International Journal of Engineering Research
Volume No.3, Issue No.10, pp : 608-612

ISSN:2319-6890)(online),2347-5013(print)
01 Oct. 2014

Performance Analysis of WDM PON and ROF Technology in Optical Communication Based on FBG

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Abstract - In the modern era good communication systems are the need of the hour. The radio over fiber technologies are a good alternative For the future provisions of wireless communication, Broadband, and Multimedia since it introduces a good data transmission rate and large bandwidth. We have demonstrated a bidirectional radio over fiber ROF system based on a reflective semiconductor optical amplifier (RSOA) using different modulation technique according to the system.We have also implemented a combination of SCM-ROF and optical wavelength division multiplexing (WDM) techniques to simplify the access network architecture. The combination of two different types has been performed to provide high bit data rate and wide bandwidth in cellular communication. The system allows different Base Stations (BS's) to be fed by a common fiber. Different wavelength channels can be allocated to different BSs depending on user requirements. Our Set-up model consist of both upstream and the down-stream data transmission. Within the down-stream AWG multiplex the signal and behaves sort of a multiplexer at the OLT aspect and demultiplex the signal at the ONU aspect. And similar is the case with the up-stream communication system. We tend to developed analytical model for learning the impact of the transmission impartment more over as the AWG characteristics on the BER performance of the WDM PON by incorporating the novel spectral-to-spectral domain transformation technique. Many measurements are found; the Variation in Gain, Q Factor, BER, OSNR, Penalty Power curves for both uplink and downlink, RSOA gain curve and noise figure with the variation of input power and temperature for each system.
Keywords: RoF, ASE, Remote Based Station, DMUX, WDM, BER, MZI, Radio Frequency, RSOA

1. Introduction

This paper discusses the effective design of Radio over Fiber (RoF) system which will be integrated with several modulation types to model a brand new diagram of a bidirectional transmission ROF system using Reflective Semiconductor Optical Amplifier (RSOA) in downlink and uplink stages. the most idea is to supply an outsized bandwidth to hide the massive data transferred between base stations and also the main office with minimum cost effective system. this may enable the clients to enjoy multimedia services. The ideas given during this paper are the author's original works. The implementations and results also are accurate and were obtained solely by the author.

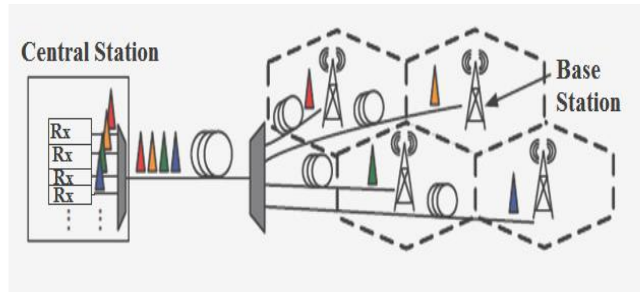

Fig . 1. Scenario for RoF link with photonic down conversion. The base stations (BS) are connected to the central station (CS) through optical fiber.

2. Radio-Over-Fiber Technology

Radio over Fiber (RoF) is an optical fiber link to distribute modulated RF signals from a central location to remote antenna units (RAUs). The RoF systems are developed to replace a central antenna with a low power distributed antennas system (DAS). RoF systems are usually composed of many base stations (BSs), which are connected to a single central station (CS) (See Fig 2). RoF systems centralize the RF signal processing function in one shared location (head end), and use optical fiber link to distribute the RF signals to the RAUs or BSs. RoF based wireless "last mile" access network architecture was proposed, as a promising alternative to broadband wireless access network. In network architecture, the CS performs all switching, routing and network operations administration maintenance (OAM). Optical fiber network interconnects a number of simple and compact antenna BSs for wireless distribution.

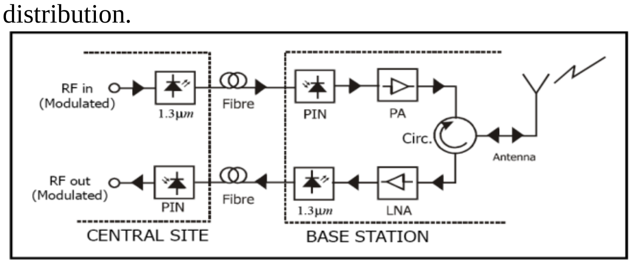

Fig.2. Radio over Fiber System

The BS has no processing function and the main function of the BS is to convert the optical signal to wireless and vice versa. This architecture assumes a centralized medium access control (MAC) located at the CS responsible for offering a reservation-based, collision-free medium access.

3. WDM System For Radio Over Fiber Communication.

A powerful aspect of an optical communication link is that many different wavelengths can be sent along the fiber simultaneously. The technology of combining a number of wavelengths onto the same fiber is known as wavelength-division multiplexing or WDM. The key system features of WDM as follows:

1. Capacity upgrade.WDM can increase the capacity of a fiber network dramatically.
2. Transparency. An important aspect of WDM is that each optical channel can carry any transmission format.
3. Wavelength routing. The use of wavelength-sensitive optical devices makes it possible to use wavelength as another dimension in designing communication network and switches.
4.Wavelength switching. Whereas wavelength-routed network are based on a rigid fiber infrastructure,wavelength-switched architectures allow reconfiguration of the optical layer.
Wavelength divisions multiplexing (WDM) can be defined as a scheme in which multiple optical carriers (which are not in phase with each other) at different wavelengths are modulated by using independent electrical bit stream and are then transmitted over the same fiber. The optical signal at the receiver is demultiplexed back into separate channel by using optical techniques. In the original form of WDM based systems, two channels in different transmission wavelength window of the optical fiber are multiplexed .One channel is near 1.3µm, and the other is near 1.55µm.Today, one hundred OC-192 channels, each at 10Gbps, can be multiplexed, and a transmission rate on the order of one Tbps is obtained. The key breakthroughs to realize WDM transmission are the fiber amplifier, tunable transmitter/receiver and wavelength multiplexer/demultiplexer.

A typical WDM system is illustrated in fig.3. Various wavelength channels are demultiplexed by the DEMUX optically, by using an optical grating or interferometer. The kind of filtering is performed coarsely, while the fine adjustment is performed by the channel selecting filter (CSF) blocks. On-zero dispersion shifted fiber (NZ-DSF) is often used in WDM based systems. Such fiber can relax the system degradation induced by fiber dispersion, without producing too much deleterious four wave mixing (FWM) effect. Since it can be suppressed effectively by the small amount of dispersion in NZ-DSF.

For each wavelength channel in WDM transmission systems, the bit rate can be up to tens of Gbps. It is much greater than the bit rate needed in most applications. So WDM techniques can be employed at the bottom level with other multiplexing or optical access techniques functioning on top of it.

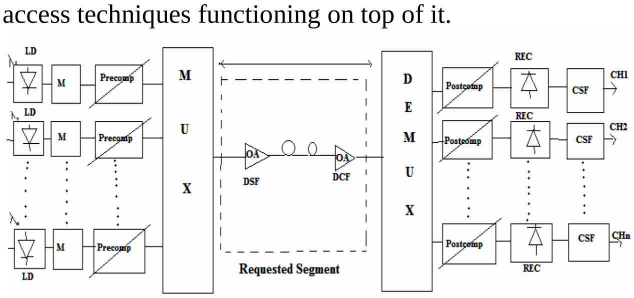

Fig 3.Configuration of typical WDM transmission system.

4. Fiber Bragg Grating

The demand for more bandwidth in telecommunication networks has rapidly expanded the event of recent optical components and devices (especially Wavelength Division Multiplexers). Bragg Gratings are vital within the phenomenal growth of a number of these products, and are recognized in concert of the foremost significant enabling technologies for fiber optic communications within the last decade. They are also widely employed in strain and light-weight reflector applications. FBG could be a periodic or non oscillatory perturbation of the effective coefficient of absorption and/or the effective index of refraction of an optical conductor. They typically reflect light over a narrow wavelength range which satisfy the Bragg condition and transmit all other wavelengths, however they can also be designed to possess additional complicated spectral responses.

$$\lambda B = 2n\Lambda$$

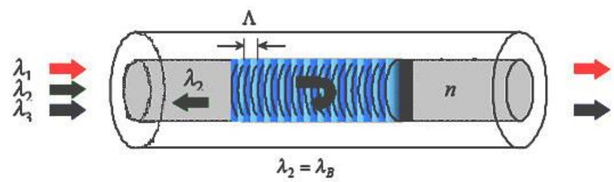

Fig.4.Principal of operation of Fiber Bragg Grating

The refractive index of the fiber has to be permanently modified to create the appropriate stack of high and low-refractive-index regions along a piece of optical fiber. This is accomplished by exposing the optical fiber to ultraviolet (UV) light with a wavelength around 240 nm or less. The photosensitivity is primarily due to the germanium dopant used in the core of most commercial fibers. Photosensitivity can be increased by raising the germanium doping level, or by in-diffusing molecular hydrogen, which acts as a catalyst to the reaction of the germanium with UV light and greatly reduces exposure time.

5. Modeling of ROF System

In this para, we mainly focus on the major parts of the system model and their functionalities which are modulator, multiplexer, RoF link, demodulators and the FBG. The proposed RoF architecture is shown in Figure.5.For down-link, the RF signals are transformed into optical signals using a series of Continuous Wave (CW) lasers with various wavelengths are modulated by MZM modulators using 1-2 Gb/s non-return to zero (NRZ) downstream data to generate the desired downstream signal. The generated signal is sent over the bidirectional Single-Mode Fiber (SMF).

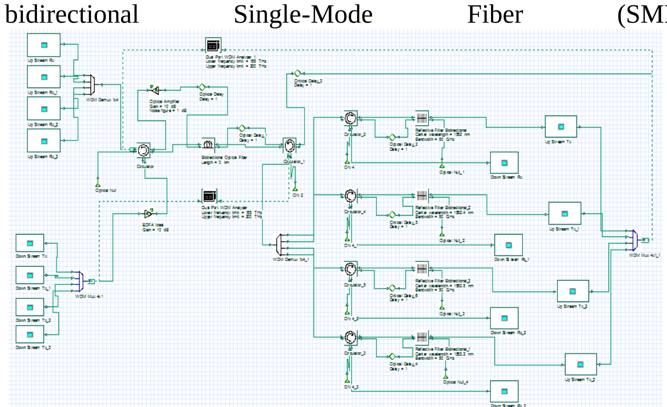

Figure 5.1 Schematic of a bidirectional RoF system

A circulator is used in the central office (CO) to separate the downstream and upstream traffic. The modulated signals are sent to Optical Network Unit (ONU). At the ONU, using optical demux to routing the incoming data for concern ONU's,. For up-link, the other portion of the downstream modulated signal from the demux is re-modulated using 1-2 Gb/s NRZ upstream data by A Modulator in the ONU. The re-modulated OOK signals re-pass through the bidirectional SMF and get to the bidirectional transmission. By using the circulator to avoid influencing the downstream signals, the upstream signals are sent to a P-type Intrinsic N-type (PIN) receiver is used to receive the upstream signal in the CO. The system model is categorized into three main parts which are Central Office (CO), single mode fiber channel, Remote Station (RS) or Base Station (BS).

The modulating signal for the system is generated by pseudo random bit sequence generator at 1-2 Gbps bit rate and it is directly modulated using AM modulator at a varying frequencies up to 2 GHz with normalized signal amplitude and 0 phase offset with 2 DC biasing.Table 5.1.display the parameters of the AM modulator as well transmitter model is shown in figure 5.1.

Parameter	Value
Frequency	1.7 GHz
Gain	10 a.u.
Bias	2 a.u.
Phase	0 deg

Table 5.1.Parameters of the AM modulator

The AM modulated signal is depicted in Figure5.3; the central frequency of the signal is 1.7 GHz with 1.7 GHz major bandwidth from 1GHz to 10 GHz in two sidebands. The parameters of CW laser are configured as shown in Table 5.2. Frequency indicates the central frequency of the laser and determines the wavelength of the emitted light wave. Average power specifies the power of output light wave.

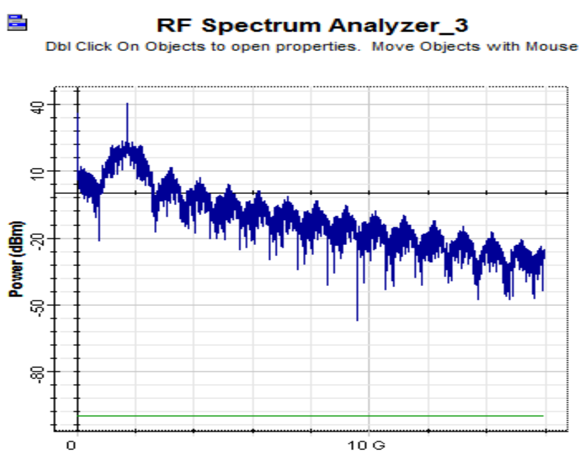

Figure 5.2 AM modulated signal.

Parameter	Value
Frequency	1552 nm
Power	10 dBm
Line-width	10 MHz
Initial phase	0 deg

Table 5.2 The parameters of CW laser

Line width characterizes the width of the frequency interval of the total emission area. Initial phase gives the initial phase of oscillation to generate wave light.

The Mach Zehnder Modulator consist of three ports: the first port is reserve for electrical modulation type signal, the second input is for optical signal (CW laser) input and the third port is the outlet of output optical signal. The extinction ratio is set to 30 dB to characterize the division power ratio of the upper path to lower path. The output optical signal is shown in Figure5.3. It is clear from the figure that there is symmetry about 1550 nm. A bidirectional single mode fiber up to 5-20 km is used to for down link transmission as well as for uplink transmission of signal and an optical delay of 1 unit in order to separate the upstream and downstream.

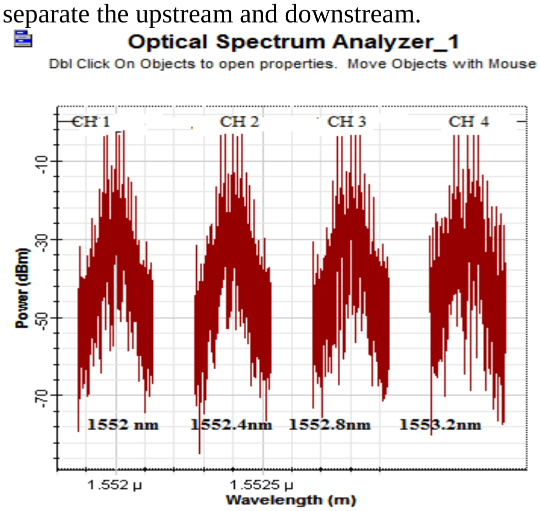

Figure 5.3
Optically modulated signals after multiplexer

The main parameters of a bidirectional optical fiber are its reference frequency; attenuation losses, all non-linear effects etc. are taken in consideration. Standard optical fiber cable has an attenuation loss of 0.2 dB/km and length of 5-20 km, this means there is a 0.2 dB/km*5-20 km which equal to 1-4 dB power loss, so that the resultant signal power is equal to 7.99 dBm -11 dB = -3.01 dBm (Theoretical Analysis). On other hand, the measured signal power after travelling up to 20 km optical fiber cable is equal to -3.01 dBm, so that there is a matching between theoretical analysis and simulated measurements. The signal passes the optical fiber to another circulator which also has 1dB insertion loss and so the resultant power signal decreases 1 dBm to become -4 dBm, then the signal is distributed into two paths the first towards FBG branch and the second towards downlink stage receiver. First; we will continue in downlink stage and hence, analysis the FBG and uplink stage.

6. Result and Discussion

As illustrate in the previous para that system has mainly three parts first transmitter part secondly transmission link part and last one is receiver part. Our result is collected with these parts. It is clear that the theoretical result as well as simulated result is close to each. Only those parameters are taken into concern which directly affects the optical data transmission. Some assumption is also made in the process. Analysis is completely based on the eye diagram and length of the fiber, power of optical source, RF voltage and the different sweep of optical fiber.

Fig.6.1 shows the Gain as a function of fiber length. It is clear that all the channels have almost 46 dB gain at 1 km but after that the gain continually decreases when the fiber length approaches to 20 km at this distance the gain goes to 41 dB level. These results were obtained when the occupied bandwidth by WDM-PON ROF system is occupied bandwidth 4nm.

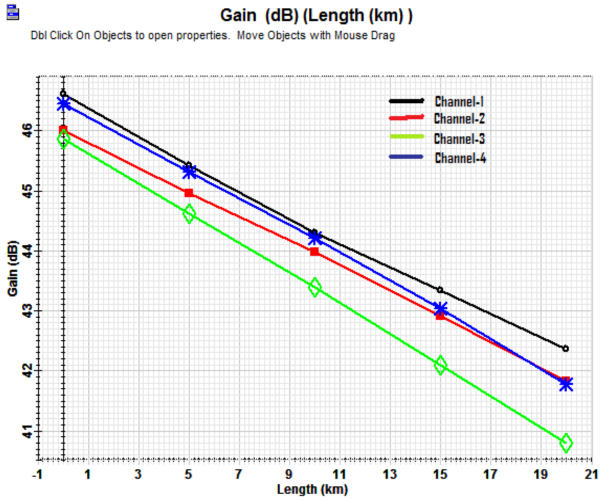

Fig.6.1 Variation in Gain vs Lengths of optical fiber

Q represents quality factor, a useful index to describe system noise performance. Even though the value of BER is low, Q can be precisely measured. Q can be represented by the Function of OSNR (mainly ASE noise) through transformation. Fig.6.2 shows the Q Factor as a function of fiber length. It is clear that all the channels have slight different value 1 km, but a drastically change occur at 10 km where system shows Q factor almost same value. After that Q factor decreases when the fiber length approaches to 20 km at this distance the Q factor goes to 2.8 dB level. According to ITU recommendation bit error rate should be< 10^{-9} we have also adopted this value as references in our design.

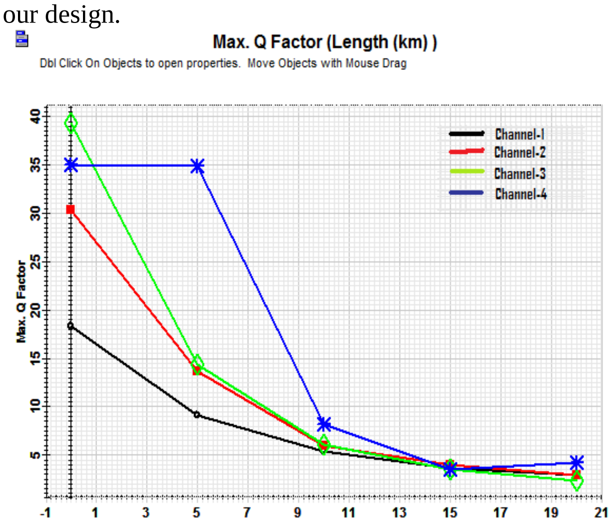

Fig.6.2 Q Factor vs Lengths of optical fiber

We take care of measured upstream BER curves for AM modulation techniques. Looking to the figure 6.3; it is clear that system performance is affected by the distance variation the systems perform excellent below 10 km but after that the system performance goes to below ITU recommendation.

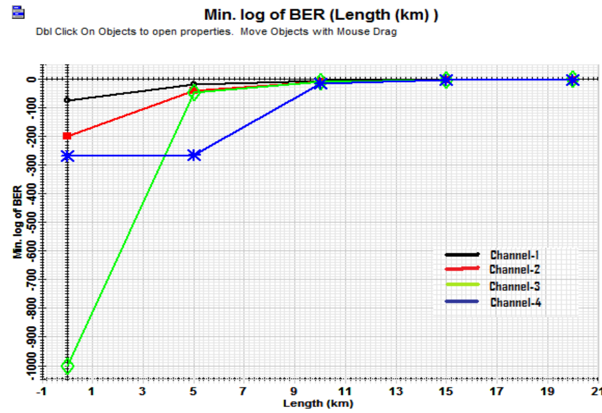

Fig.6.3 BER vs Lengths of optical fiber

Fig.6.4 shows the OSNR as a function of fiber length. It is clear that all the channels have almost 103 dB OSNR at 1 km but after that the OSNR continually decreases when the fiber length addresses to 20 km OSNR goes to 97.5 dB level. In an optical fiber communication system, the signal distortion and OSNR of the receiver's input end is the most important factor to determine the characteristic of BER in system. According to the line loss, the OSNR evolutionary process of WDM-ROF system can be estimated, which is of vital guiding significance in engineering for network planning.

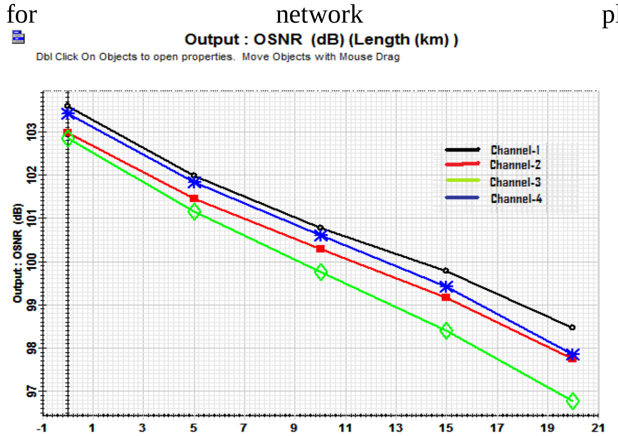

Fig.6.4 OSNR vs Lengths of optical fiber

The receiver sensitivity is -17 dBm. An attenuator is used to find the power penalty. Attenuation of the attenuator is initially set to 0 when the optimization is performed. Later, another optimization is carried out to find the power penalty by comparing back-to-back performance transmission and link performance.

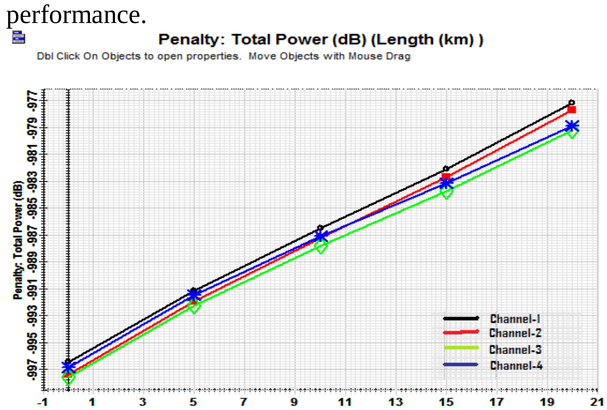

Fig 6.5 Penalty vs Lengths of optical fiber

This is done by varying the attenuation of the attenuator to get the same Q factor as we got from transmission. The received power ($P_{received}$) is then compared with the receiver sensitivity to find the power penalty. Power penalty is given as:

$P_{penalty}$ (dBm) = -17 dBm -$P_{received}$ (dBm).

7. Conclusion

In this paper, we have designed and implemented Radio over fiber ROF system with WDM and PON based on FBG for uplink and downlink stage, Our system is a very effective solution for wireless systems due to increasing the demand for multiservice operation and hence broadband access, it is a reliable and cost effective communication system that can support anytime, anywhere, and any media are needed. It is able to alleviate the increasing demand for high-bandwidth services.

The first part in our work introduces a novel bidirectional RoF network utilizing a 1 Gb/s OQPSK signal for down-link and a 1 Gb/s OOK signal for up-link. RSOA has been used for re-modulation of a down-link signal over 50 km SMF. Moreover, the RSOA is cost effective since it performs the functions a modulator (no need for local laser source) and an amplifier. We also investigated the impact of the temperature dependency of the RSOA on upstream data. The results obtained showed that the temperature had a significant impact on performance of ROF system. Also, it showed that the proposed system has potential application in next-generation convergent wireless-wired optical network.

The second part has been proposed as a solution for increasing bandwidth demand. The combination of WDM and PON has been performed to provide high data rates and bandwidth in wireless communication. We have analyzed the performance of WDM/SCM Radio over Fiber System. We presented a demonstration of 1Gb/s signal for up/downstream in 50-km bidirectional link. The upstream traffic is obtained by re modulating the downstream traffic at the BS. The results obtained here show that increasing total number of sub-carriers channels has a significant impact on performance of WDM-SCM ROF system. The most significant advantage of SCM in optical communications is its ability to place different optical carriers together closely. On the other hand, Wavelength Division Multiplexing (WDM) is a multiplexer at the transmitter to join the signals together, and a de-multiplexer at the receiver to split them apart. In WDM each laser is modulated at a given speed, and the total aggregate capacity being transmitted along the high-bandwidth fiber is the sum total of the bit rates of the individual lasers. Finally we discuss the proposed RoF model. The whole hierarchical simulation system model was constructed and simulated successfully using a commercial optical system simulator.

By varying both the input optical power and the number of subcarriers, the log of bit-error-rate (BER) can be achieved. The results obtained here show that the combination of WDM technology and ROF technology makes it possible to transform the high speed RF signal to the optical signal, so that the optical fibers with broad bandwidth can be used. The WDM technology, at the same time, was showing its advantages in speeding up the signal processing; it is also being focused in 4G wireless communication system.

REFERENCES

i. *Jincy Johny, Sreenesh Shashidharan titled their research paper "Design and Simulation of a Radio Over Fiber System and its Performance Analysis". OPNTDS 2012 IEEE, pp. 636-639, 2012.*

ii. *Fady El-Nahal, "Bidirectional WDM-Radio over Fiber System with Sub Carrier Multiplexing Using a Reflective SOA and Cyclic AWGs," (IJACSA) International Journal of Advanced Computer Science and Applications, vol. 2, no. 8, pp. 93-96, August 2011.*

iii. *Zizheng Cao, Lei Zou ,Lin Chen ,and Jianjun Yu, "Impairment Mitigation for a 60 GHz OFDM Radio-Over Fiber system through an adaptive modulation technique" J, Opt. Commun. Netw .vol 3, No 9,pp,756-766,2011.*

iv. *Z. Cao, J. Yu, M. Xia, Q. Tang, Y. Gao, W. Wen, and L. Chen, "Reduction of intersubcarrier interference and frequency-selective fading in OFDM-ROF systems," J. Lightwave Technol., vol. 28, no. 16, pp. 2423–2429, 2010.*

v. *A.M.J. Koonen, 'Radio-over-MMF techniques - Part II: microwave tomillimeter-wave systems'. Journal of Lightwave Technology, 26(15),2396-2408.2010.*

vi. *Z. Cao, J. Yu, H. Zhou, W. Wang, M. Xia, J. Wang, Q. Tang, and L. Chen, "WDM-ROF-PON architecture for flexible wireless and wire-line layout," J. Opt. Commun. Netw., vol. 2, no. 2, pp. 117–121, 2010.*

vii. *R. P. Giddings, X. Q. Jin, E. Hugues-Salas, E. Giacoumidis, J. L. Wei, and J. M. Tang, "Experimental demonstration of a record high 11.25 Gb/s real-time optical OFDM transceiver supporting 25 km SMF end-to-end transmission in simple IMDD systems," Opt. Express, vol. 18, no. 6, pp. 5541–5555, 2010.*

viii. *R. P. Giddings, E. Hugues-Salas, X. Q. Jin, J. L. Wei, and J. M. Tang, "Experimental demonstration of real-time optical OFDM transmission at 7.5 Gb/s over 25 km SSMF using a 1 GHz RSOA," IEEE Photon. Technol. Lett., vol. 22, no. 11, pp. 745–747, 2010.*

ix. *H. Yang et al, 'High Capacity Radio-over-Fiber Systems forMulticarrier Signals with Dynamic Routing', Proceeding of 22nd Annual Meeting of the IEEE Photonics Society (Photonics Annual2009), Antalya, Turkey, 3 – 8 October 2009, Paper WG 3.*

x. *[H.D. Jung et al, 'All-optical multicasting of millimetre-wave signalsusing optical frequency multiplication technique for in-buildingnetworks'. Proceedings of the 35th European Conference on OpticalCommunication (ECOC 2009) 20 - 24 September 2009, Vienna. pp.4.5.3-1/2*

xi. *P. Gamage, A. Nirmalathas, C. Lim, D. Novak, and R. Waterhouse, "Optical tandem single-sideband-based WDM interface for millimeter-wave fiber-radio multisector antenna base station," IEEE Trans. Microwave Theory Tech., vol. 57, no. 3, pp. 725–732, 2009.*