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Radio over Fibre for Wireless Access

Ms. Heena Bhalla, Prof. Dinesh

ECE Department, MRIU, Faridabad
Er.heenabhalla@yahoo.com, dinesharma07@gmail.com

Abstract— **Radio over Fibre technology (RoF), is a technology where the light modulated by a radio signal and then passed through the optical fibre. This technology can be used in wireless communication. There is a optical link between the base station and control station and a wireless link between the base station and mobile station. Previously the link between the BS and CS were coaxial cable which have been replaced by optical fibre as it offers many advantages like low loss, high bandwidth, small size, low cost. In this work we have calculated the CNR for the Rof system as a function of received power and oscillator linewidth and CNR as a function of laser linewidth and transmission distance using MATLAB SOFTWARE.**

I. INTRODUCTION

A RoF system entails the use of optical fibre links to distribute RF signals from a central CS to BS. In narrowband communication systems and WLANs, RF signal processing functions such as frequency up-conversion, carrier modulation, and multiplexing, are performed at the BS, and immediately fed into the antenna. RoF makes it possible to centralize the RF signal processing functions in one shared location (CS), and then to use optical fiber, 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 BSs, as shown in Fig. 1. By doing so, BSs are simplified significantly, as they only need to perform opto-electric conversion and amplification functions. The centralization of RF signal processing functions enables equipment sharing, dynamic allocation of resources, and simplified system operation and maintenance.[6]

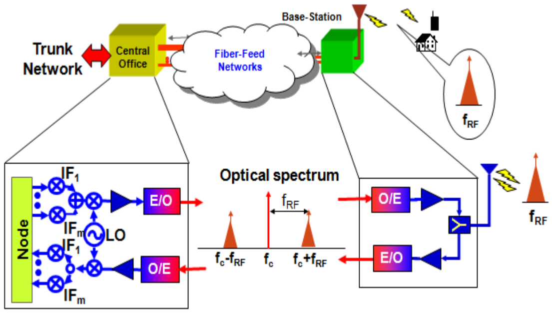

fig 1 General Radio over Fibre System[6]

II. ROF SIGNAL MODULATION FORMATS

The simplest method for optically distributing RF signals is simply to directly modulate the intensity of the light source with the RF signal itself and then to use direct detection at the photodetector to recover the RF signal. This method falls under the IM-DD.. There are two ways of modulating the light source. One way is to let the RF signal directly modulate the laser diode's current. The second option is to operate the laser in continuous wave (CW) mode and then use an external modulator such as the Mach-Zehnder Modulator (MZM), to modulate the intensity of the light.

A. EXTERNAL MODULATION TECHNIQUE

Despite its simplicity compared to the external modulation, the direct intensity modulation is not appropriate to millimeter wave bands [7] The external modulation is used instead of the direct modulation . [8]This method uses high speed external modulators such as the MZM or EAM .[9] An EAM can be easily integrated with a laser source while requiring lower drive electrical power compared to MZM. While external modulators configurations are simple, they present certain disadvantages such as significant insertion loss. Moreover, the effect of fiber chromatic dispersion is increased with such components.

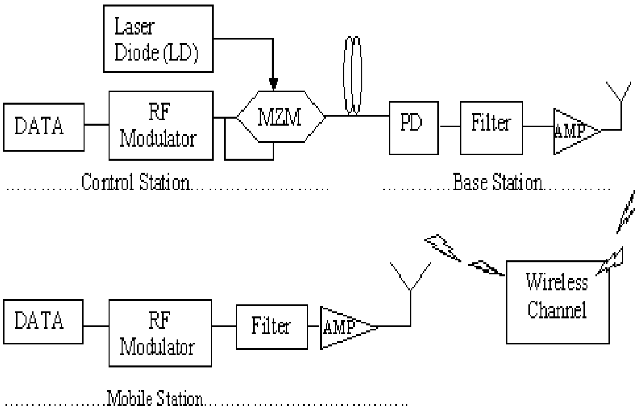

Fig 2 Rof system with external modulation technique[8]

B. OPTICAL HETERODYNING TECHNIQUE[1]

Since RoF transmission systems, based on external modulation, are limited by the fiber chromatic dispersion phenomenon, other methods have been developed for optical generation of millimeter-wave signals. For example, in the optical heterodyning technique, using two laser diodes can optically generate millimeter-wave carriers with higher performances. Their two optical output signals are both transmitted through an optical fiber. The instantaneous frequency deviation between the two transported optical waves corresponds to the desired RF frequency. As a consequence, their beating at the reception photodiode is susceptible to generate a very pure RF signal, with a low-phase noise In the optical transmitter, the light is spilt and sent along two routes. The light along route 1 is SSB modulated by broadcasting signals. The light along route 2 is frequency-shifted by 40 GHz. After being amplified with EDFAs, both lights are combined and transmitted to the relay point and FTTH networks. At the relay point, an optical receiver generates millimeter-wave signals by optical heterodyne detection and radiates it to subscribers.

II STIMULATION RESULTS

The first result sketched in Fig 3 with Table 1 represents CNR penalty with respect to two parameters:
Percentage of received power (p)
RF oscillator linewidth (Yo) in Hz

Parameters	Value
Fiber dispersion	17 ps/nm-km
Optical transmission distance	10 km
RF carrier frequency	30 GHz
Wavelength of LD	1550 nm
Half power bandwidth filter	0.5
RF oscillator linewidth	0.1 to 20 Hz
Percentage of received power	0.1 to 0.99

Table 1 the Simulation Parameters for CNR penalty as a function of the RF oscillator linewidth and percentage of received power

The linewidth of the RF oscillator has been swept from 0.1 to 20 Hz. usually; the linewidth of the RF oscillator is less than 1 Hz. However, the RF oscillator linewidth, over 1 Hz is investigated as a practically cost-aware RF oscillator. From Fig 3, it is found that:

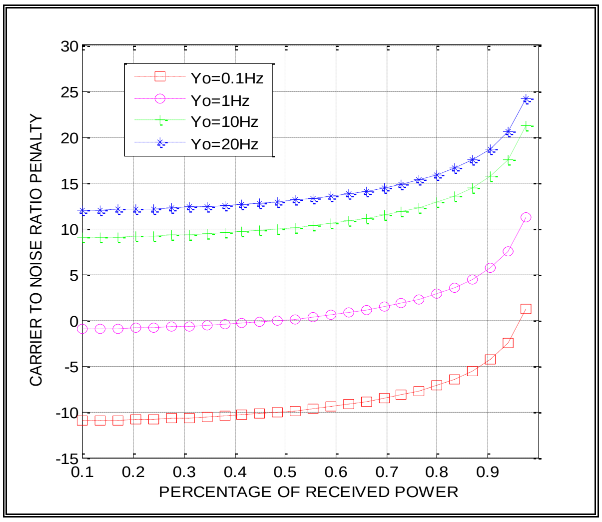

Fig.3. ΔCNR as a function of the RF oscillator linewidth and percentage of received power

The linewidth of the RF oscillator has been swept from 0.1 to 20 Hz. usually; the linewidth of the RF oscillator is less than 1 Hz. However, the RF oscillator linewidth, over 1 Hz is investigated as a practically cost-aware RF oscillator. From Fig. 3, it is found that:
The CNR penalty increases due to the increment of the RF Oscillator linewidth (γo).It means the effect of γo is linearly proportional to ΔCNR. The linear proportion means if ΔCNR increases 10 dB, which is equivalent to ten times the increment of γo. It is noticed that CNR penalty increases around 23 dB with respect to RF Oscillator linewidth from 0.1 to 20 Hz.
Further, it is found that the ΔCNR also increases as p becomes large since the increment of the noise power is greater than that of the received signal power as the bandwidth increases and thus the CNR penalty increases. It is notice that ΔCNR is around 12.2 dB increases due to increment in required power ratio from 0.1. to 0.99. Thus, the bandwidth should be considered carefully for p > 90%, since the CNR penalty increases drastically over the point as a result.

The Second result sketched in Fig. 4 & Table 2 represents CNR Penalty with respect to two parameters:
Length of Fiber (L) in Km
Laser Linewidth (Yd) in MHz

Parameters	Value
Fiber dispersion	17 ps/nm-km
Optical transmission distance	1 km to 40 km
RF carrier frequency	30 GHz
Wavelength of LD	1550 nm
Half power bandwidth filter	0.5
Laser linewidth	10 to 624 MHz
Percentage of received power	0.5

Table 2 the Simulation Parameters for CNR penalty as a function of the laser linewidth and length of fiber

The result of the laser-linewidth effect is described in Fig. 5.2. The laser linewidth is swept from 10 to 624 MHz since 10 and 624 MHz are typical linewidth values of a DFB laser and a FP laser. It is found that
ΔCNR exponentially increases as the laser linewidth (Yd). It is notice that CNR penalty due to laser linewidth from 10 to 624 MHz are 0.22, 1.2, 4.9, and 8 dB.in 2, 10, 30, and 40 km SSMFs.
Further, it is found that CNR penalty increases around 8 dB with respect to fiber length from 1km to 40 km. So, the RoF system relatively suffers from ΔCNR for a long transmission, such as 40 km, while ΔCNR is almost not changed (=0.22 dB) even for the FP laser in the short-transmission case (=2 km). It is confirmed that the FP laser can be used in a practical microcell boundary because the radius of the microcell is from 0.2 to 1 km.

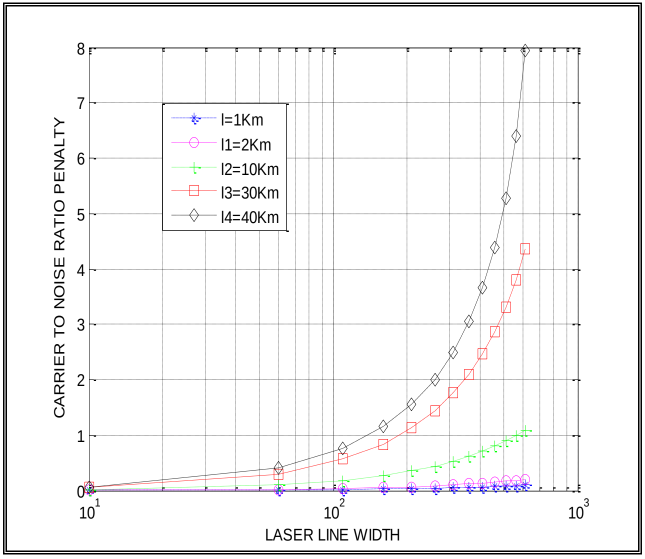

Fig.4. ΔCNR as a function of the laser linewidth and length of fiber

The CNR penalty due to the laser linewidth increases dramatically over a specific distance. Therefore, the laser linewidth should be selected carefully in a long-haul transmission since the large differential delay and large laser linewidth cause a serious CNR penalty. For a short distance, the phase noise from the RF oscillator is the dominant factor of the CNR penalty. For consideration, the CNR penalty due to RF oscillator linewidth from 0.1 to 20 Hz is around 23 dB in any case, while the CNR penalties due to the laser linewidth for 624 MHz are 0.22, 1.2, 4.9 and 8m dB in 2-, 10-, 30- and 40-km SSMFs. This means that we can employ a cheap laser such as the FP laser in the RoF system in picocell, microcell and macrocell without a severe CNR penalty.

CONCLUSION

We found that the carrier-to-noise ratio (CNR) penalty exponentially increases as the laser linewidth increases..

The effect of the RF Oscillator linewidth is linearly proportional to carrier-to-noise ratio (CNR) penalty. The linear proportion means if ΔCNR increases 10 dB, which is equivalent to ten times the increment of RF Oscillator linewidth.

The filter bandwidth at an electrical receiver should be selected carefully considering tradeoff between the CNR penalty and required signal power ratio *p*. As we obtained the CNR penalty of p=0.99 is 12.1 dB as compared to p=0.1 dB. Thus, the minimum required power to detect the signal should be carefully considered before we choosing the filter bandwidth. Also, we can conclude that the CNR penalty is more sensitive due to phase noise from RF Oscillator linewidth rather than that from laser in a relatively short distance (<10 Km) However, for long haul transmission, the system performance will suffer seriously from laser linewidth.

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