Ultra Wide Band (UWB) Radio over Fiber (ROF) using Directly Modulated VCSELs

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Abstract— The UWB radio over optical fiber technology (UWB RoF) is a novel technology for the transmission of UWB signals by using an optical carrier propagating through an optical fiber. In this approach, the UWB RF signal itself is superimposed on the optical CW carrier. This strategy makes the conversion process transparent to the UWB's modulation method, and also transparency feature allows avoiding the high costs of additional electronic components required for synchronization and other processes. RoF has an ability to carry the signal several ten of kilometres but this transmission is limited by several optical impairment. In this paper , comparison between the Q-factor of transmitted signal before passing the filter and after passing the filter has been focused.

Key words: UWB, ROF, Optsim, DAS, BER,Q-value

I. INTRODUCTION

Ultra wide band (UWB) communications is a fast emerging technology that offers new opportunities. UWB systems incorporating with time-hopping spread spectrum multiple access systems are one of the most promising technologies for short range high-throughput wireless communications. Current interests in UWB are fueled by their intrinsic properties: immunity to multi-path fading, extremely short time duration, low duty cycle, wide occupied bandwidth, and low power spectral density. UWB signals have important characteristics: huge bandwidth (0.5 to 10.6 GHz) and very low intensity, comparable to the level of parasitic emissions in a typical indoor environment (FCC part 15: -41.3 dBm/MHz) (1). The ultimate target of UWB systems is to utilize broadband unlicensed spectrum (FCC: part 15: 3.1-10.6 GHz) by emitting noise-like signals. Low complexity and low power consumption of UWB technology is suitable for broadband services in the mass markets of wireless personal area networks (WPAN) (2,7). UWB combines the high data rates with capabilities of localization and tracking features. Potential applications of UWB are wireless communications, intelligent transport system (ITS), imaging and sensors.

However, derived from the constraints on allowed emission levels and fundamental limits of thermal noise and Shannon limits (3,4) high data rate, UWB systems (e.g. 480 Mbps) are limited to short-ranges of less than 10m because of the emission requirement. While broadband access technology demands for larger coverage of high data rate UWB (10 – 10000 meters).

The UWB radio over optical fiber technology (UWB RoF) is a novel technology for the transmission of UWB signals by using an optical carrier propagating through an optical fiber. In this approach, the UWB RF signal itself is superimposed on the optical CW carrier (5). This strategy makes the conversion process transparent to the UWB's modulation method, and also transparency feature allows avoiding the high costs of additional electronic components required for synchronization and other processes.. The development of RoF systems is motivated by the demand for replacing a central high power antenna with a low power distributed antennas system (DAS). RoF systems are usually composed of many base stations (BSs), which are connected toa single central station (CS). Therefore, many efforts have already been devoted to reduce the BS' cost and move the complexity to the CS.

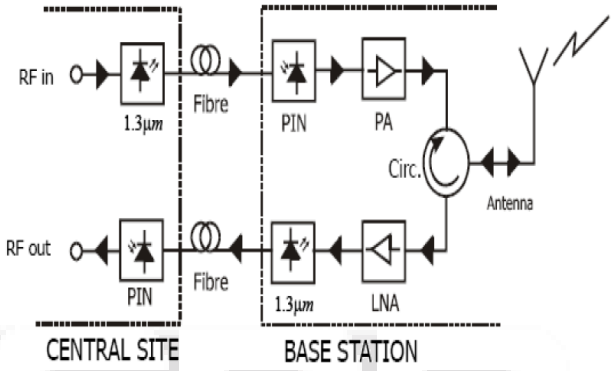


Fig. 1: Radio on Fiber System

RoF systems are usually composed of many base stations (BSs), which are connected to a single central station (CS) (Figure 1). RoF systems centralize the RF signal processing function in one shared location (headend), and use optical fiber link to distribute the RF signals to the RAUs or BSs.

II. OPTSIM SIMULATOR

OPTSIM is a modelling tool and simulation environment supporting the design and the performance evaluation of the transmission level of optical communication systems. The OptSim is a suitable platform in designing of all optical networks. In this paper, OptSim will be evaluating the performance analysis such as Q value, BER, Power, and eye diagram. Eye diagram is often used to display the transmitted or received signal quality (6,9). The eye opening is a useful parameter in determining the degradations of an optical link. An open eye with large, wide and sharp lines means good performance, while noise and inter symbol interference appears as spreading of the rails. Figure 2 shows the layout of OPTSIM used to create the optical link design.

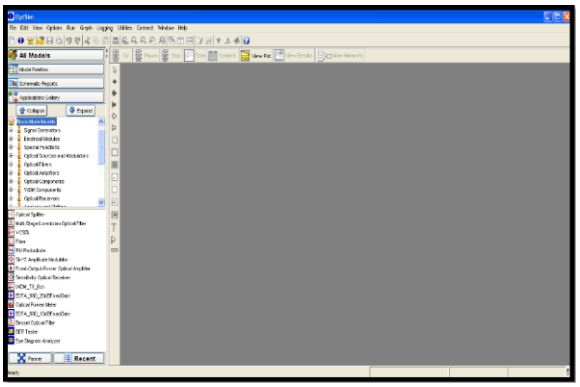


Fig. 2: OPTSIM Simulator

III. SIMULATION OF THE TRANSMISSION SYSTEM

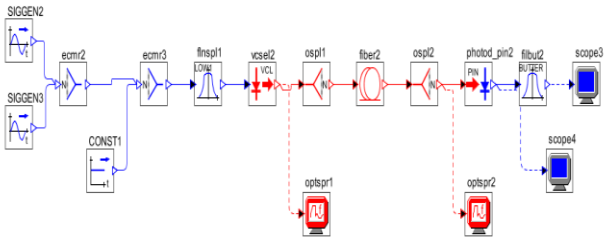
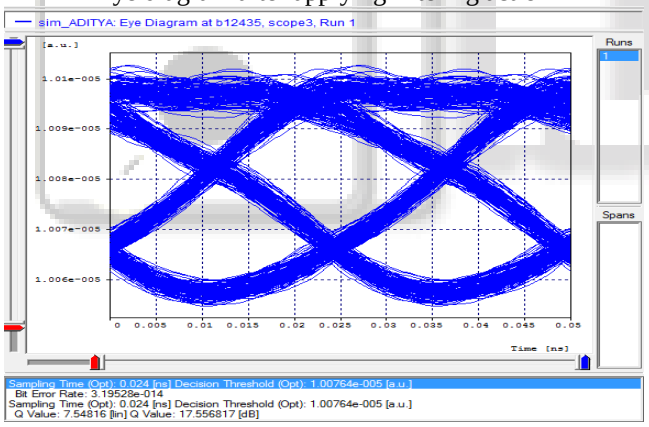


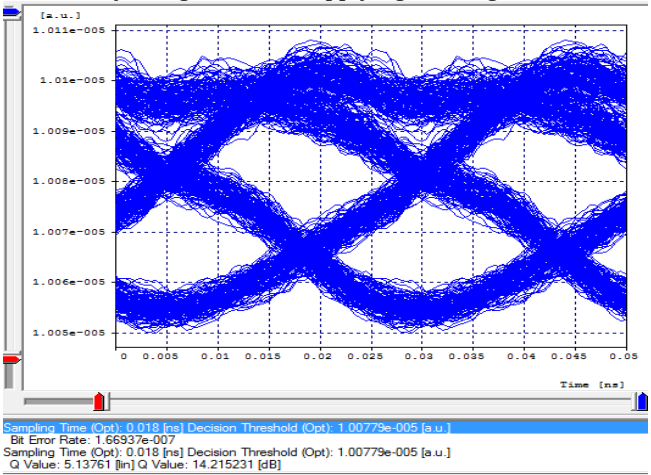
Fig. 3: Direct Modulation Through VCSELS

The optical system design consists of VCSEL diode transmitter, single/multimode fiber, attenuator, PIN diode receiver. Optsim 5.4 optical simulation tool from Rsoft Design Group is used for the design.

Eye diagram after applying filtering action



Eye diagram before applying filtering action



By comparison of both eye diagram it is clear that by applying appropriate filtering action Q-factor of signal increase. For the different length of fiber the Q-value before and after the filter is given in the table-

Fiber length(km)	Q-value before filter	Q-value after filter
5	16.2256	17.3388
15	14.215	17.5568
25	14.3483	16.22198
50	11.3274	11.5448

IV. CONCLUSION

This paper studies Radio on Fiber communication system using cost-effective VCSEL direct modulation to distribute UWB signal. The behaviour of UWB OFDM RF system and VCSEL optical system were analyzed theoretically and experimentally on the basis of Quality factor. An UWB OFDM signal pre-distortion method has been proposed to mitigate non-linear distortions for VCSEL RoF system. The pre-distortion method makes the UWB suitable for the transmission over VCSEL optical system.From the above it shows that the performance under direct high frequency modulation should depend on the modal characteristics of the VCSEL. VCSEL has a high resonance frequency and a strongly clamped carrier density because of the high photon density. So the use of a single mode VCSEL is more favorable over multimode VCSEL in analog signal transmission. By applying appropriate filtering action Q-factor of signal increases.

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