SOLUCIÓN DEL TEST DEL 16-1-01

1) b)

$$H=\sum_{i=1}^{L}p_i\cdot\log_2\left(\frac{1}{p_i}\right)=\sum_{i=1}^{L-1}0.5^i\cdot\log_2(2^i)+0.5^{L-1}\cdot\log_2\left(2^{L-1}\right)=$$

$$2\cdot\left(1-(L+1)\cdot0.5^L\right)+(L-1)\cdot0.5^{L-1}=2-2\cdot L\cdot0.5^L-2\cdot0.5^L+L\cdot0.5^{L-1}-0.5^{L-1}=$$

$$2-2\cdot L\cdot0.5^L-2\cdot0.5^L+L\cdot0.5^L\cdot0.5^{-1}-0.5^L\cdot0.5^{-1}=2-2\cdot0.5^L-2\cdot0.5^L=2-4\cdot0.5^L$$

2) a)

$$\begin{array}{lcccc} 111*x(n)= & 1 & a & & \\ & & 1 & a & \\ & & & 1 & a \\ \hline & 1 & a+1 & a+1 & a \Rightarrow y_K \end{array}$$

$$\begin{array}{lcccc} -1-1-1*x(n)= & -1 & -a & & \\ & & -1 & -a & \\ & & & -1 & -a \\ \hline & -1 & -a-1 & -a-1 & -a \Rightarrow y_K \end{array}$$

$$\text{HLSE}\rightarrow\sum_i(y-y_K)^2\ \min\quad\text{para que la media}=0$$

$$y-\text{media}=\underset{\underset{0.3}{\|}}{0.8},-0.7,-0.2,0.3$$

$$(-0.2)^2+(-1.7-a)^2+(-1.2-a)^2+(0.3-a)^2=1.8^2+(0.3+a)^2+(0.8+a)^2+(0.3+a)^2\Rightarrow$$

$$=0.04+2.89+a^2+3.4a+1.44+a^2+2.4a+0.09+a^2-0.6a=3.24+0.09+a^2+0.6a+0.64+$$

$$a^2+1.6a+0.09+a^2+0.6a\Rightarrow4.46+5.2a=4.06+2.8a\Rightarrow0.4=-2.4a\Rightarrow a=-0.16667$$

3) a)

$$\begin{array}{l}\overbrace{111...1}^{n}\\ \underbrace{0}_{k}00...0\end{array}\rightarrow d_{min}=n\ \rightarrow r=n-1\ \rightarrow(*)$$

$$\begin{array}{r}d_{min}\geq2e+1\\ r\geq2e\end{array}\rightarrow e\left\lfloor\frac{d_{min}-1}{2}\right\rfloor=\begin{array}{l}n\ \text{par},\ e=\dfrac{n-2}{2}\\ n\ \text{impar},\ e=\dfrac{n-1}{2}\end{array}$$

a) $e=\dfrac{n-1}{2}\quad\Rightarrow\quad(*)\ \ e=\dfrac{r}{2}$

b) $d=2e$

c) $d=2e\rightarrow\begin{array}{l}n-2,\ n\ \text{par}\\ n-1,\ n\ \text{impar}\end{array}$

4) c)

$\upsilon_t = 18300\ \text{bps} \qquad \upsilon_t = \upsilon_m \cdot q_1 \qquad q_1 = \log_2(A_1) \qquad \upsilon_t' = 24400\text{bps}$

$$W_{QAM} = \frac{1+\alpha}{T} \;\rightarrow 4000 = (1+\alpha)\cdot\upsilon_m \rightarrow \begin{matrix} \alpha = 0,\ \upsilon_m = 4000 \\ \alpha = 1,\ \ \upsilon_m = 2000 \end{matrix}$$

$$18300 = \upsilon_m \cdot q \quad \text{con} \quad 2000 \le \upsilon_m \le 4000 \;\Rightarrow\; q_1 = 6\frac{\text{bits}}{\text{símbolo}}$$

$$9.15 \ge q \ge 4.57 \qquad A_1 = 2^6 = 64\ \text{simbolos}$$

$$q_1 = 5, 6, 7, 8, 9 \qquad \upsilon_m = 3050\ \text{bauds}$$

$\upsilon_t' = 24400 = 3050 \cdot q'$

$q' = 8 \;\rightarrow A' = 2^8 = 256\ \text{símbolos}$

$q = 5 \rightarrow \upsilon_m = 3660 \rightarrow q' = 6.66$

$q = 6 \rightarrow \upsilon_m = 3050 \rightarrow q' = 8 \rightarrow 2^8 = 256$

$q = 7 \rightarrow \upsilon_m = 2614 \rightarrow q' = 9.33$

$q = 8 \rightarrow \upsilon_m = 2287.5 \rightarrow q' = 10.66$

$q = 9 \rightarrow \upsilon_m = 2033.3 \rightarrow q' = 12 \rightarrow 2^{12} = 4096$

5) a)

$\text{Hamming}\begin{pmatrix} \overset{n}{7}, \overset{k}{4} \end{pmatrix}$

$$G = (I_K \vdots P)$$
$$\downarrow$$
$$I_4$$

$Y(D) = R(D) + D^r \cdot X(D)$

$R(D) = D^r \cdot X(D) \bmod g(D) \quad \Rightarrow \quad \begin{array}{r|l} D^r \cdot X(D) & g(D) \\ \hline R(D) & c(D) \end{array}$

Nos interesa hallar las Y(D) de las X(D) de la base.

$n = k + r \rightarrow 7 = 4 + r \rightarrow r = 3$

$* X(D) = 1000 = D^3$

$$\begin{array}{l|l} D^3 \cdot X(D) = D^6 & D^3 + D^2 + 1 \\ \hline \underline{D^6 + D^5 + D^3} & D^3 + D^2 + D \\ D^5 + D^3 & \\ \underline{D^5 + D^4 + D^2} & \\ D^4 + D^3 + D^2 & \\ \underline{D^4 + D^3 + D} & \\ D^3 + D = R(D) & \end{array}$$

$$Y(D) = \underbrace{D^2 + D}_{R(D)} + D^3 \cdot \underbrace{D^3}_{X(D)} = D^6 + D^2 + D$$
$$\downarrow$$
$$1000 \vdots 110$$

$$* X(D) = 0100 = D^2$$

$$D^3 \cdot X(D) = D^5 \quad \Big| \; \underline{D^3 + D^2 + 1}$$

$$\underline{D^5 + D^4 + D^2} \quad D^2 + D + 1 \qquad Y(D) = \underbrace{D+1}_{R(D)} + D^3 \cdot \underbrace{D^2}_{X(D)} = D^5 + D + 1$$

$$D^4 + D^2 \qquad \downarrow$$

$$\underline{D^4 + D^3 + D} \qquad 1000 \vdots 011$$

$$D^3 + D^2 + D$$

$$\underline{D^3 + D^2 + 1}$$

$$D^2 + 1 = R(D)$$

$$* X(D) = 0010 = D$$

$$D^3 \cdot X(D) = D^4 \quad \Big| \; \underline{D^3 + D^2 + 1}$$

$$\underline{D^4 + D^3 + D} \quad D + 1 \qquad Y(D) = \underbrace{D^2 + D + 1}_{R(D)} + D^3 \cdot \underbrace{D}_{X(D)} = D^4 + D^2 + D + 1$$

$$D^3 + D \qquad \downarrow$$

$$\underline{D^3 + D^2 + 1} \qquad 0010 \vdots 111$$

$$D^2 + D + 1 = R(D)$$

$$* X(D) = 0001 = 1$$

$$D^3 \cdot X(D) = D^3 \quad \Big| \; \underline{D^3 + D^2 + 1}$$

$$\underline{D^3 + D^2 + 1} \quad 1 \qquad Y(D) = \underbrace{D^2 + 1}_{R(D)} + D^3 \cdot \underbrace{1}_{X(D)} = D^3 + D^2 + 1$$

$$D^2 + 1 = R(D) \qquad \downarrow$$

$$0001 \vdots 101$$

$$\Rightarrow G = \begin{pmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 & 0 & 1 \end{pmatrix}$$

6) d)

$\mathrm{Hamming}(\underset{n}{15}, \underset{k}{11})$

$e = 1,\ n = 2^r - 1, n = k + r \Rightarrow r = 4 \Rightarrow n = 2^4 - 1 = 15$

$\delta = 2e = 2 \rightarrow$ Detecta hasta 2 errores

$d_{min} = 2e + 1 = 3 \Rightarrow \delta = d_{min} - 1 = 2$

$$\text{Prob(no detección)} = P_{\#e} > 3 \approx P_{\#e=3} = \binom{15}{3} \cdot p^3 \cdot (1-p)^{12} \approx \binom{15}{3} \cdot p^3 = \frac{15!}{3! \cdot 12!} \cdot p^3 = 455 \cdot p^3$$

$$= 455 \cdot \left(10^{-3}\right)^3 = 455 \cdot 10^{-9} = 4.55 \cdot 10^{-7}$$

7) a)

$$E = \frac{H}{\overline{L}}$$

$$\begin{cases} H = 2 - 4 \cdot \left(\frac{1}{2}\right)^{L}\Big|_{L=5} = 2 - 4 \cdot \frac{1}{32} = 2 - \frac{1}{8} = \frac{15}{8} = 1.875 \\ H = \sum_{i=1}^{5} P_i \cdot \log_2\left(\frac{1}{P_i}\right) = \frac{1}{2} \cdot \log_2(2) + \left(\frac{1}{2}\right)^2 \cdot \log_2(2)^2 + \left(\frac{1}{2}\right)^3 \cdot \log_2(2)^3 + \left(\frac{1}{2}\right)^4 \cdot \log_2(2)^4 = \\ = \frac{1}{2} + \frac{1}{4} \cdot 2 + \frac{1}{8} \cdot 3 + \frac{1}{16} \cdot 4 = \frac{1}{2} + \frac{1}{2} + \frac{3}{8} + \frac{8}{16} = \frac{15}{8} = 1.875 \end{cases}$$

A $\frac{1}{2}$

B $\frac{1}{4}$............

C $\frac{1}{8}$.....

D $\frac{1}{16}$

E $\frac{1}{16}$

$\left.\begin{matrix} D \\ E \end{matrix}\right\} \frac{1}{8}F \qquad \left.\begin{matrix} C \\ \frac{1}{8}F \end{matrix}\right\} \frac{1}{4}G \qquad \left.\begin{matrix} B \\ \frac{1}{4}G \end{matrix}\right\} \frac{1}{2}H$

A	1			
B	0	1		
C	0	0	1	
D	0	0	0	1
E	0	0	0	0

$$\overline{L} = \frac{1}{2} \cdot 1 + \frac{1}{4} \cdot 2 + \frac{1}{8} \cdot 3 + \frac{1}{16} \cdot 4 = \frac{1}{2} + \frac{1}{2} + \frac{3}{8} + \frac{8}{16} = \frac{15}{8} = 1.875$$

$$E = 1$$

8) b)

a)

$$H = 0.25 \cdot \log_2\left(\frac{1}{0.25}\right) + 0.5 \cdot \log_2\left(\frac{1}{0.5}\right) + 0.15 \cdot \log_2\left(\frac{1}{0.15}\right) + 0.1 \cdot \log_2\left(\frac{1}{0.1}\right)$$

$$= 0.5 + 0.5 + 0.4105 + 0.3322 = 1.7427 \frac{\text{bits}}{\text{simbolo}}$$

donde $\log_2(x) = \dfrac{\log(x)}{\log 2}$

b)

$d_{min} \geq 2e + 1 \quad \Rightarrow \quad 4 \geq 2e \quad \Rightarrow \quad e = 2 \qquad r > 2e \qquad \Rightarrow \quad r = 4$

e - perfecto $\Rightarrow$ (ver debajo) $\Rightarrow$ $n = 5 \rightarrow$ código $(\underset{n}{5}, \underset{k}{1})$ $\qquad \begin{matrix} n = k + r \\ 5 = k + 4 \rightarrow 1 \end{matrix}$

$$P_{error} = P_{\#e \geq 3} \approx P_{\#e=3} = \binom{5}{3} \cdot p^3 \cdot (1-p)^2 \approx \binom{5}{3} \cdot p^3 = 10 \cdot \left(10^{-2}\right)^3 = 10^{-5}$$

$$2^{r}=1+\binom{n}{1}+\binom{n}{2} \text{ ya que } e=2$$

$$2^{r}=1+n+\frac{n!}{2!(n-2)!}=1+n+\frac{n\cdot(n-1)}{2}$$

$$2^{4}-1=n+\frac{n^{2}-n}{2} \rightarrow 30=2n+n^{2}-n \rightarrow n^{2}+n-30=0$$

$$n=\frac{-1\pm\sqrt{1+120}}{2}=\frac{-1\pm 11}{2}\rightarrow \begin{matrix}5\\-6\end{matrix} \rightarrow n=5$$

$$n=k+r$$

$$5=k+4\rightarrow k=1 \quad \rightarrow \text{código}(5,1)$$

$$P_{E}=P_{\#e\geq 3}\approx P_{\#e=3}$$

c)

1 A

2 B

3 C

4 D

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5 AC

6 CB

7 BC

8 CBA

9) d)

QAM-4	PAM
$\alpha_1=0.3$	¿α_2?, $A\uparrow\uparrow$
$\left(S/_{N1}\right)$	$\left(S/_{N2}\right)=18000\cdot S/_{N1}$
P_{E1}	$P_{E2}=P_{E1}=P_{E1}$
$P_{E1}=N_v\cdot Q\left[\sqrt{\frac{3\cdot(1+\alpha)}{A-1}\cdot\left(S/_{N1}\right)}\right]$	$P_{E2}=N_v\cdot Q\left[\sqrt{\frac{3\cdot(1+\alpha)}{A^2-1}\cdot\left(S/_{N2}\right)}\right]$
$N_{v1}=4\cdot\left(1-\frac{1}{\sqrt{A}}\right)$	$N_{v2}=2\cdot\left(1-\frac{1}{A}\right)$
$N_{v2}=4\cdot\left(1-\frac{1}{2}\right)=2$	$N_{v2}\cong 2$
$P_E=2\cdot Q\left(\sqrt{\frac{3\cdot 1.3}{3}\cdot\left(S/_{N1}\right)}\right)$	$P_E=2\cdot Q\left(\sqrt{\frac{3\cdot(1+\alpha)}{A^2-1}\cdot 18000\cdot\left(S/_{N2}\right)}\right)$

$$1.3\cdot\left(\frac{S}{N_1}\right)=\frac{3\cdot(1+\alpha)}{A^2-1}\cdot 18000\cdot\left(\frac{S}{N_1}\right) \rightarrow \left(A^2-1\right)=\frac{5400}{1.3}\cdot(1+\alpha) \quad \approx A^2=41538.46\cdot(1+\alpha)$$

$$\text{siendo } 0<\alpha<1 \rightarrow \left.\begin{matrix}\alpha=0\rightarrow A^2=41538.46\\ \alpha=1\rightarrow A^2=83076.92\end{matrix}\right\}\text{un cuadrado perfecto entre ambos}$$

$$65536=256^2 \rightarrow \alpha=0.57 \rightarrow A\in\{203.8,288.23\}\rightarrow A=2^q=256\rightarrow q=8\,\frac{\text{bits}}{\text{símbolo}}$$

10) d)

$L = 2^5 - 1 = 31$, $p^0(D) = D^2 + D^4$, $p^{31}(D) = p^0(D)$

a)

$p^n(D) = 1 + D + D^3 + D^4$

$D \cdot p^n(D) = D + D^2 + D^4 + D^5 \quad | \underline{D^5 + D^2 + 1}$

$\underline{1 + D^2 \qquad + D^5} \quad 1$

$D^4 + D + 1 \equiv 11001 \rightarrow \text{No}$

b)

$p^n(D) = 1 + D^4$

$D \cdot p^n(D) = D + D^5 \qquad | \underline{D^5 + D^2 + 1}$

$\underline{D^5 + D^2 + 1} \quad 1$

$D^2 + D + 1 \equiv 110 \rightarrow \text{No}$

c)

$p^n(D) = D^3 + D^4$

$D \cdot p^n(D) = D^4 + D^5 \qquad | \underline{D^5 + D^2 + 1}$

$\underline{D^5 + D^2 + 1} \quad 1$

$D^4 + D^2 + 1 \neq p^0(D) \rightarrow \text{No}$

11) a)

y(n) = {1.5, 0.6, -0.7}

		y_k			$\eta = y - y_k$			$\sigma_\eta^2 = \frac{\sum n^2}{3}$
1	1	1	1.5	0.5	0.5	-0.9	-1.2	0.83
1	-1	1	-0.5	-0.5	0.5	1.1	-0.2	0.5
-1	1	1	0.5	0.5	0.5	0.1	-1.2	0.56
-1	-1	-1	-1.5	-0.5	2.5	2.1	-0.2	3.56

1 1   1 -1   -1 1   -1 -1

$\underline{\quad 0.5 \;\; 0.5}$ $\underline{\quad 0.5 \;\; -0.5}$ $\underline{\quad -0.5 \;\; 0.5}$ $\underline{\quad -0.5 \;\; -0.5}$

1 1.5 0.5   1 -0.5 -0.5   -1 0.5 0.5   -1 -1.5 -0.5

12) b)

$$ECM = E\{a^2\} \cdot DCM + \underbrace{\frac{\sigma_\eta^2}{h^2(0)}}_{\downarrow \atop 0} \approx E\{a^2\} \cdot DCM$$

$DCM = \dfrac{\sum_{n \neq 0} h^2(n)}{h^2(0)}$ $\rightarrow$ será el que tenga P_E menor $\Rightarrow$ ECM menor $\Rightarrow$ DCM menor, ya que no hay ruido

$\left(S/_{N2} \right)$

GRUPO A :

a)

$$\begin{array}{lllllll} & 0.0165 & 0.168 & 0.0255 & & & \\ & & 0.11 & 1.12 & 0.17 & & \\ & & & 0.022 & 0.224 & 0.034 & \\ \hline h(n)= & 0.0165 & 0.278 & 1.1675 & 0.394 & 0.034 & \rightarrow DCM = 0.1716 \end{array}$$

b)

$$\begin{array}{lllllll} & -0.03 & 0.159 & -0.02505 & & & \\ & & -0.2 & 1.06 & -0.167 & & \\ & & & -0.04 & -0.212 & -0.0334 & \\ \hline h(n)= & -0.03 & -0.041 & 0.9949 & -\ 0.379 & -0.0334 & \rightarrow DCM = 0.1488 \end{array}$$

c)

$$\begin{array}{lllllll} & -0.0465 & 0.1755 & 0.0165 & & & \\ & & -0.31 & 1.17 & 0.11 & & \\ & & & -0.062 & 0.234 & 0.022 & \\ \hline h(n)= & 0.0465 & -0.1345 & 1.1245 & 0.344 & 0.022 & \rightarrow DCM = 0.1099 \end{array}$$

d)

$$\begin{array}{lllllll} & -0.0165 & 0.1425 & 0.045 & & & \\ & & -0.11 & 0.95 & 0.3 & & \\ & & & -0.022 & 0.19 & 0.06 & \\ \hline h(n)= & -0.0165 & 0.325 & 0.973 & 0.49 & 0.06 & \rightarrow DCM = 0.2588 \end{array}$$

GRUPO B :

a)

$$\begin{array}{lllllll} & 0.033 & 0.336 & 0.051 & & & \\ & & 0.11 & 1.12 & 0.17 & & \\ & & & 0.011 & 0.112 & 0.017 & \\ \hline h(n)= & 0.033 & 0.446 & 1.182 & 0.282 & 0.017 & \rightarrow DCM = 0.2 \end{array}$$

b)

$$\begin{array}{lllllll} & -0.06 & 0.318 & -0.0501 & & & \\ & & -0.2 & 1.06 & -0.167 & & \\ & & & -0.02 & -0.106 & -0.0167 & \\ \hline h(n)= & -0.06 & 0.118 & 0.9898 & -0.061 & -0.0167 & \rightarrow DCM = 0.0219 \end{array}$$

c)

$$\begin{array}{lllllll} & -0.093 & 0.351 & 0.033 & & & \\ & & -0.31 & 1.17 & 0.11 & & \\ & & & -0.031 & 0.117 & 0.011 & \\ \hline h(n)= & -0.093 & 0.041 & 1.172 & 0.227 & 0.011 & \rightarrow DCM = 0.045 \end{array}$$

c)

$$\begin{array}{llllll}
 & -0.033 & 0.285 & 0.09 & & \\
 & & -0.11 & 0.95 & 0.3 & \\
 & & & -0.011 & 0.095 & 0.03 \\
\hline
h(n) = & -0.033 & 0.175 & 1.029 & 0.395 & 0.03 \rightarrow \mathrm{DCM} = 0.1781
\end{array}$$

a) $\mathrm{DCM} = 0.18 = 0.65 \cdot 0.1716 + 0.35 \cdot 0.2$

b) $\mathrm{DCM} = 0.1043 = 0.65 \cdot 0.1488 + 0.35 \cdot 0.0219$

c) $\mathrm{DCM} = 0.087 = 0.65 \cdot 0.1099 + 0.35 \cdot 0.045$

d) $\mathrm{DCM} = 0.1337 = 0.65 \cdot 0.2588 + 0.35 \cdot 0.1781$

13) d)

$$\left.\begin{array}{l}
\Delta_\upsilon(n+1) = \alpha \cdot \Delta_\upsilon(n) + \dfrac{\beta}{y^2(n)} \\
E\{\Delta_\upsilon(n+1)\} = \dfrac{1}{L_e \cdot R_y(0)} \\
E\{\Delta_\upsilon(n+1)\} \approx E\{\Delta_\upsilon(n)\}
\end{array}\right\}$$

$$E\left\{\alpha \cdot \Delta_\upsilon(n) + \frac{\beta}{y^2(n)}\right\} = \alpha \cdot E\{\Delta_\upsilon(n)\} + \beta \cdot \frac{1}{\underbrace{E\{y^2(n)\}}_{R_Y(0)}}$$

$$(1-\alpha) \cdot E\{\Delta_\upsilon(n)\} = \frac{\beta}{R_y(0)}$$

$$E\{\Delta_\upsilon(n)\} = \frac{\beta}{(1-\alpha) \cdot R_y(0)} = \frac{1}{L_e \cdot R_y(0)} \Rightarrow L_e = \frac{1-\alpha}{\beta}$$

a)

$$\frac{1-\frac{1}{2}}{\frac{1}{2}} = 1 = L_e \rightarrow \mathrm{No}$$

b)

$$\frac{1-\frac{2}{3}}{\frac{3}{2}} = \frac{\frac{1}{3}}{\frac{3}{2}} = 0.22 = L_e \rightarrow \mathrm{No}$$

c)

$$\frac{1-\frac{1}{3}}{\frac{1}{2}} = \frac{\frac{2}{3}}{\frac{1}{2}} = 1.33 = L_e \rightarrow \mathrm{No}$$

14) c)

$$\sigma_{\eta} = 0 \;\rightarrow \text{óptimo} = \text{inversor canal}$$

$$\rho_x(0) = 0.86$$

$$\rho_x(1) = 0.09$$

$$\rho_x(2) = -0.02$$

$$\begin{pmatrix} 0.86 & 0.09 & -0.02 \\ 0.09 & 0.86 & 0.09 \\ -0.02 & 0.09 & 0.86 \end{pmatrix} \cdot \begin{pmatrix} c_{-1} \\ c_0 \\ c_{-1} \end{pmatrix} = \begin{pmatrix} 0.2 \\ 0.9 \\ -0.1 \end{pmatrix} \rightarrow \begin{pmatrix} c_{-1} \\ c_0 \\ c_{-1} \end{pmatrix} = \begin{pmatrix} 0.1166 \\ 1.05777 \\ -0.2242 \end{pmatrix}$$

$$h(0) = c_{-1} \cdot x_1 + c_0 \cdot x_0 + c_1 \cdot x_{-1} = 0.989$$

$$\overline{c_0} = \frac{c_0}{h(0)} = 1.060157$$

15) a)

$$\alpha = \operatorname{arctg}\left(\frac{0.76 + 0.05}{1.11 + 0.05}\right) = \operatorname{arctg}\left(\frac{0.81}{1.16}\right) = 0.609\ \text{rad} = 34.925°$$

$$\downarrow$$

$$\pi\ \text{rad} \rightarrow 180°$$

$$0.609\ \text{rad} \rightarrow \alpha$$

$$45 - \alpha = 10.07°$$

16) c)

$$v_t = C = W \cdot \log_2(1 + \tfrac{S}{N}) \rightarrow N = 10^{-3}$$

$$S = 124 \cdot 10^{-3} \cdot K^2$$

$$W = 3000$$

$$5 = \log_2\left(1 + 124 \cdot K^2\right) \qquad C = 15000$$

$$32 = 1 + 124 \cdot K^2$$

$$K = 0.5$$

17) a)

$$p = 10^{-3},\ D = 4 \text{ con } \begin{matrix} 6 > 4 \\ L \geq D \end{matrix} \rightarrow \text{Se puede suponer canal sin memoria (entrelazado)}$$

$$P_e(\text{bloque}) = P_{\#e \geq 2} \approx P_{\#e=2} = \binom{7}{2} \cdot p^2 \cdot (1-p)^5 \approx \binom{7}{2} \cdot p^2 = 21 \cdot (10^{-3})^2 = 21 \cdot 10^{-6} = 2.1 \cdot 10^{-5}$$

18) a)

$$R_y(0) = \frac{\sum_i y^2(i)}{7} = 79.23$$

$$\Delta_v \approx \frac{1}{L_e \cdot R_y(0)} = \frac{1}{3 \cdot 79.23} = 0.02945$$

19) c)

$$P_E = N_v \cdot Q\left[\sqrt{\frac{3 \cdot (1+\alpha)}{A\text{-}1} \cdot \frac{S}{N}}\right], N_v = 4 \cdot \left(1 - \frac{1}{\sqrt{A}}\right)$$

$$v_t = v_m \cdot \log_2(A)$$

$$W_{QAM} = (1+\alpha) \cdot v_m \to 21600 = 1.5 \cdot v_m \to v_m = 14400 \text{ baudios}$$

$$28800 = 14400 \cdot \log_2(A) \to A = 4$$

$$N_v = 4 \cdot \left(1 - \frac{1}{2}\right) = 2 \to P_E = 2 \cdot Q\left[\sqrt{\frac{3 \cdot 1.5}{3} \cdot \frac{S}{N}}\right] \leq 10^{-7}$$

$$Q(x) = 5 \cdot 10^{-8} = 0.5 \cdot e^{-\frac{x^2}{2}} \to x = 5.6777$$

$$\sqrt{1.5 \cdot \frac{S}{N}} = 5.6777 \to \frac{S}{N} = 21.49 \equiv 13.32 \text{ dB}$$

20) d)

a)

No, al propagar errores, es la otra configuración, la autosincronizante

c)

.....00011000....
.....01001000....

$$\downarrow \; \downarrow$$

$$1 \;\; D^2$$

$$c(D) = 1 + D^2$$