HARTLEY TRANSFORM BASED OFDM FOR OPTICAL FIBER COMMUNICATIONS

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Abstract— ***Orthogonal Frequency-Division-Multiplexing (OFDM) is widely used in many digital communication systems due to its advantages such as high bit rate, strong immunity to multipath loss and high spectral efficiency. It is effectively mitigates Inter Symbol Interference (ISI) caused by the delay spread of wireless channels. Therefore, it has been used in many wireless systems and adopted by various standards. In this paper, we present a comprehensive survey on OFDM for wireless communications and several techniques with mathematically analysation. Moreover, their applications, advantages and disadvantages of OFDM in current systems and standards are proposed.***

Keywords— ***OFDM, Inter** Symbol **Interference (ISI).***

I. INTRODUCTION

This Orthogonal Frequency Division Multiplexing (OFDM) is used in many wirelesses broadband communication systems because it is a simple and scalable solution to Inter symbol interference(ISI) caused by a multipath channel. Very recently the use of OFDM in optical systems has been attracted increasing interest. Data rates in optical fiber systems are typically much higher than in RF wireless systems. At these very high data rates, timing jitter is emerging as an important limitation to the performance of OFDM systems. A major source of jitter is the sampling clock in the very high speed analog-to-digital converters (ADCs) which are required in these systems. Timing jitter is also emerging as a problem in high frequency band pass sampling OFDM radios. The effect of timing jitter has been analyzed in the literature focus on the older low pass timing jitter which is typical of systems using phase lock loops (PLL). They consider only integral oversampling. In OFDM, fractional oversampling can be achieved by leaving some band-edge subcarriers unused. In this project work we investigate both fractional and integral oversampling. We extend the timing jitter matrix proposed in to analyze the detail of the inter carrier interference (ICI) in an oversampled system. Very high speed ADCs typically uses parallel pipeline architecture not a PLL and for these the white jitter which is the focus of this paper is a more appropriate model.

II. OFDM(ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING)

Initial proposals for OFDM were made in the 60s and the 70s. It has taken more than a quarter of a century for this technology to move from the research domain to the industry. The concept of OFDM is quite simple but the practicality of implementing it has many complexities. So, it is a fully software project.

OFDM depends on Orthogonality principle. Orthogonality means, it allows the sub carriers, which are orthogonal to each other, meaning that cross talk between co-channels is eliminated and inter-carrier guard bands are not required. This greatly simplifies the design of both the transmitter and receiver, unlike conventional FDM, a separate filter for each sub channel is not required.

Orthogonal Frequency Division Multiplexing (OFDM) is a digital multi carrier modulation scheme, which uses a large number of closely spaced orthogonal sub-carriers. A single stream of data is split into parallel streams each of which is coded and modulated on to a subcarrier, a term commonly used in OFDM systems. Each sub-carrier is modulated with a conventional modulation scheme (such as Quadrature amplitude modulation) at a low symbol rate, maintaining data rates similar to conventional single carrier modulation schemes in the same bandwidth. Thus the high bit rates seen before on a single carrier is reduced to lower bit rates on the subcarrier. In practice, OFDM signals are generated and detected using the Fast Fourier Transform algorithm. OFDM has developed into a popular scheme for wideband digital communication, wireless as well as copper wires.

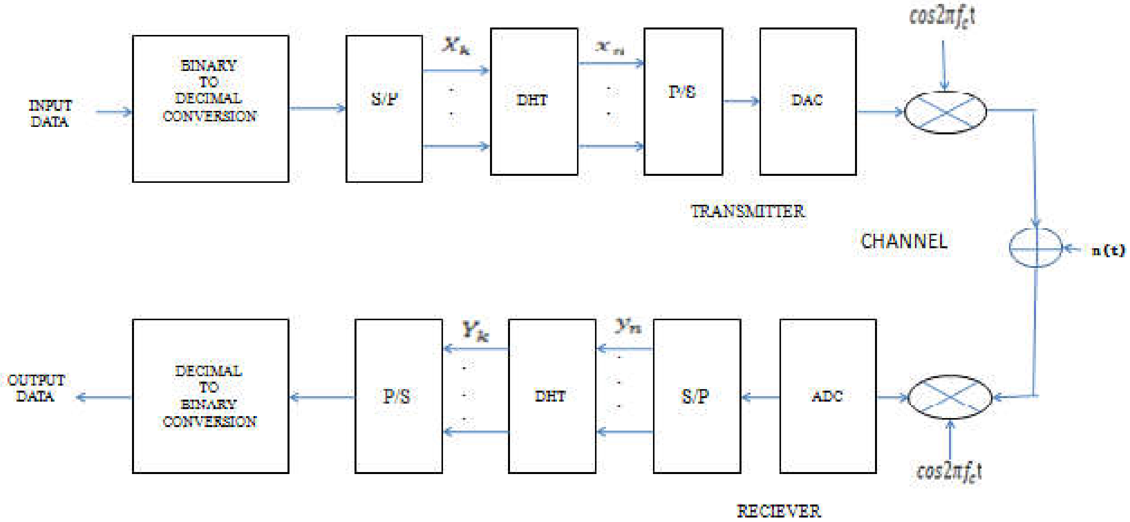
III. OPTICAL FIBRE COMMUNICATION

Since its invention in the early 1970s, the use of and demand for optical fiber have grown tremendously. The uses of optical fiber today are quite numerous. With the explosion of information traffic due to the Internet, electronic commerce, computer networks, multimedia, voice, data, and video, the need for a transmission medium with the bandwidth capabilities for handling such vast amounts of information is paramount. Fiber optics, with its comparatively infinite bandwidth, has proven to be the solution. Companies such as AT&T, MCI, and U.S. Sprint use optical fiber cable to carry plain old telephone service (POTS) across their nationwide networks. Local telephone service providers use fiber to carry this same service between central office switches at more local levels, and sometimes as far as the neighborhood or individual home. Optical fiber is also used extensively for transmission of data signals. Large corporations, banks, universities, Wall Street firms, and others own private networks. These firms need secure, reliable systems to transfer computer and monetary information between buildings, to the desktop terminal or computer, and around the world. The security inherent in optical fiber systems is a major benefit. Cable television or community antenna television (CATV) companies also find fiber useful for video services. The high information-carrying capacity, or bandwidth, of fiber makes it the perfect choice for transmitting signals to subscribers. The fibering of America began in the early 1980s. At that time, systems operated at 90 Mb/s. At this data rate, a single optical fiber could handle approximately 1300 simultaneous voice channels. Today, systems commonly operate at 10 Gb/s and beyond. This translates to over 130,000 simultaneous voice channels. Over the past five years, new technologies such as dense wavelength-division multiplexing (DWDM) and erbium-doped fiber amplifiers (EDFA) have been used successfully to further increase data rates to beyond a terabit per second (>1000 Gb/s) over distances in excess of 100 km. This is equivalent to transmitting 13 million simultaneous phone calls through a single hair-size glass fiber. At this speed, one can transmit 100,000 books coast to coast in 1 second! The growth of the fiber optics industry over the past five years has been explosive. Analysts expect that this industry will continue to grow at a tremendous rate well into the next decade and beyond. Anyone with a vested interest in telecommunication would be all the wiser to learn more about the tremendous advantages of fiber optic communication. With this in mind, we hope this module will provide the student with a rudimentary understanding of fiber optic communication systems, technology, and applications in today's information world.

IV. Discrete Hartley transform (DHT)

The Discrete Hartley transform (DHT) and the Discrete Fourier transform (DFT) are similar but differ from it in two characteristics of the DFT that are sometimes computation- ally undesirable, Since the inverse DHT is identical with the direct transform, and so it is not necessary to keep track of the +i and i versions as in the DFT. Also, the DHT has real rather than complex values and thus does not require provision for complex arithmetic operations and separately managed storage for real and imaginary parts.

DHT has been established a potential tool for signal processing applications. It has a real valued and symmetric transform kernel. In this particular work the simulation time for the DFT/IDFT and DHT/IDHT for a given set of data have been obtained. It shows that the computing speed of the DHT/IDHT is faster than DFT/IDFT.



Block diagram of OFDM with DHT

The faster transform, the FHT algorithm, in essence, is a generalization of the Cooley-Turkey FFT algorithm, but the FHT requires only real arithmetic computations as compared to complex arithmetic operations in any standard FFT. Therefore, the speed of performing a FHT should be about twice as fast as the Cooley- Turkey FFT, By exploiting the complex- to-real property of one of the special cases of this class, it is proposed in a new one parameter involuntary DHT that is also valid for any size N 16. The idea of replacing a twiddle factor by another scalar in the kernel of the DFT or DHT can be similarly applied at the algorithm level.

Various algorithms are still available that elaborate more on the comparisons of these two transforms and optimize the simulation timings depending upon the size of data taken. However the work here focuses more on the BER vs. SNR for the two transforms in both 1D and 2D. In this work the terminology DFT/IDFT and FFT/IFFT has been used interchangeably which should not affect the sense of transform as they have been used here either by means of implementation of the mathematical equations for the transform or the in-built functions of the transform. The results however are just the same in both case, in the last few decades, researchers have proposed several alternative transforms to replace IDFT DFT, such as DHT (Discrete Hartley Transform) IDHT (Inverse Discrete Hartley Transform) and DWT (Discrete Wavelet Transform) IDWT (Inverse Discrete Wavelet Transform). Past research has individually compared one of the many transforms to the DFT-based structure on one or two of the performance aspects, such as BER performance, hardware performance, or hardware complexity. For example, the DHT-based structure generates similar BER performance and lower complexity. A DWT-based structure shows better BER performance under certain conditions, implementing the hardware to lower the complexity or increase the operating speed.

VI. SIMULATIONS

The simulated results for basic model of OFDM system with QAM modulation as shown below. The SNR ratio is 10,used in wireless communication. By observing the noe and BER are very high,PAPR is also more. The PAPR is major drawback in OFDM system. The results for basic OFDM system shown in fig(1).The fig(2),fig(3) and fig(4) shows the simulated waveforms.

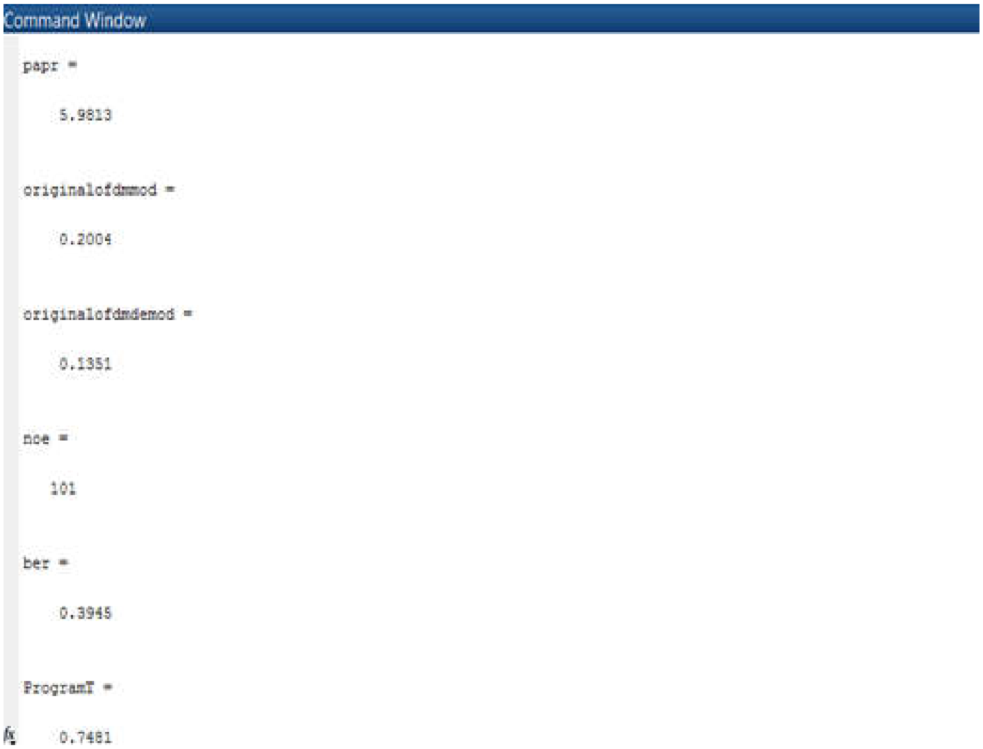


Fig 1 Results of basic OFDM with QAM modulation

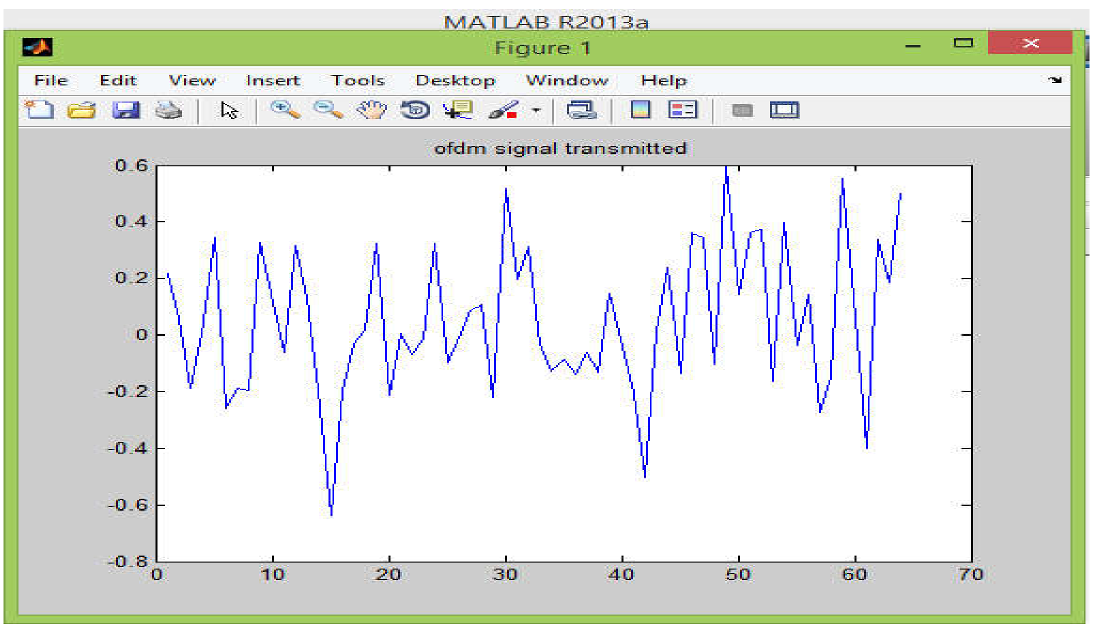


Fig 2 Simulated waveform for OFDM transmitted signal

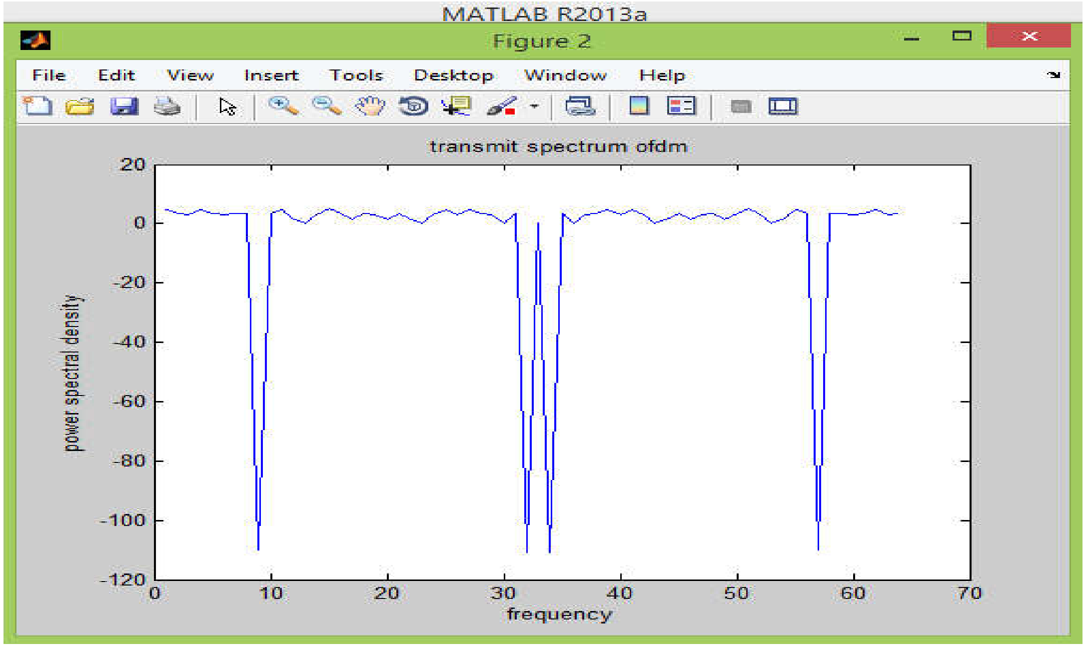


Fig 3 Simulated waveform for OFDM spectrum

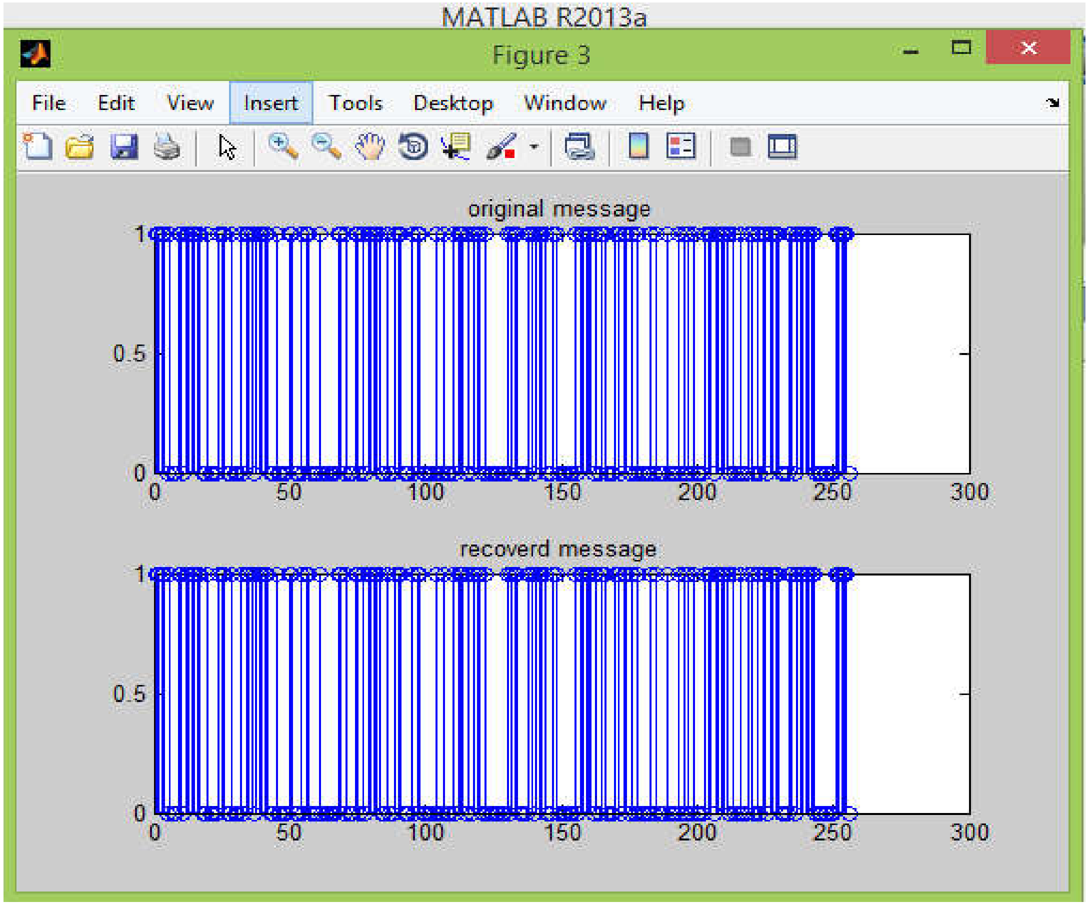


Fig 4 Simulated waveform for original and recovered OFDM signal

When we used Discrete Hartley Transform instead of Fast Hartley Transform we observed better results. The command window shows the various parameters like modulation time,demodulation time,noe,BER etc in fig(5).

Compared to basic OFDM system,by using Discrete Hartley Transform based OFDM the noe are reduced as well as time also reduced.

Fig 5 Results of OFDM with Discrete Hartley Transform

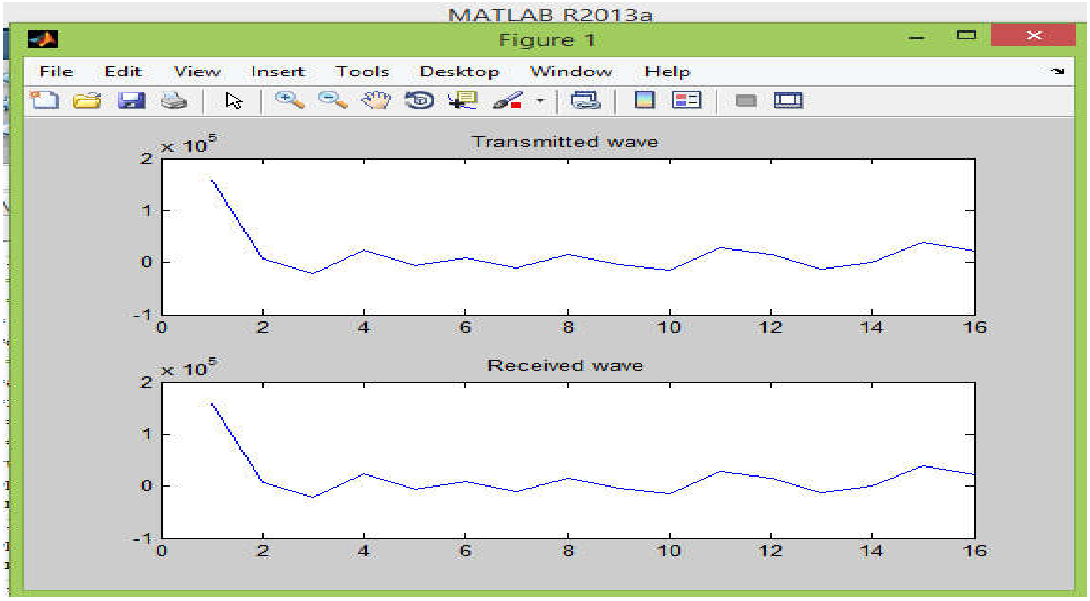


Fig 6 Simulated waveform for OFDM transmitted and received signal

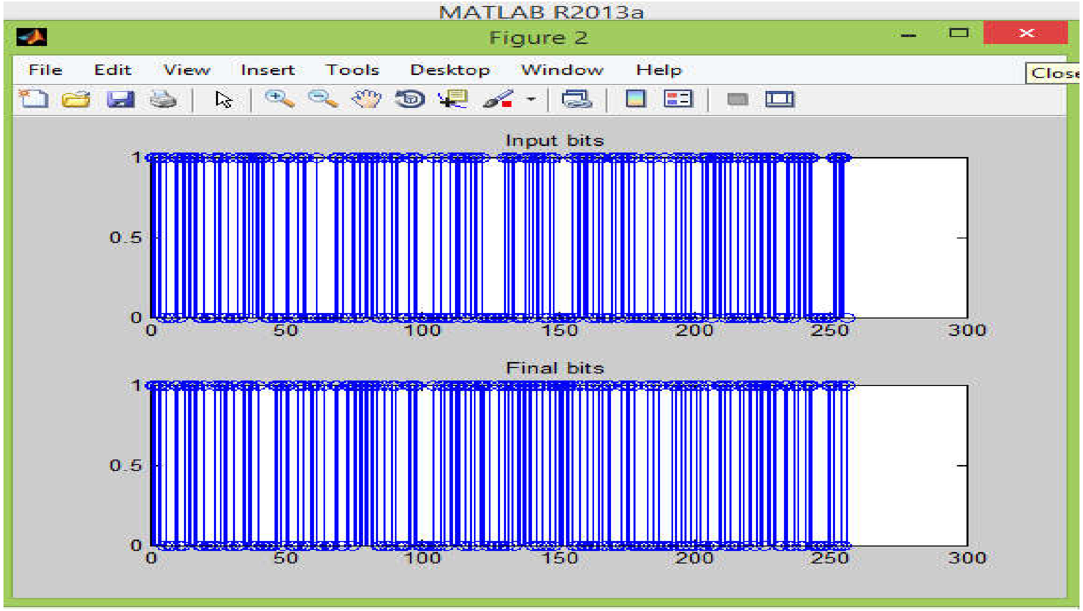


Fig 7 Simulated waveform for OFDM input and final bits

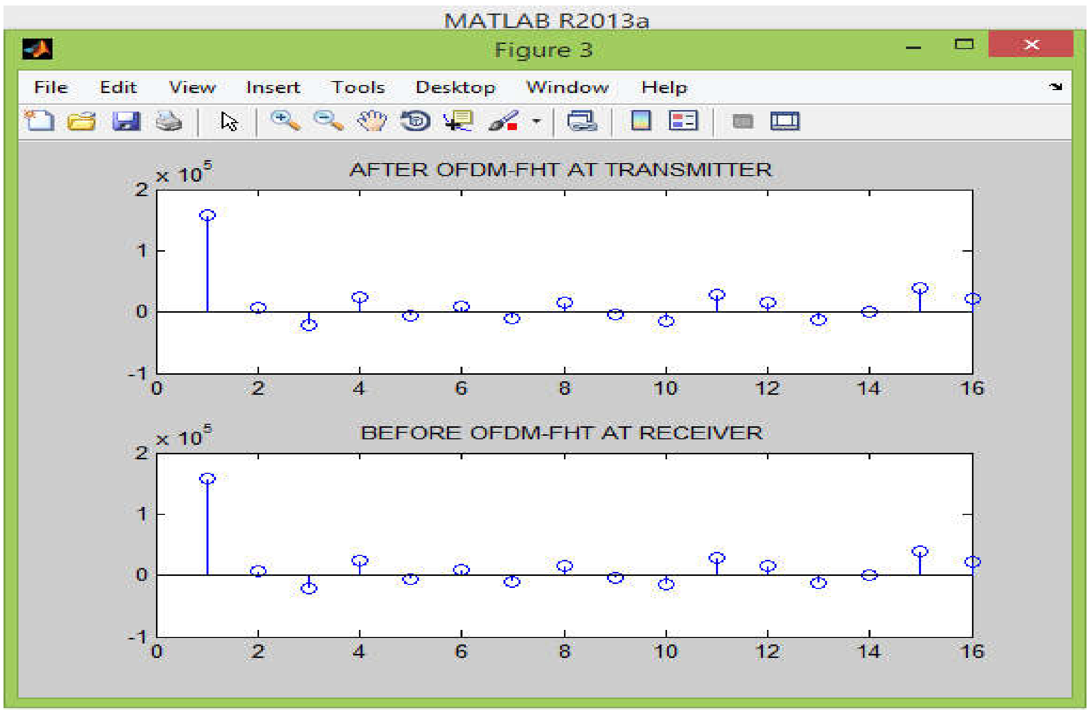


Fig 8 Simulated waveform for OFDM-FHT after transmitter and before receiver signal

By using DHT algorithm, it take more time for calculations. For fast calculations, we introduced new approach called Fast Hartley Transform. When we used FHT, we observed the time and noe are reduced as shown in fig(9).

Fig 9 Results of OFDM with Fast Hartley Transform

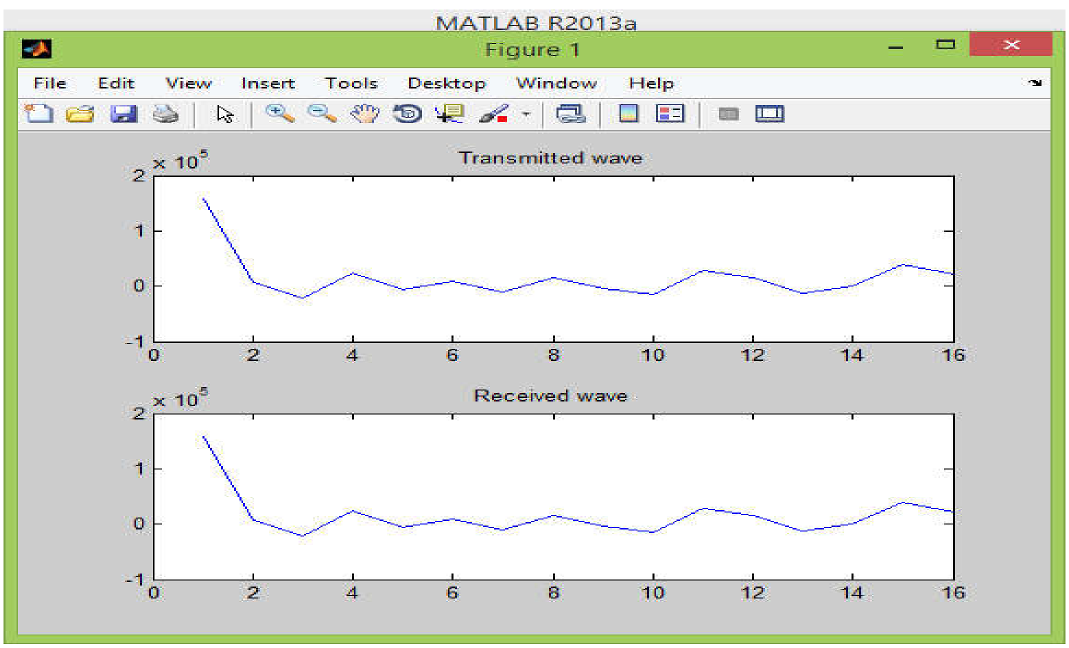


Fig 10 Simulated waveform for OFDM transmitted and received signal

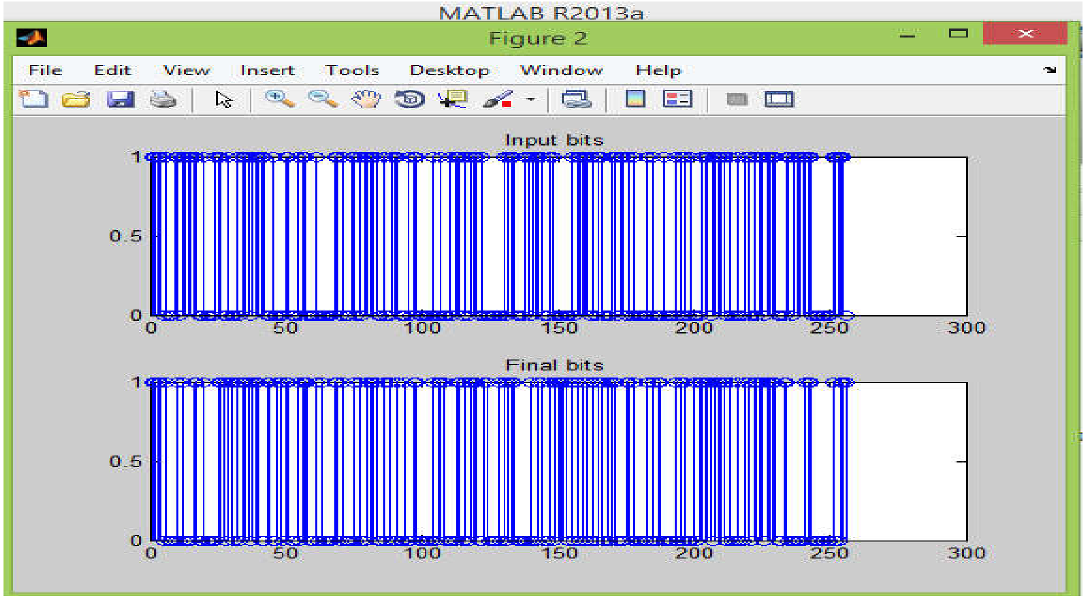


Fig 11 Simulated results for OFDM input and final bits

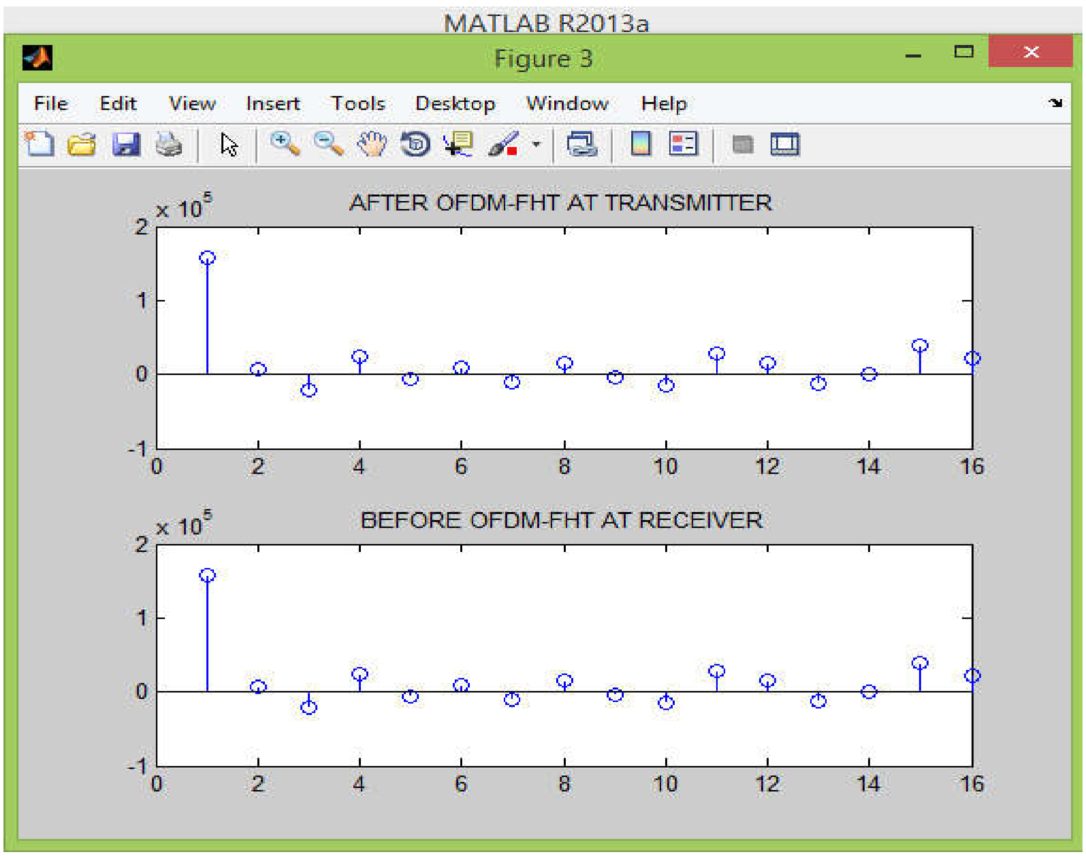


Fig 12 Simulated results for OFDM-FHT after transmitter and before receiver signal

V. CONCLUSIONS

It has been shown both theoretically and by simulation that OFDM-FHT using Companding techniques without using modulation technique and shows the reduction of PAPR, performance time and number of errors. Finally, this technique is used for optical communication system at SNR=50.

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