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(54) Title: SMALL FORM FACTOR PLUGGABLE OPTOELECTRONIC MODULES

(57) Abstract: A small form factor pluggable optoelectronic module and pluggable equipment including an elongated optoelectronic module housing with first and second ends. The housing includes a cavity formed in the first end to nestingly receive one of a plurality of different optoelectronic modules in a horizontal-axis pluggable configuration. An electrical connector, which is one of a card edge connector and a multi-pin connector, is mounted in the housing adjacent the second end. An adapter is mounted in the housing to pluggably receive the one of the plurality of different optoelectronic modules and to electrically couple the one of the plurality of different optoelectronic modules to the electrical connector in a selected configuration.



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SMALL FORM FACTOR
PLUGGABLE OPTOELECTRONIC MODULES

TECHNICAL FIELD

5 This invention relates to small form factor pluggable optoelectronic modules and pluggable components and, more particularly, to improving the interchangeability between optoelectronic modules which are originally designed according to differing standards.

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BACKGROUND ART

 At the present time, optical-to-electrical and electrical-to-optical (hereinafter "optoelectronic") packages, containing a pair of optoelectronic modules, are
15 contained in one common or standard package. The modules are generally used in pairs for two-way communication. Multiple optoelectronic packages are used in a common mounting rack to provide multiple communication channels. The optoelectronic packages are positioned in the rack in,
20 for example, rows and columns and, to save space the optoelectronic packages are positioned as close together as possible.

 Each optoelectronic package is constructed to be inserted into an opening or cage in the rack. Once the
25 optoelectronic package is inserted completely into the cage, the optoelectronic package is captured by means of a latch spring inside the cage that is positioned to engage a locking tab on the optoelectronic package. To release the optoelectronic package and remove it from the cage,
30 the latch spring must be disengaged from the locking tab, after which the optoelectronic package can be withdrawn from the cage.

 A problem with these optoelectronic packages is that the standards they are designed by are not uniform so the
35 packages are not necessarily interchangeable. The standards define the form factor, pin count and position, etc. The major disadvantage is that system developers

have to re-design their boards based on different optical module standards, which in turn causes long design cycles before and increased cost of development.

It would be highly advantageous, therefore, to remedy the foregoing and other deficiencies inherent in the prior art.

Accordingly, it is an object the present invention to provide new and improved small form factor pluggable optoelectronic modules and pluggable components.

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DISCLOSURE OF THE INVENTION

Briefly, to achieve the desired objects of the instant invention in accordance with a preferred embodiment thereof, provided is a small form factor pluggable optoelectronic module and pluggable equipment including an elongated optoelectronic module housing with first and second ends. The housing includes a cavity formed in the first end to nestingly receive one of a plurality of different optoelectronic modules in a horizontal-axis pluggable configuration. An electrical connector, which is generally one of a card edge connector and a multi-pin connector, is mounted in the housing adjacent the second end. An adapter is mounted in the housing to pluggably receive the one of the plurality of different optoelectronic modules and to electrically couple the one of the plurality of different optoelectronic modules to the electrical connector in a selected configuration.

The desired objects of the instant invention are further realized in small form factor pluggable optoelectronic module and pluggable equipment including a pluggable daughter board having a multi-module housing with first and second opposed edges, the multi-module housing defines, adjacent the first opposed edge, a plurality of cavities each designed to receive one small form factor pluggable optoelectronic module. Each of the

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cavities of the plurality of cavities has associated therewith optoelectronic connectors positioned to electrically engage electrical connectors of the received one small form factor pluggable optoelectronic module.

5 The multi-module housing mounting, adjacent the second opposed edge, a multiple-pin electrical connector. A plurality of interface integrated circuits are mounted in the multi-module housing and connected to electrically couple the electrical connectors of the received one small

10 form factor pluggable optoelectronic module to the multiple-pin electrical connector in a selected orientation.

The desired objects of the instant invention are further realized in an inter-connector including a module

15 board having electrically conductive interconnects thereon and a multiple interconnect board having electrical interconnects thereon. An elastomeric interconnect is sandwiched between the module board and the multiple interconnect board so as to couple electrically conductive

20 interconnects on the module board to electrically conductive interconnects on the multiple interconnect board. In a preferred embodiment, the elastomeric interconnect includes an elongated assembly of alternate transversely extending layers of electrically conductive

25 and electrically nonconductive elastomeric material sandwiched together and positioned with a longitudinal axis of the elastomeric interconnect parallel to adjacent surfaces of the module board and the multiple interconnect board. The two boards are clamped together to physically

30 and electrically couple them together through the elastomeric interconnect.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and further and more specific objects

35 and advantages of the instant invention will become readily apparent to those skilled in the art from the

following detailed description of a preferred embodiment thereof taken in conjunction with the drawings, in which:

FIG. 1 is an isometric view of an embodiment of an optoelectronic transceiver module in accordance with the present invention;

FIG. 2 is a plan view of another embodiment of an optoelectronic transceiver module in accordance with the present invention;

FIG. 3 is a plan view of still another embodiment of an optoelectronic transceiver module in accordance with the present invention;

FIG. 4 is a plan view of a pluggable daughter card for use with optoelectronic transceiver modules in accordance with the present invention; and

FIG. 5 is an exploded view of an interposer for use with optoelectronic transceiver modules in accordance with the present invention.

BEST MODES FOR CARRYING OUT THE INVENTION

There are currently five different standards that guide the design of optoelectronic transceiver modules. The standards are supposed to make products interchangeable, but this is only accomplished if there is one standard. For optoelectronic transceiver modules, the current standards include XENPAK, XPAK, XFP, XGP, and X2 which are defined in multi-source agreements (hereinafter referred to as "MSA's"). MSA's are voluntary agreements between different manufacturers dictating factors such as shape, size, and pin-out (number and location of I/O pins) of the optoelectronic transceiver module. The optoelectronic transceiver module is positioned between one or two data-carrying optical fibers, for example, and the on-board electronics and operates to convert between optical and electrical signals.

XENPAK:

Typical 10 Gbps Ethernet XENPAK transceiver modules consist of a high speed serial optical transmitter and receiver capable of 10.3 Gbps signaling along with highly integrated electronics which allow for seamless connection to the MAC via a four lane XAUI interface operating at 4x3.125 Gbps. XENPAK modules are specifically designed to ease manufacturing and system-upgrade issues by being hot-swappable at either the customer site or during assembly of the system.

The XENPAK multi-source agreement (MSA) defines a uniform transceiver form factor, size, connector type and electrical pin-out, and conforms to the proposed IEEE 802.3ae standard and OC-192 applications. XENPAK provides the smallest possible module that can handle all four PMD's defined by IEEE 802.3ae, allowing a single board to accept any of the lasers without extra configuration. XENPAK is designed to work with each PMD's thermal, mechanical, and electromagnetic interference requirements. XENPAK defines a z-axis loadable transponder, installed horizontally, the same way a videocassette is loaded into a VCR. Previous designs were pluggable along the y-axis, meaning they were inserted vertically from above or below.

XENPAK includes several features. For example, XENPAK includes an Adaptable Power Supply (hereinafter referred to as "APS"), which allows a system using XENPAK to sense the exact voltage required by a particular XENPAK transceiver and supply any corresponding voltage between 0.9 and 1.8 volts. The APS will allow equipment makers to use new, lower power XENPAK transceivers as they are introduced while maintaining backwards compatibility.

XENPAK also includes a Programmable Link Alarm Status which replaces a number of status and alarm signals (which were provided as discrete I/O signals in XENPAK Rev 1.0) with a single interrupt signal supported by several module

performance registers. Further, new non-volatile memory location registers to support 10 Gigabit Fiber Channel were added to XENPAK for WAN Interface Sub-layer (WIS) and Link Signaling Sub-layer (LSS) applications.

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XPAK:

XPAK is a 4-channel XAUI optical module MSA which provides a smaller module size than XENPAK.

10 XFP:

Transceiver modules compliant with the XFP MSA will be approximately 80% smaller than other 10 Gbps transceiver form factors like XENPAK and the 300 pin MSA. Increasing density with hot pluggable serial optics reduces overall system costs and permits customers to simplify inventory and sparing concerns.

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XGP:

XGP was the first MSA for optical transceiver modules. XGP is targeting a smaller form factor, one developed originally for the Gigabit Interface Converter (GBIC): 1.5 inches wide and roughly 2 inches long, compared with about 4 inches long in the XENPAK form factor. GBIC is the de facto standard for pluggable transceivers in Gigabit Ethernet and 1 Gbps Fiber Channels, and XGP had hoped to bring it to the 10-Gbit Ethernet world.

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XGP defines a z-axis loadable transponder like XENPAK, and is installed horizontally, the same way a videocassette is loaded into a VCR. Previous designs were pluggable along the y-axis, meaning they were inserted vertically from above or below.

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X2:

X2 marks the latest MSA proposal for 10 Gbps laser modules. The primary difference between XPAK and X2 is in

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their external casing. XPAK specifies a cage that wraps around the module, while X2 uses a rail attached to the side of the module, leaving the front exposed. The rail system is advantageous because it does not add to the module's height.

To help overcome incompatibility issues between the different standards, various modules have been designed to work independently of the standard. Turn now to FIG. 1 which illustrates an optoelectronic transceiver module 5 in accordance with the present invention. In the preferred embodiment, module 5 includes an elongated housing 10 designed to be frictionally inserted into a mounting rack or cage (not shown) using a guide rail 14. Elongated housing 10 includes at least one opening 12 which is designed to nestingly receive an optoelectronic module 9 (i.e. "a module within a module"). Optoelectronic module 9 can be, for example, an XFP pluggable module with the capability to support form factors as defined by the 200 or 300 pin MSA for 10 Gbps transponders. However, it will be understood that opening 12 can be designed to receive any one of a plurality of different modules designed by other standards such as XPAK, XGP, or X2. It will be understood from this disclosure that module 9 can include a transmitter optical subassembly and/or a receiver optical subassembly. Also, housing 10 has heat dispersing fins formed therein to radiate heat generated by module 9. It will be understood that housing 10 can include, or be formed completely of, heat conducting material.

In the preferred embodiment, module 5 is designed to accommodate a variety of connectors, as illustrated in FIG. 2. FIG. 2 illustrates an optoelectronic transceiver module 15 with a 16:1 SerDes adapter 14 (serial/deserializer, i.e. an electrical multiplier and de-multiplier more commonly known as mux and demux) which allows XFP module 9 to be adapted to a 200 or 300 pin FCI

Berg connector 16 as defined by the 200 or 300 pin MSA for 10 Gbps transponders.

Turn now to FIG. 3 which illustrates an optical transceiver module 19 with an adapter 18 which allows XFP module 9 to be adapted to a 40 or 70 pin card edge connector 13 such as a TycoAMP Part No. 1367337-1 connector as defined by the XENPAK 10 Gbps MSA. It will be understood that adapter 18 can include a XAUI 10 Gbps IC, an SFI 4.2 adapter, or a similar such adapter. Hence, modules 5, 15, or 19 allow system and line card developers to use existing designs with the 200 or 300 pin FCI Berg connector or a 40 or 70 pin z-pluggable Tyco connector by plugging in a generic form factor module (i.e. module 5, 15, or 19) that could have electrical connections such as XSBI, XAUI, or SFI 4.2.

Turn now to FIG. 4 which illustrates a pluggable daughter card 40 in accordance with the present invention. In the preferred embodiment, daughter card 40 includes a housing 42 which supports electrical connectors 41. Housing 42 also supports interface IC's 43, 44, etc. which provide electrical communication between optoelectronic modules 48, 49, etc. and electrical connectors 41 through a transmitter optical subassembly 45 and a receiver optical subassembly 46, respectively. It will be understood that daughter card 40 can include any number of subassemblies 45 and/or 46, as well as interface IC's and optoelectronic modules.

In the preferred embodiment, daughter card 40 allows more than one transceiver function which will simplify line card design. For example, instead of mounting four optoelectronic transceivers, only one can be used, if desired. Daughter card 40 can include, for example, a tunable laser in an optoelectronic transceiver which can simplify the transmitting function by selecting different wavelengths and reduce the number of detectors and/or transmitters. Further, the pluggability of daughter card

40 allows for upgrades and quick removal of the optical interface.

Turn now to FIG. 5 which illustrates an exploded view of an interposer 60 which is capable of adapting output
5 signals from optoelectronic modules, packages, etc. to any form factor in an MSA. Without such an adapter, there would be a need to have different motherboards and assemblies for the different MSA's. By using interposer 60, it is possible to use the same module for different
10 MSA's just by using a new interposer 60, as will be discussed presently.

In the preferred embodiment, interposer 60 includes a clamp 62 with openings 61 formed therethrough. Interposer 60 also includes a module PCB 64 with conductive
15 interconnects 63 positioned thereon and openings 61 formed therethrough. Module 60 further includes an interposer elastomeric connector 66 with sandwiched conductors 65 and insulators 67 formed thereon.

In the preferred embodiment, module 60 includes a
20 multiple interconnect PCB 68 which is designed specifically for the particular MSA. Multiple interconnect PCB 68 includes openings 61 formed therethrough and conductive interconnects 70 formed thereon. Pins 69 are inserted through openings 61 in
25 multiple interconnect PCB 68, module PCB 64, and clamp 62 to fixedly engage clamp 62 and hold module 60 together. However, it will be understood that module 60 could be held together through other means, such as solder, epoxy, glue, or the like, and the use of clamps in this
30 embodiment is for illustrative purposes only. The use of soldering, however, has several disadvantages, such as the formation of short circuits, opens circuits, heat damage, and/or cool solder joints. The use of clamps 62 in the preferred embodiment requires no heat and does not depend
35 on the quality of a solder joint, as well as being simple and easy to assemble and test.

In interposer 60, elastomeric connector 66 allows electrical communication between conductive interconnects 63 on module PCB 64 and interconnects 70 on multiple interconnect PCB 68 and behaves as an adapter between the various MSA's. This allows the flexibility to quickly meet the demands of an application and keep inventory at a minimum. Further, interposer 66 forms a reliable and uniform connection, so module 60 provides more stable performance.

Thus, a new and improved small form factor pluggable optoelectronic module is disclosed that is relatively inexpensive to manufacture and is easy to assemble and test. Also, the new and improved small form factor pluggable optoelectronic module improves the fabrication efficiency and manufacturing capabilities of optoelectronic modules and the interconnecting circuitry and equipment. Further, the new and improved small form factor pluggable optoelectronic module and interconnecting circuitry allows the use of a variety of optical components and component equipment by aiding in standardizing modules and packages.

Various changes and modifications to the embodiments herein chosen for purposes of illustration will readily occur to those skilled in the art. To the extent that such modifications and variations do not depart from the spirit of the invention, they are intended to be included within the scope thereof which is assessed only by a fair interpretation of the following claims.

Having fully described the invention in such clear and concise terms as to enable those skilled in the art to understand and practice the same, the invention claimed is:

CLAIMS

1. A small form factor pluggable optoelectronic module and pluggable equipment comprising:

an elongated optoelectronic module housing with first and second ends, the housing including a cavity formed in the first end to nestingly receive one of a plurality of different optoelectronic modules in a horizontal-axis pluggable configuration;

an electrical connector mounted in the housing adjacent the second end, the connector being one of a card edge connector and a multi-pin connector; and

an adapter mounted in the housing to pluggably receive the one of the plurality of different optoelectronic modules and to electrically couple the one of the plurality of different optoelectronic modules to the electrical connector in a selected configuration.

2. A small form factor pluggable optoelectronic module and pluggable equipment as claimed in claim 1 wherein the housing includes heat radiating fins.

3. A small form factor pluggable optoelectronic module and pluggable equipment as claimed in claim 1 wherein the housing includes heat radiating material.

4. A small form factor pluggable optoelectronic module and pluggable equipment as claimed in claim 1 wherein the electrical connector includes one of a 200 or 300 pin FCI connector and a 40 or 70 pin Z-pluggable connector.

5. A small form factor pluggable optoelectronic module and pluggable equipment as claimed in claim 1 wherein the adapter includes one of a 16:1 SerDes adapter, a XAUI 10 Gbps IC, and an SFI 4.2 adapter.

6. A small form factor pluggable optoelectronic module and pluggable equipment as claimed in claim 1 further including a pluggable daughter board including a multi-module housing with first and second opposed edges, the multi-module housing defining, adjacent the first opposed edge, a plurality of cavities each designed to receive one small form factor pluggable optoelectronic module, each of the cavities of the plurality of cavities having associated therewith optoelectronic connectors positioned to electrically engage electrical connectors of the received one small form factor pluggable optoelectronic module, and the multi-module housing mounting, adjacent the second opposed edge, a multiple-pin electrical connector, and a plurality of interface integrated circuits mounted in the multi-module housing and connected to electrically couple the electrical connectors of the received one small form factor pluggable optoelectronic module to the multiple-pin electrical connector in a selected orientation.

7. A small form factor pluggable optoelectronic module and pluggable equipment as claimed in claim 6 wherein the received one small form factor pluggable optoelectronic module includes a tunable laser.

8. A small form factor pluggable optoelectronic module and pluggable equipment as claimed in claim 6 wherein the multiple-pin electrical connector of the pluggable daughter board includes an interposer with a module board having electrically conductive interconnects thereon, a multiple interconnect board having electrical interconnects thereon, and an elastomeric interconnect sandwiched between the module board and the multiple interconnect board so as to couple electrically conductive interconnects on the module board to electrically

conductive interconnects on the multiple interconnect board.

9. A small form factor pluggable optoelectronic module and pluggable equipment as claimed in claim 8 wherein the elastomeric interconnect includes an elongated assembly of alternate transversely extending layers of electrically conductive and electrically nonconductive elastomeric material sandwiched together and positioned with a longitudinal axis of the elastomeric interconnect parallel to adjacent surfaces of the module board and the multiple interconnect board.

10. A small form factor pluggable optoelectronic module and pluggable equipment comprising:

a pluggable daughter board including a multi-module housing with first and second opposed edges, the multi-module housing defining, adjacent the first opposed edge, a plurality of cavities each designed to receive one small form factor pluggable optoelectronic module;

each of the cavities of the plurality of cavities having associated therewith optoelectronic connectors positioned to electrically engage electrical connectors of the received one small form factor pluggable optoelectronic module;

the multi-module housing mounting, adjacent the second opposed edge, a multiple-pin electrical connector; and

a plurality of interface integrated circuits mounted in the multi-module housing and connected to electrically couple the electrical connectors of the received one small form factor pluggable optoelectronic module to the multiple-pin electrical connector in a selected orientation.

11. A small form factor pluggable optoelectronic module and pluggable equipment as claimed in claim 10 wherein the received one small form factor pluggable optoelectronic module includes a tunable laser.

12. A small form factor pluggable optoelectronic module and pluggable equipment comprising:

a module board having electrically conductive interconnects thereon;

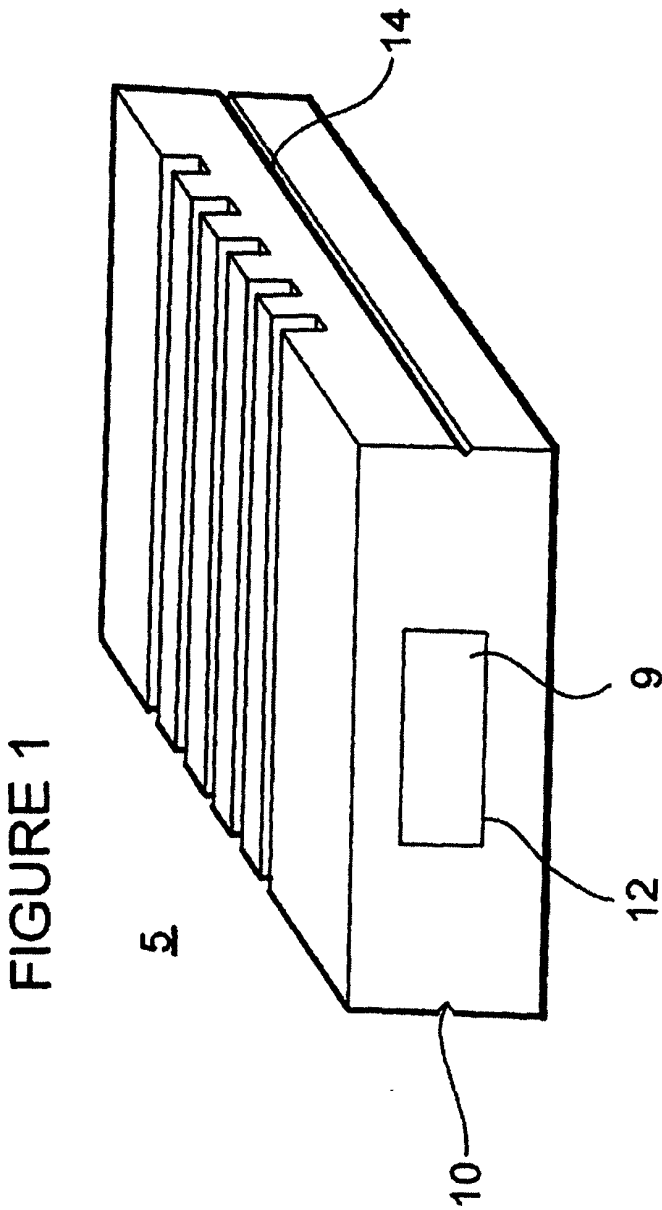
a multiple interconnect board having electrical interconnects thereon; and

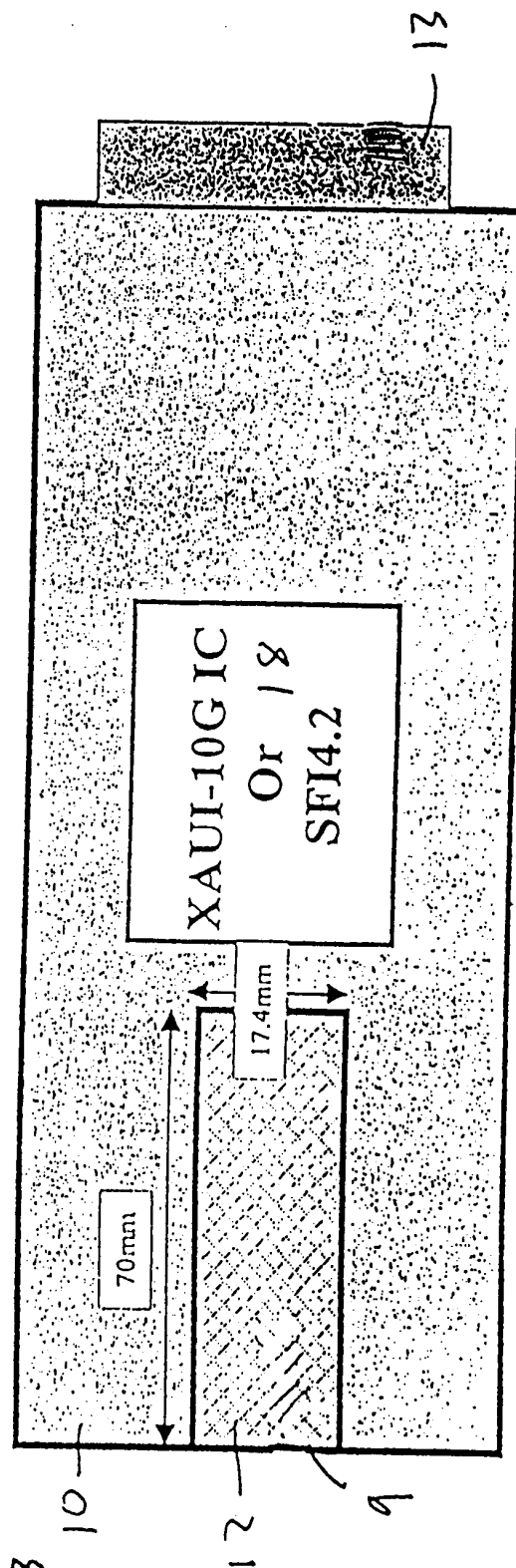
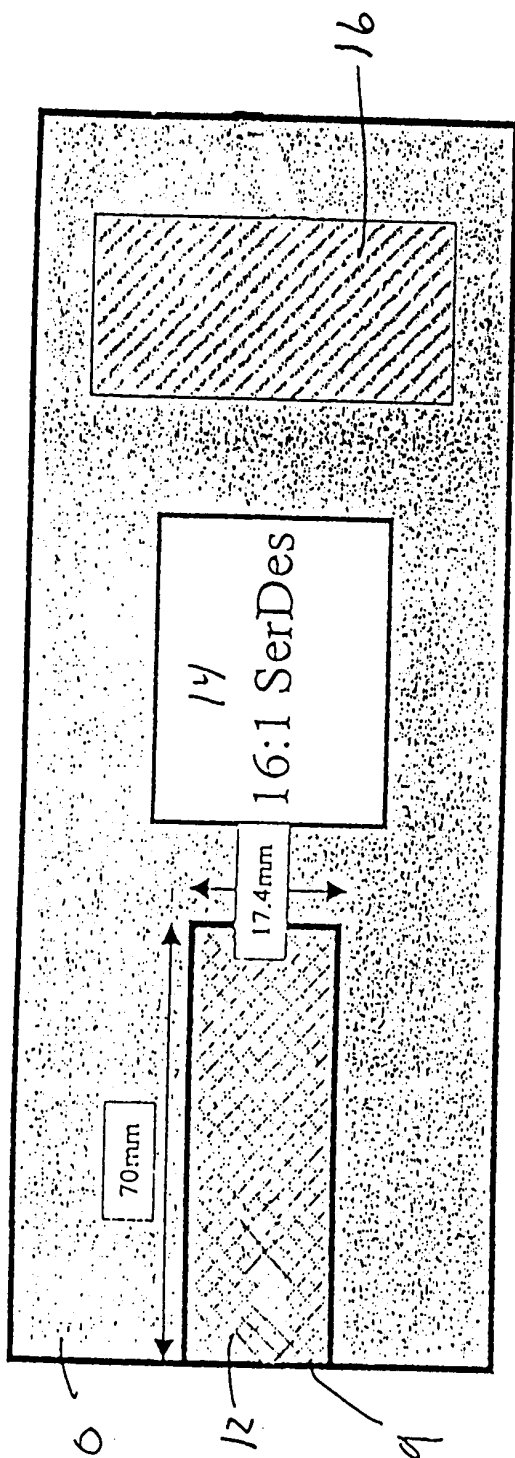
an elastomeric interconnect sandwiched between the module board and the multiple interconnect board so as to couple electrically conductive interconnects on the module board to electrically conductive interconnects on the multiple interconnect board.

13. A small form factor pluggable optoelectronic module and pluggable equipment as claimed in claim 12 wherein the elastomeric interconnect includes an elongated assembly of alternate transversely extending layers of electrically conductive and electrically nonconductive elastomeric material sandwiched together and positioned with a longitudinal axis of the elastomeric interconnect parallel to adjacent surfaces of the module board and the multiple interconnect board.

14. A small form factor pluggable optoelectronic module and pluggable equipment as claimed in claim 13 including in addition a clamp positioned to engage the module board and the multiple interconnect board and laterally bias the module board and the multiple interconnect board toward the elastomeric interconnect, whereby the module board and the multiple interconnect board are fixedly clamped together with the elastomeric

interconnect sandwiched therebetween in a selected electrical interconnection.





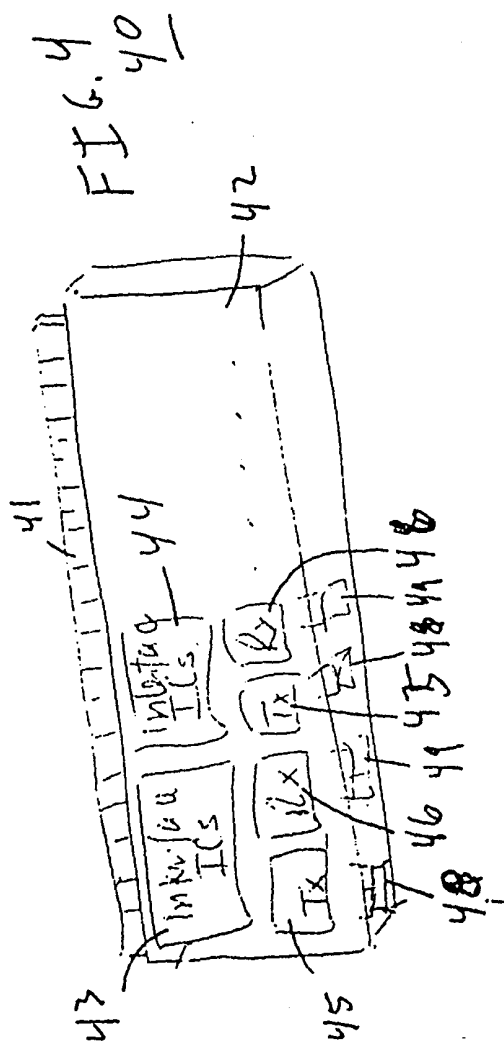


FIGURE 5

