TESTO DI ESAME - 10/01/2017

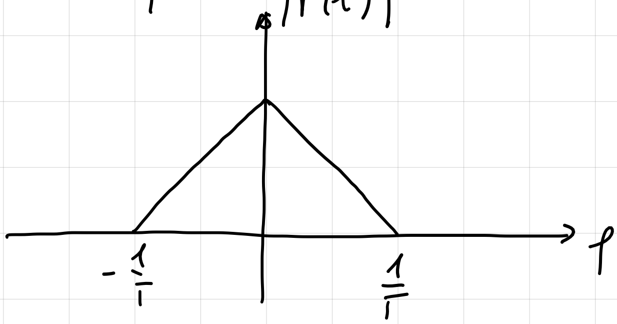
Es. 2

1) $E_s = \frac{1}{2}\left[E\left[x_c^2\right] + E\left[x_s^2\right]\right] E_p = \frac{1}{2}(4+1)\frac{1}{T} = \boxed{\frac{5}{2T}}$

$E\left[x_c^2\right] = \frac{1}{2}\cdot 4 + \frac{1}{2}\cdot 4 = 4$

$E\left[x_s^2\right] = \frac{1}{2}\cdot 1 + \frac{1}{2}\cdot 1 = 1$

$E_p = \int_{-\infty}^{+\infty} |P(f)|^2 df = \frac{1}{T}$



2) $P_{n_{u_c}} = P_{n_{u_s}} = N_0 \int_{-\infty}^{+\infty} |P(f)|^2 df = \boxed{\frac{N_0}{T}}$

3) $h(t) = p(t) \otimes c(t) \otimes h_R(t) = p(t) \otimes h_R(t)$

$H(f) = P(f)\, H_R(f) = (1 - |fT|)\, \text{rect}\left(\frac{fT}{2}\right)$

$h(t) = \frac{1}{T}\,\text{sinc}^2\left(\frac{t}{T}\right)$

$$\boxed{h(nT) = \frac{1}{T}\,\text{sinc}^2(n) = \begin{cases} \frac{1}{T} & n = 0 \\ 0 & n \neq 0 \end{cases} \quad \text{condizione di Nyquist soddisfatta (nel tempo)}}$$

4) $h(0) = \frac{1}{T}$, cond. di Nyquist soddisfatta, $P_{n_{u_c}} = P_{n_{u_s}} = \frac{N_0}{T}$

$P_E^{(c)} = Q\left(\frac{2/T}{\sqrt{\frac{N_0}{T}}}\right)$

$$P_E^{(s)} = Q\left(\frac{1/T}{\sqrt{N_0/T}}\right)$$

$$P_E(4\text{-QAM}) = P_E^{(c)} P_E^{(s)} + P_E^{(c)}\left(1 - P_E^{(s)}\right) + P_E^{(s)}\left(1 - P_E^{(c)}\right)$$

$$= \boxed{Q\left(\sqrt{\frac{4}{N_0 T}}\right) Q\left(\sqrt{\frac{1}{N_0 T}}\right) + Q\left(\sqrt{\frac{4}{N_0 T}}\right)\left(1 - Q\left(\sqrt{\frac{1}{N_0 T}}\right)\right) + Q\left(\frac{1}{\sqrt{N_0 T}}\right)\left(1 - Q\left(\sqrt{\frac{4}{N_0 T}}\right)\right)}$$