Inter-Symbol Interference Reduction by Orthogonal Frequency Division Multiplexing

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Abstract: This thesis will discuss the inter-symbol interference reduction techniques. ISI can reduce by OFDM used in wireless communication. OFDM is a multipath communication system. In telecommunication, inter-symbol interference (ISI) is a sort of deformation of a sign. In ISI one symbol interferes with following symbols has similar effect as noise, therefore fixing the communication less consistent. ISI is usually caused by multipath propagation or the inherent non-linear frequency response of a channel causing successive symbols to "smear" together. The presence of ISI in the system introduces errors at the receiver output. Therefore, in the design of the transmitting and receiving filters, the objective is to minimize the effects of ISI, and thereby deliver the digital data to its destination with the smallest error rate possible.

Keywords: *Inter-symbol interference (ISI), orthogonal frequency division multiplexing (OFDM) and cyclic prefix.*

Ⅰ. INTRODUCTION

Communication plays the important part in our lifespan. With the progression in age and its growing demands, there has been rapid growth in the field of communications. Initially signals sent in the analogue domain. At present these are being sent more and more in the digital sphere. Single-carrier waves are being replaced by multi-carriers for better transmission.[]

Multi patch adds another layer of complexity to our EVM measurement. Bluetooth signal with a symbol rate of 1M symbols per second. That implies that the receiver will expect a specific symbol with a window of one microsecond.

Figure: 1 Multipath channel propagation

If multipath delays the signal by more than one microsecond, the recipient will receive the symbol in the next symbol period causing a significant symbol error.

The quicker the data rate, the higher the chance that multi-path will cause ISI. An obvious path to slim down the error rate would be to slow down the symbol rate; each symbol would last longer and be more resistant to multipath. Unfortunately, this reduces the data rate. OFDM is a way to slow down the symbol rate without slowing the data rate.

OFDM transmits a large number of closely-spaced carrier waves, each modulated with a different sign. The symbol rate for each carrier is low, making it resistant to multipath, but because there are so many carriers the overall data rate is high. Adjacent carriers are in phase quadrate with each other, which keeps crosstalk between them to a minimum without requiring a bank of narrow-band filters. [1] [2]

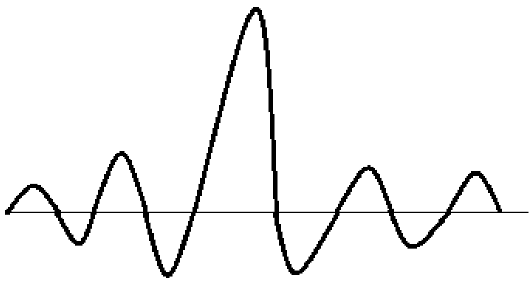

Fig: 2 A spectrum of an OFDM sub channel (during a single bit)

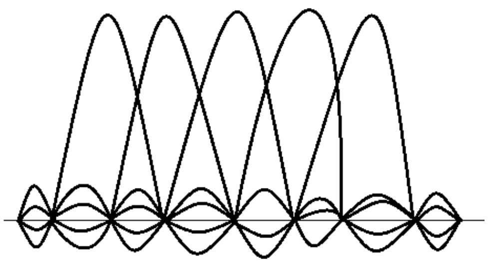

Fig.3 OFDM Spectrum

Ⅱ. Inter Symbol Interference

In the digital signal transmission, we use digital pulse which is rectangular and assume that the transmission channel is linear and distortions. Much, the canals cause a limited bandwidth, and hence transmitted pulses tend to be "spread" during transmission. This pulse spreading or dispersion causes overlap of pulses into adjacent time slots as indicated in image. The signal overlaps may result in an error at the recipient. This phenomenon of pulse overlaps and the consequent difficulty of discriminating between symbols at the receiver is termed ISI.

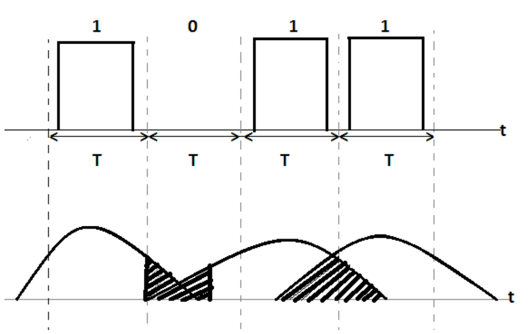

Fig.4 Inter symbol Interference in digital transmission

In order to concentrate attention on the effects of imperfections in the frequency response of the channel, on data transmission through the channel let assume the ideal channel or noiseless environment.

The receiving filter output:

$$\mathbf{y(t) = \mu \sum_{k=-x}^{x} A_K\ p(t-k\ T_b)} \qquad \mathbf{(1)}$$

Where

μ = scaling factor

Normalization

p (0) =1

The pulse μA_K p (t) is the response of the cascaded connection of the transmitting filter, the channel, and receiving filter, which produced by the pulse A_K g (t) applied to the input of this cascade connection. Therefore, we may relate p (t) to g (t) in the frequency domain as follows

$$\mathbf{\mu P\ (f) = G(f)H_T(f)H_C(f)H_R(f)} \qquad \mathbf{(2)}$$

Where

P(f) = Fourier transform of p(t)

And

G(f) = Fourier Transform of g(t).

The receiving filter output y(t) is sampled at time $t_i = iT_b$.

Where i is an integer value.

$$\mathbf{y(\ t_i) = \mu \sum_{k=-\infty}^{\infty} A_K\ p((i-k)\ T_b)}$$

$$\mathbf{\mu A_i + \mu \sum_{k=-\infty}^{\infty} A_K\ p((i-k)\ T_b) \quad , k \neq i\ , i=0,1,2\ldots} \qquad \mathbf{(3)}$$

In Equation 3, the first term represents the contribution of i^{th} transmitted bit. The second term represents the residual effect of all other transmitted bits on the decoding of the i^{th} received bit; this residual effect is called ISI.[3]

Ⅲ. Effect Of Inter Symbol Interference

In the absence of ISI and noise, the transmitted bit can be decoded correctly at the recipient. The presence of ISI will introduce errors in the finish at the receiver output. Hence, the recipient can cause an error in determining whether it has received a logic 1 or logic 0.

Ⅲ. PROTECTION AGAINST ISI

In the absence of ISI, we observe from the equation 3 that

$$\mathbf{Y\ (t_i) = \mu A_i}$$

It indicates that, under these conditions, the ith transmitted bit can be decrypted correctly. The inescapable presence of ISI in the organization, however, introduces errors in the decision device at the receiver output. Consequently, in the intent of transmitting and receiving filters, the aim is to belittle the effects of ISI and thereby save the digital information to its destinations with smallest error rate.

ISI can be treated effectively in OFDM system by using the 4-QAM technique. ISI effect can be reduced by interesting a guard interval (cyclic prefix). The cyclic prefix or guard interval is a periodic extension of the final section of an OFDM symbol that is appended to the forepart of the symbol in the transmitter, and is removed at the receiver before demodulation.

The cyclic prefix has two significant benefits-

1. The cyclic prefix acts as a guard interval. It eliminates the inter-symbol interference from the previous symbol.
2. It acts as a repetition of the end of the symbol thus allowing the liner convolution of a frequency-selective multipath channel to be modeled as circular convolution which in turn may be transformed to the frequency domain using a discrete Fourier Transform. This approach allows for simple frequency – domain processing such as channel estimation and equalization.

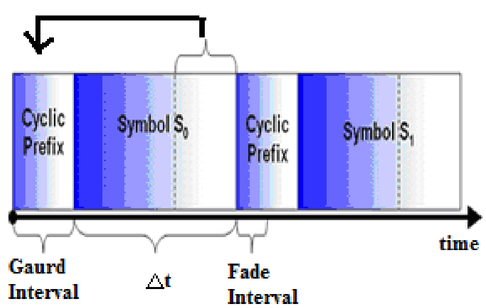

Fig. 5 Cyclic prefix

Ⅳ CONCLUSION

This paper proves that OFDM provides a cyclic prefix to remove ISI, which is a big drawback of multipath communication. We cannot reduce the peak to average power ratio but still working upon it.

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