# Orthogonal Frequency Division Multiplexing Based Wireless Communication System for Digital Broadcast Applications

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## ABSTRACT
Orthogonal frequency division multiplexing (OFDM) is a technique that allows digital data to be efficiently and reliably transmitted over a radio channel even in heavy multipath environment. In the present paper we have investigated an OFDM based wireless Communication system by transmitting and receiving a compressed image. The Bit error rate and runtime results of multicarrier OFDM are reported to investigate the effect of number of carriers and IFFT size for MPSK modulation schemes. The QPSK has come out as a suitable scheme for OFDM based systems.

## Keywords
The inter-symbol interference (lSI) the the inter-channel interference (lCI) , OFDM

## 1. INTRODUCTION
The demand for high-speed mobile wireless communications is rapidly growing. OFDM technology promises to be a key technique for achieving the high data capacity and spectral efficiency requirements for wireless communication systems of the near future.[1] OFDM has been adopted in several wireless standards such as digital audio broadcasting (DAB),digital video broadcasting (DVB-T), the IEEE 802.11a etc. OFDM converts a frequency-selective channel into a parallel collection of frequency flat sub channels. The subcarriers have the minimum frequency separation required to maintain orthogonality of their corresponding time domain waveforms, yet the signal spectra corresponding to the different subcarriers overlap in frequency. Hence, the available bandwidth is used very efficiently. If knowledge of the channel is available at the transmitter, then the OFDM transmitter can adapt its signaling strategy to match the channel [2.3] One benefit of OFDM in a wireless communications system is that the receiver does not need to constantly adapt an equalizer as a single carrier system would. OFDM system shows much favorable properties such as high spectral efficiency, robustness to channel fading, immunity to impulse interference, capability of handling very strong echoes (multipath fading ) etc. [4] In this paper we have demonstrated the concept of an OFDM system, and investigated how its performance is changed by varying some of its major parameters.

## 2. SYSTEM MODEL
### 2.1 Basic Principal
In an OFDM scheme, a large number of orthogonal, overlapping, narrow band sub-channels or subcarriers, are transmitted in parallel, that divide the available transmission bandwidth. The separation of the subcarriers is theoretically minimal such that there is a very compact spectral utilization .[5] The attraction of OFDM is mainly due to how the system handles the multipath interference at the receiver. Multipath generates two effects: frequency selective fading and ISI. The "flatness" perceived by a narrow-band channel overcomes the fading , and modulating at a very low symbol rate, which makes the symbols much longer than the channel impulse response, diminishes the ISI. Using powerful error correcting codes together with time and frequency interleaving yields even more robustness against frequency selective fading, and the insertion of an extra guard interval between consecutive OFDM symbols can reduce the effects of ISI even more. Thus, an equalizer in the receiver is not necessary spectral efficiency. These spectrums meet the orthogonality in the whole symbols cycle so that receiver receives undistorted signals. [6]

### 2.1 Block Diagram

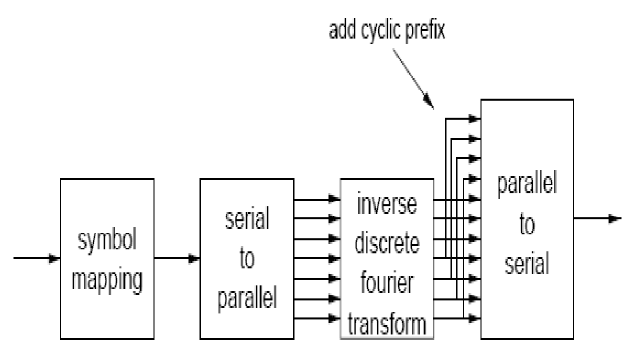



**Fig. 1 : OFDM Modulator[8]**

Figure 1 shows a block diagram of a generic OFDM Transmitter . Source data for this simulation is taken from an 8-bit grayscale (256 gray levels) bitmap image file (*.bmp) based on the user's choice[7]. The image data is converted to the symbol size (bits/symbol) determined by the choice of *M*PSK where m is the order of the PSK scheme The transmitter converts the symbols from a serial stream to parallel sets. Each set of data contains one symbol, Si, for each subcarrier. An inverse Fourier transform converts the frequency domain data set into samples of the corresponding time domain representation of this data Specifically, the IFFT is useful for OFDM because it generates samples of a waveform with frequency components satisfying orthogonality conditions. To reduce ISI the last part of the OFDM symbol is copied and put as a preamble, which serves as a cyclically extended guard interval, which is called a cyclic prefix figure 2)[8]. The use of a cyclic prefix instead of a plain guard interval, simplifies the channel equalization in the demodulator.

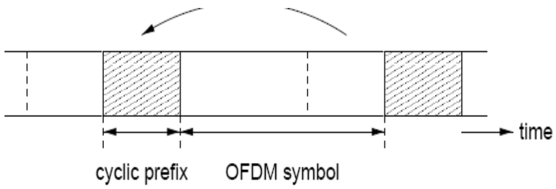



**Fig. 2 : OFDM signal with cyclically extended guard interval**

Then, the parallel to serial block creates the OFDM signal by sequentially outputting the time domain samples The communication channel is modeled by adding Gaussian white noise and amplitude clipping effect.

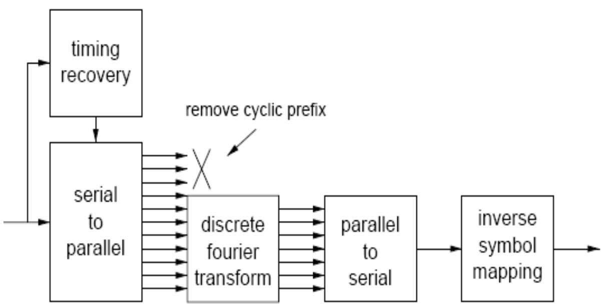



**Fig. 3 : OFDM Demodulator[8]**

The receiver performs the inverse of the transmitter. First, the OFDM data are split from a serial stream into parallel sets. The Fast Fourier Transform (FFT) converts the time domain samples back into a frequency domain representation. The magnitudes of the frequency components correspond to the original data. Finally, the parallel to serial block converts this parallel data into a serial stream to recover the original input data. The receiver detects the start and end of each symbol in the received signal by an envelope detector. The modulated data is then converted back to 8-bit word size data used for generating an output image file of the simulation. Error calculations are performed at the end of the.[7]

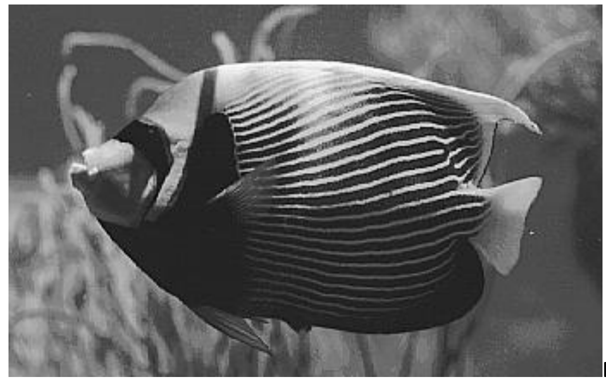
## 3. RESULTS & DISCUSSIONS

The data used in the transmission was that of a grey-scale bit-map image of a fish.

The original of the image is show below in Figure 4 . This image is processed using OFDM.

| Parameters | Values |
|---|---|
| Source Image Size | 345*216 |
| IFFT Size | 512 |
| Number of Carriers | 200 |
| Modulation Scheme | QPSK/BPSK/16PSK/256PSK |
| Peak Power Clipping | 3dB |
| Signal to Noise Ratio | 10dB |

**Table 1 :Parameters of Simulation**



**Fig**

**Fig. 4: Original image transmitted**

### 3.1 Modulation Scheme Vs Runtime

Figure 5 describes the Run time required for different modulation schemes keeping the other parameters constant.

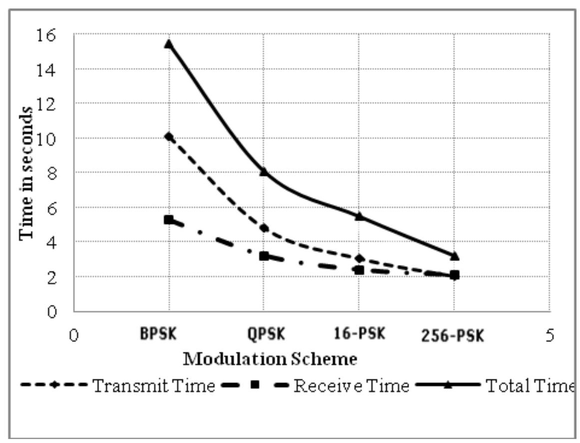



**Fig 5: Plot of Program run time v/s Modulation scheme**

Fig. 5 reveals that the time taken by BPSK is tripled as compared to 16 PSK and 256 PSK. 256PSK allows 8 bits to be sent on each carrier per symbol, compared to only 2 bits for QPSK. Thus, 256PSK on its own allows for up to 4 times the transmission data rate, So the time taken will be less. One interesting fact observed through our simulations is that If we

### 3.1 SNR v/s BER for Different Modulation Schemes

The SNR of the channel was varied from 0dB to 15dB with image quality measured at 5dB increments. Figure 6(a) – Fig 6(d) illustrates the reception of the bmp file at various channel conditions with scatter plot ( Constellations ) of various PSK Modulation schemes indicating bit error rate in each case drop the number of carriers and IFFT size to half while all other parameters are same then also the runtime for simulation does not vary too much.

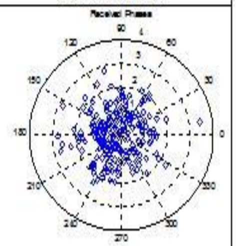
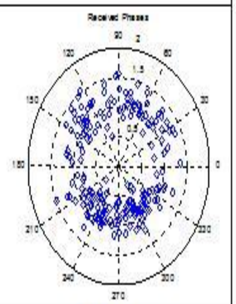
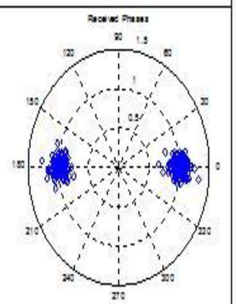
| SNR | IMAGE RECEIVED | BER(%) | CONSTELLATION |
|---|---|---|---|
| 0 |  | 14.69 |  |
| 10 |  | 0.67 |  |
| 15 |  | 0.58 |  |

**Fig. 6 ( a) : Received Profile of Image for BPSK Scheme**

Figure 6 (b) – Figure 6(d) reveals that picture sent using QPSK had a much better Quality then the picture sent by 16 PSK or above higher order schemes at low SNR ( below 10 dB) . It is observed that in higher SNR (above 10dB) the received quality of the image substantially improves even for higher order modulation schemes i.e. 16-PSK and 256PSK .

Figure 7 shows the relative performance difference between various MPSK schemes keeping the other parameters described in table 1constant. It establishes the fact that SNR is inversely proportional to error rates . It reveals that in high SNR environment higher order schemes can be used having low BER and high data rate.

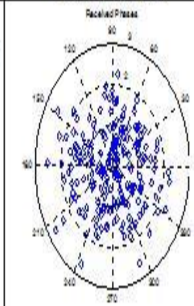
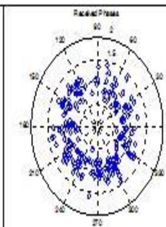
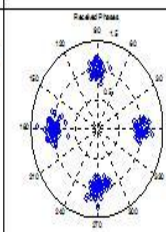
| SNR | IMAGE RECEIVED | BER | CONSTELLATION |
|---|---|---|---|
| 0 |  | 43.27 |  |
| 10 |  | 2.31 |  |
| 15 |  | 2.16 |  |

**Fig. 6( b ) : Received Profile of Image for QPSK Scheme**

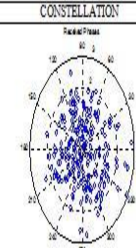
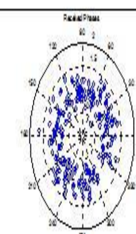
| SNR | IMAGE RECEIVED | BER | CONSTELLATION |
|---|---|---|---|
| 0 |  | 83.92 |  |
| 10 |  | 50.58 |  |

**Fig. 6 (c ) : Received Profile of Image for 16-PSK Scheme**

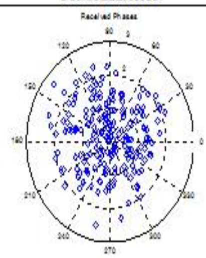
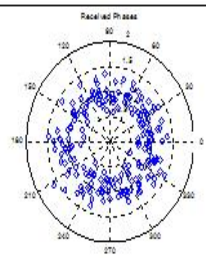
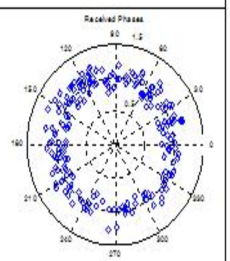
| SNR | IMAGE RECEIVED | BER | CONSTELLATION |
|---|---|---|---|
| 0 |  | 99.05 |  |
| 10 |  | 60.12 |  |
| 15 |  | 25.24 |  |

**Fig. 6 (d ) : Received Profile of Image for 256-PSK Scheme**

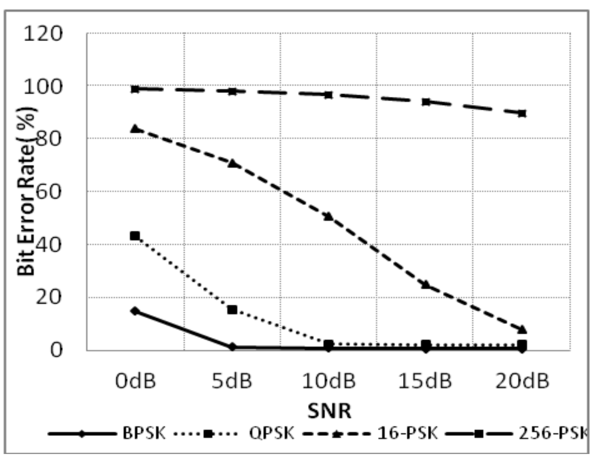



**Fig 7: Plot of Program run time v/s Modulation scheme**

## 4. CONCLUSIONS

We concluded that runtime does not reflect the variance of the efficiency based on varied numbers of carriers. However, the change in order of modulation scheme affects the runtime drastically. The run time decreases with increase in order of PSK. Higher order PSK requires a larger SNR to minimize BER . There occurs a trade off between runtime and BER as we raise the PSK order. Keeping in mind the Data rate , Bandwidth efficiency and Image quality QPSK proves to be a better modulation scheme compared to other schemes.

## 5. ACKNOWLEDGEMENT

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