



(43) International Publication Date
5 February 2015 (05.02.2015)

- (51) International Patent Classification:
G02B 6/42 (2006.01)
- (21) International Application Number:
PCT/US2014/047999
- (22) International Filing Date:
24 July 2014 (24.07.2014)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
61/861,849 2 August 2013 (02.08.2013) US
14/338,209 22 July 2014 (22.07.2014) US
- (71) Applicant (for all designated States except BR, CA, MX, US): FCI ASIA PTE. LTD [SG/SG]; 159 Kampong Ampat, #04-01/04 KA Place 368328 (SG).
- (71) Applicant (for BR, CA, MX, US only): FCI AMERICAS TECHNOLOGY LLC [US/US]; 502 East John Street, Carson City, Nevada 89706 (US).
- (72) Inventors: SCHAMUHN, Kai; Holzhauser Strasse 175-177, 13509 Berlin (DE). KRINK, Andreas; Holzhauser Strasse 175-177, 13509 Berlin (DE). DAUMENLANG, Johannes; Holzhauser Strasse 175-177, 13509 Berlin (DE). SPICKLER, John; 825 Old Trail Road, Etters, Pennsylvania 17319 (US).

(74) Agent: GEIBEL, Dean E.; FCI USA LLC, 825 Old Trail Road, Etters, Pennsylvania 17319 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: OPTO-ELECTRICAL TRANSCEIVER MODULE AND ACTIVE OPTICAL CABLE

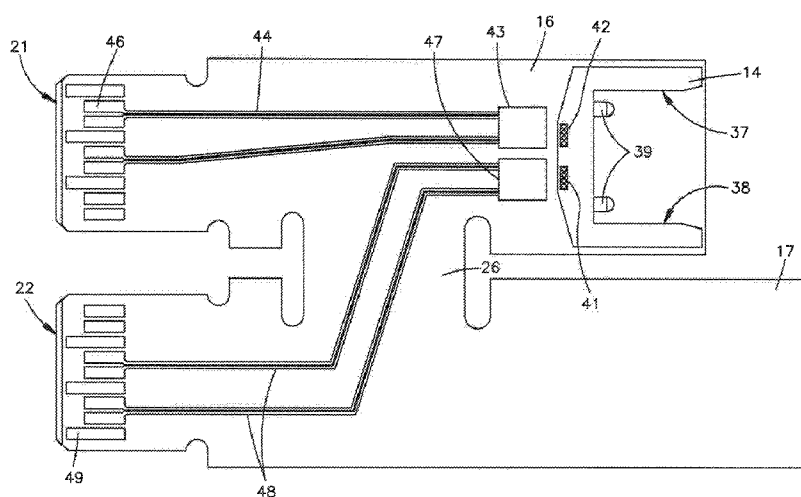


Fig 4

(57) Abstract: An opto-electrical transceiver module and an active optical cable comprising such a module are disclosed. The module includes a first printed circuit board and a second printed circuit board. The first printed circuit board carries 1) a light sources with driver circuitry that converts incoming electrical signals to optical signals, 2) optical receiver components with amplifier circuitry that converts optical signals to electrical signals, 3) a single optical coupling unit configured to optically coupling waveguides of an optical cable to the light sources as well as to the optical receiver components, and (4) one or more electrical contacts configured to connect to a host device. The second printed circuit board includes electrical contacts connected to the driver circuitry or to the amplifier circuitry on the first printed circuit board.



OPTO-ELECTRICAL TRANSCEIVER MODULE AND ACTIVE OPTICAL CABLE

BACKGROUND

[0001] The present disclosure relates to an opto-electrical transceiver module, in particular to a header or receptacle module for connecting an active optical cable to a host device. The present disclosure also relates to an active optical cable provided with such an opto-electrical transceiver module.

[0002] Active optical cables use electrical-to-optical signal conversion on the cable ends to provide high-speed signal transmission, e.g., up to 10 Gbits/s or faster, without sacrificing compatibility with standard electrical interfaces. The terminal ends of active optical cables are provided with opto-electrical modules for converting electrical signals into optical signals and vice versa. Active optical cables can replace conventional copper cables allowing longer cable lengths at higher data transmission rates.

[0003] An opto-electrical transceiver module usually includes a transmitter unit for transmitting optical signals and a receiver unit for receiving optical signals.

[0004] The transmitter unit is typically provided with electrical driver circuitry, one or more high speed light sources, such as one or more lasers and/or one or more LED's, and an optical coupling unit for guiding optical signals from the light sources to an optical waveguide, in particular optical fiber.

[0005] The receiver unit is typically provided with an optical coupling unit for receiving optical signals from optical waveguides, in particular optical fibers, photoelectric elements for converting the optical signals to electrical signals, such as PIN or APD diodes, and amplifier circuitry to amplify signals to a suitable logical output signal level.

[0006] Additionally a microcontroller can be used to control and monitor the receiver unit and/or the transmitter unit and/or to provide access to these units via a low speed interface. Such a microcontroller can also be used to store non-volatile settings and/or product related information in its memory accessible via a low speed interface.

[0007] These components are usually carried on one or more printed circuit boards (PCB's) with contact pads for contacting matching data transmission contacts of a host device. There are several possible standard configurations. In one of these standard configurations a

stack of two PCB's is used: a transmitter PCB with contact pads for receiving electrical signals from the host device and a receiver PCB with contact pads for transferring electrical signals to the host device. In present day transceiver modules the transmitter PCB carries the transmitter chip and associated components including an optical coupler for guiding outgoing optical signals from the light sources to waveguides of an optical cable, while the receiver PCB carries the receiver chip and associated components including an optical coupler for guiding incoming optical signals from optical waveguides of an optical cable.

[0008] In use optical signals coming in from optical waveguides of an optical cable are converted by the receiver unit into electrical signals traveling on the PCB to the host device, into which the opto-electrical transceiver module is plugged. In return, incoming electrical signals from the host device travel via the transmitter PCB to the driver circuitry driving the high speed light sources to convert the electrical signals to optical signals. These optical signals are fed to optical waveguides of an optical cable via the optical coupling unit.

[0009] The receiver and transmitter units and PCB's consume considerable space resulting in bulky modules. In line with the general trend of miniaturization there is a need for an opto-electrical module consuming less space. More particularly, many host devices have a communication port configured to communicate with Mini SAS HD standard interface connectors, which creates a need for an optical transceiver module that is compact enough to be designed as a Mini SAS HD module.

SUMMARY

[0010] To this end, an opto-electrical transceiver module is disclosed comprising a first PCB and a second PCB. The first PCB carries:

- one or more light sources, such as VCSEL's or LED's, with driver circuitry for converting incoming electrical signals to optical signals,
- one or more optical receiver components, such as PIN diodes or APD diodes, with amplifier circuitry for converting optical signals to electrical signals,
- a single optical coupling unit configured for optically coupling waveguides of an optical cable to the light sources as well as to the optical receiver components and
- one or more contacts for connection to a host device.

[0011] Also the second PCB has one or more contacts for connection to a host device. At least a part of the contacts of the second PCB is connected to the driver circuitry or to the amplifier circuitry.

[0012] For instance, the driver circuitry and the amplifier circuitry can each be connected to contacts on different respective PCB's. E.g., the driver circuitry can be connected to the contacts of the first PCB, while the amplifier circuitry is connected to the contacts of the second PCB or the amplifier circuitry can be connected to the contacts of the first PCB, while the driver circuitry is connected to the contacts of the second PCB. In such a configuration only a single optical coupling unit is used for incoming as well as for outgoing optical signals. This considerably reduces space consumption and makes it for example possible to configure the transceiver module a standard Mini SAS HD module.

[0013] To comply with the Mini SAS HD configuration the first and second PCB's may comprise a contact edge providing the contacts for connection to a host device. The contact edge may have contact pads connected to either driver circuitry on the first PCB associated with the light sources or to amplifier circuitry on the first PCB associated with the optical receiver components.

[0014] To bridge the two rigid PCB's a flexible board can be used to connect the contact pads of the second PCB with the driver circuitry or amplifier circuitry. The flexible board can be folded to align the first and second PCB's, both PCB's having parallel contact edges for contacting matching connections of a host device. This arrangement can be used to provide a contact edge for the transmittal path and a separate contact edge for a receiving path.

[0015] A particularly compact arrangement is achieved if the optical coupling unit is arranged between the two PCB's. The PCB's may for instance be parallel, the optical coupling unit being sandwiched between the two or more PCB's.

[0016] The rigid PCB's may for example have parallel longitudinal sides connected by the flexible board. One of the short sides of the stacked rigid PCB's can be used for connection to optical waveguides of an associated optical cable. Alternatively, the flex board may connect short sides of the two rigid PCB's or it may connect a small side of one rigid PCB to a longitudinal side of the other rigid PCB.

[0017] In a specific embodiment the opto-electrical transceiver module may comprise a microcontroller, for instance on the second rigid PCB.

[0018] To enable efficient heat management the transceiver module may for example comprise a housing with a thermoconductive bridge, typically at an inner surface of the housing, contacting the first PCB at or near the driver circuitry and/or the amplifier circuitry. This allows effective heat dissipation of heat generated by the driver and amplifier circuitries. To monitor these heat flows via the housing, the transceiver module may comprise a housing with a thermoconductive bridge, typically at an inner surface of the housing, in

thermoconductive contact with the microcontroller, which typically comprises an internal thermal sensor.

[0019] Optionally, the flexible board and the two PCB's can be made as a single part e.g., in a rigid-flex-rigid structure. Rigid-flex circuits are a hybrid construction of rigid and flexible substrates which are laminated together into a single structure. Alternatively, the rigid board can be connected by means of a board to board connector.

[0020] The opto-electronic transceiver module can for example have an open optical port connection, which can be used to connect an optical cable by plugging the terminal end of the optical cable into the open port. Alternatively, the module can be connected to an optical cable by means of a permanent connection, e.g., by means of a cable boot with a cable insert piece.

[0021] An active optical cable is disclosed comprising at least one, e.g., two terminal ends provided with an opto-electrical transceiver module according to the disclosure above.

[0022] The present disclosure will be further explained with reference to the accompanying drawings showing an exemplary embodiment of the disclosed opto-electrical transceiver module and of the disclosed active optical cable.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] Fig. 1 is a perspective view of an opto-electrical transceiver module constructed in accordance with one embodiment, shown with a housing of the opto-electrical transceiver module partly broken away;

[0024] Fig. 2 is a sectional side elevation view of the transceiver module illustrated in Fig. 1;

[0025] Fig. 3 is a sectional end elevation view of the transceiver module illustrated in Fig. 1, taken through a flexible board of the transceiver module; and

[0026] Fig. 4 is a top plan view of circuit boards of the transceiver module illustrated in Fig. 1, shown unfolded.

DETAILED DESCRIPTION

[0027] Fig. 1 shows a terminal end of an optical cable 1 with a cable boot 2 comprising a cable insert 3. The optical cable 1 holds a plurality of optical fibers 4 with terminal ends protruding from the insert piece 3 along a longitudinal direction L. The cable insert 3 connects the cable 1 to an opto-electrical transceiver module 6 with a housing 7 having a connector opening 8 at one end and a cable entry 9 at the opposite end. The connector opening 8 and the cable entry 9 can be spaced from each other along the

longitudinal direction L. The insert piece 3 can have a flanged end 11 profiled to provide a tight mechanical coupling with a correspondingly profiled inner surface 12 of the cable entry 9.

[0028] The optical fibers 4 are aligned and clamped in a ferrule 13 presenting the outer ends of these optical fibers 4 to an optical coupling unit 14 with an array of lenses (not shown), each lens being arranged in optical communication with an outer end of an associated optical fiber 4 held in the ferrule 13.

[0029] The opto-electrical transceiver module 6 further comprises two rigid printed circuit boards (PCB's), including a transmitter PCB 16 and a receiver PCB 17. The two rigid PCB's 16 and 17 are arranged in a parallel relationship, the transmitter PCB 16 being positioned above the receiver PCB 17 along a transverse direction T that is perpendicular to the longitudinal direction L. The transmitter PCB 16 carries high speed light sources 42 (see Fig. 4) for converting incoming electrical signals into outgoing optical signals, and optical receiver components 41 (see Fig. 4) for converting incoming optical signals into outgoing optical signals. The high speed light sources 42 can for example be vertical cavity surface emitting lasers (VCSEL's). The optical receiver components 41 can for example be PIN diodes.

[0030] The optical coupling unit 14 is carried by the transmitter PCB 16 in a position between the two PCB's 16 and 17. The two PCB's 16 and 17 are rigid boards with a rectangular outline. The transmitter PCB 16 has a short side 18 facing the cable entry 9 and a short side 21 at the connector opening 8. The short sides 18 and 21 can be spaced from each other along the longitudinal direction L. The receiver PCB 17 also has a short side 19 facing the cable entry 9 and a short side 22 at the connector opening 8. The short sides 19 and 22 are spaced from each other along the longitudinal direction L. The transmitter PCB 16 has a longitudinal side 23, and the receiver PCB has a longitudinal side 24. The longitudinal side 23 of the transmitter PCB 16 is connected to the oppositely arranged longitudinal side 24 of the receiver PCB 17 by a flexible board 26. The ferrule 13 and the optical coupling unit 14 are positioned between the PCB's 16 and 17 at the end facing the cable entry 9. The opposite short sides 21 and 22 of the rigid PCB's 16 and 17, respectively, are contact edges with contact fingers accessible via the connector opening 8 and arranged to be contacted by complementary contacts of a host device (not shown).

[0031] The optical coupling unit 14 receives optical signals from the fibers 4 held in the ferrule 13 and guides these optical signals to the optical receiver components 41 with associated downstream amplifier circuitry 47 (see Fig. 4). These electrical signals are then

transferred via the flexible board 26 to the receiver PCB 17 and subsequently to receiving conductors of the host device.

[0032] Electrical signals coming from the host device travel from electrical input signal contacts 46 (see Fig. 4) on the transmitter PCB 16 via electrical driver circuitry 43 (see Fig. 4) to the light sources 42, which convert electrical signals into optical signals. These optical signals are subsequently passed via the optical coupling unit 14 to the optical fibers 4 of the optical cable 1.

[0033] The optical cable 1 with the opto-electrical module 6 at one end and a similar opto-electrical module 6 at its other end forms an active optical cable compatible with electrical inputs as used with a traditional copper cable, but using optical fibers between the connectors.

[0034] In an alternative embodiment the cable entry 9 of the opto-electronic transceiver module 6 can be provided with an open optical port, allowing a user to plug in an optical cable.

[0035] The opto-electrical module 6 is shown in longitudinal cross section in Fig. 2. A microcontroller 27 is located between the housing 7 and the receiver PCB 17. The microcontroller 27 controls and monitors the driver circuitry 43 as well as the amplifying circuitry 47 on the transmitter PCB 16. Low speed electrical signals to and from the microcontroller 27 are supplied to and received from the amplifier and driver circuitries 43 and 47, respectively, via the flexible board 26 and also to the electrical connector sides 46 and 49, respectively, to provide low speed data transmission to or from a connected host device.

[0036] The inner surface of the housing is provided with a thermoconductive bridge 25 contacting the microcontroller 27. Since the microcontroller 27 comprises an internal thermal sensor, the temperature of the housing can be monitored. Similarly, a thermoconductive bridge 30 is provided between the inner surface of the housing 7 and the transmitter PCB 16 at the position of the optical coupling unit 14 and the driver and amplifier circuitries 43 and 47, respectively. This facilitates heat dissipation from the driver and amplifier circuitries 43 and 47, respectively, via the housing 7.

[0037] Fig. 3 shows a cross section of the opto-electrical transceiver module 6 along a plane perpendicular to the longitudinal direction crossing the flexible board 26. The plane can extend along the transverse direction T and a lateral direction A that is perpendicular to both the longitudinal direction L and the transverse direction T. The housing 7 can be formed of two portions 33 and 34. The portions 33 and 34 can define substantially mirrored halves 33 and 34, or the housing 7 can be alternatively constructed as desired. Edges of the transmitter

PCB 16 and the receiver PCB 17 at their respective longitudinal sides 28 and 29 are slid into matching recesses 31 and 32, respectively, in the inner side of one of the halves 34 of the housing 7. In other cross sectional planes (not shown) the opposite longitudinal edges of the transmitter PCB 16 and the receiver PCB 17 are similarly received in corresponding recesses in the inner surface of the other one of the halves 33 of the housing 7.

[0038] The flexible board 26 and the rigid transmitter PCB 16 and the receiver PCB 17 can be integrally manufactured as a single rigid-flex-rigid substrate. Such a substrate can be folded and unfolded. Such a substrate is shown unfolded in Fig. 4. The optical coupling unit 14 is substantially U-shaped having an open side that is configured to receiving the ferrule 13. The inner side of the U-shape provides first and second guiding surfaces 37 and 38, respectively, and alignment pins 39 to enable accurate positioning of the ferrule with the optical fiber ends 4.

[0039] Lenses of the optical coupling unit 14 communicate with individual fiber ends 4 and guide optical signals from the optical fiber ends 4 to an array of PIN diodes 41 or in the opposite direction from an array of VCSEL's 42 to respective optical fiber ends. Although the arrays of PIN diodes 41 and VCSEL's 42 are covered by the optical coupling unit 14, they are indicated in Fig. 4 for the purposes of illustration.

[0040] The VCSEL's 42 are connected to driver circuitry 43, which is connected via conductive paths 44 to contact fingers 46 at the short side of the transmitter PCB 16. Electrical signals from a host device travel via the contact fingers 46 to the driver circuitry 43 driving the VCSEL's 42 to convert the electrical signals to optical signals which are guided by the optical coupling unit 14 to enter the optical fibers 4 of the cable 1.

[0041] The PIN diodes 41 convert incoming optical signals to electrical signals which are transferred to the receiver chip 47 configured to amplify signals to a suitable logical output signal level. The amplified signals are transferred via conductive paths 48 on the receiver PCB 17 to contact fingers 49 at the short side 22 of the receiver PCB 17.

[0042] The array of PIN diodes 41 is in line with the array of VCSEL's 42. The optical coupling unit 14 forms a single interface between the optical waveguides of a cable one the one hand and the VCSEL's and PIN diodes on the other hand.

[0043] The foregoing description is provided for the purpose of explanation and is not to be construed as limiting the invention. While various embodiments have been described with reference to preferred embodiments or preferred methods, it is understood that the words which have been used herein are words of description and illustration, rather than words of limitation. Furthermore, although the embodiments have been described herein with

reference to particular structure, methods, and embodiments, the invention is not intended to be limited to the particulars disclosed herein. For instance, it should be appreciated that structure and methods described in association with one embodiment are equally applicable to all other embodiments described herein unless otherwise indicated. Those skilled in the relevant art, having the benefit of the teachings of this specification, may effect numerous modifications to the invention as described herein, and changes may be made without departing from the spirit and scope of the invention, for instance as set forth by the appended claims.

CLAIMS

1. An opto-electrical transceiver module comprising:
 - a first printed circuit board carrying:
 - at least one light source with driver circuitry configured to convert incoming electrical signals to optical signals,
 - at least one optical receiver component with amplifier circuitry configured to convert optical signals to electrical signals,
 - a single optical coupling unit configured to optically couple waveguides of an optical cable to the at least one light source as well as to the at least one optical receiver component; and
 - at least one first electrical contact configured to connect to a host device; and
 - a second printed circuit board having at least one second electrical contact configured to connect to the host device,
 - wherein at least a part of the at least one second electrical contact on the second printed circuit board is connected to the driver circuitry or the amplifier circuitry on the first printed circuit board.
2. The opto-electrical transceiver module according to claim 1, further comprising a flexible board that connects the at least one electrical contact of the second printed circuit board with the driver circuitry or amplifier circuitry.
3. The opto-electrical transceiver module according to claim 2, wherein the flexible board is folded to align the first and second printed circuit boards, wherein each of the first and second printed circuit boards has a respective contact edge, the contact edges parallel to each other so as to contact corresponding connections of the host device.
4. The opto-electrical transceiver module according to claim 1, wherein the optical coupling unit is disposed between the first and second printed circuit boards.
5. The opto-electrical transceiver module according to claim 1, wherein one of the first and second printed circuit boards carries a microcontroller.

6. The opto-electrical transceiver module according to claim 5, wherein the microcontroller) is carried on the second printed circuit board at a surface opposite to a surface of the second printed board that faces the first printed circuit board.
7. The opto-electrical transceiver module according to claim 5, further comprising a housing having a thermoconductive bridge that contacts the microcontroller.
8. The opto-electrical transceiver module according to claim 1, further comprising a housing having a thermoconductive bridge that contacts the first printed circuit board at a location at least proximate to one or both of the driver circuitry and the amplifier circuitry.
9. The opto-electrical transceiver module according to claim 8, wherein the location is at one or both of the driver circuitry and the amplifier circuitry.
10. The opto-electrical transceiver module according to claim 1, comprising an open optical port connection.
11. The opto-electrical transceiver module according to claim 1, wherein a board-to-board connector connects the second at least one electrical contact of the second printed circuit board with the driver circuitry or the amplifier circuitry.
12. The opto-electrical transceiver module according to claim 1, wherein the driver circuitry and the amplifier circuitry are connected to respective electrical contacts on each of the first and second printed circuit boards.
13. An active optical cable having a terminal end provided with an opto-electrical transceiver module, the opto-electrical transceiver module comprising:
 - a first printed circuit board carrying:
 - at least one light source with driver circuitry configured to convert incoming electrical signals to optical signals,
 - at least one optical receiver component with amplifier circuitry configured to convert optical signals to electrical signals,

a single optical coupling unit configured to optically couple waveguides of an optical cable to the at least one light source as well as to the at least one optical receiver component; and

at least one first electrical contact configured to connect to a host device; and
a second printed circuit board having at least one second electrical contact configured to connect to the host device,

wherein at least a part of the at least one second electrical contact on the second printed circuit board is connected the driver circuitry or the amplifier circuitry on the first printed circuit board.

14. The active optical cable according to claim 13, further comprising a flexible board that connects the at least one electrical contact of the second printed circuit board with the driver circuitry or amplifier circuitry.

15. The active optical cable according to claim 14, wherein the flexible board is folded to align the first and second printed circuit boards, wherein each of the first and second printed circuit boards has a respective contact edge, the contact edges parallel to each other so as to contact corresponding connections of the host device.

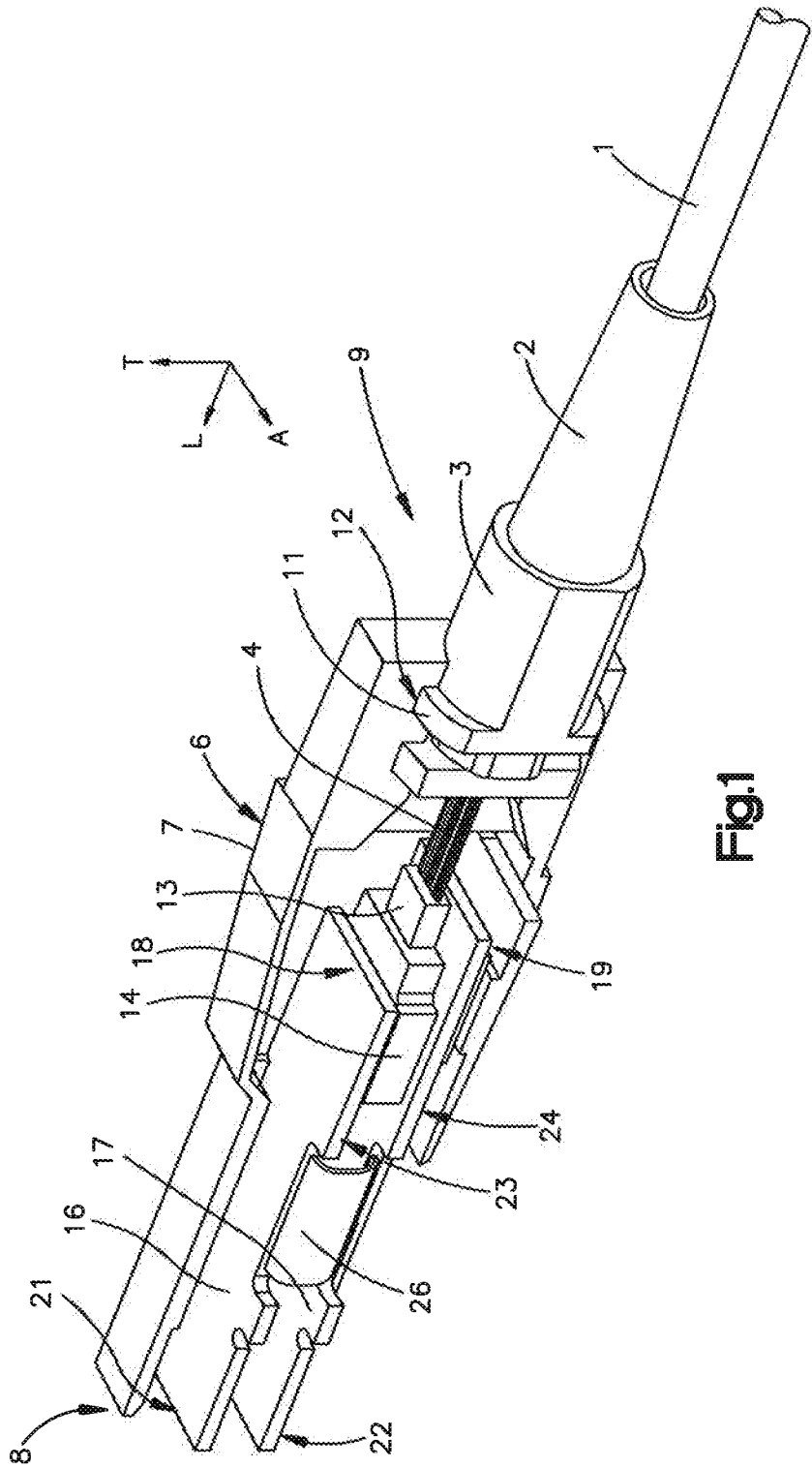
16. The active optical cable according to claim 13, wherein the optical coupling unit is disposed between the first and second printed circuit boards.

17. The active optical cable according to claim 13, wherein one of the first and second printed circuit boards carries a microcontroller.

18. The active optical cable according to claim 17, wherein the microcontroller) is carried on the second printed circuit board at a surface opposite to a surface of the second printed board that faces the first printed circuit board.

19. The active optical cable according to claim 17, further comprising a housing having a thermoconductive bridge that contacts the microcontroller.

20. The active optical cable according to claim 13, further comprising a housing having a thermoconductive bridge that contacts the first printed circuit board at a location at least proximate to one or both of the driver circuitry and the amplifier circuitry.
21. The active optical cable according to claim 20, wherein the location is at one or both of the driver circuitry and the amplifier circuitry.
22. The active optical cable according to claim 13, comprising an open optical port connection.
23. The active optical cable according to claim 13, wherein a board-to-board connector connects the second at least one electrical contact of the second printed circuit board with the driver circuitry or the amplifier circuitry.
24. The active optical cable according to claim 13, wherein the driver circuitry and the amplifier circuitry are connected to respective electrical contacts on each of the first and second printed circuit boards.



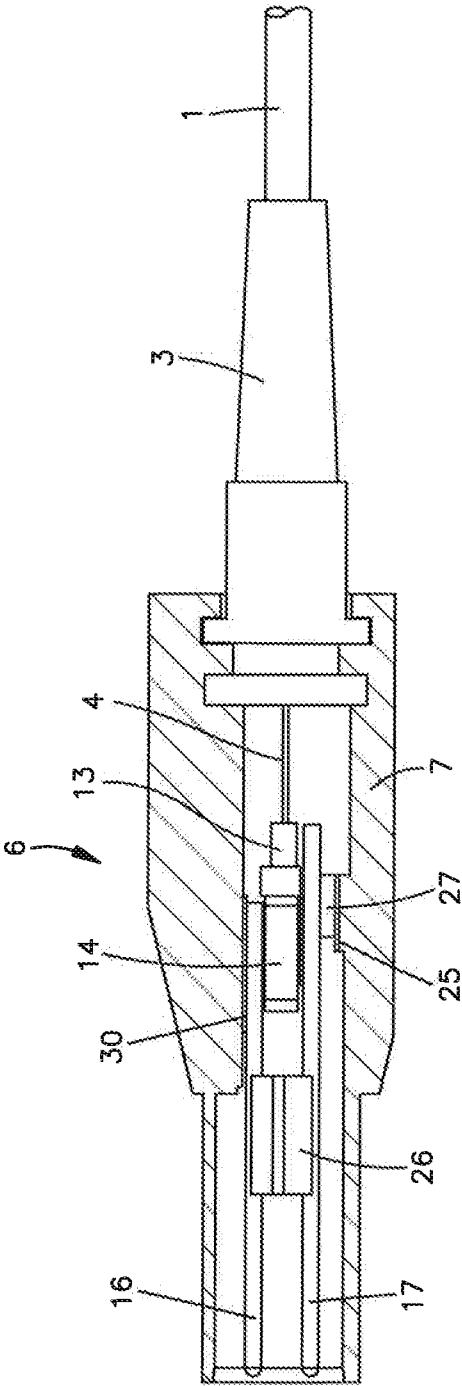


Fig.2

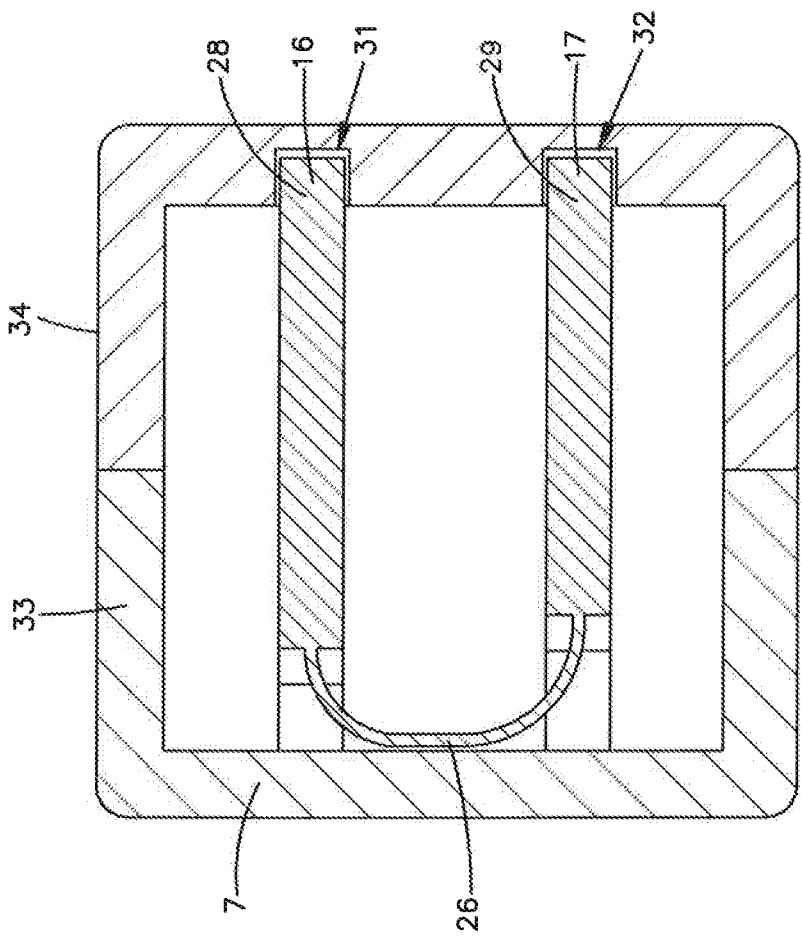


Fig.3

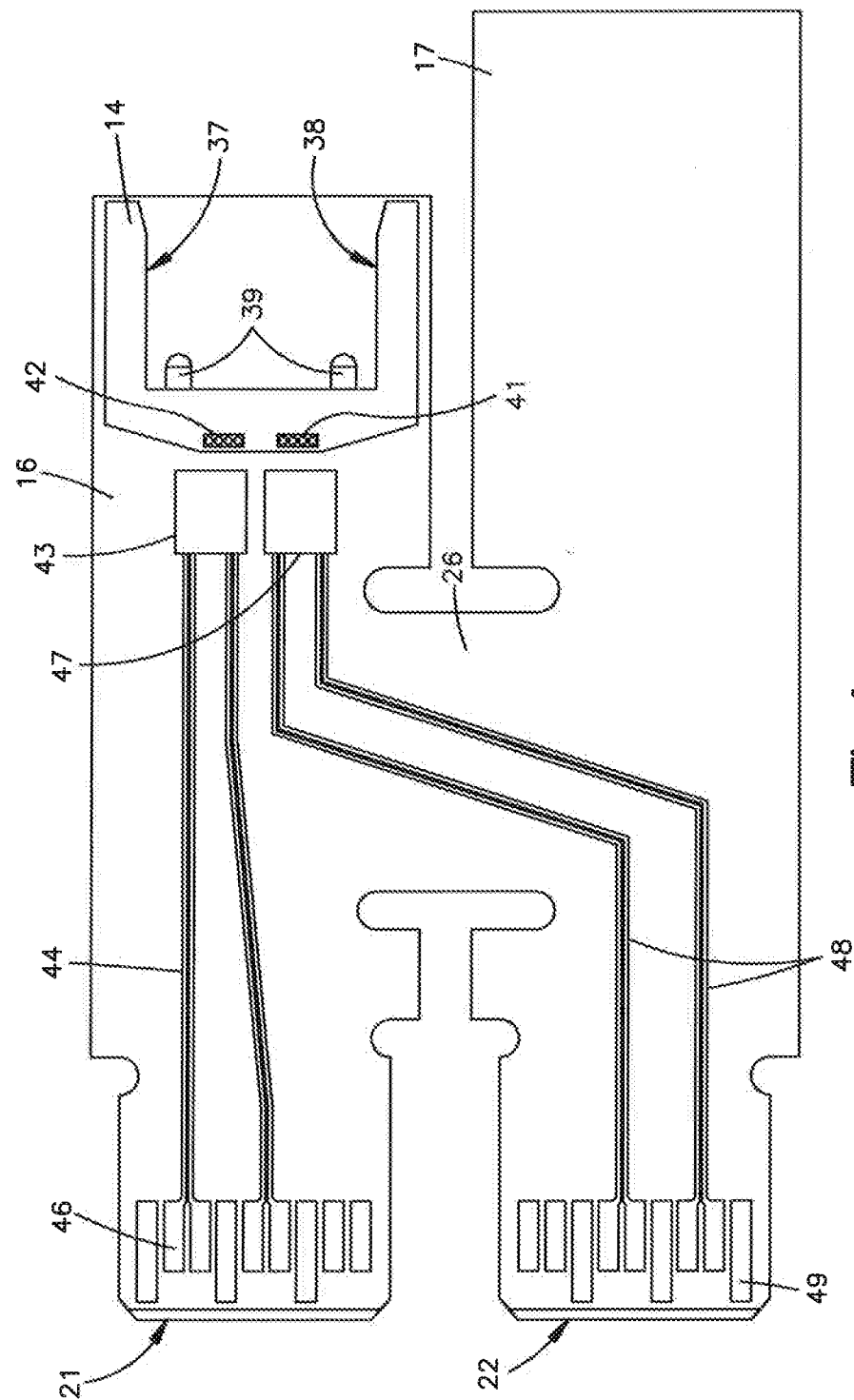


Fig.4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/047999**A. CLASSIFICATION OF SUBJECT MATTER****G02B 6/42(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G02B 6/42; G02B 006/42; H05K 5/00; H04B 1/38

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: transceiver, two PCB, optical coupling unit

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2002-0076173 A1 (JIANG et al.) 20 June 2002 See abstract, paragraphs [0028]-[0029], [0032] and figures 1-2.	1-24
Y	US 2009-0290619 A1 (FLENS et al.) 26 November 2009 See abstract, paragraphs [0023]-[0025] and figures 2B-2D.	1-24
A	US 2004-0086240 A1 (TOGAMI et al.) 06 May 2004 See abstract, paragraph [0054] and figure 17.	1-24
A	EP 0953856 A2 (LUCENT TECHNOLOGIES INC.) 03 November 1999 See abstract, claim 1 and figures 1-2.	1-24
A	US 2003-0103734 A1 (BREZINA et al.) 05 June 2003 See abstract, claims 1-8 and figures 2A-2B.	1-24



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

12 November 2014 (12.11.2014)

Date of mailing of the international search report

12 November 2014 (12.11.2014)

Name and mailing address of the ISA/KR

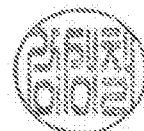
International Application Division
Korean Intellectual Property Office
189 Cheongsu-ro, Seo-gu, Daejeon Metropolitan City, 302-701,
Republic of Korea

Facsimile No. +82-42-472-7140

Authorized officer

KANG, Sung Chul

Telephone No. +82-42-481-8405



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/047999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2002-0076173 A1	20/06/2002	AU 1997-13344 B2	30/03/2000
		AU 2000-70843 A1	26/03/2001
		AU 2002-315188 B2	14/08/2008
		AU 2003-277160 A1	19/04/2004
		CA 2239775 A1	26/06/1997
		CA 2239775 C	15/07/2008
		CA 2451624 A1	27/12/2002
		CA 2451624 C	25/10/2011
		EP 0876165 A1	12/11/2003
		EP 0876165 B1	21/06/2006
		EP 1196799 A1	17/04/2002
		EP 1196799 A4	26/04/2006
		EP 1218437 A1	03/07/2002
		EP 1218437 B1	17/06/2009
		EP 1377860 A1	07/01/2004
		EP 1412404 A1	28/04/2004
		EP 1556060 A1	27/07/2005
		EP 1704878 A2	27/09/2006
		EP 1704878 A3	25/04/2007
		EP 1704878 B1	10/04/2013
		EP 2111876 A2	28/10/2009
		EP 2111876 A3	23/12/2009
		EP 2111876 B1	07/09/2011
		JP 2000-502380 A	29/02/2000
		JP 2003-501684 A	14/01/2003
		JP 2003-508564 A	04/03/2003
		JP 2004-244639 A	02/09/2004
		JP 2005-329264 A	02/12/2005
		JP 2007-231249 A	13/09/2007
		JP 2009-035744 A	19/02/2009
		JP 2009-240803 A	22/10/2009
		JP 4193917 B2	10/12/2008
		JP 4283719 B2	24/06/2009
		JP 4368339 B2	18/11/2009
		JP 5079749 B2	21/11/2012
		KR 10-0170999 B1	30/03/1999
		US 2001-0003126 A1	07/06/2001
		US 2001-0030789 A1	18/10/2001
		US 2001-0048793 A1	06/12/2001
		US 2002-0013408 A1	31/01/2002
		US 2002-0028048 A1	07/03/2002
		US 2002-0030872 A1	14/03/2002
		US 2002-0033979 A1	21/03/2002
		US 2002-0042473 A1	11/04/2002
		US 2003-0020986 A1	30/01/2003
		US 2003-0031430 A1	13/02/2003
		US 2003-0035269 A1	20/02/2003
		US 2003-0119985 A1	26/06/2003
		US 2003-0149173 A1	07/08/2003

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/047999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		US 2004-0069997 A1	15/04/2004
		US 2004-0185084 A1	23/09/2004
		US 2004-0186230 A1	23/09/2004
		US 2004-0186231 A1	23/09/2004
		US 2004-0235708 A1	25/11/2004
		US 2005-0027069 A1	03/02/2005
		US 2005-0027070 A1	03/02/2005
		US 2005-0054771 A1	10/03/2005
		US 2005-0159544 A1	21/07/2005
		US 2006-0210602 A1	21/09/2006
		US 2010-0233246 A1	16/09/2010
		US 2011-0159075 A1	30/06/2011
		US 5874500 A	23/02/1999
		US 5880616 A	09/03/1999
		US 6051648 A	18/04/2000
		US 6166130 A	26/12/2000
		US 6213651 B1	10/04/2001
		US 6323278 B2	27/11/2001
		US 6458889 B1	01/10/2002
		US 6495127 B1	17/12/2002
		US 6519154 B1	11/02/2003
		US 6534591 B2	18/03/2003
		US 6632030 B2	14/10/2003
		US 6833408 B2	21/12/2004
		US 6840686 B2	11/01/2005
		US 6873800 B1	29/03/2005
		US 6901221 B1	31/05/2005
		US 6911496 B2	28/06/2005
		US 6952532 B2	04/10/2005
		US 6969400 B2	29/11/2005
		US 7013088 B1	14/03/2006
		US 7116912 B2	03/10/2006
		US 7151135 B2	19/12/2006
		US 7176256 B2	13/02/2007
		US 7883693 B2	08/02/2011
		US 7883694 B2	08/02/2011
		US 8377466 B2	19/02/2013
		US 8617584 B2	31/12/2013
		US RE41147 E	23/02/2010
		WO 00-73833 A1	07/12/2000
		WO 00-74277 A1	07/12/2000
		WO 01-16210 A1	08/03/2001
		WO 02-077690 A1	03/10/2002
		WO 02-095452 A2	28/11/2002
		WO 02-095452 A3	21/08/2003
		WO 02-102864 A1	27/12/2002
		WO 2004-028547 A1	08/04/2004
		WO 97-22371 A1	26/06/1997
US 2009-0290619 A1	26/11/2009	CN 102100010 A	15/06/2011

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/047999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		CN 102100010 B	12/03/2014
		EP 2281345 A2	09/02/2011
		EP 2281345 A4	05/10/2011
		US 2010-0080518 A1	01/04/2010
		US 2010-0296817 A1	25/11/2010
		US 2011-0080008 A1	07/04/2011
		US 2011-0081114 A1	07/04/2011
		US 2011-0081119 A1	07/04/2011
		US 8057109 B2	15/11/2011
		US 8113723 B2	14/02/2012
		US 8328435 B2	11/12/2012
		US 8391667 B2	05/03/2013
		US 8459881 B2	11/06/2013
		WO 2009-143293 A2	26/11/2009
		WO 2009-143293 A3	05/08/2010
US 2004-0086240 A1	06/05/2004	US 2005-0168963 A1	04/08/2005
		US 7130194 B2	31/10/2006
		US 7245498 B2	17/07/2007
EP 0953856 A2	03/11/1999	EP 0953856 A3	05/04/2000
US 2003-0103734 A1	05/06/2003	US 2003-0053768 A1	20/03/2003
		US 2003-0103739 A1	05/06/2003
		US 6705769 B2	16/03/2004
		US 7093987 B2	22/08/2006