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Krenz et al.

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(54) **POWER DISTRIBUTION UNIT AND METHOD OF DISTRIBUTING HIGH DENSITY POWER**

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H02J 4/00 (2006.01)
H05K 7/14 (2006.01)

(52) **U.S. Cl.**
CPC ***H05K 7/1457*** (2013.01); *Y10T 307/696* (2015.04)

(58) **Field of Classification Search**
CPC H05K 7/1457; Y10T 307/696
USPC 307/10.1, 43, 80
See application file for complete search history.

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(57) **ABSTRACT**

A power distribution unit includes a first solid state power module comprising a first plurality of solid state power controllers, where the first solid state power module comprises a first set of power characteristics. Also included is a second solid state power module comprising a second plurality of solid state power controllers. The second solid state power module comprises a second set of power characteristics. Also, the first solid state power module and the second solid state power module are interchangeably coupled to a first location of a common chassis.

7 Claims, 3 Drawing Sheets

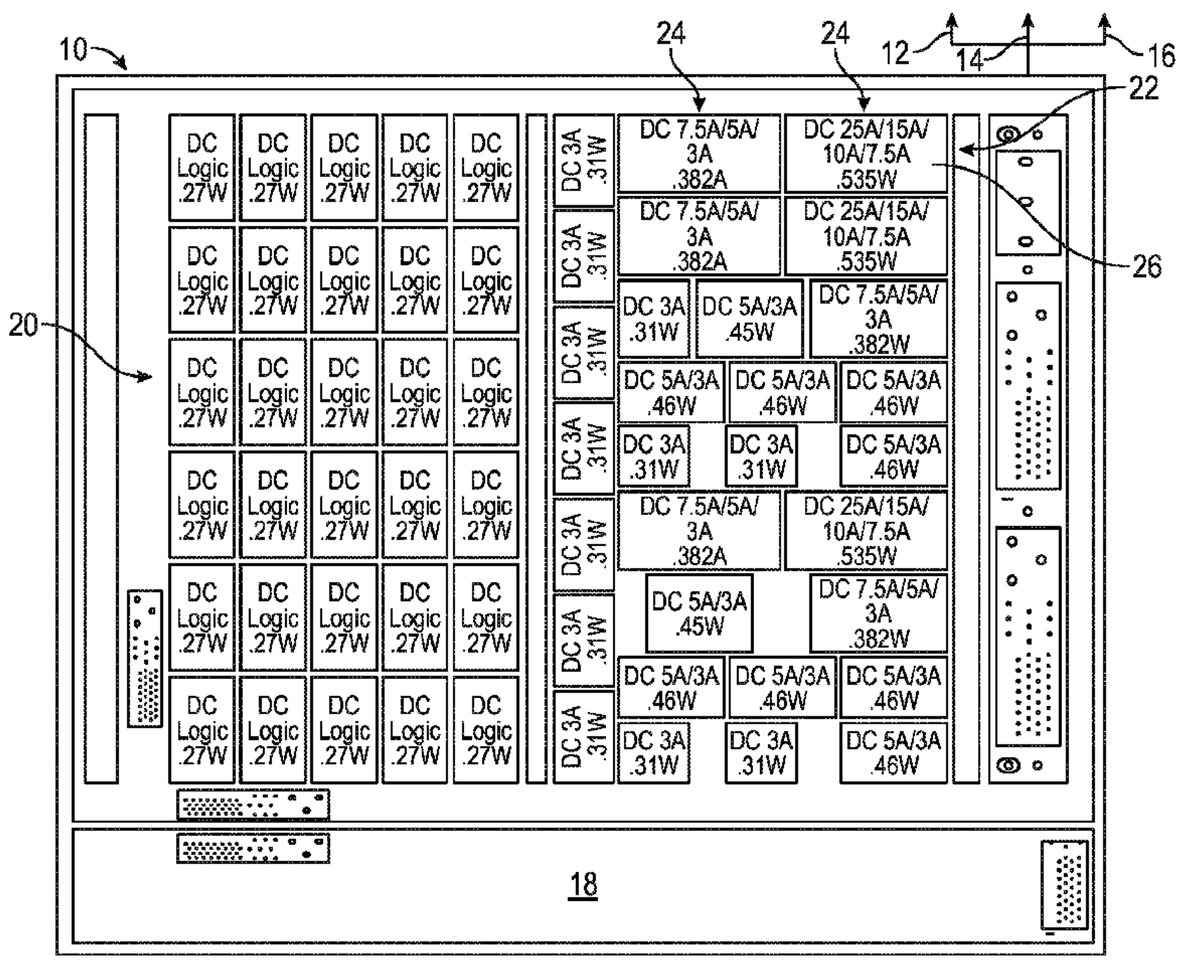
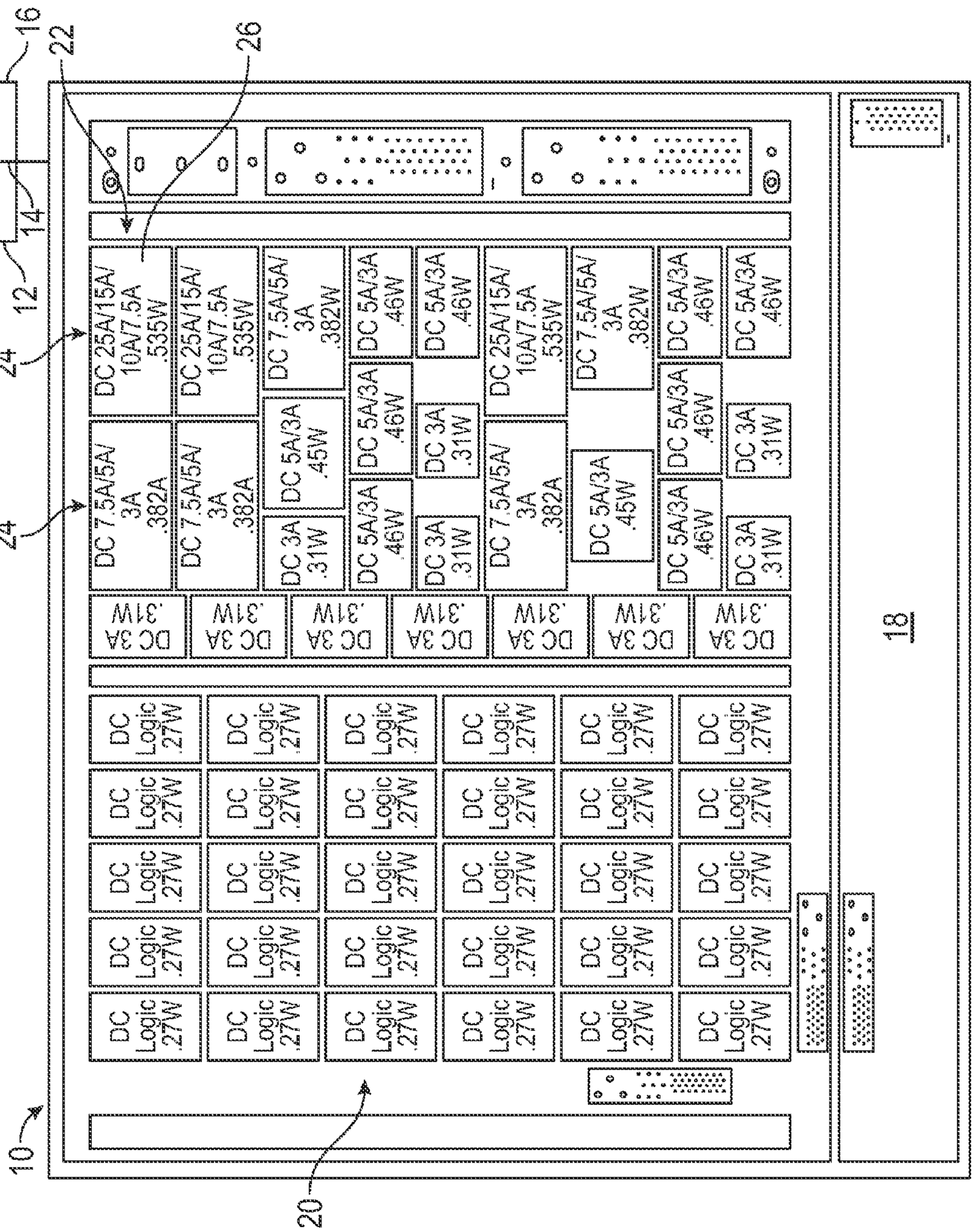


FIG. 1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22
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12
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20
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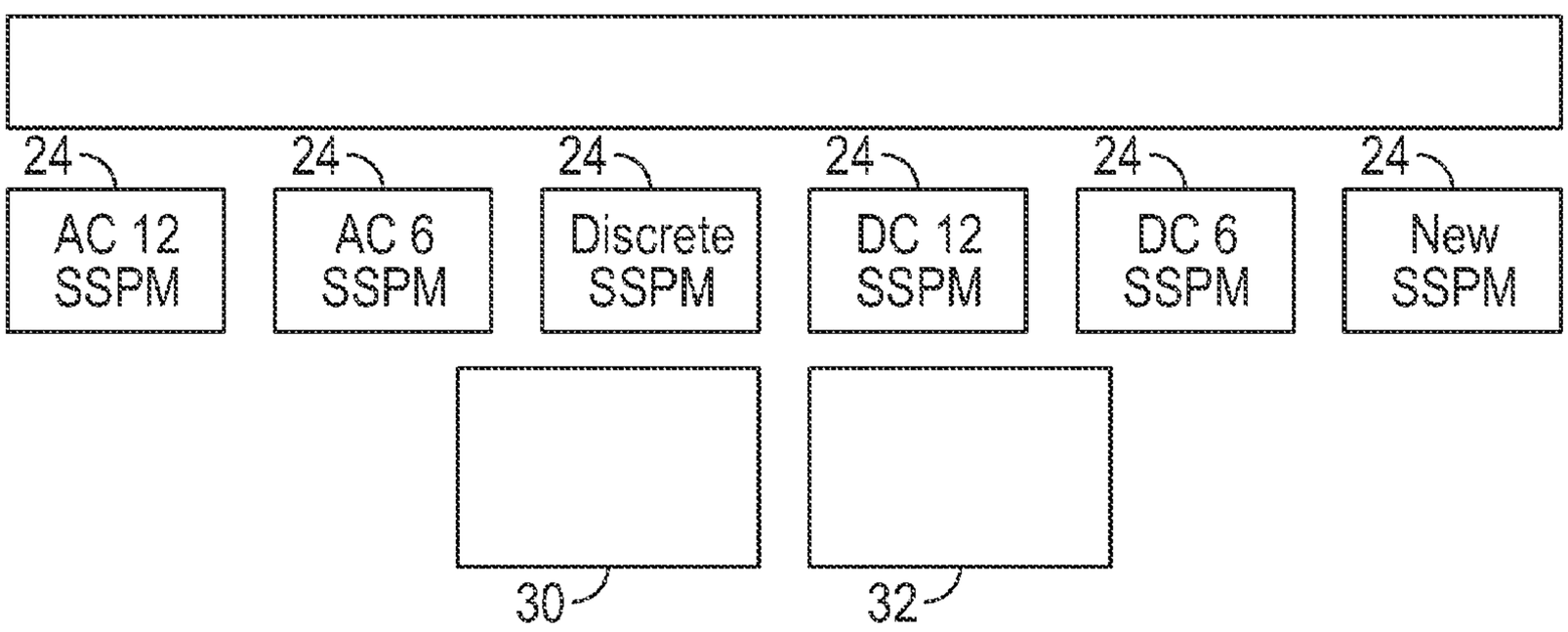

FIG. 2

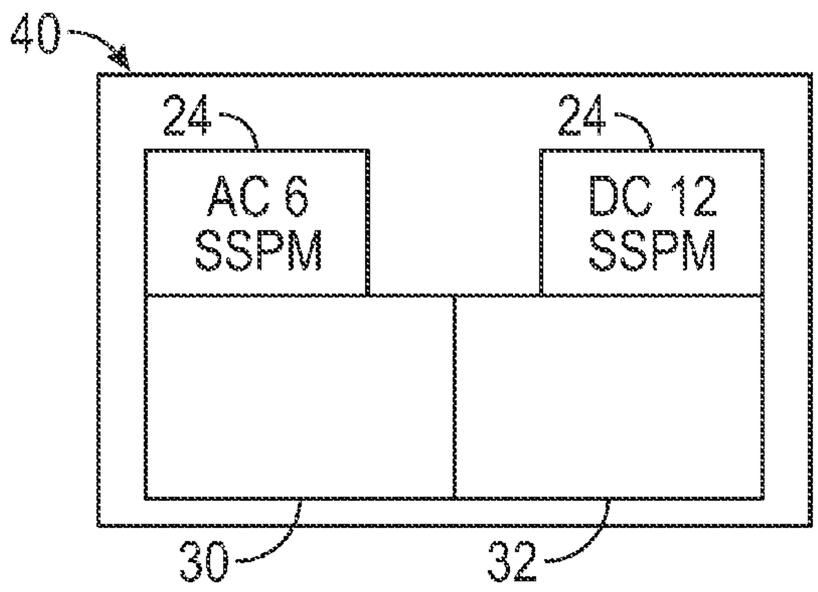

FIG. 3

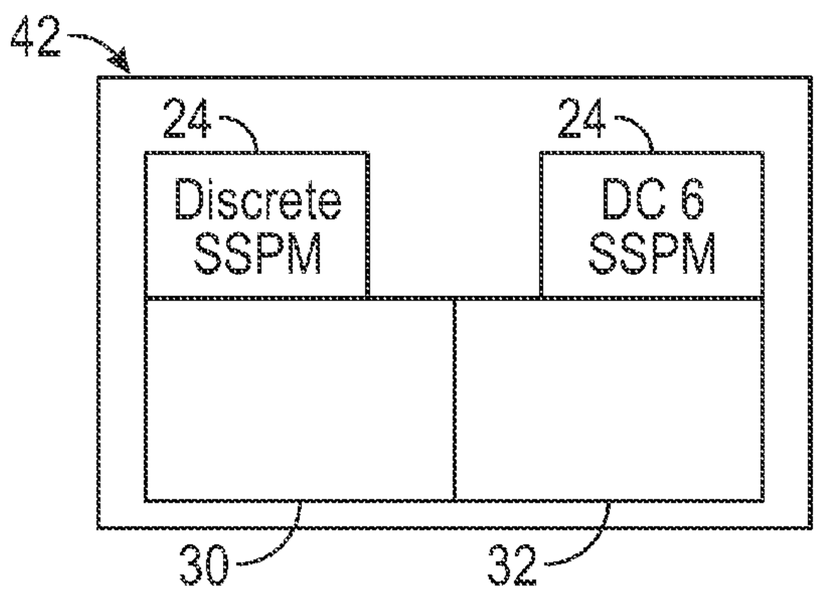

FIG. 4

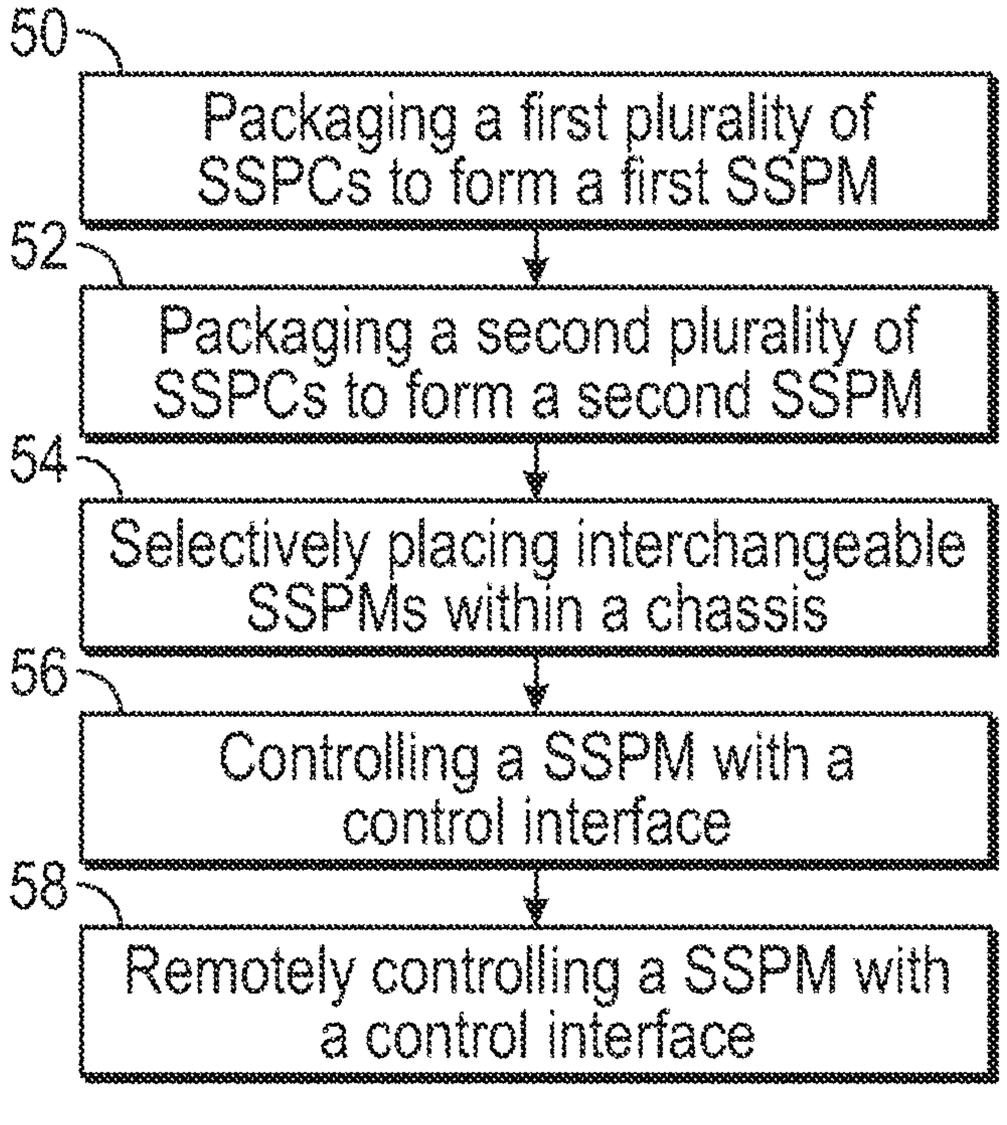
50
Packaging a first plurality of SSPCs to form a first SSPM
52
Packaging a second plurality of SSPCs to form a second SSPM
54
Selectively placing interchangeable SSPMs within a chassis
56
Controlling a SSPM with a control interface
58
Remotely controlling a SSPM with a control interface

FIG. 5

POWER DISTRIBUTION UNIT AND METHOD OF DISTRIBUTING HIGH DENSITY POWER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 61/453,249, filed Mar. 16, 2011.

BACKGROUND OF THE INVENTION

The present invention relates to power distribution systems, and more particularly to high density power systems and methods of high density power distribution.

Applications requiring power distribution often have severe space constraints for power distribution system components. An example of such an application is a vehicle, such as an aircraft. The limited space available for system components drives the requirement for high density power distribution. The power distribution system must be sufficiently compact, while still being adequately configured to distribute power to typically several loads. The loads include various types of protection against over-current, over and under-frequency, arc fault, and ground fault, to name a few potential sources of disruptions to load functionality. Circuit breaker panels are sized to attempt to fit into the space constrained areas, which are often unavailable during flight and are difficult to access on the ground, in the case of an aircraft.

BRIEF DESCRIPTION OF THE INVENTION

According to one embodiment, a power distribution unit includes a first solid state power module comprising a first plurality of solid state power controllers, where the first solid state power module comprises a first set of power characteristics. Also included is a second solid state power module comprising a second plurality of solid state power controllers. The second solid state power module comprises a second set of power characteristics. Also, the first solid state power module and the second solid state power module are interchangeably coupled to a first location of a common chassis.

According to another embodiment, a method of distributing high density power is provided. The method includes packaging a first plurality of solid state power controllers to form a first solid state power module, where the first solid state power module comprises a first set of power characteristics. Also included is packaging a second plurality of solid state power controllers to form a second solid state power module, where the second solid state power module comprises a second set of power characteristics. Further included is selectively placing one of the first solid state power module and the second solid state power module within a first position of a chassis, where the first solid state power module and the second solid state power module are interchangeable. Yet further included is controlling one of the first solid state power module and the second solid state power module with a control interface.

BRIEF DESCRIPTION OF THE DRAWINGS

The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. **1** schematically illustrates a power distribution unit having a logic section and a power section;

FIG. **2** illustrates a block diagram of a plurality of solid state power modules;

FIG. **3** illustrates a block diagram of a power block arranged in a first configuration;

FIG. **4** illustrates a block diagram of the power block arranged in a second configuration; and

FIG. **5** is a flow diagram illustrating a method of distributing high density power.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. **1**, a power distribution unit is generally schematically illustrated with reference numeral **10**. The power distribution unit **10** may be employed in a variety of applications, such as an aircraft or another vehicle (not illustrated), for example. The vehicle includes a plurality of powered vehicle systems **12**, **14**, **16**. The power distribution unit **10** provides power to the powered vehicle systems **12**, **14**, **16** and is supplied power by a power supply **18**.

The power distribution unit **10** comprises a logic section **20** and a power section **22**, with the power section **22** being made up, at least in part, by one or more solid state power modules (SSPMs) **24**, each having a plurality of solid state power controllers (SSPCs) **26**. The SSPCs **26** employs transistors to provide a switching function and use electronics to provide a circuit breaker function to protect wiring associated with the power vehicle systems **12**, **14**, **16**. The SSPMs **24**, based on the composition of SSPCs **26**, provide a variety of system protections including, but not limited to, integrated current sensing, over-current, and over-temperature protection, to name simply a few illustrative examples. Individually, the SSPCs **26** function as arc fault protection, ground fault protection, and when used as part of a larger protection network, provide differential current protection. Each of the SSPCs **26** includes a power supply (not shown) that facilitates operation of the SSPCs **26**. The SSPMs **24** include a first side and a second side and the SSPCs **26** are configured to mount to either the first side or the second side of the SSPMs **24**, thereby providing a more compact packaging of the SSPCs **26** and making more efficient use of limited space provided for the power distribution unit **10**. The plurality of SSPCs **26** that are mounted to, or packaged as, each SSPM **24** comprise a specific set of power characteristics for each SSPM **24**. The power characteristics vary between distinct SSPMs **24** and provide various functionalities, depending on the assembly of SSPCs **26**. In operation, the logic section **20** senses current at various locations proximate the SSPCs **26** to determine if appropriate functionality is occurring. In the event of a disruptive condition, the SSPCs **26** may be switched to an "off" condition. Specifically, the logic section **20** and the SSPCs **26** may include various components that are configured to receive and transmit data related to operation of the SSPCs **26**, among other things. Such components may include microcontrollers and communications interfaces.

Referring to FIG. **2**, one or more SSPMs **24** are placed within a common chassis **30** and a common backplane **32**. As described above, SSPMs **24** having a variety of power characteristics that are available for assembly and can be interchangeably used at various locations within the power distribution unit **10** (FIG. **1**), and more specifically within the power section **22** (FIG. **1**). The ability to selectively configure the SSPMs **24** having various power characteristics provides assembling flexibility and a more diverse set of power characteristics to employ in the power distribution unit **10**. It is to be appreciated that the SSPMs **24** are reusable clusters that

may be installed in various configurations on the common chassis **30** and the common backplane **32**.

Referring to FIGS. **3** and **4**, a first SSPM family **40** and a second SSPM family **42** are illustrated and it is shown that the first SSPM family **40** and the second SSPM family **42** each include distinct SSPMs **24** that are interchangeable, such that a first SSPM **24** could be positioned in replacement of a second SSPM **24**, if an alteration of power characteristics for a particular application was desired. Irrespective of the particular installation configuration of the SSPMs **24**, a consistent communication control interface is employed. By providing consistent communication control, regardless of the specific SSPM **24** arrangement, greater assembly flexibility is available without requiring rearrangement or alteration of the control interface. It is to be understood that the illustrated embodiments include two SSPMs, however, any number of SSPMs may be employed to comprise the SSPM family.

The SSPM families **40**, **42** may be part of a power block that provides functionality within the power distribution unit **10**. The term "power block" conceptually refers to hardware structure that functionally monitors and protects at least one load, but typically a plurality of load circuits. Nominally, this may include solid state power controllers (SSPCs), control logic, processing logic, internal communications busses, and power supplies to power various control elements. The protected load is any device that consumes power. This can be as simple as a resistive heating element in an air data probe, a light bulb disposed in the application, such as an aircraft, or as complex as a motor controller used to drive a hydraulic pump. By monitoring and controlling operating conditions that loads and power distribution units are encountering, the SSPCs **26** have the ability to quickly and flexibly switch power sources and limit or disrupt power to selected loads in the event of harmful operating conditions.

The power distribution unit **10** also includes a combination of remote data concentration modules and remote power control modules that are not in direct contact with the power distribution unit **10**, but are in operable communication with the power distribution unit. The remote data concentration modules and the remote power control modules are configured to facilitate remote control of the various circuit protections that the power distribution unit **10** provides. This is particularly useful in applications such as the instant case, where the spaces in which the power distribution unit **10** is disposed may be difficult to access, or even completely inaccessible during operation.

Referring to FIG. **5**, a method of distributing high density power is illustrated. The power distribution unit **10** has been previously described and specific components need not be described in further detail. The method includes packaging a first plurality of SSPCs **50** to form a first SSPM. As described above, the specific SSPCs packaged to form the first SSPM provides a first set of power characteristics. Similarly, packaging a second plurality of SSPCs **52** to form a second SSPM provides a second set of power characteristics. Based on the application of use, at least one of the first SSPM and the second SSPM is selectively placed **54** within the chassis to form a power block. Irrespective of whether the first SSPM or the second SSPM is placed on a particular location of the chassis, the method includes controlling **56** a SSPM family with a control interface that provides consistent communication control. Additionally, the SSPM may be remotely controlled **58** with a remote data module and/or a remote power control module.

Accordingly, the previously described packaging scheme for the power distribution unit **10** adequately addresses tight spatial constraints imposed in certain applications, while also providing a consistent communication control with the control interface that communicates with the power block.

While the invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

The invention claimed is:

1. A power distribution unit comprising:

a first solid state power module comprising a first plurality of solid state power controllers, wherein the first solid state power module comprises a first set of power characteristics;

a second solid state power module comprising a second plurality of solid state power controllers, wherein the second solid state power module comprises a second set of power characteristics, wherein the first solid state power module and the second solid state power module are interchangeably coupled to a first location of a common chassis;

a first side and a second side of the each of the solid state power modules, the first side having at least one first side mounting component, the second side having at least one second side mounting component, wherein the first and second plurality of solid state power controllers are configured to mount to the first side and the second side of the solid state power modules;

a plurality of common chassis locations, wherein a plurality of interchangeable solid state power modules are interchangeably coupled to the plurality of common chassis locations; and

a plurality of remote data concentration modules and a plurality of remote power control modules, wherein the control interface is configured to control the plurality of remote data concentration modules and the plurality of remote power control modules.

2. The power distribution unit of claim **1**, further comprising a control interface in operable communication with the power distribution unit, wherein the control interface is configured to control the first solid state power module and the second solid state power module.

3. The power distribution unit of claim **2**, wherein the control interface is configured to control the plurality of remote data concentration modules and the plurality of remote power control modules.

4. The power distribution unit of claim **1**, wherein the solid state power module comprises a common backplane.

5. A method of distributing high density power comprising:

packaging a first plurality of solid state power controllers to form a first solid state power module, wherein the first solid state power module comprises a first set of power characteristics, wherein the first solid state power controllers are configured to be mounted to a first side of the first solid state power module and a second side of the first solid state power module;

packaging a second plurality of solid state power controllers to form a second solid state power module, wherein the second solid state power module comprises a second set of power characteristics, wherein the second solid

state power controllers are configured to be mounted to a first side of the second solid state power module and a second side of the second solid state power module;

selectively placing the first solid state power module and the second solid state power module within respective positions of a plurality of positions of a chassis, wherein the first solid state power module and the second solid state power module are interchangeably mounted to the plurality of positions of the chassis;

controlling one of the first solid state power module and the second solid state power module with a control interface;

interchangeably mounting the first solid state power controllers and the second solid state power controllers to the first solid state power module and the second solid state power module to provide reconfigurable power characteristics of the solids state power modules;

integrating at least one remote data module and at least one remote power control module; and

controlling the at least one remote data module and the at least one remote power control module with the control interface.

6. The method of claim **5**, further comprising selectively packaging a plurality of solid state power modules to form a solid state power module family, wherein the solid state power module family comprises a plurality of alternative configurations.

7. The method of claim **6**, further comprising controlling the power block with the control interface.

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