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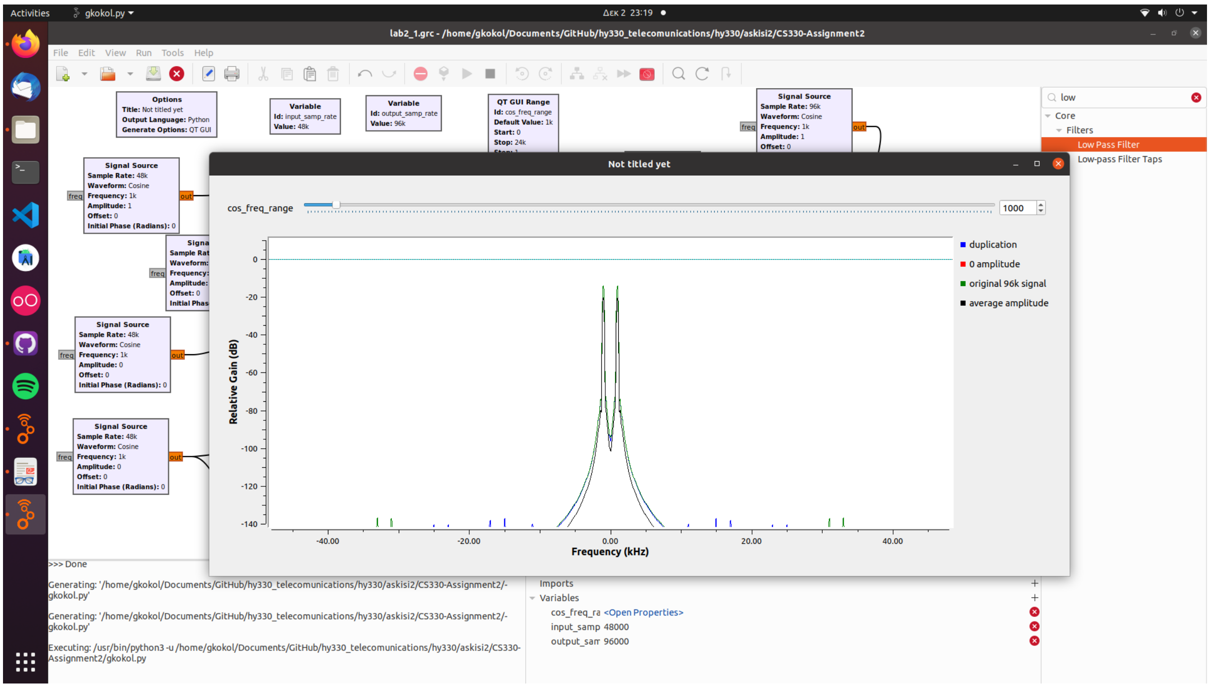
CS-330 Assignment 2

Exercise 1



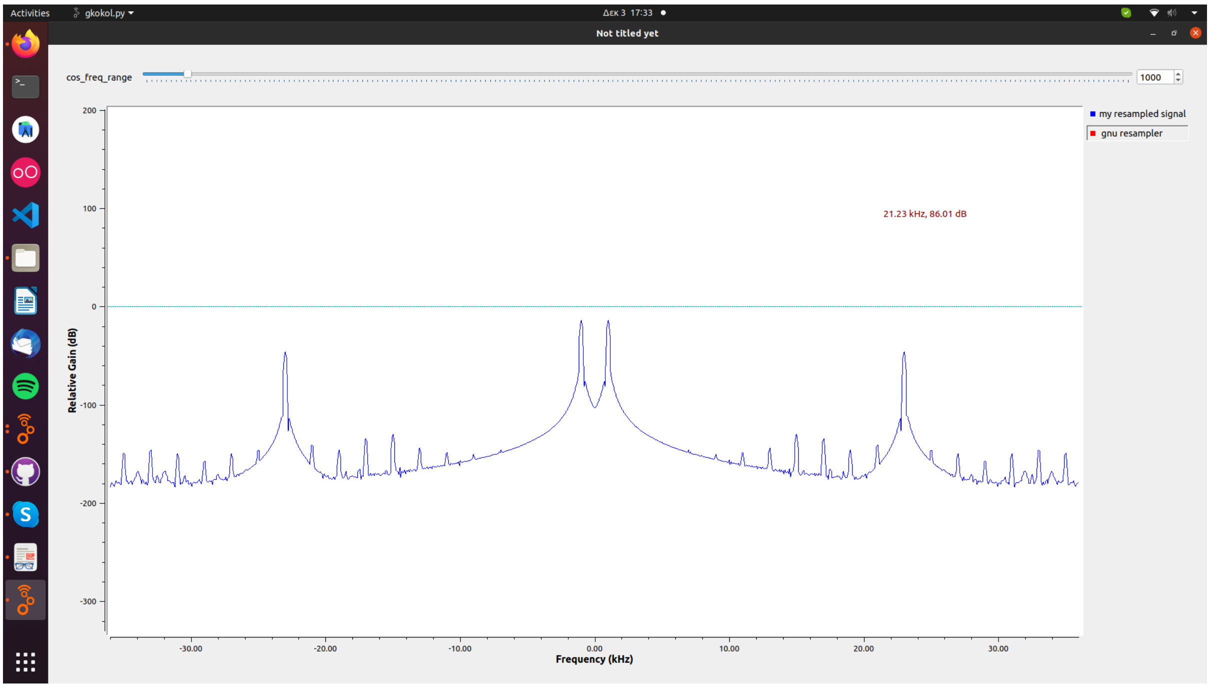
4. We observe that the average and duplication schemes are the most efficient and accurate. The best system seems to be the duplication scheme as it is almost exactly the same with an original cosine at 96k sample rate . Also the average scheme has an overhead of addition and division which can have a negative impact in performance.

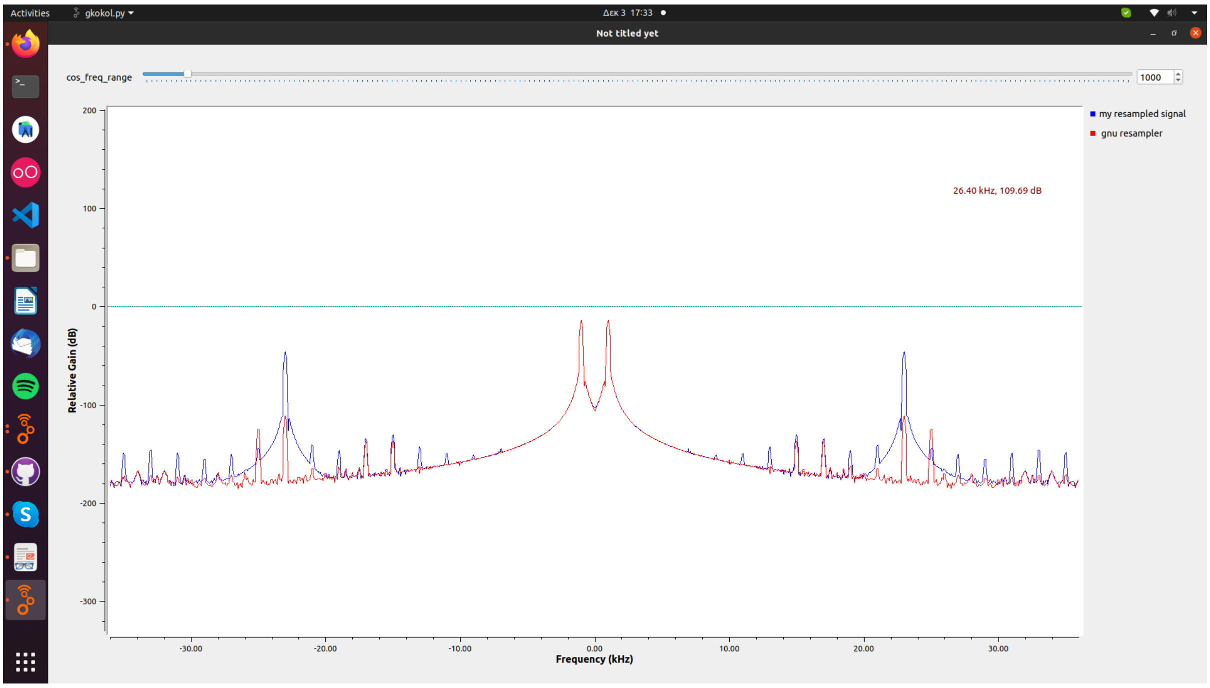
5. Yes, I observed some artifacts. This happens because of the upsampling. Basically, they are repeating information. Every time we do an upsampling, we need to apply a filter after, to eliminate aliasing effects. Thus, I applied a low pass filter to cut off the aliasing effect.

6. Another upsampling method I could think of is taking the average of the original sample and another random sample. The problem with that, is the overhead of the addition, division and the process of collecting a random sample.

Exercise 2

The first diagram shows how origina gnu resampler will upsample the signal.





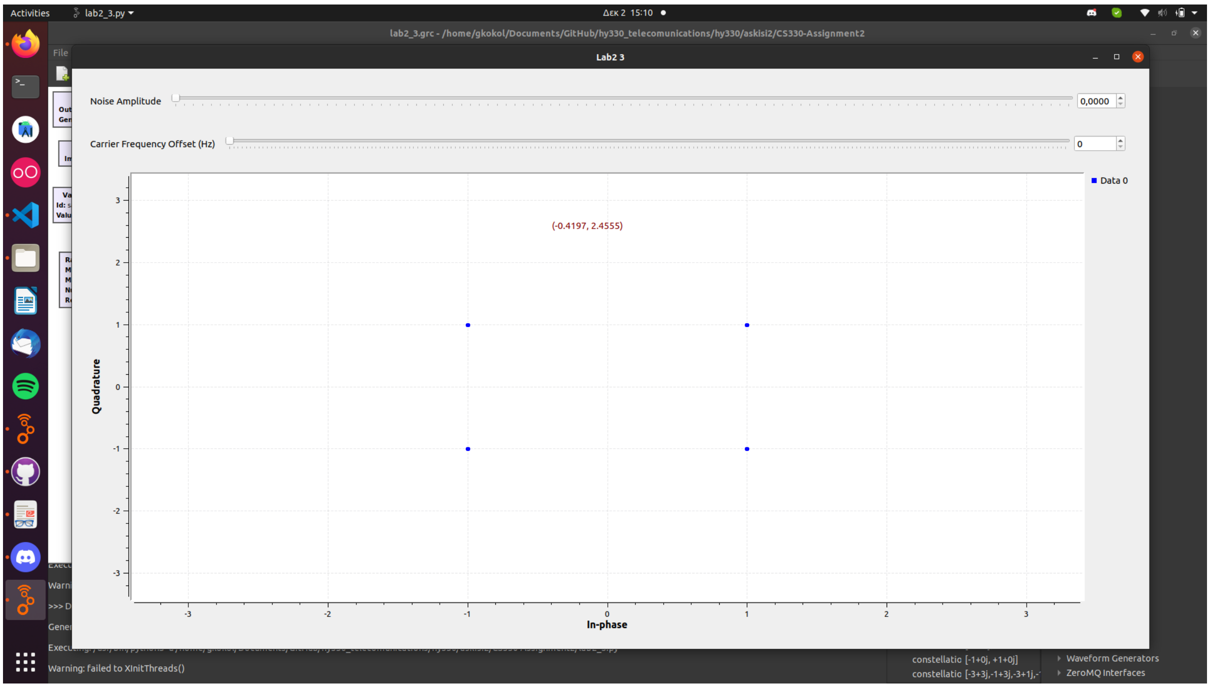
The second diagram shows how my resampler performs to gnu original resampler.

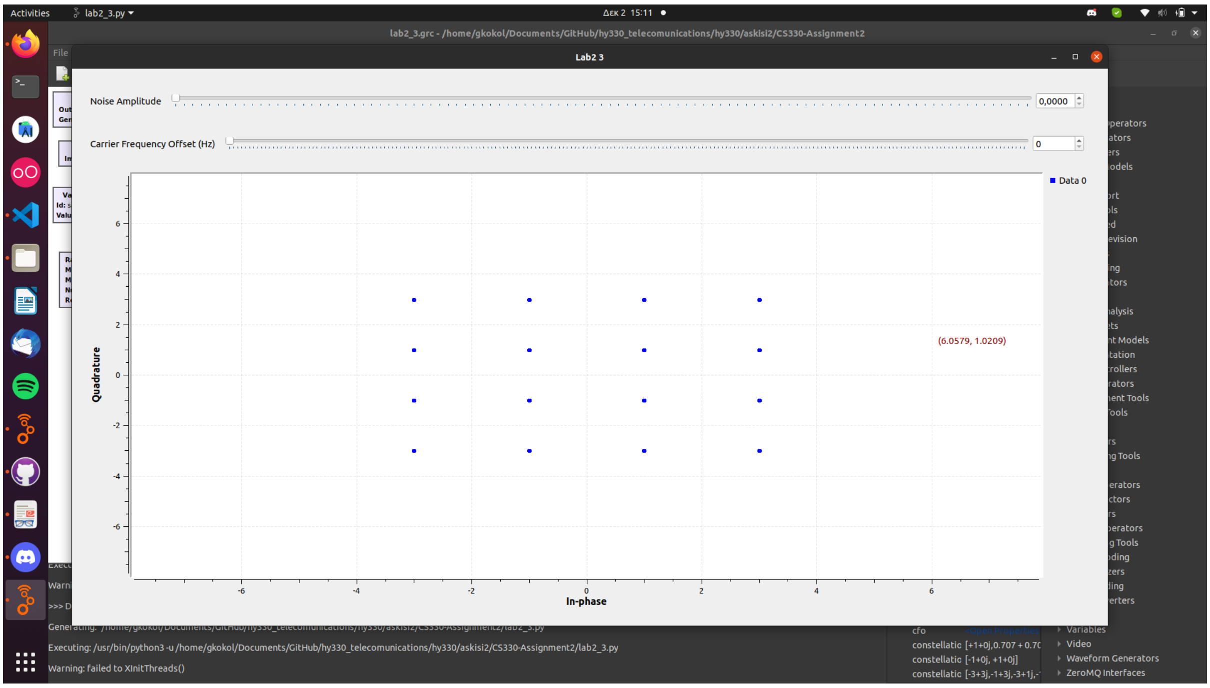
For my resampler, first I have a cosine at 48k and I double its sample rate with inteleave to 96k. Then I get 3 of the 4 samples and the sample rate goes down to 72k. Next we apply a low pass filter to eliminate the alliasing from the upsampling.

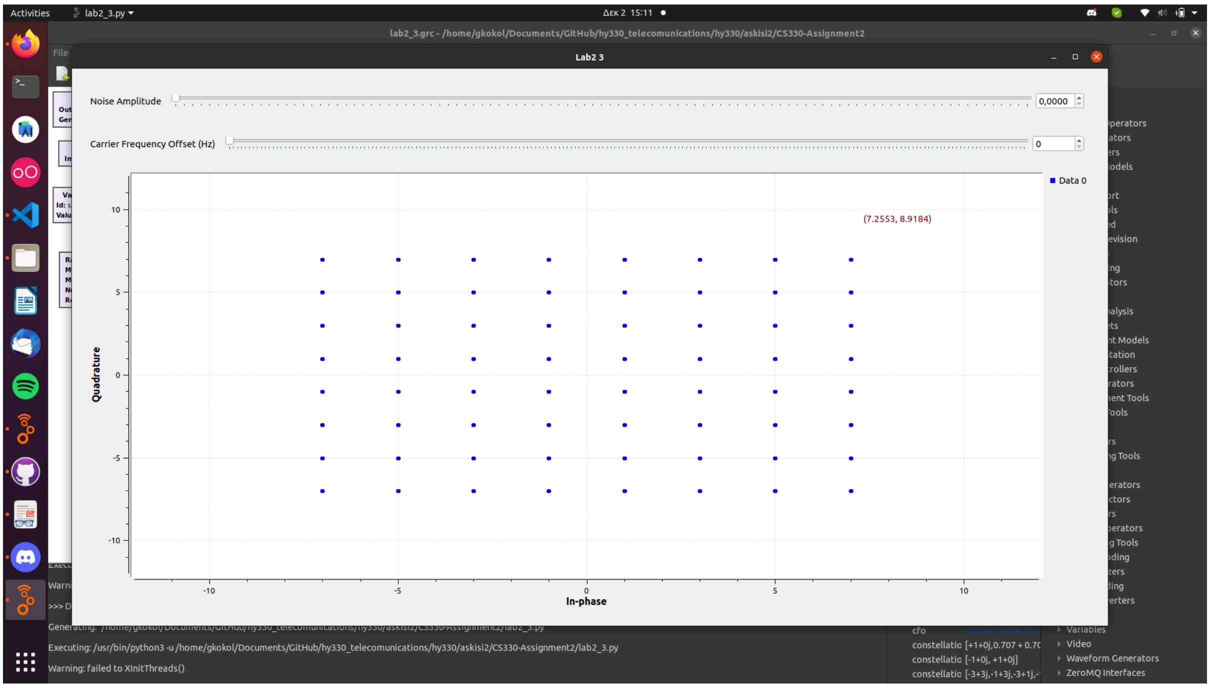
Exercise 3

1. If we increment the noise from the slide, we can observe that the constellation points are getting more sparse, and we can’t figure out the proper position of each constellation point. Thus it will lead to a large amount of data loss.
   By increasing the cfo we can see the constellation points to constantly move on a circular path.

without normalization

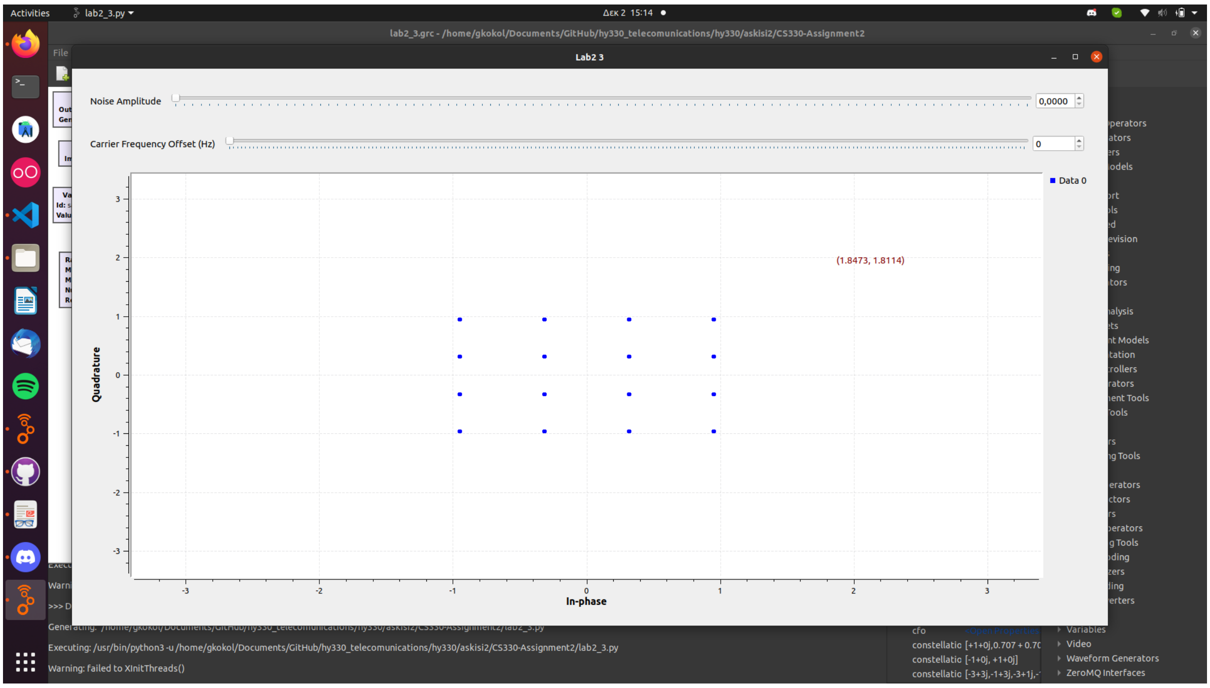


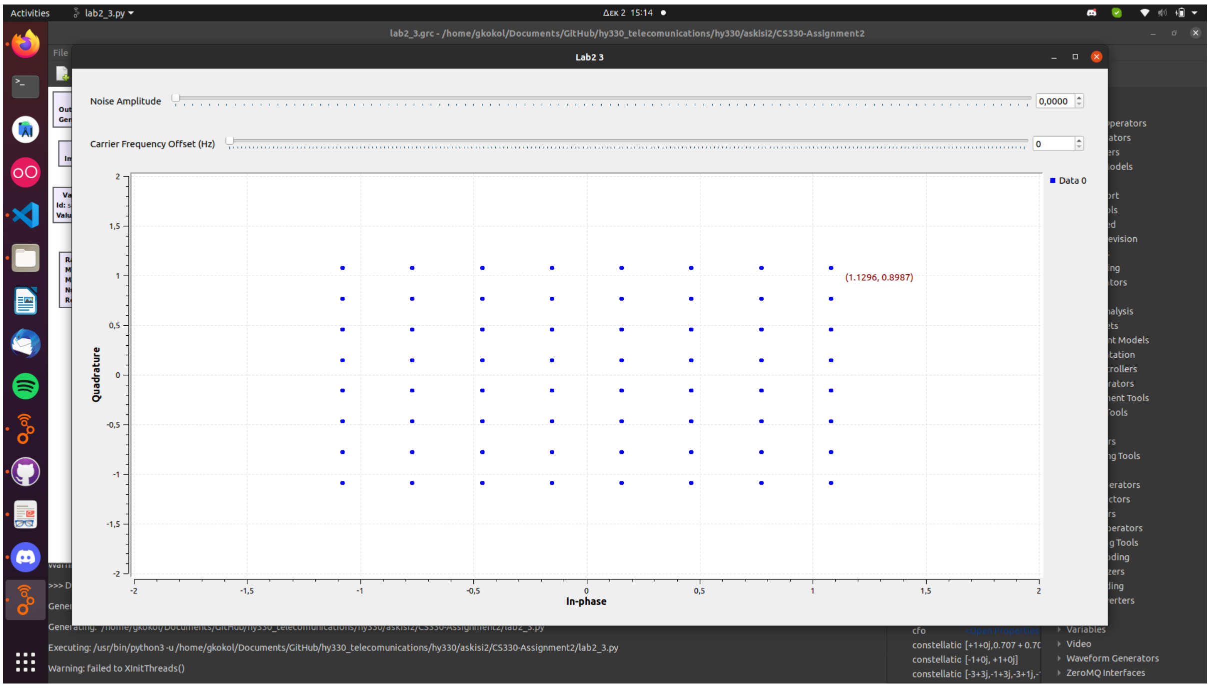




with normalization


Lab2 3
Noise Amplitude
0,0000
Carrier Frequency Offset (Hz)
0
Data 0
(1.6245, 1.5145)
Quadrature
In-phase
Executing: /usr/bin/python3 -u /home/gkokol/Documents/GitHub/hy330_telecommunications/hy330/askisi2/CS330-Assignment2/lab2_3.py
Warning: failed to XInitThreads()


Lab2 3
Noise Amplitude
0,0000
Carrier Frequency Offset (Hz)
0
Data 0
(1.8473, 1.8114)
Quadrature
In-phase
Executing: /usr/bin/python3 -u /home/gkokol/Documents/GitHub/hy330_telecommunications/hy330/askisi2/CS330-Assignment2/lab2_3.py
Warning: failed to XInitThreads()



4.

constellation	noise
BPSK	0,45
QPSK	0,3
16-QAM	0,15
64-QAM	0,1

We can see that constellations with less symbols (and bits) will have higher tolerance to noise. This is because fewer bits means that the symbols have more distance between them and the possibility of a point getting nearer to a neighbor point is less possible.

5.

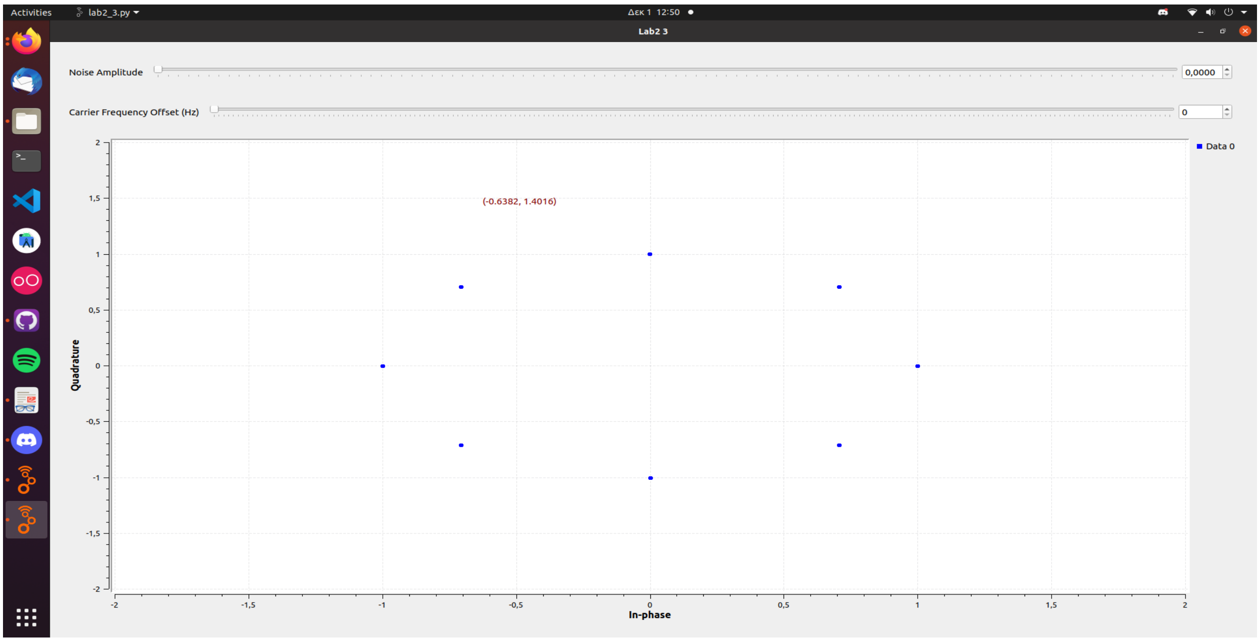
constellation	cfo
BPSK	1
QPSK	1
16-QAM	1
64-QAM	1

By changing the cfo, we observe that constellation points immediately start to get out of position and start to move around. So we conclude that all the constellation schemes get affected the same by changes on cfo, unlike noise where constellation schemes with less symbols had better tolerance in noise.

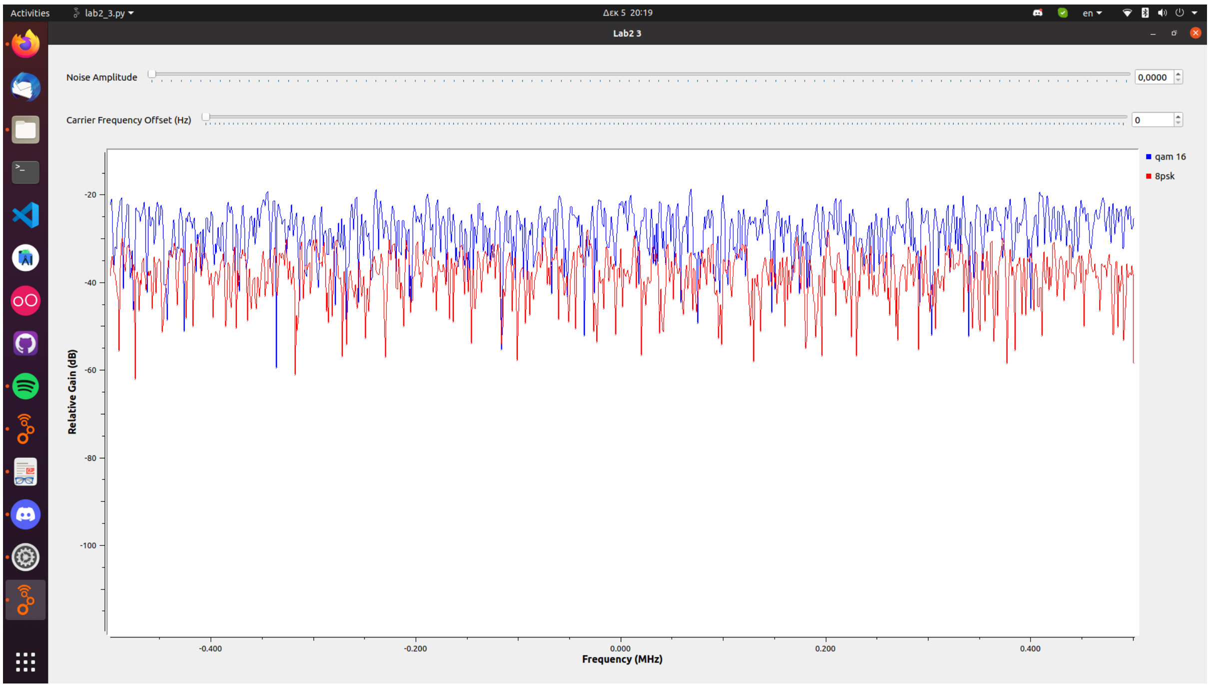
Exercise 4

1. For the 8-Psk we will need 3 bits. Also we will need to divide a circle into 8 angles. circle is 2pi and we divide by 8, so for the imaginary part we will have $e^{j*2pi/8*n}$. So by following gray code we have the following points.
   000 → $e^{j2\pi 8 \cdot 0}$ = 1 + 0j
   001 → $e^{j2\pi 8 \cdot 1}$ = $\sqrt{2}/2 + \sqrt{2}/2j$ = 0.707 + 0.707j
   011 → $e^{j2\pi 8 \cdot 2}$ = 0+1j
   010 → $e^{j2\pi 8 \cdot 3}$ = $-\sqrt{2}/2 + \sqrt{2}/2j$ = -0.707 + 0.707j
   110 → $e^{j2\pi 8 \cdot 4}$ = -1+0j
   111 → $e^{j2\pi 8 \cdot 5}$ = $-\sqrt{2}/2 - \sqrt{2}/2j$ = -0.707 - 0.707j
   101 → $e^{j2\pi 8 \cdot 6}$ = 0-1j
   100 → $e^{j2\pi 8 \cdot 7}$ = $\sqrt{2}/2 - \sqrt{2}/2j$ = 0.707 - 0.707j

2.



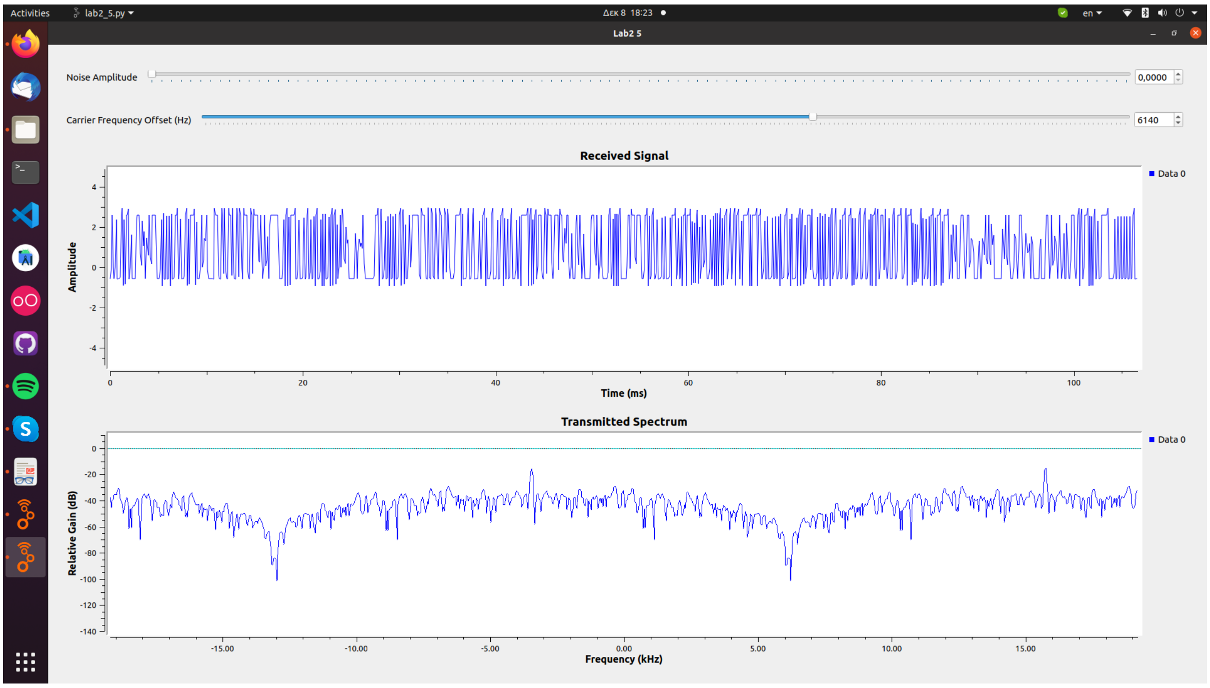
3. QPSK has better tolerance in the noise than 8psk as it uses less constellation points but it supports less bandwidth than 8psk. QPSK and 8psk seem to have the same tolerance in cfo.
4. As we observe from the diagram below, qam with 8psk seems to be similar, with the qam being shifted upwards.



Exercise 5

1. Fsk is more resilient to noise and CFO. It provides high SNR and It has higher immunity to noise due to constant envelope. Hence it is robust against variation in attenuation through channels.
2. The modulation index provides a measure of what is effectively the level of modulation and the deviation ratio a measure of the deviation relative to the modulating frequency. The modulation index is totally independent of the carrier frequency. For FSK modulation, the modulation index is defined as the ratio of the spacing between consecutive frequencies in the FSK symbol map, to the symbol rate.
   sources:
   https://www.electronics-notes.com/articles/radio/modulation/fm-frequency-modulation-index-deviation-ratio.php
   https://en.wikipedia.org/wiki/Frequency_modulation

3. The cfo shifts the signal upwards and changes the values of the amplitude of the received signal.



4. Using the DC Blocker we observe that the cfo no longer shifts upwards and changes the amplitude of the received signal.