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Feasibility Study of a Simple 100Gb/s Transmitter with Low-speed Electronics and 0.8bit/s/Hz Spectral Efficiency

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Abstract *We propose a simple 100Gb/s transmitter using multi-wavelength generation scheme and DQPSK modulation format. Only devices of lower speed are needed to reduce the system cost.*

Introduction

Over the past years, data-based traffic has grown rapidly. This trend originates from the wide deployment and rapid growth of Ethernet. Currently 10 Gb/s Ethernet (GbE) has been employed in local area networks (LANs). With the emergence of IPTV, IP Video and other broad bandwidth service, higher capacity network will be desirable in the near future. Historically Ethernet has grown by a factor of 10 and it is wildly believed that this trend is going to occur towards the next generation Ethernet of 100GbE, which is also being considered to play an important role in the metropolitan area networks (MANs) and wide area network (WANs) [1].

Recently there have been several methods proposed for the 100GbE implementation which can be divided into two categories: one using wavelength division multiplexing (WDM) [2] and the other with optical time division multiplexing (OTDM) [3] or electrical time division multiplexing (ETDM) [4]. The first method needs a set of lasers and modulators at the transmitter side, which greatly increase the system cost. As for the OTDM method, ultra short optical pulse source, which is usually at a level of pico or sub-picosecond, and optical de-multiplexer, are indispensable. Currently the ETDM method is based on the immature ultrahigh speed electronic devices. In [5], a scheme based on the multi-wavelength generation was used, but devices of high bandwidth were still needed. In this paper we propose a simple 100Gb/s transmitter utilizing multi-wavelength generation and DQPSK modulation format. Only one stable laser is needed, and the electrical devices used here are of lower bandwidths of 25GHz and 10GHz.

Structure of the proposed transmitter

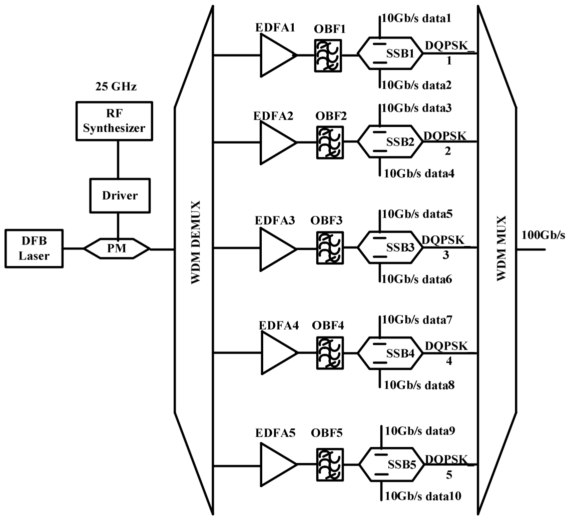

Fig 1 Structure of the 100Gb/s transmitter.

Figure 1 shows the schematic structure of the proposed transmitter. The 100Gb/s signal consists of five 20Gb/s DQPSK sub-channels. Only one highly-stable laser source is needed for the five sub-channels. This is implemented by phase modulating a continuous wave (CW) light by a 25GHz clock signal. With proper filtering and amplification, five stable, separated lightwaves are obtained with fixed channel spacing of 25GHz and similar powers. Each of the five channels is then injected into a single-side band (SSB) modulator, which modulated by the 20Gb/s DQPSK signal. After a WDM multiplexer (MUX), these five channels are combined together, resulting in a 100Gb/s signal. In this transmitter structure, only the bandwidths of phase modulator (PM) and the PM driver are 25GHz, all the other devices, including five SSBs are of 10GHz bandwidth.

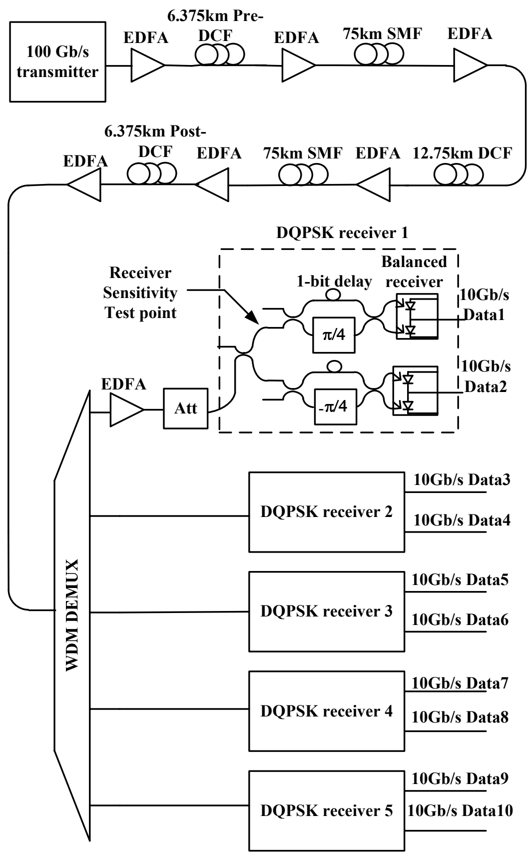

Fig 2 Simulation diagram of 100Gb/s signal generaton and transmission. Att: attenuator.

Results and discussion

Figure 2 shows the schematic diagram of the simulation for the 100Gb/s signal generation and transmission. The carrier wavelength from the DFB laser is 1553nm, with an output power of 10dBm.The modulation index of the PM is set to be 90 degree. A WDM demultiplexer (DEMUX) is used to separate the five sub-channels, including the zero-order, two first-order and two second-order mode lightwaves. In order to reduce the crosstalk between the neighbouring channels, the 3dB bandwidths of the WDM multiplexer and the demultiplexer are chosen to be 20GHz. The optical spectrum after the PM is shown in Fig.3 (a). With proper amplifications of the first and second-order mode lightwaves, we obtained five sub-channels with a comparative power around -5dBm and a fixed 25GHz channel spacing as shown in Fig.3 (b). The generated five channels are defined as C_{-2}, C_{-1}, C_0, C_1 and C_2, respectively. Each of the five channels is then separated and individually modulated by a SSB modulator with two branches of 10Gb/s PRBS signal with a word length of 2^7-1 so that to carry a 20Gb/s DQPSK signal. After combination of these five 20Gb/s QPSK signals, a 100Gb/s signal is generated whose spectrum is shown in Fig.3 (c).

The generated 100Gb/s signal is then amplified by an Erbium-doped fiber amplifier (EDFA) and sent into a 150km transmission line which is composed by two spans of 75km single mode fiber (SMF) with loss of 0.2dB/km and dispersion of 17ps/nm/km. In order to compensate the dispersion through transmission, dispersion compensation fiber (DCF) (0.5dB/km loss) of -100ps/nm/km is used. The total input powers into the DCFs and SMFs are 3dBm and 10dBm, respectively. The spectrum after transmission is shown in Fig.3 (d).

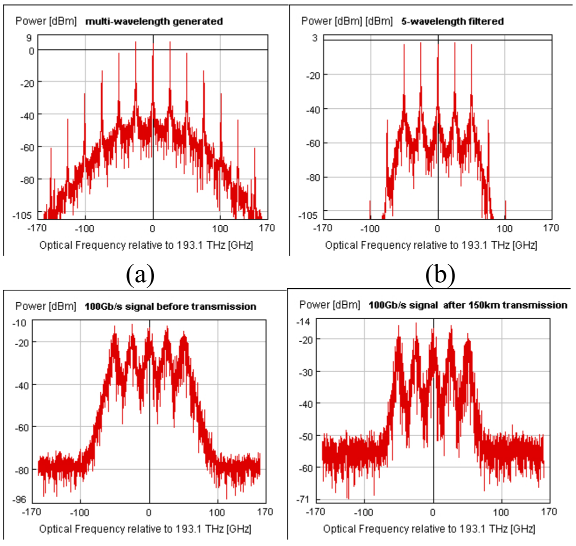

Fig 3 (a) Multi-channel generated by PM. (b) Filtered 5 channels. Optical spectra of 100Gb/s signal (c) before and (d) after transmission.

At the receiver side, a WDM DEMUX with the same characteristics as the one used in the transmitter is employed to separate the five sub-channels. The optical spectra of the filtered channels are shown in Fig. 4. From these diagrams one can see that the suppression ratio between the desired channel and its neighbouring channels is about 20dB. So the crosstalk between these channels can be sufficiently suppressed. After the filtering, each channel is sent to a DQPSK demodulator which consists of two balanced receivers for the detection of the in-phase and quadrature components. After demodulation, ten streams of 10Gb/s signal are recovered whose eye diagrams are provided in Fig.5, respectively. The received power defined at the input to the balanced receiver is set to be -20dBm. It can be seen that the eye diagrams of the ten branches of signal are widely opened, so error free operation can be expected. We also observe that there is amplitude fluctuation in the recovered data, which can be attributed to the crosstalk between these channels. As the dispersion compensation is mainly set for the original wavelength in the transmission span, inter-symbol interference is more evident in the channels of C_{-2}, C_2, C_{-1} and C_1, compared with C_0. This can be greatly alleviated by precise dispersion post-compensation at each of the receiver side.

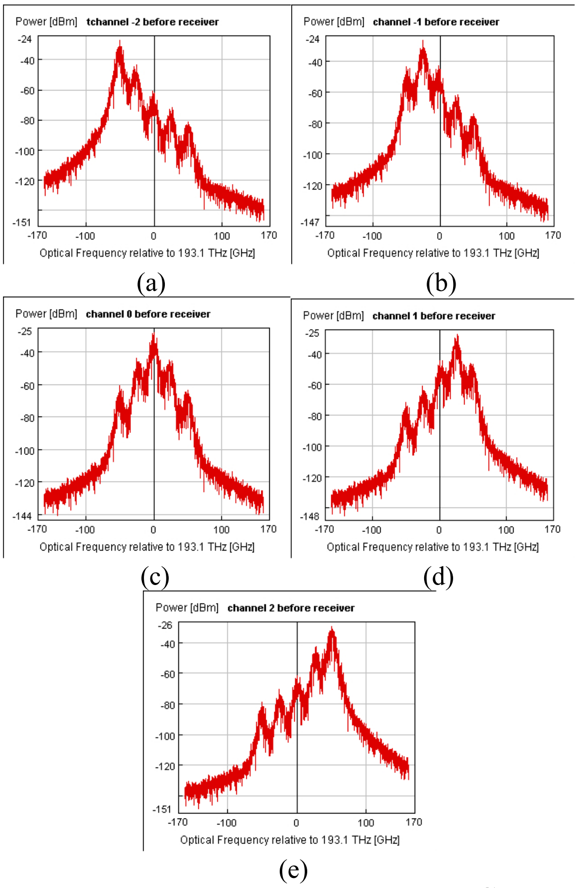

Fig 4 Optical spectra of channel (a) C_{-2}, (b) C_{-1}, (c) C_0, (d) C_1, and (e) C_2 before detection.

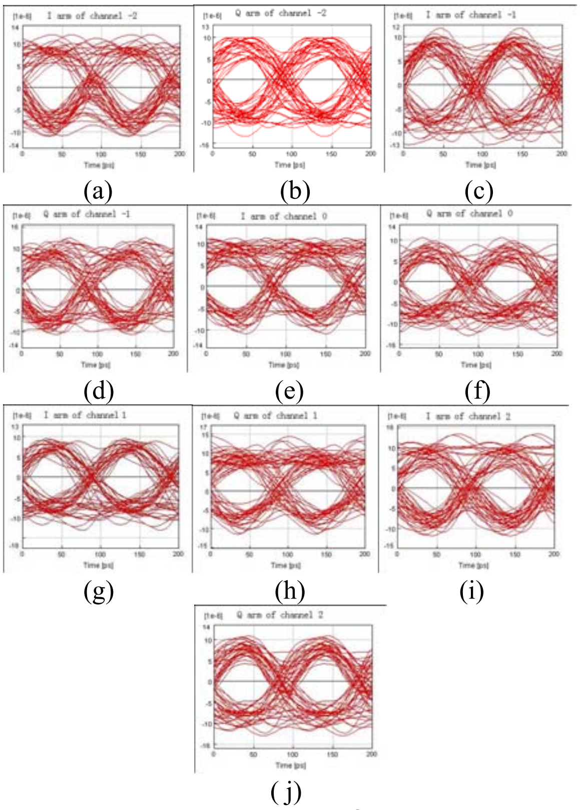

Fig 5 Eye diagrams of the recovered electrical data at a received power of -20dBm. (a) I arm and (b) Q arm of channel C_{-2}, (c) I arm and (d) Q arm of channel C_{-1}, (e) I arm and (f) Q arm of channel C_0, (g) I arm and (h) Q arm of channel C_1, (i) I arm and (j) Q arm of channel C_2.

Conclusion

We have proposed and simulated a simple transmitter with spectral efficiency of 0.8bit/s/Hz for 100Gb/s network, using five 20Gb/s DQPSK sub-channels generated from one DFB laser and one PM, with low speed optical and electrical devices. In our simulations, this novel transmitter shows good performance in a 150km transmission system.

References

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