CDMA Simulation

In this assignment, you will write MATLAB code to design a simulated CDMA system of two users,
including signal generation, detection, decoding, and calculation of error rates.

System model

Some discrete-time modifications are required to adapt CDMA to the MATLAB environment. These
are explained below.

Chip sequences. The system consists of two users, A and B, with 31-bit chip sequences. The chip
sequences for users A and B, written CA and CB respectively, are:

```
CA = [0 0 0 0 1 0 1 0 1 1 1 0 1 1 0 0 0 1 1 1 1 1 0 0 1 1 0 1 0 0 1]
CB = [0 0 0 0 1 1 0 1 0 1 0 0 1 0 0 0 1 0 1 1 1 1 1 0 1 1 0 0 1 1 1]
```

Modulating a signal. In class, we created continuous functions sA(t) and sB(t) from the chip sequences
CA and CB, respectively. Clearly, you cannot represent a continuous function in MATLAB, so simply
use the following discrete-time equivalent: replace all zeros in the chip sequence with +1, and all the
ones in the chip sequence with -1. Call these new sequences SA and SB for users A and B,
respectively.

The bit sequences for users A and B are BA and BB, respectively, while the modulated sequences for
users A and B are given by EA and EB, respectively. To generate EA, suppose for example that BA =
[0 1 1 0]. Then EA = [SA -1*SA -1*SA SA]. Notice that EA will have a length of 31 times the length
of BA.

The channel. You may assume that the users are synchronized. Once you have EA and EB, which
should be of the same length, add them together, and add a vector of Gaussian noise with the same
length as EA and EB. To obtain a vector of Gaussian noise of length k with noise power p, and store it
in n, use the command:

```
n = sqrt(p)*randn(1,k);
```

The result can be stored in a vector Y.

Detecting a signal. In class, we multiplied the received signal y(t) by the continuous functions sA(t)
and sB(t) to detect the signal for users A and B, respectively; if the result was positive, we decided that
the bit was zero, and if the result was negative, we decided that the bit was one. Now, for each bit, you
multiply the appropriate segments of Y by SA and SB and take the sum of the result. The decision rule
is the same as in the continuous case.

Use the following given MATLAB function:

This function gets a random bit sequence of length k; use it to generate either BA or BB.

```
function b = get_bits(k)
b = (rand(1,k) > 0.5);
```

Statement of Problem.

Write a MATLAB CDMA simulation program that generates BA and BB of length k, encodes them
with the chip sequences SA and SB, respectively, to obtain EA and EB; adds them together with
Gaussian noise of power p to simulate the channel; and then applies a detector to the channel output to
guess the values of BA and BB. The function then calculates the number of errors e for each user (e.g.,
for user A, the number of times when the detector's guess for BA was incorrect), and returns the
estimated probability of error, e/k, for each user.

Deliverables for this assignment include:

- All of your code, and
- The estimated probability of error for each user when k = 100000 and p = 1, 2, 5, and 10.
- If k = 100000 takes too long to execute, you may pick your own value of k (within reason).

The total value of the assignment is 30 marks, distributed as follows:

- (15 marks) Quality and clarity of code
- (10 marks) Useful and illustrative comments in the code
- (5 marks) Probability of error estimates

You may consult with others in preparing the assignment, but the final submission must be your own
work. Collaborative work is not allowed.
Electronic submission of this assignment is strongly encouraged.
Any further information can be obtained from the instructor.