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VLSI IMPLEMENTATION OF MC-CDMA TRANSCEIVER FOR WIRELESS COMMUNICATION

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Abstract

The crucial design issues for future wireless transceivers are the hall ending and contradictory necessities of the high performance, low power, and adaptability. The application requirements for wireless systems are quite diverse in terms of changing data rates and bit error rates along with changing bandwidths and other channel parameters like the delay unfold. it's essential for wireless transceivers to be tailored to operation instead of being designed for the worst-case channel conditions. The two blocks consuming most power in a multi-carrier code division multiple access (MC-CDMA) or orthogonal frequency division multiplexing (OFDM) receiver are the fast Fourier transform (FFT) and the Viterbi decoder.

In this research work we propose the low power architectures for these two important blocks, It is possible to reduce the power consumption further by dynamically reducing the complexity of the receiver architecture in real time as per the changing channel requirements like the delay spread, signal-to-noise ratio (SNR), bandwidth, bit error rate and so on. This Work proposes altering the FFT size or inverse FFT (IFFT) size in real time as per the channel delay spread instead of using a fixed large FFT-based transceiver designed for the worst-case delay spread.

The FFT/IFFT size in MC-CDMA changes from 16-point to 1024-point depending upon the delay spread, transmission rate, and Doppler frequency. The power saving is significant as it uses the most appropriate FFT/IFFT size instead of a fixed large FFT/IFFT for the worst case channel conditions. This is achieved by monitoring the channel parameters in real time.

Keywords: Matlab, converter, Transmitter, Frequency Interleaver, signal mapper.

I. Introduction

Third Generation (3G) mobile communication systems area unit already in readying in many countries and this has enabled whole new ways that to speak access data, conduct business and be pleased, liberating users from slow cumbersome instrumentality and immoveable points of access. In an exceedingly approach 3G has been the correct bridge for mobile telecommunication and therefore he web. 3G services modify users to form video calls to the workplace and surf the net at the same time, or play interactive games where they will be. Second and third generation systems like EDGE, IS-95 and WCDMA will offer nominal knowledge rates of regarding fifty-384 kbps, where as 3G is simple reworking itself into a reality from associate engineer's dream, analysis efforts area unit already on to appear into systems that may offer even higher knowledge rates and seamless properly. Such systems are unit categorized below fourth generation 4G and area unit expected to supply packet knowledge transmission rates of five Mbps in out of doors macro-cellular environments and up to ten Mbps in indoor and microcellular and the environments. Whereas wide-band systems may be a natural option to offer high knowledge rates, service suppliers got to pay dearly for the spectrum necessary. Hence, spectrum potency is usually an element on the selection of any wireless technology. terribly wide-band systems sometimes need advanced receiver because the channel is frequency selective owing to the presence of huge variety of resolvable multipath. Orthogonal Frequency Division Multiplexing (OFDM) has recently gained lots of attention and may be a potential candidate for 4G systems. OFDM is incredibly economical in spectrum usage and is incredibly effective in an exceedingly frequency selective channel. By taking advantage of recent enhancements in Digital Signal process (DSP) and RF technologies, OFDM will offer higher knowledge rates and may be a excellent selection for service suppliers to vie with wire-line carriers. A variation of OFDM that permits multiple accesses is Multi- Carrier CDMA (MC-CDMA) that is actually associate OFDM technique wherever the individual knowledge symbols area unit unfolds employing a spreading code within the frequency domain. The inherent process gain owing to the spreading helps in interference suppression additionally to providing high knowledge rates. OFDM is already the technique utilized in Digital Audio and Video Broadcasting and Wireless LANs (802.11 family) and is believed to be the technique for future broadband wireless access. Analysis into multiple antenna systems for wireless communications dates back to the Sixties. Multi-antenna receivers offer special diversity and area unit on aspect red to be the Last Frontier to enhance knowledge rates while not the requirement for extra spectrum. Additionally to utilization of such associate antenna-array helps cut back co-channel interference that transforms itself into an improvement in system capability such intelligent associate antenna array have become progressively standard and area unit and choice for future 4G systems. The motivation behind this try is to check the utilization of antenna arrays for OFDM systems. Presently there are no lots of try being focused on the utilization of adaptive antenna arrays for OFDM and MC-CDMA systems.

A. Contributions

Some of the most important contributions of the thesis are listed below.

- Studies the performance limitations of the OFDM and MC-CDMA systems in harsh channel conditions and the use of advanced detection techniques to improve performance in these channel conditions
- The trade-off between processing gain and adaptive antenna technology for MCCDMA systems in various channel conditions is discussed. This has not been in reported in literature previously.
- Presents a new beam forming technique for combining signals in time for OFDM and MC-CDMA systems. The simulation results for an equivalent square measure conferred for varied channel. Conditions. Combining Minimum Mean Square Error (MMSE) detection for OFDM systems in time and MMSE beam forming for OFDM systems is an effective solution for time varying channels that can provide interference suppression. This synergistic use of MMSE in space and frequency is a novel technique proposed in this work for time varying channels.
- The weights for joint MMSE in both space and frequency have been derived and semi-analytic results are also shown to match simulations. While joint MMSE combining in both space and frequency has been studied for CDMA systems, extending the analysis to OFDM which is presented here has not been reported in literature previously.[1]

II Modulation Methods

There is several modulation methods which basically related to CDMA concept used in wireless communication .Commonly employed modulation methods are as follows.

A. DS-CDMA

The ratio between the user symbol time and the chip time is called the spread issue. The transmit signal occupies a information measure that equals the unfold issue times the information measure of the user knowledge. Figure 1.1 DS-CDMA signal is generated by multiplication of a user data signal by a code sequence

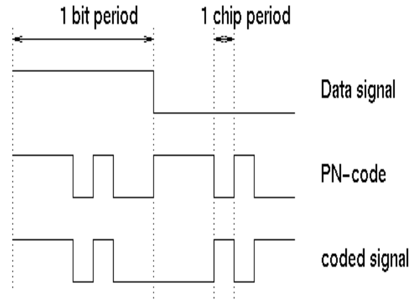

Fig. 1. User Data with PN-code (1).

In the receiver, the received signal is again multiplied by the same (synchronized) code. This operation removes the code, thus we tend to recover the transmitted user knowledge. A CDMA receiver can retrieve the wanted signal by multiplying the receive signal with constant code because the one used throughout transmission. It was found

$$\sum_{n=1}^{N} c_1^2(nT_c + t_d) = \sum_{n=1}^{N} c_1^2(nT_c) = N \qquad (1)$$

Where c_1 is the code sequence used by user one, Tc is that the chip period, td may be a four-four time offset, shared between transmitter and receiver and N is the length of the code sequence. Notice that the receive code must be perfectly time aligned with the transmit code.

B. WCDMA

WCDMA (Wideband Code Division Multiple Access) is the radio access scheme used for third generation cellular systems that are being rolled out in various parts of the globe. The 3G systems to support wideband services like high-speed Internet access, video and high quality image transmission with the same quality as the fixed networks. The access scheme for UTRA is Direct Sequence Code Division Multiple Access (DS-CDMA). The information is spread over a band of approximately 5 MHz . This wide bandwidth has given rise to the name Wideband CDMA or WCDMA.

C. MC-CDMA

Multicarrier CDMA Techniques As discussed in the previous section, a multi-carrier scheme is used to implement an OC code–based CDMA system, if the FDM technique is used to send different element codes. There is big difference between an OC code–based CDMA system implemented by a multicarrier scheme and a general multi-carrier CDMA system, which is the focal point in this section. An OC code–based CDMA system uses a multi-carrier architecture to send different element codes of a complementary code assigned to a specific user.

Thus, different frequency channels convey totally different information, each piece of which is indispensable to the successful reconstruction of ACFs or CCFs at a receiver. In this way, there is no frequency diversity in an OC code–based CDMA system.

On the other hand, a conventional multi-carrier CDMA system uses different carrier frequencies to multiplex the same input wideband data stream, such that each frequency carries only a narrowband bit stream, whose transmission rate is only 1 M -th of that of the input wideband stream if M subcarriers are used.[2]

III Aim and Scope of The Research Work

A. Description

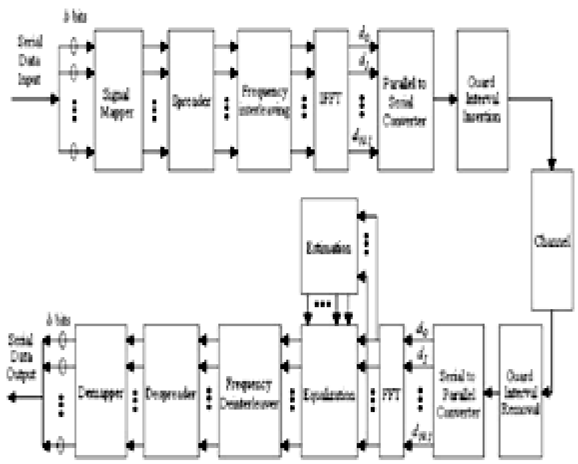

Fig. 2 .basic block diagram of MCCDMA

In this paper, data rate of 4G standard is achieved by designing the transceiver efficiently and low power architecture for the FFT and IFFT blocks in a multi-carrier code division multiple access (MC-CDMA) will be presented. It is possible to reduce the power consumption further by dynamically reducing the complexity of the receiver architecture in real time as per the changing channel requirements just like the delay unfold, signal-to-noise (SNR), bandwidth, bit error rate so on.

This Paper proposes altering the FFT size or inverse FFT (IFFT) size in real time as per the channel delay spread instead of using a fixed large FFT-based transceiver designed for the worst-case delay spread.

The FFT/IFFT size in MC-CDMA changes from 16-point to 1024-point depending upon the delay unfold, transmission rate, and Christian Johann Doppler frequency. The facility saving is important because it uses the foremost applicable FFT/IFFT size instead of a fixed large FFT/IFFT for the worst case channel conditions. This is achieved by monitoring the channel parameters in real time.

B. Scope of The Work

4G or Fourth Generation is future technology for mobile and wireless communications. It'll be the successor for the third Generation (3G) network technology. presently 3G networks are below preparation. just about 4G deployments are expected to be seen around 2012 to 2015. the essential voice was the driving force for second-generation mobile and has been a substantial success. Currently, video and television services are driving forward third generation (3G) preparation. And within the future, low cost, high speed knowledge can drive forward the fourth generation (4G) as short-range communication emerges**.[3]**

IV Proposed System

To transmit 1Mbps data with the processing gain of 20dB, the chip rate in DS-CDMA easily reaches 100Mbps and we need four times faster internal digital front-end processor or at least 100MHz analogue matched filter as in the Wide band CDMA test bed built by NTT DoCoMo. This requirement can be eased by using multi-code assignment for high speed data but the user capacity is sacrificed to the high data rate. MC-CDMA maintains the original signaling interval while it spreads the signal over wide bandwidth like DS-CDMA.

The differences of the arrival times of multipath signals in indoor wireless environment have been reported to be much less than one second. The multipath resolvability is proportional to the used chip rate. To make the rake receivers to work properly, the chip rate ought to be a lot of quicker than 1Mcps even once there's no would like for top rate service. Small delay spread and small Doppler spread help MC-CDMA work better.

Small delay spread reduces the guard interval in MC-CDMA and make it power efficient. MC-CDMA is sensitive to frequency offset and small Doppler spread is preferred. When there is a deep frequency selective fading, OFDM loses the corresponding data on corrupted subcarriers.

As MC-CDMA spreads an information bit over many subcarriers, it can make use of information contained in sound subcarriers to recover the original symbol. Various frequency domain equalizers for MC-CDMA have been proposed for this purpose and they were reported to outperform DS-CDMA with rake receivers.

In DS-CDMA, the number of fingers in a rake receiver is limited as a finger itself is one of the largest units in the receiver modem. Thus, all the scattered energy in time domain cannot be gathered. In some cases, most of energy is contained in the few strongest paths. In other cases, many paths share similar powers. This is where rake receivers lose its performance. MC-CDMA gathers nearly all the scattered powers effectively using cyclic prefix insertion technique. Because the received signals square measure sampled at the first image rate in MC-CDMA, the sampling points may not be optimum. However, it can be argued that, in general, the performance of MC-CDMA is equivalent to m-finger rake receiver in DS-CDMA, where m is the number of symbols in cyclic prefix of MC-CDMA.

A. Transmitter

The transmitter section consists of a ADC, serial to parallel converter, Spreader, Frequency interleaver, IFFT, parallel to serial device, Guard interval insertion.

B. Signal Mapper

The transmitter includes an emblem plotter for generating an emblem for every of a plurality of subcarriers. a technique of up frequency diversity of a proof that features a plurality of orthogonal frequency division multiplexing (OFDM) symbols includes receiving associate computer file sequence, mapping the knowledge input file computer file} sequence to a transmission data sequence.

Whereby the mapping includes playing a mapping operation associated generating an OFDM image mistreatment the transmission knowledge sequence. associate orthogonal frequency division multiplexing (OFDM) transmitter includes associate interface organized to receive associate computer file sequence, and a processor organized to perform a mapping operation, to map the knowledge input file computer file sequence to a transmission data sequence whereby the mapping includes playing the mapping operation, associated to come up with an OFDM image mistreatment the transmission knowledge sequence.

C. Frequency Interleaver

Frequency interleaving is used to exploit the frequency diversity in wide-band transmissions. After frequency interleaving, the local deep fading is averaged over the whole bandwidth of the system. The frequency interleaving should be implemented for all the data symbols in a single MCCDMA symbol.

This means, that the data symbols of two neighboring symbols should not be interleaved in one iteration. For this reason, the dimension of the frequency interleaved should be equal to the number of data symbols in a single symbol. The combined effect of interleaving and convolution channel coding takes advantage of the frequency diversity provided by the wideband nature of the transmitted signal.

D. IFFT

IFFT processing section carries out inverse Fourier transform processing on a plurality of parallel signals. This IFFT processing section assigns one subcarrier to one chip data signal string and carries out Frequency division multiplexing. Parallel data streams are used as inputs to an IFFT. IFFT output is sum signal samples IFFT does modulation and multiplexing in one step Filtering and D/A of samples results in baseband signal.

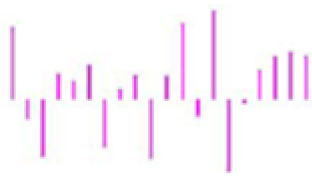

Fig.3. (a): Output of IFFT (3).

Modulation of the signals is carried out in IFFT. Varying the complex numbers at the IFFT input results in modulation of the subcarriers. BPSK modulation technique is employed in IFFT

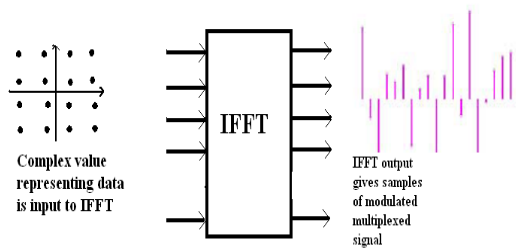

Fig. 4.(b): Signals at the input and output of transmitter of IFFT (3)

E. BPSK Modulation

The common form for BPSK follows the equation:

$$s_b(t) = \sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t + \pi(1-n)), n = 0, 1. \quad (2)$$

$$s_b(t) = \sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t + \pi(1-n)), n = 0, 1. \quad (3)$$

$$s_b(t) = \sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t + \pi(1-n)), n = 0, 1. \quad (4)$$

This yields 2 phases, 0 and π. within the specific type, binary information is usually sent with the subsequent signals:

for binary "0" $$s_1(t) = \sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t) \quad (5)$$ for binary "1"

where fc is that the frequency of the carrier-wave.

Hence, the signal-space may be delineated by the only basis operate $\phi(t) = \sqrt{\frac{2}{T_b}}\cos(2\pi f_c t)$ (7)

where ,1 is represented by $\sqrt{E_b}\phi(t)$

0 is represented by $-\sqrt{E_b}\phi(t)$

This assignment is, of course, arbitrary.

F. BIT ERROR RATE

The bit error rate (BER) of BPSK in AWGN can be calculated as

$$P_b = Q\left(\sqrt{\frac{2E_b}{N_0}}\right) \text{ or } P_b = \frac{1}{2}\operatorname{erfc}\left(\sqrt{\frac{E_b}{N_0}}\right) \quad (8)$$

Since there's only 1 bit per image, this can be conjointly the image error rate.

G. Receiver:

The receiver consists of a guard interval removal, serial to parallel converter, FFT, Frequency Deinterleaver , Despreader, Demapper , Parallel to serial converter and a DAC

V. Working Procedure

The MCCDMA consists of a transmitter and a receiver. The working of the MCCDMA transceiver shown in fig is explained as follows.

A. Transmitter

A Transmitting device for the multi-carrier CDMA scheme, comprising a serial to parallel converter for converting input data into parallel data ,a plurality of copiers for copying each of the parallel data as many times as the number of spread factors, a spreader for spreading the respective data output by using different spread codes, the spreader spreads a part of blocks composed of multi-carriers for multiplexing users and an IFFT unit for performing inverse fast Fourier transform (IFFT) on the data spread by the spreader and transmitting the IFFT-performed data through a transmit antenna. The transmitting device further comprises an interleaver for encoding the input data, interleaving the encoded data, and outputting interleaved data a mapper for converting the data output by the interleaver into signals of a predetermined modulation method, and outputting the signals. It consists of a parallel to serial converter for converting the parallel data output by the IFFT unit into serial data, and outputting the serial data; and a guard interval inserter for inserting a guard interval into the data output by the parallel to serial converter.

B. Receiver

A receiving device for the multi-carrier CDMA, comprises of an FFT unit for performing fast Fourier transform (FFT) on signals received through a receive antenna, and outputting data, a despreader for despreading the data output by the FFT with different spread codes, the different spread codes being codes used when spreading a part of blocks composed of multi-carriers for multiplexing users, a plurality of combiners for dividing the data despread by the despreader into a predetermined number of blocks, combining data of the respective blocks, and outputting the combined data, and a parallel to serial converter for converting the data output into serial data, and outputting the serial data. The receiving device, further comprises a guard interval eliminator for eliminating a guard interval from a signal received through the receive antenna, and outputting information.

It consists of a channel reckoner for using the data despread by the despreader to estimate a channel, and outputting an estimate to the combiner; a de-interleaver for de-interleaving the data and a signal demapper for obtaining output by the parallel to serial converter to output restored data.

C. Requirement Specification

The requirements specification is a technical specification of requirements for the software and hardware products. It is the first step in the requirement analysis method, it lists the wants of a selected software and hardware system including functionality, performance. The purpose of software requirement specification is to provide a detailed overview of the simulation output of the work.

D. Software Interfaces

- Modelsim
- Matlab
- Quartus tool synthesizer

E. Simulation Types

- Functional behavioral is HDL simulations
- Gate-level timing simulations

F. Simulation Flow

The basic simulation flow using the Model Sim-Altera and Quartus Cyclone III software involves the following steps:

1. Create libraries.

2. Map to libraries.

3. Compile source code and testbenches.

4. Load the design.

5. Add design stimulus.

6. View the simulation results.

G. Matlab Simulation

MATLAB simulation is used to Simulate a simple communication system and estimate bit error rate.

H. System Characterstic

- BPSKmodulation, b $\in\{1,-1\}$ with equal a priori probabilities
- Rayleigh channel
- Walsh hadamard paseduo sequence
- AWGN
- Equalizer
- Cycli prefix
- Over sampled integrate-and-dump receiver front-end,

I. Matlab Simulation Results

- Matlab simulation of a wide-band signal with anequalizer is conducted which indicate that diversity gains are possible.
- Performance at terribly low SNR suffers, probably, from inaccurate estimates.
- .Higher gains can be achieved by increasing bandwidth. This incurs more complexity in the equalizer.
- Potential issues thanks to a bigger range of channel coefficients to be calculable.

J. Quartus Tool Synthesizer

Altera Quartus II is a design software program that allows to create designs for field-programmable gate array (FPGA), Application Specific Integrated Circuit (ASIC) and complex programmable logic devices (CPLD). This program features a graphical user interface (GUI) and create programming files.

K. OFDM and MC-CDMA

Recent advances in multimedia mobile communications have sparked much research in techniques that can deliver very high data rates. Data rate is really what broadband is all about. Traditional single carrier modulation techniques can do solely restricted knowledge rates owing to the restrictions obligatory by the multipath channel and therefore the receiver complexness.

Multi-carrier techniques will give high knowledge rates at cheap receiver complexities and are more and more turning into in style in audio/video broadcasting, mobile native space networks and future generation broadband cellular systems. This chapter gives an introduction to Orthogonal Frequency Division Multiplexing (OFDM) and the CDMA version of it called the Multicarrier CDMA (MC-CDMA)

L. Advantages Of Multicarrier Modulation

Mobile radio channels introduce severe multipath propagation due to multiple scattering from objects in the vicinity of the mobile. This scattering introduces rapid fluctuation of the received signal envelope as well as phase variations. Measurements and theoretical analysis have shown that the envelope of the signal received is typically Rayleigh distributed. Also the motion of the mobile unit introduces a Doppler shift which causes a broadening of the signal spectrum.

The multipath channel can also be frequency selective in which case the fading envelope of the received signal at one frequency might not be correlated with the envelope at another frequency. This is due to the fact that the symbol duration might be less than (or on the order of) the maximum delay spread. As a result, the received signal consists of overlapping versions of the transmitted symbols or put down image Interference (ISI).

Also, if we consider a cellular environment or military applications, there is the effect of 21 co channel interference due to the frequency reuse of the available spectrum. In addition to this, the received signal is subjected to large scale fading also called shadow fading due to the propagation effects. Given these adverse mobile environments it is necessary to look for intelligent transmission and reception techniques. In a conventional serial data transmission, the symbols are transmitted sequentially with the frequency spectrum of the each transmitted symbol occupying the entire bandwidth available.

The delay spread due to the channel dictates the symbol duration or alternatively the data rate that can be achieved to prevent the effects of the ISI. The idea behind multicarrier modulation is that it is a technique where multiple low data rate carriers are combined by a transmitter to form a composite high data rate transmission.

In a parallel transmission system several sequential streams of data are transmitted simultaneously. In a classical parallel transmission system, the available spectrum is split into several non-overlapping frequency sub channels. The individual data elements are modulated into these sub channels and are thus frequency multiplexed. The main advantage is that the parallel transmission increases the symbol time by modulating the symbols into narrow sub channels. This increase in image time makes it additional strong to the channel delay unfold effects.

M. Multi-Tone CDMA (MT-CDMA)

Multi-Tone CDMA transmitter spreads the serial parallel converted data streams using a spreading code in time domain so that the spreading operation will satisfy the orthogonality condition. The MT-CDMA uses spreading codes in multiples of the number of subcarriers as compared to MC-DS CDMA.

N. Channel Estimation Using The FFT Method

A Rayleigh fading compensation technique using the FFT method was originally proposed by [Oka95] for QAM signals. We apply the same technique for a MC-CDMA signal. Pilot chips are inserted before the IFFT block at the transmitter or can be said to be in the frequency domain.

The least squares estimate of the pilots is obtained in the receiver by dividing those corrupted pilots with the known pilot symbols. To obtain the channel coefficients for the data symbols interpolation is performed in the frequency domain.

O. Advantages

- It provide environment for designing field-programmable gate array.
- It is used to create the logic for the design and test the functionality of the circuit.
- Quartus II provides simulations of both the functionality of the design and the timing of the simulation to help you ensure the correctness of the circuit.[4,5]

VI. Results and Discussion

A. Transmitter Screen Shots

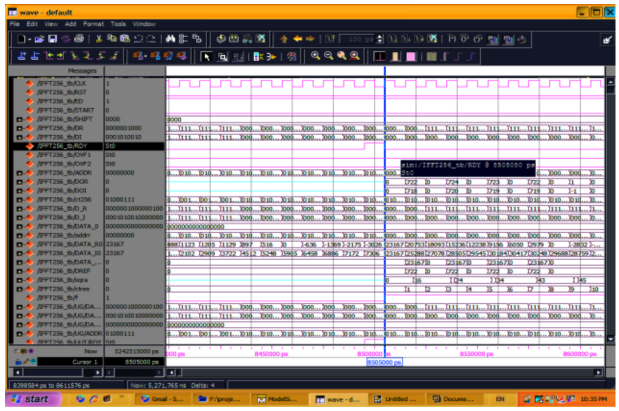

Fig. 5. Transmitter Screen Shots.

B. Receiver Screenshots

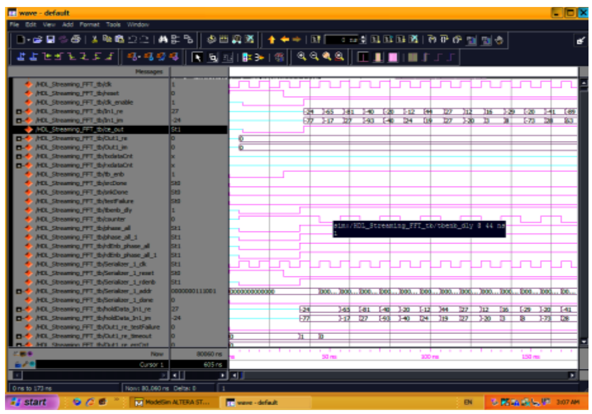

Fig. 6. Output Waveform of Receiver.

Total Thermal Power Dissipation at the Receiver Output is 69.08Mw

C. Matlab Screen Shot

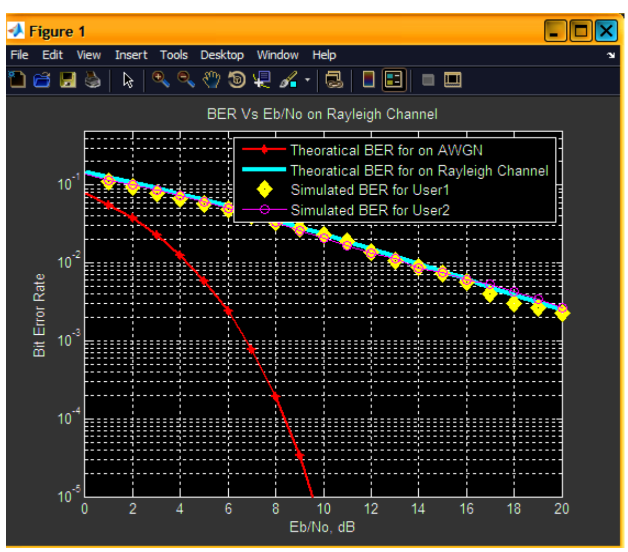

Fig.7. Matlab Screen Shot.

Here done comparison among SISO, MISO, SIMO and MIMO. Fig Showing the comparison study on various antenna at both transmitter and receiver and BER is reduced when data is transmitted with multiple antennas at transmitter and received with multiple antennas.

VII. Conclusion

Thus a wireless transceiver has been designed to be adapted to operation rather than being designed for the worst-case channel conditions. In this work the low power architectures are used for FFT block to reduce the power consumption further it dynamically reduces the complexity of the receiver architecture in real time as per the changing channel requirements like the delay spread, signal-to-noise ratio (SNR), bandwidth, bit error rate and so on. The FFT/IFFT size in MC-CDMA changes from 16-point to 1024-point depending upon the delay unfold, transmission rate, and Christian Johann Doppler frequency. High data rates are achieved in the order of giga bytes.

This thesis focuses on multi antenna receivers for OFDM and MC-CDMA systems and more specifically on algorithms that could provide interference and ICI suppression in harsh channel conditions. We have analyzed the performance of frequency domain beam forming for OFDM systems and have also pointed out that having a single weight vector across all subcarriers may not work very well if the channel delay spread is high. Hence sub-band beam forming which uses multiple weight vectors is necessary to track channel variations in frequency.

An alternative solution is to combine antenna signals in time. The performance of this time domain beam forming technique has also been discussed. The algorithm works very well in cases where the angle spread is low. Also it has been shown that the performance of frequency domain and time domain beam forming is the same in a flat Rayleigh fading channel. In terms of complexity, the two beam formers are similar. The time varying nature of the channel can corrupt the orthogonality between the subcarriers for OFDM systems. Advanced detection techniques for OFDM systems that can utilize the time diversity provided by that channel. Performance results have shown that this technique provides very good interference suppression while being robust to time variations of the channel. This work also investigated a joint MMSE in frequency and space approach and semi-analytic expressions for the BER performance were derived.

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