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**Investigate The Performance Compression Technique
Based on DWT (Discrete Wavelet Transform) OFDM
(Orthogonal Frequency Division Multiplexing) for
Wireless Channel**

A Thesis

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the Requirements for the Degree of Master in Engineering /
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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

(وَيَرَى الَّذِينَ أُوتُوا الْعِلْمَ الَّذِي أُنزِلَ إِلَيْكَ مِنْ رَبِّكَ هُوَ الْحَقُّ
وَيَهْدِي إِلَى صِرَاطٍ الْعَزِيزِ الْحَمِيدِ)

صدق الله العظيم

سورة سبأ الآية 6

DEDICATION

This thesis is dedicated to:

The sake of Allah, my Creator and my Master,

My great teacher and messenger, Mohammed (May Allah bless and grant him), who taught us the purpose of life,

My homeland Iraq, the warmest womb;

The great martyrs, the symbol of sacrifice;

Babylon University; my second magnificent home;

My great parents, who never stop giving of themselves in countless ways,

My husband, who leads me through the valley of darkness with light of hope and support,

My beloved daughter: Dima, whom I can't force myself to stop loving her.

To all my family, the symbol of love and giving,

My friends who encourage and support me,

All the people in my life who touch my heart, I dedicate this research

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Abstract

This thesis shows how to enhance the bandwidth and bit error rate (BER) performance of modern communications system by using a compression technique in multicarrier modulation systems. This technique including a compression coefficients of the wavelet transformation to frequency dimensional of multicarrier modulation. The proposed system designed for multicarrier systems was implemented using a standard OFDM system based on Fast Fourier Transform (FFT).

This proposed idea was compression the multicarrier modulation coefficients of FFT done by adding the Discrete Wavelet Transform (DWT) as compression stage to discard the details of multicarrier coefficients. This operation will be done by sending the approximation coefficients of DWT only and discard the details coefficients. The details coefficients in receiver side will compensate by adding zeros to the input of IDWT stage.

The simulation results were examined using (AWGN) and the proposed system gain a 2dB above confintaioal, flat Rayleigh fading and the proposed system gain a 1.5dB above confintaioal, selective fading channels and as well as using multipath (Extended Pedestrian A model (EVP), Extended Vehicular A model (EVA), Extended Typical Urban (ETU)).

The LTE including Extended Pedestrian A (EPA), Extended Vehicular A (EVA) and Extended Typical Urban (ETU). and examine changing for different values of maximum Doppler shift (5Hz,70Hz and 300Hz) (which is the most significant impact channel parameters) on the BER performances. LTE based on DWT in the simulation results shows that it is better than LTE based on FFT. showing that a proposed additional compression scheme after DWT can double the data rate and reduce the bit error rate (BER), The MATAB program was used for version 2020B.

List of Contents

		<i>Page no.</i>
Abstract		I
List of Contents		III
List of Abbreviations		VII
List of Symbols		VIII
List of Figures		IX
List of Tables		XI
CHAPTER ONE: Introduction		
1.1	History of OFDM	1
1.2	Literature Review	5
1.3	Aim of the study	9
1.4	Thesis Outline	9
CHAPTER TWO: Multicarrier Theory and Concept		
2.1	Theory of Multicarrier	11
2.2	Orthogonal Frequency Division Multiplexing (OFDM) system	11
2.3	Advantages and Drawbacks of OFDM	13
2.4	Data Compression	14
2.5	Discrete Wavelet Transform	15
2.6	The wireless channels Outlines	20
2.6.1	Rayleigh Fading Channel	21
2.6.2	Additive White Gaussian Noise Channel	21
2.7	The Estimation of Channel	22
CHAPTER THREE: Proposed Multicarrier System Design		
3.1	Proposed Multicarrier System	24

3.2	Multicarrier System	28
3.2.1	Multicarrier Transmitter	30
3.1.1.1	Cyclic Prefix	32
3.1.1.2	Zero Padding	33
3.2.2	Multicarrier Receiver	34
3.3	Channel and Data Equalization	34
3.3.1	Fading Channels	36
3.3.2	Additive White Gaussian Noise	36
3.3.3	Flat and Frequency Selective Fading	37
3.3.4	Multipath Fading	38
3.4	Wavelet Multicarrier System	39
CHAPTER FOUR: The Result and Discussion		
4.1	Introduction	43
4.2	Performance of Multicarrier in the AWGN Channel	44
4.3	Multicarrier Performance with Flat Fading Channel	45
4.4	Multicarrier Performance in Selective Channel	49
4.5	Performance of multicarrier with LTE Channel Models	54
4.5.1	Extended pedestrian A model	55
4.5.2	Extended Vehicular A model	58
4.5.3	Extended Typical Urban	61
CHAPTER FIVE: Conclusions And Suggested Future Works		
5.1	Conclusions	66

5.2	Suggested Future Works	67
	REFERENCES	68

List of Abbreviations

AWGN	Additive White Gaussian Noise
CDMA	Code-division multiple access
CP	Cyclic prefix
DAB	Digital Audio Broadcasting
DFT	discrete Fourier transform
DMT	Discrete Multi-Tone
DSL	digital subscriber loop
DTT	digital terrestrial television
DVB	Digital Video Broadcasting
DWT	discrete wavelet transform
EPA	Extended Pedestrian A
EVA	Extended Vehicular A
ETU	Extended Typical Urban
FDM	Frequency Division Multiplexing
FPGA	field-programmable gate array
HPF	high pass filter
ICI	inter-carrier interference
IDFT	Inverse discrete Fourier transform
IDWT	Inverse Discrete Wavelet Transform
IFFT	Inverse Fast Fourier Transform
ISI	Inter Symbol Interference
LAN	local area network
LOS	Line of Site
LPF	low-pass filter
LTE	Long Term Evolution
MB-OFDM	Multi-band orthogonal frequency-division multiplexing
MC	Multi Carrier
MCC	Multi-carrier with compression
MC-CDMA	Multi Carrier- Code Division Multiple Access

MIMO	Multi Input Multi Output
OFDM	Orthogonal Frequency Division Multiplexing
P/S	Parallel to Serial
PSD	Power Spectral Density
QAM	quadrature amplitude modulation
QMF	quadrature mirror filter
QOS	Quality of Service
RF	Radio frequency
RPL	Real-time Programming Language
S/P	Serial to Parallel
SNR	Signal to Noise Ratio
STFT	Short Time Fourier Transform
STO	symbol time offset
UWB	Ultra-wideband
WGN	white Gaussian noise
WOFDM	Wavelet OFDM
WP-OFDM	Wavelet Packet- orthogonal frequency-division multiplexing
WSN	Wireless sensor network
WT	Wavelet transform
WWW	wireless world-Wireless World Wide Web
ZP	Zero padding

List of symbols

$\Psi(t)$	scalar wavelet
D_m^n	wavelet coefficients
$P_r(R)$	Received pilot carriers
Ω	Average power of Rayleigh distributed random variable
T_s	Symbol duration
T_g	Guard interval time
B_s	signal bandwidth
B_c	Bandwidth of the fading channel
T_s	Symbol duration
δ_M	code period
$\Phi(t)$	Multi scaling Function
Δ	Impulse function
Z	Unit vector
Θ	Angle between terminal and base station
P	Delay power density spectrum
$y(t)$	Received signal
$x(t)$	Complex envelope of OFDM symbol
(Δf)	Coherence bandwidth

List of Figures

NO. of Figure	Subject	NO. of Page
1.1	(A) FDM spectral diagram displaying the guard bands(B) OFDM Spectrum with Wireless Overlapping Subcarriers	4
2.1	Stable signal	19
2.2	Unstable Signals	19
3.1	The Proposed System Structure	25
3.2	Block diagram of Multicarrier system	29
3.3	Transmitting side of Multicarrier system	31
3.4	Symbol structures of cyclic prefix	32
3.5	OFDM symbol with zero padding	33
3.6	Receiving side of multicarrier system	34
3.7	Data $x [i]$ passing through channel $h [i]$ with result $y [i]$	35
3.8	WOFDM transmission side with synthesis filter bank	40
3.9	WOFDM receiving side with a bank of analysis filters	40
3.10	System model of the Wavelet OFDM package system	41
4.1	MC system based on AWGN with 512 ,1024,2048	45
4.2	MC system 512 based on Flat Fading with Doppler shift 5 ,70,300 Hz	46
4.3	MC system 1024 based on Flat Fading with Doppler shift 5 ,70,300 Hz	47
4.4	MC system 2048 based on Flat Fading with Doppler shift 5 ,70,300Hz	48
4.5	MC system 512 based on selective with Doppler shift 5,70,300 Hz	50
4.6	MC system 1024based on selective with Doppler shift 5,70,300 Hz	51
4.7	MC system 2048 based on selective with Doppler shift 5,70,300 Hz	52
4.8	MC system 512 based on LTE (EPA) with Doppler shift 5 ,70,300 Hz	55

4.9	MC system 1024 based on LTE (EPA) with Doppler shift 5,70,300 Hz	56
4.10	MC system 2048 based on LTE (EPA) with Doppler shift 5,70,300 HZ	57
4.11	MC system 512 based on LTE (EVA) with Doppler shift 5,70,300 HZ	58
4.12	MC system 1024 based on LTE (EVA) with Doppler shift 5,70,300 HZ	59
4.13	MC system 2048 based on LTE (EVA) with Doppler shift 5,70,300 HZ	60
4.14	MC system 512 based on LTE (ETU) with Doppler shift 5,70,300 HZ	61
4.15	MC system 1024 based on LTE (ETU) with Doppler shift 5,70,300 HZ	62
4.16	MC system 2048 based on LTE (ETU) with Doppler shift 5,70,300 HZ	63

List of Tables

NO. of Table	Subject	NO. of page
4.1	Parameter of Simulation Multicarrier system	44
4.2	The SNR of system which get BER 10^{-4} at AWGN and Flat Fading based on 512 , 1024 and 2048 bit	50
4.3	The SNR of system which get BER 10^{-4} at for Selective Channel based on 512,1024,2048 bit	54
4.4	LTE channel models (EPA, EVA, ETU) and delay profiles	55
4.5	The SNR of system which get BER 10^{-4} at for LTE (EPA, EVA, ETU) Channel based on 512 bit	65

CHAPTER ONE
INTRODUCTION

Chapter One

Introduction

1.1 History of OFDM:

The ability to communicate with human beings at the circulate has developed remarkably considering the fact that Guglielmo Marconi first established radio's ability to offer non-stop touch with ships sailing the English Channel.

New wireless communications techniques and offerings were enthusiastically followed with the aid of using human beings at some stage in the world.

Particularly at some point of the beyond ten years, the cellular radio communications enterprise has grown with the aid of using orders of magnitude, fueled with the aid of using virtual and RF circuit fabrication improvements, new massive-scale circuit integration, and different miniaturization technology which make transportable radio device smaller, cheaper, and extra reliable. Digital switching strategies have facilitated the massive scale deployment of affordable, easy-to-use radio conversation networks. These traits will maintain at a fair more tempo at some point of the following decade [1].

Internet, wireless networking, embedded processing, and cloud computing convergence resulted in a multidimensional shift in computing paradigms. Wireless networking, downsizing, and sporadic high-performance embedded processors have all set the groundwork. Wireless networking ushered in a shift in the way people communicate. It has become feasible for transport without twine, even while maintaining community and Internet connectivity, the shape of the gadgets was reduced as a result of miniaturization.

Advances in battery generation in addition to a low strength embedded processing talents made the gadgets mild weight (which includes laptops, phones, PDA), powerful and transportable. With cloud computing, it becomes feasible to adopt a “pay-per-service” payment version in addition to personalized accessibility offerings anywhere, at any time Besides private conversation

gadgets, embedded generation caused self-organizing emergence decrease cost Wireless Sensor and Network Low strength wireless requirements, which include RPL, 6LoWPAN, ZigBee, and COAP imposing IPv6, have made it feasible to combine wireless sensors and networks using the Internet.

WSNs are used because it has become feasible to construct unattended, allotted data-centric networks for worldwide information dissemination. The data accrued with the aid of using WSNs will be distributed to mediating systems for the detection of crucial occasions in addition cause suitable replies from corresponding Operating systems [2].

In the previous few decades, Mobile Wireless Communication networks have skilled an exceptional alternate. The cell wireless Generation(G) normally refers to an alternate within side the system's characteristics, frequency and speed generation. Several standards, capacities, techniques and new features distinguish each generation from the previous one.

In 1973, Motorola validated the existence of the world's first portable cell phone. The 1st industrial computerized cell community become released via way of means of NTT in Japan in 1979, accompanied via way of means of the release of Nordic Mobile Telephone(NMT) system in Sweden, Finland, Denmark, Norway in 1981. After that, mobile wireless communication technology will continue to advance in generations.

The mobile wireless communication network of the first generation (first generation) was analog and only utilized for voice calls. The second generation (second generation) is a virtual generation that facilitates text-based messaging. Later, when third-generation which supplied multimedia guide alongside better improved capacity and statistics transmission charges.

The fourth generation (fourth generation) merges third generation with constant internet to guide wireless mobile internet, which is a development to overcome the limitations of third generation and also enhances the QoS, will reduce the cost

of resources and boost bandwidth. Wireless World Wide Web (WWW) will be a reality with the fifth generation [3].

Modern broadband wireless and wireline applications both use orthogonal frequency division multiplexing (OFDM), a key modulation approach. It was followed by the broadcasting of digital audio (DAB) and the broadcasting of digital video (DVB).

Orthogonal frequency division multiplexing is a rare instance of multicarrier transmission in a specific information circulation is sent over a large quantity of decreasing rate Subcarrier. When using the (CP) as a defense interval between OFDM blocks, the problem of (ISI) added via multipath channels is significantly reduced. The suggested paintings might serve as a short review of the IFFT and FFT algorithms and how they can be used effectively in an OFDM system. The primary causes to using OFDM is to improve resilience versus selective fading or narrowband interference. If a signal fades or is interfered with in a single service system, the entire connection receives fail, but in a multicarrier system, only a very small proportion of the subcarriers may be affected.

In a classical parallel information system, the bandwidth of a general signal may be split into N non-overlapping frequency sub channels. After N sub-channels are frequency multiplexed, each sub-channel is modulated with a different symbol. sub-channel spectral overlap avoidance became standard exercise to remove (ICI). And shows in Figure (1.1(A-B)) This ended in inadequate usage of the present Spectrum.

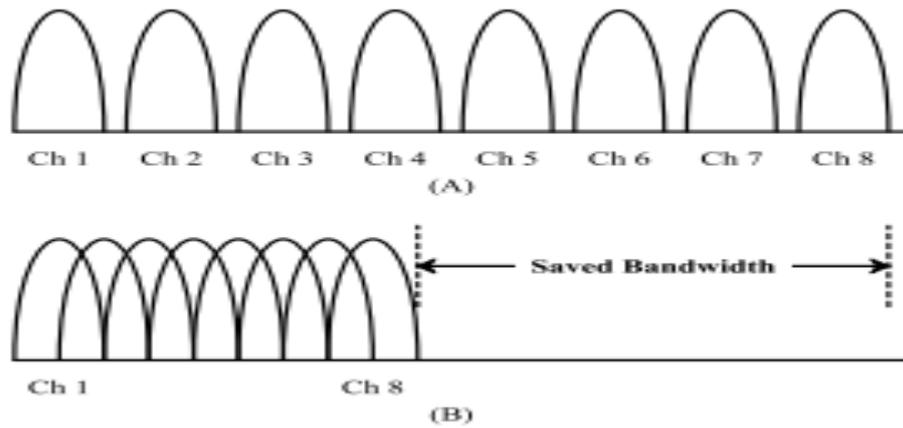


Figure (1. 1) (A) FDM spectral diagram displaying the guard bands
(B) OFDM Spectrum with Wireless Overlapping Subcarriers

As early as the mid-1960s, a concept for improving frequency division multiplexing (FDM) using overlapping sub-channels was put out. The sub-channels have been organized in order that the sideband of the individual carrier's overlap without inflicting ICI. Figure(1.1B) illustrates this precept. This can be accomplished by having carriers that are mathematically orthogonal to each other. Due to this restriction, the OFDM concept was established. Orthogonal frequency division multiplexing is a mixture of multiplexing and modulation. Multiplexing typically indicate to impartial signals, the ones produced through special system. In Orthogonal frequency division multiplexing, the signal is first divided into equal channels, then modulated using statistics and re-multiplexed to generate the Orthogonal frequency division multiplexing carrier. Orthogonal frequency division multiplexing is a unique kind from FDM [4].

1.2 Literature Review

In this section some of related works can be depicted as follows:

- ❖ **In 2008 Scott L.** Orthogonal wavelet division multiplex (OWDM) manner in order that it be considered as a suggestion to orthogonal frequency division multiplex. When using OWDM's wavelet transform instead of the inverse rapid Fourier transform to construct the output, the complexity is decreased while the versatility is enhanced [13].
- ❖ **In 2010 Taha** OFDM has been extensively followed in lots of packages because of its suitable spectral overall performance and occasional sensitivity to impulse noise and multipath channels. An excellent reconstruction of the OFDM transceiver's usage of wavelet packet trans multiplexer counters ISI degradation and also saves bandwidth. (WPM) provides considerably minimum facet cloves inside the transmitted signal as compared to FFT-OFDM, which lowers (ICI) and narrowband interruption (NBI). Because CP is not included in WPM, spectral performance is improved. To improve transceiver BER performance in wireless communication [14].
- ❖ **In 2012 Rohit Bodhe** made a comparative note on the presented DWTOFDM and FFT-OFDM systems. Various wavelet families were used, and the overall performance of the BER is in comparison with the conventional FFT-OFDM system for AWGA. The results show that when used with Unique Waves, the DWT-OFDM system performs with the best overall efficiency. The results also show that DWT-OFDM is ahead compared to FFT-OFDM on the topic of overall performance (BER) in the AWGN channel [15].
- ❖ **In 2012 Md. Mahmudul Hasan** MIMO WOFDM systems are compared to traditional FFT-based multi-user MIMO OFDM systems to see how well they work. The performance of the ODFM system is improved by using more than one Rayleigh fading channel antenna method, and an optimal beamforming method is used to handle the multiuser environment that mainly depends on the

signal-to-leak ratio (SLR). However, OFDM-based waveform is superior in performance to OFDM-based FFT [16].

- ❖ **In 2013 Alaa Ghaith** stated in his paper that with a view to enhance OFDM's overall performance and overcome a few restrictions, an opportunity OFDM technique relying solely on the Wavelet Transform is suggested. So he has a look at the overall performance of such systems in Additive White Gaussian Channel (AWGN). Overall simulation performance may be compared using MATLAB simulations [17].
- ❖ **In 2014 Kumar** in the fourth generation Long Term Evolution (LTE), OFDM provides an OFDM and MIMO strategy. Two carriers are utilized in OFDM, and it provides better spectral performance than (FDM). The usage of wavelet primarily-based OFDM gives exact orthogonality and get better the bit error rate. The spectrum performance of a wavelet-based system has improved since the cyclic prefix is no longer needed. He suggested a wavelet-based completely OFDM system to replace LTE's Discrete Fourier Transform (DFT)-based totally OFDM. [18] .
- ❖ **In 2015 C Anjana** he has explain the use of an Orthogonal Frequency Division Multiplexing communication system that includes channel estimation and concurrence, and we identify the bit error rate of the system with and without channel estimation using a matching graph. The prototype had been implemented in GNU Radio, an open-source software [19].
- ❖ **In 2015 Asif** Wave-based multi-carrier systems are superior to traditional orthogonal FFT systems because they have well-contained side lobes, improved spectrum performance, better overall bit-error rate performance, and because they no longer require a periodic prefix. This compares the bit-error performance of mainly transform-based wave systems with that of orthogonal fully Fourier-based multipath systems for Rayleigh multipath channels with AWGN using discrete wavelet transforms and wavelet packets. The zero effect

channel estimation in the frequency range was used in the proposed system. [20]

- ❖ **In 2015 B. Nagarjun Singh** The fourth generation uses two methods, multiple inputs and multiple outputs, and OFDM. With OFDM multiple carriers, the spectral efficiency is greater than that of frequency division multiplexing. The cyclic prefix makes the available bandwidth about 20 percent in order to address the problem of inter-carrier interference and inter symbol interference between sub-carriers in OFDM. It also uses optimal orthogonality based on OFDM waves and enhances bit error rates. By developing the spectral efficiency, it does not need a periodic prefix that depends on the wavelet system [21].
- ❖ **In 2015 Bouhlel** Due to the properties of nested DWT, it is presented as an alternative to the fast Fourier transform, eliminating the need for CP. By replacing the FFT in the MIMO OFDM system with DWT, higher performance is found, which leads to the development of a new entirely DWT-based system for MIMO OFDM. the system is simulated here and reads the overall performance BER (QAM 4, 16, 64) Additionally, considering traditional symbol detection strategies combined with zero effect (ZF), suggested minimum rectangular error (MMSE) and more Probability (ML) [22].
- ❖ **In 2016 Marwa Chafii** It is introduced in Wavelet-OFDM mainly based on discrete wavelet transformation, in order to make an evaluation between the overall performance of Wavelet-OFDM which is mainly based entirely on Wavelet Meyer, and OFDM in terms of PAPR and BER) for unique channels and one-type equations, implementation complexity, and power spectral density. Simulation results show that without reducing the bandwidth efficiency, the proposed scheme which is entirely based on Meyer Wavelet-OFDM, outperforms OFDM in assisted PAPR statements using up to 4.5 dB, and in assisted BER statements using up to 6.5 dB of signal ratio to noise while

using the minimum mean rectangle error equivalent without channel encoding, at the cost of increasing computational complexity [23].

- ❖ **In 2016 Aanchal Jhingan and Lavish Kansal** Discussion on the overall performance of DWT OFDM and FFT OFDM It is possible to compare the two systems by looking at how well they perform in terms of bit error rate and how it evolves within the BER. According to the simulation results, the wavelet implementation system performs better than the traditional OFDM system. The overall performance of the discrete wavelet transformation despite the CFO elements indicates a significant improvement in the TFE performance aspect compared to the completely conventional system based on FFT [24].
- ❖ **In 2017 Jungu Lee**, the wavelet-OFDM system was designed and examined entirely on the basis of the wavelet transform. As well as having a large number of wavelets, the wavelet transform also includes functions more than only the Fourier transform, such as the usage of sine and cosine functions. It is also possible to demonstrate the effect of wavelet transformation on signals by using a large number of wavelet transforms. (IFFT) is utilized in conventional CP-OFDM. (IDWT) is utilized in the wavelet-OFDM system. As a result, using simulation findings, this investigates the bit error rate, peak to average power ratio, and out of band characteristics of the two systems. A similar bit error rate overall performance may be shown when comparing conventional OFDM and wavelet-OFDM features. Nevertheless, wavelet-OFDM has been found to have lower peak to average power ratio overall performance compared to conventional OOB, and OFDM is also reduced when compared to traditional OFDM [25].
- ❖ **In 2018 Jun-Gu Lee, Heuriz-Cvoon Ryu** the prevailing inadequacies and develop a more effective MCM system than the standard OFDM system based on IFFT. Instead of traditional OFDM's IFFT operation, the suggested system uses IDWT instead. A procedure known as a wavelet transform filters a signal using wavelet and scaling foundation functions [26].

- ❖ **In 2019 Ahmad M. Jaradat** OFDM modulation options are compared in terms of spectrum efficiency, reliability, energy efficiency, peak-to-to-average power ratios, out-of-band emissions, and computing complexity to see which one performs the best overall. OFDM is an orthogonal frequency division multiplexing technology [27].
- ❖ The difference in my work from the previous works is that when entering data on the DWT, details are neglected, and the approximate is taken only when sending, but when receiving, it will compensate for the deleted details with zero

1.3 Aim of study

The main objectives addressed in this thesis are:

- 1- Design modern multicarrier system.
- 2- Compression the multi carrier output by the half size.
- 3- The compression of multi carrier will allowed the proposed system to send double the data rate of conventional system and Same conditions and environment.
- 4- Test the proposed system in the channel model like (AWGN, flat fading, selective fading and Multipath LTE channel model).

1.4 Thesis outlines:

In this thesis, the following topics will be addressed, which are divided into the chapters shown below:

- ❖ Chapter one, a literature review and a general overview of the whole work, is presented.
- ❖ Chapter two, introduction to a theoretical background about data compression algorithms and multi carrier technique which using on the proposed system.
- ❖ Chapter three, proposed system design and block diagrams of system.
- ❖ Chapter four, the results of the classifiers and Discussion.

❖ chapter five, conclusion and recommendations for future work are presented.

CHAPTER TWO

DATA COMPRESSION THEORY AND CONCEPT

CHAPTER TWO

Multicarrier Theory and Concept

2.1 Theory of Multicarrier:

The basic concept of multi-carrier transmission is to switch a high-speed sequent data stream into many low-rate parallel sub-streams. On each other sub-carrier each is modulated. The fact that the symbol rate on each sub-bus is a significant reduction in comparison to the symbol rate of the preliminary serial data means that the consequences of put off propagation, i.e. ISI, are significantly reduced, which in turn lowers the complexity of the equalizer. With the use of digital signal processing, Orthogonal Frequency Division Multiplexing may modulate many sub-carriers at once [28, 29, 30, 31, 32]. OFDM-based fully multi-wave transmission in a mobile radio channel has one of its main design aim being that for an individual OFDM symbol, the channel may be regarded time-invariant and the fading for each sub channel may be considered flat. As a result, the length of the OFDM symbol must be shorter than the channel's coherence time (t_c), and the bandwidth of the subcarrier must be smaller than the channel's coherence bandwidth (f_c). By satisfying those requirements, decreased complicated receptors may be achieved [33].

2.2 OFDM System:

The orthogonal frequency division multiplexing (OFDM) scheme continues to be a multiable-wave modulating in addition to a multiplex scheme that makes use of a comparable processing technique that lets in simultaneous broadcasting of data with the association of numerous completely scattered orthogonal subcarriers. deformation is the most important enemy for all forms of communication devices as a result of multipath channel fading.

The use of orthogonal frequency division multiplexing enables transmission of data at very high speeds since the data rates are split into a few subcarriers. Orthogonal Frequency Division Multiplexing has numerous features, very excessive spectral efficiency, to lessen on-channel pulse noise, robustness towards same-channel and inter-symbol interference. Efficiency loss happens because of periodic prefix or safety period.

The OFDM scheme's efficiency is improved with the use of wavelet transformations. As well as multiplexing the signals collectively and decoding the data code via the receiver, the traditional OFDMA system relies on the (Fast Fourier Transform) mainly. In order to avoid inter-symbol and inter-carrier interference, the periodic prefix is sent before the transmission signals are sent out. The cyclic prefix is not anything however a cyclic extension of put off propagation. But, CP spectrum suppression of channels is decreased. Ripple Transforms are used as an opportunity platform to update the OFDM system primarily based totally at the FFT.

The discrete wavelet transformation is particularly utilized in OFDM system. It has a low-pass filter in addition to a high-pass filter this is useful as a quad replicate filter technology, and it meets the perfect regeneration in addition to the traits of orthogonal bases. This is likewise known as sub-band coding and then those indicators are disbursed into sub-indicators of low frequencies additionally correspondingly excessive.

In providing systems of wireless communication, wave calls require precious applicability, through channel characterization, interference modulation, modulation after which multiplexing, more than one get right of entry to connections, broadband connections (UWB), cognitive radio in addition to interaction [34]. (DWT) is a pariah in lots of sign processing applications, along

with through video compression, Internet communication compression, further to item reputation additionally numerical study [35].

2.3 Advantages and Drawbacks of OFDM:

This section outlines the advantages and disadvantages of multi-carrier modulation, which is mainly based on OFDM.

The most important features of OFDM is:

1. A large number of sub-carriers have a quasi-square frequency spectrum, resulting in high spectral performance.
2. The Fast Fourier Transform method may be easily digitally verified.
3. With a suitably long protection period, low-complexity receivers are achieved by avoiding inter-symbol and inter-carrier interference and thereby increasing the protection interval.
4. Through the use of slit filtering, it is possible to create a more flexible version to the spectrum.
5. Different modulation methods may be employed on different sub-carriers depending on the transmission condition of each sub-carrier.

The disadvantages of OFDM are:

1. The PAPR of multi-carrier indicators necessitates the use of large linear amplifiers. Other than that, overall performance will be degraded but functionality that isn't often available will be improved.
2. Inability to maintain spectral performance as a result of the protection interval.
3. Single-carrier modulated systems are more sensitive to Doppler spreads.
4. The entire system performance may be harmed by phase noise caused by malfunctions in the transmitter and reception oscillators.
5. Synchronization of frequency and timing with pinpoint accuracy is needed [38].

2.4 Data Compression:

The first universal information compression algorithms have been able to encode strings from separate information's with asymptotically most advantageous imply per symbol period without prior provided system Possibilities using these initial universal algorithms [5,6,7,8]. Clearly, such algorithms estimate both immediately or in a roundabout way the data with growing accuracy at the same time as the string is being encoded. The equal method may be stretch, as a minimum in precept, to all desk bound sources by using accumulating and longer segments the longer data. There may be a difficulty with the rapidly expanding variety of things to be saved, and fresh ideas are required to carry out the procedure in a nearly significant way while exercising. Ziv and Lempel have created the most comprehensive set of globally applicable rules to date [9]. Their stylish set of rules achieves asymptotically most advantageous reduction for strings created through any desk-bound ergodic source, and it does the task in many instances in a very potential way. Despite the researchers' focus on the limited system structure of their information compression system and the related belief in compressibility, the set of rules' actual electricity is its handy information accumulating capabilities to demonstrate this in addition to the restrictions of the technique, it recast their set of rules in a herbal statistical model similar to that one described by Rissanen and Langdon [10,11].

Data compression techniques are labeled into four classes which describe the impact a compression technique has at the shape of the signal transmitted. Compression techniques that have received preceding investigation, which include the geometric aperture techniques, in addition to strategies that have now no longer received an awful lot attention, which include Fourier filter, most effective discrete filter, and variable sampling rate compression, are described [12].

Data compression strategies had been used in lots of regions of communications inclusive of voice, video, and telemetry transmission. This paper is involved with compression strategies which might be beneficial for analog sign transmission, in which a discount within side the bandwidth required for sign transmission is received via way of means of decreasing sign redundancy. Thus, the sign may be reconstructed after transmission inside a special error. These strategies have developed on the whole from area telemetry requirements.

However, the techniques have software to greater mundane troubles inclusive of multichannel electrocardiograph and electroencephalograph transmission over telephone channels. The essential benefit of an adaptive statistics compression system is its cap potential to growth the bandwidth usage performance for incompletely special data. This is carried out via way of means of decreasing the data redundancy which always outcomes from conservatively selecting pattern rate-bandwidth mixtures for experimental data. Redundancy discount strategies are relevant even to acknowledged desk bound alerts due to the fact the most bandwidth frequency isn't always usually gift with inside the sign; thus, a few shape of time-various compression is possible [39].

2.5 Discrete Wavelet Transform:

Wavelet transform is a device for analyzing signals within side the joint time-frequency domains. So it's miles able to offering the time and frequency data simultaneously, for this reason giving a time-frequency illustration of the signal. Without the usage of cyclic prefix, the employment of wavelet ensures a reduction in inter symbol and inter-carrier interference in the Fast Fourier Transform Based Orthogonal Frequency Division Multiplexing system [40].

In modulation and demodulation processes, the (DWT) transceiver is similar to the most effective FFT OFDM transceiver (inverse discrete wavelet transform) and (discrete wavelet transform), updating the (Inverse Fast Fourier Transform)

and (Fast Fourier Transform) of the traditional FFT based OFDM system. The inverse discrete wavelet transform's result is expressed by the following equation:

$$d(k) = \sum_{m=0}^{\infty} \sum_{n=0}^{\infty} D_m^n 2^m / 2\Psi(2^m_k - n) \quad (2.1)$$

Where $\psi(t)$ is the wavelet function with compressed element m instances and shifted n instances for every subcarrier (number k , $0 \leq k \leq N - 1$) and D_m^n are the wavelet coefficients. The signals in scale and location or time are represented by wavelet coefficients [41].

$$D_m^n = \sum_{k=0}^{N-1} d(k) 2^m / 2\Psi(2^m_k - n) \quad (2.2)$$

While FFT-OFDM has several benefits over Wavelet-based total (OFDM), researchers have shown that replacing it with Wavelet-based total (OFDM) systems is a more efficient solution. Because Cyclic Prefix isn't always needed in this scenario and the suggested machine provides almost the best reconstruction, (Discrete Wavelet Transform) based only on (Orthogonal Frequency Division Multiplexing) has the potential to reduce hardware complexity.

DWT is a powerful device for taking a look at the indicators in the time frequency joint domain, this reason it's so useful is that it can provide information on both time and frequency at the same time. In both the temporal and frequency range, wavelets have a compact localization and greater orthogonality. In order to combat narrowband interference, the (Discrete Wavelet Transform) relies entirely on (OFDM).

This is because wavelets have excessive spectral confinement characteristics, making the system more robust against inter-carrier interference than (FFT realization). Because DWT OFDM systems do not use cyclic prefix, their data rates are greater than those of FFT OFDM systems. OFDM employs wavelet transform to save transmission power by eliminating the need of cyclic prefix, this saves bandwidth and reduces transmission loss. The DWT-OFDM channel spectral confinement is greater than the FFT- OFDM's.

In OFDM systems, the discrete wavelet transform is an opportunity method for updating the Inverse Fast Fourier Transform and the Fast Fourier Transform. With

the Wavelet transform, the desired sign is broken down into a collection of foundational waveforms known as Wavelets, which reveals how to interpret the signals by studying Wavelet coefficients. Numerous applications make use of the Discrete Wavelet Transform, which has grown in popularity among engineers, technologists, and mathematicians alike.

Wavelet transform's basic capabilities are restricted in time and frequency, and each domain name has its own unique resolution, making wavelet transforms useful in a wide range of applications. The investigation of system behavior and transform power corresponds to different resolutions. As a result of these characteristics, the wavelets and wavelet transform have applications in a wide range of fields, such as image and data compression; radar; astronomy; human vision; nuclear engineering; acoustics; biomedical engineering; music; seismology; turbulence; magnetic resonance imaging; fractals; and natural mathematics. Since wavelet transform offers numerous advantages, such as flexibility, reduced susceptibility to channel distortion and interference, and better spectrum utilization, it has been proposed for the design of cutting-edge wireless communication systems.

Wavelets have many applications in wireless communication systems, including channel modelling, information visualisation, transceiver architecture, and supply and channel coding, information compression, interference reduction, and strong green networking. An ortho-regular low-pass and high-pass filter is hired to function as a QMF that provides ideal reconstruction. This kind of Orthogonal Frequency Division Multiplexing uses zero padding and vector transposing to transport the modulated signal. Discrete Wavelet Transform is described as a flexible and environmentally friendly signal decomposition method.

DWT primarily based totally OFDM is a good technique to update FFT in traditional OFDM systems. DWT has been employed to remove the use of cyclic prefix, which reduces bandwidth waste, and to reduce transmission power by using wavelet transforms. DWT-OFDM has better channel spectral confinement

than FFT-OFDM. It is possible to interpret the indicators using wavelet coefficients by decomposing the input signal into a collection of waveform foundations known as wavelets in the Wavelet Transform process. DWT has become well-known among engineers, technologists, and mathematicians for its widespread use in many applications. Wavelet transform's basic capabilities are localized in time and frequency, and each domain name has its own unique resolution, making wavelet transforms an effective device in many applications [42].

Wavelet Transform is a transformation that separates the frequency additions in an input signal into high- and low-frequency components. A technique called as multi-decision analysis is used to evaluate these decomposed frequency additions with changing time and frequency choice [43,44].

For a better understanding of wavelet transform's core software, it's necessary to first grasp some of the most basic standards. A transform is carried out to the enter sign (this is normally in time domain) to get beneficial information that isn't always to be had in its raw pattern. Frequency domain indicates which unique frequency additives exist inside the signal, whereas time area provides the unique temporal information of a frequency factor [45].

There are many transforms available, the most well-known of which being the Fourier transform. When applied to a time domain signal, the Fourier transform only provides information on the occurrences of a single frequency factor and does not provide any temporal information. For this reason, Fourier transform is only useful for desk-bound indicators since its frequency contents no longer expand with time and therefore contain all frequency additives in any respect of time and do not need any more time data.

The effectiveness of a permanent sign has been shown at figure (2.2). There are unique frequency additions for non-desk bound indications that only exist at certain times and require time and frequency data that the Fourier transform cannot supply. This means that Fourier transform may not be suitable for signals

that are not desk constrained, such as the chirp signal shown in figure (2.3). Finally, the Fourier transform merely shows the sign's frequency as an image using Fourier transform [46].

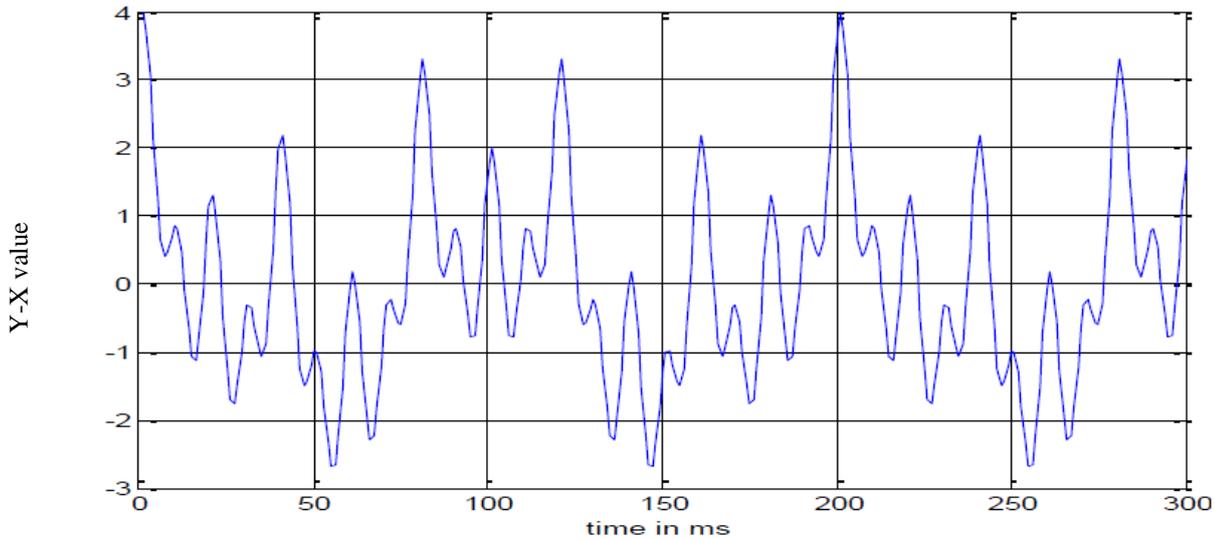


Figure (2.1) stable signal [47]

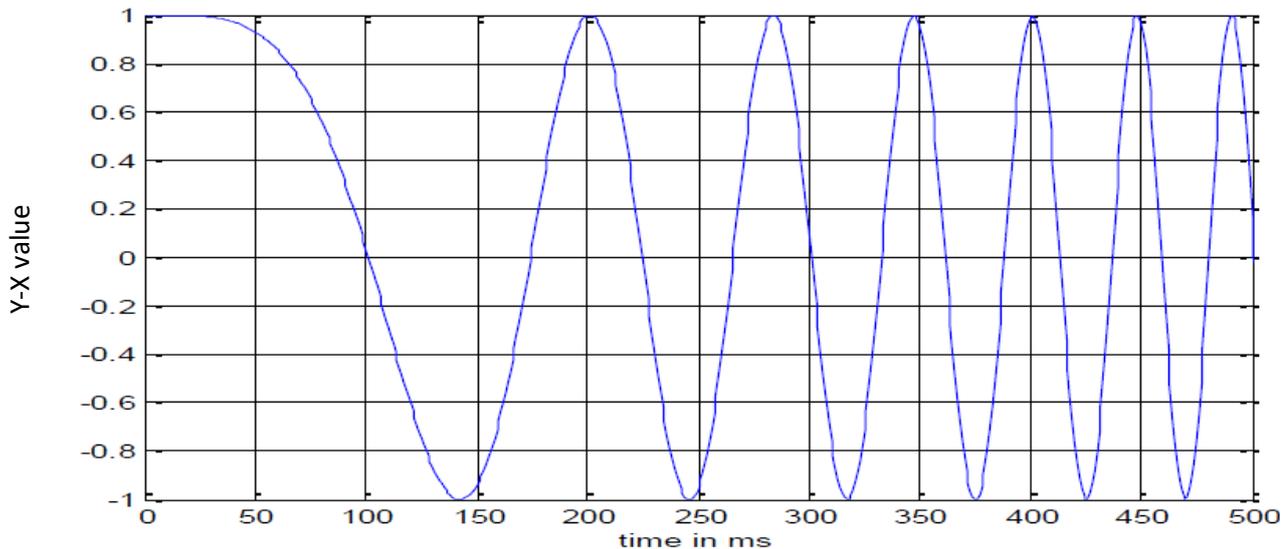


Figure (2.2) Unstable Signals [47]

In order to discover a selected frequency element, a transform is needed that offers an illustration of the time frequency. Wavelet transform (WT), is a change that

offers time and frequency data for a sign simultaneously [46, 47]. This conversion is in particular beneficial whilst sure frequency additives of a sign gift at a selected time want to be processed. Other transformations along with the Short Time Fourier Transform (STFT) additionally offer a time-frequency illustration of the sign, however with steady accuracy [46].

Wavelet transform is favored over STFT as it affords a time-frequency illustration with variable decision that facilitates to perceive time data for a selected frequency thing extra easily [46, 48]. Referring to the dedication of the place of a selected frequency thing, the presence of a selected frequency thing can't be decided in time, known as the uncertainty principle [46].

According to this principle, handiest the time frame at some stage in which a selected frequency thing is gift may be investigated. Because Wavelet Transform affords variable decision, high-frequency sign additives with short time durations have higher temporal decision [43, 46, 48]. On the other hand, low-frequency additives with long time durations have better decision-making ability. As a result, the frequency components have varying degrees of spatial and temporal resolution. [43, 46, 47, 48].

2.6 The Wireless Channels Outlines

Wireless communications generally refer to any form of transfer of information from one station to another without the physical wire connection between them. any form of communication over the air is located in the term "wireless communication". In modern times, is usually associated with the transmission of electronic information through the spread of electromagnetic waves [1]. The channel is referred to as electromagnetic media stuck Between transmitter and receiver [32].

The received signal in an ideal radio channel will compose of only one path signal which will be the perfect reconstruction of the transmitted signal. However, the signal is modified through transmission in the channel in a real channel. The

received signal is made of a set of deflection replicas for the transmitted signal, refracted, reflected, and attenuated. In addition, Associated delays paths of different signal in multi-path fading channel Change is unpredictable and can only be statistically characterized. Noise is added by the channel to the signal. On top of all this and If the receiver or transmitter is moving it can make a shift in the frequency of carrier which known as the Doppler Effect [49].

2.6.1 Rayleigh Fading Channel:

Rayleigh fading is a statistical version used by wireless devices to analyse the effect of propagation on a radio transmission. According to Rayleigh fading theories, the importance of a signal sent through a particular transmission medium would fluctuate randomly or diminish in accordance with a Rayleigh distribution. Rayleigh fading is an inexpensive type in which the radio signal is scattered by a large number of devices outside the receiving environment before it reaches the receiver. However, if there is no significant scattering factor, then this method may not have a proposal and can be randomly divided into zero and two radians. Calling this random variable R , it will have the advantage of chance density [50]

$$P_R(r) = \frac{2r}{\Omega} e^{-r^2/\Omega}, \quad r \geq 0 \quad (2.3)$$

Where,

$$\Omega = E(R^2)$$

2.6.2 Additive White Gaussian Noise Channel:

Additive white Gaussian noise channel is a regularly occurring channel type for studying modulation schemes. This type of channel, it does nothing but send a white Gaussian noise via it to any signs going across it. There is no amplitude loss and no segment distortion in the modulated signal since the channel's amplitude frequency reaction is flat (thus it has an infinite or unlimited bandwidth) and the segment frequency response is linear for all frequencies. AWGN channel is a

theoretical channel used for evaluation reason only. The received signal within side the c language of $0 \leq t \leq T$ can be expressed as:

$$R(t)=S(t)+ n(t) \quad (2.4)$$

Where $n(t)$ denotes the pattern feature of additive white Gaussian noise channel technique with power spectral density [51]

2.7 The Estimation of Channel

At the receiver facet, Channel estimation is applied. Is an estimation of the attenuation of the channel due to the wireless channel of the to be had referenced signals, the channel equalization is executed with the envisioned channel information to Reparation of signal distortion received [52] .

Channel estimation is a key era in enhancing the overall performance of the orthogonal frequency department multiplexing (OFDM) system [53]. Channel estimation can put together in now no longer the equal techniques without or with assist from a border model. By the use of time correlation or radio frequency traits on radio channel. Adaptive or non-adaptive techniques or Blind or education experimental techniques.

Informal techniques try to Estimation of hobby quantities without model of counting on a selected channel. On the contrary, the parameter estimate adopts a model with a given channel and defines the parameters of this model and concludes the vital quantities. Time-sure and frequency-spaced hyperlinks are particular traits of channel may be mixed into Estimation approach to enhance grading quality. Evaluation techniques primarily based totally on pilot education are the maximum extensively used techniques.

They are relevant to systems wherein a transmitter sends a positive regarded signal. The blind estimate however is predicated on positive signal properties (e.g. periodic bending of signal) and is regularly utilized in operational OFDM systems. In channels that alternate speedy and in a well-timed manner, adaptive estimation techniques are usually used.

The channel estimate may be completed through pilot pilots both through getting into experimental characters in all OFDM sub-carriers with a distinct duration or through placing experimental tones in every OFDM code. The first class is called "channel estimation" primarily based totally on pilot pilots and has been advanced in keeping with the slow-fade channel hypothesis.

This kind of experimental association works nicely, whilst the channel switch characteristic does now no longer alternate very speedy. The second class, an association of the pilots, may be without difficulty used to reveal the short channels. In comb arrangements, every OFDM code has a few experimental tones; for this, it really works best in very variable environments [54].

CHAPTER THREE
PROPOSED MULTICARRIER SYSTEM
DESIGN

Chapter Three

Proposed Multicarrier System Design

3.1 Proposed Multicarrier System

The data was entered on s/p converter and then entered on (32QAM Modulation). the output of (32QAM Modulation) with the (pilots carrier generator) was entered on IFFT, where the result is entered on the DWT, and therefore half of the quantity will be taken here, meaning the approximate will be taken and the details will be neglected because the approximate contains the best frequencies.

The transmitted signal is entered on P/S and then on CP, and then it enters the channel used, which is the (AWGN) and thus the transmission process is completed. While upon receipt, the CP will be removed and entered on s/p, and then zeroes will be added to compensate for the deletes that were deleted when sending, and it will also enter the half-router on IDWT in order to reverse the process that occurred when sending and then enter FFT and Channel estimation and thus enter (32 QAM Modulation) Hence on P/S converter and thus output data, can show in fig (3.1) .

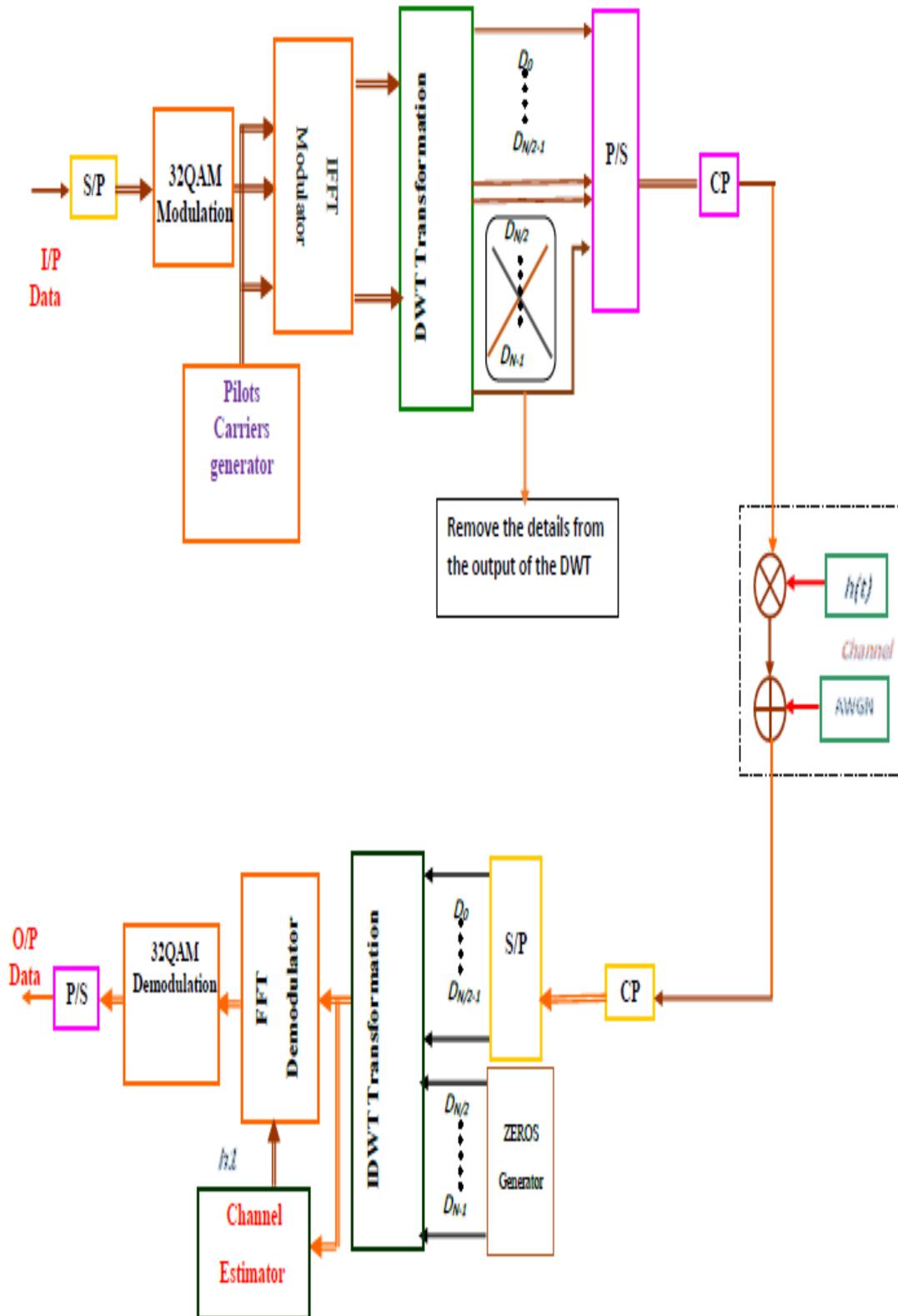


Figure (3.10) the proposed system structure.

Fig. (3.1) indicates the proposed system structure. The entire information movement is modulated, which generates modulation symbols, then those modulated symbols ship to serial to parallel (S/P) conversion. The output of the (S/P) is supplied to multicarrier modulator through the use of inverse discrete Fourier transformation rapid Fourier al (IFFT). The output symbols of IFFT are processed through Discrete wavelet transformation DWT. After this operation the approximation coefficients of DWT are pick and discard the element coefficient. This operation is proposed concept in the back of proposed system. After this operation is observed through the addition of a CP, parallel to serial (P/S) conversion, and transmission over the channel. Since the radio channel is time varying, dynamic estimation of the channel situations is necessary.

There are forms of channel estimation: block-kind pilot and comb-kind pilot. Both estimate the channel impulse responses $h(t)$ with the assist of pilot signals which might be inserted earlier than the IFFT block. At the receiver side, the inverse operations are completed commenced from delivered zeroes rather than element coefficient of IDWT as proven in fig (3.1) in receiver side. After the operation of IDWT and FFT method wireless channel $h(t)$ are estimated. This operation like in multicarrier OFDM system, the DFT symbols period recollect as T , bandwidth 20MHz, spanning takes the values $N_s = 512, 1024$ and 2048 samples (equal to 2048 sub-carriers of OFDM) to be transmitted in distinct sub-bands.

$$y(k; n) = \sum_{M=1}^2 H_M(k) s_M(k; n) + z(k; n) \quad (3.1)$$

where $z(k, n)$ is a complex-valued additive white Gaussian noise vector with entities of zero mean and variance σ_z^2 ; $H(k)$ denotes the channel frequency response according to the AWGN and Rayleigh channel model. The channel assumed that certain frequency band keeps constant within the time interval of N OFDM symbols. The (i, j) the element of $H(k)$ is given by

$$[H(k)]_{i,j} = X \sum_{l \geq 0} \sum_{m \geq 0} \alpha_{m,l}^{i,j} e^{-j2\pi k \Delta f (T_l^{i,j} + \tau_{m,l}^{i,j})} \quad (3.2)$$

where Δf is the frequency separation between two adjacent subcarriers; $\alpha_{m,l}^{i,j}$ is the multipath gain for cluster l and ray m between the j_{th} transmit antenna and the i_{th} receive antenna; the l th cluster arrives at $T_l^{i,j}$ and its k th ray arrives at $\tau_{m,l}^{i,j}$; X represents the Rayleigh's distributed random variable for shadowing, i.e., $20 \log_{10} X \propto N(0, \sigma_X^2)$, while the total energy contained in the terms $\alpha_{m,l}^{i,j}$, $\forall m, l$ for each couple (i, j) , is normalized to unity for each channel realization. For simplicity of notation, the indices of k and n , and denote $h_{i,j} = [H(k)]_{i,j}$ and $c_{i,j} =$

$$\sum_{l \geq 0} \sum_{m \geq 0} \alpha_{m,l}^{i,j} e^{-j2\pi k \Delta f (T_l^{i,j} + \tau_{m,l}^{i,j})}, \text{ respectively. Thus, it shows that}$$

$$h_{i,j} = X c_{i,j} \quad (3.3)$$

When the Alamut coding is applied, the system is equivalent to independent single-input single-output systems defined as

$$u_j = \phi d_j + \zeta_j \quad (3.4)$$

Where $\phi = \sum_{i=1}^2 \sum_{j=1}^2 |h_{i,j}|^2$, d_j denote original symbols before spreading and ζ_j is an equivalent complex Gaussian random variable with zero mean and variance $\phi \sigma_Z^2$, it can rewrite $\phi = \sum_{i=1}^2 \sum_{j=1}^2 |c_{i,j}|^2$. Therefore, the output signal to noise ratio (SNR) can be expressed as

$$\gamma = \frac{\rho_s}{\sigma_z^2} X^2 \chi \quad (3.5)$$

Where $\chi = \sum_{i=1}^2 \sum_{j=1}^2 |c_{i,j}|^2$ and ρ_s denotes the averaged power of transmitted symbols. Therefore, the SNR, (S/N), at the output of receiver, can be written as

$$\left(\text{SNR} = \frac{E\{X_I | \alpha_I^{(1)}\}^2}{\text{VAR}\{X_I | \alpha_I^{(1)}\}} \right) \equiv N^2 E_C \gamma \quad (3.6)$$

For 16QAM signaling, the evaluation of average BER for different scenarios can be approximately achieved by

$$\begin{aligned}
P_{\text{BER}}^{\text{su}} &= \int_0^{\infty} Q \left\{ \frac{E(\xi_U)}{\sqrt{\text{VAR}(\xi_U)}} \right\} f(\alpha^{(1)}) \overbrace{d\alpha_1^{(1)} \dots d\alpha_M^{(1)}}^{\text{M folds}} \\
&= \int_0^{\infty} Q(\sqrt{N^2 E_{c\gamma su}}) f_{\gamma}(\gamma_{su}) d(\delta_{su}) \tag{3.7}
\end{aligned}$$

The $Q(x)$ in (3.7) is the Gaussian Q-function. Hereafter, the average BER of a Multicarrier system over fading channel can be calculated from (3.7).

3.2 Multi Carrier System

A single record's circulation is broadcast across a few low-rate sub-carriers using Orthogonal Frequency Division Multiplexing, a unique instance of multicarrier transmission. It is possible to transmit symbols using orthogonal subcarriers in parallel by using the concept of (Orthogonal Frequency Division Multiplexing), which divides the total transmission bandwidth into some orthogonal subcarriers. Orthogonal Frequency Division Multiplexing has turn out the premise for many telecommunications requirements along with wireless nearby place networks (LAN), digital terrestrial television (DTT), and digital broadcasting in maximum elements of the world.

When entering data, the Orthogonal Frequency Division Multiplexing signal is modulated using rectangular amplitude modulation. In this case, rectangular amplitude modulation(QAM) is applied due to its superior ability to maintain bandwidth. After appearing the serial-to-parallel transformation and mapping the symbols to orthogonal subcarriers the use of Fast Fourier Transform Inverse. After the sequential transformation is parallelized, the periodic prefix is added. The periodic prefix is beneficial in retaining orthogonality and for that reason allows to remove inter-carrier interference; It furthermore removes the impact of symbol interleaving. The periodic prefix is removed at the receiver end, and the serial-to-parallel conversion is accomplished. Then the Fast Fourier Convert of each symbol is used to transform the received signal returned to the frequency

domain. Then, through estimating the appropriate channel and the equation of the authentic transmitted spectrum.

Subsequently, the parallel transformation is completed with the serial transformation, and ultimately the extraction is completed. Figure (3.2) the overall schematic diagram of the baseband time-discrete block of an OFDM transceiver that depicts the technique defined as shown below.

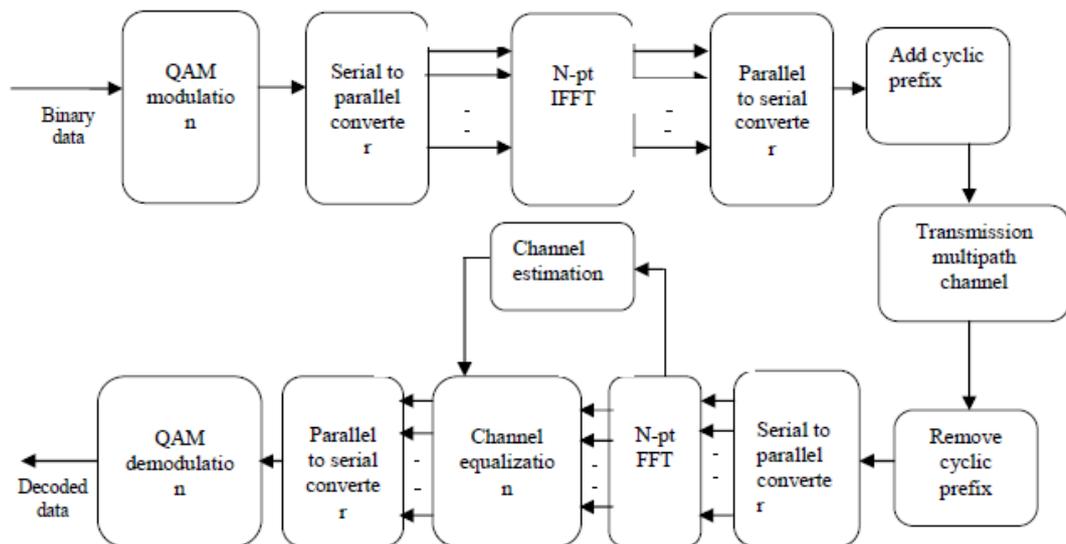


Figure (3.2) Block diagram of Multicarrier system

As a result of time-varying channel characteristics in wireless communication systems, Orthogonal Frequency Division Multiplexing (OFDM) dependability is limited and this causes interference between symbols and between carriers. It is possible to prevent inter-symbol and inter-carrier interference by prefixing each Orthogonal Frequency Division Multiplexing data block with a periodic prefix. Cyclic prefix, on the other hand, causes a reduction in transmission power and a reduction in bandwidth efficiency.

Orthogonal Frequency Division Multiplexing systems utilize Inverse Fast Fourier Transform and Fast Fourier Transform to generate and discover orthogonal subcarriers. Although those transformations lessen application intricacy and are greater Arithmetic efficiency, they have got flaws that bring

about the introduction of excessive aspect lobes because of using a square window. More importantly, since the pulse modulation function that is employed to modulate each subcarrier extends indefinitely into the frequency range, there is a lot of interference and the performance levels are lower.

Furthermore, the high peak-to-common power ratio causes intermodulation distortion within the broadcast signal in the Fast Fourier Transform based totally Orthogonal Frequency Division Multiplexing system.

There are numerous researchers who have tested using wave-based totally OFDM to update the Fast Fourier Transform based totally Orthogonal Frequency Division Multiplexing system because of the weaknesses of the former; they discovered that the former has advantages over Fast Fourier Transform based totally OFDM.

OFDM uses discrete wavelet transform and inverse discrete wavelet transform to modify just the Inverse Fast Fourier Transform and Fast Fourier Transform blocks. Shunting of Wavelet lowers the sensitivity of the sent signal to inter-carrier interference by providing less side lobes in the broadcast signal. Orthogonal Frequency Division Multiplexing based on DWT technology differs from FFT-OFDM in that FFT-OFDM signals only overlap in the frequency domain whereas DWT-OFDM signals overlap in both the time and frequency ranges simultaneously. Fast Fourier Transform Orthogonal Frequency Division Multiplexing (FFT-OFDM) systems often use Cyclic prefix or any type of shield interval (GI) to avoid utilizing DWT-OFDM temporal overlap. Thus, the channel's spectrum health is improved in Discrete Wavelet Transform-based Orthogonal Frequency Division Multiplexing, since it no longer employs Cyclic prefixes.

3.2.1 Multicarrier Transmitter

The transmitter facet of the Orthogonal Frequency Division Multiplexing system. Using a single QAM and dividing it into N low bit streams through a serial to

parallel transformer reduces the computational complexity of the system compared to first splitting the data into N data streams and then using N modulators for N sub-carriers in the discrete frequency range. Every data stream is sent at an extraordinary high subcarrier frequency. for N data flows vary from $X [0]$ up to $X [N-1]$. The IFFT method is then used to transformed these N low bit frequency additions into time samples as shown in figure (3.3).

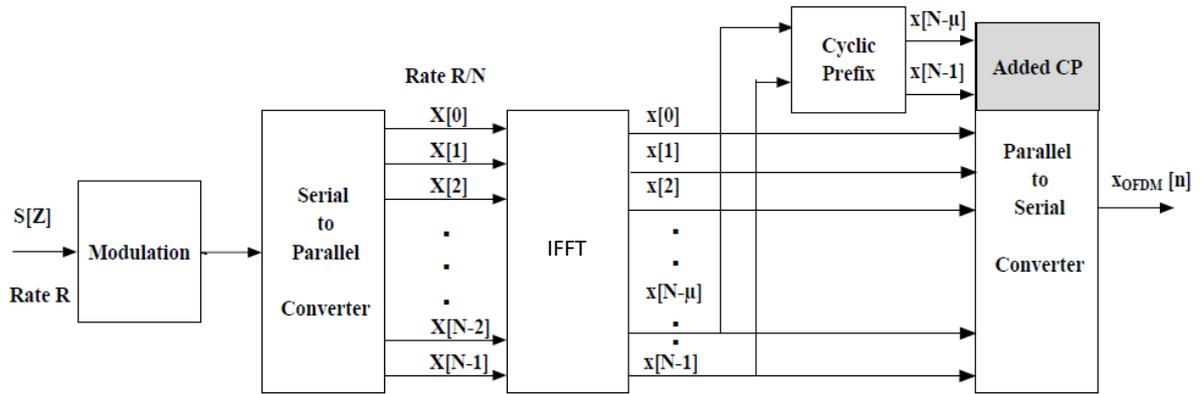


Figure (3.3) Transmitting side of Multicarrier system

Sequencing the parallel data symbols from the IFFT block is as follows: $X [0]$, $X [1]$, $X [2]$..., $X [N-2]$, $X [N-1]$ characterized by,

$$\text{IFFT}\{X[K]\}=X[N]=\mathbf{1}/\sqrt{N} \sum_{k=0}^{N-1} X [Z] e^{j2\pi kn/N} \quad \mathbf{0} < n \leq N - \mathbf{1} \quad (3.8)$$

It's important to understand this part of the equation (3.8) indicates the total number of orthogonal frequency division multiplexing (OFDM) data flows $X [K]$ modulating with QAM, where $K = 0, 1, 2, \dots, N-1$, each with an extraordinary carrier frequency. Inverse Fast Fourier Transform block data streams are transformed into serial layout once again by parallel to serial converter. To avoid Inter symbol interference, which is interference between two adjacent Orthogonal Frequency Division Multiplexing symbols, a cyclic prefix of period is given at the beginning of the Orthogonal Frequency Division Multiplexing symbol, resulting

3.2.1.2 Zero padding

An Ultra Wide-band (UWB) system uses multiband-OFDM (MB-OFDM) to implement this specific technique. Figure (3.5) display Orthogonal Frequency Division Multiplexing with zero padding and the inter-carrier interference impact of a multipath channel on Orthogonal Frequency Division Multiplexing for every subcarrier respectively. When ZP is longer than the multipath channel's maximum put off, a tiny symbol time offset (STO) results in an OFDM symbol with a strong length having a discontinuity in the FFT window. Because of this, a portion of the next OFDM symbols protect c programmer language period is copied and pasted into the pinnacle portion of the present symbol to help you avoid ICI. Real period of an OFDM symbol with ZP is shorter as compared to an OFDM symbol with CP or CS due to ZP's fullness of zeroes. To make room for a larger sinc-kind spectrum, the period of a transmission square window is also reduced. As a result, an OFDM symbol including ZP has PSD (Power Spectral Density) that has lesser in-band ripple and more out-of-band power than an OFDM symbol containing either CP or CS. This allows for additional transmission power to be used while keeping the height transmission power constant. we can see that the OFDM symbol's information rate has decreased by

$$T_{sym}/T_{sym}(G) = T_{sym}/(T_{sym}+T_G)$$

times because of the protect c program language period [73].

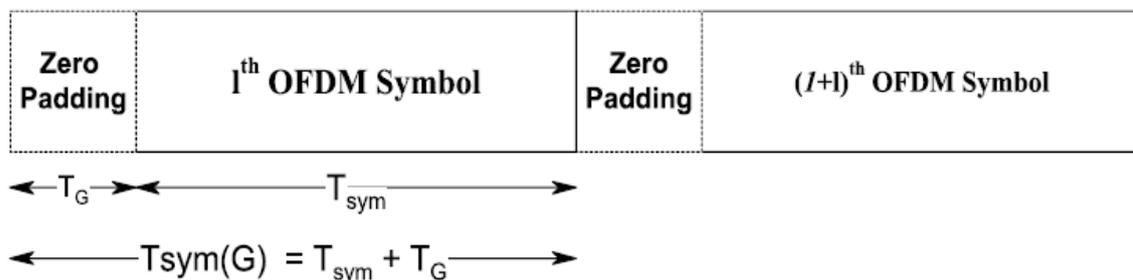


Figure (3.5) OFDM symbol with zero padding

3.2.2 Multicarrier Receiver

When CP is added, the data is sent to the receiver through the channel, which brings noise to it. The receiving side of the OFDM system is shown in Fig. (3.6) Data receiver symbols $Y_{OFDM}[n]=Y[N-\mu], Y[M-\mu+1], \dots, Y[N-1], Y[0] Y[1] \dots, Y[N-1]$, the period's cyclic prefix is removed, and inter-symbol interference loose information is obtained. The multipath fading, influences best the information observed in the shield duration this is eliminated on the receiving aspect giving ISI loose information symbols. Fast Fourier Transform procedures described in Eq. (3.9) are used to these information symbols once they have been converted from serial to parallel layout, as

$$\text{FFT}\{Y[n]\}=\hat{S}[K]=M[K]=1/\sqrt{N}\sum_{n=0}^{N-1}Y[n]e^{-\frac{2\pi jkn}{N}} \quad 0 \leq K \leq N-1 \quad (3.9)$$

The ensuing frequency additives out of Fast Fourier Transform block are parallel to serial transformed after which demodulated through QAM demodulator to get better the unique transmitted information streams.

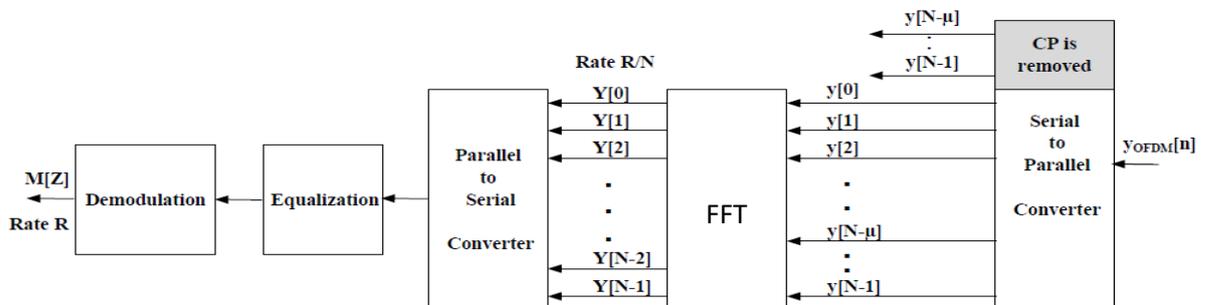


Figure (3.6) Receiving side of multicarrier system

3.3 Channel and data equalization

During wireless communication, information is transmitted among the transmitter and receiver. It suffers from multipath reversals. These multipath reflections can be because of Buildings or another barrier among the transmitter and receiver. fades away Due to more than one reflections, it impacts the sign and creates fluctuations in its amplitude and stage. Multipath fading channels motive

fluctuations in The transmitted signals are regularly categorized as rapid fading, gradual fading, frequency Selective fading and flat fading primarily based totally on consistency in bandwidth and put off Channel propagation. Figure (3.7) indicates that the signal $X_{\text{OFDM}}[n]$ this is transmitted via the channel $h[n]$ with Noise $n_{\text{noise}}[n]$ delivered to it with the ensuing output $y_{\text{OFDM}}[n]$, wherein $0 \leq n \leq N-1$ and N is the overall quantity of samples. More information about baht channels are mentioned with inside the segment 2.6. The output $y_{\text{OFDM}}[n]$ may be written as.

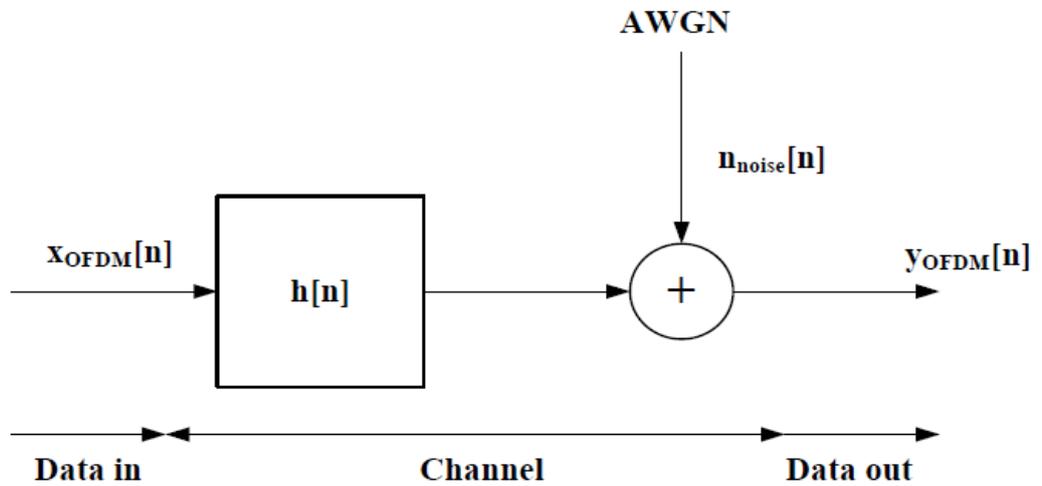


Figure (3.7) Data $x[i]$ passing through channel $h[i]$ with result $y[i]$

$$Y_{\text{OFDM}}[n] = X_{\text{OFDM}}[n] * h[n] + n_{\text{noise}}[n] \quad (3.10)$$

Time samples $y_{\text{OFDM}}[n]$ after CP elimination are transformed to a frequency domain $Y[Z]$ Through the DFT algorithm, in which $0 \leq Z \leq N-1$. The above equation is in frequency The domain may be written as

$$Y[Z] = X[Z] * H[Z] + N_{\text{noise}}[Z] \quad (3.11)$$

In order to get the expected transmitted facts streams $\hat{S}[Z]$, the signal $Y[Z]$ obtained from EQ. (3.9) is extended via way of means of the inverse of the channel switch feature $H[Z]$. this system It is known as an equation, and it seems mathematically as

$$\hat{S}[z] = M[Z] = Y[Z] * H^{-1}[Z] = (X[Z] * H[Z] + N_{\text{noise}}[Z]) * H^{-1}[Z] \quad (3.12)$$

$$\hat{S}[z]=M[Z]=X[Z]+N_{\text{noise}}[z] \times H^{-1}[z] \quad (3.13)$$

where,

$$N'_{\text{noise}}[z] = N_{\text{noise}}[z] \times H^{-1}[z] \quad (3.14)$$

Substituting equation (3.14) in equation (3.13)

$$\hat{S}[z]=X[Z]+N'_{\text{noise}}[z] \quad (3.15)$$

3.3.1 Fading Channels

In wireless communication, the enter information signal transmitted over a cell radio channel constantly suffers from the outcomes of fading. This fading influences the signal via way of means of inflicting fluctuations in its amplitude and phase. There are distinctive forms of fading that depend upon each signal parameters and channel, the channel traits consist of multipath time postpone unfold and Doppler shift. The temporal dispersion is because of the propagation of the multipath postpone ISI, which in flip reasons the transmitted signals to fade. This fading can be both a static fading or a frequency selective fading. Similarly, Doppler diffusion, which reasons frequency dispersal.

3.3.2 Additive White Gaussian Noise

Additive white Gaussian noise zero- imply white Gaussian Noise has the same spectral density at all frequencies. The term "white" is used in the experiment to indicate that white light contains identical amounts of all frequencies within the visible range of electromagnetic radiation. With the inverse Fourier transform of the noise intensity spectral density AWGN(f), the WGN autocorrelation characteristic is revealed: This function's autocorrelation value is zero at time $t \neq 0$. As a result, any unusual WGN samples, no matter how close in time they were collected together, are unconnected. The amplitude of 'integrated' (bandwidth) WGN has a Gaussian probability density distribution $P(WGN_i)$. Even with radio, which uses an analogue physical channel, noise is there. thermal noise, electric

noise within receiver amplifiers, and inter-cell interference all need to be addressed.

Inter-Symbol Interference, Inter Carrier Interference, and Inter-Modulation Distortion may all create noise inside a communications system. Because to these noise reaffirmations, the Signal to Noise Ratio (SNR) is reduced, which limits the system's spectral performance. Maximum radio communication methods are plagued with noise as their primary drawback.

In radio communication systems, almost all kinds of noise may be modelled by using AWGN. This noise has a Gaussian amplitude distribution and a homogeneous spectral density. AWGN can simulate thermal and electric noise from amplifiers as it should be, letting them be modeled as it should be with AWGN. In addition, the majority of noise reassessments have AWGN residences due to OFDM transmission. Given a high number of carriers, OFDM signals have a flat spectral density and a Gaussian amplitude distribution, resulting in inter-cell interference with AWGN residences from various OFDM systems. ICI, ISI, and IMD all have AWGN homes for OFDM signals for the same reason.

3.3.3 Flat and Frequency Selective Fading

If the channel bandwidth is extra than the signal bandwidth, the signal suffers from steady fading. Flat fading protects the spectral houses of the signal however may also reason an extrude in signal depth. This extrude in signal electricity is because of fluctuation in channel benefit because of multipath reflections. Definitely flat fading is skilled when,

$$B_s \ll B_c \quad (3.16)$$

Or

$$T_s \ll 6_M \quad (3.17)$$

Where B_s the signal bandwidth, B_c , channel bandwidth, T_s , signal 6_M code period and postpone propagation of the multipath channel. As T_s with reciprocity

BS, the above courting may be effortlessly understood. The channel bandwidth is considerably less than the transmitted signal's bandwidth when using frequency selective fading. on other words, a multipath postpone unfolds for longer than the signal code period. Inter symbol interference occurs when a frequency selective fading receiver receives several copies of the broadcast signal, each with its own unique time delay, This results in a distorted signal. Consequently, the use of frequency selective fading happens while:

$$B_s \gg B_c \quad (3.18)$$

or

$$T_s < 6M \quad (3.19)$$

The phrases for flat fading and frequency selective fading are at the contrary, as evidenced through the above equations.

3.3.4 Multipath Fading

There are two types of fading in a radio propagation channel: big range and tiny range. Big signal fading is attenuation due to loss of direction over large distances and shading results and is well represented by daily models. Tiny domain fading takes place with inside the variety of the signal wavelength and is a great deal greater random than big domain fading. Small-scale fading is particularly the final consequence of more than one multipath additives present process constructive/adverse interference at any moment. When there's no line of sight (LOS) problem between the transmitter and the receiver, the received energy follows a Rayleigh distribution and may seem to have a Rayleigh fading envelope.

3.4 Wavelet Multicarrier System

A wave is an uneven, asymmetric, and oscillating tiny wave with a median cost of zero, which has a short wavelength. As a result of the constrained wavelet carrier time duration, wavelet filters may scan a large signal's preferred neighborhood location using multi-decision analysis. Wavelet Transform analyzes the enter records signal into the transmitted and measured replica of the mom wave. Wavelet calculates the opposite and ahead conversion via way of means of filtering a separate signal via the scaling and wavelet features the usage of a low-by skip clear out $G(Z)$, and a high-by skip clear out $H(Z)$ respectively.

In opposite transfer $G(Z)$ and $H(Z)$, act as synthetic clear out financial institution and in ahead transfer they act as clear out financial institution for analysis. Wavelet Transform, via its clear out banks, affords the correct refactoring assets via way of means of pleasurable conditions, which might be given in Eq. 3.20 and eq. 3.21 as

$$G_0(-z) G_1(z) + H_0(-z) H_1(z) = 0 \quad (3.20)$$

$$G_0(z) G_1(z) + H_0(z) H_1(z) = 2Z^{-d} \quad (3.21)$$

In this case, $G_0(z)$ is the low value and $H_0(z)$ is the excessive value as determined by skip synthesis filters, whereas $G_1(z)$ and $H_1(z)$ are the low values as determined by skip evaluation filters. Figure 3.11 and 3.12 display those clear out banks with stages of wavelet transformation with down sampling and down sampling through the transmitting and receiving aspects accordingly assembly the Nyquist criteria. The first circumstance referred to within side the equation. 3.20 Sets the reconstruction, loose from the results of aliasing and the second one circumstance in Eq. 3.14 refers back to the amplitude distortion same to one.

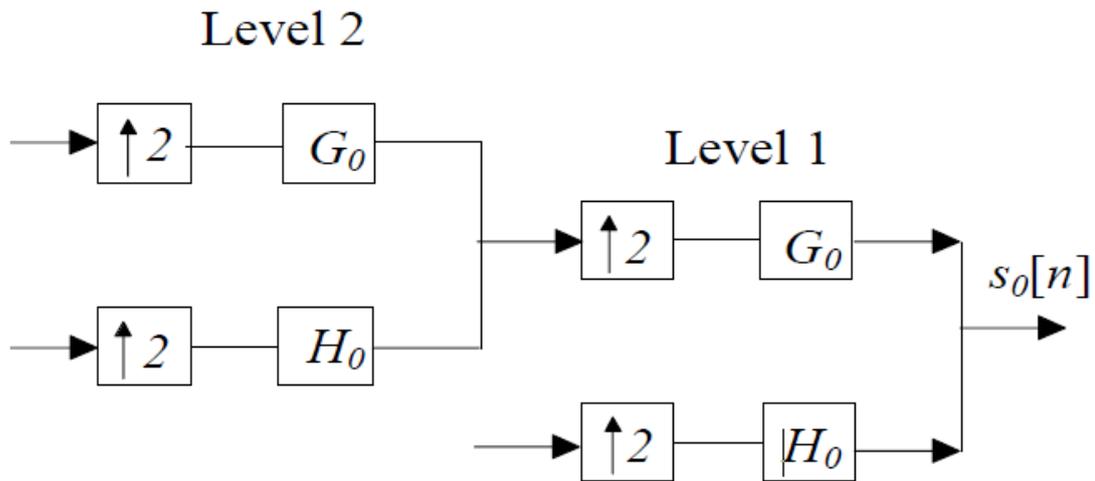


Figure (3.8) WOFDM transmission side with synthesis filter bank

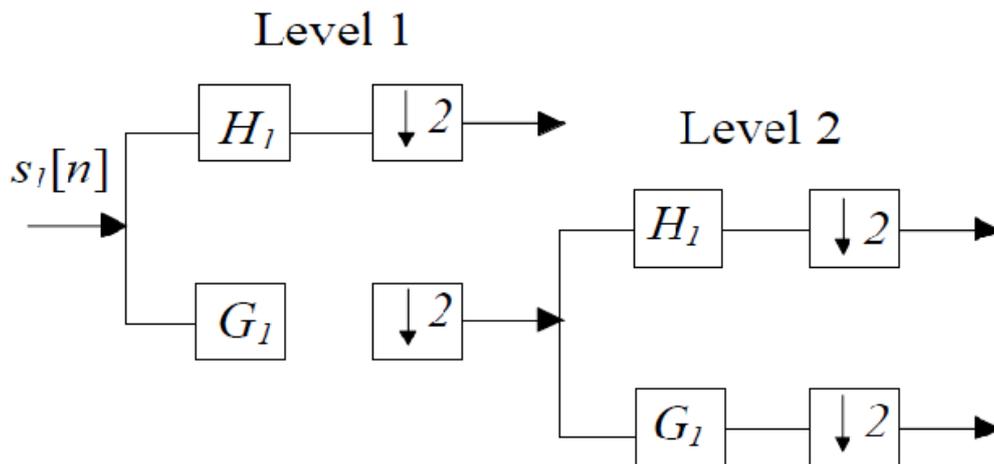


Figure (3.9): WOFDM receiving side with a bank of analysis filters

The Wavelet-primarily based totally OFDM (WP-OFDM) is just like WOFDM besides for the distinction That the preceding system gives richer decomposition of signals with longer time and Frequency localization from the latest. WP-OFDM degrades each excessive and Low frequency band, not like WOFDM, wherein most effective low frequency band decays. Figure (3. 9) indicates the operating version of OFDM system primarily based totally on wavelet. The ship facet of WP-OFDM gives encoding accompanied through interleaving Combined with modulation and inverse wavelet transformation. Wavelet transformation does

now no longer try this They require CP due to the fact their vectors overlap in each time and frequency domain

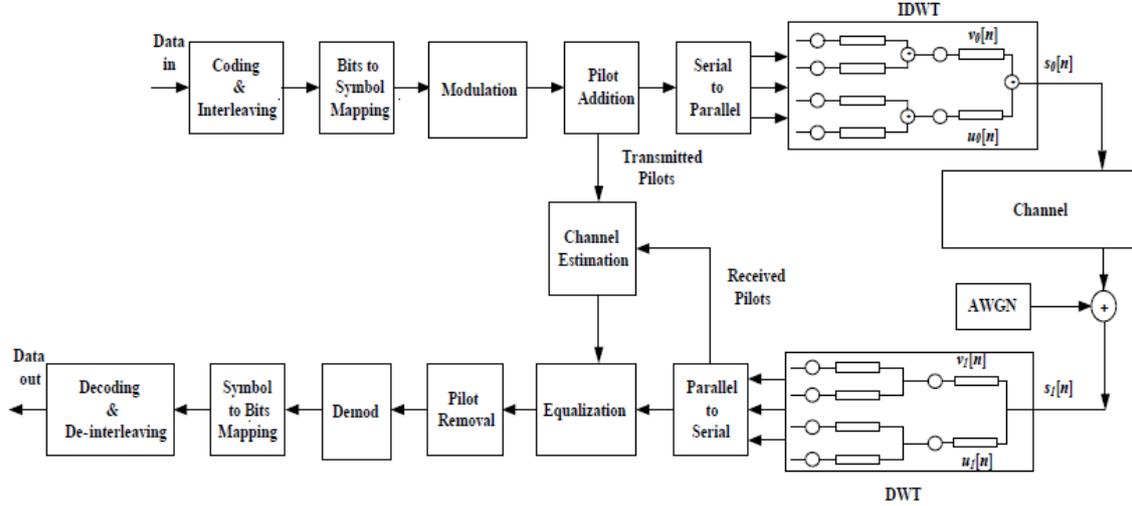


Figure (3.10) System model of the Wavelet OFDM package system

Output $S_0[n]$ after the opposite Wavelet is represented with the aid of using Eq.3.23 and Eq. 3.24 as scaling functions and wavelets, $V_0[n]$ and $U_0[n]$ as,

$$S_2 = S_1 + \text{ZEROS} \quad (3.22)$$

$$V_0[n] = 1/\sqrt{M} \sum_{K=0}^{\infty} W \varphi(j_0; k) Q_{j_0, k}[n] \quad (3.23)$$

$$U_0[n] = \sum_{j=0}^{\infty} \sum_{k=0}^{\infty} W \psi(j; k) \psi_{j; k}[n] \quad (3.24)$$

$$S_0[n] = V_0[n] + U_0[n] \quad (3.25)$$

wherein $W \varphi(j_0, k)$ and $W \psi(j, k)$ are the enter indicators to the scaling and wavelet features Respectively, the mistake of the whole wide variety of carriers, n is the parameter of time with variety $0 \leq n \leq M-1/2$, K is the shift parameter and j, j_0 is the size parameters, The features $Q_{j_0, k}[n]$ and $\psi_{j, k}[n]$ They are transformation kernels for the scaling and wavelet features Straight. Number of branches wherein serial data is damaged in WP-OFDM It relies upon on m the wide variety of iterations or levels, i.e. $M = 2^m$ On the receiving side, after Wavelet

transformation, $S_1[n]$ is represented within side the shape of scaling and wavelet features proven within side the equation. 3.26 and eq. 3.27 respectively as,

$$W\varphi(j_0; k) = 1/\sqrt{M} \sum_{n=0}^{M-1} s_1[n]Qj_0; k[n] \quad (3.26)$$

$$W\psi(j_0; k) = 1/\sqrt{M} \sum_{n=0}^{M-1} s_1[n]\psi j_0; k[n] \quad (3.27)$$

The very last information bits are retrieved after acting an equation with LS estimation, demodulation, de-interleaving, and decoding. WP-OFDM is positive whilst as compared to different transitions due to the fact its wavelet carriers are exceptionally prompted through the residences of the filters utilized in DWT and IDWT. The clear out layout traits may be modified consistent with the requirements, presenting more flexibility in its conversion. A crucial factor of this system model is convolutional encoding and Viterbi decoding, which might be mentioned in element with inside the subsequent section.

CHAPTER FOUR
RESULT AND DISCUSSION

Chapter Four

Result and Discussion

4.1 Introduction

In this section, MATLAB 2020B was used to simulate the proposed compressed Multicarrier with DWT systems. The proposed Multicarrier system's BER performance was evaluated using the models of channel (selective multipath fading, channel AWGN channel and flat fading channel). The carrier frequency in all of these scenarios was 3.6 GHz to Multicarrier system with three MDS values (7 Hz represented a mobility speed of 2 kilometers per hour, 50 Hz represented speed of thirty kilometers per hour, and 200Hz represented speed of One hundred and twenty kilometers per hour) to use AWGN, Flat fading, Selective fading channels models. The channel bandwidth was 20 MHz for 512, 1024, and 2048 subcarriers, these parameters are used in the simulation of the proposed Multicarrier systems. are shown in Table (4.1).

We measure the BER of FFT multicarrier system, and after adding DWT after FFT and take first half coefficient of DWT and discard the second half then adding the CP (1/16 of the symbol period) was used in all systems.

Table (4.1) Parameter of Simulation Multicarrier system

Parameter	Multicarrier Systems		
DWT or FFT with a multicarrier size	512	1024	2048
Number data are used as subcarriers	180	360	720
Modulation types	32QAM	32QAM	32QAM
Guard band or cyclic prefix (T_g/T_b)	1/16	1/16	1/16
Channel bandwidth (MHz)	20	20	20

4.2 Performance of Multicarrier in the AWGN Channel

As illustrated in Table (4.1), the sizes of 512, 1024 and 2048 to the subcarriers (FFT and DWT used in compressed Multicarrier) are used. Also, in this section only the channel model will be represented by the AWGN model. In addition, the performance of these systems will be compared, As the comparison level, the bit error of 10^{-4} will be used. This graph demonstrates that in the Fourier Transform System (FFT) it reaches SNR comparison levels of 36, 38, and 40 dB as well as for the compressed multicarrier, the SNR decreases to 33, 35, 39 dB for a magnitude of 512, 1024, 2048 respectively.

Therefore, the proposed system has a gain of 2, 3 and 4 dB, respectively, due to the use of a compact multi-carrier with DWT systems. Because Multicarrier compacted with DWT at the transmitter side and inverted compact multicarrier with DWT at the receiver will improve the spectral efficiency of the Multicarrier system as well as reduce error rates and these advantages are obtained without incurring additional power costs or doubling the system's bitrate.

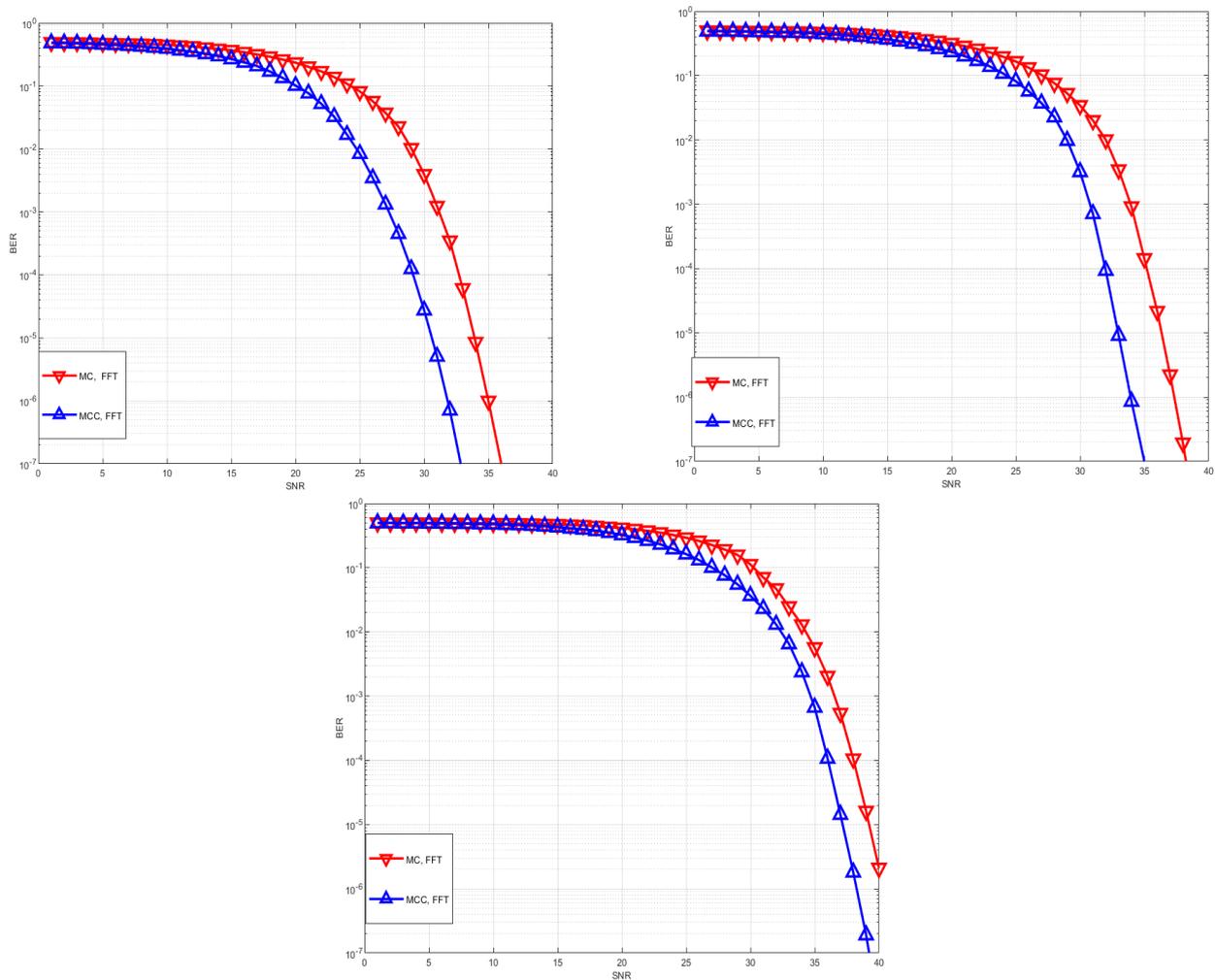


Figure 4.1 MC system based on AWGN with (512,1024 ,2048)

4.3 Multicarrier Performance with Flat Fading Channel

The model that will represent the channel model in this scenario will be the flat fading with Rayleigh distribution model. The same proposed Multicarrier systems in the previous section will be tested with the flat fading model followed by AWGN model. Therefore, Signals transmitted through this channel will suffer from continuous attenuation across the flat fade channel as well as linear phase distortion. Also, the multi-carrier with the proposed compressed DWT systems gives the lowest BER, and DWT improves the performance of the system, with

3dB gains when used in the frequency domain. Also, as for the AWGN channel, the gains increased with increasing subcarrier size. Also, by examining all the results it is clear that the proposed multicarrier system with compact multicarrier with DWT has better performance than the FFT-based multicarrier system at all Doppler frequencies (5, 70 and 300 Hz) used in the flat fading channel model.

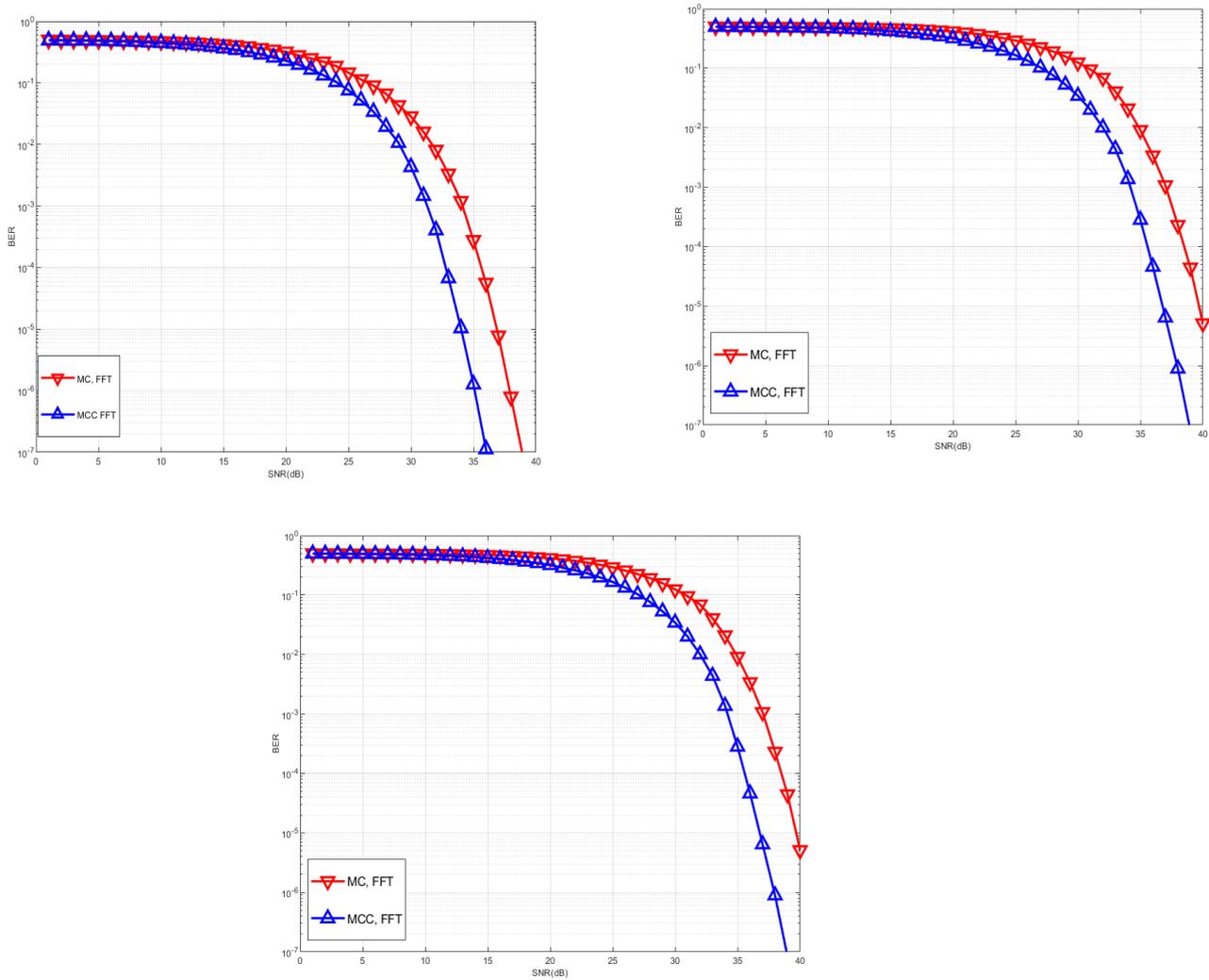


Figure (4.2) MC system 512 based on Flat Fading with Doppler shift (5 ,70,300) HZ

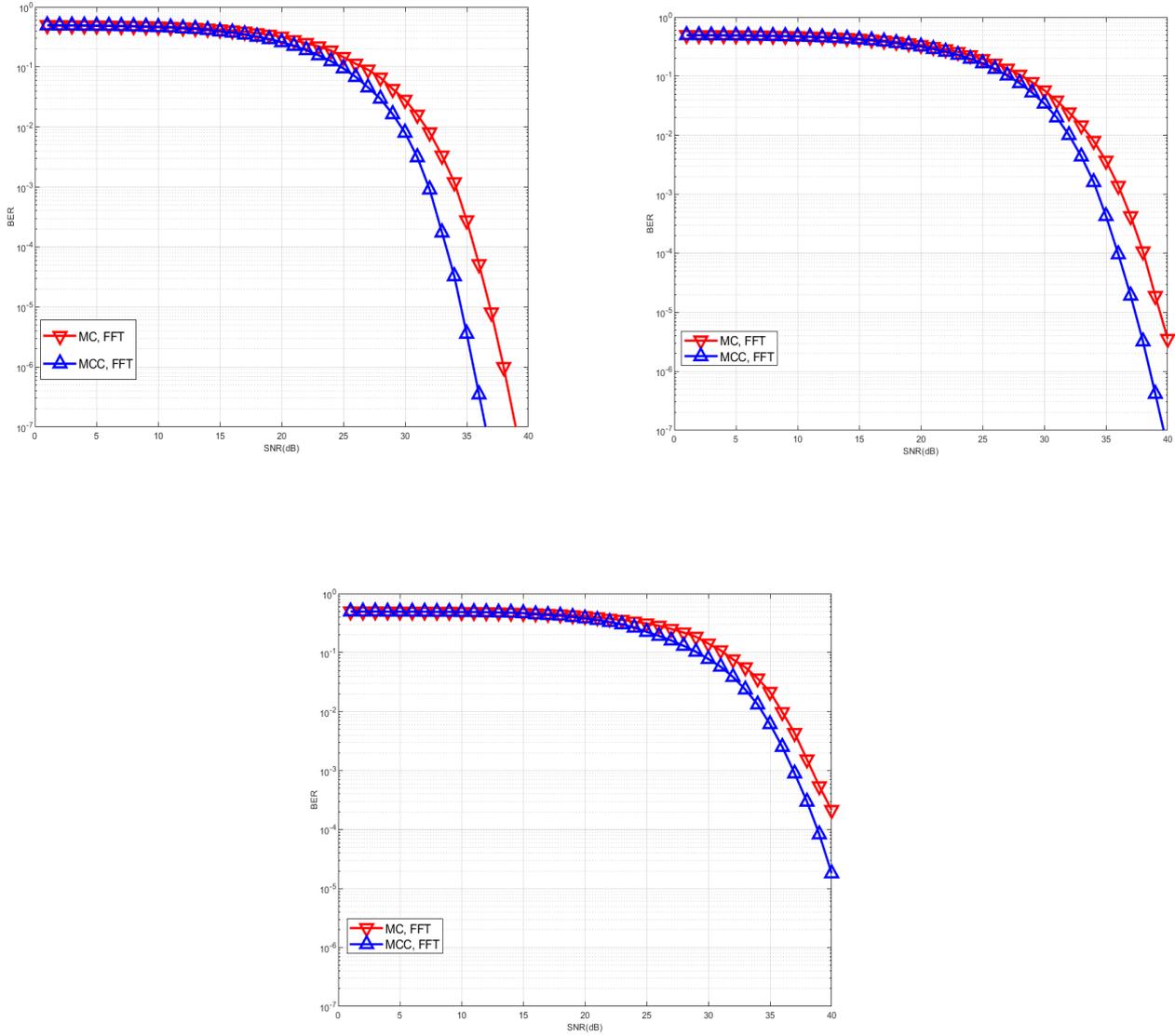


Figure (4.3) MC system 1024 based on Flat Fading with Doppler shift (5 ,70,300)Hz

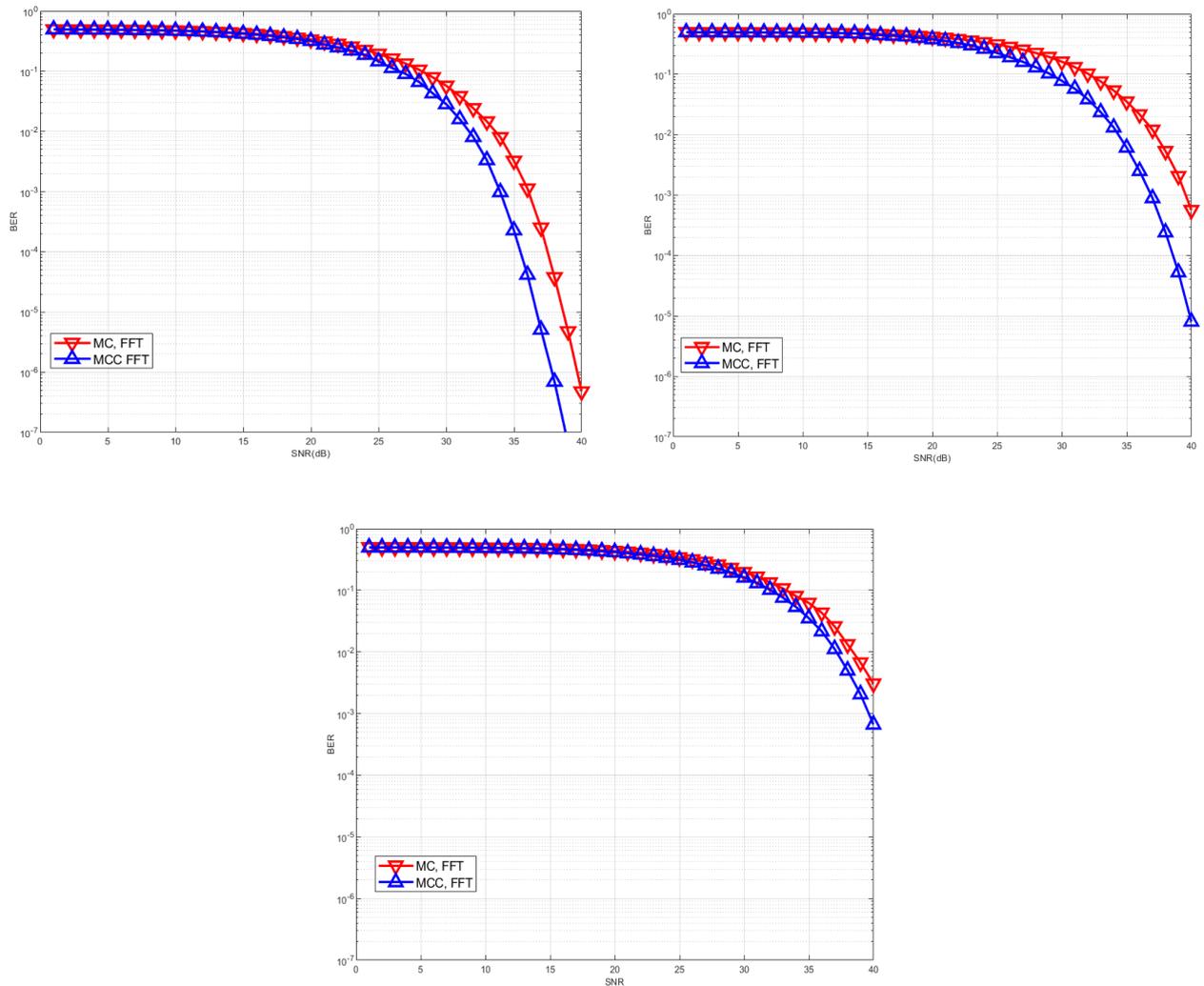


Figure (4.4) MC system 2048 based on Flat Fading with Doppler shift (5 ,70,300)Hz

From all simulation results, it is clear that LTE system downlinks with MDS=5 Better performance than LTE constructed on MDS=50 and MDS=200 as a DF used in model of “flat fading Channel”. These additions to the system are considered as benefits and improvements to the system at no additional cost of energy and little loss in bandwidth and data rate. This conclusion is seen clearly in table (4.2)

Table (4.2) The SNR in dB at BER= 10^{-4} to AWGN and Flat Fading channel model with packet length (512,1024,2048)

System Type	AWGN	5 HZ	70 HZ	300 HZ
	512 bit		Flat Fading 512	
MC-FFT	33	36.5	38	40
MCC-FFT	29	33	36	38
	1024 bit		Flat Fading 1024 bit	
MC-FFT	37	36	38	NAN
MCC-FFT	32	33	37.5	39
	2048 bit		Flat Fading 2048 bit	
MC-FFT	38	37.5	NAN	NAN
MCC-FFT	36	35	38	NAN

4.4 Multicarrier Performance in selective Channel

The model that will represent the channel model in this scenario will be a selective fading with a Rayleigh distribution model. In addition to AWGN, linear attenuation and continuous attenuation will be applied to the transmitted signals, the multicarrier with the proposed compressed DWT systems gives the lowest BER, and the DWT improves the performance of the system, with a gain of 3dB when used in the frequency domain. Simulation results show that the proposed multi-carrier system with compact multi-carrier with discrete wave transducer (DWT) shows better results than the FFT-based multi-carrier system at all Doppler frequencies (5, 70 and 300 Hz) used in the selective fading channel model.

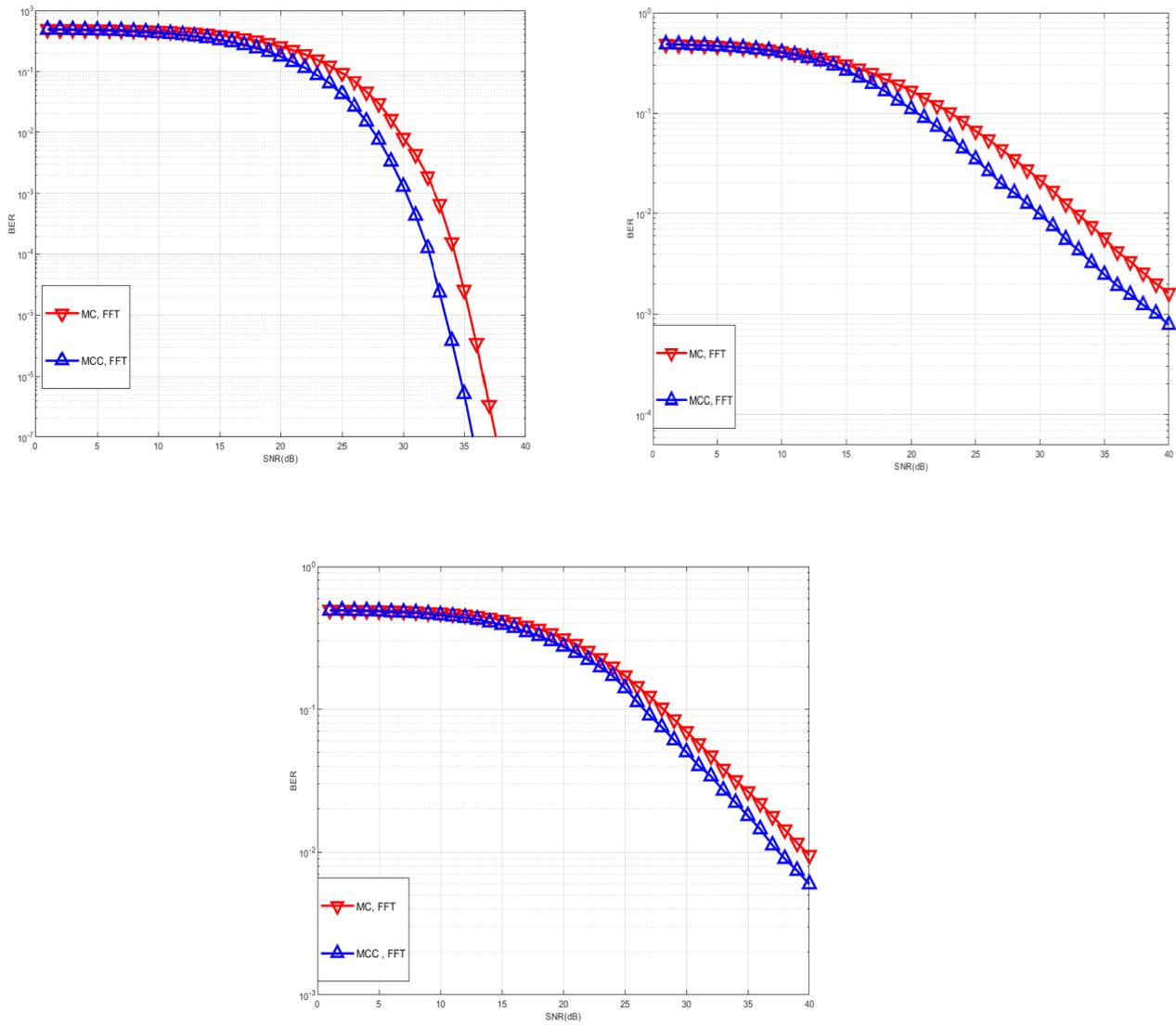


Figure (4.5) MC system 512 based on selective with Doppler shift (5,70,300) Hz

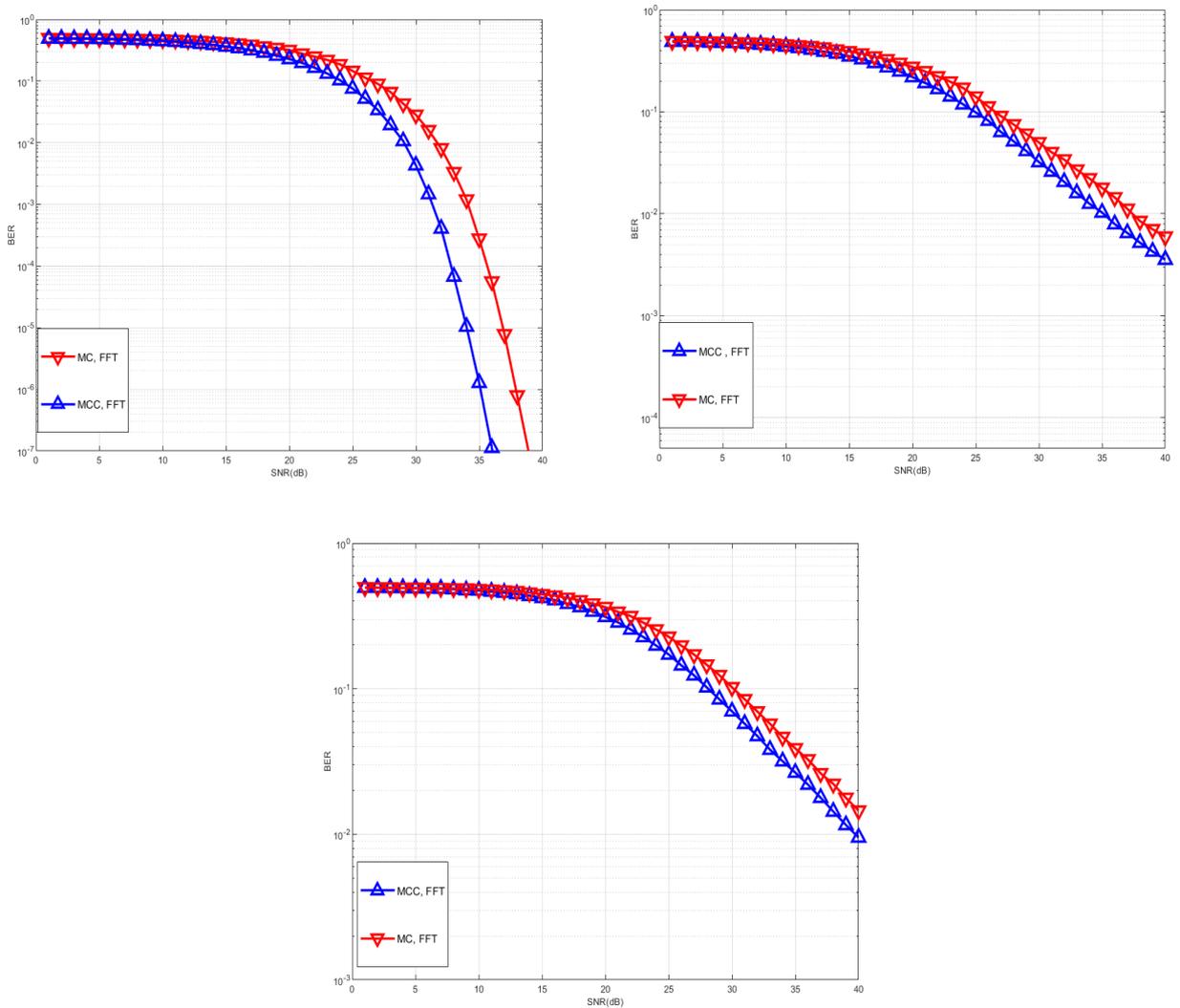


Figure (4.6) MC system 1024based on selective with Doppler shift (5,70,300) Hz

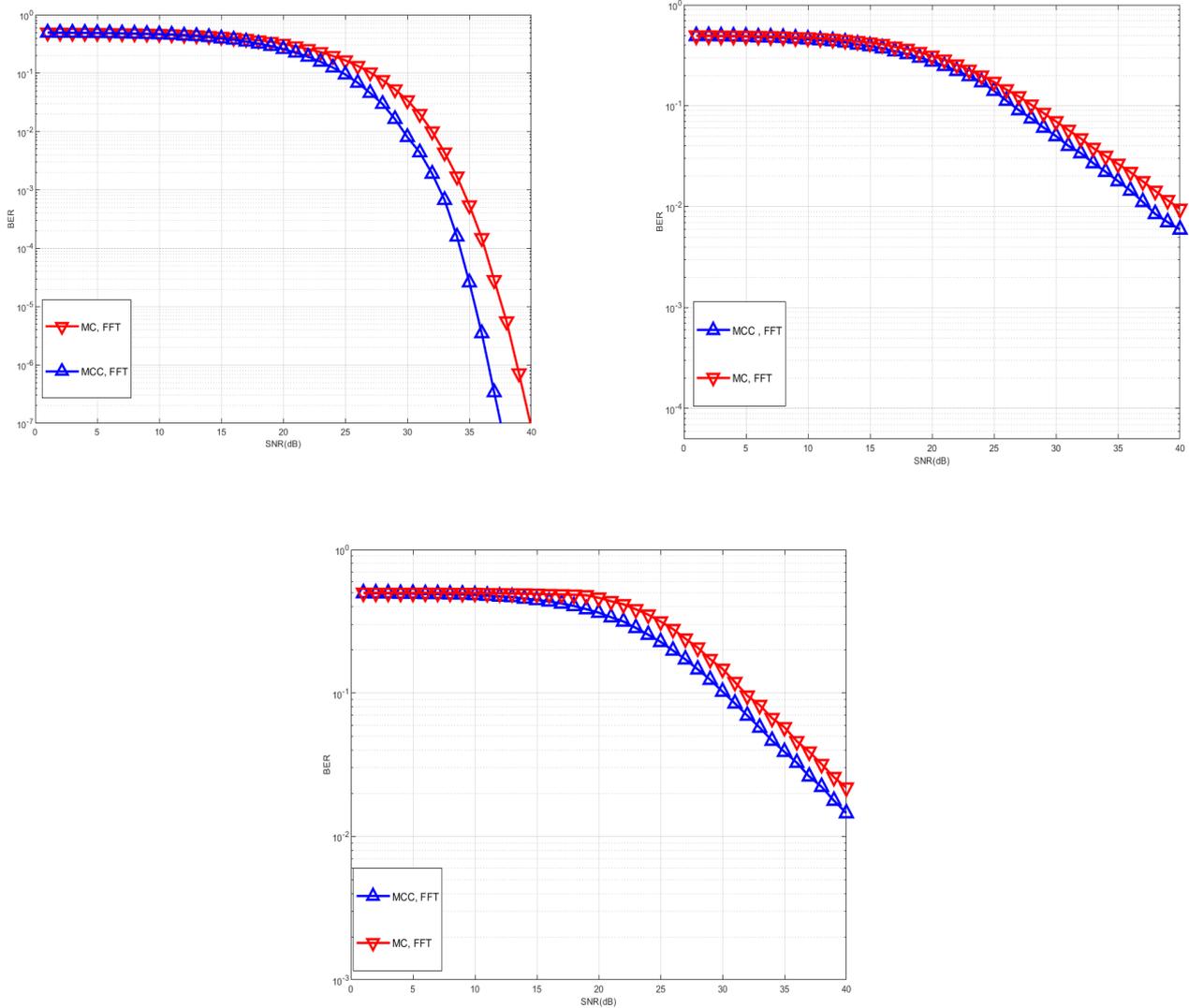


Figure (4.7) MC system 2048 based on selective with Doppler shift (5 ,70,300)Hz

Table (4.3) The SNR of system which get BER 10^{-4} at for Selective Channel based on (512,1024 ,2048) bit

System Type	5 HZ	50 HZ	200 HZ
SNR (dB) Selective 512			
MC-FFT	36.5	NAN	NAN
MCC-FFT	33	NAN	NAN
SNR (dB) Selective 1024			
MC-FFT	38	NAN	NAN
MCC-FFT	34	NAN	NAN
SNR (dB) Selective 2048			
MC-FFT	39	NAN	NAN
MCC-FFT	35	NAN	NAN

4.5 Performance of Multicarrier with LTE Channel Mode

The “Third Generation Partnership Project” 3GPP “Technical Recommendation” (TR) defines three different types of multipath fading channel models: “the Extended Pedestrian A (EPA), Extended Vehicular A (EVA), and Extended Typical Urban (ETU)”. All these channel-modeling functions will be used in this work examined the effect of these models. The higher-mobility profiles will not be used as “the closed-loop spatial-multiplexing mode”. It is applicable to high data-rate and low-mobility scenarios only. These models enable the system to evaluate the performance of the proposed LTE transceiver in multichannel conditions reference.

The model of any multipath fading channel can be defined by delay profiles and its relative power vectors. The maximum Doppler shift (MDS) or Doppler frequency must define with data rate in the channel model. The delay profiles of these models of channel define at low, medium, and high delay spread environment, respectively corresponding to (5, 70, or 300 Hz) as the maximum Doppler shift as shown in table (4.4) that clarify the channel delay profile of each model with values of tap delay (in nanoseconds) and relative power (in decibels).

Table (4.4). LTE channel models (EPA, EVA, ETU) and delay profiles

Channel model	Excess tap delay (ns)	Relative power (dB)
Extended Pedestrian A(EPA)	[0, 30, 70, 90, 110, 190, 410]	[0, -1, -2, -3, -8, -17.2, -20.8]
Extended Vehicular A(EVA)	[0, 30, 150, 310, 370, 710, 1090, 1730, 2510]	[0, -1.5, -1.4, -3.6, -0.6, -9.1, -7, -12, -16.9]
Extended Typical Urban (ETU)	[0, 50, 120, 200, 230, 500, 1600, 2300, 5000]	[-1, -1, -1, 0, 0, 0, -3, -5, -7]

EPA, EVA, and ETU are the three different types of multi path fading are studied in the proposed MMC system. The impact of these channels will be discussed in this section. This applies only to low-data rate and high bandwidth states. The

system will be able to evaluate signal to multi-channel conditions of the LTE transceiver by using the three models.

4.5.1 Extended Pedestrian A model (EPA)

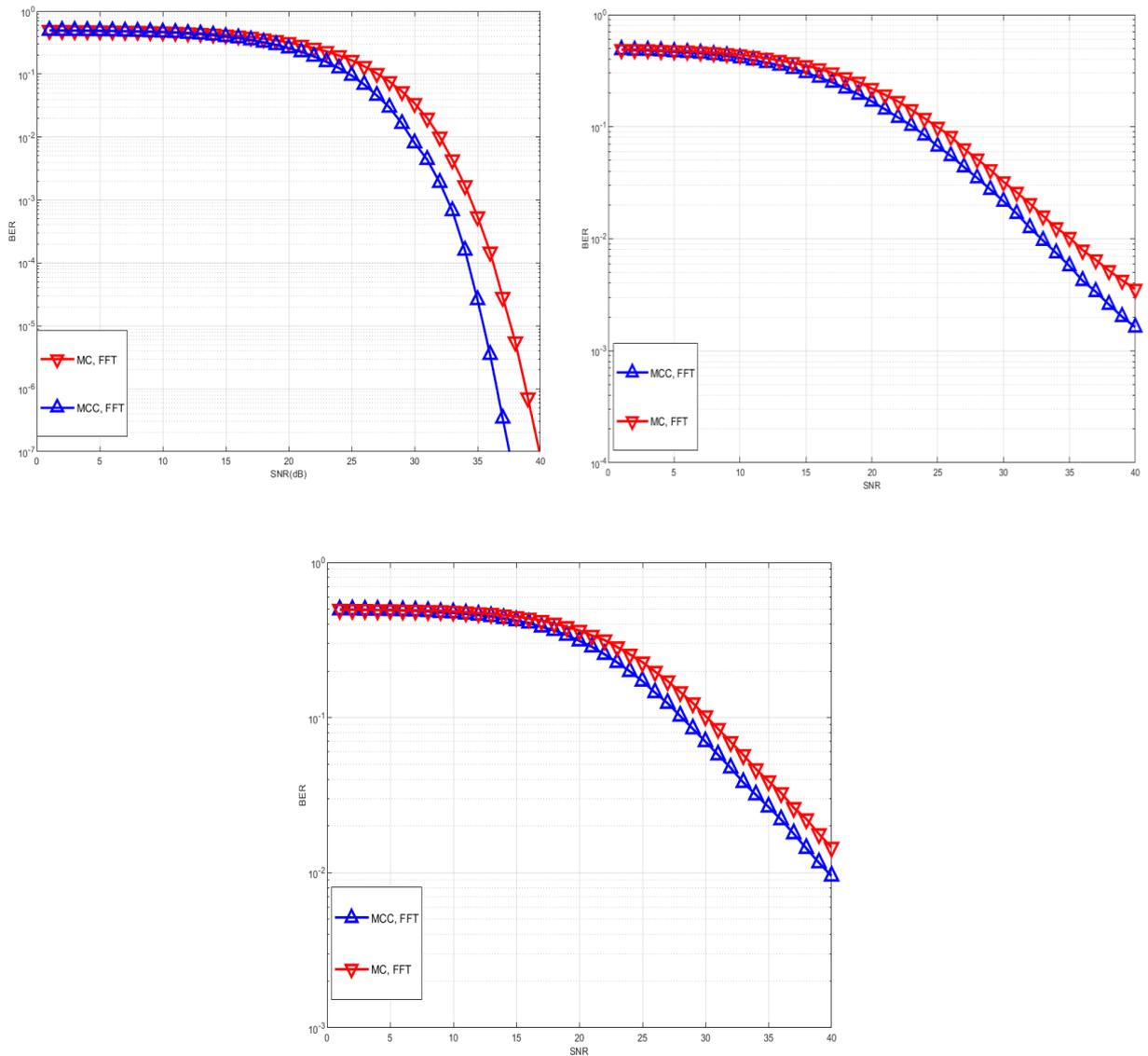


Figure (4.8) MC system 512 based on LTE (EPA)with Doppler shift (5 ,70,300)Hz

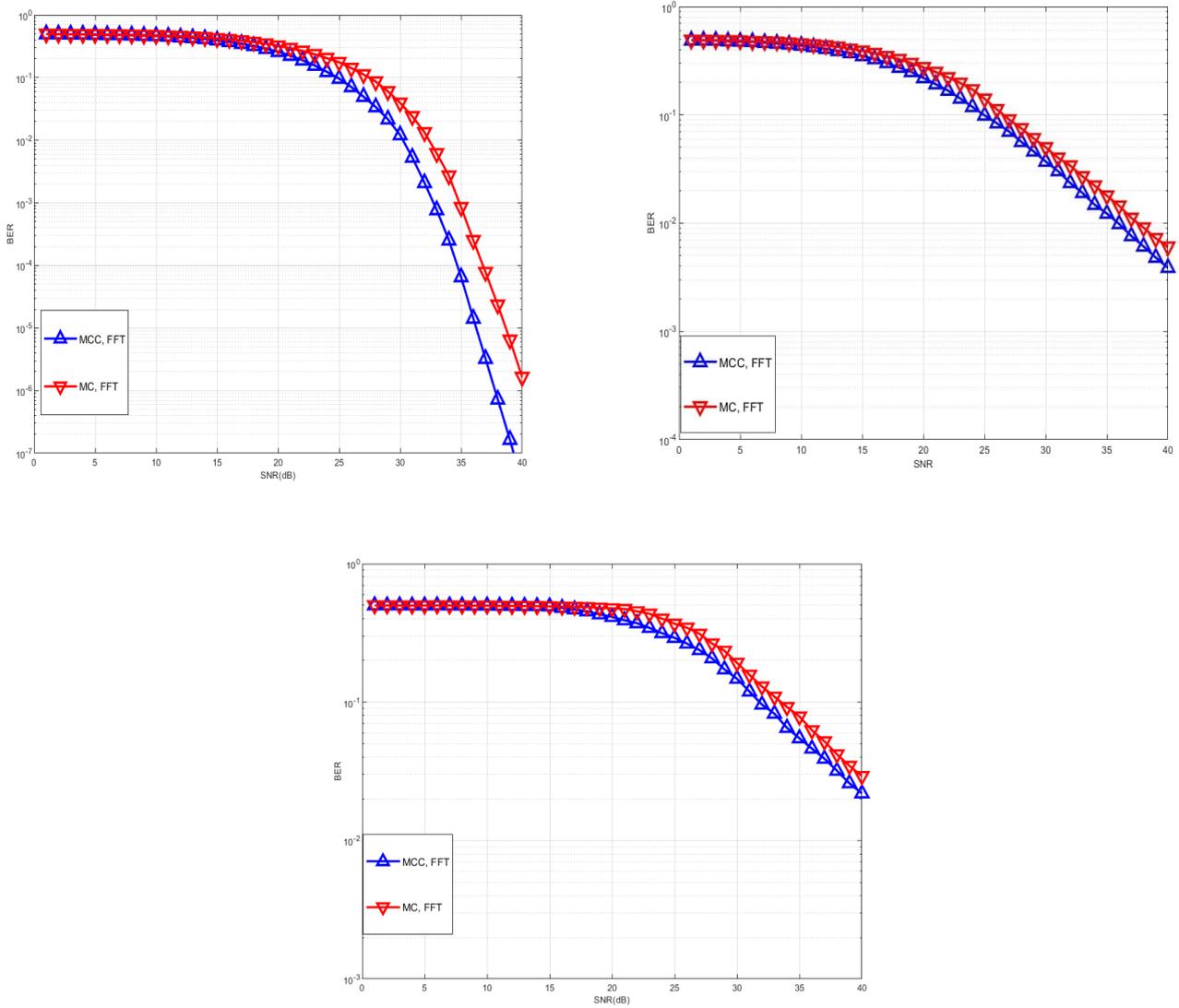


Figure (4.9) MC system 1024 based on LTE (EPA) with Doppler shift (5,70,300) Hz

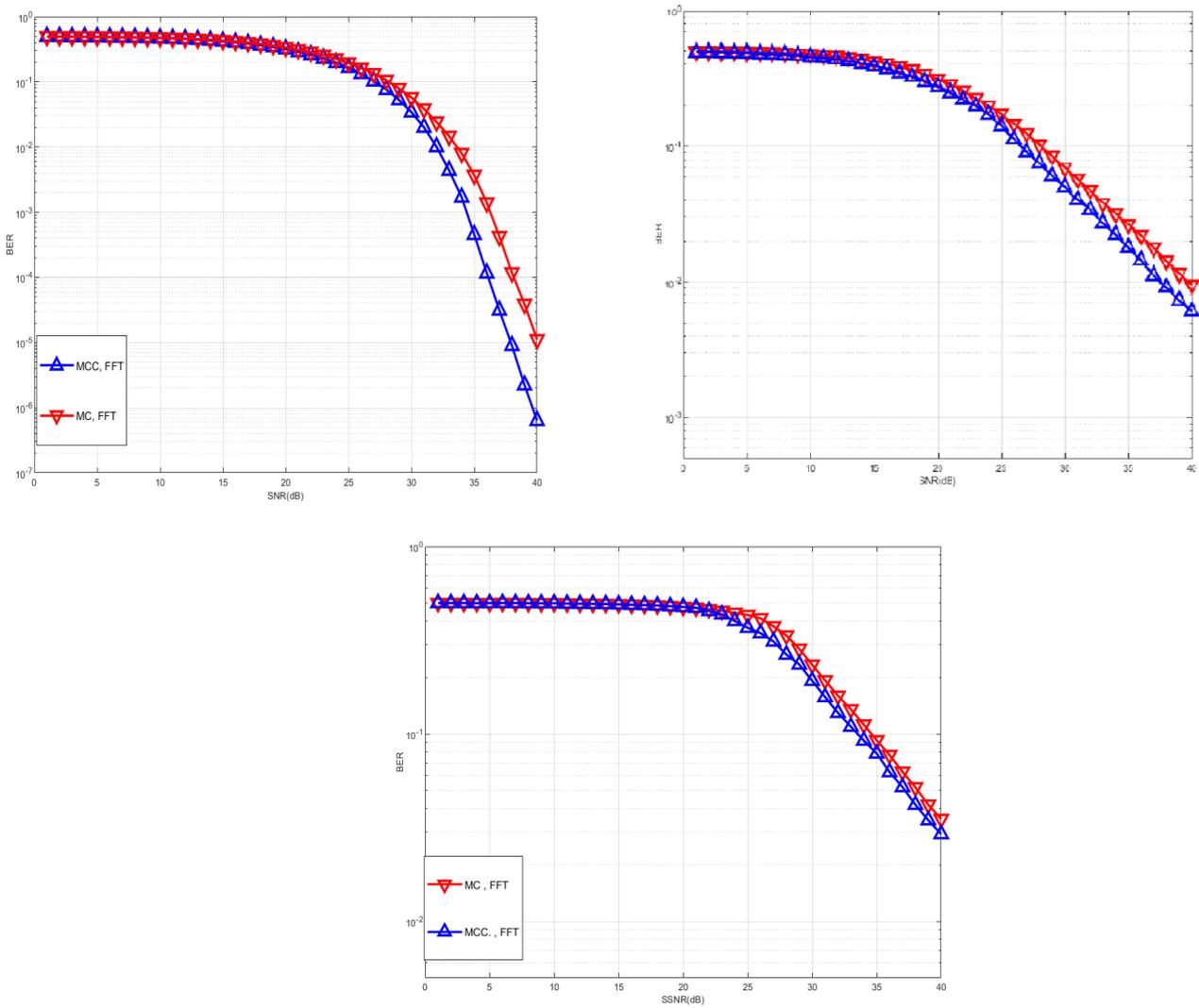


Figure (4.10) MC system 2048 based on LTE (EPA) with Doppler shift (5,70,300) HZ

4.5.2 Extended Vehicular A model (EVA)

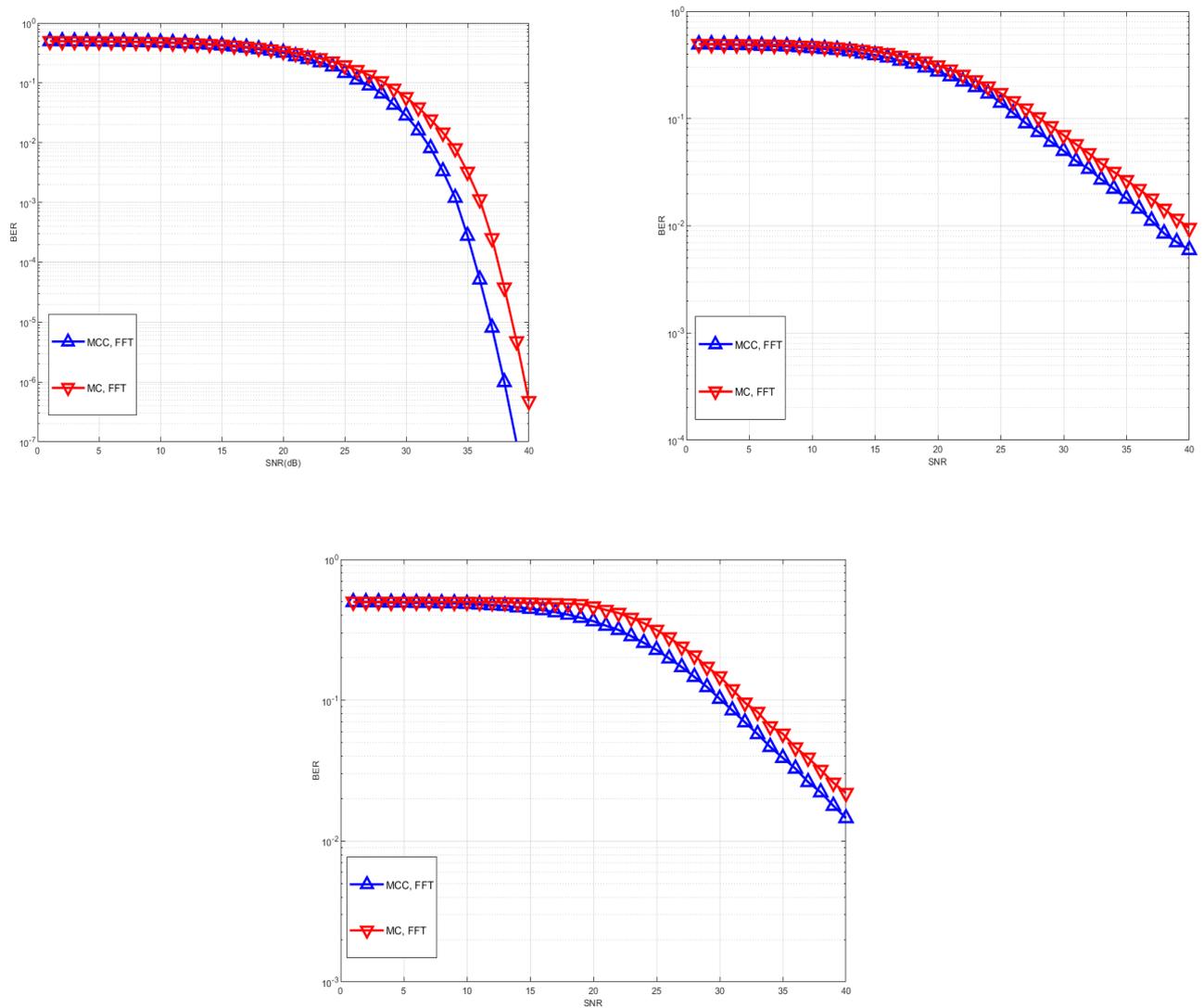


Figure (4.11) MC system 512 based on LTE (EVA) with Doppler shift (5,70,300) HZ

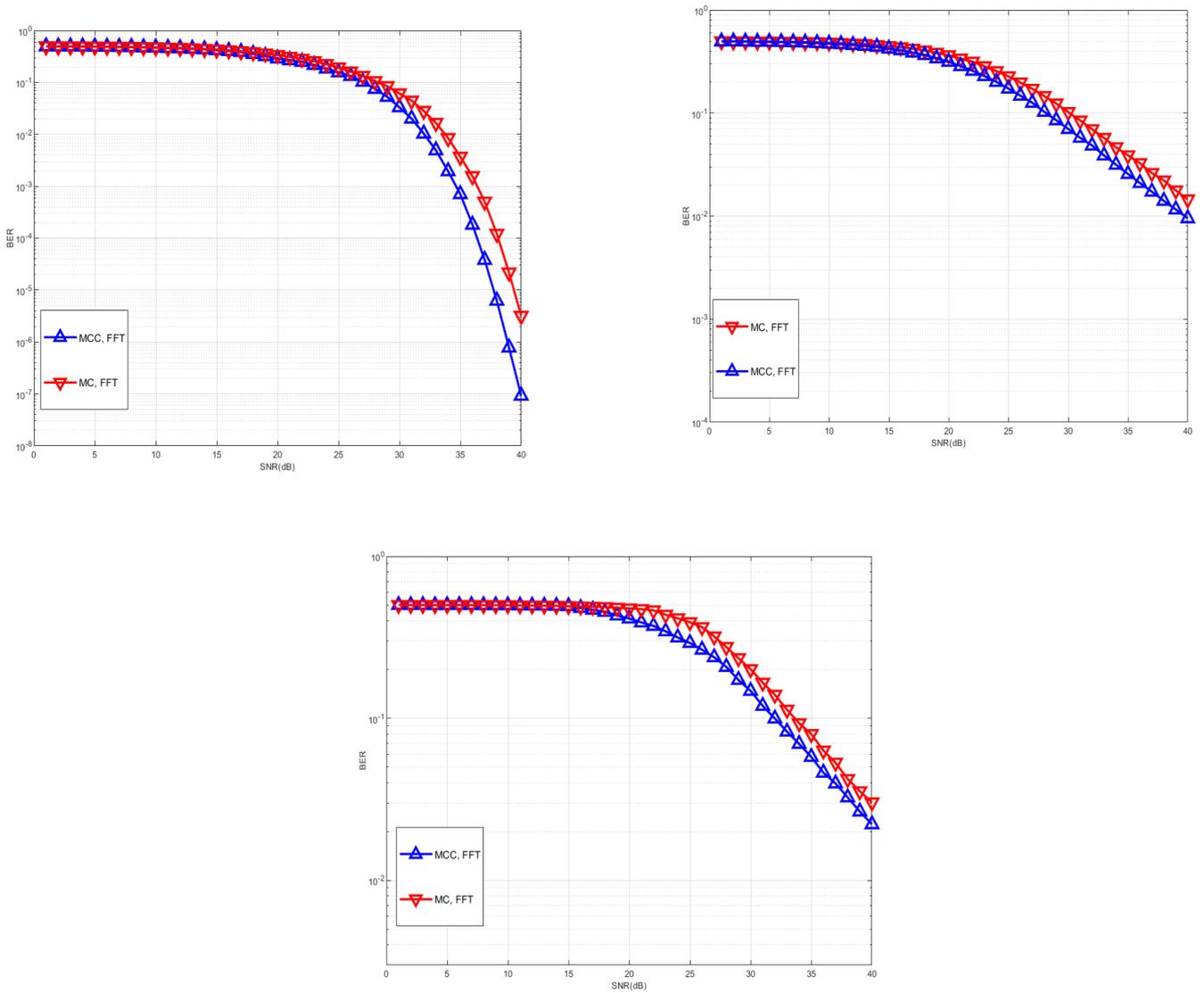


Figure (4.12) MC system 1024 based on LTE (EVA) with Doppler shift (5, 70,300) HZ

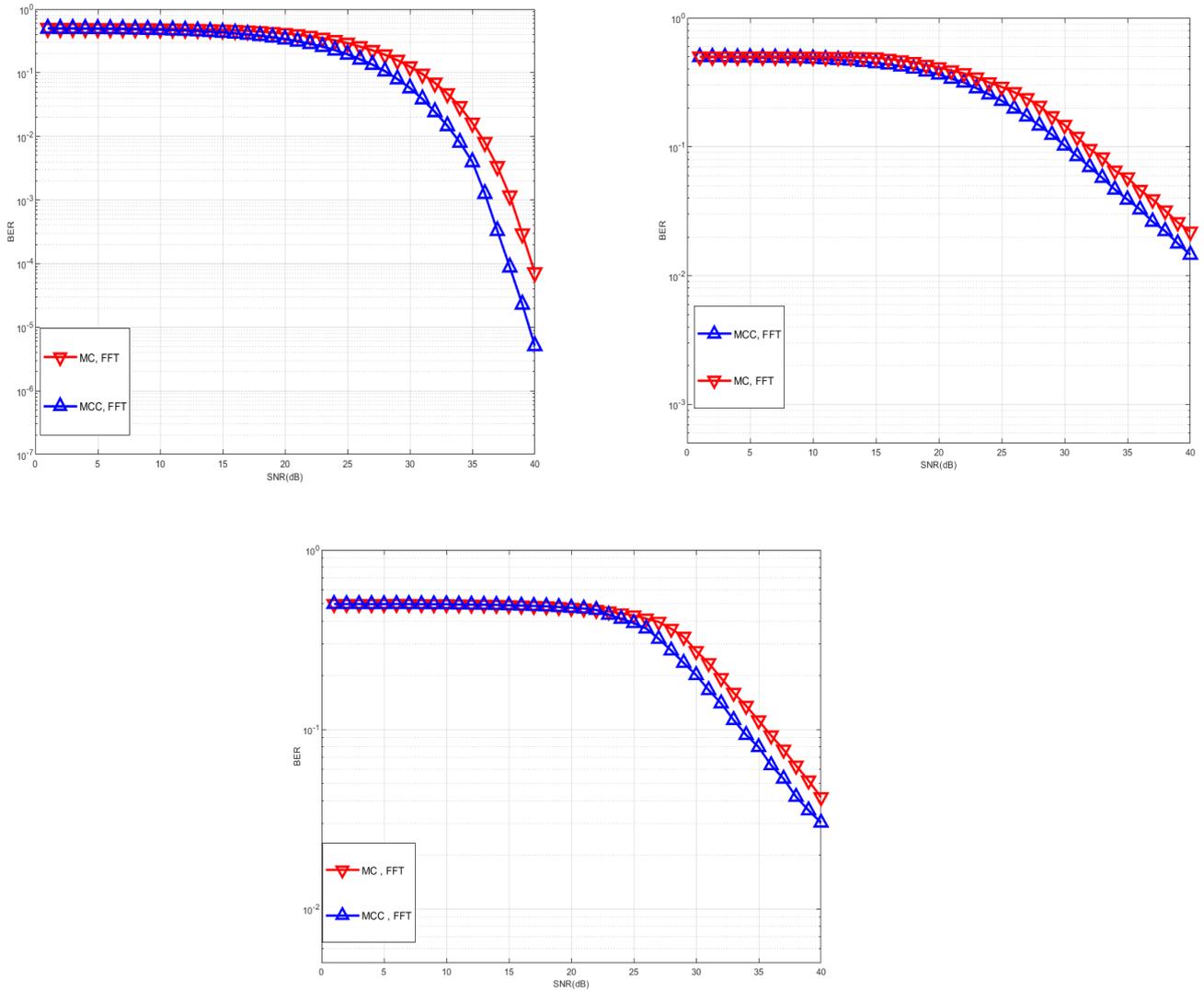


Figure (4.13) MC system 2048 based on LTE(EVA) with Doppler shift (5 ,70,300)HZ

4.5.2 Extended Typical Urban A model (ETU)

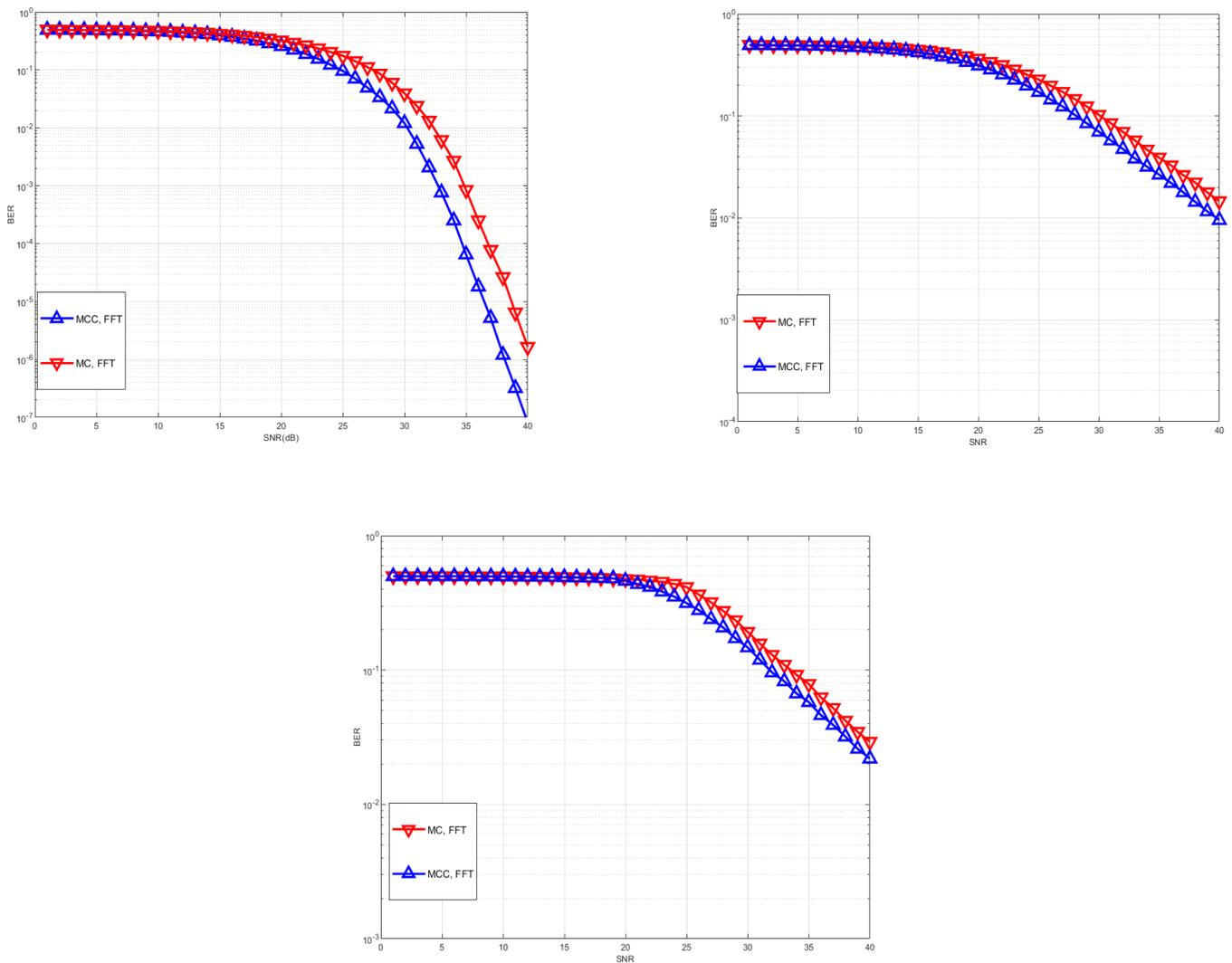


Figure (4.14) MC system 512 based on LT (ETU) with Doppler shift(5,70,300) HZ

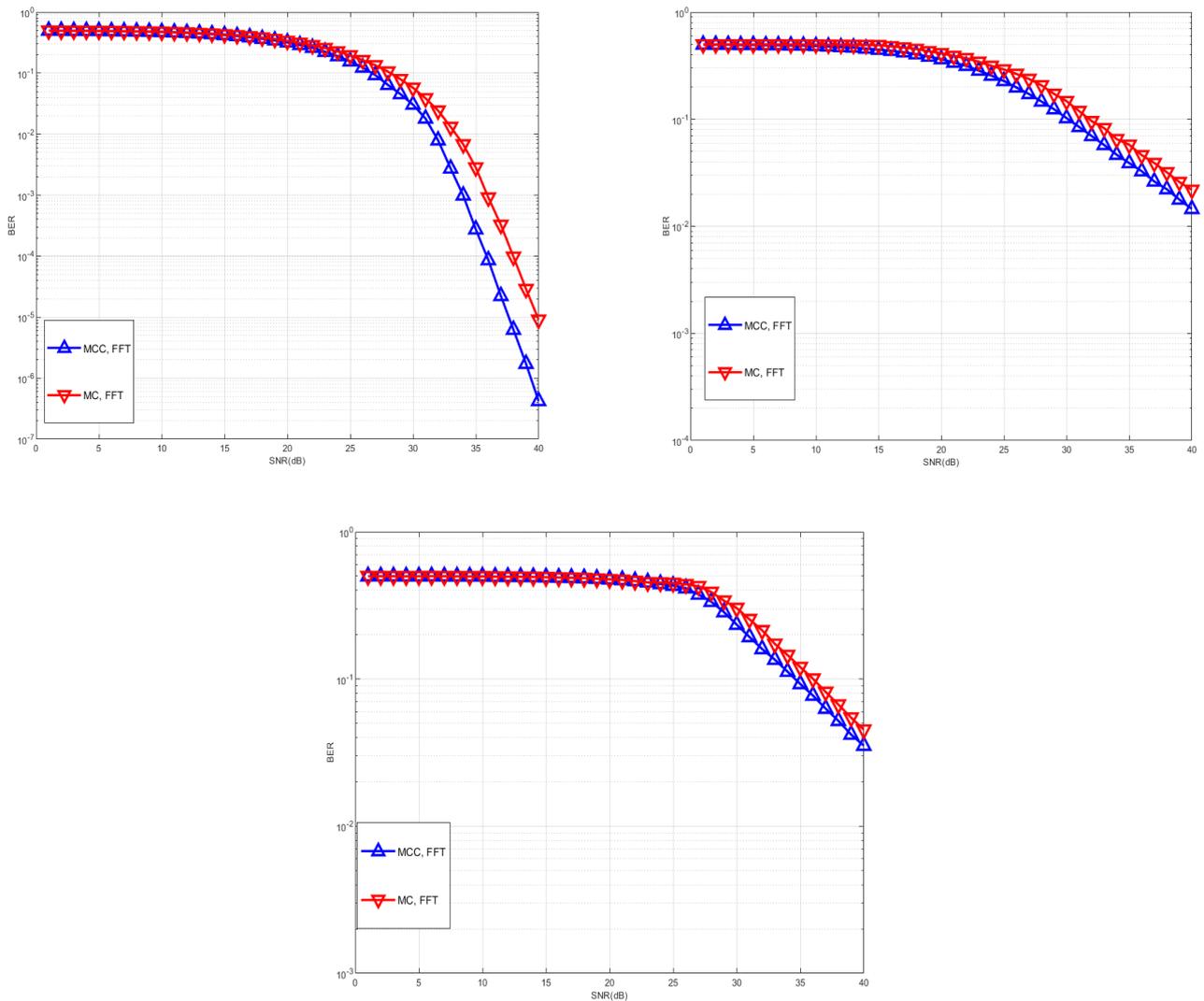


Figure (4.15) MC system 1024 based on LTE (ETU) with Doppler shift (5,70,300) HZ

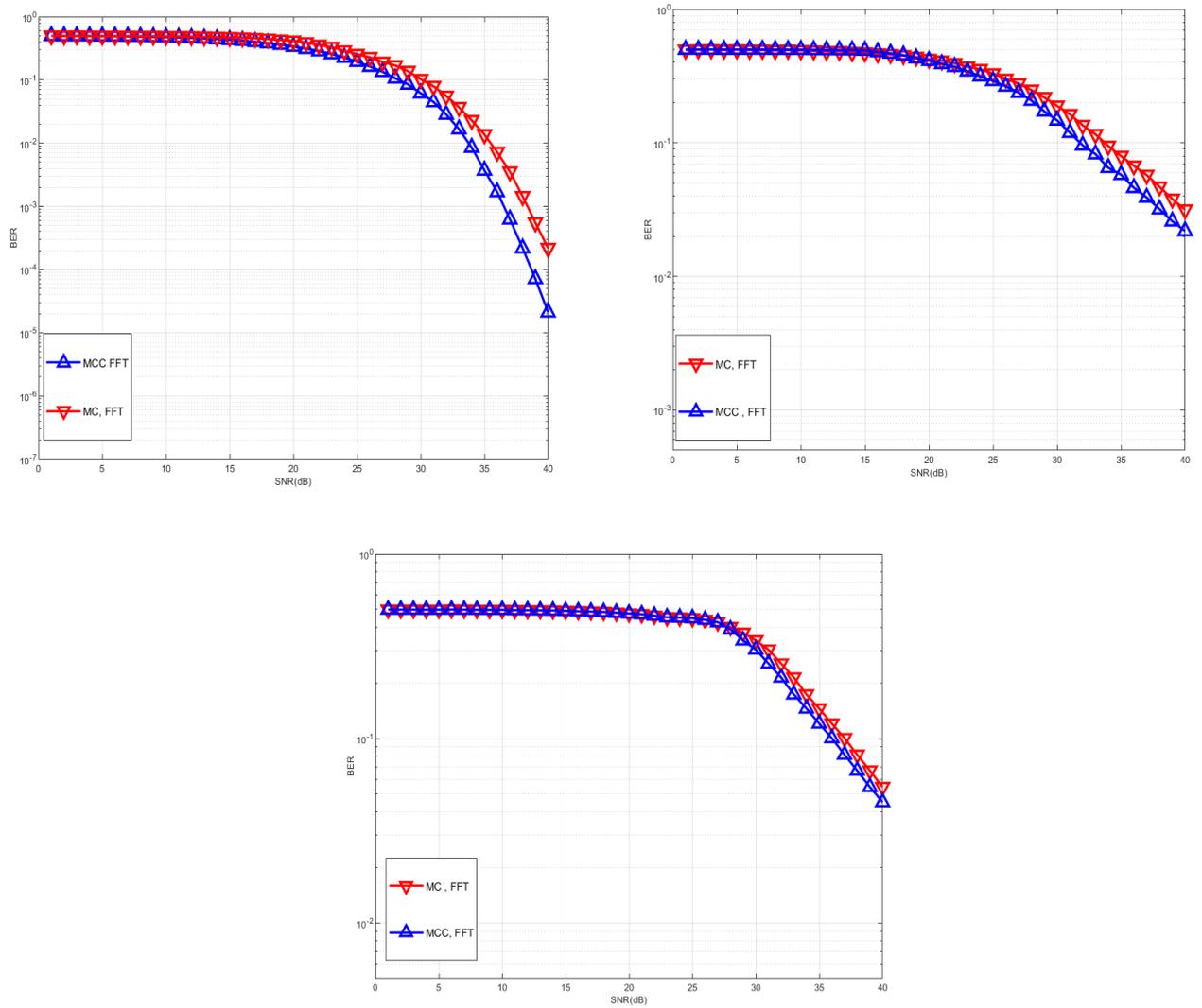


Figure (4.16) MC system 2048 based on LTE (ETU) with Doppler shift (5,70,300) HZ

The results of LTE system is shown in Figure (4.8 to 4.16) are discuses in table (4.4) below, which give comparison is better of BER enactment between Specific LTE Channel over the three MDS values.

Table (4.5) The SNR of system which get BER 10^{-4} at LTE (EPA,EVA,ETU) channel based on (512,1024,2048)bit

System Type	5 HZ	50 HZ	200 HZ
Multipath (EPA) 512bit			
MC-FFT	37	NAN	NAN
MCC-FFT	35	NAN	NAN
Multipath (EPA) 1024 bit			
MC-FFT	38	NAN	NAN
MCC-FFT	35.5	NAN	NAN
Multipath (EPA)2048 bit			
MC-FFT	38.5	NAN	NAN
MCC-FFT	36	NAN	NAN
Multipath (EVA) 512bit			
MC-FFT	37	NAN	NAN
MCC-FFT	37	NAN	NAN
Multipath (EVA) 1024 bit			
MC-FFT	37.5	NAN	NAN
MCC-FFT	38	NAN	NAN
Multipath (EVA) 2048 bit			
MC-FFT	38	NAN	NAN
MCC-FFT	39	NAN	NAN

	Multipath (ETU) 512bit		
MC-FFT	37.5	NAN	NAN
MCC-FFT	35	NAN	NAN
	Multipath (ETU) 1024 bit		
MC-FFT	38	NAN	NAN
MCC-FFT	37	NAN	NAN
	Multipath (ETU) 2048 bit		
MC-FFT	39	NAN	NAN
MCC-FFT	NAN	NAN	NAN

CHAPTER FIVE

CONCLUSIONS AND SUGGESTED

FUTURE WORKS

Chapter Five

Conclusions and Suggested Future Works

5.1 Conclusions

In this thesis, first bit error probability performance comparisons for the conventional multicarrier system and the proposed compressed multicarrier have been presented. The simulation results showed that significant gains could be obtained as the system data rate increased by combining the DWT and multicarrier techniques with very little decoding complexity:

- 1- The performance comparison shows that the carrier system compressed by DWT is more robust, has better BER at all Doppler frequencies, and has higher spectral efficiency for all different f_d values as well as multiple carrier sizes.
- 2- The proposed system improves because the orthogonal base of the wavelet transform is stronger and more impermeable than the orthogonal bases used in the FFT in channel fade.
- 3- When using a high data rate, designers require a larger multi-bus size, such as 1024 or 2048, which makes the system complex and requires a lot of power. By using the suggested system, the size is cut in half, which allows for a higher data rate while consuming less power and having less complexity on the system, making it more efficient for short-range wireless communications. Long-distance wireless can operate with less volume than multiple carriers.

5.2 Future Works

The following projects are recommended as suggestion for further study in the future:

1. Polynomial cancellation coding (PCC) is proposed to mitigate the severe inter carrier interference (ICI) in Multicarrier system caused by frequency offset, thus we suggest to combine the PCC with DWT based multicarrier to increase the performance of the communication system.
2. At the receiver, frequency and timing synchronization are assumed to be perfect. From a practical standpoint, synchronization is another active area of research for multicarrier systems and may be a good problem to investigate in future efforts.
3. Implementing the proposed DWT-based multicarrier in FPGA is a good way to investigate, as the system can be built with good hardware support in FPGA.
4. Conduct a performance test of the proposed system in the presence of multiuser multicarrier CDMA and then contrast the outcomes to traditional schemes to investigate the impact of multi-user interference on performance of the system.
5. It is also recommended to use for further enhancements, combine least square equalizers with the proposed systems, particularly for large Doppler

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الخلاصة

توضح هذه الرسالة كيفية تحسين عرض النطاق الترددي وأداء معدل الخطأ في البتات (BER) لنظام الاتصالات الحديث باستخدام تقنية الضغط في أنظمة تعديل الموجات المتعددة. تتضمن هذه التقنية معاملات الضغط لتحويل الموجة إلى أبعاد التردد لتعديل الموجات الحاملة المتعددة. تم تنفيذ النظام المقترح المصمم للأنظمة متعددة الموجات الحاملة باستخدام نظام OFDM قياسي يعتمد على تحويل فورييه السريع (FFT).

كانت هذه الفكرة المقترحة هي ضغط معاملات التعديل متعدد الناقلات لـ FFT التي تم إجراؤها عن طريق إضافة تحويل الموجة المنفصلة (DWT) كمرحلة ضغط لتجاهل تفاصيل معاملات الحامل المتعدد. ستتم هذه العملية عن طريق إرسال معاملات التقريب لـ DWT فقط وتجاهل معاملات التفاصيل. ستعوض معاملات التفاصيل في جانب المستقبل عن طريق إضافة أصفار إلى مدخلات مرحلة IDWT.

تم فحص نتائج المحاكاة باستخدام (AWGN) واكتسب النظام المقترح 2 db فوق خبو رايلي المحدود والمسطح ، ويكتسب النظام المقترح 1.5 db فوق قنوات الخبو الانتقائية والاختيارية وكذلك استخدام متعدد المسارات Extended Pedestrian A model (EVP) ، نموذج مركبة ممتدة EVA ، نموذج حضري نموذجي ممتد (ETU)).

LTE بما في ذلك نموذج المشاة الممتد EPA ، ونموذج المركبة الممتدة EVA والمدينة النموذجية الموسعة ETU ودراسة التغيير لقيم مختلفة لأقصى انزياح دوبلر (5 هرتز و 70 هرتز و 300 هرتز) (وهي أهم معاملات قناة التأثير) على أداء معدل الخطأ في البتات BER يوضح LTE المبني على DWT في نتائج المحاكاة

أنه أفضل من LTE على أساس FFT. يوضح أن مخطط الضغط الإضافي المقترح بعد DWT يمكنه مضاعفة معدل البيانات وتقليل معدل خطأ البت BER، تم ذلك باستخدام برنامج MATABL للإصدار B 2020.



جمهورية العراق
وزارة التعليم العالي والبحث العلمي
جامعة بابل
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عرض أداء تقنية الضغط بالاعتماد على محولة المويجة المتقطعة للقنوات
اللاسلكية

رسالة

مقدمة الى كلية الهندسة في جامعة بابل

كجزء من متطلبات نيل درجة الماجستير في الهندسة / الهندسة الكهربائية /
اتصالات

من قبل

زهراء عماد فاضل شاكر

أشراف

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2022م

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