ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 5, Issue 2, February 2016**

# Quality Improvement in Millimeter Wave Generation Techniques

Shify Annam Mathew[1], Sujithkumar V[2]

PG Student [OEC], Dept. of ECE, TKM Institute of Technology, Kollam, Kerala, India[1]

Assistant Professor, Dept. of ECE, TKM Institute of Technology, Kollam, Kerala, India[2]

**ABSTRACT**: Radio Over Fiber system is a technique for transmission of high-frequency radio signal from the central unit to the base stations using optical fiber as the transmission medium. 60 GHz Millimeter-wave systems have significant attenuation in free space, so this attenuation can be minimized when passing through an optical fiber. 60GHz MMW signal shows improvement in the case of power consumption and quality of the signal generated. There are several methods for the generation of Millimeter-waves such as using different modulators. Electro-absorption modulator (EAM) can be used instead of Mach-Zehnder Modulator (MZM) for better quality Millimeter-wave signals. The Quality factor and Bit error rate are checked for different Millimeter-wave generation techniques. As the fiber length increases, the quality factor decreases.

**KEYWORDS:**Electro-Absorption Modulator(EAM), Mach-Zehnder Modulator(MZM), Millimeter-wave(MMW) generation, Optical fiber, Radio-Over Fiber(RoF), Quality factor.

## I.INTRODUCTION

Radio over fiber system is one of the emerging techniques which combines wired and wireless transmission. Here radio frequency signal is used for wireless transmission and an optical fiber is used for wired transmission. Radio over fiber system supports different modulation schemes and millimeter wave transmission is one of the most popular approaches. The major benefits of RoF technologies are large bandwidth, reduced power consumption, low attenuation losses, multi- operator and multi-service operation.

Millimeter wave is a portion of the electromagnetic spectrum with frequency ranging from 30-300 GHz and the corresponding wavelength is from 10 mm-1mm. MMW range in the electromagnetic spectrum is less congested and crowded, so large bandwidth is available for signal transmission in this frequency spectrum. Among the millimeter waves, 60 GHz frequency signal undergoes severe attenuation when passing through the atmosphere which is mainly due to oxygen molecules. This problem can be minimized when this frequency signal is allowed to pass through the fiber. In this paper, generation and transmission of 60 GHz signal in radio over fiber system is done.

## II. RELATED WORKS

Recently investigation has been done to reduce the infrastructure cost, the convergence of multiservice access networks over RoF system[1]. In [2], 60 GHz millimeter waves and baseband signals are transmitted using optical tunable filtering and polarization de-multiplexing to realize reconfigurable remote access modes. Multi-band modulation with a single optical modulator technique is implemented to reduce the overall system cost. In [3], Electro-absorption modulator is used to generate millimeter waves, but the system is complex. In [4], A 60 GHz millimeter wave signal and a 20 GHz MMW signal with the same data stream are generated simultaneously by using a single MZM. In [5], a single MZM is used to generate independently wired and wireless signals, but the main limitation of this configuration is that it supports only OOK modulation format. In [6], simultaneous realization of Millimeter wave generation and 2.5 Gbps baseband transmission is done. But this system requires two MZMs.

In this paper, a novel scheme of RoF system for the generation and transmission of 60 GHz millimeter wave is proposed. Simultaneous generation and transmission of wired and wireless signals are done using lithium niobate Mach

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 5, Issue 2, February 2016**

Zehnder modulator. Here, the advantages of 60GHz signal frequency over other frequencies are also discussed and analyzed. Electro-Absorption Modulator (EAM) can be used instead of dual-electrode MZM for better quality millimeter-wave generation, which is also explained in this paper.

## III. PROPOSED SYSTEM DESIGN

The system shows the generation and transmission of 60 GHz millimeter waves using a dual-electrode lithium niobate Mach-Zehnder Modulator. In the central station, an MZM is used to modulate the carrier signal with message signal. A baseband signal is applied to one of the electrodes and to the other electrode of the modulator, a baseband signal mixed with radio frequency signal is given, that will allow the modulator to generate a modulated signal. The modulated signal is then transmitted through an optical fiber to the receiver section. At the receiver section, a filter is used to suppress the carrier signal which is shown in Fig 1. The required millimeter wave is then generated and is given to the detector section and then to the analyzer section.

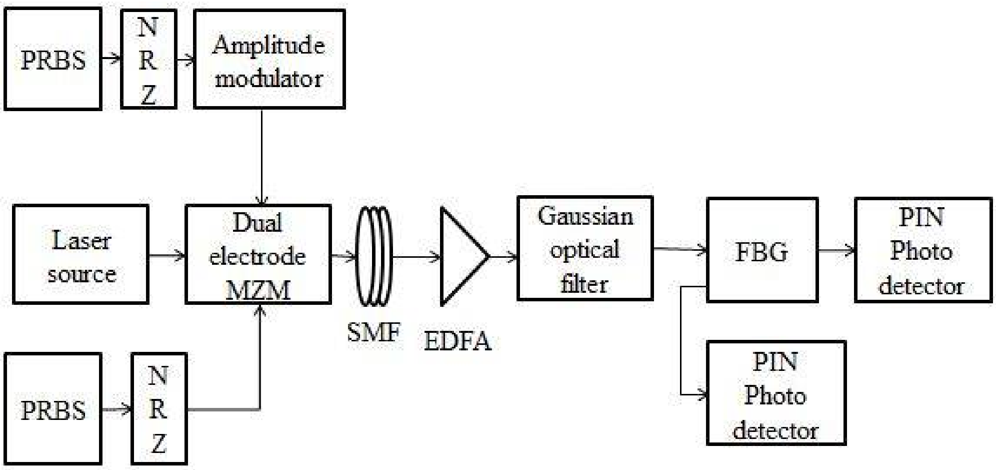



Fig 1: Block diagram of simultaneous generation of Millimeter wave signal and baseband signal using Dual electrode MZM.

The MZM can be replaced by an electro-absorption modulator to increase the quality of the received signal. Here the system is less complex and provides the better quality signal. Fig 2 shows the setup block of millimeter-wave generation using EAM.

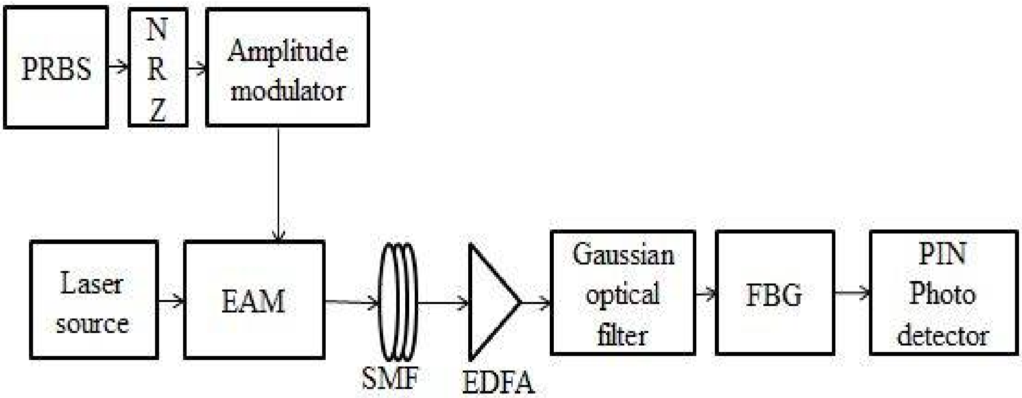



Fig 2: Block diagram of Millimeter wave signal generation using electro absorption modulator

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

**International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering**

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 5, Issue 2, February 2016**

## IV. SIMULATION MODELLING

The simulation is done using OPTISYSTEM 12 software. Using dual-electrode MZM, the simultaneous generation, and transmission of wired and wireless signals can be performed. The continuous wave laser is used to generate a wavelength of a 1550nm carrier signal. In the central office (CO), a 2.5Gb/s baseband signal for wireless service is mixed with the 30 GHz carrier. The carrier signal is given to the amplitude modulator. The mixed signal is applied to one of the electrodes of the dual-electrode MZM. Moreover, a baseband signal for wired service is directly fed into the other electrode of the dual-electrode MZM. The modulated light wave is amplified by an erbium-doped fiber amplifier before it is transmitted over single mode fiber and dispersion compensating fiber. The setup of the MMW generation for the RoF system by using dual-electrode MZM is shown in Fig 3. An optical band pass filter is employed to reject out-band amplified spontaneous emission noise.

At the base station, a fiber grating is utilized to separate these two signals and each signal is transmitted to the corresponding photo-detector. FBG with a 3-dB bandwidth of 0.1nm and a reflection ratio of 0.99 is used to separate the MMW signal and BB signal. The MMW and the baseband signal are received by the photo-detectors at the receiver end. A 60 GHz clock is used to down-convert the electrical signal to its baseband form. The received optical power of wired and wireless signals are different. The received power of millimeter wave signals is less than that of wired signals.

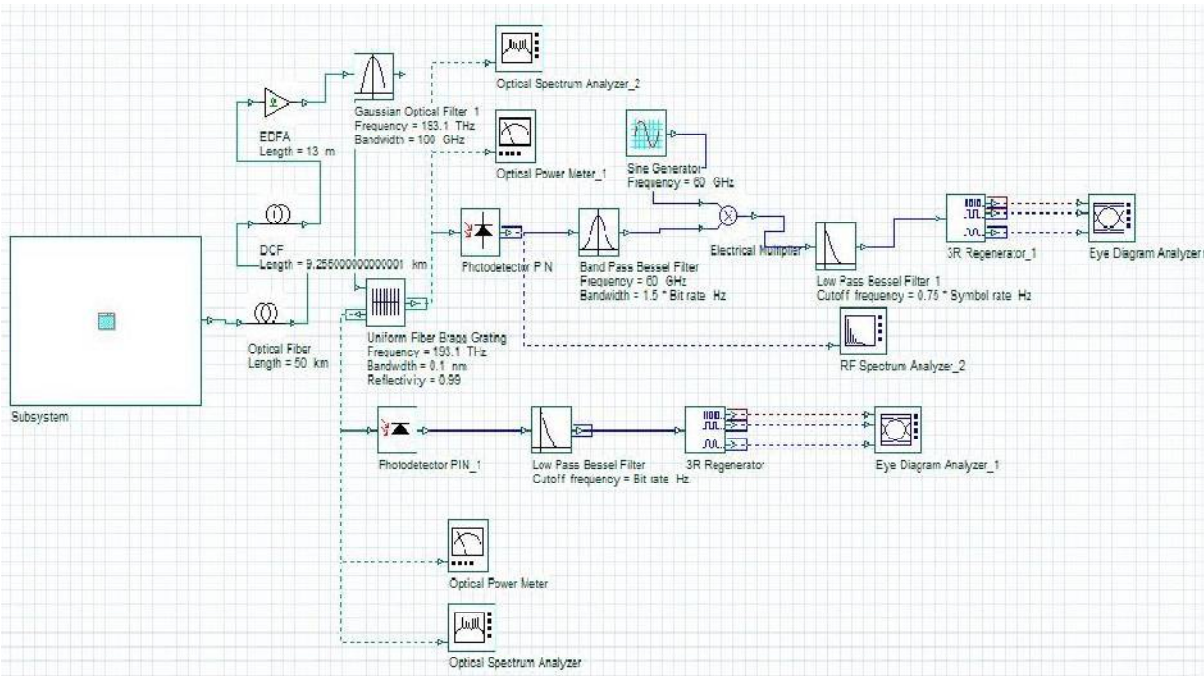



Fig 3: Simulation diagram of millimeter wave generation using dual electrode MZM

The transmitter section consists of continuous wave laser source, pseudo random bit sequence generator, NRZ pulse generator, Electrical Amplitude Modulator, LiNb Mach-Zehnder Modulator. The transmitter section is created as a subsystem and is shown in Fig 4.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

**International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering**

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 5, Issue 2, February 2016**

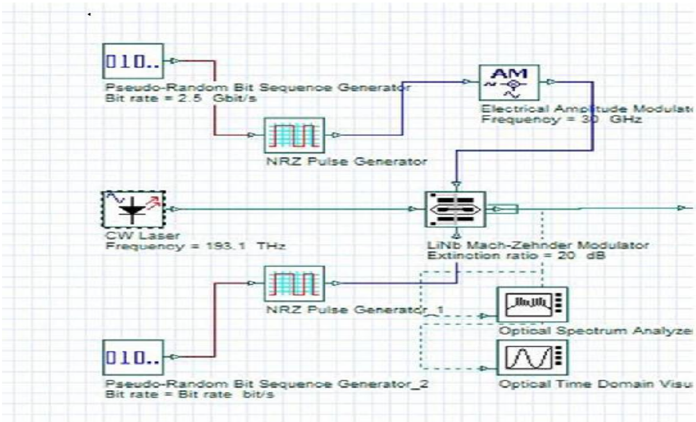



Fig 4: Transmitter section for the generation of MMW using dual electrode MZM

Fig 5 shows another method for the generation and transmission of MMW using EAM. A CW laser having a frequency of 193.1 THz and power of 10 dBm is used as the laser source. To the EAM, a message signal having the frequency of 30 GHz and a data rate of 2.5 Gb/s is given to modulate the carrier signal. The length of optical fiber is 50 km and dispersion compensation fiber is 9.29 km respectively. At the detector section, a photodiode is used.

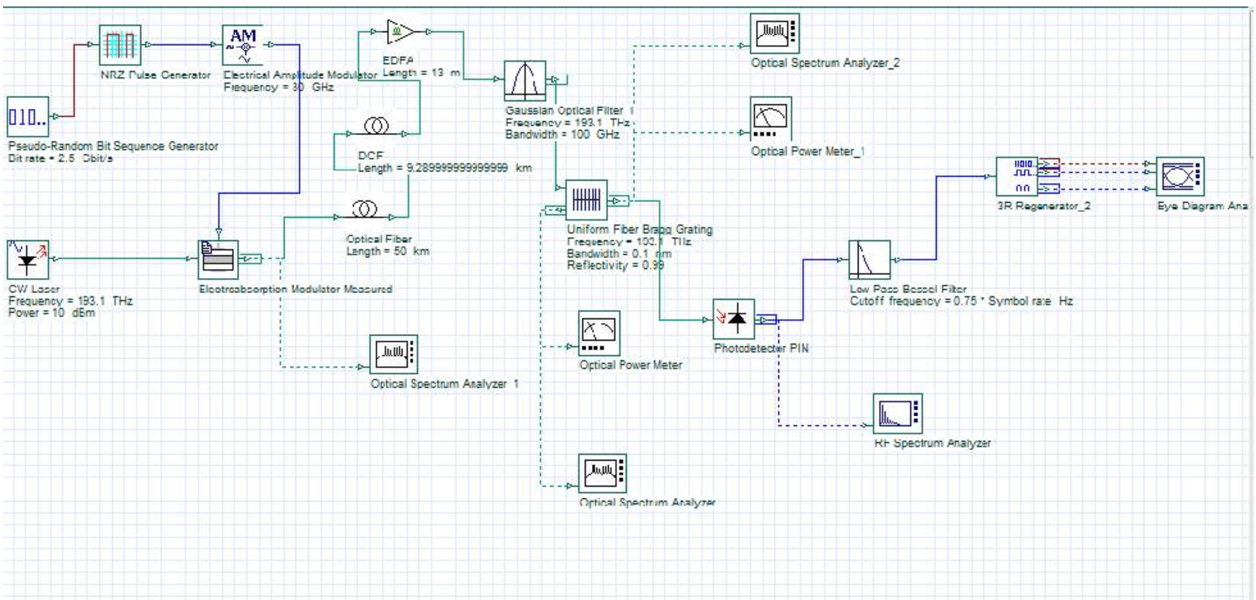



Fig 5: Simulation diagram of millimeter wave generation using EAM

## V.RESULTS

The dual-electrode MZM is used to modulate the carrier signal with the message signal. Here, the message signal given have the frequency of 30 GHz, so the modulated output of MZM have sidebands with 30 GHz spacing. The modulated output is then given to fiber Bragg grating to suppress the carrier signal. The attenuation frequency of FBG should be adjusted such that, this frequency should match with the carrier signal frequency.

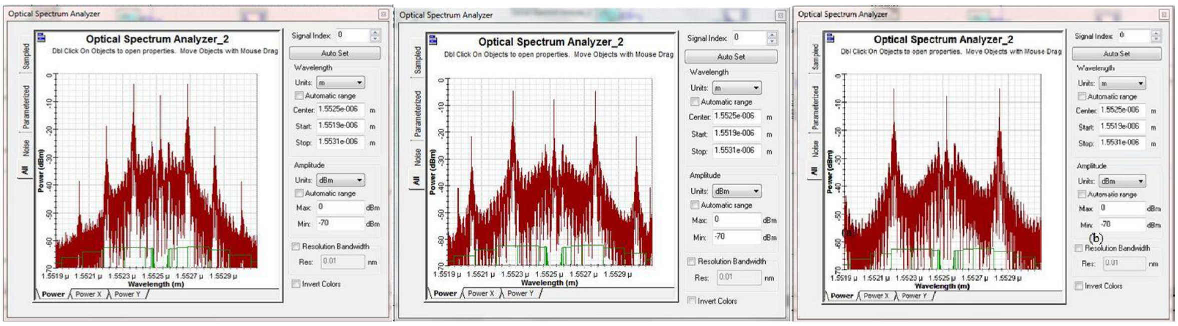
ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

**International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering**

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 5, Issue 2, February 2016**

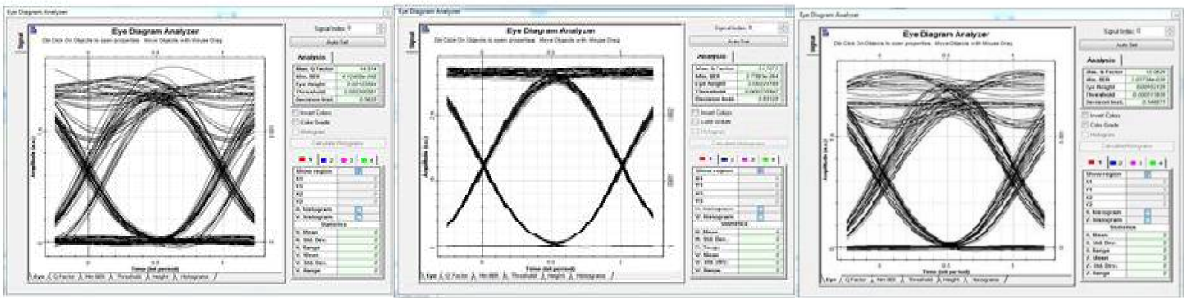
The millimeter wave signal at 60 GHz shows less power consumption and high data rate. To show this,40 GHz and 70 GHz MMW signals are generated and then the power consumption and quality factor of the signals are checked. To generate a 40 GHz millimeter wave, 20 GHz radio signal should be given to dual-electrode MZM so that 20 GHz spaced sidebands will be formed on either side of the carrier signal. The carrier signal can be suppressed by passing through a Fiber Bragg Grating. Likewise, 60GHz and 70 GHz MMW can be generated by giving 30 GHz and 35 GHz RF signal to dual-electrode MZM respectively.




(a) (b) (c)

Fig 6: Millimeter wave spectrum of (a) 40 GHz signal (b) 60 GHz signal (c) 70 GHz signal

The millimeter wave spectrum and eye diagrams for different frequencies are shown in Fig 6 and Fig 7 respectively. The Quality factor obtained for 40GHz, 60GHz, and 70GHz MMW signals are 14.514, 34.7074 and 13.0629 respectively.



(a) (b) (c)

Fig 7: Eye diagram of (a) 40 GHz MMW (b) 60 GHz MMW (c) 70 GHz MMW

The power meter is used to check the power consumption of the signals. From the power meter output of different signals, it can be concluded that 60 GHz MMW consume less power compared to 40 GHz and 70 GHz, this is shown in Fig 8.

(a) (b) (c)

Fig 8: Power spectrum of (a) 40 GHz signal (b) 60 GHz signal (c) 70 GHz signal

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 5, Issue 2, February 2016**

The millimeter-wave can also be generated using a single EAM. The quality factor of millimeter-wave generated by using this method shows better performance.

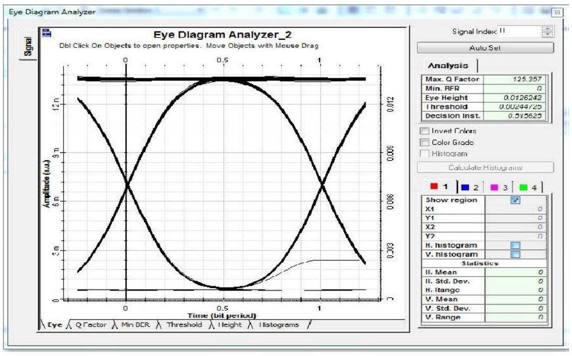



Fig 9: Eye diagram of millimeter wave using EAM

Eye diagram obtained by using this method for transmission distance of 50 km and 2.5Gb/s data rate is shown in Fig 9. The quality factor decreases as we increase the data rate. This is shown graphically in Fig 10.

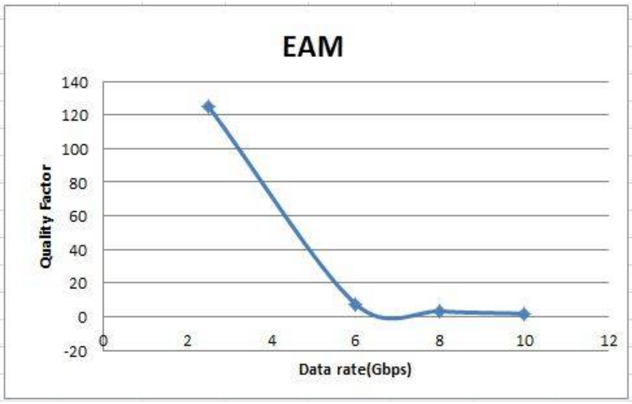



Fig 10: Graphical representation of Quality factor obtained for millimeter-wave generation using EAM versus data rate

## VI. CONCLUSION

Millimeter-wave generation and transmission using dual electrode Mach-Zehnder modulator and electro-absorption modulator in RoF system are discussed. The advantage of using EAM is that the complexity is reduced. The millimeter waves generated can be transmitted upto 50 km using optical fiber. As the fiber length increases the quality factor decreases and bit error rate increases. The system shows better performance up to 2.5 Gb/s data rate, but above that the system shows poor performance.

## REFERENCES

[1] Chenhui Ye, Liang Zhang, Xiaofeng Hu, et al., "Generation of Multiband Signals in a Bidirectional Wireless Over Fiber System with High Scalability using Heterodyne Mixing Technique", IEEE Photonics Technology Letter, Vol.24, No. 18, pp.1621-1624,2012.

[2] Christos P. Tsekrekos, Ken-ichi Kitayama,ToshiakeKuri, "Distribution of Millimeter-Wave and Baseband Services over an Integrated Reconfigurable Access Network Platform", Journal of Lightwave Technology, Vol. 28, No.19, pp. 2783-2790,2010.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 5, Issue 2, February 2016**

[3] J. J. V. Olmos, et al.,"Reconfigurable Radio-over-Fiber Networks: Multiple-Access Functionality Directly over the Optical Layer", IEEE Transaction on Microwave Theory and Technology, Vol. 58, No11, pp.3001-3010,2010.

[4] Y. T. Hsueh, et al.," A Novel Bidirectional 60-GHz Radio-over-Fiber Scheme with Multiband Signal Generation using a Single Intensity Modulator", IEEE Photonics Technology Letters, Vol. 21, No11. 18, pp.1338-1340,2009.

[5] J. Zhensheng, et al.," Simultaneous Generation of Independent Wired and Wireless Services using a Single Modulator in Millimeter-Wave-Band Radio-over-Fiber Systems", IEEE Photonics Technology Letters, Vol.19, No. 20, pp.1691-1693,2007.

[6] Flora Paresys,Tong Shao, Yannis Le Gurnnec, et al.,"Convergence of 60 GHz Radio over Fiber and WDM-PON using Parallel Phase Modulation with a Single Mach-Zehnder Modulator", Journal of Lightwave Technology, Vol. 30, No. 17, pp.2824-2831,2012.

## BIOGRAPHY

**Shify Annam Mathew** received her B.Tech degree in Electronics and Communication Engineering from University of Kerala in 2014. She is currently pursuing second year M.Tech in Optoelectronics and Communication Systems at TKM Institute of Technology.

**Sujith Kumar V** received his B.Tech degree in Electronics and Communication Engineering from Cochin University of Science and Technology in 2006 followed by M.Tech in Communication systems from Anna University in 2013. He is currently working as Assistant Professor in the Department of Electronics and Communication Engineering at TKM Institute of Technology.