Answers & Hints to exam in the course Digital Communications – Advanced Course (ETT055), March 11, 2009, 08-13.

Problem 1.

a) False. Uncoded 8PSK has three times higher bandwidth efficiency.

b) False, by definition of a CPM signal.

c) False. The decision regions are insensitive to signal attenuation.

d) True. With only one state no memory exists in the signal.

e) True. The channel information delivered to the transmitter might be outdated.

Problem 2.

$x = s_0(t)$ and $y = s_7(t)$ with the state sequence: $5, 2, 1, 0, 4, 2, 7, 3, 5, 2$.

$x = s_2(t)$ and $y = s_3(t)$ with the state sequence: $5, 2, 1, 0, 4, 6, 7, 3, 5, 2$.

In case of uncoded 8PSK we can not say anything about which of the 8 signal alternatives are present.

Problem 3.

i)

The two decision regions are obtained by first drawing the signal space diagram, and after that applying the minimum distance decision rule. The decision region for messages 5 is a square centered at $(-a, a)$, with sides equal to $2a$. The decision region for message 11 is defined by: $r_1 \geq 2a$ and $-2a \leq r_2 \leq 0$.

ii)

It is found that $D^2_{min} = a^2$ and $\mathcal{E}_b = 17a^2/8$. Hence, $d^2_{min} = 4/17 = 0.2353$.

iii)

The signal space diagram, in combination with how the information bits are mapped to each signal point, imply that if the ML symbol decision rule produces the decision $\hat{b}_3 = 0$ then this is equivalent with that $r_2 < 0$. In the same way we see that if the ML symbol decision rule produces the decision $\hat{b}_4 = 1$ then this is equivalent with that $-2a < r_2 < 2a$.

Hence, the ML symbol receiver becomes very simpel with the current mapping: r_1 gives the two decions $\hat{b}_1$ and $\hat{b}_2$, and r_2 gives the two decions $\hat{b}_3$ and $\hat{b}_4$.

Problem 4.

a) i) The upper bound is 0.125 if $L = 1$, $6.14 \cdot 10^{-4}$ if $L = 8$ and $2.39 \cdot 10^{-4}$ if $L = 16$.

ii) All curves increase with increasing P_0 and they go through the two points $(0, 6.19 \cdot 10^{-6})$ and $(1, 0.5)$. For other values of P_0, the value of the upper bound decreases as L increases (diversity!).

b) $L = 1$: $P_b = E\{Q(\sqrt{4E_{b,sent}a_1^2/(2N_0)})\} = E\{Q(\sqrt{4.7534^2 a_1^2})\} = 0.25 \cdot 0.5 + 0.75 \cdot 10^{-6} \approx 0.125$.

$L = 2$: $P_b = E\{Q(\sqrt{4E_{b,sent}((a_1^2 + a_2^2)/2)/(2N_0)})\} = 0.5/16 + Q(4.7534/\sqrt{2})6/16 + (9/16)10^{-6} \approx 3.14 \cdot 10^{-2}$.

Problem 5.

a) See the compendium.

b) The 16-ary signal constellation will be the same as in Problem 3ii). However, the bit mapping is different.