Module IT.2407

2023 – 2024

Transmission Chain

Problem 1: Single carrier modulation

A text message is transmitted using a single carrier 16QAM modulation (illustrated in Figure 1) operating on a frequency carrier 800 MHz and within a bandwidth of 1 MHz. The data rate is 2Mbps.

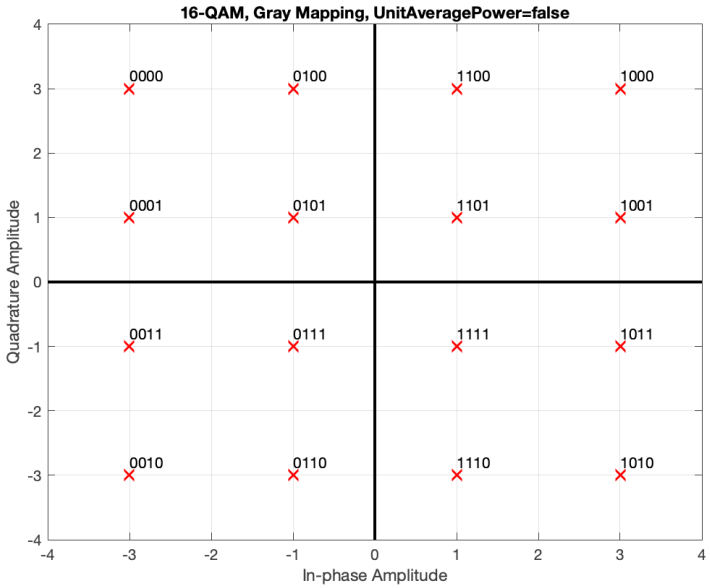


Figure 1: 16QAM constellation

The received text message over a wireless interface with SNR. = 1 dB is illustrated in Figure 2.

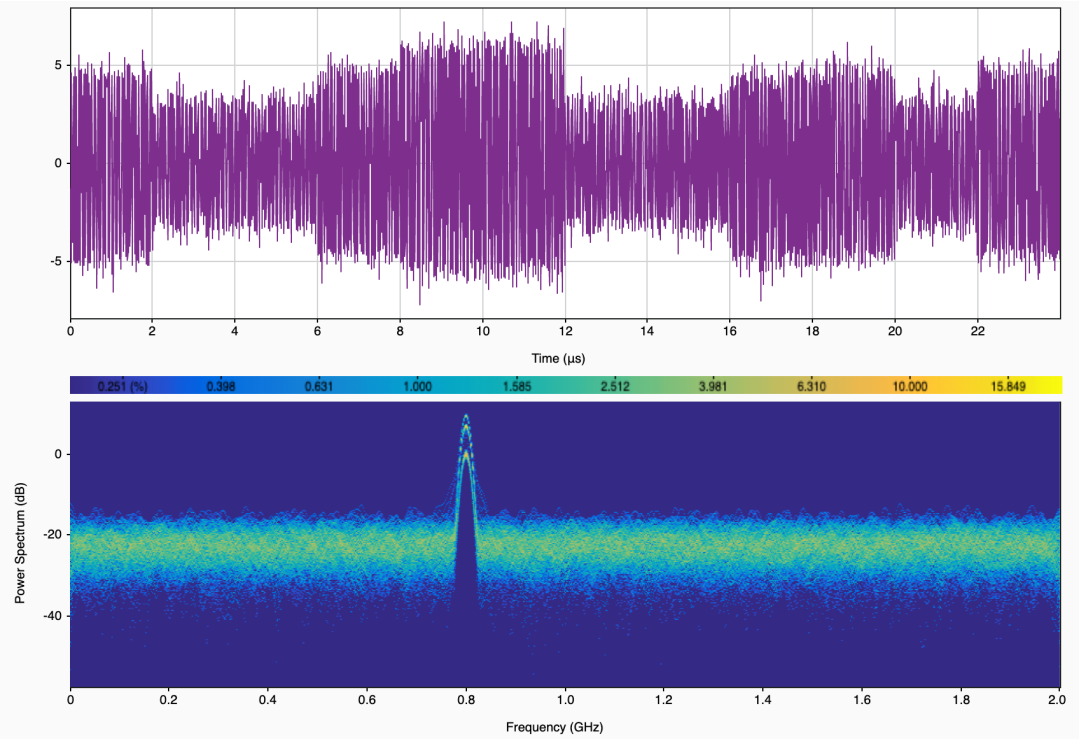
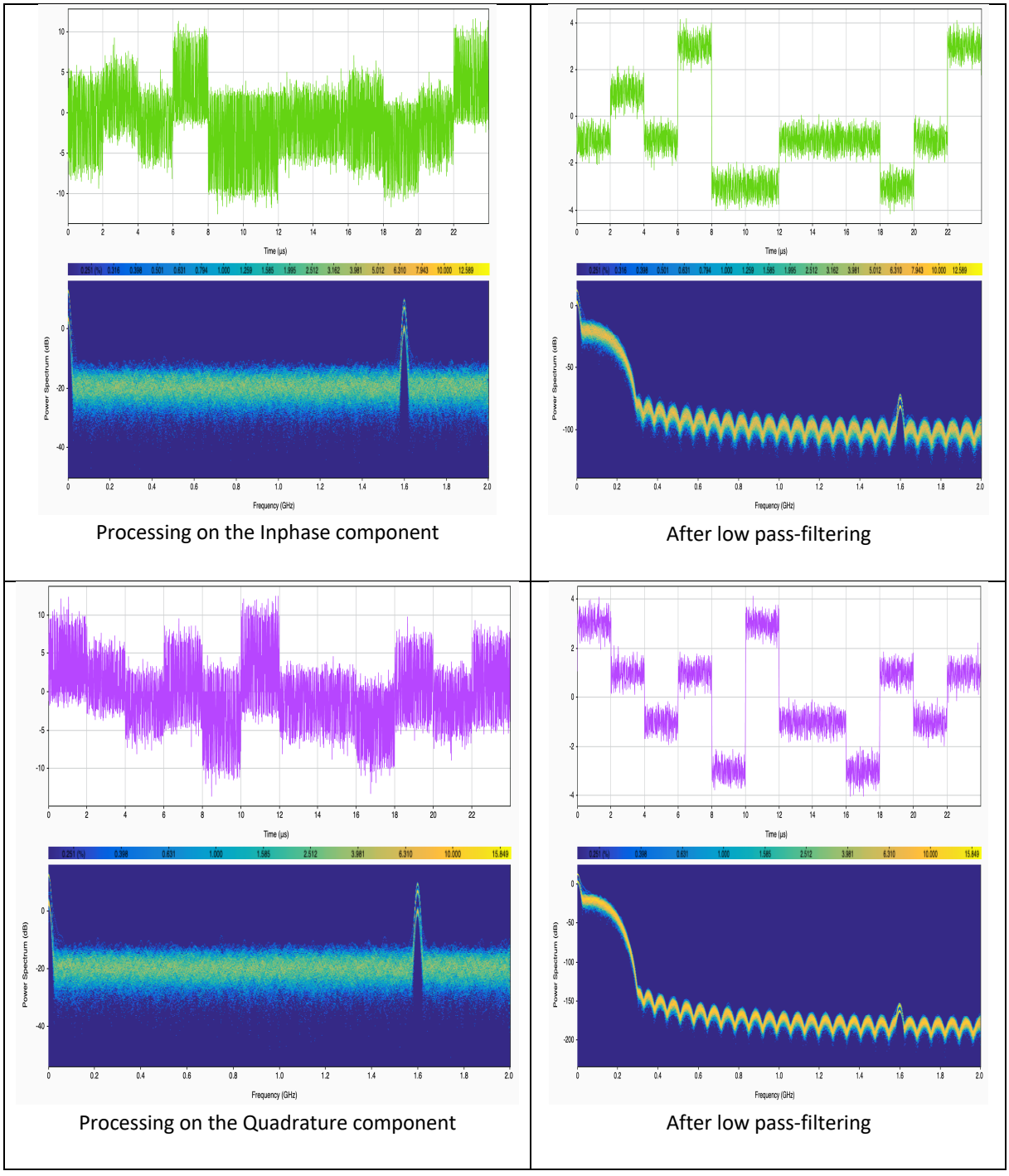


Figure 2: Received Signal

The different steps resulting from the processing of the signal are illustrated in Figure 3.



Processing on the Inphase component

After low pass-filtering

Processing on the Quadrature component

After low pass-filtering

Figure 3: Processing of the received signal at the demodulator

1. Recall how the demodulation is made to find back the signal.
2. Comment the processing of the received signal illustrated in Figure 2 at the reception.
3. Indicate the duration of the symbols and find back the 16QAM symbols.
1. Find the name of the song that was transmitted on the wireless interface. using the ascii decoder accessible on https://www.rapidtables.org/fr/convert/number/binary-to-ascii.html
   Important: Set the field Encodage de caractères (facultatif) to ASCII (THIS IS NOT DONE BY DEFAULT)

Problem 2: OFDM signal

We consider an OFDM system operating on the frequency 800 MHz. The total bandwidth of 1.4 MHz of is divided into N = 128 sub-carriers with spacing Δf. The total duration of the OFDM symbol carrying N symbols modulated with a 16QAM constellation (illustrated in Figure 1) is equal to T = N/Fs with Fs being the sampling frequency Fs = 1.92 MHz. The OFDM signal corresponds to a text message (in Figure 5) coded using an ASCII code, with an error correction code corresponding to a parity check code such that (b_0, b_1, b_2, b_3) → (b_0, b_1, b_2, b_3, $b_0 \oplus b_1 \oplus b_2 \oplus b_3$)

We recall that this OFDM signal with duration T. is:

$$x_e(t) = \sum_{k=1}^{128} (A_k \cos(2\pi f_k t) - B_k \sin(2\pi f_k t))\, rect(t, T)$$

with $f_1 = 800$ MHz and A_k and B_k correspond to the I and Q amplitude of the 32QAM symbols. The coded text message **occupies only 20 subcarriers**, and all other sub-carriers are left empty (meaning $A_k = B_k = 0$, for $21 \leq k \leq 128$).

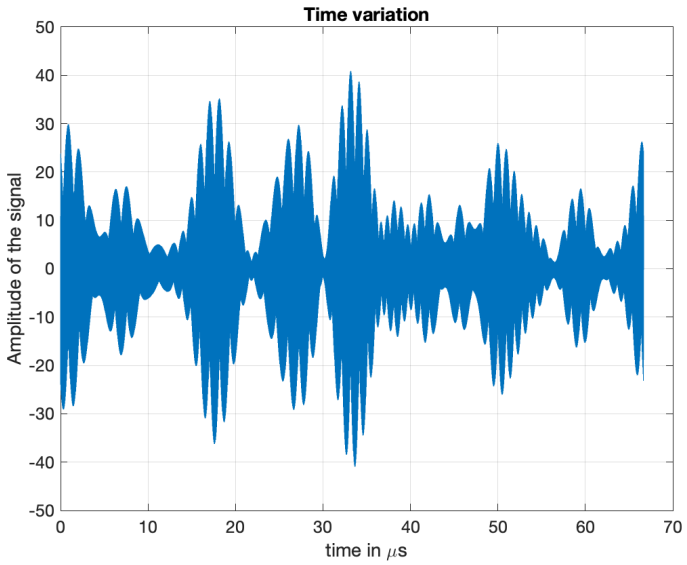


Figure 4: Time variation of OFDM signal

The spectrum analysis of this signal multiplied by 2 is a complex number. The real component of the Fourier Transform of $2\,x_e(t)$ is given in Figure 5:

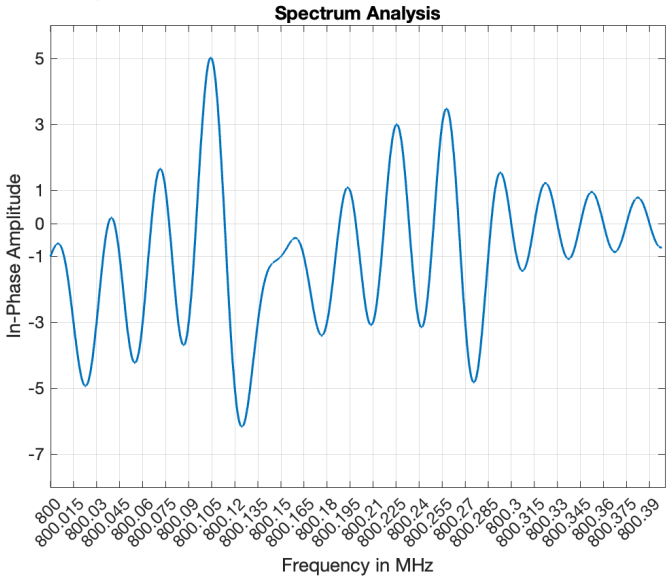


Figure 5: Real component of the Fourier Transform of 2xe(t)

And its imaginary component is given in Figure 6:

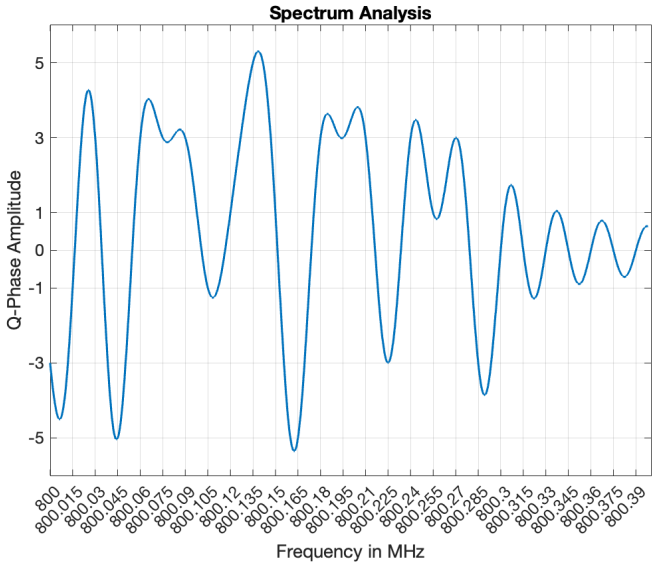


Figure 6: Imaginary part of the Fourier Transform of 2xe(t)

2. Find the spacing between the sub-carriers that guarantees orthogonal sub-carriers?
3. Find the data rate of this signal.
4. Using the spectrum analysis, find the 16QAM symbols transmitted in this message, and the corresponding binary message.
5. Remove the redundancy bits and find back the name of the song transmitted in this message using the ascii decoder accessible on https://www.rapidtables.org/fr/convert/number/binary-to-ascii.html
   Important: Set the field Encodage de caractères (facultatif) to ASCII (and not ASCII-UTF8 THIS IS NOT DONE BY DEFAULT)