

M1-IRELE

ELEC-H401 Modulation and coding

DVB-C project

Authors :

Arico Amaury

Colot Emmeran

Professor :

Horlin François

Academic year :

2024 - 2025

Contents

Introduction	1
Transmission chain blocks	2
Baseband representation	2
Modulation and Demodulation	2
Pulse shaping	3
Noise addition	5

Introduction

This report aims to complete the code that simulates a DVB-C transmission chain in matlab. It provides additional information from the theoretical part of the project.

The first part aims to simulate each block of the transmission chain and to link them together such that the received signal is the same as the transmitted signal (in a noiseless case).

Second part to be explained later

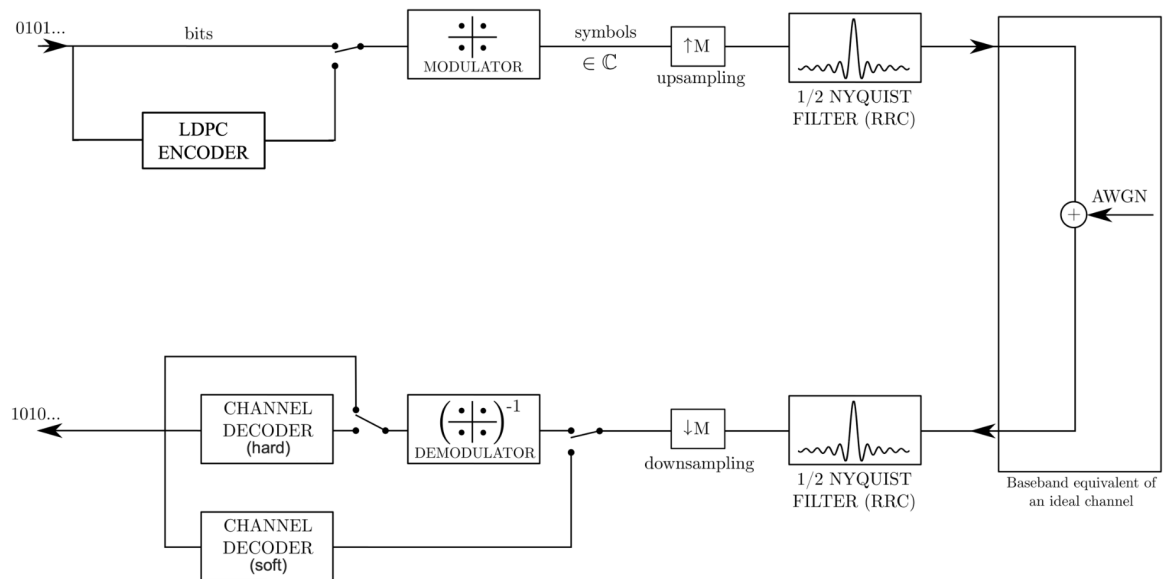


Figure 1: DVB-C transmission chain

Baseband representation

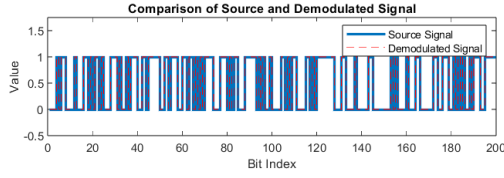
By looking at the block diagram of the transmission chain 1, one can see we never move the baseband signal to the carrier frequency. As the simulation runs on a computer, using the bandpass representation of the signal would require much more samples as the sampling frequency would need to be at least twice the carrier frequency. By simulating the chain in baseband, the minimal sampling frequency is reduced to the symbol rate in order to have at least one sample per symbol.

Because the signal is oversampled, the sampling frequency is then equal to the symbol rate multiplied by the oversampling factor.

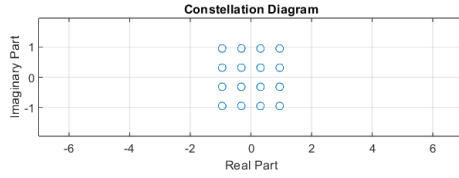
Modulation and Demodulation

After generating N random bits, they are modulated. This allows to send fewer symbols than the number of bits. We chose QAM modulation as it combines ASK and PSK. Depending on the number of bits per symbol (N_{bps}), the number of bits sent (N) had to be chosen such that $N / N_{\text{bps}} \in \mathbb{N}$.

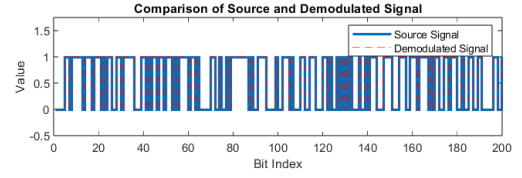
Figure 2 compares the modulation the constellation diagrams obtained for QAM-16 and QAM-64. As the constellations points are more spaced on the left, QAM-16 is less prone to a wrong demodulation (when noise will be added). This comes at the cost of a lower bitrate: for the same symbol rate, QAM-64 will send 6 bits while QAM-16 only send 4. It clearly shows a compromise between reliability and capacity.



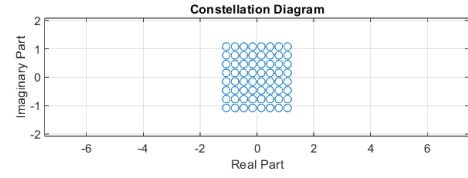
Mean Square Error: 0



(a) QAM-16 modulation



Mean Square Error: 0



(b) QAM-64 modulation

Figure 2: Comparison of QAM modulations, where the mean square error is computed between the transmitted and received bitstream

Pulse shaping

With modulation only, the bandwidth of the transmitted signal is infinite. This is problematic as it could interfere with neighboring channels. A filtering is applied to resolve this but the chosen filter must respect two other constraints: it must cancel inter-symbol interference (ISI) and must maximize the SNR.

The raised cosine filter is chosen as it limits the bandwidth and cancels ISI. To maximize the SNR, it is applied as a matched filter by using the square root of it at the transmitter and at the receiver.

The time domain and frequency domain representation of the raised cosine filter is shown in Figure 3. Figure 4 shows how the signal is shaped in the time domain and how there is indeed no ISI. Finally, the spectrum of the transmitted signal is plotted in figure 5 where the frequency band is limited to $[-3, 3]$ MHz.

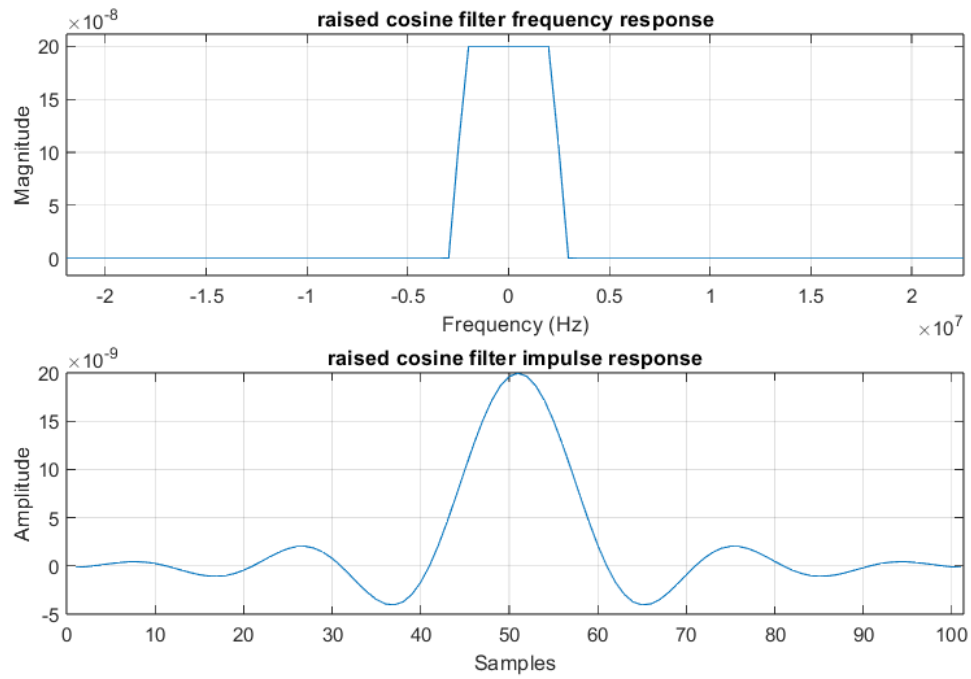


Figure 3: Time and frequency domain representation of the raised cosine filter

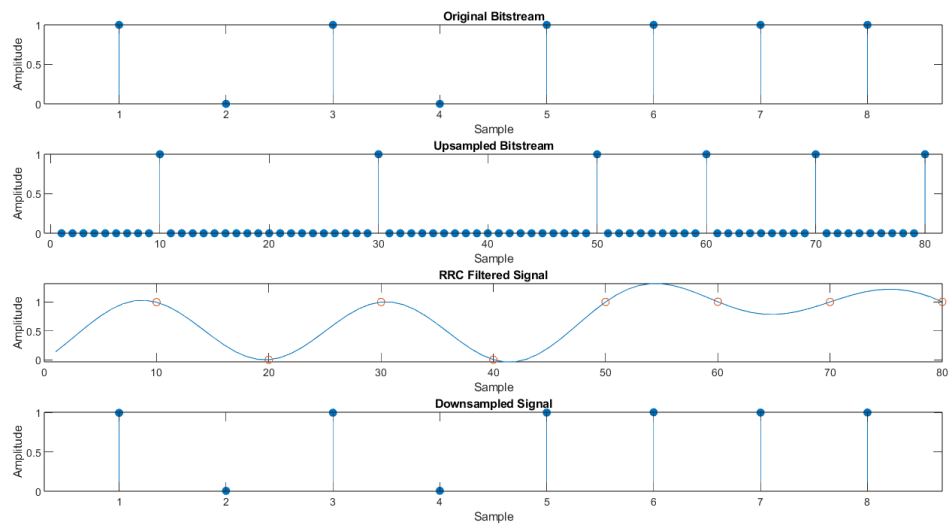


Figure 4: Pulse shaping with a raised cosine filter

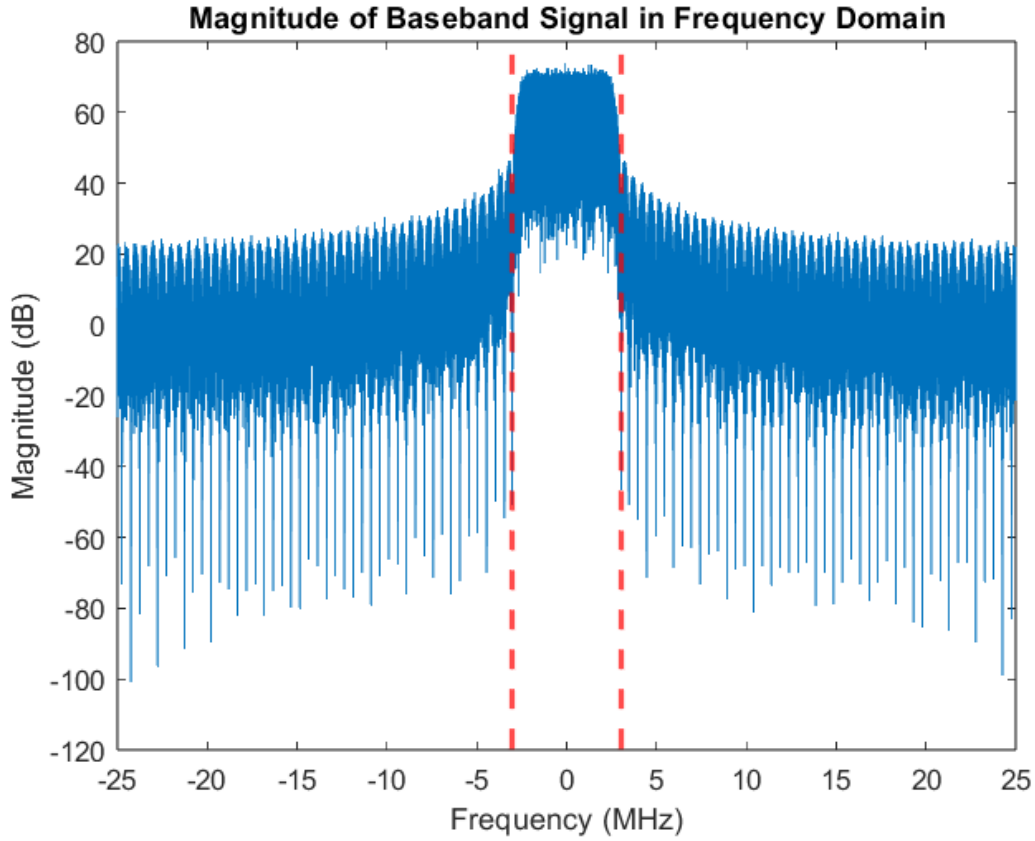


Figure 5: Spectrum of the transmitted signal after pulse shaping

Noise addition

The last building block is a noise source. It generates additive white Gaussian noise in baseband. When the signal is corrupted too much, the demodulation can fail. The BER curves are plotted in figure 6 and they show the impact of the noise power N_0 on the bit error rate. The compromise between reliability and capacity is again visible: in the same conditions (same E_b/N_0), a modulation with lower capacity will have a smaller BER.

The theoretical BER curves are plotted on figure 6 and are compared with the simulation results. They stay close to each other until the BER reaches 10^{-4} . This limit could go even lower by increasing the number of bits sent but we limited it to 10^6 in order for the code to run quite fast.

To impose a value of E_b/N_0 , we start by computing the energy of the transmitted signal before adding the noise. The power of the noise is then chosen as $N_0 = E_b / (E_b/N_0)_{\text{desired}}$.

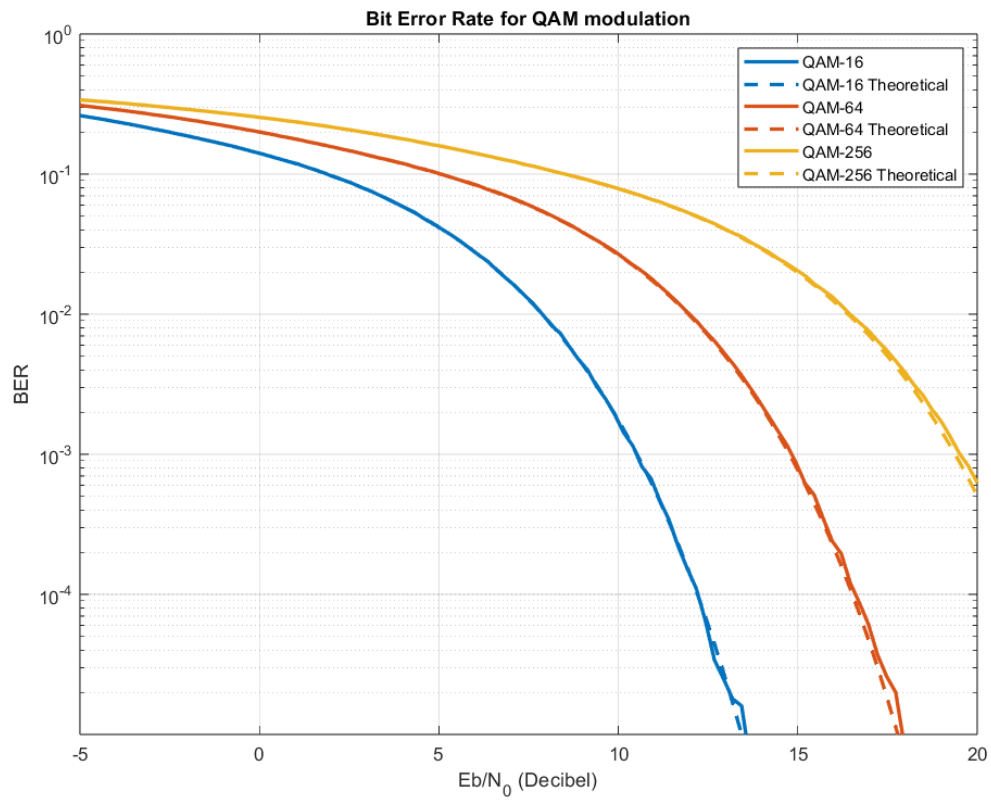


Figure 6: BER curves for different QAM modulations