Defining the Channel Parameters and Their Influence on SER for OFDM Transmission

Kiril Koichev [1], Stanimir Sadinov[2] and Georgi Traikovski [3]

Abstract **– In this report we examine the fundamental characteristics of OFDM based systems which feature transmission of very high rates. The latter allow the systems to be used for providing progressive services and applications. Based on the requirements defined in the standards these systems should satisfy some criteria such as BER and SER which are the main parameters under examination in here.**

Key words **- OFDM, FFT(IFFT), BER, SER, SNR.**

I. INTRODUCTION

Generally, we regard as well known the methods for orthogonal frequency division and multiplexing of signals (OFDM) which are connected with (*IFFT-Inverse Fast Fourier Transform)* and addition of cyclic expansion by using the window method [1].

Fig.1 shows an exemplary block diagram of an OFDM model where in its upper part is the transmitter (Tx) and the lower part corresponds to the receiver (Rx). In the centre is seen the block – *IFFT* which shapes input data into a certain number of sub-carriers. Within the receiver the subcarriers are demodulated by Fast Fourier Transform *FFT*, in which the functions from *IFFT* are reversed. Another interesting peculiarity of the *FFI/IFFT* conversion is the fact that they are almost identical; that is, *IFFT* can be converted into *FFT* by means of a complex conjugation of inputs and outputs of *FFT* and further on through their division by the output length of *FFT*. This allows the use of identical hardware on both transmitter and receiver sides provided there is no transmission and reception at one and the same point of time..

So far all activities involved prior to *IFFT* have not been the subject matter of a serious discussion Their investigation entails binary data to be encoded by corrective code in straight direction. Further this data is offset and after that converted to a quadratic amplitude modulated (*QAM)* value.

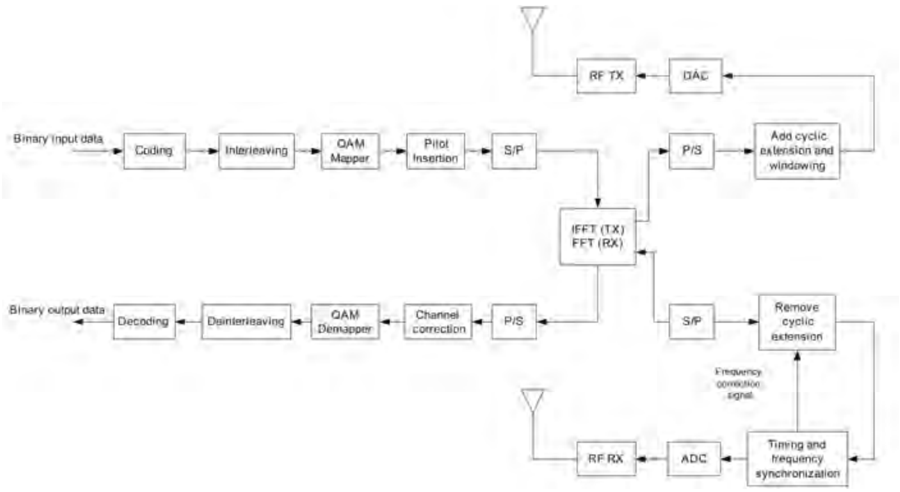

Fig. 1. Block diagram of OFDM transmitter

II. MULTI-PATH DISSIPATION

Within a certain radio connection the transmitter signal can be reflected by a number of objects such as blocks of flats, cars, mountains etc. This is the reason for the multi-path radio connection as well as for the reception of reflected signals at the receiver side. Fig.2 illustrates the possible ways of occurrence of multi-path transmission.

[1, 2] Kiril R. Koitchev and Stanimir M. Sadinov are with the Faculty of Electrical Engineering and Electronics, Technical University – Gabrovo, 4 H. Dimitar St., 5300 Gabrovo, Bulgaria, E-mail's: koitchev@tugab.bg; murry@tugab.bg
[3] Georgi Traikovski,MSc is with the Communications Technology and Equipment Department of Technical University- Gabrovo, 5300Gabrovo,Bulgaria, No4 "H.Dimitar" street
e-mail:gorgi_to@yahoo.com

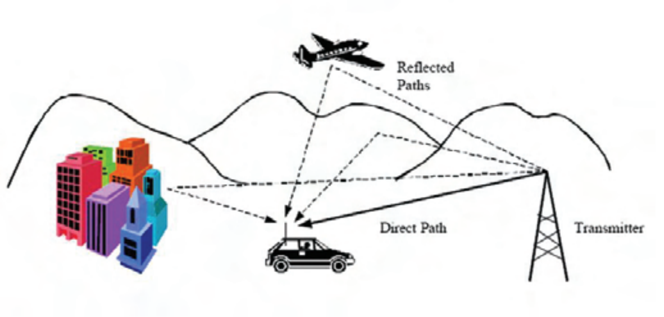

Fig. 2. Multi-path dissipation

This effect may cause serious problems which most often are regarded as undesired interference at the receiver side. Fig. 3 shows the levels of the reflected signal which may appear as resulting from the fading effect [2] [8].

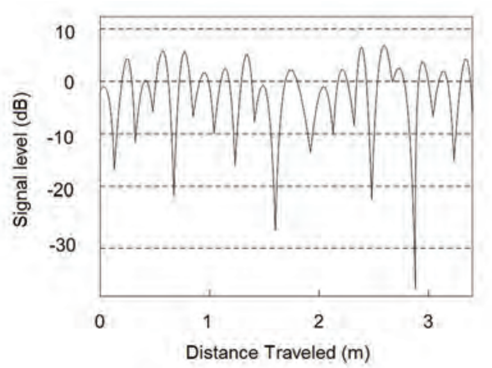

Fig. 3. Typical fading of Rayleigh when the mobile station is on the go (for at 900 MHz)

It is known that the distribution of Rayleigh is usually used for statistical description of time variation in the character of the received signal. Table 1 shows the variation in probabilities for the levels of a certain signal by using Rayleigh's distributions.

TABLE 1. CUMULATIVE DISTRIBUTION FOR RAYLEIGH DISTRIBUTION

Level of signal [dB]	Probable variation in signal level [%]
10	99
0	50
-10	5
-20	0.5
-30	0.05

III. DOPPLER EFEKT

Another well known fact is the difference in frequency of the source and reception signals when the distance between the source and the receiver varies due to their motion.When both move away from each other ,the frequency of the received signal is greater than that of the source; alternatively, as they come closer to each other, the frequency grows smaller [3].

Frequency variation with regard to Doppler effect depends on the relative movement between the data source and the receiver as well as on the rate of dissipation of the wave.Doppler displacement then can be expressed as

$$\Delta f \approx \pm f_0 \frac{\upsilon}{c} ,$$

where Δf is the frequency variation of the source, which is related to the received signal, f_0, v is the speed difference between the receiver and transmitter and c is the speed of light.

For example, if $f_0 = 1GHz$ and $v = 16,67 km/h$ than Doppler displacement will be

$$\Delta f = 10^9 \frac{16,67}{3.10^8} = 55,5Hz .$$

Basically, this displacement of $55Hz$ will not substantially mar the transmission itself. Yet, on the other hand, it may occur as a real problem if the transmission technology employed is very sensitive to frequency displacements in the carrier signals as is the case with OFDM.

IV. INVESTIGATION OF NOISE EFECT IN OFDM SYSTEMS

By means of the Simulink module of the software package Matlab it was possible to implement the simulation model from Fig. 1.Based on the simulation results it was found out that the signal-to-noise ratio (*SNR*) within OFDM systems is similar to a standard digital transmission with two carriers. Fig. 4 shows the results which bring about to correlation depending on the type of modulation used. It is clearly seen that in the case of employing quadrature phase manipulation (QPSK) the permissible value of signal-to-noise ratio *SNR* is from 10 to 12 dB. The value of *BER* becomes non-permissible when the signal-to-noise ratio drops below 6 dB. However, by using binary phase manipulation (BPSK) it is possible to eliminate this fault at the expense of the capacity of the transferred data.

By using BPSK with available OFDM the permissible value of *SNR* is from 6 to 8 dB.

In a channel of particularly low noise it is possible to use 16PSK which will boost system's capacity.

If *SNR* is 25 dB and more, 16PSK is used thus increasing the capacity two times as compared with QPSK.

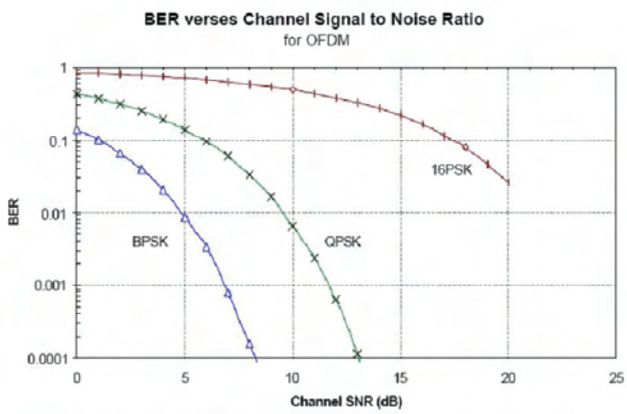

Fig. 4. *BER* compared to *SNR* for OFDM in using BPSK, QPSK и 16PSK

V. SIMULATION RESULTS

The simulation results in these models are based on the change of the basic parameters which these systems feature such as the signal-to-noise ratio, Doppler effect and the number of symbol errors plus SER coefficient. The results are shown on a graph. Fig. 5 shows the graphic dependence of SER on the signal energy/the spectrum density of noise (E_s / N_o) with various Doppler frequencies which are in full compliance with the standards. It should be noted that these results are obtained before the RS coder which implies that external coding is not taken into account.

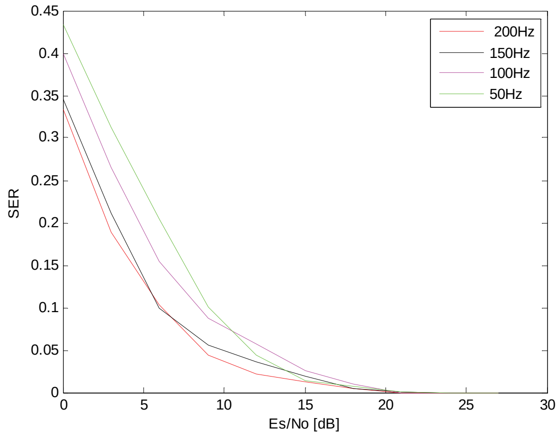

Fig. 5. Graphic presentation of *SER* with regard to E_s / N_o and $f_{dop.}$ before RS coder

As is evident from the graphs the coefficient *SER* decreases substantially as the signal-to-noise ratio (E_s/N_0) increases and is retained within the permissible boundaries.SER equals naught with large values in this ratio. Similarly, it is seen that better results are obtained with Doppler frequency values being high; the most optimal ones are obtained with frequency of *175 Hz*.

Fig.6 shows the variation in the number of errors *SER*, which appear under the same conditions but after the RS coder.

It is evident that these results are inter-related and the number of errors varies by the same law, i.e with greater signal-to-noise ratio they drop low and are of lesser value with higher Doppler frequencies.

The results of the simulation investigation are shown on a graph, however, in this case *Reed-Solomon* coding has been taken into account, therefore ,the bulk of transmitted data will be greater.

These simulation results are produced based on the change in the same parameters. The graph on fig.6 shows the dependence of *SER* from E_s / N_o with various Doppler frequencies.

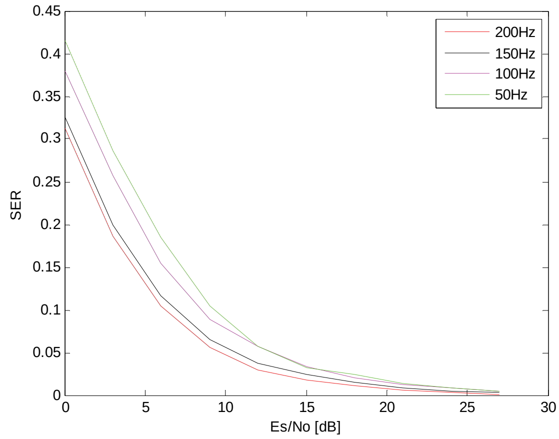

Fig. 6. Graphics determination of *SER* depending on E_s / N_o and $f_{dop.}$ after RS coder

Here, as is in the graphs of fig.5, it is evident that the *SER* error is negligible at higher values for the E_s / N_o ratio.

VI. CONCLUSION

The use of OFDM technology is appropriate as a type of modulation technique which can be successfully employed in high-tech telecommunications wireless networks as is the case with Wireless Local Area Network (WLAN) or the European Standard HIPERLAN/2. Here have been done just a number of tests of the OFDM technology followed by presentation of major parameters and characteristic features. Simulation results have been obtained on the basis of *SER*, *SNR*, E_s / N_o, $f_{dop.}$, *BER* parameters as well as some other parameters which are important for the delay in signal distribution. There are other parameters which have not been taken into account during these simulations such as the efficiency of frequency stability and the efficiency related to noises generated by the use of rectangular pulses, etc.

OFDM technology yields very good results when it is jointly used with CDMA (Code Division Multiple Access) no matter whether CDMA is used as a system of single carrier frequency or as a multiple-path system.

The difference in consumer capacity between OFDM and CDMA is reduced to whether there is sectorization of the cells and some available information concerning customers activity within the systems.

It may well be claimed that CDMA technology ensures good results only with multi-cellular systems where a single frequency is used for all cells. This enlarges the capacity for joint operation with the other systems and reduces intercellular interference.

A possible further investigation will be connected with the problems which arise in the employment of OFDM with numerous subscribers. One such potential problem could be the requirement for the transmitter to cover a much larger area in order to cope with the high level of signal instability between subscribers. At present this is accomplished by OFDM systems through the use of *forward error correction* which helps to improve the system's effectiveness and productivity.

This particular area is still not well investigated and more should be done to improve the patterns of forward error correction as is the case in telephony and data transmission systems [6] [7]. Several modulation techniques are used with OFDM such as BPSK, QPSK, 16-QAM and 256-PSK, but the real system configurations have the capacity to dynamically select the technique of modulation with regard to the data being transferred.

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