Effect of Guard Period with Cyclic Prefix on OFDM Technique

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Abstract— Orthogonal frequency-division multiplexing is popularly discussed term now a days. Orthogonal frequency-division multiplexing is the technique of choice in the digital system implementations that divides a channel with a higher data rate into several orthogonal characterized sub-channels with a lower data rate. It is an special feature of OFDM technique affect the new generation of communication system, which in mobile communication terminology called as "4G technology". The paper is an approach towards the key aspect/ performance parameter of the system. Initially we will talk about the major role of (GP)Guard Period insertion in OFDM system in optimize Inter-Symbol Interference. Then, discus how the numerous methods of adding guard period effect the OFDM system characteristics and explain the with MATLAB simulated results.

Index Terms— OFDM Guard Period(GP); Cyclic Suffix (CS).Zero Padding; Cyclic Prefix (CP).

I. INTRODUCTION

OFDM has become so popular over its last few decades because of robustness to frequency selective fading (FSF) in both wired systems (DSL) & wireless LAN (IEEE 802.11a). The fundamental of OFDM system is to divide the bandwidth into N narrow sub- channel at equidistant frequencies. The single high-rate data stream is subdivided into many low-rate data streams for the sub-channels. Every sub-channel is modulated independently and will be transmitted simultaneously in a superimposed and parallel form. But like other technology OFDM system also has its own advantages & disadvantages like High Inter-channel/ Symbol interference (ISI/ICI), Sensitiveness to frequency synchronization (PAPR) peak to average power ratio, Sensitive to Doppler Shift & problem.. This gave rise to find the solution for overcoming or reducing to the extent The time till the multi path propagation delays do not exceed the duration of the interval, zero inter symbol interference occurs and no channel equalization is required.

possible these lacunas in OFDM to design a cost effective high performance system. There has been many studies has been in this direction to deal with the different aspect of improving OFDM system performance. In this paper based on some simulation result, we will explain how the insertion of guard interval is so important in optimizing the Inter-Symbol Interference (ISI). Here we will discuss that how optimizing techniques can be beneficial to us.

And how effect fully and efficiently, the OFDM system's implementation with other technique to implement a less complex & value-adding system.

The discussion has two parts to understand these two different the features of OFDM. In one hand, we have put forward the different way of adding guard interval to OFDM system & Simulation result to demonstrate the same. On other hand a brief analysis of different multiple access technique in conjunction with OFDM has been mentioned.

II. COMBATING ISI WITH GUARD PERIOD

For optimization of the performance of an OFDM link, time and frequency matching between the sender and receiver is most importance, and this is achieved by using known pilot tones embedded in the OFDM system signal or attaches fine frequency timing tracking algorithms within the OFDM signal's cyclic extension (guard Period/ Interval). for prevent Inter symbol Interface, the individual segments are separated by guard intervals wherein the blocks are periodically extended. In addition of it, once the incoming signal is split into the respective transmission sub-carriers, guard intervals are added between each symbol.

Delay spread longer than the effective guard period/ Interval, the Bit Error Rate rises rapidly due to the inter symbol interference. The maximum Bit error rate that occur when the delay spread is too long and this will cause high inter symbol interference.

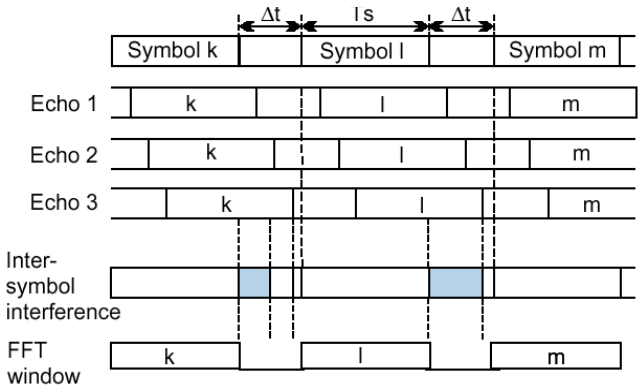

Fig.1 Combating ISI using a guard interval/ Period

With a practical system the length of the guard period can be selected depending on the necessary multipath delay spread immunity required.

Inter symbol interference effect of the multipath channel for two consecutive OFDM symbols. If Tsub stands for the duration of the (effective) OFDM symbol without guard interval. Since (W = 1/Ts) and thus, {Δf = W/N = 1/ (NTs)} and {Tsub = NTs = 1/Δf} extending the symbol duration by N times (i.e., Tsub= NTs), and the effect of the MF channel is nearly reduced to zero on the OFDM symbol. However, its effect still remains as a deleterious factor that may contradict orthogonality among the subcarriers in the OFDM system. The primary received symbol (plotted in a solid line) is mixed up with the second received symbol (plotted in a discontinued line), which incurs the ISI. It is obvious that all contributing subcarriers are no longer orthogonal over the duration of each OFDM symbol. To check the performance of OFDM, there must be some means of dealing with the ISI effect over the multipath channel. As discussed in the sequel, a guard interval between two consecutive OFDM symbols will be essential.

OFDM System's Guard Period can be inserted in two ways. first way is the zero padding (ZP) ,that means pads the guard interval with zeros. The second way is the cyclic extension of the symbol (for some continuity) with insertion of cyclic prefix or cyclic suffix. Cyclic prefix is to extend the OFDM symbol by copying the ending samples of the OFDM symbol into its front.

A. Cyclic Prefix

If TG stands for the length of Cyclic Prefix in terms of samples. The prefix extended OFDM symbols will have the duration of Tsym = Tsub + TG. Fig. 4 shows two consecutive OFDM.

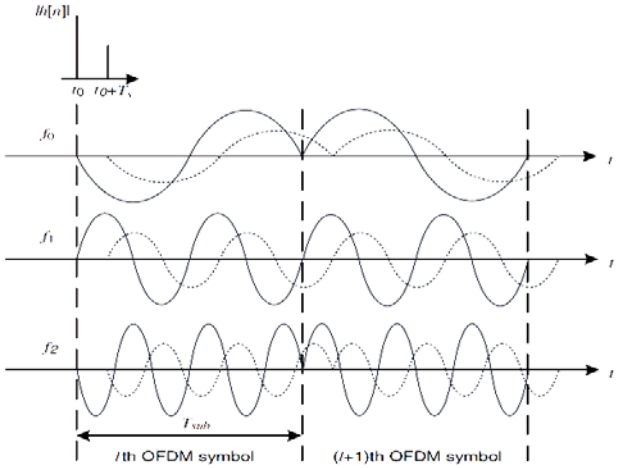

Fig. 2 ISI Effect of a multipath channel for each sub-carrier

It can be seen from this figure that if the length of the guard interval (Cyclic Prefix) is set longer than or equal to the maximum delay of a multipath channel, the Inter symbol interference effect of an OFDM symbol (plotted in a dotted line) on the next symbol is confined within the guard interval so that it may not affect the FFT of the next OFDM symbol, taken for the duration of Tsub. Symbols, each of which has the CP of length TG, while illustrating the OFDM symbol of length Tsym=Tsub +TG Figure 3(b) represent them jointly in the time and frequency domains. Figure 3(c) shows the Inter symbol interference effects of a multipath channel on some subcarriers of the OFDM symbol. This implies that the guard interval longer than the maximum delay of the multipath channel allows for maintaining the orthogonality among the subcarriers. As the continuity of each delayed subcarrier has been warranted by the CP, its orthogonality with all other subcarriers is discussed over Tsub.

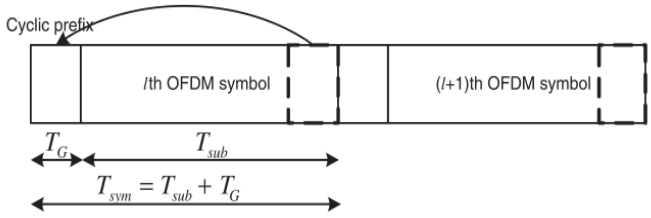

Fig.3(a) OFDM symbol with CP [1]

B. Cyclic Suffix (CS)

Cyclic suffix is nothing but the cyclic extension of the OFDM system. the difference is that the CS is the copy of the head part of an effective OFDM symbol, that it is added at the end of the symbol. CS is used to prevent the interference between upstream and downstream, and is also

used as the guard interval for frequency-hopping or RF convergence, and so on. CP and CS are used in Zipper-based (VDSL) technique in which the Zipper-duplexing technique an alternate of Frequency-Division Duplexing that allocates different frequency bands sub-carriers to downstream or upstream transmission in an OFDM symbol, allowing for bi-directional data flow simultaneously. The Objective of cyclic prefix and Cyclic suffix is to suppress the Inter Symbol Interference effect of the multipath channel, along with assurance of orthogonality between the upstream and Therefore, the length of Cyclic Prefix is set to cover the time dispersion of the channel, and the length of CS is set according to the difference time between the upstream transmit time and downstream receive time. Figure 4 shows the structure of the OFDM symbol used in Zipper-based VDSL systems, here the length of the guard interval is the addition of CP length TCP and CS length TCS.

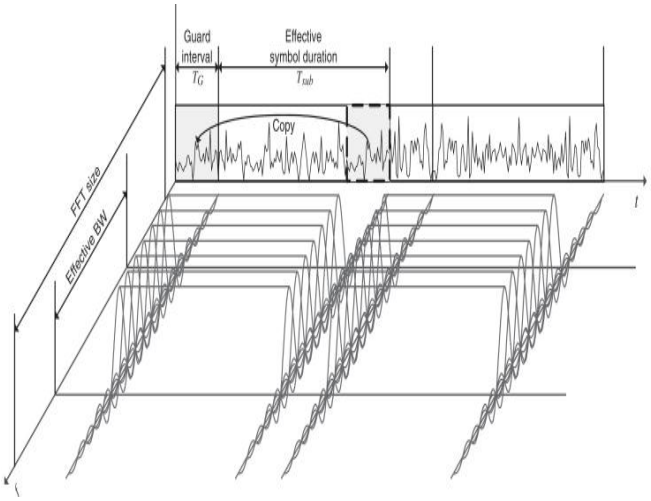

Fig.3(b) Time/ frequency domain description of OFDM symbol with CP

C. Zero Padding (ZP)

We may insert '0' into the guard interval. Tthe idea is adopted by multiband-OFDM (MB-OFDM) in an Ultra-Wide-band (UWB) system. Figures .5 show OFDM symbols with Zero Padding and the Inter Symbol Interference effect of a multipath channel on OFDM symbols for each subcarrier, respectively. here the length of Zero Padding is channel, a small STO causes the OFDM symbol of an effective duration to have a discontinuity within the Fast Fourier Transform window and therefore, the guard interval part of the next OFDM symbol is replicated and added into the starting part of the current symbol to prevent Inter Carrier Interference as described in Figure 6.

Since the Zero Padding is filled with zeros, the actual length of an OFDM symbol containing Zero Padding is less than that of an OFDM symbol containing CP or CS and accordingly, the length of a rectangular window for transmission is also shorter, so that the corresponding sinusoidal spectrum could be wider. This shows that compared with an OFDM symbol containing CP or CS, an OFDM symbol containing Zero Padding has PSD (Power Spectral Density) with the smaller in-band ripple and the larger out of band power, allowing more power to be used for transmission with the peak transmission power fixed.

Here the data rate of the OFDM signal is reduced by {Tsub/Tsym = Tsub/(Tsub+TG)} (Fig.4) times due to the guard interval.

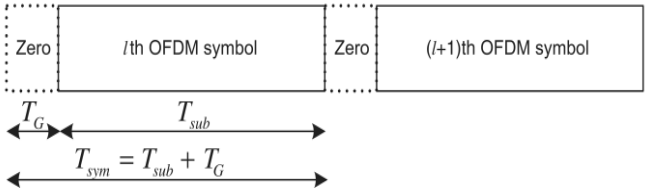

Fig.4 Guard Interval

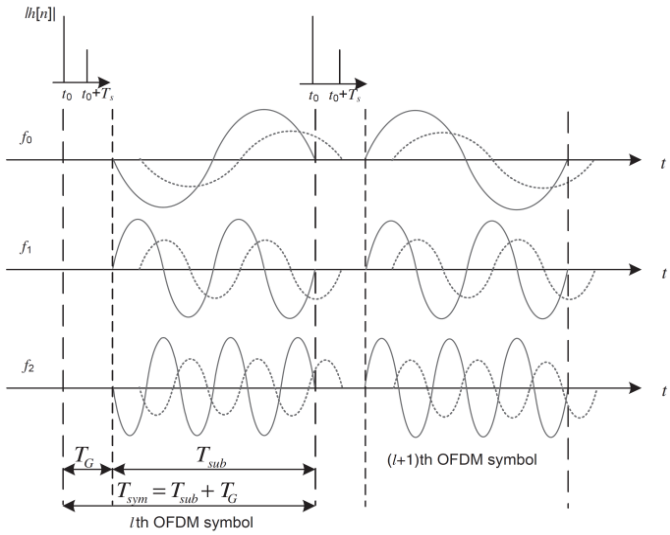

Fig. 5 ISI Effect of a multipath channel on OFDM symbols with ZP

III. RESULTS

The impact of Guard-period insertion has been evaluated by comparing the simulation result obtained by plotting Bit Error Rate (BER) versus the Signal to Noise Ratio (SNR) for different & value of Guard-Period Insertion in the MIMO-OFDM System

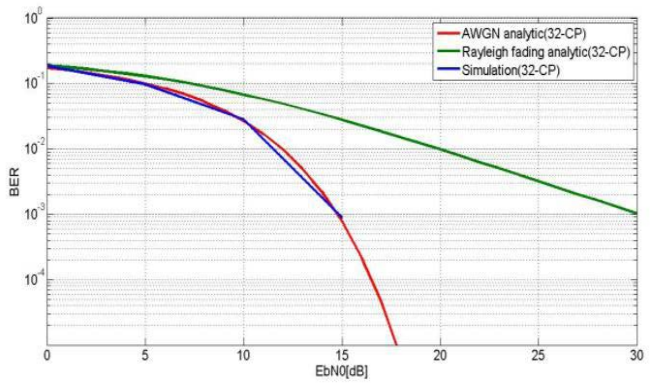

Fig. 6(a) GP length: Ng = N/2 = 32 for CP

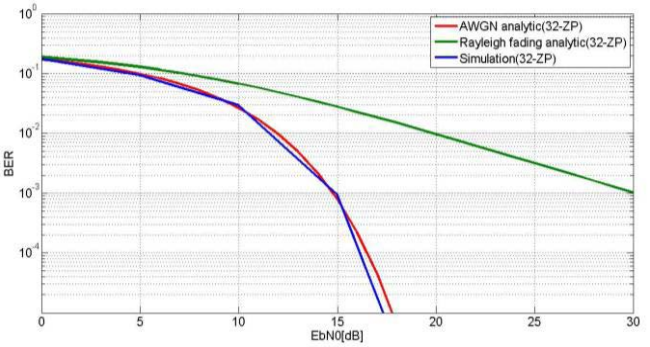

Fig. 6(b) GP length: Ng = N/2 = 32 for ZP

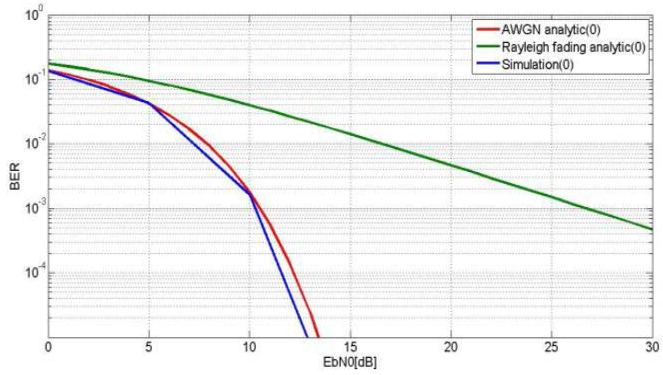

Fig. 6(c) GP length: Ng = 0 (i.e. no CP & ZP)

Figure 6(a) & 6(b), it is obvious that the BER results with CP or ZP of length 32 samples is consistent with that of the analytical result in the Rayleigh fading channel. This implies that the OFDM system is just subjected to a fading channel (flat) as long as CP or ZP is larger than that. It is also clear that the BER performance in an AWGN channel is consistent with the analytical results. This is obvious regardless of how long GP is, just because there is no existence of multipath delay in the AWGN channel & also that ZP gives far better result than CP. As illustrated in Figure 6(c), however, the effect of Inter Symbol Interference on the BER performance becomes excellent in the multipath Rayleigh fading channel as the length of GP becomes less , and eventually leads to an error floor.

IV. CONCLUSION

It is clear from the above study analysis & results reveals the fact that Guard Period, which is also known as "Guard Interval if properly taken can optimize the Inter-Symbol-Interference to the extent that it can be ignored for the analysis purpose. We should also understand from results that the different methods of guard-period insertion are also have effect on the performance of OFDM-system.

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