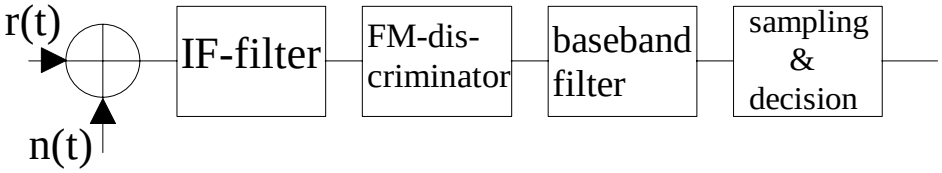
S-72.3230 Radio transmission and network access
Exercise 5 - 6

P14 In a digital mobile communication system QPSK is used. Due to the use of a learning sequence differential encoding is not required.

a) How large in dB is the improvement of the E_S/N_O-ratio is achieved on the BEP-values 10^{-2} and 10^{-4} compared to a differentially encoded transmission?

b) How many dB does the transmit power level chante, if the learning sequence increases the transmission rate by 20%?

P15. The block diagram of a sub-optimal FSK-receiver is given below. The modulation index h = 0,5.

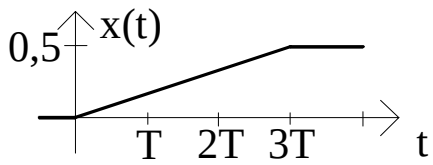


The doublesided power spectral density of the AWGN channel noise is $N_O/2$. The bandwidth of the ideal IF-filter is dimensioned with the thumb rule $B = 2(\Delta f + 2R_s)$,The impulse response of the baseband filter is $h(t) = \frac{1}{T}\text{rect}\left(\frac{\text{t-}T/2}{T}\right)$. Hoe many dB is the degradation of this receiver compared to the coherent reference receiver?

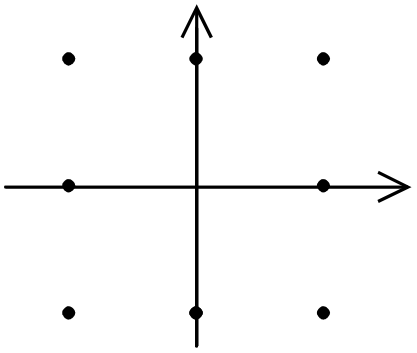
P16 In a CPM-system the phase pulse is given in the adjacent figure, h = 0.5.

a) Draw the phase tree diagram.

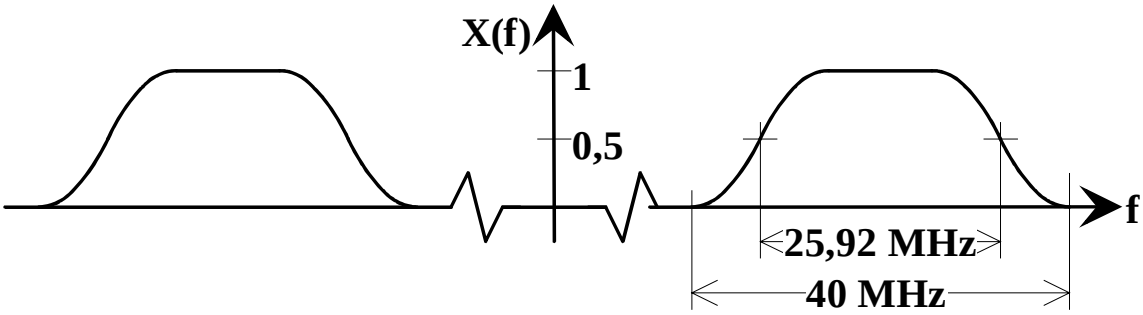
b) Draw the trellis diagram.



P17 A possible 8QAM:n constellation diagram is shown in the adjacent figure. Derive an upper bound for the symbol error probability of an optimum receiver in the AWGN-channel assuming a fully known carrier phase. Present the result using the average symbol energy and the power spectral density of the white noise.



P18 The pulse spectrum of a 64QAM system using raised cosine spectrum filtering is shown in the figure below.



a) Determine the roll-off factor α.
b) Determine the bit rate of the transmitted 64QAM signal.
c) How large should the signal-to-noise ratio defined as $SNR = 10\log\left(\frac{P_{rx}}{N_o R_s}\right)$ dB be to give a symbol error probability of 10^{-6}?

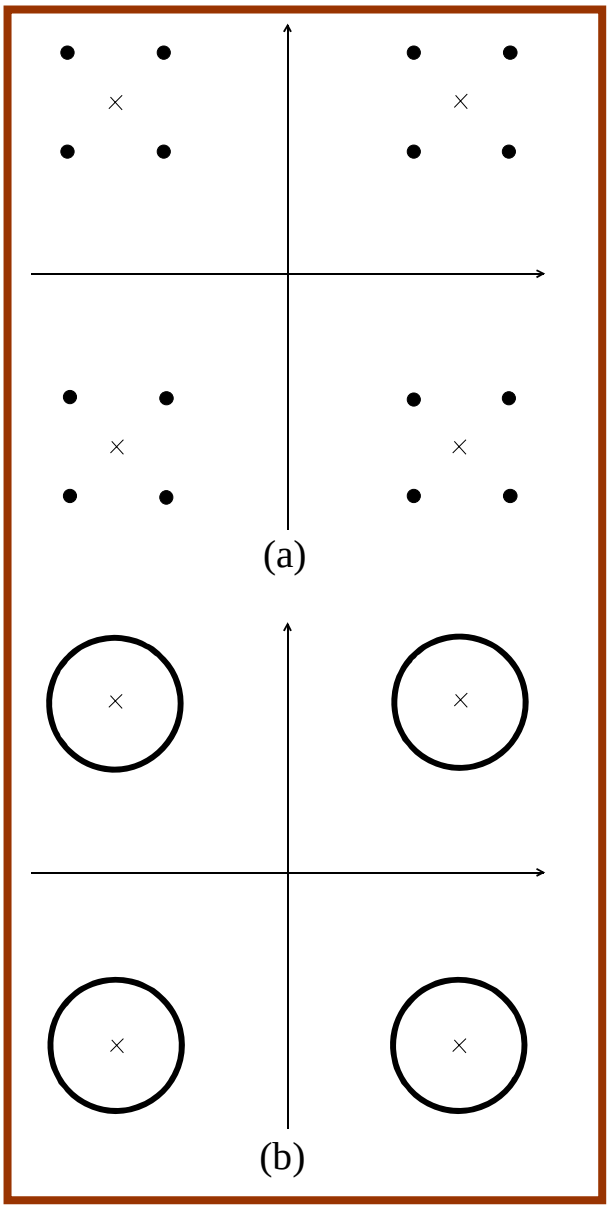
P_{rx} is the received average power, N_O is the one-sided power spectral density of the additive white Gaussian noise, and R_S is the symbol rate. Matched filter reception is assumed.

P19 Determine the required average signal to noise ratio required in the flat and slowly Rayleigh-fading AWGN-channel when the average bit error probability should be 10^{-6}:

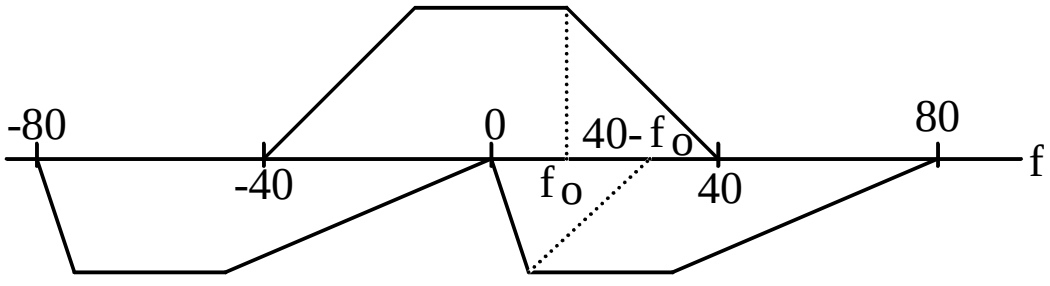
a) in a coherent BPSK-system,
b) in a coherent BFSK-system,
c) in a non-coherent FSK-system

P20

In the case of a fully synchronised and identically modulated interfering signal the constellation of a 4QAM signal is given in figure (a). In the case of an unsynchronised, but identically modulated interfering signal the constellation of a 4QAM signal is shown in figure (b). On large signal to noise values a symbol error occurs, when the constellation point is in another decision area due to the interfering signal.
Determine the largest allowable signal to interference ratio (dB) so that such a phenomenon would never occur in either case, i) in a 4QAM-system, ii) in a 16QAM-system, and iii) in a 64QAM-system?



P21



The channel spacing in a radio relay system is 40 MHz, the transmission rate in a channel is 2×155,52 Mbit/s + 5% from the radio frame. The total matched filtering gives the trapezoidal pulse spectrum shown in the figure.

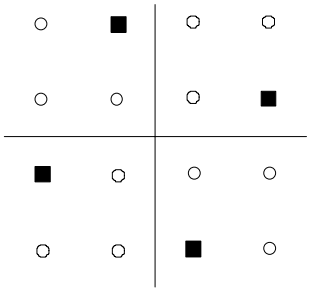
a) Investigate which MQAM-methods (M is a power of 2) can be used (spectrum roll-off parameter $\alpha \in [0, 1]$), when the co-polarised spectra just do not overlap. Give also the used α-values.

b) Derive the centre channel signal to interference ratio (dB) needed with the possible modulation methods, and which the matched filtering gives.

c) How large should the system cross-polarisation attenuation be to give a 40 dB signal to interference ratio with the investigated modulation methods?

Homework 5

When the signal to noise ratio in the radio channel is decreasing the constellation with the black squares (4QAM) is used, otherwise the full constellation (16QAM) is used.



a) If the bandwidth and thus the symbol rate is kept constant, how much is the bit rate reduced in the bad channel?

b) How many dB does the average symbol energy change by the change of constellation?

c) How many dB may the noise level increase in the bad channel from the value in the good channel, that the bit error probability would be the same as in the good channel?

All cases are investigated under low error probability conditions.

Homework 6

The bit error probability of differentially decoded BPSK in the AWGN-channel is $BEP = 0.5\exp(-E/N_o) = 0.5\exp(-\gamma)$.

a) Derive the average error probability expression in the slowly flat fading Rayleigh-channel, wher the probability density function of the signal to noise ratio is $p(\gamma) = \left[\exp(-\gamma/\gamma_m)/\gamma_m\right]\mathrm{u}(\gamma)$.

b) Calculate how many dB must the average signal to noise ratio γ_m be increased due to Rayleigh-fading on the BEP-values 10^{-2} and 10^{-4}.