MODERN EDUCATION SOCIETY'S

WADIA COLLEGE OF ENGINEERING,

19 V. K. Joag path, Wadia Campus PUNE-01

Subject: Digital Communication

Experiment No:

Title: Generation and reception of BPSK (without noise)

Name: Prasad Nikam

Class: TE-A B

Roll no: 58

Date Of performance:

Date of Submission:

Signature:

OBJECTIVE:

① Generate BPSK signal, observe & draw BPSK signal.

② Observe spectrum of BPSK signal & find bandwidth

③ Reconstruction of original signal using demodulation of BPSK.

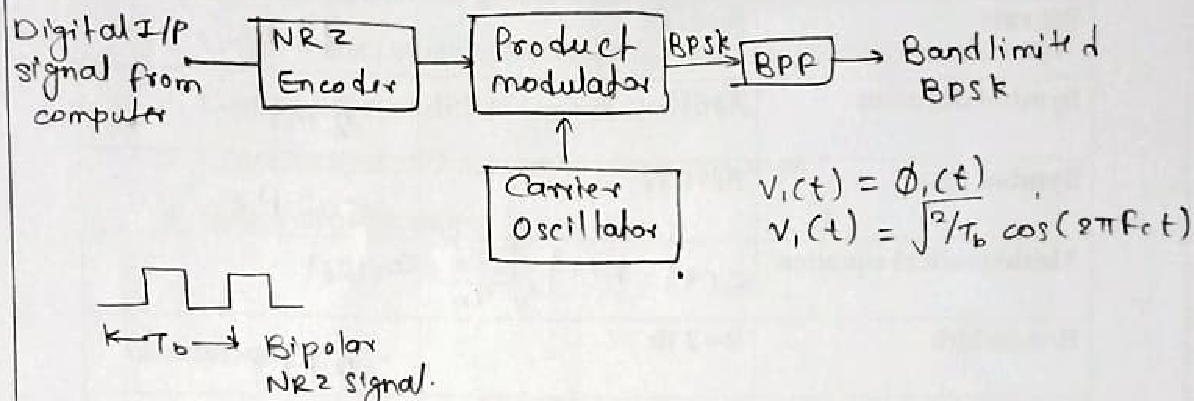
APPARATUS:

Instruments	Specification
DSO	
Rastronica kit	

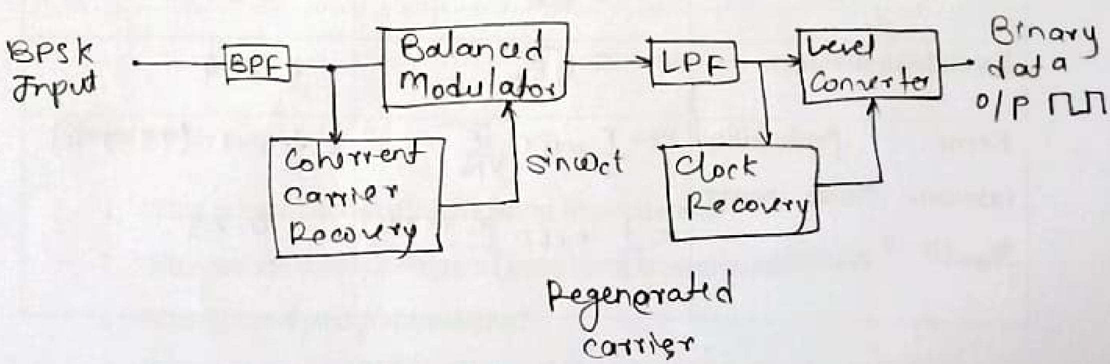
PREREQUISITE:

Concept of BPSK modulator & demodulator.

Block Schematic Diagram of BPSK Transmitter



Block Schematic Diagram of BPSK Receiver



Observation and calculation

Bit duration	**Tb**	1 ms
Bit rate	**fb=1/Tb**	1 kHz
Symbol duration	**Ts=Tb**	2 ms
Symbol rate	**Fs=1/Ts**	500 Hz
Mathematical equation	$s(t) = b(t)\sqrt{\frac{2E_b}{T_b}} \cos \omega_c t$	
Bandwidth	**B= 2 fb**	2 kHz
Signal power	**Ps=** $\frac{A^2}{2} = \frac{(2.4)^2}{2}$	2.8
Bit energy	**Eb=** $P_s \cdot T_b$	2.88×10^{-3}
Symbol energy	**E=** $2E_b$	5.76×10^{-3}
Euclidean distance	**d=** $2\sqrt{E_b}$	0.104
Error Probability (assume Noise power $N_0=10^{-10}$ Watts/Hz	**Pe=** $\frac{1}{2} \operatorname{erfc} \sqrt{\frac{E}{N_0}}$ $= \frac{1}{2} \operatorname{erfc} \sqrt{\frac{5.76\times10^{-3}}{10^{-10}}}$	$= \frac{1}{2} \operatorname{erfc}(7589.4)$ $= 0.25$

Procedure:

1. Connect output of pattern generator to input of OR gate.
2. Connect output of OR gate to input of transmitter block.
3. Connect output of multiplier block to input of 1496 sequence generator.
4. Connect output of BPF to input of /2 network.
5. Connect output of /2 network to phase comparator.
6. Switch on power supply.

Conclusion:-

Hence we learned about generation and reception of BPSK signal without noise, its spectrum, modulator and demodulator.

Question:

1. What is base band communication transmission?
2. What are the disadvantages of base band transmission?
3. What is band pass transmission?
4. Draw and explain BPSK TR and RX with mathematical expression.
5. What is coherent and non coherent detection?
6. Define BPSK and write Equation.
7. Explain spectral representation and bandwidth.
8. In geometrical representation, what is a distance between two symbols and how we can change this distance and what will be effect of changing distance?
9. Explain relationship between Bit rate and baud rate for BPSK and 8psk?

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Expt - 1.

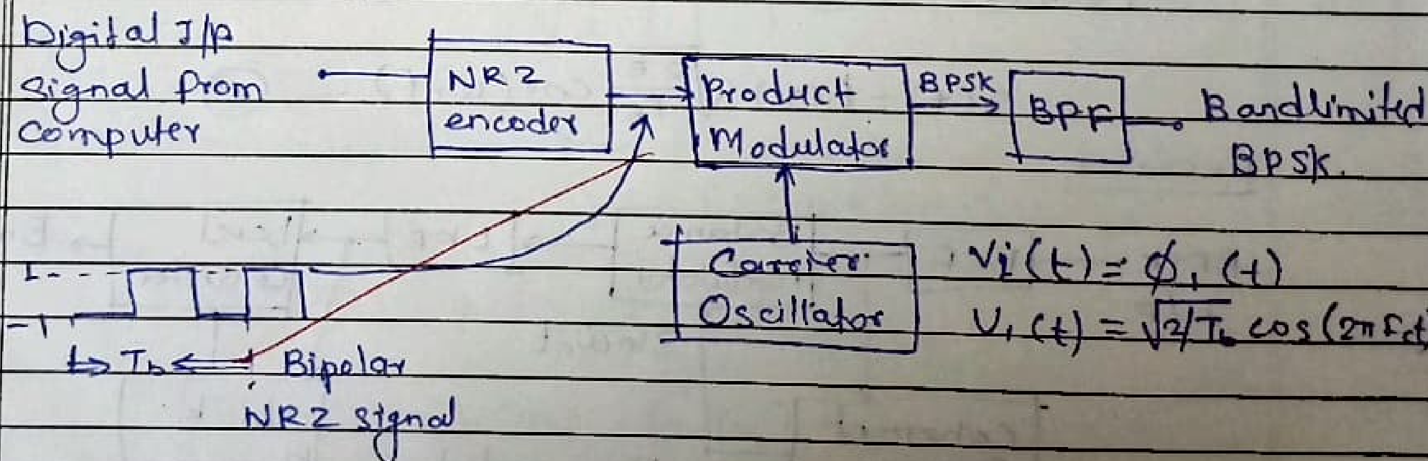
Questions

Q.1. What is baseband communication transmission ?
⇒ Baseband is a digital signal transmitter on the medium using one of signal code like NRZ RZ, manchester biphase. M codes etc called baseband transmission.

Q.2 What are the disadvantages of baseband transmission ?
⇒ ① Limited distances.
② Data & voice only.

Q.3 What is bandpass transmission ?
⇒ Bandpass transmission is a transmission after shifting. The bandpass frequencies to some higher freq. range using modulation. It is used for long distances.

Q.4 Draw & explain BPSK, TR & Rx with mathematical expⁿ
⇒ Generation.



$V_i(t) = \phi_1(t)$

$V_1(t) = \sqrt{2/T_b}\cos(2\pi f_c t)$

Normalized power given by,

$$P = \frac{A^2}{2}$$

$$A = \sqrt{2P} \quad \text{--- (1)}$$

but $s(t) = V_{BPSK}(t) = A\cos(\omega_c t)$

For both $b(t) = +1$ for logic 1.

$$[s_1(t) = \sqrt{2P}\cos(\omega_c t) \quad \text{--- (2)}$$

For $b(t) = 1$ for logic 0.

0 bit is in 180° phase shift

$$[s_2(t) = -\sqrt{2P}\cos(\omega_c t)] \quad \text{--- (3)}$$

From (2) & (3)

$$s(t) = b(t)\sqrt{2P}\cos(\omega_c t) \quad \text{--- (4)}$$

where $b(t) = 1$ logic 1

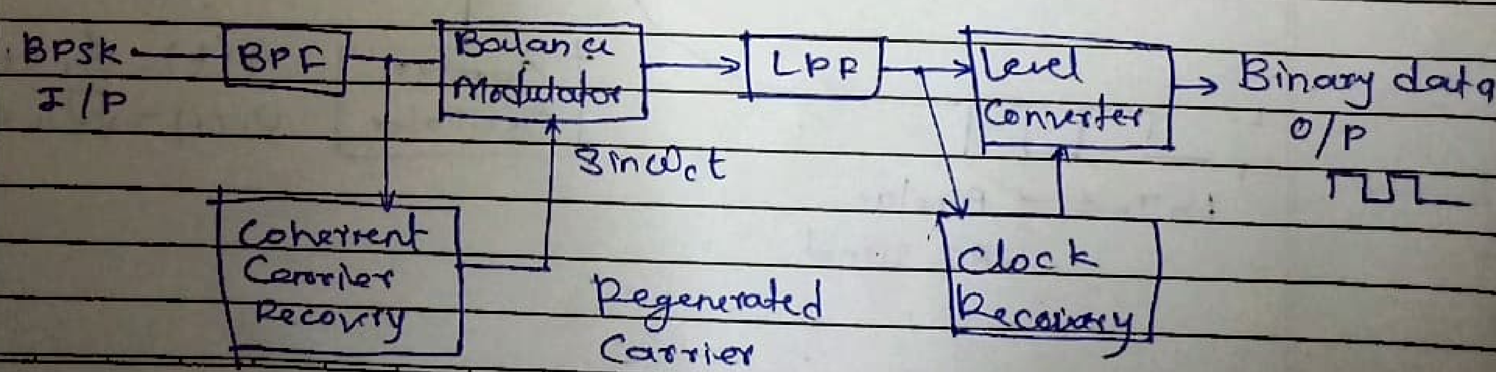
$b(t) = -1$ logic 0

but $P = \frac{E}{T_0}$ --- (5)

From (4) & (5)

$$s(t) = b(t)\sqrt{\frac{2E}{T_b}}\cos(\omega_c t) \quad \text{--- (6)}$$

Receiver



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$$s(t) = b(t)\sqrt{2P}\cos(\omega_c + \theta) \quad \text{—} ①$$

As o/p of square law devider

$$s(t) = \cos^2(\omega_c t + \theta)$$

$$s(t) = \frac{1 + \cos[2(\omega_c t + \theta)]}{2} \quad \text{—} ②$$

This signal is then pass through BPF & we get

$$s(t) = \cos[2(\omega_c t + \theta)] \text{—} ③$$

it will ~~remove~~ all ~~the~~ dc component

This is then passed through frequency divider op the o/p of which we get

$$s(t) = \cos(\omega_c t + \theta) \text{—} ④$$

The signal written in eqn ① & ④ is applied to multiplier & we get

$$m(t) = b(t)\sqrt{2P}\cos^2(\omega_c t + \theta)$$

$$= b(t)\sqrt{2P}\left\{\frac{1 + \cos 2(\omega_c t + \theta)}{2}\right\} \text{—} ⑤$$

The signal is applied to LPF we get,

Replace $t = kT_b$

$$M(kT_b) = b(t)\sqrt{\frac{P}{2}}\left[\int_{(k-1)T_b}^{kT_b}\{1 + \cos[2(\omega_c t + \theta)]\}\,dt\right]$$

If we are integrating sine or cosine for one complete cycle then it is 0,

$$\therefore \int \cos[2.(\omega_c t + \theta)]\,dt = 0.$$

Hence,

$$M(kT_b) = b(t)\sqrt{\frac{2}{P}}\,[T]_{(k-1)T_b}^{kT_b}$$

$$\left[m(kT_b) = b(T_b)\sqrt{\frac{2}{P}}\,T_b\right] \text{—} ⑥$$

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Q.5. What is coherent & non-coherent detection?

⇒ ① Coherent Detection :-

- In this we use a phase synchronization locally generated carrier at receiver to recover the Information Signal.
- Coherent Techniques are complex but guaranteed better performance.
- The frequency & phase of this carrier produced at the receiver should be perfectly synchronized with that at transmitter.

② Non-Coherent Detection.

- In the non-coherent detection no phase synchronised local carrier is needed at the receiver.
- These technique are less complex.
- The performance is not as good that of coherent technique.

Q.6. Define BPSK and write equation.

⇒ Depending on incoming signal the phase of carrier is changed.
This phenomenon is called BPSK.

$$S(t) = b(t)\sqrt{\frac{2E_b}{T_b}}\cos(\omega_c t)$$

Q.7. Explain spectral representation & bandwidth.?

⇒ In BPSK bits in NRZ uniform which has two peaks $+\sqrt{PS}$ & $-\sqrt{PS}$
measure each pulse → T_b sec wide wich is exist from $-T_b/2$ to $T_b/2$ around center then fourier transform

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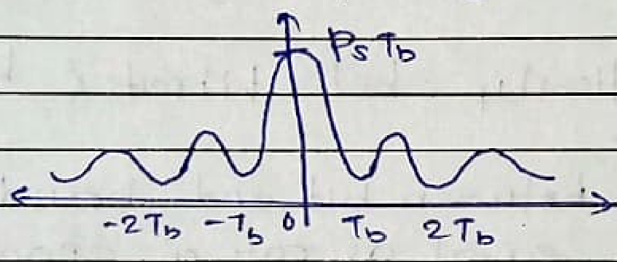
$$X(f) = \frac{\sqrt{P_s}\ T_b \sin(\pi f T_b)}{(\pi f T_b)}$$

$$= \sqrt{P_s}\ T_b \operatorname{sinc}(\pi f T_b)$$

Power spectral density $P_s(f)$

$$S(f) = \frac{1 \times \bar{f}}{T_b} \times |\bar{f}|$$

$$S(f) = P_s T_b \left[\frac{\sin \pi f T_b}{\pi f T_b}\right]^2$$



* Bandwidth.

From the freq. spectrum of BPSK signal.

$$BW = \text{High freq} - \text{low freq},$$

$$= (f_c + f_b) - (f_c - f_b).$$

$$BW = 2f_b$$

Where $f_b = \frac{1}{T_b}$

Q.8. In geometrical representation what is distance between two symbol & how can change distance and what will be effect of changing distance.

→ The effect of changing distance betn symbol depend upon context on purpose of representation.

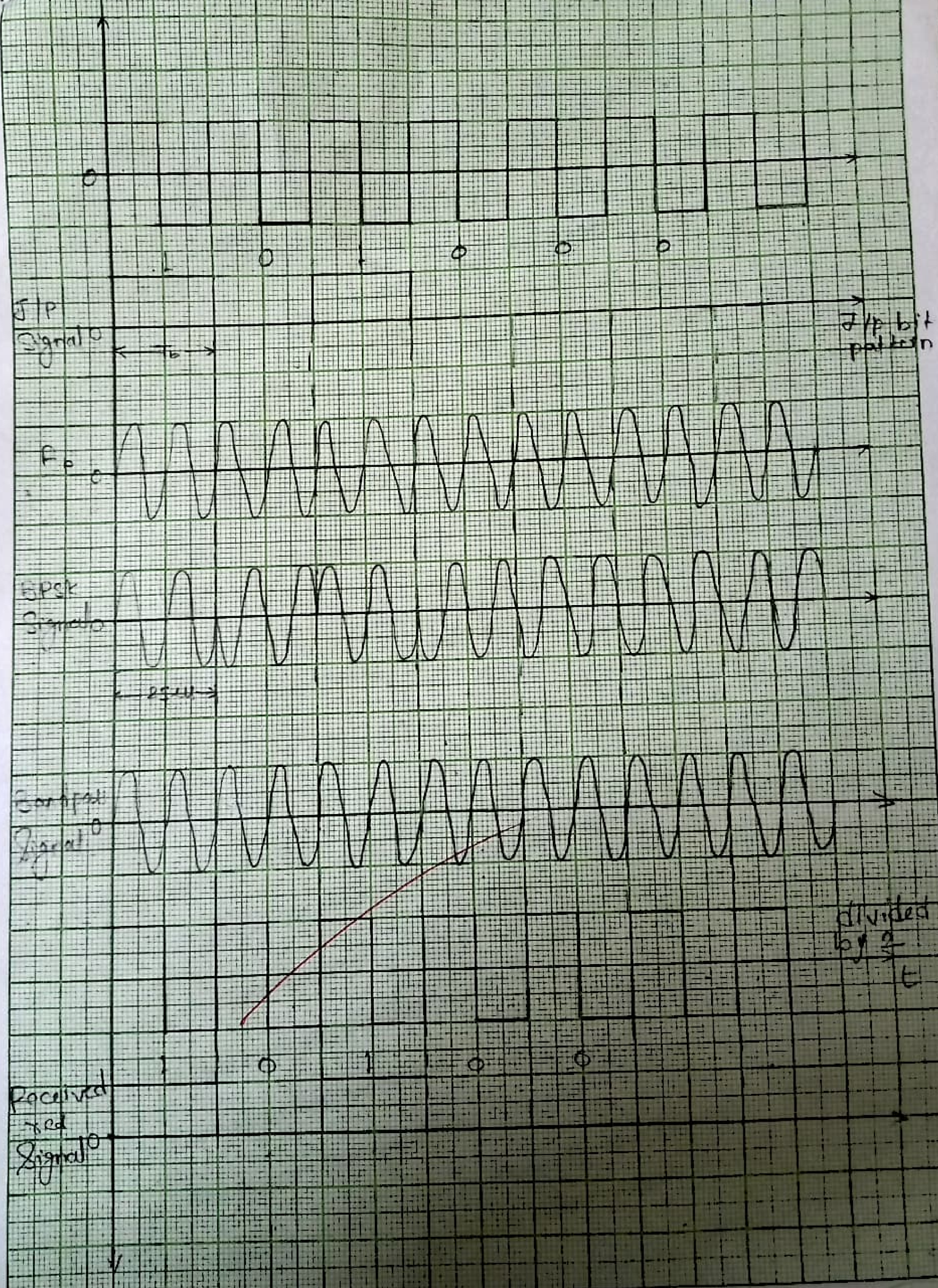
- Variety and readability Increasing the distance betn symbol can enhance clarity & readability especially if the

Symbol represent distinct entities or data point.
- Emphasis :- You can ~~g~~ use varying distance to emphasize relationship or different emphasize relationship or difference betn symbol.
- Grouping : Adjusting distance can be used to group related symbol together or separate them based on categories or attributes.
- Precision :- In some case, precise movement might dictate the distance betn symbol.

Q.9. Explain Relationship betn bitrate & baud rate for BPSK & QPSK.

⇒ The relation between bit and baud rate for BPSK & QPSK are equal as rate of change of info in o/p are same. The rate of change in signal determined in this signal determines the signal bandwidth but the throughput or bit rate for 8 psk is 3 times the Baud ~~&~~ rate.

BPSK
$f_b = 1\,kHz$



I/P Signal
I/p bit pattern
T_b
f_c
BPSK Signal
Output Signal
divided by 2
Received Signal

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Subject: Digital Communication

Experiment No: **Title:** **Generation and reception of QPSK without noise**

Name: Prasad Nikam **Date Of performance:**

Class: TE-A **Date of Submission:**

Roll no: 58 **Signature:**

OBJECTIVE:

1. Generate QPSK signal , observe and draw QPSK signal
2. Observe Spectrum of QPSK signal and find Bandwidth.
3. Observe Lissajous pattern of signal.
4. Reconstruction of original signal using demodulation of QPSK

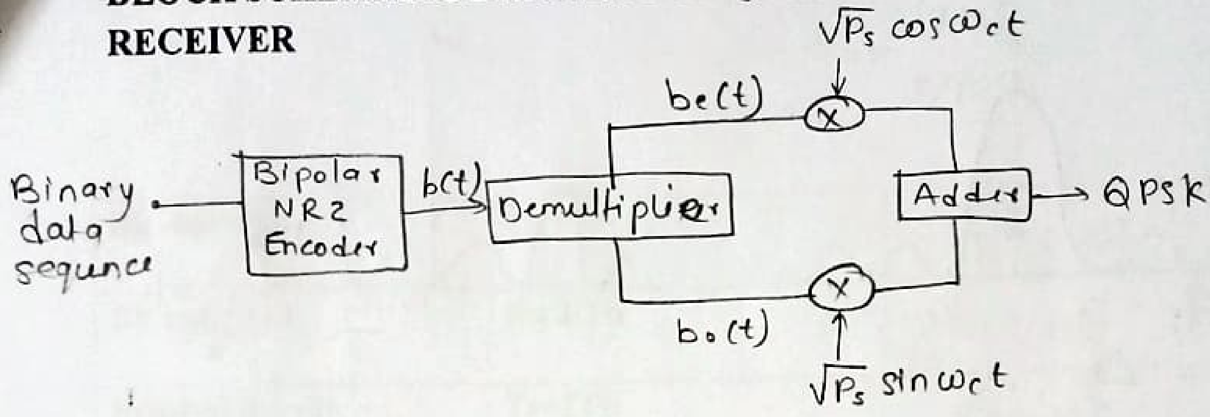
APPARATUS:

Instruments	Specification
DSO	
Kaytronic Kit	

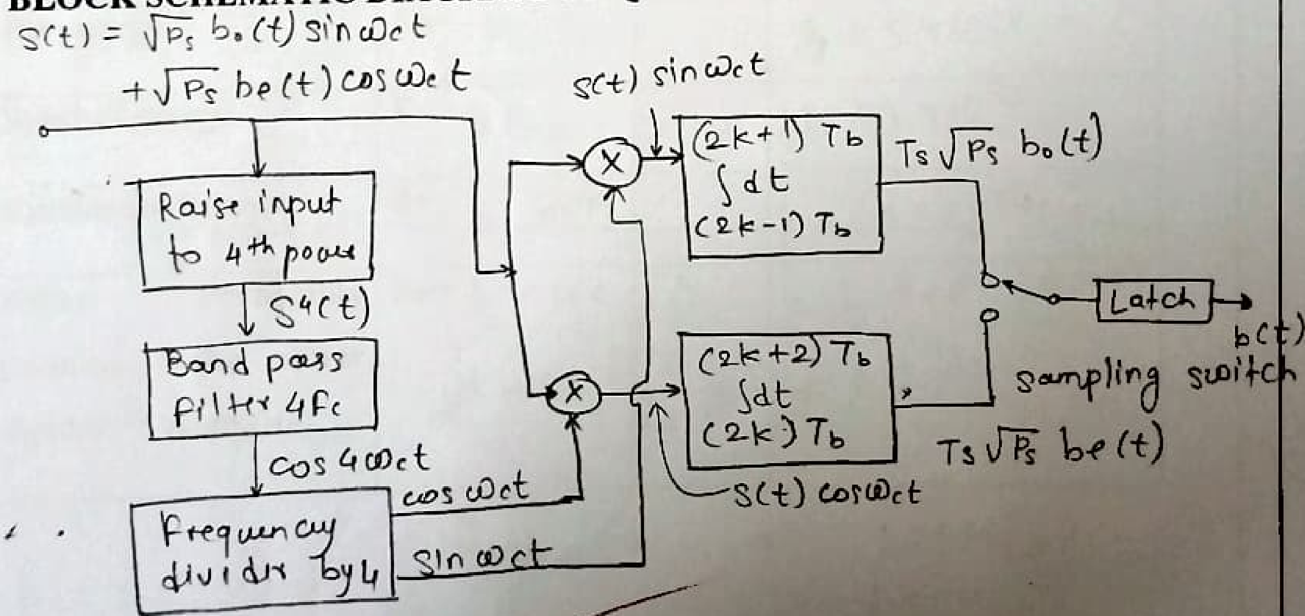
PREREQUISITE:

Concept of QPSK modulation & demodulation.

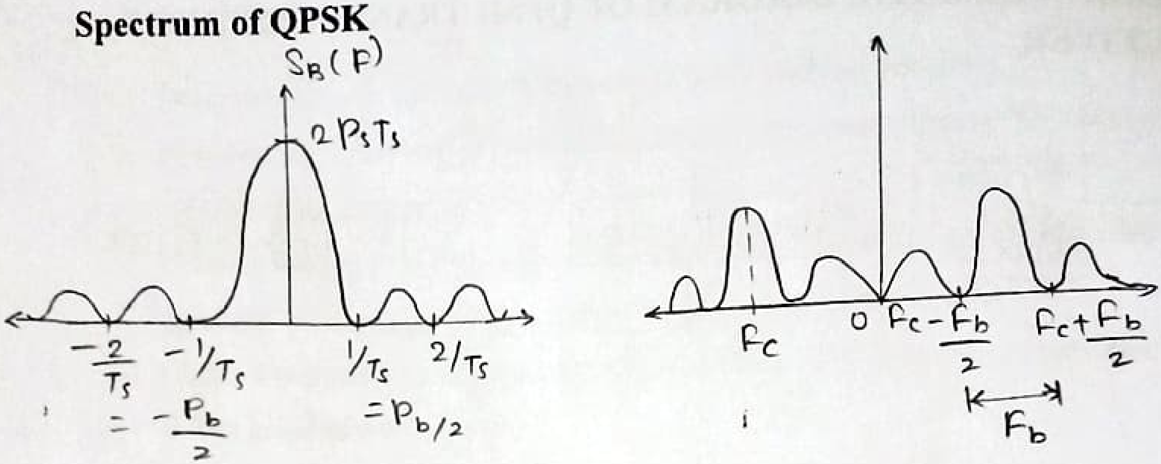
BLOCK SCHEMATIC DIAGRAM OF QPSK TRANSMITTER AND RECEIVER



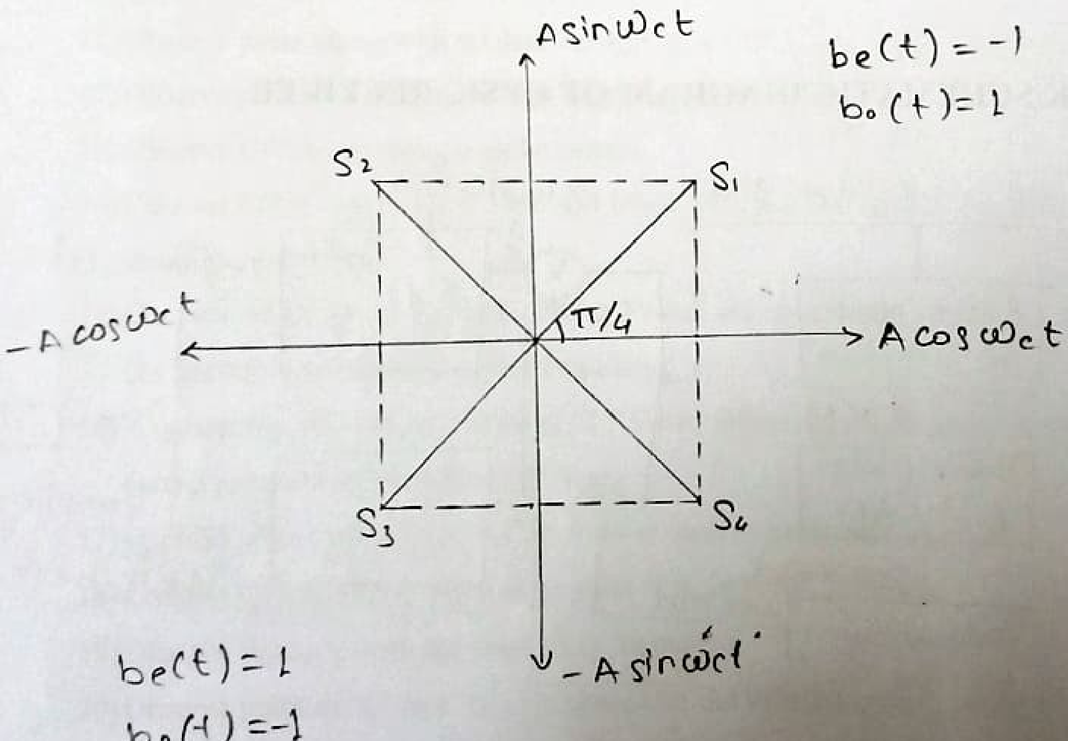
BLOCK SCHEMATIC DIAGRAM OF QPSK RECEIVER



Spectrum of QPSK



Constellation diagram of QPSK



OBSERVATION AND CALCULATION

Bit duration	**Tb**	250 μs
Bit rate	**fb=1/Tb**	4 kHz
Symbol duration	**Ts=2Tb**	500 μs
Symbol rate	**Fs=1/Ts**	2 kHz
Mathematical equation	$s(t) = \sqrt{P_s T_b}\, b_o(t)\, \phi_1(t) + \sqrt{P_s T_b}\, b_e(t)\, \phi_2(t)$	
Bandwidth	**B= fb**	8 kHz
Signal power	**Ps=** $\frac{A^2}{2} = \frac{(2.6)^2}{2}$	3.38
Bit energy	**Eb=** $P_s \cdot T_b$	8.45×10^{-4}
Symbol energy	**E=** $2E_b$	1.69×10^{-3}
Euclidean distance	**d=** $2\sqrt{E_b}$	0.0581
Error Probability (assume Noise power $N_0=10^{-10}$ Watts/Hz	**Pe=** $\frac{1}{2}\,\mathrm{erfc}\sqrt{\frac{E}{N_0}}$ $= \frac{1}{2}\,\mathrm{erfc}\sqrt{\frac{1.6\times10^{-3}}{10^{-10}}}$	$= \frac{1}{2}\,\mathrm{erfc}\,(4000)$ $= 0$

CONCLUSION:-

Hence we have studied and learned about the generation & reception of QPSK signal without noise, spectrum & reconstruction of original signal using demodulation.

STUDY QUESTIONS:

1. Define QPSK and draw waveform, spectral representation, geometrical representation and bandwidth
2. Draw and explain QPSK transmitter and receiver.
3. Explain relationship between Bit rate and Symbol rate
4. Compare BPSK ,QPSK and M-aryPSK
5. what is the probability of error, symbol rate, bandwidth, euclidean distance of QPSK system

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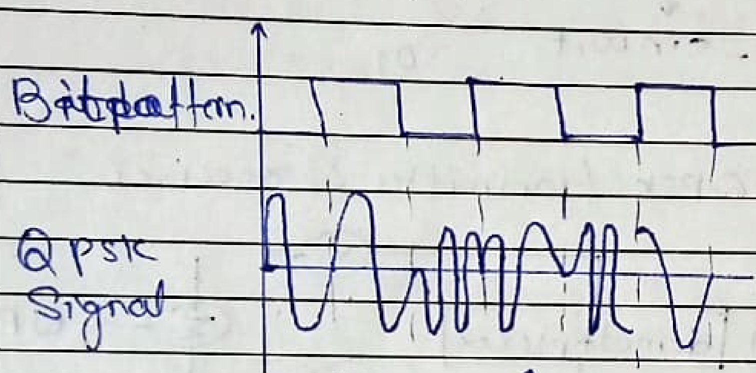
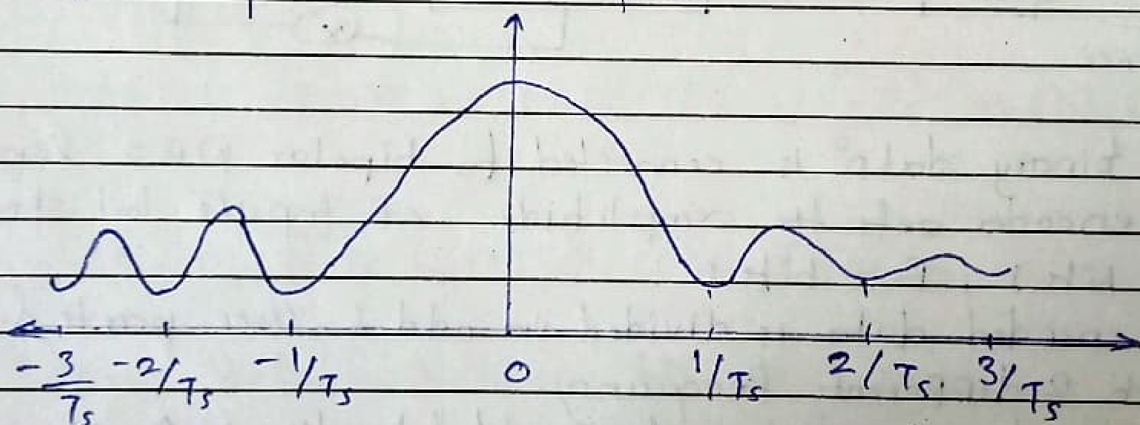
Expt - 2.

Q.1. Define QPSK and draw waveform spectral representation, geometrical representation and bandwidth.

→ QPSK is form of phase shift begin in which two bits are modulated at once selecting in one of four possible carrier phase shift ($0°, 90°, 180°, 270°$)



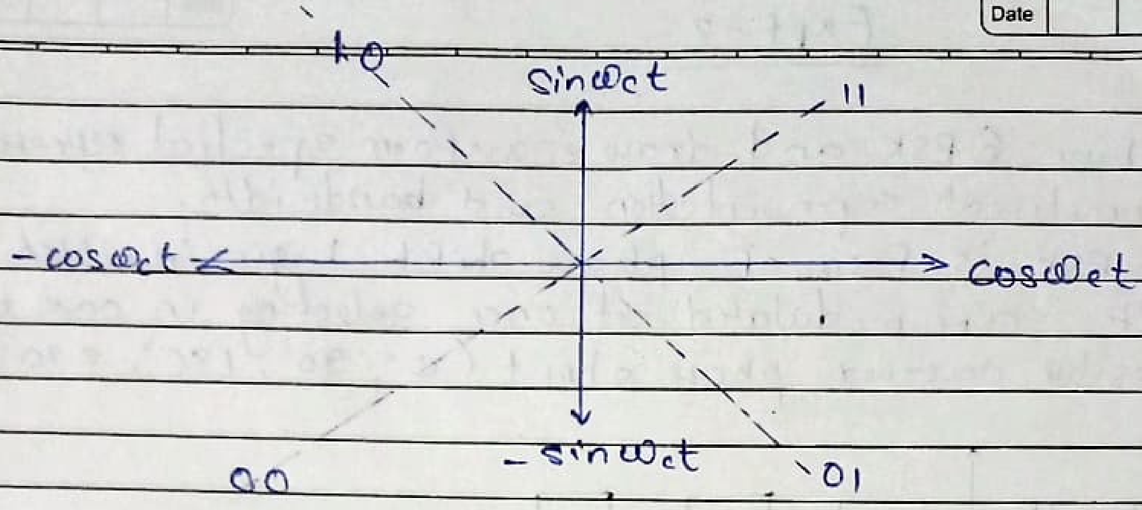


BW = High freq. − low freq

$= F_H - F_q$

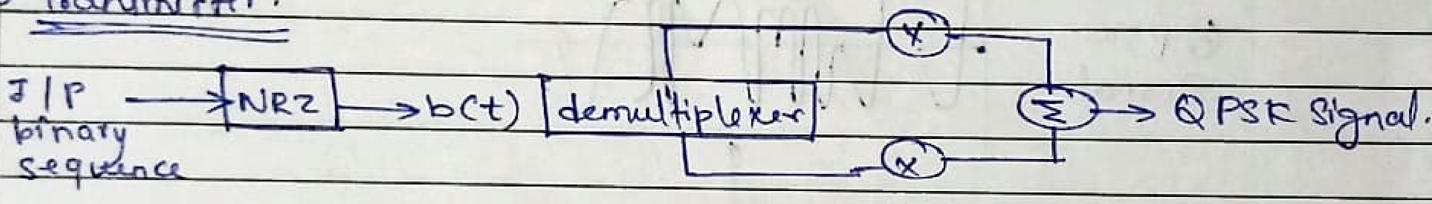
$= 1/T_s - (-1/T_{s}) = \frac{2}{T_s}$

$\boxed{BW = 1/T_b}$



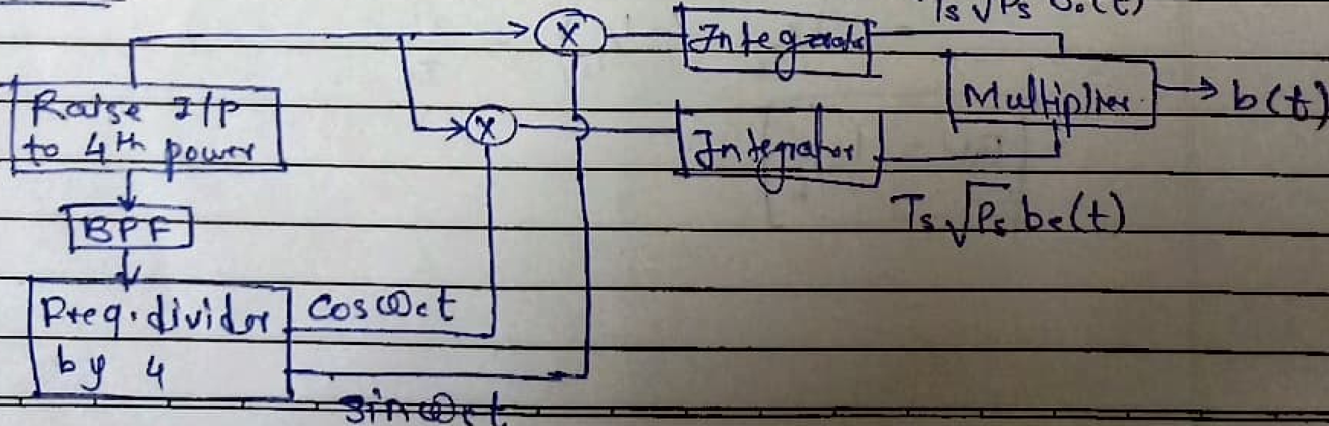
Q.2. Draw and explain QPSK transmitter & receiver.

→ Transmitter.



- I/P binary data is connected to bipolar NRZ level encoder the encoder sets the amplitude of inputs bit stream at t, for bits 1, for bits 0
- The encoded data is divided in odd & user parts & multiplied with 2 different frequency.
- Multiplied sequence signal is added together & QPSK generator.

Receiver



- s(t) signal is raised to 4th power $s^4(t)$.
- Signal then pass to BPF which centered around $4f_0$
- Carrier Signal is 4 which generator both carrier frequency.
- Carrier signal is multiplied with s(t) & demultiplier
- Signal is multiplied to get back to original bit sequence

$$s(t) = \sqrt{2P_s} \cos\{\omega_c t + (2m+1)\pi/4\}, \; m = 0, 1, 2$$

$$\cos(A+B) = \cos A \cos B - \sin A \cdot \sin B.$$

$$s(t) = \sqrt{2P_s} \cos(\omega_c t) \cos(2m+1)\pi/4 - \sqrt{2P_s} \sin(\omega_c t) \cdot \sin(2m+1)\pi/4$$

$$s(t) = \sqrt{2P_s} \cos(2m+1)\pi/4$$

$$b(t) = \sqrt{2} \sin(2m+1)\pi/4.$$

$$s(t) = \frac{\sqrt{P_s T_s}}{2} b_o(t)\, \phi_1(t) = \frac{\sqrt{P_s T_s}}{2} b_e(t)\, \phi_2(t)$$

$$T_s = 2T_b$$

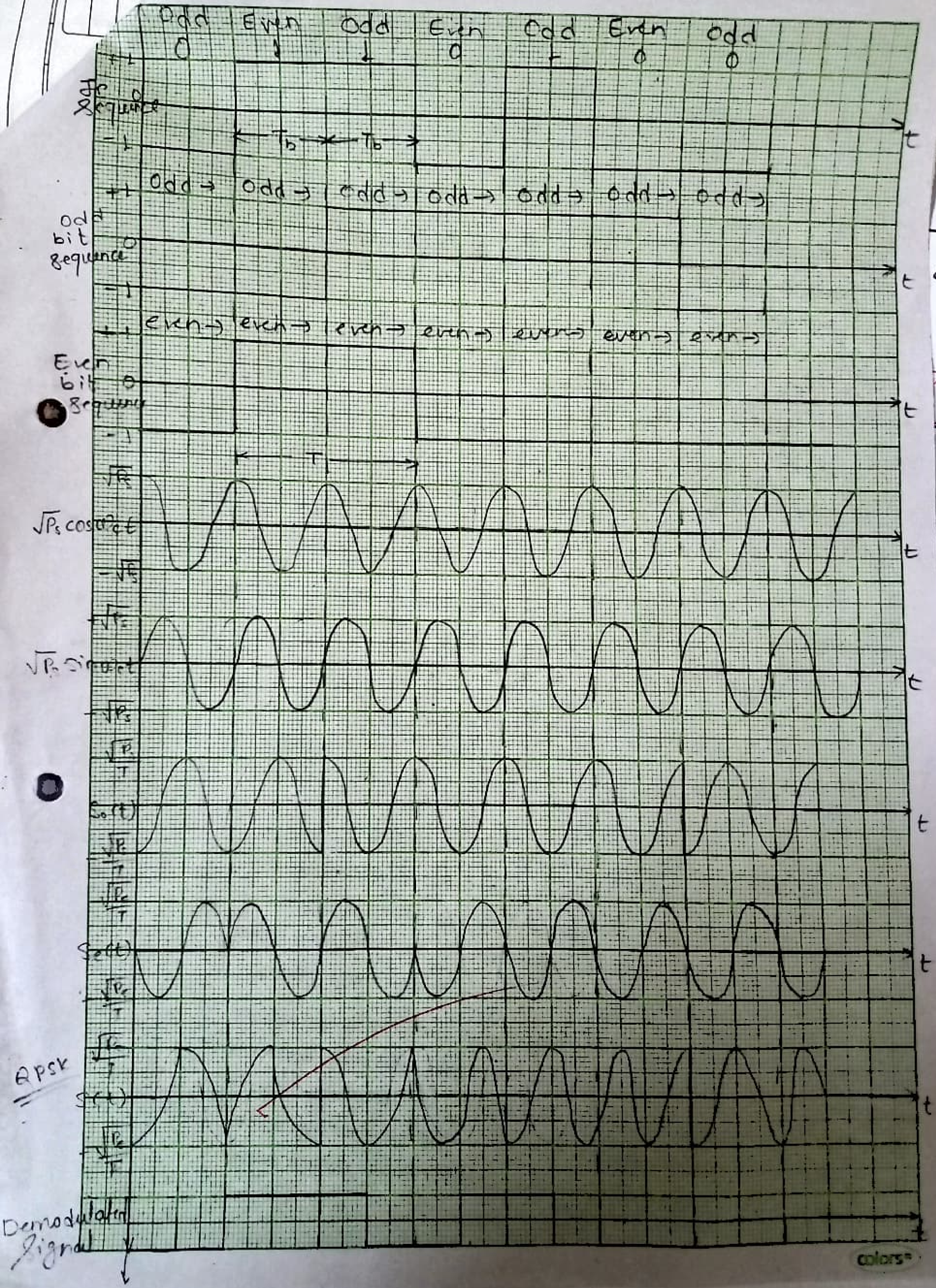
$$s(t) = \sqrt{P_s T_b}\, b_o(t)\, \phi_1(t) + \sqrt{P_s T_b}\, b_e(t)\, \phi_2(t)$$

Q.3 Explain relation between bitrate & symbol.

→ In QPSK symbol rate = 1/2 bitrate.

Q.4. Compare QPSK & 16 PSK

QPSK	16-PSK.
2 bits per symbol	4 bits per symbol.
minimum bandwidth ($f_b/2$)	Minimum bandwidth ($f_b/4$)
Baud rate ($f_b/2$)	Baud rate ($f_b/4$)
Bit rate 2400 bps	Bit rate 2400 bps


Odd 0
Even 1
Odd 1
Even 0
Odd 1
Even 0
Odd 0
Bit Sequence
Tb
odd bit sequence
Even bit sequence
T
√Ps cos ωc t
√Ps sin ωc t
So(t)
Se(t)
QPSK
s(t)
Demodulated Signal
t

Subject: Digital Communication

Experiment No: **Title:** Simulatin study of OFDM transmitter & receiver.

Name: Prasad Nitam **Date Of performance:**

Class: TE -A **Date of Submission:**

Roll no: 58 **Signature:**

OBJECTIVE:

Implement algorithm of OFDM system in MATLAB

PREREQUISITE:

Students should know the concept of digital modulation and multiplexing technique.

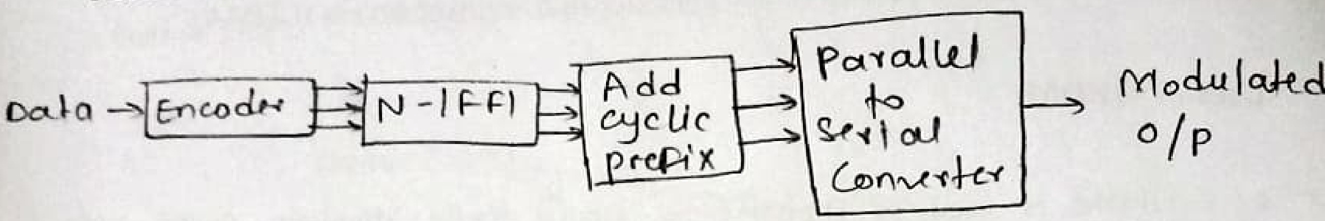
THEORY:

Orthogonal frequency-division multiplexing (OFDM) is a digital communication technique initially developed for use in cable television systems. OFDM is similar to the broadcasting technique known as frequency division multiplexing (also known as FDM), which uses a multitude of transmitters and receivers to send information on different frequencies over a single wire, such as an electrical power cable

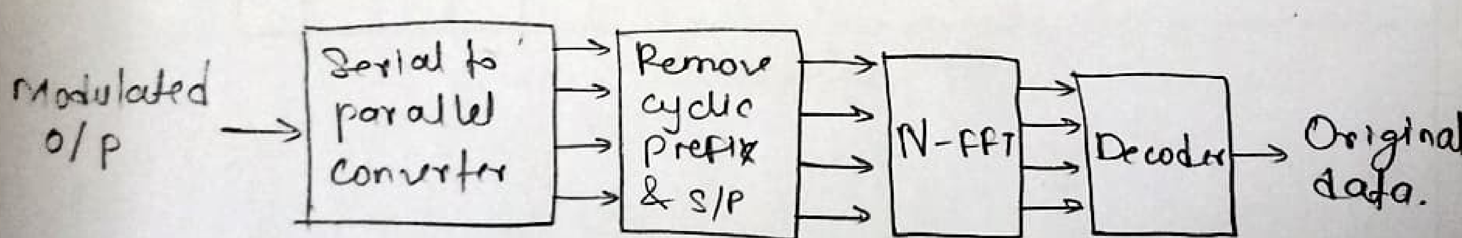
The first use of OFDM was by Bell Labs in 1984, and it has since become widely used in wireless applications such as mobile telephony and broadband communications. In wireless communications, OFDM has become an alternative to single-carrier modulation techniques such as frequency division multiple access (FDMA), time-division multiple access (TDMA), and code-division multiple access (CDMA). It is

BLOCK DIAGRAM:

Modulator



Demodulator



Algorithm or flowchart of Implementation of OFDM system

Algorithm.

1. Subcarrier generation.
2. Data encoding
3. Guard Interval insertion
4. (IFFT) (Inverse Fast Fourier Transform)
5. Addition of cyclic prefix.
6. Transmission & reception.
7. (FFT) ~~Reverse~~ Fast Fourier Transform
8. Data demapping & decoded.
9. Guard Interval Removal
10. Data fusion.

CONCLUSION:

An OFDM demodulator demultiplexes a multi subcarrier time-domain signal using orthogonal frequency division multiplexing. Hence we have learnt concept of OFDM of digital modulation and multiplexing technique.

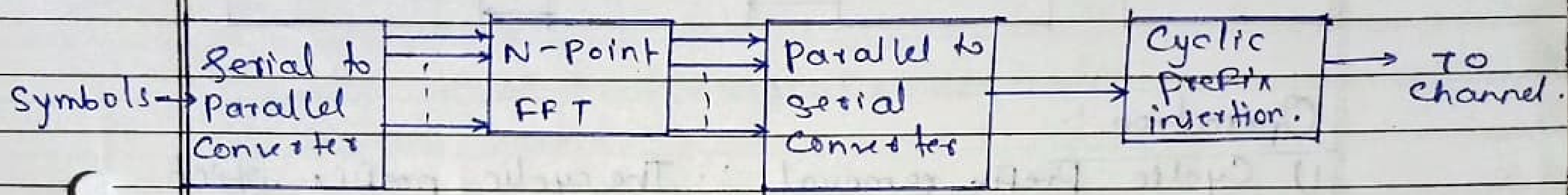
QUESTIONS:

Explain block diagram of OFDM System in detail.

What are advantage and disadvantages of OFDM system.

Q.1. Explain block diagram of OFDM system in detail.
→ OFDM (Orthogonal Frequency Division Multiplexing)

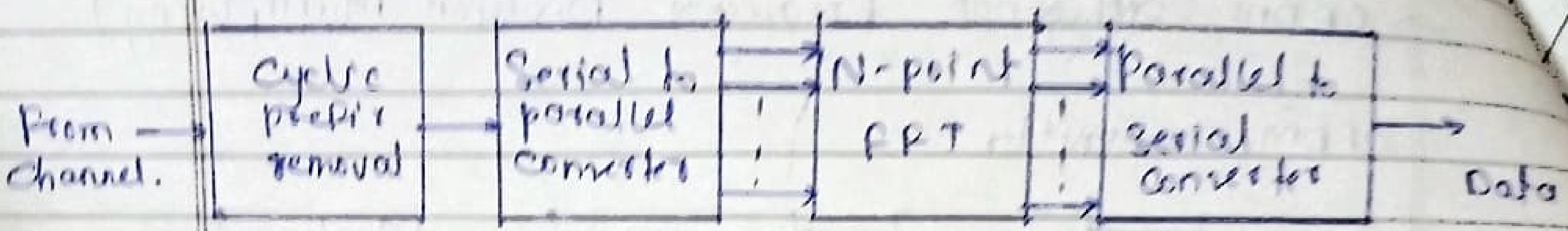
OFDM Transmitter :-



Operation :-

1) Data input :- The process begins with digital data, such as voice, video or other information that you want to transmit.
2) Serial to parallel conversion :- The data stream is converted from serial to parallel format, splitting it into multiple substreams.
3) N-point IFFT :- Each substream undergoes an IFFT operation which transforms the data from the time domain into the frequency domain.
4) Parallel to serial conversion :- The substreams are converted into serial format.
5) Cyclic Prefix Insersion :- To combat the effects of multipath propogation & guard against intersymbol interference, a cyclic prefix is added to each OFDM symbol. The prefix is essentially a copy of the end of the symbol, which is pscuspended to the symbol.

OFDM Receiver :



Operation :

1) Cyclic Prefix removal. :- The cyclic prefix which was added to each OFDM symbol at the transmitter is removed. This step helps in mitigating the effects of multipath propogation & eliminating ISI.

2) Serial to parallel conversion → The signal from cyclic prefix removal is converted into ||^{el} format.

3) N-point FFT → Each substream undergoes an FFT operation which convert the signal from the frequency domain back into the time domain.

4) Parallel to serial converter back into a serial bitstream by parallel to serial converter.

Q.2. What are the advantages & disadvantages of OFDM system.

→ Advantages of OFDM →

① Spectral efficiency

② Resistance to frequency - selective fading.

③ Tolerant to delay spread.

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4. Flexibility in subcarrier allocation.
5. Coexistence with other signals.
6. High data rate.

- Disadvantage of OFDM.
  1. Complexity.
  2. High peak to average process ratio.
  3. Guard band.
  4. Freq^n offset sensitivity.
  5. Limited performance in narrow band channel.
  6. Doppler spread limitations.

MODERN EDUCATION SOCIETY'S

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19 V. K. Joag path, Wadia Campus PUNE-01

Subject: Digital Communication

Experiment No: **Title:** Study of FHSS transmitter and receiver

Name: Prasad Nikam **Date Of performance:**

Class: TE-A **Date of Submission:**

Roll no: 58 **Signature:**

Q1 Draw and Explain FHSS spread spectrum system with transmitter and receiver

Q2. Explain Fast and Slow frequency hopping techniques

Q3. Compare DSSS with FHSS system

Q4. Compare low frequency hopping and Fast frequency hopping

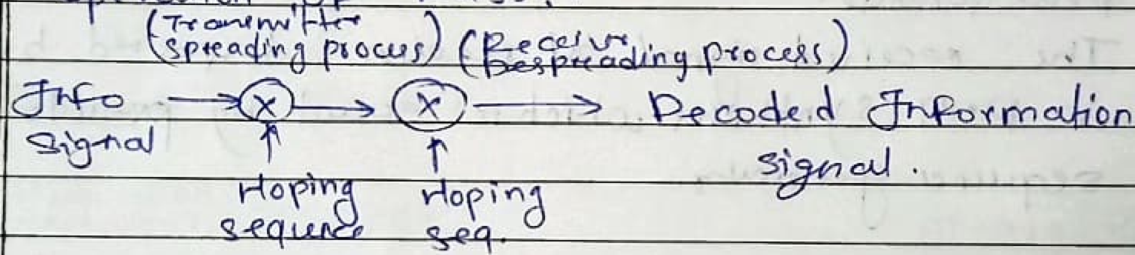
OC

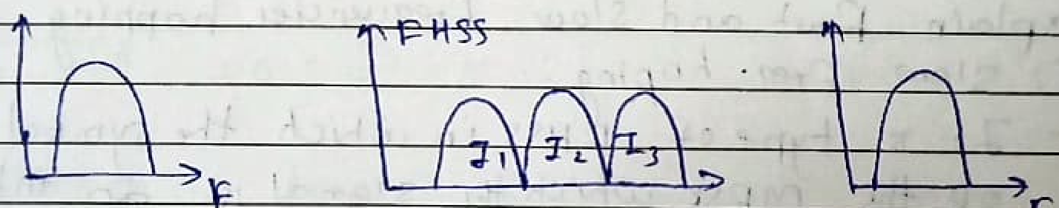
Practical - 4

Q.1. Draw and explain FHSS spread spectrum system with transition & receiver.

⇒ Defⁿ :- FHSS is method of transmitting media signal by rapidly switching a carrier among many frequency channel using a PN sequence known to transmitter & receiver.

Operation of FHSS :-





- The frequency hopped multiple access is based on hopping spread spectrum (FHSS) modulation scheme.
- The SS signal with a wide band frequency spectrum is generated in frequency hoping technique.
- In frequency hopping, the transmission priodically changed over a wideband.
- Whereas the specific order is function of a code seq.
- Hoping occurs over a frequency band that includes a No. of channels and each channel a spectral band with a central frequency in the hop set & sufficient bandwidth.
- The FHSS transmitter send data by changing the

Frequency from to other random manner which is known only to desired receiver.

- At the transmitter Freq. hoping is used for changing the radio signal frequency randomly across a broad frequency band in random manner.
- In this way FHSS radio transmitter freq. hops from one to another channel in predetermined but pseudorandom mode.
- The received signal at receiver despread by using a freq. synthesis which is count by pseudo sequence generator.

Q.2. Explain fast and slow frequencies hopping technique.

→ (1) Slow freq. hoping:-

- It is type of FHSS in which the symbol rate R_s of the MFSK which the signal is an integer multiple of the hop rate.
- That means several symbols are transmitted corresponding to each freq. hop.

(2) Fast freq. hoping:-

- It is type of FHSS where R_h is integer multiple of MFSK symbol rate R_s.
- That means during the transmission of one symbol it will hop several times.
- Each symbol transmission several freq. hops. Thus freq. hopping takes place at fast rate.

Q.3. Compare DSSS with FHSS system.

Parameter	DSSS	FHSS
1) Definition	~~Data~~ sequence of large band width is multiplied with narrow band data signal.	Data bits are transmitted in different frequencies slots which are changed by PN sequence.
2) Chip rate	$RC = 1/TC$	$RC = max(Rn, Rs)$
3) Modulation Technique.	BPSK	M-ary PSK.
4) Processing gain	$PG = \frac{Tb}{Tc} = N$	$PG = 2^k$.
5) Effect of coding	Less	More.
6) Acquisition time	Long	Short.
7) Effect of distance	Distance relative	Effect of distance is less

Q.4. Compare slow freq. hoping & fast freq. hoping

→ Slow Frequency Hopping	Fast Frequency Hopping.
① More than one symbol are transmitted per freq. hopp.	① More than 1 freq. hops are required to transmit 1 symbol.
② Chip rate is equal to the symbol rate.	② Chip rate is equal to hop rate.
③ Symbol rate is higher than hop rate.	③ Hop rate is higher than symbol rate.
④ Same carrier freq. is used to transmit 1 or more symbols.	④ One symbol is transmitted over multiple carriers in different hops.
⑤ A jammer can detect this signal.	⑤ This signal can't be detected by jammer.

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Subject: Digital Communication

Experiment No: **Title:** Simulation study of Performance of M-ary QAM .

Name: Prasad Nikam
Class: TE - A
Roll no: 58

Date Of performance:
Date of Submission:
Signature:

OBJECTIVE:

1. Generate transmitter constellation of M-QAM of different M=4,16,64
2. Generate receiver constellation of M-QAM of different M=4,16, 64 for different SNR.
3. Plot BER VS SNR of M-PSK of different M=4,16,64
4. Conclude

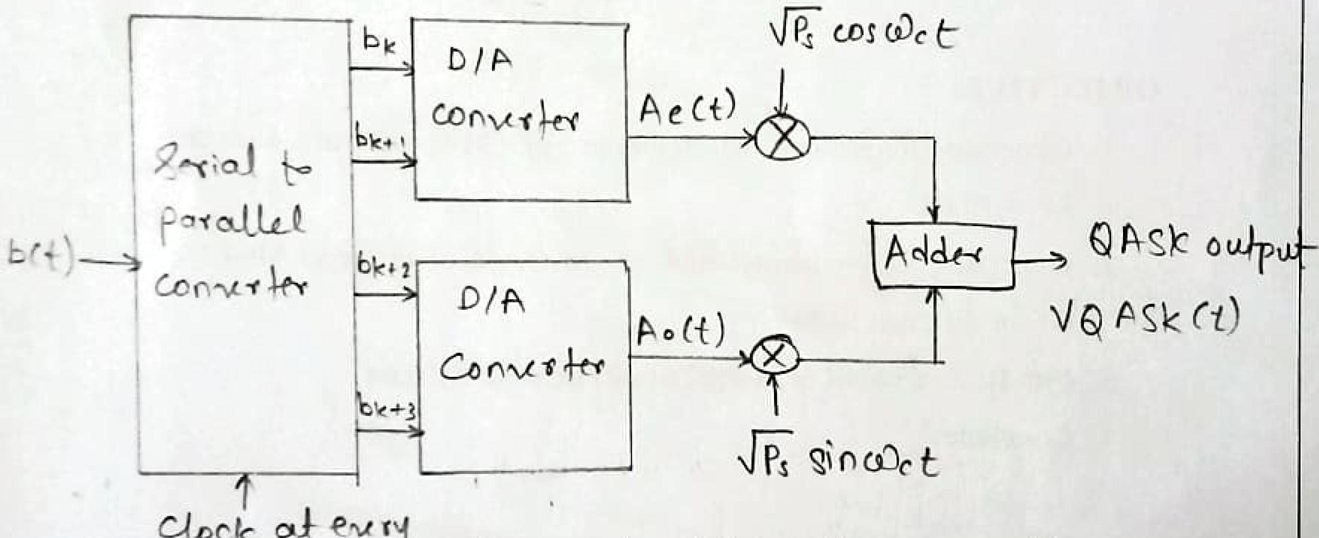
Definition of M-ARY QAM

The two carrier waves of the same frequency are out of phase with each other by 90° a condition known as quadrature. It is a technique of both analog and digital QAM modulator works like a translator helping to translate digital packets into an analog signal to transfer data seamlessly.

Mathematical expression of M-ARY QAM

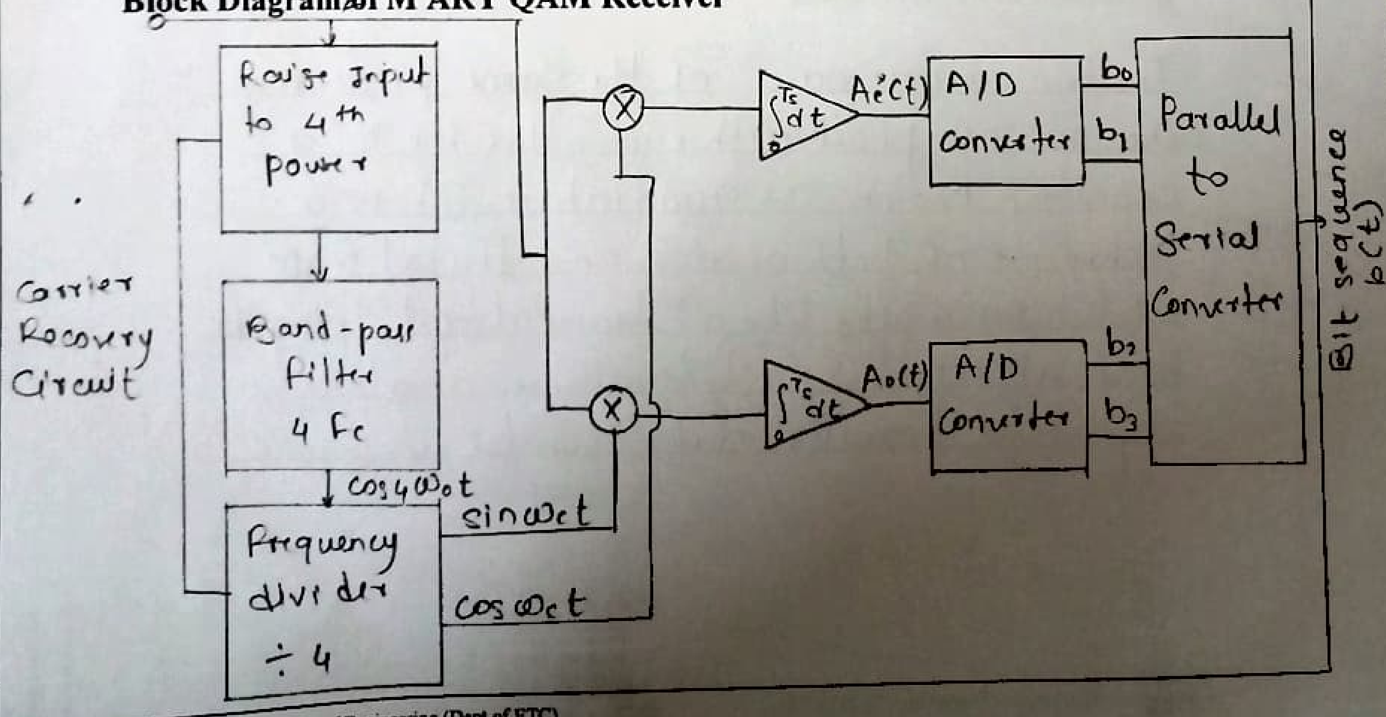
$$V_{QASK}(t) = A_e(t) \times \sqrt{P_s}\cos\omega_c t + A_o(t) \times \sqrt{P_s}\sin\omega_c t$$

Block Diagram of M ARY QAM Transmitter



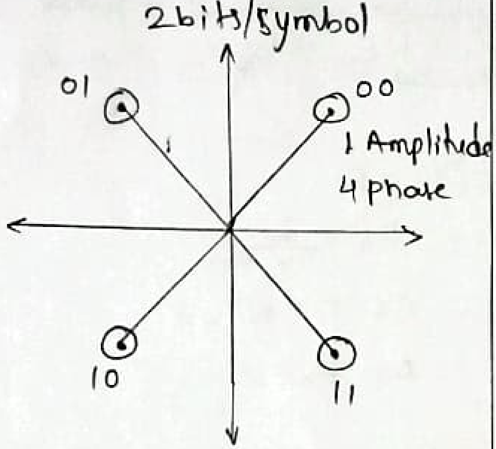
$$V_{QASK}(t) = \sqrt{P_s}\,A_e(t)\cos\omega_c t + \sqrt{P_s}\,A_o(t)\sin\omega_c t$$

Block Diagram of M ARY QAM Receiver

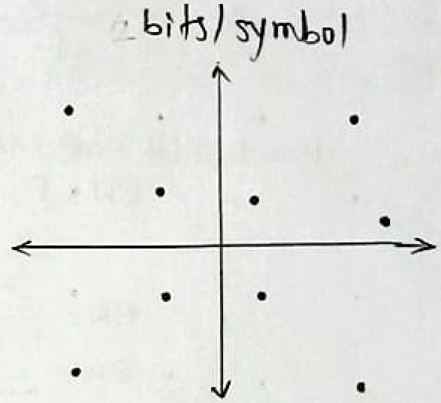


Constellation diagram of M QAM of M=4,8,16 and show Euclidean distance

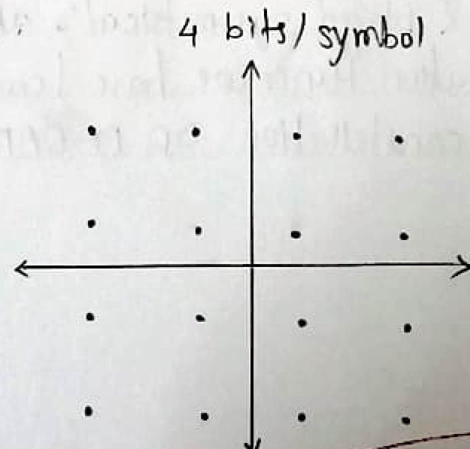
M=4



M=8

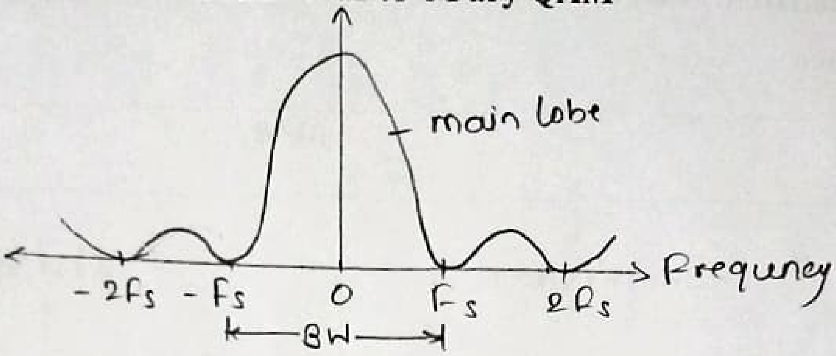


M=16



~0.4 bps/ Hz

Draw Spectrum and show bandwidth of M ary QAM



Bandwidth of MQAM

$$BW = f_s - (-f_s) = 2f_s$$

$$= \frac{2}{T_s} \quad \text{As, } f_s = \frac{1}{T_s}$$

$$BW = \frac{2}{NT_b} \quad \text{--- As } T_s = NT_b$$

$$BW = \frac{2f_b}{N} \quad \text{--- As } f_b = \frac{1}{T_b}$$

Thus Bandwidth of QAM system is same that of M-ary psk system.

Conclusion:-

QASK ~~&~~ or QAM is an phase modulation technique which is equally spaced & placed symmetrically about origin, synchronous type of demodulation. Hence we have learnt that concepts and generation of constellation of M-QAM.

Question:

Explain BER vs SNR of M QAM Graph

⇒ SNR (in dB) = 10*log(signal power / noise power) [base 10]. QAM modulation techniques are introduced which is combination of Amplitude modulation and PSK. Which shows better performance than only PSK and most of the information technology and consumer companies have already adopted this modulation technique for high data rate communication. for ex. If we are using 4 QAM then we can send 2 bits in a symbol where data rate is twice as compared to binary PSK for 16QAM we send 4 bits in a symbol where data rate is 4 times as compared to BPSK. QAM performs better than PSK in normal SNR. But if the channel is extremly noisy then we go for BPSK.

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Subject: Digital Communication

Experiment No: **Title:** Generation & detection of DS-SS BPSK..

Name: Prasad Nikam **Date Of performance:**

Class: TE-A **Date of Submission:**

Roll no: 58 **Signature:**

OBJECTIVE:

1. Observe and Draw waveform of input signal
2. Observe and Draw waveform of PN sequence
3. Observe and draw waveform of spreaded signal
4. Observe and Draw waveform of Modulated signal

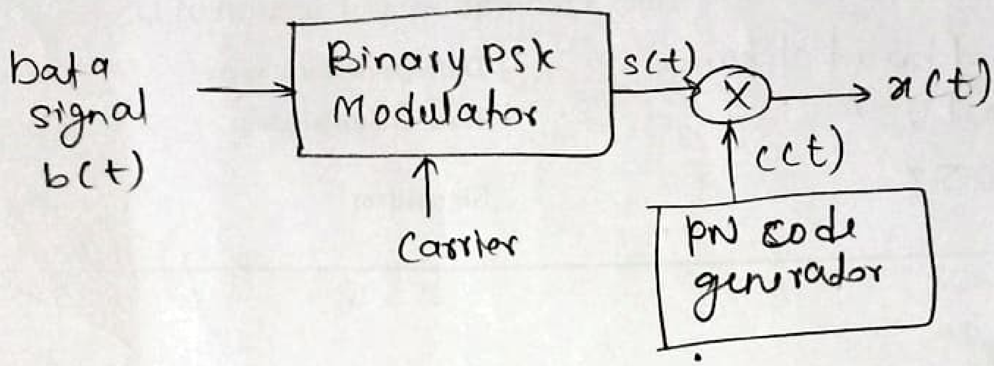
APPARATUS:

Name of Instrument	Specification /Range
Sigma trainer kit.	1) On board pseudo noise (PN) code generator Bits-16 a clock freq - 100 Hz. 2) On board digital data generator to generate any binary i/p word of word length 8 bit clock freq. = 6.66 Hz data format NRZ. 3) Modulator type - coherent binary PSK. 4) Demodulator type - coherent detector Low pass filter cut off freq - 105 kHz code dispreading using EX-NOR GATE.

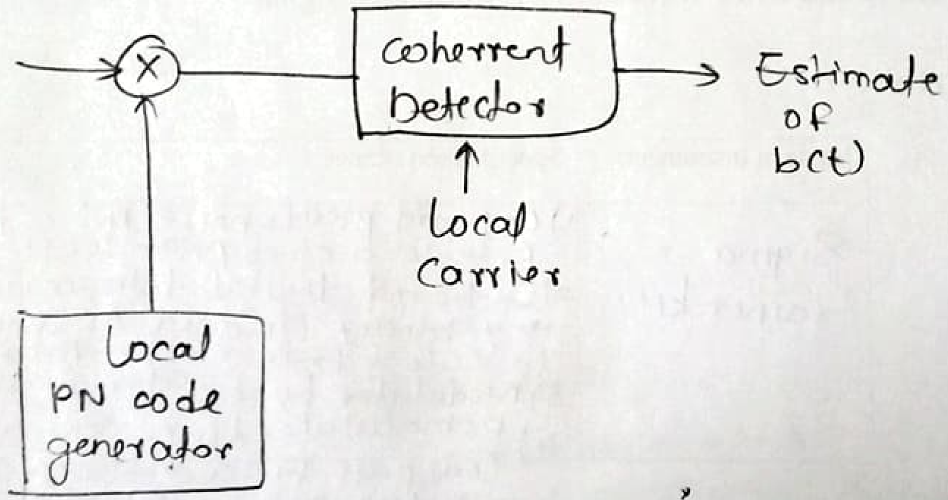
PREREQUISITE:

① BPSK Modulation.
② PN sequence.

BLOCK DIAGRAM OF DSSS-BPSK Transmitter :



BLOCK DIAGRAM OF DSSS-BPSK Receiver:



OBSERVATION AND CALCULATION:

BPSK	DSSS-BPSK
Bit duration Tb= 50 µ sec	**n= number of Bits in PN sequence=** 8 **Chip Duration =Tchip= Tb/n** = $\frac{T_b}{8}$ = 6.25 µs
Bit rate=fb=1/Tb = 20 kHz	**Chip rate= fchip=1/Tchip** = 0.16
Bandwidth=2fb = 40 kHz	**Bandwidth=2fchip=2nfb** = 2×8 fb = 320 kHz
	Process Gain= Tb/Tchip= ~~50/6.25~~ = ~~0.5 µsec~~ 50/6.25 = 8 µsec

4 Number of Flipflop required for 8 bit PN sequence.

CONCLUSION-

DSSS is a direct sequence spectrum DSSS is a Spread spectrum modulation technique primarily used to reduce overall signal interference. Hence we have successfully generated & detected of DS-SS BPSK.

Expt - 3

Q. 1 What is PN sequence generator.

→ PN sequence generator is device that produces a sequence of binary data that appears random but determined.

Q. 2. What are the properties of PN sequence?

→ ① Balanced property.

- In each period of sequence i.e. N^{th} no. of always 1 more than no. of 0's.

② Run property.

- This property states that the "run" of 1's & 0's in each kind are length one fourth are length.
- Run mean subsequence of identical symbol width one period of sequence.
- length subsequence is length of run total no. of run will be $\left(\frac{m+1}{2}\right)$ if m stage feedback shift register is used

③ Correlational property.

- The auto-correlation is maximum.

Q. 3. What is relation between no. of flip flops & length of sequence?

→ The relation between no. of flip flop & length is $N = 2^m - 1$, $m \rightarrow$ no. of flip flop

Q. 4. What is role of of PN sequence in DSSS?

→ PN sequence are used to spread & receive data in direct sequence spread spectrum.

Q.5. Explain concept of DSSS?

→ DSSS stands for direct sequence spread. It's a technique in wireless communication where data is spread over wide freq. band using spreading. This make signal means to interference & easier is commonly used in technology like WiFi.

Q.6. What do you mean by bit rate & chiprate?

→ Bitrate :- Bitrate is no. of transmitted per unit time in digital data stream. It's typically in bits per second & represent the actual data over a communication channel for eg. in 1Mbps connection the bit rate is 1 million bits per second.

Chiprate :- Chiprat is rate at which the spreading code is generated & modulated onto carrier signal in spread spectrum second or chips per bit. Spreading signal over wider bandwidth a higher chip rate can provide greater resistance.

Q.7. What is relation between & improve the system performance

→ The relation chip is determined by spreading factor (SF) is key parameter that define how much signal is spread across frequency spectrum.

$$\boxed{T_c = \frac{T_b}{SF}}$$

Q-8. Classification of spread spectrum modulation techniques.

→ Spread Spectrum refers to a system originally developed for military applications to provide secure communications by spreading the signal over a large frequency band. In this narrow band signal in the frequency domain These narrowband signals are easily jammed by any other signal in the same band.

They are classified as follows :-

1. Direct Sequence (DS) SS Systems.
   i) DSSS transmitter
   ii) DSSS receiver
   iii) PN codes properties.
2. Frequency Hoping (FH) SS systems.
   i) FHSS transmitter.
   ii) FHSS receiver
   iii) Time Hoping (TH) SS systems.
   iv) Recovery of spread spectrum signals :- Important timing signals.

Q-9. Advantages and applications of spread spectrum.

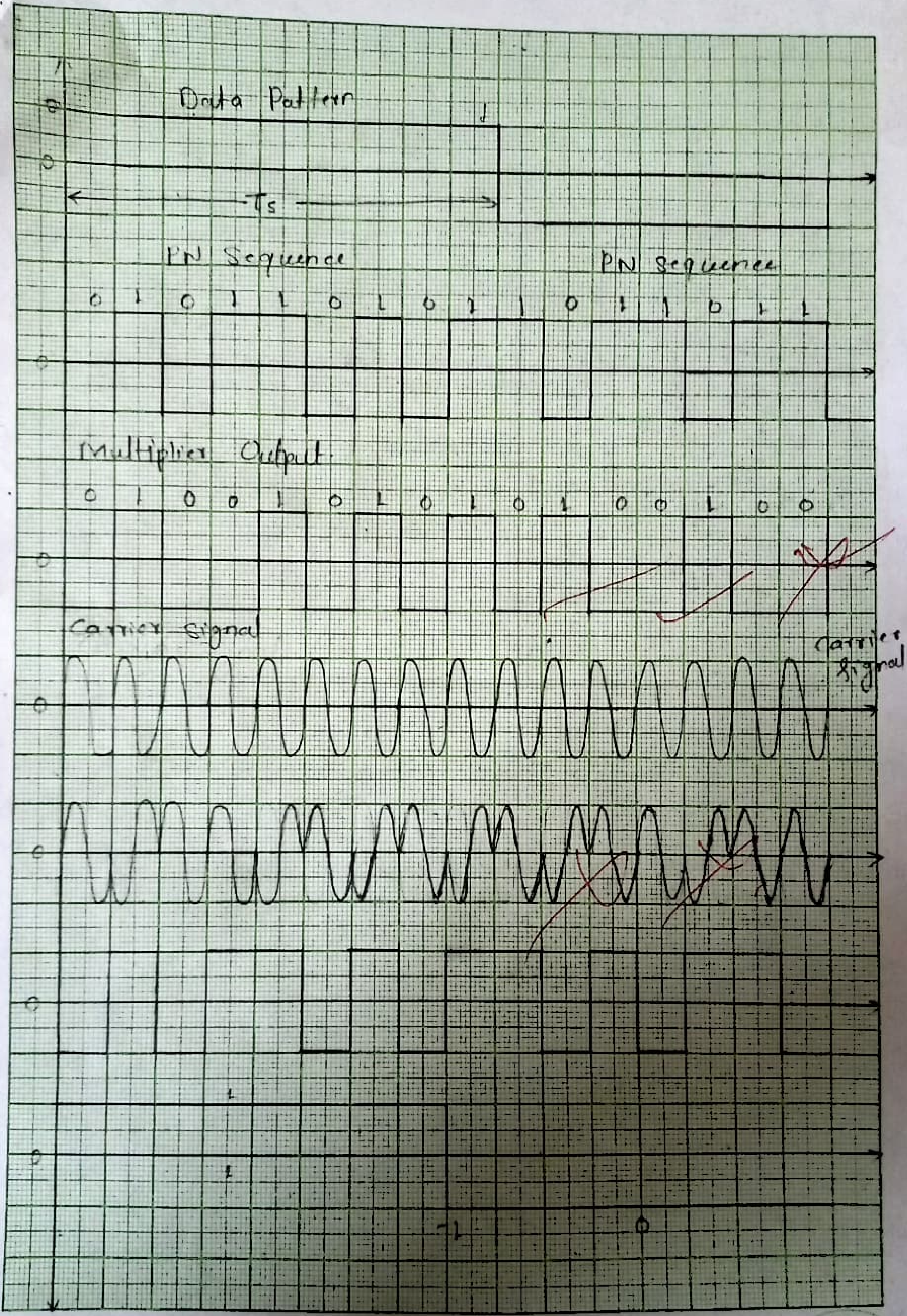
→ Advantages :-

i) Cross talk elimination.
ii) Better output with data integrity
iii) Reduced effect of multipath fading.
iv) Better security.
v) Reduction in noise.
vi) Co-existence with other system.

vii) Longer operative distances.
viii) Hard to detect.
ix) Not easy to demodulate / decode.
x) Difficult to jam the signal.

Applications:-
i) It is used in mobile communications.
ii) It is used in distance measurement.
iii) It is used in selective calling.
iv) It is used in CDMA communication.

Q.10 Define processing gain.
→ The processing gain PG of a spread spectrum signal can be defined as the ratio of the spreading bandwidth B_{ss} to the minimum required signal bandwidth B_d.



Data Pattern
Ts
PN Sequence
PN Sequence
0 1 0 1 1 0 1 0 1 1 0 1 1 0 1 1
Multiplier Output
0 1 0 0 1 0 1 0 1 0 1 0 0 1 0 0
Carrier Signal
Carrier Signal

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Subject: Digital Communication

Experiment No:

Title: TO STUDY VARIOUS ENTROPIES AND MUTUAL INFORMATION IN A COMMUNICATION SYSTEM

Name: Prasad Nikam **Date Of performance:**

Class: TE -A **Date of Submission:**

Roll no: 58 **Signature:**

OBJECTIVE:

Implementation of algorithm for determination of various Entropies, Mutual Information and Channel capacity of the Binary Symmetrical Channels.

PREREQUISITE:

Students should know the concept of probability theory, various types of channels and self-information.

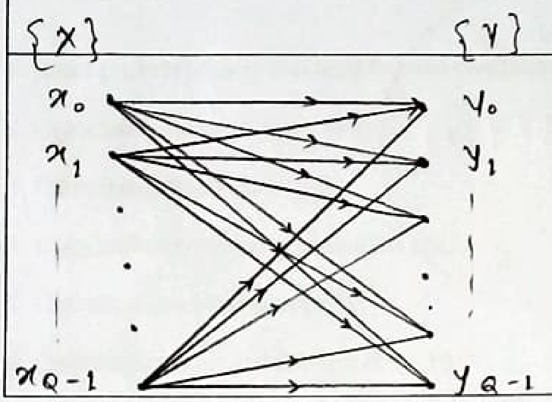
THEORY:

Consider a discrete random variable X with possible outcomes x_i, $i = 1, 2 \dots n$. The **self-Information** of the event $X = x_i$ is defined as

$$I(x_i) = \log_2(1/p(x_i))\text{----}bits$$

DIAGRAM:

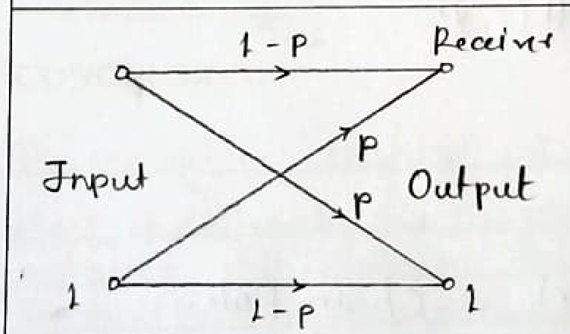
Discrete memory less channel :



Channel matrix

$$P = \begin{bmatrix} P(y_0/x_0) & P(y_1/x_0) & \cdots & P(y_{K-1}/x_0) \\ P(y_0/x_1) & P(y_1/x_1) & \cdots & P(y_{K-1}/x_1) \\ \vdots & & & \\ P(y_0/x_{j-1}) & P(y_1/x_{j-1}) & \cdots & P(y_{K-1}/x_{j-1}) \end{bmatrix}$$

Binary symmetric channel :



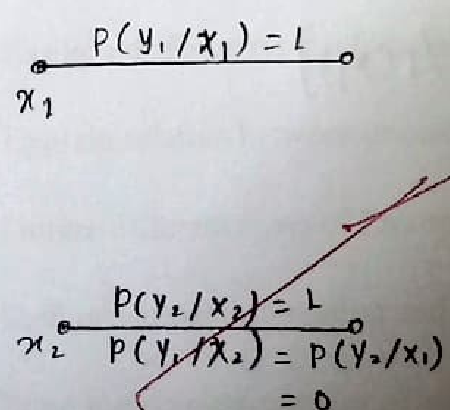
Channel matrix

$$P(y/x) = \begin{array}{c|cc} & y_1 & y_2 \\ \hline x_1 & 0.6 & 0.4 \\ x_2 & 0.4 & 0.6 \end{array}$$

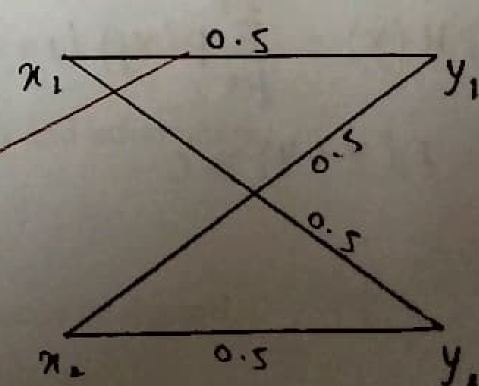
$P(y_1/x_1) = 0.6,\ P(y_2/x_1) = 0.4$

$P(y_1/x_2) = 0.4,\ P(y_2/x_2) = 0.6$

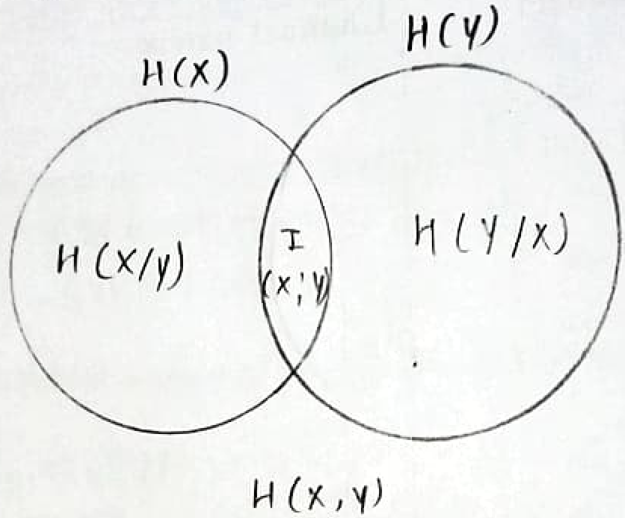
Noiseless channel :



Useless Channel:



Relation diagram between entropies and Mutual Information :



Relationship equation between Entropies and Mutual Information :

$$I(X,Y) = H(X) + H(Y)\ H(X,Y)$$

* Conditional Entropy :-

① $H(Y/X) = 0$

② $H(Y/X) = H(Y)$

③ $H(Y/X) = H(Y/X) - H(X)$ ---Chain Rule.

④ $H(Y/X) = H(X/Y) \rightarrow H(X) + H(Y)$

* Mutual Information :-

① $H(X) = \sum_{j=0}^{I-1} P(x_j) \log_2 [1/P(x_j)]$

② $I(X ! Y) \geq 0$

ALGORITHM:

1. Input probabilities of message(Px) and conditional probabilities (Py/x)of the given channel.
2. Calculate joint probability matrix
3. Calculate probabilities (Py)
4. Calculate conditional probabilities (Pxy)
5. Calculate marginal entropy Hx
6. Calculate conditional entropy Hx/y, Hy/x
7. Calculate joint entropy Hxy
8. Calculate mutual information I(x,y).
9. 10. Display the results.

CONCLUSION:

The concept of mutual information is intemately linked to that of entrophy by of random variable of fundamental notation in information theory that qualifies the expected amount of information held in random variable. Hence, we have studied various entrophy & mutual information in communication system.

QUESTIONS:

1. Explain different types of communication channels.
2. Explain relation between uncertainty and information.
3. Define different types of Entropies.
4. Define Mutual information and capacity of channel.
5. State important properties of entropy and Mutual Information.

Name :- Prasad Nikam
~~Roll~~.

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Date	

Q.1. Explain different types of communication channel.

→ Communication channels are physical or logical pathways through which information is transmitted from sender to receiver.

Here are some different type of communication.

① Wireline channel.
ⓐ Twisted pair cable
ⓑ Coaxial cable
ⓒ Fibre optic cable.

② Wireless communication.
ⓐ Radiowave.
ⓑ Infrared (IR)
ⓒ Microwave.
ⓓ Cellular network.

Q.2. Explain relation between uncertainity & information.

→ Concept of uncertainity & information are closely related in field of information theory which has developed by clouds shannon.

Understanding relationship betn these two concepts. is fundamental to grouping the core ideas of Info. theory.

Q.3. Define different type of entropies.

① Shannon Entropy :-

Shannon entropy named after cloud shannon measures amount of uncertainity or information content associated with random variable or probability distribution

② Joint Entropy :-

~~Q.4.~~ Joint entropy measures the uncertainity or info content associated with 2 or more random variables considered together

③ Conditional Entropy :-

Conditional entropy measured the remaining uncertain or information content in one random variable (X) given knowledge of another random variable (Y)

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Date

(4) Cross Entropy :-
Cross entropy measures the average no. of bits needed to encode that one probability distribution when using different distribution as encoding model.

Q.4. Define mutual info & capacity of channel.
→ (1) Mutual information :-
Mutual information measures the amount of information that one random variable contain about another random variable. It quantifies reaction in uncertainity of one variable when other is known.
(2) Capacity of channel :-
Channel capacity represent maximum rate of which information can be reliably transmitted through a communication channel while maintaining very low error probability.

Q.5. State important properties of entropy & mutual information.

→ (1) Properties of Entropy
- Non negativity.
- Maximum entrophy
- Minimum entropy
- Sub additivity.
- Chain rule.

(2) Mutual Information.
- Non-negativity.
- Symmetry
- Maximum value.
- Independence
- Conditional Independence.

Prasad Nikam

ss: TE A (ENTC)

Roll No. : 58

Sub: Digital Communication

```
close all;
clc;
clear all;

    px(1)=input('enter probability of x1 = ');
px(2)=1-px(1);
py=[0 0];

        p=input('Enter conditional probability P(y1/x1)= p = ');
    pybx= [p 1-p ; 1-p p]
```

```
pybx = 2x2
    0.6667    0.3333
    0.3333    0.6667
```

```
for i=1:2
    for j=1:2
        pxy(i,j)=(px(i)*pybx(i,j));
    end
end
py=[0 0];
for i=1:2
    for j=1:2
        py(i)= py(i)+pxy(j,i);
    end
end
hx=0;
for i=1:2
    h=px(i)*(log(1/px(i))/log(2));
    hx=hx+h;
end
hy=0;
for i=1:2
    y=py(i)*(log(1/py(i))/log(2));
    hy=hy+y;
end

Hxy=0;
for i=1:2
    for j=1:2
        if pxy(i,j)==0
            hxy=0;
        else
        hxy=-pxy(i,j)*log2(pxy(i,j));
```

```
        Hxy=Hxy+hxy;
        end
    end
end
Hygx=Hxy-hx;
Ixy=hy-Hygx;
Hxgy=Hxy-hy;
if pybx(1,1)~=1
c=1+[p*log2(p)+(1-p)*log2(1-p)]
elseif p==1
    c=log2(2);
end
```

```
c = 0.0817
```

```
z= [' Input probabilities are = ',num2str(px)];disp(z)
```

```
Input probabilities are = 0.75          0.25
```

```
disp(' Channel conditional probability matrix is = ');
```

```
Channel conditional probability matrix is =
```

```
pybx
```

```
pybx =
    0.6667    0.3333
    0.3333    0.6667
```

```
disp(' Channel joint probability matrix is =');
```

```
Channel joint probability matrix is =
```

```
pxy
```

```
pxy =
    0.5000    0.2500
    0.0833    0.1667
```

```
y=['Desale Tejas'];
disp(y);
```

```
Desale Tejas
```

```
z= [' Output probabilities  P(y1) and P(y2) are = ',num2str(py)];
disp(z)
```

```
Output probabilities P(y1) and P(y2) are = 0.58333        0.41667
```

```
z= [' Entropy of source H(X) = ',num2str(hx), ' bits/msg' ];disp(z)
```

```
Entropy of source H(X) = 0.81128 bits/msg
```

```
z= [' Entropy of destination H(Y) = ',num2str(hy), 'bits/msg' ];
```

```
(z)
ntropy of destination H(Y) = 0.97987bits/msg

= [' Conditional entropy H(Y/X) = ',num2str(Hygx), 'bits/msg' ];
disp(z)

Conditional entropy H(Y/X) = 0.9183bits/msg

z= ['Joint entropy H(X,Y) = ',num2str(Hxy), 'bits/msg' ];
disp(z)

Joint entropy H(X,Y) = 1.7296bits/msg

z= [' Conditional probability H(X/Y) = ',num2str(Hxgy), 'bits/msg' ];
disp(z)

Conditional probability H(X/Y) = 0.74971bits/msg

z= [' Mutual information  I(X,Y) = ',num2str(Ixy), 'bits' ];
disp(z)

Mutual information I(X,Y) = 0.061573bits

z= [' The Channel capacity of channel is C = ',num2str(c), 'bits/sec' ];
disp(z)

The Channel capacity of channel is C = 0.081704bits/sec
```

COMMAND WINDOW:-

enter probability of x1 =

3/4

Enter conditional probability P(y1/x1)= p =

2/3

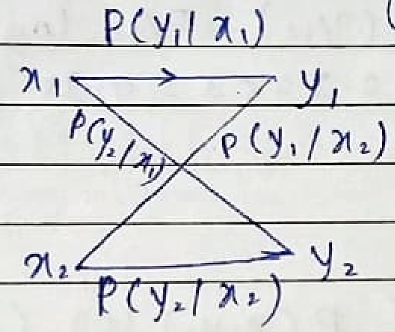
Q

Q. ⇒ Given :- $p(x_1) = 3/4$ $\quad p(x_2) = 1/4$

$p = 2/3$ $\quad (1-p) = 2/3$

To find :- $H(x)$, $H(y)$, $H(x,y)$, $H(x/y)$, $H(y/x)$

Step-1 :- Draw Channel diagram.



Step-2 :-

$$H(x) = p(x_1) \log_2 p(x_1) - p_2(x_2) \log_2 p(x_2)$$

$$= -\frac{3}{4} \log_2 (0.75) - \frac{1}{4} \log_2 (0.25$$

$$= 0.3113 + 0.5 = 0.8113 \text{ bits/msg}$$

Step-3 :- Find $H(y)$ & $H(x,y)$

$$p(y/x) = \begin{array}{c|cc} & y_1 & y_2 \\ \hline x_1 & 1/3 & 2/3 \\ x_2 & 2/3 & 1/3 \end{array}$$

$$p(x) = [x_1 \; x_2] = [3/4 \;\; 1/4]$$

$$p(x_1, y_1) = p(x_1) \cdot p(y_1/x_1) = \frac{3}{4} \times \frac{2}{3} = \frac{1}{2}$$

$$p(x_1, y_2) = p(x_1) \cdot p(y_2/x_1)$$

$$= 3/4 \times 1/3 = 1/4$$

$$p(x_2 y_1) = p(x_2) \cdot p(y_1/x_2) = 1/4 \times 1/3 = 1/12$$

$$p(x_2, y_2) = p(x_2) \cdot p(y_2/x_2) = 1/4 \times 2/3 = 1/6$$

$$P(x,y) = \begin{bmatrix} 1/2 & 1/4 \\ 1/12 & 1/6 \end{bmatrix}$$

$P(y_2) = P(x_1 y_2) + P(x_2 y_1) = 1/4 + 1/6 = 5/12$

$P(y_1) = P(x_1 y_1) + P(x_2 y_1) = 1/2 + 1/12 = 7/12$

$H(y) = P(y_1) \log_2 (y_1) - P(y_2) \log_2 (y_2)$

$= -7/12 \log_2 (7/12) - 5/12 \log_2 (5/12)$

$= 0.4536 + 0.5263 = 0.98$ bits/msg.

To find $H(xy)$

$$H(xy) = \sum_{j=1}^{m} \sum_{k=1}^{n} P(x_1 y_1) \log_2 (P(x_1 y_k))$$

$H(xy) = -1/12 \log_2 (1/12) - 1/4 \log_2 (1/4)$

$= -1/12 \log_2 (1/12) - 1/4 \log_2 (1/6)$

$H(xy) = 1.73$ bits/msg.

Find $H(x/y)$, $H(y/x)$; $I(X:Y)$

$H(x/y) = H(xy) - H(y)$

$= 1.73 - 0.98$

$= 0.75$ bits/msg.

$H(y/x) = H(xy) - H(x) = 1.73 - 0.8113$

$= 0.9187$ bits/msg.

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$I(X;Y) = H(X) - H(X/Y) = (0.8113 - 0.75)$
$= 0.0613$ bits/msg.

$C = I_{max}(XY)$
$= 1 - H(P)$
$= 1 - \left[p \log_2 \frac{1}{p} + (1-p) \log_2 \frac{1}{1-p} \right]$

$\therefore C = 0.0817$ bits/sec.

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Subject: Digital Communication

Experiment No: **Title:** Simulation study of Performance of M-ary PSK .

Name: Prasad - Nikam
Class: TE - A
Roll no: 58

Date Of performance:
Date of Submission:
Signature:

OBJECTIVE:

1. Generate transmitter constellation of M-PSK of different M=2,4,8,16
2. Generate receiver constellation of M-PSK of different M=2,4,8,16 for different SNR.
3. Plot BER VS SNR of M-PSK of different M=2,4,8,16
4. Conclude

Definition of M-ARY PSK

M-ary phase shift keying or MPSK is a modulation where data bits select one of M phase shifted versions of the carrier to transmit the data. Thus, the M possible waveforms all have the same amplitude and frequency but different phases. The signal constellations consist of M equally spaced points on a circle, $M=2^n$ where n is integer no. 1, 2, 3, - - - - -

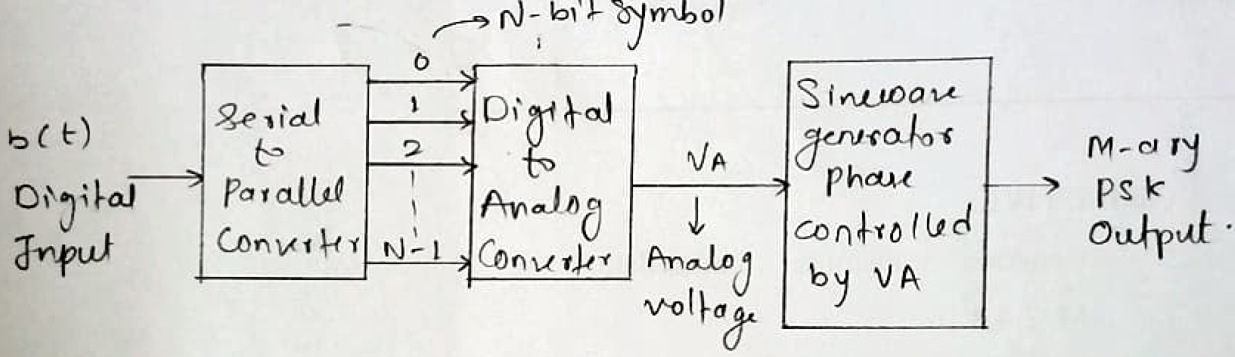
Mathematical expression of M-ARY PSK

$2^N = M$ possible symbols. These M symbols are represented by sinusoidal signals of duration $T_s = NT_b$ which differ from one another by phase $2\pi/M$ radians thus the M-ary PSK waveform can be mathematical represented as,

$$V_{M\text{-}ary\ PSK} = \sqrt{2P_s}\cos(\omega_c t + \phi_m)$$

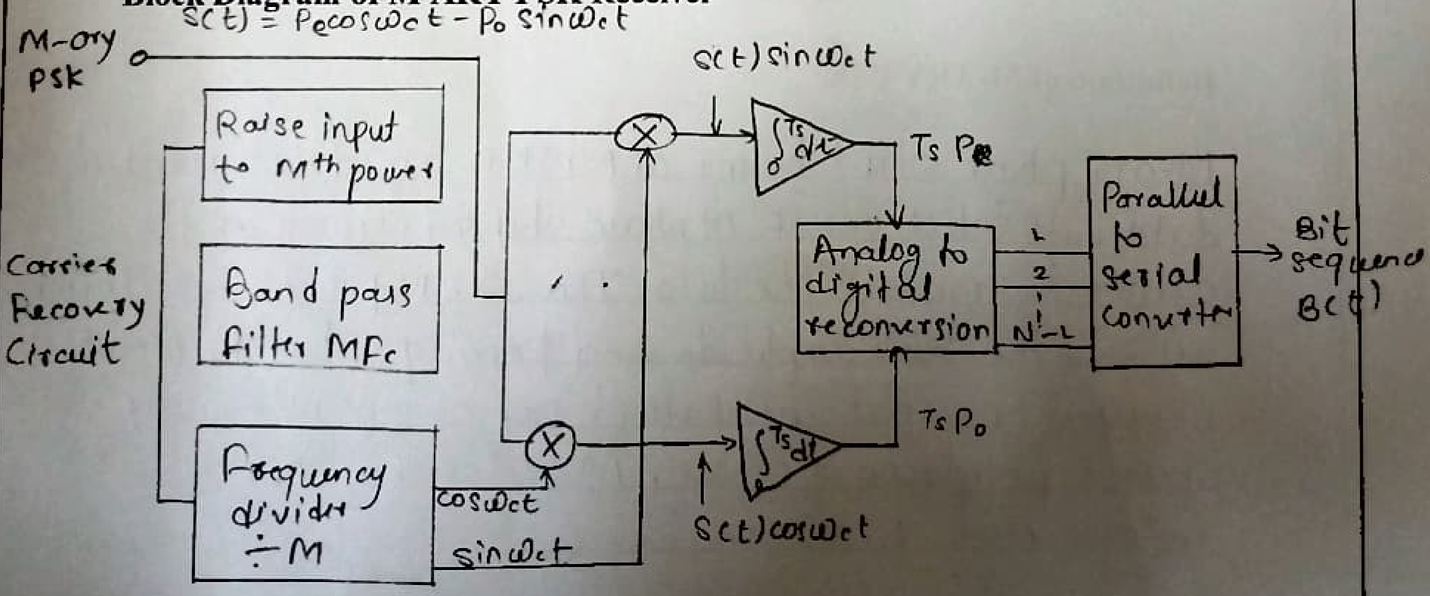
Where, $m = 0, 1, 2, 3, \ldots M-1$

Block Diagram of M ARY PSK Transmitter

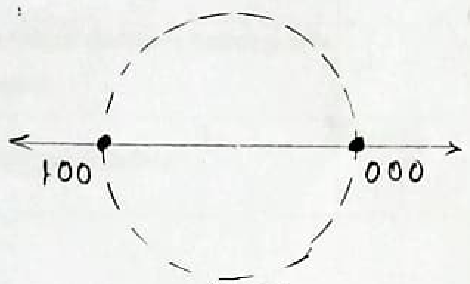
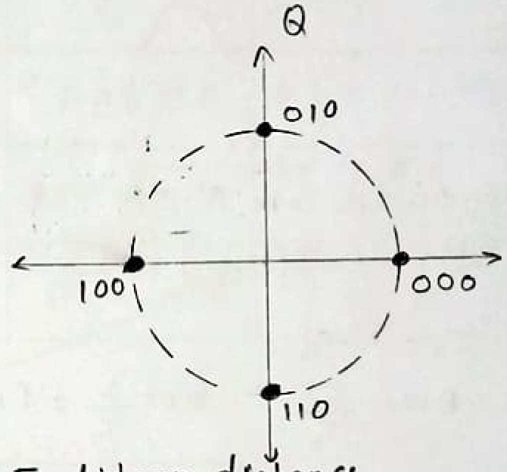
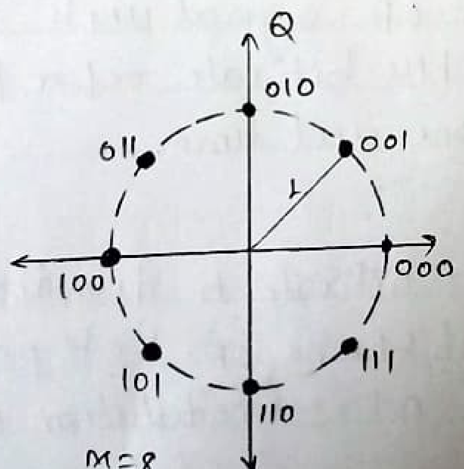
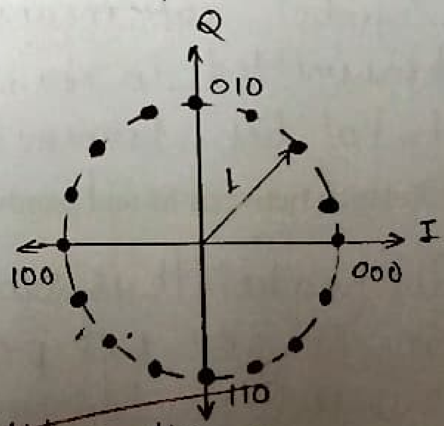


(M-ary Transmitter)

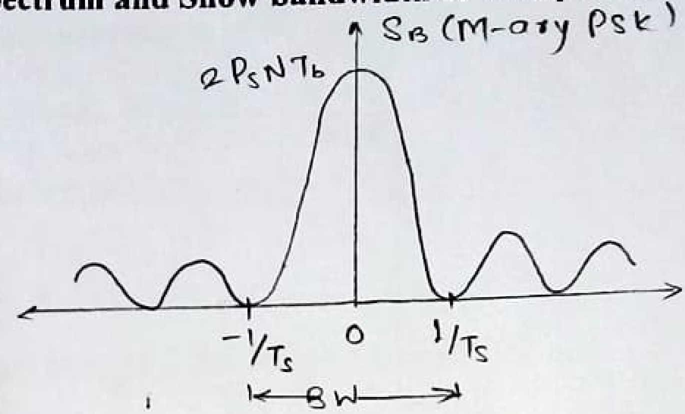
Block Diagram of M ARY PSK Receiver



Constellation diagram of M PSK of M=2,4,8,16 and show Euclidean distance

M=2	M=4
 M=2 Euclidean distance $d = 2\sqrt{E_s}\,\sin(\pi/M)$ $d = 2\sqrt{E_s}\,\sin(\pi/2)$	 Euclidean distance $d = 2\sqrt{E_s}\,\sin(\pi/M)$ $d = 2\sqrt{E_s}\,\sin(\pi/4)$
M=8	**M=16**
 M=8 Euclidean Distance $d = 2\sqrt{E_s}\,\sin(\pi/M)$ $d = 2\sqrt{E_s}\,\sin(\pi/8)$	 Euclidean distance $d = 2\sqrt{E_s}\,\sin(\pi/m)$ $d = 2\sqrt{E_s}\,\sin(\pi/16)$

Draw Spectrum and Show bandwidth of M ary PSK



Bandwidth of M-ary PSK

$$BW = \frac{1}{T_s} - \left(-\frac{1}{T_s}\right) = \frac{2}{T_s}$$

$$T_s = N T_B$$

$$BW = \frac{2}{T_b} \quad , \text{ but } \frac{1}{T_b} = f_b$$

$$\therefore \boxed{BW = \frac{2F_b}{N}}$$

Conclusion:-

1. Relation between Symbol rate and bit rate

Symbol rate means total no. of signal units transmitted in one second while bit rate refer to total bit transmitted in one unit time

2. Relation between M and bandwidth

The bandwidth is symbol rate = bit rate b divided by no. of bit per symbol. the no. of bits per symbol is log 2 m within M is modulation order.

3. Relation between M and BER

M is PSK modulation order while BER is number of acceptable errors to tolerate.

Question:

Parameters	BPSK	QPSK	16-ARY PSK
Symbol duration	$T_s = T_b$	$T_s = 2T_b$	$N \cdot T_b = T_s$
Symbol rate	$1/T_s$	$1/T_s$	$1/T_s$
Bandwidth	$2f_b$ Hz	f_b Hz	$2f_b/N$ Hz
Euclidian distance between two symbol	$d = 2\sqrt{E_b}$	$d = 2\sqrt{P_s T_b}$ $= 2\sqrt{E_b}$	$d = 2\sqrt{E_s}$ $\sin(\pi/m)$
Error probability	$P_e = 1/2 \; erfc \sqrt{\frac{0.6E}{N_0}}$ E	$P_e = erfc \sqrt{\frac{E_b}{N_0}}$	$P_e(m) = erfc \left[\frac{E_s}{N_0} \sin\frac{\pi}{m}\right]$

Explain BER vs SNR of M PSK Graph

Q. Explain BER and SNR of MPSK graph.

→ BER (Bit error rate) is measure of the quality of digital communication system it qualifies the probability of an incorrect bit ~~too~~ being received at receiver compares to transmitted bit lower BER indicate better system performance.

SNR (Signal to Noice Ratio) is of the power at signal to power of noise in the channel.

Higher SNR indicate a stronger & more reliable signal.

The BER v/s SNR graph helps to visualize the system performance under different level of noise.

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Subject: Digital Communication

Experiment No: **Title: Study of Source Coding Technique.**

Name: Prasad Nikam **Date Of performance:**

Class: TE-A **Date of Submission:**

Roll no: 58 **Signature:**

AIM: GENERATION AND EVALUATION OF HUFFMAN CODING METHOD.

OBJECTIVE:

1. Implementation of algorithms for generation and evaluation using Huffman coding
2. Find Entropy of source.
3. Find average codeword length.
4. Check coding efficiency and redundancy.

PREREQUISITE:

Students should know the concept of fixed length source coding, variable length source coding and Prefix condition.

THEORY:

In computer science and information theory, a **Huffman code** is a particular type of optimal prefix code that is commonly used for lossless data compression. The process of finding and/or using such a code proceeds by means of **Huffman coding,** an algorithm developed by David A. Huffman while

4. Above procedure is repeated until we have two messages left out for which a 0 and a 1 is assigned.

5. The code for each message is found by going backward from last reduction till the message such that we trace the sequence of 1s and 0s leading to the message.

ALGORITHM:

1. List sources symbols (messages) in the order of decreasing probability.

↓

2. The two source symbols of lowest probability are assigned numbers 0 & 1.

↓

3. These two source symbols are combined into a new message.

↓

4. The probability of this new message is equal to the sum of probabilities of the 2 original symbols.

↓

5. The probability of this new message is placed in the list according to its value.

↓

6. Repeat this procedure until we are left with only two source ~~symbols~~ symbols for which a 0 and a 1 are assigned.

CONCLUSION: Huffman coding technique is constructed based on the set of symbols & their probabilities & it is used for data compression. Hence we have learnt that implementation and other concepts of Huffman coding.

QUESTIONS:

1. Explain How VLC is better than FLC technique
2. What is principle of source coding techniques and why we need source coding technique?
3. What is prefix condition?

Q.1. Explain the VLC is better than FLC tech.

→ Variable-length codes (VLC'S) are widely used in media transmission compared to fixed-length codes (FLC'S), VLC'S can represent the same message with lower bit rate, thus having a better compression performance but inevitably VLC'S are very sensitive to transmission error.

Q.2 What is principle of source coding technique & why we need source coding technique.

→ Source coding tech operator on principle of exploting red undeak and statistical principle in source data to represent it more efficiency.
The aim of source coding is to represent information as accurately as possible using as few bits as possible and in order to do redundancy from the source needs to be removed.

Q.3. What is prefix condition?

→ It refers to a property of codes used in variable length encoding scheme prefix code are types of uniquely decodable code in which no codewords is prefix of matter codeword it is important for efficiency, unambigorow decoder.

Q.4. State example of source coding tech.

→ Consider an example of source coding technique using Huffman coding. Huffman coding is a widely used technique for lossless data compression particularly in text & file compression.

Q.5. Write advantages of Huffman coding on Shannon Fannon coding tech.

→ ① Optimality.
② Lossless Compression.
③ Wider Applicability.
④ Efficiency encoding & decoding.
⑤ Simplicity.
⑥ Divide & Conquer approach.

Q.6. Is Huffman coding source coding technique & Explain.

→ Certainly Huffman coding is widely used source coding technique. In the field of data compression it is designed to efficiency represent data by assigned shorter codes to more frequent symbol.

7) Is Huffman coding VLC or FLC & Explain.

→ Here is why Huffman coding is considered to be a variable - length coding.

① In variable - length coding.
In Huffman coding symbol is represent a binary codes, length of these binary codes varies more frequent symbol get shorter data of codes, resulting in variable length code.

Q.8. Write procedure for Huffman Coding technique.
→ Huffman code for given set of symbol & their tech. You can follow their step-to-procedure.

① Frequency Analysis
② Creating leaf nodes.
③ Priority queue.
④ Construction the Huffman tree.
⑤ Assigning binary codes.
⑥ Generating Huffman code.
⑦ Encoding.
⑧ Decoding.
⑨ Compression & decomposition.

Q.9 Write procedure for Shannon Fano technique procedure.
For Shanon Fano coding technique as follows
→ ① Freq analysis.
② Sorting Symbol.
③ Creating initial group.
④ Divide & assign code.
⑤ Repeat step-4.
⑥ Generating Shanon Fano coding.
⑦ Encoding.
⑧ Decoding.
⑨ Compression & decompression.

Q.10 State Shannon Fano second & third theorem.

→ ① First theorem (Noiseless coding theorem):
It states that here a describe memory less source with set of symbol & their associated probability there exist a uniquely decode whose avg code length is bounded by source entropy.
Mathematical expression.

$$H(X) <= L < H(x) + 1.$$

Where $H(x)$ is an entrophy.

② Second theorem:
It is called noise coding theorem which deals with reliable transmission i.e. which states that from any given code rate below that the channel capacity there exist on encoding & decoding scheme such that exists on encoding & decoding scheme such that probability of error in transmission approaches zero as B.P.

③ Third theorem.
It states that communication system involving a source a noisy channel & receiver the optimal strategy for encoding & decoding can be separated into 2 distinct stages without loss of optimality.

Q.11 ② Define code efficiency
Code efficiency is a crucial consideration various application including data compression the higher the code efficiency the more compact the data is represented.

Q.12. Obtain the ...

Q.12. Obtain the encoding efficiency of Shannon fano & Huffman code for non zero memory source that exist message (O,N,H, A,E,S) with probability attribut of {0.19, 0.15, 0.02, 0.16, 0.4, 0.08} respectively.

→ Shannon fano code.

Message	Probability	Step 1	2	3	4	code.
E	0.4	0	0			00
O	0.19	0	1			01
A	0.16	1	0			10
N	0.15	1	1	0		110
S	0.08	1	1	1	0	1110
H	0.01	1	1	1	1	1111

Average information per message (H)

$$H = \sum_{i=1}^{M=6} p(x_i) \log_2 [1/p(x_i)]$$

$$= 0.4 \log_2 (1/0.4) + 0.19 \log_2 (1/0.19) + 0.16 \log_2 (1/0.16) + 0.15 \log_2 (1/0.15) + 0.08 \log_2 (1/0.08) + 0.02 \log_2 (1/0.02)$$

$H = 2.22$ bit/message.

Average codeword length.

$$L = \sum_{i=1}^{m} p_k \times (\text{length of m in bits})$$

$$= (0.4 \times 2) + (0.19 \times 2) + (0.16 \times 2) + (0.15 \times 3) + (0.08 \times 4) + (0.02 \times 4)$$

$L = 2.35$ bit/message.

Code efficiency

$$\eta = \frac{H}{L} \times 100 = \frac{2.22}{2.35} \times 100 = 94.47\ \%$$

Huffman's code :-

Message	Stage	I	II	III	IV
E	0.4	0.4	0.4	0.4	0.6
G	0.19	0.19	0.25	0.35	0.4
A	0.16	0.16	0.19	0.25	
N	0.15	0.15	0.16		
S	0.08	0.1			
H	0.02				

(2) Average information per message (H)

$$H = \sum p(x_i) \times \log_2 [1/p(x_i)]$$

$H = 2.22$ bits/message as part I is calculate.

(3) Average code length (L) :-

$$L = \sum_{k=1}^{6} P_k \times (\text{length of main bits})$$

$$L = (0.4 \times 1) + (0.19 \times 3) + (0.16 \times 3) + (0.15 \times 3) + (0.08 \times 4) + (0.02 \times 4)$$

$L = 2.3$ bits/message.

(4) Code efficiency

$$\eta = \frac{H}{L} \times 100 = \frac{2.22}{2.3} \times 100 = 96.52\%$$