Barcode Modulation using DPSK OFDM in Mobile Phones

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Abstract- *Nowadays we are using 2-D barcodes on any product which contains some information or we can say data. The performance of 2-D barcodes we are going to check in handheld electronic devices such as mobile phones. We transmit the data in wireless communication to a mobile phone through images on LCD and that data is acquired as well decoded for further process by second mobile phone. In this project we considered new approach for 2-D barcodes and its performance is compared with other standard methods.*

In this project we used OFDM (orthogonal frequency division multiplexing) with DPSK (Differential Phase Shift Keying) over adjacent frequency domain elements. The main of new approach is to establish a system that performs very well in some camera movement, picture blur and leakage of the pixel.

Keywords- Orthogonal frequency-division multiplexing (OFDM), Differential phase shift keying (DPSK), wireless data transmission, Barcodes (2-D)

I. INTRODUCTION

BARCODES have played a great role in facilitating numerous identification processes since their invention in 1952. In fact barcode is a simple and cost-effective method of storing machine readable digital data on paper or product packages. As pressing needs to transfer even more data faster and with high reliability have emerged, there have been many improvements that were made on the original barcode design. Invention of two dimensional (2D) or matrix barcodes opened a new front for these cost-effective codes and their application in more complex data transfer scenarios like storing contact information, URLs among other things, in which QR codes have become increasingly popular. A comparison of 2D barcode performance in camera phone applications can be found. Much of the efforts in matrix barcode development have been dedicated to barcodes displayed on a piece of paper as that is the way they are normally used. With the replacement of books with tablets and e-Book readers one could contemplate that replacement of the paper with LCD may open another promising front for broader applications of 2D barcodes as a mean of data transfer. Moreover unlike the static paper, the LCD may display time-varying barcodes for the eventual transfer of streams of data to the receiving electronic device(s) as depicted.

This idea has been implemented where transmission of data between two cell phones through a series of 2D QR codes is studied, achieving bit rates of fewer than 10 kbps for state of the art mobile devices. Later the idea was further developed in which a computer monitor and a digital camera are used for transmission and reception with bit rates of more than 14 Mbps achieved in docked transmitter and receiver conditions over distances of up to 4 meters. However, this rate drops to just over 2 Mbps when the distance is increased to 14 meters. The superior performance of the later implementation is achieved using a more effective modulation and coding scheme for mitigation of image blur and pixel to pixel light leakage. The general idea is to use the inverse Fourier transform (IFT) of data like OFDM to modulate LCD pixels. While image blur and light leakage greatly reduce the performance of QR decoders they have a limited effect on OFDM modulation. Furthermore their performance degradation is confined to known portions of the decoded data. This prior knowledge on non-uniform error probability may be used for adaptive error correction coding based on data region. There is an increasing interest in design and implementation of LCD-Camera based communication systems as indicated. This would require additional investigations in determining optimal modulation and demodulation schemes for this type of innovative communications medium.

Current study extends this idea through additional modifications on the modulation scheme in a way to mitigate LCD-camera relative movements during the capture of a single frame, which results in motion blur distortion on the captured images. This kind of distortion as would be detailed later severely degrades the performance of Quadrature Phase Shift Keying (QPSK) modulated OFDM signals. The required movement tolerance is achieved by putting data in phase differences of adjacent frequency components leading to a DPSK-OFDM scheme which would be called simply the DPSK method throughout this study. Observing that any phase distortion due to motion blur would affect neighboring frequency components negligibly, data may be transmitted reliably even in the vicinity of high LCD, camera relative motion.

A diagram of the system envisioned. This method also eliminates the channel estimation requirements resulting in lower processing power. To maximize data transmission rate, one should consider extracting maximum data from a single image shown on an LCD and then increase the rate at which consecutive frames will be decoded. In consideration of this issue, any method that is introduced should efficiently utilize the available bandwidth considering motion distortions. Previous studies have demonstrated the feasibility of such systems and have addressed the effects of single distortions like linear misalignment, defocus blur and vignetting on the modulation methods under consideration, but they have not provided a comparative assessment of these systems in a controlled environment.

Moreover, no comparisons were made in case of LCD camera motions which greatly affect the performance of the system in applications that involve handheld camera-phone receivers.

As a consequence, this study introduces DPSK-OFDM as a means of mitigating LCD camera motion distortions.

Sets a series of simulations based on mathematical modeling for blur and motion on the received images in a way that the distortion would be the same for PAM (Pulse Amplitude Modulation), QPSK-OFDM and DPSK-OFDM modulations.

The regardless of other parameters affecting the performance of such practical systems.

As a result, a reliable comparison can be made between these major modulation methods.

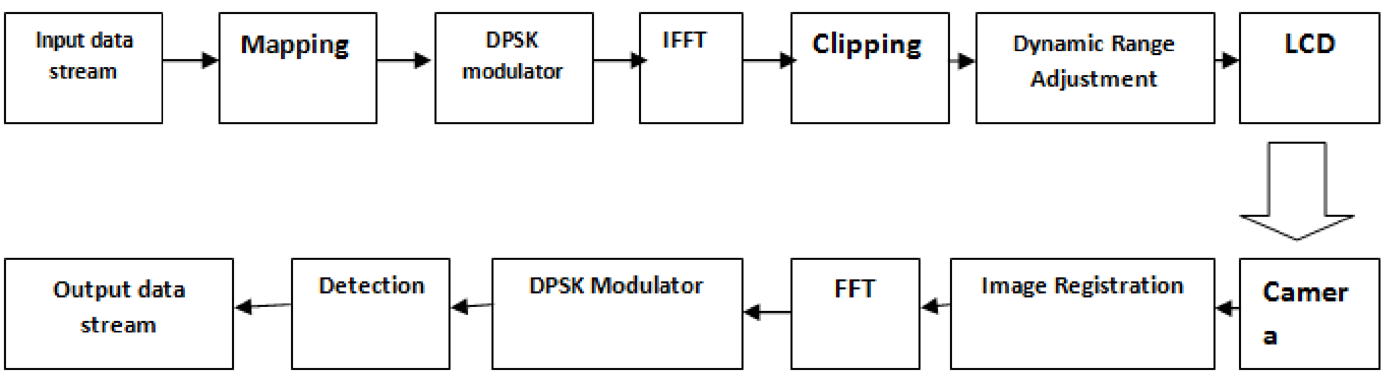

Fig1: Diagram of the algorithm used for data transfer, Data stream is supposed to include source coding and error correction coding

II. BARCODE

A barcode is an optical machine-readable representation of data relating to the object to which it is attached. Originally barcodes systematically represented data by varying the width and spacing of parallel lines, and may be referred to as linear or one-dimensional. Later they evolved into rectangles, dots, hexagons and other geometric patterns in two dimensions (2D). Although 2D systems use a variety of symbols, they are generally referred to as barcodes as well. Barcodes originally were scanned by special optical scanners called barcode readers. The different regions of barcode are as follows:

Figl: Barcode structure

A. Structure of Barcode

Quiet Zone: The minimum required space for bar code scan-ability, preceding the Start Character of a bar code symbol. The quiet zone should be free from any printing and be the same color and reflectance as the background of bar code symbol. The Quiet Zone should be ten times the width of the narrowest element in the bar code, or 0.25 inch minimum, also known as Clear Area.

Start Code: Indicates the start of the barcode. These are special bar code characters & they signify the start of data to the scanner/reader. Start characters are usually stripped off and not transmitted to the host.

Check Digit: Check digit (not always present) is a mathematical sum that is used to verify the accuracy of the other elements of the barcode. It is the extra digit added at the end of a bar code to allow the scanner to confirm that it read the bar code correctly. It is typically stripped from the data and not transmitted to the host. Stop Code: Indicates the stopping point of the barcode. These characters signify the end of data to the scanner/reader. They are also stripped-off and not transmitted to the host.

B. Working of Barcode

Laser beam is incident on a mirror/prism which is then directed on the barcode from left to right. The dark bars of barcode absorb the incident light but the light is reflected by light spaces. Photodiode measures the reflected light and gives out electrical signal. The analog electrical signal is then converted into digital one. And corresponding barcode is read.

Fig2: Working of Barcode

III. QR CODE

Bar codes have become widely popular because of their reading speed, accuracy, and superior functionality characteristics. As bar codes became popular and their convenience universally recognized, the market began to call for codes capable of storing more information, more character types, and that could be printed in a smaller space. As a result, various efforts were made to increase the amount of information stored by bar codes, such as increasing the number of bar code digits or layout multiple bar codes. However, these improvements also caused problems such as enlarging the bar code area, complicating reading operations, and increasing printing cost. 2D Code emerged in response to these needs and problems. The creator intended the code to allow its contents to be decoded at high speed. Unlike the older one-dimensional barcode that was designed to be mechanically scanned by a narrow beam of light to extract data, the QR code is detected as a 2-dimensional digital image by a semiconductor image sensor and is then digitally analyzed by a programmed processor. The processor locates the three distinctive squares at the corners of the image, and uses a smaller square near the fourth corner to normalize the image for size, orientation, and angle of viewing. The small dots are then converted to binary numbers and their validity checked with an error-correcting code. The QR (Quick Response) Code is a two-dimensional (2-D) matrix code that belongs to a larger set of machine readable codes, all of which are often referred to as barcodes, regardless of whether they are made up of bars, squares or other shaped elements. Compared with 1-D codes, 2-D codes can hold a larger amount of data in a smaller space, and compared with other 2-D codes, the QR Code can hold much more data still.

Fig 3: QR code and Barcode

A. Versions of QR-Code

QR codes are divided in various categories according to information capacity they hold.


Version 1(21*21) content ‘version1’ ‘version2’ Version 2(25*25) content


Version 3(29*29) content: ’version3 ‘version4’ Version 4(33*33) content:

QR-code’ QR-code’

. Fig4. Versions of QR Code

Table 1: Comparison of QR code and Barcode

QR Code	Barcode
UPTO 7089 numeric digits	10-20 digits
40 digit Numeric (approx 5 mm 5mm)	10 digit Numeric (approx 50 mm 20 mm)
Supports 360d reading	Horizontal reading

QR code is used for Advertising, Business cards, Social networking, Branding, registration.

II. PROPOSED METHOD

I. DATA TRANSFER CAPACITY

There are many factors affecting the amount of data that can be extracted from a particular LCD, some of them depend on the LCD design itself and others on the camera working as the receiver. Moreover, there are some limitations due to the system's processing capability and power consumption. Although in practice, it might be challenging to obtain a fair assessment of the system's performance, it is important to know what affects the transfer rate and what can be done about each limiting factor in this data transmission medium. The data capacity of an LCD may be calculated by considering for instance the maximum number of bits in a raw image as shown on the LCD. A display having M_D the rows and N_D columns, showing a color image in L_D channels (typically $L_D$for red, green and blue) and color bit depth of B_D bits per channel, would have the maximum information of:

$$C_I = M_D \times N_D \times L_D \times B_D \text{ bits per image} \quad (1)$$

This is the maximum information that can be shown on the LCD on a single image due to the discrete nature of the data shown. A refresh rate R of for the LCD leads to a data rate of C_V = R× C_i. For a state of the art cell phone with a high resolution display having 16M colors, the parameters would be M_D=1136, $N_D = 640$, $P_D = 3$, $B_D = 8$ *and* $R_D = 60$Hz resulting in $C_I \approx 17$Mbits and $C_V \approx 1$Gbps, which is an extremely high data rate even when compared to current radio frequency wireless technologies. Unfortunately, this rate cannot be achieved due to the limitations.

A. Camera Limitations

A digital camera could be considered as a device which digitally samples a 2D signal. For correct sampling of consecutive frames in time, camera capture rate should be 2 times the display refresh rate (R_D) unless there is a synchronization system in place to activate the camera shutter when the image is stabilized on the display (exactly between frame changes). As it is not normally the case, if the camera capture rate is for example $R_c = 8$ Hz then the display refresh rate could not exceed 4 Hz. To satisfy the Nyquist criteria for image resolution, each pixel of the image shown on the LCD should be sampled by 2 or more pixels in the camera. The image sensor uses limited number of bits per channel for conversion of each color pixel, resulting into quantization noise. To limit the effect of this noise on the overall detection performance it should be maintained 6-10dB below system noise level, which on the other hand must be maintained well below signal power level, depending on the modulation method used, in order to have acceptable bit error rates (BER).

B. Power Limitations

The capacity of every communication channel depends on the power of the signal sent through that medium as predicted by Shannon theorem, and in this case the power would be limited by the intensity of light an LCD can generate. Increasing this intensity would improve signal to interference and noise ratio (SINR) in the receiver. Like RF power transmitters, LCD displays are limited in terms of the maximum power leading to the Peak to Average Power Ratio (PAPR) limitation, which is a common challenge for OFDM signals. When maximum available intensity is fixed, higher PAPR yields lower average intensity and thus lower SINR. Therefore transmission of OFDM signals over an LCD requires a trade-off between the average power transmitted and the resulting distortion due to clipping of the peaks, another issue that is addressed in this study. Although various PAPR reduction methods are available, they would affect QPSK-OFDM and DPSK-OFDM methods in a same manner, and DPSK modulation would still be superior when the same method of PAPR reduction is used. Further discussions on clipping OFDM signals can be found.

C. Inter-Symbol Interference (ISI)

When a barcode is printed on paper, a white pixel does not affect its neighboring black pixels provided that the print quality is good and the resolution is high enough. On the other hand, when data is shown on an LCD, light that is passing through white pixels may leak into neighboring black pixels making them look gray. The straightforward solution to this problem is to increase the size of the pixels so that they have minimal effects on each other. This is called barcode granularity in QR coding. On a lower level this is exactly the way a printed barcode is generated, where each printed dot is not corresponding to a data symbol but rather many printer dots contribute to a single black symbol. In the case of LCD, each pixel $k \times k$ set is assigned the same color to generate just one symbol, isolating the center pixel from bordering pixels that may be affected by neighbors. Unfortunately this method greatly decreases the transfer rate because the $M \times N$ independent data symbols reduce to which leads to a K^2 to 1 rate decrease. The inter-symbol interference could happen in the receiver camera as well becoming a major obstacle for increasing the pixel density of barcodes. Moreover, any movements between camera and LCD during the capture of an image for barcode processing results in motion blur which is translated into ISI as neighboring pixels affect each other in the captured image.

At first this effect might not be evident based on common experiments with 2D barcodes like QR codes. These codes are decoded successfully without major efforts in terms of stability of code or camera. While performance of some QR code detection algorithms are studied and first read rate performances of some 2D barcodes have been studied, the research is rather focused on user experience as an important factor, which is to determine if the user is able to decode the barcode at first try. In fact, performance of 2D barcode decoders are measured by the frames processed per second, thus when a barcode scanner tries to decode a stationary 2D barcode, multiple frames are processed within a second and a successful decode will be reported if only one frame is captured in good conditions. To investigate if a relative barcode camera motion affects the performance of the decoder, the following experiment was conducted. Alphanumeric strings of various lengths of number π were encoded into QR Codes of increasing dimensions, in a way to fill the barcode capacity as shown in Fig. 3. Error correction level is set to medium (M) which is capable of correcting roughly 15% error rate. Consecutive frames were captured using a hand-held camera phone, first by fixing the camera and then by holding it in one hand by a non-experienced user. Camera focus was locked the same way in both cases and normal office lighting and a distance of 12 cm were maintained. Moreover, the width of rectangular QR code pixels was. 312 mm regardless of the code capacity. As a result the largest QR code which had 121×121 pixels was 37.7 mm in width which is double the density of ordinary QR barcode. Encoding and decoding of the QR codes were accomplished using ZXing open-source libraries.

In order to limit the effect of perspective distortion, camera and barcode are held parallel in the docked case, and although this angle cannot be guaranteed in the handheld scenario, the performance drop would be negligible as reported. The captured images taken at 10 frames per second where processed to detect the QR code, and the percentage of decodable images are shown in Table I. As can be seen from these results, for smaller QR codes it does not make any difference if the camera is held by hand or fixed as all the frames would be detected successfully. However, as the size of the QR code increases, more and more frames are dropped in the moving case compared to the fixed camera setup. In any setup studied, user experience would not be a problem as there was at least one detectable frame within one second of recording onset.

D. Interference, Distortion, and Noise

When a camera is used to take a picture of a 2D barcode, certain image artifacts could impact the result of data extraction method. These artifacts are mainly due to the following:

TABLE READ RATE OF QR CODES IN DOCKED AND HANDHELD CONDITIONS

QR Version	V1	V6	V11	V16	V21
QR Size	21× 21	41× 41	61× 61	81× 81	101× 101
Docked	100%	100%	97%	99%	10%
Handheld	100%	100%	84%	71%	6%

- Distance and angle between camera and LCD (perspective distortion);
- Camera and subject relative motion;
- Out of focus lens;
- Compression distortions;
- Unwanted ambient light sources;
- Dirt and permanent marks on the LCD;
- Noise (primarily additive Gaussian noise).

Moreover, nonlinear distortions exist in a typical optical wireless data transmission setup due to transmitter and receiver physical limitations that are discussed in [21]. These undesirable effects should be addressed to ensure the feasibility of the algorithm under realistic scenarios, while preserving the ability for attaining high data transfer rates.

III. DPSK-OFDM

While LCD technology is improving on pixel to pixel isolation, some of the image capture distortions still remain, causing neighboring pixels of the barcode mix up in the image and resulting in some kind of Inter Symbol Interference. The main idea in resolving this problem is to interpret the barcode image as a wireless radio signal for which ISI reduction techniques have already been proven successful. One of the best and most feasible modulation methods capable of coping with severe conditions in band limited communication channels is the so-called Orthogonal Frequency Division Multiplexing or OFDM. The general idea is that when dealing with band-limited, power-constrained, multipath channels, it is more efficient to transfer a bunch of narrow-band signals in parallel instead of a single high bandwidth signal.

A. Similarities of Barcode and Wireless RF Channel

For simplicity each 2D image is reformulated into a 1D row vector containing all pixels in the 2D image. Each row can be considered as a time domain signal which has Pulse Amplitude Modulation (zeros are black and ones are white pixels). Consider taking a picture of this single row, in a band limited channel which has a combination of camera focus problems, resolution limitations, light leakage from white to black pixels, among other things. Moreover in a multipath channel in which the camera moves during image capture and mixes up the image of several neighboring pixels, the resulting image will suffer from high ISI. To solve these problems in a time domain radio signal, OFDM method is used to essentially divide the channel into multiple orthogonal low bandwidth channels and the low rate data is sent into these channels in parallel. So in case of the 1D data the inverse Fourier transform is used for displaying the data instead of using the PAM modulated process, where Hermitian symmetry conditions should be met to have real-valued outputs. As a result, most artifacts only affect the high frequency components leaving low frequency components intact for data transmission.

This idea may be generalized to 2D signals to meet the requirement for transferring the entire image at once. Instead of 1D inverse Fourier transform, the 2D version is used such that the effect of artifacts acting on two axes would be confined to high frequency components. The exact modulation scheme will be discussed later in this study.

In general each sub-carrier in an OFDM signal is modulated using M-quadrature amplitude modulation (M-QAM). Thus proper phase shift of each element should be estimated and compensated for before demodulation. This generally requires specific conditions on the channel characteristics like fast fading where pilot tones are used for channel estimation or slow fading where most methods would require multiple symbols in seeking similar channel responses (i.e.. similar transfer functions) [23] and [24].

When using OFDM for transmission of data as images, all the channel equalization computations should be based on a single OFDM frame due to the independent channel response between subsequent frames, unless the frame rate is very high. In fact each frame is distorted by LCD-Camera relative motion during its own capture time. To mitigate this problem the phase difference between adjacent elements is used to convey data. Using DPSK modulation prior to applying the inverse Fourier transform in OFDM modulation, data would not have to be stored in the absolute phase of the received elements but rather in its phase difference to the neighboring element, which eliminates the requirement for channel estimation and equalization if the channel response does not vary abruptly between adjacent subcarriers.

B. Transmitter :

One of the advantages of using OFDM is its effective computation method which uses the Inverse Fast Fourier Transform (IFFT) to modulate input data into orthogonal frequencies. The modulated signal should be real-valued in order to be shown on an LCD, so the input to the IFFT algorithm should have Hermitian symmetry. This requirement is shown in the following equation:

$$\mathbf{T}(\mathbf{M}-\mathbf{m}, \mathbf{N}-\mathbf{n}) = \mathbf{T}(\boldsymbol{m},\boldsymbol{n})^{*} \qquad \textbf{(2)}$$

Where $0\leq m < M$ and $0 \leq n < N$, and * denotes the complex conjugate operator. Fig. 4 shows the elements relationship in order to have a real-valued IFFT for T matrix. In this con- figuration, only regions 1 and 2 are used for data transmission independently, and regions 3 and 4 are calculated accordingly to have a real-valued IFFT. Moreover, the symmetry requirements for elements that have been deliberately set to zero would be automatically satisfied.

Constellation Mapping: The input data is decomposed into 2-bit symbols. Each symbol is converted to a complex phase by the following rules:

$$\mathbf{11} \rightarrow e^{j\frac{1\pi}{4}}, \mathbf{10} \rightarrow e^{j\frac{7\pi}{4}}, \mathbf{01} \rightarrow e^{j\frac{3\pi}{4}}, \mathbf{00} \rightarrow e^{j\frac{5\pi}{4}}$$

Therefore the first bit modulates the real component and the second bit modulates the imaginary component of the phase for each data symbol. These symbols are placed in a matrix which contains the absolute phase elements that are going to be modulated using DPSK.

Differential PSK: Matrix is transferred into a differential matrix using the following method:

- **D (0,0)= S(0,0) ;**
- **D (0, n) = D (0, n-1)×** $\mathbf{S(0,n) 1 \le n < N-2}$ **;**
- **D (m, n) = D (m-1, n)×** $\mathbf{S(m,n) 1 \le m < \frac{M}{2} - 1, 0 \le n < N-2.}$

Subsequently, the DPSK modulated matrix is divided into two matrices:

- $\boldsymbol{D^1(m,n) = D(m,n)}$ **;**
- $\boldsymbol{D^2(m,n) = D(m, n + \frac{N-2}{2})}$ **;**

Where $\mathbf{0 \le m < \frac{M}{2} - 1, 0 \le n < \frac{N}{2} - 1}$. These two matrices are used to fill regions 1 and 2 of the matrix T. Regions 3 and 4 of are generated based on the Hermitian symmetry requirement, and all the remaining strips on are set to zero. These small regions, especially around region 1 (left top corner), may be used for special data transmission such as frame rate or type of error correction coding used.

Inverse FFT: Considering is the frequency domain representation of the signal, the IFFT is applied on it to have the time domain signal referred to as D_i. This signal would have zero mean because T (0, 0) =0, so it should be adjusted in order to use the full dynamic range of pixels.

PAPR Adjustment: is a real-valued 2D signal with high peak to average ratios. In fact, the probability of having a high PAPR increases as the number of frequency components increases as can be seen in Fig. 5. There are several methods to limit the PAPR of OFDM signals which might be applied here with slight modifications for 2D signals. One of the most practical methods would be soft clipping of the signal in which a threshold level of based on signal average power level is set such that:

$$\textbf{Clip Ratio} = \frac{A_{max}}{\sqrt{P_{avg}}} \qquad \textbf{(3)}$$

Where P_{avg} is average power per element in the OFDM signal before clipping. Any components with higher amplitude than A_{max} are consequently clipped to A_{max} resulting in a 2D matrix D_c .

Amplitude Adjustment: The pixel levels in the PAPR adjusted image need to be transformed into LCD dynamic range levels for efficient utilization of transmission power. Normally the intensity levels on the LCD goes from 0 to I_{max} . So D_c values are transformed linearly to this range using the following equation:

$$\boldsymbol{D_a(i,j) = \frac{D_c(i,j) - Min(D_c)}{Max(D_c) - Min(D_c)}} \qquad \textbf{(4)}$$

Thus the average power of is maximized for LCD projection.

Finder Patterns: Proper demodulation of data requires precise extraction of the modulated data from captured image and compensating for any perspective distortions. General finder patterns used with 2D barcodes may be used here like the 1, 1, 3, 1, 1 pattern used in QR-codes, for which fast and efficient detection algorithms have already been developed. A sample 128× 128 image generated by the preceding method is shown in Fig. as it would be shown on the LCD of the transmitting device.

C. Cyclic Extension :

OFDM systems require cyclic extension to prevent inter carrier interference (ICI). To be sufficient, the length of the added cyclic extension must be more than the time spread of the channel. In case of the 2D barcode, periodic extension of the image generated by 2D-IFFT is required to prevent ICI. The length of this extension is determined by the impulse response of the channel, which in turn depends on the image blur and the amount of movement anticipated between LCD and camera. However, since in this study the channel response is modeled in the frequency domain, frequency domain filtering is applied on the barcode, and effective cyclic extension is achieved by frequency domain multiplication which results in time domain cyclic convolution. Hence in all the following simulations the length of the cyclic extension is the same for DPSK-OFDM and QPSK-OFDM ensuring ICI elimination in the longest channel responses simulated.

D. Receiver:

After displaying the generated image of Fig. 6, the receiver uses its camera for sampling and registering the acquired image so that a fairly acceptable copy of is created at the receiver end. The effects of interference, noise and distortions encountered in this step are addressed in the simulation section. To obtain the transmitted data successfully, the following steps should be taken into consideration at the receiver end.

Image Capture: Digital camera and display systems have a limited refresh rate which tends to be more than 23 Hz for different standards. In a synchronous system the camera can capture each displayed frame at the exact moment when it is fully stable. However if the receiver does not know when a new frame is ready on the display, the sampling rate should be at least twice the display rate to ensure capture of at least one acceptable frame. Moreover the relative distance and angle between camera and display is bounded by the Nyquist criteria where each pixel on the display frame should map into a minimum of 2×2 block in the camera.

Image Registration: The first step in processing the captured image is to extract the displayed image from background which depends on predefined finder patterns put into the image. For example, data matrix guidance lines are used. Because measurement errors in finder pattern location and perspective correction errors are not part of this study, the simulated images and their distorted received signals are ideally registered isolating the effects of blur and camera movement on error rate of different schemes.

FFT: Applying Fast Fourier Transform on the registered image results in frequency domain data which is comprised of the differential phase modulated elements stored in R_f matrix.

DPSK Demodulation: The original constellation mapped data can be extracted using phase differences between respective elements, but first data corresponding to regions 1 and 2 should be concatenated together to form matrix corresponding to the transmitted matrix T.

- $R_d(0, 0) = \mathrm{R}(0, 0);$
- $R_d(0, \mathrm{n}) = \mathrm{R}(0, \mathrm{n})\times \mathrm{R}^*(0, \mathrm{n}-1) 0 < \mathrm{n} < N-2$.
- $R_d(\mathrm{m}, \mathrm{n}) = \mathrm{R}(\mathrm{m}, \mathrm{n})\times \mathrm{R}^*(\mathrm{m}-1, \mathrm{n}) 0 < n < N-2, 0 < m < \frac{\mathrm{M}}{2}-1.$

The resulting would be a distorted copy of in transmitter path.

Detection: Now that the phase differences have been extracted, each input bit may be calculated using the constellation map of the transmitter. Each element is evaluated using its real and imaginary components. The sign of the real component determines the first bit and the sign of the imaginary component determines the second bit.

E. Error Correction:

Error correction coding is often used in communication systems to correct for the different number of bits lost in the transmission process. For example, Reed-Solomon (RS) coding is used in QR codes, where depending on the level of error correction used, error rates of 7% up to 30% can be corrected at the receiver end. While the selection of error correction coding has a great influence on the overall performance of the communication system, they are generally used on top of the modulation-demodulation scheme and after source coding. Therefore, based on the achievable error rates without error correction coding, one can select an appropriate coding scheme to create a reliable communication channel. As a result, when considering the BER performance plots provided in the simulation section (IV), it should be noted that error rates in excess of 30% are not correctable even with the most redundant RS codes de- fined in [2] and would consequently be considered a non-reliable channel for this kind of transmission.

F. Computational Complexity

An important issue regarding the applicability of such a system would be the computational power required to implement the system. Although a thorough investigation of such requirements and any optimization process can be subject to further study, it should be noted that the proposed DQPSK-OFDM system has a limited processing overhead compared to the equivalent QPSK-OFDM system which is already implemented and tested. More specifically, on the transmitter side, although the differential modulation is described by complex multiplications, it can be easily implemented using a small look-up table taking current phase and data to be modulated as inputs. However, in the receiver side about $\mathrm{M}\times N$ multiplications are required to extract phase differences before detection which is not prohibitive compared to the complexity of the 2D FFT preceding it which is in the order of $\mathrm{M}\times N\times \log(M\times N)$.

IV. RESULTS

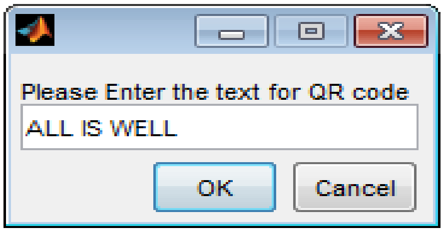

Figure 1: Entering Text for QR code

Fig.1. Analysis: The first step is to enter the text to generate a QR code. Our main aim is to retrieve the entered text back. So, now I have entered “ALL IS WELL”.

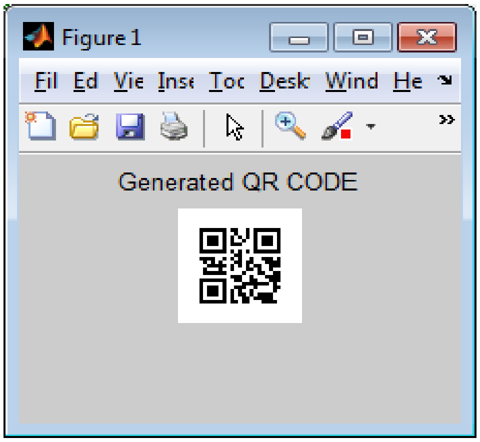

Figure 2: Generated QR Code

Figure 2: Analysis: The text which was entered is generated as a QR code as shown in the above Fig.2.

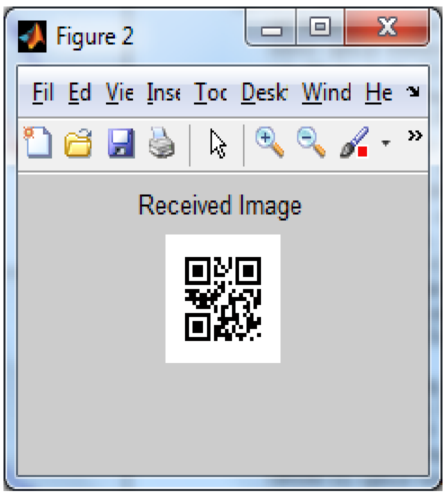

Figure 3: Received image

Figure 4: Shows Entered Text

Figure 4: Analysis: Finally the above QR code is analysed and the original text is retrived as shown in above Fig.

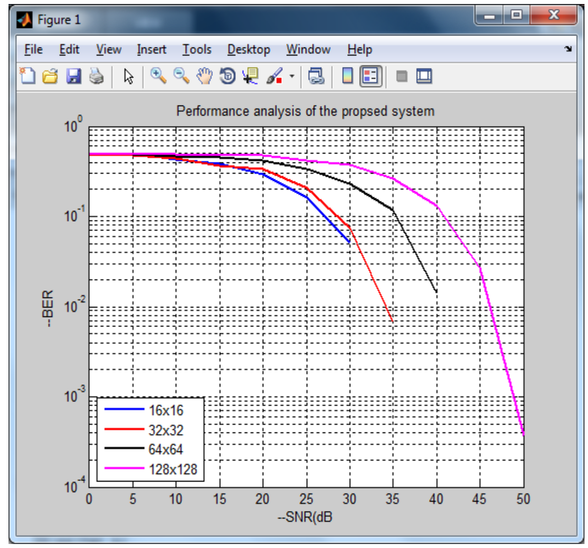

Figure 5: Performance Analysis of Proposed Method

Figure 5: Analysis: Now the next step is to analyze the performance of the received QR code for 16 × 16, 32 × 32, 64 × 64, 128 × 128. The above figure shows as the bits size increases BER also increases. So, our main Aim is to reduce BER and for 16 × 16 the BER has got reduced.

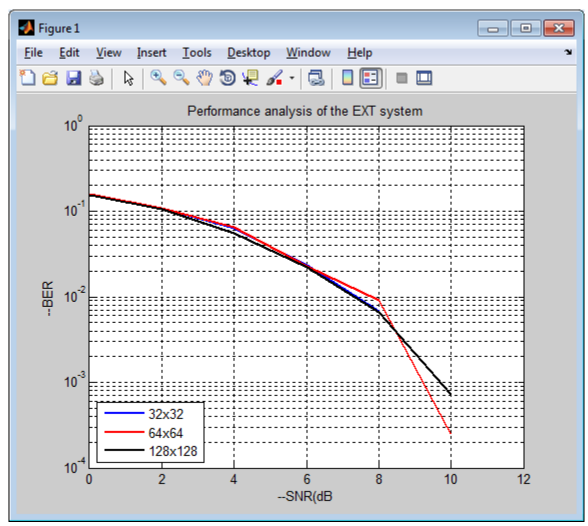

Fig.6. Performance Analysis of Extension Method

Fig.6. Analysis: The above performance is the extension of the proposed method. In this Discrete Wavelet Transform (DWT) is used to increase the SNR as well as to reduce the BER. The performance is shown for32 × 32 ,64 × 64 ,128 × 128. As compared to the proposed technique BER is much more less in the extension method.

V. CONCLUSION

If we check literature, this as one of RFID‘s benefits since tags can be scanned without being in the user‘s line of sight. This is immediately preferable over barcode technology as well QR code technology in the majority of operational environments where rapid throughput of product is of paramount importance, such as into and out of chilled warehouses. Recent advances in two dimensional barcodes and laser scanning equipment, however, could help to improve the time it takes for barcodes to be scanned and further empirical analysis of this particular technology is required.

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