ADVANCED BI-DIRECTIONAL ROF SYSTEM DESIGN USING REFLECTIVE SEMICONDUCTOR OPTICAL AMPLIFIERS

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The rising demand for high bandwidth transmission capability link along with security and ease in installation has led to the interest in optical-wireless communication technology. In this paper an efficient and cost effective bi- directional RoF system with remote modulation using a reflective semiconductor optical amplifier (RSOA) is proposed. The system is capable of delivering a data rate up to 1 Gbps per cell in indoor environment .Since this proposed system uses optical sources only for downlink transmission, it simplifies the base station design and reduces overall system cost. Good transmission performance estimated by eye diagram is obtained in this proposed system.

KEYWORDS*:* Radio over Fiber (RoF), Reflective semiconductor optical Amplifier (RSOA),Optical Network Units (ONUs), Passive Optical Network(PON).

1. INTRODUCTION

The concept of Radio over Fiber (RoF) briefly refers to the merging of two conventional technologies - radio frequency (RF) for wireless and optical fiber for wired transmission. In this network a central station (CS) is connected to numerous functionally simple base stations (BS) via optic fiber. The main function of BS is to convert optical signal to RF and vice versa. Almost all processing including modulation, demodulation, coding and routing is performed at the CS. That means, RoF networks use highly linear optic fiber links to distribute RF signals between the CS and BS. In narrow band 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, and then to distribute the RF signals to the BSs using optical fibers, which offers low signal loss (0.3dB/km for 1550 nm, and 0.5dB/km for 1310 nm wavelengths), as shown in Fig.1. Hence BSs are simplified significantly, as they only need to perform optoelectronic conversion and amplification functions. The centralization of RF signal processing functions enables equipment sharing, dynamic allocation of resources, simplified system operation and maintenance. These benefits can translate into major system installation and operational savings especially in wide coverage broadband wireless communication systems.

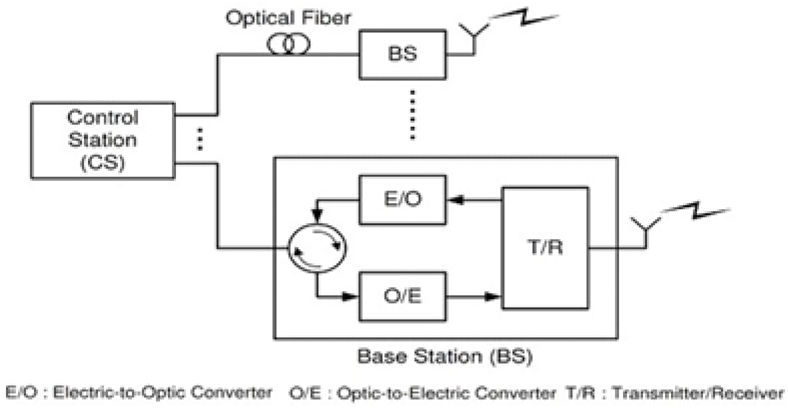


Fig. 1. Radio over Fiber System

A typical RoF link configuration is classified based on the kinds of frequency bands (baseband (BB), intermediate frequency (IF), RF bands transmitted over an optical fiber link. At the BSs, the RF/IF/BB signal is recovered by using a photodiode (PD) [2]. The recovered signal, which needs to be up converted to RF band is transmitted to the mobile terminals via the antennas of the BSs. Signal distribution as RF-over-Fiber has the advantage of a simplified BS design but is susceptible to fiber chromatic dispersion that severely limits the transmission distance. In IF-over-Fiber configuration, the effect of fibre chromatic dispersion on the distribution of IF signals is much reduced, although antenna BSs implemented for RoF system incorporating IF-over-Fiber transport require additional electronic hardware such as a mm-wave frequency local oscillator (LO) for frequency up and down conversion. In BB-over-Fiber configuration, the modulated signal is generated at the CS in baseband and transmitted to the BSs. At each BS, the modulated signal is recovered by detecting the modulated optical signal with a PD, up converted to an RF band through an IF band or directly, and transmitted to the mobile terminals. In the baseband transmission, influence of the fibre dispersion effect is negligible.

To reduce the overall system cost, it is desirable to simplify the structure of the base station (BS). The development of colorless optical network units (ONUs) is a key issue in Wave length Division multiplexed Passive Optical Network (WDM PON) technologies to reduce the system cost dramatically. Among various solutions, the use of a reflective semiconductor optical amplifier (RSOA) in an ONU is a good candidate because this approach has the flexibility to assign a wavelength to the upstream signal, and the signal is directly modulated without an external modulator.

The paper is organized as follows: In section 2 the architecture of the proposed system is discussed. In section 3, simulation set up of the same is illustrated. Section 4 deals with results and discussion and section 5 with the conclusion and future work.

2. PROPOSED SYSTEM

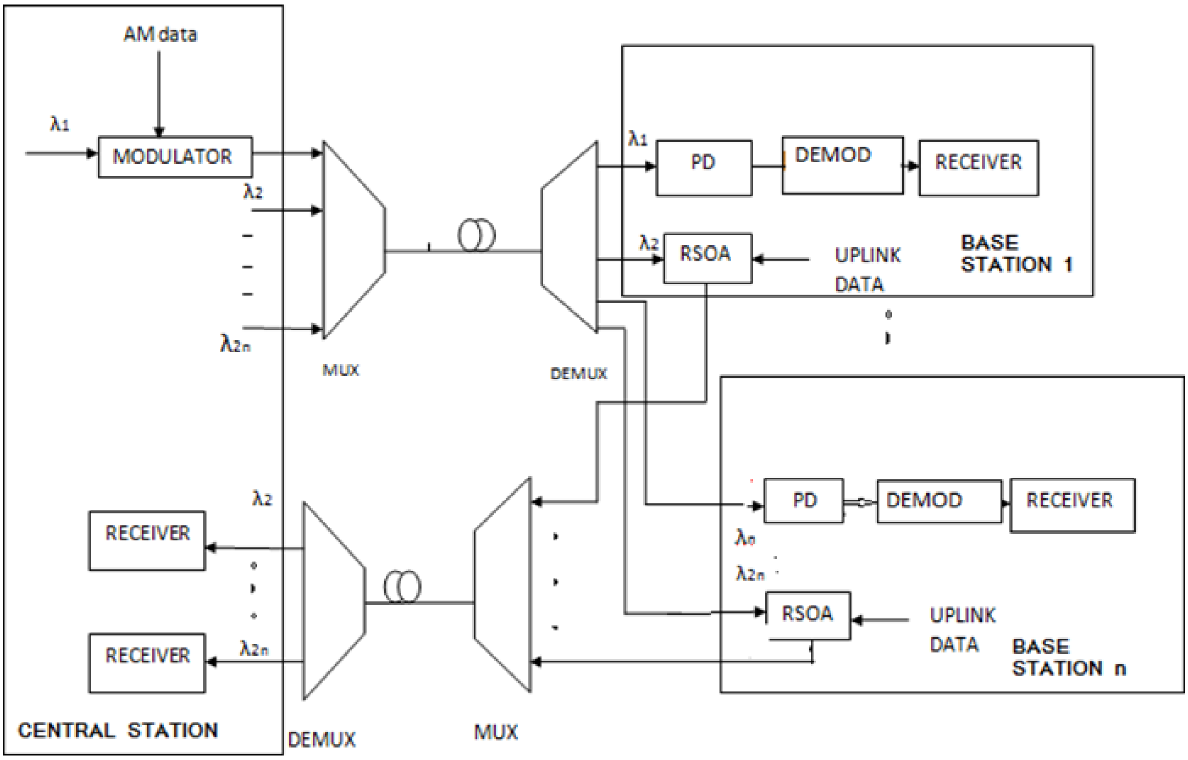


Fig. 2. Proposed System

The architecture of the proposed system is shown in Fig.2 , which consists of the basic building blocks: Central Station (CS), optical multiplexer/demultiplexer (MUX/DEMUX) and Base Stations (BSs).

The CS is mainly composed of three parts: the downstream, the upstream, and the control processes. In the downstream, the data is injected into the radio process unit, which is an array of radio process sub-units corresponding to each downstream and upstream wavelength. Each sub-unit uses a radio baseband process and IF stage to perform modulation/demodulation process per downstream/upstream wavelength pair. The wavelength to carry the radio signals is predefined for each radio sub-unit, here letting λ1 denote the wavelength for the sub-unit1. The RF downstream data is modulated (λ1) with a Mach-Zehnder modulator (MZM). In this proposed scheme remote modulation is employed. The light source of the BS is remotely fed by the CS (λ2). The optical carrier supply unit (OCSU) in the CS is responsible for generating optical carriers for each BS. These signals are given to a wavelength division multiplexer. The combined signal is given to the optical transmission channel, from which a de-multiplexer is used to segregate the wavelengths.

The design of the base station is as follows. From the downstream each base station receives two wavelengths, one carrying downstream data and the other carrying carrier for the upstream. The PIN diode with the de-modulator extracts the downstream data. The reflective semiconductor optical amplifier (RSOA) which is operated in the gain saturation region at the BS modulates the incoming wavelength with the uplink data. This design results in a low cost BS with the wavelength-selection-free property. The upstream data in the BS goes through an opposite process as compared to the downstream data.

3. SIMULATION SETUP

The above conceptual scheme was built and tested in Optisystem v.11. The simulation setup is shown in fig.3. A pseudo-random number generator was used to drive an NRZ pulse generator to generate the baseband signals. The PRBS signifies the random source of data such as speech, music, pictures or video. The NRZ pulse generator was chosen in order to have a simple low speed electrical network. The data rate was set at 1 Gbps for simulation of both downlink and uplink. The downlink data was amplitude modulated by 3.5 GHz signal. The modulated radio signals are transformed to optical signals by a CW laser source (1552.52 nm) using a Mach-Zehnder modulator (MZM). The light source of the BS was remotely fed by the CS. A CW laser with 1551.72 nm was used as carrier for upstream transmission. The downstream optical signal which carry the downlink data was converted to electrical signal by a photodiode. The RSOA used at the base station modulates the uplink data(1Gbps).

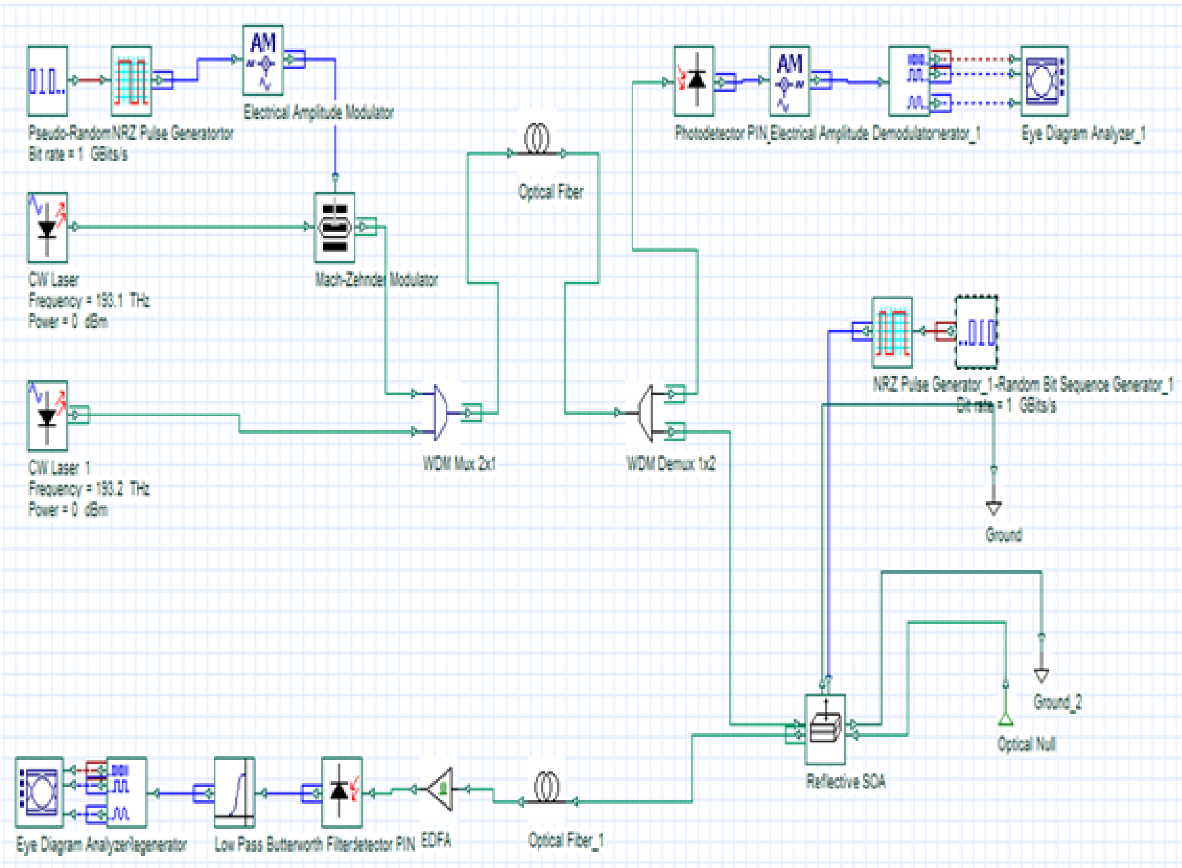


Fig. 3. Simulation set up of the proposed system

4. RESULTS AND DISCUSSION

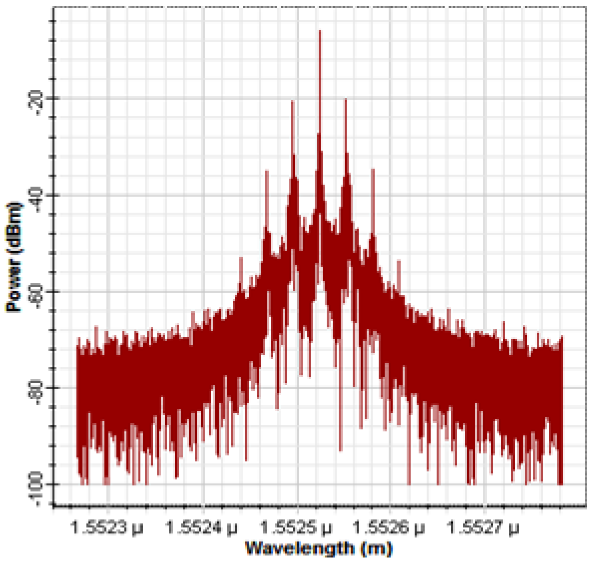


Fig. 4. Downlink spectrum after moduation

The global parameters of Optisystem were suitably set to visualize the results. Fig.4 illustrates the optical spectrum of the downstream data after modulation. The side bands are obtained with a power level of 20 dBm. The extremely high data rate is limited by the speed of operation of the MZM, thus in practical design there is a trade off between cost of installation and the operational data rate.

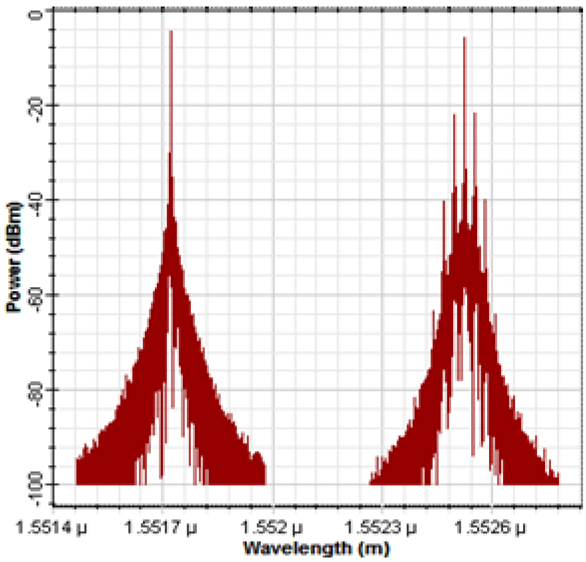
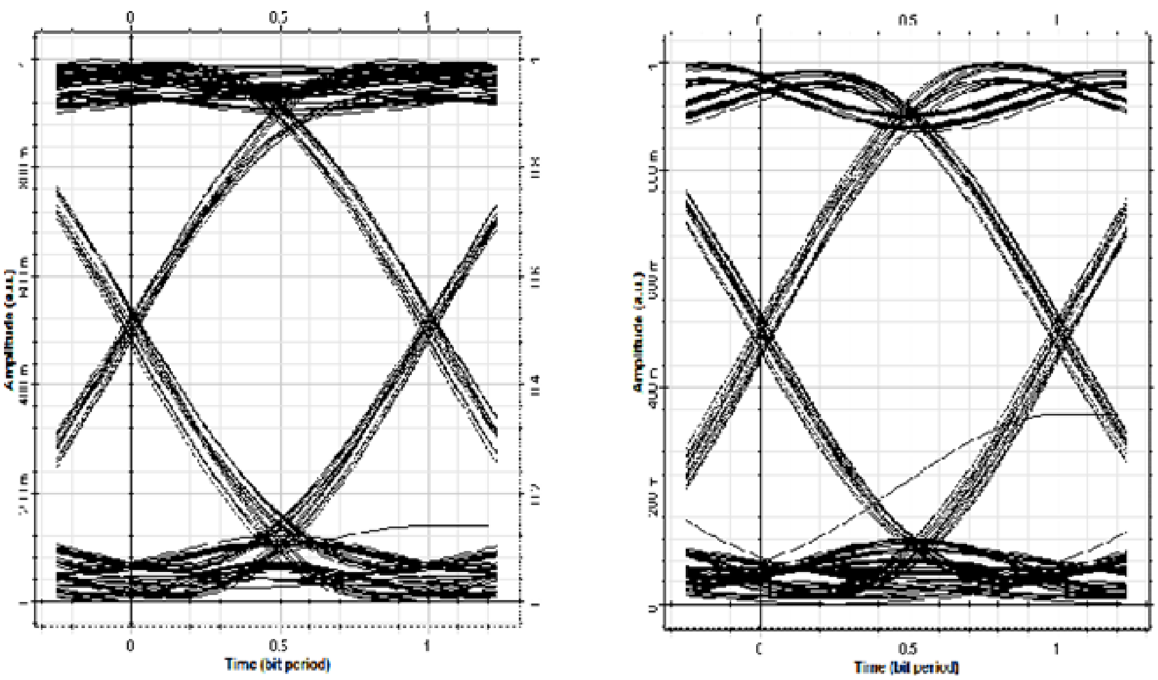


Fig.5. Spectrum after multiplexing

Fig. 5 shows the spectrum after multiplexing. The uplink carrier and modulated downstream spectrum are obtained at wavelengths 1551.72 nm and 1552.52 nm respectively. The power levels should be carefully adjusted in order to prevent interchannel distortion and nonlinearities.

The fiber was assumed to have a fixed attenuation (0.2dB/Km). The model was simulated with and without amplifier and link performance was evaluated for various fiber lengths. The eye pattern for downlink and uplink data is shown in fig.6 for a data rate of 1Gbps. The eye opening is very good for a reliable communication link. The eye pattern seems to validate the proposed scheme to be deployed in the real world.



(a) Downlink (b) Uplink

Fig. 6. Eye diagram for downlink and uplink

5. CONCLUSION AND FUTUREWORK

A novel architecture for a bidirectional RoF system with remote modulation is proposed. The simulative analysis demonstrated a 1Gbps downlink and 1Gbps uplink, which is suitable for short haul networks. The unique feature of the system is the high data rate support among a large number of small cells. By using remote modulation the BS can be designed without any light source. Also, we observe that this scheme is a cost effective design when the number of subscribers increase.

For the future work, the remodulation scheme can be considered, in which the downstream carrier can be reused for the upstream transmission.

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