10/04/2018

lunedì 20 giugno 2022 11:14

1

$$F_X(x) = \begin{cases} 1 - e^{(-x/\lambda)} & x > 0 \\ 0 & x < 0 \end{cases}$$

FUNZIONE DI DISTRIBUZIONE DI PROBABILITA'

$$P(x \leq 1000) = 1 - P(X > 1000) = 1 - e^{-1} = F(1000)$$

$$1 - e^{-1} = 1 - e^{(-x/\lambda)}$$

$\lambda = 1000$

2

$$1 - e^{(-x/1000)} = 0.09$$

$$e^{\left(-\frac{x}{1000}\right)} = 1 - 0{,}09$$

$$-\frac{x}{1000} = \ln(0{,}91)$$

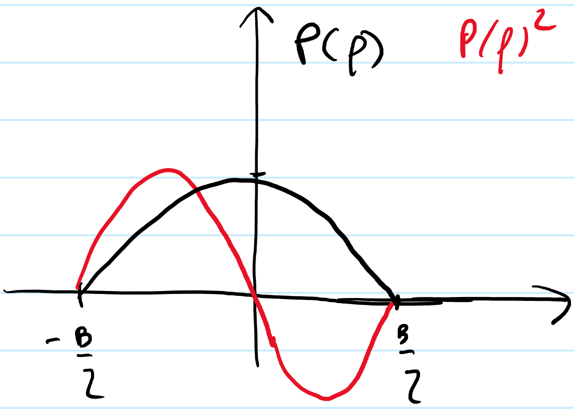
$$x = -\ln(0{,}91) \cdot 1000$$

$$P(f) = \frac{1}{2}\,\mathrm{rect}\left(\frac{f}{2B}\right) e^{-j2\pi f \cdot \frac{1}{4B}} + \frac{1}{2}\,\mathrm{rect}\left(\frac{f}{2B}\right) e^{j2\pi f \cdot \frac{1}{4B}}$$

$$= \mathrm{rect}\left(\frac{f}{2B}\right)\left[\frac{e^{j2\pi f \cdot \frac{1}{4B}} + e^{-j2\pi f \frac{1}{4B}}}{2}\right]$$

$$= \mathrm{rect}\left(\frac{f}{2B}\right) \cos\left(j2\pi f \cdot \frac{1}{4B}\right)$$

$$T = \frac{2\pi}{\omega}$$



$$E_p = \int_{-\infty}^{+\infty} \cos^2(\alpha)\, \mathrm{rect}(\beta) = \int_{-\frac{B}{2}}^{\frac{B}{2}} \frac{1}{2} + \cancelto{0}{\frac{1}{2}\cos(2\alpha)}$$

$$E_p = B$$

17/07/2018

lunedì 20 giugno 2022 11:33

LTI = lineare tempo invariante

$$S_X(f) = S_n(f)\ |H(f)|^2$$

$$h(t) = e^{-2t}\, u(t)$$

$$H(f) = \frac{1}{2 + j2\pi f}$$

$$P_n = \int_{-\infty}^{+\infty} S_n$$

$$\boxed{S_n = \frac{N_0}{2} \cdot \text{rect}\left(\frac{f}{2B}\right)}$$

$$S_X(f) = \frac{N_0}{2}\, \text{rect}\left(\frac{f}{2B}\right) \cdot \left|\frac{1}{2 + j2\pi f}\right|^2$$

$$\frac{1}{4 + 4\pi^2 f^2}$$

ⓑ $\eta_X = \emptyset$

$$\sigma_X^2 = E[(x - \eta_x)^2] = E[x^2] = P_X$$

$$R_X(\tau) = \frac{N_0}{2}\delta(t) \otimes \underbrace{h(\tau) \otimes h(-\tau)}_{C_h(\tau)}$$

P_n

$$C_h(\tau) = \int_{-\infty}^{+\infty} e^{-2t} u(t)\ e^{-2(t-\tau)}\ u(t-\tau)\, dt$$

per $\tau < 0$

$$\int_0^{+\infty} e^{-2t}\ e^{-2(t-\tau)} = \int_0^{+\infty} e^{-4t} e^{2\tau}\, dt$$

$$= \frac{e^{2\tau}}{4}(0 + 1) = \frac{e^{2\tau}}{4}$$

per $\tau > 0$

$$e^{2\tau}\int_{\tau}^{+\infty} e^{-4t}\,dt = \frac{e^{2\tau}}{4}\; e^{-4t}\Big|_{\tau}^{+\infty} = -\frac{e^{2\tau}}{4}\left(0 - e^{-4\tau}\right) = \frac{e^{-2\tau}}{4}$$

$$C_h(\tau) = \frac{e^{-2|\tau|}}{4}$$

$$R_x = \frac{N_0}{2}\,\delta(\tau) \otimes \frac{e^{-2|\tau|}}{4}$$

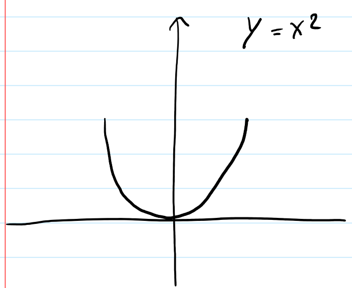
$$P_x = R_x(0) = \frac{N_0}{2} \otimes \frac{1}{4} = \frac{N_0}{8}$$

$$P_x = \sigma_x^2$$

$$\boxed{f_x(x) = \frac{1}{\sqrt{2\pi\sigma_x^2}} \cdot e^{\frac{-x-\eta_x}{2\sigma_x^2}}}$$

(c)

$$\boxed{f_y(y) = \sum_{i=1}^{N} \frac{f_x(x_i)}{|g'(x_i)|}}$$



$y<0 \rightarrow \emptyset$ soluzioni

$y \geq 0 \rightarrow 2$ soluzioni

$$g'(x) = 2x \quad \left[\frac{d}{dx}\, g(x)\right]$$

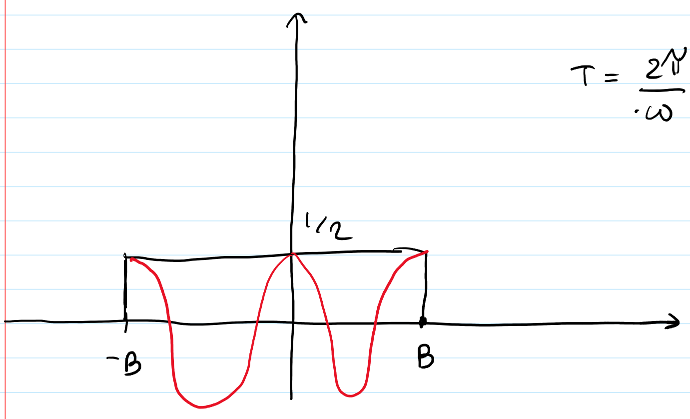
Soluzioni: $y = x^2$

$\rightarrow x = \pm\sqrt{y}$

$$f_y(y) = \frac{1}{\sqrt{2\pi\sigma_x^2}}\, e^{\frac{-\sqrt{y}-\eta_x}{2\sigma_x^2}} \cdot \frac{1}{|2(-\sqrt{y})|} + \frac{1}{\sqrt{2\pi\sigma_x^2}}\, e^{\frac{+\sqrt{y}-\eta_x}{2\sigma_x^2}} \cdot \frac{1}{|2(+\sqrt{y})|}$$

$$\mathrm{rect}\left(\frac{t}{B}\right) \rightleftharpoons B\,\mathrm{sinc}(fB)$$

$$P(f) = \frac{1}{2}\, rect\left(\frac{t}{2B}\right) - \frac{1}{2} \cdot rect\left(\frac{t}{2B}\right) \cdot \cos\left(2\pi f \frac{1}{B}\right)$$



$$T = \frac{2\pi}{\omega} = B$$

17/01/2019

venerdì 17 giugno 2022 09:46

①

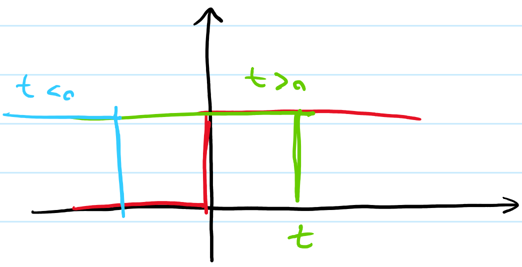
$$H_1(f) = \frac{1}{\alpha + j2\pi f}$$

$$H_2(f) = \frac{1}{\beta + j2\pi f}$$

$$h(t) = h_1(t) \otimes h_2(t)$$

$$= \int_{-\infty}^{+\infty} h_1(\tau)\, h_2(t-\tau)\, d\tau$$

$$= \int_{-\infty}^{+\infty} e^{-\alpha\tau}\, e^{-\beta(t-\tau)}\, u(\tau)\, u(t-\tau)\, d\tau$$



$t > 0$:

$$\int_{t}^{+\infty} e^{-\alpha\tau} e^{-\beta(t-\tau)}\, d\tau = e^{-\beta t} \int_{t}^{+\infty} e^{\tau(\beta-\alpha)}\, d\tau$$

$$= e^{-\beta\tau} \cdot \frac{1}{\beta-\alpha}\, e^{\tau(\beta-\alpha)} \Big|_{0}^{t} = \frac{e^{-\beta t}}{(\beta-\alpha)} \left(e^{t(\beta-\alpha)} - 1\right) = \frac{e^{-\alpha t} - e^{-\beta t}}{\beta - \alpha} = h(t)$$

$t < 0 \rightarrow h(t)$

$$h(t) = \begin{cases} 0 & t < 0 \\ \dfrac{e^{-\alpha t} - e^{-\beta t}}{\beta - \alpha} & t > 0 \end{cases}$$

$$H(f) = \frac{1}{(\alpha + j2\pi f)(\beta + j2\pi f)}$$

②

$$R_Y(\tau) = R_X(\tau) \otimes h(\tau) \otimes h(-\tau)$$

$$P_Y = R_Y(0) = R_X(0) \otimes R_h(0)$$

$$R_h(0) = h(0) \otimes h(0) = \int_{-\infty}^{+\infty} |h(t)|^2$$

$$= \int_{-\infty}^{+\infty} \left[\frac{e^{-\alpha t} - e^{-\beta t}}{\beta - \alpha} \right]^2 u(t)\, \partial\tau$$

$$= \frac{1}{\beta - \alpha} \int_{-\infty}^{+\infty} e^{-2\alpha t} + e^{-2\beta t} - 2e^{-(\alpha+\beta)t}$$

$$= \frac{1}{(\beta-\alpha)^2} \left(\frac{1}{2\alpha} + \frac{1}{2\beta} - \frac{2}{\alpha+\beta} \right)$$

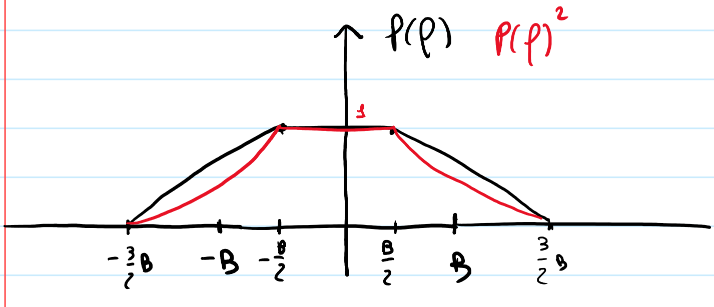
$$P_Y = \frac{N_0}{2} \cdot \frac{1}{(\beta-\alpha)^2} \cdot \left(\frac{1}{2\alpha} + \frac{1}{2\beta} - \frac{2}{\alpha+\beta} \right)$$

---

② $$E_S = E_P \cdot E[X^2] \cdot \frac{1}{2}$$

$$E[X^2] = (-1)^2 \cdot \frac{2}{3} + (3)^2 \frac{1}{3} = \frac{11}{3}$$

$$P(f) = \left(1 - \frac{|f - \frac{B}{2}|}{B}\right) \mathrm{rect}\left(\frac{f - \frac{B}{2}}{2B}\right) + \left(1 - \frac{|f + \frac{B}{2}|}{B}\right) \mathrm{rect}\left(\frac{f + \frac{B}{2}}{2B}\right)$$



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

$$E_s = \frac{11}{3} \cdot \frac{5}{3}B \cdot \frac{1}{2} = \frac{55}{18}B$$

3 $H(f) = P(f)$

$$h(nT) = 2B \operatorname{sinc}^2\left(\cancel{B}\, n \frac{1}{\cancel{B}}\right) \cos\left(\pi \cancel{B}\, n \frac{1}{\cancel{B}}\right)$$

$$= 2B\,\delta(n) \qquad \text{ok!}$$

4 $P_{n_y} = E_{h_R} \cdot N_0 = 3N_0B$

5

$$h(0) = 2B$$

$$y\big|_{x=-1} \in \mathcal{N}\left(-2B\cos(\varphi-\theta),\ 3N_0B\right)$$

$$y\big|_{x=3} \in \mathcal{N}\left(6B\cos(\varphi-\theta),\ 3N_0B\right)$$

$$P_E = \frac{1}{3} Q\left(\frac{6B\cos(\varphi-\theta)}{\sqrt{3N_0B}}\right) + \frac{2}{3}\left(\frac{2B\cos(\varphi-\theta)}{\sqrt{3N_0B}}\right)$$

07/02/2019

sabato 25 giugno 2022 12:10

①

$x(t) = B\cos(2\pi f_0 t)\,\text{sinc}(Bt)$

$h(t) = B\,\text{sinc}^2(Bt)$

$p(t) = B\,\text{sinc}(Bt)$

$x_1(t) = x(t)\cos(2\pi f_0 t + \varphi) \otimes h(t)$

$= B\,\text{sinc}(Bt)\left[\cos(2\pi f_0 t)\cos(2\pi f_0 t + \varphi)\right]$

$= \frac{B}{2}\text{sinc}(Bt)\left[\cos(\varphi) + \cos(4\pi f_0 t + \varphi)\right]$

$x_2(t) = B\,\text{sinc}(Bt)\left[\cos(2\pi f_0 t)\,\sin(2\pi f_0 t + \varphi)\right]$

$= B\,\text{sinc}(Bt)\left[\sin(\varphi) + \sin(4\pi f_0 t + \varphi)\right]$

$y_1(t) = x_1 \otimes h(t) = \frac{B}{2}\text{sinc}(Bt)\cos(\varphi) \otimes h(t)$

$y_2(t) = x_2(t) \otimes h(t) = \frac{B}{2}\text{sinc}(Bt)\sin(\varphi) \otimes h(t)$

frequente a $2f_0$ tagliate dal filtro

$Y_1(f) = X_1(f) \cdot H(f)$

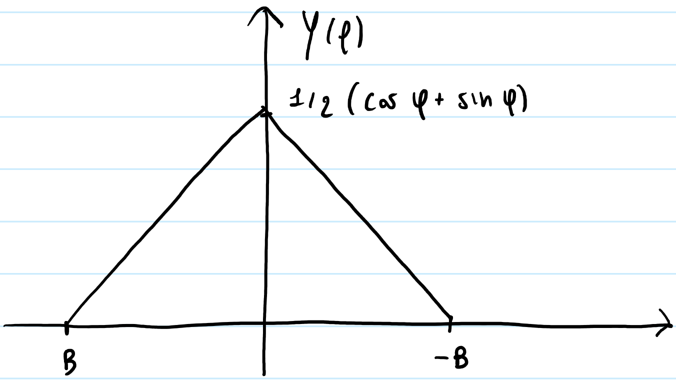
$Y_2(f) = X_2(f) \cdot H(f)$

$H(f) = \left(1 - \frac{|f|}{B}\right)\text{rect}\left(\frac{f}{2B}\right)$

$Y_1(f) = \frac{1}{2}\text{rect}\left(\frac{f}{B}\right)\cos(\varphi) \cdot H(f)$

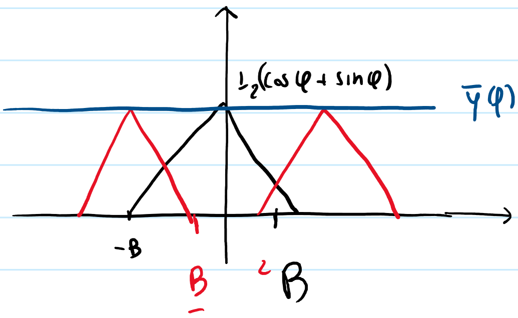
$Y_2(f) = \frac{1}{2}\text{rect}\left(\frac{f}{B}\right)\sin\varphi \cdot H(f)$

$$Z(f) = Y_1(f) + Y_2(f) = \frac{1}{2}(\cos\varphi + \sin\varphi)\,\mathrm{rect}\left(\frac{f}{B}\right) \cdot \left(1 - \frac{|f|}{B}\right)\mathrm{rect}\left(\frac{f}{2B}\right)$$



$$y[n] = Y(nT) = y\left(n\,\frac{2}{B}\right)$$

$$\overline{Y}(f) = \frac{1}{T}\sum_{n=-\infty}^{+\infty} Y\left(f - \frac{n}{T}\right) = \frac{B}{2}\sum_{n} Y\left(f - n\cdot\frac{B}{2}\right)$$

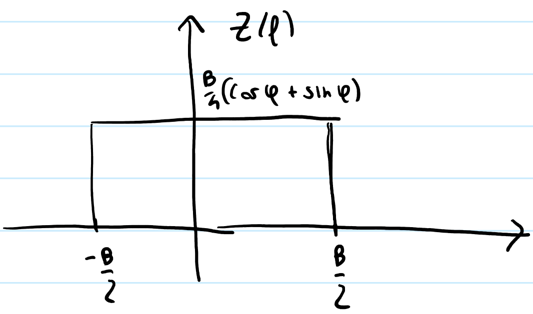


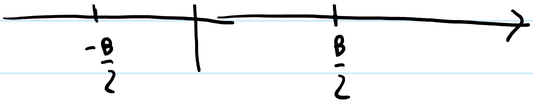
$$\overline{Y}(f) = \frac{B}{2}\cdot\frac{1}{2}(\cos\varphi + \sin\varphi)$$

$$= \frac{B}{4}(\cos\varphi + \sin\varphi)$$

$$Z(f) = Y(f)\cdot P(f)$$

$$= \frac{B}{4}(\cos\varphi + \sin\varphi)\,\mathrm{rect}\left(\frac{f}{B}\right)$$





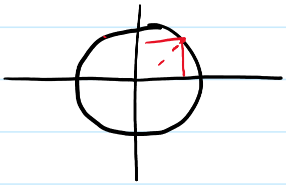
$$E_z = B \cdot \left(\frac{B}{4}(\cos\varphi + \sin\varphi)\right)^2 = \frac{B^3}{16}(\cos\varphi + \sin\varphi)^2$$

Max E_z : $\cos\varphi + \sin\varphi = 1$

$\cos\varphi = -\sin\varphi$

$\Downarrow$

$\varphi = \frac{\pi}{4} + k\pi$



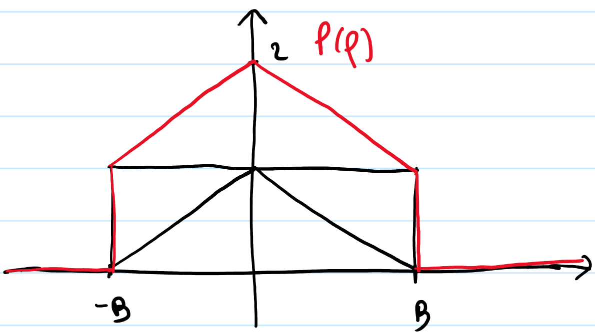
2

1 $E_s = E[x[n]^2]\, E_p \cdot \frac{1}{2}$

$E[x[n]^2] = \frac{1}{2} + 2 = \frac{5}{2}$

E_p :

$$P(f) = \mathrm{rect}\left(\frac{f}{2B}\right) + \left(1 - \frac{|f|}{B}\right)\mathrm{rect}\left(\frac{f}{2B}\right)$$



$$P(f)^2 = \mathrm{rect}\left(\frac{f}{2B}\right) + \left(\left(1 - \frac{|f|}{B}\right)\mathrm{rect}\left(\frac{f}{2B}\right)\right)^2$$
$$+ 2\left(1 - \frac{|f|}{B}\right)\mathrm{rect}\left(\frac{f}{2B}\right)$$

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

$= \frac{3B + 2B}{3} = \frac{9B + 2B}{3} = \frac{10}{3} B$

$E_p = 2B + \cancel{2} \cdot \frac{1}{3} \cdot \frac{B}{\cancel{2}} \cdot 4 = 2B + \frac{4}{3} B = \frac{6+4}{3} B = \frac{10}{3} B$

② $P_{nu} = E_{nR} \cdot N_0 = 2 N_0 B$

③ $h(t) = p(t)$

$h(nT) = 3B\, \delta(t) \cos\left(\frac{\pi}{3}\right) = \frac{3}{2} \delta(t)$

$h(0) = \frac{3}{2} B$

$y\Big|_{x=-1} \in \left(-\frac{3}{2}B, 2N_0B\right)$

$y\Big|_{x=2} \in \left(3B, 2N_0B\right)$

$P_E = \frac{1}{2} Q\left(\frac{3B}{\sqrt{2N_0B}}\right) + \frac{1}{2} Q\left(\frac{3/2\, B}{\sqrt{2N_0B}}\right)$

25/02/2019

martedì 21 giugno 2022 12:30

1

$$\eta_z = \eta_x + \eta_y$$

$$\eta_y = \frac{1}{2}$$

$$\boxed{f_x(x) = \frac{1}{\eta_x} e^{-\frac{1}{\eta}x}} \qquad \eta_x = \frac{1}{\lambda}$$

$$\eta_z = \frac{1}{2} + \frac{1}{\lambda} = \frac{2+\lambda}{2\lambda}$$

2

$$f_z(z) = f_x(x) \otimes f_y(y)$$

pto medio

$$\boxed{f_y(y) = \frac{1}{D} \operatorname{rect}\left(\frac{x-\eta}{D}\right)}$$

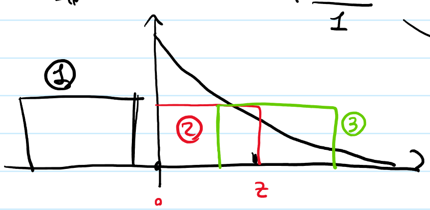
DURATA $= T$

$[0, T]$

$$f_y(y) = \operatorname{rect}\left(x - \frac{1}{2}\right)$$

$$f_z(z) = \int_{-\infty}^{+\infty} f_x(\tau)\, f_y(z-\tau)\, d\tau$$

$$= \int_{-\infty}^{+\infty} \lambda e^{-\lambda\tau} u(\tau) \operatorname{rect}\left(\frac{z-\frac{1}{2}-\tau}{1}\right) d\tau \rightarrow \operatorname{rect}\left(\tau - z - \frac{1}{2}\right)$$



CASI:

1. $z \le 0 \rightarrow f_z(z) = 0$ (no interset)
2. $z \in [0, 1] \rightarrow \int_0^z \lambda e^{-\lambda\tau} = 1 - e^{-\lambda z}$
3. $z \geq 1 \rightarrow \int_{z-1}^{z} \lambda e^{-\lambda\tau} = -e^{-\lambda z} + e^{-\lambda(z-1)}$

3

$$F_z(z) = \int_{-\infty}^{+\infty} f_z(z)$$

$$P(X \le 1) = F_z(1) = \int_{-\infty}^{1} f_z(z)$$

$$P(X \geq 1) = 1 - F_z(1)$$

$$F_z(1) = \int_{-\infty}^{1} f_z(1) = \int_0^1 1 - e^{-\lambda z}$$

$$= \int_0^1 1 - \int_0^1 e^{-\lambda z}$$

$$= z\Big|_0^1 + \frac{1}{\lambda} e^{-\lambda z}\Big|_0^1$$

$$= 1 + \frac{1}{\lambda} e^{-\lambda} - \frac{1}{\lambda}$$

---

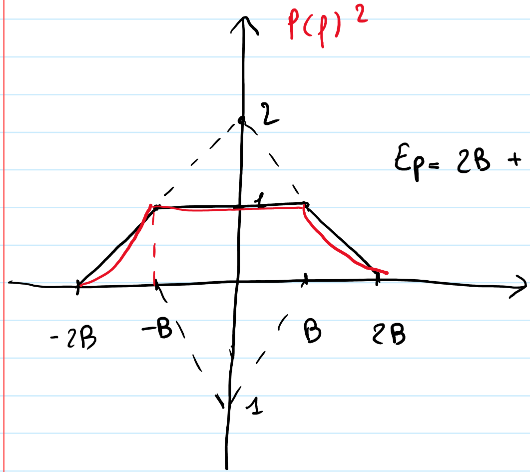
(2)

(1) $E_S = \frac{1}{2} E_p \cdot E[x^2]$

$E[x^2] = (-1)^2 \frac{1}{2} + (2)^2 \frac{1}{2} = \frac{1}{2} + 2 = \frac{1+4}{2} = \frac{5}{2}$

E_p:

$P(f) = 2\left(1 - \frac{|f|}{2B}\right) \text{rect}\left(\frac{f}{4B}\right) - \left(1 - \frac{|f|}{B}\right) \text{rect}\left(\frac{f}{2B}\right)$



$E_p = 2B + 2 \cdot \frac{1}{3} \cdot B = \frac{8}{3} B$

$E_S = \frac{1}{2} \cdot \frac{8}{3} B \cdot \frac{5}{2} = \frac{\cancel{40}}{\cancel{12}} B = \frac{10}{3} B$

(2) $P_{nu} = E_{he} \cdot N_0$

$= 4B N_0 = 4 N_0 B$

(3)

$h(t) = p(t)$

$h(nT) = 3B\,\delta(t) \rightarrow$ No ISI

$h(0) = 3B$

$Y\big|_{x=-1} \in \mathcal{N}\left(-3B\cos^{\left(\frac{\pi}{3}-\theta\right)} ; 4N_0 B\right)$

$Y\big|_{x=2} \in \mathcal{N}\left(6B\cos^{\left(\frac{\pi}{3}-\theta\right)} ; 4N_0 B\right)$

$$P_E = \frac{1}{2} Q \left(\frac{6B\cos\left(\frac{\pi}{3}-\theta\right)}{\sqrt{4 N_0 B}}\right) + \frac{1}{2} Q \left(\frac{3B\cos\left(\frac{\pi}{3}-\theta\right)}{\sqrt{4 N_0 B}}\right)$$

4

$$\cos\left(\frac{\pi}{3}-\theta\right) = 1$$

$$\theta = \frac{\pi}{3} \qquad Q_{min}$$

12/04/2019

giovedì 16 giugno 2022 11:19

(1)

$A = \{ A \text{ e } B \text{ connessi} \}$

T1 T2 T3

$$P(A) = 1 - P(\bar{A}) = \underbrace{\frac{1}{2}}_{T_4 \text{ APERTO}} + \frac{1}{2}\left[1 - \left(\frac{1}{2}\cdot\frac{1}{2}\right)\right]$$

la probabilità non cambia perché se T1 è chiuso passa comunque corrente

---

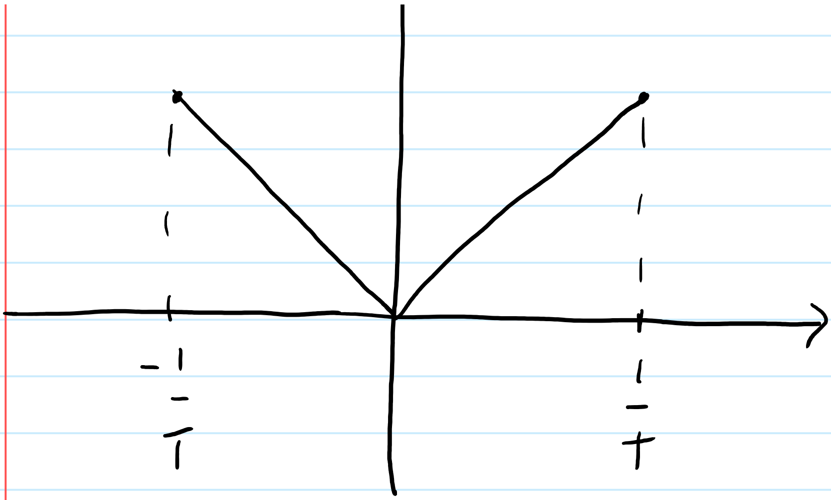
(2)

$$E_S = \frac{1}{2} E_p \, E\left[X_c^2 + X_s^2\right]$$

$$E\left[X_c^2 + X_s^2\right] = \frac{1}{2}(-1)^2 + \frac{2}{3}(-2)^2 + \frac{1}{3}(2)^2 + \frac{1}{2}(1)^2 = 5$$

E_p:

$$P(f)^2 = |fT| \operatorname{rect}\left(\frac{fT}{2}\right)$$



$E_p = \frac{1}{T}$

$E_s = \frac{1}{2} \cdot \frac{1}{T} \cdot 5 = \frac{5}{2T}$

(2) $P_{n_{uc}} = P_{n_{us}} = P_{nu} = E_{nq} \cdot N_0 = \frac{N_0}{T}$

(3) $\sum_{n=-\infty}^{+\infty} H\left(f - \frac{n}{T}\right) = k$

Somma costante $\Rightarrow$ ASSENZA ISI

$$H(f) = \mathrm{rect}\left(\frac{f}{2/T}\right) - \left(1 - \frac{|f|}{1/T}\right)\mathrm{rect}\left(\frac{f}{2/T}\right)$$

$h(t) = 2\,\mathrm{sinc}\left(t \ldots\right) - f \ldots \mathrm{sinc}^2\left(t \ldots\right)$

$$h(t) = \frac{2}{T} \operatorname{sinc}\left(\frac{t}{2/T}\right) - \frac{1}{T} \operatorname{sinc}^2\left(\frac{t}{1/T}\right)$$

$$h(0) = \frac{2}{T} - \frac{1}{T} = \frac{1}{T}$$

P_E^c:

$$y\big|_{x=-2} \in \mathcal{N}\left(-\frac{2}{T}, \frac{N_0}{T}\right)$$

$$y\big|_{x=2} \in \mathcal{N}\left(\frac{2}{T}, \frac{N_0}{T}\right)$$

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

$$y\big|_{-1} \in \left(-\frac{1}{T}, \frac{N_0}{T}\right)$$

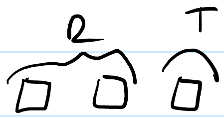
$$y\big|_{1} \in \left(\frac{1}{T}, \frac{N_0}{T}\right)$$

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

04/06/2019

mercoledì 15 giugno 2022

1



$P(1) = P(2) = 1/4$

$P(3) = P(4) = P(5) = P(6) = 1/8$

a

$A = \{$ pesco 1 R e 1 T $\}$

$B = \{$ pesco 2 R $\}$

$P(A) = \frac{1}{3} \cdot 1 + \frac{2}{3} \cdot \frac{1}{2} = \frac{1}{3} + \frac{2}{6} = \frac{2}{3}$

$P(B) = \frac{2}{3} \cdot \frac{1}{2} = \frac{1}{3}$

$C = \{$ esce 1 e 2 $\}$

$$P(C) = \left(\frac{1}{4} \cdot \frac{1}{6} + \frac{1}{4} \cdot \frac{1}{6}\right) P(A) + \left(\frac{1}{6} \cdot \frac{1}{6} + \frac{1}{6} \cdot \frac{1}{6}\right) P(B)$$

$$= \left(\frac{1}{24} + \frac{1}{24}\right) \frac{2}{3} + \left(\frac{1}{36} + \frac{1}{36}\right) \frac{1}{3}$$

$$= \frac{1}{\cancel{12}\,6} \cdot \frac{2}{3} + \frac{1}{18} \cdot \frac{1}{3} = \frac{1}{18} + \frac{1}{54} = \frac{2}{27}$$

b

$D = \{$ estratto 1 e 3 $\}$

$$P(A|D) = \frac{P(D|A)\,P(A)}{P(D)}$$

$$P(D) = P(D|A)\,P(A) + P(D|B)\,P(B)$$

$$= \left(\frac{1}{4}\cdot\frac{1}{6} + \frac{1}{8}\cdot\frac{1}{6}\right)\frac{2}{3} + \left(\frac{1}{6}\cdot\frac{1}{6} + \frac{1}{6}\cdot\frac{1}{6}\right)\frac{1}{3}$$

$$= \left(\frac{1}{24} + \frac{1}{48}\right)\frac{2}{3} + \frac{1}{54}$$

$$= \frac{1}{\cancel{16}\,8}\cdot\frac{\cancel{2}}{3} = \frac{1}{24} + \frac{1}{54} = \frac{13}{216}$$

$$P(D|A) = \frac{3}{48} \qquad P(A) = \frac{2}{3}$$

$$P(A|D) = \frac{\frac{3}{48}\cdot\frac{2}{3}}{\frac{13}{216}} = \frac{9}{13}$$

---

②

$$A = \{-1, +3\}$$

$$P(-1) = \frac{1}{4} \qquad P(3) = \frac{3}{4}$$

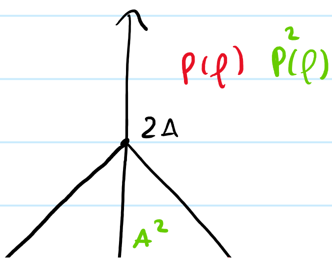
a)

$$E_s = \frac{1}{2}\,E[x^2]\,E_p$$

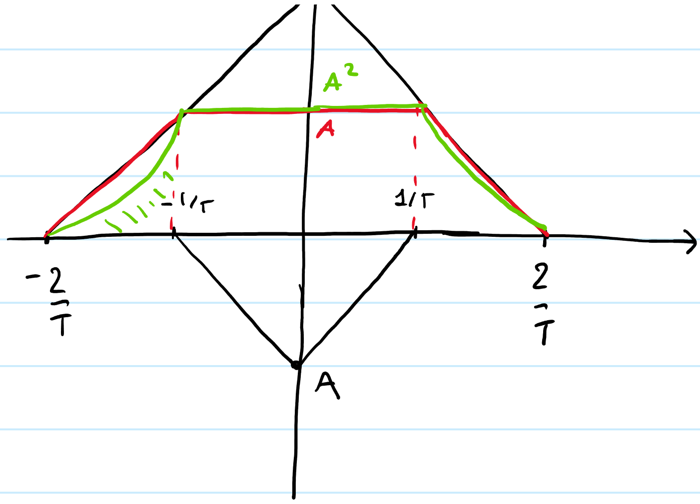
$$E[x^2] = \frac{1}{4} + \frac{3}{4}\cdot 9 = 7$$

E_p:

$$P(f) = 2A\left(1 - \frac{|f|T}{2}\right)\mathrm{rect}\left(\frac{fT}{4}\right) - A\left(1 - |f|T\right)\mathrm{rect}\left(\frac{fT}{2}\right)$$



$$E_p = \frac{8A^2}{3T}$$



$$E_p = \frac{8A^2}{3T}$$

$$E_s = \frac{\overset{4}{\cancel{8}}A^2}{3T} \cdot 7 \cdot \frac{1}{8} = \frac{28A^2}{3T}$$

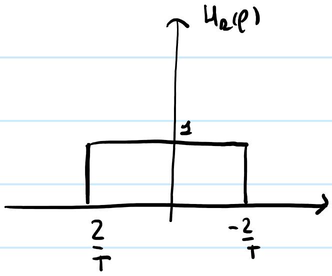
(b) $h(t) = p(t) \otimes c(t) \otimes h_R(t)$

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

$$h(nT) = h[n] = \frac{4A}{T}\,\mathrm{sinc}^2\left(2\frac{n\cancel{T}}{\cancel{T}}\right) - \frac{A}{T}\,\mathrm{sinc}^2\left(\frac{n\cancel{T}}{\cancel{T}}\right)$$

$$= \left(\frac{4A}{T} - \frac{A}{T}\right)\delta(t) = \frac{3A}{T}\,\delta(t) \Rightarrow \text{No ISI}$$

(c) $P_{nu} = N_0 \cdot E_{HR} = N_0 \frac{4}{T} = \frac{4N_0}{T}$



(d) $h(0) = \frac{3A}{T}$ $\quad P_{nu} = \frac{4N_0}{T}$ $\quad h'(0) = h(0)\cos(\varphi - \theta)$

d) $h(0) = \frac{3A}{T}$ $\quad P_{nu} = \frac{4N_0}{T}$ $\quad h'(a) = h(a)\cos(\varphi - \theta)$

$$y\big|_{x=-1} \in \mathcal{N}\left(-\frac{3A}{T}\cos(\varphi-\theta)\,;\ \frac{4N_0}{T}\right)$$

$$y\big|_{x=3} \in \mathcal{N}\left(\frac{9A}{T}\cos(\varphi-\theta)\,;\ \frac{4N_0}{T}\right)$$

$$P_E = \frac{1}{4}\,Q\left(\frac{\frac{3A}{T}\cos(\varphi-\theta)}{\sqrt{\frac{4N_0}{T}}}\right) + \frac{3}{4}\,Q\left(\frac{\frac{9A}{T}\cos(\varphi-\theta)}{\sqrt{\frac{4N_0}{T}}}\right)$$

e) P_E minima $\Longrightarrow \cos(\varphi - \theta) = 1$

$$\underline{\underline{\varphi = \theta}}$$

Poiché arg $Q(\cdot)$ max

$\downarrow$

$Q(\cdot)$ min

$\downarrow$

P_E min

28/06/2019

lunedì 20 giugno 2022 10:17

1

$$\eta = 0.1 \cdot 0.4 + 0.6 \cdot 0.25 = 0.19$$

2 $P(X \leq 0.1) = F_X(0.1)$

$$f_{X_1}(x) = \frac{1}{0.2} \, \text{rect}\left(\frac{x - 0.1}{0.2}\right)$$

$$f_{X_2}(x_2) = \frac{1}{0.5} \, \text{rect}\left(\frac{x - 0.25}{0.5}\right)$$

$$F_X(x) = \int_{-\infty}^{0.1} 0.4 \cdot \frac{1}{0.2} \, \text{rect}\left(\frac{x - 0.1}{0.2}\right) + \underbrace{0.6 \, \frac{1}{0.5} \, \text{rect}\left(\frac{x - 0.25}{0.5}\right)}$$

$$= \int_0^{0.1} 2 \, dx + \int_0^{0.1} \frac{6}{5} \, dx$$

$$= 2x \Big|_0^{0.1} + \frac{6}{5} x \Big|_0^{0.1}$$

$$= \frac{1}{5} + \frac{3}{25} = \frac{9}{25} = 0.36$$

3 $$P(C_2 \mid X \leq 0.1) = \frac{P(X \leq 0.1 \mid C_2) \, P(C_2)}{P(X \leq 0.1)}$$

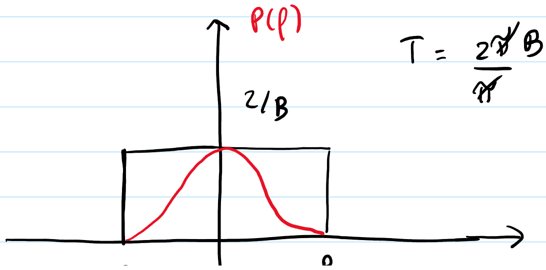
2

$$E_s = \frac{1}{2} \cdot E_p \cdot E[X_c^2 + X_s^2]$$

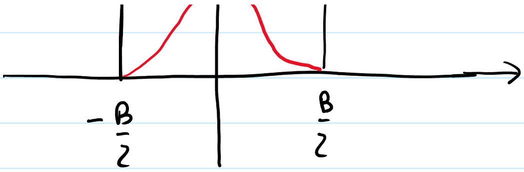
$$E[X_c^2 + X_s^2] = (-2)^2 \frac{1}{2} + 1 \frac{1}{2} + 1 \frac{1}{2} + \frac{4}{2} = 5$$

E_p:

$$P(f) = \frac{2}{B} \, \text{rect}\left(\frac{f}{B}\right) \cos\left(\cancel{2}\pi f_0 \cdot \frac{1}{\cancel{2}B}\right)$$



$$T = \frac{2\cancel{\pi} B}{\cancel{\pi}}$$



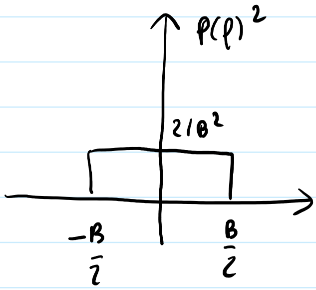
$$P(f)^2 = \frac{4}{B^2}\, \mathrm{rect}\left(\frac{f}{B}\right) \cos^2\left(\frac{\pi f}{B}\right)$$

$$\boxed{\cos^2(\alpha) = \frac{1}{2} + \frac{1}{2}\cos(2\alpha)}$$

$$\int_{-\infty}^{+\infty} P(f)^2 = \frac{4}{B^2}\, \mathrm{rect}\left(\frac{f}{B}\right)\left[\frac{1}{2} + \cancel{\frac{1}{2}\cos\left(\frac{2\pi f}{B}\right)}\right]$$

$$\Downarrow \quad \emptyset$$

$$= \frac{2}{B^2}\, \mathrm{rect}\left(\frac{f}{B}\right)$$



$$E_p = \frac{2}{B^2}\cdot B = \frac{2}{B}$$

$$E_s = \frac{\cancel{1}}{\cancel{2}}\cdot\frac{\cancel{2}}{B}\cdot 5 = \frac{5}{B}$$

(2) $P_{nu} = P_{nc} = P_n = E_{hR}\cdot N_0$

$$= E_p \cdot N_0 = \frac{2N_0}{B}$$

(3) $P(f)^2 = \frac{4}{B^2}\, \mathrm{rect}\left(\frac{f}{B}\right)\left[\frac{1}{2} + \frac{1}{2}\cos\left(\frac{2\pi}{B}\right)\right]$

$$p(t)^2 = \mathrm{sinc}^2\left(B\left(t - \frac{T}{4}\right)\right) + \mathrm{sinc}^2\left(B\left(t + \frac{1}{2B}\right)\right) + 2\,\mathrm{sinc}\left(B\left(t - \frac{1}{2B}\right)\right)\mathrm{sinc}\left(B\left(t + \frac{1}{2B}\right)\right)$$

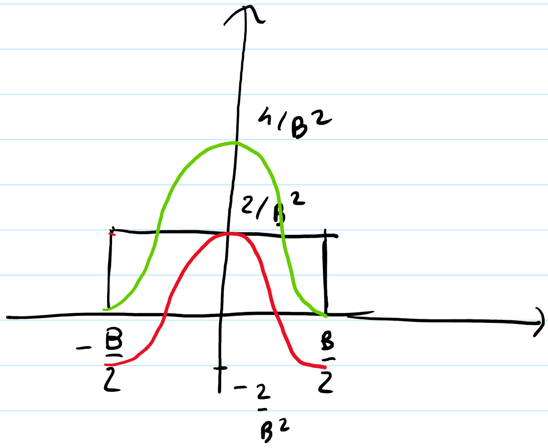
$$p(nT) = \mathrm{sinc}^2\left(\frac{2}{T}\left(nT - \frac{T}{4}\right)\right) + \mathrm{sinc}^2\left(\frac{2}{T}\left(nT + \frac{T}{4}\right)\right) + 2\,\mathrm{sinc}\left(\frac{2}{T}\left(nT - \frac{T}{4}\right)\right)\mathrm{sinc}\left(B\left(nT + \frac{T}{4}\right)\right)$$

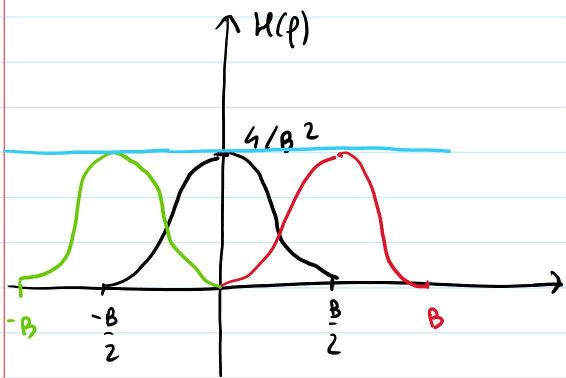
Cond Nyq:

$$\sum_{n=-\infty}^{+\infty} H\left(f - \frac{n}{T}\right) = k$$

Cond. Nyq.: $\displaystyle\sum_{n=-\infty}^{+\infty} H\left(f - \frac{n}{T}\right) = k$

$$P(f)^2 = \frac{2}{B^2}\,\mathrm{rect}\left(\frac{f}{B}\right) + \frac{2}{B^2}\,\mathrm{rect}\left(\frac{f}{B}\right)\cos\left(\frac{2\pi f}{B}\right)$$





$B = \frac{2}{T}$

$T = \frac{2}{B} \rightarrow n\frac{B}{2}$

$$\sum_{n=-\infty}^{+\infty} H\left(f - \frac{n}{T}\right) = 4/B^2 \longrightarrow \text{No ISI}$$

$$h(t) = \mathrm{sinc}^2\left(B\left(t - \frac{T}{4}\right)\right) + \mathrm{sinc}^2\left(B\left(t + \frac{1}{2B}\right)\right) + 2\,\mathrm{sinc}\left(B\left(t - \frac{1}{2B}\right)\right)\mathrm{sinc}\left(B\left(t + \frac{1}{2B}\right)\right)$$

$$h(0) = \mathrm{sinc}^2\left(-\frac{1}{2}\right) + \mathrm{sinc}^2\left(\frac{1}{2}\right) + 2\,\mathrm{sinc}\left(-\frac{1}{2}\right)\mathrm{sinc}\left(\frac{1}{2}\right)$$

16/07/2019

giovedì 16 giugno 2022 12:08

1

$$\eta_y = \eta_x \otimes h(t) = \eta_x \cdot H(0)$$

$$\eta_y = \emptyset$$

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

$$h(t) = e^{-t} u(t) \rightleftarrows \frac{1}{1 + j2\pi f}$$

$$S_y = \frac{N_0}{2} \cdot \frac{1}{1 + 4\pi^2 f^2}$$

$$\eta_y = \emptyset$$

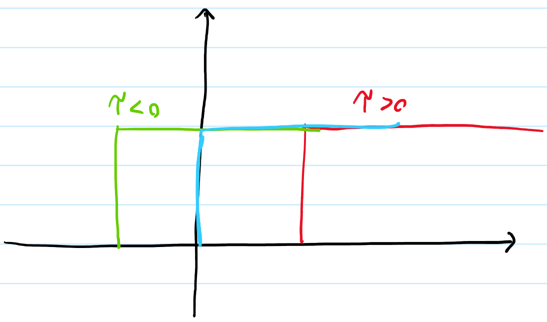
$$\sigma_y^2 = P = R_y(0)$$

$$R_y = R_x \otimes h(\tau) \otimes h(-\tau)$$

$$R_x \rightleftarrows S_x \rightarrow R_x = \frac{N_0}{2} \delta(t)$$

$$R_y = \frac{N_0}{2} \delta(t) \otimes h(\tau) \otimes h(-\tau)$$

$$h(\tau) \otimes h(-\tau) = \int_{-\infty}^{+\infty} h(t)\, h(t-\tau)\, dt$$



$\tau > 0$

$$\int_{\tau}^{+\infty} h(t)\, h(t-\tau)\, d\tau = \int_{\tau}^{+\infty} e^{-t} \quad e^{-(t-\tau)} \quad dt$$

$$= e^{\tau} \int_{\tau}^{+\infty} e^{-2t} = e^{\tau} \; -\frac{1}{2} e^{-2t} \Big|_{\tau}^{+\infty} = -\frac{e^{\tau}}{2} \left(0 - e^{-2\tau} \right) = \frac{e^{-\tau}}{2}$$

$\tau < 0$

$$-\frac{e^{\tau}}{2}\, e^{-2t}\Big|_{0}^{+\infty} = -\frac{e^{\tau}}{2}\left(0-1\right) = \frac{e^{\tau}}{2}$$

$$h(\tau) \otimes h(-\tau) = \frac{e^{-|\tau|}}{2}$$

$$R_Y = \frac{N_0}{2}\,\delta(\tau) \otimes \frac{e^{-|\tau|}}{2}\Bigg|_{\tau=0} = \frac{N_0}{4}$$

$$P_Y = \frac{N_0}{4}$$

---

1 in modo più semplice

1

$$X: \begin{cases} S_X(f) = \frac{N_0}{2} \\ \eta_X = \emptyset \end{cases}$$

$$h(t) = e^{-t}\,u(t)$$

$$\eta_Y = \underset{\overset{\parallel}{\emptyset}}{\eta_X} \otimes h(t) = \emptyset$$

$$S_Y(f) = S_X(f)\cdot |H(f)|^2$$

$$H(f) = \frac{1}{1+j2\pi f}$$

$$|H(f)|^2 = \frac{1}{1+4\pi^2 f^2}$$

$$S_Y(f) = \frac{N_0}{2}\cdot\frac{1}{1+4\pi^2 f^2}\cdot\frac{2}{2}$$

$$f_Y(y) = \frac{1}{\sqrt{2\pi\sigma_Y^2}}\, e^{-\frac{(y-m_Y)^2}{2\sigma_Y^2}}$$

$$\sigma_Y^2 = E\left[(y-m_Y)^2\right] = E\left[y^2\right] = P_Y = \int_{-\infty}^{+\infty} S_Y(f) = R_Y(0)$$

$$\underset{\overset{\parallel}{\frac{N_0}{4}e^{-|\tau|}}}{R_Y(\tau)} \rightleftharpoons S_Y(f) \Rightarrow R_Y(0) = \frac{N_0}{4} = \sigma_Y^2$$

$$f_Y(y) = \frac{1}{\sqrt{\frac{N_0}{2}\pi}}\, e^{-\frac{y^2}{N_0/2}}$$

---

① $E_S = E[x(n)^2]\, E_p$

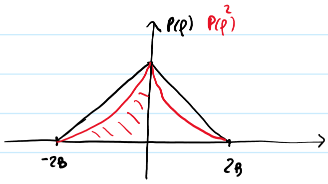
$E[x(n)^2] = (-3)^2 \cdot \frac{1}{2} + (1)^2 \cdot \frac{1}{2} = 5$

E_p:

$p(t) = 2B\,\mathrm{sinc}^2(2Bt)$

$\Updownarrow$

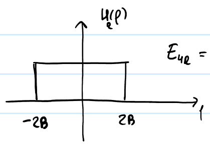
$P(f) = \left(1 - \frac{|f|}{2B}\right) \mathrm{rect}\left(\frac{f}{4B}\right)$



$E_p = 2 \cdot \frac{1}{3} \cdot 2B = \frac{4}{3} B$

$E_S = \frac{4}{3} \cdot 5B = \frac{20}{3} B$

② $P_{nu} = \frac{N_0}{2} \cdot E_{H_R}$



$E_{H_R} = 4B \Rightarrow P_{nu} = \frac{N_0}{\cancel{2}} \cdot B \cdot \cancel{4}^{2} = 2N_0 B$

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

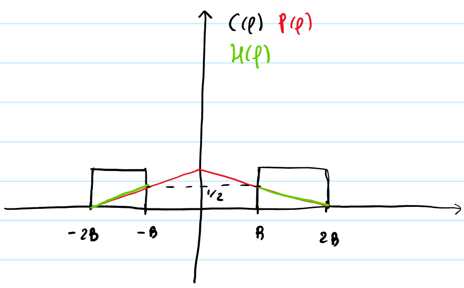
$\Updownarrow$

$H(f) = P(f) \cdot C(f) \cdot H_R(f)$

$c(t) = 4B\,\mathrm{sinc}(4Bt) - 2B\,\mathrm{sinc}(2Bt)$

$\Updownarrow$

$C(f) = \mathrm{rect}\left(\frac{f}{4B}\right) - \mathrm{rect}\left(\frac{f}{2B}\right)$



$H(f) = \left(1 - \frac{|f|}{2B}\right) \mathrm{rect}\left(\frac{f}{4B}\right) - \frac{1}{2}\mathrm{rect}\left(\frac{f}{2B}\right) - \frac{1}{2}\left(1 - \frac{|f|}{B}\right) \mathrm{rect}\left(\frac{f}{2B}\right)$

$h(t) = 2B\,\mathrm{sinc}^2(2Bt) - \frac{1}{2} \cdot 2B\,\mathrm{sinc}(2Bt) - \frac{1}{2} \cdot B\,\mathrm{sinc}^2(Bt)$

$= 2B\,\mathrm{sinc}^2(2Bt) - B\,\mathrm{sinc}(2Bt) - \frac{B}{2}\mathrm{sinc}^2(Bt)$

$h(nT) = \left(2B - B - \frac{B}{2}\right)\delta(n) = \frac{B}{2}\delta(n) \Leftarrow$ No ISI

$h(0) = \frac{B}{2}$

$y\big|_{-3} \in \mathcal{N}\left(-\frac{3}{2}B;\ 2N_0B\right) \qquad y\big|_{x=1} \in \mathcal{N}\left(\frac{B}{2};\ 2N_0B\right)$

$P_{E(b)} = \frac{1}{2} Q\left(\frac{3/2\,B}{\sqrt{2N_0B}}\right) + \frac{1}{2} Q\left(\frac{B/2}{\sqrt{2N_0B}}\right)$

20/09/2019

venerdì 17 giugno 2022 11:18

① $A = \{A \text{ e } B \text{ convenì}\}$

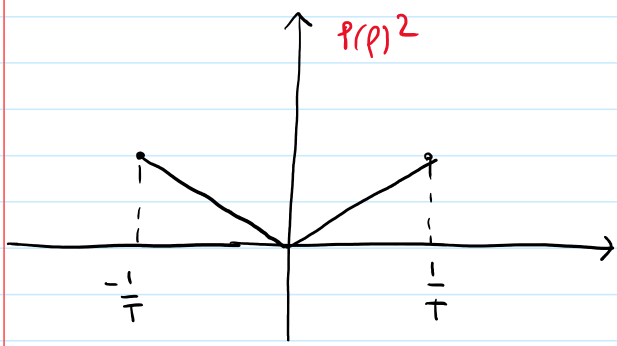
$$P_E = (1 - P_E^c) = 1 - \left[\frac{1}{5} + \frac{1}{4}\left(1 - \frac{9}{10}\cdot\frac{4}{5}\right)\left(1 - \frac{7}{8}\cdot\frac{5}{6}\right)\right]$$

1 - Prob nessuno guasto

---

② $E_S = \frac{1}{2} E_p \, E[x_c^2 + X_s^2]$

$$E[x_c^2 + X_s^2] = (-1)^2\frac{1}{2} + (3)^2\frac{1}{2} + (-2)^2\frac{1}{2} + (3)^2\frac{1}{2} = \frac{23}{2}$$



$E_p = 1/T$

$$E_S = \frac{1}{T}\cdot\frac{23}{2}\cdot\frac{1}{2}$$

② $S_{nu}(f) = \frac{N_0}{2}|H_R(f)|^2$

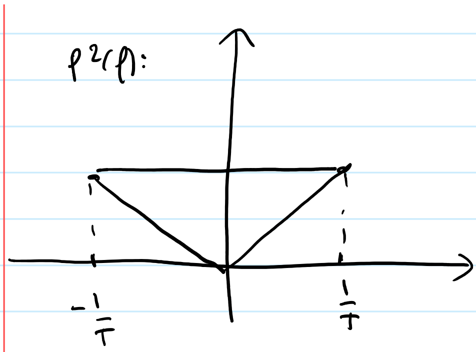
$$= \frac{N_0}{2}|P(f)|^2 = \frac{N_0}{2}|fT| \operatorname{rect}\left(\frac{fT}{2}\right)$$

③ $P_{nu} = E_{HR}\cdot N_0 = \frac{N_0}{T}$

⑤

$h(t) = p^2(t)$

$P^2(f)$:



$$P^2(f) = \mathrm{rect}\left(\frac{fT}{2}\right) - \left(1 - |f|T\right)\mathrm{rect}\left(\frac{fT}{2}\right)$$

$$p^2(t) = \frac{2}{T}\mathrm{sinc}\left(t\cdot\frac{2}{T}\right) - \frac{1}{T}\mathrm{sinc}^2\left(t\cdot\frac{2}{T}\right)$$

$$p(nT) = \frac{1}{T}\delta(n)$$

$$h(0) = \frac{1}{T}$$

$$y\Big|_{-1} \in \mathcal{N}\left(-\frac{1}{T}, \frac{N_0}{T}\right) \qquad P_E^c = \frac{1}{2}Q\left(\frac{1/T}{\sqrt{N_0/T}}\right) + \frac{1}{2}Q\left(\frac{3/T}{\sqrt{N_0/T}}\right)$$

$$y\Big|_{+3} \in \mathcal{N}\left(\frac{3}{T}, \frac{N_0}{T}\right)$$

$$y\Big|_{-2} \in \mathcal{N}\left(-\frac{2}{T}\cos\varphi, \frac{N_0}{T}\right) \qquad P_E = \frac{1}{2}Q\left(\frac{\frac{2}{T}\cos\varphi}{\sqrt{N_0/T}}\right) + \frac{1}{2}Q\left(\frac{\frac{3}{T}\cos\varphi}{\sqrt{N_0/T}}\right)$$

$$y\Big|_{3} \in \mathcal{N}\left(\frac{3}{T}\cos\varphi, \frac{N_0}{T}\right)$$

11/11/2019

giovedì 16 giugno 2022 09:47

(1)

$$SSL = \begin{cases} \eta_y = k \\ R_y(t_1,t_2) = R_y(\tau) \end{cases}$$

$$\eta_y = \underset{\downarrow \atop 0}{\eta_x} + \underset{\downarrow \atop 0}{\eta_w} = \emptyset$$

$$R_y(t_1,t_2) = R_y(\tau) = E[y(t_1)\,y(t_2)]$$

$$= [[X(t_1) + W(t_1)][X(t_2) + W(t_2)]]$$

$$= [X(t_1)X(t_2) + X(t_1)W(t_2) + X(t_2)W(t_1) + W(t_1)W(t_2)]$$

$$= E[X(t_1)X(t_2)] + E[X(t_1)W(t_2)] + E[X(t_2)W(t_1)] + E[W(t_1)W(t_2)]$$

$$= E[A^2] + \overset{\text{indip.}}{E[A]\underbrace{E[W(t_2)]}_{\to 0}} + \emptyset + E[W(t_1)W(t_2)]$$

$$= \sigma_A^2 + E[W(t_1)W(t_2)]$$

$$= \sigma_A^2 + R_W(t_1,t_2)$$

Se il rumore e' bianco in banda:

$$\underline{S_W(f) = k}\ \mathrm{rect}\left(\frac{f}{2B}\right)$$

$$\underline{P_W = \int_{-\infty}^{+\infty} S_W} = \int_{-B}^{B} k = k \cdot 2B$$

$$\underline{P_W = \sigma_w^2} \to k = \frac{\sigma_w^2}{2B}$$

poiche' $P_W = \sigma_w^2 - \eta_w$

$$S_W = \frac{\sigma_w^2}{2B}\,\mathrm{rect}\left(\frac{f}{2B}\right) \rightleftharpoons \sigma_w^2\,\mathrm{sinc}(2B\tau) = R_W(\tau) \to SSL$$

(2) $S_y = TCF[R_y(\tau)]$

$$= TCF[\sigma_w^2\,\mathrm{sinc}(2B\tau) + \sigma_A^2] = \sigma_w^2\,\frac{1}{2B}\,\mathrm{rect}\left(\frac{f}{2B}\right) + \sigma_A^2\,\delta(f)$$

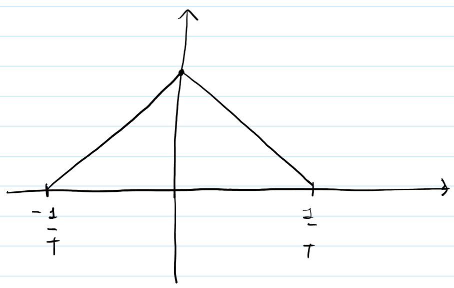
ES (2)

$$E_s = \frac{1}{2} E_p\, E[X_c^2(t) + X_s^2(t)]$$

$$E[X_c^2 + X_s^2] = P(-2)(-2)^2 + P(1)\,1^2 + P(-1)(-1)^2 + P(1)(1)^2$$

$$= 3$$

$$P^2(f) = (1 - |fT|)\,\mathrm{rect}\left(\frac{fT}{2}\right)$$



$E_p = \frac{2}{T} \cdot \frac{1}{2} = \frac{1}{T}$

$E_S = \dots$

② $P_{nu} = N_0 \cdot E_{h_R} = \frac{N_0}{T}$

③ $H(f) = |P(f)|^2$

$\left(1 - \frac{|t|}{T}\right) \mathrm{rect}\left(\frac{t}{2T}\right) \rightleftarrows T \operatorname{sinc}^2(fT)$

$P(f)^2 = \left(1 - \frac{f}{1/T}\right) \mathrm{rect}\left(\frac{f}{2/T}\right)$

$\Downarrow \mathcal{F}^{-1}$

$p(t)^2 = \frac{1}{T} \operatorname{sinc}^2\left(\frac{t}{1/T}\right)$

$h(nT) = \frac{1}{T} \operatorname{sinc}^2\left(n\cancel{T}\frac{1}{\cancel{T}}\right)$

$h(nT) = \frac{1}{T} \delta(n)$ ok!

④ $P_E = P_E^c + P_E^s$

P_E^c :

$h(0) = \frac{1}{T}$ $P_{nu} = \frac{N_0}{T}$

$y|_{x=-2} \in \left(-\frac{2}{T}, \frac{N_0}{T}\right)$

$y|_{x=1} \in \left(\frac{1}{T}, \frac{N_0}{T}\right)$

$P_E^c = \frac{2}{3} Q\left(\frac{1/T}{\sqrt{N_0/T}}\right) + \frac{1}{3} Q\left(\frac{2/T}{\sqrt{N_0/T}}\right)$

$y|_{-1} \in \mathcal{N}\left(-\frac{1}{T}, \frac{N_0}{T}\right)$

$y|_{1} \in \mathcal{N}\left(\frac{1}{T}, \frac{N_0}{T}\right)$

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

13/01/2020

sabato 18 giugno 2022 10:20

(1)

$$\boxed{C_{xx}(\tau) = R_x(\tau) - \eta_x^2}$$

$$C_{xx}(\tau) = A e^{-\alpha|\tau|}\cos(2\pi f_0 \tau)$$

$$\eta_x = 5$$

$$R_x(\tau) = A e^{-\alpha|\tau|}\cos(2\pi f_0 \tau) + 5$$

$$\downarrow \mathcal{F}$$

$$S_x(f) = A\left(\frac{\cancel{2}}{\alpha + 4\pi^2(f-f_0)^2}\cdot\frac{1}{\cancel{2}} + \cancel{2}\cdot\frac{1}{\cancel{2}}\,\frac{1}{\alpha + 4\pi^2(f+f_0)^2}\right) + 25\,\delta(f)$$

$$S_x(f) = \frac{A}{\alpha + 4\pi^2(f-f_0)^2} + \frac{A}{\alpha + 4\pi^2(f+f_0)^2}$$

---

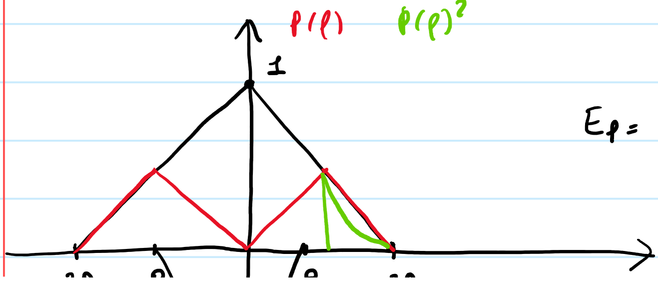
(2)

1 $\quad E_s = E_p \, E[x^2]\cdot\frac{1}{2}$

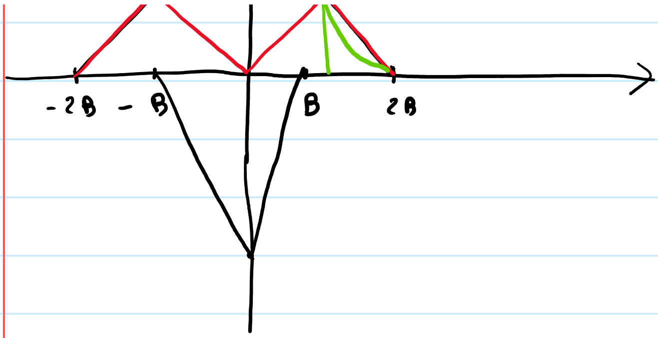
$$E[x^2] = (-2)^2\frac{1}{2} + \frac{1}{2}(3)^2 = \frac{4}{2} + \frac{9}{2} = \frac{13}{2}$$

$E_p =$

$$P(f) = \left(1 - \frac{|f|}{2B}\right)\text{rect}\left(\frac{f}{4B}\right) - \left(1 - \frac{|f|}{B}\right)\text{rect}\left(\frac{f}{2B}\right)$$



$E_p = \frac{4}{3}B$



$$E_S = \frac{\cancel{4}^{2}}{3} B \cdot \frac{13}{\cancel{2}} \cdot \frac{1}{2} = \frac{26}{6} B$$

② $P_{nu} = E_{he} \cdot N_0 = N_0 \cdot 4B$

③ $\varphi = -\frac{\pi}{3}$ θ:

$H(f) = P(f)$

$h(nT) = B\,\delta(n) \rightarrow$ Nyquist ok!

$h(0) = B$

$$y|_{x=-2} = \in \mathcal{N}\left(-2B\cos\left(-\frac{\pi}{3}-\theta\right) ; 4N_0B\right)$$

$$y|_{x=3} = \in \mathcal{N}\left(3B\cos\left(-\frac{\pi}{3}-\theta\right) ; 4N_0B\right)$$

$$P_E = \frac{1}{2} Q\left(\frac{3B\cos\left(-\frac{\pi}{3}-\theta\right)}{\sqrt{4N_0B}}\right) + \frac{1}{2} Q\left(\frac{2B\cos\left(-\frac{\pi}{3}-\theta\right)}{\sqrt{4N_0B}}\right)$$

④ $\cos\left(-\frac{\pi}{3}-\theta\right) = 1$

$$\Downarrow$$

$$\theta = -\frac{\pi}{3}$$

31/01/2020

venerdì 1 luglio 2022 17:08

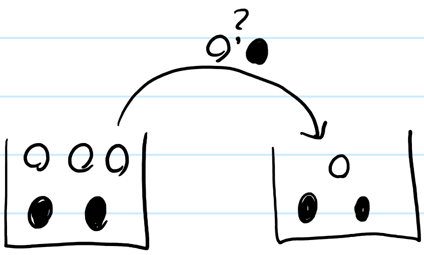
09:15

A = { 1 biawca e 1 nera }

$$P(A) = \frac{3}{5}\cdot\frac{1}{2} + \frac{\cancel{2}}{5}\cdot\frac{3}{\cancel{4}\,2}$$

$$= \frac{3}{10} + \frac{3}{10} = \frac{6}{10}$$

(2)



A = { inserisio nera in 2 }

B = { inserisio biawca in 2 }

$P(A) = \frac{2}{5}$ $P(B) = \frac{3}{5}$

C = { pesco nera da 2 }

$$P(C) = P(C|A)\,P(A) + P(C|B)\,P(B)$$

$$= \frac{3}{\cancel{4}\,2}\cdot\frac{\cancel{2}}{5} + \frac{1}{2}\cdot\frac{3}{5} = \frac{3}{10} + \frac{3}{10} = \frac{6}{10}$$

③ $A = \{$ pallina bianca dalla prima $\}$

$B = \{$ pallina nera dalla seconda $\}$

$$P(C|A) = \frac{3}{4}$$

$$P(A|B) = \frac{P(B|A)\,P(A)}{P(B)} \sim \frac{2}{5}$$

$$P(B) = \frac{6}{10}$$

$$= \frac{2\cancel{\frac{3}{4}} \cdot \frac{8}{5}}{\frac{6}{10}} = \frac{\frac{3}{10}}{\frac{6}{10}} = \frac{\cancel{3}}{\cancel{10}} \cdot \frac{\cancel{10}}{\cancel{6}} = \frac{1}{2}$$

---

②

① $E_S = E[X^2[n]]\, E_P$

$$E[X[n]^2] = (-2)^2 \cdot \frac{1}{2} + (3)^2 \cdot \frac{1}{2}$$

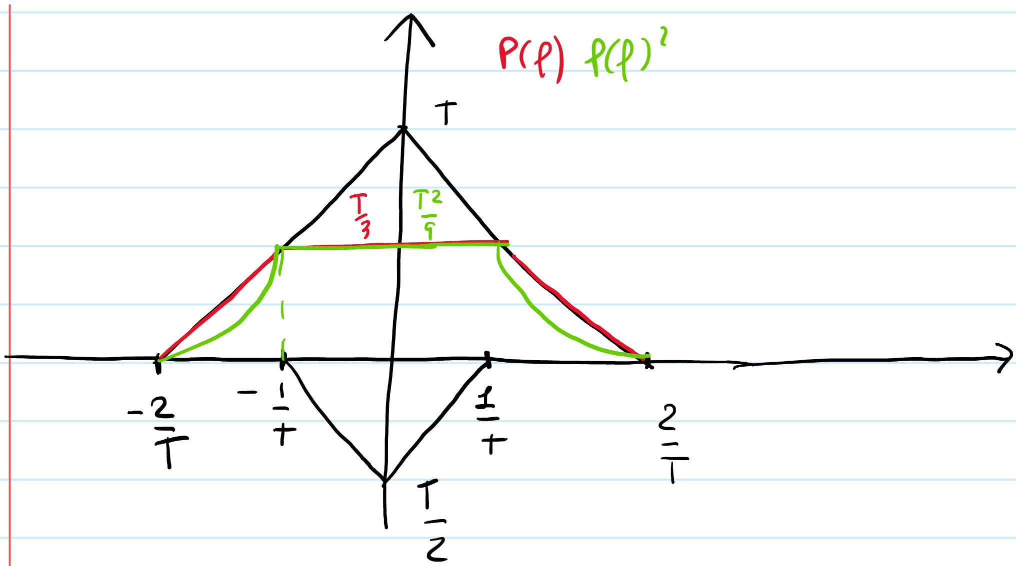
$$= \frac{4}{2} + \frac{9}{2} = \frac{13}{2}$$

E_P:

$$P(t) = \frac{2}{3}\left[2\,\mathrm{sinc}^2\left(\frac{2t}{T}\right) - \frac{1}{2}\,\mathrm{sinc}^2\left(\frac{t}{T}\right)\right]$$

$$= \frac{2}{3}\left[T \cdot \frac{2}{T}\,\mathrm{sinc}^2\left(\frac{2t}{T}\right) - \frac{1}{2} \cdot T \cdot \frac{1}{T}\,\mathrm{sinc}^2\left(\frac{t}{T}\right)\right]$$

$$P(f) = \frac{2}{3}\left[T\left(1 - \frac{|f|T}{2}\right)\mathrm{rect}\left(\frac{fT}{4}\right) - \frac{T}{2}\left(1 - \frac{|f|}{T}\right)\mathrm{rect}\left(\frac{f}{2T}\right)\right]$$



$$E_p = 2 \cdot \frac{1}{3} \cdot \frac{T^{\cancel{2}}}{9} \cdot \frac{1}{\cancel{T}} + \frac{2}{\cancel{T}} \cdot \frac{T^{\cancel{2}}}{9}$$

$$= \frac{2}{27} T + \frac{2}{9} T = \frac{8}{27} T$$

$$E_s = \frac{\overset{4}{\cancel{8}}}{27} T \cdot \frac{13}{\cancel{2}} = \frac{52}{27} T$$

②

$$S_s(f) = \frac{1}{T} \overline{S_x(f)} \cdot |P(f)|^2$$

$$\overline{S_x(f)} = TFS[R_x[m]]$$

$$R_x[m] = C_x[m] + \eta_x^2$$

$$C_x[m] = \sigma_x^2[m] \quad \delta[m]$$

$$\sigma_x^2[m] = E[x[m]^2] - E[x]^2$$

$$= \frac{13}{2} - \left(-1 + \frac{3}{2}\right)^2 = \frac{13}{2} - \frac{1}{4} = \frac{25}{4}$$

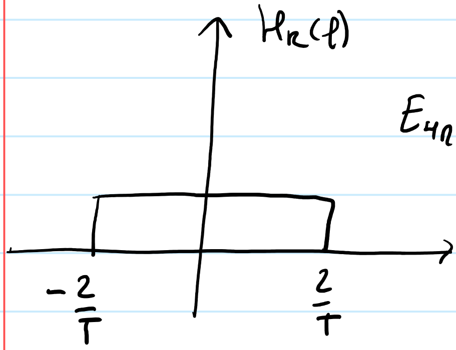
$$R_x[m] = \frac{25}{} \delta[m] + \frac{1}{} \sim \eta_x^2$$

$$R_X[m] = \frac{25}{4}\delta[m] + \frac{1}{4} \sim \eta_x^2$$

$$\bar{S}_X(f) = \frac{25}{4} + \frac{1}{4}\cdot\frac{1}{T}\sum_{n=-\infty}^{+\infty}\delta\left(f-\frac{n}{T}\right)$$

$$S_S(f) = \frac{1}{T}\cdot\frac{25}{4}P(f)^2 + \frac{1}{36}P(f)^2 + \frac{1}{36}P^2\left(f-\frac{1}{T}\right) + \frac{1}{36}P^2\left(f+\frac{1}{T}\right)$$

3 $P_{nu} = \frac{E_{hR}}{2}\cdot N_0 =$

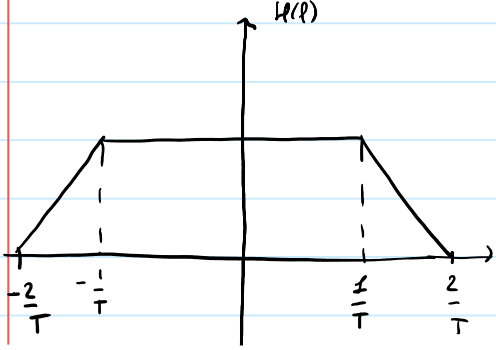


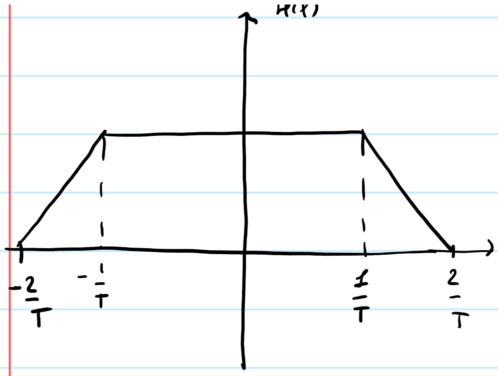
$E_{4R} = \frac{4}{T}$

$$P_{nu} = \frac{\cancel{4}^{\,2}}{T}\cdot\frac{1}{\cancel{2}}\cdot N_0 = \frac{2N_0}{T}$$

4

$$H(f) = P(f)\cdot H_R(f)$$





$h(nT) = \frac{1}{3}\delta(t) - \frac{1}{3}\delta(t) = \delta(t) \Leftarrow$ No ISI

$h(0) = 1$

$y\big|_{x=-2} \in \mathcal{N}\left(\frac{-2}{\sqrt{\frac{2N_0}{T}}}\right)$

$y\big|_{x=3} \in \mathcal{N}\left(\frac{3}{\sqrt{\frac{2N_0}{T}}}\right)$

$P_E = \frac{1}{2} Q\left(\frac{3 - 1/2}{\sqrt{\frac{2N_0}{T}}}\right) + \frac{1}{2} Q\left(\frac{1/2 + 2}{\sqrt{\frac{2N_0}{T}}}\right)$

(1) $\int_{-\infty}^{+\infty} f_X(x) = 1$

$E_f = 8A + \frac{8A}{2} = 12A$

$A = \frac{1}{12}$

(2) $P(X \leq 3) = F(3)$

$= \int_{-\infty}^{3} f_X(x) =$

$f_X(x) = \frac{A}{8}x = \frac{1}{96}x$

$F(3) = \int_0^3 \frac{1}{96}x = \frac{1}{96} \cdot \frac{1}{2} x^2 \Big|_0^3$

$= \frac{1}{96} \cdot \frac{1}{2} \cdot 9 = \frac{3}{64}$

(3) $P(X \leq 3 \mid X < 10) = \frac{\overset{1}{P(X \leq 10 \mid X \leq 3)} \; \overset{F(3)}{P(X \leq 3)}}{P(X \leq 10)}$

$\int_0^{10} f_X(x)\,dx = 4A + 2A = 6A$

$P(X \leq 3 \mid X \leq 10) = \frac{P(X \leq 10 \mid X \leq 3)\,P(X \leq 3)}{P(X \leq 10)} = \frac{1 \cdot \frac{3}{64}}{\frac{1}{2}} = \ldots$

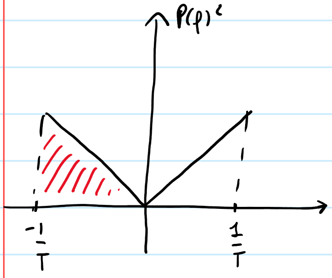
---

(2) $E_s = \frac{1}{2} E_p \, E[X_c[n] + X_s[n]]$

$E[X_c[n] + X_s[n]] = (-1)^2 \cdot \frac{2}{3} + (2)^2 \frac{1}{3} + (1)^2 \cdot \frac{3}{4} + (3)^2 \cdot \frac{1}{4}$

$= \frac{2}{3} + \frac{4}{3} + \frac{3}{4} + \frac{9}{4} = \frac{8+16+9+27}{12} = \frac{60}{12} = 5$

E_p: $\quad P(f)^2 = |fT| \, rect\left(\frac{fT}{2}\right)$



$E_p = 2 \cdot \frac{1}{T} \cdot \frac{1}{2} = \frac{1}{T}$

$E_s: \; 5 \cdot \frac{1}{T} \cdot \frac{1}{2} = \frac{5}{2T}$

② $P_{nu} = P_{ns} = P_{nc}$

$P_{nu} = N_0 \cdot E_{hr}$

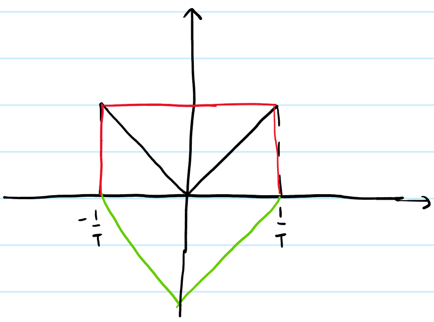
$h_r(t) = p(t) \Rightarrow E_{hr} = E_p$

$P_{nu} = N_0 \cdot \frac{1}{T} = \frac{N_0}{T}$

③ $h(t) = p(t) \otimes h_r(t) \otimes \cancel{c(t)}$ $\uparrow \delta(t)$

$H(f) = P(f) \, H_R(f) = P^2(f)$

$h(t) = p^2(t)$



$P^2(f) = rect\left(\frac{fT}{2}\right) - \left(1 - |f|T\right) rect\left(\frac{fT}{2}\right)$

$\Updownarrow$

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

$$h(nT) = \left(\frac{2}{T} - \frac{1}{T}\right)\delta(t)$$

$$= \frac{1}{T}\delta(t) \implies \text{No ISI}$$

$$h(0) = \frac{1}{T}$$

$$Y|_{-1} \in N\left(-\frac{1}{T}, \frac{N_0}{T}\right) \qquad Y|_{x=2} \in N\left(\frac{2}{T}, \frac{N_0}{T}\right)$$

$$P_E^c = \frac{2}{3} Q\left(\frac{\frac{1}{T}}{\sqrt{\frac{N_0}{T}}}\right) + \frac{1}{3} Q\left(\frac{2/T}{\sqrt{N_0/T}}\right)$$

$$P_E^s = \frac{3}{4} Q\left(\frac{1/T}{\sqrt{\frac{N_0}{T}}}\right) + \frac{1}{4} Q\left(\frac{3/T}{\sqrt{N_0/T}}\right)$$

$$P_E = 1 - (1 - P_E^c)(1 - P_E^s)$$

16/02/2022

mercoledì 22 giugno 2022 09:46

$$S_{nu} = S_n(f) \cdot |H(f)|^2$$

$$H(f) = \text{rect}\left(\frac{f}{2B}\right) \cos\left(2\pi f \cdot \frac{1}{2}\right)$$

$$H(f) = \cos^2(\pi f)\ \text{rect}\left(\frac{f}{B}\right)$$

$$S_{nu} = \frac{N_0}{2}\ \text{rect}\left(\frac{f}{B}\right) \cos^2(\pi f)$$

$$R_x \overset{\text{ATCF}}{\rightleftarrows} S_n$$

$$S_{nu} = \frac{N_0}{2} \text{rect}\left(\frac{f}{2B}\right)\left[\frac{1}{2} + \frac{1}{2}\cos(2\pi f)\right]$$

$$= \frac{N_0}{4} \text{rect}\left(\frac{f}{2B}\right) + \frac{N_0}{4} \text{rect}\left(\frac{f}{2B}\right) \cos(2\pi f)$$

$$R_{nu}(t) = \frac{N_0}{4} 2B \,\text{sinc}(Bt) + \ldots$$

$$\frac{N_0}{4}\int_{-\infty}^{+\infty} \text{rect}\left(\frac{f}{2B}\right) \cos(2\pi f)\, df$$

$$\frac{N_0}{4}\int_{-B}^{B} \cos(2\pi f)\, e^{j2\pi f t}\, df$$

$$= \frac{N_0}{4}\int_{-B}^{B} \frac{e^{j2\pi f} + e^{-j2\pi f}}{2}\, e^{j2\pi f t}\, dt$$

$$= \frac{N_0}{8}\int_{-B}^{B} e^{j2\pi f(t+1)} + \frac{N_0}{8}\int_{-B}^{B} e^{j2\pi f(t-1)}$$

$$= \frac{N_0}{8}\, \frac{1}{j2\pi(t+1)}\, e^{j2\pi f(t+1)}\Big|_{-B}^{B} + \frac{N_0}{8}\, \frac{1}{j2\pi(t-1)}\, e^{j2\pi f(t-1)}\Big|_{-B}^{B}$$

$$= \frac{N_0}{\ } \cdot \frac{1}{\ } \left(\frac{e^{j2\pi B(t+1)} - e^{-j2\pi B(t+1)}}{\ }\right) + \frac{N_0}{\ }\, \frac{1}{\ } \left(\frac{e^{j2\pi B(t-1)} - e^{-j2\pi B(t-1)}}{\ }\right)$$

$$= \frac{N_0}{8} \cdot \frac{1}{\cancel{J2}\pi(t+1)} \left(\frac{e^{J2\pi B(t+1)} - e^{-J2\pi B(t+1)}}{2J} \right) + \frac{N_0}{8} \frac{1}{\cancel{J2}\pi(t-1)} \left(\frac{e^{J2\pi B(t-1)} - e^{-J2\pi B(t-1)}}{2J} \right)$$

$$= \frac{N_0 B}{4\cancel{8}} \frac{\sin(2\pi B(t+1))}{2\pi(t+1)} + \frac{N_0 B}{4\cancel{8}} \frac{\sin(2\pi B(t-1))}{2\pi(t-1)}$$

$$= \frac{N_0}{4} B \ \mathrm{SINC}(2B(t+1)) + \frac{N_0}{4} B \ \mathrm{SINC}(B(t-1))$$

$$R_{nn} = \frac{N_0}{4} B \ \mathrm{SINC}(2B(t+1)) + \frac{N_0}{4} B \ \mathrm{SINC}(B(t-1)) + \frac{N_0}{2} B \ \mathrm{SINC}(Bt)$$

2 GAUSSIANA:

$$\eta_z = \emptyset$$

$$\sigma_z^2 = P_z = R_z(0) =$$

$$R_z(0) = \frac{N_0}{2} B$$

$$p_z(z) = \frac{1}{2\pi \sigma_z^2} \cdot e^{-\frac{(z-\eta_z)}{2\sigma_z^2}}$$

$$= \frac{1}{\pi N_0 B} e^{-\frac{z}{N_0 B}}$$

08/06/2022

mercoledì 22 giugno 2022 10:27

①

$$Y(f) + \frac{Y(f)}{j2\pi f} = \frac{3\,X(f)}{j2\pi f}$$

$$Y(f)\left[\frac{j2\pi f + 1}{j2\pi f}\right] = \frac{3\,X(f)}{j2\pi f}$$

$$Y(f) = \frac{3\,X(f)}{\cancel{j2\pi f}}\left[\frac{\cancel{j2\pi f}}{j2\pi f + 1}\right]$$

$$H(f) = \frac{3}{j2\pi f + 1}$$

$$S_x = \frac{N_0}{2} \rightleftarrows R_x = \frac{N_0}{2}\,\delta$$

$$S_y = \frac{N_0}{2} \cdot \frac{9}{4\pi^2 f^2 + 1}$$

$$R_y = \frac{9}{4} N_0 \cdot e^{-|t|}$$

②

$$P_y = R_y(0) = \frac{9}{4} N_0$$

$$P_x = R_x(0) = \frac{N_0}{2}$$

③

$$\eta_y = \emptyset$$

$$\sigma_y^2 = P_y = \frac{9}{4} N_0 \qquad f_y(y) = \frac{1}{\sqrt{\pi \frac{9}{2} N_0}}\, e^{\frac{-y}{\frac{9}{2} N_0}}$$

④ $$P\left(y > \sqrt{\tfrac{N_0}{2}}\right) = 1 - P\left(y \le \sqrt{\tfrac{N_0}{2}}\right) = 1 - F\left(\sqrt{N_0/2}\right)$$

$$F\left(\sqrt{\tfrac{N_0}{2}}\right) = \int_{-\infty}^{\sqrt{\frac{N_0}{2}}} f_y(y)\,dy = \frac{\sqrt{2}}{\sqrt{9\pi N_0}} \int_{-\infty}^{\sqrt{\frac{N_0}{2}}} e^{-\frac{2y}{9N_0}}\,dy$$

$$= \sqrt{2} \quad 9N_0 \quad e^{-\frac{2y}{9}} \Big|^{\sqrt{\frac{N_0}{2}}}$$

$$= \sqrt{\frac{2}{9\pi N_0}} \cdot \frac{9N_0}{-2} \, e^{-\frac{2y}{9N_0}} \Big|_{-\infty}^{\sqrt{\frac{N_0}{2}}}$$

$$= \sqrt{\frac{2}{9\pi N_0}} \cdot \frac{9N_0}{-2} \left(e^{-\frac{2}{9N_0}\cdot\sqrt{\frac{N_0}{2}}} - \infty \right)$$

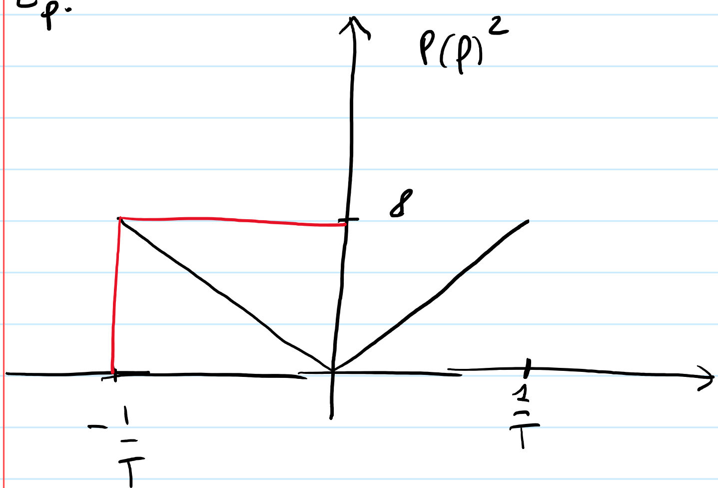
---

② $E_S = \frac{1}{2} E_X E_P$

$$E_X = (-2)^2 \frac{1}{2} + (3)^2 \frac{1}{2} + (-1)^2 \frac{1}{2} + (1)^2 \frac{1}{2}$$

$$= \frac{4}{2} + \frac{9}{2} + \frac{1}{2} + \frac{1}{2} = \frac{15}{2}$$

E_P:



$$E_P = \frac{1}{T} \cdot 2 = \frac{2}{T}$$

$$E_S = \frac{2}{T} \cdot \frac{15}{2} = \frac{15}{T} \cdot \frac{1}{2} = \frac{15}{2T}$$

②

$$P_{nu} = E_{nn} \cdot N_0$$

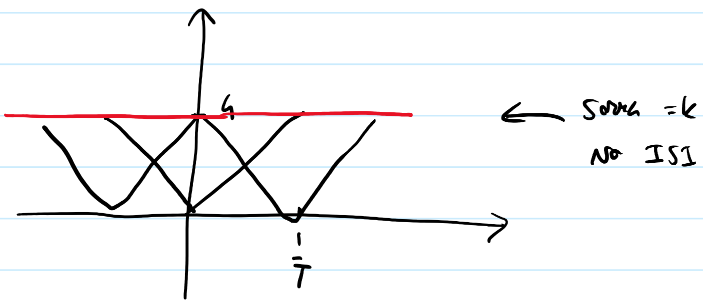
$$E_{nn} = 4 \cdot \frac{2}{T} = \frac{8}{T}$$

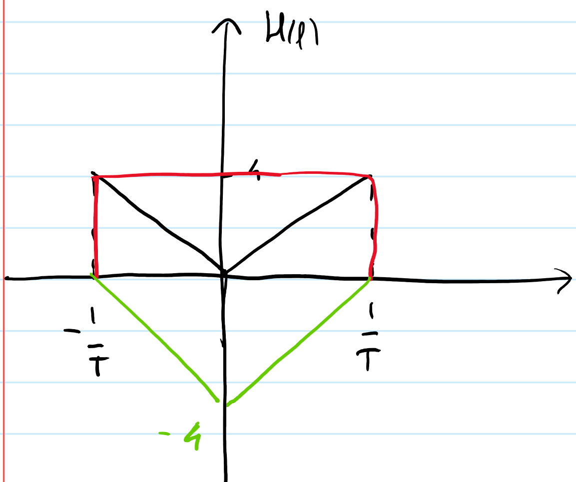
$$P_{nu} = \frac{2 N_0}{T}$$

③ No cross-talk ramo fase

④ $H(f) = 2|P(f)|^2$

$$\sum_n H\left(f - \frac{n}{T}\right) = k$$





$$H(f) = 4 \; rect\left(\frac{Tf}{2}\right) - 4\left(1 - |f|T\right) rect\left(\frac{fT}{2}\right)$$

$$h(t) = 4 \cdot \frac{2}{T} \; sinc\left(t \cdot \frac{2}{T}\right) - 4 \cdot \frac{1}{T} \; sinc^2\left(t \cdot \frac{1}{T}\right)$$

$$h(0) = \frac{8}{T} - \frac{4}{T} = \frac{4}{T}$$

$$Y\Big|_{-2} \in \left(-\frac{8}{T}, \frac{8 N_0}{T}\right)$$

$$y\big|_3 \in \left(\frac{12}{T}, \frac{8N_0}{T} \right)$$

$$P_E^c = \frac{1}{2} Q\left(\frac{8/T}{\sqrt{\frac{8N_0}{T}}} \right) + \frac{1}{2} Q\left(\frac{12/T}{\sqrt{\frac{8N_0}{T}}} \right)$$

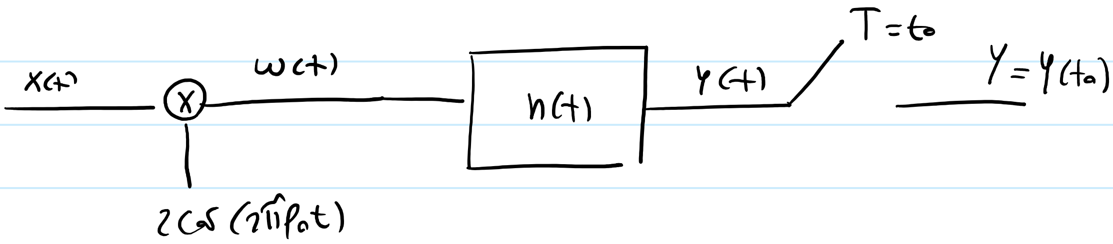
29/06/2022

giovedì 30 giugno 2022 12:34

$$S_x(f) = \frac{N_0}{2}\left[\mathrm{rect}\left(\frac{f-f_0}{2B}\right) + \mathrm{rect}\left(\frac{f+f_0}{2B}\right)\right]$$

$h(t) = B\,\mathrm{sinc}^2(Bt)$

① $R_w(t_1, t_2)$



$w(t) = x(t)\cdot 2\cos(2\pi f_0 t)$

$R_w(t_1,t_2) = E[w(t_1)\,w(t_2)]$

$$= 4\underbrace{E[x(t_1)x(t_2)]}_{R_x(t_1,t_2)}\cos(2\pi f_0 t_1)\cos(2\pi f_0 t_2)$$

$$R_x(t_1,t_2) \overset{\mathrm{ATCF}}{\rightleftharpoons} S_x(f) = \frac{N_0}{2}\left(\mathrm{rect}\left(\frac{f+f_0}{2B}\right) + \mathrm{rect}\left(\frac{f-f_0}{2B}\right)\right)$$

$$\mathrm{rect}\left(\frac{f}{2B}\right) \rightleftharpoons 2B\,\mathrm{sinc}(2Bt)$$

$R_x(t_1,t_2) = 2N_0B\,\mathrm{sinc}(2Bt)\cos(2\pi f_0 t)$

$R_w(t_1,t_2) = 4N_0B\,\mathrm{sinc}(2B(t_1-t_2))\cos(2\pi f_0(t_1-t_2))$

$\cdot\left[\cos(2\pi f_0(t_1+t_2)) + \cos(2\pi f_0(t_1-t_2))\right)$

$$= 2N_0B\,\text{sinc}(2B(t_1-t_2))\left[\cos(4\pi f_0 t_1) + \cos(4\pi f_0 t_2)\right.$$

$$\left. + \cos(4\pi f_0(t_1-t_2)) + 1\right]$$

② $Y(t)$ SLS = ? $\begin{cases} \eta_y = \emptyset \\ R_y(t_1,t_2) = R_y(\tau) \end{cases}$

• $\eta_y = \eta_x \otimes h(t) = \eta_x H(f)$

$\eta_x = \emptyset \Longrightarrow \eta_y = \emptyset$ ok!

• $R_y(t_1,t_2) = R_w(t_1,t_2) \otimes h(\tau) \otimes h(-\tau)$

$$= 2N_0B\,\text{sinc}(B(t_1-t_2))\left[\cancel{\cos(4\pi f_0 t_1)} + \cancel{\cos(4\pi f_0 t_2)} + 1 + \cancel{\cos(4\pi f_0(t_1-t_2))}\right] \otimes h(\tau) \otimes h(-\tau)$$

$$H(f) = \left(1 - \frac{|f|}{B}\right) \text{rect}\left(\frac{f}{2B}\right)$$

$$R_y(t_1-t_2) = 2N_0B\,\text{sinc}(B(t_1-t_2))$$

$\quad \| \qquad\qquad\qquad \uparrow$

$R_y(\tau)$

③ $$f_y(y) = \frac{1}{\sqrt{2\pi\sigma_y^2}} e^{\frac{-(y-\eta_y)^2}{2\sigma_y^2}}$$

$\eta_y = \emptyset$, $\sigma_y^2 = P_y = R_y(0) = 2N_0B$

$$f_y(y) = \frac{1}{\sqrt{\ldots}} e^{\frac{-y^2}{4N_0B}}$$

$$p_y(y) = \frac{1}{\sqrt{4\pi N_0 B}} \, e^{\frac{\quad}{4 N_0 B}}$$

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(2)

(1) $E_s = \frac{1}{2} E_p \, E[x_c^2(n) + x_s^2(n)]$

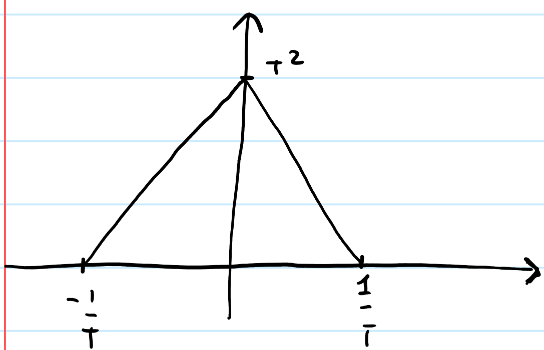
$$E[x_c(n)^2 + x_s(n)^2] = (-2)^2 \cdot \frac{1}{3} + (2)^2 \cdot \frac{2}{3}$$

$$+ 1 \cdot \frac{1}{2} + 1 \cdot \frac{1}{2} = 5$$

E_p:

$$P(f) = T\sqrt{1 - |fT|} \; \mathrm{rect}\left(\frac{fT}{2}\right)$$

$$P(f)^2 = T^2 (1 - |fT|) \; \mathrm{rect}\left(\frac{fT}{2}\right)$$



$$E_p = \frac{1}{T} \cdot T^2 = T$$

$$E_s = 5 \cdot \frac{1}{2} \cdot T = \frac{5}{2} T$$

(2) $P_{n_c} = P_{n_s} = P_{nu}$

$$P_{nu} = N_0 \cdot E_{uR}$$

$h_r(t) = p(t)$

$\Updownarrow$

$H_R(f) = P(f) \Longrightarrow E_p = E_{hR}$

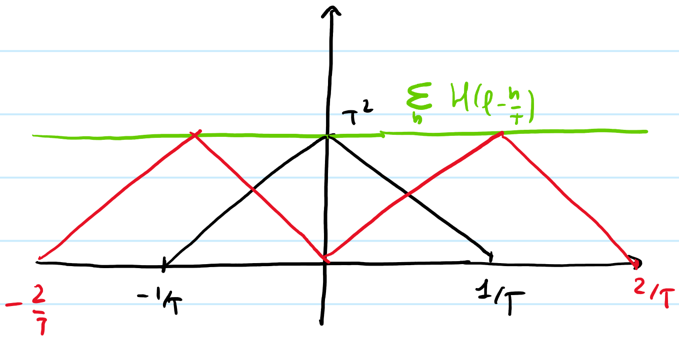
$P_{nu} = N_0 \cdot T = N_0 T$

③ ISI?

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

$\Updownarrow$

$H(f) = P(f)\cancel{C(f)}H_R(f) = |P(f)|^2 = T^2 \left(1 - \frac{|f|}{1/T}\right) \text{rect}\left(\frac{f}{2/T}\right)$



No ISI $\Rightarrow \frac{1}{T}\sum_{n=-\infty}^{+\infty} X\left(f-\frac{n}{T}\right) = \frac{T^2}{T} = T \Rightarrow$ No ISI

$h(t) = T^{\cancel{3}} \cdot \cancel{\frac{1}{T}} \text{sinc}^2\left(\frac{1}{T}t\right)$

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

$h(nT) = T\,\text{sinc}^2\left(\frac{n\cancel{T}}{\cancel{T}}\right) = T\,\delta[n]$

$h(0) = T$

FASE: $X_c[n] \in \{\overset{1/3}{-2}, \overset{2/3}{2}\}$ $\qquad \sigma_x^2 = P_{nu} = N_0 T$

$y|_{X_c[n]=-2} \in \mathcal{N}(-2T;\ N_0 T)$

$$y\big|_{x_c(n)=2} \in \mathcal{N}\left(2T;\ N_0T\right)$$

$$P_E^c = \frac{1}{3} Q\left(\frac{\lambda-(-2T)}{\sqrt{N_0T}}\right) + \frac{2}{3} Q\left(\frac{2T-\lambda}{\sqrt{N_0T}}\right)$$

$$= Q\left(\frac{2T}{\sqrt{N_0T}}\right)$$

QUADRATURA: $X_s \in \{\overset{1/2}{-1}, \overset{1/2}{1}\}$

$$y\big|_{x=-1} \in \mathcal{N}\left(-T,\ N_0T\right)$$

$$y\big|_{x=1} \in \mathcal{N}\left(T,\ N_0T\right)$$

$$P_E^s = Q\left(\frac{T}{\sqrt{N_0T}}\right)$$

$$P_E = 1 - \left(1 - Q\left(\frac{2T}{\sqrt{N_0T}}\right)\right)\left(1 - Q\left(\frac{T}{\sqrt{N_0T}}\right)\right)$$