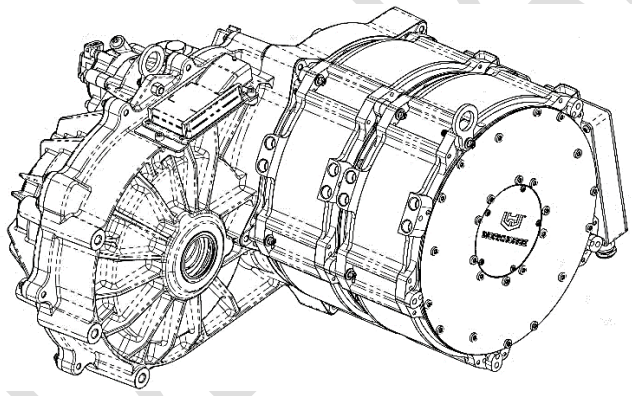
MAGELEC Electric Powertrain System User Manual

For Workhorse



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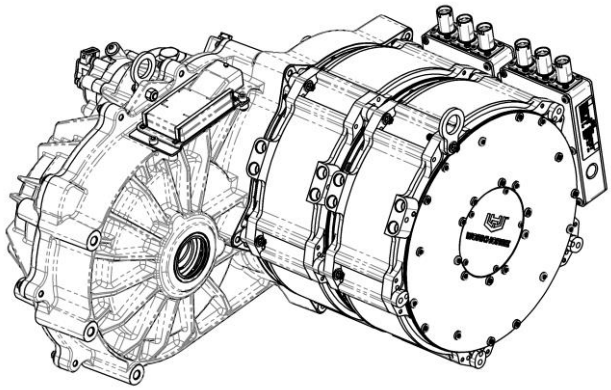

PART NO.: M88-000062-B

Revision	Comment	Issued by	Confirmed by	Approved by	Date
A01	First Release	A Deeming	M Yang	N Rossi	05/12/2020
A02	UPDATE 2.1 Basic Principles for Electric Powertrain System 9.1 MGU Liquid Cooling Connection Coolant flow rate update	A Deeming	M Yang	N Rossi	03/15/2021
A03	4.3 Marking Definition 4.4 Component Identification 6.1 Powertrain Assembly 7 Fault Code Instruction 8 Firmware Instruction	A Deeming	M Yang	N Rossi	03/26/2021
A04	9.1 Service Intervals 9.2 Gear Oil	A Deeming	M Yang	N Rossi	03/30/2021
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A06	6.2.4 MAGELEC-N GEN 1000 Part Number 6.3.1 HVIL Controller and Motor Circuit Diagram	A Deeming	M Yang	N Rossi	10/12/2021

Table of Subjects

1 GENERAL INFORMATION

1.1 Scope

The electric powertrain system user manual provides important information about the traction drive system by using MAGELEC Propulsion electric powertrain as well as the details on system configuration between each unit and vehicle systems.

1.2 Definitions, acronyms and abbreviations

PPE	Personal Protection Equipment
MGU	Motor / Generator Unit
MCU	Motor Control Unit
RESS	Rechargeable Energy Storage System (High Voltage Battery)
HVIL	Hazardous Voltage Interlock Loop
PMSM	Permanent Magnet Synchronous Motor
NVH	Noise, Vibration & Harshness

1.3 Safety First

Due to the electric powertrain system will be operating under **High Voltage, High Temperature and High Speed,** special attentions must be paid to the information presented in Dangers, Warnings and Notes when they appear in this manual. The symbols of style and purpose of each are shown below.

High Voltage / Electrical Shock

Extreme care should be taken to protect against shock.

Always working with another person in case an emergency occurs. Disconnect power before checking or performing maintenance. Be sure equipment is properly grounded. Appropriate PPE required

Heavy

Refer to products outline drawing to confirm the weight of the products before handling

Appropriate PPE required

Appropriate lifting means required

Strong Magnetic Field

Do Not Disassemble The Motors.

Attention need to be paid when open motor HV terminal cover if need

Interaction with metallic objects may produce Pinch Hazards

High Temperature

During operation the system can reach very high temperatures

Appropriate PPE required

Rotating Equipment

Keep clear of rotating equipment during operation

This symbol identifies a terminal which is intended for connection to an external grounding conductor for protection against electric shock if there is a fault

2 System Description

The electric powertrain system basically consists of one longitudinal gearbox, one double stage MGUs and two motor control units MCUs. Each MGU includes one single stage MGUs. And which is controlled by each MCU respectively.

The e-Powertrain system implements the bi-direction energy conversion. In the traction mode, the power is supplied by the RESS, the inverter converts the DC power to the AC power to energize the motor, then the motor converts the AC power to the mechanical power on its shaft, then the power will be further transmitted to the wheels by the driveline. In the Re-generation mode, the power will be transmitted to the motor shaft through the driveline, then the motor converts the mechanical power to the AC power and inverter converts the AC power to DC power to recharge the RESS system.

To run this system well, the e-Powertrain requires a properly setup with the rest of vehicle systems. The description in this manual will provide the related information and requirement on e-Powertrain system.

2.1 Basic Principles for Electric Powertrain System

The schematic below describes the motor installation in the context of the wider vehicle system.

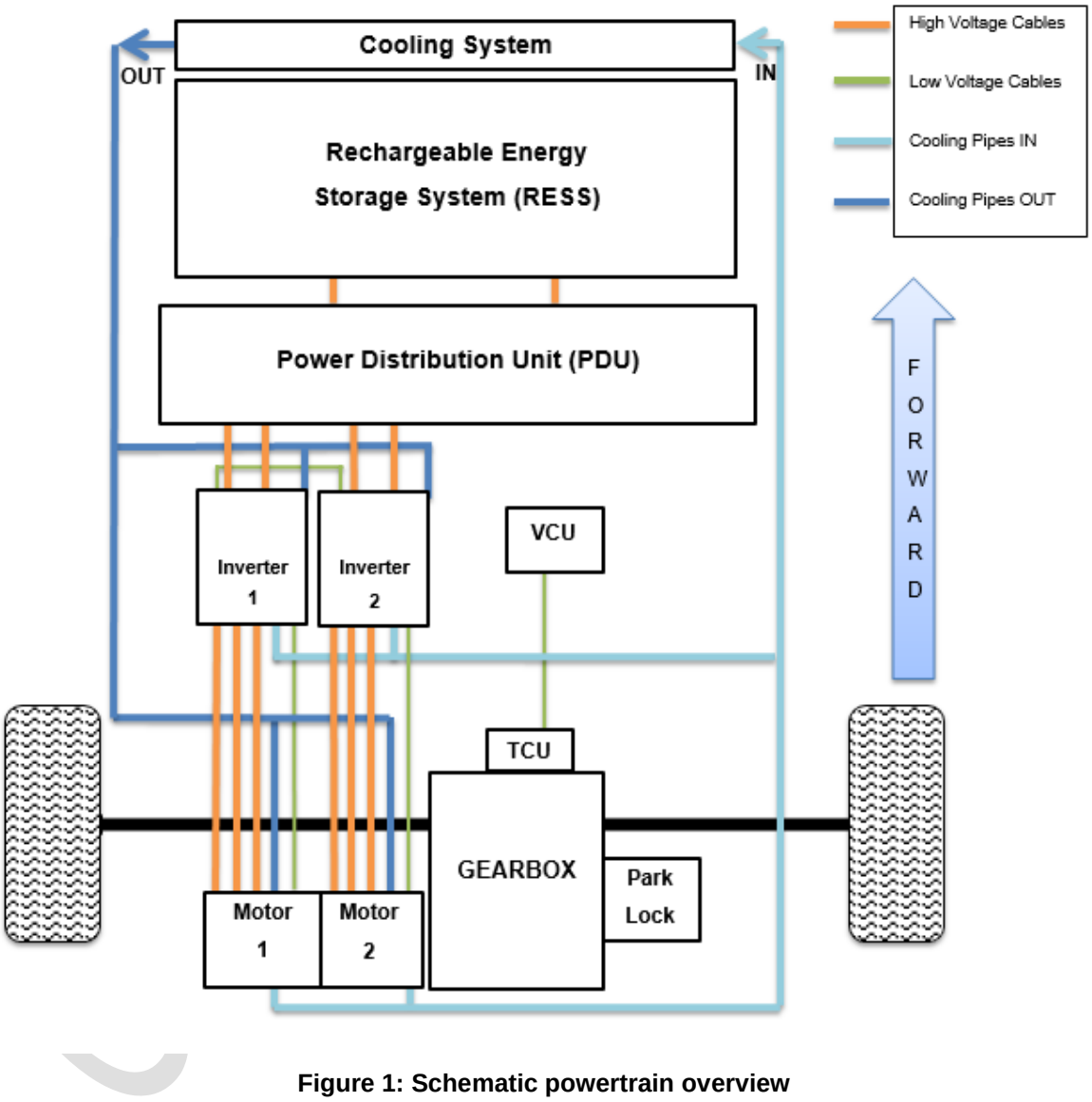


Figure 1: Schematic powertrain overview

2.2 System Dimensions

2.2.1 Gearbox

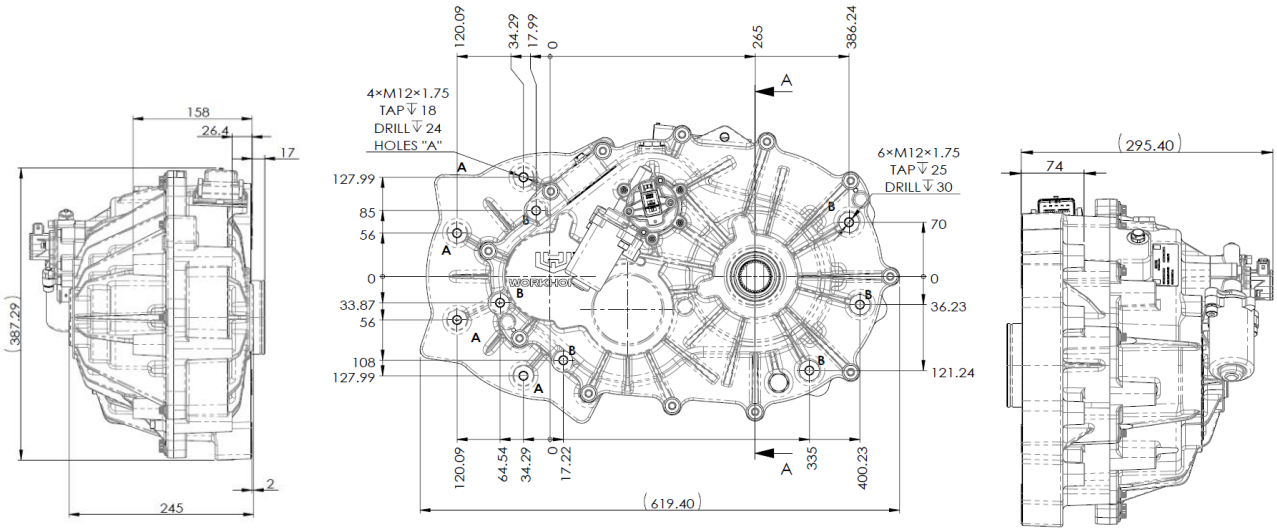
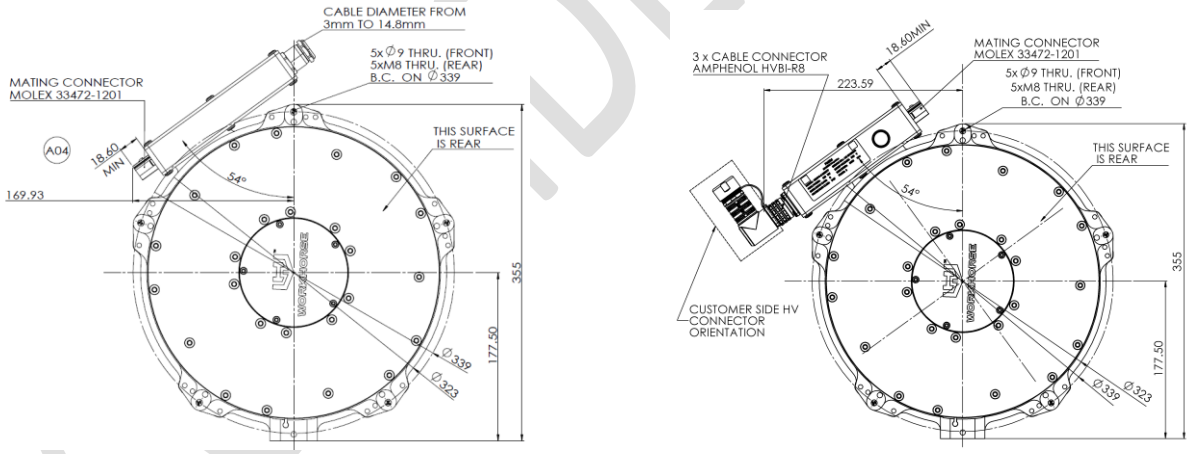


Figure 2: Gearbox Dimensions

2.2.2 MGU



PART NO.: M88-000062-A

PART NO.: M88-000062-B

Figure 3: MGU Dimensions

2.2.3 MCU

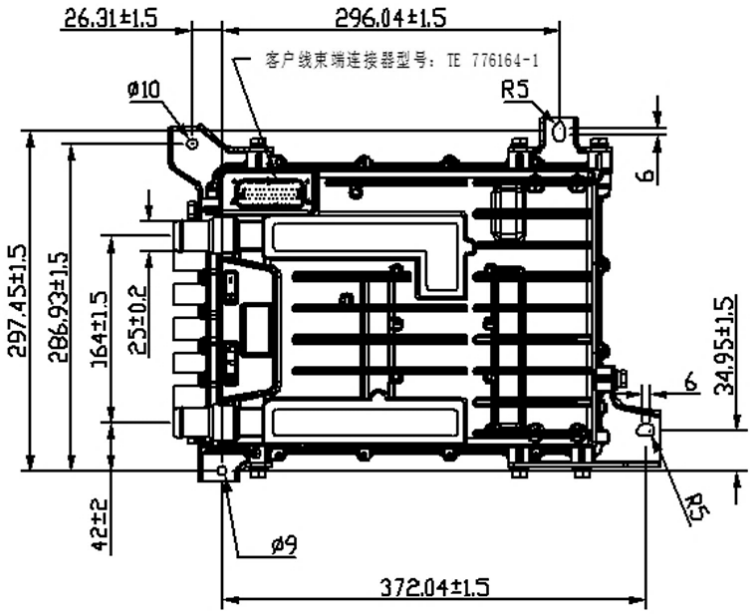


Figure 4: MCU Dimensions

2.2.4 Park Lock

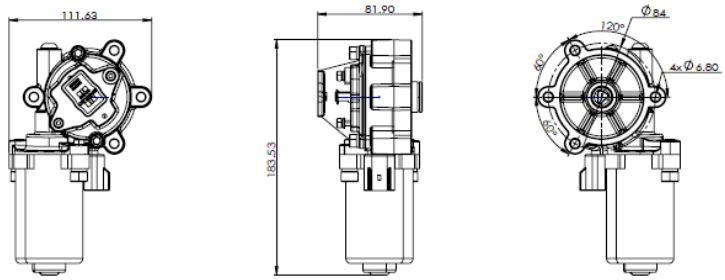


Figure 5: Parking Lock Dimensions

2.2.5 TCU

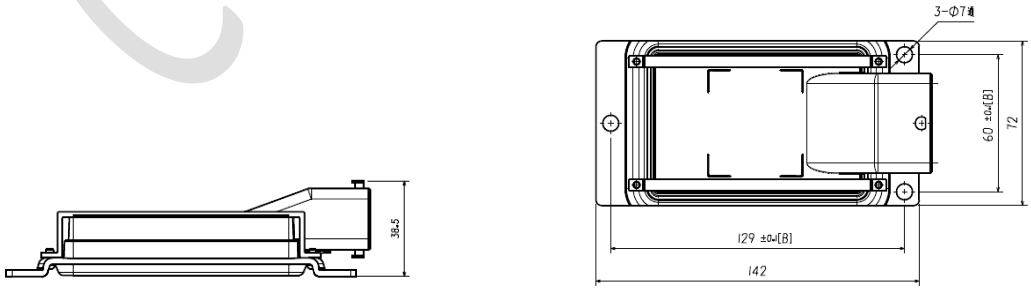


Figure 6: TCU Dimensions

2.3 System Component Mass

Gearbox	MGU	MCU	Park Lock	TCU
w/out output flange	w/out resolver & HV cables	w/out HV cables		
49.5 kg	32.5 kg	8.5 kg	1.35 kg	0.20 kg

Table 1: System Dry Weight

3 High Voltage Safety

NOTE:

Safety Instruction before making electrical installation

Carefully read all safety instruction before making an electrical connection to the system.

WARNING

This product generates high-voltage that can cause an electrical discharge or electrocution resulting in serious injury or death

Before manipulating the products, verify that:

- The RESS (High-voltage battery) is disconnected
- The Auxiliary battery (12 V battery) is disconnected

Incorrect assembly or an incorrect connection during assembly of this product may result in electrocution and /or fire.

The assembly and connections must comply with the system user manual.

The internal electronics are sensitive to electrostatic discharge.

Risk of shock – Do not open the MCU or MGU.

The electrical installation of the system does not require the MCU and / or the MGU to be opened or dismantled.

Risk of shock – capacitor stores hazardous energy

Please wait 10 minutes after powering OFF all sources of supply prior to removing cables and / or service

3.1 Hazardous Voltage Interlock Loop

The HVIL helps ensure safe operation by monitoring the condition of every high voltage component and high voltage connection in the vehicle system.

To maintain the HV safety, the correct tools will be required to access the HV components. Due to the inverter contains a substantial amount of capacitance on the DC bus.

Therefore, the high voltage system must be de-energized and the voltage needs to be surely dropped down to the voltage level under safety before to do anything operation related HV system/components.

3.2 Motor Back-EMF

The motor back EMF need to be taken into account during system integration. As the property of the PMSM, the motor will produce a sinusoidal voltage on the motor phase terminals once machine is spinning. The AC voltage is generally proportional to the spinning speed of the motor.
Meanwhile, if inverter is connected with the motor phase terminals, the inverter will convert the sinusoidal AC voltage to DC voltage and apply it to the DC bus directly even when inverter is non-powered by the 12Volts system. The maximum motor back-EMF need to be considered when sizing the voltage rating for the components on the DC bus and inverter AC side

4 E-Powertrain System Marking Rule

In order to better manage the e-powertrain system, MAGELEC define the marking rule to identify the connection of every component of the e-powertrain system. The proposed marking rule was shown as below.

4.1 MGU Marking Rule Definition

a. MGU Position Identification
   - The left and right hands is defined when facing the forward direction of the vehicle
   - The Double stage MGU located on the LEFT side is defined as LEFT hand motor generator unit, abbreviated to “LH MGU
b. Each MGU Unit
   - Define motor / generator unit in 1, 2, order from LEFT hand side and mark the unit with the order number.

4.2 Cables Marking Rule Definition

a. LV cables
   - LV cable for LH MGU is defined with “P1”
   - LV cable for RH MGU is defined with “P2”
   - LV cable branch for motor temperature resolver sensor is defined in “TR + motor unit number” format (e.g. TR1, TR2…).
b. HV cables
   - Both terminals of each HV cable will be marked in “motor phase + motor unit number” format (e.g. W1, V1, U1, W2…).

   See Figure **7:** for MGU and HV cable marking rules

4.3 MCU Marking Definition

a. MCU Position Identification

- The Left and Right hands is defined when facing the forward direction of the vehicle
- The MCU located on the LEFT side is defined as LEFT Hand Motor Control Unit, abbreviated to “LH MCU”
- The MCU located on the RIGHT side is defined as RIGHT Hand Motor Control Unit, abbreviated to “RH MCU”.

b. Each MCU Unit

- LF MCU is defined with number 1,
- RH MCU is defined with number 2

See Figure **8**: for MCU marking rules

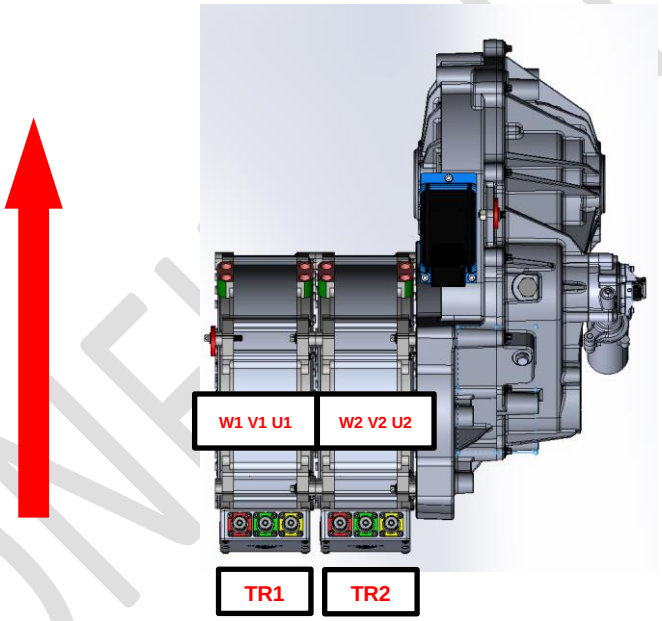


Figure 7: MGU & HV Marking Rule

(View from vehicle REAR. Arrow indicates the car forward direction)

Figure 8: MCU Marking Rule

4.4 Component Identification Numbers

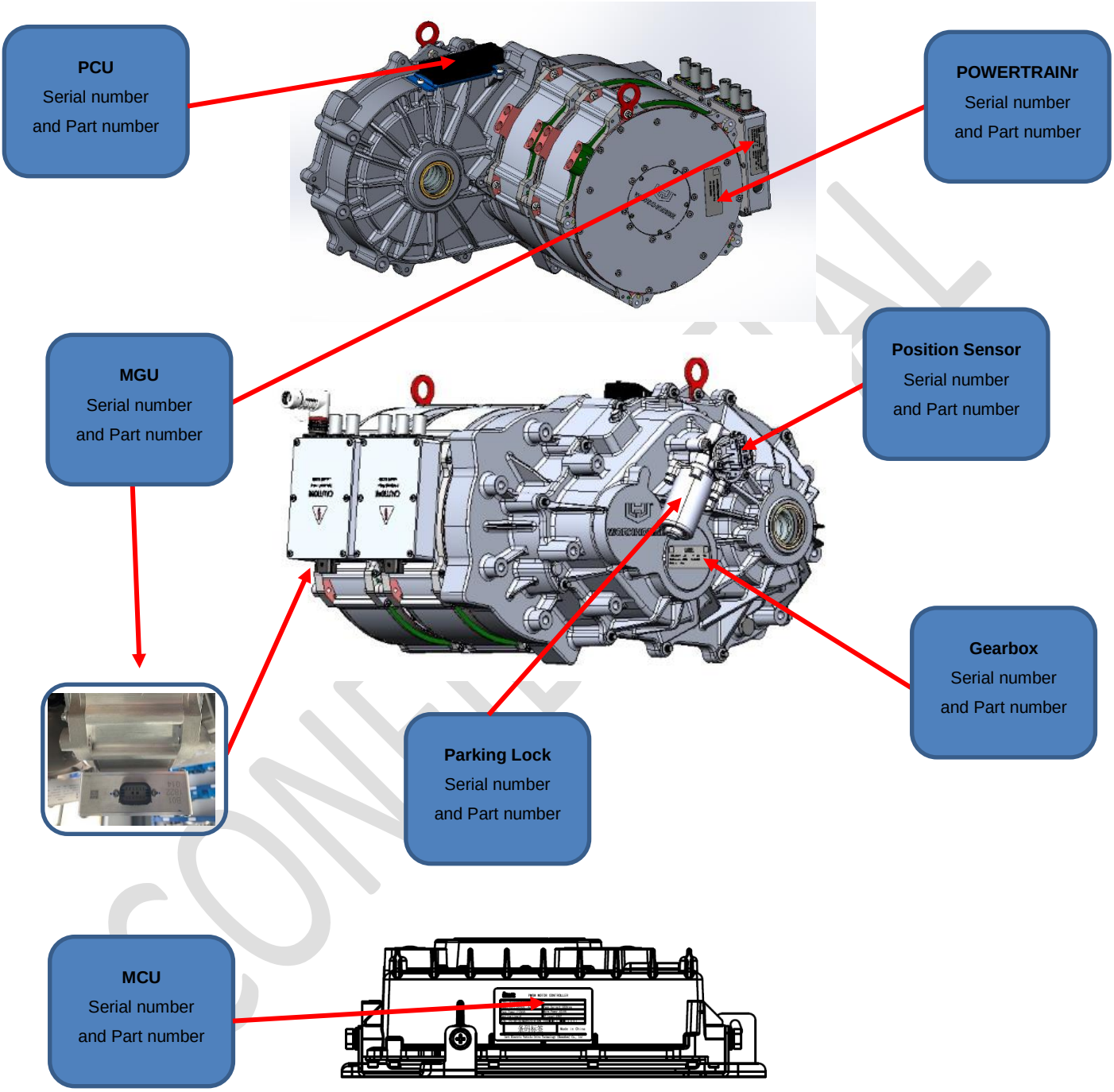


Figure 9 Component Identification Numbers

5 Grounding

5.1 Motor Grounding

See below marking for the grounding location of the motor units

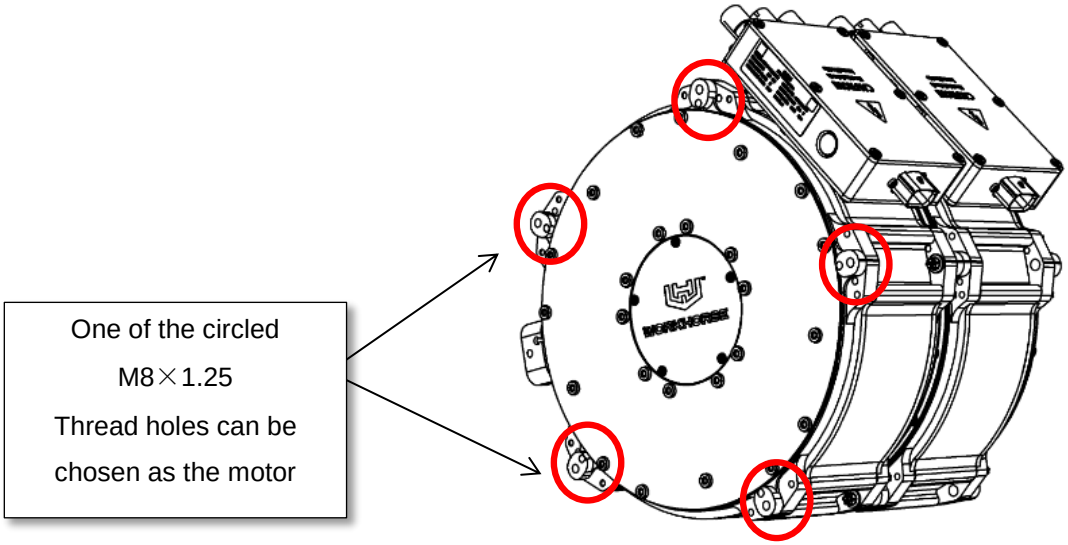


Figure 10: MGU Grounding

5.2 Inverter Grounding

The inverter housing has a location for connecting the case to ground. The inverter housing must be connected to the motor case. It must also be connected to the vehicle chassis and this assumes that the vehicle chassis is at the same potential as the 12V GND. The inverter housing should not be allowed to be more than a few volts above the 12V GND. If the inverter housing was disconnected hazardous voltages could develop on the housing.

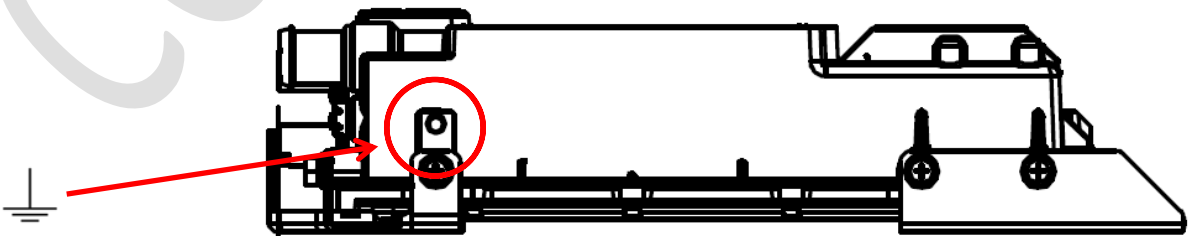


Figure 11: MCU Grounding

5.3 Gearbox Grounding

Use any one Gearbox mounting points M8 X 1.25

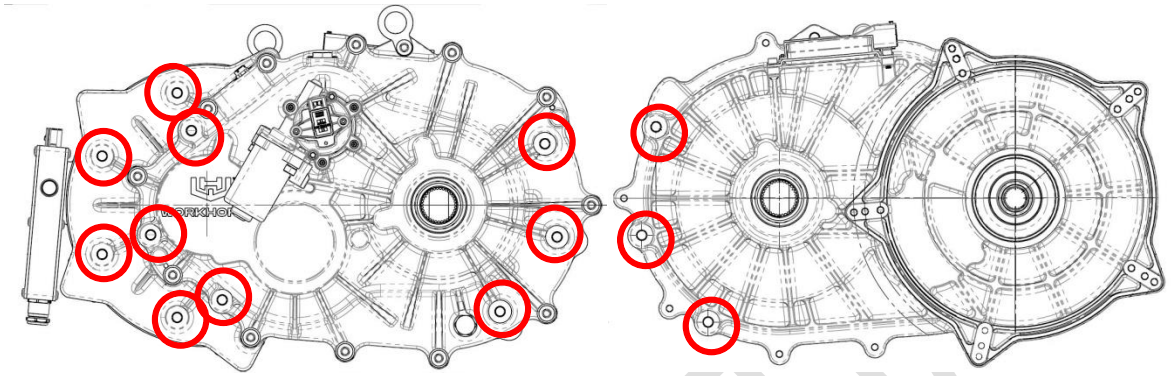


Figure 12: Gearbox Grounding

5.4 Grounding Strap

The Grounding Strap must be connected to its dedicated point on the MGU/MCU/Gearbox.

Specification	Unit	Value
Wire size	AWG	3

Table 2: Recommended Value

The system must be grounded to ensure user safety in case of an insulation fault in the MGU or MCU. An incorrect grounding connector may result in functionality losses and safety risk for the user.
When the grounding strap is connected, apply a layer of conductive grease before connecting the strap then test the resistance between the ground points and the MGU / MCU ground tab is less than 0.1 ohm.

Note: The user MUST ensure that the connection is made and that the interface is clean and free from corrosion or damage and remains so throughout the season. To prevent oxidation of the aluminum surfaces and any malfunction of the connector during operation, we recommend that you abrade the surface of the contact point and apply a layer of conductive grease on the grounding strap contact surfaces before connection.

6 E-Powertrain System Set up

6.1 E Powertrain Assembly

Mounting of the MAGELEC PWT is possible using both rigid and soft mounting systems as the PWT provides threaded hole connections for use during installation, however, the PWT can be sensitive to external loads and vibration therefore the following topics must be considered during system integration and installation:

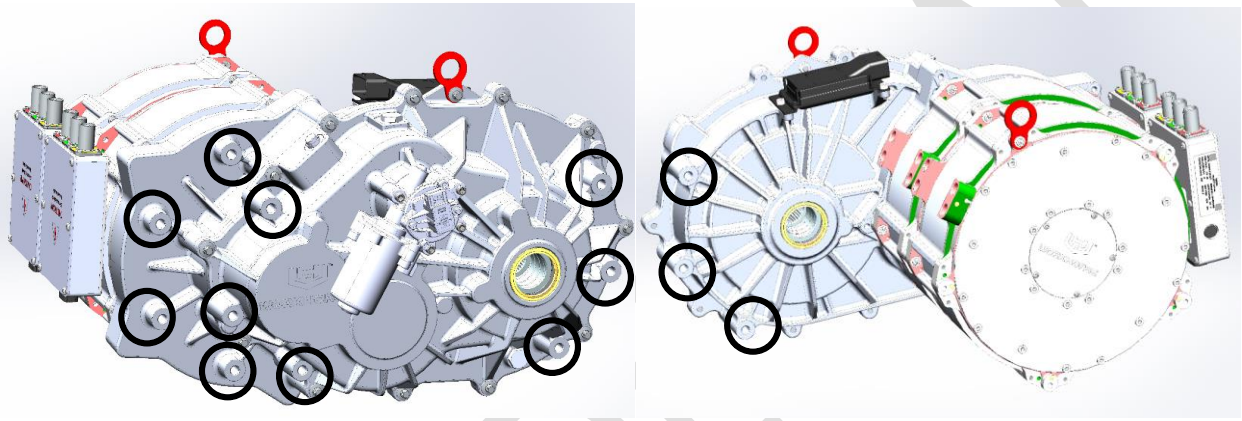


Figure 13: Position of thread holes on gearbox

— **Noise, Vibration and Harshness –** the MAGELEC PWT should be isolated from other components where possible to offset any NVH issues

— **External loading –** The MAGELEC PWT has NOT been designed to be used as a structural member within the system and must be isolated from any vehicle frame OR sub-frame using appropriate products, such as elastomer mounts. The PWT must not be used as a frame to mount any other components. The PWT has been designed such that the gearbox mounting faces are used as the primary interfaces for mounting, to react torque or transverse/longitudinal loads, as there are more available bolt holes and the connections are typically larger in size compared with the e-motor.

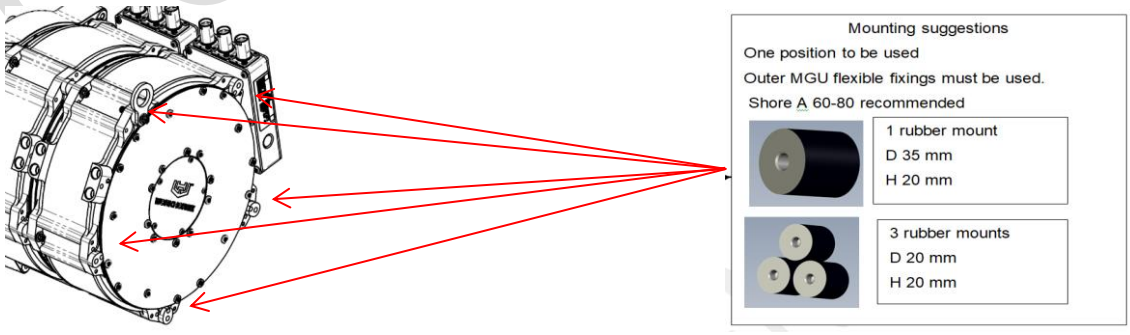


Figure 14: Position of thread holes on Motor

The recommended class and torque of tightening blots are as indicated in the table below:

Bolt size (mm)	Class	Tightening torque (Nm)
M8×1.25	10.9	26±10%
M10×1.5	10.9	52±10%

Table 3: Recommended Value.

Motor to Motor connection

- Firstly install snap ring (6) and O-rings (5) on connecting shaft.
- Apply grease ALTEMP Q NB 50 or similar products to the splines before installing any connecting shafts to reduce fretting corrosion which can lead to reduced lifetime and NVH issues later on.
- Insert connecting shaft to MGU 1 in the orientation as **Figure 15**
- Apply a light pulling load on the shaft by hand when the shaft is installed to make sure it does not come out to ensure snap ring has actually opened up.
- Ensure the O-rings (3) had been installed in the groove on the MGU Centring Tube to the requirements specified on the customer outline drawing.
- Fix the MGU Centring Tube in the orientation as **Figure 16**
- Attach MGU2 to MGU1
- Use M8 Torx flanged head bolt (tightening torque 26Nm ± 2.5Nm) to fix the motor to motor.

Related parts are as follows：

No.	Description	Qty.
1	Connecting shaft	1
2	O-Ring on shaft	2
3	Snap ring	1

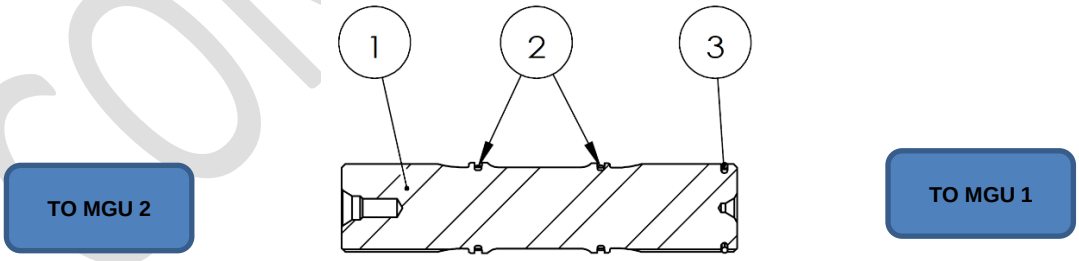


Figure 15: Connecting shaft installation with O-rings and Snap Ring

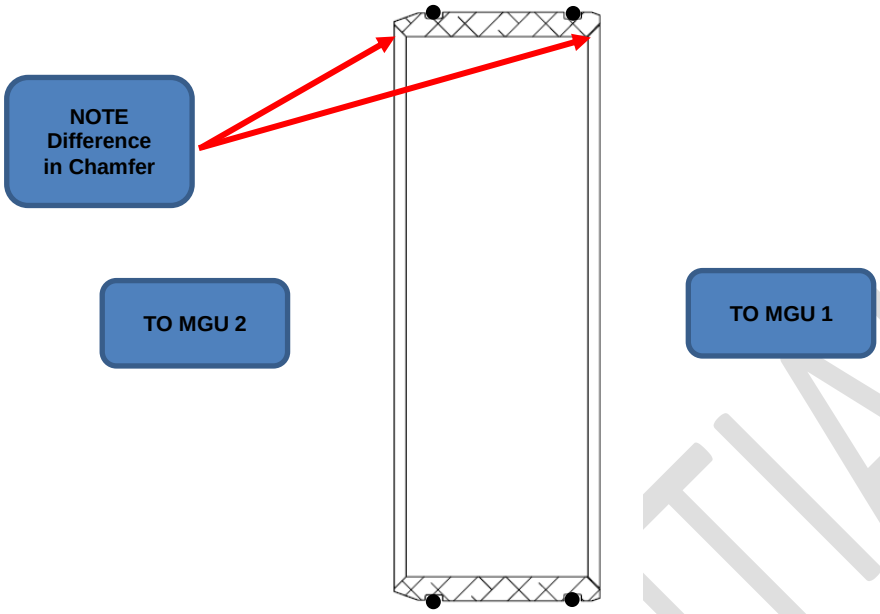
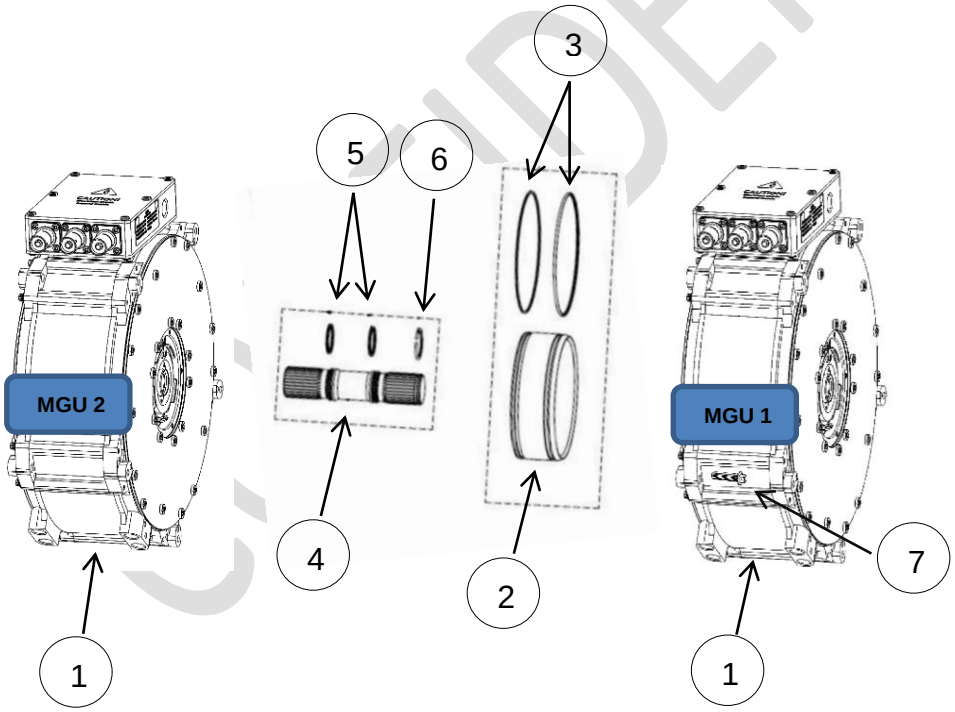


Figure 16 Connecting tube



Item No.	Description
1	Motor
2	MGU Centring Tube
3	O-Ring Ø 92×2
4	Connecting Shaft
5	2x O-Ring Ø 20.35X1.78
6	Snap Ring
7	Mounting Bolt

Figure 17: Exploded View, Motor to Motor Connection

Motors and Gearbox Connection

If gearboxes and motors have to be installed separately due to the limitation of assembly space and assembly method, please refer to the following steps to re-assembling the gearbox with the double motors as shown in figure **19**

- Firstly install snap ring (6) and O-rings (5) on connecting shaft.
- Apply grease ALTEMP Q NB 50 or equivalent products to the splines before installing any connecting shafts to reduce fretting corrosion which can lead to reduced lifetime and NVH issues later on.
- Insert connecting shaft to MGU 1 in the orientation Figure **18**
- Apply a light pulling load on the shaft by hand when the shaft is installed to make sure it does not come out to ensure snap ring has actually opened up.
- Ensure the O-rings (3) had been installed in the groove on the adapter of the gearbox to achieve the requirements specified on the customer outline drawing.
- Use M8 Torx flanged head bolt (tightening torque 26Nm ± 2.5Nm) to fix the motor to gearbox.
- The final configuration is shown in figure **20**

Related parts are as follows：

No.	Description	Qty.
1	Connecting shaft	1
2	O-Ring on shaft	2
3	Snap ring	1

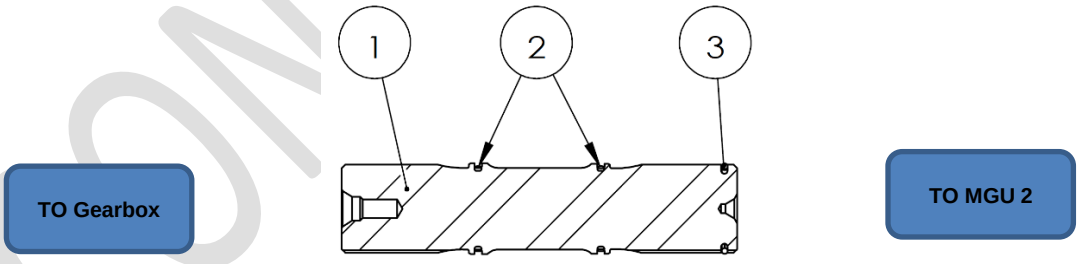
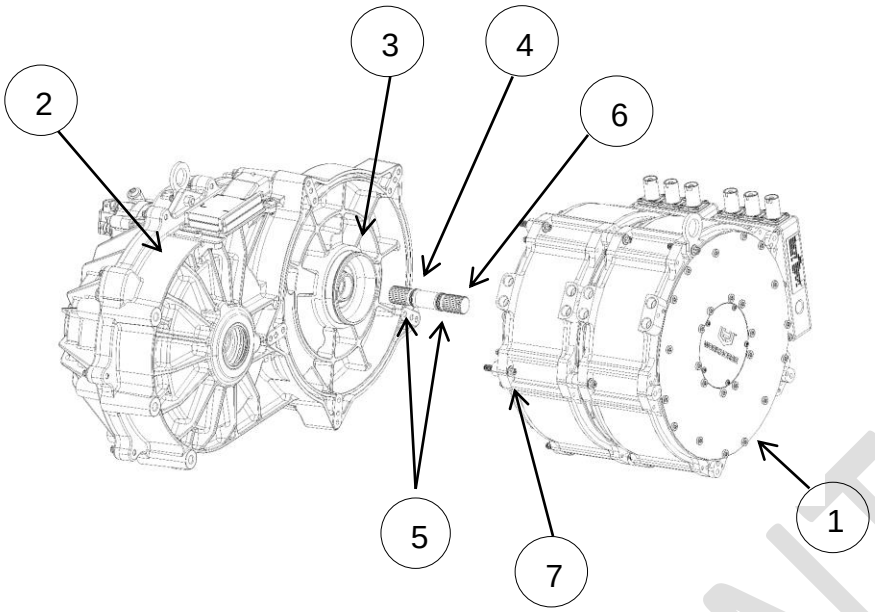


Figure 18: Connecting shaft installation with O-rings and Snap Ring



Item No.	Description
1	Double Motor
2	Gearbox
3	O-Ring Ø 92×2
4	Connecting Shaft
5	2x O-Ring Ø 20.35X1.78
6	Snap Ring
7	Mounting Bolt

Figure 19: Exploded View, Double Motors on gearbox installation

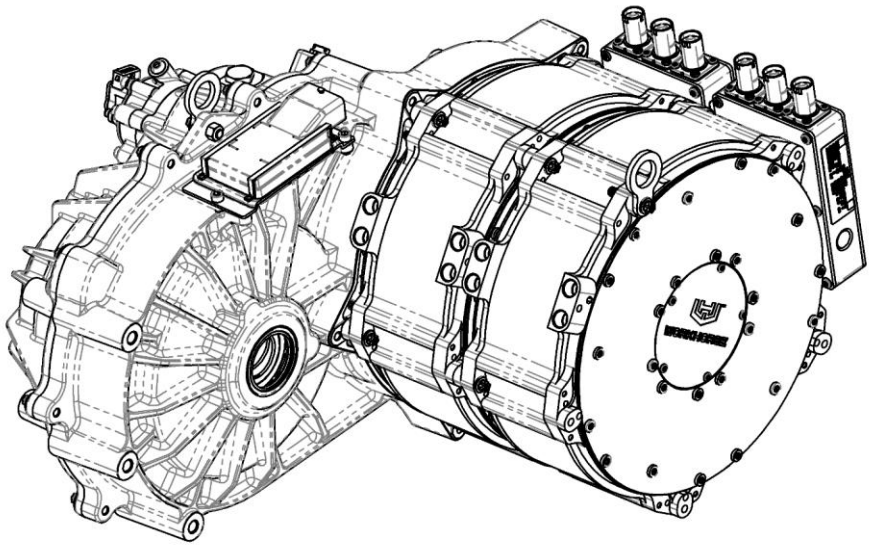


Figure 20: Motor installed on Gearbox

6.2 Low Voltage Connection

6.2.1 MCU

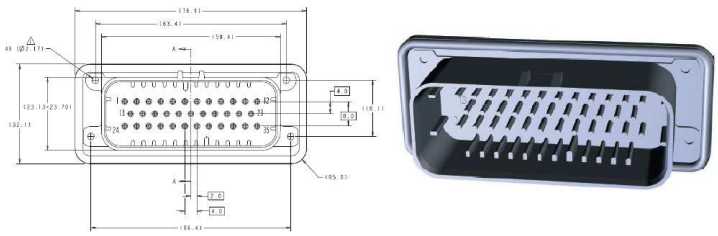
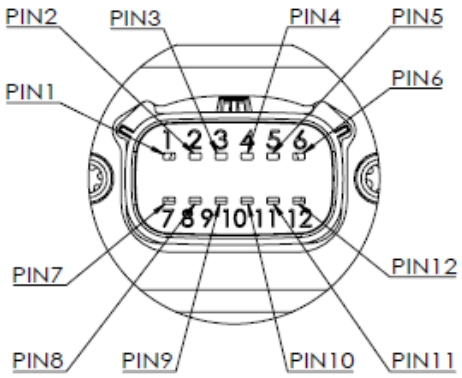
Control Port 35 PIN Signal Definition		
		
PIN	Signal Network Name	Signal Definition
1	+12V_BAT	12v Power +
2	+12V_BAT	12v Power +
3	CON_INTLOC_IN	Hazardous voltage interlock loop input
4	CON_KL15	Auxiliary power supply (key on) KEY
5	PE	Motor Resolver S2/S4 Signal Shield
6	PE	Motor Resolver R1/R2 Signal Shield
7	CON_CTP_MOT2_N	Motor temperature2_TEMP_L
8	CON_CTP_MOT2_P	Motor temperature2_TEMP_H
9	CON_CTP_MOT1_N	Motor temperature1_TEMP_L
10	CON_CTP_MOT1_P	Motor temperature1_TEMP_H
11	CON_EXCI_LO	Motor Resolver Excitation Signal R2
12	CON_EXCI_HI	Motor Resolver Excitation Signal R1
13	-	-
14	CON_INTLOC_OUT	Hazardous Voltage Interlock Loop_OUT
15	CON_INTLOC_MOT_OUT	Motor Hazardous Voltage Interlock Loop_OUT
16	CON_INTLOC_MOT_IN	Motor Hazardous Voltage Interlock Loop_IN
17	-	-
18	CON_CAN_INV_L	Inverter Calibration CAN Bus CAN_L
19	CON_CAN_INV_H	Inverter Calibration CAN Bus CAN_H
20	-	-
21	-	-
22	CON_RESSINLO	Motor Resolver Sin- Signal S4
23	CON_RESSINHI	Motor Resolver SIN+ Signal S2
24	M12V_BATT	12V Power -
25	M12V_BATT	12V Power -
26	CON_CHG_WK	Charging wake up signal
27	-	-
28	PE	Motor temperature signal shielded
29	-	-
30	PE	CAN Bus Signal Shield
31	CON_CAN_DRV_L	Vehicle CAN Bus CAN_L
32	CON_CAN_DRV_H	Vehicle CAN Bus CAN_H
33	PE	Motor Resolver S1/S2 Signal Shield
34	CON_RESCOSLO	Motor Resolver Cos- Signal S3
35	CON_RESCOSHI	Motor Resolver Cos+ Signal S1

Table 4: Control Port 35 PIN Signal Definition

6.2.2 MGU



PIN	PIN-OUT	Wire Color in Data Cable
1	T1-P (+) FRONT	RED
2	T1-N (-) FRONT	WHITE
3	T2-P (+) REAR	RED
4	T2-N (-) REAR	WHITE
5	R1 (EX-P)	RED
6	R2 (EX-N)	BLACK
7	S2 (SIN-P)	WHITE
8	S4 (SIN-N)	BLUE
9	S1 (COS-P)	YELLOW
10	S3 (COS-N)	GREEN
11	HVIL - IN	BLACK
12	HVIL - OUT	BLACK

Table 5: MGU Pin Data

6.2.3 LV Harness

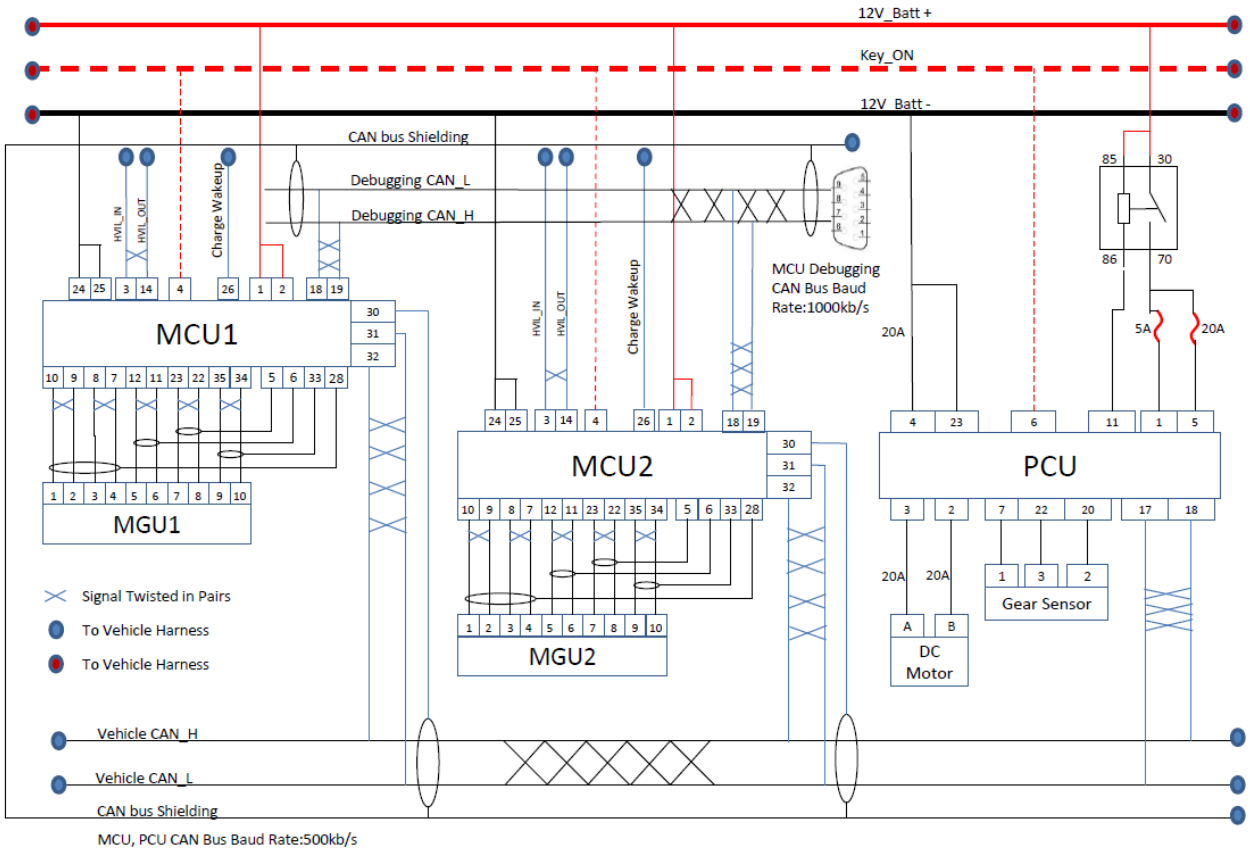
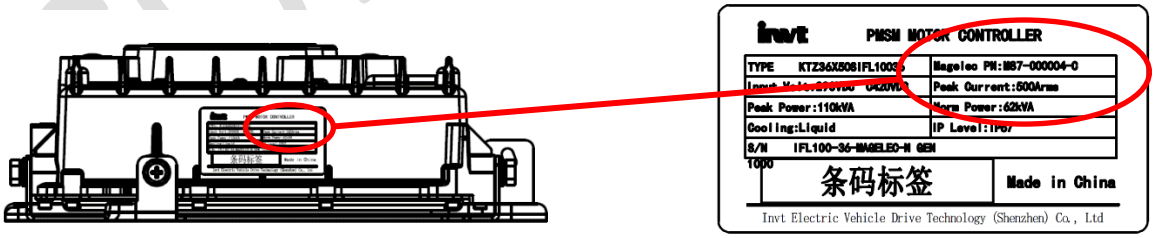


Table 6: Wiring Diagram

6.2.4 MAGELEC-N GEN 1000 Part Number



The MAGELEC part number M87-00004-C can be found on the IFL100-36-MAGELEC-N GEN 1000 this inverter ONLY should be used.

Figure 21: Part Number

6.3 High Voltage Connection

6.3.1 HVIL Controller and Motor Circuit Diagram.

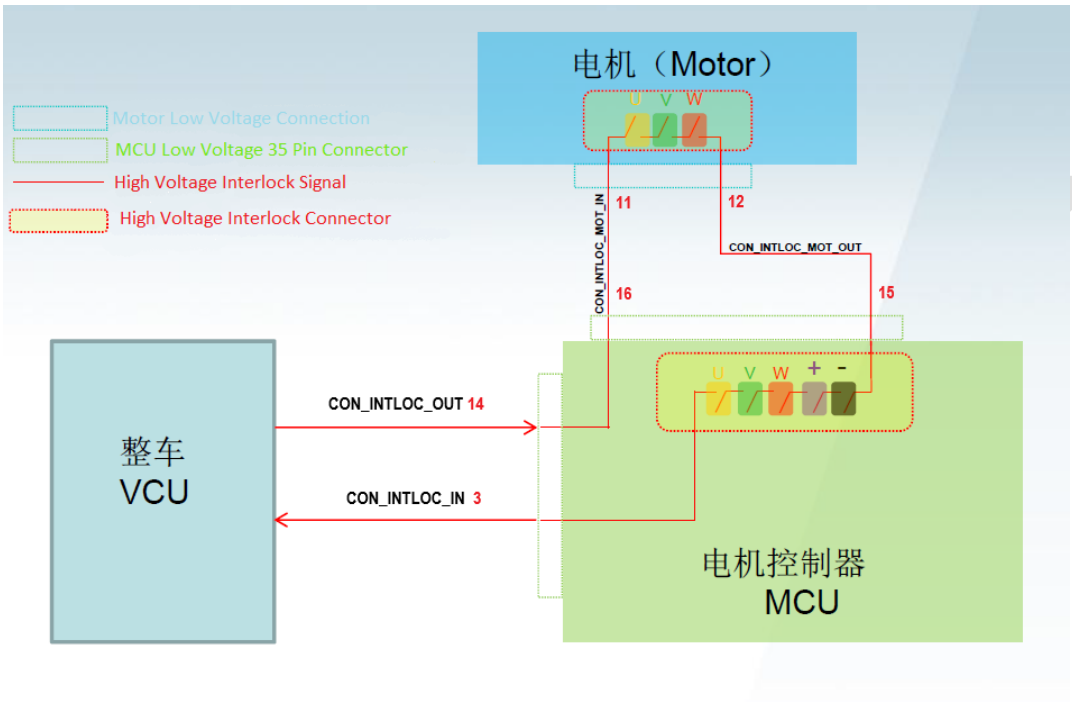
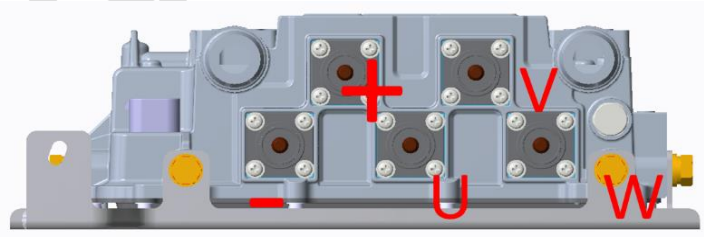


Figure 22: HVIL Circuit Diagram

6.3.2 MCU

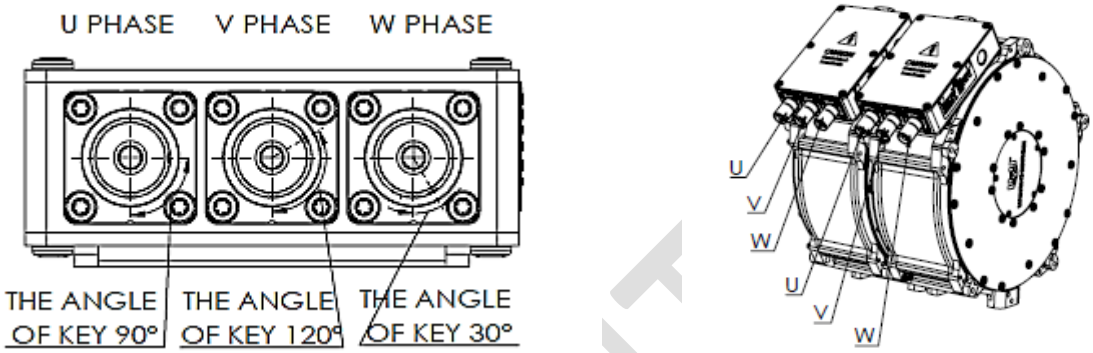


PIN	Network Name	Socket
-	HV Battery Input Negative	HVBI003R8AMH6BBK to match 50mm^2 cable
+	HV Battery Input Positive	HVBI003R8AMH6FPU to match 50mm^2 cable
U	Motor Output U Phase	HVBI003R8AMH6CYL to match 50mm^2 cable
V	Motor Output V Phase	HVBI003R8AMH6DGR to match 50mm^2 cable

W	Motor Output W Phase	HVBI003R8AMH6ARD to match 50mm^2 cable

Table 7: MCU HV Connection

6.3.3 MGU



CONNECTOR INFORMATION	
INTERFACE	**CONNECTOR TYPE**
U PHASE	**HVBI-0-03R8-AMH6C-YL**
V PHASE	**HVBI-0-03R8-AMH6D-GR**
W PHASE	**HVBI-0-03R8-AMH6A-RD**

Table 8: MGU HV Connector

7 Fault Code Reading Instruction

Please refer to Instruction Manual 00004584

8 Flash Firmware Instruction

Please refer to Instruction Manual 00004585

9 Gearbox

9.1 F06T Service Intervals

Workhorse F06T	Miles / km	Time
1st Service	3000***** 4800*	3 months*****
Service interval	25000***** 40000*	12 months*****
	***whichever comes first**	

Table 9: Service Intervals

9.2 Gear Oil

Gearbox	Full Synthetic	Quantity
Workhorse F06T	85W-140	3500 ml

Table 10: Recommended Values

Oil viscosity at 40 °C	410 mm²/s
Oil viscosity at 100 °C	29 mm²/s
Viscosity Index	97

Table11: Viscosity Index

9.3 Gearbox Drain and Fill

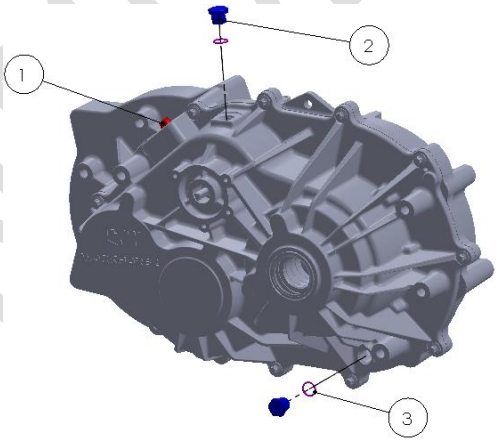


Figure 23: Gearbox Drain and Fill

Item No	Description	Thread Size	Tightening Torque (Nm)
1	Breather flange plug	M12X1.5X10	1Nm ±10%
2	Hex head magnetic plug	M18X1.5	10Nm ± 10%
3	O-ring	15.3X2.2	N/A

Table 12: Recommended Value

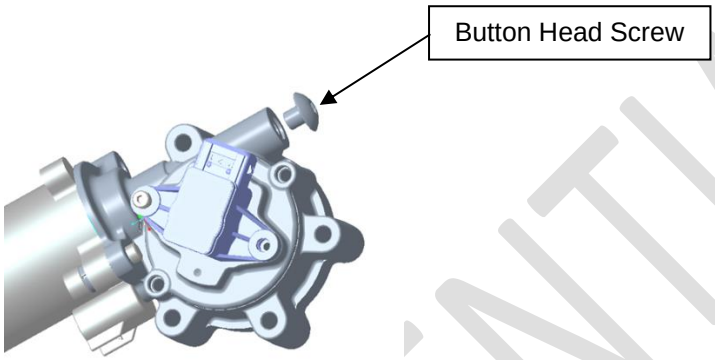
10 Parking Lock

1, Mechanical Parking lock manual release.

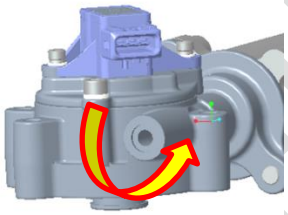
In the event that the vehicle had a loss of battery power and the vehicle requires towing, the parking lock will have to me manually removed.

Step 1

Use 5mm Allen wrench to release the button head screw M8*1 anticlockwise (release torque more than 10Nm)



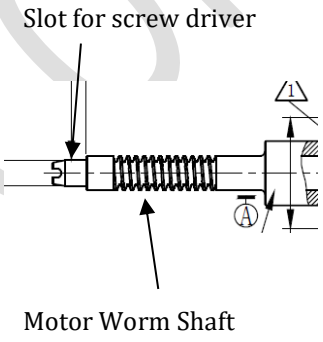
Step 2



Use flat head screw driver (width <8mm) match with the slot on the motor worm shaft.

Rotate motor worm shaft anti clockwise until stop (about 19 circles) than rotate clockwise one circle, the manual unlock finished.

After the manual unlock, mount and tighten the button head screw M8*1 use 5mm Allen wrench.



2, Parking lock communication protocols:

Please refer to Parking Lock System User Manual 00003307

11 Cooling System Connection

11.1 11.1 MGU Liquid Cooling Connection

Motor units must be cooled by passing liquid through each cooling channels during and after operating. Each motor unit has two cooling channels, which are located at motor front and rear side respectively in axial direction. Each front and rear cooling channel has two cooling ports. The cooling channel was design to distribute uniformly on the cooling plate, and is less sensitive to fluid direction, and the position of cooling port does not affect the cooling performance.

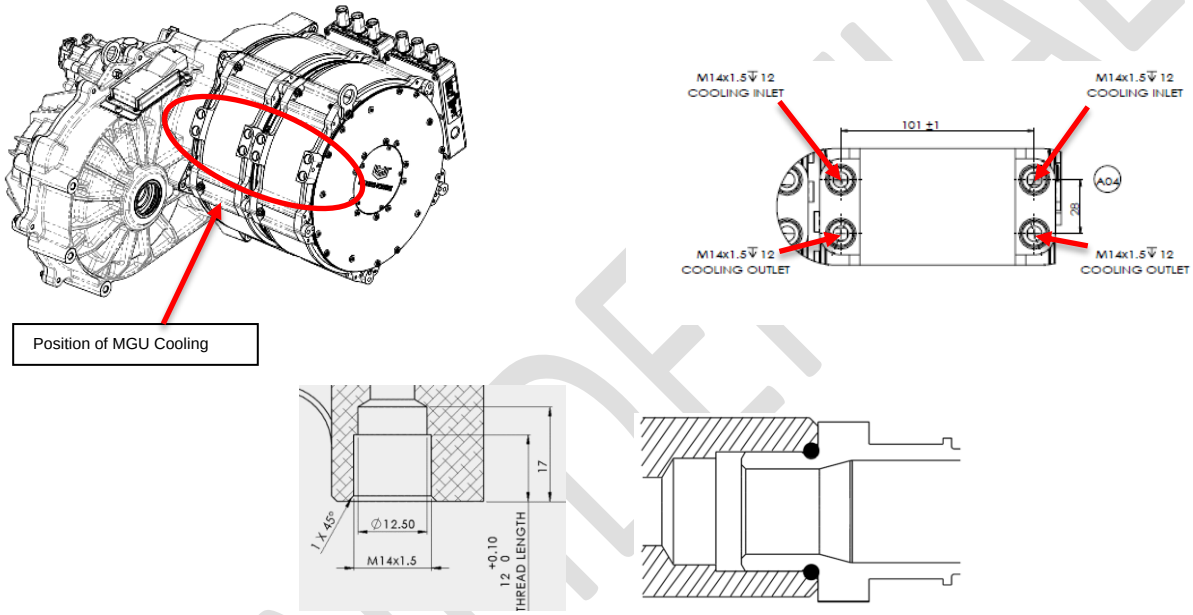


Figure 24: M14 cooling port fitting with 1x45° chamfer and 12.42x1.78mm ISO 3601-1 O-ring

The cooling requirement for motor unit shows on the table as below:

Coolant type	50/50 Water-Glycol with Aluminium corrosion inhibitor additive
Motor coolant temperature range	5~55°C full performance, 55~80°C, continuous performance de-rating
Coolant flow rate (per single motor)	10 LPM
Coolant pressure drop	0.4bar @55°C coolant, 8LPM (per single motor)
Cooling port size	M14x1.5 threaded holes with 1x45° chamfer to accept pipe fittings with O-ring seals. See figure 18.

Table 13: Cooling Requirement for Motor

11.2 MCU Liquid Cooling Connection

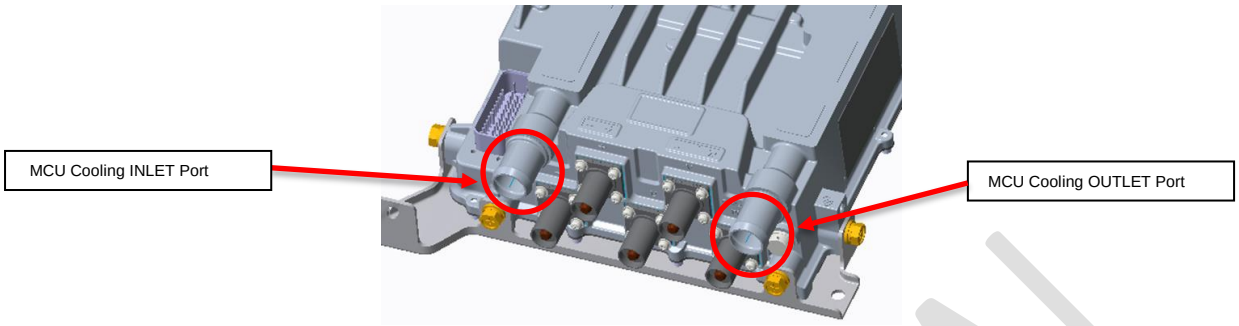


Figure 25: MCU Cooling Ports

Coolant type	50/50 Water-Glycol with Aluminium corrosion inhibitor additive
Inverter coolant temperature range	-40~65°C
Coolant flow rate (per unit)	8~12 LPM
Cooling port size	ø25±0.2mm

Table 14: MCU Cooling Ports

12 Power train handling.

- On receiving the product, Verify that the crate is undamaged.
- On opening the crate, perform a physical check of the contents:

  Inspect for damage to the packing materials.

  Verify that the product has remained in place in the crate during Shipping.

  Remove all packing material before carrying out a full visual inspection to ensure that is entirely to your satisfaction.

1) Remove the box cover and you should find on top the HV cable

2) Removing HV cable you find the package material

3) The protection material is divided in 2 portion and fitted between the box and the Powertrain. Remove without damage the Powertrain component (attention to the ECU)

4) To lift the Powertrain use the 2 hock located on top of the gearbox (near the ECU) and on the external part of the E-Motors (close to the HV box)

5) During the lift must avoid to damage the HV box & the ECU

6) IF possible better to use this arrangement on the lift

Note: If the packaging and/or the product are damaged, take photographs of the damage, save all the packaging materials and immediately notify the carrier as well as MAGELEC.