- Please form a group of 3 to 5 people and email me the list of group members by next Wednesday (15 Azar). Designate one person as the group coordinator who will email me, cc'ing the other group members. My email address is mojahedian@sharif.edu.
- In your email, please choose one of the following two topics.
- This is the first phase of the project. In this phase, you will find the answers to the questions I mentioned for each topic. In the second week of Dey, we will arrange a meeting where I will ask you about the details. Please use the references mentioned for each project, search the internet, and utilize ChatGPT to find and understand the answers. I encourage members to help each other understand the answers.
- For the second phase of the project, you need to simulate a communication system using MATLAB and also provide a 4-page report in English (using ChatGPT) with the details I will mention later.
- Phase 1 and 2 of the project collectively constitute 15% of your grade. The grading will be relative to the best group grade. The best group (or groups) will receive the full score, and the remaining groups will be assigned scores relative to the best group.
- Project 2 is slightly more challenging. To provide extra motivation, it carries an additional 0.5 points. Moreover, for the best effort in this project, I will assist in developing a paper later on.

1 Phase-Locked Loop (PLL)

Please find the answers to the following questions:

- In your course, you become familiar with two applications of PLL: coherent detection of amplitude modulations and demodulation of FM. What are the other applications of PLL?
- Assuming the loop filter transfer function is denoted by

$$H(s) = \frac{1 + \tau_1 s}{1 + \tau_2 s}, \tag{1}$$

  what is the closed-loop transfer function? You can refer to Section 5.2.1 in "Communication systems engineering" written by Proakis and Salehi for more details.

  - Analyse The resulted second-order closed loop transfer function? (bandwidth, stability, ...)

  - To ensure the stability of a feedback system, what condition should be satisfied? (Discussion from the linear control course)

- What are the definitions of the hold-in and capture ranges?
- If we intend to utilize a PLL for the demodulation of FM, what design parameters should we take into consideration? How are these design parameters related to the components of the PLL? Please provide a comprehensive list of design parameters.
- Provide instructions for designing a PLL.
- Do PLL or FM demodulator blocks exist in MATLAB? If yes, what are their parameters?

2 Frequency-Modulated Continuous-Wave Joint Radar and Communications

- How does FMCW help in finding the distance and Doppler of an object? We can design an FMCW signal to have a defined accuracy for Doppler and delay. Learn about this design procedure. Please refer to the YouTube videos.
- How can we utilize an FMCW signal for both communication and radar purposes? Please carefully read this paper.
- What is the concept of index modulation?
- Can you propose a novel scheme for embedding bits in radar signals?