Lab3 – Questions

1. For the current setup, how many bits of the pseudo-random code sequence are used to modulate one bit of the message signal? What is the processing gain? (0.5 points)

Ans: 10 bits are used to modulate one bit of the message signal.
Processing gain is 10.

2. Use your PSD plot to determine the effect of increasing the length of the pseudo-random code sequence on spreading and processing gain? While experimenting, don't exceed the length beyond 500, as it can get resource-intensive. (0.5 points)

Ans: Spreading is better with a longer sequence of spreading code because the original signal is spread well below the noise level with increasing length.
Processing gain increases with the increasing length of pseudo-random code because chip rate increases with increase in length of pseudo random code.

3. In addition to the security benefits, can you think of other use cases and advantages (non-security) of using DSSS (or in general any other code-based spreading technique)? (0.5 points)

Ans: DSSS can have the following advantages:

1. It supports high coverage range due to low SNR requirements at the receiver.
2. Since the transmission makes use of noise, it avoids intentional interference like jamming effectively [due to large bandwidth it's difficult to actually jam this signal]. Due to this, its performance compared to FHSS is also better in presence of noise.
3. It discriminates against multipath signals very well.
4. These reasons also make it better to be used in military applications.
5. Due to high reliability, The DSSS technology applies to a fixed environment or applications requiring high transmission quality.

4. You are given the task of designing a spread spectrum receiver that can reliably detect signals even when subjected to a jamming signal that is 500 times stronger than the legitimate information signal and with the following constraints. The duration of one message bit is 5.012 ms (approximately 200bps). The minimum normalized energy per bit required for reliable decoding at the receiver is 10 dB. What is the jammer margin (in dB) of the system? What is the required processing gain? What is the rate of chipping sequence that is required to achieve this processing gain? Mention at least two factors other than the chipping sequence length that can impact the required processing gain. (1.5 points)

Ans:

The jammer margin refers to the difference in power (in dB) between the jamming signal and the legitimate information signal that is required to ensure reliable detection at the receiver.

Given: jamming signal is 500 times stronger than the legitimate signal

=> jammer margin = 10 * log10(500) = 26.99 dB.

The processing gain refers to the ratio of the signal's bandwidth to its data rate, expressed in dB. To achieve a processing gain of 10 dB, we need a bandwidth that is 10 dB greater than the data rate.

Jamming margin = processing gain - system loss - SNR

=> Processing gain = jamming margin + SNR
=> Processing gain = 27 + 10 = 37 dB

Chip rate = Information rate * 10^(Processing gain (dB) / 10)

= 200*(10^3.7)

= 1002374 bps

Two factors that can impact the required processing gain -

1.spectral characteristics of the jamming signal - if these are similar to those of info signal then their separation might be difficult and need higher processing gain.

2. receiver's noise floor - if its high then its difficult to detect information signal when theres jamming and need higher processing gain.