Implementation of OFDM Transceiver using GMSK and QPSK Encoding Technique

Gunjan Negi
Student, ECE
GRD Institute of Management
and Technology
Dehradun, India

Arun Kumar
Assistant Professor, ECE
GRD Institute of Management
and Technology
Dehradun, India

Anuj Saxena
Information Technology
Karnataka State University
Karnataka, India

ABSTRACT
OFDM (Orthogonal Frequency Division Multiplexing) transmissions are arising as important modulation techniques because of its robustness against interference. Various modulation schemes have been used to implement OFDM. In this paper, the OFDM transceiver system is implemented using MATLAB. Gaussian Minimum Shift Keying modulation technique has been implemented in the proposed OFDM. The bit error rate (BER) performance has been evaluated in AWGN (Additive White Gaussian Noise) channel and is compared to Quadrature Phase Shift Keying modulation scheme.

General Terms
Bit error rate, Matlab, Additive White Gaussian Noise.

Keywords
Orthogonal Frequency Division Multiplexing, Gaussian Minimum Shift Keying, Quadrature Phase Shift Keying

1. INTRODUCTION
OFDM can be implemented by using various modulation techniques. Researchers have proposed various modulation techniques like QPSK, QAM, and MSK etc. This paper demonstrates the simulation of an OFDM transceiver using Gaussian Minimum Shift Keying modulation technique and Quadrature Phase Shift Keying technique.

The paper is organized as follows. Section II gives the implementation of the OFDM transceiver with OFDM system requirements and specifications. Section III gives the experimental results of system evaluation in term of simulation environment. Section IV includes conclusions of OFDM implementation.

1.1 System Design
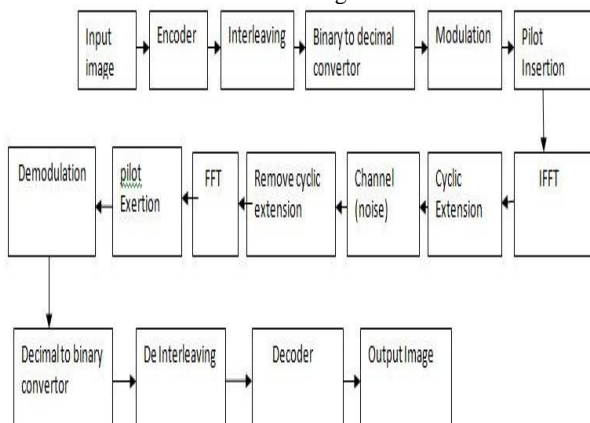The general structure of OFDM transceiver system using Matlab simulation is illustrated in figure 1.

Figure 1: Block Diagram of OFDM Transceiver

1.1.1 Transmitter
In an OFDM system, the data block of N symbols, denoted by $X=[X_0, X_1, X_3, XN_{-1}]^T$, is modulated by a set of orthogonal sub-carrier, f_k, {k=0, 1, 2, N-1}, where T denotes the transpose. In OFDM system to sustain the orthogonality of the signals, the spacing Δf between neighboring subcarriers is set to be a multiple of 1/T. i.e., $\Delta f=m1/T$, where T is the duration of an OFDM symbol, then the transmitted OFDM symbol is given by

$$x(t)=1/N\sum_{k=0}^{N-1} X(k)e^{j2\pi ft} \quad 0<=t>=T \qquad (1)$$

The Input image is converted to source data and is passed through the encoder. Convolution codes are used to encode the data. Then the signal is passed through interleaver. Interleaving increases the resistance to fading. Binary to decimal convertor converts the binary vector to decimal number.

1.1.1.1 Modulator
(a) GMSK modulator
The signal is then passed through modulator (GMSK). Gaussian Minimum Phase Shift Keying is a continuous phase modulation scheme which is generated by filtering NRZ data with a Gaussian shaping filter. The GMSK modulated waveform is characterized by the BT product. Where, B is the bandwidth of the Gaussian filter and T is the duration of the data bit.
The resulting signal is represented by

$$S(t) = a_I(t) \cos(\pi t/2T) \cos(2\pi f_c t) - a_Q(t)\sin(2\pi f_c t) \qquad (2)$$

Where, $a_I(t)$ and $a_Q(t)$ are the even and odd information respectively. $a_I(t)$ has pulse edges on t= {-T,T,3T..} and $a_Q(t)$ on t={0,2T,4T…..}. The carrier frequency is f_c.

This equation can be rewritten in a form of phase and frequency modulation,

$$S(t) = \cos[2\pi f_c t + b_k(t)\pi t/2T + \phi_k] \qquad (3)$$

where $b_k(t)$ is +1 when $a_I(t)=a_Q(t)$ and -1 if they are of opposite signs, and ϕ_k is 0 if $a_I(t)$ is 1, and π otherwise. Therefore, the signal is modulated in frequency and phase, and the phase changes continuously and linearly.

(b)QPSK modulator
In QPSK modulation, the input binary data is first converted to bipolar NRZ type of signal. The demultiplexer divides the signal into two separate bit streams. Here, $b_e(t)$ represents even numbered sequence and $b_o(t)$ represents odd numbered sequence. The bit stream $b_e(t)$ modulates carrier $\sqrt{P_s}\cos(2\pi f_c t)$

and $b_o(t)$ modulates $\sqrt{Ps}(\sin 2\pi f_c t)$. The two modulated signals are:

$S_e(t) = b_e(t)\ \sqrt{Ps}(\sin 2\pi f_c t).$ (4)

$S_o(t) = b_o(t)\ \sqrt{P_s}\cos(2\pi f_c t)$ (5)

The output of the adder is the QPSK signal and is given by:

$S(t) = S_e(t) + S_o(t)$ (6)
$S(t) = b_o(t)\ \sqrt{P_s}\cos(2\pi f_c t) + b_e(t)\ \sqrt{Ps}(\sin 2\pi f_c t)$ (7)

After modulation the signal is passed through pilot insertion. Pilots are the unmodulated data sequences which are transmitted along with the data. They are used for synchronization and channel estimation purposes. Inverse fast Fourier transform (IFFT) is basically used to transform the signals on different carriers from frequency domain to time domain.

$$x(n) = 1/N \sum_{k=0}^{N-1} X(K)e^{j2\pi kn/N} \quad n = 0,1,2\ldots\ldots N-1 \quad (8)$$

Guard intervals or cyclic extension are added to the signal so as to eliminate Inter Symbol Interference.
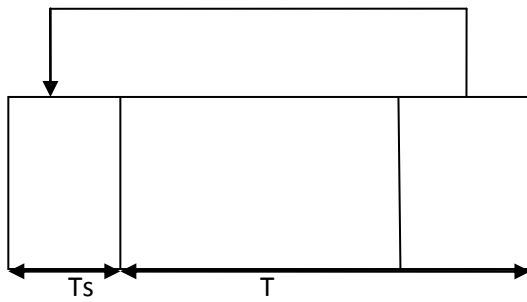

Figure 2: Cyclic Prefix

Where T is the length of one OFDM symbol and $s\ T$ is the length of CP in time domain respectively in Figure 2. The shadowed part in Figure 2 is the cyclic prefix. It copies the rear part of the OFDM symbol and puts it to the front of the symbol, so that the period will increase from T to T +Ts and s T is the Cyclic Prefix.

1.1.2 Channel
Additive White Gaussian Noise is added to the channel.
The probability density function of Gaussian noise is given by:

$P_x(x) = 1/\sqrt{2\pi}(e^{-(x-m_x)^2})/2\sigma^2$ (9)

1.1.3 Receiver
At the receiver, the signal is passed through the decoder.Vertibi algorithm is used as a decoding algorithm. The signal is then passed through deinterleaver. It restores the ordering of symbols. Decimal to binary convertor converts the decimal number to the binary vectors.

The signal is then passed through the QPSK and GMSK demodulator. The demodulator demodulates the OFDM signal and moves it back to the baseband signal. The fast Fourier transform is basically needed to transform signal from time domain into the frequency domain. The pilot extension block removes the pilot data sequences which are added at the transmitter.

The added cyclic extension is also removed from the received noisy signal. And we receive the output image.

2. IMPLEMENTATION
The steps for implementation are as follows:

Initialize required variables

Step 1. fp ← read image file
Step 2. [or oc on] ← get size of image
Step 3. Rimage ← reshape image
Step 4. t_data ← convert image to logical form
Step 5. for d=0:1:9
Step 6. data ← divide into packets
Step 7. trellis ← convolutional code polynomials to trellis
Step 8. codedata ← Convolutionally encode binary data
Step 9. End For
Step 10. S← get size
Step 11. matrix← reshape
Step 12. intlvddata ← Interleave
Step 13. dec ← convert to decimal
Step 14. y ← modulate using GMSK/QPSK
Step 15. ifft_sig ← perform inverse fft
Step 16. Add Cyclic Prefix
Step 17. Ofdm_sig ← add White Gaussian Noise
At Receiver end reverse the steps 3 through 17

3. SIMULATION AND RESULTS
Table 1 shows the input parameters of the ofdm system simulation.

(.jpg) file has been used as the input to test performance of the ofdm transceiver. MATLAB software has been used to implement the ofdm transceiver. There are total 5 plots available in this simulation including transmitted image, received image, transmitted OFDM signal, received OFDM signal and BER plot.

Table 1: The Input Parameters

Parameter	Value
Source Data	(.jpg) Size 600×400
IFFT Size	64
Pilot Data	04
Code	Convolution Coding
No of Carrier	64
Modulation method	GMSK,QPSK
SNR	0-10 dB

3.1 GMSK Technique
Figure 3.Shows the (.jpg) image that has been used as an input for ofdm transceiver. Figure 4.Illustrates the transmitted OFDM signal.
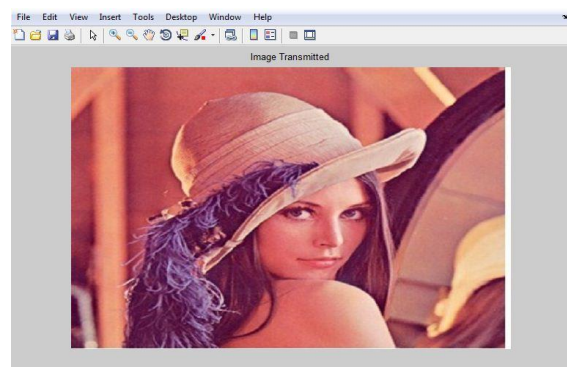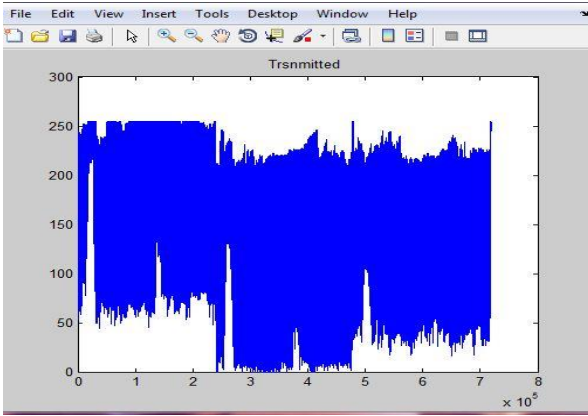

Figure 3: Transmitted input Image

Figure 4: Transmitted OFDM signal

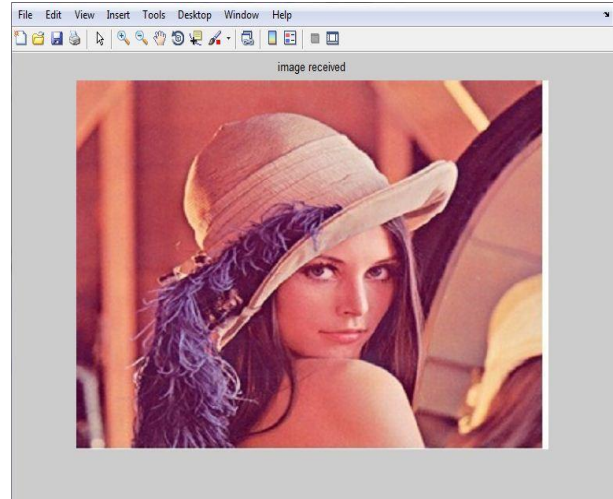Figure 5 shows the received image and figure 6 shows the received OFDM signal.
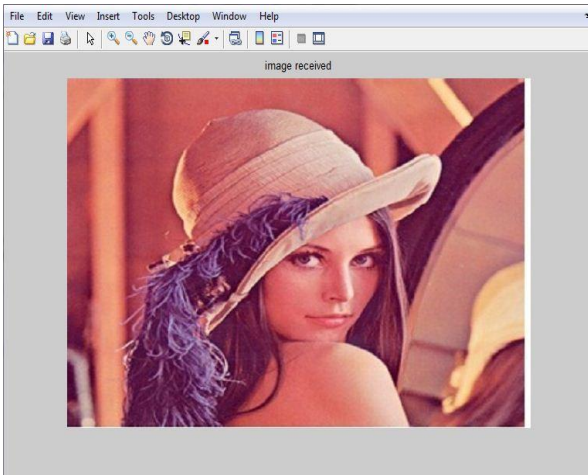

Figure 5: Received Image
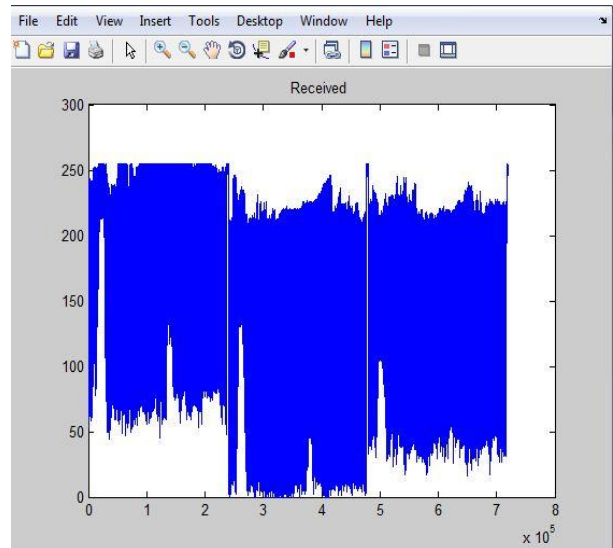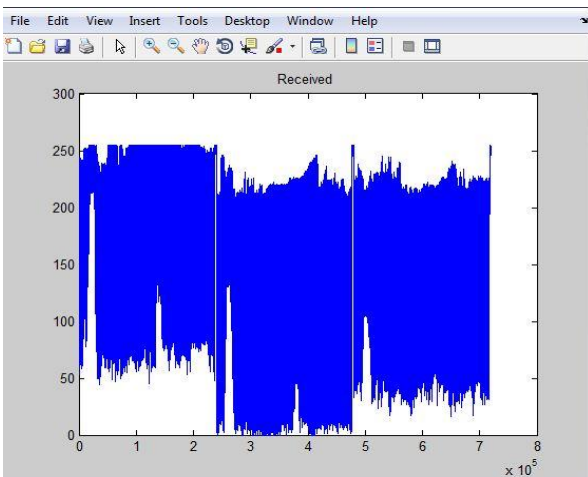

Figure 6: Received OFDM Signal

3.2 QPSK Technique

The same input parameters are used to implement the OFDM Transceiver using QPSK modulation technique. For the same input image, the output image and OFDM signal is obtained. Figure 7 and Figure 8 shows the received image and the received OFDM signal.

.**Figure 7: Received Image**

Figure 8: Received OFDM Signal

The performance of the system has been evaluated for AWGN channel, where the bit error rate analysis has been done for GMSK modulation technique and QPSK Modulation Technique. Figure 9.Shows the Bit Error Rate performance of GMSK in comparison to QPSK.
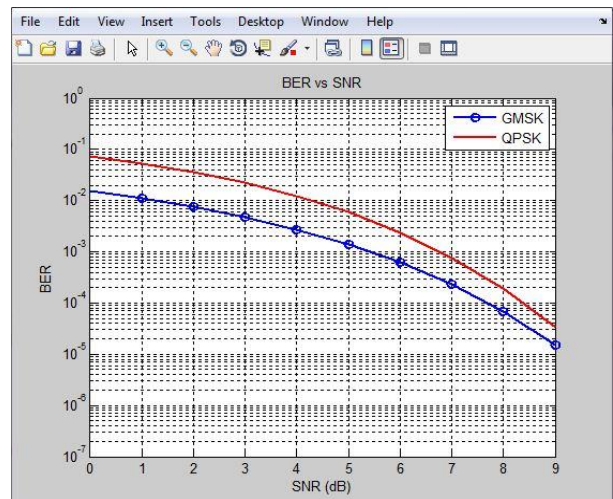

Figure 9: Simulation Results of BER Performance

4. CONCLUSION

This paper describes the design of OFDM transceiver system based on simulation. GMSK and QPSK encoding technique have been used in this system to analyze the effect of modulation scheme against AWGN channel. The BER performance of GMSK has been evaluated in AWGN environment and is compared to QPSK encoding technique.

By comparing the Bit Error Rate performance of GMSK and QPSK, it is concluded that the Bit Error ate performance of GMSK is better as compared to QPSK.

The BER is comparatively high for low values of SNR (Signal to Noise Ratio). As SNR increases, the BER decreases gradually for both the encoding techniques. The observation confirms that GMSK gives best performance as compare to QPSK. The BER of GMSK can be further reduced by increasing the number of symbols. GMSK encoding technique has been used to implement OFDM transceiver. In GMSK technique, the input binary sequence is passed through a pre modulator Gaussian shaping filter. This reduces the side lobe levels of the spectrum and thus the interference between the sub carriers. But this Gaussian filter causes Inter Symbol Interference. Thus to reduce this interference, Channel Equalization algorithms could be used at the receiver end. There are various equalization techniques that can be adopted such as DFE, ZF equalization, MLSE etc.

5. ACKNOWLEDGEMENT

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