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Study and Design TDM-PAM Transmitter Receiver by Using MATLAB Software Program and Spectrum Analyzer

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ABSTRACT

The aim of this paper is to evaluate and study the frequency spectrum of modulated signal and determined the frequency deviation, modulation index and bandwidth for varies values of amplitude and frequency of modulating signal by using the spectrum analyzer and the oscilloscope instruments. at first ; study and analyze the theoretical point of view, analyzing the FM and AM signal, using the MATLAB simulation program, by studying the incoming signal and modifying it to FM or AM modulation, depending on the resolution band width, then discuss the simulation results of the frequency spectrum of DSB –SC waveform from spectrum analyzer communication lab instrument. The signal graph of the spectrum analyzer shows the characteristics of the signal, the vertical axis represents the amplitude and the horizontal axis represents the frequency and is known as the frequency domain representation, the spectrum analyzer is a device used to analyze the amplitude of the signal with respect to the frequency, so the input waveform presented to the spectrum analyzer is analyzed based on variable frequency. This test equipment is mainly used in the design, testing and maintenance of radio frequency circuits. It graphically displays the amplitude spectrum of radio signals with respect to the frequency. The amplitude is represented vertically on a logarithmic scale, while the frequency can be represented on a logarithmic or ordinary scale horizontally, then discuss the simulation results of the frequency spectrum of DSB –SC waveform from spectrum analyzer communication lab instrument.

1. Introduction

In today's fast-paced world, communication is essential for the exchange of information between people, machines and systems. Digital communication systems have revolutionized the way we communicate by providing faster, more efficient and reliable transportation TDM was first developed for applications in telegraphy to route multiple transmissions simultaneously over a single transmission line. In the 1870s, Émile Baudeau devised a system of time multiplexing for several Hughes telegraph machines. In 1953, 24-channel TDM was put into commercial operation by RCA Next-generation optical communication systems demand more capacity, a large nuinber of users, and high data rates this is solved by using dense wavelength division

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multiplexing (DWDM) systems with lower interchange space and high input power. However, increasing power and decreasing space can cause nonlinear effects such as four wave mixing (WM) Time-division multiplexing (TDM) can be used to decrease the power of FWM products. Figure1. Shows the TDM system.

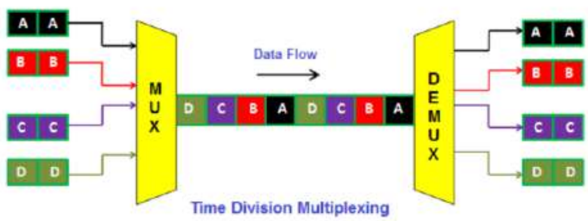

Figure 1. the TDM system

[4] nextgeneration time-division multiplexed passive optical network (TDM-PON) based on multilevel differential modulation formats is proposed. Multilevel modulation enables the efficient scaling of bit rates without resorting to very high-speed electronics and photonics. While differential detection simplifies the detection process. [5] We demonstrated a 40-Gbps TDM-PON over a 42- km, 64-split fiber plant using optical duobinary modulation. In the ONU a 25 Gb/s APD-based receiver was used for a cost-effective and low-power-consumption upgrade of TDM-PON. Experimental results show that our system supports 31 dB of power budget for a differential reach of 26 km at 1550 nm without DSP. Results of simulations to investigate optimization of the transmission performance are also presented [6]. A 20 Gb/s quaternary TOM-PAM access network has been demonstrated as upgrade path for legacy PONS. A loss budget of 27.3 dB can be supported in combination with a high loud-soft power ratio of 10 dB. Chirped, non-linear transmitters are also compatible [7]. the authors investigate the performance of various PAM techniques for optical fiber

Communications using MATLAB simulations. The study analyzes the impact of different parameters, such as number of levels, transition times, and pulse shaping, on the system performance. The results show that the optimal choice of PAM parameters depends on the specific application, but that overall PAM is an effective technique for optical fiber communications [8]. the authors present a system that transmits and receives multiple signals using PAM and TDM techniques. MATLAB software is used to simulate and optimize the system. The system is tested in both simulated and real-world environments, and the results show good performance and robustness[9]. Figure2. Shows the simplified diagram of TDM system.

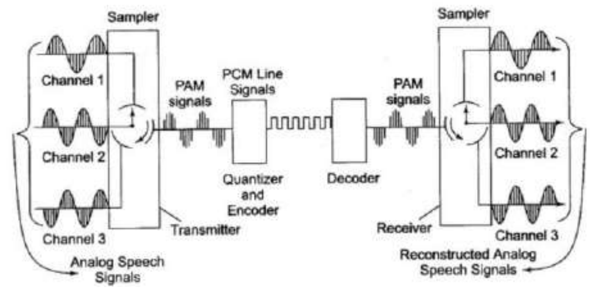

Figure 2. the simplified diagram of TDM system

Communications to transmit audio information between RCA's facility on Broad Street, New York, its transmitter station at Rocky Point, and its receiving station at Riverhead on Long Island, New York. Communication was via a microwave system throughout Long Island. The experimental TDM system was developed by RCA Laboratories between 1950 and 1953. [1] In 1962, Bell Labs engineers developed the first D1 channel banks, which combined 24 digital voice calls over a four-wire copper stem between the analog switches of the Bell central office. A bank has divided a digital signal channel of 1.544 Mbit/s into 8000 separate frames, each consisting of 24 contiguous bytes. Each byte represents one phone call encoded to a fixed bit rate signal of 64 kbit/s. Channel banks used the fixed position (time alignment) of a single byte in the frame to determine which call it belonged to.[2] There are three types of synchronous time division multiplexing: • T1 • SONET/SDH • ISDN.[3] It has developed digital hierarchy (PDH) as a standard for multiplying frames. PDH created higher numbers of channels by multiplying the European standard 30 channels of TDM frames. This solution worked for a while. However PDH suffered from several inherent drawbacks that eventually resulted in the development of Synchronous Digital Hierarchy (SDH). Pulse amplitude modulation (PAM) and time division multiplexing (TDM) are common methods used in digital communication systems to transmit multiple signals over a single channel

.In this project, we aim to design and implement a multi-channel transceiver system using PAM and TDM technologies on MATLAB software. The project will provide insight into the practical application of PAM and TDM technologies and contribute to the advancement and development of digital communications research. The project will also provide valuable guidance for the implementation of PAM and TDM technologies in digital communication systems

Some of the challenges that one might face while working on the TDM and PAM transmitter and receiver project using MATLAB software are:

.Designing and implementing an efficient and robust transmitter that can modulate multiple signal sources into a single channel using PAM and TDM required a good understanding of the concepts. Identifying and minimizing signal distortion and noise interference during transmission using different signal processing techniques, such as filtering, demodulation, and error correction. Determining the optimum settings for TDM and PAM parameters to optimize system performance. Debugging and error correction in the program if any, to get the accurate simulation and results. Understanding the trade-off between bandwidth, signal-to-noise ratio, and transmission capacity. Debugging the MATLAB code, especially when dealing with complex mathematical operations that may cause computation errors. Figure 3. Shows the Type of Multiplexing.

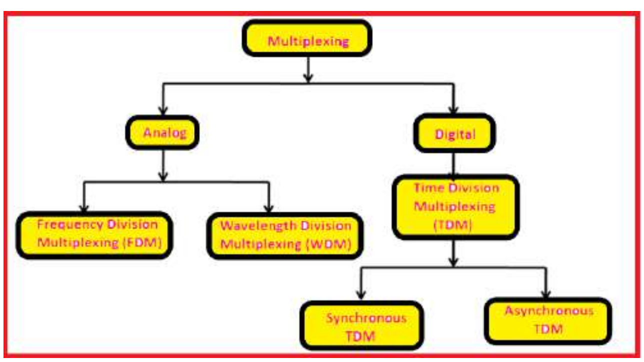

Figure3. The type of multiplexing

Overall, the project requires a good understanding of signal processing and communication systems concepts, as well as the proficiency in programming and MATLAB software. TABLE1. Shows the Comparing between FDM, WDM, and TDM.

TABLE1. Comparing between FDM, WDM, and TDM

FDM	WDM	TDM
1. The communication channel is divided by frequency.	1. The communication channel is divided by wavelength.	1. The communication channel is divided by time.
2. Analog technique.	2. Analog technique.	2. Digital technique.
3. Synchronization is not required.	3. Synchronization is not required.	3. Synchronization is required.
4. It requires complex circuitry at the transmitter and receiver.	4. It requires complex circuitry at the transmitter and receiver.	4. It does not require complex circuitry.
5. In FDM, the problem of crosstalk is severe.	5. In WDM, the problem of crosstalk is severe.	5. In TDM, the problem of crosstalk is not severe.
6. The channel bandwidth is effectively used.	6. The channel bandwidth is effectively used.	6. The channel bandwidth is wasted.

The article contributes to the design of a wireless communication system that uses TDM and PAM technologies. This system can be used in many applications that require wireless communication, such as wireless sensor networks, mobile communications, and satellite communication. The project uses Matlab software to simulate and analyze a wireless communication system. Matlab provides a flexible and powerful environment for simulating wireless communication systems and analyzing their performance. Optimization of the TDM and PAM communication system to achieve better performance. This optimization can be achieved by adjusting the modulation parameters, such as pulse width, modulation index, and sampling rate. This project can be used as a reference for researchers and engineers who are interested in designing and analyzing wireless communication systems. To design and develop a multi-channel transmitter and receiver system using PAM and TDM modulation techniques. To study the theoretical background of PAM and TDM techniques in digital communication. To simulate the designed systems In MATLAB and analyze their performance under different conditions. To verify the functionality of the designed systems through hardware implementation. To compare the performance of the designed systems with existing techniques and evaluate their advantages and limitations. To provide practical guidelines for the Implementation of PAM and TDM techniques In digital communication systems.to contribute to the advancement of digital communication research and development in the area of multi-channel transmission and reception.

2. Methology

In this section, we will explain the structure of the system using codes in the matlab according to this methodology, to implement a TDM and PAM transceiver using MATLAB software, we follow the following general methodology: We define the signal we want to transmit using MATLAB variables. For example, if you want to send an audio signal, you can load the audio file and store it in a variable. Implementation of TDM technology by dividing the time into several time slots for each signal. You can do this using MATLAB's time division functions. Convert the signals into a digital format, using MATLAB's analog-todigital conversion functions. Applying PAM technology by changing the amplitude of the pulses in the digital signal according to the digital data. Transmission of TDM and PAM digital signals over a communication channel. As in channel simulation in MATLAB. We turn on the receiver by converting the PAM signal into a digital signal using demodulation techniques. Then use MATLAB's TDM functions to separate the different signals. Finally, convert the digital signals back to their original analog form, if necessary, using MATLAB's digital-to-analog conversion functions. To analyze the performance of tdm we need the following parts: Computer and Matlab software program. In this part, we explain the code part by part to understand how it works. Figure 4. Shows the first part for the code.

```
Clc;
Close all;
Clear all;
% Signal generation
X=0:.5:4*pi; % signal taken up to 4pi
Sig1=8*sin(x); % generate 1st sinusoidal signal
L=length(sig1);
Sig2=8*triang(l); % Generate 2nd triangular Signal
```

Figure4. The first part for the code

In the first part we use the clc, close all, and clear commands To get rid of the previous data and changes that affect the products later Then we generate two signals, The first signal: a sinusoidal signal based on the sin() function, by generating a set of points based on time steps, where x is used as the input of the function, which represents the distribution of points in time. Where 'x' represents the extension from 0 to 4*pi second signal: a triangular signal based on the triang() function, which is produced depending on the details of the first signal (sig1). The two experimental waves (sig1 and sig2) were generated for further signal analysis. Figure 5. Shows second part for the code.

```
%Display of Both Signal
Subplot(2,2,1);
Plot(sig1);
Title('Sinusoidal Signal');
Ylabel('Amplitude-→');
Xlabel('Time-→');
Subplot(2,2,2);
Plot(sig2);
Title('Triangular Signal');
Ylabel('Amplitude-→');
Xlabel('Time-→');
```

Figure5. The second part for the code

This part starts with demonstrating the statistical results of collected data followed by explaining and analyzing each item of the questionnaire. This part of the code displays the information for both signals generated. The subplot command is used to create a single rectangular display window and divide it into two small grid areas, each representing a set of signals. The variables “sig1” and “sig2” show the two binary signals generated using the “sin” function, both of which consist of different amplitude values at given moments in time. The functions "plot", "title", "xlabel" and "ylabel" are used to visually display the data contained in the variables, indicating the properties of the signs, labeling the horizontal and vertical axis and titles of the graphs. Figure6. The third part for the code

```
% Display of Both Sampled Signal
Subplot(2,2,3);
Stem(sig1);
Title('Sampled Sinusoidal Signal');
Ylabel('Amplitude-->');
Xlabel('Time-->');
Subplot(2,2,4);
Stem(sig2);
Title('Sampled Triangular Signal');
Ylabel('Amplitude-->');
Xlabel('Time-->');
L1=length(sig1);
L2=length(sig2);
For i=1:l1
Sig(1,i)=sig1(i); % Making Both row vector to a matrix
Sig(2,i)=sig2(i);
End
```

Figure6. The third part for the code

As shown from Figure 6 in the mythology section in this article , the This part of the code is used to display the signals used after modification to the previous signals. The code consists of four parts. Part one and two use the subplot function to create a rectangular window and divide it into two small regions, each representing a set of signals. The "stem" function returns the signals generated by the "sin" and "sawtooth" functions. The "title", "xlabel", and "ylabel" functions are used to display some signal properties, horizontal and vertical axis labels, and graph titles. The third part Is used to make the signals displayed in the previous two fields into an array format, whereby a "sig" array is created and filled with both the "sig1" and "sig2" signals. The fourth part calculates the length of "sig1" and

"sig2", then uses a loop to create a "sig" matrix using the previous signals so as to convert each signal into an array form separately and combine them into on matrix . shows the below figure 7. The fourth part for the code.

```
% TDM of both quantize signal
Tdmsig=reshape(sig,1,2*l1);
% Display of TDM Signal
Figure
Stem(tdmsig);
Title('TDM Signal');
Ylabel('Amplitude-->');
Xlabel('Time-->');
% Demultiplexing of TDM Signal
Demux=reshape(tdmsig,2,l1);
For i=1:l1
Sig3(i)=demux(1,i); % Converting The matrix into row vectors
Sig4(i)=demux(2,i);
End
```

Figure 7. The fourth part for the code

In this part of the code, the different signals from the different samples generated by the frequency conversion are parsed and divided and summed at the same time using a technique called virtual multiplexing (TDM). The code starts by creating a new value called tdmsig using the reshape function and previous variables to convert the formula from an array to a single matrix. Accordingly, tdmsig was drawn using the "stem" function to display the signal emitted from the previous technique. Then the "reshape" function is used again to divide "tdmsig" into a 2×l1 matrix, where each signal is distributed to the right place after aggregation. These signals are rearranged into the original array by creating an array "sig3" and "sig4" using a for loop, where the signal from the matrix form is distributed to the array form for each signal separately, and the signals "sig3" and "sig4" are returned as the original form for use in subsequent applications. Figure 8. Shows the fifth part of the code.

```
% Demultiplexing of TDM Signal
Demux=reshape(tdmsig,2,l1);
For i=1:l1
Sig3(i)=demux(1,i); % Converting The matrix into row vectors
Sig4(i)=demux(2,i);
End
```

Figure 8 The fifth part for the code

This code decodes the previously implemented Virtual Multiplexing. Multiplexing (TDM) signals. The "reshape" function is used to split the perceived TDM signal into two separate signals. The resulting form is generated by "reshape" as a 2×l1 matrix. The loop applies the values of the elements in the array "demux" to convert the array into hashed forms and saves it in new variables sig3 and sig4 so that the signs become vertical by adding the code "sig3(i)=demux(1,i)" and "sig4(i)=demux (2,i)". This process is called Demultiplexing or De-Muxing, where signals overlapping in time are transformed into signals that are discrete in time. Figure 9. Shows The sixth part for the code

```
% display of demultiplexed signal
Figure
Subplot(2,1,1)
Plot(sig3);
Title('Recovered Sinusoidal Signal');
Ylabel('Amplitude-->');
Xlabel('Time-->');
Subplot(2,1,2)
Plot(sig4);
Title('Recovered Triangular Signal');
Ylabel('Amplitude-->');
Xlabel('Time-->');
```

Figure 9. The sixth part for the code

This code displays the demultiplexed signals from the filter outputs associated with the input signal, after the necessary conversion and division operations to decompose the transmitted signal. Uses the "figure" function to create a new window to display the decoded signals. In line 2 and 3, the "subplot" function is used to display the deconstructed signals in two different shapes in the same window. The deconstructed signal related to the first filter is shown in the first figure, labeled "Recovered Sinusoidal Signal", "Amplitude- "Time" on the y-axis respectively, in line 4 and 5. The deconstructed signal related to the second filter is shown in the second figure, labeled "Recovered Triangular Signal", "Amplitude", " Time-" on the y- axis respectively, in line 6 and 7. The purpose of this code is to verify that the signal decoding is correct and successful.

1. Simulation result:

If the simulation is too slow, we could speed up it using the MATLAB code. With the MATLAB coder, the compiled MATLAB code can be generated, which significantly improves processing speed. A supporting MATLAB-coder is used to build the Radar Stream Run-mex feature in Figures 6.a and b. The following command is shown: In the concept of system output, a radar system, the RF front end also plays an important part. Improving speed depends on many factors such as the computer CPU speed and the memory available. Notice that MATLAB Coder does not speed up the visualization of data using scopes and is still done with the MATLAB interpreter. From the simulation result , resulting signals, it can be said:

1. The system works well under different conditions.
2. Improved parameters resulted in higher spectral efficiency
3. And a higher data rate With lower bit error rate through advanced encryption and decryption techniques.
4. The TDM and PAM transceiver system developed using MATLAB software provides a valuable tool for transmitting digital signals. Figures 10,11 Shows the Sinusoidal Signal and Triangular Signal.

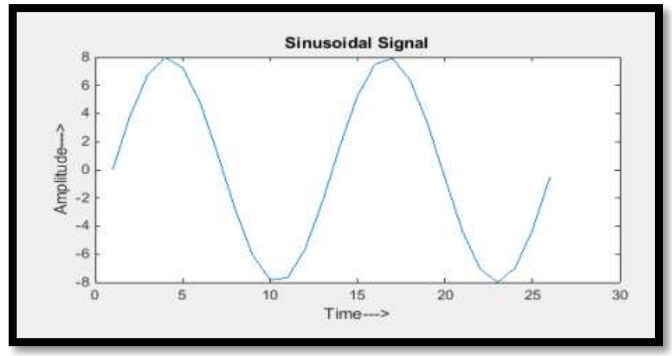

Figure 10. Sinusoidal Signal

This signal is repeated in a systematic and continuous manner. This signal consists of a frequency value, which is calculated as the number of times the signal is repeated during one second

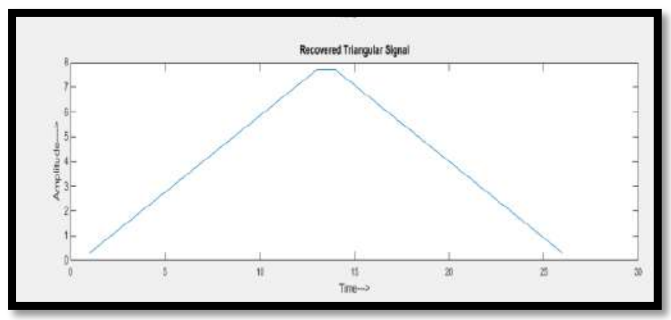

Figure 11. Triangular Signal

A triangular signal is that changes in a triangular wave function in time, starting from zero and then rising continuously to reach a specific value, and then decreasing in the same way to return to the first value (zero) in a full cycle. Figures 12,13 shows the Sampled sinusoidal and Triangular Signal. And figure 14 shows the TDM signal respectively.

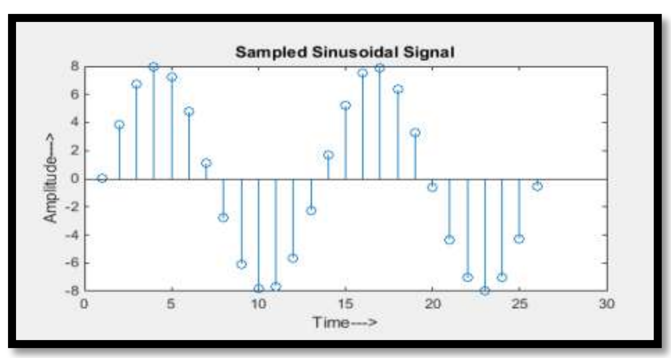

Figure 12.Sampled sinusoidal Signal

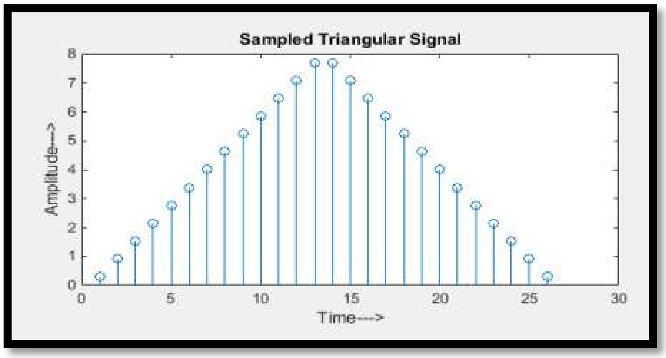

Figure 13. Sampled Triangular Signal

A TDM signal consists of a set of different digital signals converted into a single digital signal by time frequency modulation. Thus, the signal generated by TDM technology consists of a set of different time periods within a single cycle. The duration of the time period for each signal is determined by the frequency of its original signal.

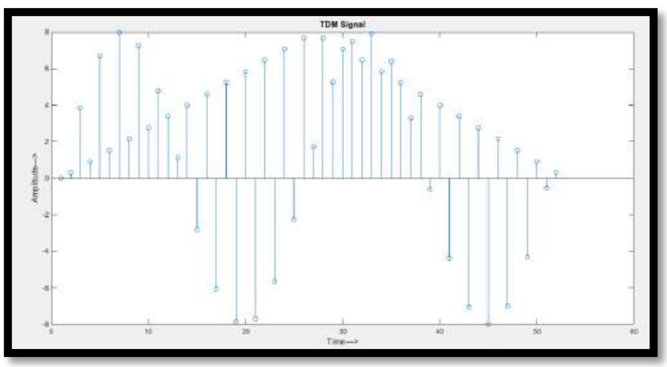

Figure 14 TDM Signal

At last, Figures 15,16 shows the Recovered sinusoidal and Triangular Signal respectively.

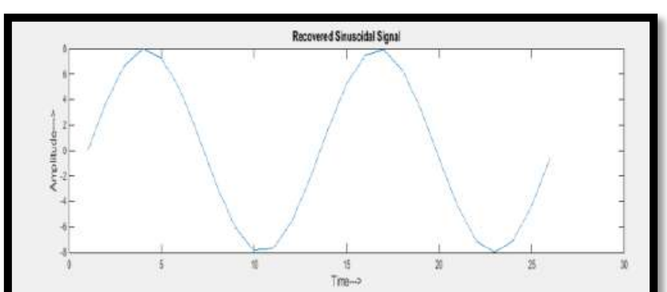

Figure 15. Recovered (Sinusoidal)Signal

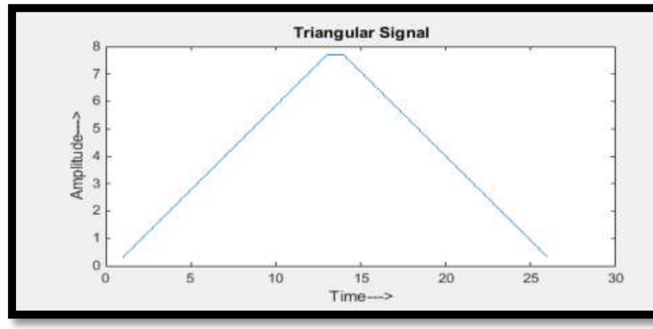

Figure 16. Recovered (Triangular)Signal

3. CONCULSION

This paper design a Future work includes the design and implementation of a multi-channel

transceiver system using PAM and TDM techniques on MATLAB software. Increase the number of channels because the current design supports a limited number of channels. Business can focus on increasing the number of channels that can be sent and received simultaneously. It also improves the system's resistance to noise because PAM and TDM systems are susceptible to noise and distortion, which may affect the quality of transmitted signals. In the future, it also works to improve system noise resistance through the use of more sophisticated error correction techniques. Integration of other modulation techniques Various modulation techniques are available for digital communication systems. The integration of other modulation techniques, such as Quadrature Amplitude Modulation (QAM), can also be explored to improve system performance. Develop a more user-friendly interface as the current implementation relies heavily on MATLAB commands and scripts, which can be challenging for non-experts. We are also developing a more user-friendly interface that facilitates system configuration and operation. Check out the real-time implementation as the current design runs in a simulated environment. Future work can investigate the real-time implementation of designed systems on hardware platforms to evaluate their performance and reliability in practical applications. Evaluate the scalability of the system as the current design is optimized for a limited number of channels. The scalability of the system, ie its ability to support varying numbers of channels with optimal performance, can be investigated. Investigate the effect of channel interference where the designed

system assumes that each channel operates independently. The effect of channel interference, that is, how system performance is affected when channels interfere with each other, can be investigated and the integration of interference avoidance techniques can be investigated. Explore alternative signal coding techniques where the current design uses PAM for signal coding. Future work explored alternative signal coding techniques, such as Pulse Code Modulation (PCM), to evaluate their performance and suitability for the designed system.

4. Referenses

[1]. Amenah E.kanaan, sabaF. Ahmed Jaf," Design Linear Array Antenna for Celllular system", Przeglad elektrotechniczny , ISSN 0033-2097,R,99 NR4, 2023.

[2]. Maria Isabel Gandia Carriedo, "Time Division "Multiplex System for Signals of Different Bandwidth Maria.

[3]. Maria Isabel Gandia Carriedo (August 31, 1998). "ATM: Origins and State of the Art" (https://web.archive.org/web/20060623211435/http://www.dit.upm.es/infowin/atmeurope/CH2/atmbackg.html). Universidad Politécnica de Madrid. Archived from the original(http://www.dit.upm.es/infowin/atmeurope/CH2/atmbackg.html) on June 23, 2006. Retrieved September 23, 2009

[4]. Alishah Khalid - Habib Ullah Manzoor, "Optimization of different TDM techniques in DWDM optical networks for FWM suppression" Article number: 206 (2023). [4]

[5]. Nikolaos Sotiropoulos, AMJ Koonen, Huug de Waardt, "IEEE Photonics Technology Letters 25 (5), 418-421, 2013

[6]. Doutje van Veen, Vincent Houtsma, "Demonstration of 40-Gbps TDM-PON over 42- km with 31 dB Optical Power Budget using an APD-based Receiver

[7]. Jochen Verbrugghe, Bernhard Schrenk, "Quaternary TDM-PAM and its Implications for TDMA Equipment, Optics Express 20 (26), B15-B20, 2012".

[8]. Sham. M. S."Performance Analysis of Pulse Amplitude Modulation Techniques for Optical Fiber Communications". 2017.

[9]. Amenah E.kanaan, Saba F. Ahmed Jaf ," Study the RCS effect on Monostatic radar system performance", IEEE Xplore, 2021.

[10]. Jalal, G. K., Al-Khafaji, S. J. (2020). Heavy Metals and Polycyclic Aromatic Hydrocarbons (PAHs) Distribution in Conocarpus Lancifolius Plant Leaves in Basrah, Iraq. *Journal of Global Scientific Research*. 11: 936-950.