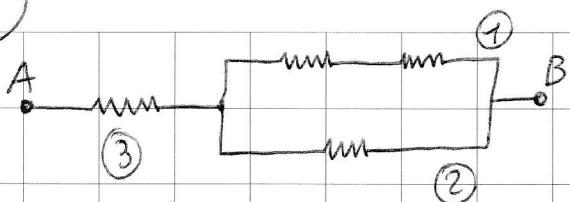


# Tektronix®

ES.  
1



$$P_F^1 = P\{\text{ramo } ① \text{ funziona}\} = \\ = (1 - 0,4) \cdot (1 - 0,15) = 0,51$$

$$P_G^1 = P\{\text{ramo } ③ \text{ è guasto}\} \\ = 1 - P_F^1 = 0,49$$

$$P_G^{1/1/2} = P_G^1 \cdot P_G^2 = 0,49 \cdot 0,2 = 0,098$$

$$P_F^{1/1/2} = 1 - P_G^{1/1/2} = 0,902$$

$$P_F^{AB} = P_F^3 \cdot P_F^{1/1/2} = (1 - 0,3) \cdot 0,902 = 0,6314$$

ES.  
2

$$F_X(x) = P\{X \leq x\} = (1 - e^{-\frac{x}{\lambda}}) u(x)$$

$$\text{a)} \quad P\{X > 10 \text{ minuti}\} = e^{-2} \Rightarrow 1 - F_X(10) = e^{-2}$$

$$1 - (1 - e^{-\frac{10}{\lambda}}) = e^{-2}$$

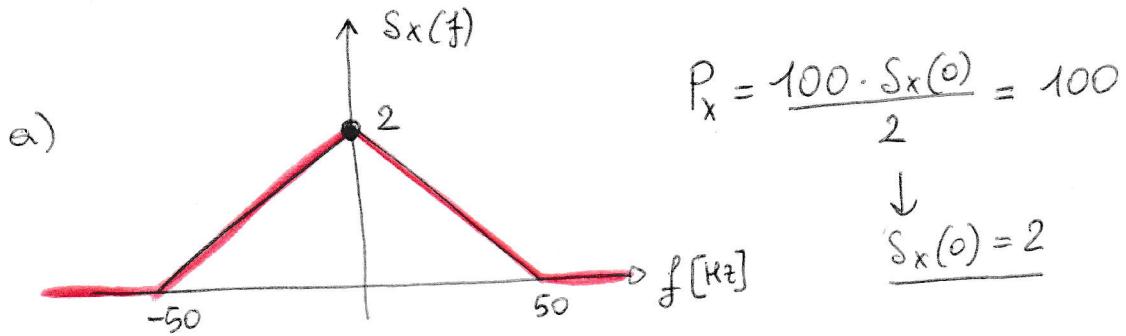
$$e^{-\frac{10}{\lambda}} = e^{-2}$$

$$-\frac{10}{\lambda} = -2 \rightarrow \boxed{\lambda = 5 \text{ min}}$$

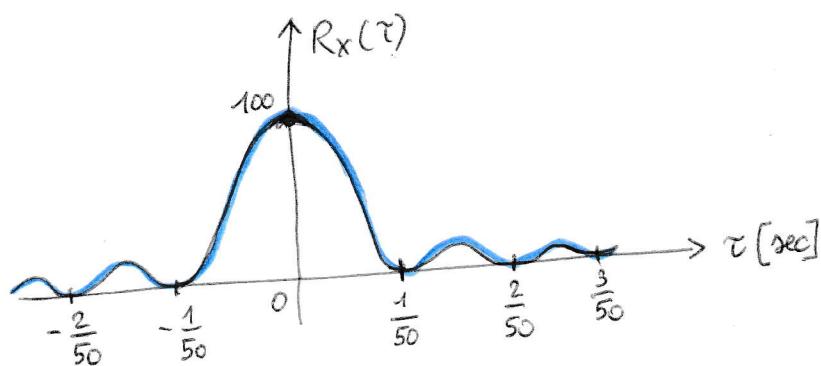
$$\text{b)} \quad P\{X \leq x_0\} = F_X(x_0) = 0,05 = \frac{1}{20}$$

$$1 - e^{-\frac{x_0}{5}} = \frac{1}{20} \Rightarrow e^{-\frac{x_0}{5}} = \frac{19}{20} \Rightarrow -\frac{x_0}{5} = \ln \frac{19}{20}$$

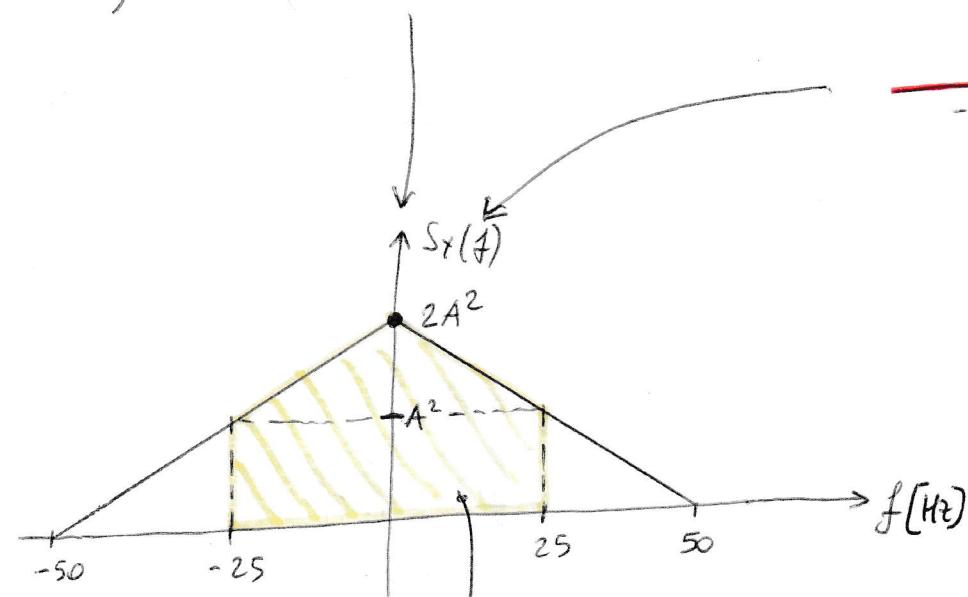
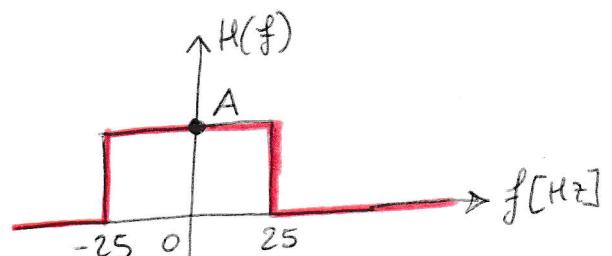
$$x_0 = 5 \cdot \ln \left( \frac{20}{19} \right) \simeq 0,26 \text{ min} \simeq 15 \text{ secondi}$$

ES  
③

b)  $R_x(\tau) \Leftrightarrow S_x(f) \rightsquigarrow R_x(\tau) = 100 \cdot \text{sinc}^2(50\tau)$



c)  $S_y(f) = S_x(f) \cdot |H(f)|^2$



$$P_y = 2 \cdot \underbrace{\frac{(2A^2 + A^2) \cdot 25}{2}}_{\text{aree del trapezio}} = 75A^2$$

ESSERE, HO → 4

$$a) \quad x(t) = e^{-\frac{t}{T}} u(t)$$

Calcoliamo la trasformata di Fourier:

$$\begin{aligned} X(f) &= \int_{-\infty}^{\infty} x(t) e^{-j 2\pi f t} dt \\ &= \int_0^{\infty} e^{-\frac{t}{T}} e^{-j 2\pi f t} dt \\ &= \int_0^{\infty} e^{-\left(\frac{1}{T} + j 2\pi f\right)t} dt \end{aligned}$$

Tanto canto che:

$$\int_0^{\infty} e^{-at} dt = -\frac{1}{a} e^{-at} \Big|_0^{\infty} = -\frac{1}{a} (0 - 1) = \frac{1}{a}$$

$$= \frac{1}{\frac{1}{T} + j 2\pi f} = \frac{T}{1 + j 2\pi T f}$$

$$b) X(f) = \frac{1}{1 + j \frac{f}{f_T}} \quad f_T = \frac{1}{2\pi T}$$

$$|X(f)|^2 = \frac{T^2}{1 + \left(\frac{f}{f_T}\right)^2}$$

$$\left| |X(f)|^2 \right|_{dB} - 10 \log_{10} \frac{|X(f)|^2}{|X(0)|^2}$$

$$\left| |X(f)|^2 \right|_{dB} = -3 \text{ dB} \quad \rightarrow \quad \frac{|X(f)|^2}{|X(0)|^2} = \frac{1}{2}$$

$$\frac{|X(f)|^2}{|X(0)|^2} = \frac{1}{1 + \left(\frac{f}{f_T}\right)^2} = \frac{1}{2}$$

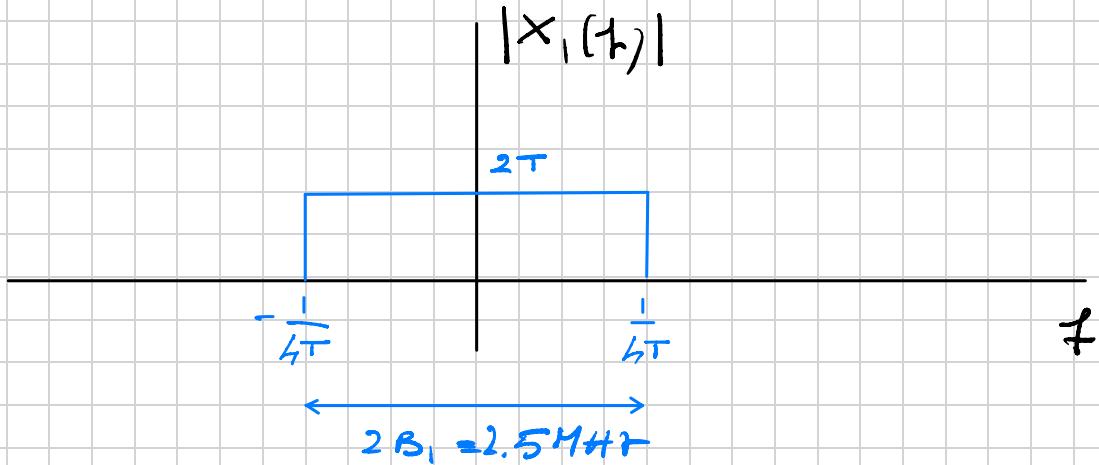
$$f = f_T$$

Daumdi:  $B_{-3 \text{ dB}} = f_T = \frac{1}{2\pi T} = \frac{1}{2\pi} \text{ kHz} \approx 160 \text{ Hz}$

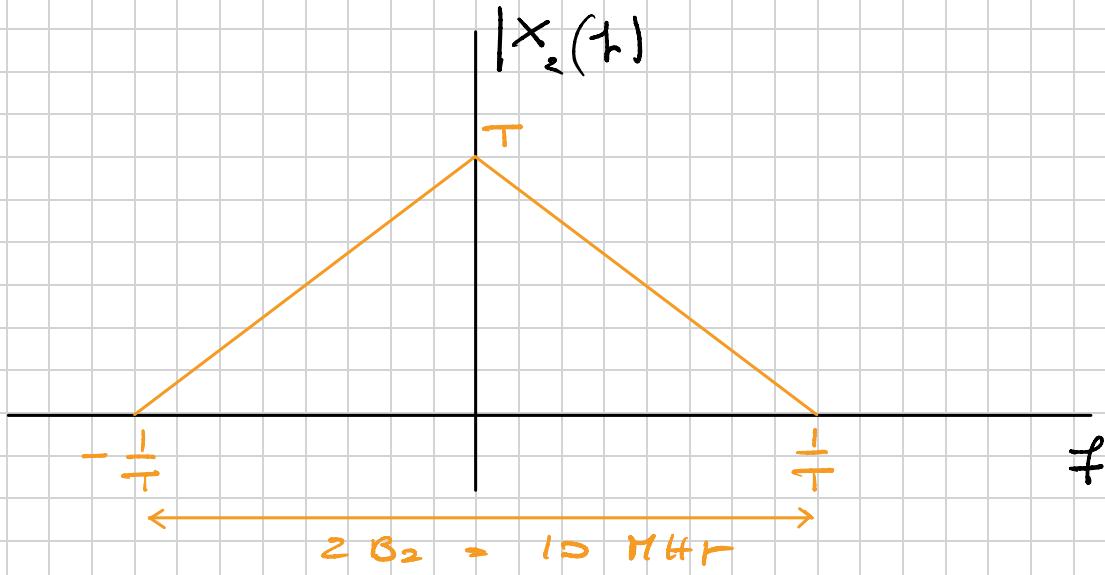
## FSS kci kdo 5

a)

$$x_1(t) = \text{sinc}\left(\frac{t}{2T}\right) \iff x_1(f) = 2T \text{ rect}(2fT)$$



$$x_2(t) = \text{sinc}^2\left(\frac{t}{T}\right) \iff x_2(f) = T^2 \text{ rect}(fT) \otimes \text{rect}(fT)$$

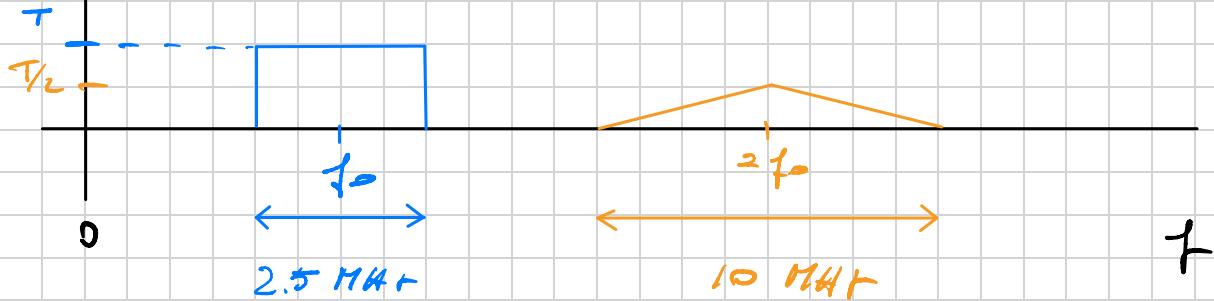


Tentativa conto che:

$$X(f) = \frac{X_1(f + f_0) + X_1(f - f_0)}{2}$$

$$+ \frac{X_2(f + 2f_0) + X_2(f - 2f_0)}{2}$$

$$|X(f)|$$

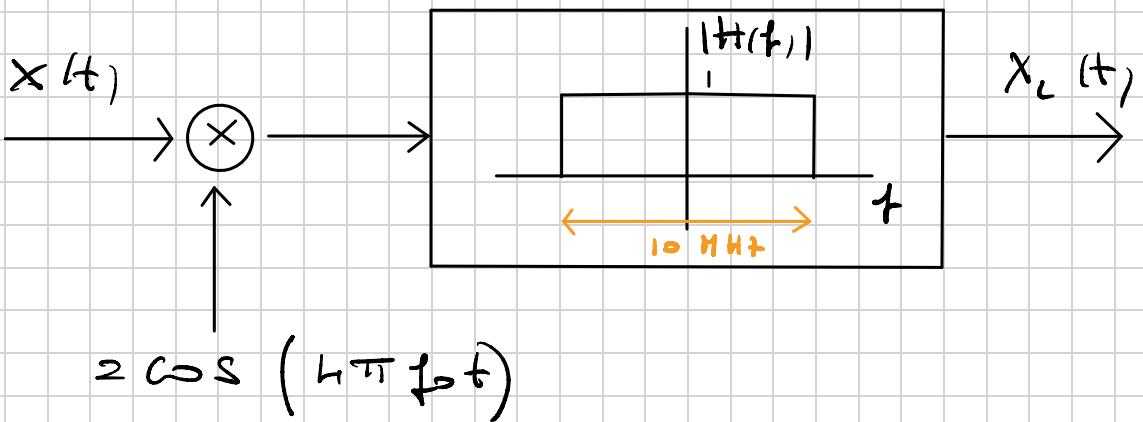


b) Per recuperare il segnale  $X_2(t)$  deve

demodularlo con un  $\cos(\cdot)$  alla

frequenza  $2f_s$  e filtrarlo con

un filtro passa-bassi di banda  $5\text{MHz}$



## ESERCIZIO 6

La matrice controllo di parità c'è:

$$H = \begin{bmatrix} P^T & I_3 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 & 0 & 1 \end{bmatrix}$$

Le sindrome di parità:

$$S = y H^T = [0 \ 1 \ 0]$$

Siccome  $S = y H^T = e H^T$  si trova

$$e = [0 \ 0 \ 0 \ 0 \ 1 \ 0]$$

da cui segue  $y + e = [0 \ 1 \ 1 \ 1 \ 1 \ 0]$

## Esercizio 7

a) La densità spettrale di potenza d'

$$S_S(f) = \frac{1}{T_s} S_R(f) |G_r(f)|^2$$

dove

$$S_R(f) = \sum_m R_R(m) e^{-j 2\pi f T_s}$$

$$R_R(m) = \begin{cases} \sigma_a^2 + \eta_a^2 & m=0 \\ \eta_a^2 & m \neq 0 \end{cases}$$

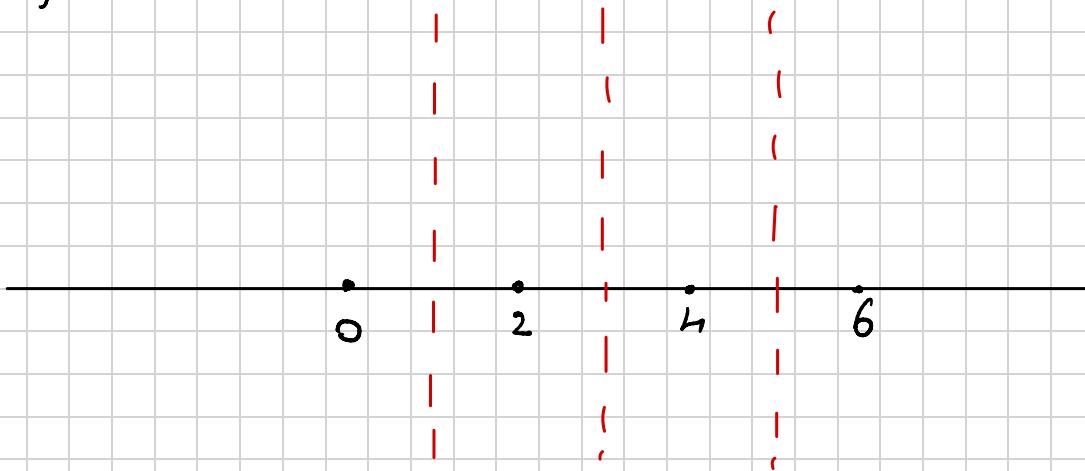
Calchiamo  $\eta_a \in \sigma_a^2$ :

$$\eta_a = E\{\varepsilon_i\} = \frac{1}{4} (0+2+4+6) = 3$$

$$\sigma_a^2 = E\{\varepsilon_i^2\} - \eta_a^2 = \frac{1}{4} (0^2+2^2+4^2+6^2) - 3^2$$

$$= \frac{56}{4} - 9 = 5$$

b)



la probabilità di errore è la stessa di una

h-PAR con un solo bit momento che

$$\text{dipende da } Q\left(\frac{h-q}{\sigma}\right)$$

Quindi:

$$P(e) = \frac{1}{h} \left( 2 P(e | c_k=2) + 2 P(e | c_k=0) \right)$$

$$= \frac{1}{2} \left( 2 Q\left(\frac{1}{\sigma_h}\right) + Q\left(\frac{1}{\sigma_h}\right) \right) = \frac{3}{2} Q\left(\frac{1}{\sigma_h}\right)$$

## Esercizio 8

a) Tenuto conto che  $B = \frac{1+\alpha}{T_s} = \frac{1+\alpha}{r \log_2 D} R_L$

$$y = \frac{R_b}{B} = \frac{r \log_2 M}{1+\alpha} = \frac{s}{\gamma}$$

$$R_b = y B = 5 \text{ Mbit/s}$$

Il tempo necessario per trasmettere il file è

$$T_{TTLG} = \frac{s \cdot f^2}{R_b} = 0.2 \text{ s}$$

b) La probabilità d'errore in ingresso al codificatore è

$$P(e) = Q\left(\frac{1}{\sqrt{\frac{T_s}{N_0}}}\right) = Q\left(\sqrt{\frac{T_s}{N_0}}\right) \cdot Q\left(\sqrt{\frac{T_b + \log_2 D}{N_0}}\right)$$

$$\text{Se } \frac{T_b}{N_0} = 6 \text{ dB} = 4 \text{ mJ} \text{ ottiene } P(e) = Q\left(\sqrt{6}\right) \approx 6 \cdot 10^{-3}$$