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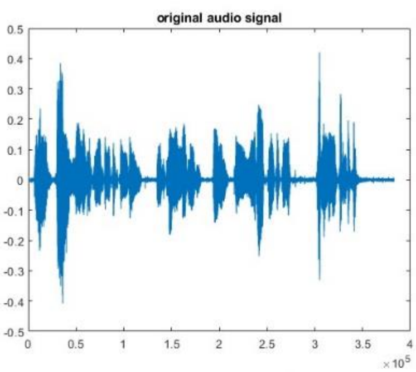
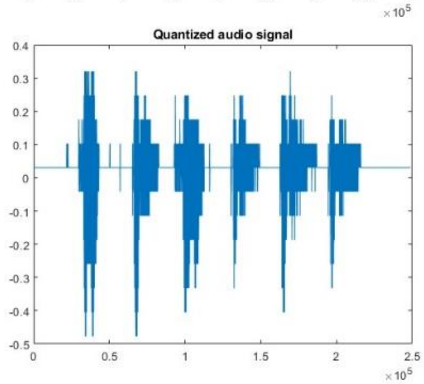
Project Report

Design of Modulation and demodulation for QAM(16, 32, 64, 128) with comparison between OOK and PPM modulation

I have included two codes in this directory. The first code implements Quadrature Amplitude Modulation (QAM) with 16, 32, 64, and 128 levels, comparing the differences by introducing Additive White Gaussian Noise (AWGN) and analyzing their respective outputs. In the second code, I compare QAM modulations with On-Off Keying (OOK) and Pulse Position Modulation (PPM). Additionally, I introduce two distinct Signal-to-Noise Ratio (SNR) values to evaluate the impact of SNR during the modulation implementation.

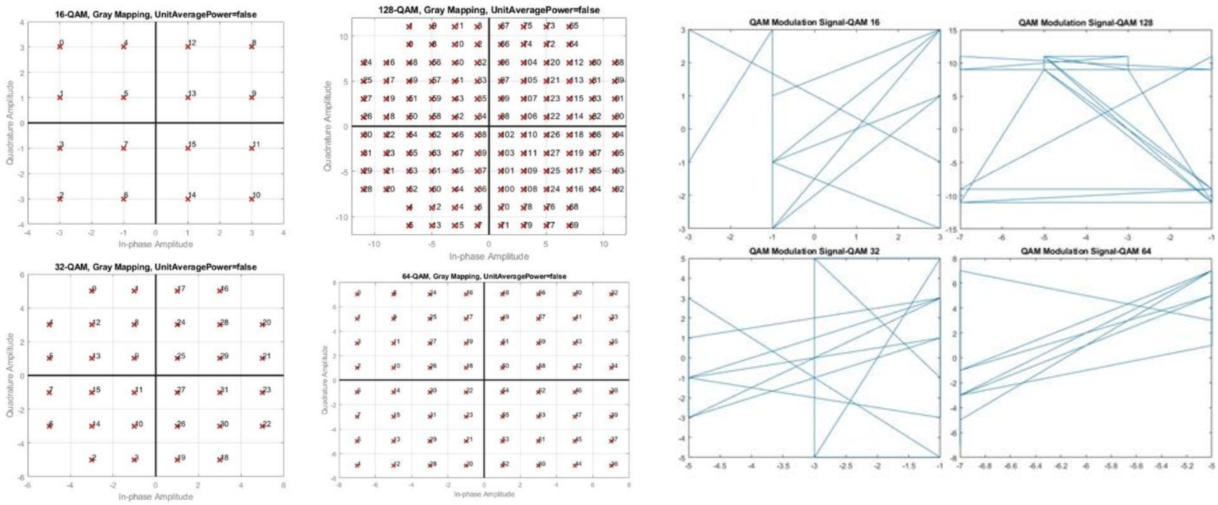
##QAM(16,32,64,128)





In the initial phase, sound input is digitally transformed, as illustrated in the image to the left. Subsequently, Additive White Gaussian Noise (AWGN) is introduced into the audio signal to emulate noise effects within a real-world scenario. Following this step, the audio signal undergoes quantization into discrete levels, as predetermined within the signal range stipulated in the MATLAB code.

Upon quantization, the signal is readied for Quadrature Amplitude Modulation (QAM), and a constellation diagram is presented. In this context, plots are employed for four QAM types: 16 QAM, 32 QAM, 64 QAM, and 128 QAM. Following the execution of the program, the demodulation results are displayed through plots showcasing the demodulated outcomes for all QAM types.



(a) (b)

Figure 1) Comparison of QAM Types: a) Constellation Plot; b) Modulated Signals using QAM

Figure 1a depicts the constellation of each QAM type, where the number of constellations will continue to increase with the increment of bit values in QAM, calculated using the formula 4^n. Constellations will also appear if the entered bits align with those specified in constellation theory; the absence of constellation points indicates incorrect or improperly entered bit inputs. Subsequently, in Figure 1b, the modulation results of the signal before modulation are illustrated. Audio signals processed through various types of QAM modulation yield varying bit readings at discrete levels. Therefore, higher QAM levels enable the representation of more information per symbol; however, this may also escalate system complexity and bandwidth requirements.

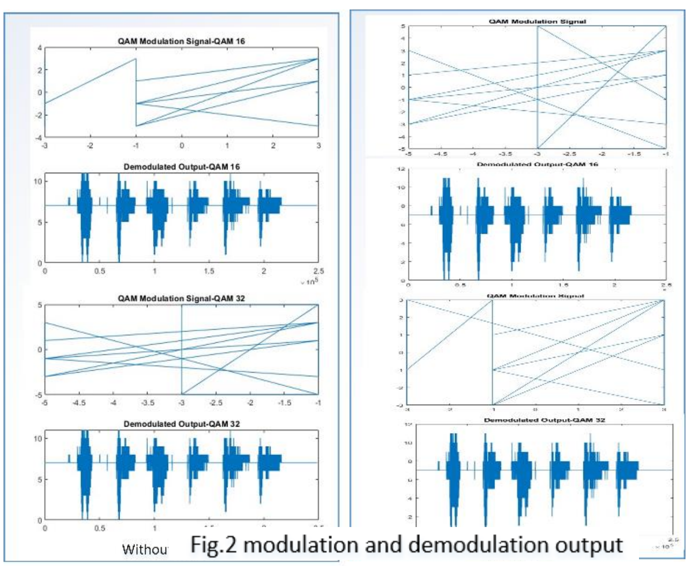
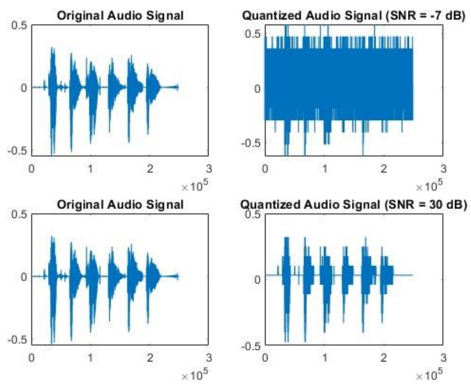


Fig.2 modulation and demodulation output

Figure 2 show the results of the modulation and demodulation analysis are presented using Additive White Gaussian Noise (AWGN) and without AWGN (I only selected two samples: QAM 16 and QAM 32). It can be observed that there is a difference in the formed signal when using AWGN; the signal undergoes changes due to the introduction of bit noise, resulting in signal variation. Nevertheless, the demodulation output generated from adding noise to the discrete image does not show significant differences. However, the differences in the values of this demodulation output can be scrutinized in detail by examining the demodulation results through programming in MATLAB.

Kode 2#



After comparing the four QAM types, I proceeded to examine the demodulation performance of QAM and compare it with On Off Keying (OOK) and Pulse Position Modulation (PPM) modulation. In this program, I included two types of Signal-to-Noise Ratios (SNR) to evaluate the impact of SNR differences on the modulation process. In Figure 3, the original audio signal undergoes two SNR variations: -7dB and 30dB. Each SNR value is utilized to observe its impact on each modulation type.

Fig.3 Quantized audio signal using SNR

Subsequently, quantization is performed on QAM modulation, followed by the demodulation process on the modulation results (as before). Next, the On Off Keying (OOK) modulation process is carried out, which is a simple modulation form where the carrier signal represents "1" as ON and "0" as OFF. In the provided MATLAB program, OOK modulation is performed by measuring whether the quantized signal value "y1" is above or below a certain threshold.

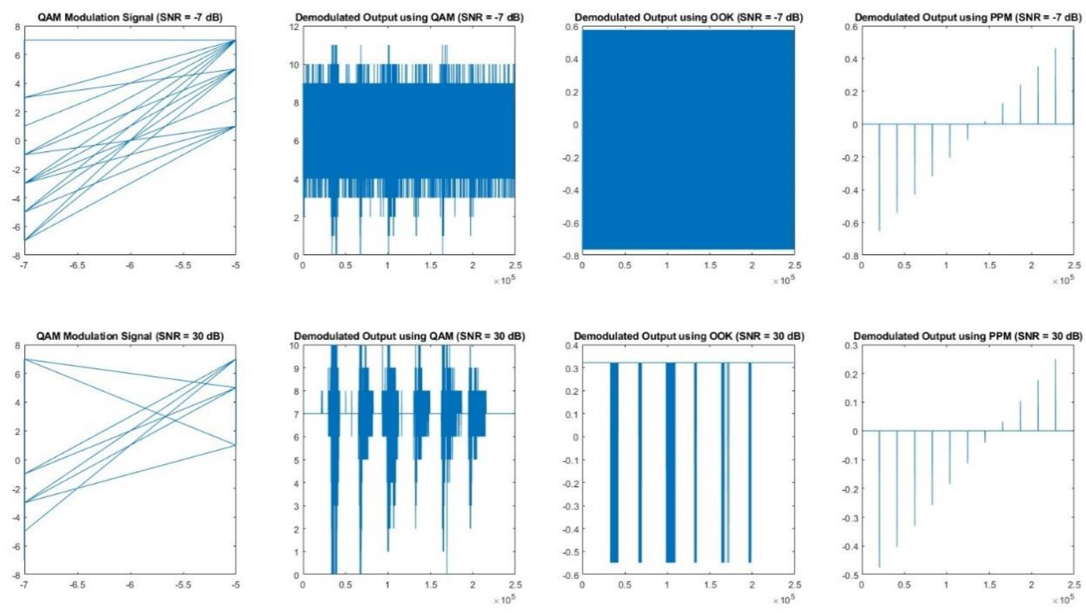


Figure 4) Results of demodulating QAM, OOK, and PPM, taking into account the SNR effect.

The process of PPM modulation is carried out with a modulation form where information is conveyed through the relative position of pulses (pulse position) within a modulation period. In the Matlab code proposed, each value of the quantization signal "y1" determines the pulse position during modulation. If the signal value is 0, no pulse is generated at that position; if the signal value is 1, a pulse is generated at that position. The pulse width is controlled by the variable "ppm_pulse_width."

Figure 4 depicts the results of demodulating the three modulation types I utilized. The variance in SNR values used in modulation significantly influences the quality of the resulting signal. Examining the output of the demodulation results, an SNR value of -7dB in the system produces poor demodulation output due to the noise level generated being greater than the signal strength. This is evident, especially in the implementation of QAM and OOK modulation, where the demodulation signal is heavily distorted by noise, making it challenging to identify the actual signal patterns. In PPM modulation, despite some interference, the results can be identified better than with QAM and OOK at an SNR of -7dB. Conversely, at an SNR of 30dB, the demodulation results show better signal quality. The demodulation signals in QAM and OOK appear clearer and align with the original signals. In PPM modulation, although there is some interference, the demodulation results can still be identified well.

Conclusion:

- Based on the testing results of the QAM 16, 32, 64, and 128 implementations, the differences among QAM types lie in the number of symbols carried by each modulation symbol and how much information can be transmitted in each symbol.
- The introduction of AWGN into a modulation system will cause distortion and impact the Bit Error Rate (BER) value in the system.
- The SNR value significantly influences the demodulation quality of a system. The use of low SNR can result in significant distortion in the demodulated signal, making it challenging to interpret the information contained in the signal.