Werkcollege 6: huiswerkopgaven

Hieronder volgen de huiswerkopgaven voor het 6e werkcollege Telecommunicatietechniek. Bij het werkcollege wordt verwacht dat je de stof tot dan toe goed hebt bestudeerd en deze opgaven vooraf thuis hebt voorbereid.

Tijdens het werkcollege kun je verder werken aan de opgaven waar je niet bent uitgekomen. Tijdens de werkcolleges worden de antwoorden van de opgaven gegeven.

Question 1.

A digital transmission system is used to transmit a data signal with a bit rate of $R_b = 1$ Mbit/s. The following modulation schemes are available to be selected: BPSK, 8-PSK and 16-QAM. The minimum distance between two signal states of the complex envelope signal $g(t)$ is $z = 2$ V, as indicated in the figure.
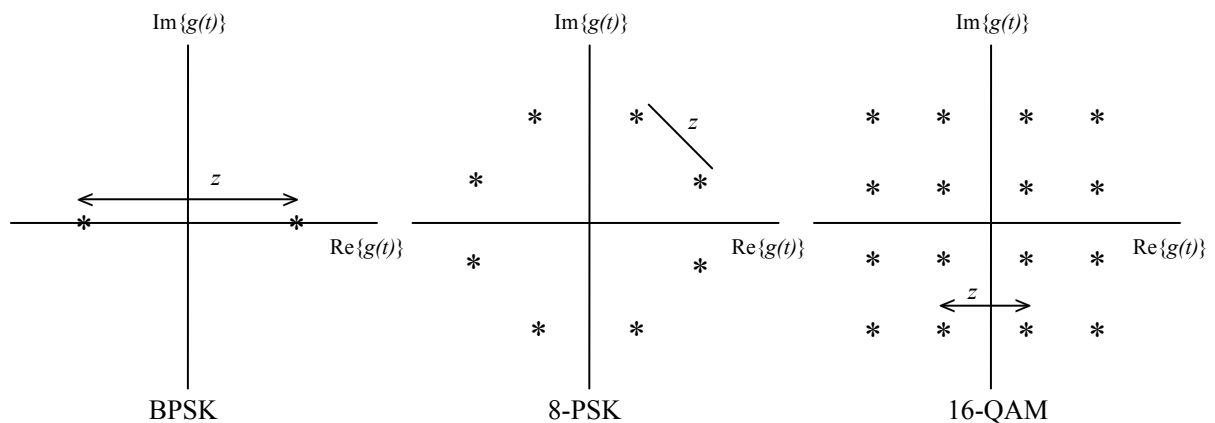

Figure: Signal states for BPSK, 8-PSK and 16-QAM.

a) Calculate the mean normalized power P_g of $g(t)$ for BPSK, 8-PSK and 16-QAM, if the signal states occur with equal probability.

b) Calculate the mean energy per symbol $E_s = P_g T_s$ for each of the modulation schemes.

c) Determine the "null-to-null" transmission bandwidth BW_{0-0} for each of the modulation schemes.

Question 2.
A data signal with bit rate R_b = 32 kbit/s is transmitted using FSK modulation.

a) Determine the transmission bandwidth B_T if the frequency deviation ΔF = 15 kHz.

b) The bit rate of the system is adapted in such a way that MSK modulation is obtained (while keeping ΔF as under a)). Determine the bit rate for MSK modulation.

c) Determine the bandwidth of the transmitted MSK signal for which the PSD is 6 dB below its maximum level.

Question 3.
A data signal with a bit rate R_b = 1 Mbit/s is transmitted with a kind of PSK modulation where the transmitted signal is given by:
$$s(t) = A_c \cos[2\pi f_c t + \theta_\Delta d(t)]$$
where $d(t)$ is a polar data signal, $d(t) \in \{-1,+1\}$ volt with a rectangular pulse shape and θ_Δ is the phase sensitivity in [rad/V]. The received signal power -14 dBm.

a) Show that for $\theta_\Delta \neq \pi/2$ rad/V, the signal $s(t)$ contains an unmodulated carrier component.

b) Calculate θ_Δ for which 25% of the transmitted power is contained in the carrier component.

c) Provide a detailed figure of the power spectral density of this signal for $f_c = 50$ MHZ, $\theta_\Delta = 3\pi/4$ for the frequency range $f_c \pm 5$ MHz. Clearly indicate the numbering of the axis and their dimensions.

Question 4.

A bandwidth of 10 MHz is available for the design of a digital communication system based on OFDM. The required bit rate is 20 Mbit/s.

a) Determine the required modulation level M of an OFDM with $N = 8$ subcarriers in case all subcarriers use the same modulation.

b) Determine the available bitrate for this system.

d) Determine the spectral efficiency of the system.