This project aims at practice of the various techniques of CDMA we learnt in class. Three signal sets will be given with a single user, 3 users and 5 users, respectively. The goal is to detect the information data for user 1 in these three signal sets using Matlab simulation. The tasks include demodulation, PN code acquisition and detection.

- Known nature of signal set 1:
  - Modulation format: BPSK with square signal pulses (and square chip pulses as well). The binary information data $a_k \in \{0, 1\}$ are translated to $d_k \in \{+1, -1\}$ s.t. $d_k = (-1)^{a_k}$.
  - The packet of data starts with a known 13-bit preamble which is the Barker sequence:
    $$Barker = (+1, +1, +1, +1, +1, -1, -1, +1, +1, -1, +1, -1, +1).$$
  - Following the preamble are 60 differentially encoded data bits $b_k, k = 1, 2, \cdots, 60$:
    $$b_k = d_k b_{k-1},$$
    where $b_0 = 1$.
  - The packet is DS-spreaded with an m-sequence $C$ of length $N = 15$:
    $$C = (-1, -1, -1, -1, +1, +1, +1, -1, +1, -1, +1, -1, -1, +1, -1, +1).$$
  - It is single user with narrowband interference $J(t)$ and white Gaussian noise $n(t)$ (in complex envelop):
    $$R(t) = S(t)e^{j\theta(t)} + J(t) + n(t),$$
    where $\theta(t)$ is a random phase noise that is slow time-varying.
  - The data and the preamble are sampled at a rate of $Q = 5$ samples/chip. The entire packet contains 5700 samples.

- Known nature of signal set 2:
  - There are three users with perfect power control. There is no narrow band interference, but each user suffers from MAI from the other two users:
    $$R(t) = \sum_{k=1}^{3} S_k(t)e^{j\theta_k} + n(t),$$
    where $\theta_k$ is the phase delay for user $k$ and it remains constant during the entire transmission.
The signaling format is exactly the same as signal set 1 except that the spreading code for user 1 (the desired user) is a Gold sequence of length $N = 15$ instead of an m-sequence:

$$C_1 = (-1, +1, +1, +1, -1, +1, -1, -1, -1, -1, -1, -1, +1).$$

The two interfering users have PN codes given by

$$C_2 = (-1, -1, +1, +1, -1, -1, +1, +1, -1, +1, -1, +1, +1),$$
$$C_3 = (-1, -1, -1, +1, -1, -1, -1, -1, -1, +1, +1, +1, -1).$$

User 1 starts transmission with the same Barker sequence as in signal set 1, but none of the interfering signals have this Barker sequence at the beginning of their transmission.

Transmission of the three CDMA users’ signals is asynchronous and the SNR for the desired user signal is approximately 30 dB.

- Known nature of signal set 3:
  - Signal set 3 has almost the same environment as signal set 2 except that the number of users is increased to 5. The additional two interfering users use the following PN code sequences:
    $$C_4 = (+1, -1, -1, -1, -1, -1, +1, -1, -1, +1, -1, +1),$$
    $$C_5 = (-1, +1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1).$$

You are requested to detect the information data for user 1 in the three signal sets. You need to choose appropriate timing estimation methods (conventional correlator PN code acquisition, MMSE, MUSIC, etc) and (multi-user) detection techniques (multistage interference canceller, decorrelating detector, MMSE receiver, etc). A 10-15 page project report is expected in which you need to

1. Explain what strategy you used in detecting the data in each case and why you selected this specific method.

2. Explain how you performed detection and justify any assumption you made. It should be in such clarity that another reader of your report will be able to reproduce the results.

3. Write the detected data of each signal set in octal form.

4. Attach your computer programs.