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DEPARTMENT OF ELECTRONICS AND COMMUNICATION
ADVANCED COMMUNICATION LABORATORY (10ECL67)
VI SEMESTER ECE

LABORATORY MANUAL

ACADEMIC YEAR 2015 – 2016

List of Experiments

Sl. No.	Title of the Experiment	Page No.	
		From	To
1	TIME DIVISION MULTIPLEXING (TDM)	3	6
2	AMPLITUDE SHIFT KEYING (GENERATION AND DETECTION)	7	11
3	FREQUENCY SHIFT KEYING (MODULATION AND DEMODULATION)	12	15
4	PHASE SHIFT KEYING (MODULATION AND DEMODULATION)	16	18
5	DIFFERENTIAL PHASE SHIFT KEYING(MODULATOR AND DEMODULATOR)	19	22
6	QUADRATURE PHASE SHIFT KEYING (MODULATOR AND DEMODULATOR)	23	26
7	MEASUREMENT OF FREQUENCY, GUIDE WAVELENGTH, POWER, VSWR, ATTENUATION IN A MICROWAVE TEST BENCH.	27	31
8 a	STUDY OF LOSSES IN OPTICAL FIBER	32	34
8b	MEASUREMENT OF NUMERICAL APERTURE	35	36
9	MICROSTRIP POWER DIVIDER	37	38
10	MICROSTRIP RING RESONATOR AND DIRECTIONAL COUPLER	38	42
11	MEASUREMENT OF DIRECTIVITY AND GAIN OF ANTENNAS (STANDARD DIPOLE ,MICRO STRIP PATCH ANTENNA AND YAGI ANTENNA)	43	48

Experiment No:1

TIME DIVISION MULTIPLEXING (TDM)

Aim: To study and demonstrate the working of TDM and recovery of two band limited signals of PAM(PULSE Amplitude modulation) signals .

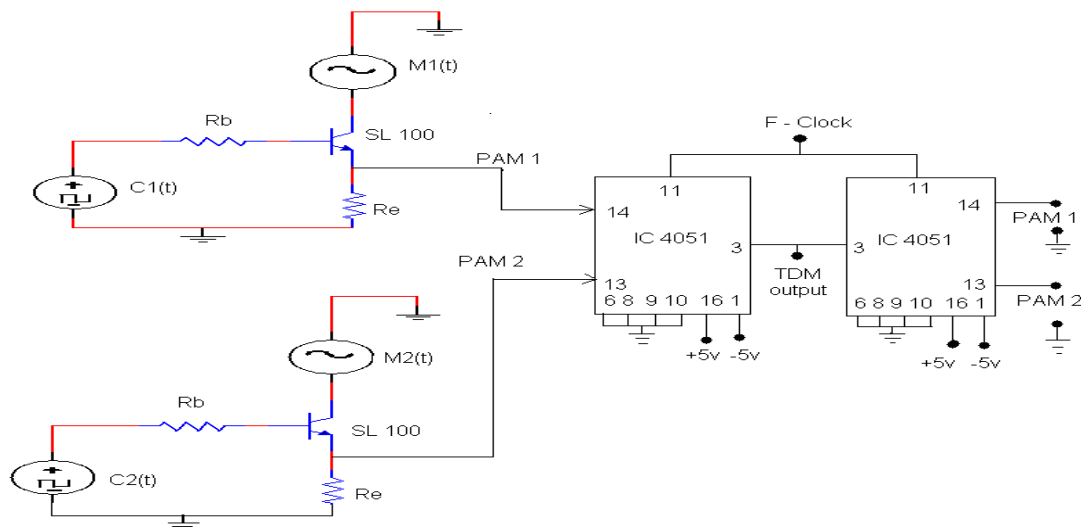
Specifications: $M_1(t) = 3V, 500Hz$ $M_2(t) = 5V, 1KHz$ $C_1(t) = 3V, 500Hz$, $C_2(t)=5V,1KHz$

Equipment used:

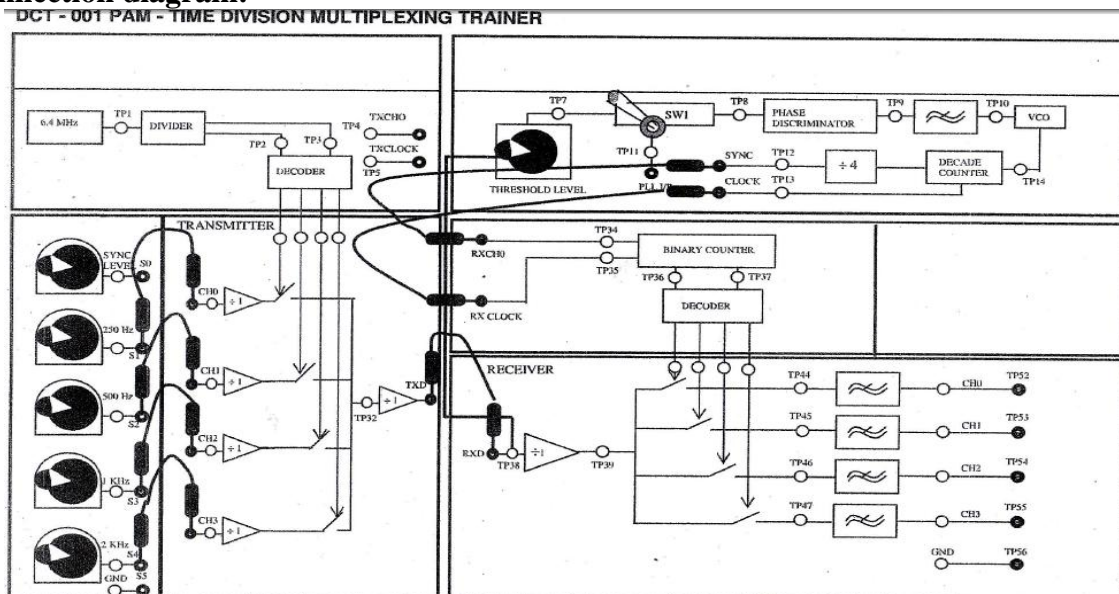
DCT-001 Trainer kit---1

Experimental Set up:

Circuit diagram:



Connection diagram:



Theory:

TDM is a technique used for transmitting several message signals over a communication channel by dividing the time frame into slots, one slot for each message signal. This is a digital technique in which the circuit is highly modular in nature and provides reliable and efficient operation. There is no cross talk in TDM due to circuit non-linearity's since the pulses are completely isolated. But it also has its disadvantages, which include timing jitter and synchronization is required.

In pulse-amplitude modulation, the amplitude of a periodic train of pulses is varied in proportion to a message signal. TDM provides an effective method for sharing a communication channel.

TDM:

Time-division multiplexing (TDM) is a method of putting multiple data streams in a single signal by separating the signal into many segments, each having a very short duration. Each individual data stream is reassembled at the receiving end based on the timing. The circuit that combines signals at the source (transmitting) end of a communications link is known as a multiplexer. It accepts the input from each individual end user, breaks each signal into segments, and assigns the segments to the composite signal in a rotating, repeating sequence. The composite signal thus contains data from multiple sender. At the other end of the long-distance cable, the individual signals are separated out by means of a circuit called a de-multiplexer, and routed to the proper end users. A two-way communications circuit requires a multiplexer/de-multiplexer at each end of the long-distance, high-bandwidth cable. If many signals must be sent along a single long-distance line, careful engineering is required to ensure that the system will perform properly. An asset of TDM is its flexibility. The scheme allows for variation in the number of signals being sent along the line, and constantly adjusts the time intervals to make optimum use of the available bandwidth. The Internet is a classic example of a communications network in which the volume of traffic can change drastically from hour to hour. In some systems, a different scheme, known as frequency-division multiplexing (FDM), is preferred.

Procedure:

1. Connect the AC Adaptor to the mains and the other side to the Experimental Trainer.
2. Feed the input message signals M1 and M2 of ----- volts P-P at ---- Hz.
3. Observe the multiplexed output. .
4. Connect transmitter to receiver.
5. Observe the de-multiplexed output in the CRO.

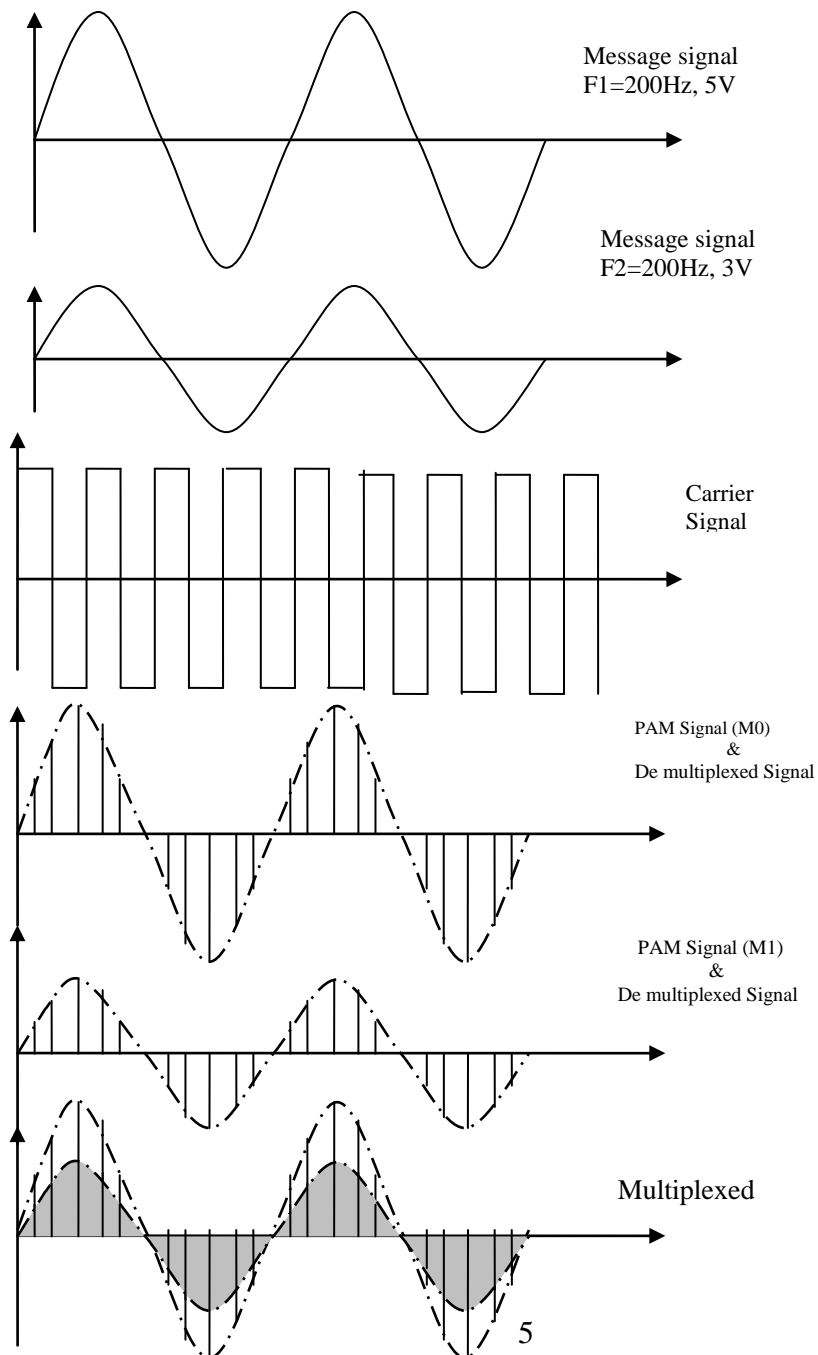
Pre-viva Questions:

1. State different types of Digital Multiplexing techniques?
2. What is Multiplexing?
3. What is a binary modulation technique?
4. Define Time Division Multiplexing?

Table :TDM Modulation & Demodulation (Amplitude & Frequency)

Sl.No	Input signal		Modulated signal		Demodulated signal	
	Amplitude	Frequency	Amplitude	Frequency	Amplitude	Frequency
1	M1(t)	M2(t)				
2						
3						

Expected waveform:



Results: TDM waveforms for input message signals $M_1(t)$ & $M_2(t)$ (1-10V) are verified and found correct.

Verification/Validation: TDM waveforms are validated against expected output for different voltages of input message signals $M_1(t)$ & $M_2(t)$ ranging from 1-10V and found correct.

Conclusions: TDM setup is Implemented using TDM trainer kit DCT-001 and the waveforms are validated and verified.

Post viva Questions:

1. How signals are Multiplexed and de multiplexed in TDM?
2. What is the frequency range of the multiplexed signal and why?
3. How many signals can be multiplexed using TDM technique?
4. What is the bandwidth range required for TDM ?

Experiment No:2

AMPLITUDE SHIFT KEYING (GENERATION AND DETECTION)

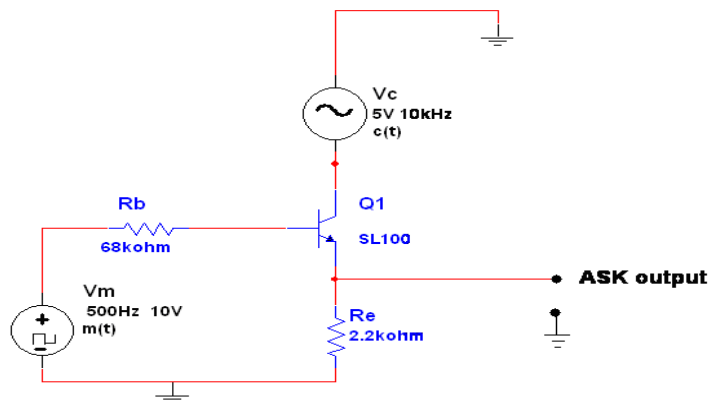
Aim: To design and study the working of ASK modulation and demodulation system with the help of suitable circuit

Specifications: $M(t) = 10V, 500Hz$, $C(t) = 5V, 10KHz$.

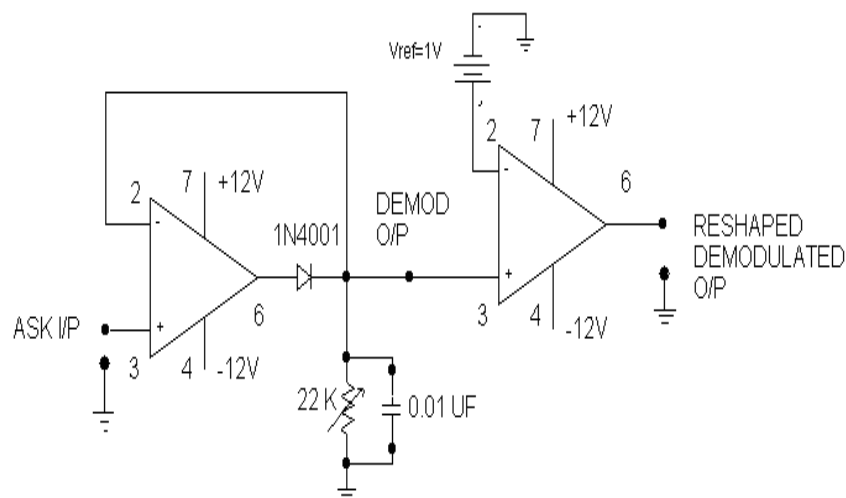
Equipment used:

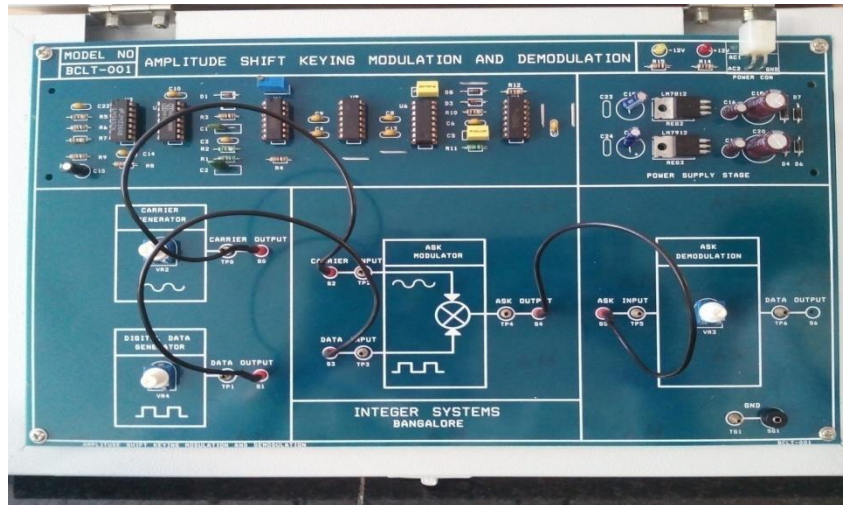
BCLT-001 Trainer kit ---1

ASK MODULATION CIRCUIT DIAGRAM:



ASK DEMODULATION CIRCUIT DIAGRAM:





Theory:

The transmission of digital signals is increasing at a rapid rate. Low-frequency analog signals are often converted to digital format (PAM) before transmission. The source signals are generally referred to as baseband signals. We can send analog and digital signals directly over a medium. From electro-magnetic theory, for efficient radiation of electrical energy from an antenna it must be at least in the order of magnitude of a wavelength in size; $c = f\lambda$, where c is the velocity of light, f is the signal frequency and λ is the wavelength. For a 1kHz audio signal, the wavelength is 300 km. An antenna of this size is not practical for efficient transmission. The low-frequency signal is often frequency-translated to a higher frequency range for efficient transmission. The process is called modulation. The use of a higher frequency range reduces antenna size.

Amplitude shift keying - ASK - in the context of digital communications is a modulation process, which imparts to a sinusoid two or more discrete amplitude levels. These are related to the number of levels adopted by the digital message.

For a binary message sequence there are two levels, one of which is typically zero. Thus the modulated waveform consists of bursts of a sinusoid.

A binary ASK (BASK) wave is obtained by multiplying the message signal with the carrier. The B-ASK signal has two levels '1' and '0' representing the presence and absence of the sinusoid respectively. This can be shown in the waveform below. The message signal must be represented in NZR uni polar format only. Binary ASK system has the largest probability of bit error when compared to FSK and PSK systems.

There are sharp discontinuities shown at the transition points. These result in the signal having an unnecessarily wide bandwidth. Band limiting is generally introduced before transmission, in which case these discontinuities would be 'rounded off'. The band limiting may be applied to the digital message, or the modulated signal itself. One of the disadvantages of ASK, compared with FSK and PSK, for example, is that it has not got a constant envelope. This makes its processing (e.g., power amplification) more difficult, since linearity becomes an important factor. However, it does make for ease of demodulation with an envelope detector.

Procedure:

1. Connect the AC Adaptor to the mains and the other side to the experimental trainer.
2. Observe the Bit Clock frequency on the Oscilloscope. Adjust the frequency to 10 KHz and connect it to -----.
3. Set the SPDP switches pattern to the desired code (say 0000 1111).
4. Parallel load by changing the switch to opposite side to shift side for a short duration and get back to shift position.
5. Observe the 8 Bit word pattern at the output of the 8 Bit word generator. This is the actual modulating signal.
6. Adjust the carrier frequency of ---- KHz and --- Volt p-p, give this input to the ASK modulator inputs using a patch chord.
7. Connect the 8 Bit word generators output to the data input terminal of the ASK Modulator.
8. Observe the data input on one channel on a CRO and ASK output on the second channel.
9. To get demodulated signal, connect the ASK modulator output to demodulator input.
10. Adjust the two knobs simultaneously to get the original digital message at the demodulator output on a CRO.

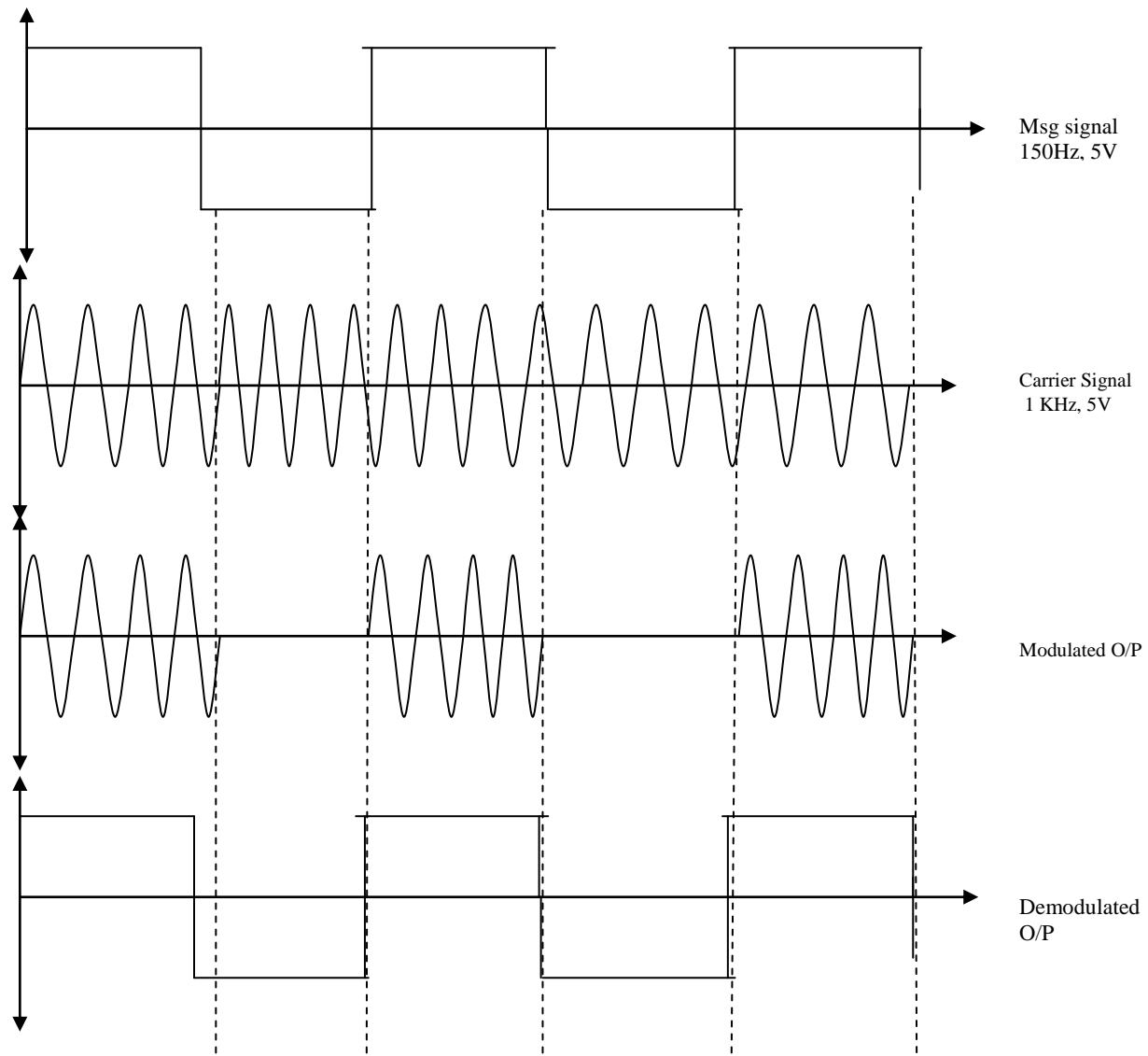
Pre-viva Questions:

1. State different types of Digital modulation techniques?
2. What is shift keying? What are applications of shift keying?
3. What is a binary modulation technique?
4. Define ASK?

Table : ASK Modulation & Demodulation (Amplitude & Frequency)

Sl.no	Input signal		Binary data	Modulated signal		Demodulated signal	
	Amplitude	Frequency		Amplitude	Frequency	Amplitude	Frequency
1							
2							
3							

Expected Waveforms



Results: ASK waveforms for different amplitude (1 - 10V) values of message signal verified and found correct.

Verification/Validation: ASK waveforms are validated against expected output waveforms for different amplitude (1 - 10V) values of message signal and is found correct.

Conclusions: ASK setup is Implemented using ASK BCLT-001 Trainer kit and the waveforms are validated and verified.

Post Viva Questions:

1. How signals are Multiplexed and de multiplexed in ASK?
2. What is the frequency range of the multiplexed signal and why?
3. How many signals can be multiplexed using ASK technique?
4. What is the bandwidth range required for ASK ?

Experiment No: 3

FREQUENCY SHIFT KEYING (MODULATION AND DEMODULATION)

Aim: To study the working of FSK modulation and demodulation with the help of a suitable circuit.

Specifications: $M(t) = 10V, 500Hz$, $C1(t) = 5V, 1KHz$. $C2(t) = 5V, 2KHz$.

Equipment used:

BCLT-002----Trainer kit –1

FSK MODULATOR:

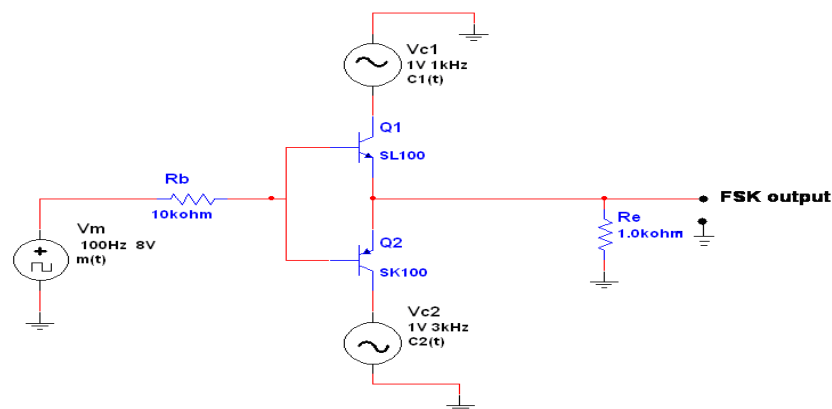


Fig.1

FSK DEMODULATOR:

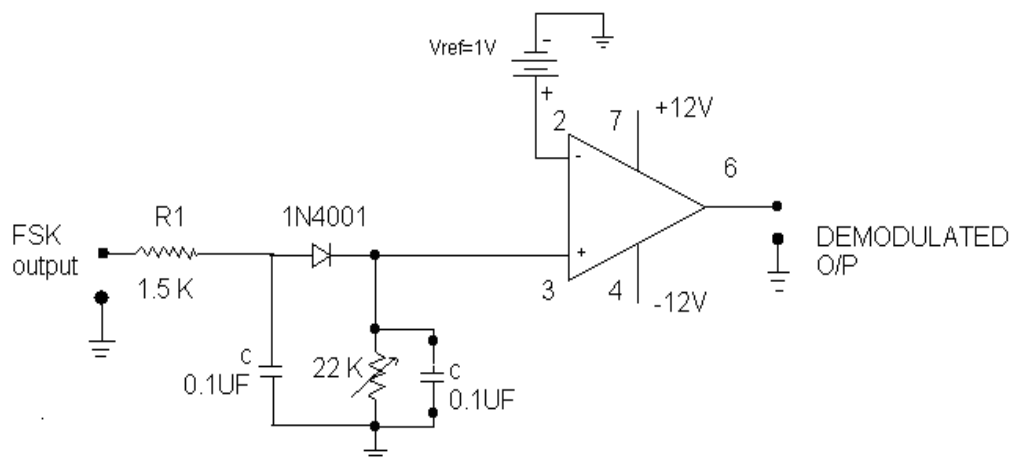
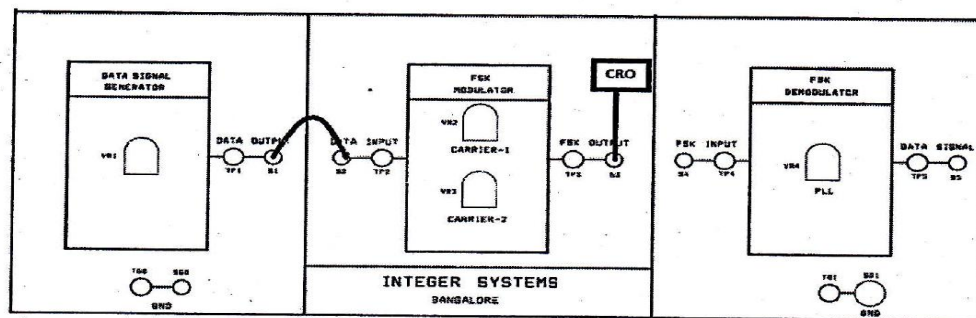


Fig.2

FSK Modulator Connection Diagram.



Theory:

FSK is one of the digital modulation technique. Here frequency of the carrier is switched between two values. A sinusoidal of amplitude 'A' and frequency f_{c1} is used to represent a binary '1' and frequency f_{c2} is used to represent binary '0'. FSK modulated waveform can be

represented as,
$$S(t) = \begin{cases} A, \cos(2\pi f_{c1}t), & \text{symbol '1'} \\ A, \cos(2\pi f_{c2}t), & \text{symbol '0'} \end{cases}$$

As its name suggests, a frequency shift keyed transmitter has its frequency shifted by the message. Although there could be more than two frequencies involved in an FSK signal, in this experiment the message will be a binary bit stream, and so only two frequencies will be involved. The word 'keyed' suggests that the message is of the 'on-off' (mark-space) variety, such as one (historically) generated by a Morse key or more likely in the present context, a binary sequence. Conceptually, and in fact, the transmitter could consist of two oscillators (on frequencies f_1 and f_2), with only one being connected to the output at any one time. Unless there are special relationships between the two oscillator frequencies and the bit clock there will be abrupt phase discontinuities of the output waveform during transitions of the message.

Bandwidth:

Practice is for the tones f_1 and f_2 to bear special inter-relationships, and to be integer multiples of the bit rate. This leads to the possibility of continuous phase, which offers advantages, especially with respect to bandwidth control. FSK signals can be generated at baseband, and transmitted over telephone lines (for example). In this case, both f_1 and f_2 (of Fig.2) would be audio frequencies. Alternatively, this signal could be translated to a higher frequency. Yet again, it may be generated directly at 'carrier' frequencies.

Minimum-shift keying:

Minimum frequency-shift keying or minimum-shift keying (MSK) is a particularly spectrally efficient form of coherent FSK. In MSK the difference between the higher and lower frequency is identical to half the bit rate. Consequently, the waveforms used to represent a 0 and a 1 bit differs by exactly half a carrier period. This is the smallest FSK modulation index that can be chosen such that the waveforms for 0 and 1 are orthogonal. A variant of MSK called GMSK is used in the GSM mobile phone standard.

Procedure:

1. Connect the AC Adaptor to the mains and the other side to the Experimental Trainer.
2. Apply any one Data output of the Counter to the Data input point of the FSK Modulator and observe the Same Signal in one Channel of a Dual Trace Oscilloscope.
3. Observe the output of the FSK Modulator on the second channel of the CRO.
4. During the Demodulation, Connect the FSK output to the input of the Demodulator

Pre-viva Questions:

1. State different types of Digital modulation techniques?
2. What is shift keying? What are applications of shift keying?
3. What is a binary modulation technique?
4. Define FSK?

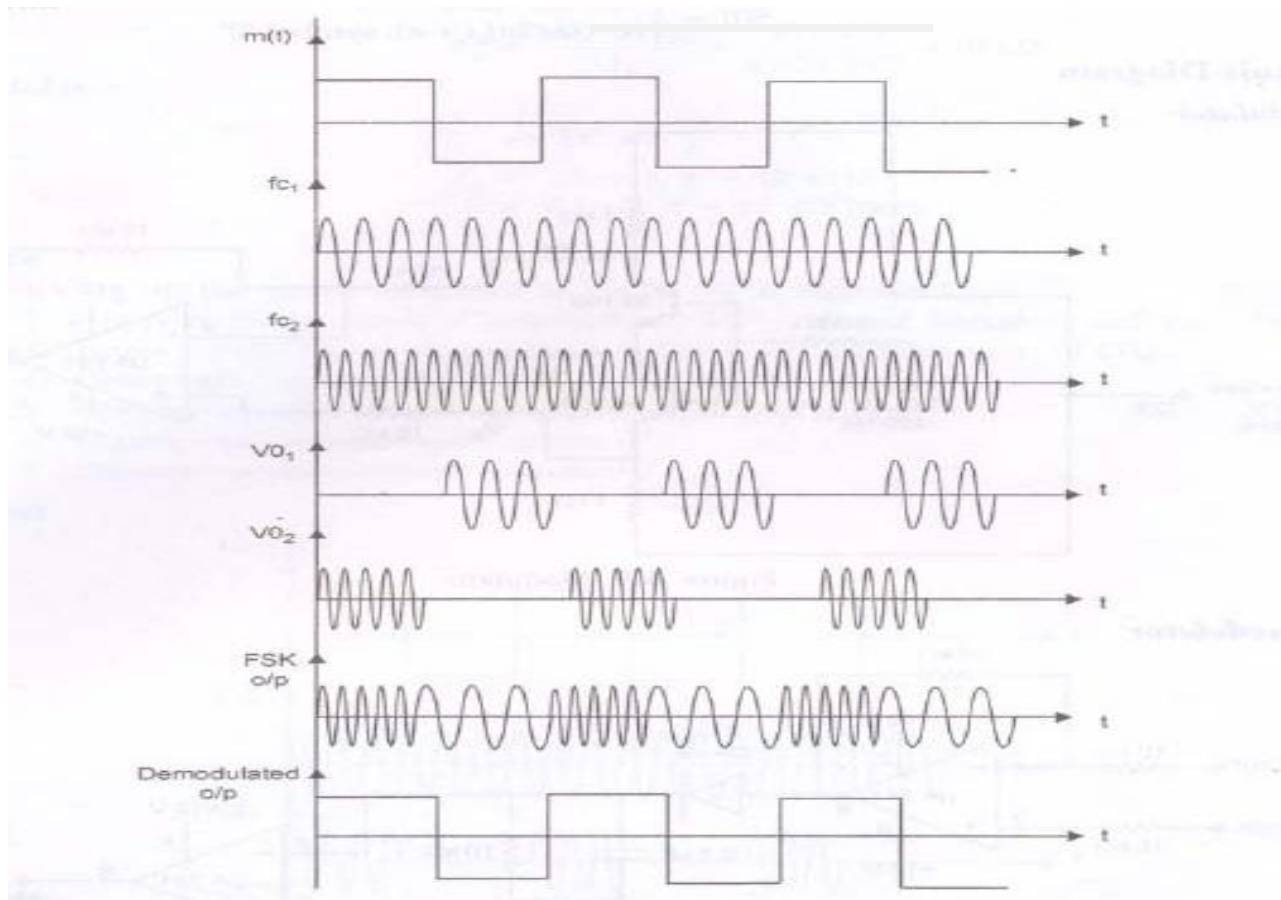
Expected waveform:

Table : FSK Modulation & Demodulation (Amplitude & Frequency)

Sl.no	Input signal		Binary data	Modulated signal		Demodulated signal	
	Amplitude	Frequency		Amplitude	Frequency	Amplitude	Frequency
1							
2							
3							

Results: FSK waveforms for $M(t) = 10V, 500Hz$, $C1(t) = 5V, 1KHz$. $C2(t) = 5V, 2KHz$ are verified and found correct.

Verification/Validation: FSK waveforms are validated against expected output waveforms for different frequencies $C1(t) = 5V, 1KHz$. $C2(t) = 5V, 2KHz$ and found correct.

Conclusion: FSK setup is Implemented using FSK trainer kit BCLT-002 and the waveforms are validated and verified.

Post Viva Questions:

1. How signals are modulated and de modulated in **FSK**?
2. What is the frequency range of the input and output signal and why?
3. What are the applications of FSK technique?
4. What is the bandwidth range required for **FSK** ?

Experiment no: 4

PHASE SHIFT KEYING (MODULATION AND DEMODULATION)

Aim:

To study the working of PSK circuit and to demodulate the above signal with a suitable circuit.

Specifications: $M(t) = 10V, 500Hz$, $C(t) = 5V, 10KHz$.

Equipment used:

DCT--004---Trainer kit -1

Circuit Diagram

PSK MODULATOR:

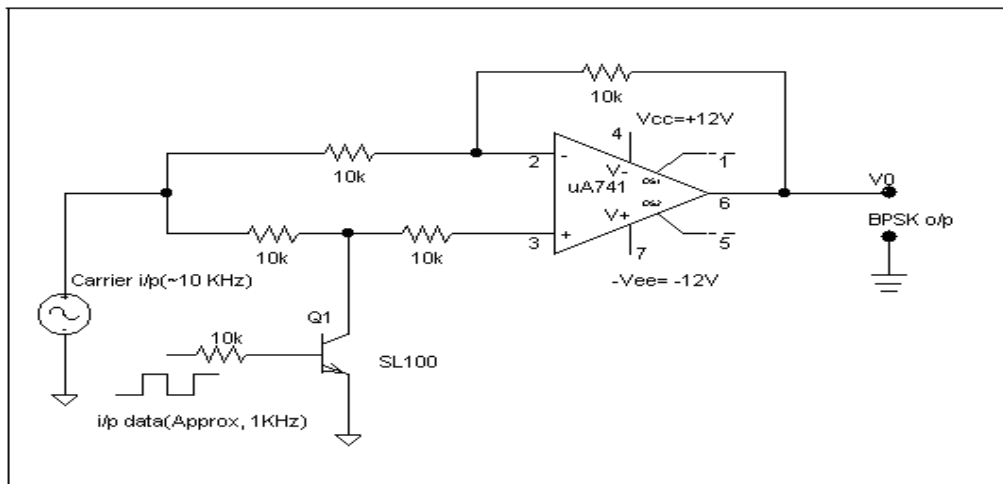


Fig.1

PSK DEMODULATOR:

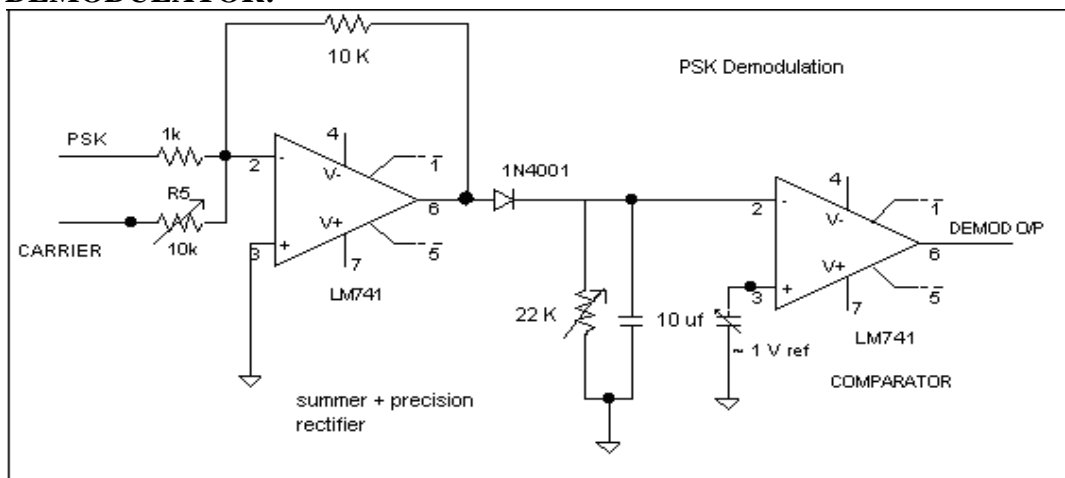


Fig.2

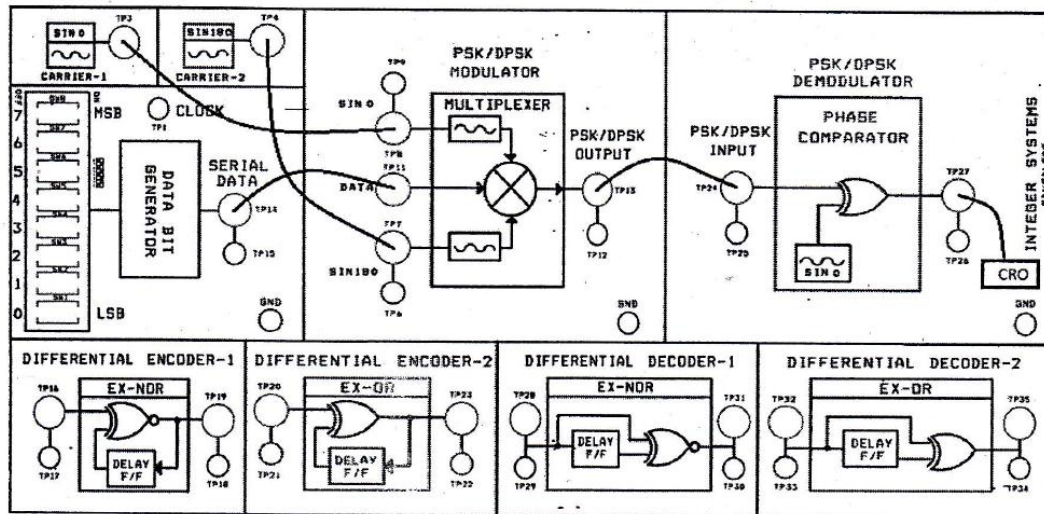
Connection Diagram of PSK Modulator and demodulator**Theory:**

Fig.1 shows the circuit diagram of the Phase Shift Key modulation and demodulation. In this carrier Generator is generated by a wein bridge oscillator around 28KHz. At $\pm 5V_{p-p}$ sine wave using 741 IC. The sine wave is converted into square wave using TL084 in comparator mode. The transistor BC 107 converts the square wave signal to TTL level. This is used as a basic bit clock or 180° for a mark and 0° for space. This square wave is used as a clock input to a decade counter (IC7490) which generates the modulating data outputs. IC CD4051 is an Analog multiplexer to which carrier is applied with and without 180° 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° phase shift to the carrier signal created by an operational amplifier using 741 IC during the demodulation, the PSK signal is converted into a +5 volts 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 +5 volts signal. So the EX-OR gate output is equivalent to the modulating data signal.

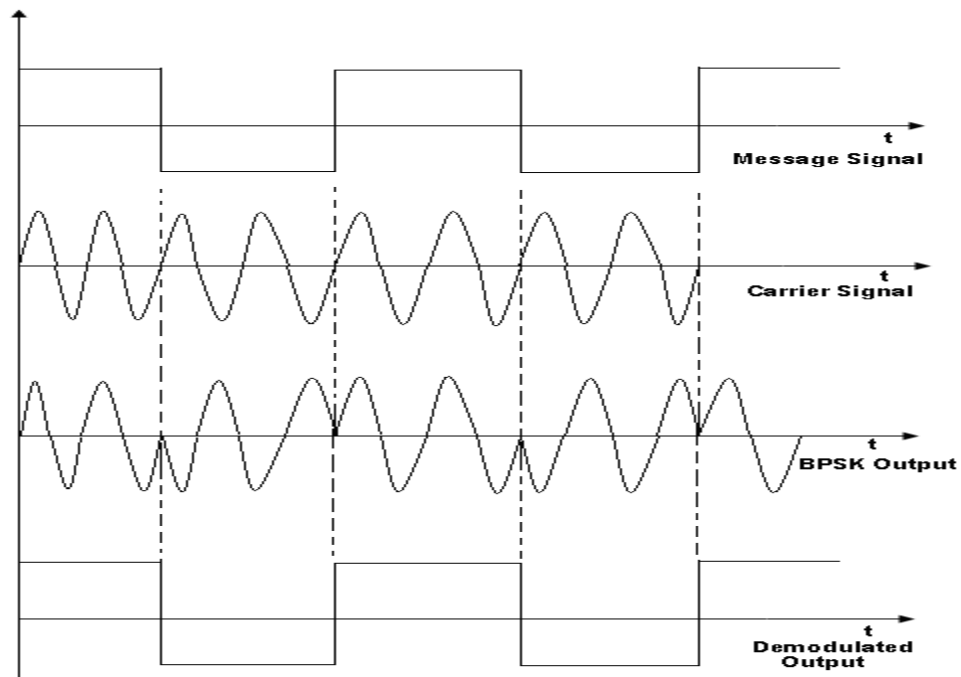
Procedure:

1. Switch ON the experimental board.
2. Apply the carrier signal to the input of the modulator
3. Apply the modulating data signal to the modulator input and observe this signal on channel 1 of the CRO
4. Observe the output of the PSK modulator on the channel 2 of the CRO
5. Apply this PSK output to the demodulator input and also apply the carrier input.
6. Observe the Demodulator output and compare it with the modulating data signal applied to the modulator input which is identical.

Pre-viva Questions:

1. State different types of Digital modulation techniques?
2. What is shift keying?
3. What is a binary modulation technique?
4. Define DPSK?

Expected Waveform:



Results: PSK waveforms for the different binary values of message signal $M(t) = 10V, 500Hz$, $C(t) = 5V, 10KHz$ are verified and found correct.

Verification/Validation: PSK waveforms are validated against expected output waveforms for the different binary values of message signal $M(t) = 10V, 500Hz$, $C(t) = 5V, 10KHz$ and found correct.

Conclusions: PSK setup is Implemented using PSK trainer kit DCT--004 and the waveforms are validated and verified.

Post Viva Questions:

1. How signals are modulated and de modulated in **PSK**?
2. What is the frequency range of the input and output signal and why?
3. What are the applications of PSK technique?
4. What is the bandwidth range required for **PSK** ?

Experiment No: 5

DIFFERENTIAL PHASE SHIFT KEYING (MODULATOR AND DEMODULATOR)

Aim: To generate a DPSK for a given binary (digital) signal and Observe, Demodulate the same DPSK to get back the original Digital signal, using carrier-receiving circuit & Demodulator.

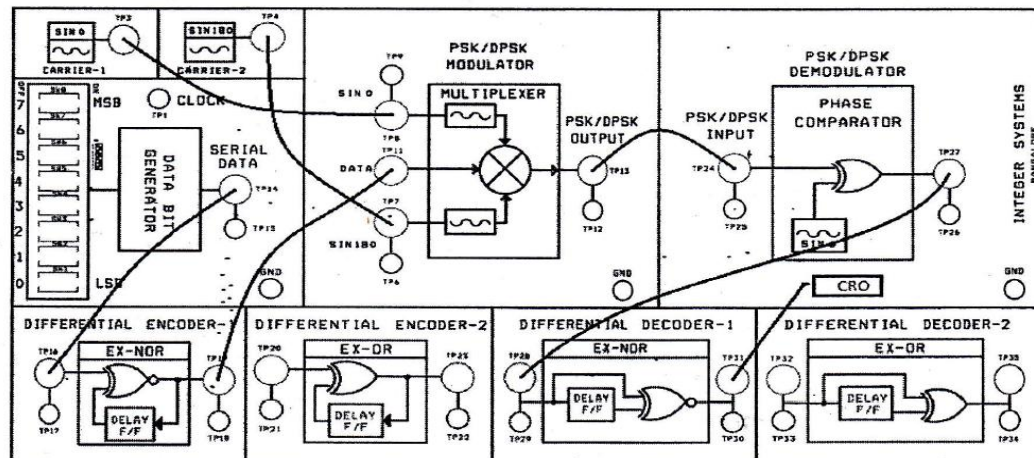
Specifications: $M(t) = 10V, 500Hz$, $C(t) = 5V, 10KHz$.

Equipment used:

DCT--004----Trainer kit -1

Connection Diagram

Connection Diagram of DPSK Modulator and demodulator with EX-NOR Differential encoder and decoder



Theory:

The carrier wave signal is generated by a weinbridge oscillator around ***KHZ at $\pm 5V$ P-P sine wave using 741 the sine wave is convert into square wave using TL084 in comparator mode. The Transistor BC 107 converts the square signal to TTL levels. This is used as a basic bit clock or 180° for a mark and 0° for space. This Square wave is used as a clock input to a decade counter(IC 7490) which generates the modulating data outputs.

The modulation is performed as follows:

The Differential signal to the modulating is generated using an Exclusive-OR gate(7486) and a 1-bit delay circuit using D flip-flop 7474 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 input of the TL084. Differential signal generated by Ex-OR gate (IC 7486) is given to the multiplexer's control signal input. Depending upon the level of the control signal, carrier signal applied with or without phase shift is steered to the output. 1-bit delay generation of differential signal to the input is created by using a D-flip-flop (IC 7474).

The demodulation is performed as follows:

During the demodulation, the data and carrier are recovered through a TL084 op amp in comparator mode. This level is brought to TTL level 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 1-bit delay the same signal is given. So the output of this EX-OR gate is the recovered modulating signal.

Procedure:

1. 'Switch ON' the experimental board.
2. Check the carrier Signal and the data generator signals initially.
3. Apply the carrier signal to the carrier input of the DPSK modulator and give the data generated to the data input of DPSK modulator and Bit clock output to Bit clock input of modulator. Observe the DPSK modulating output with respect to the input data generator signal of dual trace Oscilloscope (Observe the DPSK modulating signal on channel 1 and the data generator signal on channel 2), and observe the DPSK signal with respect to Differential data also.
4. Give the output of the DPSK modulator signal to the input of demodulator, give the Bit clock output to the Bit clock input to the demodulator and also give the carrier output to the carrier input of demodulator.
5. Observe the demodulator output with respect to data generator signal (Modulating Signal)

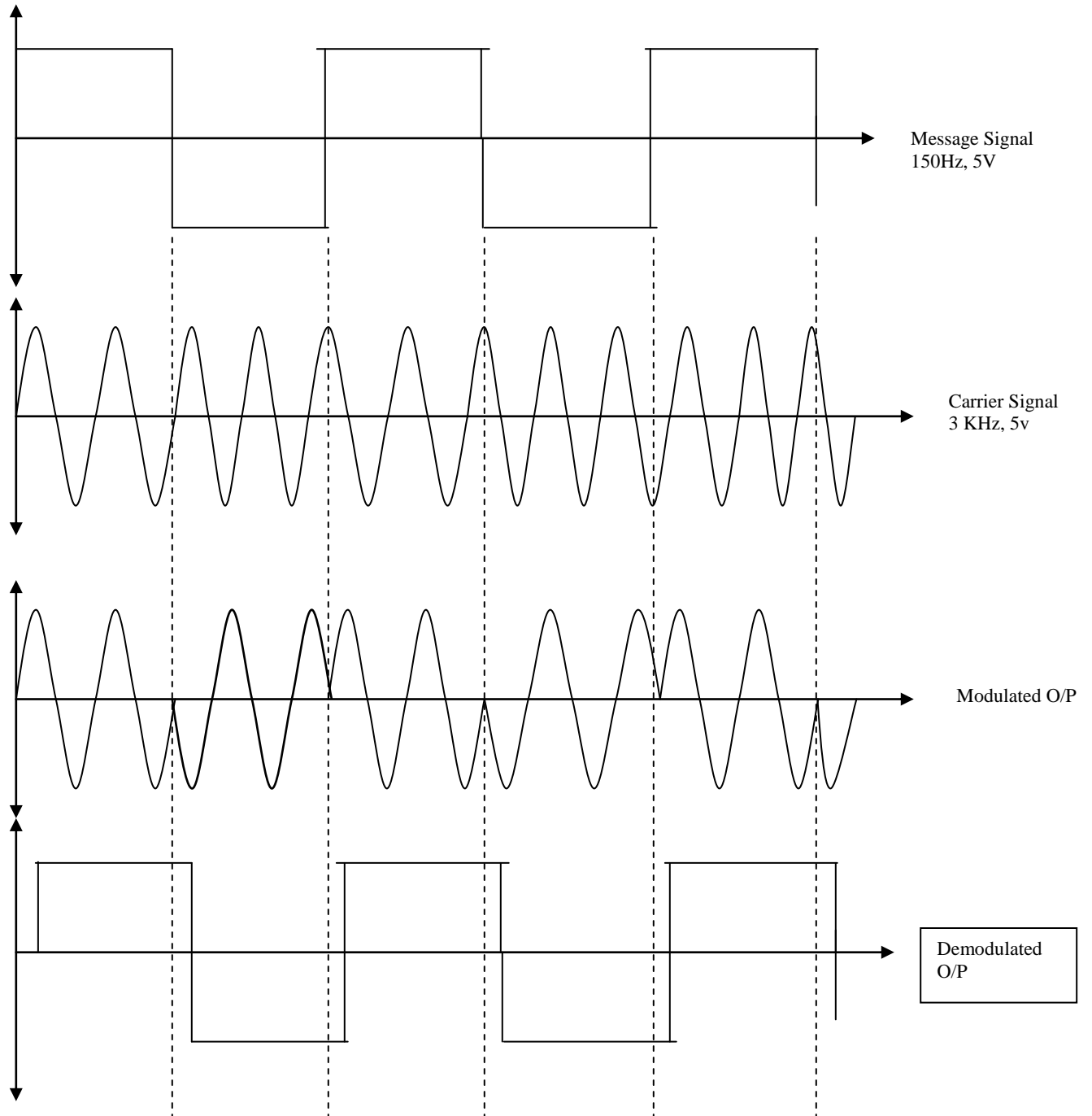
Pre-viva Questions:

1. State different types of Digital modulation techniques?
2. What is shift keying?
3. What is a binary modulation technique?
4. Define DPSK?

Table 1:

Sl.no	Input signal amplitude and frequency	Binary data	Modulated signal amplitude.	Demodulated signal amplitude.
1				
2				
3				

Expected waveform:



Results: DPSK waveforms for the different binary values of message signal $M(t) = 10V, 500Hz$, $C(t) = 5V, 10KHz$ are verified and found correct.

Verification/Validation: DPSK waveforms are validated against expected output waveforms for the different binary values of message signal $M(t) = 10V, 500Hz$, $C(t) = 5V, 10KHz$ and found correct.

Conclusion: DPSK setup is Implemented using DPSK trainer kit DCT--004 and the waveforms are validated and verified.

Post Viva Questions:

1. How signals are modulated and de modulated in **DPSK**?
2. What is the frequency range of the input and output signal and why?
3. What are the applications of DPSK technique?
4. What is the bandwidth required for the transmission using DPSK?

Experiment No: 6

QUADRATURE PHASE SHIFT KEYING (MODULATOR AND DEMODULATOR)

Aim:

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

Specifications: $M(t) = 10V, 500Hz$, $C(t) = 5V, 10KHz$.

Equipments used:

Kit , Patch cards, Power supply and two-channel oscilloscope.

Block diagram:

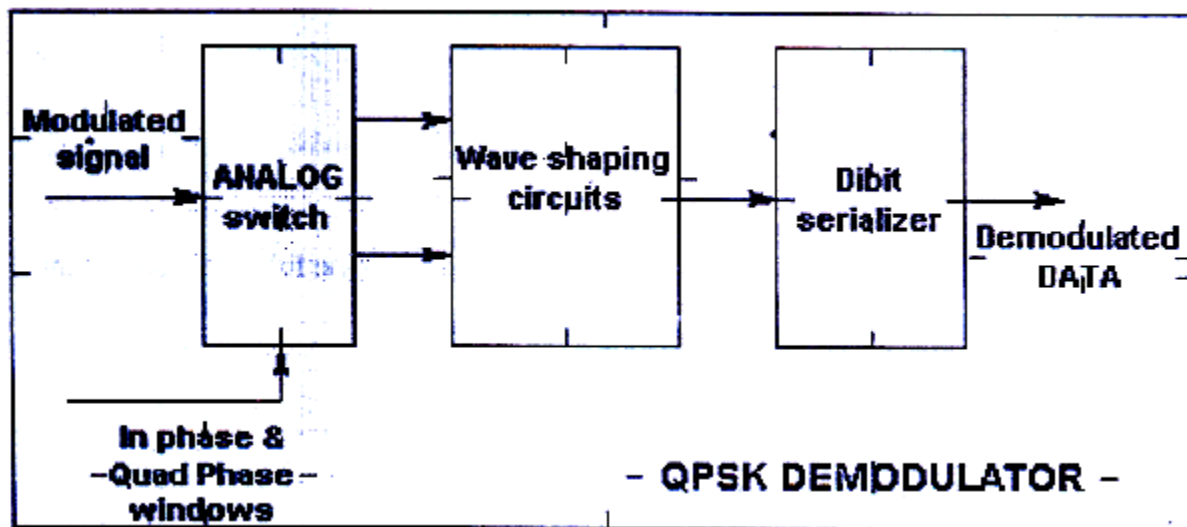


Fig:1

Theory:

The QPSK is the type of modulation in which the information is carried by the transmitted wave is contained in the phase. In particular, the phase of the carrier takes on one of the four equally spaced value such as .each possible value of the phase corresponds to a unique pair of bits called debit.

For exited phase value can represent set digits 10, 00, 01 and 11.

The QPSK waveform is widely used because it offers the best tradeoff between power and bandwidth requirements. also, it provides very low probability of error

The modulated signals are:

$$S_e = b_e(t) \sqrt{p_s} \sin 2\pi f_o t$$

$$S_o = b_o(t) \sqrt{p_s} \cos. 2\pi f_o t$$

The output of the adder is:

$$S(t) = S_e(t) + S_o(t).$$

$$S(t) = b_e(t) \sqrt{p_s} \sin(2\pi f_o t) + b_o(t) \sqrt{p_s} \cos. (2\pi f_o t).$$

Digital Phase Modulation (or Phase Shift Keying - PSK) is very similar to Frequency Modulation. It involves changing the phase of the transmitted waveform instead of the frequency, these finite phase changes representing digital data. In its simplest form, a phase-modulated waveform can be generated by using the digital data to switch between two signals of equal frequency but opposing phase. Taking the above concept of PSK one stage further, it can be supposed that the number of phase shifts is not limited to only two states. The transmitted "carrier" can undergo any number of phase changes and by multiplying the received signal by a sine wave of equal frequency will demodulate the phase shifts into frequency independent voltage levels. This is, indeed the case in QPSK (Quadrature Phase Shift Keying, Sometimes this is known as *quaternary PSK*, *quadriphase PSK*, 4-PSK). With QPSK, the carrier undergoes four changes in 4 phases and can thus represent two bits of binary data. While this may seem insignificant at first glance, a modulation scheme has now been supposed that enables a carrier to transmit two bits of information instead of one, thus effectively doubling the bandwidth of carrier. QPSK has four phases and for a given bit-rate, the QPSK requires half the bandwidth of PSK and is widely used for this reason.

(In quadrature Phase Shift keying each pair of consecutive data bit is treated as a two bit (or dibit) code which is used to switch the phase of the carrier sine wave between one of four phases 90° apart. The four possible combination of dibit code are 00, 01, 10 and 11. Each code represents either a phase of 45°, 135°, 225°, and 315° lagging, relative to the phase of the original un-modulated carrier. The choice of these phases is arbitrary as it is convenient to produce them. Quadrature phase shift keying offers an advantage over PSK, in a manner that now each phase represents a two bit code rather than a single bit. This means now either we can change phase per second or the same amount of data can be transmitted with half as many phase changes per second. The second choice results in a lowering of bandwidth requirement. The four phases are produced by adding two carrier waves of same frequency but 90° out of phases. The 0° phase carrier is called In-phase carrier and is labeled I The other is 90° (lagging) phase carrier termed as the quadrature carrier and is labeled Q.)

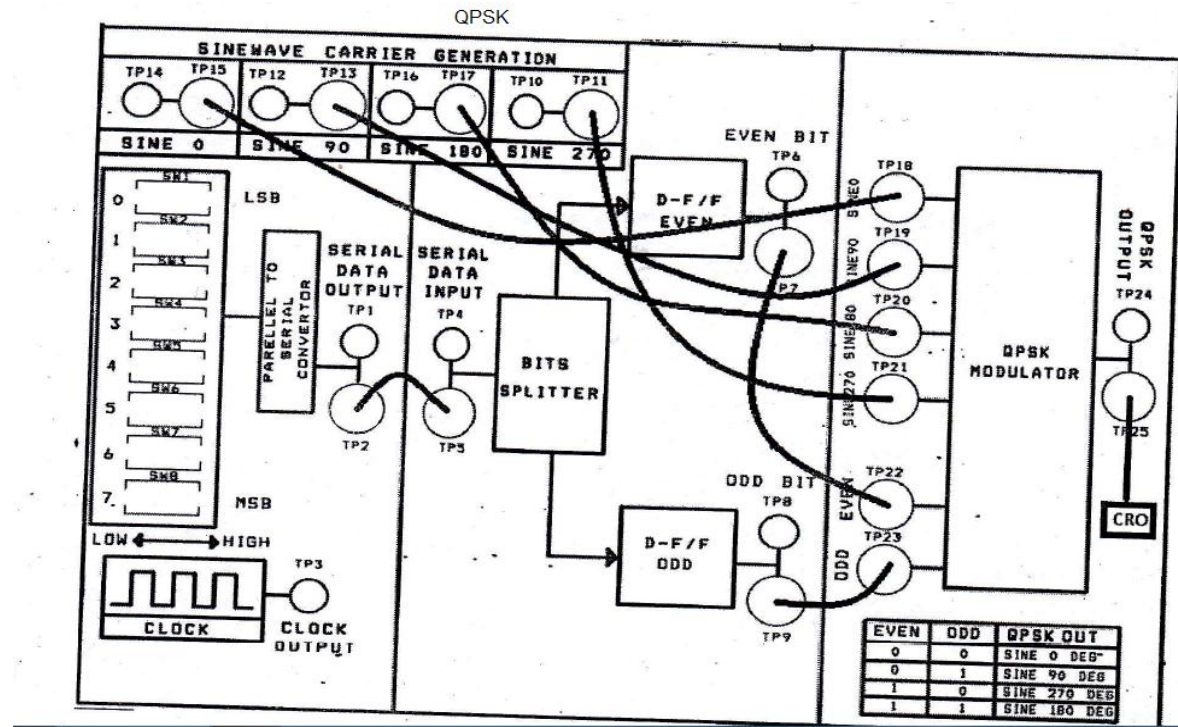


Fig:2

Procedure:

Modulation

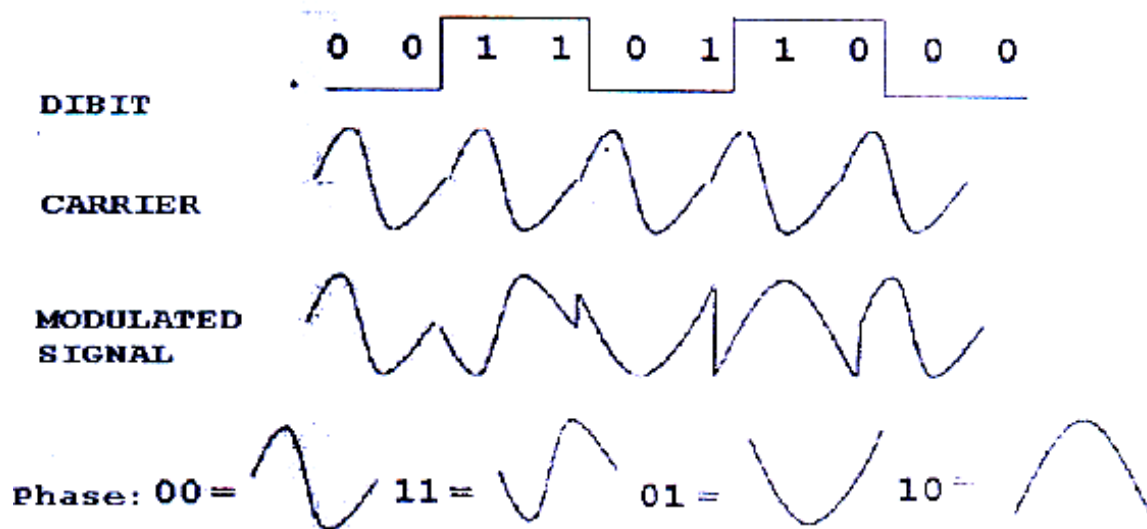
1. Connect the power supply cable at the POWER IN connector and switch ON the power.
2. Connect the QPSK-TX to QPSK-RX.
3. Give the input through Dip switch S1 and observe the phase shift at QPSK-TX, compare the waveform with fig.
4. EX: Through the Dip switch select the bits as 11100100 (The switch is upper side=0, the switch is lower side= 1)
5. Change the bit pattern by using the Dipswitch and observe the corresponding changes at SLDATA-TX.
6. Demodulated output can be observed at SLDATA-RX at this point you will get the same pattern as that at SLDATA-TX and you can see the same at the 8-LEDs.
7. Ex: If your selected bit pattern is 11100100 then at the demodulation side LED D3, D4, D5 & D8 Should be ON and D6, 07, 09 & 010 should be OFF,
8. Note the delay between, SLDATA-TX and SLDATA-RX, There is 0.2 In sec delay. This is due to the delay between LT6/5-6(ISIG-QSIG)and U6/ I(SH/LD). Here first data is shifting and after 0.2 m sec

Pre-viva Questions:

1. State different types of Digital modulation techniques?
2. What is shift keying?

3. What is a binary modulation technique?
4. Define QPSK?

Expected Waveform:



Results: QPSK waveforms for different binary values of message signal $M(t) = 10V, 500Hz$, $C(t) = 5V, 10KHz$ are verified and found correct.

Verification/Validation: QPSK waveforms are validated against expected output waveforms for the given message signal $M(t) = 10V, 500Hz$, $C(t) = 5V, 10KHz$ and found correct.

Conclusion: QPSK setup is Implemented using QPSK trainer kit DCT—004 and the waveforms are validated and verified.

Post Viva Questions:

1. How signals are modulated and de modulated in QPSK?
2. What is the frequency range of the input and output signal and why?
3. What are the applications of DPSK technique?
4. What is the bandwidth range required for QPSK ?

Experiment No: 7

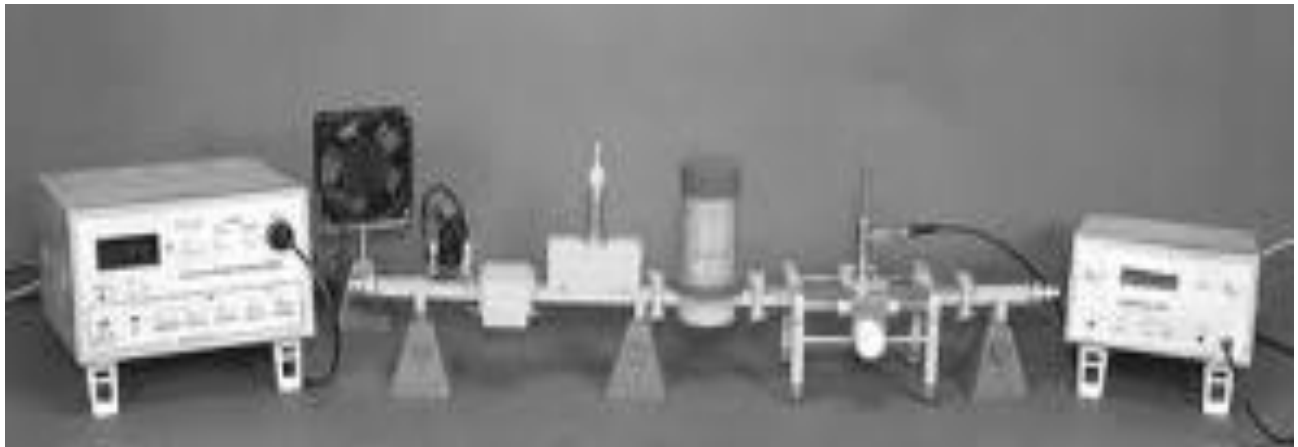
MEASUREMENT OF FREQUENCY, GUIDE WAVELENGTH, POWER, VSWR, ATTENUATION IN A MICROWAVE TEST BENCH.

Aim:

To measure the Guide wavelength, operating frequency, power, attenuation and VSWR of a reflex klystron.

Specifications: VSWR = 1.1 , Frequency=9.8GHz, repeller voltage 60-100V, & Beam voltage 300V

Experimental Setup:



Components Required:

1. Reflex klystron Power supply
2. Reflex klystron oscillator
3. Isolator
4. Pin modulator
5. Variable Attenuator
6. frequency meter
7. Slotted probe carriage
8. Tunable detector
9. VSWR meter
10. CRO

Block Diagram:

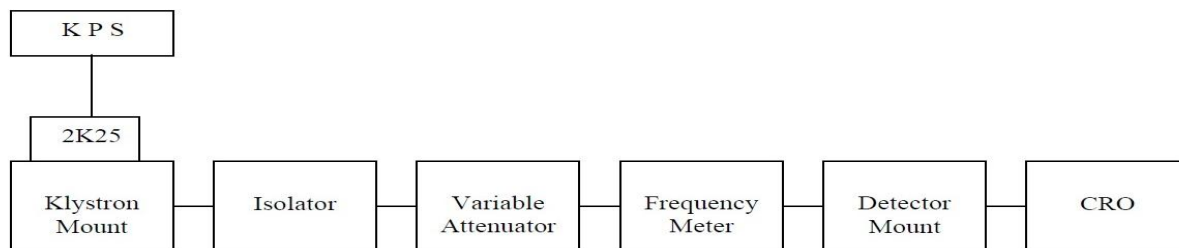


Fig.1

Theory:

The reflex klystron makes use of velocity modulation to transform a continuous electron beam into microwave power. Electrons emitted from the cathode are accelerated and passed through the positive resonator towards negative reflector, which retards and finally, reflects the electrons and the electrons turn back through the resonator, suppose an rf field exist between the resonators the electrons traveling forward will be accelerated electrons leave the resonator at an the voltage at the Resonator changes in amplitude. The accelerated electrons leave the resonator at an increased velocity and the retarded electrons leave at the reduced velocity. The electrons leaving the resonator will need different time to return, due to change in velocities. As a result, returning electrons group together in bunches. As the bunches pass through resonator, they interact with voltage at resonator grids. If the bunches pass the grid at such a time that the electrons are slowed down by the voltage then energy will be delivered to the resonator and Klystron will oscillate. The dimensions of resonant cavity primarily determine the frequency. Hence, by changing the volume of resonator, mechanical tuning of Klystron is possible. Also a small frequency change can be obtained by adjusting the reflector voltage. This is called Electronic Tuning. For further details refer Microwave Devices and Circuits by Samuel Y. Liao Important: Firing the Reflex Klystron.

Initial Setup:

1. Keep the High Tension power in OFF position.
2. Set the beam voltage at zero level.
3. Set the knob in amplitude modulation position.
4. Set the repeller voltage at maximum level.
5. Set the AM frequency at middle range.
6. Keep the beam voltage at 300V.
7. Adjust repeller voltage, AM amplitude and tunable probe (slotted line) to get maximum output in the CRO.

Experimental Procedure:

(a) TO FIND GUIDED WAVELENGTH (λ_g) and OPERATING FREQUENCY (f_0)

1. Set the klystron bias in such a way that the diode operates in Negative Resistance region.
2. Tune the crystal detector such that the demodulated square wave o/p is maximum.
3. Short circuit the load ends of the slotted line and calculate the count of the slotted line scale.
4. Without disturbing the Gunn bias, rotate the frequency meter till a dip in square wave is observed on CRO.
5. At that point read the Frequency meter to obtain the operating frequency of the gunn diode(f_0).
6. The above steps are called as frequency determination using the direct method.
7. Locate a maxima on the CRO. This is also called a node.

8. Move the slotted line carriage to any node or antinodes and note down the first reading as X_1 .
9. Move the slotted section to the immediate next node or antinodes and note down the 2nd reading X_2 .
10. Guide wavelength (λ_g) is twice the difference of X_1 and X_2 i.e. $\lambda_g = 2(X_2 - X_1)$

Pre-Viva Questions:

1. Define modes?
2. Differentiate between TE and TM waves?
3. What is the range of microwaves?
4. What is the advantage of waveguides?

Calculation

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

The value 'a' is the width of the waveguide known to us as 2.3cm. Therefore $\lambda_c = 2 \times 2.3 = 4.6$ cms

(b) TO FIND VSWR

(i) Direct method

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

(ii) Double Minima method:-

Measure λ_g following appropriate procedure.

1. Locate any minima and note down the corresponding power in db.
2. Move the slotted line section to the right till power increases by 3 dB(X_1) and bring it back.
3. Move slotted line section to the left till power decreases by 3 dB (X_2)
5. If distance between two points is d , then $VSWR = \lambda_g / \pi d$,
where $d = (X_2 - X_1)$.

(c) TO MEASURE POWER:-

1. Set for max output using slotted probe line carriage
2. Connect from detector to VSWR meter.
3. Adjust the Coarse and Fine knob in the VSWR meter and set it to MID position
4. Measure the power at Detector(Range in dB + Reading in the dB scale)
5. To measure the power at slotted probe line carriage repeat step 1 & 2 and connect from slotted probe line carriage to VSWR meter.

(d) TO MEASURE ATTENUATION:-

Set for max output using slotted probe line carriage

1. Connect from slotted probe line carriage to VSWR meter
2. Adjust coarse and fine knob and bring it to 0dB.
3. Vary the variable attenuator and note the reading from the SWR meter.
4. Repeat the procedure for various values by adjusting variable attenuator.

TABLE 1 (Mode 1)

SL.NO	Repeller Voltage (V)	Output Signal amplitude p-p	Frequency in GHz
	60		
	47		
	6.7		

TABLE 2 (Mode 2)

SL.NO	Repeller Voltage (V)	Output Signal amplitude p-p	Frequency in GHz
	95		
	89		
	99		

Results: Using Microwave setup the following values are found and verified.

Frequency, $f_0 = 9.8\text{GHz}$

Guided wavelength, $\lambda_g = 2.4\text{m}$

VSWR (direct method) = 1.1

VSWR (double minima method) = 1.1

Verification/Validation: Using Microwave test-bench setup the values of Frequency, Guided wavelength, VSWR are validated against different values of VSWR repeller voltage 60-100V, & Beam voltage 300V and found correct.

Conclusion: Microwave test-bench setup is Implemented using reflex klystron and the values of Frequency, Guided wavelength, VSWR are validated and verified.

Post Viva Questions:

1. Define VSWR?
2. What is a Klystron?
3. State the classification of microwave tubes?
4. What are O-type and M-type tubes?
5. State application of klystron?
6. State the mechanism of oscillation in klystron?
7. How modulation occurs in reflex klystron?

Experiment No: 8a

STUDY OF LOSSES IN OPTICAL FIBER

Aim:

The objective of this experiment is to measure propagation or attenuation loss in optical fiber.

Specifications: Optical fiber of length-0.5M, 1M, & 1.5M.

Block Diagram:

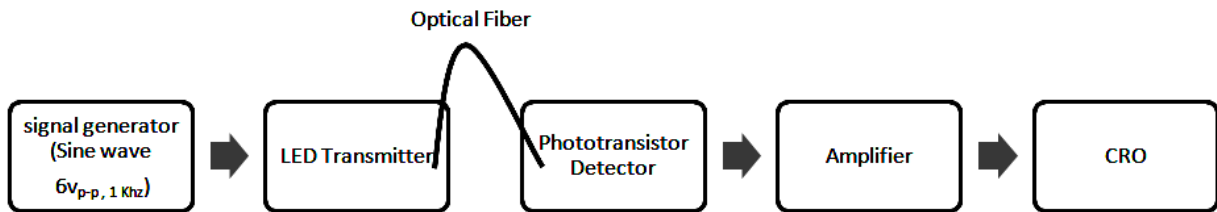


Fig.1

Theory:

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

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

Where α is Loss in dB/Meter

EXPERIMENTAL PROCEDURE:

PROPAGATION LOSS

1. Set up the analog link as shown in the block diagram.
2. Use an optical fiber link of length 1 meter and note down the output voltage V_1 Volts.
3. Use an optical fiber link of length 3 meters and note down the output voltage say V_2 Volts.

4. If α is the attenuation of the fiber,

$$P_1/P_2 = V_1/V_2 = e^{[\alpha(L_1+L_2)]}$$

Where α = nepers/meter

L1=fiber length V1

L2=fiber length for V2 this α is peak wavelength of 950 nm.

Table :Input Cable length

Cable length	Output voltage	loss
1 meter		
3 meter		

MEASUREMENT OF BENDING LOSS:

1. Setup an analog link using 1 meter cable as shown in the block diagram.
2. Apply 2V (p-p) sinusoidal signal of 1kHz at EXT-ANALOG terminal.
3. Observe the received signal at ANALOG- OUT.
4. Bend the fiber in a loop. Measure the received signal amplitude (Vo). Go on decreasing the diameter of the loop and note down the output voltage
5. Plot the graph of loop diameter versus Vo.

Pre-viva Questions:

1. What are the advantages of using optical fibers?
2. What is the principle of operation of OFC?
3. State the difference between step-index and graded index fiber?
4. Define TIR Principal?

Table :Optical Fiber Cable length

Sl.No	No of bends	Bending Diameter	Output signal voltage in volts
1	Without bending		
2	1st bend		
3	2nd bend		
4	3rd bend		

Results: Using optical fiber communication setup for Optical fiber of length-0.5M ,1M,&1.5M are found and verified.

Attenuation loss =

Bending loss =

Numerical Aperture=

Verification/Validation: Using optical fiber communication setup the values of Attenuation loss, Bending loss are validated against experimental values for different length and diameter of optical fiber and is found correct.

Conclusions: optical fiber communication setup is Implemented and the values of Attenuation loss, Bending loss, Numerical Aperture are validated and verified.

Post Viva Questions:

1. What is the principle of operation of OFC?
2. State the difference between step-index and graded index fiber?
3. State the formula to find the numerical Aperture?
4. What are the different types of losses in OFCS?

Experiment No: 8b

MEASUREMENT OF NUMERICAL APERTURE

Aim: The Objective of this experiment is to measure to the Numerical Aperture (NA) of the Fiber.

Specifications: Optical fiber of length-0.5M ,1M,&1.5M.

Theory:

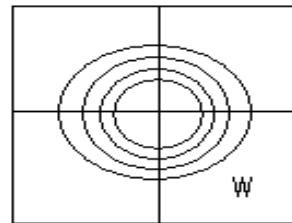
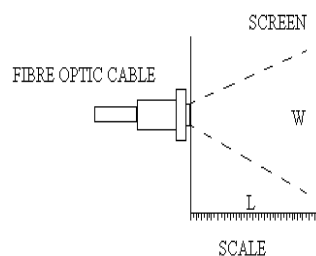
Numerical aperture refers to the maximum angle at which the light incident on the fiber end is totally internally reflected and is transmitted properly along the fiber. The cone formed by the rotation of this angle along the axis of the fiber is the cone of acceptance of the fiber. The light ray should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

Consideration in NA measurement:

It is very important that the optical source should be properly aligned with the cable and the distance from the launched point & cable be properly selected to ensure that the maximum amount of optical power is transferred to the cable.

Experimental Procedure:

1. Connect power supply to the board.
2. Connect the frequency generator's 1 KHz sine wave output to input of emitter 1 circuit. Adjust its amplitude at 5V p-p.
3. Connect one end of fiber cable to the output socket of emitter 1 circuit and the other end to the Numerical aperture measurement jig. Hold the white screen facing the fiber such that its cut face is perpendicular to the axis of the fiber.
4. Hold the white screen with 4 concentric circles (10, 15, 20 & 25mm diameter) vertically at a suitable distance to make the red spot from the fiber coincide with 10mm circle.



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

$$N.A = \frac{W}{4L^2 + W^2} = \sin \theta_{MAX}$$
7. Vary the distance between in screen and fiber optic cable and make it coincide with one of the concentric circles. Note its distance.
8. Tabulate the various distances and diameter of the circles made on the white screen and compute the numerical aperture from the formula given above.

Table 1:

SL.NO	Distance of the screen L in meters	Diameter W of the spot in meters	Numerical Aperture (NA)

Results: Using optical fiber communication setup for the Optical fiber of length-0.5M ,1M,&1.5M are found and verified.

Numerical Aperture=

Verification/Validation: Using optical fiber communication setup the values of Numerical Aperture are validated against experimental values for different length of optical fiber and is found correct.

Conclusions: optical fiber communication setup is Implemented and the values of Attenuation loss, Bending loss, Numerical Aperture are validated and verified.

Post Viva Questions:

5. What is the principle of operation of OFC?
6. State the difference between step-index and graded index fiber?
7. State the formula to find the numerical Aperture?
8. What are the different types of losses in OFCS?

Experiment No: 9

MICROSTRIP POWER DIVIDER

Aim:

1. To measure resonance characteristics of Microstrip Ring Resonator and determine dielectric constant of the substrate.
2. To measure power division and isolation characteristics of microstrip 3dB power divider.

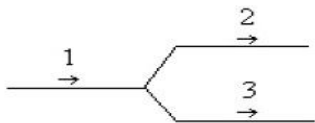
Specifications: 3dB Power Divider, Isolation factor in dB=6dB, Coupling factor in dB=3dB

Theory:

The open-end effect encountered in a rectangular resonator of the feed long gaps can be minimized by forming the resonator as a closed off. Such resonator is called as Ring resonator. The Ring resonator find applications in the design of filters, oscillator and mixers. Resonance is established when the mean circumference of the ring is equal to integral multiplies of guide wave length.

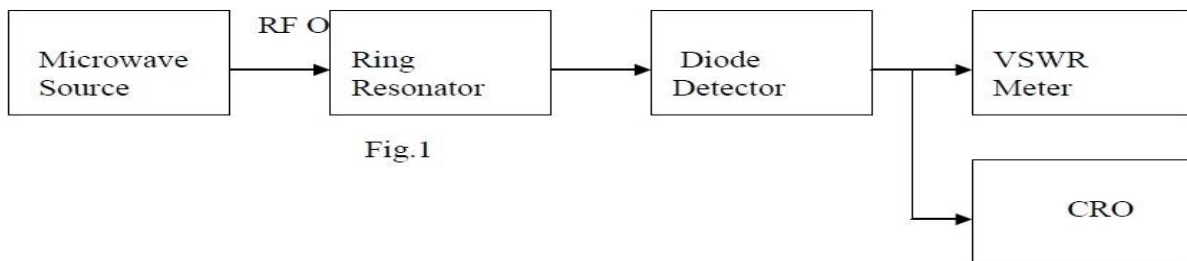
Power Divider:

The function of a power division network is to divide the input power into two or more outputs. As an equal split power divider, the power incident at port 1 gets divided equally between the two output ports 2 & 3. Power at 2 & 3 is half power. i.e.-3dB down power.



Power at 2 & 3 is half power. i.e.-3dB down power.

EXPERIMENTAL SET UP/BLOCKDIAGRAM:



Experimental Procedure:

1. Experiment set up as shown in fig.1
2. Keep microwave generator in Internal AM mode.
3. Vary the RF out frequencies at 2.2GHz to 3GHz insteps of 0.1GHz and note down output detector power in VSWR meter.

4. Note down/ tabulate these results & note down the resonant frequency at which the output power maximum.
5. Plot the graph output power Vs frequency.
6. Determine dielectric constant of the substrate of Ring Resonator.

Pre viva questions:

1. Define VSWR?
2. Define properties of S-Matrix?
3. What are waveguide tees?
4. State properties of E-plane tees and H-plane tees?

Table 1:

RADIO FREQUENCY SIGNAL IN GHz	OUTPUT POWER IN dB

Calculation:

Power division (dB) at arm3 = $P_1 - P_3$

Power division(dB) at arm2 = $P_1 - P_2$

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

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

Results: Measurement of power division and isolation characteristics of a micro strip 3dB power divider is achieved and the following values are found and verified.

Isolation factor in dB=6dB

Coupling factor in dB=3dB

Verification/Validation: Using Microwave Power divider the values of Isolation factor and coupling factor are validated against experimental values for different radio frequency signals and found is correct.

Conclusions: Measurement of power division and isolation characteristics of a micro strip 3dB power divider is validated and verified.

Post Viva Questions:

1. What is the principle of operation of power divider?
2. State the difference between coupling loss and isolation loss?
3. State the formula to find the power division in DB between different arms of power divider
4. What are the parameters of S-Matrix?

Experiment No: 10

MICROSTRIP RING RESONATOR AND DIRECTIONAL COUPLER

Aim

To Study & determine coupling and isolating characteristic of Micro strip Directional Coupler.

Specifications: 3dB Power Divider, Isolation factor in dB=6dB, Coupling factor in dB=3dB

Components Used:

10dB directional coupler Branch line directional coupler (3dB) Parallel line directional coupler (15dB) VSWR meter Microwave source.

Block Diagram:

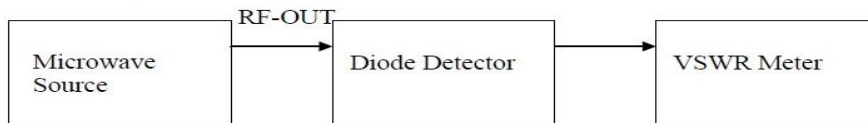


Fig.1

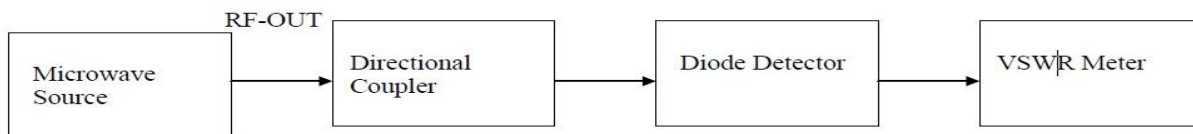


Fig. 2

Theory:

Directional coupler is four port waveguide junction consisting of 2 primary waveguide 1-2 and secondary waveguide 3-4. When all ports are terminated in either characteristic impedance, there is free transmission of power without reflection between port1 and port2 and there is no transmission of power between port1 and port3 or between 2 & 4. Because no coupling exists between these two pairs of ports. These are 3 directional coupler 3dB directional coupler, 10dB and 15dB branch line directional coupler.

Experimental Procedure:

1. Experiment set up as shown in fig.1.
2. Keep microwave source in internal AM mode.
3. Tabulate the direct power at frequencies 2.2GHz to 3GHz in steps of 0.1 GHz and note down output power from VSWR meter.
4. Now experiment is setup as shown in fig.2.
5. Keep microwave source in Internal AM mode.
6. Apply RF signal to input port and vary the frequencies from 2.2GHz to 3GHz in steps of 0.1GHz and note down coupling power in VSWR meter.
7. Terminate isolation port & direct port by 50 standard frequencies. Ω

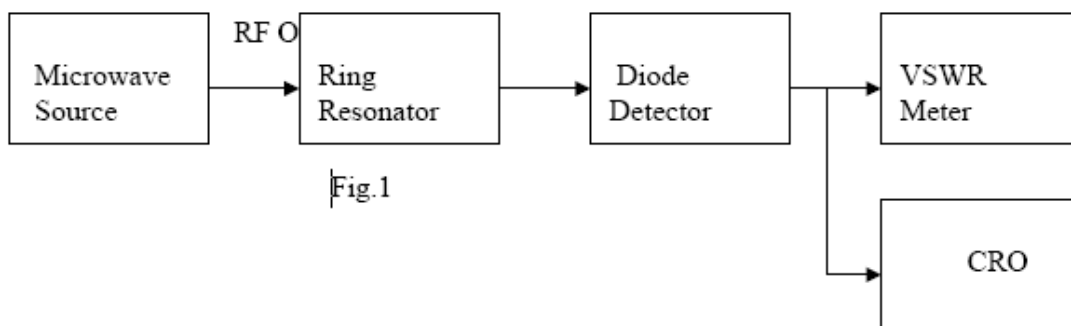
8. Repeat these steps to find the output power at direct port and isolating port.
9. Terminate unused ports by $50\ \Omega$
10. Experiment is conducted for -3dB,-10dB,-15dB directional coupler.

Direct Power & Coupling proof Power for -3dB Directional Coupler:

Sl.No.	RF Signal in GHz	Direct Frequency	Coupling Power	Direct Power	Isolator proof Power
1	2.1				
2	2.2				
3	2.3				
4	2.4				
5	2.5				
6	2.6				
7	2.7				
8	2.8				
9	2.9				
10	3.0				

RING RESONATOR:

EXPERIMENTAL SET UP/BLOCKDIAGRAM:



Experimental Procedure:

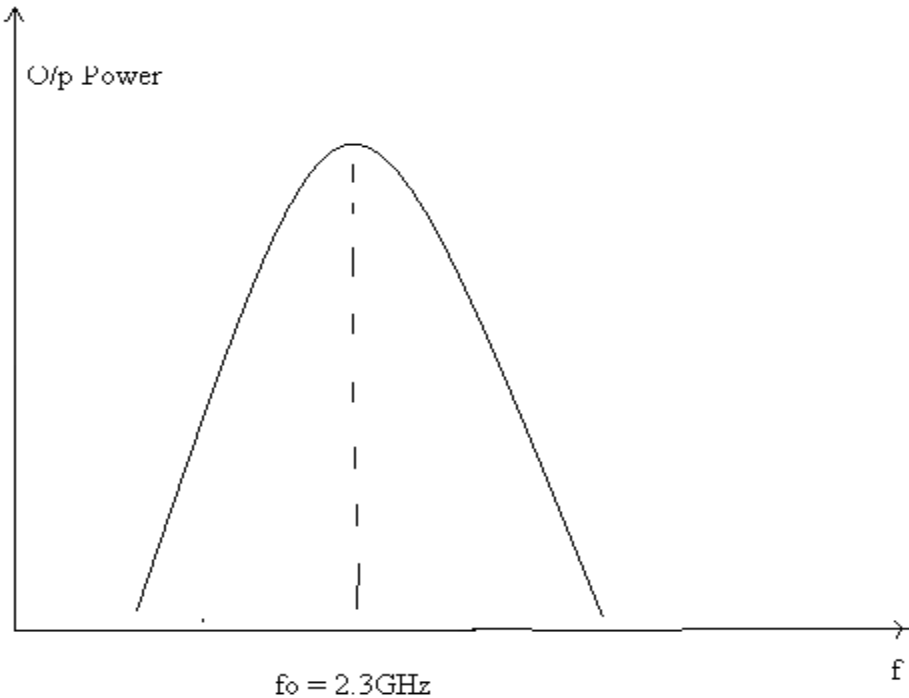
1. Experiment set up as shown in Fig.1
2. Keep microwave generator in Internal AM mode.
3. Vary the RF out frequencies at 2.2GHz to 3GHz insteps of 0.1GHz and note down output detector power in VSWR meter.
4. Note down/ tabulate these results & note down the resonant frequency at which the output power maximum.
5. Plot the graph output power Vs frequency.
6. Determine dielectric constant of the substrate of Ring Resonator.

Pre viva Questions:

1. What are waveguide tees?
2. State properties of E-plane tees and H-plane tees?
3. State the properties of magic tee?
4. Define Isolator?

SL.NO.	RF IN GHZ	VSWR METER READING	SL.NO.	RF IN GHZ	VSWR METER READING
1	2.05		8	2.4	
2	2.1		9	2.45	
3	2.15		10	2.5	
4	2.2		11	2.55	
5	2.25		12	2.6	
6	2.3		13	2.66	
7	2.35		14	2.7	

EXPECTED GRAPH:



Results: Measurement of resonant frequency using ring resonator and coupling, isolation characteristics of a micro strip directional coupler are found and verified.

Resonant frequency in Hz=2.5 KHz

Isolation factor in dB= 6dB

Coupling factor in dB=3dB

Verification/Validation: Using Micro-strip Directional Coupler the values of Isolation factor and coupling factor are validated against experimental values for different values of radio frequency signal and is found correct.

Conclusion: Measurement of resonant frequency, coupling and isolation characteristics of a micro strip directional coupler is validated and verified.

Post Viva Questions:

1. What is the principle of operation of Ring Resonator?
2. State the difference between coupling loss and isolation loss with respect to Directional coupler?
3. What is the principle of Directional coupler?
4. State different types of Directional couplers?

Experiment No: 11:

MEASUREMENT OF DIRECTIVITY AND GAIN OF ANTENNAS

(STANDARD DIPOLE ,MICRO STRIP PATCH ANTENNA AND YAGI ANTENNA)

Aim: To find the directivity and gain of Antennas.

Specifications: Gain of 3dB , directivity in dB

Apparatus required :

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

Theory :

If a transmission line propagating energy is left open at one end, there will be radiation from this end. The Radiation pattern of an antenna is a diagram of field strength or more often the power intensity as a function of the aspect angle at a constant distance from the radiating antenna. An antenna pattern is of course three dimensional but for practical reasons it is normally presented as a two dimensional pattern in one or several planes. An antenna pattern consists of several lobes, the main lobe, side lobes and the back lobe. The major power is concentrated in the main lobe and it is required to keep the power in the side lobes and back lobe as low as possible. The power intensity at the maximum of the main lobe compared to the power intensity achieved from an imaginary Omni-directional antenna (radiating equally in all directions) with the same power fed to the antenna is defined as gain of the antenna. As we know that the 3dB beam width is the angle between the two points on a main lobe where the power intensity is half the maximum power intensity. When measuring an antenna pattern, it is normally most interesting to plot the pattern far from the antenna. It is also very important to avoid disturbing reflection. Antenna measurements are normally made at anechoic chambers made of absorbing materials.

Antenna measurements are mostly made with unknown antenna as receiver. There are several methods to measure the gain of antenna. One method is to compare the unknown antenna with a standard gain antenna with known gain. Another method is to use two identical antennas, as transmitter and other as receiver. From following formula the gain can be calculated.

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

Where, P_t is transmitted power

P_r is received Power,

G_1, G_2 is gain of transmitting and receiving antenna

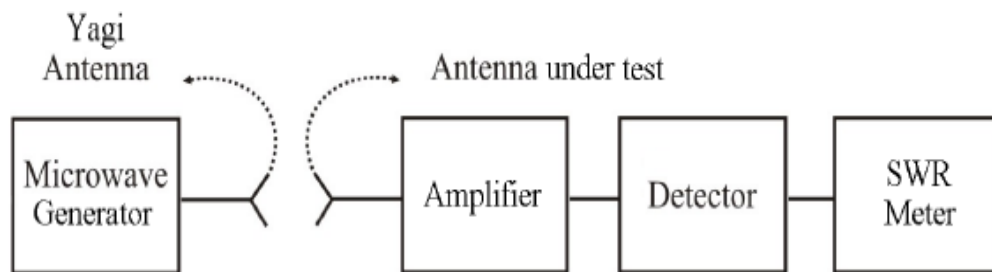
S is the radial distance between two antennas λ_0 is free space wave length.

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

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

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

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

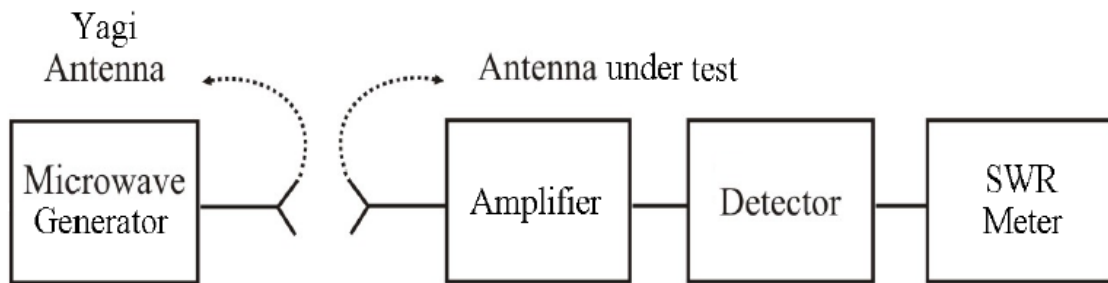


Setup for Directivity measurement

Procedure:

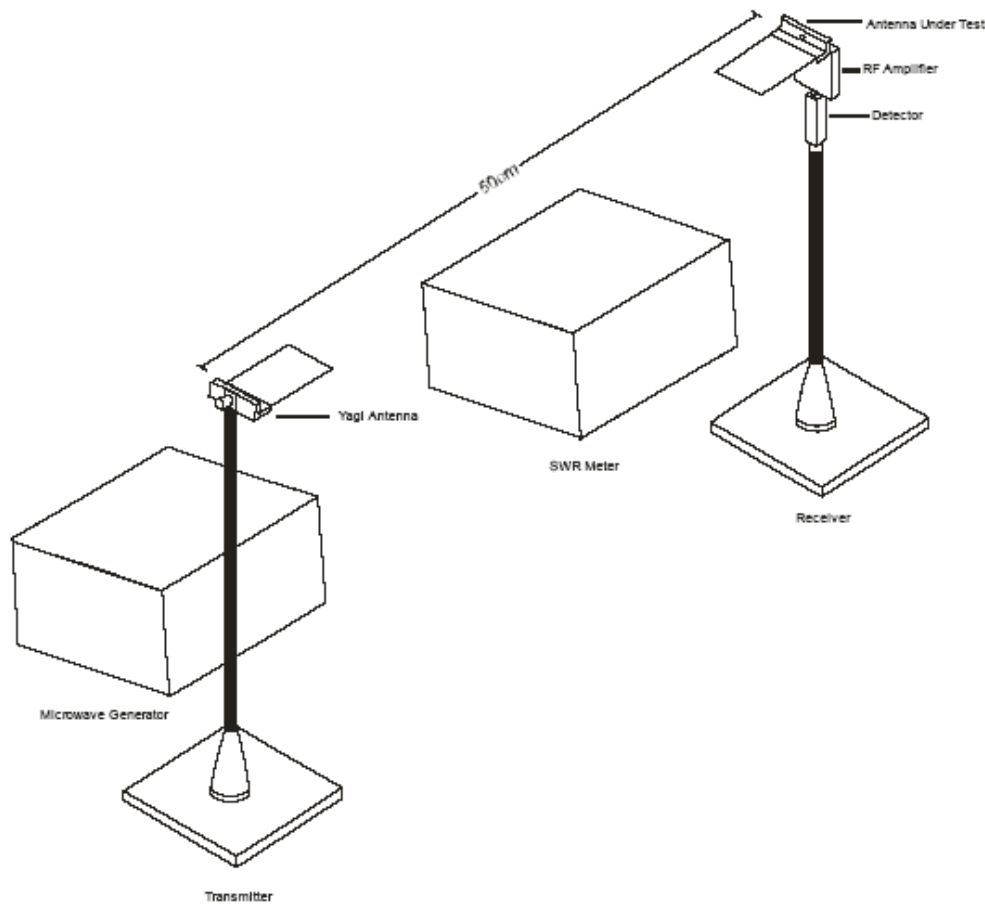
Directivity Measurement:

1. Connect a mains cord to the Microwave Generator and SWR Meter.
2. Now connect a Yagi antenna in horizontal plane to the transmitter mast and connect it to the RF Output of microwave generator using a cable (SMA to SMA).
3. Set both the potentiometer (Mod Freq & RF Level) at fully clockwise position.
4. Now take another Yagi antenna and RF Amplifier from the given suitcase.
5. Connect the input terminal of the Amplifier to the antenna in horizontal plane using an SMA (male) to SMA (female) L Connector.
6. Now connect the output of the Amplifier to the input of Detector and mount the detector at the Receiving mast.
7. Connect one end of the cable (BNC to BNC) to the bottom side of receiving mast, and another end to the input of SWR meter.
8. Now set the distance between Transmitter (feed point) and the receiver (receiving point) at half meter.
9. Now set the receiving antenna at zero degree (in line of Transmitter) and Switch on the power supply for Microwave Generator, SWR Meter. Also connect DC Adapter of RF Amplifier to the mains.
10. Select the transmitter for internal AM mode and press the switch "RF On".
11. Select the range switch at SWR meter at – 40dB position with normal mode.
12. Set both the gain potentiometers (Coarse & Fine) at fully clockwise position and input select switch should be at 200 Ohm position. In case if reading is not available at – 40dB range then press 200 kOhm (Input Select) to get high gains reading.
13. Now set any value of received gain at – 40dB position with the help of - o Frequency of the Microwave Generator.
 - o Modulation frequency adjustment .
 - o Adjusting the distance between Transmitter and Receiver.
14. With these adjustments you can increase or decrease the gain.
15. Mark the obtained reading on the radiation pattern plot at zero degree position.
16. Now slowly move the receiver antenna in the steps of 10 degree and plot the corresponding readings.
17. This will give the radiation pattern of the antenna under test.
18. Directivity of the antenna is the measures of power density an actual antenna radiates in the direction of its strongest emission, so if the maximum power of antenna (in dB) is received at θ degree then directivity will bedB atDegree.
19. In the same way you can measure the directivity of the Dipole antenna.
20. For directivity measurement of the transformer fed Patch antenna connect transmitter Yagi antenna in the vertical plane (Patch Antenna is vertically polarized). Since it is comparatively low gain antenna distance can be reduced between transmitter and receiver.



Setup for Directivity measurement

meter.



Gain Measurement:

1. Connect a power cable to the Microwave Generator and SWR Meter.
2. Now connect a Yagi antenna in horizontal plane to the transmitter mast and connect it to the RF Output of microwave generator using a cable (SMA to SMA).
3. Set both the potentiometer (Mod Freq & RF Level) at fully clockwise position.
4. Now take another Yagi antenna from the given suitcase.
5. Connect this antenna to the detector with the help of SMA (male) to SMA (female) L Connector.
6. Connect detector to the receiving mast.
7. Connect one end of the cable (BNC to BNC) to the bottom side of receiving mast, and another end to the input of SWR meter.

8. Now set the distance between Transmitter (feed point) and the receiver (receiving point) at half meter.
9. Now set the receiving antenna at zero degree (in line of Transmitter) and Switch on the power from both Generator & SWR Meter.
10. Select the transmitter for internal AM mode and press the switch “RF On”.
11. Select the range switch at SWR meter at – 40dB position with normal mode.
12. Set both the gain potentiometers (Coarse & Fine) at fully clockwise position and input select switch should be at 200 Ohm position. In case if reading is not available at – 40dB range then press 200 kOhm (Input Select) to get high gains reading.
13. Now set the maximum gain in the meter with the help of following - o Frequency of the Microwave Generator. o Modulation frequency adjustment . o Adjusting the distance between Transmitter and Receiver.
14. Measure and record the received power in dB. $P_r = \dots\dots\dots$ dB
15. Now remove the detector from the receiving end and also remove the transmitting Yagi antenna from RF output.
16. Now connect the RF output directly to detector without disturbing any setting of the transmitter (SMA-F to SMA-F connector can be used for this).
17. Observe the output of detector on SWR meter that will be the transmitting power P_t .
 $P_t = \dots\dots\dots$ dB
18. Calculate the difference in dB between the power measured in step 14 and 17 which will be the power ratio P_t/P_r . $P_t/P_r = \dots\dots\dots$
 $P_r/P_t = \dots\dots\dots$
19. Now we know that the formula for Gain of the antenna is:

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

Where :

P_t is transmitted power P_r is received Power,

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

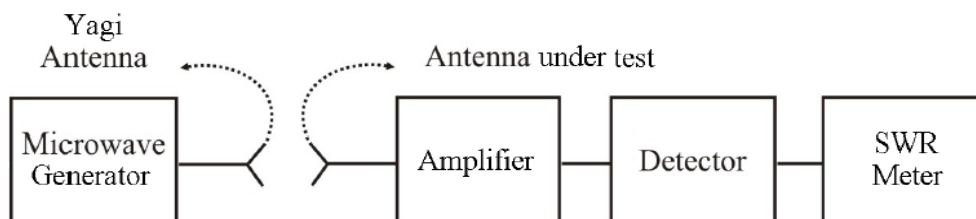
S is the radial distance between two antennas

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

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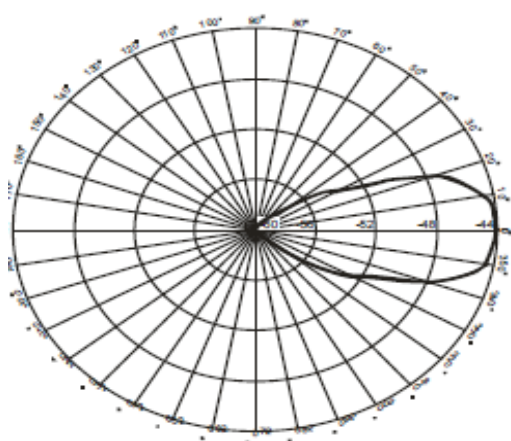
20. Now put the measured values in the above formula and measure the gain of the antenna which will be same for both the antennas. Now after this step you can connect one known gain antenna at transmitter end and the antenna under test at receiver end, to measure the gain of the antennas.

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

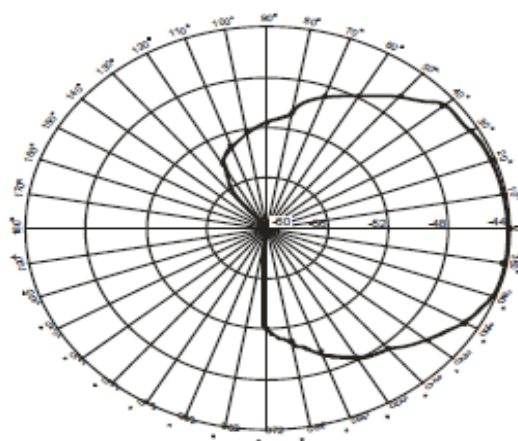


Setup for Directivity measurement

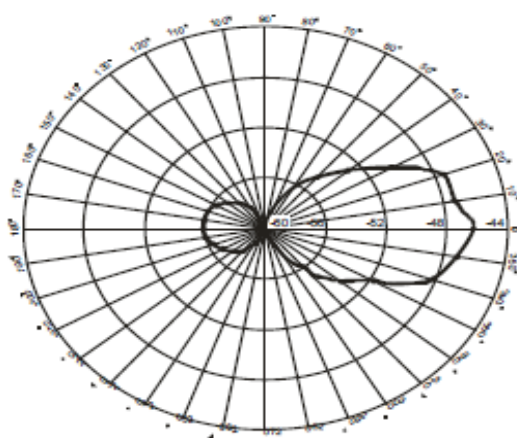
Radiation Patterns of Different Antennas:



Yagi Antenna



Patch Antenna



Dipole Antenna

Pre-viva Questions:

1. What is antenna?
2. Define Gain & Directivity.
3. Mention the different types of antennas.
4. Define radiation efficiency, beam width and bandwidth of an antenna?

Table 1

SL. NO	ANGLES IN DEGREES	GAIN IN DECIBEL	SL. NO	ANGLES IN DEGREES	GAIN IN DECIBEL
1			11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

Results: Measurement of Gain, Directivity for the different antennas are found and verified.

Directivity in dB=

Gain in dB=3dB

Verification/Validation: Using Antenna experimental setup the values of Directivity & Gain are validated against experimental values for different tilted angles in clockwise and anti-clockwise and is found correct.

Conclusions: Measurement of Directivity & Gain for different types of antennas are validated and verified.

Post Viva Questions:

1. What are the radiation patterns for Yagi-Uda antenna, patch antenna?
2. State the formula to find directivity for an antenna?
3. What is the difference between Yagi-Uda antenna & patch antenna?