Digital Signal Processing Project
A.Y. 2018-2019

The file `signal_XXX.wav`, where `XXX` is the progressive number associated to the student name, contains a discrete-time signal of duration 42 seconds and with sampling frequency $F_s = 96000$ Hz.
It is a modulated signal (for double-sideband reduced-carrier transmission) of the form

$$y(nT) = \big(x_1(nT) + A_1\big)\cos(2\pi f_1 nT) + \big(x_2(nT) + A_2\big)\cos(2\pi f_2 nT)\,,$$

where $x_1(nT)$ and $x_2(nT)$ are two real audio information signals with frequency band $[20, 8000]$ Hz, f_1 and f_2 are the frequencies of the two sinusoidal carriers, where $10000 \text{ Hz} \leq f_1 < f_2 \leq 38000$ Hz $\big($frequencies f_1 and f_2 are chosen such that there is no frequency overlap between the two modulated components, and specifically such that $f_2 - f_1 \geq 17000$ Hz$\big)$, and A_1 and A_2 are the amplitudes of the carriers.

Write a MATLAB® procedure that finds the two carrier frequencies f_1, f_2 and their amplitudes A_1, A_2 by means of a DFT analysis, extracts the two sinusoidal carriers by means of appropriate filtering with two band-pass filters with very narrow bandwidths, and demodulates the two audio information signals $\big($multiplying the modulated signal by the previously extracted carriers and filtering the results with a band-pass filter having pass-band $[20, 8000]$ Hz$\big)$. The two resulting signals must be saved on the two channels of a stereo audio file in `.wav` format.

In particular the procedure must:

- read the file containing the input signal;
- compute the spectrum of the input signal;
- find the frequencies f_1 and f_2 of the sinusoidal carriers;
- find an estimate of the amplitudes A_1 and A_2 of the carriers;
- extracts the two carriers by filtering the input signal;
- demodulate the two information signals using the extracted carriers;
- design the filters so that the demodulated signals do not present audible distortions;
- report the design parameters of the filters and plot their frequency resposnses;
- compute the spectrum of the two demodulated signals;
- write the stereo audio file containing the two output signals.

The procedure must work in a completely autonomous way (no contribution from the user of any kind).

Hints:

The very narrow bandwidth bass-band filters required to extract the two carriers can be designed using simple second order IIR filters.
To implement the band-pass filter with passband $[20, 8000]$ Hz it is convenient to use the cascade of a low-pass filter (e.g., a linear-phase FIR filter) with appropriate attenuation in the stop-band (at least 80 dB), and of a high-pass notch IIR filter with a very narrow bandwidth to remove the DC component due to the carrier.
The low-pass filter can be designed using the MATLAB® command `firpm` in case of a linear-phase FIR filter.

It can be helpful to take a look at the MATLAB® procedures available at the WEB site of the course in the Section *Useful material / Matlab demos*.