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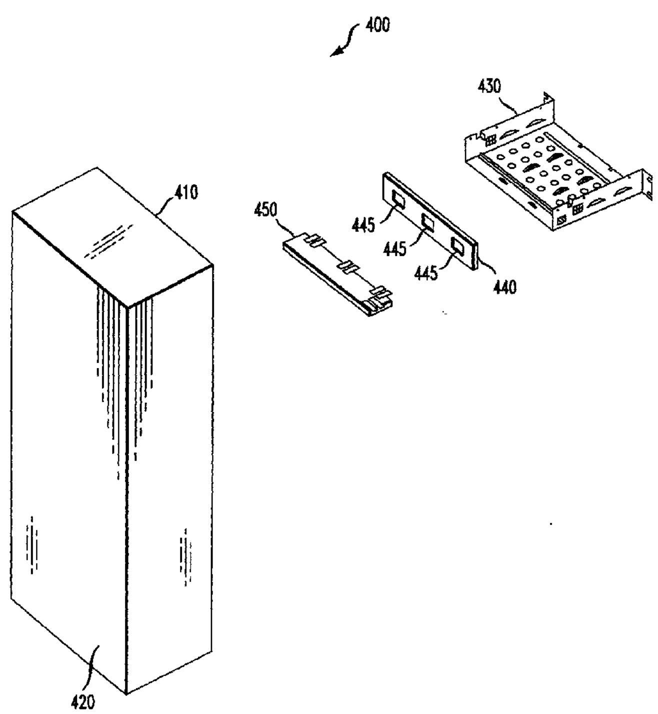
(54) **Rigid, multiconductor power distribution bus and modular equipment rack employing the same**

(57) For use with a backplane of an equipment rack, the backplane having power connectors affixed substantially linearly therealong, a power distribution bus for, and a method of, delivering electric power to the power connectors and an equipment rack containing the power distribution bus. In one embodiment, the power distribution bus includes: (1) a rigid substrate having conductive layers associated therewith and corresponding to first and second conductors of the power distribution bus and (2) first and second power terminals affixed to predetermined locations along the substrate and projecting therefrom to register with corresponding exposed first and second power terminals of the power connectors.

FIG. 4



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Description

Technical Field of the Invention

[0001] The present invention is directed, in general, to power distribution and, more specifically, to a rigid, multiconductor power distribution bus and modular equipment rack employing the power distribution bus.

Background of the Invention

[0002] A shelf or rack-mount system, having a plurality of bays into which modules can be inserted, is a commonly-used structure for coupling separate power supply modules together to provide a complete system. Typically, each power supply module has its own input requirements and output capabilities. A power supply is a device used to convert electrical energy from one form to another, e.g., converting an alternating current (AC) to direct current (DC), or vice versa, or to transform an AC or DC voltage to a different level. A power system may consist of one or more power supplies, which can be operated in parallel to provide greater energy capacity. For example, two AC-to-DC converters, each capable of providing 20 amps of current at a particular output voltage, can be coupled in parallel to provide 40 amps of current. A shelf-mount system is also often used in the telecommunications industry to house various system modules, including AC-to-DC rectifiers, DC-to-DC converters, "ringer" modules, etc.

[0003] A shelf-mount system typically includes a power distribution bus structure that includes a power receptacle, attached to a backplane of the shelf, to couple a module inserted into the shelf to a source of AC power. Each power receptacle includes power terminals, e.g., line and neutral, and an earth, or "ground," terminals. Conventional shelf-mount modules are constructed such that they can be easily inserted into a shelf-mount bay. To facilitate quick installation, equipment modules have included a conventional AC power connector, positioned at the rear of the module, that automatically engages an AC power receptacle in the shelf's backplane as the module is inserted.

[0004] A conventional method to provide AC power to the AC power receptacles in the shelf's backplane is to use either a wiring harness or a wiring harness and terminal blocks. A common problem with a power distribution bus utilizing a wiring harness is miswiring, e.g., line power is connected to a neutral terminal. Miswiring of the power distribution bus typically occurs during original installation or during subsequent maintenance. A serious consequence from miswiring the power distribution bus is destruction of the equipment modules that are installed in the shelf. Responding to customers' demands, equipment manufacturers are continually reducing their modules in size and "packing" more modules into the shelves, further exacerbating the miswiring problem. The more densely packed shelves increases the difficulty with the installation of the wiring harness making it more susceptible to miswiring.

[0005] Accordingly, what is needed in the art is an improved power distribution bus that overcomes the above-described limitations. More particularly, what is needed in the art is a power distribution bus that will substantially eliminate the possibility of miswiring.

Summary of the Invention

[0006] To address the above-discussed deficiencies of the prior art, the present invention provides, for use with a backplane of an equipment rack, the backplane having power connectors affixed substantially linearly therealong, a power distribution bus for, and a method of, delivering electric power to the power connectors and an equipment rack containing the power distribution bus. In one embodiment, the power distribution bus includes: (1) a rigid substrate having conductive layers associated therewith and corresponding to first and second conductors of the power distribution bus and (2) first and second power terminals affixed to predetermined locations along the substrate and projecting therefrom to register with corresponding exposed first and second power terminals of the power connectors.

[0007] The present invention therefore introduces the broad concept of employing a rigid substrate as a support for both the conductors of a power distribution bus and the first and second power terminals that extend therefrom to ensure proper registration with the corresponding first and second power terminals of power connectors. In a preferred embodiment, this proper registration prevents first and second power terminals from being cross-connected and therefore being miswired.

[0008] In one embodiment of the present invention, the first power terminals of the power connectors are line terminals and the second power terminals of the power connectors are neutral terminals. Alternatively, the first or second power terminals of the power connectors can be ground (or "earth") terminals. Further, the power distribution bus can include a conductor and power terminals corresponding to ground terminals of power connectors.

[0009] In one embodiment of the present invention, the first and second power terminals of the power connectors are blades and the first and second power terminals of the power distribution bus are spades. Alternatively, the blades and spades can be reversed, or can take the form of pins and receptacles or any other conventional or later-developed electrical coupling.

[0010] In one embodiment of the present invention, the first and second power terminals of the power distribution bus project from the substrate in a direction substantially parallel to a plane thereof. Alternatively, the first and second power terminals can project from the substrate in a direction substantially normal to the plane thereof.

[0011] In one embodiment of the present invention, the power connectors are International Electrotechnical Commission (IEC) power connectors. Those skilled in the art are familiar with such connectors and their widespread use in electrical apparatus today. The present invention can, of course, register with power terminals of other conventional or later-developed power connectors.

[0012] In one embodiment of the present invention, the substrate is a printed circuit board and the conductive layers are planar traces thereon. The traces may be advantageously sized to conduct a specified quantity of electrical current and shaped to minimize electromagnetic interference, as needed.

[0013] In one embodiment of the present invention, the first and second power terminals of the power distribution bus project from the substrate in different directions. This allows the power distribution bus to register with a line power input connector of a modular equipment rack, if such is desirable. Such embodiment will be illustrated and described hereinafter.

[0014] The foregoing has outlined, rather broadly, preferred and alternative features of the present invention so that those skilled in the art may better understand the detailed description of the invention that follows. Additional features of the invention will be described hereinafter that form the subject of the claims of the invention. Those skilled in the art should appreciate that they can readily use the disclosed conception and specific embodiment as a basis for designing or modifying other structures for carrying out the same purposes of the present invention. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the invention in its broadest form.

Brief Description of the Drawings

[0015] For a more complete understanding of the present invention, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

FIGURE 1 illustrates an exemplary backplane used in an equipment rack that supports power modules employing a conventional wiring scheme;
FIGURE 2A illustrates a side view of an embodiment of a power distribution bus constructed using the principles of the present invention;
FIGURE 2B illustrates a top view of an embodiment of a power distribution bus constructed using the principles of the present invention;
FIGURE 3 illustrates a flow diagram of an embodiment of a process to manufacture the power distribution bus illustrated in FIGUREs 2A and 2B; and
FIGURE 4 illustrates an exemplary modular equipment rack that provides a suitable environment for the practice of the present invention.

Detailed Description

[0016] Referring initially to FIGURE 1, illustrated is an exemplary backplane 100 used in an equipment rack that supports power modules employing a conventional wiring scheme. The backplane 100 includes a plurality of power connectors (generally designated as 110) such as International Electrotechnical Commission (IEC) power connectors. The power connectors 110 are shown connected to a power source (not shown) using a conventional power distribution scheme; in the illustrated embodiment, a cable harness 120 is employed wherein the power connectors 110 are coupled to the power source in a "daisy-chained" structure. Each of the power connectors 110 also includes first, second and third power terminals 130, 140, 150 that corresponds to line, or "hot," neutral and earth terminals, respectively.

[0017] As discussed previously, with a conventional power distribution scheme, such as the cable harness 120, miswiring of the first, second and third power terminals 130, 140, 150 is always a potential possibility with serious consequences, which may include the destruction of electronic components which are coupled to the power source via the power connectors 110.

[0018] The present invention discloses a power distribution scheme that substantially eliminates the possibility of miswiring the power connectors that is inherent in conventional wiring schemes. The power distribution bus disclosed by the present invention is described in greater detail by referring to FIGUREs 2A and 2B.

[0019] Turning now to FIGUREs 2A and 2B, illustrated are views of an embodiment of a power distribution bus 200 constructed using the principles of the present invention. More specifically, FIGURE 2A illustrates a side view of an embodiment of a power distribution bus 200 constructed using the principles of the present invention. FIGURE 2B illustrates a top view of an embodiment of a power distribution bus 200 constructed using the principles of the present invention.

[0020] The power distribution bus 200 includes a rigid substrate 210 that has conductive layers, corresponding to first and second conductors 220, 230, respectively. In the illustrated embodiment, the substrate 210 is substantially planar and is composed of a nonconductive material such as epoxy-glass, polyester-glass or flex polyimide. In another embodiment, the substrate 210 is a printed circuit board and the conductive layers are planar traces on the substrate 210. Also shown are a plurality of first and second power terminals (generally designated as 240 and 250, respectively) coupled to the first and second conductors 220, 230, respectively. In the illustrated embodiment, the first and second power terminals 240, 250 are line and neutral terminals, respectively, which correspond in location to the first and second power terminals 130, 140 of the backplane 100 illustrated in FIGURE 1. It should be noted that the term "rigid" is used within the context of the present invention to include a material with sufficient rigidity, e.g., polyimide, such that proper registration (alignment) between the power terminals of the backplane and the substrate can be maintained.

[0021] Turning now to FIGURE 3, with continuing reference to FIGUREs 2A and 2B, illustrated is a flow diagram of an embodiment of a process 300 to manufacture the power distribution bus 200 illustrated in FIGUREs 2A and 2B. The process 300 begins in step 305. A substrate, such as a printed circuit board, is formed in step 310.

[0022] In step 320, conductive layers, corresponding to the first and second conductors 220. 230, are formed as planar traces on the substrate using conventional methods that are well known in the art. The first and second conductors are generally formed on separate sides of the substrate with the substrate functioning as an electrical insulator between the two conductive layers. Those skilled in the art should readily recognize that the conductive layers may also be deposited on one side of the substrate only, with an insulated barrier between the two conductors. In advantageous embodiments, the conductive traces are sized accordingly, e.g., based on design specifications or anticipated maximum current draw, to conduct a specific quantity of electrical current. Additionally, the conductive traces may be shaped so as to minimize electromagnetic interference.

[0023] In step 330, following the formation of the conductive layers, the power terminals (first and second power terminals 240, 250 illustrated in FIGURE 2) are attached to the substrate using conventional fastening methods well known in the art, such as soldering. In an advantageous embodiment, the power terminals are projected from the substrate in a direction substantially parallel to a plane of the substrate. In other advantageous embodiments, the first and second power terminals 240, 250 are projected from the substrate in different directions. Those skilled in the art are aware that the power terminals orientation, with respect to each other, is primarily (although not necessarily) dependent on their mating receptacles orientation within the power connectors. For example, the first power terminal 240 may be orientated at a right angle (90°) from the second power terminal 250 as illustrated by the plurality of phantom outlines (generally designated 245) in FIGURE 2. Each power terminal is also coupled to a particular conductive layer, e.g., the first power terminal 240 is coupled to the first conductor 220 and the second power terminal 250 is coupled to the second conductor 230.

[0024] The power terminals are located on the substrate at predetermined locations that will align the power terminals with their respective mating power terminals of the power connectors, i.e., line and neutral terminals, which are located on the backplane 100 illustrated in FIGURE 1. In the power distribution bus 200, a pair of power terminals are also shown projecting from the power distribution bus 200 in a different direction from the other power terminals. This will allow the power distribution bus 200 to register with a line power input connector (not shown) of a modular equipment rack to couple the first and second conductors 220, 230 to a power source. In an advantageous embodiment, the power terminals of the power distribution bus are spades and the power terminals of the power connectors are blades. Those skilled in the art should readily appreciate that the blades and spades can be reversed, or may take the form of pins and receptacles or any other conventional or later-developed electrical coupling methods.

[0025] Following the attachment of the power terminals to the power distribution bus, the process 300 ends in step 340.

[0026] Turning now to FIGURE 4, illustrated is an exemplary modular equipment rack 400 that provides a suitable environment for the practice of the present invention. The modular equipment rack includes a conventional cabinet 410 with a standard frame; the rear wall is designated 420. Also shown is a shelf 430 that will be located inside and attached to the frame of the cabinet 410. The shelf 430 is used to support equipment modules, such as power processing modules, inside the cabinet 410. A backplane 440 with a plurality of power connectors (generally designated as 445) is attached to one end of the shelf 430 to provide electrical power to the equipment modules. A power distribution bus 450, constructed using the principles of the present invention, couples a source of electrical power (not shown) to the power connectors 445. As illustrated in FIGURE 4, the miswiring problem inherent in convention power distribution schemes is substantially eliminated. To attach the power distribution bus 450 to the backplane 440 requires that the line and neutral terminals of the power distribution bus 450 be aligned with their respective line and neutral mating terminals of the power connectors 445 thereby substantially eliminating the possibility of miswiring.

[0027] From the above, it is apparent that the present invention provides a power distribution bus that includes: (1) a rigid substrate having conductive layers associated therewith and corresponding to first and second conductors of the power distribution bus and (2) first and second power terminals affixed to predetermined locations along the substrate and projecting therefrom to register with corresponding exposed first and second power terminals of the power connectors.

[0028] Although the present invention has been described in detail, those skilled in the art should understand that they can make various changes, substitutions and alterations herein without departing from the spirit and scope of the invention in its broadest form.

Claims

1. For use with a backplane of an equipment rack, said backplane having power connectors affixed substantially linearly therealong, a power distribution

bus for delivering electric power to said power connectors, comprising:

a rigid substrate having conductive layers associated therewith and corresponding to first and second conductors of said power distribution bus; and
first and second power terminals affixed to predetermined locations along said substrate and projecting therefrom to register with corresponding exposed first and second power terminals of said power connectors.

2. For use with a backplane of an equipment rack, said backplane having power connectors affixed substantially linearly therealong, a method of manufacturing a power distribution bus to deliver electric power to said power connectors, comprising the steps of:

forming conductive layers on a rigid substrate, said conductive layers corresponding to first and second conductors of said power distribution bus; and
affixing first and second power terminals to predetermined locations along said substrate, said first and second power terminals projecting from said substrate for registration with corresponding exposed first and second power terminals of said power connectors.

3. A modular equipment rack, comprising: a cabinet having a rear wall;

a shelf, located within and coupled to said cabinet, that supports equipment modules within said cabinet;
a backplane having power connectors affixed substantially linearly therealong; and
a power distribution bus for delivering electric power to said power connectors, including:
a rigid substrate having conductive layers associated therewith and corresponding to first and second conductors of said power distribution bus, and
first and second power terminals affixed to predetermined locations along said substrate and projecting therefrom to register with corresponding exposed first and second power terminals of said power connectors.

4. The bus of claim 1, or the method of claim 2, or the rack of claim 3, wherein said first power terminals of said power connectors are line terminals and said second power terminals of said power connectors are neutral terminals.

5. The bus of claim 1, or the method of claim 2, or the rack of claim 3, wherein said first and second power terminals of said power connectors are blades and said first and second power terminals of said power distribution bus are spades.

6. The bus of claim 1, or the method of claim 2, or the rack of claim 3, wherein said first and second power terminals of said power distribution bus project from said substrate in a direction substantially parallel to a plane thereof.

7. The bus of claim 1, or the method of claim 2, or the rack of claim 3, wherein said power connectors are International Electrotechnical Commission (IEC) power connectors.

8. The bus of claim 1, or the method of claim 2, or the rack of claim 3, wherein said substrate is a printed circuit board and said conductive layers are planar traces thereon.

9. The bus of claim 1, or the method of claim 2, wherein said first and second power terminals of said power distribution bus project from said substrate in different directions.

10. The modular equipment rack as recited in claim 3, wherein said first and second power terminals of said power distribution bus project from said substrate in different directions to register with a line power input connector of said modular equipment rack.

FIG. 1

PRIOR ART

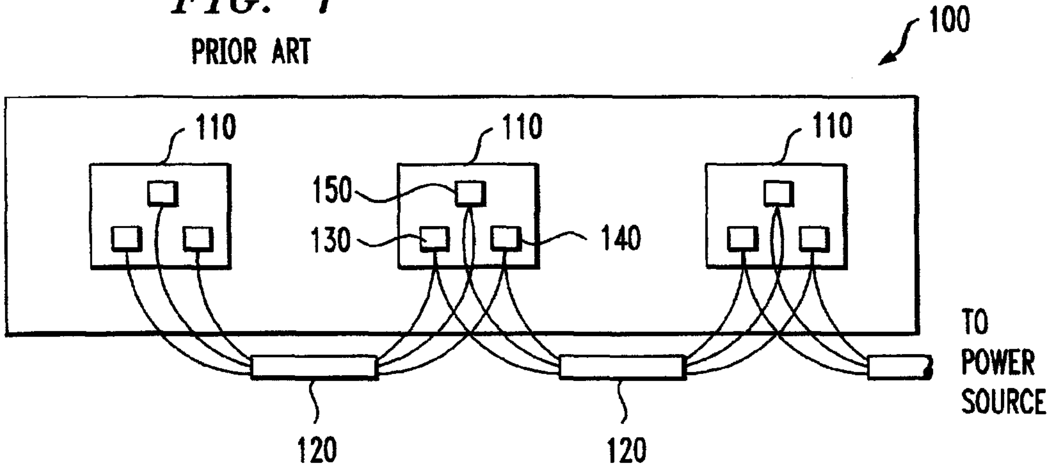

FIG. 2A

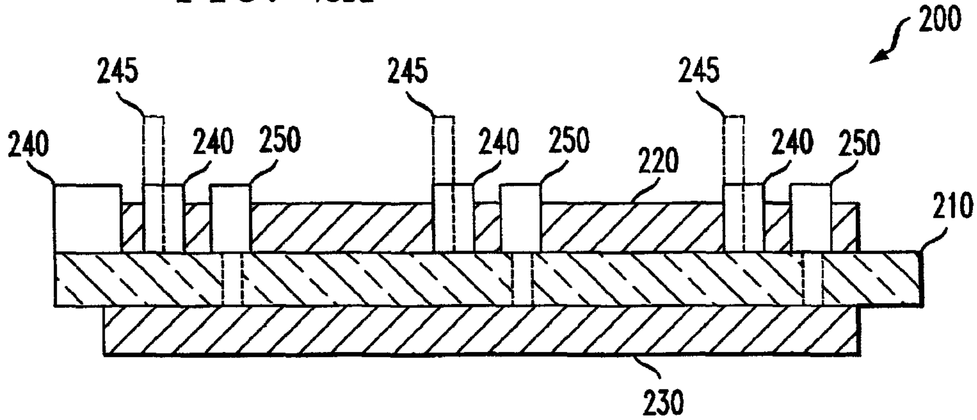

FIG. 2B

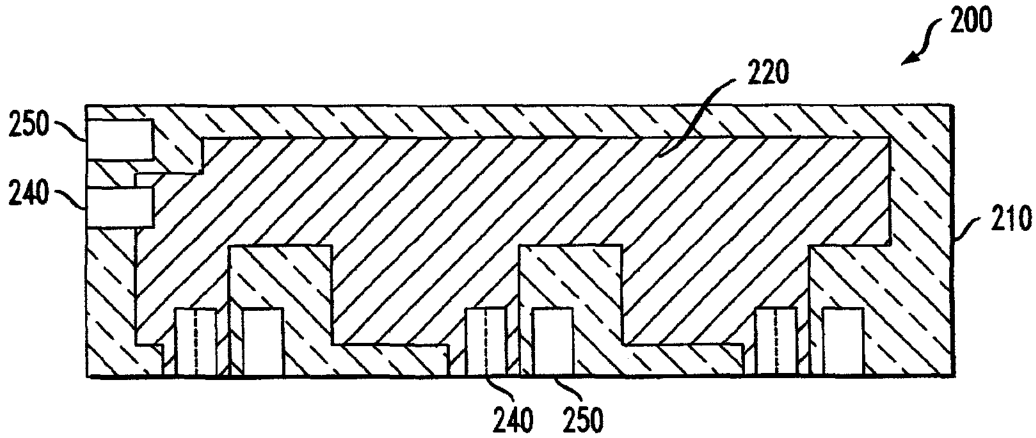

FIG. 3

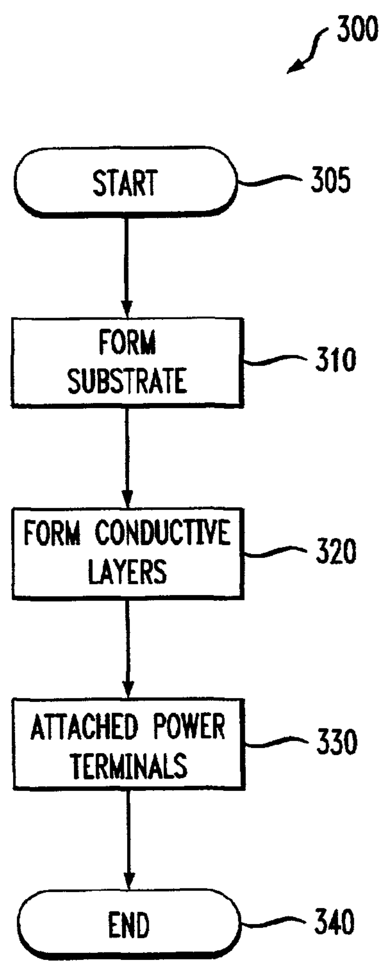
300
START
305
FORM SUBSTRATE
310
FORM CONDUCTIVE LAYERS
320
ATTACHED POWER TERMINALS
330
END
340

FIG. 4