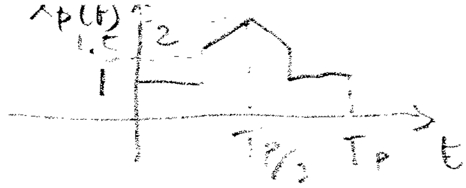
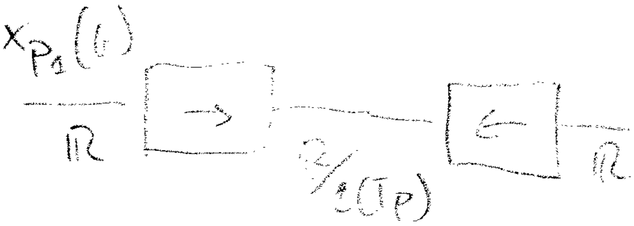
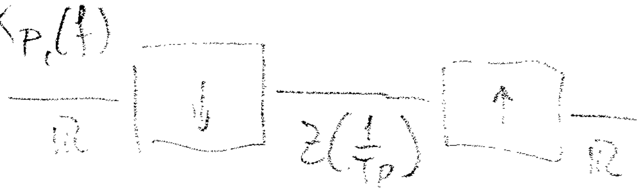
1) $$x(t) = 1 + \sum_{k=-\infty}^{+\infty} x_{p_1}(t - kT_p)$$



$$x_{p_1}(t) = 0.5 \, \text{rect}\left(\frac{t - T_p/2}{T_p/2}\right) + 0.5 \, \text{triangle}\left(\frac{t - T_p/2}{T_p/4}\right)$$

$$X_{p_1}(f) = \frac{T_p}{4} \, \text{sinc}\left(f \frac{T_p}{2}\right) e^{-j2\pi f \frac{T_p}{2}} + \frac{T_p}{8} \, \text{sinc}^2\left(f \frac{T_p}{4}\right) e^{-j2\pi f \frac{T_p}{2}}$$





$$X(f) = \delta_{\mathbb{R}}(f) + \frac{1}{T_p} \sum_{k=-\infty}^{+\infty} X_{p_1}\left(\frac{k}{T_p}\right) \delta_{\mathbb{R}}\left(f - \frac{k}{T_p}\right)$$

$$X_{p_1}\left(\frac{k}{T_p}\right) = \left(\frac{T_p}{4} \, \text{sinc} \, \frac{k}{2} + \frac{T_p}{8} \, \text{sinc}^2\left(\frac{k}{4}\right)\right)(-1)^k$$

2) $$x(kT) = x_1 * x_2(kT)$$

$$x_1(kT) = \frac{1}{T} \, 0.5^k \, 1_0(kT)$$

$$x_2(kT) = \begin{cases} 1 & k = -1, 0, \dots, 10 \\ 0 & \text{altrimenti} \end{cases}$$

$$X(f) = X_1(f) X_2(f) \qquad X_2(f) = 12T e^{-j2\pi f \frac{11}{2} T} e^{+j2\pi f T} \, \text{sinc}_{12}(12 f T)$$

$$X_1(f) = \frac{1}{T} \cdot \frac{T}{1 - 0.5 e^{-j2\pi f T}}$$

3) $e^{-\pi t^2} \longleftrightarrow e^{-\pi f^2}$

$-j 2\pi t\, e^{-\pi t^2} \longleftrightarrow -2\pi f\, e^{-\pi f^2}$

$-4\pi^2 t^2 e^{-\pi t^2} \longleftrightarrow -2\pi \left(e^{-\pi f^2} - 2\pi f^2 e^{-\pi f^2}\right)$

$t^2 e^{-\pi t^2} \longleftrightarrow \frac{1}{2\pi}\left(e^{-\pi f^2} - 2\pi f^2 e^{-\pi f^2}\right)$

area $t^2 e^{-\pi t^2} = \frac{1}{2\pi}$

4) $x(t)$ è l'uscita di un filtro interpolatore con ingresso

$x_1(kT) = 0.2^k\, 1_0(kT)$

e risposta impulsiva $g(t) = \frac{1}{T}$ triangle $\frac{t}{T}$

$X(f) = X_1(f) \cdot G(f) = \frac{T}{1 - 0.2\, e^{-j2\pi f T}}\, \mathrm{sinc}^2 fT$

5)

$H(f) = \frac{1+\rho}{2}\, \frac{1 - e^{-j2\pi f T}}{1 - \rho\, e^{-j2\pi f T}}$ $\quad e^{j k\pi} = e^{j 2\pi k \frac{1}{2T} T}$

$y(kT) = 1 \cdot H(0) + H\left(\frac{1}{2T}\right) \cdot (-1)^k$

$= 1 \cdot 0 + 1\,(-1)^k = (-1)^k$

1) $r_x(\tau) = R_0 B \,\mathrm{sinc}^2\left(\frac{\tau}{2} B\right)$

$x(t) + x(t+t_0)$ è gaussiana a media nulla e varianza

$E\left[x^2(t) + x^2(t+t_0) + 2x(t)x(t+t_0)\right] = 2r_x(0) + 2r_x(t_0)$

$= 2\left(R_0 B + R_0 B \,\mathrm{sinc}^2 \frac{1}{2}\right) \triangleq \sigma^2$

$P\left[x(t) + x(t+t_0) < 2V_0\right] = \phi\left(\frac{2V_0}{\sigma}\right)$

2) $c(t)$ è a coseno rialzato con $C(f)$ tale che

$C(0) = V_0 T \cdot A_M \Rightarrow c(0) = \text{area } C(f) = V_0 A_M = V_0'$

$\sigma_n^2 = R_0 E_h$. Ora $|H(f)|^2$ è a coseno rialzato

con $|H(f)|^2\big|_{f=0} = T \Rightarrow E_h = 1 \Rightarrow \sigma_n = \sqrt{R_0}$

$P_e = \frac{4}{3} \cdot Q\left(\frac{V_0'}{2\sigma_n}\right)$

3) se $f_x(a)$ è esattamente costante all'interno di un intervallo di quantizzazione $\Rightarrow$

$M_e = \frac{\Delta^2}{12} \qquad \Delta = \frac{V}{2}$

$= \frac{V^2}{48}$

4) $F_c = 10$ Mcampioni/s per SNR > 45 dB $\Rightarrow$

8 bit/campione bit rate = 80 Mbit/s.

bit/simbolo PSK: 2 $\Rightarrow$ 40 Msimboli/s $\Rightarrow$ banda

minima $= \frac{1}{T} = 40$ MHz

5)

$$r_y(\tau) = E\left[(s_u(t+\tau)+n_u(t+\tau))(s_u(t)+n_u(t))\right] =$$

$$= r_{s_u}(\tau) + r_{n_u}(\tau) \quad \text{in quanto}$$

$$E[n_u(t+\tau)\,s_u(t)] = E[s_u(t+\tau)\,n_u(t)] = 0$$

(indipendenti e medie nulle)

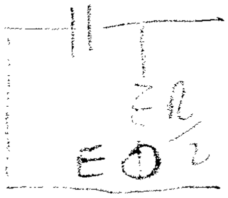
$$R_y(f) = R_{s_u}(f) + R_{n_u}(f)$$

<u>Segnale</u>

$$S_u = S\,\frac{R/2}{\frac{R}{2}+\frac{1}{j2\pi fC}} = S\,\frac{j\pi fCR}{1+j\pi fCR}$$

$$R_{s_u}(f) = R_s(f)\cdot\frac{\pi^2C^2R^2f^2}{1+\pi^2f^2R^2C^2}$$

<u>Rumore</u>



$$N_u = E\,\frac{\frac{1}{j2\pi fC}}{\frac{R}{2}+\frac{1}{j2\pi fC}} = E\,\frac{1}{1+j\pi fRC}$$

$$R_{n_u}(f) = 2kT_0\frac{R}{2}\cdot\frac{1}{1+\pi^2f^2R^2C^2}$$