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Research Paper

VLSI IMPLEMENTATION OF BARCODE MODULATION TECHNIQUE IN WIRELESS SENSOR NETWORK

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One of the most important multi-carrier transmission techniques used in the latest wireless communication arena is known as Orthogonal Frequency Division Multiplexing (OFDM). It has several characteristics such as providing greater immunity to multipath fading and impulse noise, eliminating Inter Symbol Interference (ISI) and Inter Carrier Interference (ICI) using a guard interval known as Cyclic Prefix (CP). A regular difficulty of OFDM signal is high Peak to Average Power Ratio (PAPR) which is defined as the ratio of the peak power to the average power of OFDM Signal. In an OFDM system, typical sub-carrier modulation schemes include Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK), and Quadrature Amplitude Modulation (QAM). High level of modulation is used in order to increase the data rate of the OFDM system. The modulation techniques decide the data rate and bit error rate expectation at the receiver side. In above said the OFDM modulation is combinely tested with Barcode Modulation to test the bit error rate capability of the OFDM. The result analysis proves that the combined barcode modulation technique provide high data recovery.

Keywords: OFDM, Cyclic prefix, PAPR, ISI, ICI

INTRODUCTION

The ever increasing demand for very high rate wireless data transmission calls for technologies which make use of the available electromagnetic resource in the most intelligent way. Key objectives are spectrum efficiency (bits per second per Hertz), robustness against multipath propagation, range, power consumption, and implementation complexity. These objectives are often conflicting, so techniques and implementations are sought which offer the best possible tradeoff between them. The Internet revolution has created the need for wireless technologies that can deliver data at high speeds in a spectrally efficient manner. However, supporting such high data rates with sufficient

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robustness to radio channel impairments requires careful selection of modulation techniques. Currently, the most suitable choice appears to be OFDM (Orthogonal Frequency Division Multiplexing). OFDM is becoming the chosen modulation technique for wireless communications. OFDM can provide large data rates with sufficient robustness to radio channel impairments.

OFDM is a special form of multi carrier modulation technique which is used to generate waveforms that are mutually orthogonal. In an OFDM scheme, a large number of orthogonal, overlapping, narrow band sub-carriers are transmitted in parallel. These carriers divide the available transmission bandwidth. The separation of the sub-carriers is such that there is a very compact spectral utilization. With OFDM, it is possible to have overlapping sub channels in the frequency domain, thus increasing the transmission rate. In order to avoid a large number of modulators and filters at the transmitter and complementary filters and demodulators at the receiver, it is desirable to be able to use modern digital signal processing techniques, such as Fast Fourier Transform (FFT). After more than forty years of research and development carried out in different places, OFDM is now being widely implemented in high-speed digital communications. OFDM has been accepted as standard in several wire line and wireless applications. Due to the recent advancements in Digital Signal Processing (DSP) and very large-scale integrated circuits technologies, the initial obstacles of OFDM implementations do not exist anymore. In a basic communication system, the data are modulated onto a single carrier frequency. The available bandwidth is then totally occupied by each symbol. This kind of system can lead to Inter-Symbol-Interference (ISI) in case of frequency selective channel. The basic idea of OFDM is to divide the available spectrum into several orthogonal sub channels so that each narrowband sub channels experiences almost flat fading. Many research centers in the world have specialized teams working in the optimization of OFDM systems. The attraction of OFDM is mainly because of its way of handling the multipath interference at the receiver. Multipath phenomenon generates two effects (a) Frequency selective fading; and (b) ISI. The “flatness” perceived by a narrowband channel overcomes the frequency selective fading. On the other hand, modulating symbols at a very low rate makes the symbols much longer than channel impulse response and hence reduces the ISI. Use of suitable error correcting codes provides more robustness against frequency selective fading. The insertion of an extra guard interval between consecutive OFDM symbols can reduce the effects of ISI even more. The use of FFT technique to implement modulation and demodulation functions makes it computationally more efficient. OFDM systems have gained an increased interest during the last years. It is used in the European digital broadcast radio system, as well as in wired environment such as asymmetric digital subscriber lines. This technique is used in Digital Subscriber Lines (DSL) to provide high bit rate over a twisted-pair of wires.

The major advantages of OFDM are its ability to convert a frequency selective fading channel into several nearly flat fading channels and high spectral efficiency. However, one of the main disadvantages of OFDM is its sensitivity against carrier frequency offset which causes attenuation and rotation of subcarriers, and Inter Carrier Interference (ICI). The undesired ICI degrades the performance of the system.

EVOLUTION OF OFDM

The evolution of OFDM can be divided into three parts. There are consists of Frequency Division Multiplexing (FDM), Multicarrier Communication (MC) and Orthogonal Frequency Division Multiplexing.

A. Frequency Division Multiplexing

Frequency Division Multiplexing (FDM) has been used for a long time to carry more than one signal over a telephone line. FDM is the concept of using different frequency channels to carry the information of different users. Each channel is identified by the center frequency of transmission. To ensure that the signal of one channel did not overlap with the signal from an adjacent one, some gap or guard band was left between different channels. Obviously, this guard band will lead to inefficiencies which were exaggerated in the early days since the lack of digital filtering is made it difficult to filter closely packed adjacent channels.

B. Multicarrier Communication

The concept of multicarrier (MC) communications uses a form of FDM technologies but only between a single data source and a single data receiver. As multicarrier communications was introduced, it enabled an increase in the overall capacity of communications, thereby increasing the overall throughput. Referring to MC as FDM, however, is somewhat misleading since the concept of multiplexing refers to the ability to add signals together. MC is actually the concept of splitting a signal into a number of signals, modulating each of these new signals over its own frequency channel, multiplexing these different frequency channels together in an FDM manner; feeding the received signal via a receiving antenna into a demultiplexer that feeds the different frequency channels to different receivers and combining the data output of the receivers to form the received signal.

C. Orthogonal Frequency Division Multiplexing

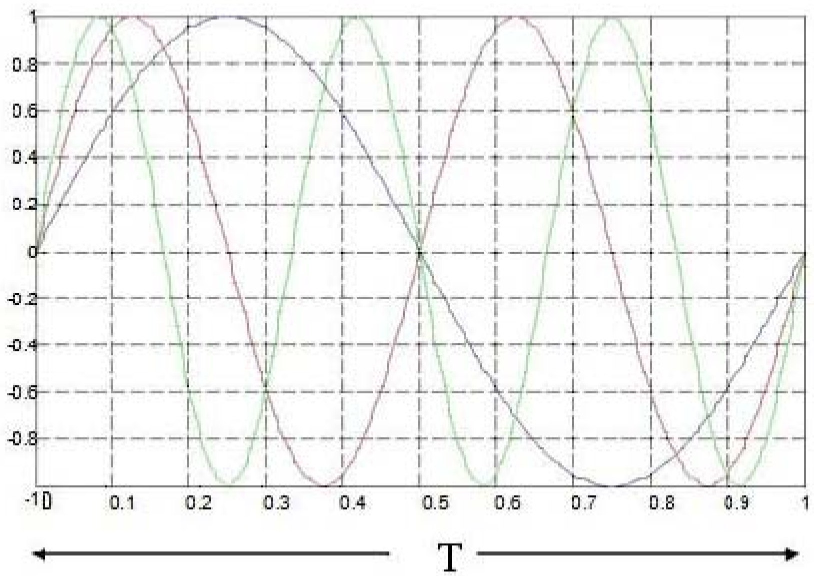
Orthogonal Frequency Division Multiplexing (OFDM) is simply defined as a form of multi-carrier modulation where the carrier spacing is carefully selected so that each sub-carrier is orthogonal to the other sub-carriers. Orthogonality can be achieved by carefully selecting the subcarrier frequencies. One of the ways is to select sub-carrier frequencies such that they are harmonics to each other.

D. Orthogonality

OFDM is simply defined as a form of multi-carrier modulation where the carrier spacing is carefully selected so that each sub carrier is orthogonal to the other sub carriers. Two signals are orthogonal if their dot product is zero. That is, if you take two signals multiply them together and if their integral over an interval is zero, then two signals are orthogonal in that interval. Orthogonality can be achieved by carefully selecting carrier spacing, such as letting the carrier spacing be equal to the reciprocal of the useful symbol period. As the sub carriers are orthogonal, the spectrum of each carrier has a null at the center frequency of each of the other carriers in the system.

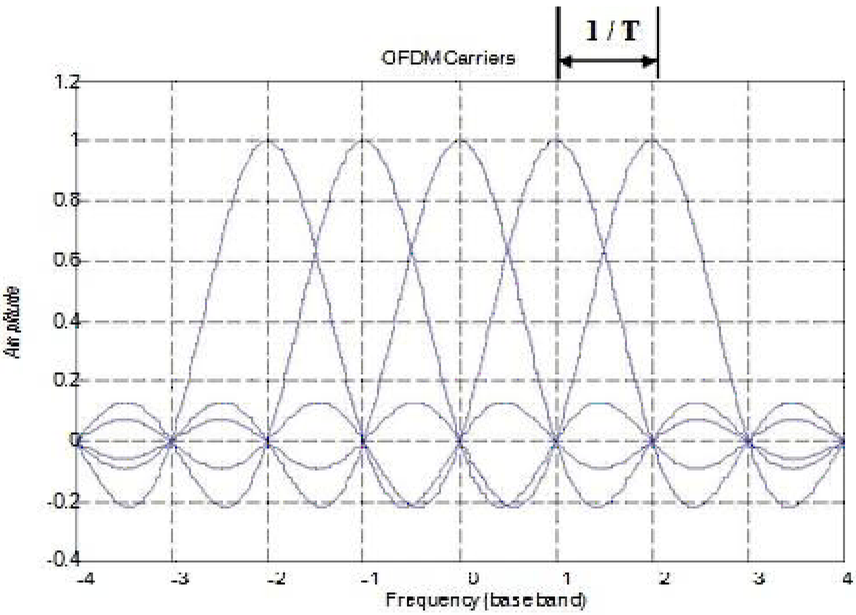
This results in no interference between the carriers. The signals are orthogonal if the integral value is zero over the interval [aa+T], where T is the symbol period. Since the carriers are orthogonal to each other the nulls of one carrier coincides with the peak of another sub carrier. As a result it is possible to extract the sub carrier of interest.

Figure 1: Frequency Spectrum of OFDM Transmission



OFDM transmits a large number of narrowband sub channels. The frequency range between carriers is carefully chosen in order to make them orthogonal each another. In fact, the carriers are separated by an interval of 1/T, where T represents the duration of an OFDM symbol.The frequency spectrum of an OFDM transmission is illustrated in Figure 1. The figure

Figure 2: Carrier Signals in an OFDM Transmission

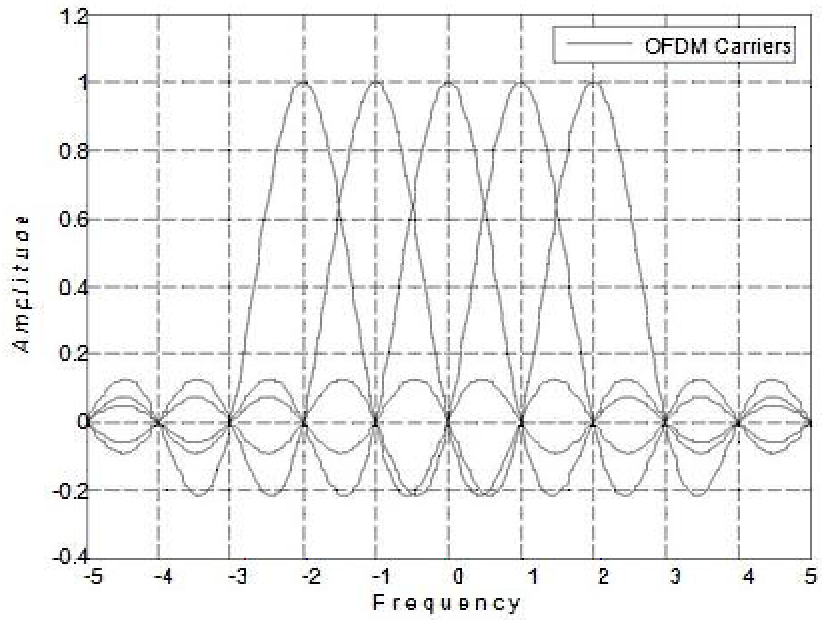


indicates the spectrum of carriers significantly over laps over the other carrier. This is contrary to the traditional FDM technique in which a guard band is provided between each carrier. Each sine of the frequency spectrum corresponds to a sinusoidal carrier modulated by a rectangular waveform representing the information symbol. One could easily notice that the frequency spectrum of one carrier exhibits zerocrossing at central frequencies corresponding to all other carriers. At these frequencies, the intercarrier interference is eliminated, although the individual spectra of subcarriers overlap. It is well known that orthogonal signals can be separated at the receiver by correlation techniques. The receiver acts as a bank of demodulators, translating each carrier down to baseband, the resulting signal then being integrated over a symbol period to recover the data. If the other carriers beat down to frequencies which, in the time domain means an integer number of cycles per symbol period (T), then the integration process results in a zero contribution from all these carriers. The waveforms of some of the carriers in an OFDM transmission are illustrated in Figure 2.

E. Principle of OFDM Transmission

As stated above OFDM is a multi-carrier modulation technology where every sub-carrier is orthogonal to each other. The "orthogonal" part of the OFDM name indicates that there is a precise mathematical relationship between the frequencies of the carriers in the system. It is possible to arrange the carriers in an OFDM Signal so that the sidebands of the individual carriers overlap and the signals can still be received without adjacent carriers interference. In order to do this the carriers must be mathematically orthogonal. Two signals are orthogonal if their dot product is zero. That is, if we take two signals multiply them together and if their integral over an interval is zero, then two signals are orthogonal in that interval. Since the carriers are all sine/ cosine wave, area under one period of a sine or a cosine wave is zero which is as shown below.

Figure 3: Carriers of OFDM Signal



If a sine wave of frequency m is multiplied by a sinusoid (sineor cosine) of a frequency n, then the product is given by $f(t)$= sinmwt*sinnwt where both m and n are integers. By simple trigonometric relationship, this is equal to a sum of two sinusoids of frequencies (n-m) and (n+m). Since these two components are each a sinusoid, the integral is equal to zero over one period. As the sub carriers are orthogonal, the spectrum of each carrier has a null at the center frequency of each of the other carriers in the system. This results in no interference between the carriers, allowing them to be spaced as close as theoretically possible. The orthogonality allows simultaneous transmission on a lot of sub-carriers in a tight frequency space without interference from each other. So, in the receiver side easily we can extract the individual subcarriers. But in traditional FDM systems overlapping of carriers are not possible, rather a guard band is provided between each carrier to avoid inter-carrier interference.

F. Intersymbol and Intercarrier Interference

In a multipath environment, a transmitted symbol takes different times to reach the receiver through different propagation paths. From the receivers point of view, the channel introduces time dispersion in which the duration of the received symbol is stretched. Extending the symbol duration causes the current received symbol to overlap previous received symbols and results in intersymbol interference. In OFDM, ISI usually refers to interference of an OFDM symbol by previous OFDM symbols. For a given system bandwidth the symbol rate for an OFDM signal is much lower than a single carrier transmission scheme. For example for a single carrier BPSK modulation, the symbol rate corresponds to the bit rate of the transmission. However for OFDM the system bandwidth is broken up into N subcarriers, resulting in a symbol rate that is N times lower than the single carrier transmission. This low symbol rate makes OFDM naturally resistant to effects of Inter-Symbol Interference caused by multipath propagation. Multipath propagation is caused by the radio transmission signal reflecting off objects in the propagation environment, such as walls, buildings, mountains, etc. These multiple signals arrive at the receiver at different times due to the transmission distances being different. This spreads the symbol boundaries causing energy leakage between them. In OFDM, the spectra of subcarriers overlap but remain orthogonal to each other. This means that at the maximum of each sub-carrier spectrum, all the spectra of other subcarriers are zero. The receiver samples data symbols on individual sub-carriers at the maximum points and demodulates them free from any interference from the other subcarriers. Interference caused by data symbols on adjacent sub-carriers is referred to inter carrier interference. The orthogonality of subcarriers can be viewed in either the time domain or in frequency domain. From the time domain perspective, each subcarrier is a sinusoid with an integer number of cycles within one FFT interval. From the frequency domain perspective, this corresponds to each subcarrier having the maximum value at its own center frequency and zero at the center frequency of each of the other subcarriers. The orthogonality of a subcarrier with respect to other subcarriers is lost if the subcarrier has nonzero spectral value at other subcarrier frequencies. From the time domain perspective, the corresponding sinusoid no longer has an integer number of cycles within the FFT interval. ICI occurs when the multipath channel varies over one OFDM symbol time. When this happens, the Doppler shift on each multipath component causes a frequency offset on the subcarriers, resulting in the loss of orthogonality among them. This situation can be viewed from the time domain perspective, in which the integer number of cycles for each subcarrier within the FFT interval of the current symbol is no longer maintained due to the phase transition introduced by the previous symbol. Finally, any offset between the subcarrier frequencies of the transmitter and receiver also introduces ICI to an OFDM symbol.

G. Guard Period

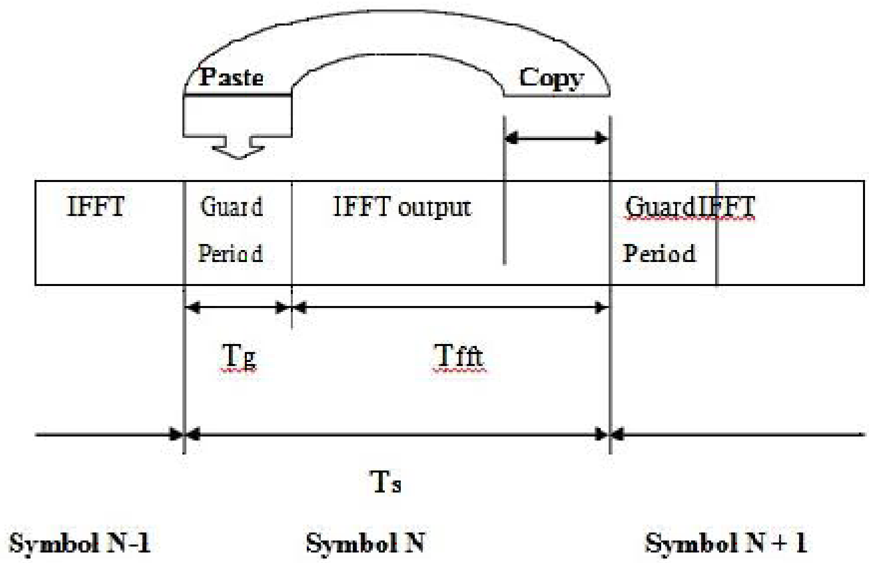
The effect of ISI on an OFDM signal can be further reduced by the addition of a guard period to the start of each symbol. This guard period is a cyclic copy that extends the length of the symbol waveform. Each subcarrier, in the data section of the symbol has an integer number of cycles. Because of this, placing copies of the symbol end-to-end results in a continuous signal, with no discontinuities at the joins. Thus by copying the end of a symbol and appending this to the start results in a longer symbol time. $TS=TG+TFFT$, where TS is the total length of the symbol in samples, TG is the length of theguard period in samples, and $TFFT$ is the size of the IFFT used to generate the OFDM signal. In addition to protecting the OFDM from ISI, the guard period also provides protection against time-offset errors in the receiver. A Guard time is introduced at the end of each OFDM symbol in form of cyclic prefix to prevent Inter Symbol Interference (ISI).

The Guard time is cyclically extended to avoid Inter-Carrier Interference (ICI) - integer number of cycles in the symbol interval.

H. Additive White Gaussian Noise Channel

Noise exists in all communications systems operating over an analog physical channel, such as radio. The main sources are thermal background noise, and electrical noise in the

Figure 4: Guard Period Insertion in OFDM



receiver amplifiers, and inter-cellular interference. In addition to this noise can also be generated internally to the communications system as a result of Inter-Symbol Interference (ISI), Inter-Carrier Interference (ICI), and Inter- Modulation Distortion (IMD). These sources of noise decrease the Signal to Noise Ratio (SNR), ultimately limiting the spectral efficiency of the system. Noise, in all its forms, is the main detrimental effect in most radio communication systems. It is therefore important to study the effects of noise on the communications error rate and some of the tradeoffs that exists between the level of noise and system spectral efficiency. Most types of noise present in radio communication systems can be modeled accurately using Additive White Gaussian Noise (AWGN). This noise has a uniform spectral density (making it white), and a Gaussian distribution in amplitude (this is also referred to as a normal distribution). Thermal and electrical noise from amplification, primarily have white Gaussian noise properties, allowing them to be modeled accurately with AWGN. Also most other noise sources have AWGN properties due to the transmission being OFDM. OFDM signals have a flat spectral density and a Gaussian amplitude distribution provided that the number of carriers is large (greater than about 20 subcarriers), because of this the inter-cellular interference from other OFDM systems have AWGN properties. For the same reason ICI, ISI also have AWGN properties for OFDM signals. In the study of communication systems, the classical (ideal) additive white Gaussian noise (AWGN) channel, with statistically independent Gaussian noise samples corrupting data samples free of intersymbol interference (ISI), is the usual starting point for understanding basic performance relationships. An AWGN channel adds white Gaussian noise to the signal that passes through it.

I. Advantages of OFDM

- Makes efficient use of the spectrum by allowing overlap.
- By dividing the channel into narrowband flat fading sub channels, OFDM is more resistant to frequency selective fading than single carrier systems are, i.e., robustness to frequency selective fading channels.
- Eliminates ISI through use of a cyclic prefix.
- Using adequate channel coding and interleaving one can recover symbols lost due to the frequency selectivity of the channel.
- Channel equalization becomes simpler than by using adaptive equalization techniques with single carrier systems.
- It is possible to use maximum likelihood decoding with reasonable complexity.
- OFDM is computationally efficient by using FFT techniques to implement the modulation and demodulation functions.
- Provides good protection against co channel interference and impulsive parasitic noise.
- Is less sensitive to sample timing offsets than single carrier systems.

J. Applications of OFDM

- Digital Audio Broadcasting..
- Digital Video Broadcasting.
- Used for wideband data communications over mobile radio channels such as
- High-bit-rate Digital Subscriber Lines at 1.6 Mbps.

- Asymmetric Digital Subscriber Lines up to 6 Mbps.
- Very-high-speed Digital Subscriber Lines at 100 Mbps.
- ADSL and broadband access via telephone network copper wires.
- Power line communication.
- Point-to-point and point-to-multipoint wireless applications.
- OFDM is under consideration for use in 4G Wireless systems.

BARCODE MODULATION

As the information technology industry continues to grow at a rapid rate, digital communications have become prevalent in every domain of life. The virtual world is ever expanding. However, a considerable portion of business, advertising, and logistics depends heavily on physical media for communication. Despite the prominence of digital devices and computers in the business world, paper continues to play a significant role. For this reason, methods of interfacing documents and objects with digital formats and virtual databases can significantly increase efficiencies and enhance communication. Perhaps the most recognizable of such methods is the barcode.Since their commercial debut in the 1960 s, barcodes have become essential to many industries and are now omnipresent in our world. A barcode is a machine-readable representation of information displayed on a surface. Generally, barcodes use dark markings on a light surface to create a high and low reflectance that can be converted into binary digits. However, several techniques have diverged from the traditional encoding methods by using color, as well as representations that are invisible to the human eye. Barcodes are read using optical scanners, or decoded from images using the required software. The original one-dimensional barcodes encode several characters into a linear series of bars. Because of their low data-density, these linear barcodes are used to simply link an item to an existing database when scanned. For this reason, they are termed license plate files. The Universal Product Code (UPC) is one such barcode that plays a crucial role in facilitating the trade of commercial items, such as groceries.The desire to encode more data into a small spatial region motivated several advancements in barcode technology. Two-dimensional barcodes were developed in the mid-eighties in order to encode all of the necessary information about an item into the barcode itself, as opposed to just its address in an existing database. Two-dimensional barcodes encode information along the vertical axis as well as the horizontal axis, while one-dimensional barcodes encode data in the horizontal direction only, with vertical redundancy. Several types of two dimensional barcode encoding schemes, called symbologies, have emerged over the past twenty years. Applications extend over several areas of business and government, including the labelling of electronics, health care equipment management, package tracking, as well as encoding information onto personal identification cards and passports. The data-densities achieved by some of today s symbologies are hundreds of times greater than those of the original linear barcodes.

There are trade-offs to consider when evaluating barcodes. A higher data-density generally comes at the cost of a higher decoding complexity as well as higher resolution printing and scanning requirements. Different symbologies of varying densities can be valuable for different applications. For this reason, barcodes are often designed with a particular application in mind. For example, the ArrayTag barcode is optimized to be read in variable lighting or at a distance and can be read from up to 50 m away. Other barcodes have been designed to blend into pictures or even be invisible to the human eye. In general, barcode symbologies attempt to incorporate powerful error-correction coding to increase the robustness of the code. This allows them to be decoded correctly in the presence of distortion and noise, which will inevitably arise from a variety of sources.

Although barcodes are already being used extensively in many fields, there are still limitless possibilities. Mobile ticketing and couponing solutions are currently being implemented through barcodes that can be captured and decoded by cell phones equipped with a digital camera. Recently, the drive to advertise corporate messages to consumers across every possible medium has prompted a new application of barcodes: advertising through barcodes scanned by cell phone cameras.

A. Background

Two-dimensional barcodes have proven to be an effective method of labeling where central databases are infeasible and physical surface area is limited. The potential roles of these 2-D barcodes have certainly not been exhausted and there are several promising applications emerging with the everexpanding digital world.In April, 2007, BBC News presented the High Capacity Color Barcode (HCCB) for cell phone scanning, and indicated that the symbol would appear on DVDs within a year. Fujitsu recently introduced an encoding technology that embeds data invisibly into a picture to be decoded specifically by mobile phones. This was in response to aversion toward the obtrusive appearance of Quick Response symbols on advertisements. QR Code and Data Matrix decoders for cell phones are increasing in popularity, and a high percentage of Japanese people have used QR Codes for a cell phone application.In order to capitalize on the barcode possibilities presented through personal wireless devices, such as cell phones and blackberries, many considerations must be made. Al-though a high data-density is appealing to corporations looking to advertise, the user experience must be taken into account. Cell phone processor sizes must be considered, as well as the distortion presented by capturing the barcode with the cell phone camera. In order to create a barcode system that is practical for use with a cell phone, it is imperative that the probability of decoding failure is low so that the consumer finds it easy and enjoyable to use.

Some recent reviews of barcode scanning and decoding with cell phones have been dis-appointing. It might be worth considering camera phone specifics when designing a symbology, as opposed to forcing an ill-suited symbology into the desired application. Although the HCCB shows promise in this domain and claims to be suited to camera phone applications, its data-density is inferior to some other symbologies despite its use of eight different colors.

Perhaps a combination of spatially bandwidth-efficient coding, the use of colour, and consideration to cell phonespecific applications could yield a superior code for this particular function. Investigations into this area are worthwhile, especially since the processing power of cell phones has been increasing, and will continue to do so. There are other applications and potential symbology improvements. If 2-D barcode systems are to be adopted by industries to provide a simple and convenient interface between the paper and digital domains for their consumers, aesthetics will play a role. The ideal barcode is as flexible in size, shape and colour as possible. This will allow it to blend discreetly into packaging, advertisements, or company logos. Fixed architectures, fiducials, and other position locator markings lessen the appeal of most current symbologies. There are many possibilities for 2-D barcodes in the near future. A barcode designed judiciously to have a high data-density, a reasonable decoding complexity, a flexible size and appearance, and sufficient robustness to noise and distortion has the potential to take barcodes from their specialized functions in industry to a universally employed interface between printed and digital domains. The design of a datadense, robust, flexible, and easily decodable 2-D barcode will allow barcode systems to penetrate new markets and succeed in new applications. Given the technology available, there are no obvious obstacles to achieving such a code, and therefore the R&D process should not be delayed. Before delving into a new barcode design, it is worth looking at current symbologies and identifying their features and limitations.

B. Symbology Background

The first barcode patent was issued to Joseph Woodland and Bernard Silver in 1952. Since their major debut in grocery stores as the distinguished Universal Product Code (UPC), barcodes have evolved significantly and are prominent in our world today.Barcode symbology refers to the mapping between the message and the barcode. The first barcodes employed one-dimensional symbologies, meaning that encoding is done in only one spatial dimension (along one axis). Two-dimensional symbologies revolutionized barcode technology by also encoding data in the second dimension of the surface. Today, further advancements are being made to take 2D symbologies away from their traditional encoding schemes in order to increase data-density and enhance performance.

C. One-Dimensional Linear Symbologies

There are several distinguished linear barcodes in addition to the ubiquitous UPC, such as the well-known International Standard Book Number (ISBN) used to uniquely identify each edition of every published book and book-like product. One dimensional barcodes encode data along the horizontal axis through the use of bars and spaces. The specifications include the actual encoding of digits as well as the marking of bars and spaces. One-dimensional barcodes can be categorized as being discrete or continuous, as well as having two bar widths or many bar widths .Continuous symbologies have characters adjoined, with one character ending in a bar and the next beginning in a space, or vice versa. Discrete symbologies use characters that begin and end with bars. The inter-character space is generally ignored.Two-width symbologies have one designated narrow bar width and one wide bar width. The widths are specified in relative quantities, usually with the wide width being two or three times greater than the narrow, so there is no dependency on the absolute measurements. Many width symbologies use bars and spaces that are all multiples of a specified width, called the module of the code. One-dimensional barcodes are read using optical scanners, often called barcode readers. The scanners are either hand-held or fixed-mount. Handheld scanners are used forstationary items, while fixed-mount scanners require that the item be physically passed by the scanner. This is usually done by hand in retail applications and by conveyor belt in industrial applications. In general, both handheld and fixed-mount scanners employ either a laser or a CCD (charged-coupled device) imager. Laser scanners were the first type of barcode reader to be utilized. They use a laser diode to create an infrared beam which is spread in an arc parallel to the barcode by a rapidly rotating mirror. A photodiode is then employed to measure the intensity of the light reflected back from the barcode surface. More sophisticated scanners often use revolving polygons or oscillating mirrors to enhance performance. The optimal scanning distance for laser scanners is typically 6-12 inches, but can range up to 35 feet for certain reflective barcodes.CCD scanners use a stationary flood of light, usually LEDs (light emitting diodes), to reflect the symbol image back onto an array of photo sensors. The optimal scanning distance usually ranges from physical contact to six inches. CCD scanners are generally less expensive than laser scanners and have a durability advantage, primarily because they contain no moving parts. As a result, CCD imagers are surpassing laser scanners as the preferred technology for reading linear barcodes. Linear barcodes are used extensively in libraries, grocery stores, and almost all commercial environments. Their role of efficiently linking an item to its location in a database is expected to continue despite significant advancements in barcode symbologies. Higher density, two-dimensional barcodes are generally unnecessary for applications where linear barcodes currently dominate. However, RFID (Radio Frequency Identification) tags may offer advantages over barcodes to manufacturers in such domains. If linear barcode systems are replaced in retail venues, RFID tags would probably be a more appropriate substitute than two-dimensional barcodes. RFID tags (also known as transponders) do not require a direct line of sight for reading and may be read through hard material such as book covers or other packaging material. Each tag can uniquely identifythe object to which it is attached, even if that object is one of a multitude of identicalitems. However, RFID tags are more costly than barcodes and raise privacy concerns.

Linear barcodes play a well-established role in industry that is not currently threatened by higher density barcodes. However, there are a multitude of other applications for whichlinear barcodes are insufficient because a central database is simply not feasible, or surface area is limited.

D. Two-Dimensional Barcodes

In order to meet the demand for a higher data-density barcode system, two-dimensional symbologies were developed. The ability to encode a portable database in a limited spatial area has allowed barcodes to prevail in applications originally prohibited by the linear symbology. The health care industry benefited by being able to label unitdose packages, with the labelling of other medicines and tools to follow. The electronics industry also began using two dimensional barcodes to label small parts. Several other industries have followed with a variety of applications. The two-dimensional concept was initiated in 1984 when the Automotive Industry Action Group introduced a standard for shipping and identification labels which consisted of four Code 39 barcodes (a linear symbology) stacked on top of each other. Then in 1988, Code 49 was introduced by the Intermec Corporation to become the first truly two-dimensional barcode on the market. Like the stacked Code 39 barcode, Code 49 also used the idea of layering linear barcodes along the vertical axis. Several different two-dimensional barcodes have been introduced since Code 49. For the most part, they can be categorized as having either a stacked or a matrix symbology. However, many barcodes do not fit into either of these categories, particularly those most recently developed.

E. Stacked Symbologies

A stacked symbology is the most primitive of all possible two-dimensional schemes, and perhaps the most intuitive when starting with a linear barcode system. Several linear barcodes of a given symbology are truncated and then layered vertically to create the stacked symbology. A much higher data-density than the linear code is achieved at the price of less vertical redundancy.Stacked barcodes were optimized to be read using a laser scanner in which the laserbeam is swept several times horizontally as it makes its way down the barcode vertically.Certain symbologies, such as Codablock, allow the barcode to be read by a linear barcodereader (a standard moving beam laser) with very little modification.CCD imagers are also used to read stacked symbology barcodes. The scanning requirements and constraints are specific to the code symbology. Many stacked symbology barcodes continue to be used in various industries, such as Code 16K and Coda block in the health care industry, and PDF 417 in transportation, personal identification and inventory management domains.

F. Matrix Symbologies

Matrix codes encode data through the positioning of equal-dimension spots within a matrix (dark spots on a light surface). The symbology usually includes patterns that indicate the orientation of the barcode, and often convey the size and printing density of the barcode as well. CCD imagers and camera capture devices are used to scan matrix barcodes.

There are several matrix symbologies in the public domain, as well as many proprietary ones. United Parcel Service (UPS) developed its own well-known matrix symbology, Maxi-code (or UPSCode), in 1992 to label and track packages. Maxicode is made up of interlocking hexagons and includes a central bulls-eye marking to aid in acquisition. The code requires a very high resolution printer, but can be read by a CCD scanner or cam-era when even up to 25% of the symbol is destroyed.Matrix symbologies are often created with specific practical constraints in mind. For instance, the Aztec Code was designed to be easily printed and decoded, the QR Code was designed for rapid reading using CCD array cameras, and the Data Matrix was created to achieve a very high data-density. As a result, matrix symbologies tend to be more application-specific than stacked symbologies.

Matrix symbologies generally offer many advantages over stacked symbologies, primarily because they use space more efficiently and scatter redundancy to increase robustness. However, the drawbacks of matrix codes are prompting the creation of symbologies that diverge from the traditional matrix model. Although most new symbologies do not fit either the stacked or matrix definitions, many do resemble matrix codes in some way, and often employ many of the same concepts.

G. Other Two-Dimensional Symbologies

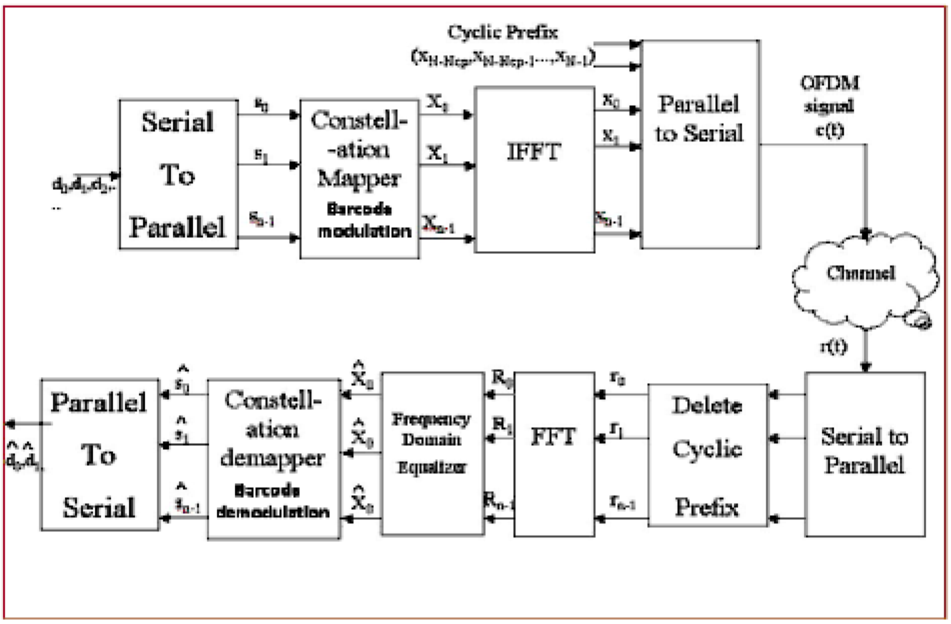
Several 2-D barcodes cannot be categorized as having either a stacked or a matrix symbology. DataGlyphs, for instance, are made up of forward and backward slashes (= and n), representing binary 0 s and 1 s respectively.

INTACTA.CODE is a propriety code that converts binary files and software into a very high-density machine readable symbol of scattered dots. Advancements in computer imaging techniques and devices have made colored barcodes more feasible for a variety of applications. As a result, some barcodes use colour to increase data-density, such as the HCCB (High Capacity Color Barcode), the Ultracode and the Hue Code. The newest barcode symbologies offer more unique features and are difficult to categorize. Developments continue as demands on current barcode systems grow and new barcode applications emerge. There are advantages and drawbacks to each barcode design, and symbologies are usually designed for specific requirements and constraints. There has been significant progress in recent years, and development is expected to continue in the barcode symbology domain.

SYSTEM ARCHITECTURE

Barcodes are of great relevance for use in wireless data transmission between electronic devices. In internet and telecommunication the OFDM has the highest priority to be used in data transmission. So, we design and implement a OFDM system with Barcode modulation. Any data from a PC can be transferred to a second PC through a series of images using barcode modulation in OFDM. This work provides the validation and implementation of OFDM Transceiver on FPGA which is completely digital, and the whole work is done using VHDL language. Software tools and hardware used in the implementation are MATLAB, Xilinx ISE and Spartan 3E FPGA. The transmitter section

Figure 5: Proposed System Architecture



converts digital data to be transmitted, into a mapping of subcarrier amplitude and phase. It then transforms this spectral representation of the data into the time domain using an Inverse Discrete Fourier Transform. The Inverse Fast Fourier Transform performs the same operation, except that it is much more computationally efficiency and so is used in all practical systems. In order to transmit the OFDM signal the calculated time domain signal is then mixed up to the required frequency.

The receiver performs the reverse operation of the transmitter, mixing the RF signal to base band for processing, then using a Fast Fourier Transform (FFT) to analyze the signal in the frequency domain. The amplitude and phase of the subcarriers is then picked out and converted back to digital data. The IFFT and the FFT are complementary function and the most appropriate term depends on whether the signal is being received or generated. In cases where the signal is independent of this distinction then the term FFT and IFFT is used interchangeably.

The high data rate serial input bit stream is fed into serial to parallel converter to get low data rate output parallel bit stream. Input bit stream is taken as binary data. The low data rate parallel bit stream is modulated in Signal Mapper. The modulated data are served as input to inverse fast Fourier transform so that each subcarrier is assigned with a specific frequency. The frequencies selected are orthogonal frequencies. In this block, orthogonality in subcarriers is introduced. In IFFT, the frequency domain OFDM symbols are converted into time domain OFDM symbols. Guard interval is introduced in each OFDM symbol to eliminate inter symbol interference (ISI). All the OFDM symbols are taken as input to parallel to serial data. These OFDM symbols constitute a frame. A number of frames can be regarded as one OFDM signal. This OFDM signal is allowed to pass through digital to analog converter (DAC). In DAC the OFDM signal is fed to RF power amplifier for transmission. Then the signal is allowed to pass through additive white Gaussian noise channel (AWGN channel). At the receiver part, the received OFDM signal is fed to analog to digital converter (ADC) and is taken as input to serial to parallel converter. In these parallel OFDM symbols, Guard interval is removed and it is allowed to pass through Fast Fourier transform. Here the time domain OFDM symbols are converted into frequency domain. After this it is fed into Signal Demapper for demodulation purpose. And finally the low data rate parallel bit stream is converted into high data rate serial bit stream which is in form of binary.

A. Signal Mapping

A large number of modulation schemes are available allowing the number of bits transmitted per carrier per symbol to be varied. Digital data is transferred in an OFDM link by using a modulation scheme on each subcarrier. A modulation scheme is a mapping of data words to a real (In phase) and imaginary (Quadrature) constellation, also known as an IQ constellation. For example 256-QAM (Quadrature Amplitude Modulation) has 256 IQ points in the constellation constructed in a square with 16 evenly spaced columns in the real axis and 16 rows in the imaginary axis.

The number of bits that can be transferred using a single symbol corresponds to log2(M), where M is the number of points in the constellation, thus 256-QAM transfers 8 bits per symbol. Increasing the number of points in the constellation does not change the bandwidth of the transmission, thus using a modulation scheme with a large number of constellation points, allows for improved spectral efficiency. For example 256-QAM has a spectral efficiency of 8 b/s/Hz, compared with only 1 b/s/Hz for BPSK. However, the greater the number of points in the modulation constellation, the harder they are to resolve at the receiver.

B. Serial to Parallel and Parallel to Serial Conversion

Data to be transmitted is typically in the form of a serial data stream. In OFDM, each symbol transmits a number of bits and so a serial to parallel conversion stage is needed to convert the input serial bit stream to the data to be transmitted in each OFDM symbol.

The data allocated to each symbol depends on the modulation scheme used and the number of subcarriers. At the receiver the reverse process takes place, with the data from the subcarriers being converted back to the original serial data stream.

Figure 6: Serial to Parallel Conversion

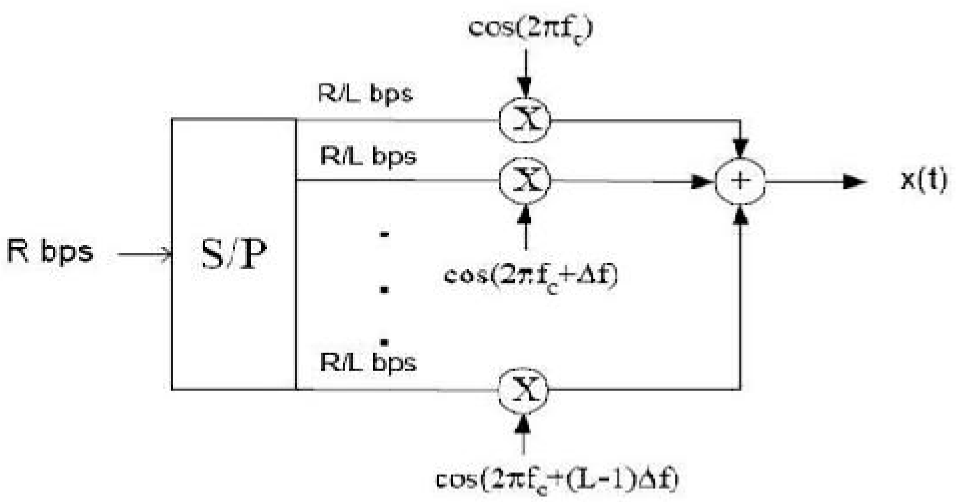
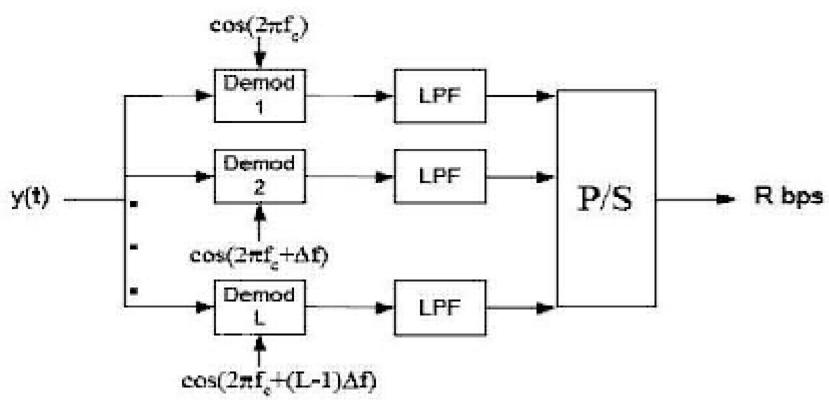


Figure 7: Parallel to Serial Conversion



C. Frequency to Time Domain Conversion

The OFDM message is generated in the complex baseband. Each symbol is modulated onto the corresponding subcarrier using variants of phase shift keying or different forms of quadrature amplitude modulation (QAM). The data symbols are converted from serial to parallel before data transmission. The frequency spacing between adjacent subcarriers is Nπ/2, where N is the number of subcarriers. This can be achieved by using the inverse discrete Fourier transform, easily implemented as the inverse fast Fourier transform operation. As a result, the OFDM symbol generated for an N-subcarrier system translates into N samples, with the ith sample. At the receiver, the OFDM message goes through the exact opposite operation in the Fast Fourier Transform (FFT) to take the corrupted symbols from a time domain form into the frequency domain. In practice, the baseband OFDM receiver performs the FFT of the receive message to recover the information that was originally sent.

SOFTWARE TOOL

A. Mathematical Channel Model

In order to develop and optimize a barcode for a particular channel, a simulation environ-ment is desirable. To assess performance and adjust the barcode design, simulations allow for a more iterative and efficient design and optimization process. Field tests will ultimately determine the success of a barcode, but only after a significant amount of adjusting and optimizing has been performed to design the barcode appropriately.

MATLAB, which stands for Matrix Laboratory, is a high performance array-oriented language for technical computing. It is complemented by application-specific solutions called tool boxes, one of which is the Image Processing Toolbox. Because MATLAB aims to facilitate matrix calculations and offers a wide range of image-specific functions, it is a natural choice for the simulation environment.

To achieve the desired channel simulation, a MATLAB function was developed. It accepts a barcode (or other) image as input and carries out each of the distortion functions before adding Gaussian noise to the image. The output of the MATLAB function is a distorted and noisy version of the image (in RGB format)

All stages of the simulator store the image in unsigned 8-bit integer RGB format unless otherwise specified. This means all three colors per pixel take on integer values in the range. If the input image is of a different format, it is converted to uint RGB before simulation commences. Input images should exhibit 4:3 aspect ratios for a 4:3 aspect ratio output.

B. Point Spread Function

The Point spread function is the channel impulse response, describing the response of an imaging system to a point source. The wireless optical communication channel can be described as a two-dimensional low-pass filter. To gain an understanding of this low-pass characteristic and the relationships between optics and communication theory, an overview of Fourier Optics and the underlying mathematical Fourier analysis is required.

C. Diffraction

Fourier Optics is based on the plane wave spectrum representation of optical fields, which is analogous to Fourier analysis of electrical signalsThe bandwidth in electrical signals relates to the difference between the highest and lowest frequencies present in the spectrum of the signal. For optical systems, spatial bandwidth is a measure of how far a plane wave is tilted away from the optic axis. It takes more frequency bandwidth to produce a short pulse in an electrical circuit, and more spatial bandwidth to produce a sharp spot in an optical system.

D. Mutual Information Calculations

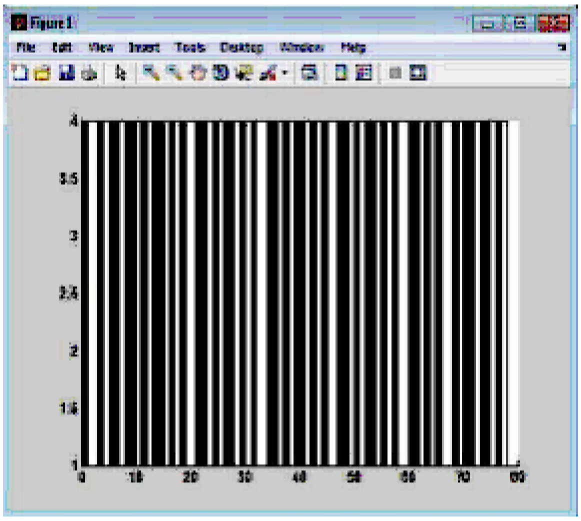
In order to design a near-optimal symbology for the camera phone channel, the right processing and encoding techniques must be established. In theory, with a strong mathematical model of the channel, simulation is unnecessary. However, to develop an SDMT approach to barcode encoding, the mathematical model must also describe the channel in the frequency domain. Although the linear components of the camera phone channel are well defined in the frequency domain, some nonlinear components, such as perspective projection, are not. This means that simulation is the only method of studying the effects of different processing techniques and measuring the overall mutual information.

Before an encoding method can be designed, a mathematical model of the channel in the frequency domain, as well as the overall channel capacity, should be estimated. This was accomplished through mutual information calculations, as well as noise analysis, in each of the encoded frequency bins. Mutual information calculations are central to the design process for the barcode. Therefore, the experimental setup was carefully designed to achieve accurate measurements for mutual information and capacity.

EXPERIMENTAL RESULTS

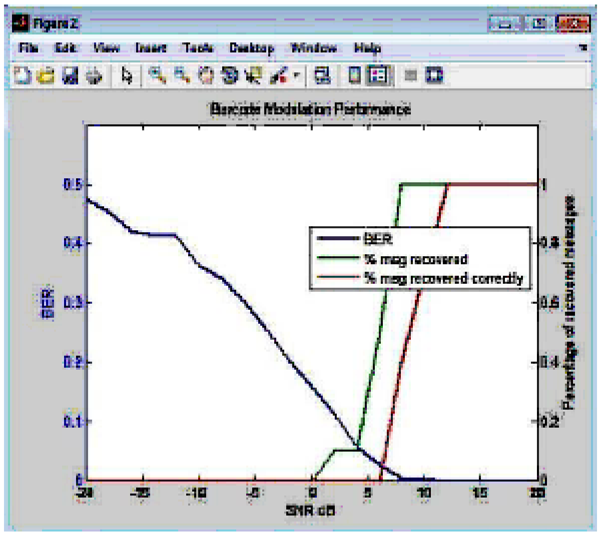
The simulation results of the OFDM method with barcode modulation is shown in the Figure 8.

Figure 8: Simulation Results



The bit error ratio analysis of the barcode modulation shown in Figure 9.

Figure 9: Ber Analysis



CONCLUSION AND FUTURE WORK

The project implemented a complete BER test inside the OFDM transmitter with barcode modulation and demodulation and thus reduces a bit error rate and increased the performance of the system. The result analysis proves that the combined barcode modulation technique provide high data recovery. In this project, different problems of OFDM system have been considered and suitable solutions have been provided. Following are the works that may be considered as a future scope in this direction. The channel estimation is an area which required a lot of attention and improper channel estimation degrades the performance of system.in this work, it is assumed that channel is estimated perfectly. Hence one can evaluate the performance of proposed work with different channel estimation method. The algorithm of timing offset channel estimation can be extended for channel estimation in OFDM system. The windowing elf cancellation method of ICI reduction can be clubbed with ICI cancellation method.

REFERENCES

1. Belussi L F F and Hirata N S T (2013), “Fast component-based QR code detection in arbitrarily acquired images,” *J. Math. Imag. Vis.,* Vol. 45, No. 3, pp. 277–292.
2. Bruckstein A, Gorman L O, and Orlitsky A (1998), “Design of shapes for precise image registration,” *IEEE Trans. Inf. Theory,* Vol. 44, No. 7, pp. 3156–3162, Nov. 1998.
3. Coleri S, Ergen M, Puri A, and Bahai A (2002), “Channel estimation techniques based on pilot arrangement in OFDM systems,” *IEEE Trans.Broadcast.*, Vol. 48, No. 3, pp. 223–229.
4. Kato H and Tan K (2007), “Pervasive 2d barcodes for camera phone applications,” *Pervasive Comput.,* Vol. 6, No. 4, pp. 76-85.
5. Kuzdeba S, Wyglinski A M and Hombs B (2013), “Prototype implementation of a visual communication system employing video imagery,” in Proc. CCNC, pp. 184–189.
6. Lin J A and Fuh C S (2013), “2D barcode image decoding,” in *Mathematical Problems in Engineering. New York,* USA: Hindawi PublishingCorp.
7. Liu X, Doermann D and Li H (2008), “Vcode-pervasive data transfer using video barcode,” *IEEE Trans. Multimedia*, Vol. 10, No. 3, pp. 361–371.
8. Memeti J, Santos F, Waldburger M, and Stiller B (2013), “Data transfer using a camera and a three-dimensional code,” *Praxis der Informationsverarbeitungund Kommunikation,* Vol. 36, No. 1, pp. 31–37.
9. Mondal M and Armstrong J (2012), “Impact of linear misalignment on a spatial OFDM based pixelated system,” in Proc. 18th Asia-Pacific Conf.Commun., Oct., pp. 617–622.
10. Morelli M and Mengali U (2001), “A comparison of pilot-aided channel estimation methods for OFDM systems,” *IEEE Trans. Signal Process.*, Vol. 49, No. 12, pp. 3065–3073.
11. Morrison R, Cimini L, and Wilson S (2001), “On the use of a cyclic extension in OFDM,” in Proc. 54th IEEE Veh. Technol. Conf., 2001, Vol. 2, pp. 664–668.
12. Pei C, Zhang Z and Zhang S (2013), “Softoc: Real-Time Projector-Wall camera Communication System,” In Proc. ICCE, Jan. 2013, Pp.100–101.
13. Perli S D, Ahmed N and Katabi D (2010), “Pixnet: Interference-free wireless links using LCD-camera pairs,” in Proc. MobiCom, pp. 137–148.

14. Sathananthan K and Tellambura C (2001), "Probability of error calculation of OFDM systems with frequency offset," *IEEE Trans. Commun.,* Vol. 49, No. 11, pp. 1884-1888.

15. Woodland N J and Silver B (1952), "Classifying apparatus and method," US Patent 2 612 994, Oct. 7.

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