université evry val-d'essonne
université PARIS-SACLAY

Lab n°2
Implementation of analog and digital modulations on a Fibula signal processing model

Objective:

In this lab we will study several types of modulations: AM, ASK and PSK. For this, we will use the DSP Kit of real time signal processing, rapid prototyping by graphic compiler Fibula G (Ref: ETD410000) whose diagram is the following (figure 1):

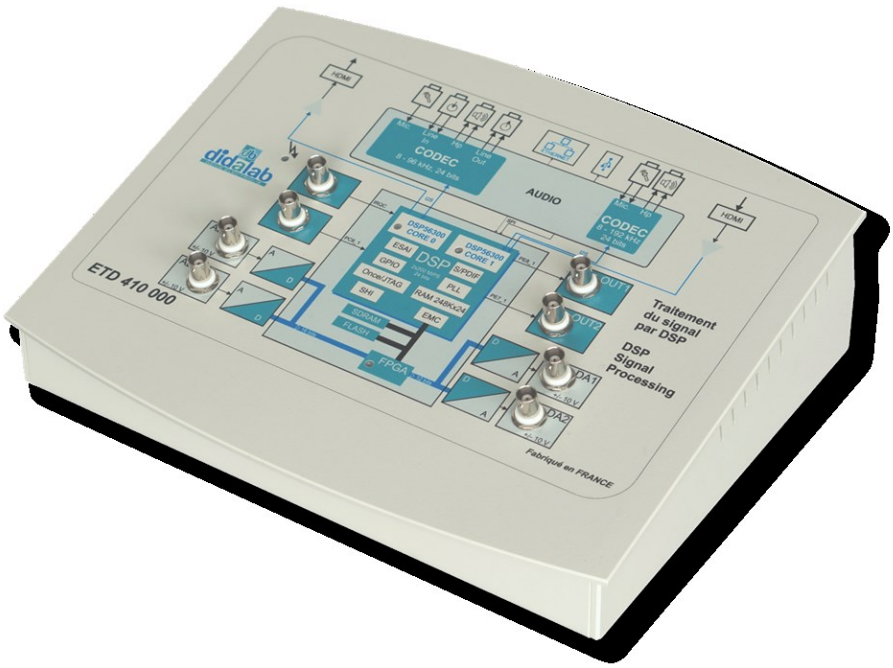

Figure 1: Fibula model

Getting started with Fibula: AM ANALOG MODULATION

Before starting the exercises on digital modulations, you are invited to study the AM modulation case which will allow you to better know the software.

The amplitude modulation consists in modifying the amplitude of a signal of high frequency (the carrier) by a signal of low frequency (the modulator). The obtained signal (the modulated) has an amplitude A(t) which varies depending on the characteristics of the modulator.

Launch the FIGRA software.

1- Modulation

Go to catalog then Arithmetic and click on the "mul" function then Demo.

You obtain the figure 2 which includes the following elements:

- The " Sample AD-DA " module (found in Analog InOut) determines the sampling frequency according to the Shannon theorem.

- The SCOPE module is the 8-channel virtual oscilloscope.

- The DA (Digital Analog) outputs allow the signals to be displayed on an external oscilloscope.

- The G_TRI and G_SIN blocks are function generators.

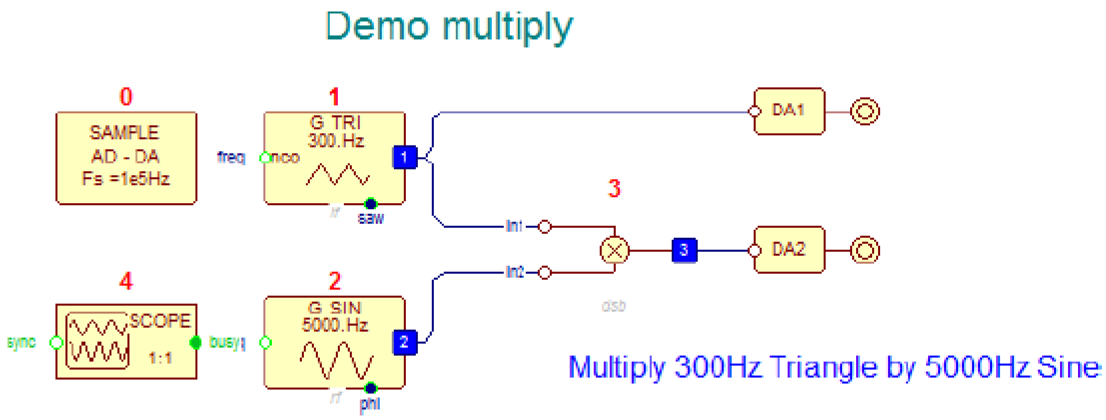

Figure 2: AM modulation scheme

Press the green arrow to compile the program and upload it to the DSP target card in real time.

Click on SCOPE to visualize the different signals. Analyze the obtained curves. Conclude.

Replace the triangular signal by a sinusoidal signal S1 with a frequency of 500 Hz (Catalogue Generators) then put a probe at the output of this signal. Set the frequency of the second signal S2 to 10 000 Hz.

- What does this scheme represent?

- Visualize the output signal of the multiplier Sm.

- Show the spectrum of the output signal Sm on an external oscilloscope, you can change the frequency fm =2kHz to better visualize the spectrum. Comment.

Visualize the spectrum on Fibula, following these steps:

- Delete the Sample block "AD-DA" and replace it with the "INTERRUPT" block

- Place the "Spectrum" block at the output of the multiplier

- Interrupt all other blocks (except the Spectrum block)

Read and comment the obtained spectrum.

2- Demodulation

Take the diagram in Figure 2 and complete it to recover the signal S2 from Sm (demodulation). Which method did you apply? Explain the different steps and justify your choice theoretically.

If you have chosen a demodulation method that requires a filter, you must study the influence of the choice of the cutoff frequency on the demodulated signal.

Compare the output signal with the initial low frequency signal. Conclude.

Note: *To modify the amplitude of a signal, simply multiply by a gain (go to Catalogue Arithmetic). You must choose the value of the gain such that you don't exceed the amplitude of 1V, otherwise there will be saturation, which is due to a limitation of the Fibula software.*

ASK DIGITAL MODULATION:

The modulating signal will be a binary NRZ signal and the modulations studied will be at a rate of 1 bit/symbol.

1. Modulation

The modulator is digital, of the form:

$$m(t) = \sum a_k g(t - kT)$$

The amplitude of the carrier will vary in ALL OR NOTHING. The modulated signal is given by:

$$s_{mod}(t) = \sum a_k g(t - kT)\cos(\omega_0 t + \phi_0)$$

Where $\mathbf{a_k}$ takes the value **0 or 1** (bits of the binary signal to be transmitted).

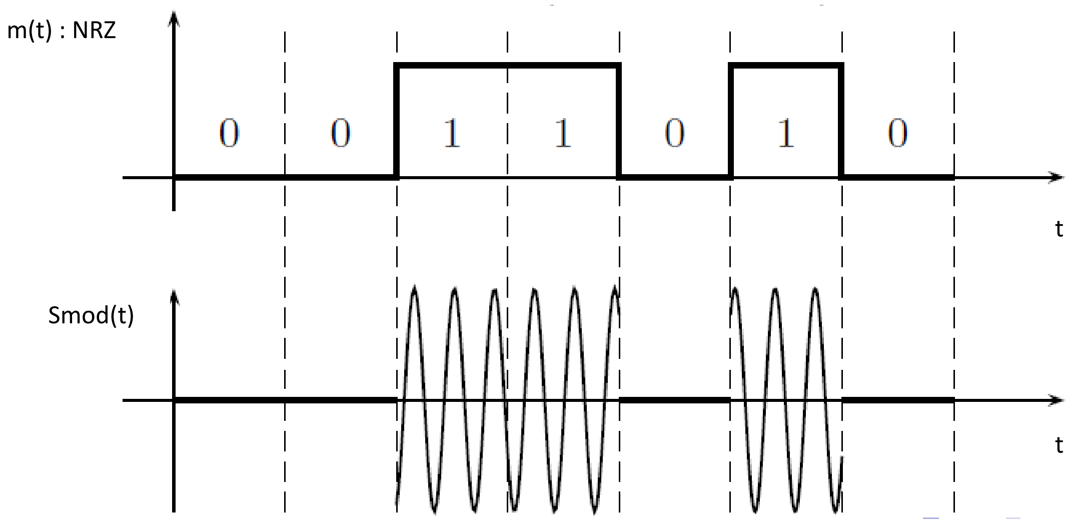

Figure 3: ASK timeline

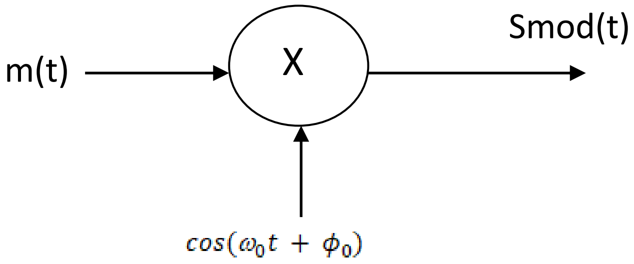

Figure 4: ASK modulator

2. *Demodulation*

The method used is the **coherent demodulation**.

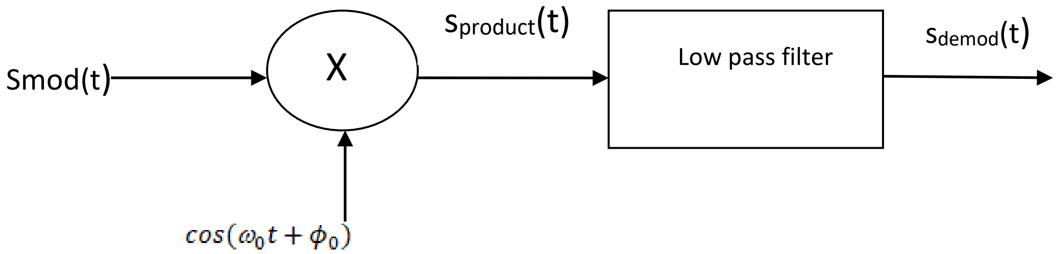

Figure 5: ASK coherent demodulator

Give the expression of the signal at the output of the demodulator, according to the input signal (you will develop the corresponding mathematical calculations).

3. *Implementation on FIBULA*

The details of the Message block and the block diagram are given below (figure 6 and figure 7).

Implement the diagram and give the time and frequency profiles of both the information and modulated signals. Analyze the results.

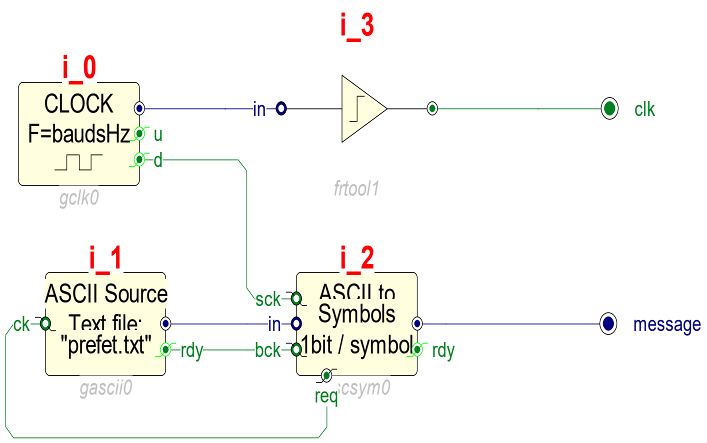

Figure 6: MESSAGE block

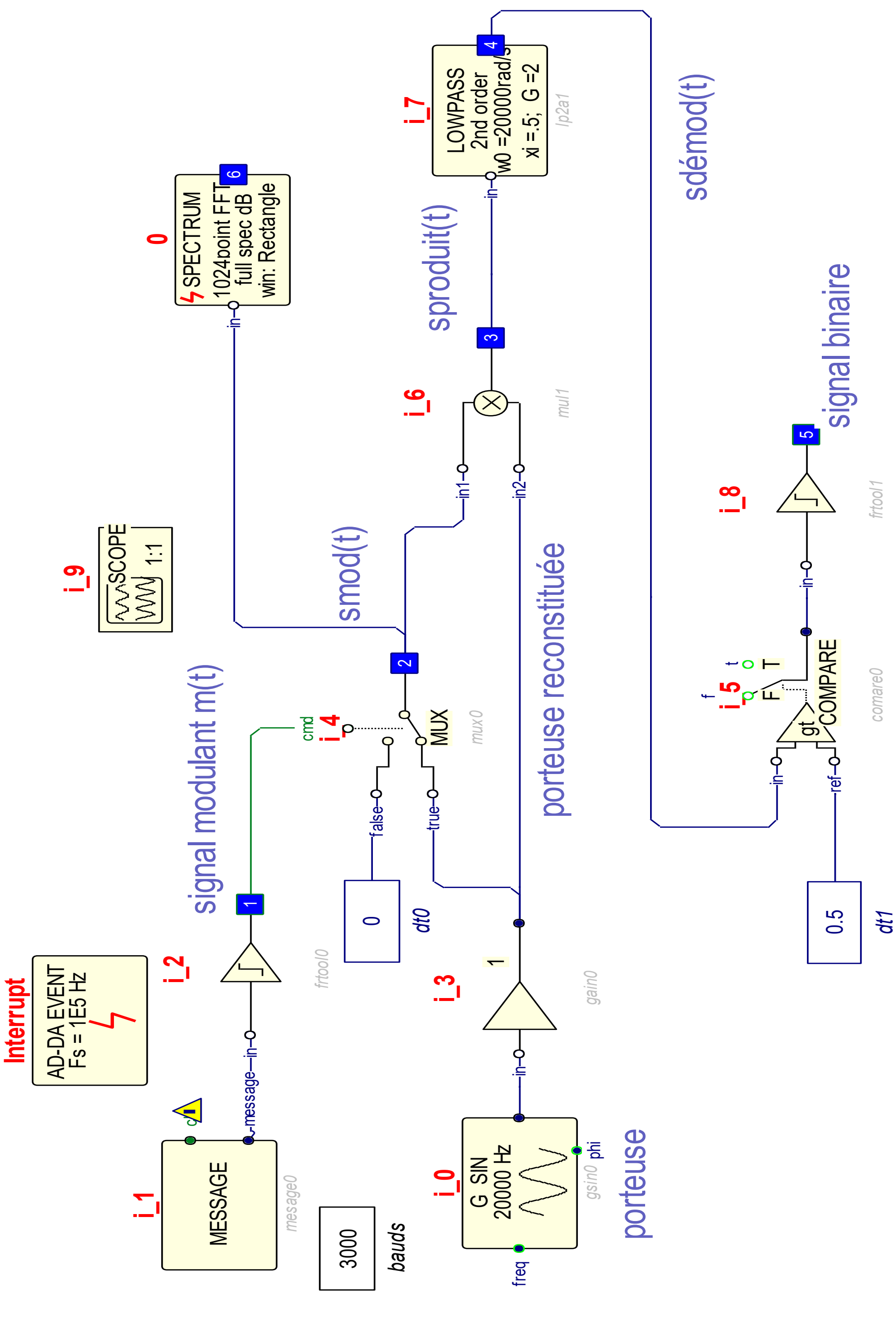

Figure 7: ASK modulator and demodulator

PSK DIGITAL MODULATION:

1. Modulation

The message is always in the form:

$$m(t) = \sum a_k g(t - kT)$$

This time the modulated signal is of the form:

$$s_m(t) = A \sum \cos(\omega_0 t + \phi_0 + \phi_k)$$

Example: the phase shift ϕ_k will have the following values :

$$\phi_k = \phi_0 + 0 = \phi_0 \text{ for } a_k = 0$$
$$\phi_k = \phi_0 + \pi \qquad \text{for } a_k = 1$$

It is possible to apply the opposite hypothesis.

This gives for the modulated signal the expression:

$$s_m(t) = A\sum cos(\omega_0 t + \phi_0 + \phi_k)$$

$$s_m(t) = A\sum \left(cos(\omega_0 t + \phi_0)\, cos\phi_k - sin(\omega_0 t + \phi_0) sin\phi_k\right)$$

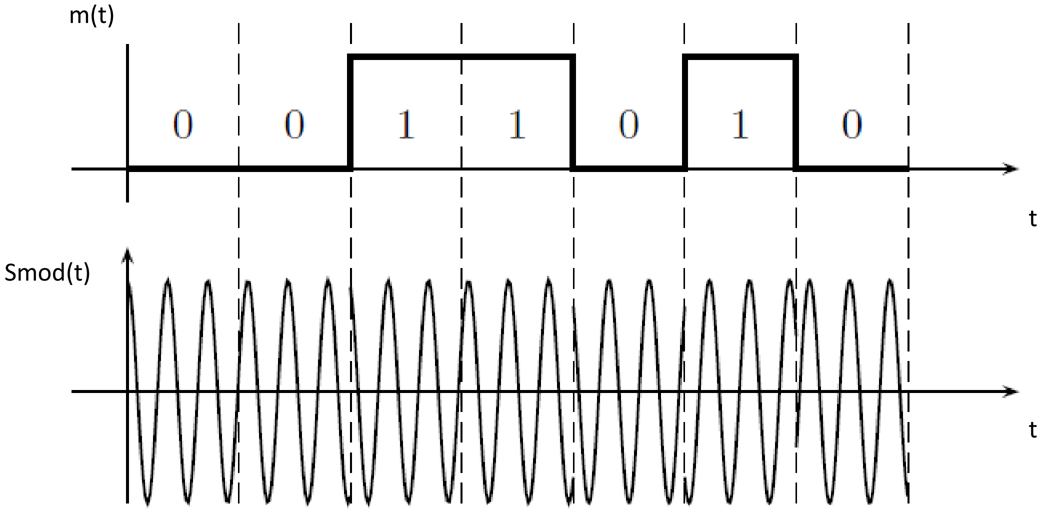

Figure 8: PSK timeline

2. Demodulation

The used methodology is also the **coherent demodulation**.

Give the expression of the signal at the output of the demodulator, according to the input signal (You will develop the corresponding mathematical calculations).

3. Implementation on FIBULA

Implement the diagram and give the time and frequency profiles of both the information signals and the modulated signals.

Analyze the results.

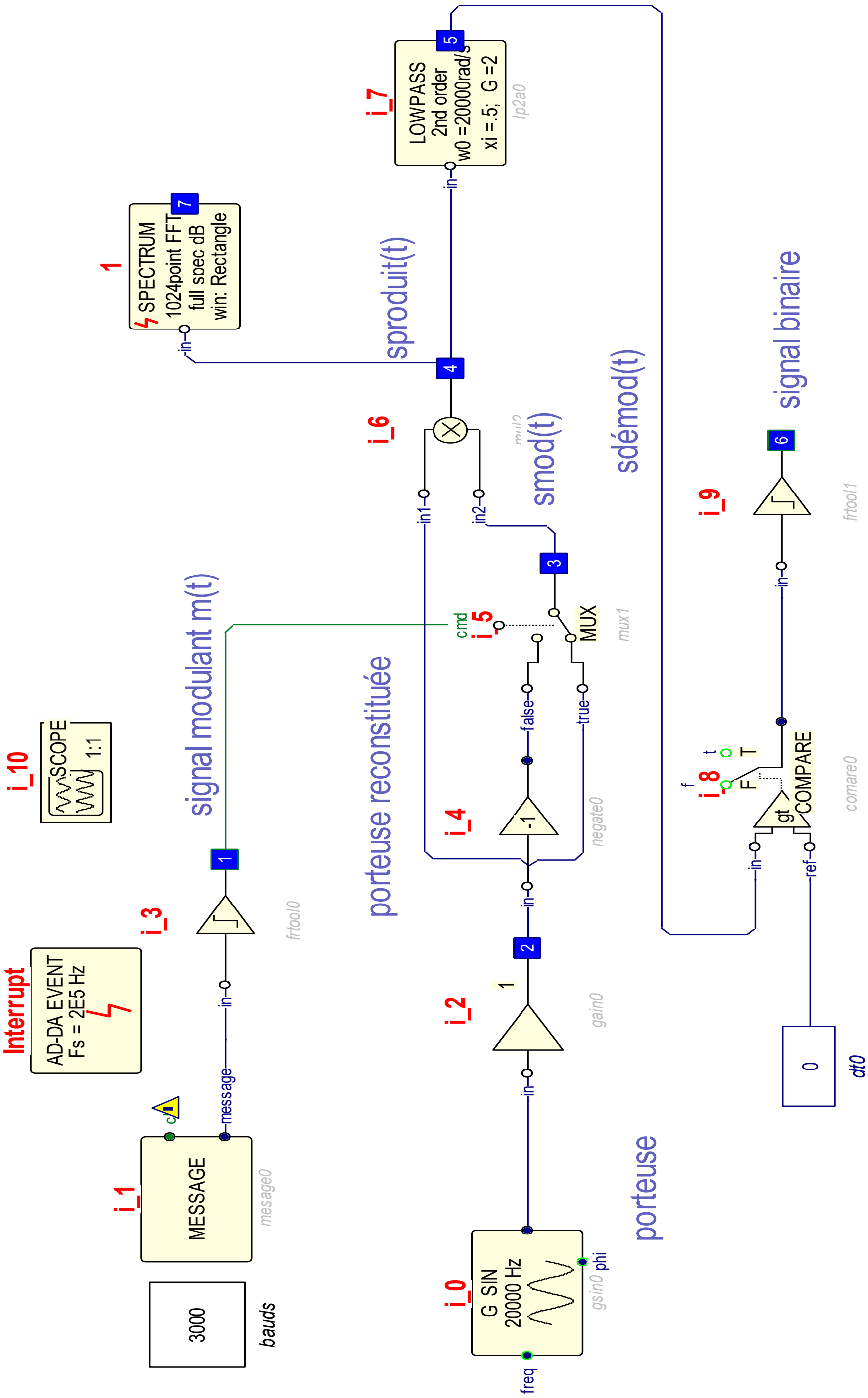

Figure 9: PSK modulator and demodulator