US 20060002704A1

(19) **United States**
(12) **Patent Application Publication**
Jasti

(10) **Pub. No.: US 2006/0002704 A1**
(43) **Pub. Date: Jan. 5, 2006**

(54) **OPTICAL SWITCH HAVING AN AUTORESTORATION FEATURE FOR SWITCHING FROM A BACKUP OPTICAL PATH TO A PRIMARY OPTICAL PATH**

(76) Inventor: **Chandra Sekhar Jasti**, Cupertino, CA (US)

Correspondence Address:
GENERAL INSTRUMENT CORPORATION DBA THE CONNECTED HOME SOLUTIONS BUSINESS OF MOTOROLA, INC.
101 TOURNAMENT DRIVE
HORSHAM, PA 19044 (US)

(21) Appl. No.: **11/214,535**

(22) Filed: **Aug. 29, 2005**

Related U.S. Application Data

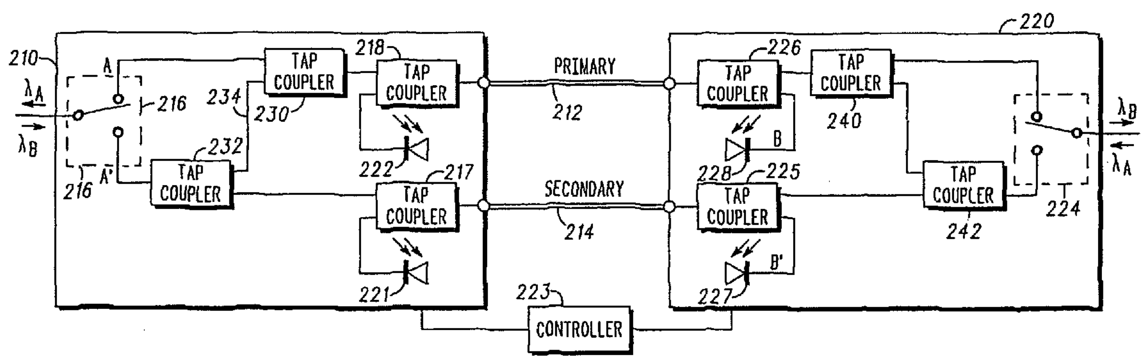
(62) Division of application No. 10/364,825, filed on Feb. 11, 2003, now Pat. No. 6,944,362.

Publication Classification

(51) **Int. Cl.**
H04B 10/08 (2006.01)
(52) **U.S. Cl.** **398/12**

(57) **ABSTRACT**

Optical switches are provided in an optical transmission system having at least two optical nodes in optical communication over a primary optical path and a backup optical path. An optical switch is located in each of the optical nodes. Each of the optical switches includes a switching element having an input port and a plurality of output ports coupled to the primary and backup optical paths, respectively. The switching element has a first state optically coupling an optical signal from the input port to the primary path and a second state optically coupling an optical signal from the input port to the backup path. First and second optical taps are located in the primary optical path. Third and fourth optical taps are located in the backup optical path. A first photodetector is optically coupled to the second optical tap for receiving a portion of the optical signal traveling in the primary optical path. A second photodetector is optically coupled to the third optical tap for receiving a portion of the optical signal traveling in the secondary optical path. A first optical path optically couples the first optical tap to the fourth optical tap such that a portion of an optical signal traveling in the secondary path is coupled onto the primary path. Finally, a controller is electrically coupled to each of the optical switches. The controller is configured so that when each of the switching elements are in the second state and the first photodetector in each of the optical switches detects an optical signal, the controller returns the switching elements to the first state.



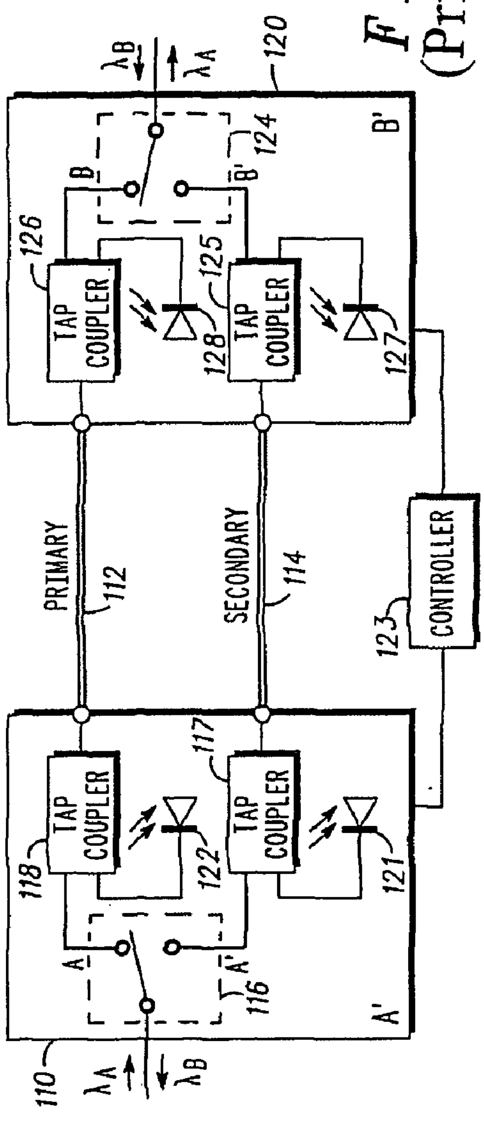


FIG. 1 (Prior Art)

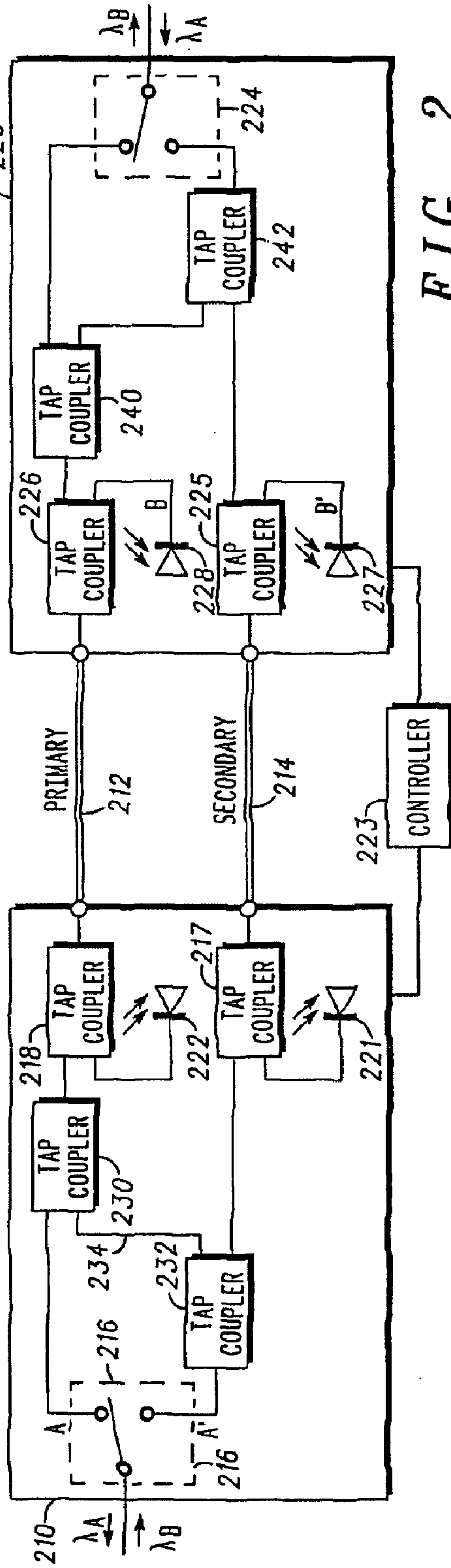


FIG. 2

OPTICAL SWITCH HAVING AN AUTORESTORATION FEATURE FOR SWITCHING FROM A BACKUP OPTICAL PATH TO A PRIMARY OPTICAL PATH

[0001] This is a divisional application of U.S. application Ser. No. 10/364,825 filed on Feb. 11, 2003.

FIELD OF THE INVENTION

[0002] The present invention relates generally to optical switches, and more particularly to an optical switch that restores optical traffic from a secondary optical transmission path to a primary optical transmission path after a fault in the primary optical transmission path has been repaired.

BACKGROUND OF THE INVENTION

[0003] Currently, transmission systems employed in the cable television (CATV) industry provide two-way transmission of information; e.g., video, audio, multimedia and/or data; between a head end and a plurality of subscribers. Typically, the head end transmits the information destined for individual subscribers ("downstream information") in an optical format, via one or more fiber optic links, to one or more optical nodes. Each node converts the optically-formatted downstream information into electrical signals for distribution, typically via a coaxial cable plant having a tree and branch architecture, to individual subscribers. In addition to receiving the downstream information, each individual subscriber may generate information in the form of voice, video, data, or any combination thereof, destined for the bead end. The subscriber- generated information ("upstream information") is aggregated by the coaxial cable plant and passes to the node for conversion into an optical format for transmission to the head end.

[0004] CATV service providers and their subscribers are accustomed to high reliability service. One way in which high reliability is achieved is by providing two optical paths between the head end and each optical node, one of which serves as a primary optical path and the other of which serves as a secondary or backup optical path. An optical switch switches the optical information signals from the primary path to the secondary path in the event of an unanticipated failure in the primary path. The optical switches are often located in the head end and the optical nodes.

[0005] The aforementioned optical switches generally employ an optomechanical switching component that switches between the primary path and the secondary path based on the electrical voltage that is applied to it. A portion of the optical signal in the primary and secondary paths is tapped off and converted to an electrical voltage. The voltages are monitored and if a threshold condition is violated, indicating a failure in the primary path, the switch is activated so that traffic is transferred to the secondary path. Unfortunately, the optical switch does not include any arrangement for switching back from the secondary to the primary path after the primary path has been restored. Rather, an operator or technician must perform a manual power cycle to restart the optical switches in both the head end and the optical node so that the switches return to the primary path. Restoration in this manner can be difficult because the head end and the optical node may be located 50 to 100 km apart from one another. Also, there may be many such optical switches in both the head end and the nodes, thus requiring the operator to take proper care to ensure that the correct combination of switches are power cycled so that there is no interference with traffic on the other paths.

[0006] Accordingly, it would be desirable to provide a method and apparatus for automatically restoring optical traffic from a secondary optical transmission path to a primary optical transmission path after a fault in the primary optical transmission path has been repaired without the need to perform a manual power cycle.

SUMMARY OF THE INVENTION

[0007] In accordance with the present invention, optical switches are provided in an optical transmission system having at least two optical nodes in optical communication over a primary optical path and a backup optical path. An optical switch is located in each of the optical nodes. Each of the optical switches includes a switching element having an input port and a plurality of output ports coupled to the primary and backup optical paths, respectively. The switching element has a first state optically coupling an optical signal from the input port to the primary path and a second state optically coupling an optical signal from the input port to the backup path. First and second optical taps are located in the primary optical path. Third and fourth optical taps are located in the backup optical path. A first photodetector is optically coupled to the second optical tap for receiving a portion of the optical signal traveling in the primary optical path. A second photodetector is optically coupled to the third optical tap for receiving a portion of the optical signal traveling in the secondary optical path. A first optical path optically couples the first optical tap to the fourth optical tap such that a portion of an optical signal traveling in the secondary path is coupled onto the primary path. Finally, a controller is electrically coupled to each of the optical switches. The controller is configured so that when each of the switching elements are in the second state and the first photodetector in each of the optical switches detects an optical signal, the controller returns the switching elements to the first state.

[0008] In accordance with one aspect of the invention, the two optical nodes respectively comprise a head end and an optical node in a CATV transmission system.

[0009] In accordance with another aspect of the invention, the switching element is an optomechanical switching element.

[0010] In accordance with yet another aspect of the invention, the first and second photodetectors are photodiodes.

[0011] In accordance with another aspect of the invention, the primary and secondary optical paths are unidirectional paths. Alternatively, the primary and secondary optical paths may be bi-directional paths.

[0012] In accordance with another aspect of the invention, a method is provided for switching optical traffic from a secondary optical path to a primary optical path, each of which establish an optical communication path between first and second optical nodes. The method begins by: detecting a presence or absence of an optical signal traveling in the primary path through the first optical node; detecting a presence or absence of an optical signal traveling in the primary path through the second optical node; detecting a presence or absence of an optical signal traveling in the secondary path through the first optical node; and detecting a presence or absence of an optical signal traveling in the secondary path through the second optical node. A portion of an optical signal traveling in the first optical node is coupled from the secondary path to the primary path. A switching element is switched in each of the first and second optical nodes from a second state to a first state so that the optical traffic traverses the primary optical path when an optical signal is detected traveling in the primary path through both the first and second optical nodes.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] **FIG. 1** shows a simplified block diagram of a conventional arrangement for providing a primary and second optical path between the head end and an optical node in a CATV transmission system.

[0014] **FIG. 2** shows a simplified block diagram of an arrangement for providing a primary and second optical path between the head end and an optical node in a CATV transmission system in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0015] **FIG. 1** shows a simplified block diagram of a conventional arrangement for providing a primary and second optical path between the head end and an optical node in a CATV transmission system. Optical switches **110** and **120** are located in the head end and the optical node, respectively. Optical transmission path **112** serves as the primary path while optical transmission path **114** serves as the secondary or backup optical path. Traffic along the primary path **112** and the secondary path **114** may be unidirectional or bidirectional. Optical switch **110** includes an optomechanical switching element **116**, tap couplers **117** and **118** and photodiode **121** and **122**. Likewise, optical switch **120** includes an optomechanical switching element **124**, tap couplers **125** and **126** and photodiodes **127** and **128**. A switch controller **127** controls the operation of switches **110** and **120**.

[0016] Referring to switch **110**, tap couplers **118** and **121** respectively couple a small portion of the optical signals traveling in paths **112** and **114** to photodiodes **121** and **122**. Controller **123** receives the electrical signals from the photodiodes **121** and **122** and determines the position of the optomechanical switching element **124**. As shown, switch **120** is configured in a manner similar to switch **110**.

[0017] In operation, switches **110** and **120** are initially in states A and B, respectively. That is, the switches **110** and **120** provide a continuous optical path to points A and B on the primary path so that the signals are transmitted along the primary path **112**. If transmission along the primary path **112** is now lost because of a fiber break, the controller **127** will respectively force the optomechanical switching elements **116** and **124** to switch from positions A and B to positions A' and B', respectively. As a result, traffic is now transported along the secondary path **114**. As previously mentioned, transmission will continue along the secondary path **114** even after the primary path **112** has been restored. The only way to restore switches **110** and **120** to states A and B, respectively, is to perform a manual power cycling in which the optomechanical switching elements **116** and **124** return to their initial states. This limitation is overcome with the inventive optical switches depicted in **FIG. 2**.

[0018] **FIG. 2** shows a simplified block diagram of an arrangement for providing a primary and second optical path between the head end and an optical node in a CATV transmission system in accordance with the present invention. Optical switches **210** and **220**, which are located in the head end and the optical node, respectively, switch optical traffic between primary transmission path **212** and secondary transmission path **214**. Optical switch **210** includes an optomechanical switching element **216**, tap couplers **217**, **218**, **230** and **232** and photodetectors **221** and **222**. Likewise, optical switch **220** includes an optomechanical switching element **224**, tap couplers **225**, **226**, **240** and **242** and photodetectors **227** and **228**. A switch controller **227** controls the operation of switches **210** and **220**. Each switch **210** and **220** has its own controller because the switches are often located 50-100 km apart.

[0019] Optomechanical switching elements **216** may be any arrangement that employs physical motion of one or more optical elements to perform optical switching. In this way, a spatial displacement of a reflected beam is affected. Photodetectors **221**, **222**, **227** and **228** may be any component that converts an optical signal received from the tap couplers to an electrical signal such as a photodiode, for example.

[0020] Referring to switch **210** in more detail, tap couplers **218** and **221** respectively couple a small portion of the optical signals traveling in paths **212** and **214** to photodiodes **221** and **222**. In addition, tap couplers **230** and **232** are also located in the primary path **212** and the secondary path **214**, respectively. Tap coupler **230** couples a small portion of the optical traffic traveling along the primary path **212** and directs it along optical fiber **234** to tap coupler **232**. Tap coupler **232**, in turn, couples the portion of the optical traffic received from primary path **212** onto the secondary path **214**. That is, a portion of the traffic traveling along the primary path **212** is placed on the secondary path **214**. Likewise, tap coupler **232** couples a small portion of the optical traffic traveling along the secondary path **214** and directs it along optical fiber **234** to tap coupler **230**. Tap coupler **230**, in turn, couples the portion of the optical traffic from the secondary path **214** onto the primary path **212**. That is, a portion of the traffic traveling along the secondary path **214** is placed on the primary path **212**. As shown, switch **220** is configured in a manner similar to switch **210**.

[0021] In operation, assume switches **210** and **220** are in states A' and B', respectively, as a result of a fiber break along the primary path **212**. A small portion of the optical signal traveling in the secondary path **214** is coupled to the primary path **212**. Photodetector **222** in switch **210** detects the signal but, because of the fiber break, photodetector **228** in switch **220** will not detect the portion of the signal tapped from the secondary transmission path **214**. However, when the primary path **212** has been restored, both photodetectors **222** and **228** will detect the portion of the signal tapped from the secondary transmission path **214**. In response to the signals detected by both photodetectors **222** and **228**, controller **227** activates the optomechanical switching elements **216** and **224** so that the switches **210** and **220** are returned to state A and B. That is, the transmission is automatically restored to the primary state. Power cycling is not required at either the head end or the optical node.

[0022] The state of the optomechanical switching elements **216** and **224** is determined by the voltage that is applied to them via electrical boards incorporated into the switches **216** and **224**. A threshold condition is established for the switches **216** and **224** in software that determine the value of the voltage pulse (or current pulse) that changes their state. The threshold condition can be adjusted either by the operator or can be factory-set based on the distance over which the signal is transmitted and customer requirements.

[0023] The analog voltages generated by the photodetectors are directed to the controller **227** via logarithmic amplifiers, which are used by firmware to determine the appropriate state of the optomechanical switching elements. The firmware then sends a voltage pulse (or current pulse) to the optomechanical switching elements **216** and **224** to switch them from the primary path to the secondary path, or visa versa.

[0024] Although various embodiments are specifically illustrated and described herein, it will be appreciated that modifications and variations of the present invention are covered by the above teachings and are within the purview of the appended claims without departing from the spirit and intended scope of the invention. For example, while the invention has been described in terms of an optical switch that provides a secondary or backup path in a CATV system, the optical switch more generally may be employed in any optical transmission system in which a backup path is to be provided.

1. A method for switching optical traffic from a secondary optical path to a primary optical path, each of which establish an optical communication path between first and second optical nodes, said method comprising the steps of: detecting a presence or absence of an optical signal traveling in the primary path through the first optical node; detecting a presence or absence of an optical signal traveling in the primary path through the second optical node; detecting a presence or absence of an optical signal traveling in the secondary path through the first optical node; detecting a presence or absence of an optical signal traveling in the secondary path through the second optical node; coupling a portion of an optical signal traveling in the first optical node from the secondary path to the primary path; and switching a switching element in each of the first and second optical nodes from a second state to a first state so that the optical traffic traverses the primary optical path when an optical signal is detected traveling in the primary path through both the first and second optical nodes.

2. The method of claim 1 wherein said two optical nodes comprise a head end and an optical node in a CATV transmission system.

3. The method of claim 1 wherein said switching element is an optomechanical switching element.

4. The method of claim 1, wherein the detecting steps are performed by photodiodes.

5. The method of claim 1, wherein the primary and secondary optical paths are unidirectional paths.

6. The method of claim 1, wherein the primary and secondary optical paths are bi-directional paths.

* * * * *