METHOD AND APPARATUS FOR PROVIDING OPTICAL INDICATIONS ABOUT A STATE OF A CIRCUIT

BACKGROUND OF THE INVENTION

[0001] Transceiver connector modules typically provide for bi-directional data transmission between two or more devices, such as modems, network interfaces and computer systems. Small Form-Factor Pluggable (SFP) transceiver modules are one industry standard used for this purpose. SFP supports both fiber optic and cable assemblies. The SFP transceiver module is inserted into a complimentary metal cage assembly mounted to a printed circuit board. In order to verify that a connection has been established between the transceiver modules, indicators, such as light emitting diodes (LEDs), are incorporated into the printed circuit board behind the SFP cage to indicate whether or not data is being received. Because the circuit connection is established behind a front panel of a circuit board that supports these devices, the status of the circuit, and the light generated by an associated LED, must be relayed outside of the device to an operator's side of the front panel for an operator to know the status of a circuit.

[0002] An ability to provide visual monitoring of the status of internal circuits is useful to knowing the functional state of transceiver modules or other circuits on a circuit board. One approach to this problem is to incorporate an optical waveguide or "light pipe" adjacent to the LED mounted on the printed circuit board such that it extends to the front panel. The optical waveguide transmits the LED-emitted light to a display area on the front panel. However, advances in the telecommunications industry and the quest for greater functionality have diminished the circuit board space available for devices providing state information of a circuit to an observer at a rack supporting the circuit board.

SUMMARY OF THE INVENTION

[0003] One example embodiment of the invention is an apparatus or corresponding method to indicate the state of a circuit. The example embodiment of the invention may include a connector component connected to a circuit board to accept a mating connector component at a location that may be a non-perpendicular first angle relative to an edge of the circuit board. The example embodiment may also include an optical light transmission element and at least three mounting features to connect the transmission element to the circuit board. The optical light transmission element may include a light-receiving end configured to accept a light projected by an optical light-generating device configured to illuminate as a function of a state of the circuit. The optical light transmission element may further include a light propagation region configured to support propagation of the light for a given length. The optical light transmission element may also include a light-emitting end to output the light at the mating location of the connector component at a second angle relative to the edge of the circuit board, other than at the first angle, to associate light output by the light-emitting end with the state of the circuit on the circuit board.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] The foregoing will be apparent from the following more particular description of example embodiments of the invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating embodiments of the present invention.

[0005] FIG. **1** is a diagram of an electronics rack (e.g., network system) with circuit boards equipped with network interfaces employing an example embodiment of the invention;

[0006] FIG. **2** is a mechanical diagram of a circuit board assembly with a circuit board inside the electronics rack and multiple light transmission elements arranged in an array above Small Form-Factor Pluggable (SFP) cages;

[0007] FIG. **3**A is a close-up of a mechanical diagram of a circuit board with multiple light transmission elements according to an example embodiment of the invention;

[0008] FIG. **3**B is a bottom view of the circuit board of FIG. **3**A illustrating mounting features of the multiple light transmission elements;

[0009] FIGS. **4**A-**1**, **4**A-**2**, and **4**A-**3** are mechanical diagrams at multiple angles of an example embodiment of the invention illustrating the mounting features, light-receiving end, light propagation region, light-emitting end, and a support between adjacent light propagation regions;

[0010] FIG. **4**B is a close-up view of an example embodiment of the invention illustrating a textured surface of a light-emitting end of a light transmission element;

[0011] FIG. **5** is an optical ray trace diagram of an embodiment of the invention redirecting light from a light-emitting diode (LED) toward an observer;

[0012] FIG. **6** is a flow diagram of an example method of the invention;

[0013] FIG. **7** is a flow diagram of a method of manufacturing a circuit board employing an example embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0014] A description of example embodiments of the invention follows.

[0015] Telecommunications industry advances have reduced circuit board space availability for devices providing state information of a circuit to an observer at a rack supporting a circuit board with the circuit. There is also a trend in the telecommunication industry, and other industries, towards development of high density transceiver components, which, in some applications, causes small form-factor pluggable (SFP) cage modules to be angled to increase their density. In such cases, the spatial allotment and placement positions available for state information indicators, including light guides that project light representing a state of a circuit, are even more restricted.

[0016] Because of this, many light guides are either mounted in an unstable manner, making them prone to tilting, especially where multiple light guides are to be positioned relative to each other during assembly and aligned at a perpendicular angle for assembly with a front panel. The cost of manufacturing electronic equipment containing conventional light guides is increased by this problem, as is the difficulty in dismantling front display panels and circuit boards for servicing.

[0017] A conventional light guide typically provides stability by fastening the light guide to a connector module with a clip. Other conventional methods utilize notched hooks on a light-emitting end of the light guide for hooking the light guide to an inside of the front panel. However, neither of these solutions provides satisfactorily secure mounting, and neither