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DEVELOPMENT OF OFDM SYSTEM IN MATLAB

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ABSTRACT

Orthogonal frequency division multiplexing (OFDM) is becoming the chosen modulation techniques for wireless communications and networks and computer since and information security, OFDM can provide large data rates with sufficient robustness to radio channel impairments, We will separate some of the basics of OFDM used widely in the communication system where we can consider it a kind of modulation technique and also a kind of technique multiplexing If we talk about the basic of OFDM is a splitting or separation high data rate stream for low data rate stream They are all sent at the same time on more than one carrier. The frequency band is divided into more than one sub-channel and is called a multi carrier modulation and is transmitted via a sub-channel and each two subcarrier is perpendicular and each is separated separately.

The purpose of this report is to provide MATLAB code to simulate the basic processing involved in the generation and reception of an OFDM signal in a physical channel and to provide a description of each of the steps involved. For this purpose, we shall use, as an example, one of the proposed OFDM signals of the Digital Video Broadcasting (DVB) standard for the European terrestrial digital television (DTV) service, the main idea came after the evaluation of the communication system and the increasing demand for the need for data transfer speed, the idea of OFDM but this technique that split the channel into sub-carrier and dividing the carrier into sub-carrier so that we send more than two different signals on the same band given to us at the same time and this helps solve several problems were in former where we used to use the band given to us in sending one signal and then we send the other where this caused several problems. OFDM is based on the well-known technique of Frequency Division Multiplexing (FDM). In FDM different streams of information are mapped onto separate parallel frequency channels. Each FDM channel is separated from the others by a frequency guard band to reduce interference between adjacent channels.

INTRODUCTION

Topicality

Is one of the technologies used in networks and communication systems, a technique that has been used since 1970 but has not been used on a wide tally because this technique needed expensive possibilities and was then difficult to use on a wide range.

OFDM it has already been used to sender information for FM channels, digital broadcasting (AB), DVB-T and ADSL, but Now it is more used, mostly in cellular and wireless communications systems, mostly the fourth generation such as LTE and Wi-MAX [5].

The main ideas comes after the development for communication systems and the rising demand for the need for speed of data sender. Hence the idea of FDM, but this techniques which be divided the channel into a sub- channel and dividing the carrier into a sub- carrier so that we send more than two different signals on the same band Given to us at the same time and this helps solve many several problems were in the former where we used to use the band given to us in transmission one signal and then we send the other where this caused several problems, especially in the television where we send the image and then the sound and thus the picture precedes the sound Often there means there is a delay between the two signals.

So using FDM was divided into band and also divided the information into Farm means to say I divide our band into many parts as we divide the information into parts and send each part after the other to assume that the information voice and video and image we are dividing the sound into parts as well as pictures and then we carry the first part of the image on Carrier At the same time we carry the first part of the sound on the Carrier secondary and send them and then repeat the process for the other parts of the sound and picture sure they will arrive at the same time without interference if we eliminate the first problem With the rapid growth of the digital communications sector in recent years, demand for high speed data transmission systems has increased. In addition, future wireless systems are expected to support a wide range of services including video, data and voice.

OFDM is a promising candidate to ensure high speed data transmission in the wireless medium due to its resistance to ISI, which is a common problem that limits the speed of data transfers and this mean send many data on one channel without any interference between them so and this technology very important in this time because the main reason for the evolution of our current world is the application of this technique in all devices phone but we did not know where and when in other word it is applied in 2G and 3G and 4G and maybe in 5G.

Despite being a nearly 50 year old concept, it is only in the last decade that OFDM becomes the modem of choice in wireless applications. One of the biggest advantages of an OFDM modem is the ability to convert dispersive broadband channels into parallel narrowband sub-channels, thus significantly simplifying equalization at the receiver end. Another intrinsic feature of OFDM is its flexibility in allocating power where we send the image and then the sound and thus the picture precedes the sound often there means there is a delay between the two signals, the rapid growth of the digital communication sector in recent years, the demand for high speed data sender systems has increased, in addition, future wireless system are expected to support a wide range of services including video, data and voice, OFDM is a promising candidate to ensure high speed data sender on the wireless medium due to its resistance to the speed of data transfer, in OFDM the include is done in a differential or read a modulation, there is no need to estimate the radio channel.

Orthogonal frequency division multiplexing is commonly implemented in many emerging communications protocols because it provides several advantages over the traditional FDM approach to communications channels. More specifically, OFDM systems allow for greater spectral efficiency reduced inter symbol interference (ISI). Relative resistance to multipath fading and frequency domain equalization is relatively simpler compared to single carrier system.

Research goal and objectives

The goal of the research is the development technology OFDM for wireless networks and communication system digital.

For the reaching this goal we must achieve following objectives.

1. Analyze of the subject area.

2. Send and receive packages from information.

3. Analyze of modern tools that used in OFDM and choose tools for project development.

4. Design the system.

5. Design the system function requirement by using case diagram.

6. Implement the system (coding).

7. Test all of system.

The practical significance

In OFDM data is transmitted by multiple carriers and every two adjacent channel is perpendicular to frequency and no guard band is placed between them but guard time is placed and added to each symbol where we can overcome the delay separated for each channel.

This project useful, because it contains important many features of it.

1. Digital television.

2. OFDM is a key wireless technology used in WI-FI, WIMAX, LTE (3G and 4G cellular network and maybe in 5G).

3. South America and European and Australian standard.

4. High data rates in 4G, WI-FI, WIMAX are possible because of OFDM technology.

5. Wireless Local Area Network (LAN).

6. OFDM is a key broadband wireless technology.

7. Low cost and high gain.

8. High efficiency in send and receive.

9. Less losses in 4G.

Structure of the thesis

The thesis comprises of four chapters, introduction, conclusion and references list

In chapter one, the problem statement is given as well as the overview and comparative analysis of OFDM system. Additionally we talked about all technologies that support OFDM and what is the difference between them.

In chapter two, there is a description of functional requirement, use case diagram, structure of OFDM, great model of OFDM system.

In chapter three, we enter the data after that we receive this data on the shape signals and we analyze each signal according to success and failure rate of the transmitter.

In chapter four, is devoted to the testing of the system.

The thesis has 60 pages; the list of references 21 resources.

1. THE ANALYSIS OF THE SUBJECT AREA

This chapter investigates, analyses and discuss why needing this technology, what is the problem domain, what are best current OFDM development technologies available, which technologies OFDM used to development the project, and cost effectiveness for developing the project.

1.1. Analyze the domain of problem

The phenomenon of overlapping symbols, which is symbolized by inter symbol interference ISI, is a phenomenon that occurs as a result of the intersection n of two sides of the symbol . This leads to an increase in the band assigned to this symbol. The process of flattening is called dispersion and it leads to loss of orthogonal property in OFDM.

1. There are some obstacles in using OFDM in sender system in contrast to its advantages. A major obstacle is the OFDM signal exhibits a very high peak to advantage power ratio. So when want to send information from sender into receiver during channel(medium) it will some losses in data because environment factors so and it is normal in communication system [16].

2. The other limitation of OFDM in many application is that it is very sensitive to frequency errors caused by frequency between the local oscillators in the transmitter and the receiver.

If we had a user trying to use my mobile while moving from one place to another we will notice there are some obstacles that hinder it. For example, the buildings and cars are all obstacles to the transmission of the signal from transmission to receiver, we find that the signal collides with these obstacles and change the path, so access to the receiver at different times depending on the type of obstacle that hit him. One of the causes of inter symbol interference is multipath propagation in which a wireless signal from a transmitter reaches the receiver via multiple paths.

3. The other limitation of OFDM in many application is that it is very sensitive to frequency errors caused by frequency between the local oscillators.

4. Carrier frequency offset causes a number of impairments including attenuation and rotation of each of the subcarriers and inter carrier interference between subcarrier in the mobile radio environment the relative movement between sender and receiver causes Doppler frequency shift , in addition , the carrier can never be perfectly synchronized .these random frequency errors in OFDM system distort orthogonally between subcarrier and thus interference occurs, a number of methods have been developed to reduce this sensitivity to frequency offset.

1.2. OFDM Basics

In digital communications, information is expressed in the form of bits. The term symbol refers to a collection, in various sizes, of bits. OFDM data are generated by taking symbols in the spectral space using M-PSK, QAM, etc, and convert the spectra to time domain by taking the Inverse Discrete Fourier Transform (IDFT) [18]. Since Inverse Fast Fourier Transform (IFFT) is more cost effective to implement, it is usually used instead. Once the OFDM data are modulated to time signal, all carriers transmit in parallel to fully occupy the available frequency bandwidth. During modulation, OFDM symbols are typically divided into frames, so that the data will be modulated frame by frame in order for the received signal be in sync with the receiver. Long symbol periods diminish the probability of having inter-symbol interference, but could not eliminate it. To make ISI nearly eliminated. A cyclic extension (or cyclic prefix) is added to each symbol period. An exact copy of a fraction of the cycle, typically 27% of the cycle, taken from the end is added to the front. The data to be transmitted on an OFDM signal is spread across the carriers of the signal, each carrier taking part of the payload. This reduces the data rate taken by each carrier. The lower data rate has the advantage that interference from reflections is much less critical. Inter symbol interference is a signal distortion in telecommunication. One or more symbols can interfere with other symbols causing noise or a less reliable signal.

1.3. The best current development technology OFDM available

One of the most important features of the use of 4G technology is the speed of data transfer, providing the user with high speed of data transfer with the possibility of doubling in high-speed Internet connection as in fig.1. Which is one of the most important features of interest to the user as well as higher sound quality [12].

Fig. 1. Stages of generations

We know each generation has specific speed in transfer data rate and type of protocol is support as below in table .1 so not of them have packet circuit

Table .1 comparison in different function between 1G, 2G, 3G , 4G [3] in OFD system

NO.	Key Parameter	1Generation Wireless network	2Generation Wireless network	3Generation Wireless network	4Generation Wireless network
1.	Designed	Basic voices service	Designed for voice	Designed for voice with same data	Designed primarily of data
2.	Protocol type	Analog-based protocol	Improved coverage	First mobile Broadband	IP based protocols [LTE]
3.	Speed	High speed	First digital standards[GSM]	Speeding more than 1G	Speeding more than 3G
4.	Development	1970-1980	1990-2004	2004-2010	2015-till now because the 4G it support 5G in next time so still till now

End of table 1

5.	Data Rate	2 Kbps	14.4-64 Kbps	3.1Mbps average speed 0.5Mbps-1.5 Mbps	2-12 Mbps average speed of 100Mbps-300 Mbps - 500Mbps
6.	Download	-	144 Kbps	100 Mbps	1Gbps
NO.	Key Parameter	1Generation Wireless network	1Generation Wireless network	1Generation Wireless network	1Generation Wireless network
7.	Bandwidth	800-900 MHz	850- 1900 MHz(GS M) 825-849MHz (CDMA)	1.8 – 2.5GHz	2 – 8 GHz
8.	Switching Technology	Circuit	Circuit, Packet	Both circuit and packet switching	Packet switching
9.	Network architecture	AMPS	GSM	Cell-Based (WAN)	WAN-LAN
10.	Internet	-	GPRS	Air link	IPv4, Ipv6

In fig. 9 we made curve for all technologies that support OFDM system and stages of development of generations in wireless communication system [9].

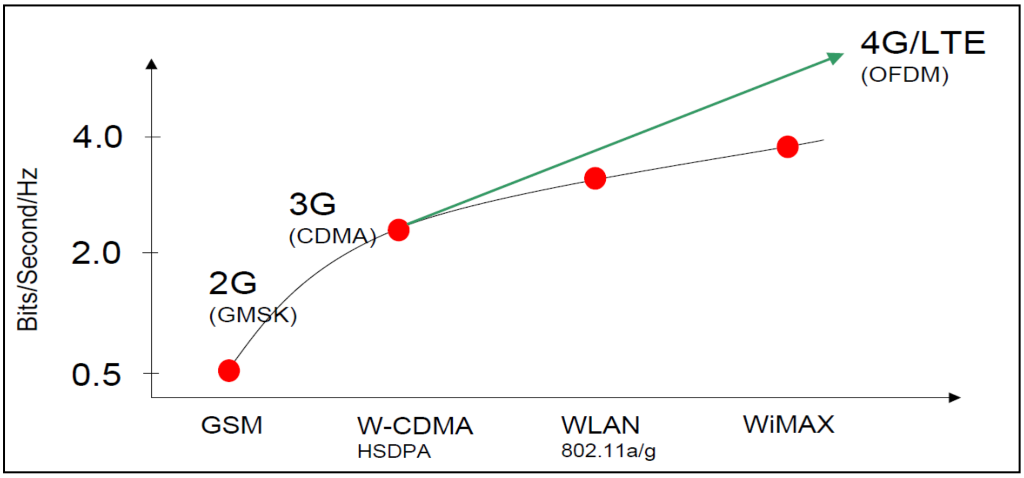


Fig. 2. Stages of development of generations

1.4. Technologies used to develop the project

There are many technologies that have been used to develop OFDM, which have played a major role in the development of the communications system and computer networks including, for example technology Long Term Evolution (LTE) Participating in the third-generation fourth-generation 3G, the fourth version of LTE is really 3.9G technology so as not to fully lead to the requirements of the fourth generation, the advanced AMT. The fourth standard of the fourth generation (fourth generation) 4G.

1.4.1. Long Term Evolution

LTE transports voice and image data in a radius cell with up to 100km support to a BS base station. The OFDM technology and encoding is used to transmit transmission in downlink and uplink data transmissions, enhancing spectrum flexibility and cost effectiveness. Fig. 2. Work technology 4G with previous technologies such as GSM and UMTS, which benefit from lower operating costs and wider coverage and operate uninterrupted as it provides a transfer from one station to another "Handover" smoothly and flexibly without any interruptions or problems. The first improvement of the 4G network is of course speed, with the new technology providing faster data transfer speeds of 4 to 10 times the 3G. It is difficult to give figures here because 3G speed is not fixed and varies from state to state[11].

Fig. 3. Technology 4G In mobile

1.4.2. Code division multiple access

In OFDM-CDMA, user information are spread over several and/or OFDM symbols using spreading codes, and combined with signal from other users. The idea of OFDM – CDMA can be attributed to several researchers working independently at almost the same time on hybrid access schemes combining the benefits of OFDM and CDMA. OFDM provides a simple method to overcome the ISI effect of the multipath frequency selective wireless channel, fig. 4. Appling CDMA in USA while CDMA provides the frequency diversity and the multi-user access scheme. Different type of spreading codes have been investigated. Orthogonal codes are preferred in case of DL, since loss of orthogonal is not as not as severe in DL as it is in UL. Several users transmit over the same sub-carrier. In essence this frequency domain spreading, rather than time-domain spreading, as it is conceived in a CDMA system. The channel equalization can be highly simplified in DL, because of the one-tap channel equalization benefit offered by OFDM. In OFDM-CDMA, the flexibility lies in the allocation of the available codes to the users, depending on the required data rates. As OFDM-CDMA is applied using coherent modulation, the necessary channel estimation provides information about the sub-carrier attenuations; this information can be used when performing an equalization in the receiver [13].

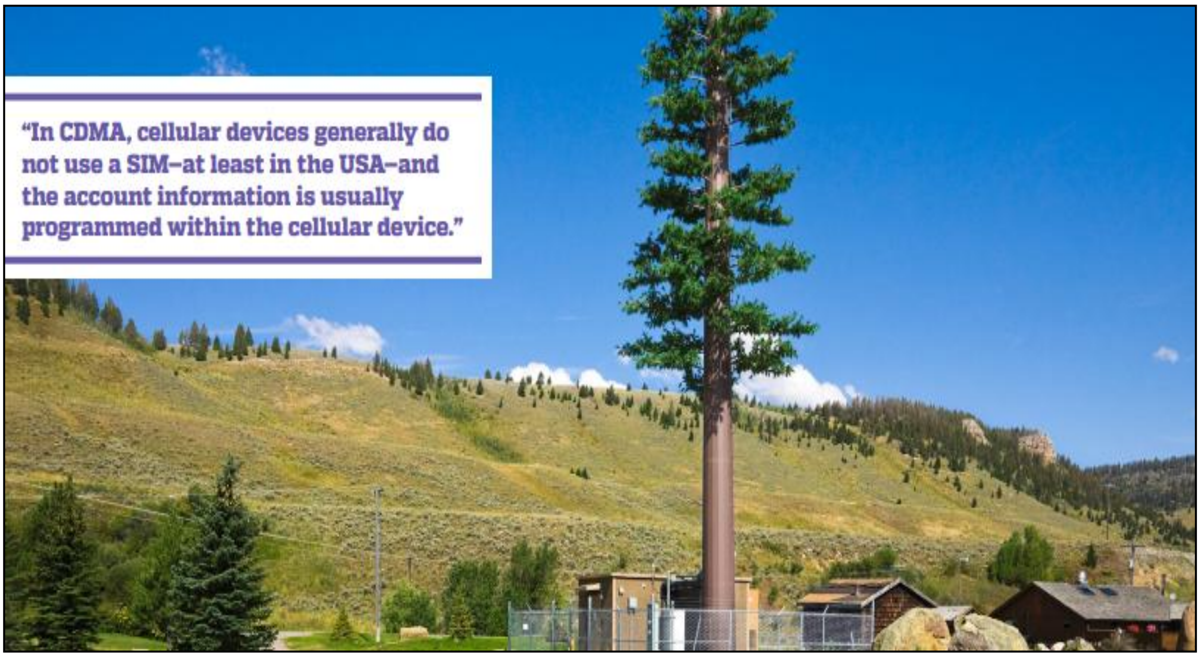


Fig. 4. Code division multiple access

1.4.3. Global system Mobility

The most important part of a mobile wireless network in OFDM from the mobility point of view is how the handover process from one cell or base station (BS) to another is done. With the reality of different standards existing side by side like 2G, GSM and 3G, UMTS/WCDMA/HSPA or even4G, LTE the handover process can be very tricky and complicated as it involves two completely different techniques two communicate and handle the migration. With the world wide extent of GSM coverage often the best fallback network is the GSM. Mobility management is the procedure that manages among others: location update of the user's and roaming. Fig. 5. expand technology GSM in mobility management of GSM mainly depends on a centralized approach. GSM operator has the responsibility of providing data in the Home Location Register (HLR). HLR holds an indication as reference to Mobile Switching Center (MSC) with a concerning Visitor Location Register (VLR), where the mobile station is presently registered and the corresponding location information, the key/identifier of the location area is stored. When the location entry needs to update, the concerned HLR and VLR are updated [15].

Fig. 5. Global system for mobile

1.5. Comparative analysis between LTE, CDMA,GSM systems in OFDM

See tab. 2 we explained about all technologies that support 4G and type each operation in the network for the users.

Table 2. Comparison in different function between GSM, CDMA, LTE [9] in OFDM system

No	GSM	CDMA	LTE
1.	For GSM cellular technologies, the 2rd Generation Partnership Project ("3GPP") provides the technical specifications for six international SDO, specifically: ARIB, ATIS, CCSA, ETSI, TIA and TTC2.	For CDMA cellular technologies, the 3rd Generation Partnership Project 2 ("3GPP2") provides the technical specifications on the ANSI-41/TIA/EIA41 network and radio technologies for five SDO - specifically: ARIB, CCSA, TIA, TTA and TTC3.	For LTE(4G) cellular technologies, the 4rd Generation Partnership Project 4 ("3GPP3").
2.	The GSM cellular technologies are sometimes referred to as "3GPP technologies".	the CDMA cellular technologies are sometimes referred to as "3GPP2 technologies" [19].	The GSM cellular technologies are sometimes referred to as "3GPP3 technologies".
3.	For simplicity in this document, Operators who deployed GSM technologies are called "GSM Operators".	Operators who deployed CDMA technologies are called "CDMA Operators". So used in USA	Operators who deployed 4G technologies are called "LTE Operators".

End of table 2

NO.	GSM	CDMA	LTE
4.	GSM Operator Technology Deployments, Operators moved from AMPS-mostly in North and South American markets-to a digital cellular system using TDMA called the Global System for Mobile Communication ("GSM").	CDMA Operator Technology Deployments, the Operators moved from the Analog cellular system, called AMPS, to a digital cellular system using CDMA encoding, as defined by the TIA/IS-95 CDMA standard.	LTE Operator Technology Deployments, Operators moved from OFDM-mostly in North and South American markets-to a digital cellular system using OFDM called the long term evaluation("LTE").
5.	In GSM, each cellular device has a unique serial number called an IMEI	In CDMA, each cellular device has a unique serial number called an MEID	In LTE, each cellular device to other cellular according to the user.
6.	GSM It is the basis for both technology LTE and CDMA so There are problems occur in the synchronous process, whether in the symbol or frequency.	CDMA is a technology developed to enable OFDM to reach those speeds and be noticeably faster than 2G so here are problems occur in the synchronous process, whether in the symbol or frequency for each user.	LTE is a technology developed to enable 4G to reach those speeds and be noticeably faster than 3G There are problems occur in the synchronous process.

1.6. IP data operation

Again, the GSM (3GPP) and CDMA (3GPP2) networks for IP data in OFDM operation are similar in many ways. Fig. 6 operation data in PTS here the names of the network infrastructure elements are quite a bit different (unlike the network for cellular operation), but, again, the functions are publically quite similar [1].

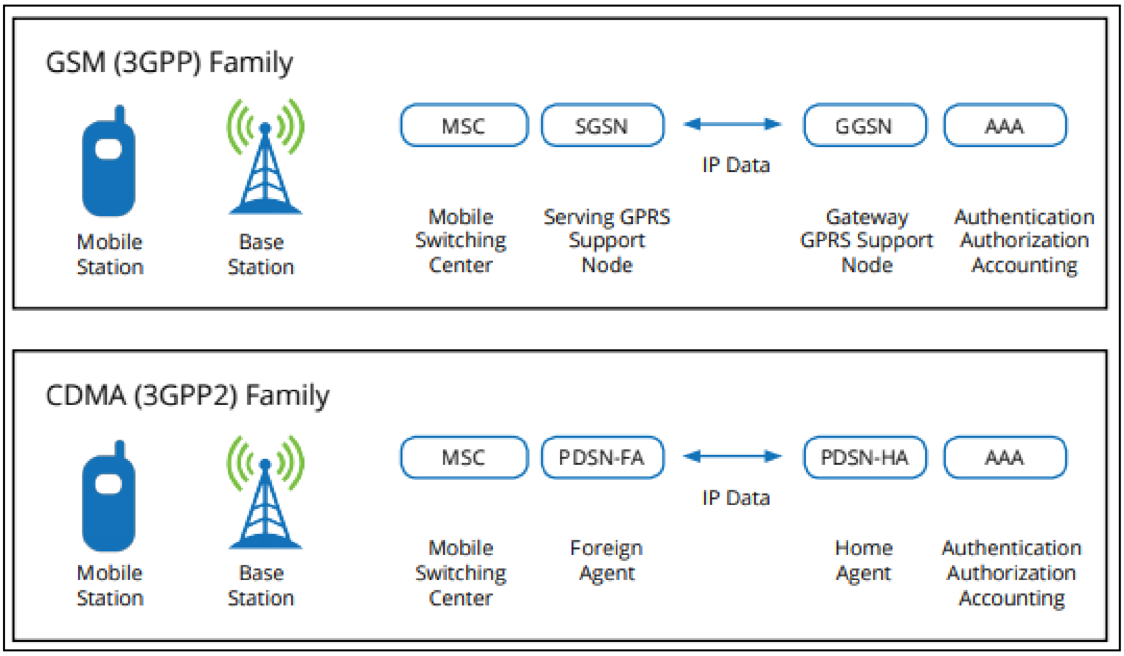


Fig. 6. IP data operation in the PTS

And, just like cellular operation, the actual sequences in the call flows whether authentication, authorization, or data related between GSM and CDMA devices and the respective networks, are quite different, and beyond the scope of this document, for example the switch uses the destination MAC address to forward frames and it is a device mainly found on the Local Area Network (LAN). The switch learns where hosts are connection by looking at the source MAC address of incoming frames.

1.7. Working and using orthogonal frequency division multiplexing

In order to understand the OFDM function, we need to talk about FDM (frequency division multiplexing) in which mapped for data stream is transmitted and transmitted via the frequency channel completely separately and every two adjacent channel is placed with a so-called guard band with you. The interference is present and since the number of users has become So it is difficult to stay on this technique because it is an analog method and is influenced by noise quickly and the interaction is present. Fig. 7 OFDM data is transmitted by multiple carriers and every two adjacent channel is perpendicular to frequency and no guard band is placed between them but guard time is placed and added to each symbol where we can overcome the delay separated for each channel [25].

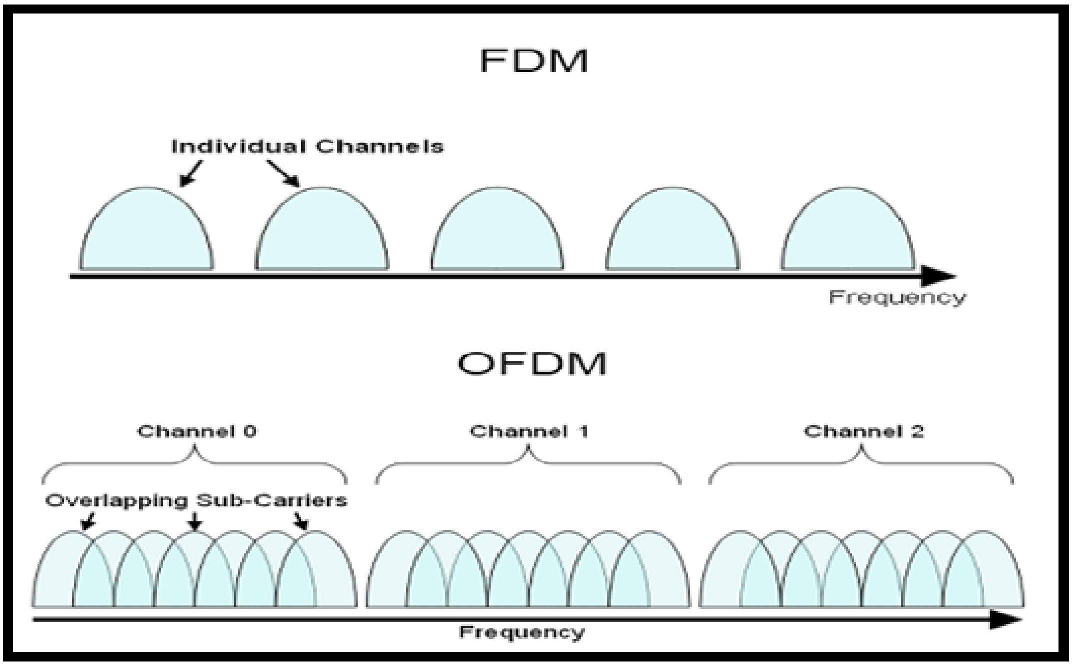


Fig. 7. OFDM Technical action mechanism

OFDM is that by using a reduced symbol rate of 250,000 symbols per second the negative effects of multipath distortion are reduced. Since each occupies more time, there is more resilience to delay spread which is caused by multipath when signal reflections cause multiple copies for the same sender symbol to arrive the receiver.

As mentioned below, multipath transmission caused some interaction with the symbol. This phenomenon was overcome in the ways explained above, but in the high data rate it was found that the use of such equalizers channel is relatively complex and somewhat expensive.

A new technology called orthogonal frequency division multiplexing is a relatively simple phenomenon to overcome multipath transmission. Through this we can separate the sub-channel with each other and thus there is no interference with the signals. Fig. 8 IP network in the mobile also provided us with more modulation using the inverse fast Fourier transform at transmission and demodulation via the fast Fourier transform at receiver which will be explained in this detail.

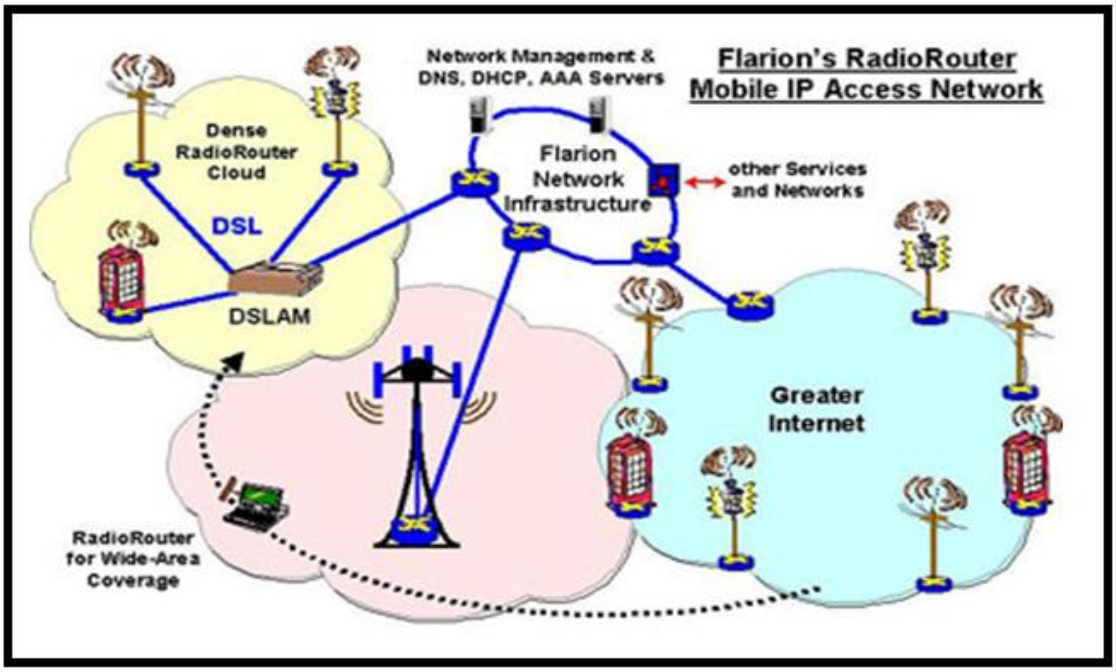


Fig. 8. mobile IP access network

Because of the problems that corresponded to the signal with the previous techniques and also because of the increase in the number of users had to find a way to try to overcome or reduce these problems and there is a strong need to increase the rate of data transfer in light of this terrible development in the world of communications and the beginning to rely on the transfer of satellite channels Scientists and engineers have discovered that if their signals are aligned, they will be far from each other, so they are allowed to intersect rather than overlap the sub-carriers and thus be orthogonal if their integrals are equal to zero.

1.8. Data Multiplexing

Multiplexing is a method of working for sharing for medium is a sharing for channel. In other words, if we have more than one device and want to send data to more than one device in this case we can take one channel to assemble more than channel as in fig. 9 below and we are working for sharing for medium so that the process of communication at the lowest cost, short multiplexing works for medium sharing for more than one device [8].

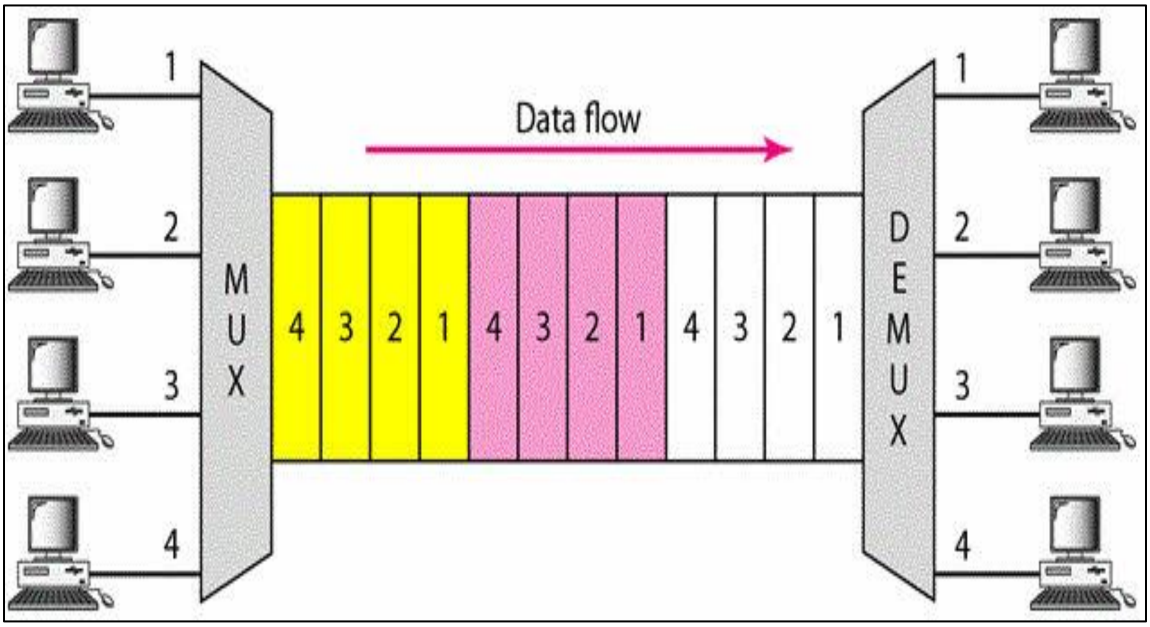


Fig. 9. Data multiplexing and De-multiplexing

The multiplexer used for digital applications, also called digital multiplexer, is a circuit with many input but only one output by applying control signals, we can steer any input to the output. multiplexer handle two type of data that is analog and digital It has several inputs and a single output and also has control inputs that allow digital data on any line of input to open on the output This method packs several signals or brings them together by time [13].

1.8.1. Frequency division multiplexing

Frequency division multiplexing (FDM) involves the allocation of each channel to a unique frequency range. This frequency range prescribes both the center frequency and channel width (bandwidth). Because these channels are non-overlapping, multiple users can operate concurrently simply by using different channels of the frequency domain. below, we illustrate the frequency domain of an FDM system. Note from the diagram that each channel operates a different carrier frequency and that these channels are band limited to operate within a defined bandwidth. Here, the band is split into the FDM, but the difference is that it becomes the general carrier. In the sense that once the user has finished using it, it will not be owned by another user who enters the network. If the first user wants to enter the network, it will be given another frequency. Increase Capacity but not too much [5].

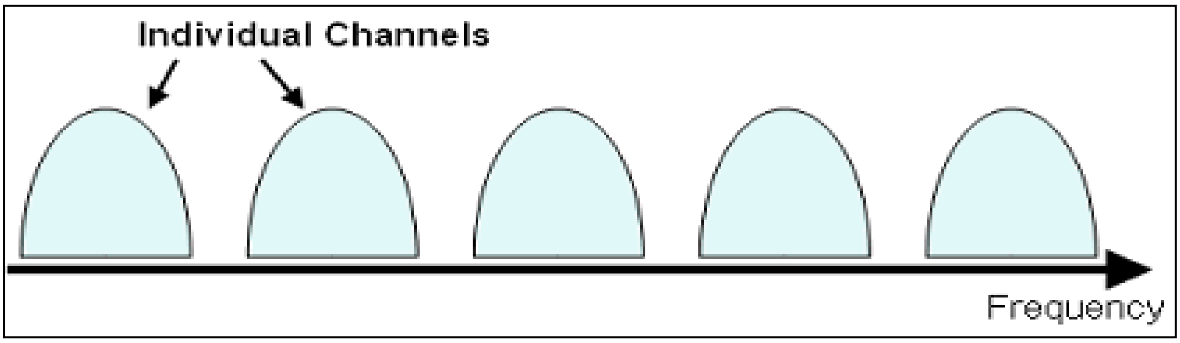


Fig. 10. Work (FDM)

FDM is also used by telephone system to sender multiple telephone calls through high capacity trunk- lines, communication satellites to sender multiple channels of data on uplink and down link radio beams, and broadband DSL in the modems to sender large amounts of computer data through twisted pair telephone lines, among many other uses, when FDM is used to allow multiple users to share a signal physical communication medium, the technology is called frequency division multiple access In some systems, a different scheme, known as time division multiplexing is used instead line the necessary bandwidth is large, and careful engineering is required to ensure that the system will perform properly.

1.8.2. Work of frequency division multiplexing

In this way, band bandwidth is divided between user according to frequency. For example, if we have a channel that has a large band width and therefore will divide the band width into a small band width, Another example if we have BW = 10MHZ we will divide 10MHZ into 10 channel each channel will take 1MHZ and thus divide our channel according to frequency [1]. The existing band is divided into small parts, each part used by a particular system to guarantee There is a small gap called the Guard Band which is a very small part that is empty and is not dedicated to a particular system and its usefulness is to prevent interference between the system on the right and the other on the left Because, as we all know, in fig.11 we have many data and there is no perfect speculator, it is possible that there will be a slight deviation in the frequency of either of the two systems around that empty space [2].

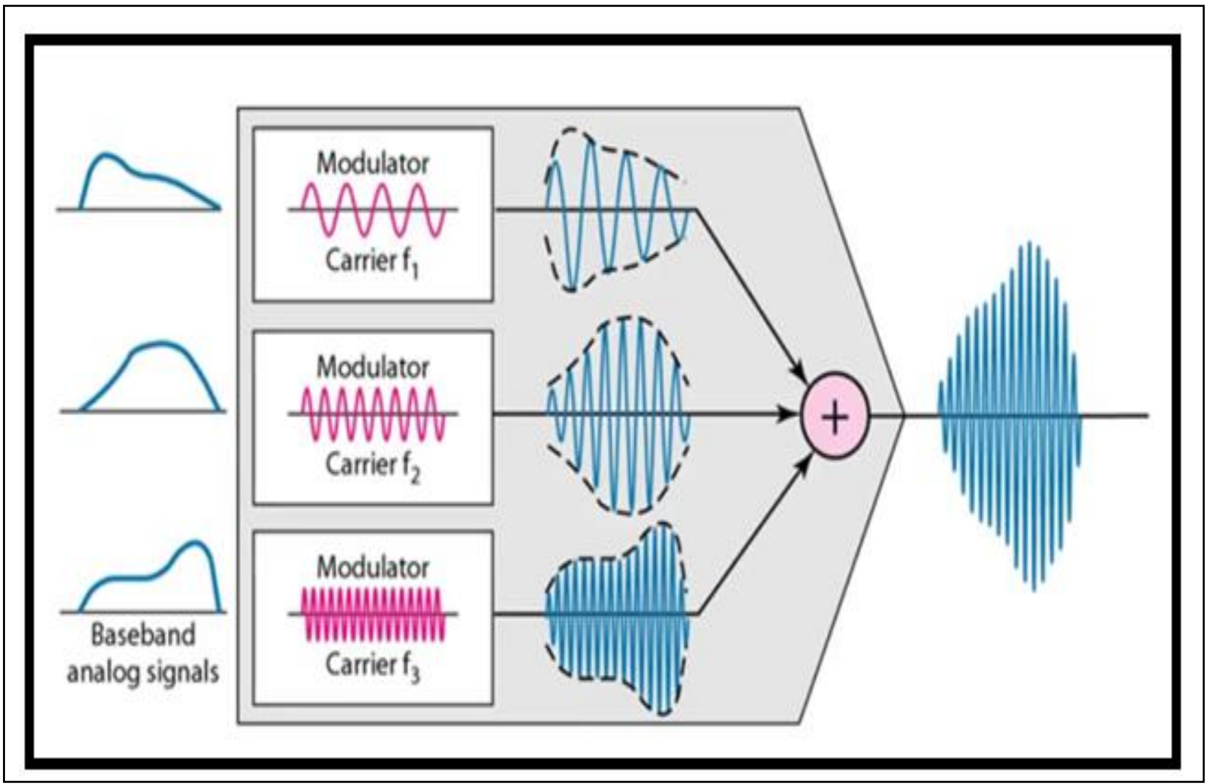


Fig. 11. Example about work (FDM)

As shown in the diagram above, each sender will send its signal at a given modulation carrier. Sender (1) & (2) & (3) will carry on three modulation carrier and then it will serve them summation until they send on the sharing medium either at the receiver end we will find that the multiplexing contains a set of filters b where each.

1.8.3. De frequency division multiplexing

The multiple separate information (modulation) data that are sent over an FDM system, such as the video data of the television channels that are sent over a cable TV system, are called baseband signals. At the source end, for each frequency channel, an electronic oscillator generates a carrier signal, a steady oscillating

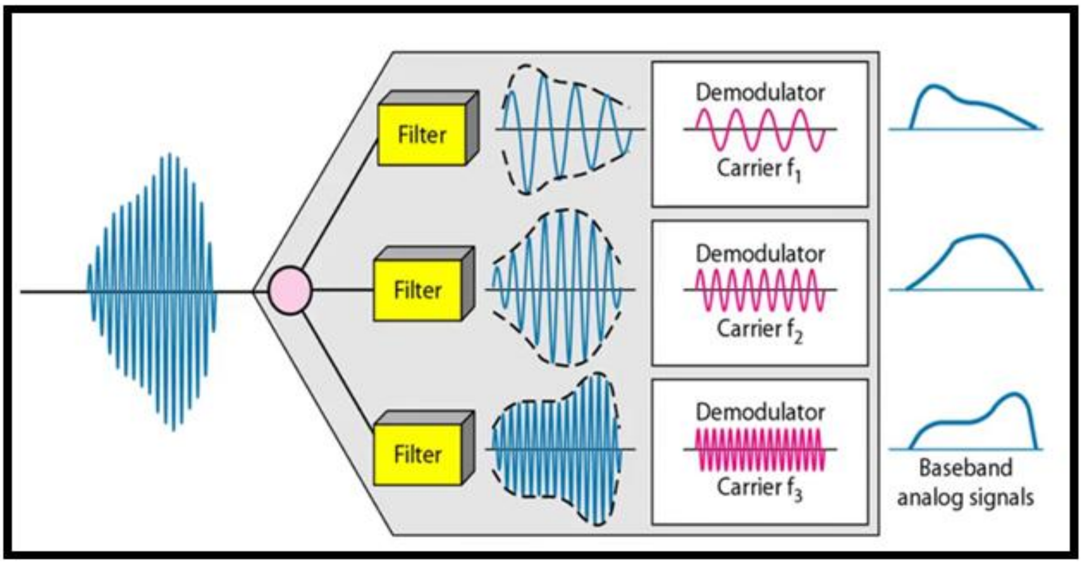


Fig. 12. Example about work (FDM)(De-multiplexing)

By drawing above in fig. 12 we will mention that the receiver end will process the De-multiplexing and as we observe the signals will be collected so that these signals will pass on a set of filter so that each filter passes a certain frequency and then the process of demodulation of the carrier is done. For example, if we have 7 Users, they send their data on a medium share [10]. In this case, we need to divide the channel into 7 separate channel so that each channel takes a certain frequency range as show in table 3.

Note that each channel as show in table. 3 and another distance is empting f- or about 20khz and this distance is called guard band [17]so that we ensure that in e- ach channel does not interfere with each other and note that the guard band is a big.

Table 3. The relationship between the channel and frequency range for each user on the network

Channel	Frequency range
1	100 khz – 300 khz
2	320 khz- 520khz
3	540 khz-740 khz
4	760 khz-960khz
5	980 khz- 1180 khz
6	1200 khz- 1400 khz
7	1420khz-1620khz

1.8.4. Comparative analysis between FDM and OFDM system

We have in table .4 comparison describes two FDM, OFDM [3] and we will know where applied OFDM technology in the network and speed each user.

Table 4. Comparison in different function between FDM, OFDM.

NO.	FDM	OFDM
1.	Bandwidth dedicated to several sources.	All sub-channels are dedicated to a signal data source.
2.	No relationship between the carrier.	Sum of a number of orthogonal carriers.
3.	There is a guard band.	No guard band.
4.	Low spectral efficiency.	Better spectral efficiency.
5.	More subject to ISI and external interference from other RF sources.	Overcome ISI and delay spread in each channel.
6.	In traditional FDM systems the frequency bands for different sub channels were widely separated. If they are spaced sufficiently far apart [5].	due to the operation of DFT, the sub-carriers are spaced very close to each other. This means better spectral efficiency, used for latest communication standards.
7.	High cost and low gain	Low cost and high gain
8.	Data doesn't divided among large number of closely spaced carriers	Data divided among large number of closely spaced carriers
9.	Low efficiency in transmission.	High efficiency in transmission
10.	In FDM the overlap is in the time domain	In OFDM the overlap is in the time frequency
11.	needs to be kept some GUARD band between the adjacent sub-carriers	No need of keeping guard band. In fact, the subcarriers can now be partially overlapping

1.9. IEEE 802.11 and Wi-Fi in OFDM

In recent years, the demand for rendering multimedia applications over wireless has motivated the development and raise of IEEE 802.11 wireless local area network (LAN). Compared to the traditional Ethernet LAN, Wireless LAN has the feature of easy installation, low cost and backup sure degree of mobility. 802.11 is a part of the 802 standard family for local area networks. This family describe the physical and data link layer specified in the International Organization for Standardization (ISO) Open Systems Interconnection(OSI)basic reference model. More specifically, 802.11 describe the medium access control (MAC) layer and physical (PHY) layer, Several common commercial protocols, such as digital video broadcast (DVB), asymmetric digital subscriber line (ADSL), and wireless Ethernet (Wi-FI) implement OFDM. With Wi-FI, the IEEE 802.11a and IEEE 802.11g implementations specifically use OFDM techniques. With IEEE 802.11g, each channel take 16.25MHz of bandwidth at the 2.5GHz frequency range. In addition, each channel is split into 54 sub-carriers of 313.5kHz. Together, these sub-carriers overlap to fully utilize the 16.25MHz channel bandwidth dedicated per channel [20]. In addition, each sub-carrier can use a unique modulation scheme.

Table 5. Standards 802.11 and table 5. Below also we will know speed each standard according to the parameter

802.11	Means
A	54 Mbps OFDM , 5.9 GHZ Band , 20 MHZ channels .
B	11 Mbps CCK , 2.4 GHZ (Legacy , not OFDM).
G	What you can easily buy now – same as (a) , but at 2.4 GHZ.
J	Japanese version of (g) that uses half the sample rate.
N	Not a finished standard yet. Like (g) , but up to 600Mbps. OFDM. MIMO. 20 and 40 MHZ channels.

2. DESIGN OF MANAGEMENT INFORMATION SYSTEMFOR DEVELOPMENT OFDM

2.1. Functional requirements

Functional requirement are something any project must have in order not to get fail during the work.

The feature that are available for OFDM system.

1. The OFDM system must give an ability to the user success rate of data transmission.

2. The OFDM system must give an ability to the user to see the full catalog of data.

3. The OFDM system must give an ability to the user to see the data of all user.

4. The OFDM system must make the punishment for a users if the data was returned in later than he had to.

The feature that are available for the sender .

1. The sender must be able to add and modify data about user.

2. The sender must be able to analyze of data.

3. The sender must be able to detection and correction of error in data.

4. The sender must be able to searches for data if it happens to be lost.

5. The sender must be able to remove any user.

6. The sender must be able to register date and time send for each user.

The feature that are available for the receiver.

1. The receiver must able to recovery for original data.

2. The receiver must able to Display the status of sender and receiver.

The feature that are available for the channel(medium).

1. The medium must can able to Convert the data to other expression for purpose security from hacker.

2. The medium must can able Matching between the sender and receiver when there is disconnect between the sender and receiver so that the channel work link between of them.

2.2. Use case diagram

Unified Modeling Language (UML) enable IT professionals to model computer applications [4]. This diagram shows ten use cases. There are three types of sender, receiver, channel (medium) all of them represented as actors. These actors are connected with these use cases by relationships to show the capability for each user in the system. Fig. 13 shows the Use case diagram for the system functions.

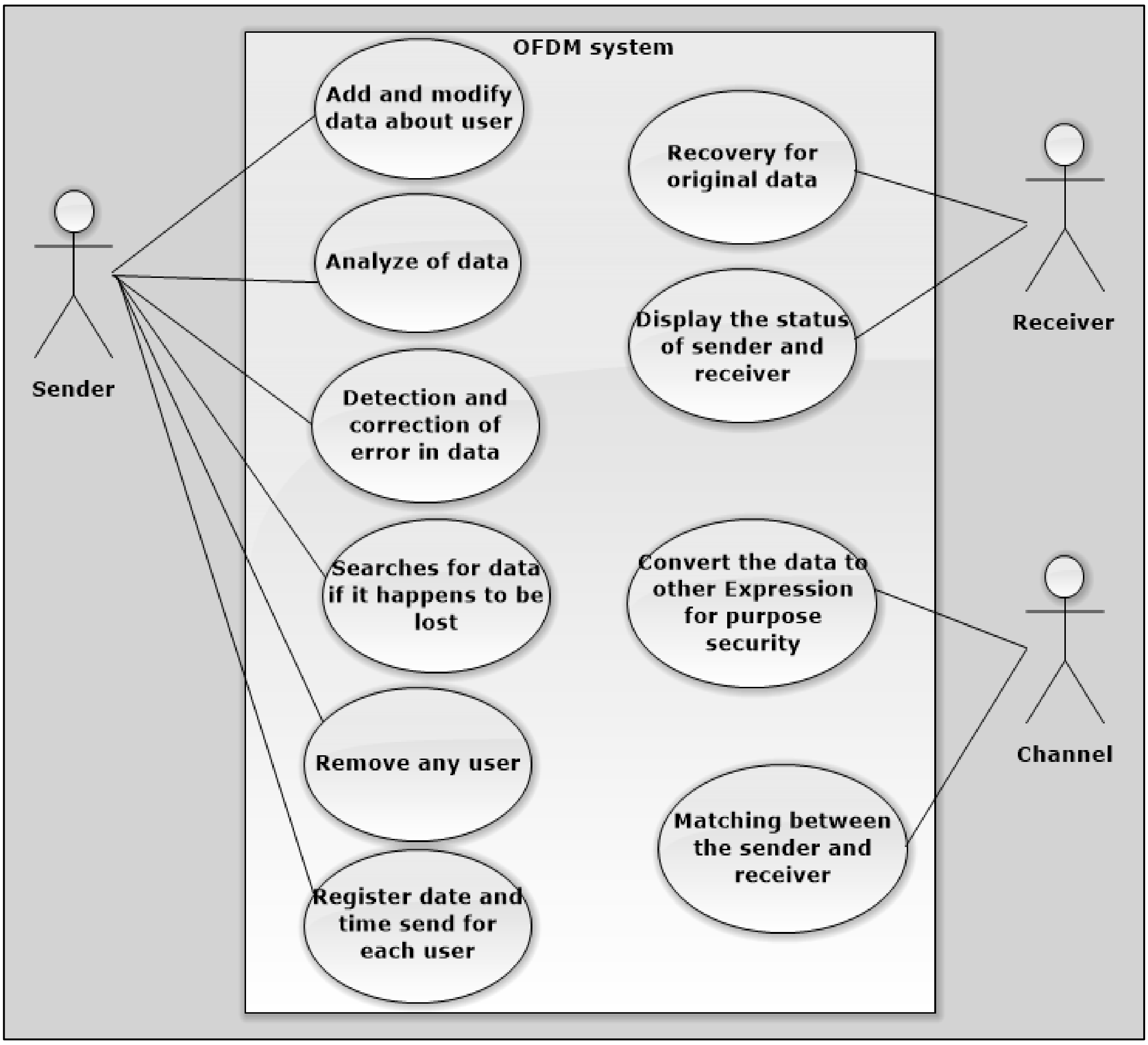


Fig. 13. Use case diagram

Use case "add and modify data about user" is available for sender only.

Use case "analyze of data" is available for the sender only.

Use case "detection and correction of error in data" is available for the sender only.

Use case "searches for data if it happens to be lost" is available for the sender only.

Use case "remove any user" is available for the sender only.

Use case "register date and time send for each user" is available for the sender only.

Use case "recovery for original data" is available for the receiver only.

Use case "Display the status of sender and receiver" is available for the receiver only.

Use case " Convert the data to other expression for purpose security from hacker" is available for the channel(medium) only.

Use case "Matching between the sender and receiver" is available for the channel(medium) only.

2.3. Great model of OFDM

A simplified model of modulated data of OFDM system transmitting in the satellite channel is show in Fig. 14 below, IFFT is short for inverse Fast Fourier Transform and FFT is the abbreviation of Fast Fourier Transform, CP needs to be added to each OFDM symbol to mitigate multipath effect [6].

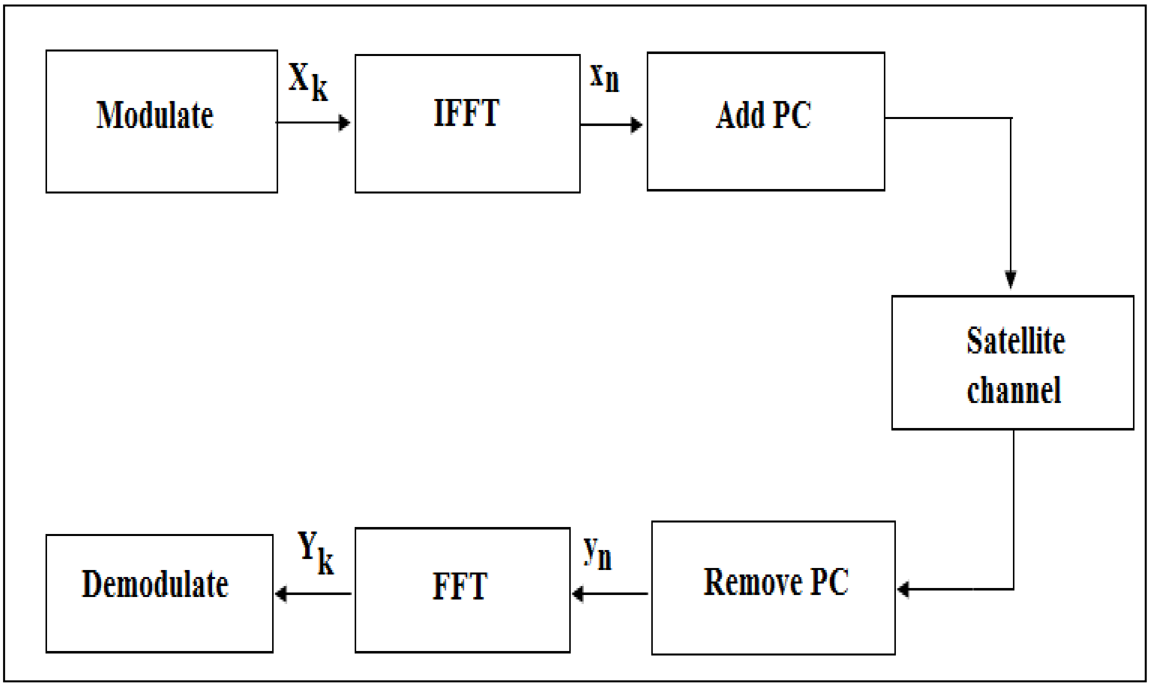


Fig. 14. Great model of OFDM

Hence: X_k is a number of signal,

X_n is Number of point in OFDM before the sender,

Y_n is Number of point in OFDM before the sender,

Y_k is output of signal.

2.4. Structure of OFDM

Through the block diagram below in fig. 15 we note that the data sent using the OFDM algorithm is entered into the source encoder until the encoding process of the data and then to the channel encoder so that it is appropriate with the nature of the channel through which data is sent and then mapping the symbol of each location symbol on the channel [3].

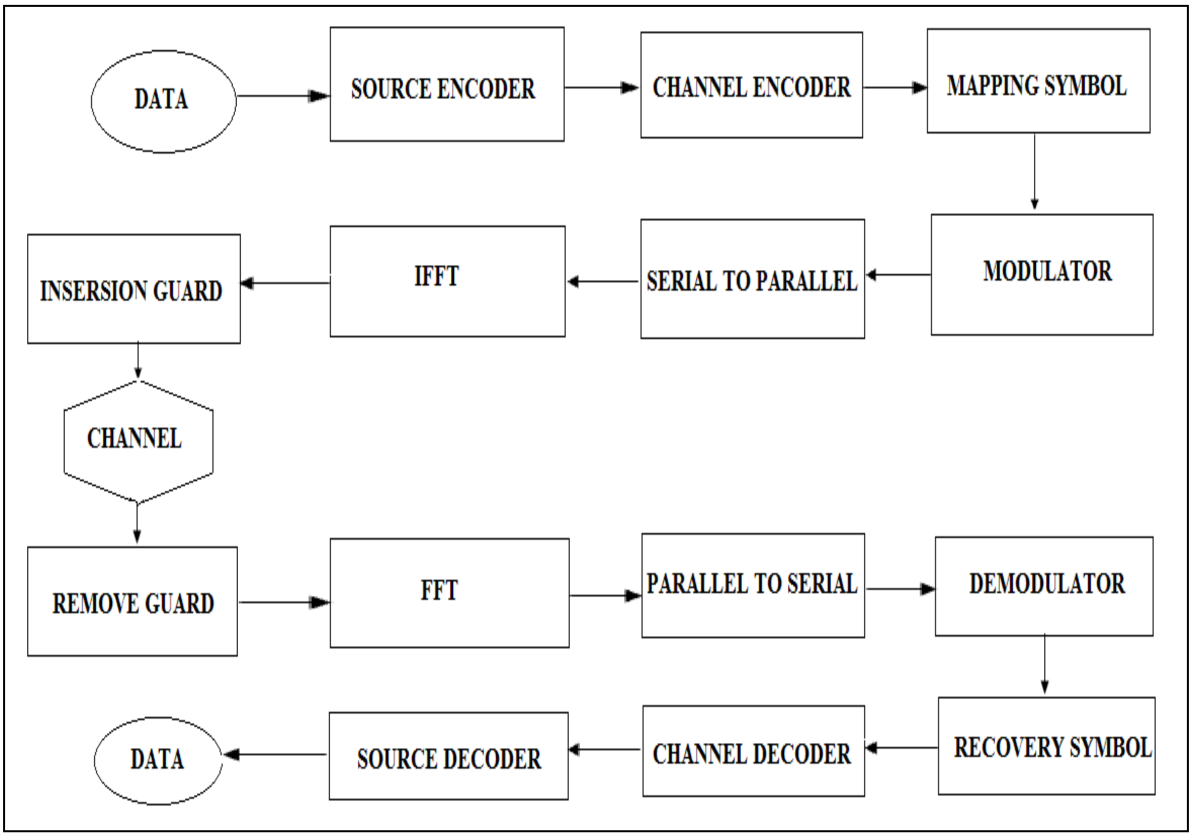


Fig. 15. OFDM block diagram

And then modulation process until the data modulation is converted from serial to parallel, where we can send each set of bits at the same moment and then insert them into (IFFT) until the guard band is done for each symbol. We can overcome the delay spread in each channel It is then converted into a radio wave format until it is transmitted via a channel. In the receiver, the process is almost the opposite. It is then inserted into the (FFT) to separate each carrier from the other and data is then converted from parallel to series, by bit and then the process of demodulation is done until the signal reaches the receiver in each symbol is drawn on the other and then the process channel encoder down to the source decoder until the data is restored to its original format.

1. SOURCE ENCODER: There is a transmission that any data sent by image or voice or text and converted to binary data bit.

2. SOURCE DECODER: The original bit is extracted again and the data format is restored to its original form, whether image, voice or text

3. CHANNEL ENCODER: be at transmission and used in the work of encrypting data [10]. There are many types of code used for example (RCPC) rate compatible punctured convolution and this type is used to protect data during transmission in the channel.

Channel rate varies from 1/3, 1/2 and 2/3.

A. 1/3 Each of the three bits uses one bit for data and two bits for protection.

B. 1/2 Each of the two bits is used for single data and is used for single protection.

C. 2/3 of each three bit uses two bits for data and one bit is used for protection.

4. Channel decoder: When the receiver is used to restore the original data again.

5. MAPPING OF SYMBOL: When transmission for single carrier transmission group or collect a bit depending on the type of inclusion used for the carrier transmission multi zeros is added to bit to be a symbol.

6. RECOVERY OF SYMBOLR: When a receiver is retrieved bit of the symbol and restore the bit of its natural form.

7. MODULATION: We also note in the diagram below in fig. 16 that each symbol consists of a set of serial bits are entered in serial to parallel is a register with one entry and has more than the exit outlets are dealt with through the range of the carrier.

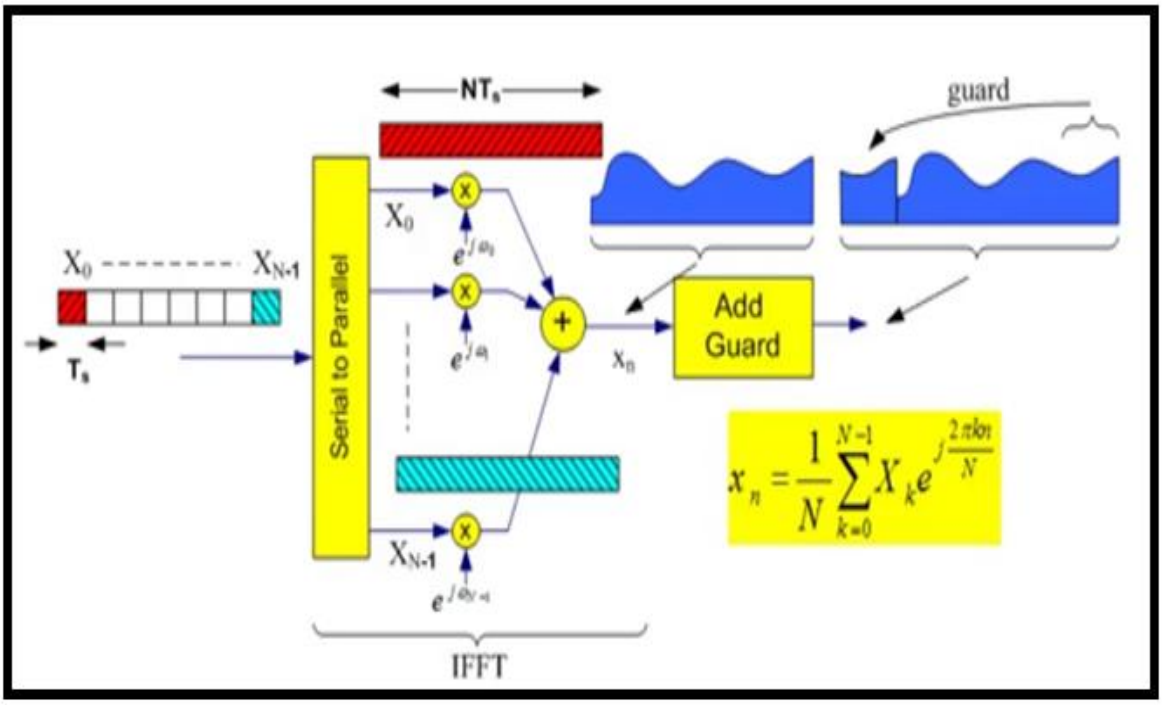


Fig. 16. Convert data from sequence to parallel

8. FAST FOURIER TRANSFORM INVERSE (IFFT)

The main purpose of the transmission is to transfer data from the frequency domain to the time domain and then send it via channel.

9. FAST FOURIER TRANSFOERM (FFT)

(FFT) is the conversion of data from time domain to frequency domain and retrieval of data in its original form.

10. GUARD BAND: After the IFFT operation occurs in the transmitter, the guard band is added to the beginning of each symbol and is required to be greater than the maximum delay of the channel so that the (ISI) phenomenon arising from the multipath does not occur.

3. SIMULATION USING MATLAB CODE OFDM

3.1. This section of MATLAB source code include OFDM sender and OFDM receiver basic chain coded in MATLAB.

Since MATLAB has a built-in function "IFFT()" which performs Inverse Fast.

Fourier Transform, IFFT is opted for the development of this simulation. Six m-files are written to develop this MATLAB program of OFDM simulation. One of them is the main program script file, which is the only file that needs to be run, while other m-files will be invoked accordingly. A 256-grayscale bitmap image is required as the source input. Another bitmap image file will be generated at the end of the simulation as the output.

Three MATLAB data storage files (err_calc.mat, ofdm_parameters.mat, and received.mat) are generated during the simulation.

Err_calc.mat is to archive the baseband data before the transmission, and be retrieved at the end of the simulation for the purpose of error calculations.

ofdm_parameters.mat is to archive the parameters initialized at the beginning of the simulation and reserve them for the receiver to use later. In the reality, the receiver would always have these parameters; in this simulation, these parameters are configured by the user at the beginning, so they are passed to the receiver by ofdm_parameters.mat as if being preset in the receiver. received.mat stores the time signal after it travels through the channel, and lets the receiver to read it directly.

When the simulation proceeds through the OFDM transmitter and communication channel, it pauses and waits for the user to trigger for proceeding to the receiver.

The reason for using the last two mat files is that as soon as the OFDM receiver proceeds, the program will clear all data/variables stored in MATLAB workspace. This is to simulate the real situation in which OFDM receivers have no knowledge of the data except for the received signal at the exit of the communication channel Simulation runtime for both the transmitter and receiver are measured and shown on MATLAB command screen as a rough measurement of relative data rate.

In figure below fig. 18 shows full information of a trial of the OFDM simulation while code contains all the MATLAB source codes for this project with detailed comments for explanations [28].

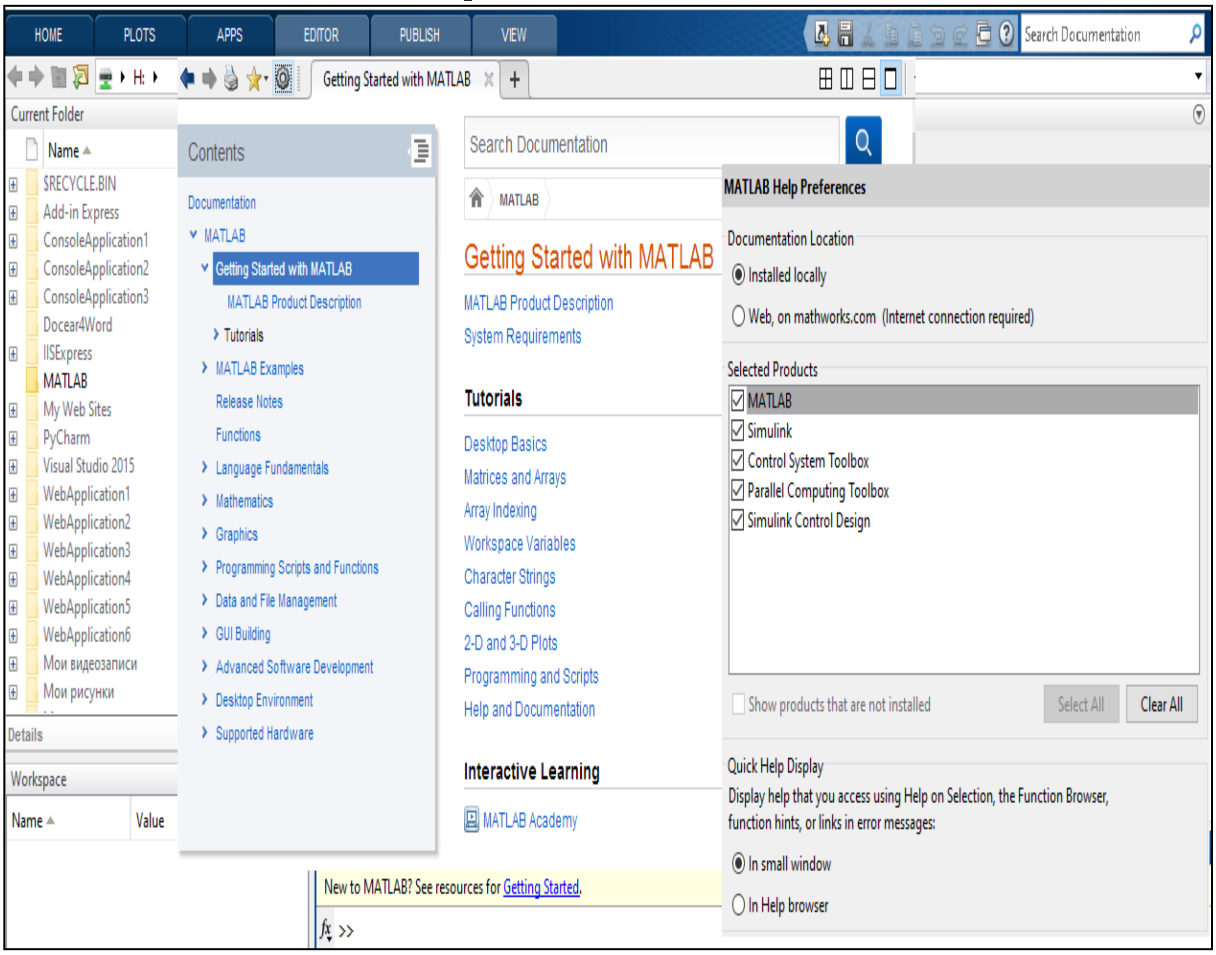


Fig. 18. Interface program

The OFDM modulator object modulates using the orthogonal frequency division modulation method. The output is a baseband representation of the O-FDM modulated signal.

So we used MATLAB for development OFDM.

1. MATLAB is development environment consist of tools used for building “OFDM” system.

2. MATLAB the main language in education in master program for foreign student in college computational mathematics.

3. Project type, this project is about developing and analyzing orthogonal frequency division multiplexing by MATLAB. To simulate an OFDM system, following design parameters are essential. Let's consider the OFDM system in parameters as in fig .19 we have parameter to purpose define original data.

```
clc;
clear all;
close all;
%
% Initiation
%
no_of_data_bits = 64%Number of bits per channel extended to 128
M =4 %Number of subcarrier channel
n=256;%Total number of bits to be transmitted at the transmitter
block_size = 16; %Size of each OFDM block to add cyclic prefix
cp_len = floor(0.1 * block_size); %Length of the cyclic prefix
%
% Transmitter
%
%
% Source generation and modulation
%
% Generate random data source to be transmitted of length 64
```

Fig. 19. Initial code for OFDM

Workspace

Name	Value
block_size	16
cp_len	1
M	4
n	256
no_of_data_bits	64

Fig. 20. Analyze Initial code

In fig. 20 we have block size and number of data bits and all of them parameter to define original data to be transmitted on an OFDM signal is spread across the carriers of the signal, each carrier taking part of the payload.

3.2. Original signal

In fig. 20 we will send this data, which contains a set of information as shown in the figure below , to the receiving party after it passes after the stages for the purpose of arriving correctly to the receiver in less losses in data and in fig. 21 data it is appearing but this before the sender.

originaldata.m

```
figuare(1) ,stem(data); grid on; xlabel('Data Points'); ylabel('Amplitude')
title('Original Data ')
% Perform QPSK modulation on the input source data
qpsk_modulated_data = pskmod(data, M);
```

Fig. 20. Generation code original data

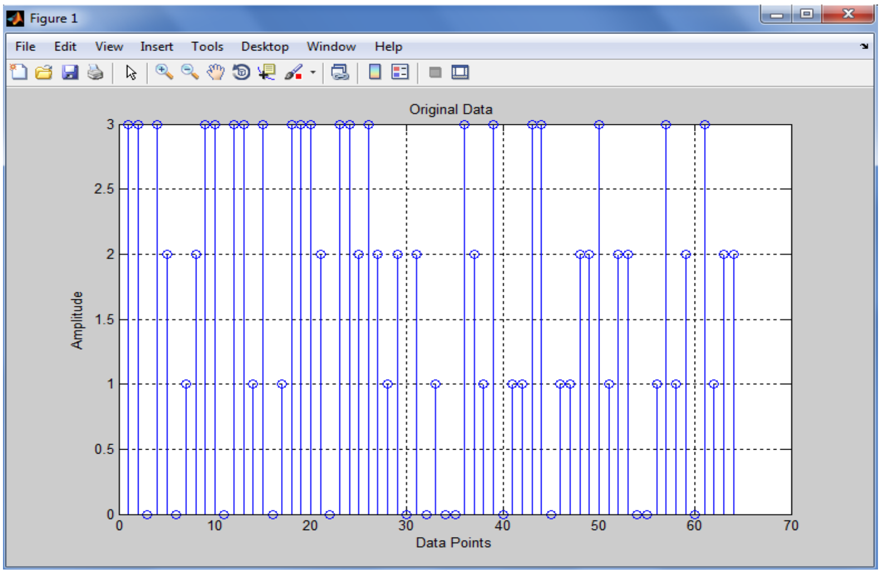


Fig. 21. Result original code

Workspace

Name	Value	Min
block_size	16	16
cp_len	1	1
data	*1x64 double*	0
M	4	4
n	256	256
no_of_data_bits	64	64

Fig. 22. Analyze result data

The above in figure. 22 simulation analysis shows that the 256 data bit are transmitted to receiver in the form of 64 symbols and we have block size for ea-ch user 16 so that rates for sender it will be well according to length of the data.

3.3. QPSK Modulation

In fig. 23 when the signal reaches to QPSK which works to remove the signal on the up and down after it was in the original data in the up side only. As in the figure below fig. 24 that converting the series data stream into four parallel data stream to form sub-carrier each one it has complex double.

QPSKMODULATION.m

```
figure(2),stem(qpsk_modulated_data);title('QPSK Modulation ')
%
%
% Converting the series data stream into four parallel data stream to form
% four sub carriers
S2P = reshape(qpsk_modulated_data, no_of_data_bits/M,M)
Sub_carrier1 = S2P(:,1)
Sub_carrier2 = S2P(:,2)
Sub_carrier3 = S2P(:,3)
Sub_carrier4 = S2P(:,4)
```

Fig. 23. Generation code QPSK modulation

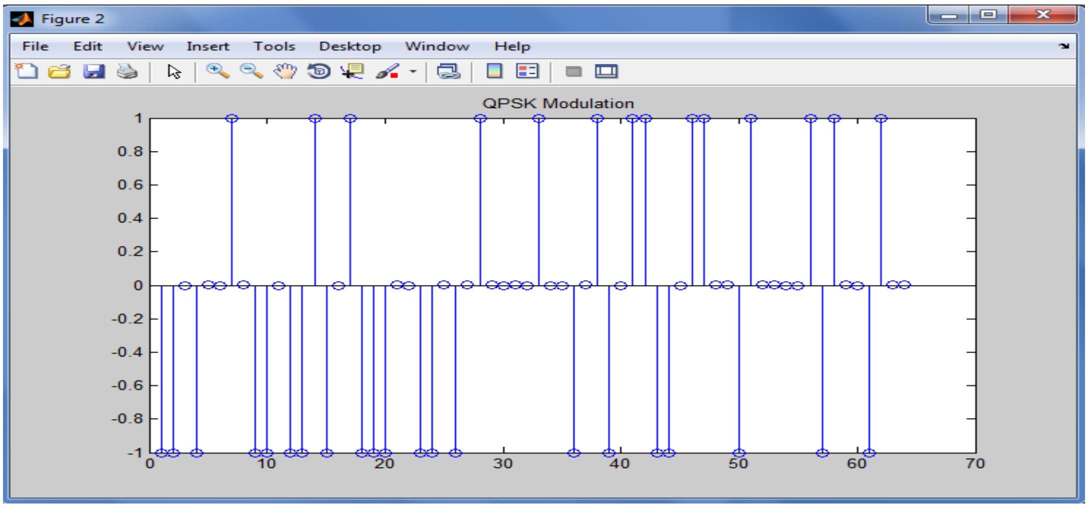


Fig. 24. Result code QPSK Modulation

Workspace

Name	Value	Min
data	1x64 double	0
M	4	4
n	256	256
no_of_data_bits	64	64
qpsk_modulated_...	1x64 complex double	1
S2P	16x4 complex double	1
Sub_carrier1	16x1 complex double	1
Sub_carrier2	16x1 complex double	1
Sub_carrier3	16x1 complex double	1

Fig. 25. Analyze result QPSK

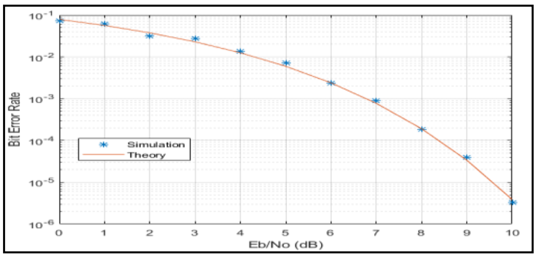


Fig. 26. Curve QPSK

In fig. 25 we have result about number of data it is 64 in value and minimum all of them constant in value 16 bits so we work to divide each symbol according to the original signal as show curve fig. 26 on the data QPSK for user.

Example: OFDM sender with BPSK modulation

Input data is 10101111010001010011

Solution**:**

Time	D0	D1	D2	D3	D4
T1	1	0	1	0	1
T2	1	1	1	0	1
T3	0	0	0	1	0
T4	1	0	0	1	1

Time	S0	S1	S2	S3	S4
T1	1	-1	1	-1	1
T2	1	1	1	-1	1
T3	-1	-1	-1	1	-1
T4	1	-1	-1	1	1

Time	K0	K1	K2	K3	K4
T1xΔ	1xsin(2∏f0t)	-1xsin(2∏f1t)	1xsin(2∏f2t)	-1xsin(2∏f3t)	1xsin(2∏f4t)
T2xΔ	1xsin(2∏f0t)	1xsin(2∏f1t)	1xsin(2∏f2t)	-1xsin(2∏f3t)	1xsin(2∏f4t)
T3xΔ	-1xsin(2∏f0t)	-1xsin(2∏f1t)	-1xsin(2∏f2t)	1xsin(2∏f3t)	1xsin(2∏f4t)
T4xΔ	1xsin(2∏f0t)	-1xsin(2∏f1t)	-1xsin(2∏f2t)	1xsin(2∏f3t)	1xsin(2∏f4t)

Note that: Δ=sin2∏FT

where: Δ is variable between two data;

T is Time;

(2∏FT) is like ϴ.

3.4. Dividing data by sub-carrier OFDM

In fig. 27 we made divide the original signal into four signals (Subcarrier1, Subcarrier2, Subcarrier3, Subcarrier4) and gave each of two levels up and down also gave 16-bit for each signal distributed 8 and up 8 down for the purpose of expanding the range of data.

```
sucarrier.m
figure(3), subplot(4,1,1),stem(Sub_carrier1),title('Subcarrier1'),grid on;
subplot(4,1,2),stem(Sub_carrier2),title('Subcarrier2'),grid on;
subplot(4,1,3),stem(Sub_carrier3),title('Subcarrier3'),grid on;
subplot(4,1,4),stem(Sub_carrier4),title('Subcarrier4'),grid on;
%
%
% IFFT OF FOUR SUB_CARRIERS
%
%
number_of_subcarriers=4;
cp_start=block_size-cp_len;
ifft_Subcarrier1 = ifft(Sub_carrier1)
ifft_Subcarrier2 = ifft(Sub_carrier2)
ifft_Subcarrier3 = ifft(Sub_carrier3)
ifft_Subcarrier4 = ifft(Sub_carrier4)
```

Fig. 27. Generation code for dividing data

Workspace

Name	Value	Min
n	256	256
no_of_data_bits	64	64
number_of_subca...	4	4
qpsk_modulated_...	1x64 complex double	1
S2P	16x4 complex double	1
Sub_carrier1	16x1 complex double	1
Sub_carrier2	16x1 complex double	1
Sub_carrier3	16x1 complex double	1
Sub_carrier4	16x1 complex double	1

Fig. 28. Analyze result QPSK

In fig. 28 we see each user has subcarrier and this carrier 16x1 complex double and this according to the number of sub-carrier.

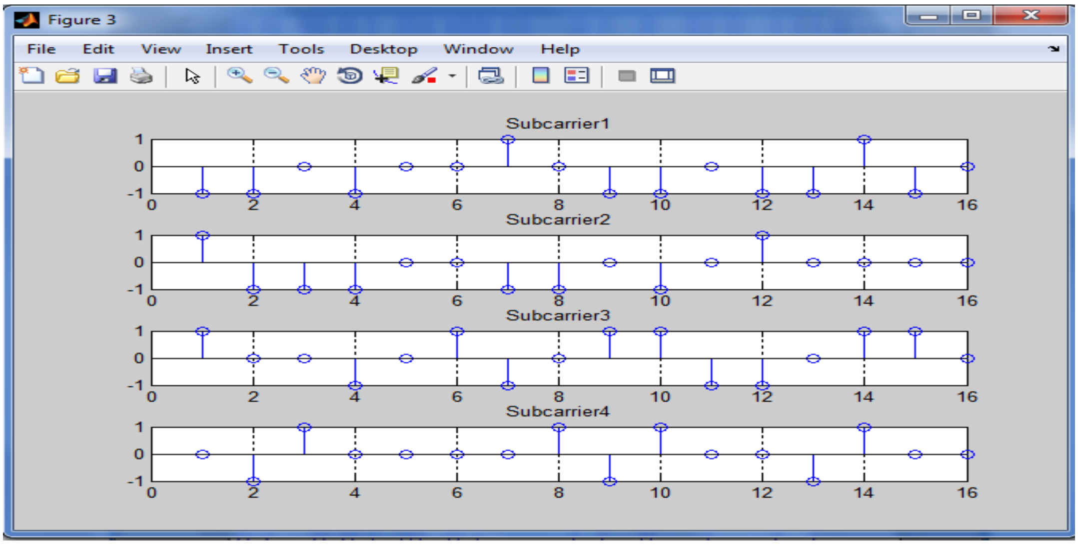


Fig. 29. Result code divide of data

In fig. 29 has subcarrier1 and subcarrier2 and subcarrier3 and subcarrier4 each one it has two levels up and down the level of up has 8 and 8 down so when we want to send information into receiver the first we divide the data on the two level.

3.5. IFFT on all the sub-carrier

IFFT It Is working on convert the data from serial to parallel before to arrive to the channel so that cyclic prefix as fig. 30 the code below make divide the data into many subcarrier depend on number of sub-carrier as the table below. We know when we use inverse fast fourier transform directly convert data into signals in the channel (medium) as in the Fig. 31 below so that cyclic prefix works divide the symbol in the signal to the arrive for receiver which works recovery for original data so that value cyclic prefix as the result above it has range from (-0.2325 to 0.0112i).

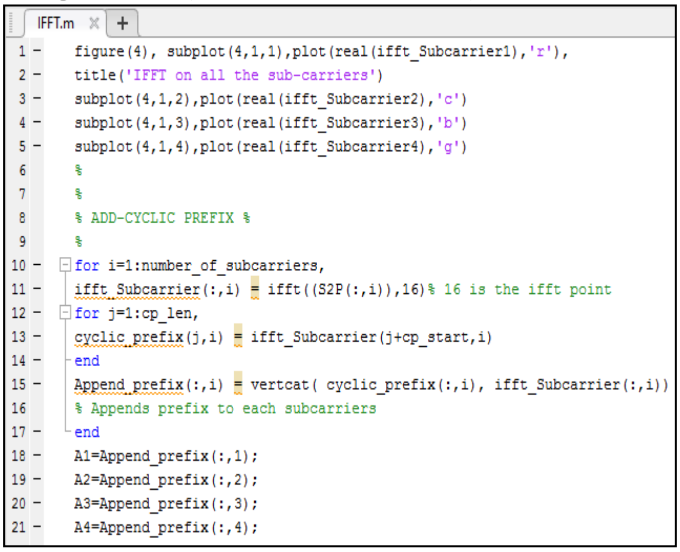


Fig. 30. Code for generation IFFT

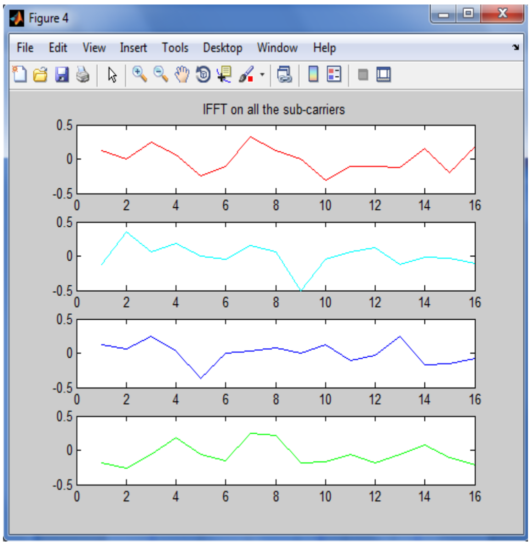


Fig. 31. Result IFFT code

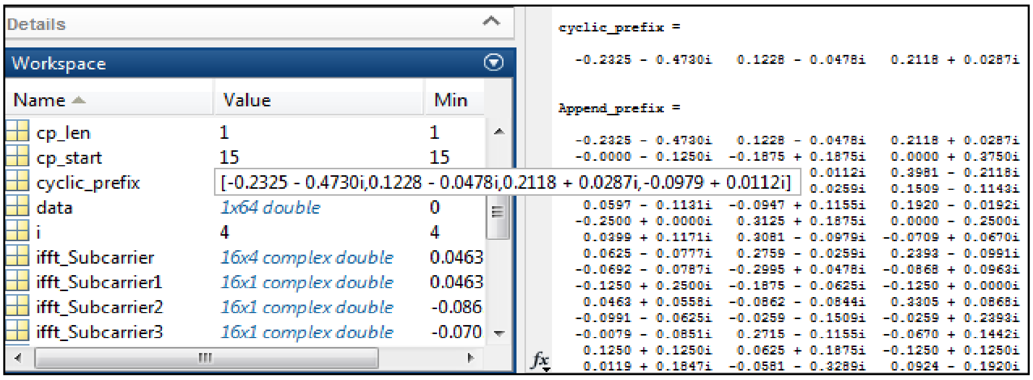


Fig. 32. Analyze IFFT results

In fig. 32 above we have cyclic prefix has 15 in value and minimum so after the cyclic prefix we should work modulate for security the data from hacker during the send of information into the receiver and make like cover.

3.6. Cyclic prefix added to all the sub-carrier

A Cyclic prefix extends the length of each symbol beyond just that of one for IFFT length so that the IFFT cab be (hopefully) done over a portion of the signal past where all the orthogonal subcarrier have been messed up in fig. 33 we have length of cyclic prefix has1.

Editor - \\profile01\FRW7\alnussairiakd\Desktop\cyclic.m

cyclic.m

```
figure(5), subplot(4,1,1),plot(real(A1),'r'),title('Cyclic prefix added to all the sub-carriers')
subplot(4,1,2),plot(real(A2),'c')
subplot(4,1,3),plot(real(A3),'b')
subplot(4,1,4),plot(real(A4),'g')
figure(11),plot((real(A1)),'r'),title('Orthogonality'),hold on
,plot((real(A2)),'c'),hold on ,
plot((real(A3)),'b'),hold on ,plot((real(A4)),'g'),hold on ,grid on
%Convert to serial stream for transmission
[rows_Append_prefix cols_Append_prefix]=size(Append_prefix)
len_ofdm_data = rows_Append_prefix*cols_Append_prefix
% OFDM signal to be transmitted
ofdm_signal = reshape(Append_prefix, 1, len_ofdm_data);
```

Fig. 33. Generation code cyclic prefix

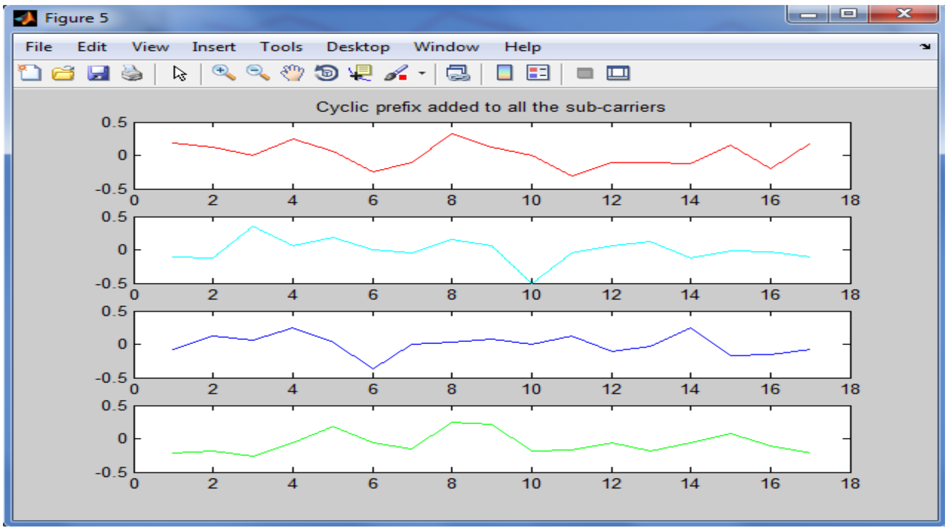


Fig. 34. Result cyclic prefix added to all the sub-carrier

During the sender convert the original data into the other expression by the medium as fig. 34 where each data it has specific color according to distance between the sender and receiver and value each lose on the data of user in the network.

The cyclic refix property specifies the length of the OFDM cyclic prefix. If you specify a scalar, the prefix length is the same for all symbols through all antennas. If you specify a row vector of length, the prefix length can vary across symbols but remains the same length through all antennas. The default value is 17 as below in fig. 35.

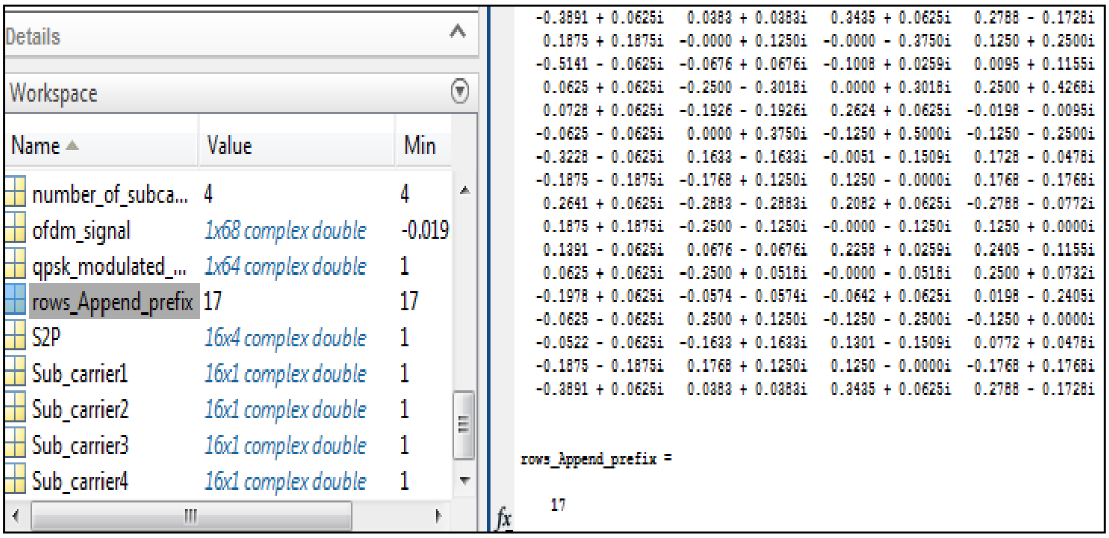


Fig. 35. Analyze cyclic prefix results

Example: Find cyclic prefix

[1 2 1 -2 3 1 2]*[3 2 1]=[3 8 8 -2 6 7 11 5 2]

Solution:

Cyclic Prefix [1 -2 3 1 2]*[3 2 1 0 0]

A good ratio between the CP interval and symbol duration should be found, so that all multi paths are resolved and not significant amount of energy is lost due to CP.

As a thumb rule, the CP interval must be two to four times larger than the root mean square (RMS) delay spread.

3.7. OFDM signal

This is the last operation of the transmission stage before reaching the channel where we note, as in the figure below 36, that the signal suffers from some attenuation and weakness with constant length OFDM data 68-bit in value and MAX and MIN as in table below in fig. 37 as shown in the table above, the values remains constant in the case of length OFDM signal(86) and also number of carrier channel(4) and number of bits to be transmission (256) and number of data bits(64) and number of sub-carrier(4) just value OFDM signal changed (1x68).

OFDMsignal.m

```
figure(6),plot(real(ofdm_signal)); xlabel('Time'); ylabel('Amplitude');
title('OFDM Signal');grid on;
%
```

Fig. 36. Generation code OFDM signal

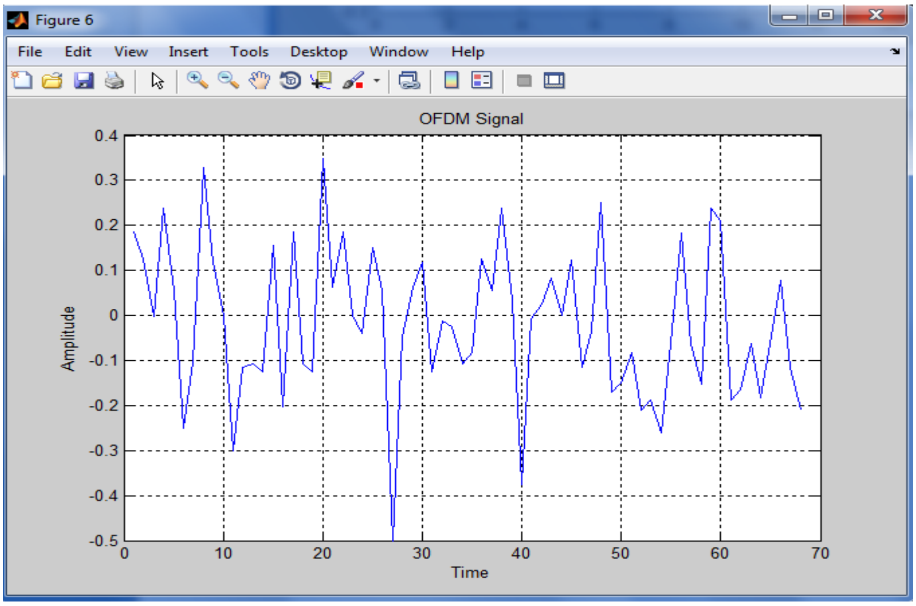


Fig. 37. Result of code for OFDM Signal

Name	Value	Min
ifft_Subcarrier4	16x1 complex double	-0.036
j	1	1
len_ofdm_data	68	68
M	4	4
n	256	256
no_of_data_bits	64	64
number_of_subca...	4	4
ofdm_signal	1x68 complex double	-0.007
qpsk_modulated_...	1x64 complex double	1

Fig. 38. Analyze of result OFDM signal

in fig. 38 we have name of parameter and value of each user in the network and minimum value also for each user according to the rates successful and failure t-e sender and during send information of user on the network in OFDM systems.

3.7. OFDM Signal after passing during medium

Analogously to a serial system, the bit error rate (BER) verses signal to noise rate (SNR) characteristics are determined by the modulation scheme used.

It can see form the fig. 39 that the experiment BER performance of the OFDM system is in very good accordance with the theoretical BER curves of conventional serial system in AWGN channel.

```
%
channel = randn(1,2) + sqrt(-1)*randn(1,2);
after_channel = filter(channel, 1, ofdm_signal);
awgn_noise = awgn(zeros(1,length(after_channel)),0);
recvd_signal = awgn_noise+after_channel; % With AWGN noise
figure(7),plot(real(recvd_signal)),xlabel('Time'); ylabel('Amplitude');
title('OFDM Signal after passing through channel');grid on;
%
```

Fig. 39. Generation code OFDM after medium

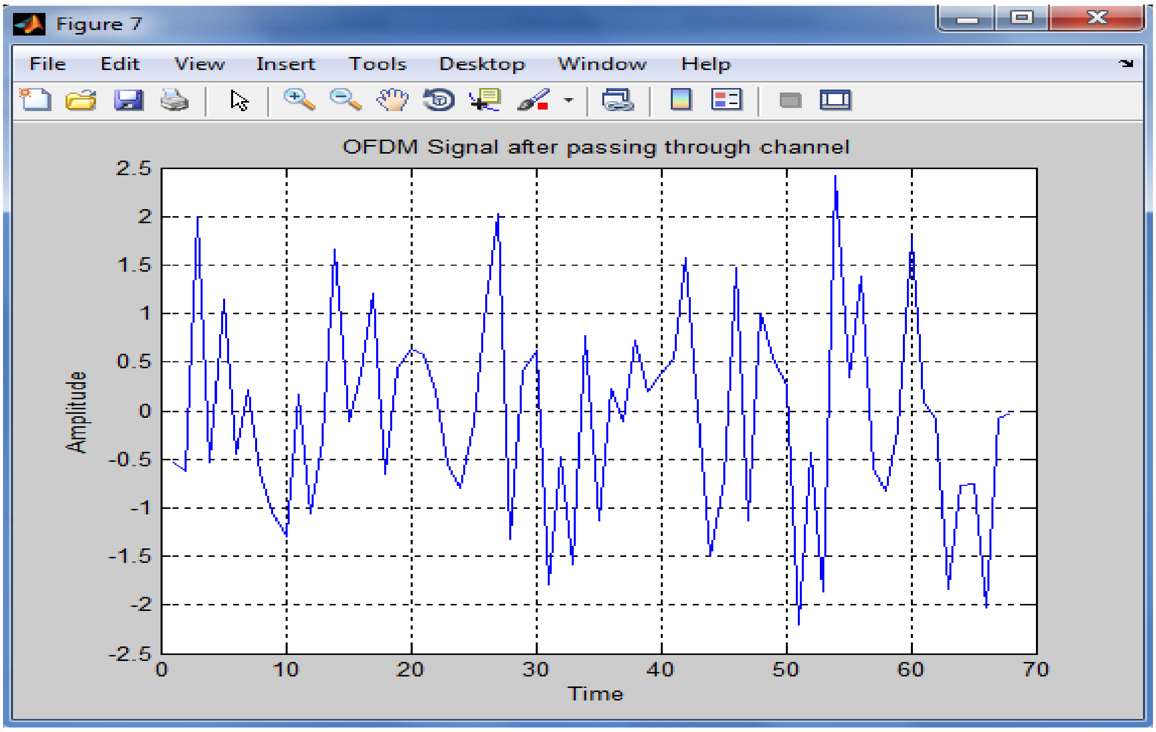


Fig. 40. Code result of OFDM Signal after passing during medium

The analysis of the bit error rate in the fig. 40 (BER) performance of the wavelet based orthogonal frequency division multiplexing is good than the conventional DFT based on orthogonal frequency division multiplexing. The (BER)

Based OFDM does not required cyclic prefix and the main advantage of the wavelets over traditional discrete Fourier transform (DFT) is multi resolution analysis where the respective input signal is decomposed into frequency components for the accurate in fig. 41 we see relationship between BER and SNR for each user.

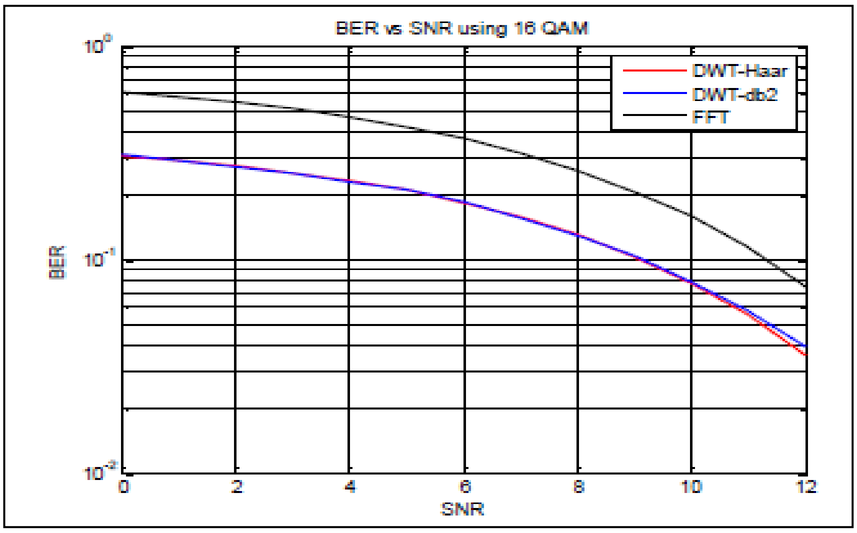


Fig. 41. Relationship between BER and SNR

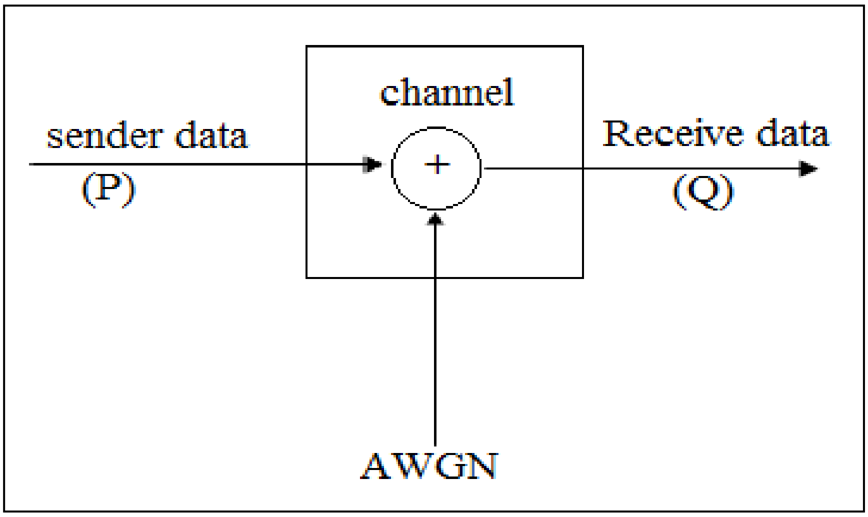


Fig. 42. Model channel in AWGN

To evaluate the stability and reliability of the DFT based and DWT based OFDM in our proposed work, different values of PSNR are taken and the recorded analysis are passed during Additive white Gaussian noise (AWGN) channel. In fig. 42 we have simulation process are followed as follows.

1. Consider P transmitter, Q receiver and an high equipped channel namely Additive white Gaussian noise (AWGN) channel are considered for the simulation process initially. For example consider the data of 9600 bits are estimating sent through around 100 symbols from P transmitter and Q receiver

2. The above simulation analysis shows that the 9600 data bits are transmitted to receiver in the form of 100 symbols where each symbol represents one individual signal for each 96 bits.

3. The simulation process shows that the averaging of the any value of SNR is performed and the task is accomplished in different step for different averaging values in order to yield the final BER value by repeating the task consistently till to reach final level.

3.9. Cyclic prefix removed from the four subcarrier

A cyclic prefix is often used in coupling with modulation to retain sinusoids' properties in multipath channels. It is well known that sinusoidal signals are delegation of linear, in fig. 43 has FFT data and this work to transform from time domain into frequency domain.

cyclicprefixremove.m

```
figure(8),plot((imag(R1)),'r'),subplot(4,1,1),plot(real(R1),'r'),
title('Cyclic prefix removed from the four sub-carriers')
subplot(4,1,2),plot(real(R2),'c')
subplot(4,1,3),plot(real(R3),'b')
subplot(4,1,4),plot(real(R4),'g')
%
%
% FFT Of recievied signal
for i=1:number_of_subcarriers,
% FFT
fft_data(:,i) = fft(recvd_signal_paralleled(:,i),16);
end
F1=fft_data(:,1);
F2=fft_data(:,2);
F3=fft_data(:,3);
F4=fft_data(:,4);
```

Fig. 43. Generation code Cyclic prefix removed from the four subcarrier

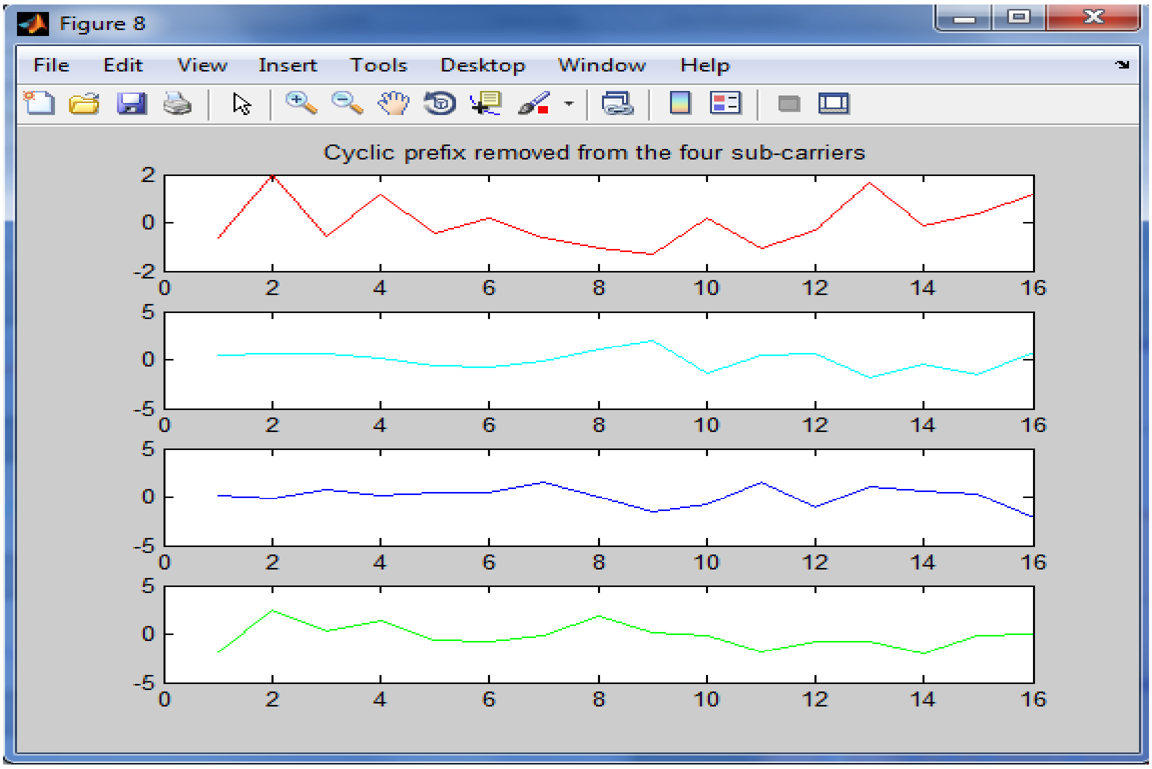
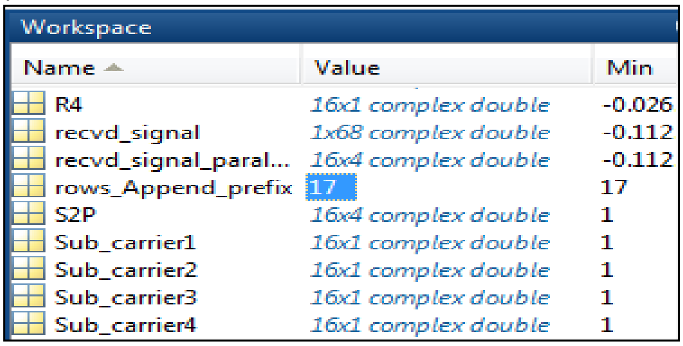


Fig. 44. Code result Cyclic prefix removed from the four subcarrier

The BER analysis in the fig. 45 based OFDM required cyclic prefix here the respective input signal is decomposed into frequency components for the actuating in analysis because when the signal is input into system it has some error and week.



Workspace

Name	Value	Min
R4	16x1 complex double	-0.026
recvd_signal	1x68 complex double	-0.112
recvd_signal_paral...	16x4 complex double	-0.112
rows_Append_prefix	17	17
S2P	16x4 complex double	1
Sub_carrier1	16x1 complex double	1
Sub_carrier2	16x1 complex double	1
Sub_carrier3	16x1 complex double	1
Sub_carrier4	16x1 complex double	1

Fig. 45. Analyze result Cyclic prefix

The CP length must be larger than the time delay spread in order to minimize the ISI as fig. 45 above considers shortening CP length so as to improve system capacity according to the fact that satellite channel has weaker time delay.

3.10. Inverse IFFT of the four sub-carrier

The main purpose from using FFT of the receive is to transfer data from the frequency domain to the time domain and then sender it via channel In the figure below is the conversion of data from time domain to frequency domain and retrieval of data in its original form.

```
FFT.m
figure(9), subplot(4,1,1),plot(real(F1),'r'),title('FFT of all the four sub-carriers')
subplot(4,1,2),plot(real(F2),'c')
subplot(4,1,3),plot(real(F3),'b')
subplot(4,1,4),plot(real(F4),'g')
%
%
% Signal Reconstructed
%
%
% Conversion to serial and demodulationa
recvd_serial_data = reshape(fft_data, 1,(16*4));
qpsk_demodulated_data = pskdemod(recvd_serial_data,4);
```

Fig. 46. Generation code Inverse IFFT of the four sub-carrier

Inverse Fourier transform is used to convert the signal back from the frequency domain to the time domain as above fig . 46. The Fourier transform is a powerful tool to analyze the signals and construct them to and from their frequency components. the signal is discrete in time that is sampled, one uses the discrete Fourier transform to convert them to the discrete frequency form DFT, and vice verse, the inverse discrete transform IDFT is used to back convert the discrete frequency form into the discrete time form. In transmitters using OFDM as a multicarrier modulation technology, the OFDM symbol is constructed in the frequency domain by mapping the input bits on the I- and Q- components of the QAM symbols and then ordering them in a sequence with specific length according to the number of subcarriers in the OFDM symbol. That is by the mapping and ordering process, one constructs the frequency components of the OFDM symbol. To transmit them, the signal must be represented in time domain. This is accomplished by the inverse fast Fourier transform IFFT we know each user on the network has code and this code ca not divide into other user but in fig. 47 we divided the data on the one channel without any overlap between of them and this advantage for OFDM system when we want to send information into user the first we should divide the data of user according to length of data.

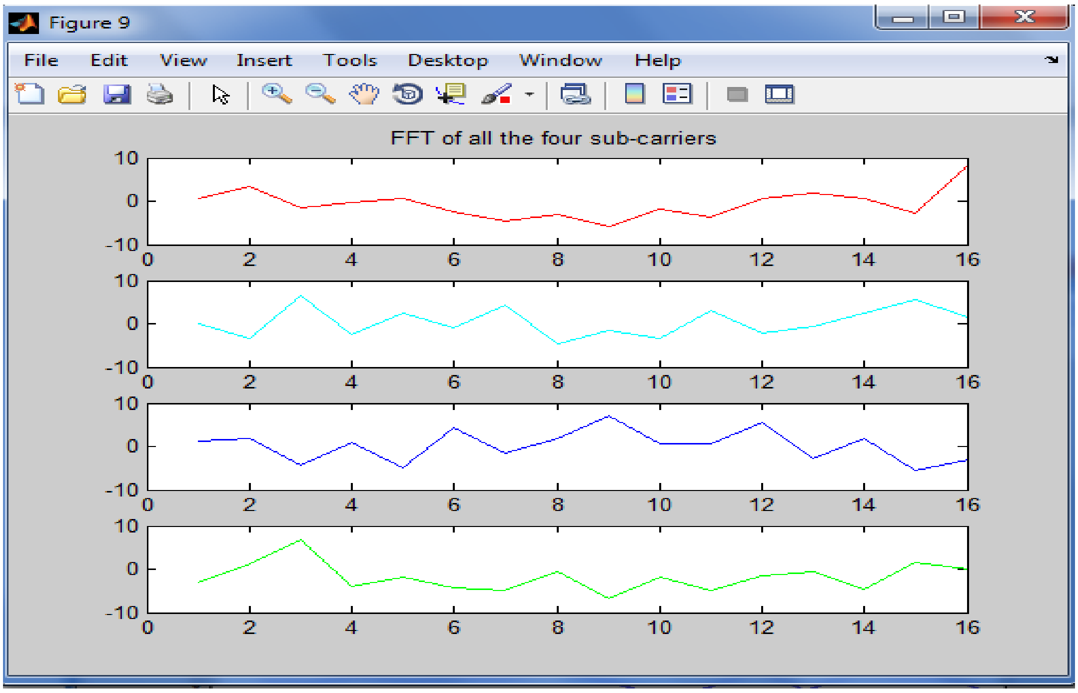


Fig. 47. Code result FFT of all the four sub-carrier

fft_data

16x4 complex double

	1	2	3	4
1	0.7336 - 2.6...	0.1198 + 2.6...	1.2768 + 2.6...	-3.0340 + 1....
2	3.4643 - 0.3...	-3.5377 - 3....	1.8425 - 2.6...	1.2963 - 6.9...
3	-1.6595 - 3....	6.5721 - 3.0...	-4.2818 + 0....	6.7068 - 1.1...
4	-0.3854 + 0....	-2.4629 - 2....	0.8341 - 1.7...	-3.8746 - 1....
5	0.4939 - 1.8...	2.3204 + 4.5...	-5.0031 - 1....	-1.9854 + 2....
6	-2.4146 + 1....	-0.7988 - 1....	4.3768 - 2.4...	-4.3397 - 0....
7	-4.6731 - 2....	4.1779 + 2.4...	-1.5100 + 0....	-4.9000 - 5....
8	-2.9872 - 4....	-4.5460 + 2....	1.8184 - 1.9...	-0.7399 - 3....

Fig. 48 Rate error in each data

As above in fig. 48 It takes the combined stream from data it is began from (0.7336) into (-2.9872) and using the FFT function "plots" a spectrums of the transmitted signal. But the spectrum bins actually correspond the individual channels transmitted and in this table we calculate rates all errors in each user so we made this technology.

3.10. Received signal with error

When the data reaches the recipient, it will be with noise because it may have passed after the stages led to the noise on it and this is normal so that the receiver at the beginning works to reduce the noise then restore the original data format as in the original data in the previous as show in fig .49.

```
Receivedsignal.m
figure(10)
stem(data)
hold on
stem(qpsk_demodulated_data,'rx');
grid on;xlabel('Data Points');ylabel('Amplitude');
title('Recieved Signal with error')
%
```

Fig. 49. Generation code for receiving data

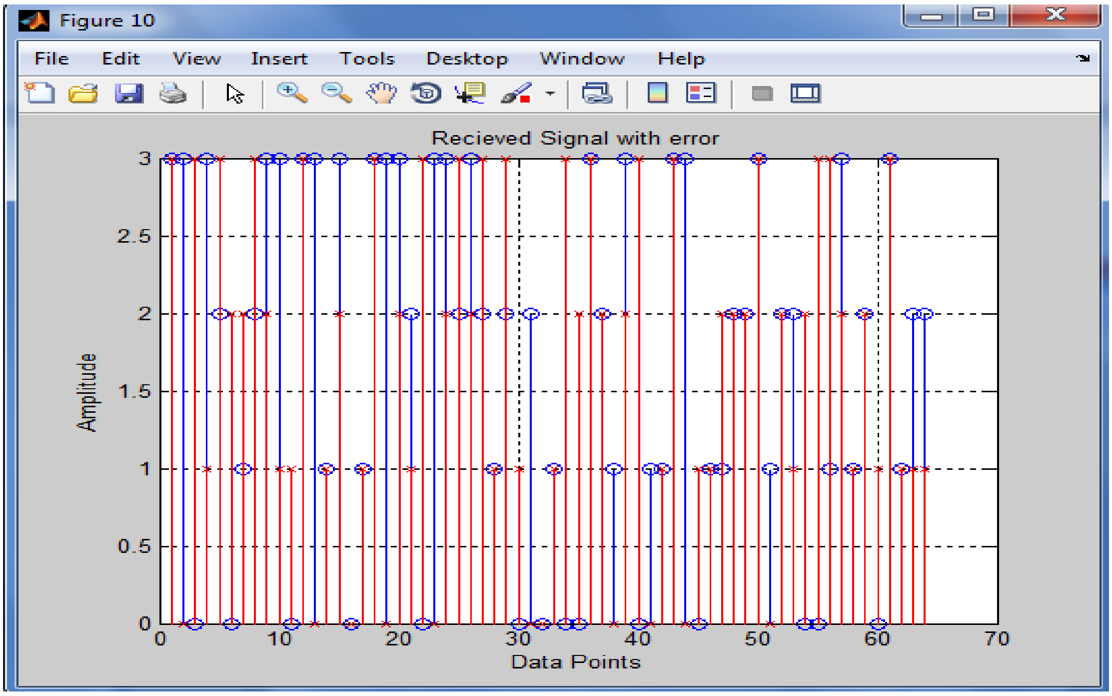


Fig. 50. Code result of received data with error

From the fig. 50 that when the information arrives to the recipient with some noise due to environmental factors, therefore, the value (recvd-signal-parallel) multiple(16x4).

4. TEST RESULTS

Functional system tests should be based around coverage of the functionality described in the requirements, but it is common for the design document to be used as the baseline for testing because the requirements cannot be related to the final product as in table 7. Each test of my system contains input and output data. Therefore, we compare the actual results and the expected results.

Table 7. The protocol of functional testing of the OFDM system

NO.	Function	Expected result	Obtained result	Conclusion
1.	The sender must be able to add and modify data about user	The receiver can see the all information about user	The receiver can see the all information about user	The function works
2.	The sender must be able to analyze of data.	The receiver can read all data	The receiver can read all data	The function works
3.	The sender must be able to detection and correction of error in data	The receiver can return data if it has some error	The receiver can return data if it has some error	The function works
4.	The sender must be able to searches for data if it happens to be lost	The receiver can see all losses and delay or attenuation in data	The receiver can see all losses and delay or attenuation in data	The function works
5.	The sender must be able to remove any user	The receiver can see any problem with any user on the network	The receiver can see any problem with any user on the network	The function works

No.	Function	Expected result	Obtained result	Conclu-sion
6.	The sender must be able to register date and time send for each user	The receiver can know size any da-ta on the channel according to time	The receiver can know size any data on the channel ac-cording to time	The function works
7.	The receiver must able to recovery for original data	The sender can cancel any for any person	The sender can can-cel any for any per-son	The function works
8.	To show the OFDM system	Any user can watch work data on OFDM system	Any user can watch work data on OFDM system	The function works
9.	The receiver must able to Display the status of sender and receiver	The sender can add a new data on the one channel without any inter-ference between them	The sender can add a new data on the one channel without any interference be-tween them	The function works
10.	The medium must can able to Con-vert the data to other expression for purpose securi-ty from hacker	The data at the sender must be binary data ,that is mean to be(1,0)	The data at the sender must be bi-nary data, that is mean to be(1,0)	The function works
11.	The medium must can able Matching between the sender and receiver at any time	The sender can send many infor-mation one me-dium	The sender can send many information one medium	The function works

The end of table 7

No.	Function	Expected result	Obtained result	Conclu-sion
12.	The system must show all the users in the network	Any user can see this network	Any user can see this network	The function works
13.	Adding a another user for a network	Any another user can see the net-work	Any another user can see the network	The function works
14.	Read the user on-line in the network at any time	Any user can sent and receive the information on the network	Any user can sent and receive the in-formation on the network	The function works
15.	Showing message with an error while add a new user	If the user, while transmission his user name of user , number of data, enters name of user or number of data and the sys-tem shows the message with a mistake	If the user, while transmission his us-er name of user , number of data, en-ters name of user or number of data and the system shows the message with a mistake	The function works
16.	Make a search for specific user	Any user can see all information in the list of main section	Any user can see all information in the list of main section	The function works

CONCLUSION

An OFDM system is successfully simulated using MATLAB in this project. All major components of an OFDM system are covered. This has demonstrated the basic concept and feasibility of OFDM, which was thoroughly described and explained in Chapter 3 of this report. Some of the challenges in developing this OFDM simulation program were carefully matching steps in modulator and demodulator, keeping track of data format and data size throughout all the processes of the whole simulation, designing an appropriate frame detector for the receiver, and debugging the MATLAB codes.

Chapter 4 showed and explained some analyses of the performance and characteristics of this simulated OFDM system. It was noted that for some

combinations of OFDM parameters, the simulation may fail for some trials but may succeed for repeated trails with the same parameters. It is because the random noise generated on every trial differs, and trouble may have been caused for the frame detector in the OFDM receiver due to certain random noise. Future work is required to debug this issue and make the frame detector free of error.

Other possible future works to enhance this simulation program include adding ability to accept input source data in a word size other than 8-bit, adding an option to use QAM (Quadrature amplitude modulation) instead of *M*-DPSK as the modulation method.

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