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Review Article

A Review on Advantages and Applications of Radio over Fiber System

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Abstract

Radio over Fiber (RoF) system uses a process in which light is modulated by radio frequency (RF) signal and then this RF signal is transmitted with the help of optical fiber. In other words, we can say that a system which is used to transfer a RF signal over a link of optical fiber is known as RoF system. RoF accommodates the large no. of users as compared to traditional wireless communication system as it utilized large bandwidth of optical fiber. With the help of RoF system signals can be transmitted in outdoor ranges as well as in densely populated areas. Nowadays, RoF seems to be an attractive system for communication because of its advantages which are explained in this review paper. Applications of RoF are also described in this paper.

Keywords: *RoF, RF, Optical Fiber, Base Station (BS), Central Office (CO).*

1. Introduction

RoF system uses the huge bandwidth of optical system for transmission. In Wireless networks, as the number of users increases, that is with the increase of spectrum demand, RoF comes out to be cost effective and flexible choice for users (Wake D *et al*, 2010, Yan Cui *et al*, 2012). Communication in RoF system is more secured than traditional wireless communication because the tapping of optical fiber is not an easy task. A basic block diagram of RoF system is shown in figure 1.

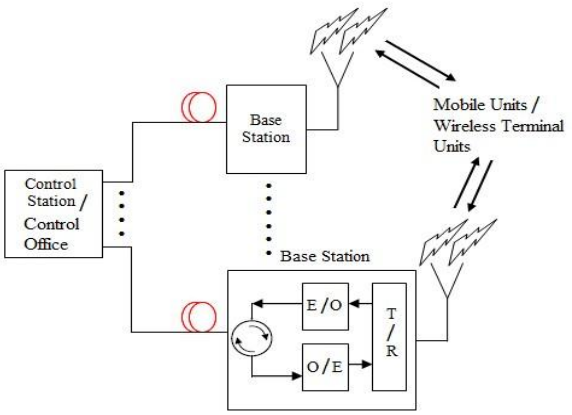

Figure 1: General RoF System

In this figure, Central Office (CO) / Control Station (CS) is used for the generation of signal. To get suitable transmission, on this Control Station the modulation as well as signal processing appears in order to build the baseband signal. Then RF Signal is transferred by the help of optical fiber link. Attenuation loss in this transferred signal is negligible. After that, this signal is detected on to the Base Station (BS). At the Base Station Unit (BSU) the operation of both the electrical to optical (E/O) and optical to electrical (O/E) conversion take place (Sze-Chun Chan *et al*, 2006). The transmission of signal between user/Mobile Unit (MU)/Wireless Terminal Unit (WTU) and BSU take place with the help of antenna which is placed at the BSU. Also BSU communicate to CS with the help of optical signal. The cost of transmission equipments (antenna and amplifiers) are get reduced. We can say that in terms of system resource management, RoF system looks a more efficient system than the conventional wireless networks (Hong Bong Kim, 2005).

2. Advantages of RoF System

RoF system has many advantages. Some of the most important advantages are discussed below.

2.1 Large Bandwidth

Theoretically, the optical fiber has unlimited bandwidth. The optical carrier frequencies are typically ~200 THz; in contrast with the microwave carries frequencies, typically ~ 1 GHz. Thus, the increase in information being transmitted over the optical fiber is ensured due to the high frequency carrier. If we take the limiting factor of 1%, the modulated carrier will

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have the bit rate of ~2 Tbps. This is a huge bandwidth which makes the optical fiber the best option in terms of bandwidth. Most of the optical systems which are deployed nowadays run at the bit rate 10 Gbps. We notice now that there is big room for improving the system bandwidth. There are two main technologies to increase the system band width:

- Wavelength Division Multiplexing (WDM)
- Optical Time Division Multiplexing (OTDM)

The best technique to efficiently improve the system capacity is WDM depending on how different channels are spaced (R. Karthikeyan *et al*, 2013; Xiupu Zhang *et al*, 2006). The functionality of remote antennas is enhanced by the implementation of RoF in WDM system (Yu-Min Lin *et al*, 2010). However since each user is assigned a separate wavelength in WDM, it reduces the spectral utilization. In OTDM, the frequency is split into different time slots which are thereafter assigned to different users.

The only thing which limits the utilization of the whole bandwidth is the nonlinear effects as well as dispersion frequently encountered in optical systems. Since the advent of EDFA, the losses which take place in optical system are no longer a problem. As well, the research is going on to find the modulation technique which may be efficient in reducing nonlinear effects and dispersion. After all, there is a hope that the whole bandwidth of the optical fiber will be once utilized provided special techniques are deployed.

2.2 Low Attenuation Loss

The distribution of RF signals in electrical form present many drawbacks like impedance rise, absorption and reflection. This is due to the nature of medium of transmission. For example, the transmission of the RF signal in free space is much affected by absorption and reflection losses which increase with frequency. Thus the transmission of high frequency signal requires robust signal regenerating equipment.

In electrical transmission lines, impedance rise takes place due to the increase of frequency. It is costly to counteract the effects of those factors mentioned above by utilizing regenerating equipment. Thus, the RoF system comes to solve those problems, simply because the optical fiber used between the CO and BS has several advantages as compared to free space and copper cable transmission media. Thereafter the signal is radiated by the antenna located at the BS up to different users. The optical fibers available in the market have very low attenuation, thus they can be used to serve the purpose of reducing the losses between CO and CS which are separated far apart. The typical example is the Corning SMF which has the attenuation of 0.2 dB/km at the operating frequency of 1550 nm.

2.3 Easy installation and Maintenance

In RoF system, Modulation and Switching equipments are installed in the CO/CS and shared by several BSs. This facility makes the installation and maintenance cost to be reduced at an appreciable level. This is in contrast with conventional wireless communication where the modulators and switching equipments are centralized at the BS. This makes the system maintenance costly in case of conventional wireless communication since many several BSs are required in order to provide sufficient coverage to different users.

2.4 Immunity to RF interference

Since the RF signal is transmitted over the optical fiber, there is no way for electromagnetic interference. This property is very attractive because it provides security and privacy. Moreover, the quality and integrity of the information are preserved since the eavesdropping is banned in optical communication.

2.5 Dynamic Resource Allocation & Opertional flexibility

It is beneficial to keep the switching and new modulation equipments at the CS since it allows to dynamically allocating the capacity. In fact, it is possible to allocate more capacity to a certain areas in peak time while reducing the capacity allocation in off-peak. The allocation of channels to different users can be made dynamically in order to ensure efficient resource management as it would be a wastage of resources to allocate the capacity to unpopulated area.

2.6 Low Power Consumption

Since complex equipment are kept at the CS, it reduces the power consumption, Thus the BS which are not active at certain point of time can be switched to passive mode in order to save the power consumption.

Beside of its advantage, Signal impairments such as noise & distortion is the main drawback of this RoF system. There may be a possibility of nonlinear effects as well as dispersion in optical fiber. We can minimize such kind of different challenges/impairments present in RoF system by developing some method or modulation techniques as a proposed solution. Research is also going on to the different kind of modulation techniques which are capable, to minimize the nonlinear effect and dispersion. Instead of this disadvantages, RoF is a reliable system for users which provides communication with minimal degradation of wireless range (Wake, D. *et al*, 2010)

3. Applications of RoF system

Due to the many advantages and quality of signal provided by RoF system, it has many applications, some most common are discussed below.

3.1 Video Distribution Systems (VDSs)

The large bandwidth provided by the RoF system is a key factor to VDs. A typical example of VDSs is the

Common-Antenna (cable) Television (CATV) networks that have used historically electrical communication techniques (Ton Koonen, 2006). The replacement of low bandwidth coaxial cables by the optical fiber provides better quality of service in terms of number of users. For instance the coaxial cable bandwidth cannot exceed 1GHz whereas the optical fiber easily exceeds this value.

3.2 Satellite Control

The control of a remote antenna located at satellite earth station can be done via optical fiber. The CO/CS can be centralized at a specific location in order to service many remote satellite earth stations. The choice of deploying the optical fiber between the CO/CS and the satellite earth station is the best choice since the satellite earth stations require high bandwidth in order to manage the efficient working of the satellites. This is a cost-effective method since it saves the number of CO/CS required.

3.3 Cellular Networks

Cellular networks have become more attractive nowadays and all mobile network service providers are deploying their resources to cope with the increase in capacity needs. Talking about the capacity, we automatically understand that the RoF system is the best option since the optical fiber relayed between CO/CS and BS has a large capacity. Therefore with increase in capacity, more services, such UMTS-based services, can be provided in the broadband network.

3.4 Vehicle Communication

The RoF system can be to control the traffic of vehicle by deploying several BSs along the roads. These BSs communicate with the vehicles moving in the road via the microwave signal while the BSs are connected to the centralized CO/CS. Due to the tracking of fast moving vehicles, the high frequency signal is a necessity. Thus the RoF system is well suited for this purpose.

3.5 Wireless LANs (WLAN)

The current WLAN provides maximum capacity of 11 Mbps per carrier. The next generation capacity is expected to provide 54 Mbps which requires the high frequency carrier. The RoF system come as a solution in this regard since copper cables have shown to be inefficient at higher frequencies.

3.6 Mobile Broadband Services

The fast growing of the mobile broadband services requires definitely large bandwidth. The typical example is the 4G services which use the bit rate in several MBs. Thus, the RoF system is the best choice to deal with the need of large bandwidth to support more users. Moreover, The RoF will help to provide good quality signal as the losses, reflection and other impairments are minimized.

Conclusion

Nowadays, RoF communication system has drawn much attention. In this review paper we described main advantages along with applications of RoF system. Large bandwidth, low attenuation loss, easy installation & maintenance, immunity to RF interface, dynamic resource allocation & operation flexibility and low power consumption are the main advantages of RoF system. RoF mainly used in some applications like in Video Distribution systems, Satellite Control, Cellular networks, vehicle communication, Wireless LANs and Mobile Broadband Services. Thus optical fiber has huge bandwidth and less attenuation losses which make it to be more attractive than coaxial cables and conventional wireless transmission. Research is still going on to minimize its drawbacks. Beside of its disadvantages still RoF is a reliable transmission system for users than the traditional wireless communication system.

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