

43-Gbps EAM-LD Module / PD Module

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We have developed an electroabsorption modulator laser diode (EAM-LD) module with a built-in driver IC and a photodiode (PD) preamp module, both for the next-generation 40-Gbps optical communication system applications. We applied a new offset circuit design to the EAM-LD module with a built-in driver IC to reduce the load on the driver IC and also to reduce heat generation from the termination resistor, and achieved a good optical output waveform and low power consumption. In the PD preamp module, we applied an asymmetric waveguide structure to the PD, achieving a high light-receiving sensitivity and wide bandwidth, as well as a 15.3-dB dynamic range of the receiving sensitivity characteristics.

1. Module Structure

Figures 1 (a) and (b) show schematic drawings of the 43-Gbps EAM-LD module and PD module, respectively. In the 43-Gbps EAM-LD module, a built-in driver IC is integrated in one package, and GPPO™ connectors are used as the high-frequency input interface. These devices reduce the number of expensive high-frequency packages and cables, making optical transceivers smaller and cheaper. A differential electric signal input to the module is amplified by the driver IC. The operating conditions of the driver IC are adjusted to provide an optimum optical output waveform. Since the characteristics of the EAM and LD are sensitive to the temperature, a thermo-electric cooler (TEC) is used to maintain a constant temperature. The PD module has a built-in trans-impedance amplifier (TIA) to convert and amplify an optical signal to a voltage signal. The converted high-frequency signal is then AC coupled in the module and connected to the GPPO™ connectors for output. Figure 2 shows photos of the packages. The package size of the EAM-LD module is 18 mm (length) × 22 mm (width) × 8.5 mm (height) excluding the fiber and pins, and the PD module is 15 mm (length) × 22 mm (width) ×

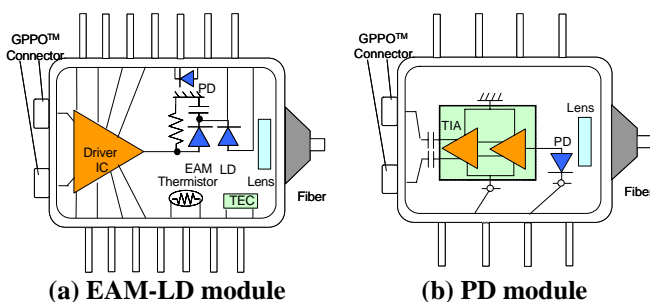


Fig. 1 Schematic drawing of modules

8.5 mm (height), both compliant with the 40 Gbit/s Miniature Device Multi Source Agreement (XLMD-MSA), which is the standard for 40-Gbps optical modules.

2. EAM-LD Module Built-in Driver IC

2.1 Design

As the operating speed of a transistor increases, collector-emitter breakdown voltage generally decreases. The driver IC for the modulator needs to be carefully designed in terms of the breakdown voltage in particular, because the IC needs to operate at high speed with a high output voltage swing.

Figure 3 shows schematic drawings of (a) the present drive circuit, (b) the DC coupled drive circuit, and (c) the bias-T drive circuit. In the conventional DC-coupled drive circuit, the EAM, termination resistor, and driver IC are DC coupled, and the voltage swing, cross point, and offset voltage (a high level voltage applied to the EAM) are adjusted by the driver IC⁽¹⁾. Considering that the EAM needs a voltage swing of 2.5 V_{pp} , and the offset voltage of the EAM is lowered to -1 V for optimizing the transmission characteristics, the collector-emitter breakdown voltage of the transistor needs to be at least 3.5 V. In the present drive circuit, an adjustable offset voltage is directly applied to the cathode of the EAM. Since no offset DC voltage is required at the anode electrode, the breakdown voltage required for the transistor can be reduced to 2.5 V. In addition, heat generation from the termination resistor is suppressed, and the power consumption of the TEC can also be reduced. Compared to the bias-T circuit, although the same collector-emitter breakdown voltage of over 2.5 V is required, the present drive circuit reduces high-frequency losses because it does not need any capacitor or coil for AC coupling to the signal line.

The operating temperature of the EAM is set to 40°C. At a high temperature, this setting reduces the difference between ambient temperature and the EAM setting temperature, thus reducing the power con-

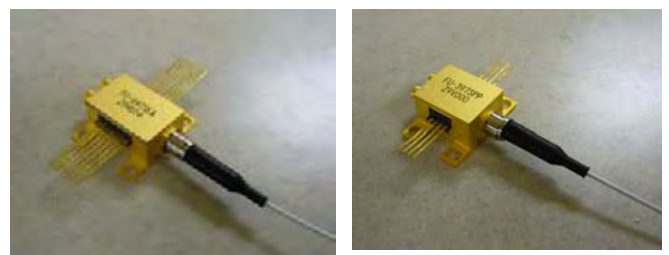


Fig. 2 Photo of modules

sumption of the TEC.

2.2 Results

The module was evaluated by connecting it to a 16:1 multiplexer (MUX). Figure 4 shows 43-Gbps optical output waveforms with the PN31 pattern when the package temperature was varied from -5°C to 80°C . The LD current was 70 mA, and the setting temperature of the TEC was 40°C . We achieved an extinction ratio of 13.8 dB to 14.1 dB (specification: 8.2 dB or greater), and a mask margin of 13% to 16% (specification: 0% or greater) using the ITU-T standard mask. Good transmission characteristics have also been achieved. As shown in Fig. 5, the evaluation results indicate the power penalty after 40 ps/nm dispersion to be 1.2 dB or lower at the full temperature range (specification: 2.0 dB or lower). Figure 6 shows the TEC power consumption. By setting the operating temperature of the EAM to 40°C and suppressing the heat generation from the termination resistor, the TEC power consumption has been suppressed to 0.70 W at a case temperature of 80°C .

3. PD Preamp Module

3.1 Design

Figure 7 shows the structure of the PD. The PD has an edge illuminated type waveguide structure to achieve wideband frequency response and high sensitivity characteristics, with the anode and cathode electrodes arranged on the same plane. Generally, in an optical waveguide, the difference in refractive index between the InP clad layer and InGaAsP optical confinement layer varies, and thus the amount of confinement varies with the wavelength. Therefore, we applied our proprietary asymmetric waveguide structure, resulting in high sensitivity at both the $1.55\ \mu\text{m}$ and $1.31\ \mu\text{m}$ wave bands.

Figure 8 shows the frequency response characteristics of the PD. A 3-dB bandwidth of over 50 GHz has been achieved at either wavelength. The light-receiving sensitivity was 0.82 A/W and 0.91 A/W at $1.31\ \mu\text{m}$ and $1.55\ \mu\text{m}$, respectively. High sensitivity and wide bandwidth have been achieved at both wavelengths^(2,3).

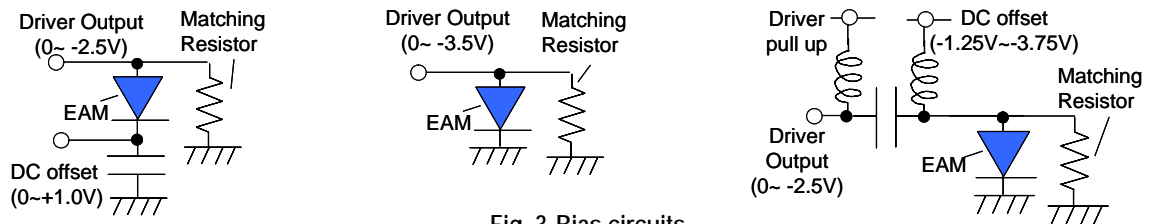


Fig. 3 Bias circuits

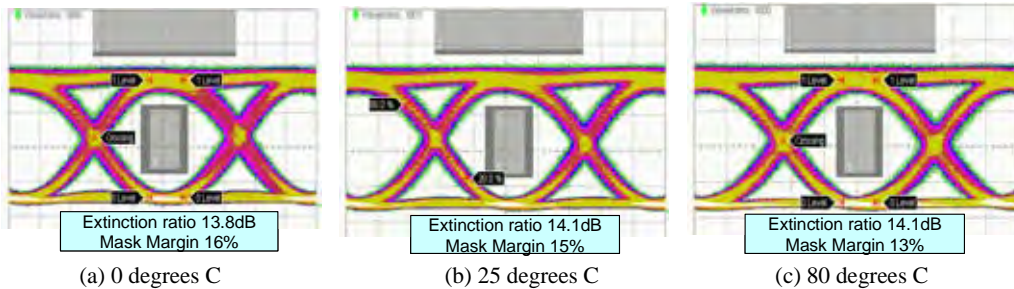


Fig. 4 43 Gbps optical output waveforms

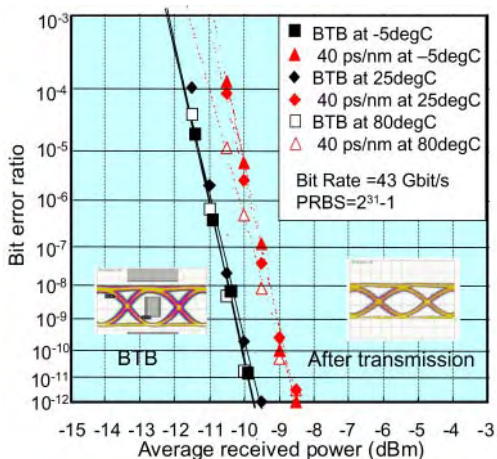


Fig. 5 Measured 43Gbps BER versus received optical power

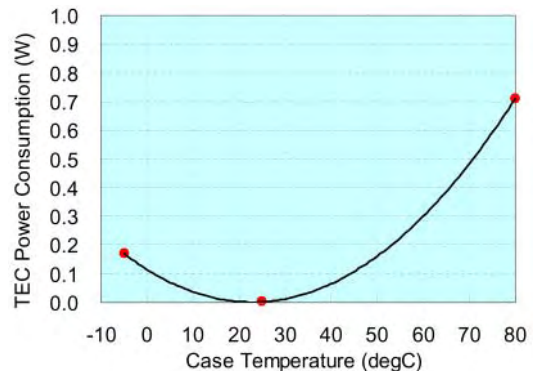


Fig. 6 TEC power consumption

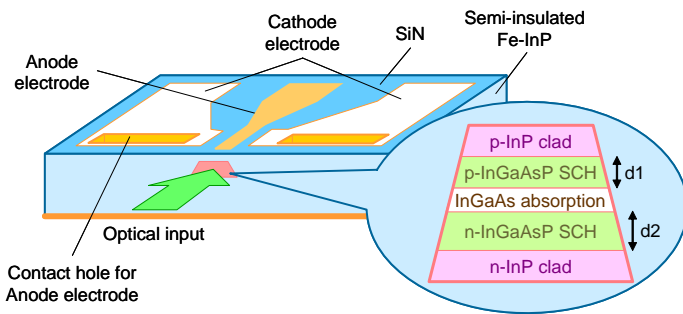


Fig. 7 Schematic drawing of PD chip

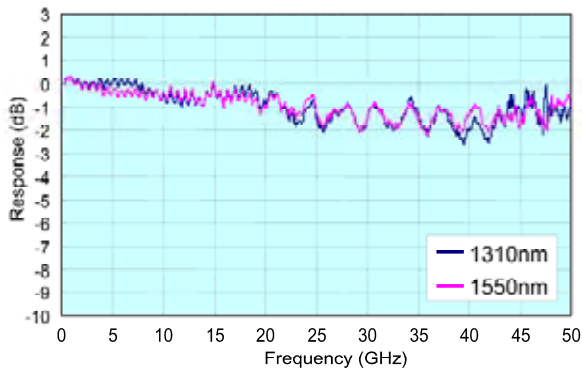


Fig. 8 Frequency response of PD chip

3.2 Results

All evaluations were performed using a light source with a wavelength of 1.55 μm . Figure 9 shows the frequency response characteristics of the PD preamp module. A good frequency response without any large ripples was achieved with a 3-dB bandwidth of 30 GHz. Figure 10 shows 43-Gbps electrical output waveforms at input levels of (a) -10 dBm and (b) +3 dBm. During either small signal or large signal operation, clear eye opening with a low jitter waveform was achieved. The small signal differential gain was 62 dB Ω . Figure 11 shows the bit error ratio with the PN31 pattern. The bit error ratio was measured with the module connected to a 1:16 demultiplexer (Demux). The error-free range, i.e. the range where the bit error ratio is 1×10^{-12} or lower,

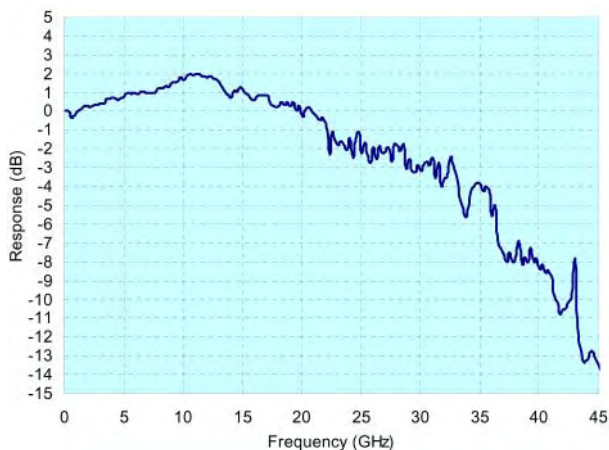


Fig. 9 Frequency response of PD preamp module

was -12.7 to -11.7 dBm for the minimum sensitivity and +3.6 to +3.7 dBm for the maximum sensitivity, both corresponding to a temperature range of -5°C to +80°C, resulting in a dynamic range of 15.3 dB. The International Telecommunications Union - Telecommunication (ITU-T) G.693 specification is -6 dBm to +3 dBm, and thus our device complies with the standards with sufficient margin. The power consumption was 0.19 W.

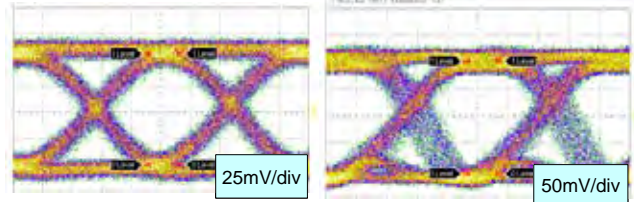


Fig. 10 43Gbps electrical output waveforms

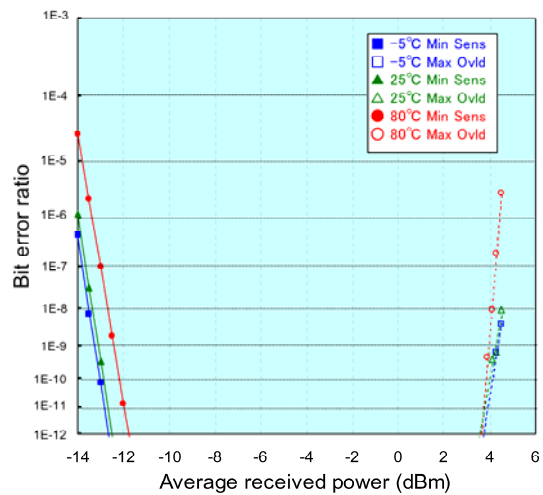


Fig. 11 BER

4. Conclusions

We have developed a 43-Gbps EAM-LD module and a PD module. Both modules exhibited good optical, high frequency and bit error ratio characteristics, in addition to much smaller size, lower power consumption, and lower cost. The newly developed products are expected to become established as core elements of next-generation optical communication technologies, and rapidly introduced for commercial applications.

References

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