17.9.18

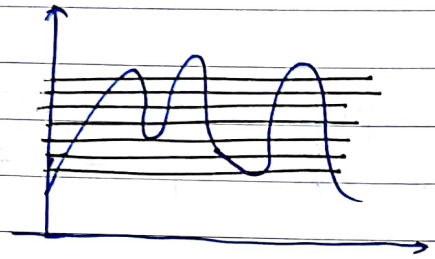
Digital Communication

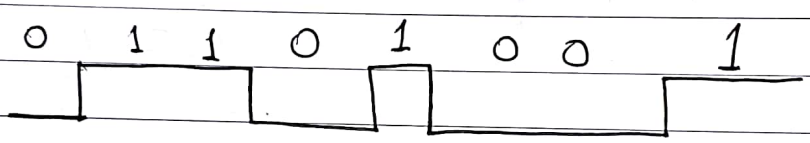
Digitized → discretized in levels
Analog : Information is not digitized
Digital : Information is digitized

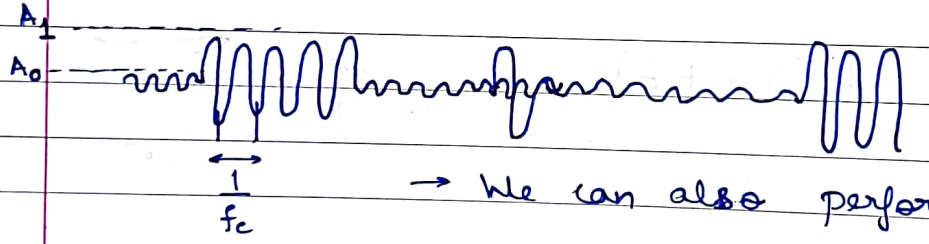
Q→ What is the point of high precision in Analog.

In Digital

AM → ASK (Amp. Shift keying)
FM → FSK (Freq. " ")
PM → PSK (Phase " ")



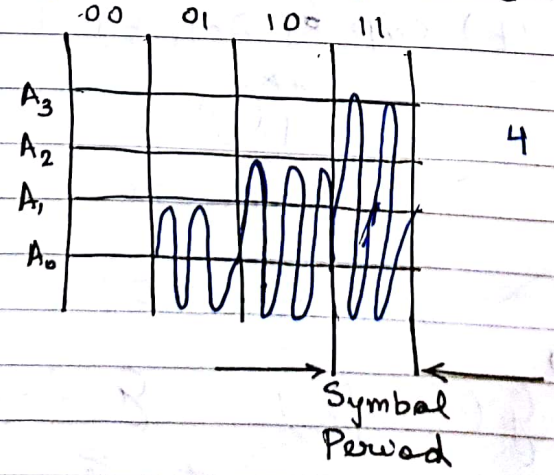




(Ask waveform)

→ We can also perform OOK : On-Off Keying, where Amp. = 0 for Symbol "0"

→ >2 Symbols example (4-ASK) in General M-ASK, M-PSK etc.



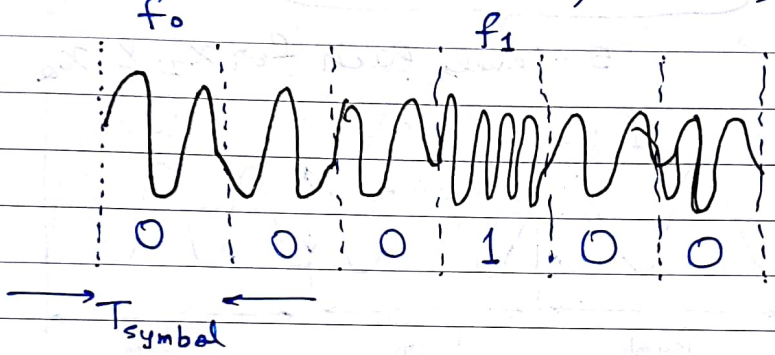
4 levels or 4 possible Symbol values

ex Bit-rate = 1 Mbps

Symbol rate = $\frac{\text{Bit rate}}{\text{Bits/Symbol}}$ = 500 K sym/s for 4-Ask

Sym. rate = $\frac{\text{Bit-rate}}{\lceil \log_2 M \rceil}$ for M-Ask

FSK : (2 Symb. FSK, 2-FSK)



4-FSK

1 - MHz	00_2
1.1 - MHz	01_2
1.2 - MHz	10_2
1.3 - MHz	11_2

} trade-off : b/w

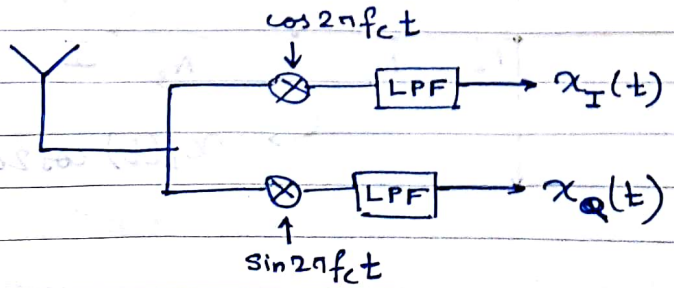
"0"

PM : $\cos(2\pi f_c t + \phi_m(t))$

PSK → $\in \{0, \frac{\pi}{4}, \frac{\pi}{2}, \frac{3\pi}{4}, \pi, \frac{5\pi}{4}, \frac{3\pi}{2}, \frac{7\pi}{4}\}$ ← 8-PSK

$(000)_2$ $(001)_2$

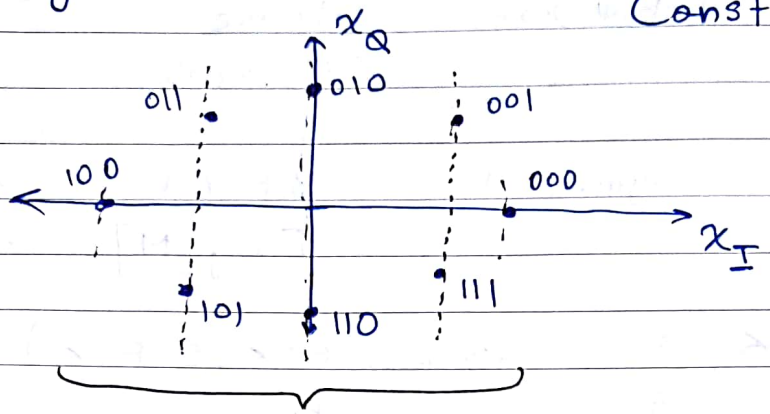
→ How to demodulate this



$\phi_m = \tan^{-1}\left(\frac{x_Q(t)}{x_I(t)}\right)$

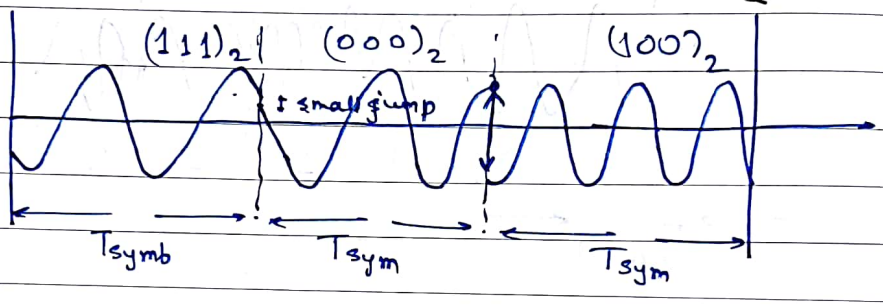
→ Encoding in x_I and x_Q

Constellation Diagram



5-Levels each for x_I & x_Q

ex



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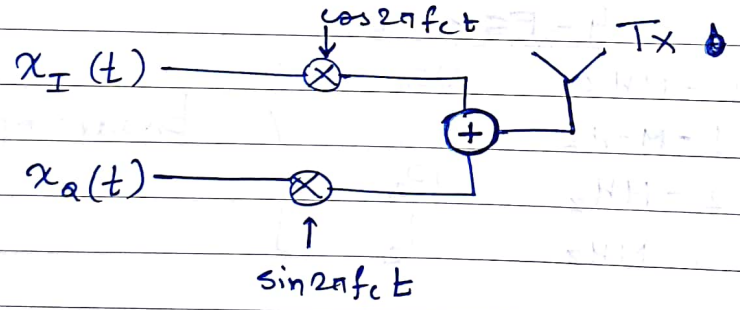
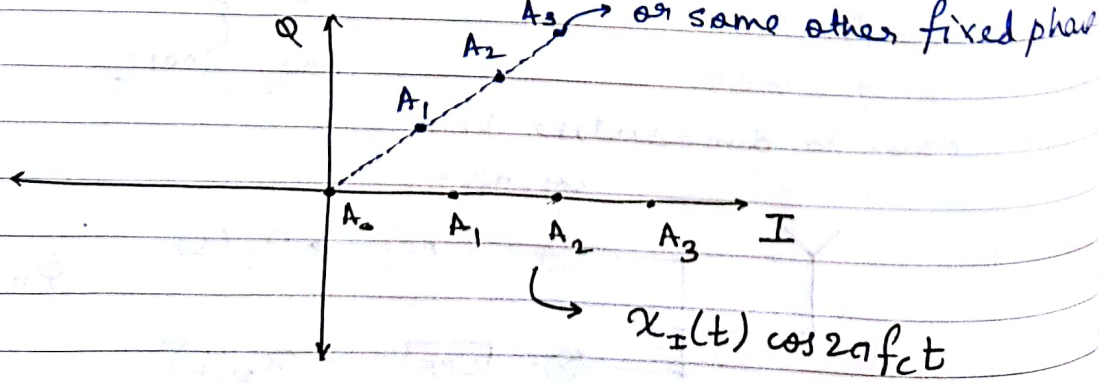
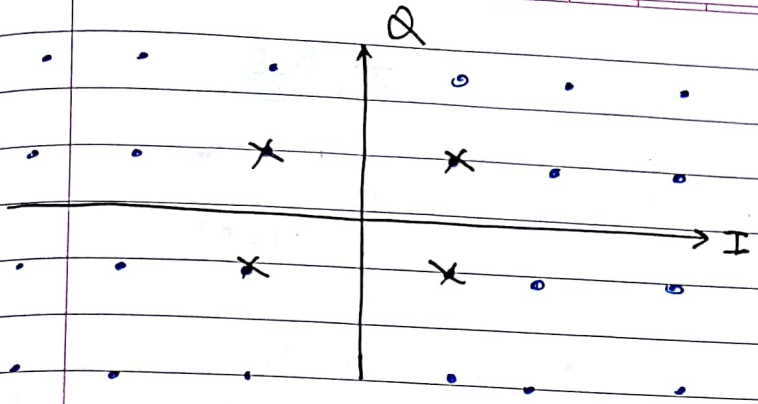


Bandwidth Efficiency = $\frac{(\text{Bits/sec})}{\text{Hz}}$

Constellation Diagram for 4-ASK





× → 4-QPSK

• → 16-QAM

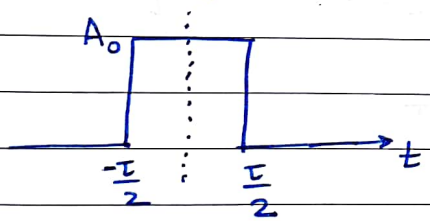
QAM: (General Case): Quadrature Amplitude Modulation
↳ General case

QPSK: Amplitude is constant
↳ modified PSK

18.9.18

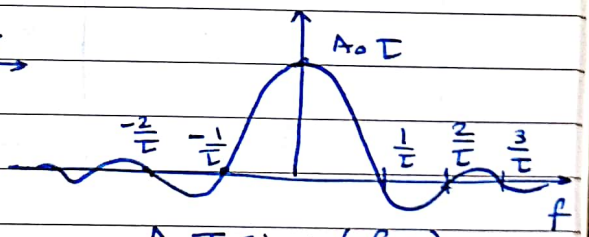
Lecture

- Recap: Digital modulation Schemes



$A \cdot rect\left(\frac{t}{\tau}\right)$

F.T →



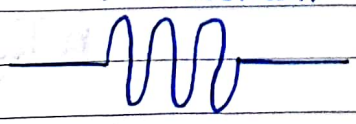
$A_0 \tau \, sinc(f\tau)$

$sinc x$ ~~$\sin x$~~ $\triangleq \frac{\sin x}{x}$ (w/o Normalization)

$\triangleq \frac{\sin(\pi x)}{(\pi x)}$ (Normalized)

→ ASK (Digital AM)

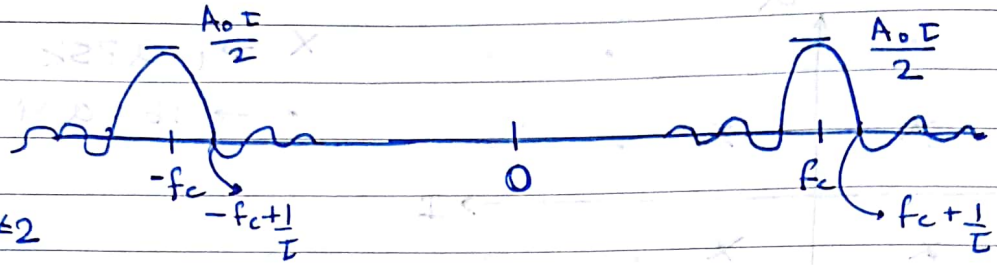
time domain

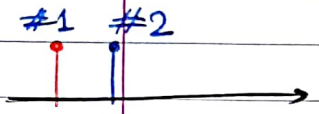


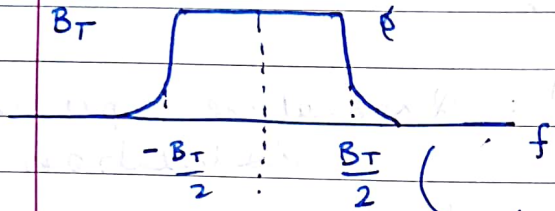
$A_0 \cos 2\pi f_c t \times rect\left(\frac{t}{\tau}\right)$

→ $\frac{A_0 \tau}{2}\left[sinc(f-f_c)\tau + sinc(f+f_c)\tau\right]$

freq. domain

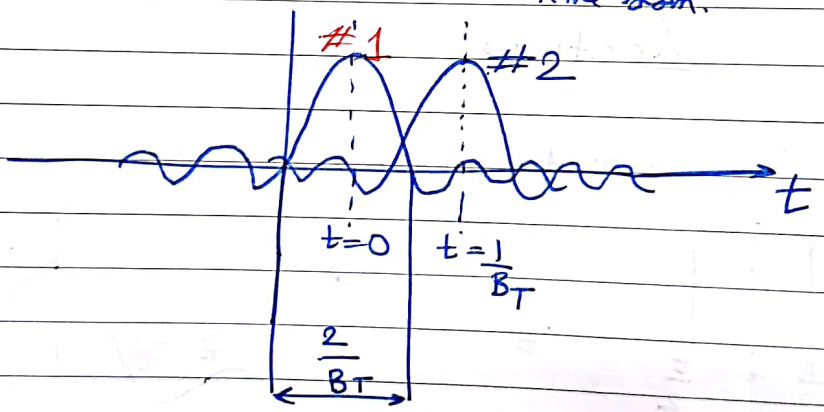




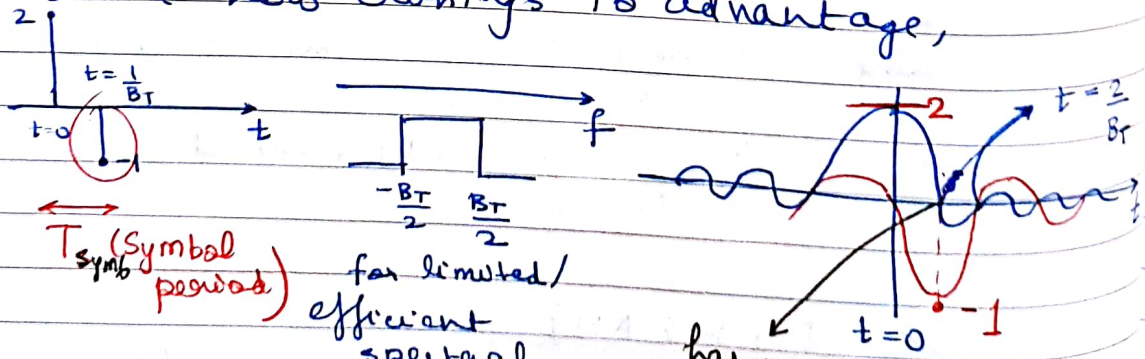


→ To make the signal transfer band limited we use "ideal brickwall filter"

→ taking Convolution with its time domain in time dom.

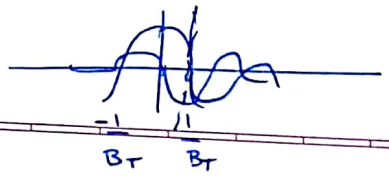


→ So we zero crossings to advantage,

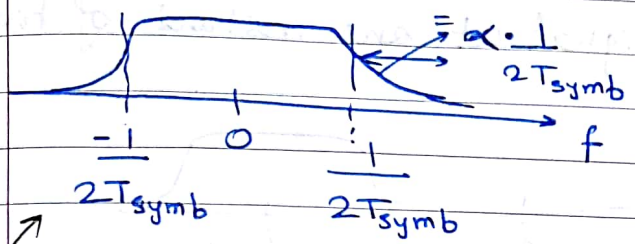


for limited/ efficient spectral usage

has zero crossing at nT_{symb}



$B_T = \frac{1}{T_{symb}} (1+\alpha)$

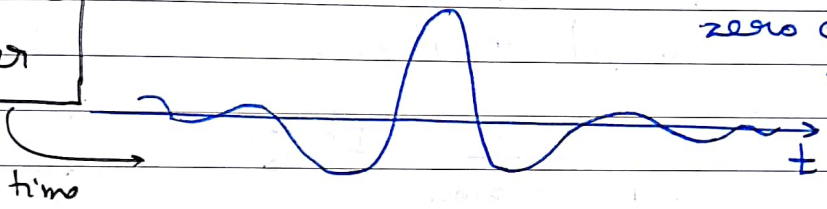


: Pulse shaping filter (PSF)

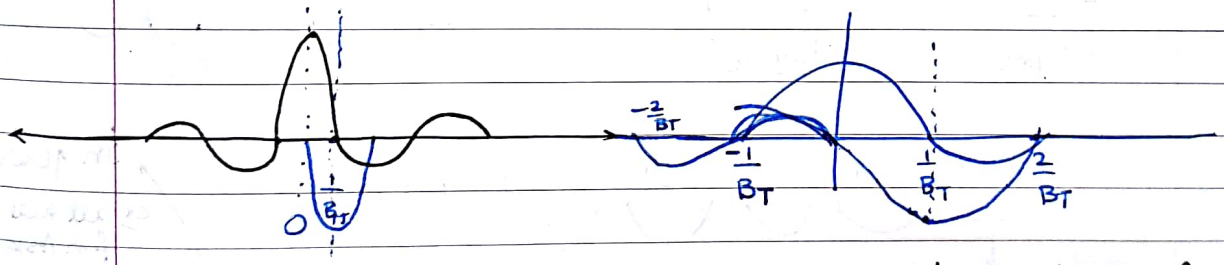
freq $\xrightarrow{ex}$ (Raised cosine filter) $\xrightarrow{\text{Impulse response}}$

Sinc like shape with faster Roll-offs / Decays

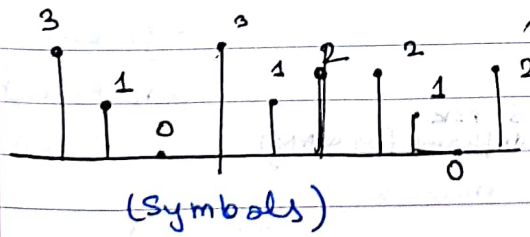
Nyquist filter



zero crossings are still at $n \cdot T_{symb}$ as before



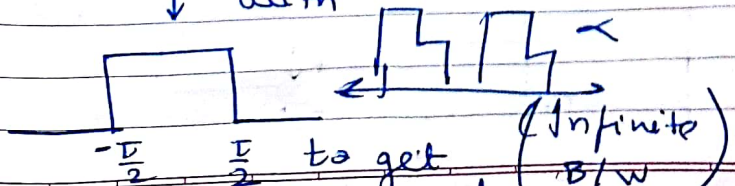
ex



(Discrete samples) → in AM we simply x Impulses with carriers

PSF → $\times \cos(2\pi f_c t)$ → ASK pass band signal

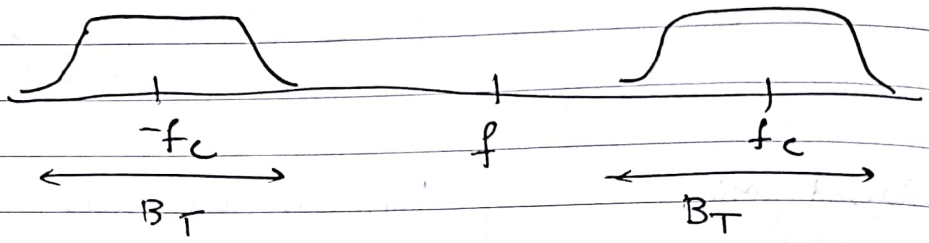
Can't convolve with



to get what we need

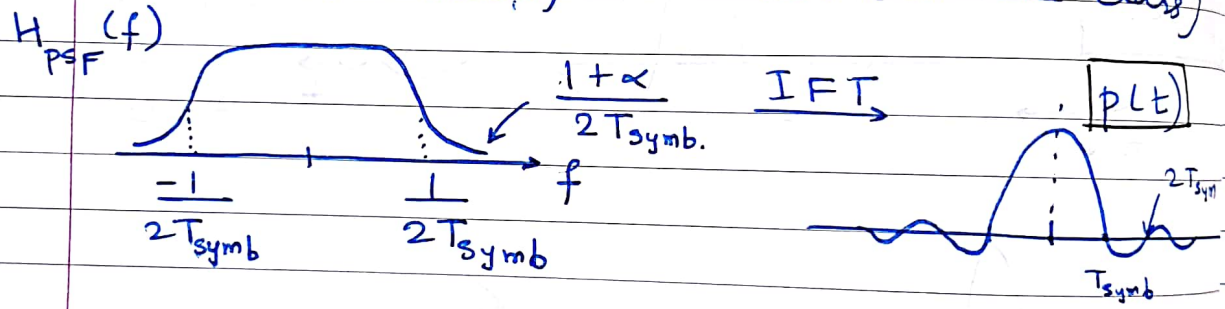
Page No.:
Date:

Pass-Band Signal at one instant of time



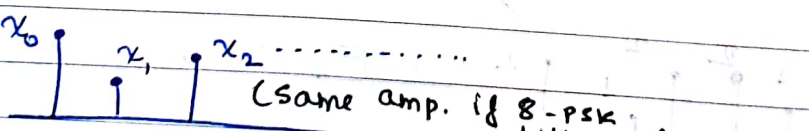
↳ Can be considered at one Instant or an an average

20.9.18 Quib Session: Wed 6-7pm, MS, Q1, Q2
Quiz (10 marks) on Thurs. (in the class)



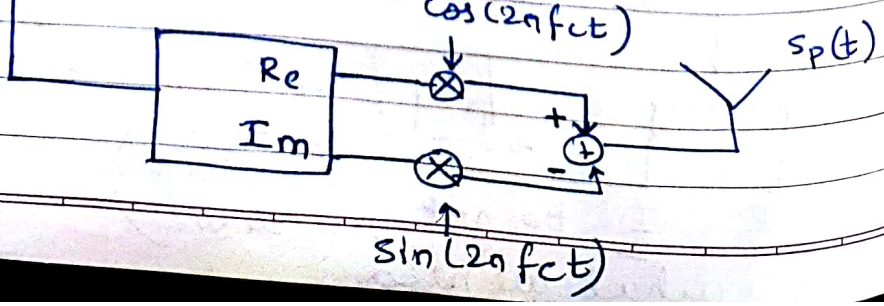
101 001 011 101 000 011

x_0 x_1 x_2 x_3 x_4 x_5 → Complex symbols (Constellation points

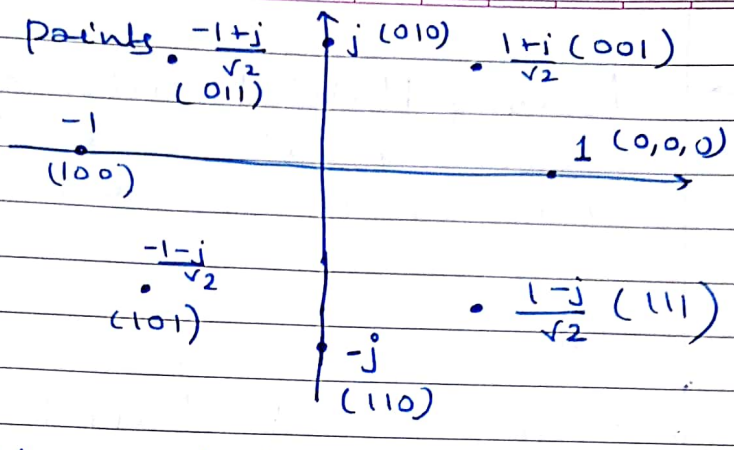


$$x_{BB}(t) = \sum x_k \, p(t - kT_{symb})$$

(complex)



ex of complex points



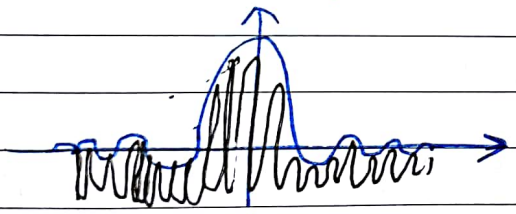
ex Transmit 101 : $\frac{-1-j}{\sqrt{2}}$

$$\text{Re}\left[\left(\frac{-1-j}{\sqrt{2}}\right) \times p(t) \times [\cos 2\pi f_c t + j \sin 2\pi f_c t]\right]$$

→ transmitted signal

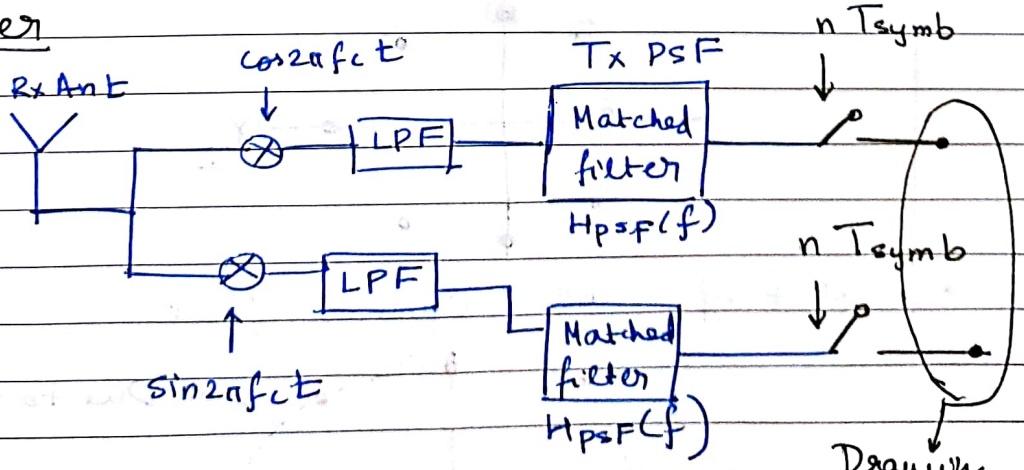
$$= \frac{p(t)}{\sqrt{2}} \left(-\cos 2\pi f_c t + \sin 2\pi f_c t\right)$$

→ envelope → determines phase



(Alignment requires pre-)

Receiver

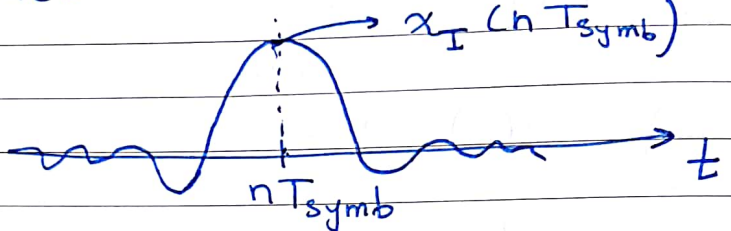


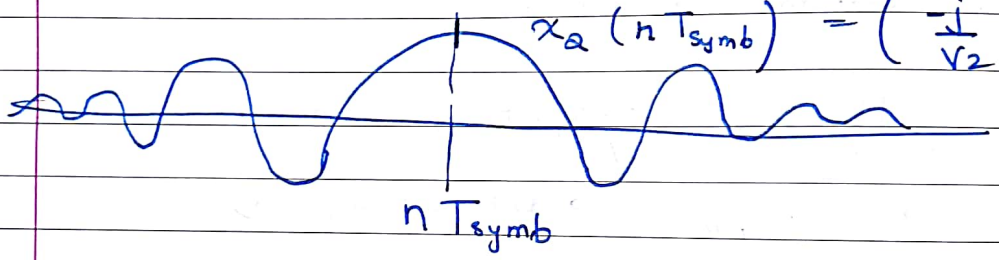
(Matched Filter : Gives best SNR)

→ Applying Matched filter in frequency domain is convolving with same sinc like time domain waveform ($p(t)$) with itself.

O/P

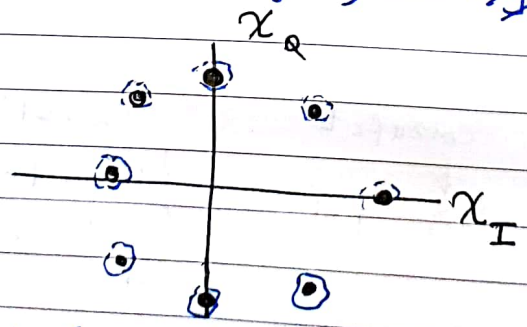
$\cos 2\pi f_c t$ Demod Channel



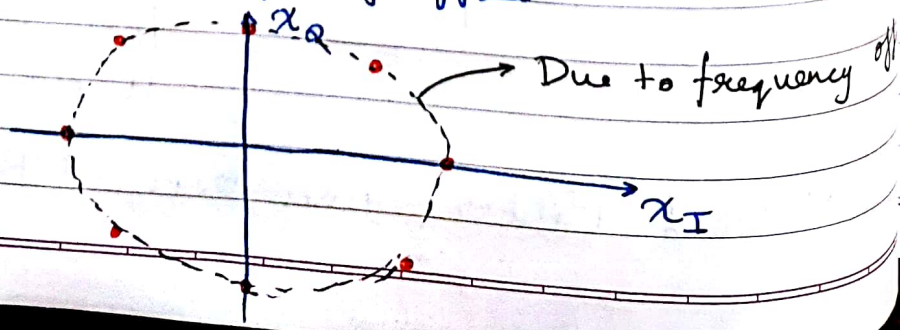


→ Received Complex Symbol

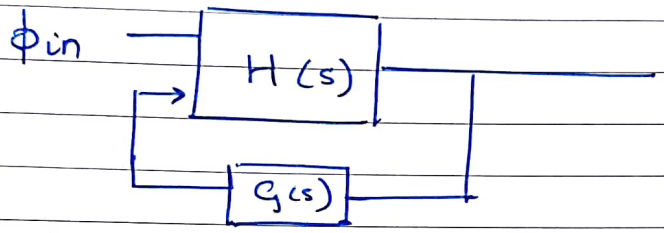
$= x_I(n T_{symb}) + j x_Q(n T_{symb})$



→ Effect of Small frequency offset :



- Solution: Precise Coherent detection,
  Coarse Adjustment: FLL (with Band-edge filters)
  Fine Adjustment: Costas Loop
  → Also does phase in addition to freq.
  → just like -ve feedback in op-amp



→ Sampling time issues

say $T_{sym} = 1\mu s$ & receiver → has $0.99\mu s$
even then as $n \uparrow$ nT_{sym} will have a large mismatch

→ Precise T_{symbol} matching important