Tutorial 01

Q1 What is analogue modulation and main reasons for analogue modulation.

Q2 Describe the steps involved in the development of the complex baseband equivalent model of a modulated signal, in both frequency and time domain, in as much detail as possible.

Q3 Draw a signal space diagram for the following constellations and their receiver decision areas: a) BPSK b) QPSK c) 4-PAM d) 4-QAM e) 8-PSK f) 16-QAM.

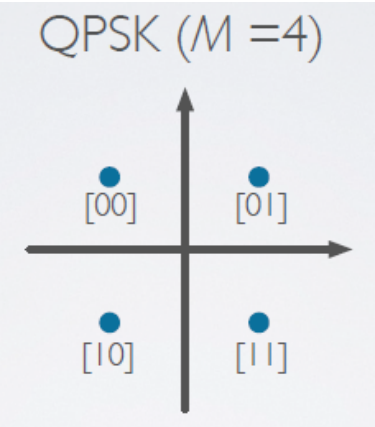
Q4 Assuming each constellation in Q3 is allocated unit average energy (corresponding to average squared distance from the origin of unity)

$$E_S = \frac{1}{M}\sum_{i=1}^{M} A_i^2 = 1 \tag{1}$$

where M is the total number of symbols in the constellation and A_i is the distance between every symbol and the constellation origin.

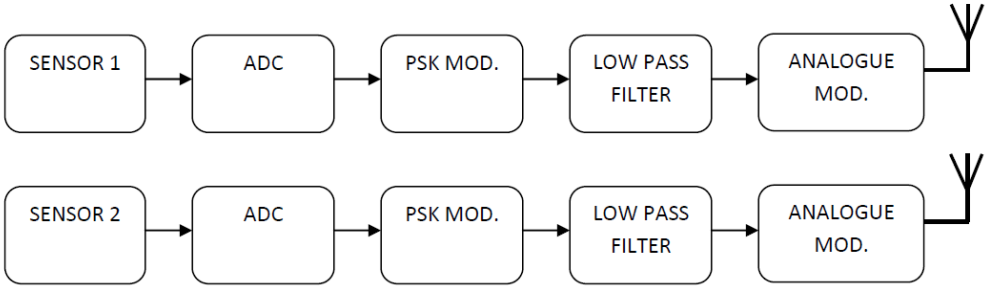
- For each constellation, calculate the minimum distance between any two signal points in the constellation.
- Explain which one is the most robust constellation.

Q5 The data source of a digital wireless communication system produces a data throughput of 2048 kbits/s. The digital modulation scheme employed is Quadrature Phase Shift Keying (QPSK), with the following symbol mapping



Considering that the carrier is a cosine signal with frequency 2048 kHz, draw the transmitted signal for the bit sequence: 01100011.

Q6 It is desired to transmit the signals from two analogue sensors installed in a weather monitoring station. To transmit both signals, the wireless communication system showed in the figure is used.



The frequency band reserved for both channels goes from 100 kHz and 114 kHz. A guard band equal to 2 kHz is necessary between both channels. The analogue signals produced by the sensors a have a peak voltage of ± 1V, which is equal to the dynamic range of the ADCs. In addition, the output signal from the sensors has a maximum frequency component equal to 375 Hz. Each of the sensor outputs is processed by an ADC which carries out the signal sampling at the Nyquist frequency. The quantification is uniform with a maximum error of 7812.5 /2 μV and the codification is binary symmetric (the first bit is used to indicate if the value is positive or negative). The output of each modulator is fed into a PSK modulator to map the information bits into symbols. The digital signal at the output of the PSK modulator is filtered by an ideal brick-wall low pass filter. Finally both digital baseband signals are modulated onto a cosine carrier signal in the analogue modulation operation. It is requested to:

(a) Calculate the number of bits used for each sample taken in each of the ADCs.

(b) Calculate the bit rate at the input of each of the PSK modulators.

(c) Explain what is the minimum number of phases needed by the PSK modulators.

(d) Calculate the carrier frequencies for each of the two analogue modulators.

(e) What is the value assigned by one of the ADCs to a sample equal to 0.6 V?

(f) If now the frequency band reserved for the two channels has a bandwidth of 8 kHz (between 100 and 108 kHz) and values for the ADC, signals and guard bands are kept from the previous sections; calculate the new minimum number of phases in the modulator and carrier centre frequencies in order to meet the new requirements.