Digital Communications - Advanced Course.

Answers/Hints to exam 19/12 - 2013

Note! X = ignored since it belongs to 8.2.1 - 8.4 !!

1.

a) FALSE since $\rho = \frac{R_b}{c R_s} = \frac{r_c \log_2(M)}{c} =$

$$= \begin{cases} \frac{3.75}{c} \\ \frac{3.2}{c} \quad \text{smallest} \end{cases}$$

b) FALSE since $\rho = r_c \frac{\log_2(M)}{c} = r_c \cdot \rho_{unc} < \rho_{unc}$

c) TRUE since for M-PSK $-E_{z_i}/2$ is not needed. See page 341.

d) FALSE since it is needed only at the ML-receiver (always).

e) False since attenuation decreases $D^2_{z_m, z_\ell}$.

2.

$$\text{Prob}\{\text{error} \mid z_4\} = Q\left(\sqrt{\frac{8a^2}{N_0}}\right)$$

$$-\text{''}- \quad \mid z_5\} = Q\left(\sqrt{\frac{8a^2}{N_0}}\right) + Q\left(\sqrt{\frac{a^2}{2N_0}}\right)$$

$$-\text{''}- \quad \mid z_6\} = 2Q\left(\sqrt{\frac{a^2}{2N_0}}\right)$$

$$-\text{''}- \quad \mid z_7\} = Q\left(\sqrt{\frac{a^2}{2N_0}}\right) + Q\left(\sqrt{\frac{2a^2}{N_0}}\right)$$

$$P_s = \sum_{i=0}^{7} P_i \, \text{Prob}\{\text{error} \mid z_i\} =$$

$$= Q\left(\sqrt{\frac{a^2}{2N_0}}\right) + \frac{1}{4} Q\left(\sqrt{\frac{2a^2}{N_0}}\right) + \frac{1}{2} Q\left(\sqrt{\frac{8a^2}{N_0}}\right)$$

$$\mathcal{E}_b = 5.25a^2 \Rightarrow \frac{a^2}{N_0} = 19.05$$

$$P_s = Q(3.086) + \frac{1}{4} Q(6.172) + \frac{1}{2} Q(12.344) \approx$$

$$\approx 9.7 \cdot 10^{-4}$$

3.

a) The curve goes through the point: ($SNR = 10$, $\mathcal{E}_b/N_0 = 2.89$)

($SNR = 31$, $\mathcal{E}_b/N_0 = 6.2$)

($SNR = 63$, $\mathcal{E}_b/N_0 = 10.5$)

($SNR = 100$, $\mathcal{E}_b/N_0 = 15.02$)

$SNR = 130$, $\mathcal{E}_b/N_0 = 18.48$)

Use that $\frac{\mathcal{E}_b}{N_0} = \frac{SNR}{\log_2(1+SNR)}$

b)

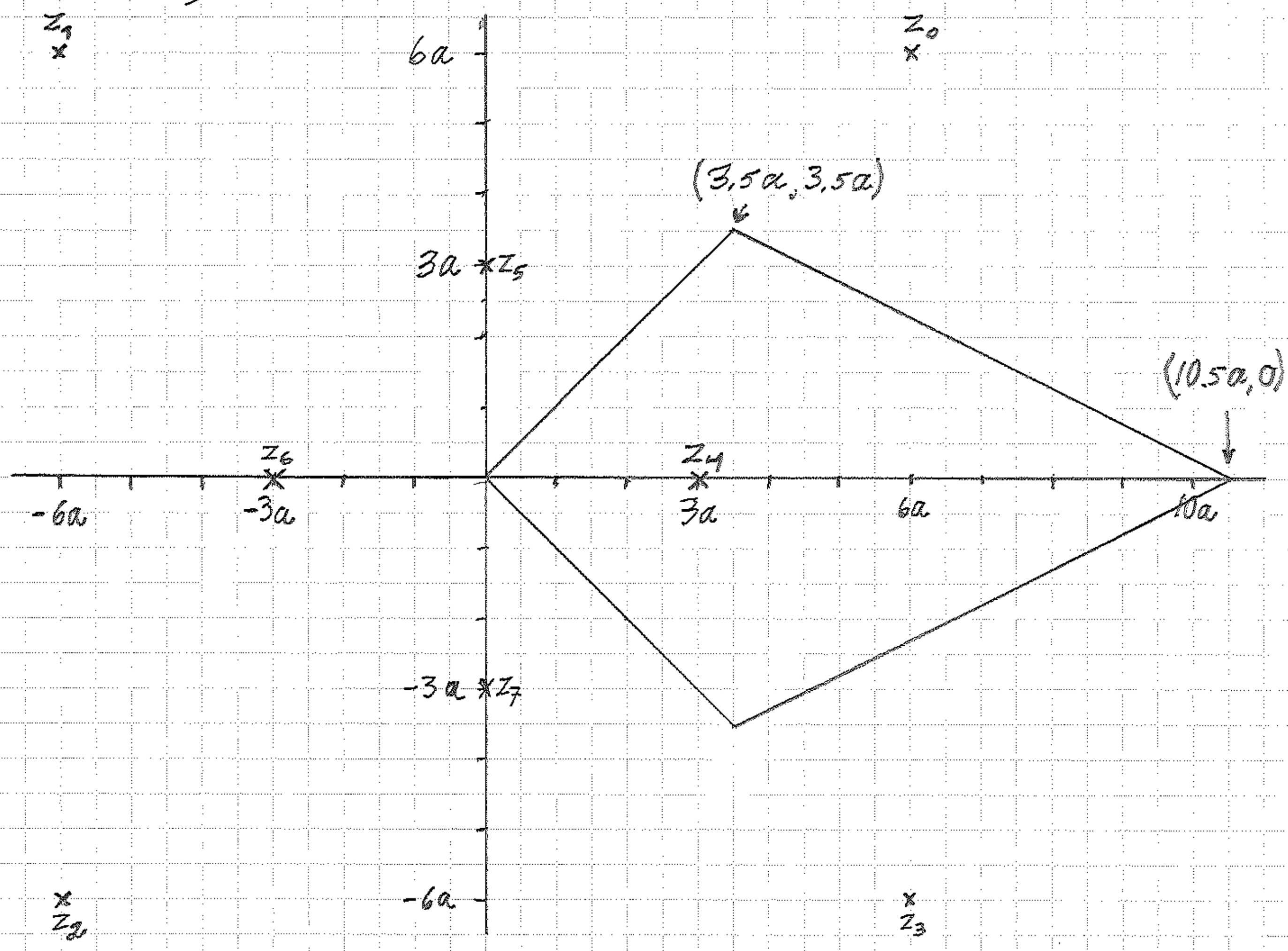
i) Please see the compendium.

ii) The error probability needs to be <u>significantly</u> improved.

iii) X

4. X

5. i)



ii) From the figure is seen that a symbol error will happen if $W_1 < -a$ or if $W_1 > 3.5a$.

iii) We here need the decision border between Z_3 and Z_7. This border goes through the points $(3{,}5a, -3{,}5a)$ and $(0, -10.5a)$. Therefore, a symbol error will happen if $W_1 < -5a$.