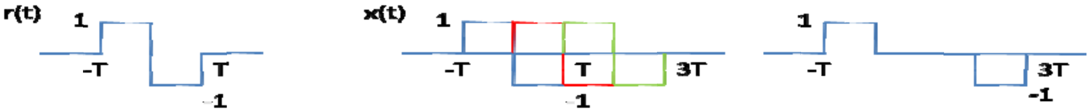
1º Teste 2019/2020

1. Entrada com riscas nas frequências 0 (termo DC igual a 1), 1 (com amplitude 1) e 20 (com amplitude 0.1). Na saída fica o sinal $1+\cos(2\pi t)$
2. a)



b) Não causal, pois $r(t)$ começa em $-T$. Estável, pois $\int_{-\infty}^{+\infty} |r(t)|\,dt = 2T < \infty$

3. a) $R_b = 2B\nu \Rightarrow \nu = 16/2 = 8 \Rightarrow L = 2^{\nu} = 256$

   b) $\nu = 16/4 = 4 \Rightarrow L = 2^{\nu} = 16$

4. a) $x_n = \dfrac{AT}{T_0}\operatorname{sinc}\left(\dfrac{nT}{T_0}\right) - \dfrac{AT}{T_0}\operatorname{sinc}\left(\dfrac{nT}{T_0}\right)e^{-j2\pi nT/T_0}$

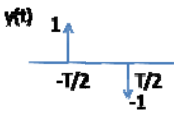
   b) 0

   c)

   $x(t) = 0 \Rightarrow x_n = 0$

2º Teste 2019/2020

1. a)



b)

$$y(t) = \delta(t+T/2) - \delta(t-T/2)$$

$$Y(f) = e^{j2\pi fT/2} - e^{-j2\pi fT/2} = 2j\sin(\pi fT/2)$$

2. a)

$$\overline{a}_n = 0 \Rightarrow S_x(f) = \frac{\overline{a_n^2}}{T}|R(f)|^2 = A^2 T\operatorname{rect}(fT)$$

$$P_x = \int_{-\infty}^{+\infty} |S_x(f)|\,df = A^2$$

b)

$$L = 2^{\nu} = 32 \Rightarrow \nu = 5$$

$$R_b = 1/T = 1\text{Mbps} = 2B\nu \Rightarrow B = 100\,\text{kHz}$$

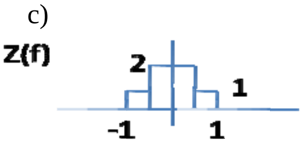
3. a)

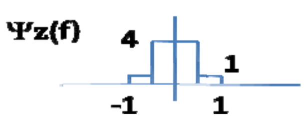
$X(f) = \operatorname{rect}(f) \qquad Y(f) = \operatorname{rect}(f/2)$

b)

$B_{3dB} = 0.5 \qquad B_{90\%} = 0.45$

c)





4.

$$x_1(-t) = x_1(t) \Rightarrow \operatorname{Im}\{X_1(f)\} = 0$$

$$x_2(-t) = x_2(t) \Rightarrow \operatorname{Re}\{X_2(f)\} = 0$$

3º Teste 2019/2020

1.

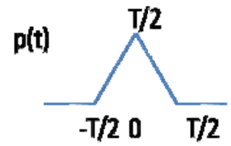
a) $P_x = A^2/4 \Rightarrow E_b = A^2T/4$

b) $S_n(f) = S_w(f)|H(f)|^2 \Rightarrow P_n = \int_{-\infty}^{+\infty} S_n(f)df = \frac{N_0}{2}\int_{-\infty}^{+\infty}|H(f)|^2\, df = \frac{N_0}{2}\int_{-\infty}^{+\infty}|h(t)|^2\, dt = \frac{N_0 T}{4}$

c)

$y(t) = x(t) * h(t) = \sum_n a_n p(t - nT)$

$p(t) = r(t) * h(t) \quad \Rightarrow \quad p(nT) = 0, n \neq 0 \quad \Rightarrow \quad y(nT) = a_n p(0) = a_n T/2$



$$P_b = Q\left(\frac{AT/4}{\sigma}\right) = Q\left(\sqrt{\frac{A^2T^2/16}{\sigma^2}}\right) = Q\left(\sqrt{\frac{A^2T^2/16}{N_0T/4}}\right) = Q\left(\sqrt{\frac{E_b}{N_0}}\right)$$

2.

d)

a) $x(t) = \sum_n a_n r(t - nT_a)\cos(2\pi f_c t) = x_I(t)\cos(2\pi f_c t)$

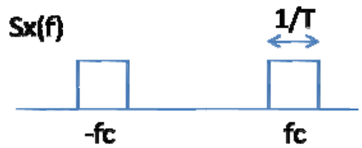
$a_n \pm A \Rightarrow x(t)$ BPSK

b)

$S_{x_I}(f) = \frac{\overline{a_n^2}}{T}|R(f)|^2 = A^2 T \text{rect}(fT)$

$\Rightarrow S_x(f) = \frac{1}{4}S_{x_I}(f - f_c) + \frac{1}{4}S_{x_I}(f + f_c)$

$B = 1/T$



3. $f_c - A_1 k_f < f_i(t) < f_c + A_2 k_f \Rightarrow B_{FM} \approx 2B + (A_1 + A_2)k_f \approx \begin{cases} 2B, & NB \\ (A_1 + A_2)k_f, & WB \end{cases}$

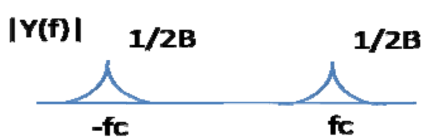
Exame 2019/2020

1. a)

$x(t) = \frac{1}{2B}\frac{2/B}{(1/B)^2 + (2\pi t)^2} \rightarrow X(f) = \frac{1}{2B}e^{-|f|/B}$

$Y(f) = \frac{1}{2j}X(f - f_c) - \frac{1}{2j}X(f + f_c)$

b)



c)

$E_y = E_x/2$

d)

$B_y = 2B_x$

2. $\psi_x(-f) \neq \psi_x(f) \Rightarrow x(t)$ tem que ser complexo

3.

a)

$$x_n = \frac{A}{2}\text{sinc}(n/2) \Rightarrow S_x(f) = \sum_n |x_n|^2\ \delta(f - n/T)$$

$$y(t) = \sum_n a_n r(t - nT),\ a_n = \pm A,\ r(t) = \text{rect}(2t/T)$$

$$S_y(f) = \frac{\overline{a_n^2}}{T}|R(f)|^2 = \frac{A^2T}{2}\text{sinc}^2(fT/2)$$

b)

$$z(t) = \sum_n (a_n + A)r(t - nT) = \sum_n a'_n r(t - nT),\ a'_n = 2A \text{ ou } 0$$

c)

$S_z(f) = S_x(f) + S_y(f)$ pois um só tem riscas e o outro não tem riscas

4.

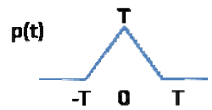
a) $P_x = (0 + A^2 + (2A)^2 + (3A)^2)/4 = 7A^2/2 \Rightarrow E_b = P_x T/2 = 7A^2/4$

b) $S_n(f) = S_w(f)|H(f)|^2 \Rightarrow P_n = \int_{-\infty}^{+\infty} S_n(f)df = \frac{N_0}{2}\int_{-\infty}^{+\infty}|H(f)|^2\ df = \frac{N_0}{2}\int_{-\infty}^{+\infty}|h(t)|^2\ dt = \frac{N_0 T}{2}$

c)

$$y(t) = x(t) * h(t) = \sum_n a_n p(t - nT)$$

$$p(t) = r(t) * h(t) \quad \Rightarrow \quad p(nT) = 0, n \neq 0 \quad \Rightarrow \quad y(nT) = a_n p(0) = a_n T$$



d)

$$P_s = \frac{P_{s/0} + P_{s/A} + P_{s/2A} + P_{s/3A}}{4} = \frac{Q() + 2Q() + 2Q() + Q()}{4} = \frac{3}{2}Q\left(\frac{AT/2}{\sigma}\right)$$

$$P_b \overset{\text{(Mapeamento de Gray)}}{\approx} \frac{P_2}{2} = \frac{3}{4}Q\left(\frac{AT/2}{\sigma}\right) = \frac{3}{4}Q\left(\sqrt{\frac{A^2T^2/4}{\sigma^2}}\right) = \frac{3}{4}Q\left(\sqrt{\frac{A^2T^2/4}{N_0T/2}}\right) = \frac{3}{4}Q\left(\sqrt{\frac{2E_b}{7N_0}}\right)$$

e)

5.

a)

$$\bar{a}_n = 3A/2, \quad \overline{a_n^2} = 7A^2/2, \quad R(f) = T\text{sinc}(fT), \quad R(n/T) = T\text{sinc}(n)$$

$$S_x(f) = \frac{\overline{a_n^2} - (\bar{a}_n)^2}{T}|R(f)|^2 + (\bar{a}_n)^2\delta(f) = \frac{5A^2}{4}T\text{sinc}^2(fT) + \frac{9A^2}{4}\delta(f)$$

$$S_y(f) = \frac{S_x(f - f_c) + S_x(f + f_c)}{4}$$

b) Banda infinita

c) Teria que se usar impulsos raised cosine com roll-off 0.

$$B \overset{(DSB,\rho=0)}{=} \frac{1}{T} = \frac{R_b}{2} \Rightarrow R_b = 2Mbps$$