International Journal of Innovation and Scientific Research
ISSN 2351-8014 Vol. 7 No. 2 Aug. 2014, pp. 78-84

http://www.ijisr.issr-journals.org/

# Radio-Over-Fiber (ROF) Technology With WDM PON System

***Vikas Kumar Pandey, Sanjeev Gupta, and Bharti Chaurasiya***

Department Of Electronics and Communication Engineering,
Scope College Of Engineering, Bhopal, India



**ABSTRACT:** Radio over fiber is becoming an increasingly important technology for the wireless market since it introduces a good data transmission rate and large bandwidth. We have implemented a bidirectional radio over fiber (ROF) system. It is 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.
This paper consists of two parts:
I. Introduction of Radio of Fiber technology & methodology
II. Quality parameter & Challenges for Implementation.
Wireless communication was one of the paramount ways in term ofhigh bandwidth data communication. Technology like microwave, wireless, optical communication & their combination are used and have improved the performance of the communication. Radio over Fiber technology (RoF), an Integration of microwave and optical communication is an essential technology for the provision of unmetered access to broadband wireless communications. For the future provisions of broadband, multimedia the radio over fibre systems are a good alternative. RoF systems are used basically because of their low loss and extremely wide bandwidth and robustness. Radio over fibre can use millimetre waves and serve as a high speed wireless local or personal area network. In this paper various parts of the Radio over fibre systems are studied, ROF is an analog optical link transmitting optical carrier modulated by the radio frequency signal. This technique facilitates to transmit radio frequency signal through the optical fiber in downlink and uplink

**KEYWORDS:** RoF, Intermediate frequency, Remote Based Station, EAM, WDM, MAHO, QoS, MCHO, Medium access control.

## 1 INTRODUCTION

With the evolution of high data rate broadband access networks, high carrier frequencies of 10 GHz and above are required for in-building broadband wireless services, resulting in the reduction of wireless cell size and the increase of the cost for antenna sites (AS). Meanwhile, fiber-to-the-home markets have recently Gbit/s link direct to the gateway in the home. Thus, the bottleneck of wireless access network has moved into the in-building environment. The emerging radio over-fiber (RoF) technology potentially provides a low-cost solution for in-building wireless access network, by centralizing microwave signal processing in the central office (CO) for the delivery of radio frequency (RF) signals to as via optical fiber, hence simplifying the antenna. In RoF systems, the transmission of radio signals over optical fiber has been vastly investigated by the means of intensity modulation/direct detection (IM/DD) and optical heterodyning methods. Next to the high capacity transmission of RoF systems, the flexible optical routing of the RoF signals should be developed as well. This will enable flexible mobility management, dynamic capacity allocation, and dynamic network dimensioning and efficient radio resource management. The Radio over fiber (ROF) communication technology combines the technical advantage of the both fiber communication and wireless communication to solve the problems of bandwidth, flexibility and electromagnetic interference. Research of the technology is drawing wide concerns around the world. But the high cast becomes a drawback of this technology. Radio over fiber (ROF) Technology an integration of wireless and fiber optics networks is an essential technology for the provision of unlettered access to broadband wireless communications in a range of application including last mile solving extension of existing radio coverage capacity and backhaul.The Radio over fiber (ROF) communication technology combines the technical advantage of the both fiber communication and wireless communication to solve the problems of bandwidth, flexibility and electromagnetic interference. Research of the technology is drawing wide concerns around the world. But the high cast becomes a drawback of this technology. Radio over fiber (ROF) Technology an integration of wireless and fiber optics networks is an essential technology for the provision of unlettered access to broadband wireless communications in a range of application including last mile solving extension of existing radio coverage capacity and backhaul .Hence by incorporating SCM-WDM along with the optical fiber, the RoF system can be used for both short distance as well as long-haul transmission at very high data rate. This improves the system flexibility and provides a very large coverage area without increasing the cost and complexity of the system very much. Recently, it has been proved that SCM-WDM is better compared to the conventional single carrier modulation for long haul optical transmission. Such technology is expected to play an important role in present and future wireless networks since it provides an end user with a truly broadband access to the network while guaranteeing the increasing requirement for mobility.ROF is very attractive technique for wireless access network infrastructure; because it can transmit microwaves and millimeter-waves through optical fibers for a long distance.

## 2 RADIO-OVER-FIBER TECHNOLOGIES

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 1). RoF systems centralize the RF signal processing function in one shared location (headend), 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. 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.

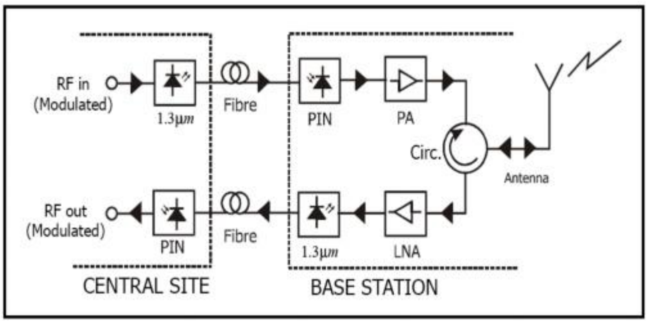


*Fig.1 Radio over Fiber System*

## 3 ARCHITECTURES OF ROF NETWORKS

Several RoF concepts have been developed. The main difference between these concepts resides in techniques used for carrier generation and data distribution over optical fiber. These concepts repose on three proposed architectures for RoF links. They are implemented according to their frequency bands as shown in Fig 2, which are: (i) Radio Frequency (RF) band; (ii) Intermediate Frequency (IF) band, and (iii) Base Band (BB).

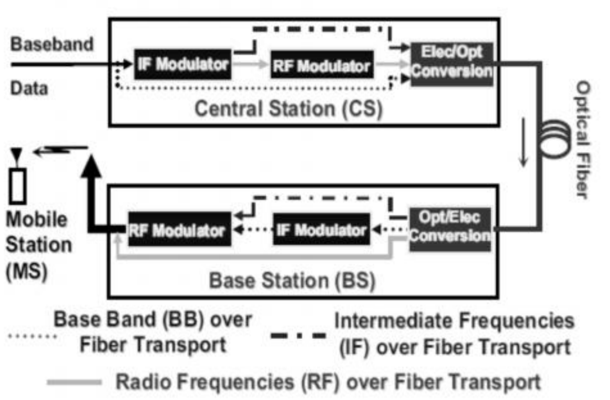


*Fig 2 Transport schemes for Fiber/Wireless systems*

In general, optical distribution techniques of electrical data signals can be classified according to two approaches. The first approach consists in transporting the signal in either the BB or the IF band. It leads to significant complexity reduction at the optical-link level. The BB transport method consists of a direct modulation of a laser diode by the BB data signal. Thereafter, the resulting optical signal is injected into an optical fiber and transported from the CS to the BS (downlink). Symmetrically, in the up-link, the transmitted BB electrical signals undergo the same process. For the BB transport method, only low band-width optoelectronic components are necessary. However, this optical-link simplification is accompanied by an increased complexity for the BS Fig 2 Transport schemes for Fiber/Wireless systems where BB to RF up-conversion and RF to BB down-conversion are required. Moreover, this strengthens the complexity of the problem since the BS RF equipment must be replicated by the number of hertzian network deposits. Furthermore, if new channels need to be added the complexity of the BS makes the system reconfiguration difficult. In the case of the IF transport option; the optical data transmission is performed after optically modulating the electrical signal as shown in Fig 3 below. The later should undergo a prior modulation by a common generated IF carrier. At every BS, an IF-to-RF up-conversion is necessary before the radio transmission.

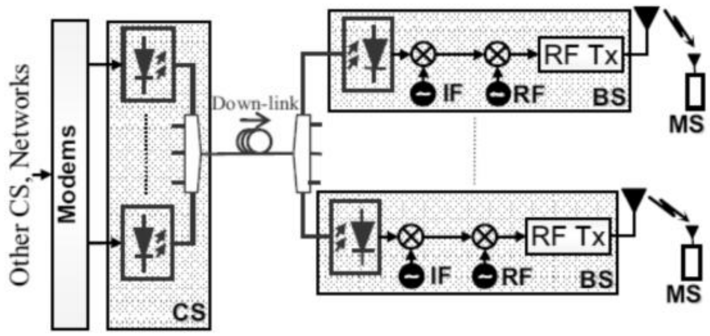


***Fig.3 IF to RF up-conversion at the base stations***

The second approach consists of a maximum simplification of the BS configuration, where the RF signal generation is centralized at the CS. Consequently, the BS architecture is simplified. This centralized architecture of RoF systems allows avoiding the problem of RF equipment duplications when several BSs are interconnected with the CS. This reduces the network cost and increases its flexibility. In this architecture, the BS as well as the CS should contain an external optical modulator. This component is required for operating at the millimeter-wave band frequencies (30-70 GHz). Photo detectors should also present high performances in this frequency band. Thus, the BS role is reduced to three basic functions only: RF amplification, multiplexing, demultiplexing, as well as downlink Optical-to-RF and up-link RF-to-Optical conversions.

## 4 WDM SYSTEM FOR RADIO OVER FIBER COMMUNICATIONS

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. Trasparency.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.4. 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.

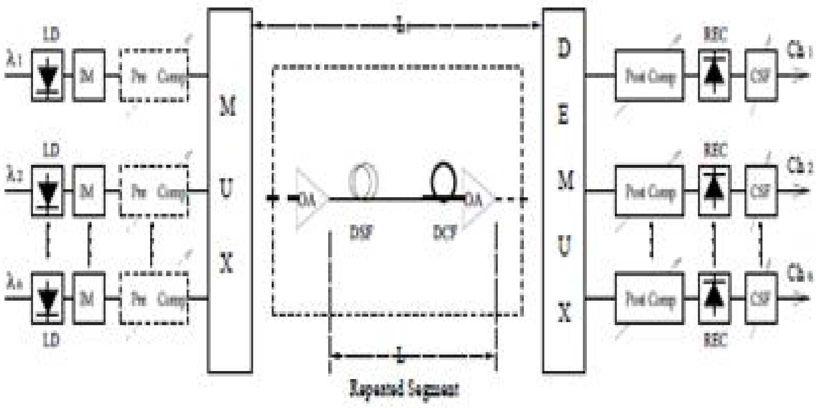


*Fig 4 configuration of typical WDM transmission system including the wave*

## 5 WDM-ROF SYSTEM MODEL

Radio over Fiber (ROF) is integration of optical fiber for radio signal transmission within network infrastructures that is considered to be cost effective, practical and relatively flexible system configuration for long-haul transport of millimeter frequency band wireless signals. Fiber optic LANs will be carrying traffic at data rates of tens of giga bits per second in the near future, whereas data rates of tens of megabits per second are difficult to provide to mobile users.

In this case, optical channels, offering terahertz of bandwidth, have many advantages. First ROF systems were mainly used to transport microwave signals, and to achieve mobility functions in the central office or exchange (CO). That is, modulated microwave signals had to be available at the input end of the ROF system, which subsequently transported them over a distance to the RS (Remote Site) in the form of optical Today ROF systems, are designed to perform added radio system functionalities besides transportation and mobility functions. These functions include data modulation, signal processing, and frequency conversion. For a multifunctional ROF system, the required radio signal at the input of the ROF system depends on the ROF technology and the functionality desired. ROF offers operational benefits in terms of operational flexibility. Depending on them microwave generation technique, a ROF distribution system can be made signal format transparent. The Intensity Modulation and Direct Detection technique can be made to operate as a linear system and therefore as a transparent system. A fiber-radio network differs from a traditional fiber-to-the-home (FTTH) access network in that the transported data is at a wireless frequency and not at baseband. One promising alternative to the first issue is an ROF based network since in this network functionally simple and cost effective Bs are utilized in contrast to conventional wireless systems. However, the second issue is still challenging and difficult to realize as the conventional handover procedures cannot easily be applied to the system. In first ROF network architecture operating at mm-wave bands with special emphasis on mobility management. Specially, our concern is how to support fast and simple handover in such networks using ROF network's centralized control capability a fiber-radio network comprises two distinct domains, one optical and one wireless. In the optical domain, Wavelength Division multiplexing (WDM) can be used to combine several wavelengths together to send them through fiber-optic network, greatly increasing the use of the available fiber bandwidth and maximizing total data throughput that in order to meet future wireless bandwidth requirements, a single CO feeds each remote radio BS and has access to a separate optical WDM involves multiplexing multiple wavelengths and transporting them in a single fiber. Current technology allows one to two hundred channels to be transported in a single fiber, achieving Tb/s total capacity If WDM is used in a fiber-radio network, and then each BS can be assigned a single wavelength. A WDM network requires wavelength selective optical components that can multiplex or demultiplex channels or that can drop or add channels These components are imperfect and cannot fully remove unwanted channels, leading to optical crosstalk, i.e. the presence of an undesired optical signal .Although optical components can reject adjacent wavelength channels by up to 30 dB or more some residual signals will still be present, particularly if channels powers are unequal. This type of unwanted crosstalk is referred to as in homodyne or heterodyne or inter- channel crosstalk, or simply as out-of band crosstalk. This type of crosstalk does not severely impair network performance as it is at a different wavelength as the desired signal and is simply added to the signal in the electrical domain. In the present study, we have investigated the propagation problems in ROF systems, in addition to its transmission properties; the insensitivity of the fiber optic cables to electromagnetic radiation is a key benefit in their implementation as the backbone of the advanced optical communication networks. Moreover, we have presented the transmission capacity of ROF systems with different transmission and multiplexing.

## 6 EXPERIMENTAL SETUP

The experimental setup consists of 2 channels for downstream as well as 2 channels for up-stream covering the L-band starting from 193.1 to 193.4 THz along with radio frequency using continuous wave lasers as shown in Fig. We have investigated the integration of radio communication with optical communication media. The data stream from a 10 Gbps pattern generator with a NRZ binary sequence is pre-coded and drives a sine squared amplitude modulator. The output of two way communication are received by pin-diode along with AM modulator and displayed at ber analyser quality factor approximated upto 7 to 12. At the receiver side the PIN photodetector is used with a responsivity of 0.9A/W and dark current of 10 nA.

## 7 RESULTS

A relation between Q factor vs input power is shown in figure.it is clearly shown in graph the down-stream indicates higher Q factor as compare to up-stream due to the effect of CO which have high power transmitter with respects to ONU transmitter. All the simulated channels almost have shown linear relation with increasing input power.The figure and shows the up-stream and down-stream eye diagram. In the result the dark circle shows the distortion in the signal which is taken from up-stream whereas in down-stream eye diagram the upper portion does not have thinner part. The eye diagrams that illustrated below as we could see most ofthe eye opening is not so wide and high. Based on the theory as explained before inthe first paragraph of this section, most open part eye means best signal to noiseratio. So this system might have some noise distortion and because of that it mighthave some modification in the future works.

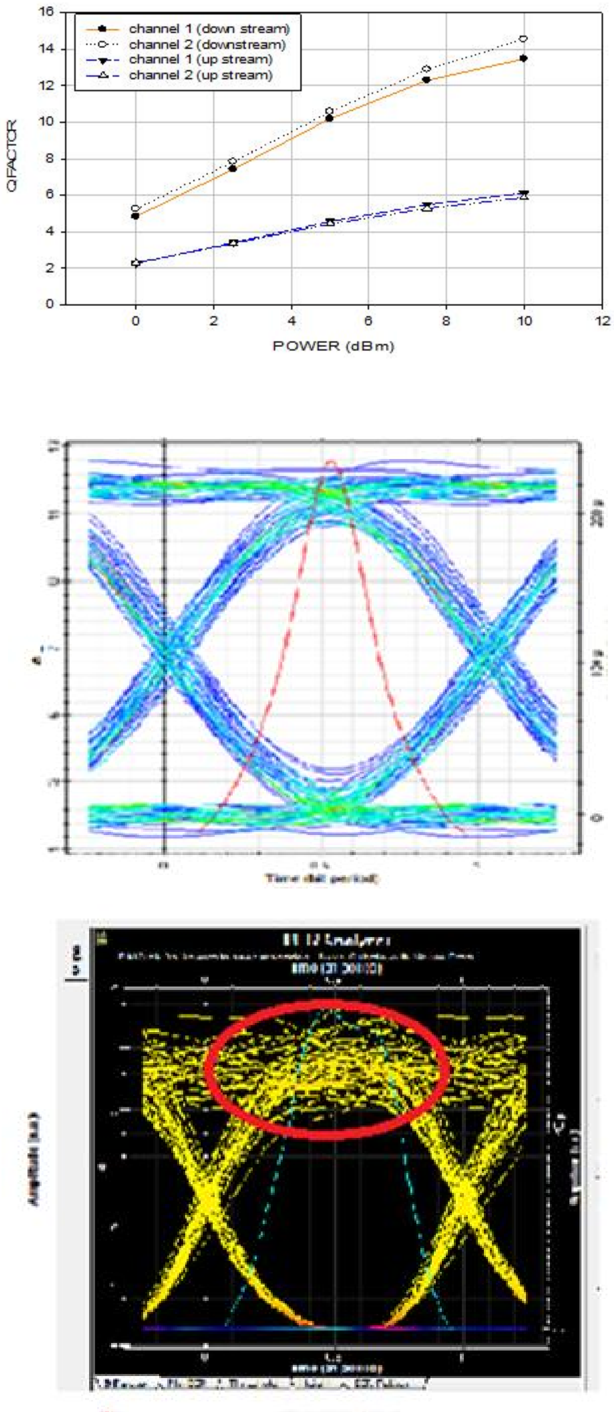


*Fig 5 Outcomes in Setup*

## 8 CONCLUSION

The study of incorporating SCM WDM modulation technique with RoF technology is essential in nowadays implementation of optical communication. With the combination of the advantages from WDM and RoF, the system can be used for both short distance as well as long haul transmission at very high data rate. This improves the system flexibility and provides a very large coverage area of telecommunication networks without increasing the cost and complexity of the system very much. Also recently, it has been proved by many researchers that SCM-WDM is better compared to the conventional single carrier modulation for long haul optical transmission. In this paper the simulation of modeling the SCM-WDM scheme for Radio over Fiber system has been completely done by using commercial software Opt system. Some consideration has been added to system design in order to meet the applicable design for using in the reality. The system model has been design to accommodate WLAN IEEE 802.16 b/g which is using data rate 54 Mbps over frequency carrier 3.5 GHz. This paper shows that total power of the SCM-WDM signal that being carried over the fiber network is decreasing while the length of fiber is increasing from 10 to50 Km. It is observed that as distance increases, the performance is degraded due to fiber dispersion. Overall, the paper offered vast learning opportunity in the SCM-WDM and Radio over Fiber technology and how to simulate using Opti-system software. The studying of SCM-WDM modulation and radio over fiber technology became very important because both of them have been developed to support some important future wireless systems.

## REFERENCES

[1] Ernest l. Walker. Senior member, IEEE “a model for the a-profile multimode optical fiber channels: a linear systems approach” journal of light wave tech.,vol 12, no. 11,November 1994.

[2] A. Powell, “Radio over Fiber Technology: CurrentApplications and Future Potential in Mobile Networks –Advantages and Challenges for a Powerful Technology” inRadio over Fiber Technologies for MobileCommunications Networks”, H. Al-Raweshidy, and S.Komaki, ed. (Artech House, Inc, USA,2002).

[3] U. Gliese, S. Norskow, and T. N. Nielsen, “ChromaticDispersion in Fiber-Optic Microwave and Millimeter-Wave Links”, IEEE Trans. Microwave Theory Tech., vol.44, no. 10, pp. 1716-1724, Oct. 1996.

[4] Eugenio Iannone, Roberto Sabella, “Monica Avattaneo,Gabriele de Paolis, Modeling of In-Band Crosstalk inWDM Optical Networks”, Journal of LightwaveTechnology, vol. 17, Issue 7, p.1135

[5] G.H. Smith, D. Novak, and C. Lim, “A millimeter-wavefull-duplex WDM/SCM fiber-radio access network,” OFC’98, paper TuC5, 1998.

[6] F. Yamamoto and T. Sugie, “Reduction of optical beatinterference in passive optical networks usingCDMAtechnique,” IEEE Photon. Tech. Lett., vol. 12, pp.1710–1712, (Dec. 2000).

[7] K. Kitayama, “OCDM/WDM networks for gigabit access:1.24 Gbit/s, 2×OCDM by 2×WDM experiment,” ECOC’99, pp. 194–195 (1999).

[8] K. Kitayama and N. Wada, “Photonic IP routing,” IEEEPhoton. Tech. Lett.,vol. 11, pp. 1689–1691 (Dec. 1999).