory:

Optical Fibers are available in different variety of materials. These materials are usually selected by taking into account their absorption characteristics for different wavelengths of light. In case of Optical Fiber, the signal is transmitted in the form of light, which is completely different in nature as that of electrons. Losses are introduced in fiber due to various reasons. As light propagates from one end of Fiber to another end, part of it is absorbed in the material exhibiting absorption loss. Also part of the light is reflected back or in some other directions from the impurity particles present in the material contributing to the loss of the signal at the other end of the Fiber. In general terms it is known as propagation loss. Plastic Fibers have higher loss of the order of 180 dB/Km. Whenever the condition for angle of incidence is violated the losses are introduced due to refraction of light. This occurs when fiber is subjected to bending. Lower the radius of curvature more is the loss. Other losses are due to the coupling of Fiber at LED & photo detector ends.

Procedure:

MEASUREMENT OF PROPAGATION LOSSES:

1. Make connections as shown in FIG2 Connect the power supply cables with proper polarity to Kit. While connecting this, ensure that the power supply is OFF.
2. Connect 1m FO cable between FOTx and FORx points as shown in Fig2.
3. Switch ON the power supply.
4. Check a signal of 1KHz at TP1 by varying voltage variable knob at TP21 notedown input voltage as V1.
5. Feed sinusoidal signal of 1KHz from TP1 to the **IN** post TP3 and check output on CRO at TP12 and measure output voltage V2.
6. Calculate the attenuation factor of the Fiber **α in dB** using $\alpha(\mathrm{dB}) = 10 \log_{10} (V2/V1)$

   Where α = dB /m, L1 = Fiber Length for V1 , L2 = Fiber Length for V2

MEASUREMENT OF BENDING LOSSES:

1. With 1m FOC connected bend the Fiber in a loop of 2 to 3 cm as shown in **FIG3** and measure the amplitude of the received signal.
2. Keep reducing the diameter of bend to about 2 cm & take corresponding out voltage readings. (Do not reduce loop diameter less than 1 cm).
3. Calculate the bending loss for both 3 cm bend and 2 cm bend as follows

   Output Vo (without bending) = Vo1

   Output Vo (After bending) = Vo2

   Bending loss = 10 Log_{10}(Vo1/Vo2)

Block Diagram:

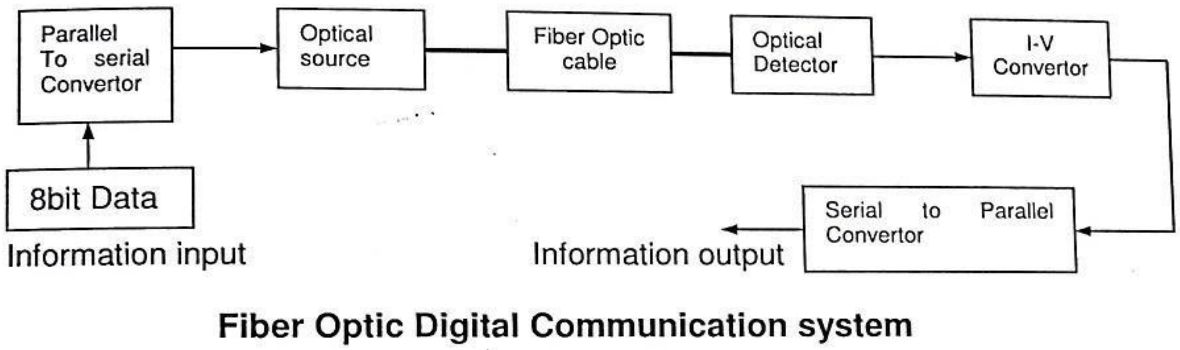


Fig.1

Kit connection for Losses

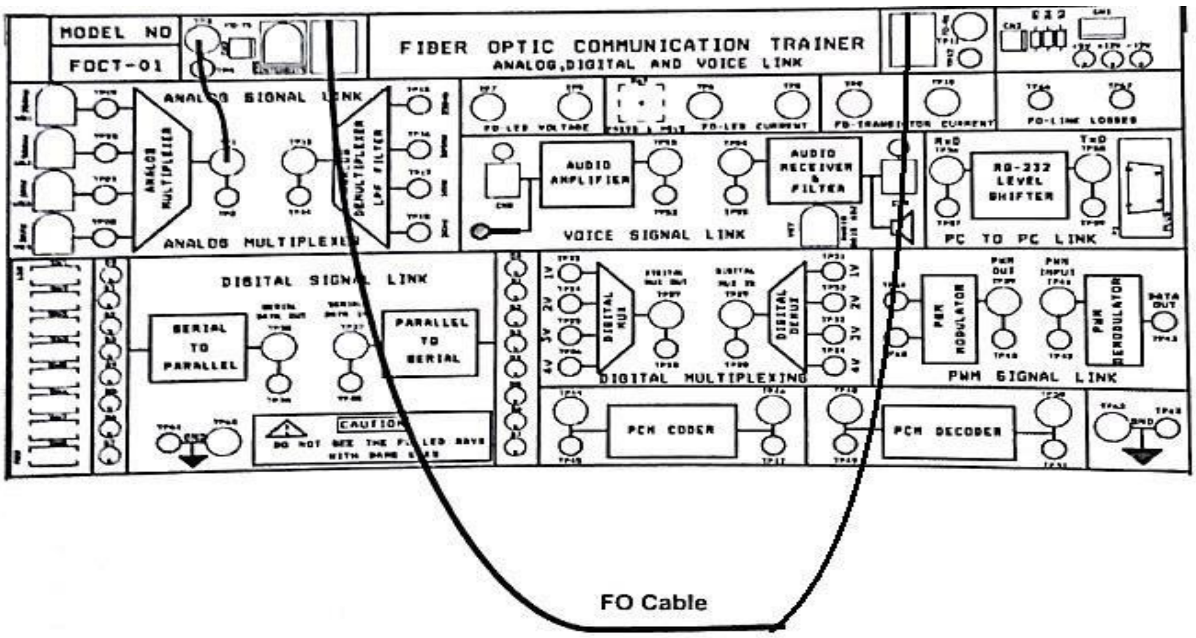


Fig2: Connection for losses

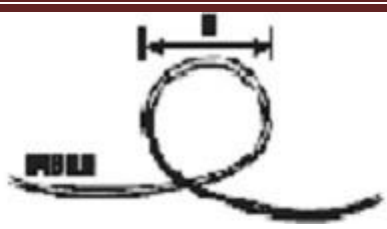


Fig.3

NUMERICAL APERTURE

Aim: The objective of this experiment is to measure the numerical aperture of the plastic Fiber provided with the kit using 660nm wavelength LED.

Apparatus/Components required: FO Kit with power supply, Patch chords , 1-Meter Fiber Cable, Numerical aperture measurement Jig

NOTE: KEEP ALL SWITCH FAULTS IN OFF POSITION.

Theory:

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

CONSIDERATION IN A MEASUREMENT:

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

Procedure:

1. Connect the power supply cables with proper polarity to Kit. While connecting this, ensure that the power supply is OFF.
2. Connect 1m FO cable between FOTx and NA Jig input points as shown in Fig.4 (insert the other end of the Fiber into the numerical aperture measurement jig. Adjust the fiber such that its cut face is perpendicular to the axis of the Fiber)
3. Switch ON the power supply.
4. Check a signal of 1KHz at TP1 and measure the voltage by varying voltage variable knob at TP21.
5. Feed sinusoidal signal of 1KHz from TP1 to the IN post TP3 and observe the illuminated circular patch of light on the screen kept on front of the open end of FOC as shown in fig4.
6. Measure exactly the distance L and also the W.
7. Radius is calculated using the following formula r = W/2
8. Find the numerical aperture of the Fiber using the formula
   $NA = \text{Sin}(\theta_{max}) = r / \sqrt{(L^2 + r^2)}$

Where θ max is the maximum angle at which the light incident is properly transmitted through the fiber.

Connection Diagram:

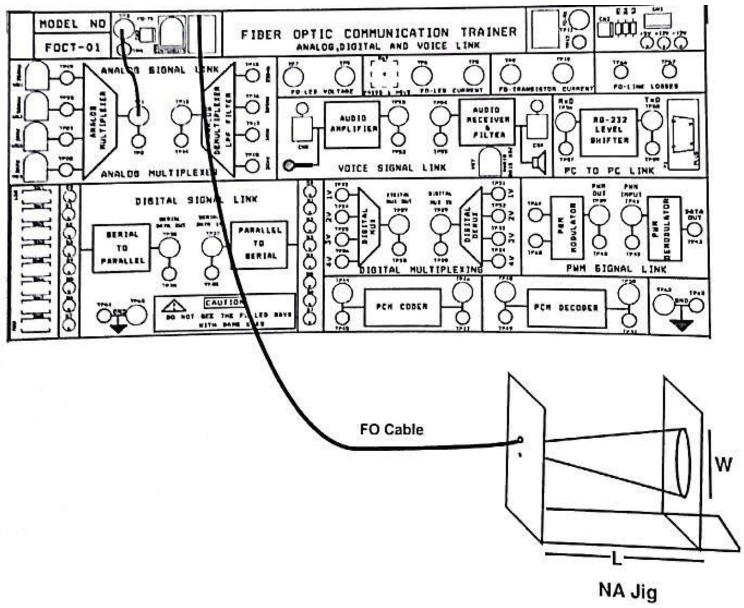


Fig.4

Results:
Applications:
Remarks :

Signature of Staff Incharge with date:

Probable viva questions:

1. What is an Optical fiber?
2. What are the different types of losses in optical fiber communication?
3. What is the frequency of operation and wavelength of optical fibre?
4. What are the advantages offered by optical fibre?
5. Give simple construction of optical fibre
6. What is snell's law?
7. What is bit rate, launching angle,Acceptance Angle, attenuation, coupling loss, bending loss and Numerical Aperture?

References:

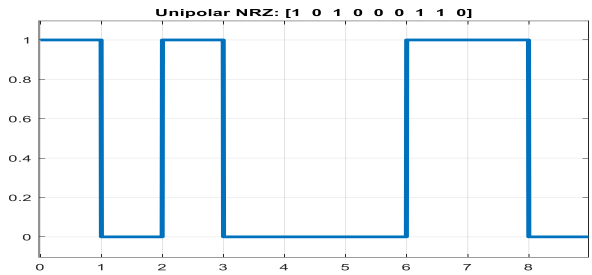
1. "Optical Fiber Communication", Gerd Keiser, 4th Ed., MGH,2008.
2. "Optical Fiber Communications", John M. Senior, Pearson, Education. 3 rd Impression,

Experiment No. : 12 Date : / / .

Experiment No. : 12. Simulate NRZ, RZ, half-sinusoid and raised cosine pulses and generate eye diagram for binary polar signaling.

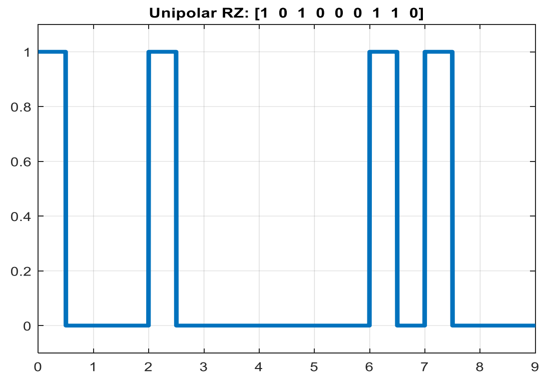
12 a) Simulation of NRZ

```
bits = [1 0 1 0 0 0 1 1 0];
bitrate = 1; % bits per second  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) ']']);
function [t,x] = unrz(bits, bitrate)
T = length(bits)/bitrate; % full time of bit sequence
n = 200;
N = n*length(bits);
dt = T/N;
t = 0:dt:T;
x = zeros(1,length(t)); % output signal
for i = 0:length(bits)-1
    if bits(i+1) == 1
        x(i*n+1:(i+1)*n) = 1;
    else
        x(i*n+1:(i+1)*n) = 0;
    end
end
end
```



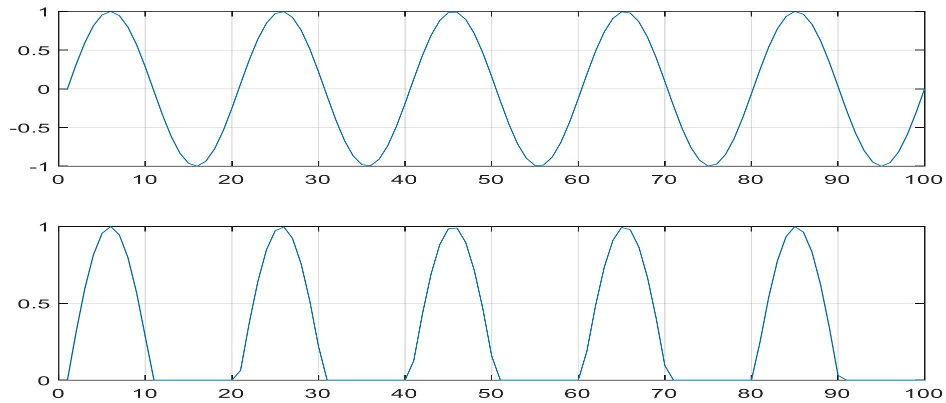
12 b) Simulation of RZ

```
bits = [1 0 1 0 0 0 1 1 0];
bitrate = 1; % bits per second
[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) ']']);
function [t,x] = urz(bits, bitrate)
T = length(bits)/bitrate; % full time of bit sequence
 n = 200;
 N = n*length(bits);
dt = T/N;
t = 0:dt:T;
x = zeros(1,length(t));%
   output signal
for i = 0:length(bits)-1
if bits(i+1) == 1
x(i*n+1:(i+0.5)*n) = 1;
x((i+0.5)*n+1:(i+1)*n) = 0;
else  x(i*n+1:(i+1)*n) = 0;
end
end
end
```



12 c) Simulation of half sinusoid

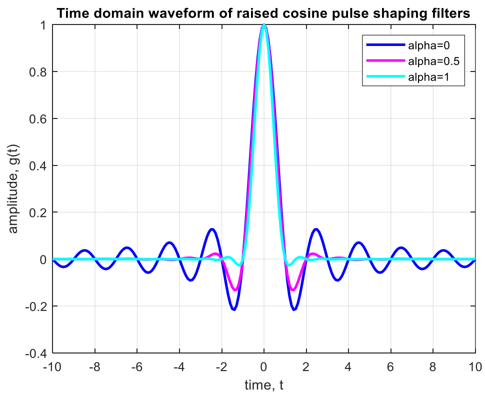
```
l=linspace(0,10,100);
sig=sin(2*pi*50*l);
subplot(211)
plot(sig);
grid
% u=1:9;
% t=(1:)
for t=1:100

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
```

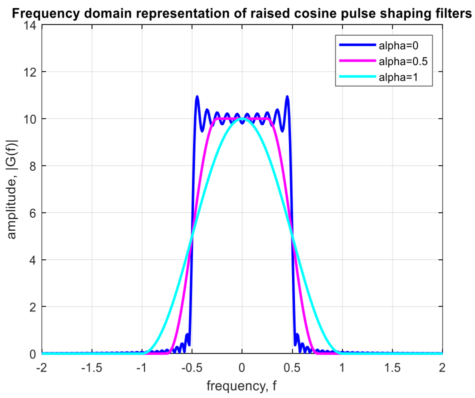


12 d) Simulation of raised cosine pulses

```
clear all
fs = 10;

% defining the sinc filter
sincNum = sin(pi*[-fs:1/fs:fs]); % numerator of the sinc function
sincDen = (pi*[-fs:1/fs:fs]); % denominator of the sinc function
sincDenZero = find(abs(sincDen) < 10^-10);
sincOp = sincNum./sincDen;
sincOp(sincDenZero) = 1; % sin(pix/(pix) =1 for x =0

alpha = 0;
cosNum = cos(alpha*pi*[-fs:1/fs:fs]);
cosDen = (1-(2*alpha*[-fs:1/fs:fs]).^2);
cosDenZero = find(abs(cosDen)<10^-10);
cosOp = cosNum./cosDen;
cosOp(cosDenZero) = pi/4;
gt_alpha0 = sincOp.*cosOp;
GF_alpha0 = fft(gt_alpha0,1024);

alpha = 0.5;
cosNum = cos(alpha*pi*[-fs:1/fs:fs]);
cosDen = (1-(2*alpha*[-fs:1/fs:fs]).^2);
```

```
cosDenZero = find(abs(cosDen)<10^-10);
cosOp = cosNum./cosDen;
cosOp(cosDenZero) = pi/4;
gt_alpha5 = sincOp.*cosOp;
GF_alpha5 = fft(gt_alpha5,1024);

alpha = 1;
cosNum = cos(alpha*pi*[-fs:1/fs:fs]);
cosDen = (1-(2*alpha*[-fs:1/fs:fs]).^2);
cosDenZero = find(abs(cosDen)<10^-10);
cosOp = cosNum./cosDen;
cosOp(cosDenZero) = pi/4;
gt_alpha1 = sincOp.*cosOp;
GF_alpha1 = fft(gt_alpha1,1024);

close all
figure
plot([-fs:1/fs:fs],[gt_alpha0],'b','LineWidth',2)
hold on
plot([-fs:1/fs:fs],[gt_alpha5],'m','LineWidth',2)
plot([-fs:1/fs:fs],[gt_alpha1],'c','LineWidth',2)
legend('alpha=0','alpha=0.5','alpha=1');
grid on
xlabel('time, t')
ylabel('amplitude, g(t)')
title('Time domain waveform of raised cosine pulse shaping
filters')

figure
plot([-512:511]/1024*fs,
abs(fftshift(GF_alpha0)),'b','LineWidth',2);
hold on
plot([-512:511]/1024*fs,
abs(fftshift(GF_alpha5)),'m','LineWidth',2);

plot([-512:511]/1024*fs,
abs(fftshift(GF_alpha1)),'c','LineWidth',2);
legend('alpha=0','alpha=0.5','alpha=1');
axis([-2 2 0 14])
grid on
xlabel('frequency, f')
ylabel('amplitude, |G(f)|')
title('Frequency domain representation of raised cosine pulse
shaping filters')
```





Results:

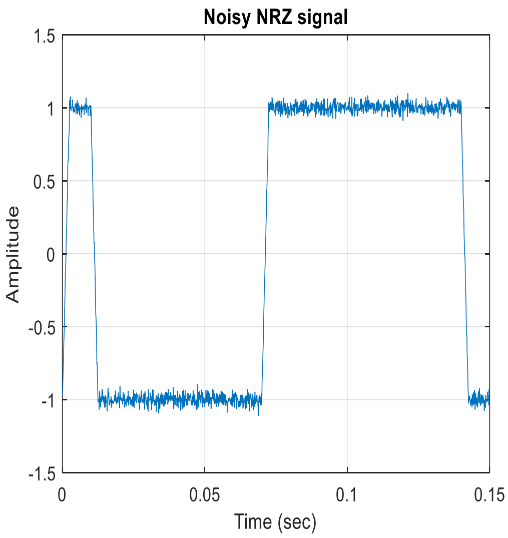
Applications:

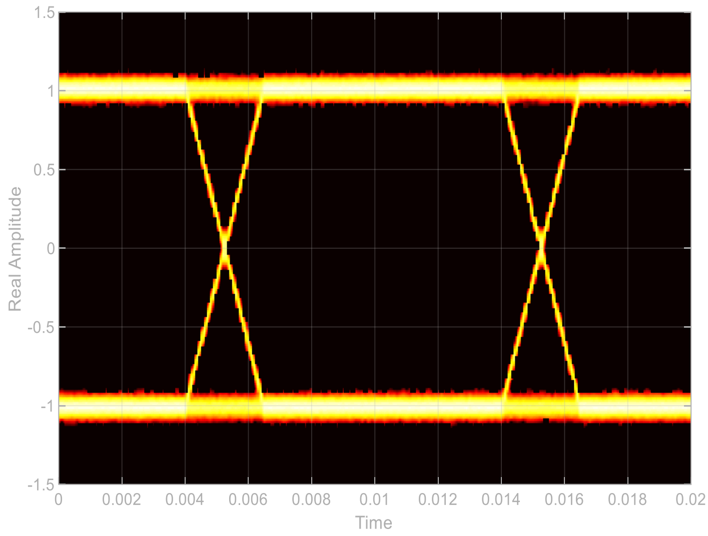
Remarks :

Signature of Staff Incharge with date:

12 e) Simulation of bipolar signaling and study of eye diagram.

```
% Initialize system parameters
Fs = 10000;             % Sample rate
Rs = 100;               % Symbol rate (Sps)
sps = Fs/Rs;            % Number of samples per symbol
SNR = 30;               % Signal to noise ratio (dB)
Trise = 1/(5*Rs);       % Rise time of the NRZ signal
Tfall = 1/(5*Rs);       % Fall time of the NRZ signal
frameLen = 5000;        % Number of symbols in a frame
% Set up the pattern generator
src = commsrc.pattern('SamplingFrequency', Fs, ...
                      'SamplesPerSymbol', sps, ...
                      'RiseTime', Trise, ...
                      'FallTime', Tfall) %#ok

% Generate NRZ signal
message = generate(src, frameLen);

% Create an comm.AWGNChannel System object.
% Set the NoiseMethod property of the channel to 'Signal to noise ratio
% (SNR)'. The commsrc.pattern object generates unit power signals; set
           the
% SignalPower property to 1 Watt.
channel = comm.AWGNChannel('NoiseMethod', 'Signal to noise ratio
           (SNR)',...
  'SNR', SNR, 'SignalPower', 1);

% Add AWGN
received = channel(message);

% Create an eye diagram and display properties
eyeObj = comm.EyeDiagram(...
    'YLimits', [-1.5 1.5], ...
    'SamplesPerSymbol', sps, ...
    'SampleRate', Fs, ...
    'SampleOffset', 0.004*Fs, ...
    'DisplayMode', '2D color histogram', ...
    'ColorScale', 'Logarithmic') %#ok

% Update the eye diagram object with the noisy NRZ signal
eyeObj(received);

% Plot the time domain signal
t = 0:1/Fs:15/Rs-1/Fs; idx = round(t*Fs+1);
hFig = figure('Position', [0 0 460 360]);
plot(t, received(idx));
title('Noisy NRZ signal');
xlabel('Time (sec)');
ylabel('Amplitude');
grid on;

% Manage the figures
hFig.Position = [10 10 hFig.Position(3:4)];
eyeObj.Position = [hFig.Position(1)+hFig.Position(3)+10 hFig.Position(2)
           ....
                   eyeObj.Position(3)*0.75 eyeObj.Position(4)*0.75];
```





Results:

Applications:

Remarks :

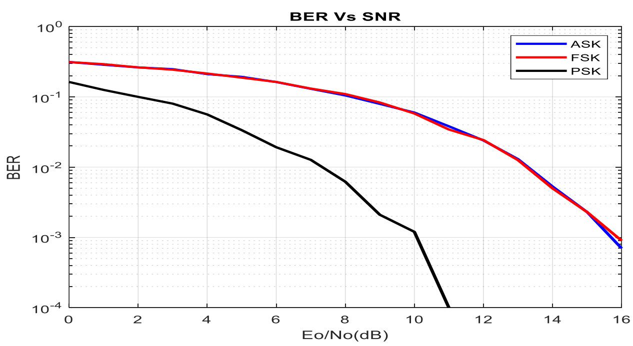
Signature of Staff Incharge with date:

Experiment No. : 14	Date : / / .

Experiment No-14 Computations of the Probability of bit error for coherent binary ASK, FSK and PSK for an AWGN Channel and Compare Performance.

```
clc;
clear all;
close all;
msglen=10000;
n=msglen;
b=randi(1,n);
f1=1;f2=2;
t=0:1/30:1-1/30;
%ASK
sa1=sin(2*pi*f1*t);
E1=sum(sa1.^2);
sa1=sa1/sqrt(E1); %unit energy
sa0=0*sin(2*pi*f1*t);
%FSK
sf0=sin(2*pi*f1*t);
E=sum(sf0.^2);
sf0=sf0/sqrt(E);
sf1=sin(2*pi*f2*t);
E=sum(sf1.^2);
sf1=sf1/sqrt(E);
%PSK
sp0=-sin(2*pi*f1*t)/sqrt(E1);
sp1=sin(2*pi*f1*t)/sqrt(E1);
%MODULATION
ask=[];psk=[];fsk=[];
for i=1:n
    if b(i)==1
        ask=[ask sa1];
        psk=[psk sp1];
        fsk=[fsk sf1];
    else
        ask=[ask sa0];
        psk=[psk sp0];
        fsk=[fsk sf0];
    end
end

%AWGN
for snr=0:20
    askn=awgn(ask,snr);
    pskn=awgn(psk,snr);
    fskn=awgn(fsk,snr);
    %DETECTION
    A=[];F=[];P=[];
    for i=1:n
        %ASK Detection
        if sum(sa1.*askn(1+30*(i-1):30*i))>0.5
            A=[A 1];
        else
            A=[A 0];
        end
```

```
%FSK Detection
if sum(sf1.*fskn(1+30*(i-1):30*i))>0.5
    F=[F 1];
else
    F=[F 0];
end
%PSK Detection
if sum(sp1.*pskn(1+30*(i-1):30*i))>0
    P=[P 1];
else
    P=[P 0];
end
  end
  %BER
  errA=0;errF=0; errP=0;
  for i=1:n
      if A(i)==b(i)
          errA=errA;
      else
          errA=errA+1;
      end
      if F(i)==b(i)
          errF=errF;
      else
          errF=errF+1;
            end
      if P(i)==b(i)
          errP=errP;
      else
                errP=errP+1;
      end
        end
        BER_A(snr+1)=errA/n;
        BER_F(snr+1)=errF/n;
        BER_P(snr+1)=errP/n;
    end
    figure(1)
    semilogy(0:20,BER_A, 'b','linewidth',2)
    title('BER Vs SNR')
    grid on;
    hold on
    semilogy(0:20,BER_F,'r','linewidth',2)
    semilogy(0:20,BER_P, 'k','linewidth',2)
    xlabel('Eo/No(dB)')
    ylabel('BER')
    hold off
```




```
    legend('ASK','FSK','PSK');
```

Results:

Applications:

Remarks :

Signature of Staff Incharge with date:

Advanced Communication LABORATORY (17EC6DLADC)

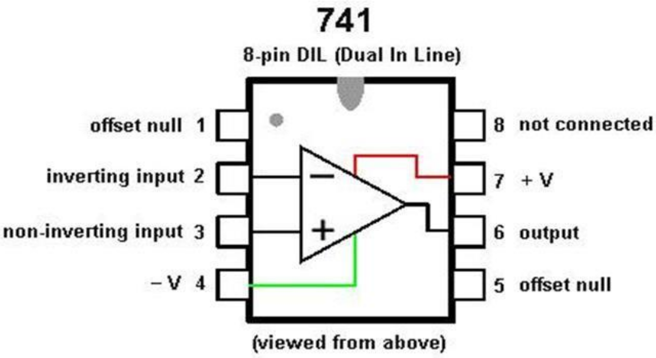
PROBABLE/SUGGESTED QUESTION BANK

1.	Design and simulate an ASK system to transmit digital data using a suitable carrier. Demodulate the ASK signal with the help of suitable circuit. Determine the minimum frequency of carrier for proper detection.
2.	Design and simulate the working of FSK with a suitable circuit for _____ Hz and __ Hz carrier signals. Demodulate the FSK signal with the help of suitable circuit.
3.	Design and simulate the working of BPSK modulated signal for a given carrier signal of ______ Hz. Demodulate the BPSK signal to recover the digital data.
4.	Design and simulate the working of TDM for PAM signals with _____ Hz and _____ Hz message signals. Also de-multiplex the message signals.
5.	Conduct a suitable experiment using slotted line carriage to obtain the following for the given load. a) λg and λo b) VSWR
6.	Conduct a suitable experiment using fiber optic trainer kit to determine the numerical aperture of the optical fiber.
7.	Conduct a suitable experiment using fiber optic trainer kit to determine: a)Propagation loss b) Bending loss
8.	With the help of suitable circuit demonstrate the working of DPSK encoder and Decoder for the specified input stream and carrier frequency simulate the same in software.
9.	With the help of a suitable circuit demonstrate the working of QPSK modulator and demodulator.
10.	Conduct an experiment using fiber optic trainer kit to establish digital link for the realization of PCM technique
11.	Conduct an experiment to find the characteristics of micro strip ring resonator. Also calculate the dielectric constant of the given dielectric material.
12.	Conduct an experiment on a given micro strip directional coupler to determine the following: a) Isolation b) Coupling factor c) Insertion Loss
13.	Conduct an experiment on a given micro strip power divider to determine the following: a) Isolation b) Coupling factor
14.	Conduct an experiment to obtain the radiation pattern of micro strip patch antenna. Also calculate the directivity and gain of the antenna.
15.	Conduct an experiment to obtain radiation pattern of micro strip dipole antenna. Also calculate the directivity and gain of the antenna

Appendix

LM 741 OPAMP

One of the cheapest and most-popular OP-AMP is the 741. Operational amplifiers can be used to perform mathematical operations on voltage signals such as inversion, addition, subtraction, integration, differentiation, and multiplication by a constant. The pinout for an LM741 is shown below:



The basic parameters for a 741 are :

Rail voltages : +/ 15v DC (+/ 5v min, +/ 18v max)

Input impedance: approx 2M

Low Frequency voltage gain: approx 2,00,000

Input bias current: 80 nA

Slew rate: 0.5 v per microsecond

Maximum output current: 20 mA

Recommended output load: not less than 2 k

Transistors: SL100 & SK100

SK100 is a general purpose, medium power PNP transistor. The basic applications of a transistor are switching, amplification and regulation. Its DC current gain ranges from 100 to a maximum of 300.

The transistor terminals require a fixed DC voltage to operate in the desired region of its characteristic curves. This is known as the biasing. For amplification applications, the transistor is biased such that it is partly on for all input conditions. The input signal at base is amplified and taken at the emitter. The voltage divider is the commonly used biasing mode. For switching applications, transistor is biased so that it remains fully on if there is a signal at its base. In the absence of base signal, it gets completely off.

The emitter leg of SK100 is indicated by a protruding edge in the transistor case. The base is nearest to the emitter while collector lies at other extreme of the casing.

SL100 is a general purpose, medium power NPN transistor. It is mostly used as switch in common emitter configuration.

The transistor terminals require a fixed DC voltage to operate in the desired region of its characteristic curves. This is known as the biasing. For switching applications, SL100 is biased in such a way that it remains fully on if there is a signal at its base. In the absence of base signal, it gets turned off completely.

The emitter leg of SL100 is indicated by a protruding edge in the transistor case. The base is nearest to the emitter while collector lies at other extreme of the casing.

Pin Diagram and circuit symbols of transistors