CIE-442: Digital Signal Processing

Project 2

Submission Deadline: Week 14 [Dec 31, 2022]

Main Objectives:

- Understanding Software Defined Radio (SDR).
- Preparing an informative presentation about SDR.
- Implementing and documenting basic tasks related to SDR.

Part I (Presentation) [5%]:

In this part, each team is required to prepare a presentation about Software Defined Radio (SDR) after reading carefully the document "SDR_basics.pdf" and watching this video:

https://www.youtube.com/watch?v=BK9QkHxeYQI

Part I - Grading Rubric:

- Each member can get a total maximum of 15 points for the presentation which will be scaled to and approximated to **5%**.
- All the points will be equally assigned to the team members except the 'individual' ones, which will discriminate each member.

Criteria	Details
Technical Content	1. Showing understanding of the role of sampling in SDR systems including the undersampling technique. **(1 point)** 2. Covering both SDR transmitter and receiver block diagrams and highlighting the main differences. **(1 point)** 3. Specifying the core steps of digital up and down conversion processing while commenting on the main differences. **(2 points)** 4. Elaborating the role(s) of DSP in SDR systems. **(2 points)** 5. Mentioning the common filters used in SDR systems including their types, main principle, usage, and inputs/outputs. **(2 points)** 6. Proper selection for the concepts, laws, mathematical equations, and visuals appropriate to the topic. **(1 point)**
Organization	1. All the team members participated in the presentation. **(0.5 point)** 2. Fair content distribution among the team members. **(0.5 point)** 3. Sufficient time management; the time distribution of the presentation parts should be proportional to the content. **(0.5 point)** 4. Commitment to the predefined presentation time [**10 ~ 15 min**.]. **(1 point)** 5. Relevant slides content to the speech. **(0.5 point)**
Presentation Quality	1. Maintaining adequate speaking speed and clear voice [avoid noisy background]. **(1 point) (Individual)** 2. Well preparation and clear delivery. **(1 point) (Individual)** 3. Clear fonts within the slides. **(0.5 point)** 4. Using visuals within the slides if needed. **(0.5 point)**

Part II (Implementation) [5%]:

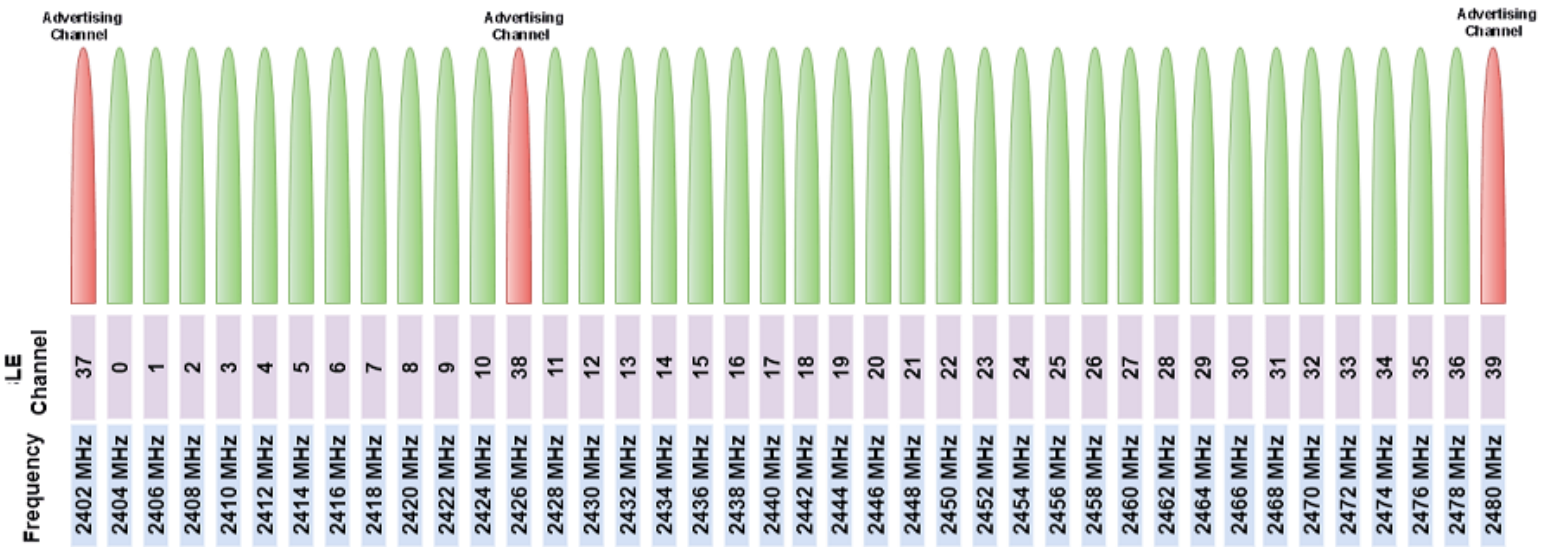
In this part, coding tasks related to SDR are required starting from handling two baseband signals to just upsample, interpolate, then digitally upconvert to two different frequencies, add noise, and receive via reverse processing and selection of the desired channel. You should plot the spectrum of the signals at different stages.

Please read the following requirements carefully.

Required Tasks

It is required to implement and document the following tasks:

1) **Transmitter** (Refer to Transmitter Block Diagram in SDR_basics.pdf)
    a) Generate **Bluetooth Low Energy** (**BLE**) waveform with **samples per symbol** (**SPS**) = **8** using the provided function *generateBLEWaveform(SPS)*. It returns the **baseband waveform** and the **sampling rate** f_s .
    b) Implement a **Digital Up Converter (DUC)** consisting of:
        i) **Interpolation Filter** (Try to implement trigonometric interpolation)
        ii) **Digital Mixer**
    c) You should perform Digital Up Conversion on the signal to generate **RF signal** and be able to be sent on **the channel number corresponding to your group number** i.e. group 1 should transmit a signal centered in channel 1 according to the **BLE spectrum** shown in Figure 1**.**
2) **Channel**
    a) Simulate an **Additive White Gaussian Noise (AWGN)** Channel by injecting AWGN on the signal.
3) **Receiver**
    a) Implement a **Digital Down Converter (DDC)** consisting of:
        i) Digital Mixer
        ii) Low Pass Decimation Filter
    b) You should perform Digital Down Conversion on the signal to return it to the baseband signal with similar samples per symbol.



Part II - Grading Criteria (0.5 each):

1. Determining the appropriate new sampling rate for conversion with justification.
2. Plotting the generated signal vs the upsampled interpolated signal (baseband) on the same plot in time domain.
3. Plotting the generated signal vs the upsampled interpolated signal (baseband) on the same plot in frequency domain.
4. Determining the Bandwidth of the baseband signal.
5. Determining the appropriate carrier frequency for the specified channel.
6. Plotting the baseband vs RF signal in the time domain.
7. Plotting the RF signal in the frequency domain showing the frequencies in Hz on the x-axis.
8. Designing the Low Pass Filter.
9. Plot the Received baseband signal before and after filtering.
10. Plot the filtered and decimated baseband signal vs the originally generated signal.

Important Notes:

- Team members are maximum **3**.
- There will be another **5%** for the individual discussion at the end of the semester.
- Any plagiarized codes or documentations, either fully or partially, will receive **zero** as final project grade.
- A documentation of your implementation tasks is a mandatory requirement in this project (submissions without documentation will not be accepted). The documentation is required along with the code itself using **MATLAB Live Editor and transforming it also to PDF format**. In the documentation, you should explain clearly all your used modules and their corresponding inputs, outputs, internal variables, etc., and how they map to the implemented task. You should also display the relevant outputs in your live editor according to the tasks described above.
  This is a short video about the MATLAB live editor:
  https://www.youtube.com/watch?v=bu4g8ID3aEk