International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 11, November - 2013

MIMO-OFDM

Ankit Dalela*, Parul**
*(Department of Electronics and Communication Engineering, BBD University, India)
** (Department of Information Technology, BBDNIIT, India)

ABSTRACT
The amelioration of multicarrier OFDM with multiple – input multiple – output (MIMO) system has various benefits. Orthogonal frequency division multiplexing (OFDM) is a modulation technique which is used in most of the emerging broadband wired and wireless communication systems because it is an effective solution to intersymbol interference caused by dispersive channel. With the advent of MIMO assisted OFDM systems, the transmission rate, the transmission range and transmission reliability may be simultaneously improved. Although MIMOs can be combined with any modulation or multiple access technique, but recent research suggests that the implementation of MIMO – aided OFDM is more efficient, as a benefit of the straightforward matrix algebra invoked for processing the MIMO OFDM signals [1].
Keywords *– Beamforming, MIMO, OFDM SDMA, Spatial Diversity*

I. INTRODUCTION

OFDM is a combination of modulation and multiplexing. Modulation is a mapping of the information on changes in the carrier phase, frequency or amplitude or combination[2]. Multiplexing is a method of sharing a bandwidth with other independent data channels. In OFDM, the signal is first split into independent channels, modulated by data and then multiplexed again to create the OFDM carrier. The main concept in OFDM is orthogonality of sub – carriers which allows simultaneous transmission on a lot of sub – carriers in a tight frequency space without interference from each other. Both modulation and multiplexing are achieved digitally using an inverse fast Fourier transform (IFFT) and as a result, orthogonal signals are generated precisely and in a very computationally efficient way. Data is transmitted in parallel on a number of different frequencies and as a result the symbol period is much longer then for a serial system with the same total data rate. Because the symbol period is longer, ISI affects at most one symbol, and equalization is simplified[3]. In most OFDM implementations any residual ISI is removed by using a form of guard interval called a cyclic prefix. In OFDM, the spectra of individual subcarriers overlap, but because of the orthogonality property, as long as the channel is linear, the subcarriers can be demodulated without interference and without the need for analog filtering to separate the received subcarriers. Demodulation and de – multiplexing is performed by a fast Fourier transform (FFT).

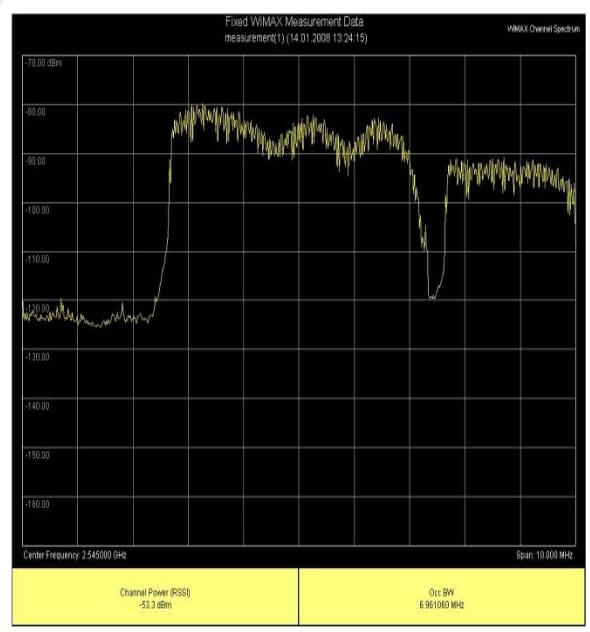

Fig 1: OFDM Signal Properties

II. MULTIPLE-INPUT MULTIPLE-OUTPUT ASSISTED OFDM

The employment of multiple antennas at both transmitter and the receiver, which is called MIMO technique, constitutes a cost effective approach to high throughput wireless communications. The four main applications of MIMOs in wireless communication are:

1. Space Division Multiplexing (SDM) Systems: - SDM systems employ multiple antennas which aim for increasing the throughput of a wireless system in terms of the number of bits per symbol that can be transmitted by a given user in a given bandwidth at a given integrity[4]

2. Space Division Multiple Access (SDMA):- It allows the system to support multiple users within the same frequency band or time slot.[5]

3. Spatial Diversity:- In spatial diversity schemes, such as space time block codes or trellis codes, the multiple antennas are positioned as far apart as possible, so that the transmitted signals of the different antennas experience independent fading, resulting in the maximum achievable diversity gain.[5]

4. Beamforming: - Smart antennas using beamforming have been employed for mitigating the effects of co-channel interfering signals and for providing beamforming gain.[6]

The main merit of OFDM is that the radio channel is divided into many narrow – band, low rate, frequency non – selective sub – channels or subcarriers, so that multiple signals can be transmitted in parallel, while maintaining a high spectral efficiency. Each sub – carrier may also deliver information for a different user, resulting in a simple multiple access scheme known as orthogonal frequency division multiple access (OFDMA). This enables different media such as video, graphics, speech, text, or other data to be transmitted within the same radio link, depending on the specific types of services and their quality of service requirements. In OFDM systems different modulation schemes can be employed for different subcarriers or even for different users.

MIMO-OFDM was developed by Lospan Wireless, which uses OFDM to break up a signal and wirelessly transmit the pieces simultaneously via multiple antennas.

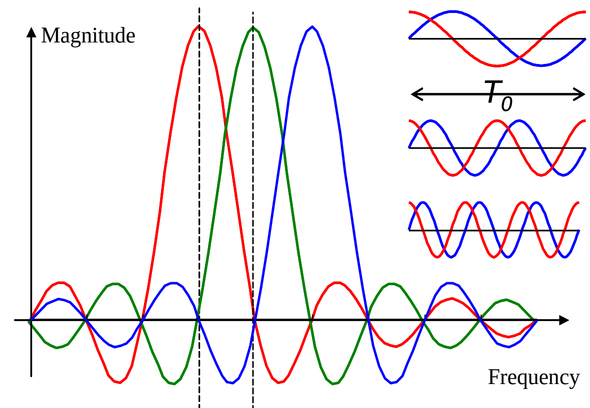

Fig 2: OFDM Signal Orthogonality

III. MIMO – OFDM : PROPERTIES

The MIMO system designed for achieving the maximum diversity gain requires a lower channel signal-to-noise-ratio (SNR) than its counterpart dedicated to attain the maximum multiplexing gain and lower operating SNR is maintained at the cost of a lower bit/symbol throughput[7]

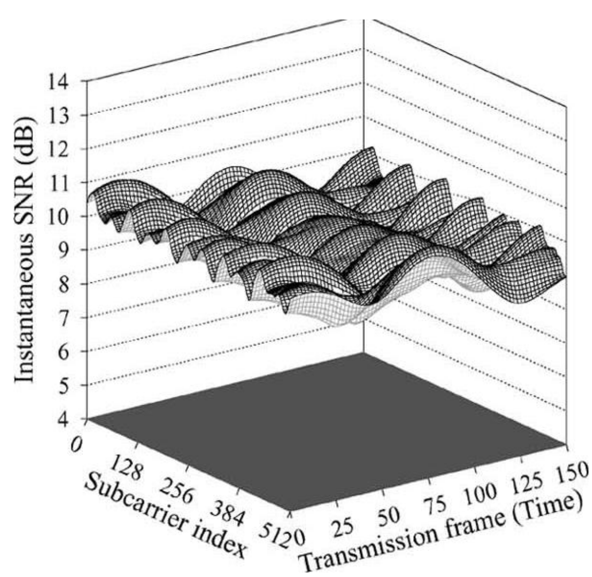

Fig 3: Instantaneous channel SNR versus both time and frequency for a OFDM modem.

In OFDM, the carrier spectrums are overlapped and orthogonal to each other. A guard time is added to each symbol to combat the channel delay spread. It is easy to avoid/reject narrowband dominant interference and the less interfered part of the carrier can still be used.

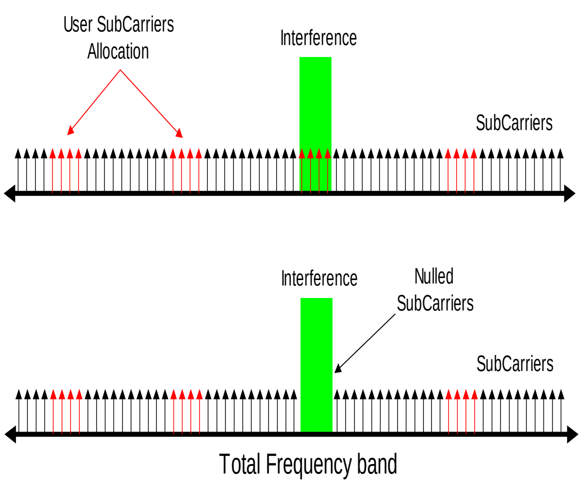

Fig 4: Interference rejection/avoidance

An OFDM signal consists of number of independently modulated signals. The sum of independently modulated subcarriers can have large amplitude variations.

$$x(t) = \sum_{k=0}^{N_c-1} a_k \cdot e^{j2\pi k\Delta f t}$$

This results in a large peak to average power ratio (PAPR)[8]

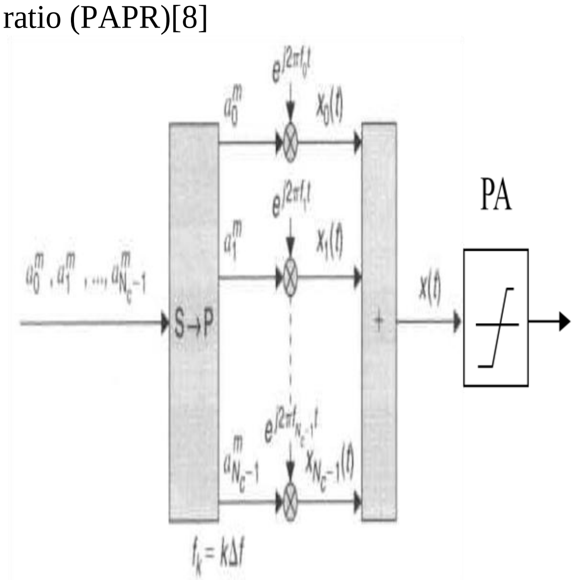

Fig 5: Basic OFDM System

A large PAPR is negative for the power amplifier efficiency. Non-linearity results in inter – modulation which degrades BER performance. Different tools to deal with large PAPR are signal distortion techniques like clipping and windowing, coding techniques and scrambling techniques.

Low timing sensitivity is needed and simple phase and channel estimators solve timing problem. Frequency sensitivity is solved by locking onto the base station transmission and deriving the subscriber unit's clocks from it. No equalizers are needed, channel impairment and timing problems are both solved with simple phase and channel estimators. OFDM enables adaptive modulation for every user QPSK, 16 QAM, 64 QAM and 256 QAM. It offers frequency diversity by spreading the carriers all over the spread spectrum and time diversity by optional interleaving of carrier groups in time. Fig shows the OFDM methodology.

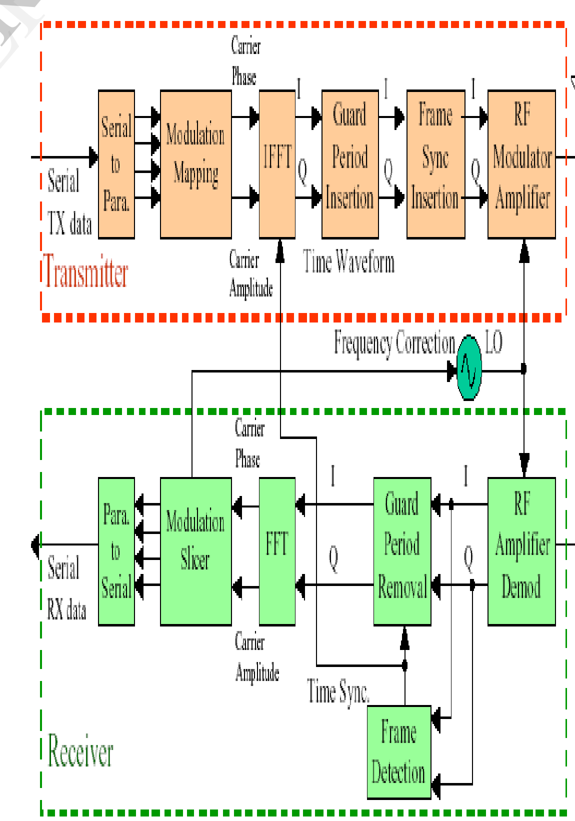

Fig 6: OFDM Methodology

To maintain orthogonality $\frac{1}{T_s} = \Delta f$

Where Δf = sub-carrier spacing

T_s = symbol duration

If N-point IDFT (or FFT) is used

Total bandwidth (in Hz) = $W = N\Delta f$

$T_S + T_{CP}$ = symbol duration after CP addition

OFDM is fundamentally well suited for high bit rate applications as it has simple frequency domain equalization and lower complexity than RAKE or TDMA equalization. Timing recovery is very straight forward and timing jitter is easier to handle due to long symbol duration.

IV. CONCLUSION

OFDM overcomes even severe intersymbol interference through the use of the IFFT and a cyclic prefix. Limiting factor is frequency offset which is correctable via simple algorithm. Two key details of OFDM implementation are synchronization and management of the peak – to – average ratio. Since multiple – antenna techniques require channel knowledge, the MIMO – OFDM channel can be estimated, and this channel knowledge can be relayed to the transmitter for even larger gains.

Although the theoretical basis for OFDM was laid several years ago and OFDM became the basis of many communication standards for wireless and wired applications in 1990's, it is only recently that the application of OFDM to optical communication has been considered. OFDM has a number of drawbacks including its high peak – to – average power ratio and sensitivity to frequency offset and phase noise.

V. REFERENCES

[1] http://www.airgonetworks.com/

[2] "Improving quality of service using OFDM technique for 4G network: by PSK Reddy.

[3]"OFDM for indoor optical wireless communications using visible light LEDs" by V. Naresh Kumar.

[4] G. J. Foschini, BLayered space-time architecture for wireless communication in a fading environment when using multi-element antennas,[Bell Labs Tech. J., vol. Autumn, pp. 41–59, Oct. 1996.

[5] L. Hanzo, M. Mu¨nster, B. J. Choi, and T. Keller, OFDM and MC-CDMA for Broadband Multi-User Communications, WLANs and Broadcasting. Piscataway, NJ: IEEE Press/Wiley, 2003.

[6] J. Blogh and L. Hanzo. (2002). Third-Generation Systems and Intelligent Networking. Piscataway, NJ, IEEE Press/Wiley. [Online]. Available: http:// www-mobile.ecs.soton.ac.uk

[7] "Multiuser MIMO-OFDM for next generation wireless systems" by Ming Jiang and Lajos Hanzo.

[8]"Digital Reciever" by Mohd. Khairul Mizan Bin Hussin.