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Structure and Working Principle of PEU

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Foreword

With the continuous development and maturity of the NEV (new energy vehicle) industry, various systems of NEV are becoming increasingly lightweight and integrated. As a leading brand in the commercial vehicle industry, Foton has made remarkable achievements in the all-in-one integrated controller of NEV.

Foton's all-in-one integrated controller excels in several indicators. For example, it features high efficiency, energy saving, stability and reliability, excellent safety, as well as high compatibility and adaptability. Foton's integrated controller has been widely used in different types of vehicles, such as passenger cars, trucks and engineering vehicles, making positive contributions to the improvement of Foton's product quality and technical strength.

Abbreviation:

Abbreviation	Full name	Chinese name
VCU	Vehicle Control Unit	整车控制器
MCU	Motor Control Unit	电机控制器
DCDC	DC to DC buck converter	直流转直流降压转换器
DCAC	DC to AC converter	直流转交流转换器
PTO	Power Take Out (port)	高压取电口
EAC	Electrical Air Conditioner	电动空调
EHP	Electro-Hydraulic Power assist (pump)	电动液压助力油泵
PTC	Positive Temperature Coefficient (heater)	PTC电加热器
PEU	Power Electronic Unit	电力电子单元
IGBT	Insulated-Gate Bipolar Transistor (module)	绝缘栅双极性晶体管模块
OBC	On Board Charger (AC)	车载充电机
HV	High Voltage power	高压电的……
LV	Low Voltage power	低压电的……
PWM	Pulse Width Modulation	脉宽调制
PDU	Power Distribution Unit	电力分配单元
HVIL	High-Voltage Interlock Loop	高压互锁回路

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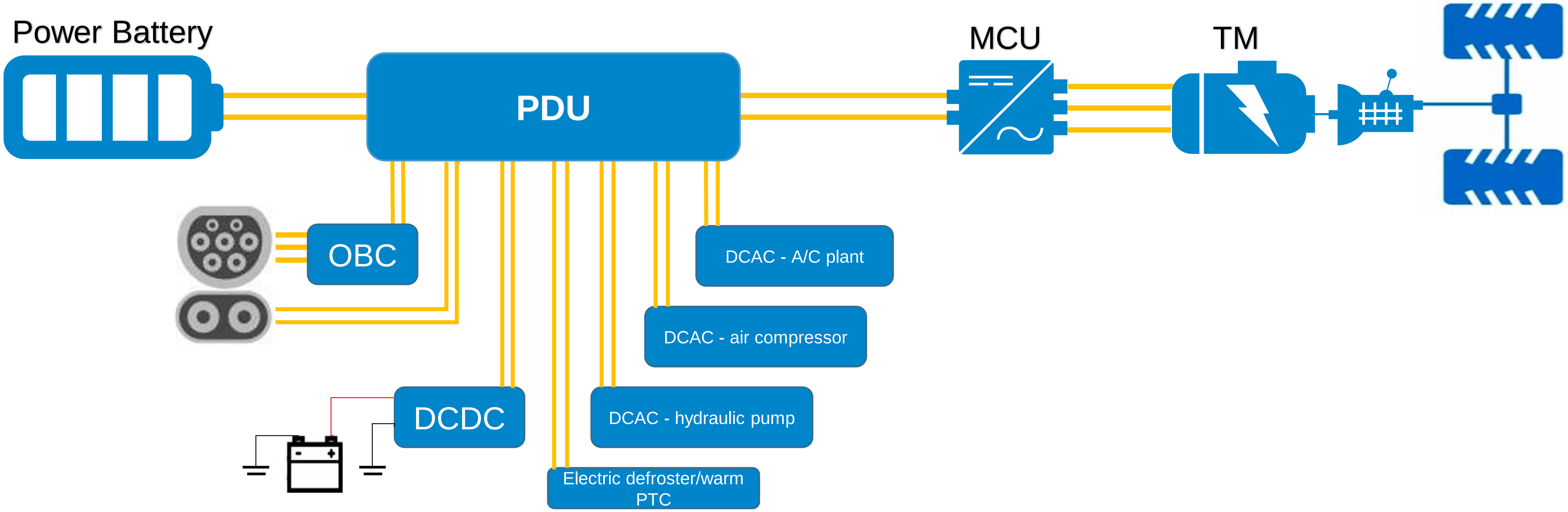
1.0

Overview of PEU

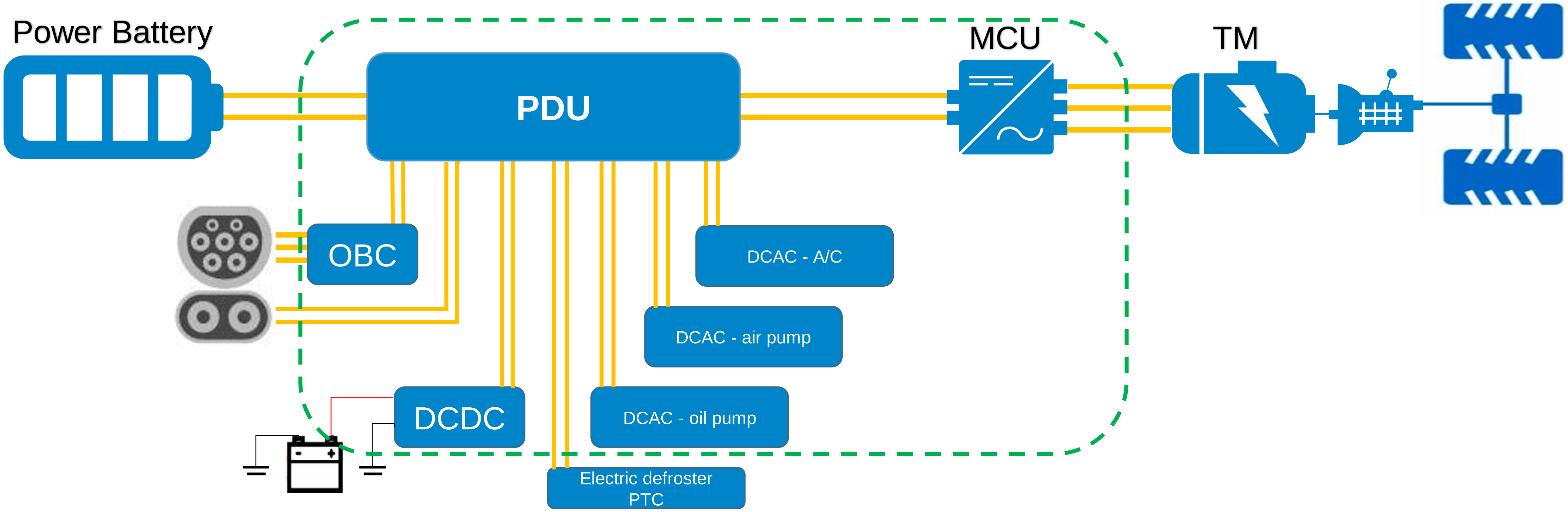
1.1.1 Early HV system infrastructure of EV

The early HV system infrastructure of EV can be briefly described as follows:
The electric power of the power battery is distributed to the motor drive system (MCU + motor), DCDC buck converter, DCAC converter (hydraulic pump, air compressor, A/C plant), and electric defroster through the PDU, and the charging circuit is accessed through the PDU as well. Due to the capacitive devices inside the MCU, a pre-charge circuit is required inside the PDU to safely realize HV power-on; for other modules or systems, the electric power is distributed to the DCAC or DCDC controller of each module through HV contactors and cables, and then DC or AC electric power is supplied respectively.
In addition, the early auxiliary systems such as EAC, hydraulic pump and air compressor are mostly AC equipment, and the cooling mode shall be considered for each module, so the NEV architecture is complicated and bulky, and the vehicle layout is difficult, making it impossible to achieve lightweight design.



1.1.2 The trend of HV system architecture of EV

Nowadays, the HV system architecture of EV tends to as follows:
The MCU, DCDC converter, OBC, etc. are combined with PDU to form a more integrated all-in-one controller, and the HV pre-charge/power-on function and DC charging circuit are designed in the BDU. In this design, the cooling system can be shared by MCU, DCDC converter, OBC and other modules, with higher integration level, more flexible layout and lighter weight.
Auxiliary systems such as EAC, hydraulic pump, air compressor, etc. are also designed to be DC equipment or with built-in controllers.
As shown by the dotted dash below, this integrated all-in-one controller is called a power electronic unit, PEU for short:



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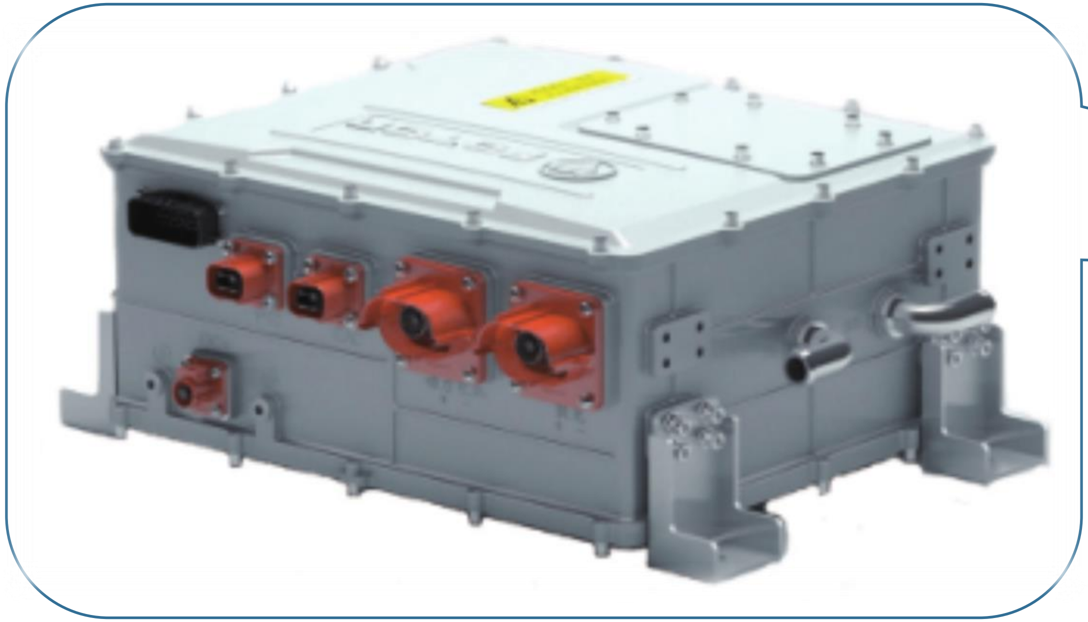
Overview of PEU

1.2.1 Appearance and installation position of FOTON PEU

Take the light-duty EV truck in Australian market as an example:

The PEU is located in the middle position under the cab and is in a cuboid aluminum shell. After the integrated design is realized, the PEU is only about the same size as a single early MCU, with at least four function modules integrated inside.



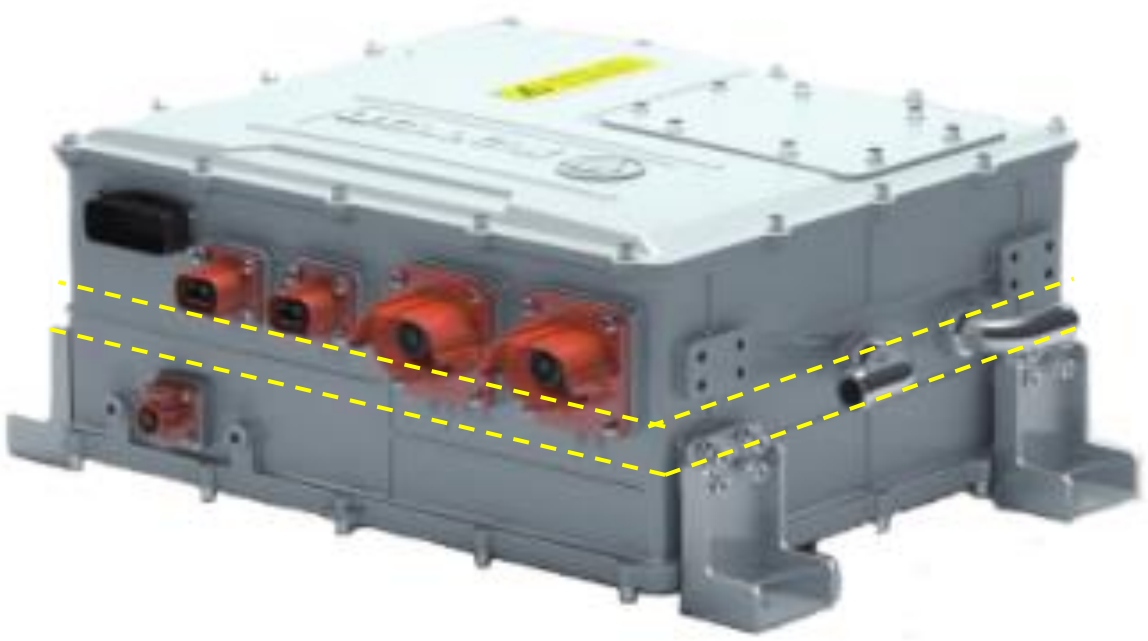
1.2.2 Overall structure of FOTON PEU

Take the light-duty EV truck in Australian market as an example:

The PEU is cuboid, with a cooling passage wall (as shown by the dotted dash below) running horizontally through the PEU, dividing the PEU into upper and lower chambers, and there are modules in both upper and lower chambers.

The modules which need to be cooled in the two chambers are all attached to the cooling wall, and can be cooled through contact heat exchange.

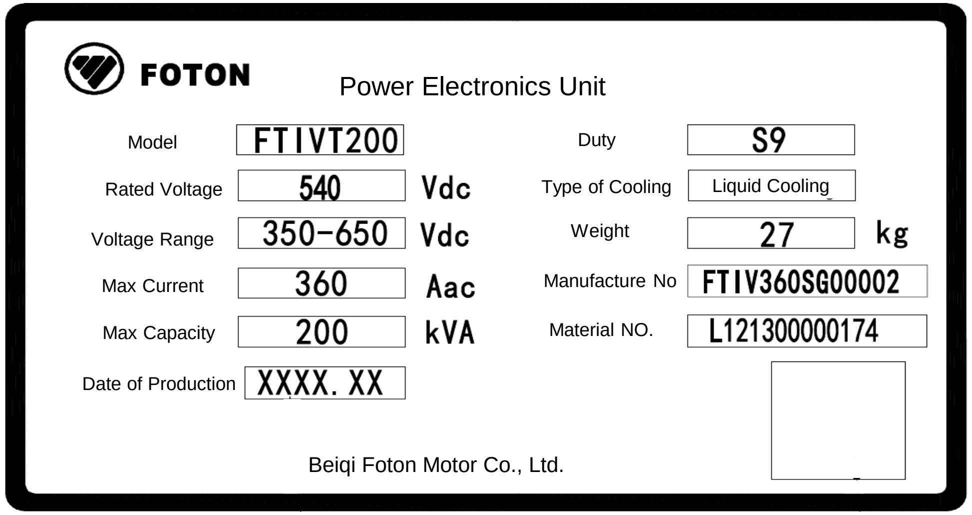
The front and back of the PEU are provided with HV and LV interfaces, and one side is provided with cooling pipeline inlet and outlet. The upper cover is designed with a small cover plate for easy access to the distribution fuse.



1.2.3 Basic parameters of PEU

Take the light-duty EV truck in Australian market as an example:
Different types of PEU will be designed and adopted for different vehicle models, such as dual-motor type, type with PTO interface, type with different number of module combinations;

PEU nameplate include some key parameters:



Other relevant parameters such as overall dimensions, IP rating, insulation grade, dielectric strength, cooling mode:

Basic product parameters

No.	Parameter	Value
1	Model	HC60LKPIC-K21
2	Overall dimensions	439.5*369.5*193 (mm*mm*mm)
4	Installation dimensions	422*355 (mm*mm)
4	Weight	27kg
5	IP rating	IP67
6	Insulation grade	The measured insulation resistance at steady state must be more than 20MΩ
7	Dielectric strength	The dielectric strength of the HV part of the controller to the ground (housing) can withstand a voltage of 3500VDC for 1 minute, with a leakage current of less than 10mA
8	Storage temperature	-40℃~105℃
9	Cooling mode	Liquid cooling
10	Flow rate	≥12L/min

1.0

Overview of PEU

1.3 Advantages of PEU integration mode

The PEU (Power Electronics Unit) is one of the core control units in EV. Its main function is to convert the DC power of battery into AC power to drive the motor of EV. Early electronic control system typically consists of multiple independent electronic devices that need to be designed, processed and installed separately, increasing manufacturing costs and maintenance difficulties, while the integrated PEU integrates MCU, DCDC and PDU functions into one module, with the following advantages:

1. Lower cost: The integrated PEU can integrate the functions of multiple independent devices into a single module, reducing the number of components and the cost of design and processing, resulting in a lower cost of the entire system.
2. Smaller size: The integrated PEU reduces the size and weight of the system by centrally cooling multiple independent devices, helping to reduce the overall weight of the EV.
3. Lower failure rate: The integrated PEU consists of multiple function modules with good coordination and interlocking mechanisms between the modules, which helps to reduce the incidence of system failure and the difficulty of maintenance.
4. Higher reliability: In the integrated PEU, the data and control signals are digitally communicated between the function modules, providing higher anti-interference ability and stability.
5. Better adaptability: The integrated PEU has better adaptability and flexibility, and can be designed and configured for different EV types and use scenarios.

In summary, the integrated PEU has advantages in cost, size, failure rate, reliability and adaptability, and is the trend of NEV in the future.

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2.0

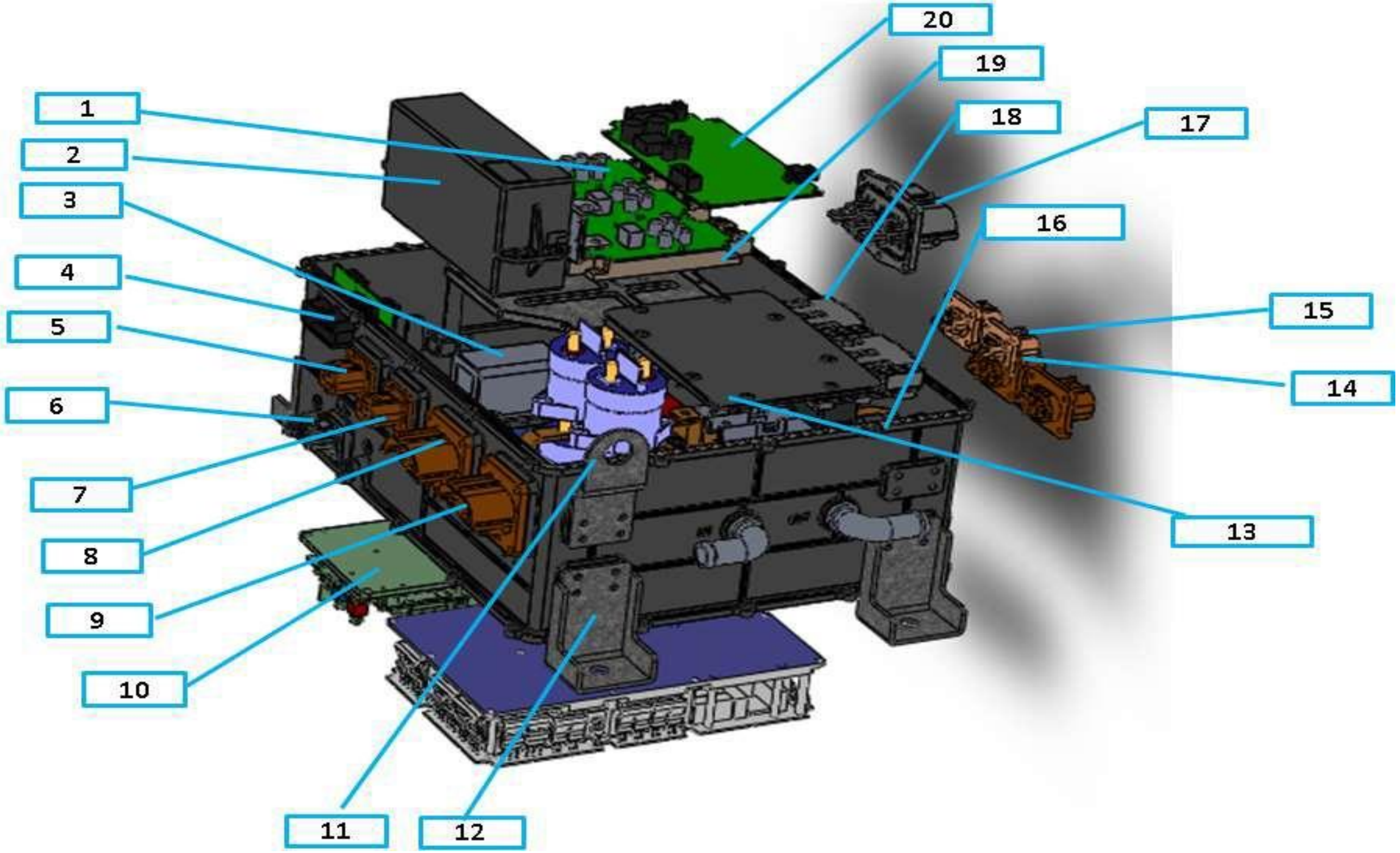
Introduction to key components of PEU

2.1.1 Exploded view of PEU

The MCU, DCDC buck converter, PDU, DC busbar, contactors, EAC, EHP, PTO, OBC and other HV interfaces are integrated into the PEU; some models may have two IGBT modules due to dual motors; and some models also have integrated DCAC module.

For PEU on Europe standard LDT EV, the OBC is located outside the PEU due to its power of 11KW and extra size. The AC power is converted into DC through the OBC and connected to the PEU, thus realizing AC charging.

As a function extension interface, the PTO interface can supply HV electric power to the bodywork equipment and allow various function modifications as required, such as refrigerator, hydraulic dumping, hoisting, etc.



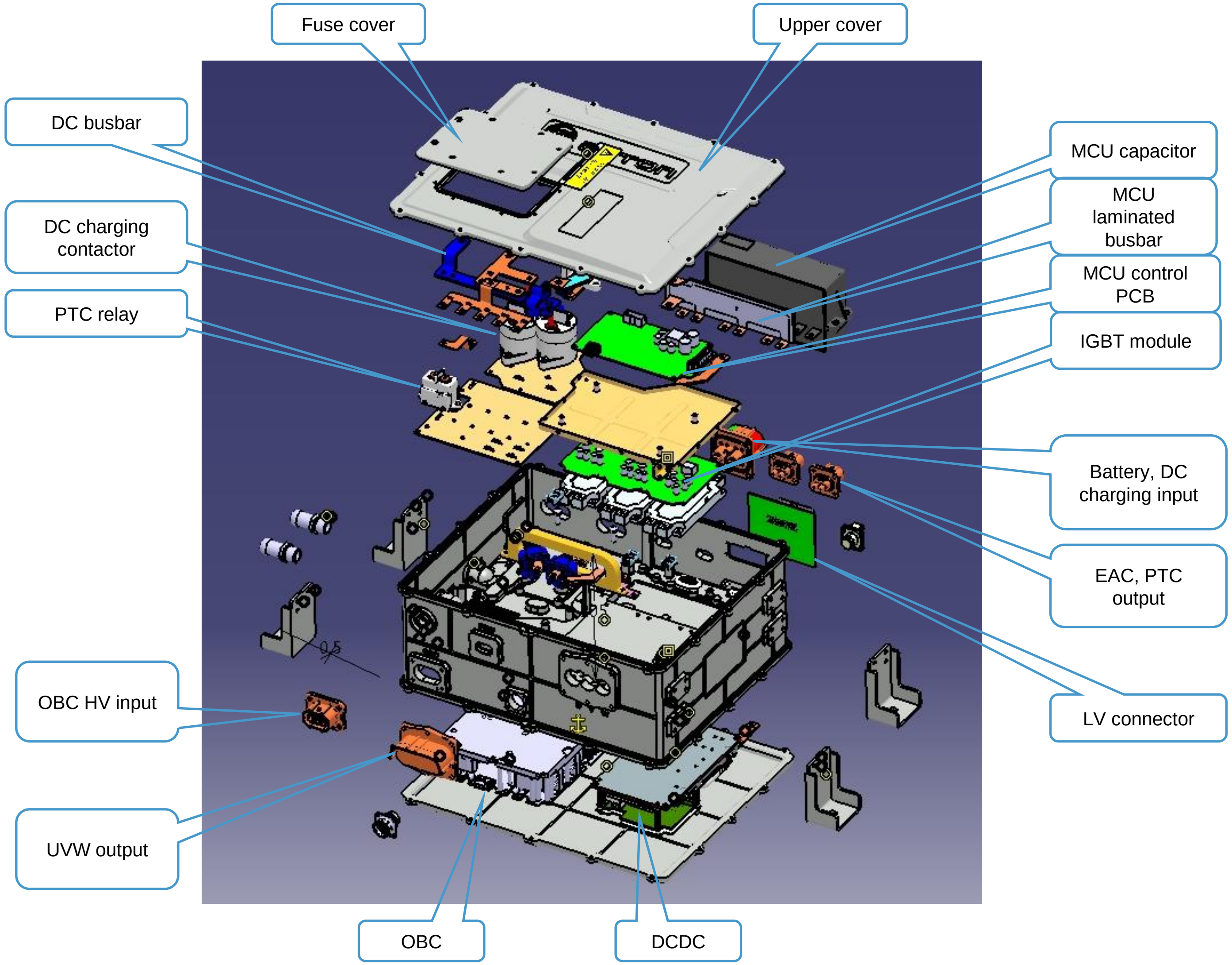
No.	Name		No.	Name
1	Driver PCB		11	Lifting lug
2	MCU Film capacitor		12	Mounting Bracket
3	EMC ring		13	Fuse cover
4	35PIN LV connector		14	OBC DC input
5	PTC HV output		15	PDU HV output (EHP)
6	DC output +		16	Warm PTC relay
7	EAC HV output		17	Motor 3-phase output
8	Battery HV input		18	PDU fuse
9	DC charging input		19	IGBT module
10	DC/DC convertor		20	Control PCB

2.1.1 Exploded view of PEU

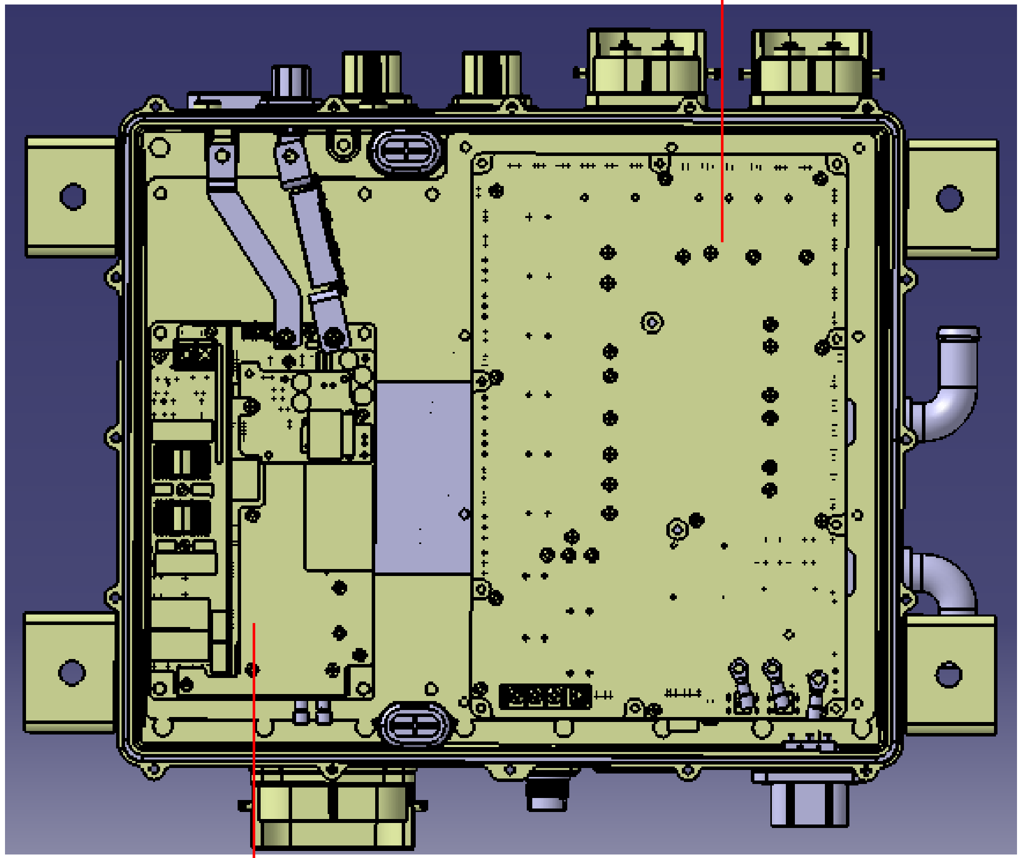
The PEU has double covers and cooling wall designed in the middle.

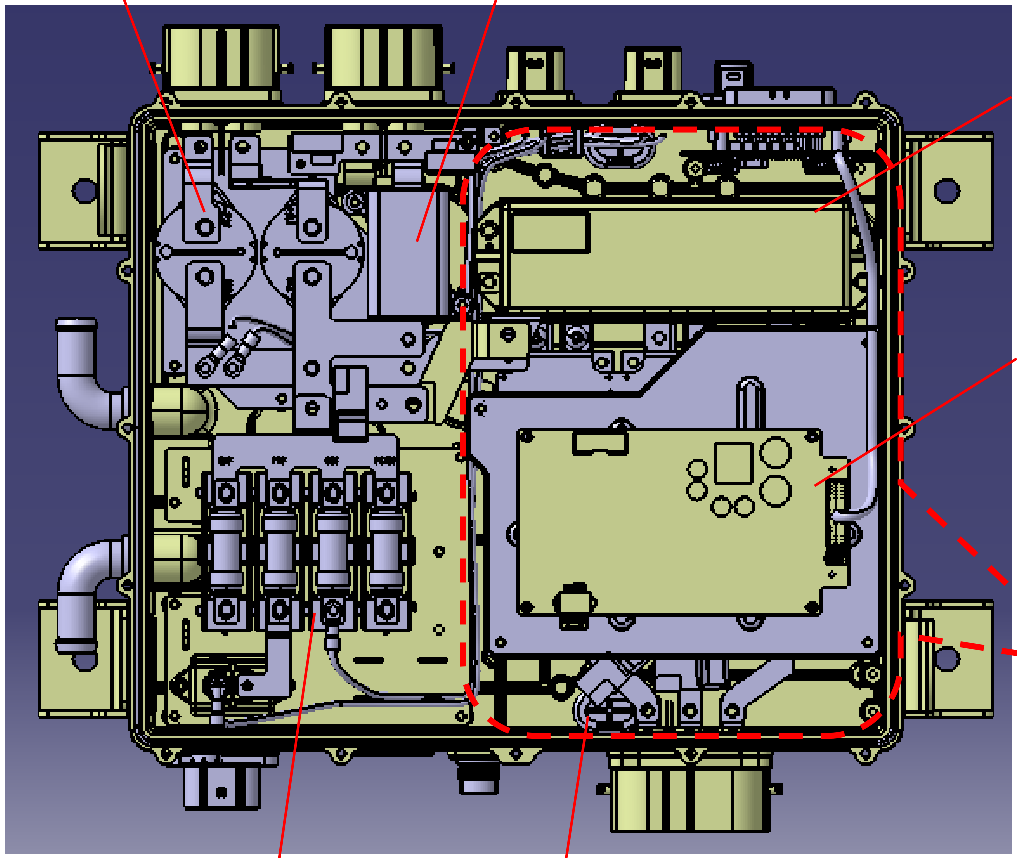
The upper chamber includes MCU and PDU, and the bottom chamber includes DC/DC converter and OBC.

The power battery harness, auxiliary HV harness and LV control harness interfaces are designed at the front panel, including DC charging, power battery, DC positive, A/C, heating, and LV control connectors.
The rear side includes interfaces of motor 3-phase harness and charging harness.



2.1.2 Interior layout of PEU - Schematic

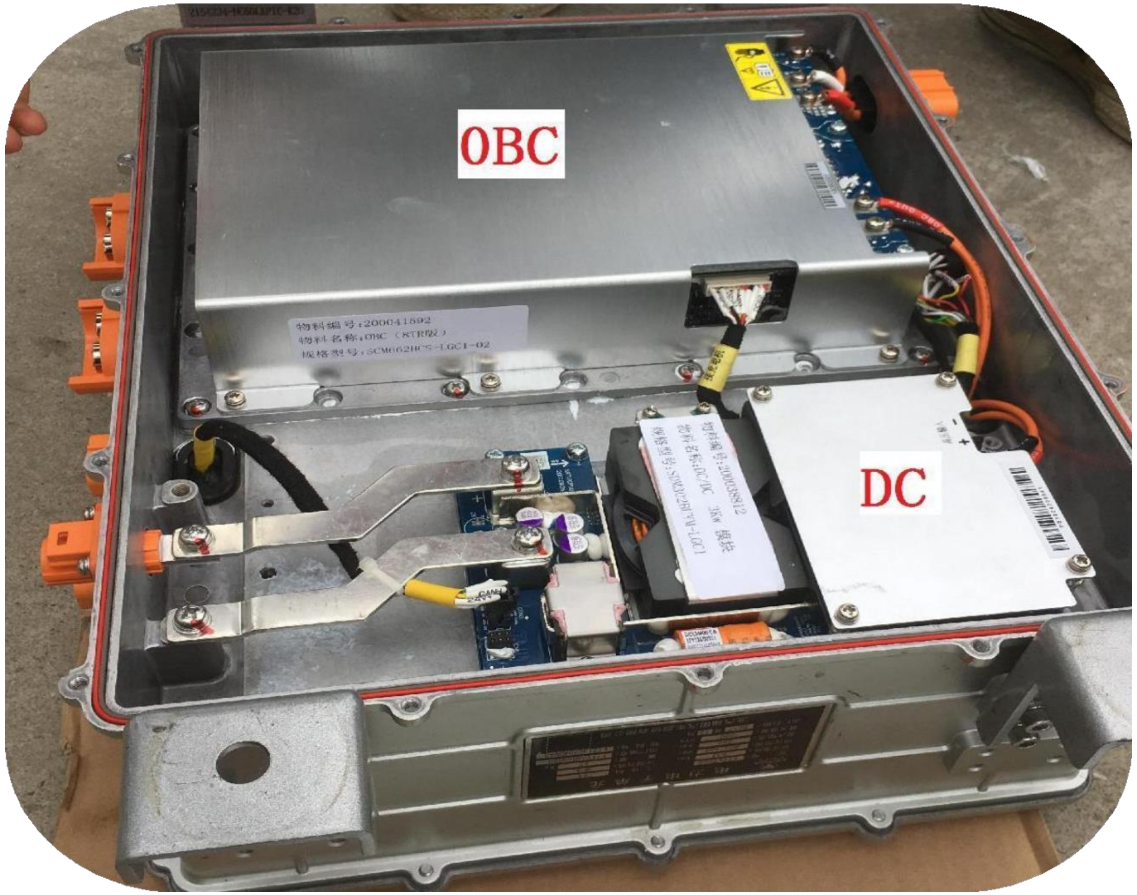




2.1.3 Interior layout of PEU - Photos

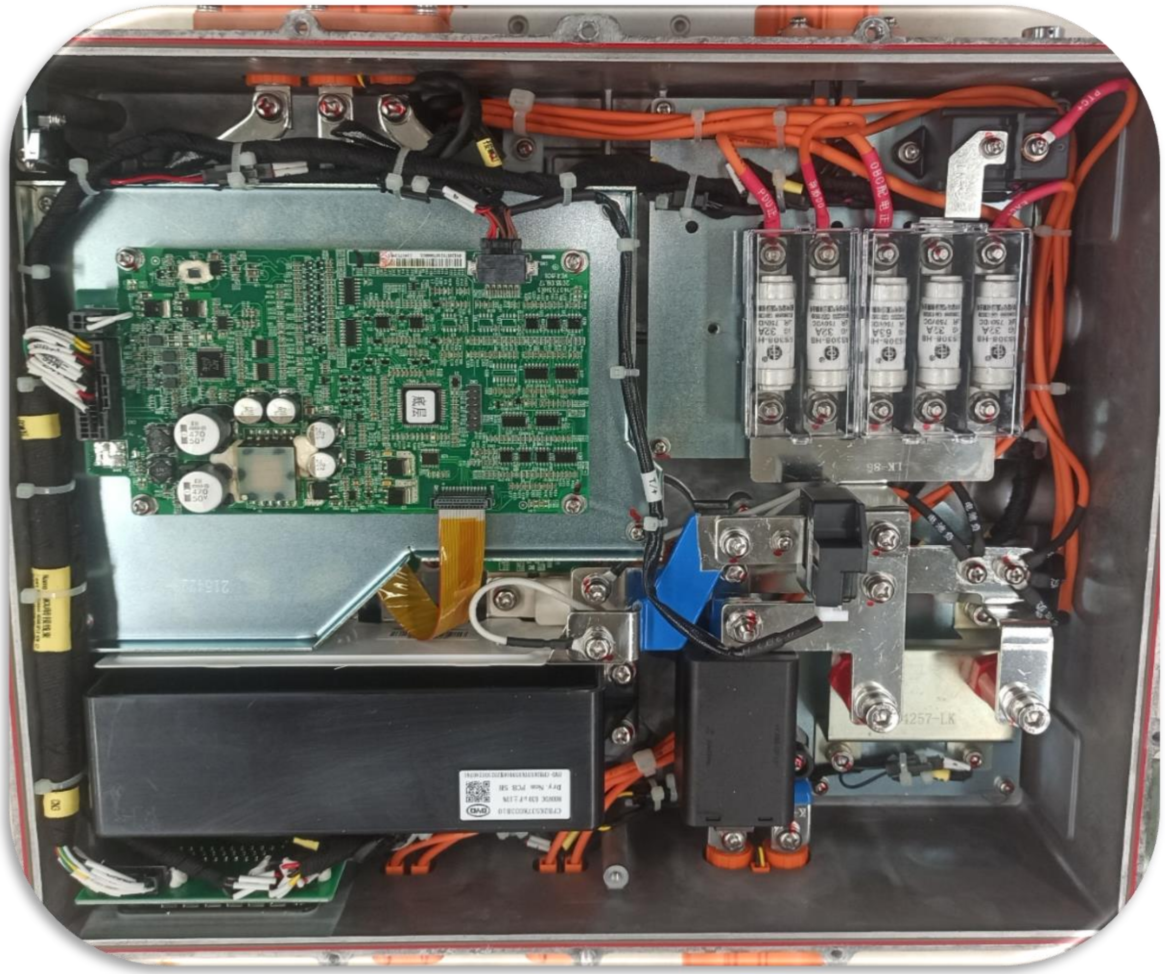
The MCU assembly, PDU, DC busbar, DC charging contactor, PTC contactor, EAC, EHP, PTO HV interfaces and PDU fuses are integrated in the upper part of PEU;

The DCDC converter, OBC and OBC input interface (AC) are integrated into the lower part of PEU.



2.1.4 Interior layout of PEU - European standard LDT (comparison)

The MCU assembly, PDU, DC busbar, PTC contactor, PTC, EAC, EHP, PTO HV interfaces and PDU fuses are integrated in the upper part of PEU;



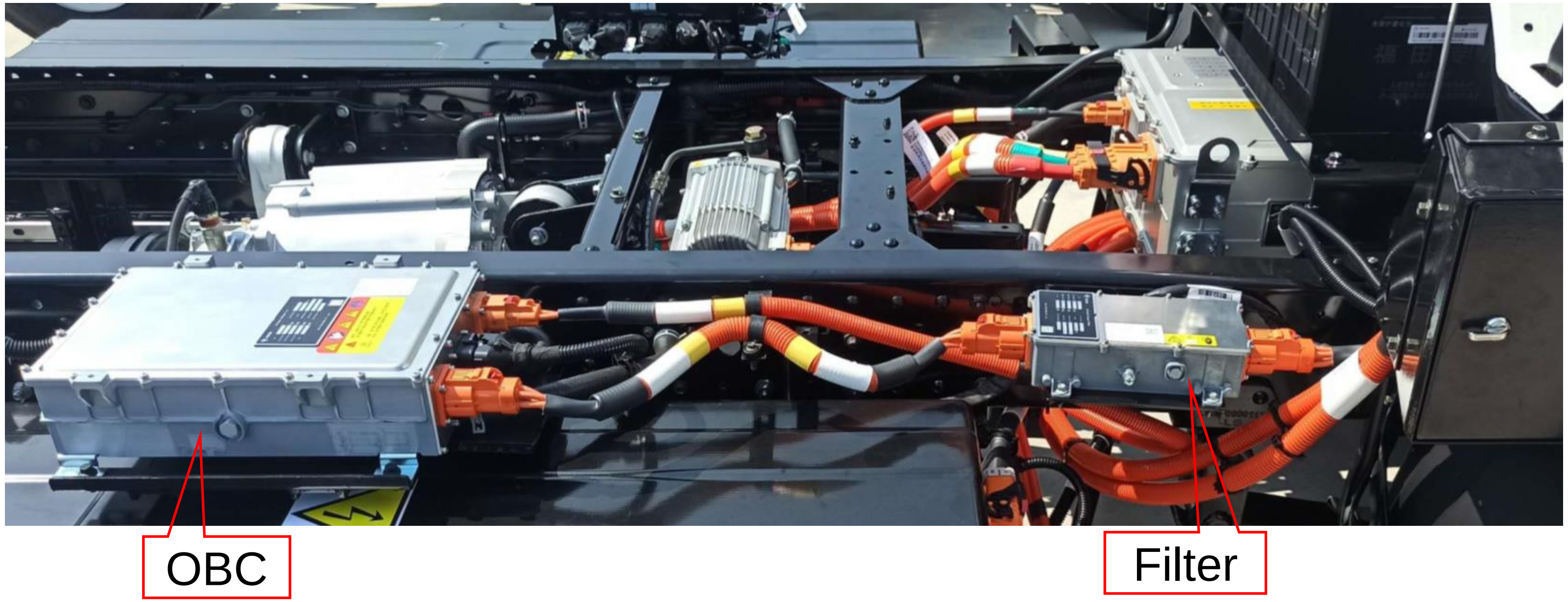
The DCDC converter is integrated in the lower part of PEU, and the blank area is designed for the OBC;

For European standard LDT EV, the OBC is not integrated into the PEU due to its high power and extra size.

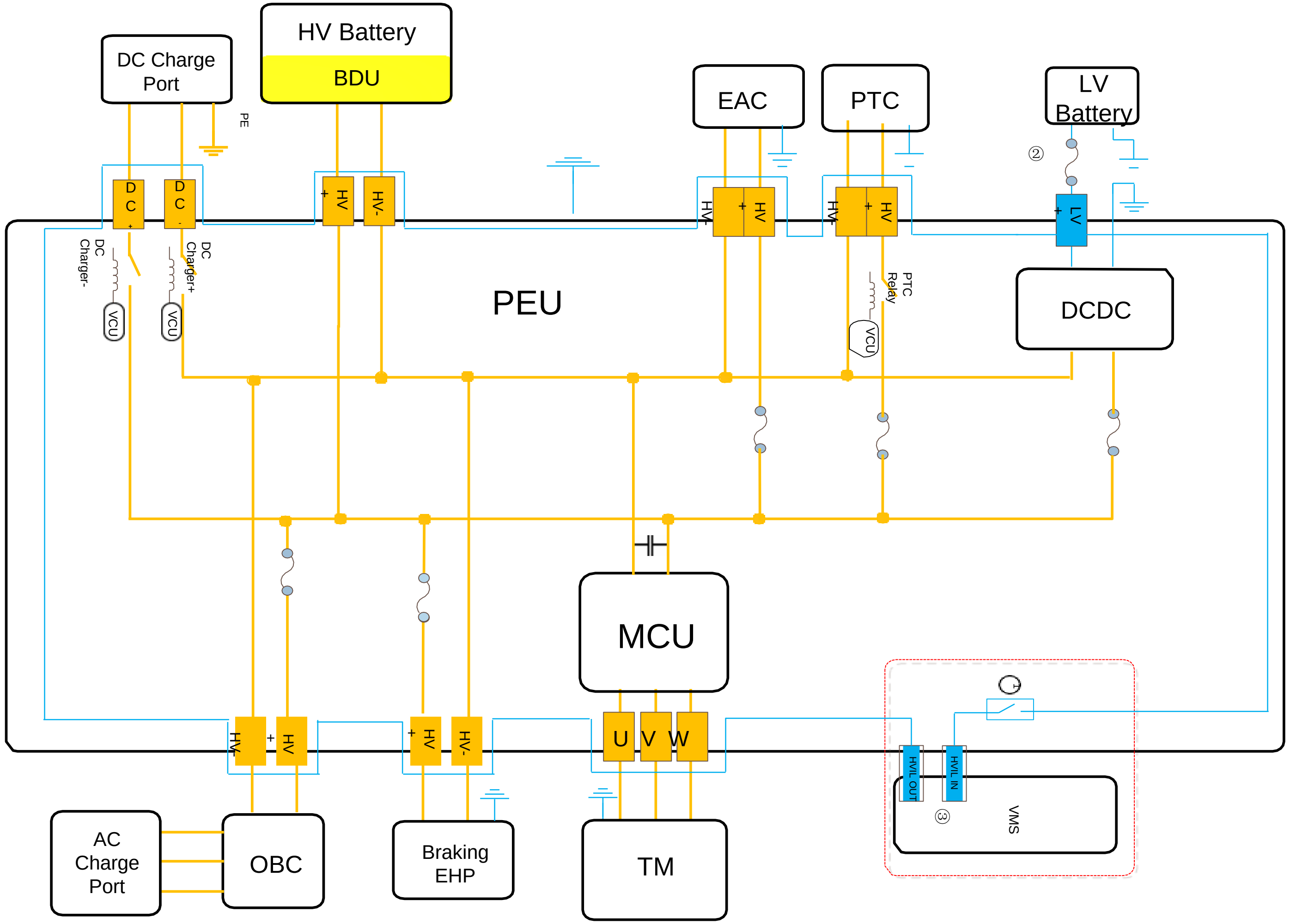
2.1.5 OBC layout - European standard LDT EV

OBC + filter

For European standard LDT EV, the OBC is designed and located outside of the PEU due to its high power and extra size. After being filtered by the filter, the civil AC power is converted into DC power by the OBC through rectification and boost to charge the battery.



2.1.6 Schematic diagram of PEU



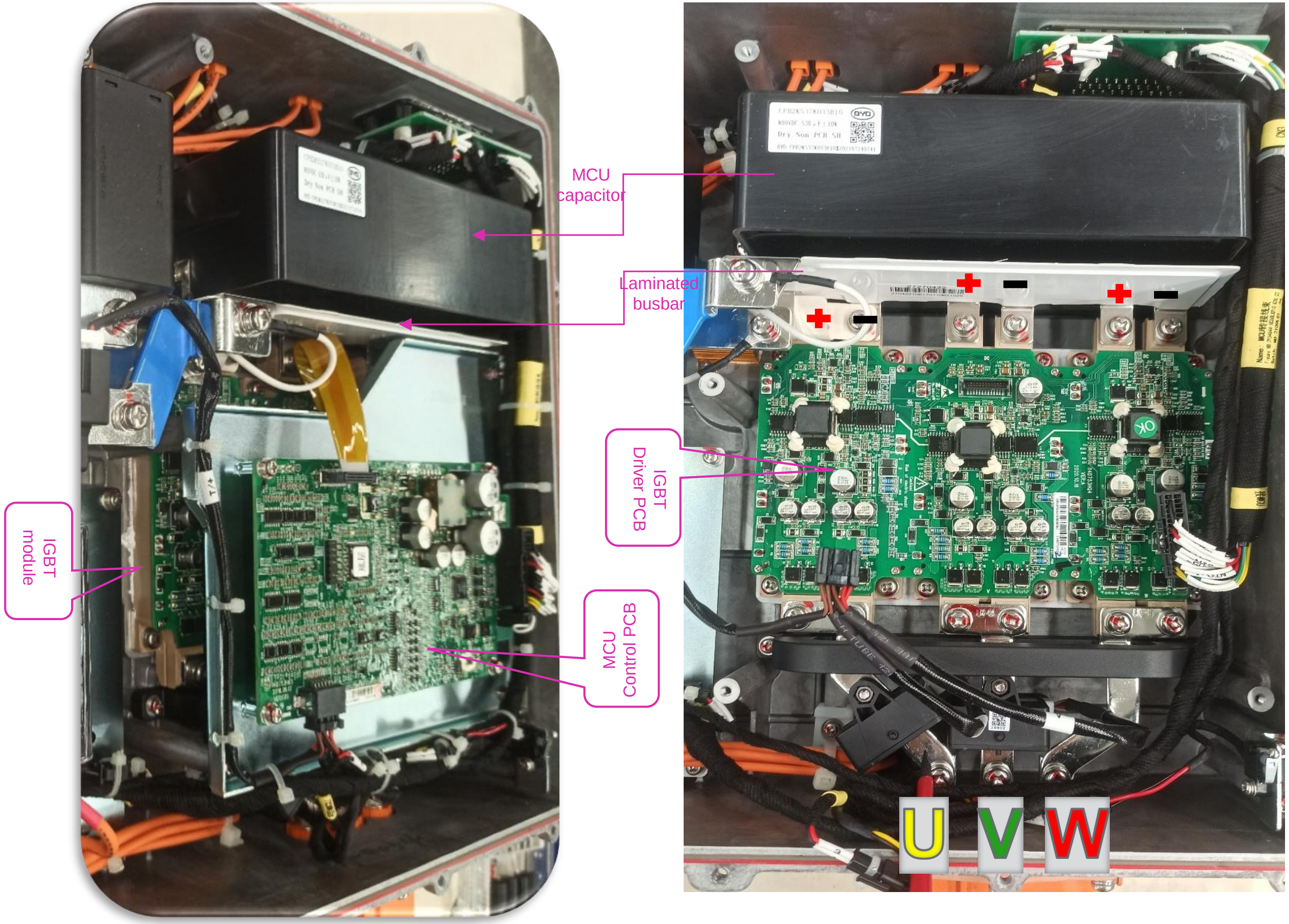
2.0

Introduction to key components of PEU

2.2.1 Basic composition of MCU - Real vehicle

The MCU assembly includes the control PCB, IGBT driver PCB, IGBT module, MCU capacitor, DC laminated busbar, AC and DC sensors, etc.

Laminated busbar: It distributes DC power to the DC side of three IGBT modules respectively; the la mination can minimize the size.
MCU capacitor: It stores charge and releases it when need to provide instantaneous current support. Capacitor is critical in MCU because the motor requires fast response and high current support to provide high performance and energy efficiency.
IGBT module: It converts DC to 3-phase AC with controllable amplitude and frequency to drive the motor, so as to drive the vehicle to run forward or backward or brake.
Driver PCB: It controls the switching frequency and operating duration of IGBT according to the commands from the control PCB to realize the controllable conversion between AC and DC.
Control PCB: It receives the torque or speed command from the VCU to control the IGBT, and realize the motor torque, speed, reversing and braking, and monitors the motor status, detects and protects the entire electric drive system status in real time for safe and stable operation.
Current sensor: It monitors AC and DC current in real time.

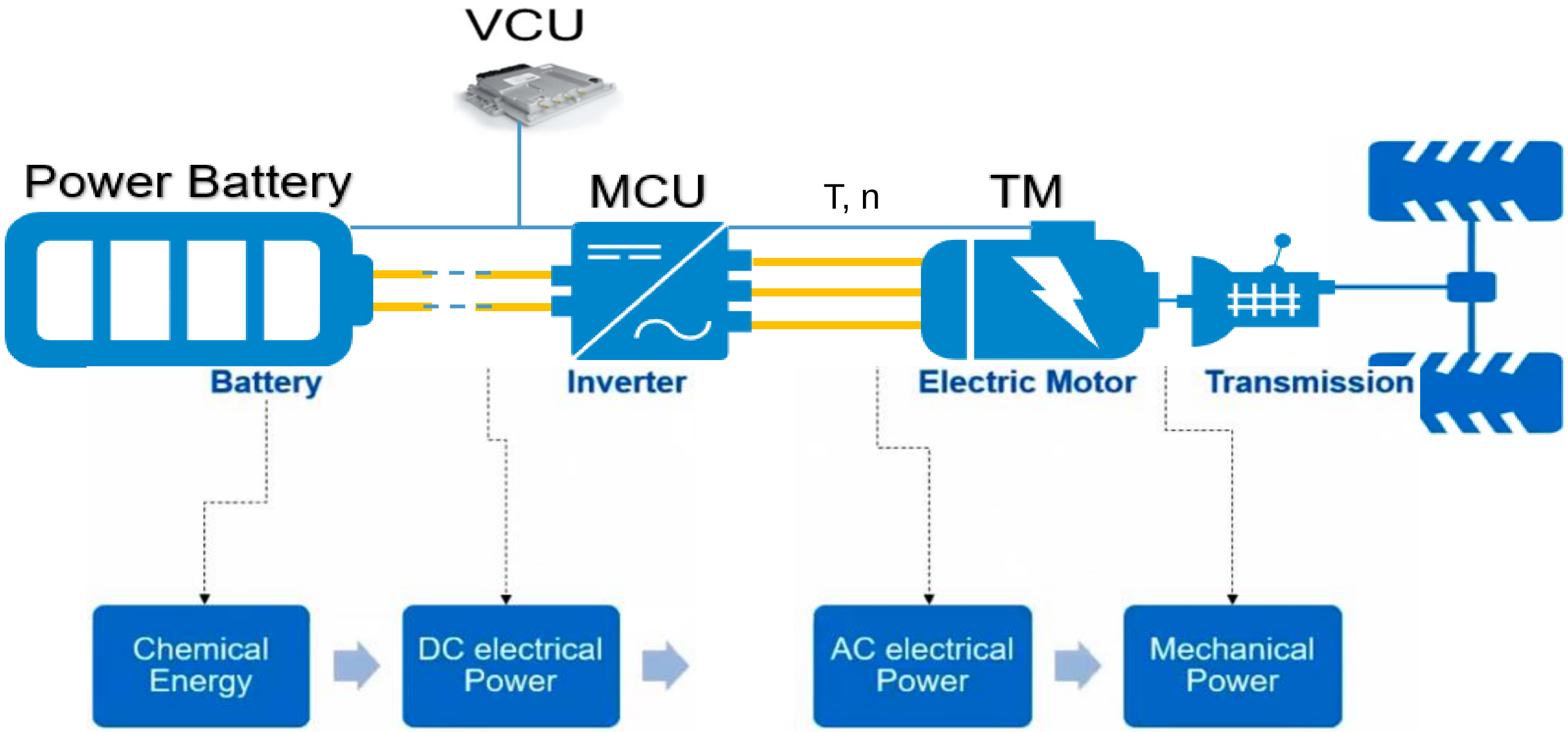


2.2.2 Function of MCU

The MCU receives the commands from the VCU, and converts the DC power from the power battery to 3-phase AC with controllable voltage and frequency through the internal control algorithm and signal processing, controlling the rotation speed and direction of the motor and thus realizing the operation of the EV.
On the one hand, the MCU receives the commands from the VCU, and on the other hand, it monitors the temperature and speed of the motor in real time, and feeds back the real-time torque and speed to the VCU.

By controlling the 3-phase AC of the motor, the MCU can realize the following main functions:
① Idle speed control (creep)
② Control of forward and reverse rotation of the motor (driving forward and reversing)
③ Regenerative braking (AC to DC)
④ Hill-holding (anti-rolling)

In addition, the MCU also monitors the voltage and current of the DC bus and the 3-phase AC voltage and current of the motor in real time, monitors the temperature of the IGBT module and the motor stator winding, and measures the rotation direction and speed of the motor rotor in real time through the resolver, protecting the electric drive system from undervoltage, overcurrent, overtemperature and overspeed.



2.2.3 Working principle of MCU

The control PCB in the MCU is responsible for communicating with the VCU, and is embed with MCU control software to monitor the torque, speed, temperature and other status of the motor in real time;

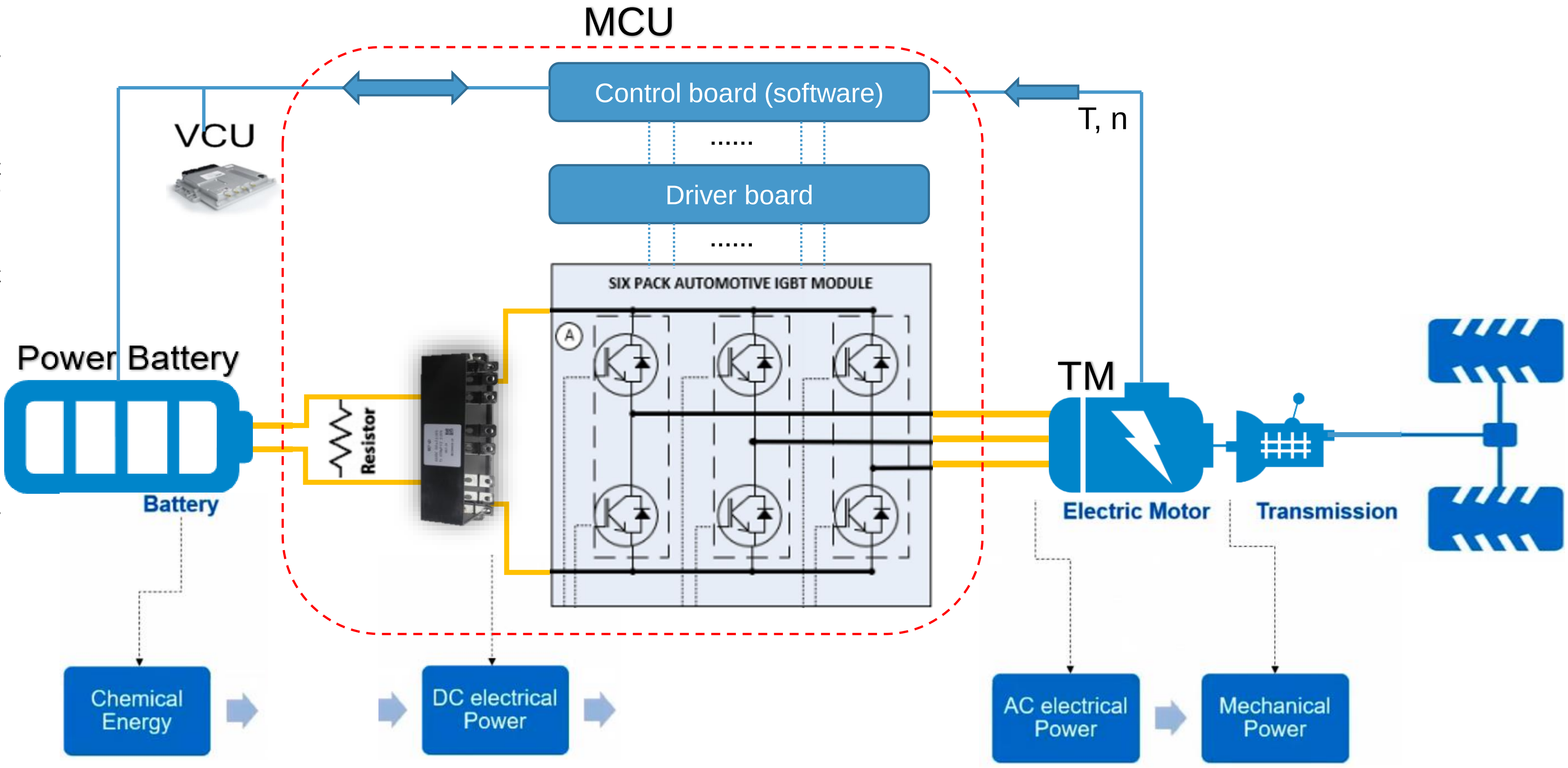
The **control PCB** converts the torque or speed command from the VCU into a numerical value of the required AC voltage and current through calculation, and sends the numerical value to the driver PCB;

The **driver PCB** controls the IGBT module to invert the DC from the battery to controllable 3-phase AC which is finally output to the motor to drive the rotor.

IGBT module is the most critical component in the MCU, which controls the conversion between AC and DC, and realizes important functions such as dual direction driving of motor and regenerative braking.

The **MCU capacitor** stores charge and releases it when needed to provide instantaneous current support. Capacitor is critical in MCU because the motor requires fast response and high current support to provide high performance and energy efficiency.

The **passive discharge resistor** is connected in parallel with the front busbar of the MCU capacitor, and forms an RC loop, after the vehicle HV power off, to release the internal charge of the capacitor, so that the capacitor voltage is gradually reduced, avoiding the danger of HV.

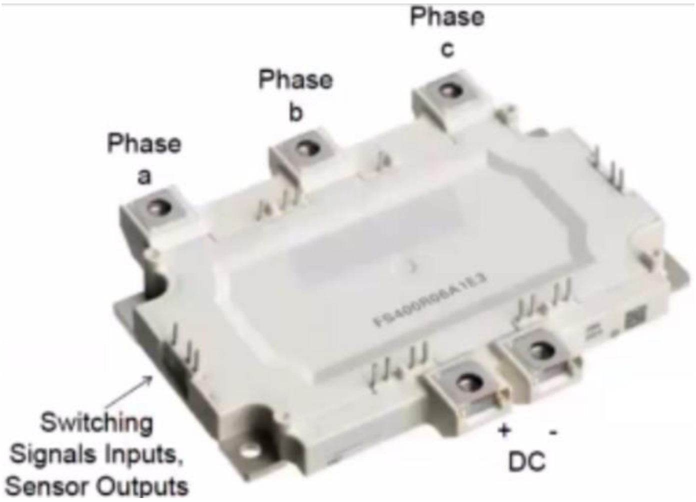


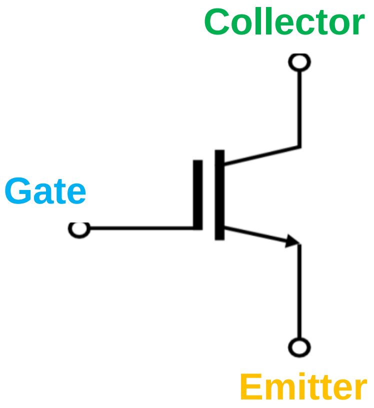
2.2.4 Working principle of IGBT

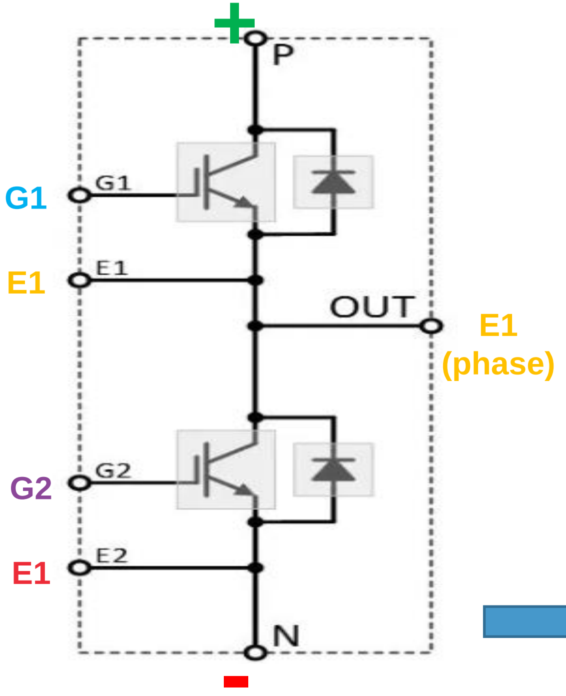
IGBT is the core component of the IGBT module. Before understanding the working principle of the IGBT module, first understand the IGBT.

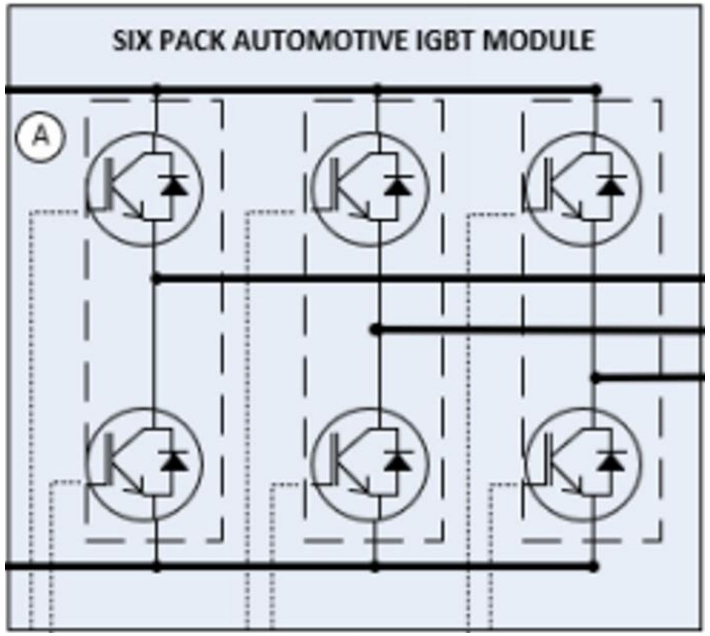
The working principle of IGBT is that the forward bias of P-N junction is controlled by the gate to control the IGBT to turn on and off. IGBT is widely used in high voltage and high power switching circuits such as frequency converters, inverters and AC drives in the field of power electronics because of its low on-resistance and ability to withstand high voltage and high current.

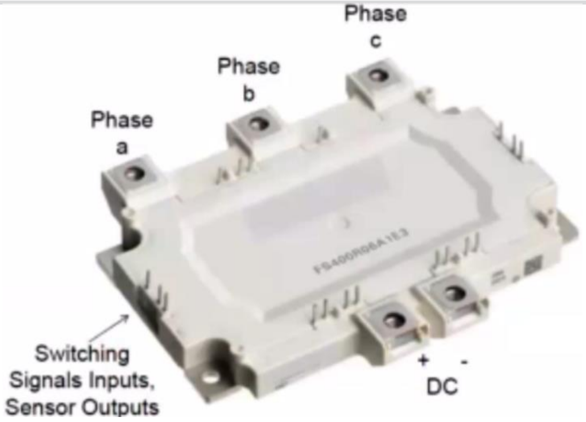
A single IGBT can control the opening and closing of the circuit, the combination of two IGBTs can control the transformation of the current direction, and three IGBTs arranged as shown can be packed to form an IGBT module.





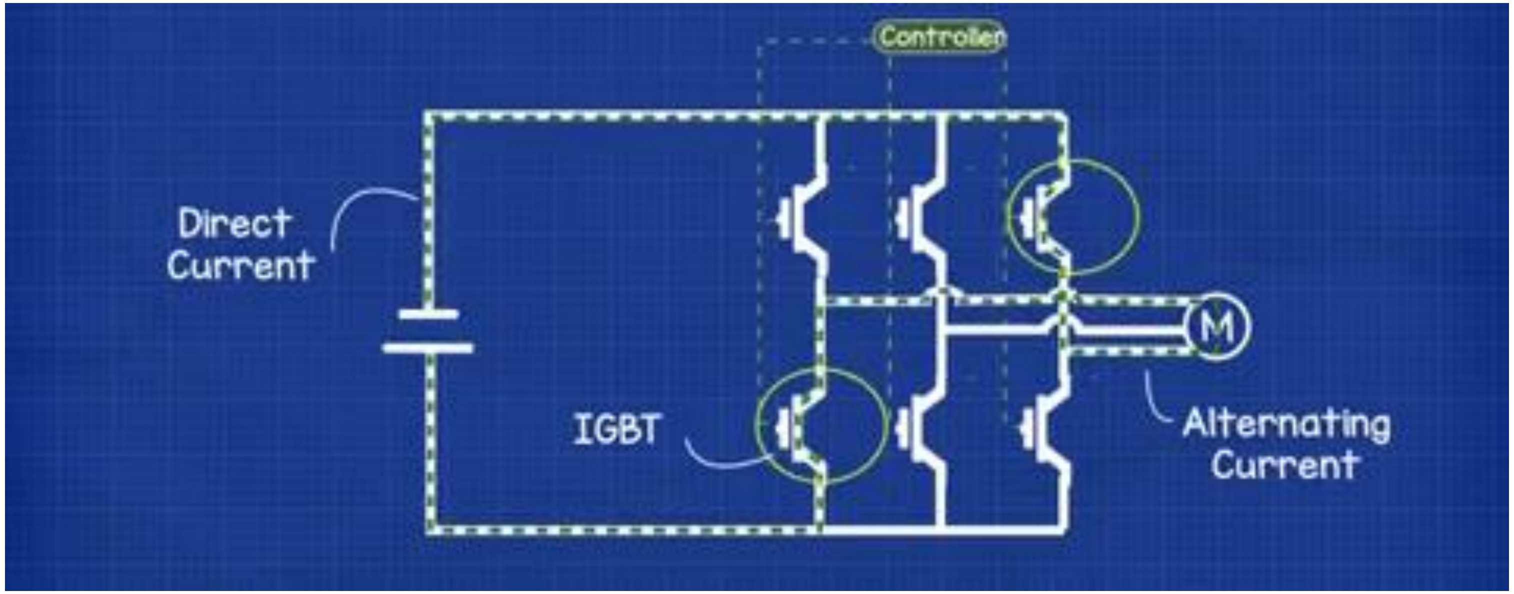






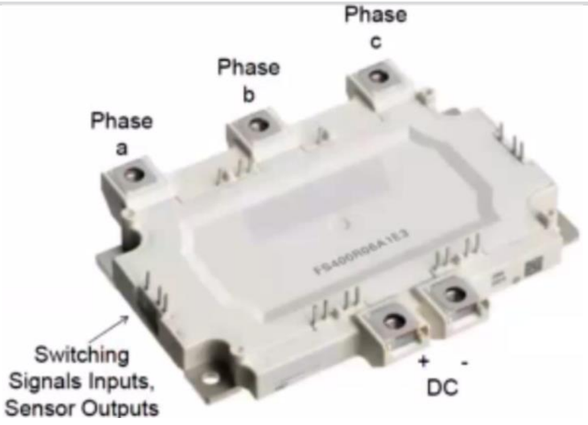
2.2.5 Working principle of IGBT module

As shown below, the combined opening and closing of IGBT can realize the controllable transformation of current direction. But the simple combined opening and closing can only form square waves with opposite current direction, and can not be used for 3-phase AC drive.



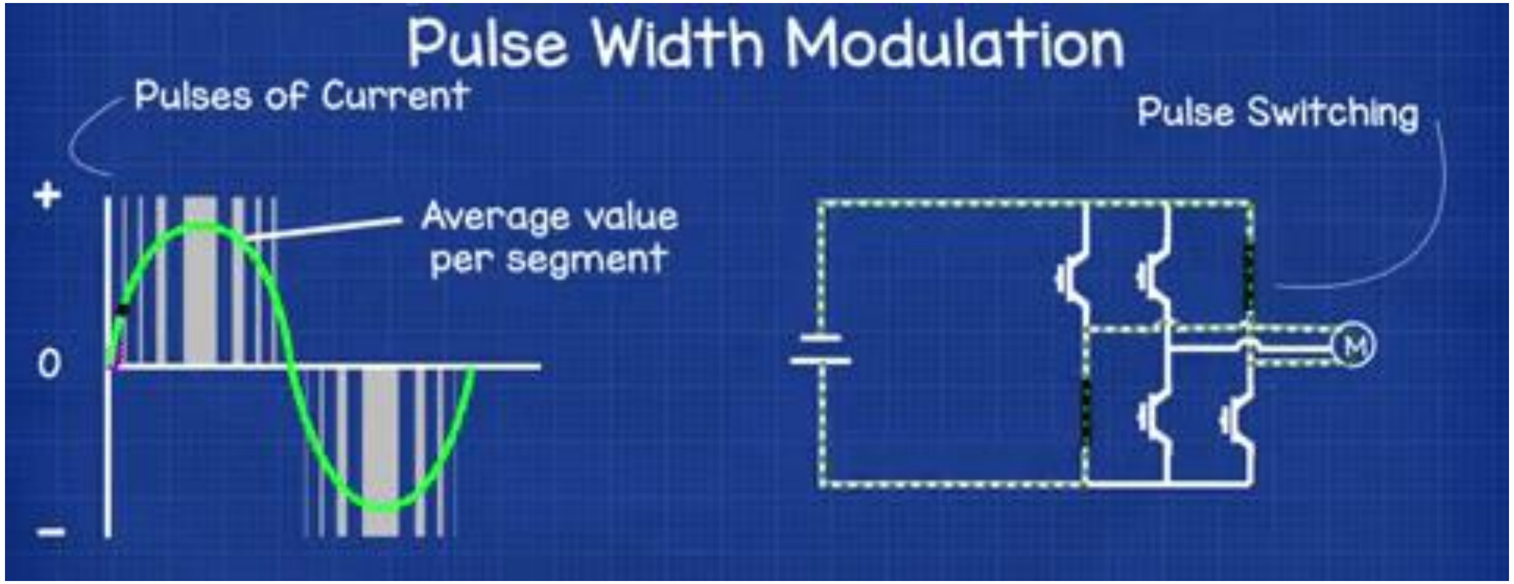
2.2 Basic composition and working principle of MCU

2.2.5 Working principle of IGBT module



Through the fine control by PWM, the switching frequency of one of the IGBTs can be processed to obtain square waves with different widths in unit time. The average values of these square waves in unit time can be connected to obtain a waveform infinitely close to sine wave. If the PWM control is fine enough, the current can be smoother and closer to sine wave.
Similarly, by PWM control of three IGBTs at the same time, three identical sine waves can be obtained and staggered 120° apart in phase, thus forming 3-phase AC.

DC



AC

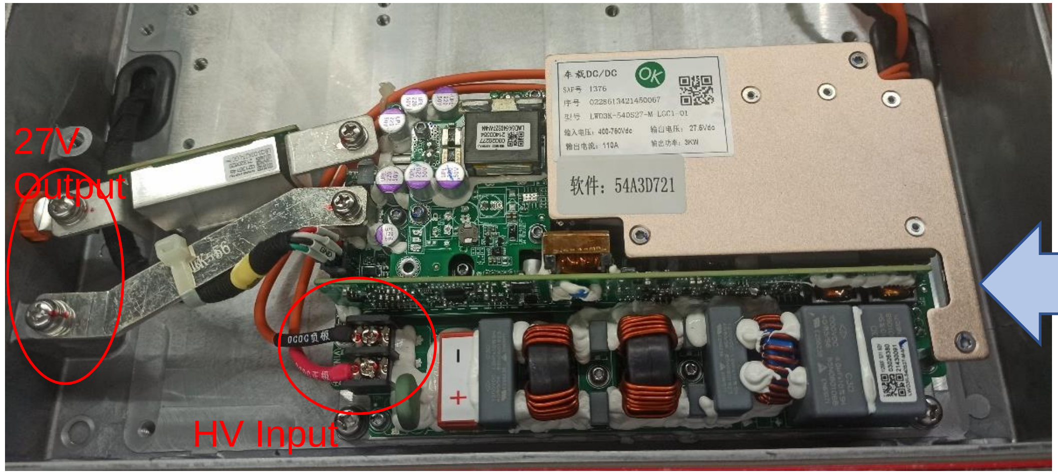
2.0

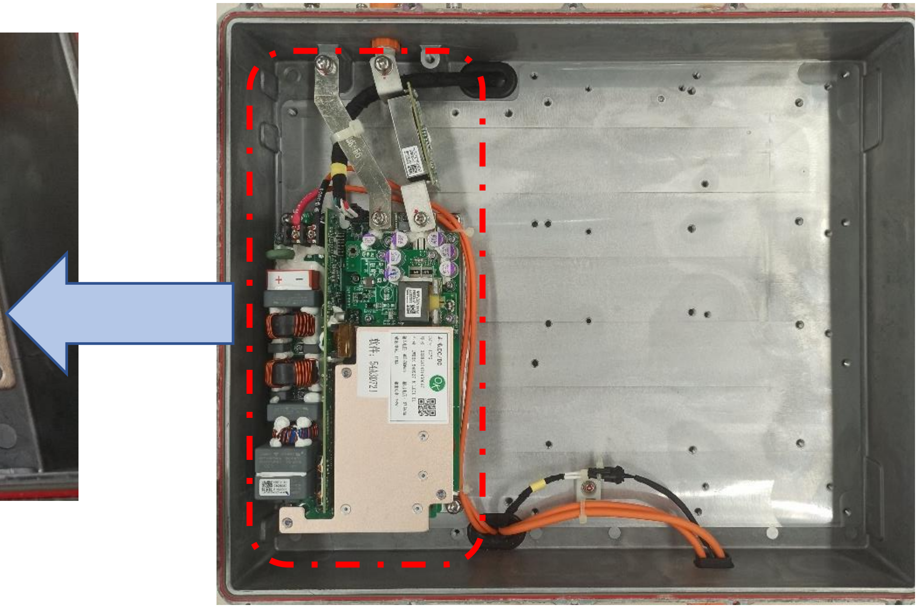
Introduction to key components of PEU

2.3.1 DCDC converter

The DCDC buck converter module is located in the bottom chamber of the PEU and attached on the cooling wall.

Its function is to convert HVDC into LVDC to supply power for LV electrical apparatus and circuits of the vehicle, and also to charge the LV battery. It acts as an alternator in a ICE vehicle.



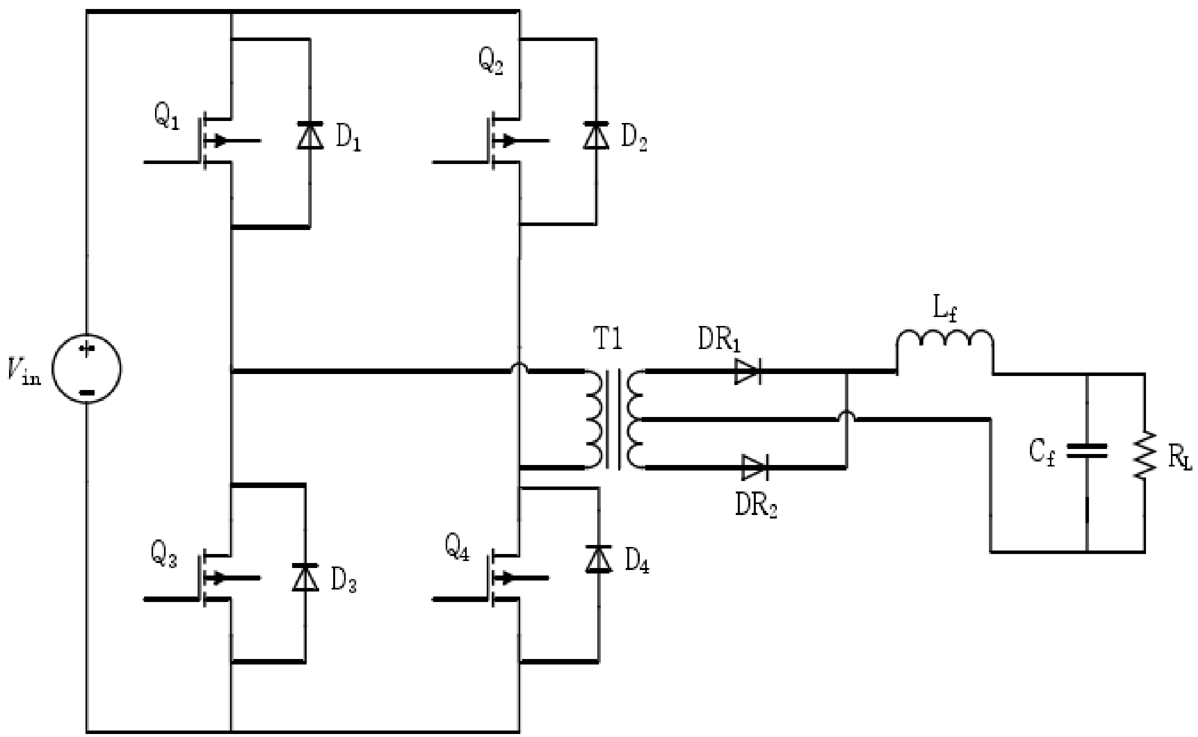


2.3 Basic structure and working principle of DCDC converter

2.3.2 Working principle of DCDC converter

The working principle of the DCDC module is to use high-frequency AC transformer, capacitor and other components to transform, rectify and filter the voltage of HVDC battery, and then output it to the LV electronic equipment in the vehicle.

As shown, V_{in} is the input voltage, which needs to pass through the DCDC loop to obtain a required output voltage at the output.
The primary switching circuit modulates the input current into a rectangular wave, which mainly relies on the controller to modulate the PWM wave with a specific duty cycle to drive the four switching transistors to open and close in a given order and time, so as to realize the current inversion.
The primary input voltage can be adjusted by the duty cycle. The output voltage increases as the duty cycle increases, and the output voltage decreases as the duty cycle decreases. The frequency can be adjusted by adjusting the switching frequency.
T1 is a transformer, which can achieve both electrical isolation and voltage regulation. Different voltage levels can be obtained by changing the number of turns of the secondary winding with a fixed number of turns of the primary winding. The input of the transformer is a pulse rectangular wave obtained through the inversion of the full-bridge circuit on the left side, which is transmitted to the secondary side of the transformer to obtain an AC sine wave of another voltage amplitude. After being rectified by DR_1 and DR_2, it is filtered by C_f and R_l to obtain DC provided to the output.



2.0

Introduction to key components of PEU

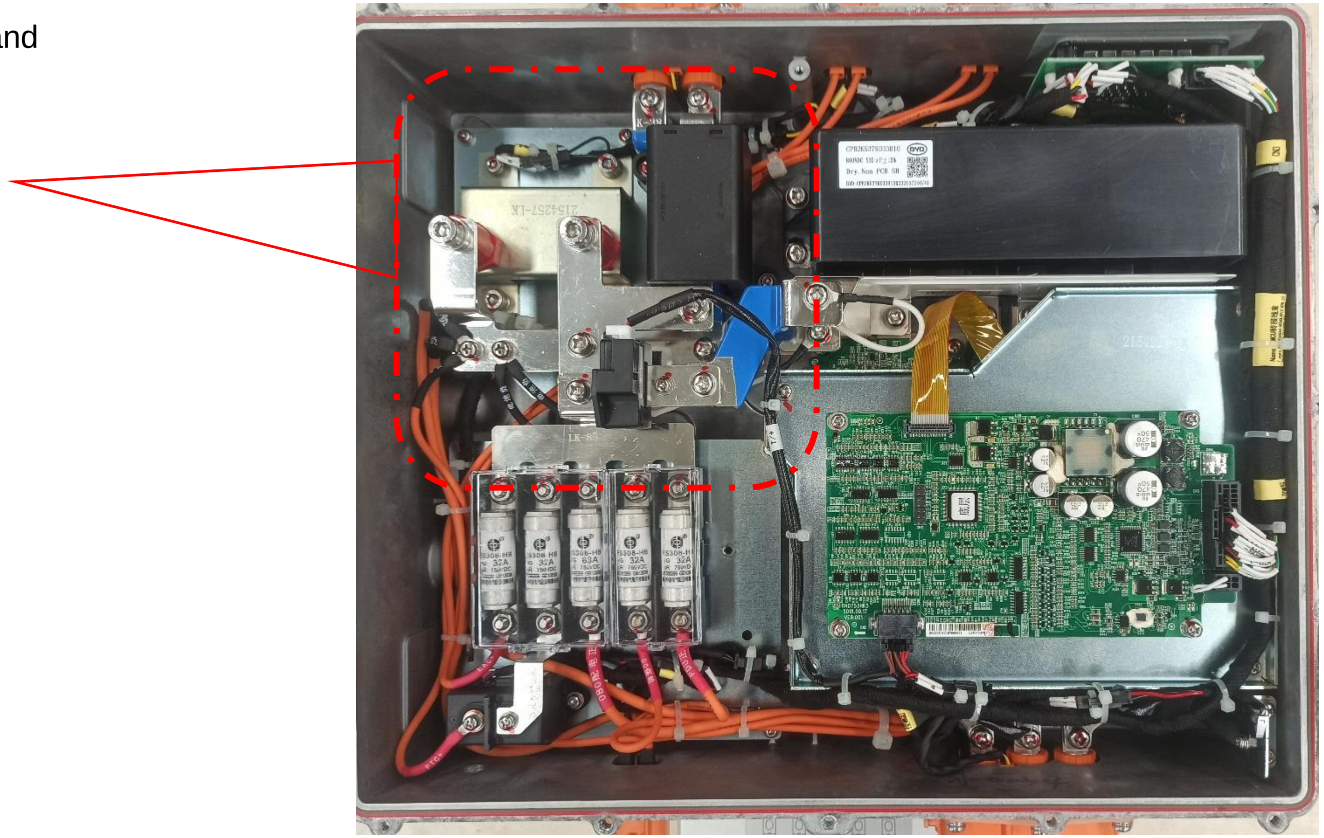
2.4 Introduction to other accessories

2.4.1 Other accessories of PEU

In addition to MCU and DCDC converter, there are PDU, DC busbar, PDU fuse, PTC heater relay, passive discharge resistor, upper cover status detector, HVIL detection circuit, etc. inside the PEU; for European standard LDT EV, there is also an OBC located independently outside.

2.4.2 PEU DC busbar

The DC busbar is a hard copper conductor, which is supported and fixed on the PEU body by the insulator to form the main power grid among the battery, MCU, DC charging interface and auxiliary system PDU fuse.



2.4.3 PEU distribution fuse

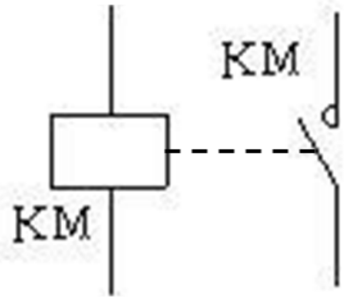
Fuses are connected in series in the circuit by using a metal conductor encapsulated inside the fuse as a fuse element, and when an overload or short-circuit current passes through the fuse element, the fuse element will be fused due to self-heating, thereby breaking the circuit.

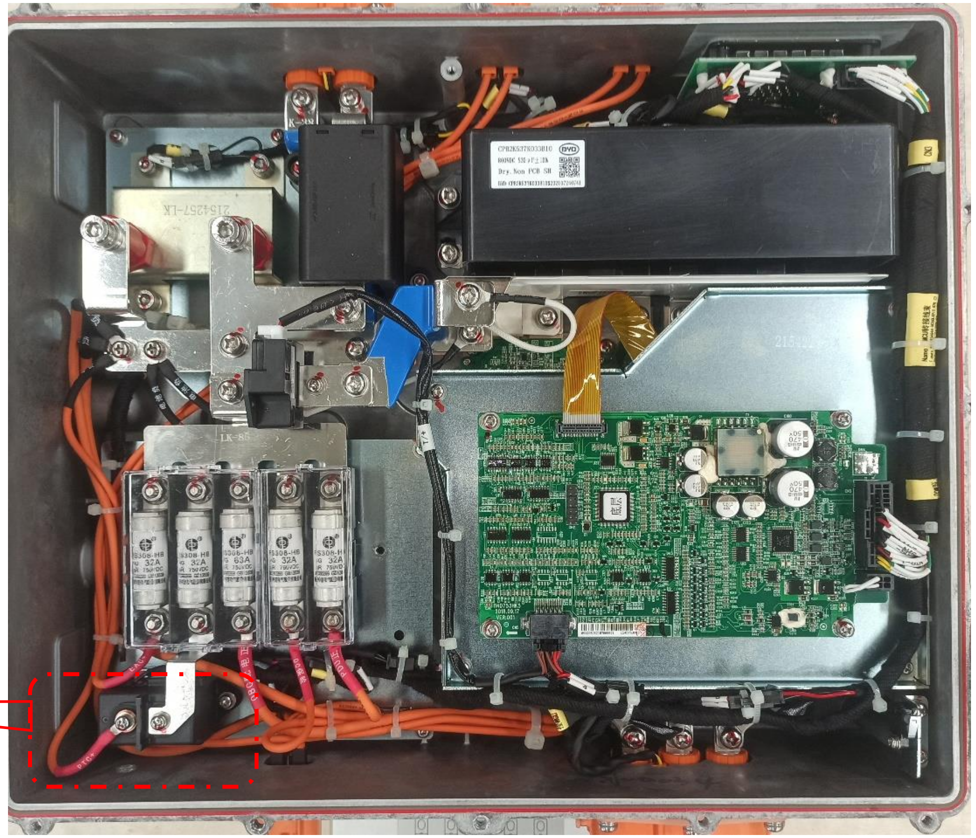
The PEU of LDT EV is equipped with fuses in the EAC, PTC, OBC (IN), DCDC converter, EHP and PTO circuits, of which the OBC fuse is rated at 63A and the other fuses 32A.

2.4 Introduction to other accessories

2.4.4 PTC relay

The PEU is internally integrated with a power supply relay for the PTC heater, which is controlled by the VCU via a hard wire. The structure of the relay is simple, and its schematic diagram and real picture are as follows:





2.4.5 Internal HVIL of PEU

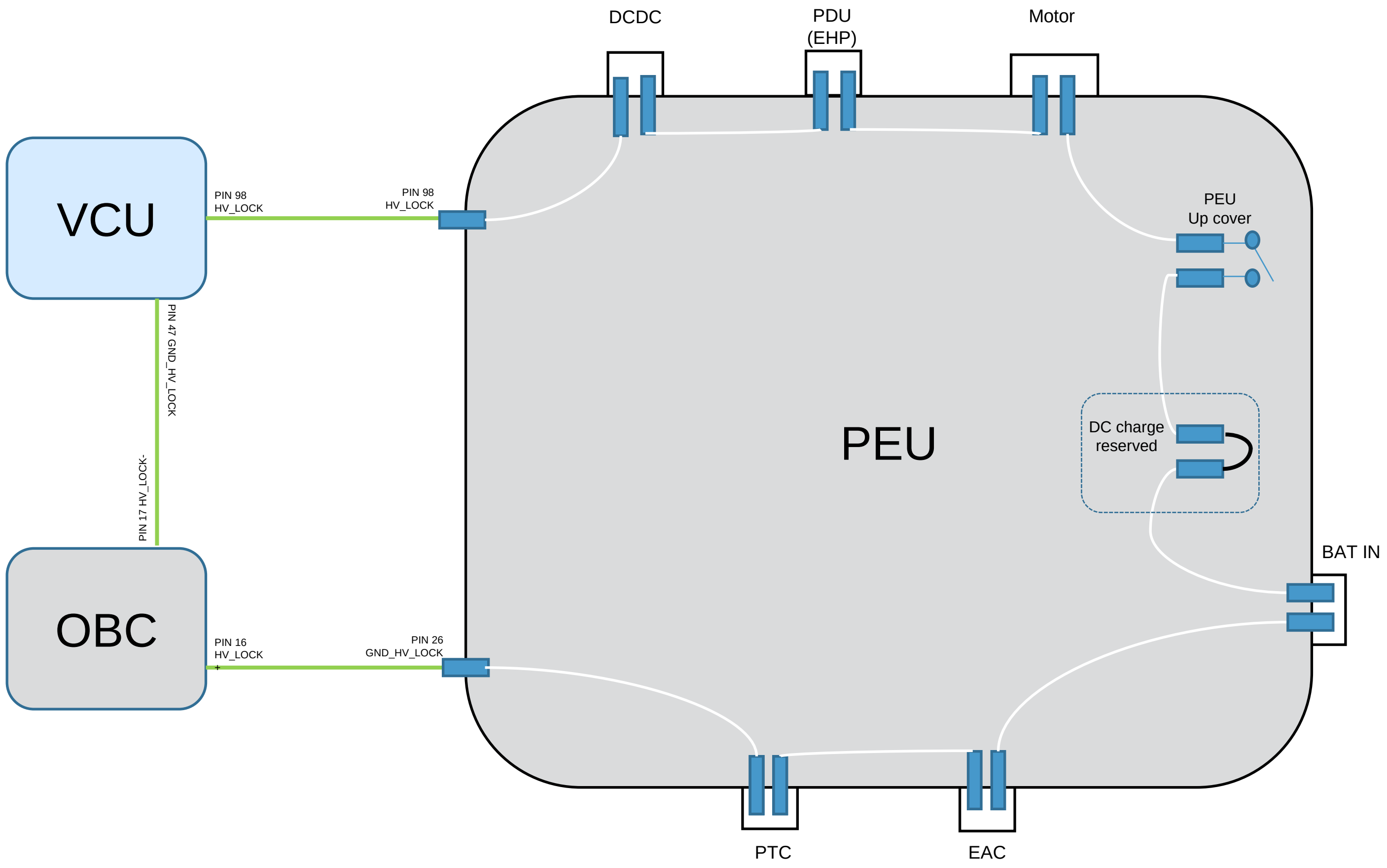
A series of wires inside the PEU and simple switches on the HV connector bodies constitute the HVIL detection circuit of the PEU. In addition, there is an upper cover status detector used to detect the open/close state of the upper cover.

The HVIL is set to monitor the integrity of cable connections between HV equipment. If any HV connector is not plugged in place, the HVIL will be open, and the VCU will display "HVIL" fault on the ICM to prompt the driver. At this time, the vehicle cannot be powered on with HV, or the vehicle will be HV power off.

The HVIL circuit of PEU is connected in series with the HVIL circuit of external OBC, with both ends connected to the VCU pins respectively. The VCU judges whether there is a poorly connection in the system according to the open or closed state of the entire loop.

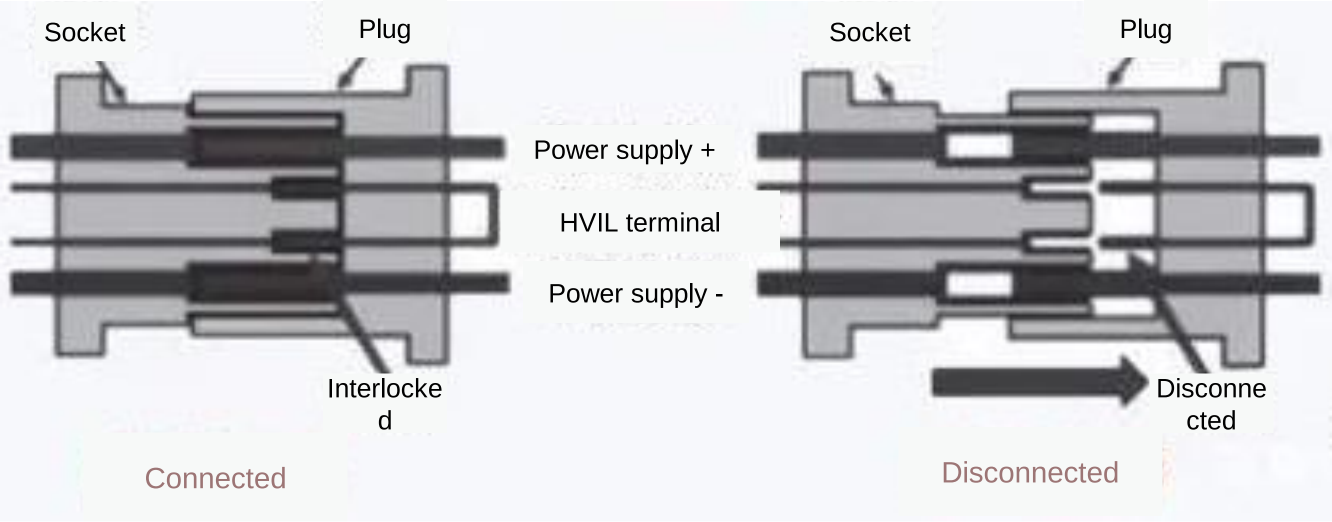
In case of a HVIL fault, the entire LV loop for detection shall be considered in addition to the HV connector.

The monitoring points of HVIL are as shown:



2.4.5 Internal HVIL of PEU

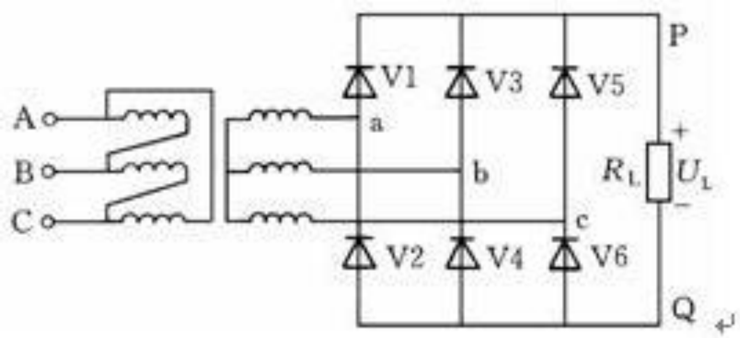
The principle of HVIL detection can be simplified as a series of simple "switches" connected in series. As shown, after the plug of the HV cable is inserted into the socket on the PEU body, the simple "switch" is closed. All the closed switches are connected in series to form a path. The VCU is connected to both ends of the path and indicates that all HV connectors have been plugged in place according to this path.

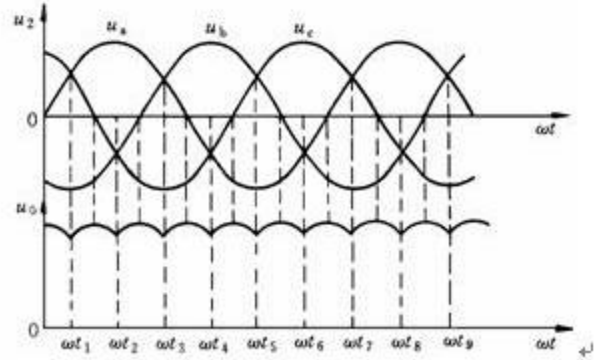


2.4.6 OBC

The OBC converts the single-phase or 3-phase AC power to DC power which is higher than the battery voltage through step-up and rectification, and then directs it to the HV power grid through the PEU to charge the battery.
The maximum power can reach 6.6kW for single-phase charging, and 11kW for 3-phase charging.

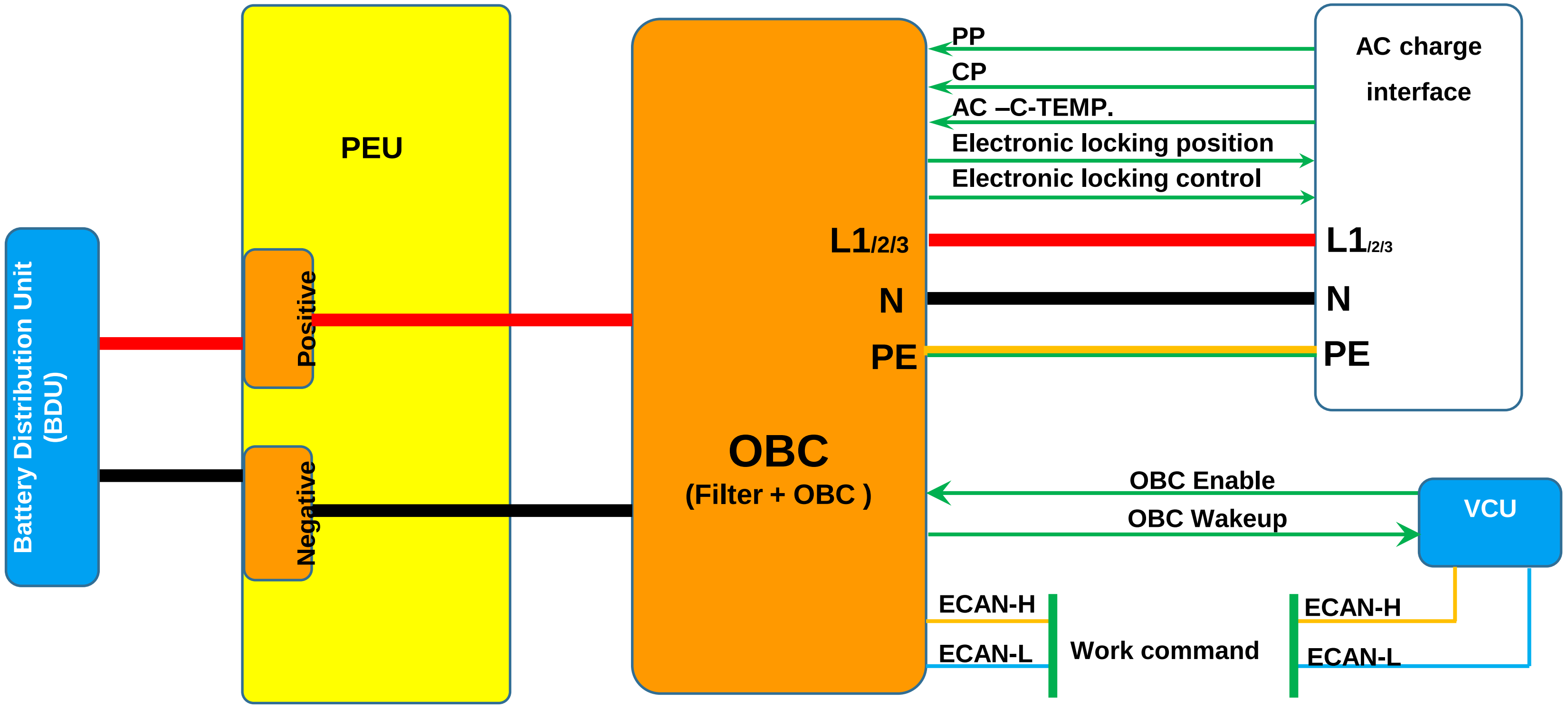
The schematic diagram is as follows:





2.4.6 OBC

The OBC converts the single-phase or 3-phase AC into DC higher than the battery voltage through step-up and rectification, and then directs it to the HV power grid through the PEU to charge the battery. The schematic diagram is as follows:



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3.0

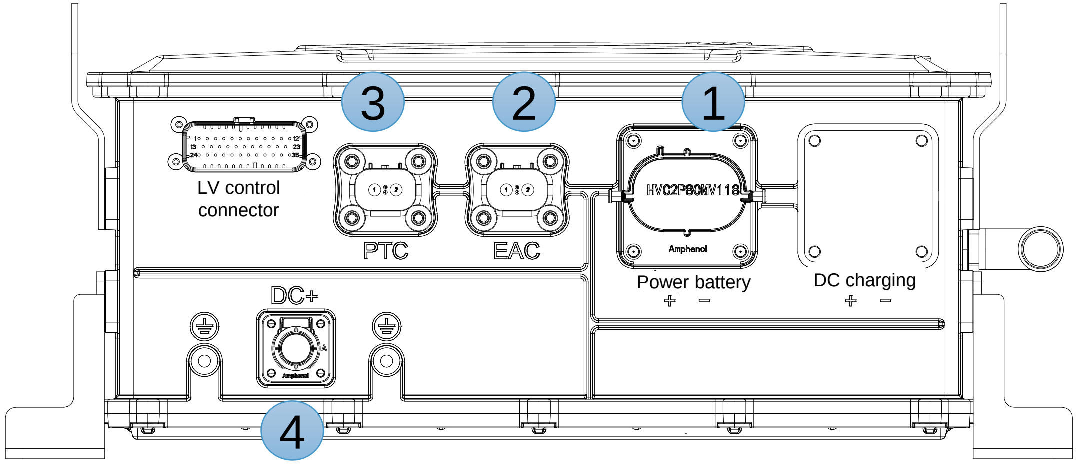
PEU external interfaces

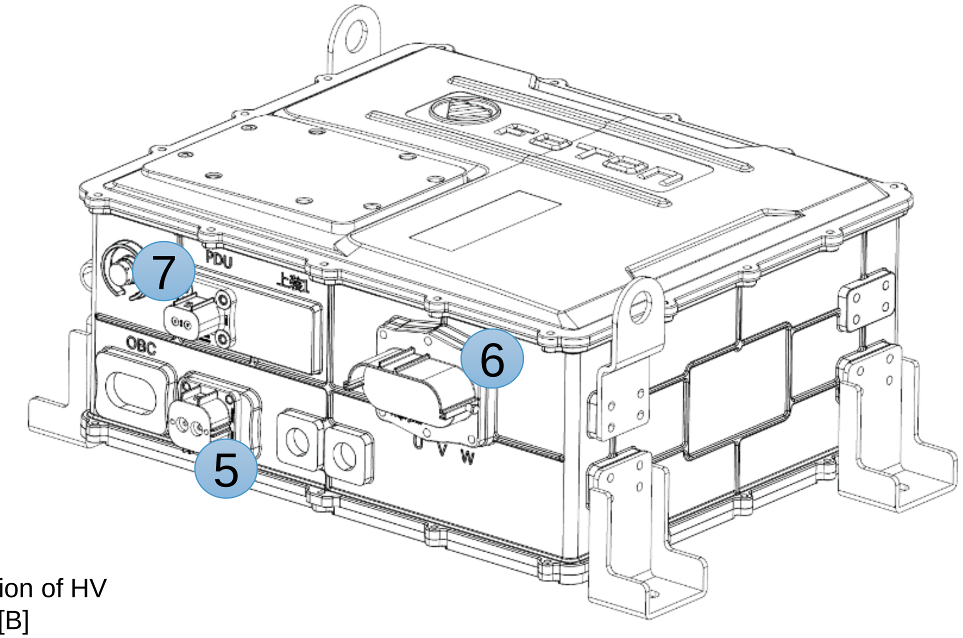
3.1.1 PEU HV interface

Model and definition of HV connector [B]

Name	Model	Definition
1 Power Battery input	Amphenol HVC2P80MV118	1: Busbar +; 2: Busbar -
2 EAC HV output	BADA OPTICAL-ELECTRICAL F02-720000-RAO	1: Busbar +; 2: Busbar -
3 PTC HV output	BADA OPTICAL-ELECTRICAL FO2-720000-RYO	1: Busbar +; 2: Busbar -
4 DCDC output + 24V+	Amphenol HVSC1P80MV102	Positive
5 OBC HV input (DC)	Amphenol HVC2P63MV406	1: Busbar +; 2: Busbar -
6 3-phase output	Amphenol HVC3P80MV104	1: U phase; 2: V phase 3: W phase
7 PDU HV output EHP	Amphenol HVC2P28MV304	1: Busbar +; 2: Busbar -

3.1.1 PEU HV interface





Model and definition of HV connector [B]

Name	Model	Definition
1 Power Battery input	Amphenol HVC2P80MV118	1: Busbar +; 2: Busbar -
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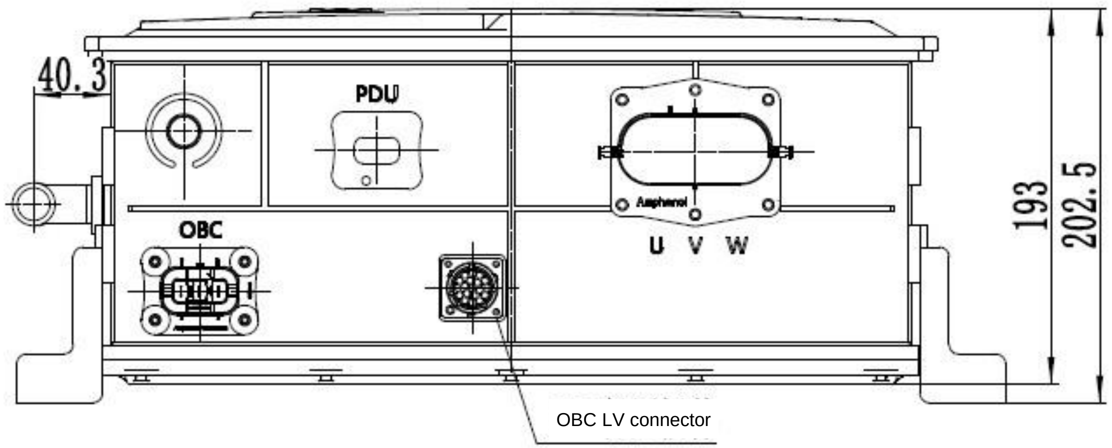
6 3-phase output	Amphenol HVC3P80MV104	1: U phase; 2: V phase 3: W phase
7 PDU HV output EHP	Amphenol HVC2P28MV304	1: Busbar +; 2: Busbar -

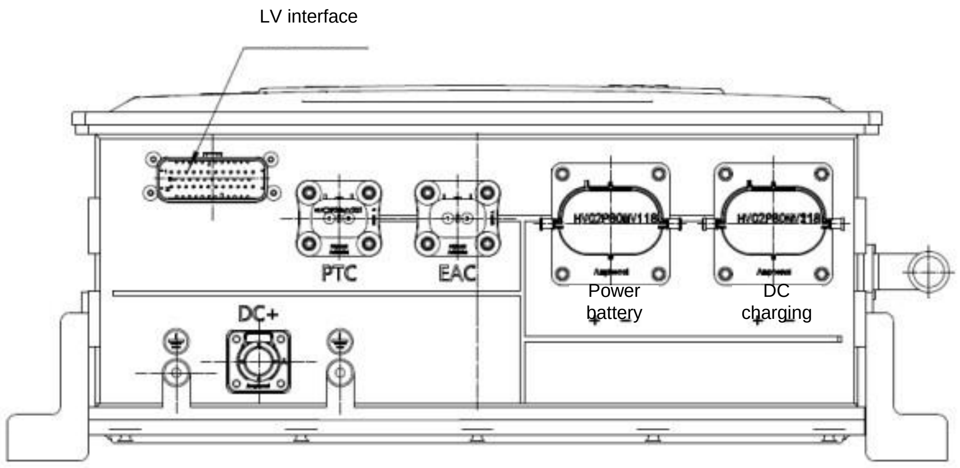
3.0

PEU external interfaces

3.2.1 PEU LV interface

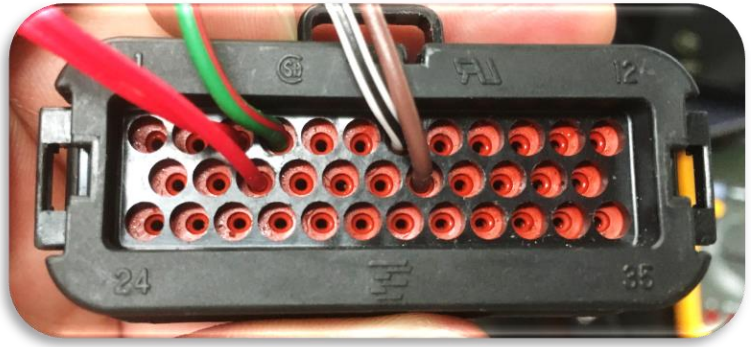
The PEU LV interface is mainly the LV control interface for LV constant power, wake-up power, CAN, enable signal, motor resolver and temperature signal.
Some models have built-in OBC, and there will be LV connector for OBC.

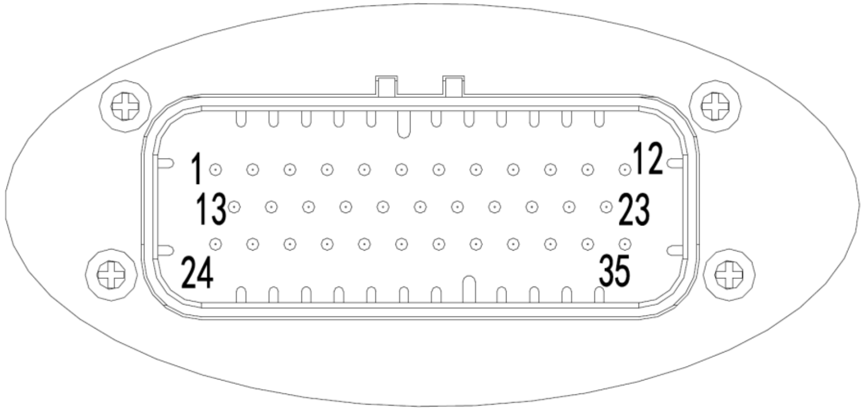




3.2.2 Definition of PEU LV interface - 35pin connector

The LV interface is responsible for the LV power supply, enable, communication and other signal transmission for modules inside the PEU. There are corresponding pin numbers on the outlet side of the connector. As shown below:



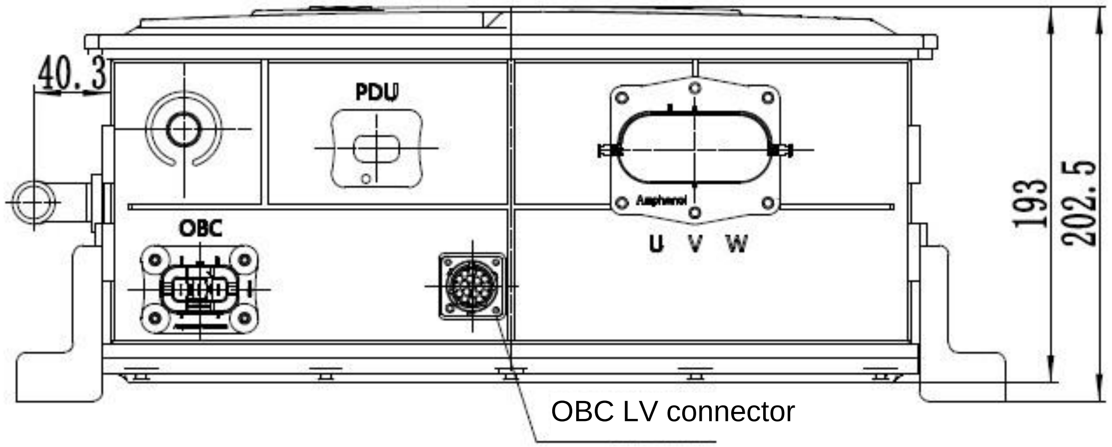


35pin connector definition

Pin	definition	Pin	Definition
1		19	CANH (for MCU calibration）
2	PTC contactor control -	20	Resolver excitation (R1)
3	MCU power supply +, DCDC power supply +	21	Resolver sine output - (S4_SIN-)
4	MCU power supply -	22	Resolver cosine output + (S1_COS+)
5		23	Motor identification resistance signal input 2 (reserved)
6	CANH	24.	Battery - (reserved)
7	CANL (for MCU calibration）	25	HVIL +
8	Resolver excitation (R2)	26	HVIL -
9	Resolver sine output + (S2_SIN+)	27	PTC contactor control + DC charging positive contactor coil control + DC charging negative contactor coil control +
10	Resolver cosine output - (S3_COS-)	28	DC charging positive contactor coil control -
11	Motor identification resistance signal input 1 (reserved)	29	DC charging negative contactor coil control -
12	Resolver harness shielding	30	
13		31	
14	DCDC enable	32	
15	MCU enable/wake-up	33	
16	DCDC power supply-	34	Motor U-phase temperature detection resistance pin 2 (NTC0_2)
17	CANL	35	Motor U-phase temperature detection resistance pin 1 (NTC0_1)
18	CAN shielding		

3.2.3 PEU LV interface – OBC 19PIN connector

This connector is only available on models integrated with OBC as per GB standard



Definition of 19pin LV connector			
Pin number	Function definition	Pin number	Function definition
A	OBC_EN_VCU	L	CAN H
B	VCU_EN_OBC	M	CAN L
C	Electronic lock feedback pin 1 (green)	N	CC OUT
D	Electronic lock feedback pin 2 (yellow)	P	Charging socket thermistor 1+
E	Electronic lock power supply pin 1 (red)	R	Charging socket thermistor 1-
F	Electronic lock power supply pin 1 (white)	S	
G	12V+ battery power supply	T	
H	12V- battery power supply	U	
J	OBC_EN_VCU	V	
K	VCU_EN_OBC		

3.0

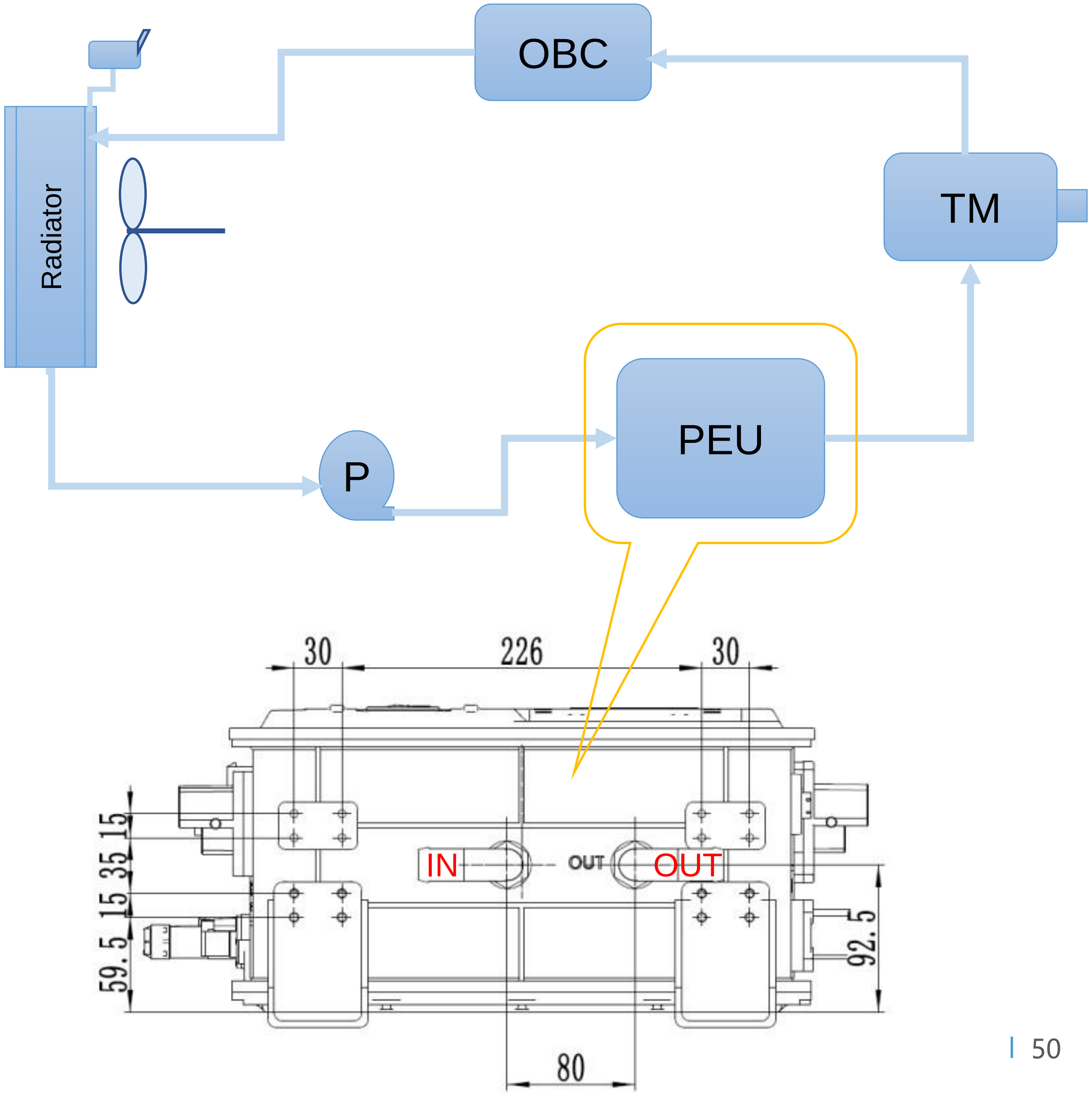
PEU external interfaces

3.3 PEU cooling interface

3.3.1 Cooling pipeline interface

The PEU, motor and OBC share a cooling circuit.

The PEU body is made of aluminum, and the coolant shall be the special coolant for the aluminum radiator; the flow rate of the coolant shall not be less than 12L/min.



3.3.2 Required cooling temperature threshold and overheat threshold

The PEU, motor and OBC share a cooling circuit. The cooling pump will start to operate after HV on (READY or charging) the fan will operate at high or low speed or stop under the control of VCU according to the temperature of MCU, motor and OBC:

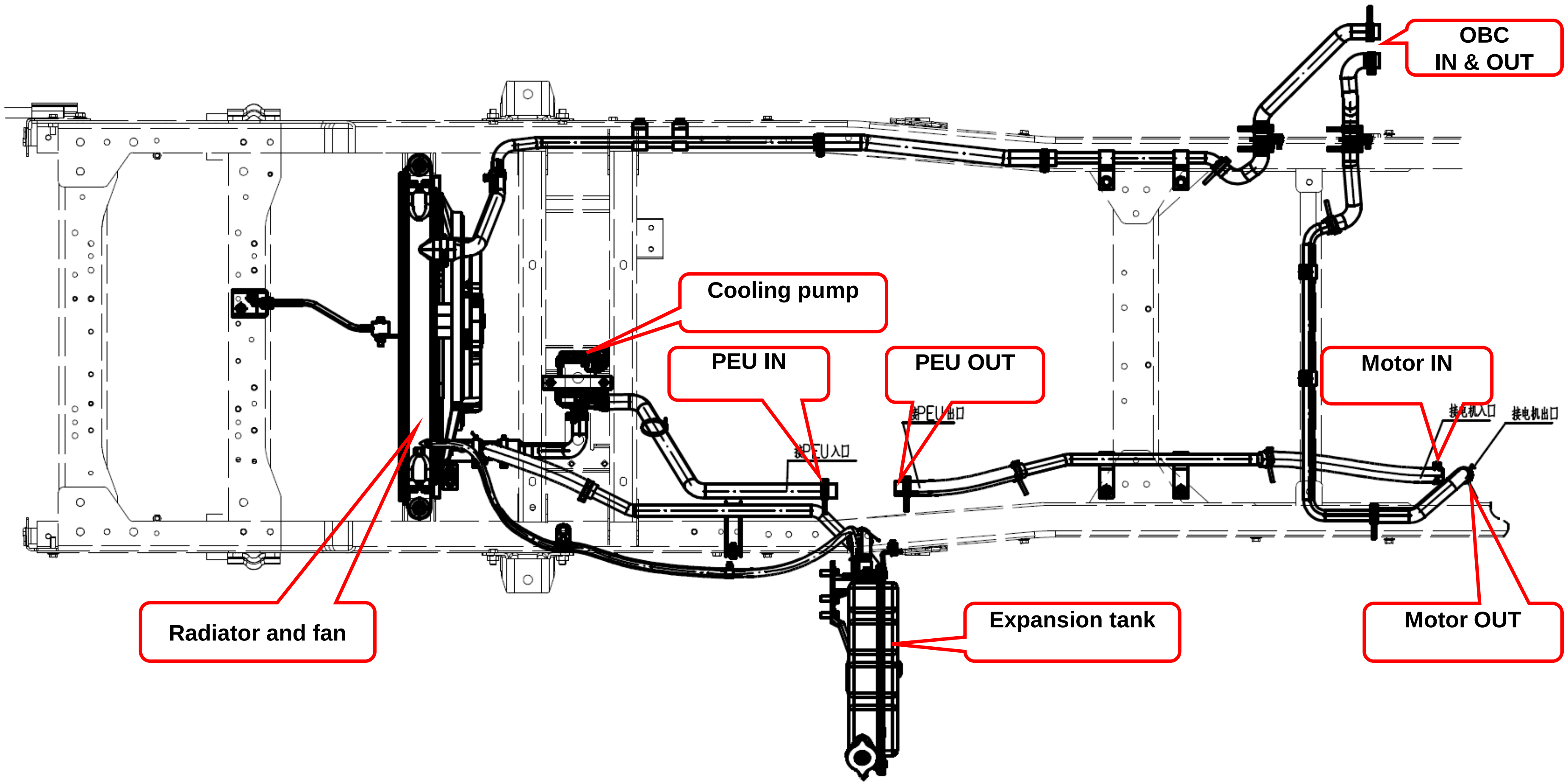
Name	Low-speed fan OFF (℃)	Low-speed fan ON (℃)	High-speed fan OFF (℃)	High-speed fan ON (℃)
MCU	＜55	≥60	＜60	≥65
Motor	＜80	≥85	＜90	≥95
OBC	＜50	≥55	/	/

In case of poor working conditions or poor cooling due to cooling system failure, the electric drive system will run at reduced power due to overheat to actively protect the system; serious overheating may also lead to breakdowns. The temperature thresholds for an overheat fault are as follows:

Name	Temperature threshold	Fault description
MCU	＞90℃	Level 1 fault, power is limited, and turtle light and motor overheat light are on
	＞100℃	Level 3 fault, MCU turns off the IGBT, and motor overheat light and motor fault light are turned on
Motor	＞140℃	Level 1 fault, power is limited, and turtle light and motor overheat light are on
	＞160℃	Level 3 fault , MCU turns off the IGBT, and motor overheat light and motor fault light are turned on

3.3.2 Connection of cooling pipeline

The PEU, motor and OBC share a cooling circuit.



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4.0

Common faults of PEU

4.1 PEU communication failure

PEU communication failure is usually manifested as HV power on failure, and abnormal values of the E-drive system can be observed on the ICM.

Data analysis shows that the message information of MCU and motor is missing on the CAN bus; the causes of communication failure are generally considered from the aspects of LV power supply, CAN bus and MCU control PCB:

Possible cause	Countermeasure
Abnormal LV power supply	Check the external LV power supply
Wrong connection against pin definition	Check against the pin definition
Connector loose or not in place	Check the connector
Control PCB damaged	Replace the control PCB

4.0

Common faults of PEU

4.2 PEU overheating

The PEU overheating is usually manifested by electric drive system running at reduced power or even vehicle shutdown.

Overheating is usually caused by cooling system failure, or temperature sensor failure, including motor temperature sensor signal failure:

Possible cause	Countermeasure
Coolant level low	Check that there is no leakage in the pipeline, and add coolant to the normal level
Abnormal operation of coolant pump	Check the working condition of the coolant pump
Abnormal operation of fan	Check the working condition of the fan
Blocked cooling pipeline or air in the pipeline	Check that the pipeline is free from bending or blockage
Wrong temperature sensor pin	Check the connector pin
Motor temperature sensor failure	Check the resistance of the motor temperature sensor

4.0

Common faults of PEU

4.3 PEU insulation fault

PEU insulation fault will result in failure to HV power on.

There are usually poor insulation of external cables and HV electrical consumers, water and moisture inside the controller, damaged HV components inside the controller, etc.

Possible cause	Countermeasure
HV cable broken	Check the appearance of the cable and measure the insulation resistance to determine the cause of leakage
Water in PEU or moisture in HV connector	Replace the controller
HV components burnt out inside the controller	Replace the controller or replace the internal components
Motor or other electrical consumer burnt out	Replace burnt electrical consumer

4.0

Common faults of PEU

4.4 The vehicle shows no fault but cannot be driven

As the core component of the electric drive system, PEU is often the first to be considered as the fault source when there is no fault display but the vehicle cannot be driven. This kind of fault needs to be considered in many ways, such as logic gear position, vehicle interlock signal, and even incorrect phase sequence of 3-phase cable occurring in the assembly of new vehicle.

Possible cause	Countermeasure
Incorrect phase sequence of motor 3-phase cable	Check whether the phase sequence of 3-phase cable is normal
Abnormal state of resolver	Measure the resistance of each winding of the motor resolver to determine whether it is normal
Brake not released	If there is torque output when the accelerator pedal is depressed but the vehicle does not move, check whether the mechanical brake part works normally
Abnormal accelerator pedal signal	If there is no torque output when the accelerator pedal is depressed, check whether the analog signal of the accelerator pedal is normal
Abnormal brake pedal signal	If there is no torque output when the accelerator pedal is depressed, check whether the digital signal of the brake pedal is normal
Abnormal gear signal	Check whether the gear position displayed on the ICM is consistent with the gear of the shift knob.

Safety tips

1. There are capacitors inside the PEU. Even if the HV power is cut off, there will still be residual charge, which may cause a risk of electric shock. Be sure to check that the voltage is lower than 36V before starting any operation.
2. Fault inspection must be carried out by professionals, non-professionals are strictly prohibited from inspection, maintenance and repair of the controller; otherwise there will be a risk of electric shock!
3. During disassembly and inspection, be sure to prevent foreign matters such as chips, oil, water, etc. from entering the controller; otherwise the controller may fail.

THANKS