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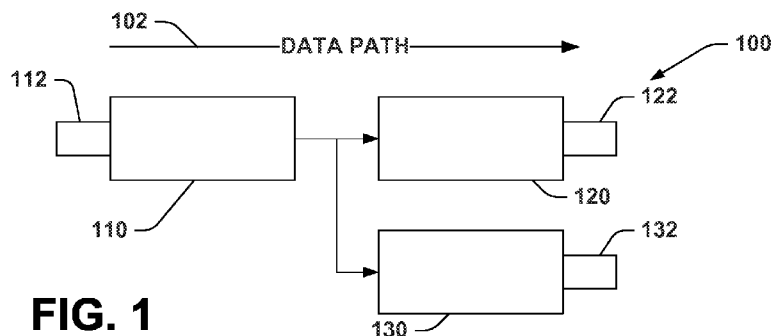


FIG. 1

(57) Abstract: A fiber optic tap system includes a first receiver module having an input port configured to receive an optical fiber. The first receiver module is operable to convert a received optical signal to an electrical signal. A first transmitter module is coupled to receive the electrical signal from the first receiver module and convert the received electrical signal to an optical signal. The first transmitter module has an output port for outputting the optical signal. A first tap module is coupled to receive the electrical signal from the first receiver module.

OPTICAL SPLITTER

Cross-Reference to Related Application(s)

[0001] This application is being filed on March 31, 2015, as a PCT International Patent application and claims priority to U.S. Patent Application Serial No. 61/975,414 filed on
5 April 4, 2014, the disclosure of which is incorporated herein by reference in its entirety.

Background

[0002] The present disclosure relates generally to fiber optic systems.

[0003] Fiber optic communication systems are becoming prevalent in part because service providers want to deliver high bandwidth communication capabilities (e.g., data and
10 voice) to customers. Fiber optic communication systems employ a network of fiber optic cables to transmit large volumes of data and voice signals over relatively long distances. Fiber cables are connected between switching devices so that data can be transported between the switches. In some fiber optic systems it is necessary or desirable to “copy” or “tap” the data being transported in the optical channel. This copied data is then used for
15 traffic analysis and other maintenance purposes.

Summary

[0004] In accordance with aspects of the present disclosure a fiber optic tap system includes a first receiver module having an input port configured to receive an optical fiber. The first receiver module is operable to convert a received optical signal to an electrical
20 signal. A first transmitter module is coupled to receive the electrical signal from the first receiver module and convert the received electrical signal to an optical signal. The first transmitter module has an output port for outputting the optical signal. A first tap module is coupled to receive the electrical signal from the first receiver module.

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Brief Description of the Drawings

[0005] Figure 1 is a block diagram illustrating aspects of an example fiber optic tap system in accordance with the present disclosure.

[0006] Figure 2 is a block diagram illustrating further aspects of an example fiber optic tap system in accordance with the present disclosure.

[0007] Figure 3 is a block diagram illustrating an example of fiber optic tap system mounted on a printed circuit board.

5 [0008] Figure 4 is a perspective view illustrating aspects of an example of a modular fiber optic tap system.

[0009] Figure 5 is an exploded view of portions of the modular fiber optic tap system shown in Figure 4.

10 [0010] Figure 6 is a cross section view of portions of the modular fiber optic tap system shown in Figures 4 and 5.

[0011] Figure 7 is a top view of portions of the modular fiber optic tap system shown in Figures 4-6.

[0012] Figure 8 is a block diagram illustrating an example of a modular fiber optic tap system employing SFP/SFP+ ports.

15 [0013] Figure 9 is a block diagram illustrating another example of a modular fiber optic tap system employing SFP/SFP+ ports.

[0014] Figure 10 is a block diagram illustrating an example of a fiber optic system having bi-directional data flow.

20 [0015] Figure 11 is a block diagram illustrating an example of a fiber optic tap system for a fiber optic system having bi-directional data flow.

[0016] Figure 12 is a block diagram illustrating aspects of an example tap module used in the system shown in Figure 11.

[0017] Figure 13 is a block diagram illustrating an example of a modular fiber optic tap system employing QSFP/QSFP+ ports.

25 [0018] Figure 14 is a block diagram illustrating another example of a modular fiber optic tap system employing QSFP/QSFP+ ports.

Detailed Description

[0019] In the following Detailed Description, reference is made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. In this regard, directional
5 terminology, such as top, bottom, front, back, etc., is used with reference to the orientation of the Figure(s) being described. Because components of embodiments can be positioned in a number of different orientations, the directional terminology is used for purposes of illustration and is in no way limiting. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope
10 of the present invention. The following detailed description, therefore, is not to be taken in a limiting sense.

[0020] Typically, passive optical splitters and couplers are used to insert a “tap” into an optical link. Passive splitters, however, can contribute considerable insertion loss into an optical link. This reduces the overall length that can be supported, which can handicap
15 multi-mode applications. Since the operational range of optical devices used in high speed optical links (in terms of transmit power and receiver sensitivity as defined by standard specifications) is very wide, additional insertion loss may cause the overall system to operate on a marginal basis, or even not at all. Also, since the same types of optical transceivers are often used to monitor the tapped optical signals, the tapped optical signal
20 must have a power level that is within range of the receiver sensitivity range of the optical signal. The result is that a user must define performance criteria and pick devices that will work in the application.

[0021] Figure 1 is a block diagram conceptually illustrating an example of a fiber optic tap system 100 in accordance with aspects of the present disclosure. The illustrated fiber optic tap 100 includes a first receiver module 110 having an input port 112 configured to receive
25 an optical fiber. The first receiver module 110 is operable to convert a received optical signal to an electrical signal. A first transmitter module 120 is coupled to receive an electrical signal from the first receiver module 110, and is operable to convert the received electrical signal to an optical signal. The first transmitter module has an output port 122
30 for receiving an optical fiber and outputting the optical signal thereto. A tap module 130 is also coupled to receive an electrical signal from the first receiver module 122.

[0022] In the illustrated example, the primary optical data channel is indicated by an arrow 102, showing the primary flow of data from the first receiver module 110 to the first transmitter module 120. It is sometimes desired to “copy” or “tap” the data being transported in the optical channel 102. This copied data is then used for traffic analysis and other maintenance purposes. The tap module 130 provides this function, receiving the converted electrical signal from the first receiver module 110 so that the signal flowing through the primary channel 102 can be provided via an output port 132 of the tap module 130 for traffic analysis, for example.

[0023] Rather than passively split a portion of the optical signal from the primary optical channel 102, the first receiver module 110 converts the received optical signal to an electrical signal. The signal for the primary path 102 is converted from an electrical signal back to an optical signal by the first transmitter module 120, allowing the signal to continue in the primary optical path 102. In some examples, the tap module 130 also converts the received electrical signal to an optical signal, which can be transmitted to a switch device for analysis of the signal, for example. In other embodiments, the electrical signal from the first receiver module 110 is transmitted from the tap module via an electrical conductor for analysis. The logic used to accomplish the splitting or “copying” of data is accomplished using a transceiver/driver arrangement with and without programmable logic in some examples.

[0024] Figure 2 illustrates further aspects of an example optical system 200 employing the fiber optic tap system 100. In Figure 2, the primary optical path is indicated by an arrow 202. The primary optical path 202 provides a two-way data path between first and second switching devices 210, 220, for example. In other implementations, the primary fiber optic path 202 could be between different types of network devices.

[0025] Since the fiber optic path 202 provides two-way data flow, two of the fiber optic tap systems 100 (labeled as 100a, 100b in Figure 2) shown in Figure 1 are employed to tap or copy data flowing in both directions indicated by the arrow 202. Thus, optical signals flowing out of the first switch 210 (left to right as depicted in Figure 1) via optical fibers are received at an input of the first receiver module 110a of the first optical tap system 100a. The first receiver module 110a converts the received optical signal to an electrical signal, which is then split into two output signals. One output signal is sent to a first transmitter module 120a, which converts the electrical signal output by the first receiver

module 110a to an optical signal. The optical signal is then output from the first transmitter module 120a to the second switch 220. The second electrical signal output by the first receiver module 110a, which is the tapped signal, is provided to a third switch 230.

5 [0026] Optical signals flowing from the second switch 220 to the first switch 210 (right to left as depicted in Figure 2) are received by the second receiver module 110b. The second receiver module 110b converts the received optical signal to an electrical signal, which is split into two output signals. One output signal is sent to the second transmitter module 120b, which converts the electrical signal output by the second receiver module 110b to an
10 optical signal. The optical signal is then output from the second transmitter module 120b to the first switch 210. The second electrical signal output by the second receiver module 110b, which is the tapped signal, is provided to the third switch 230. In some embodiments, first and second tap modules 130a, 130b receive the electrical signals output by the first and second receiver modules 110a, 110b, respectively, and convert the
15 electrical signals to optical signals that are output to the third switch 230.

[0027] In one example, the receiver and transmitter modules 110, 120, as well as the tap modules 130 are mounted on a printed circuit board (PCB). Figure 3 illustrates such a PCB mounted tap system 300, in which the transmit, receive and tap modules 310, 320, 330 include PCB mountable adapters (LC adapters, for example) that are equipped with a
20 Transmit Optical Sub-Assembly (TOSA) or Receiver Optical Sub-Assembly (ROSA) and a transceiver chip (XRC). Thus, the first and second receiver modules 310a, 310b each include a ROSA that converts the received optical signal to an electrical signal. The electrical signal is routed to the transmitter modules 320a, 320b and the tap modules 330a, 330b, which each include a TOSA that converts the received electrical signals to optical
25 signals using a Vertical-Cavity Surface-Emitting laser (VCSEL), Fabry-Perot (FP), Distributed Feedback Laser (DFB), or Multiple Quantum Well Laser arrangement. The modules are all mounted to a PCB 302, and the signals are routed between the various modules using conductive traces disposed in or on the PCB 302.

[0028] In Figure 3, the optical signal is received by the ROSA which consists of a
30 positive-intrinsic-negative diode (PIN) and a transimpedance amplifier (TIA). The PIN detects the optical signal and the changes in modulation (usually ON-OFF KEYING or "OOK") that cause the impedance of the PIN to change. These impedance changes cause a

change in the current flow through the PIN. These changes in current are measured by the TIA and converted into a usable output voltage signal. The output of the ROSA is analog so the XRC is required to convert the analog signals into digital signals and into current-mode logic (CML) signaling. In this format, the signal can be directed and otherwise manipulated with minimal concern over noise, latency, and signal degradation.

[0029] CML signaling is a logic level signaling format that can be fanned out (e.g., copied) to two parallel devices such as the XCR used to drive a VCSEL or FP laser diode in a TOSA assembly. A Line Driver/Receiver or 1:2 CML Fanout buffer may be required to serve as a buffer interface between the output of the ROSA XCR and the TOSA XCR input. The TOSA and ROSA assemblies also incorporate the XCR and are interchangeable to accommodate multi-mode to single mode media conversion.

[0030] The PCB mounted system 300 is generally low cost and compact. In some implementations, a connection point identification (CPID) device is integrated into the LC adapters of the ROSA and TOSA modules 310, 320, 330 to provide network management and monitoring capabilities, among other things. In such embodiments, a processor 304 monitors the CPID lines that are on each optical port for managed connectivity support. It also utilizes an I2C buss which is interconnected to all of the XCR devices so the processor 304 can access real time operational information about each ROSA and TOSA. The processor 304 can be a slave to a master processor in a multi-splitter chassis configuration in which the master provides a web server or REST interface to enable remote data collection. In single splitter applications the processor provides a web server interface for remote access. The web server enables a user to access operational data about the splitter using any HTML web browser on a workstation or mobile device. No special application is required.

[0031] Other embodiments employ small form-factor pluggable (SFP) and/or enhanced small form-factor pluggable (SFP+) transceivers. SFP and SFP+ are compact, hot-pluggable transceivers used for both telecommunication and data communications applications. These devices interface a network device (switch, router, media converter, etc.) to a fiber optic or copper networking cable. Figure 4 illustrates an example of a modular tap system 400 in accordance with disclosed embodiments. An SFP/SFP+ module 410 is configured to receive an optical plug 402 such as an LC duplex optical

plug, which is connected to an optical cable 404. The module 410 is received by an SFP/SFP+ connector 408 of a host device such as a switch or router.

[0032] Figures 5-7 illustrate further aspects of the example module 410. The module 410 includes a lower shell 412 and an upper shell 414 that together form an enclosure 420.

5 The enclosure 420 is fabricated using die cast or aluminum in some embodiments. ROSA and TOSA devices 430, 432 provide the optical interface. The ROSA 430 and TOSA 432 are received in the enclosure 420 and are mounted on a main PCB 422, which has conductive traces configured to connect the ROSA 430 and TOSA 432 to contacts 424, which electrically connect the module 410 to the host device connector 408. In the
10 illustrated embodiment, a CPID device 440 is also situated in the enclosure 420. The CPID device 440 includes a CPID PCB 442 on which CPID components are mounted, such as a retainer 444, an LED 446 and contacts 448 that engage a CPID chip 450 on the fiber optic connector 402. An EMI skirt 452 is positioned around the enclosure 420.

[0033] Figure 8 illustrates an example data flow in a system using embodiments of the
15 modular tap system 400. A primary data through path 460 is shown in the upper portion of the diagram, where data would flow between two switching devices, for example. LC duplex optical plugs 402 connect optical cables 404 to the modules 410, which are labeled 410a, 410b, 410c and 410d in Figure 8. Typical implementations could include many such modules. Data flows from the module 410a to module 410b at a first wavelength λ_1 and
20 from the module 410b to the module 410a at a second wavelength λ_2 . As noted above, the modules 410 include transceivers that convert received optical signals to electrical signals. A logic matrix 462 provides an electrical interface between the modules 410, routing the electrical signals output by the modules 410 as desired. In the example shown in Figure 8, the electrical signals from the module 410a are also routed to the module 410c by the logic
25 matrix 462, where the electrical signals are converted to optical signals. The module 410c thus provides tapped signals from the module 410a of the left to right through path 460 to tap ports for data monitoring and analysis, for example. Copied or tapped signals from the right to left flow path are routed from the module 410b to the module 410d via the logic matrix 462, which converts the electrical signals to optic signals.

30 [0034] In some examples, SFP twin axial cables (e.g., copper cables) are used for short tap links. Figure 9 illustrates such an embodiment, where twin axial cables 474 are connected

to SFP/SFP+ ports 470 via twin axial cable interfaces 472. Thus, tapped signals are routed from the modules 410a and 410b to the SFP/SFP+ ports 470.

[0035] Examples of the modular system 400 support media conversion, allowing multi-node to multi-mode, multi-node to single-mode, multi-mode to SFP twin axial (copper), single-mode to SFP twin axial (copper), etc. As noted above, some disclosed
5 embodiments include CPID devices including microcontrollers, allowing the system to be queried for real time information such as launch power and received power, and accessing the system to enable or disable a main or tap link, for example.

[0036] Figure 10 illustrates an example where bi-directional (BiDi) communications using
10 40 Gb/s aggregate bandwidth between two network elements using multi-mode optical fiber is provided. This accomplished by using two bi-directional 20 Gb/s channels 510,512. Each optical channel operates over a single multi-mode optical fiber 514 using respective wavelengths λ_1 and λ_2 . Some typical BiDi devices use a transceiver in a quad (4-channel) small form-factor pluggable (QSFP/QSFP+) footprint, but the optical interface
15 is a standard optical connector such as a duplex LC connector. Each LC port operates at 10 Gb/s bi-directional for a total of 20 Gb/s per fiber (or LC port). This provides an aggregate of 40 Gb/s for the entire transceiver.

[0037] Figure 11 illustrates a system 520 using QSFP modules. The primary data path is between a first switch 610 and a second switch 620. A third switch 630 receives tapped
20 signals via QSFP ports 632. The QSFP ports 632 of the third switch 630 are used only to receive the tapped signals. As described above, the system 600 provides BiDi communications using 40 Gb/s aggregate bandwidth between network devices such as the first switch 610 and the second switch 620 using multi-mode optical fiber over two bi-directional 20 Gb/s channels 510,512. The optical channels 510,512 each operate over a
25 single multi-mode optical fibers 514 using respective wavelengths λ_1 and λ_2 . A tap coupler 640 receives optical signals from the optical channels 510,512 and couples a portion of the energy from the optical channels to tap ports 642, which are connected to the QSFP ports 632 of the third switch 630. Figure 12 conceptually illustrates the tap
coupler 640, wherein the bi-directional signals from each of the optical channels 510, 512
30 are routed to respective output tap ports 642 for the first and second wavelengths λ_1 and λ_2 .

[0038] Figure 13 illustrates another example system 700 in which the modular active tap modules 410 include QSFP ports to provide BiDi communications using 40 Gb/s aggregate bandwidth. The primary data through path 760 is shown in the upper portion of the diagram, where data would flow between two switching devices, for example. LC duplex optical plugs 402 connect optical cables 404 to a plurality of active modules 710. The modules 710a, 710b, 710c and 710d are similar to the modules 410 shown in Figures 4-7, though the modules 710 include QSFP/QSFP+ transceivers rather than SFP/SFP+ transceivers. Bi-directional data flows through each optical cable 404 in the primary through path 760 at a first wavelength λ_1 for left to right data flow and at a second wavelength λ_2 for right to left data flow. The modules 710 include transceivers that convert received optical signals to electrical signals, and the logic matrix 462 provides the electrical interface between the modules 710 so that the digital data signals between the modules 710a, 710b can be coupled and copied to other transceivers such as those used for tap modules 710c, 710d. The modules 710c, 710d convert the electrical signals to optical signals which are then routed to a monitor system, for example.

[0039] Figure 14 illustrates an example in which an electrical interface (copper) is provided for the TAP ports using a data grade twin-axial cable 774 to connect the tapped signals to the monitor system. This reduces the number of modules 710 required in implementations where the distance between the monitor system and the modules 710 is relatively short (7 meters or less, for example). The twin axial cables 774 are connected to QSFP/QSFP+ ports 770 via twin axial cable interfaces 772. Thus, tapped signals are routed from the modules 710a and 710b to the QFP/QSFP+ ports 770 via the logic matrix 462..

[0040] As with the embodiment shown in Figure 9, the modular system 700 supports media conversion, allowing multi-node to multi-mode, multi-node to single-mode, multi-mode to QSFP twin axial (copper), single-mode to QSFP twin axial (copper), etc. Embodiments of the system 700 also may include CPID devices including microcontrollers, allowing the system to be queried for real time information such as launch power and received power, and accessing the system to enable or disable a main or tap link, for example.

[0041] The examples shown in Figures 8, 9, 13 and 14 include an active splitter arrangement in which multi-source agreement (MSA) standard devices such as an SFP,

SFP+, QSFP, and QSFP40G are used as the optical interface. The output or host side of the MSA devices are already in a CML signaling format. In some implementations, the illustrated logic matrix 462 is equipped with high speed CML transceivers, a programmable logic matrix, and a MIPS or ARM9 processor core (CPU). The
5 programmable logic is used to route and copy the data to and from the MSA devices. The CPU initially sets up the programmable logic which can be changed at any time to accommodate network requirements. An example is the ability to switch traffic from one link to another in the event there is a link failure. The host side of the QSFP or QSFP40G is essentially four lanes of 10 Gb/s SFP traffic, therefore the logic matrix 462 supports and
10 routes four lanes per device. Thus, the splitter can also support a quad SFP to single QSFP aggregation by using the logic matrix to route the four inputs to a single device.

[0042] The CPU utilizes an I2C buss interconnected to all of the MSA devices so the CPU can access the MSA tables in each MSA device, real time operational information, and CPID information that can be equipped on each MSA optical device for managed
15 connectivity support. The CPU provides a web server interface for remote access. The web server enables a user to access operational data about the splitter using any HTML web browser on a workstation or mobile device. No special application is required.

[0043] As noted above, the embodiments shown in Figures 8 and 9 support the use of copper twin axial cable for short link SFP interconnection, and the embodiments shown in
20 Figures 13 and 14 support the use of copper twin axial cable for short link QSFP interconnection. This, in conjunction with the flexibility of the logic matrix, allows the SFP or QSFP active splitter to be used as a top of rack switch.

[0044] Various modifications and alterations of this disclosure may become apparent to those skilled in the art without departing from the scope and spirit of this disclosure, and it
25 should be understood that the scope of this disclosure is not to be unduly limited to the illustrative examples set forth herein.

What is claimed is:

1. A fiber optic tap system, comprising:
 - a first receiver module having an input port configured to receive an optical fiber, the first receiver module being operable to convert a received optical signal to an electrical signal;
 - a first transmitter module coupled to receive the electrical signal from the first receiver module, the first transmitter module being operable to convert the received electrical signal to an optical signal, the first transmitter module having an output port for receiving an optical fiber and outputting the optical signal thereto; and
 - a first tap module coupled to receive the electrical signal from the first receiver module.
2. The fiber optic tap system of claim 1, wherein the tap module is operable to convert the received electrical signal to an optical signal, the second transmitter module having an output port for receiving an optical fiber and outputting the optical signal thereto.
3. The fiber optic tap system of claim 1, wherein the tap module includes an output port for outputting the electrical signal.
4. The fiber optic tap system of claim 1, further comprising:
 - a first switch connected to the first receiver module via a first optical fiber;
 - a second switch connected to the first transmitter module via a second optical fiber;
 - and
 - a third switch connected to the first tap module.
5. The fiber optic tap system of claim 4, wherein the tap module includes an output port for outputting the electrical signal, and wherein the third switch is connected to the output port of the tap module via an electrical conductor.
6. The fiber optic tap system of claim 4, further comprising:

a second receiver module having an input port receiving a third optical fiber, the third optical fiber connecting the second switch to the second receiver module, the second receiver module being operable to convert a received optical signal to an electrical signal;

a second transmitter module coupled to receive an electrical signal from the second receiver module, the second transmitter module being operable to convert the received electrical signal to an optical signal, the second transmitter module having an output port receiving a fourth optical fiber, the fourth optical fiber connecting the first switch to the second transmitter module;

and

a second tap module coupled to receive an electrical signal from the second receiver module, the second tap module being connected to the third switch.

7. The fiber optic tap system of claim 1, wherein the first receiver module, the first transmitter modules and the tap module are mounted on a printed circuit board.

8. The fiber optic tap system of claim 1, wherein the input port and the output port each include an LC adapter.

9. The fiber optic tap system of claim 1, wherein the first receiver module and the first transmitter module include small form-factor pluggable ports.

10. The fiber optic tap system of claim 1, wherein the first tap module includes a small form-factor pluggable port.

11. The fiber optic tap system of claim 1, wherein the first receiver module and the first transmitter module include quad small form-factor pluggable ports.

12. The fiber optic tap system of claim 1, wherein the first tap module includes a quad small form-factor pluggable port.

13. The fiber optic tap system of claim 4, wherein the first receiver module receives optical signals defining a first wavelength and the first transmitter module

transmits optical signals defining the first wavelength, and wherein the second receiver module receives optical signals defining a second wavelength and the second transmitter module transmits optical signals defining the second wavelength.

14. The fiber optic tap system of claim 4, wherein the first receiver module receives optical signals defining first and second wavelengths and the first transmitter module transmits optical signals defining the first and second wavelengths, and wherein the second receiver module receives optical signals defining the first and second wavelengths and the second transmitter module transmits optical signals defining the first and second wavelengths.

15. A method of tapping a signal from a fiber optic system, comprising:
receiving a first optical signal by a first receiver module;
converting the received first optical signal to a first electrical signal by the first receiver module;
transmitting the first electrical signal from the first receiver module to a first transmitter module;
converting the received first electrical signal to the first optical signal by the first transmitter module; and
transmitting the electrical signal from the first receiver module to a first tap module.

16. The method of claim 15, further comprising converting the received electrical signal to the first optical signal by the first tap module.

17. The method of claim 15, further comprising transmitting the received electrical signal to a switch device by the first tap module.

18. The method of claim 16, further comprising transmitting the converted optical signal to a switch device by the first tap module.

19. The method of claim 15, wherein the first receiver module receives optical signals defining first and second wavelengths, and wherein the first transmitter module transmits optical signals defining the first and second wavelengths.

20. The method of claim 15, wherein the first receiver module receives the first optical signal from a first switch and the first transmitter module transmits the first optical signal to a second switch, and wherein the method further comprises:

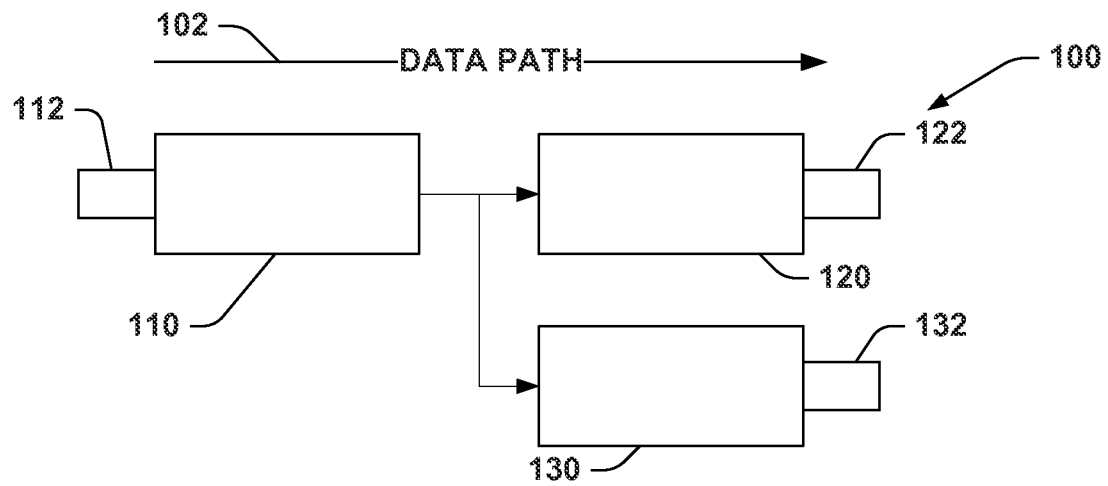
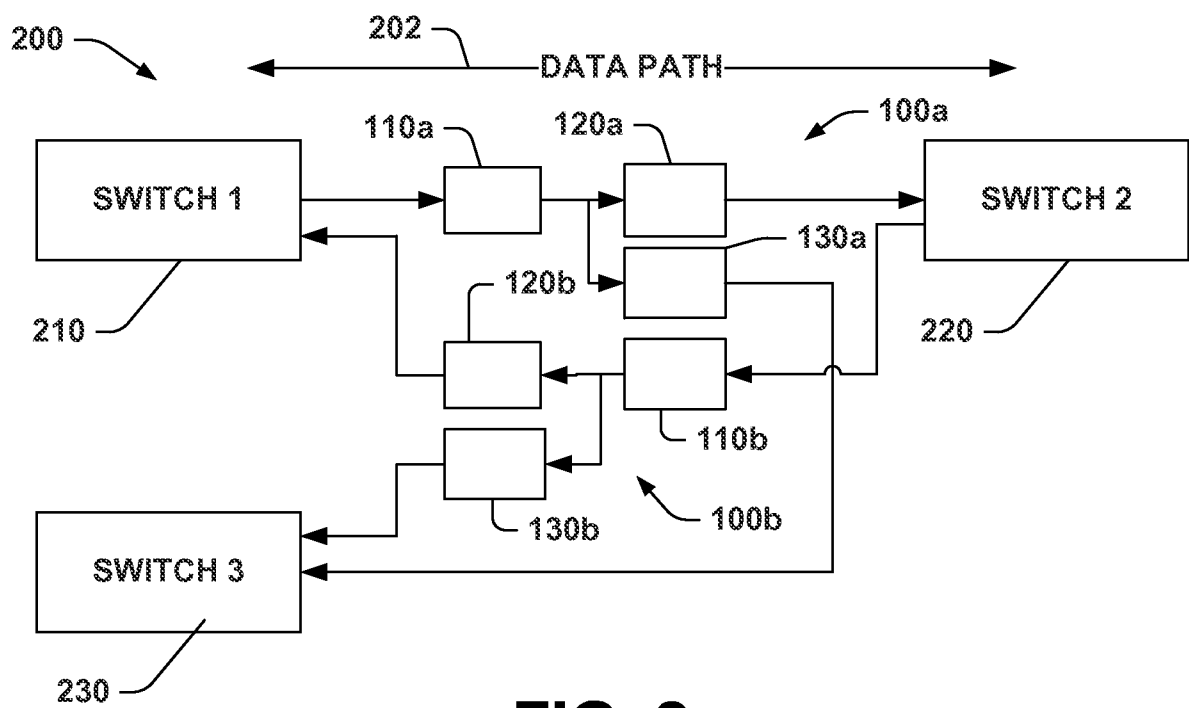
receiving a second optical signal from the second switch by a second receiver module;

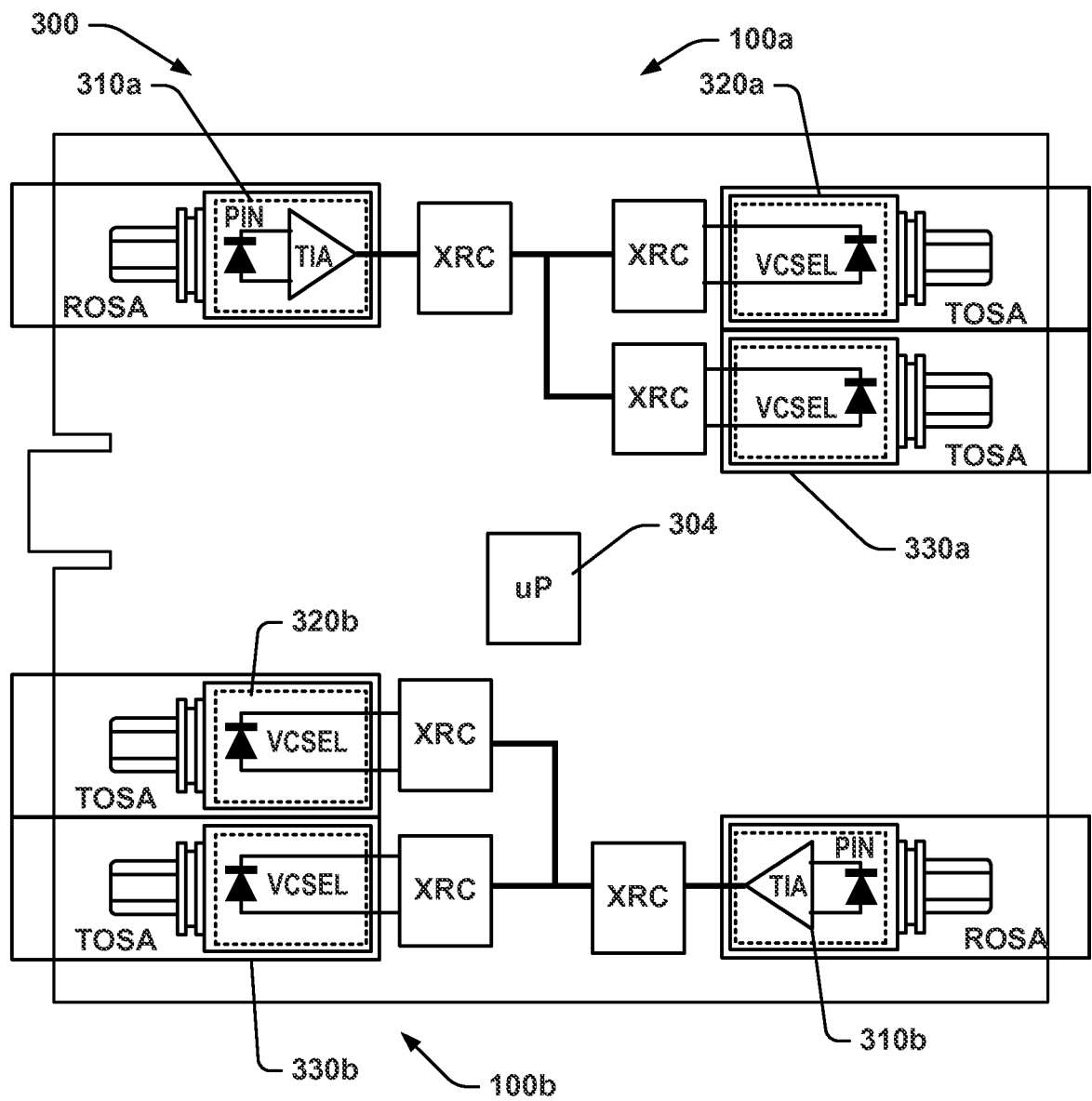
converting the received second optical signal to a second electrical signal by the second receiver module;

transmitting the second electrical signal from the second receiver module to a second transmitter module;

converting the received second electrical signal to the second optical signal by the second transmitter module; and

transmitting the second electrical signal from the second receiver module to a second tap module.

**FIG. 1****FIG. 2**

**FIG. 3**

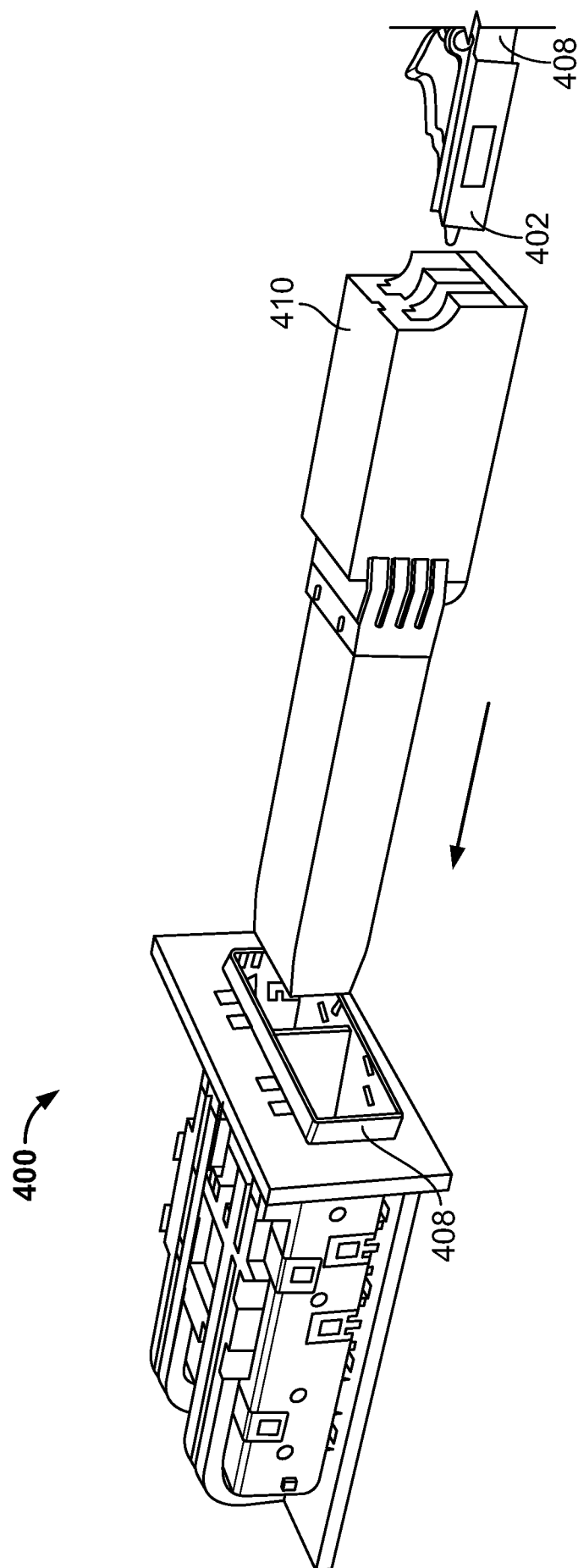


FIG. 4

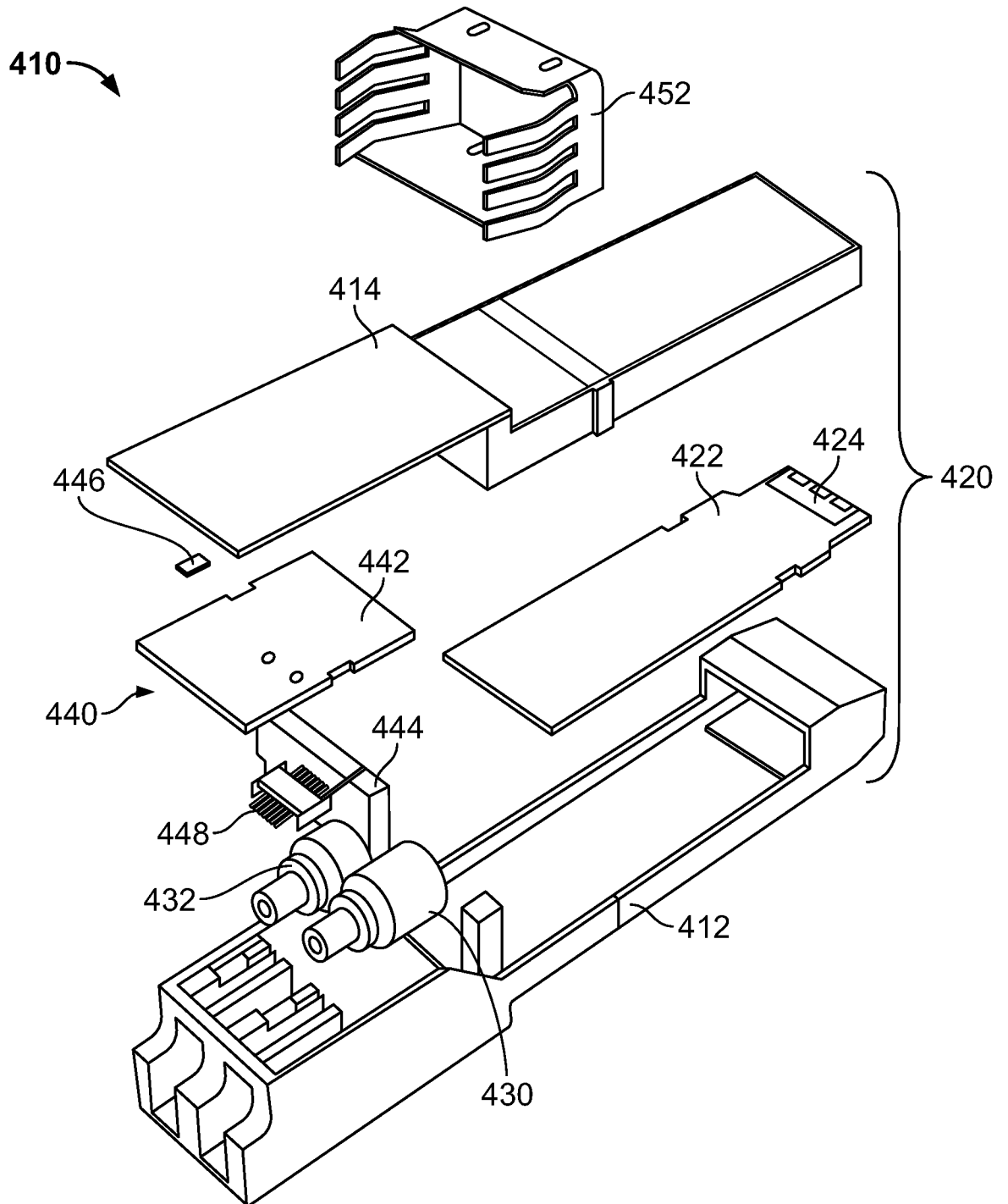


FIG. 5

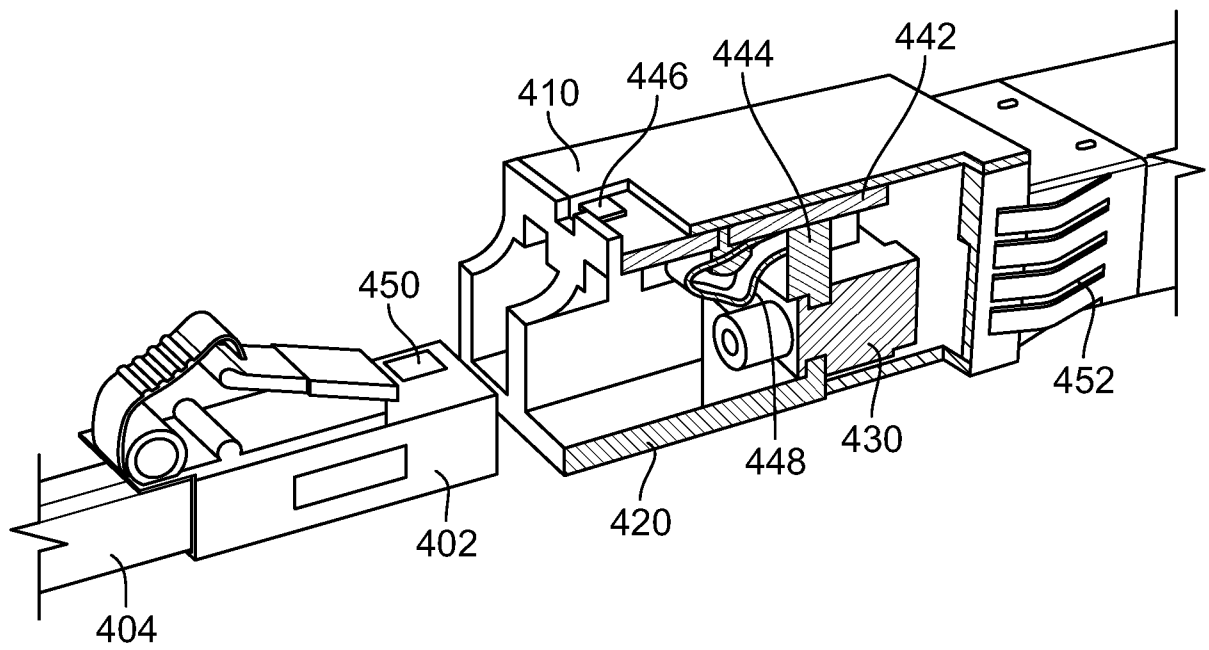


FIG. 6

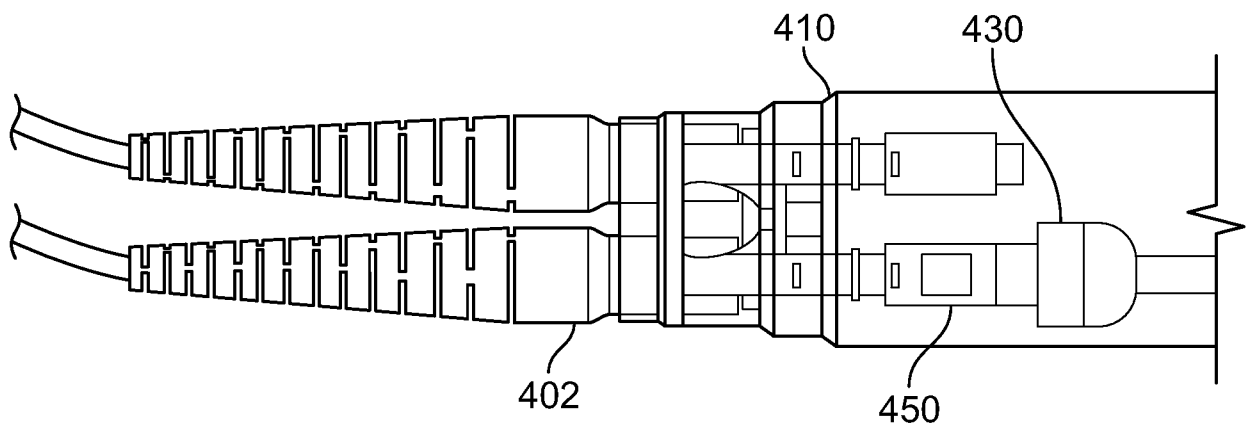


FIG. 7

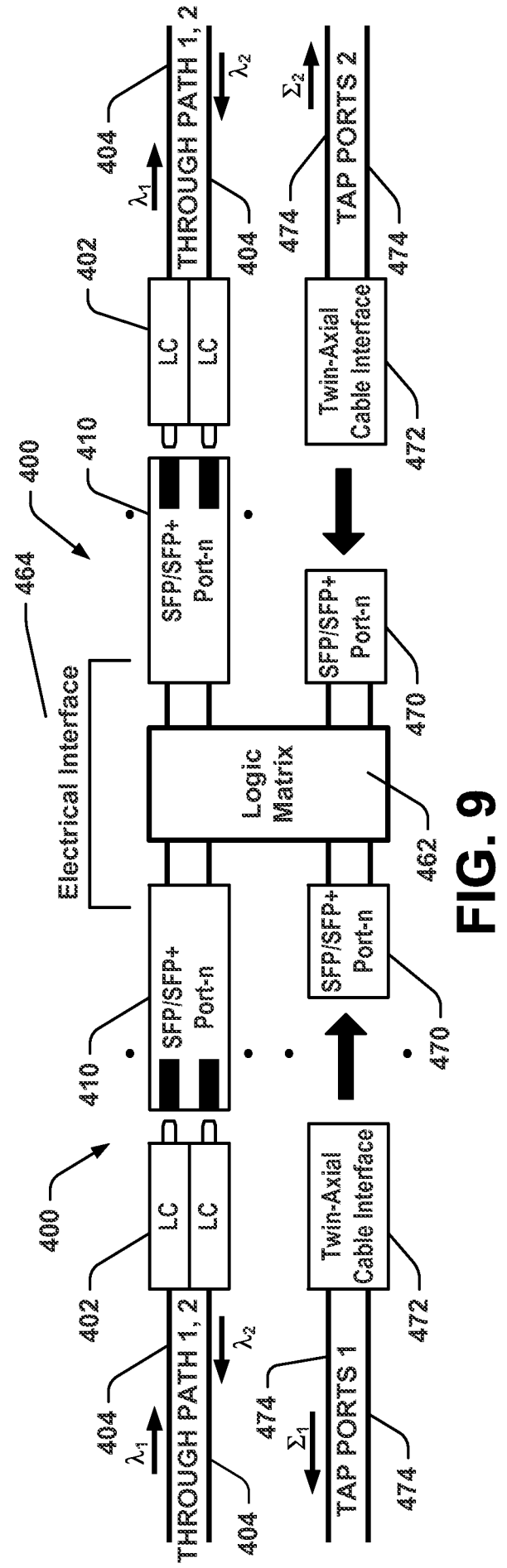
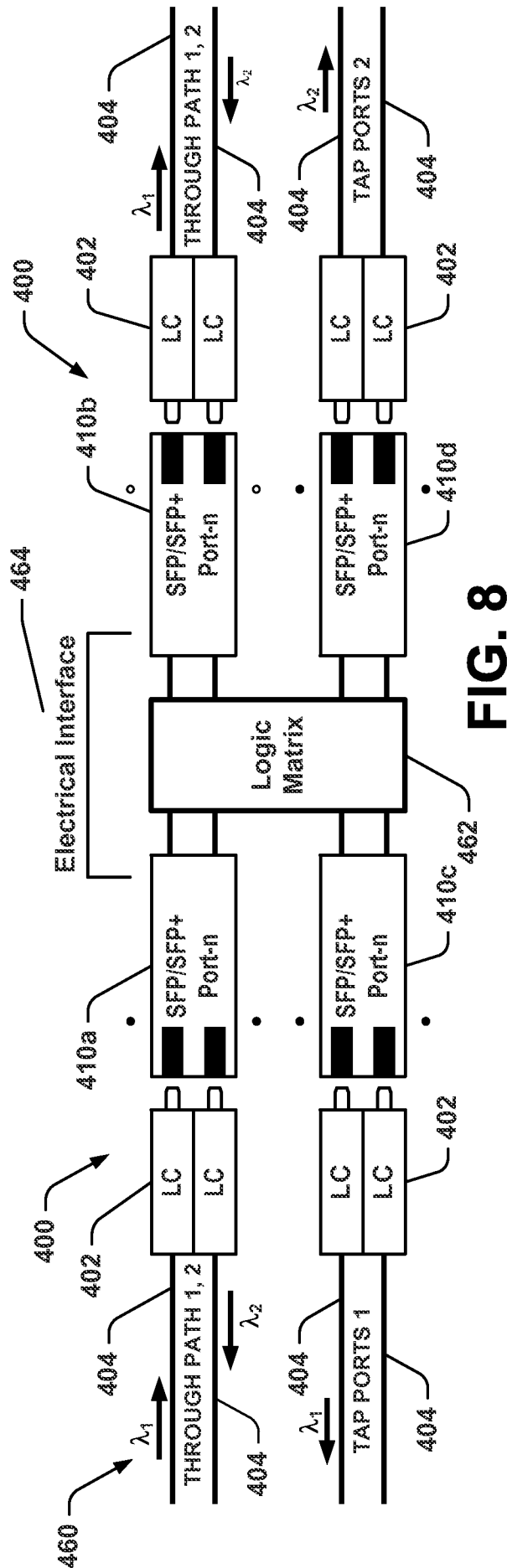
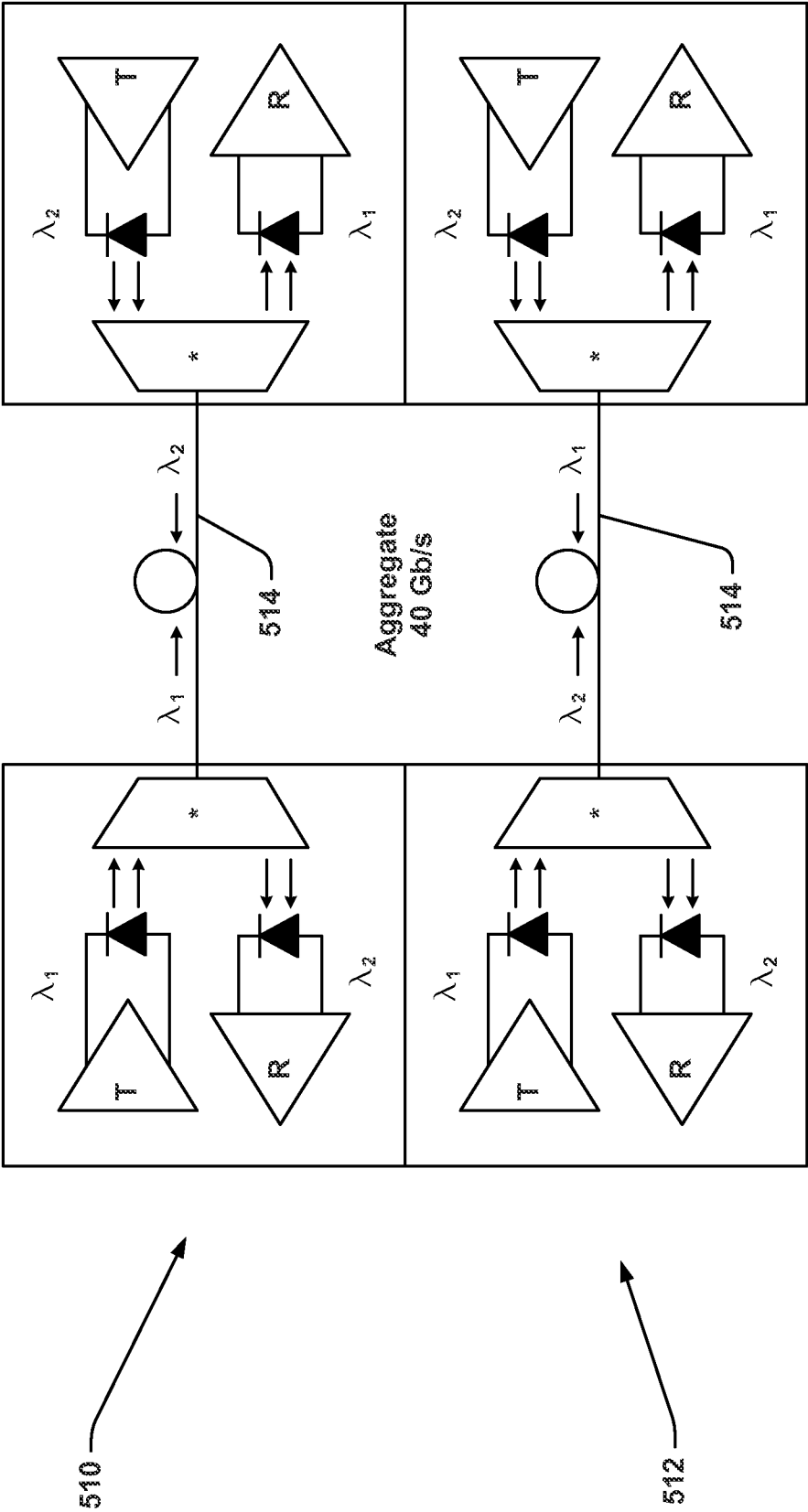


FIG. 10



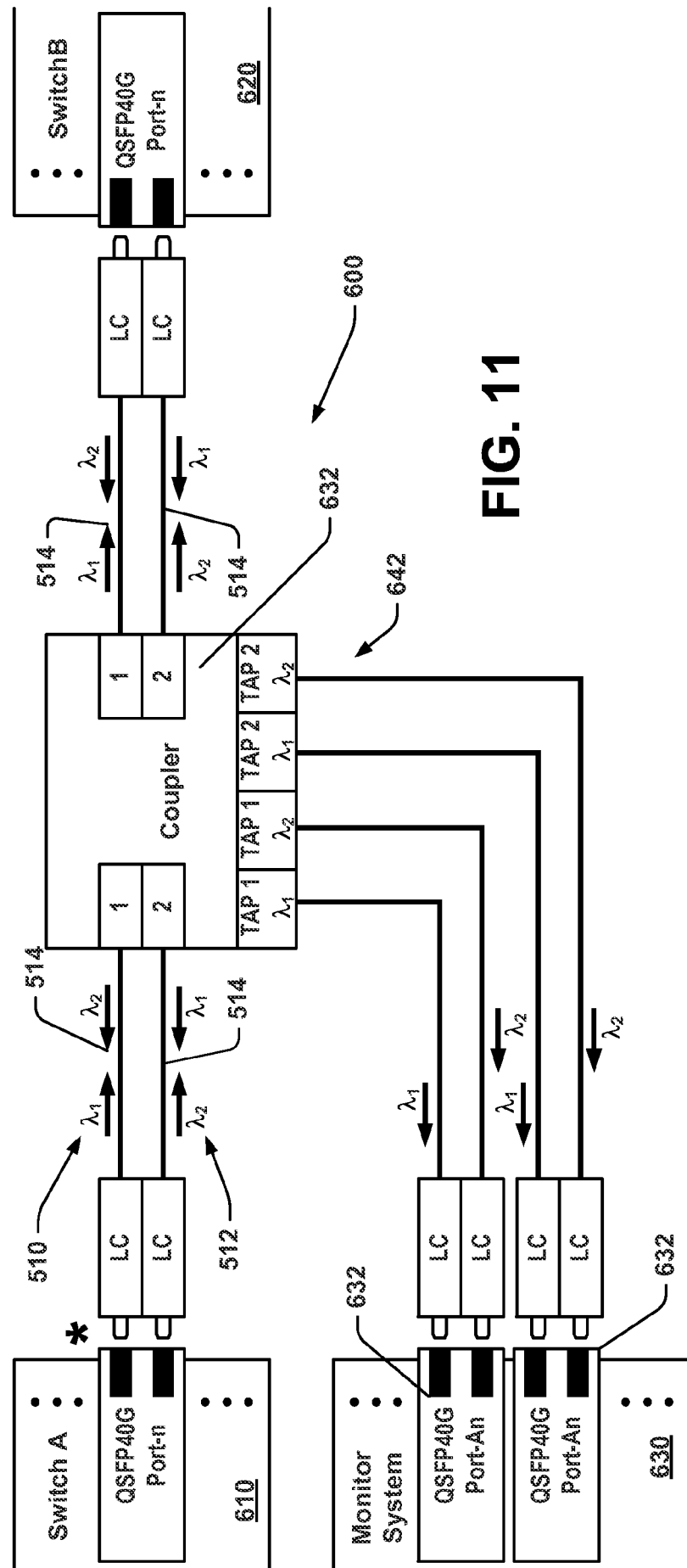
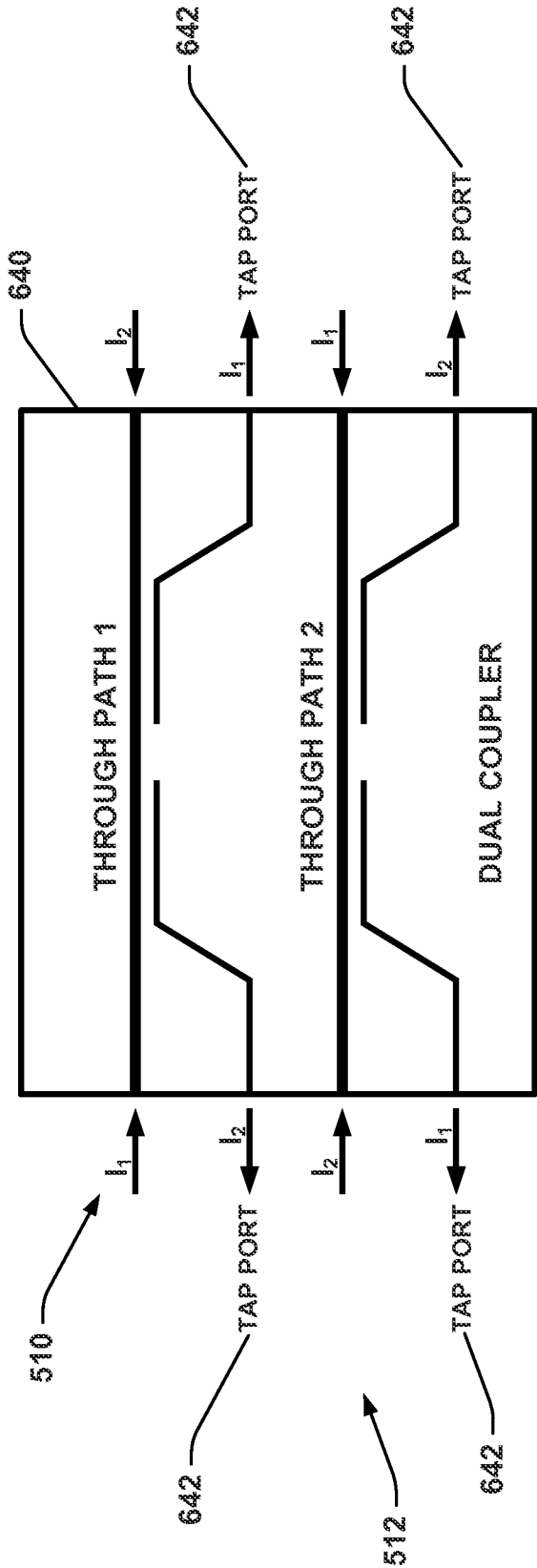


FIG. 12



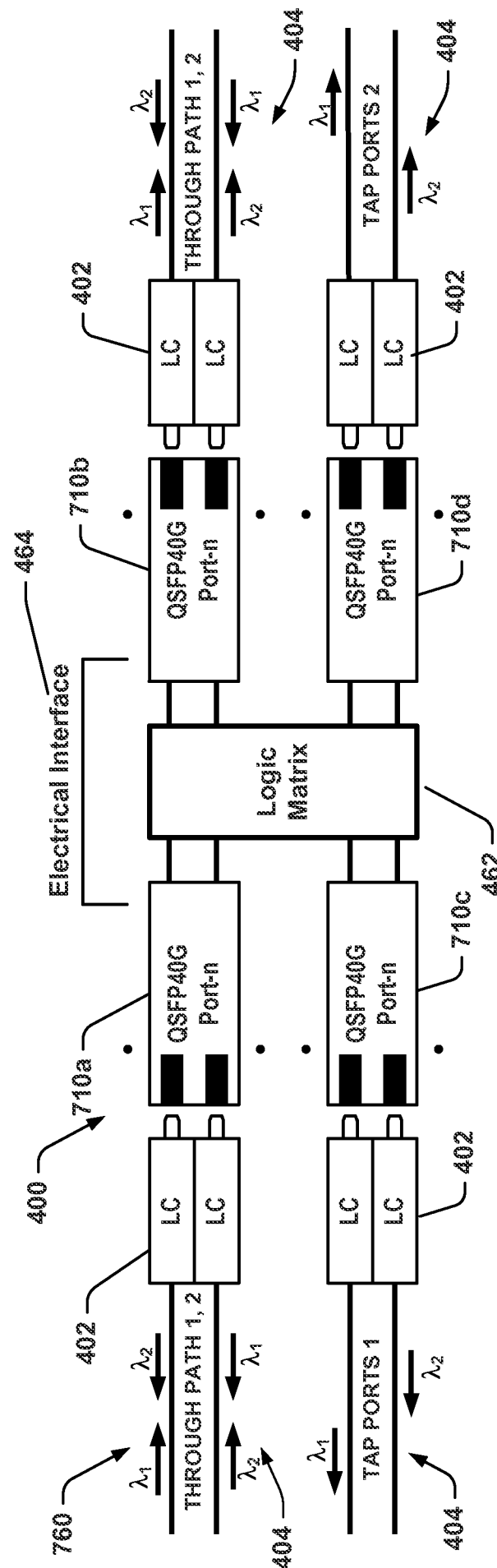


FIG. 13

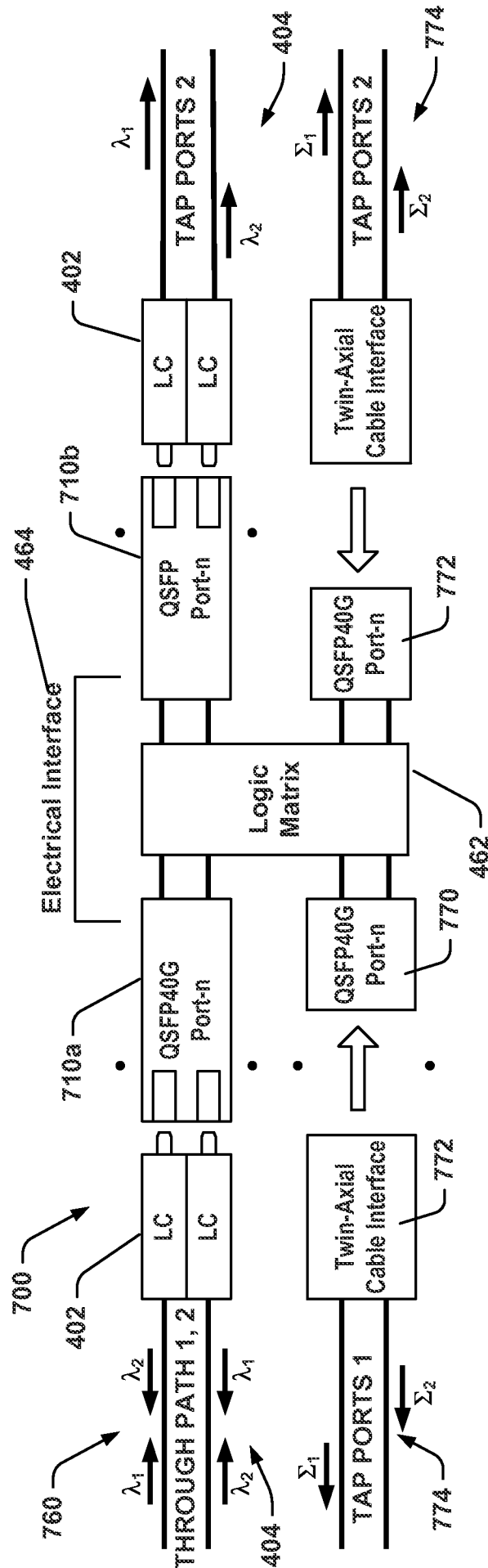


FIG. 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/023545**A. CLASSIFICATION OF SUBJECT MATTER****G02B 27/10(2006.01)i**

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

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
G02B 27/10; H01S 3/067; G02B 6/38; G06F 1/26; G06F 1/32; H04B 10/04; G02B 6/00; H01S 3/08Documentation 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 modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords:optical signal, electrical signal, module, tap module, convert**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2012-0191997 A1 (MILLER) 26 July 2012 See claims 1, 11.	1-20
Y	US 2004-0223769 A1 (HOSHIDA) 11 November 2004 See claims 3, 13.	1-20
Y	US 2014-0023312 A1 (SHANG et al.) 23 January 2014 See claim 1.	4-7, 13-14
Y	US 2013-0279856 A1 (BODUCH et al.) 24 October 2013 See paragraphs [0027]-[0030].	9-12
A	KR 10-2013-0009134 A (LUXPERT TECHNOLOGIES CO., LTD.) 23 January 2013 See claim 1 and figure 1.	1-20

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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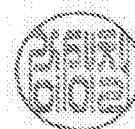
Date of the actual completion of the international search
29 June 2015 (29.06.2015)Date of mailing of the international search report
30 June 2015 (30.06.2015)

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/023545

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