QPSK UWB BASED MODULATOR FOR REUSABLE SIMULINK MODELED PON

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ABSTRACT

This work presents the MATLAB SIMULINK 7.9 model of wavelength division multiplexed communication system incorporating QPSK modulation format for simultaneously without and with reusable UWB PON. To the best of our knowledge this simulator has been implemented for optically amplified transmission through single mode fiber. In the other hand the wave length is reused from the UWB down stream in optical network. Both the schemes are demonstrated with the Bernoulli binary data transmission through WDM PON over the SMF. The performance is evaluated by measuring the BER, SNR, eye diagram over fiber length increasing manner.

Keywords: Bit Error Rate (BER), Fiber Length, Micro Wave Photonics, Passive Optical Network (PON), Quadrature Phase Shift Keying (QPSK), Single Mode Fiber (SMF), Signal To Noise Ratio (SNR), Ultra Wide Band(UWB), Wavelength Division Multiplexing (WDM), Wave Length Reuse.

I. INTRODUCTION

A traditional UWB modulated optical PON network is proposed\textsuperscript{[1]} below. In this method, the data and UWB signals are QPSK modulated before reaching the optical modulator MZI. The wavelength of the Laser diode is reused by modulating the optical signal generated by LASER diode with the UWB carrier and transmitting via SMF as upstream signal. At the wired downstream side the detected UWB waves can be further modulated with a (different frequency band) message data and it can be used as an upstream for further transmission.

Simultaneously, the detected raw UWB signals can be up streamed to different wireless systems for further modulation with (different frequency band) data. Thus the wavelength of one time generated and UWB modulated centralized Light source is reused\textsuperscript{[1]} for various applications. Thus the data is included in the communication in the downstream side and the un modulated UWB optical signal can be further used to other networks.
II. MODELING

The experimental [2] implementation of the PON network with fixed data stream will be implemented in a MATLAB SIMULINK Modeling environment, since the practical implementation of the network costs beyond the scope of a student and SIMULINK is proven to be trustworthy for accurate modeling of Dynamic Systems. This simulator prototype was completed using MATLAB 7.9[3].

The first prototype that was designed in MATLAB SIMULINK was the Non-return to Zero Transmitters from the experimental setup. The first stage of that design was signal modulation, where the signal is modulated with two sources, a data generator and a random binary generator. The next stage involved in designing the voltage bias function block.

![Fig 1: Simulink Modelled Optical Network](image1)

![Fig 2: Simulink model of QPSK modulated reusable optical network](image2)

A optical modulated model consists of a QPSK modulated Binary, UWB, a 1500nm wavelength LASER source, a configurable Single mode fiber in transmitter and a optical detector in receiver side.

The only difference in the proposed system from the existing is the data modulation is done in the downstream instead of upstream side. This completely changes the advantages of the system in the application perspective, whereas the performance characteristics of the receiver sides are untouched. Since previously used blocks are repeated with different combination we are directly probing into the characteristic responses instead of the explanation. A random number generator Data Block is included exclusively performance of the Random Data Characteristics.

2.1. QPSK UWB MODULATOR

Higher order modulation schemes, such as QPSK [4], are often used in preference to BPSK when improved spectral efficiency is required. QPSK utilizes four constellation points, as shown in figure below, each representing two bits of data. Again as with BPSK the use of trajectory shaping (raised cosine, root raised cosine etc) will yield an improved spectral efficiency, although one of the principle disadvantages of QPSK, as with BPSK, is the potential to cross the origin, hence generating 100% AM.
2.2. LASER SOURCE

A Laser source[^5] is nothing but an ON and OFF high frequency state change. To simplify this part of the simulation development, let us consider an ideal laser source (i.e. no frequency chirp present) and implement this, in Simulink by selecting the “Signal Generator” block shown Fig.3.

![Signal Generator DFB laser source 1550nm](image)

**Fig 3:** Signal Generator DFB laser source 1550nm

This block models the desired sinusoidal optical carrier obtained from an ideal DFB laser which takes the mathematical form (1), (2), (3).

\[ c(t) = A \cos ( \omega_n t + \phi) \]  

Where \( \omega_n \) and \( \phi \) are the frequency and phase of the optical carrier respectively, with \( \omega_n = 2 \pi \times 1.93 \times 10^{14} \text{ rad/s} \) corresponding to the 1550 nm operating wavelength. \( A \) is the amplitude of the optical carrier which has been normalized for simplicity and is thus set to unity.

\[ f_{\text{sampling}} \geq 2B \] \hspace{2cm} (2)

\[ T_{\text{sampling}} \leq \frac{1}{2B} = 2.59 \times 10^{-15} \text{ s} \] \hspace{2cm} (3)

According to the Nyquist theorem, this sampling interval is at least twice the highest frequency in the system. The Wavelength Of the LASER block is reconfigurable just by double clicking it.

2.3. OPTICAL MODULATOR

An (modulator) interferometer is an optical device which utilizes the effect of interference. Typically, it starts with some input beam, splits it into two separate beams with some kind of beam splitter (a partially transmissive mirror), and possibly exposes some of these beams to some external influences (e.g. some length changes or refractive index changes in a transparent medium), and recombines the beams on another beam splitter.

The Mach–Zehnder interferometer[^6-7] was developed by the physicists Ludwig Mach and Ludwig Zehnder. As shown in above Figure 6. It uses two separate beam splitters (BS) to split and recombine the beams, having two outputs, which can be sent to photo detectors. The optical path lengths in the two arms may be nearly identical, (or) may be different. The distribution of optical powers at the two outputs depends on the precise difference in optical arm lengths and on the wavelength (optical frequency).

If the interferometer is well aligned, the path length difference can be adjusted (by slightly moving one of the mirrors) so that for a particular optical frequency the total power goes into one of the outputs. For misaligned beams (e.g. with one mirror being slightly tilted), there will be some fringe patterns in both outputs, and variations of the path length difference affecting mainly the shapes of these interference patterns, whereas the distribution of total powers on the outputs may not much change.
2.4. DETECTOR

In order for the receiver to receive the data that was transmitter by the receiver, demodulation has to be done. In the demodulation block, the low pass filter excludes the high frequency components and hence producing the demodulated signal by suppressing the carrier and the QPSK symbols are detected again using a QPSK demodulator.

III. RESULTS

Comparison of Eye diagrams with out and with resue

![Eye Diagram](image1.png)

SMF distance of 5,000km

![Eye Diagram](image2.png)

SMF distance of 10,000km

![Eye Diagram](image3.png)

SMF distance of 15,000km

![Eye Diagram](image4.png)

SMF distance of 20,000km
SMF distance of 25,000km

SMF distance of 30,000km

SMF distance of 35,000km

SMF distance of 40,000km
IV. COMPARISON OF GRAPHS

Graph 1. SMF Length VS BER (WITH OUT REUSE)

Graph 2. SMF Length VS SNR (WITH REUSE)

V. CONCLUSIONS

The concept of wavelength reuse over Single mode fiber and wireless channel is achieved and tested using CAD design tools. The concern of the signal to noise ratio and the bit-error rate parameters remain almost unchanged for both the methods of optical communication. The method of reusing the wavelength for multiple applications is proved to be effective, since the SNR ratio of this system resembles the previous method (without reuse).

This Bit error rate is varied from 0.0 to 0.0698, when the transmission of the single mode fiber cable is shortened to below 5,000km. The bit error rate variation was found to be 0.1166, when the transmission of the single mode fiber cable length is up to 40,000km. The variation in the SMF cable length will also affect SNR variation from 50.49 to 15.0261 for length of the cable from 5,000km to 40,000km. This implies that as the SNR decreases the BER increases, as expected from theory. This is depicted graphically by the eye diagram. A comparison of both the system is represented graphically through curves. This shows that the method of reusing the wavelength, does not degrade the performance of the system.

The aim of achieving wavelength reuse in the optical network is shown to compensate the high implementation cost of the photonic systems. The performance characteristics of the system is plotted. This indicates that noise is eliminated.

By analyzing the two performance curves, the proposed reuse scheme is proven to be effective by completely resembling the performance of the old method without any degradation, at the same time the frequency curve can be reused.

The studies carried out may further be extended beyond 40,000km and compared with the experimental studies carried out by Dept. of Telecommunications, Govt. of India (or) Reliance Communications.

REFERENCES


