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(57)[Abstract]

[Problem] To provide an XFP optical transceiver with built-in LD element temperature adjustment function, achieving an expansion of XFP optical transceiver transmission distance and compatibility with WDM transmission systems, so as to expand the optical transceiver application area.

[Solution Means] An optical transceiver in which an LD element module 8 with built-in temperature adjustment function and electric circuit board 9 fitted with a control unit for same, as well as a PD element module 14 and electric circuit board 16 fitted with a control unit for same, are stacked and housed in a single chassis consisting of a lower chassis 6 and an upper chassis 7; whereby an optical connector connecting portion 4 is disposed at

one end in the longitudinal direction of said chassis, an electrical connector connecting portion 15 is disposed at the other end thereof; and the LD element module 8 has surface contact with a metal surface of the chassis through a thin electrical insulating layer 13, and a drive/control section for at least the temperature adjustment function is mounted on the electrical circuit board 9 fitted with LD element module 8.

[Claims]

[Claim 1]

In an optical transceiver wherein an LD element module and PD element module are housed in a single chassis, an optical connector connecting portion is disposed at one end in the longitudinal direction of said chassis, and an electrical connector connecting portion is disposed at the other end in the longitudinal direction of said chassis, the optical transceiver includes two electrical circuit boards within the chassis.

[Claim 2]

The optical transceiver of Claim 1, wherein one of the two electrical circuit boards is fitted with at least an LD element module and control unit for same, while the other is fitted with at least a PD element module and control unit for same.

[Claim 3]

The optical transceiver of Claims 1 or 2, wherein the electrical connector connecting portion is formed on the circuit board fitted with the PD element module.

[Claim 4]

The optical transceiver of Claims 1, 2, or 3, wherein the LD element module mounted on the circuit board is in surface contact with the metal surface of the chassis through a thin electrical insulating layer.

[Claim 5]

The optical transceiver of Claims 1, 2, 3, or 4, wherein the LD element module has a built-in LD element temperature adjustment function, and a drive/control unit for at least the temperature adjustment function is mounted on the circuit board fitted with the LD element module.

[Claim 6]

The optical transceiver of Claims 1, 2, 3, 4, or 5, wherein the thickness of the LD element module with built-in temperature adjustment function is 5 mm or less, and the circuit board on which the LD element module is mounted and the circuit board on which the PD element module is mounted are stacked in the thickness direction within the chassis.

[Claim 7]

The optical transceiver of Claims 1, 2, 3, 4, 5, or 6, wherein a drive circuit directed at a DFB-LD element in which an electro-absorption-type modulator is monolithically

integrated is mounted inside the LD element module and is electromagnetically shielded by the chassis.

[Detailed Description of the Invention]

[Technical Field]

[0001]

The present invention pertains to an optical transceiver.

[Background Art]

[0002]

In the specifications for an XFP (10Gb/s small form factor pluggable) optical transceiver defined by specifications common among optical communication equipment development companies, normally referred to as MSAs (Multi Source Agreement), LD element temperature adjustment functionality was omitted in order to reduce size (Non-Patent Document 1).

[0003]

Also, as shown in Figure 6(a), in an XFP optical transceiver structure an LD element module 2 and PD element module 3 are attached to one end of a circuit board 1, at the other end of which a pad pattern capable of insertion and removal from an electrical connector is formed; thereafter an LD element module 2 and PD element module 3 stub 5 is fitted into an optical connector receptacle portion 4 affixed or integrally formed in a lower chassis 6, as shown in Fig. 6(b); circuit board 1 is then affixed.

[0004]

Next, as shown in Figure 6(c), a mounting form in which [the circuit board] is covered by upper chassis 7 and affixed by screws or the like is widely adopted. External dimensions of the XFP optical transceiver are determined by specifications, and measure 78 mm x 18.5 mm x 8.2 mm.

[Non-Patent Document 1] "10 Gigabit/s small form factor pluggable Module" Revision 0.92 July 19, 2002 copyright 2002 by XFP MSA

[Non-Patent Document 2] "10 Gbps Small Form Factor Pluggable Optical Transceiver Module," Hidaka et al., 2003 Electronics Society Conference of the Institute of Electronics, Information and Communication Engineers, C-3-130 pp. 263

[Disclosure of the Invention]

[Problems to be Solved by the Invention]

[0005]

However the aforementioned XFP optical transceiver has the following problems.
(1) No temperature control functionality is included, therefore the XFP optical transceiver range of application is limited to non-wavelength multiplexing transmission methods at a

transmission distance of 10 km or less (Non-Patent Document 2).

(2) To reduce size, a structure is adopted in which the upper chassis 6 serving as optical receiver heat dissipation surface does not directly contact LD element module 2, resulting in poor heat dissipation characteristics for the heat-sensitive LD element. When upper chassis 6 and LD element module 2 are brought into direct contact to improve heat dissipation, stress is applied to the stub 5 affixed to the optical connector, inducing axial misalignment in the LD-fiber optical coupling.

[0006]

(3) Due to the poor heat dissipation of LD element module 2, the LD element drive circuit, which generates a large amount of heat, is mounted on circuit board 1 instead of within the shielded LD element module, causing degradation of high-speed signal waveforms and increased crosstalk between transmitted and received signals due to the increased distance between the LD element and the drive circuit.

The present invention seeks to provide an optical transceiver that solves the above problems. Specifically, [the invention] seeks to provide an XFP optical transceiver with built-in LD element temperature adjustment function, to achieve expanded XFP optical transceiver transmission distance and compatibility with WDM transmission systems, thereby broadening the range of applications for said optical transceiver.

[Means for Solving the Problems]

[0007]

The optical transceiver of Claim 1 of the present invention, which solves the above problems, houses an LD element module and a PD element module within a single chassis, with an optical connector connecting portion disposed at one end in the longitudinal direction of the chassis and an electrical connector connecting portion disposed at the other end thereof, and includes two electrical circuit boards within the chassis.

[0008]

In the optical transceiver of Claim 2 of the present invention, which solves the above problems, one of the two electrical circuit boards in the optical transceiver of Claim 1 is fitted with at least an LD element module and control unit for same, while the other is fitted with at least a PD element module and control unit for same.

[0009]

In the optical transceiver of Claim 3 of the present invention, which solves the above problems, the electrical connector connecting portion in the optical transceiver of Claims 1 or 2 is formed on the circuit board fitted with the PD element module.

[0010]

In the optical transceiver of Claim 4 of the present invention, which solves the above

problems, the LD element module mounted on the circuit board in the optical receiver of Claims 1, 2, or 3, is in surface contact with the metal surface of the chassis through a thin electrical insulating layer.

[0011]

In the optical transceiver of Claim 5 of the present invention, which solves the above problems, the LD element module in the optical receiver of Claims 1, 2, 3, or 4 has a built-in temperature adjustment function, and a drive/control unit for at least the temperature adjustment function is mounted on the circuit board on which the LD element module is mounted.

[0012]

In the optical transceiver of Claim 6 of the present invention, which solves the above problems, the thickness of the LD element module with built-in temperature adjustment function in the optical receiver of Claims 1, 2, 3, 4, or 5 is 5 mm or less, and the circuit boards on which the LD element module is mounted and on which the PD element module is mounted are stacked in the thickness direction within the chassis.

[0013]

In the optical transceiver of Claim 7 of the present invention, which solves the above problems, a drive circuit directed at a DFB-LD element in the optical receiver of Claims 1, 2, 3, 4, 5, or 6, in which an electric field absorption modulator is monolithically integrated, is mounted inside the LD element module, and is electromagnetically shielded by the chassis.

[Effect of the Invention]

[0014]

The present invention confers a temperature adjustment function to an XFP optical transceiver without compromising compatibility with conventional non-temperature-controlled type [devices], not only expanding the transmission distance thereof but also enabling control of the signal light wavelength emitted from the LD element mounted in the XFP optical transceiver, making it compatible with WDM transmission systems.

Furthermore, because LD element module heat dissipation is improved, [the invention] is also effective for expanding the usable environmental temperature range of the XFP module and improving reception sensitivity by reducing crosstalk.

[Best Mode for Practicing the Invention]

[0015]

To solve the problems above, the XFP optical transceiver of the present invention uses an LD element module with a built-in temperature adjustment element.

To maintain compatibility with conventional non-temperature-adjustable XFP

optical transceivers, all peripheral components for driving and controlling the temperature adjustment element are housed inside the chassis.

To accommodate these additional components within the chassis dimensions specified by the MSA, the XFP optical transceiver of the present invention has the following structural features.

[0016]

1) The LD element module with a built-in temperature adjustment element and the peripheral components for driving and controlling the temperature adjustment element are mounted on a separate circuit board from the circuit board on which the PD element module is mounted.

2) The thickness of the LD element module with built-in temperature adjustment element is 5 mm or less, and the circuit boards on which the LD element module is mounted and on which the PD element module is mounted are stack-mounted in the thickness direction inside the chassis of the XFP optical transceiver.

3) The entire heat dissipation surface of the LD element module with built-in temperature adjustment element makes surface contact with the heat dissipation surface of the XFP optical transceiver chassis through a thin insulator.

[0017]

Therefore the present invention enables expansion of the XFP optical transceiver transmission distance to 80 km, as well as compatibility with WDM transmission methods.

External dimensions of the XFP optical transceiver are determined by specifications, and measure 78 mm x 18.5 mm x 8.2 mm. Stack-mounting the circuit board with the PD element module and the LD element module in the thickness direction requires only that the thickness of the LD element module with built-in temperature control function be 5 mm or less.

[Example 1]

[0018]

Below we explain the effect of the present invention with reference to specific embodiments.

The present embodiment is an example depicting the effect of the present invention; needless to say, various modifications may be undertaken provided they do not depart from the spirit of the present invention.

We explain embodiments of the present invention below with reference to figures.

Figure 1(a) shows an overview of an LD element module 8 with built-in temperature adjustment mounted in the XFP optical transceiver of the present invention.

[0019]

To enable stack-mounting, the LD element module 8 makes use of a compact package with a thickness of 4.7 mm, a length of 6.8 mm, and a width of 12 mm.

An electro-absorption (EA) modulator with monolithically integrated DFB-LD element ("EADFB-LD") is mounted inside the package; by controlling the LD element temperature to a desired temperature between 10-45°C using a built-in temperature adjusting element, the transmitted signal light wavelength can be matched to a desired WDM grid.

[0020]

A component called a stub 5 for attaching to an optical connector receptacle is mounted at the end of a pigtail optical fiber attached to LD element module 8.

To avoid crosstalk to the receiving PD element and the receiving circuit, an EA modulator drive circuit is mounted inside LD element module 8 with built-in temperature adjustment, electromagnetically shielded by the module chassis.

[0021]

LD element module 8 with a built-in temperature adjustment element is mounted on transmission circuit board 9, as shown in Figure 1(b), together with control circuit components including a temperature-adjustment element driver circuit, an LD output adjustment circuit, and an interface referred to as I²C.

A male 6-pin connector 10 for connecting power and control signals to wiring on the board where the PD element module is mounted, and a thin coaxial cable 11 and male coaxial cable 12 for connecting high-frequency electrical signals to wiring on the board where the PD element module is mounted, are [respectively] mounted on transmission circuit board 9.

[0022]

After an LD element module 8 with built-in temperature adjustment element is mounted [thereto], transmission circuit board 9 is screwed onto the XFP upper chassis 7 serving as heat dissipation surface, as shown in Figure 1(c).

A 0.1 mm thick electrical insulation film 13 is inserted at this time between the LD element module 8 heat dissipation surface and the upper chassis 7.

[0023]

Meanwhile the PD element module 14 with built-in preamp uses the package shown in Fig. 2(a), known as a TO-Can pin-PD, fitted with a pin-PD formed of ternary mixed crystal semiconductor InGaAs, and with a Si preamplifier circuit.

A stub 5 for insertion into to the optical connector receptacle is also mounted on this TO-Can.

[0024]

A PD element module 14 with built-in preamp is mounted on a receive-side circuit board 16 on which pads 15 for connection to electrical connectors are formed, shown in Fig. 2(b), together with peripheral circuit components such as a receiving host amp circuit, a clock recovery circuit ("CDR circuit" below), and I²C interface components.

In addition, a female 6-pin connector 17 fitting a male 6-pin connector 10 on a board for mounting the LD element, and a female coaxial connector 18 for connecting to a male coaxial connector 12, are [respectively] mounted on a receive-side circuit board 16.

[0025]

After mounting the above peripheral circuit components, the receiving side circuit board 16 is screwed onto XFP lower chassis 6, as shown in Figure 2(c).

When so doing, the leads on PD element module 14 with built-in preamp are bent to and stubs 5 aligned so that stubs 5 fit into optical receptacle 4.

[0026]

Next, as shown in Figure 3, upper chassis 7, to which is affixed a circuit board 7 [*sic; typo for circuit board 9*] fitted with LD module 8 with built-in temperature adjustment and peripheral circuit components, is connected to XFP lower chassis 6, to which circuit board 16 is affixed after mounting the PD element module 14 with built-in preamp.

Prior to this connection, the pigtail optical fiber end stubs 5 attached to LD element module 8 with built-in temperature adjustment are engaged with optical connector receptacle 4 and affixed.

[0027]

Connection of the upper and lower chassis is accomplished by engagement of the circuit board 9 male pin connector 10 and female coaxial connector 12 with the circuit board 16 female 6 pin connector 17 and coaxial connector 18.

After connecting, a heat dissipating fin 19 is attached to the upper chassis 7 serving as heat dissipating surface, thereby completing the XFP transceiver.

[0028]

The completed XFP optical transceiver was mounted on an evaluation board to investigate the range of wavelength variability using LD element temperature control.

Figure 4 shows the relationship between LD element temperature and transmission light wavelength.

By controlling LD element temperature in the range of 10 to 45°C, the transmission wavelength can be adjusted to any desired wavelength between 1550.5 nm and 1554.0 nm.

[0029]

This indicates that [the invention] can be used with the four WDM grids (1550.93, 1551.73, 1552.53, 1553.33) specified in ITU-T SG15.

Next we connected the LD element to the PD element using an 80 km optical fiber to evaluate transmission characteristics at wavelengths of 1550.925 nm and 1553.325 nm.

The bit error rate characteristics measured using a 10.3125 Gb/s NRZ pseudo-random signal are shown in Figure 5.

[0030]

For both wavelengths, error-free reception after 80 km of transmission was

confirmed, and reception sensitivity was -16.0 to -15.7 dBm, regardless of wavelength.

This reception sensitivity shows an improvement of 1 to 1.5 dB compared to a -14.5 dBm reception sensitivity when the EA modulator drive circuit is not built into the LD element module 8 rather than on the transmission side circuit board, thus confirming the crosstalk suppression effect resulting from a built-in drive circuit.

[0031]

Average power of transmitted light at this time is +2 dBm, satisfying ITU-T G.691 L-64.2a and .3 specifications for 80 km transmission.

In this embodiment a package with a thickness 4.7 mm, length 6.8 mm, and width 12 mm is used as the LD element module 8 with built-in temperature adjustment, but as shown in Figure 1(a), an XFP optical transceiver with built-in temperature adjustment having the same structure as the present embodiment can be fabricated by using an LD element module with built-in temperature adjustment in a package having a thickness of 5 mm or less, length 7.5 mm or less, and width 14 mm or less.

[0032]

The LD element module described in Japanese Patent Application No. 2002-110007 by the present inventors may, for example, be used as the LD element module with a thickness of 5 mm or less. I.e., in an optical module with built-in drive circuit housed in a module chassis fitted with connecting terminals for electrical and optical signals, wherein a semiconductor optical element with a function for converting a high speed electrical signal (2.5 Gb/s or greater) to an optical signal and an electrical circuit for driving said semiconductor optical element are respectively mounted on different carriers, that carrier on which the semiconductor optical element is mounted is [itself] mounted on an element having a temperature adjusting function; a low heat-conducting material is inserted between [that carrier] and the carrier on which the electrical circuit is mounted, thus suppressing the transmission of heat from the electrical circuit to the semiconductor optical element.

[0033]

As explained, the present embodiment is such that in an XFP standard optical transceiver, first, the LD element module with built-in temperature adjustment element, and peripheral components for driving and controlling a temperature adjustment element, are mounted on a circuit board separate from the circuit board on which the PD element module is mounted; second, the thickness of the LD element module with built-in temperature adjustment element is 5 mm or less, and the circuit boards on which the LD element module and the PD element module are mounted are stack-mounted in the thickness direction inside the XFP optical transceiver chassis; and third, the entire heat dissipation surface of the LD element module with built-in temperature adjustment element is in surface contact with the heat dissipation surface of the XFP optical

transceiver chassis through a thin insulator.

[Industrial Applicability]

[0034]

The present invention may be utilized in XFP-type optical transceivers that handle high-speed optical signal (10 Gb/s) digital data at bit rates from 9.9 Gb/s to 11.5 Gb/s in small to medium-sized optical communication networks referred to as MANs (Metropolitan Area Network) or LANs (Local Area Network).

[Brief Description of Drawings]

[0035]

[Figure 1] A perspective view showing the mounting form of an LD element module according to an embodiment of the present invention.

[Figure 2] A perspective view showing the mounting form of a PD element module according to an embodiment of the present invention.

[Figure 3] A perspective view showing an assembly method for an optical transceiver chassis according to an embodiment of the present invention.

[Figure 4] A graph showing the temperature dependence of the transmission light wavelength in an optical transceiver with built-in temperature adjustment manufactured according to an embodiment of the present invention.

[Figure 5] A graph showing code error rate characteristics of an optical transceiver with built-in temperature adjustment manufactured according to an embodiment of the present invention.

[Figure 6] A perspective view showing a mounting structure for a conventional non-temperature-adjusted XFP optical transceiver.

[Explanation of Reference Numerals]

[0036]

- 1 Conventional circuit board
- 2 LD element module
- 3 PD element module
- 4 Optical connector receptacle portion
- 5 Stub
- 6 Lower chassis
- 7 Upper chassis
- 8 LD element module with built-in temperature adjustment
- 9 Circuit board for transmission
- 10 Male 6-pin connector

- 11 Thin coaxial cable
- 12 Male coaxial connector
- 13 Electrical insulating film
- 14 PD element module
- 15 Pad for connecting electrical connectors
- 16 Receive-side circuit board
- 17 Female 6-pin connector
- 18 Female coaxial connector
- 19 Heat dissipating fan

[Selected Figure] Figure 1

FIG. 1

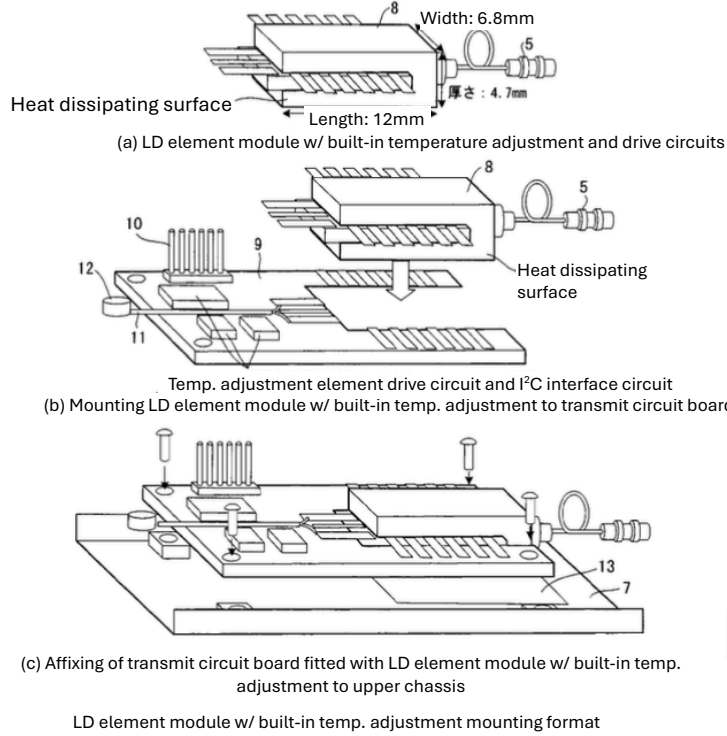


FIG. 2

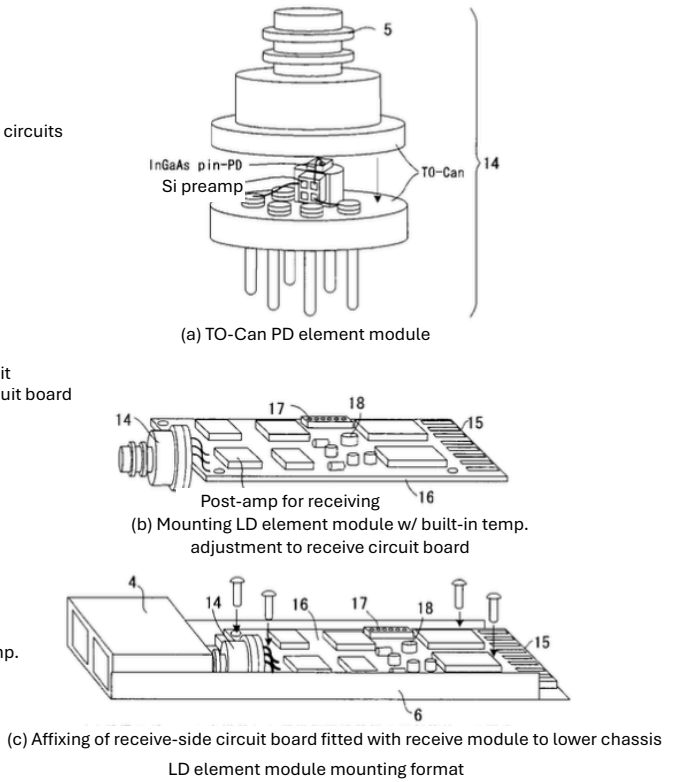


FIG. 3

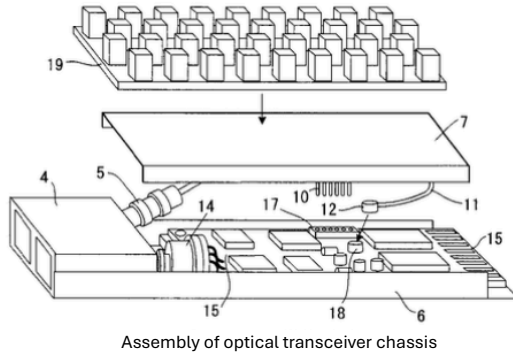
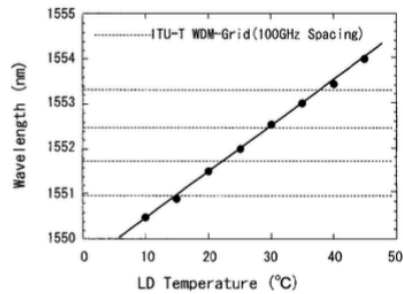
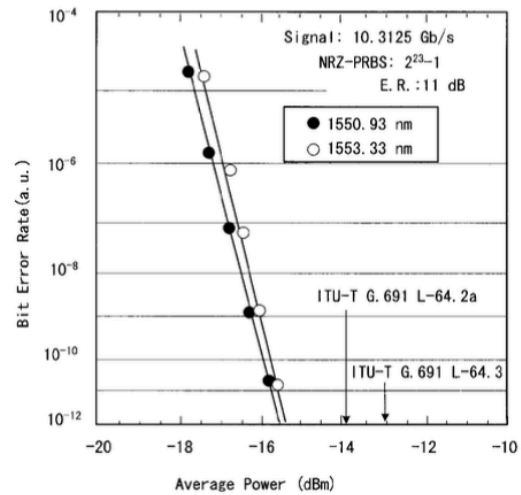


FIG. 4



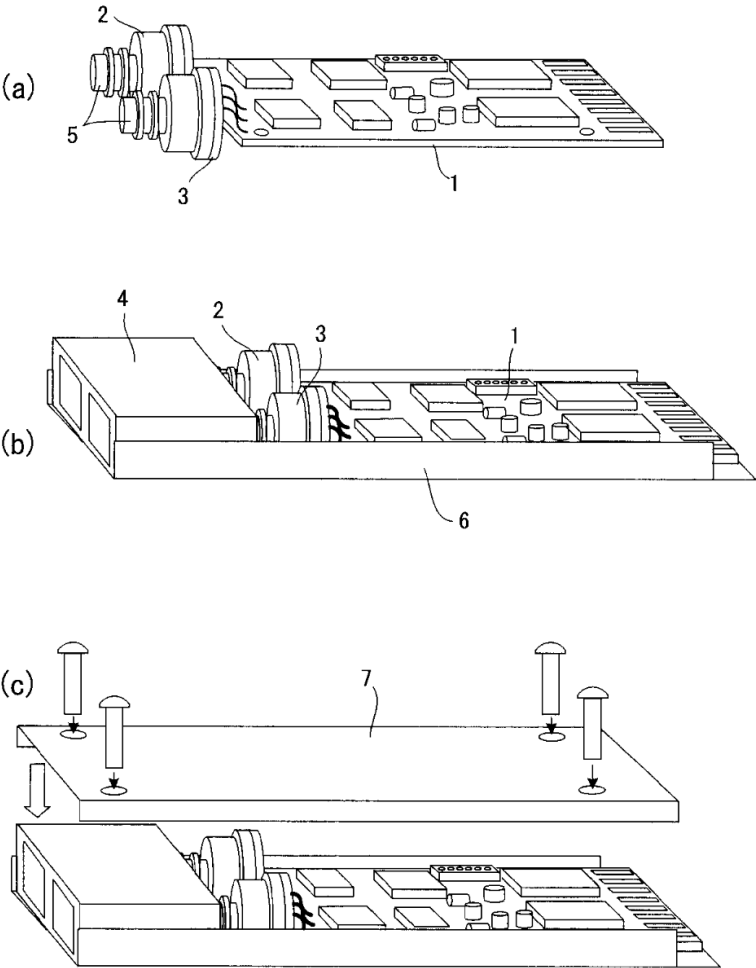
LD element temperature dependence on transmission light wavelength

FIG. 5



Coding error rate characteristics

FIG. 6



Conventional XFP optical transceiver mounting structure

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CERTIFICATION OF TRANSLATION

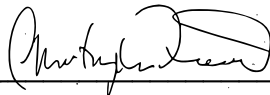
I, Christopher L. Field, residing at 52 Sherman Bridge Rd., Wayland MA, 01778, United States of America, declare and state as follows:

I am well acquainted with the English and Japanese languages. I have translated numerous Japanese documents of legal and/or technical content into English. I am fully accredited by the American Translators Association (ATA) for Japanese to English translation, and my ATA certification number is 423514.

I have personally translated the attached document, entitled "**JP 2005-269474**." I hereby certify that the English translation of the attached documents is an accurate translation to the best of my knowledge and ability.

I further declare that all statements made herein of my own knowledge are true, that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Executed at Wayland, Massachusetts, 11 September 2025.

Signed, 

Christopher Field

ATA Certified Translator, Japanese to English, Certificate No. 423514