Lab Session 4: IF Signals Correlations

Laboratory on digitalized navigation signal, correlation and serial acquisition

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Wipe-off, correlation and serial acquisition

Objective:

The goal of this lab exercise is to implement the **acquisition stage** of a GNSS receiver.

Notes:

Download the additional material from Portale della didattica.

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Step 1: generation of the GNSS carrier

TASK

1

Write a Matlab function able to generate a carrier used to perform the down-conversion of a GNSS signal from the receiver Intermediate Frequency (IF) to base band.

Hint: use the following prototype

```
function carrierOut = generateLocalIF(samplingFreq,
IntermediateFrequency, ...)
```

where:

- `samplingFreq` is the sampling frequency, in Hz;
- `IntermediateFrequency` is the frequency of the IF carrier, in Hz;
- `carrierOut` is the generated sequence of samples; each sample is a complex number where the real part is the cosine, and the imaginary part is the sine;
- `...` includes other possible parameters, such as the number of samples OR (equivalently) the signal length to be generated.

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Step 1: generation of the GNSS carrier

Consider the following parameters:

- IF carrier frequency: 4.092 MHz
- Sampling frequency: 16.368 MHz
- Doppler (fixed): 0 Hz
- Amplitude: $\sqrt{2}$
- Signal length (time): 1 ms (equivalent to [?] samples)

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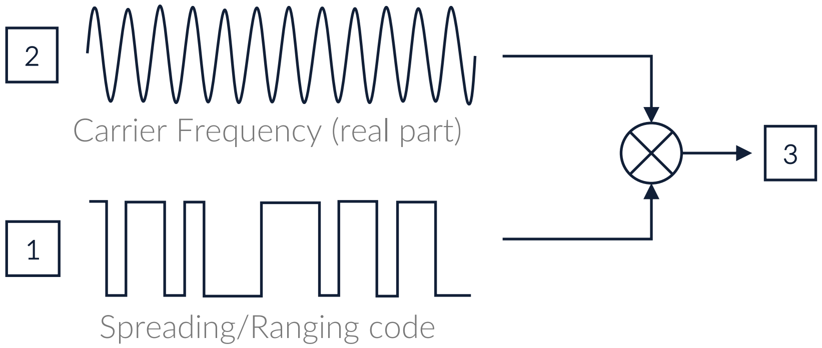
Step 2: Signals in time and frequency

TASK
1

Visualize the following signals in time and frequency domain and comment the results obtained.

1. the code generated in Lab 3, Step 4;
2. the carrier (real part) generated at the Step 1 of the current Lab;
3. the product between the code and the carrier

Note:
To plot the signal in frequency domain use the `pwelch` function already considered in Lab 3, Step 5.



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Step 3: Correlations

The correlation stage of a GNSS receiver can be implemented by means of different strategies: **linear**, **circular**, and **FFT-based** correlation.

In **Lab 3**, **Step 2**, you already wrote **linear** and **circular** correlation function, to evaluate the **auto-correlation** and **cross-correlation** between two sequences. In this lab you are requested to compute the **circular** and **FFT-based** correlation with a "received" unknown sequence.

The "received" unknown sequence (`codeReceived.mat`) can be downloaded from the *Portale della didattica* and loaded to your MATLAB workspace.

The local sequence can be generated using your own `GenerateLocalCode` function, according to the following parameters:

- **sampling frequency**: 16.368 MHz
- **code rate**: 1.023 MHz
- **signal length**: 1 ms

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Step 3: Correlations

TASK 1 Compute the **circular** and **FFT-based** cross-correlation, between the received sequence and a local code.

TASK 2 Determine which PRN code is "hidden" in the received sequence and the delay of the received code.

TASK 3 Analyse, compare and comment the results of the two different strategies.

Notes and hints (circular correlation function):

- do not use the Matlab function `xcorr`, use your own script from Lab 3;
- implement a for loop to compute the multiply-and-sum operation of the two sequences: each iteration produces one value of the output sequence;
- when performing circular correlation, you can circularly shift one of two sequences, or you can "circularly" insert a certain number of samples at the end of one sequence, to simplify the computation.

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Step 4: Serial acquisition

TASK 1

Write a Matlab function able to acquire an ideal GPS signal using the serial acquisition scheme.

1. Read the GNSS raw IF signal samples;
2. Create local carrier and code;
3. Perform serial acquisition;
4. Plot cross ambiguity function in the search space.

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Step 4: serial acquisition

Hints:

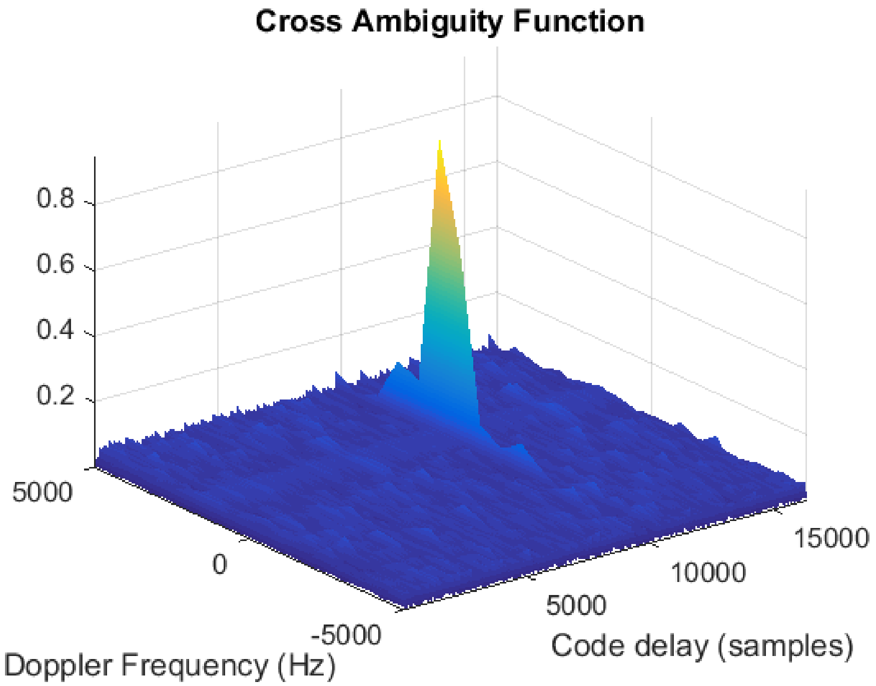
- You can use the GPS codes generated in Lab 3, as well as the `GenerateLocalIF` and `GenerateLocalCode` functions already coded.

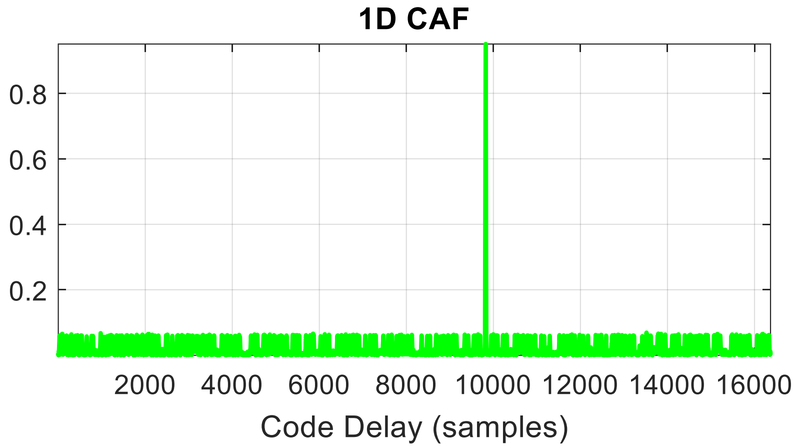
Signal parameters:

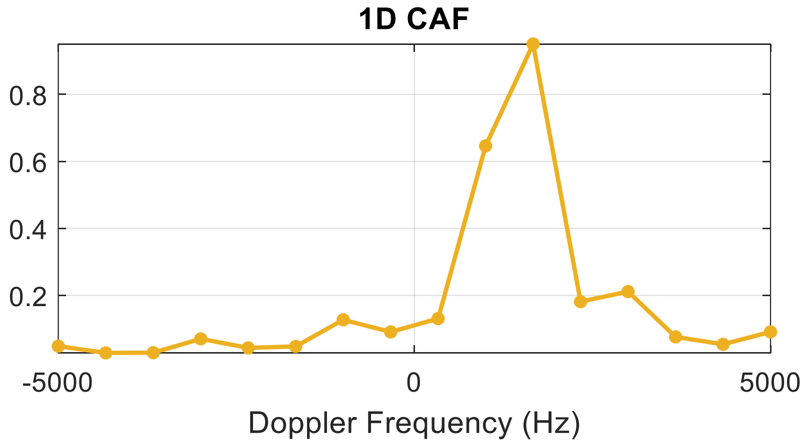
- The raw IF GPS signal is available on the *Portale della didattica* (`SignalRX_1.bin`).
- The signal is ideal (no noise, no navigation message, no front-end filter).
- The parameters of the signal needed to perform acquisition are:

Signal length	50 ms
Signal type	double
Sampling frequency	16.368 MHz
IF frequency	4.092 MHz
Constellation and signal	GPS L1 C/A
PRN	5
Coherent integration time	1 ms

Step 4: example of results







How to read IF samples data

```
fileName = './SignalRX_1.bin';
[fid, message] = fopen(fileName, 'rb');

samplesToRead = ...;
[rawData, cntData] = fread(fid, samplesToRead, 'double');
fclose(fid);
```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