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Performance analysis and Power Loss Management of reconfigurable UWB pulse generation through Dual-Drive Mach-Zehnder Modulator

Akanksha Kumari, Prof. A.K. Jaiswal, Er. Neelesh Agrawal

Abstract- ***In the present scenario, Ultra Wideband (UWB) technology is considered an interesting technology for its application in wireless communication, sensor networks, location and radar systems. In this seminar reconfigurable UWB pulse generation through Dual-Drive Mach-Zehnder Modulator is proposed by carefully setting the parameters of two electrical signals and bias voltage of the DDMZM. The distribution of UWB signals over optical fiber (UWBoF) extends the area of coverage and offers the availability of undisrupted service across different networks. Performance analysis of UWB Pulse Generated is being carried out by changing the phase of the output pulse to control the power loss of the signal.***

***Index Terms*—** **Ultra Wideband (UWB), Dual-Drive Mach- Zehnder Modulator (DDMZM), UWBoF, Photonic Generation, Phase Modulation.**

I. INTRODUCTION

Over past few years, Ultrawideband (UWB) radio has recently been considered as a promising candidate to meet the ever-growing demand for wide bandwidth and high speed in the future wireless personal-area networks (WPANs)[1]. UWB technology is attractive due to its many abilities such as low complexity, low cost, low power consumption, high data capacity, multipath fading immunity and sharing the radio spectrum with the existing wireless systems**.**

Ultra-Wideband (UWB) impulse signal provides a promising solution for future wireless communications due to low power consumption and high bit-rate. To overcome its limitation of short transmission distance,UWB-over-fiber (UWBoF) technology has been proposed for generations and transmission of UWB impulse signals in optical domain[5]. Many approaches to photonic generations of UWB pulses were proposed in recent years. UWB signal generations based on phase modulation to intensity modulation (PM-IM) conversion have been extensively studied[12], where the phase-modulated signals were converted to UWB pulse signals by using optical frequency discriminator or other methods. Moreover, nonlinear effects in semiconductor optical amplifiers (SOAs) and delayed interference of phase modulated signals have been demonstrated to achieve UWB pulse signals[5] [6]. Nevertheless, most of the previous methods can only generate a fixed UWB pulse shape, which may limit potential applications.
In this paper, we generate reconfigurable UWB pulse through an optical modulator and analyze and study the performance of Ultra Wideband technology[18]. Especially the challenges of energy usage, power consumption and performance metrices of UWB signal pulses shapes through regenerating it by Phase Modulator. Here we have worked on controlling power consumption and losses through varing the phase shift of the signal to change its phase.

***Akanksha Kumari**, Department of Electronics And Communication Engineering, SHIATS, Allahabad, INDIA, +918004487088*

***Prof. A.K. Jaiswal**, Department of Electronics And Communication Engineering, SHIATS, Allahabad ,INDIA, +919839463654*

***Er. Neelesh Agrawal** , Department of Electronics And Communication Engineering, SHIATS, Allahabad ,INDIA, +919935854545*

II. CHALLENGES WITH UWB COMMUNICATION SYSTEM

CHALLENGES	PROBLEMS
Pulse-Shape distortion	Low performance using classical matched filter receivers.
Channel estimation	Difficulty predicting the template signals.
High-Frequency synchronization	Very fast Analog To Digital conversion is required.
Multiple-Access Interference	Detecting the desired user's information is more challenging than in narrowband communication.
Low Transmission Power	Information can travel only short distance

Table1. Some challenges and problems associated with UWB system

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III. OVERVIEW OF UWBoF COMMUNICATION SYSTEM

A. Uwbof Technology

To increase the area of coverage and to offer the availability of undisrupted service across different networks, a technique to distribute UWB signals over optical fiber, or UWB over fiber is employed. In the UWBoF systems, optical UWB signals are generated in the central office and distributed to the access points via optical fibers[6]. An UWB signal in an UWBoF system must be distributed to a remote site via optical fibers. Due to the wide bandwidth and high data rate of an UWB signal, the performance of an UWBoF system would be affected by transmission losses of the optical fiber. It is well known that the transmission performance of an optical system is mainly determined by the optical spectral width and frequency chirp of the optical signal in propogation.

B. Optical Modulators

An Optical Modulator is a device allowing one to manipulate or change the properties of light beams, such as the optical power or optical pulse.
For high speed communications (10Gbit/s and beyond) it becomes extremely difficult to modulate the laser directly, therefore external optical modulators are used[22]. The electro-absorption modulator is such a modulator.Although it improves the chirp performance but is not much reliable.
Another possibilty to modulate light pulse is a Mach-Zehnder structure in a mterial showing strong electro-optic effect. By applying a voltage the optical signal in each path is phase modulated as the optical path length is altered by the electric field. Combining the two paths with different phase modulation converts the phase modulation into intensity modulation.

IV. PRINCIPLE OF OPERATION

A. Dual-Drive Mach Zehnder Modulator

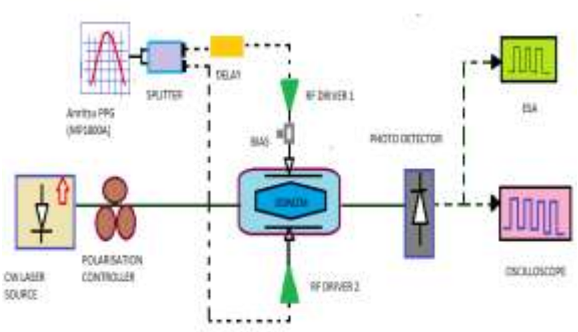

Figure .1. Setup of the reconfigurable UWB pulse generation using DDMZM.

A Dual- Drive Mach Zehnder Modulator is based on electro-optical effect in which the application of an electric field changes the R.I of the LbNbO3 resulting change of propagation of light[16].
DDMZM is an integrated optical modulator having an applied voltage at both ends of the electrodes which results in electric field generation with opposite polarities in the two arms of DDMZM [24] and therefore the coming wavelight from the source gets splitted between the two arms of the modulator and undergoes propogation delay in presence of applied voltage.For DDMZM , two phase shift arms are connected to different voltage source. The dual drive configuration uses data and inverted data to generate the intensity variation.
As we know that by applying a voltage the optical signal in each path is phase modulated as the optical path length is altered by the electric field.

B. Reconfigurable UWB Pulse

By carefully adjusting the signal amplitudes, the time delay between the two electrical signals and the bias voltage of the DDMZM, different UWB pulse shapes can be obtained at the interference output of the DDMZM. The proposed method can be used to realize pulse-shape modulation and flexible UWB pulse generation[16].
In the theoretical calculation, We set We set A_1=1.5Vπ, and A_2= 0, UWB doublet pulse is realized as presented in Fig.2.
In addition, if A_1 =A_2 = 1.5Vπ and Γ=0.5To., UWB quintuple pulse can be generated as observed in Fig.3.
It is worth noting that the polarity of the UWB pulse can be switched by adjusting the bias voltage of the DDMZM[24]. The output signal than undergoes phase modulation creating a phase shift which in turns create phase change and hence frequency is changed as per need so we can control and even minimise the power loss.

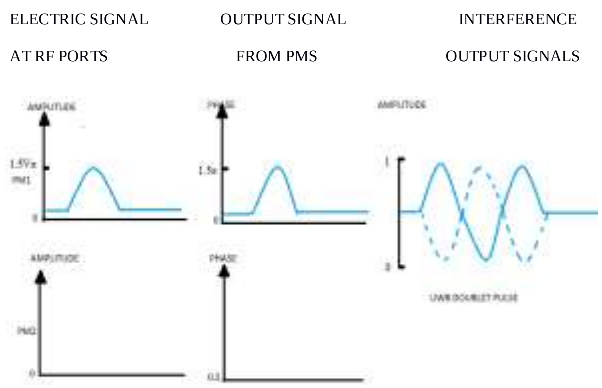

Figure 2. Waveforms of the UWB doublet pulse

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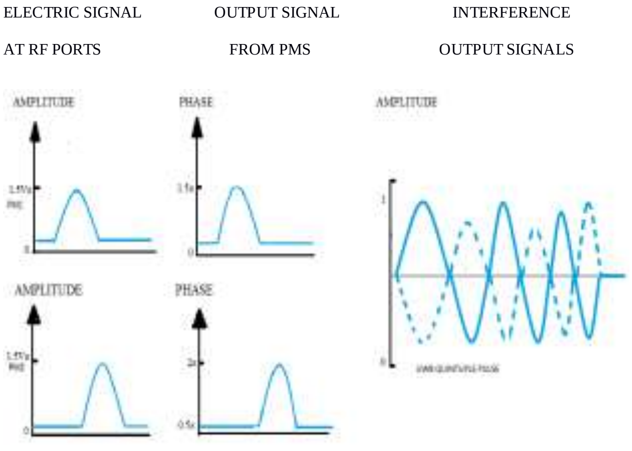

Figure 3. Waveforms of the UWB quintuple pulse

C. Characteristic Of Generated UWB Pulse

The electrical signals from the PPG with the same amplitude and certain relative time delay are directly fed to the two RF ports of the DDMZM. Then UWB pulse can be achieved by properly adjusting the amplitudes of the two electrical signals and the bias voltage of the DDMZM[16]. It is worth noting that the bias drifting problem of the DDMZM can affect the waveforms of the generated UWB pulses, which can be overcome by using feedback control.

a). Doublet Pulse

As we know that we have two phase modulators in a DDMZM. For generation of UWB doublet pulse we have introduced the driving signal only in PM1.The amplitude that is fed is $1.5V\pi$ and the second modulator PM2 is kept at 0 amplitude.As interference is the characteristic feature of the pulse generated through DDMZM , we can see the constructive and destructive interference pattern in the pulse twice in the same cycle.

b). Quintuple Pulse

For quintuple pulse we have fed input in both the phase modulators.A amplitude of $1.5V\pi$ is driven through both the PMs and a phase shift of 1.5π is maintained.In the interference pattern for quintuple pulse light waves undergoes interference as overlapping of four waves on one complete cycle of the wave pulse.

D. Phase Modulation

Modulation is nothing but converting the electrical message into proper format and secondly impressing the modulated signal onto the wave generated by the source.

Phase Modulation works by modulating the phase of the signal, i.e. changing the rate at which the point moves around the circle. This changes the phase of the signal and hence frequency is changed[6]. Phase and frequency are inseparably linked as phase is the integral of frequency. One of the major advantages of PM is improvement of spectral efficiency with minimal degradation of signal. By utilizing the principle of interference, the process of phase modulation can also be used to cause an intensity modulation of the optical light pulse.

In this research, we have modified the phase of the modulating signals creating a phase shift and studied the power loss characteristics of the output signal.

The effect of the phase modulation is to chirp the pulse and broaden its spectrum.

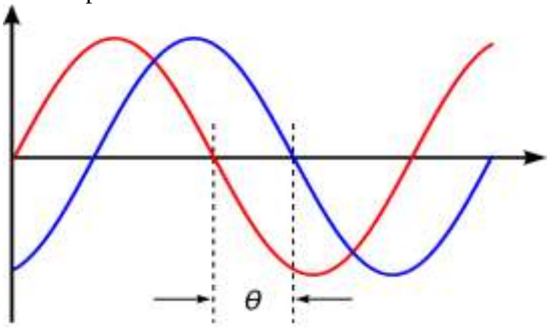

Figure 4. A typical sinusoidal pulse

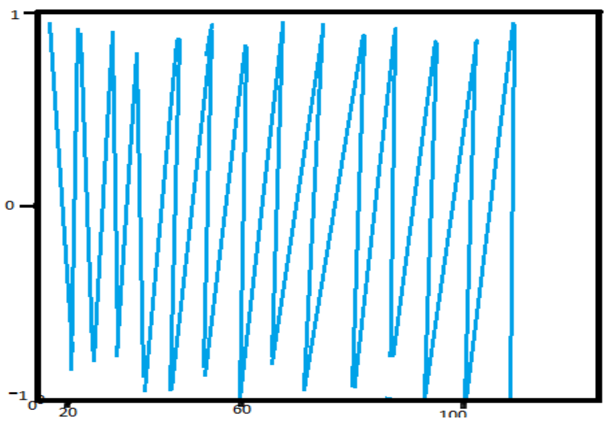

Figure 5. A typical phase modulated signal

E. Managing Power Loss

As we know that any light signal or light pulse has three main characteristics. They are Reflection, transmission and losses. The losses that light pulse undergoes lowers down the intensity of the signal and results in high power loss degrading the quality of the signal.

Here, we have made the signal to pass through the phase modulator, creating a phase shift which in turns create phase change and hence frequency is changed as per need so we can control and even minimise the power loss according to the requirement.

The generated reconfigurable signal is being used as an input to the phase modulator as a form of feedback control.

V. PERFORMANCE EVALUATION METRICES

A. Power and Field Transfer Characteristics.

A signal power describes the signal power distribution over the frequency whereas the field transfer is defined as the

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quantative expression of the intensity of an electric field at prescribed location.

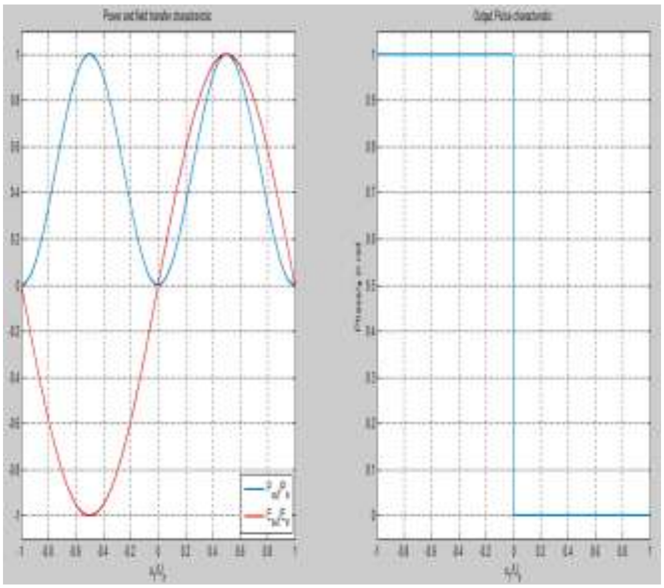

Figure 6. Power and field transfer characteristic and output pulse characteristic of UWB Pulse

B. Power Spectral Density.

Power Spectral Density shows the strength of the variation (energy) as function of frequency. In other words, it shows at which frequencies variation are strong and at which frequencies variations are weak.

As we can see in fig 7.that after the phase modulation we have achieved a power excess loss of 1.89dB for doublet pulse. As we minimize the loss we know that intensity and power of the signal is enhanced.

Here, the graph shown between the output electric field and the driving signal. The output electric field acquires a constant frequency value of 3Hz with power density varying from -90Db to -52Db.

The driving signal also gain the constant frequency value after being increased from power density of -94Db to 0Db and then start decreasing after -60 db and continues decreasing till frequency value of 8Hz and power density value of -95Db.

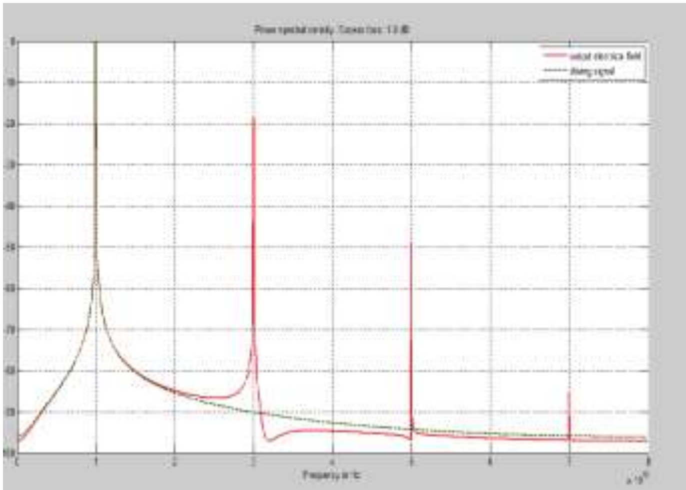

Figure 7. Power spectral density loss for doublet pulse.

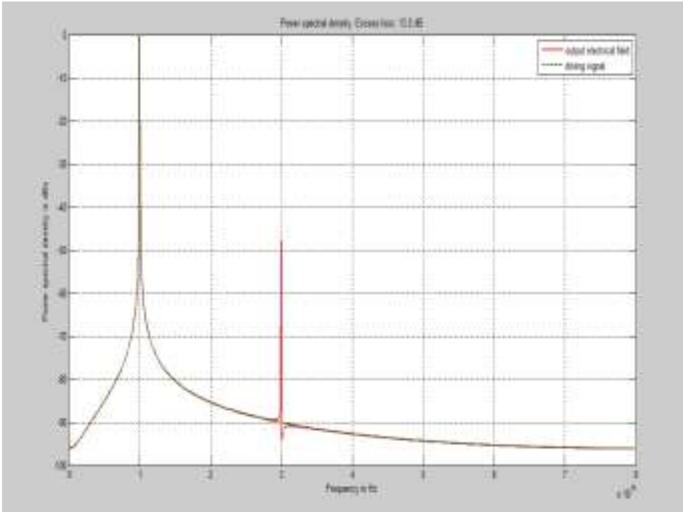

Figure 8. Power spectral density loss for quintuple pulse

Now figure 8. shows the characteristics of the Power spectral density after the signal being passed through the phase modulater with a phase shift for quintuple pulse. Here we can see variation in output electric field signal due to change of phase. We have maintained the driving signal as above but the electric field shows variations.

Here, the power spectral density loss has been reduced to a minimum value of 13.2 Db for quintuple pulse. The performance of the signal is enhanced as we know that controlling and managing the power loss of the system provides a better performance.

VI. CONCLUSION AND FUTURE SCOPE

This research work mainly dealt with quality improvement of UWB signal transmission by converting it into optical domain. The conversion into optical domain meet the challenges faced by UWB communication.

In this approach the distribution of UWB signals over optical fiber (UWBoF) extends the area of coverage and offers the availability of undisrupted service across different networks and gives the varied performances of the generated signal characterized in terms of Power and Field Transfer Characteristics, Power Spectral Density and Output Pulse Characteristics. We know that power loss in any system creates hindrance in the functioing so here we have controlled the losses of the output signal so that the quality of the signal can be upgraded.We have employed phase shift here so that power loss can be detected and controlled.

In future this paper will deal with the problem of UWB communication system by converting it to optical domain with increased efficiency and power. The issue of power loss in the transmission of the pulse can be improved and load on the signal bandwidth can be controlled and efficiently minimized.

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BIOGRAPHY

Akanksha Kumari, Received her B.Tech Degree in Electronics and Communication Engineering. from SHIATS in 2014. She is pursuing her M.Tech in OFCE (Optical Fiber Communication) from SHIATS, Allahabad. Her area of interest includes Optical Fiber systems..

Prof. A.K. Jaiswal is working as a Professor and HOD in the Department of ECE at SHIATS Allahabad. He worked for the promotional activities in optical fiber communication system sponsored by Government of India, in association with IIT Kharagpur and Madras. His research interests are Optical system, sensors and networks.

Er. Neelesh Agrawal is working as an Assistant Professor in the Department of ECE at SHIATS. He received the degree of M.Tech (ECE Add System) from SHIATS , Allahabad . His area of interest is advanced communication system engineering.

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