

1) Chirp compression. In the computer, create a data record consisting of 2048 complex samples, which contains a chirp signal with the following parameters:

$$\begin{aligned}\text{Slope (s)} &= 10^{12} \text{ Hz s}^{-1} \\ \text{Pulse length } (\tau) &= 10^{-5} \text{ s} \\ \text{Sample rate (fs)} &= 10^8 \text{ Hz}\end{aligned}$$

Position the chirp at the beginning of the array, zero-filling the unused portion.

a) Plot the chirp spectrum in the form $20 \log (|S(f)|)$ vs. f . We will call this form a dB plot. Identify the bandwidth with the frequency axis values implied by the sample rate and compare to the theoretical bandwidth.

b) Compress the chirp with a perfect reference signal. Plot the main lobe of the response plus several (<5) sidelobes on both sides of the main lobe on a dB plot. What is the relative height of the first sidelobe compared to the main lobe?

c) Repeat (b) for a reference chirp with $s = 1.01 \times 10^{12} \text{ Hz s}^{-1}$ and also with $s = 1.03 \times 10^{12} \text{ Hz s}^{-1}$.

2) Separating multiple chirps. Using the chirp parameters given in (1) above, create a signal record consisting of the sum of 3 chirps, one beginning at location 100 in the array with amplitude 1, the second beginning at location 400 with amplitude 5, and the third beginning at location 500 with amplitude 2.

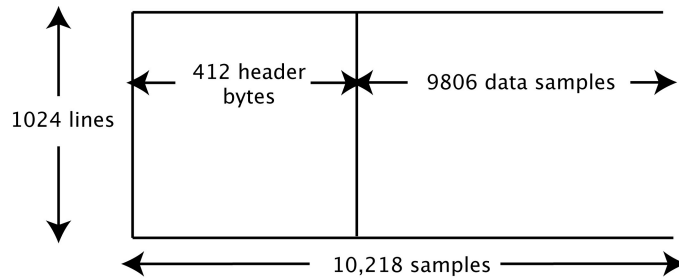
a) Plot the raw signal amplitude vs. time and comment on the separability of the chirps.

b) Compress the signal by correlation with an ideal reference function. Plot the result on a linear scale and again comment on the chirp discrimination.

3) Actual data. Download to your computer a data file containing actual data from the ERS satellite. The data file is available on the class web site under the Homework tab, for Homework 2. The file name is "ersdata". You may also want to download the fft routines in C or Fortran available under the software tab.

The file consists of 1024 lines of 10,218 samples each, each sample being one byte in size. ERS data are quantized in complex (I/Q) format to 5 bits, with an average value of 15.5.

a) Display this byte file on your screen and observe the 412 bytes preceding the actual data, as in this picture:



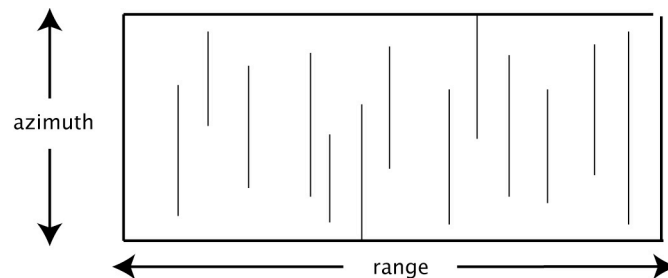
b) The ERS chirp parameters are

$$\begin{aligned} \text{Slope (s)} &= 4.189166 \times 10^{11} \text{ Hz s}^{-1} \\ \text{Pulse length } (\tau) &= 37.12 \times 10^{-6} \text{ s} \\ \text{Sample rate (fs)} &= 18.96 \times 10^6 \text{ Hz} \end{aligned}$$

Plot the chirp spectrum for these parameters.

c) Average the 1024 spectra in the ersdata file, excluding the header data. Plot the result and compare to your plot from (b).

d) Compress each range line and create a “range-compressed” image by stacking each processed line to form a two-dimensional array, and display the result. You should see something like this:



In other words, there is a lot of detail in the range direction but not much in azimuth. Submit your solution as a tiff image file electronically.

4) I/Q and offset video processing. Consider a chirp signal with the following parameters:

Chirp slope: 10^{11} Hz/s
Pulse length: 30 μ s
Sample rate f_s : 20 MHz
Center frequency f_c : 10 MHz

a) Assume an I/Q system and that the chirp is centered at the carrier f_c . Compress the chirp and plot the impulse response.

b) Now, assume you are using an offset video system. What are the maximum and minimum chirp frequencies? Double your sample rate to 40 MHz, create a real (imaginary part zero) chirp, and compress it. Plot your impulse response. How similar is it to your answer in (a)?

5) Sidelobe filtering.

What are the peak and integrated sidelobe levels for the chirp in problem 4 above?

Now, weight the chirp according to $w + (1-w) \cos()$. Let w vary from 0.4 to 1 (1 is no weighting). Plot the ISLR and PSLR as a function of w . What w minimizes these?