8. REKA Zadatki za vježbu (s kraja)

Teorija informacije, kapacitet diskretnog komunikacijskog kanala:

① $X = \{x_1, x_2, x_3, x_4\}$

$p(x_1) = 0.4$
$p(x_2) = 0.3$
$p(x_3) = 0.2$
$p(x_4) = 0.1$

$C = x_1 x_2 x_1 x_3$

$I(x) = ? = -(p_1 \log p_1 + p_2 \log p_2 + p_1 \log p_1 + p_3 \log p_3) = 1.85$ bit/simbol

$= 8.132$ bit/poruka

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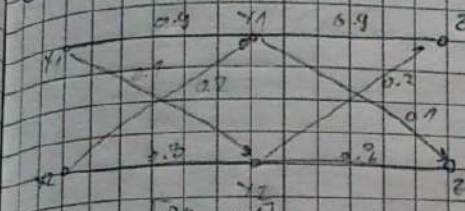
② $p(x_1) = p(x_2) = 0.5$



$I(x,z) = ?$

$$[p(y|x)] = \begin{bmatrix} 0.9 & 0.1 \\ 0.8 & 0.2 \end{bmatrix}$$

$$[p(z|y)] = \begin{bmatrix} 0.9 & 0.1 \\ 0.8 & 0.2 \end{bmatrix}$$

$$[p(z|x)] = [p(y|x)] \cdot [p(z|y)] = \begin{bmatrix} 0.89 & 0.11 \\ 0.88 & 0.12 \end{bmatrix}$$

$$[p(x,z)] = [p(x)] \cdot [p(z|x)] = \begin{bmatrix} 0.445 & 0.055 \\ 0.44 & 0.06 \end{bmatrix}$$

$P(z) = [0.885 \quad 0.115]$

$I(x,z) = H(x) - H(z) - H(x,z) = 1 + 0.5148 - 1.5146$

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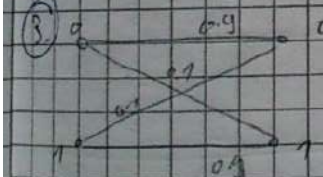
③



000
011
101
110

$p_1 = p_2 = p_3 = p_4 = 0.25$

$I(x,y) = ?$

$P_{ostali} = 0.9^3 = 0.729$

$P_{1 greške} = \binom{3}{2}(0.9)(0.1)^2 = 0.027$

$P_{2 greške} = \binom{3}{1}(0.9)^2(0.1) = 0.243$

$P_{3 greške} = 0.001$

$e \to 1; 3$ greške

$$P(y|x) = \begin{array}{c|cccc} & 000 & 011 & 101 & 110 \\ 000 & 0.729 & 0.009 & 0.009 & 0.009 \\ 011 & 0.009 & 0.729 & 0.009 & 0.009 \\ 101 & 0.009 & 0.009 & 0.729 & 0.009 \\ 110 & 0.009 & 0.009 & 0.009 & 0.729 \end{array} \quad \begin{array}{c} e \\ 0.243 \\ 0.243 \\ 0.243 \\ 0.243 \end{array}$$

$$p(x,y) = \begin{bmatrix} 0.18225 & 0.00225 & \cdots & 0.061 \end{bmatrix}$$

$p(y) = [0.183, 0.183, 0.183, 0.183, 0.244]$

$H(y) = 2$

$H(x,y) = 1.953$

$H(y) = 2.3176$

$I(x,y) = 1.3864$ bit/simbol

c) $k = ?$

$f = 2f_{max}$

$k = f_{vz} \cdot n = 16k \cdot 8 = 128\ kbit/sec$

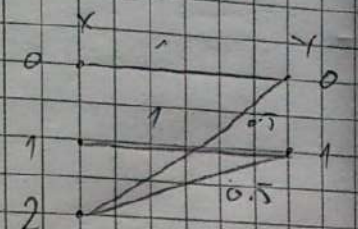
Kolokvij: 26.6.2012 (jesenski)

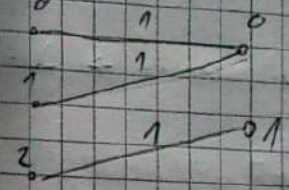
a) $X = [0, 1, 2]$

$p(0) = 0.25$

$p(1) = 0.25$

$p(2) = 0.5$





$[P(y_j|x_i)]$

$[P(z_k|x_i)]$

b) $H(X) = -\sum_{i=0}^{2} p(x_i) \log_2 p(x_i) = 1.5\ bit/simbol$

c)

$$[P(y_j|x_i)] = \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0.5 & 0.5 \end{bmatrix} \quad P(x,y) = \begin{bmatrix} 0.25 & 0 \\ 0 & 0.25 \\ 0.25 & 0.25 \end{bmatrix} \quad [P(y)] = [0.5 \quad 0.5]$$

$$[P(z_k|x_i)] = \begin{bmatrix} 1 & 0 \\ 1 & 0 \\ 0 & 1 \end{bmatrix} \quad P(x,z) = \begin{bmatrix} 0.25 & 0 \\ 0.25 & 0 \\ 0 & 0.5 \end{bmatrix} \quad [P(z)] = [0.5 \quad 0.5]$$

$H(Y) = 1\ bit/simbol$

$H(Z) = 1\ bit/simbol$

d) $[P(x_i|y_j)] = \frac{P(x,y)}{P(y)} = \begin{bmatrix} 0.5 & 0 & 0.5 \\ 0 & 0.5 & 0.5 \end{bmatrix}$ $[P(z_k|x_i)]^T [P(y_j|x_i)] = [P(z_k|y_j)] = \begin{bmatrix} 0.5 & 0 \\ 0.5 & 0 \end{bmatrix}$

$[P(Y,Z)] = [P(Z/Y)] \cdot [P(Y)] = \begin{bmatrix} 0.25 & 0.25 \\ 0.25 & 0.25 \end{bmatrix}$

$H(Y,Z) = 2$ bit/simbol

d) $I(X;Y) = H(X) + H(Y) - H(X,Y) = 0.5$ bit/simbol

e) $I(X;Z) = H(X) + H(Y) - H(Z,X) = 1$ bit/simbol

(2) riješen (Pok 8. m. 2012)

(3) $X = \{a, b, c\}$

$p: [0.4999999, 0.4999999, 0.0000002]$

kodira se optimalno!! → DuH!!

a) $H(X) = 1.0000045$ bit/simbol

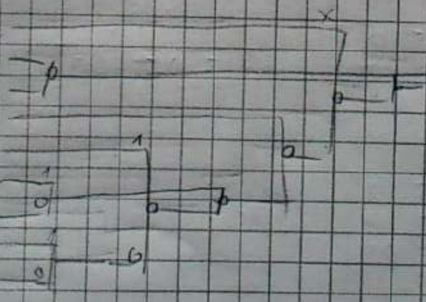
b) minimalna duljina bloka!! → L_B

$H(x) < L < 1.01 \cdot H(x)$

1.0100045

$L_B = 2$

a a	a a
a b	a b
a c	b a
b a	b b
b b	a c
b c	b c
c a	c a
c b	c b
c c	c c



a a	X X
a b	X X
b a	X X
b b	X X X
a c	X X X X X
b c	X X X X
c b	X X X X X
c c	X X X X X

$L \approx 4$!!

??

(3.) $k = [15, 7]$

$g(x) = x^8 + x^7 + x^6 + x^4 + 1$

a) $R = \frac{k}{n} = \frac{7}{15} = 0.4667$

b) $r = n - k = 8$

stupanj $g(x) = 8$

$(x^{15} + 1) : (x^8 + x^7 + x^6 + x^4 + 1) = x^7 + x^6 + x^4 + 1$

$x^{15} + x^{14} + x^{13} + x^{11} + x^7$

$x^{14} + x^{13} + x^{11} + x^7 + 1$

$x^{14} + x^{13} + x^{12} + x^{10} + x^6$

$x^{12} + x^{11} + x^{10} + x^7 + x^6 + 1$

$x^{12} + x^{11} + x^{10} + x^8 + x^6$

$x^8 + x^7 + x^6 + x^4 + 1$

$g(x)$ dijeli $(x^n + 1)$

c) $i(x) = x^6 + x + 1$

$i(x) \cdot x^r = (x^{14} + x^9 + x^8) : (x^8 + x^7 + x^6 + x^4 + 1) = x^6 + x^3$

$x^{14} + x^{13} + x^{12} + x^{10} + x^6$

$x^{13} + x^{12} + x^{10} + x^9 + x^8 + x^6$

$x^{13} + x^{12} + x^{11} + x^9 + x^7$

$x^{11} + x^{10} + x^8 + x^7 + x^6$ ... $x^7 + x^4 + x^3$ crc

$c = x^6 + x + 1 \mid x^7 + x^4 + x^3 = [0010011 ; 10011000]$

d) $c(x) = x^{14} + x^5 + x + 1$

$c(x) \bmod g(x) = (x^{14} + x^5 + x + 1) : (x^8 + x^7 + x^6 + x^4 + 1) = x^6 + x^5 +$

$x^{14} + x^{13} + x^{12} + x^{10} + x^6$

$x^{13} + x^{12} + x^{10} + x^6 + x^5 + x + 1$

$x^{13} + x^{12} + x^{11} + x^9 + x^5$

$x^{11} + x^{10} + x^9 + x^6 + x + 1$

⋮

C nije kodna riječ!!

(23.) {00000, 10010, 10100, 00110

$C = \begin{bmatrix} 10010 \\ 10100 \end{bmatrix}$ → zamjenom redaka i zbrajanjem se nemože dobit: $G = [I|A]$

$G = \begin{bmatrix} 10010 \\ 10100 \end{bmatrix} = \begin{bmatrix} 10010 \\ 00110 \end{bmatrix} = G'$

$L' = \{00000, 10010, 00110, [illegible], 11000$

(24.) $L = \{10011, 11101, 01110, 00000$

↳ $d = 3$

$s = \left\lfloor \frac{d}{2} \right\rfloor = 1$ //

Linearan je $a \cdot x = x \in L$ ✓

$x + x = 7 \in L$ ✓

(25.) $k=(n,4,d)$

$000\ldots0,\ 111\ldots1 \in k \Rightarrow m=2$

$d=n$

$K=1 \quad (0 \text{ in } 1) \rightarrow m=2^k=2^1=1$

(26.)

$$H=\begin{bmatrix}1&1&0&1&0&0&1\\0&0&0&1&1&0&1\\1&0&1&1&0&0&1\\0&0&0&0&0&1&1\end{bmatrix} \quad 1:2 \quad G=\begin{bmatrix}1&1&1&0&0&0&0\\0&1&1&1&1&0&0\\0&1&1&0&1&1&1\end{bmatrix}$$

$$H'=\begin{bmatrix}1&0&0&1&0&0&1\\0&0&0&1&1&0&1\\0&1&1&1&0&0&1\\0&0&0&0&0&1&1\end{bmatrix} \quad 2:5,\ 4:6 \quad G'=\begin{bmatrix}1&1&1&0&0&0&0\\1&0&1&1&1&0&0\\1&0&1&0&1&1&1\end{bmatrix}$$

$$H'=\left[\begin{array}{cccc|ccc}1&0&0&0&1&1&1\\0&1&0&0&0&1&1\\0&0&1&0&1&1&1\\0&0&0&1&0&0&1\end{array}\right] \rightarrow G'=\begin{bmatrix}1&0&1&0&1&0&0\\1&1&1&0&0&1&0\\1&1&1&1&0&0&1\end{bmatrix}$$

$k=4$

$0000 \rightarrow 0000000$
$0001 \rightarrow 0110111$
$0010 \rightarrow 0111106$
$0011 \rightarrow 0001011$
$0100 \rightarrow 1110000$
$0101 \rightarrow 1000111$
$0110 \rightarrow 1001106$
$0111 \rightarrow 1111001$ //

(27.)

$$H=\begin{bmatrix}1&1&0&1&0&1\\1&1&0&0&1&0\\1&0&1&1&0&0\end{bmatrix}$$

$$H^T=\begin{bmatrix}1&1&1\\1&1&0\\0&0&1\\1&0&1\\0&1&0\\1&0&0\end{bmatrix} \cdot c=[110110]=[110]$$

napaka na 2. bitu

$c=100110$ //

(28.) $k[n,4]=[7,4]$

$$G=\begin{bmatrix}1&0&0&0&1&1&1\\0&1&0&0&1&1&0\\0&0&1&0&1&0&1\\0&0&0&1&0&1&1\end{bmatrix} \rightarrow \begin{bmatrix}0&1&0&0&0&1&1\\1&0&1&0&0&1&0\\1&0&0&1&0&1&1\\1&0&0&0&1&0&1\end{bmatrix}$$

$$G'=\begin{bmatrix}1&0&0&0&0&1&1\\0&1&0&0&1&1&0\\0&0&1&0&1&0&1\\0&0&0&1&0&1&1\end{bmatrix}$$

$$H' = \begin{bmatrix} 0&1&1&1&1&0&0&0 \\ 1&1&1&0&0&1&0&0 \\ 1&1&0&1&0&0&1&0 \\ 1&0&1&1&0&0&0&1 \end{bmatrix} \rightarrow H = \begin{bmatrix} 1&1&1&1&0&0&0&0 \\ 1&1&0&0&1&1&0&0 \\ 1&0&1&0&1&0&1&0 \\ 0&1&1&0&1&0&0&1 \end{bmatrix}$$

$$H^T = \begin{bmatrix} 1&1&1&0 \\ 1&1&0&1 \\ 1&0&1&1 \\ 1&0&0&0 \\ 0&1&1&1 \\ 0&1&0&0 \\ 0&0&1&0 \\ 0&0&0&1 \end{bmatrix}$$

$c = [0\,1\,1\,1\,1\,0\,0\,1]$

$s = H^T \cdot c = [1\,0\,0\,0]$

(29.) a) $R = \frac{k}{n}$, $k = \lceil \log_2 n \rceil$

$R = 0.5$

b) $\log_2 \lceil 5 \rceil = 2.32$

$R = \frac{2.32}{4} = 0.58$

c) $R = \frac{3}{4}$

d) $n = 16 \Rightarrow k = 4$

$R = \frac{4}{7}$

(30.) $H^T = \begin{bmatrix} 1&1&1 \\ 1&0&1 \\ 0&1&0 \\ 1&0&0 \\ 0&1&0 \\ 0&0&1 \end{bmatrix} \rightarrow H = \left[\begin{array}{ccc|ccc} 1&1&0&1&0&0 \\ 1&0&1&0&1&0 \\ 1&1&0&0&0&1 \end{array}\right]$

$G = \begin{bmatrix} 1&1&1&1&0&0 \\ 1&0&1&0&1&0 \\ 0&1&0&0&0&1 \end{bmatrix} = \begin{bmatrix} 1&0&0&1&1&1 \\ 0&1&0&1&0&1 \\ 0&0&1&0&1&0 \end{bmatrix}$ $k = 2$

$c = 001010$

(31.) $k = \{0101, 1000, 1100\}$

$k^{-1} = ?$

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

$k^{-1} = \{0000, 1111\}$

$H = [P^T | I] = [1\,1\,1]$

(32.) $H^T = \begin{bmatrix} 1&0&0 \\ 0&1&0 \\ 1&1&0 \\ 0&0&1 \\ 1&0&1 \\ 0&1&1 \\ 1&1&1 \end{bmatrix}$ $c = [1\,1\,0\,1\,1\,1\,0]$

$\cdot c = [0\,0\,1]$ //

(33) $p_y = 0.004$

$p_{inp} = 1x + 0x$

$= \binom{7}{0} \cdot (1-p_y)^7 \cdot p_0^0 + \binom{7}{1} (1-p_y)^6 p_0^1 = 0.9996684$

$p_{sys} = 1 - \left(\binom{7}{2} (1-p_y)^5 p_y^2 + \binom{7}{4} (1-p_y)^3 p_0^4 + \binom{7}{6} (1-p_0) p_0^6 \right) = 0.9996706$

??

(34) $P_1 = 1011$
$P_2 = 0110$
$P_3 = 1011$

metoda 1:

X X B X B B B

1 0 1 0 1 0 1
0 1 1 0 0 1 1
0 0 0 1 1 1 1

P_1 0 1 1 0 0 1 1
P_2 1 1 0 0 1 1 0
P_3 0 1 1 0 0 1 1

priklad

0 0 1 0 0 1 1
1 1 0 0 1 1 0
0 1 0 0 1 1 1

metoda 2

$\begin{bmatrix} 1&0&0 \\ 0&1&0 \\ 1&1&0 \\ 0&0&1 \\ 1&0&1 \\ 0&1&1 \\ 1&1&1 \end{bmatrix} \cdot [0010011] = [010]$

$\cdot [1100110] = [000]$

$\cdot [0100011] = [110]$

4) ?

6)

(35) $128 = M \rightarrow k = 7$

$B = 4\,kHz$

$SNR = 30\,dB$

prenos/sec

2^0
2^1
2^2
$2^3 = 8 \rightarrow n = 4$

$n = 11$ bitu

$C = B \cdot \log_2(1 + SNR) = 39868.9$

$R = 3624$ paketu/sec

(36) $d_1\ d_2\ d_3\ c_1\ c_2\ c_3$

$c_1 = d_1 + d_2 + d_3$

$c_2 = d_1 + d_3$

$c_3 = d_2 + d_3$

0 0 0 0 0 0
0 0 1 1 1 0
0 1 0 1 0 1
0 1 1 0 1 0

$n = 8 \rightarrow 4 = 3$

1 0 0 1 1 1
1 0 1 0 0 1
1 1 0 0 1 1
1 1 1 1 0 0

$G = \left[\begin{array}{ccc|ccc} 1&0&0&1&1&0 \\ 0&1&0&1&0&1 \\ 0&0&1&1&1&0 \end{array}\right]$

$H^T = \begin{bmatrix} 1&1&0 \\ 1&0&1 \\ 1&1&0 \\ 1&0&0 \\ 0&1&0 \\ 0&0&1 \end{bmatrix}$

$c = 0101111$

$\cdot c^T = 010 = 5$

$C = 0101011$

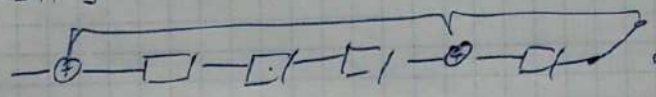
(37) $k[n,k] = [3,2]$

$$c = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 2 \end{bmatrix}$$

000 101 202
012 110 211
021 122 220

$d = 2$

(38) $k[15,4]$



$g(x) = 1 + x^3 + x^4 \quad k = 11$

$d(x) = x^{10} + x^8 + x^6 + x^5 + x^2 + 1$

$(x^{14} + x^{12} + x^{10} + x^9 + x^6 + x^4) : (x^4 + x^3 + 1) = x^{10} + x^9 + x^5 + x^2 + 1$

$x^{14} + x^{13} + x^{10}$

$x^{13} + x^{12} + x^9 + x^6 + x^4$

$x^{13} + x^{12} + x^9$

$x^9 + x^8 + x^6 + x^4$

$x^9 + x^8 + x^5$

$x^6 + x^5 + x^4$

$x^6 + x^5 + x^2$

$x^4 + x^2$

$x^4 + x^3 + 1$

$x^3 + x^2 + 1 \rightarrow [1101]$

(39) $g(x) = x^3 + x^2 + 1$

$k[12,k] \rightarrow k = 4$

$(x^6 + x^5 + x^2 + x) \cdot x^3 = (x^9 + x^8 + x^5 + x^4) : (x^3 + x^2 + 1) = x^6 + x^5 + x^4 + x^3 + x$

$x^9 + x^8 + x^6$

$x^8 + x^5 + x^4$

$x^8 + x^7 + x^5$

$x^7 + x^4$

$x^7 + x^6 + x^5$

x^6

$x^6 + x^5 + x^3$

$x^4 + x^3$

$x^4 + x^3 + x^2$

$x^2 + x$

(41) $x(t) = 1 + \cos(2\pi 1000 t + \pi/8)$

$R = 10\ \Omega$

$P = 1^2 \cdot \frac{1}{2} = 1.5\ W \rightarrow$ za 1Ω

za 10Ω $P = 0.15\ W$

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(42) $x(t) = \begin{cases} e^{-\alpha t}, & t \geq 0 \\ 0, & t < 0 \end{cases}$

amplitudni spektar

$A = 10$

$\alpha = 30$

$$X(f) = \int_{-\infty}^{\infty} x(t)\, e^{-j2\pi f t}\, dt = \int_0^{\infty} e^{-\alpha t} e^{-j2\pi f t}\, dt = \int_0^{\infty} e^{-t(\alpha + j2\pi f)}\, dt$$

$$= \frac{1}{-(\alpha + j2\pi f)} e^{-t(\alpha + j2\pi f)} \Big|_0^{\infty} = \frac{1}{\alpha + j2\pi f}$$

$$|X(f)| = \frac{1}{\sqrt{\alpha^2 + (j2\pi f)^2}} = \frac{1}{\sqrt{900 + (20\pi)^2}} = 0.01$$

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(43) $x(t) = \begin{cases} A, & \text{če } |t| \leq \tau/2 \\ 0, & \text{če } \tau/2 < |t| \leq T_0/2 \end{cases}$

impuls : pavza = 1 : 4 $\rightarrow \tau/T_0 = 1/5$

istosmerni $P_0 = A^2 \left(\frac{\tau}{T}\right)^2$

uliper $P_u = A^2 \frac{\tau}{T}$

$$\frac{P_0}{P_u} = \frac{A^2 \left(\frac{\tau}{T}\right)^2}{A^2 \frac{\tau}{T}} = \frac{1}{5} \rightarrow 20\%$$

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(44) NPF $f_g = 10\ MHz$

$N_0/2 = 10^{-10}\ W/Hz$

$|H(f)| = 0.2$

S_x na izhodu

$N = B \cdot 2 \cdot N_0/2 = 2 \cdot 10^{-3}\ W$

$S_y = S_x \cdot |H(f)|^2 = 0.08\ mW$

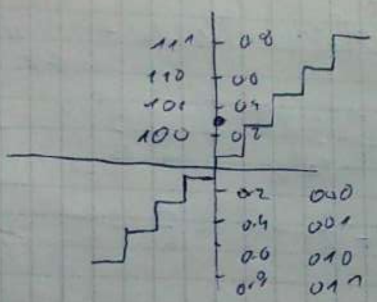
45. $u_m(t) = 0.8 \sin(2\pi 1000t + \frac{\pi}{4})$

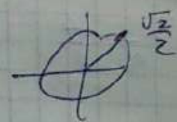
prigušitev od 5 dB

$|u(t)| \le 0.8V$

$L = 8$

kod v $t = 0$ = ?





$u_m(0) = 0.8 \sin\frac{\pi}{4}$

$= 0.8 \frac{\sqrt{2}}{2} = 0.5657 V$ → prigušitev → $u_{mp}(0) = 0.3181 V$

$\frac{u_m}{u_{m_i}} = 10^{\frac{5}{20}} = 1.778$

$20 \log(x)$

↳ kod = 101

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46. $u_m(t) = \sin(2\pi 1000t + \pi/4)$ [V]

$f_{vz} = 4 kHz$

$L = 32$

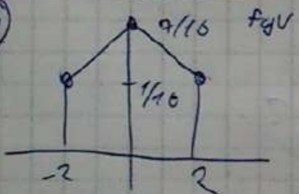
$U_{p2p} = -3 \Rightarrow 3 V$

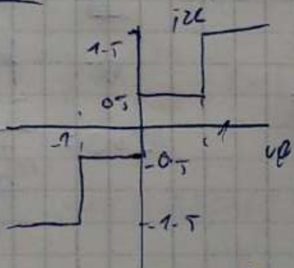
SNR = ?

$SNR = \frac{3S}{A_{max}^2} \cdot L^2 = 170.66 \rightarrow 22.32 dB$

~~vr2. SNR = 4.70 + 6.02 = 4.26 + 6.02·5~~

47.





$L = 4$

$B = 4kHz$ (0–4)

a) Snago = ?

$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)$

$y - \frac{6}{16} = \frac{0 - 6/16}{2 - 0}(x - 0)$

$y - \frac{6}{16} = -\frac{3}{16}x$

$y = -\frac{3}{16}x + \frac{6}{16}$ + istosmerni

$y = -\frac{3}{16}x + \frac{7}{16}$

$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)$

$y - 0 = \frac{6/16 - 0}{0 + 2}(x + 2)$

$y = \frac{3}{16}x + \frac{7}{16}$

$f(x) = \begin{cases} -\frac{3}{16}x + \frac{7}{16} & 0 < x < 2 \\ \frac{3}{16}x + \frac{7}{16} & -2 < x < 0 \end{cases}$

$$P_s = \int_{-2}^{2} u^2 f(u) = \int_0^2 u^2\left(-\tfrac{3}{16}u + \tfrac{7}{16}\right)du + \int_{-2}^{0} u^2\left(\tfrac{3}{16}u + \tfrac{7}{16}\right)du$$

$$= -\tfrac{3}{16}\cdot\tfrac{u^4}{4}\Big|_0^2 + \tfrac{u^3}{3}\cdot\tfrac{7}{16}\Big|_0^2 + \tfrac{u^4}{4}\cdot\tfrac{3}{16}\Big|_{-2}^{0} + \tfrac{u^3}{3}\cdot\tfrac{7}{16}\Big|_{-2}^{0} =$$

$$= -\tfrac{3}{4} + \tfrac{7}{6} - \tfrac{3}{4} + \tfrac{7}{6} = \tfrac{14}{6} - \tfrac{6}{4} = \tfrac{10}{12} = 0.833$$

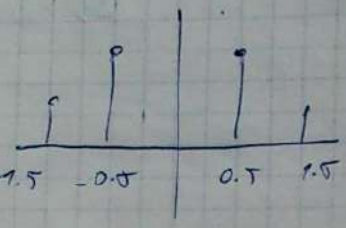
b) fgv razdelna

$$f_{gv} = \begin{cases} -\tfrac{3}{16}u + \tfrac{7}{16} & 0 < u < 2 \\ \tfrac{3}{16}u + \tfrac{7}{16} & -2 < u < 0 \end{cases}$$

0.5 →

1.5 → $\frac{5}{32}$

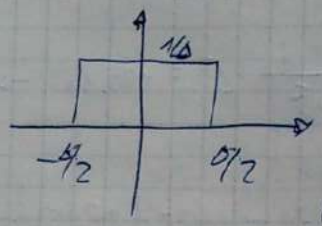
0.5 → $\frac{11}{32}$



c) $SNR = ?$

$SNR = \frac{3 \cdot 5}{A_{max}} \cdot L^2$

$\cdot \frac{0.833}{4} \cdot 16$



$$\beta = \frac{2 r_{max}}{L} = \frac{4}{4} = 1$$

$$N = \int_{-1/2}^{1/2} u^2 du = \frac{u^3}{3}\Big|_{-1/2}^{1/2}$$

$= 1/12$

$\frac{0.833}{1/12} = 9.996$

isto!

$$SNR = \frac{3S}{A_{max}^2} L^2$$

---

(40) $B = 16\,kHz$

$f_{vz} = 20\,kHz$

$L = 256 \rightarrow r = 8$

$\tau = ?$

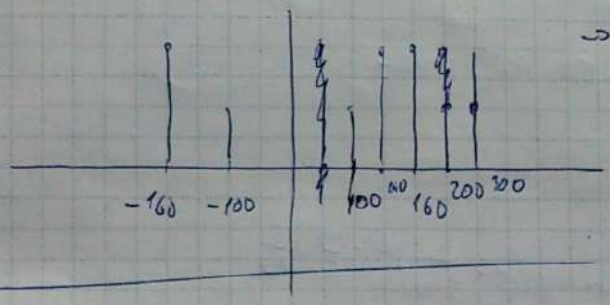
$R = 20 \cdot 8 = 160\,kbit/s$

$\tau = \frac{1}{R} = 6.25\,\mu s$

(4.) $s(t) = \cos(200\pi \cdot t) + 2\cos(320\pi \cdot t)$

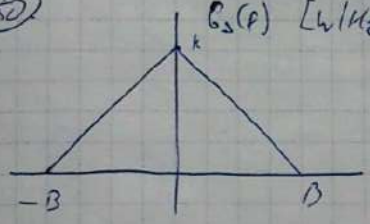
$f_{0Z} = 300\ Hz$

KPP - $f_g = 250\ Hz$ → što je prošlo



→ 100, 140, 160, 200

(5.)



Spektralna gustoća signala

$$y - k = \frac{0-k}{B-0}(x-0)$$

$$y - k = -\frac{k}{B}x$$

$$y = -\frac{k}{B}x + k$$

$$f(x) = \begin{cases} -\frac{k}{B}x + k & x \geq 0 \\ \frac{k}{B}x + k & x < 0 \end{cases}$$

$$S = \int_0^B \left(-\frac{k}{B}x + k\right)dx + \int_{-B}^0 \left(\frac{k}{B}x + k\right)dx =$$

$$= -\frac{k}{B}\frac{x^2}{2}\Big|_0^B + kx\Big|_0^B + \frac{k}{B}\frac{x^2}{2}\Big|_{-B}^0 + kx\Big|_{-B}^0 =$$

$$= -\frac{Bk}{2} + kB - \frac{kB}{2} + kB = 2kB - kB = kB$$

(5.) $H(x) = 0.25 \cdot 10^6$ bita

$N_0/2 = 4 \cdot 10^{-13}\ W/kHz$

$T = 30s$

$B = 1kHz$

$S = ?$

$$R = \frac{H}{T} = 2000\ b/s$$

$$\nu = 2 \cdot B \cdot N_0/2 = 8 \cdot 10^{-13}$$

$$2^k = 1 + \log_2\left(1 + \frac{S}{8 \cdot 10^{-13}}\right) / 2^{\wedge}$$

$$4 = 1 + \frac{S}{8 \cdot 10^{-13}}$$

$$S = 3 \cdot 8 \cdot 10^{-12}\ W$$

(53) AWGN

$$C = B\log\frac{S}{N}\cdot X = B\log\frac{S}{N} + B\log X$$

(54) $S = 1.9\,W$
$N_0/2 = 7.5\cdot 10^{-9}\ W/Hz \rightarrow N_0 = 15\cdot 10^{-9}\ W/Hz$

$$C = B\log_2\left(1+\frac{S}{B\cdot N_0}\right)$$

$$C = \lim_{B\to\infty} B\log_2\left(1+\frac{S}{B\cdot N_0}\right) = \lim_{B\to\infty}\log_2\left(1+\frac{S}{B\cdot N_0}\right)^{B\cdot\frac{N_0}{S}\cdot\frac{S}{N_0}}$$

$$C = \log_2 e^{\frac{S}{N_0}} = \text{digiton care} = 182.74\ Mbit/s$$

(55) ∞

(56) $|H(f)| = 0.8$

$$S_s(f) = \begin{cases} a\frac{|f|}{B} & |f|\le B \\ 0 & \text{in rest} \end{cases}$$

$N_0/2 = a\cdot 10^{-10}\ W/Hz$

$\Gamma = 0$

$C = ?$

$$S_{s;2}(f) = 0.64\,a\frac{|f|}{B}\Big|_0^B$$

$$S_{;2} = 0.64\int_{-B}^{B} a\frac{|f|}{B} = 0.64\left(\int_0^B af\,df - \int_{-B}^{0} af\,df\right)$$
$$= 0.64\,\frac{aB}{2}\cdot 2 = 0.64\,aB$$

$$C = B\log_2\left(1+\frac{0.64B}{B\cdot 10^{-10}}\right) = 32.57\,B$$

(24) $R_x(\tau) = e^{-0.5|\tau|}$

$E[x] = 0$

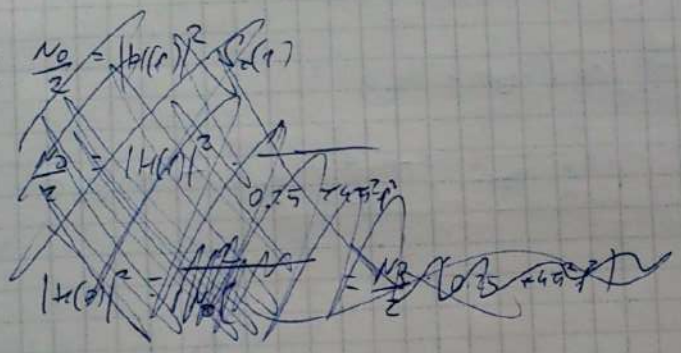
$N_0/2$?

$$S_x(f) = \int_{-\infty}^{\infty} R_x(\tau) e^{-j2\pi f\tau} d\tau = \int_{-\infty}^{0} e^{0.5\tau} e^{-j2\pi f\tau} d\tau + \int_{0}^{\infty} e^{-0.5\tau} e^{-j2\pi f\tau} d\tau =$$

$$= \int_{0}^{\infty} e^{-(0.5+j2\pi f)\tau} d\tau + \int_{0}^{\infty} e^{-(0.5-j2\pi f)\tau} d\tau =$$

$$= -\frac{1}{(0.5+j2\pi f)} e^{-(0.5+j2\pi f)\tau} \Big|_0^\infty + \frac{1}{0.5-j2\pi f} e^{-(0.5-j2\pi f)\tau} \Big|_0^\infty =$$

$$= \frac{1}{0.5+j2\pi f} + \frac{1}{0.5-j2\pi f} = \frac{1}{0.25+4\pi^2 f^2}$$



$$S_x(f) = |H(f)|^2 \cdot N_0/2$$

$$\frac{1}{0.25+4\pi^2 f^2} = |H(f)|^2 \cdot \frac{N_0}{2}$$

$$|H(f)|^2 = \frac{2}{N_0(0.25+4\pi^2 f^2)}$$