

A REVIEW ON RADIO OVER FIBER TECHNOLOGY

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ABSTRACT

Radio over Fiber technology (RoF), an integration of wireless and optical systems is a promising solution for increasing the capacity and mobility of the access network cost effectively. RoF has the potentiality to the backbone of the wireless access network and it has gained significant momentum in the last decade as a potential last-mile access scheme. This paper gives the brief introduction of radio over fiber technology used in communication system. In these paper quality parameters, optical transport schemes for wireless signals, advantages and limitations of the RoF technology are discussed. Some transmission techniques for generating and transporting radio signal over fiber are also explained in this review paper.

Keywords: RoF Technology, IFOF, BBOF, Wireless, Bandwidth.

I INTRODUCTION

Next-Generation access networks are driving the convergence of wired and wireless services to offer end users greater choice, convenience, and a variety of ultrahigh bandwidth services in a cost-efficient way. The drastic increase in the demand for higher capacity and data rate, and the increased availability of affordable broadband technologies has encouraged the deployment of optical fiber technologies in fixed-line access networks due to the low loss and large bandwidth of an optical fiber and the guarantee of mobility. Broadband and low loss capability of transmission over fiber link has led to an increasing interest in Radio-over-Fiber (RoF) systems. Therefore, the RoF system, the integration of microwave and optical networks is a promising means of reducing the overall cost and increasing coverage of a wireless access network owing to its nearly unlimited bandwidth and extremely low propagation loss. Fig. 1 illustrates the basic architecture of RoF system.

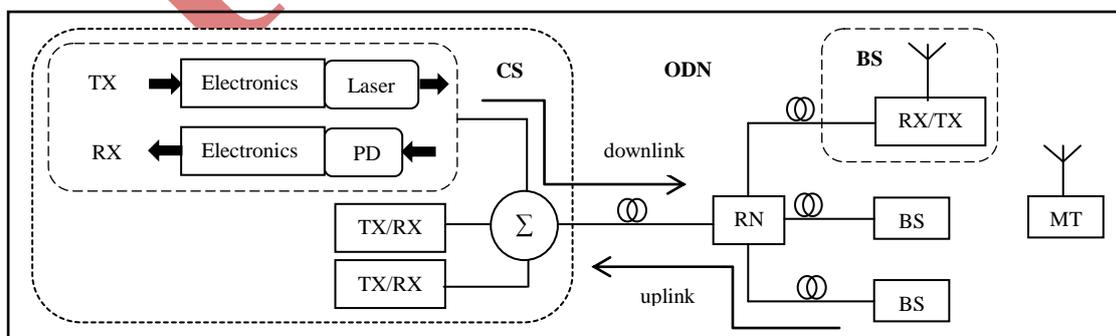


Figure 1. Basic RoF system architecture presenting Central Station (CS), Remote Node (RN), Optical Distribution Network (ODN), and Base Stations (BS).

RoF technology entails the use of optical fiber links to distribute RF signals from a central location (headend) to Remote Antenna Units (RAUs). RoF systems centralize the RF signal processing functions such as switching, routing and network operations administration maintenance (OAM) in one shared location (headend), and use optical fiber link, which offers low signal loss (0.3 dB/km for 1550 nm, and 0.5 dB/km for 1310 nm wavelengths) to distribute the RF signals to the RAUs or BSs as shown in Fig. 1. The main function of BS is to realize optical/electrical conversion and broadcasting by antenna. The centralization of RF signal processing functions enables equipment sharing, dynamic allocation of resources, simplified system operation and maintenance [1]. Such a network can give several advantages such as low RF power RAUs, frequency reuse, better coverage, high capacity, high quality signal as well as low fiber attenuation. These benefits make RoF as an attractive technology for many different signal radio applications especially in mobile communication system [2].

II QUALITY PARAMETER

2.1 Attenuation

Attenuation of optical signal is a significant consideration in the design of optical communication system. Single mode fiber (SMF) is very appropriate for RoF, subsequently the fiber dispersion is not much countable for low frequencies (10 GHz) 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 for an optical link can be calculated as

$$OL = 2(NL_c + ML_{sp} + \alpha L_f) \text{ dB} \quad (1)$$

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

$$OL = 2(NL_c + ML_{sp} + SL_{split} + \alpha L_f) \text{ dB} \quad (2)$$

Where, S is the number of splitters each with loss L_{split} .

2.2 Scattering

One of the most intense nonlinear impairments is Stimulated Brillouin Scattering (SBS). If the input power into a fiber reaches a critical value known as the SBS threshold (SBST), both the amount of backscattered optical power and generated noise rapidly increases with the input power. Thus, SBS imposes limitations on the amount of optical power that can be launched into the fiber without degrading the signal quality. Recently, there have been several investigations on PON systems for radio signal distribution that target applications like WiMax service distribution and 3G cellular, with SBS being the major limiting factor. The SBS in ROF transmission can be strongly suppressed with the proper choice of a segmented SMF.

2.3 Dispersion

RoF that builds broadband wireless and wired connectivity has become a favorable application area for analog optical links. As in this frequency band employed moving to the microwave and millimeter-wave (mm-wave)

bands, the performance will be distinctly degraded by the chromatic distance especially for increased distance. Chromatic dispersion compensation scheme using parallel electro-optic phase and intensity modulators is appropriate for long-reach RoF links. By properly adjusting the time delay and optical power between the two modulated signals, the power fading caused by the dispersion adequately compensated over a vast operating bandwidth of 0–18 GHz over a 34- km SMF. Optical Fiber is optimized for reduced chromatic dispersion so that pulse spreading is kept minimum and then used in the proposed system.

2.4 Bit Error Rate

Impairments such as interference, transmission channel noise, attenuation, distortion, wireless multipath fading and bit synchronization problems may influence bit error rate (BER). Strong signal strength or a slow and robust modulation scheme improves BER. From the various studies it shows that the BER for a multimode fiber, the bit rate is more. As the length of the fiber increases the pulse broadening increases and thus decreases the bit rate. Comparison of Analog ROF and digital ROF links concludes that BER of Digital link is less as compare to Analog link and hence has superior performance. BER of BPSK is less than QPSK and 16 QAM in analog as well as in digital link. BPSK stands out for its BER although 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 preferred choice for digital link. Digital RoF offers improved performance over analog link. Greater the data symbol modulation the more is the spectrum efficiency but less is the system robustness.

2.5 Carrier to Noise Ratio

In ROF networks optical amplifiers and Mach-Zehnder (MZ) modulators are under consideration for a variety of applications, including antenna remoting. In these links, fiber amplifiers are used to widen the dynamic range and RF gain and thus improve the noise figure. Modulator bias control in narrowband links can also be used to increase the dynamic range and the carrier-to-noise ratio (CNR). 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 CN improvement is maximum, if link CNR is limited by saturation of the detector or by laser intensity noise, the optical power over the fiber can be high enough to excite nonlinear effects including SBS. SBS is a significant impairment for signals with narrow optical spectrum that restricts the power to be transmitted through SMF. By controlling the modulator bias, optical carrier can cause to suppression of SBS-induced noise and simultaneous optimization of RF gain. This improves CNR, even for SBS noise limited links, with no complexity of an additional phase modulation.

III OPTICAL TRANSPORT SCHEMES FOR WIRELESS SIGNALS

Recently many researchers have been carried out on the development and exploitation of optically-fed wireless technologies, with prior work focusing on fiber link arrangements for wireless signal allocations. Usually there are three possible approaches to transport the mm-wave signals over the optical link as shown in Fig. 2. Choosing the optical transport scheme will also determine the hardware required in the CO and antenna BS. The optical transport schemes for wireless signals are briefly discussed below.

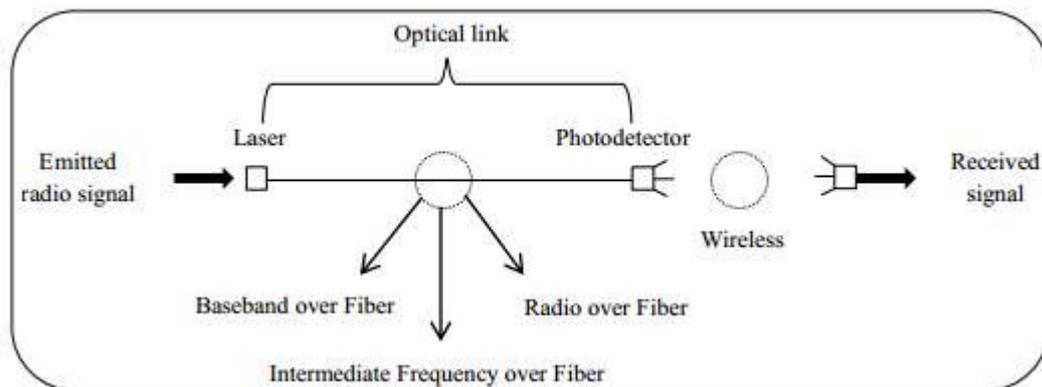


Figure 2. The RoF Principle

3.1 RF-Over-Fiber

The simplest strategy for transporting mm-wave signals through an optical fiber feed system is to directly transport the signals over fiber (RF-over-fiber) without any requirement for frequency translation at the remote BS. In this arrangement, the wireless signals are externally modulated onto the optical carrier resulting in an optical double sideband (ODSB) signal. These two sidebands are placed at the wireless carrier frequency apart from the optical carrier. At the BS, the signals can be retrieved by direct detection using a high-speed photo detector. This transport scheme has the advantage of perceiving simple BS designs with supplementary benefits such as enabling multi-wireless band operation, independence of the air-interface and also centralized control. Although one of its significant drawback is the requirement for high-speed optical modulation techniques that have the ability to generate mm-wave modulated optical signals and also high speed photo detection schemes that directly convert the modulated optical signals back to mm-wave signals in the RF domain. The remarkable effect of fiber chromatic dispersion on the detected wireless signals is another major issue.

3.2 IF-Over-Fiber

Instead of transmitting mm-wave signals over fiber, the signals can be down converted to a lower intermediate frequency (IF) at the CO before optical transmission. This significantly reduces the effects of fiber chromatic dispersion on the optical distribution of IF signals. Moreover IF-over-fiber transport scheme has the benefit of using low speed optoelectronic devices. Though the IF signal transport scheme for mm-wave wireless access systems increases the complexity of the antenna BS hardware, this requires a stable mm-wave local oscillator (LO) and high-speed mixers for the frequency translation processes in the BS. This may cause a drawback when considering the potential to improve or reconfigure the wireless network for the inclusion of additional wireless channels or modification to the wireless frequency. The next requirement for mm-wave LO at the antenna BS can be overcome by remotely transmitting the LO signal optically from the CO. This also permit centralized control of the LO signals themselves.

3.3 Baseband-Over-Fiber

The third transport scheme delivers the wireless signal as a baseband signal over fiber and up-converts the information to the required radio frequency at the antenna BS. This strategy provides the benefit of using mature digital and electronic circuitry at the BS for signal processing. Additionally, it also permits the use of low-speed optoelectronic devices within the BS. IF-over-fiber scheme significantly reduces the effects of fiber chromatic dispersion. Further the need of a physical LO in the BS can be overcome by remotely transmitting mm-wave LO signal from the CO. This transport scheme depends on the air-interface which signifies that the BS must have the perception to completely process the wireless signals before sending the baseband information back to the CO. Therefore it allows the additional hardware within the BS to perform the tasks which extremely increases complexity of the BS. With the modern developments in CMOS technology, high-frequency radio-on-chip has been illustrated. Moreover, the emergence of silicon photonic technology may facilitate the future low-cost integration of electronic and optoelectronic devices to achieve a cost-effective, compact transceiver module in the antenna BS.

IV TRANSMISSION TECHNIQUES FOR RoF TECHNOLOGY

There are several optical techniques for generating and transporting radio signals over fiber. Some of these techniques are briefly discussed in this section.

4.1 Direct Modulation Technique

The simplest and low cost method for optically distributing RF signals is to directly modulate the intensity of the light source with the RF signal and then use direct detection at the photo detector (PD) to recover the RF signal. It is referred to as intensity-modulation direct-detection (IMDD) [3]. The RF signal must be appropriately pre-modulated with data prior to transmission. After transmission through the fiber and direct detection on a PD, the photocurrent is a replica of the modulating RF signal applied directly at the headend [1]. Subsequently, at the remote antenna site, the PD and band-pass amplifier convert the received optical signal to a RF signal to be radiated by the antenna.

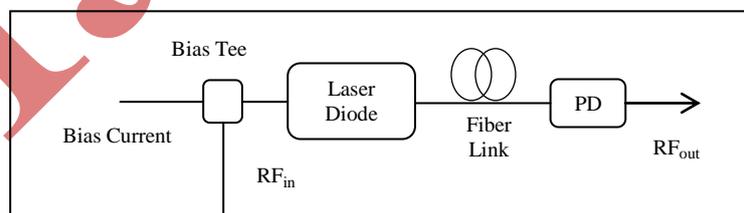


Figure 3. Radio signal generation based on direct intensity modulation method by laser.

The main advantage of this method is that it is simple, robust and low cost. Secondly, the system becomes linear if low dispersion fiber is used together with a (linearised) external modulator. Consequently, the optical link acts only as an amplifier or attenuator and is therefore transparent to the modulation format of the RF signal. Such a

system needs little or no upgrade whenever changes in the modulation format of the RF signal occur [1]. The transmitter configuration is extremely simple and cost effective but its performance is severely limited by the laser modulation impairments. The frequency chirp, significant non-linearities and high RIN cause poor frequency stability and transmission integrity. In terms of the energy consumption, although a priori it is low because a single component is used, the low capacity makes the consumption per bit ratio (Joules per bit) quite high [10]. RoF systems using direct microwave intensity modulation of a laser diode are commercially available up to limited radio frequencies (up to about 2 GHz, for wireless services such as GSM and UMTS). Therefore, the major drawback of this technique is that the operation at higher microwave frequencies is prohibited by the restricted modulation bandwidth of the laser diode and by the fiber dispersion, which causes fading of the two modulation sidebands. Such microwave frequencies may only be handled by sophisticated very high frequency optical analog transmitters and receivers, and careful fiber dispersion compensation techniques [5]. Another disadvantage of this technique is the changing of the wavelength with the laser bias current. This chirp of the resulting pulses, where the carrier frequency of the transmitted pulses changes with time, produces a broadening of the optical spectrum relative to the bandwidth and possesses very poor dispersion limits. Serious degradation of the system will appear if the operating wavelength does not lie close to the zero-dispersion wavelength [6]. The simplicity of direct modulation of semiconductor lasers has proved attractive for many applications and following early work on modulation characteristics. Rapid progress has been made in reducing electrical parasitics of laser structures and optimizing laser parameters for high-speed operation [7]. Applications of direct analogue laser modulation include cable TV, base station links for mobile communication, and remote antenna.

4.2 External Modulation Technique

In order to overcome the impairments of the direct modulation, external modulation is the straightforward solution. At higher radio frequencies, say, above 10 GHz, the external modulation is often used instead of the direct modulation. Of all schemes, an optical external modulation technique is a good option to generate optical mm-wave signal with high spectral purity. The simplest implementation consists of a Continuous Wave laser followed by an external modulator that modulates the laser light with an IF or an mm-wave tone [10]. In external modulation the operation of the laser in CW mode avoids the excessive chirp of the pulses. This method uses high speed external modulators, such as the Mach-Zehnder modulators (MZM) or electro-absorption modulators (EAM) or a Phase Modulator (PM), whose output is optically filtered.

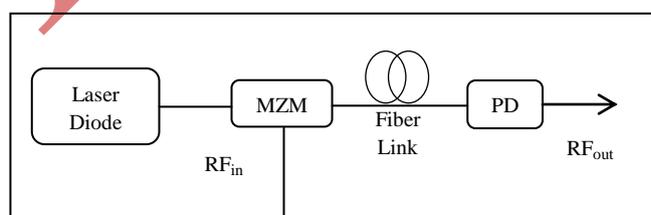


Figure 4. Microwave signal generation based on external modulation using a Mach-Zehnder modulator

There are two approaches to generate mm-waves signals are briefly discussed as:

4.2.1. Intensity-Modulation-Based Approach

The significance of this technique is that no tunable optical filter is required, which simplifies greatly the system implementation. The system consists of a MZM that is biased at the maximum transmission point of the transfer function to suppress the odd-order optical sidebands. A wavelength-fixed notch filter is then used to filter out the optical carrier. A stable and low phase noise mm-wave signal having frequency four times that of the RF drive signal is generated at the output of the PD. In order to suppress the odd-order or even-order optical sidebands, the MZM should be biased at the minimum or maximum point of the transfer function, which would cause the bias-drifting problem, leading to poor system robustness, or have to employ sophisticated control circuit to minimize the bias-drift.

4.2.2 Phase-Modulation-Based Approach

A simple solution to the problem in Intensity-Modulation based approach is to replace the MZM by an optical phase modulator. The key advantage of using an optical phase modulator is that no DC bias is required, which eliminates the bias drifting problem [8]. The limitation of the above techniques is that an ultra-narrowband optical filter is required, which causes poor system stability and high cost. To avoid using an ultra-narrowband optical filter, a technique based on two cascaded MZMs and a tunable electrical phase shifter for frequency quadrupling was proposed recently.

External modulators can operate with bandwidths of up to 40 GHz and bit rates of more than 10 Gbps, which makes them particularly attractive for long-haul optical communication networks [6]. While external modulators are simple, they present certain disadvantages such as significant insertion loss. Moreover, the method of external modulation suffers from distortion due to the intrinsic nonlinearity of the modulators, high power consumption, and complexity. Of course, this modulation system is more expensive than the direct modulation. To support high frequency RF signals, the MZM requires high drive voltages, which makes use of costly drive amplifiers necessary. Moreover, inherent static and dynamic non-linearity of the external modulator has to be compensated, which makes the system more complex.

4.3 Heterodyne Modulation Technique

In optical heterodyning technique, two or more optical signals are simultaneously transmitted and are heterodyned in the receiver. One or more of the heterodyning products is the required RF signal. The optical intensity-modulated signal from a LD is subsequently modulated by an external modulator which is biased at its inflexion point of the modulation characteristic and driven by a sinusoidal signal at half the microwave frequency. Thus, a two-tone optical signal emerges at the modulator output, with a tone spacing equal to the microwave frequency. The desired amplitude modulated microwave signal is generated after heterodyning. The transmitter may also use multiple LDs, and thus a multi-wavelength RoF system can be realized with a tunable WDM filter to select the desired wavelength radio channel at the antenna site [5]. As phase noise is a major

problem in mm-wave transmission, care must be taken to produce a small phase noise only by the heterodyned signals. This can be achieved if the two or more optical signals are phase coherent and if the different frequency optical signals are somehow deduced from a common source or they are phase-locked to one master source. This approach overcomes chromatic dispersion effect and also offers flexibility in frequency since frequencies from some megahertz up to the terahertz region is possible [3].

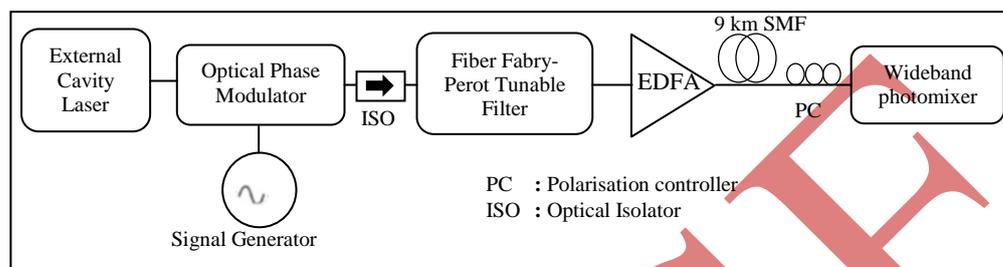


Figure 5. Remote Heterodyning by using a filter.

Using optical heterodyning, very high frequencies can be generated, limited only by the PD bandwidth. Moreover, heterodyning yields high-detected power and higher CNR, because the optical powers of the two optical fields contribute to the power of the generated microwave signal. Heterodyning has an inherent advantage concerning chromatic dispersion. System sensitivity to chromatic dispersion can be reduced greatly, if only one of the two optical carriers is modulated with data. Heterodyne detection permits low-frequency data modulation at the headend since high frequency electro-optical components are not required. Another important attribute of optical heterodyning is that it is capable of producing signals with 100% intensity modulation depth. Other benefits of this technique include photonic signal processing and radio system function capabilities such as phase control, filtering, and frequency conversion. The major drawback of heterodyne detection is the strong influence of laser phase noise and optical frequency variations on the purity and stability of the generated RF carriers [1]. Since semiconductor lasers have large spectral widths, extra measures to reduce the linewidth of the generated RF signals have to be taken, which lead to more complex systems.

4.4 Optical Frequency/Phase Locked-Loops

Optical frequency/phase locked loop (OFLL/OPLL) technique is used to reduce phase noise sensitivity. (OFLL/OPLL) strives to maintain the required mean frequency offset. It does not suppress small-scale frequency variations caused by phase noise and are also able to track small scale phase perturbations. The basic configuration of OFLL/OPLL techniques is shown in Fig 6. It consists of a free running master laser, a slave laser, a PIN photodiode, a frequency or phase detector, an amplifier, a loop filter, and a microwave reference oscillator. The combined outputs of the master and slave lasers are split into two parts; one is used in the OPLL/OFLL at the headend while the other part is transmitted to the RAU. To generate a microwave signal, the optical signal at the headend is heterodyned on a PD. This generated signal is then compared to the reference signal. A frequency error signal in the case of the OFLL (and a phase error signal in the case of OPLL) is fed

back to the slave laser [1]. Hence, the slave laser is forced to track the master laser at a frequency offset corresponding to the frequency of the microwave reference oscillator.

The main advantage of this technique is that it is capable of producing high quality RF signals with narrow linewidth and also has good temperature tracking capabilities. In addition, OPLLs exhibit a wide locking range [9]. On the other hand, OFLL techniques have the advantage that they can be realized with standard and fairly inexpensive DFB lasers.

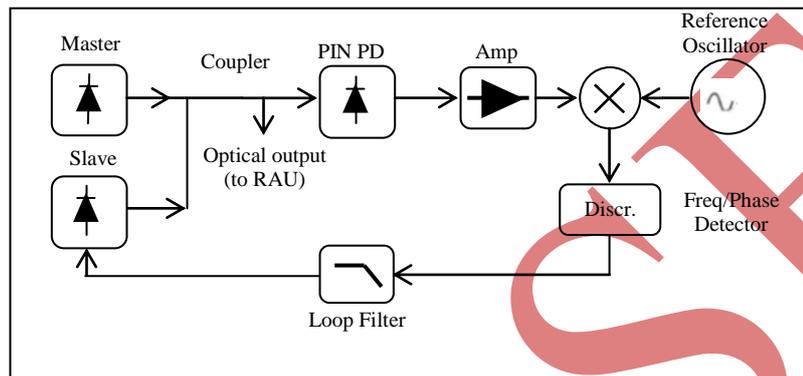


Figure 6. Principle of Optical Frequency-/Phase-Locked Loop

The main disadvantage of OFLL techniques is that they generate microwave signals with broad linewidths. The linewidth of the signal generated by the OFLL system is roughly the sum of the linewidths of the lasers. Therefore, in order to produce narrow linewidth microwave signals using OFLL, lasers with narrow linewidths are necessary. However reducing the source linewidth reduces the maximum power that can be transmitted in the fiber. The major drawback of OPLLs is that they require far more complex laser structures such as 3-contact DFBs.

4.5 Dual Mode Lasers

The major drawback of optical heterodyning-based techniques is the sensitivity to phase noise of the two heterodyning signals, and the dependence of the RF beat signal on the polarization state difference of the two heterodyning carriers. One way to achieve correlation of optical modes is to remove the phase shift in the DFB laser so that no oscillation occurs at the Bragg frequency which result in a device called the dual mode laser (DML) as it emits two modes; one on either side of the Bragg frequency [9]. By tuning the grating strength coefficient, the required mode separation can be obtained. A dual mode laser designed to test the viability of this technique showed that in order to generate a pure mm-wave, direct electrical injection at a sub-harmonic of the beat frequency was still needed. The main advantage of this approach is that it does not require complex feedback circuitry. However, because of narrow locking range, this method has limitations regarding tenability.

V ADVANTAGES

The most significant figures of merit of the different ROF subsystems; namely the BS, the ODN and the CS must be taken into account for overall performance assessment and integral system design to satisfy the network requirements. These figures of merit are briefly discussed as:

5.1 Easy Installation and Maintenance

Various cost effective system models have been proposed to establish the directions and design principle for the network operation efficiency. For a ROF system, the goal of reducing capital and operational expenses of the system includes the selection of the appropriate technologies for each subsystem. At the CS high frequency electro-optical modulators and electronics must be avoided due to their high price and power consumption. Similarly complicated implementations of downlink transmission techniques are also avoided due to their high manufacturing and maintenance costs. For the next generation of ODN, integration of optical segments into hybrid solutions (fiber sharing) is a major factor as it allows cost reductions. For making BSs simpler in ROF systems, complicated and costly equipment are kept at the headend. Modulation and switching functions are performed in the CS and then shared by several BSs, this leads to smaller and lighter BSs, which effectively reduce system installation and maintenance costs as well as reduced environmental impact. Easy installation and low maintenance costs of BSs are very significant demand for ROF systems, because elevated numbers of BSs are required. Simplicity of the BSs drives the reduction of price associated with energy consumption, site leasing and site acquisition. Therefore, the increasing demand for new services in current cellular system will lead ROF systems to support different traffic characteristics. Hence, a suitable pricing scheme must be selected that allow service providers to assure the uninterrupted quality of service provisioning and simultaneously to be economically survivable.

5.2 Large Bandwidth

The availability of low dispersion (or dispersion shifted) fiber, the Erbium Doped Fiber Amplifier (EDFA) for the 1550 nm window, and the use of advanced multiplex techniques namely Optical Time Division Multiplexing (OTDM) in combination with Dense Wavelength Division Multiplex (DWDM) techniques are the major driving factors towards unlocking more and more bandwidth out of the optical fiber. The high optical bandwidth allows high speed signal processing which is just impossible to do in electronic systems. Thus, some demanding microwave functions such as filtering, mixing, up-conversion and down-conversion can be easily executed in the optical domain. Besides, it becomes possible to use cheaper low bandwidth optical components such as modulators and laser diodes when processing is done in optical domain and still easily handles high bandwidth signals. The limitation in bandwidth of electronic systems which are the primary sources and receivers of transmission data seriously hinders the exploitation of the enormous bandwidth offered by optical fibers; such problem is referred as “electronic bottleneck” and can be solved by effective multiplexing. Digital optical systems use OTDM and DWDM techniques. SCM technique is used in analogue optical systems including ROF technology in order to increase optical fiber bandwidth utilization [10].

5.3 Low Attenuation Loss

Either through transmission lines or in free space, electrical distribution of high-frequency microwave signals is problematic and expensive. Losses due to absorption and reflection in free space increase with frequency, whereas in transmission line, impedance rises with frequency and leads to very high losses. Hence, expensive regenerating equipment is required for electrically distributing high frequency radio signals over long distances. Distribution of mm-waves through the transmission lines is not feasible even for short distances. Therefore, distribution of baseband signals or signals at low IF from the CS to the BS is an alternative solution to this problem. At each BS, the baseband or IF signals are up-converted to the required mm-wave frequency, amplified and then radiated. Since, for up-conversion at each BS, high performance LOs would be required which leads to complex BS with tight performance requirements. However, RoF technology can be used to achieve both low-loss distribution of RF signal and simplification of BS at the same time, since optical fiber offers very low loss. Hence, comparing to electrical distribution of RF signal either in free space or transmission lines, transmission distances are increased several time by transmitting RF in the optical form and the required transmission power reduces greatly.

5.4 Reduced Power Consumption

The power consumption of a system is one of the important figures of merit that can be expressed by the power consumption per user versus the average access rate (Watts/Mbps). The energy efficiency of a system can also be measured as the energy consumed per bit of data transferred (Joules per bit). The power consumption of an access network infrastructure is designed on the basis of network segmentation. The energy consumption of each part of the system for a range of access rates is computed using manufacturer's data on equipment energy consumption for a range of typical types of hardware. To predict the rise in power consumption because the number of users and access rate per user is increasing rapidly, this perspective provides a better platform. For a ROF system, the power efficiency should account for both optoelectronic and electrical components in the CS. With less offering, most of the power consumption of optoelectronic components is required in the amplifier's pump lasers and transmission lasers of an active ODN, and also in the electronic components at the RNs that perform the control and management functions. Power consumption of the BSs is of special importance, since the large numbers of BSs are needed to cover a service area. Since, BS accounts for up to 70% of the total power consumption in commercial cellular systems, therefore BS design has the most opportunities for saving energy. In ROF, the power consumption model for BS includes the mm-wave frequency to be radiated, the expected cell coverage or transmitting power and the transmission schemes for uplink and downlink. The BS power consumption varies depending on the transmitting power and traffic load, the higher is the traffic or transmitting power, higher power will be consumed by the BS [10].

5.5 Dynamic Resource Allocation

It is possible to dynamically allocate peak times capacity; since modulation, switching and other RF functions are performed at a centralized headend. For example more capacity can be allocated to an area (e.g. shopping mall) during and then re-allocated to other areas (e.g. to populated residential areas in the evenings) when off-

peak in a ROF distribution system for GSM traffic. This can be attained by allocating optical wavelengths through WDM technique whenever needed. Dynamic capacity allocation obviates the requirement for allocating permanent capacity, which would be a waste of resources where traffic loads vary frequently. Moreover, the centralized headend enables other signal processing functions such as macro diversity transmission and mobility functions.

VII DISADVANTAGES

As RoF involves analogue modulation as well as detection of light, it is fundamentally an analogue transmission system. Thus, signal impairments such as distortion and noise limit the Dynamic Range (DR) and Noise Figure (NF) of the RoF links. DR is a very significant parameter for wireless communication systems such as WLAN and GSM because the received power at the BS from the MUs varies widely (e.g. 80 dB). That is, the RF power received from a MU which is close to the BS can be much higher than the RF power received from a MU which is several kilometers away from the BS, but within the same cell.

The noise sources in analogue optical fiber links include the laser phase noise, the amplifier's thermal noise, laser's Relative Intensity Noise (RIN), the fiber's dispersion, and the photodiode's shot noise. In SMF based RoF systems, chromatic dispersion may limit the fiber link lengths and also cause phase de-correlation which leads to increased RF carrier phase noise. In Multi-Mode Fiber (MMF) based RoF systems, modal dispersion strictly limits the available link bandwidth and distance. However the RoF transmission system itself is analogue so the radio system being distributed need not to be analogue, but it may be digital (e.g. UMTS, WLAN) that use comprehensive multi-level signal modulation formats such as Orthogonal Frequency Division Multiplexing (OFDM) or xQAM [1].

VIII CONCLUSION

In this paper the review of the ROF technology has been explained in which some techniques for implementation of RoF technology are also explained. The main advantages of the ROF technology are low attenuation loss, large bandwidth and easy installation and maintenance. The main drawback of the ROF technology is signal impairments such as noise and distortion which should be eliminated in the future. We conclude in this paper that RoF is a flexible and cost effective technique that enables multiple functionalities required for the support of wireless access systems. Assistance of RoF technique is reducing the attenuation, dispersion, scattering, can improve bit error rate and bandwidth. Additionally, RoF techniques are smoothly merged with broadband access optical networks allowing a flexible convergence of high capacity optical fiber and wireless access flexibility, which increases the total power and minimize the losses. This area offers enormous opportunities for basic and applied research and development in the near future focusing on increasing the bit rate and reducing the effect of impairments. The field is therefore in need for a thorough assessment of its current state.

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