192-300302N3
30.03.2021

GVI Frame G & H

Global Vehicle Inverter – High Voltage

Hardware Installation Manual

ENGINEERING YOUR SUCCESS.

Non-warranty clause

The contents of this manual have been verified against the associated hardware and software. Although every effort has been taken to ensure the accuracy of this document it may be necessary, without notice, to make amendments or correct omissions. Parker Hannifin Manufacturing cannot accept responsibility for damage, injury, or expenses resulting therefrom

Production site:

Germany

Parker Hannifin Manufacturing Germany GmbH & Co. KG
Electromechanical & Pneumatic Division [EMPD]
Robert-Bosch-Strasse 22
77656 Offenburg (Germany)
Tel.: + 49 (0781) 509-0
Fax: + 49 (0781) 509-98176
Internet: **www.parker.com/eme http://www.parker.com/eme**
E-mail: **EM-Motion@parker.com**

Certified according to ISO 9001:2015

Parker Hannifin Manufacturing Germany GmbH & Co KG - Sitz: Bielefeld - Amtsgericht: Bielefeld HRA 15699
Partner liable to unlimited extent: Parker Hannifin GmbH, Sitz Bielefeld, Amtsgericht Bielefeld HRB 35489
Geschäftsführung der PARKER Hannifin GmbH: Dr.-Ing. Hans-Jürgen Haas, Kees Veraart, Chairman of the board: Dr.-Ing. Gerd Scheffel

Table of Contents

1 Introduction

1.1 About this document

1.1.1 Definitions

This product manual contains technical description, installation, safety and commissioning instructions and other relevant information for the GVI inverter frames G & H.

The terms GVI and inverter are used interchangeably.

1.1.2 Terms and abbreviations

Application	**A customer specific use of GVI hardware and software**
Application software	Customer-specific configuration of GVI parameters
CAN	Controller Area Network
EMC	Electromagnetic compatibility
EMF	Electromotive force
ESD	Electrostatic discharge
HV	High voltage
HVIL	Hazard Voltage Interlock Loop
HVL	High Voltage Level
HW	Hardware
I2t	Overload protection based on a thermal model
Integration	Software integration means to activate all necessary functions to control the hardware design for a customer-specific application Hardware integration is the physical installation of the GVI in a customer's equipment
MCU	Motor control unit
MTO	Motor Torque Off
OEM	Original equipment manufacturer
OVP	Overvoltage Protection
RMA	Return of Material Authorization
SSC	Safe Short Circuit
SW	Software
WEG	Water Ethylene Glycol mixture

1.1.3 This revision

This revision replaces all previous revisions of this document. Parker has made every effort to ensure that this document is complete and accurate at the time of printing. In accordance with our policy of continuous product improvement, all data in this document is subject to change or correction without prior notice.

1.1.4 Scope

This product manual presents instructions, guidelines and other information relevant to integration and installation of the GVI frames G & H.

1.1.5 Document structure

This document is structured with two main target groups in mind:

Chapter 10 is intended for installation and maintenance personnel. It contains step-by-step instructions for installation and maintenance of the inverter using Parker's recommendations. These instructions must be complemented and revised for use in equipment-specific manuals.

The other chapters in this document are mainly intended for designers, and contain Parker's general recommendations and guidelines for integration of the GVI frames G & H.

1.1.6 Warning, caution and information notices

Special attention must be paid to the information presented in warning, caution and information notices when they appear in this manual. Definitions of caution, warning and information notices are shown below:

WARNING

This section describes the risk of the hazard, for example High voltage - risk of personnel injury

A Warning informs the user of a hazard or potential hazard that could result in serious or fatal injury and damage to the equipment if the precautions or instructions given in the warning notice are not observed/followed.

CAUTION

This section describes the risk of the hazard, for example Risk of damage to equipment

A Caution informs the user of a hazard or potential hazard that could result in damage to the equipment if the precautions or instructions given in the caution notice are not observed/followed.

NOTE

A note contains supplemental information or references to supplemental information on a topic.

1.1.7 Personal safety Warning, caution and information notices

For more information about the inverter, see the following related documents.

Reference number	Document	Description
1	GVI Object Dictionary	The CAN object dictionary is product/firmware dependent. The object dictionary for each GVI is available from Parker as an HTML file
2	GVI CAN Message Database	Describes the implemented communication objects: CANopen messages, default CANopen PDO messages and J1939 messages
3	GVI Configuration manual	General procedure for the configuration, start-up and verification of a GVI following installation.
4	Application Note: Integration of GVI with IQAN	

2 Personal safety

Parker provides this and other manuals to assist manufacturers in using the GVI frames G & H in a proper, efficient and safe manner. Installation, operation and maintenance of the equipment should be carried out by competent personnel. A competent person is someone who is technically qualified and familiar with all safety information and established safety practices; with the installation process, operation and maintenance of this equipment; and with all the hazards involved.

WARNING

High voltage/high power - risk of personnel injury

The high voltage/high power levels available from a GVI inverter can cause severe or fatal injury.

Before installation, always verify that the GVI inverter model is correct for the vehicle's battery supply voltage.

2.1 Safety signs on the equipment

Table 1Table 1 Safety signs used on Parker GVI equipment

shows the signs used on Parker's products. Use of the signs varies between products.

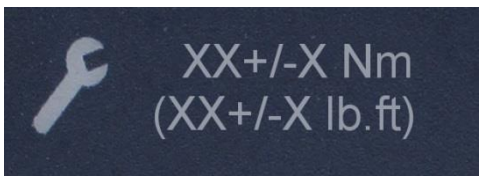
Safety sign	Description
	Take care to avoid coming in to contact with electricity.
	Read the product manual before starting any maintenance work on the equipment.
	Persons with active implanted cardiac devices shall not be in the vicinity of the equipment due to the strong electromagnetic field it generates.
	Tighten the power connection screws to the specified tightening torque (example shown).

Table 1 Safety signs used on Parker GVI equipment

3 Original Equipment manufacturer responsibility

The Parker inverter products are intended for controlling motors in electric powered mobile machines. These inverters are supplied to original equipment manufacturers (OEMs) for incorporation into their machines and machine control systems.

The OEM, through its own analysis and testing, is solely responsible for making the final selection of the system and components and assuring that all performance, endurance, maintenance, safety and warning requirements of the application are met. The OEM must analyze all aspects of the application, follow applicable standards and regulations, and follow the information concerning the product in the current product catalogue and in any other materials provided from Parker Hannifin Corporation or its subsidiaries or authorized distributors. OEMs are responsible for ensuring that the GVI inverter is used for its intended purpose only and that their equipment functions in a safe way at all times.

To the extent that Parker Hannifin Corporation or its subsidiaries or authorized distributors provide component or system options based upon data or specifications provided by the OEM, the OEM is responsible for determining that such data and specifications are suitable and sufficient for all applications and reasonably foreseeable uses of the components or systems. The above disclaimer is being specifically brought to the user's attention and is in addition to and not in substitution to the Exclusions and Limitations on Liability which are set out in the terms and conditions of sale.

4 Technical support

Parker supports original equipment manufacturers (OEM's) with additional information on any topic covered in this document, or for additional information about other Parker products. End customers and third parties are requested to refer to the OEM for support.

Addresses for Parker locations may be found on the back page.

5 Warranty

5.1 Warranty claims

Failure analysis and testing of the GVI is available for the OEM at Parker. The addresses may be found on the back page.

Parker does not provide any warranty or service directly to GVI end users. End users are asked to refer to the original equipment manufacturer for warranty issues, service and spare part needs.

5.1.1 Return of material authorization

Contact Parker before a product is returned in order to ensure an efficient handling of the product with a high level of traceability. Parker provides a return of authorization (RMA) number for returns and a form (RMA request), which describes how to proceed.

5.2 Product warranty

The general terms and conditions of sale of goods and/or services of Parker Hannifin Europe Sàrl, Luxembourg, Switzerland Branch, Etoy, apply to this contract unless otherwise agreed. The terms and conditions are available on our website: www.parker.com/termsandconditons/switzerland

6 Product overview

In a typical application, the GVI inverter converts power from a DC power source (a battery in a vehicle for example) to three phase AC power to drive a motor.

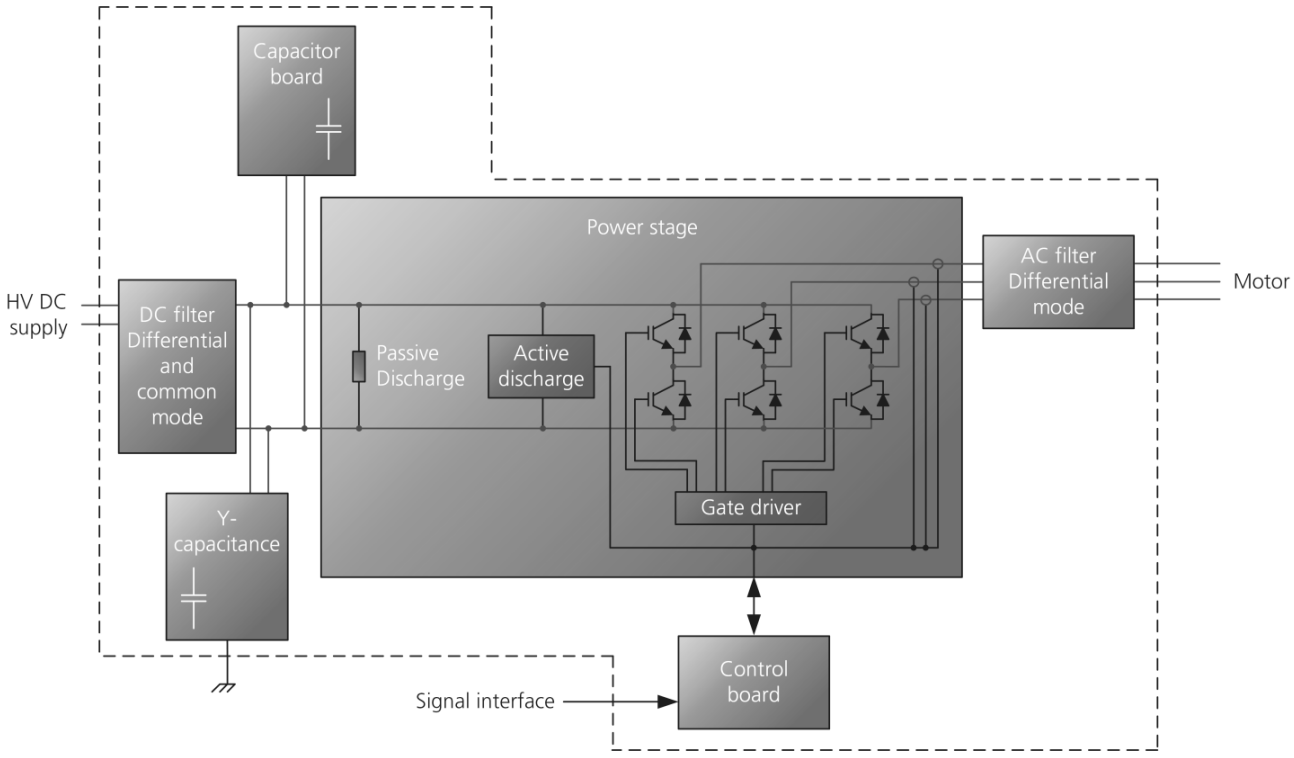


Figure 1: GVI frames G & H circuit diagram

6.1 Product Versions

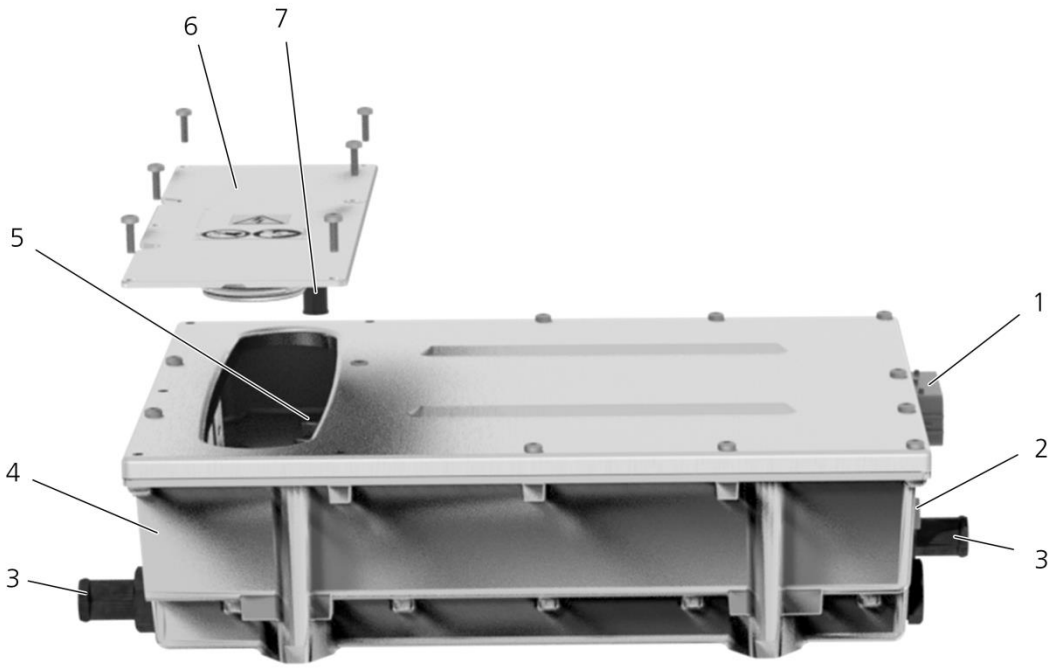
The high voltage GVI product range consists of two mechanical sizes (G and H) each with its own current and power output rating characteristics.

Order Code										
		1		2,3		4,5,6		7,8		9
Order Example		**GVI**	-	**G650**	-	**0300S1**	-	**R00**	-	**G0000**
1	**Product Familiy**									
	GVI	Global Vehicle Inverter								
2	**Frame Size**									
	G	Frame Size G								
	H	Frame Size H								
3	**Nominal DC Supply**									
	650	650V DC								
4	**Current Rating**									
	0300	300A Frame G								
	0500	500A Frame H								
5	**Package**									
	S	Single								
6	**Series**									
	1	Series 1								
7	**Feedback Type**									
	R	Resolver								
8	**Reserved**									
	00									
9	**Special Option**									
	G0000	Global Specification								
	E0000	European Specification								
	N0000	North American Specification								

Order Code	**Description**
GVI-GH-ADAPTORKIT	Power Connection Gland Plate Adaptor Kit

Table 2: GVI Product Coding

6.2 Main Components



Pos	Name	Pos	Name
1	I/O connection	2	Moisture vent
3	Coolant connection x 2	4	Heat sink
5	Terminal x 5	6	Service lid
7	HVIL magnet		

Figure 2: Main components on the GVI

Communication with the GVI is transmitted through the I/O connection (1).

The moisture vent (2) equalizes pressure inside the GVI with the external pressure and reduces condensation in the GVI.

The GVI is cooled by heat transfer from the aluminum heat sink (4) to the surroundings, and by cooling water in an internal cooling channel. Hoses for cooling water are connected to a coolant connection (3) in each end of the GVI.

The heat sink (4) also protects the components inside the GVI from electrical, chemical and mechanical damage, and encapsulates dangerous live voltage parts.

For maintenance purposes, removal of the service lid (6) gives access to the high voltage DC connection and motor connection terminals (5) while other internal parts are still covered. The service lid (6) is mounted with screws.

The hazardous voltage interlock (HVIL) circuit (see chapter **7.7.2**) protects operators from coming in to contact with live voltage parts during maintenance. The HVIL magnet (7) is one of three HVIL magnets in the GVI.

6.3 Product Identification Label

A label containing pertinent product identification information is attached to the GVI cover. The product label fields relevant to product identification are described in Figure 3 and Table 3.

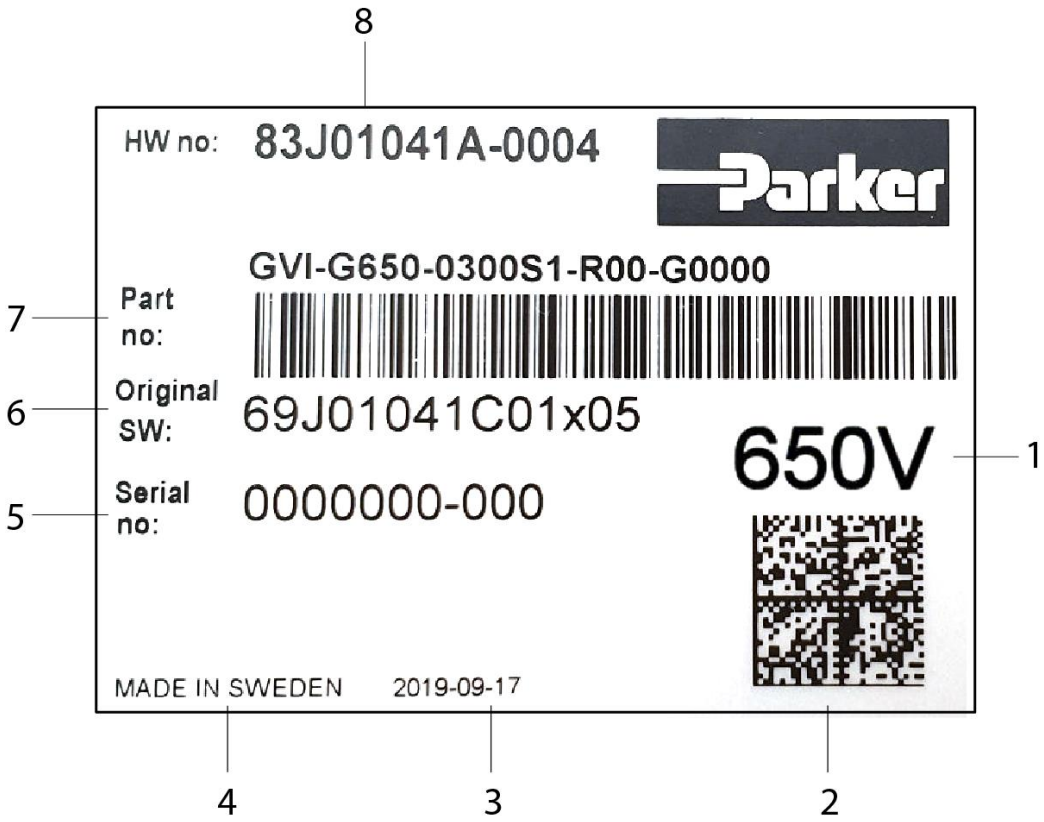


Figure 3: Example of product identification label

Pos	Description
1	Nominal voltage
2	2D bar code containing the GVI part number and serial number
3	Date of manufacture
4	Country of manufacture
5	GVI serial number
6	GVI software number as shipped
7	GVI product code / order code (see Table 2)
8	Hardware identification number as shipped

Table 3: Description of product identification label

7 Integration guidelines

7.1 Introduction

This chapter describes guidelines for integration of the inverter. Integration is the installation of the inverter in a vehicle or machine.

The information is general in nature. Instructions for mounting of the inverter in a vehicle or machine are found in chapter 10.

7.2 CAN communication

Two CAN-buses are provided on GVI Frames G and H.

CAN_Open defaults to CANopen and is used for diagnostics, parameterization and SW downloading. CAN_Open may also be used for vehicle/machine communication as required. An external 120Ω termination resistor may be required in the harness, dependent on the position of the drive in the CAN network.

CAN_J1939 defaults to J1939 protocol and can only be used for vehicle/machine communication. CAN_J1939 is provided with internal 120Ω termination resistors which may be enabled using links in the connection cable/plug.

7.3 List of diagnostic information

Refer to the GVI Object Dictionary HTML file for details.

7.4 Monitoring

In this chapter some standard monitoring features of the inverter are described. The behavior of some monitoring features may be modified to fit a specific application. This manual describes the standard implementation of the features and settings. Refer to the OEM vehicle manual for information specific to a certain application.

7.4.1 Temperature monitoring

The GVI inverter continuously monitors the power stage and the motor temperature to prevent the inverter and the motor from being damaged by overheating. An application should be designed such that the inverter and motor stays within the normal operating temperature for normal operation of the vehicle. An elevated temperature often indicates a fault in the system, for example that the coolant pump has stopped working properly, or that the ambient temperature is too high.

To protect the power stage in the inverter and the electrical motor from damage, torque-producing current is reduced at temperatures outside the normal operating temperature range. At 90 °C power stage temperature, the torque-producing current is fully reduced.

CAUTION

Overheating - risk of damage to equipment

The speed of the electrical motor to which the GVI is connected must be limited in high temperature situations when field weakening is activated.

If this cannot be done by the inverter, it must be done on system level.

7.4.2 Motor current monitoring

The AC motor current is monitored by software and hardware. If the software or the hardware measures excessive AC current, the motor PWM output is shut down.

7.4.3 Voltage monitoring

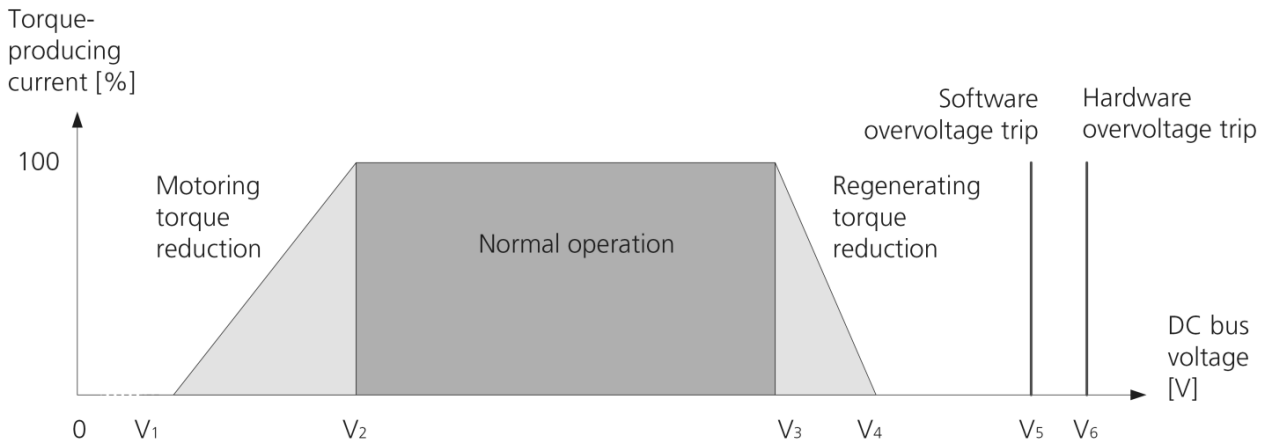


Figure 4 Voltage monitoring (voltages V_1 – V_5 are application-specific)

The GVI monitors the DC bus voltage and initiates a response if the voltage is outside normal operating limits. The GVI response is either a software voltage trip (chapter 7.4.3.1) or a hardware overvoltage trip (chapter 7.4.3.2), depending on whether the DC bus voltage is below or above the normal operating limits, the level of overvoltage and motor type. This is illustrated in 4.

Refer to chapter 12.6 for available voltage monitoring values (V_1-V_6 in Figure 4).

7.4.3.1 Software voltage limits

Two types of software voltage limit are available:

7.4.3.1.1 Software Torque reduction

The inverter can be configured to limit its torque-producing current in two ways if the DC bus voltage is outside the normal operating range:

- **Motoring torque reduction**
  The motoring torque is reduced If the DC bus voltage is too low
  (between V_1-V_2 in Figure 4)
- **Regenerating torque reduction**
  The regenerating torque is reduced If the DC bus voltage is too high
  (between V_3-V_4 in Figure 4)

The upper (V_4) and lower (V_1) limit values of the DC bus voltage are parameters that can be adjusted to suit the application. Refer to the supplied Object Dictionary HTML file for details

7.4.3.1.2 Software overvoltage trip

The software overvoltage trip level V_5 is adjustable based on application requirements. The response to a software overvoltage trip can be configured. Refer to the supplied Object Dictionary HTML file for details.

7.4.3.2 Hardware overvoltage trip

Hardware overvoltage trip (V_6 in Figure 4) is a hardware overvoltage protection for the vehicle and the GVI. This is fixed at 880VDC.

The GVI is designed to work with high-speed permanent magnet motors in field weakening.

If, for any reason, current control is not properly maintained when a motor is above base speed, the GVI is disabled. Reasons for not being able to control the motor in field weakening include:

- The low voltage supply to the inverter is removed. This could be caused by many reasons, for example if Unit_Enable is disabled, main power supply switch is off or in case of a blown fuse
- Software-detected issues

With hardware overvoltage protection, the GVI AC power stage is disabled (IGBTs are opened) when an overvoltage condition is detected. This feature is implemented in the hardware to assure that protection always functions independently of the software.

CAUTION

Permanent magnet - risk of damage to equipment

Rotating an electrical permanent magnet (PM) motor while the GVI is disabled can result in damage or overheating of the electrical machine, inverter and/or cabling.

Never rotate the electrical PM motor when the GVI is disabled and the WEG cooling is not in operation.

Mechanically disconnect the PM motor or disconnect it with a gearbox by using a neutral gear before disabling the GVI.

7.5 DC bus discharge

WARNING

High voltage capacitors - risk of personnel injury and/or damage to equipment

The DC bus cannot be discharged unless external power sources have been deactivated. For example, the main power supply must be disconnected and if a permanent magnetized electrical motor is connected to the inverter, the electrical motor must be brought to an immediate stop or disconnected from the GVI with a three phase breaker.

The DC bus discharge circuit discharges the internal capacitor bank on the DC bus from nominal voltage to a safe level (< 60 V) within five seconds. Chapter 9.1.1 describes when DC bus discharge is activated.

When active, the discharge current is limited to 1 A.

The DC bus discharge function is turned off during normal operation to reduce power loss in the GVI. The discharge circuit is supplied from the HV DC Bus. This assures that the discharge always functions independently of software, CPU logic and low voltage supply.

WARNING

High voltage capacitors - risk of personnel injury and/or damage to equipment

Always verify that the DC Bus is at a safe level (< 60 V) before removing the DC-voltage service lid.

7.6 EMC protection

The inverter has been EMC tested and meets requirements according to UN ECE Regulation No. 10.

The inverter has a DC EMC filter, see chapter 9.5.

The high voltage connections (4, 6, 7, 8 and 9, 11) must fulfil the requirements in chapters 7.6.1 and 7.6.2 for the inverter to be fully EMC protected.

7.6.1 Shielding of cables

CAUTION

Electrical disturbances – risk of malfunctioning equipment

Make sure to connect the GVI as described in this chapter and to follow the installation instructions in chapter 10.5.4.

Contact Parker for assistance if necessary.

In general, use cables with a low impedance shield. Motor power connection cables and HV DC supply connection cables must be shielded.

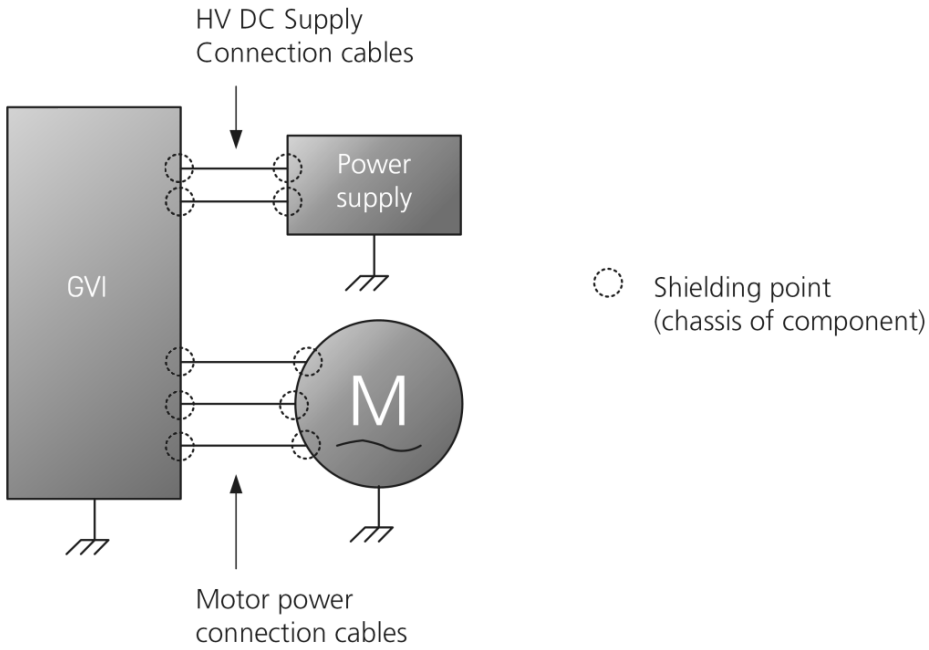


Figure 5 GVI cable shielding concept

Connect the shields of motor power connection cables HV DC supply connection cables as below. The concept is illustrated in 5.

- On the GVI side, connect all the cable shields to the GVI chassis
- On the DC side, connect the HV DC supply connection cable shields to the power supply chassis
- On the motor side, connect the motor power connection cable shields to the motor chassis

Proper cable glands provide the necessary connection between cable shields and the chassis of components (see chapter 7.6.2).

7.6.1.1 Recommended maximum resistance for shielding points

The shielding points are shown in figure 7:

Cable	Recommended maximum resistance
Motor power connection cables	$R_{Shielding\ point}$ < 20 mΩ (each shield)
HV DC supply connection cables	

Table 4: Recommended maximum resistance for shielding points

7.6.2 Cable glands

- Parker recommends cable glands with shield clips to provide the proper connection between cable shield and component chassis as described in chapter 7.6.1). Chapter 10.5.4 describes how to connect motor power connection cables and HV DC supply connection cables with this type of cable gland. The GVI-GH-Adaptorkit (sold separately) includes glands of the correct specification.
- The cable glands shall have the correct protection class (see chapter 12.8.1)

7.7 Electrical safety

The inverter is designed with creepage and clearance distances according to IEC60664-1:1992. The inverter design incorporates ingress protection and insulation sufficient to isolate high voltage circuits from direct contact, from the vehicle chassis and from the low voltage conductors. All serviceable lids and connectors that expose live parts are supervised by HVIL (chapter **7.7.2**).

The inverter is designed to not interfere with an external isolation fault monitor.

NOTE

It is the OEM's responsibility to provide a function that measures the isolation periodically when the DC bus is powered.

7.7.1 High Voltage system design assumptions

The design of the GVI is based on a set of system design assumptions regarding implementation of high voltage safety on a vehicle/machinery level. The purpose is to make the GVI fulfill the protection requirements according to ISO6469-3:2018 and applicable parts of UN ECE R100.

The following assumptions form a base for the GVI high voltage design:

- The high voltage supply to the GVI must be floating with respect to vehicle chassis.
- The chassis of the GVI must be grounded to the chassis of the vehicle.
- The vehicle chassis and logic supply ground (that is 12/24 V DC negative supply) must be connected to each other in at least one point in the vehicle.
- An isolation check must be implemented in the system to continuously verify the system isolation between the high and low voltage circuits.
- The system must be designed to disconnect or disable the high voltage supply within 0.5 seconds after an isolation fault has been detected.

7.7.1.1 Protection of personnel against electric shock

WARNING

Failure to apply the high voltage system design assumptions - risk of personnel injury and/or damage to equipment

The GVI only fulfills the safety requirements in ISO6469-3:2018 if the design assumptions are applied according to chapter 7.7.1

7.7.2 Hazardous Voltage Interlock, HVIL

The hazardous voltage interlock (HVIL) is a separate circuit that supervises all access points in the vehicle where high voltage live parts can be exposed and be potentially dangerous for an operator. The GVI requires a 15mA DC current source (figure 6) to be supplied by the main power supply in the vehicle.

HVIL may be configured within the application software such that HVIL events are enabled or disabled:

- **Disabled HVIL Events:** The HVIL circuit continues to be monitored, however the GVI will NOT take any action should the circuit be broken. The GVI will report an open circuit HVIL through CAN messages (refer to GVI Configuration manual for details), however no indication will be given that the service lid has been opened. The HVIL controller must monitor the loop and disconnect the battery if the loop is broken. This mode allows the use of HVIL methods other than a DC current source. If no HVIL loop is present the HVIL events should be disabled.
- **Enabled HVIL Events:** The HVIL circuit within the GVI will expect to see a current source connected. Should this source be removed, or if the lid of the GVI be opened, the GVI will report an open circuit HVIL through CAN messages AND will disable the output power stage.

7.7.2.1 HVIL working principle

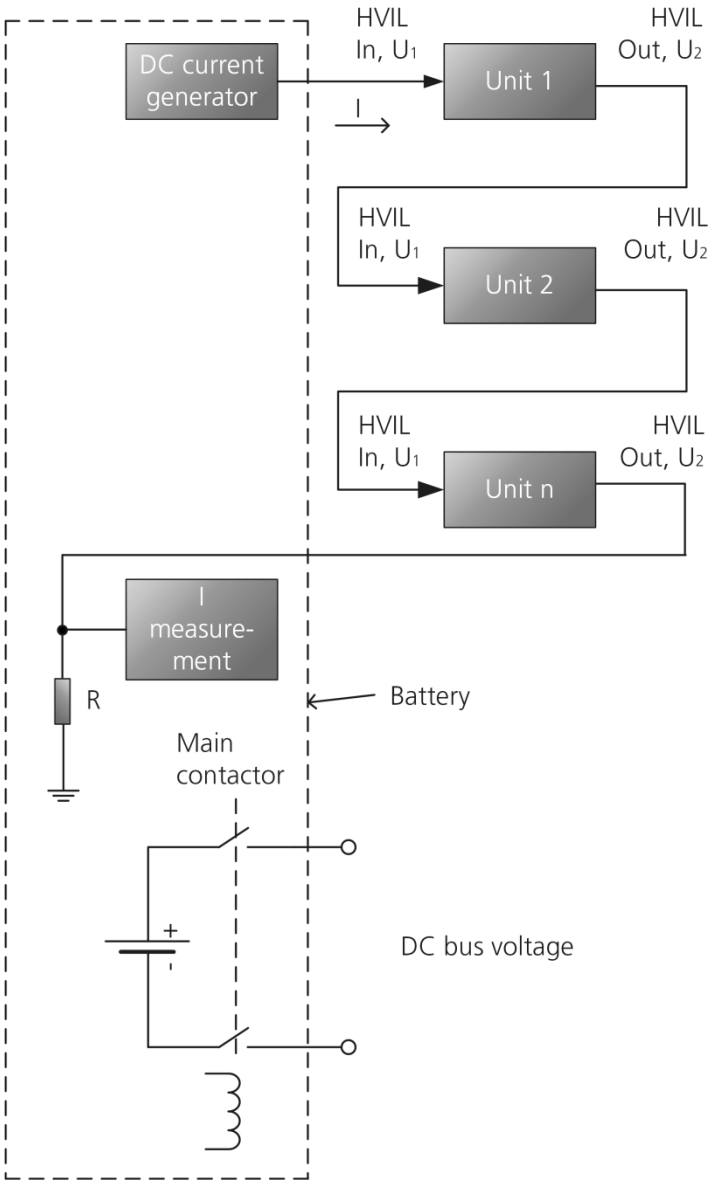


Figure 6 HVIL circuit concept

In 6, the GVI could be any of the units 1 to n.

Each unit measures the current, (I, Figure) in the HVIL circuit and compares it with a low and a high level (typically 5 to 30 mA). If the unit detects a current outside the levels, software-defined actions are taken. Each unit reports where in the HVIL circuit the fault is located (before, in or after the unit).

See chapter 12.2 for required supply current to the HVIL circuit.

7.7.2.2 HVIL in the GVI

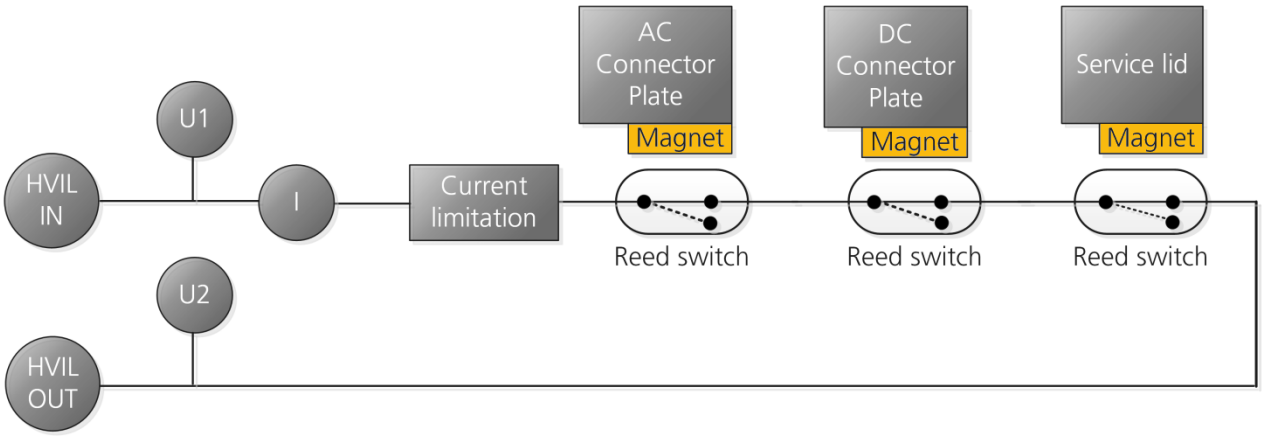
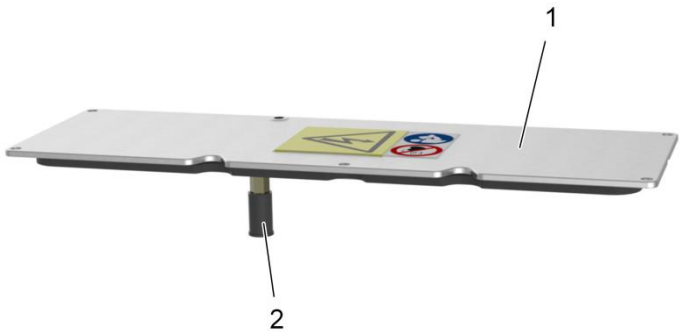


Figure 7 GVI HVIL circuit concept

In the GVI, the HVIL monitors the service points on the AC connector plate, DC connector plate and service lid. Each of these service points has a magnet that keeps a magnetic switch closed as long as the service point is installed on the GVI. The magnetic switch opens when the associated service point is dismounted, which interrupts the current in the HVIL circuit.



Pos	Name	Pos	Name
1	Service lid	2	HVIL magnet

Figure 8 Example of HVIL magnet

If HVIL is not used in the GVI, or if the HVIL is not of DC current source type, the HVIL events must be disabled within the application.

7.7.3 Permanent magnet electrical motors

WARNING

High voltage - risk of personnel injury and/or damage to equipment

A rotating permanent magnet electrical motor connected to the inverter may feed power back to the DC bus even if the inverter is not enabled.

Follow the guidelines below.

Electromotive force (EMF) generated by a rotating, permanent magnet electrical motor may cause overvoltage, for example during towing of a vehicle with engaged clutch. Cooling of the inverter shall always be active for as long as the electrical motor is rotating.

7.7.4 Isolation faults

NOTE

OEM's are recommended to implement a continuous isolation test for the high voltage DC-bus as this is not included in the GVI.

In case of an isolation fault between any high voltage component and chassis, the high voltage power supply to the inverter must be disconnected within 0.5 seconds.

The following must be performed:

- Command a "disable" signal to the inverter.
- All high voltage supplies shall be disconnected.
- If a permanent magnet electrical motor is connected to the inverter, the motor must be brought to a stop or disconnected from the inverter.

7.7.5 I2t protection

The inverter has a built-in I^2t protection to protect the inverter against continuous overload.

The I^2t protection monitors the energy accumulation in the inverter to protect it from overheating caused by repeated operation cycles exceeding the continuous current rating.

CAUTION

Configuration of inverter cooling – risk of damage to equipment

If the required coolant properties are not fulfilled the lifetime of the inverter might be reduced. See chapter 7.9 Cooling requirements.

7.8 Dust and liquid ingress prevention

The dust/moisture protection of the inverter is only valid when the mating motor power and HV DC connections and the I/O connector are inserted and correctly assembled with appropriate cable seals.

The connections are shown in Figure 10.

7.9 Cooling requirements

CAUTION

Configuration of inverter cooling – risk of damage to equipment

If the required coolant properties are not fulfilled the lifetime of the inverter might be reduced. Follow the guidelines in this chapter.

The inverter must be supported with adequate cooling. The required coolant flow depends on coolant temperature (see chapter 12.7). The GVI unit is WEG-cooled (water ethylene glycol). The coolant mixture is specified in chapter 12.7.

The inverter is designed to operate with a maximum nominal heat sink temperature of 65 °C. During performance testing of a new machine/vehicle design, it is necessary to ensure that the machine/vehicle can fulfill its environmental and performance specifications without exceeding this temperature of the inverter. If this is not possible to achieve, the OEM should consider improving cooling of the inverter, switching to larger inverters, or reduce machine/vehicle performance.

If the heat sink temperature exceeds 65 °C the maximum available motor current is automatically reduced. The inverter still operates, with reduced performance, up to 85 °C. It should be noted though, that the inverter is operating outside its specification in this case, and it should only be used as a "limp home" option to let the operator return the machine/vehicle to a service area where the reason for the overheating can be remedied.

In case of extreme over temperature the built-in temperature protection reduces the maximum available motor current to prevent inverter damage.

7.9.1 Coolant mixture

CAUTION

Ensure correct coolant mixture – risk of damage to equipment

Incorrect coolant mixture may cause freezing of the coolant, cracks in the heat sink, corrosion in the cooling system, water ingress and insufficient cooling. The coolant mixture is specified in chapter 12.7

Follow the machine/vehicle instructions for coolant level check intervals and filling procedure.

Exchange the coolant liquid based on data from the coolant liquid supplier.

Ensure that the coolant liquid is free from dirt and debris.

Higher coolant liquid temperature or lower coolant flow are possible but requires reduction in inverter performance ratings. See chapter 12.7.

7.10 Mounting

7.10.1 Unallowable mechanical forces

Mounting of the unit shall be done such that it will not be subjected to either tensile, pressure or shearing forces. Mounting of the unit shall therefore allow for thermal expansion of it (the degree of expansion depends on ambient temperature and work load on the unit). For the same reason, no other units shall be mounted upon the unit.

7.10.2 Orientation

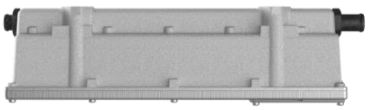
Example of orientation	Suitability
Cover up, long side horizontal 	☺ OK
Cover down, long side horizontal 	☺ OK
On the long side, long side horizontal 	☺ OK
Moisture vent up, long side vertical 	☺ OK provided the cooling system is free from air. This can be obtained by vacuum-filling it. ☹ Avoid if the cooling system is not vacuum-filled
Moisture vent down, long side vertical 	☹ Avoid: ■ The moisture vent (Figure) can get blocked by condensed water inside the GVI ■ The I/O connector can get filled by condensed water outside the GVI

Table 5 Suitability of different mounting orientation options

Figure 9 Moisture vent

7.11 Wiring, connections and fasteners

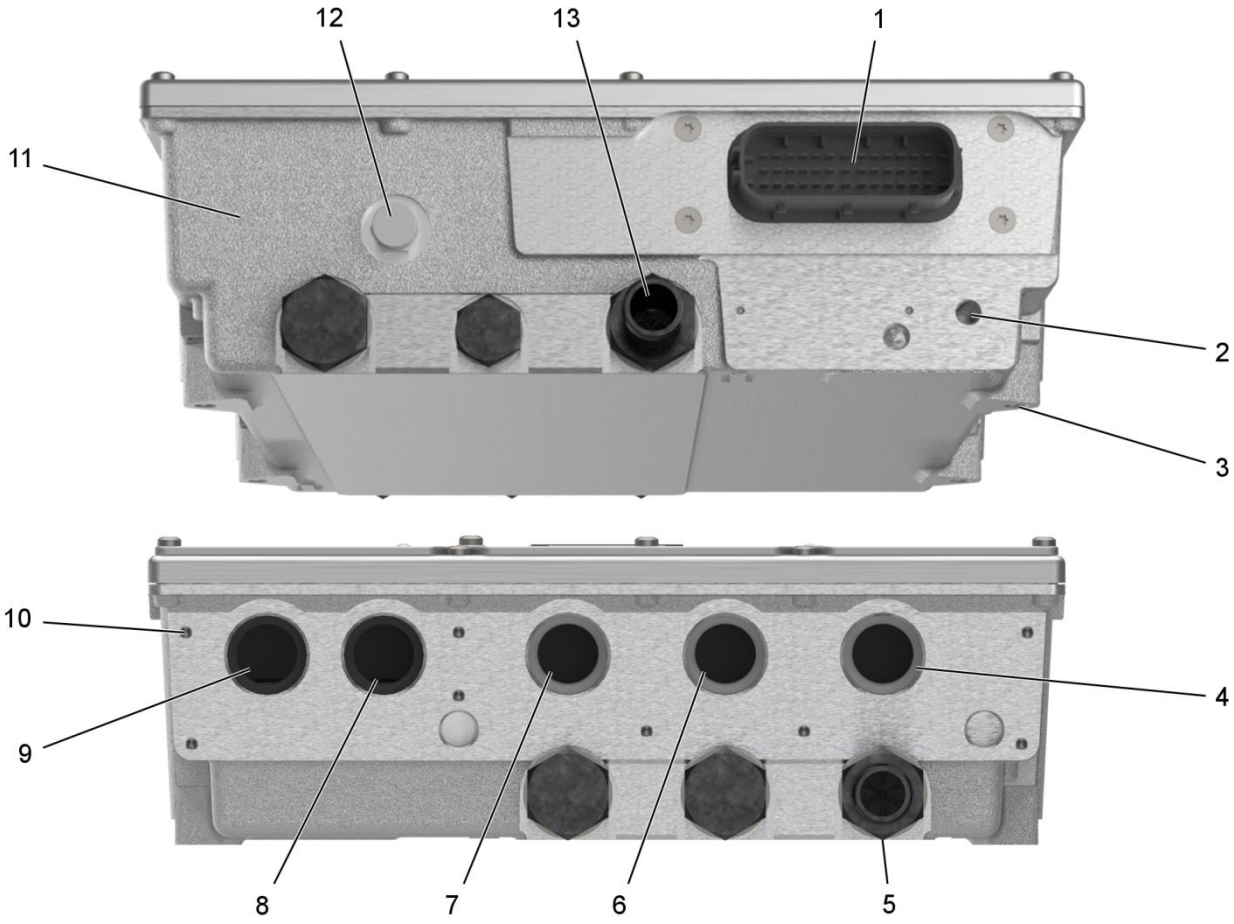


Figure 10 GVI Connections

NOTE

Assembly instructions for motor power connections (4), (6) and (7) and HV DC supply connections (8) and (9) are found in chapter 10.5.4.

Pos	Name	Connection Type	Connection to GVI frames G & H	Tightening Torque
1	I/O connector	Tyco MCP 39 MCP, 2,8 mm contacts. Part number 5-1418363-3	Receptacle housing 5-1718321-3 and Cover 1418882-1 see chapter 7.11.5	-
2	Ground connection	M10	Thread engagement 16-25 mm Additional information, see chapter 7.11.5	45 Nm ± 10 %
3	Mounting screw hole	4 x M10	Thread engagement 16-25 mm	45 Nm ± 10 %
4	Motor power connection W	Adapter kit, GVI-GH-Adapter kit (delivered separately, see chapter 7.11.3.1)	Ring terminal KRTS 50-8 (50 mm2, M8) or KRTS 70-8 (70 mm2, M8) Screw engagement (ring terminal screw): 12-18 mm	23 Nm ± 10 % (terminals) See chapter 10.5.5
5	Coolant connection (recommended out)	End fittings 22xM26x1.5	Hose clamps	-
6	Motor power connection V	Adapter kit, GVI-GH-Adapter kit (delivered separately, see chapter 7.11.3.1)	Ring terminal KRTS 50-8 (50 mm2, M8) or KRTS 70-8 (70 mm2, M8) Screw engagement (ring terminal screw): 12-18 mm	23 Nm ± 10 % (terminals) See chapter 10.5.5
7	Motor power connection U	Adapter kit, GVI-GH-Adapter kit (delivered separately, see chapter 7.11.3.1)	Ring terminal KRTS 50-8 (50 mm2, M8) or KRTS 70-8 (70 mm2, M8) Screw engagement (ring terminal screw): 12-18 mm	23 Nm ± 10 % (terminals) See chapter 10.5.5
8	HV DC supply + connection	Adapter kit, GVI-GH-Adapter kit (delivered separately, see chapter 7.11.3.1)	Ring terminal KRTS 50-8 (50 mm2, M8) or KRTS 70-8 (70 mm2, M8) Screw engagement (ring terminal screw): 12-18 mm	23 Nm ± 10 % (terminals) See chapter 10.5.5
9	HV DC supply – connection	Adapter kit, GVI-GH Adapter kit (delivered separately, see chapter 7.11.3.1)	Ring terminal KRTS 50-8 (50 mm2, M8) or KRTS 70-8 (70 mm2, M8) Screw engagement (ring terminal screw): 12-18 mm	23 Nm ± 10 % (terminals) See chapter 10.5.5
10	Screws for adapter plates. Included in Adapter kit, GVI-GH Adapter kit (delivered separately, see chapter 7.11.3.1)	8 x M5 x 16 surface-treated, for example as Würth ZFSHL or VDA235-104/A26-27	Adapter kit, GVI-GH Adapter kit (delivered separately, see chapter 7.11.3.1)	5.5 Nm ± 1 Nm
11	Heat sink	-	-	-
12	Moisture vent	-	-	-
13	Coolant connection (recommended in)	End fittings 22xM26x1.5	Hose clamps	-

Figure 11 Connections on GVI frames G & H

7.11.1 I/O connector

Refer to chapter 7.14.3 Default parameters, EEPROM considerations

The EEPROM memory needs special considerations regarding safety. Most failures in the EEPROM will cause the data contained in it to be corrupt.

At startup a checksum is calculated for the parameters in each EEPROM segment. The checksum is compared to the checksum that was stored at last EEPROM write. If the two checksums do not match, it is assumed that the parameters contained in the EEPROM are not valid, and default parameters are loaded from flash memory instead.

During normal operation, the EEPROM is only used for storing time-counters, error log details, etc. RAM memory is used to contain parameters used for operation.

A system design where the motor controller is utilized must ensure that loading of default parameters from a flash memory doesn't cause a dangerous failure in the system.

NOTE

According to EN 1175-1:1998 + A1:2010 chapter 5.9.11 Parameter:

At startup of the vehicle, it is recommended that the truck master reads the EEPROM parameter checksum from the motor controller and checks its validity.

I/O interface description for a description of the electrical connector pin configuration.

Figure 12 shows a minimum wiring connection for a single GVI/GVM that is connected to the Parker GVI configuration software tool. Note that the pre-charge function must be controlled external to the GVI.

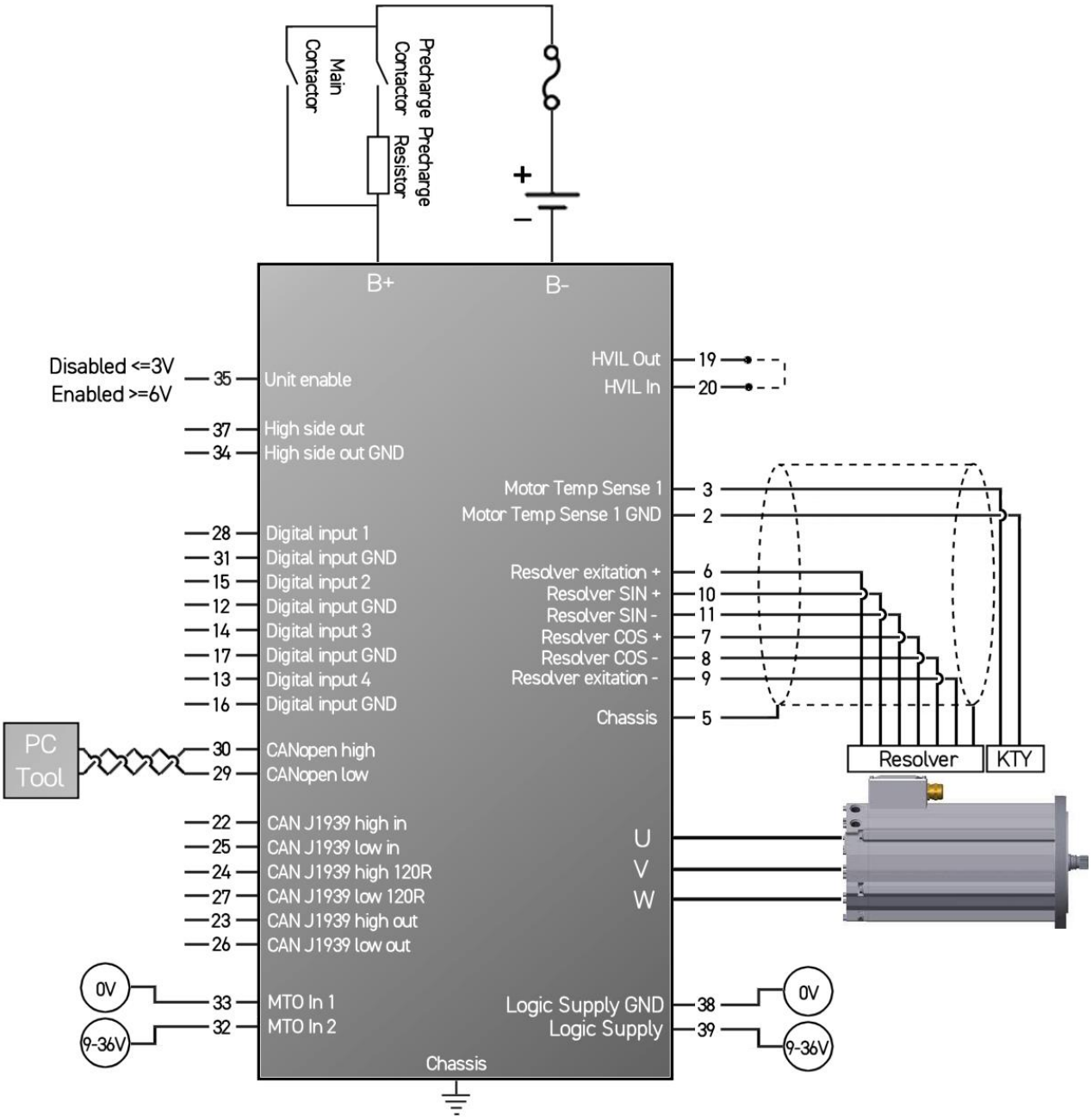


Figure 12 Minimum connection diagram.

7.11.2 Coolant connection

The GVI is delivered with 22 x M26 x 1.5 end fittings on the coolant connections as standard. Recommended inner diameter of hoses is Ø 22 mm (7/8 inches).

The end fittings are installed in the GVI with self-centralizing bonded washers, Ø26 mm, Pamargan Products Ltd part number SCV2G3548-P18:

- The washer is made of mild steel tensile, strength min Rm 540. Hardness min HV 165
- The rubber quality is ASTM D2000 M6 HK 810A1-10B38 EF31 E088 F15
- Similar washers can be used

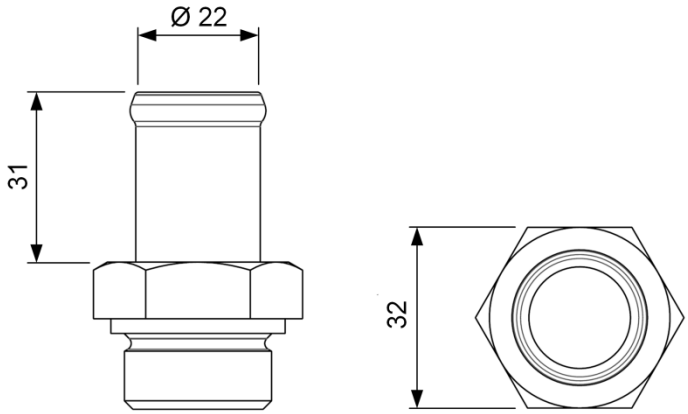


Figure 13 End fitting. Measures in mm

7.11.3 Motor power and HV DC supply connections

7.11.3.1 AC and DC adapter kit

NOTE

The adapter kit is not included with the GVI and must be ordered separately.

- AC and DC connection adapter kit: GVI-GH-ADAPTORKIT

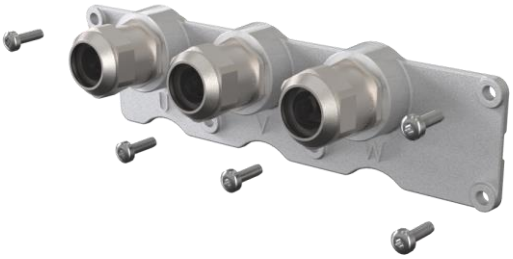


Figure 14 AC adapter plate and cable glands

Figure 15 DC adapter plate and cable glands

The AC and DC adapter kit is for mounting of the motor power and HV DC supply connection cables in the inverter, and consists of:

- One DC adapter plate
- One AC adapter plate
- Five shielded cable glands (for outside cable diameters of 12.5 - 20.5 mm)
- Eight screws (M5 x 16) for mounting

HVIL-magnets (see chapter 7.7.2) are mounted in the AC and DC adapter plates.

7.11.4 Fuse selection

The main DC supply to the GVI must be fused.

7.11.4.1 Main DC Fuse

The main DC fuse may be part of the battery pack. If an additional fuse is required, it must be rated for the maximum voltage of the battery and be rated to open under the short circuit current that the battery can produce. The main DC fuse should be continuously rated in accordance with the maximum input current of the GVI.

7.11.4.2 Logic Fuse

Parker recommends installing a fuse on the logic supply to the inverter. Use one 10 A fuse per inverter. Use DC fuse(s) specified for automotive applications

7.11.5 Ground connection

The GVI shall be connected to ground.

Figure 16 Ground connection

The surface of the ground connection (Figure 16) is cast aluminium.

Connect a ground strap of sufficient size between the ground connection and the vehicle chassis.

The connection point for the ground strap on the vehicle chassis shall be bare metal and be coated in dielectric grease to prevent corrosion.

The electrical resistance between the ground strap and the chassis must be less than 40 mΩ.

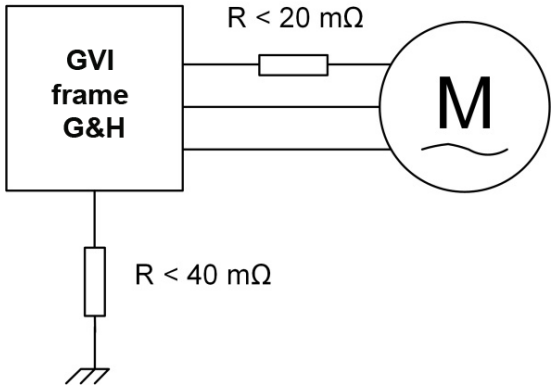


Figure 17 Connections to ground

7.12 Motor feedback sensor

WARNING

Installation and integration of motor feedback sensor – risk of personnel injury and/or damage to equipment due to unintended movement of the vehicle

Incorrect rotational direction or improper operation of the motor may be caused by:

- A faulty position/speed feedback sensor wiring
- A mechanically misaligned position sensor
- Faulty software alignment parameters

Contact the motor manufacturer to get the correct wiring and relationship between rotational direction and feedback sensor signals.

The GVI inverter supports Resolver type motor feedback sensors only

To minimize the risk of electrical noise coupling into motor feedback sensor lines, avoid routing cables next to conductors carrying high currents or high current pulses. Noise immunity may also be improved by using twisted signal cables for the motor feedback sensor.

7.12.1 Resolver signals

It is possible to interface an analog resolver sensor output according to the following:

- Differential analog inputs: 2-phase with 90 degrees phase difference, sin and cos
- Maximum modulation frequency: 16 kHz
- Voltage range: 10 Vpp to 30 Vpp (nominal 25 Vpp)
- Maximum sin and cos frequency: 750 Hz

The angle is estimated with accuracy better than +/-0.2 degree (electrical).
The resolver is powered by the internal resolver excitation circuit mounted in the controller.
The shield of the resolver cable shall be connected to pin 5 (Chassis) in the signal connector.

7.12.2 Motor Temperature Sensor

A temperature sensor embedded in the motor winding provides a means for the inverter to monitor motor temperature. Motor temperature is used in the vector control algorithms and can also be used to protect the motor from overheating.

The standard temperature sensor supported by the inverter is KTY 84-130.

Connector name	Description	Connection
Motor temperature sensor 1	Isolated motor temperature sensor input	GVM KTY Sensor
Motor temperature sensor 1 GND	Isolated motor temperature ground	GVM KTY Sensor
Motor temperature sensor 2	Isolated motor temperature sensor input	Not Connected. See Chapter 8.10
Motor temperature sensor 2 GND	Isolated motor temperature ground	Not Connected. See Chapter 8.10

Table 6 Pin connector description

NOTE

Installation of the motor temperature sensor is by the motor manufacturer. Contact the motor manufacturer to obtain the correct wiring details. If the temperature sensor cables are not connected with the right polarity, the sensor readings will not be correct and over-temperature protection of the motor will not work properly.

With KTY sensors the cathode is connected to pin Motor temperature sensor 1 GND

7.13 Start-up and commissioning

7.13.1 Configuring the inverter for the application

WARNING

Testing vehicle parameters – risk of personnel injury/damage to equipment

All GVI settings and functionality must be verified and validated by the OEM.

The complete range of parameter values that are updated by the machine/vehicle inverter (or any other device) must also be verified and validated before use in the field by the end user.

During the process when the parameter values are established it is of major importance to take proper safety precautions when testing, since wrong parameter values may jeopardize the operation of the machine/vehicle's safety critical functions.

It is the OEMs responsibility to ensure that the machine/vehicle is configured and set up to conform to applicable safety regulations.

Setting up a prototype inverter for a new machine/vehicle, may require extensive parameterization and possibly also re-programming of the inverter via the CAN bus.

Refer to the GVI Configuration manual for details and instruction on communications, setting of parameters and control modes, or contact to your designated Parker application centre for further assistance.

Optionally, inverters shipped for OEM series production are programmed during manufacturing with the correct parameters and do not require any further configuration. Refer to the OEM documentation for any further setup required during vehicle commissioning.

7.14 General considerations for system design

CAUTION

Inappropriate design and assembly – risk of damage to equipment

Follow the design and assembly guidelines in this manual to avoid damage to the equipment.

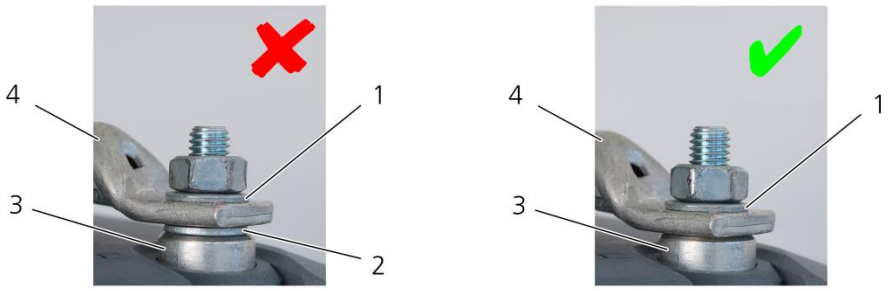
The following section contains some common causes for issues in a system, together with general information on how to avoid them through proper system design.

7.14.1 I/O and signal cables

- Physically separate power cables from signal cables. As a rule of thumb a minimum separation of 100 mm is necessary.
- Consider alternative paths for I/O cables to find the one that generates least noise (EMC).
- Resolver and temperature sensor cables between the GVI and motor should be screened.

7.14.2 Power Cables

- To avoid burning or overheating of the high-current terminals, ensure that the cable connection has been made according to chapter 7.11 and that the correct torque has been applied to screws, bolts and nuts. If the power cables are not connected properly, excess heat is generated which could damage both the inverter and other equipment in the vehicle.



Pos	Name	Pos	Name
1	Allowed washer	2	Non-permissible washer
3	Terminal	4	Cable lug

Figure 18 Use of washers for cable lug connections (example illustration)

- Parker recommends cable type Huber+Suhner Radox 155(S) with EMI screen. Do not use washers between cable lug (4, Figure 18) and terminal (3, Figure 18) as overheating will occur.
- Motor and HV DC supply connection cables must be thermally dimensioned to match the power of the inverter and the motor. Cable selection depends on the cable construction, so refer to the cable manufacturers technical documentation to choose wire sizes.
- All high voltage cables must be shielded.
- The cable area must be selected to match the 1 hour rating of the application. The rating of a chosen cable diameter will vary between manufacturers and shall consider derating for installation method and ambient temperature.
- The GVI-GH-Adaptorkit is supplied with glands that will accept cables with an overall outside diameter between 12.5mm and 20.5mm. Smaller cables will require replacement glands to be fitted. Replacement glands must meet IP6K9K requirements.
- The selected cable should be capable of being fitted with the correct lugs (chapter10.5.4)
- The motor power and HV DC supply connection terminals in the inverter are not designed for transfer of heat from the cables. Prevent overheating of the terminals and cables by choosing appropriate cable area dimensions.

Entry Thread	Clamping Range (with insert)		Clamping Range (without insert)	
M25x1.5mm	Min	Max	Min	Max
	12.5mm	16.0mm	16.0mm	20.5mm

Table 7 Allowable power cable outside diameters

7.14.3 Default parameters, EEPROM considerations

The EEPROM memory needs special considerations regarding safety. Most failures in the EEPROM will cause the data contained in it to be corrupt.

At startup a checksum is calculated for the parameters in each EEPROM segment. The checksum is compared to the checksum that was stored at last EEPROM write. If the two checksums do not match, it is assumed that the parameters contained in the EEPROM are not valid, and default parameters are loaded from flash memory instead.

During normal operation, the EEPROM is only used for storing time-counters, error log details, etc. RAM memory is used to contain parameters used for operation.

A system design where the motor controller is utilized must ensure that loading of default parameters from a flash memory doesn't cause a dangerous failure in the system.

NOTE

According to EN 1175-1:1998 + A1:2010 chapter 5.9.11 Parameter:

At startup of the vehicle, it is recommended that the truck master reads the EEPROM parameter checksum from the motor controller and checks its validity.

8 I/O interface description

8.1 Mating connector specification

Parker recommends the use of crimp pins suitable for for wire size 0.5-1.0 mm. Use of wire seals is mandatory to maintain IP6K9K rating. A connector shroud should also be fitted. Unused pins can be blanked off using cavity plugs if preferred. The harness side (plug) connector comprises the below parts:

- I/O harness side connector for GVI inverter: TE Connectivity 5-1718321-3
- I/O harness side connector shroud: TE Connectivity 1418882-1
- MCP-2.8 female pins for wire size 0.5-1.0 mm : TE Connectivity 1-968855-3
- Size 2.8 Wire seals : TE Connectivity 828904-1
- Size 2.8 Blanking plug (for unused pin holes) : TE Connectivity 828922-1

Refer to TE Connectivity Product Specification 108-18696 and Application Specification 114-18376 for assembly instructions of the harness side (plug) connector. http://www.te.com

8.2 Connector pin assignment

Pin	Name	Chapter	Pin	Name	Chapter
1	Motor temperature sensor 2 (N/C)	8.10	21	Not used (N/C)	-
2	Motor temperature sensor 1 GND	8.10	22	CAN_J1939_High in	8.9
3	Motor temperature sensor 1	8.10	23	CAN_J1939_High out	8.9
4	Motor temperature sensor 2 GND (N/C)	8.10	24	CAN_J1939_High_120R	8.9
5	Chassis	8.7	25	CAN_J1939_Low in	8.9
6	Resolver excitation +	8.8	26	CAN_J1939_Low out	8.9
7	Resolver COS+	8.8	27	CAN_J1939_L_120R	8.9
8	Resolver COS-	8.8	28	Digital input 1	8.5
9	Resolver excitation -	8.8	29	CAN_CANopen_Low	8.9
10	Resolver SIN+	8.8	30	CAN_CANopen_High	8.9
11	Resolver SIN-	8.8	31	Digital input GND	8.5
12	Digital input GND	8.5	32	MTO_IN_2	8.6
13	Digital input 4	8.5	33	MTO_IN_1	8.6
14	Digital input 3	8.5	34	High side out GND	8.12
15	Digital input 2	8.5	35	Unit_Enable	8.4
16	Digital input GND	8.5	36	Chassis	8.3
17	Digital input GND	8.5	37	High side out/Low side out	8.12
18	Not used (N/C)	-	38	Logic_Supply GND	8.4
19	HVIL_OUT	8.11	39	Logic_Supply	8.4
20	HVIL_IN	8.11			

Figure 19 Connector pinout

8.3 General EMC and ground interface

8.3.1 Functions

This interface contains ESD protection, ground connection for signal I/O and EMC filters

8.3.2 Protection

In general all signals leads in the connector have an ESD overvoltage protection with bi-directional ESD diodes connected to chassis (housing) of the inverter via a capacitor, see figure 20.

8.3.3 Circuit

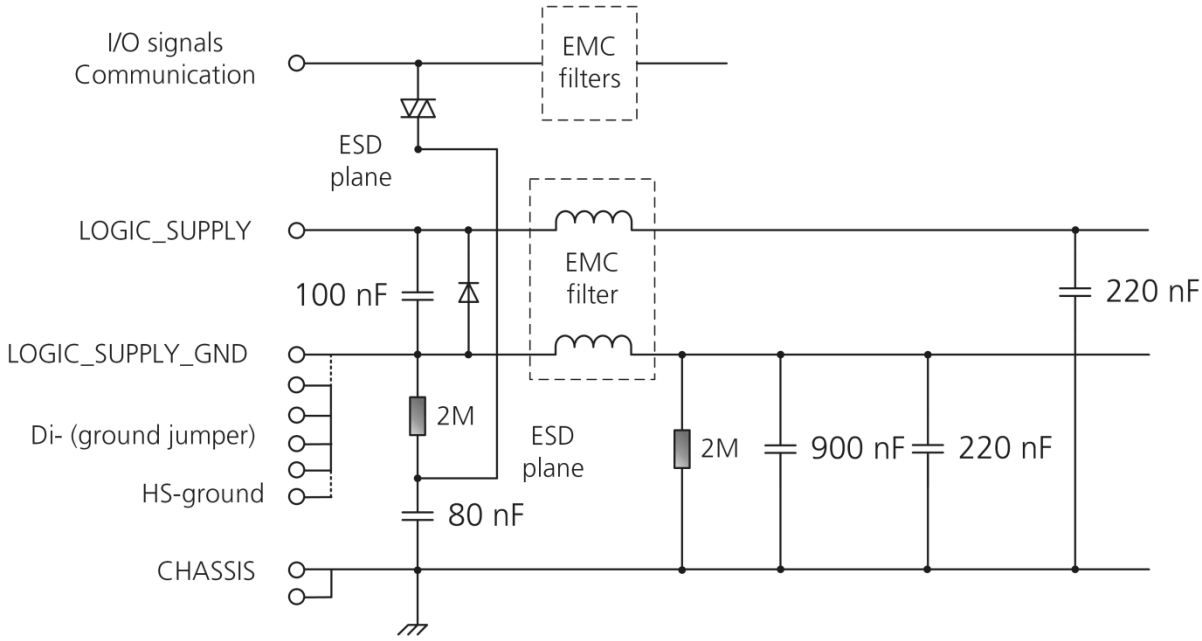


Figure 20: Ground connection in signal connector

8.4 Logic supply and Unit enable

8.4.1 Logic_Supply

Refer to chapter 12.5.3 for technical data.

The LOGIC_SUPPLY is used to power up the GVI.

Signal name	Description
LOGIC_SUPPLY	Supply input (9 V to 36 V) for the internal power supply of the control parts
LOGIC_SUPPLY_GND	Logic supply ground

Table 8 Pin connector description

8.4.2 Unit Enable

Refer to chapter 12.5.2 for technical data.

The UNIT_ENABLE is used to control power up and power down of the GVI. Depending on the software settings, the GVI may delay power down until defined conditions for a controlled power down are fulfilled. These conditions may include a CAN command to disable the power stage.

NOTE

In a standard configuration, the GVI only initiates a power down if the power stage has been disabled by a CAN command.

Signal name	Type	Description
UNIT_ENABLE	Wake up trigger	Digital input signal to enable the unit. The signal controls the state of the logic power supply – On or Off. The input has an internal pull-down resistor

8.4.3 Functions

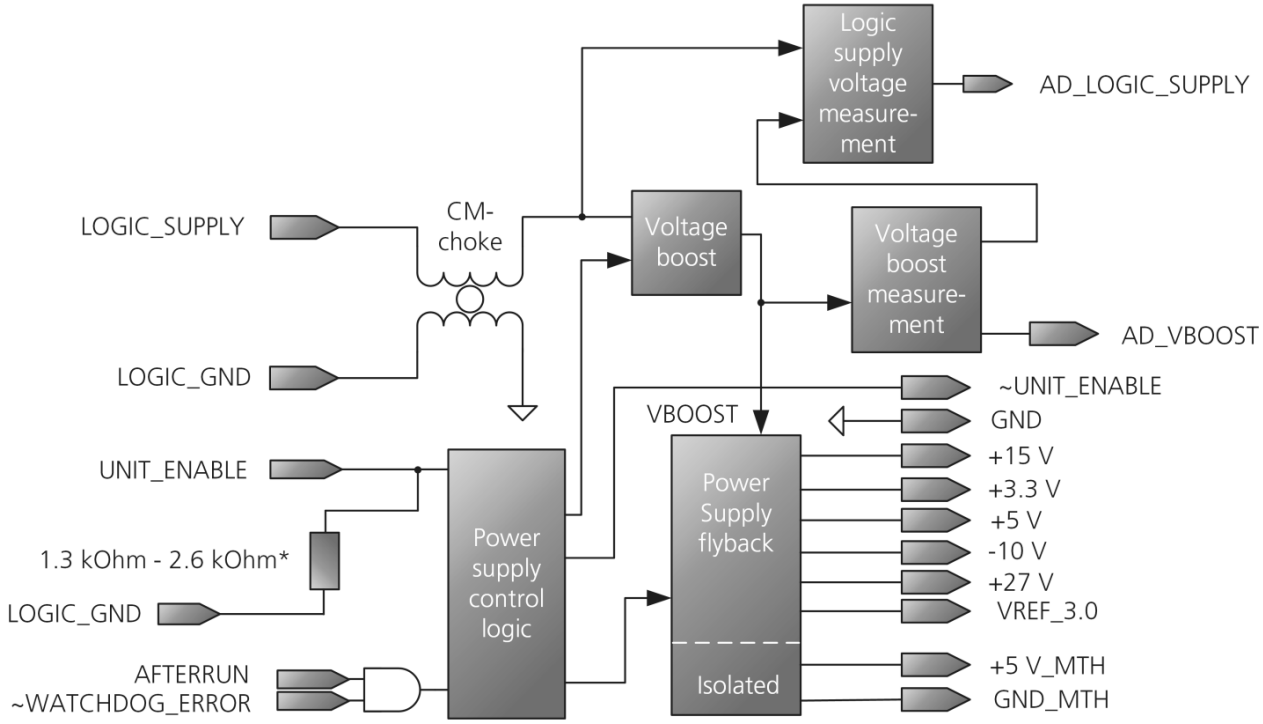
- LOGIC_SUPPLY is the input to the internal power supply for powering the GVI. Internally the voltage is boosted to a higher stabilized voltage and then converted to lower voltages used by the internal modules

8.4.4 Protection

ESD, see Figure 20.

The logic supply is protected from reverse polarity with a diode between LOGIC_SUPPLY and LOGIC_GND, see Figure 21.

8.4.5 Circuit



*The pull-down resistor is a current-limited circuit which behaves as a variable resistor

Figure 21: Internal power supply

8.5 Digital inputs

Refer to chapter 12.5.1 for technical data.

8.5.1 Functions

- Four digital inputs with internal pull-up resistors are provided
- The interface is dimensioned to give a wetting current between 9 – 11 mA
- Digital input 1 and Digital input 2 are by default used for hardware ID configuration, enabling up to four identical GVI inverters to be connected to the same CAN network.
- Digital input 3 and Digital input 4 are general purpose inputs which can be read by the master controller over CAN.

Hardware ID	Digital Input Wiring	CANOpen Node ID	J1939 Source Address
0	None	6	0xC8 (200_{dec})
1	HW_ID1 (pin 28) to GND	7	0xC9 (201_{dec})
2	HW_ID2 (pin 15) to GND	8	0xCA (202_{dec})
3	HW_ID1 (pin 28) to GND & HW_ID2 (pin 15) to GND	9	0xCB (203_{dec})

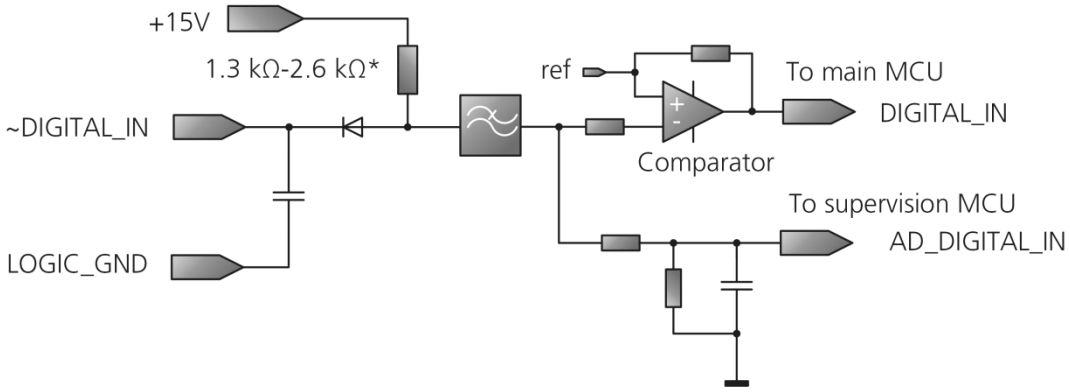
Table 9 : Hardware ID selection

8.5.2 Protection

ESD, see Figure 20.

Digital inputs are protected from overvoltage with a diode, see Figure 22.

8.5.3 Circuit



*The pull-down resistor is a current-limited circuit which behaves as a variable resistor

Figure 22: Digital input circuit

8.6 Motor Torque OFF (MTO_IN_1 and MTO_IN_2)

Signal name	Description
MTO_IN_2	Motor Torque Off, digital input with internal pull-down resistor
MTO_IN_1	Motor Torque Off, digital input with internal pull-up resistor

Table 10 MTO Pin connector description

MTO_IN_1	MTO_IN_2	Power stage state
Low	Low	Off (Torque_off)
Low	High	On (Active)
High	Low	Off (Torque_off)
High	High	Off (Torque_off)

Table 11 Power stage state as a function of MTO signals

The MTO function cannot be disabled in the software configuration. The pins must be connected as shown in Table **11** for the GVI to function.

The MTO function complies with requirement for a Category 1 function with

- DC: none
- CCF: 0
- MTTFd >100 years
- Reaction time <100 ms

It is the responsibility of the customers/OEMs to review the above data to evaluate and decide on if it fulfils the application requirements.

8.6.1 Functions

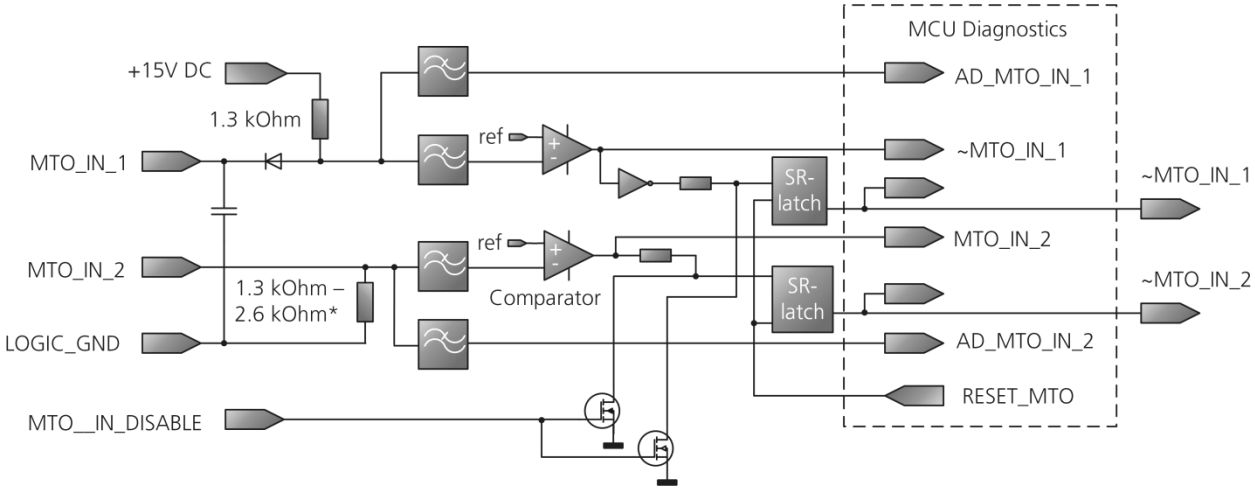
- Motor Torque OFF (MTO) is an external signal used to shut down the power stage without software involvement. The input uses two pins in the signal connector with complementary signals i.e. with pull-up (PU) and pull-down (PD)
- The interface is dimensioned to give a wetting current between 9-11 mA

8.6.2 Protection

ESD, see Figure 20.

MTO_IN_1 and MTO_IN_2 are protected from overvoltage.

8.6.3 Circuit



* The pull-down resistor is a current limited circuit which behaves as a variable resistor

Figure 23: Motor torque off (MTO) Circuit

8.7 Chassis

Signal name	Description
CHASSIS	For termination of a cable shield

Table 12 Pin connector description

8.8 Resolver

Refer to 12.5.4 for technical data.

Signal name	Description
RESOLVER_EXCITATION +	Excitation output for resolver. AC voltage pulses
RESOLVER_COS+	Input resolver COS
RESOLVER_COS-	Input resolver COS
RESOLVER_EXCITATION -	Excitation output for resolver
RESOLVER_SIN+	Input resolver SIN
RESOLVER_SIN-	Input resolver SIN

Table 13 Pin connector description Functions

- See also the description in chapter 12.5.4
- The resolver excitation uses a resonant circuit that generates a half wave sinus output signal
- The nominal resonance is approximately 10 kHz unloaded. The resonance frequency differs depending on the connected resolver impedance. The excitation pulses are repeated with 4kHz
- The resolver excitation amplitude is controlled by the motor control unit. The software controls the excitation amplitude so that the measured value at the resolver sinus and cosine inputs has an
- optimal amplitude for the analogue to digital conversion

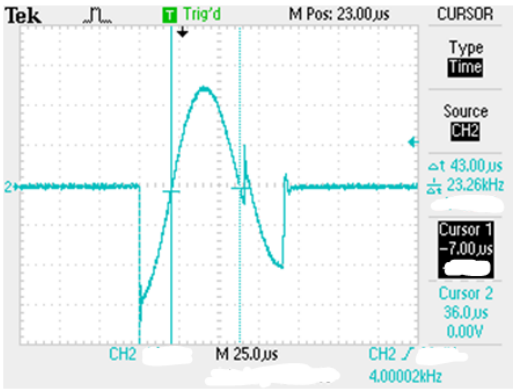


Figure 24: Resolver excitation

8.8.1 Diagnostics

Connected/not connected resolver can be diagnosed.

8.8.2 Protection

ESD, see Figure 20.

8.8.3 Circuit

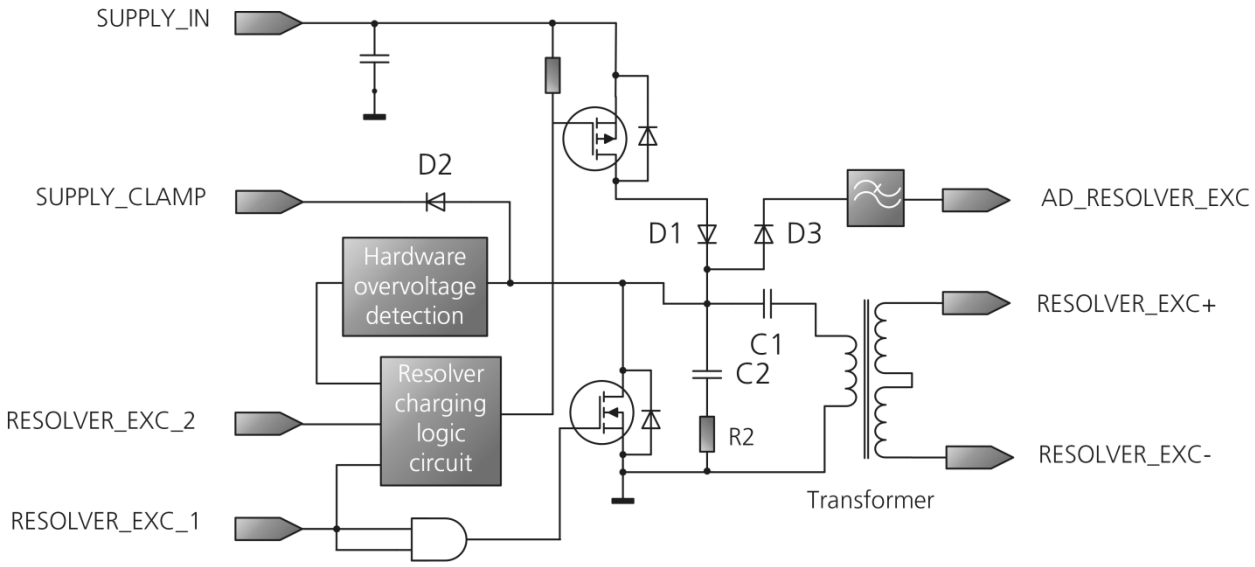


Figure 25: Resolver excitation

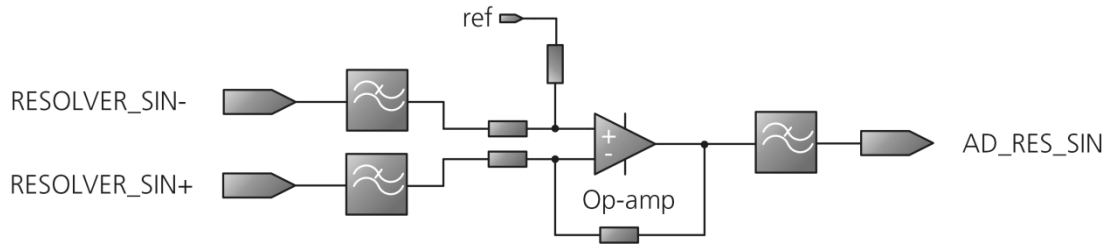


Figure 26: Resolver input

8.9 CAN_J1938 and CAN_CANopen

An error frames counter is available in the inverter and helps diagnosing the CAN bus noise immunity.

Two CAN-buses are provided. CAN_J1939 is by default used for vehicle communication and CAN_CANopen is used for diagnostics, parameterization and software downloading. CAN_CANopen may also be used for vehicle communication if J1939 is not preferred.

CAN-cabling must use a pair of twisted wires (total impedance 120 Ω) for the CAN_HIGH and CAN_LOW connections.

Signal name	Type	Description
CAN_CANopen_HIGH	CANopen	CAN_CANopen_HIGH in/output
CAN_CANopen_LOW	CANopen	CAN_CANopen_LOW in/output
CAN_J1939_HIGH_IN	J1939	CAN_J1939_HIGH input
CAN_ J1939_HIGH_OUT	J1939	CAN_J1939 HIGH output to next unit or to termination. Internally connected to CAN_J1939_HIGH_IN
CAN_J1939_HIGH_120R	Configuration of J1939 termination resistor	Used for CAN termination. Active when jumper is placed between CAN_J1939_HIGH_OUT and CAN_J1939_HIGH_120R
CAN_J1939_LOW_IN	J1939	CAN_J1939_LOW input
CAN_ MAIN_LOW_OUT	J1939	CAN_J1939_LOW output to next unit or to termination. Internally connected to CAN_J1939_LOW_IN
CAN_J1939_LOW_120R	Configuration of J1939 termination resistor	Used for CAN termination. Active when jumper is placed between CAN_J1939_LOW_OUT and CAN_J1939_LOW_120R

Table 14 Pin connector description

CAN_J1939

CAN_J1939 is intended to be connected to the vehicle controller. Pins CAN_J1939_HIGH_OUT and CAN_J1939_LOW_OUT can be used either to connect a split termination resistor (pins CAN_J1939_HIGH_120R and CAN_J1939_LOW_120R) or to pass the signal to an additional unit.

Transceiver: TJA1042T

8.9.1 Protection

ESD, see Figure 20.

Application-specific.

8.9.2 Circuit

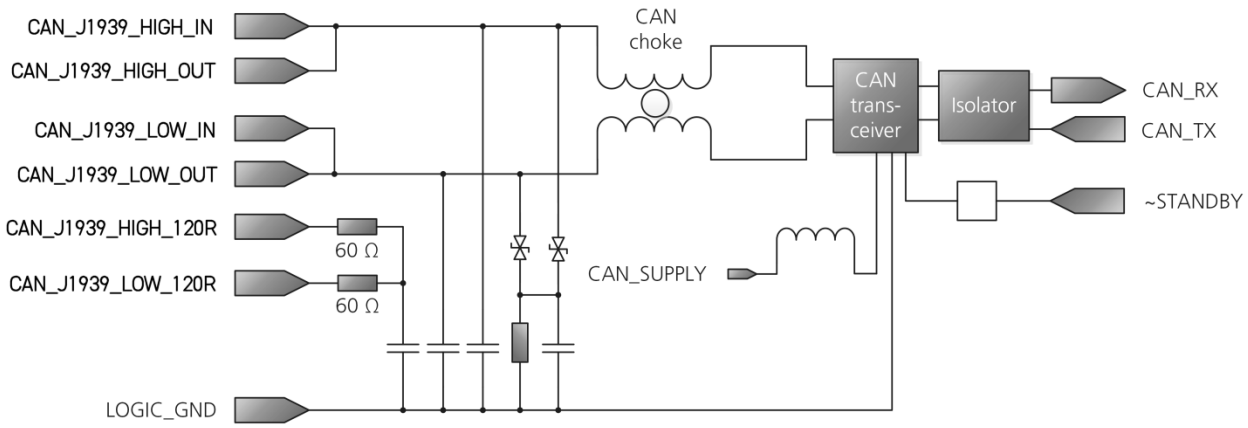


Figure 27 CAN_J1939 bus module

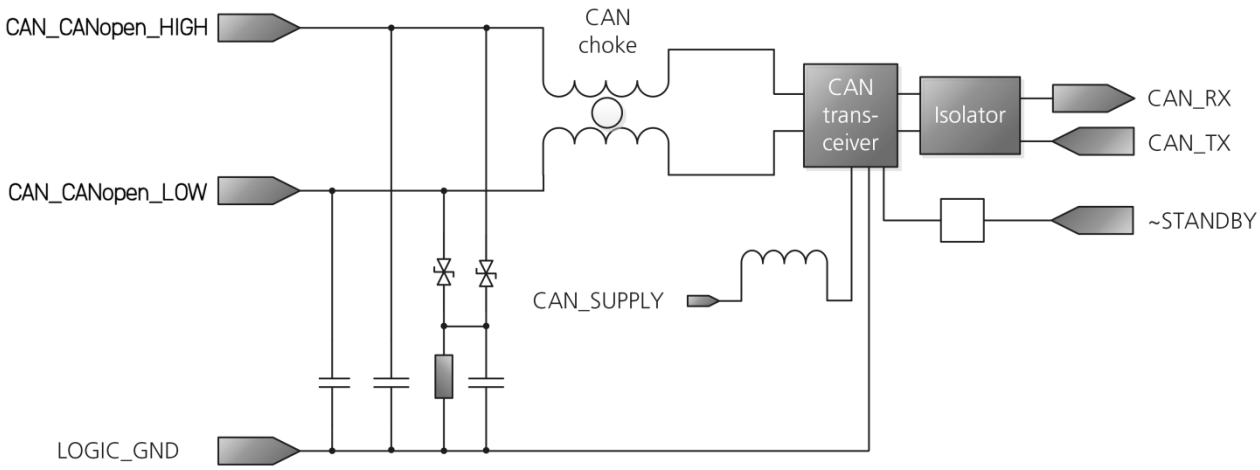


Figure 28 CAN_CANopen bus module

8.10 Motor temperature sensor

Connector name	Description
MOTOR_TEMPERATURE_SENSOR_1	Isolated motor temperature sensor input
MOTOR_TEMPERATURE_SENSOR_1_GND	Isolated motor temperature ground
MOTOR_TEMPERATURE_SENSOR_2	Isolated motor temperature sensor input (see below)
MOTOR_TEMPERATURE_SENSOR_2_GND	Isolated motor temperature ground (see below)

Table 15 Pin connector description

8.10.1 Functions

- Dual motor temperature sensor input for measurement of the motor winding temperature
- GVM motors are fitted with only one KTY sensor, therefore temperature input 2 is not used and should be left disconnected.

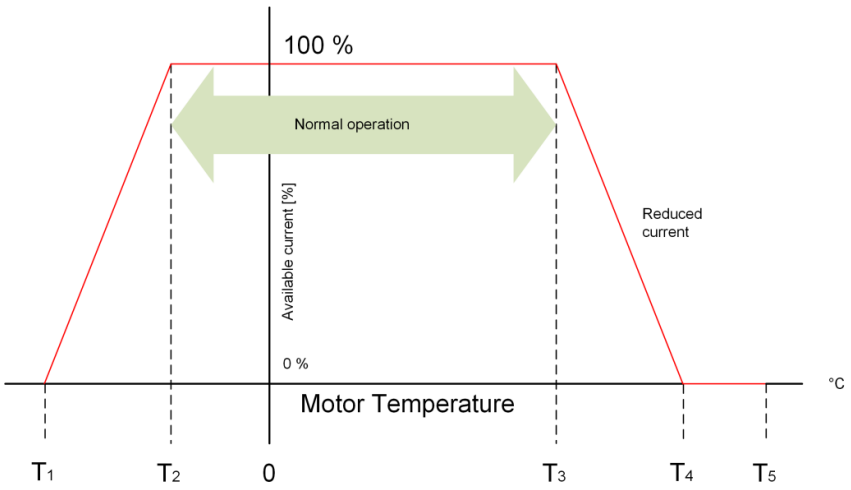


Figure 29 Motor temperature operation

8.10.2 Diagnostics

See GVI Configuration Manual.

8.10.3 Protection

ESD, see Figure 20.

The motor temperature interface is internally isolated from the other modules to avoid isolation problems if the temperature sensor in the motor is shorted to high voltage.

8.10.4 Circuit

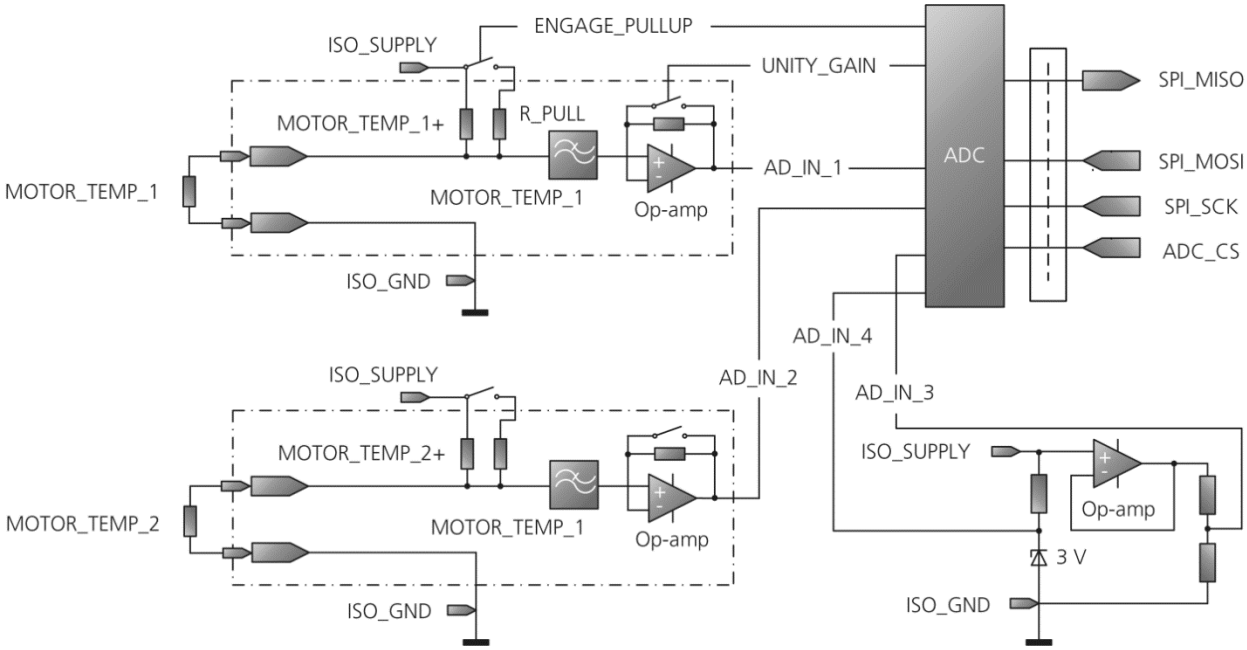


Figure 30: Motor temperature sensor input circuit

8.11 HVIL inputs/output

Refer to chapter 12.2.1 for technical data.

Signal name	Description
HVIL_OUT	Hazardous Voltage Interlock loop output
HVIL_IN	Hazardous Voltage Interlock loop input

Table 16 Pin connector description

8.12 High side output

The high side switch supplies voltage (24 V or 12 V) to the loads from the input Logic supply.

The high side switch is internally supplied from the LOGIC_SUPPLY input voltage. The output is able to deliver up to 2 A continuous and 4 A/100 ms peak in the voltage range 8 – 32 V.

The output is able to handle the coil energy generated when opening a circuit with a 500 mH coil (that is, no external free-wheel diode is required).

The external load must be connected between the pins “High side out” and “High side out GND”. No other connection of the load is allowed.

Signal name	Description
HIGH_SIDE_OUT_GND	For external load connected to high side out
HIGH_SIDE_OUT	On/Off MOSFET from logic supply for external load e.g. relay

Table 17 Pin connector description

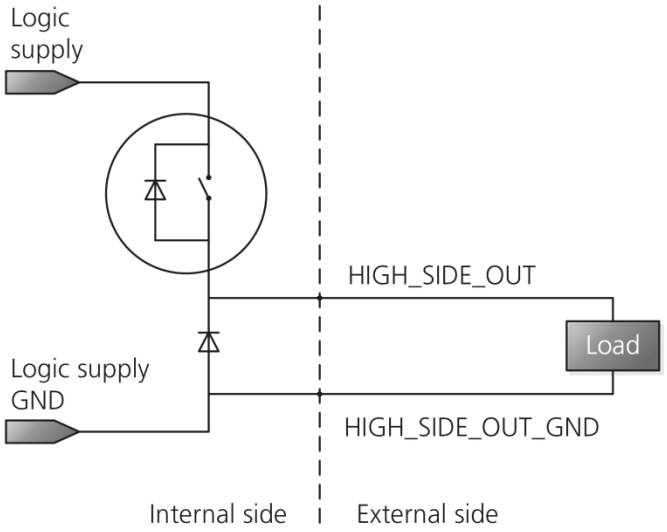


Figure 31: High side switch

8.12.1 Functions

- Application-specific

8.12.2 Protection

- ESD, see Figure 20

8.12.3 Circuit

Application-specific.

9 High voltage interface description

9.1 Active discharge

9.1.1 DC bus discharge

See also the description in 7.5.

9.1.1.1 Functions

WARNING

High voltage capacitors - risk of personnel injury and/or damage to equipment

The DC bus cannot be discharged unless external power sources have been deactivated. For example, the main power supply must be disconnected and if a permanent magnetized electrical motor is connected to the inverter, the electrical motor must be brought to an immediate stop or disconnected from the inverter with a three phase breaker.

- Discharges the DC bus capacitors to a safe voltage below 60 V DC in 5 seconds in these situations:
  - If both UNIT_ENABLE is OFF and the power stage has been disabled with a CAN command
  - Logic supply turned OFF
  - Hardware errors
  - Detected software errors
- Hardware is implemented with three redundant circuits
- With active discharge the added load on the DC bus is:
  - 60 W above 100 V DC
  - 220 mA below 100 V DC

9.1.1.2 Protection

Not applicable.

9.1.1.3 Circuit

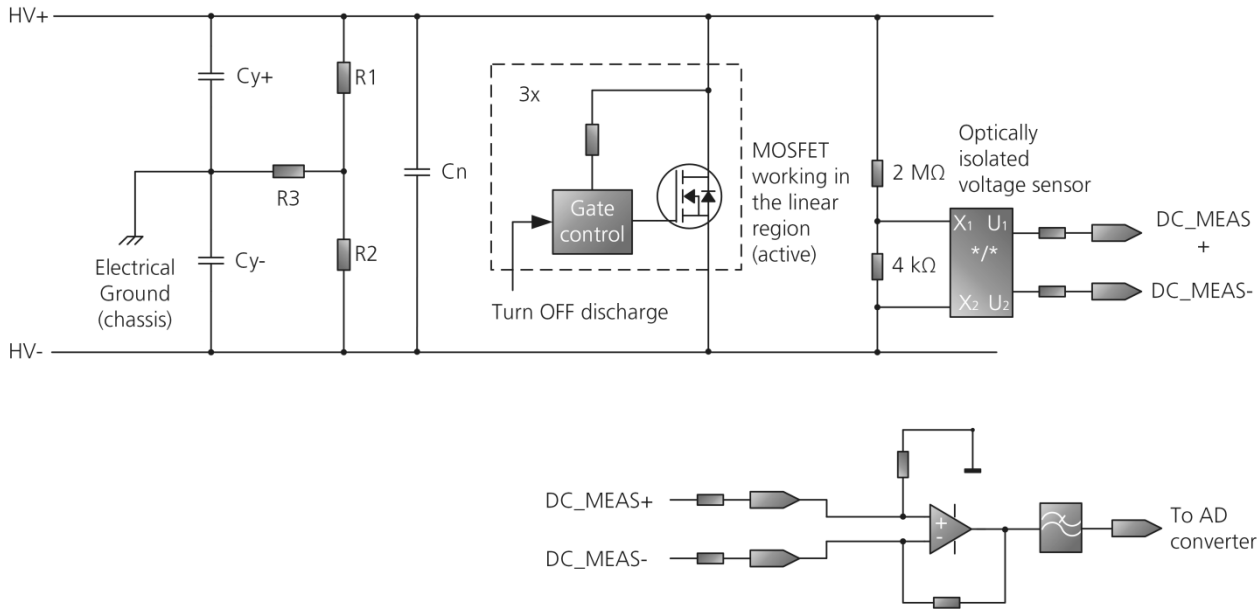


Figure 32 High voltage overview

9.2 Passive discharge

9.2.1 Functions

- Y-capacitors between positive and negative DC potentials and chassis (housing) are discharged with a fixed resistance connected in a Y configuration, see Figure 32
- Resistance between chassis and HV potentials is > 25 MΩ

9.2.2 Protection

Not applicable.

9.2.3 Circuit

See Figure32.

9.3 Y-capacitors

9.3.1 Functions

- Y-capacitors between positive and negative DC potentials and chassis (housing) are included in the design in order to reduce high frequency currents in the system which potentially could cause electromagnetic interference problems

9.3.2 Protection

Not applicable.

9.3.3 Circuit

See Figure32.

9.4 Inrush current limiting

CAUTION

Inrush current – risk of damage to equipment

Make sure to limit inrush current to specified peak current (chapter 12.3.

It is essential to provide external pre-charge control to prevent excessive inrush current. The externally supplied precharge resistor should be connected between the battery and B+ of the GVI (figure 12) and controlled by a contactor. When the DC bus voltage has risen sufficiently the pre-charge resistor may be bypassed to allow full voltage to be applied. Under no circumstances may the GVI be used to run a motor with the pre-charge resistor in circuit.

The pre-charge resistor should be selected to ensure a maximum inrush current no larger than the peak AC current rating of the GVI (chapter 12.3). It shall be rated to dissipate as much energy as may be stored in the DC link capacitors.

GVI model	Nominal power stage DC capacitance
GVI-G650-0300S1	540 µF
GVI-H650-0500S1	900 µF

Table 18 Nominal power stage DC capacitance

9.5 DC EMC filter

The DC EMC filter concept is shown in Figure 33

The DC EMC filtering circuit consists of a differential mode filter, a common mode filter and 90 nF Y2 capacitors on the power board.

The common mode filter attenuates signals that appear identically on each of the wires going through the filter.

The differential mode filter attenuates signals that appear on just one of the wires going through the filter.

9.5.1 Functions

9.5.1.1 Common mode filtering (High frequency)

- Damping of common mode high frequency interference in the MHz –range

9.5.1.2 Differential mode filtering (Low frequency)

- Lowers the DC bus voltage ripple generated by the GVI
- Minimizes resonance currents with other loads on DC bus
- The resulting resonance currents is dependent of OEM DC bus configuration – main power supply, cabling and other third party loads/inverters connected to the DC bus

9.5.2 Protection

Not applicable.

9.5.3 Circuit

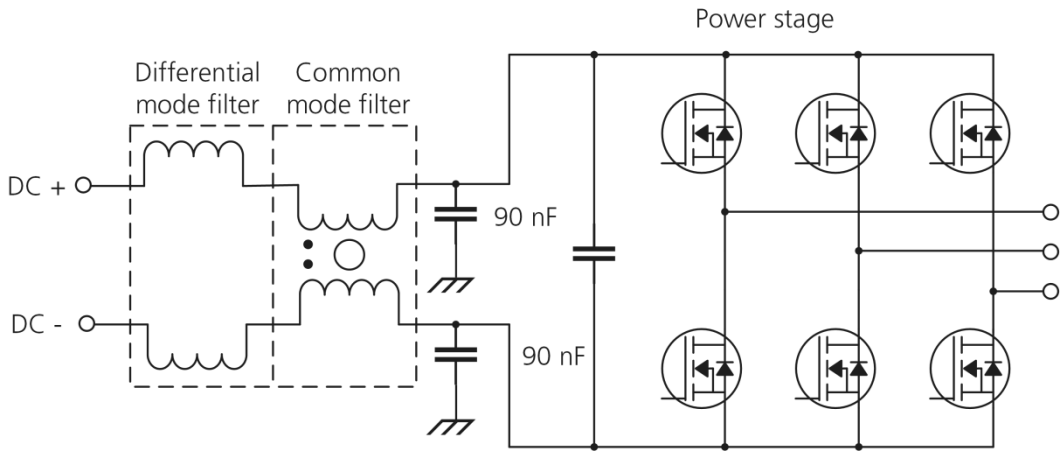


Figure 33 DC EMC Filter concept

9.6 AC filter

A ferrite choke on each motor phase output acts as an AC filter.

10 Installation and maintenance instructions

10.1 Introduction

This chapter contains general instructions for installation and maintenance of the inverter.

Fasteners and tightening torques for mounting of the inverter must be specified in accordance with chapter 10.5.4.

The actual procedures for installation and maintenance of the inverter in a specific vehicle may vary from what is described here or include additional steps. It is the responsibility of the vehicle manufacturer to develop detailed instructions for installation and maintenance of the inverter in the target vehicle.

CAUTION

Sensitive equipment - risk of damage to equipment

The inverter contains no user adjustable or user replaceable components beneath its protective cover. Do not remove the cover.

CAUTION

Sensitive equipment - risk of damage to equipment

Take precaution during handling of the inverter to protect external connections such as coolant connections, I/O connector, gore vent and open HV DC supply and motor power connections from shocks, other kinds of damage and debris.

CAUTION

Heavy load – risk of damage to equipment

Do not step on the unit.

NOTE

The maintenance instructions in this chapter are general-purpose procedures that do not address vehicle-specific requirements. Personnel performing maintenance should consult the vehicle manufacturer's instructions, which always supersede the instructions in this document.

10.2 Periodic inspection & preventive maintenance

No period inspection or maintenance is required.

It is recommended to keep the inverter clean externally.

10.3 Filling of coolant

Prepare the coolant according to the coolant specification in chapter 12.7.

Use vacuum filling when filling the inverter with coolant to prevent air pockets in the cooling circuit.

10.4 Inverter removal

WARNING

High voltage - risk of personnel injury and/or damage to equipment

To prevent personnel injury and protect the inverter from possible damage due to voltage transients, the inverter's internal filter capacitors shall be discharged and the main power supply shall be disconnected as described in the instruction below.

Do not short the high voltage terminal as this may cause an arc.

WARNING

Hot surfaces - risk of personnel injury

The inverter may be too hot to touch after operation. Allow it to cool before performing any maintenance work on the inverter.

WARNING

Heavy equipment - risk of personnel injury

GVI frame G weighs 21 kg and GVI frame H weighs 25 kg. Use suitable lifting equipment when lifting the units.

Attach the lifting equipment according to chapter 10.5.1.

CAUTION

Dirt and water sensitive equipment - risk of damage to equipment

The inverter shall always have protection on the inlet and outlet nozzles and the electrical connections when it is not mounted in the vehicle.

Electrical connections requirements are specified in chapter 7.11. Position numbers refer to Figure 10.

1. Make sure that the main power switch is off, that is, the main power supply.
2. Disconnect the inverter logic cable from I/O connector (1).
3. Verify that the internal filter capacitors have discharged for at least five seconds (= DC bus voltage < 60 V).
4. Remove service lid (chapter 10.5.4.1).
5. Disconnect HV DC supply + connection (8).
6. Disconnect HV DC supply – connection (9).
7. Disconnect motor power connection W (4), motor power connection V (6) and motor power connection U (7).
8. Disconnect ground cable from ground connection (2).
9. Block the water flow in the cooling circuit by placing clamps on the two hoses on coolant connections (5) and (13).
10. Disconnect the two hoses from the coolant connections (5) and (13).
11. Remove the four screws from mounting screw holes (3) and remove the inverter.
12. Empty the cooling circuit.

10.5 Inverter installation

WARNING

High voltage - risk of personnel injury and/or damage to equipment

To prevent personnel injury, turn off the main power switch before starting any work on the equipment.

WARNING

Heavy equipment - risk of personnel injury

GVI frame G weighs 21 kg and GVI frame H weighs 25 kg. Use suitable lifting equipment when lifting the units.

Attach the lifting equipment according to chapter 10.5.1.

CAUTION

In dirty environments – risk of damage to equipment

Make sure to connect the motor power connections (4, 6 & 7) and the HV DC supply connections (8 & 9) in a clean environment to avoid debris in the GVI.

The sealing plates for the cable assembly and the box lid are equipped with magnets to close the HVIL–loop. Make sure that the sealing plates and the box lid are clean from dirt and debris before mounting them in the inverter.

10.5.1 Lifting of GVI frames G & H

WARNING

Heavy equipment - risk of personnel injury

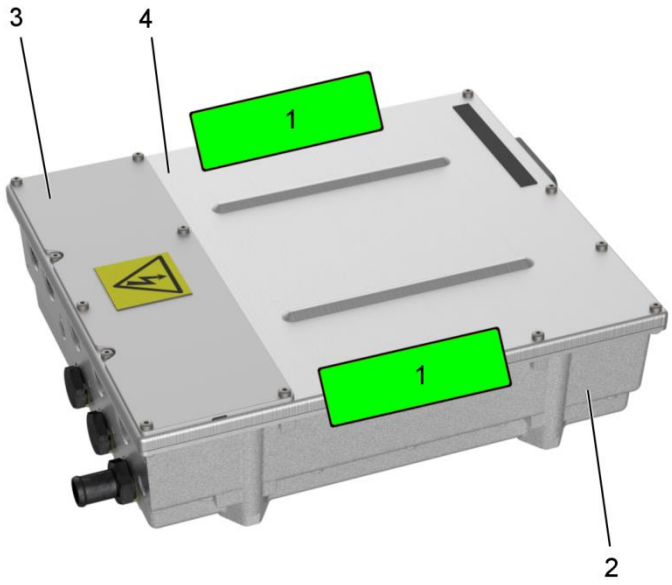
GVI frame G weighs 21 kg and GVI frame H weighs 25 kg. Use suitable lifting equipment when lifting the units.

CAUTION

Use recommended lifting area - risk of damage to equipment

Lifting straps may exert pressure to the lid which may deform the lid and/or components in the GVI frames G & H.

Only use the recommended areas according to Figure34 when attaching any kind of lifting arrangement.



Pos	Name	Pos	Name
1	Recommended area	2	Heat sink
3	Service lid	4	Lid

Figure 34: Recommended areas for lifting arrangements

The four mounting holes (3, Figure 10) can be used for attachment of a lifting device.

Lifting and handling of the GVI may also be done by gripping the unit with a fork arrangement. The gripping tool shall be soft gripping around the edge of the heatsink (2, Figure 34) in such way that no force is applied on the lid (4, Figure 34).

The area around the service lid is the least stable part of the lid (3, Figure 34). The recommended area (1, Figure 34) for attachment of lifting arrangements provides lid stability and balance of the inverter.

10.5.2 Mounting of GVI frames G & H

WARNING

Heavy equipment - risk of personnel injury

GVI frame G weighs 21 kg and GVI frame H weighs 25 kg. Use suitable lifting equipment when lifting the units.

Attach the lifting equipment according to chapter 10.5.1.

1. Mount the inverter with screws in the mounting holes (3, Figure 10).

10.5.3 Connecting cooling circuit

Cooling circuit connection requirements are specified in chapter 7.11. Position numbers refer to Figure 10.

1. Connect hoses to the coolant connections (5, Figure 10 and (13, Figure 10).

10.5.4 Connecting HV DC supply connection cables and motor cables

CAUTION

Electrical disturbances – risk of malfunctioning equipment

The shields of the HV DC supply connection cables (8 and 9, Figure) and the motor power connection cables (4, 6 and 7, Figure) shall be connected to the GVI frames G & H chassis. This is done by following the instructions in this chapter.

NOTE

This chapter describes a typical installation with 50 or 70 mm² cables. Other cables areas can be used.

The procedure in this chapter describes how to connect the cables for motor power connection W (4, Figure 10), motor power connection V (6, Figure 10) and motor power connection U (7, Figure 10). This is also the procedure for connection of HV DC supply + connection (8, Figure 10) and HV DC supply - connection (9, Figure 10).

10.5.4.1 Removal of service lid

WARNING

High voltage - risk of personnel injury and/or damage to equipment

Always verify that the DC Bus is at a safe level (<60V) before removing the DC-voltage service lid.

WARNING

Magnetic fields - risk of damage to safety equipment

Keep the HVIL magnets away from strong magnetic fields and high temperature (see example of HVIL magnet (2, Figure 35)).

Take care not to damage the HVIL magnets during handling.

Protect the HVIL magnets from dust and dirt.

Pos	Name	Pos	Name
1	Screw (six pieces)	2	HVIL magnet for service lid
3	Service lid		

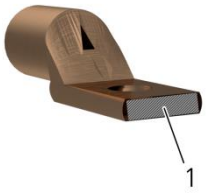
Figure 35 Removal of service lid

Remove service lid (3) by removing screws (1).

10.5.4.2 Preparation of the cables

NOTE

If the cable lugs are crimped onto the cables before these are passed through the AC and DC adapter kit, the cross-section (1, Figure 36) of the cable lugs must be able to pass through a hole with diameter Ø19.79 mm.



Pos	Name
1	Cross-section area

Figure 36 Cable lug cross-section area

NOTE

The cable strip lengths in Figure 38 for a KRT 70-8 cable lug with the measurements shown in Figure 37. If cable lugs with other dimensions are used, the cable strip lengths (measurements c and d in Figure 38) shall be calculated on the basis of the longest distance in Figure 38.

NOTE

Maximum allowable width of the cable lugs is 22 mm.

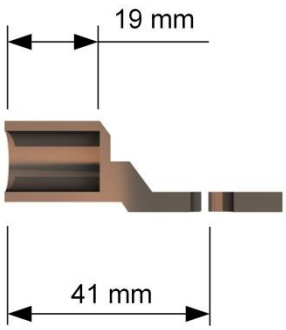
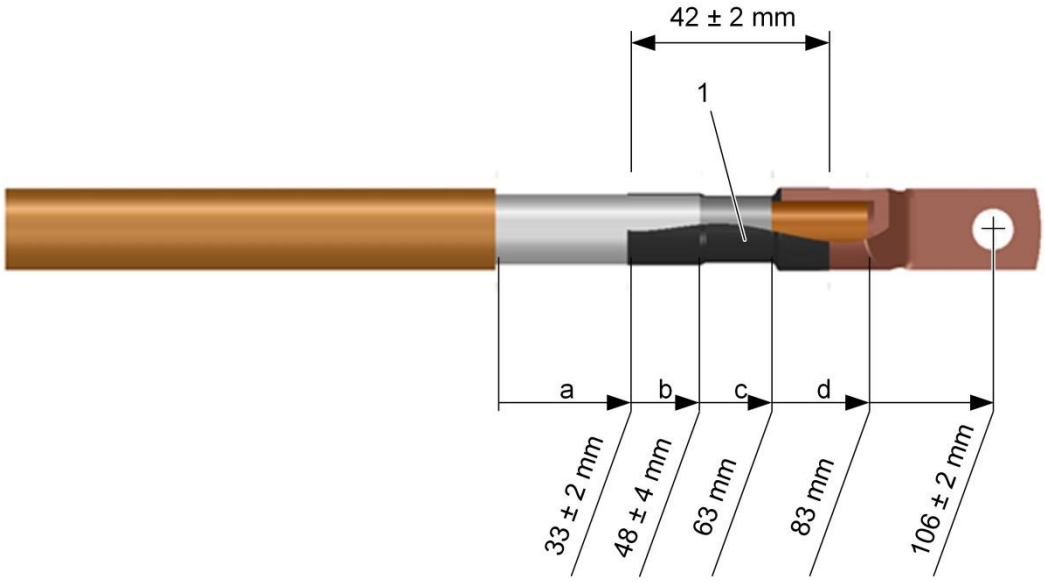


Figure 37 KRT 70-8 Cable lug



Pos	Name	Pos	Name
1	Heat shrink tubing	a	Distance from the cable protective jacket to heat shrink tubing (1)
b	Stripped shield	c	Stripped insulation
d	Stripped core	e	Distance d + distance from end of cable to center of cable lug hole
f	Length of crimped heat shrink tubing (1)		

Figure 38 Cable strip lengths when a cable lug with measurements as in Figure 37 is used

1. Strip cores, insulations, and shields of each cable according to Figure 38 (the strip lengths depend on the cable lugs used; see the note above Figure 37).
2. Mount a cable lug on each of the cables according to Figure 38.
3. Crimp a heat shrink tubing to length f onto each of the cables according to Figure 38.

10.5.4.3 Mounting of cable glands

WARNING

Magnetic fields - risk of damage to safety equipment

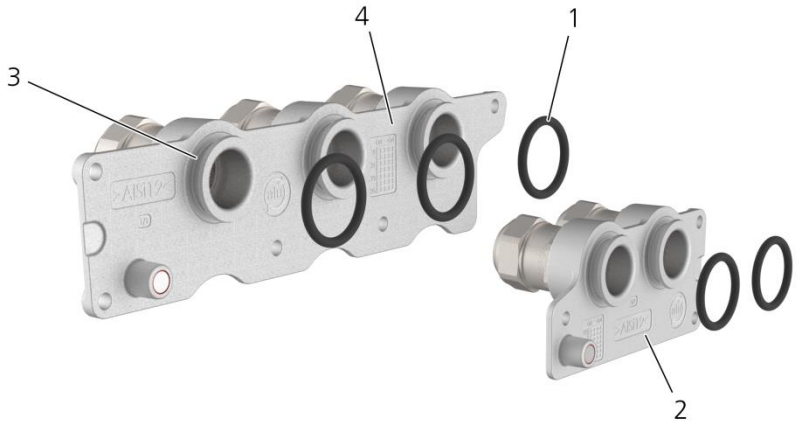
Keep the HVIL magnets away from strong magnetic fields and high temperature.

Take care not to damage the HVIL magnets during handling.

Secure the HVIL magnets from dust and dirt.

NOTE

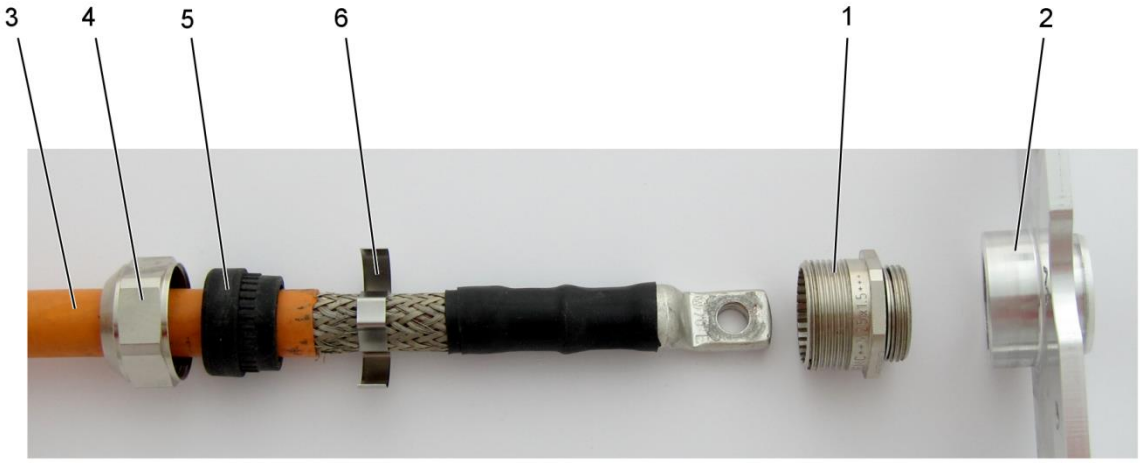
This instruction can be used when installing a new GVI or when reinstalling a GVI after maintenance. Apply the necessary steps depending on the situation.



Pos	Name	Pos	Name
1	O-ring x 5	2	DC adapter plate
3	Contact groove x 5	4	AC adapter plate

Figure 39 Cleaning of AC and DC adapter kit

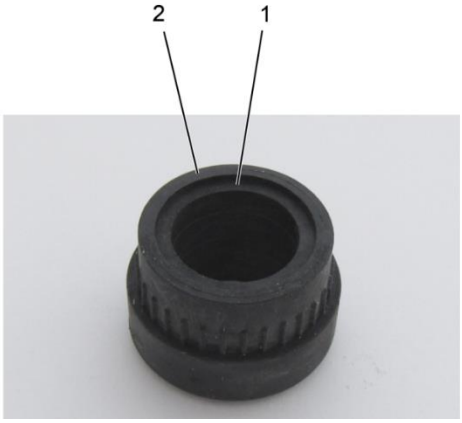
1. Visually inspect DC adapter plate (2), AC adapter plate (4) and o-rings (1). The parts must be free from debris and o-rings (1) must be greased. If these conditions are met, continue with the next numbered step. If the conditions are not met, do the following:
   a. Remove o-rings (1). Clean o-rings (1) and contact grooves (3) from debris and grease. A small amount of residual grease (less than 5 % of total necessary amount) is acceptable.
   b. Grease o-rings (1) as follows: **If the service area temperature is above -5 °C**, use Fluoronox S 90/2 or Fluoronox MS 10/2. **If the temperature is below -5 °C**, use Fluoronox MS 10/2.
   c. Install o-rings (1) in contact grooves (3).



Pos	Name	Pos	Name
1	Cable gland connector ring	2	Adapter plate
3	Cable	4	Cable gland retaining ring
5	Sealing rubber	6	Shield clip

Figure 40 Cable assembly on GVI frames G & H exterior side

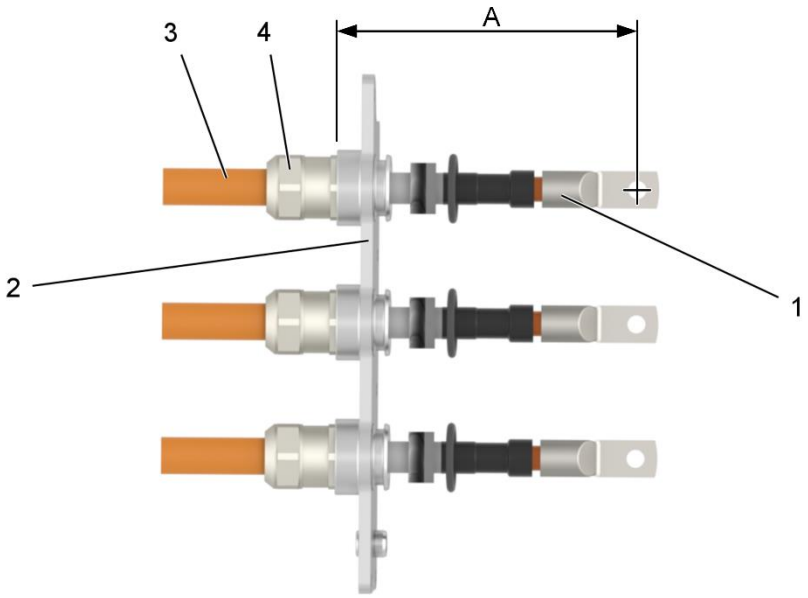
2. Protect cable gland connector ring (1) against inadvertent loosening and screw it into adapter plate (2). Tightening torque 10 Nm.
3. Place cable gland retaining ring (4) on cable (3).



Pos	Name	Pos	Name
1	Inner ring for smaller OD cable	2	Outer ring for larger OD cable

Figure 41 Sealing rubber

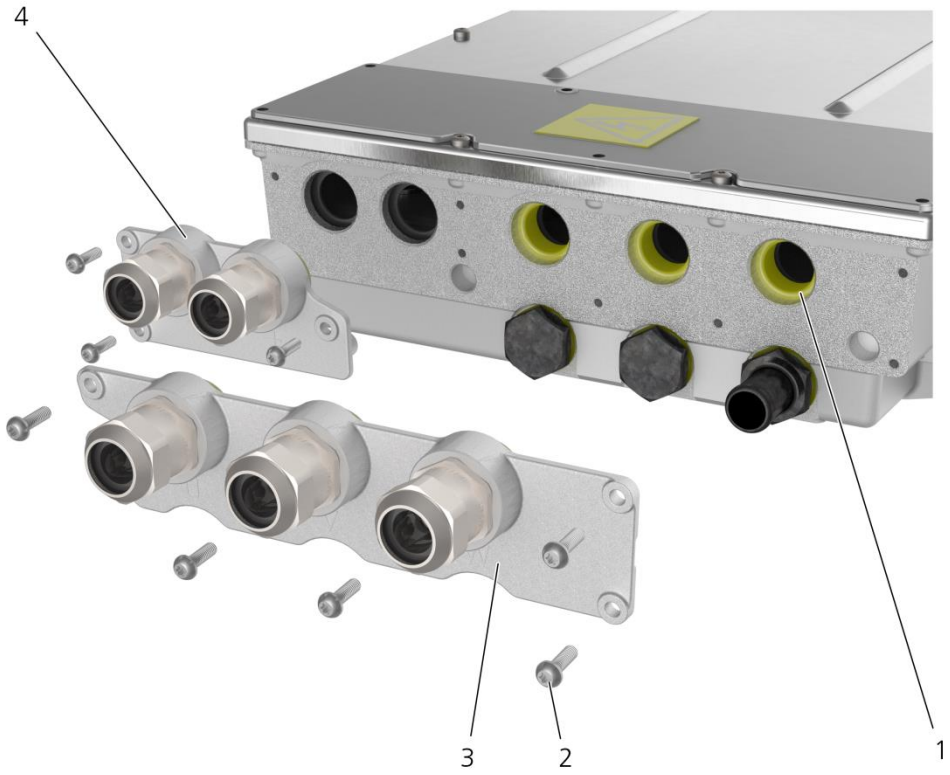
4. If using cables with an overall diameter greater than 16mm: Remove inner ring (1, Figure) from sealing rubber (5, Figure 40).
5. Place sealing rubber (5, Figure 40) on cable (3, Figure 40).
6. Place shield clip (6, Figure) on the stripped shield as shown in the Figure .
7. Fit cable (3, Figure 40) in cable gland connector ring (1, Figure 40) without tightening cable gland retaining ring (4, Figure 40).



Pos	Name	Pos	Name
1	Cable lug	2	Adapter plate (AC or DC adapter plate)
3	Cable	4	Cable gland retaining ring
A	92 mm		

Figure 42 Assembly of adapter plate

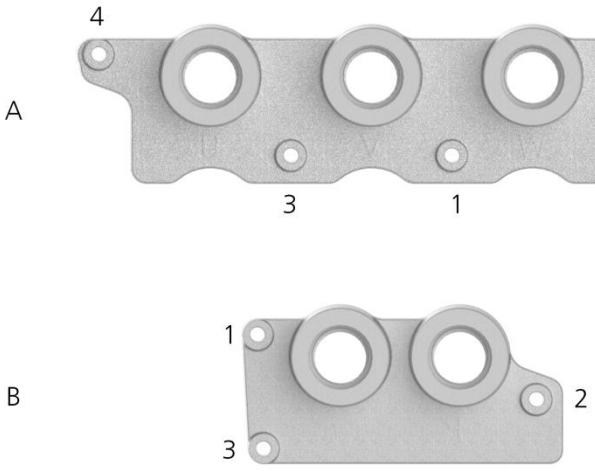
8. Adjust the cable lug (1, Figure 42) according to distance (A) (make a fixture to provide sufficient accuracy).



Pos	Name	Pos	Name
1	Sealing surface x 5	2	Screw x 8 (refer to pos. 10, Figure11 for screw specifications)
3	AC adapter plate	4	DC adapter plate

Figure 43 Mounting of AC and DC adapter kit

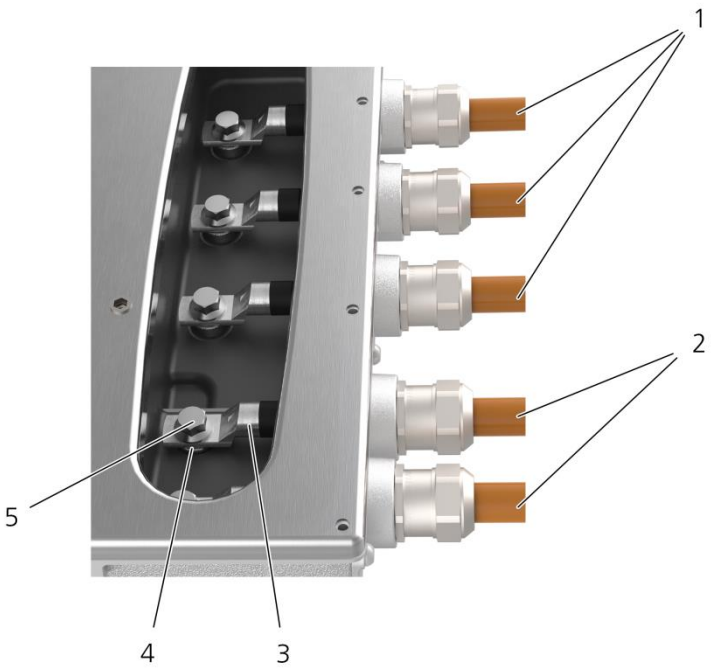
9. Clean sealing surfaces (1) from debris and grease if necessary.



Pos	Name	Pos	Name
A	AC adapter plate	B	DC adapter plate

Figure 44 Mounting screw tightening order for AC and DC adapter kit

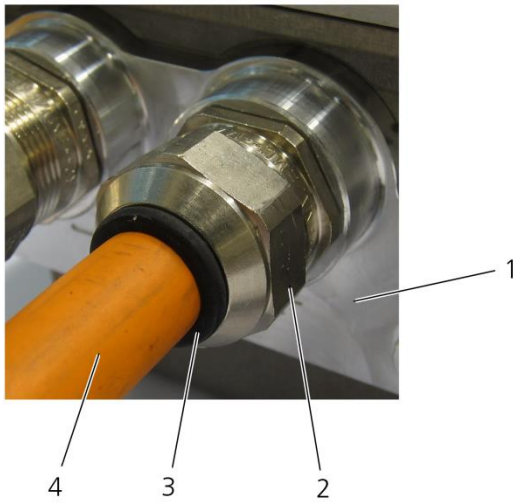
10. Secure AC adapter plate (3, Figure 43) and DC adapter plate (4, Figure 43) to the GVI with screws (2, Figure 43). Tighten them two to three turns in the tightening order shown in Figure .
11. Torque tighten screws (2, Figure 43) in the order shown in Figure 44. Tightening torque according to position 10, Figure8.



Pos	Name	Pos	Name
1	Motor cable x 3	2	HV DC connection cable x 2
3	Cable lug x 5	4	Terminal x 5
5	Screw x 5		

Figure 45 Connecting HV DC supply connection cables and motor cables

12. Connect motor cables (1) and HV DC connection cables (2) to terminals (4) with screws (5). Recommended screws (5):
    - M8, class 8.8
    - Tightening torque 23 Nm ± 20 %
    - Screw engagement 12 – 18 mm



Pos	Name	Pos	Name
1	Adapter plate (AC or DC adapter plate)	2	Cable gland retaining ring
3	Sealing rubber	4	Cable (motor cable or HV DC connection cable)

Figure 46 Cable gland mounting for AC and DC adapter kit

13. Secure the cable (4) in position by tightening cable gland retaining ring (2) according to the following:
    d. Either fully (until sealing rubber (3) protrudes from cable gland retaining ring (2) from the end opposite to adapter plate (1) as shown in Figure 46, or
    e. Until maximum allowable torque Nm is reached, see table 17.

Cable area [mm²]	Tightening torque [Nm]
50	7
70	4

Table 19 Maximum allowable tightening torques for M25x1.5 cable gland retaining ring (4, Figure 42)

10.5.5 Installation of service lid

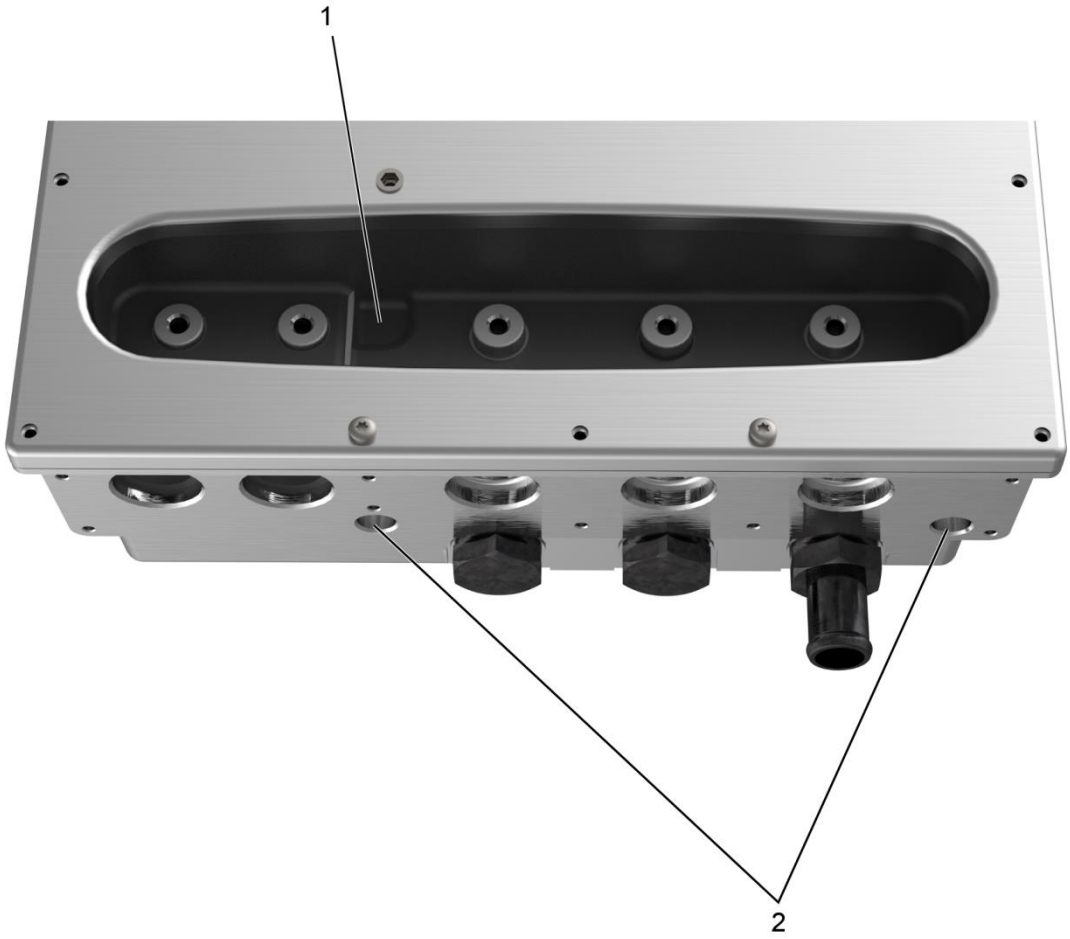
WARNING

Magnetic fields - risk of damage to safety equipment

Keep the HVIL magnets away from strong magnetic fields and high temperature.

Take care not to damage the HVIL magnets during handling.

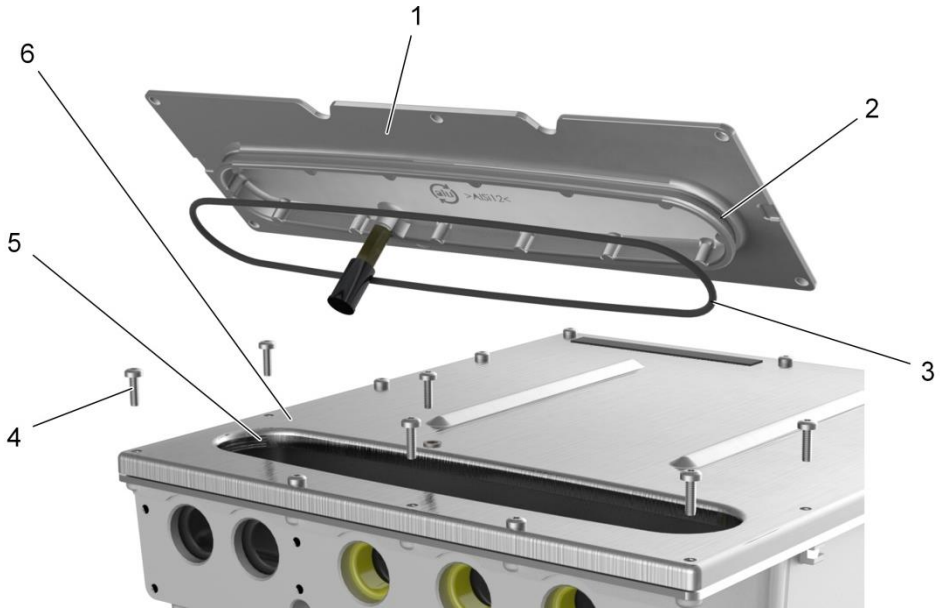
Protect the HVIL magnets from dust and dirt.



Pos	Name	Pos	Name
1	Service lid contact point	2	Adapter plate contact point (bottom of hole) x 2

Figure 47 HVIL contact point

1. Clean HVIL contact points (1 and 2) to remove metal chips if necessary.



Pos	Name	Pos	Name
1	Service lid	2	Contact groove
3	O-ring	4	M5 x 16 screw x 6
5	Sealing surface	6	GVI lid

Figure 48 Mounting of service lid

2. Visually inspect contact groove (2), sealing surface (5) and o-ring (3). The parts must be free from debris and o-ring (3) must be greased.O-ring (3) must not be damaged or loose. If these conditions are met, continue with the next numbered step. If the conditions are not met, do the following:
   a. Remove o-ring (3) from service lid (1). Replace o-ring (3) if it is damaged or loose, otherwise clean o-ring (3), contact groove (2) and sealing surface (5) from debris and grease. A small amount of residual grease (less than 5 % of total necessary amount) is acceptable.
   b. Grease o-ring (3) as follows: **If the service area temperature is above -5 °C**, use Fluoronox S 90/2 or Fluoronox MS 10/2. **If the temperature is below -5 °C**, use Fluoronox MS 10/2.
   c. Install o-ring (3) in contact groove (2).
3. Place service lid (1) on to GVI lid (6) making sure o-ring (3) is correctly positioned in contact groove (2).

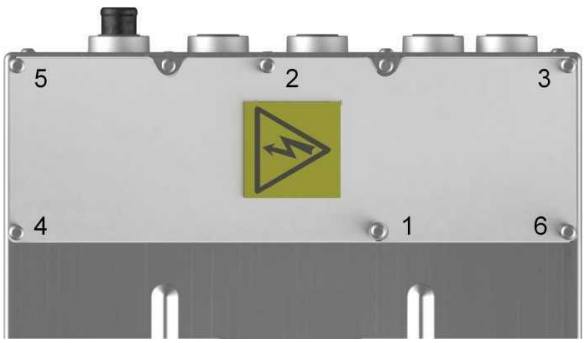


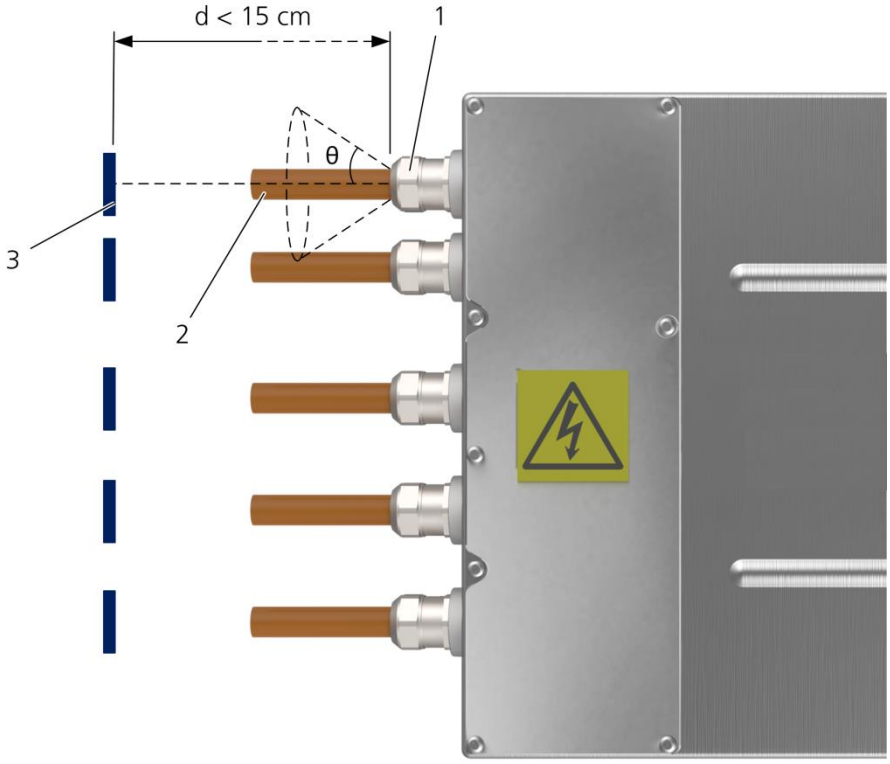
Figure 49 Screw tightening order

4. Fit screws (4). Tighten them two to three turns in the tightening order shown in Figure49.
5. Make sure o-ring (3, Figure 48) is correctly positioned in contact groove (2, Figure 48) by lifting service lid (1, Figure 48) carefully, if possible.
6. Tighten screws (4, Figure 48) with tightening torque 5.5 Nm ± 20 % in the order shown in Figure 48.

10.5.6 Connecting electrical and coolant connections

Electrical connections requirements are specified in chapter 7.11.

4. Connect ground connection (2).
5. Connect motor power connection W (4), motor power connection V (6) and motor power connection U (7).
6. Connect GVI logic cable to I/O connector (1).
7. Connect coolant connections (5) and (12).
8. Connect HV DC supply + connection (8).
9. Connect HV DC supply - connection (9).



Pos	Name	Pos	Name
1	Cable gland retaining ring x 5	2	HV DC connection cable x 2 Motor cable x 3
3	Cable support x 5	θ	Max. allowed angle for cables (2) = 30° in relation to axis of cable/cable retaining ring (1)
d	Distance to nearest cable supports (3)		

Figure 50 Positioning of cable supports. The dotted line indicates that the figure is not according to scale

CAUTION

Vibration – risk of damage to equipment

Distance ʻdʼ in Figure50 between cable retaining rings (1) and the nearest cable supports (3) must not be more than 15 cm to prevent vibration damage to the GVI from movements during operation of the equipment.

1. Support cables (2) at distance ʻdʼ from the cable retaining rings (1). Distance ʻdʼ must not exceed 15 cm. Cable angles must not exceed θ in any direction.
   More cable supports may be needed depending on the specific vehicle design.
2. Fill the GVI with coolant according to chapter 12.7

10.6 Painting of the inverter

The inverter can be painted. The following parts must be masked before painting:

- Labels and warning signs
- Connections for coolant hoses (refer to Figure 10)
- Screws for service lid (see Figure 35)
- Areas where the AC and DC adapter plates (chapter 7.11.3.1) meet the inverter including open screw holes
- Moisture vent (refer to Figure 9
- Ground connection area including ground marking (refer to Figure 11)

After painting, the unit can be dried at maximum 90 °C for maximum 30 minutes.

10.7 Welding

Before welding is performed in a vehicle or equipment where the GVI is installed the following instruction must be followed:

3. Disconnect all electrical connectors from the GVI except the ground strap, which must remain connected.
4. Protect the GVI from heat and exposure to sparks.
5. Make sure that the GVI ambient temperature doesn't exceed the storage temperature specified in chapter 12.8.2.

10.8 Start-up and commissioning

This section presents a general procedure for startup and verification of the GVI installation in a vehicle.

WARNING

Commissioning a vehicle - risk of personnel injury or damage to equipment

Wiring errors, improper setup, or other conditions may cause the vehicle to move in the wrong direction or at the wrong speed.

Take necessary precautions to prevent injury to personnel or damage to equipment prior to applying power for the first time.

10.8.1 Checks prior to initial power up

Perform the following checks before applying power to an GVI inverter for the first time:

1. Verify that the correct GVI inverter with item number for the application has been installed.
2. Verify that the correct software for the application has been loaded into the GVI inverter.
3. Verify that all power and signal wiring to the GVI are correctly done.
4. Check that the motor power connections and the HV DC supply connections are tightened according to 10.5.4.3.
5. Verify that the control I/O plug is fully mated and latched into position with the mating connector on the GVI inverter.

11 Troubleshooting

Error codes can vary with the unit's software version. Therefore no general information is given here. To get error codes for a specific unit, contact Parker Application Engineer and state serial number, part number and date of manufacturing.

The symptom, emergency error codes, error and warning bitfield and related troubleshooting charts presented in this section utilize the CANopen communications protocol.

12 Product Specifications

12.1 General

Description	Value
Motor type	Permanent Magnet AC
Switching frequency	1, 2, 4 and 6 kHz, (optional 8,12, 16 & 20 kHz with de-rating)
stator current frequency	0- 599 Hz
Control mode	Current, Speed, Torque and DC Voltage Control Modes
Communication	CANopen, CAN J1939
Connector	TYCO MCP 39-pin
Nominal WEG coolant temp/flow	60°C @ 20 l/min
Sealing level	IP6K9K
Operating temperature	-40°C to + 85°C (-40°F to +185°F)
Storage temperature	-40°C to + 85°C (-40°F to +185°F) ambient humidity of 95%

12.2 Electrical safety

See also chapter 12.8 for isolation testing and standards compliance.

12.2.1 HVIL

Description	Value
Required current supply	15 mA DC current

12.2.2 UN-ECE-R100 compliance

The following harmonized sections of UN-ECE-R100 have been applied:

Chapter	Description
5.1.1.4	Service disconnect
5.1.1.5.1	Marking
5.1.2.1	For protection against electrical shock
5.1.2.2	The resistance between all exposed conductive parts
5.1.3.1	Isolation resistance
5.1.3.2	Isolation resistance

12.3 Current and power output ratings

GVI model	Nominal DC supply voltage [V DC]	Rated current [ARMS]		Power [KVA]	
		S2, 60 s	S2, 1 h	S2, 60 s	S2, 1 h
Frame G	650	320*	225**	180***	130***
Frame H	650	500*	375**	300***	220***

* 60 sec rating at 4 kHz switching frequency and 25ºC ambient temperature.

** 1 h rating at 4 kHz switching frequency, 60ºC coolant temperature, 85ºC ambient temperature and 18 l/min coolant flow.

*** At nominal DC bus voltage.

12.4 DC supply voltage requirement

Nominal DC supply voltage [V DC]	Operating range [V DC]	Hardware Overvoltage [V DC]	Instantaneous maximum (< 5 s) [V DC]
650	100 - 750	880	1 100

12.5 I/O Interface technical data

12.5.1 Digital inputs

Description	Value
Threshold level for logic low	3 V
Threshold level for logic high	6 V

12.5.2 Unit enable

Description	Value
Threshold level for logic low	3 V
Threshold level for logic high	6 V

12.5.3 Logic supply

Description	Value
Input power	30 W
Start-up voltage	9 V
Nominal operating voltage range	8 – 36 V

Supply voltage [V]	**Signal pin number**	**Unit enable** OFF **[mA]**	**Unit enable** ON		
			Power stage disabled [mA]	Power stage enabled, 4kHz [mA]	Power stage enabled, 6kHz [mA]
14	Unit Enable #35	101.0	111	111	111
14	Logic Supply #39	101.0	1 000	1 300	1 450
28	Unit Enable #35	50.5	55.5	55.5	55.5
28	Logic Supply #39	50.5	275	350	387.5

Table 20 Typical current consumption for GVI with resolver feedback

12.5.4 Sensor supply resolver

Description	Value
Sensor supply	Selectable, 5 or 12 V
Maximum output current	140 mA

12.6 Voltage monitoring

$V_{1\text{-}6}$ refer to Figure 4.

Data type	Voltage Range	Functionality
Voltage measurement range	0 – 1 000 [V ±2%]	Standard
Software overvoltage trip (V_5)	Configurable	Standard
Hardware overvoltage trip (V_6)	>880 [V ±2%]	Standard
DC bus voltage range	100-750 [V ±0.5%]	Standard
Motoring torque reduction (V_1 - V_2)	< 100 [V]	Configurable
Regenerating torque reduction (V_3 - V_4)	750-800 [V]	Configurable

12.7 Coolant specification

Description	Value
Minimum required coolant flow	See Figure
Maximum coolant flow	18 l/min
Coolant mixture (WEG) requirements	Minimum 38% ethylene glycol and remaining part water (percent of total volume @20C)
	Maximum 52% ethylene glycol and remaining part water (percent of total volume @20C)
Coolant amount	GVI Frame G = 0,46 dm³
	GVI frame H = 0,64 dm³
Max. coolant operational pressure	200 kPa (relative to atmospheric pressure)
Max. coolant pressure drop	See Figure 51 (GVI Frame G) See Figure 52 (GVI Frame H)
Max. coolant test pressure	for 60 sec 300 kPa (relative to atmospheric pressure)
Max. negative pressure (vacuum filling)	-85 kPa (relative to atmospheric pressure)
Max. coolant temperature rise	5 °C
Max. coolant inlet temperature	60 °C

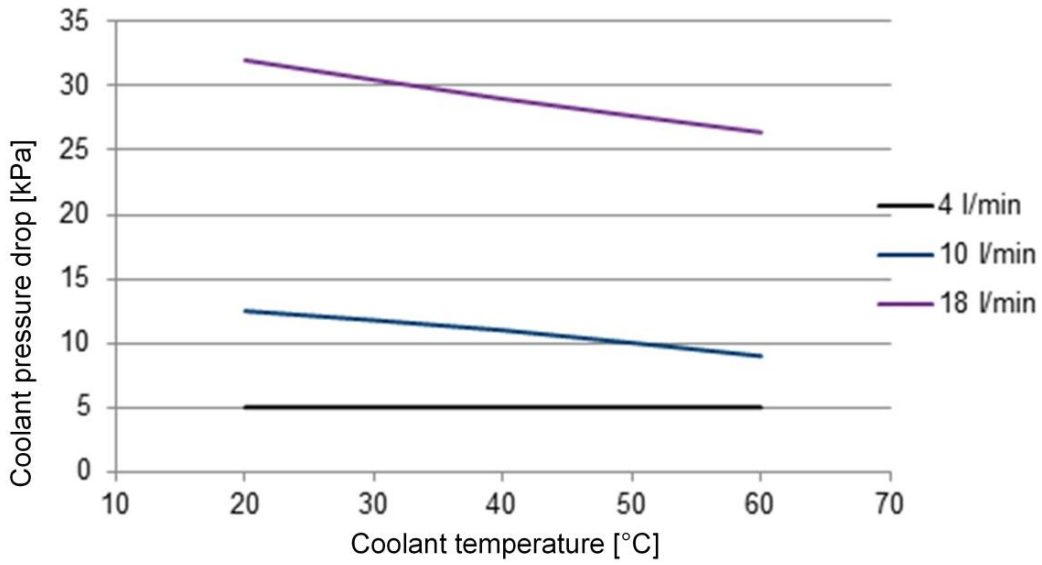


Figure 51 GVI frame G maximum coolant pressure drop (50/50% coolant mixture)

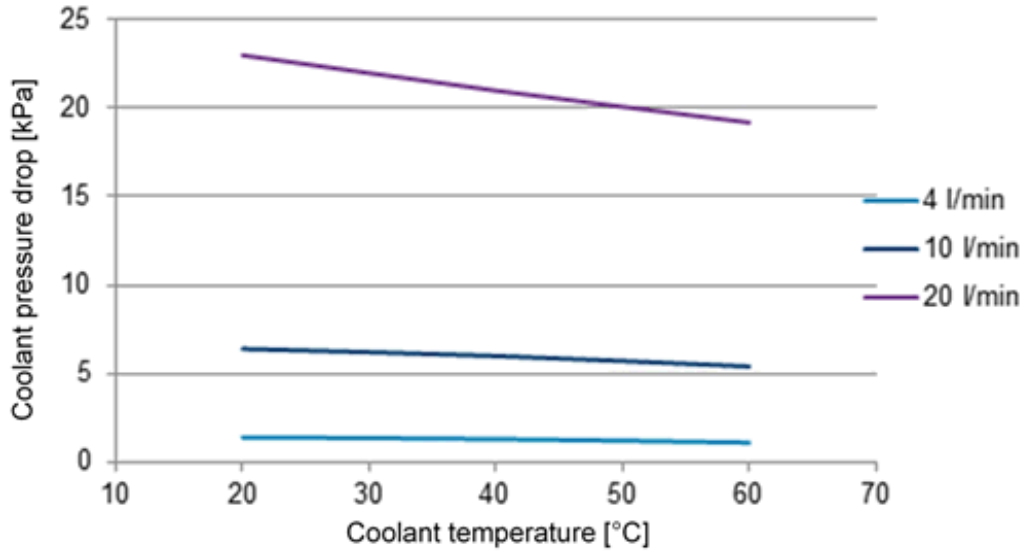


Figure 52 GVI frame H Maximum coolant pressure drop (50/50% coolant mixture)

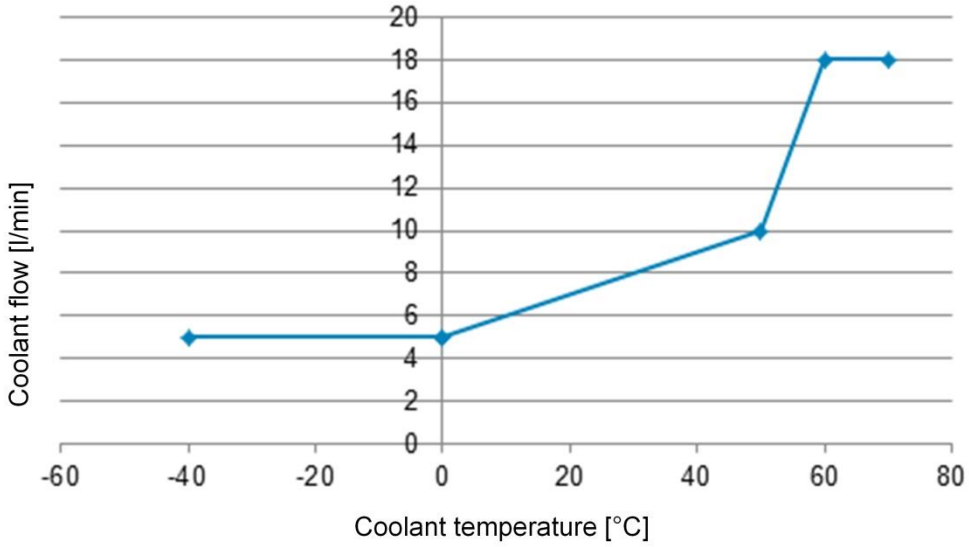


Figure 53 GVI minimum coolant flow (50/50% coolant mixture)

12.8 Environmental testing & standards appliance

12.8.1 General

Subject	Standard
Protection class	IP6K9K Test ISO20653:2006 (with mating I/O connector installed)

12.8.2 Temperature

Subject	Standard
Operation -40 °C to 85 °C	ISO 16750-4:2010 code letter G
Cold storage/dry heat storage -40 °C /85 °C	ISO16750-4, chapter 5.1 Test at constant temperature. Duration 48 hours
Change of temperature -40 °C to 85 °C	ISO16750-4, chapter 5.3.1 according to IEC68-2-14, Test Nb. 30 cycles
Rapid temperature change -40 °C to 85 °C	ISO16750-4, chapter 5.3.2 according to IEC68-2-14, Test Na. 100 cycles

12.8.3 Ice water

Subject	Standard
Splash	ISO16750-4, chapter 5.4.2. 100 cycles
Submersion	ISO16750-4, chapter 5.4.2. 10 cycles

12.8.4 Salt spray

Subject	Standard
Corrosion	ISO16750-4, chapter 5.5.1 according to IEC60068-2-52 Test Kb. 2 cycles of 7 days duration
Leakage and function	ISO16750-4, chapter 5.5.2 according to IEC60068-2-11 Test Ka. 6 cycles with 24 hour profile

12.8.5 Humidity

Subject	Standard
Composite temperature/humidity cyclic test	ISO16750-4, chapter 5.6 according to IEC60068-2-38, Test Z/AD
Damp heat, steady-state	ISO16750-4, chapter 5.7 according to IEC60068-2-78. Duration 21 days

12.8.6 Mechanical tests

Subject	Standard	
Vibration random	Vibration test (random): ISO 16750-3, chapter 4.1.2.7	
	Frequency	**Acceleration PSD**
	[Hz]	[g2/Hz]
	6	0.03
	8	0.2
	10	0.7
	20	0.36
	30	0.36
	49	0.75
	100	0.15
	200	0.05
	500	0.015
	1000	0.01
	2000	0.001
	Total g RMS	8.34
	Crest factor	3.0
	Duration	48 h in each direction X, Y and Z
Vibration and thermal cycling	ISO 16750-3 Mechanical loads, Code: N, O ISO 16750-4 5.3.1 Table 2, simultaneous vibration and temperature cycling with the exceptions: Operating mode 3.2 ramping from Tmin to Tmax Operating mode 1.2 where no operation is required. Pass criteria: FSC A during operating mode 3.2. FSC C during operating mode 1.2	
Bump 30 g	EN60068-2-29:1994 Test Eb. 1 000 positive and 1 000 negative half sine pulses with acceleration of 30g, pulse length 6 ms for all 3 octagonal axes.	
Shock 50 g	EN60068-2-27:2008 Test Ea 10 positive and 10 negative half sine pulses with acceleration of 50 g, pulse length 6 ms for all 3 octagonal axis	

12.8.7 EMC

Subject	Standard
Emission	CISPR25 Edition 4, Class 3
Immunity 200 MHz – 3 GHz 100 V/m	Immunity to electromagnetic far field from antenna for level IV[1] in accordance with ISO11452-2.
Bulk current injection	ISO 11452-4 150 KHz – 400 MHz, 200 mA
Conducted susceptibility	ISO 7637-2
Immunity to low frequency magnetic fields	ISO 11452-8 level IV
Legislation	ECE-R10
ESD air discharge	ISO 10605 level III

12.8.8 Isolation

Subject	Standard
Each DC-bus terminal to chassis	> 25 MOhm
Total capacitance DC-bus to chassis	< 200 nF
Creepage and clearance distances	IEC60664-1:2007 for the test voltage required by ISO6469-3:2011 (800 Vdc)

12.8.9 Environment liquids

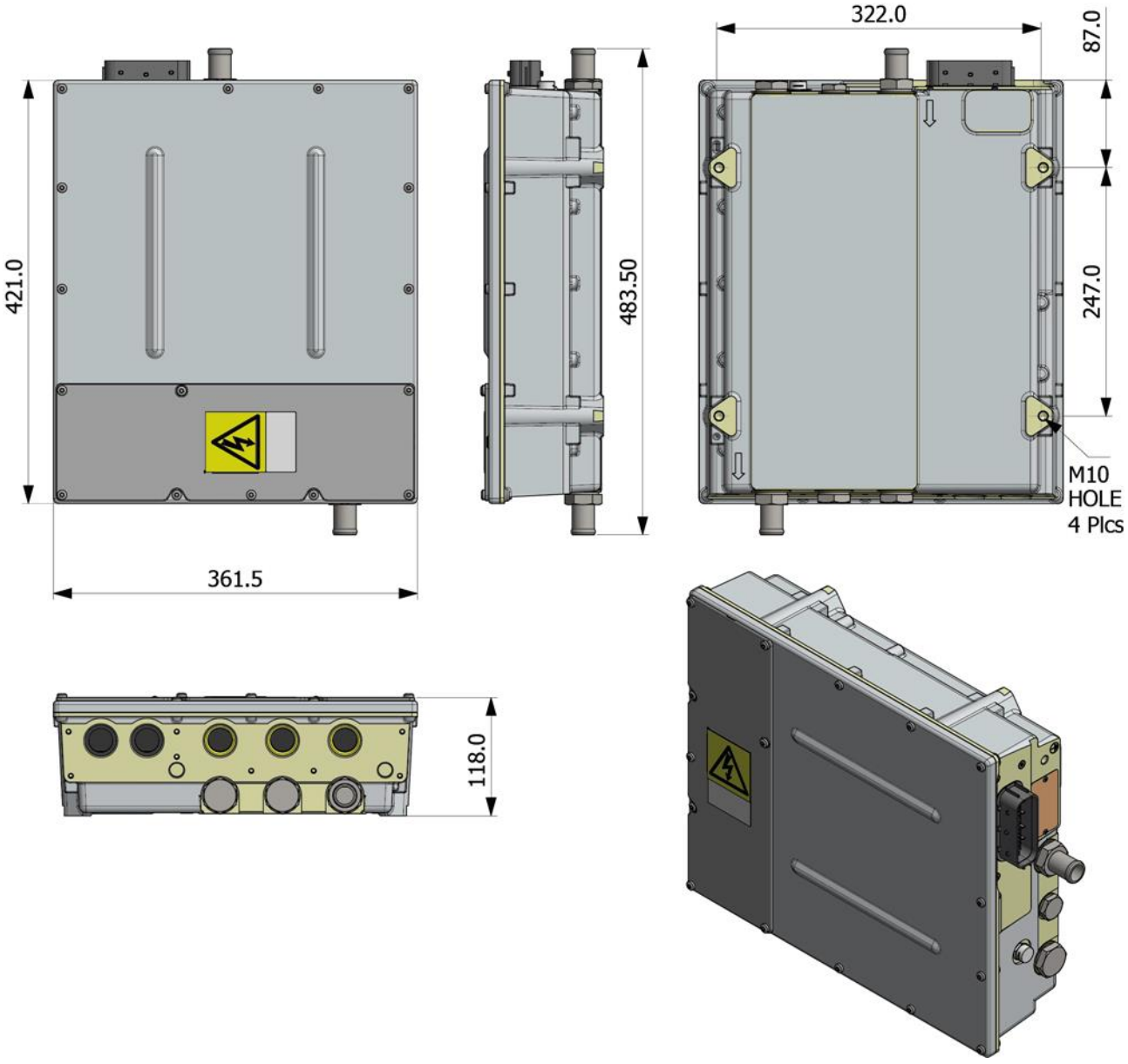
The unit is designed to withstand liquids like transmission oil, solvents, diesel fuel and engine oil. Tested according to ISO16750-5 code Z.

[1] Actual level depends on GVI type, motor design and system installation.

12.9 Physical characteristics

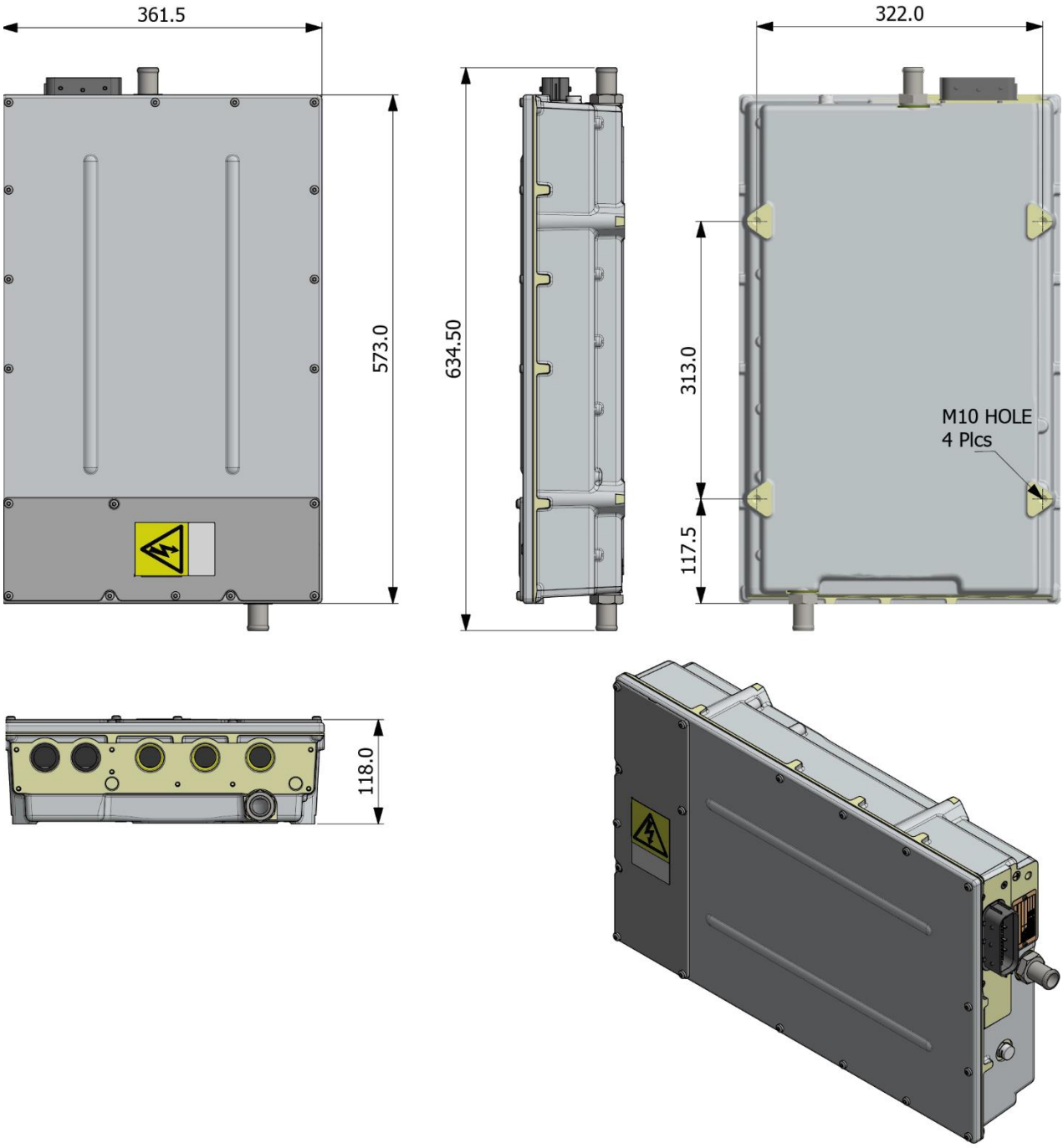
12.9.1 Dimensions and weight

12.9.1.1 GVI_ frame G



Weight frame G: 21 kg

12.9.1.2 GVI_ frame H



Weight frame H: 25 kg

13 Material identification

13.1.1 Plastics

Plastic parts with a weight of more than 100 grams are marked according to ISO 11469; ISO 1043-1, 1043-2 and 1043-4.

13.1.2 Aluminum

Aluminium parts with a weight of more than 200 grams are marked with:

- Alloy
- Recycling symbol

For example: Alloy type >AlSi10Mg< and symbol below.

14 Declaration of Incorporation

Parker Hannifin Manufacturing Germany GmbH & Co KG

Robert-Bosch-Straße 22
D-77656 Offenburg

Tel.: +49 (0) 781-509-0
Fax.: +49 (0) 781-509-98176

www.parker.com/eme

DECLARATION OF INCORPORATION

DOCUMENT: DOI009-R1.0 - DECLARATION OF INCORPORATION GVI GH.DOCX

Manufacturer **Parker Hannifin Manufacturing Germany GmbH & Co KG**

Address **Robert-Bosch-Straße 22**
77656 Offenburg
Germany

declares under sole responsibility compliance of the following products

Product **GVI Mobile Inverters**

Product name **GVI Frames G & H**

with:

UN-ECE-R100 compliance

The following harmonized sections of UN-ECE-R100 have been applied:

Chapter	Description
5.1.1.4	Service disconnect
5.1.1.5.1	Marking
5.1.2.1	For protection against electric shock
5.1.2.2	The resistance between all exposed conductive parts
5.1.3.1	Isolation resistance
5.1.3.2	Isolation resistance

General

Subject	Standard
Protection class	IP6K9K Test ISO20653:2006 (with mating I/O connector installed)

Temperature

Subject	Standard
Operation -40 °C to 85 °C	ISO 16750-4:2010 code letter G
Cold storage/dry heat storage -40 °C /85 °C	ISO16750-4, chapter 5.1 Test at constant temperature. Duration 48 hours
Change of temperature -40 °C to 85 °C	ISO16750-4, chapter 5.3.1 according to IEC68-2-14, Test Nb. 30 cycles
Rapid temperature change -40 °C to 85 °C	ISO16750-4, chapter 5.3.2 according to IEC68-2-14, Test Na. 100 cycles

Ice water

Subject	Standard
Splash	ISO16750-4, chapter 5.4.2. 100 cycles
Submersion	ISO16750-4, chapter 5.4.2. 10 cycles

Salt spray

Subject	Standard
Corrosion	ISO16750-4, chapter 5.5.1 according to IEC60068-2-52 Test Kb. 2 cycles of 7 days duration
Leakage and function	ISO16750-4, chapter 5.5.2 according to IEC60068-2-11 Test Ka. 6 cycles with 24 hour profile

Humidity

Offenburg, 22. März 2021
Frank Durban, Division Marketing & Engineering Manager

Parker Hannifin GmbH
Sitz: Bielefeld HRB 35489
USt.-IdNr.: DE 122 802 922
Steuernummer: 5349 5747 1543

Commerzbank Offenburg
BLZ 664 400 84
Konto-Nr. 45 0 19 12 00
BIC/Swift-Code: COBADEFF
IBAN DE95 6644 0084 0450 1912 00

Geschäftsführung:
Dr.-Ing. Hans-Jürgen Haas, Achim Kohler, Kirsten Stenvers, Kees Veraart
Vorsitzender des Aufsichtsrates: Dr.-Ing. Gerd Scheffel

Parker Hannifin Manufacturing Germany GmbH & Co KG

Robert-Bosch-Straße 22
D-77656 Offenburg

Tel.: +49 (0) 781-509-0
Fax.: +49 (0) 781-509-98176

www.parker.com/eme

Subject	Standard
Composite temperature/humidity cyclic test	ISO16750-4, chapter 5.6 according to IEC60068-2-38, Test Z/AD
Damp heat, steady-state	ISO16750-4, chapter 5.7 according to IEC60068-2-78. Duration 21 days

Mechanical tests

Subject	Standard	
Vibration random	Vibration test (random): ISO 16750-3, chapter 4.1.2.7	
	Frequency (Hz)	**Acceleration PSD** (g^2/Hz)
	6	0.03
	8	0.2
	10	0.7
	20	0.36
	30	0.36
	49	0.75
	100	0.15
	200	0.05
	500	0.015
	1000	0.01
	2000	0.001
	Total g RMS	8.34
	Crest factor	3.0
	Duration	48 hours in each direction X, Y and Z
Vibration and thermal cycling	ISO 16750-3 Mechanical loads; Code: N, O ISO 16750-4 5.3.1 Table 2, simultaneous vibration and temperatire cycling with the exceptions: Operating mode 3.2 ramping from Tmin to Tmax Operating mode 1.2 where no operation is required. Pass criteria: FSC A during operating mode 3.2 FSC C during operating mode 1.2	
Bump 30 g	EN60068-2-29:1994 Test Eb. 1 000 positive and 1 000 negative half sine pulses with acceleration of 30g, pulse length 6 ms for all 3 octagonal axes	
Shock 50 g	EN60068-2-27:2008 Test Ea 10 positive and 10 negative half sine pulses with acceleration of 50 g, pulse length 6 ms for all 3 octagonal axis	

EMC

Subject	Standard
Emission	CISPR25 Edition 4, Class 3
Immunity 200 Mhz – 3GHz 100 V/m	Immunity to electromagnetic far field from antenna for level IV[3] in accordance with ISO11452-2
Bulk current injection	ISO11452-4 150 kHz – 400 MHz, 200 mA
Conducted susceptibility	ISO 7637-2
Immunity to low frequency magnetic fields	ISO 11452-8 level IV
Legislation	ECE-R10
ESD air discharge	ISO 10650 level III

Isolation

Subject	Standard
Earth DC-bus terminal to chassis	>25 MΩ
Total capacitance DC-bus to chassis	< 200 nF
Creepage and clearance distances	IEC60664-1:2007 for the test voltage required by ISO6469-3:2011 (800 Vdc)

Offenburg, 22. März 2021
Frank Durban, Division Marketing & Engineering Manager

Parker Hannifin GmbH
Sitz: Bielefeld HRB 35489
USt.-IdNr.: DE 122 802 922
Steuernummer: 5349 5747 1543

Commerzbank Offenburg
BLZ 664 400 84
Konto-Nr. 45 0 19 12 00
BIC/Swift-Code: COBADEFF
IBAN DE95 6644 0084 0450 1912 00

Geschäftsführung:
Dr.-Ing. Hans-Jürgen Haas, Achim Kohler, Kirsten Stenvers, Kees Veraart
Vorsitzender des Aufsichtsrates: Dr.-Ing. Gerd Scheffel

Parker Hannifin Manufacturing Germany GmbH & Co KG
Robert-Bosch-Straße 22
D-77656 Offenburg
Tel.: +49 (0) 781-509-0
Fax.: +49 (0) 781-509-98176
www.parker.com/eme

Environment liquids
The unit is designed to withstand liquids like transmission oil, solvents, diesel fuel and engine oil. Tested according to ISO16750-5 code Z.

APPENDIX: ORDER CODE FOR MANUFACTURER DECLARATION

	1		2,3		4,5,6		7,8		9	
Order example	GVI	-	G650	-	0300S1	-	R00	-	G0000	

1	**Product Family**	
	GVI	Global Vehicle Inverter
2	**Frame Size**	
	G	Frame Size G
	H	Frame Size H
3	**Nominal DC Supply**	
	650	650V DC
4	**Current Rating**	
	650V DC Nominal Voltage	
	0300	300A Frame G
	0500	500A Frame H
5	**Package**	
	S	Single
6	**Series**	
	1	Series 1
7	**Feedback Type**	
	R	Resolver
8	**Reserved**	
	00	
9	**Special Option**	
	G0000	Global Specification
	H0000	European Specification
	N0000	North American Specification

Offenburg, 22. März 2021
Frank Durban, Division Marketing & Engineering Manager

Parker Worldwide

Europe, Middle East, Africa

AE – United Arab Emirates,
Dubai
Tel: +971 4 8127100
parker.me@parker.com

AT – Austria, St. Florian
Tel: +43 (0)7224 66201
parker.austria@parker.com

AZ – Azerbaijan, Baku
Tel: +994 50 2233 458
parker.azerbaijan@parker.com

BE/NL/LU – Benelux,
Hendrik Ido Ambacht
Tel: +31 (0)541 585 000
parker.nl@parker.com

BG – Bulgaria, Sofia
Tel: +359 2 980 1344
parker.bulgaria@parker.com

BY – Belarus, Minsk
Tel: +48 (0)22 573 24 00
parker.poland@parker.com

CH – Switzerland, Etoy
Tel: +41 (0)21 821 87 00
parker.switzerland@parker.com

CZ – Czech Republic, Klecany
Tel: +420 284 083 111
parker.czechrepublic@parker.com

DE – Germany, Kaarst
Tel: +49 (0)2131 4016 0
parker.germany@parker.com

DK – Denmark, Ballerup
Tel: +45 43 56 04 00
parker.denmark@parker.com

ES – Spain, Madrid
Tel: +34 902 330 001
parker.spain@parker.com

FI – Finland, Vantaa
Tel: +358 (0)20 753 2500
parker.finland@parker.com

FR – France, Contamine s/Arve
Tel: +33 (0)4 50 25 80 25
parker.france@parker.com

GR – Greece, Piraeus
Tel: +30 210 933 6450
parker.greece@parker.com

HU – Hungary, Budaörs
Tel: +36 23 885 470
parker.hungary@parker.com

IE – Ireland, Dublin
Tel: +353 (0)1 466 6370
parker.ireland@parker.com

IL – Israel
Tel: +39 02 45 19 21
parker.israel@parker.com

IT – Italy, Corsico (MI)
Tel: +39 02 45 19 21
parker.italy@parker.com

KZ – Kazakhstan, Almaty
Tel: +7 7273 561 000
parker.easteurope@parker.com

NO – Norway, Asker
Tel: +47 66 75 34 00
parker.norway@parker.com

PL – Poland, Warsaw
Tel: +48 (0)22 573 24 00
parker.poland@parker.com

PT – Portugal
Tel: +351 22 999 7360
parker.portugal@parker.com

RO – Romania, Bucharest
Tel: +40 21 252 1382
parker.romania@parker.com

RU – Russia, Moscow
Tel: +7 495 645-2156
parker.russia@parker.com

SE – Sweden, Borås
Tel: +46 (0)8 59 79 50 00
parker.sweden@parker.com

SK – Slovakia, Banská Bystrica
Tel: +421 484 162 252
parker.slovakia@parker.com

SL – Slovenia, Novo Mesto
Tel: +386 7 337 6650
parker.slovenia@parker.com

TR – Turkey, Istanbul
Tel: +90 216 4997081
parker.turkey@parker.com

UA – Ukraine, Kiev
Tel: +48 (0)22 573 24 00
parker.poland@parker.com

UK – United Kingdom, Warwick
Tel: +44 (0)1926 317 878
parker.uk@parker.com

ZA – South Africa, Kempton Park
Tel: +27 (0)11 961 0700
parker.southafrica@parker.com

North America

CA – Canada, Milton, Ontario
Tel: +1 905 693 3000

US – USA, Cleveland
Tel: +1 216 896 3000

Asia Pacific

AU – Australia, Castle Hill
Tel: +61 (0)2-9634 7777

CN – China, Shanghai
Tel: +86 21 2899 5000

HK – Hong Kong
Tel: +852 2428 8008

IN – India, Mumbai
Tel: +91 22 6513 7081-85

JP – Japan, Tokyo
Tel: +81 (0)3 6408 3901

KR – South Korea, Seoul
Tel: +82 2 559 0400

MY – Malaysia, Shah Alam
Tel: +60 3 7849 0800

NZ – New Zealand, Mt Wellington
Tel: +64 9 574 1744

SG – Singapore
Tel: +65 6887 6300

TH – Thailand, Bangkok
Tel: +662 186 7000

TW – Taiwan, Taipei
Tel: +886 2 2298 8987

South America

AR – Argentina, Buenos Aires
Tel: +54 3327 44 4129

BR – Brazil, Sao Jose dos Campos
Tel: +55 800 727 5374

CL – Chile, Santiago
Tel: +56 2 623 1216

MX – Mexico, Toluca
Tel: +52 72 2275 4200

EMEA Product Information Centre
Free phone: 00 800 27 27 5374
(from AT, BE, CH, CZ, DE, DK, EE, ES, FI, FR, IE, IL, IS, IT, LU, MT, NL, NO, PL, PT, RU, SE, SK, UK, ZA)

US Product Information Centre
Toll-free number: 1-800-27 27 537

www.parker.com

Your local authorized Parker distributor