Modulation and Coding – labolatory

Digital Modulation

Quadrature Amplitude Modulation (QAM)

The aim of the exercise is to develop algorithms for modulation and decoding for digital modulation named *Quadrature Amplitude Modulation (QAM)*. The second aim will be comparing a QAM modulation with PSK (Phase Shift Keying). The second aim will be comparing a QAM modulation with PSK (Phase Shift Keying). Will be compared sensitivity of both methods (for noise generated in the channel).

1. *Quadrature Amplitude Modulation (QAM):*

Quadrature Amplitude Modulation or QAM is a form of modulation which is widely used for modulating data signals onto a carrier used for radio communications. Quadrature Amplitude Modulation, QAM is a signal in which two carriers shifted in phase by 90 degrees are modulated and the resultant output consists of both amplitude and phase variations. In view of the fact that both amplitude and phase variations (see fig. 1) are present it may also be considered as a mixture of amplitude and phase modulation.

Very important advantage of QAM modulation is the ability to encode information by changes in the amplitude and phase of the signal (in amplitude and phase in one time). In QAM and PSK modulation are used constelation diagrams (see fig. 1). Constellation diagram is based on quadrature signal representation. Each point on constellation diagram is related to the amplitude and phase of the signal. When using QAM, the constellation points are normally arranged in a square grid with equal vertical and horizontal spacing and as a result the most common forms of QAM use a constellation with the number of points equal to a power of 2 i.e. *4, 16, 64 , 256. . .*

For example, when we use 256-QAM modulation (with *256* points on constellation diagram), then we can send *8 bits* on one baud. So, if our symol rate = *2000 bounds/second*, then bit rate = 16*000 bits/second* (16*kbps*).

The downside is that the constellation points are closer together and therefore the link is more susceptible to noise. As a result, higher order versions of QAM are only used when there is a sufficiently high signal to noise ratio.

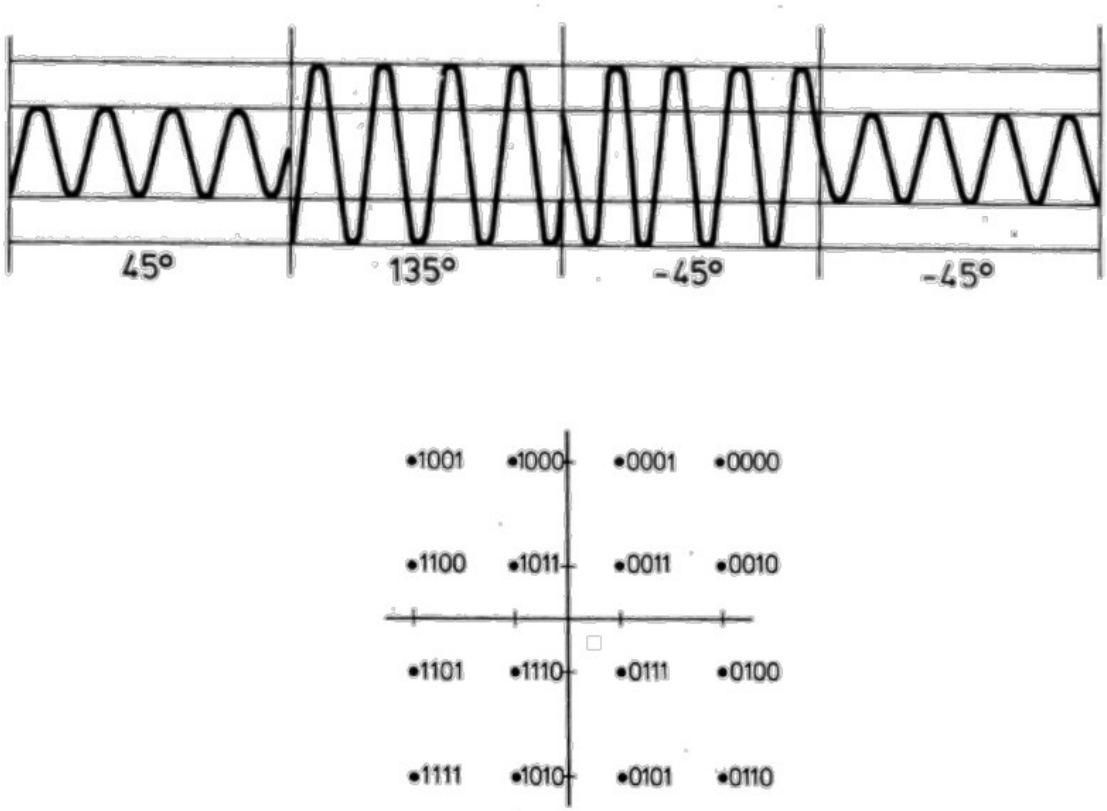


Fig. 1: Quadrature amplitude modulation (QAM), at the top: signal modulated by QAM - seen four different phase of the signal and two amplitude. At the bottom: example of constellation diagram of 16-QAM modulation (the carrier signal may take one of *16* states - representation of bits).

1.2 Data transmission system based on QAM modulation:

- Build QAM modulator according to the following diagram (Figure 2).
- Set *samp_rate* to *32...48KHz* (Should be math to wave file sampling rate).
- Components “*Delay*", "*Keep 1 in N*” and "*WX GUI Scope Sink*” its used to display constellation diagram (a built-in component for constellation diagram could work only with PSK modulation)
    - in "*Delay*" component, field "*Delay*" set to *1*.
    - in "*Keep 1 in N*" component, field "*N*" set to *1*.
    - “*WX GUI Scope Sink*” in “*XY mode*” set to “*On*”.
- Parameter "N*oise Voltage*" in "*Channel Model*" component could be adjusted in range from 0 to 1 V (use *WX slider*).
- Number of constellation points should be equal to *16* (QAM modulator and demodulator).

- Set parameters of *"Packet Encoder"* component as below:

  field *„Sample per symbol”* set to *2*.
  field *„Bits per symbol”* set to *4*.

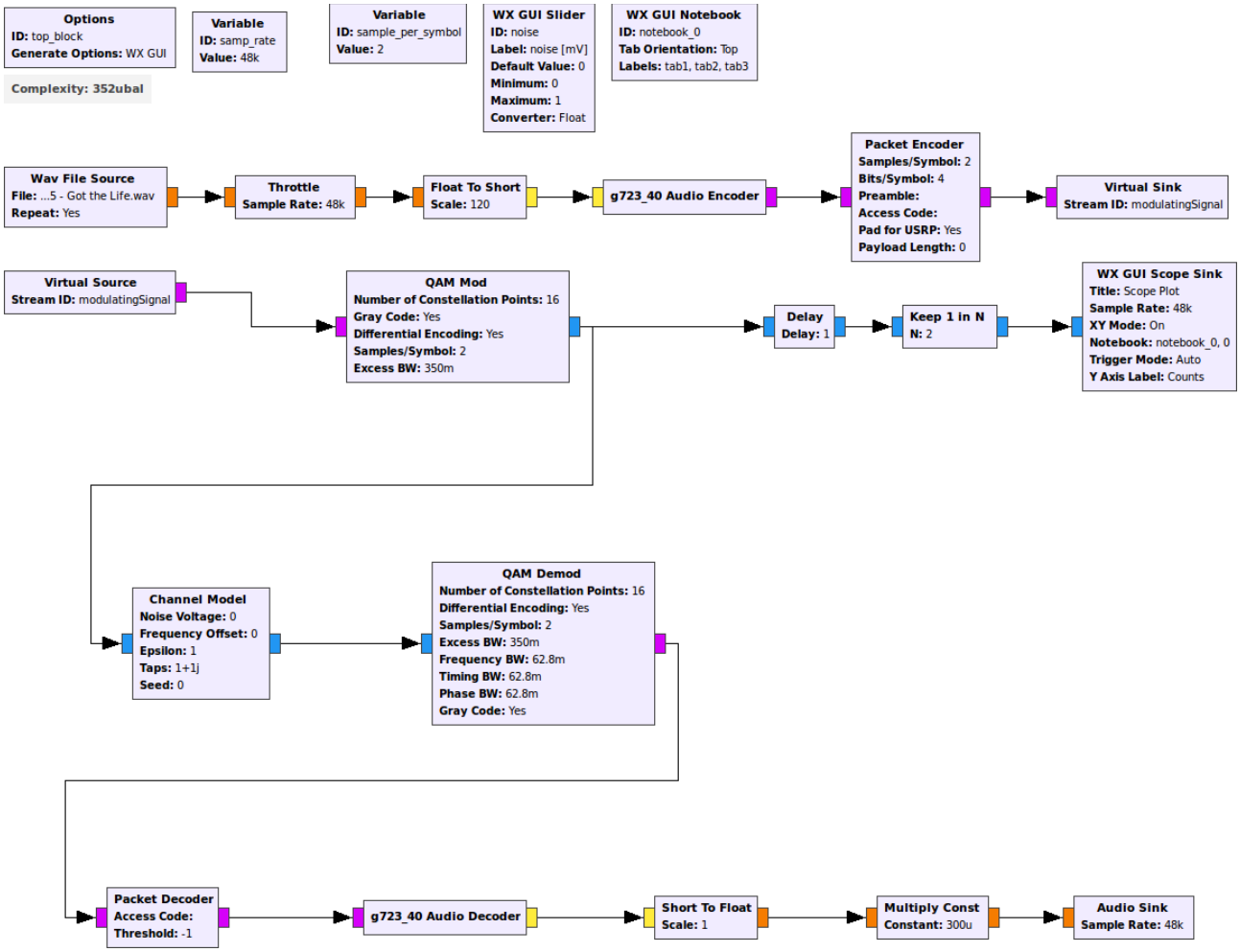


Fig. 2: Block diagram of a data transmission system using QAM modulation method.

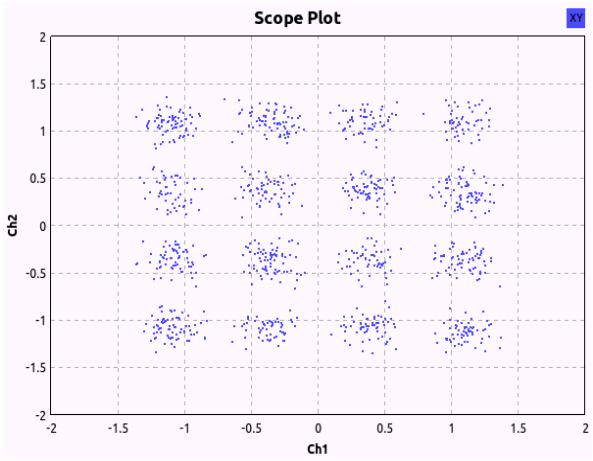
- Run the script. The sound should play properly. Look at the constellation diagram (should be similar to constellation diagram presented in fig. 3a).
- Increase the value of the noise level. Determine at which point the transmission becomes unreadable, and when it is interrupted. Save this value.

1.2 Comparison of noise sensitivity: QAM and PSK.

- Modify the diagram from the previous point by switching modulation method (from QAM to PSK). You can disable the QAM component, and put PSK instead of QAM.
- Change the number of constellation points to *16*.

- Run the script. The sound should play properly. Look at the constellation diagram (should be similar to constellation diagram presented in fig. 3b).
- Increase the value of the noise level. Determine at which point the transmission becomes unreadable, and when it is interrupted. Save this value.
- Which modulation (PSK or QAM) is less sensitive to noise ? And Why ?

a)



b)

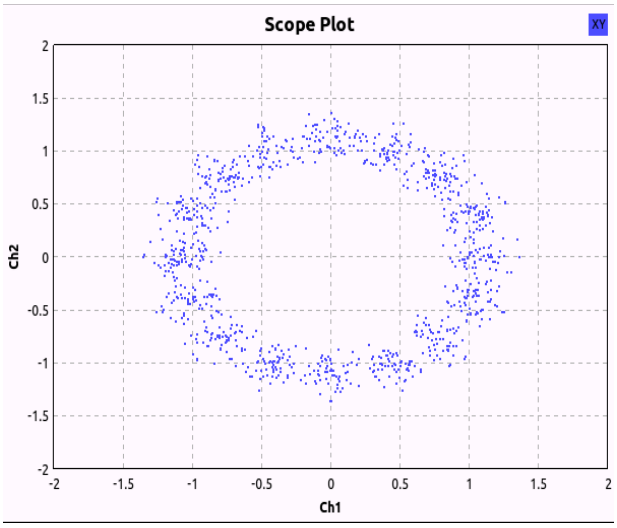


Fig. 3: Constellation diagram for (a) 16-QAM, (b) 16-PSK.