43-Gb/s Differential Receiver Module for RZ-DPSK

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Abstract

We have developed a 43-Gb/s differential receiver module for RZ-DPSK. A wide bandwidth of 42 GHz and a high transimpedance gain of 58 dBΩ were achieved.

Introduction

The Return-to-zero differential phase-shift keying (RZ-DPSK) modulation format has been proposed as an attractive approach to long haul communications system over 43-Gb/s due to its superior OSNR sensitivity and nonlinearity tolerance [1]-[2]. A differential or a balanced optical receiver is required for the RZ-DPSK modulation format and a variety of approaches have been reported [3]. Because the differential architecture makes parasitic capacitance a half compared with balanced architecture, it is advantageous on the frequency response. However, the design of an integrated differential receiver can be quite challenging because it requires balanced signal phase adjustment.

In this paper, we report the first 43-Gb/s RZ-DPSK differential receiver module that consists of Dual Evanescently Coupled Waveguide Photodiodes (Dual EC-WG-PDs) and a differential Trans-impedance Amplifier (TIA) IC. The differential receiver module is designed symmetrically to achieving balanced signal phase adjustment. The differential receiver module achieves wide bandwidth of 42 GHz and high transimpedance gain of 58 dBΩ.

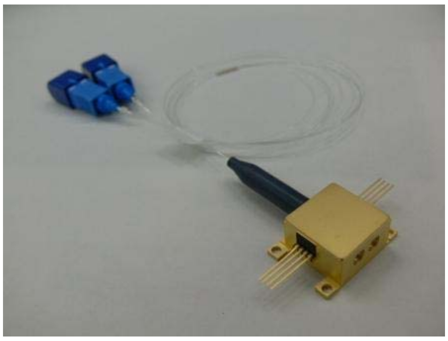
Differential Receiver Module Design

Figure 1 shows a photograph of the differential receiver module and its internal structure. The differential receiver module is 16 mm x 16.3 mm x 9 mm in size. The differential receiver module has balanced optical inputs, and has differential electrical outputs with GPPO connectors.

Balanced optical signals through a 1bit delay interferometer were coupled to the Dual EC-WG-PDs [4] via an airtight sapphire window with an aspherical lens. The balanced optical signals axis adjustment was done only 0.5 dB coupling loss and within 2% balance degree by the batch. To enable the adjustment Dual EC-WG-PDs and 2-port taped fiber by the batch, the gap between two PDs was designed to be 44 μm and the magnification equation was set as 3.

To obtain balanced signal phase adjustment, Dual EC-WG-PDs were integrated on one chip symmetrically with accuracy. The TIA consisted of all differential stages and a ceramic substrate was designed symmetrically too.

The ceramic substrate converted GSGSG outputs pattern of TIA to GPPO connectors with impedance matching.



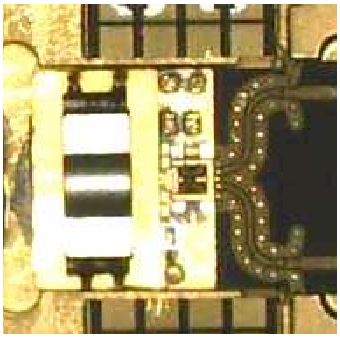


Figure 1: Photograph of the Differential Receiver Module and its internal structure

Transimpedance amplifier

We used a differential TIA based on InP HBT technology configuration for the differential receiver module. Figure 2 shows a block diagram of the differential TIA. The TIA has a differential transimpedance amplifier stage, a differential amplifier gain stage, and an output buffer stage. The differential amplifier stage consists of differential Cherry-Hooper amplifiers to obtain a wide bandwidth. The inputs of the differential TIA stage were connected with each anode of Dual EC-WG-PDs and detected RZ-DPSK data signals. The feedback resistances are 200 Ω and transimpedance gain is 58 dBΩ. The layout is kept symmetric to match the delays for the differential signals. The input and output signal lines are coplanar waveguide transmission lines with 50 Ω characteristic impedance. The TIA chip is 1.25 x 1.25 mm in size, the supply voltage is 3.3 V.

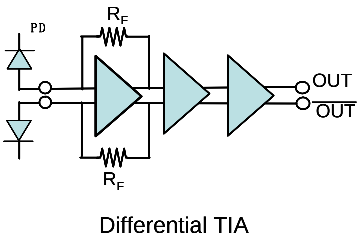


Figure 2: block diagram of the TIA

Receiver module performances

Typical bias voltage and power consumption of the differential receiver module were 3.3V / 5V and 0.33W. Responsivities of two PDs were respectively 0.75 A/W and 0.75 A/W. The frequency response of differential receiver module is shown in Fig. 3. It was measured in single-ended and input power was set on -3dBm. A bandwidth obtained 42 GHz and S22 obtained less than -10dB up to 42 GHz.

We also demonstrated the suitability for 43-Gb/s RZ-DPSK applications. The system setup is shown in Fig. 4. 43-Gb/s RZ-DPSK signal was generated using LN-modulator and transmitted from Tx part. Figure 5 shows the output waveforms when the RZ-DPSK signal of 43-Gb/s was input with a 1bit delay interferometer. The output voltage swings were as large as 350mVp-p. Clear and symmetrical Eye-opening of each output was obtained. The OSNR characteristic is shown in Figure 6. The measurement set the input level to -12 dBm respectively, and an excellent characteristic was obtained. Becoming it point OSNR of 1×10^{-3} or less that was able to be the recovery with FEC it was 14.3 dB. It was possible to apply, and enough to 43-Gb/s RZ-DPSK.

Conclusions

We have developed a 43-Gb/s RZ-DPSK differential receiver module with dual-EC-WG-PDs and TIA. A 42 GHz bandwidth and a high transimpedance gain of 58 dBΩ were obtained. Its applicability was proved successfully through the 43-Gb/s RZ-DPSK operation.

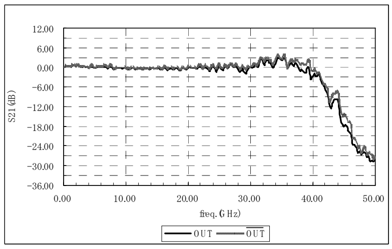


Figure 3: Frequency responses of the Differential Receiver Module

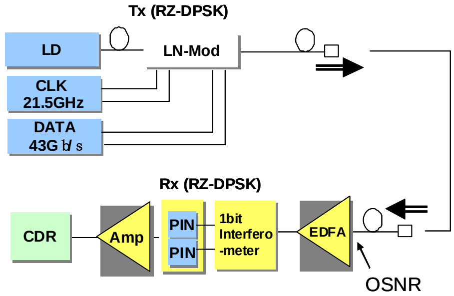


Figure 4: System setup for 43-Gb/s RZ-DPSK

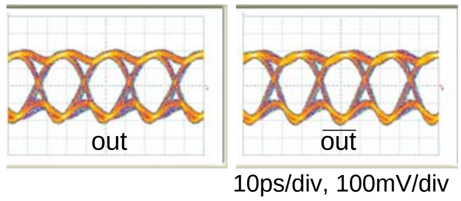


Figure 5: Output waveforms of the Differential Receiver Module

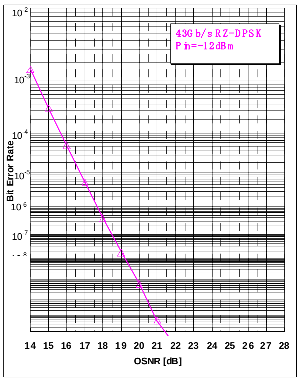


Figure 6: OSNR sensitivity

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