Single-Package 2-channel Balanced Receiver Module for 43-Gbit/s DQPSK

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Abstract *We have developed a single-package 2ch-balanced receiver module composed of a monolithically integrated 4-PDs and a 2ch-IC. The module has excellent receiver characteristics and is suitable for 43-Gbit/s DQPSK.*

Introduction

Optical differential quadrature phase shift keying (DQPSK) is a promising modulation format for 40-Gbit/s long-haul core optical network systems, because of its high spectral efficiency and large dispersion tolerance [1]. To reduce optical signal to noise ratio (OSNR) tolerance requirements, a balanced receiver is indispensable [2]. Several types of balanced receivers have been reported [3], [4], and DQPSK system demonstrations have been performed using two 1-channel balanced receiver modules [5]. For commercial system applications, however, compact and low-price modules are required.

To overcome this problem, we have developed a monolithically integrated dual PD chip (4 PDs) and a 2-channel InP HBT IC chip and fabricated, for the first time, a single-package 2-channel balanced receiver module. The module exhibits the excellent characteristics suitable for a 43-Gbit/s DQPSK front end.

Fabrication

Fig. 1 shows a photograph of the fabricated receiver. The receiver consists of a metal butterfly package with leads for RF outputs and DC bias supplies, and taped fiber, which consists of four pigtailed fibers with equal length. Using taped fiber, the skew of this module is less than 2 ps. The module size including the fiber boot is 21.5 x 34.5 x 6.7 mm^3, which is almost the same as the volume of current commercialized 1-channel balanced receiver modules. Therefore, the developed module can reduce the area occupied by the receiver module in the system.

Fig. 2 shows a micrograph of the core part of the fabricated module. The four monolithically integrated InP/InGaAs pin-PDs [6] are optically coupled to four optical signals from the taped fiber using one aspheric lens. The lens and taped fiber are welded onto the package using a YAG laser welder. The average responsivity of the four PDs is 0.95 A/W at room temperature and a wavelength of 1550 nm. The variation in responsivity is about 0.2 dB. The polarization dependent loss is less than 0.1 dB owing to the bottom-illuminated configuration. The 3-dB down bandwidth is 24 GHz.

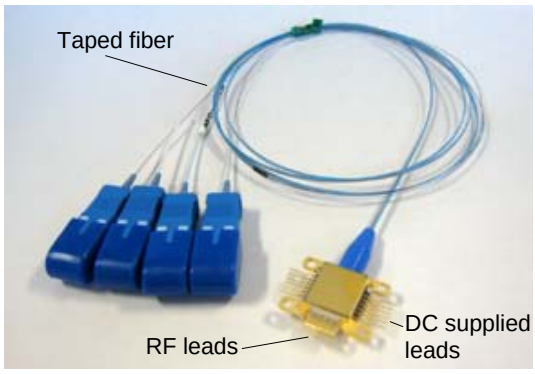

Fig. 1 Photograph of a single-package 2-channel receiver module.

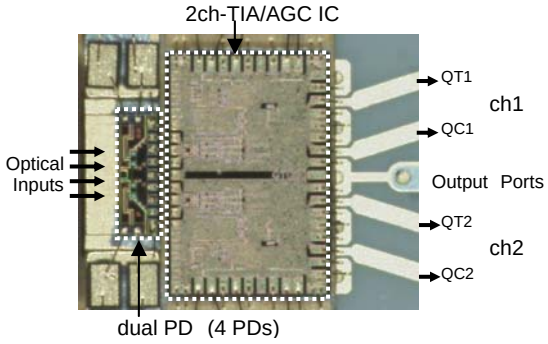

Fig. 2 Micrograph of assembled PD and IC chips in fabricated module.

The output ports of the PD chip are connected to an IC chip, which consists of a transimpedance amplifier (TIA) and an auto gain controll (AGC) amplifier. The circuit design is differential for balanced operation for the input signals from the PDs. The IC is fabricated using a 1-micrometer-emitter InP HBT technology [7], [8]. High gain of 28 dB and bandwidth of 18 GHz are obtained for each channel. It also has an integrated power monitor, which can be used for controlling a DQPSK demodulator. The differential output ports of the IC

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are finally connected to the AC coupled output leads. The output lead design is based on the coupled micro-strip-line and we also consider receiver board parameters, such as dielectric constant and board thickness. The power supply and power consumption are -5.2 V and 1.1 W, respectively.

Characterization

Fig. 3 shows the frequency characteristics of the receiver measured with an optical component analyzer. The variation between channels is very small. The single-end O/E gain is 28 dB A/W with a 3-dB down bandwidth of 14 GHz. The group delay variation and electrical return loss for frequencies up to 20 GHz are about 20 ps and more than 10 dB, respectively.

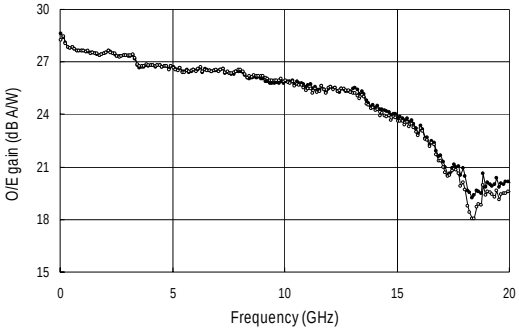

Fig. 3 Single-end O/E conversion gain

Fig. 4 shows the output waveforms of the receiver for three different PD input powers for each PD (PD_{in}). The input optical signal was a single 21.5 Gbit/s channel of 43-Gbit/s RZ-DQPSK signal. The output eye amplitudes for both channels take a nearly constant value of 320 mV for the PD_{in} range of -4 to -8 dBm, which implies proper operation of the AGC function.

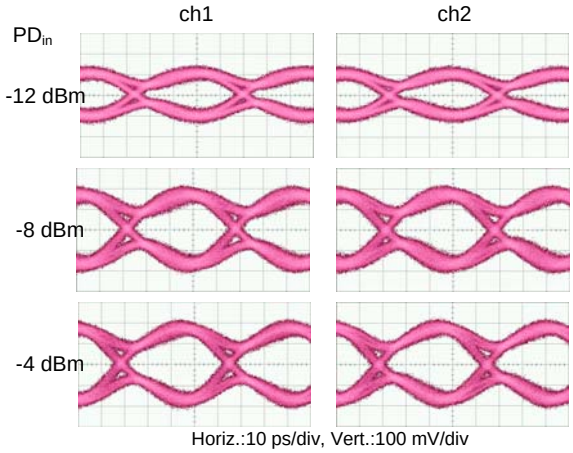

Fig. 4 Waveforms at three different PD_{in}

We also performed OSNR tolerance measurements with a back-back configuration. The PD_{in} dependence of the Q-value at the OSNR of 19.5 dB is plotted in Fig. 5. The Q-value is better than 15.0 dB in the wide PD_{in} range, and the variation is less than 0.2 dB.

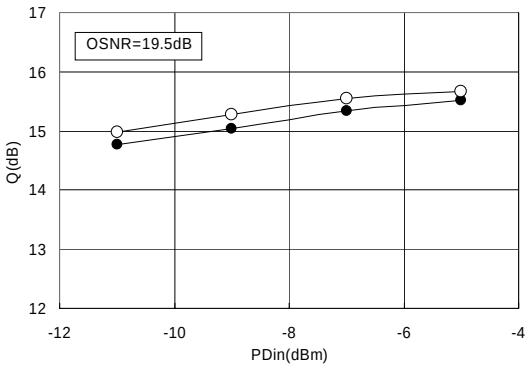

Fig. 5 Q-values of the receiver (OSNR=19.5 dB)

Summary

We have developed a single-package 2-channel balanced receiver module, composed of a monolithically integrated dual PD (4 PDs) chip and a 2-channel InP HBT IC chip. The module size, 21.5 x 34.5 x 6.7 mm^3, can reduce the area occupied by the module in the system. From a back-back transmission test with an OSNR of 19.5 dB, the Q-values are above 15.0 dB with good uniformity over a wide input power range. From these results, we can concluded that the fabricated single-package 2-channel balanced receiver module is extreamly promising for a compact commercial 43 Gbit/s DQPSK front end.

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