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RESEARCH ARTICLE

OFDM A PROMINENT TECHNOLOGY IN MODERN WIRELESS COMMUNICATION

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ABSTRACT

Orthogonal Frequency division Multiplexing is a prominent technology in modern wireless communication and is the key technology employed in 4G wireless communication. OFDM is a popular method for high data rate (Gordon *et al*., 2004). The orthogonal Frequency Division Multiplexing has a very large bandwidth of about 20 Mega Hz where as a GSM system has a bandwidth of 200KHz because of the large bandwidth the data rate in OFDM is very high about 500Mb/sec or 1Gb/sec. OFDM has gain importance in modern wireless communication because of its ability to overcome Inter symbol Interference (ISI). OFDM is employed in 4G cellular standards such as LTE (Long Term Evolution) is a 4G cellular standard, Wi-Max (World-wide interoperability for microwave access) (Mohamed *et al*., 2012). Several Wi-Fi standards such as 802.11a, 802.11g, 802.11n and 802.11ac which enable high data rate are also based on OFDM (Mohamed *et al*., 2012). In broadband communication the problem of inter symbol interference occurs because the symbol time is very less than the delay spread of the channel. Interference means degradation or loss of information. This paper gives a overview of how inter symbol interference can be avoided in broadband wireless communication using OFDM technology.

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INTRODUCTION

OFDM is a key wireless broadband technology with a very high data rate. Orthogonal frequency division multiplexing (OFDM) is a widely used modulation and multiplexing technology which has become the basis of many telecommunications standards including wireless local area networks (LANs) (Manushree Bhardwaj *et al*., 2012). The OFDM concept is based on spreading the data to be transmitted over a large number of carriers, each being modulated at a low rate. The carriers are made orthogonal to each other by appropriately choosing the frequency spacing between them. OFDM is a form of multicarrier modulation. An OFDM signal consists of a number of closely spaced modulated carriers. When modulation of any form - voice, data, etc. is applied to a carrier, then sidebands spread out either side. It is necessary for a receiver to be able to receive the whole signal to be able to successfully demodulate the data. As a result when signals are transmitted close to one another they must be spaced so that the receiver can separate them using a filter and there must be a guard band between them. This is not the case with OFDM.

Although the sidebands from each carrier overlap, they can still be received without the interference that might be expected because they are orthogonal to each another. This is achieved by having the carrier spacing equal to the reciprocal of the symbol period.

Basic principal of OFDM : Let us consider a communication systemhaving a bandwidth B and single carrier at the centre of the bandwidth at a carrier frequency. For example let us consider B=10 MHz which is a broadband system. When communication takes place the symbol time T is given by

$$T = 1/B$$
$$=1/10*10^6$$
$$=0.1\mu s$$

The delay spread of the channel is usually 2 to 3 μs denoted by T_d

$T << T_d$ which results in inter symbol interference (ISI). From this we can observe that as the bandwidth B increases, the symbol time T = 1/B decreases which results in ISI that is degradation of the performance of a broadband wireless communication. Thus ISI is a significant challenge in broadband wireless communication.

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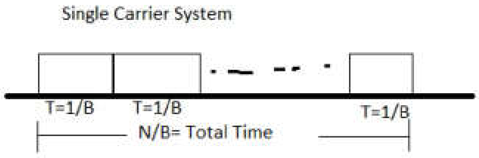
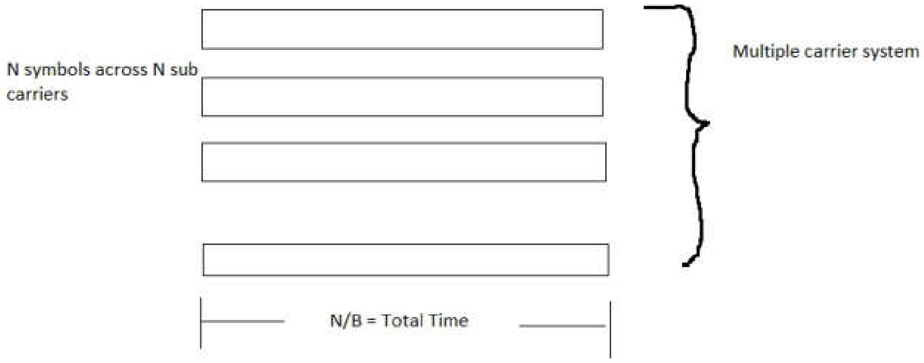
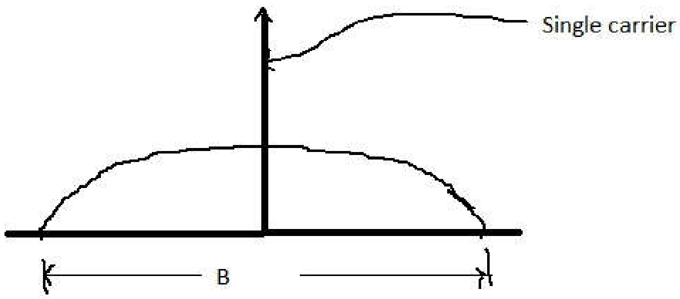


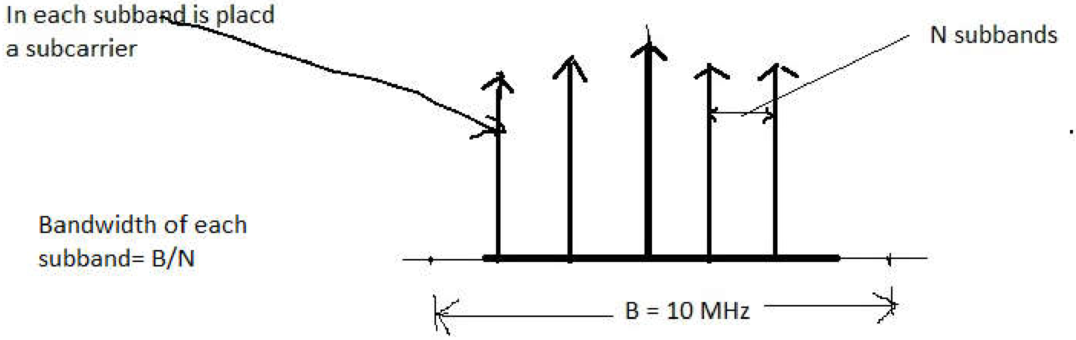




Principle to overcome the ISI in broadband wireless communication:

Let us consider a communication system with a broad bandwidth B. Instead of using the entire bandwidth for communication let us divide into N sub bands and each sub band has its own carrier known as subcarrier and the bandwidth of each of the subband is B/N.

For example let B= 10 MHz, N = 1000
The bandwidth of each subband is B/N = 10 MHz/1000
$=10\ 10^6/\ 10^3$
=10 KHz
Now let us calculate the symbol time T in each sub band which is given by
T = 1/B/N
T = 1/10 KHz



$T = 0.1\text{ms}$ or $100\mu\text{s}$

Let us compare the new symbol time with the delay spread T_d

$T >> T_d$

$100\mu\text{s} >> 2\ \mu\text{s}$

Since the symbol time is much greater than the delay spread there is no inter symbol interference in the system when multiple sub bands and multiple sub carriers in each sub band are used. This system is termed as multi carrier modulated (MCM) this is the basis for OFDM. So OFDM is basically a multi carrier modulated system where we have multiple carrier and multiple sub band, each sub band has small bandwidth resulting in large symbol time greater than the delay spread thus overcoming inter symbol interference. This enables smooth transmission and smooth reception in broadband wireless communication.

Principal of operation of OFDM

Transmission in MCM

In a multicarrier system a large bandwidth B is divided into a number of smaller sub bands each of bandwidth B/N. Each sub band has a sub carrier which is placed at equidistance. The first carrier is placed at 0 the second at B/N then at 2B/N and so on. If we denote B/N as F_0 then the sub carriers are placed at $-2F_0$,-F_0,F_0, 2 F_0, $3F_0$……..there are total of N sub carriers. Let the kth sub carrier be placed at kB/N and the kth sub carrier is given by $e^{j2\pi kF0}$and the kth symbol is given by X_k.

Then the transmitted signal on the kth sub carrier is given by

$S_k(t) = X_k e^{j2\pi kF0t}$

Therefore the net transmitted MCM signal over the N sub carriers is given by

$=\sum_k \text{Xk}e^{j2\pi kF0t}$

The received signal is given by

$Y(t)= \sum_k \text{Xk}e^{j2\pi kF0t}$

Reception in MCM

The received MCM signal is given by

$Y(t)= \sum_0^N \text{Xk}e^{j2\pi kF0t}$

The above equation is similar to Fourier series. To extract the lth symbol denoted by X_l which is the symbol on lth sub carrier from the received MCM signal we have

$F_0 \int_0^{1/F0} e^{-j2\pi lF0t} .y(t)\ d(t)$

$F_0 \int_0^{1/F0} e^{-j2\pi lF0t} .\sum_k \text{Xk}e^{j2\pi kF0t}dt$

$\Sigma_k X_k\ F_0\int_0^{1/F0} e^{j2\pi(k-l)F0t}dt$

The above equation is a sinusoid with period F_0 whose value is given by

1if k = l or

0if K# l

The lth symbol X_l is recovered

Conclusion

Thus the orthogonal frequency division multiplexing avoids inter symbol interference as the symbol time in each sub band is much larger than the delay spread. In single carrier system having a bandwidth B we are transmitting N symbols over time N/B with symbol time 1/B. Where as in multi carrier system we are transmitting N symbols in parallel over N sub carriers with symbol time N/B.

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