US 20250266757A1

(19) **United States**

(12) **Patent Application Publication**

Xin et al.

(10) **Pub. No.: US 2025/0266757 A1**

(43) **Pub. Date: Aug. 21, 2025**

(54) **INDUCTOR ASSEMBLY, VRM MODULE AND PIN LAYOUT OF SEMICONDUCTOR SWITCH DEVICE**

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(21) Appl. No.: **19/057,980**

(22) Filed: **Feb. 20, 2025**

(30) **Foreign Application Priority Data**

Feb. 20, 2024 (CN) 202410189719.8
Mar. 19, 2024 (CN) 202410311282.0
Jul. 17, 2024 (CN) 202410960993.0

Publication Classification

(51) **Int. Cl.**

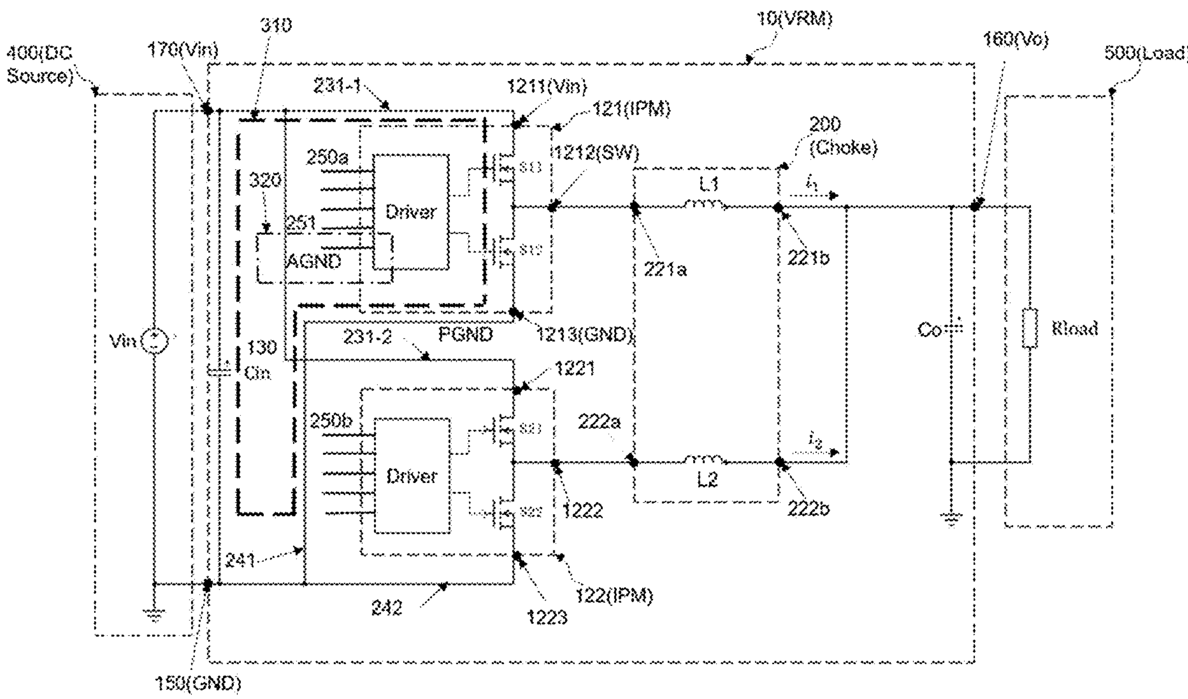
H02M 3/00	(2006.01)
H01F 27/26	(2006.01)
H01F 27/29	(2006.01)
H02M 1/00	(2007.01)
H02M 3/158	(2006.01)

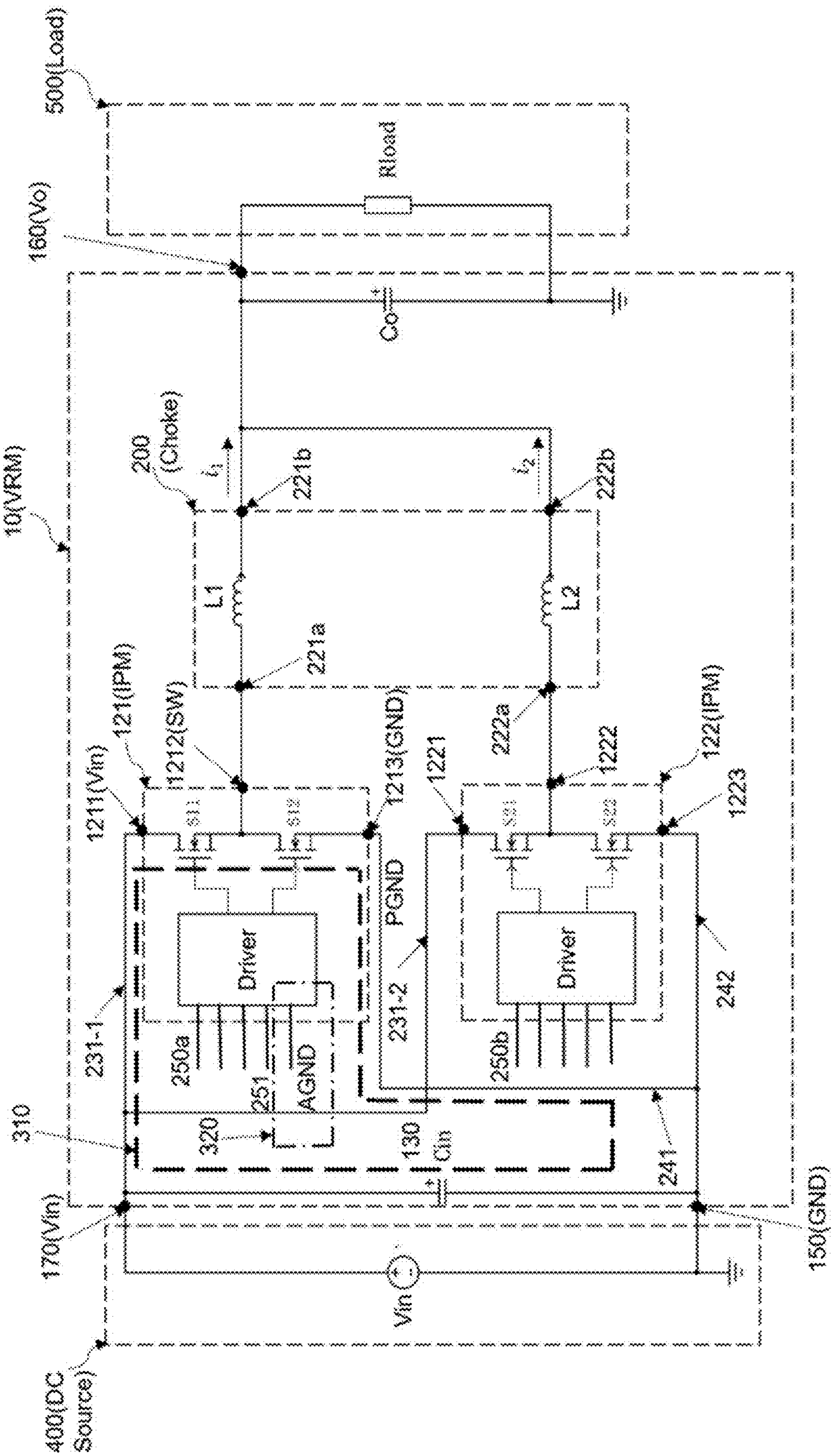
(52) **U.S. Cl.**

CPC ***H02M 3/003*** (2021.05); ***H01F 27/266*** (2013.01); ***H01F 27/292*** (2013.01); ***H02M 1/0083*** (2021.05); ***H02M 3/1584*** (2013.01)

(57) **ABSTRACT**

An inductor assembly includes an integrated inductor and signal assembly; the signal assembly includes a signal connector and a shielding layer; the shielding layer is arranged between the signal assembly and the integrated inductor, so that protecting the signal circuit from interference from the power circuit. A VRM module is provided. The VRM module includes an inductor assembly, a top assembly and a bottom assembly; the inductor assembly includes a magnetic core, a winding, VIN electrical connector and GND electrical connector; the top assembly includes a semiconductor switching device and an input capacitor; and an input power loop including VIN electrical connector, the GND electrical connector and the input capacitor is arranged around at least one part of the magnetic core.




500(Load)
Rload
160(Vo)
Co
10(VRM)
200 (Choke)
221b
222b
L1
L2
221a
222a
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1211(Vin)
1212(SW)
1213(GND)
S11
S12
PGND
Driver
1221
1222
122(IPM)
1223
S21
S22
231-1
231-2
242
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AGND
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170(Vin)
150(GND)
Vin
400(DC Source)

FIG. 1

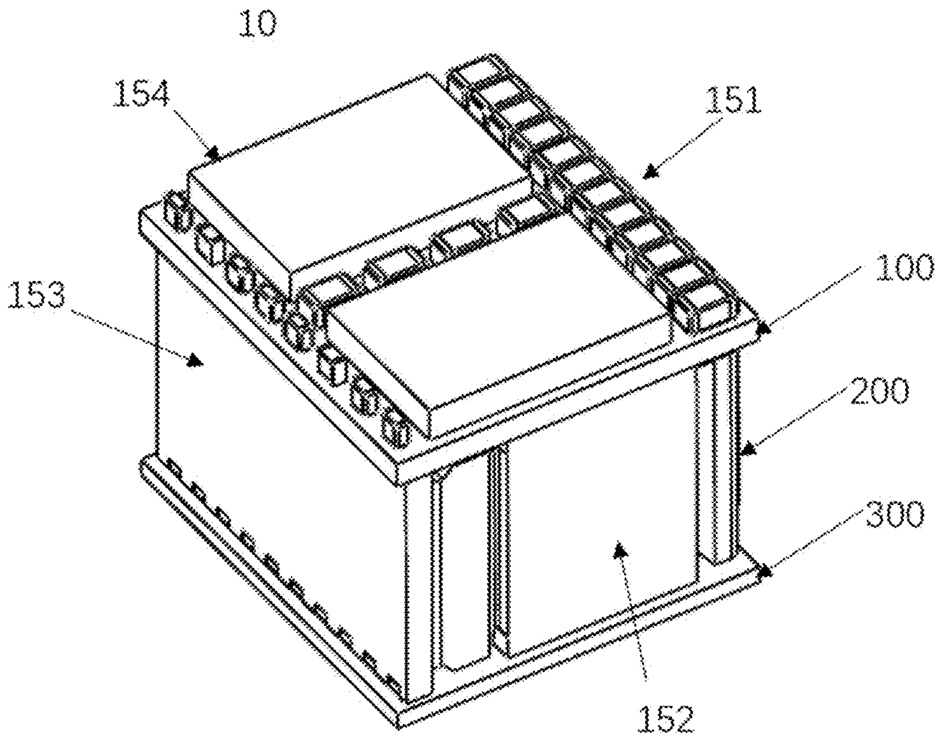

FIG. 2A

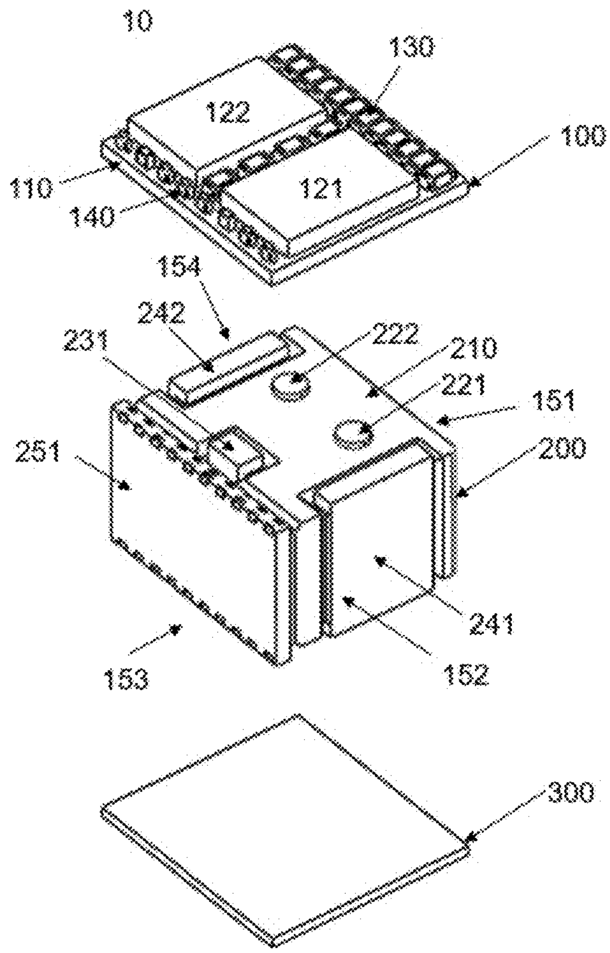
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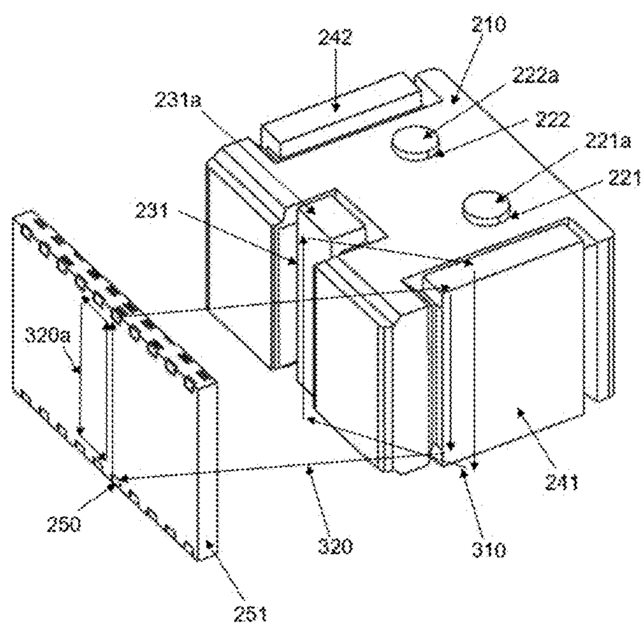
FIG. 2B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320a
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250
320
310
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FIG. 2C

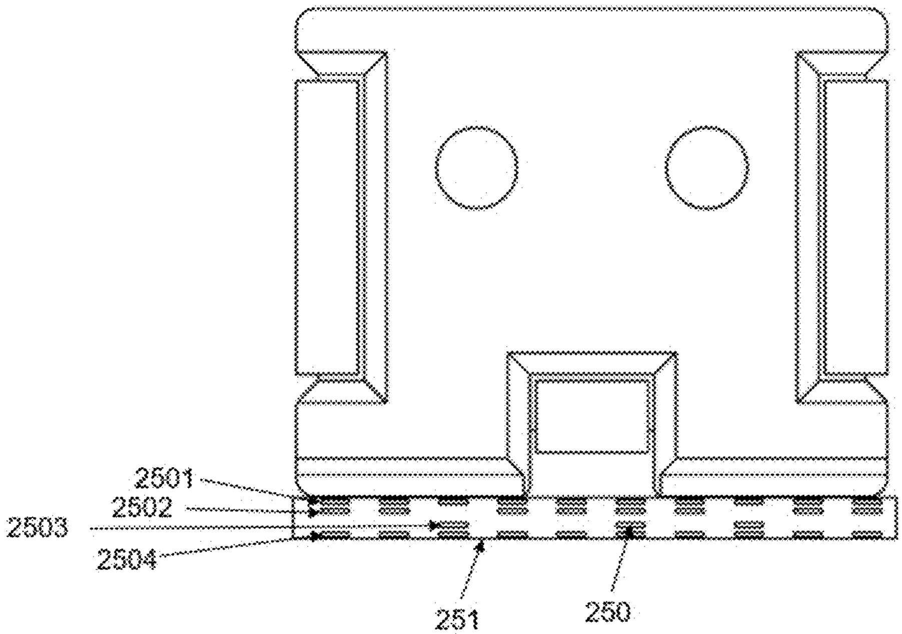

FIG. 2D

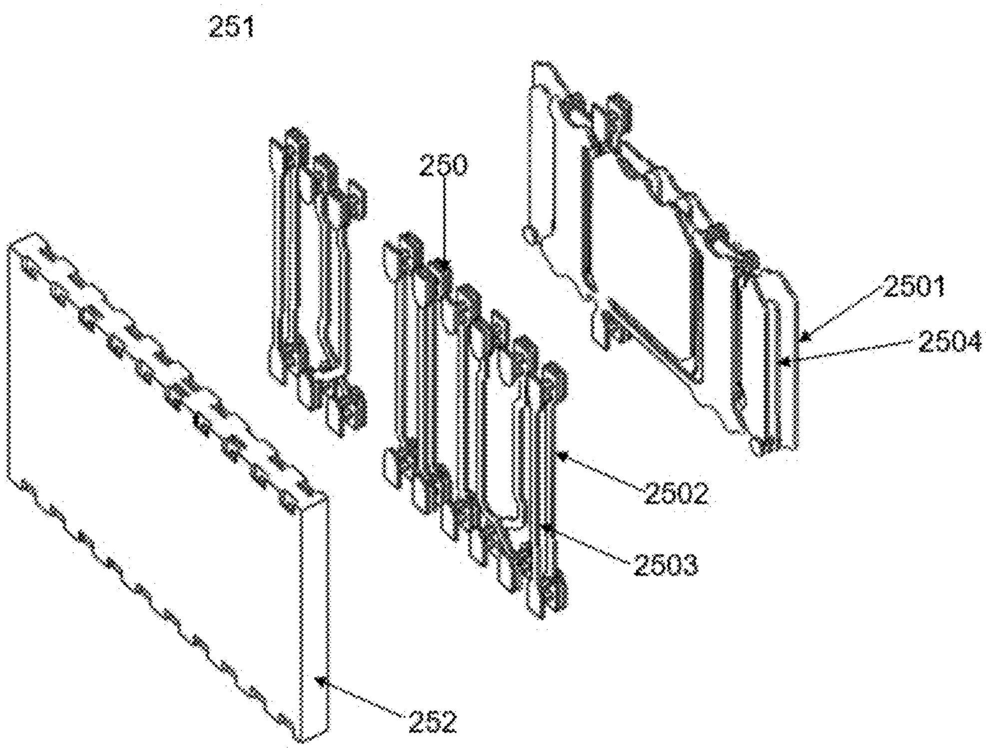

FIG. 2E

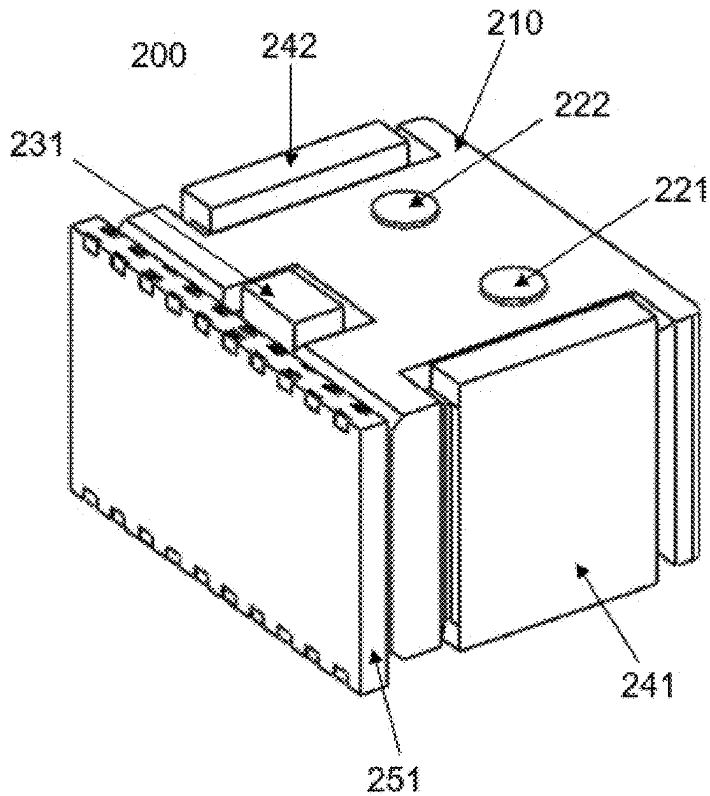
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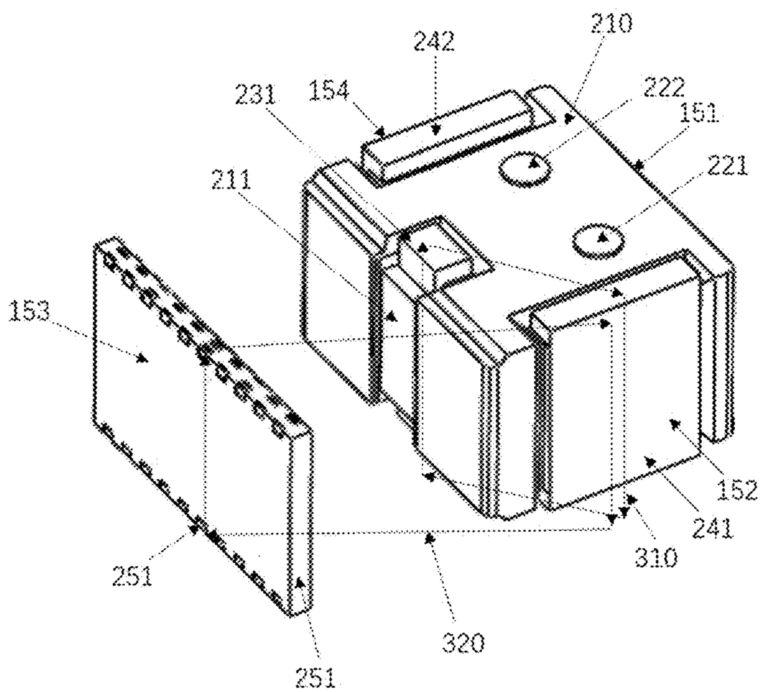
FIG. 3A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241
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251
320
251

FIG. 3B

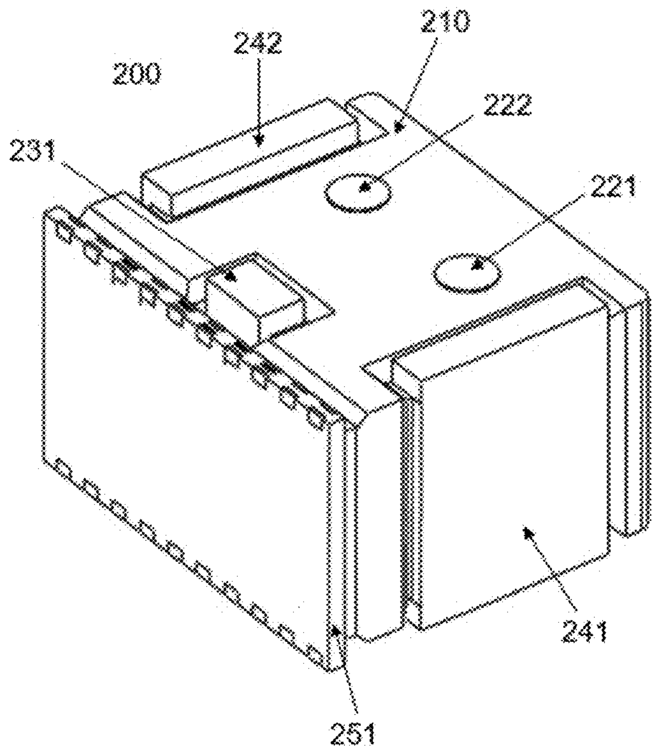
200
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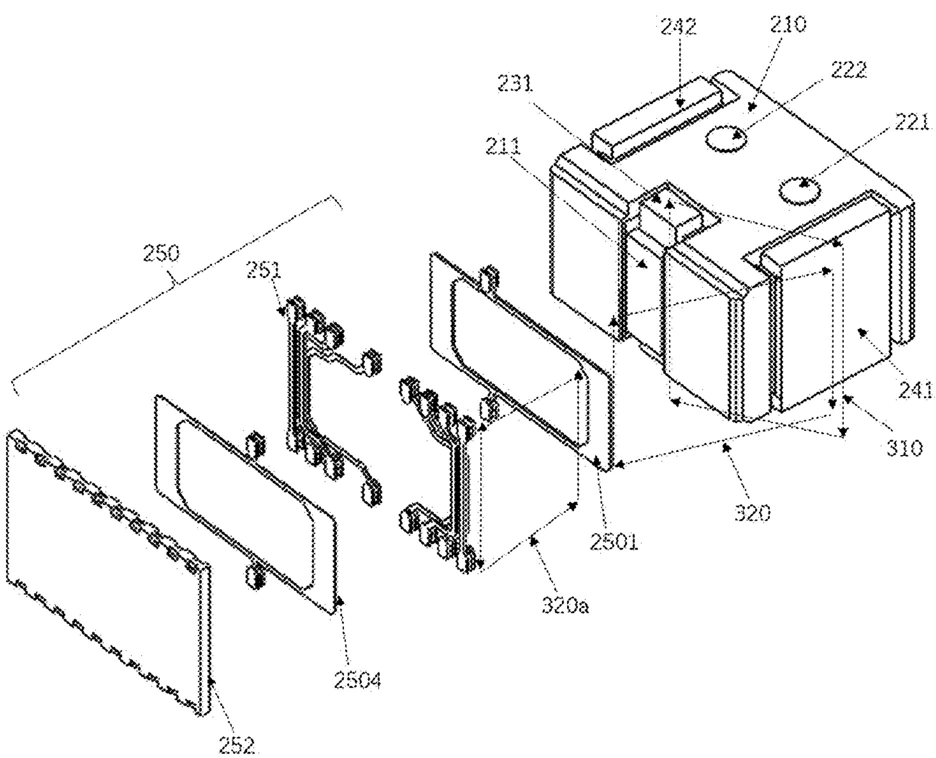
FIG. 4A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241
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2501
320a
2504
252

FIG. 4B

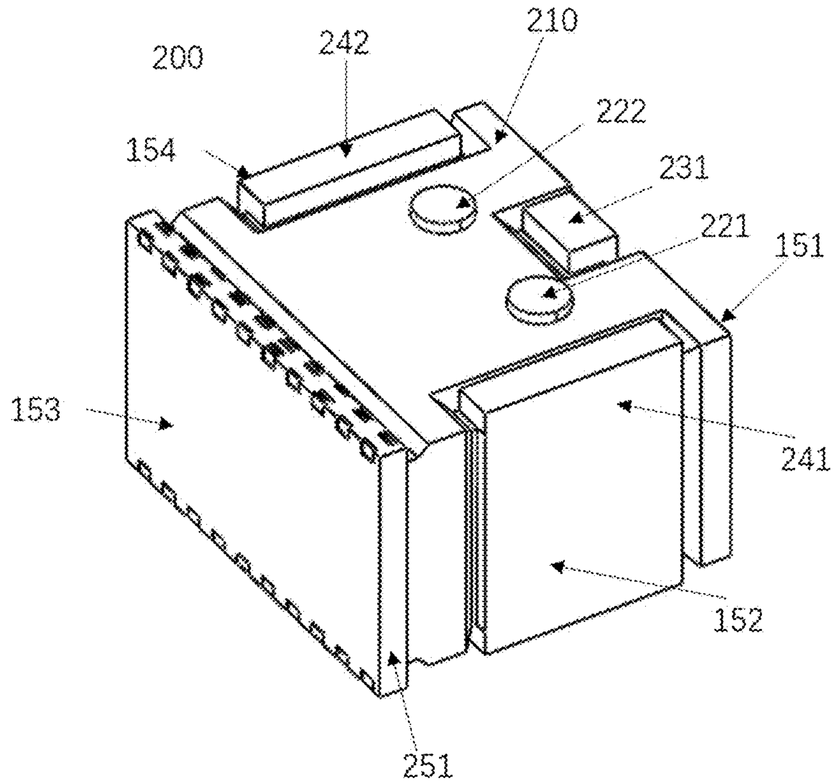
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FIG. 5A

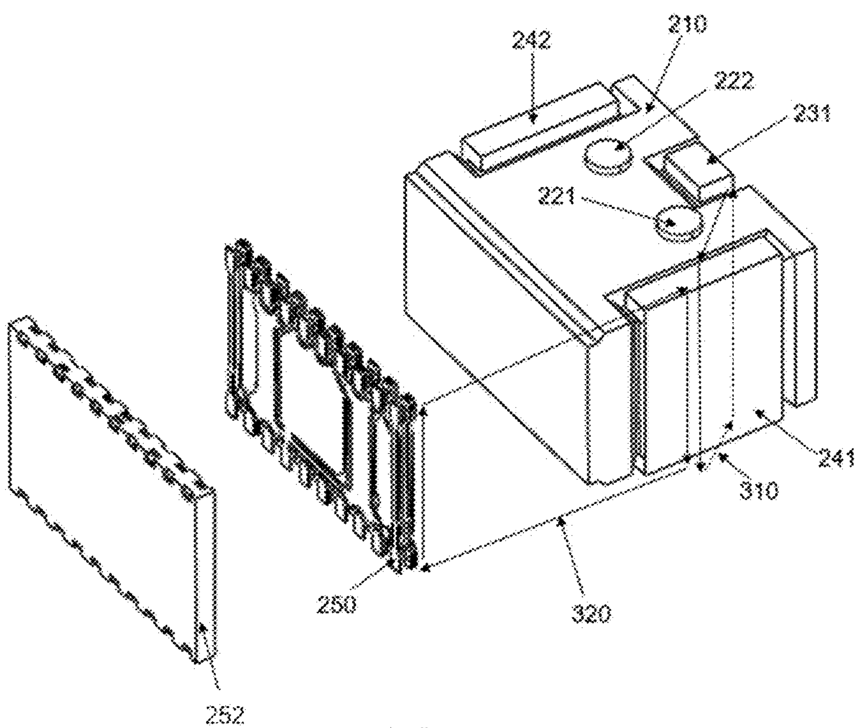
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FIG. 5B

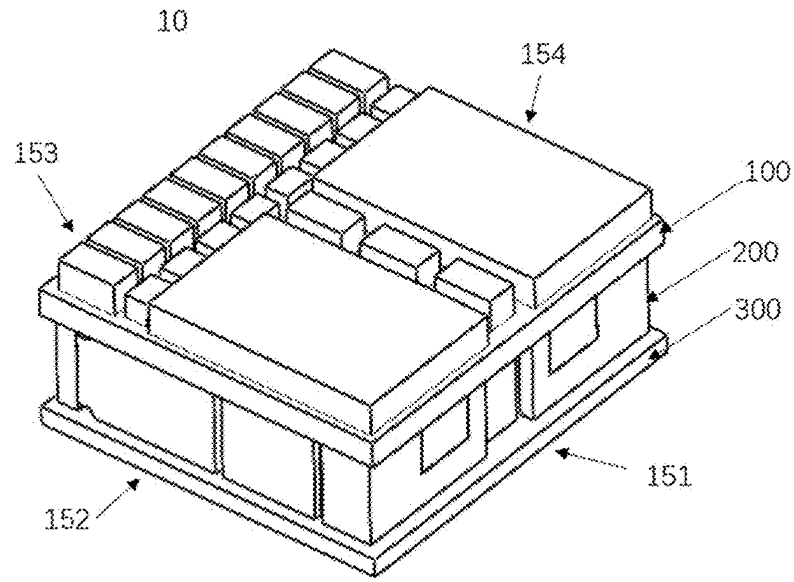


FIG. 6A

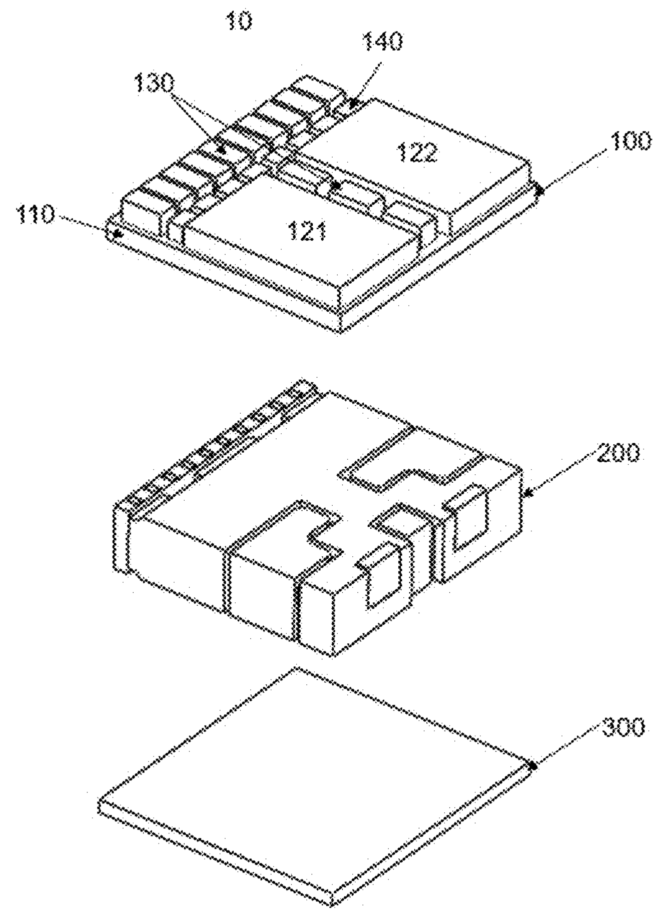
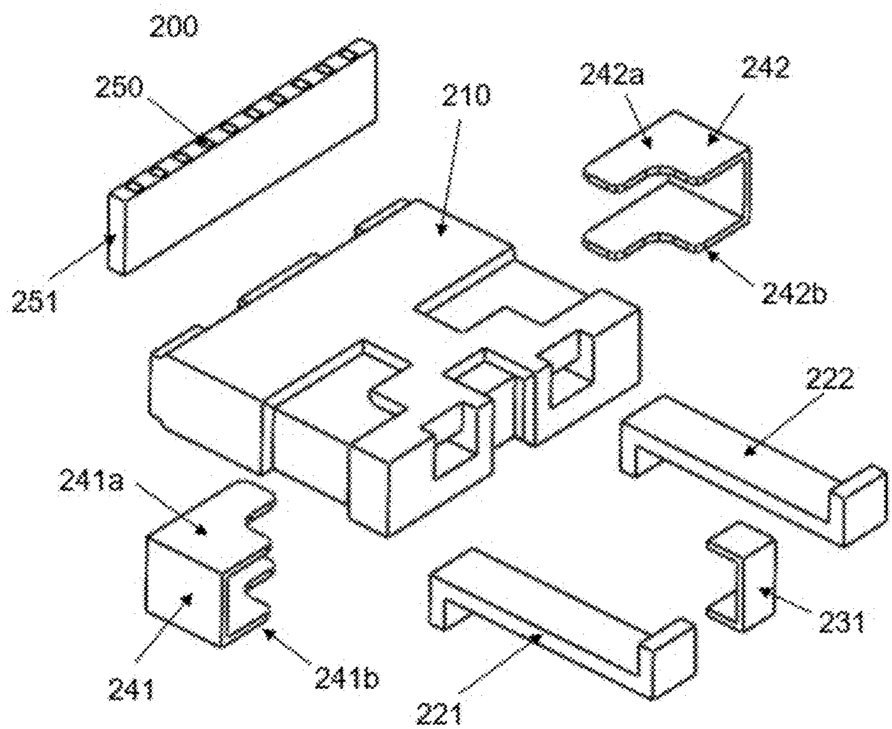


FIG. 6B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242b
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241a
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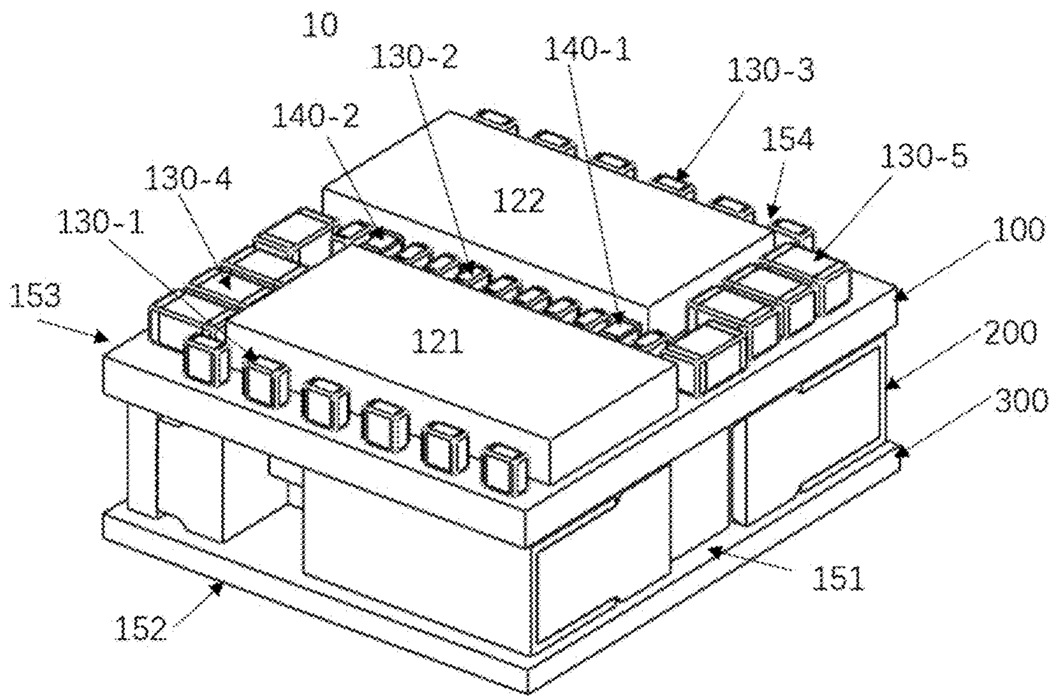
241b
221

FIG. 6C


10
130-2
140-1
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130-5
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FIG. 7A

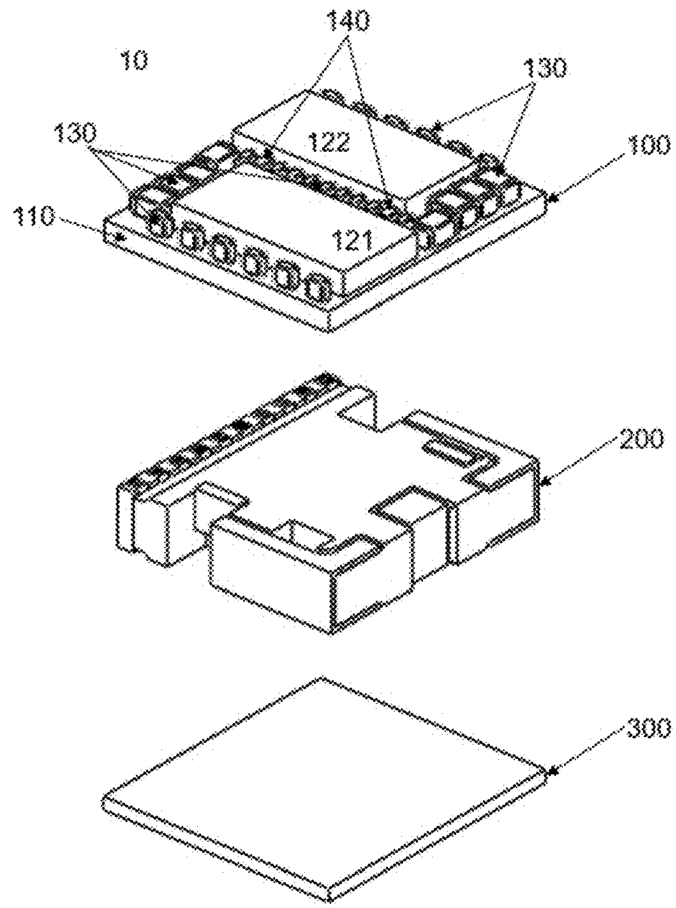
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FIG. 7B

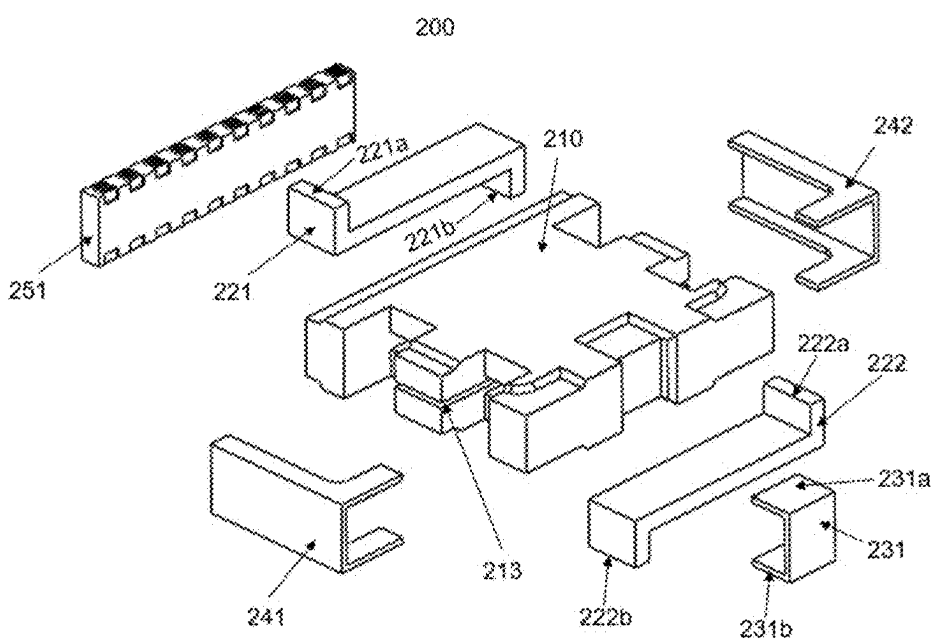
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FIG. 7C

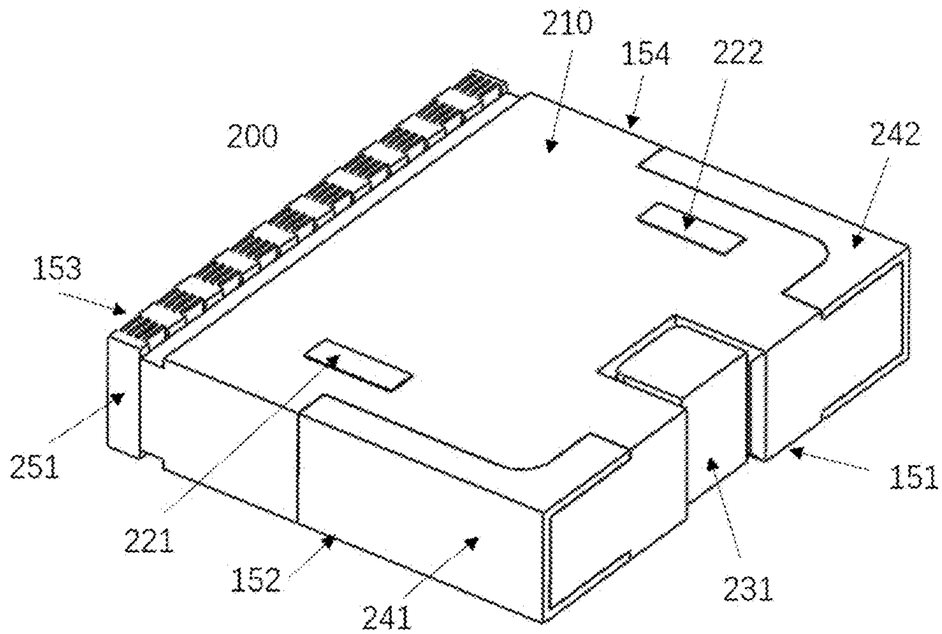
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FIG. 8A

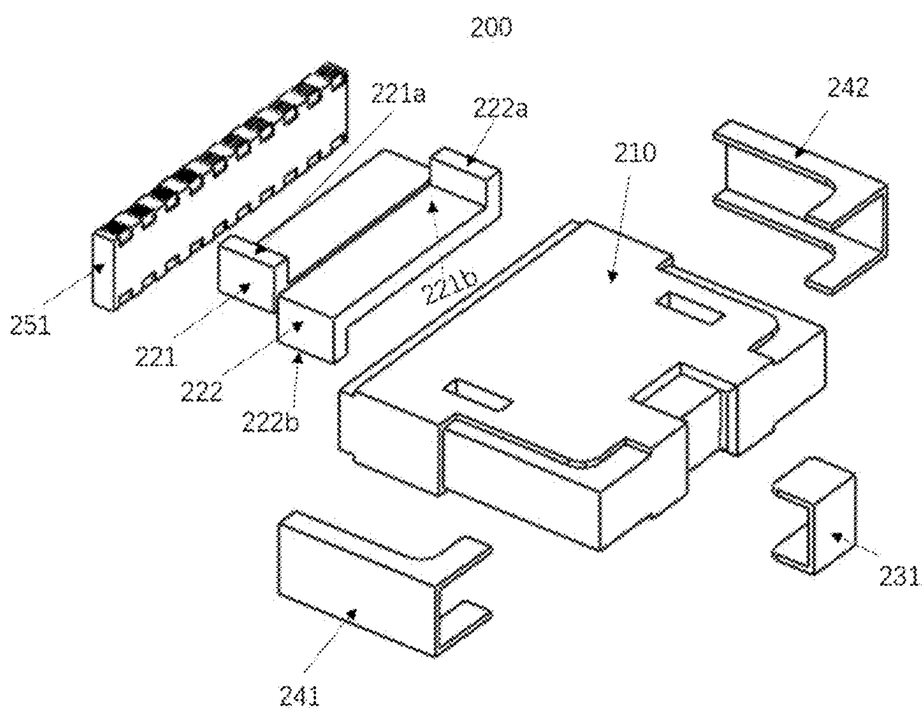
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FIG. 8B

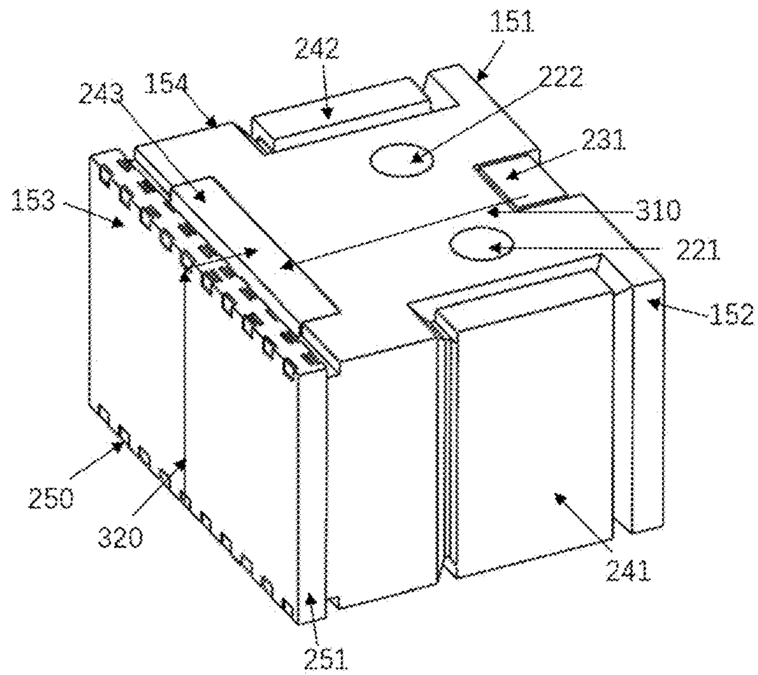
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FIG. 9A

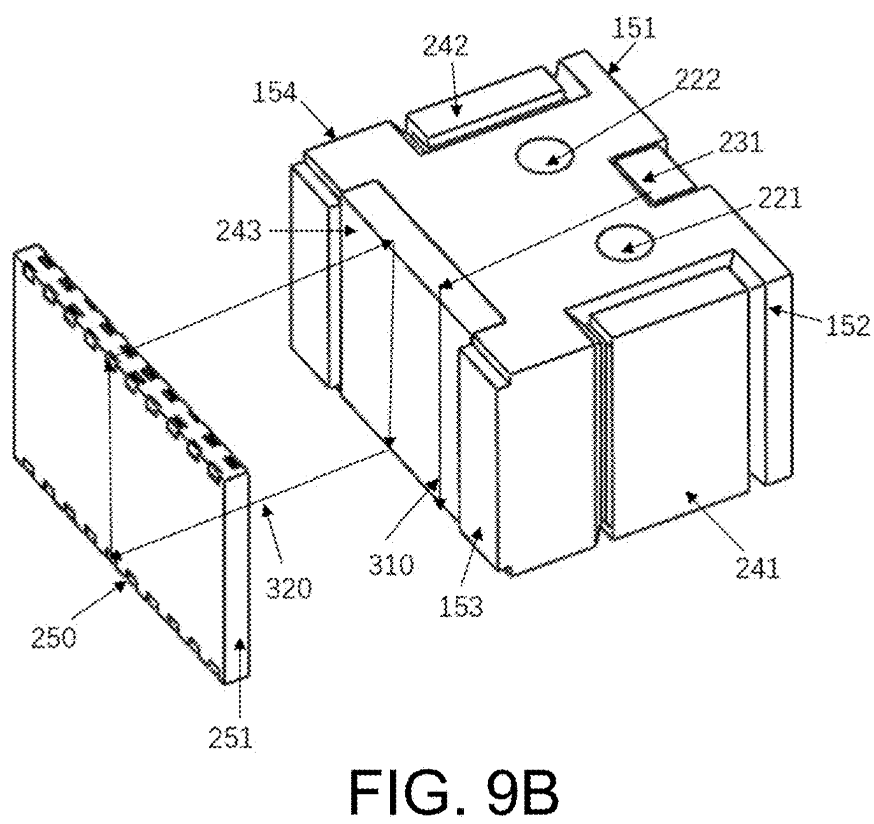
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FIG. 9B

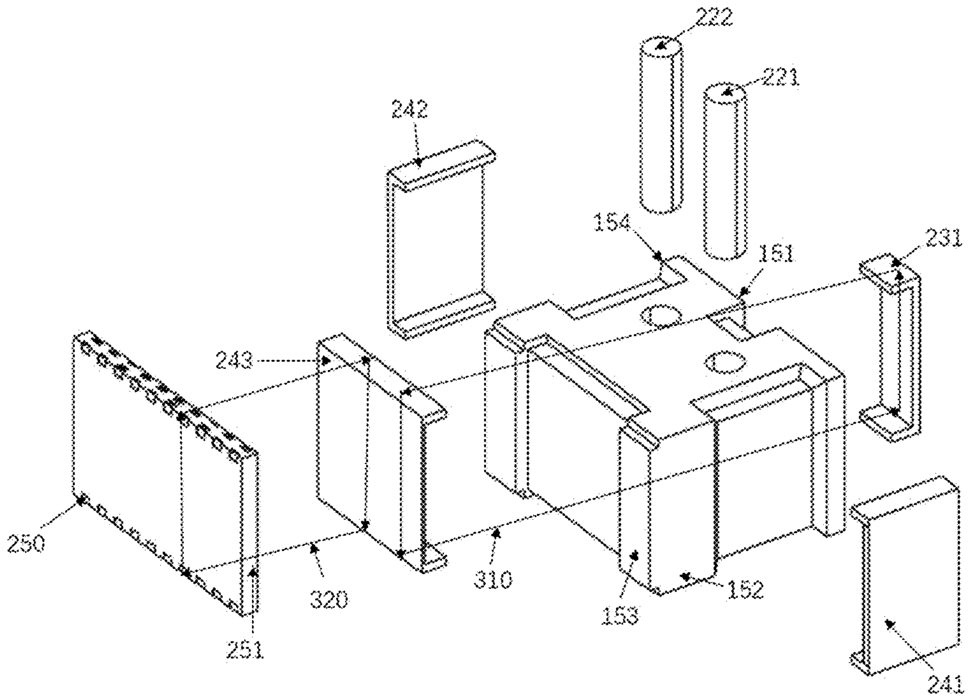
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FIG. 9C

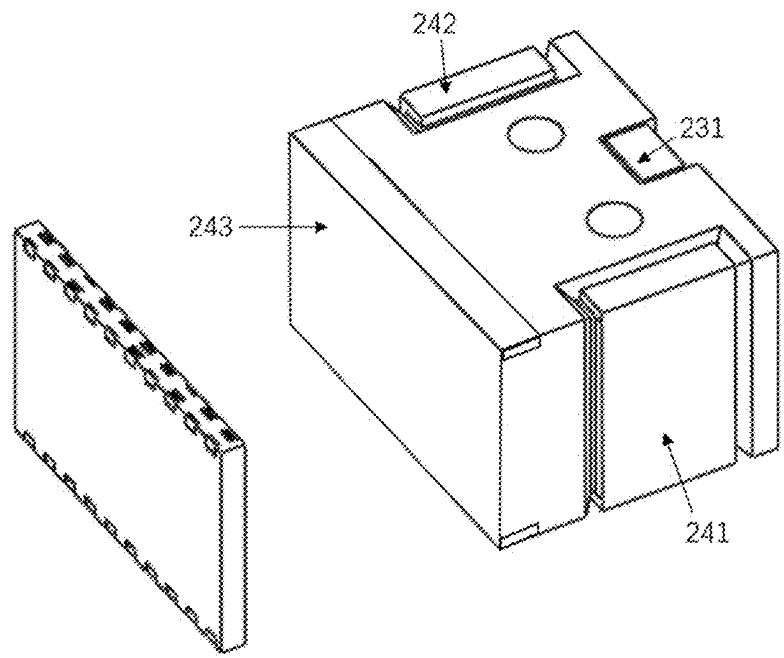
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FIG. 9D

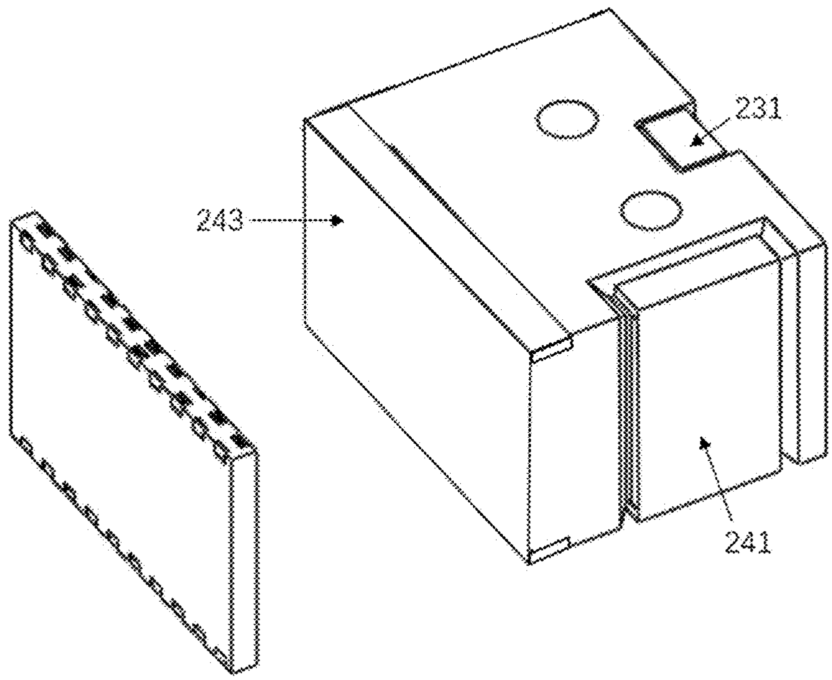

FIG. 9E

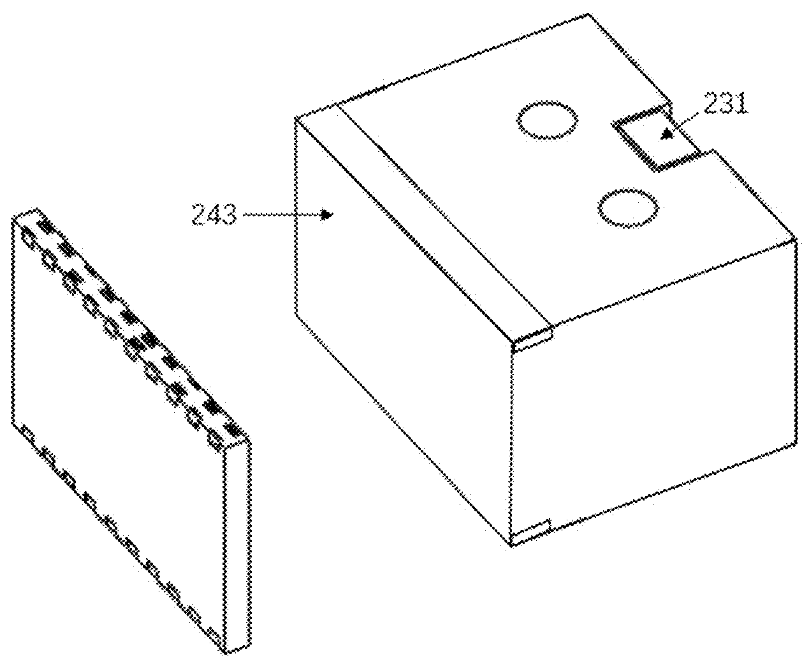

FIG. 9F

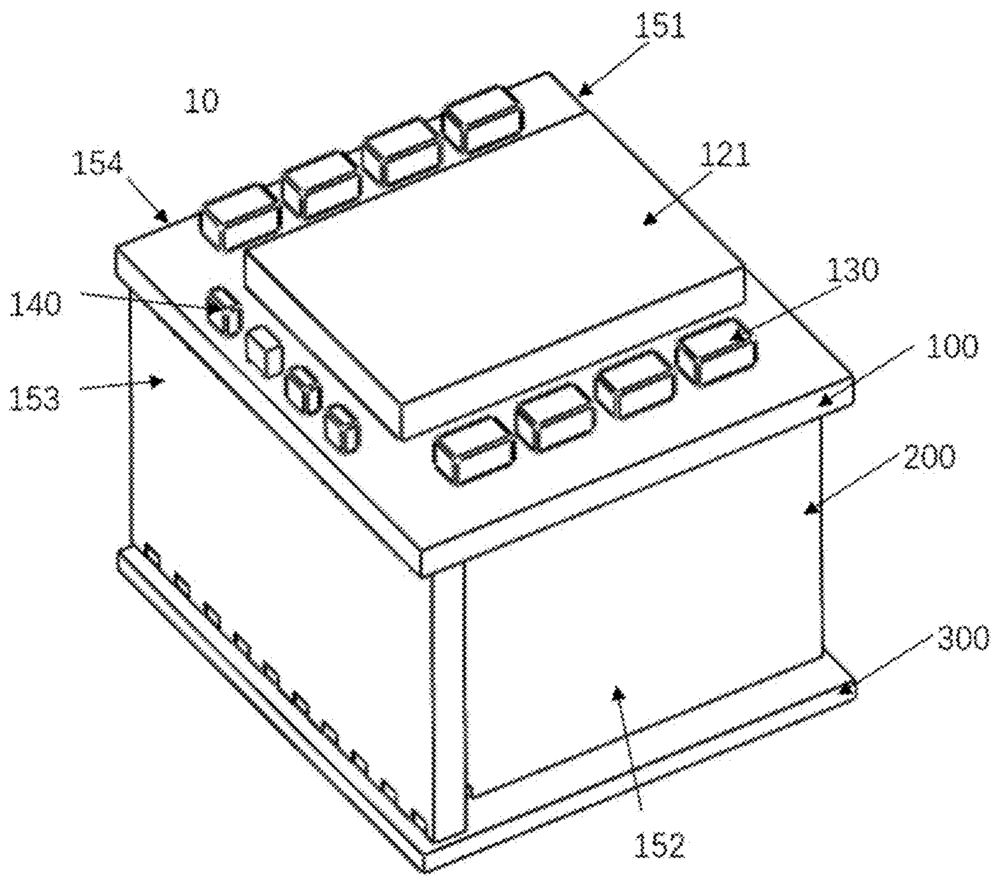

FIG. 10A

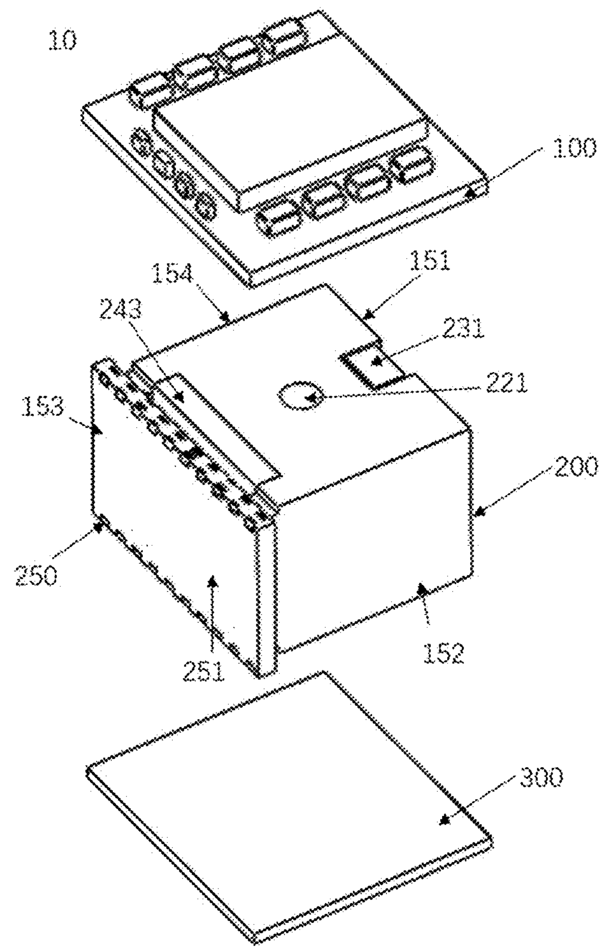

FIG. 10B

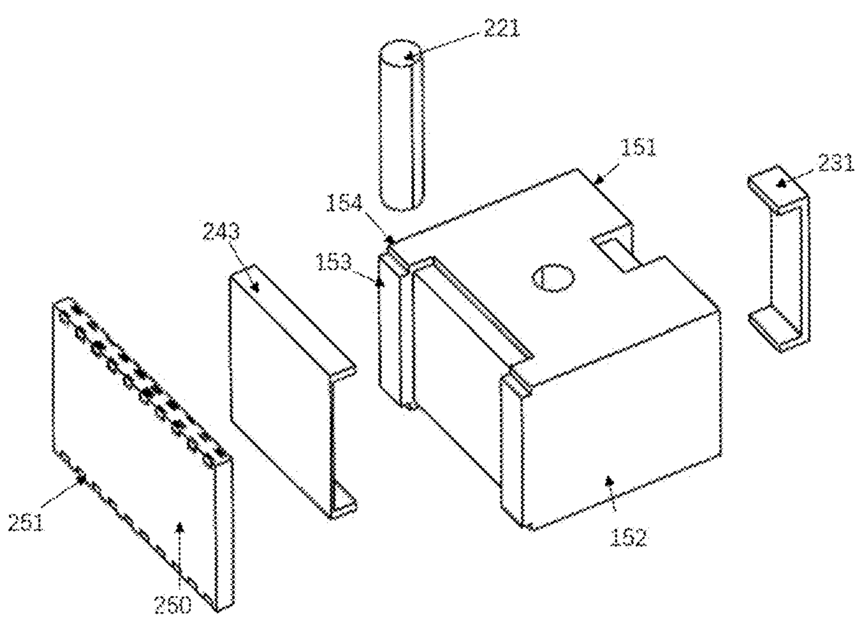

FIG. 10C

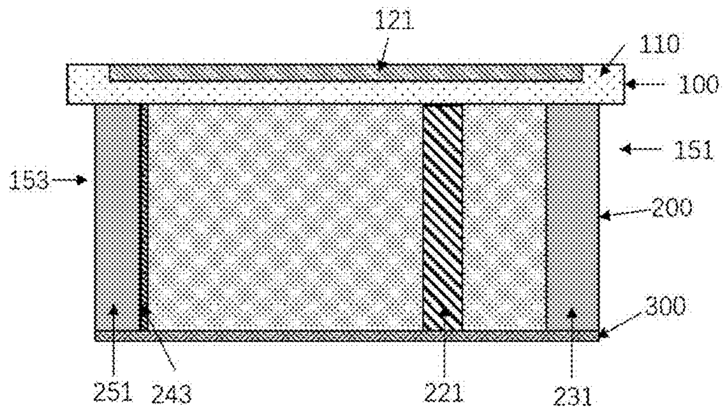

FIG. 11A

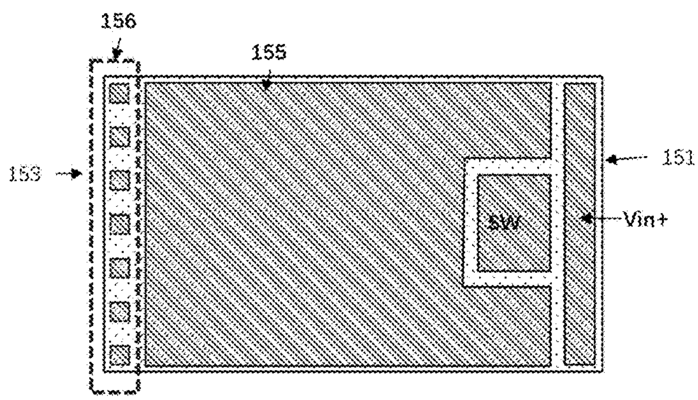

FIG. 11B

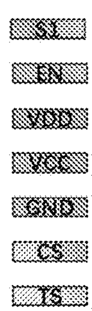

FIG. 11C

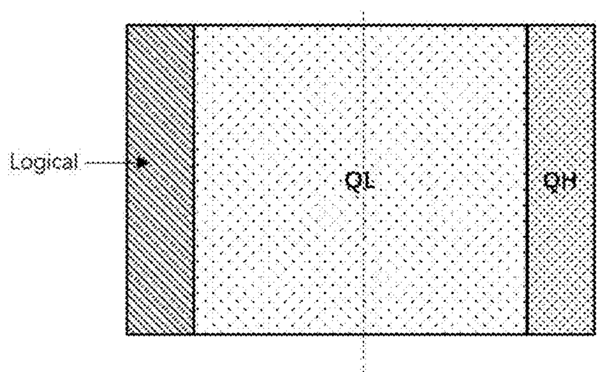

FIG. 11D

INDUCTOR ASSEMBLY, VRM MODULE AND PIN LAYOUT OF SEMICONDUCTOR SWITCH DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the priority benefit of Chinese patent application CN202410189719.8 filed on Feb. 20, 2024, and Chinese patent application CN202410311282.0 filed on Mar. 19, 2024, and Chinese patent application CN202410960993.0 filed on Jul. 17, 2024. The entirety of each of the above-mentioned patent applications is hereby incorporated by reference herein and made a part of this specification.

BACKGROUND

Technical Field

[0002] In recent years, with the development of technologies such as data centers, artificial intelligence, supercomputers and the like, more and more powerful ASICs are applied, such as CPUs, GPUs, machine learning accelerators, network switches, servers and the like, which consume a large amount of current, for example, the required current can reach thousands of amperes; and the current has the characteristic of rapid jump. A voltage regulation module (VRM, Voltage Regulator Modules, i.e., a voltage regulation module according to the present application), which comprises buck circuits (Buck), is traditionally used to supply such loads.

Description of Related Art

[0003] As the load current continues to increase, the heat dissipation problem of the VRM module is increasingly prominent. In the prior art, in order to share the radiator with the load ASIC, the VRM module reduces the upward thermal resistance from the top surface of the VRM module, the switching device of the main heat source is arranged on the top surface of the VRM module, the output inductor is arranged below the switching device, and the bottom surface of the output inductor is connected to the system mainboard to supply power to the load. According to the scheme, the output inductor is arranged between the switch device and the VRM module pin, and power transmission and signal transmission between the top surface and the bottom surface pin of the VRM module are achieved through the power electrical connector and the signal electrical connector. Magnetic coupling exists between an input power loop formed by the power electrical connector and a signal loop formed by the signal electrical connector, so that the signal loop has the risk of being interfered by the magnetic field under the extreme condition.

SUMMARY

[0004] In view of the above, one of the objectives of the present application is to provide an inductor assembly comprising an integrated inductor and a signal assembly; the integrated inductor comprises a magnetic core and a winding, the integrated inductor is provided with a side surface, a top surface and a bottom surface opposite to each other, the side surface comprises a first side surface, a second side surface, a third side surface and a fourth side surface; the second side surface and the fourth side surface are adjacent to the third side surface respectively.

[0005] A top surface connecting part is arranged on the top surface of the integrated inductor, and a bottom surface connecting part is arranged on the bottom surface of the integrated inductor.

[0006] The signal assembly comprises a signal electrical connector and a shielding layer, the shielding layer is disposed between the signal electrical connector and the magnetic core; the signal assembly is arranged close to the third side surface of the integrated inductor; the signal connector and the winding are connected with the top surface connecting part and the bottom surface connecting part.

[0007] Preferably, wherein the shielding layer is an inner metal layer; the signal assembly further comprises an outer metal layer; and the signal electrical connector is arranged between the outer metal layer and the inner metal layer; the inner metal layer is arranged adjacent to the third side surface of the integrated inductor.

[0008] Preferably, wherein the outer metal layer and the inner metal layer are used for an analog ground.

[0009] Preferably, wherein the outer metal layer and the inner metal layer are large-area copper laying layers.

[0010] Preferably, wherein copper laying or wiring of the outer metal layer and the inner metal layer is around the periphery of the signal assembly, and the wiring of the signal electrical connectors is distributed around the periphery of the signal assembly.

[0011] Preferably, wherein the outer metal layer, the inner metal layer and the signal connector are arranged in a vertical plate.

[0012] Preferably, wherein the winding comprises a first winding and a second winding; an air gap is formed between the first winding and the second winding; and the coupling coefficient between the first winding and the second winding is greater than or equal to 0.2.

[0013] Preferably, wherein the winding comprises a first winding and a second winding, and the first winding and the second winding are both "Z"-shaped copper sheets; the first winding and the second winding both comprise a main body part, and the main body part of the first winding and the main body part of the second winding are arranged in parallel.

[0014] Preferably, wherein the top surface connecting part of the first winding and the second winding are both disposed adjacent to the first side surface, and the bottom surface connecting part of the first winding and the second winding are both disposed adjacent to the third side surface.

[0015] Preferably, wherein the top surface connecting part of the first winding and the bottom surface connecting part of the second winding are arranged close to the second side surface; and the bottom surface connecting part of the first winding and the top surface connecting part of the second winding are arranged close to the fourth side surface.

[0016] Preferably, wherein two ends of the main body part of each winding are respectively exposed out of two opposite side surfaces of the magnetic core.

[0017] Preferably, wherein the winding comprises a first winding and a second winding, and the first winding and the second winding penetrate through the bottom surface from the top surface of the magnetic core.

[0018] A VRM module comprises an inductor assembly and a top assembly; the top assembly is disposed on the top surface of the inductor assembly, and the top assembly is electrical connected with the top surface connecting part.

[0019] Preferably, wherein the VRM module further comprises a bottom assembly; the bottom assembly is disposed on the bottom surface of the inductor assembly, and the bottom assembly is electrical connected with the bottom surface connecting part; the bottom assembly is used for being connected with a load; the top assembly and/or the bottom assembly is electrical connected with a power ground.

[0020] Preferably, wherein the VRM module further comprises a first power electrical connector and a second power electrical connector, and the first power electrical connector and the second power electrical connector are respectively disposed adjacent to different side surfaces of the integrated inductor; the first power electrical connector and the second power electrical connector form a top surface power connecting part on the top surface of the integrated inductor respectively, and the top surface power connecting part is connected with the corresponding top assembly; the first power electrical connector and the second power electrical connector form a bottom surface power connecting part on the bottom surface of the integrated inductor respectively, the bottom surface connector bonding pad is used for being connected with the input end of the VRM module, and the input end is a power input end; the shielding layer is an inner metal layer; the signal assembly further comprises an outer metal layer; and the signal electrical connector is arranged between the outer metal layer and the inner metal layer; the inner metal layer is arranged adjacent to the third side surface of the integrated inductor; the outer metal layer and the inner metal layer are used for an analog ground; the analog ground is electrical connected with the power ground through the top assembly and/or the bottom assembly.

[0021] Preferably, wherein the top assembly comprises a semiconductor switching device; the top surface connecting part of the winding is vertically corresponding to and electrically connected with the connecting end of the semiconductor switching device.

[0022] Preferably, wherein the top assembly further comprises an input capacitor, and an electrical loop comprising the first power electrical connector, the second power electrical connector and the input capacitor, the electrical loop surrounds at least a part of the magnetic core.

[0023] Preferably, wherein the first power electrical connector is a VIN electrical connector, and the second power electrical connector is a GND electrical connector; the first power electrical connector is arranged close to the third side surface or the first side surface of the integrated inductor; and the second power electrical connector is arranged adjacent to the second side surface and the fourth side surface.

[0024] Preferably, wherein the first power electrical connector is a VIN electrical connector, and the second power electrical connector is a GND electrical connector; the first power electrical connector is arranged adjacent to the first side surface of the integrated inductor; and the second power electrical connector is arranged adjacent to the third side surface, the second side surface and/or the fourth side surface.

[0025] Preferably, wherein the width of the second power electrical connector disposed adjacent to the third side surface is equal to or less than the width of the third side surface of the integrated inductor.

[0026] Preferably, wherein the first power electrical connector and the second power electrical connector are metal sheets, and the first power electrical connector and the second power electrical connector are assembled with the magnetic core or sintered together.

[0027] Preferably, wherein the VRM module further comprising a groove; the groove is disposed on the third side surface or the first side surface of the integrated inductor; the first power electrical connector is disposed in the groove of the third side surface or in the groove of the first side surface of the integrated inductor.

[0028] Preferably, wherein the magnetic core comprises a magnetic core main body and an auxiliary magnetic core, the first power electrical connector is arranged in a groove on the third side surface of the magnetic core main body, and the auxiliary magnetic core is arranged between the first power electrical connector and the signal assembly.

[0029] Preferably, wherein the material of the auxiliary magnetic core can be a material of the magnetic core main body, a magnetic adhesive having different equivalent magnetic permeability to the magnetic core main body, or other types of alloy magnetic materials.

[0030] Preferably, wherein the first power electrical connector and the second power electrical connector are formed by bending a rectangular copper sheet; a placement groove is formed in the position on the surface of the magnetic core, the position is corresponding to the first power electrical connector and the second power electrical connector; and the tail end of the second power electrical connector is arc-shaped.

[0031] Preferably, there are two semiconductor switch devices, the semiconductor switch devices comprise signal pins, and the signal pins are arranged adjacent to the third side surface; the VRM module further comprises an input capacitor, and the input capacitor is arranged between the semiconductor switch devices and adjacent to the third side surface.

[0032] Preferably, wherein the semiconductor switching device comprises a first semiconductor switching device and a second semiconductor switching device, and each semiconductor switching device comprises an SW end; the SW end of the first semiconductor switching device is arranged adjacent to the first side surface, and the SW end of the second semiconductor switching device is arranged adjacent to the third side surface; and the VRM module further comprises an input capacitor, and the input capacitor is arranged around and between the semiconductor switching device.

[0033] A VRM module comprises a top assembly, an inductor assembly and a bottom assembly; the inductor assembly comprises an integrated assembly and a signal assembly; the integrated assembly comprises a power electrical connector, a magnetic core and a winding.

[0034] The integrated inductor is provided with a side surface, a top surface and a bottom surface opposite to each other, the side surface comprises a first side surface, a second side surface, a third side surface and a fourth side surface; the second side surface and the fourth side surface are adjacent to the third side surface respectively.

[0035] The signal assembly comprises a signal electrical connector.

[0036] A top surface connecting part is arranged on the top surface of the integrated inductor, and a bottom surface connecting part is arranged on the bottom surface of the integrated inductor; the power electrical connector, the signal electrical connector and the winding are electrical connected with the top surface connecting part and the bottom surface connecting part.

[0037] The power electrical connector comprises a power ground electrical connector; the signal electrical connector is arranged adjacent to the power ground electrical connector.

[0038] The inductor assembly is arranged between the top assembly and the bottom assembly; the top assembly and the bottom assembly are electrical connected with the inductor assembly through the top surface connecting part and the bottom surface connecting part.

[0039] Preferably, wherein the signal assembly further comprises an inner metal layer and an outer metal layer; and the signal electrical connector is arranged between the outer metal layer and the inner metal layer; the inner metal layer is arranged adjacent to the third side surface of the integrated inductor; the outer metal layer and the inner metal layer are used for an analog ground; the analog ground is electrical connected with the power ground electrical connector through the top assembly and/or the bottom assembly.

[0040] Preferably, wherein the power ground electrical connector is the second power electrical connector; the power electrical connector further comprises a first power electrical connector; the first power electrical connector is arranged adjacent to the first surface of the integrated inductor.

[0041] A pin layout of a semiconductor switch device, wherein the pin comprises a Vin+ pin, an SW pin, a power ground pin and a signal pin area; the semiconductor switch device comprises a first side surface and a third side surface which are opposite to each other, and a second side surface and a fourth side surface which are opposite to each other; the Vin+ pin is adjacent and is arranged along the first side surface; the signal pin area is adjacent and is arranged along the third side surface; the power ground pin is arranged between the Vin+ pin and the signal pin area; and the SW pin is arranged between the Vin+ pin and the power ground pin.

[0042] Preferably, wherein the signal pin area comprises a control signal pin, a state pin and an analog ground pin of the semiconductor switch device.

[0043] Preferably, wherein the semiconductor switch device is a single wafer and comprises an upper switch QH area, a lower switch QL area and a LOGICAL area; the upper switch QH area is arranged adjacent to the first side surface, and the LOGICAL area is arranged adjacent to the third side surface; and the lower switch QL area is arranged between the upper switch QH area and the LOGICAL area.

[0044] Preferably, wherein the semiconductor material in the upper switch QH area exceeds 50%.

[0045] Compared with the prior art, the application has the following beneficial effects.

[0046] (1) According to the VRM module provided by the application, the magnetic field coupling between the signal loop and the input power loop is reduced by optimizing the arrangement between the input power loop and the signal loop, so that the VRM module can work reliably under the extreme condition.

BRIEF DESCRIPTION OF THE DRAWINGS

[0047] FIG. **1** is a schematic circuit diagram of a VRM module;

[0048] FIG. **2**A to FIG. **2**E are schematic diagrams of a first embodiment of the present application;

[0049] FIG. **3**A to FIG. **3**B are schematic diagrams of a second embodiment of the present application;

[0050] FIG. **4**A to FIG. **4**B are schematic diagrams of a third embodiment of the present application;

[0051] FIG. **5**A to FIG. **5**B are schematic diagrams of a fourth embodiment of the present application;

[0052] FIG. **6**A to FIG. **6**C are schematic diagrams of a fifth embodiment of the present application;

[0053] FIG. **7**A to FIG. **7**C are schematic diagrams of a sixth embodiment of the present application;

[0054] FIG. **8**A to FIG. **8**B are schematic diagrams of a seventh embodiment of the present application;

[0055] FIG. **9**A to FIG. **9**F are schematic diagrams of an eighth embodiment of the present application;

[0056] FIG. **10**A to FIG. **10**C are schematic diagrams of a ninth embodiment of the present application; and

[0057] FIG. **11**A to FIG. **11**D are schematic diagrams of a tenth embodiment of the present application.

DESCRIPTION OF THE EMBODIMENTS

[0058] One of the objectives of the present application is to reduce magnetic field coupling between a signal loop and an input power loop by optimizing the setting between an input power loop and a signal loop, thereby enabling reliable operation of the VRM module in an extreme case.

[0059] According to the technical scheme in the embodiment of the application, the technical scheme in the embodiment of the application is clearly and completely described below in combination with the drawings in the embodiment of the application, obviously, the described embodiments are only a part but not all of the embodiments of the present application. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present application without creative efforts shall fall within the protection scope of the present application.

[0060] FIG. **1** is a schematic circuit diagram of a VRM module. As shown in FIG. **1**, the present application provides a VRM module **10**, comprising an IPM unit **121**, an IPM unit **122**, a VIN electrical connector **231-1**, a VIN electrical connector **231-2**, a GND electrical connector **241**, a GND electrical connector **242**, an input capacitor **130**, a signal electrical connector **250*a*** and a signal electrical connector **250*b***. The IPM units **121/122** each comprise two semiconductor switch devices which are respectively an upper switch and a lower switch, the switch can be at least one of a MOSFET (Metal-Oxide-Semiconductor Field Effect Transistor), an SiC and a GaN; in the present application, the switch is described by taking an MOSFET as an example. The two MOSFETs are connected in series to form a bridge arm. One end of the bridge arm is connected to the input voltage end VIN **170** through the VIN electrical connector **231-1** or **231-2**; the other end of the bridge arm is connected to the ground end GND **150** through the GND electrical connector **241** or **242**. The midpoints of the bridge arm corresponding to the IPM unit **121/122** are the SW end **1212/1222**; the SW end **1212/1222** is connected with the input end of the corresponding output inductor respectively; the output ends of the output inductors are connected with the load **500** in parallel or individually, and energy is provided for the load. The input capacitor **130** is used for bypassing the high-frequency switch ripple current generated by the IPM unit **121/122**, so as to ensure that the input voltage is stable; and the signal electrical connector **250*a*/250*b*** is used for transmitting a sampling signal of the IPM unit **121/122**, and transmitting a driving signal or a control signal required by the IPM unit **121/122**.

Embodiment 1

[0061] FIG. **2**A is a schematic structural diagram of a VRM module **10** according to the embodiment, and the circuit diagram and element naming of the VRM module **10** are basically in one-to-one correspondence with FIG. **1**; FIG. **2**B is an exploded view of FIG. **2**A; FIG. **2**C is a schematic structural diagram of an integrated inductor; FIG. **2**D is a top view of an integrated inductor; and FIG. **2**E is an exploded view of the signal assembly. As shown in FIGS. **2**A-**2**E, the VRM module **10** comprises a top assembly **100**, an inductor assembly **200** and a bottom assembly **300**, wherein the top assembly **100** comprises a first substrate **110**, an IPM unit **121**, an IPM unit **122**, a plurality of input capacitors **130** and other passive elements **140**. The first substrate **110** comprises a first side surface **151**, a second side surface **152**, a third side surface **153**, and a fourth side surface **154**; and the four side surfaces sequentially satisfy a clockwise rotation relationship.

[0062] The other passive elements **140** are mainly used for filtering at the control pins of the IPM units **121/122**, the control pins of the IPM units **121/122** are arranged adjacent to the third side surface **153** of the first substrate **110**; in order to obtain a better filtering effect, the other passive elements **140** are arranged between the third side surface **153** of the first substrate and the IPM units **121/122**. In the embodiment, the input capacitor **130** is divided into two parts, one part is arranged adjacent to the first side surface **151** of the first substrate **110**, and the other part is arranged between the two IPM units **121/122**.

[0063] As shown in FIG. **2**B, the inductor assembly **200** includes a first power electrical connector **231**, a second power electrical connector **241** and **242**, an integrated inductor, and a signal assembly **251**; optionally, the first power electrical connector is a VIN electrical connector, and the second power electrical connector is a GND electrical connector; the Vin electrical connector **231** corresponds to the combination of the Vin electrical connectors **231-1** and **231-2** in FIG. **1**; the signal assembly **251** integrates the signal electrical connectors **250***a* and **250***b* in FIG. **1**. The integrated inductor comprises a magnetic core **210**, and a first winding **221** and a second winding **222**; the first winding **221** and the second winding are surrounded by the magnetic core **210**. In the embodiment, the first winding **221** and the second winding **222** are best in an "I"-shaped copper column. The magnetic core **210** has side surfaces, and the side surfaces of the magnetic core **210** are the same as the side surface of the integrated inductor, the side surface of the VRM module and the side surface of the first substrate **110**. An electrical loop comprising the VIN electrical connector **231**, the GND electrical connector **241/242** and the input capacitor **130** surrounds at least a portion of the magnetic core **210**. Optionally, the VIN electrical connector **231** and the GND electrical connector **241/242** are respectively disposed on different side surfaces of the integrated inductor.

[0064] As shown in FIG. **2**C, the signal assembly **251** includes a signal electrical connector **250** disposed adjacent to a third side surface **153** of the magnetic core. The top assembly **100** is electrical connected with the bottom assembly **300** through a signal electrical connector **250** (**250** corresponding to **250***a* and **250***b* in FIG. **1**) in the signal assembly **251**. Due to the fact that parasitic inductance exists in the input power loop **310** which comprises the VIN electrical connector **231**, the input capacitor **130** and the GND electrical connector **241/242**, the parasitic inductance and the input capacitor **130** generate resonance, which is referred to as an input power loop resonance for short. If the resonant frequency is close to the equivalent switching frequency of the two-phase VRM module **10**, the normal operation of the VRM module is interfered, and the conversion efficiency of the VRM module is reduced. Increasing the parasitic inductance of the input power loop **310** and/or increasing the equivalent capacitance of the input capacitor **130** can reduce the resonant frequency of the input power loop resonance, so that the resonant frequency is far lower than the equivalent switching frequency of the VRM, and the efficiency of the VRM is prevented from reducing. According to the embodiment of the application, the VIN electrical connector **231** and the GND electrical connector **241/242** are arranged on different side surfaces of the integrated inductor, and the parasitic inductance of the input power loop is increased by utilizing the corner part of the magnetic core **210**.

[0065] The VIN electrical connector **231** functions as a corresponding VIN electrical connector **231-1/231-2** in FIG. **1**; and the GND electrical connector **241/242** functions as the GND electrical connector **241/242** in FIG. **1**; the Vin electrical connector **231** is provided with a first bonding pad **231***a* on the top surface and a second bonding pad **231***b* on the bottom surface; the GND electrical connector **241/242** is provided with a first bonding pad **241***a*/**242***a* on the top surface and a second bonding pad **241***b*/**242***b* on the bottom surface. The first winding **221** is provided with a first bonding pad **221***a* on the top surface of the integrated inductor and is used for being connected with an SW end of the IPM unit **121** of the top assembly **100**; and the first winding **221** is provided with a second bonding pad **221***b* at the bottom surface of the integrated inductor and used for being connected with an output positive end (Vo end) **160** on the bottom assembly **300** to supply power to the load **500**; the second winding **222** is provided with a first bonding pad **222***a* on the top surface of the integrated inductor and is used for being connected with the SW end of the IPM unit **122** of the top assembly **100**; the second winding **222** is provided with a second bonding pad **222***b* on the bottom surface of the integrated inductor and is used for being connected with the output positive end (Vo end) **160** on the bottom assembly **300** to supply power to the load **500**.

[0066] In the embodiment, the VIN electrical connector **231** and the GND electrical connector **241/242** are assembled with the magnetic core **210** together through the metal copper sheet; in other embodiments, the metal copper sheet and the magnetic core **210** can also be sintered together. Specifically, as shown in FIG. **2**C, the VIN electrical connector **231** is disposed adjacent to the third side surface **153** of the magnetic core **210**; the GND electrical connector **241** is disposed adjacent to the second side surface **152** of the magnetic core **210**; the GND electrical connector **242** is disposed adjacent to the fourth side surface **154** of the magnetic core **210**. The signal assembly **251** is disposed adjacent to the third side surface **153** of the magnetic core **210**. The first power electrical connector is arranged adjacent to the third side surface of the integrated inductor. Specifically, the first power electrical connector

231 is arranged in a groove in the third side surface of the magnetic core, and the groove is a vertically extending groove.

[0067] As shown in FIG. 2E, the signal assembly **251** in the embodiment comprises a multilayer wiring layer, preferably, the signal assembly **251** is a multilayer wiring board, and the multilayer wiring layer comprises at least two layers. As an example, the signal assembly **251** comprises four wiring layers, and specifically comprises an inner metal layer **2501**, a first interlayer **2502**, a second interlayer **2503** and an outer metal layer **2504** arranged sequentially, and the four layers are all arranged in the substrate **252**; the inner metal layer **2501** is adjacent to the magnetic core **210**. The wiring layers in the first interlayer **2502** and the second interlayer **2503** are used for forming the signal electrical connector **250**; the inner metal layer **2503** and the outer metal layer **2504** are both copper laying layers with a large area, and is used for forming an analog ground wiring (defined as AGND), and is short-circuited with the GND electrical connector **241/242** on the top assembly **100** and/or the bottom assembly **300**. The advantage of this arrangement is that the inner metal layer **2501** can shield the voltage jump on the first winding **221** and the second winding **222**, so that the signal electrical connectors **250***a* and **250***b* are not interfered by the electric field.

[0068] Another preferred solution, **2501** and **2504** can be respectively configured to analog ground and power ground, so that a loop area between a signal ground and a power ground is small, which is beneficial to reduce noise interference between a power ground and a signal ground, and improve the reliability of the module.

Embodiment 2

[0069] FIG. **3**A is a schematic structural diagram of an inductor assembly **200** of the present embodiment, and FIG. **3**B is an exploded view of FIG. **3**A. As shown in FIGS. **3**A-**3**B, the embodiment has a similar technical effect as Embodiment I. The difference between the embodiment and Embodiment I lies in that the magnetic core comprises a magnetic core main body **210** and an auxiliary magnetic core **211**; the VIN electrical connector **231** is arranged on the magnetic core and is adjacent to the third side surface **153**; specifically: the VIN electrical connector **231** is arranged in a groove on the magnetic core main body **210**, the groove is located on the third side surface **153** of the magnetic core main body **210**; the auxiliary magnetic core **211** is arranged on the outer side of the VIN electrical connector **231**; the outer side is one side and away from the center of the magnetic core body **210**. Optionally, the auxiliary magnetic core **211** is also arranged in the groove, so that the VIN electrical connector **231** is surrounded by the magnetic core; the auxiliary magnetic core **211** can be a magnetic block made of the same magnetic material as the magnetic core main body **210**, magnetic glue with different equivalent magnetic permeability, or other types of alloy magnetic materials, such as an iron-manganese alloy; and after the auxiliary magnetic core **211** is arranged, the parasitic inductance of the input power loop **310** comprising the VIN electrical connector, the GND electrical connector and the input capacitor **130** can be improved, and it is ensured that the resonant frequency of the input power loop resonance does not affect the normal work of the VRM module.

Embodiment 3

[0070] FIG. **4**A is a schematic structural diagram of an inductor assembly **200** of the present embodiment, and FIG. **4**B is an exploded view of FIG. **4**A. As shown in FIG. **4**A to FIG. **4**B, the embodiment and the second embodiment have similar technical effects; the difference between this embodiment and the second embodiment lies in that: the wiring shape of the wiring layer in the signal assembly **251** is different; the wiring on the wiring layer of the signal assembly **251** is located on the periphery of the signal assembly **251** and is a " " shape; specifically, 1) copper laying or wiring of the inner metal layer **2501** and the outer metal layer **2502** is around the periphery of the signal assembly, and no copper laying or wiring is arranged in the middle of the two metal layers; 2) the wiring of the first interlayer **2502** and the second interlayer **2503** is also arranged around the periphery of the signal assembly **251**, and no wiring is arranged in the middle of the two interlayers. The" "-shaped wiring further increases the parasitic inductance of the input power loop **310**, so that the resonant frequency of the input power loop resonance is further away from the equivalent switching frequency of the VRM module, and it is ensured that the resonant frequency of the input power loop does not affect the normal operation of the VRM module.

Embodiment 4

[0071] FIG. **5**A is a schematic structural diagram of an inductor assembly **200** of the present embodiment, and FIG. **5**B is an exploded view of FIG. **5**A. As shown in FIG. **5**A to FIG. **5**B, the embodiment has a similar technical effect as the first embodiment. The difference between this embodiment and the first embodiment lies in that the VIN electrical connector **231** is arranged adjacent to the first side surface **151** of the magnetic core **210**; the signal assembly **251** is still arranged adjacent to the third side surface **153** of the magnetic core **210**, that is, the signal assembly **251** and the VIN electrical connector are arranged on the two opposite side surfaces of the magnetic core **210** respectively; so that the input power loop **310** has a larger loop parasitic inductance; and a signal loop **320** is arranged at a position away from the input power loop **310**, wherein the signal loop **320** comprise the signal electrical connectors **250***a* and **250***b*, or comprises the signal electrical connector **250***a* and the GND electrical connector, or comprises the signal electrical connector **250***b* and the GND electrical connector; that is, the distance between the signal loop **320** and the input power loop **310** is increased. Therefore, the magnetic coupling between the input power loop **310** and the signal loop **320** is weakened; the effect of the signal loop **320** resisting magnetic field interference is better, and the operation reliability of the VRM module under extreme working conditions is improved.

Embodiment 5

[0072] FIG. **6**A is a schematic structural diagram of a VRM module **10** of the present embodiment, FIG. **6**B is an exploded view of FIG. **6**A, and FIG. **6**C is an exploded view of the inductor assembly. As shown in FIGS. **6**A-**6**C, the two-phase VRM module **10** in the embodiment comprises a top assembly **100**, an inductor assembly **200** and a bottom assembly **300**; wherein the top assembly **100** comprises a first substrate **110**, an IPM unit **121/122**, an input capacitor

130 and other passive elements **140**; the IPM unit **121/122** is disposed adjacent to the first side surface **151** of the first substrate **110**; the signal pins of the IPM units **121/122** are arranged in a direction opposite to the first side surface of the first substrate **110**, that is, adjacent to the third side surface **153** of the first substrate **110**; and the other passive elements **140** are arranged close to the third side surface of the first substrate **110** and are tightly attached to the positions of the IPM units **121/122**; the input capacitor **130** is arranged between the IPM units **121/122** and adjacent to the third side surface **153** of the first substrate **110**.

[0073] As shown in FIG. **6**C, the inductor assembly **200** comprises a magnetic core **210**, a first winding **221**, a second winding **222**, a VIN electrical connector **231**, a GND electrical connector **241**, a GND electrical connector **242** and a signal assembly **251**; there is no coupling relationship between the first winding **221** and the second winding **222**, or only weak positive coupling is present, for example, the coupling coefficient is less than 0.2. The first winding **221** and the second winding **222** are both “Z”-shaped copper sheets, penetrate through the third side surface **153** of the magnetic core from the first side surface **151** of the magnetic core **210**; one end extends from the first side surface to the top surface of the magnetic core, and form pins on the top surface of the magnetic core; the other end extends from the third side surface to the bottom surface of the magnetic core, and pins are formed on the bottom surface of the magnetic core; the main body parts of the first winding **221** and the second winding **222** are parallel to the top surface of the magnetic core **210**.

[0074] The Vin electrical connector **231** is disposed adjacent to the first side surface **151**; the GND electrical connector **241** is arranged adjacent to the second side surface **152** of the magnetic core **210**; the GND electrical connector **242** is arranged adjacent to the fourth side surface **154** of the magnetic core **210**; the signal assembly **251** is arranged adjacent to the third side surface **153** of the magnetic core **210**; that is, the VIN electrical connector **231** and the signal assembly **251** are arranged on two opposite side surfaces. Optionally, the VIN electrical connector and the GND electrical connector are both formed by bending a rectangular copper sheet. The tail end of the GND electrical connector is arc-shaped. The surface of the magnetic core is provided with a placement groove corresponding to the VIN electrical connector and the GND electrical connector; the placement groove is adapted to the shape of the VIN electrical connector and the GND electrical connector. The performance of the signal loop’s anti-interference in the embodiment is the same as that of implementation **4**, wherein the interference is from the input power loop, and details are not described herein again.

Embodiment 6

[0075] FIG. **7**A is a schematic structural diagram of a VRM module **10** of the present embodiment, FIG. **7**B is an exploded view of FIG. **7**A, and FIG. **7**C is an exploded view of the inductor assembly. As shown in FIGS. **7**A-**7**C, the two-phase VRM module **10** of the embodiment comprises a top assembly **100**, an inductor assembly **200** and a bottom assembly **300** which are sequentially arranged from top to bottom; the top assembly **100** comprises a first substrate **110**, an IPM unit **121/122**, an input capacitor **130** and other passive elements **140**; and the IPM unit **121** is arranged on the first substrate **110** and is adjacent to the first side surface **151**; and an SW end of the IPM unit **121** is adjacent to a third side surface **153** of the first substrate **110**; the IPM unit **122** is arranged on the first substrate **110** and is adjacent to the third side surface **153**; the SW end of the IPM unit **122** is adjacent to the first side surface **151** of the first substrate **110**; the input capacitor **130** is arranged around the IPM units **121** and **122**, and is arranged between the IPM units **121** and **122**; for example, 130-1, 130-2, 130-3, 130-4 and 130-5, a better filtering effect is achieved. Other passive elements **140** are disposed between the two-phase IPM units **121** and **122**, such as **140-1** and **140-2**, and respectively disposed adjacent to the signal pins of the two-phase IPM unit.

[0076] As shown in FIG. **7**C, the integrated inductor **200** comprises a magnetic core **210**, a first winding **221**, a second winding **222**, a VIN electrical connector **231**, a GND electrical connector **241**, a GND electrical connector **242**, and a signal assembly **251**.

[0077] Both the first winding **221** and the second winding **222** penetrate through the fourth side surface **154** from the second side surface **152** of the magnetic core **210**; wherein a first winding bonding pad (i.e., a first bonding pad **221***a*) of the first winding **221** extends from the second side surface **152** to the top surface, and a second winding bonding pad (i.e., a second bonding pad **221***b*) of the first winding **221** extends from the fourth side surface **154** to the bottom surface; a first winding bonding pad (i.e., a first bonding pad **222***a*) of the second winding **222** extends from the fourth side surface **154** to the top surface, and a second winding bonding pad (i.e., a second bonding pad **222***b*) of the second winding **222** extends from the second side surface **152** to the bottom surface. The main body parts of the first winding **221** and the second winding **222** are parallel to the top surface of the magnetic core **210**, and the main body parts of the first winding **221** and the second winding **222** are also parallel to each other. The first winding is disposed adjacent to the third side surface **153** of the magnetic core **210** and is parallel to the third side surface **153**. The second winding **222** is disposed adjacent to the first side surface **151** of the magnetic core **210** and is parallel to the first side surface **151**.

[0078] In the magnetic core **210**, an air gap **213** is provided between the first winding **221** and the second winding **222**; the air gap may be filled with air or a magnetic material, and the magnetic permeability of the magnetic material is lower than that of the magnetic core **210**. Optionally, the air gap **213** is parallel to the top surface of the magnetic core **210**. In the embodiment, the coupling coefficient between the first winding **221** and the second winding **222** is greater than or equal to 0.2.

[0079] The VIN electrical connector **231** is disposed adjacent to the first side surface **151** of the magnetic core **210**.

[0080] The GND electrical connector **241** is disposed adjacent to the second side surface **152** of the magnetic core, and the GND electrical connector **242** is disposed adjacent to the fourth side surface **154** of the magnetic core; the signal assembly **251** is disposed adjacent to the third side surface **153** of the magnetic core **210**; the performance of the signal loop’s anti-interference in the embodiment is the same as that of the embodiment shown in FIG. **6**B, wherein the interference is from the input power loop, and details are not described herein again.

Embodiment 7

[0081] FIG. **8**A is another embodiment of the inductor assembly **200** in the VRM module **10** of the present embodiment, and FIG. **8**B is an exploded view of FIG. **8**A. As shown in FIG. **8**A and FIG. **8**B, the inductor assembly **200** in the present embodiment comprises a magnetic core **210**, a first winding **221**, a second winding **222**, a VIN electrical connector **231**, a GND electrical connector **241** and **242**, and a signal assembly **251**.

[0082] Neither the first winding **221** nor the second winding **222** passes through the second side surface **152** and the fourth side surface **154** of the magnetic core **210**; wherein the first winding **221** extends from one end adjacent to the second side surface **152** to the top surface to form a top surface bonding pad **221***a* (i.e., a first bonding pad **221***a*) of the first winding, and the first winding **221** extends from one end adjacent to the fourth side surface **154** to the bottom surface to form a bottom surface bonding pad **221***b* (i.e., a second bonding pad **221***b*) of the first winding; the second winding **222** extends from one end adjacent to the fourth side surface **154** to the top surface to form a top surface bonding pad **222***a* (i.e., a first bonding pad **222***a*) of the second winding, and the second winding **222** extends from one end adjacent to the second side surface **152** to the bottom surface to form a bottom surface bonding pad **222***b* (i.e., a second bonding pad **222***b*) of the second winding. The main body part of the first winding **221** and the main body part of the second winding **222** are parallel to each other, are arranged adjacent to each other and are parallel to the top surface of the magnetic core **210**; and the distance between the first winding **221** and the second winding **222** meets the electrical isolation between the first winding **221** and the second winding **222**.

[0083] The difference between this embodiment and the sixth embodiment lies in that in the embodiment, because the first winding **221** and the second winding **222** are arranged adjacent to each other, an air gap does not need to be arranged, and only the distance between the two windings is required to meet electrical isolation, so that a high coupling coefficient can be realized; and therefore, small dynamic inductance and high steady-state inductance are realized, and excellent dynamic performance and high conversion efficiency are obtained. In addition, in other embodiments, in the embodiment, the magnetic core **210** can adopt a magnetic powder core and a hot-press forming process, the magnetic core **210** and the winding **221**/**222** are integrally pressed to form an inductor, the integrally-formed inductor can simplify the manufacturing process, and the production efficiency is improved.

Embodiment 8

[0084] In the embodiment, in order to further increase the parasitic inductance on the input power loop **310**, the signal loop **320** is further away from the VIN electrical connector **231**. According to the embodiment, the GND electrical connector **243** is arranged adjacent to the third side surface **153** of the magnetic core **210**, and the GND electrical connector **243** is arranged between the signal assembly **251** and the magnetic core body **210**. FIG. **9**A is a schematic structural diagram of an inductor assembly **200** according to an embodiment, and FIG. **9**B and FIG. **9**C are exploded schematic diagrams of FIG. **9**A. The VRM module structure suitable for the embodiment is the same as the first embodiment, the VRM module structure comprises a top assembly **100**, an intermediate assembly **200** and a bottom assembly **300**; as shown in FIGS. **9**A to **9**C, the difference between the first embodiment and the current embodiment lies in that the inductor assembly **200**; the VIN electrical connector **231** is disposed adjacent to the first side surface **151**; the GND electrical connector comprises three parts, which are respectively **241**, **242**, and **243**; the GND electrical connector **241** is disposed adjacent to the second side surface **152**; the GND electrical connector **242** is disposed adjacent to the fourth side surface **154**; the GND electrical connector **243** is disposed adjacent to the third side surface **153** and is disposed between the analog ground AGND and the magnetic core **210**. The path of the input power loop **310** comprising the GND electrical connector **243** and the VIN electrical connector **231** is further increased, and the parasitic inductance on the input power loop **310** is increased, so that the resonant frequency of the input power loop resonance is far away from the working frequency of the VRM module. Furthermore, the GND electrical connector and the analog ground GND are arranged on the third side surface of the inductor assembly **200**, so that the voltage difference between the power ground and the analog ground can be reduced. The GND electrical connector **243** can be arranged close to the magnetic core **210** and can also be integrated on the signal assembly **251**, and the requirements of the application can be met as long as the GND electrical connector **243** is arranged between the simulation ground and the winding. The width of the GND electrical connector **243** can be less than the width of the third side surface **153**, as shown in FIG. **9**B, or can be equal to the width of the third side surface **153**, as shown in FIG. **9**D. In the technical effect, the GND electrical connector **243** needs to cover the third side surface **153** of the magnetic core **210** as much as possible, so that it is optimal than the two widths are equal.

[0085] In another embodiment, the GND electrical connector in the inductor assembly **200** may include two parts, which are 241 and 243 respectively, as shown in FIG. **9**E; the GND electrical connector does not include a GND electrical connector **242**, and the GND electrical connector **241** and **243** are disposed adjacent to the second side surface **152** and the third side surface **153**, respectively. As shown in FIG. **9**F, the GND electrical connector only comprises 243 and is arranged adjacent to the third side surface **153**, and the technical effects disclosed in the above embodiment can also be obtained.

Embodiment 9

[0086] The application further provides a structure of the one-phase VRM module. As shown in FIG. **10**A to **10**C, the one-phase VRM module **10** comprises a top assembly **100**, an inductor assembly **200** and the bottom assembly **300**; the top assembly **100** comprises a first substrate **110**, an IPM unit **121**, a plurality of input capacitors **130** and other passive elements **140**. The input capacitors **130** are arranged adjacent to the second side surface **152** and the fourth side surface **154** respectively, the other passive elements **140** are arranged adjacent to the third side surface **153**, and the IPM unit **121** is arranged in an area enclosed by the first side surface **151**, the input capacitor **130** and other passive elements **140**. Correspondingly, the inductor assembly **200** only comprises one winding **221**; the SW pin of the IPM unit **121** is electrically connected with one end of the winding **221**, and furthermore, one end of the winding **221** is arranged vertically below the SW pin; the GND electrical connector can comprise three parts **241**/**242**/**243**, and can also comprise two parts **241** and **243**, and can also comprise only one GND electrical connector **243**, and the arrangement position of the GND electrical connector is the same as that shown in the eighth embodiment, so that the same technical effect can be obtained.

[0087] The structure of the two-phase VRM module shown in the first embodiment to the eighth embodiment is suitable for a one-phase VRM module, and the technical effects disclosed by the application can be obtained.

[0088] The technical means from the first embodiment to the ninth embodiment can be combined with each other. For example, the first side surface or the third side surface of the magnetic core is provided with a groove, the technical solution for accommodating the VIN electrical connector **231** can be applied to all the embodiments described above, and the same benefits can be obtained; similarly, the technical solution that the auxiliary magnetic core **211** is provided on the outer side of the VIN electrical connector **231** is also applicable to all the embodiments described above.

[0089] In addition, the air gap can be applied to some embodiments when needed, and details are not described herein again.

Embodiment 10

[0090] The embodiment also discloses the layout of the pin position of the IPM unit **121** and the layout of the internal wafer suitable for the structure of the embodiment. FIG. **11**A is a schematic side view from the perspective of the second side surface **152**, FIG. **11**B is a schematic diagram of a pin layout of the IPM unit **121**, FIG. **11**C is a schematic diagram of signal pin layout of the IPM unit **121**, and FIG. **11**D is a schematic diagram of layout of a wafer inside the IPM unit. FIG. **11**A to FIG. **11**C can be applied to a one-phase VRM module, and can also be applied to a two-phase VRM module. As shown in FIG. **11**A, the IPM unit **121** is embedded in the first substrate **110**, and the pins of the IPM unit **121** is electrically connected to the electrical connector corresponding to the inductor assembly **200** and one end of the winding respectively by means of the wiring in the first substrate **110**.

[0091] As shown in FIG. **11**A and FIG. **11**B, the IPM unit comprises a Vin+ pin, an SW pin, a power ground pin **155** and a signal pin area **156**. The Vin+ pin is arranged adjacent to the first side surface **151**, the Vin electrical connector **231** in the intermediate assembly **200** is arranged adjacent to the first side surface **151**, and the Vin+ pin is electrically connected with the Vin electrical connector **231** nearby; the signal pin area **156** is arranged adjacent to the third side surface **153**, the signal assembly **251** of the intermediate assembly **200** is arranged adjacent to the third side surface **153**, the signal pins and the signal assembly **251** are arranged nearby, and the signal pins and the signal assembly **251** are used for setting a control signal pin required by the IPM unit **121**, a state pin of the IPM unit **121**, an analog ground pin and the like. The power ground pin with the large-area **155** is arranged between the Vin+ pin and the signal pin area and is used for realizing the large current requirement of the IPM unit **121**. The SW pin is arranged between the Vin+ pin and the power ground pin and is arranged nearby one end of the winding **221**. According to the structure of the IPM pin position layout combined with the inductor assembly disclosed by the embodiment, the shortest electrical connection path in the VRM module can be realized, so that the loss in the VRM module is reduced, and the complexity of internal wiring of the first substrate **110** is simplified.

[0092] A detailed layout within the signal pin area **156** may be described with reference to FIG. **11**C, but is not limited thereto.

[0093] As shown in FIG. **11**B and FIG. **11**D, the IPM unit **121** is a single wafer and comprises an upper switch QH area, a lower switch QL area and a LOGICAL area, the upper switch QH area is arranged adjacent to the first side surface, the LOGICAL area is arranged adjacent to the third side surface, and the lower switch QL area is arranged between the upper switch QH area and the LOGICAL area. An upper switch QH arranged in the upper switch QH area and a lower switch QL arranged in the lower switch QL area are electrically connected to the SW pin in series, one end of the upper switch QH is electrically connected with the VIN+ pin, and one end of the lower switch QL is electrically connected with a power ground pin **155**. The LOGICAL area is used for setting a required signal of the upper switch QH and the lower switch QL and a connecting wire of the analog ground AGND. The upper switch QH is arranged on the right side of the central axis of the single wafer; and in the composition of the upper switch QH, the semiconductor material exceeds 50%.

[0094] The IPM pin layout and the internal wafer layout shown in the embodiment are not limited to the VRM module shown in the embodiment, and are also suitable for VRM modules or other power converters with other structures.

[0095] In the VRM module **10** shown in the present application, the included IPM unit **121** may include at least one DRMOS, that is, the DRMOS includes at least two power switches connected in series and a driver required for the power switches; but the IPM unit is not limited to DRMOS, it can be any switch, as long as the technical features described above and the foregoing technical benefits can be obtained. In the VRM **10**, one surface of the IPM unit **121** is arranged as the upper surface of the VRM module **10**, the upper surface serves as a main heat dissipation surface of the power switch, and 60% of heat generated by the module can be dissipated. The power ground pin of the IPM unit **121** is connected to the PGND pin of the lower surface of the VRM module **10** through a GND electrical connector; and an input positive pin of the IPM unit is connected to a Vin+ pin on the lower surface of the VRM module **10** through the VIN electrical connector; the SW pin of the IPM unit is electrically connected with one end of the winding; and furthermore, one end of the winding is arranged vertically below the SW pin; the input capacitor **130** is arranged on the top assembly **100** and is electrically connected with the input positive pin and the power ground pin of the IPM unit **121**; and related signal pins and signal ground pins of the IPM unit **121** are electrically connected with pins of the lower surface of the VRM module **10** through corresponding connectors on the signal assembly **251**, and are used for receiving control signals of the system and/or reporting the working state of the VRM module **10** to the system.

[0096] In this invention, the connection between the top assembly and the inductor assembly, the connection between the inductor assembly and the bottom assembly are using the bonding pad. However, this is not limited to the bonding pad; other connecting parts, such as those fixed by conductive adhesives, can also be used.

[0097] The "equal" or "same" or "equal to" disclosed by the application needs to consider the parameter distribution of engineering, and the error distribution is within +/−30%; and the included angle between the two line segments or the two straight lines is less than or equal to 45 degrees; the included angle between the two line segments or the two straight lines is within the range of [**60**, **120**]; and the definition of the phase error phase also needs to consider the parameter distribution of the engineering, and the error distribution of the phase error degree is within +/−30%.

[0098] In addition, relational terms such as first and second are used herein to distinguish one entity or operation from another entity or operation, and do not necessarily require or imply that there is any such actual relationship or sequence between these entities or operations. Moreover, the terms "comprising", "including" or any other variation thereof are intended to cover a non-exclusive inclusion, such that a process, method, article, or device that includes a series of elements includes not only those elements, but also other elements that are not explicitly listed, or elements inherent to such a process, method, article, or device. In the absence of more restrictions, a statement comprising a defined element does not preclude the existence of additional identical elements in the process, method, article, or device that includes the element.

[0099] The embodiments in the specification are described in a progressive manner, each embodiment focuses on the difference from other embodiments, and the same similar parts between the embodiments can be referred to each other.

[0100] The above description of the disclosed embodiments enables a person skilled in the art to implement or use the present application. Various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be implemented in other embodiments without departing from the spirit or scope of the application. Thus, the present application will not be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

What is claimed is:

1. An inductor assembly, comprising an integrated inductor and a signal assembly; wherein the integrated inductor comprises a magnetic core and a winding, the integrated inductor is provided with a side surface, a top surface and a bottom surface opposite to each other, the side surface comprises a first side surface, a second side surface, a third side surface and a fourth side surface; the second side surface and the fourth side surface are adjacent to the third side surface respectively;

a top surface connecting part is arranged on the top surface of the integrated inductor, and a bottom surface connecting part is arranged on the bottom surface of the integrated inductor;

the signal assembly comprises a signal electrical connector and a shielding layer, the shielding layer is disposed between the signal electrical connector and the magnetic core; the signal assembly is arranged close to the third side surface of the integrated inductor; the signal connector and the winding are connected with the top surface connecting part and the bottom surface connecting part.

2. The inductor assembly of claim **1**, wherein the shielding layer is an inner metal layer; the signal assembly further comprises an outer metal layer; and the signal electrical connector is arranged between the outer metal layer and the inner metal layer; the inner metal layer is arranged adjacent to the third side surface of the integrated inductor.

3. The inductor assembly of claim **2**, wherein the outer metal layer and the inner metal layer are used for an analog ground.

4. The inductor assembly of claim **2**, wherein the outer metal layer and the inner metal layer are large-area copper laying layers.

5. The inductor assembly of claim **2**, wherein copper laying or wiring of the outer metal layer and the inner metal layer is around a periphery of the signal assembly, and wiring of the signal electrical connector is distributed around the periphery of the signal assembly.

6. The inductor assembly of claim **2**, wherein the outer metal layer, the inner metal layer and the signal connector are arranged in a vertical plate.

7. The inductor assembly of claim **1**, wherein the winding comprises a first winding and a second winding; an air gap is formed between the first winding and the second winding; and a coupling coefficient between the first winding and the second winding is greater than or equal to 0.2.

8. The inductor assembly of claim **1**, wherein the winding comprises a first winding and a second winding, and the first winding and the second winding are both "Z"-shaped copper sheets; the first winding and the second winding both comprise a main body part, and the main body part of the first winding and the main body part of the second winding are arranged in parallel.

9. The inductor assembly of claim **8**, wherein the top surface connecting part of the first winding and the second winding are both disposed adjacent to the first side surface, and the bottom surface connecting part of the first winding and the second winding are both disposed adjacent to the third side surface.

10. The inductor assembly of claim **8**, wherein the top surface connecting part of the first winding and the bottom surface connecting part of the second winding are arranged close to the second side surface; and the bottom surface connecting part of the first winding and the top surface connecting part of the second winding are arranged close to the fourth side surface.

11. The inductor assembly of claim **8**, wherein two ends of the main body part of each of the first winding and the second winding are respectively exposed out of two opposite side surfaces of the magnetic core.

12. The inductor assembly of claim **1**, wherein the winding comprises a first winding and a second winding, and the first winding and the second winding penetrate through a bottom surface from a top surface of the magnetic core.

13. A voltage regulation module (VRM) module, comprising the inductor assembly of claim **1** and a top assembly, wherein the top assembly is disposed on a top surface of the inductor assembly, and the top assembly is electrical connected with the top surface connecting part.

14. The VRM module of claim **13**, further comprising a bottom assembly, wherein the bottom assembly is disposed on the bottom surface of the inductor assembly, and the bottom assembly is electrical connected with the bottom surface connecting part; the bottom assembly is used for being connected with a load; the top assembly and/or the bottom assembly is electrical connected with a power ground.

15. The VRM module of claim **14**, wherein the VRM module further comprises a first power electrical connector and a second power electrical connector, and the first power electrical connector and the second power electrical connector are respectively disposed adjacent to different side surfaces of the integrated inductor; the first power electrical connector and the second power electrical connector form a top surface power connecting part on the top surface of the integrated inductor respectively, and the top surface power connecting part is connected with the corresponding top assembly; the first power electrical connector and the second power electrical connector form a bottom surface power connecting part on the bottom surface of the integrated inductor respectively, the bottom surface connector bonding pad is used for being connected with the input end of the VRM module, and the input end is a power input end; the shielding layer is an inner metal layer; the signal assembly further comprises an outer metal layer; and the signal electrical connector is arranged between the outer metal layer and the inner metal layer; the inner metal layer is arranged adjacent to the third side surface of the integrated inductor; the outer metal layer and the inner metal layer are used for an analog ground; the analog ground is electrical connected with the power ground through the top assembly and/or the bottom assembly.

16. The VRM module of claim **14**, wherein the top assembly comprises a semiconductor switching device; the top surface connecting part of the winding is vertically corresponding to and electrically connected with the connecting end of the semiconductor switching device.

17. The VRM module of claim **15**, wherein the top assembly further comprises an input capacitor, and an electrical loop comprising the first power electrical connector, the second power electrical connector and the input capacitor, the electrical loop surrounds at least a part of the magnetic core.

18. The VRM module of claim **15**, wherein the first power electrical connector is a VIN electrical connector, and the second power electrical connector is a GND electrical connector; the first power electrical connector is arranged close to the third side surface or the first side surface of the integrated inductor; and the second power electrical connector is arranged adjacent to the second side surface and the fourth side surface.

19. The VRM module of claim **15**, wherein the first power electrical connector is a VIN electrical connector, and the second power electrical connector is a GND electrical connector; the first power electrical connector is arranged adjacent to the first side surface of the integrated inductor; and the second power electrical connector is arranged adjacent to the third side surface, the second side surface and/or the fourth side surface.

20. The VRM module of claim **19**, wherein a width of the second power electrical connector disposed adjacent to the third side surface is equal to or less than a width of the third side surface of the integrated inductor.

21. The VRM module of claim **15**, wherein the first power electrical connector and the second power electrical connector are metal sheets, and the first power electrical connector and the second power electrical connector are assembled with the magnetic core or sintered together.

22. The VRM module of claim **19**, further comprising a groove, wherein the groove is disposed on the third side surface or the first side surface of the integrated inductor; the first power electrical connector is disposed in the groove of the third side surface or in the groove of the first side surface of the integrated inductor.

23. The VRM module of claim **22**, wherein the magnetic core comprises a magnetic core main body and an auxiliary magnetic core, the first power electrical connector is arranged in a groove on the third side surface of the magnetic core main body, and the auxiliary magnetic core is arranged between the first power electrical connector and the signal assembly.

24. The VRM module of claim **23**, wherein the material of the auxiliary magnetic core is configured to be a material of the magnetic core main body, a magnetic adhesive having different equivalent magnetic permeability to the magnetic core main body, or other types of alloy magnetic materials.

25. The VRM module of claim **15**, wherein the first power electrical connector and the second power electrical connector are formed by bending a rectangular copper sheet; a placement groove is formed in the position on the surface of the magnetic core, the position is corresponding to the first power electrical connector and the second power electrical connector; and the tail end of the second power electrical connector is arc-shaped.

26. The VRM module of claim **16**, wherein there are two semiconductor switch devices, the semiconductor switch devices comprise signal pins, and the signal pins are arranged adjacent to the third side surface; the VRM module further comprises an input capacitor, and the input capacitor is arranged between the semiconductor switch devices and adjacent to the third side surface.

27. The VRM module of claim **16**, wherein the semiconductor switching device comprises a first semiconductor switching device and a second semiconductor switching device, and each semiconductor switching device comprises an SW end; the SW end of the first semiconductor switching device is arranged adjacent to the first side surface, and the SW end of the second semiconductor switching device is arranged adjacent to the third side surface; and the VRM module further comprises an input capacitor, and the input capacitor is arranged around and between the semiconductor switching device.

28. A VRM module, comprising a top assembly, an inductor assembly and a bottom assembly;

wherein the inductor assembly comprises an integrated assembly and a signal assembly; the integrated assembly comprises a power electrical connector, a magnetic core and a winding;

the integrated inductor is provided with a side surface, a top surface and a bottom surface opposite to each other, the side surface comprises a first side surface, a second side surface, a third side surface and a fourth side surface; the second side surface and the fourth side surface are adjacent to the third side surface respectively;

the signal assembly comprises a signal electrical connector;

a top surface connecting part is arranged on the top surface of the integrated inductor, and a bottom surface connecting part is arranged on the bottom surface of the integrated inductor; the power electrical connector, the signal electrical connector and the winding are electrical connected with the top surface connecting part and the bottom surface connecting part;

the power electrical connector comprises a power ground electrical connector; the signal electrical connector is arranged adjacent to the power ground electrical connector;

the inductor assembly is arranged between the top assembly and the bottom assembly; the top assembly and the bottom assembly are electrical connected with the inductor assembly through the top surface connecting part and the bottom surface connecting part.

29. The VRM module of claim **28**, wherein the signal assembly further comprises an inner metal layer and an outer metal layer; and the signal electrical connector is arranged between the outer metal layer and the inner metal layer; the inner metal layer is arranged adjacent to the third side surface of the integrated inductor; the outer metal layer and the inner metal layer are used for an analog ground; the analog ground is electrical connected with the power ground electrical connector through the top assembly and/or the bottom assembly.

30. The VRM module of claim **29**, wherein the power ground electrical connector is the second power electrical connector; the power electrical connector further comprises a first power electrical connector; the first power electrical connector is arranged adjacent to the first surface of the integrated inductor.

31. A pin layout of a semiconductor switch device, comprising a Vin+ pin, an SW pin, a power ground pin and a signal pin area; wherein the semiconductor switch device comprises a first side surface and a third side surface which are opposite to each other, and a second side surface and a fourth side surface which are opposite to each other; the Vin+ pin is adjacent and is arranged along the first side surface; the signal pin area is adjacent and is arranged along the third side surface;

the power ground pin is arranged between the Vin+ pin and the signal pin area; and the SW pin is arranged between the Vin+ pin and the power ground pin.

32. The pin layout of claim **31**, wherein the signal pin area comprises a control signal pin, a state pin and an analog ground pin of the semiconductor switch device.

33. The pin layout of claim **31**, wherein the semiconductor switch device is a single wafer and comprises an upper switch QH area, a lower switch QL area and a LOGICAL area; the upper switch QH area is arranged adjacent to the first side surface, and the LOGICAL area is arranged adjacent to the third side surface; and the lower switch QL area is arranged between the upper switch QH area and the LOGICAL area.

34. The pin layout of claim **33**, wherein a semiconductor material in the upper switch QH area exceeds 50%.

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