INTERNATIONAL JOURNAL OF RECENT TRENDS IN ENGINEERING & RESEARCH
Impact Factor 4.101 ISSN -2455-1457
RECENT ADVANCES IN ELECTRONICS & COMMUNICATION ENGINEERING (RAECE-2K17)

Comparative Study Of Different ROF Technologies

B. Bhavana,

Assistant Professor, NNRG Integrated Campus, Chowdariguda(V), Gatkesar(M), Medchal Dist

Abstract- This paper presents the comparative study on Analog ROF and Digital ROF with Advanced ROF network Technology. Wireless Communication was one of the dominant way in term of high bandwidth data communication. Technology like optical, wireless, microwave communication and their combination are used and have improved the performance of the communication. Radio Over Fiber (ROF) is a future technology, refers to a technology whereby light is modulated by a radio frequency signal and transmitted over an optical fiber link. Major technical advantages by using fiber optical links are minor transmission errors and reduced sensitivity to noise and radio frequency interference compared to all-electrical signal transmission. A key challenge in successfully realizing the optical distribution network for future wireless fronthaul will be the very large bit rates per cell site that must be supported. Quality Parameters like Attenuation, BER and Carrier-to-Noise Ratio (CNR) are compared.

Keywords-Analog ROF, Digital ROF, Attenuation, BER, CNR, EMI.

I. INTRODUCTION

As there is a increasing demand for broadband services which escort to ever-growing data traffic volumes over these services. In-addition to high speed, guaranteed bandwidth demands in present video services, the next generation access networks are driving the needs for the convergence of wired and wireless services. In recent years, a radio-over-fiber (ROF) transmission system, in which the radio frequency (RF) signal is modulated on a light wave signal at a central unit (CU) and transmitted over a fiber optic cable to a remote unit (RU), has attracted widespread interest[1-2].ROF Technology, the integration of microwave and optical networks (shown in figure 1) is a potential solution for increasing capacity and mobility as well as decreasing costs in the access network, by ROF. The concept of ROF means to transport information over optical fiber by modulating the light with radio signal.

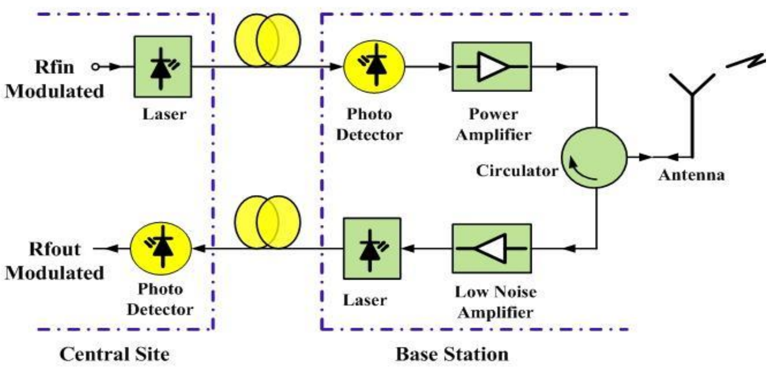

Figure 1: Basic Diagram Radio Over Fiber Technology.

The fundamental principle of RoF transmission is the transport of information over optical fiber by modulating the light with the radio signal. ROF technology uses a linear optical fiber links to distribute Radio Frequency (RF) from a Central Office (CO) to Remote Antenna Units (RAUs). This relies on simplifying the RAUs, since they only need to contain optoelectronic conversion devices and amplifiers. Consequently, power consumption and the costs of both equipment and maintenance are reduced [3]. The transmission of the radio signal over fiber has other advantages such as [4-5]:

Low fiber attenuation loss: About 0.2dB/km and 0.5dB/km in the 1550 nm and the 1300 nm windows, respectively.

Large bandwidth: The optical fiber technology offers a huge bandwidth. The combination of optical fiber from central office to the RAUs increases the capability of transporting information transmitted through microwave signals. The large optical bandwidth enables high speed signal processing which is more difficult, and sometimes even impossible, to do in electrical systems.

Immunity to Radio Frequency Interference: Immunity to Electromagnetic Interference (EMI) is a well-known and very attractive property of fiber-optic communications. This property alongside with the fiber's low attenuation (around 0.2dB/km), is a good choice for signal transmission of radio frequency.

Easy Installation and Maintenance: In ROF systems, complex and expensive equipment is kept in the central office, thereby making the RAUs simpler. That's one of the major advantages of ROF Technology because the reduction of the base station complexity implies smaller and lighter RAUs, effectively reducing system installation and maintenance costs

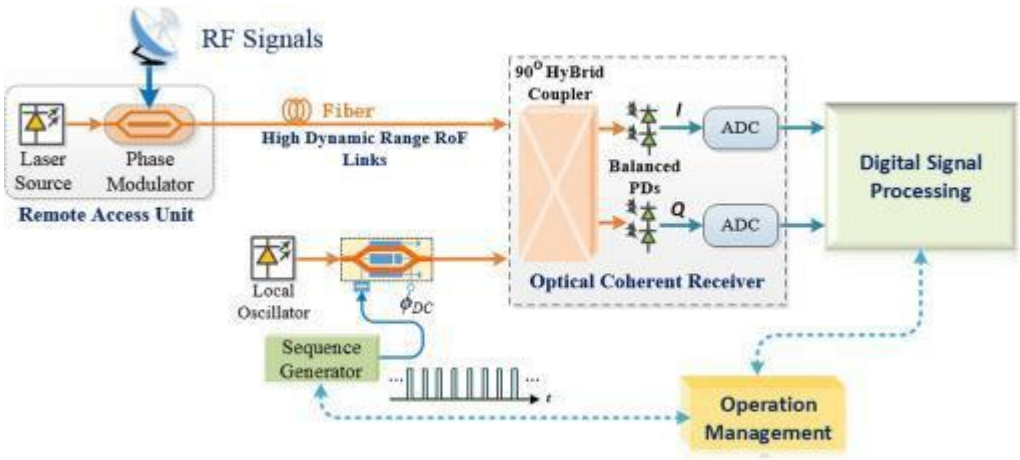

Figure 2: Basic Schematic of Digital ROF.

II. ROF Technologies

1. Analog ROF

In this analog ROF technology, the analog signal transmitted over the optical fiber can either be radio frequency signal (RF), intermediate frequency signal (IF) or baseband signal (BB). In the optical transmitter, the RF/IF/BB signal is modulated onto the optical carrier by either using direct or external modulation of the laser. The signal distribution through RoF has the advantage of simplified base station (BS) design, as mentioned previously; it is susceptible to fiber chromatic dispersion and other impairments from analog communication systems.

2. Digitized ROF

While analog ROF link suffers from some impairments as mentioned previously, the Digitized ROF appears as an alternative to the next generation of ROF systems. The digitization of a RF signal consists in the production of a sampled digital signal in a serial form that can be modulated on an optical carrier. Modulation of the digital signal onto an optical carrier minimizes the nonlinear effects originated from the optical-to-electrical conversion function presented on analog RoF. In order to not use considerably high sample rates at the ADC/DAC components, such as the bandpass sampling technique, are generally applied to the RF signal. All the functions and protocols can still be centralized at the central office and the digital signal can be recovered by direct detection at the RAUs. The DROF inherits benefits from analog ROF and is able of maintaining its dynamic range independent from the fiber's transmission length until the received signal goes below the sensitivity of the link. Other improvement presented on DROF systems is that it utilizes less transmission power to achieve the same performance of the analog ROF systems.

3. Band-pass ÄÓ-modulated DROF system:

A typical ROF system is shown in Fig. 3. However, the quality of the transmitted RF signal over the conventional analog RoF link deteriorates in proportion to the link length. Moreover, it is considerably affected by the nonlinearity of both electrical and optical components in the transmission system [4-5]. Therefore, transmission systems that prevent the signal quality deterioration and thereby enable more robust and reliable operation need to be developed.

A solution for this problem is to digitize the analog RF signal before transmission over the ROF system [6–11]. This solution is promising because the impairments of the analog ROF link are mainly due to the analog nature of the signal. Among several candidates for digitizing analog communication signals, ΔÓ modulation has recently drawn attention [8–11]. As depicted in Fig. 4, the ΔÓ modulation-based DROF system does not require a digital-to-analog converter (DAC) in RUs because the signal reconstruction is easily performed by a filter, which in turn simplifies the RU structure. This advantage is considerably enhanced as the number of RUs increases.

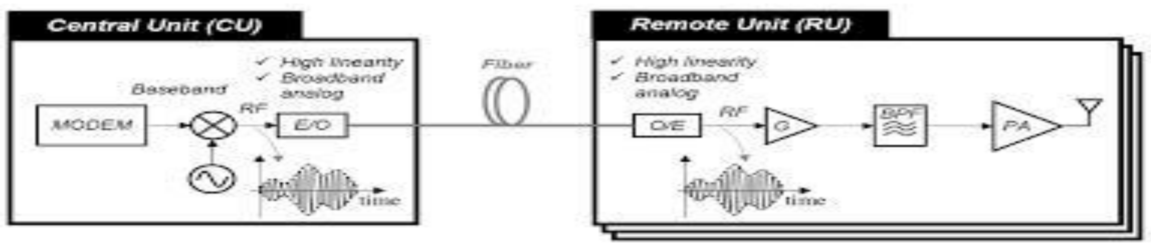

Figure 3: Block diagram of a conventional analog radio-over-fiber system.

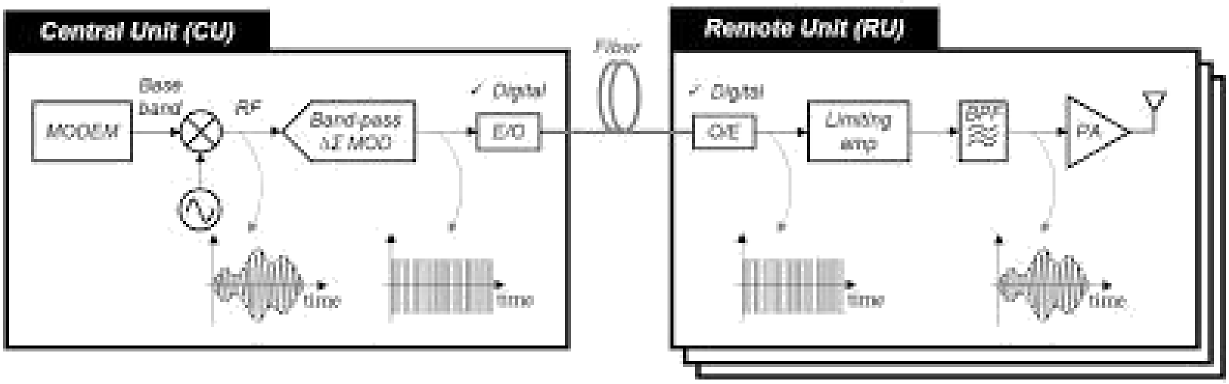

Figure 4: Block diagram of a band-pass ÄÓ-modulated DROF system.

4. N-pulse Manchester encoding ÄÓ modulated DROF system:

In Manchester coding, input bits are encoded into directional transitions, such as a low to high level, or a high to low level, at the middle of each bit period. Two conventions exist for the directions of the transitions. In this paper, the input bit of ‘0’ and ‘1’ is expressed by a high-to-low transition and a low-to-high transition, respectively, according to the IEEE 802.3 convention.

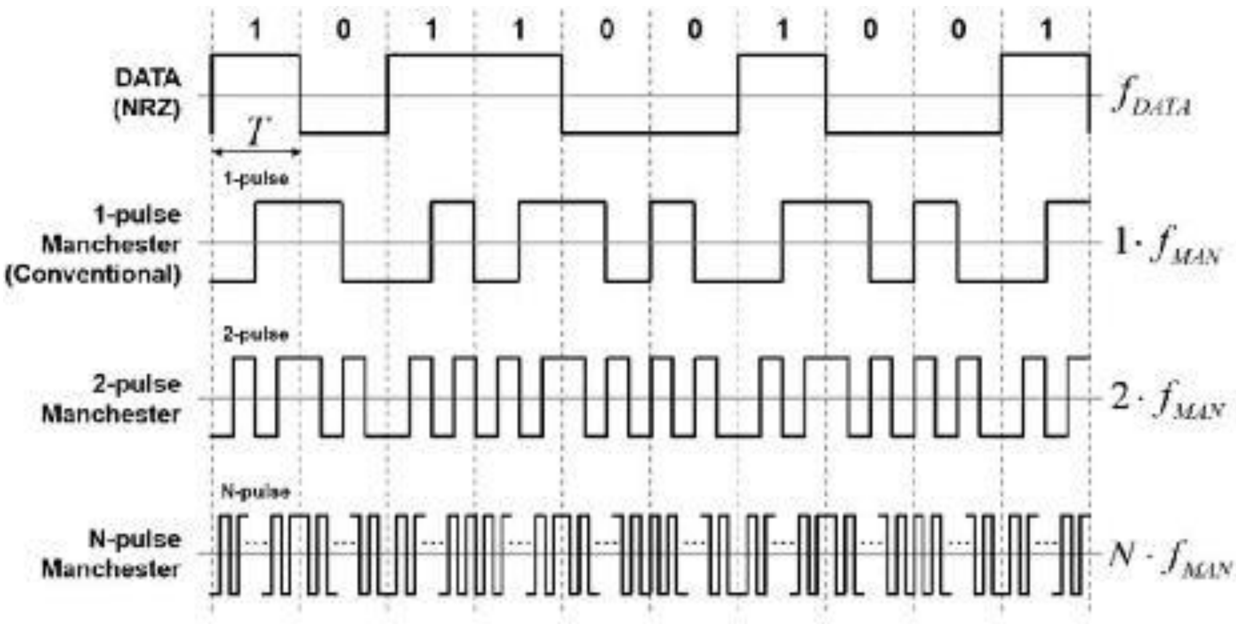

Figure 5: Examples of N -pulse Manchester encoding.

Owing to the fact that a transition always exists for each bit period regardless of the input bit, the Manchester-coded signal has no DC components; rather, it contains spectral humps at certain frequencies above DC. Because the spectrum of the digital pulse train is significantly affected by the power spectral density (PSD) shapes, replica signals at higher frequencies, rather than the fundamental in the pulse train, can experience larger amplitude gains with the Manchester coding technique. They can then be used as a transmit signal. To exploit an even higher-order replica signal for transmission, an integer multiple, N, of the Manchester pulse can be used to modulate each bit of the input pulse train, called N-pulse Manchester encoding in this paper. It enables the spectral peaks of the N-pulse Manchester encoded signal to transition to higher frequencies. Figure 5 shows the encoding principle of the N-pulse Manchester code. *fDATA* is defined as the output rate of a digital data with NRZ signaling scheme, and *fMAN* (= 2·*fDATA*) is the rate of a conventional Manchester code determined by the minimum pulse width. For the first data bit of '1' in two-pulse Manchester encoding, two consecutive Manchester '1' pulse waveforms are used for the bit encoding. In the same manner, two consecutive Manchester '0' pulses are modulated in the case of the encoding for the input bit of '0.' For the N-pulse case, N consecutive Manchester pulses are used in the encoding.

III. Proposed work

Electromagnetic Interference or Radio frequency Interference when in the radio frequency spectrum, is a disturbance generated by an external source that affects an electrical circuit by electromagnetic induction, electrostatic coupling, or conduction. The disturbance may degrade the performance of the circuit or even stop it from functioning. In the case of a data path, these effects can range from an increase in error rate to a total loss of the data. Both man-made and natural sources generate changing electrical currents and voltages that can cause EMI: ignition systems, cellular networks of mobile phones, lightning, solar flares, and auroras (Northern/Southern Lights). EMI frequently affects AM radios. It can also affect mobile phones, FM radios, and television, as well as observations for radio astronomy.EMI can be used intentionally for radio jamming, as in electronic warfare.

Attenuation of optical signal is an important consideration in the design of optical communication system. Single mode fiber is very suitable for radio over fiber, subsequently the fiber dispersion in not much countable for low frequencies (`10Ghz) up to several tens of kilometer. Attenuation is a parameter which is dependent on wavelength. Modern fibers offer as low as 0.2 dB/km loss at 1.55 µm. The optical losses (OL) including fiber attenuation and connector losses and splices loss. It can be calculated for an optical link:

$$= 2(+ \quad + \propto \quad)$$

Where NL_c is the connector loss with N connectors; ML_{sp} is the splicing loss with M splices, and á is the fiber attenuation in dB/km. The OL is very large with every time the power split can be computed as follows:

$= 2(\; + + + \propto)$ Where there are S splitters each with loss L_{split} .

Bit Error Rate may be affected by transmission channel noise, interference, distortion, bit synchronization problems, attenuation, wireless multipath fading. The BER may be improved by choosing strong signal strength or choosing a slow and robust modulation scheme. From the various studies it shows that the BER for a multimode fiber, the bit rate is more. As the length of fiber increases the pulse broadening increases and thus decreases the bit rate. Analog ROF and digital ROF links are compared and it can be concluded that BER of Digital link is less as compare to Analog link and hence has superior performance.BER of BPSK is seen to be less than QPSK and 16 QAM in Analog as well as Digital Link. BPSK stands out for its BER even though it is spectrally less efficient.

Though noise robustness of BPSK is a little higher than that of 16 QAM, but spectral efficiency 16 QAM is better choice for Digital Link. Digital Radio over Fiber shows improved performance over Analog link. Greater the data symbol modulation the more is the spectrum efficiency but less is the system robustness.

Carrier to Noise Ratio: In ROF networks Mach-Zehnder (MZ) modulators and optical amplifiers are under contemplation for a variety of applications, including antenna remoting. In these links, fiber amplifiers are used to increase the RF gain and dynamic range, and improve the noise figure. Modulator bias control in narrowband links can also be used to increase the CNR and the dynamic range. Dynamic range is improved because the bias variations do not increase the odd-order nonlinearities, which are the only ones affecting narrowband signals such as those used in 802.11a/g systems. In such a link, because the CNR improvement is maximum, if link CNR is limited by laser intensity noise or by saturation of the detector, the optical power over the fiber can be high enough to excite nonlinear effects including stimulated Brillouin scattering (SBS). SBS is a serious impairment for signals with narrow optical spectrum: it limits the power that can be transmitted on a single-mode fiber. Optical carrier by controlling the modulator bias can lead to simultaneous optimization of RF gain and suppression of SBS-induced noise. This translates into improvement of the CNR, even for SBS noise limited links, without the complexity of an additional phase modulation.

Parameter	**SCM**	**WDM**	**OFM**
Attenuation	Moderate	Low	Low
Dispersion	Chromatic & PMD	Chromatic	Chromatic
BER	Less	More	More
CNR	Less	More	More

Table1: Comparison of parameter for AROF.

Where SCM-Sub-Carrier Multiplexing, WDM-Wavelength Division Multiplexing and OFM-Optical Frequency Multiplexing

IV Conclusion

In this paper we presented a discussion related to the quality parameters of various ROF technologies. Moreover, we presented the comparison in the following Table2. N-pulse Manchester encoding ÄÓ modulated DROF system is effective technology as it is low attenuated, less BER, more CNR, low cost, low bandwidth. N-pulse Manchester encoding ÄÓ modulated DROF schemes enhance the reliability and flexibility of ROF transmission systems.

Parameters	**Analog ROF**	**Digital ROF**	**Band-pass ÄÓ-modulated DROF system**	**N-pulse Manchester encoding ÄÓ modulated DROF system**
Attenuation	Moderate	Low	Low	Low
BER	More	Less	Moderate	Less
CNR	Less	Moderate	Good	More
Cost	Medium	Low	High	Low
Bandwidth Requirements	High	High	Moderate	Low

Table 2: Comparison of parameters for ROF Technologies.

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