PERFORMANCE ANALYSIS OF EDFA FOR SCM/WDM RADIO OVER FIBER COMMUNICATION LINK

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ABSTRACT

The radio-over-fiber (RoF) system is one of the potential schemes for the future broadband wireless communication systems such as mobile communications, hotspots and suburban areas. In this paper, we present 16 channels of RF carrier modulation of the Sub Carrier Multiplexing (SCM), which then integrated, with Wavelength Division Multiplexing (WDM) for the Radio over Fibre Link. The integration of the two systems is responding to the demands for high data rate applications and reasonable mobility for broadband communication. The work also investigates the performance of EDFA for the optical fiber length up to 200km. The EDFA introduced as the optical amplifier in the designed system model to encounter the effects of attenuation, distortion and Rayleigh scattering. The deploying of RF carrier performs by double side band and single side band of the SCM for bandwidth utilization shown to be much better than conventional optical WDM. However, by applying EDFA with the length varies from 0m – 5m, the performance show that total power transmission has magnifying the optical signal significantly and the optical fiber length expanded to 150 km. The simulation result has shown that pre-amplifier EDFA in 150km of SCM/WDM RoF system significantly boost the performance of optical signal strength over the link.

INTRODUCTION

The increases of bandwidth demand are linear with the supply of networked services in many cellular operators. The network are setup to provide the user the services that are requires large bandwidth in the traffic, the services such as video streaming, data communication, push email, teleconference, mobile banking, etc. Therefore, the needs of broadband consumption of a user are increases. In order to supply the needs of bandwidth, many researchers currently actively investigate and focuses on three main components; spectrum allocation of the frequency band, efficiency and to increase the capacity of the cell. In this work we propose Sub-Carrier Multiplexing (SCM) that complemented with Wavelength Division Multiplexing (WDM) to be introduced for the RoF. Thus, the combinations of SCM/WDM expected to supply the demand of bandwidth increases for the cellular communication. The shortcoming of cell distribution in cellular communication is limitation in bandwidth, range and spectrum allocation in order to maintain high quality of delivered signal among Mobile Switching Centre (MSC) to Base Station Controller's (BSCs) or Base Transceiver System (BTS). Radio over fiber techniques offered to optimize the limitation range and bandwidth provided. In order to overcome the losses and attenuation of the traveled signal, we introduce Erbium Doped Fiber Amplifier (EDFA) in SCM/WDM RoF system for over 150km - 200km of optical fiber link.

SCM/WDM SYSTEM FOR ROF SYSTEM MODEL

The oldest method of signal distribution for the mobile application between the Mobile Switching Centre (MSC) and Base Station (BS) was using cooper cabling and microwave radio for data transceiver. In a system the spectrum allocation and bandwidth are required highest power, low data rate, highest attenuation and highly losses is not sufficient to overall the traffic demand by end-users.

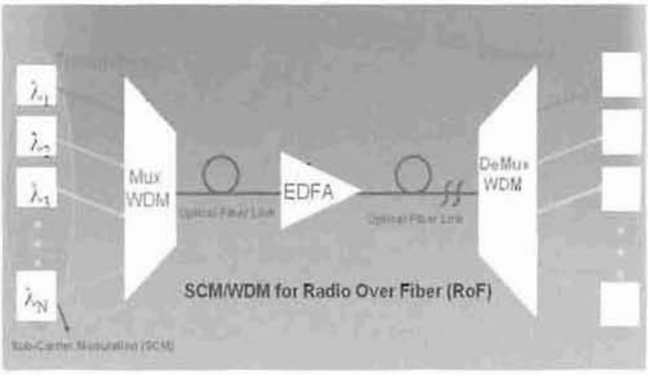

Figure 1 The SCM/WDM RoF with EDFA Communication Link System

The SCM/WDM for RoF system architectures comprises of two main systems that can found in Figure 1: (a) SCM/WDM transmitter, (b) SCM/WDM Receiver. The SCM/WDM for RoF link configurations are digitized the RF signals. However on the CS, RF signal is down-converted to the IF band and the signal digitized before modulated and directly transmitted to the BSs through the fiber. At the BS, the modulated signal detected by the Photodetector (PD) and converted back to analogue IF signal before up-converted to the desired RF band and transmitted to mobile hosts.

Table 1 The parameter of the SCM/WDM RoF communication Link with EDFA

Parameter	Value
Duplexing	SDD
RF Modulation	BPSK
Optical Modulation	MZM
Channel BW	1.8 GHz
Bit Rate/Sub-Carrier Channel	1.8 Gbps
Sample /bit	64
Sequence Length	128 bits
Fiber Length	1 km – 150 km

(a) SCM/WDM FOR RoF TRANSMITTER SYSTEM

The system architecture comprises of 2 block of RF module that generate of 8 Binary Phase Shift Keying (BPSK) in different frequency channel which is the width among the channels is 1.8 GHz In the SCM/WDM, the RF transmitter parts consists of 2x8 channels RF modulated which modulated in single wavelength. BPSK are introducing as RF carrier modulator on system architecture furthermore 1.8 Gbps bit rate are setup. CW Laser and MZM Modulator carried the RF modulated data in 1550 nm single wavelength. For this experiment, we take two sample of SCM channel consisting of 2x8 channels that carried digital data generates by Pseudo Random Bit Sequence (PRBS). Each of the data will be modulated by BPSK modulator with varies number of subcarrier which was in gigahertz.

One subcarrier may carry digital data, while another might modulated with an analogue signal such as video or telephone traffic. The composite electrical signal that has generated by the electrical transmitter that was amplified to10 dB by an electrical amplifier and transform to optical domain through external optical modulator, MZM and CW laser applied as the optical source.

The Wavelength Division Multiplexing (WDM) was setup for multiplexing a single wavelength in order to transmit through SMF optical link. Two port channel setup for two link SCM channels for multiplexing in single wavelength. The WDM was installed to multiplexing optical signal carrier to the link; the basic operation of the WDM is several base band-modulated channels are transmitted along a single fiber but with each channel located at a different wavelength.

In the optical link distance varies between 20 km up to 150 km for long distance communication it's refers to the low cost distance and resources efficient. The scenarios for optical amplifier can be setup in preamplifier and post-amplifier, pre-amplifier applied before WDM Mux and post amplifier assigned after WDM Mux in link of optical fiber.

The optical amplifier, EDFA was utilized in this design to amplified signal power with the fiber length are varied between 2 m up to 5 m. The EDFA is a length of glass fiber that has doped with the rare-earth metal Erbium ions. These ions act as an active medium with the potential to experience inversion of carriers and emit spontaneous and stimulated emission light near a desirable signal wavelength. The pump is typically another light source whose wavelength is preferentially absorbed by the ions, 0.98 or 1.48 mm for EDFA. The pump and signal (1.55 mm) must combined, typically by a wavelength-selective coupler (WDM), and may co- or counter-propagate with respect to each other inside the doped length of fiber. Therefore, the light is absorbed by the doped fiber at a certain pump wavelength and then produce gain for a signal at a different wavelength. Since the transmission and the active medium are both fiber based, the insertion losses are minimal.

The propose SCM/WDM system was model and simulate to verify design using a commercial optical system simulator by Optiwave . The setup parameter for the EDFA can be found in Table 2, while the fiber optic specifications for signal distribution are listed in Table 3.

Table 2 The EDFA Parameter

Parameters	Value
Core radius	2.2 μm
Er doping radius	2.2 μm
Er metastable lifetime	10 ms
Numerical aperture	0.24
Er ion density	1e+25 m^{-3}
Loss at 1550 nm	0.1 dB/km
Forward pump power	100 mW
Backward pump power	0 mw
Length	0 m 5 m

Table 3 Parameter setup for SMF Optic

Parameters	Value
Reference Wavelength	1550 nm
Length	1 km – 150 km
Attenuation	0.2 dB/km
Dispersion	16.75 ps/nm/km
Dispersion Slope	0.075 ps/nm^2/km

(b) SCM/WDM FOR RoF RECEIVER SYSTEM

After transmitted through a high-bandwidth optical fiber, the combined optical signals must demultiplexed at the receiving end by distributing the total optical power to each output port and then requiring that each receiver selectively recover only one wavelength by using a tunable optical filter. At the receiver, the received optical signal will be demultiplex by WDM Demux and converts into electrical signal by a high speed APD photodetector. In this works an ideal WDM Demux was installed as function as optical signal demultiplexer. It is works as optical filtering that compress, split, and filtering desire optical signals. The desired received signals are then selected through a Band Pass Rectangle filter, which split into individual SCM channel frequency. One of the main parameter that is in the top priority to sustain system quality is the photodetector sensitivity, which determine the minimum light power could be detected by the photodetector. This parameter determines the length of a fiber-optic link imposed by a power limitation. The more sensitive the photodiode, the longer the link can afford.

RESULT AND ANALYSIS

In the optical communication link, power is one of the components that used to transmit optical signal. Through the fiber link, naturally power drops due to attenuation, distortion and losses. In this work the propose system was successfully model and simulated, the results will illustrate the effect of using EDFA or without EDFA. The distance link was setup for 100 km and 150 km to evaluate how total power and EDFA have an effect to the link. In this paper we initiate the power is 0 W for 100km and 0 dBm for 150km

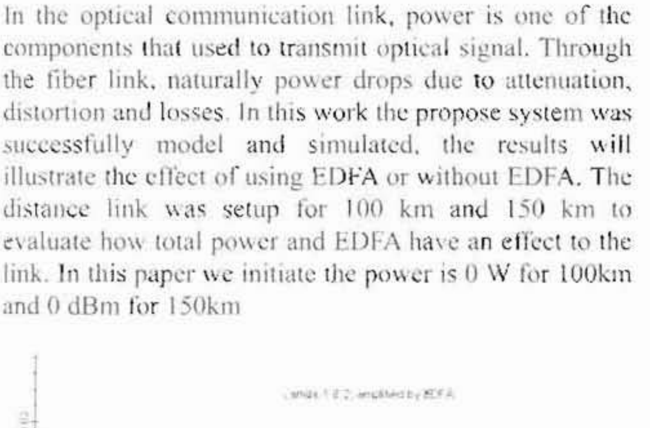

Fig. 2 The performance of SCM/WDM RoF with and without EDFA for 100km

Figure 2 and 3 illustrates the performance of total power to the length with and without EDFA. Figure 2 shows that EDFA can influence the total power to the link distance 100 km, where significantly increases 0.025 Watt to 0.037 Watt. In other hand, the total power also increases to the level of -20 dBm for the distance link of 150 km as shown in Figure 3. It is mean that the power reduced or attenuated over the link without EDFA. The slope of λ1 and λ2 began from 90km has decrease, down to the below level of -40 dBm, it indicate the implication of high frequency carrier are used affect to the quality of the power signal. These affect also happen when the signal traveled over the fiber link, it's reduced linearly in line of the distance. The limitation can overcome with the choosing quality of the optical fiber, light source, frequency carrier and EDFA parameters itself. However, EDFA is able to boost the total power that travel over the SMF fiber optic in the SCM/WDM RoF.

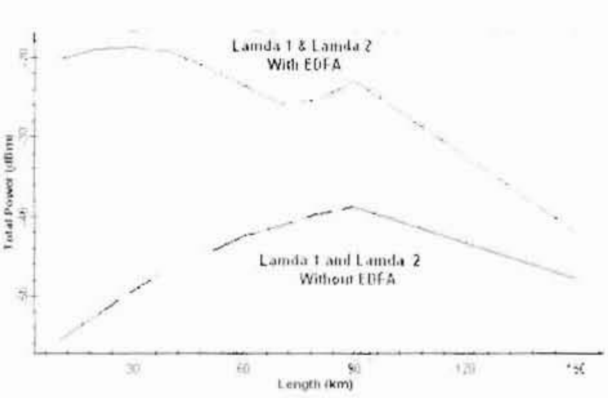

Fig. 3 The performance of SCM/WDM RoF with and without EDFA for 150km

However, EDFA model in the SCM/WDM RoF can proposed for optical cellular and distance extended up to 200km. Therefore, the EDFA system model works to augmented total powers that travel over the fiber link and significantly increases is much better that without EDFA. Finally, EDFA able to support the SCM/WDM RoF system model to maintain the bandwidth provide optical cellular communication link.

For better result in a future works, the values of EDFA applied varying the range of 10m – 20m to obtain the better gain of optical signals. Moreover, the simulation can be done in other commercial software such as Matlab to compare and tuned the desired results of EDFA.

CONCLUSION

Optical cellular communication system require signal guarantee that capable to overcome distortion and attenuation in the communication link. The expected system has shown can reduce and minimize the losses until the total power maintained. Hence, the signal quality improved by utilizing EDFA for 100km and 150km of SMF for the SCM/WDM RoF with significantly increases the total power and minimize the losses. The system simulation with 0m – 5m length EDFA has verify that technique capable to boost up to power quality of the optical signal. EDFA proficient to maintain of the signal power augmented more than 50 % of the initiate power.

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