EXPERIMENT NUMBER : 6

EXPERIMENT NAME : QUADRATURE AMPLITUDE MODULATION (QAM)

DATE: 26/11/2022, SATURDAY

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* **AIM:**

To perform Quadrature Amplitude Modulation (QAM) of the input digital signal and to verify the output.

* **SOFTWARE REQUIRED:**

① Oracle VM VirtualBox 6.1.38, Oracle Corporation

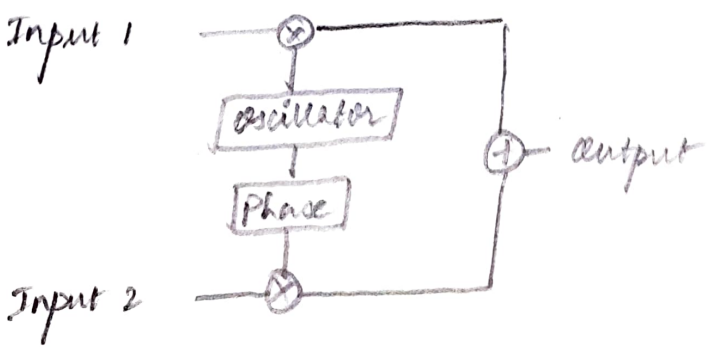
② Ubuntu 22.04 (64-bit) Operating system

③ GNU Radio Companion Application, v3.10.1
(sudo apt-get install gnuradio)

* **THEORY:**

Quadrature Amplitude Modulation (QAM) is a form of modulation that is a combination of phase and amplitude modulation.

In modulation, there are two carrier signals with a phase shift of 90° between them. These are then amplitude modulated with two data stream known as in-phase and quadrature phase. These signals are added thus converting them to required frequency and amplifying them.



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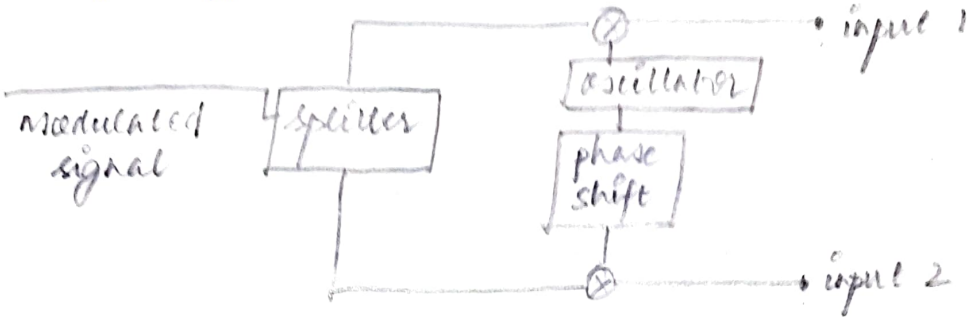
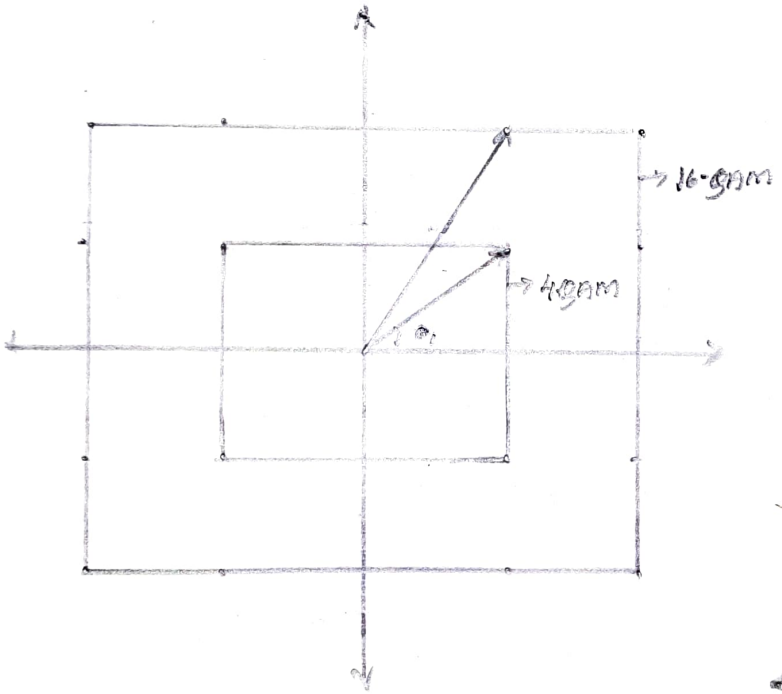
During modulation, the modulated signal is split and each side is applied to a mixer. One half has impulse local oscillator applied, then the another half has quadrature oscillator signal applied.



Since it includes both amplitude and phase modulation, we obtain a grid called constellation map.



Each vector changes in amplitude and phase. The signal waveform may be expressed as -

$$S_m(t) = Re\left[(A_{mi} + jA_{mq})\, g(t)\, e^{j2\pi f_c t}\right]$$

$$= A_{mi}\, g(t) \cos 2\pi f_c t - A_{mq}\, g(t) \sin 2\pi f_c t \;;$$

$$m = 1, 2, \ldots, M$$

PTO

QAM signal waveform can be expressed as -

$$s_m(t) = Re\left[s_m e^{j\theta_m} e^{j2\pi f_c t}\right]$$

$$= s_m \cos(2\pi f_c t + \theta_m)$$

where $s_m = \sqrt{A_{mi}^2 + A_{mq}^2}$ and $\theta_m = \tan^{-1}\left(\frac{A_{mq}}{A_{mi}}\right)$

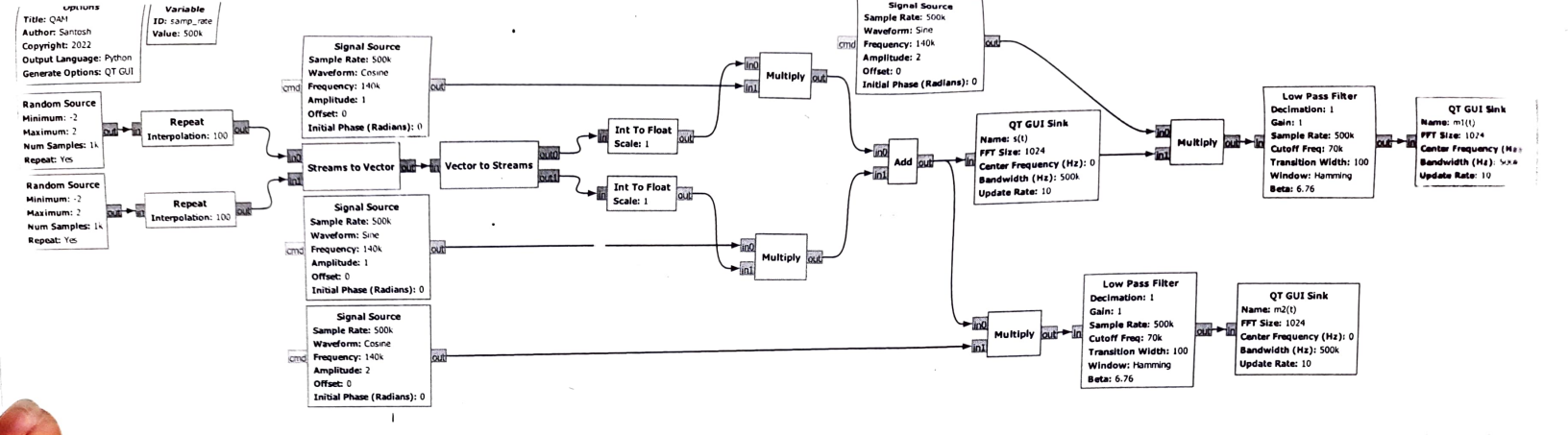
Euclidean distance, $d_{mn} = \sqrt{\|s_m - s_n\|^2}$

$$= \sqrt{\frac{\varepsilon_q}{2}\left[(A_{mi} - A_{ni})^2 + (A_{mq} - A_{nq})^2\right]}$$

Distance between adjacent points, $d_{mn} = \sqrt{2}g$.

* RESULT:

Quadrature Amplitude modulation (QAM) has been performed for digital signal and signal added with noise. All the simulation results were verified successfully.


Options
Title: QAM
Author: Santosh
Copyright: 2022
Output Language: Python
Generate Options: QT GUI
Variable
ID: samp_rate
Value: 500k
Random Source
Minimum: -2
Maximum: 2
Num Samples: 1k
Repeat: Yes
Random Source
Minimum: -2
Maximum: 2
Num Samples: 1k
Repeat: Yes
Repeat
Interpolation: 100
Repeat
Interpolation: 100
Signal Source
Sample Rate: 500k
Waveform: Cosine
Frequency: 140k
Amplitude: 1
Offset: 0
Initial Phase (Radians): 0
Streams to Vector
Vector to Streams
Signal Source
Sample Rate: 500k
Waveform: Sine
Frequency: 140k
Amplitude: 1
Offset: 0
Initial Phase (Radians): 0
Signal Source
Sample Rate: 500k
Waveform: Cosine
Frequency: 140k
Amplitude: 2
Offset: 0
Initial Phase (Radians): 0
Int To Float
Scale: 1
Int To Float
Scale: 1
Multiply
Multiply
Signal Source
Sample Rate: 500k
Waveform: Sine
Frequency: 140k
Amplitude: 2
Offset: 0
Initial Phase (Radians): 0
Add
QT GUI Sink
Name: s(t)
FFT Size: 1024
Center Frequency (Hz): 0
Bandwidth (Hz): 500k
Update Rate: 10
Multiply
Low Pass Filter
Decimation: 1
Gain: 1
Sample Rate: 500k
Cutoff Freq: 70k
Transition Width: 100
Window: Hamming
Beta: 6.76
QT GUI Sink
Name: m1(t)
FFT Size: 1024
Center Frequency (Hz)
Bandwidth (Hz): 500k
Update Rate: 10
Multiply
Low Pass Filter
Decimation: 1
Gain: 1
Sample Rate: 500k
Cutoff Freq: 70k
Transition Width: 100
Window: Hamming
Beta: 6.76
QT GUI Sink
Name: m2(t)
FFT Size: 1024
Center Frequency (Hz): 0
Bandwidth (Hz): 500k
Update Rate: 10

OUTPUTS :

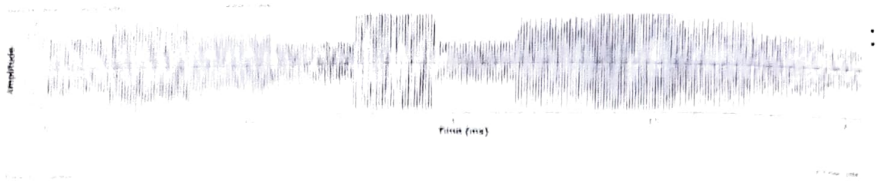


Figure 1 - Quadrature Amplitude modulated Signal, s(t)

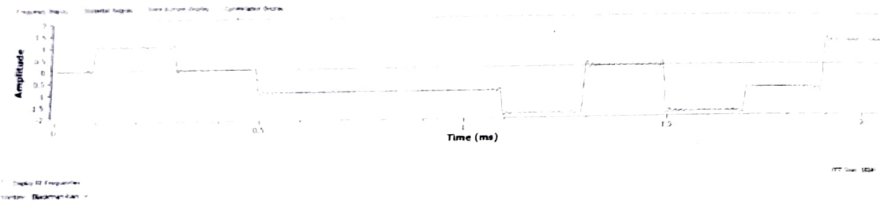


Figure 2 - Demodulated Signal, $m_1(t)$

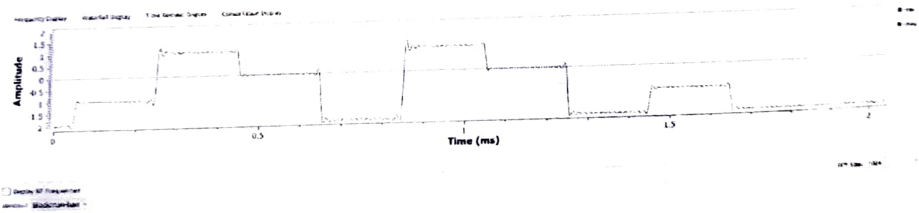


Figure 3 - Demodulated Signal, $m_2(t)$