Werkcollege 7: 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.

An air traffic control radar system should give an alarm when a signal reflected off an airplane is received.
In the received signal also Additive White Gaussian Noise (AWGN) $n(t)$ is present with a mean value $\overline{n(t)} = 0$.

We whish to choose the threshold level V_T of the detection system such that the probability of false alarm (an alarm without an airplane being present) only occurs with a probability of 2 %.

a. Calculate V_T if the rms-noise voltage is 1 volt.

b. A specific airplane results in a reflected signal of 3 volt. What is the probability of missed target P_{mt} (the airplane is not detected), if V_T is set as determined in a.

The radar operator wants to have the probability of false alarm P_{fa} and the probability of missed target P_{mt} to be in the same order of magnitude.

c. Determine the resulting optimum threshold $V_T = V_{opt}$ for $P_{fa} / P_{mt} = 2$, if the strength of the reflected signal due to an airplane is 3 volt.

Question 2.

A digital baseband transmission system uses bipolar NRZ signaling with equally likely symbols: $s_1(t) = \pm A$ and $s_2(t) = 0$, with A = 8V. The detection levels are set to V_{T-} = -4V and V_{T+} = +5V. The standard deviation of the noise is σ_n = 1.4V.

a. Determine the signal-to-noise ration SNR at the input of the detector.

b. Determine the conditional bit error probabilities P_{e1} and P_{e2} for the symbols s_1 and s_2, and calculate the total bit error probability P_e.

Question 3.

A digital signal with bit rate R_b = 1.5 Mbit/s is transmitted using OOK modulation. The received signal power at the receiver input is -18 dBm.

a) Calculate the bit error probability P_{e_OOK} for a coherent matched filter detector if the single sided noise power spectral density at the receiver input is N_0=-92 dBm/Hz.

To prevent interference to other users of the radio channel, the transmitted power is reduced by using a different modulation technique, however, the bit error probability has to be the same as under a) determined.

The following modulation schemes are evaluated:
- DPSK (Differential Phase Shift Keying)
- BPSK (Binary Phase Shift Keying)

b) Calculate the power saving (in dB) that is obtained with DPSK and BPSK.

Question 4.

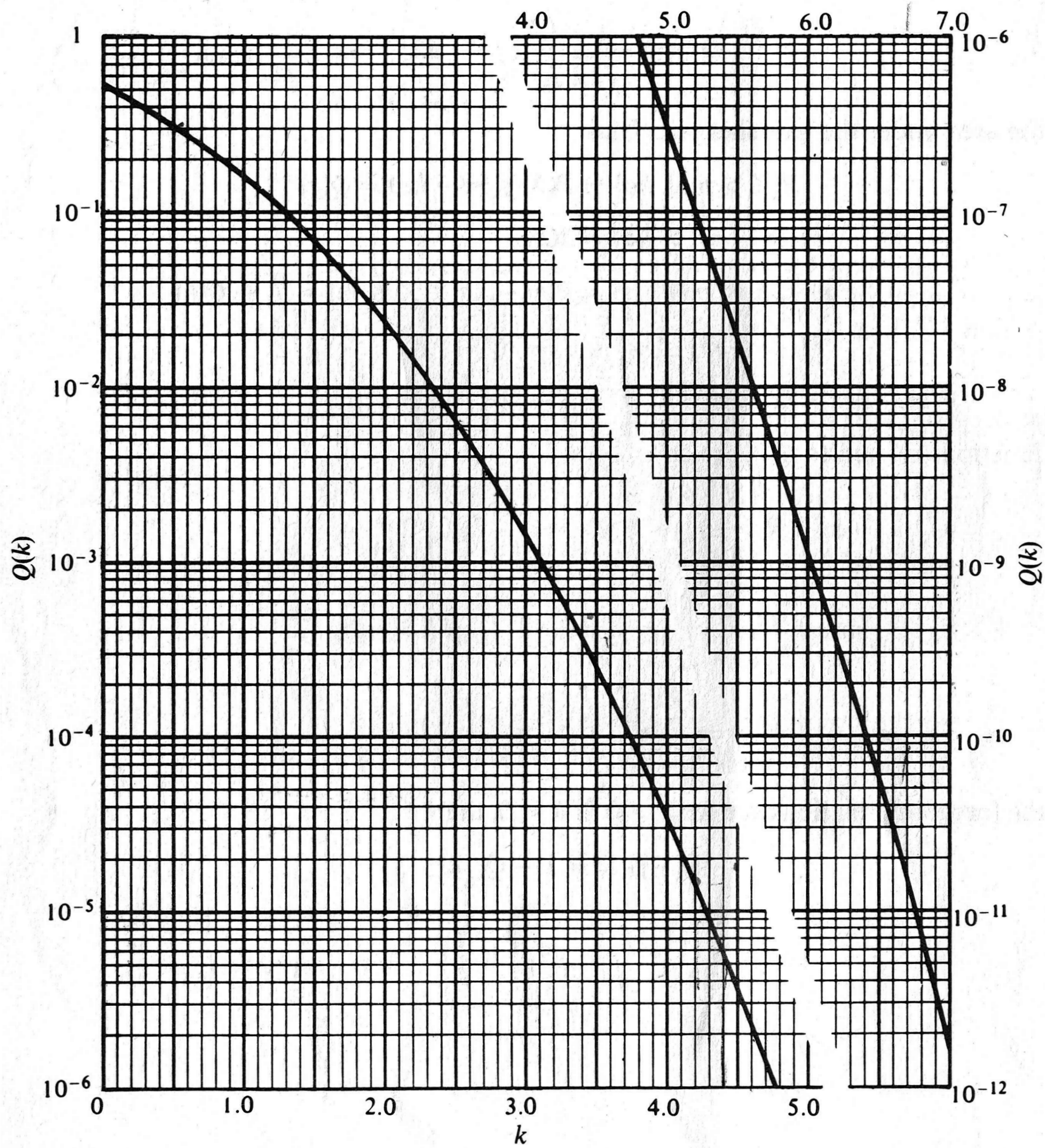
A binary transmission system uses a special kind of Amplitude Shift Keying (ASK) with symbol rate R_s=150 kbit/s. The transmitted signal is given by:

$$s(t) = A_c[\alpha + \beta d(t)]\cos 2\pi f_c t$$

where $\alpha = 4.5$, β =2.5 and *d(t)* is a polar data signal, $d(t) \in \{-1, +1\}$. The single sided noise power spectral density is N_0=-91 dBm/Hz, and the equivalent noise bandwidth of the coherent matched filter is $R_s / 2$. The received signal power is -21.2 dBm.

a) Calculate the bit error probability P_e.

b) Calculate the bit error probability P_e when in stead of the matched filter a filter with an equivalent noise bandwidth of $2R_s$ is used.



The Q-function $Q(\kappa) = \frac{1}{\sqrt{2\pi}} \int_{\kappa}^{\infty} e^{-\lambda^2/2} d\lambda \approx \frac{e^{-\kappa^2/2}}{\kappa\sqrt{2\pi}}$ for $\kappa > 4$