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Research on Error Correction Signal in Wireless Communication by AWGN

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ABSTRACT

This study focuses on three basic digital modulation techniques: ASK, FSK, and PSK. The conveyed signals of these modulation techniques are defined by a distinct system of values appearing at gradually separated times. The bandwidth efficiency and easy implementation are important factors in deciding which digital modulation method to use for a given application, but so are the bit error rate (BER) & signal to noise ratio. Binary modulation systems employ two values, are simple to implement, give adequate error substantiation. The bit error rate (BER) is an important statistic for evaluating systems that transmit signal data from one location to another. The SNR is a well-known metric for comparing signal and noise power. It has a direct impact on a system's chance of bit error rate. Authors used MATLAB to construct BPSK, QPSK, QAM in this paper. As a carrier wave, the cosine signal was used. The analysis is carried out with SNR over AWGN channel as the reference factor in this work, which proposes a comprehensive examination of BER performance of QPSK, BPSK, QAM for channel usage.

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KEYWORD: *Digital Modulation, ASK, FSK, PSK, QAM, AWGN Channel, Signal-to-Noise Ratio, Probability of Bit Error*

I. INTRODUCTION

Information is the order of the day in today's world. Wireless techniques have developed the most important form of communication. The ability of good transmitting & receiving devices to work well is critical. Attenuation, distortion, and noise should be minimized for as much as feasible in order to achieve good efficiency. As a result, reliable measurements of the transmitting and receiving signals are required. The communication quality & accuracy of the received signal could be affected by several digital modulation techniques parameters, coding, and filtering. The modulation schemes used to modify a carrier wave using discrete signals are known as digital modulation. High carrier frequencies are utilized in digital modulation so that signals could be transmitted across vast distances using existing long-distance multimedia like radio channels [1]. Noise in the channel does not have the same negative impact.

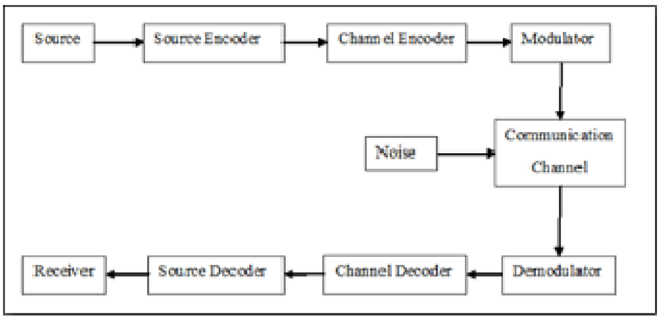

Figure 1: A Modal of Communication System [2]

Information Source: - It is an equipment / software entity that generates the information or symbols to be transmitted, such as human voice, television picture, and text messages. Analog and discrete information sources are the two types of information sources based on their output nature. Microphones, TV cameras, and other analogue sources provide constant amplitude signals. Discrete generators contain discrete symbols, like computer numerical output, teletype, and so on.

Source Encoder: - A hardware or software entity that provides the data by assigning binary bits to source symbols. The source encoder transforms the source symbols into a binary bit series of 0s and 1s.

Channel Encoder: - A channel encoder is a hardware or software entity that controls mistakes by adding additional parity bits (error control bits) to the source encoder's output.

Communication Channel: - It's a path or medium that electrical pulses travel across. A communication channel is a channel that transmits data, like sound, data, and video, from a source to a receiver within a certain bandwidth. Noise is an unwanted signal that distorts the original signal's form.

Channel Decoder: - The error controlling bits are removed by the channel decoder; the remainder binary bits are assigned to the source decoder.

Decoder: - A hardware or software entity that converts coded data back into its original form. It A hardware or software entity that restores the original form of initial codes. It reverses the source encoder's work by transforming the channel decoder's binary output into a sequence of symbols.

Receiver: - A signal-accepting hardware gadget. The transmitter carries messages that pass over the communication channel and thus are received by the receiver at the other end [3].

The article is structured as obeyed: Section II explains Digital Modulation Schemes. Section III & IV AWGN and literature survey the proposed work. Section V explains problem formulation & objectives. Finally, Section VI shows the results of proposed work and Section VII gives the conclusion.

II. DIGITAL MODULATION SCHEMES

The term "modulation" is seen a lot in this thesis to describe the act of putting an input signal onto a carrier wave. This method of imposing signals on a carrier wave is achieved by altering the carrier signal's characteristics in response to the modulating signal. Modulation is the process of changing the structure of a carrier wave in order to contain the data signal that will be transmitted. One or more periodic waveforms known as carrier signals can constitute one of the features.

➢ BPSK Modulation

Binary Phase Shift Keying (BPSK) is an acronym for Binary Phase Shift Keying. In this stage, the keying is modified, but the amplitude maintains the same. The sent signal is a sinusoid with a fixed amplitude that varies in phase depending on the data level. Basic functions such as sin(t) and cos(t) are employed to achieve modulation according to message bits. When the data is at one level, it has one set phase, and when the data is at another level, the phase is 180 degrees changed. The following is a definition of a BPSK signal:

$$S0(t)=A\cos(\omega t) \rightarrow \text{represents '0'}$$

$$S1(t)=A\cos(\omega t+\pi) \rightarrow \text{represents '1'}$$

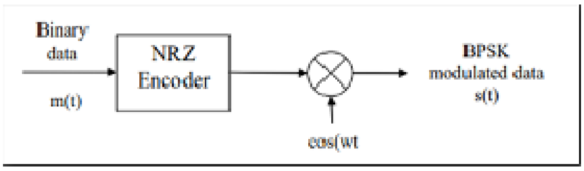

Figure 2: BPSK Modulator 8]

➢ QPSK Modulation

A modulation scheme is a set of basic functions for a particular modulation technique that is chosen for communication as a carrier wave. Any vector in signal space can be represented as a linear combination of basic functions after choosing the basic function. The acronym QPSK stands for Quadrature Phase Shift Keying. For coding binary bits, keying uses four phases: 0, 90, 180, and 270 degrees. Sinusoids (sin and cos) are the most basic functions, modulation is performed by changing the phase of these functions. The cosine function is used for even numbers of bits, as well as the sin function is used for odd numbers of bits. By using a serial to parallel conversion, the odd bits in the quadrature arm or the even bits in the phase arm are split and afterwards transformed to NRZ format. All NRZ encoders' outputs are multiplied by sine-cosine components. The cosine element of the in-phase arm signal is multiplied by the sine component of the quadrature arm signal, as well as the frequency modulation is formed by combining these signals. Quadrature is derived from quadrants, so it improves performance and throughput.

➢ Quadrature Amplitude Modulation

To improve spectrum utilization, QAM changes both magnitude and phase. The elements of in-phase and quadrature phase are orthogonal to one another. It is a technology that involves both analog or digital modulation [4]. It's used to send and receive high-speed data. More bits can be modulated each symbol as the order of QAM increases. As a result, the data rates will increase. In QAM, the constellation points are laid out in a square grid with equal vertical and horizontal spacing. The likelihood of inaccuracy rises as the distance between constellation points reduces as the order increases. From cellular phones to Wi-Fi, QAM is employed in a variety of applications. Wi-Fi, cable modems, digital video broadcast (DVB), Wi MAX are all examples of communications networks that utilize QAM. QAM is most commonly employed in cable television since data loss is tolerable. The transmission is modified by QAM.

$$y(t)=M_I(t)\cos(2\pi f_c t+\phi_c)++M_Q(t)\sin(2\pi f_c t+\phi_c)$$

III. AWGN CHANNEL

Between the transmitter and the receiver, a radio channel is just an electromagnetic medium. The Gaussian channel, often known as the additive white Gaussian noise (AWGN) channel, is the most extensively used channel model. The AWGN channel is relatively basic, so it is frequently used as a starting point for developing a rudimentary performance evaluation system [6]. The AWGN channel model is commonly utilized in OFDM research. Only linear addition of white noise with a constant spectral density and Gaussian amplitude distribution is used in this design. The method ignores fading, frequency selectivity, noise, and other factors [5]. Despite the reality that it is not ideal for most terrestrial links, it is still used to provide simple & controlled statistical formulas for studying the basic behavior of a device in the lack of the aforementioned elements.

IV. LITERATURE SURVEY

Diponkor Bala et al., (2021) aimed to offer relevant theoretical knowledge for several digital modulation schemes, as well as highlight some important parameters that are commonly employed in digital communication systems. This study discusses a comparison of alternative digital modulation schemes based on their Probability of Bit Error performance over an AWGN channel. This study also shows the output modulated waveforms of several digital modulations based on their digital input and carrier signals. The analysis of Probability of Bit Error results for various digital modulation schemes reveals that the BPSK, QPSK, and 4-QAM methods present the lowest Probability of BER under low SNR conditions, while the 32-FSK technique provides the lowest Probability of Bit Error value under both medium and high SNR conditions. Therefore, it would be determined that BPSK, QPSK, 4-QAM, and 32-FSK are more suitable for low, medium, and high SNR conditions, respectively, to improve organizational performance [7].

Menezla et al.,(2019) examine and analyze the coding and decoding functions of a transmission channel using deferent coders in the most efficient way possible (Turbo-Code, Convolution Code, Code en Bloc, Code LDPC). Disturbances and errors may occur regardless of the quality of the communication channel and transmission systems employed. The received binary sequence will not be identical to the transmitted one in certain circumstances. Methods for preventing transmission errors can be utilized to solve these issues. On the other hand, an Error Correcting Encoder (ECC) must be added to this chain to remove noise supplied by the channel and to improve the communication system's transmission. Turbo codes can be used as a code because they allow you to get close to Shannon's theoretical maximum of correction. As a result, most current communications methods incorporate turbo codes. Under conditions consistent with a hardware realization of the encoder and decoder, the generated simulation results reveal very close performances to the theoretical limits of channel coding [8].

Radder et al., (2019) outlines a framework for making a QPSK system in FPGA, with the device being designed in such a way that it performs better in an AWGN environment. We chose an approach that resembles the Box-Muller technique, which creates two independent random variables with a normal distribution, to simulate the AWGN environment. The produced noise number sequences are then added to the I-channel and the Q-channel individually. Signal smoothing is accomplished via Raised Cosine Filtering. To demonstrate the potential for FEC codes to increase performance, authors employ (2, 1, 7) convolutional encoding after pulse shaping, then introduce noise, and rectify the faults with Viterbi decoding. Model Sim PE Student Edition 10.4a was used to simulate the entire system, which was then constructed using the Xilinx XC6SLX45 Spartan 6 FPGA and Chip Scope Pro software [9].

Balevi, et al., (2020) Proposed employing a concatenation of a turbo code and an auto-encoder as an implicit regularization using turbo codes. Authors show empirically that this architecture performs nearly as well as a supposedly perfectly trained auto-encoder, and we also present a theoretical justification for this. Because the auto-encoder uses the excess bandwidth from pulse shaping and packs signals more wisely thanks to sparsity in neural networks, the suggested coding method is as bandwidth efficient as the integrated (outer) turbo code. Even with QPSK modulation, suggested results show that the proposed coding technique surpasses traditional turbo codes for finite block lengths. Furthermore, even for 16-QAM, the suggested coding scheme can make one-bit quantization possible [10].

Ahmed et al. (2019) On varied constraint lengths, the Viterbi method is investigated for BPSK modulated convolutional encoded data over AWGN channel. At BER= 10-5, simulation findings indicate that code gain rises by a factor of about 0.5 dB As the BER decreases, the code gain increases, but only to a certain point; after that, there is no change in BER at the cost of increasing code gain, so truncating the path memory at 6K will save memory & computation.

The decoder's practical implementation is limited to K≤ 15[11].

Gobika Asaithambi **et al. (2021)** attain greater data rate and to transmit the data in a secured manner authors merged FEC and CFH technology, described as Code & Chaotic Frequency Modulation (CCFM) . In particular, two rate adaptation methods named Static retransmission rate ARF (SARF) and Fast rate reduction ARF (FARF) are applied in CFH method to dynamically change the code cost depends on channel situation to reduce a packet retransmission. The system's Symbol Error Rate (SER) performance is studied for various code rates with conventional OFDM in the presence of AWGN & Rayleigh channel, the CFH method's reliability is evaluated under various jammers [12].

V. PROBLEM FORMULATION & OBJECTIVES

Problem formulation

Due to the demand at the present era of wireless communication technology, it is highly required a dependable communication system that can transmit more data with the lower probability of bit error. The digital modulation technique plays a vital role in modern wireless communication technology. Digital modulation technique provides the ability of more data transmission rates with better communication quality and higher data security using optimum bandwidth. By estimating the Probability of Bit Error, it will be possible to evaluate the quality of the performance of different modulation techniques. In traditional work discuss about the appropriate information of different digital modulation techniques which are extensively used in digital wireless communication systems. Finally by analyzing the Probability of Bit Error (BER) performance of various digital modulation techniques, it could be concluded that which modulation technique is suitable for different Signal-to-Noise Ratio conditions. The existing author was especially focused on the comparison of the Probability of Bit Error (BER) performance among ASK, FSK, PSK and QAM modulation techniques. As per the analysis of traditional work we need to focus on error-correction technique and reduce impact on channel noise.

➢ **Objectives**

1. To implement convolution coding in wireless communication for error-correcting.
2. To introduce Viterbi decoding to recover the signal corrupted by AWGN.
3. To perform comparative analysis of proposed system.

The examination of Probability of BER of different modulation schemes will be performed with respect to different SNR in wireless communication technology. As a consequence, in order to plot the Probability of BER simulation outcomes of various modulation schemes, we used the Probability of Bit Error (Pbe) and SNR) values on the y-axis and x-axis, accordingly, SNR values of - 4 to 30dB. Authors used a logarithmic function to calculate the cost of the Probability of Bit Error in decibel units in this investigation. The likelihood of BER performance was modeled using the MATLAB framework, as well as the numerical simulations of the modulation methods BPSK, QPSK, QAM are shown below:

Probability of Bit Error Performance for Different Modulation Techniques

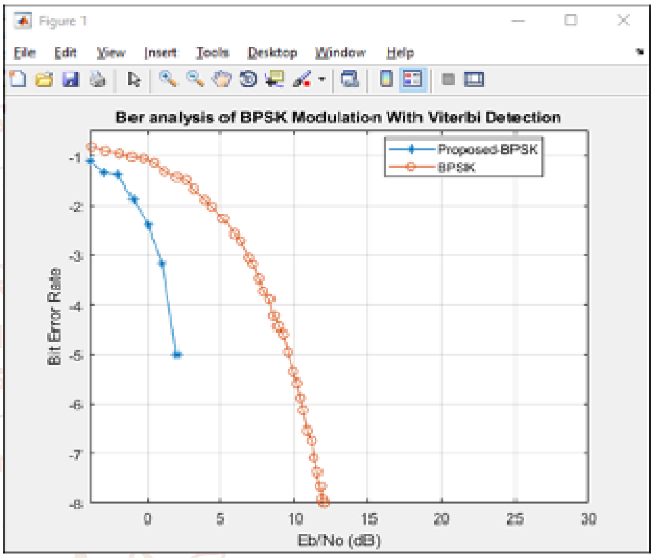

Figure 3: BER Analysis of BPSK Modulation

The numerical simulations of the BPSK & suggested BPSK modulation schemes are shown in Figure 3. The suggested BPSK modulation schemes are clearly demonstrated in the above figure to have the lowest Probability of Bit Error.

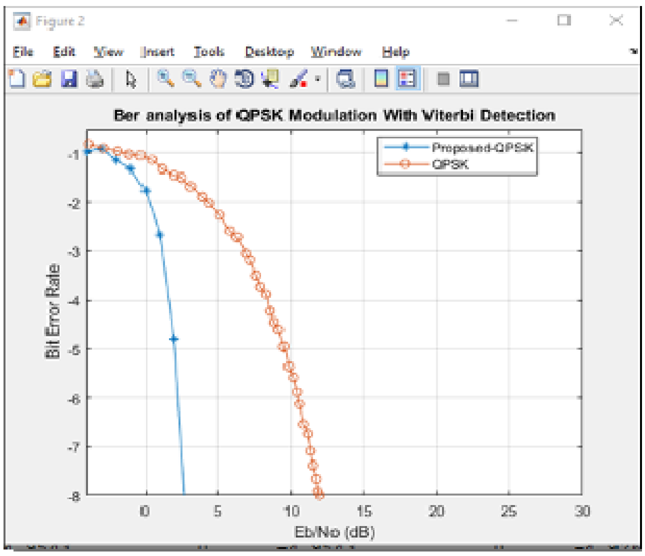

Figure 4: BER Analysis of QPSK Modulation

The numerical simulations of the QPSK & recommended QPSK modulation approaches are shown in Figure 4. The proposed QPSK modulation approaches are clearly demonstrated in the above picture to have the lowest Probability of Bit Error.

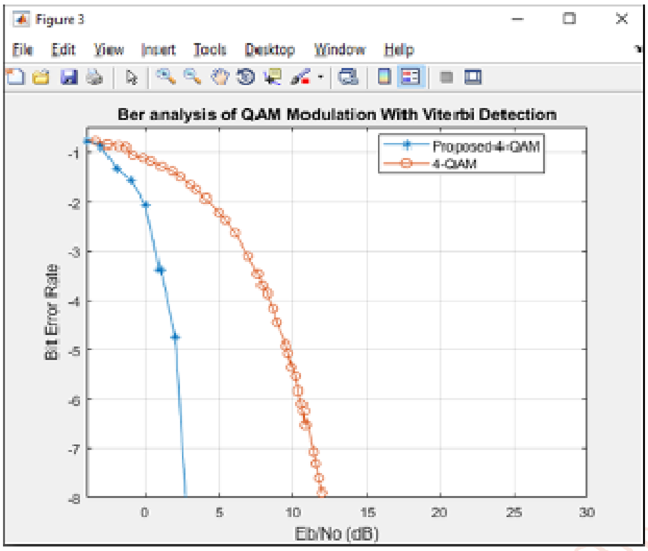

Figure 5: BER Analysis of QAM Modulation

The numerical simulations of the QAM & suggested QAM modulation approaches are shown in Fig. 5. The suggested QAM modulation approaches are clearly demonstrated in the above figure to have the lowest Probability of BER.

The Probability of BER of all modulation approaches in some specified SNR values is shown in Figure 6, where the values are 1dB, 5dB, 10 dB for low, medium, large SNR values, correspondingly, and the minimal Probability of Bit Error (BER) values are shown in each column.

SNR_dB	tBPSK_BER	BPSK_BER	tQPSK_BER	QPSK_BER	tQAM_BER	QAM_BER
-4	-0.81101	-1.0986	-0.81101	-0.96103	-0.78109	-0.79851
-3	-0.89622	-1.3567	-0.89622	-0.91006	-0.78829	-0.83347
-2	-0.95379	-1.3943	-0.95379	-1.1552	-0.85263	-1.3375
-1	-1.0203	-1.8806	-1.0203	-1.3155	-0.87392	-1.5766
0	-1.0487	-2.3979	-1.0487	-1.7501	-0.91062	-2.0495
1	-1.1378	-3.1811	-1.1378	-2.6514	-1.0578	-3.4075
2	-1.3255	-5.0207	-1.3255	-4.0036	-1.1094	-4.7795
3	-1.4505	0	-1.4505	-9.2103	-1.1743	-9.2103
4	-1.4957	0	-1.4957	0	-1.292	-8.8117
5	-1.6718	0	-1.6718	0	-1.3886	0
6	-1.8901	0	-1.8901	0	-1.5087	0
7	-2.0264	0	-2.0264	0	-1.6704	0
8	-2.2728	0	-2.2728	0	-1.7762	0
9	-2.5736	0	-2.5736	0	-1.9523	0
10	-2.7044	0	-2.7044	0	-2.2224	0
11	-3.054	0	-3.054	0	-2.3805	0
12	-3.1914	0	-3.1914	0	-2.6514	0
13	-3.4867	0	-3.4867	0	-3.101	0
14	-3.7259	0	-3.7259	0	-3.4796	0
15	-3.8819	0	-3.8819	0	-3.7212	0
16	-4.2365	0	-4.2365	0	-3.8752	0
17	-4.4458	0	-4.4458	0	-4.1677	0
18	-4.5978	0	-4.5978	0	-4.4641	0
19	-4.9543	0	-4.9543	0	-4.926	0
20	-5.3616	0	-5.3616	0	-5.3608	0
21	-5.5773	0	-5.5773	0	-5.0771	0
22	-5.8933	0	-5.8933	0	-5.5551	0
23	-6.1335	0	-6.1335	0	-5.8489	0
24	-6.5309	0	-6.5309	0	-6.1047	0
25	-6.7326	0	-6.7326	0	-6.5403	0
26	-7.0922	0	-7.0922	0	-6.2536	0
27	-7.3756	0	-7.3756	0	-7.0783	0
28	-7.6524	0	-7.6524	0	-7.3249	0
29	-7.9222	0	-7.9222	0	-7.6299	0
30	-8	0	-8	0	-7.9051	0

Figure 6: Comparison of BER

VI. CONCLUSION

This research is the result of research into novel methods for implementing Viterbi decoder designs with the goal of reducing computation memory, power consumption, BER, and latency. The decoding mechanism of the Viterbi algorithm, the design of the Viterbi decoder, and the implementations of the core functions are all examined in this report. This allows for the detection of design flaws. Then, in attempt to optimize the decoder's efficiency, a variety of design strategies are presented and applied to it. The new concepts are put to the test using software and hardware simulations. The findings demonstrate how the adjustments have improved, and they enable the development of a revolutionary generic method for greatly decreasing the difficulty of decoding convolutional codes.

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