Politecnico di Torino

Thesis Title:

Power box design, assembling and Electrical schematics of Electric car

Masters Thesis

Student: Rao Muhammad Wajdan 289627

Professor: CARABELLI STEFANO (DAUIN)

Company name: Brain Technologies (Evergrin Project) Company
Manager: Giovanni Guida

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Contents

1- Abstract:

This thesis focuses on the EVERGRIN project, which is being developed by Brain Technologies with the aim of converting internal combustion engines into full electric vehicles. The project involves the creation of a set of components that can transform a traditional car engine into a more environmentally friendly alternative. Specifically, my Thesis focuses on the design of the Power Box, updating and modifying the Electrical schematics to integrate the new SME inverter. The Power Box is a key component in the transformation process and requires careful design and assembly to ensure it functions effectively. This thesis work aims to provide a detailed overview of the Power Box design process, as well as the necessary modifications to the electrical schematics to accommodate the new inverter. The results of this thesis work will contribute to the ongoing development of the EVERGRIN project and could have wider implications for the future of electric vehicle technology.

2. Introduction:

The automotive industry has experienced exponential growth in the past two centuries, with the actual birth estimated to be around 1860. From the invention of the steam engine in the eighteenth century to the hybrid and electric cars of recent years, humans have made significant advancements in the field of mobility. The automotive industry is now one of the most important in the world in terms of turnover, with China being the current leader in the sector.

For many years, automobiles were tied to Internal Combustion Engine (ICE) technology, especially in the Otto and Diesel designs, which delivered high performances and considerable autonomy. However, due to the increasing attention towards reducing air pollution and the exhaustion of oil reserves, there is a need for new technologies and alternative propulsion systems that are not powered by petrol. The solutions considered to be the most valid today are Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), and Fuel Cell Vehicles (FCV).

Vehicle categories are classified based on the degree of electrification, ranging from 0 for conventional ICE vehicles to 1 for Full Electric vehicles. Full Electric vehicles are powered by one or more battery packs that drive electric motors used to propel the vehicle. Extended Range Electric (EREV) vehicles have a small combustion engine used as an electric power generator for recharging the batteries, which allows an increase in the autonomy of the vehicle. HEVs contain all the components of a conventional ICE plus most of the components of a pure EV, requiring two energy sources, the fuel tank for the engine and a battery for the electric motors. HEVs offer numerous advantages such as reduced fuel consumption, downsizing, and energy recovery capability.

The Idle stop/start function, which automatically switches off the ICE when the vehicle is stationary, is present in many cars to reduce overall fuel consumption. In the HEV case, the battery is recharged when the engine is working in the most fuel-efficient point or when the vehicle is braking, thereby reducing the load torque on the engine and fuel consumption.

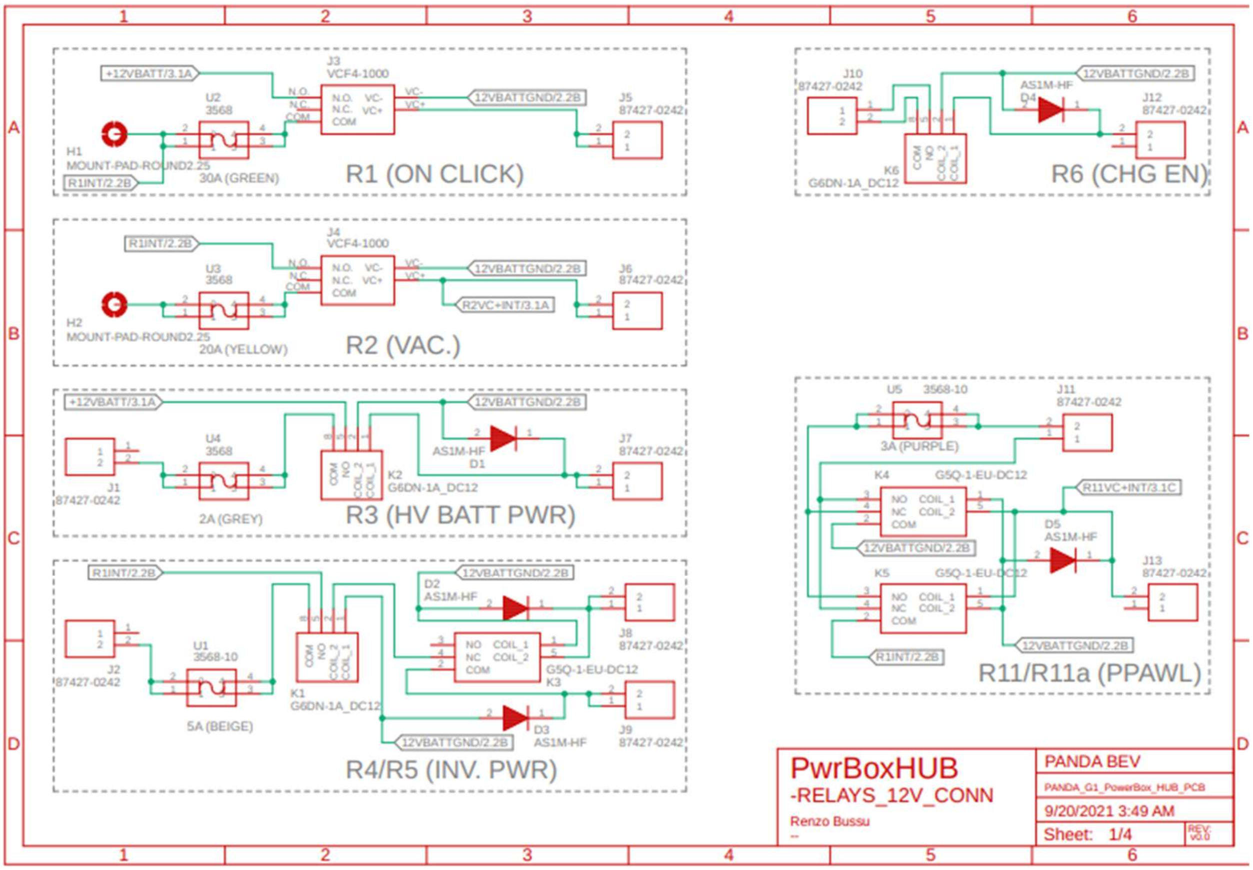
The development of software follows a production process that strongly affects the quality of the final result. Software engineering offers a systematic and quantifiable approach to software development, operation, and maintenance by defining methods, models, techniques, and tools to govern the software's life cycle. The development process is divided into various phases, such as requirements and specifications, analysis and functional description of the system, design, implementation, testing, and use and maintenance, which are structured differently depending on the process model adopted. The waterfall model, which organizes the phases sequentially, was the first and simplest model applied when software development began. The Agile model proposes a less structured approach, focusing on producing functioning and quality software in a short time, and is performed in limited time windows called iterations.

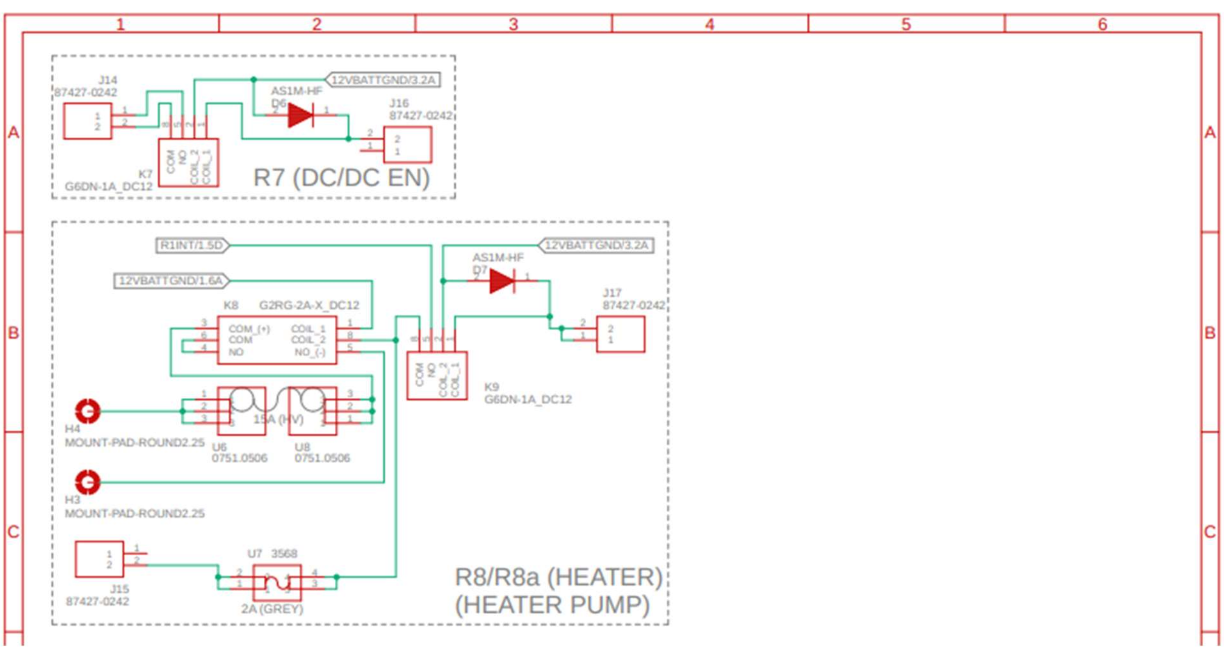
3, V-Cycle:

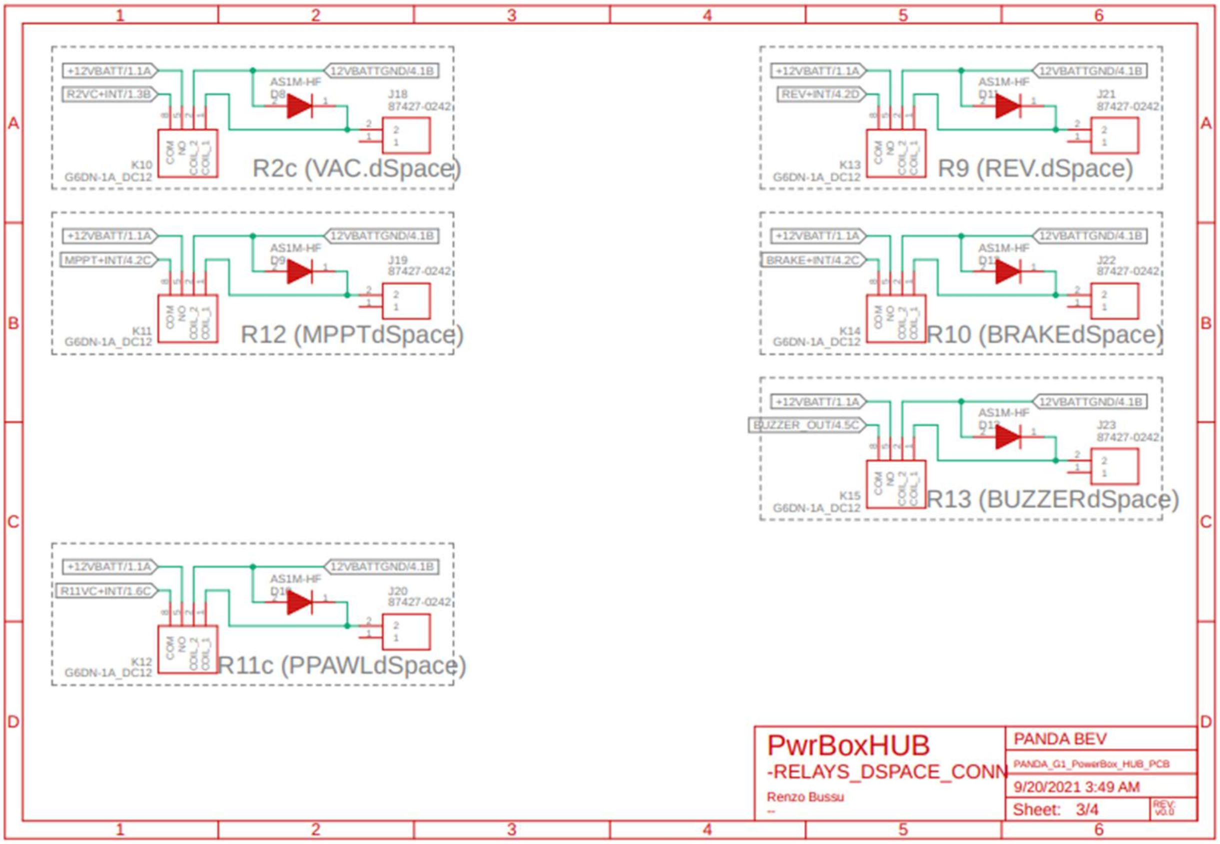
The V-Cycle model is an extension of the waterfall model that aims to give equal weight to development and testing, using the same relationships between the phases defined in the waterfall model but developing abstractly with the shape of the letter "V." This model foresees the possibility of feedback between the testing/integration phases and the definition/development phases at the same level and between different levels of abstraction. The V-Model's first step is the requirements analysis phase, where a document is drawn up to collect the system requirements by analyzing the user's needs. The system design phase is where systems engineers build an architectural plan for the development phase by analyzing and understanding the tasks of the proposed system.

The V-Cycle model aims to avoid the detachment between the various activities present in the waterfall model, which forces the designers to terminate a phase completely before continuing with the next one, not allowing them to go back. Feedback loops are often necessary to correct errors by making jumps from one phase to another doing changes at different times. This model is useful to understand the software's production and the benefits it brings, as it gives equal importance to development and testing, which helps in the development of high-quality software.

3. EverGrin Project and Power box design:







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R2VC+INT/1.3B
12VBATTGND/4.1B
AS1M-HF
D8
J18
87427-0242
K10
G6DN-1A_DC12
R2c (VAC.dSpace)
MPPT+INT/4.2C
D9
J19
K11
R12 (MPPTdSpace)
R11VC+INT/1.6C
D10
J20
K12
R11c (PPAWLdSpace)
REV+INT/4.2D
D11
J21
K13
R9 (REV.dSpace)
BRAKE+INT/4.2C
J22
K14
R10 (BRAKEdSpace)
BUZZER_OUT/4.5C
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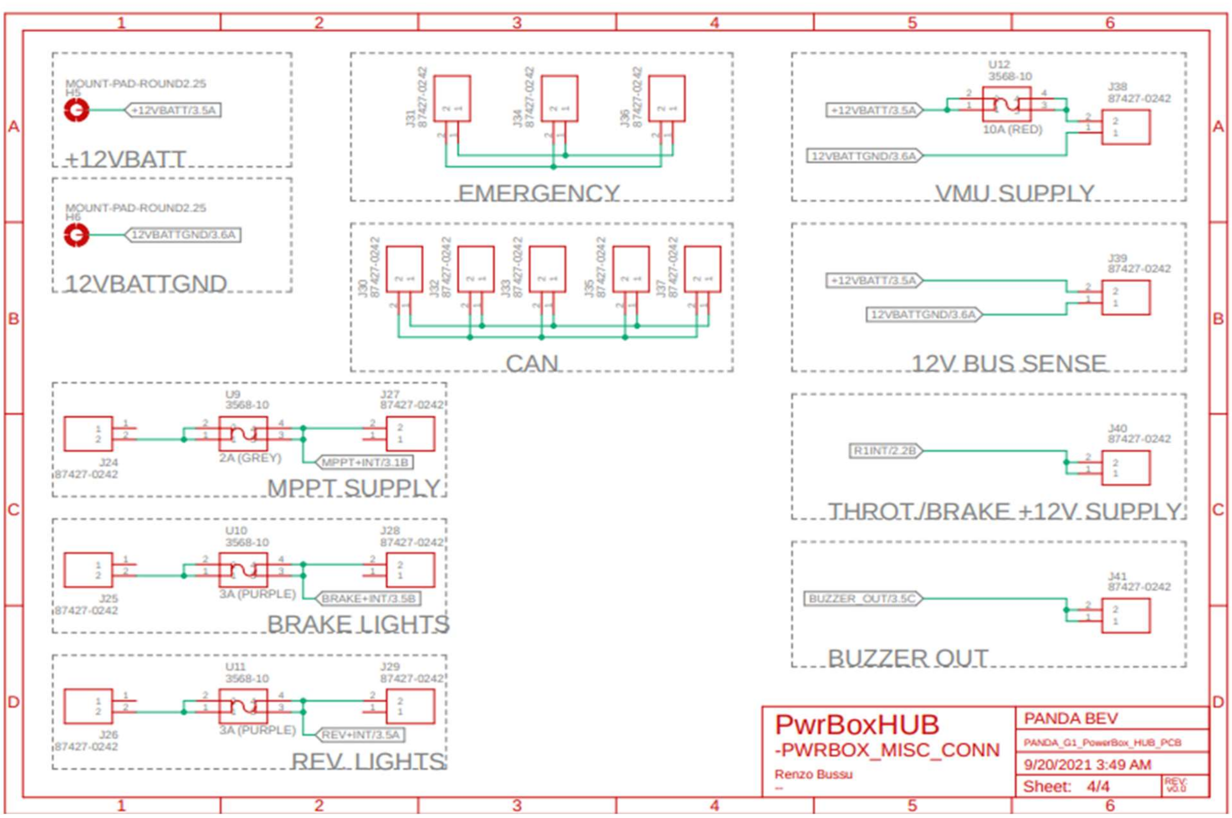

MOUNT-PAD-ROUND2.25
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+12VBATT/3.5A
+12VBATT
H6
12VBATTGND/3.6A
12VBATTGND
J31
J34
J36
87427-0242
EMERGENCY
J30
J32
J33
J35
J37
CAN
U12
3568-10
10A (RED)
J38
VMU SUPPLY
J39
12V BUS SENSE
U9
2A (GREY)
J24
J27
MPPT+INT/3.1B
MPPT SUPPLY
R1INT/2.2B
J40
THROT./BRAKE +12V SUPPLY
U10
3A (PURPLE)
J25
J28
BRAKE+INT/3.5B
BRAKE LIGHTS
BUZZER_OUT/3.5C
J41
BUZZER OUT
U11
J26
J29
REV+INT/3.5A
REV LIGHTS
PwrBoxHUB
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Renzo Bussu
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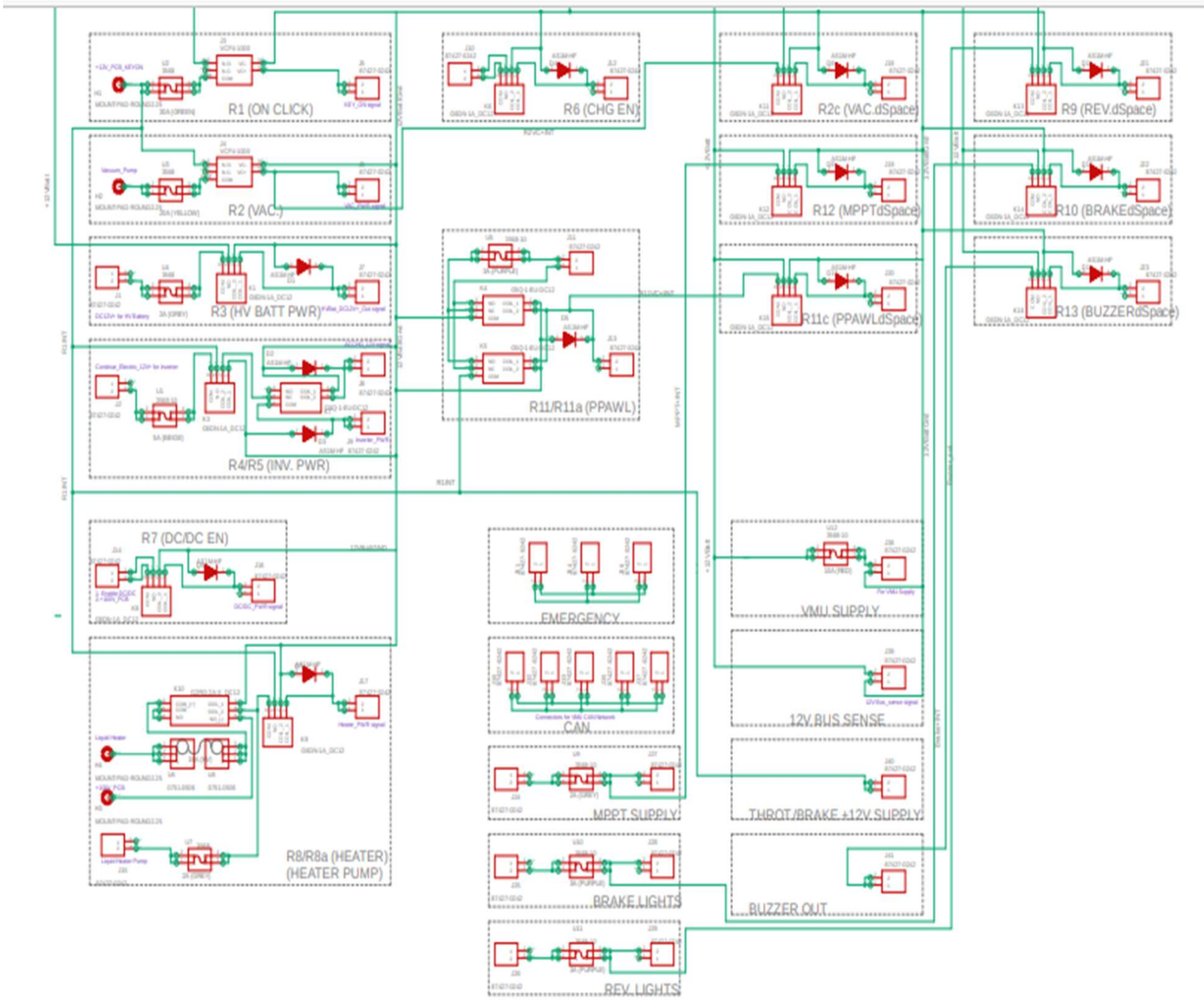
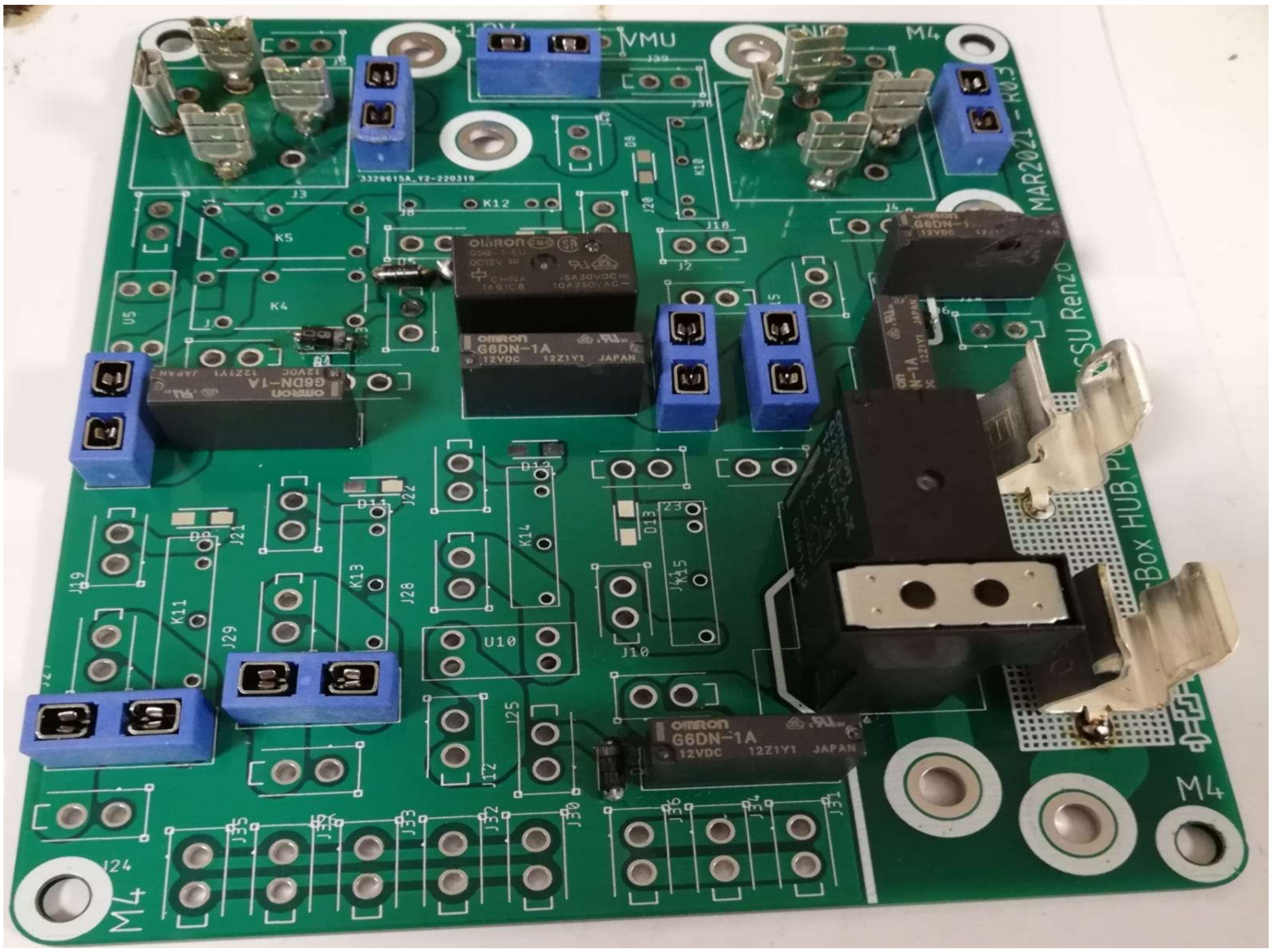
REV: v0.0

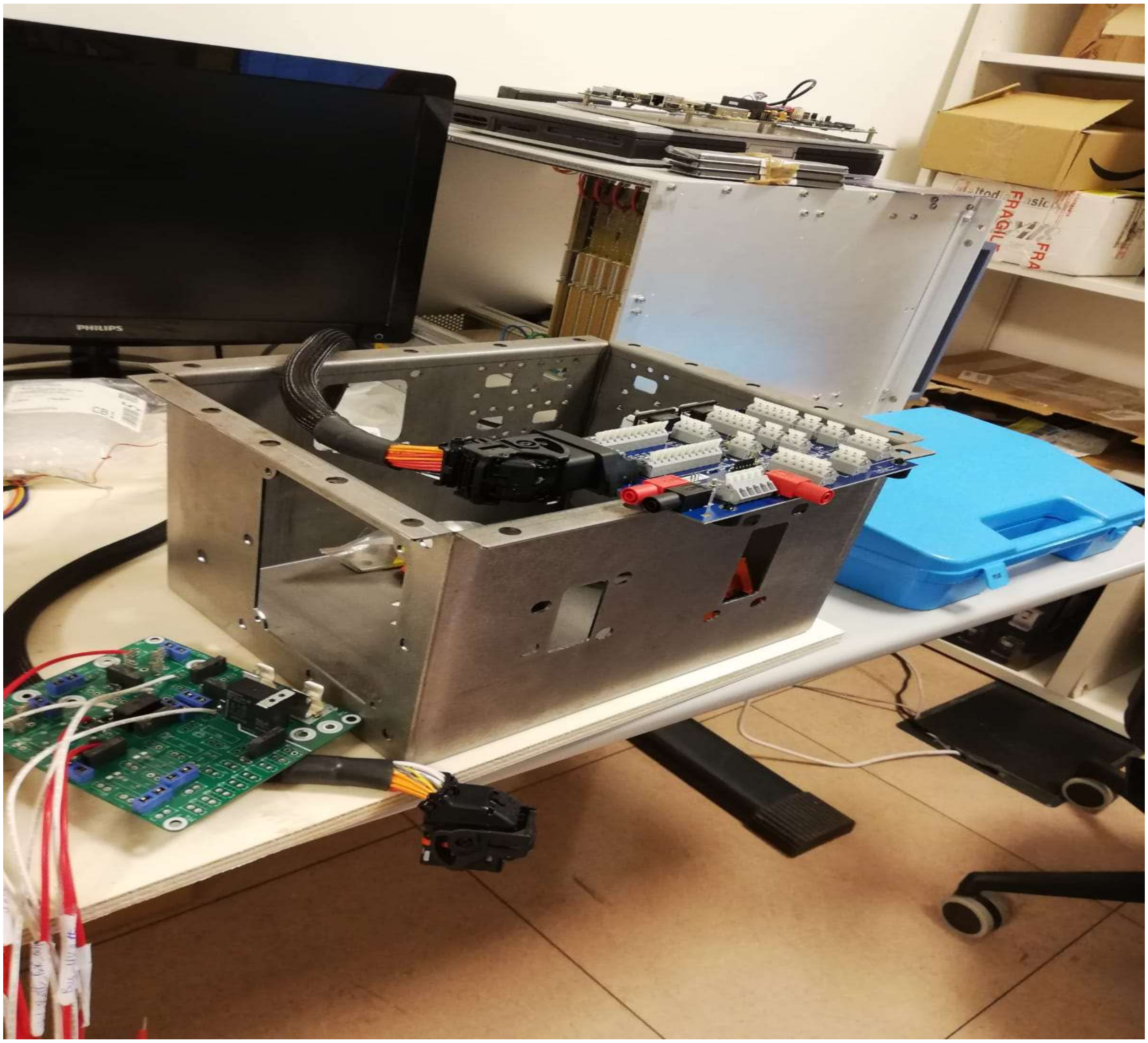
Complete PCB Schematic design:



4. PCB design and assembling of Power Box

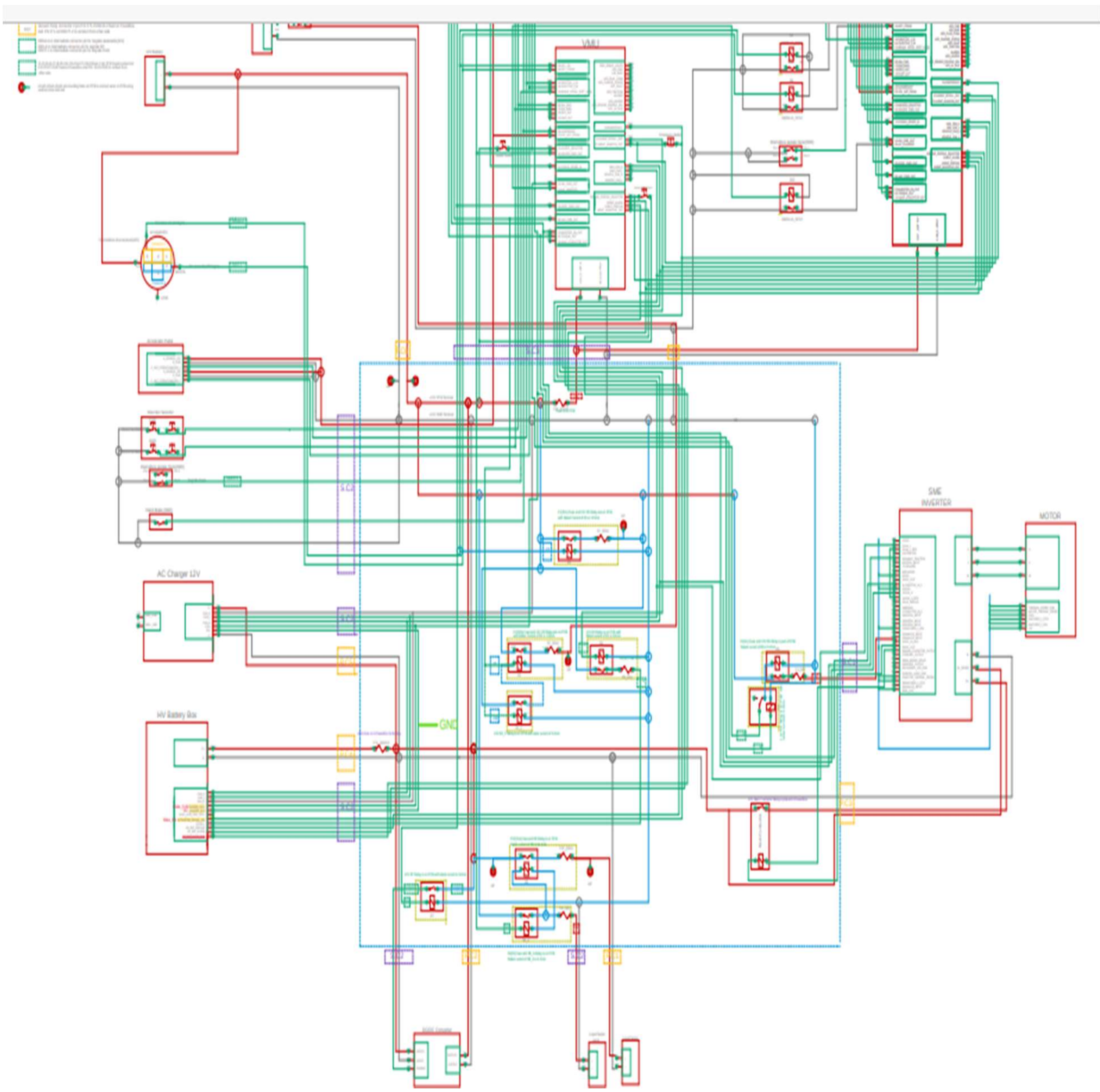


5. Power Box assembling & Testing

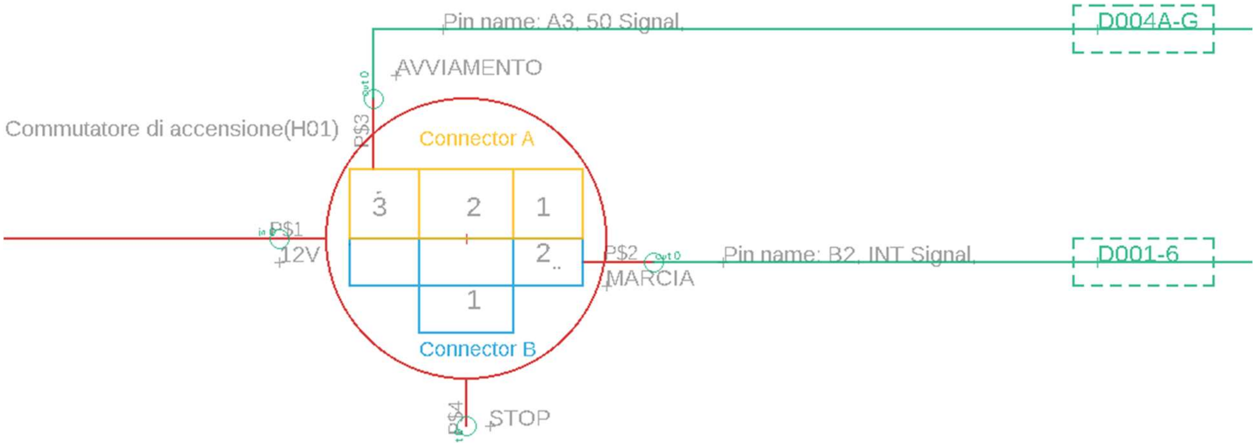


6. Electrical Schematics

Complete scheme:



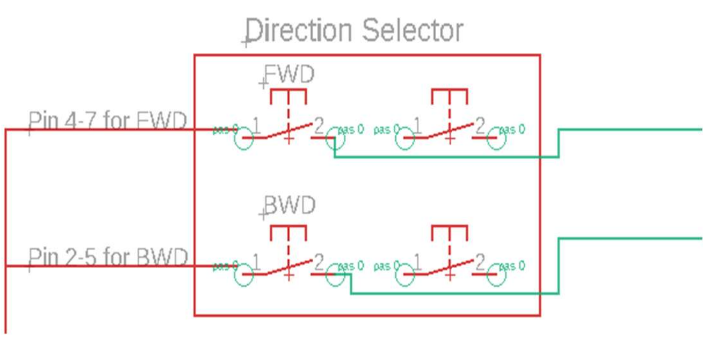
Key Block:



The Key Block (Commutatore di accensione H01) has 5 terminals and 2 connectors i.e Connector A and B. Pin A3 with Signal ID 50 is used for Key Crank(Avviamento) and intermediate connector D004A-G used and Pin B2 with Signal ID INT is used for KEY ON(Marcia) and intermediate connector D001-6 used for it.

N: 571-DRB16-60SAE-L018 and P.N: 571-DRBF-2A Connector used to connect signals to PowerBox. The male part will be mounted from inside powerbox.

Direction Selector:



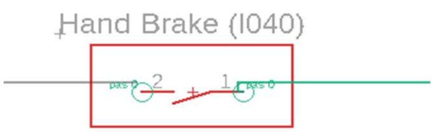
The Direction selector is the Joystick XD2PA24and its detail is available in the [Datasheet](). It has 4 NO switches. Out of the 8 pins of direction selector, Pin 2-5 NO Switch used for Backward and Pin 4-7 NO switch used for Forward.

Connector used to connect signals to PowerBox is P.N: 571-DRB16-60SAE-L018 and P.N: 571-DRBF-2A. The male part will be mounted from inside powerbox.

Brake Switch:

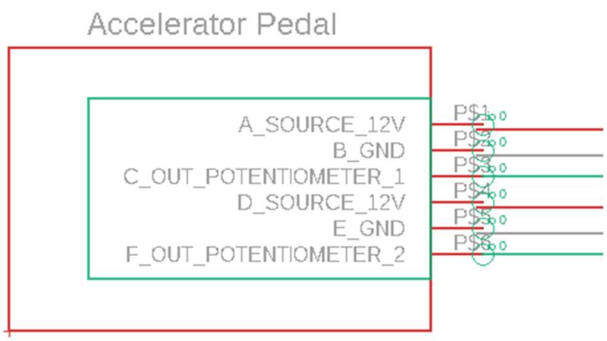
The Brake pedal(Interruttore pedale freno I030) has 2 switches: one is NO and other is NC. Brake signal of Brake switch (I030) connection ends at Body computer (M001) ABS control unit (M050) with Connector Code-pin B-5 20 and intermediate connector code D097C – 1.

Hand Brake:



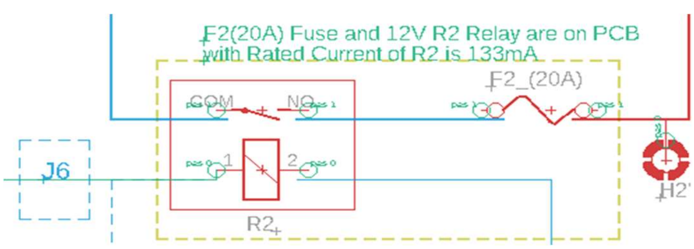
The handbrake has component ID I040 according to Panda 169 manual.

Accelerator Pedal:



Accelerator Pedal is supplied 12V from a stable voltage source(VMU). There are 6 pins and numbering of pins from top to bottom is done according to workshop manual.

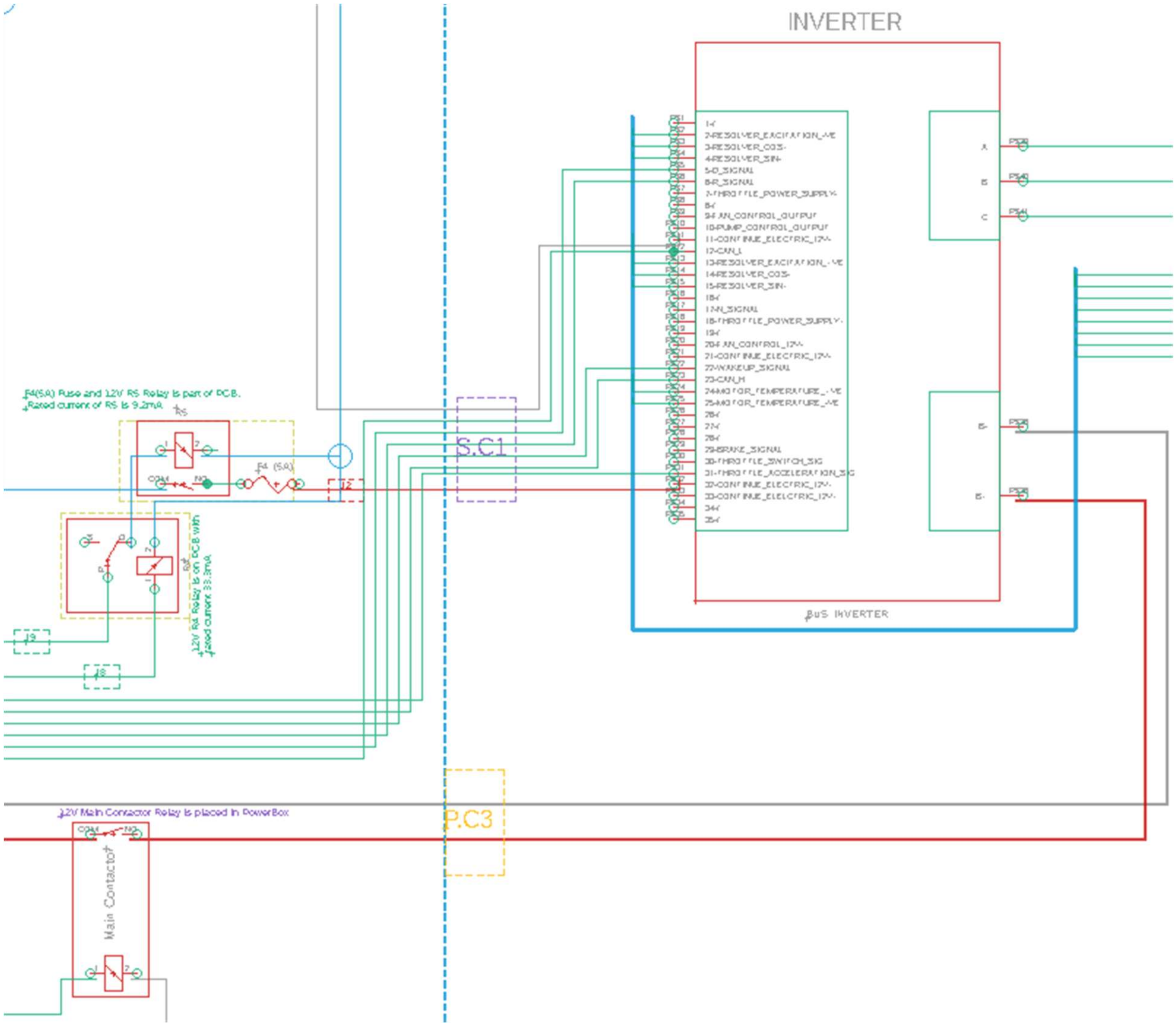
Vacuum Pump:



Vacuum Pump is controlled by VMU through VAC_PWR signal and R2 relay of PCB is used. J6 2 pin PCB Signal connector P.N: 87427-0242 fixed on PCB. And P.N: 39-01-2020 to connect from other side to connect signal to VMU. H2 mounting hole used to supply to Vacuum pump.

2 pin connector P.N: 571-2103124-4 fixed on PowerBox for Vacuum Pump. And P.N 571-4-2103177-2 to connect from other side.

Inverter:



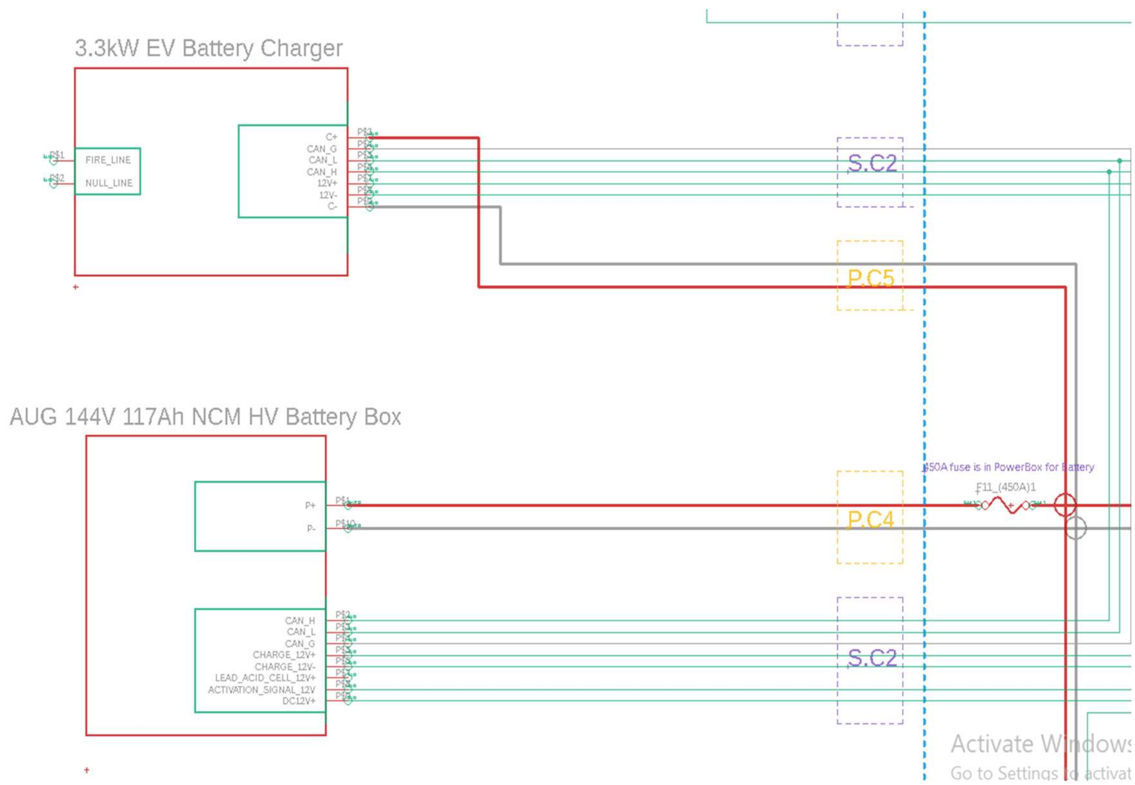
The Inverter is connected to the PowerBox using 35 pins Signal Connector for Inverter P.N:571-776164-4 fixed on PowerBox with P.N: 571-770520-1-CT Inverter signal connector pin. R4 and R5 relays are on PCB inside PowerBox, R4 relay is used for Interlock and R5 to supply 12V to Inverter from +12V_Key_ON controlled by R1 relay. J2,J8,J9 are 2 pins PCB Signal connectors P.N: 87427-0242 fixed on PCB. And P.N: 39-01-2020 to connect from other side to connect signal to VMU for Inverter_PWR and ACCHG_12V used for Interlock.
Main_Contactor used to control high voltage supply for Inverter, is mounted inside the PowerBox.

Inverter connector 2 pin P.N: 829-35254402 fixed on PowerBox for high voltage connection
And P.N 829-35254366 to connect from other side.

For harness installation according to datasheet, see the connector specifications,

Part Name	Connector Name	Part Side Connector		Mating Connector (wiring harness)	
		P/N	Supplier	P/N	Supplier
Motor controller assembly	Controller low-voltage signal line and vehicle	Socket 776231-1	AMP	Sheath: 771644-1 Terminal: 770520-1	AMP

HV_Battery and 3.3kW Charger:

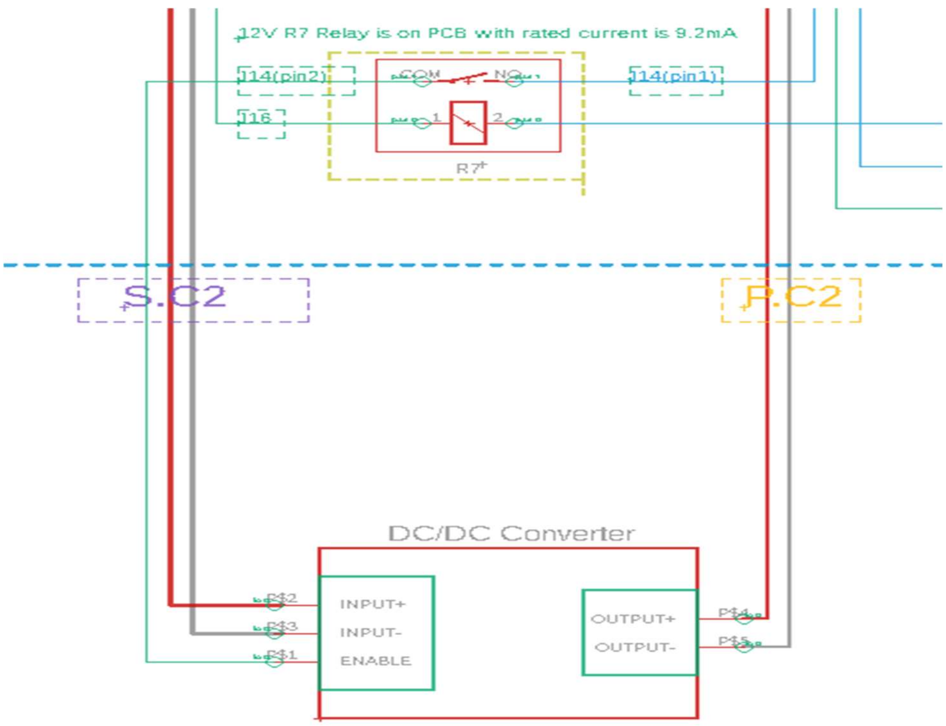


2 pin connector P.N: 829-35254402 fixed on PowerBox and P.N 829-35254366 to connect from other side for High voltage from HV Battery. 450A fuse for battery is inside PowerBox. 3.3kW AC Charger 2 pin connector P.N: 571-2103124-4 fixed on PowerBox. And P.N 571-4-2103177-2 to connect from other side.
For connecting signals to PowerBox, Signal Connector 2 is used which is 60 pins connector P.N: 571-DRB16-60SAE-L018 and P.N: 571-DRBF-2A for other side. The male part will be mounted from inside powerbox.

InterLock:

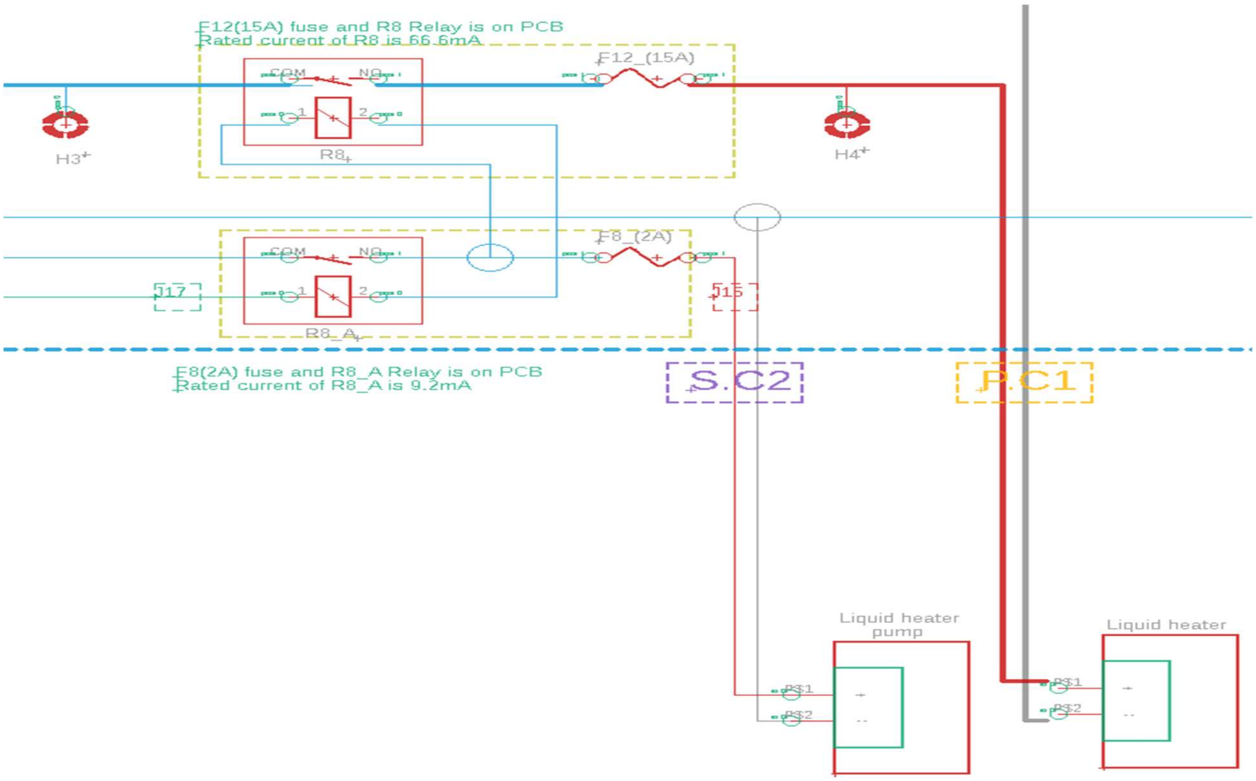
Hardware needed: R4 Relay on PCB and ACCHG_12V signal
When ACCHG_12V signal applied at 12V+ pin of Battery Charger, means Battery is at charging state which stops the inverter working as, R4 relay of inverter is also, attached with ACCHG_12V signal which at the time of battery charging, stops inverter and hence, protects the inverter to run at the time of Battery Charging. R4 relay and R5 relay are on PCB. ACCHG_12V signal of R4 controls the relay to connect Inverter to +12V_PCB_KeyOn.

DC/DC Converter:



DC/DC Converter is controlled by R7 relay of PCB . J16, J14 connectors used with it. J14, J16 are 2 pins PCB Signal connectors P.N: 87427-0242 fixed on PCB. And P.N: 39-01-2020 to connect from other side. Signal Connector P.N: 571-DRB16-60SAE-L018 and P.N: 571-DRBF-2A used to connect with PowerBox. The male part will be mounted from inside powerbox. DC/DC Converter output connector 2 pin P.N: 571-2103124-4 fixed on PowerBox. And P.N 571-4-2103177-2 to connect from other side.
Further information on DC/DC Converter is available in Datasheet.

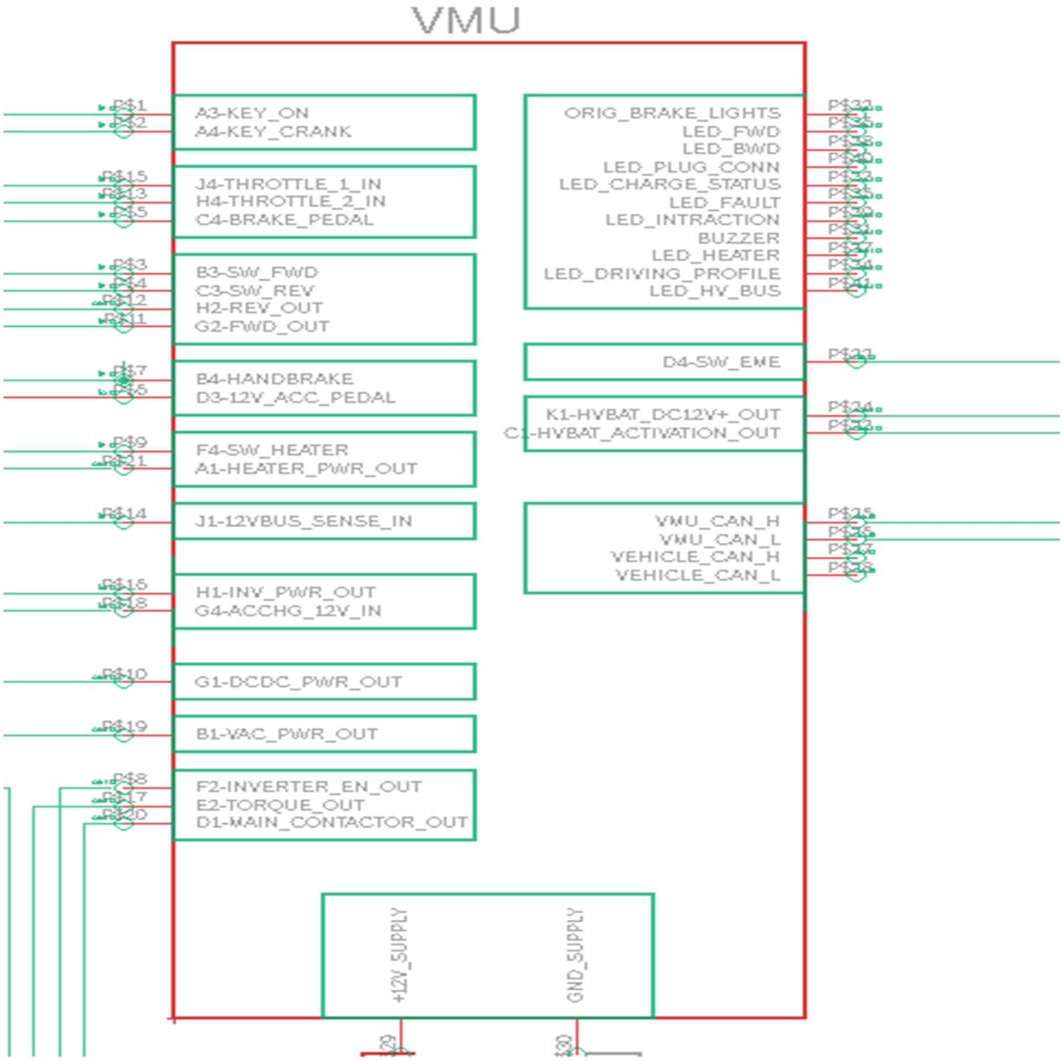
Liquid Heater & Liquid Heater Pump:



Liquid heater connector 2 pin P.N: 571-2103124-4 fixed on PowerBox. And P.N 571-4-2103177-2 to connect from other side. Signal Connector P.N: 571-DRB16-60SAE-L018 and P.N: 571-DRBF-2A used for Liquid Heater pump. The male part of connector will be mounted from inside PowerBox. Mounting hole H3 used to supply high voltage and H4 used to connect Liquid Heater. R8 and R8_A relay of PCB used for Liquid heater and Liquid Heater Pump. J17 connector of PCB used to connect Heater_PWR signal and J15 used to connect Liquid Heater Pump.

Further, Information from Supplier on Liquid Heater is available in Datasheet. Information from Supplier on Liquid Heater pump is also available in Datasheet.

VMU:



Signal Connector P.N: 571-DRB16-60SAE-L018 and P.N: 571-DRBF-2A used for VMU. The male part of connector will be mounted from inside powerbox.

Conclusion:

In conclusion, the thesis has outlined the design and assembly process for the Power Box in the EVERGRIN project, which is aimed at converting internal combustion engines into full electric vehicles. The Power Box plays a crucial role in the transformation process and requires careful consideration and modifications to the electrical schematics to integrate the new SME inverter. Through this thesis work, a detailed overview of the Power Box design process has been provided, and the necessary modifications to the electrical schematics have been made to accommodate the new inverter. The results of this work will contribute to the ongoing development of the EVERGRIN project and have wider implications for the future of electric vehicle technology. Overall, this thesis report has demonstrated the importance of careful design and assembly in the development of key components for electric vehicle technology.