MICROWAVE ENGINEERING
&
DIGITAL COMMUNICATIONS

LAB MANUAL

Subject Code	:	A70499
Regulations	:	R15 – JNTUH
Class	:	IV Year I Semester (ECE)

Prepared by

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Department of Electronics & Communication Engineering

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal – 500 043, Hyderabad

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Electronics & Communication Engineering

Vision
To produce professionally competent Electronics and Communication Engineers capable of effectively and efficiently addressing the technical challenges with social responsibility.

Mission
The mission of the Department is to provide an academic environment that will ensure high quality education, training and research by keeping the students abreast of latest developments in the field of Electronics and Communication Engineering aimed at promoting employability, leadership qualities with humanity, ethics, research aptitude and team spirit.

Quality Policy
Our policy is to nurture and build diligent and dedicated community of engineers providing a professional and unprejudiced environment, thus justifying the purpose of teaching and satisfying the stake holders. A team of well qualified and experienced professionals ensure quality education with its practical application in all areas of the Institute.

Philosophy
The essence of learning lies in pursuing the truth that liberates one from the darkness of ignorance and Institute of Aeronautical Engineering firmly believes that education is for liberation. Contained therein is the notion that engineering education includes all fields of science that plays a pivotal role in the development of world-wide community contributing to the progress of civilization. This institute, adhering to the above understanding, is committed to the development of science and technology in congruence with the natural environs. It lays great emphasis on intensive research and education that blends professional skills and high moral standards with a sense of individuality and humanity. We thus promote ties with local communities and encourage transnational interactions in order to be socially accountable. This accelerates the process of transfiguring the students into complete human beings making the learning process relevant to life, instilling in them a sense of courtesy and responsibility.

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ELECTRONICS AND COMMUNICATION ENGINEERING

Program Outcomes	
PO1	**Engineering knowledge**: An ability to apply knowledge of basic sciences, mathematical skills, engineering and technology to solve complex electronics and communication engineering problems (**Fundamental Engineering Analysis Skills**).
PO2	**Problem analysis**: An ability to identify, formulate and analyze engineering problems using knowledge of Basic Mathematics and Engineering Sciences. (**Engineering Problem Solving Skills**).
PO3	**Design/development of solutions**: An ability to provide solution and to design Electronics and Communication Systems as per social needs**(Social Awareness)**
PO4	**Conduct investigations of complex problems**: An ability to investigate the problems in Electronics and Communication field and develop suitable solutions (**Creative Skills**).
PO5	**Modern tool usage** An ability to use latest hardware and software tools to solve complex engineering problems (**Software and Hardware Interface**).
PO6	**The engineer and society**: An ability to apply knowledge of contemporary issues like health, Safety and legal which influences engineering design (**Social Awareness**).
PO7	**Environment and sustainability** An ability to have awareness on society and environment for sustainable solutions to Electronics & Communication Engineering problems(**Social awareness**).
PO8	**Ethics**: An ability to demonstrate understanding of professional and ethical responsibilities(**Engineering impact assessment skills**).
PO9	**Individual and team work**: An ability to work efficiently as an individual and in multidisciplinary teams(**Team Work**).
PO10	**Communication**: An ability to communicate effectively and efficiently both in verbal and written form(**Communication Skills**).
PO11	**Project management and finance**: An ability to develop confidence to pursue higher education and for life-long learning(**Continuing education awareness**).
PO12	**Life-long learning**: An ability to design, implement and manage the electronic projects for real world applications with optimum financial resources**(Practical engineering analysis skills**).
Program Specific Outcomes	
PSO1	**Professional Skills:** An ability to understand the basic concepts in Electronics & Communication Engineering and to apply them to various areas, like Electronics, Communications, Signal processing, VLSI, Embedded systems etc., in the design and implementation of complex systems.
PSO2	**Problem-solving skills:** An ability to solve complex Electronics and communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.
PSO3	**Successful career and Entrepreneurship:** An understanding of social-awareness & environmental-wisdom along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

ATTAINMENT OF PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

S. No.	Experiment	Program Outcomes Attained	Program Specific Outcomes Attained
1	PCM Generation and Detection.	PO1, PO2	PSO1
2	Differential Pulse Code modulation.	PO1, PO2	PSO1
3	Delta modulation.	PO1, PO2	PSO1, PSO2
4	Frequency Shift Keying: Generation and Detection.	PO1, PO2	PSO1
5	Phase Shift Keying: Generation and Detection.	PO1, PO2, PO3	PSO1, PSO2
6	DPSK: Generation and Detection.	PO1, PO2, PO3	PSO1
7	Reflex Klystron Characteristics.	PO1, PO2	PSO1
8	Gunn diode characteristics.	PO1, PO2	PSO1
9	Measurement of scattering parameters of magic tee.	PO1, PO2, PO3	PSO1
10	Measurement of Scattering Parameters of Circulator.	PO1, PO2, PO3	PSO1, PSO2
11	Attenuation Measurement.	PO1, PO2, PO4, PO12	PSO1, PSO2
12	Measurement of Microwave Frequency.	PO1, PO2, PO3	PSO1
Content Beyond Syllabi			
1	Time Division Multiplexing.	PO1, PO2	PSO1
2	Amplitude shift Keying: Generation and Detection.	PO1, PO2	PSO1
3	Sampling Theorem	PO1, PO2	PSO1, PSO2
4	Directional coupler characteristics.	PO1	PSO1
5	VSWR measurement.	PO1, PO2	PSO1
6	Measurement of impedance measurement using reflex klystron	PO1	PSO1

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Certificate

This is to Certify that it is a bonafied record of Practical work done by Sri/Kum. ____ bearing the Roll No. __________________________ of ______________ Class ____ Branch in the _________________________________ laboratory during the Academic year ______________________ under our supervision.

Head of the Department

Lecture In-Charge

External Examiner

Internal Examiner

MICROWAVE ENGINEERING AND DIGITAL COMMUNICATION LABORATORY

Course Overview:

This laboratory course builds on the "digital communication and microwave communication" which is mandatory for all students of electronics and communication engineering. The course aims at practical experience with the processing the digital signals for various modulations and demodulations and the process of the microwaves in the microwave transmission lines. Experiments cover fundamental concepts of the digital modulation and demodulation process and also cover the propagation of the electromagnetic waves in the waveguide at microwave frequency. The objective of this laboratory is to enable the students to acknowledge with various digital modulation techniques and waveguides. They can critically analyze the behavior of their implementation

Course Outcomes :

Upon the completion of Digital Communication and Microwave Engineering practical course, the student will be able to:

1. Understand Basics of conversions from analog signals into digital signals.
2. Analyze the generation Various Signals and detection of the signals.
3. Determine the bandwidth and phase of the of the signals.
4. Understand the reduction of the conversion signals and difference of the phase of the signals.
5. Verification of microwave tube characteristics and gunn characteristics.
6. Analyze the frequency and wavelength of the rectangular wave guide
7. Understand the Waveform Synthesis using Laplace Transform.
8. Analyze the distribution of the power in the tee waveguide

INSTRUCTIONS TO THE STUDENTS

1. Students are required to attend all labs.
2. Students should work individually in the hardware and software laboratories.
3. Students have to bring the lab manual cum observation book, record etc along with them whenever they come for lab work.
4. Should take only the lab manual, calculator (if needed) and a pen or pencil to the work area.
5. Should learn the prelab questions. Read through the lab experiment to familiarize themselves with the components and assembly sequence.
6. Should utilize 3 hour's time properly to perform the experiment and to record the readings. Do the calculations, draw the graphs and take signature from the instructor.
7. If the experiment is not completed in the stipulated time, the pending work has to be carried out in the leisure hours or extended hours.
8. Should submit the completed record book according to the deadlines set up by the instructor.
9. For practical subjects there shall be a continuous evaluation during the semester for 25 sessional marks and 50 end examination marks.
10. Out of 25 internal marks, 15 marks shall be awarded for day-to-day work and 10 marks to be awarded by conducting an internal laboratory test.

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DIGITAL COMMUNICATION AND MICROWAVE ENGINEERING

LAB SYLLABUS

S. No.	List of Experiments	Page No.	Date	Remarks
1	PCM Generation and Detection.			
2	Differential Pulse Code modulation.			
3	Delta modulation.			
4	Frequency Shift Keying: Generation and Detection.			
5	Phase Shift Keying: Generation and Detection.			
6	DPSK: Generation and Detection.			
7	Reflex Klystron Characteristics.			
8	Gunn diode characteristics.			
9	Measurement of scattering parameters of magic tee.			
10	Measurement of Scattering Parameters of Circulator.			
11	Attenuation Measurement.			
12	Measurement of Microwave Frequency.			
Content Beyond Syllabi				
1	Time Division Multiplexing of 2band Limited Signals.			
2	Amplitude shift Keying: Generation and Detection.			
3	Sampling theorem			
4	Directional coupler characteristics.			
5	VSWR measurement.			
6	Measurement of impedance measurement using reflex klystron.			

***Content beyond the university prescribed syllabi**

EXPERIMENT No 1

PULSE CODE MODULATION AND DEMODULATION

AIM: To study the circuit of pulse code modulation and demodulation.

APPARATUS :

1. Physitech's Pulse Code Modulation &Demodulation
2. CRO
3. Connecting wires.

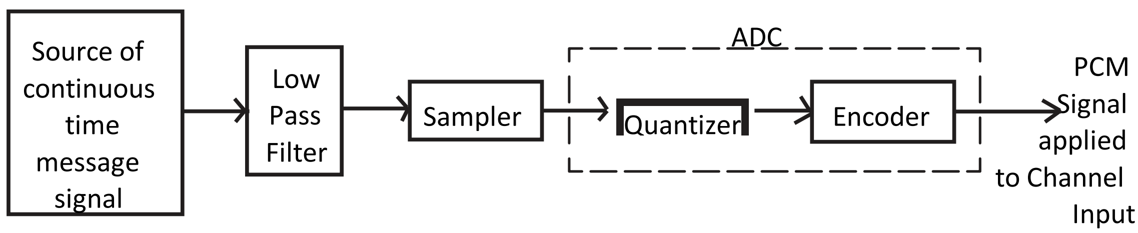
THEORY :

In pulse code modulation (PCM), a message signal is represented by a sequence of coded pulses, which is accomplished by representing the signal in discrete from in both time and amplitude. The basic elements of a PCM system is shown in fig. Below.

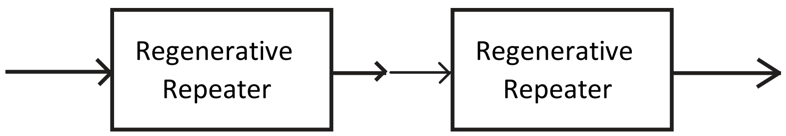
The basic operations performed in the transmitter of a PCM system are sampling, quantizing and encoding. The Low pass filter prior to sampling is included to prevent aliasing of the message signal. The incoming message signal is sampled with a train of narrow rectangular pulses so as to closely approximate the instantaneous sampling process. To ensure perfect reconstruction of the message signal at the receiver, the sampling rate must be greater than twice the highest frequency component W of the message signal in accordance with the sampling theorem.

The quantizing and encoding operations are usually performed in the same circuit, which is called an analog-to-digital converter. The same circuit, which is called an analog-to-digital converter. The sampled version of the message signal is then quantized, thereby providing a new representation of the signal that is discrete in both time and amplitude.

In combining the process of sampling and quantization, the specification of a continuous message (baseband) signal becomes limited to a discrete set of values, but not in the form best suited to transmission. To exploit the advantages of sampling and quantizing for the purpose of making the transmitted signal more robust to noise, interference and other channel impairments, we require the use of an encoding process to translate the discrete set of sample values to a more appropriate form of signal.

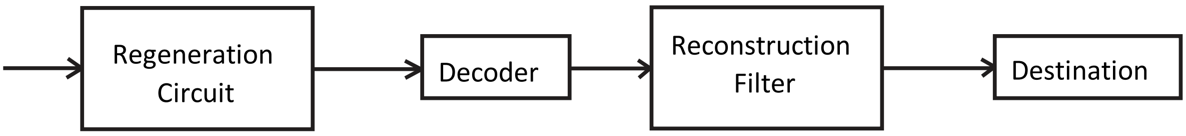


DistortedPCM

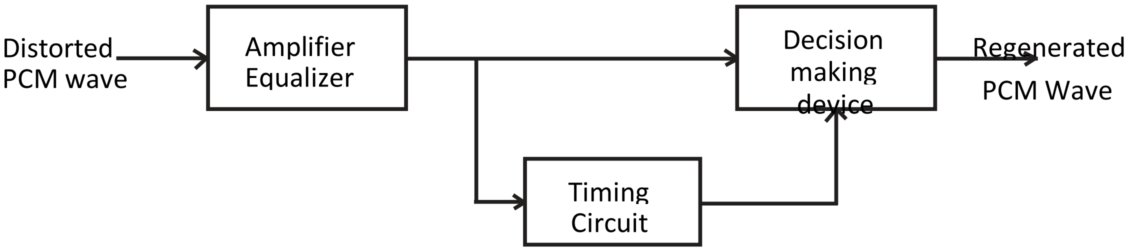


Reenerated PCM signal Produced Signal applied at channelto the Output receiver

(b) Transmission Path



(c) Receiver



REGENERATION :

The most important feature of PCM systems lies in the ability to control the effects of distortion and noise produced by transmitting a PCM signal through a channel. This capability is accomplished by reconstructing the PCM signal by means of a chain of regenerative repeaters located at sufficiently close spacing along the transmission route. As illustrated in fig. Below three basic functions are performed by a regenerative repeater: equalization, timing and decision making.

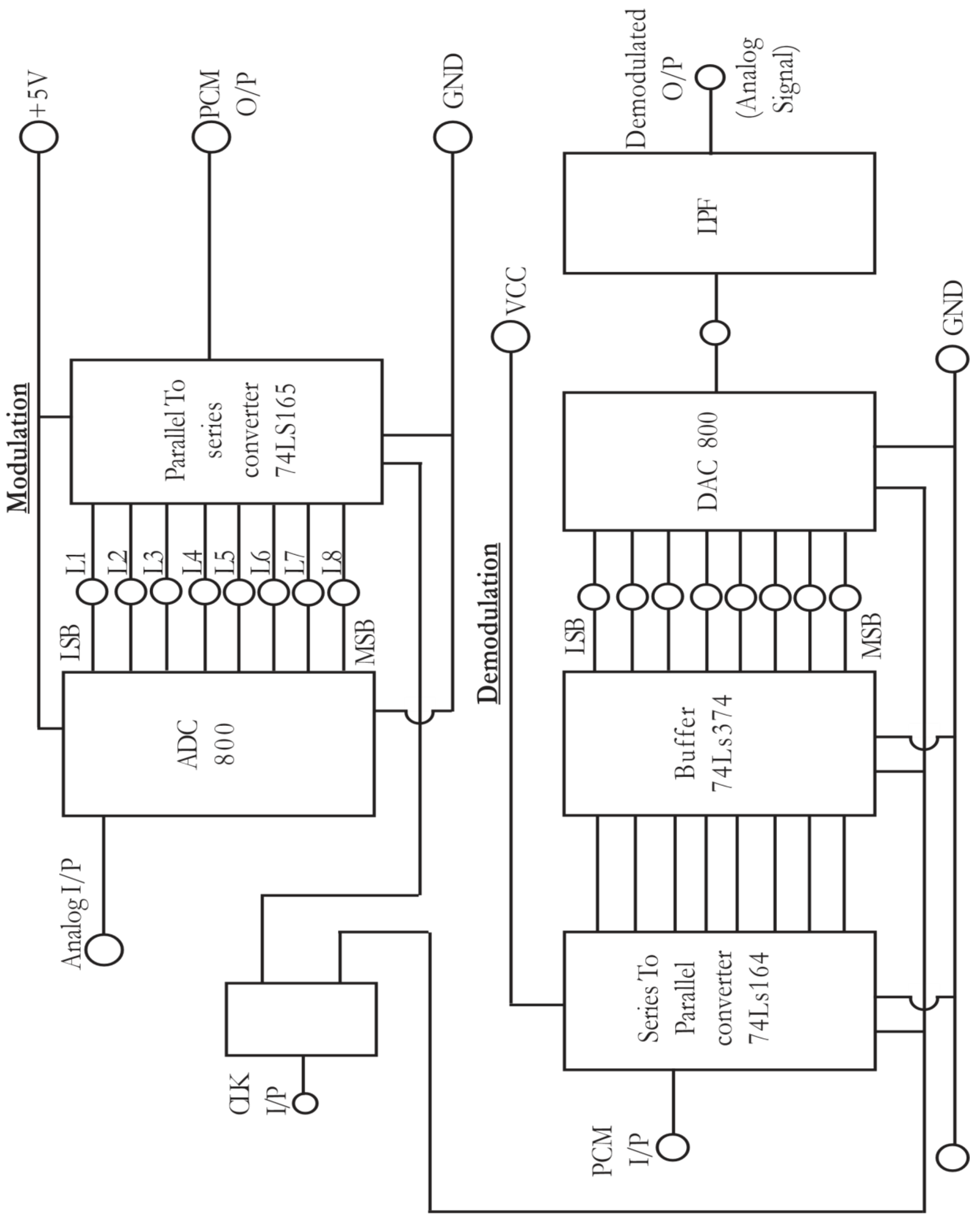
The equalizer shapes the received pulses so as to compensate for the effects of amplitude and phase distortions produced by the non ideal transmission characteristics of the channel.

The timing circuitry provides a periodic pulse train, derived from the received pulses, for sampling the equalized pulses at the instants of time where the signal-to-noise ratio is maximum.

Each sample so extracted is compared to a predetermined threshold in the decision making device. In each bit interval, a decision is then made whether the symbol is a 1 or 0 on the basis of whether the threshold is exceeded or not. If the threshold is exceeded, a pulse representing symbol '1' is transmitted. In the way, the accumulation of distortion &noise in a repeater span is completely removed.

The basic operations in the receiver are regeneration of impaired signals, decoding and reconstruction of the train of quantized samples. The first operation in the receiver is to regenerate (i.e., reshape & clean up) the received pulses one last time. These clean pulses are then regrouped into code words and decoded into a quantized PAM signal. The decoding process involves generating a pulse, the amplitude of which is the linear sum of all the pulses in the codeword. The final operation in the receiver is to recover the message signal by passing the decoder output through a low-pass reconstruction filter whose cutoff frequency is equal to the message bandwidth W. Assuming that the transmission path is error free, the recovered signal includes no noise with the exception of the initial distortion introduced by the quantization process.

CIRCUIT DIAGRAM:



CIRCUIT DESCRIPTION :

A variable sinusoidal frequency generator is provided with frequency from 0Hz to 200Hz. To see the actual bits that are transmitted through the communication channel, a variable dc (-5V to 5V) source is provided on the panel.

The modulating signal is applied to the input of Analog to-Digital (A/D) converter which performs the two functions of quantization and encoding, producing a 8-bit binary coded number. The signal is to be transmitted i.e., modulating signal is sampled at regular intervals. To transmit all the bits in one channel actually it is often sent as binary number back to front by par allel to serial converter transmits the code bits in serial fashion.

--As the receiver, the received data will be in serial form. The serial data is converted back to parallel form by serial to parallel converter and passes the bits to a Digital-to-Analog converter for decoding which has in-built sample and hold amplifier which maintains the pulse level for the duration of the sampling period, recreating the staircase waveform which is approximation of modulating signal. A lowpass filter may be used to reduce the quantization noise and to yield the original modulating signal .

PROCEDURE :

1 Switch on PHYSITECH's Pulse code modulation and demodulation.

2 Connect the variable DC O/P to the Analog I/P of modulation s e c t i o n .

3 Connect the clock O/P of bit clock generator to the clk I/P of modulation section.

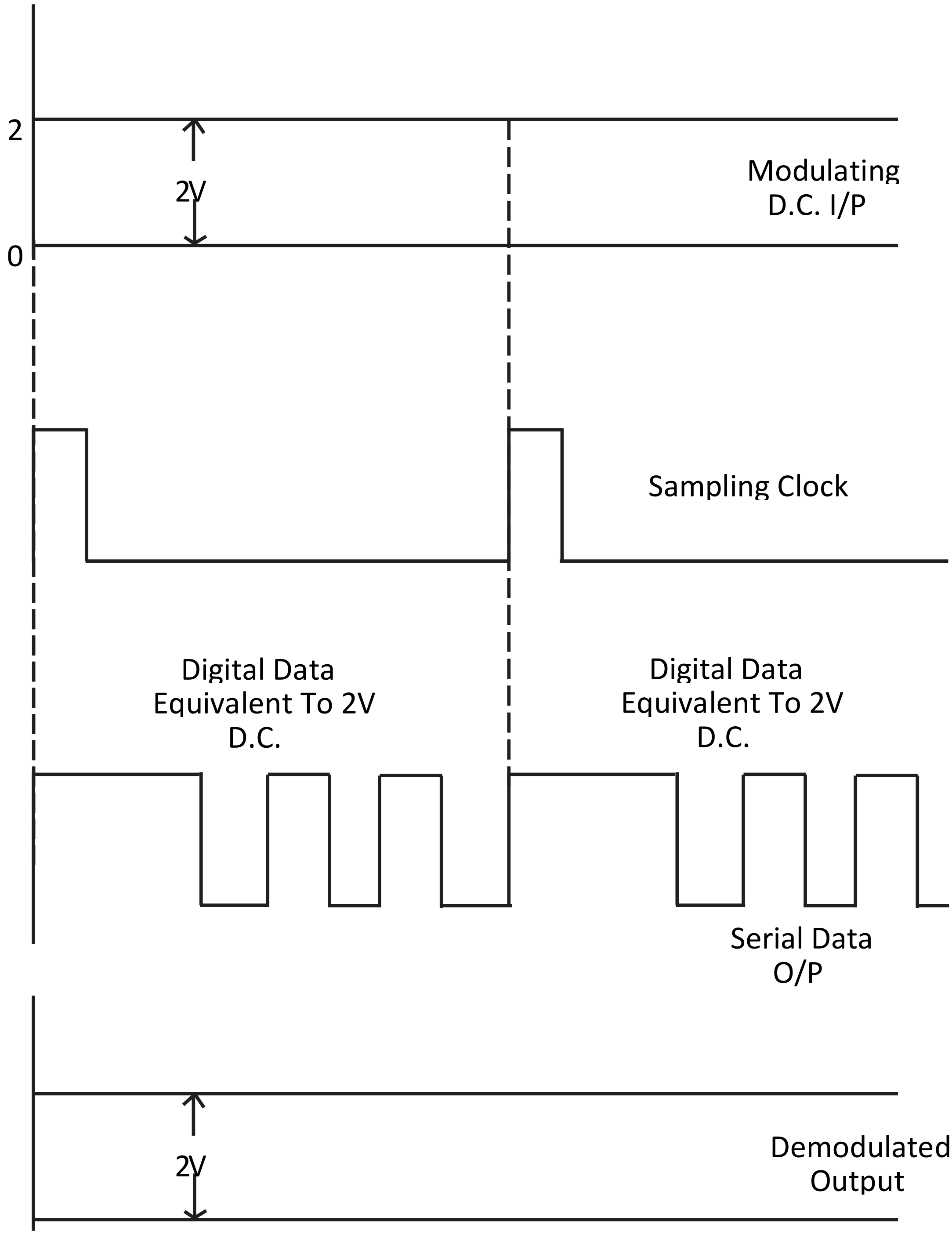
4 By varying the variable DC O/P observe the PCM O/P on CRO.

5 Connect the AF output to Analog I/P of modulation section by removing variable DC O/P

6 Connect the PCM O/P to PCM I/P of demodulation section.

7 Observe the DAC O/P at channel 1 of CRO and observe the demodulated O/P at channel 2 of CRO.

EXPECTED WAVEFORMS:



PRE LAB QUESTIONS

1) What is sampling theorem?
2) What is quantization?
3) What is encoder?

LAB ASSIGNMENT

1) What is the difference between analog and digital communication?
2) What is pulse code modulation?

POST LAB QUESTIONS

1) What is the need of processing of analog to digital convertion?
2) What is sample and hold circuit?
3) What are the applications of PCM?

RESULT:

Hence the Pulse Code Modulation and Demodulation has been studied and the modulated and demodulated output wave forms were observed.

EXPERIMENT No 2

DIFFERENTIAL PULSE CODE MODULATION AND DEMODULATION

AIM: To Study & understand the operation of the Differential Pulse Code Modulation.

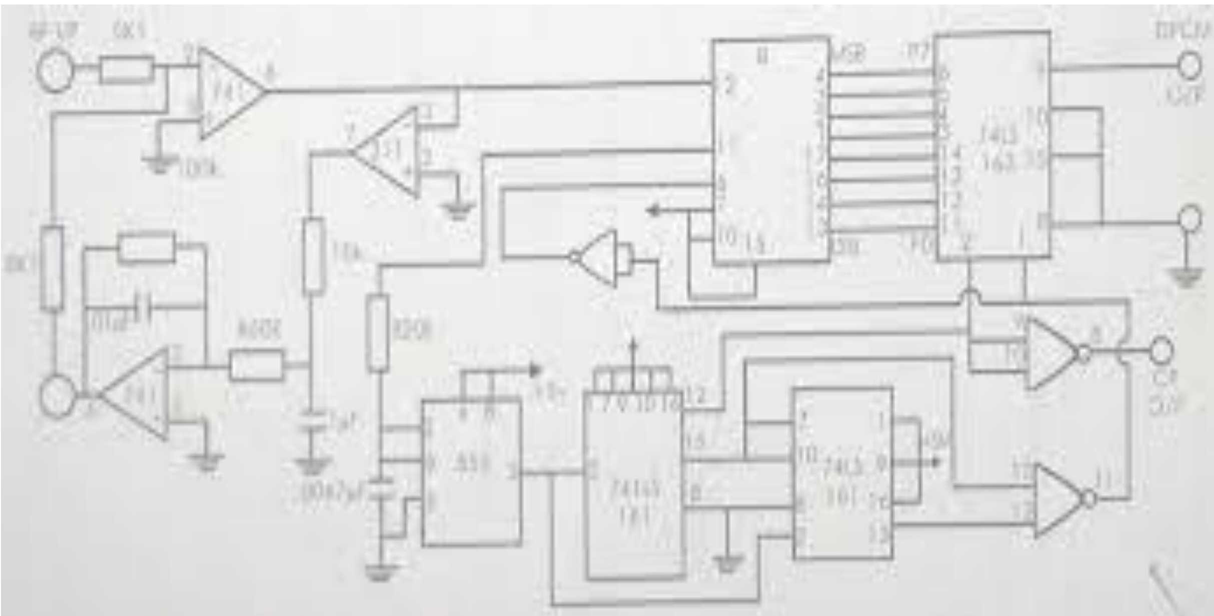
APPARATUS:

1. DPCM Modulator and Demodulator trainer
2. CRO
3. Connecting Wires

THEORY:

Differential PCM is quite similar to ordinary PCM. However, each word in this system indicates the difference in amplitude, positive or negative, between this sample and the previous sample. Thus the relative value of each sample is indicated rather than, the absolute value as in normal PCM.

BLOCK DIAGRAM:



PROCEDURE:

1. Study the theory of operation thoroughly.
2. Connect the trainer (Modulator) to the mains and switch on the power supply.
3. Observe the output of the AF generator using CRO, it should be Sine wave of 400 Hz frequency with 3V pp amplitude.
4. Verify the output of the DC source with multimeter/scope; output should vary 0 to +290mV.
5. Observe the output of the Clock generator using CRO, they should be 64 KHz and 8 KHz frequency of square with 5 Vp-p amplitude.
6. Connect the trainer (De Modulator) to the mains and switch on the power supply.
7. Observe the output of the Clock generator using CRO; it should be 64 KHz square wave with amplitude of 5 pp.

DPCM Operation (with DC input):

Modulation:

1. Keep CRO in dual mode. Connect one channel to 8 KHz signal (one which is connected to the Shift register) and another channel to the DPCM output.
2. Observe the DPCM output with respect to the 8 KHz signal and sketch the Waveforms.

   Note: Form this waveform you can observe that the LSB bit enters the output First.

Demodulation

3. Connect DPCM signal to the demodulator (S-P register) from the DPCM modulator with the help of coaxial cable (supplied with the trainer).
4. Connect clock signal (64 KHz) from the transmitter to the receiver using coaxial cable.
5. Connect transmitter clock to the timing circuit.
6. Observe and note down the S-P shift register output data and compare it with the transmitted data (i.e. output A/D converter at transmitter) notice that the output of the S-P shift register is following the A/D converter output in the modulator.
7. Observe D/A converter output (demodulated output) using multimeter/scope and compare it with the original signal and can observe that there is no loss in information in process of conversion and transmission.

DPCM Operation (with AC input):

Modulation:

8. Connect AC signal of $3V_{PP}$ amplitude to positive terminal of the summer circuit.

9. The output of the summer is internally connected to the sample and hold circuit

10. Keep CRO in dual mode. Connect one channel to the AF signal and another channel to the Sample and Hold output. Observe and sketch the sample & hold output

11. Connect the Sample and Hold output to the A/D converter and observe the DPCM output using oscilloscope.

12. Observe DPCM output by varying AF signal voltage.

Demodulation:

13. Connect DPCM signal to the demodulator input (S-P shift register) from the DPCM modulator with the help of coaxial cable (supplied with trainer).

14. Connect clock signal (64 KHz) from the transmitter to the receiver using coaxial cable.

15. Connect transmitter clock to the timing circuit.

16. Keep CRO in dual mode. Connect one channel to the sample& hold output and another channel to the D/A converter output.

17. Observe and sketch the D/A output

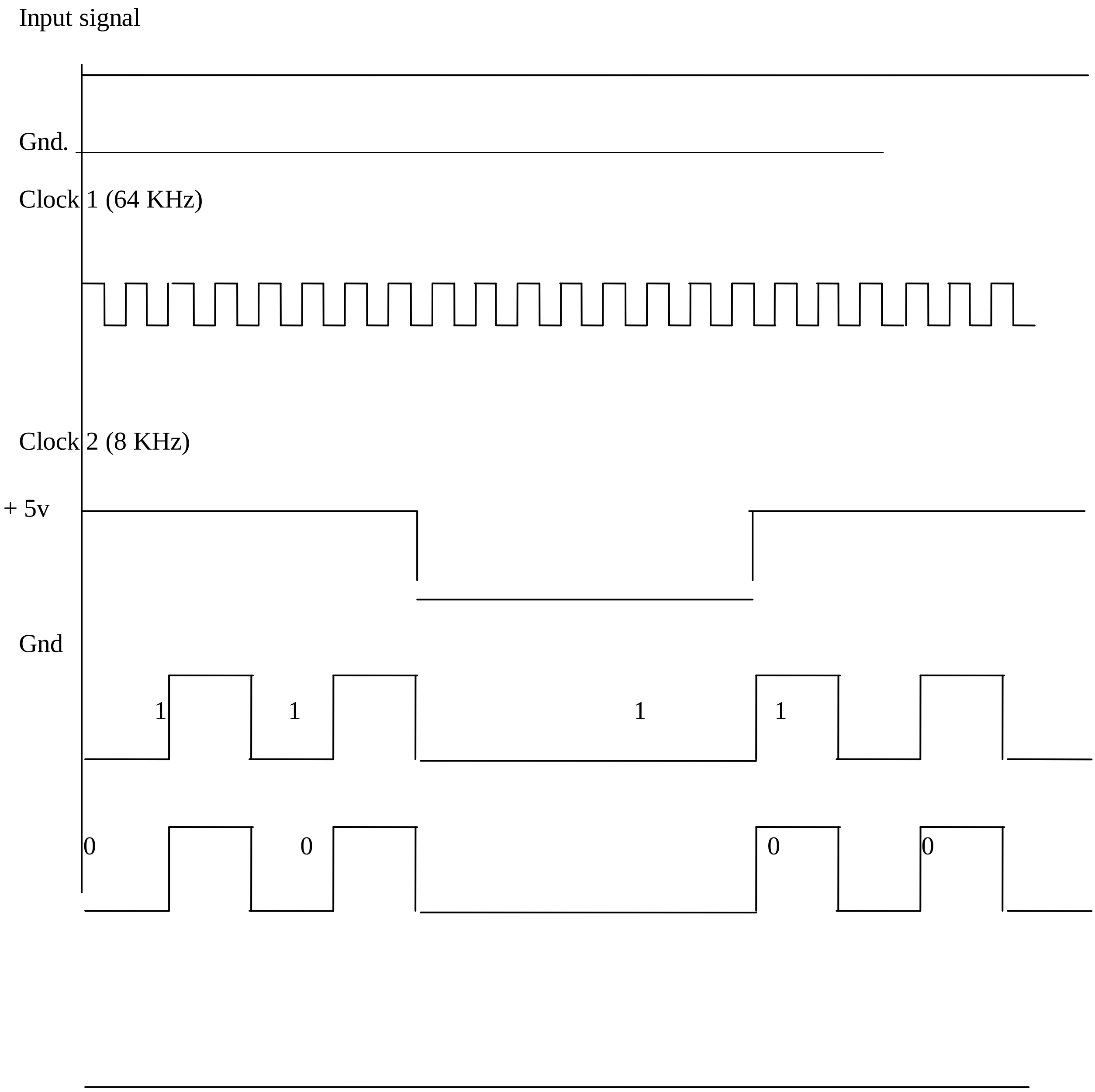
18. Connect D/A output to the LPF input and observe the output of the LPF.

19. Observe the wave form at the output of the summer circuit.

20. Disconnect clock from transmitter and connect to the local oscillator (i.e., clock generator output from Demodulator) with remaining setup as it is.

Observe D/A output and compare it with the previous result. This signal is little bit distorted in shape. This is because lack of synchronization between clock at transmitter and clock at receiver.

EXPECTED WAVEFORMS:



PRE LAB QUESTIONS

1. Define modulation?
2. How,Dpcm gives improved performance over PCM?
3. What is quantization?

LAB ASSIGNMENT

1) Difference between PCM and DPCM?
2) What are the advantages of DPCM?

POST LAB QUESTIONS

1) How many levels are reduced in DPCM over PCM?
2) How to applicable the DPCM in real time applications?
3) Why converting the parallel to serial conversion in the modulation?

RESULT:

Hence the Differential Pulse Code Modulation and Demodulation has been studied and the modulated and demodulated output wave forms were observed.

EXPERIMENT No 3

DELTA MODULATION AND DEMODULATION

AIM: To study the Delta modulation process by comparing the present signal with the previous signal of the given modulating signal.

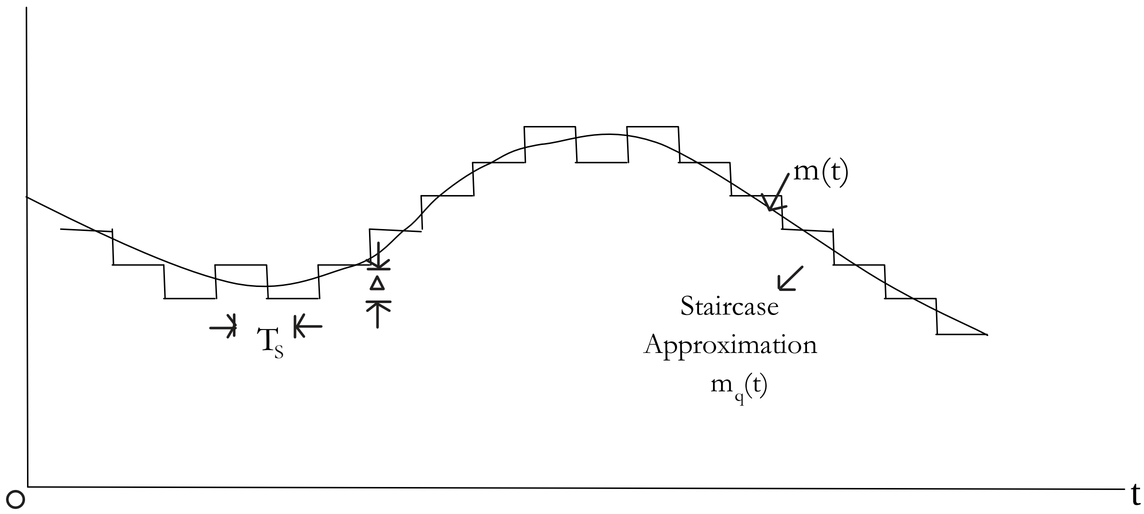
APPARATUS :

1. **PHYSITECH**'S Delta Modulation trainer
2. CRO
3. Connecting wires.

THEORY :

By the Delta Modulation technique, an analog signal can be encoded into bits. Hence, in one sense a DM is also a PCM. Differential pulse code modulation (DPCM) and Delta modulation (DM) are the two most commonly used versions of the PCM. DPCM systems use differential quantizes and PCM encoders. Delta modulation schemes use a differential quantizer with two output levels Ìor -Ì; these two levels are encoded using a single binary digit before transmission. Thus Delta modulation is a special case of DPCM.

In its basic form, DM provides a stair case approximation to the over sampled version of the message signal, as illustrated in fig. below.



Binaries sequece at modulator o/p 0 0 1 0 1 1 1 1 1 0 1 0 0 0 0 0 0

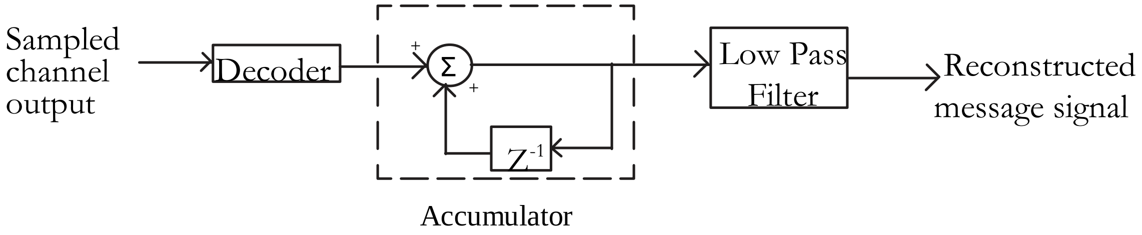
Illustration of Delta Modulation

The difference between the input and the approximation is quantized into only two levels namely,+Ì, corresponding to positive and negative differences. Thus if the approximation falls below the signal at any sampling epoch, it is increased byÌ. Or if the approximation lies above the signal, it is diminished by ê. Provided that the signal does not change too rapidly from sample to samples we find that the staircase approximation remains within +Ìof the input signal.

At the sampling instant nTs, the accumulator increments the approximation by a step ê in a positive or negative direction depending on the algebraic sign of the error sample e(n).

If the input sample m(n) is greater than the most recent approximation mq(n), a positive increment +Ìis applied to the approximation. If the input sample is smaller, a negative increment -Ìis applied to the approximation.

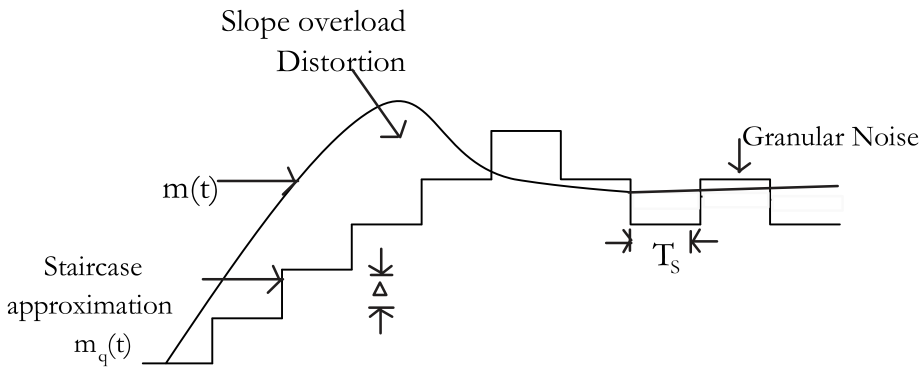
In the Receiver shown in fig. below, the staircase approximation is reconstructed by passing the sequence of positive and negative pulses, produced at the decoder output, through an accumulator in a manner similar to that used in the transmitter. Low pass filter is used to reject the out- of- band quantization noise in the high frequency staircase waveform, with a bandwidth equal to the original message bandwidth.



Receiver of Delta modulation

Delta modulation is subject to two types of quantization errors:

1. Slope overload distortion.
2. Granular Noise.



Two different forms of quantization errors in DM

The step sizeÌis too small for the staircase approximation mq(t) to follow a steep segment of the input waveform m(t), with result that mq(t) falls behind m(t), as illustrated in fig. above. This condition is called slope overload and the resulting quantization error is called slope – overload distortion.

Granular noise occurs when the step size ê is too large relative to the local slope characteristics of the input waveform m(t), there by causing the staircase approximation mq(t) to hunt around a relatively flat segment of the input waveform. Granular noise is analogous to quantization noise in PCM system.

The limitations of Delta modulation can be alleviated by filtering the signal to limit the maximum rate of change or by increasing the stepsize and/or the sampling rate. Filtering the signal & increasing the stepsize will result in poor signal resolution, and increasing the sampling rate will lead to larger bandwidth requirements.

To avoid these limitations, we need to make the Delta modulator “Adaptive”, in the sense that the step size is made to vary in accordance with the input signal. Systems using signal dependent stepsizes are called Adaptive Delta modulation (ADM) systems.

ADM is also known as continuous variable slope Delta modulator (CVSDM).

CIRCUIT DESCRIPTION :

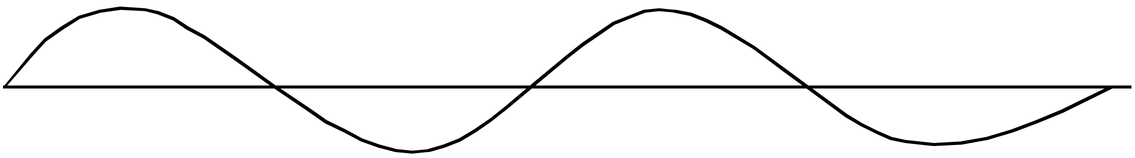
In modulator section, the comparator compares the input signal m(t) and reconstructed signal r(t). If m(t)>r(t) a logic 1 is generated at the output of the comparator, otherwise logic 0 is generated. The value of logic 1 or logic 0 turned as Ì(t) is held for the bit duration by the sample and hold current to generate the Delta modulated output.

During demodulation, the delta modulated output is fed to the 8 bit binary up/ down counter to control its count direction. A logic 1 at the mode control input increases the count value by one and a logic 0 decrements the count value by one. All the 8 outputs of the counter are given to DAC to reconstruct the original signal. In essence the counter and decoder forms the Delta modulator in the feedback loop of the comparator. Thus, if the input signal is higher than the reconstructed signal the counter increments at each step so as to enable the DAC output ot reach to the input signal values. Similarly if the input signal m(t) is lower than the reconstructed signal r(t), the counter decrements at each step, and the DAC output gets reduced to reach a value to that of m(t).

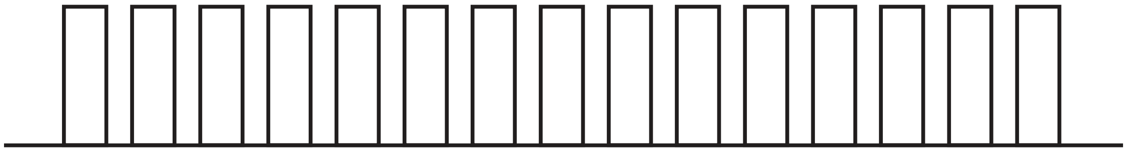
PROCEDURE:

1. Switch on the experimental board
2. Connect the clock signal of Bit clock generator to the bit clock input of Delta modulator circuit.
3. Connect modulating signal of the modulating signal generator to the modulating signal input of the Delta modulator.
4. Observe the modulating signal on Channel 1 of CRO
5. Observe the Delta modulator output on channel 2 of CRO
6. Connect the DM o/p of modulator to the DM I/P of Demodulator circuit.
7. Connect the clock signal to the Bit clock I/P of Demodulator circuit.
8. Observe the demodulated o/p on channel 2 of CRO.
9. Connect the demodulated o/p to the filter input of demodulator circuit.
10. Observe the demodulated o/p with filter on CRO.

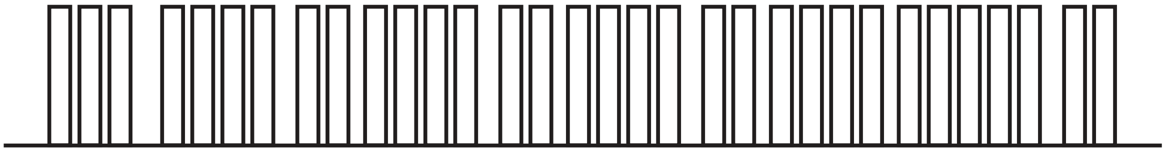
EXPECTED WAVEFORMS:



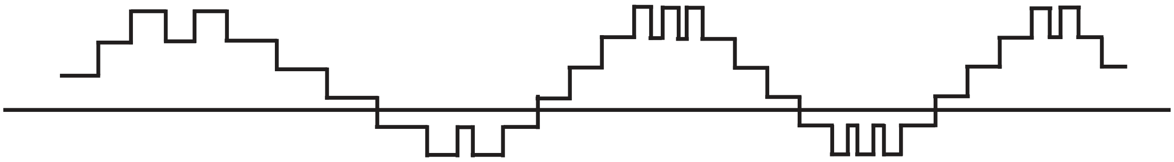
Modulating Signal I/P



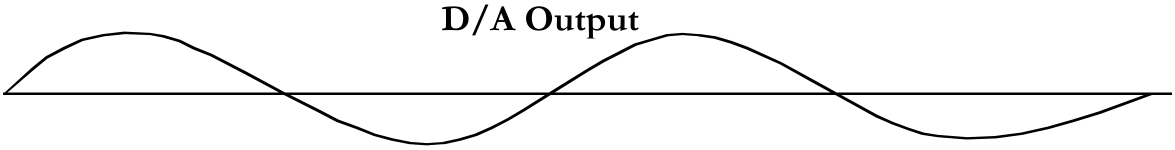
Clock I/P



Delta Modulator O/P



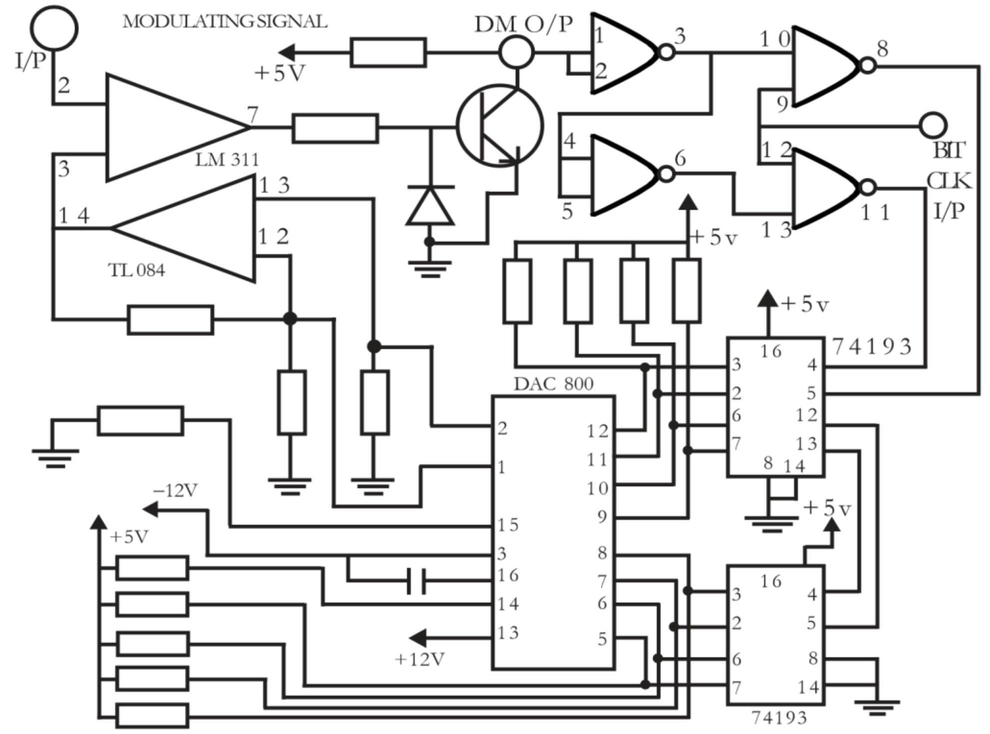
D/A Output



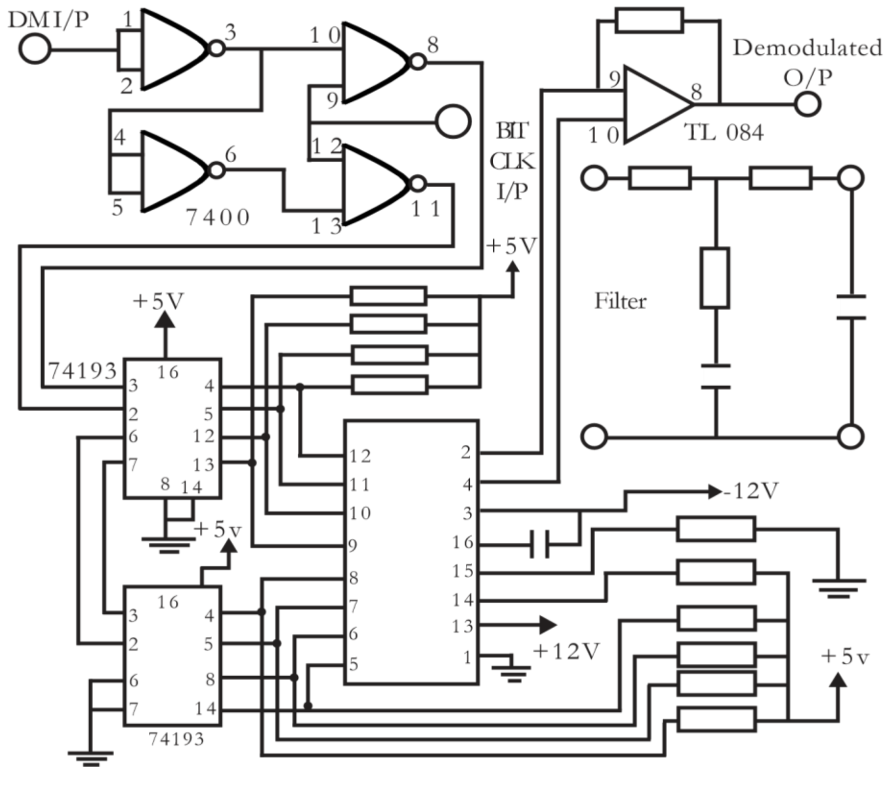
Filtered Output

Circuit Diagram :

Modulator



Demodulator



POST LAB QUESTIONS

1) What are two types of quantization errors?
2) What is the advantage of delta modulation over PCM?
3) What is slope overload distortion ?

LAB ASSIGNMENT

1) What is granular noise?
2) What happens to the output signal if the variation of the message signal is (i)greater than the step size (ii) less than the step size

PRE LAB QUESTIONS

1) Compare DPCM ,PCM& Delta modulation?
2) How to reduce the quantization noise that occurs in DM?
3) Mention the applications of DM?

RESULT:

Hence the Delta Modulation and Demodulation has been studied and the modulated and demodulated output wave forms were observed.

EXPERIMENT No 4

FREQUENCY SHIFT KEYING GENERATION AND DETECTION

AIM: To study frequency shift key (FSK) Modulator and Demodulator.

APPARATUS:

1 .Physitech's FSK Modulator-FSK Demodulator.

2 .Function Generator.

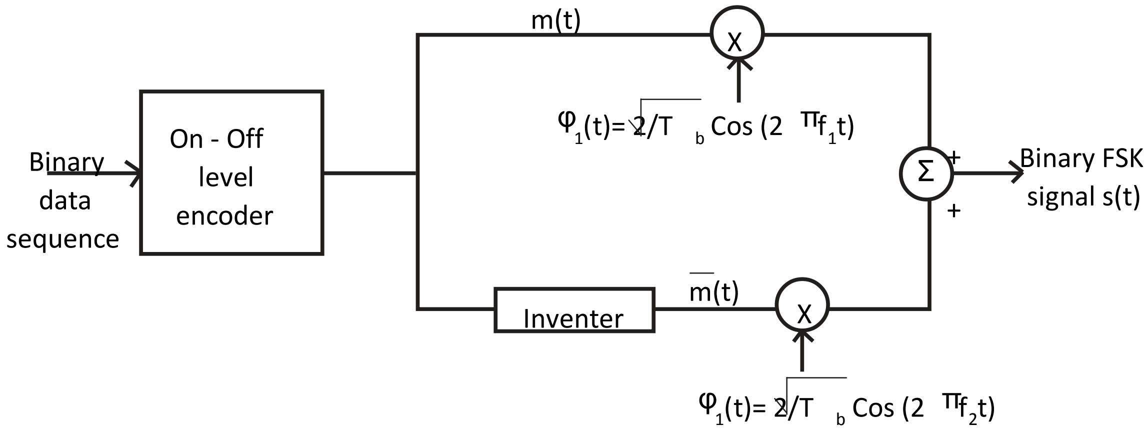
3 .CRO.

4 .BNC Probes.

THEORY :

Coherent frequency- shift keying (FSK) is a non-linear method of passband data transmission.

To generate a binary FSK signal, we may use the scheme shown in fig. Below.



BLOCK DIAGRAM FOR A FSK MODULATOR:

The incoming binary data is first applied to an on-off level encoder, at the output of which symbol 1 is represented by a constant amplitude of E_b volts and symbol o is represented by zero volts. By using an inverter in the lower channel shown in fig., we ineffect make sure that when we have symbol 1 at the input, the oscillator with frequency f_1 in the upper channel is switched ON, While oscillator with frequency f_2 in the lower channel is switched OFF, with the result that frequency f_1 is transmitted, Conversely, when we have symbol 0 at the input, the oscillator in the upper channel is switched OFF and the oscillator in the lower channel is switched ON, with the result that frequency f_2 is transmitted. The two frequencies f_1& f_2 are chosen to equal different integer multiples of the bit rate $1/T_b$.

In a binary FSK system, symbols 1 and 0 are distinguished from each other by transmitting one of two sinusoidal waves that differ in frequency by a fixed amount. A typical pair of sinusoidal waves is described by

$Si(t) = \sqrt{2E_b/T_b} \; Cos\,(2pf_i t), \quad 0 \leq t \leq T_b$

$\qquad\quad 0, \qquad\qquad\qquad\qquad\qquad elsewhere$

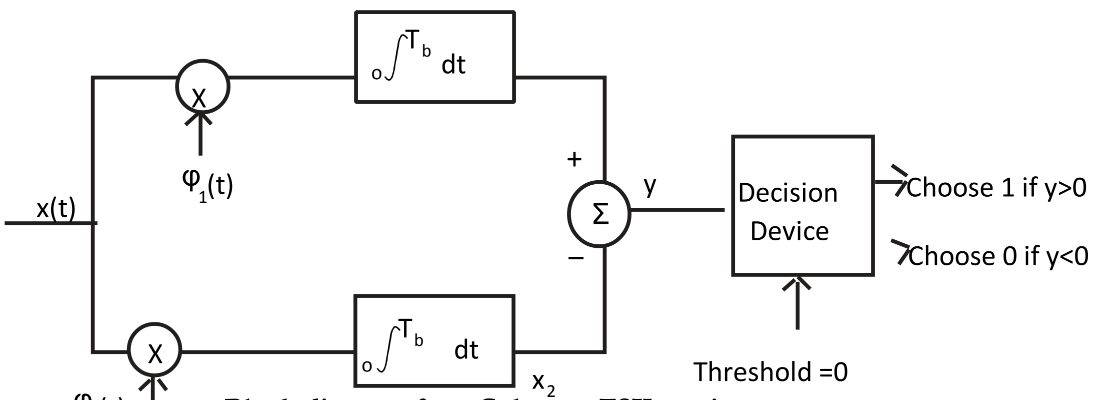
Where i=1,2,......and Eb is transmitted signal energy per bit. In the transmitter, we assume that the two oscillators are synchronized, so that their outputs satisfy the requirements of the two orthonormal basis functions $f_1(t)$ and f_2 (t). The form for the set of orthonormal basis function is

$$f_1(t) = \sqrt{2/T\{b}\; Cos\,(2pf_i t), \qquad 0 \leq t \leq T_b$$

$$0\,, \qquad\qquad\qquad elsewhere$$

Alternatively, we may use a single keyed (Voltage controlled) Oscillator. In either case, the frequency of the modulated wave is shifted with a continuous phase, in accordance with the input binary wave.

To detect the original binary sequence given the noisy received signal x(t), we may use the receiver shown in fig, below.



Block diagram for a Coherent FSK receiver

It consists of two correlators with a common input, which are supplied with locally generated coherent reference signals $f_1(t)$ and $f_2(t)$. The correlator outputs are then subtracted, one from the other, and the resulting difference, y, is compared with a threshold of zero volts. If y>0, the receiver decides in favour of 1. On the other hand, if y<0 it decides in favour of 0. If y is exactly 0, the receiver makes a random guess in favour of 1 or 0.

An FSK signal with continuous phase doesnot produce as much interference outside the signal band of interest as an FSK signal with discontinuous phase.

CIRCUIT DESCRIPTION:

The FSK generator is formed by using a 555 as an astable multi vibrator whose frequency is controlled by the transistor of Q_1. The output frequency of the FSK generator depends on the logic state of the digital data input. 150Hz is one of the standard frequencies at which the data are commonly tansmitted. When the input is logic 1, transistor Q_1 is off. Under these conditions, the

555 works in its normal mode as an astable multi vibrator; that is , capacitor C charges through R and R to 2/3 V_{CC} and discharges through R to 1/3V_{CC}. Thus capacitor C charges and discharges alternately between 2/3 V_{CC} and 1/3 V_{CC} as long as the input is at logic 1 state.

When the input signal is logic 0, Q_1 is on (Saturated), which inturn connects the resistance Rc across Ra. This action reduces the charging time of the capacitor and increases the output frequency.

The output of the 555 FSK generator is then applied to the 565 FSK demodulator. Capacitive coupling is used at the input to remove a dc level. As the signal appears at the input of the 565, the loop locks to the input frequency and tracks it between the two frequencies with a corresponding dc shift at the output. Resistor R_1 and capacitor C_1 determine the free-running frequency of the VCO, while C_2 is a loop filter capacitor that establishes the dynamic characteristics of the demodulator. Here C_2 must be choosen smaller than usual to eliminate overshoot on the output pulse. A three stage RC ladder (Low-pass) filter is used to remove the carrier component from the output. The high cutoff frequency (f_h=1/2 RC) of the ladder filter is chosen to be approximately half way between the maximum keying rate of 150Hz and twice the input frequency.

The output signal of 150Hz can be made logic compatible by connecting a voltage comparator between the output of the ladder filter and pin 6 of the PLL. The VCO frequency is adjusted with R_1, So that a slightly positive voltage is obtained at the output.

PROCEDURE :

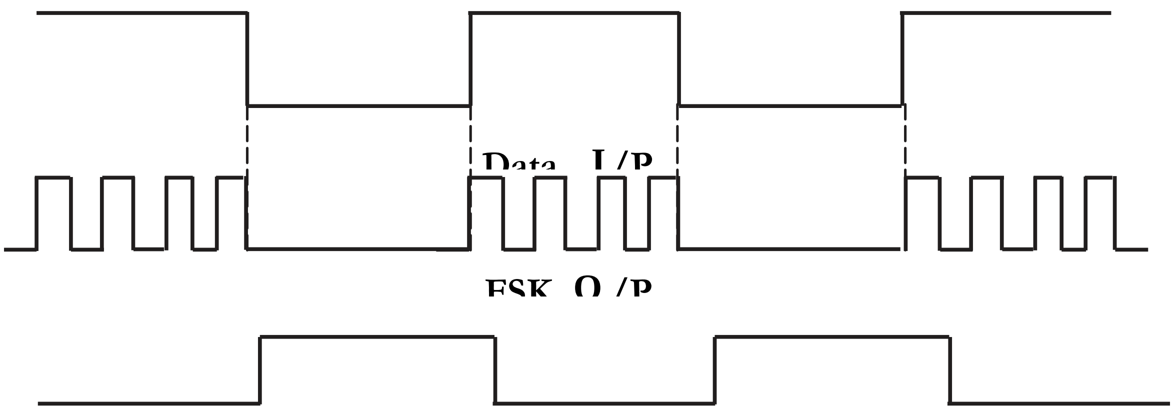
1 . Switch on Physitech's FSK modulator & demodulator Trainer K it .

2 . Connect 150Hz square wave from function generator to Input digital data terminal.

3 . Observe FSK O/P on channel 1 of CRO.

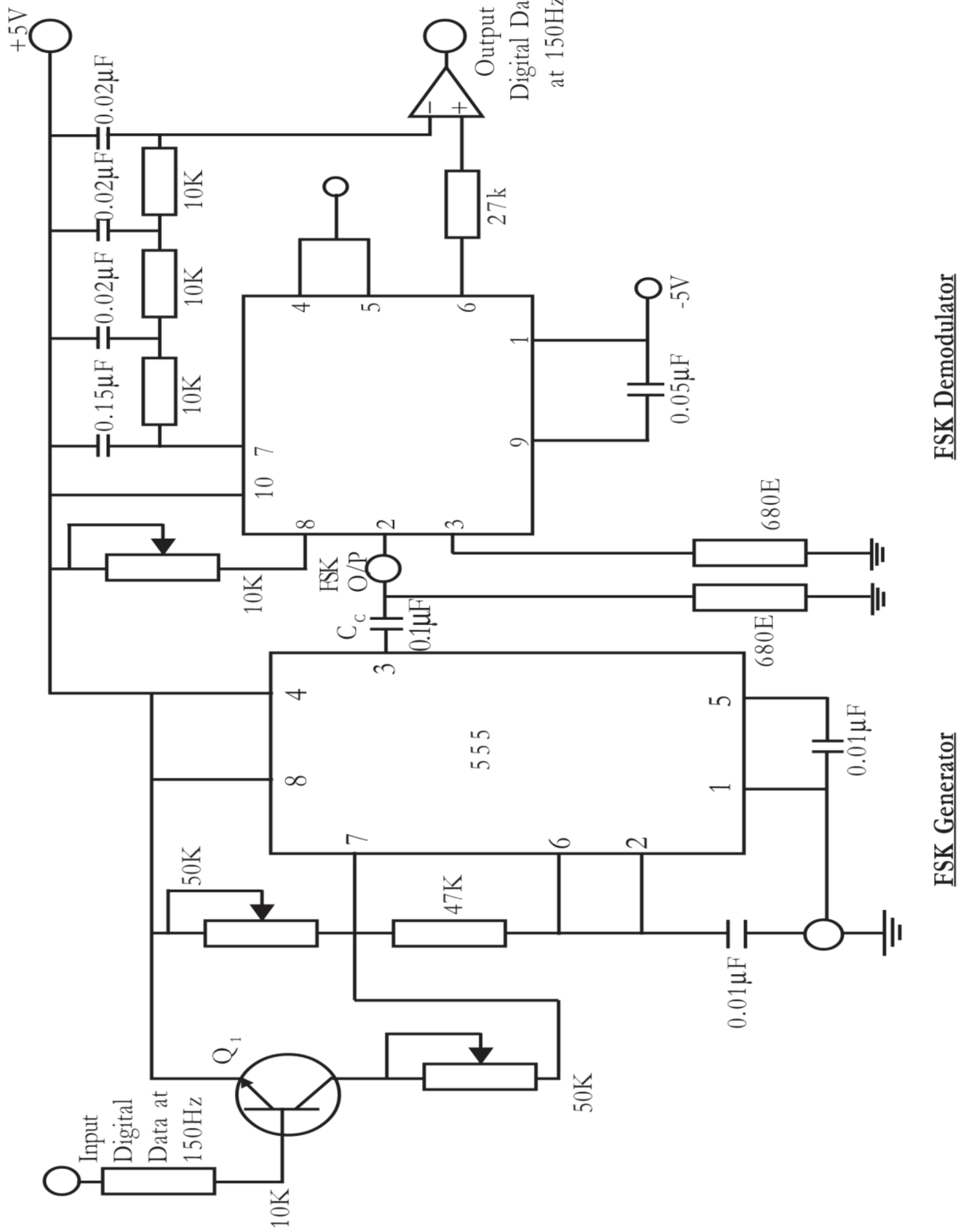
4 . Observe the demodulator output at output digital data terminal on channel 2 of CRO. To get correct waveform adjust the potentio meter knobs.

EXPECTED WAVEFORMS:



Demodulator O/P

Circuit Diagram :



PRE LAB QUESTIONS

1) Explain the concept of FSK?
2) Draw the waveforms of FSK?
3) What is the formula for Band Width required in FSK?

LAB ASSIGNMENT

1) Explain the demodulation scheme of FSK?
2) What is the minimum B.W for an FSK signal transmitting at 2000bps(haifduplex),if carriers are separated by 3KHz?

POST LAB QUESTIONS

1) Compare ASK, FSK & PSK?
2) Is FSK more susceptible to noise than ASK?
3) What are the limiting factors of FSK?

RESULT: Hence the FSK modulation and demodulation has been studied and the modulated and demodulated wave forms were observed.

EXPERIMENT No 5

PHASE SHIFT KEYING GENERATION AND DETECTION

AIM : To study the various steps involved in generating the phase shift keyed signal at the modulator end and recovering the binary signal from the received PSK signal.

APPARATUS:

1. Physitech's PSK Modulation & Demodulation
2. CRO
3. Connecting Wires

THEORY :

If the carrier phase is shifted between two values then the method is called phase shift keying (PSK). In PSK the amplitude of the carrier remains constant.

To generate a binary PSK signal, we have to represent the input binary sequence in polar form with symbols 1 and 0 represented by constant amplitude levels of + $\sqrt{E_b}$ and- $\sqrt{E_b}$, repectively. This signal transmission encoding is performed by a polar non returnto-zero (NRZ) level encoder. The resulting binary wave and a sinusoidal carrier f(t), whose frequency $f_C=(n_C/T_b)$ for some fixed integer n_C, are applied to a product modulator as shown fig.1. the carrier and the timing pulses used to generate the binary wave are usually extracted from a common master clock. The desired PSK wave is obtained at the modulator output.

To detect the original binary sequence of 1s and 0s, we apply the noisy PSK signal x(t) (at the channel output) to a correlator, which is also supplied with a locally generated coherent reference signal $f_1(t)$ as shown in fig.2. The correlator output, X_1 is compared with a threshold of zero volts. If $X_1>0$, the receiver decides infavour of symbol 1. On the other hand, if $X_1<0$, it decides in favour of symbol 0. If X_1 is exactly zero, the receiver makes a random guess in favour of 0 or 1.

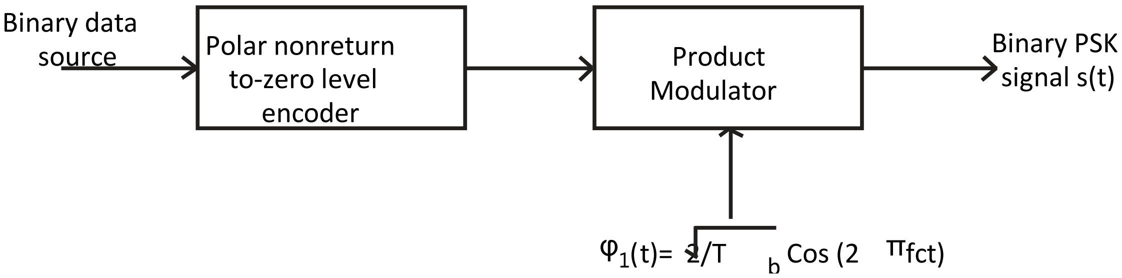


fig.1Block diagram for Binary PSK transmitter

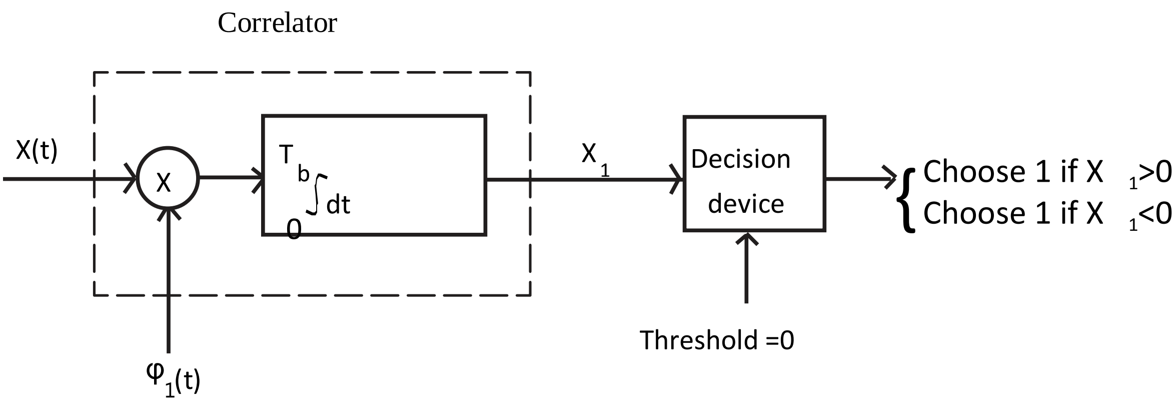


fig .2

Block diagram for Binary PSK receiver

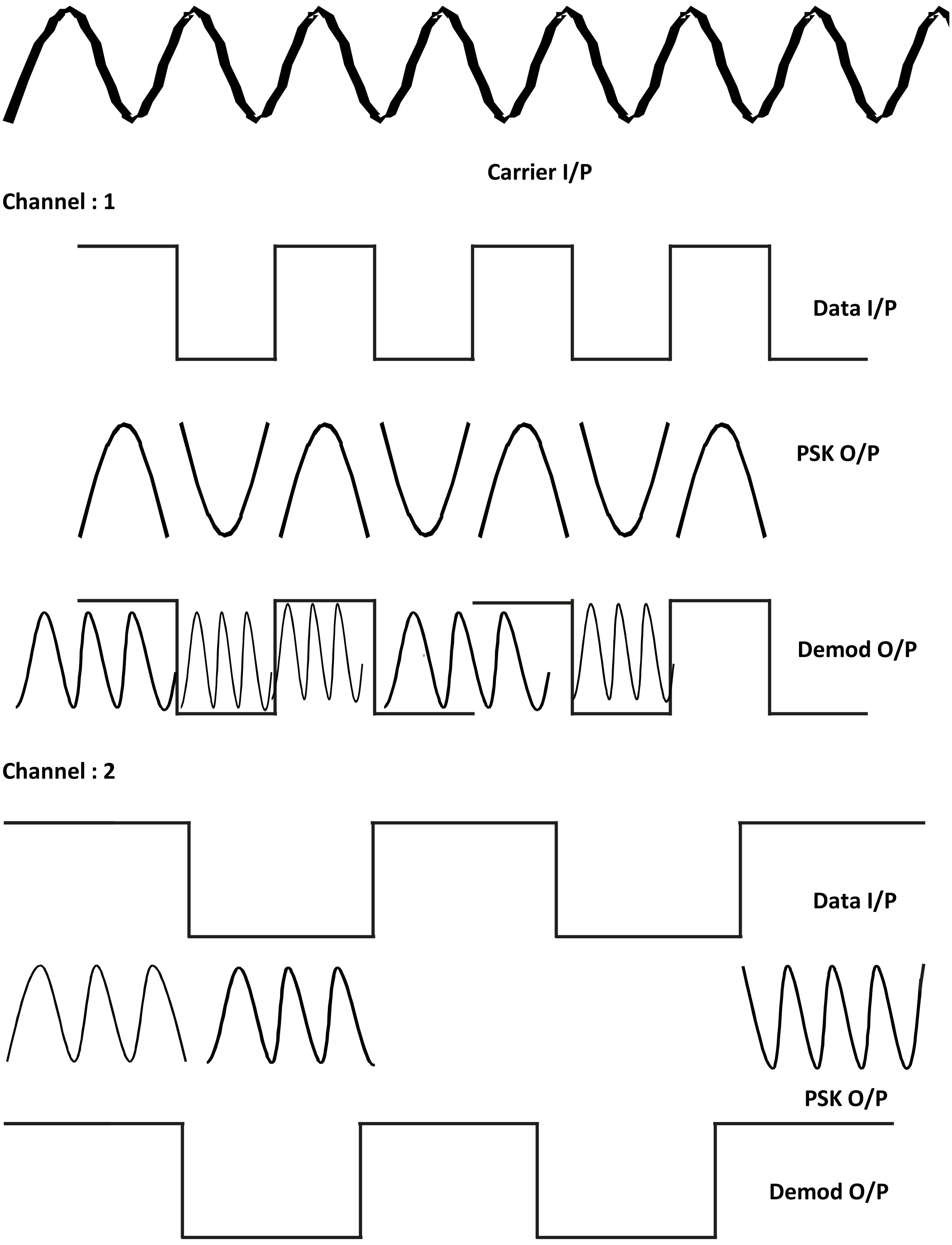
In PSK modulation and demodulation, the IC 8038 is a basic wave form generator which generates sine, Triangle and square waveforms. The sine wave generated by this 8038 IC is used as carrier signal to the system. The square wave generated by IC 8038 is at ± 12 volts level. So this is converted into a +5 volts signal with the help of a transistor and diode. This square wave is used as a clock input to a decade counter (IC 7490) which generates the modulating data outputs. IC CD4051 is an analog multiplexer to which carrier is applied with and without 180^0 phase shift to the two multiplex inputs of the IC. Modulating data input is applied to its control input. Depending upon the level of the control signal, carrier signal applied with or without phase shift is steered to the output. The 180^0 phase shift of the carrier signal is created by an operational amplifier using 324 IC.

During the demodulation, the PSK signal is converted into a +5volts square wave signal using a transistor and is applied to one input of an EX -OR gate. To the second input of the gate, carrier signal is applied after conversion into a +5volts signal. So the EX -OR gate output is equivalent to the modulating data signal.

PROCEDURE :

1. Switch on Physitech's PSK modulation and demodulation trainer.
2. Connect the carrier O/P of carrier generator to the carrier I/P of modulator.
3. Connect the data O/P of Data generator to the Data I/P of Modulator.
4. Compare these two signals.
5. Connect the PSK O/P of modulator to the PSK I/P of demodulator.
6. Connect the carrier O/P of carrier generator to carrier I/P of demodulator.
7. Connect CH_1 OF CRO to Data generator o/p and CH_2 tothe demodulator o/p.

PSK Expected wave forms



PRE LAB QUESTIONS

1) Explain the concept of PSK?
2) Draw the waveforms of PSK?
3) Is the maximum baud ate in PSK & ASK are same?

LAB ASSIGNMENT

1) Explain the demodulation scheme of PSK?
2) What is the advantage of PSK over ASK, FSK?

POST LAB QUESTIONS

1) Compare ASK, FSK, PSK?
2) What is the minimum B.W required in PSK?
3) Is the maximum bit rate in PSK is greater than ASK?

RESULT:

Hence the PSK modulation and demodulation has been studied and the modulated and demodulated wave forms were observed.

EXPERIMENT No 6

DPSK GENERATION AND DETECTION

AIM : To study the various steps involved in generating differential phase shift keyed signal at the modulator end and recovering the binary signal from the received DPSK signal.

APPARATUS :

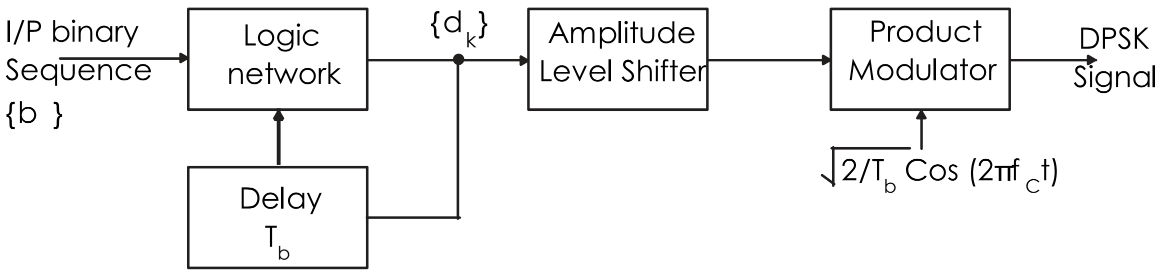
1. **PHYSITECH**'S Differential Phase shift keying Trainer.
2. CRO
3. Connecting Wires.

THEORY :

DPSK may be viewed as the noncoherent version of PSK. It eliminates the need for a coherent reference signal at the receiver by combining two basic operations at the transmitter :

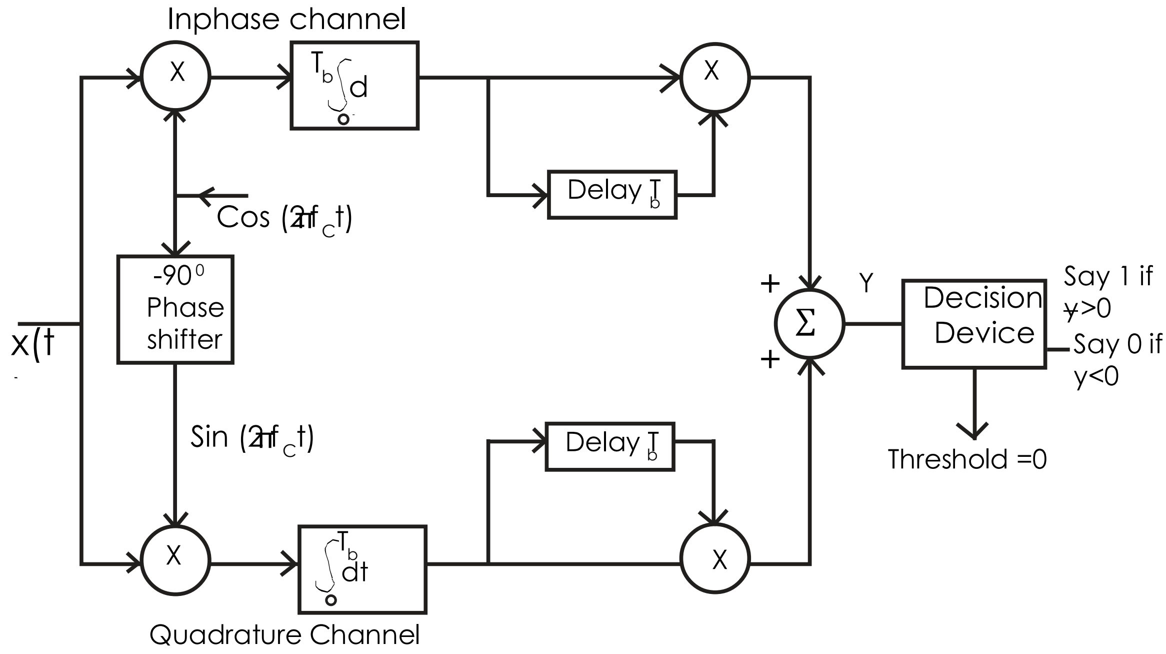
1. Differential encoding of the input binary wave and
2. Phase-Shift Keying -hence, the name, differential phase shift keying (DPSK).

In effect to send symbol 0, we phase advance the current signal waveform by 180 degrees, and to send symbol 1, we 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 θ contained in the received wave varies slowly, the phase difference between waveforms received in two successive bit intervals will be independent of θ.

The block diagram of a DPSK transmitter is shown in fig.1 below. It consists, in part, of a logic network and a one-bit delay element interconnected so as to convert the binary sequnecy $\{b_K\}$ into a differentially encoded sequence $\{d_K\}$. This sequence is amplitude -level encoded and then used to modulate a carrier wave of frequency f_C, thereby producing the desired DPSK signal. The optimum receiver for differentially coherent detection of binary DPSK is as shown in fig.2 below. This implementation merely requires that sample values be stored, thereby avoiding the need for delay lines that may be needed otherwise. The equivalent receiver implementation that tests squared elements is more complicated, but its use makes the analysis easier to handle in that the two signals to be considered are orthogonal.



Block Diagram of DPSK Receiver

In DPSK modulation and demodulation, the IC 8038 is a basic waveform generator which generates sine, square, triangle waveforms. The sine wave generated by this 8038 IC is used as carrier signal to the system. the square wave generated by 8038 IC is at +/- 12V level. So this is converted into a +5V signal with the help of a transistor and diode. This square wave is used as a clock input to a decade counter (IC7490) which generates the modulating data outputs.

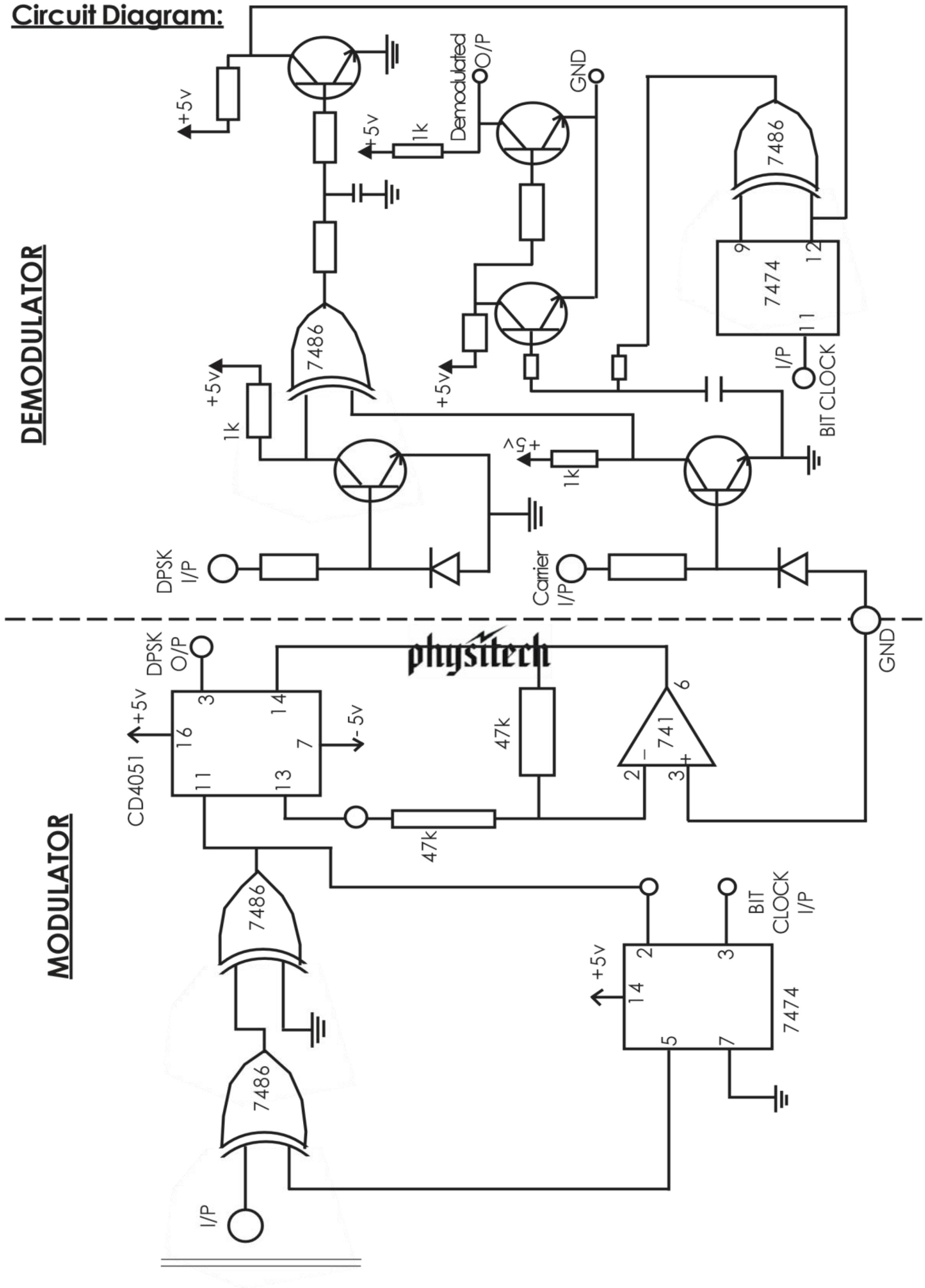
The differential signal to the modulating signal is generated using an exclusiveOR gate and a 1-bit delay circuit. CD 4051 is an analog multiplexer to which carrier is applied with and without 180 degrees phase shift (created by using an operational amplifier connected in inverting amplifier mode) to the two inputs of the IC 741. Differential signal generated by EX-OR gate (IC 7486) is given to the multiplexers control signal input. Depending upon the level of the control signal, carrier signal applied with or without phase shift is steered to the output. One-bit delay generation of differential signal to the input is created by using a D-flipflop (IC7474).

During the demodulation, the DPSK signal is converted into a +5V square wave signal using a transistor and is applied to one input of an EX - OR gate. To the second input of the gate, carrier signal is applied after conversion into a +5V signal. So, the EX-OR gate output is equivalent to the differential signal of the modulating data. This differential data is applied to one input of an Exclusive-OR gate and to the second input, after one-bit delay the same signal is given. So the output of this EX -OR gate is modulating signal.

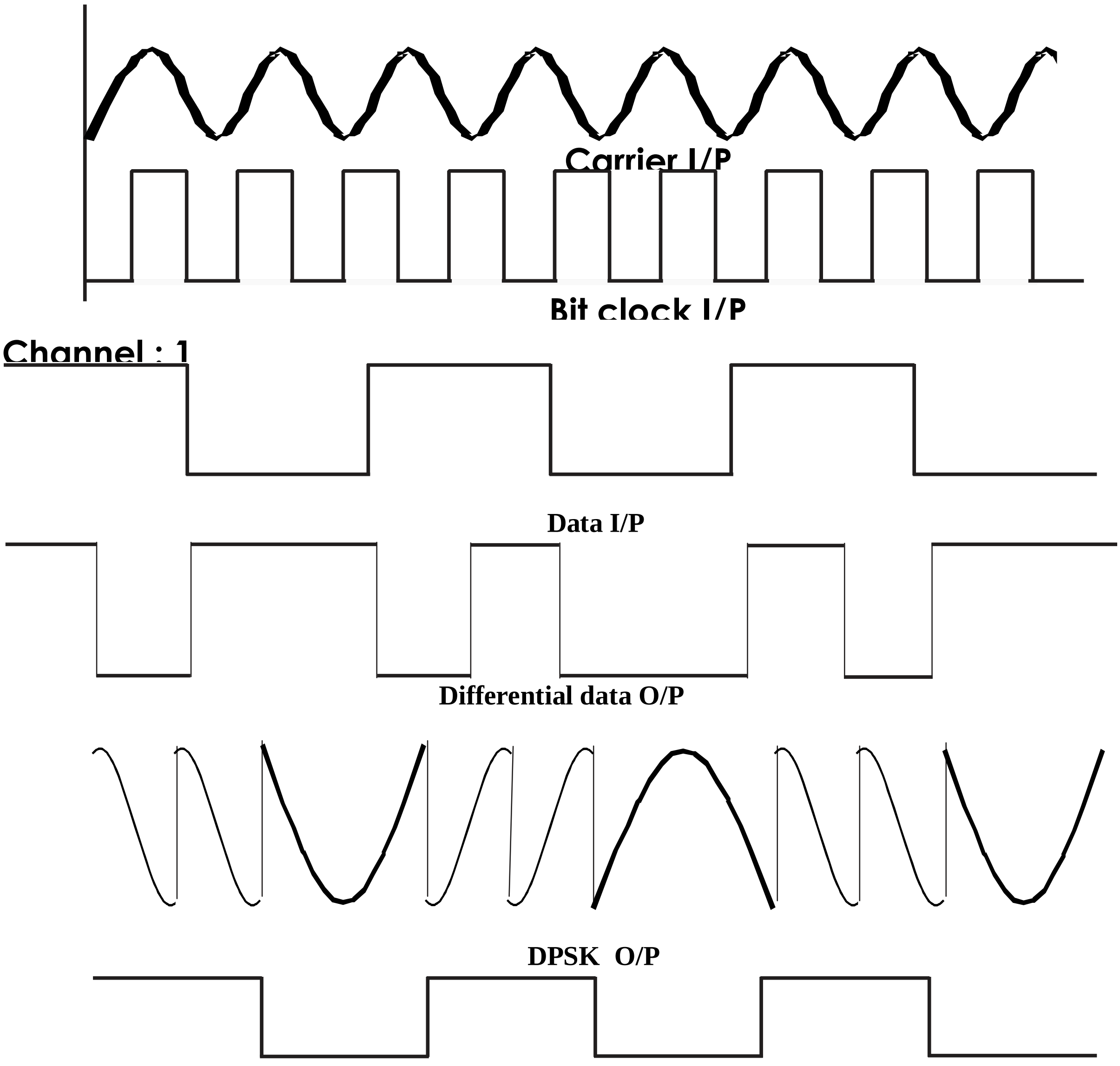
PROCEDURE :

1. Switch on Physitech's differential Phase shift Keying trainer.
2. Connect the carrier output of carrier generator to the 13th pin of CD4051 (Analog mux) of modulator.
3. Connect the Bit clock output to the Bit clock input at pin 3 of 7474 (8-bit converter) of modulator.
4. Connect the data output of data generator to the input of modulator circuit.
5. Connect channel 1 of CRO to the data generator.
6. Observe the differential data output at pin 2 of 7474 IC on channel -1 of CRO.
7. Observe the DPSK modulated output on channel-2 of CRO.
8. During demodulation, connect the DPSK modulated output to the DPSK I/P of Demodulator.
9. Connect the Bit clock O/P to the Bit clock I/P of Demodulator and also connect the carrier O/P to the carrier I/P of demodulator.
10. Observe the demodulated data O/P at demodulator.
11. The frequency of modulation data signal should be equal tothe demodulated O/P.

Circuit Diagram:



EXPECTED WAVEFORMS:



Demodulated O/P

PRE LAB QUESTIONS

1) How does DPSK differ from PSK?
2) What is the advantage of DPSK over PSK?
3) What are the applications of DPSK?

LAB ASSIGNMENT

1) What is the disadvantages of DPSK.?
2) Is the error rate of DPSK is greater than PSK?

POST LAB QUESTIONS

1) Explain theoretical modulation & demodulation of DPSK using arbitrary bitsequence and assuming initial bit 0 and 1?
2) Why do we need 1 bit delay in DPSK modulator & demodulator?
3) What is the relation between carrier frequency & the bit interval T?

RESULT: Hence the Differential Phase Shift Keying Modulation and Demodulation has been studied and the modulated and demodulated output wave forms were observed.

EXPERIMENT No7

REFLEX KLYSTRON CHARACTERISTICS

AIM: To study the mode characteristics of the reflex klystron tube and to determine its Electronic tuning range.

EQUIPMENT REQUIRED:

1. Klystron power supply – {SKPS – 610 }
2. Klystron tube 2k-25 with klystron mount – {XM-251}
3. Isolator {X_1-625}
4. Frequency meter {XF-710}
5. Detector mount {XD-451}
6. Variable Attenuator {XA-520}
7. Wave guide stand {XU-535}
8. VSWR meter {SW-215}
9. Oscilloscope
10. BNC Cable

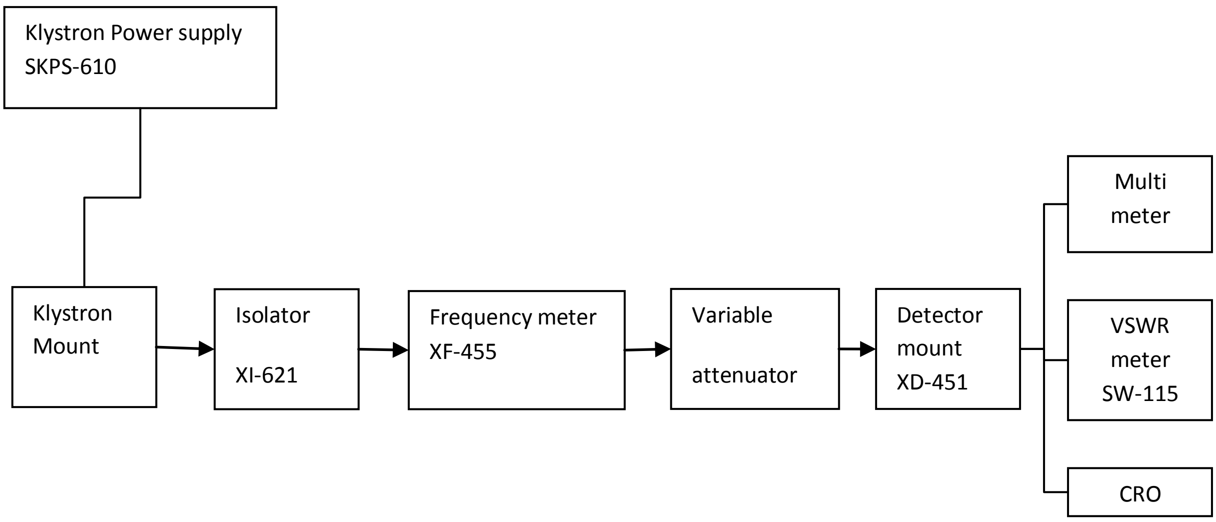
THEORY: The reflex klystron is a single cavity variable frequency microwave generator of low power and low efficiency. This is most widely used in applications where variable frequency is desired as

1. In radar receivers
2. Local oscillator in µw receivers
3. Signal source in micro wave generator of variable frequency
4. Portable micro wave links.
5. Pump oscillator in parametric amplifier

Voltage Characteristics: Oscillations can be obtained only for specific combinations of anode and repeller voltages that gives farable transit time.

Power Output Characteristics: The mode curves and frequency characteristics. The frequency of resonance of the cavity decides the frequency of oscillation. A variation in repeller voltages slightly changes the frequency.

BLOCK DIAGRAM:



EXPERIMENTAL PROCEDURE:

CARRIER WAVE OPERATION:

1. Connect the equipments and components as shown in the figure.
2. Set the variable attenuator at maximum Position.
3. Set the MOD switch of Klystron Power Supply at CW position, beam voltage control knob tofully anti clock wise and repeller voltage control knob to fully clock wise and meter switch to 'OFF' position.
4. Rotate the Knob of frequency meter at one side fully.
5. Connect the DC microampere meter at detector.
6. Switch "ON" the Klystron power supply, CRO and cooling fan for the Klystron tube..
7. Put the meter switch to beam voltage position and rotate the beam voltage knob clockwise slowly up to 300 Volts and observe the beam current on the meter by changing meter switch to beam current position. The beam current should not increase more than 30 mA.
8. Change the repeller voltage slowly and watch the current meter, set the maximum voltage on CRO.
9. Tune the plunger of klystron mount for the maximum output.
10. Rotate the knob of frequency meter slowly and stop at that position, where there is less output current on multimeter. Read directly the frequency meter between two horizontal lineand vertical

marker. If micrometer type frequency meter is used read the micrometer reading and find the frequency from its frequency calibration chart.

11. Change the repeller voltage and read the current and frequency for each repeller voltage.

B. SQUARE WAVE OPERATION:

1. Connect the equipments and components as shown in figure
2. Set Micrometer of variable attenuator around some Position**.**
3. Set the range switch of VSWR meter at 40 db position, input selector switch to crystal impedance position, meter switch to narrow position.
4. Set Mod-selector switch to AM-MOD position .beam voltage control knob to fully anti clockwise position.
5. Switch “ON” the klystron power Supply, VSWR meter, CRO and cooling fan.
6. Switch “ON” the beam voltage. Switch and rotate the beam voltage knob clockwise up to 300V in meter.
7. Keep the AM – MOD amplitude knob and AM – FREQ knob at the mid position.
8. Rotate the reflector voltage knob to get deflection in VSWR meter or square wave on CRO.
9. Rotate the AM – MOD amplitude knob to get the maximum output in VSWR meter or CRO.
10. Maximize the deflection with frequency knob to get the maximum output in VSWR meter or CRO.
11. If necessary, change the range switch of VSWR meter 30dB to 50dB if the deflection in VSWR meter is out of scale or less than normal scale respectively. Further the output can be also reduced by variable attenuator for setting the output for any particular position.

C. **MODE STUDY ON OSCILLOSCOPE**:

1. Set up the components and equipments as shown in Fig.
2. Keep position of variable attenuator at min attenuation position.
3. Set mode selector switch to FM-MOD position FM amplitude and FM frequency knob at mid position keep beam voltage knob to fully anti clock wise and reflector voltage knob to fully clockwise position and beam switch to ‘OFF’ position.
4. Keep the time/division scale of oscilloscope around 100 HZ frequency measurement and volt/div. to lower scale.
5. Switch ‘ON’ the klystron power supply and oscilloscope.
6. Change the meter switch of klystron power supply to Beam voltage position and set beam voltage to 300V by beam voltage control knob.
7. Keep amplitude knob of FM modulator to max. Position and rotate the reflector voltage anti clock wise to get the modes as shown in figure on the oscilloscope. The horizontal axis represents reflector voltage axis and vertical represents o/p power.

8. By changing the reflector voltage and amplitude of FM modulation in any mode of klystron tube can be seen on oscilloscope.

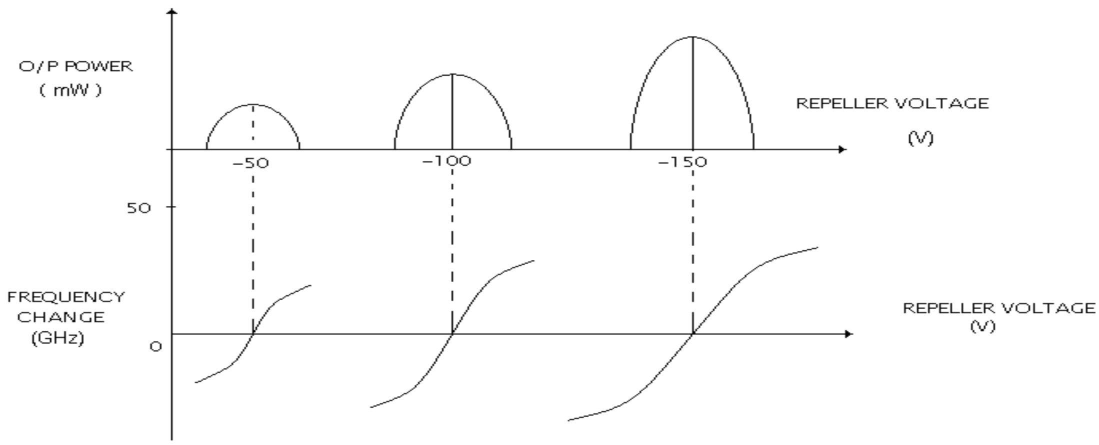
OBSERVATION TABLE:

Beam Voltage :…………V (Constant)

Beam Current :………….mA

Repeller Voltage (V)	Current (mA)	Power (mW)	Dip Frequency (GHz)

EXPECTED GRAPH:



PRE LAB QUESTIONS

1)What is klystron tube?
2)What is velocity modulation?
3)What is bunching?

LAB ASSIGNMENT

1) Observe the reflex klystron characteristics ?
2) Determine the electronic tuning range?

POST LAB QUESTIONS

1)Importance of multicavity klystron?
2)What is electronic tuning?

RESULT:

The characteristics of Reflex Klystron has been studied and modes have been found.

EXPERIMENT No 8

GUNN DIODE CHARACTERISTICS

AIM: To study the V-I characteristics of Gunn diode.

EQUIPMENT REQUIRED:

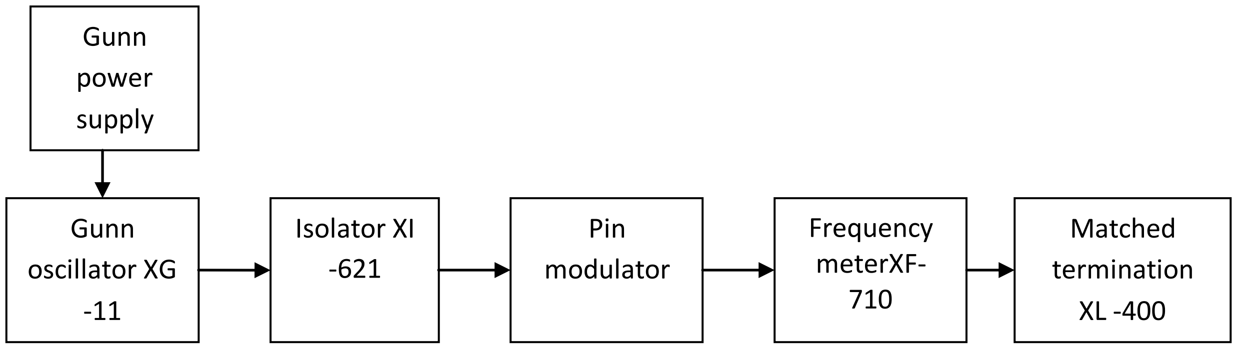
1. Gunn power supply
2. Gunn oscillator
3. PIN Modulator
4. Isolator
5. Frequency Meter
6. Variable attenuator
7. Slotted line
8. Detector mount and CRO.

THEORY:

Gunn diode oscillator normally consist of a resonant cavity, an arrangement for coupling diode to the cavity a circuit for biasing the diode and a mechanism to couple the RF power from cavity to external circuit load. A co-axial cavity or a rectangular wave guide cavity is commonly used.

The circuit using co-axial cavity has the Gunn diode at one end at one end of cavity along with the central conductor of the co-axial line. The O/P is taken using a inductively or capacitively coupled probe. The length of the cavity determines the frequency of oscillation. The location of the coupling loop or probe within the resonator determines the load impedance presented to the Gunn diode. Heat sink conducts away the heat due to power dissipation of the device.

BLOCK DIAGRAM



EXPERIMENTAL PROCEDURE:

Voltage-Current Characteristics:

1. Set the components and equipments as shown in Figure.
2. Initially set the variable attenuator for minimum attenuation.
3. Keep the control knobs of Gunn power supply as below

   Meter switch – "OFF"

   Gunn bias knob – Fully anti clock wise

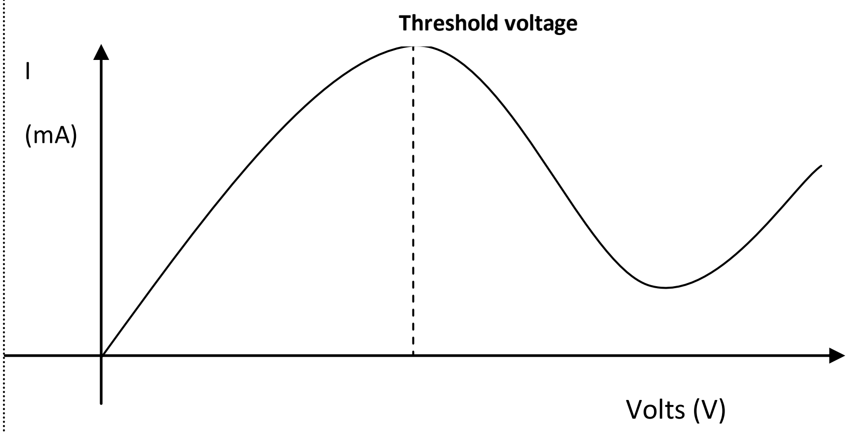
   PIN bias knob – Fully anti clock wise

   PIN mode frequency – any position

4. Set the micrometer of Gunn oscillator for required frequency of operation.
5. Switch "ON" the Gunn power supply.
6. Measure the Gunn diode current to corresponding to the various Gunn bias voltage through the digital panel meter and meter switch. Do not exceed the bias voltage above 10 volts.
7. Plot the voltage and current readings on the graph.
8. Measure the threshold voltage which corresponding to max current.

Note: Do not keep Gunn bias knob position at threshold position for more than 10-15 sec. readings should be obtained as fast as possible. Otherwise due to excessive heating Gunn diode may burn

EXPECTED GRAPH:



I-V CHARACTERISTICS OF GUNN OSCILLATOR

OBSERVATION TABLE:

Gunn bias voltage (v)	Gunn diode current (mA)

PRE LAB QUESTIONS

1) What is GUNN diode ?
2) Draw the equivalent Circuit for GUNN?
3) How many junctions are there in GUNN?

LAB ASSIGNMENT

1) What is the use of Gunn diode?
2) State Gunn effect?

POST LAB QUESTIONS

1) What are the different modes in GUNN diode oscillator?
2) Explain the transferred electron effect in GUNN?
3) What are applications of GUNN?

RESULT: The Gunn diode characteristics have been observed and are drawn.

EXPERIMENT No 9

SCATTERING PARAMETERS OF MAGIC TEE

AIM: To Study the operation of Magic Tee and calculate Coupling Co-efficient and Isolation.

EQUIPMENT REQUIRED: Microwave source : Klystron tube (2k25)

1. Isolator (XI-621)
2. Frequency meter (XF-710)
3. Variable Attenuator (XA-520)
4. Slotted line (SX-651)
5. Tunable probe (XP-655)
6. Detector Mount (XD-451)
7. Matched Termination (XL-400)
8. Magic Tee (XE-345/350)
9. Klystron Power Supply + Klystron Mount
10. Wave guide stands and accessories

THEORY:

The device Magic Tee is a combination of E and H plane Tee. Arm 3 is the H-arm and arm 4 is the E-arm. If the power is fed, into arm 3 (H-arm) the electric field divides equally between arm1 and 2 with the same phase and no electric field exists in the arm 4. If power is fed in arm 4 (E-arm) it divides equally into arm 1 and 2 but out of phase with no power to arm 3, further, if the power is fed in arm 1 and 2 simultaneously it is added in arm 3 (H-arm) and it is subtracted in E-arm i.e., arm 4.

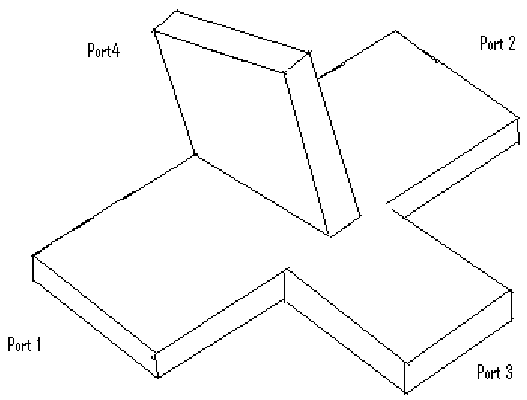


Fig: Magic Tee

A. Isolation:

The Isolation between E and H arm is defined as the ratio of the power supplied by the generator connected to the E-arm (port 4) to the power detected at H-arm (port 3) when side arm 1 and 2 terminated in matched load.

Isolation (dB) = $10 \log_{10} [P4/P3]$

Similarly, Isolation between other ports may be defined.

B. Coupling Factor:

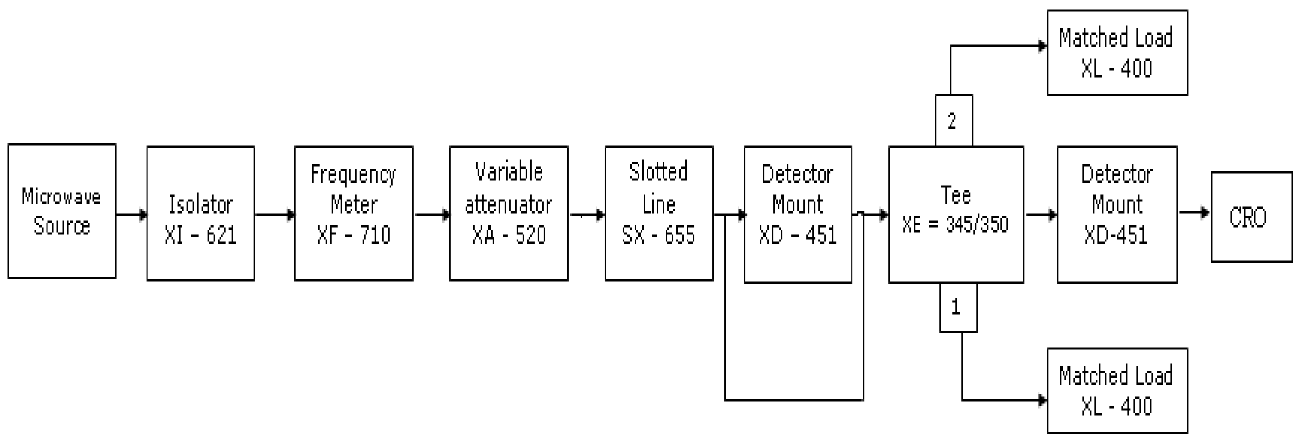
It is defined as $Cij = 10 - \propto/20$

Where '$\propto$' is attenuation / isolation in dB when 'i' is input arm and 'j' is output arm.

Thus, $\propto = 10 \log_{10} [P4/P3]$

Where P3 is the power delivered to arm 'i' and P4 is power detected at 'j' arm.

BLOCK DIAGRAM:



EXPERIMENTAL PROCEDURE:

1. Setup the components and equipments as shown in figure.
2. Energize the microwave source for particular frequency of operation and tune the detector mount for maximum output.
3. With the help of variable frequency of operation and tune the detector mount for maximum output attenuator, set any reference in the CRO let it be V_3.
4. Without disturbing the position of the variable attenuator, carefully place the Magic Tee after the slotted line, keeping H-arm to slotted line, detector mount to E-arm and matched termination to Port-1 and Port-2.
5. Note down the amplitude using CRO, Let it be V_4.
6. Determine the Isolation between Port-3 and Port-4 as V_3-V_4.
7. Determine the coupling co-efficient from the equation given in theory part.
8. The same experiment may be repeated for other Ports also.

OBSERVATIONS:

Ports	Power(W)

Calculations:

Coupling Co-efficient:

$$\alpha = 10 \log \frac{Vi}{Vj}$$

Therefore $C = 10^{-\alpha/20}$

PRE LAB QUESTIONS

1) What is magic tee?
2) How many ports does it have?
3) Difference between magic tee to directional coupler?

LAB ASSIGNMENT

1) Calculate the coupling factor?
2) Calculate the directivity and isolation?

POST LAB QUESTIONS

1) What is magic behind this?
2) How magic tee works?
3) Why the name magic tee suggested?

RESULT:

Magic Tee Characteristics are observed by giving input to different ports and by seeing outputs at other ports. By using those values Scattering Matrix has been formed.

EXPERIMENT 10

SCATTERING PARAMETERS OF CIRCULATOR

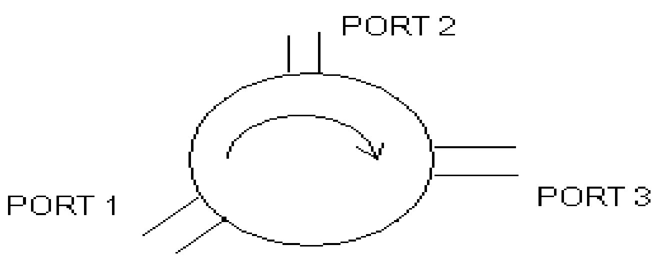
AIM: To study the Isolator and circulators and measure the Insertion Loss and Isolation of Circulator.

EQUIPMENT REQUIRED:

1. Microwave Source (Klystron or Gunn-Diode)
2. Isolator, Frequency Meter
3. Variable Attenuator
4. Slotted Line
5. Tunable Probe
6. Detector Mount Matched Termination
7. Circulator
8. Waveguide Stand
9. Cables and Accessories
10. VSWR Meter.

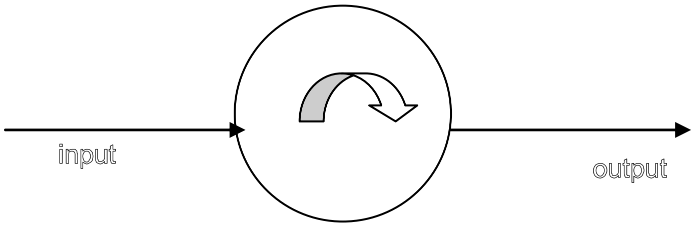
CIRCULATOR:

Circulator is defined as device with ports arranged such that energy entering a port is coupled to an adjacent port but not coupled to the other ports. This is depicted in figure circulator can have any number of ports.



ISOLATOR:

An Isolator is a two-port device that transfers energy from input to output with little attenuation and from output to input with very high attenuation.



The isolator, shown in Fig. can be derived from a three-port circulator by simply placing a matched load (reflection less termination) on one port.

The important circulator and isolator parameters are:

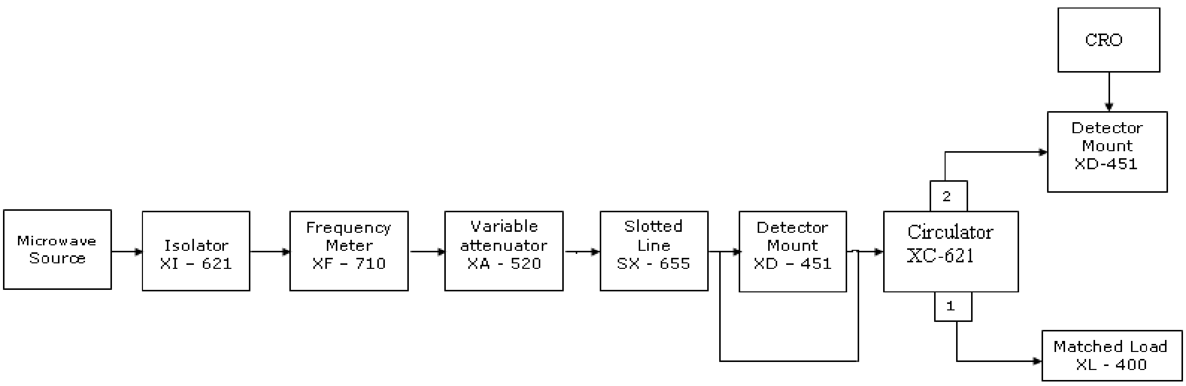
A. *Insertion Loss*

Insertion Loss is the ratio of power detected at the output port to the power supplied by source to the input port, measured with other orts terminated in the matched Load. It is expressed in dB.

B. *Isolation*

Isolation is the ratio of power applied to the output to that measured at the input. This ratio is expressed in db. The isolation of a circulator is measured with the third port terminated in a matched load.

BLOCK DIAGRAM:



EXPERIMENTAL PROCEDURE:

Measurement of insertion

1. Remove the isolator or circulator from slotted line and connect the detector mount to the slotted section. The output of the detector mount should be connected with CRO.
2. Energize the microwave source for maximum output for a particular frequency of operation. Tune the detector mount for maximum output in the CRO.
3. Set any reference level of output in CRO with the help of variable attenuator, Let it be V_1.
4. Carefully remove the detector mount from slotted line without disturbing the position of the set up. Insert the isolator/circulator between slotted line and detector mount. Keep input port to slotted line and detector its output port. A matched termination should be placed at third port in case of Circulator.
5. Record the output in CRO,Let it be V_2.
6. Compute Insertion loss given as V_1-V_2 in db.

Measurement of Isolation:

7. For measurement of isolation, the isolator or circulator has to be connected in reverse i.e. output port to slotted line and detector to input port with other port terminated by matched termination (for circulator).
8. Record the output of CRO and let it be V_3.
9. Compute Isolation as V_1-V_3 in db.
10. The same experiment can be done for other ports of circulator.
11. Repeat the above experiment for other frequency if needed.

PRECAUTIONS:

1. Avoid loose connections.
2. Avoid Parallax errors.

PRE LAB QUESTIONS

1) What is Circulator and Isolator?
2) What is Insertion loss?
3) What is input VSWR of a circulator or isolator?

LAB ASSIGNMENT

1) What is Faraday rotation in Ferrites?
2) What is the function of resistive card in an isolator?

POST LAB QUESTIONS

1) How many ports a circulator can have?
2) What are the applications of circulator?
3) If direction of travel of wave reverses, does the direction of polarization change?

RESULT: The characteristics of Circulator has been observed by applying input power at one of the ports and observing powers in other ports.

EXPERIMENT No 11

ATTENUATION MEASUREMENT

AIM: To study insertion loss and attenuation measurement of attenuator.

EQUIPMENT REQUIRED:

1. Microwave sourceKlystron tube (2k25)
2. Isolator (xI-621)
3. Frequency meter (xF-710)
4. Variable attenuator (XA-520)
5. Slotted line (XS-651)
6. Tunable probe (XP-655)
7. etector mount (XD-451)
8. Matched termination (XL-400)
9. Test attenuator
   a) Fixed
   b) Variable
10. Klystron power supply & Klystron mount
11. Cooling fan
12. BNC-BNC cable
13. VSWR or CRO

THEORY:

The attenuator is a two port bidirectional device which attenuates some power when inserted into a transmission line.

Attenuation A (dB) = 10 log (P1/P2)

Where P1 = Power detected by the load without the attenuator in the line

P2 = Power detected by the load with the attenuator in the line.

BLOCK DIAGRAM

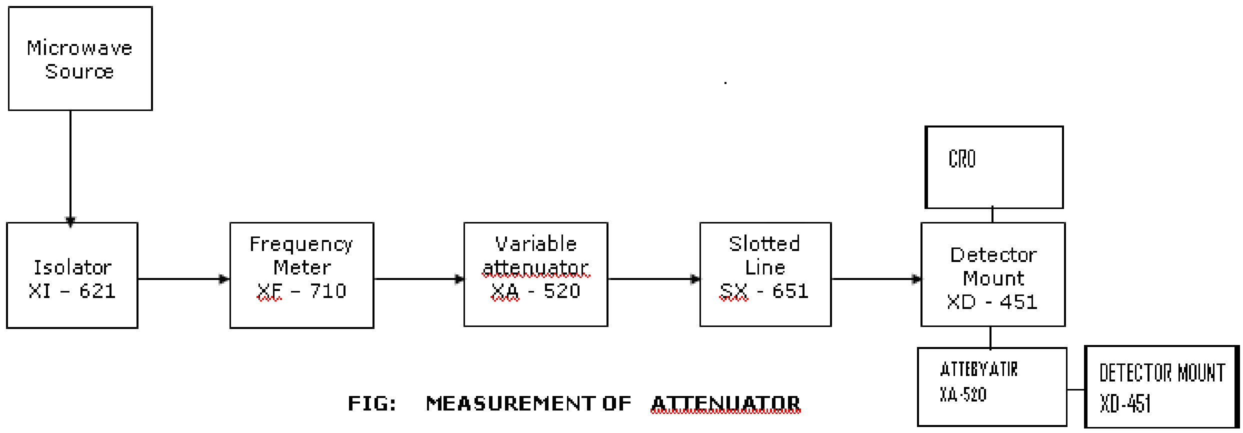


FIG: MEASUREMENT OF ATTENUATOR

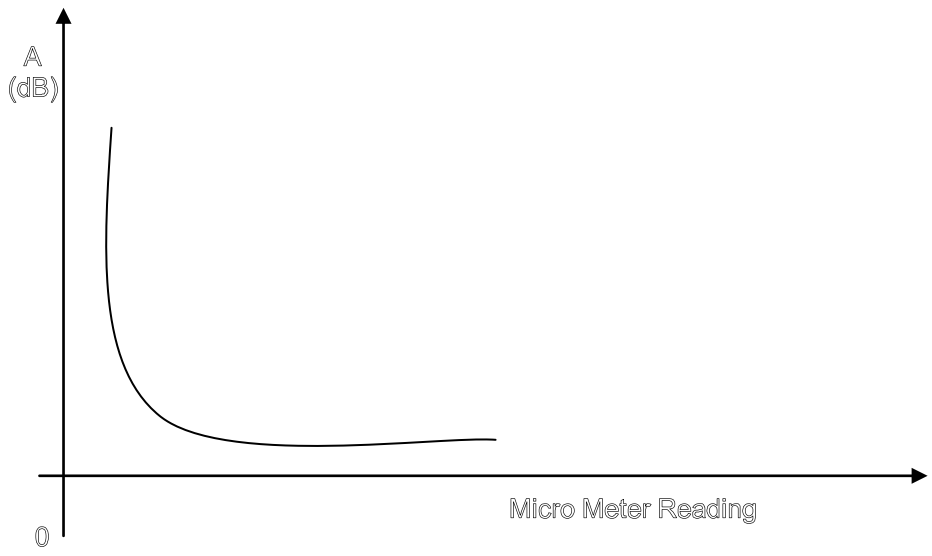
PROCEDURE:

1. Connect the equipments as shown in the above figure.
2. Energize the microwave source for maximum power at any frequency of operation
3. Connect the detector mount to the slotted line and tune the detector mount also for max deflection on VSWR or on CRO
4. Set any reference level on the VSWR meter or on CRO with the help of variable attenuator. Let it be P1.
5. Carefully disconnect the detector mount from the slotted line without disturbing any position on the setup place the test variable attenuator to the slotted line and detector mount to O/P port of test variable attenuator. Keep the micrometer reading of text variable attenuator to zero and record the readings of VSWR meter or on CRO. Let it to be P2. Then the insertion loss of test attenuator will be P1-P2 db.
6. For measurement of attenuation of fixed and variable attenuator. Place the test attenuator to the slotted line and detector mount at the other port of test attenuator. Record the reading of VSWR meter or on CRO. Let it be P3 then the attenuation value of variable attenuator for particular position of micrometer reading of will be P1-P3 db.In case the variable attenuator change the micro meter reading and record the VSWR meter or CRO reading. Find out attenuation value for different position of micrometer reading and plot a graph.

7. Now change the operating frequency and all steps should be repeated for finding frequency sensitivity of fixed and variable attenuator.

<u>Note</u>:1. For measuring frequency sensitivity of variable attenuator the position of micrometer reading of the variable attenuator should be same for all frequencies of operation.

EXPECTED GRAPH:



OBSERVATION TABLE:

Micrometer reading	P1 (dB)	P2 (dB)	Attenuation = P1-P2 (dB)

PRECAUTIONS

1. To protect repeller from damage the repeller negative voltage is always applied before anode voltage.

2. While modulating repeller should never become positive with respect to cavity.

3. Cooling should be provided to reflex klystron.

PRE LAB QUESTIONS

1) What is attenuation?
2) How many types of attenuators are there?
3) What is insertion loss?

LAB ASSIGNMENT

1) What is the necessity of attenuation?
2) Classift the types of attenuation?

POST LAB QUESTIONS

1) What is the min value of insertion loss?
2) What are the methods used for measuring attenuation?
3) What are the methods used for measuring insertion loss?

RESULT: The attenuation and insertion loss of the wave guide have calculated.

EXPERIMENT No 12

MEASUREMENT OF FREQUENCY AND WAVELENGTH

AIM: To determine the frequency and wavelength in a rectangular wave guide working in TE_{10}mode.

EQUIPMENT REQUIRED:

1. Klystron tube
2. Klystron power supply 5kps – 610
3. Klystron mount XM-251
4. Isolator XI-621
5. Frequency meter XF-710
6. Variable attenuator XA-520
7. Slotted section XS-651
8. Tunable probe XP-655
9. VSWR meter SW-115
10. Wave guide stand XU-535
11. Movable Short XT-481
12. Matched termination XL-400

THEORY:

The cut-off frequency relationship shows that the physical size of the wave guide will determine the propagation of the particular modes of specific orders determined by values of m and n. The minimum cut-off frequency is obtained for a rectangular wave guide having dimension a>b, for values of m=1, n=0, i.e. TE_{10} mode is the dominant mode since for TM_{mn}modes, n#0 or n#0 the lowest-order mode possible is TE_{10}, called the dominant mode in a rectangular wave guide for a>b.

For dominant TE_{10} mode rectangular wave guide λo, λg and λc are related as below.

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

Where λo is free space wave length

λg is guide wave length

λc is cut off wave length

For TE_{10} mode λc – 2a where 'a' is broad dimension of wave guide.

BLOCK DIAGRAM

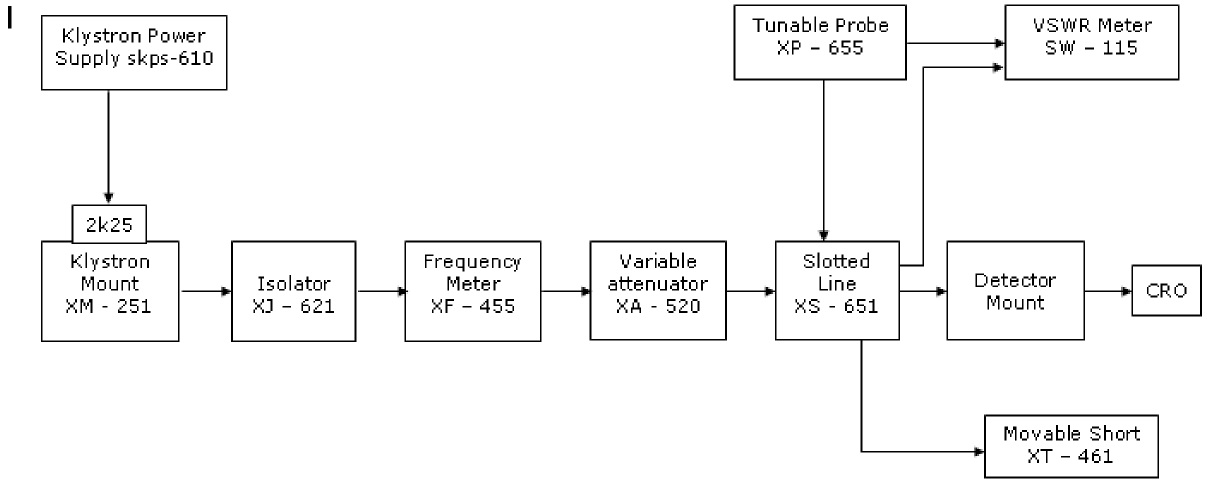


FIG: SET UP FOR FREQUENCY AND WAVELENGTH MEASUREMENT

PROCEDURE:

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

   Beam voltage – OFF

   Mod-switch – AM

   Beam voltage knob – Fully anti clock wise

   Repeller voltage – Fully clock wise

   AM – Amplitude knob – Around fully clock wise

   AM – Frequency knob – Around mid position

4. Switch 'ON' the klystron power supply, CRO and cooling fan switch.
5. Switch 'ON' the beam voltage switch and set beam voltage at 300V with help of beam voltage knob.
6. Adjust the repeller voltage to get the maximum amplitudein CRO
7. Maximize theamplitude with AM amplitude and frequency control knob of power supply.
8. Tune the plunger of klystron mount for maximum Amplitude.
9. Tune the repeller voltage knob for maximum Amplitude.

10. Tune the frequency meter knob to get a ‘dip’ on the CRO and note down the frequency from frequency meter.
11. Replace the termination with movable short, and detune the frequency meter.
12. Move the probe along with slotted line. The amplitude in CRO will vary .Note and record the probe position , Let it be d1.
13. Move the probe to next minimum position and record the probe position again, Let it be d2.
14. Calculate the guide wave length as twice the distance between two successive minimum position obtained as above.
15. Measure the wave guide inner board dimension ‘a’ which will be around 22.86mm for x-band.
16. Calculate the frequency by following equation.

$$f = \frac{c}{\lambda} = \sqrt{\left(\frac{1}{\lambda^2{}_g} + \frac{1}{\lambda_c{}^2}\right)}$$

Where C = $3x10^8$ meter/sec. i.e. velocity of light.

17. Verify with frequency obtained by frequency modes
18. Above experiment can be verified at different frequencies.

$f_o = C/\lambda o$ => C => $3x10^8$ m/s (i.e., velocity of light)

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

$$\lambda_0 = \frac{\lambda_g \lambda_c}{\lambda_g{}^2 + \lambda_c{}^2}$$

$\lambda g = 2x\Delta d$

For TE_{10}mode => $\lambda c = 2a$

a→ wave guide inner broad dimension

a = 2.286cm” (given in manual)

$\lambda c = 4.6$cm

OBSERVATION TABLE:

voltage(v)	Beam current (mA)	Repeller voltage(v)	fo (using freq meter) (GHZ)	d1 (cm)	d2 (cm)	d3 (cm)	d4 (cm)	Δd1= d2-d1 (cm)	Δd2= d3-d2 (cm))	d4-d3	Δd=(Δd1+Δd2	λg=2x Δd	λo (cm)	fo (HZ)

PRE LAB QUESTIONS

1) Write the range of X-band frequency?
2) What is the relationship between frequency and wavelength?
3) What is cut off frequency?

LAB ASSIGNMENT

1) What is the range of radio frequency?
2) What is the difference between radio waves and microwaves?

POST LAB QUESTIONS

1) Which microwave component can measure the frequency in test bench set-up?
2) The reactangular wave guide acts as which filter?
3) What are the degenerative modes in waveguides?

RESULT: The frequency and wave length in a rectangular waveguide working in TE10 mode has been and verified with direct reading.

<u>CONTENT BEYOND SYLLABI</u>

EXPERIMENT 1

TIME DIVISION MULTIPLEXING

AIM : To verify the operation of Time-Division multiplexing.

APPARATUS :

1. Time-Division Multiplexing and Demultiplexing trainer Kit.
2. CRO
3. BNC Probes and Connecting wires.

THEORY :

The Sampling Theorem provides the basis for transmitting the information contained in a band-limited message signal m(t) as a sequence of samples of m(t) taken uniformly at a rate that is usually slightly higher than the nyquist rate. An important feature of the sampling process is a conservation of time. That is, the transmission of the message samples engages the communication channel for only a fraction of the sampling interval on a periodic basis, and in this way some of the time interval between adjacent samples is cleared for use by other independent message sources on a time-shared basis. We thereby obtain a time-division multiplexing (TDM) system, which enables the joint utilisation of a common communication channel by a plurality of independent message sources without mutual interference among them.

The TDM system is highly sensitive to dispersion in the common channel, that is, to variations of amplitude with frequency or lack of proportionality of phase with frequency. Accordingly, accurate equalization of both magnitude and phase response of the channel is necessary to ensure a satisfactory operation of the system. Unlike FDM, TDM is immune to nonlinearities in the channel as a source of cross-talk. The reason for this is, that different message signals are not simultaneously applied to the channel.

The primary advantage of TDM is that several channels of information can be transmitted simultaneously over a single cable

In the circuit diagram the 555 timer is used as a clock generator. This timer is a highly stable device for generating accurate time delays. In this circuit this timer generates clock signal, which is of 100KHz frequency (approximately). This clock signal is connencted to the 74163 IC. 74163 IC is a synchronous presettable binary counter. It devides the clock signal frequency into three parts and those are used as selection lines for multiplexer and demultiplexer. In built signal generator is provided with sine,square and triangle outputs with variable frequency. These three signals can be used as inputs to the multiplexer. IC 4051 is a 8 to 1 analog multiplexer.It selects one-ofeight signal sources as a result of a unique three-bit binary code at the select inputs. Again IC 4051 is wired as 1 to 8 Demultiplexer. Demux input receives the data source and transmits the data signals on different channels.

PROCEDURE :

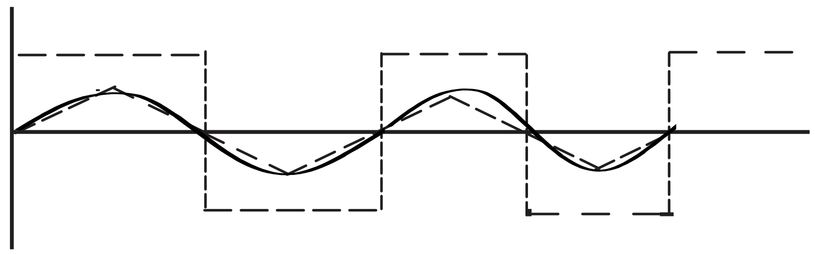
1. Switch on **PHYSITECH**'S Time division multiplexing and demultiplexing trainer.
2. Connect the sine wave to ch_1 , square wave to ch_2 and Triangle wave form to ch_3 terminals of 8 to 1 multiplexer.
3. Observe the Multiplexer output on channel 1 of a CRO.
4. Connect Mux output to demux input.
5. Observe corresponding signal outputs at channel 2 of CRO.

PRECAUTIONS:

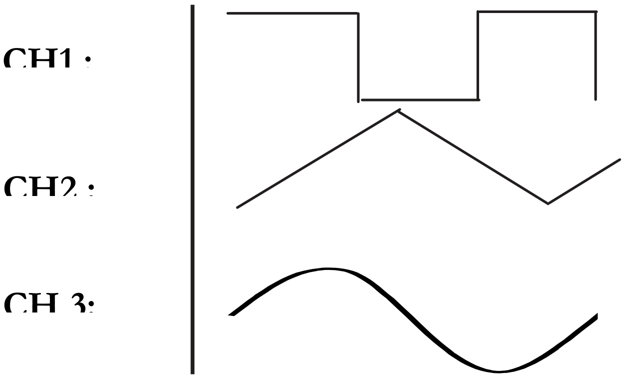
1. Connect the circuit properly.
2. Apply the voltages wherever required.
3. Do not apply stress on the components.

EXPECTED WAVE FORMS :

Multiplexer O/P



De-Multiplexer Outputs :



PRE LAB QUESTIONS

1) Draw the TDM signal with 2 signals being multiplexedover the channel?
2) Explain block schematic of TDM?
3) what are the applications of TDM?

LAB ASSIGNMENT

1) Is TDM system is relatively immune to interference with in channels (inter channel cross talk) as compared to FDM?
2) In what aspects, TDM is superior to FDM?

POST LAB QUESTIONS

1) What type of filter is used at receiver end in TDM system?
2) Is the bandwidth requirement for TDM & FDM will be same?
3) How TDM differ from FDM?

RTESULT: Time division multiplexing and Demultiplexing waveforms are verified.

EXPERIMENT No 2

ASK MODULATOR AND DEMODULATOR

AIM : To study Amplitude shift Key (ASK) Modulator and Demodulator.

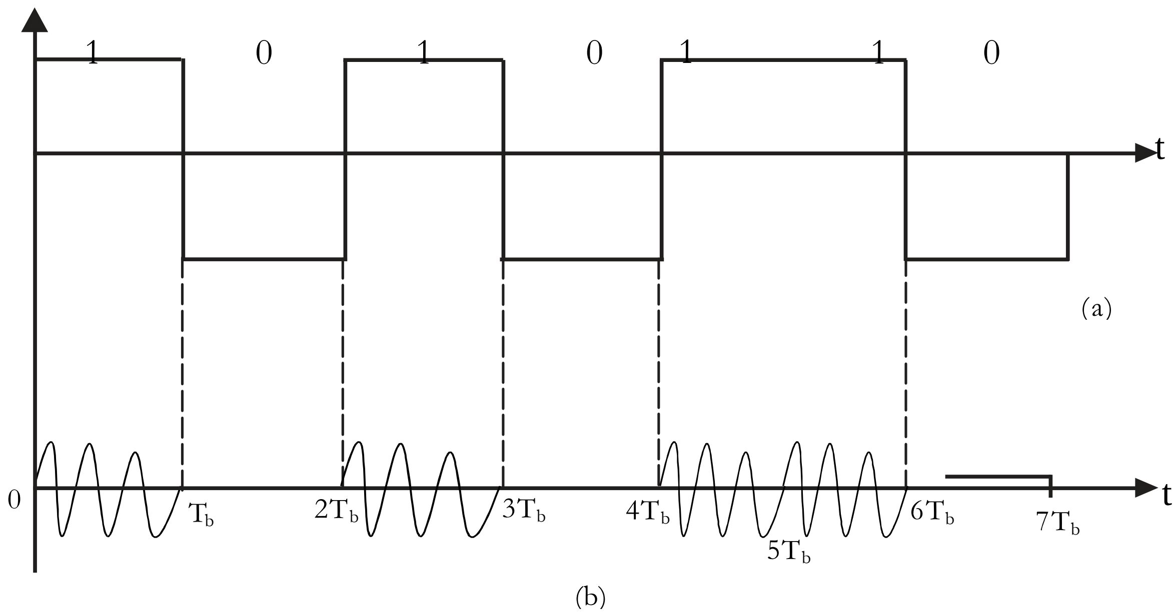
APPARATUS :

1. **PHYSITECH**'S ASK Modulator and Demodulator Trainer.
2. CRO.
3. Connecting Wires.
4. BNC Probes.

THEORY :

The Amplitude -Shift Key (ASK) signalling scheme was one of the earliest forms of digital modulation used in wireless (radio) telegraphy. While ASK is no longer widely used in digital communications. ASK is the simplest form of digital modulation and serves as a useful model for introducing certain concepts.

The wave form shown in figure below corresponds to discrete amplitude modulation or an Amplitude-shift keying (ASK) scheme where the amplitude of the carrier is switched between two values (ON and OFF). The resultant waveform consists of "ON" (mark pulses representing binary 1 and "OFF" (Space) pulses representing binary 0.



a) Binary Signal
b) ASK Signal

In ASK demodulator the amplitude of the carrier is switched between two values (on and off). The resultant waveform consists of on(mark)pulses representing binary 1 and off(space) pulses representing binary ‘0’.

LIMITATIONS OF ASK:

If Bandwidth is of primary concern, ASK scheme is generally not considered for high speed data transmission over a noisy band pass channel.

ASK scheme require the same amount of average power as the FSK Schemes. If the Peak Power requirement is of primary concern, then ASK schemes are not used.

ASK Schemes are more sensitive to variations in received signal level due to changes in channel characteristics.

CIRCUIT DESCRIPTION :

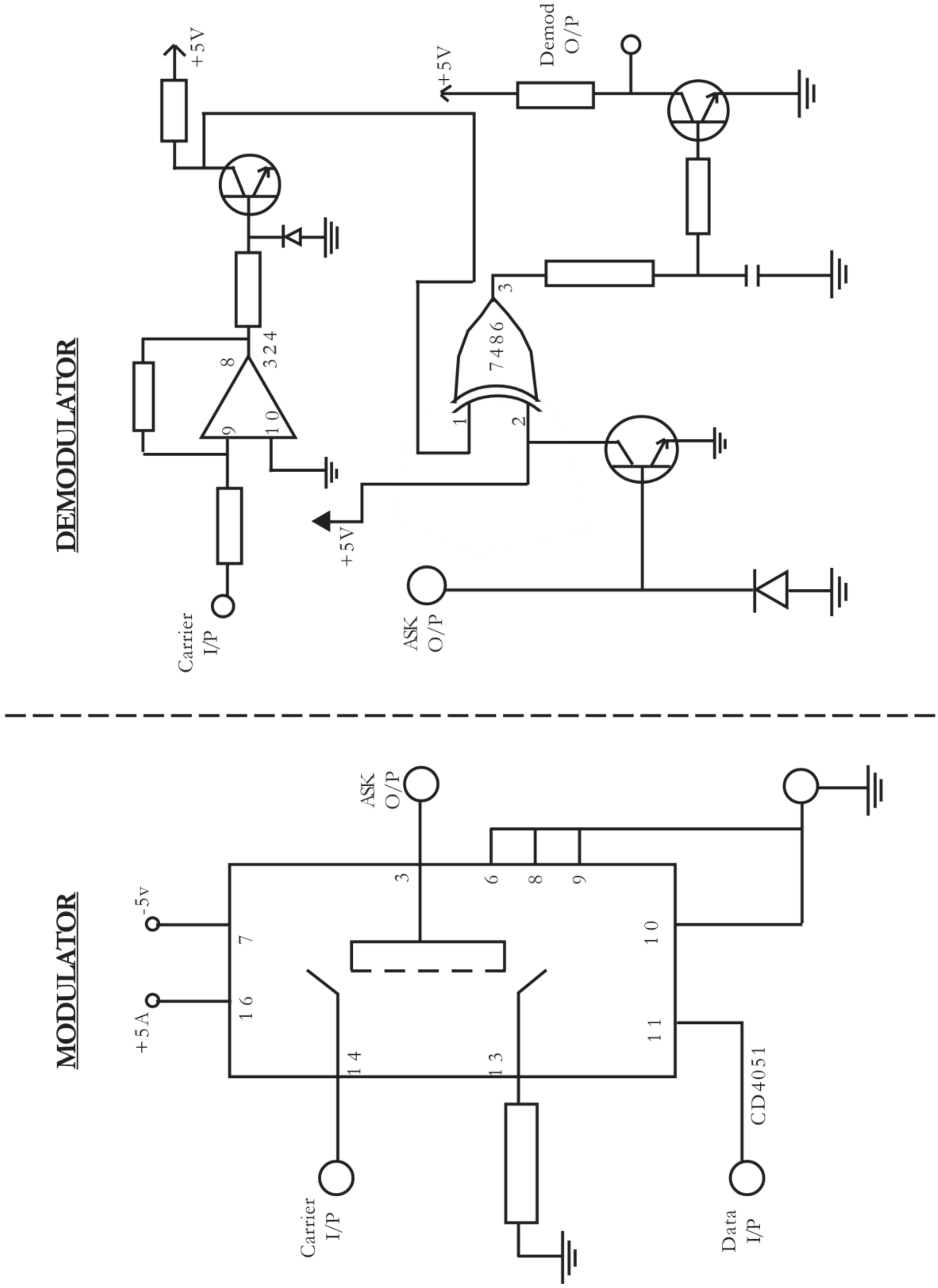
In this circuit IC 8038 is used as carrier generator. Generally IC 8038 produces sine, square and triangle waveforms. In this circuit we provided this IC to give 20KHz sine wave as a carrier. And preset is provided to adjust carrier wave symmetry.

The 9^{th} pin of 8038 provides square wave. This wave will be amplified by the transistor. In this circuit the two IC’s of 7490 will generates one hundreth signal of carrier signal. This ICis used for synchronization.

In modulator section IC CD4051 is used. It is a 1-Of-8 switch. It may be used as a 1-of-8 analog data multiplexer or demultiplexer, or as a 1-of-8 digital selector or distributor. Here it is working in analog mode. In this mode, -5V is applied to pin 7 and digital control signals of low=ground and high =+5 are applied to the A,B, C and INH inputs. Here INH is low, therefore, the channel selected is determined by the binary word input. Analog signals may be any value betweem +5 and -5Volts.

In demodulator section the IC 324 works as a buffer. The transistor is in saturation region and it will generates the square signal. And this signal goes to one of the inputs of Ex-OR gate. ASK I/P is amplified by the transistor and this will goes to the second input of EX-OR gate. IC 7486 works as an EX-OR gate. It will compare the two input signals and generates the output depending upon high and low input signals.

This signal is amplified by the transistor, and then gives the demodulated output.


DEMODULATOR
MODULATOR
+5V
Demod O/P
324
7486
Carrier I/P
ASK O/P
-5v
+5A
CD4051
Data I/P

PROCEDURE:

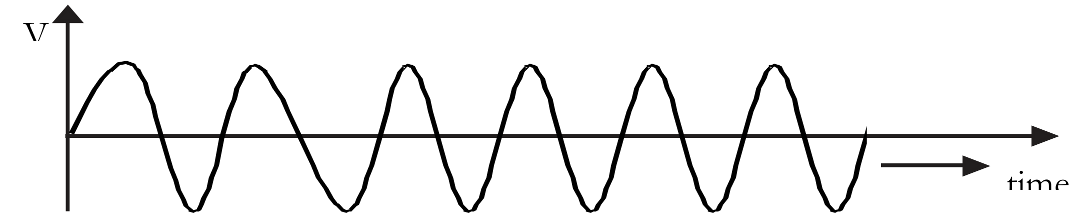
MODULATOR :

1) Connect the carrier signal output to the input of the Modulator.
2) Connect the data input provided on board to the data input of the Modulator.
3) Connect channel one of the CRO at the O/P and channel two at data signal.
4) Now observe the Modulated (ASK) signal on channel one with respect to data signal.

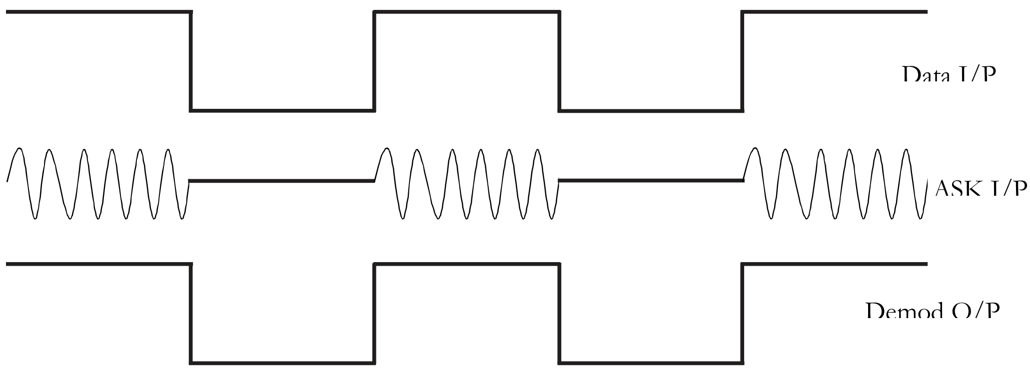
DEMODULATOR :

1) Connect the ASK output to the input of Demodulator.
2) Connect the carrier signal as mentioned on the trainer.
3) Connect channel one of the CRO at the O/P of Demodulator and channel two at data signal.
4) Observe the Demodulated signal and compare that with data signal.

EXPECTED WAVE FORMS :



Carrier I/P



PRE LAB QUESTIONS

1) What is amplitude shift keying?
2) What is the advantage of ON-OFF keying in ASK?
3) What are the applications of ASK?

LAB ASSIGNMENT

1) If the bit rate of an ASK signal is 1200bps,what is the baud rate?
2) Find the minimum band width for an ASK signal transmitting at 2000bps.The transmission made is half duplex?

POST LAB QUESTIONS

1) What are the characteristics of transmission medium which effect speed of transmission in ASK?
2) If B.W is 5000Hz for an ASK signal, what are the baud rate?
3) Given the bandwidth of 10KHz(1Hz to 1KHz), Find the band width for upper side & lower side band of carrier in full duplex ASK?

RESULT: The amplitude shift keying modulation and demodulation outputs are observed and verified.

EXPERIMENT No 3

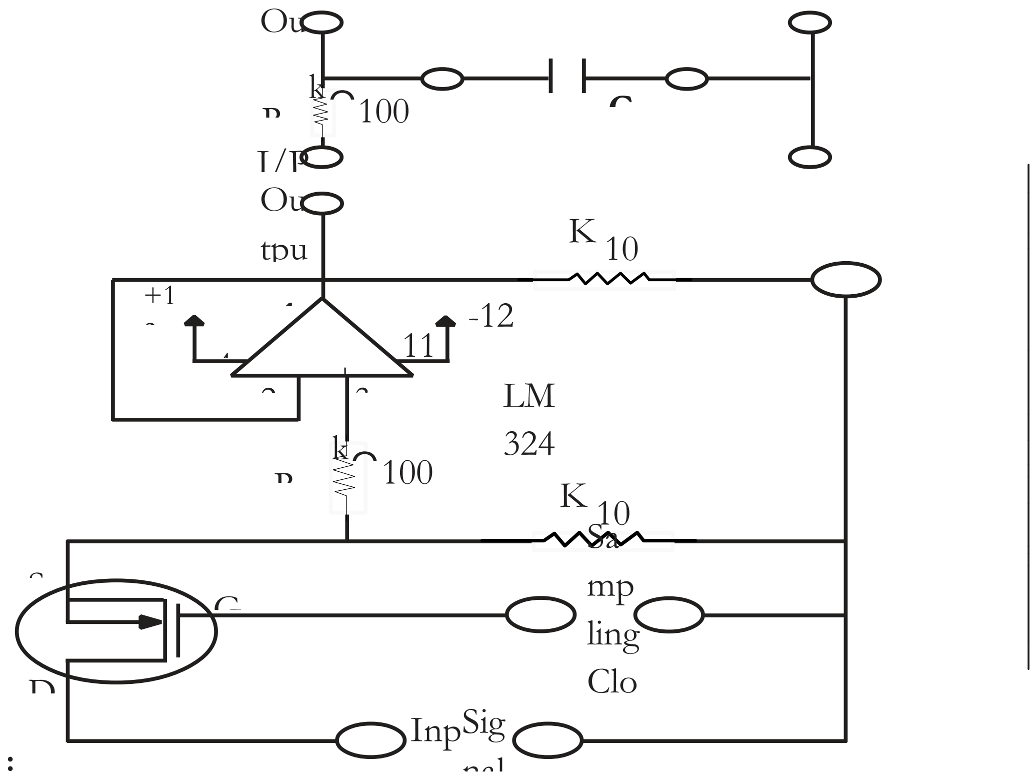
SAMPLING THEOREM

AIM: To study and verify the sampling theorem and reconstruction of sampled wave form.

APPARATUS:

1. PHYSITECH's Sampling Theorem Trainer Kit
2. Function Generator
3. CRO
4. Connecting wires.
5. BNC Probes.

CIRCUIT DIAGRAM



The Sampling Verification Circuit

THEORY :

Sampling theorem states that if the sampling rate in any pulse modulation system exceeds twice the maximum signal frequency the original signal can be reconstructed in the receiver with minimum distortion.

Let m(t) be a signal whose highest frequency component is fm. Let the value of m(t) be obtained at regular intervals separated by time T far far less than (1/2 fm) The sampling is thus periodically done at each T_S seconds. Now the samples $m(nT_S)$ where n is an integer which determines the signals uniquely. The signal can be reconstructed from these samples without distortion.

Time Ts is called the SAMPLING TIME.
The minimum sampling rate is called NYQUIST RATE.

The validity of sampling theorem requires rapid sampling rate such that atleast two samples are obtained during the course of the interval corresponding to the highest frequency of the signal under analysis.

Let us consider an example of a pulse modulated signal, containing speech information, as is used in telephony. Over standard telephone channels the frequency range of A.F. is from 300 Hz to 3400 Hz. For this application the sampling rate taken is 8000 samples per second. This is an International standard. We can observe that the pulse rate is more than twice the highest audio frequency used in this system. Hence the sampling theorem is satisfied and the resulting signal is free from sampling error.

CIRCUIT DESCRIPTION :

Sampling circuit using E-MOSFET as control switch and an op-amp as buffer is used here. In this circuit E-MOSFET works as a switch that is controlled by the control voltage Vs, and the capacitor C serves as a storage element. The circuit operates as follows.

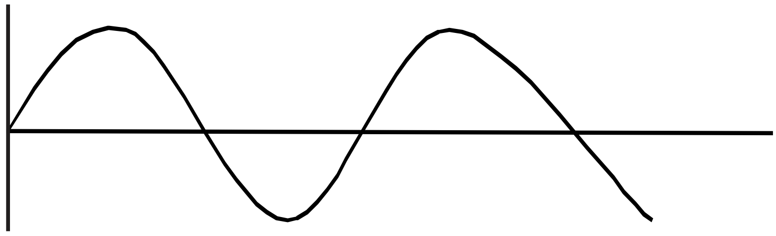
The analog signal “Vin” to be sampled is applied to the drain, and sampling control voltage Vs is applied to the gate of the E-MOSFET. During the positive portion of Vs, the E-MOSFET conducts and acts as a closed switch. On the other hand, when Vs is zero (or negative), the E-MOSFET is off (non-conductive) and acts as an open switch. The only discharge path for C is, therefore, through the op-amp. However, the input resistance of op-amp voltage follower is also very high; hence the voltage across C is retained. To obtain close approximation of the input wave form, the frequency of the sample control voltage must be significantly minimum twice higher than that of the input. In critical applications a precision and for high-speed op-amp is helpful.

PROCEDURE :

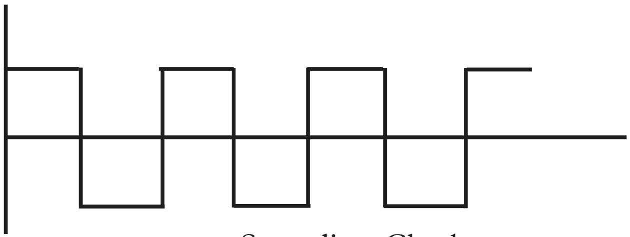
1. Connections are made as per the Circuit diagram.

2. Apply the input signal with a frequency of 500Hz (V_{P-P}) using a function generator.
3. Sampling clock frequency which is variable of 3KHz to 50KHz should be connected across the terminals which is indicated.
4. Now observe the sampling output of the circuit at the o/p.
5. By using the capacitors provided on the trainer, reconstruct the signal and verify it with the given input.
6. Reconstructed signal voltage will be depends on capacitor value.
7. Vary the sampling frequency and study the change in reconstructed signal.
8. If the sampling clock frequency is below 20KHz you will observe the distorted demodulated output.

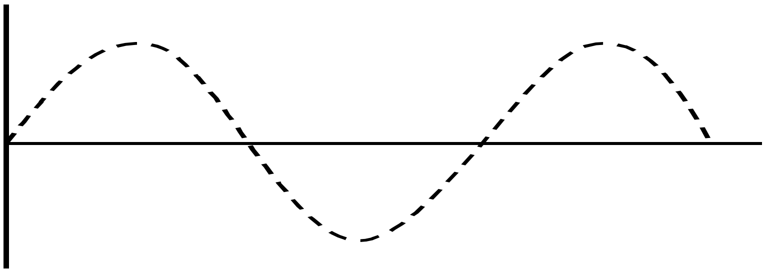
EXPECTED WAVE FORMS:



Modulating Signal



Sampling Clock



Sampling Output

PRE LAB QUESTIONS

1) What is sampling theorem?
2) Which square wave should be reconstructed more accurately? Why?

3) Which wave form will be easier to sample and reconstruct triangle wave or square wave? Why?

LAB ASSIGNMENT

1) What is Nyquist rate?
2) What is sampling?

POST LAB QUESTIONS

1) Give the expression for aliasing error and the bound for aliasing error?
2) What do you mean by quantizing process?
3) What are the various steps involved in A/D conversion?

RESULT: Thus the sampling theorem was performed and graphs were plotted.

EXPERIMENT No 4

DIRECTIONAL COUPLER CHARACTERISTICS

AIM: To study the function of multi-hole directional coupler by measuring the following parameters.TheCoupling factor, Insertion Loss and Directivity of the Directional coupler.

EQUIPMENT REQUIRED:

1. Microwave Source (Klystron or Gunn-Diode)
2. Isolator, Frequency Meter
3. Variable Attenuator
4. Slotted Line
5. Tunable Probe
6. Detector Mount Matched Termination
7. MHD Coupler
8. Waveguide Stand
9. Cables and Accessories
10. CRO.

THEORY:

A directional coupler is a device with which it is possible to measure the incident and reflected wave separately. It consist of two transmission lines the main arm and auxiliary arm, electromagnetically coupled to each other Refer to the Fig.1. The power entering, in the main-arm gets divided between port 2 and 3, and almost no power comes out in port (4) Power entering at port 2 is divided between port 1 and 4.

The coupling factor is defined as

Coupling (db) = 10 $\log_{10}$ [P1/P3] where port 2 is terminated, Isolation (dB) = 10 $\log_{10}$ [P2/P3] where P1 is matched.

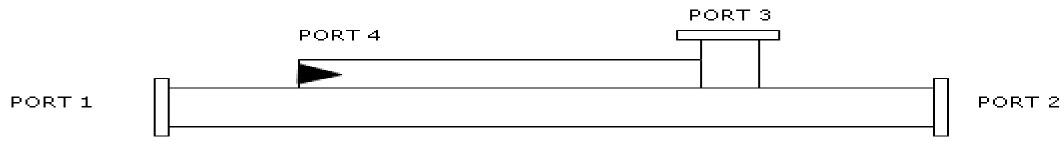


FIG. DIRECTIONAL COUPLER

With built-in termination and power entering at Port 1, the directivity of the coupler is a measure of separation between incident wave and the reflected wave. Directivity is measured indirectly as follows:

Hence Directivity D (db) = I-C = 10 $\log_{10}$ [P2/P1]

Main line VSWR is SWR measured, looking into the main-line input terminal when the matched loads are placed at all other ports.
Auxiliary live VSWR is SWR measured in the auxiliary line looking into the output terminal when the matched loads are placed on other terminals.

Main line insertion loss is the attenuation introduced in the transmission line by insertion of coupler, it is defined as:

Insertion Loss (dB) = 10 $\log_{10}$ [P1/P2]

BLOCKDIAGRAM:

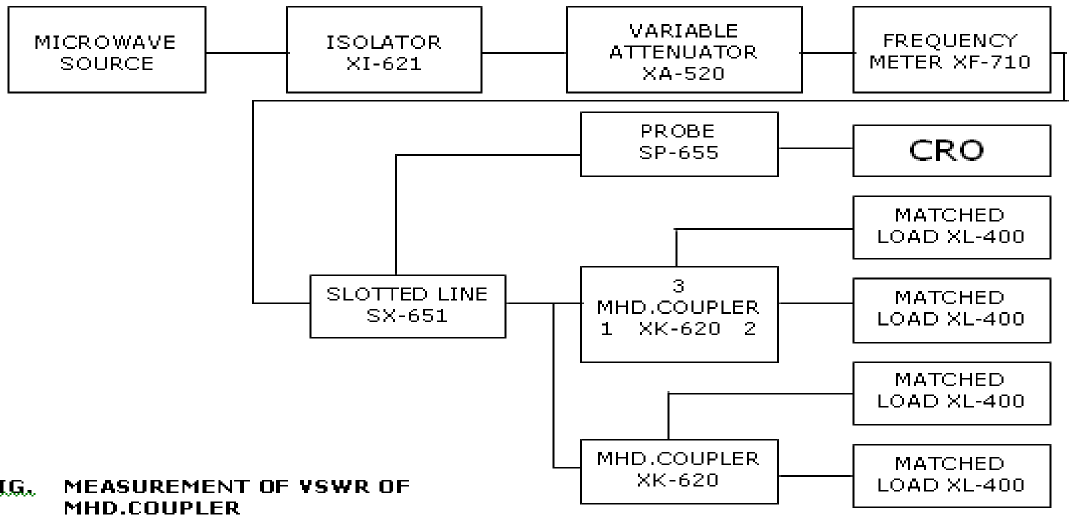


FIG. MEASUREMENT OF VSWR OF MHD.COUPLER

EXPERIMENTAL PROCEDURE:

1. Set up the equipments as shown in the Figure.
2. Energize the microwave source for particular operation of frequency .
3. Remove the multi hole directional coupler and connect the detector mount to the slotted section.
4. Set maximum amplitude in CRO with the help of variable attenuator, Let it be X.
5. Insert the directional coupler between the slotted line and detector mount. Keeping port 1 to slotted line, detector mount to the auxiliary port 3 and matched termination to port 2 without changing the position of variable attenuator.

6. Note down the amplitude using CRO, Let it be Y.
7. Calculate the Coupling factor X-Y in dB.
8. Now carefully disconnect the detector mount from the auxiliary port 3 and matched termination from port 2 , without disturbing the setup.
9. Connect the matched termination to the auxiliary port 3 and detector mount to port 2 and measure the amplitude on CRO, Let it be Z.
10. Compute Insertion Loss= X – Z in dB.
11. Repeat the steps from 1 to 4.
12. Connect the directional coupler in the reverse direction i.e., port 2 to slotted section, matched termination to port 1 and detector mount to port 3, without disturbing the position of the variable attenuator.
13. Measure and note down the amplitude using CRO, Let it be Y_0.
14. Compute the Directivity as $Y-Y_0$ in dB.

PRECAUTIONS:

1. Avoid loose connections.
2. Avoid Parallax errors.

PRE LAB QUESTIONS

1) What is directional coupler?
2) How many ports does it have?
3) What is the difference between directional coupler to magic tee?

LAB ASSIGNMENT

1) What is the use of directional coupler?
2) List the types of directional couplers.
3) List the performance of a directional coupler.

POST LAB QUESTIONS

1) Define the directivity `D' of a directional coupler.
2) Define coupled factor C.
3) What is multihole directional coupler?
4) Draw a basic directional coupler?

RESULT: The characteristics of the directional coupler have observed and various parameters of the directional coupler are calculated.

EXPERIMENT No 5

VSWR MEASUREMENT

AIM: To determine the standing-wave ratio and reflection coefficient.

EQUIPMENT REQUIRED:

1. Klystron tube (2k25)
2. Klystron power supply (skps - 610)
3. VSWR meter (SW 115)
4. Klystron mount (XM – 251)
5. Isolator (XF 621)
6. Frequency meter (XF 710)
7. Variable attenuator (XA – 520)
8. Slotted line (X 565)
9. Wave guide stand (XU 535)
10. Movable short/termination XL 400
11. BNC CableS-S Tuner (XT – 441)

THEORY:

Any mismatched load leads to reflected waves resulting in standing waves along the length of the line. The ratio of maximum to minimum voltage gives the VSWR. Hence minimum value of S is unity. If S<10 then VSWR is called low VSWR. If S>10 then VSWR is called high VSWR. The VSWR values more than 10 are very easily measured with this setup. It can be read off directly on the VSWR meter calibrated. The measurement involves simply adjusting the attenuator to give an adequate reading on the meter which is a D.C. mill volt meter.

The probe on the slotted wave guide is moved t get maximum reading on the meter. The attenuation is now adjusted to get full scale reading. Next the probe on the slotted line is adjusted to get minimum, reading on the meter. The ratio of first reading to the second gives the VSWR. The meter itself can be calibrated in terms of VSWR. Double minimum method is used to measure VSWR greater than 10. In this method, the probe is inserted to a depth where the minimum can be read without difficulty. The probe is then moved to a point where the power is twice the minimum.

BLOCK DIAGRAM

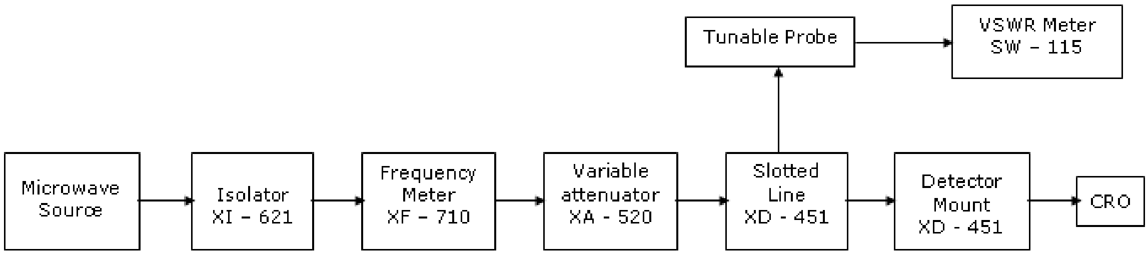


FIG: SET UP FOR LOW VSWR MEASUREMENT

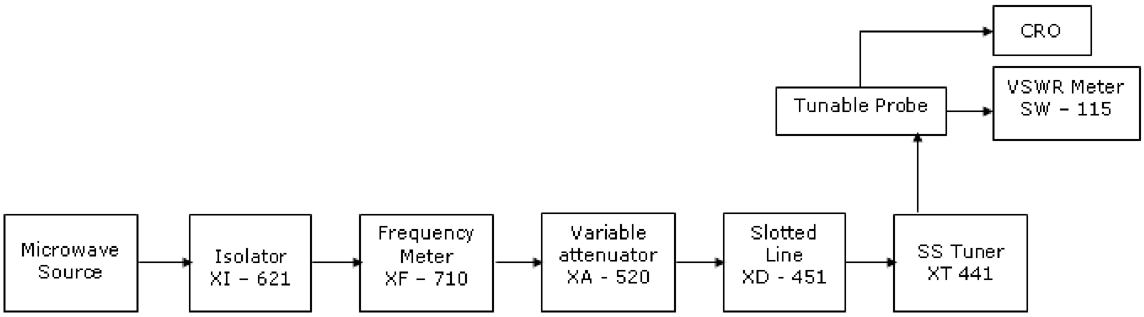


FIG: SET UP FOR HIGH VSWR MEASUREMENT

PROCEDURE:

1. Set up equipment as shown in figure.
2. Keep variable attenuator in minimum attenuation position.
3. Keep control knobs of VSWR meter as below

   Range dB = 40db / 50db

   Input switch = low impedance

   Meter switch = Normal

   Gain (coarse fine) = Mid position approximately

4. Keep control knobs of klystron power supply as below.

   Beam Voltage = OFF

   Mod-Switch = AM

   Beam Voltage Knob = fully anti clock wise

   Reflection voltage knob = fully clock wise

   AM-Amplitude knob = around fully clock wise

AM frequency and amplitude knob = mid position

5. Switch ‘ON’ the klystron power supply, VSWR meter and cooling fan.
6. Switch ‘ON” the beam voltage switch position and set (down) beam voltage at 300V.
7. Rotate the reflector voltage knob to get deflection in VSWR meter.
8. Tune the O/P by turning the reflector voltage, amplitude and frequency of AM modulation.
9. Tune plunges of klystron mount and probe for maximum deflection in VSWR meter.
10. If required, change the range db-switch variable attenuator position and (given) gain control knob to get deflection in the scale of VSWR meter.
11. As your move probe along the slotted line, the deflection will change.

A. MEASUREMENT OF LOW AND MEDIUM VSWR:

1. Move the probe along the slotted line to get maximum deflection in VSWR meter.
2. Adjust the VSWR meter gain control knob or variable attenuator until the meter indicates 1.0 on normal VSWR scale.
3. Keep all the control knob as it is move the probe to next minimum position. Read the VSWR on scale.
4. Repeat the above step for change of S-S tuner probe depth and record the corresponding SWR.
5. If the VSWR is between 3.2 and 10, change the range0dB switch to next higher position and read the VSWR on second VSWR scale of 3 to 10.

B. MEASUREMENT OF HIGH VSWR: (DOUBLE MINIMUM METHOD)

1. Set the depth of S-S tuner slightly more for maximum VSWR.
2. Move the probe along with slotted line until a minimum is indicated.
3. Adjust the VSWR meter gain control knob and variable attenuator to obtain n a reading of 3db in the normal dB scale (0 to 10db) of VSWR meter.
4. Move the probe to the left on slotted line until full scale deflection is obtained on 0-10 db scale. Note and record the probe position on slotted line. Let it be d1.
5. Repeat the step 3 and then move the probe right along the slotted line until full scale deflection is obtained on 0-10db normal db scale. Let it be d2.
6. Replace S-S tuner and termination by movable short.
7. Measure distance between 2 successive minima positions of probe. Twice this distance is guide wave length λg.
8. Compute SWR from following equation

$$SWR = \frac{\lambda g}{\pi (d1 - d2)}$$

OBSERVATION TABLE:

LOW VSWR

VSWR = _______

HIGH VSWR

Beam Voltage(v)	x_1(cm)	x_2(cm)	x_1(cm)	x_2(cm)	Avg $(x_1-x_2) = x$(cm)	$\lambda g=2x$ (cm)

$\lambda g = 6$cm

d1(cm)	d2(cm)	d1-d2 (cm)	VSWR = $\lambda g / \pi(d1-d2)$

PRE LAB QUESTIONS

1) What is standing wave?
2) What is reflection coefficient?
3) Whendo standing waves form?

LAB ASSIGNMENT

1) Determine the reflection coefficient?
2) Determine standing wave ratio?

POST LAB QUESTIONS

1) How they are useful in microwave engg?
2) What is min. value of VSWR?
3) What is range of reflection coefficient?

RESULT: The standing wave ratio and reflection coefficient of the wave guide hasdetermined and observed.

EXPERIMENT No 6

IMPEDANCE MEASUREMENT USING REFLEX KLYSTRON

AIM: To measure an unknown impedance of a given load using the smith chart.

EQUIPMENT REQUIRED:

1. Klystron tube 2k25
2. Klystron power supply Skps-610
3. Klystron mount XM-251
4. Isolator XF 62
5. Frequency meter XF 710
6. Variable attenuator XA – 520
7. Slotted line XS 565
8. Tunable probe XP 655
9. VSWR meter
10. Wave guide stand SU 535
11. S-S tuner (XT 441)
12. Movable short/termination

THEORY:

The impedance at any point on a transmission line can be written in the form R+jx.

For comparison SWR can be calculated as

$$S = \frac{1 + |R|}{1 - |R|}$$ where reflection coefficient 'R'

Given as

$$R = \frac{Z - Z_0}{Z + Z_0}$$

Z_o = characteristics impedance of wave guide at operating frequency.
Z is the load impedance

The measurement is performed in the following way.

The unknown device is connected to the slotted line and the position of one minima is determined. The unknown device is replaced by movable short to the slotted line. Two successive minima portions are noted. The twice of the difference between minima position will be guide wave length. One of the minima is used as reference for impedance measurement. Find the difference of reference minima and minima position obtained from unknown load. Let it be ‘d’. Take a smith chart, taking ‘1’ as centre, draw a circle of radius equal to S. Mark a point on circumference of smith chart towards load side at a distance equal to d/λg.

Join the center with this point. Find the point where it cut the drawn circle. The co-ordinates of this point will show the normalized impedance of load.

BLOCK DIAGRAM

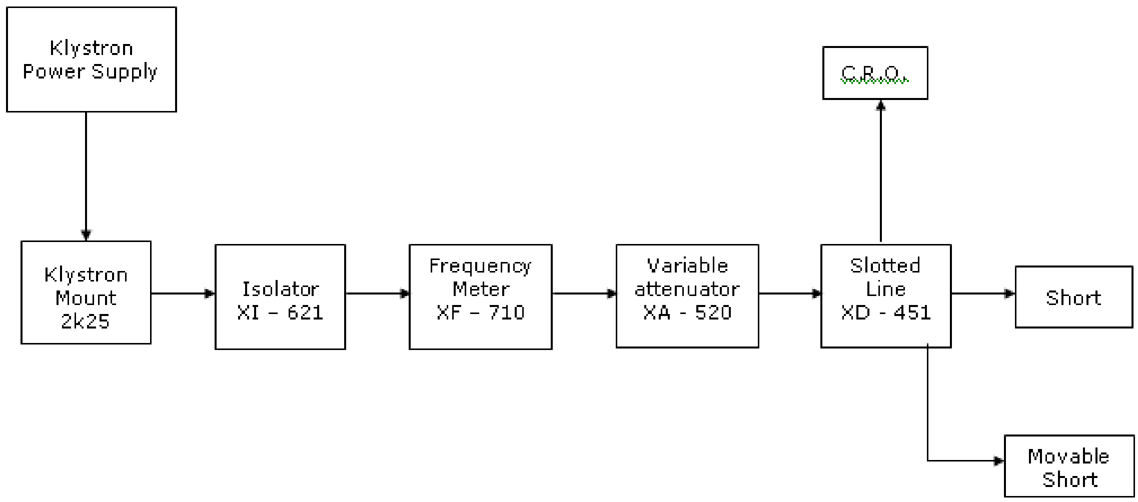


FIG: SET UP FOR IMPEDANCE MEASUREMENT

PROCEDURE:

1. Calculate a set of Vmin values for short or movable short as load.
2. Calculate a set of Vmin values for S-S Tuner + Matched termination as a load.

Note: Move more steps on S-S Tuner

3. From the above 2 steps calculate $d = d_1 \sim d_2$
4. With the same setup as in step 2 but with few numbers of turns (2 or 3). Calculate low VSWR.

Note: High VSWR can also be calculated but it results in a complex procedure.

5. Draw a VSWR circle on a smith chart.

6. Draw a line from center of circle to impedance value ($d/\lambda g$) from which calculate admittance and Reactance ($Z = R \pm jx$)

OBSERVATION TABLE:

Load (short or movable short)					
x_1(cm)	x_2(cm)	x_1(cm)	x_2(cm)	x_1(cm)	x_2(cm)

x = _______

λg = ______

Load (S.S. Tuner + Matched Termination)

S.S Tuner + Matched Termination	Short or Movable Short

d1= , d2 =

d = d1 ~ d2 =

$Z = d/\lambda g$ =

PRE LAB QUESTIONS

1) Indicate the frequency Vs wave length for X-band?
2) Explain the principle of isolator & circulator?
3) What is impedance?

LAB ASSIGNMENT

1) What type of frequency meter used in microwave test bench?
2) What are the types of methods used in microwave frequencies to measure impedance?

POST LAB QUESTIONS

1) How will you measure the impedance of the unknown load in the microwave setup bench?
2) What are the application of smith chart?
3) Explain the principle of frequency meter?

RESULT: The unknown load impedance of a given load has determined.