Development of 4G Mobile Communication System using Efficient Trellis Encoding and 4-QAM Modulation

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Abstract - BER is the key parameter for indicating the system performance of any data link. In our research work we analyzed that for different values of SNR, the BER increases for high order modulation. On the other hand, the lower order modulation schemes (4-QAM and QPSK) experience less BER at receiver thus lower order modulations improve the system performance in terms of BER. The BER increases for high order modulation because of the fact that higher order modulation techniques use more bits per symbol. Hence it is easily affected by the noise. From the simulation results, it is observed that the 4-QAM allows the BER to be improved in a noisy channel at the cost of maximum data transmission capacity. Use of QPSK allows higher transmission capacity, but at the cost of slight increase in the probability of error.

Keywords- OFDM, 4G mobile, Additive White Gaussian Noise (AWGN), BER & SNR.

I. INTRODUCTION

Wireless mobile communication technology has been progressing in a booming speed. Presently, the technology has advanced into its third gen (3G). Be that as it may, new applications, for example, better execution media, Internet and broadband services are much requested in the new mobile correspondence frameworks. These services require higher speed and larger limit data transmission. In this manner, the fourth era (4G) and past are being developed.

The main purpose of 4G is to provide the users broader bandwidth, higher data rate, wider coverage, more secure communications, but with lower cost, compared to previous generations. Briefly speaking, it is expected to provide the users much better services on an ‘Anytime, Anywhere’ basis.

Because of the huge impact of the future information and communication technology on the international economy, there is plenty of related research on 4G. A number of advanced techniques are presented as potential candidates for the coming 4G wireless communication systems. Among all the techniques, orthogonal frequency division multiplexing (OFDM) and its advanced versions, and combined with multi-input and multi-output (MIMO) antennas are considered best to meet the requirements of the 4G system, due to the advantages it can offer in wideband wireless communications. However, as other schemes, it has some disadvantages. Researchers try to find methods to balance the properties to make the schemes get better performance. In other words, they try to overcome the disadvantages, while keeping the advantages.

OFDM is one of the special cases of multi-carrier modulation (MCM) which originally dates back to 1950s and early 1960s in military high frequency radio links. However, OFDM was firstly introduced in mid 1960s by R. W. Chang but it hadn’t been developed much during that time, because of the high complexity of using analogue filters to implement this system. In the year of 1971, S. B. Weinstein and P. M. Ebert addressed a method in which they used Discrete Fourier Transform (DFT) to implement multicarrier modulation.

II. OFDM ARCHITECTURE

OFDM is a typical multicarrier system, which subdivides the available bandwidth into a large number of orthogonal, overlapping, narrowband subchannels or subcarriers and these subcarriers transmit in parallel. A simplified OFDM system block diagram is shown in Fig. 2.1. In this figure, the top half represents the transmitter and the bottom half represents the receiver, respectively. At the transmitter, the incoming data are firstly modulated by binary phase shift keying (BPSK), quadrature phase shift keying (QPSK) or M-quadrature amplitude modulation (M-QAM). After that, the serial stream is converted into parallel format by a serial to parallel (S/P) converter. In this process, every N symbols are grouped to be sent to the inverse fast Fourier transform (IFFT) modulator. IFFT does the same thing as Inverse Discrete Fourier Transform (IDFT) but it is only more efficient and low complexity. In the IFFT block, these symbols are modulated into different N subcarriers. In my project, the difference between IFFT and IDFT is not distinguished.

Following the IFFT and before being transmitted, the parallel symbols are converted into a serial stream again and a cyclic prefix (CP) is added in order to eliminate the effect of inter-symbol interference (ISI) and inter-carrier interference (ICI). To satisfy the condition, the CP has to be longer than the length of the channel.

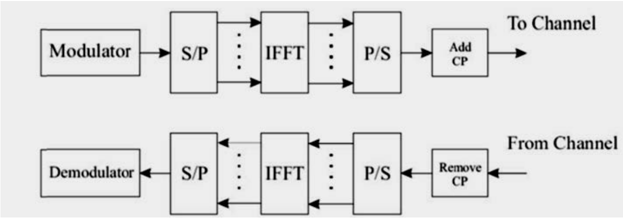

Figure 2.1 Block Diagram of an OFDM system

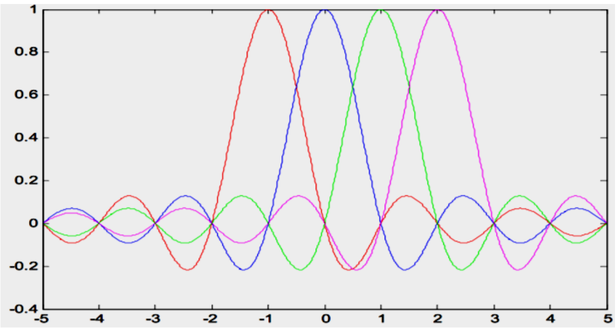

Figure 2.2 OFDM spectrums with subcarriers.

Figure 2.2 shows the spectrum of an OFDM signal. From this, the orthogonality of the sub-carriers can be seen. Every subcarrier falls into other sub-channels' zero value there is no overlap and little interference is created, and the crosstalk between sub-channels is eliminated and this greatly simplifies the design of both the transmitter and the receiver. The receiver performs the opposite of the transmitter. After receiving the signal, it removes the CP first, and followed by a parallel to serial process. Then it implements an N point DFT.

III. PROPOSED METHODOLOGY

In this proposed model we are using complex conjugate coding with QPSK/4-QAM modulation. AWGN channel is used for transmission with cyclic prefixing.

Here first of all Trellis Encoding is done followed by modulation. After OFDM modulation it comes the filtering of the data, which provides the orthogonality to the subcarriers.

IFFT will convert time domain signal to the frequency domain. To reduce the interference Cyclic Prefix are added. After passing through the channel cyclic prefix are removed followed by FFT will be performed with Trellis Decoding and decoding process. Demodulated data is converted to binary form to obtain the original data transmitted. The Block Diagram in the above described proposed system is shown in below figure 3.2. And the flow chart of proposed work is demonstrated in figure 3.1.

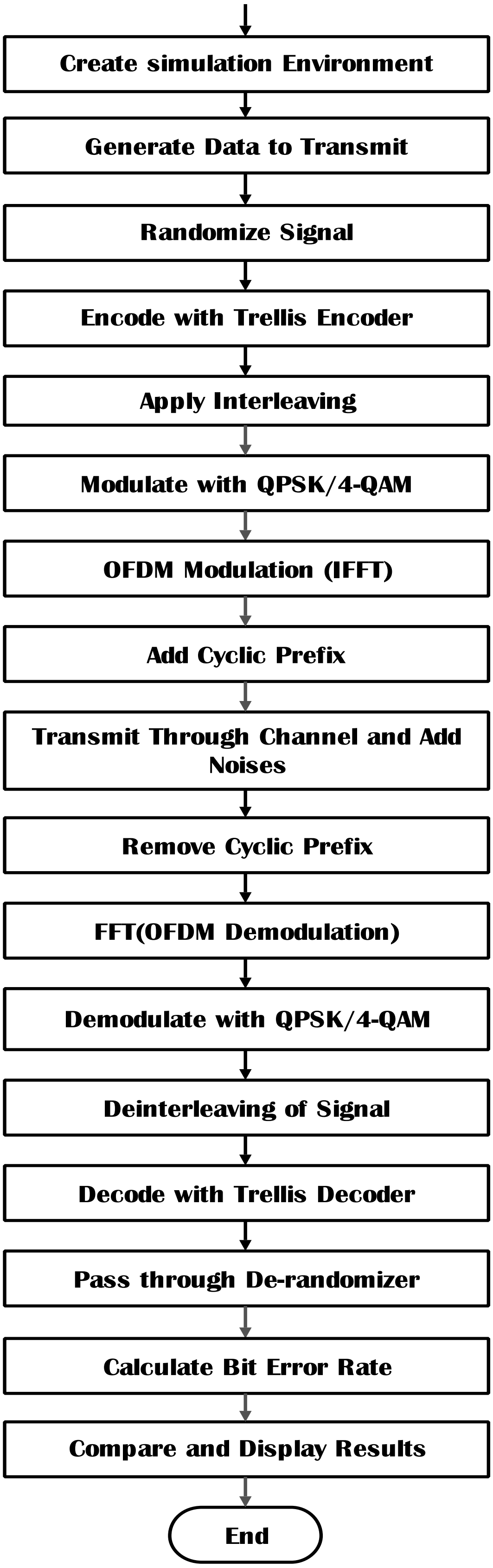

Figure 3.1 Flow Chart of the Proposed Methodology.

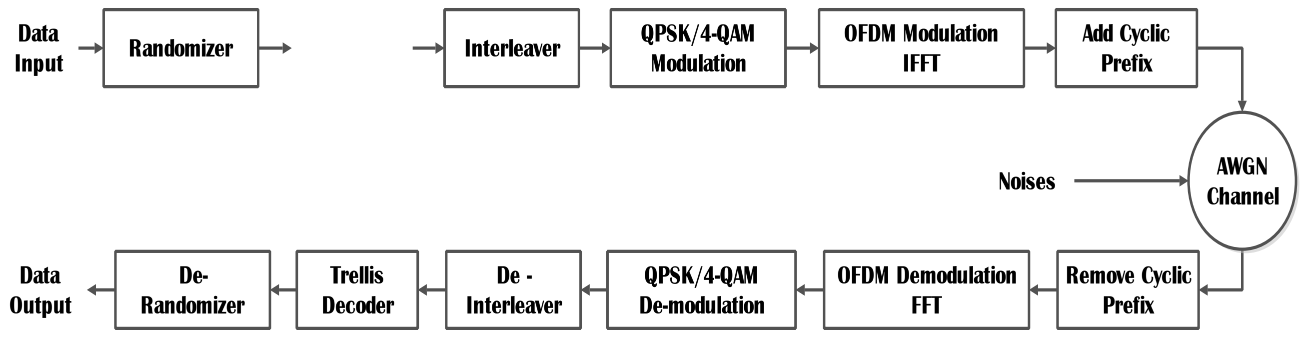

Figure 3.2 Block Diagram of Proposed Methodology

IV. SIMULATION RESULTS

The proposed system is discussed and explained in the previous section. In this section the outcomes of simulations performed on the proposed system is discussed. The system in evaluated under different data lengths and with m-PSK modulation. The results are compared for different symbol sizes with 1-D digital filter. The simulation outcomes are shown in below figures.

In Fig. 4.1 the simulation results with 2-FFT is displayed, and the performance of the proposed with QPSK /4-QAM modulation and Trellis Encoding. So here Trellis Encoding proposed technique adopted for efficient 4G system and optimum BER achieved is $2x10^{-7}$ with 4-QAM Modulation.

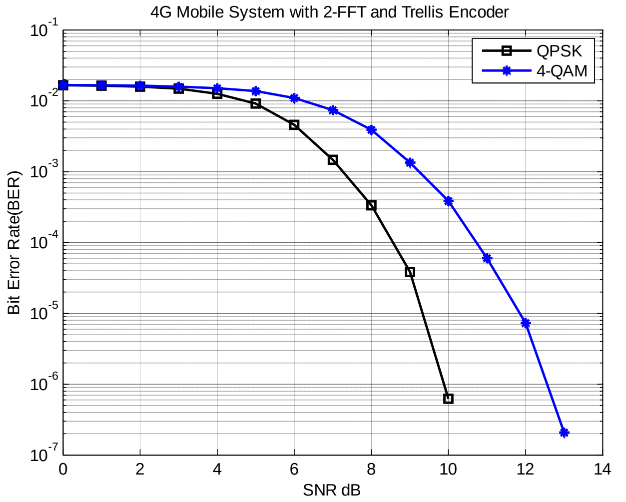

Fig. 4.1 BER Curve for 4G Mobile Communication System using 2 FFT Points

In Fig. 4.2 the simulation results with 8-FFT is displayed, and the performance of the proposed with QPSK /4-QAM modulation and Trellis Encoding. So here Trellis Encoding proposed technique adopted for efficient 4G system and optimum BER achieved is $2x10^{-7}$ with QPSK Modulation.

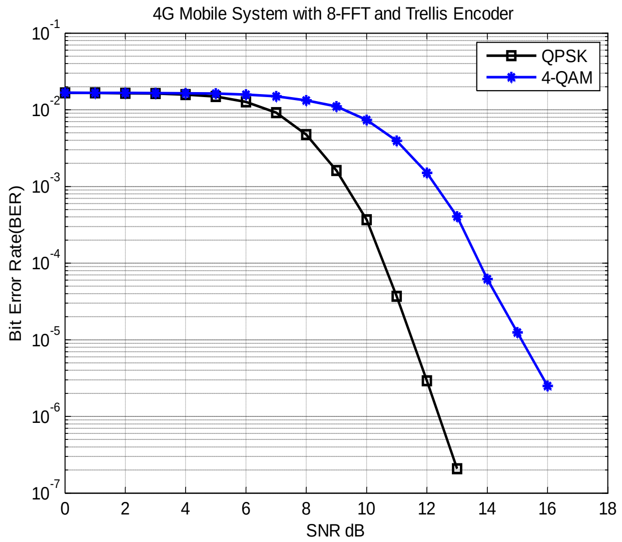

Fig. 4.2 BER Curve for 4G Mobile Communication System using 8 FFT Points

In Figure 4.3 the simulation results with 16-FFT is displayed, and the performance of the proposed with QPSK /4-QAM modulation and Trellis Encoding. So here Trellis Encoding proposed technique adopted for efficient 4G system and optimum BER achieved is $6x10^{-7}$ with 4-QAM Modulation.

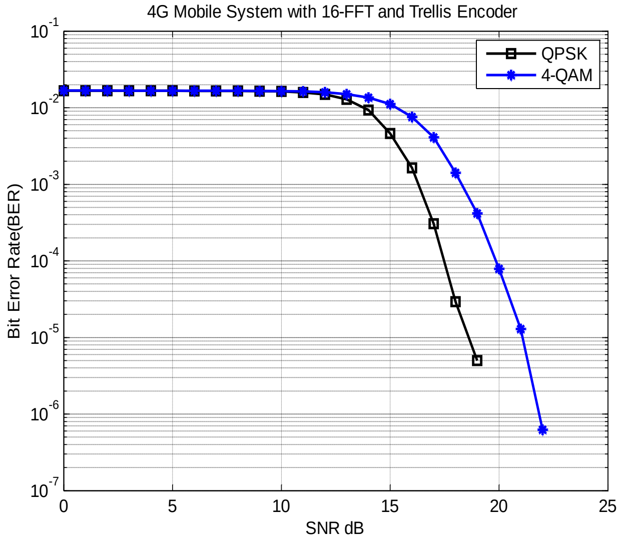

Fig. 4.3 BER Curve for 4G Mobile Communication System using 16 FFT Points

Table 1 - Comparison of BER with Different Modulation Technique

SNR	BER with 2 FFT Points		
	QPSK	4-QAM	Existing Work
0	0.0165	0.0165	0.06
1	0.0162	0.0165	0.04
2	0.0158	0.0164	0.03
3	0.0148	0.0159	0.02
4	0.0125	0.01501	0.019
5	0.00910	0.01352	0.0055
6	0.00453	0.01101	0.0021
7	0.00154	0.00733	0.00073
8	0.00041	0.00371	0.00031
9	0.00003	0.00142	0.00003
10	0.00002	0.00041	$1x10^{-6}$

V. CONCLUSION AND FUTURE SCOPE

The OFDM makes efficient use of available spectrum by allowing overlapping among the carriers. It basically converts the high data rate stream in to several parallel lower data rate streams and thereby eliminating the frequency selective fading. It has been seen that the OFDM is a powerful modulation technique that is capable of high data rate and is able to eliminate ISI. It is computationally efficient due to the use of FFT techniques to implement modulation and demodulation functions. Using MATLAB software, the performance of OFDM system was tested for the QPSK and 4-QAM digital modulation technique. The performance of OFDM system was also tested for the Three different FFT points and data bits. The further enhancement in the performance of the 4G system can be done with the utilization of the digital modulation techniques or the use of more complex encoding schemes. The detection and combining techniques will also help to reduce the error rate at receiver side.

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