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(54) **BOARD-TO-BOARD ELECTRICAL COUPLING WITH CONDUCTIVE BAND**

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(57) **ABSTRACT**

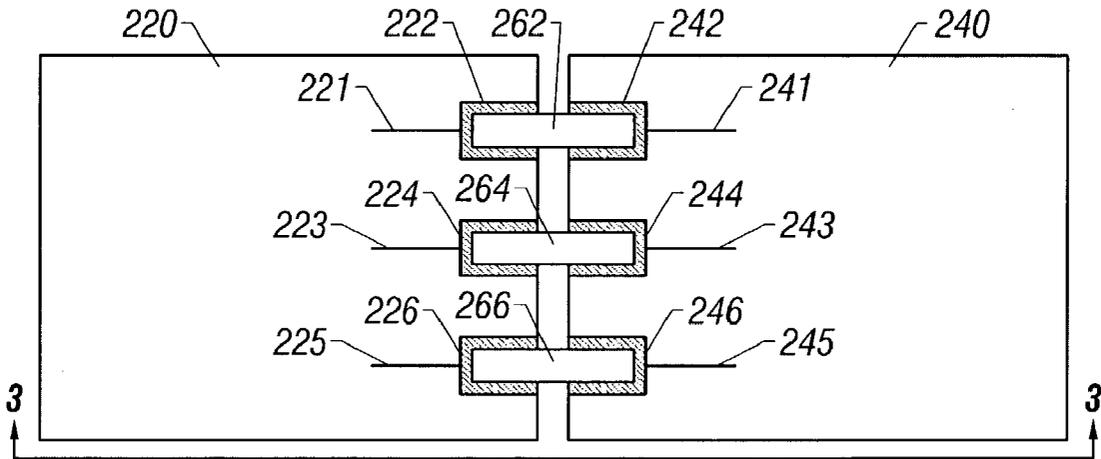
A first printed circuit board has a contact area, and a second printed circuit board has a contact area. An electrically conductive band is to couple the contact area of the first printed circuit board to the contact area of the second printed circuit board. The conductive band may be selected from the group consisting essentially of a band formed from solder, a band coupled by a weld, a band coupled by a wire bond, a band comprising conductive film, and a band comprising conductive rope. The conductive band may couple the first printed circuit board and the second printed circuit board in a substantially coplanar position.

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**Related U.S. Application Data**

(62) **Division of application No. 09/409,978, filed on Sep. 30, 1999, now Pat. No. 6,594,152.**



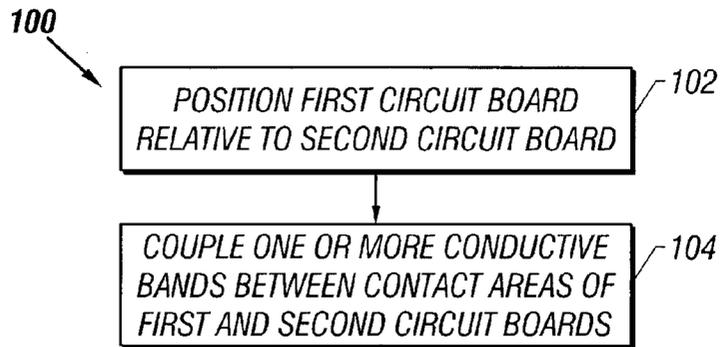


FIG. 1

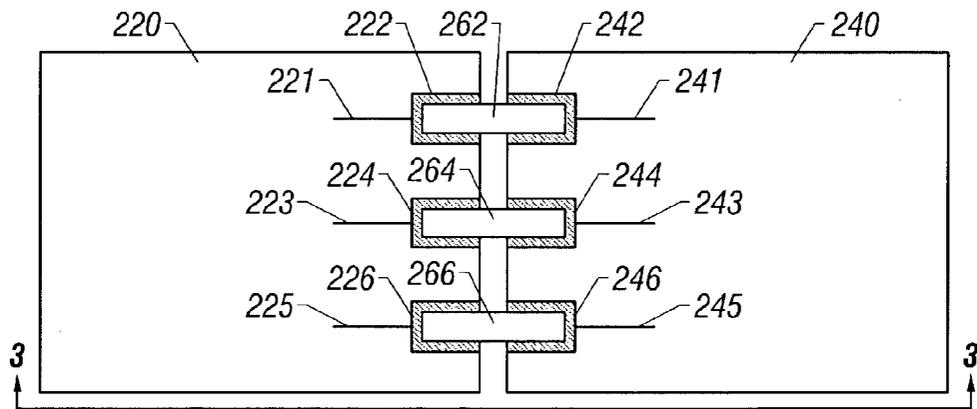


FIG. 2

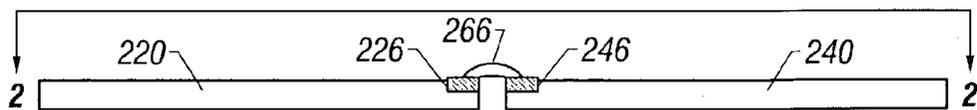


FIG. 3

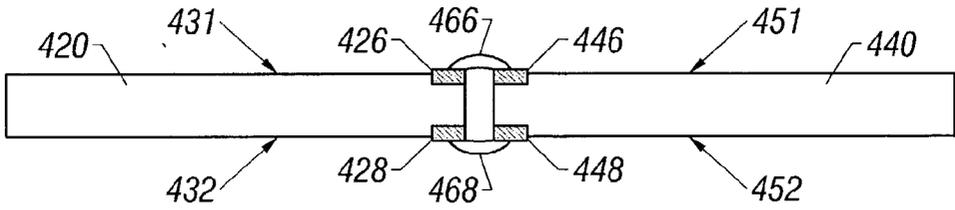


FIG. 4

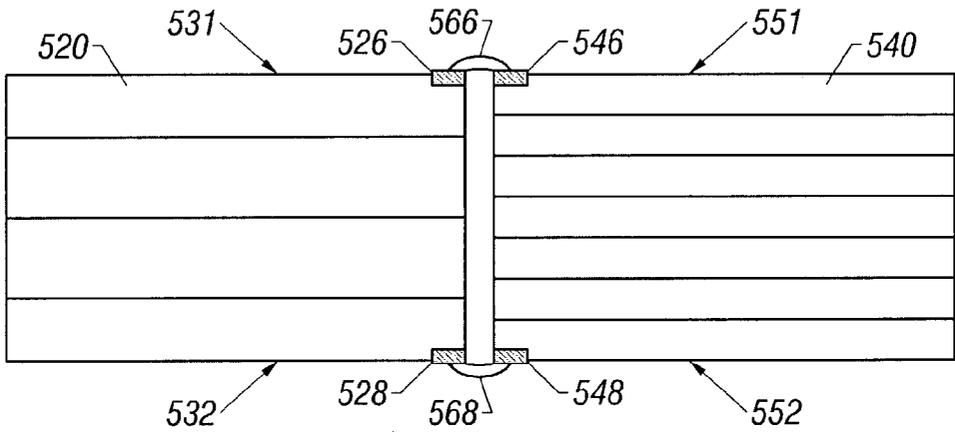


FIG. 5

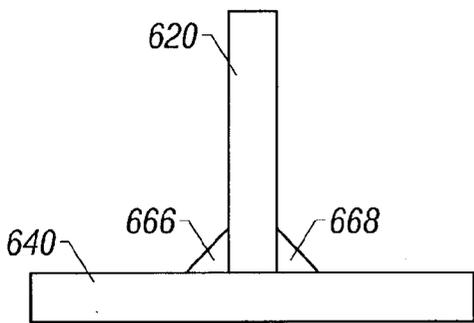


FIG. 6

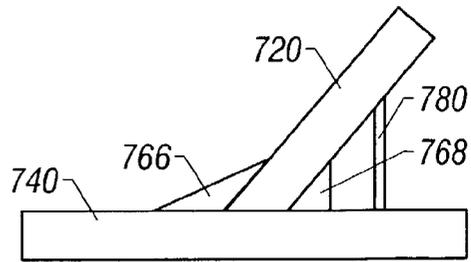


FIG. 7

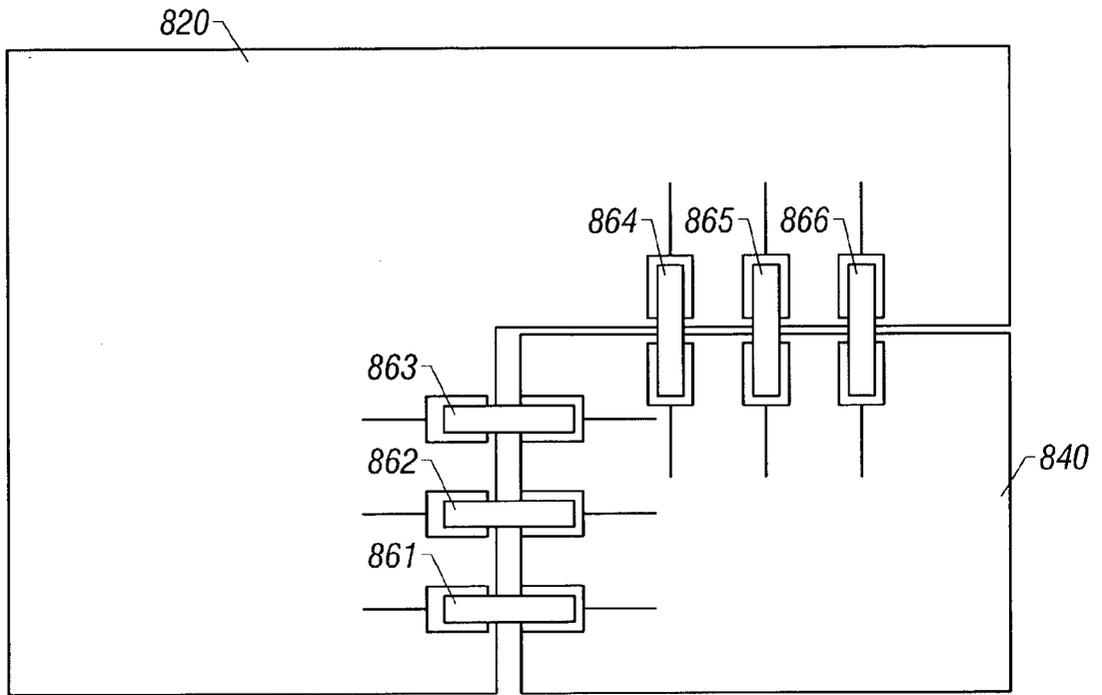


FIG. 8

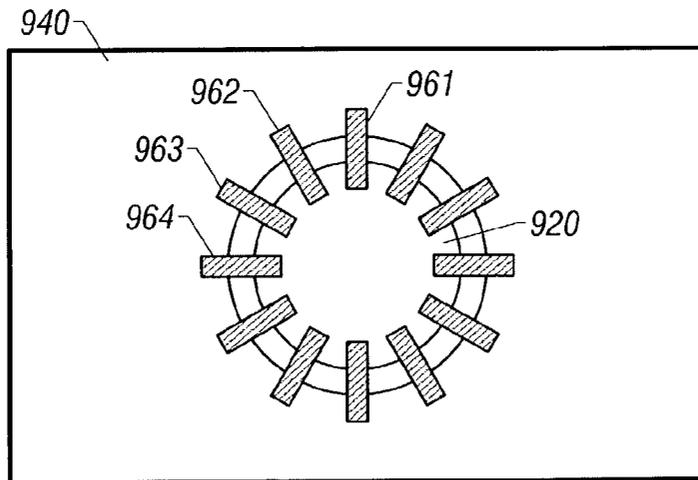


FIG. 9

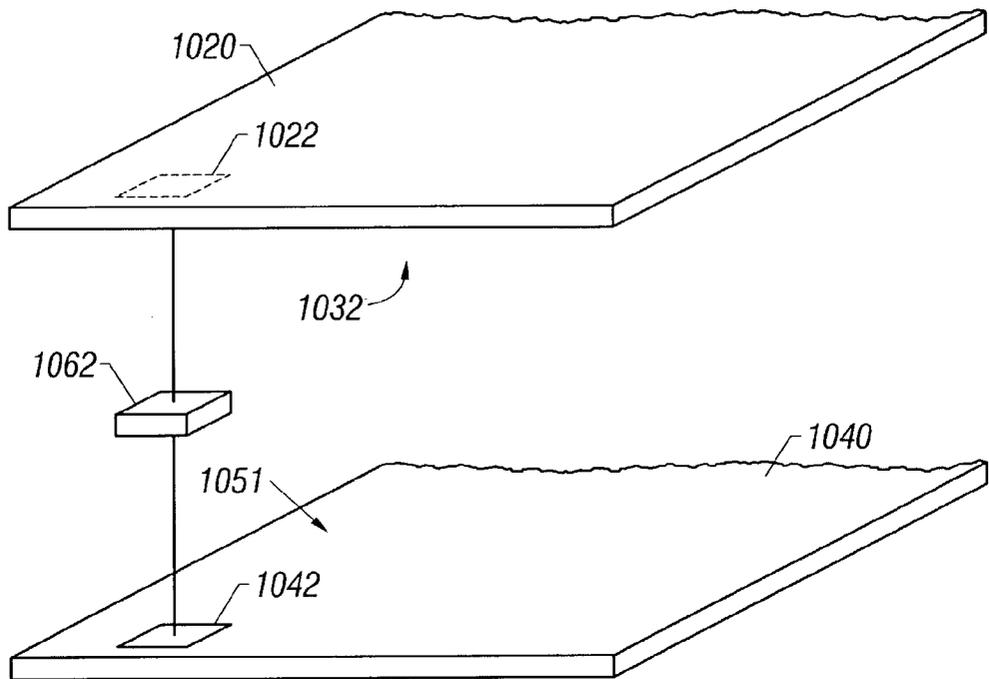


FIG. 10

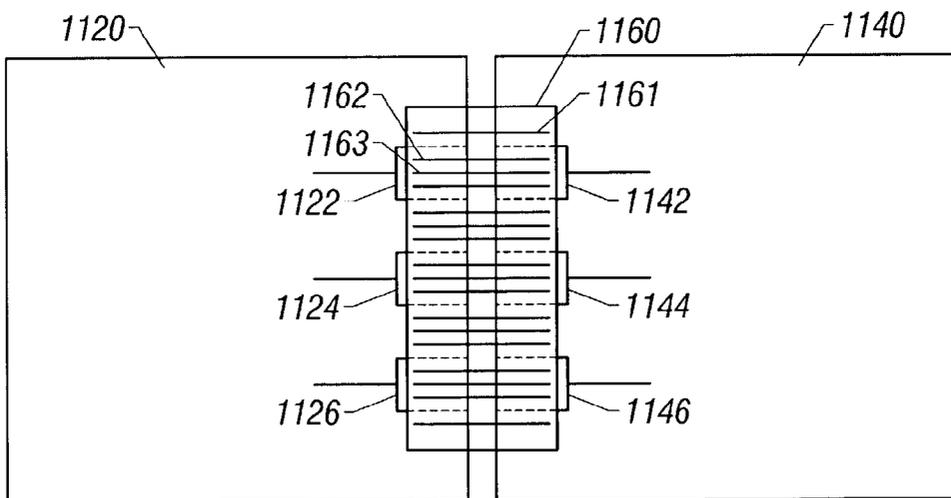


FIG. 11

## BOARD-TO-BOARD ELECTRICAL COUPLING WITH CONDUCTIVE BAND

### CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a divisional of co-pending application Ser. No. 09/409,978, filed Sep. 30, 1999, and claims the priority of that filing date.

### BACKGROUND

[0002] 1. Technical Field

[0003] The present invention relates generally to the field of packaging of electrical components. More particularly, the present invention relates to the field of electrically coupling printed circuit boards.

[0004] 2. Description of Related Technology

[0005] Mechanical connectors, such as friction-fit card edge connectors or pin-in-socket connectors for example, are typically used for electrically interconnecting printed circuit boards. Such connectors, however, are disadvantageous as each board must typically be configured with a respective correlating male or female connector. The ability to interconnect one board with another depends, then, on the type of connector on each board. Also, such connectors typically require some forced mechanical contact and are therefore inherently less reliable. To ensure proper alignment, each line or pin connection for such connectors typically requires a minimum width and spacing. Forced mechanical connections using long traces, dissimilar metals, and/or angular geometries, for example, also compromise the quality of the signal transferred and produce greater electromagnetic interference emissions. Typical mechanical connectors also consume relatively more space on printed circuit boards.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The present invention is illustrated by way of example and not limitation in the figures of the accompanying drawings, in which like references indicate similar elements and in which:

[0007] **FIG. 1** illustrates, for one embodiment, a method for electrically coupling printed circuit boards with a conductive band;

[0008] **FIG. 2** illustrates, for one embodiment, a top view of two substantially coplanar printed circuit boards electrically coupled with conductive bands;

[0009] **FIG. 3** illustrates a side view of the coupled printed circuit boards of **FIG. 2**;

[0010] **FIG. 4** illustrates, for one embodiment, a side view of two substantially coplanar printed circuit boards electrically coupled with conductive bands on opposite sides of each board;

[0011] **FIG. 5** illustrates, for one embodiment, a side view of two substantially coplanar printed circuit boards of different layer counts electrically coupled with conductive bands;

[0012] **FIG. 6** illustrates, for one embodiment, two substantially perpendicular printed circuit boards electrically coupled with a conductive band;

[0013] **FIG. 7** illustrates, for one embodiment, two non-coplanar printed circuit boards electrically coupled with a conductive band;

[0014] **FIG. 8** illustrates, for one embodiment, an L-shaped mother printed circuit board electrically coupled to a daughter printed circuit board with conductive bands;

[0015] **FIG. 9** illustrates, for one embodiment, two printed circuit boards electrically coupled with conductive bands with one printed circuit board residing in an opening of the other printed circuit board;

[0016] **FIG. 10** illustrates, for one embodiment, two printed circuit boards electrically coupled with a conductive band with at least a portion of one printed circuit board over at least a portion of the other printed circuit board; and

[0017] **FIG. 11** illustrates, for one embodiment, a top view of two substantially coplanar printed circuit boards electrically coupled with conductive tape.

### DETAILED DESCRIPTION

[0018] The following detailed description sets forth an embodiment or embodiments in accordance with the present invention for board-to-board electrical coupling with conductive band. In the following description, details are set forth such as specific materials, printed circuit boards, etc., in order to provide a thorough understanding of the present invention. It will be evident, however, that the present invention may be practiced without these details. In other instances, well-known techniques, etc., have not been described in particular detail so as not to obscure the present invention.

[0019] In accordance with the present invention, printed circuit boards are electrically coupled with one or more conductive bands. Any suitable printed circuit boards may be electrically coupled with one or more conductive bands in any suitable manner.

[0020] For one embodiment, two printed circuit boards may be electrically coupled with one or more conductive bands in accordance with flow diagram **100** of **FIG. 1** and with reference to **FIGS. 2 and 3**, for example.

[0021] A first printed circuit board **220** is positioned **102** relative to a second printed circuit board **240**. First printed circuit board **220** comprises one or more contact areas for electrical coupling to one or more contact areas of second printed circuit board **240**. As illustrated in **FIGS. 2 and 3**, first printed circuit board **220** comprises, for example, bonding pads **222**, **224**, and **226** deposited over traces **221**, **223**, and **225**, respectively, and second printed circuit board **240** comprises, for example, bonding pads **242**, **244**, and **246** deposited over traces **241**, **243**, and **245**, respectively. In positioning first printed circuit board **220** and second printed circuit board **240**, contact areas of first and second printed circuit boards **220** and **240** are aligned for electrical coupling with one or more conductive bands. As illustrated in **FIG. 2**, bonding pads **222** and **242** are aligned; bonding pads **224** and **244** are aligned; and bonding pads **226** and **246** are aligned.

[0022] A conductive band is coupled **104** between contact areas of first and second printed circuit boards **220** and **240**. As illustrated in **FIGS. 2 and 3**, a conductive band **262** is coupled between bonding pads **222** and **242**; a conductive

band 264 is coupled between bonding pads 224 and 244; and a conductive band 266 is coupled between bonding pads 226 and 246.

[0023] Each conductive band may comprise any suitable material and may be coupled between contact areas in any suitable manner. For one embodiment, as illustrated in FIGS. 2 and 3, each conductive band may comprise a suitable solder and may be coupled between contact areas, for example, while first and second printed circuit boards 220 and 240 are delivered through a wave solder. Tin lead solder or silver solder, for example, may be used. For other embodiments, each conductive band may comprise any suitable material and may be coupled between contact areas using a suitable cold formed weld technique, a suitable pin point spot weld technique, or a suitable wire bonding technique, for example.

[0024] For still other embodiments, each conductive band may also comprise, for example, suitable conductive glue or adhesive, suitable conductive film, suitable conductive tape, or suitable conductive rope. Conductive glue or adhesive defines one or more conductive paths using a suitable material of a suitable shape within a suitable glue or adhesive material. The glue or adhesive may be used to couple the conductive band to a contact area. One exemplary conductive adhesive is an anisotropic epoxy. Conductive film defines one or more conductive paths between opposite surfaces of the film using a suitable material of a suitable shape. The film may be coupled to a contact area, for example, by using mechanical pressure or by using a suitable adhesive conductive film such as those manufactured by Minnesota Mining and Manufacturing (3M) Company under product numbers 5303 and 7303. Conductive tape defines one or more conductive paths along the length or width of the tape using a suitable material of a suitable shape. The conductive paths may be at least partially exposed in an adhesive portion on one side of the tape for coupling to a contact area. A conductive rope defines one or more conductive paths along the length of the rope using a suitable material of a suitable shape within a suitable rope-like or string-like material or within any other suitable material. A suitable conductive path for a conductive rope may be defined, for example, by a plurality of conductive disks stacked on top of one another. The rope may be coupled to a contact area using, for example, mechanical pressure.

[0025] Compared to the use of typical mechanical connectors, electrical coupling of printed circuit boards with one or more conductive bands helps provide a more reliable electrical coupling and a relatively lower coupling impedance where forced mechanical contact is avoided. Also, conductive bands consume less space than typical mechanical connectors and are therefore particularly beneficial in manufacturing portable laptop or notebook computers. Use of conductive bands further allows printed circuit boards to be designed with relatively finer contact area widths and spacings and therefore a higher contact area density.

[0026] As illustrated in FIGS. 2 and 3, electrically coupling first and second printed circuit boards 220 and 240 with one or more conductive bands allows first and second printed circuit boards 220 and 240 to be electrically coupled while positioned in a substantially coplanar relationship with respect to one another. As each conductive band is substan-

tially coplanar with first and second printed circuit boards 220 and 240, each conductive band essentially forms a substantially coplanar electrical coupling or interconnect for first and second printed circuit boards 220 and 240. Coupling first and second printed circuit boards 220 and 240 in this manner effectively creates a single, planar board and advantageously allows both boards to be mounted, for example, to the same chassis within a computer system for stability and thermal dissipation. As the plane of both first and second printed circuit boards 220 and 240 as well as conductive bands 262, 264, and 266 lie in substantially the same x-y plane, coupling first and second printed circuit boards 220 and 240 in this manner may prove particularly beneficial in manufacturing portable laptop or notebook computers. For one embodiment, a suitable stiffening support, such as a stiffening bar for example, may be coupled to both first and second printed circuit boards 220 and 240 to help provide mechanical support for first and second printed circuit boards 220 and 240 when electrically coupled by one or more conductive bands. Compared to the use of typical mechanical connectors, electrical coupling of printed circuit boards with one or more conductive bands decouples the electrical and mechanical requirements for board-to-board couplings.

[0027] Conductive bands may also be used to electrically couple contact areas on opposite sides of printed circuit boards. As illustrated in FIG. 4, a conductive band 466 is coupled between a bonding pad 426 on a first side 431 of a first printed circuit board 420 and a bonding pad 446 on a first side 451 of a second printed circuit board 440. Also, a conductive band 468 is coupled between a bonding pad 428 on a second side 432 of first printed circuit board 420 and a bonding pad 448 on a second side 452 of second printed circuit board 440. Providing a two-sided electrical coupling in this manner advantageously allows for more electrical connections to be made between first and second printed circuit boards 420 and 440, allowing for more communication between first and second printed circuit boards 420 and 440.

[0028] Printed circuit boards having different layer counts may also be electrically coupled with conductive bands on only a single side of the printed circuit boards or, alternatively, on opposite sides of the printed circuit boards. As illustrated in FIG. 5, a conductive band 566 is coupled between a bonding pad 526 on a first side 531 of a first printed circuit board 520 having four layers and a bonding pad 546 on a first side 551 of a second printed circuit board 540 having seven layers. A conductive band 568 may also be coupled between a bonding pad 528 on a second side 532 of first printed circuit board 520 and a bonding pad 548 on a second side 552 of second printed circuit board 540 to establish a two-sided electrical coupling. For two-sided electrical couplings, the thickness of the layers of each printed circuit board may be altered as necessary to alter the overall thickness of each printed circuit board and help align traces for electrical coupling.

[0029] Although the printed circuit boards illustrated in FIGS. 2, 3, 4, and 5 are positioned in a substantially coplanar relationship, printed circuit boards may be electrically coupled with one or more conductive bands in any suitable position, including a suitable non-coplanar position.

[0030] As illustrated in FIG. 6, a first printed circuit board 620 may be positioned in a substantially perpendicular

relationship relative to a second printed circuit board **640**. Contact areas of first and second printed circuit boards **620** and **640** may be electrically coupled with conductive bands **666** and **668**, for example. Similarly, a first printed circuit board **720** may be positioned at a suitable angle greater than zero degrees and less than 90 degrees relative to a second printed circuit board **740**, as illustrated in **FIG. 7**. Contact areas of first and second printed circuit boards **720** and **740** may be electrically coupled with conductive bands **766** and **768**, for example. For one embodiment, a support **780** is coupled between printed circuit boards **720** and **740** to support first printed circuit board **720**. Support **780** provides stability despite vibration or other mechanical shock. Support **780** may be coupled between printed circuit boards **720** and **740** in any suitable manner, such as by soldering for example.

[0031] Electrically coupling printed circuit boards with one or more conductive bands helps in the production of configurable boards for computer systems. As one example, as illustrated in **FIG. 8**, an L-shaped mother printed circuit board **820** may be electrically coupled to a suitable daughter printed circuit board **840** with conductive bands **861**, **862**, **863**, **864**, **865**, and **866**, for example, to produce an effectively single, planar board. Daughter printed circuit board **840** may be any suitable printed circuit board, such as a processor board, a memory board, or a communications board, such as a modem card or a local area network card for example. Electrically coupling printed circuit boards with one or more conductive bands allows for the manufacture of a variety of mother printed circuit boards and daughter printed circuit boards without concern for the type of mechanical connector required for electrical coupling of any one printed circuit board with another in producing configurable boards. Where solder is used for each conductive band, an effectively single, planar printed circuit board may be manufactured as the mother and daughter printed circuit boards are delivered through a wave solder.

[0032] A variety of differently shaped printed circuit boards may be electrically coupled with one or more conductive bands. As one example, as illustrated in **FIG. 9**, a circular printed circuit board **920** may be positioned in an accommodating opening of another printed circuit board **940** and electrically coupled to printed circuit board **940** with conductive bands **961**, **962**, **963**, and **964**, for example. Aside from circles, other suitable shapes such as ovals, triangles, stars, squares, etc. may also be considered for printed circuit board **920** and for the opening of printed circuit board **940**.

[0033] At least a portion of each printed circuit board may also be positioned over one another and electrically coupled with one or more conductive bands. As illustrated in **FIG. 10**, at least a portion of first printed circuit board **1020** may be positioned over at least a portion of second printed circuit board **1040**. A contact area **1022** on one side **1032** of first printed circuit board may be electrically coupled to a contact area **1042** on one side **1051** of second printed circuit board **1040** with a conductive band **1062**. Conductive band **1062** may comprise any suitable material and may be coupled to contact areas **1022** and **1042** in any suitable manner. For one embodiment, conductive band **1062** comprises a suitable solder. For other embodiments, each conductive band may comprise any suitable material and may be coupled between contact areas using a suitable cold formed weld technique,

a suitable pin point spot weld technique, or a suitable wire bonding technique, for example. Each conductive band may also comprise, for example, suitable conductive glue or adhesive, suitable conductive film, suitable conductive tape, or suitable conductive rope.

[0034] For one embodiment using conductive tape for each conductive band, a respective piece of conductive tape may be coupled between a pair of contact areas such that one or more conductive paths defined along the length or width of the tape electrically couples the pair of contact areas. For another embodiment, as illustrated in **FIG. 11**, a single piece of conductive tape **1160** defining a plurality of conductive paths **1161**, **1162**, and **1163**, for example, across the width of tape **1160** may be coupled between a plurality of contact areas **1122**, **1124**, and **1126** on a first printed circuit board **1120** and a plurality of contact areas **1142**, **1144**, and **1146** on a second printed circuit board **1140**, respectively. As the conductive paths of tape **1160** run only along the width of tape **1160** between first and second printed circuit boards **1120** and **1140**, tape **1160** may be placed over a plurality of contact areas on the same board without shorting any two contact areas on the same board. Tape **1160** may define only one or more than one conductive path per contact area coupling. Defining relatively more conductive paths per contact area coupling allows tape **1160** to be placed over contact areas **1122**, **1124**, **1126**, **1142**, **1144**, and **1146** with reduced concern for alignment of conductive paths between contact areas.

[0035] In the foregoing description, the invention has been described with reference to specific exemplary embodiments thereof. It will, however, be evident that various modifications and changes may be made thereto without departing from the broader spirit or scope of the present invention as defined in the appended claims. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.

What is claimed is:

1. An apparatus comprising:

a first printed circuit board having a contact area;

a second printed circuit board having a contact area; and

an electrically conductive band to couple the contact area of the first printed circuit board to the contact area of the second printed circuit board, wherein the conductive band couples the first printed circuit board and the second printed circuit board in a substantially coplanar position.

2. The apparatus of claim 1, wherein the conductive band is to couple contact areas on one side of the first and second printed circuit boards, the apparatus comprising another conductive band to couple contact areas on another side of the first and second printed circuit boards.

3. The apparatus of claim 2, wherein the first and second printed circuit boards each comprise a different number of layers.

4. The apparatus of claim 1, comprising a plurality of conductive bands to couple contact areas of the first and second printed circuit boards.

5. The apparatus of claim 1, wherein the first printed circuit board is a mother printed circuit board and the second printed circuit board is a daughter printed circuit board

selected from the group consisting essentially of a processor board, a memory board, and a communications board.

**6.** A method comprising:

positioning a first printed circuit board and a second printed circuit board in a substantially coplanar position; and

coupling a contact area of the first printed circuit board to a contact area of the second printed circuit board with a conductive band.

**7.** The method of claim 6, wherein the coupling comprises coupling contact areas on one side of the first and second printed circuit boards, the method comprising coupling contact areas on another side of the first and second printed circuit boards with another conductive band.

**8.** The method of claim 6, comprising coupling contact areas of the first and second printed circuit boards with a plurality of conductive bands.

**9.** The method of claim 6, wherein the first printed circuit board is a mother board and the second printed circuit board is selected from the group consisting essentially of a processor board, a memory board, and a communications board.

**10.** An apparatus comprising:

a first printed circuit board having a contact area;

a second printed circuit board having a contact area; and

an electrically conductive band to couple the contact area of the first printed circuit board to the contact area of the second printed circuit board, wherein the conductive band is selected from the group consisting essentially of a band coupled by a cold formed weld and a band coupled by a pin point spot weld.

**11.** The apparatus of claim 10, wherein the conductive band couples the first printed circuit board and the second printed circuit board in a substantially coplanar position.

**12.** The apparatus of claim 10, wherein the conductive band couples the first printed circuit board and the second printed circuit board in a non-coplanar position.

**13.** The apparatus of claim 10, wherein at least a portion of the first printed circuit board is positioned over at least a portion of the second printed circuit board.

**14.** The apparatus of claim 10, comprising a plurality of conductive bands to couple contact areas of the first and second printed circuit boards.

**15.** The apparatus of claim 10, wherein the first printed circuit board is a mother printed circuit board and the second printed circuit board is a daughter printed circuit board

selected from a group consisting of a processor board, a memory board, and a communications board.

**16.** The apparatus of claim 10, wherein the first printed circuit board defines an opening and the second printed circuit board resides in the opening.

**17.** The apparatus of claim 10, wherein the conductive band is to couple contact areas on one side of the first and second printed circuit boards, the apparatus comprising another conductive band to couple contact areas on another side of the first and second printed circuit boards.

**18.** The apparatus of claim 17, wherein the first and second printed circuit boards each comprise a different number of layers.

**19.** A method comprising:

positioning a first printed circuit board relative to a second printed circuit board; and

coupling a contact area of the first printed circuit board to a contact area of the second printed circuit board with a conductive band selected from the group consisting essentially of a band coupled by a cold formed weld and a band coupled by a pin point spot weld.

**20.** The method of claim 19, wherein the positioning comprises positioning the first printed circuit board and the second printed circuit board in a substantially coplanar position.

**21.** The method of claim 19, wherein the positioning comprises positioning the first printed circuit board and the second printed circuit board in a non-coplanar position.

**22.** The method of claim 19, wherein the positioning comprises positioning at least a portion of the first printed circuit board over at least a portion of the second printed circuit board.

**23.** The method of claim 19, wherein the coupling comprises coupling contact areas on one side of the first and second printed circuit boards, the method comprising coupling contact areas on another side of the first and second printed circuit boards with another conductive band.

**24.** The method of claim 19, comprising coupling contact areas of the first and second printed circuit boards with a plurality of conductive bands.

**25.** The method of claim 19, wherein the first printed circuit board is a mother board and the second printed circuit board is selected from the group consisting essentially of a processor board, a memory board, and a communications board.

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