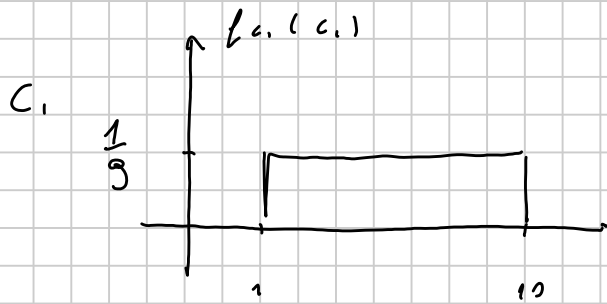
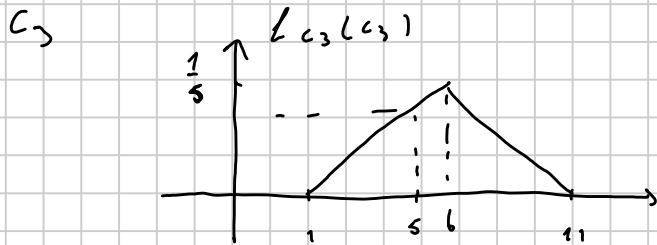


ESERCIZIO 1



C_2

$$f_{C_2}(c_2) = \frac{1}{5} e^{-\frac{c_2}{5}} \quad c_2 > 0$$



$A = \{ \text{STAMPARE ALMENO 100 PAGINE IDENTICHE} \}$

$$P_n\{A\} = \frac{1}{3} P_n\{A \mid \text{Sceglia stampante 1}\} + \frac{1}{3} P_n\{A \mid \text{Sceglia 2}\} + \frac{1}{3} P_n\{A \mid \text{Sceglia 3}\}$$

$$P_n\{A \mid \text{Sceglia } i\} = P_n\{C_i \leq 5 \text{ mlt/px}\}$$

$$P_n\{A \mid \text{Sceglia 1}\} = \frac{1}{3} \cdot 4 = \frac{4}{3}$$

$$P_n\{A \mid \text{Sceglia 2}\} = \int_0^5 \frac{1}{5} e^{-\frac{c_2}{5}} dc_2 = \frac{1}{5} (-5) e^{-\frac{c_2}{5}} \Big|_0^5 =$$

$$= \left(1 - \frac{1}{e} \right)$$

$$P\{A \mid \text{Succ}_{\text{old}} 3\} = \frac{8}{25}$$

$$P\{A\} = \frac{5}{27} + \frac{8}{73} + \frac{1}{3} \left(1 - \frac{1}{e} \right)$$

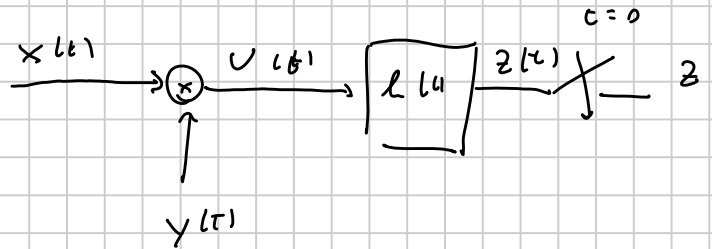
ESERCIZIO 2

$$X(t) = \frac{A}{r} \exp\left(-\frac{t}{r}\right) \cos(2\pi f_0 t)$$

$$Y(t) = \cos(2\pi f_0 t + \theta)$$

$$A \in \mathcal{U}(0, 1)$$

$$\theta \in \mathcal{U}(-\pi, \pi)$$



$$U(t) = X(t) Y(t) = \frac{A}{r} \exp\left(-\frac{t}{r}\right) \cos(2\pi f_0 t) \cos(2\pi f_0 t + \theta) =$$

$$= \frac{1}{2r} A \exp\left(-\frac{t}{r}\right) [\cos(4\pi f_0 t + \theta) + \cos \theta]$$

$$Z(t) = \frac{1}{2} A \exp\left(-\frac{t}{r}\right) \cos(\theta)$$

$$Z(0) = Z = \frac{1}{2} A \cos(\theta)$$

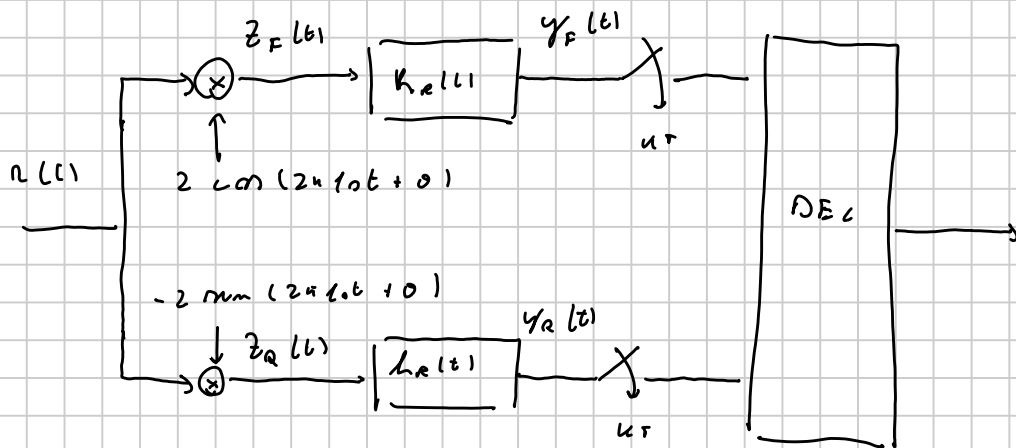
$$E\{Z\} = E\left\{ \frac{1}{2} A \cos(\theta) \right\} = \frac{1}{2} E\{A\} E\{\cos \theta\} = 0$$

"0"

$$E\{Z^2\} = \frac{1}{4} E\{A^2\} E\{\cos^2 \theta\} = \frac{1}{4} \cdot \frac{1}{3} \cdot \frac{1}{2} = \sigma_Z^2 = \frac{1}{24}$$

"1/3" "1/2"

ESERCIZIO 3



$$E_s = E \left\{ \int_{-\infty}^{+\infty} s_c^2(t) dt \right\}$$

$$s_c(t) = x_c(i) p(t - \tau) \cos(2\pi f_0 t) - x_s(i) p(t - \tau) \sin(2\pi f_0 t)$$

$$E_s = E \left\{ \int_{-\infty}^{+\infty} \left(x_c^2(i) p^2(t - \tau) \cos^2(2\pi f_0 t) + x_s^2(i) p^2(t - \tau) \sin^2(2\pi f_0 t) + 2 x_c(i) x_s(i) p^2(t - \tau) \cos(2\pi f_0 t) \sin(2\pi f_0 t) \right) dt \right\} =$$

$$= E \{ x_c^2(i) \} \int_{-\infty}^{+\infty} p^2(t - \tau) \left(\frac{1}{2} + \frac{1}{2} \cos(4\pi f_0 t) \right) dt +$$

$$+ E \{ x_s^2(i) \} \int_{-\infty}^{+\infty} p^2(t - \tau) \left(\frac{1}{2} - \frac{1}{2} \cos(4\pi f_0 t) \right) dt +$$

$$- E \{ x_c(i) x_s(i) \} \int_{-\infty}^{+\infty} p^2(t - \tau) \frac{1}{2} \sin(4\pi f_0 t) dt =$$

$$= \frac{1}{2} E \{ x_c^2(i) \} E_p + \frac{1}{2} E \{ x_s^2(i) \} E_p =$$

$$= \frac{1}{2} \cdot \frac{5}{2} E_p + \frac{1}{2} E_p = \frac{3}{2} E_p = \frac{3}{5} B$$

$$E_p = \int_{-\infty}^{+\infty} |P(f)|^2 df = B$$

$$r(t) = s(t) \otimes c(t) + n(t) =$$

$$= s(t - t_0) + n(t) =$$

$$= \sum_n x_c(n) p(t - nT - t_0) \cos(2\pi f_0 t - \underbrace{2\pi f_0 t_0}_{\alpha = -2\pi f_0 t_0}) +$$

$$+ \sum_n x_s(n) p(t - nT - t_0) \cos(2\pi f_0 t - 2\pi f_0 t_0) + n(t)$$

RATIO IN FASE

$$z_F(t) = z_{Fs}(t) + z_{Fn}(t)$$

\hookrightarrow componente di rumore
 \hookrightarrow componente di segnale

$$z_{Fs}(t) = \sum_n x_c(n) p(t - nT - t_0) \cos(2\pi f_0 t + \alpha) \cos(2\pi f_0 t + \theta) +$$

$$+ \sum_n x_s(n) p(t - nT - t_0) \sin(2\pi f_0 t + \alpha) \cos(2\pi f_0 t + \theta) =$$

$$= \sum_n x_c(n) p(t - nT - t_0) (\cos(\alpha - \theta) + \cos(4\pi f_0 t + \alpha + \theta))$$

$$- \sum_n x_s(n) p(t - nT - t_0) (\sin(\alpha - \theta) + \sin(4\pi f_0 t + \alpha + \theta))$$

$$y_F(t) = y_{Fs}(t) + y_{Fn}(t)$$

$$y_{Fs}(t) = \sum_n x_c(n) g(t - nT) \cos(\alpha - \theta) +$$

$$= \sum_n x_s(n) g(t - nT) \cos(\omega_c t - \theta)$$

$$g(t) = p(t) \otimes c(t) \otimes h_e(t)$$

$$G(f) = P(f) C(f) H_e(f) = P^2(f)$$

$$y_{MF}(t) = u_{MF}(t)$$

$$P_{MF} = N_0 \int_{-\infty}^{+\infty} |H_e(f)|^2 df = N_0 \int_{-\infty}^{+\infty} P^2(f) df = N_0 B$$

RANO IN QUADRATURA

$$z_{es}(t) = - \sum_n x_c(n) p(t - nT - t_0) \cos(2\pi f_0 t + \alpha) \sin(2\pi f_0 t + \theta) + \\ + \sum_n x_s(n) p(t - nT - t_0) \sin(2\pi f_0 t + \alpha) \cos(2\pi f_0 t + \theta) =$$

$$= \sum_n x_c(n) p(t - nT - t_0) \sin(4\pi f_0 t + \alpha + \theta) \sin(\alpha - \theta) + \\ + \sum_n x_s(n) p(t - nT - t_0) (\cos(\alpha - \theta) - \cos(4\pi f_0 t + \alpha + \theta))$$

$$y_{es}(t) = \sum_n x_s(n) h(t - nT) \cos(\alpha - \theta) + \\ + \sum_n x_c(n) h(t - nT) \sin(\alpha - \theta)$$

ASSEMBLA DI CROSS-TALK

$$\alpha - \theta = 2\pi K$$

$$\theta = \alpha + 2\pi K = -2\pi f_0 t_0 + 2\pi K$$

$$P_{m \sim a} = N_0 B$$

Verificare anche che $1 \leq 1$

$$G(1) = P_{11}^2$$

$$\sum_i G\left(1 - \frac{1}{r}\right) = 1 \quad \Rightarrow \quad h(1) = \frac{1}{r}$$

$$P_E^{(QAM)}(b) = P_E^{(CF)}(b) + P_E^{(R)}(b)$$

\uparrow
 Probabilità di errore
 come in base

\uparrow
 P. err. come
 in per struttura

$$P_E^{(CF)} = \frac{1}{2} Q\left(\frac{1/\sqrt{r}}{\sqrt{N_0 B}}\right) + \frac{1}{2} Q\left(\frac{2/\sqrt{r}}{\sqrt{N_0 B}}\right)$$

$$P_E^R = Q\left(\frac{1/\sqrt{r}}{\sqrt{N_0 B}}\right)$$

ESERCIZIO 4

1) H_0 verda $S_{x(1)}$ avrebbe componenti ≤ 0

2) H_0 verda non ha il minimo in 0

3) S_1 rispetta tutte le proprietà