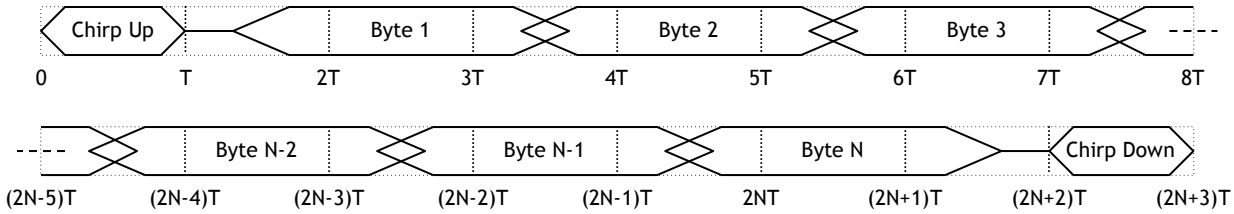
Use of basic signal processing tools to decode an OFDM message

The file "ofdm_1030_1240_rec.wav" contains a digital message that was transmitted acoustically between a source and a receiver. This message has been coded using OFDM. The goal of this assignment is to decode the message. The details of the message are:

- The message is composed of N bytes.
- The message was generated in base band in the [30, 240] Hz frequency interval and up-converted with a 1 kHz wave, occupying the channel band of [1030, 1240] Hz.
- The sampling rate of the message is 44100 Hz.
- The message is divided into blocks of T=33.(3) msec, corresponding to 1470 samples each and to 30 blocks per second.
- Each byte (8 bits) of the message is coded into one block using OFDM.
- The orthogonal frequencies are precisely {30, 60, 90, 120, 150, 180, 210, 240} Hz in base band, the first corresponding to the most significant bit and the last to the least significant bit.
- Presence of the each frequency, regardless of phase, stands for "1" and absence stands for "0".
- Between two blocks corresponding to consecutive bytes an interleaving block is inserted, to avoid inter-symbolic interference due to multipath. In these interleaving blocks the first half of the previous block and the last part of the following block are repeated, with a smooth transition between them. Therefore, the data rate is 15 bytes per second (120 bits per second).
- At the beginning of the message a synchronization signal is inserted, in the format of a linear chirp between 30 Hz and 240 Hz (upwards). Another chirp (same frequencies, downward direction) is inserted after the message.
- Interleaving blocks are also inserted between the chirps and the byte coding blocks.
- The upward and downward chirps are contained in each of the two channels of the file "ofdm_1030_1240_chirps.wav".

Here is a diagram of the message structure:



Suggestions to decode the message:

- Multiply the signal by a 1 kHz complex sinusoid;
- Low pass filter the result to obtain the base-band (complex) signal;
- Correlate with the two chirps to synchronize the message and determine the number of bytes;
- Select the samples corresponding to each block/byte;
- Compute the discrete Fourier transform of each selected block and register the absolute values for frequencies {30, 60, 90, 120, 150, 180, 210, 240} Hz;
- Find a decision value for the presence of each frequency;
- Convert presence of each frequency into bits and assemble bits into bytes.