C.Padmaja, Dr.B.L.Malleswari / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 2, Issue5, September-October 2012, pp.325-327

Bit Error Rate Performance Analysis of OFDM Using Matlab Simulation

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Abstract:

Orthogonal Frequency Division Multiplexing (OFDM) is a bandwidth efficient signalling scheme for wide band digital communications. A general problem found in high speed communication is Inter-Symbol Interference (ISI). ISI occurs when a transmission interferes with itself and the receiver cannot decode the transmission correctly. Orthogonal frequency division multiplex (OFDM) modulation is being used more and more in telecommunication, wired and wireless. DVB and DAB already use this modulation technique and ADSL is based on it. The advantages of this modulation are the reason for its increasing usage. OFDM can be implemented easily, it is spectrally efficient and can provide high data rates with sufficient robustness to channel imperfections.
The purpose of this paper is to use a Matlab simulation of OFDM to analyse the Bit Error Ratio (BER) of a transmission varies when Signal to Noise Ratio (S/N Ratio) and Multipropagation effects are changed on transmission channel.

Index Terms— BER, FFT, ISI, OFDM, S/N

I. INTRODUCTION

The main idea behind OFDM is the so called Multi Carrier Modulation (MCM) transmission technique. MCM is the principle of transmitting data by dividing the input bit stream into several parallel bit streams, each of them having a much lower bit rate, and by using these sub-streams to modulate several carriers [19].

The two main drawbacks of OFDM are the large dynamic range of the signals being transmitted and the sensitivity to frequency errors.

Using a Matlab simulation we can easily change the values of S/N ratio [2] and change the multipropagation effects on the transmission. Then we can analyze the results of each transmission and see how the BER [1] is changed.

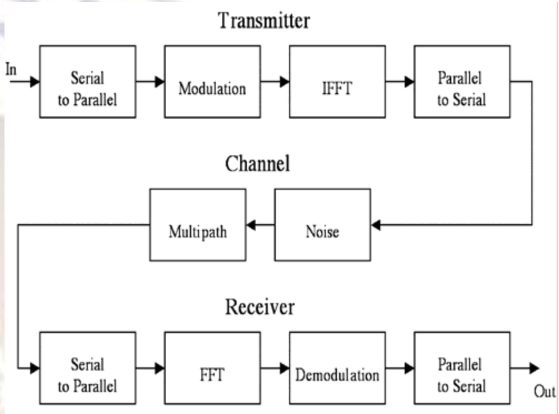

Figure 1. Matlab Flow Chart

II. OFDM SIMULATION

A. *General Options in the Simulation*

The general options of each transmission are in the *setup.m* file of the simulation. Two of the most important variables are analyzed.

One of the main characteristics of every simulation model of OFDM is the size of the fast Fourier transformation (FFT) used to generate the signal. In the simulation it is equal to the number of samples for the transmission signal. In the code this variable is named *fft_size*. The more the size of the FFT is increased the more samples there are for each signal. The more samplesthere are the smoother and more accurate the signal is.

Another very important variable is the number of the carriers (or the sub – channels) being used in every simulation. This variable is named *num_carriers*.

According to the number of sub – carriers the data is cutinto pieces, which are called chunks. Each carrier transmits 2 data bits. The first is coded in the real part of the Fourier transformation of signal and the second in the imaginary.

B. Variables which have an effect on S/N ratio

In this implementation noise is added to the transmission signal. In the *setup.m* file there is the variable called *noise_level*. This variable changes the level of the noise of the channel. The level of the noise is given by the following equation:

$$A_n = A_s . noise\_level \quad (1)$$

Where An is the level of the noise

As is the level of the signal

We know that the S/N ratio is given by the following equation [2]

$$S/N = (A_s/A_n)^2 = 1/(noise\_level)^2 \quad (2)$$

The noise produced is uniformly distributed in the closed space:

$[-noise\_level . A_s, noise\_level. A_s]$

The noise after being generated is added to the signal.This is done in the *ch_noise.m* file.

C. Variables which have an effect on multipropagation

Adding two delayed and attenuated copies of the signal to itself simulates multipath propagation. The copies arenamed echoes. The first echo is delayed less and has a higher level than the second.

The time of the delay of the two echoes are changed by the variables *d1* and *d2*. But it is also a function of the number of carriers. Actually the time of the delay for both echoes is analog to the number of carriers. So each time the number of carriers changed in the tests, to keep the time of delay stable, *d1* and *d2* variables were divided by the change. This is done in order to make the tests equivalents.

The level of the echoes is changed by the variables *a1*and *a2* and it is given by the following equation.

$$A_{echo1} = a_1 A_s$$
$$A_{echo2} = a_2 A_s \quad (3)$$

Where Aecho1 is the level of the first echo

Aecho2 is the level of the second echo

III. PLOTS OF BER AS A FUNCTION OF S/N RATIO AND MULTIPROPAGATION

A. BER and S/N ratio

To make the plots of the BER as a function of the S/N ratio a file was transmitted for many S/N ratios. As mention before the S/N ratio can be changed by the *noise_level* variable, which changes the S/N ratio according to the equation (2).

Each time a transmission took place the *noise_level* variable changed. The lowest S/N ratio was decided tohave the value 0.1 and the highest 10. Therefore, by solving the equation (2), the *noise_level* variable varies from 0.3162 to 3.162.

The transmission was simulated for 5 sets of carriers 32, 64, 128, 256 and 512 carriers. For each set of carriers a BER curve as a function of S/N ratio was plotted.

There are two plots. In the first the echoes have high level and in the second low levels. To be exact, in the first plot the two echoes have a level of 0.50 and 0.40 times and in the second 0.10 and 0.05 times the level of the signal. The results can be seen in Fig 2. and Fig 3.

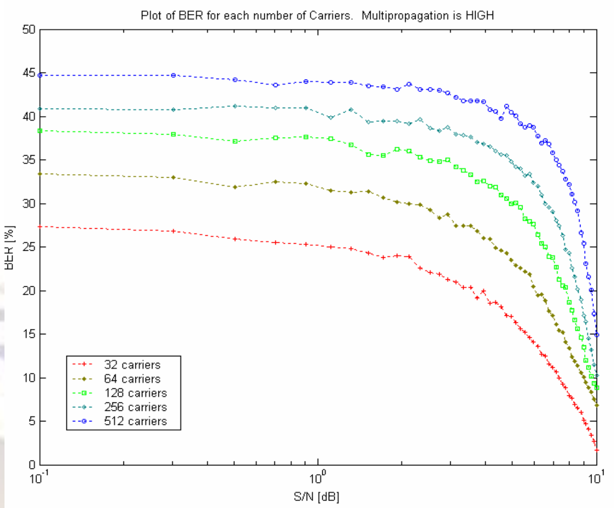

Figure 2. BER as a function of S/N ratio. Multipropagation effects are high

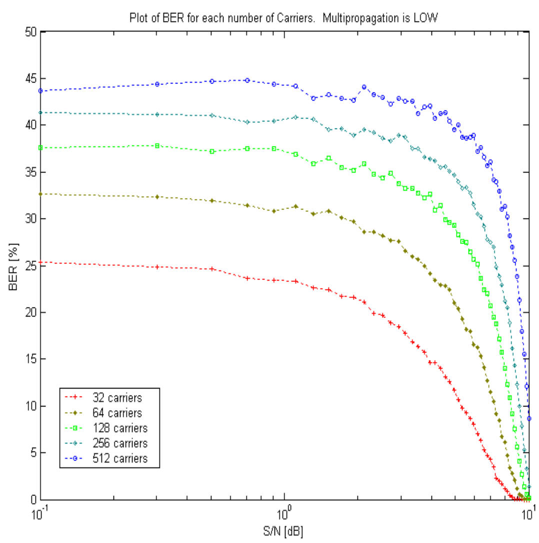

Figure 3. BER as a function of S/N ratio. Multipropagation effects are low

IV. CONCLUSION

The first and obvious thing we can notice from all the Plots is that the more we increase the number of carriers for certain S/N Ratio and Multipropagation effect the

more the BER increases. This is to be expected, because the more we increase the number of carriers the more we increase the symbol rate and therefore the data rate From the plots of the BER as a function of the S/N ratio we can see that when the S/N ratio is very low (0.1) multipropagation does not have any impact on the BER. Furthermore, it has an impact when the S/N ratio has high values, for example 512 carriers have 15% BER when Multipropagation is low and the S/N ratio is 10 but it drops to 8% BER when Multipropagation is high and the S/N ratio is again 10.This can be seen from the plot of BER as a function of Multipropagation when we have the S/N ratio is equal to 0.1. The BER by every set of carriers stays constant though the multipropagation effects are increased. From the Plot of BER as a function of Multipropagation with a high S/N ratio we can notice thatthe less the number of carriers, the more immunity the transmission to the Multipropagation effects.

ACKNOWLEDGMENT

This work was done in the VSLI design / DSP lab of MIT and software used MATLAB 7.5.

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