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Design and Performance Analysis of Radio Over Fiber System: A Review

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***Abstract*— Radio over fiber (ROF) is an essential technology whereby light is modulated with radio frequency signals and transmitted over the optical fiber to accomplish wireless access.. In this review paper different techniques for evaluating the performance of ROF system are described and also their results are discussed among various optical parameters such as bit error rate (BER), fiber length, frequency, etc.**

***Index Terms*—ASK, Bit error rate, DPSK, OSSB, ROF, Sub carrier multiplexing.**

I. Introduction

The services that are provided by internet play an important role in today's life, and are considered as one of the most important communication platforms. As communication demands are increasing day by day, it is very important that must there be a system which would satisfy the increasing demands. Radio over fiber technology provides solution to this. Radio over fiber refers to a technology in which light is modulated with radio signal and then transmitted over an optical fiber to facilitate wireless access, such as 3G. In other words radio signal are carried over fiber optic cable. Thus a single antenna can receive any and all radio signals carried over a fiber cable[1]. It is a suitable technology for wireless network and provides a low cost configuration because the optical modulated signals are transmitted to the base station through fiber without significant loss and reaches the mobile user via RF transmission.

II. BASIC ROF SYSTEM ARCHITECTURE

A basic RoF system is shown in Figure 1. In the downlink transmission, RF signals modulate the laser diode directly and results in intensity modulated optical signals. Afterwards, they are transmitted through an optical fiber to the base station. At the BS, the signals are demodulated directly employing a photodiode for recovering the RF signals. Furthermore, they are amplified and radiated by an

antenna. ROF technology is known as intensity modulation and direct-detection based on modulation and detection. The opposite process is carried out at the BS , where the RF signals from the antenna directly modulate the laser diode and then the resulting optical signals are transmitted through an optical fiber to the CS. At the CS, the intensity modulated optical signals are demodulated directly employing a PD for recovering the RF signals. After that, the signals are amplified and further processed. The basic configuration of RoF link system consist of central station and remote access unit (RAU) connected by a single mode fiber[2]. Radio over fiber offers many advantages like large bandwidth, low attenuation loss, immunity to radio frequency interference, satellite communication and many more.

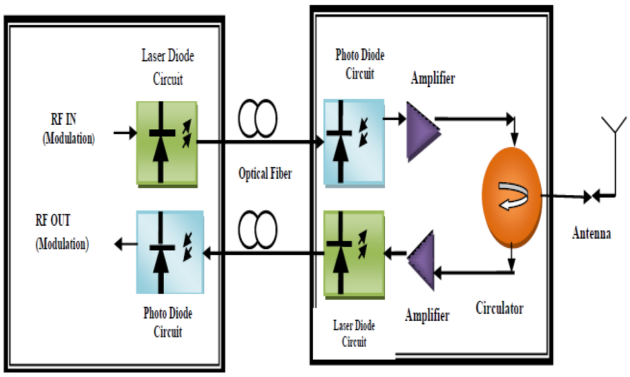

Fig.1 Radio over fiber system architecture

III. SUB-CARRIER MULTIPLEXING

The basic configuration of SCM system is illustrated in figure 2. In SCM, n numbers of signals are modulated individually with different frequency in RF domain. The modulated RF signal are then added up by a RF multiplexer (or by an adder) before transform the RF signal into Optical signal through optical source and optical modulator on a single wavelength. All the operation above was carried out by a single transmitter[3].

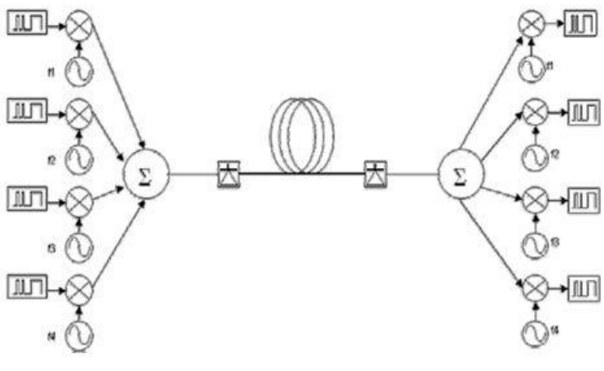

Fig.2 Basic configuration of SCM

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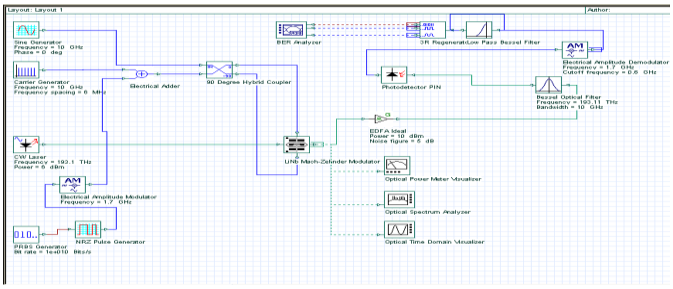
SCM combines two step of modulation that were operating at different domain. First modulation was occupied at RF part such that several low bandwidth RF channel carrying analog or digital signal add up together by using multiplexer or adder. Thus the signal will be very close to each other in the frequency domain depending to local oscillator frequency that applied in the modulation part[3]. This resultant signal actually modulated onto higher frequency microwave carrier. The up-converted signals are in different frequency bands and can therefore be combined by a microwave power combiner forming a microwave subcarrier multiplexed composite signal. Second modulation was occupied at optical domain, the modulated signal then convert to optical domain by using laser diode and optical modulator. SCM is less sensitive to fiber dispersion.



. Fig.3.Simulation setup of SCM

Table I: Comparsion of parameter for ROF

Parameter	SCM	WDM	OFM
Attenuation	Moderate	Low	Low
Scattering	SBS	SBS&FWM	SBS
Dispersion	Chromatic &PMD	Chromatic	Chromatic
BER	Less	More	More
CNR	Less	More	More

IV. DIFFERENT TECHNIQUES/METHODS FOR PERFORMANCE EVALUATION OF RADIO OVER FIBER SYSTEM

A. Performance analysis of SCM based ROF system using phase shift keying modulation technique:

The performance analysis of SCM employing OSSB modulation scheme using PSK showed that bit error rate performance linearly increases for the transmission link from 1 km until 18 km fiber link. The BER performance constantly remain high once it reaches 118 km fiber length. The BER is 5.871*10^-4 at 65km fiber length[3].

Using this technique it has been analysed that SCM employing OSSB using PSK gives good results as it has higher spectral efficiency and demodulation of the transmitted signal is simple[3]. Therefore SCM using OSSB modulation becomes very attractive method for transmitting data to longer distances.

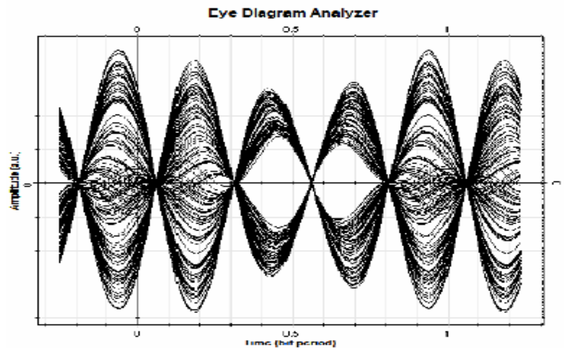


Fig.4 Eye diagram for SCM channel 1

B. Performance evaluation of radio fiber system using differential phase shift keying:

This techniques make use of differential phase shift keying modulation. Differential phase shift keying is a common form of phase modulation that conveys data by changing the phase of the carrier wave. This technique investigated the variations in Q factor , BER and eye opening with respect to the wavelength, bit rate and fiber length .The system employing DPSK, MSK, CPFSK and OQPSK modulation techniques used in RoF system for a bit rate in Gbps have been compared[4].

The value of Q-Factor using DPSK was found out to be 15.0662. This shows that out of various modulation techniques (DPSK ,MSK, FSK, CPSK), DPSK gives the best results.

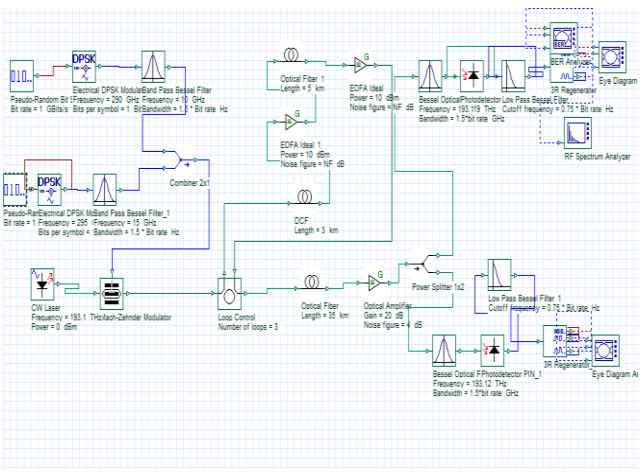


Fig.5.Simulation setup for ROF employing DPSK

C. Analysis of temperature dependence in multimode fiber for radio over fiber:

Temperature dependence in radio-over-fiber (RoF) broadband transmission applications far from baseband for short and middle reach distances is analyzed. This technique evaluates the Frequency response temperature dependence by means of the transfer function of a multimode optical fiber (MMF) link based on the electric field propagation model. A Radio-over-Fiber link with multimode optical fiber is experimentally and theoretically evaluated studying the changes of the frequency response with regards to the temperature induced to the optical fiber link[5].

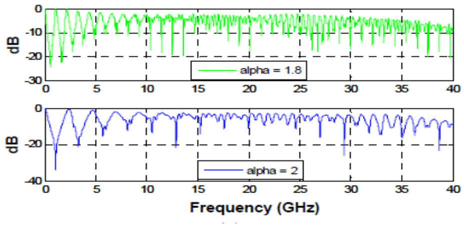


Fig.6.Simulation result for the transfer function for 10 MMF

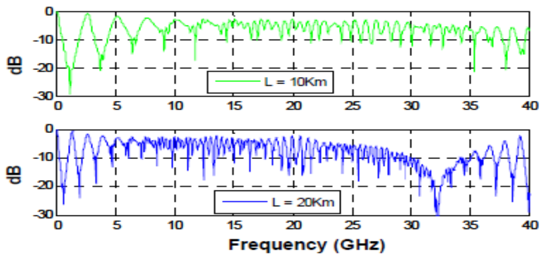


Fig.7. Simulation result for the transfer function for L=10 and 20 km

An experimental analysis of the temperature dependence of the frequency response in multimode optical fibers with radio-over-fiber (RoF) broadband transmission applications far from baseband is reported. A RoF MMF link has been evaluated showing that temperature must be taken into account when selecting a transmission band far from baseband for high-speed data rates applications. However, further research in temperature dependence is needed in order to evaluate the capability of these radio-over-fiber broadband transmissions.

D. Improved Receiver Technique For Radio Over Multi-Fiber System:

Multimode fiber links can offer a useful approach for low cost and short Radio over Fiber (RoF) systems. However, in these connections the distortion effects are higher than in a single mode fiber system. These effects can be compensated by a suitable optical receiver[6]. This improved receiver structure is investigated for Radio over Multimode fiber systems. N-QAM radio signal transmission is simulated and measured on multimode fiber connections. From the different improved methods and installations an optimum solution is chosen for Radio over Multimode Fiber systems

E. *Wideband code division multiple access (wcdma) for radio over fiber system:*

The Wideband Code Division Multiple Access air interface is to provide the basis for the third generation (3G) wireless personal communication system known as the UMTS. These systems will make extensive use of microcells and pico-cells in order to deliver high-bandwidth services to customers[7].

Table II. Basic parameters of WCDMA

Parameter	Value
Frequency band(MHZ)	1920-1980(Uplink) 2110-2170(downlink)
Duplexing	FDD
Modulation	BPSK, QPSK
Channel BW	~5MHZ
Chip rate	3.8Mcps
Data rate	384Kbps/2Mbps

The analysis was carried out in order to regards the achievable fiber length for a BER below -90 dB. Observing the results it can be concluded that a fiber length of around 80 km (for P_{in}= 1 mW) and 100 km (for P_{in}= 10 mW) can be achieved.

V. Conclusion

The review of radio over fiber system has been analysed. In this paper various techniques for evaluating the performance of radio over fiber system have been reviewed. The performance was evaluated with the help of simulation parameters like BER, Q-factor, Eye-Height etc. Beyond all these techniques, a technique can be designed by combining Sub carrier multiplexing with ASK modulation for the performance evaluation of radio over fiber system.

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