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Effective Performance Estimation of ROF-Based Hybrid WDM Passive Optical Network

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Abstract: Multimedia comunication is an imperative component of existence. There are numerous broadband interfaces in place, such as Digital Subscriber Line (DSL) offer high speeds up to a few Giga bits per second (Gb/s), but they are insufficient for offering extremely hugely powerful networks, are necessary to, and handle bandwidth-hungry applications and radically rising number of users. A promising method for offering exceptionally large capacities with minimal transmission loss is through the utilisation of optical fibre. The aptitude to transmit over long distances exclusive of the use of a repeater, imperviousness to electromagnetic interference, and portability due to its modest weight are auxiliary reimbursement.In Fiber to the home (FTTH) centralised sends data to the ultimate customer across an all-optical network.The Radio-over-fiber (RoF) technology, fosters combining optical networks Highlighting the problems encountered with previous wireless networks is countless applications of optical fibre in telecommunications. RoF techniques are used for transmitting data from the centralised station to the remote antenna unit(RAU), and exchange of data across the end users and the RAU is accomplished using wireless connection. This paper presents many techniques to restoring heterogeneous wireless standards and assesses them all In conjunction with of cost, consumption of energy, transmission performance, and feasibility. Wavelength division multiplexing(WDM) multiplexing techniques will modelled with simulation software to resolve concern of a large number of users, and the operation of each method will be described with respect to of required power, bit error rate (BER), constellation analyzer, eye diagram analyzer, and RF analyzers.Furthermore, there are other modern modulation techniques like quadrature amplitude modulation.

I. INTRODUCTION

A. Introduction

Before the 1960s internet revolution, speech data transmission was the best method of communication. The concept of light using as a form of communication has revolutionised communications sector [1]. Coaxial cables are still used to meet many standards, but nowrising demand for fast data speeds is creating challenges to these long-standing frameworks. Applications like 4K video streaming, online gaming, and video conferencing require a highly broad bandwidth backbone network, such optical fibres.[2]. Optical fibre networks can be differentiated from one another by offering a range of transmission lengths and data rates. For lesser distances, metropolitan area networks (MAN) are employed, but optical fibre lengths of at least 50 kilometres are needed for long-haul transmission. [3]. A common fibre optic transmission network is made up of three parts: the connecting receiver side, the optical medium, and ultimately the transmitter side. In densely populated areas or in places where installing fibre optic cable is difficult and expensive, radio-over-fiber (RoF) technology techniques are used [4]. Therefore, a variety of techniques, There are options to deliver these broadband services, notably coaxial cable and digital subscribers. [5]. Due to physical media limitations, copper wire bandwidth has reached saturation; As a result, an option for meeting those throughput bandwidth requirements is an optical access framework. Furthermore, In order to transmit the necessary data between the base stations, wireless or radio technology A significant amount of base stations and optical access points will be added soon,which will lower the network's cost [6].Radio-over-fiber methodology represents one of the various ways that optical fibre is used in communications, which facilitates the integration of optical systems the established over-the-air natworks. [7].Main goals of the initial RoF systems were to boost central office agility (CO) and exchange microwave pulses.In particular, the modulated microwave pulses are present Light waves are transmitted through a path from the faraway location (RS) to the source of the RoF network.At RS, antennas reconstruct and release the microwave waves. [8]. Furthermore the network was configured to handle GSM 900 network traffic. Modern RoF systems include capabilities for movement and transportation as well as additional radio system functions. These features include signal processing, statistical modulations, and frequency conversion (up and down) [9].Additionally, necessary capabilities in a flexible RoF technology, the essential wireless RoF input pulses hang out. With the aid of an analogue optical fibre link, The currently present audio or digitally modulated methods used to send the optical pulses of a conventional RF [10].

The precise modulated RF signal that constitutes scattered, modulated IF, or baseband data are the three types of delivered communications. This RF signal is utilised to modulate the optical light basis in the transmitter.

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The light is transmitted through an optical fibre emanating from a modulated optical source, and at the receiver end, the optical signals must be transformed back into RF form. The electrical shape of the signals that are generated must adhere to the requirements for GSM, simple to reach; such a setup has several benefits. The single fibre, on another case, containe simplex properties since it only transmits information in one direction, as shown in Figure 1. However, an efficient form of communication necessitates a duplex communication configuration that can carry two side signals.Consequently, the single fibre optical communication network is now largely owing to modern WDM.

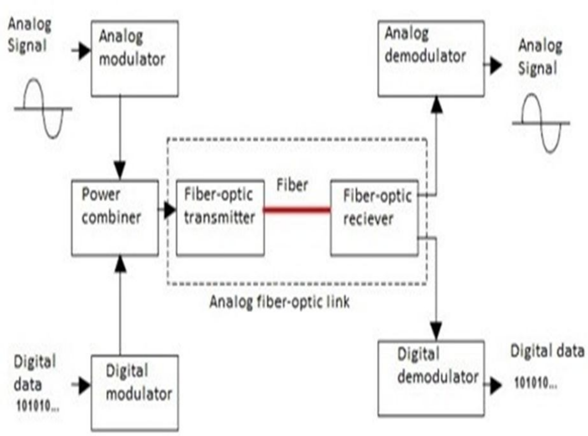

Figure 1 RoFbasicmodel.

By using the straightforward stated wavelengths technique, you can transmit two-way information over the same signal fibre. [13]. A WDM works by combining many wavelengths of optical pulses, after which the combined signals are sent across a single fibre network. As a result, the system's capacity is boosted, which can be used in the future to distribute more users. Therefore, the amount of data needed is much reduced when employing the WDM technique. The CO connects international networks such as a physical rather than wired network, LAN, and MAN.The physical less route connectivity to mobile stations is made possible by a number of base stations.as shown in Figure 2. [14].As wireless signals are propagated, The classic fiber-to-the-home access network system is clearly different from the optical fibre radio access system.

This chapter includes introduction and background of the proposed model, a statement of the linked problem, the basic objectives of the suggested model, ultimately, the thesis' organisational structure, scope, and methods.

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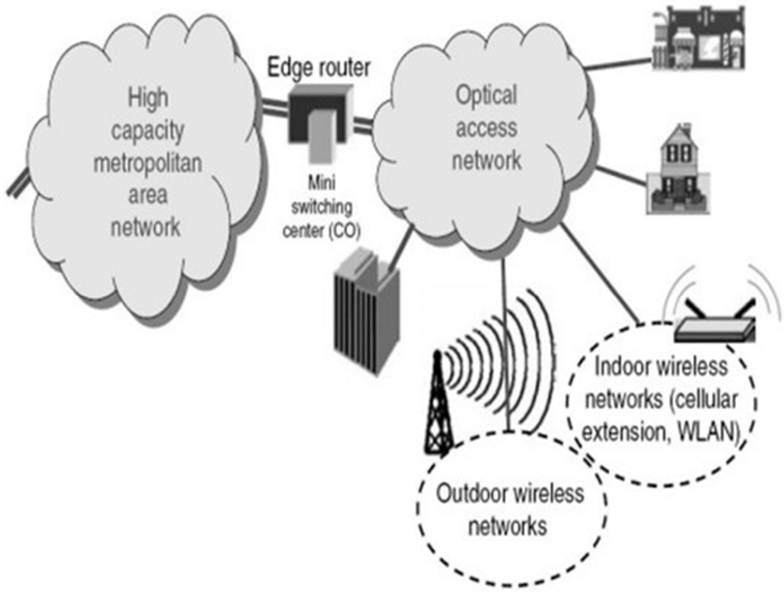

Figure 2 : Combined model of radio and wireless technology.

B. Background

Each organisation must now prioritise communication in order to interact with one another inentireglobe. Additionally, communication technology is evolving at a rapid pace in Due to the growing need for fast data rates, bandwidth, and user-friendly services throughout the 1previous decade [14].Wireless communication has continued this spectacular expansion because of the constant need for better data speeds from popular bandwidth-hungry applications like high definition video, which are requiring wireless communication technologies to boost traffic and data rates.The use of optical frameworks might be the solution for huge demands of telecommunication-systems, because it provides end users with the bandwidth they desire. As a result, several authors have examined the present demands placed on smart towns. Basically focused on the framework layout and generating plans, we propose a mix optical-wireless network structural design operating as the metro access network. as the metro access network, primarily concentrating on the structure's layout and planning 16]. In order to fulfill demands of smart cities and the increased amount of data being multiplexed into a single fibre line using various frequency channel mechanisms at higher costs, techniques such as wavelength division multiplexing (WDM) have been developed and employed. [17].This increases the optical network's capacity and makes it possible to provide bidirectional transmission over regular fibre optic. Effective convergence of optical and wireless access network systems is made possible by the clever technique known as RoF in optical communication systems. [18], [19The combination of RoF and a centralised radio access network is a viable way to meet the rising traffic and bandwidth needs. Additionally, RoF helps mobile stations communicate while using less power and with lower mistake rates. Passive optical network (PON), a practical architecture for the distribution of BSs, has modernisedRoF technology. By incorporating RoF hybrid PON with WDM/TDM framework, this present technology can be improved to boost system capacity. Thus, the advanced RoF system based on PON, WDM/TDM, and advanced modulation formats that supports the highest user capacity and the fastest data rate with the lowest error rate is examined in this thesis.

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C. Problem Statement

For improving the telecommunication infrastructure the optical framework is necessary which could supply the needed bandwidth for end users. To suggest an optical-wireless hybrid network architecture for the metro-access network, several writers have examined the present requirements encountered by smart cities. They did this by primarily focusing on the framework layout and planning. [16]. To meet the demands of smart cities and the increasing data traffic at rising costs, techniques like wavelength-division-multiplexing (WDM) are developed for optical networks. [17].This increases the optical network's capacity and makes it possible to provide bidirectional transmission over standard fibre optic.Effective convergence of optical and wireless access network systems is made possible by the clever technique known as RoF in optical communication systems. [18], [19]. As a result, although though the usage of RoF in smart city settings is extremely contemporary, it has not yet been used on a broad scale. [20].The modern RoF system setup was carried out in a variety of programmes over mobile access networks, satellite communication through distant antennas, and wireless access systems.[21]. In [22],: Max Q-factor = 7.1, Minimum BER = 7.9*9, Overall output strength (dbm) = -27. 592, OSNR (dB) = 33. 88505 consequences. Utilizing simulation software Optisystem, at 10 Gbitsper second to compensate for the dispersion in the op- tical communication device. To improve the transmission system's quality, erbium-doped-fibre amplifiers (EDFA) have been researched within the evolving optical communication community.QAM and differential quadrature-phase shift keying (DQPSK) are two other the effect evaluation of modulation forms in digital RoF is also introduced. The sophisticated model has been contrasted with earlier research that applies RoF technology and is consist of mostly concerning constellation maps, Optical power at the receiving end, different types of modulation , fibre dispersion, channel spacing versions, and power of laser.The findings consistently shown outstanding reliability performance, demonstrating the effectiveness of the suggested model. We assessed the RoF system's performance on the basis of constellation, OSNR, WDM analyzer, Radio Frequency spectrum analyzer, and Bit Error Rate in order to highlight the advantages of the newly introduced design.

D. Aims and Objectives

In order to show the benefits of the recently developed design, we evaluated the Radio Over the Fiber system's performance .

1) To evaluate each RoF transport technique's performance for the identical received power at the connection end, based on BER and Q-factor and see if it is possible for each one to enable the multiplexing of data from many users.
2) To model a WDM-based system in order to handle 8 users at a time and examine the impact of user channel spacing for various fibre lengths for transmission
3) Comparison of several RoF transport strategies in respect to the quantity and complexity of optical and electrical components needed, as well as the amount of laser power needed

E. Methodology

A preliminary grasp will be an examination of passive optical networks, RoF methods, and multiplexing methods in optical fibrecommunication developed in order to carry out the suggested task. The following points discuss the overall:

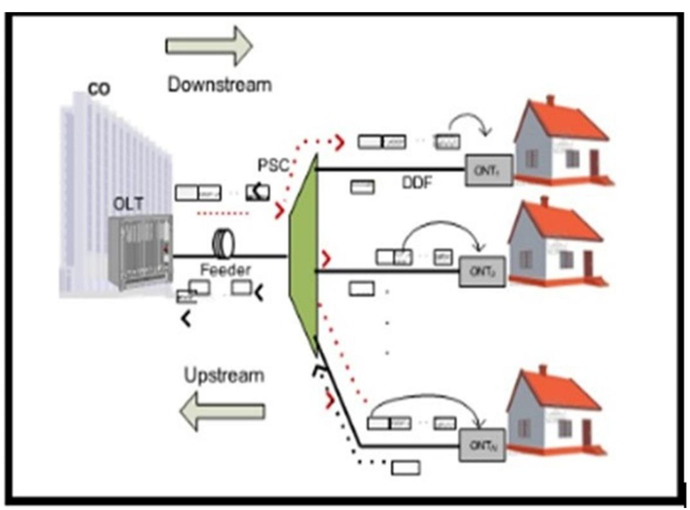

Figure 3 shows the RoF system using TDM technology.

To start, a literature review will be conducted to gather thorough background information on these technologies.In the subsequent stage, a given model for fundamental RoF techniques will be established in the Opti system software and evaluated for various component characteristics. Various modulation schemes, Multiplexing will be implemented to boost capability by initially using TDM and then WDM. These multiplexing methods include 16-Quadrature Amplitude Modulation (16QAM), 32-Quadrature Amplitude Modulation (32QAM), 64-Quadrature Amplitude Modulation (64QAM), and Differential Quadrature Phase Shift Keying (DQPSK) the optimal set for the full downlink network was investigated.

Different source laser will used in the simulations. At different stages of the downlink setup. Network dismissal evaluations of BER, OSNR, RF spectrum analyzers, WDM analyzers, and constellations calculated. Analyzers can determine how optical fibre transmission impacts BER the full set of simulation analyses also includes variable fibre length.

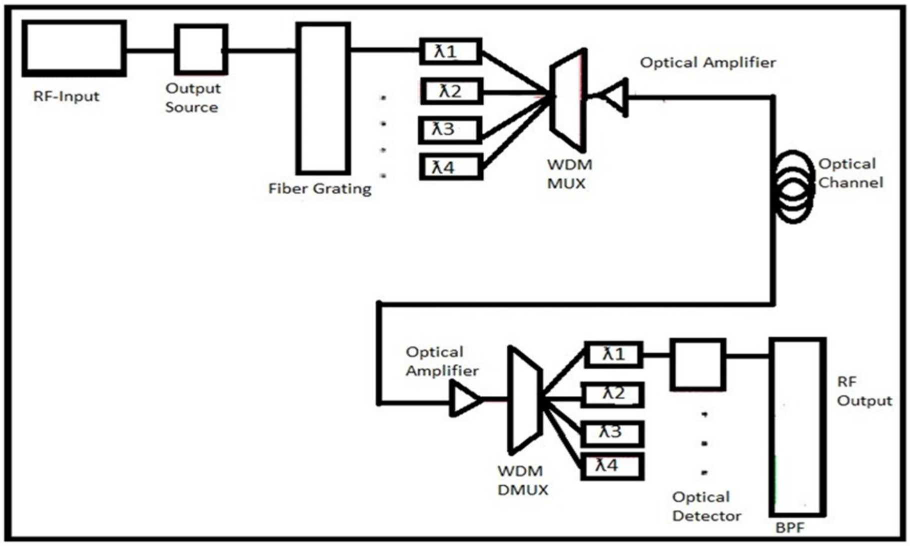

Figure 4 RoF system through used WD Mtechnology.

F. Layout of the Thesis that is Being Given

This thesis consist of chapters given below

1) Chapter: 1 The basic introduction with current technologies, background information on RoF and optical communication models, significant problems withthe present design, In Chapter 1, the nature of RoF technology, the main objectives of the given work, the design and analysis process used for the proposed work, and a summary of Chapter 1 are all covered.
2) Chapter: 2 investigates the fundamental investigative model of RF waves particularly optical medium, the advanced mathematical model of the model presented, and the characteristics of advanced modulation schemes in comparison to existing modulation techniques, the model's methodology, and a summary of the entire chapter.
3) Chapter: 3 The framework of the proposed model is presented in Chapter 3, along with information on the receiver side's internal layout, how received RF waves are converted into light on the transmitter side, how WDM the multiplexing and de-multiplexing work, how the optical medium is amplified, and an enlightenment of each parameter along with its installed internal components and operating ranges.
4) Chapter: 4 Simulation software use to evaluate performance of the suggested model is also covered in Chapter 4, along with discussions of outcomes in relation to input power,
5) Chapter: 5 Final examines findings of the entire research project in order to make simpler total work. It compares the effectiveness of the proposed sculpt to the contemporary WDM RoF system and examines the results of the suggested simulation model.

G. Summary

In this study, the ideal RoF model that utilises WDM technology is proposed with the aim of enhancing the transmission range, capacity, and user number. Both traditional and more contemporary wireless principles are explored, and the drawbacks of current systems are also looked at.

An updated system is needed to support large number of users andAccessibility to high data speeds, capacity, and long distance connection are all made possible by the most cutting-edge technology, Radio over Fibre (RoF), according to an essential analysis is being researched for its many benefits, include secure long-distance communication, ease of use, cost, and low error ratio. The investigation of WDM technology and its integration with the proposed RoF model is also looked at.

II. MODEL FOR ANALYSIS AND LITERATURE REVIEW

A. Introduction

In order to increase the flexibility of a WDM-based RoF architecture, this research investigates the effectiveness of advanced modulation schemes such as 16QAM and OFDM. The backdrop, problem description, technique, and problems of wireless and optical communication are explained in the preceding chapter. Also, the characteristics of optical domain integration with wireless communication setup are thoroughly examined. . Both traditional and more contemporary wireless principles are explored, and the drawbacks of current systems are also looked at. An updated system is needed to support large number of users and Accessibility to high data speeds, capacity, and long distance connection are all made possible by the most cutting-edge technology, Radio over Fibre (RoF), according to an essential analysis is being researched for its many benefits, include secure long-distance communication, ease of use, cost, and low error ratio. The investigation of WDM technology and its integration with the proposed RoF model is also looked at.The most recent mechanisms applied inRoF system, significant drawbacks like dispersion and polarisation, and the key aspects of the proposed model, notably performance against current problems, are all covered in this chapter.

B. Main Application Fields

A hybrid system called Radio over Fibre (RoF), which combines radio and optical technologies, is suggested to improve the functionality of the existing wireless communication framework.TheRoF system is a component of contemporary technologies that seek to transfer radio signals across optical media; as a result, it excludes wireless communication but maintains the primary framework of inter-base station communication.

So, the main advantage of this thesis is to investigate the RoF technology's structure in order to utilise the advantages of an optical transmission system for wireless signal distribution between numerous access points. Also, the framework's key benefit is that it reduces the complexity of the system and the physical system that is already in place, making it simpler to transmit data. The RoF mechanism is thought to be superior than wireless technology as it is currently configured [33]. In contrast to this proposed RoF framework, digital communication methods like Ethernet (IEEE 802.11) and HDMI (HD wireless system) require a complex solution (DAC and ADC) protocols to transmit and distribute the required data among various access locations. While the RoF technology organises the native transmission method of the RF signals, which can only be communicated from one place to another point across an optical domain utilising light source, these protocols cause drawbacks such buffering, Qos difficulties, and latency rate [34]. The major goal of this method is to transmit RF through an optical cable in light form, which provides high bandwidth, security, and low latency. As a result, changing the modulation format is not necessary in this procedure..As a result, the RoF technology actually offers more efficient, low-cost long-distance communication. In addition to the RoF system's characteristics, this system expands the radio waves' coverage area to include the entire house or multiple organisations connected by a home area network, as shown in Figure 5. separate auto radio signals, known as micro cells, are combined to create a single equivalent radio signal, known as a macro cell [35].. Both traditional and more contemporary wireless principles are explored, and the drawbacks of current systems are also looked at. An updated system is needed to support large number of users and Accessibility to high data speeds, capacity, and long distance connection are all made possible by the most cutting-edge technology, Radio over Fibre (RoF), according to an essential analysis is being researched for its many benefits, include secure long-distance communication, ease of use, cost, and low error ratio. The investigation of WDM technology and its integration with the proposed RoF model is also looked at. The situation where two radio channels establish a point-to-point connection at either end of a Rof transducer is the simplest. This transducer's function is to trans late unified RF waves via an optical fibre, converting the optical energy into electrical form at the receiver end. Similar to this, the RoF system maintains the E/O and O/E conversion by converting the electrical signal into light form a second time. [36].

Coaxial cables are still used to meet many standards, but now rising demand for fast data speeds is creating challenges to these long-standing frameworks. Applications like 4K video streaming, online gaming, and video conferencing require a highly broad bandwidth backbone network, such optical fibres.[2].

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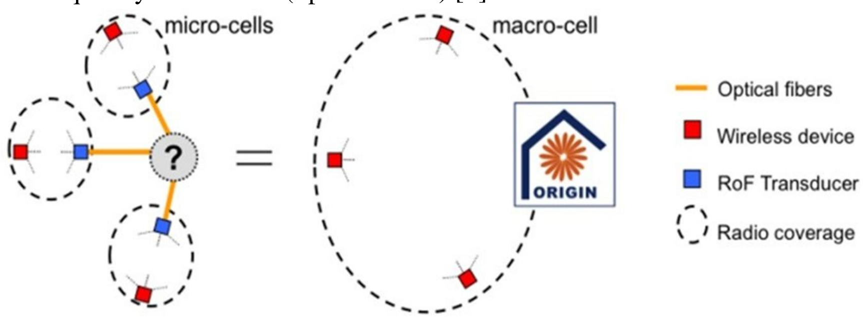

Figure 5:The method use by RoF technology to produce radio signals in the context of micro and macro cells is currently being studied.

RoF technology uses the properties ofthe laser output and photodetector for transmission of O/E and E/O,as shown in Figure 6. There are essentially three forms of modern RoF technology, depending on the radio frequency spectrum that is meant to be conveyed. The following are these categories:

The base band over optical fiber Last section consist of radios over fibre. Figure 2.3 provides a description of these three groups. Form of radio signals are converted to baseband before being transmitted over optical fibre with zero centre frequency in the baseband over optical fibre transmission method. Nevertheless, since the data lines channels are modulated using the OFDM approach, it is not practicable for these signals to broadcast in baseband [38]. A common fibre optic transmission network is made up of three parts: the connecting receiver side, the optical medium, and ultimately the transmitter side. In densely populated areas or in places where installing fibre optic cable is difficult and expensive, radio-over-fiber (RoF) technology techniques are used [4]. Therefore, a variety of techniques, There are options to deliver these broadband services, notably coaxial cable and digital subscribers. [5]. Due to physical media limitations, copper wire bandwidth has reached saturation; As a result, an option for meeting those throughput bandwidth requirements is an optical access framework. Furthermore, In order to transmit the necessary data between the base stations, wireless or radio technology A significant amount of base stations and optical access points will be added soon,which will lower the network's cost [6].Radio-over-fiber methodology represents one of the various ways that optical fibre is used in communications, which facilitates the integration of systems with the established. [7].Main goals of the initial boost central office agility (CO) and exchange microwave pulses.In particular, the modulated microwave pulses are present at the input of the RoF network and transferred through a path in the manner of light waves, to the remote site (RS). At RS, antennas reconstruct and release the microwave waves. [8]. Furthermore the network was configured to handle GSM 900 network traffic. Modern RoF systems include capabilities for movement and transportation as well as additional radio system functions. These features include signal processing, statistical modulations, and frequency conversion (up and down) [9]. In order to enable real value modulated signals.

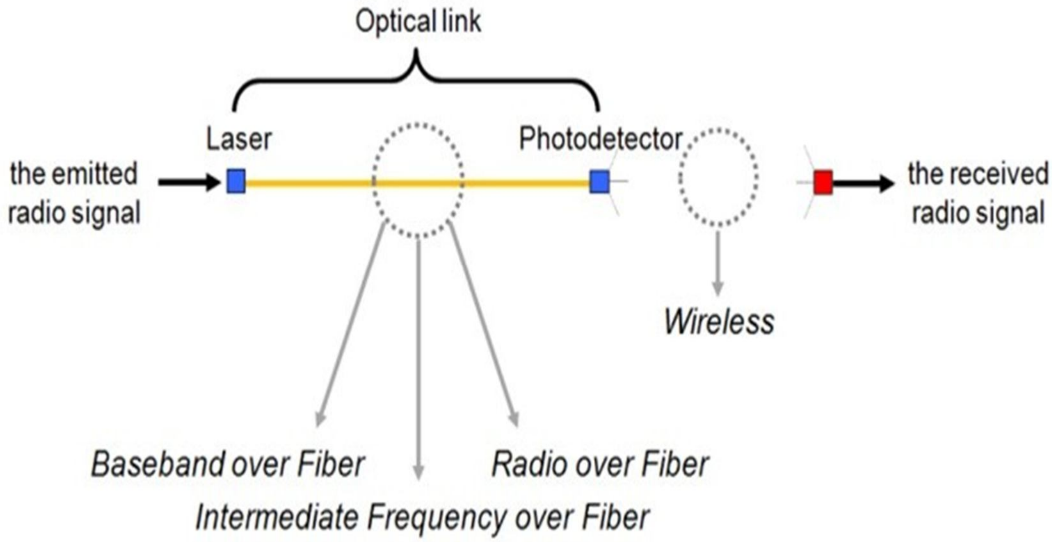

Figure 6:RoF technology usage framework based on installed components.

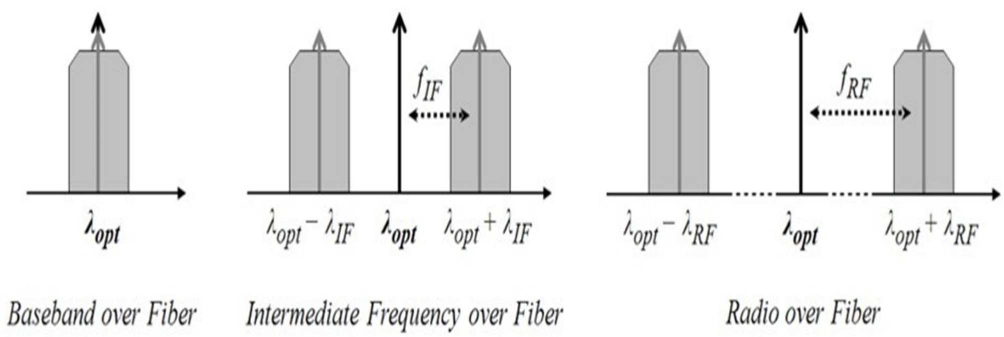

Figure 7 The installed components' framework

Figure 7. The installed components' framework for using RoF technolog

The current communication methods where a remote antenna is required simplified, Full radio demodulation, often known as digital RoF, is the another kind of RoF transmission is also an option [39].Intermediary over optical fibre, which transposes the radio channels prior transmitting through optical domain into Intermediate Frequency, is the third and final form of RoF system.This system reduces the need for optoelectronic components, which leads to a reduction in system complexity [40].This modern frequency band lies between the 60 GHz centre frequency of the original radio bandwidth RoF systems considerably simplify the design of wireless access points, requiring just a physical layer and no intelligence, which allows for significant cost savings in the deployment of future HANs [41]. A common fibre optic transmission network is made up of three parts: the connecting receiver side, the optical medium, and ultimately the transmitter side. In densely populated areas or in places where installing fibre optic cable is difficult and expensive, radio-over-fiber (RoF) technology techniques are used [4]. Therefore, a variety of techniques, There are options to deliver these broadband services, notably coaxial cable and digital subscribers. [5]. Due to physical media limitations, copper wire bandwidth has reached saturation; As a result, an option for meeting those throughput bandwidth requirements is an optical access framework. Furthermore, In order to transmit the necessary data between the base stations, wireless or radio technology A significant amount of base stations and optical access points will be added soon,which will lower the network's cost [6].Radio-over-fiber methodology represents one of the various ways that optical fibre is used in communications, which facilitates the integration [7].Main goals were to boost central office agility (CO) and exchange microwave pulses.In particular, the modulated microwave pulses are present antennas reconstruct and release the microwave waves. [8]. Furthermore the network was configured to handle GSM 900 network traffic. Modern RoF systems include capabilities for movement and transportation as well as additional radio system functions. These features include signal processing, statistical modulations, and frequency conversion (up and down) [9].

The RoF linkages operate as repeaters capable of carrying any of the 60GHz wireless standards, which is another significant benefit brought about by the absence of a radio chipset in the transducers. In actuality, only elements of the radio signal's physical layer—such as the RF power (amplifier and attenuator) or the spectrum—are changed (filter, centern frequency). Future home networks will be built on hybrid designs that combine the advantages of 60GHz wireless systems and fibre optic (high-speed and low attenuation) systems into a single system (high-speed and wireless). Owing to RoF, mobility is restored, but health and hacking issues are not: radio waves are effectively contained in the spaces where RoF transducers are install, and users continue to limit their exposure to Electro-Magnetic Fields (EMFs) and share their data only within their own homes [42].
As a recap of these systems' benefits and drawbacks:
The enhancement of coverage of radio signals.
The creation of an accurate method for radio layer protocol design
The creation of precise remote antennas to lower failure rates. Straightforward remote antennas that reduce failure risk.
RoF transducers' compact design and minimal weight.
The RoF system's transducers use little electricity.
Benefits (not too much cost)
Balancing the long-distance and optical communication infrastructure.
Installation of new wires in houses and organizations are needed
The optical transmission and processing of additional disturbances and distortions onto the transmitted signal.

C. The Description of Intensity Modulation-Direct Detection (IM-DD) Direct modulation

The direct modification of a laser's intensity through current drive is the simplest method for transmitting an RF signal. Similar to amplitude modulation, the optical spectrum has two adjacent sidebands that are placed on the opposite end of the carrier frequency, as depicted in Figure 8. Hence, Double SideBand (DSB) is the name given to the output signal [43].

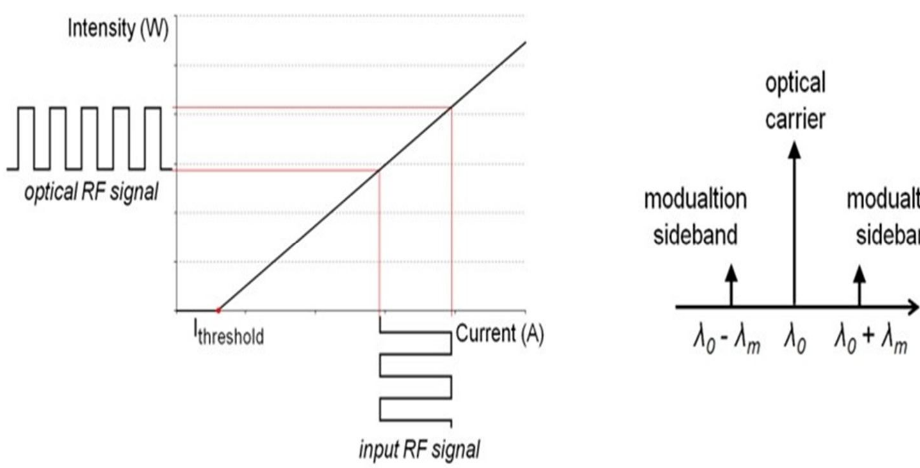

Figure 8 Explanation of DSB signals and the direction modulation technique.

Even if this method is inexpensive now, it might end up costing a lot once high-speed lasers are needed. As a result, IFoF systems are particularly well suited for direct modulation [44]. The laser frequency chirp and fibre dispersion both occur at extremely high frequencies are further constraints with IM-DD. Electroabsorption semiconductors are preferred to reduce the chirp [47, 48] while rely on Mach Zehnder interferometers [45, 46].

D. Overview to the Mach Zehnder Modulator(MZM) to transmit using SSB or DSB

The MZM is a two-arm or two-branches interferometer. As shown in figure 9, an incident optical wave is split into two equal-intensity beams by a 50/50 splitter (Y1) and steered in the interferometer's two arms. The most common material used for this operation is lithium niobate (LiNbO3), which exhibits the electro-optic Pockels phenomenon. When an electrical field is applied, the optical signal on one arm experiences a phase change. [47]. Lastly, a second coupler (Y2) at the MZM's output enables the combining of the two mutually interfering waves. Theopticaloutputpowerequalsto[48]

$$P_o=P_i/2[1+cos(\delta\omega(V))] \quad (2.1)$$

The phase difference across the two overlapping beams is determined by the optical powers that exist at MZM's input and output,Pi and Po. It is possible to see how Equation 2.1 works by.A common fibre optic transmission network is made up of three parts: the connecting receiver side, the optical medium, and ultimately the transmitter side. In densely populated areas or in places where installing fibre optic cable is difficult and expensive, radio-over-fiber (RoF) technology techniques are used [4]. Therefore, a variety of techniques, There are options to deliver these broadband services, notably coaxial cable and digital subscribers. [5]. Due to physical media limitations, copper wire bandwidth has reached saturation; As a result, an option for meeting those throughput bandwidth requirements is an optical access framework. Furthermore, In order to transmit the necessary data between the base stations, wireless or radio technology A significant amount of base stations and optical access points will be added soon,which will lower the network's cost [6].Radio-over-fiber methodology represents one of the various ways that optical fibre is used in communications, which facilitates the integration.The main goals of the initial RoF systems were to boost central office agility (CO) and exchange microwave pulses.In particular, the modulated microwave pulses are present input of the RoF network and are then transferred through a path to form of light waves. Antennas reconstruct and release the microwave waves. [8]. Furthermore the network was configured to handle GSM 900 network traffic. Modern RoF systems include capabilities for movement and transportation as well as additional radio system functions. These features include signal processing, statistical modulations, and frequency conversion (up and down) [9]. The electrical field D0 is a representation of this total, which is:

$$D_0 = M/2[cos(\varphi ctT+\delta\omega(B))+cos(\omega ct)] = Mcos(\omega cT+\delta(\omega(2V)/2)cos(\delta\omega(V)/2) \quad (2.2)$$

Where A and φ care the amplitude and the angular frequency (ωc=2πfc) of the optical wave, respectively. As cos(φ ct+ $\delta\omega$(V)/2) range of photo detector, Output power is proportional to the square of cos($\delta\omega$(V)/2): Hence, Equation 2.1. Last but not least, it should be noted that there is a different MZM type called a push-pull MZM, in which both arms are controlled by the same RF signal but with a different phase. One that provides the same result at the output[50].

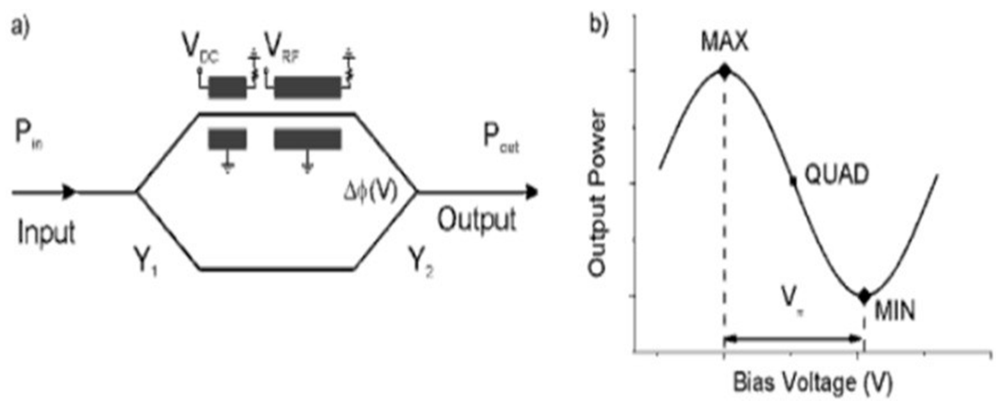

Figure 9 shows the MZM single drive system's mechanism and power response.

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Three distinct operational locations can be seen in Figure 2.5: the quadrature point, that is located in the middle of a linear region perfect for changing the optical wave, the highest point, which enables complete transmission, and the lowest point, which gives complete extinction [51]. Two adjacent sidebands are seen in the frequency domain when the RF signal is translated into the optical domain using a direct modulation or a MZM [52]. Chromatic dispersion, which depends on fibre length, fibre dispersion parameter, the wavelength, and the modulation frequency, affects this double sideband (DSB) signal and causes a phase mismatch between the two bands. The worst case scenario is destructive interferences caused by The apparent phase difference between the photo detector's two bands. But, there are some options available: using dispersion compensating optical fibers.

Coaxial cables are still used to meet many standards, but now rising demand for fast data speeds is creating challenges to these long-standing frameworks. Applications like 4K video streaming, online gaming, and video conferencing require a highly broad bandwidth backbone network, such optical fibres.[2]. Optical fibre networks can be differentiated from one another by offering a range of transmission lengths and data rates. For lesser distances, metropolitan area networks (MAN) are employed, but optical fibre lengths of at least 50 kilometres are needed for long-haul transmission. [3].

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Removing one sideband by means of an optical filter, such as a Bragg grating filter [53].
• Producing a single sideband (SSB) signal utilising sophisticated modulations phase-modulated dual-drive MZM used on its two arms can provide an optical signal in a single sideband [54].

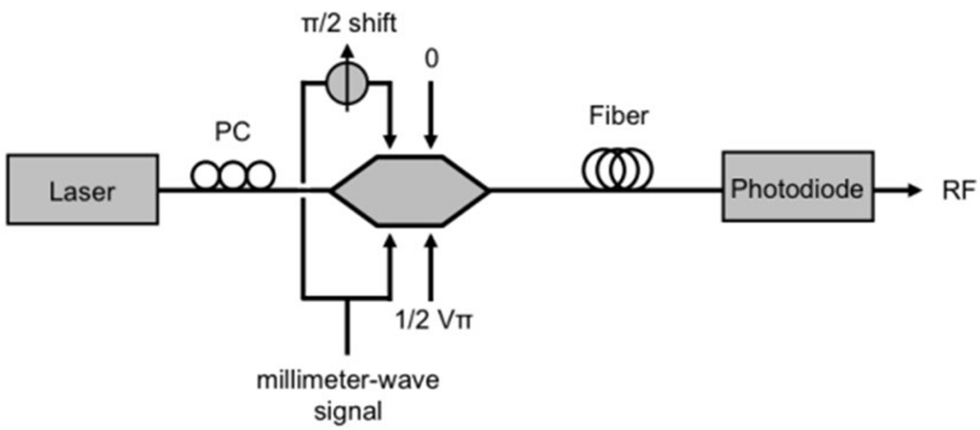

Figure 10 A description of the double drive MZM modulation technique used to produce SSB-type signals

Figure 10, demonstrates how a laser emits an optical wave that has a constant frequency (fc) and amplitude (A). amplitude VAC and frequen cy fm is used to modulate this wave. π/2phase shift between the two electrodes, instead of π, a SSB at the output, a signal can be seen [55].The electrical field E0, a representation of this output signal, can be written as the sum of two fields A/2cos(ωct+φ), with ω the phase shift attained one a charm:

$D_0 = A2\ [cos(\varphi ct\ + \beta\pi + \alpha\pi cos\ (\varphi mt)\ ) + cos\ (\varphi ct\ + \alpha\pi sin\ (\varphi mt)\ )\ ]$ (2.3)

Know that,
α = (VAC /2) /Vπ – β = VDC / Vπ =1/2 (quadraturepoint).
$V\pi$isthemodulationvoltagerequiredtochangethephasebyπinonearm,meanstomovefromfulltransmissiontofullextinction[56].

φciscalledangularfrequencyoftheoptical wave,φc=2πfc.
$\varphi m$is called angularfrequencyoftheRFsignal, φm =2$pifm$. Equation2.3becomes:

$$E_0 = A2\ [cos\ (\varphi ct\ + \beta\pi)\ cos\ (\alpha\pi cos\ (\varphi mt)) - sin\ (\varphi ct\ + \beta\pi)\ sin\ (\alpha\pi cos\ (\varphi mt)\ )]$$
$$+ [cos\ (\varphi ct)\ cos\ (\alpha\pi sin\ (\varphi mt)) - sin\ (\varphi ct)\ sin\ (\alpha\pi sin\ (\varphi mt))\ ] \quad 2.4$$

Thedecompositionsof$cos(\alpha\pi sin(\omega mt))andsin(\alpha\pi sin(\omega mt))$inFourierseriescanbewrit-tenasBesselfunctionsofthefirstkind[57]:

$$cos(\omega\pi)sin(\varphi\pi)= \quad (2.5)$$
$$M_0(\omega\varphi)+2[M_2(\omega\pi)cos(\omega nt+...)]$$
$$sin(\omega\pi)sin(\varphi nt)+2[M_1(\omega\pi)sin(\omega nt)]$$

with$\omega<1/\pi$,i.e.asmallRFsignalamplitude,onlythezeroandfirstorderstermsaresignificant:

$$cos(\omega\pi)sin(\varphi nt)=M_0(\omega\pi)sin(\omega\pi)sin(\varphi nt)=2[M_1(\omega\pi)sin(\omega nt)] \quad (2.6)$$

Equation2.4nowdevelopedinBesselfunctionsofthefirstkind,andβisfixedto1/2(quadraturepoint)[58]:

$$D_0=A_2[cos(\omega ct+\pi 2)cos(\alpha\pi sin(\omega mt+\pi 2))-sin(\omega ct+\pi 2)sin(\alpha\pi sin(\omega mt+$$
$$\pi 2))+cos(\omega ct)cos(\alpha\pi sin(\omega mt))-sin(\omega ct)sin(\alpha\pi sin(\omega mt))]$$
$$(2.7)$$

$$D_0=A_2[-sin(\varphi ct)M_0(\alpha\pi)-cos(\varphi ct)2M1(\alpha\pi)sin(\varphi mt+\varphi 2)+$$
$$cos(\varphi ct)M_0(\alpha\pi)-sin(\omega ct)2M1(\alpha\pi)sin(\omega mt)] \quad (2.8)$$

$$D_0=A_2[M_0(\alpha\pi)cos(\omega ct)-M_0(\alpha\pi)sin(\omega ct)-2M_1(\alpha\pi)cos((\varphi c-\varphi m)t)] \quad (2.9)$$

First two terms of the equations 2.7 to 2.9 correspond to optical tone and the final phrase stands for the rightmost neighboring sideband. Therefore, the SSB signal detected at the MZM's output has an amplitude of $AJ_1(\alpha\pi)$.Shown in figure 2.7, the link between the output signal's amplitude,, and the modulating signal's, $AM_1(\alpha\pi)$, can be roughly represented by a straight line crossing the origin and having a slope of Aπ/2[59].

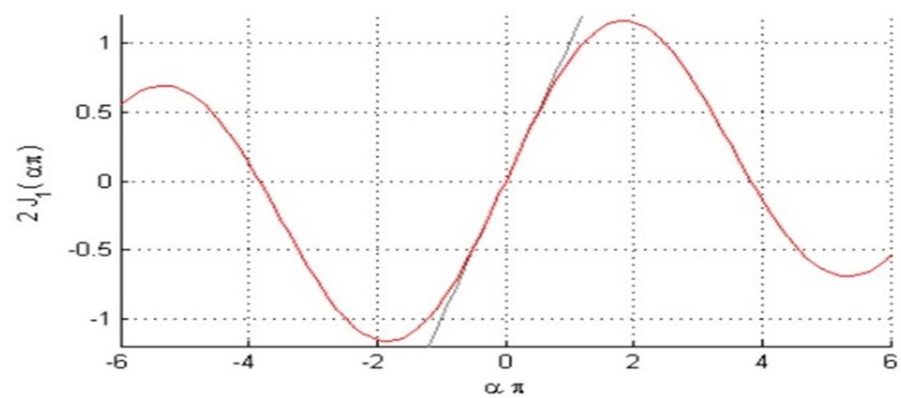

Figure 2.7: 2 $M_1(\omega\pi)$as a function of$\omega\pi$.

E. Outline of the Optical up Conversion Process's Mechanism

As the other approaches are comparable, We will just talk about frequency doubling and quadrupling approaches.

F. The process of Doubling of Frequency

The creation of a DSB signal and subsequent up- pushing of the optical carrier is one technique for doubling optical frequency. This objective was achieved by modulating a dual-drive MZM biassed at the lowest possible point, as indicated in the setup of figure 11. According to [65], A common fibre optic transmission network is made up of three parts: the connecting receiver side, the optical medium, and ultimately the transmitter side. In densely populated areas or in places where installing fibre optic cable is difficult and expensive, radio-over-fiber (RoF) technology techniques are used [4]. Therefore, a variety of techniques, There are options to deliver these broadband services, notably coaxial cable and digital subscribers. [5]. Due to physical media limitations, copper wire bandwidth has reached saturation; As a result, an option for meeting those throughput bandwidth requirements is an optical access framework. Furthermore, In order to transmit the necessary data between the base stations, wireless or radio technology A significant amount of base stations and optical access points will be added soon,which will lower the network's cost [6].Radio-over-fiber methodology represents one of the various ways that optical fibre is used in communications, which facilitates the integration.The main goals of the initial RoF systems were to boost central office agility (CO) and exchange microwave pulses.In particular, the modulated microwave pulses are present. At RS, antennas reconstruct and release the microwave waves. [8]. Furthermore the network was configured to handle GSM 900 network traffic. Modern RoF systems include capabilities for movement and transportation as well as additional radio system functions. These features include signal processing, statistical modulations, and frequency conversion (up and down) [9].In the context (OCS) approach performs better than and occupying half the optical bandwidth (great interest for WDM).

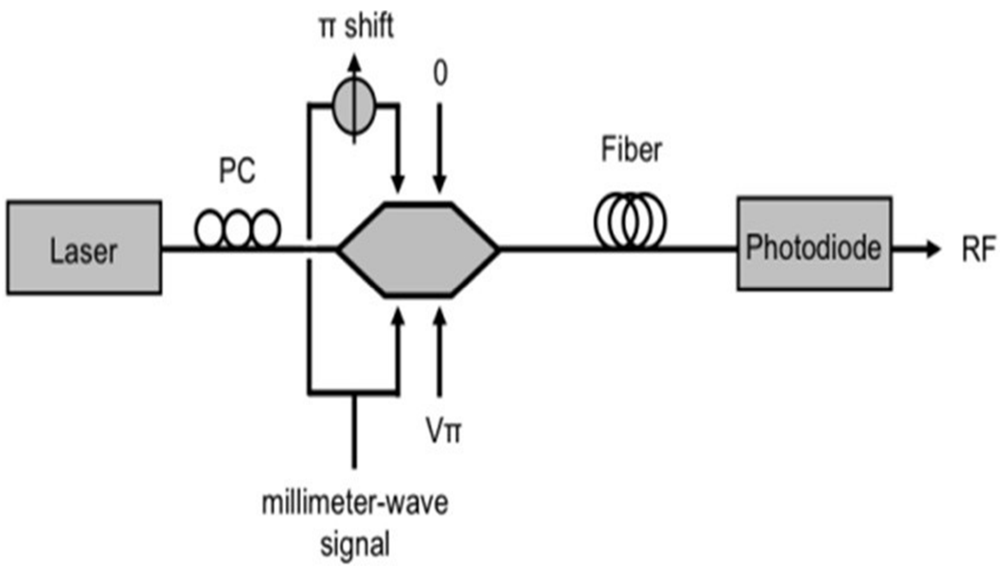

Figure 11 The optical carrier suppressing process.

$$D_0 = A2[cos(\omega ct + \beta\pi + \alpha\pi cos(\omega mt)) + cos(\omega ct + \alpha\pi cos(\omega mt + \pi))] \qquad (2.10)$$

where,–α=(VAC/2)/Vπ.–β=VDC/Vπ=1(minpoint).Asaconsequence:

$$D_0 = A2[cos(\omega ct - \alpha\pi cos(\omega mt)) - cos(\omega ct + \alpha\pi cos(\omega mt))] \qquad (2.11)$$

Equation 2.9 eliminate the optical tone. The equation's initial parameter stands in for the right side band, while its second term stands in for the left side band. [67] describes an alternative technique for frequency doubling: In [68], an optical carrier at 1550 nm is modulated with an RF tone using a single-arm MZM, and following photodetection, the carrier is filtered to create an oscillator at the double frequency. A common fibre optic transmission network is made up of three parts: the connecting receiver side, the optical medium, and ultimately the transmitter side. In densely populated areas or in places where installing fibre optic cable is difficult and expensive, radio-over-fiber (RoF) technology techniques are used [4]. Therefore, a variety of techniques, There are options to deliver these broadband services, notably coaxial cable and digital subscribers. [5].

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$Din(t)=Acos(\omega ct)$ (2.12)

MZM-c is biased at the minimum point (β=1) while MZM-a and MZM-b are biased at themaximum point (β=0) [71].S0, the optical field at Equations 2.3 and 2.4 can be used to compute the output of MZM-c:

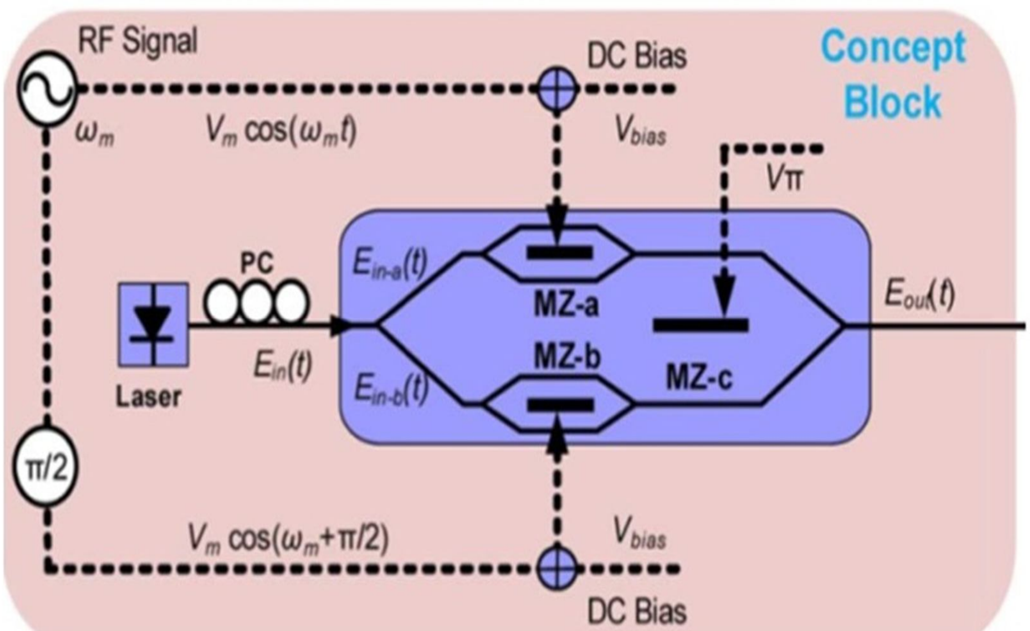


Figure 12 The mechanism for accomplishing up conversion in the optical domain is shown

$D_0=A2[cos(\omega ctcos(\alpha\pi/2)cos(\omega mt))+cos(\omega ct)cos(\alpha\pi/2cos(\omega mt+\pi/2)+\pi)]$

withα=Vm/Vπ.AfteradevelopmentinBesselfunctionsofthefirstkind:

$D_0=A2[cos(\omega ct)(M_0(\alpha\pi/2)+2M_2(\alpha\pi/2))cos(4\omega mt+4\pi/2)++2M_6(\alpha\pi/2)cos(6\omega mt+6\pi/2)]$

(2.14)

Therefore:

$D_0=A2[cos(\omega ct)(-2M2(\alpha\pi/2)cos(2\omega mt)-2M_6(\alpha\pi/2))cos(6\omega mt)-cos(\omega ct)cos(6\omega mt))]$

(2.15)

First two terms of equation 2.14 correspond to two sidebands centered at λ c-2λRF andλc+2λRF, respectively, while the last two terms correspond to two side bands centeredatλc-Λrf and λc+6λRF. Theoretically, others terms existatλc±10λRF,λc±14λRF, etc...but these high order term shave been neglected in equation 2.13 because they are extraneous to a modulation range between θ and π. Infact, as shown in Figure13, only the terms of amplitude equal to M2($\alpha\pi$/2) are kept. Finally, the photo detected signal is centered at 4ωmas the optical tone has been removed [72].

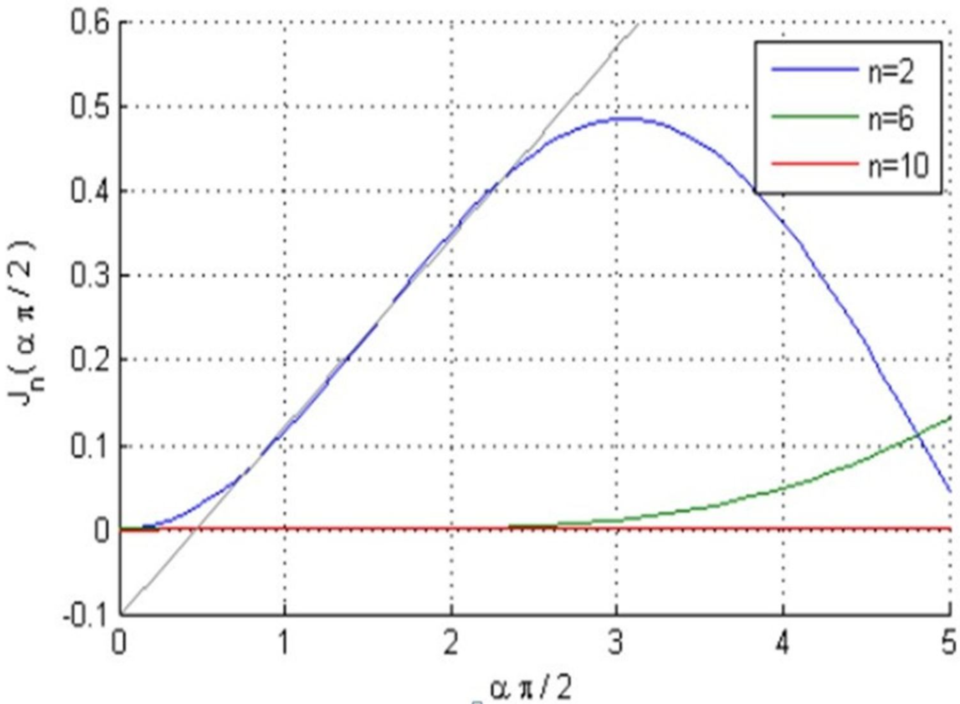


Figure 13 Jn($\alpha\pi$/2)asafunctionof$\alpha\pi$/2.

The generation and transmission of millimeter-wave signals using optical heterodyne detection techniques is a common strategy in RoF papers. Using this method, two optical beams are emitted, separated by the target RF frequency [73]:

$D_1=D_{01}cos(\omega_1 t)$ (2.16)

$D_2=D_{02}cos(\omega_2 t)$ (2.17)

Where E1 is the first optical field at the angular frequency $\omega_1(\lambda_1= 2\pi c/\omega_1)$ and E_2 is the second optical field atω_2. A MMW is produced on a photodiode by the optical blending of these two fields [74]. Photo detected current is, in fact sum of the optical fields due to its quadratic detection:

$i_{PD}=(E_1+E_2)2=E_{01}+cos(2\omega_1 t)/2+2E_{01}E_{02}cos[(\omega_1-\omega_2)t]+E_{02}+cos(2\omega_2 t)/2$ (2.18)

The photodiode cannot detect the initial harmonic terms because they are too high. onlytheD01D02cos((ω1ω2)t)The fact remains: it demonstrates how the frequency difference between the two light fields affects the beat signal. Forinstance,at1550nm,To achieve a frequency spacing of 60.48GHz, the two optical fields must have a wavelength separation of 484.7pm [75].

δv=cλ2 (2.19)

Hence, optical heterodyning is a viable method for high frequency generation since it eliminates the requirement for millimeter-wave oscillators at the emission and lowers the laser modulation speeds. The photodiode still needs a large amount of bandwidth, though, in order to detect the beat signal of incoming optical pulses [76].

G. Related Work

The increasing need for greater data rates and longer transmissions in the information technology era, or the 21st century. High speed transmission is necessary to avoid network congestion. Fiber optics is thought to be an appropriate approach to meet the demand for high data rates. While using "waveguides," a technology known as fibre optics, information is transferred as light.

A general optical system consists of a transmitter, such as a laser or LED (light emitting diode), that produces the light signal; an optical fibre that uses total internal reflection to carry the light; and a receiver, such as a photodiode, that transforms the light signal into an electrical signal. It has completely changed how we communicate, how we send and receive information, and it has contributed greatly to the emergence of the information era. It stimulates scientists' curiosity and drives them to develop new forms of communication. A common fibre optic transmission network is made up of three parts: the connecting receiver side, the optical medium, and ultimately the transmitter side. In densely populated areas or in places where installing fibre optic cable is difficult and expensive, radio-over-fiber (RoF) technology techniques are used [4]. Therefore, a variety of techniques, There are options to deliver these broadband services, notably coaxial cable and digital subscribers. [5]. Due to physical media limitations, copper wire bandwidth has reached saturation; As a result, an option for meeting those throughput bandwidth requirements is an optical access framework. Furthermore, In order to transmit the necessary data between the base stations, wireless or radio technology A significant amount of base stations and optical access points will be added soon, which will lower the network's cost [6].Radio-over-fiber methodology represents one of the various ways that optical fibre is used in communications, which facilitates the integration of the established over-the-air networks. [7]Main goals of the initial RoF systems were to boost central office agility (CO) and exchange microwave pulses. In particular, the modulated microwave pulses are present .At RS, antennas reconstruct and release the microwave waves. [8]. Furthermore the network was configured to handle GSM 900 network traffic. Modern RoF systems include capabilities for movement and transportation as well as additional radio system functions. These features include signal processing, statistical modulations, and frequency conversion (up and down) [9]. In recent years, optical communication research has attracted a lot of attention. The Rof technology is regarded as a unique solution for building a communication network that is healthier against advancing dispersion. Researchers have a lot of room to work with in this period to create precise structures that can meet current demands while overcoming dispersion.

As a result, numerous research projects have been completed to date and are detailed below. In order to preserve power consumption and account for NLIs, scientists in [77] studied an unique networks. [77] examines the 22 OFDM technology. This work then illustrates a 2 2 MIMO-OFDM-based orthogonal and biorthogonal wavelet-based RF transmission system in the S-band using a variety of PSK modulation methods. The authors use spatial diversity, one of the MIMO setups that promises to be reliable in noisy networks. Yet, the optical sub-system non-linearity has a significant impact on how Wavelet-OFDM (W-OFDM) signals are distributed across a radio over fibre (RoF) link. In order to get over this non-linearity and get a less sophisticated detection, the simplest 2 2 Alamouti space-time block coding (STBC) is used in this work. The work is further expanded to implement an adaptive MIMO-RoF system using the W-OFDM scheme to adapt to the best PSK technique that is available depending on the link circumstances in order to maintain the ideal balance of link quality and spectral efficiency [77]. The WDM-Rof Network is examined in [78],.A common fibre optic transmission network is made up of three parts: the connecting receiver side, the optical medium, and ultimately the transmitter side. In densely populated areas or in places where installing fibre optic cable is difficult and expensive, radio-over-fiber (RoF) technology techniques are used [4]. Therefore, a variety of techniques, There are options to deliver these broadband services, notably coaxial cable and digital subscribers. [5]. Due to physical media limitations, copper wire bandwidth has reached saturation; As a result, an option for meeting those throughput bandwidth requirements is an optical access framework. Furthermore, In order to transmit the necessary data between the base stations, wireless or radio technology A significant amount of base stations and optical access points will be added soon,which will lower the network's cost [6].Radio-over-fiber methodology represents one of the various ways that optical fibre is used in communications, which facilitates the integration.The main goals of the initial RoF systems were to boost central office agility (CO) and exchange microwave pulses.In particular, the modulated microwave pulses are present.At RS, antennas reconstruct and release the microwave waves. [8]. Furthermore the network was configured to handle GSM 900 network traffic. Modern RoF systems include capabilities for movement and transportation as well as additional radio system functions. These features include signal processing, statistical modulations, and frequency conversion (up and down) [9]. The authors in [78] discuss a RoF transmission system with wireless multimode operating in terms of a multi-wavelength optical comb and pulse forming. Before sending signals through WDM inside the 5G carrier frequency, the 4-QAM OFDM technique is used. [79] examines the creation and propagation of D-band vector millimetre waves using cascaded intensity modulators and in-pulse quadrature modulators (QMs). To produce two pairs of dual single sideband signals, these two modulators work in optical carrier suppressing mode. [80] presents.based on synchronisation and multiband multiplexing methods. In [81], authors present a 22 MIMO-OFDM system for S-band RF transmission that uses orthogonal and biorthogonal wavelets as well as the phase-shift keying (PSK) modulation format. The radio access network (RAN), which provides wireless connection users with nonlinear energy harvesting, studies optimization of signal processing algorithms for downlink and uplink (EH).

Similar to this, in [83], the authors present a full duplex RoF system using a coherent dual wavelength closer source and an integrated silicon ring modulator. However, there is room for alternative solutions in WDM RoF system due to limitations.this research offers a unique WDM-RoF system based on multi carrier advance modulation methods.

H. Comparison

The most widely used solutions have been briefly discussed. The usage of RoF in HAN is subject to the following restrictions and requirements: cost, performance, and integration compactness.

The transducers must be as straightforward as feasible in order to lower the price of the RoF systems. For example, approaches based on intricate MZM modulation are required, such as SSB generation or optical up-conversion. In a domestic setting when the distances do not exceed 100m, high performance is not absolutely necessary; the system merely needs to be dependable and inexpensive for all. Because of this, tried-and-true methods that don't need high bandwidth components are recommended [77]. At 60GHz, neither an optical up-conversion nor a heterodyne detection is advised because they just slow down the laser modulation speed. The IM-DD approaches in Intermediate Frequency, particularly the direct modulation since it provides a high level of integration, are more appropriate solutions. In fact, for a significant portion of consumers to adopt RoF transducers, they must be small and inconspicuous [78].A common fibre optic transmission network is made up of three parts: the connecting receiver side, the optical medium, and ultimately the transmitter side. In densely populated areas or in places where installing fibre optic cable is difficult and expensive, radio-over-fiber (RoF) technology techniques are used [4]. Therefore, a variety of techniques, There are options to deliver these broadband services, notably coaxial cable and digital subscribers. [5]. Due to physical media limitations, copper wire bandwidth has reached saturation; As a result, an option for meeting those throughput bandwidth requirements is an optical access framework. Furthermore, In order to transmit the necessary data between the base stations, wireless or radio technology A significant amount of base stations and optical access points will be added soon,which will lower the network's cost [6].Radio-over-fiber methodology represents one of the various ways that optical fibre is used in communications, which facilitates the integration of OS with the established boost central office agility (CO) and exchange microwave pulses.In particular, the modulated microwave pulses are present at the input of the RoF network and are then transferred At RS, antennas reconstruct and release the microwave waves. [8]. Furthermore the network was configured to handle GSM 900 network traffic. Modern RoF systems include capabilities for movement and transportation as well as additional radio system functions. These features include signal processing, statistical modulations, and frequency conversion (up and down) [9]. It makes reasonable to implement a millimeter-wave to IF conversion now before the optical transmission and the opposite after the photodetector. The industry makes significant efforts to target the mass market and reduce costs with the launch of new millimeter-wave radio systems, such as the IEEE 802.11ad solutions of the well-known Wi-Fi family. Since they are a part of the millimeter-wave front end of the future products, mixers and oscillators at such frequencies are becoming more affordable. Although the direct modulation in IF is a simple solution, it is nevertheless competitive when compared to other approaches [79].

This method has really been contrasted with a mode-locked laser emission with a heterodyne detection in [40]. According to the IEEE 802.15.3c standard, HSI mode, the transmitted signal is an OFDM signal with QPSK subcarriers operating at 3.08Gbit/s. At 4.5GHz, the IM-DD optical transmission is first implemented using inexpensive optoelectronic components developed for 10Gbit/s digital communication at 850nm. A local oscillator at 54.5GHz upconverts the radio signal at the receiver so it can be sent over 10m of empty space.A common fibre optic transmission network is made up of three parts: the connecting receiver side, the optical medium, and ultimately the transmitter side. In densely populated areas or in places where installing fibre optic cable is difficult and expensive, radio-over-fiber (RoF) technology techniques are used [4]. Therefore, a variety of techniques, There are options to deliver these broadband services, notably coaxial cable and digital subscribers. [5]. Due to physical media limitations, copper wire bandwidth has reached saturation; As a result, an option for meeting those throughput bandwidth requirements is an optical access framework. Furthermore, In order to transmit the necessary data between the base stations, wireless or radio technology A significant amount of base stations and optical access points will be added soon,which will lower the network's cost [6].Radio-over-fiber methodology represents one of the various ways that optical fibre is used in communications, which facilitates the integration of OS with the established. At RS, antennas reconstruct and release the microwave waves. [8]. Furthermore the network was configured to handle GSM 900 network traffic. Modern RoF systems include capabilities for movement and transportation as well as additional radio system functions. These features include signal processing, statistical modulations, and frequency conversion (up and down) [9]. The Mode-Locked Fabry-Perot Laser (ML-FPL) at 1550 nm, whose self-pulsating frequency is 54.8 GHz, is then directly modulated to transmit the identical OFDM signal at 4.5 GHz. Due to a high speed photodiode with a 70GHz bandwidth, a heterodyne detection up-converts the radio signal into 60GHz at the reception [80].

I. Summary

RF waves are transmitted by the RoF system using an optical carrier, and they are converted back into RF at the point of reception. In order to maximise bandwidth and transmission range whilst minimising system complexity, this communication channel is helpful. The basic structure of modulation systems is discussed using mathematical techniques. It has been found that the typical framework for communication is often a more sophisticated system since it involves a significant amount of DAC and ADC conversion. It has been found that the typical framework for communication is often a more sophisticated system

III. PROPOSED MODEL

A. Introduction

As was already discussed that Due to the increasing demands of high data rates, subscribers, and long distance communication, the communication system is presently unstable.Physical communication also has a complex structure, a high energy consumption rate, and a high failure ratio that prevent it from supporting big capacity transmission over long distances. In order to make up for these limitations, researchers developed a physical-less framework for communication, which made it less complicated and more effectively implementable. Yet, as the number of users who require high definition data grows over time, the current wireless communication setup has been unable to support customers who require high data rates and long distance connection. Researchers currently Utilise the RoF technique with several features, including reduced bit error rate (BER), enhanced security, large capacity for transmitting, and an easy-to-understand model. In order to enhance the quality of wireless communication systems and support huge data capacities over long distances, The WDM-RoF technology's suggested framework is outlined in this chapter. The chapter also provides a quick overview of the model parameters used.The model is then put up against the most updated demonstrate the capability and capacity of the recommended task.

B. Proposed Architecture

As it has been described, transmitting radio signals across optical media offers a promising way to increase system capacity, user count, privacy, high data flow, low rate of errors, and sophisticated model. In addition, the bending and dispersion losses of the optical medium are produced when used for long-distance communication. Because of this, employing the radio over fibre mechanism is seen to be a successful way to compensate for the bending and dispersion losses. As a result, a large volume of data may be easily transmitted across long distances with improved performance and a lower error ratio.The basic form of the proposed RoF-WDM is shown in Fig. 15. It consists of three parts: the transmitter side, which modulates and converts RF signals into optical medium before multiplexing, The optical medium physically transfers the necessary data across an optical fibre, and the receiver side's goal is to transform the optical source into RF waves, which are then sent to the end - user or the next optical media. The effectiveness and performance of the suggested WDM-RoF model are evaluated using the robust OptiSystem simulation programme.

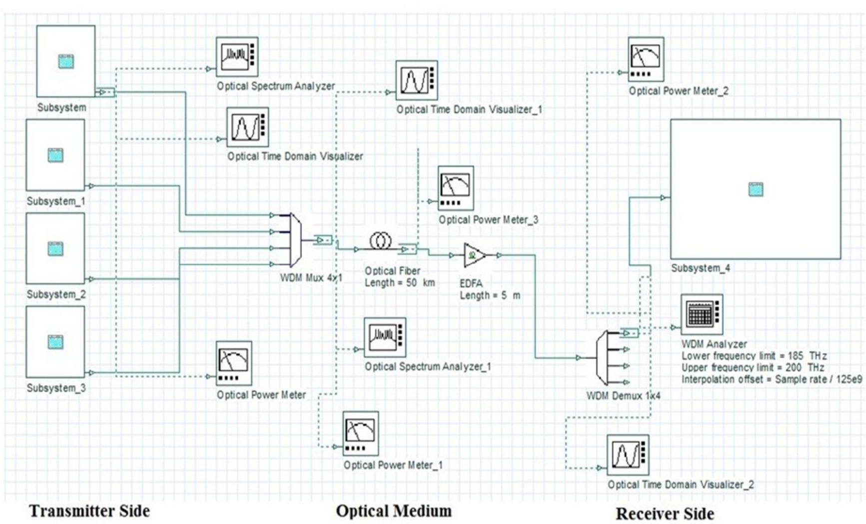


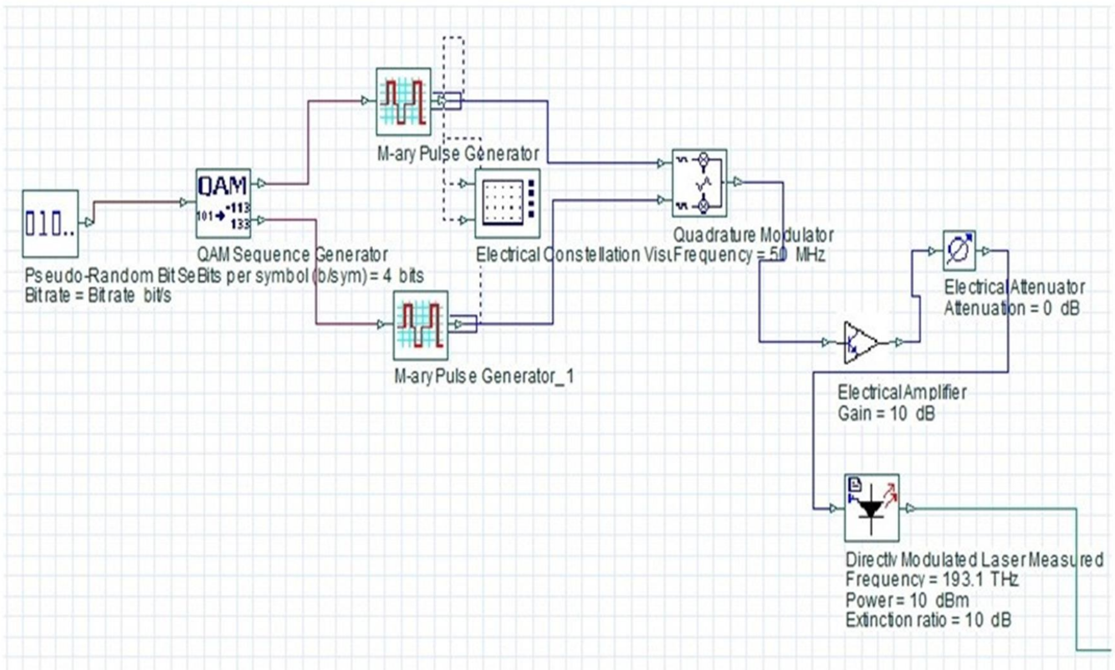
Figure 14 Signal Processing Architecture Figure 15 Architecture RoF being proposed

the parts below, each component used in the suggested WDM-RoF model with configured parameters is described.

C. The Suggested Model's Transmitter Side

To evaluate the effectiveness of the proposed WDM-transmitter RoFs model, 16QAM and OFDM are installed, as well as a directly modulator laser an electrical amplifier, a quadrature modulator, an electrical attenuator, and an M-array pulse generator tested. The Figs.16 and 17 shows internal structures of the QAM and OFDM transmitters.For each element, the following descriptions are given:

Figure3.2:Interior design of the suggested model's 16QAM transmitter.



Signal processing mechanism inside transmitter of the proposed model

Figure 16Signal Processing ransmitters Side

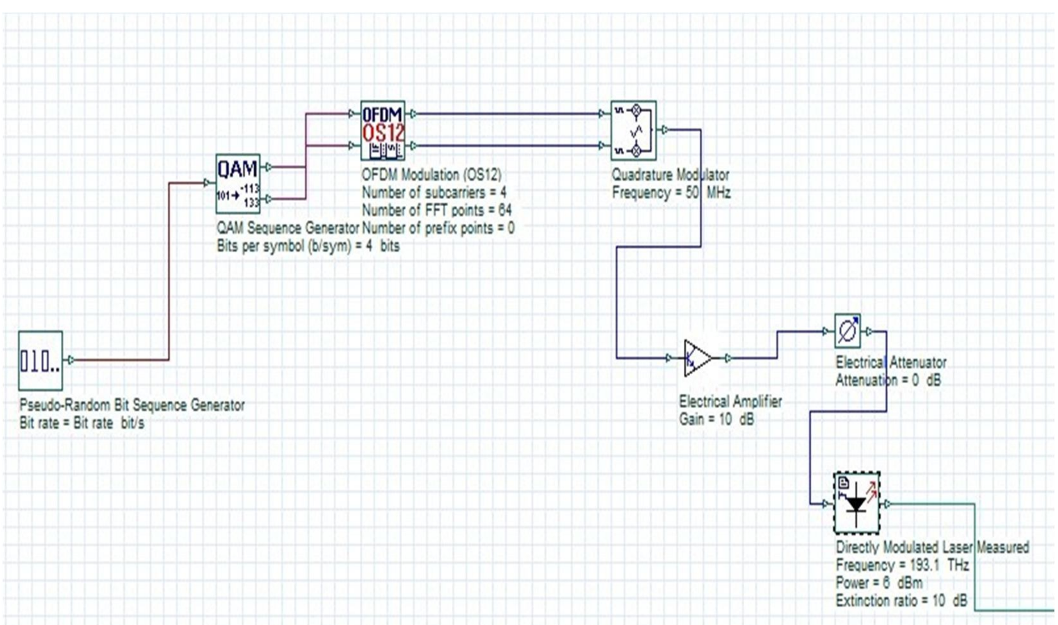


Figure 17 Internal design of the suggested model's OFDM-based transmitter.

D. *Pseudo-Random Bit Sequence (PRBS) Generator*

PRBS generator is a tool that produces bits in a pseudo-random manner. Before being transformed and modulated into light form, the radio impulses are converted to binary. This tool makes it possible to alter the data transmission speed and evaluate how well the suggested model will function. The PRBS sign is shown in Figure 18, which explains that there is only one output. The list of parameters utilised in PRBS to assess system performance and capacity is shown in figure (Table) 19.

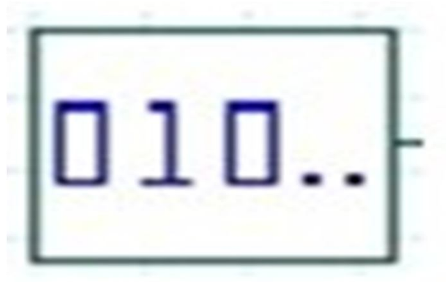


Figure 18 PRBS generator symbol

Description	Valuesrangewithunits
Bitrate	1.602×10^{-12}
Operationmode	Probability
No.ofleadingzeros	(Timewindow*3/100)bitrat e
No.oftrailingzeros	(Timewindow*3/100)bitrat e

Figure 19 :List of factors used by PRBS to determine the effectiveness of the RoF system.

Nameofparameter	Rangeandvalueofparameter
Sequenceofbit	Binaryfrominput
I-output	M-ary
Q-output	M-ary
Bitspersymbol	0-100bits/sym(2for4QAM,4for16QAMetc)

Figure 20 Comprehensive overview of the QAM components.

1) Technical Knowledge

PRBS generates the bit stream represented by M, which is described mathematically as

$$M=W_N R_B \quad (3.1)$$

$$M_D=M-m_1-m_2 \quad (3.2)$$

the details time bits and bit of window rate are explained by WN and RB, respectively. Through MD, the number of bits is reduced. m1 and m2 stand for the number of leading and trailing zeros, respectively. An operation mode that maintains the likelihood of generated bits is implemented to control the PRBS algorithm.

2) Quadrature Amplitude Modulation Sequence Generator

Main function of the QAM sequence creation is to generate parallel M-aray symbol sequences from binary pulses (description is supplied in the part below of this chapter). The QAM sign, which has a single input and two outputs, is shown in Figure 21.

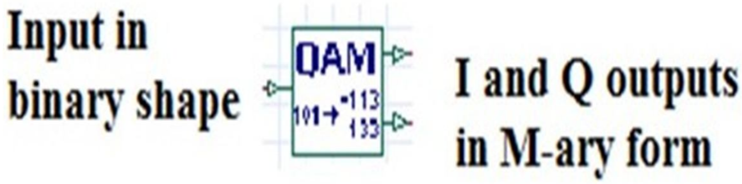


Figure 21 :QAM symbol used in model proposal.

3) Technical Background of QAM

By creating a QAM modulator. By employing a serial to parallel converter, this is accomplished. We can adjust a signal's loudness while transferring data in accordance with the source symbols. One of the values from the collection of amplitudes is selected as the amplitude for each output port, which is calculated as

$C_1=(2_i-1-N), i=1,2,\ldots M$ (3.3)

$M=2^{j/2}$ (3.4)

where j is the symbol's bit count. The square of N yields the comparable QAM set. This implies: If j =2, N =2 , then we have a 4-QAM. If j = 4, N=4, we have a16-QAM.Ifj=6,N=8,thenwehavea64-QAM.Ifj=8,N=16, then a 256-QAM is used.

Name&description	Defaultvalue	Units	Valuerange
Bias	1	a.u.	-INF,+INF
Dutycycle	1		[0,1]
Position	0		[0,1]
Risetime	0.05	Bit	
Falltime	0.05	Bit	
Frequency simulation window	Samplerate	Hz	Hz,GHz,THz

Figure 22 Implemented inside of M-ary are listed.

4) M-arypulse generator

A multilayer wave is produced by the M-ary parameter using an M-ary input signal. Figure 22 shows. The parameters utilised within the M-ary element are listed in Table 3.3 in a manner similar to that. These components make it simple to maintain the function of pulse.

Technical knowledge

M-ary element's produced pulses are calculated as shown following;

The term **Uout** refers to the input M-ary signal, b to the linear gain, and a to the bias parameter. **T** stands for bit duration or period, **tc** for duty cycle, and **t1** for pulse position.

Quadraturemodulator

The QM, which has a signal output and two inputs, is shown symbolically in Figure 25, and its internal structure is shown in Figure 27. A quadrature analogue amplitude modulator is implemented by the QM. The modulation of the output signal is determined by:

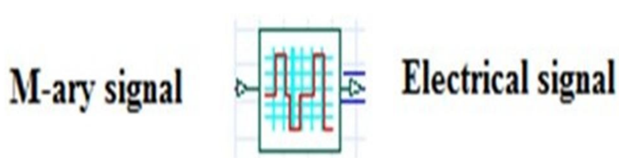


Figure 23 Symbol of M-ary signal.

Name&description	Default value	Default unit	Value range
Frequency of the input signal carrier	50	MHz,Hz,GHz,Thz	0,+INF
Bias DC Offset to the pulse	1	a.u.	-INF,+INF
Linear gain to be applied to the signal input	1		-INF,+INF
Phase of the input signal carrier	0	deg,rad	-INF,+INF

Figure 24 A list of the components utilised in QM.

$$u_{out}=g[I(t)cos(\omega t+\psi c)Q(t)sin(2\omega t+\psi_c)]+a \qquad (3.6)$$

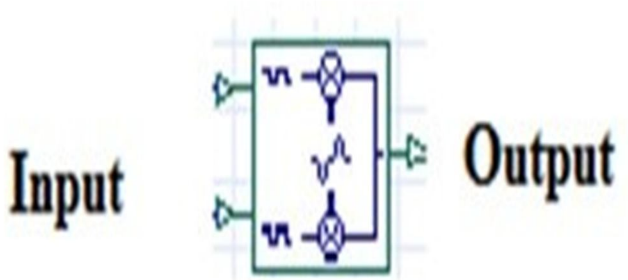


Figure 25 : QM (Symbol)

Q and I are the electrical signals being inputted, g is the parameter gain, an is the bias, is the carrier frequency, and c is the carrier phase. Table 3.4 lists the names of the parameters that are used inside of QM.

Name & description	Default value	Default unit	Value range
Gain	10	dB	[-1e+100,1e+100]
Include noise	Yes		
PSD	Yes		
Noise power	–60	dBm	W,mW,dBm

Figure 26 Definition of the electrical amplifier's parameters..

5) Electrical Amplifier

The parts that constitute the electrical amplifier are represented by the electrical symbol in Figure 3.8. as well as their values and units, are listed in Figure (Table) 26.

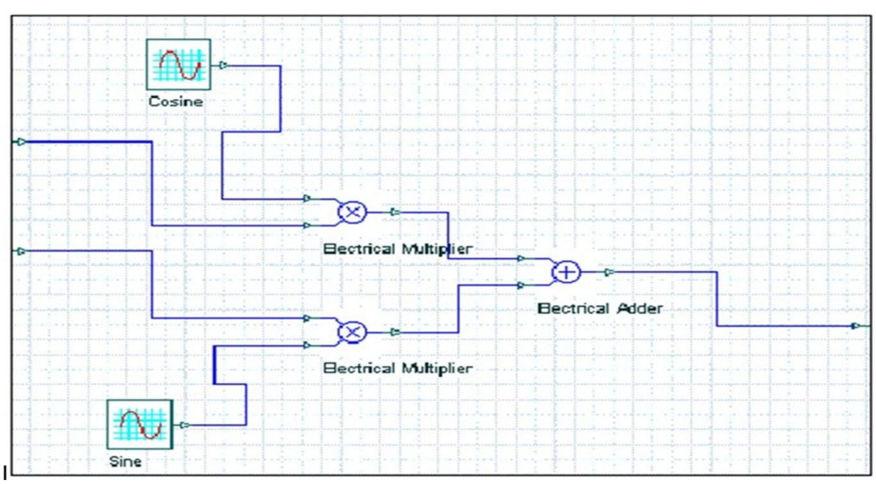


Figure 27 Internal structure of QM.

6) Technical back ground of electrical amplifier

It is possible to estimate the linear gain of an electrical amplifier component as

$$\frac{P_o}{P_i}=10^{g/10} \qquad (3.7)$$

Decibels (dB) are used to quantify electrical gain, and the output of an electrical signal is measured as follows:

$$D_{out}=D_{in}\sqrt{(lineargain)} \quad (3.8)$$

$$PSD=\sqrt{(Noisepower.frequencygridspacing)} \qquad (3.9)$$

Frequency gridspacing,calculatedas

$$Frequencygridspacing=(Rateofsample)/(numberofsamples) \qquad (3.10)$$

$$Frequencygridspacing=(noiseofpower)/(numberofsamples) \qquad (3.11)$$

The RoF system's transmitter side electrical amplifier symbol is depicted in Figure 3.9.

7) Directly Modulated Laser Measured

Which enables to adjust laser's dynamic depends on detected variables. We can enter parameters such as line width, chirp, side mode,

Name & description	Default value	Default unit	Units
Frequency Emission	193.1	THz	Hz,THz,nm
Configuration	Digital		
Power Laser output power	10	dBm	W,mW,dBm
Extinction ratio	10	dB	

Figure 28 Definition of the electrical amplifier's parameters.

suppression and relative intensity noise(RIN). The symbol for directly modulated laser measurements is explained in Figure 30, and Figure. 28 lists descriptions of the parameters that are used inside these measurements

Figure 29 : Electrical amplifier's Symbol.

8) Information On The Development Of Directly Modulated Laser Measurement Technologies

Figure 3.10 describes the symbol for directly modulated laser measurements, Table 3.6 provides a description of the values that were employed. You can insert measured values here that, by constructing the laser output signal, describe the dynamics of the laser. The input signal's amplitude range is balanced between 0 and 1 if the parameter Configuration is set to digital. This indicates that the input signal is transformed into a series of squared pulses by this model.A common fibre optic transmission network is made up of three parts: the connecting receiver side, the optical medium, and ultimately the transmitter side. In densely populated areas or in places where installing fibre optic cable is difficult and expensive, radio-over-fiber (RoF) technology techniques are used [4]. Therefore, a variety of techniques, There are options to deliver these broadband services, notably coaxial cable and digital subscribers. [5]. Due to physical media limitations, copper wire bandwidth has reached saturation; As a result, an option for meeting those throughput bandwidth requirements is an optical access framework.

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Furthermore, In order to transmit the necessary data between the base stations, wireless or radio technology A significant amount of base stations and optical access points will be added soon,which will lower the network's cost [6].Radio-over-fiber methodology represents one of the various ways that optical fibre is used in communications, which facilitates the integration of optical networks integrated with the existing over-the-air networks [7]. Furthermore the network was configured to handle GSM 900 network traffic. Modern RoF systems include capabilities for movement and transportation as well as additional radio system functions. These features include signal processing, statistical modulations, and frequency conversion (up and down) [9].

$$D_r = 10 \log P_o / P_i \qquad (3.12)$$

where Pi is the steady-state power at the level 0, Po is the parameter power, Dr is the parameter extinction ratio, and

E. Optical Medium

Primary source, where information is actually sent optically in the optical media. EDFA,SMF, a WDM multiplexer,WDM de-multiplexer (EDFA) are all components of this medium. Here is a description of each element.

F. WDM Multiplexer

Figure 33 illustrates how this technology, helps to increase user numbers, multiplexes multiple signals onto a single line. Comparable parameters utilised inside the WDM multiplexer are listed with descriptions in Figure 33.

Figure 30 Directly modulated laser measurement Symbol

An optical filter combines the four signals that enter into one signal. An optically MUX and DEMUX elements both, the filter's bandwidth, ripple, and depth influence how much crosstalk occurs. When determining a channel's performance.

Name & description	Default value	Default unit	Value range
Bandwidth 3dB filter bandwidth	10	GHz	0,+INF
Insertion loss of the demux	0	dB	0,+INF
Depth	0	dB	0,+INF
Filter type	Bessel		Rectangle, Gaussian, Bessel
Filter order	2		[1,1000]
Sample rate	128	GHz	0,+INF

Figure 31 lists the components of a WDM-MUX

Name & description	Symbol	Default values	Value unit and range
Reference Wavelength	λ_0	1550	[100-2000]nm
Length	L	50	[0,100,000]km
Attenuation	A	0.2	[0,10^10]dB/km
Dispersion	D	16.75	[-10100,10100]ps/nm.km

Figure 32 list of single-mode fibre parameters

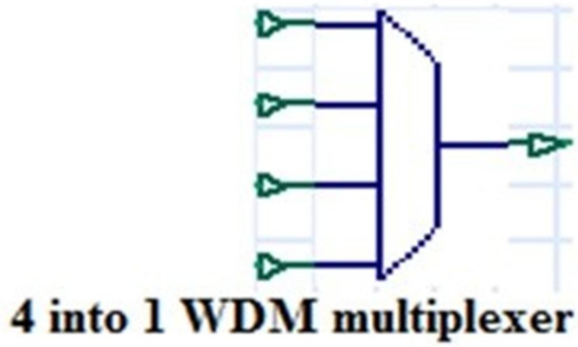

Figure 33 WDMmultiplexer (Symbol)

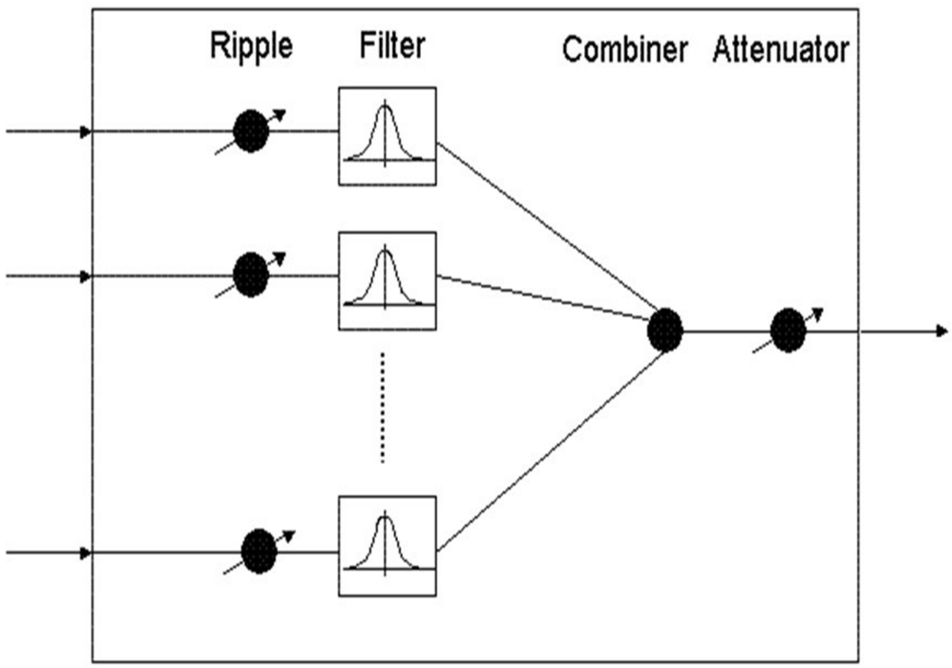

Figure 34 SubsystemofWDMmultiplexer.

The depth parameter is the most crucial one because it will have the biggest impact on how powerful surrounding channels are.

G. A depiction of single-mode fibre (SMF)

A WDM-RoF setup's main objective is to transmit RF signals as light using an optical cable. There are many different types of optical fibre, such as multimode, single model, single index, and double index fibres.The recommended method uses Single Mode Fibre (SMF) type optical cable to transfer RF signals as light. The main benefit of this kind of fibre is its capacity to transport data across great distances with little mistake.A common fibre optic transmission network is made up of three parts: the connecting receiver side, the optical medium, and ultimately the transmitter side. In densely populated areas or in places where installing fibre optic cable is difficult and expensive, radio-over-fiber (RoF) technology techniques are used [4]. Therefore, a variety of techniques, There are options to deliver these broadband services, notably coaxial cable and digital subscribers. [5]. Due to physical media limitations, copper wire bandwidth has reached saturation; As a result, an option for meeting those throughput bandwidth requirements is an optical access framework. Furthermore, In order to transmit the necessary data between the base stations, wireless or radio technology A significant amount of base stations and optical access points will be added soon,which will lower the network's cost [6].Radio-over-fiber methodology represents one of the various ways that optical fibre is used in communications, which facilitates the integration of OS.

At RS, antennas reconstruct and release the microwave waves. [8]. Furthermore the network was configured to handle GSM 900 network traffic. Modern RoF systems include capabilities for movement and transportation as well as additional radio system functions. These features include signal processing, statistical modulations, and frequency conversion (up and down) [9]. However, various losses including dispersion losses, bending, and nonlinear issues are taken into account when transferring a significant amount of data over a long distance. Numerous restrictions are investigated and theoretically and numerically changed, including dispersion and nonlinear issues.

Total field refers to a set of optical sampling signals that are contained inside a single frequency band. The given signals and noise bins get only attenuation. Data passes through glass fibres as light based on reflection laws.It is the most widely used form of communication in terms of cost, security, complexity, and flaws. Multiple channels can be transmitted with enormous bandwidth and extreme speed using a single fibre. Additional protection layers are used over the fibre to prevent mechanical and other issues following installation in the depths of the soil. The terms "core" and "cladding" relate to these layers. Signal losses, such as linear and nonlinear disturbances, occur during the transmission of light waves via fibre. These losses can be somewhat minimised by using compensating methods such modulation designs, light sources, sequence coding, and amplification procedures.Figure 3.13 depicts the optical fibre sign, and Table 3.8 outlines the ingredients used to create an optical fibre.

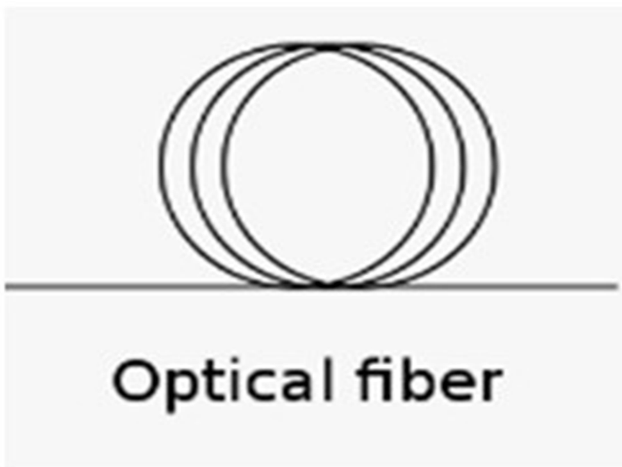

Figure 35 Single-mode fibre used to transport optical signals, represented by a symbol.

Name&description	Defaultvalue	Defaultunits	valuerange
Coreradius	2.2	μm	[0.1-10]
$E_r$dopingradius	2.2	μm	[0.1-10]
Numericalaperture	0.24	-	[0.1-1]
lossat1550nm	0.1	dB/cm	[0-100]

Figure 36 EDFAparameterswithmagnitudes.

H. Description of the erbium-doped fibre amplifier (EDFA)

This module enables you to choose the pump power values as well as the forward and/or backward pump.The energy level diagram serves as the foundation for the rate equations.In this model are those that are covered in the EDFA module.A common fibre optic transmission network is made up of three parts: the connecting receiver side, the optical medium, and ultimately the transmitter side. In densely populated areas or in places where installing fibre optic cable is difficult and expensive, radio-over-fiber (RoF) technology techniques are used [4]. Therefore, a variety of techniques, There are options to deliver these broadband services, notably coaxial cable and digital subscribers. [5]. Due to physical media limitations, copper wire bandwidth has reached saturation; As a result, an option for meeting those throughput bandwidth requirements is an optical access framework. Furthermore, In order to transmit the necessary data between the base stations, wireless or radio technology A significant amount of base stations and optical access points will be added soon,which will lower the network's cost [6].

Radio-over-fiber methodology represents one of the various ways that optical fibre is used in communications, which facilitates the integratio. [7].The main goals of the initial RoF systems were to boost central office agility (CO) and exchange microwave pulses.In particular, the modulated microwave pulses are present at the RoF network's input and are thereafter transported as light waves over a channel to the far removed site (RS). Here at RS, antennas reconstruct and release the microwave waves. [8]. Furthermore the network was configured to handle GSM 900 network traffic. Modern RoF systems include capabilities for movement and transportation as well as additional radio system functions. These features include signal processing, statistical modulations, and frequency conversion (up and down) [9]. Most of the changes can be attributed to the selection of the amplifier pump technique. Figure 37 depicts the basic operation of figure,38 includes a list of the parts that were installed inside the EDFA.

I. Model's Suggested Receiver Side

The model's receiver side aims to convert the signals that are received back into electrical or digital form so that they may be transferred for other necessary tasks.Receiver's internal structure is depicted in Figure 38 and includes the following components.
Dispersion-Compensating Fiber Bragg Grating
A p–i–n photodiode
A low-pass filter (LPF)
Electricalamplifier
Quadraturedemodulator
M-AryThresholdDetector

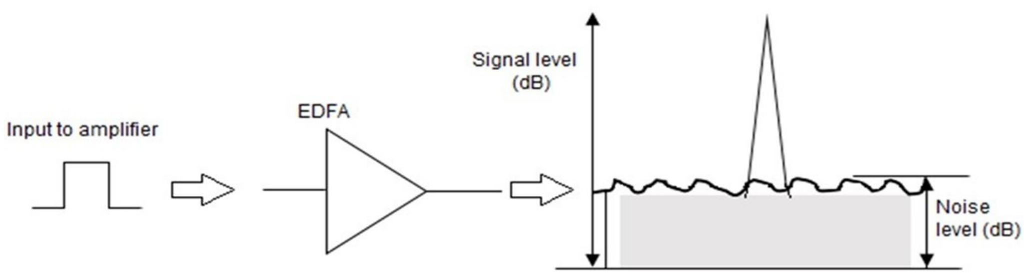

Figure 37:inside an optical fibre, the EDFA symbol and its purpose.

QAMsequencedecoder
Non-Return to Zeropulsegenerator
3R-regenerator
Bit Error Ratio (BER)analyzer
Together with above data, the model also has a power metre, optical spectrum analyzer, WDM analyzer, constellation analyzer, and oscilloscope visualizer attached.
Visualizers' main function is to compute model's effectiveness and performance at various phases. The received signals at the receiver side of the model can be sent using TDM to the end users or over another RoF model.

J. Summary

The proposed model's intricate internal structure is explored in detail in this chapter wireless communication systems need to be strengthened.

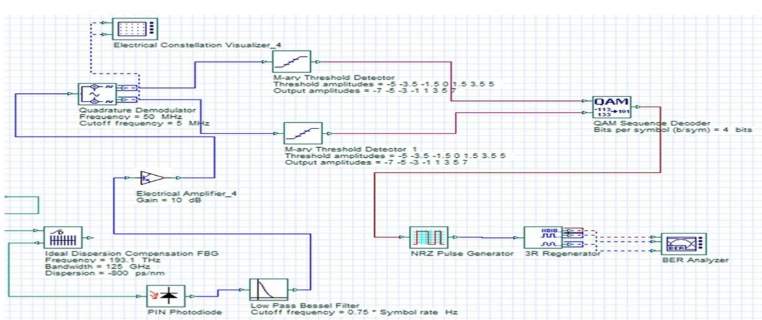

Figure 38 The proposed WDM-RoF model's receiver side internal structure.

As a result, a straightforward and thorough model of WDM-RoF is discussed and used to demonstrate in this chapter. Modern 2single mode fibres are used to transport extremely fast data waves through a single fibre. Every component used in the model is examined in detail, including its underlying structure and parameter list. Also, the performance can be assessed with the aid of these installed components.A common fibre optic transmission network is made up of three parts: the connecting receiver side, the optical medium, and ultimately the transmitter side. In densely populated areas or in places where installing fibre optic cable is difficult and expensive, radio-over-fiber (RoF) technology techniques are used [4]. Therefore, a variety of techniques, There are options to deliver these broadband services, notably coaxial cable and digital subscribers. [5]. Due to physical media limitations, copper wire bandwidth has reached saturation; As a result, an option for meeting those throughput bandwidth requirements is an optical access framework. Furthermore, In order to transmit the necessary data between the base stations, wireless or radio technology A significant amount of base stations and optical access points will be added soon,which will lower the network's cost [6].Radio-over-fiber methodology represents one of the various ways that optical fibre is used in communications, which facilitates the integration of optical systems with the established over-the-air networks. [7].Main goals the initial RoF systems boost central office agility (CO) and exchange microwave pulses.In particular, the modulated microwave pulses are present Aantennas reconstruct and release the microwave waves. [8]. Furthermore the network was configured to handle GSM 900 network traffic. Modern RoF systems include capabilities for movement and transportation as well as additional radio system functions. These features include signal processing, statistical modulations, and frequency conversion (up and down) [9].According to the model's structure, each parameter is composed of a variety of elements that can be altered according to how effectively the system functions.

IV. RESULTS AND DISCUSSION OF THE PROPOSED MODEL

A. Introduction

The purpose of this study is existing communication network infrastructure by utilising the RoF mechanism. This state-of-the-art system uses WDM to multiplex and send modulated messages across a single optical cable. The essential analytical models and the suggested model's framework are thoroughly examined in the earlier chapters. The nomenclature used is given, and the currently present components and their descriptions are carefully scrutinised. In Chapter 3, it is learned that there are several internal values for each parameter that can be used to evaluate the suggested model.Using theoptisystem software, version 13, the suggested model is assessed. This simulation program's key feature is that it provides the helpful values for assessing a network model's output. Additionally, most universities cannot afford to update their labs so that students may evaluate experimental work on optical equipment since optical equipment is so expensive. The results and their analysis of the proposed model are examined in this chapter. The Optisystem tool's attributes and background are also covered in this chapter.

B. OptisystemV.13

The comprehensive software design package from OptiSystem allows users to construct, for the communication layer of contemporary optical networks, test and simulate optical links. The OptiSystemPractically any type of optical link can be planned, tested, and simulated by users from LAN, SAN, and MAN to ultra-long-haul optical networks, at the transmission layer. The inventive, potent, and ever-expanding software design tool known as OptiSystem. It offers analysis and visually presented scenarios as well as planning and design for channel layer optical communication systems from the element to the system level. A wide variety of can be analysed using OptiSystem, including nearly any sort of optical link in the physical layer (LANs).OptiSystem offers a sizable library of example optical design (.osd) files that are suitable for use as templates for optical design tasks as well as for instruction and demonstration. A common fibre optic transmission network is made up of three parts: the connecting receiver side, the optical medium, and ultimately the transmitter side. In densely populated areas or in places where installing fibre optic cable is difficult and expensive, radio-over-fiber (RoF) technology techniques are used [4]. Therefore, a variety of techniques, There are options to deliver these broadband services, notably coaxial cable and digital subscribers. [5]. Due to physical media limitations, copper wire bandwidth has reached saturation; As a result, an option for meeting those throughput bandwidth requirements is an optical access framework. Furthermore, In order to transmit the necessary data between the base stations, wireless or radio technology A significant amount of base stations and optical access points will be added soon, which will lower the network's cost [6].Radio-over-fiber methodology represents one of the various ways that optical fibre is used in communications, which facilitates the integration. The main goals of the initial RoF systems were to boost central office agility (CO) and exchange microwave pulses.

In particular, the modulated microwave pulses are present.Antennas reconstruct and release the microwave waves. [8]. Furthermore the network was configured to handle GSM 900 network traffic. Modern RoF systems include capabilities for movement and transportation as well as additional radio system functions. These features include signal processing, statistical modulations, and frequency conversion (up and down) [9]. With the addition of user components, OptiSystem's capabilities are increased, and it can work with a variety of tools. Figure 39 shows the basic structure of the opti-system softwaremakes clear that it is divided into five sections: a status bar, a component library window, a project layout window, and a description window.

C. OptiSystem–Advantages

Optical communication system design at the physical layer

OptiSystem provides solutions for a wide range of applications, including the construction of CATV/WDM networks, SONET/SDH rings, maps, transmitters, channels, amplifiers, and receivers.

• FTTx based on passive optical networks (PON)

Free space optic(FSO)systems

Radio over fiber(ROF)systems

Dispersion map design

Several receiver models for BER and system penalty estimation

Amplified system BER and link budget calculations

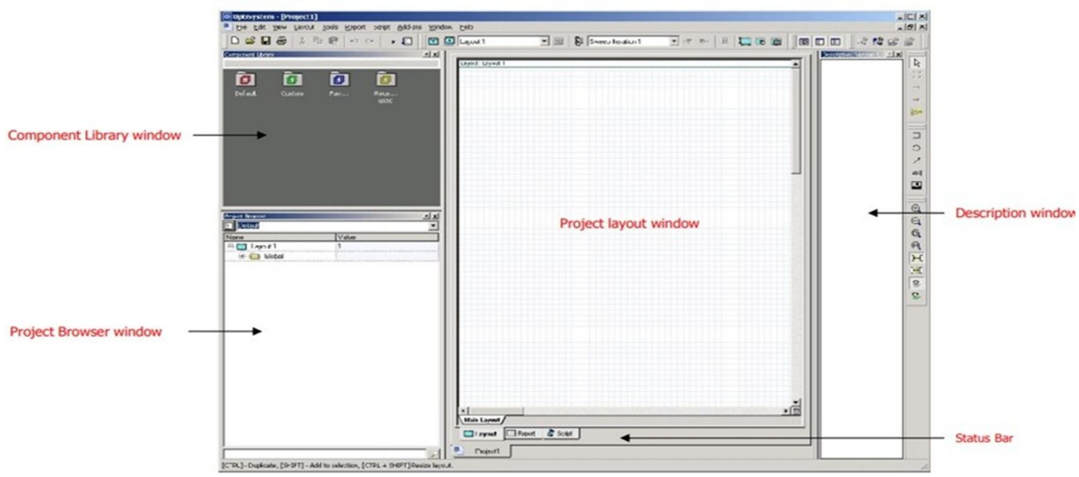

Figure 39 Version 13 of the Opti-system software's main interface

Name of parameter	Value
Bits per symbol	4bits
Frequency of QM	50MHz
Gain of EA	10dB
Input power	-10to6dBm
Frequency range	193.1to194THz
Extension ratio	10dB
Length of fiber	10to50km
Attenuation	0.2dB/km
Dispersion	16.75ps/nm/km
Dispersions lope	0.075ps/nm^2/km
Length of EDFA	5m
Effective area	90μm^2
Number of channels	2to8channels

Figure 40 Elements and their values that were utilized to evaluate the suggested model.

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D. Consequences and Discussion

To demonstrate the effectiveness of the model, OFDM and QAM modulation techniques are used to record the simulation findings and the results are then analyzed using the RoF system as it is now.The most crucial component of optical transmission is effective area;the error rate may be easily decreased by modifying the optical fiber's actual effective area. Figures, 42 and 44 shows block diagram of the proposed WDM-RoF paradigm in terms of 16QAM and OFDM. The names of the parameters with their ranges that were employed for the experiment were also included in figure,40. In contrast, Table 4.2 compares the proposed setup to the most recent research. Effective area and BER results using the OFDM and QAM modulation techniques are shown in Figure,45 The result shows that the model's accuracy increases with increasing effective area. The outputs of the proposed model using the OFDM technique reveal that current QAM modulation is far better than

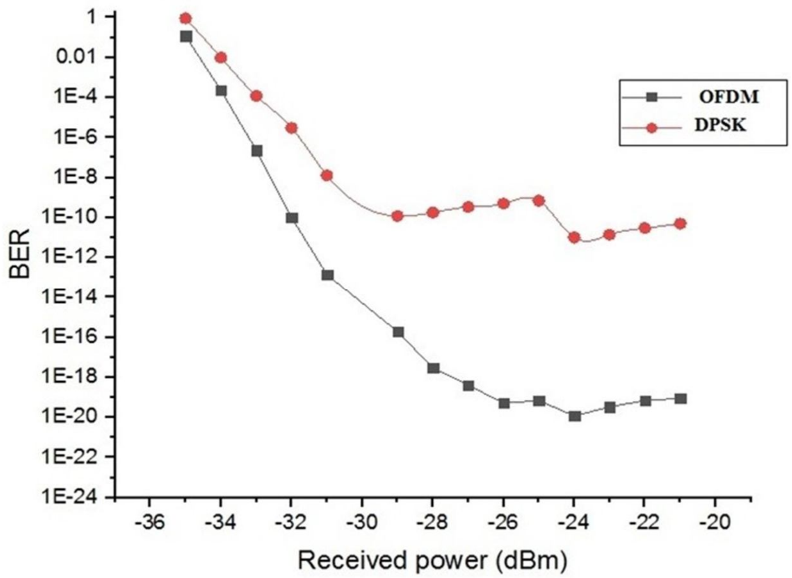

Figure 40 BER Vs Received Power

OFDM, although they are still acceptable.

In figure, 41 shows results on the basis of IP along with BER function and also verify that in the absence of dispersion adjustment the system performance degraded.

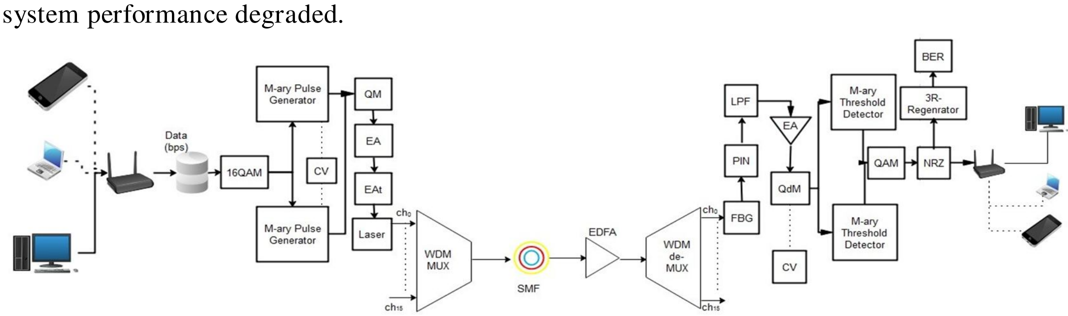

Figure 41 WDM-RoF block description using the 16QAM approach.

Name of parameter	[77]	[78]	[79]	[80]	Proposed work
Modulation format	OFDM	OFDM	Duo-binary	OFDM	OFDM/16QAM
Data rate	10Gbps	10Gbps	40Gbps	20Gbps	100Gbps
Length of fiber	20km	25km	40km	20km	50km
Type of fiber	SMF	SMF	SMF	SMF	SMF
BER	$3.1*10^{-8}$	$4.32*10^{-6}$	$2.4*10^{-9}$	$1.1*10^{-10}$	$5.3*10^{-14}$
Channels	4	2-6	8	2to4	2-8
CV	No	No	No	No	Yes
RF analyzer	No	No	No	No	Yes

Figure 42 comparison of the suggested model with the existing research.

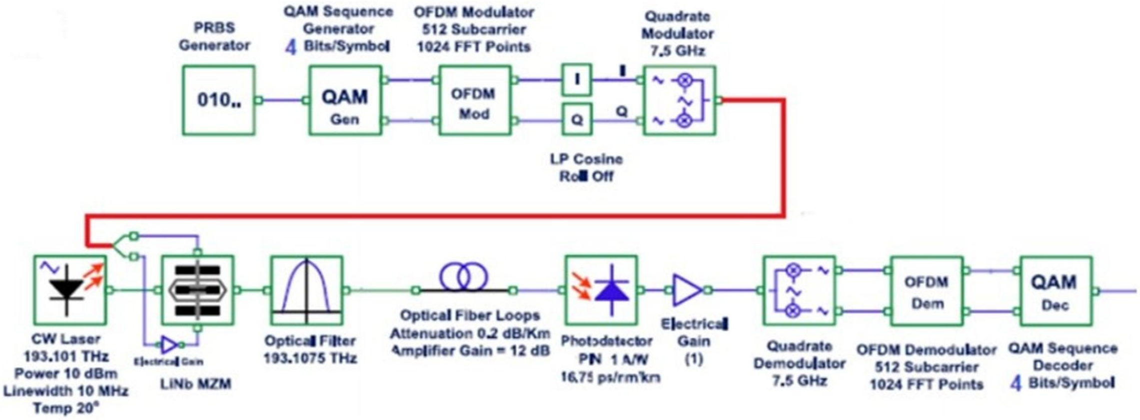

Figure 43 Block explanation of the WDM-RoF using the OFDM method.

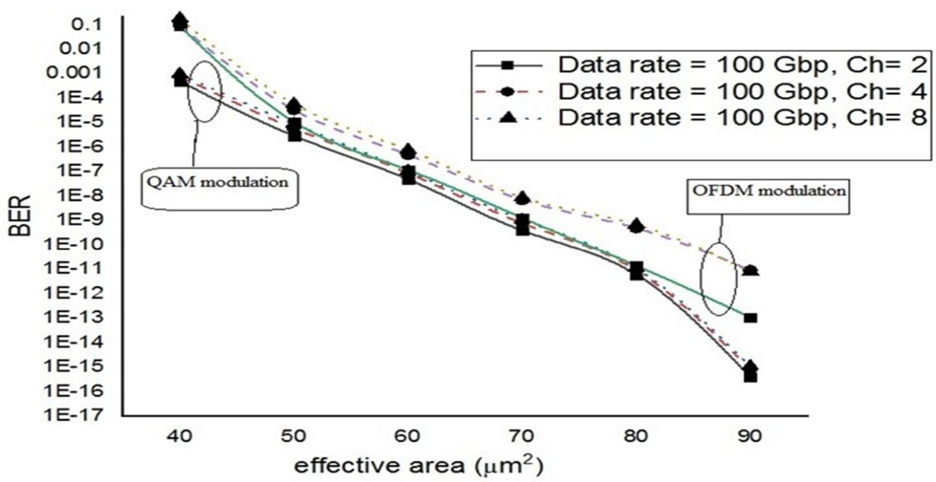

Figure 45 Results of the proposed model's simulation for effective area versus BER using various modulation schemes and channels.

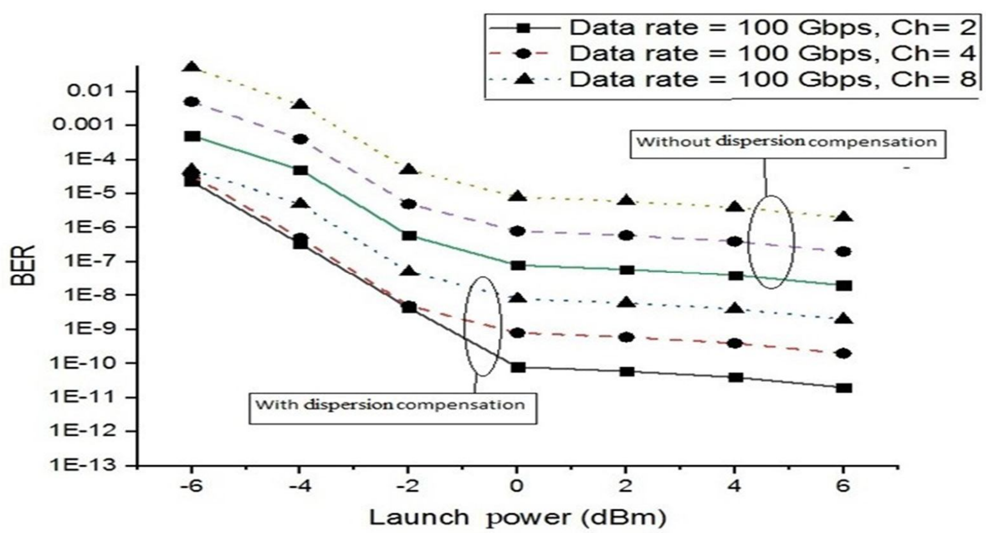

Figure 44 Launch power against BER utilizing the OFDM modulation type.

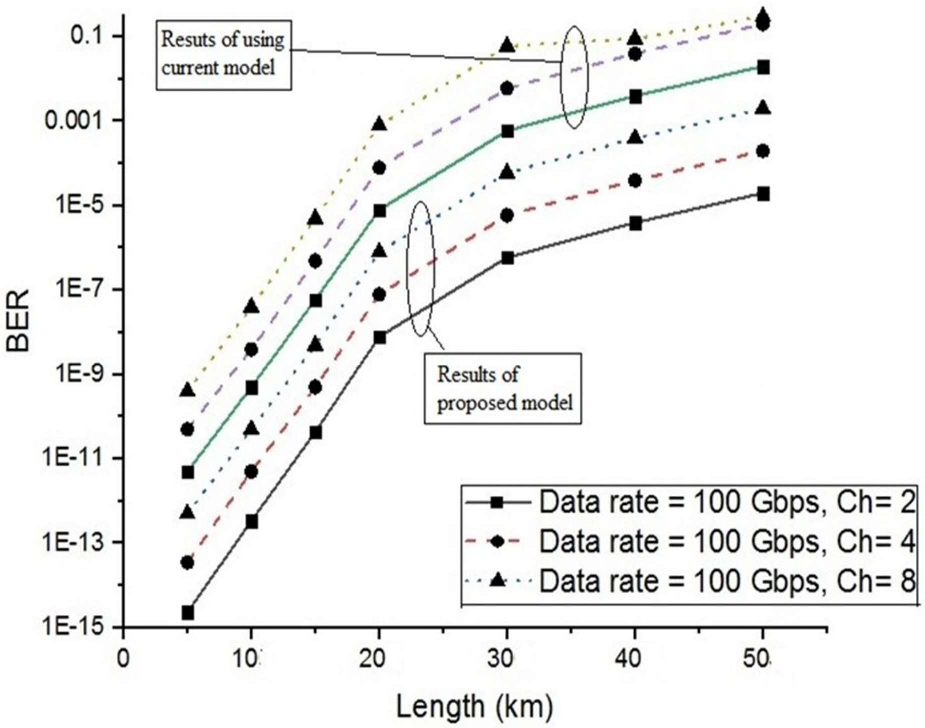

Figure 45 length versus BER.

The result of recommended work in Figure, 47 depend on the path cover and BER and explains the error ratio increases with fibrelength. Furthermore it shows when number of users increases it disturbed the signal broadcasting. The proposed model is differentiated with currentRoF system's configuration as well.

The suggested framework is tested using the benchmark wavelength and BER shown in figure, 48. The results indicate that, as compared to reference wavelengths of 1548 to 1552 nm, the model performs satisfactorily at 1553 nm.

The power that was acquired results for the existing DPSK modulation and the expected OFDM modulation are contrasted in Figure, 48.demonstrating that the proposed model's results are significantly more efficient than those of the existing system.

The power that was obtained results for the existing DPSK modulation and the expected OFDM modulation are contrasted in Figure, 49.

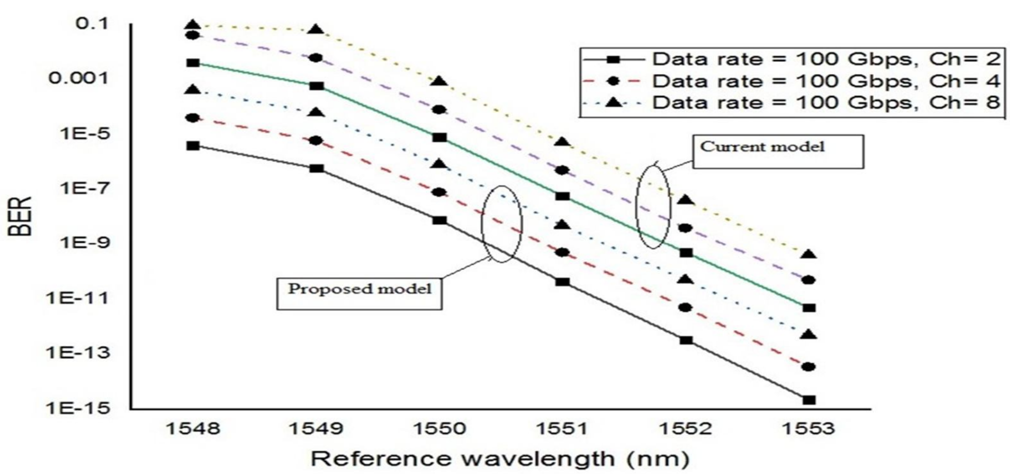

Figure 46 Reference wave length against BER.

Figure4.8: Results from simulations comparing BER at received power using OFDM and DPSK modulation.

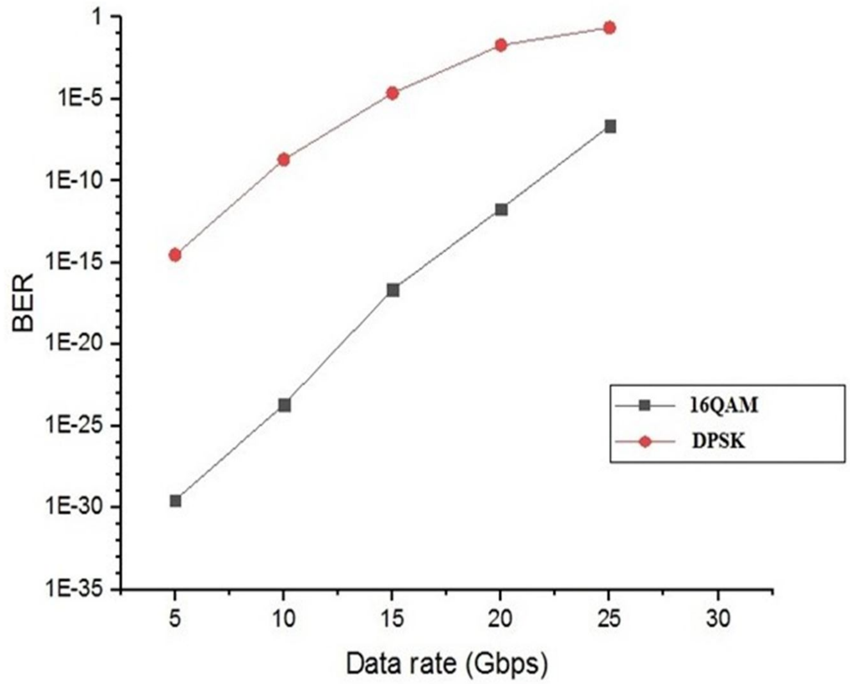

Figure 47 Data rate verses BER.

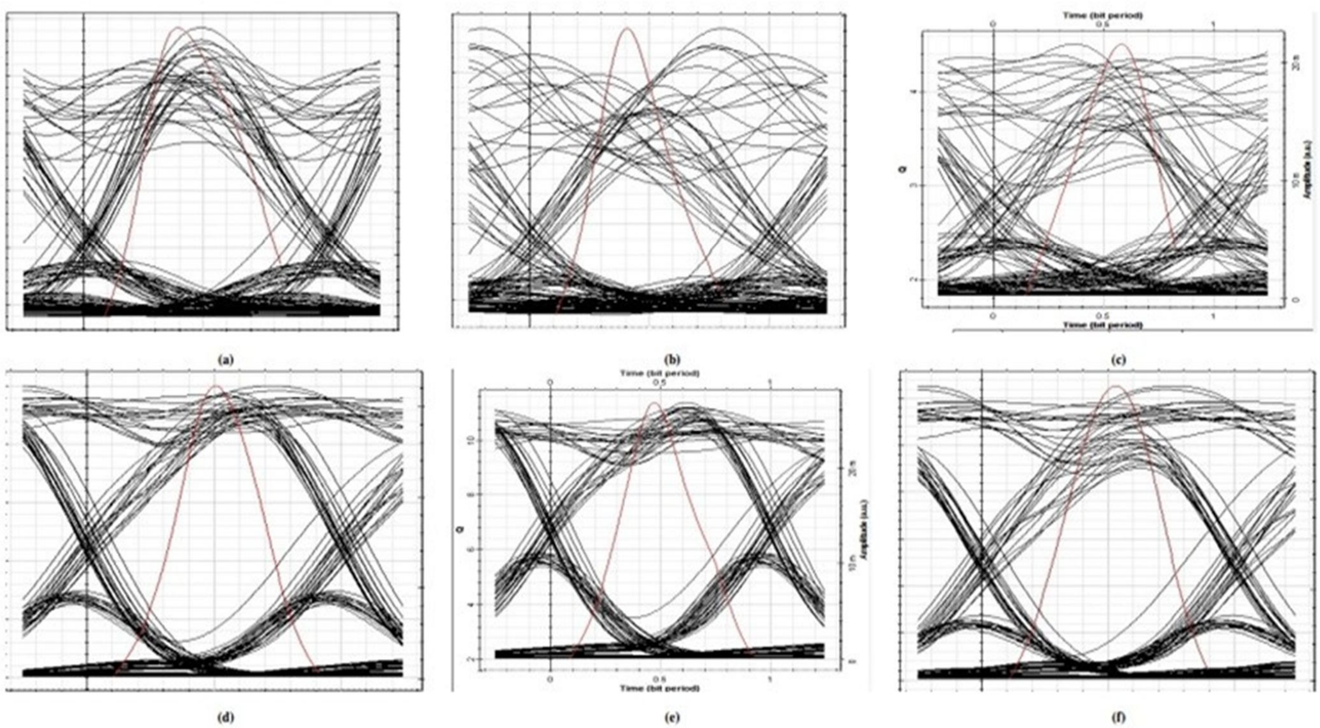

Figure 48 eye diagram

Figure, 50. is an eye diagram with the following options: Fig. 50a: Without dispersion compensation at 2 channels, Fig. 50b: Without dispersion compensation at 4 channels, Fig. 50c: Without dispersion compensation at 8 channels, Fig. 50d: With dispersion compensation at 2 channels, Fig. 50e: With dispersion compensation at 4 channels, and Fig. 50f: With dispersion compensation at 8 channels.

Above proposed set up's performance behaviour is investigated using an eye diagram analyzer and an RF analyzer, which are shown in Figures 50a to 50f and 4.11a to 4.11d, respectively. the system's outcomes at this time at 2, 4, and 8 channels are shown in Figures 50a, 50b, and 50c, respectively, when no strategies are used to maintain dispersion. As a result, the eye diagrams are worse, which indicates that the error ratio in the received signals is significant. While the eye diagrams in Figures 50d, 50e, and 50f represent The findings of the conceptual model show significantly better performance than the dispersion compensated model for 2, 4, and 8 channels, respectively. When the DSP module is used for channels 4 and 8, it can show the signal strength, power spectral density, and phase as shown in Figures 51a to 51d to show the improvement. The successes the lengthy, large RoF network with adjusted dispersion are shown in the diagrams in Figures 51a and 51b. While Figures 51c and 51d describe how system performs for long-haul, high capacity RoF networks in terms of dispersion. Without mending the dispersion, long-distance RoF communication is not conceivable, according to the detailed description of the simulation results in this section.

The suggested configuration's signal and auto-correlation are displayed using an oscilloscope analyzer Figs. 52a, 52b, and 52c. The input signal is shown in Figure 52A, the output signal is shown in Figure 52B with unadjusted dispersion problems, and the results with dispersion adjustment are shown in Figure 52C. As seen in Figs. 52a, 52b, and 51c, the behaviour of the suggested model is also examined with the use of the constellation visualizer. Whereas Fig. 52a details the input signals, Fig. 52b outlines the outcomes of received channels without compensating for dispersion effects, and Fig. 52c examines the behaviour of received signals with compensating for dispersion impairments.

E. Summary

Long-distance data transfer provided to customers using the current, according to research from prior chapters.

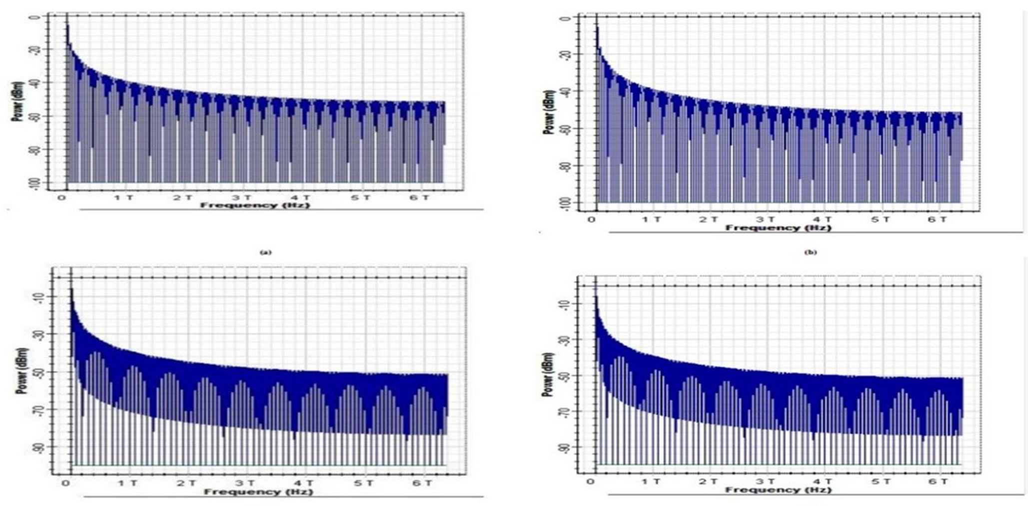

Figure 49 shows RF visualizer diagrams

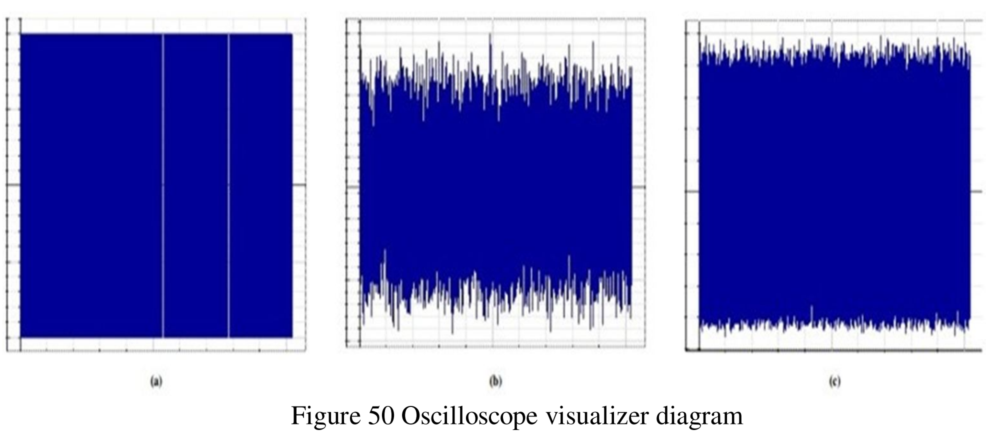

Figure 50 Oscilloscope visualizer diagram

Figure: 52 Oscilloscope visualizer diagrams are shown in Figure 52; Figure 52a shows input signals, Figure 52b shows the behaviour of received signals without dispersion compensation, and Figure 52c shows the behaviour of received signals with dispersion factors adjustment.

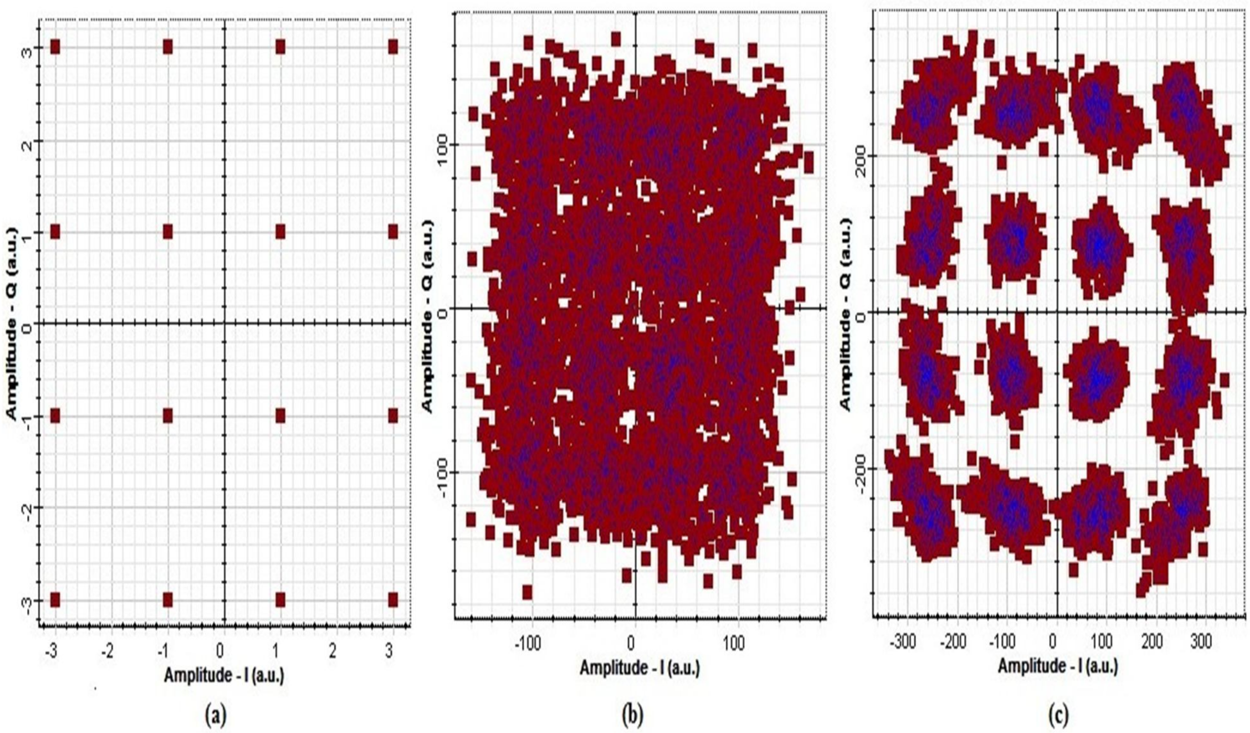

Figure 51 Diagrams of constellations

Figure 53: Diagrams of constellations; in Figure 53a. The current wireless paradigm must be upgraded in order to accommodate consumers who demand high amounts of bandwidth and extensive gearbox ranges. As a result, this research effort develops a novel communication technique known as the WDM-RoF framework. Its main goal is to give RF signals an optical channel so that information propagation at access networks can happen more quickly. The simulation findings are finally analysed in depth in this chapter using the analytical model and simulation model that were described in Chapters 2 and 3. Based on the findings, it can be said that the suggested method is highly capable of making up for dispersion losses during long-distance transmission. The results demonstrate that, in comparison to the traditional communication model, the model has a low BER. progressive modulation It is evident that QAM modulation outperforms OFDM when QAM and OFDM are compared and analysed for transmitting RF signals. The presented model is also investigated in relation to a number of other characteristics, such as transmission fibre length, input power, received power, effective area, refractive index, and different modulation schemes. The suggested model's output is additionally evaluated making use of different component.

V. CONCLUSION AND FUTURE WORK

A. Conclusion

The optimal RoF system founded on WDM technology in this study is proposed with the aim of enhancing the transmission range, capacity, and user number.Basics of both traditional and more contemporary wireless technologies are discussed, and the flaws in the current system are also looked at. In ability for a significant amount of people to have access to a developed system, it is absolutely necessary that the ability to utilize high data rates, capacity, and long-distance communication, based on initial assessment. current-generation tools, investigated with a numeral of advantages,flexibility, cost, and low error ratio. Also, the projected paradigm for linking the WDM technology well with RoF system is looked at, as well as the WDM technology itself. According to the study, the suggested WDM-RoF system is a good choice for providing customers with long-distance connectivity, high data speeds, and an easier-to-use model.RF waves are transmitted by the RoF system using an optical carrier, and they are converted back to RF at the receiver end.

Method of this communication lowers system complexity while increasing bandwidth and transmission range. This thesis also looks into the issue of wireless installations and optical transmission systems being unable to function over long distances.The best technique to maximise performance improvements while reducing drawbacks like polarisation and dispersion. Long-distance data transfer employing the most recent wireless connection technologies, users can receive HD videos. according to research from prior chapters. It is clearly found that the typical framework for communication is often a more complex system since it involves a significant amount of DAC and ADC conversion. In contrast, The WDM-RoF telecommunications system's primary objective is to transmit.Now compared to the current long distance communication framework, the WDM-RoF set of communication is many times more favorable. Existing wired and wireless communication networks have been found to require strengthening In order to increase the network's capability in regard to data rate and bandwidth, and to lower the load of losses, and range. It is demonstrated how the system will use an optical connection to transfer radio frequency signal Modern single mode fibres are used to transport high data rate waves via a single fibre. Most advanced single mode fibre allows for the transmission of high data rate throughout a single fibre. Each employed component in the model is mathematically explored in full, including its underlying structure and list of parameters. Also, the performance can be assessed with the aid of these installed components. According to the model's structure, each parameter is composed of a variety of elements that can be altered according to how effectively the system functions. Only HD videos and long-distance transmission are possible with the existing wireless communication technology, according to analytical and experimental studies. For customers to have access to bandwidth-hungry gadgets and lengthy transmission distances, wireless technology must be improved. As a result, this study work develops a novel communication process known as the WDM-RoF framework. Its major objective is to give RF signals an optical path in order to strengthen the signals that are already being propagated. In this thesis, the suggested strategy is conceptually and analytically examined to demonstrate its effectiveness in contrast to the existing gearbox system. Then, both the analytical model and a simulation model are used to thoroughly investigate the simulation results. Findings demonstrate that the proposed model is capable of successfully addressing dispersion losses in long-haul transmission.. $BER < 10^{-13}$is shown by the result of this model, which is significantly lower than the BER of the traditional model of communication. Progressive modulation It is evident that QAM modulation outperforms OFDM when QAM and OFDM are compared and analysed for transmitting RF signals. Several more factors, including transmission In relation to the given model, Refractive index, effective area, fibre length, input power, and received power as well as many modulation methods are looked at. These findings demonstrate that the RoF communication model produces the lowest performance, as indicated in the model's graphical depiction, when the system's flaws are not addressed.

B. Future Work

To transfer radio signals to access points whilst employing the optical domain is the aim of the improved RoF communication system established in this research. This method overcomes the current issue of excessive demand for radio transmission services and provides ample room for researchers to continue working on it and expand the system's capacity in the near future. For varied users, a variety of optical fibre installation methods will soon be accessible. Researchers can enhance propagation path for the future as long as users have a strong need for transmitting radio signal.

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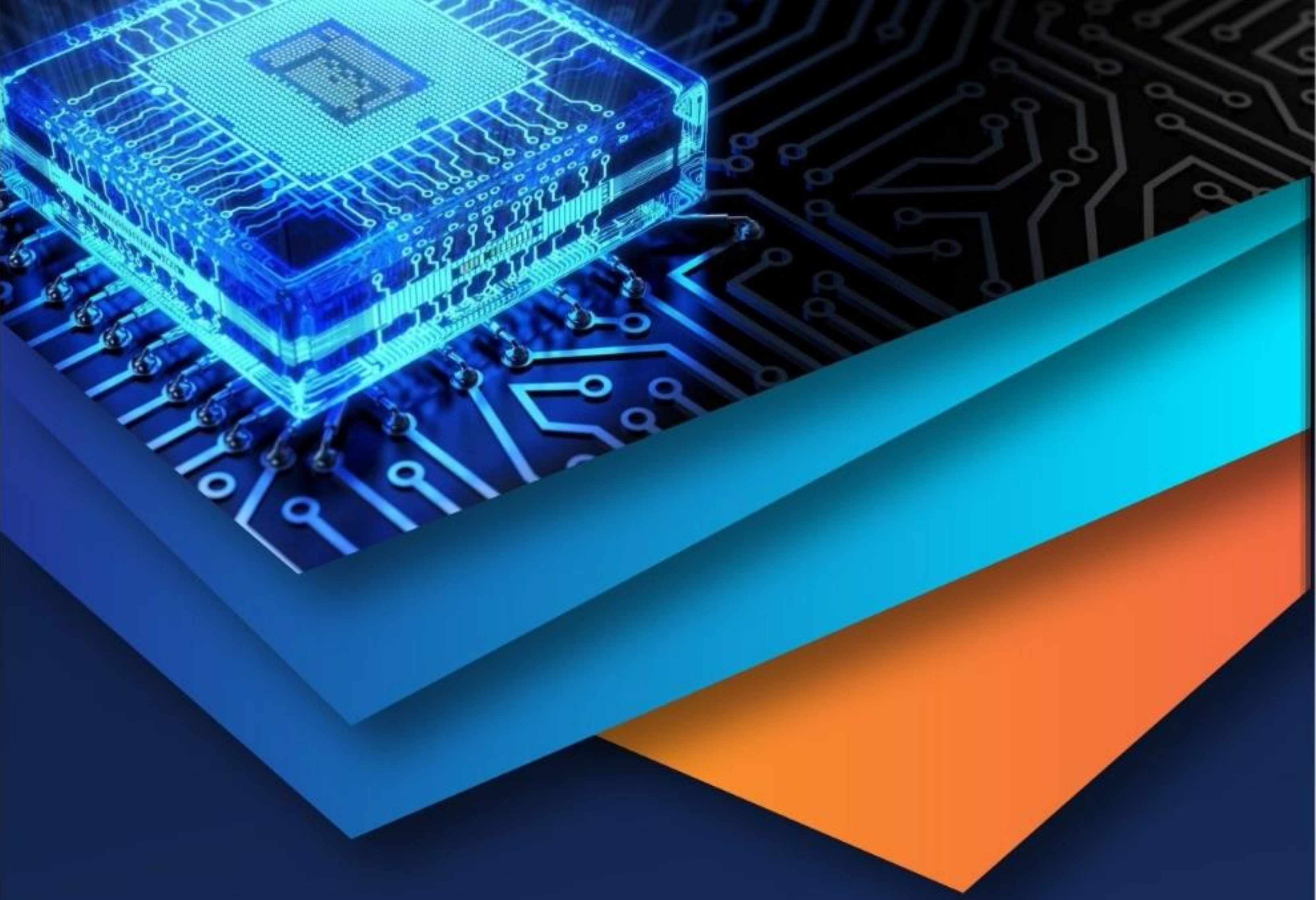

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