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(54) **MODULAR POWER DEVICE**

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See application file for complete search history.

(71) Applicant: **Chicony Power Technology Co., Ltd.**,
New Taipei (TW)

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(72) Inventors: **Yung-Hung Hsiao**, New Taipei (TW);
Ju-Tang Lo, New Taipei (TW);
Yen-Ming Chen, New Taipei (TW);
Hao-Te Hsu, New Taipei (TW); **Pei-Li Chang**, New Taipei (TW); **Chia-Hsien Yen**, New Taipei (TW); **Shin-Bin Lin**, New Taipei (TW); **Yu-Hsuan Wu**, New Taipei (TW); **Chih-Hang Lee**, New Taipei (TW); **Huei-Fang Lin**, New Taipei (TW); **Ping-Yu Chen**, New Taipei (TW); **Chi-Chang Ho**, New Taipei (TW)

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(73) Assignee: **CHICONY POWER TECHNOLOGY CO., LTD.**, New Taipei (TW)

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Primary Examiner — Yuriy Semenenko

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(74) *Attorney, Agent, or Firm* — Chun-Ming Shih; HDLS IPR Services

Related U.S. Application Data

(62) Division of application No. 13/647,385, filed on Oct. 9, 2012, now Pat. No. 9,198,319.

(57) **ABSTRACT**

(30) **Foreign Application Priority Data**

Jul. 23, 2012 (TW) 101126470 A

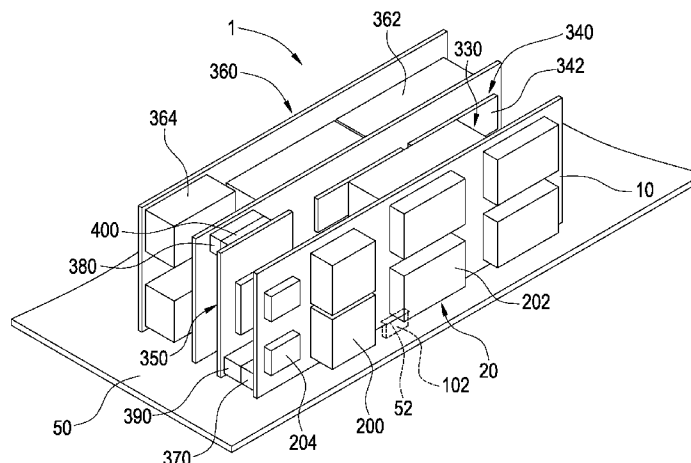
A modular power device is used for mounting on a main plate. The modular power device includes a first substrate, a driving module, and a converting module. The first substrate having a first axial direction and a second axial direction perpendicular to the first axial direction is inserted into the main plate to make the second axial direction be perpendicular to the main plate. The driving module is located on one side of the first substrate, and the converting module is located on the other side of the first substrate and includes a second substrate, wherein the second substrate is inserted into the main plate. A length of the converting module is substantially equal to that of the first substrate in the first axial direction, and a width of the converting module is smaller than a length of the first substrate in the first axial direction.

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H05K 5/00 (2006.01)
H05K 7/08 (2006.01)
H05K 7/02 (2006.01)

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CPC . **H05K 7/08** (2013.01); **H05K 7/026** (2013.01)

(58) **Field of Classification Search**
CPC H05K 7/1432; H05K 1/18

2 Claims, 12 Drawing Sheets



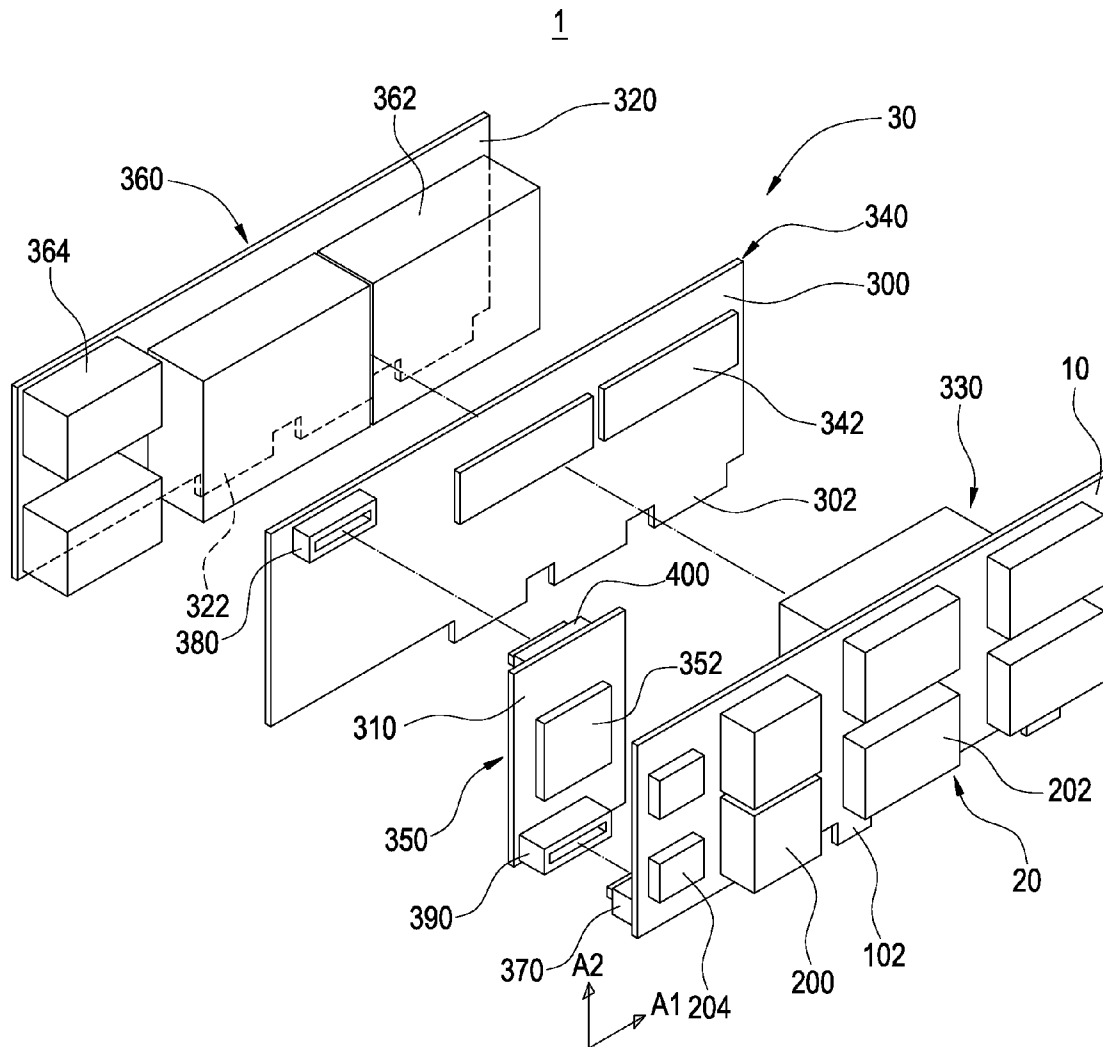


FIG.1

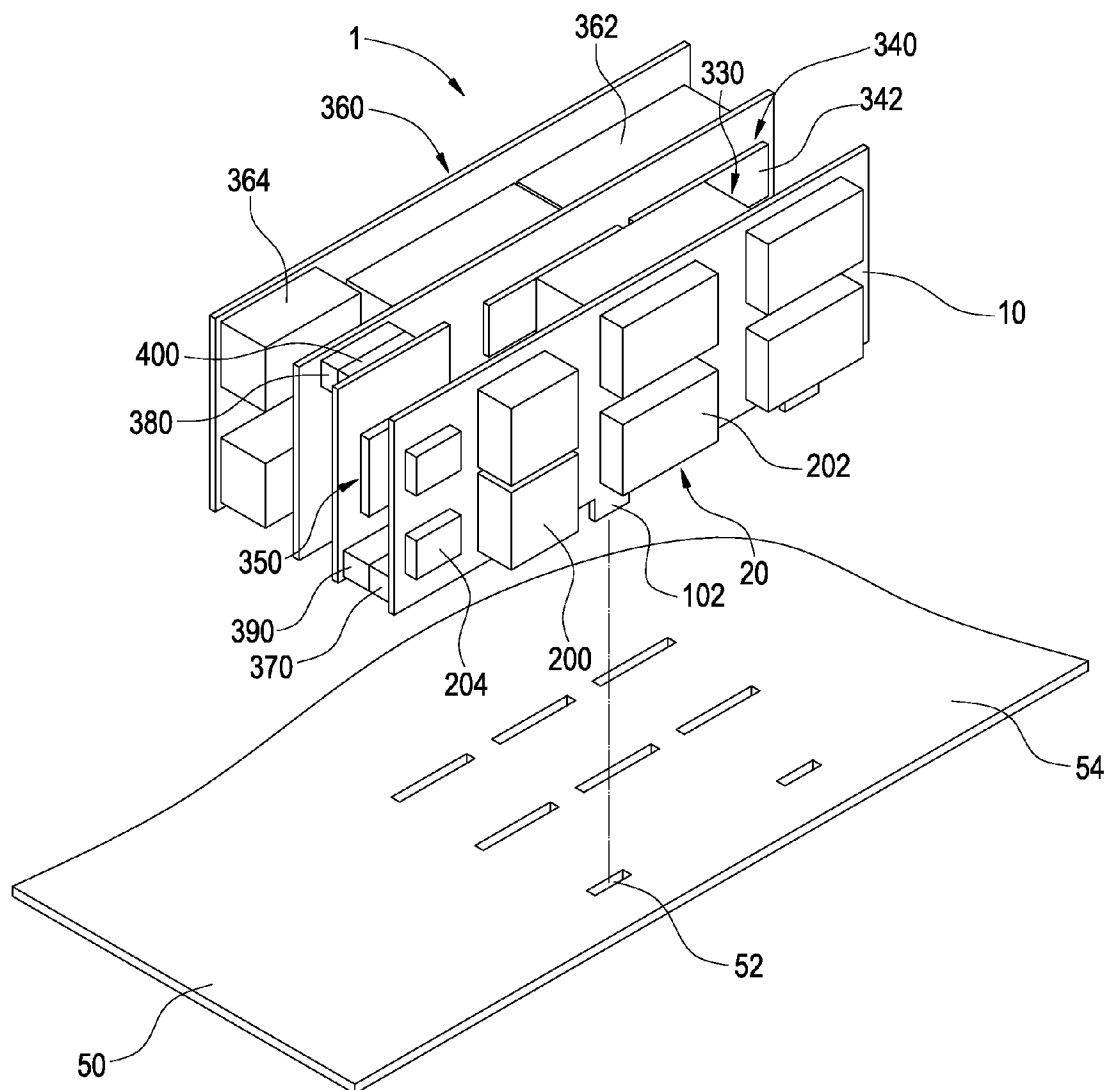


FIG.2

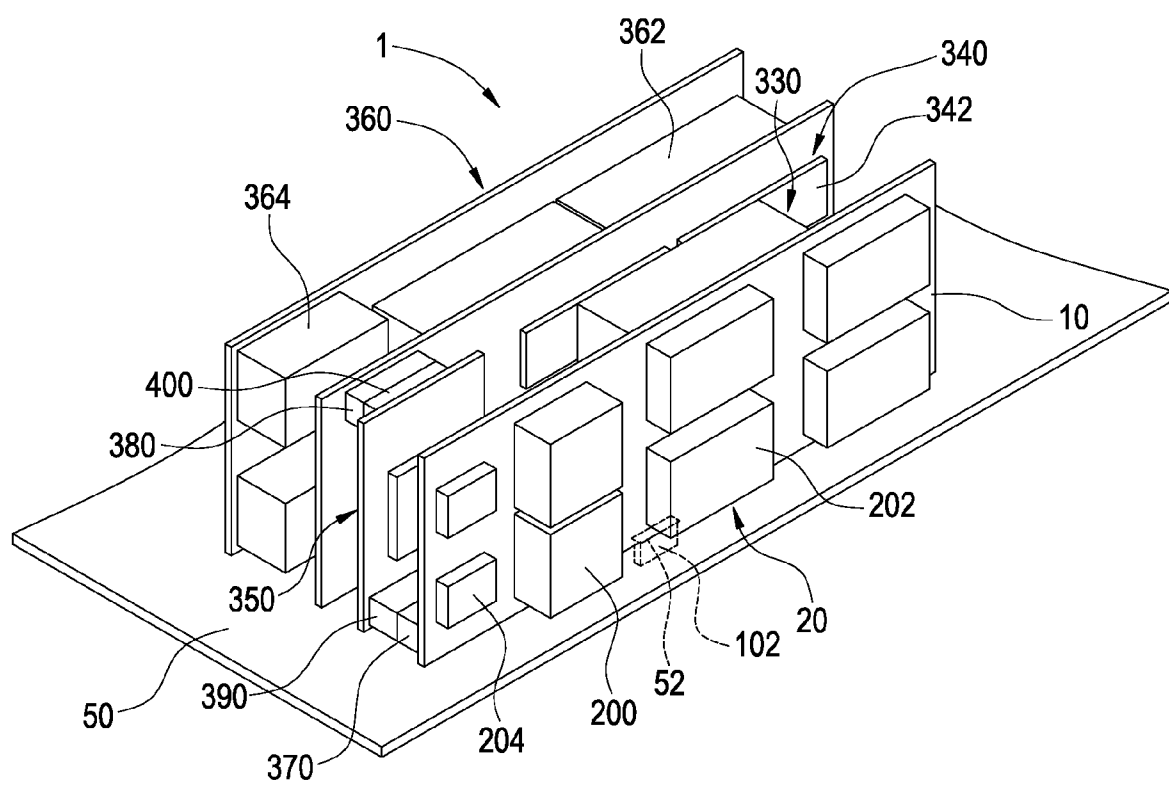


FIG.3

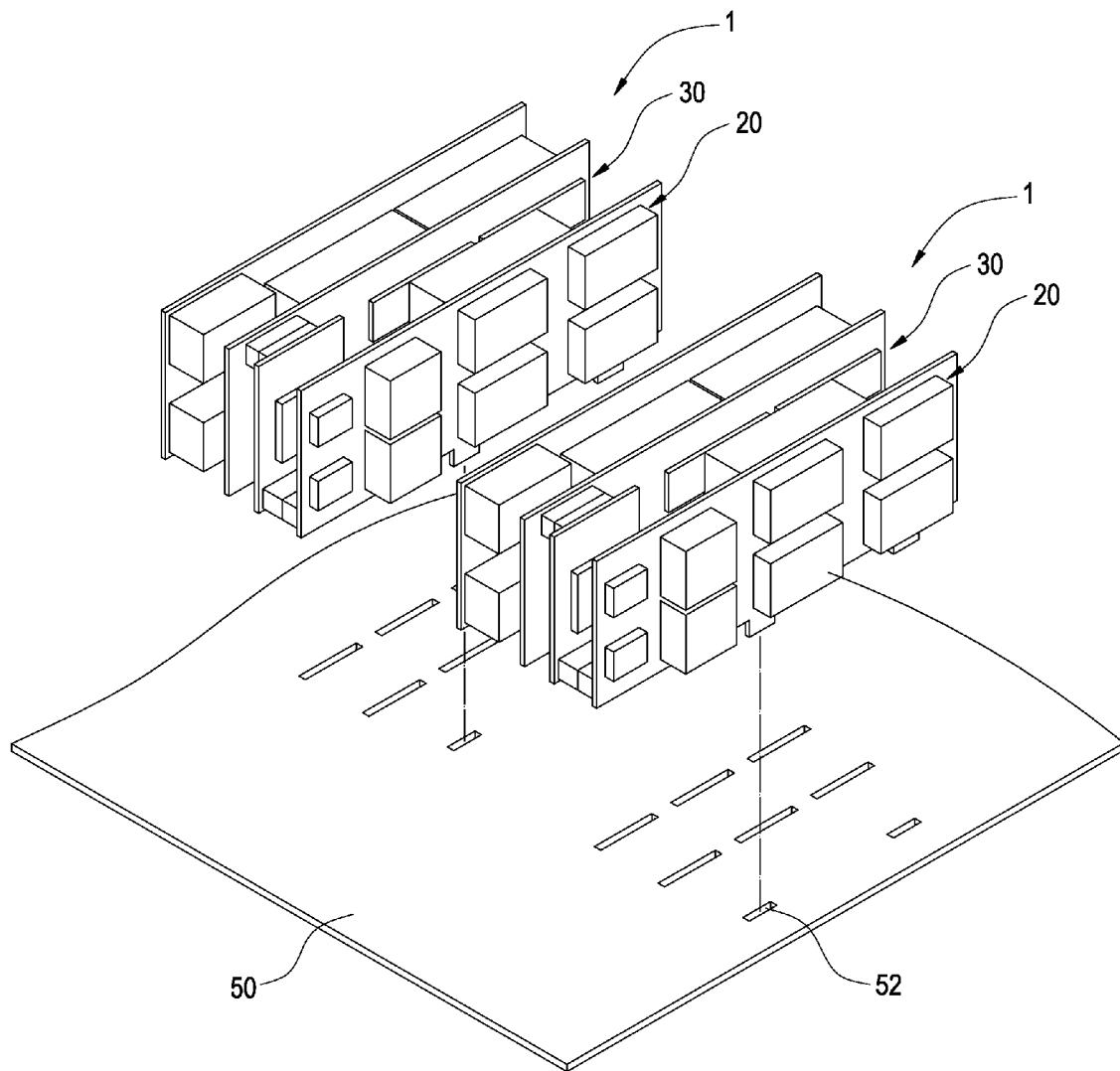


FIG.4

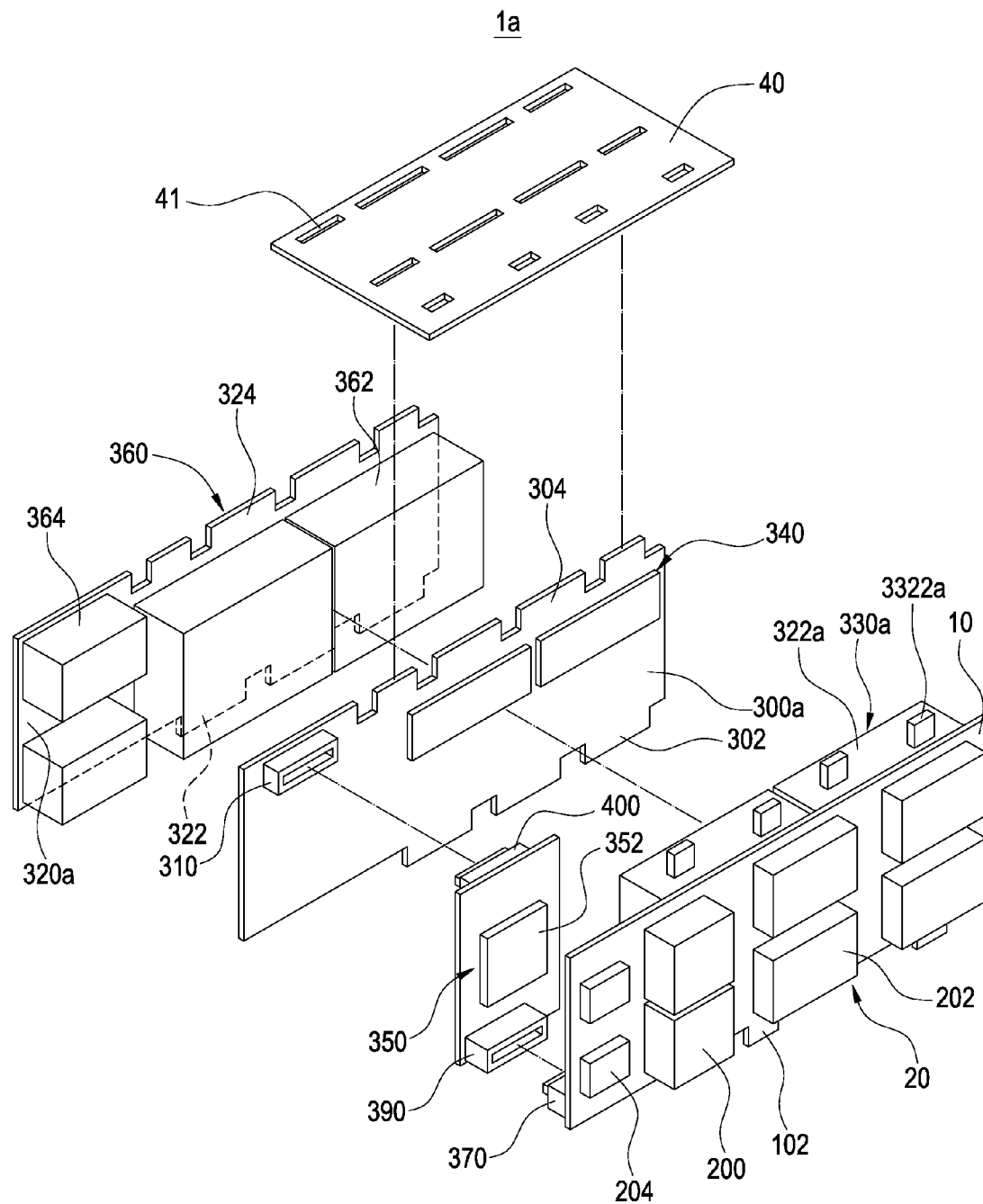


FIG.5

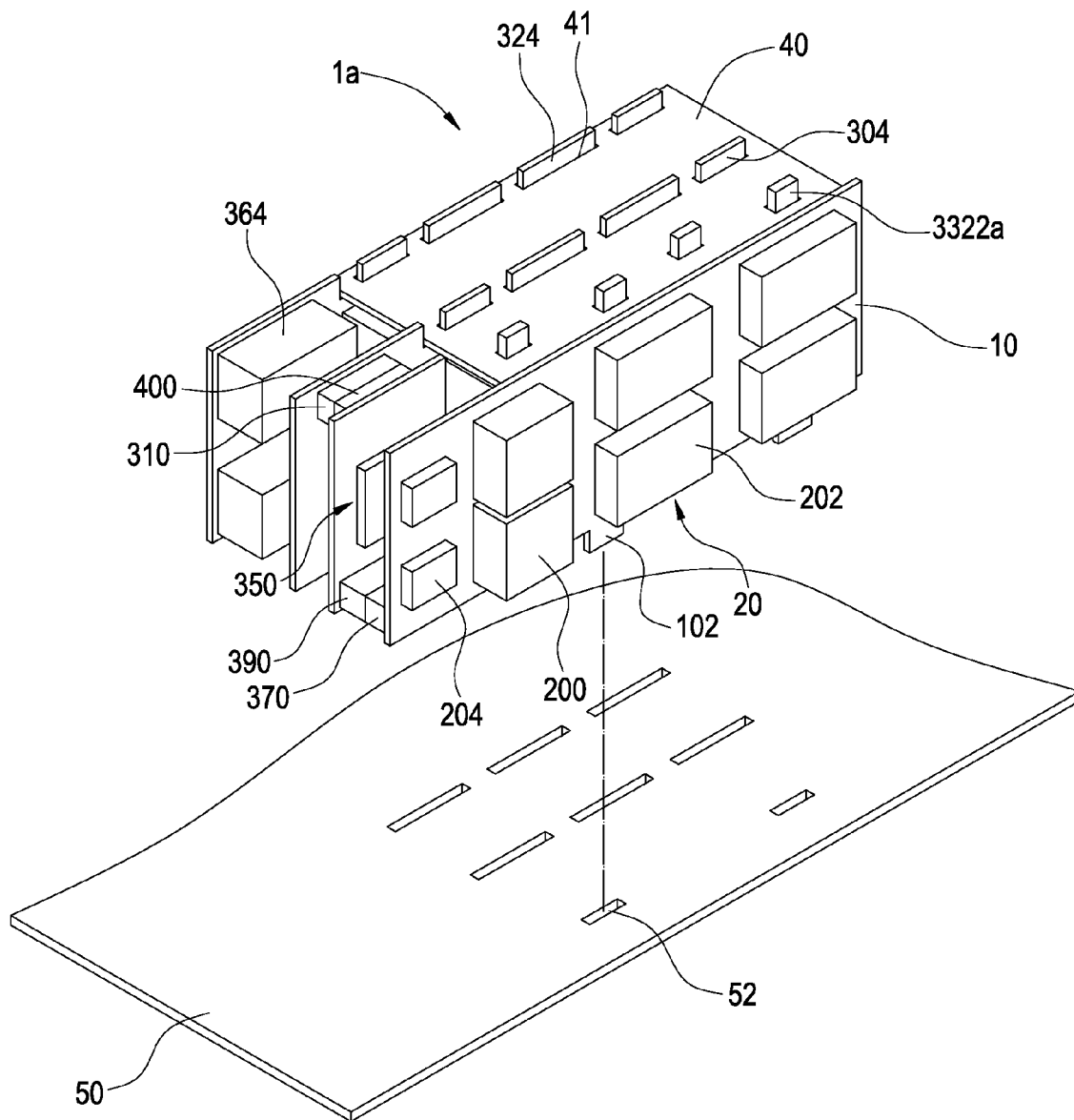


FIG.6

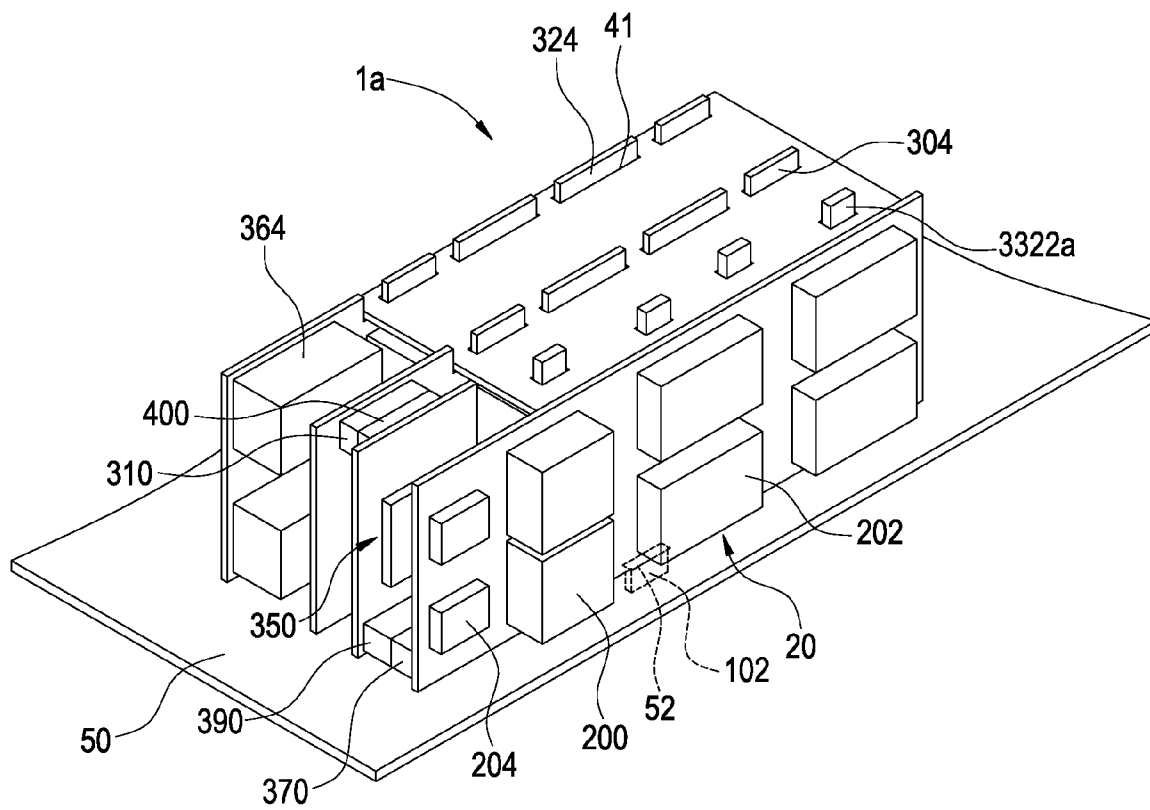


FIG. 7

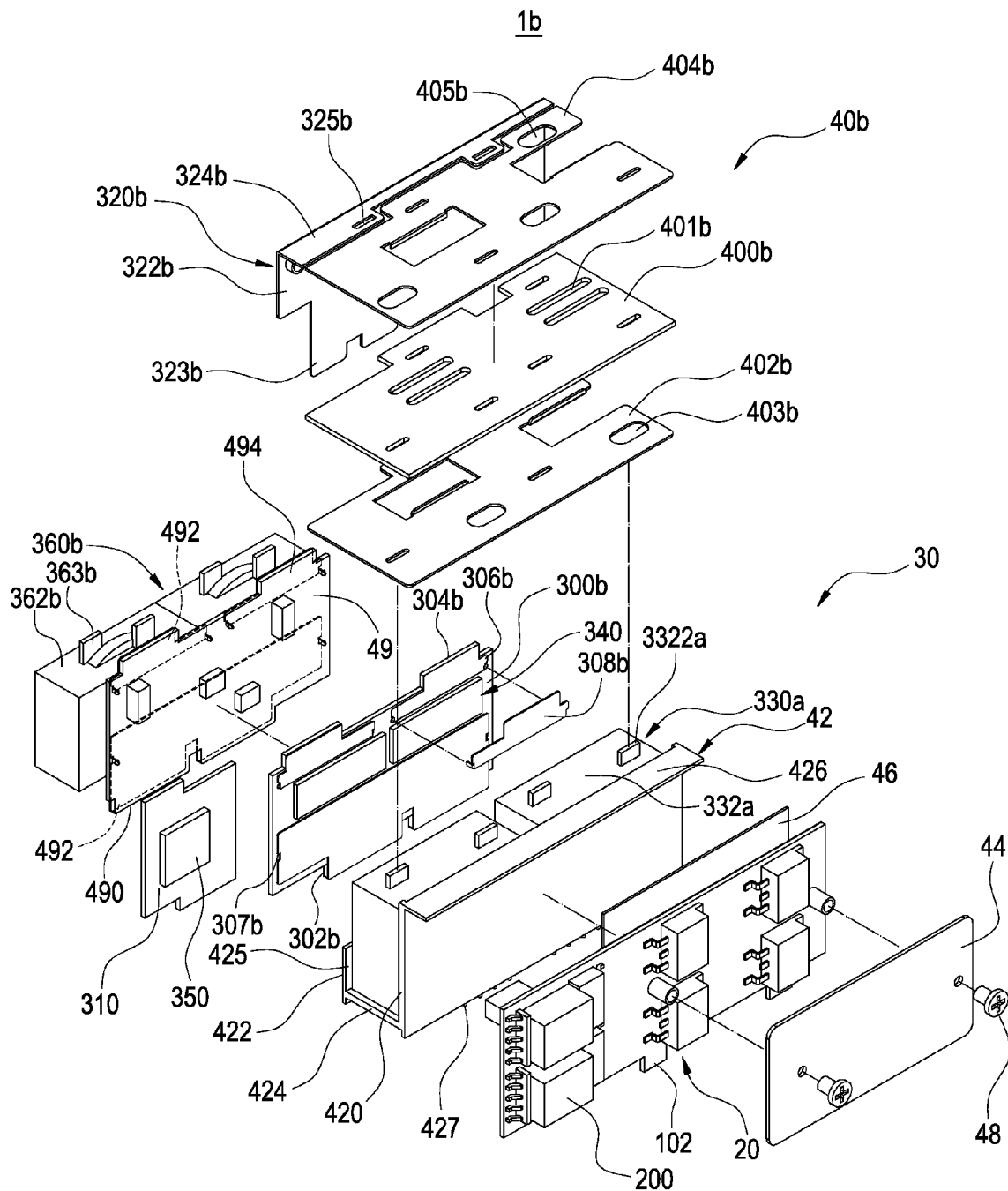


FIG.8

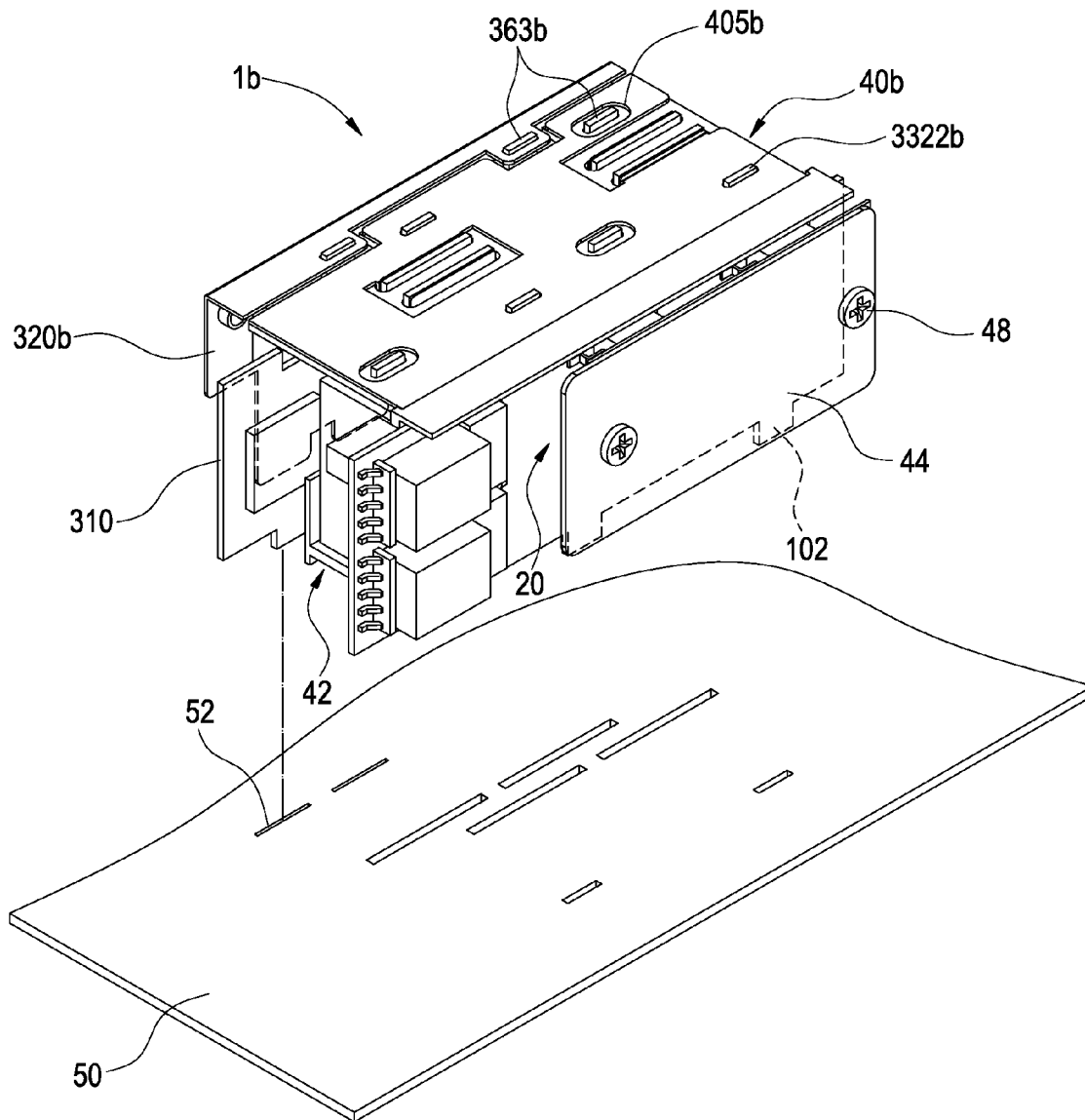


FIG.9

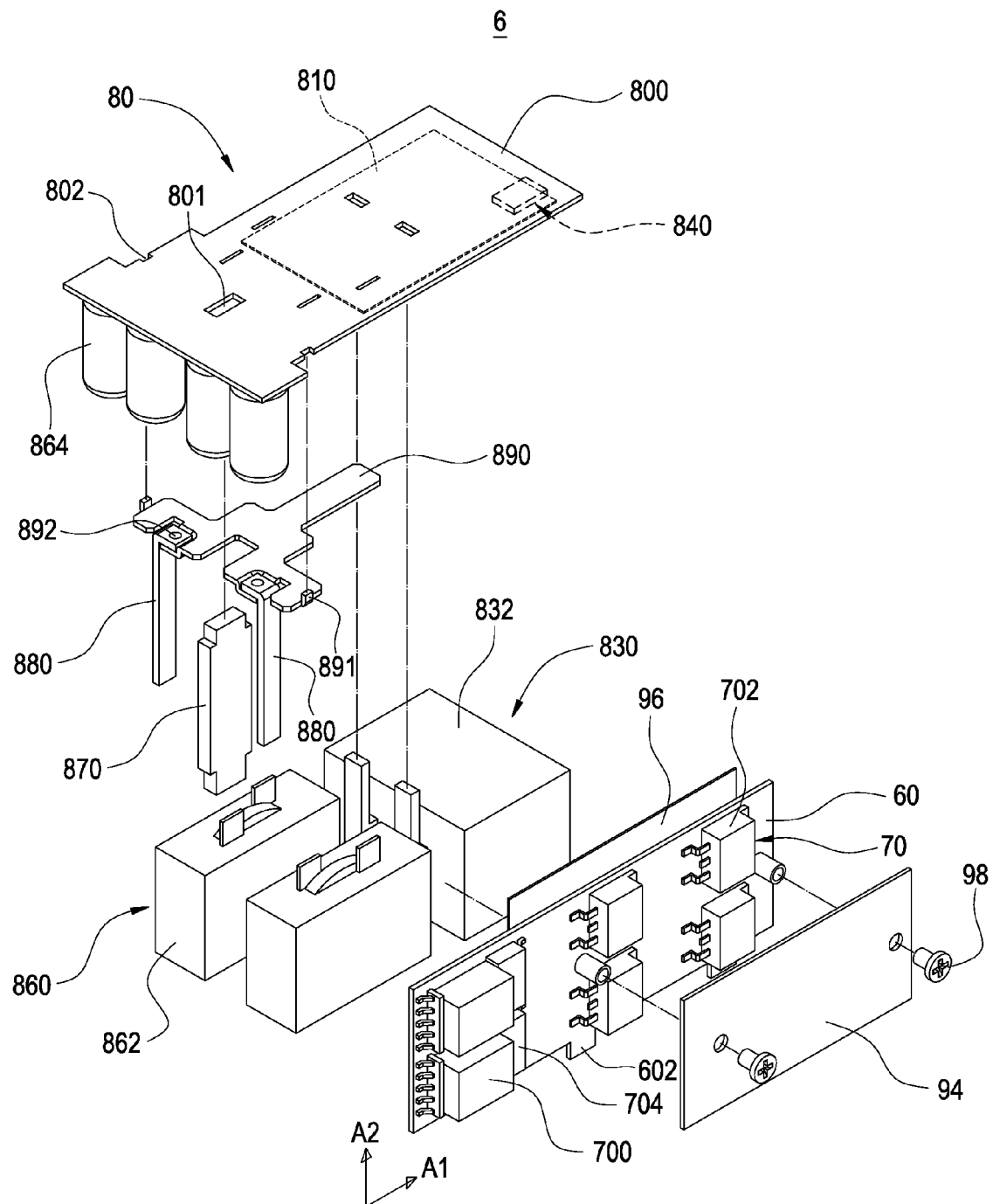


FIG.10

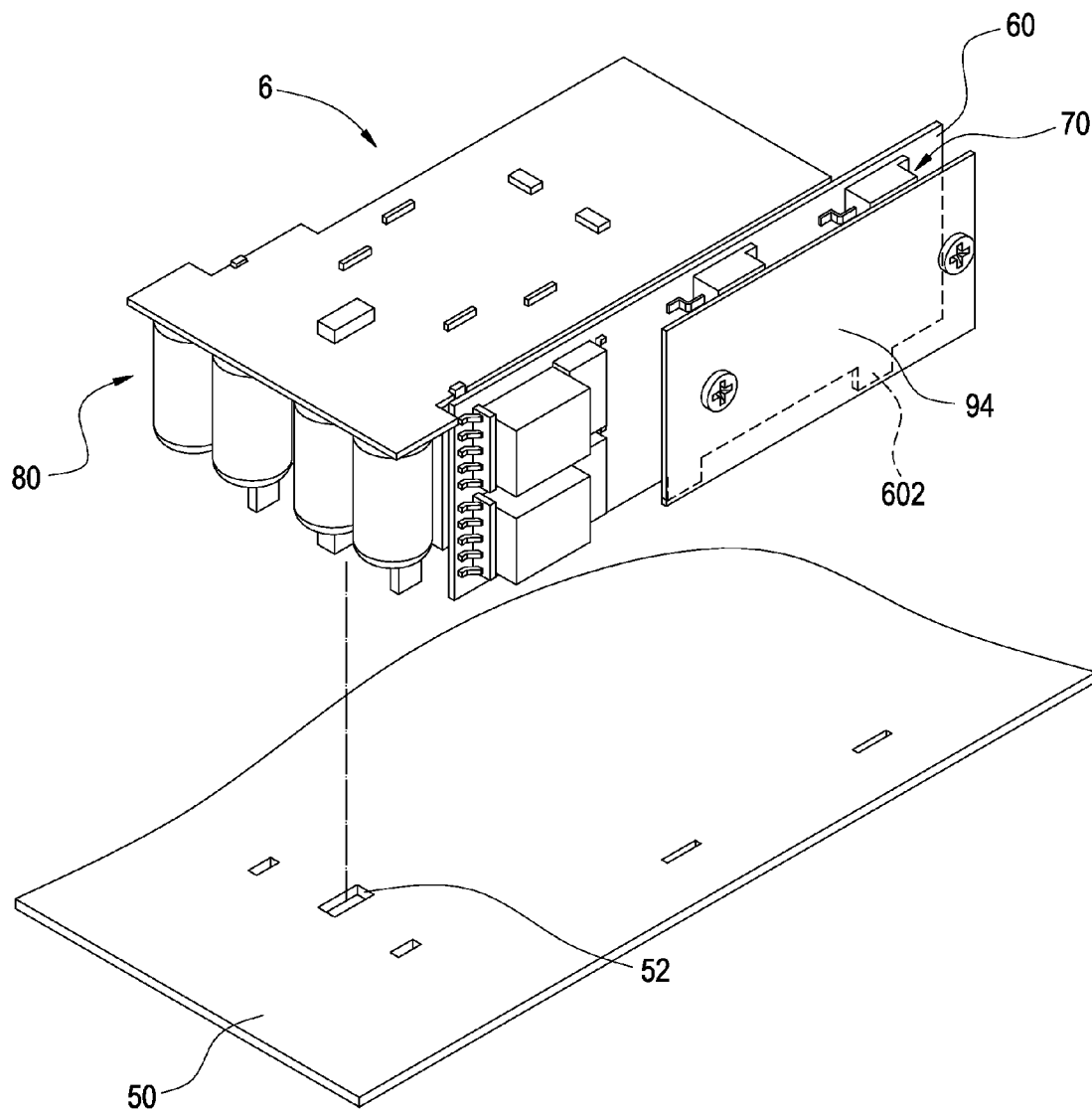


FIG.11

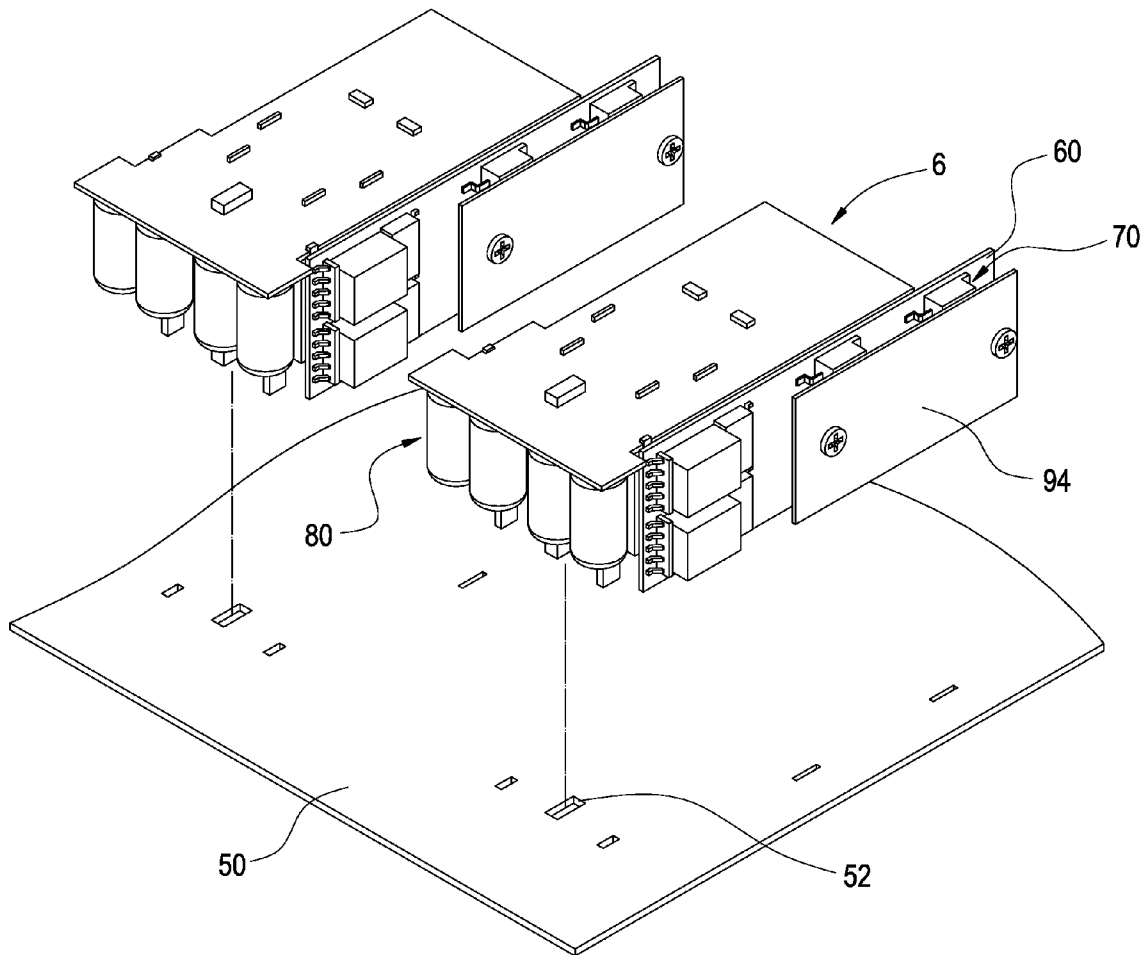


FIG.12

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MODULAR POWER DEVICE**CROSS-REFERENCE TO RELATED APPLICATION**

This application is a division of application Ser. No. 13/647,385 filed on Oct. 9, 2012, which claims priority to Taiwan Application No. 101126470 filed Jul. 23, 2012. The entire disclosure is incorporated herein by reference.

BACKGROUND OF THE INVENTION**1. Field of the Invention**

The present invention relates to a power device. More particularly, the present invention relates to a modular power device.

2. Description of Prior Art

Power supply devices are the essential components of industrial equipment, and are used for converting alternating current (AC) electric power into direct current (DC) electric power or providing functions of bucking or boosting. A conventional power supply device includes a flat circuit board, at least one converter and a plurality of electrical components. The converter and the electrical components are individually placed on the circuit board and electrically connected to thereto via traces formed on the circuit board.

While the demanded functions of industrial equipment increased, the internal devices which are disposed within the industrial equipment are increased accordingly. In order to sufficiently driving the internal devices, the output power of the power supply device must be increased simultaneously. When the outputting power of the power supply device is increased, the tolerance (such as rated working voltage) of the converter and the electronic components may also be increased. The volume of part of electronic component, such as capacitor, is direct proportion to the rated working voltage, namely, the larger rated working voltage and the greater volume. While the electronic components with greater volume are placed on the circuit board, will occupy a lot of space in the circuit board, this becomes the main reason of the high power supply system cannot miniaturization.

SUMMARY OF THE INVENTION

It is an object to provide a modular power device with small volume.

According to one aspect of the present invention is used for mounted on a main plate. The module power device comprises a first substrate, a driving module, a converting module, and an intermediate plate. The first substrate has a first axial direction and a second axial direction substantially perpendicular to the first axial direction. The first substrate is inserted into the main plate, such that the second axial direction of the first substrate is perpendicular to the main plate. The driving module is placed on one side of the first substrate and electrically connected to the first substrate. The converting module is located on the other side of the first substrate and electrically connected to the driving module. A length of the converting module is substantially equal to that of the first substrate in the first axial direction, and a width of the converting module is smaller than a length of the first substrate in the first axial direction. The converting module comprises a second substrate, a third substrate, a fourth substrate, a converting unit, a controlling unit, a signal transmitting unit, and an outputting unit. One end of the second substrate is inserted into the main plate to make the second substrate be perpendicular to the main plate, wherein the other end of the second

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substrate opposite to where the second substrate is inserted to the main plate is inserted into the intermediate plate. The third substrate is located between the first substrate and the second substrate. The converting unit is disposed on the first substrate. The fourth substrate is located at one side of the second substrate which is opposite to where the third substrate is disposed, and one end of the fourth substrate is inserted into the main plate and perpendicular to the main plate. The controlling unit is placed on the second substrate and electrically connected to the second substrate. The signal transmitting unit is placed on the third substrate and electrically connected to the third substrate for electrically connecting the controlling unit and the converting unit. The outputting unit is placed on the fourth substrate and electrically connected to the fourth substrate.

In the present invention, the first substrate of the modular power device is directly inserted into the main plate and substantially perpendicular to the main plate. The driving module and the converting module are respectively located at two side of the first substrate, and the driving module is directly placed on first substrate. Thereby, the volume of the modular power device can be substantially reduced, and prevent outputting electric power by interference from inputting electric power. Besides, the route for transmitting current is also reduced.

BRIEF DESCRIPTION OF DRAWING

The features of the invention believed to be novel are set forth with particularity in the appended claims. The invention itself however may be best understood by reference to the following detailed description of the invention, which describes certain exemplary embodiments of the invention, taken in conjunction with the accompanying drawings in which:

FIG. 1 is a perspective view of a modular power device according to a first embodiment of the present invention.

FIG. 2 is a perspective view of a modular power device and a main plate according to a first embodiment of the present invention.

FIG. 3 is an assemble view of the modular power device and the main board according to the first embodiment of the present invention.

FIG. 4 is a perspective view of a power system according to a first embodiment of the present invention.

FIG. 5 is a perspective view of a modular power device according to a second embodiment of the present invention.

FIG. 6 is a perspective view of a modular power device and a main plate according to a second embodiment of the present invention.

FIG. 7 is an assemble view of the modular power device and the main plate according to the second embodiment of the present invention.

FIG. 8 is a perspective view of a modular power device according to a third embodiment of the present invention.

FIG. 9 is a perspective view of a modular power device and a main plate according to the third embodiment of the present invention.

FIG. 10 is a perspective view of a modular power module according to a fourth embodiment of the present invention.

FIG. 11 is a perspective view of a modular power device and a main plate according to the fourth embodiment of the present invention.

FIG. 12 is a perspective view of a power system according to a second embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

A preferred embodiment of the present invention will be described with reference to the drawings.

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Referring to FIG. 1 to FIG. 3, FIG. 1 is a perspective view of a modular power device according to a first embodiment of the present invention, FIG. 2 is a perspective view of a modular power module and a main plate according to a first embodiment of the present invention, and FIG. 3 is an assemble view of the module power device and the main plate according to the first embodiment of the present invention. The modular power device 1 is used for mounting on a main plate 50. The main plate 50 has a plurality of grooves 52 for the modular power device 1 to be inserted therein. The main plate 50 may be a printed circuit board (PCB) or a substrate provided with conductive traces (not shown), and the substrate mentioned above may be copper substrate, aluminum substrate, ceramic substrate or other substrate with good thermal conductivity. However, the main plate 50 may also be combined PCB with copper slice or other material with good electrical conductivity.

The modular power device 1 includes a first substrate 10, a driving module 20 and a converting module 30. The driving module 20 is placed on one side of the first substrate 10 and electrically connected to the first substrate 10. The converting module 30 is located on the other side of the first substrate 10 and electrically connected to the driving module 20.

The first substrate 10 is a PCB or a substrate provided with conductive traces (not shown). In more particular, the substrate mentioned above may be copper substrate, aluminum substrate, ceramic substrate or other substrate with good thermal conductivity. However, the first substrate 10 may also be combined PCB with copper slice or other material with good electrical conductivity.

The first substrate 10 has a first axial direction A1 and a second axial direction A2 substantially perpendicular to the first axial direction A1. In this embodiment, the first axial direction A1 is lengthwise direction of the first substrate 10, and the second axial direction A2 is widthwise direction of the first substrate 10. The first substrate 10 is inserted into the main plate 50, such that the second axial direction A2 of the first substrate 10 is substantially perpendicular to a board 54 of the main plate 50. An end of the first substrate 10 has at least one pillar 102. The first substrate 10 can include one or more pillars 102. As non-limiting examples, the first substrate 10 includes two pillars 102. The pillars 102 are inserted into the grooves 52, such that the first substrate 10 is substantially perpendicular to the main plate 50 and electrically connected thereto.

The driving module 20 is directly placed on the first substrate 10 and electrically connected thereto for receiving electric power inputting to the modular power device 10 and driving the modular power device 10. The driving module 20 includes at least one converter 200, at least one switching component 202 and a plurality of active or passive components 204. The driving module 20 can include one or more converters 200 and switch components 202, respectively. As a non-limiting example, the driving module 20 of the modular power device 1 includes two converters 200 and four switch components 202. In preferably, each switch component 202 is metal-oxide-semiconductor field-effect transistor (MOS-FET). The converters 200, the switching components 202 and the active or passive components 204 collectively construct a driving circuit.

The converting module 30 receives voltage source outputted by the driving module 20 and provides a function of voltage converting for reducing voltage value of the voltage source. A length of the converting module 30 is substantially equal to that of the first substrate 10 in the first axial direction A1, and a width of the converting module 30 is smaller than a length of first substrate 10 in the first axial direction A1.

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The converting module 30 includes a second substrate 300, a third substrate 310, a fourth substrate 320, a converting unit 330, a controlling unit 340, a signal-transmitting unit 350, an outputting unit 360, a first connector 370, a second connector 380, a third connector 390 and a fourth connector 400.

The converting unit 330 is placed on a board of the first substrate 10 (which is opposite to where the driving module 20 is disposed) and is used for receiving the electric power outputted by the driving module 20. The converting unit 330 includes at least one converter 332 and multiple active or passive components (not shown) for collectively constructing a power modulating circuit.

The first connector 370 is mounted on the first substrate 10 which is the same side where the converting module 330 is placed, and electrically connected to the first substrate 10.

The second substrate 300 may be a PCB or a substrate provided with conductive traces (not shown). In more particular, the substrate mentioned above may be copper substrate, aluminum substrate, ceramic substrate or other substrate with good thermal conductivity. However, the second substrate 300 may also be combined PCB with copper slice or other material with good electrical conductivity. In preferably, the second substrate 300 is multi-layer (more than or equal to two layers) circuit board. The second substrate 300 is inserted into the main plate 50 and electrically connected thereto, such that the second substrate 300 is parallel to the first substrate 10. In addition, one end of the second substrate 300 has at least one pillar 302. The second substrate 300 can include one or more pillars 302. As a non-limiting example, the second substrate 300 includes two pillars 302. The pillars 302 are inserted into the grooves 52, such that the second substrate 300 is perpendicular to the main plate 50 and electrically connected thereto.

The controlling unit 340 is placed on the second substrate 300 and electrically connected thereto. The controlling unit 340 includes a plurality of controlling components 342, which can be active or passive components, for collectively constructing a circuit with controllable function. However, the controlling components 342 can be an integrated circuit (IC) with function of control.

The second connector 380 is mounted on the second substrate 300 and electrically connected to the controlling unit 340. In this embodiment, the second connector 380 is mounted on a lateral side of the second substrate 300 which is faced to where the first substrate 10 is disposed.

The third substrate 310 may be a PCB or a substrate provided with conductive traces (not shown). In more particular, the substrate mentioned above may be copper substrate, aluminum substrate, ceramic substrate or other substrate with good thermal conductivity. However, the third substrate 310 may also be combined PCB with copper slice or other material with good electrical conductivity. The third substrate 310 is disposed between the first substrate 10 and the second substrate 300, and is parallel to the first substrate 10. The signal-transmitting unit 350 including a plurality of electronic components 352 for constructing a signal-transmitting circuit is placed on the third substrate 310 and electrically connected thereto.

The third connector 390 is mounted on the third substrate 310 and electrically connected thereto. The third connector 390 is assembled with the first connector 370, such that the signal-transmitting unit 350 is electrically connected to converting unit 330.

The fourth connector 400 is mounted on the third substrate 310 and electrically connected thereto. The fourth connector

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400 is assembled with the second connector 380, such that the signal-transmitting unit 359 is electrically connected to the controlling unit 340.

The fourth substrate 320 may be a PCB or a substrate provided with conductive traces (not shown). In more particular, the substrate mentioned above may be copper substrate, aluminum substrate, ceramic substrate or other substrate with good thermal conductivity. However, the fourth substrate 320 may also be combined PCB with copper slice or other material with good electrical conductivity. The fourth substrate 320 is disposed at one side of the second substrate 300 which is opposite to where the third substrate 310 is disposed, and is substantially parallel to the second substrate 300. The fourth substrate 320 is inserted into the main plate 50 and electrically connected thereto. One end of the fourth substrate 320 includes at least one pillar 322. The fourth substrate 320 can include one or more pillars 322. As a non-limiting example, the fourth substrate 320 includes three pillars 322. The pillars 322 are inserted into the grooves 52, such that the fourth substrate 320 is perpendicular to the main plate 50 and electrically connected thereto.

The outputting unit 360 including at least one inductor 362 and at least one capacitor 364 is placed on the fourth substrate 320 and electrically connected thereto. The outputting unit 360 can include one or more inductors 362 and capacitors 364, respectively. As non-limiting example, the outputting unit 360 includes two inductors 362 and two capacitors 364. The inductors 362 and the capacitors 364 are collectively constructing a π -type filter for stabilizing outputting current and reducing outputting noise.

In the practical application, the user can adjust the specifications (such as rated working voltage) of the driving module 20, the converting unit 330, the controlling unit 340, the signal-transmitting unit 350 and the outputting unit 360 according to demanded outputting power, and the user can respectively insert the first substrate 10, the second substrate 300, the third substrate 310 and the fourth substrate 320 (where the driving module 20, the converting unit 330, the controlling unit 340, the signal-transmitting unit 350 and the outputting unit 360 is disposed) into the main plate 50 and electrically connected to the main plate 50, and then assemble the first connector 370 and the second connector 380 with the third connector 390 and the fourth connector 400, respectively, such that the converting unit 330 can electrically connect to the controlling unit 340 via the signal-transmitting unit 350. Therefore, the electric power inputting from the modular power device 1 can be converted into a demanded electric power, and outputted from the outputting unit 360. For this result, the modular power device 1 has advantages of easily fabricating and easily modulating specifications.

To sum up, the modular power device 1 has advantage of small volume, and the arrangement of the modular power device 1 can effectively isolate the outputting unit 360 from the converting unit 330, so as to reduce outputting power by interference from inputting power, and then stabilize outputting electric power. Besides, the space formed between each two substrate allows air flowing therethrough, such that the heat dissipating effect can be enhanced.

Reference is made to FIG. 4, which is a perspective view of a power system according to a first embodiment of the present invention. The power system includes a main plate 50 and a plurality of modular power devices 1 mentioned above. The modular power devices 1 are mounted on the main plate 50 and electrically connected thereto. In this embodiment, the power system includes, for example, two modular power devices 1, and the modular power devices 1 electrically connected in parallel are arranged in an alignment manner.

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Therefore, when the power system is operated with light load, only one modular power device 1 is activated for reducing outputting electric power. When the power system is operated with heavy load, a plurality of modular power devices 1 are activated to increase outputting electric power. In addition, when activate more modular power devices 1, the controlling units 340 of the modular power devices 1 can collectively construct the function of phase-shift, such that the effect of power system can be enhanced, and the outputting ripple current is reduced. For this result, the power system can achieve optimal efficiency wherever operating with light load or heavy load, and prevent the problem of pool efficiency of high power system as operating with light load.

Referring to FIG. 5 to FIG. 7, FIG. 5 is a perspective view of a modular power device according to a second embodiment of the present invention, FIG. 6 is a perspective view of a modular power device and a main plate according to a second embodiment of the present invention, and FIG. 7 is an assemble view of the modular power device and the main plate according to the second embodiment of the present invention. The modular power device 1a is similar to the modular power device 1 mentioned above, and the same reference numbers are used in the drawings and the description to refer to the same parts.

The modular power device 1a further includes an intermediate plate 40. The intermediate plate 40 may be a PCB or a substrate provided with conductive traces (not shown). In more particular, the substrate mentioned above may be copper substrate, aluminum substrate, ceramic substrate or other substrate with good thermal conductivity. However, the intermediate plate 40 may also be combined PCB with copper slice or other material with good thermal conductivity. A plurality of accommodating slots 41 are formed on the intermediate plate 40.

In addition, one end the second substrate 300a which is opposite to where the pillars 302 are formed has at least one rib 304. The second substrate 300a can include one or more ribs 304. As non-limited example, the second substrate 300a includes four ribs 304. The ribs 304 are inserted into the accommodating slots 41 formed on the intermediate plate 40, such that the second substrate 300a is substantially perpendicular to the intermediate plate 40 and electrically connected thereto.

One end of the fourth substrate 320a which is opposite to where the pillars 322 are formed has at least one rib 324. The fourth substrate 320a can include one or more ribs 324. As non-limiting example, the fourth substrate 320a includes four ribs 324. The ribs 324 are inserted into the accommodating slots 41, such that the fourth substrate 320a is substantially perpendicular to the intermediate plate 320a and electrically connected thereto.

Each converter 332a of the converting unit 330a has at least one protrusion 3322a. The converter can include one or more protrusions 3322a. As non-limiting example, each converter 330a includes two protrusions 3322a. The protrusions 3322a are inserted into the accommodating slots 41 of the intermediate plate 40, and then electrically connect the intermediate plate 40 and the converting unit 330a.

Thereby, the controlling unit 340 placed on the second substrate 300a and the outputting unit 360 placed on the fourth substrate 320a are electrically connected to the converting unit 330a and the driving module 20 via the main plate 50 and the intermediate plate 40. Preferably, the potentials transmitted by the main plate 50 and the intermediate plate 40 are different in level.

The function and relative description of other components of the module power device 1a is the same as that of first

embodiment mentioned above and are not repeated here, and the modular power device **1a** can fulfill the functions as the modular power device **1** does.

Besides, a power system may be constructed by the main plate **50** and a plurality of modular power devices **1a**. The arrangement of the modular power devices **1a** is the same as the modular power devices **1** mentioned above and its description is not repeated here.

Referring to FIG. **8** and FIG. **9**, FIG. **8** is respectively a perspective view of a modular power device according to a third embodiment of the present invention, and FIG. **9** is an assemble view of a modular power device according to the third embodiment of the present invention. The modular power device **1b** is similar to the modular power device **1a** mentioned above, and the same reference numbers are used in the drawings and the description to refer to the same parts.

It should be noted that the second substrate **300b** is a multi-layer circuit board and a plurality of engaging slots **306b** are formed thereon for disposing a plurality of electric layers **308a** therein. Preferably, a plurality of engaging parts **307b** are respectively formed on a wall of each engaging slot **306b** for fastening each electric layer **308b**. Each electric layer **308b** is made of copper or other material with good electrical conductivity and used as current transmitting routes.

The intermediate plate **40b** includes a multi-layer circuit board **400b**, a first metallic layer **402b** and the second metallic layer **404b**. Multiple through holes **401b** are formed on the multi-layer circuit board **400b**. The first metallic layer **402b** and the second metallic layer **404b** are made of copper or other material with good electrical conductivity and used as current transmitting routes.

The first metallic layer **402b** is attached to a lower surface of the multi-layer circuit board **400b**, and a plurality of first holes **403b** corresponding to the through holes **401b** are formed thereon. The second metallic layer **404b** is attached to an upper surface of the multi-layer circuit board **400b**, and a plurality of second holes **405b** corresponding to the through holes **401b** are formed thereon.

The protrusions **332a** of the converters **332a** and the ribs **304b** of the second substrate **300b** are inserted into the through holes **401b**, the first holes **403b** and the second holes **405b**, and electrically connected to the intermediate plate **40b**.

The fourth substrate **320a** includes a flat part **322b** and a bent part **324b**. The flat part **322b** is parallel to the first substrate **10** and has a plurality of pillars **323b** for inserting into the main plate **50**, such that the first substrate **320b** is electrically connected to the main plate **50**. The bent part **324b** is substantially perpendicular to the flat part **322b** and a plurality of openings **325b** are formed thereon. A plurality of pins **363b** of each inductor **362b** of outputting unit **360b** are inserted into the openings **325b** of the fourth substrate **320b**, the through holes **401b** of the intermediate plate **40b**, the first holes **403b** and the second holes **405b**, such that the fourth substrate **320b** is electrically connected to the intermediate plate **40b**.

The modular power device **1b** further comprises a carrier **42**, a first isolating and thermal-dissipating board **44**, a second isolating and thermal-dissipating board **46**, a plurality of fixing component **48** and a fifth substrate **49**. The carrier **42** includes a first board **420**, a second board **422**, a connecting part **424** and a shoulder-part **426**. The first board **420** is disposed adjacent to the first substrate **10**, and the second board **422** is disposed adjacent to the second substrate **300b**. In his embodiment, the first board **420** and the second board **422** are of rectangular shape, a length of the second board **422**

is substantially equal to that of the first board **420**, and a width of the second board **422** is smaller than that of the first board **420**. The connecting part **424** is located at one end of the first board **420** and the second board **422** and connected thereof. The first board **420**, the second board **422** and the connecting part **424** collectively construct an accommodating space **425** for accommodating the converter **332a** of the converting unit **330a**, so as to prevent the converters **332a** from electromagnetic interference produced by the converters **200** of the driving module **20**. The connecting part **424** further includes a plurality of supporting components **427** for inserting into the main plate **50**. The shoulder-part **426** is disposed on one end of the first board **420**, which is opposite to where the connecting part **424** is disposed, and extending toward a direction where the first substrate **10** is disposed for disposing the carrier **42** on the first substrate **10**. The first isolating and thermal-dissipating board **44** is disposed in one side of the first substrate **10**, the second isolating and thermal-dissipating board **46** is disposed on the other side of the first substrate **10**. The fixing component **48** penetrates the first isolating and thermal-dissipating board **44** and is fastened on the second isolating and thermal-dissipating board **46** so as to provide electromagnetic isolating effect and thermal-dissipating effect.

The fifth substrate **49** is disposed at one side of the second substrate **300b** which is opposite to where the first substrate **10** is disposed. The fifth substrate **49** is a PCB or a substrate provided with conductive traces (not shown). In more particular, the substrate mentioned above may be copper substrate, aluminum substrate, ceramic substrate or other substrate with good thermal conductivity. However, the fifth substrate **49** may also be combined PCB with copper slice or other material with good thermal conductivity. Preferably, the fifth substrate **49** is multi-layer (more than or equal to two layers) circuit board. At least one pillar **490** is formed at one end of the fifth substrate **49**. The fifth substrate **49** can include one or more pillars **490**. As non-limiting example, the fifth substrate **49** includes two pillars **490**. The pillars **490** are inserted into the intermediate plate **40b** and electrically connected thereto. At least one rib **494** formed on the other end of the fifth substrate **49** is inserted into the main plate **50** and electrically connected to the main plate **50**.

The fifth substrate **49** further includes at least one electric layer **492** for functioning as routes of current transmitting. The controlling unit **340** is simultaneously disposed on the second substrate **300b** and the fifth substrate **49** and electrically connected thereto. For this result, the controlling elements of the controlling unit **340** can be disposed with intervals for enhancing the effect of thermal-dissipation.

The function and relative description of other components of the module power device **1b** is the same as that of second embodiment mentioned above and are not repeated here, and the modular power device **1b** can fulfill the functions as the modular power device **1a** does.

Besides, a power system may be constructed by the main plate **50** and a plurality of modular power devices **1b**. The arrangement of the modular power devices **1b** is the same as the modular power devices **1** mentioned above and the description thereof is not repeated here.

Referring to FIG. **10** and FIG. **11**, FIG. **9** is a perspective view of a modular power device and main plate according to a fourth embodiment of the present invention, and FIG. **10** is an assemble view of a modular power device and main plate according to the fourth embodiment of the present invention. The modular power device **6** is used for mounting on a main plate **50**. The main plate **50** has a plurality of grooves **52** through which the modular power device **6** is inserted therein.

The main plate **50** may be a printed circuit board (PCB) or a substrate provided with conductive traces (not shown), and the substrate mentioned above may be copper substrate, aluminum substrate, ceramic substrate or other substrate with good thermal conductivity. However, the main plate **50** may also be combined PCB with copper slice or other material with good electrical conductivity.

The modular power device **6** includes a first substrate **60**, a driving module **70** and a converting module **80**. The converting module **70** is placed on one side of the first substrate **60** and electrically connected the first substrate **60**. The converting module **80** is located at the other side of the first substrate **60**, and electrically connected to the driving module **70**.

The first substrate **60** may be a (PCB) or a substrate provided with conductive traces (not shown), and the substrate mentioned above may be copper substrate, aluminum substrate, ceramic substrate or other substrate with good thermal conductivity. However, the first substrate **60** may also be combined PCB with copper slice or other material with good thermal conductivity. The first substrate **60** has a first axial direction **A1** and a second axial direction **A2** substantially perpendicular to the first axial direction **A1**. In this embodiment, the first axial direction **A1** is lengthwise direction of the first substrate **60**, and the second axial direction **A2** is widthwise direction of the first substrate **60**. The first substrate **60** is inserted into the main plate **50**, such that the second axial direction **A2** of the first substrate **60** is substantially perpendicular to a board **54** of the main plate **50**. An end of the first substrate **60** has at least one pillar **602**. The first substrate **60** can include one or more pillars **602**. As non-limiting examples, the first substrate **60** includes two pillars **602**. The pillars **602** are inserted into the grooves **52**, such that the first substrate **60** is substantially perpendicular to the main plate **50** and electrically connected thereto.

The driving module **70** is directly placed on the first substrate **60** and electrically connected thereto. The driving module **70** receives electric power inputting to the modular power device **6** and drives thereof. The driving module **70** includes at least one converter **700**, at least one switch **702** and a plurality of active and passive components **704**. The driving module **70** can include one or more converters **700** and switch components **702**, respectively. As a non-limiting example, the driving module **70** includes two converters **700** and four switches **702**, and each switch **702** is MOSFET. The converters **700**, the switches **702** and the active or passive components **704** collectively construct a driving circuit.

The converting module **80** receives voltage source passing through the driving module **70** and provides the function of voltage converting so as to reduce the voltage value of the voltage source. A length of the converting module **80** is substantially equal to that of the first substrate **60** in the first axial direction **A1**, and a width of the converting module is smaller than a length of the first substrate **60** in the first axial direction **A1**.

The converting module **80** includes a second substrate **800**, at least one conductive layer **810**, a converting unit **830**, a controlling unit **840**, an outputting unit **860**, a first connecting post **870**, two second connecting posts **880** and an electric layer **890**.

The second substrate **800** is disposed opposite to the main plate **50**. The second substrate **800** may be a PCB or a substrate provided with conductive traces (not shown), and the substrate mentioned above may be copper substrate, aluminum substrate, ceramic substrate or other substrate with good thermal conductivity. However, the second substrate **800** may also be combined PCB with copper slice or other material

with good thermal conductivity. Preferably, the second substrate **800** is multi-layer (more than or equal to two layers) circuit board.

The conductive layer **810** is made of copper or other material with good electrical conductivity. The conductive layer **810** is attached to the second substrate **800** for functioning as route of current transmission. Preferably, a containing slot (not shown) is formed on the second substrate **800** for containing the conductive layer **810** and fastening the conductive layer **810**.

The converting unit **830**, the controlling unit **840** and the outputting unit **860** are placed on the second substrate **800** and electrically connected thereto. The converting unit **830** receives the power outputted by the driving module **70** and converts the outputted power into a demand voltage value. The converting unit **830** includes at least one converter **832** and a plurality of active or passive components (not shown). The converter **832** and the active or passive components collectively construct a voltage-converting circuit.

The controlling unit **840** is used for controlling the operating state of the modular power device **6**. The controlling unit **840** includes multiple controlling components for constructing a controlling circuit. However, the controlling unit **840** may be a integrate circuit (IC) with controlling function. The outputting unit **860** includes at least one inductor **862** and at least one capacitor **864**. The outputting unit **860** can include one or more inductors **862** and capacitors **864**, respectively. As non-limiting example, the outputting unit **860** includes two inductors **862** and four capacitors **864**. The inductors **862** and the capacitor **864** collectively construct a π -type filter for stabilizing outputting current and reducing outputting noise.

The first connecting post **870** is located between the main plate **50** and the second substrate **800**, and inserted into the grooves **52** of the main plate **50** and the through hole **801** of the second substrate **800**, and electrically connected to the main plate **50** and the second substrate **800**.

The electric layer **980** is made of copper or other material with good electrical conductivity. The electric layer **810** is attached to the second substrate **800** for providing connective path between the outputting unit **860** and the second substrate **800**, and then current can flow between the outputting unit **860** and the second substrate **800**. A plurality of buckles **891** are formed on the electric layer **980**, the buckles **891** are locked on a plurality of positioning slots **802** formed on the second substrate **800** for achieving the effect of position and enhancing the connecting strength of the electric layer **890** and the second substrate **800**. In this embodiment, the electric layer **890** is of T-shape. In the practical application, the profile of the electric layer **890** may be adjusted by demand.

The electric layer **890** is connected to each second post **880** through at least one connecting component **892**. The connecting component **892** is preferably rivet for riveting the electric layer **890** to one end of each second connecting post **880**, such that current can transmit between the electric layer **890** and the second connecting posts **880**. The other end of each second connecting post **880** is inserted into the groove **52** of the main plate **50** and electrically connected to the main plate **50**, such that electric power can transmit between the main plate **50** and the second substrate **800** via second connecting posts **880**. Preferably, the potentials transmitted by the second connecting posts **880** and the first connecting post **870** are different in level.

The modular power device **6** further comprises a first isolating and thermal-dissipating board **94**, a second isolating and thermal-dissipating board **96** and a plurality of fixing

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components **98**. The first isolating and thermal-dissipating board **94** is disposed in one side of the first substrate **60**, the second isolating and thermal-dissipating board **96** is disposed on the other side of the first substrate **60**. The fixing components **98** penetrate the first isolating and thermal-dissipating board **94** and fastened on the second isolating and thermal-dissipating board **96** so as to provide electromagnetic isolating and thermal-dissipating effect.

To sum up, the modular power device **6** has advantage of small volume and air can flow therein to enhance heat dissipating effect.

In the practical application, the user can adjust the specifications (such as rated working voltage) of the driving module **70**, the converting unit **830**, the controlling unit **840** and the outputting unit **860** according to demanded outputting power. Therefore, the electric power inputting from the modular power device **6** can be converted into a demanded electric power, and output from the outputting unit **860**. For this result, the modular power device **6** has advantages of easily fabricating and easily modulating specifications.

Reference is made to FIG. **12**, which is a perspective view of a power system according to a second embodiment of the present invention. The power system includes a main plate **50** and a plurality of modular power devices **6** mentioned above. The modular power devices **6** are mounted on the main plate **50** and electrically connected thereto. In this embodiment, the power system includes, for example, two modular power devices **6**, and the modular power devices **6** electrically connected in parallel are mounted on the main plate **50** in an alignment manner.

Therefore, when the power system is operated with light load, only one modular power device **6** is activated for reducing outputting electric power. When the power system is operated with heavy load, a plurality of modular power devices **6** are activated to increase outputting electric power. In addition, when activate more modular power devices **6**, the controlling units **840** of the modular power device **6** can collectively construct the function of phase-shift, such that the effect of power system can be enhanced, and the outputting current ripple can be reduced. For this result, the power system can achieve optimal efficiency wherever operating with light load or heavy load, and prevent the problem of pool efficiency of high power system as operating with light load.

Although the present invention has been described with reference to the foregoing preferred embodiment, it will be understood that the invention is not limited to the details thereof. Various equivalent variations and modifications can still occur to those skilled in this art in view of the teachings of the present invention. Thus, all such variations and equivalent modifications are also embraced within the scope of the invention as defined in the appended claims.

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What is claimed is:

1. A modular power device is used for mounting on a main plate, the modular power device comprising:

a first substrate having a first axial direction and a second axial direction perpendicular to the first axial direction, the first substrate inserted into the main plate, such that the second axial direction is perpendicular to the main plate;

a driving module placed on one side of the first substrate and electrically connected to the first substrate;

a converting module located on the other side of the first substrate and electrically connected to the driving module, the converting module comprising:

a second substrate, one end of the second substrate inserted into the main plate, such that the second substrate is perpendicular to the main plate;

a third substrate located between the first substrate and the second substrate;

a fourth substrate located at one side of the second substrate opposite to where the third substrate being disposed, and one end of the fourth substrate inserted into the main plate and perpendicular to the main plate;

a converting unit disposed on the first substrate;

a controlling unit placed on the second substrate and electrically connected to the second substrate;

a signal transmitting unit placed on the third substrate and electrically connected to the third substrate for electrically connecting the controlling unit and the converting unit; and

an outputting unit placed on the fourth substrate and electrically connected to the fourth substrate; and

an intermediate plate, wherein the other end of the second substrate opposite to where the second substrate is inserted to the main plate is inserted into the intermediate plate, and the other end of the fourth substrate opposite to where the fourth substrate is inserted to the main plate is inserted into the intermediate plate;

wherein a length of the converting module is equal to that of the first substrate in the first axial, and a width of the converting module is smaller than a length of first axial direction of the first substrate.

2. The modular power device in claim **1**, wherein the intermediate plate comprises:

a multi-layer circuit board;

a first metallic layer attached to a surface of the multi-layer circuit board; and

a second metallic layer attach to the other surface of the multi-layer circuit board.

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