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# Green Antenna and Radio over Fiber Technology for a Cellular Wireless

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***Abstract*— Now a day's, the main problem in the mobile communication networks is, in addressing the problem of reduction of the power consumption as well as RF radiations from the base stations (BS)/antennas, which are harmful to the people in the surrounding locations. Cellular phones have become an essential part of modern life. Energy consumption of communication networks and emissions from base stations (BSs) and mobile stations (MSs) has received increased attention. To minimize the human exposure to RF radiation, transmit powers of BS as well as MS has to be reduced or BSs has to be placed far away from the densely populated areas. The Mobile operators are facing challenges and competition in providing high data rate services as well as coverage to the users instead of very high maintenance cost. Modulation of RF subcarrier onto optical carrier over a optical fiber network is called "Radio over Fiber Technology (RoF)". For the above problems, RoF is one of the efficient solutions. Integration of wireless communications and fiber optics provides coverage for outdoors as well as indoors such as inside the buildings, tunnels, shopping malls, airports etc, in a cost effective manner. RoF supports wideband signals like UMTS and WiMAX. In this paper, overview of Radio over fiber (RoF) technology for mobile networks has been presented and power reduction in the uplink and downlink transmission has been shown.***

***Index Terms*— WCDMA, Radio Over Fiber, Wimax, UMTS, QPSK.**

## I. INTRODUCTION

The general architecture of RoF for downlink transmission and uplink transmission is shown in figures 1 and 2. RoF technology has decreased the cost of BS (Base Station) replacing it with Control Station/Central Office (CS/CO) which is MSC (Mobile Switching Center), where transmission process is carried out which includes coding, multiplexing, RF transmission etc. making BS design and circuitry very simple consisting of O/E converter (optical - electrical) and E/O converter (electrical - optical) and amplifiers if needed. In order to provide the latest technology facilities to the mobile subscribers which include high data rates and increasing demand for multimedia, coverage and capacity parameters of cellular operators using different schemes, modulation techniques, dynamic allocations leads to complexity at the Base Station (BS) as well as it costs a lot. An alternative for this complexity at the BS is, the use of RoF technology where BS complexity is shifted to Control Station (CS). All the signal processing, dynamic resource allocation

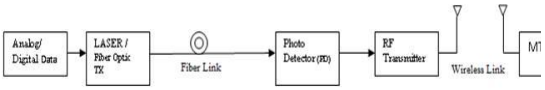


**Fig. 1 Downlink Transmission**

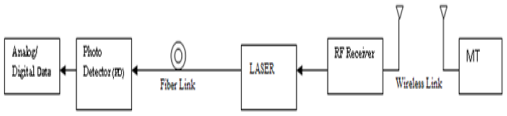


**Fig. 2 Uplink Transmission**

RoF is used because of its low loss (0.2dB/km) and high bandwidth transmission (in THz). RoF is an analog transmission system, as it transmits the signal at radio carrier frequency; the radio carrier can be modulated using digital schemes as GMSK in GSM and QPSK in UMTS. There are many advantages of using optical fiber for radio transmission like low attenuation, large bandwidth, low power consumption, operational flexibility, low interference, easy installation and maintenance. The use of RoF technology splits the large cell to more number of small cells such as Micro cells or Pico cells, increasing frequency reuse, and at the RAPs replaces the use of high power amplifiers, reduces the co-channel interference and the power consumption. Each of the small cells is provided with RAPs and these RAPs are connected to the CS through optical fiber link. Single Mode Fiber (SMF) or Multimode Fiber (MMF) is used as fiber link depending on the limitation provided by them such as its lossless transmission distance, attenuation characteristics etc. Generally, for small distances (up to0km) and for indoor applications MMFs are used and for distances above 10kms SMFs are used. There are three types of dispersions that occur in fibers– intermodal dispersion, Material or Chromatic dispersion and Waveguide dispersion. Intermodal dispersion widens the pulse leading to intersymbol interference if more than one mode of same signal propagates. MMF introduces intermodal dispersion limiting it to few kilometers of transmission distance, whereas SMF eliminates intermodal dispersion making it to transmit over longer distances. Material or chromatic dispersion (CD) occurs if more than one wavelength

consisted by transmitted signal depends on refractive indices
– limits the transmission distance. Waveguide dispersion occurs due to waveguide structure, shape of the fiber (core and cladding). In case of MMF, LEDs are used to couple light because of low coupling loss and semiconductor lasers are used to couple light in SMF for long distance transmission. Modulation of the signal is carried out in two ways: Direct Intensity Modulation - by turning on and off the laser, signal is modulated. DM leads to frequency chirp. External modulation - modulating the light externally coming from the laser. Remote Heterodyning – optical signals are generated from laser and modulated by information signal and are heterodyned. For high bit rates above 10 Gbps and for frequencies above 10GHz, external modulation is preferred. Direct detection process is employed at the receiver side by using PIN photodiode or PN photodiode. In RoF, for downlink external modulation or direct intensity modulation is preferred depending upon the requirement and for uplink direct intensity modulation is preferred.

***A. Radio over Fiber***

Radio over Fiber (RoF) application has attracted much attention recently because of the increasing demand for capacity/coverage and the benefits it offers in terms of low-cost base station deployment in macro cellular system. RoF systems are now being used extensively for enhanced cellular coverage inside buildings such as office blocks, shopping malls and airport terminals etc. RoF is fundamentally an analog transmission system because it distributes the radio waveform, directly at the radio carrier frequency, from a central unit to a Radio Access Point (RAP). Note that although this transmission system is analog, the radio system itself may be digital such as GSM. Mainstream optical fiber technology in digital Telecommunication networks, use synchronous digital hierarchy (SDH) transmission technology in their cores. Fiber-based data networks such as fiber distributed data interface (FDDI) and gigabit Ethernet all use digital transmission. Fiber transmission links to base stations in mobile communications systems are digital. Digital optical fiber transmission links are therefore ubiquitous in telecommunications and data communications, constituting a high volume market worth billions of dollars worldwide.

***B.Wideband Code Division Multiple Access***

Wideband Code Division Multiple Access (WCDMA), air interface is now regarded as a mature technology ready to provide the basis for the third generation wireless personal communication systems, known's as "universal Mobile Telecommunication Systems (UMTS) (3G). These systems will make extensive use of microcells and picocells in order to deliver high bandwidth services to customers. WCDMA is also known as Third Generation System (3G). The systems are designed for multimedia communication, can be enhanced with high quality images and video and access to information and services on public and private networks will

be enhanced by the higher data rates and new flexible communication capabilities of third generation systems (3G). This together with the continuing evolution of the second-generation systems (2G) will create new business opportunities for manufacturers, operators and the providers of content and applications using these networks. In the standardization forum, WCDMA technology has emerged as the most widely adopted third generation air interface. Its specification has been created in 3GPP (the 3rd Generation Partnership Project), which is the joint standardization project of the standardization bodies from Europe, Japan, Korea, the USA and China. Within 3GPP, WCDMA is called UTRA (Universal Terrestrial Radio Access). WCDMA is being used to cover both FDD (Frequency Division Duplex) and TDD (Time Division Duplex) operation. The benefit of using RoF for WCDMA distributed antenna systems is expected to be even more important, partly because of their higher frequency and bandwidth requirements. In this paper, the simulation of WCDMA RoF using Matlab has been successfully developed. The complete simulink block has been successfully compiled-processed and obtained BER performance is obtained to rate it.

***C. Merging of the Wireless and Fiber Optics World***

For the future provision of broadband, interactive and multimedia services over wireless media, current trends in cellular networks - both mobile and fixed are (1) to reduce cell size to accommodate more users and (2) to operate in the microwave/millimeter wave (mm-wave) frequency bands to avoid spectral congestion in lower frequency bands. It demands a large number of base stations (BSs) to cover a service area, and cost-effective BS is a key to success in the market. This requirement has led to the development of system architecture where functions such as signal routing/processing, handover and frequency allocation are carried out at a central control station (CS), rather than at the BS. Furthermore, such a centralized configuration allows sensitive equipment to be located in safer environment and enables the cost of expensive components to be shared among several BSs. An attractive alternative for linking a CS with BSs in such a radio network is via an optical fiber network, since fiber has low loss, is immune to EMI (Electromagnetic Interference) and has broad bandwidth. The transmission of radio signals over fiber, with simple optical-to electrical conversion, followed by radiation at remote antennas, which are connected to a CS, has been proposed as a method of minimizing costs. The reduction in cost can be brought about in two ways. Firstly, the remote antenna BS or radio distribution point needs to perform only simple functions, and it is small in size and low in cost. Secondly, the resources provided by the CS can be shared among many antenna BSs. This technique of modulating the radio frequency (RF) subcarrier onto an optical carrier for distribution over a fiber network is known as Radio over Fiber (RoF) technology. To be specific, the RoF network typically comprises a central

CS, where all switching, routing, media access control (MAC) and frequency management functions are performed, and an optical fiber network, which interconnects a large number of functionally simple and compact antenna BSs for wireless signal distribution. The BS has no processing function and its main function is to convert optical signal to wireless one and vice versa. Since RoF technology was first demonstrated for cordless or mobile telephone service in 1990, a lot of research efforts have been made to investigate its limitation and develop new, high performance RoF technologies. Their target applications range from mobile cellular networks wireless local area network (WLAN) at mm-wave bands [5], broadband wireless access networks to road vehicle communication (RVC) networks for intelligent transportation system (ITS). Due to the simple BS structure, system cost for deploying infrastructure can be dramatically reduced compared to other wire line alternatives. In addition to the advantage of potential low cost, RoF technology has further the benefit of transferring the RF signal to and from a CS that can allow flexible network resource management and rapid response to variations in traffic demand due to its centralized network architecture.

## II. SYSTEM MODEL

The main objective of this paper is to move around the minimization of the transmit power from the base station as well as the mobile terminal, which leads to the low health impairments as well as the less effective to the environment. Using RoF technology as the transmission medium for RF signals for communication – data, voice, multimedia etc, minimizes usage of high as well as complex components at the base station termed as RAU(Radio Access Unit), making the base station part in a very simple way – integrating the processes (modulation, signal processing etc) to be carried out in base station has been shifted to CBS (Central Base Station) or CS (Control Station). Keeping in view the above considerations, work/study has been carried out to propose an architecture which provide a system with better performance (low transmit power and signal quality). In this study, WCDMA system parameters have been considered for system simulations. In order to show the architecture with RoF technology, green antenna - is a distributed antenna with disabled transmission capability, but in this study green antenna is considered for both transmission and reception purpose. Simulation has been done for uniformly distributed users in the cell of 1.8km, placing the green antenna at 30% of the maximum radius at the centre of the cell sector. Cell has been sectored for three types – 3, 4 and 6 sectors per cell and successfully shown that capacity of a cell can be increased with very low transmit power. Next part of the study, deals with the performance of WCDMA transmission over RoF for signal quality. Generation of spreading code (M sequence, Gold and Orthogonal gold sequences) and including Rayleigh fading in the simulation has been carried

out and system is found to be providing the almost same
signal quality in RoF (low transmit power) and better one compared to the direct transmission of the WCDMA.

***A. Cell Architecture***

Block diagram of WCDMA transmission using RoF technology, which is being used for the simulation process is shown below

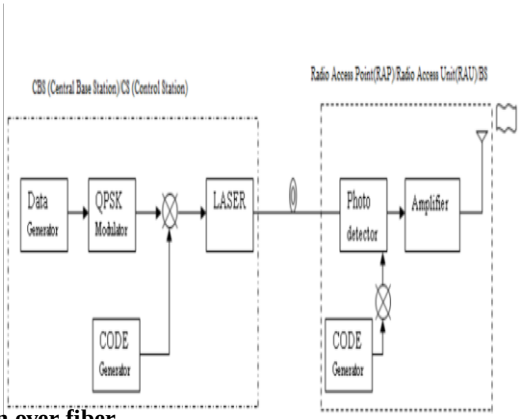


**Fig 3: WCDMA transmission over fiber**

WCDMA air interface is now regarded as a mature technology ready to provide the basis for the third generation wireless personal communication systems, known as **Universal Mobile Telecommunication Systems** (UMTS) (3G). These systems will make extensive use of microcells and picocells in order to deliver high bandwidth services to customers. Basic cell architecture with single base station is shown below.

**Fig 4: Basic cell architecture with base station**

There is an improvement in the capacity of the network, as the antenna distance is moving away from the center of the cell, which is shown by the simulation graph. Radio over fiber cell architecture with 6 sectoring is shown below