(V)

Frank

UNAC
FIEE

PRIMERA PRACTICA DE TELECOMUNICACIONES III

1.-Sea la función:

$$f(t) = (2 + \cos w_0 t) \cos w_1 t$$

a) Hallar la Transformada de Fourier
b) Hallar la autocorrelación
c) Hallar la D.E.P. y graficar

2.-La probabilidad de error de un proceso de transmisión es 4.8×10^{-6} se desea transmitir 700 Kbps,

a) Hallar el (C/No) teórico en modulación PSK
b) Repetir a) en modulación FSK
c) Si se cuenta con un (C/No) disponible de 70 dBHz, y manteniendo la misma probabilidad de error, hasta que velocidad se puede transmitir en modulación ASK.

3.-Se desea transmitir 800 Kbps, en modulación PSK, la potencia del transmisor es 50 Watts, las antenas tienen una ganancia de 14 dBi cada una, el receptor tiene una DEP de -100 dBW/Hz, la distancia entre el transmisor y el receptor es de 23 Km y la frecuencia de operación 850 Mhz.

Sa(a)

a) Hallar la Pe.
b) Si la potencia aumentamos a 70 watts, cual es la nueva probabilidad de error?
c) Si la potencia disminuimos a 40 watts y la velocidad a 100 kbps, cual es la nueva probabilidad?

Su(a)

Instrucciones:
1.-Con copias y apuntes de clases
2.-Duración: 2 horas
El Profesor del Curso
Ing. Julio Venero Villafuerte
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Primera Practica de Telecomunicaciones III

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① $f(t) = (2 + \cos \omega_2 t) \cos \omega_1 t$

ⓐ $f(t) = 2 \cos \omega_1 t + \cos \omega_2 t \cos \omega_1 t$

$f(t) = 2 \cos \omega_1 t + \frac{1}{2} \cos (\omega_2 - \omega_1) t + \frac{1}{2} \cos (\omega_2 + \omega_1) t$

$F(\omega) = 2\pi \left(\delta(\omega - \omega_1) + \delta(\omega + \omega_1) \right) + \frac{1}{2}\pi \left(\delta(\omega - \omega_2 + \omega_1) + \delta(\omega + \omega_2 - \omega_1) \right)$

$+ \frac{\pi}{2} \left(\delta(\omega - \omega_2 - \omega_1) + \delta(\omega + \omega_2 + \omega_1) \right)$

ⓑ $R(\tau) = \lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} f(t) f(t-\tau) \, dt$

Sea: $A_t = 2 \cos \omega_1 t$

$B_t = (\cos \omega_2 t)(\cos \omega_1 t)$

$\int f(t) f(t-\tau) \, dt = \int (A_t + B_t)(A_{(t-\tau)} + B_{(t-\tau)}) \, dt = \int \Big[\underbrace{A_t A_{(t-\tau)}}_{(1)} + \underbrace{A_t B_{(t-\tau)}}_{(2)} + B_t A_{(t-\tau)}$

$+ \underbrace{B_t B_{(t-\tau)}}_{(3)} \Big] dt$

$\Rightarrow (1) \int A_t A_{(t-\tau)} = \int_{-T/2}^{T/2} 2 \cos \omega_1 t \, (2 \cos \omega_1 (t - \tau)) \, dt$

$= 4 \int_{-T/2}^{T/2} \frac{1}{2} \left(\cos(-\omega_1 \tau) + \cos(2\omega_1 t - \omega_1 \tau) \right) dt = 2 \cos \omega_1 \tau - 2 \int_{-T/2}^{T/2} \cos(2\omega_1 t - \omega_1 \tau) \, dt$

$= 2T \cos \omega_1 \tau - \frac{1}{2\omega_1} \sin(2\omega_1 t + \omega_1 \tau) \Big|_{-T/2}^{T/2}$

~~Resolviendo~~ $4 \int \left[\cos \omega_1 t \left(\sin(\omega_1 t) \sin(\omega_1 \tau) - \cos(\omega_1 t) \cos(\omega_1 \tau) \right) \right] dt$

$4 \int \sin(\omega_1 \tau) \sin(\omega_1 t) \cos(\omega_1 t) \, dt - 4 \cos(\omega_1 \tau) \int \cos^2 \omega_1 t \, dt$

$\frac{4 \sin \omega_1 \tau}{\omega_1} \int \sin(\omega_1 t) \, d(\sin \omega_1 t) - 4 \cos(\omega_1 \tau) \int \frac{1}{2} (\cos(2\omega_1 t) + 1) \, dt$

$$\frac{4\,\mathrm{Sen}\,\omega_1 \tau}{\omega_1 \tau} \frac{\int \mathrm{Sen}^2(\omega_1 t)}{2} - 4\,\mathrm{Co}(\omega_1 \tau)\int \frac{1}{2}\left(\mathrm{Co}(2\omega_1 t) + 1\right) dt$$

$$2\tau\,\mathrm{Sa}(\omega_1 \tau)\,\mathrm{Sen}^2(\omega_1 t) - 2\,\mathrm{Co}(\omega_1 \tau)\left(\frac{1}{2\omega_1}\mathrm{Sen}\,2\omega_1 t + \frac{t}{2}\right) = 2\tau\,\mathrm{Sa}(x)\,\mathrm{Sen}^2(\omega_1 t) - 2\mathrm{Co}(\omega_1 \tau)\left(\frac{\mathrm{Sen}\,2\omega_1 t}{2\omega_1}\right.$$

$$2) = \int 2\,\mathrm{Co}(\omega_1 t)\,\mathrm{Co}\,\omega_1(t-\tau) = \mathrm{Co}(\omega_1(t-\tau))\,dt = \int \left(\mathrm{Co}(-\omega_1 \tau) - \mathrm{Co}(2\omega_1 t + \omega_1 \tau)\right)\mathrm{Co}\,\omega_1(t+\tau)$$

$$\Rightarrow f_t = f_1 + f_2 = \underbrace{2\,\mathrm{Co}\,\omega_1 t}_{f_1} + \underbrace{\mathrm{Co}\,\omega_1 t\,\mathrm{Co}\,\omega_2 t}_{f_2}$$

$$R(\tau)_{(1)} = \frac{1}{T}\int_{-T/2}^{T/2} f_1(t)\, f_1(t-\tau)\,dt \Rightarrow \frac{1}{T}\int 2\,\mathrm{Co}(\omega_1 t)\,\mathrm{Co}\,\omega_1(t-\tau)\,dt = \frac{2}{T}\int \mathrm{Co}(\omega_1 \tau) - \mathrm{Co}(2\omega_1 t - \omega_1 \tau)$$

$$R(\tau)_{(1)} = \frac{2}{T}\int \mathrm{Co}(\omega_1 \tau)\,dt - \frac{2}{T}\int$$

$\sqrt{\frac{2E}{\eta}}$ 2,047

$4{,}75$ — $1{,}02 \times 10^{-6}$
x — 10^{-6}
$4{,}8$ — 0.793×10^{-6}

$$\frac{4{,}75 - 4{,}8}{x - 4{,}8} = \frac{1{,}02\times10^{-6} - 0.793\times10^{-6}}{10^{-6} - 0.793\times10^{-6}}$$

$$\frac{-0.05}{x - 4.8} = 1.0966$$

$$\frac{4{,}25 - 4{,}3}{x - 4{,}30} = \frac{1{,}05\times10^{-5} - 8{,}54\times10^{-6}}{10^{-6} - 8{,}54\times10^{-6}}$$

$$\frac{-0.05}{x - 4{,}3} = -0.26$$

$$-x - 1.075 = 0.05$$

$$\boxed{x \approx 1.125}$$

2) a) $4{,}8 \times 10^{-6} = Q\sqrt{\frac{2E}{\eta_0}}$ $R = 700\,\mathrm{Kbps}$

$$\left(\frac{C}{N_0}\right) = 10\log R - \left(\frac{E}{N_0}\right) \quad \text{---}(a)$$

$5{,}91 - 1{,}8 = 4{,}61$ $5{,}91 - 4{,}29 = 1{,}12$

De la tabla de gauss:

x	$Q(x)$
4,40	$5{,}42 \times 10^{-6}$
x	$4{,}48 \times 10^{-6}$
4,45	$4{,}29 \times 10^{-6}$

Interpolando $\quad \frac{5{,}42 - 4{,}8}{5{,}42 - 4{,}29} = \frac{0{,}93}{1{,}12} = \frac{4{,}4 - x}{-0{,}05} \Rightarrow x = 4{,}4041$

$$\Rightarrow \sqrt{\frac{2E}{N_0}} = 4{,}40 \Rightarrow \boxed{\frac{E}{N_0} = 9{,}68\,\mathrm{W}} \Rightarrow \left(\frac{E}{N_0}\right) \approx 9{,}85\,\mathrm{dB}$$

En (a) $\quad \left(\frac{C}{N_0}\right) = 10\log(700\times10^3) + 9{,}85$

$$\left(\frac{C}{N_0}\right) = 10\log(700\times10^3) + 9{,}85 = \underline{68{,}3\,\mathrm{dBHz}}$$

(b) FSK 1

$P_E = Q\sqrt{\frac{E}{n_0}} \Rightarrow \sqrt{\frac{E}{n_0}} = \frac{4{,}40}{\sqrt{2}} \Rightarrow \frac{E}{n_0} = 19{,}36 \Rightarrow \left[\frac{E}{n_0}\right] = 10\log(19{,}36)$

$$\boxed{\frac{E}{N_0} = 12{,}87\, dB}$$

$\Rightarrow \left[\frac{C}{n_0}\right] = 10\log(700\times10^3) + 12{,}87$

$$\left[\frac{C}{n_0}\right] = 71{,}32\, dBHz$$

(c) $70 = 10\log R + 15{,}87$

$$\boxed{R = 258\ Kbps}$$

$P_{E(PSK)} = Q\sqrt{\frac{E}{2n_0}}$

$\Rightarrow \sqrt{\frac{E}{2n_0}} = 4{,}40$

$\frac{E}{n_0} = 38{,}72$

$\Rightarrow \frac{E}{n_0} = 15{,}87\, dB$

(3)

(a) $P_E = Q\sqrt{\frac{2E}{N_0}}$ --- (PSK)

$\left[\frac{C}{n_0}\right] = 10\log R + \left[\frac{E}{n_0}\right]$ --- (α)

$f \Rightarrow Ghz \quad d = Km$

$C = P_R = P_T + G_T + G_R - \text{Perdida} \Rightarrow \text{Perdida} = 92{,}46 + 20\log(0{,}85) + 20\log(23)$

$\text{Perdida} = 118{,}28$

$C = 17 + 14 + 14 - 118{,}28$

$$C = -73{,}28\, dBW$$

$\Rightarrow$ en $(\alpha) \Rightarrow -73{,}28 - (-100) = 10\log(800\times10^3) + (Eb/n_0)$

$= 26{,}72 - 10\log(800\times10^3) = [Eb/n_0]$

$10\log a = x$

$$[Eb/n_0] = -32{,}31\, dB$$

$\Rightarrow Eb/n_0 = 10^{-3{,}231} = 5{,}87\times10^{-4}\, W$

$\Rightarrow P_e = Q\sqrt{2(5,37\times10^{-4})} = \boxed{Q(0,034) = P_e}$

$\Rightarrow P_e =$

0,03	→	0,4880
0,034	→	X
0,04	→	0,4840

(b) $C = 18,45 + 14 + 14 - 118,28$

$C = -71,83$

$\Rightarrow \Rightarrow \quad -71,83 - (-100) = 10\log(800\times10^{3}) + [E_b/N_0]$

$28,72 - 10\log 800\times10^{3} = [E_b/N_0]$

$-32,31\,dB = [E_b/N_0]$

$\Rightarrow \frac{E_b}{N_0} = 10^{-3,23} = \boxed{5,88\times10^{-4} = E_b/N_0}$

$P_e = Q\sqrt{2(5,88\times10^{-4})} \Rightarrow \boxed{P_e = Q(0,034)}$

(c)

$C = 16 + 14 + 14 - 118,28$

$C = -74,28\ dB/W$

$\Rightarrow (*) \Rightarrow -74,28 - (-100) = 10\log(100\times10^{3}) + [E_b/N_0]$

$25,72 - 10\log(100\times10^{3}) = [E_b/N_0]$

$\boxed{[E_b/N_0] = -24,28\,dB}$

$\Rightarrow \frac{E_b}{N_0} = 10^{-2,428} \Rightarrow \boxed{\frac{E_b}{N_0} = 3,73\times10^{-3}}$

$\Rightarrow P_e = Q\sqrt{\frac{2E_b}{N_0}} \Rightarrow P_e = Q\sqrt{2(3,73\times10^{-3})}$

$\boxed{P_e = Q(0,086)}$