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ECE 300

Homework 4.

1. $f_s = 2W + W_A = 2(\cancel{}20kHz) + 4kHz = 44kHz$

3. $\hat{s} = \arg_{s_i} \min ||r - s_i||^2$

Due to the interference of noise, the recieved signal is almost never exactly one of trasmitted signal S_i.

A least square decision system decides what signal S_i that the recieved signal is / belongs to.

$S_0 = -2.5V, \quad 0 \le t \le A$ if energy $> 0 \rightarrow S_1$

$S_1 = 2.5V, \quad 0 \le t \le A$ energy $< 0 \rightarrow S_0$

4. LS Yes, they're the same because they're both looking for max power.

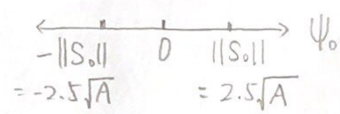
ML Yes. LS = ML due to AWGN.

MAP No, unless equiprobable + AWGN. + equal energy.

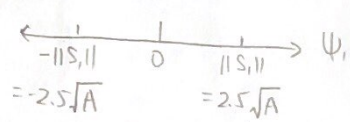
5. Binary Pulse Amplitude Modulation.

Amplitude $T_s = A$

Where: $\psi_0 = \frac{S_0}{||S_0||} = \frac{A}{\sqrt{A^2 T_s}} = \frac{1}{\sqrt{T_s}} = \frac{1}{\sqrt{A}}$



$\psi_1 = \frac{S_1}{||S_1||} = \frac{A}{\sqrt{A^2 T_s}} = \frac{1}{\sqrt{T_s}} = \frac{1}{\sqrt{A}}$



6. $\alpha = \frac{N_0}{4\sqrt{\mathcal{E}_s}} \log\left(\frac{P_0}{P_1}\right)$ $\qquad \mathcal{E}_s = \int_0^{T_s} A^2\,dt = A^2 T_s = 2.5^2 A.$

$N_0 = 4 k_B TR$ $\qquad \mathcal{E}_s = 2.5^2 A.$

$$\therefore \alpha = \frac{4 k_B TR}{4\sqrt{2.5^2 A}} \log\left(\frac{0.25}{0.75}\right).$$

$$= \frac{k_B TR}{2.5\sqrt{A}} \log\left(\frac{1}{3}\right) = \frac{(1.38\times10^{-23}\,J/k)(52.7\,m\Omega/m)}{2.5} \frac{TL}{\sqrt{A}} \log\left(\frac{1}{3}\right)$$

$$SNR = \frac{2\mathcal{E}_s}{N_0} = \frac{2(2.5^2 A)}{4 k_B TR} = \frac{2.5^2 A}{2 k_B TR}$$

$$= \frac{2.5^2}{2(1.38\times10^{-23}\,J/k)(52.7\,m\Omega/m)} \cdot \frac{A}{TL}.$$

7. $SNR = \frac{2\mathcal{E}_s}{N_0} = \frac{2(2.5^2)A}{4 k_B TR} = \frac{2.5^2 A}{2(1.38\times10^{-23}\,J/k)\,T\,(52.7\,m\Omega/m)L}$

$$= \frac{2.5^2}{2(1.38\times10^{-23}\,J/k)(52.7\,m\Omega/m)} \cdot \frac{A}{TL}$$

$$P_{error} = Q\left(\sqrt{\frac{2\mathcal{E}_s}{N_0}}\right) = Q\left(\sqrt{\frac{2.5^2}{2(1.38\times10^{-23}\,J/k)(52.7\,m\Omega/m)} \frac{A}{TL}}\right)$$

8. $P_{error} = \frac{1}{10} = Q\left(\sqrt{\frac{2.5^2}{2(1.38\times10^{-23}\,J/k)(52.7\,m\Omega/m)} \frac{A}{TL}}\right)$

qfuncinv $\left(\frac{1}{10}\right) = 1.2816$

using ~~Ma~~ Matlab

$$\therefore \sqrt{\frac{2.5^2}{2(1.38\times10^{-23}\,J/k)(52.7\,m\Omega/m)} \frac{A}{L(298.15k)}} = 1.2816.$$

Assuming $A = 1s$, $L = 8.77\times10^{18}\,m$ = 926.99 Light years

Comparing to size of Milky Way = 52,850 light years.