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50G-PON-BASED DP-QPSK TECHNIQUE BY UTILIZING THE MILLIMETER FREQUENCY SPECTRUM

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ABSTRACT

For the fifth generation (5G) broadband fronthaul network, the architecture of the 50 Gbps passive optical network (50G-PON) is provided. This research makes use of a quadrature phase shift keying (QPSK) structure with a coherent receiver network and the dual polarization (DP) idea. In order to maximize band usage, the millimeter wave at 32 GHz is modulated over 50G DP-QPSK that spans a 60 km fiber span. A more effective technique to utilize millimeter wave in the high spectrum region for mobile broadband is through passive optical network solutions. The performance is assessed using the constellation figure and signal spectra.

Keywords: 5G, Millimeter Wave, Dual Polarization-Quadrature Phase Shift Keying.

INTRODUCTION

5G is rolling out in India too as in other countries due to its high speed performance that offers the high transmission rate, massive bandwidth, and utilization of millimeter wave spectrum(Konstantinou et al. 2020). 50G-PON is getting popular for 5G fronthaul network that serves the 50 Gbps of rate to a single wavelength(ZTE 2020)(Lagkas et al. 2020). Moreover for the massive bandwidth demand and spectrum efficiency, millimeter wave is trending too that provides the low data loss, interference resistant etc.(Raddo et al. 2019)(Series and Science 2018). Digital modulation techniques enhance the broadband network performance like quadrature amplitude modulation (QAM), QPSK and DP-QPSK etc.(Gupta, Bhatia, and Kaur 2014).

DP-QPSK combines the quadrature and phase shifting to present the input data that is modulated the two bits together at once (Kasangottuwar, Tagare, and Vibha 2018). It is very helpful to transmit the high amount of informative data for the better utilization of optical resources and to enhance the signal capacity, presented system can be optimum option(Faraj 2020)(Series and Science 2018). The system that is being given has two polarizations, X and Y, each of which may carry two bits per symbol, giving a total of four bits per symbol. DP-QPSK can provide the high bit rate that is beneficial for long haul too(Sharma, Agrawal, and Kapoor 2022). It may perform better depending on the fronthaul network's convenience. Several studies in recent years have concentrated on the bit rate per wavelength and unique spectrum band millimeter wave, which offers enormous bandwidth to enable the 5G fronthaul under the 50G-PON conditions.

JI Xingping et al. (2018) proposed the concept of radio frequency at 15 GHz and 20 GHz over single mode fiber at space of 20 km. External modulation method was used to generate the radio frequency via 8PSK and 16PSK. Comparison was showed that 8PSK was better than 16PSK and enhanced the communication(Series and Science 2018).

Kun Qu et al. (2018) proposed the photonic vector signal generation via DP-QPSK that modulate the millimeter wave spectrum with the help of frequency quadrupling, was used without precoding to balance the detection. The option that produced QPSK for the +4th order sideband was 16-QAM and DP-QPSK utilized as sub-modulators to balance the signal detection process. The proposed vector signal was modulated at 40 GHz that used the spectrum quadrupling. Millimeter vector signal was assessed via error rate, eye and constellation diagram at the 20 km of fiber span(Qu et al. 2018).

Neeraj Sharma et al. (2019) analyzed laser link width effects via dense wavelength division multiplexing (DWDM) that utilized the DP-QPSK technique. The eight channels were multiplexed at 50 GHz of spacing between the transmitted channels. The comparison was done to validate the gray and deferential encoding. The performance was enhanced via differential encoding system that was optimum of laser(Sharma et al. 2019).

Subhrajit Pradhan et al. (2019) proposed the FSO for the ultra-transmission rate that employed the digital modulation format DP-QPSK. 16 input channel DWDM was evaluated at the 120 Gbps signal transmission rate. The outcome was evaluated for three advanced digital formats such as QPSK, QAM and DP-QPSK. The proposed system was aimed to enhance the FSO performance(Pradhan, Patnaik, and Panigrahy 2019).

Neeraj Sharma et al. (2022) reviewed the enhancements in WDM that used the DP-QPSK for link of long haul. The two bits were encoded per symbol and polarization. It was provided the economical legacy architecture that was considered as spinal column. Paper was aimed to review the enhanced transceiver for the coherent architecture(Sharma, Agrawal, and Kapoor 2022).

Simarpreet Kaur (2022) proposed 16x100 Gb/s DP-QPSK and DP-MZM that accessed OFDM with the coherent transceiver for the satellite wireless link. The DSP was used to guesstimate the compensation of nonlinearity effects, carrier phase and spectrum offset that were merged together. With the concern of security, the tuned filters were used that had the noise resistance property and this property was beneficial in the occurrence of jammers. The comparison was done that got that for the satellite wireless link; the performance was enhanced in terms of security, bulky bandwidth efficiency and improvement(Kaur 2022).

After review the literature in this manuscript, digital modulation process is discussed for the broadband fronthaul network by utilizing DP-QPSK technique. Millimeter wave is modulated over single mode fiber at 60 km by using digital technique as above mentioned. 50 Gbps of data is carried by the carrier wave at 1340nm under 50G-PON standard. Concept of dual polarization X and Y is used with the coherent receiver. The millimeter wave is modulated at 32 GHz in light form and the rest of the manuscript is detailed below: detail of simulation structure DP-QPSK 50G-PON network is explained with modulation process of millimeter wave in section II, outcome of the proposed structure is validated in section III with concern of constellation and spectrum diagram and manuscript is concluded in section IV.

SIMULATION SETUP

Fig. 1 depicts the modulation and demodulation procedure of a transceiver using digital signal processing scheme. The external modulator Mach-Zehnder modulator (MZM) is used to carry out the external modulation procedure (MZM). The data is transmitted at a wavelength of 1340 nm using a DP-QPSK transmitter. The 50 Gbps data rate is sent across a single wavelength in accordance with ITU-T standards. Data is received by the MZM modulator after being amplified by an optical amplifier. Moreover, the millimetre wave at 32 GHz that is connected to the MZM is created using a sine wave from a subcarrier frequency source. The proposed method, DP-QPSK at 32 GHz, modulates the millimeter wave in optical form over fiber that spans a 60 km area. Table 1 lists the essential variables used in the modulation and demodulation processes.

Two erbium doped fiber amplifiers (EDFA) are employed to boost the transmitted signal

and connect to the Gaussian filter during transmission. After being filtered by a Gaussian optical filter, the signal is received by a coherent DP-QPSK receiver which separated the signal into two polarizations called X and Y. Polarized signals X and Y are transmitted to DPS unit that utilize the dual polarized QPSK format. Presented signal is decoded using two PSK sequence decoders, which then convert it from parallel to serial after beam uniting. In the part after , the proposed system's results are thoroughly detailed.

RESULTS AND DISCUSSION

Data is sent at 50 Gbps with a 60 dB extinction ratio using the QPSK modulation scheme with dual pillarization at 1340 nm. The optical amplifier increases the input signal at a gain of 20 dB with a noise figure of 4 dB. Over the single mode fiber that extends 60 km, the input signal is modulated in optical form. Modulated light input signal over fiber is amplified using two EDFAs that have gain values of 10 dB and 5 dB, respectively, and carry noise figures of 6 dB for both. The transmitted signal must be filtered for long fiber distances in order for a network architecture to be practical, and the Gaussian filter can be used because it provides long coverage distance.

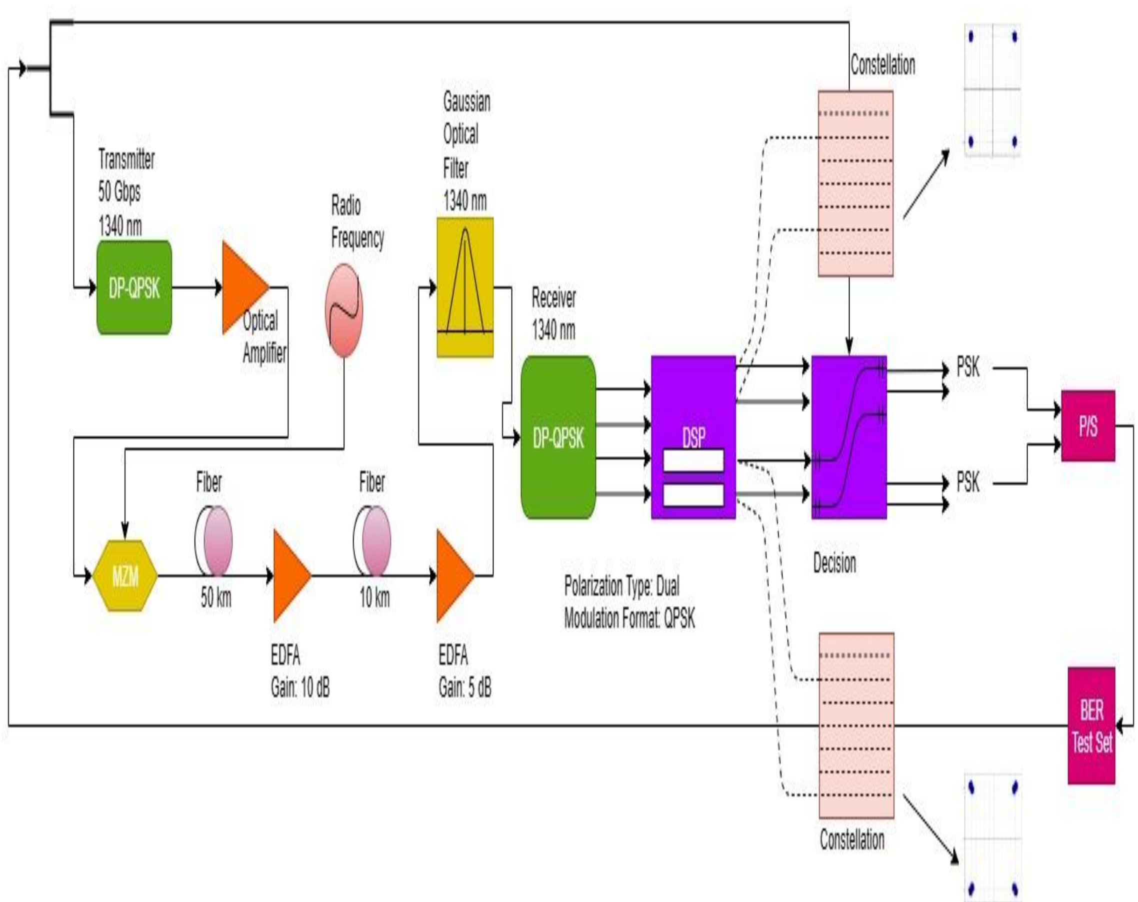

Fig. 1: Millimeter wave generation via DP-QPSK 50G-PON network for fronthaul network.

Table 1. Key parameters for proposed system architecture.

Parameters	Values
Transmitter	DP-QPSK transmitter
Bit rate	50 Gbps
Wavelength	1340 nm
Millimeter wave	32 GHz
Power	0 dB
External modulator	MZM
Optical amplifier	1
Single mode fiber	60 km
EDFA	2
Gaussian optical filter	1
Receiver	DP-QPSK receiver
DSP	Dual polarized
PSK sequence decoder	2
P/S	Parallel to serial convertor

Power spectrum for the modulated millimeter wave signal where the obtained band lies between 1.5495 µ and 1.5505 µ at the 60 km for 50G DP-QPSK, is examined in order to confirm the effectiveness of the proposed network. Fig. 2 and Fig. 3 illustrate power versus wavelength for spectrum analyzers both before and after input signal transmission.

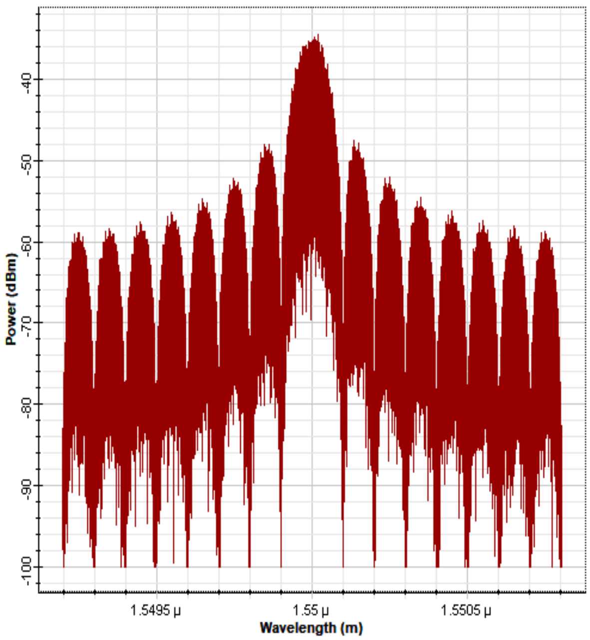

Fig. 2: Signal spectrum of 50G DP-QPSK before transmission.

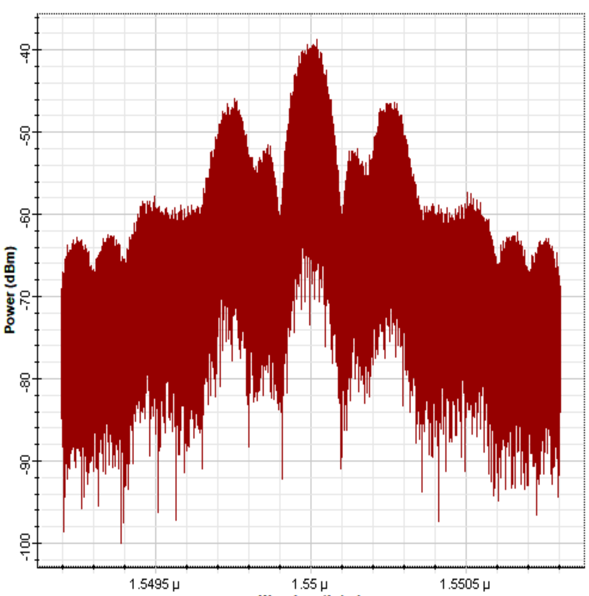

Fig. 3: Signal spectrum of DP-QPSK 50G-PON after transmission

It demonstrates the network system's improved performance. Fig. 4 and 5 for the polarizations X and Y, respectively, show the constellation diagrams that illustrate the relationship between in-phase and quadrature amplitude. In the plots, the signal accuracy is shown.

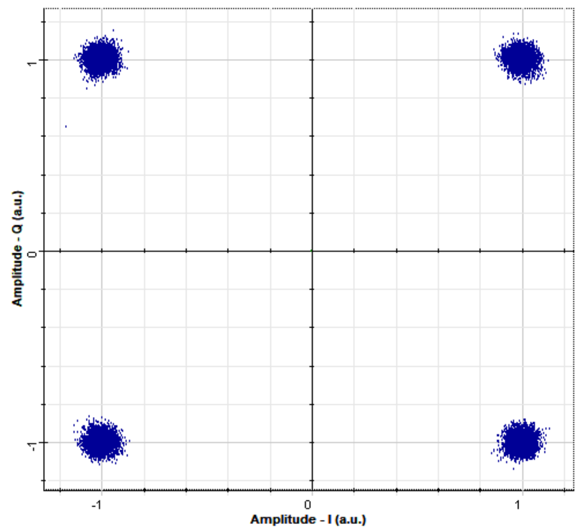

Fig. 4: DP-QPSK 50G-PON constellation figure for X-Polarization.

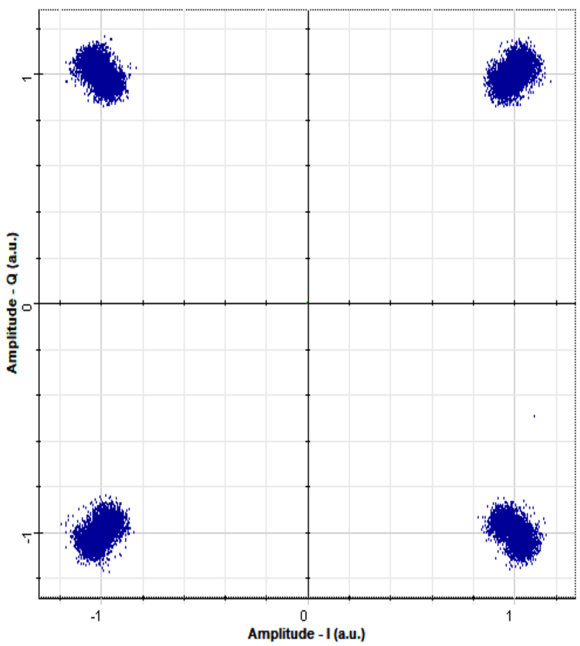

Fig. 5: DP-QPSK 50G-PON constellation figure for Y-Polarization

It is obvious from the description above that the simulated work outperforms the previously mentioned work. 50 Gbps of data is transmitted per wavelength at the 32 GHz by employing the approach of DP-QPSK.

CONCLUSION

In this manuscript, millimeter wave over DP-QPSK is presented under the standard 50G-PON for the 5G mobile fronthaul network. In this research, data is transmitted at a 50 Gbps per wavelength at 1340nm that is modulated over fiber at 32 GHz millimeter wave. Input signal is detected at receiver end via Coherent receiver with two polarizations X and Y. The outcome is evaluated the performance of the proposed structure at the 60 km of fiber span via constellation figure and signal spectrum.

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