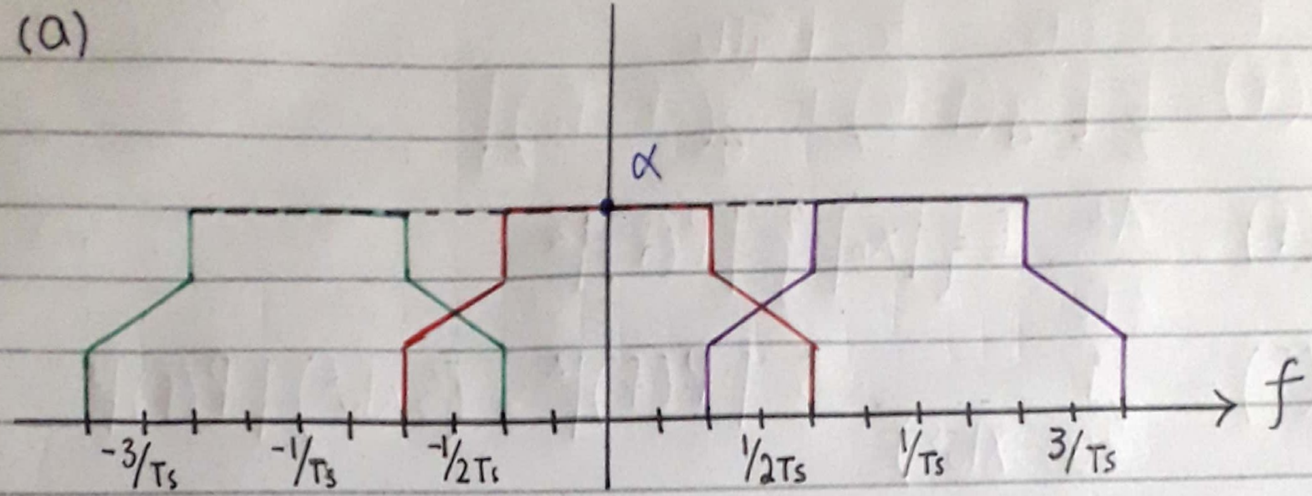
(a)



Condition for ISI free transmission:

$$P_\Sigma(f) \triangleq \frac{1}{T} \sum_{n=-\infty}^{\infty} P\left(f+\frac{n}{T}\right) = p_0$$

The above condition indicates that the folded spectrum $P_\Sigma(f)$ must be flat.
The given $P(f)$ corresponds to a Nyquist pulse since the folded spectrum $P_\Sigma(f)$ is constant as indicated in the figure by black dashed line.

(b) $x_n \in \{+1, -1, +3j, -3j\}$

$P_{x_n} = \frac{1}{4}$

$$\mu_x = E[X] = \sum_n x_n P_{x_n} = (1)\left(\frac{1}{4}\right) + (-1)(1/4) + (3j)(1/4) + (-3j)(1/4) = 0$$

$$\sigma_x^2 = E[|X|^2] = \sum_n |x_n|^2 P_{x_n} = |1|^2 \cdot \frac{1}{4} + |-1|^2 \cdot \frac{1}{4} + |3j|^2 \cdot \frac{1}{4} + |-3j|^2 \cdot \frac{1}{4} = \frac{1+1+9+9}{4}$$

$$= 5$$

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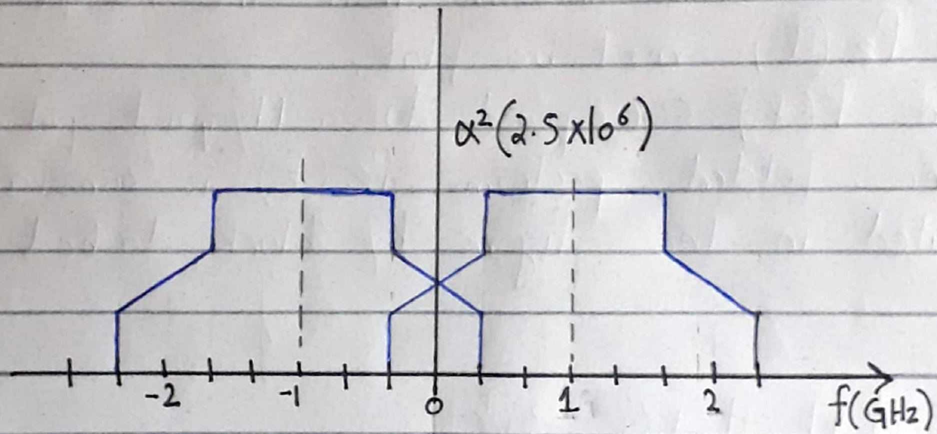
(c) $T_s = 0.5\mu s$, $f_c = 1\,GHz$

$$S_s(f) = \frac{1}{2}\left[S_g(f-f_c) + S_g(-f-f_c)\right]$$

$$S_g(f) = \frac{A^2}{2T_s} E\{|x_n|^2\} |P(f)|^2$$

$$S_g(f) = \frac{1}{2(0.5\times10^{-6})} \cdot 5\,|P(f)|^2 = (5\times10^6)\,|P(f)|^2$$

$$S_s(f) = (2.5\times10^6)\left[|P(f-f_c)|^2 + |P(-f-f_c)|^2\right]$$



(d) Ideally, the k^{th} sample depends on only k^{th} symbol and noise. However, in the given case, $x_k + 0.1\,x_{k-1}$, the recieved signal includes as additional sample, which is attenuated and delayed in time, hence the ~~time~~ recieved signal is distorted. This problem is called as intersymbol interference (ISI), which may arise due to:

- Multipath fading (frequency selective fading)
- Use of non-nyquist pulses
- If the recieved signal is not sampled at exactly the bit instants (Synchronization error)

The problem of ISI can be ~~solve~~ overcome through:

- Using nyquist pulses
- Applying equilization techniques
- Overcoming the synchronization problem at the sampler.

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