International Journal on Recent and Innovation Trends in Computing and Communication
Volume: 3 Issue: 9
ISSN: 2321-8169
5503 - 5507

Performance Analysis of Ofdm Transceiver using Gmsk Modulation Technique

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Abstract— Orthogonal Frequency Division Multiplexing is one of the most arising technologies for digital communication. An OFDM signal is the addition of many individual signals modulated over a group of orthogonal subcarriers with same bandwidth. Because of its high robustness against interference, this technology becomes fundamental for modern wireless standards.

In the proposed paper, OFDM is implemented using Gaussian Minimum Shift Keying encoding technique. The bit error rate (BER) performance has been evaluated in AWGN (Additive White Gaussian Noise) channel. The system performance has been interpreted by using BER Vs SNR plot.

Keywords-*component; Orthogonal Frequency Division Multiplexing, Gaussian Minimum Shift Keying, Additive White Gaussian Noise, BER, SNR*

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I. INTRODUCTION

OFDM is a technique in which multiple carriers can be modulated at the same time. Multi-carrier modulation is a method in which we send data by breaking it into number of components, and transmitting each of the components over individual carrier signals. The single carrier has narrow bandwidth, but the complex signal can have broad bandwidth. Due to the high data rate transmission and robustness against fading, orthogonal frequency division multiplexing (OFDM) is a favourable technique in the present broadband wireless communication systems.

This paper demonstrates the implementation of an OFDM transceiver using Gaussian Minimum Shift Keying modulation technique. The whole paper is divided into 4 sections- section 2 gives the implementation of the OFDM transceiver with OFDM system requirements and specifications. Section 3 gives the experimental results of system evaluation in term of simulation environment. Section 4 includes conclusions of OFDM implementation.

A. System Design

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

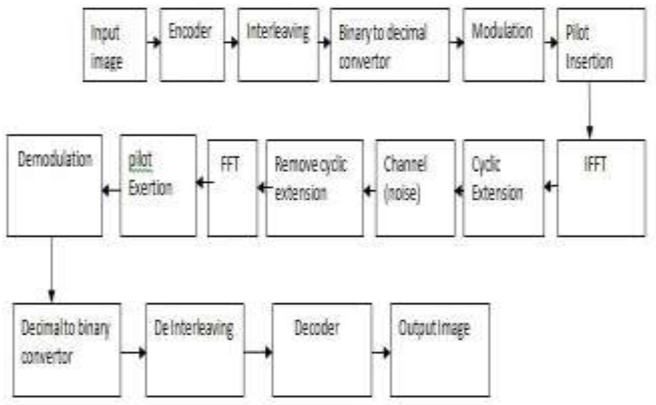

Figure 1: Block Diagram of OFDM Transceiver System

B. Transmitter

The input image is first converted to source data. The data is then passed through the encoder. Convolution encoding is done to encode the data sequence. The interleaving increases resistance to channel conditions such as fading. Binary to decimal convertor converts binary vector to a decimal number.

C. GMSK Modulator

GMSK is a Continuous Phase Modulation scheme generated by filtering NRZ data with a Gaussian shaping filter. The GMSK performance is measured by BT product, where B is the bandwidth of the Gaussian filter and T is the symbol

ISSN: 2321-8169
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duration. As the BT product increases, the spectrum becomes narrow but it may lead to increase in inter symbol interference. The impulse response for Gaussian filter is given by:

$$h(t) = 1/(\sqrt{2\pi}\,\boldsymbol{\sigma}\,T)e\wedge(-t^2/2\boldsymbol{\sigma}^2T^2) \qquad (1)$$

Figure 2 shows the block diagram of GMSK modulator.

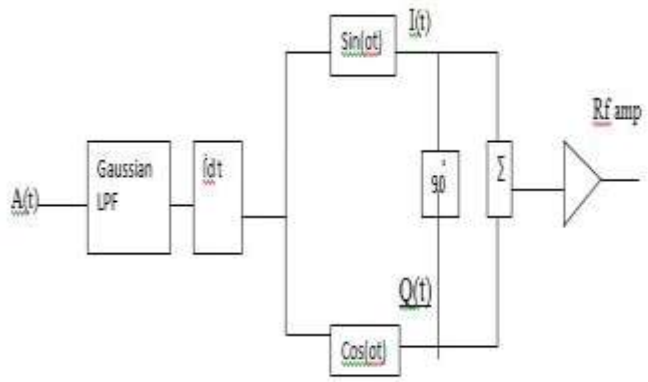

Figure 2: GMSK Modulator

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,

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

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.

After modulation, Pilot data is added to the modulated data. Pilots are the unmodulated data sequences which are transmitted along with the data. They are used for synchronization and channel estimation purposes. The signal then undergoes IFFT (Inverse Fast Fourier Transform) which transform the signal from frequency domain to time domain.

To eliminate Inter Symbol Interference (ISI) guard band or cylic prefix is added before the data symbol. Figure 3 shows the cyclic prefix.

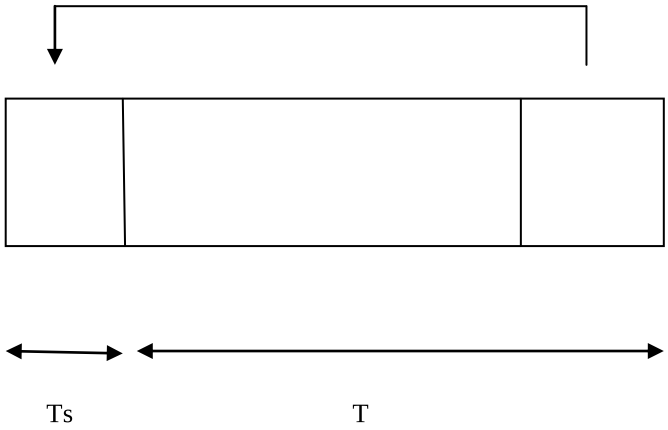

Figure 3: Cyclic Prefix

Here, T is the Symbol duration and Ts is the length of cyclic prefix. The cyclic prefix copies the rear part of the OFDM symbol and puts it to the front end.

D. Channel

AWGN (Additive White Gaussian Noise) is added to the channel. The probability density function for AWGN is given by:

$$P_x(x) = \left(\frac{1}{\sqrt{2\pi\sigma}}\right)(e^{-(x-m_x)}\wedge 2)/2\boldsymbol{\sigma}^2 \qquad (4)$$

E. Receiver

At the receiver end, the cyclic prefix is removed from the signal. The signal then undergoes FFT (Fast Fourier Transform) which transforms the signal from time domain to frequency domain.

$$\text{FFT: } X(k)= \sum_{n=0}^{N-1} x(n)e^{j2\pi kn/N} \qquad (5)$$

Then the introduced pilot data is removed from the OFDM signal. The signal is then passed through the GMSK demodulator. The demodulator demodulates the OFDM signal and moves it back to the baseband signal. Decimal to binary convertor converts the decimal number to the binary vector. Deinterleaver restores the ordering of symbol. Vertibi decoding is used to decode the data sequence and finally we get the output image.

II. 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

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.

III. 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	4
Code	Convolution Coding
No of Carrier	64
Modulation method	GMSK
SNR	0-10dB

Figure 4.Shows the (.jpg) image that has been used as an input for ofdm transceiver. Figure5.Illustrates the transmitted OFDM signal

Figure 4: Transmitted Input Image

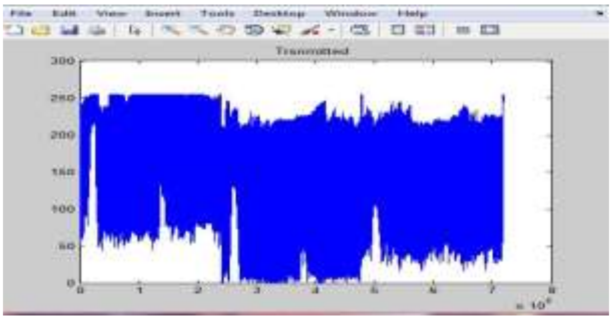

Figure 5: Transmitted OFDM signal

Figure 6 shows the received image and figure 7 shows the received OFDM signal.

Figure 6: Received Image

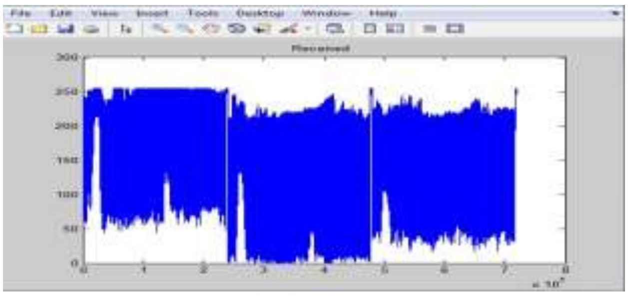

Figure 7: Received OFDM Signal

A. Error Calculation Results

Mean Square Error and Peak Signal to Noise Ratio are the parameters used to measure the Image quality. For the proposed technique, the percentage value of MSE and PSNR is calculated.

Mean Square Error Result = 0.999674

Result of PSNR = 84.28

The performance of the system has been evaluated for AWGN channel and Bit Error Rate analysis has been done for GMSK modulation technique. Figure 8 shows the Bit Error Rate curve for GMSK technique.

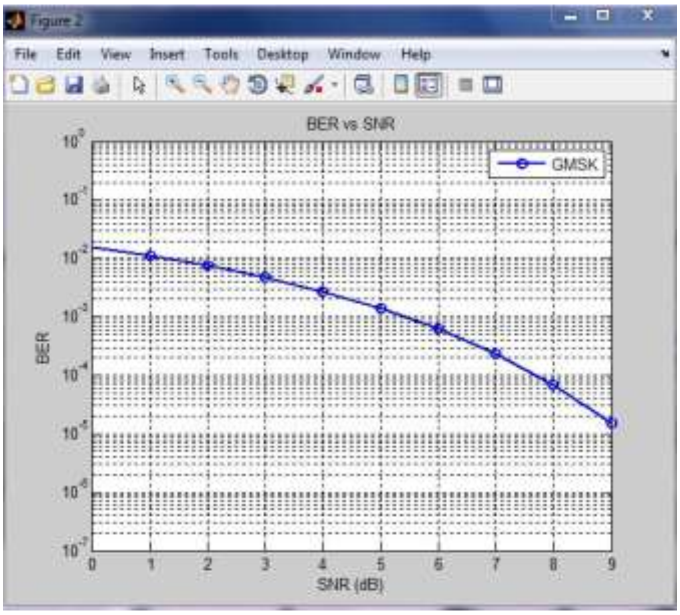

Figure 8: Bit Error Rate Performance of GMSK

IV. CONCLUSION

Input image of dimensions 600×400 is transmitted through channel and received at the receiver. In the transmitter, the image experiences convolution coding, interleaving, conversion, GMSK modulation, IFFT, pilot insertion and cyclic extension. In the channel, Additive White Gaussian Noise is added to the signal. Then the noise added signal undergoes removal of cyclic extension, pilot exertion, FFT, de-modulation, conversion, de-interleaving, decoding and the original image can be received at the receiver. The system performance is interpreted by using BER Vs SNR plot. 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

ACKNOWLEDGMENT

I would like to thank my guide Mr. Arun Kumar, my co-guide Mr. Anuj Saxena and my HOD Mr. Ankit Jha for helping me throughout the work. Also, I would like to thank all the faculty members of ECE department for their assistance. Without their cooperation, it would not be a success.

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