1) $\dfrac{e_k}{z(T)} \boxed{\uparrow g(t)} \dfrac{x(t)}{\mathbb{R}}$

$$\bar{R}_x(f) = R_e(f)\cdot|G(f)|^2$$

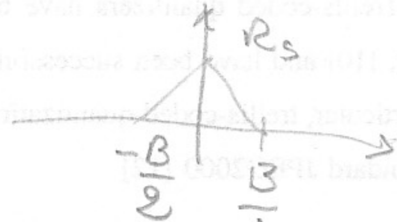
$$R_e(f) = \sigma_e^2 \cdot T = T$$

$$G(f) = T\,\mathrm{rect}(fT)$$

$$\bar{P}_x = \int_{-\infty}^{+\infty} \bar{R}_x(f)\,df = \int_{-\infty}^{+\infty} T\cdot T^2\,\mathrm{rect}^2(fT)\,df$$

$$= T^2$$

2) $\Lambda = 10^5$  Banda : $\frac{B}{2}$




$$\Lambda = \frac{M_R \cdot A}{2R_0\cdot\frac{B}{2}} \qquad A = 10^{-6}$$

$$M_x = \frac{B R_s}{2}$$

$$= \frac{\frac{1}{4} M_x \cdot A_T^2 \cdot A}{R_0 B}$$

$$= \frac{\cancel{B} R_s A_T^2 \cdot A}{8 R_0 \cancel{B}}$$

$$A_T^2 = \frac{10^5 \cdot 8\cdot 10^{-13}\cdot}{2\cdot 10^{-4}\cdot 10^{-6}}$$

$$= 400$$

$A_T = 20$

3) 4-PSK => 2 bit/simbolo

si trasmettono

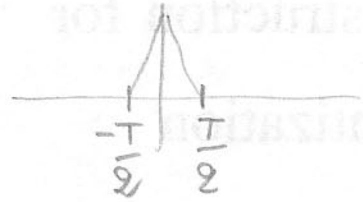
$\frac{4}{2}$ simbolo/s

sono necessari 2 MHz.

4) $c(t) = g * h(t)$ ha estensione $(-T, T) \Rightarrow$

non c'è ISI

$$c(0) = \int_{-\infty}^{+\infty} g(\tau) h(-\tau) d\tau = \int_{-\infty}^{+\infty} V_0 h_0 \operatorname{triangle}^2\left(\frac{2\tau}{T}\right) d\tau$$



$$= V_0 h_0 \cdot 2 \cdot \frac{T}{2} \frac{1}{3} = \frac{V_0 h_0 T}{3}$$

$$V_0' = \frac{V_0 h_0 T}{3}$$

$$\sigma_n^2 = R_0 \int_{-\infty}^{+\infty} h^2(t)\, dt = R_0 \cdot h_0^2 \frac{T}{3}$$

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

5)

$$Z_u = R \| C \qquad Z_u = \frac{R \frac{1}{j 2\pi f C}}{R + \frac{1}{j 2\pi f C}} = \frac{R}{1 + j 2\pi f R C}$$

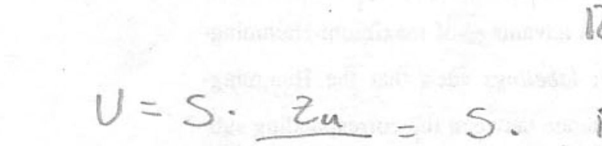
$$U = S \cdot \frac{Z_u}{R + Z_u} = S \cdot \frac{R}{1 + j 2\pi f R C} \cdot \frac{1}{R + \frac{R}{1 + j 2\pi f R C}}$$

$$= S \cdot \frac{1}{2 + j 2\pi f R C}$$

$$R_u(f) = R_S(f) \left| \frac{1}{2 + j 2\pi f R C} \right|^2 = \frac{R_S(f)}{4 + 4\pi^2 f^2 R^2 C^2}$$

$$n_u = \int_{-B}^{B} \frac{R_0}{4(1 + \pi^2 f^2 R^2 C^2)} df = \frac{R_0}{4} \cdot \frac{1}{\pi R C} \operatorname{arctg}(\pi f R C) \Big|_{-B}^{B}$$

$$= \frac{R_0}{4 \pi R C} 2 \cdot \operatorname{arctg} \pi B R C$$



$$N = E \frac{1}{j 2\pi f C} \cdot \frac{1}{\frac{R}{2} + \frac{1}{j 2\pi f C}} = E \frac{1}{1 + j \pi f R C}$$

$$n_n = \int_{-\infty}^{+\infty} 2kT \cdot \frac{R}{2} \cdot \frac{1}{1 + \pi^2 f^2 R^2 C^2} df = kTR \frac{1}{\pi R C} \cdot \pi$$

v. s.

1) $s_1(t) = A_0\left(\sin 2\pi f_0 t \cos\frac{\pi}{6} + \cos 2\pi f_0 t \sin\frac{\pi}{6}\right) h(t)$

$\tilde{\phi}_1(t) = A_0\, h(t) \cos 2\pi f_0 t$

$\tilde{\phi}_2(t) = A_0\, h(t) \sin 2\pi f_0 t$

sono ortogonali

$$\int_{-\infty}^{+\infty} \tilde{\phi}_1(t)\tilde{\phi}_2(t)\,dt = \int_{-\infty}^{+\infty} A_0^2 h^2(t)\,\frac{1}{2}\sin 2\pi 2 f_0 t\,dt$$

$$= \frac{A_0^2}{4j}\left\{ \mathcal{F}\left[h^2(t)\right]\Big|_{f=2f_0} - \mathcal{F}\left[h^2(t)\right]_{f=-2f_0}\right\}$$

$$= 0$$

avendo $h^2(t)$ banda $\frac{1.1}{T}$.

$\tilde{\phi}_1(t)$ e $\tilde{\phi}_2(t)$ hanno le stesse energie

$$E_\phi = \int_{-\infty}^{+\infty} A_0^2 h^2(t)\cos^2 2\pi f_0 t\,dt = \frac{A_0^2 E_h}{2}$$

$E_h = \left(\sqrt{H_0 T}\right)^2 \frac{1}{T} = H_0$

$\phi_1(t) = \dfrac{\tilde{\phi}_1(t)}{\sqrt{E_\phi}}$ , $\phi_2(t) = \dfrac{\tilde{\phi}_2(t)}{\sqrt{E_\phi}}$

2) $s_1 \equiv \left[A_0\sqrt{\frac{H_0}{2}}\sin\frac{\pi}{6},\ A_0\sqrt{\frac{H_0}{2}}\cos\frac{\pi}{6}\right] = [s_{11}\ s_{12}]$

$s_2 \equiv \left[A_0\sqrt{\frac{H_0}{2}},\ 0\right] = [s_{21}\ s_{22}]$

$E_{s_1} = s_{11}^2 + s_{12}^2 \qquad E_{s_2} = s_{21}^2 + s_{22}^2$

3) $d^2 = (s_{11}-s_{21})^2 + (s_{12}-s_{22})^2 \qquad P_e = Q\left(\frac{d}{2\sqrt{N_0/2}}\right)$