2.14

Set A

1. Explain various types of sampling procedure

2. Define Quantization. Explain the accurate of quantization error of ADC

3. For the given binary bit 10110100, plot unipolar, NRZ, Polar, RZ, AMI and quantary binary format.

4. Explain the method of minimise ISI in binary bassband Transmission 4.41 - 4.42

5. Explain BPSK. 5-3

Set B

1. State & prove sampling theorem for a Low pass signal. 2.2 - 2.7

2. With neat diagram, explain various block of ADC.

Morning

3. Explain the details about various types of quantization 2.39 - 2.43

4. Explain with neat diagram of ISI. 4-38 - 4.41

5. Explain in detail about QPSK. 5.21

~~BFSK~~

~~QPSK~~

~~Block of~~ ADC

Sampling theorem

A C.T signal Can be represented in its samples and reconstructed from its samples to a C.T signal, If the sampling frequency is twice that of the highest frequency content of the signal.

i.e $f_s \geq 2W$.

Part I :- Represent^n of C.T signal $x(t)$ into its samples $x(nT_s)$

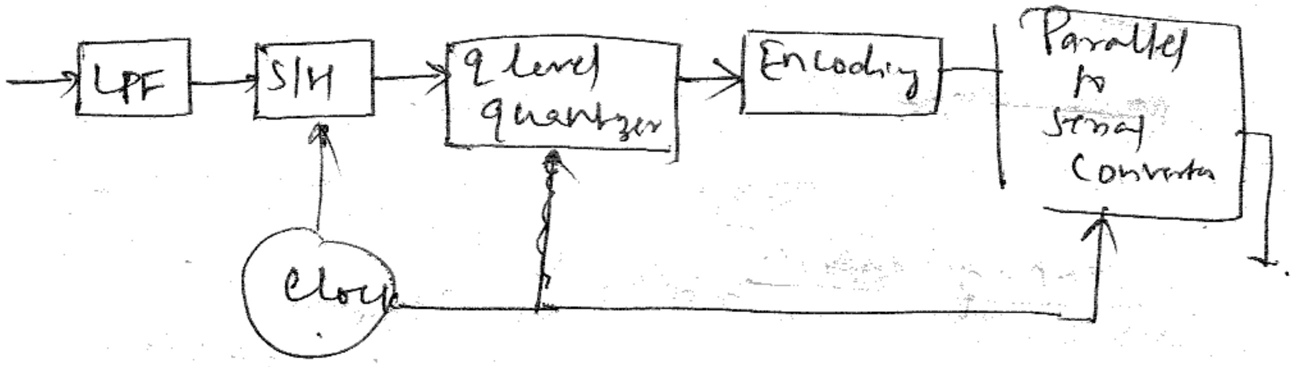
Part II :- Reconstruct of $x(t)$ from $x(nT_s)$

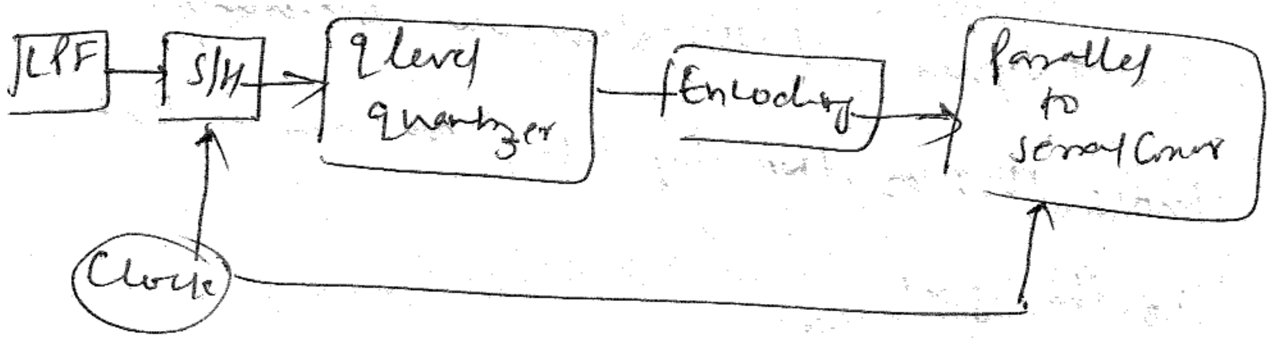
Proof Part I :-

Step :-

$$x_\delta(t) = \sum_{n=-\infty}^{\infty} x(t) \cdot \delta(t - nT_s)$$

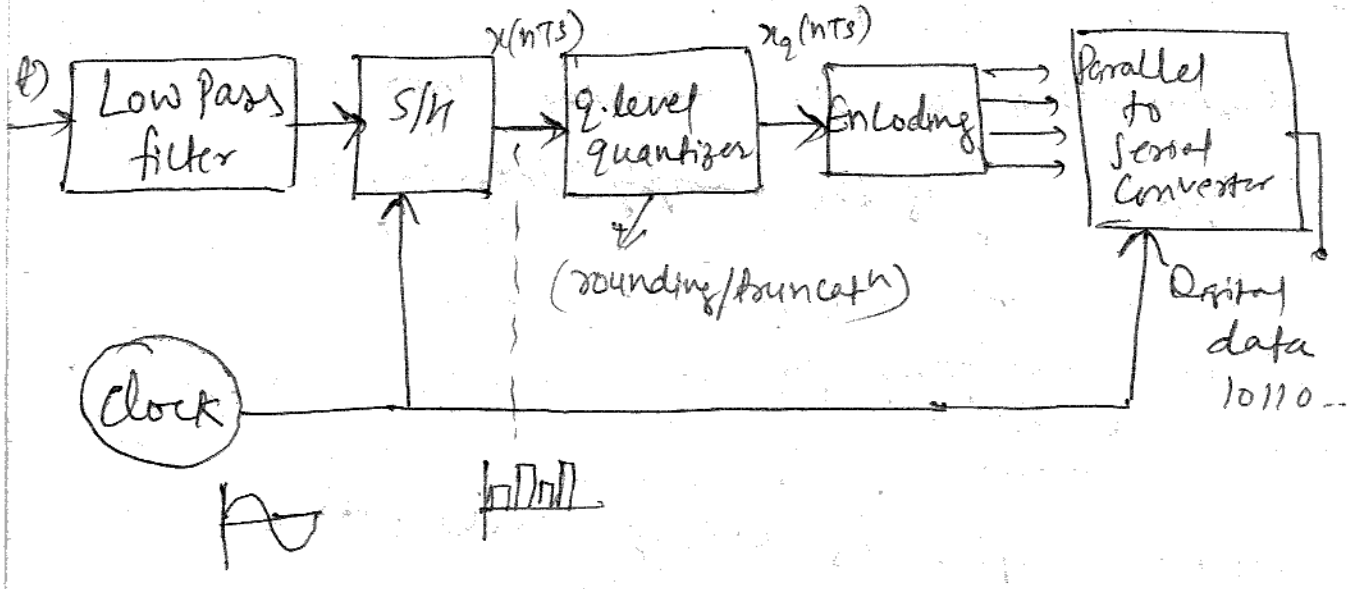
ADC


LPF
S/H
q level quantizer
Encoding
Parallel to Serial Converter
Clock


LPF
S/H
q level quantizer
Encoding
Parallel to serial Conver
Clock

A/D Converter

Basic or Primary Line Coding.



S/H → Sample & Hold.

Sampling T

A. C.T signal is represented in its samples and reconstructed from its samples into a C.T signal, only if the sampling frequency is twice that of highest freq content.

$$\boxed{f_s \geq 2W}$$

Part I :- Repres^n of C.T signal $x(t)$ into its samples $x(nT_s)$

Pa II Reconst^n of $x(t)$ from its samples $x(nT_s)$

Part I

Step 1

$$x_\delta(t) = \sum_{n=-\infty}^{\infty} x(t) \cdot \delta(t - nT_s)$$

St 2

$$X_\delta(f) = FT[x_\delta(t)]$$

$=$

$$x_\delta(t) = \sum_{n=-\infty}^{\infty} x(t)\,\delta(t-nT_s)$$

$$X_\delta(f) = FT\left[\delta\, x_\delta(t)\right]$$

$$= FT\left[\sum_{n=-\infty}^{\infty} x(t)\,\delta(t-nT_s)\right]$$

= FT{ Product of {x(t)} and impulse train }

$$F\{x(t)\} = X(f)$$

$$\cancel{FT\{\delta(t-nT_s)\} = \delta(f-nf_s)}\ f_s$$

$$FT\{x(t)\} = X(f)$$

$$FT\{\delta(t-nT_s)\} = f_s \sum_{n=\infty} (f-nf_s)$$

$$X_\delta(f) = X(f) * f_s \sum_{n=-\infty}^{\infty} \delta(f-nf_s)$$

$$= \cancel{f_s \sum_{n=-\infty}^{\infty} X(f) *}$$

$$X_\delta(f) = f_s \sum_{n=-\infty}^{\infty} X(f) * \delta(f-nf_s)$$

$$= f_s \sum_{n=-\infty}^{\infty} X(f-nf_s)$$

$$= \ldots f_s X(f-2f_s) + f_s X(f-f_s) + f_s X(f)$$
$$+ f_s X(f-f_s) + f_s X(f-2f_s)$$
$$+ \ldots$$

PF $x(t) \longrightarrow x(nT_s)$

Step 1. Sampled Signal

$$x_\delta(t) = \sum_{n=-\infty}^{\infty} x(t) \cdot \delta(t - nT_s)$$

S.2

$$X_\delta(f) = FT\{x_\delta(t)\}$$

$$= FT\left\{\sum_{n=-\infty}^{\infty} x(t) \cdot \delta(t - nT_s)\right\}$$

$= FT\{$ Product of $x(t)$ and impulse train $\}$

$$F\{x(t)\} \rightarrow X(f)$$

$$F\{\delta(t - nT_s)\} = f_s \sum_{n=-\infty}^{\infty} \delta(f - nf_s)$$

$$X_\delta(f) = X(f) * f_s \sum_{n=-\infty}^{\infty} \delta(f - nf_s)$$

$$= f_s \sum_{n=-\infty}^{\infty} X(f) * \delta(f - nf_s)$$

$$= f_s \sum_{n=-\infty}^{\infty} X(f - nf_s)$$

$$= \cancel{X f_s} \; f_s X(f - 2f_s) + f_s X(f - f_s) + f_s X(f) + f_s X(f - f_s) + f_s X(f - 2f_s) + \cdots$$

$X\cancel{(f)} \cancel{=} \cancel{\frac{X_\delta(f)}{f(s)}}$

$$X(f) = \frac{X_\delta(f)}{f_s}$$

relatⁿ betⁿ $x(t)$ & $x(nT_s)$

Binary phase SK BPSK

In digital communi, entire informⁿ is transmitted in the form of 0's & 1's.

Let the carrier signal be

$$s(t) = \sqrt{2P}\cos(2\pi f_0 t)$$

⇒ Whenever the symbol changes, then phase of carrier is shifted by 180°, or π radian

eg
when symbol 1 is tran^x,

$$S_1(t) = \sqrt{2P}\cos(2\pi f_0 t)$$

when next symbol '0' is transmitted,

$$S_2(t) = \sqrt{2P}\cos(2\pi f_0 t + \pi)$$

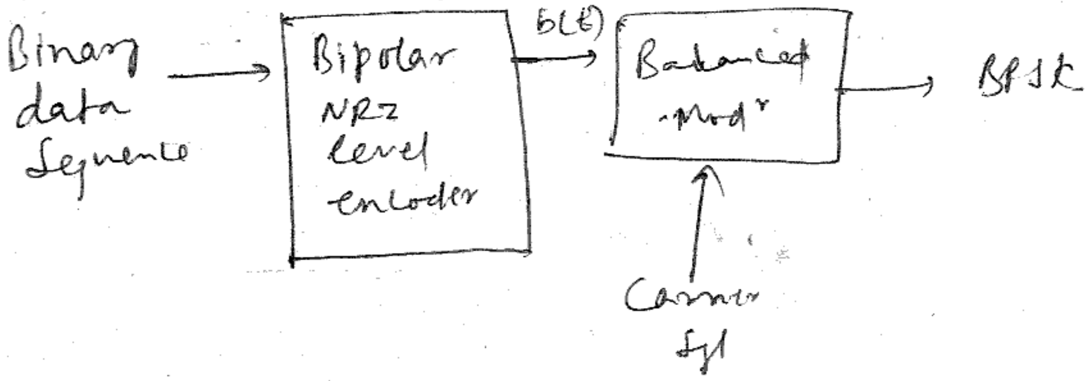
$$S_2(t) = -\sqrt{2P}\cos(2\pi f_0 t)$$

In general for BPSK,

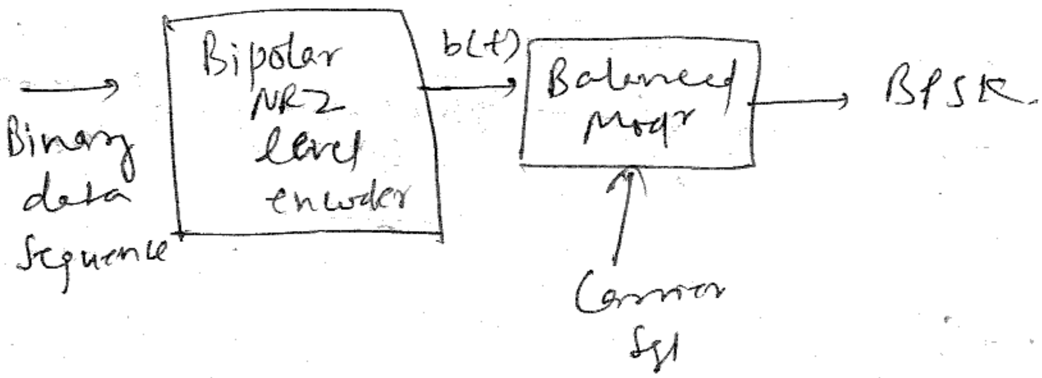
$$S(t) = b(t)\sqrt{2P}\cos(2\pi f_0 t)$$

$$b(t) = +1 \quad \text{if symbol 1 is tran.}$$
$$= -1 \quad \text{if sy 0 is tr}$$

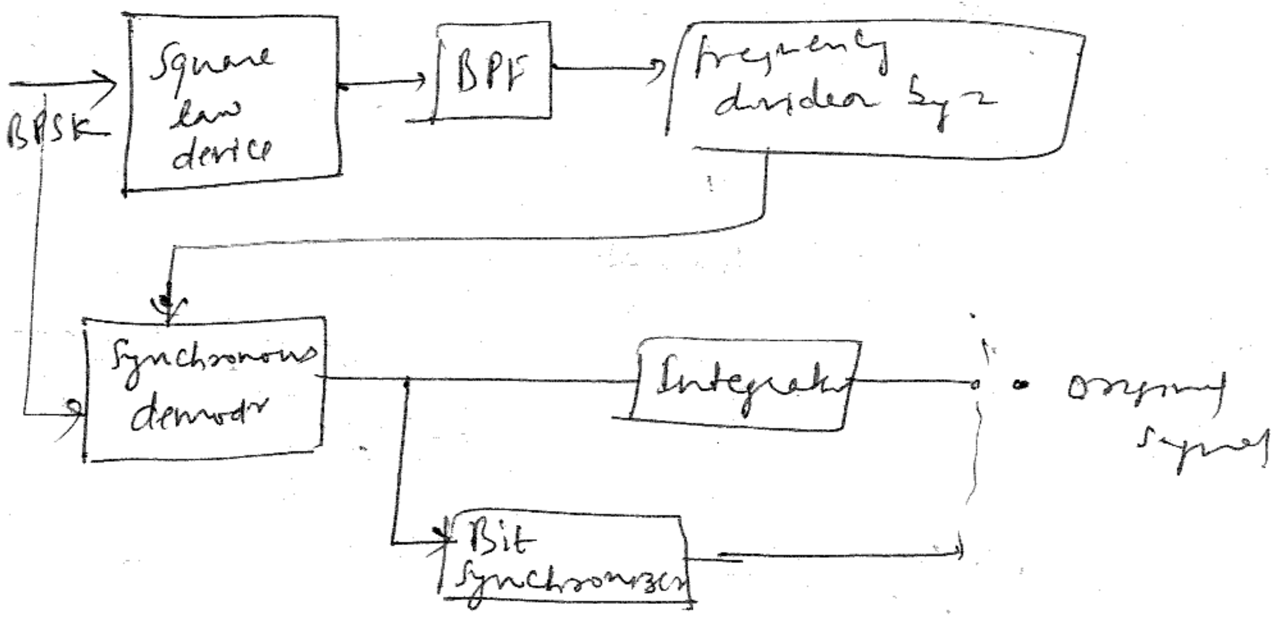
Generatⁿ of BPSK sgl



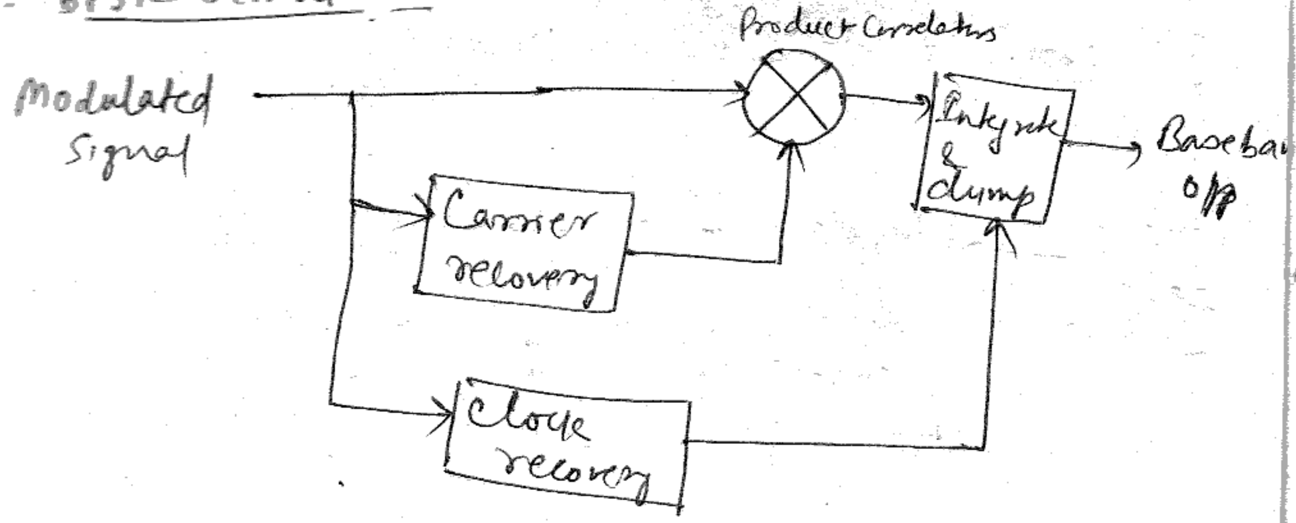
Generatⁿ of BPSK signal



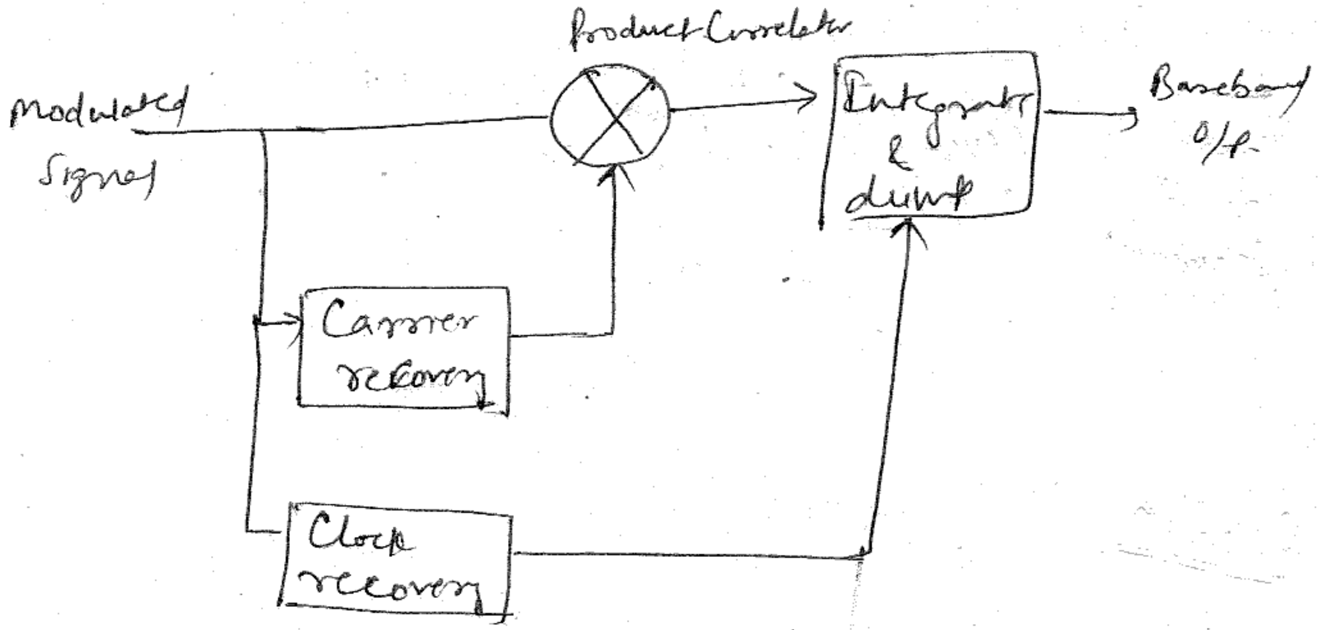
Receptⁿ



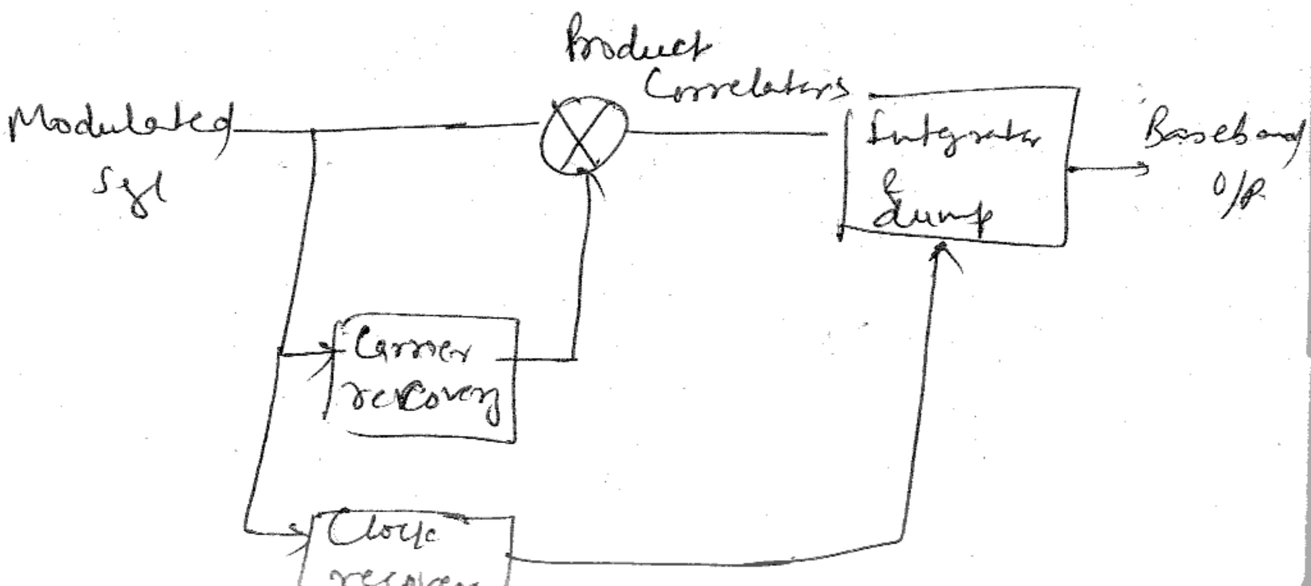
BPSK Demod^n :



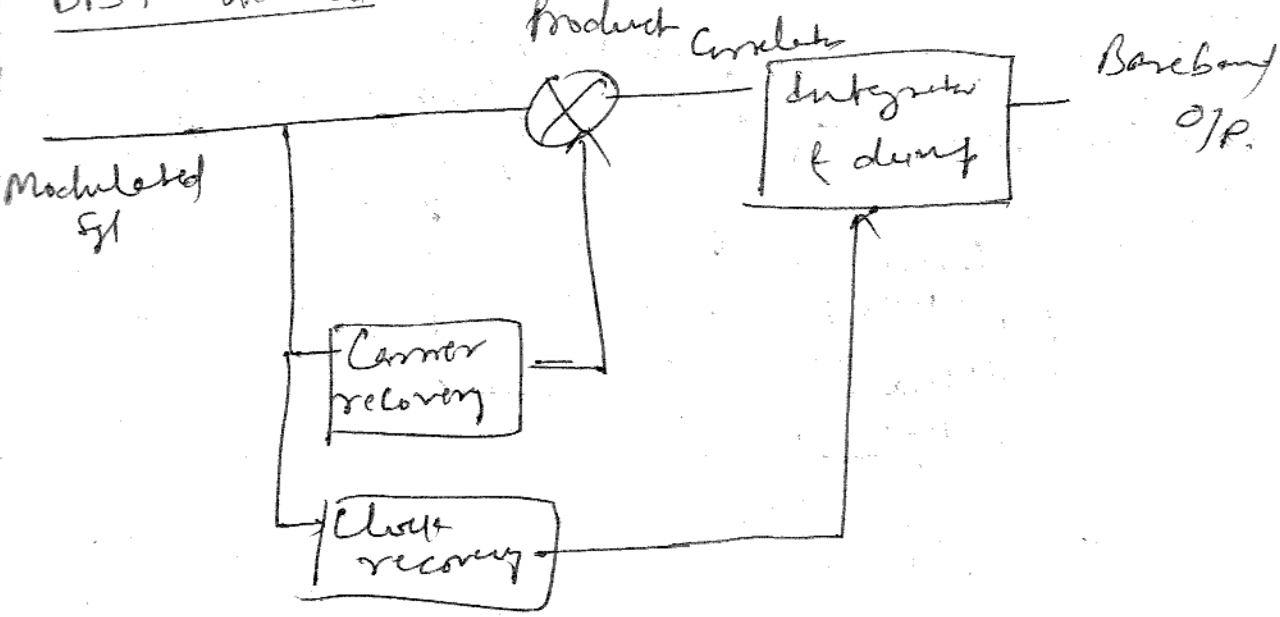
BPSK Demod^n :



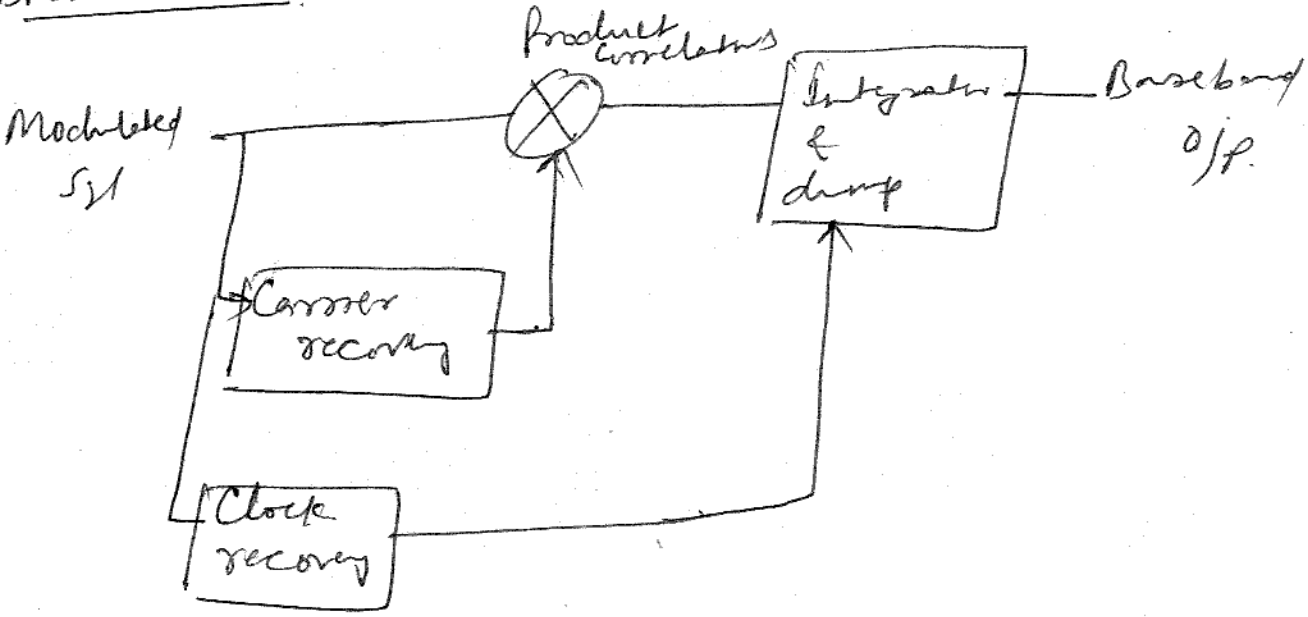
BPSK demod^n :



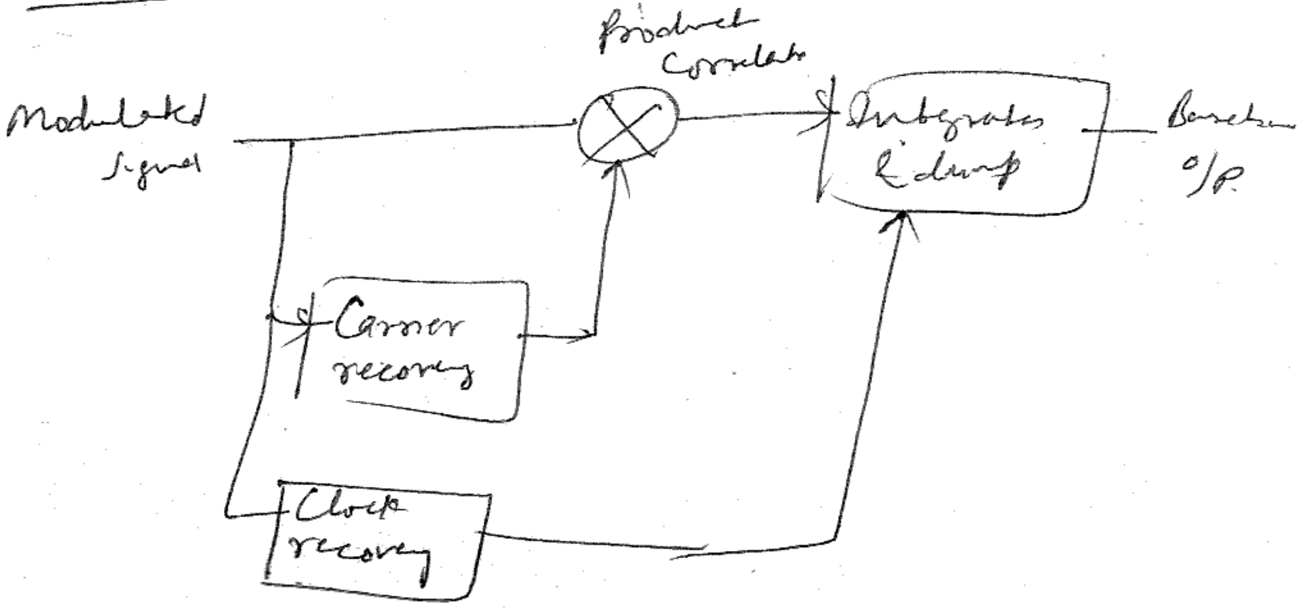
BPSK demod^{n}



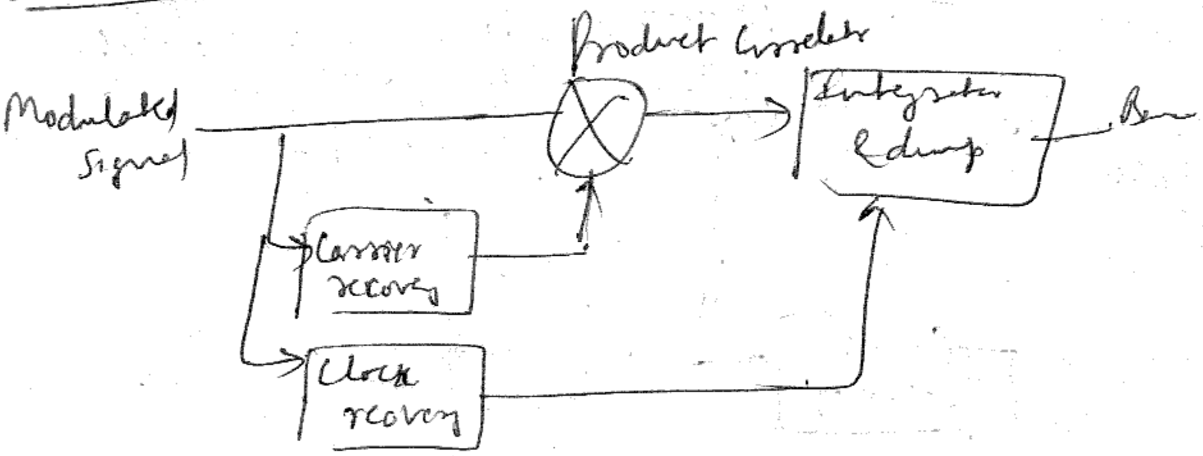
BPSK demod^{or}:-



BPSK demod^{r}



BPSK demod^r:-


Product Correlator
Modulated Signal
Integrator & dump
Carrier recovery
Clock recovery

5.)

PE proof

Sampled Signal is $x_\delta(t)$

$$x_\delta(t) = \sum_{n=-\infty}^{\infty} x(t)\,\delta(t-nT_s)$$

$$X_\delta(f) = FT\left[x_\delta(t)\right]$$
$$= FT\left[\sum_{n=-\infty}^{\infty} x(t)\,\delta(t-nT_s)\right]$$

$$FT\{x(t)\} = X(f)$$

$$FT\{\delta(t-nT_s)\} = f_s \sum_{n=\infty}^{\infty} \delta(f-nf_s)$$

$$X_\delta(f) = X(f) * f_s \sum_{n=-\infty}^{\infty} \delta(f-nf_s)$$

$$= f_s \sum_{n=-\infty}^{\infty} X(f) * \delta(f-nf_s)$$

$$= f_s \sum_{n=-\infty}^{\infty} X(f-nf_s)$$

$$= \ldots f_s X(f-2f_s) + f_s X(f-f_s) + f_s X(f)$$
$$+ f_s(X-f_s) + f_s(f-2f_s) + \ldots$$

Relat^n bet^n $X(f)$ & $X_\delta(f)$

$$X(f) = \frac{X_\delta(f)}{f(s)}$$

Relat^n bet^n $X(f)$ & $X_\delta(f)$

$$X(f) = \frac{X_\delta(f)}{f_s}$$

4 Relat^n bet^n $x(f)$ & $x(nT_s)$

DTFT $\cdot \; x(\Omega) = \sum_{n=-\infty}^{\infty} x(n)\, e^{-j\Omega n}$

$$X(f) = \sum_{n=-\infty}^{\infty} x(n)\, e^{-j2\pi f n}$$

$$X(f) = \sum_{n=-\infty}^{\infty} x(n) e^{-j2\pi f n}$$

$f \to$ frequency of DT signal

$$X_\delta(f) = \sum_{n=-\infty}^{\infty} x(n)\, e^{-j2\pi \frac{f}{f_s} n}$$

$$= \cancel{\sum_{n=-\infty}^{\infty} x(n)\, e^{-j2\pi}}$$

$$= \sum_{n=-\infty}^{\infty} x(nT_s)\, e^{-j2\pi f n T_s}$$

$$X(f) = \frac{X_\delta(f)}{f_s}$$

$$= \frac{1}{f_s} \sum_{n=-\infty}^{\infty} x(nT_s)\, e^{-j2\pi f n T_s}$$

$$x(t) = IFT\left[\frac{1}{f_s} \sum_{n=-\infty}^{\infty} x(nT_s)\, e^{-j2\pi f n T_s}\right]$$

Rel^n bet $x(t)$ & $x(nT_s)$

$$DTFT\{x(n)\} = X(f)$$

$$\Rightarrow X(f) = \sum_{n=-\infty}^{\infty} x(n) e^{-j2\pi f n}$$ $f \rightarrow$ freq of DT signal

$$X_\delta(f) = \sum_{n=-\infty}^{\infty} x(n) e^{-j2\pi \frac{f}{f_s} n}$$

$$X_\delta(f) = \sum_{n=-\infty}^{\infty} x(n) e^{-j2\pi \frac{f}{f_s} n}$$

$$= \sum_{n=-\infty}^{\infty} x(nT_s) e^{-j2\pi f n T_s}$$

$$X_f = \frac{X_\delta(f)}{f_s}$$

$$X(f) = \frac{X_\delta(f)}{f_s}$$

$$X(f) = \frac{X_\delta(f)}{f_s}$$

$$X(f) = \frac{X_\delta(f)}{f_s}$$

$$= \frac{1}{f_s} \sum_{n=-\infty}^{\infty} x(nT_s) e^{-j2\pi f n T_s}$$

$$\Rightarrow x(t) = IFT\left[\frac{1}{f_s} \sum_{n=-\infty}^{\infty} x(nT_s) e^{-j2\pi f n T_s}\right]$$

$\boxed{f_s \geq 2w}$

P.I step1 Sampled signal is

$$x_\delta(t) = \sum_{n=-\infty}^{\infty} x(t)\,\delta(t-nT_s)$$

$$FT[x_\delta(t)] \longrightarrow X_\delta(f)$$

$$X_\delta(f) = FT[x_\delta(t)]$$

$$= FT\left[\sum_{n=-\infty}^{\infty} x(t)\cdot\delta(t-nT_s)\right]$$

$=$

$$FT\{x(t)\} \rightarrow X(f)$$

$$FT\{\delta(t-nT_s)\} = f_s \sum_{n=-\infty} \delta(f-nf_s)$$

$$X_\delta(f) = FT[x_\delta(t)]$$

$$= FT\left[\sum_{n=-\infty}^{\infty} x(t)\,\delta(t-nT_s)\right]$$

$$= X(f) * f_s \sum_{n=-\infty}^{\infty} \delta(f-nf_s)$$

$$= \cancel{X(f)}\ f_s \sum_{n=-\infty} X(f) * \delta(f-nf_s)$$

$$= f_s \sum_{n=-\infty}^{\infty} X(f-nf_s)$$

$$= \cdots f_s X(f-2f_s) + f_s X(f-f_s)$$

$$+ f_s X(f) + f_s X(f-f_s) + f_s X(f-2f_s)$$

<u>relⁿ betⁿ</u> $X(f)$ & $X_\delta(f)$

$$X(f) = \frac{X_\delta(f)}{f_s}$$

Relⁿ bet $x(t)$ & $x(nT_s)$

$$DTFT\{x(n)\} = X(f)$$

$$\Rightarrow X(f) = \sum_{n=-\infty}^{\infty} x(n) e^{-j2\pi f n}$$

$f \rightarrow$ freq of DT sgl.

$$X_\delta(f) = \sum_{n=-\infty}^{\infty} x(nT_s)\, e^{-j2\pi \frac{f}{f_s} n}$$

$$= \sum_{n=-\infty}^{\infty} x(nT_s)\, e^{-j2\pi f n T_s}$$

$$X(f) = \frac{X_\delta(f)}{f_s} = \frac{1}{f_s} \sum_{n=-\infty}^{\infty} x(nT_s)\, e^{-j2\pi f n T_s}$$

$$x(t) = IFT\{X(f)\}$$

$$\boxed{f_s \geq 2W}$$

step1. Sample sgl $x_\delta(t)$

$$x_\delta(t) = \sum_{n=-\infty}^{\infty} x(t)\cdot\delta(t-nT_s)$$

St2 $FT\{x_\delta(t)\} = X_\delta(f)$

$$X_\delta(f) = FT\{x_\delta(t)\}$$

$$= FT\left[\sum_{n=-\infty}^{\infty} x(t)\cdot\delta(t-nT_s)\right]$$

$$FT\{x(t)\} = X(f)$$

$$FT\{\delta(t-nT_s)\} = f_s \sum_{n=-\infty}^{\infty}\delta(f-nf_s)$$

$$\therefore X_\delta(f) = X(f) * f_s \sum_{n=-\infty}^{\infty}\delta(f-nf_s)$$

$$= f_s \sum_{n=-\infty}^{\infty} X(f) * \delta(f-nf_s)$$

$$= f_s \sum_{n=-\infty}^{\infty} X(f-nf_s)$$

$$= \cdots f_s X(f-2f_s) + f_s X(f-f_s)$$

$$+ f_s X(f) + f_s X(f-f_s)$$

$$+ f_s X(f-2f_s)$$

$$X(f) = \frac{X_\delta(f)}{f_s}$$

Relⁿ bet $x(t)$ & $x(nT_s)$

$$DTFT\{x(n)\} = X(f)$$

$$X(f) = \sum_{n=-\infty}^{\infty} x(n)\, e^{-j2\pi f n}$$

$f \to$ freq of DT sgl.

$$X_\delta(f) = \sum_{n=-\infty}^{\infty} x(nT_s)\, e^{-j2\pi f n T_s}$$

$$X(f) = \frac{X_\delta(f)}{f_s}$$

$$= \frac{1}{f_s} \sum_{n=-\infty}^{\infty} x(nT_s)\, e^{-j2\pi f n T_s}$$

$$x(t) = IFT[X(f)]$$

$$= \cancel{\frac{f}{f_s}}\, IFT\left[\frac{1}{f_s} \sum_{n=-\infty}^{\infty} x(nT_s)\, e^{-j2\pi f n T_s}\right]$$

^{ch}s

$$x(t) = \int_{-\infty}^{\infty} \left[\frac{1}{f_s} \sum_{n=-\infty}^{\infty} x(nT_s)\, e^{-j2\pi f n T_s}\right] e^{j2\pi f t}\, df$$

$$= \int_{-W}^{W} \left[\frac{1}{f_s} \sum_{n=-\infty}^{\infty} x(nT_s)\, e^{-j2\pi f n T_s}\right] e^{j2\pi f t}\, df$$

$$= \sum_{n=-\infty}^{\infty} \cancel{f}\, x(nT_s) \cdot \frac{1}{f_s} \int_{-W}^{W} e^{-j2\pi f n T_s}\, e^{j2\pi f t}\, df$$

$$= \sum_{n=-\infty}^{\infty} x(nT_s) \cdot \frac{1}{f_s} \int_{-W}^{W} e^{j2\pi f(t - nT_s)} df$$

$$= \sum_{n=-\infty}^{\infty} x(nT_s) \cdot \frac{1}{f_s} \left[\frac{e^{j2\pi f(t-nT_s)}}{j2\pi(t-nT_s)} \right]_{-W}^{W}$$

$$= \sum_{n=-\infty}^{\infty} x(nT_s) \cdot \frac{1}{f_s} \left[\frac{e^{j2\pi W(t-nT_s)} - e^{-j2\pi W(t-nT_s)}}{j2\pi(t-nT_s)} \right]$$

$$= \sum_{n=-\infty}^{\infty} x(nT_s) \cdot \frac{1}{f_s} \left(\frac{\sin 2\pi W(t-nT_s)}{\pi(t-nT_s)} \right)$$

$$= \sum_{n=-\infty}^{\infty} x(nT_s) \frac{\sin 2\pi W(t-nT_s)}{\pi(f_sT - f_s nT_s)}$$

S.T.

St ① Sampled Signal is $x_\delta(t)$

$$x_\delta(t) = \sum_{n=-\infty}^{\infty} x(t)\,\delta(t-nT_s)$$

② $FT[x_\delta(t)] = X_\delta(f)$

$$X_\delta(f) = FT[x_\delta(t)]$$

$$= FT\left[\sum_{n=-\infty}^{\infty} x(t)\,\delta(t-nT_s) \right]$$

$$FT\left[\delta(t-nT_s)\right] = f_s \sum_{n=-\infty}^{\infty} \delta(f-nf_s)$$

$$X_\delta(f) = X(f) * f_s \sum_{n=-\infty}^{\infty} \delta(f-nf_s)$$

$$= f_s \sum_{n=-\infty}^{\infty} X(f) * \delta(f-nf_s)$$

$$= f_s \sum_{n=-\infty}^{\infty} X(f-nf_s)$$

$$= \cdots f_s X(f-2f_s) + f_s X(f-f_s) + f_s X(f) + \cdots f_s X(f+f_s) + \cdots$$

③ Relat^n bet $X(f)$ & $X_\delta(f)$

~~X(f)~~ $X(f) = \dfrac{X_\delta(f)}{f_s}$

$DTFT\{x(n)\} = X(f)$

$$X(f) = \sum_{n=-\infty}^{\infty} x(n) e^{-j2\pi f n}$$

$$X_\delta(f) = \sum_{n=-\infty}^{\infty} x(nT_s) e^{-j2\pi \frac{f}{f_s} n}$$

$$= \sum_{n=-\infty}^{\infty} x(nT_s) e^{-j2\pi f n T_s}.$$

$$X(f) = \frac{X_\delta(f)}{f_s}$$

$$= \frac{1}{f_s} \sum_{n=-\infty}^{\infty} x(nT_s) e^{-j2\pi f n T_s}.$$

$$\{x(t)\} = IFT\{X(f)\}$$

$$= \int_{-\infty}^{\infty} \frac{1}{f_s} \sum_{n=-\infty}^{\infty} x(nT_s)\, e^{-j2\pi f n T_s} \cdot e^{j2\pi f t}\, df$$

S.T

① $$x_\delta(t) = \sum_{n=-\infty}^{\infty} x(t)\,\delta(t-nT_s)$$

② $$FT[x_\delta(t)] = X_\delta(f)$$

$$X_\delta(f) = FT[x_\delta(t)]$$

$$= FT\left[\sum_{n=-\infty}^{\infty} x(t)\,\delta(t-nT_s)\right]$$

$$FT[x(t)] \rightarrow X(f)$$

$$FT[\delta(t-nT_s)] = f_s \sum_{n=-\infty}^{\infty} \delta(f-nf_s)$$

$$\therefore X_\delta(f) = X(f) * f_s \sum_{n=-\infty}^{\infty} \delta(f-nf_s)$$

$$= f_s \sum_{n=-\infty}^{\infty} X(f) * \delta(f-nf_s)$$

$$= f_s \sum_{n=-\infty}^{\infty} X(f-nf_s)$$

$$= \cdots f_s X(f-2f_s) + f_s X(f-f_s) + f_s X(f) + f_s X(f-f_s) + \cdots$$

Relatⁿ betⁿ

$X(f)$ & $X_\delta(f)$

$$X(f) = \frac{X_\delta(f)}{f_s}$$

$$DTFT\{x(n)\} = X(f)$$

$$X(f) = \sum_{n=-\infty}^{\infty} x(n)\, e^{-j2\pi f n}$$

$$X_\delta(f) = \sum_{n=-\infty}^{\infty} x(nT_s)\, e^{-j2\pi \frac{f}{f_s} n}$$

$$X_\delta(f) = \sum_{n=-\infty}^{\infty} x(nT_s)\, e^{-j2\pi f n T_s}.$$

$$X(f) = \frac{X_\delta(f)}{f_s}.$$

$$= \frac{1}{f_s} \sum_{n=-\infty}^{\infty} x(nT_s)\, e^{-j2\pi f n T_s}$$

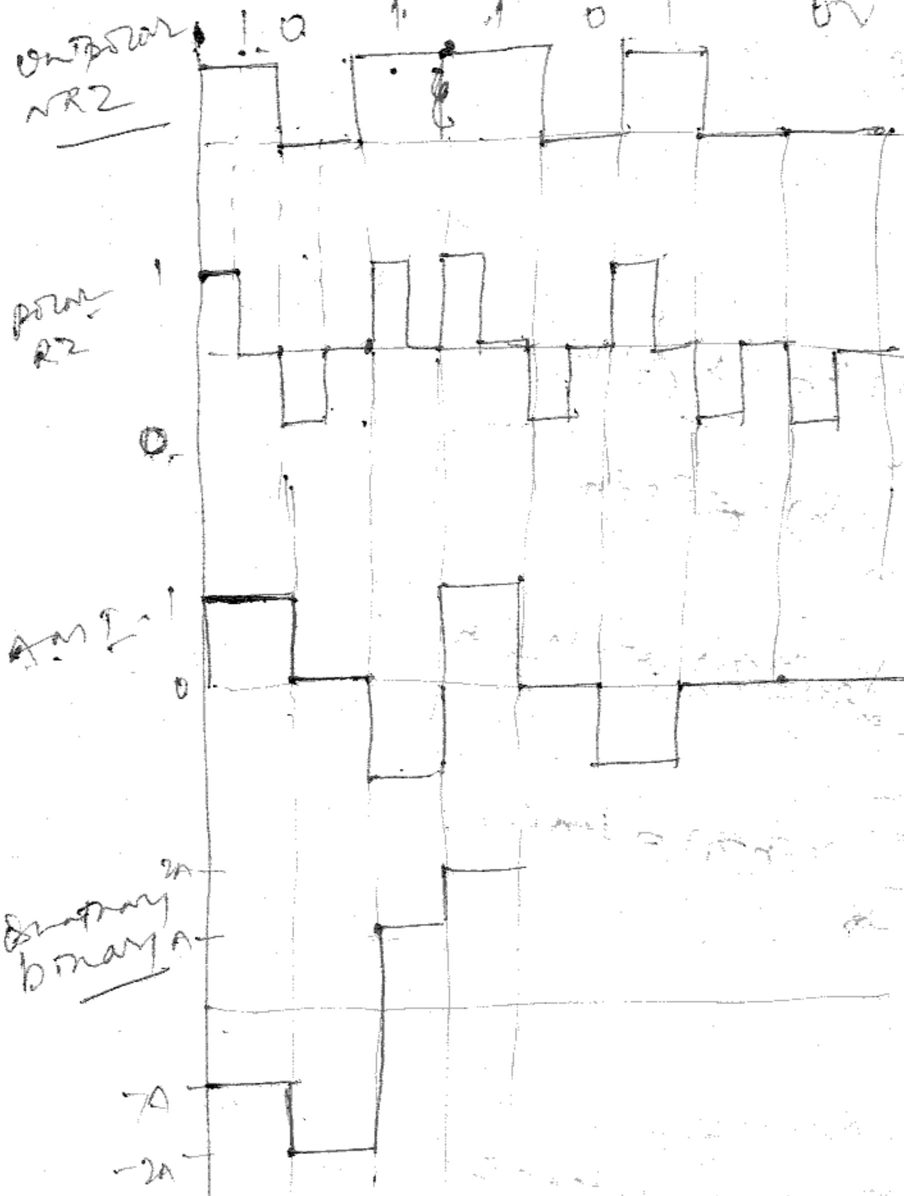
$$x(t) = IFT\{X(f)\}$$

$$=$$

1 0 1 1 0 1 0 0

Unipolar NRZ

1 → upper
0 → lower



00 +2A
01 +A
10 −A
11 −2A

00 +2A
01 +A
10 −A
11 +2A

00 2A
01 A
10 A
11 2A

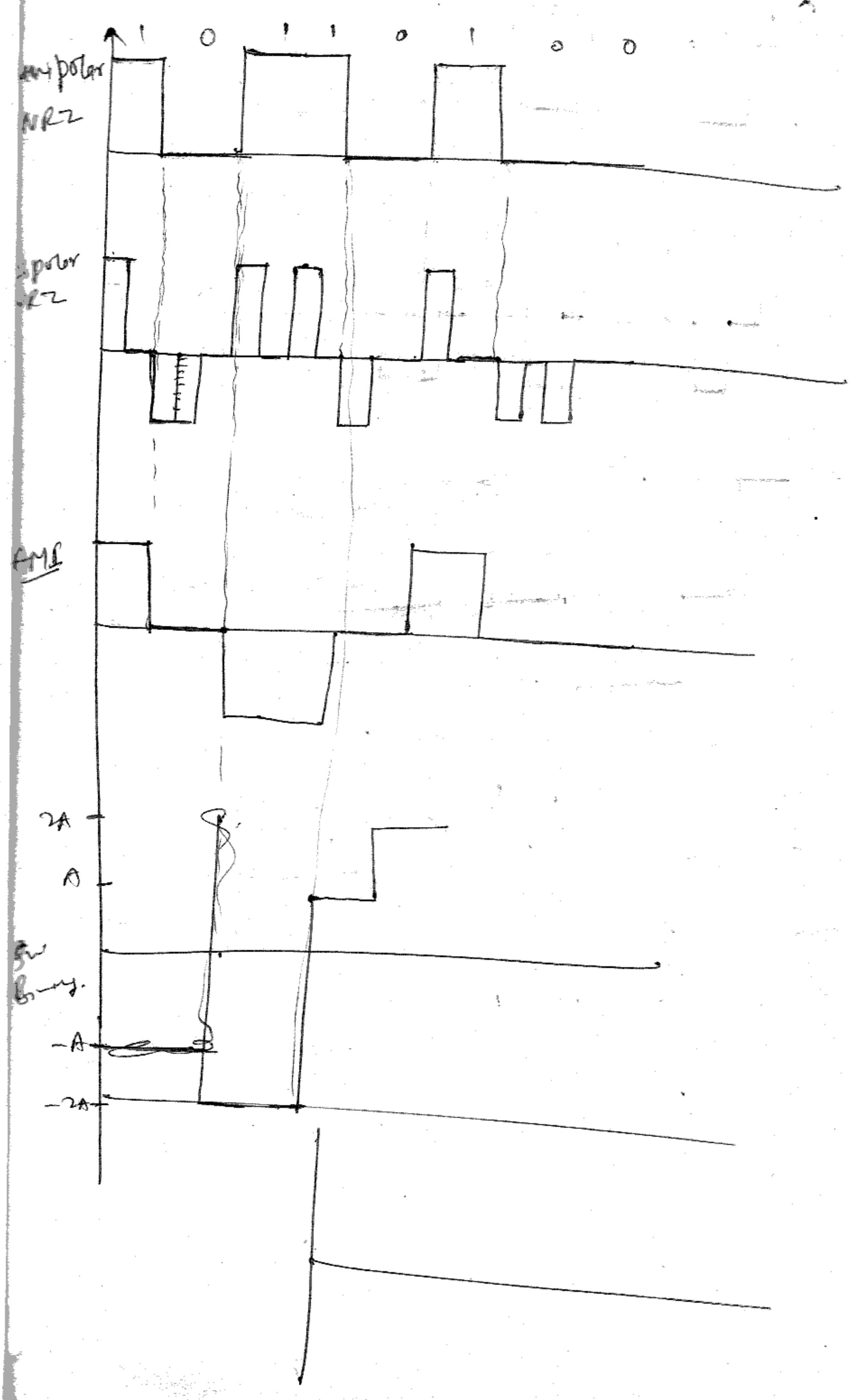
00 +2A
01 +A
10 −A
11 −2A

00 +2A
01 +A
10 −A
11 −2A

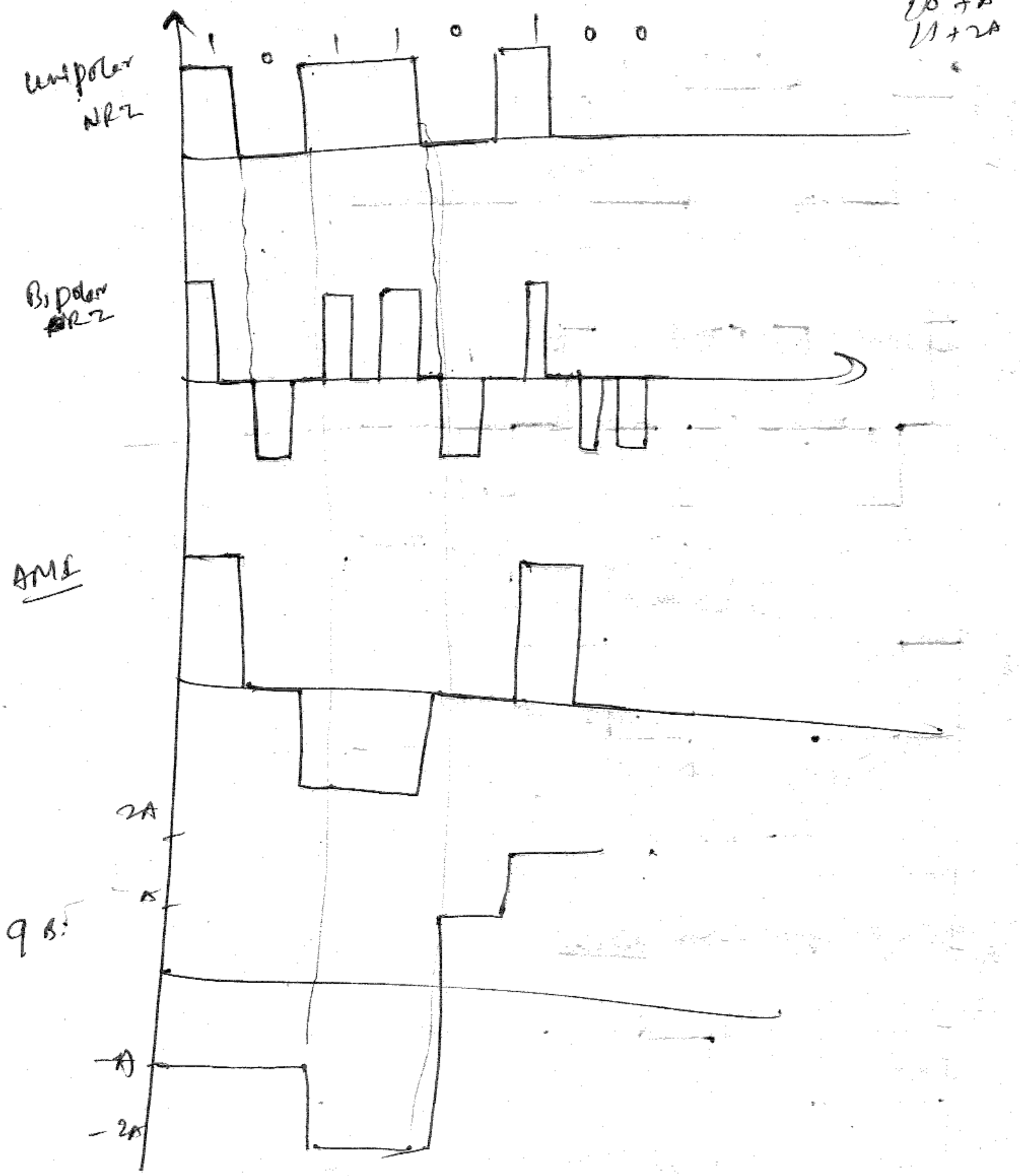
00 2A
01 A
10 A
11 2A

NRZ

10110100



10110100



1 0 1 1 0 1 0 0
Unipolar NRZ
Bipolar RZ
AMI
2A
A
-A
-2A
QB:
00 -2A
01 -A
10 +A
11 +2A

10/8/11

UNIT 3

SYNCRONIZATION

Classification :-

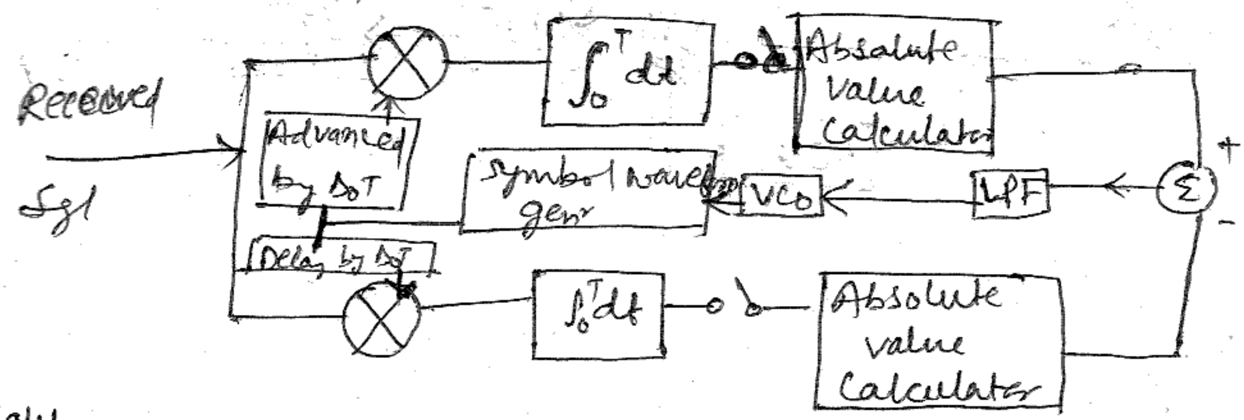
(i) Carrier Synchronizatⁿ (Carrier recovery).
(ii) Symbol " (Clock syn)

The synchronizatⁿ which occurs betⁿ frequency & phase shift of carrier signal is called Carrier Synchronizatⁿ.

In Coherent detection the knowledge of both the frequency & phase of the carrier is necessary. The estimatⁿ of carrier phase & the frequency is called Carrier recovery or carrier Synchronization.

In demodulation the reciever has to know the instant of time in which modulator can change its state, i.e it must know the starting & finishing time of an intermediate symbol, so that it may determine when ~~two~~ sample & product intermediate, This estimation of time is called Clock recovery, or symbol synchronizatⁿ.

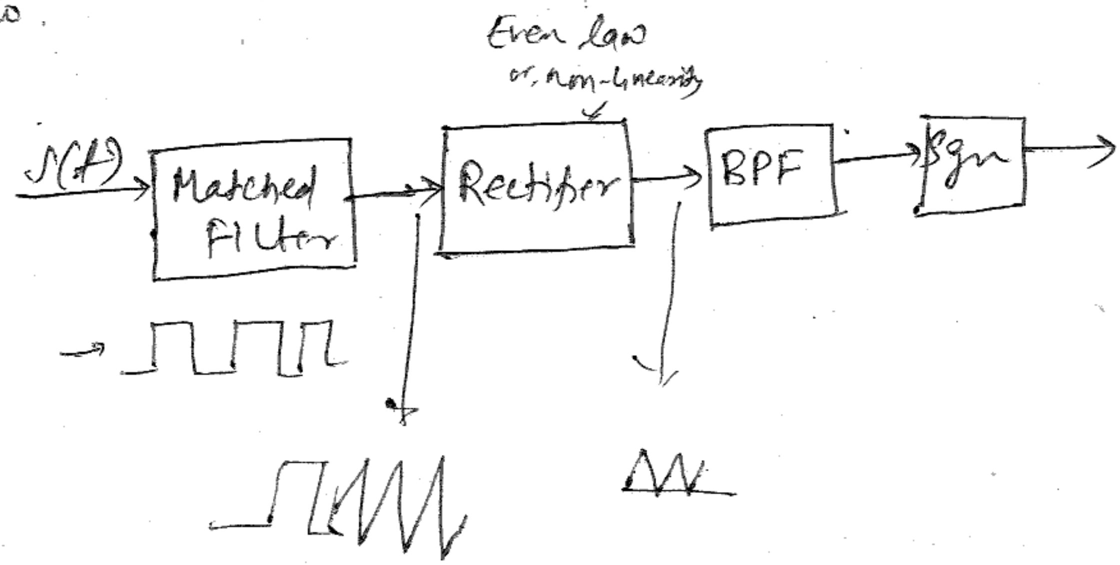
Symbol Synchronization:-



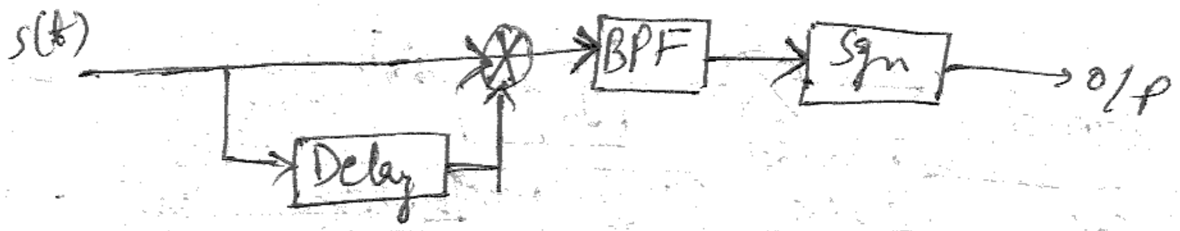
19/8/11

Open loop Symbol Synchronization

→ is olassionaly called non-linear filter Synchronization, this class of synchronization generates a frequenty component with the combination of filtering & non-linear devices. In the present case the desired frequenty component at a data symbol rate is isolated with a band pass filter & shaped with the saturating amplifier so.



(ii) Symbol Syn using Delay N/wk



(iii)