Part-2 Coursework EE303: Communication Systems "DS/QPSK Spread Spectrum Systems"

Name: Zheng Yang Lee

CID: 01042500

Results

Define desired message and jammer:

- Message data:

'A huge new leak of financial documents has revealed how the powerful and ultra-wealthy, including the Queens private estate, secretly invest vast amounts of cash in offshore tax havens. Donald Trumps commerce secretary is shown to have a stake in a firm dealing with Russians sanctioned by the US. hi' (300 characters)

- Jammer data:

'This is a free online calculator which counts the number of characters or letters in a text, useful for your tweets on Twitter, as well as a multitude of other applications. Whether it is Snapchat, Facebook or just a note to co-workers or business officials, the number of actual characters matters.' (300 characters)

Task 1: Absence of both noise and jammer

Decoded message:

'A huge new leak of financial documents has revealed how the powerful and ultra-wealthy, including the Queens private estate, secretly invest vast amounts of cash in offshore tax havens. Donald Trumps commerce secretary is shown to have a stake in a firm dealing with Russians sanctioned by the US. hi'

Constellation diagram:

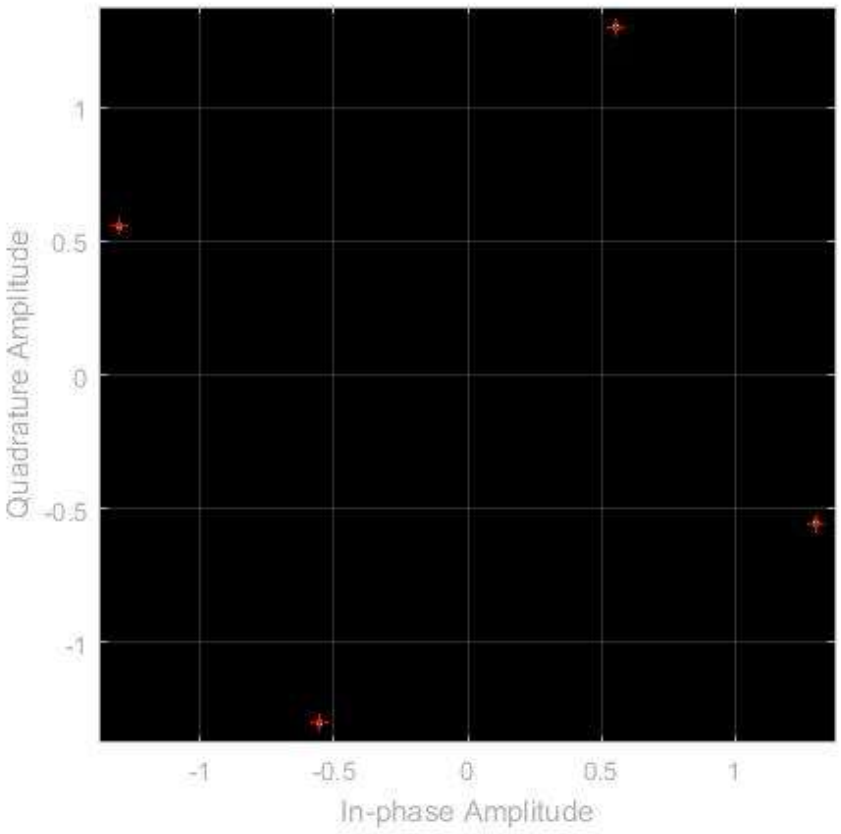

Figure 1: Constellation Diagram for Task 1

Comments: No errors. No deviation from the ideal coordinates.

Task 2: SNR_{in} =30dB at point $\hat{\hat{T}}$ and absence of jammer

Decoded message:

'A huge new leak of financial documents has revealed how the powerful and ultra-wealthy, including the Queens private estate, secretly invest vast amounts of cash in offshore tax havens. Donald Trumps commerce secretary is shown to have a stake in a firm dealing with Russians sanctioned by the US. hi'

Constellation Diagram:

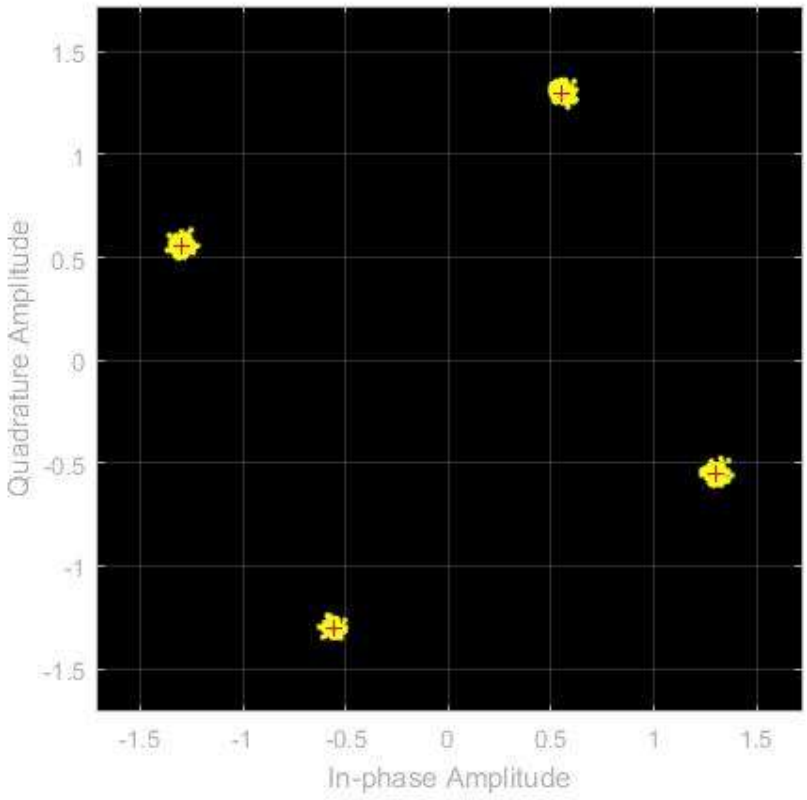

Figure 2: Constellation diagram for Task 2

Total number of bits in error: 0

Bit error probability: 0

Theoretical bit error probability: 0

Comments: There is a slight scattering of points for the constellation diagram, but they are insignificant as all the points are still very close to the reference points. Theoretical bit error probability is approximated by the formula $p_e = T\{\sqrt{2EUE}\}$, where $EUE = \frac{E_b}{N_0} = 10^{\frac{SNR(dB)}{10}}$. This approximation will be used for task 2, 3 and 4. For SNR = 30dB, the theoretical bit error probability is too small that it can be assumed to be zero. The decoded message is identical to the desired message. We can conclude that SNR = 30dB is good enough in a jammer-less environment for perfect transmission.

Task 3: SNR_{in} =20dB at point $\hat{\hat{T}}$ and absence of jammer

Decoded message:

'A huge new leak of financial documents has revealed how the powerful and ultra-wealthy, including the Queens private estate, secretly invest vast amounts of cash in offshore tax havens. Donald Trumps commerce secretary is shown to have a stake in a firm dealing with Russians sanctioned by the US. hi'

Constellation Diagram:

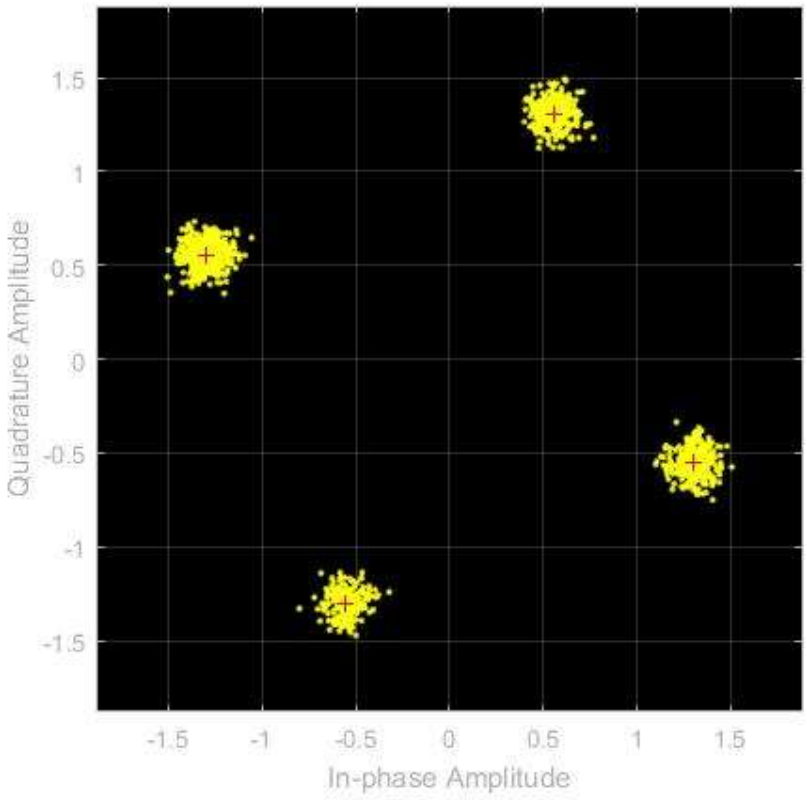

Figure 3: Constellation diagram for Task 3

Total number of bits in error: 0

Bit error probability: 0

Theoretical bit error probability: 1.0442e-45

Comments: The points on the constellation diagram are more scattered than in task 2. However, the effect of the white noise channel is still negligible. The theoretical bit error probability is only 1.0442e-45, a very small value that we can assume it to be zero as well. This results in a perfect transmission. The decoded message is identical to the transmitted message. Hence, we can conclude that SNR = 20dB is good enough in a jammer-less environment for perfect transmission.

Task 4: SNR_{in} =0dB at point $\hat{\hat{T}}$ and absence of jammer

Decoded message:

‘C hugu îeW ,f9c0 f f)lcngé`l d/cumíf0s8h#s peve¡led"hlv vh% powE fõ< and qìtóá)wealt(}¬0iNcltäIng#t`u Qudens`0pkv!tw erpate- segre|I) `nv`qt$÷ast amïun4r of ãash i~  df3h  bd(te90havEns& Do¢eü& DruopC ão-merCa segret`ry*iS s`ow/`të hmæå!a w|!ie$In d¨Firm0deahijf"wIvh Rus3é!ns vylcuyo.eä by$P`e DS ìi’

Constellation Diagram:

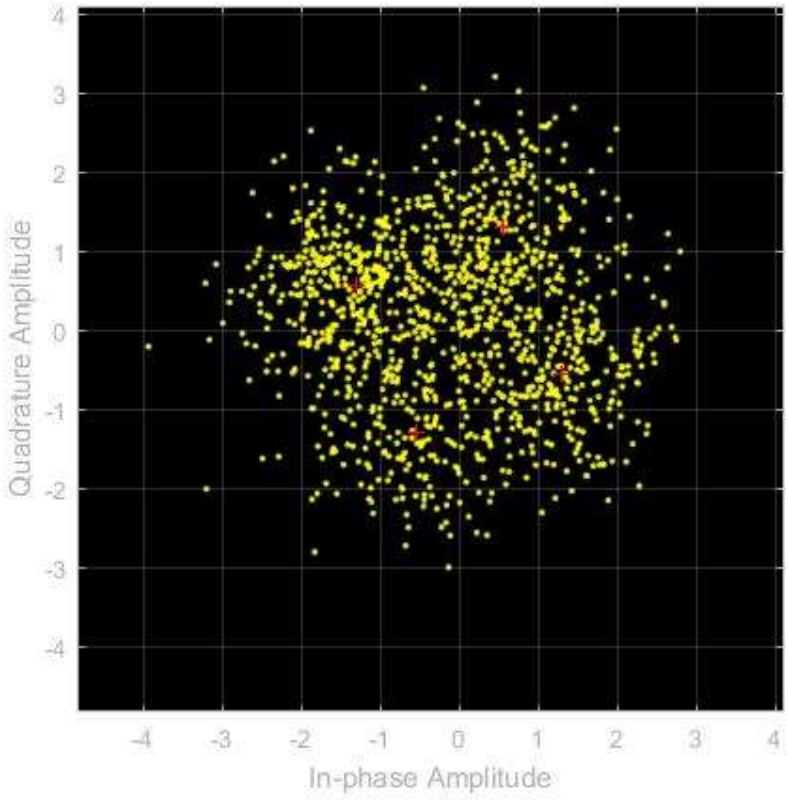

Figure 4: Constellation diagram for Task 4

Total number of bits in error: 192

Bit error probability: 0.08

Theoretical bit error probability: 0.0786

Comments: The points on the constellation diagram are very scattered. They look just like a set of completely random points. The theoretical bit error probability is 0.08. Each character in the message data is converted to an 8-bit integer. Any of the 8 bits in error will cause the message to be decoded wrongly. This has resulted in a decoded message that is completely incomprehensible. Hence, we can conclude that SNR = 0dB is too low for transmission, even in a jammer-less environment.

Task 5: Calculate the total number of bits in error, the bit error probability and the theoretical bit error probability for tasks 2, 3 and 4.

The answers of part 5 are stated under tasks 2, 3 and 4 along with some comments. Please refer to the previous section.

Task 6: For a SNR_{in} = 30dB at the receiver's input ("desired" signal). In this task the jammer transmits a jamming message of 300 characters, at the same time, on the same frequency band with a power 10dB above the desired signal power.

Decoded message:

'This is a free online calculator which counts the number of characters or letters in a text, useful for your tweets on Twitter, as well as a multitude of other applications. Whether it is Snapchat, Facebook or just a note to co-workers or business officials, the number of actual characters matters.'

Constellation Diagram:

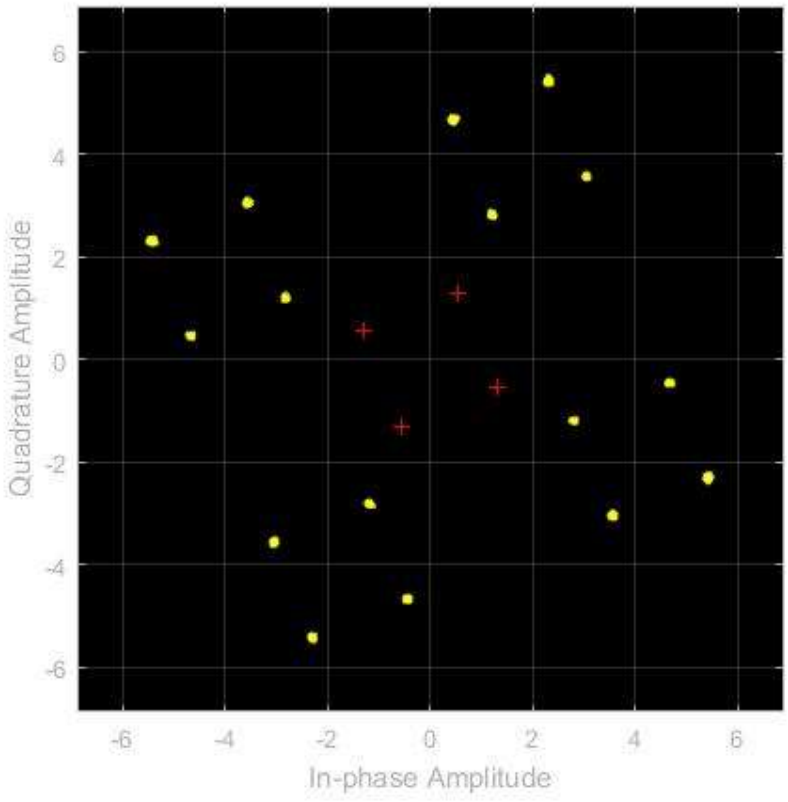

Figure 5: Constellation diagram for Task 6

Comments: The jammer signal has a power 10dB higher than the desired message signal. The desired message signal now looks like noise to the jammer signal. The decoded message is identical to the jammer signal. We can conclude that, for SNR = 30dB, even though it can decode the message signal perfectly in a jammer-less environment, it failed completely when a jammer intentionally interfere with the channel on the same frequency band. We need some mechanism to protect the message from jammer attack, for example: Spread Spectrum System.

Task 7: DS-Spread Spectrum System

Balanced Gold sequence for desired message: (k=7)

[-1 -1 -1 1 1 -1 1 -1 1 1 -1 1 -1
-1 -1 -1 1 1 -1 1 1 1 -1 -1 1 1
-1 -1 1 1 -1]

Number of +1s = 15

Number of -1s = 16

Balanced Gold sequence for jammer: (k=8)

[1 1 1 -1 -1 -1 -1 -1 1 -1 1 -1 -1
-1 -1 1 1 1 1 1 -1 -1 -1 1 -1 -1
1 -1 1 1 1]

Number of +1s = 15

Number of -1s = 16

Decoded message:

'A huge new leak of financial documents has revealed how the powerful and ultra-wealthy, including the Queens private estate, secretly invest vast amounts of cash in offshore tax havens. Donald Trumps commerce secretary is shown to have a stake in a firm dealing with Russians sanctioned by the US. hi'

Constellation diagram of the de-spread signal:

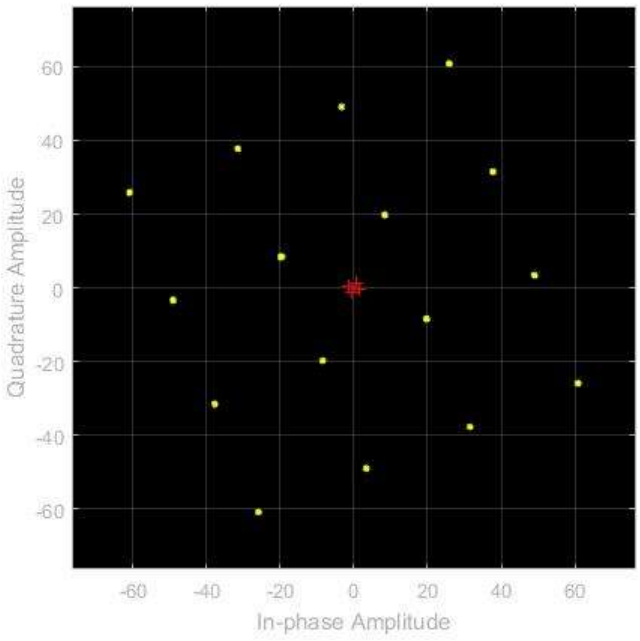

Figure 6: Constellation diagram for task 7

Comments: This is a Direct Sequence Spread Spectrum System. The balanced gold sequences are generated by adding two m-sequence, with one being delayed by k samples. The PN-sequence acts as a password to access the message bits. Even though both message signal and jammer are PN-encoded and sharing a same frequency band, they were encoded with different PN-sequence. The desired message is extracted by correlating the signal with the PN-sequence of the desired message. The output message is identical to the desired message, proving the effectiveness of DS-SSS against broadband jammer.