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Analysis of 100Gbps Based Optical AP-DCDM Network

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Abstract: Multiplexing is a method by which multiple analog message signals or digital data streams are combined into one signal over a shared medium. The aim is to share an expensive resource. TDM is the most widely used multiplexing technique in today's communication, in which the main issue is a clock recovery that may render the system highly complicated and costly for TDM system. Therefore, many investigations have been done to design and develop reliable and cost-effective clock recovery modules for TDM in both electrical and optical versions. These problems can be resolved by an absolute polar duty cycle division multiplexing (APDCDM). APDCDM also decreases the complexity of receiver and improved the capacity of channels as compare to the DCDM system. In this workfive user APDCDM system has been designed and each user has data rate of 20Gbps, $20 \times 5 = 100$ Gbps signal is transmitted through optical fiber cable and data is successfully transmitted up to 75 km distance using a standard single mode fiber.

Keywords: APDCDM, BER.

I. INTRODUCTION

Multiplexing is one of the fundamental necessities in today's digital communications. Multiplexing allows multiple users (or data inputs) to share the bandwidth of the transmission medium. In existing systems, the medium is normally shared based on time slot (TDM), carrier frequency (FDM) or spectrum coding (CDM). The goals of all multiplexing techniques are to support as many users at as high speed and at the lowest cost possible [3].

However, for multiplexing high number of users with high data rates, high speed multiplexer and de-multiplexer are required. At higher speeds clock recovery is another essential issue which limit the conventional multiplexing techniques.

Realizing these problems the design of five users Absolute Polar Duty Cycle Division Multiplexing (APDCDM) based Optical communication system has been proposed in this paper.

The absolute polar duty cycle division multiplexing is a variant of DCDM. APDCDM require less bandwidth and less energy for transmission as compared to DCDM technique.

It is based on having each channel modulated with a unique RZ duty cycle. In this technique each multiplexing user transmits bit '0' with zero volts and for the case of bit one, the odd users transmit with +A volts and the even users transmit with –A volts.

Based on the linear distribution of duty cycle, the i^{th} multiplexing user transmits bit 1 within $T_i$second which is calculated as:

$$T_i = \frac{i \times T_S}{(n+1)}$$

Where, 'n' represents number of multiplexing users.
For example, assigning the duty cycle value for 5 users using DCDM technique:

For the 1st user = $T_s/6$.
For the 2nd user = $2T_s/6$.
For the 3rd user = $3T_s/6$.
For the 4th user = $4T_s/6$.
For the 5th user = $5T_s/6$.
For n=5, 2^5=32 possible combinations are shown in table-1

Table 1: Possible combination of five user APDCDM System

Cases	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
User-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
User-4	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
User-3	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
User-2	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
User-1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1

Cases	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
User-5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
User-4	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
User-3	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
User-2	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
User-1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1

Five user APDCDM has 32 cases out of them some cases are discuss below as-

Case-4,Symbol-1 generates by User-1 & User-2
Symbol-0 generates by User-3, User-4& User-5

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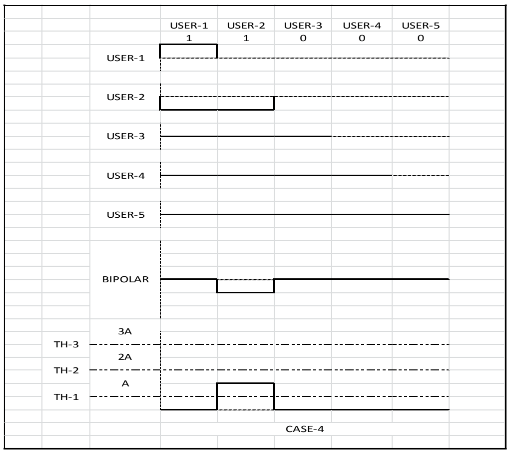

Figure 1.1: Wave form of case-4 for five user APDCDM system

Case-8, Symbol-1 generates by User-1, User-2&User-3 Symbol-0 generates by User-4 &User-5

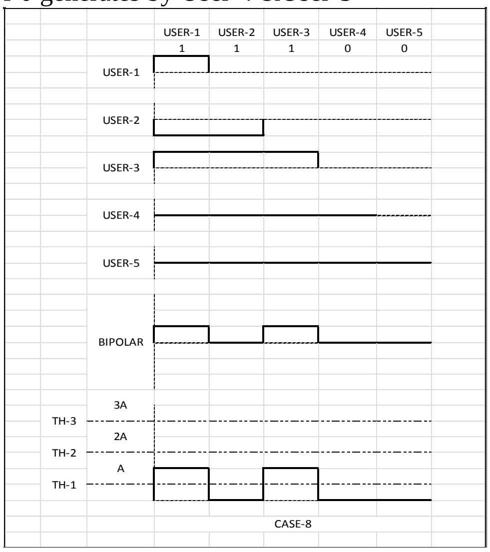

Figure 1.2: Wave form of case-8 for five user APDCDM System

Case-16, Symbol-1 generates by User-1,2,3 and 4 Symbol-0 generates by User-5

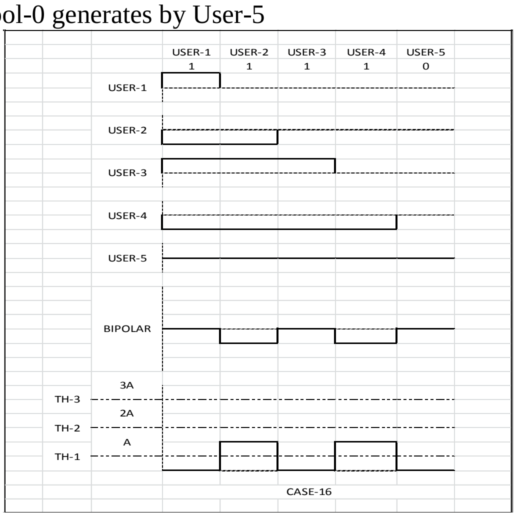

Figure 1.3: Wave form of case-16 for five user APDCDM system

Case-32,Symbol-1 generates by User-1, 2, 3, 4 and 5

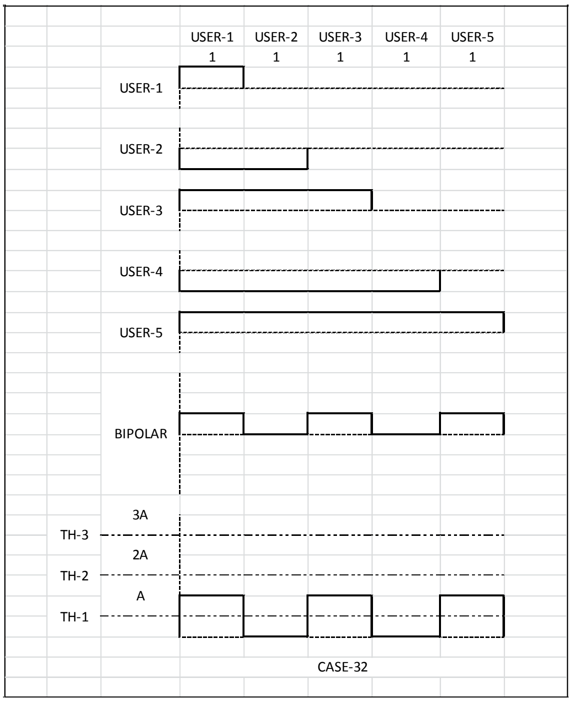

Figure 1.4: Wave form of case-32 for five user APDCDM system

II. SIMULATION SETUP

In transmitter section, the five users send their data at different duty cycles. There are five user define Bit Sequence Generators (BSG), the output of BSGs are modulated by Return to Zero (RZ) pulse generators. The RZ pulse generator modulates duty cycle of input signal as shown in figure-2. The RZ-PG1 modulates 15%, RZ-PG2 modulates 30%, RZ-PG3 modulates 45%, RZ-PG4 modulates 60%, and RZ-PG5 modulates 75%. The last 25% is used for guard band purpose, to avoid symbol overlapping in communication system.

The output of RZ pulse generators are electrically multiplexed using Electrical adder. The Output of electrical adder is passed through the absolute polar circuit and then multiplexed data is converted in optical signal by modulating the continuous wave (CW) laser (light source) and transferred through an optical fiber.

The optical signal is received and detected by a PIN detector which converts the optical signal in electrical form. Then low pass filter (LPF) is used to eliminate the noise that produced in optical fiber.

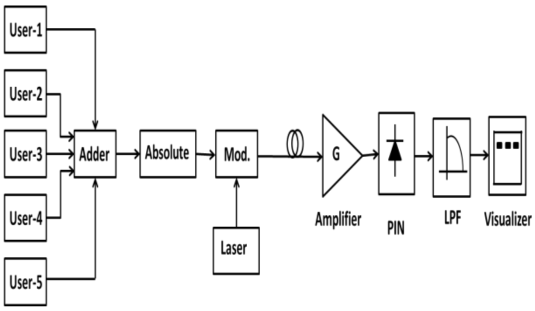

Figure 2: Block diagram of 100 GBPS WDM Optical Network

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III. RESULTS

III.I Data Recovery Rules-

The digital receiver uses probability theory for decision making based on that each amplitude has a threshold, below threshold signal is considered as logic-0 otherwise logic-1.There are five users; each user has different data recovery rule for all 32 cases. Here five user uses five sampling points (sp_1, sp_2, sp_3, sp_4 and sp_5) in x-axis (time) and three threshold values (th_1, th_2 and th_3) in y-axis (amplitude).

Table 2: Data recovery rule for User-1

Rules For User-1			
Rules		Cases	Data U-1
1.	If $sp_1 < th_1$,$sp_2 < th_1$	1,7,13,19,25,30,31	0
2.	If $th_1 \le sp_1 < th_2$, $sp_2 < th_1$	2,8,14,20,26,32	1
3.	If $th_1 \le sp_1 < th_2$, $th_1 \le sp_2 < th_2$	3,5,9,15,17,23,28	0
4.	If $sp_1 < th_1$, $th_1 \le sp_2 < th_2$	4,6,10,16,27	1
5.	If $th_2 \le sp_1 < th_3$, $th_2 \le sp_2 < th_3$	11,21	0
6.	If $th_1 \le sp_1 < th_2$, $th_2 \le sp_2 < th_3$	12	1
7.	If $th_2 \le sp_1 < th_3$, $th_1 \le sp_2 < th_2$	18,24,29	1
8.	If $th_3 \le sp_1$, $th_2 \le sp_2 < th_3$	22	1

Table 3: Data recovery rule for User-2

Rules For User-2			
Rules		Cases	Data U-2
1.	If $sp_2 < th_1$,$sp_3 < th_1$	1,2,13,14,25,26	0
2.	If $th_1 \le sp_2 < th_2$, $sp_3 < th_1$	3,4,15,16,27	1
3.	If $th_1 \le sp_2 < th_2$, $th_1 \le sp_3 < th_2$	5,6,9,10,17,18,28,29	0
4.	If $sp_2 < th_1$, $th_1 \le sp_3 < th_2$	7,8,19,20,30.31.32	1
5.	If $th_2 \le sp_2 < th_3$, $th_1 \le sp_3 < th_2$	11,12	1
6.	If $th_2 \le sp_2 < th_3$, $th_2 \le sp_3 < th_3$	21,22	0
7.	If $th_1 \le sp_2 < th_2$, $th_2 \le sp_3 < th_3$	23,24	1

Table 4: Data recovery rule for User-3

Rules For User-3			
Rules		Cases	Data U-3
1.	If $sp_3 < th_1$,$sp_4 < th_1$	1,2,3,4,25,26,27	0
2.	If $th_1 \le sp_3 < th_2$, $sp_4 < th_1$	5,6,7,8,28,29,30,31,32	1
3.	If $th_1 \le sp_3 < th_2$, $th_1 \le sp_4 < th_2$	9,10,11,12,17,18,19,20	0
4.	If $th_2 \le sp_3 < th_3$, $th_1 \le sp_4 < th_2$	21,22,23,24	1

Table 5: Data recovery rule for User-4

Rules For User-4			
Rules		Cases	Data U-4
1.	If $sp_4 < th_1$,$sp_5 < th_1$	1,2,3,4,5,6,7,8	0
2.	If $th_1 \le sp_4 < th_2$, $sp_5 < th_1$	9,10,11,12,13,14,15,16	1
3.	If $th_1 \le sp_4 < th_2$, $th_1 \le sp_5 < th_2$	17,18,19,20,21,22,23,24	0
4.	If $sp_4 < th_1$, $th_1 \le sp_5 < th_2$	25,26,27,28,29,30,31,32	1

Table 6: Data recovery rule for User-5

Rules For User-5			
Rules		Cases	Data U-5
1.	If $sp_5 < th_1$	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	0
2.	If $sp_5 \ge th_1$	17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32	1

From above graphs it is conclude that if value at Sp_i and Sp_{i+1} is at same level than i^{th} user sends zero bit. And if value at Sp_i is one more level than value at Sp_{i+1} than i^{th} user send one bit. Based on these data recovery rules the multiplexed data of five users is recovered. There are different rules for different users.

III.II BER versus Length-

Figure-3, shows BER versus length graph for five user APDCDM system at the data rate of 100Gbps. The multiplexed data is transmitted through a SSMF of 100km length; the BER is successfully maintained up to 75km.

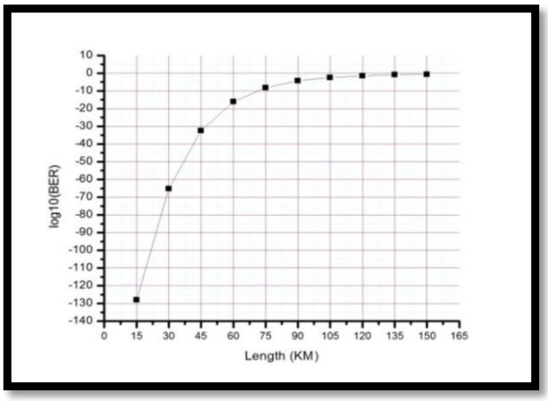

Figure 3: Log BER Vs Length for five user APDCDM

IV. CONCLUSION

The five user Absolute Polar Duty Cycle Division Multiplexing (APDCDM) based optical communication has been designed successfully. The data recovery rules also designed for five user APDCDM system. The 100Gbps multiplexed signal is transmitted on the network and data is successfully transmitted up to 75 km distance.

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