UNIT V

DIGITAL MODULATION

① BASE BAND TRANSMISSION

- LINE CODING (RZ, NRZ)
- ISI
- PULSE SHAPING
- NIQUIST CRITERION
- RAISED COSINE SPECTRUM

② PASS BAND TRANSMISSION

- GEOMETRIC INTERPRETATION of SIGNAL
- orthogonalization
- ASK, PSK, FSK, QPSK, MSK modulation Techniques, coherent detection & Calculation of error Probabilities.

A Base Band Digital Communication System

A Baseband digital communication system is made up of several elements :-

1. Source :- The input to a digital system is in the form of sequence of digits. The Input can be the output from such sources as a data set, a computer, a digitized voice signal (PCM or DM).
2. Multiplexer :- Generally speaking, the capacity of a practical channel of transmitting data is much larger than the data rate of individual sources.

To utilize this capacity effectively, we combine severel sources through a digital multiplexer using the process of interleaving. Thus a channel is time shared by several messages simultaneously.

3. Line Coder :- The output of a multiplexer is coded into electrical pulses or waveforms for the purpose of transmission over the channel.
This process is known as line coding or transmission coding.

There are severel possible ways of assigning waveforms (pulse) to a digital data.
Concepually the simplest line code is ON-OFF, where a 1 is transmitted by a pulse p(t) & a 0 is transmitted by no pulse (zero signal).

4. Regenerative Repeater :-

Regenerative Repeater are used at regularly spaced intervals along a digital transmission line to detect the incoming digital signal & regenerate new clear pulses for further transmission along the line.

LINE CODING & ITS PROPERTIES

The Digital Data can be transmitted by various Tx or line codes such as ON-OFF, Polar, bipolar & so on. This is called line coding. Each type of line coding has its Advantages & disadvantages.
Thus Among the other desirable properties, a line code must have following properties.

① Transmission Bandwidth

for a line-code, the transmission Bandwidth must be as small as possible.

② Power Efficiency

for a given Bandwidth and a specified detection error probability, the transmitted power for a line code ~~[illegible]~~ should be as small as possible.

③ Error Detection & Correction Capability

It must be possible to detect & preferably correct detection error probability, the transmitted power for a line code should be as small as possible.

④ favourable Power spectral density

It is desirable to have zero power spectral density (PSD) at $\omega = 0$.

⑤ Adequate timing content

It must be possible to extract timing or clock information from the signal.

⑥ Transparency

It must be possible to transmit a digital signal correctly regardless the pattern of 1's & 0's.

VARIOUS PAM FORMATS OR LINE CODES

(i) Non-Return to Zero (NRZ) & Return to Zero (RZ) Unipolar format

(ii) NRZ & RZ polar format

(iii) Non Return to Zero Bipolar format

(iv) Manchester format

(v) Polar Quaternary NRZ format

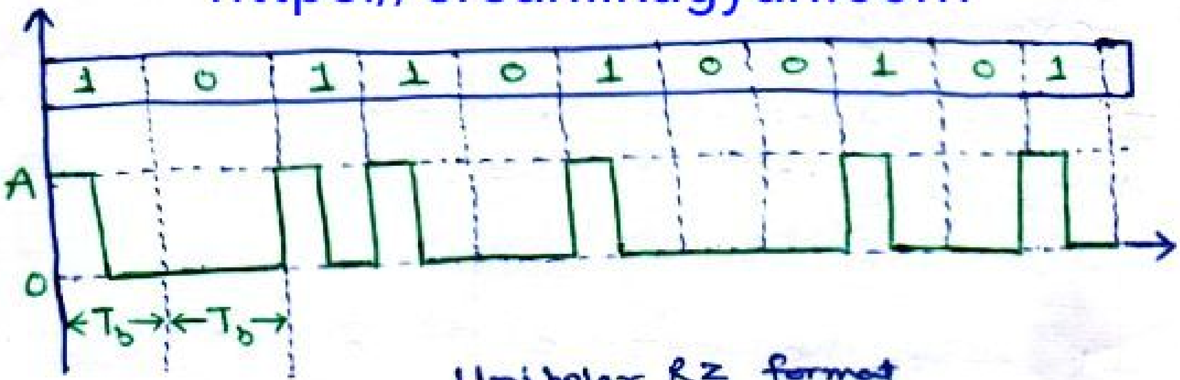
UNIPOLAR RZ & NRZ

In Unipolar format the waveform has a single polarity. The waveform can have +5 or +12 volt when high. The waveform is simple ON – OFF.

UNIPOLAR RZ: waveform & Expression

In the Unipolar RZ form, the waveform has zero value when symbol '0' is transmitted & waveform has 'A' volts when '1' is transmitted.

In RZ form, the 'A' volts is present for $T_b/2$ period if symbol '1' is transmitted & for remaining $T_b/2$, waveform return to zero value that is for Unipolar.



Unipolar RZ format

If symbol 1 is Transmitted, then we have

$$x(t) = \begin{cases} A & \text{for } 0 \le t < T_b/2 \text{ (Half Inter)} \\ 0 & \text{for } T_b/2 \le t < T_b \text{ (Half Inter)} \end{cases}$$

& if symbol 0 is Transmitted then

$$x(t) = 0 \quad \text{for } 0 \le t < T_b$$

(Complete Interval)

Hence in Unipolar RZ format, each pulse return to a zero value.

UNIPOLAR NRZ :- Waveform & Expression

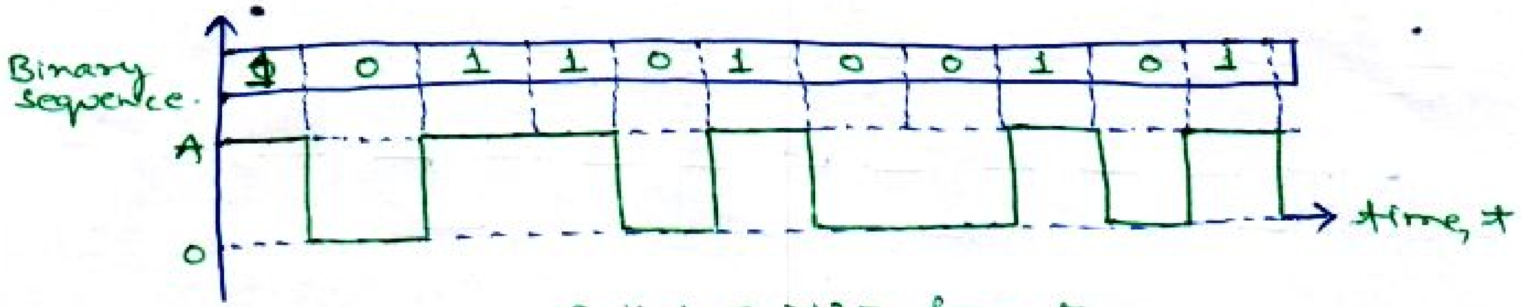
A Unipolar NRZ is Non-Return to zero.
when symbol '1' is to be transmitted, the signal has 'A' volts for full duration.
when symbol '0' is to be transmitted, the signal has zero volts (no-signal) for complete symbol Duration.

Thus for Unipolar NRZ format
If symbol '1' is transmitted, we have

$$x(t) = A \quad \text{for} \quad 0 \leq t < T_b \text{ (Complete Interval)}$$

If symbol '0' is transmitted, we have

$$x(t) = 0 \quad \text{for} \quad 0 \leq t < T_b \text{ (Complete Interval)}$$



Unipolar NRZ format

Important Points.

(i) for NRZ, it may be observed that the pulse does not Return to zero on its own. If the symbol '0' transmitted, then pulse becomes zero.
(ii) Internal computer waveforms are usually of Unipolar NRZ type.
(iii) Because there is no seperation between the pulses, therefore, the Reciever needs synchronization to detect Unipolar NRZ pulse.
(iv) As compared to RZ, NRZ pulse width is more. Thus Energy of the pulse is more.
(v) Unipolar format has some average DC value. This DC value does not carry any Information.

POLAR RZ & NRZ

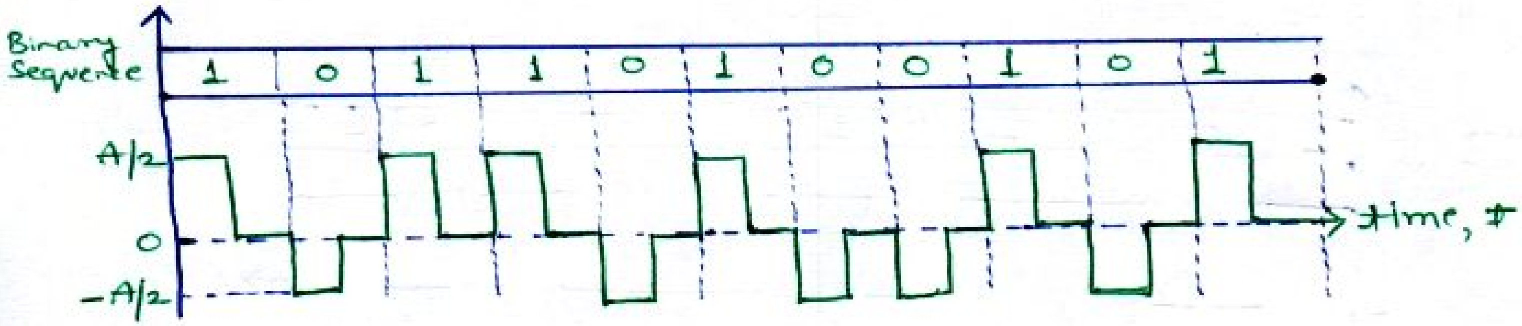
1) POLAR RZ - WAVEFORM & EXPRESSION

In the Polar RZ format, symbol '1' is represented by + voltage polarity whereas symbol '0' is represented by − voltage polarity. Because this is RZ format, the pulse is transmitted only for half duration. Thus for polar RZ, if symbol '1' is transmitted, then

$$x(t) = \begin{cases} +\frac{A}{2} & \text{for } 0 \le t < T_b/2 \\ 0 & \text{for } T_b/2 \le t < T_b \end{cases}$$

& if symbol '0' is transmitted, then

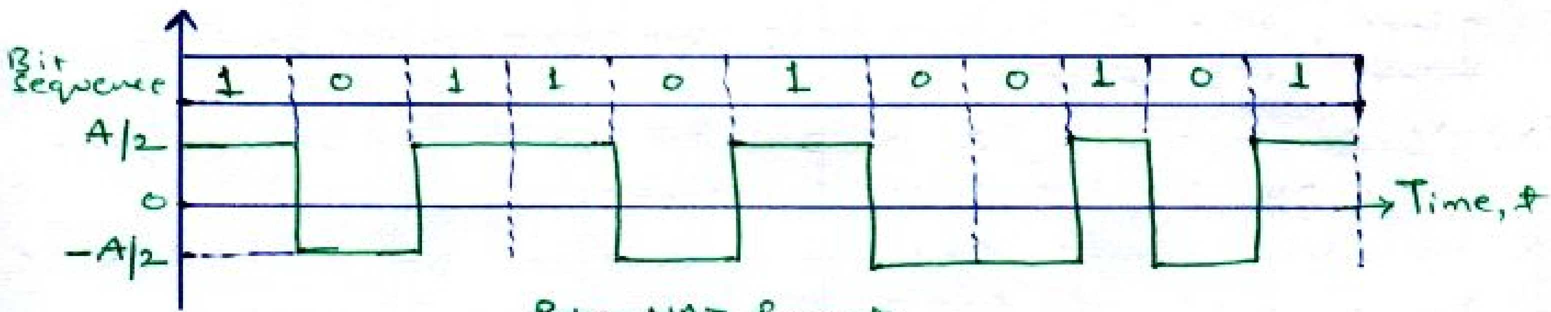
$$x(t) = \begin{cases} -\frac{A}{2} & \text{for } 0 \le t \le T_b/2 \\ 0 & \text{for } T_b/2 \le t < T_b \end{cases}$$



Polar RZ format

2. Polar NRZ: Waveform & Expression

In Polar NRZ format, symbol '1' is represented by positive polarity & symbol '0' is represented by negative polarity. These polarities are maintained over the complete pulse duration, i.e.. for polar NRZ, we have.



Polar NRZ format.

If symbol '1' is transmitted, then

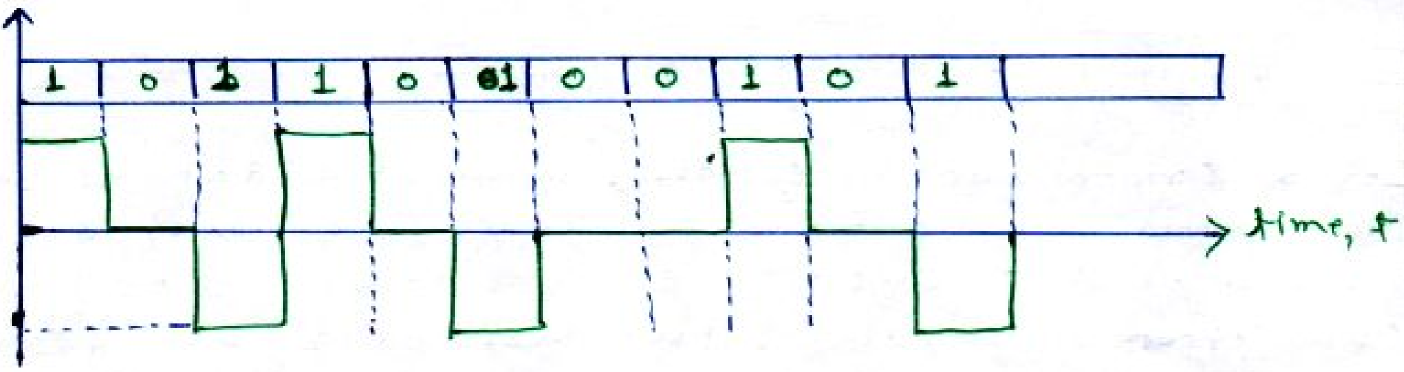
$$x(t) = +\frac{A}{2} \quad \text{for} \quad 0 \le t < T_b$$

& if symbol '0' is transmitted, then

$$x(t) = -\frac{A}{2} \quad \text{for} \quad 0 \le t < T_b$$

BIPOLAR NRZ [Alternate Mark Inversion] (AMI)

Definition :- In this format, the successive '1's are represented by pulses with alternate polarity & '0's are represented by no pulses.



Bipolar NRZ format (AMI)

SPLIT PHASE MANCHASTER FORMAT.

Definition & waveform :-

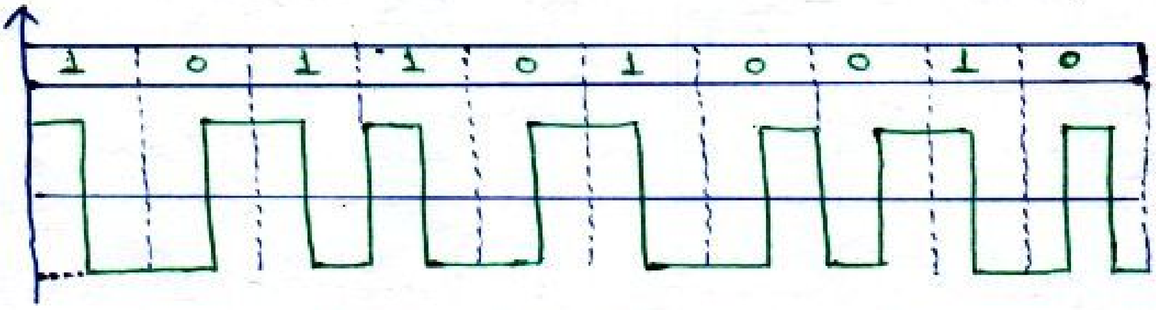
This type of waveform is shown in fig. In this case if symbol '1' is to be transmitted, then a positive half interval pulse is followed by a negative half interval pulse. If symbol '0' is to be transmitted, then a negative half interval pulse is followed by a positive half interval pulse. Hence for any symbol the pulse takes positive as well as negative value.

If symbol '1' is to be transmitted, then

$$x(t) = \begin{cases} \frac{A}{2} & \text{for} \quad 0 \le t < T_b/2 \\ -\frac{A}{2} & \text{for} \quad \frac{T_b}{2} \le t < T_b \end{cases}$$

& if symbol '0' is to be transmitted, then

$$x(t) = \begin{cases} -\frac{A}{2} & \text{for } 0 \le t < \frac{T_b}{2} \\ \frac{A}{2} & \text{for } \frac{T_b}{2} \le t < T_b \end{cases}$$



Split phase Manchester format

Intersymbol Interference (ISI)

In a communication system, when the data is being transmitted in the form of pulses (i.e... bits), the o/p produced at the reciever due to other bits or symbol interferes with the output produced by the desired bit. This is known as Intersymbol Interference (ISI)
The Intersymbol Interference will introduce errors in the detected signal.

factors Responsible for ISI

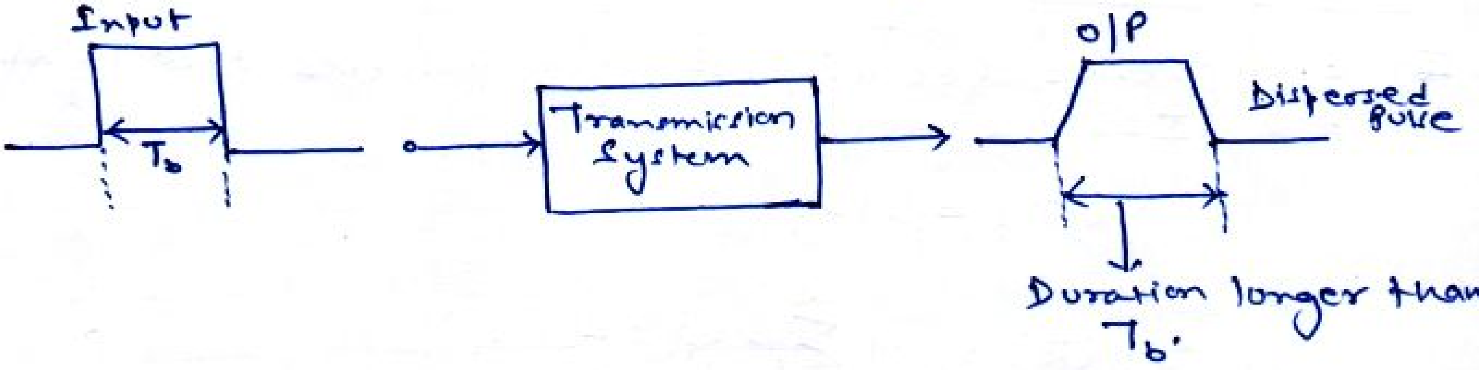
The Intersymbol Interference arrises due to the imperfections in the overall frequency response of the system when a short pulse of duration T_b sec. is transmitted through a band limited system, then the freq. components contained in the input pulse are differentially attenuated & more importantly differentially delayed. by the system..

Due to this the pulse Appearing at the output of the system will be dispersed over an Interval which is longer than T_b sec.

Due to this dispersion, the symbols each of duration T_b

will interfere with each other, when transmitted over a communication channel.

This will result in the intersymbol interference (ISI)



Cause of ISI

Effects of ISI

(i) In the Absence of ISI & Noise, the transmitted bit can be decoded correctely at the Receiver.

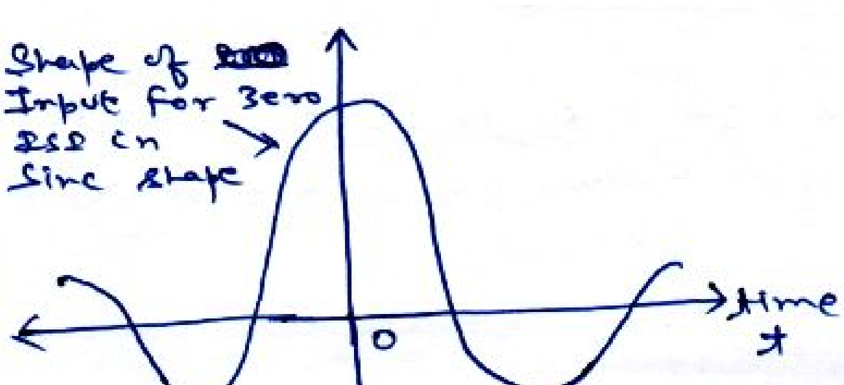
(ii) The presence of ISI will introduce errors in the decision at the receiver output.

(iii) Hence, the receiver can make an error in deciding whether it has received a logic 1 or a logic 0.

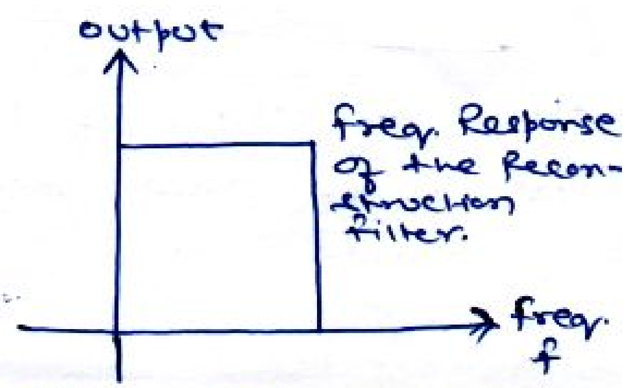
Remedy to Reduce ISI

(i) It has been proved that the function which produces a zero intersymbol interference is a sinc function. Hence, instead of a rectengular pulse if we transmit a sinc pulse then the ISI can be reduced to zero.

(ii) This is known as Niqwist pulse shaping. The sinc pulse transmitted to have a zero ISI. is shown below.



(a) Ideal pulse shape for zero ISI.



(b) freq. Response of filter.

NIQUIST CRITERION FOR DISTORTIONLESS BASEBAND BINARY TRANSMISSION

1. BASIC CONCEPT:-

In the previous section, we have observed that in Absence of the ISI, we have

$$y(t_i) = \mu \alpha_i$$

&

$$y(t) = \mu \sum_{k=-\infty}^{\infty} \alpha_k p(t - kT_b)$$

This shows that o/p $y(t)$ is dependent on α_k, the recieved pulse $p(t)$ & the scaling factor μ.

2. Extraction:-

Extraction is basically the process of sampling. The ~~sample~~ signal $y(t)$ is sampled at $t = iT_b$

3. Decoding:-

The decoding should be such that the contribution of the weighted pulse that is $\alpha_k p(iT_b - kT_b)$ for $i=k$ be free from ISI.

4. frequency Domain Representation:-

$$\boxed{\sum_{n=-\infty}^{\infty} P(f - nR_b) = \frac{1}{R_b} = T_b}$$

this Expression is called as the Niquist Criterion for distortionless baseband transmission is the Absence of Noise.

5. Pulse Shaping :-

In digital comm^n., pulse shaping is the process of changing the waveform of transmitted pulse.

Its purpose is to make the transmitted signal suit better to the communication channel by limiting the effective bandwidth of the transmission, by filtering the transmitted pulses this way, the ISI caused by the channel can be kept in control in RF-Communication.

Typical pulse shaping occurs after the line coding & before Modulation.

6:- Criterion :-

The freq. response of the channel & the transmitted pulse shape are specified & the problem is to determine the freq. response of the transmit & reciever filters.

So as to reconstruct the original binary data sequence $\{b_k\}$.

This can be done by the extracting & then decoding the corresponding sequence of co-efficients, $\{a_k\}$. for the O/P $y(t)$ at the receiver.

The Extraction involves sampling the O/P $y(t)$ at time $t = iT_b$.

we can say that the condition for zero ISI is satisfied if

$$\boxed{\sum_{n=-\infty}^{\infty} = P(f - nR_b) = T_b}$$

RAISED COSINE SPECTRUM

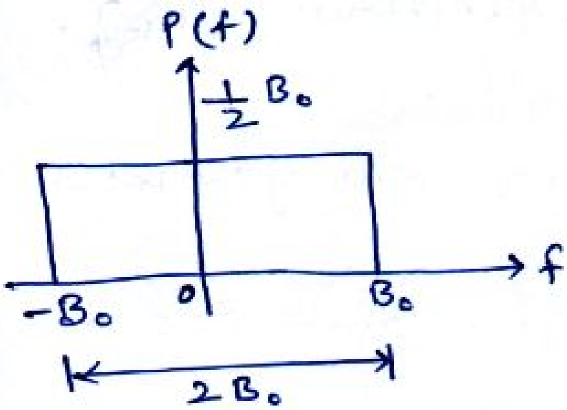
The Two difficulties experienced by the ideal Nyquist channel can be overcome by increasing the bandwidth from its minimum value $B_0 = R_b/2$ to an Adjustable value between B_0 & $2B_0$.

A condition is put on the overall freq. response $P(f)$ to satisfy the given condition.

Difficulties.

(i) It is necessary that the Amplitude characteristics of $P(f)$ should be flat from $-B_0$ to B_0 & zero outside the band.
But Abrupt transition at $\pm B_0$ is not physically relizable.

(ii) Due to Discontinuty of $P(f)$ at $\pm B_0$, there is practically no margin of error is sampling times at the reciever end.



(a) Graphical Representation of $P(f)$

Types of digital Modulation Technique:-

Basically, digital modulation techniques may be classified into cohrent or non co-horent techniques, depending on whether the reciever is equipped with a phase recovery circuit or not.

(i) Coherent digital Modn techniques.

Coherent digital modn techniques are those techniques which employ coherent detection. In coherent detection the local carrier generated at the reciever is phase locked ~~detection~~ with the carrier at the Transmitter. The coherent detection is synchronous detection.

(ii) Non-coherent digital modulation techniques:-

Non-coherent digital modulation techniques are those techniques in which the detection process does not need reciever carrier to be phase locked with Transmitter carrier.

COHERENT BINARY MODn TECHNIQUES.

There are three basic forms:-

(i) ASK (ii) FSK (iii) PSK

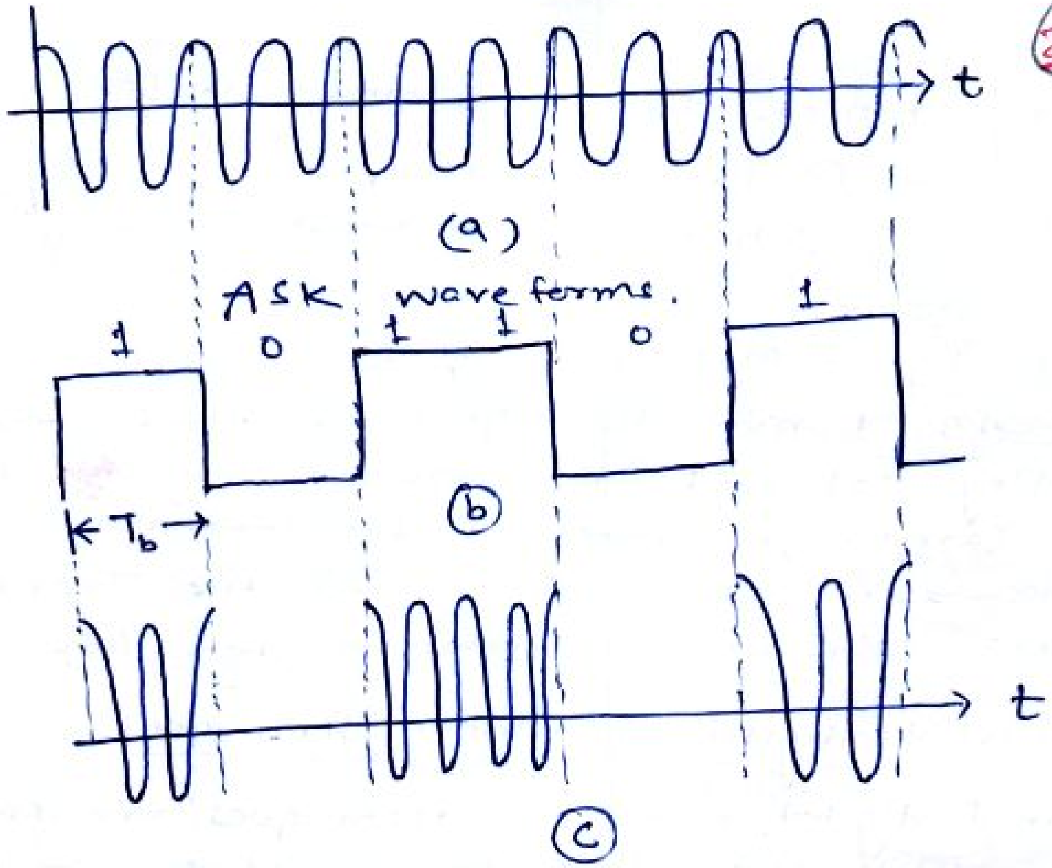
(i) Coherent Binary ASK or ON-OFF keying:-

Amplitude shift keying (ASK) or ON-OFF keying (OOK) is the simplest digital modulation technique. In this method there is only one unit energy carrier & it is switched on or off depending upon the input binary sequence. The ASK waveform may be represented as,

$$s(t) = \sqrt{2P_s}\ \cos(2\pi f_c t)$$

(To transmit 1)

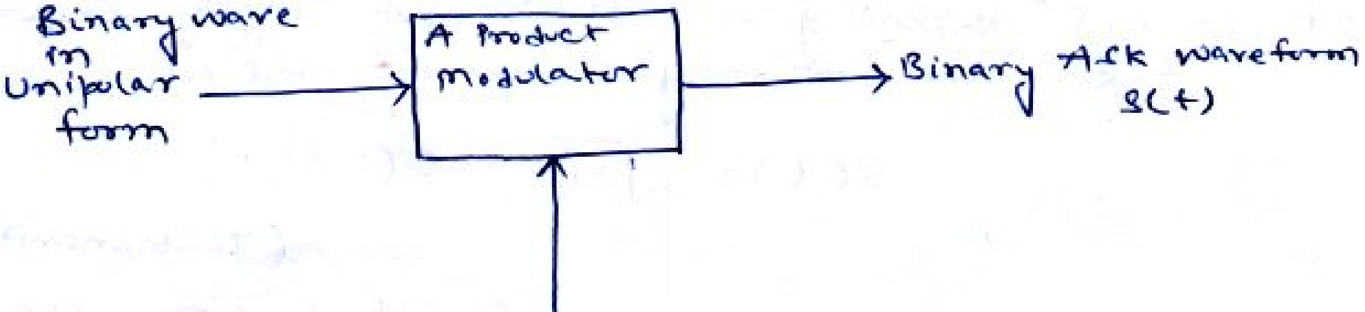
To transmit symbol '0', the signal $s(t) = 0$, that is no signal is transmitted. Signal $s(t)$ contains some complete cycles of carrier frequency 'f_c'.



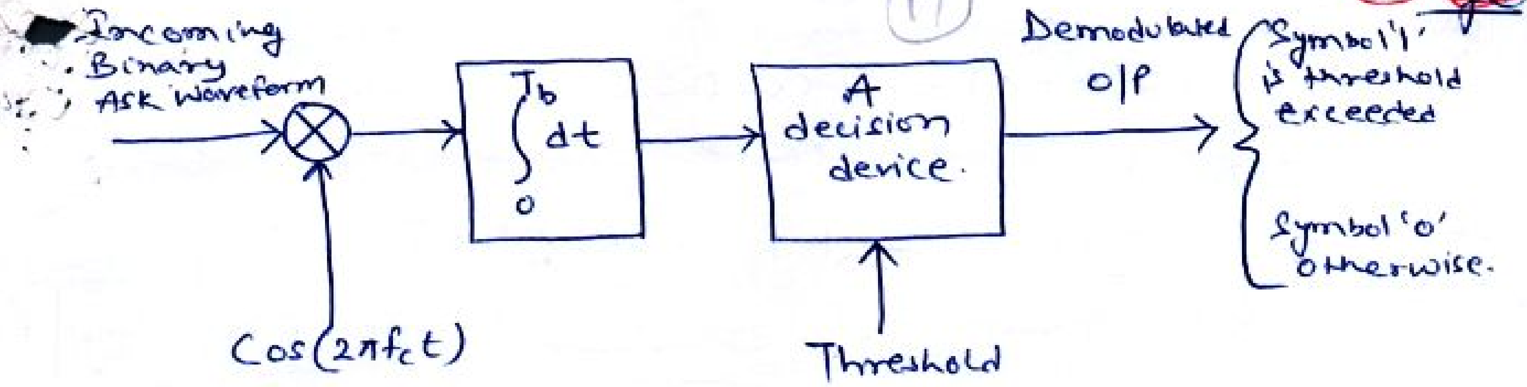
(a) Unmodulated Carriers.
(b) Uniplar Bit sequence.
(c) ASK waveforms.

Generation of ASK

ASK signal may be generated by simply Applying the incoming binary data & the sinusodial carrier to the two inputs of a product modulator. the resulting o/p will be the ASK waveform.



COHERENT DEMODULATION of ASK (Binary)



The Incoming ASK signal is Applied to one I/P of the product modulator. The other I/P of the product modulator is supplied with a sinusodial carrier which is Generated with the help of local oscillator.
The o/p of the product modulator goes to I/P of the Integrator.
Now the decision making device compares the o/p of the Integrator. It makes decision in favour of symbol '1' when the threshold is Exceeded & in favour of symbol '0' otherwise.

(ii) BINARY PHASE SHIFT KEYING (BPSK) :-

In a Binary phase shift keying the binary symbol '1' & '0' modulate the phase of the carrier.

Carrier is given as:

$$s(t) = A \cos(2\pi f_c t)$$

Here, A represents peak value of sinusodial carrier. The Power would be,

$$P = \frac{1}{2}A^2$$

or

$$A = \sqrt{2P}$$

Now when the symbol is changed, then the phase of the carrier will also be changed by an Amount of 180°.
Let us consider for Example.

for symbol '1', we have,

$$S_1(t) = \sqrt{2P}\cos(2\pi f_c t)$$

If next symbol is '0', then we have,

$$S_2(t) = \sqrt{2P}\cos(2\pi f_c t + \pi)$$

Now,

because $\cos(\theta + \pi) = -\cos\theta$

So the Last eq. can be written as,

$$s_2(t) = -\sqrt{2P}\cos(2\pi f_c t)$$

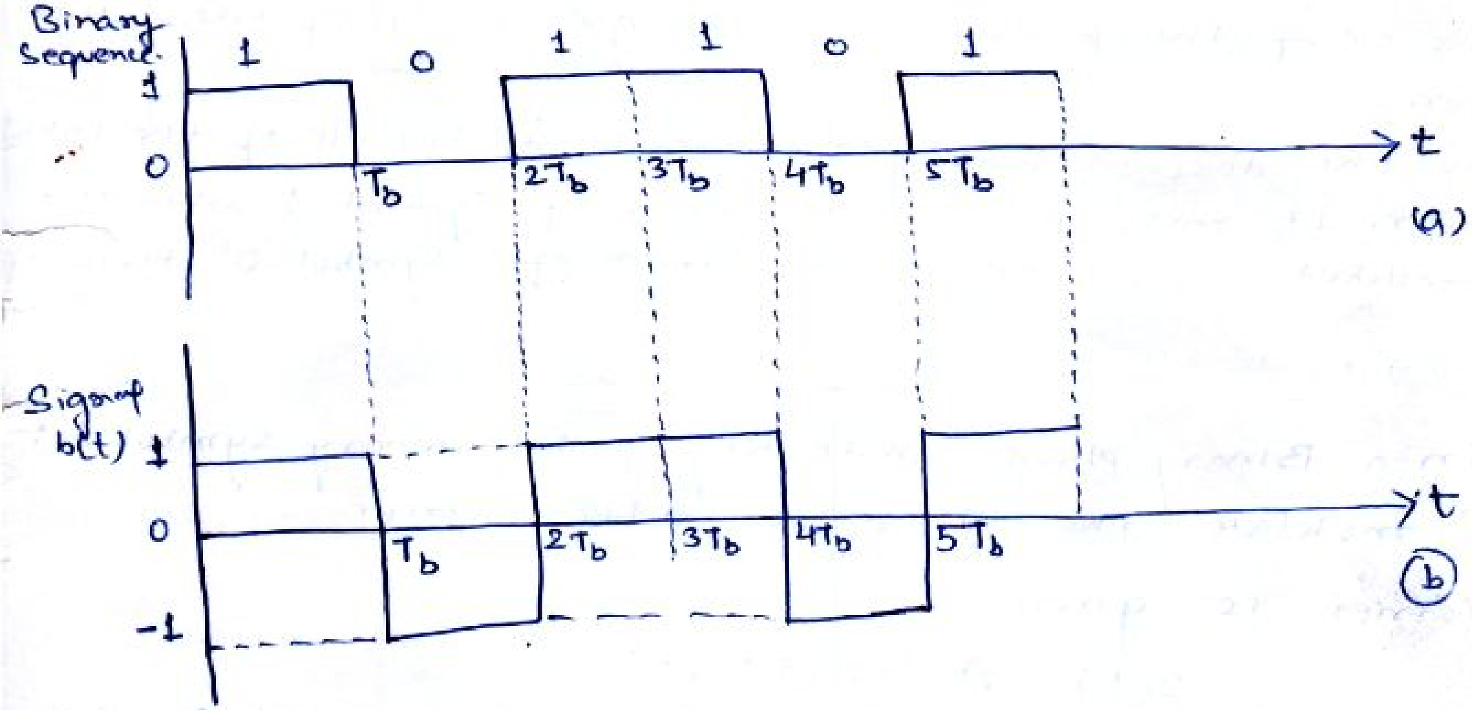
With the Above eq., we can define BPSK signal as,

$$s(t) = b(t)\sqrt{2P}\cos(2\pi f_c t)$$

where,

$b(t) = +1$ when binary '1' is to be transmitted.

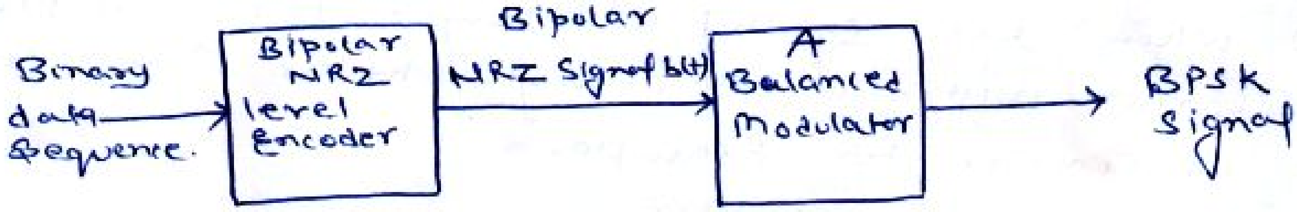
$= -1$ when binary '0' is to be transmitted.



(a) Binary sequence.

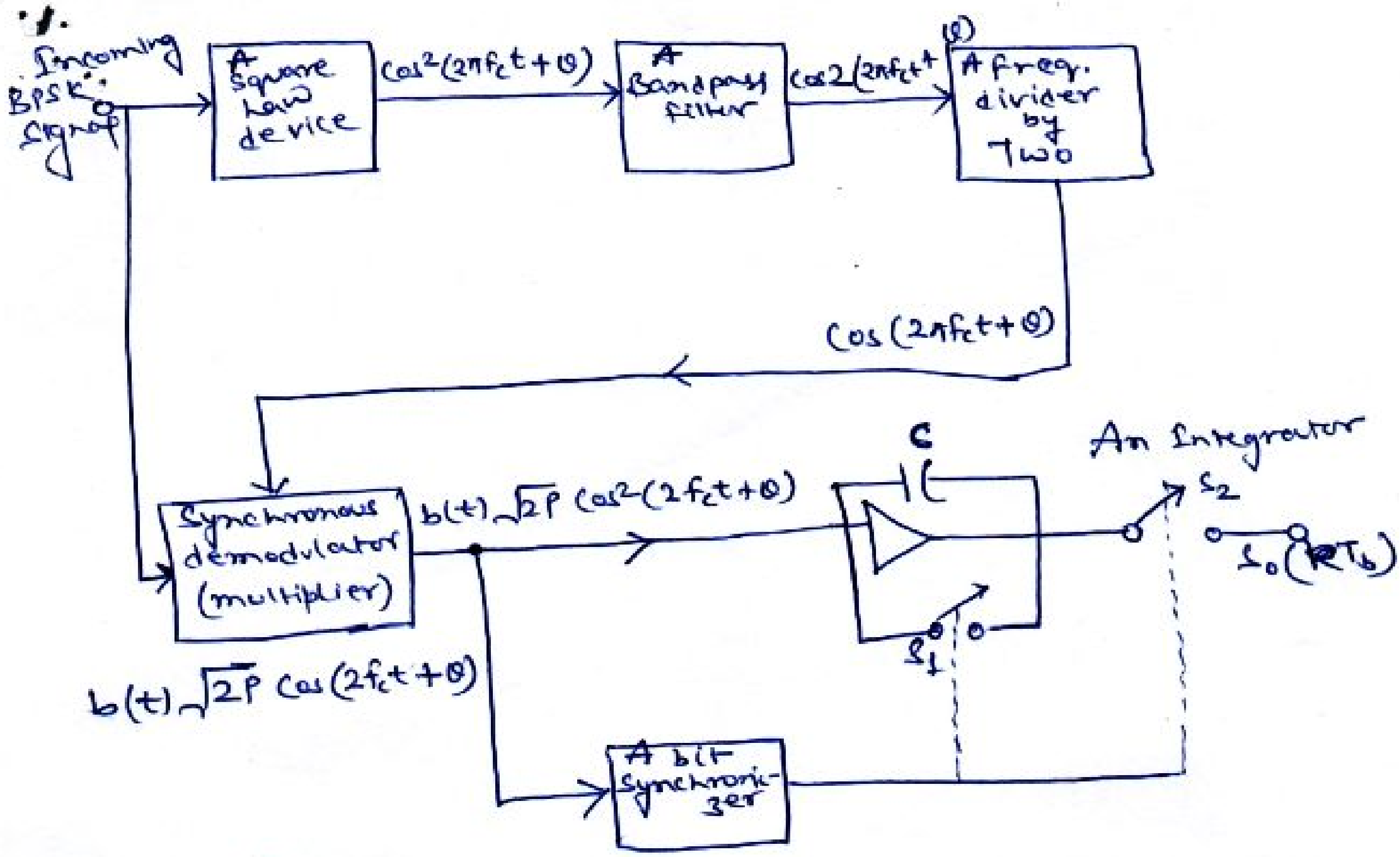
(b) The corresponding bipolar signal $b(t)$.

Generation of BPSK Signal.



A NRZ level Encoder Converts the Binary data sequence into bipolar NRZ signal.

Reception of BPSK Signal



→ FSK *
→ QPSK *
→ MSK *

} Do it

UNIT-VI

SPREAD SPECTRUM

(1) DSSS
(2) FHSS
(3) CDMA

} Do it.