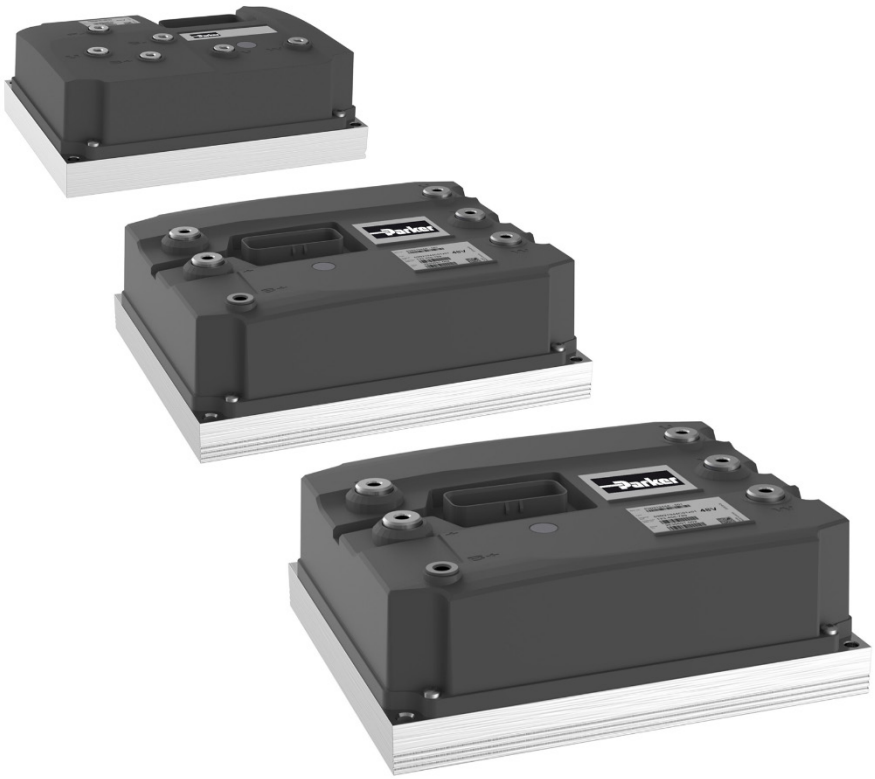

192-300300N7
18.11.2024

GVI Frames C, D and E

Global Vehicle Inverter – Low 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 thereof.

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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 C, D and E.

The terms GVI, motor controller 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
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
LED	Light Emitting Diode
OEM	Original equipment manufacturer
PTC	Positive temperature coefficient
RMA	Return of Material Authorization
PWM	Pulse width modulation
SW	Software

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 C, D & E.

1.1.4.1 Document structure

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

Chapter 9 is intended for installation and maintenance personnel and contains step-by-step instructions for installation and maintenance of the inverter using Parker's recommendations.

The other chapters in this document are mainly intended for designers and contain Parker's general recommendations and guidelines for integration of the motor controller.

1.1.5 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 - ELECTRICITY

This section describes the risk of the hazard

Warns against risk of death or injury where dynamic electricity is the cause

GENERAL WARNING

This section describes the risk of the hazard

Warns against risk of death, injury or damage to equipment with other causes than electricity

WARNING HOT SURFACE

Warns against a hot surface which may cause burn if touched

ELECTROSTATIC SENSITIVE DEVICE

Indicates an electrostatic discharge (ESD) sensitive component, that may be damaged by an electrostatic discharge

Warning magnetic field

Warns against a strong magnetic field that may cause damage to equipment

NOTE

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

1.1.6 Signal word explanations

Signal word	Explanation
Warning	A warning note informs the user of a hazard or potential hazard that could result in serious injury or death if the precautions or instructions given in the warning notice are not observed/followed.
Caution	A caution note informs the user of a hazard or potential hazard that could result in minor or moderate injury if the precautions or instructions given in the caution notice are not observed/followed.
Attention	An attention note informs the user of a hazard or potential hazard that could result in damage to equipment if the precautions or instructions given in the attention notice are not observed/followed.
Note	A note contains supplemental information or references to supplemental information on a topic.

1.1.7 Related documents

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 GVI I/O Control	
5	Application Note: Integration of GVI with IQAN	
6	Application Note: Encoder Offset	

Table 1 : References

2 Personal safety

Parker provides this and other manuals to assist manufacturers in using the GVI inverter 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 torque - risk of personnel injury

The high power levels and high torque available from a motor and motor controller combination can cause severe or fatal injury.

The motor controller is intended for connection to battery voltage sources and is used with low-voltage AC motors.

Before installation, always verify that the motor controller model is correct for the vehicle's battery supply voltage. The DC Supply nominal voltage is shown on the motor controller's identification label

2.1 Safety signs on the equipment

Table 2 shows the signs used on Parker's products. Use of the signs varies between products.

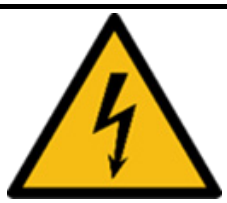
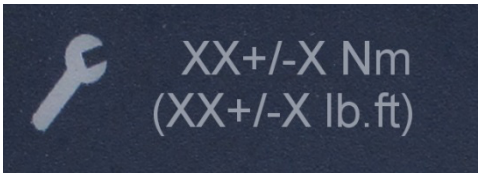
Safety sign	Description
	Take care to avoid coming in to contact with electricity.
	Read the product manual before starting any maintenance work on the equipment.
	Persons with active implanted cardiac devices shall not be in the vicinity of the equipment due to the strong electromagnetic field it generates.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

Table 2 : Safety signs used on Parker GVI equipment

3 Original Equipment manufacturer responsibility

These 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 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

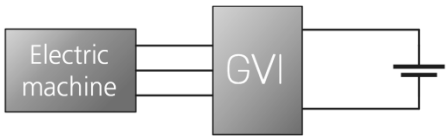


Figure 1 A typical system with the GVI

Figure 1 shows the implementation of the GVI in a typical electric vehicle application.

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

The GVI can be delivered with nominal voltages according to chapter 11.2.

6.1 Product versions

The GVI product range consists of three single drives: frames C, D and E, each with its own size, current and power output rating characteristics.

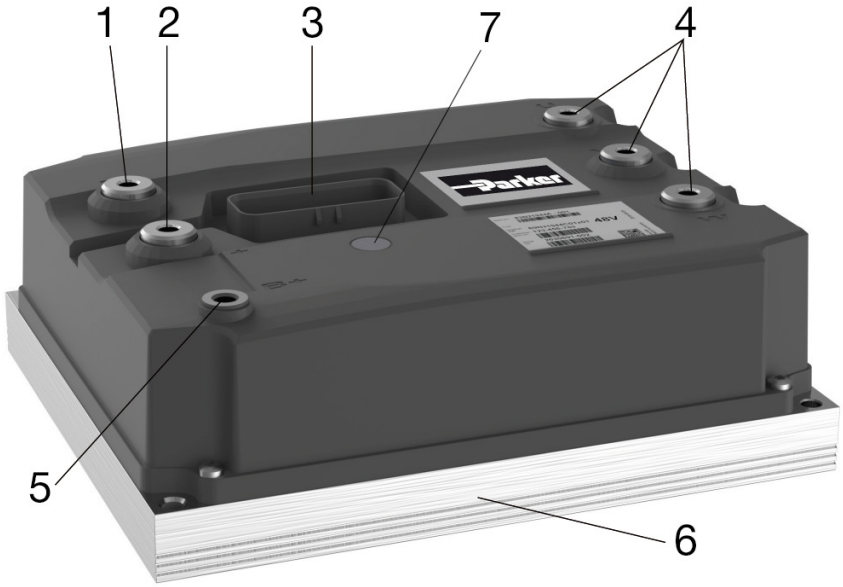
Available peak currents are found in chapter 11.2 while available nominal DC supply voltages are found in chapter 11.3.

6.1.1 GVI drives

Figure 2 GVI Frame C

Figure 3 GVI Frame D

Figure 4 GVI Frame E



Pos	Name	Pos	Name
1	B- connection	2	+ connection (frame dependent)
3	I/O connector	4	U1, V1 and W1 connections
5	B+ Connection	6	Heat sink
7	Moisture Vent		

Figure 5 Components on the GVI (GVI Frame E Shown)

Communication with the GVI is through the I/O connector (3). Chapter 8 contains the I/O pinout.
The terminal posts are designed for ring lug connections and the moisture vent (7) reduces condensation in the GVI.
The GVI is mounted in the vehicle on the heat sink (6). The heat sink transfers heat from the GVI to its surroundings by direct contact with the vehicle chassis.

6.2 Terminal posts

The terminal posts are designed for ring lug connections and are supplied with threaded connections (screw connection).

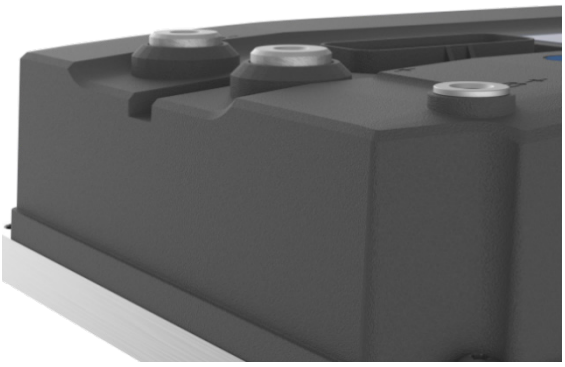


Figure 6 Terminal posts for power connections

6.3 Product identification label

A label containing pertinent product identification information is attached to the GVI. The product label fields relevant to product identification are described in Figure 7 and Table 3

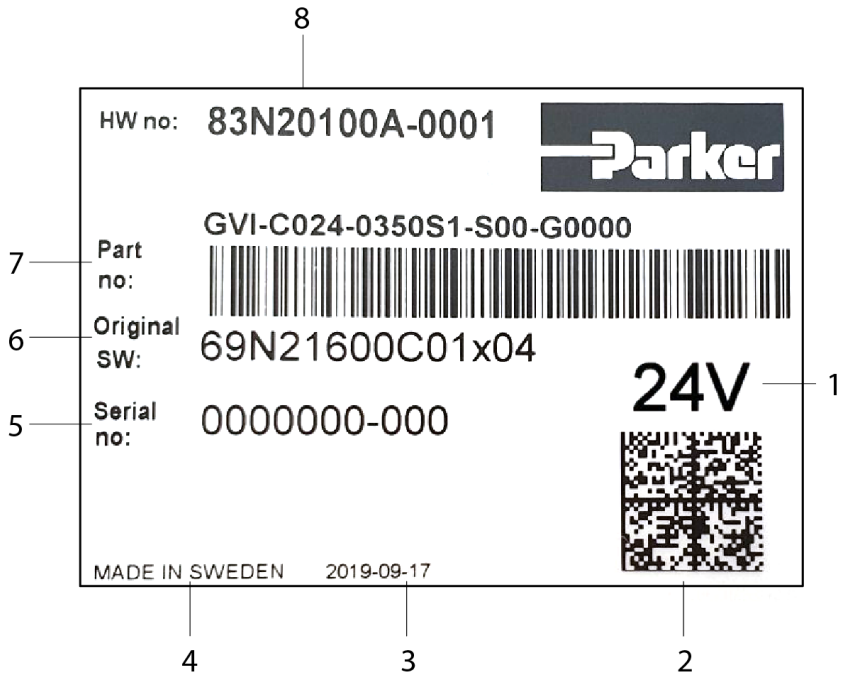


Figure 7 Example of product identification label

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	**Order Code** Order Example: **GVI** - **C024** - **0350S1** - **S00** - **G0000** **1 Product Familiy**: GVI Global Vehicle Inverter **2 Frame Size**: C Frame Size C; D Frame Size D; E Frame Size E **3 Nominal DC Supply**: 024 24V DC; 048 48V DC; 080 80V DC; 096 96V DC **4 Current Rating** **24VDC Nominal Voltage**: 0350 350A Frame C; 0550 550A Frame D **48VDC Nominal Voltage**: 0280 280A Frame C; 0450 450A Frame D; 0550 550A Frame D; 0700 700A Frame E **80VDC Nominal Voltage**: 0230 230A Frame D; 0350 350A Frame D; 0400 400A Frame D; 0500 500A Frame E; 0700 700A Frame E **96VDC Nominal Voltage**: 0230 230A Frame D; 0350 350A Frame D; 0400 400A Frame D; 0500 500A Frame E; 0700 700A Frame E **5 Package**: S Single **6 Series**: 1 Series 1 **7 Feedback Type**: S Sin/Cos Encoder **8 Reserved**: 00 **9 Special Option**: G0000 Global Specification; E0000 European Specification; N0000 North American Specification
8	Hardware identification number as shipped

Table 3 Description of product identification label

6.4 LED status indicator

The LED status indicator (see 10.1), provides useful diagnostic information when troubleshooting vehicle problems (see chapter 3).

7 Integration guidelines

7.1 Introduction

This chapter describes guidelines for integration of the inverter. Integration is the installation of the inverter into a vehicle.

The information is general in nature. Further instructions for mounting of the GVI in a vehicle or machine are found in chapter 9.

WARNING

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

High power levels are exposed at each of the connection posts. Protect these terminals from accidental contact which could result in personnel injury and/or short circuit.

WARNING

ESD - risk of damage to equipment

Electrostatic discharges (ESD) can damage sensitive electronic components.

Do not touch the I/O connector pins.

The GVI meets all necessary standards for ESD-protection. However, very high levels of static electricity can build up during handling of the equipment. The built-in ESD-protection does not replace a professional and careful handling.

7.2 Residual Voltages above 60V

WARNING

High voltage - risk of personnel injury

The GVI does not self-discharge according to EN 1175 clause 4.3.6. Therefore, a warning/safety label shall be provided. This label shall be:

- Permanent and indelible
- Affixed on, or in close proximity to, the enclosure containing the GVI

Safety signs EN ISO 7010 W001 and EN ISO 7010 W012 can be used:

It is the OEM's responsibility to provide this label.

7.3 Monitoring

7.3.1 General

In this chapter some standard monitoring features of the motor controller are described. The behavior of some monitoring features may be modified to fit a specific application.

7.3.2 Temperature monitoring

The motor controller continuously monitors the power stage temperature and the motor temperature. The purpose of the temperature monitoring is to avoid damage to the motor controller or motor caused by high temperatures. An application must be designed such that the motor controller or motor stays within the normal operating temperature for normal operation of the vehicle. An elevated temperature can be a sign that something is amiss in the application, for example that the cooling fans have stopped working.

7.3.2.1 Power stage monitoring

To protect the power stage from damage, the GVI will reduce the available power at temperatures outside the normal operating temperature range as seen in Figure 8, and the motor controller will shut down completely at 110 °C.

CAUTION

Operation at reduced power – risk of damage to equipment and/or malfunction

Operation of the inverter at reduced power is meant as a 'limp home' opportunity for a limited time only. Operation for longer periods of time outside normal operating temperature will reduce the lifetime of the inverter and may also cause malfunction of the GVI. See also chapter 7.6.

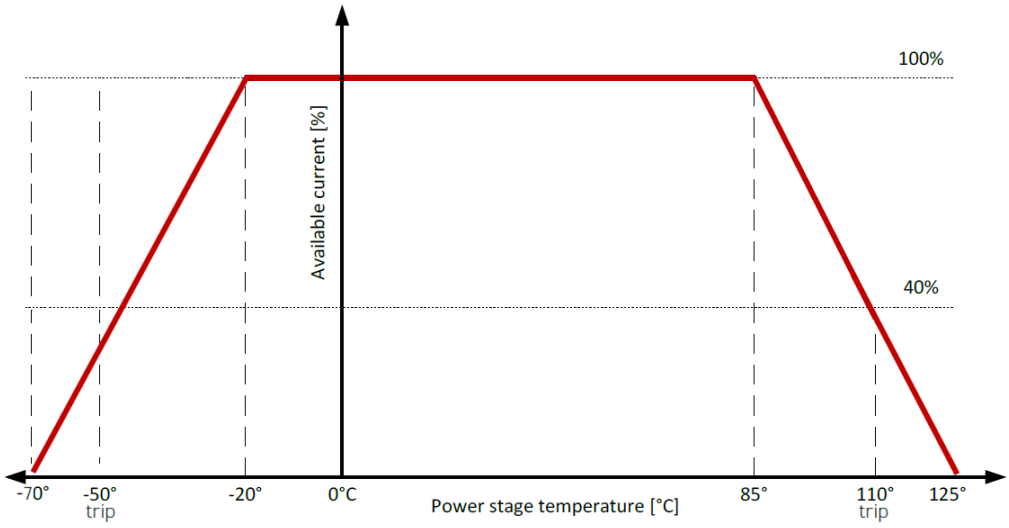


Figure 8 Available power as a result of power stage monitoring

7.3.2.2 Motor winding monitoring

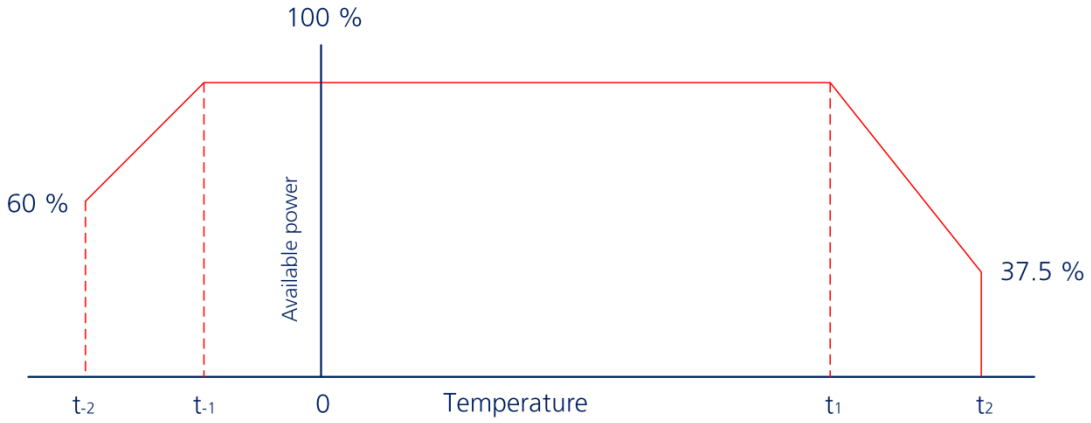


Figure 9 Available power as a result of motor winding monitoring

To protect the motor from damage, power will be reduced at temperatures outside the normal operating temperature range as seen in Figure 9, and the motor controller will shut down completely at t_2. Temperatures t_1, t_2, t_{-1}, and t_{-2} are configurable in the application software.

7.3.3 Motor current Monitoring

NOTE

Routing of power cables from other devices across the top surface of the motor controller may affect the accuracy of the current measurement.

- Current measurement for V and W motor-phase, calibrated to ±10 %.
- Overload and short circuit protection.

7.3.4 Voltage monitoring

Voltage monitoring data	GVI 24V	GVI 48V	GVI 80V	GVI 96V
Voltage measurement range [V ±5%]	0 – 33.6	0 – 67.2	0 – 112	0-134.4
Calibrated voltage measurement range [V ±0.5%]	20.4-26.4	40.8-52.8	68-88	84.6-105.6
Overvoltage trip [V ±5%]	33.6	67.2	112	134.4
Battery voltage range [V ±0.5%]	20.4-26.4	40.8-52.8	68-88	84.6-105.6

Table 4 Voltage Monitoring data

7.3.5 CANopen PDO timeout monitoring

There is a CAN communication watchdog timeout for CANopen PDO monitoring, default timeout value is 50 ms.

7.3.6 Pre-charge timeout monitoring

During power up, the filter capacitor bank must be pre-charged within 10 sec (default value). See also chapter 7.20.4

7.4 Permanent magnet motors and overvoltage

WARNING

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

A rotating permanent magnet motor connected to the motor controller may generate an electromotive force (EMF) which is fed to the DC bus even if the motor controller is not enabled. This may, for example, happen during towing of the vehicle with engaged clutch. The risk of harmful back-EMF must be taken into consideration when selecting a motor for the application. The output voltage from the motor must never exceed the maximum instantaneous voltage according to chapter 11.3. Sufficient cooling of the motor controller must be provided as long as the electrical motor is rotating.

7.5 Dust and liquid ingress prevention

The dust/moisture protection of the motor controller is only valid when the mating I/O connector is inserted and correctly assembled with appropriate cable seals.

CAUTION

Water sensitive equipment - risk of damage to equipment

The motor controller cover provides a measure of protection from liquids and particles dripping, splashing or spraying onto it. The motor controller must not be subjected to liquids under high pressure.

Do not clean the motor controller using high-pressure water.

7.6 Cooling requirements

The motor controller is mounted upon a solid heat sink. This is the surface that transfers heat from the power conversion components.

In order to cool the power conversion components efficiently, it is important to consider the thermal resistance between the heat sink and the surroundings according to chapter 7.6.1. The motor controller operating temperature is specified in chapter 11.1.

CAUTION

Operation at reduced power – risk of damage to equipment and/or malfunction

Higher than intended operating temperature will cause a reduction of max output power, may result in a reduced lifetime of the motor controller and may also cause malfunction of the GVI (see chapters 7.3.2 and 11.2).

The GVI is designed to operate with a maximum heat sink temperature of 85 ºC. During performance testing of a new vehicle design, it is necessary to ensure that the vehicle can fulfill its environmental and performance specifications without exceeding this temperature of the motor controller. If this is not possible to achieve, the OEM should consider improving cooling of the motor controller, switching to larger motor controllers, or reduce vehicle performance.

If the heat sink temperature exceeds 85 °C the maximum available motor current is automatically reduced. The motor controller will still operate, with reduced performance, up to 110 °C, when an emergency shutdown will take place. It should be noted though, that the motor controller is operating outside its specification in this case, and it should only be used as a “limp home” option.

It is strongly recommended that an error message is generated and that vehicle performance is decreased if the motor controller temperature exceeds 85 °C.

7.6.1 GVI with flat heat sink

The GVI comes with a flat (cold plate) heat sink and is cooled through surface contact with the vehicle body. Specifications for surface roughness and surface flatness where motor controller is mounted to the vehicle body must be observed (see chapter 11.6.3). Application of thermal grease to the cold plate heat sink before mounting the motor controller will achieve the best cooling effect.

The required heat sink-to-vehicle mounting surface thermal resistance shown in Table 5 must be achieved by the installation in order for the GVI to meet the published current ratings in the application.

For recommendations regarding mounting of the motor controller see chapters 7.9 and 9.5.

Motor controller model	Thermal resistance*
GVI Frame C	0.23 ˚C/W
GVI Frame D	0.12 ˚C/W
GVI Frame E	0.063 ˚C/W

Table 5 Required thermal resistance for flat heat sink

*Values for the highest performing version of the respective motor controller model

If additional cooling is required, a secondary finned heatsink or cold plate can be fitted to increase heat dissipation.

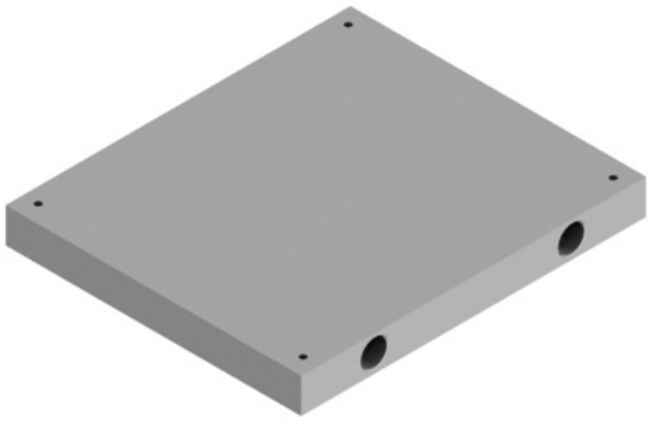


Figure 10 Example Cold Plate

7.7 GVI Power Terminals

7.7.1 Protection against reversed polarity

WARNING

High current – risk of personnel injury and/or damage to equipment

Design the vehicle according to this chapter to protect against accidentally reversed battery polarity.

In addition to the measures in this chapter, Parker recommends designing the physical battery connection such that accidental reversion of the battery polarity is not possible.

7.7.1.1 Main contactor control

The power terminals B- (1, Figure 5) and + (2,Figure 5) must be protected by a function which allows the main contactor to be activated only when both the following conditions are met:

- The battery polarity is confirmed by a voltage measurement to be correct
- The DC bus capacitors are charged up to the predefined voltage

7.7.1.2 Protection of logic pins

Whether the logic pins are protected against reverse polarity or not depends on the GVI model according to Table 6.

NOTE

It is the responsibility of the OEM to ensure that the necessary protective functions are provided in those cases when the functions are not built in.

GVI Size	Logic pins	Protection against reverse polarity
C D	HIGH_SIDE_IN/PRE_CHARGE	Built-in as standard
	KEY_INPUT	
	HIGH_SIDE_OUT	
	OPEN_DRAIN_1-OPEN_DRAIN_6	
E	HIGH_SIDE_IN/PRE_CHARGE	Not protected. See below for addition measures required on Frame E
	KEY_INPUT	
	HIGH_SIDE_OUT	
	OPEN_DRAIN_1-OPEN_DRAIN_6	

Table 6 Reverse polarity protection for logic pins

Additional measure for Frame E

The OEM must prevent the HIGH_SIDE_IN/PRE_CHARGE pin from being connected to the battery in case of reverse polarity. This is regardless of whether the open drain outputs are used or not.

7.8 Orientation

NOTE

The vibration test of the GVI does not include a horizontal mounting position with the I/O connector facing downwards.

The inverter can be mounted vertically or horizontally with the I/O connector facing upwards. The vibration test of the GVI does not include a horizontal mounting position with the I/O connector facing downwards. Parker do not recommend this orientation of the GVI.

When multiple inverters are used in an application each of the units must be arranged such that they have sufficient cooling for the required duty cycle.

Consideration should be given to accessibility and visibility of the I/O connector, terminals and on-board LED status indicator (1, Figure 11) for maintenance purposes.

Pos	Name
1	LED status indicator

Figure 11 LED status Indicator

7.9 Selecting GVI mounting fasteners

Recommended screws and washers for mounting of the motor controller are specified in chapter 9.5.1.

7.10 Wiring and connections

WARNING

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

High power levels are exposed at each of the connection posts. Protect these terminals from accidental contact which could result in personnel injury and/or short circuit.

This section provides schematic diagrams and related information for connecting the inverter in a vehicle. This circuit diagram presents a basic – but functional – general purpose wiring configuration. The OEM may choose to modify these generic wiring configurations to fit their individual requirements or conventions. It is the responsibility of the OEM to develop vehicle specific wiring schematics and instructions for each vehicle mode.

7.10.1 Ground Connection

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

Connect a ground strap of sufficient size between the ground connection (5, Figure 16) and the vehicle chassis.

The surface of the ground connection on the GVI is extruded aluminum. The connection point for the ground strap on the vehicle chassis must be bare metal and be coated in dielectric grease to prevent corrosion.

7.10.2 Wiring of KEY INPUT and HIGH_SIDE_IN/PRE_CHARGE

CAUTION

Incorrect wiring – risk of malfunction/damage to equipment

The KEY INPUT and the HIGH_SIDE_IN/PRE_CHARGE must be separated when the start key is turned off. The vehicle design must follow the guidelines in this chapter.

The KEY INPUT and/or the HIGH_SIDE_IN/PRE_CHARGE must be separated when the start key is turned off. This is to avoid that the controller logic (KEY input) is temporarily powered by the HIGH_SIDE_IN/PRE_CHARGE circuit after shutdown. Failure to separate them could cause an incorrect shutdown sequence and in rare cases damage the motor controller. Parker recommends using a two-pole start key switch as shown in Figure 12, Figure 13 and Figure 14.

If the KEY INPUT and/or the HIGH_SIDE_IN/PRE_CHARGE are powered by the outputs of another unit in the vehicle, separation is achieved by the wiring itself as illustrated in Figure 13

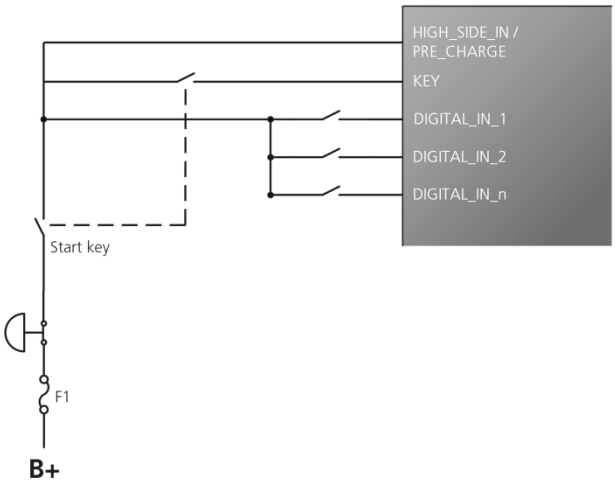


Figure 12 KEY and HIGH_SIDE_IN/PRE_CHARGE wiring alternative 1

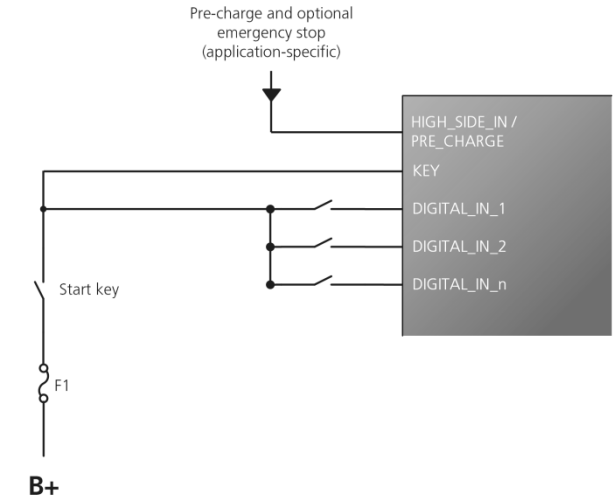


Figure 13 KEY and HIGH_SIDE_IN/PRE_CHARGE wiring alternative 2

7.10.3 GVI standalone controller typical wiring

NOTE

The motor temperature sensor must be isolated from other signals in the system to avoid malfunction caused by incorrect wiring.

Connect the motor temperature sensor to pins MOTOR_TEMP+ and MOTOR_TEMP- only.

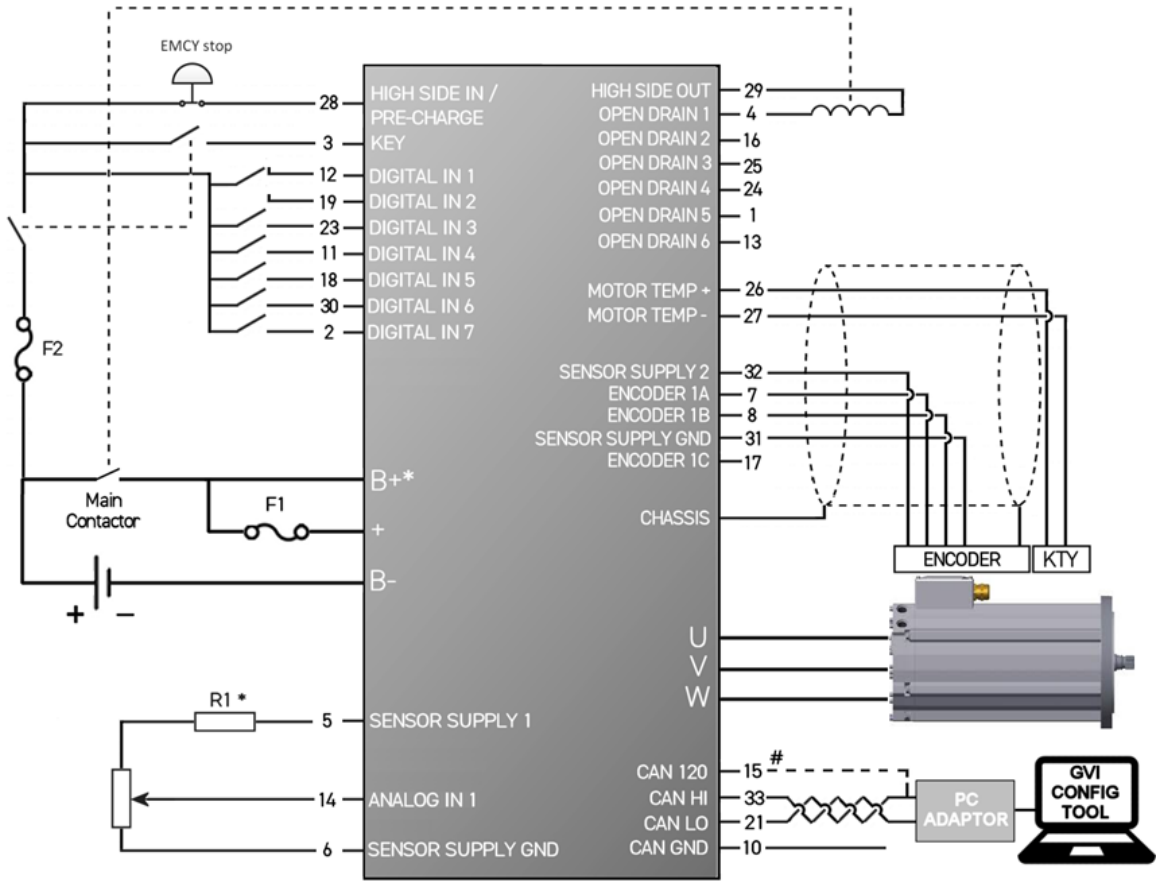
Figure 14 shows an example wiring diagram for a motor controller that is used as a standalone controller, with multiple I/O directly interfacing vehicle logic.

Figure 15 shows and example minimum connection drawing for a motor controller that is connected to and controlled over CAN.

The GVI does not have multiple CAN pins, so if the motor controller is placed in the middle of a CAN bus, care should be taken to minimize length of the stub lines.

If the motor controller is placed at one end of the CAN bus, the built in 120 Ω termination resistor can be utilized by placing a jumper between pin 15 and pin 33.

In this example, the emergency stop button is placed in line with HS_IN→HS_OUT which powers the main contactor. With this configuration logic power is still present when emergency switch is operated, allowing logging/troubleshooting also with the emergency button depressed.



Link CAN 120 (15) to CAN High (33) for termination if the GVI is the last item on the CAN bus
* R1 to be fitted to reduce 12V from Sensor Supply 1 to 5V suitable for analog inputs

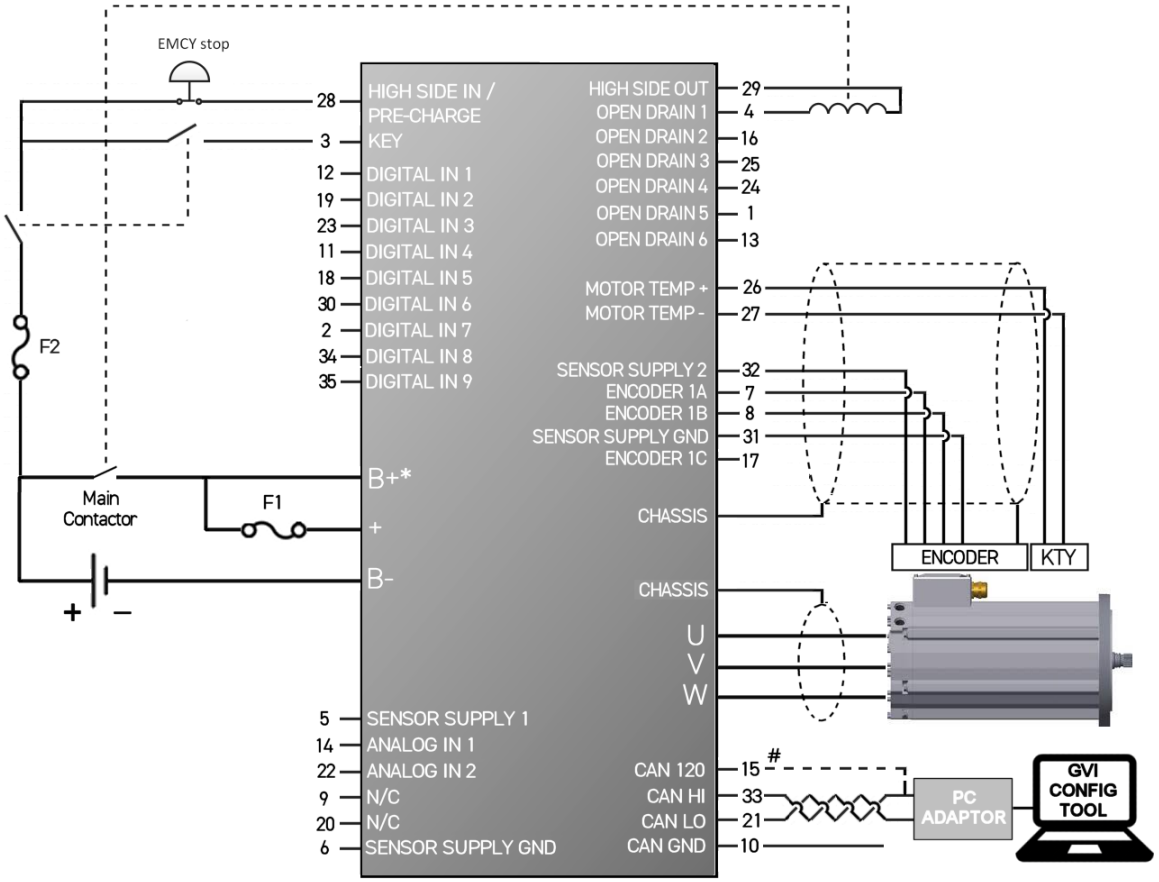
Figure 14 Typical wiring of GVI I/O controller with 5 V feedback sensor

NOTE

Figure 14 is a simplified and generic schematic drawing. The actual wiring in a vehicle may differ. The feedback sensor wiring is shown as 5V to match the GVM encoder

NOTE

GVI Frame C are not fitted with a + terminal. Frame C shall have a fuse installed remotely, between battery positive and B+



Link CAN 120 (15) to CAN High (33) for termination if the GVI is the last item on the CAN bus
* B+ is fitted to frame D and E GVI only

Figure 15 Minimum wiring of GVI controller with GVM and CANopen/J1939 communication

NOTE

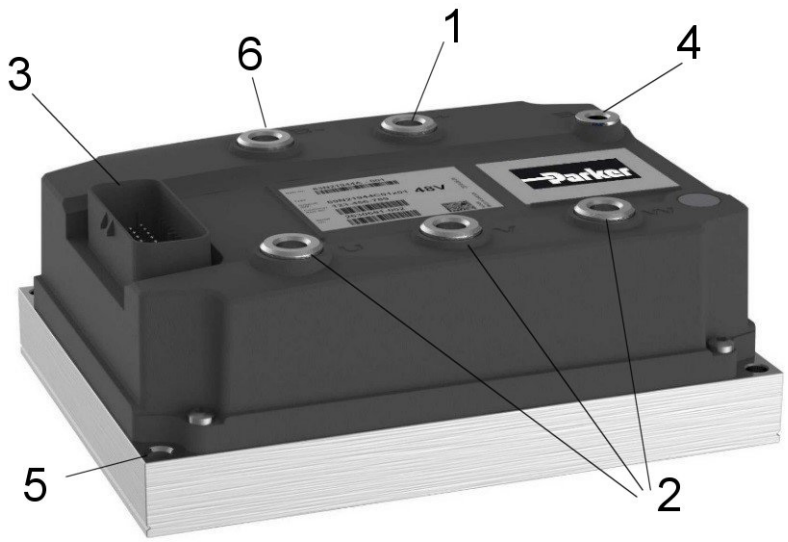
Figure 15 is a simplified and generic schematic drawing. The actual wiring in a vehicle may differ. The feedback sensor wiring is shown as 5V to match the GVM encoder

NOTE

GVI Frame C are not fitted with a + terminal. Frame C shall have a fuse installed remotely, between battery positive and B+

The Parker GVI Configuration PC Tool has been designed for use with the Kvaser Leaf Light HS v2 and IXXAT USB to CAN V2 PC adaptors only.

7.10.4 Connections



Pos	Name	Connection on GVI	Connection to GVI	Tightening Torque
1	Power terminal + connection	Chapter 9.6	Chapter 9.6	Chapter 9.6
2	Power terminals U, V and W connections	Chapter 9.6	Chapter 9.6	Chapter 9.6
3	I/O connection	Chapter 8.1	Chapter 8.1	Not Applicable
4	Power terminal B+ connection	Chapter 9.6	Chapter 9.6	Chapter 9.6
5	GVI mounting hole	Chapter 9.5	Chapter 9.5	Applied torque must be defined by OEM according to material used in vehicle body
6	Power terminal B- connection	Chapter 9.6	Chapter 9.6	Chapter 9.6

Figure 16 Connections on GVI (Frame D shown)

CAUTION

Incorrect dimensioning of connections – risk of overheating

Ring lugs for motor and battery connections must be adequately rated to carry motor and battery currents. Otherwise cables and power terminals may be overheated. See also power cable sizing guidelines in chapter 7.20.2.

7.11 Sizing and selection of on-board fuse

NOTE

An on-board fuse is not supplied with the Motor Controller. This component must be sourced separately.

An on-board fuse (F1 in Figure 14 and Figure 15) installed between the B+ and + terminals* on each motor controller protects the motor controller and power distribution circuit in the event of a short circuit fault in the power conversion section.

Consider the fuse accessibility for maintenance purposes when choosing location of the motor controller.

Each motor controller must be fused against internal faults and short circuits. Instead of an on-board fuse, a user may choose to locate this fuse remotely (i.e. at a central fuse panel). In this configuration battery power is connected directly to the motor controller + terminal*. It may be necessary to install the fuse remotely on 96V GVI products if a suitable voltage rated fuse cannot be sourced.

*+ is a frame dependent terminal. It is not fitted to GVI Frame C products. The fuse should be installed remotely to the GVI on frame C products.

NOTE

The fuse is not intended to protect the motor controller or motor against overloads.

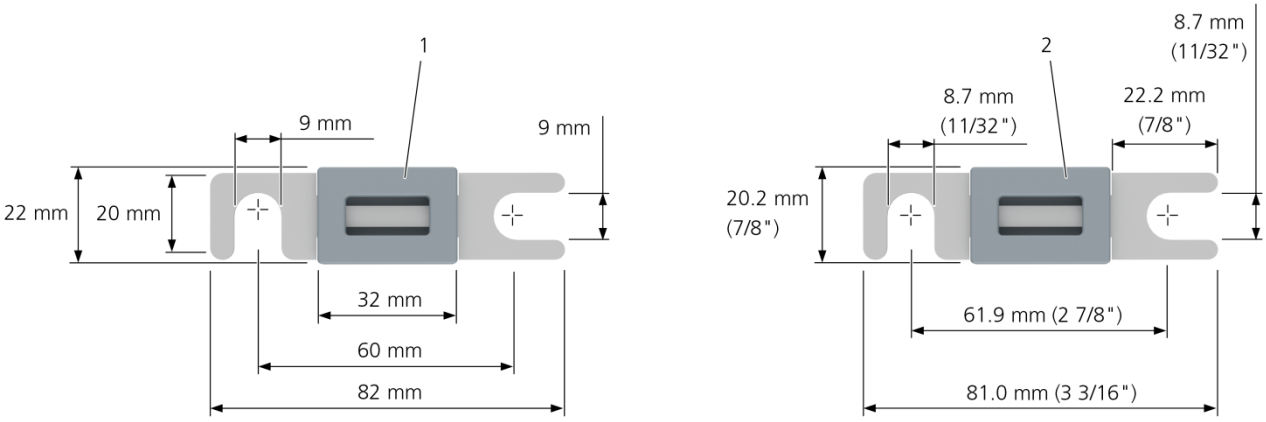
Selection of appropriate fuse ratings is a system design issue and falls under the OEMs responsibility. As a rule of thumb, the fuse shall be rated based on the motor controller's power output (2 min. rating) listed in chapter 11.2.

Calculate DC input current as follows:

$$I_{DC\_IN} = \frac{\text{Power output [kVA](2 min rating)} \times 1\,000}{\text{V DC}}$$

Select a fuse with rating and time delay characteristics which will carry I_{DC_IN} indefinitely, but blow within 2 – 3 seconds for 2 x I_{DC_IN}.

Figure 17 shows typical dimensions of the fuse for on-board mounting. Bussman (ANN series), Littelfuse and others manufacture fuses that satisfy the time delay and dimension requirements.



Pos	Name	Pos	Name
1	Littelfuse (Pudenz)	2	Bussman (ANN series)

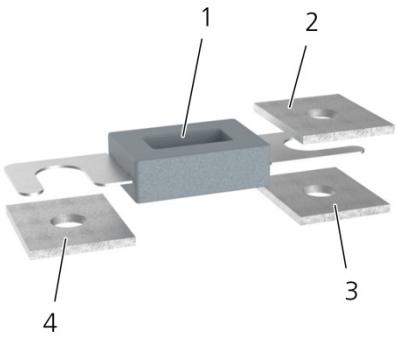
Figure 17 On-board fuse dimensions

7.11.1Selecting washers for fuse mounting

WARNING

High current – risk of personnel injury and/or damage to equipment

To avoid burning or overheating of the high-current terminals, the washers used for the optional on-board fuse must be made of tin-plated copper.



Pos	Name	Pos	Name
1	On-board fuse	2	Washer (terminal +)
3	Washer (terminal +)	4	Washer (terminal B+)

Figure 18 On-board fuse washers

The following issues shall be taken into consideration when selecting washers for mounting of an on-board fuse:

- Both rectangular and circular washers can be used. Rectangular washers shall be mounted according to chapter 9.6.2.
- The washers shall be tin-plated copper to conduct high current and minimize losses between fuse and terminal.
- Washer (4) shall have same thickness as washer (3) for alignment of fuse. No current goes through this washer (4).
- Washer (2) serves to distribute pressure between on-board fuse (1) and washer (3). No current flows through this washer (2).
- The washers (2, 3 and 4) are used as reinforcement for thin (weak) fuse terminals. If fuse terminal thickness is > 2mm washers are not necessary (on-board fuse (1) is stable in itself).

7.12 Sizing of logic supply fuse

The logic supply fuse (F2 in

Figure 12,Figure 13, Figure 14 and Figure 15) is part of the KEY_INPUT protection, see chapter 8.3.2.

The fuse should be sized according to the number of motor controllers connected to the fuse and to protect the cable area in the circuit and the current consumption of the KEY_INPUT.

Name	Recommended value
Fuse size	Slow acting fuse 6-10 A (depending on the load)
KEY_INPUT power input	< 15 W

Table 7 Recommended values for sizing of logic supply fuse

7.13 Main contactor

The main contactor in a vehicle functions both as a power distribution component and as a key component in the motor controller protective interlock circuit.

During start-up (after voltage has been supplied to the KEY_INPUT of the motor controller), the motor controller monitors the voltage of the DC bus capacitors. When the voltage on the capacitors has reached a pre-defined level, the motor controller will indicate that it is ready to switch on the main contactor. The motor controller can be configured to control the main contactor directly, with the functionality described above.

De-energize the main contactor if motion is not permitted as a result of some error/fault condition.

Selection and sizing of the main contactor circuit is the OEM's responsibility. The following power output vs. DC input current relationship may be used when sizing a main contactor and associated cabling:

$$I_{DC\_IN} = \frac{\text{Output power [kVA]} \times 1\,000}{\text{V DC}}$$

7.14 Emergency stop switch

A manually operated Emergency Stop switch is required for most applications. When activated, the emergency stop switch de-energizes the main contactor, removing battery power from the power conversion section of the motor controllers.

WARNING

De-activated power section – risk of personnel injury and/or damage to equipment

Note that when removing power in this manner the motor controller *cannot* stop motion or produce any braking action.

7.15 Motor feedback sensor

For information regarding correct motor sensor setup in the application software, refer to the GVI Configuration manual 192-300303Nx.

WARNING

Induced noise in sensor signal wires – risk of personnel injury and/or damage to equipment

Careful routing of the sensor signal wires is crucial to avoid induction of noise which may cause unpredictable motor behavior.

CAUTION

Electrical overstress – risk of damage to equipment

Parker advise against using motor speed or position sensors without protection against electrical overstress.

NOTE

Care must be taken to ensure that the feedback sensor device matches the motor controller sensor supply voltage and current (see chapter 11.5.8).

7.15.1 General

To minimize the possibility of electrical noise coupling into motor feedback sensor wires, avoid routing cables next to conductors carrying high currents or high current pulses. Noise immunity may also be improved by using twisted conductor cable for the motor feedback sensor cables from motor to the motor controller.

WARNING

Incorrect wiring – risk of personnel injury and/or damage to equipment

Wiring of feedback sensor and the relationship between feedback sensor vs. rotational direction depends upon feedback sensor installation in the motor. Contact the motor manufacturer to get the correct wiring and relationship between rotational direction and feedback sensor signals. Swapping the channels from feedback sensor will lead to improper motor operation.

WARNING

Misaligned absolute position sensors – risk of personnel injury and/or damage to equipment due to unintended vehicle movements

In vehicles with synchronous motors, the OEM must ensure that an absolute position sensor is aligned with the motor's rotor position. Either the motor and sensor are pre-aligned with an offset, which must be configured in the unit with an offset parameter, or the motor and sensor must be aligned for each motor and inverter combination with an offset parameter in the unit using the calibration routine

ATTENTION

ESD – risk of damage to equipment

The motor feedback sensor may be ESD sensitive; see ESD related system design suggestions in chapter 7.20.3

7.15.2Sinusoidal motor speed sensor input

The sinusoidal speed sensor for synchronous motors provides position, speed and direction feedback for the motor controller. The sinusoidal analog sensor produces a single-ended two-phase sinusoidal wave output (see Figure 20).

Description	Value
Phase shift	90 ˚ ±10 ˚
Frequency	Max 300 Hz
Signal amplitude	Min 1 V to max 2 V
Offset	+2.5 V ±0.5 V

Table 8 Sinusoidal motor speed sensor input data

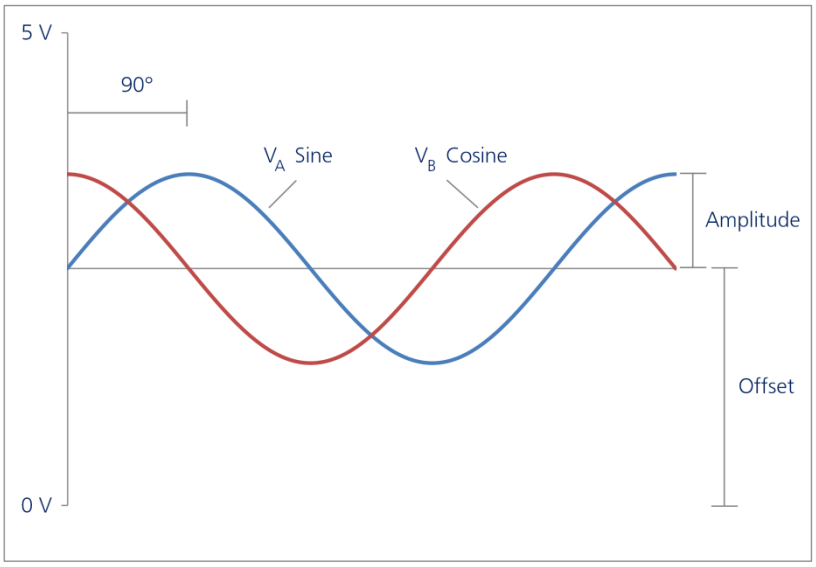


Figure 19. Sinusoidal analog sensor signal

Connect the feedback sensor according to chapter 8.8.1.

Dynamic offset and gain adjustments (individual for each channel) are done in software to compensate for minor changes in feedback sensor characteristics. For a new motor/feedback sensor it is necessary to setup correct default values for amplitude and offset according to sensor data sheet in the application software before testing the motor. For further information refer to the ‘Encoder offset’ application note.

7.16 Motor temperature sensor

A temperature sensor with a positive temperature coefficient embedded in the motor winding provides a means for the motor controller 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 motor controller can be configured to operate with different sensors such as KTY 84, PT1000 and similar.

CAUTION

Incorrect wiring – risk of damage to equipment

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

7.17 I/O interface

The I/O interface is described in chapter 8.

7.18 Start-up and Commissioning

7.18.1 Configuring the motor controller for the application

WARNING

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

All motor controller settings and functionality must be verified and validated by the OEM before use in the field by an end user.

The complete range of parameter values that are updated by the truck controller (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 incorrect parameter values may jeopardize the operation of the truck's safety critical functions.

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

The motor controller is a software-configurable device. In a CAN slave system, some or all aspects of the motor controller setup and operation may be managed by a vehicle master controller communicating over the CAN bus. For standalone operation (primarily the I/O version), customized software must be installed in the motor controller.

Built-in diagnostics functions monitor battery voltage, heat sink temperature, motor temperature, and other conditions. Error and warning information is available to the master controller, and all event information is stored in an event log for service access. The event log provides additional information as well as procedures for pinpointing and eliminating causes for warning and error conditions.

Optionally, controllers 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.

Setting up a prototype controller for a new vehicle, within a vehicle development program, may require extensive parameterization and possibly also re-programming of the inverter via the CAN bus. Refer to your local Parker application team for further assistance.

7.19 Incorporation of GVI and vehicle safety

OEM's are responsible for ensuring that the motor controllers are used for their intended purpose only, safe function of the system and for compliance with all applicable regulations.

7.19.1 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 According to EN 1175 clause 4.8.3:

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.

7.19.2 Over-current protection

Over-current protection according to EN 1175 clause 4.3.7 is provided by external fuses (chapter7.11).

7.20 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.

In the following section some common causes for issues in a system are listed, together with general information about how to avoid them through proper system design.

7.20.1 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.
- Do not connect any signal ground to the vehicle frame, (even if it is allowed in system up to 60V according to EN1175 clause 4.3.5.1).
- Verify noise levels on analog and digital inputs with different functions in operation running (traction, hydraulics etc.).
- Very high currents may circulate between motor controller and battery. Even if cables are dimensioned correctly, this may lead to a significant voltage drop between motor controller power terminal B- and negative power terminal on the battery. This means that there may be voltage differences between GND references of different units in a control system. Therefore, connecting all wires of sensors supplied by the motor controller directly to the intended GVI I/O connector pins is strongly recommended.
- Consider alternative paths for I/O cables to find the one that generates least noise (EMC).
- To avoid damage to PCs or other external instrumentation connected to the mains network, use a galvanic isolated CAN interface.

7.20.2 Power cables

- Parker recommends cable type Huber+Suhner Radox 155(S) with EMI screen
- Keeping the cable length between KEY_INPUT and battery less than 10 m is recommended.
- To avoid burning or overheating of the power terminals, ensure that the cable connection has been made according to chapter 9.6, 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 motor controller and other equipment in the vehicle.
- If a washer is used between cable-lug and terminal, it must be made of tin-plated copper. Otherwise overheating may occur.
- Use sturdy ring lugs made from a tube (see Figure 20), not from a plate.

Figure 20 Ring lug made from tube

- Motor and battery cables must be thermally dimensioned to match the power of the motor controller and the motor. The European standard EN1175-1 clause A.3.6 requires that the battery connector parts must withstand 90 ºC. It is recommended as a minimum that all cables are chosen to withstand this temperature.
- All high voltage cables must be shielded.
- The cable size must be selected to match the 1 hour rating of the application, EN1175-1 (5.10.2). As a rule of thumb, use current density of 3 A/mm2 to get an indication of necessary cable area.

$$\text{Cable area in mm}^2 = \frac{(\text{1h current})}{\left(3\frac{\text{A}}{\text{mm}^2}\right)}$$

- As an alternative to unwieldy, heavy gauge cables, two thinner cables in parallel can be used. The total area of the thinner cables must exceed the area of the large cable.

7.20.3Electromagnetic Compatibility (EMC)

Figure 21 Example of copper braids for grounding of motors

- To minimize potential EMC issues, both motor controller and motor must have good electrical connection to the vehicle frame. A low ohm connection for high frequency (EMC), between motor controller heat sink and vehicle frame is achieved by clamping the heat sink firmly to an unpainted part of the vehicle frame and/or connecting the heat sink to the frame with a tinned copper braid (Figure 21) .
- Battery (positive and negative) cables must be routed in parallel to each other and close together. If they are routed in different directions they could create a loop that leads to EMC issues. Motor cables must also be routed in parallel and clamped to the vehicle frame, to avoid them acting as antennas for EMC. If motor cables must be routed in the air, a metallic plate or a cable connected to the frame could reduce the EMC if placed in parallel with the motor cables.
- Motor cable shields should be connected directly to the same heatsink earth point as the chassis braid. Keeping the length of the braid ‘tails’ as short as possible.
- If an electric motor is placed on rubber dampers, or mounted on a plastic tank, the motor housing must be connected to vehicle frame with a tinned copper braid to ensure good electric connectivity
- If the main battery is on a separate cart (i.e., is not part of the main machine/vehicle), connect the frame of the cart/battery chassis to the frame of the machine/vehicle to avoid different charge levels on vehicle frame and battery. Different levels may damage the unit or motor.
- The GVI has an internal resistor (≥10 MΩ) to prevent build-up of excessive static electricity between frame and battery. The resistor is connected to battery minus and to the vehicle frame through the GVI heat sink.

7.20.4 Start-up & Turn-off Sequences

- The DC bus capacitors of the motor controller must be charged. The time required to charge is monitored and an error is set if it takes longer than the set limit for charge time-out (default value is 10 seconds).
  If an external pre-charge circuit is used, required charging time and number of units in parallel should be taken into account when dimensioning the circuit. DC bus capacitance values for the GVI models are found in Table 17 DC bus capacitance values.
- Check how the master controller handles normal turn on/off of the units in the system. No error codes should be saved during normal sequences.

7.20.5 Motor

- Check that the motor phase cables are correctly connected to U, V & W
- If the motor runs only at slip-speed or oscillates, check the speed-sensor wires. If the cables are OK, test by swapping the two pulse-encoder signals

8 I/O interface description

Refer also to chapter 11.5.

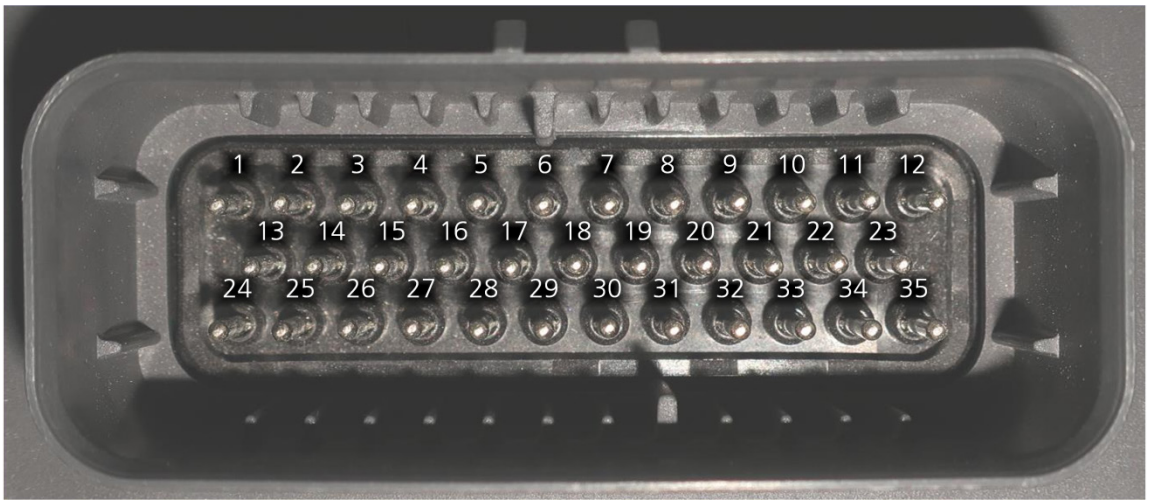
8.1 Mating connector specification

Parker recommends the use of crimp pins suitable for for wire size 0.5-1.5 mm. A harness strain relief shroud should also be fitted. Unused pins can be blanked off using cavity plugs if preferred to maintain IP rating. The harness side (plug) connector comprises the below parts:

- I/O harness side connector for GVI inverter: TE Ampseal 776164-1
- I/O harness side connector strain relief: TE Ampseal 776463-1
- Female pins for wire size 0.5-1.5 mm : TE Ampseal 770520-1
- Blanking plug (for unused pin holes) : TE Ampseal 770678-1

Refer to TE Connectivity Product Specification 108-11329 and Application Specification 114-16016 for assembly instructions of the harness side (plug) connector. http://www.te.com

8.2 GVI I/O Interface pinout



Pin	Name	Chapter	Pin	Name	Chapter
1	OPEN_DRAIN_OUT_5	8.9	19	DIGITAL_IN_2	8.4
2	DIGITAL_IN_7	8.4	20	ENCODER_IN_2B (N/C)	8.8
3	KEY_INPUT	8.3	21	CAN_LOW	8.14
4	OPEN_DRAIN_OUT_1	8.9	22	ANALOG_IN_2	8.7
5	SENSOR_SUPPLY_1 (+12 V)	8.12	23	DIGITAL_IN_3 (mode)	8.4
6	SENSOR_SUPPLY_GND	8.13	24	OPEN_DRAIN_OUT_4	8.9
7	ENCODER_IN_1A	8.8	25	OPEN_DRAIN_OUT_3	8.9
8	ENCODER_IN_1B	8.8	26	MOTOR_TEMP+	8.11
9	ENCODER_IN_2A (N/C)	8.8	27	MOTOR_TEMP-	8.11
10	CAN_GND	8.14	28	HIGH_SIDE_IN/PRE_CHARGE	8.10
11	DIGITAL_IN_4 (Mode)	8.4	29	HIGH_SIDE_OUT	8.10
12	DIGITAL_IN_1	8.4	30	DIGITAL_IN_6 (ID_2)	8.4
13	OPEN_DRAIN_OUT_6	8.9	31	SENSOR_SUPPLY_GND	8.13
14	ANALOG_IN_1	8.8	32	SENSOR_SUPPLY_2 (+5 V)	8.12
15	CAN_120R	8.14	33	CAN_HIGH	8.14
16	OPEN_DRAIN_OUT_2	8.9	34	DIGITAL_IN_8	8.4
17	ENCODER_IN_1C	8.8	35	DIGITAL_IN_9	8.4
18	DIGITAL_IN_5 (ID_1)	8.4			

Figure 22 GVI I/O Connector Pinout

8.3 Key_INPUT

8.3.1 Function

The KEY_INPUT supplies battery voltage to the motor controller for its logic circuitry. The vehicle start Key Switch often controls power to the KEY_INPUT, as shown in Figure 14 and Figure 15. The KEY_INPUT voltage is monitored.

8.3.2 Protection

CAUTION

Inrush current – risk of damage to equipment

The Key Switch connected to the KEY_INPUT must handle the short inrush current spike to the ESD protection capacitors. The current peak is depending on the external circuit and wire.

The KEY_INPUT is protected against reverse polarity with a diode and has a capacitance to B- for ESD protection and other filtering. This capacitance may give a high current spike at KEY_INPUT depending on the external circuit.

An internal resistor reduces the inrush current to the DC/DC main capacitor at KEY_INPUT. During the DC/DC startup, ripple current is drawn from the Key Switch line.

For fuse F2, shown in Figure 14 and Figure 15, see chapter 7.12.

8.4 Digital input

8.4.1 Function

The digital inputs are intended for connection to +/B+ via a switch, as seen in the example in Figure 14. Dependent on the mode selected (see chapter 8.6) the digital inputs shall either control the GVI in I/O control, or are available in the CAN object dictionary to be read by the master controller as general purpose inputs.

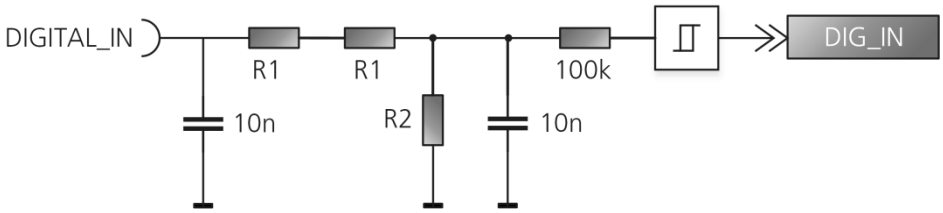
NOTE

For critical functions where good diagnostic coverage is necessary, using two digital inputs for plausibility check is recommended. For example, use of both normally open and normally closed switches.

8.4.2 Protection

The Digital Inputs have a capacitor to B- for ESD protection.

8.4.3 Circuit



GVI model	R1	R2
GVI-024 GVI-048	2.7k	2.7k
GVI-080	10k	6.8k
GVI-096	15K	10K

Figure 23 Schematic of the Digital input circuit

8.5 ID_PIN

8.5.1 Function

Digital input 5 and Digital input 6 are by default used for hardware ID configuration, enabling up to four identical GVI inverters to be connected to the same CAN network.

Hardware ID	Digital Input Wiring	CANOpen Node ID	J1939 Source Address
0	None	6	0xC8 (200_{dec})
1	HW_ID1 (pin 18) to B+	7	0xC9 (201_{dec})
2	HW_ID2 (pin 30) to B+	8	0xCA (202_{dec})
3	HW_ID1 (pin 18) to B+ & HW_ID2 (pin 30) to B+	9	0xCB (203_{dec})

Table 9 ID_PIN_1 and ID_PIN_2 function

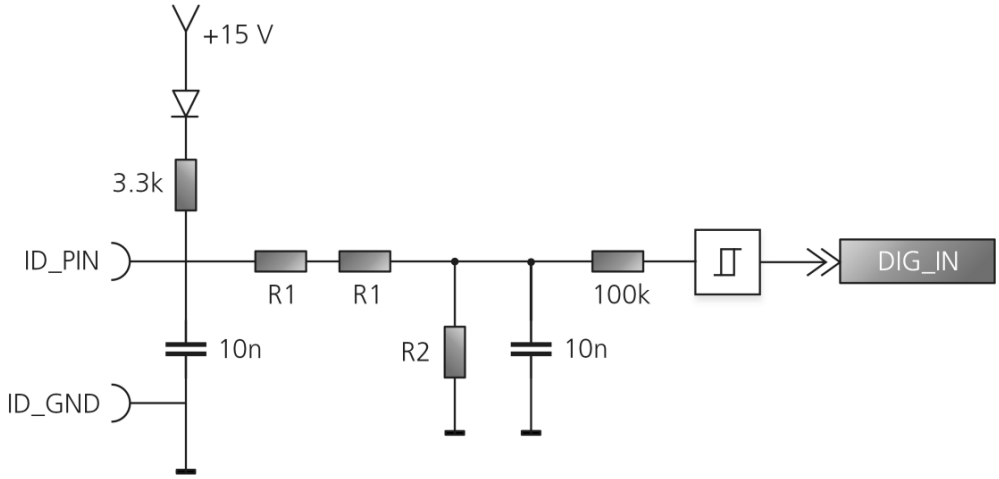
8.5.2 Protection

ID_PIN_1 and ID_PIN_2 inputs have a capacitor to B- for ESD protection. The input is protected against unintentional connection to +/B+ and B-.

NOTE

The ID_GND pins are not protected against short circuit to +/B+.

8.5.3 Circuit



Model	R1	R2
GVI 24V GVI 48V	2.7k	2.7k
GVI 80V	10k	6.8k
GVI 96V	15K	10K

Figure 24 Schematic of the ID_PIN input circuit

8.6 Interface Mode Select

8.6.1 Function

Digital input 3 and Digital input 4 are by default used to select one of three modes of operation, as shown in Table 10

Digital Input 3	Digital Input 4	Interface Mode
0 (pin 23)	0 (Pin 11)	CAN open
1 (pin 23 to B+)	0 (Pin 11)	CAN open
0 (pin 23)	1 (Pin 11 to B+)	J1939
1 (pin 23 to B+)	1 (Pin 11 to B+)	I/O Control

Table 10 Interface mode selection by digital inputs

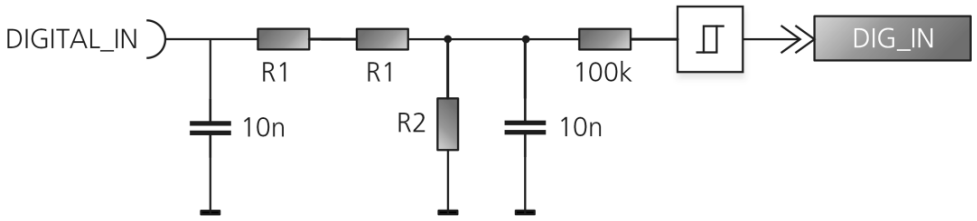
8.6.2 Protection

Digital input 3 and Digital input 4 have a capacitor to B- for ESD protection. The input is protected against unintentional connection to +/B+ and B-.

NOTE

The ID_GND pins are not protected against short circuit to +/B+.

8.6.3 Circuit



Model	R1	R2
GVI 24V GVI 48V	2.7k	2.7k
GVI 80V GVI 96V	10k	6.8k

Figure 25 Schematic of the mode select input circuit

8.7 Analog IN

8.7.1 Functions

The analog inputs are for application use, such as speed or brake potentiometers. Analog inputs are connected to an Analog to Digital Converter (ADC).

The Analog inputs may also be used as extra Digital inputs. The ADC-value is then used to indicate input status. As an example: A switch supplied from +/B+ is connected to an analog input.

For further information regarding the use of analog inputs, please refer to the GVI I/O control application note.

8.7.2 Protection

Analog inputs are +/B+ and B- protected and have a capacitor to B- for ESD protection.

8.7.3 Circuit

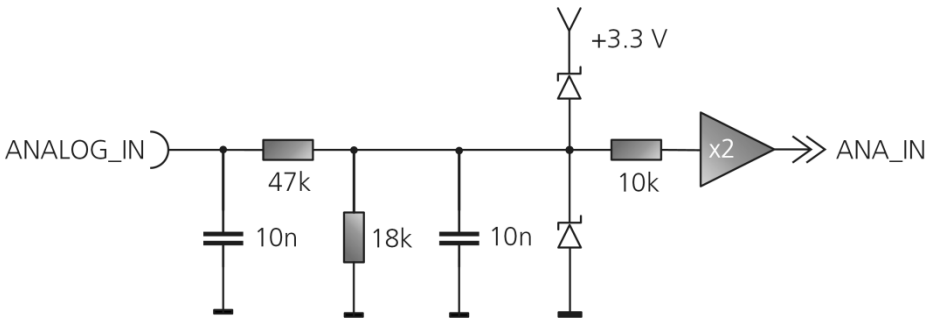


Figure 26 Schematic of the Analog input circuit

8.8 Encoder input

8.8.1 Function

The encoder inputs are multi-function inputs that can be used in different modes:

- Active low digital input (with internal pull-up activated). **Note:** the inputs shut down if the input voltage exceeds 5 – 8 V
- Active high digital input
- Analog input

The encoder inputs can be used as general purpose I/O pins, but are primarily designed to interface motor feedback sensors.

The encoder connections are named with numbers for feedback sensors and letters for channels (A, B and C, see Table 11 Encoder pin connections

- Analog (SinCos) sensor : 2 x analog inputs (A, B)

Motor	Feedback sensor	I/O pin
1	1	ENCODER_IN_1A (SIN) ENCODER_IN_1B (COS) ENCODER_IN_1C (N/C)

Table 11 Encoder pin connections

Examples of connections are shown in Figure 14 and Figure 15.

The internal pull-up is activated by software settings. Threshold level for low signal is 2 V and the max usable frequency of an open-drain type encoder is 20 kHz.

ENC1 pull-up is controlled from the MCU. ENC2 is hard-wired to pull-up type.

8.8.2 Protection

Encoder inputs are protected against +/B+, B-, and ESD.

8.8.3 Circuit

WARNING

Electric noise – Risk of personnel injury/damage to equipment

To minimize risk of electric noise causing disruptions of encoder signals, separate encoder cabling from motor power cables or e.g. electric brake actuation wiring.

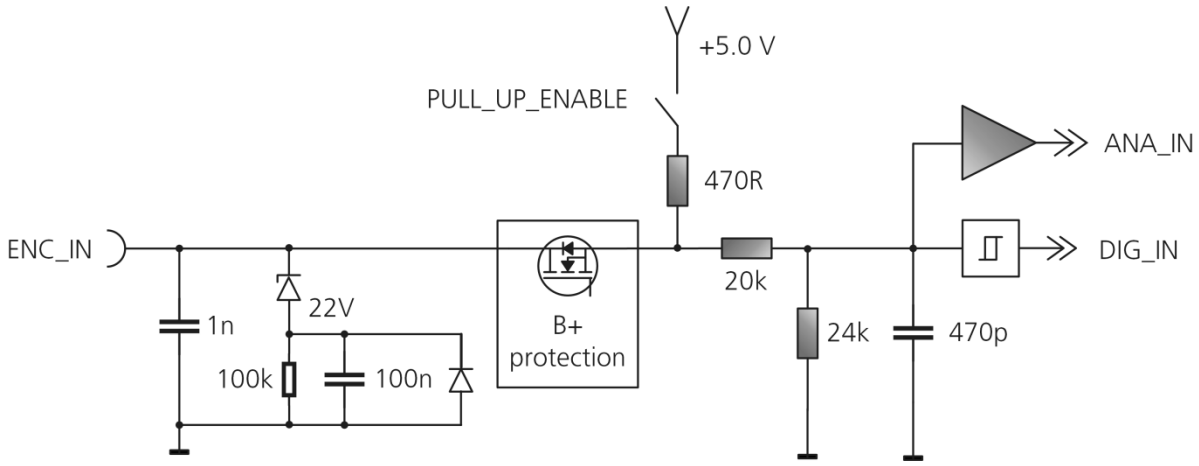


Figure 27 Schematic of the Encoder input circuit

8.9 Open Drain Output

8.9.1 Function

Open Drain outputs can be used for operating services such as the main contactor, relay, hydraulic valves, parking brake, etc.

The Open Drain outputs may work in different modes depending on the expected behavior of the connected load. The operating modes are:

- On/Off
- Voltage control (Pull/Hold)
- Current control
- Open-loop PWM control

In order to utilize the built-in free-wheeling diodes, loads connected to OPEN_DRAIN_type B (see Figure 29) must be supplied from the HIGH_SIDE_IN, while the loads connected to OPEN_DRAIN_type A (see Figure 29) must be supplied by HIGH_SIDE_OUT. Recommended wiring of loads, utilizing redundant shut-off capability of the high side switch, is shown in Figure 29.

In case the vehicle design does not allow usage of the built-in free-wheeling diodes, i.e. if the return path integrity cannot be guaranteed in all situations, external free-wheeling diodes must be applied over the inductive loads controlled by the open drain outputs.

Open drain output #	ON/OFF control	PWM control	Closed loop current control
1,2	Yes	Yes	Yes
3,4	Yes	Yes	No
5,6	Yes	No	No

Table 12 Open drain functionality

PWM frequencies are settable. The setting applies to all PWM outputs. PWM must only be used for inductive loads such as relays, contactors, motor brakes or hydraulic valves.

Each “open loop PWM” output can be voltage controlled with separate pull and hold voltage software parameters.

The current measurement can be used as open-load and overload detection. Each output has individual hardware for short circuit detection and rapid shut off to prevent damage to the circuit.

Refer to chapter 11.5.5 for current measurement range. The current is only measured when the open drain MOSFET is ON, see circuit in Figure 28. Current measurement offset error is compensated in software.

When using current control it is possible to add dithering by giving the current a low frequency, low amplitude oscillating waveform.

8.9.1.1 Dithering

When using current control, dithering can be added by giving the current a low frequency, low amplitude oscillating waveform.

Dithering is typically used when controlling proportional valves to create microscopic movements in the valve to prevent it from “sticking”. Successful dithering improves the valve response for small changes.

Set value Hz					
250	125	83	62	50	41

Table 13 Dithering frequency in fixed steps

The dithering frequency and current amplitude are adjustable. Actual dithering amplitude is dependent on load inductance, dithering frequency and current control regulator parameters i.e. P-gain and I-gain.

8.9.2 Protection

The open Drain outputs are protected against inductive discharge with internal freewheeling diodes to HIGH_SIDE_OUT/IN, internal short circuit detection and a capacitor to B- for ESD protection.

Protect the open drain outputs against reverse polarity of the battery according to picture in chapter 8.10.1.

NOTE

When driving inductive loads on PWM open drain outputs there must always be a path for the current to the freewheeling diodes. Do not connect any switch or fuse in series with the diode.

8.9.3 Circuit

CAUTION

Overvoltage sensitive equipment – risk of damage to equipment

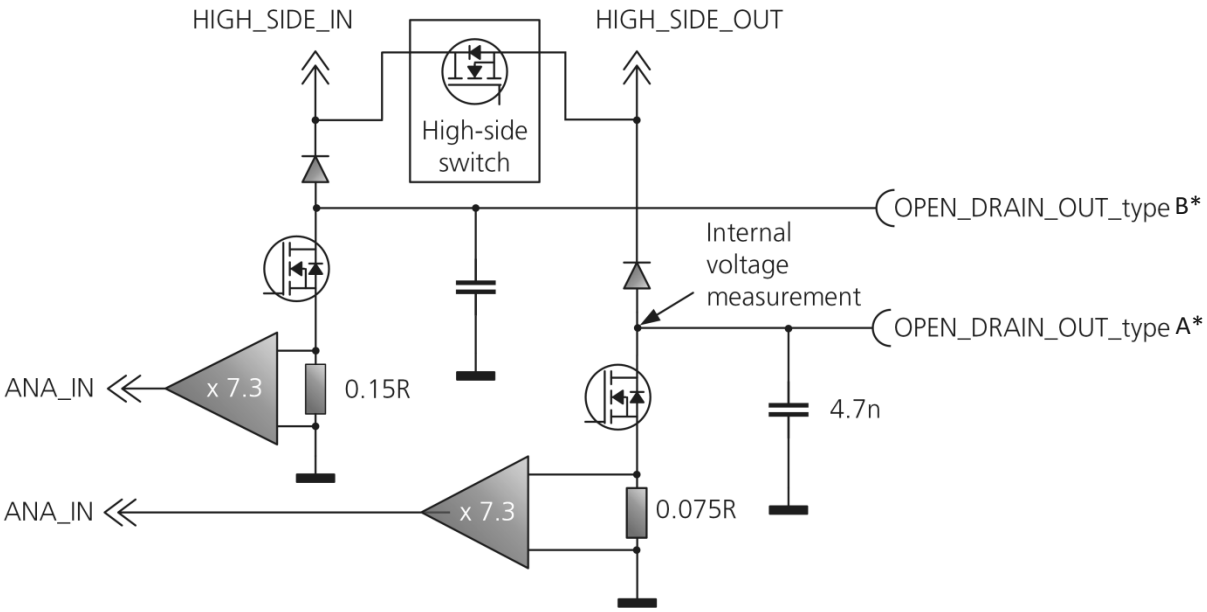
Internal free-wheeling diodes are provided to protect the motor controller from overvoltage at inductive load.

For OPEN_DRAIN_type A (see Figure 29); internal free-wheeling diodes are connected to the HIGH_SIDE_OUT pin.

For OPEN_DRAIN_type B (see Figure 29); internal free-wheeling diode s are connected to the HIGH_SIDE_IN pin.

Ensure that inductive loads are connected such that the path for the free-wheeling diode is always intact (see chapter 8.10.1), or use an external free-wheeling diode if this is not possible.

Use of brushless fan or other loads with built-in capacitor can give high inrush current when turned ON, which will give an open drain overcurrent trip. The inrush current must be below the open drain peak current.



* See Figure 29

Figure 28 Schematic of the Open Drain Output circuit

8.10 HIGH_SIDE_IN/PRE CHARGE and HIGH_SIDE_OUT

8.10.1Function

CAUTION

High current – risk of damage to equipment

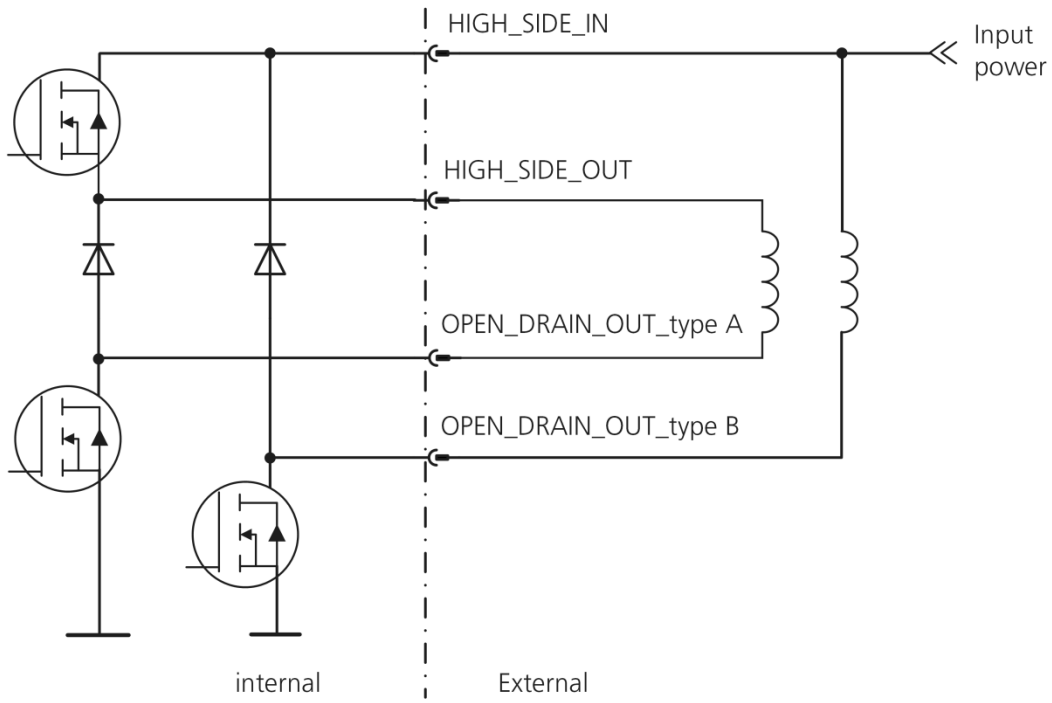
Keep Cable length from +/B+ to HIGH_SIDE_IN as short as possible. High current on open drain outputs with PWM can cause ripple voltage on the HIGH_SIDE_IN and HIGH_SIDE_OUT.

Ripple current must be less than 2 A continuous.

In addition to the open drain outputs there is also a high side switch for critical safety functions, providing redundancy to turn OFF the open drain loads. If an open drain output is short circuited, it is possible to turn OFF the High side switch to disconnect the load. The High side switch is automatically switched on as soon as the DC bus is charged.

The high side switch has a maximum output current. The high side switch has only ON/OFF control.

There are two types of open drain outputs: Type A and type B. The number of each type for a specific GVI model is explained in the table for Figure 29. Input voltage to power type A outputs shall be routed via the high side switch and type B outputs bypass the high side switch as indicated in Figure 29.



OPEN_DRAIN_1	OPEN_DRAIN_OUT_type A
OPEN_DRAIN_2	OPEN_DRAIN_OUT_type A
OPEN_DRAIN_3	OPEN_DRAIN_OUT_type A
OPEN_DRAIN_4	OPEN_DRAIN_OUT_type B
OPEN_DRAIN_5	OPEN_DRAIN_OUT_type B
OPEN_DRAIN_6	OPEN_DRAIN_OUT_type B

Figure 29 Open drains 1 – 6

High Side In voltage has a minimum required value for correct function (see chapter 11.5.6). A voltage below this value will shut down the high side output and indicate short circuit detection (which needs to be handled in the application). The HIGH_SIDE_OUT voltage is monitored and the high side in is monitored by a digital input.

8.10.1.1 PRE_CHARGE

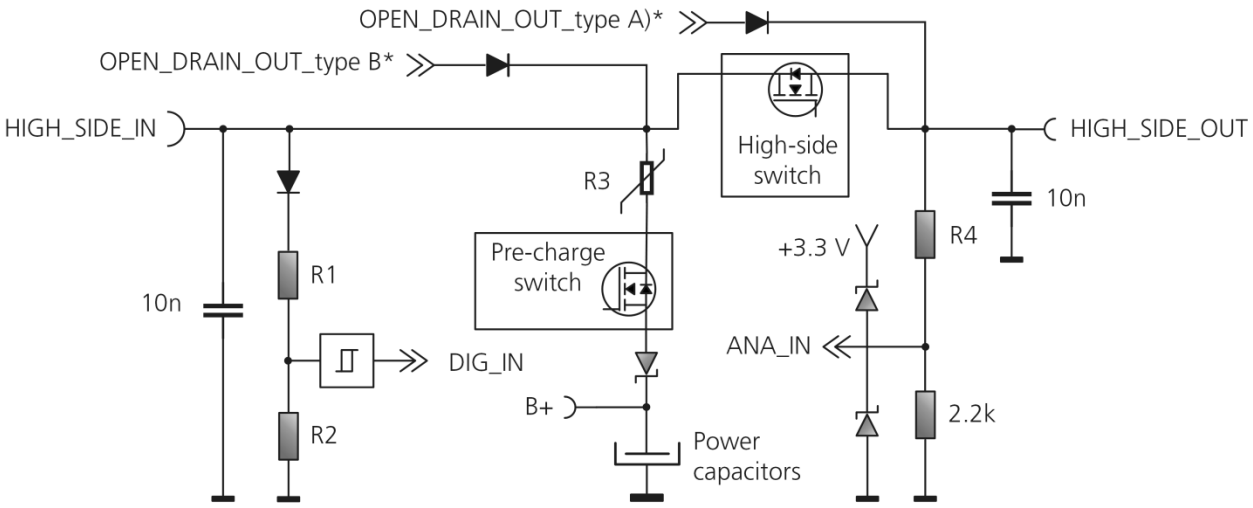
The GVI has an internal pre-charge PTC-resistor with a series diode connected between HIGH_SIDE_IN and the DC bus capacitors. The inrush current limiting resistance can be activated and deactivated in the motor controller software.

The pre-charge time is maximum 0.5 second to 70 % of the DC BUS charge.

8.10.2Protection

Internal hardware short circuit detection and a capacitor to B- on input and output are provided for ESD protection.

8.10.3Circuit



* See Figure 29

GVI	R1	R2	R3	R4
GVI 24V	5.4k	2.7k	6.6R	22k
GVI 48V	5.4k	2.7k	11R	47k
GVI 80V	20k	6.8k	22R	82k
GVI 96V	30k	10k	22R	100k

Figure 30 Schematic of the high side switch

8.11 MOTOR TEMP

8.11.1Function

Motor temperature sensor input for measurement of the motor winding temperature. The input is optimized for temperature sensors KTY84 with 1 000 Ω @ 100 °C or PT1000 with 1 000 Ω @ 0 °C, see chapter 7.16.

8.11.2Protection

The input is +/B+ protected. Input capacitors provide ESD protection and filtering of signal.

8.11.3Circuit

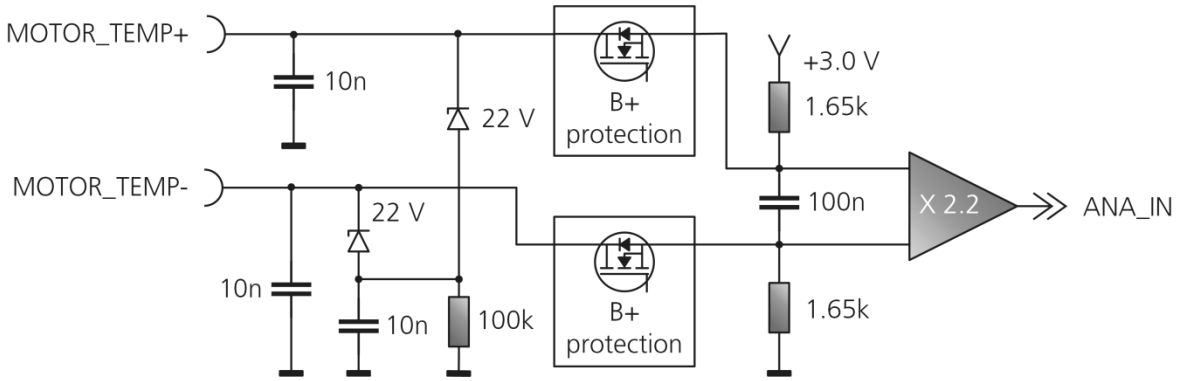


Figure 31 Schematic of the MOTOR_TEMP input circuit

8.12 SENSOR SUPPLY

8.12.1Function

Supply for external motor speed sensors and for analog inputs. The sensor supply output current is monitored in order to detect if a load is connected. SENSOR_SUPPLY_GND pin must be used for ground reference.

8.12.2Protection

Sensor supply output is over current protected with a thermal shut down and protected against accidental connection to +/B+ with a diode.

8.12.3Circuit

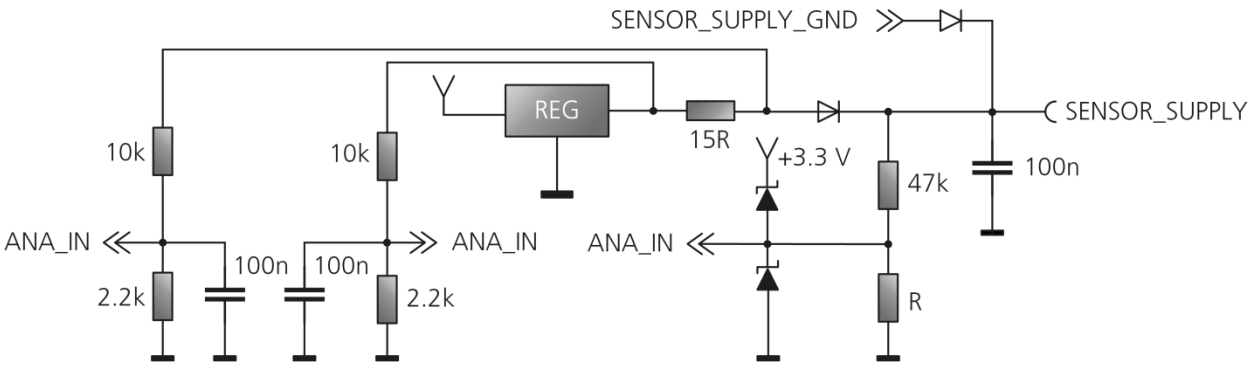


Figure 32 Schematic of the Sensor Supply Output circuit

8.13 SENSOR SUPPLY GND

8.13.1Function

NOTE

Do not connect SENSOR_SUPPLY_GND to B- externally.

Do not use SENSOR_SUPPLY_GND as supply ground for B+ supplied units.

Ignoring this note may result in severe noise problems or that the vehicle motor is shut off.

Ground Reference for analog sensors and sensors supplied from SENSOR SUPPLY output, i.e. potentiometers and feedback sensors.

In sleep mode, the external sensors supply current consumption is reduced by disconnecting the SENSOR_SUPPLY_GND pin from the ground reference.

NOTE

The diode from the SENSOR_SUPPLY_GND will protect the sensor supply load from reverse polarity when the SENSOR_SUPPLY_GND disconnects the load ground reference in Sleep mode.

8.13.2Protection

SENSOR_SUPPLY_GND is +/B+ protected with a MOSFET switch, which also used for Sleep mode. When short circuit current is detected, the MOSFET switch is turned off.

8.13.3Circuit

CAUTION

SENSOR_SUPPLY_GND must NOT be connected to B- externally – severe noise problems can be the result.

SENSOR_SUPPLY_GND must NOT be used as supply ground for +/B+ supplied units.

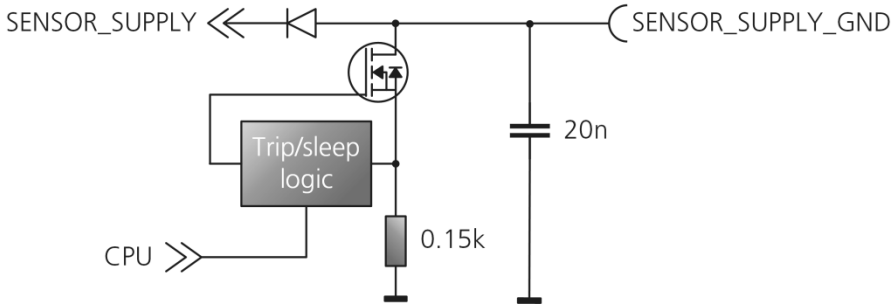


Figure 33 Schematic of the Sensor Supply GND circuit

8.14 CAN

NOTE

Error frames counter is available in the motor controller and is a good help for diagnostic of the CAN bus noise immunity.

8.14.1Function

WARNING

Incorrect use of isolation – risk of personnel injury

Isolation is only for increased noise immunity when running high current to the motor. The isolation must not be used for safety i.e. CAN_GND and B- shall be externally connected together in one point in the vehicle system.

Isolated CAN bus interface with Opto-couplers and internal +5 V supply from isolated DC/DC. Communication circuits with common-mode filter (choke and capacitor).

Physical Interface according to ISO 11898-2.

The CAN driver gives maximum amplitude on the CAN_HIGH to CAN_LOW signal.

Ground reference for CAN, CAN_GND, must be routed together with CAN_HIGH and CAN_LOW in the CAN-bus to avoid communication problems. There is no internal connection between CAN_GND and B- except for ESD protection and EMC suppression components.

NOTE

Using units with +3.3 V CAN drivers in this type of application with high current motor controllers is not recommended. The noise margins are reduced and there is a high risk of CAN error frames in the CAN system.

8.14.1.1 CAN_120R

CAN-cabling must use a pair of twisted wires for CAN_HIGH and CAN_LOW wires.

The CAN-cabling shall have a characteristic impedance of 120 Ω and both physical ends of the CAN Bus must be terminated with 120 Ω between CAN_HIGH and CAN_LOW for best possible noise immunity.

The motor controller has an internal 120 Ω termination resistor connected between CAN_LOW and CAN_120R pin. To activate internal termination, CAN_120R must be connected to CAN_HIGH with a jumper in the vehicle wire harness.

8.14.2Protection

Protected against +/B+, B- and ESD.

8.14.3Circuit

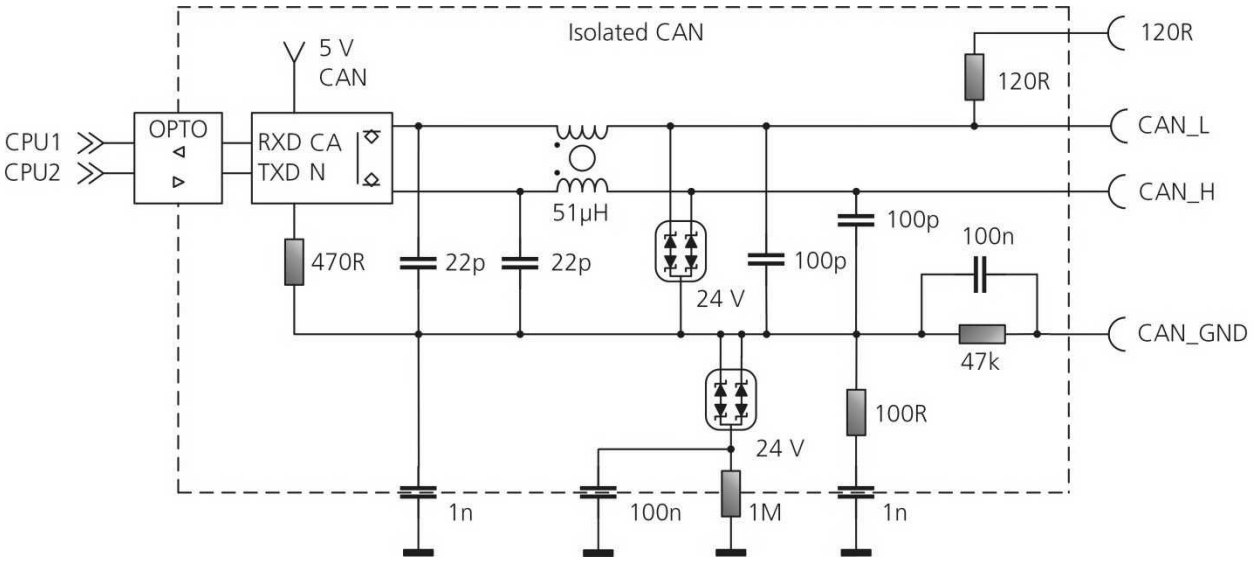


Figure 34 Schematic of the CAN circuit

9 Installation and maintenance instructions

9.1 Introduction

This chapter contains general instructions for installation and maintenance of the GVI inverter. Fasteners and tightening torques for mounting of the GVI inverter must be specified in accordance with Chapter 7. Fasteners for connection of the terminal posts on the motor controller must be specified according to chapter 9.6.

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

WARNING

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

High power levels are exposed at each of the power terminals (1, 2, 4, 7 and 10, Figure **5**). Protect these terminals from accidental contact which could result in personnel injury and/or short circuit.

CAUTION

Sensitive equipment – risk of damage to equipment

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

Do not clean the motor controller using high-pressure water.

CAUTION

Sensitive equipment – risk of damage to equipment

Take precaution during handling of the controller to protect external connections such as I/O connector, moisture vent, power terminals, coolant connections and motor power connections from shocks, other kinds of damage and debris.

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.

9.2 Periodic inspection & preventive maintenance

The recommended periodic preventive inspection and maintenance for the motor controller and associated components are minimal. Parker recommends that the below items are performed regularly. Refer also to chapter 3.

WARNING

High voltage – risk of electric chock

Disconnect the battery power supply before starting any work on the vehicle.

WARNING

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

To prevent personnel injury and protect the GVI from possible damage due to voltage transients, the inverter's DC bus capacitors must be discharged as described in the instruction below. Do not short the +/B+ to B- terminal as this may cause an arc.

CAUTION

Hot surfaces – risk of personnel injury

After operation of the motor controller, the heat sink may be too hot to touch. Allow it to cool before performing any maintenance work on the motor controller.

CAUTION

Water sensitive equipment – risk of damage to equipment

Do not clean the motor controller using high-pressure water.

1. Wait 5 minutes for the DC bus capacitors to self-discharge, or apply a 100Ω 10W resistance between +/B+ and B- terminals for 15 seconds to discharge the capacitors. Check that the voltage between +/B+ and B- is below 10V DC.
2. Check screw torque at terminal posts according to the values in chapter 9.6.
3. Inspect and, if necessary, remove dirt and debris from the fins of the motor controller heat sink to ensure cooling performance is maintained.
4. Reconnect the battery power supply.

9.3 Replacement of on-board fuse

WARNING

High voltage – risk of electric chock

Disconnect the battery power supply before starting any work on the vehicle.

WARNING

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

To prevent personnel injury and protect the GVI from possible damage due to voltage transients, the inverter's internal filter capacitors shall be discharged as described in the chapter 9.2. Do not short the +/B+ to B- terminal as this may cause an arc.

WARNING

Hot surfaces – risk of personnel injury

After operation of the motor controller, the heat sink may be too hot to touch. Allow it to cool before performing any maintenance work on the motor controller.

Replace the on-board fuse according to chapter 9.6.

9.4 GVI removal

WARNING

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

To prevent personnel injury and protect the GVI from possible damage due to voltage transients, the inverter's internal filter capacitors shall be discharged as described in the chapter 9.2. Do not short the +/B+ to B- terminal as this may cause an arc.

WARNING

Hot surface – risk of personnel injury

After operation of the motor controller, the heat sink may be too hot to touch. Allow it to cool before performing any maintenance work on the motor controller.

CAUTION

ESD – risk of damage to equipment

Connecting both the motor controller heat sink and the frame of the motors to the chassis of the truck is recommended for EMC and ESD purposes.

5. Disconnect the battery power supply.
6. Wait 5 minutes for the DC bus capacitors to self-discharge, or apply a 100Ω (10W) resistance between +/B+ and B- terminals for 15 seconds to discharge the filter capacitors. Check that the voltage between +/B+ and B- is below 10Vdc.
7. Depress locking latch on I/O connector housing and remove mating connector from the motor controller.
8. Mark the power cables to the terminals on the GVI (Table 15) in order to reconnect them properly again.
9. Remove the power cables from the +/B+, B-, U, V and W terminals.
10. Remove the screws securing the motor controller to the vehicle.

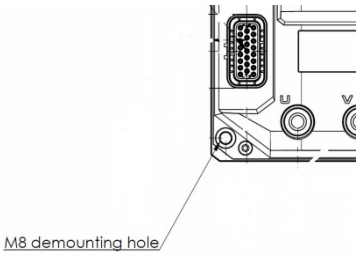


Figure 35 Demounting hole and slot

11. GVI frame D and E:
    Use a screw in the M8 demounting hole to release the motor controller from vehicle body.

9.5 GVI installation

WARNING

High voltage – risk of electric chock

Disconnect the battery power supply before starting any work on the vehicle.

WARNING

Electric arc – Risk of personnel injury and/or damage to equipment

Do not short the +/B+ to B- terminal as this may cause an arc.

CAUTION

ESD – risk of damage to equipment

Connecting both the motor controller heat sink and the frame of the motors to the chassis of the truck is recommended for EMC and ESD purposes.

NOTE

Orientation of the motor controller is the OEM' responsibility. See Chapter 7.8.

1. Verify that the item number stated on the motor controller label is correct for the application.
2. For flat heat sink version, apply thermal grease evenly over the heat sink surface.
3. Mount the motor controller to the vehicle body and tighten the screws slightly. See chapter 9.5.1 for recommended screws.
4. Tighten the screws. Applied torque must be defined by OEM according to material used in vehicle body.
5. Insert mating I/O connector plug to the motor controller.
6. Perform initial start-up according to the procedure described in chapter 9.7.1.
7. Connect the power cables to the terminals (Table 15) on the motor controller according to chapter 9.6.
8. Reconnect the battery power supply.

9.5.1 Assembly material for GVI mounting

The following sub-chapters describe recommended assembly materials (not included with product) for mounting of the different GVI models.

Drilling pattern for the GVI mounting holes is shown on the GVI mechanical product drawing.

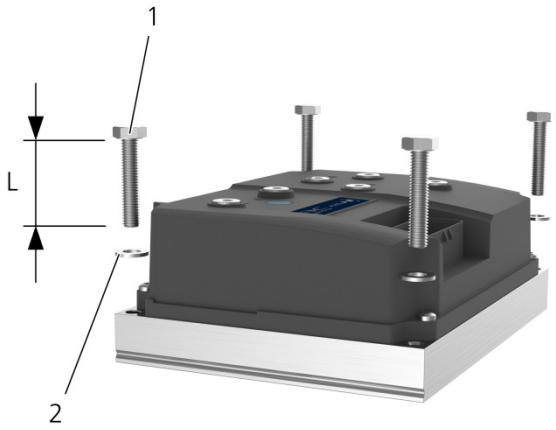
Screws and nuts (when used) for the different GVI models are specified in Table 14.

WARNING

High current – risk of personnel injury and/or damage to equipment

To avoid burning or overheating of the power terminals, ensure that:

The correct torque is applied to screws or bolts at production.
The proper mounting screw length is used in installations with threaded studs.



Pos	Name	Pos	Name
1	Screw	2	Washer
L	Length of screw (1). The depth of thread in the vehicle body should be at least 1.5 x Ø mm. For calculation of L, see heat sink dimensions in chapter 11.6.2		

Figure 36 Principle illustration of assembly materials

Pos	Name	Characteristics	Pieces
1	Screw	MC6S M6 x L (see Figure 36), 8.8 fzb (DIN 912), MRT M6 x L, 8.8 fzb, T30 (DIN 7985) or equivalent (1/4 UNC)	4
2	Washer	BRB 8.8 HB 200 fzb (DIN125A)	4
-	Thermal grease	Electrolube HTC or Dow Corning 340, approximate 9 grams	-

Table 14 Assembly materials for GVI

9.6 Connecting power terminals

WARNING

High current – risk of personnel injury and/or damage to equipment

To avoid burning or overheating of the high-current terminals, ensure that the correct torque is applied to screws or bolts at production, and that proper screw length is used. Any washers used for the optional on-board fuse must be made of tin-plated copper.

WARNING

High current – risk of personnel injury and/or damage to equipment

Make sure that the vehicle battery polarity is correct. It is the OEM's responsibility to ensure that reverse polarity cannot cause short-circuiting of the battery.

NOTE

The power terminals U, V, and W (2, Figure 16) are not interchangeable and must be connected to the corresponding terminals on the motor(s).

The following sub-chapters describe recommended assembly materials (not included with product) for the different motor controller models.

Table 15 describes the power terminal connections on the motor controller.

Terminal name	Description
B+	Frames D and E only: Terminal for on-board fuse (optional). There is no connection to internal circuitry from this terminal. Frame C only: Positive supply to the power stage. (external fuse required).
+	Positive supply to the power stage. (When external fuse is used connection is made directly to this terminal.).
B-	Battery negative terminal.
U, V, W	Motor U, V, W – phase terminal.

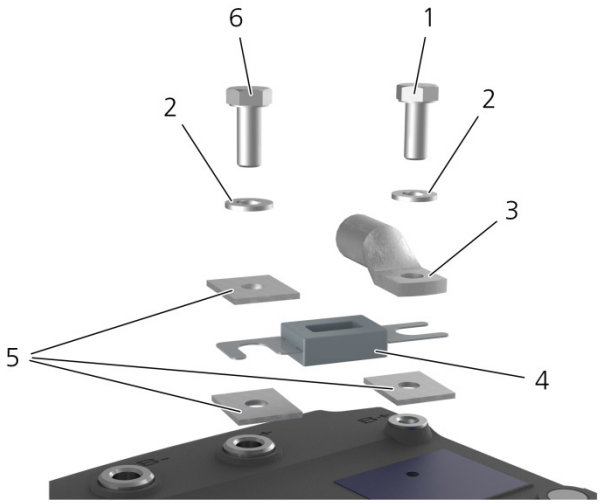
Table 15 Motor controller power terminal connections

9.6.1 Power Terminals

Figure 37 shows the assembly order for the terminal connection fasteners.

NOTE

Mount the optional on-board fuse according to chapter 9.6.2 if rectangular washers are used. Circular washers can also be used.

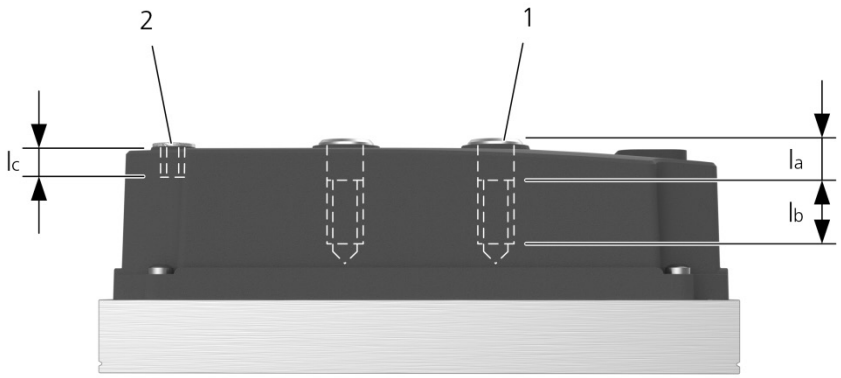


Pos	Name	Frame C	Frame D	Frame E
1	Screw for terminal B+ (for optional on-board fuse) [1 piece]	M6 x L Pitch 1 Screw engagement 8-12.5 mm Tightening torque 8 ± 1 Nm	M8 x L Pitch 1.25 Screw engagement 12-16 mm Tightening torque 15 ± 2 Nm	M8 x L Pitch 1.25 Screw engagement 8-12 mm Tightening torque 15 ± 2 Nm
2	Flat washer [6 pieces]	ISO 7089 12 x 6.4 x 1.6 – 200 HV or similar	ISO 7089 16 x 8.4 x 1.6 – 200 HV or similar	ISO 7089 16 x 8.4 x 1.6 – 200 HV or similar
3	Ring lug [5 pieces]	6.5 mm hole diameter for battery and motor connections	8.5 mm hole diameter for battery and motor connection	8.5 mm hole diameter for battery and motor connection
4	On-board fuse (optional) [1 piece]	Not applicable	OEM's responsibility. See chapter 7.11.1	OEM's responsibility. See chapter 7.11.1
5	Washer (for optional on-board fuse) [3 pieces]	Not applicable	Tin plated copper washer	Tin plated copper washer
6	Screw for terminals U, V, W, B- and + [5 pieces]	M6 x L Pitch 1 Screw engagement 8-12.5 mm Tightening torque 8 ± 1 Nm	M8 x L Pitch 1.25 Screw engagement 28-32 mm Tightening torque 15 ± 2 Nm	M8 x L Pitch 1.25 Screw engagement 12-19 mm Tightening torque 15 ± 2 Nm

Figure 37 Fasteners for power terminals

NOTE

On GVI Frame D, the first part of the screw holes for terminals U, V, W, B- and + is non-threaded (see Figure 38).



Pos	Name	Pos	Name
1	Terminal (U, V, W, B- and +)	2	Terminal B+
L_a	Length (non-threaded) = 11.5 mm	L_b	Length (threaded) = 21 mm
L_c	Length (threaded) = 6 mm		

Figure 38 Thread lengths in screw holes for terminals on GVI Frame D

9.6.2 Placement of rectangular washers for on-board fuse

The optional on-board fuse is described in chapter 7.11. and is applicable to GVI frames D and E.

This chapter describes how to place rectangular washers for mounting of the on-board fuse on the terminal posts of the motor controller. Circular washers can also be used.

Orient the rectangular washers as shown in the picture to the right.

Washer must touch only the conductive forks of the fuse, not the fuse body.

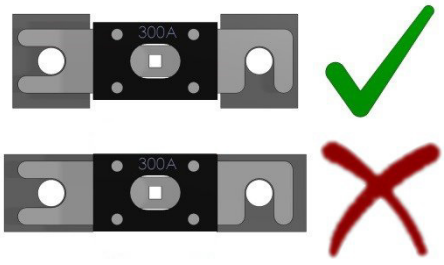


Figure 39 Correct and incorrect placement of rectangular washer for optional on-board fuse

9.7 Start-up and commissioning

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

WARNING

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

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

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

9.7.1 Checks before initial power up

Perform the following checks before applying power to a motor controller for the first time:

1. Verify that the proper GVI for the application has been installed. Verify that the vehicle battery voltage matches the motor controller's Nominal DC Supply Voltage rating listed on the product identification label (Figure 7).
2. Verify that the correct software for the application has been loaded into the GVI.
3. Verify that all power and signal wiring to the GVI is correctly connected. Refer to chapter 9.6 for power connections.
4. Verify that connections to battery and motor terminals are tightened with appropriate torque (chapter 9.6).
5. Verify that the control I/O plug is fully mated and latched into position with the mating connector on the GVI.
6. Verify that the GVI is correctly fused for the application. Refer to the vehicle manufacturer's maintenance documentation for the correct fuse size.
7. For traction applications, raise up or otherwise disable drives wheels to prevent the possibility of unexpected vehicle motion or motion in the wrong direction during initial commissioning. For hydraulic applications, open the valve to prevent the possibility of excess pressure build-up (in the event of a pressure relief valve malfunction).

9.7.2 Verifying motor controller readiness for operation

The following procedure can be used to verify that a GVI is functional and able to communicate over CAN bus.

1. Apply logic power to the GVI by applying battery power to KEY_INPUT.
2. Verify that the LED status indicator (see chapter 10.1) on the GVI lights steadily in *on* condition.
3. If the indicator is *flashing* or *off*, it indicates an error/warning or other fault condition within the GVI (see chapter 10.1).

10 Troubleshooting

Refer to the relevant EPF file for a complete and product-specific error list for the GVI.

10.1 LED status indicator

The LED status indicator (Figure 11) informs about the current state of the motor controller according to Table 16.

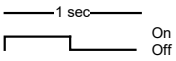
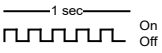
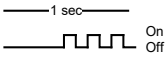
LED status indicator appearance	Drive condition
Off	GVI is not powered, or powered but not functional.
On (steady light)	GVI is fully operational with no error condition.
Blinking very slowly (0.1 Hz)	Sleep mode is activated.
Blinking slowly 	A warning condition is active. This may cause the GVI to reduce maximum available output power to the motor.
Blinking rapidly 	An error condition is active. This may cause the GVI to shut down output power to the motor.
Intermittent blinking 	GVI is in software boot mode, caused either by an on-going software download or by missing or corrupt application software.

Table 16 LED status indicator

11 Product Specifications

11.1 General

Description	Value
Supported motor types	Synchronous AC (PMAC)
Switching frequency	4, 8, 12, 16 kHz
Operating stator current frequency	0-599 Hz
Control modes	Speed (rpm), Torque (Nm), Current (ARMS) or Voltage (VDC)
Communication	CAN (CANopen, J1939)
Connector	AMP SEAL 35-pin (TE 776164-1)
Ambient Operating temperature	-40 °C to + 65 °C (- 40 °F to + 149 °F with reduced 1 hour current above + 40 °C (+ 104 °F)
Maximum operating altitude above sea level	2 000 m (6 561 feet)
Recommendations for short-term storage/transportation Temperature Relative humidity	 - 40 °C to + 85 °C (- 40 °F to + 185 °F) < 60 % (non-condensing)
Recommendations for long-term storage Temperature Relative humidity	 + 10 °C to + 30 °C (+ 50 °F to + 86 °F) < 60 % (non-condensing)

11.2 Current and power output ratings

GVI model	Nominal DC supply voltage [V DC]	Rated current (S2 2 min) [ARMS]**	Rated current (S2 1 h) [ARMS]***	Rated power (S2 2min) [kVA]**	Rated power (S2 1h) [kVA]***
Frame C					
GVI-C024-0350	24	350	150	10	4.4
GVI-C048-0280	36-48	280	120	12/16	5.3/7.1
Frame D					
GVI-D024-0550	24	550	275	16	8.1
GVI-D048-0450	36-48	450	225	20/26	9.9/13
GVI-D048-0550	36-48	550	275	24/32	12/16
GVI-D080-0230	36-80	230	115	23	11
GVI-D080-0350	80	350	175	34	17
GVI-D096-0230	96	230	115	27	14
GVI-D096-0350	96	350	175	41	21
GVI-D096-0400	96	400	180	47	21
Frame E					
GVI-E048-0700	36-48	700	350	31	15
GVI-E080-0500	80	500	250	49	24
GVI-E080-0700	80	700	350	69	34
GVI-E096-0500	96	500	250	59	29
GVI-E096-0700	96	700****	350	82	41

** 2 minute rating at 8 kHz switching frequency and 25ºC ambient temperature.

*** 1 hour rating at 8 kHz switching frequency, 40ºC ambient temperature, and 6 m/s air flow through finned heat sink (not supplied)

**** Current rating limited to S2 90 seconds

11.3 DC supply voltage ratings

GVI Model	Nominal DC supply voltage [VDC]	Operating range [VDC]	Instantaneous min. (< 100 ms) [VDC]	Instantaneous max. (< 10 s) [VDC]
GVI-x024	24	16 – 32	12	34
GVI-x048	36-48	33 – 63	15	68
GVI-x080	80	50 – 104	40	112
GVI-x096	96	56 – 125	48	134

11.4 DC bus capacitance values

GVI model	DC bus capacitance [µF]
GVI-C024-0350	24 000
GVI-C048-0280	10 880
GVI-D024-0550	17 680
GVI-D048-0450	15 640
GVI-D048-0550	17 680
GVI-D080-0230	4 590
GVI-D080-0350	6 210
GVI-D080-0400	7020
GVI-D096-0230	4 680
GVI-D096-0350	4 680
GVI-D096-0400	4 680
GVI-E048-0700	21 760
GVI-E080-0500	8 640
GVI-E080-0700	12 420
GVI-E096-0500	6 480
GVI-E096-0700	8 640

Table 17 DC bus capacitance values

11.5 I/O Interface technical data

11.5.1Key input

Description	Value
Function	
Inrush current (reduced by internal resistor)	< 3 A
The current ripple peaks may initially exceed 5 A.	
Circuit	
Capacitor (B-) for ESD protection	Approximately 20 nF

11.5.2Digital inputs

Refer to Figure 23

Description	Value
Function	
Threshold level for logic low	< 2 V
Threshold level for logic high	> 10 V
Maximum input voltage	+/B+
Circuit	
Input impedance GVI 24 – 48 V GVI 80 V GVI 96 V	 8.1 ±0.5 kΩ 27 ± 1 kΩ 40 ± 2 kΩ
Input capacitance (ESD protection)	10 nF

11.5.3Analog inputs

Refer to Figure 26

Description	Value
Function	
Analog to Digital Converter	12 bit ADC, input range 0-5 V
Maximum input frequency	100 Hz
Circuit	
Input impedance	65 kΩ
Input capacitance (ESD protection)	10 nF

11.5.4Encoder input

Refer to Figure 27

Description	Value
Function	
Threshold level for Low	< 2 V
Analog to digital converter connection	12 bit ADC, input range 0-5 V
Circuit	
Input impedance (pull-down)	44 k Ω
Internal pull-up to +5V (SW controlled)	470 Ω
Input capacitance (ESD protection)	1 nF

11.5.5Open drain output

Refer to Figure 28

Description	Value
Function	
Open drain output continuous (hold) current	2.0 A (Open drain 1, 2, 3) 0.7 A (Open drain 4, 5, 6)
Open drain output peak (pull) current (max 200ms)	2.8 A (Open drain 1, 2, 3) 2.0 A (Open drain 4, 5, 6)
PWM frequency setting interval	1-16 kHz
Voltage measurement	Open drain 1, 2, 3
Current measurement and control	
Current measurement	0 – 5.4 A with 12 bit resolution (Open drain 1, 2, 3) 0 – 2.7 A with 12 bit resolution (Open drain 4, 5, 6)
Dithering current amplitude	up to 20% of reference value
Recommended PWM Duty cycle for closed loop current control	> 15% for best accuracy
Circuit	
Capacitor (B-) for ESD protection	4.7 nF

11.5.6High side in and out

Refer to Figure 30

Description	Value
Function	
High_side minimum input voltage	+10 V
High side switch maximum output current	6 A continuous
Maximum allowable ripple current	2 A continuous
Circuit	
Capacitor for ESD protection	10 nF

11.5.7Motor temperature measurement input

Refer to Figure 31

Description	Value
Circuit	
Internal voltage reference	+3.0 V
Input impedance	1.65 kΩ
Difference voltage measurement gain	2.2
Input capacitance	10nF

11.5.8Sensor supply

Refer to Figure 32

Description	Value
Sensor supply 1	+12 V
Sensor supply 2	+5 V
Maximum output current	75 mA

Table 18 Sensor supply

11.5.9CAN

Refer to Figure 34

Description	Value
Function	
Internal supply	+5 V
Data rate	125, 250 or 500 kbit/s
CAN driver supply	+5 V
Circuit	
Capacitor (B-) for ESD protection	1 nF
Termination resistor	120 Ω

11.6 Physical characteristics

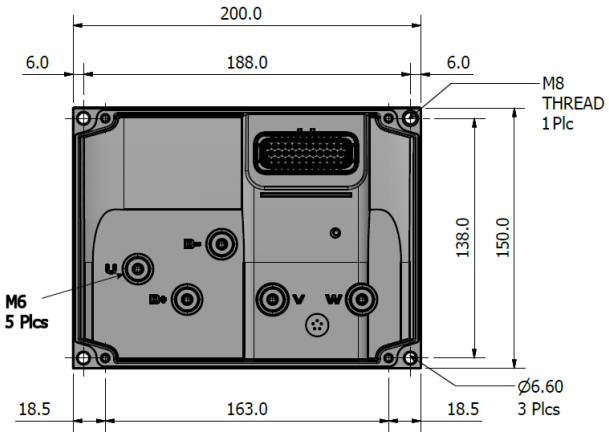
11.6.1Weight

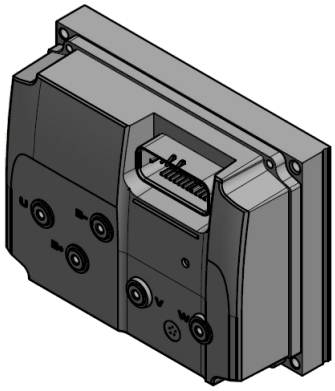
Weight accuracy is ± 10 % depending on actual product configuration.

GVI Size	[Kg]
Frame C	2.6
Frame D	2.9
Frame E	4.8

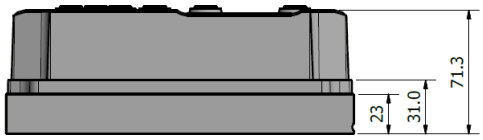
11.6.2Dimensions

11.6.2.1 GVI Frame C

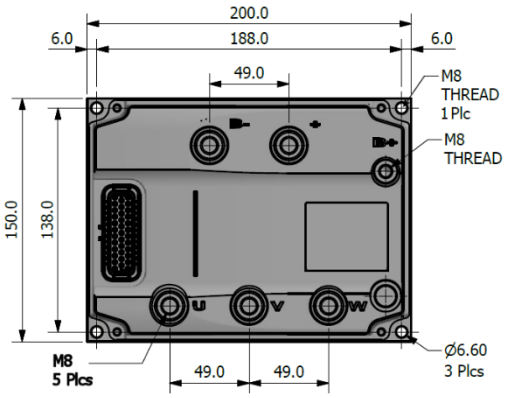


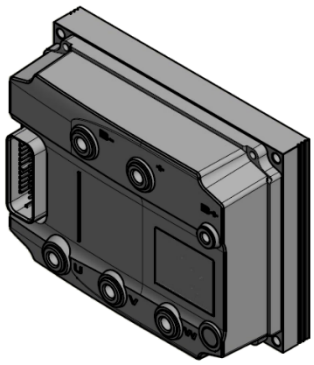


3D VIEW

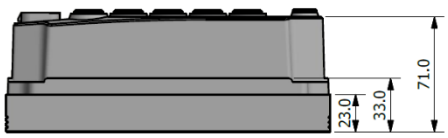


11.6.2.2 GVI Frame D

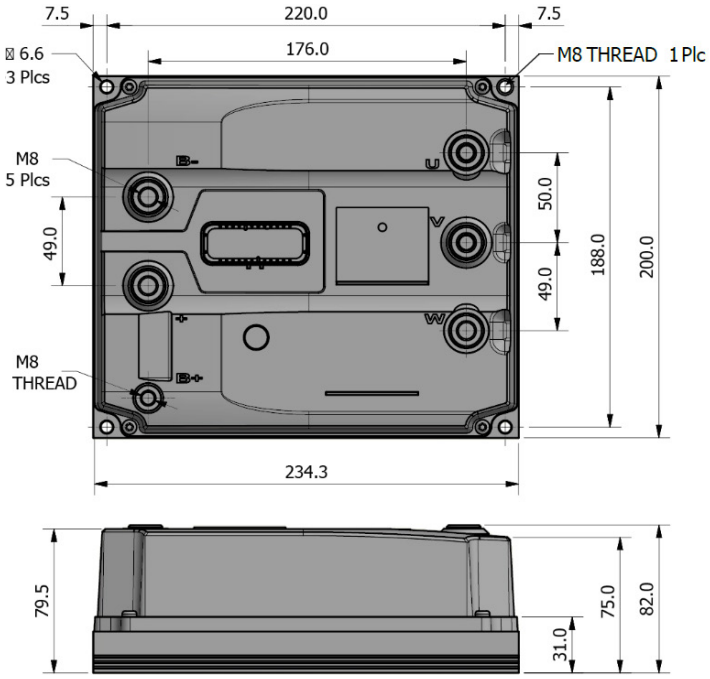


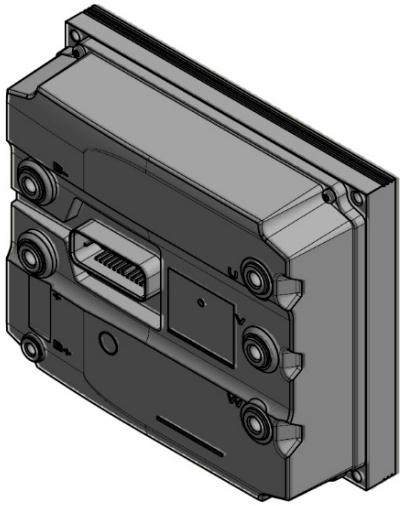


3D VIEW

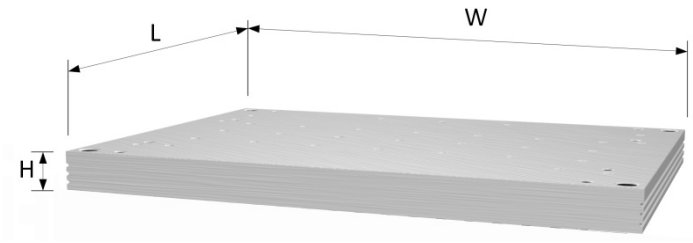


11.6.2.3 GVI Frame E





3D VIEW



GVI Size	H x W x L [mm]
Frame C	12.5 x 200 x 150
Frame D	23 x 200 x 150
Frame E	23 x 200 x 235

Figure 40 Width (W) and length (L) of heat sinks

11.6.3Surface requirement

For all GVI frames, the mounting surface in the vehicle shall fulfill this requirement for full rating according to chapter 11.2.

GVI Frame	Tolerance	Roughness
All models	▱ 0.1/200x150 mm	1.6 Ra 1.6

Table 19 Roughness and flatness requirement

11.7 Environmental testing & standards compliance

11.7.1 General

Subject	Standard
Protection class	IP65 Test IEC 60529 (with mating connector installed)
Standard	UL 583 and EC declaration of incorporation of partly completed machinery according to EN1175-1

11.7.2 Temperature

Subject	Standard
Cold storage -40 °C, 16 hours	IEC 60068-2-1 test Ad
Dry heat storage +85 °C, 16 hours	IEC 60068-2-2 test Bd
Cold operation -40 °C, 16 hours	IEC 60068-2-1 test Ad
Dry heat operation 65 °C, 16 hours	IEC 60068-2-2 test Bd
Change of temperature -40 °C to 65 °C, 20 cycles	IEC 60068-2-14 test Na

11.7.3 Humidity

Subject	Standard
Damp heat steady-state 85 % Rh 85 °C, 500 hours	IEC 60068-2-78 test Cab
Composite temperature/humidity cyclic test -10 °C to +65 °C	IEC 60068-2-38 test Z/AD

11.7.4Mechanical tests

Subject	Standard	
Random vibration accelerated life	EN 60068-2-64 test Fh	
	Frequency	**Acceleration PSD**
	[Hz]	[g2/Hz]
	5	0.02
	8	0.025
	14	0.2
	25	0.05
	100	0.05
	200	0.04
	250	0.03
	275	0.075
	350	0.02
	500	0.02
	Total g RMS	4.5
	Duration	50 h in each direction
	The drive was in operation during the test	
Bump 25 G	2 500 positive and 2 500 negative half sine pulses with acceleration of 25 g, pulse length 6 ms for all 3 octagonal axis, tested as described in EN60068-2-27 Test Ea	
Shock 50 G	5 positive and 5 negative half sine pulses with acceleration of 50 g, pulse length 6 ms for all 3 octagonal axis, tested as described in EN 60068-2-27 test Ea	

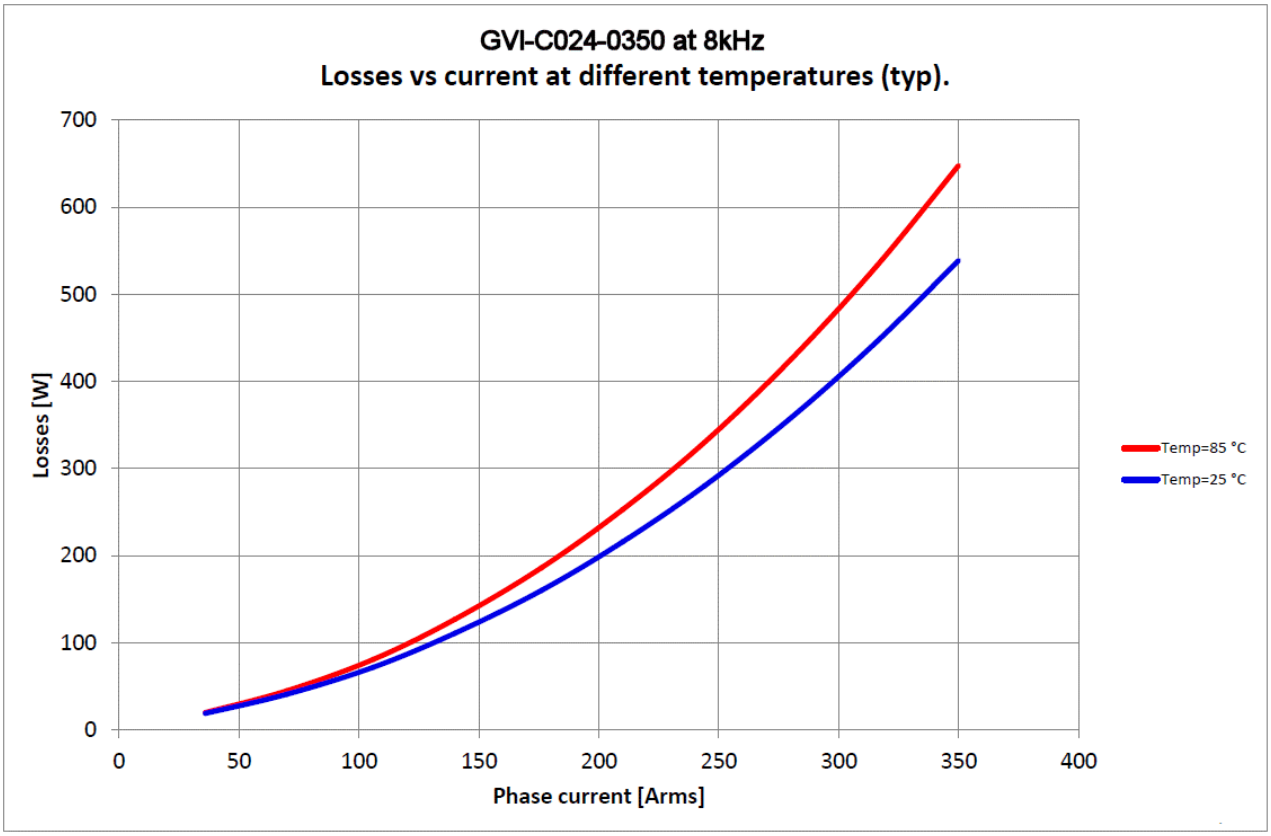
11.7.5EMC

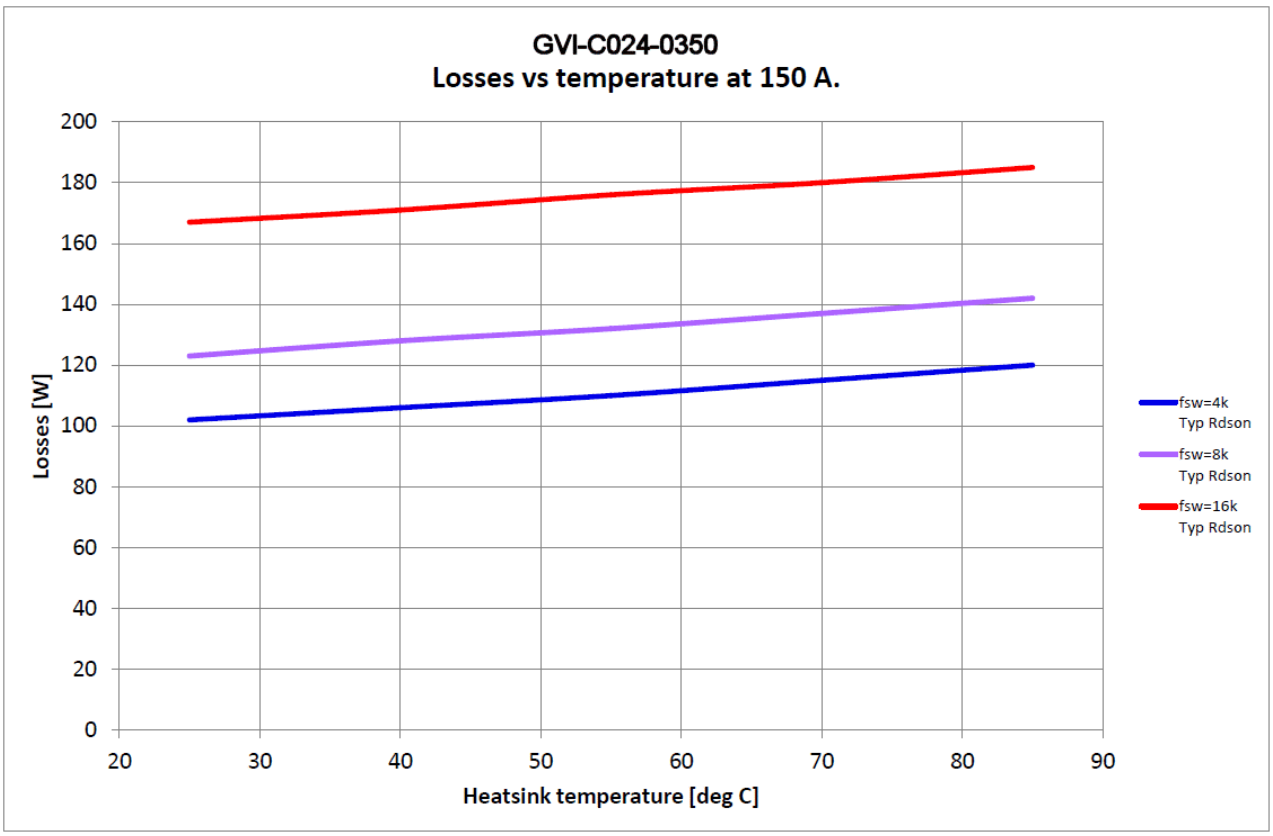
Subject	Standard
Emission	According to EN12895, Industrial Trucks (radiated emission test EN 55022 class B)
Immunity 27 -1 000 MHz 20V/m	EN 61000-4-3
ESD 8 kV contact 15 kV air discharge	EN 61000-4-2
Electrical fast transient /burst	EN61000-4-4 level 2

11.7.6Isolation

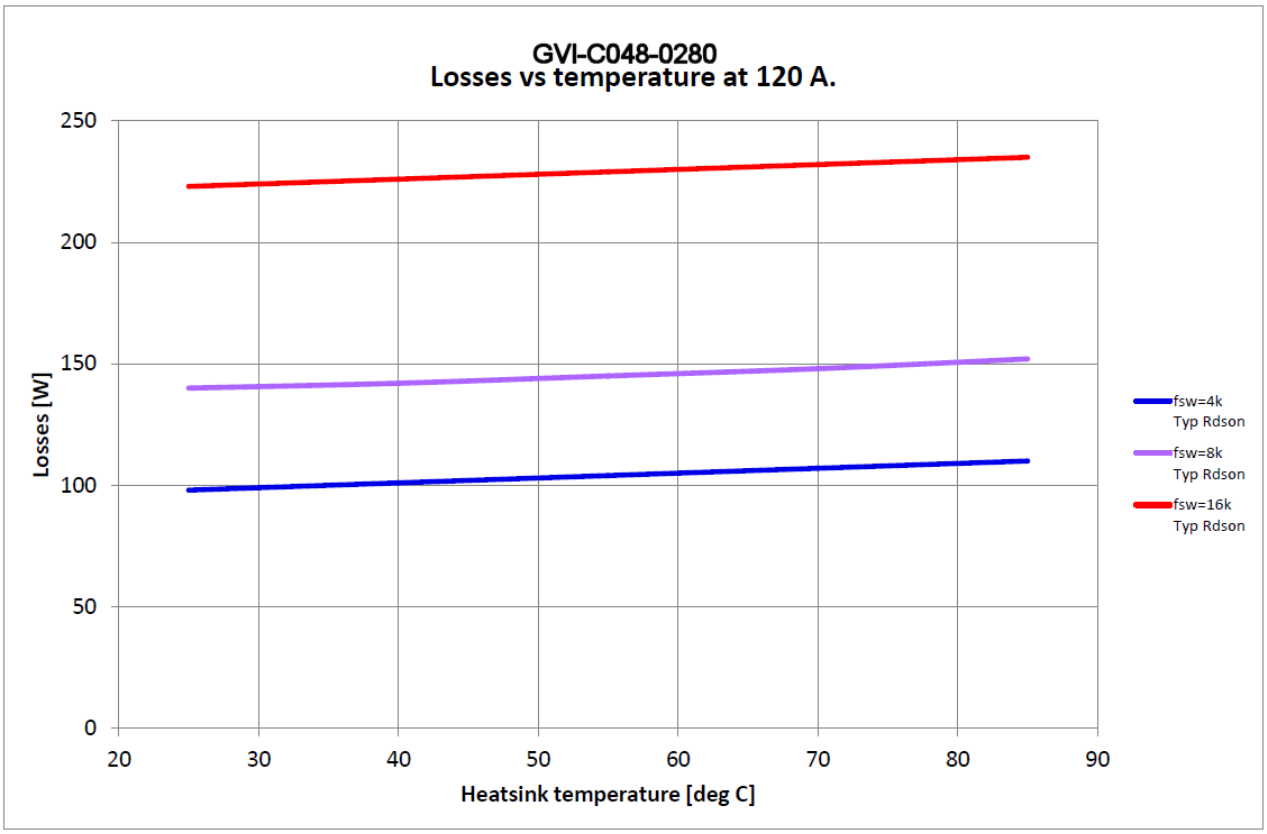
Subject	Standard
GVI 24-48 V B- terminal to heat sink : 500 Vac (50 Hz/60 Hz)	According to EN 1175-1 clause 4.10.1
GVI 80 V B- terminal to heat sink : 1000 Vac (50 Hz/60 Hz)	According to EN 1175-1 clause 4.10.1
GVI 96 V B- terminal to heat sink : 1000 Vac (50 Hz/60 Hz)	According to EN 1175-1 clause 4.10.1

11.8 Temperature Loss Curves

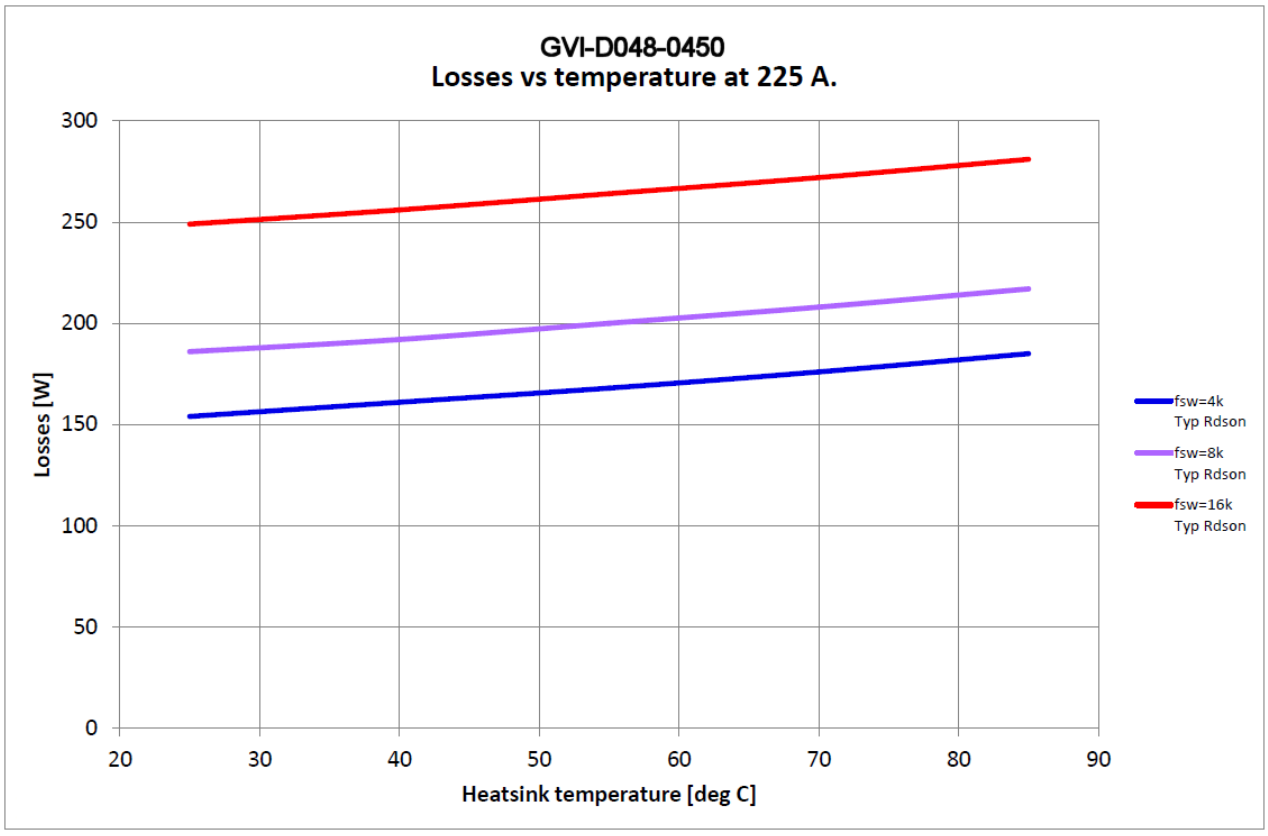


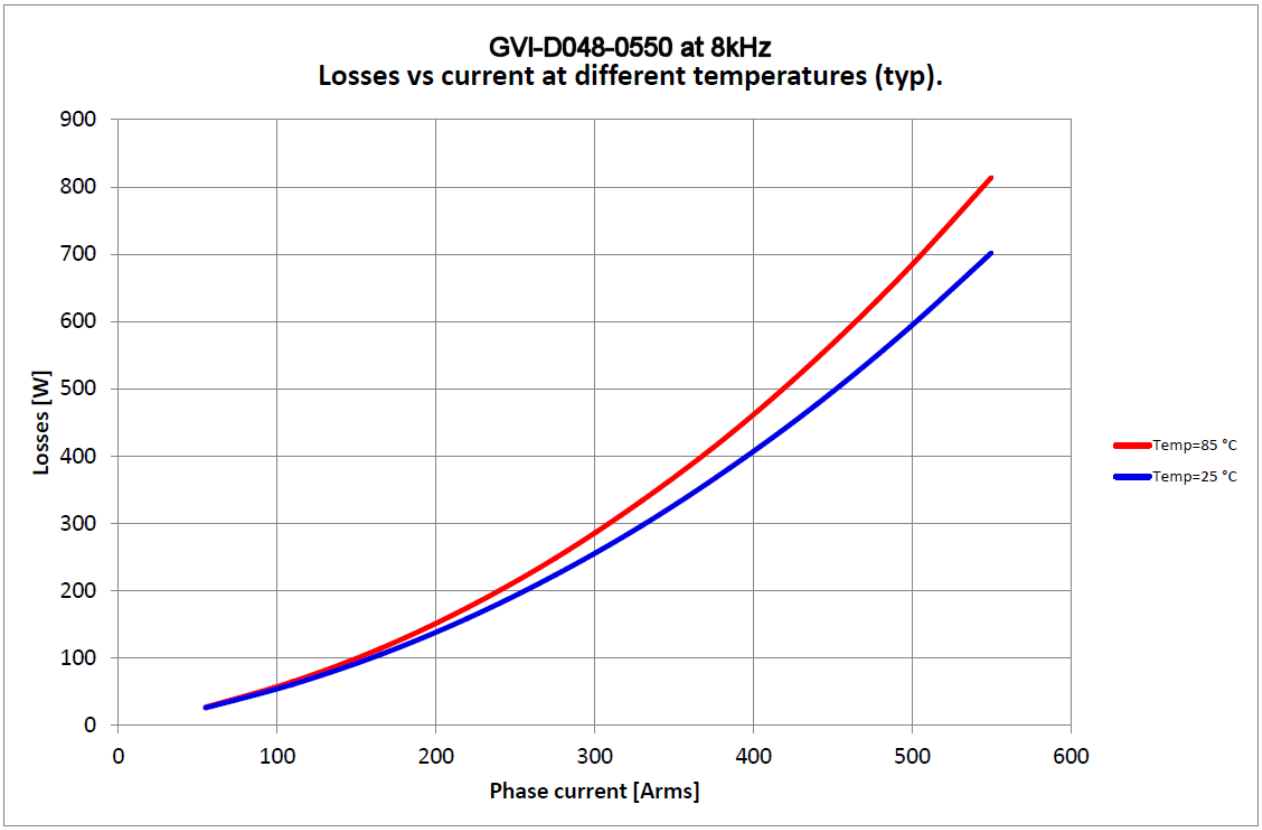


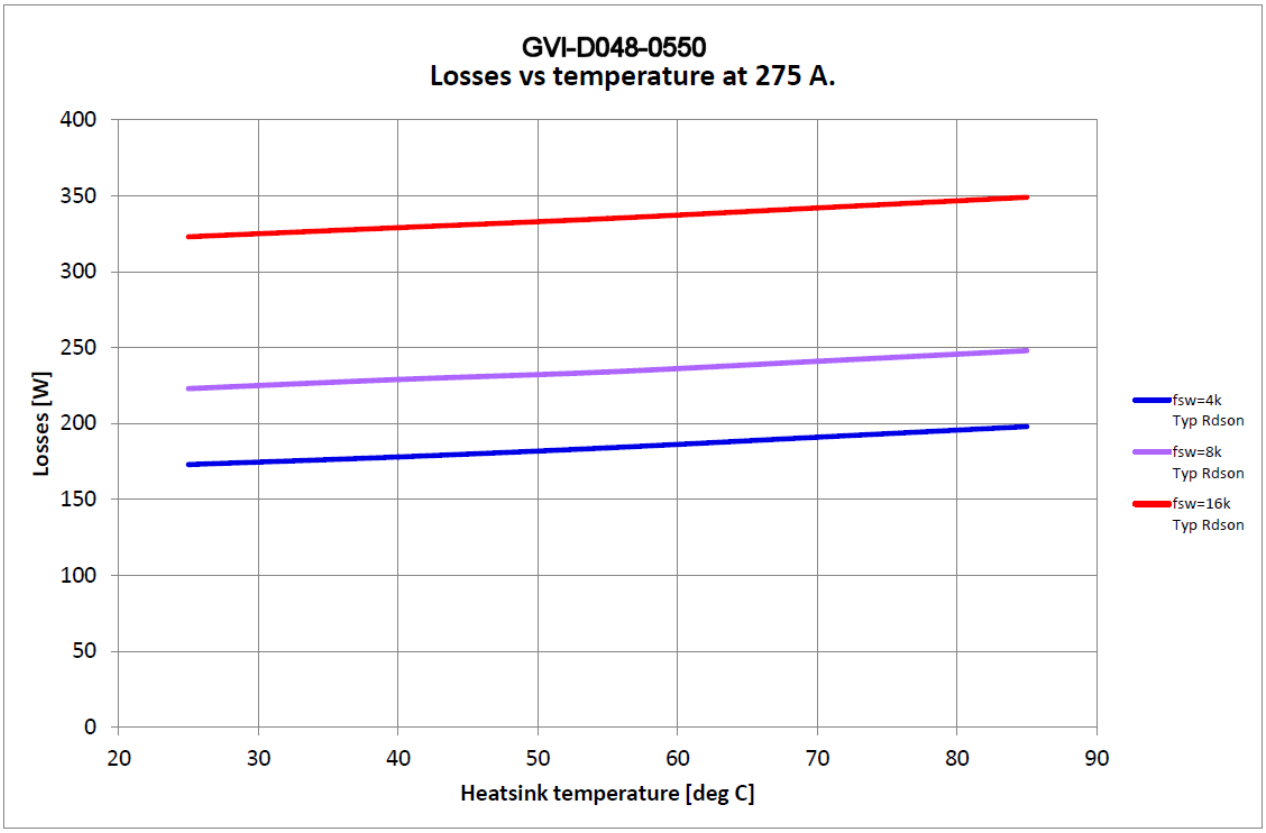

GVI-C048-0280 at 8kHz
Losses vs current at different temperatures (typ).
Losses [W]
Phase current [Arms]
0
100
200
300
400
500
600
700
0
50
100
150
200
250
300
Temp=85 °C
Temp=25 °C

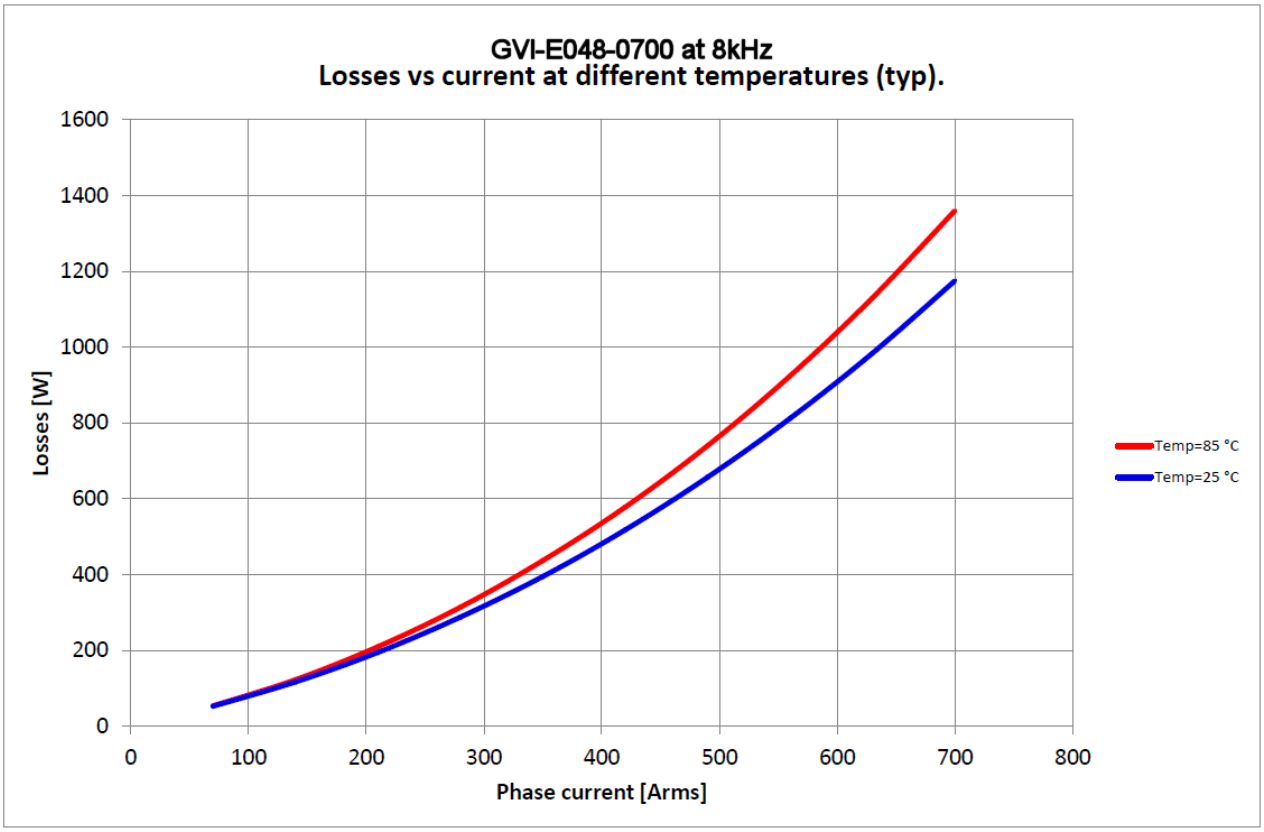

GVI-C048-0280
Losses vs temperature at 120 A.
Losses [W]
Heatsink temperature [deg C]
0
50
100
150
200
250
20
30
40
50
60
70
80
90
fsw=4k
Typ Rdson
fsw=8k
Typ Rdson
fsw=16k
Typ Rdson

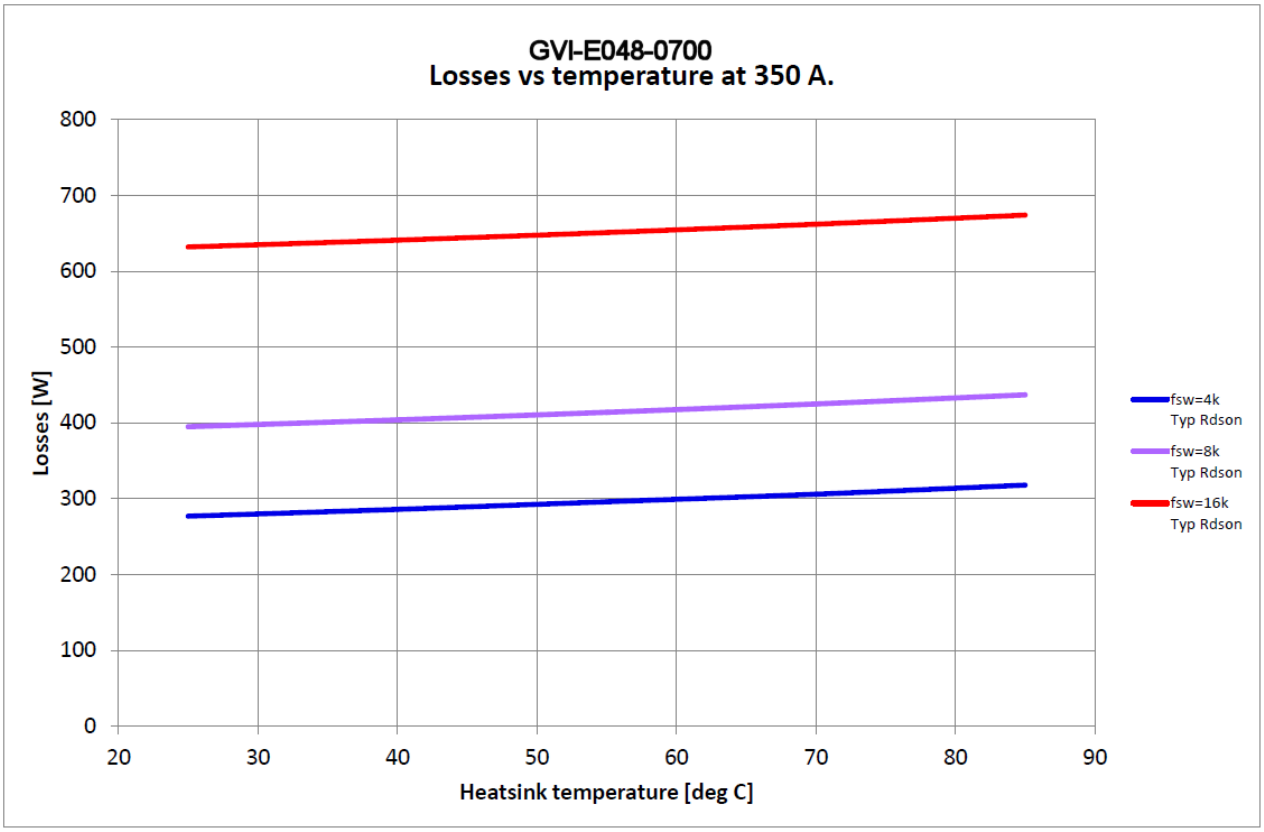

GVI-D048-0450 at 8kHz
Losses vs current at different temperatures (typ).
Losses [W]
Phase current [Arms]
0
100
200
300
400
500
600
700
800
900
0
50
100
150
200
250
300
350
400
450
500
Temp=85 °C
Temp=25 °C

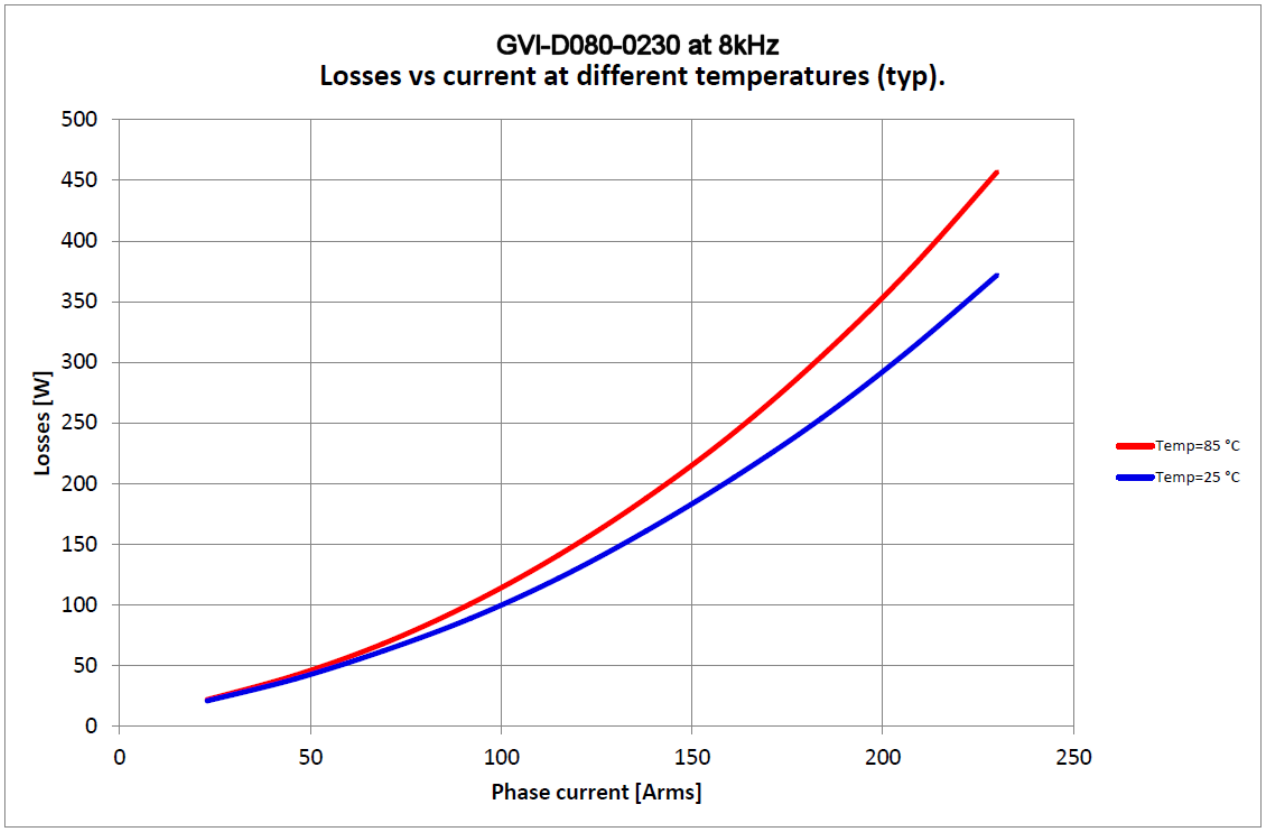

GVI-D048-0450
Losses vs temperature at 225 A.
Losses [W]
Heatsink temperature [deg C]
0
50
100
150
200
250
300
20
30
40
50
60
70
80
90
fsw=4k
Typ Rdson
fsw=8k
Typ Rdson
fsw=16k
Typ Rdson

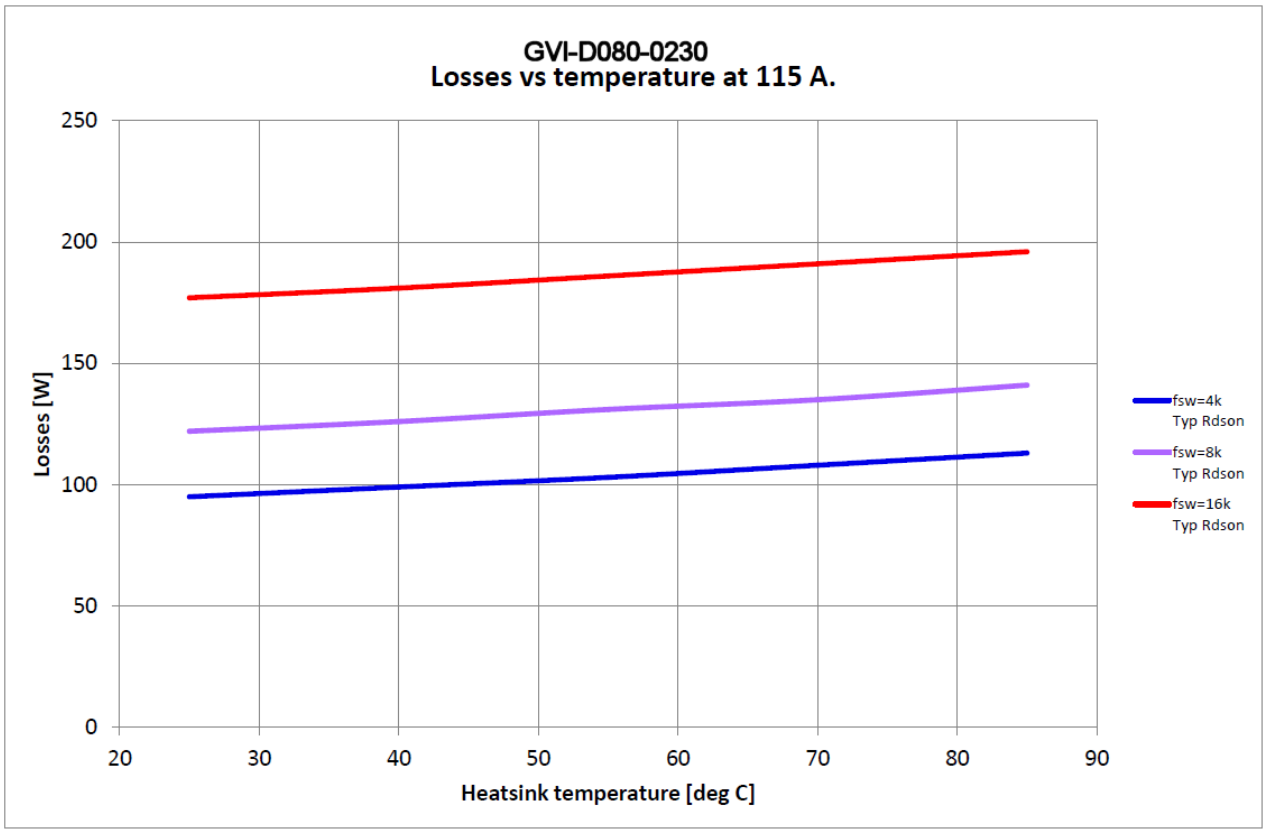

GVI-D048-0550 at 8kHz
Losses vs current at different temperatures (typ).
Losses [W]
900
800
700
600
500
400
300
200
100
0
0
100
200
300
400
500
600
Phase current [Arms]
Temp=85 °C
Temp=25 °C

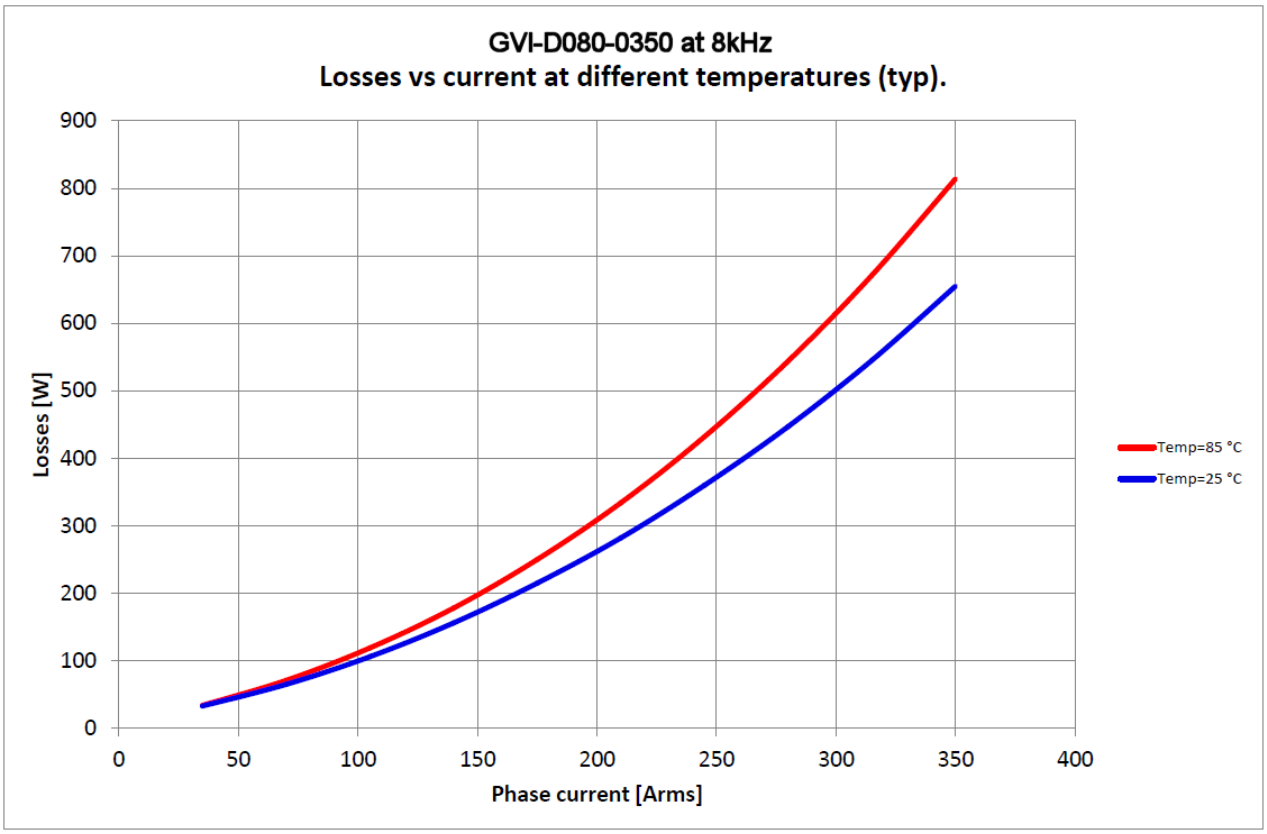

GVI-D048-0550
Losses vs temperature at 275 A.
Losses [W]
400
350
300
250
200
150
100
50
0
20
30
40
50
60
70
80
90
Heatsink temperature [deg C]
fsw=4k
Typ Rdson
fsw=8k
Typ Rdson
fsw=16k
Typ Rdson

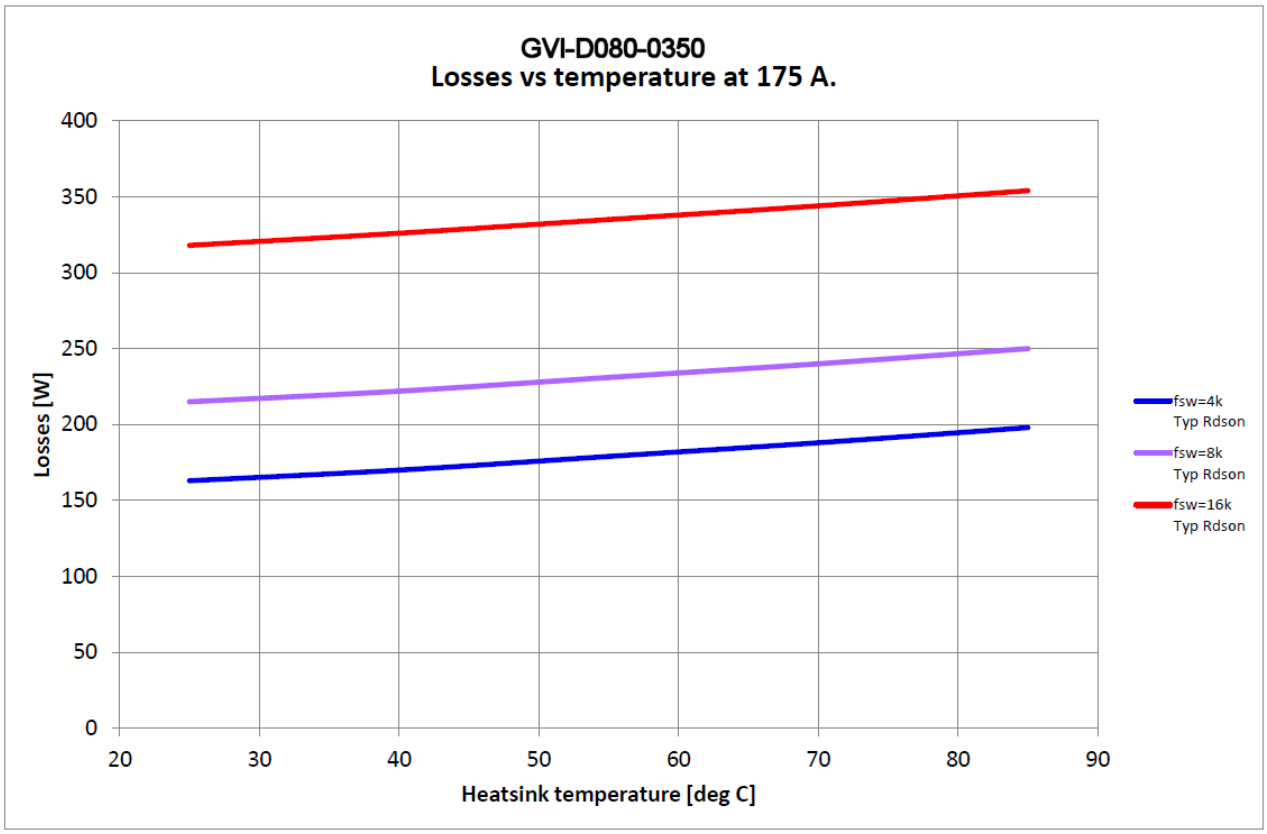

GVI-E048-0700 at 8kHz
Losses vs current at different temperatures (typ).
Losses [W]
1600
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
600
700
800
Phase current [Arms]
Temp=85 °C
Temp=25 °C

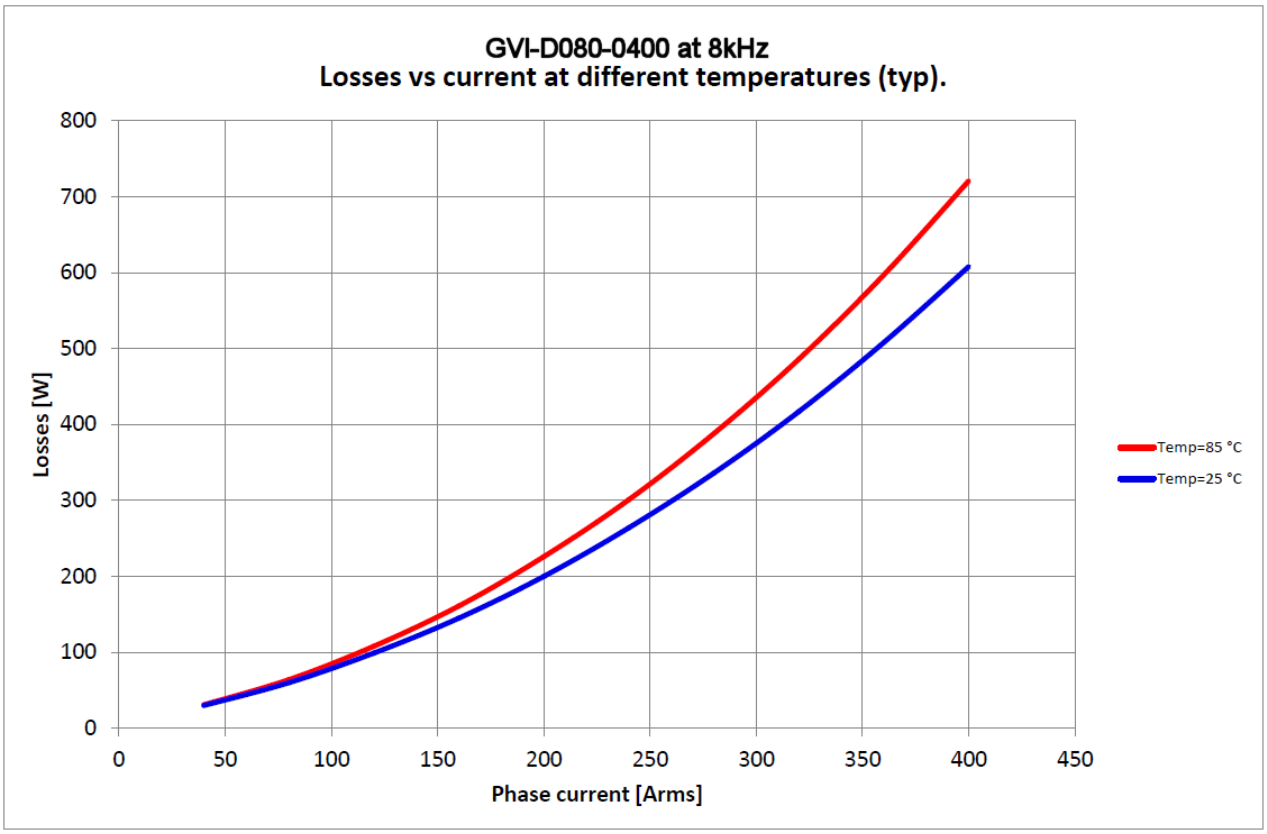

GVI-E048-0700
Losses vs temperature at 350 A.
Losses [W]
800
700
600
500
400
300
200
100
0
20
30
40
50
60
70
80
90
Heatsink temperature [deg C]
fsw=4k
Typ Rdson
fsw=8k
Typ Rdson
fsw=16k
Typ Rdson

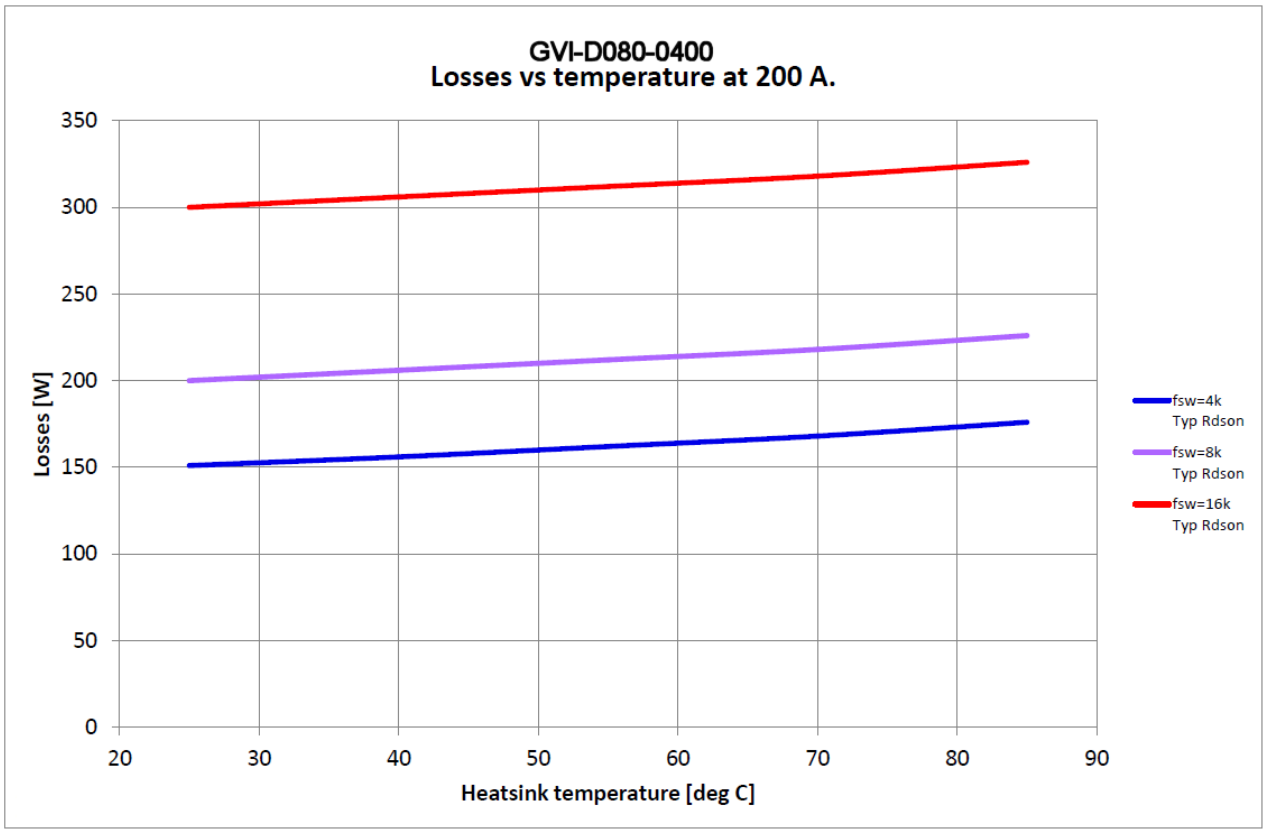

GVI-D080-0230 at 8kHz
Losses vs current at different temperatures (typ).
Losses [W]
500
450
400
350
300
250
200
150
100
50
0
0
50
100
150
200
250
Phase current [Arms]
Temp=85 °C
Temp=25 °C


GVI-D080-0230
Losses vs temperature at 115 A.
Losses [W]
250
200
150
100
50
0
20
30
40
50
60
70
80
90
Heatsink temperature [deg C]
fsw=4k
Typ Rdson
fsw=8k
Typ Rdson
fsw=16k
Typ Rdson

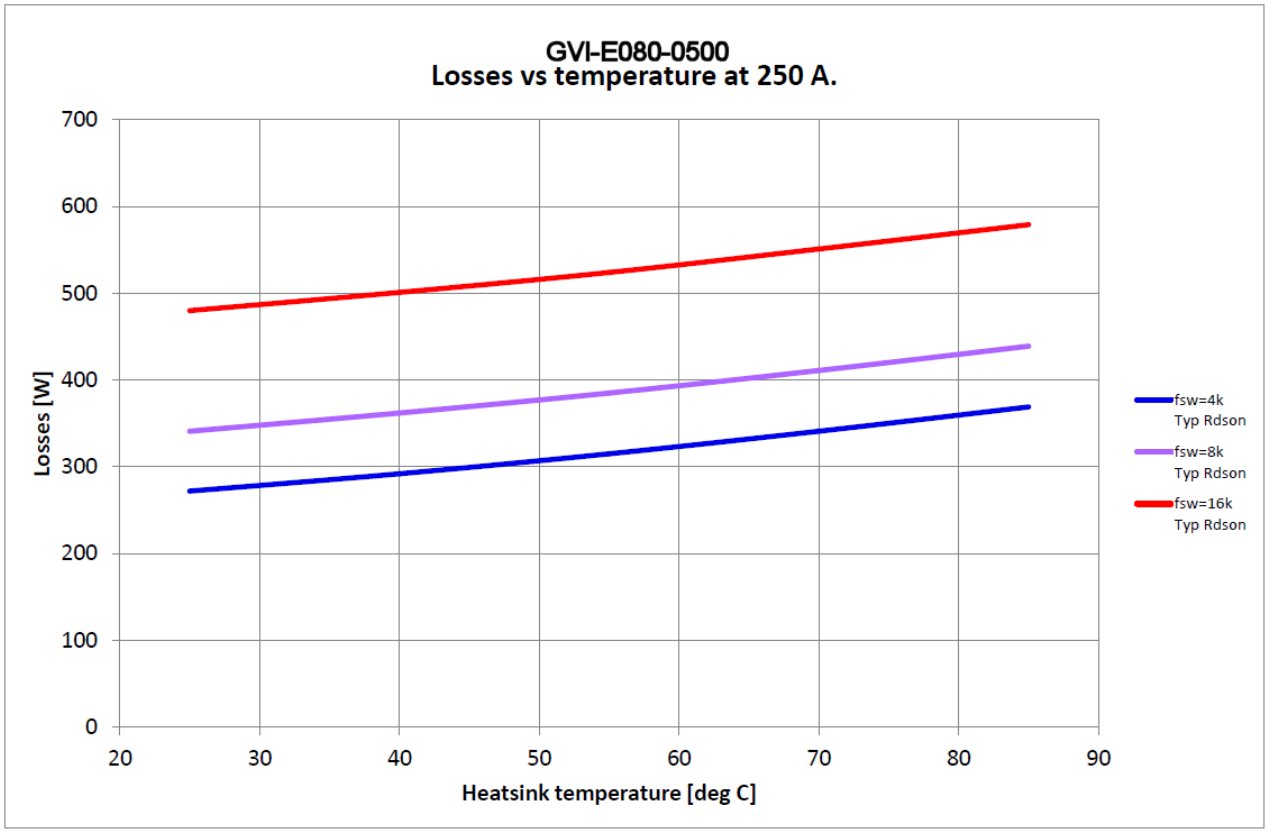

GVI-D080-0350 at 8kHz
Losses vs current at different temperatures (typ).
Losses [W]
900
800
700
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
400
Phase current [Arms]
Temp=85 °C
Temp=25 °C

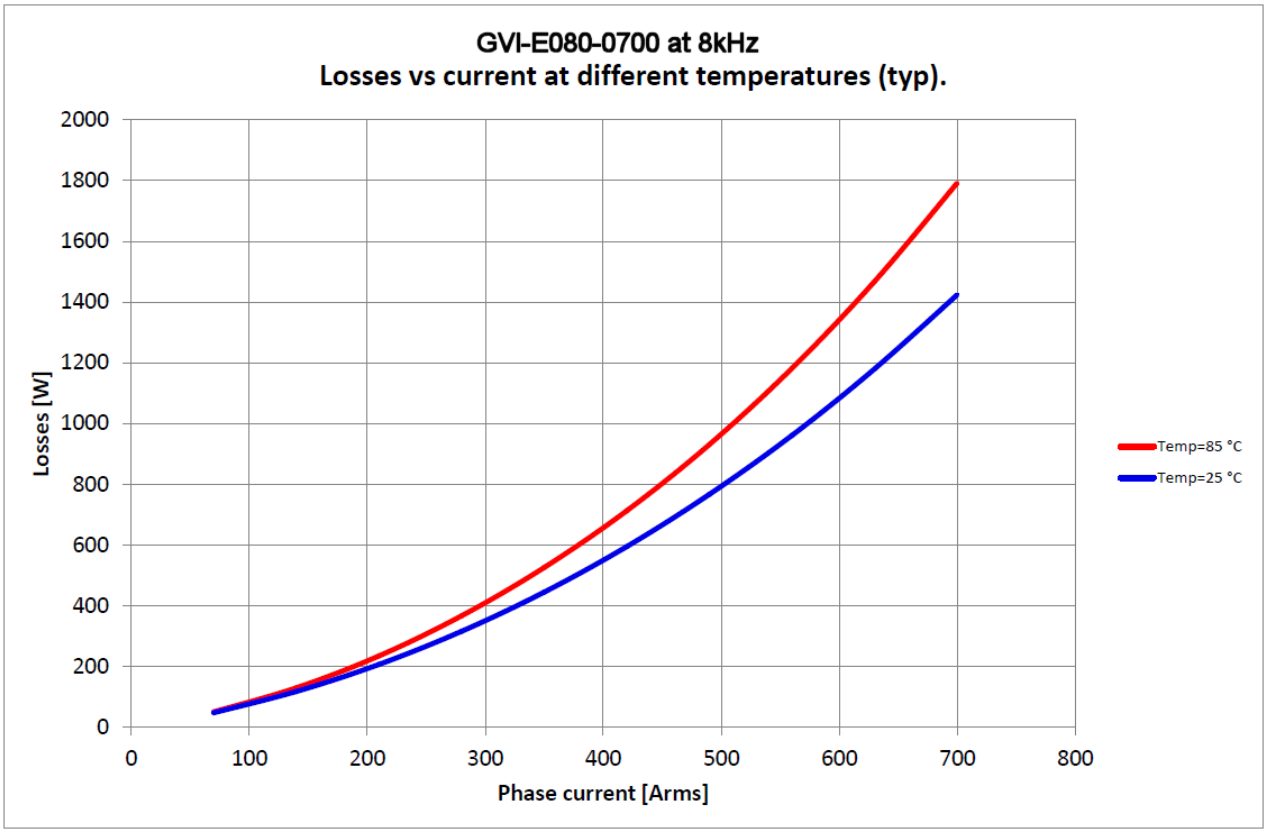

GVI-D080-0350
Losses vs temperature at 175 A.
Losses [W]
400
350
300
250
200
150
100
50
0
20
30
40
50
60
70
80
90
Heatsink temperature [deg C]
fsw=4k
Typ Rdson
fsw=8k
Typ Rdson
fsw=16k
Typ Rdson

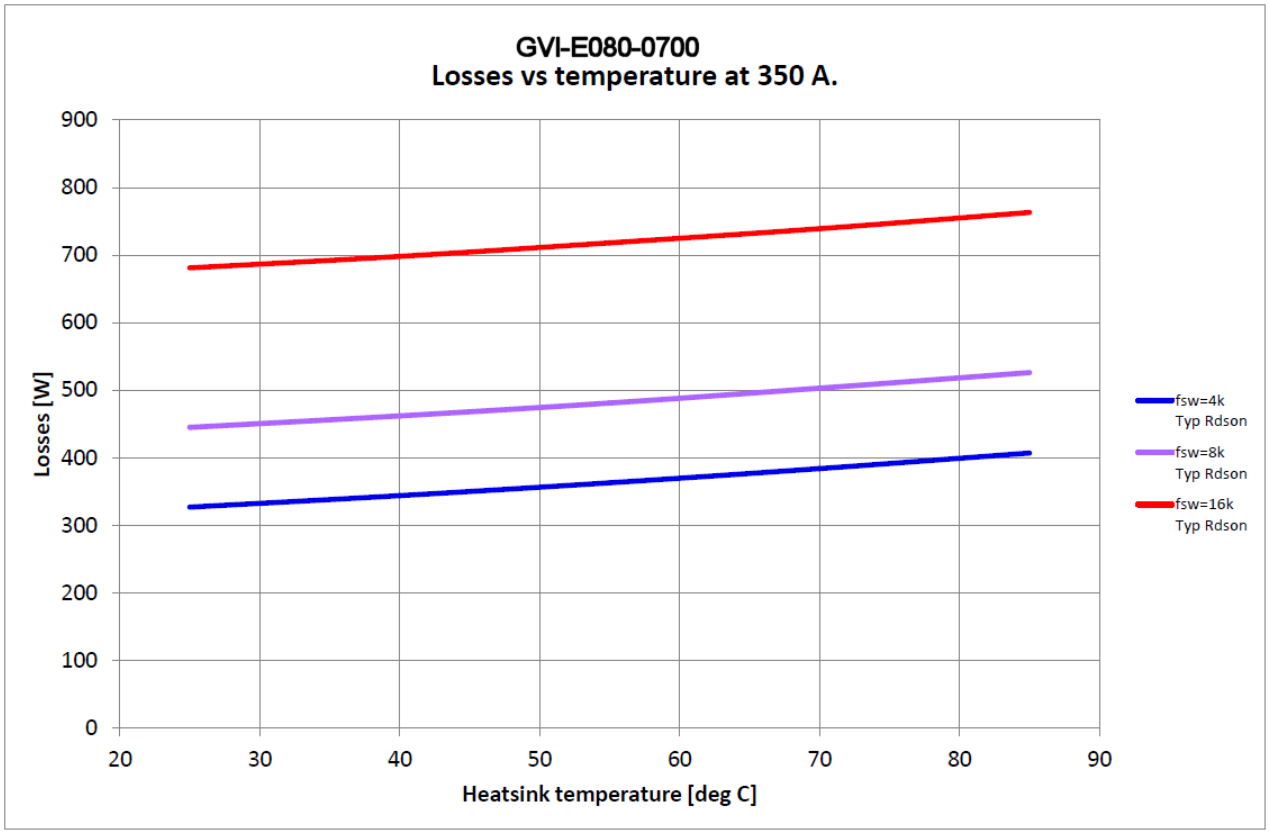

GVI-D080-0400 at 8kHz
Losses vs current at different temperatures (typ).
Losses [W]
Phase current [Arms]
0
100
200
300
400
500
600
700
800
0
50
100
150
200
250
300
350
400
450
Temp=85 °C
Temp=25 °C


GVI-D080-0400
Losses vs temperature at 200 A.
Losses [W]
Heatsink temperature [deg C]
0
50
100
150
200
250
300
350
20
30
40
50
60
70
80
90
fsw=4k
Typ Rdson
fsw=8k
Typ Rdson
fsw=16k
Typ Rdson

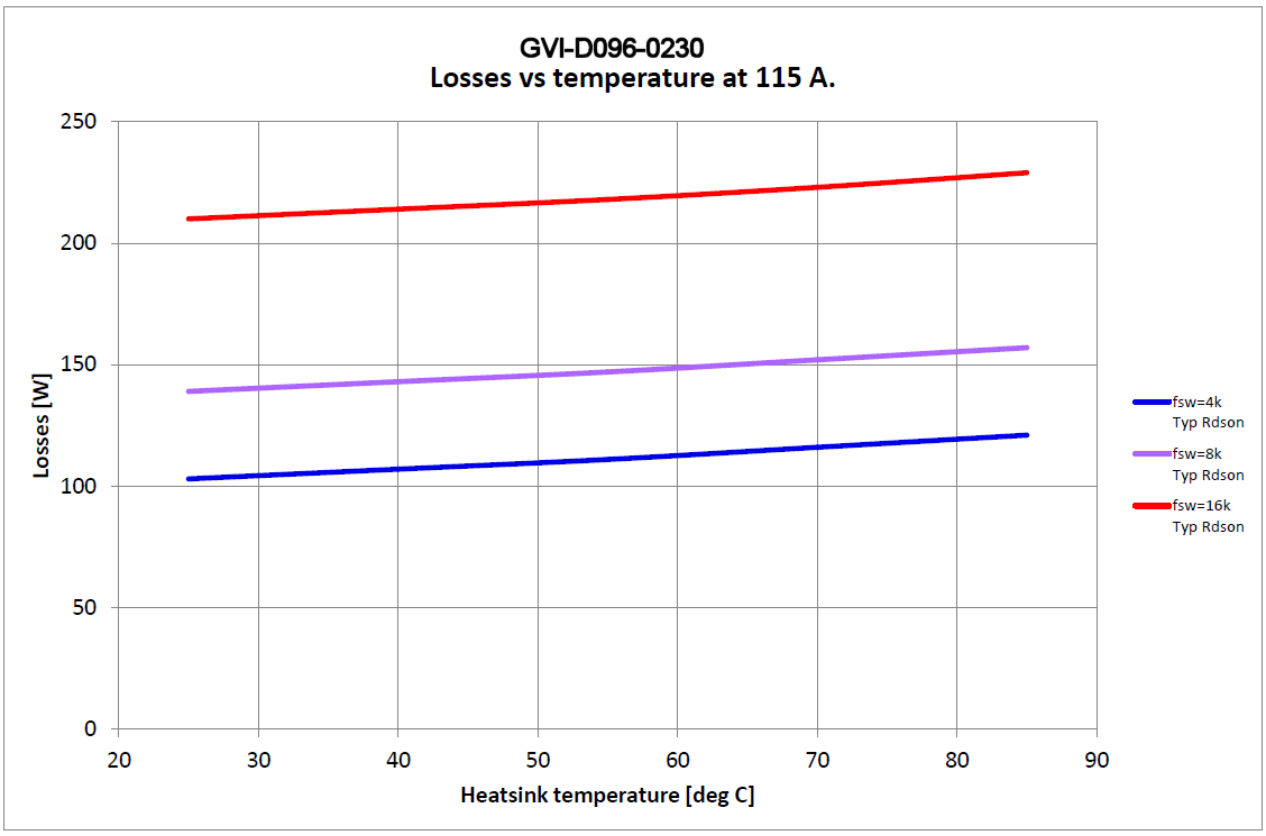

GVI-E080-0500 at 8kHz
Losses vs current at different temperatures (typ).
Losses [W]
1800
1600
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
600
Phase current [Arms]
Temp=85 °C
Temp=25 °C

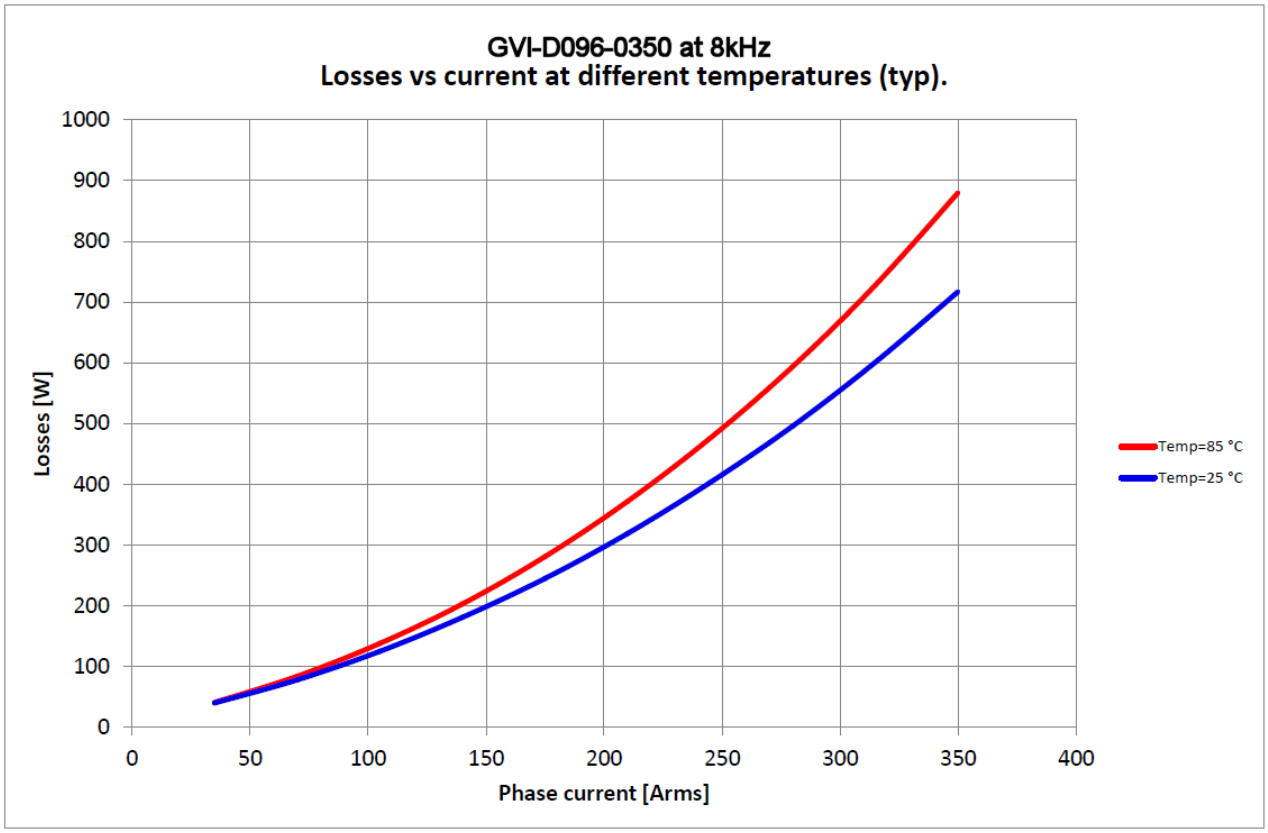

GVI-E080-0500
Losses vs temperature at 250 A.
Losses [W]
700
600
500
400
300
200
100
0
20
30
40
50
60
70
80
90
Heatsink temperature [deg C]
fsw=4k
Typ Rdson
fsw=8k
Typ Rdson
fsw=16k
Typ Rdson

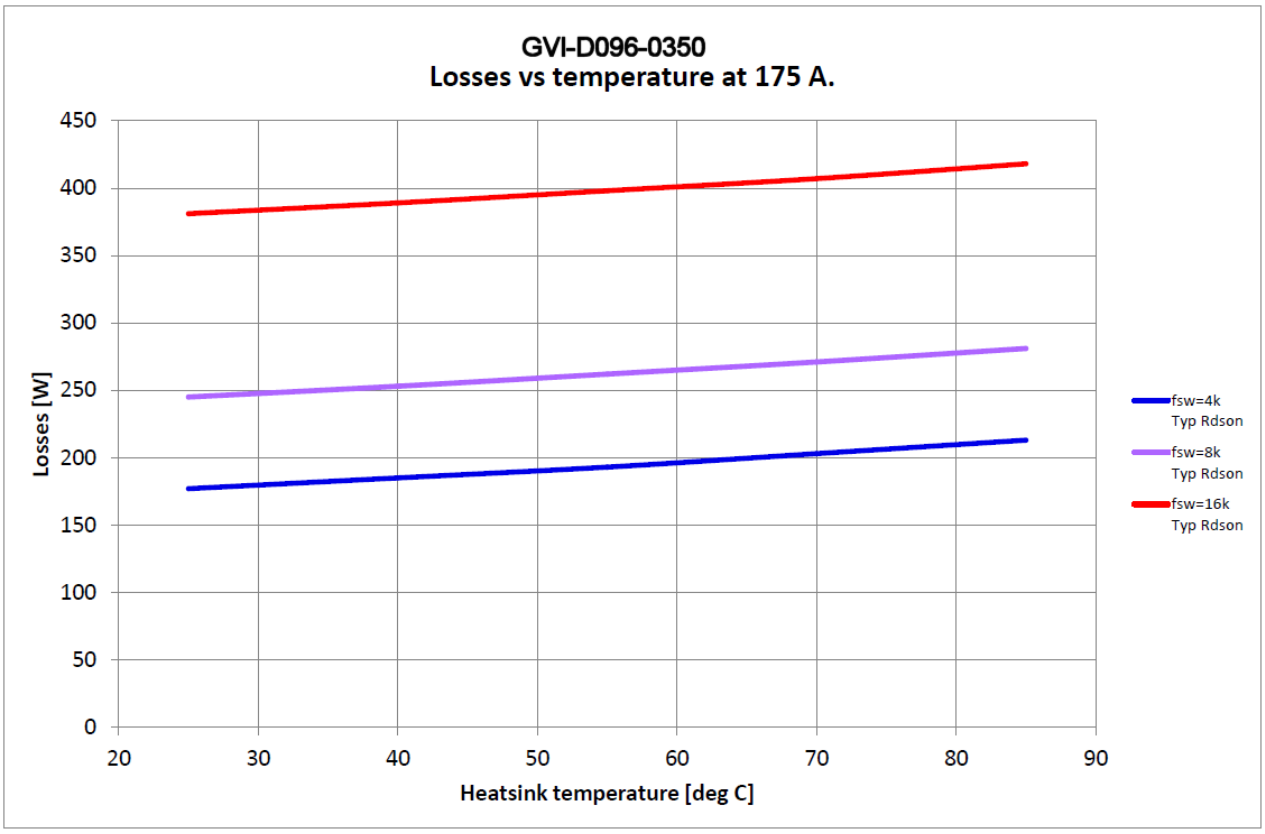

GVI-E080-0700 at 8kHz
Losses vs current at different temperatures (typ).
Losses [W]
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
600
700
800
Phase current [Arms]
Temp=85 °C
Temp=25 °C


GVI-E080-0700
Losses vs temperature at 350 A.
Losses [W]
900
800
700
600
500
400
300
200
100
0
20
30
40
50
60
70
80
90
Heatsink temperature [deg C]
fsw=4k
Typ Rdson
fsw=8k
Typ Rdson
fsw=16k
Typ Rdson

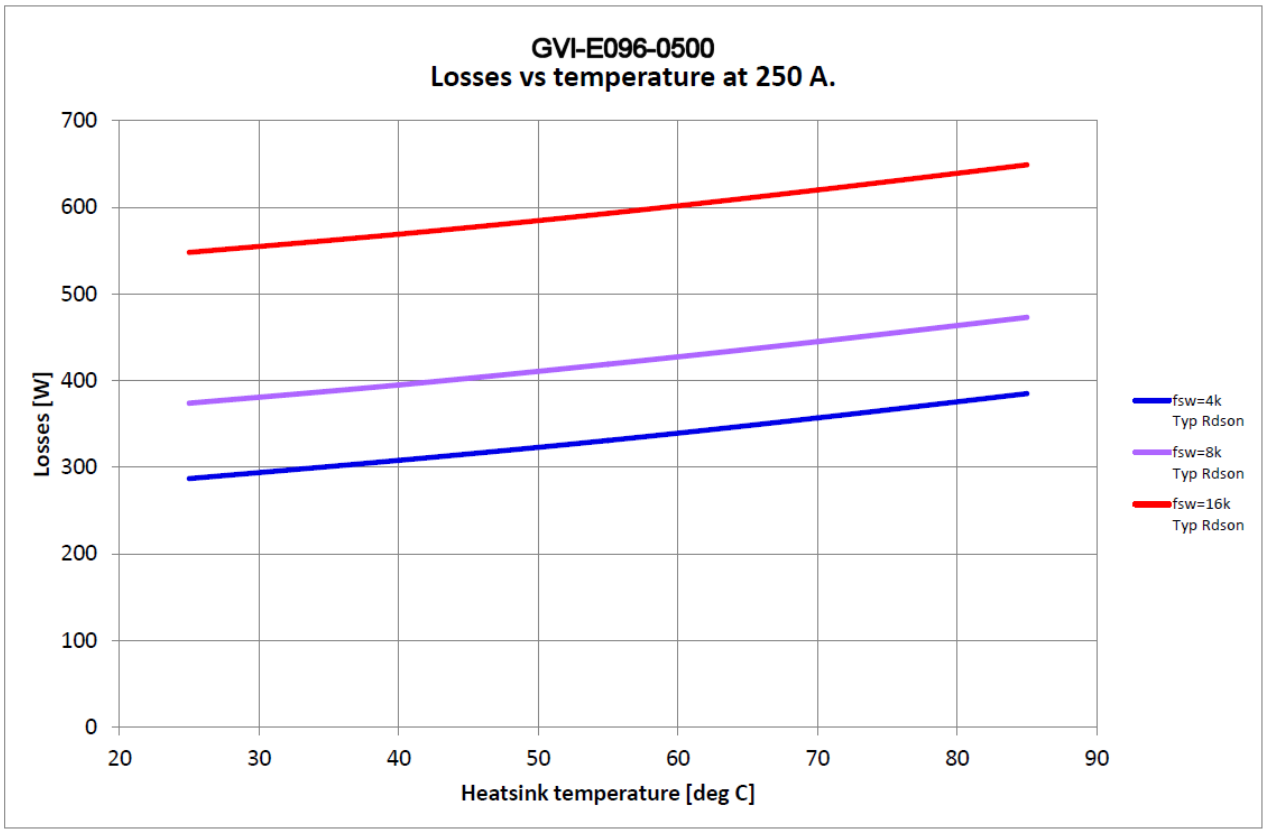

GVI-D096-0230 at 8kHz
Losses vs current at different temperatures (typ).
Losses [W]
600
500
400
300
200
100
0
0
50
100
150
200
250
Phase current [Arms]
Temp=85 °C
Temp=25 °C

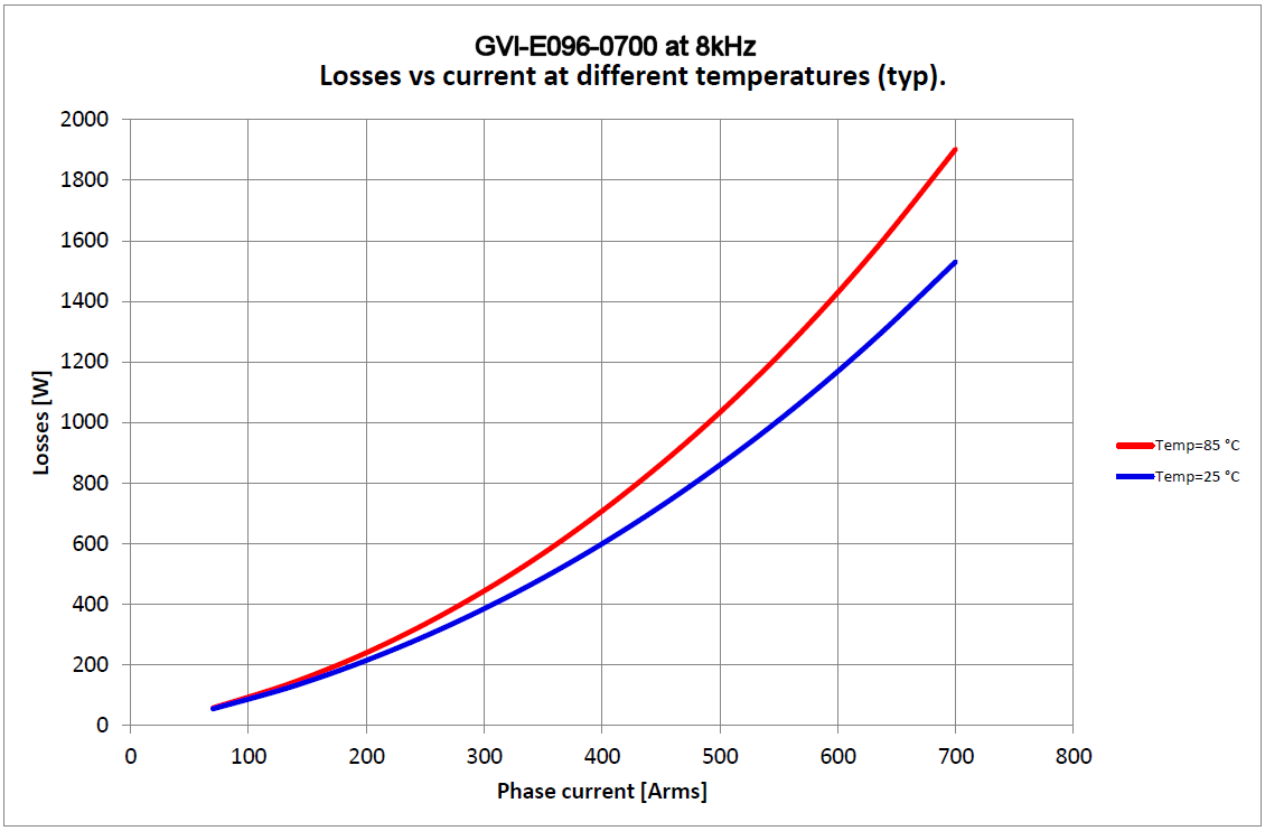

GVI-D096-0230
Losses vs temperature at 115 A.
Losses [W]
250
200
150
100
50
0
20
30
40
50
60
70
80
90
Heatsink temperature [deg C]
fsw=4k
Typ Rdson
fsw=8k
Typ Rdson
fsw=16k
Typ Rdson

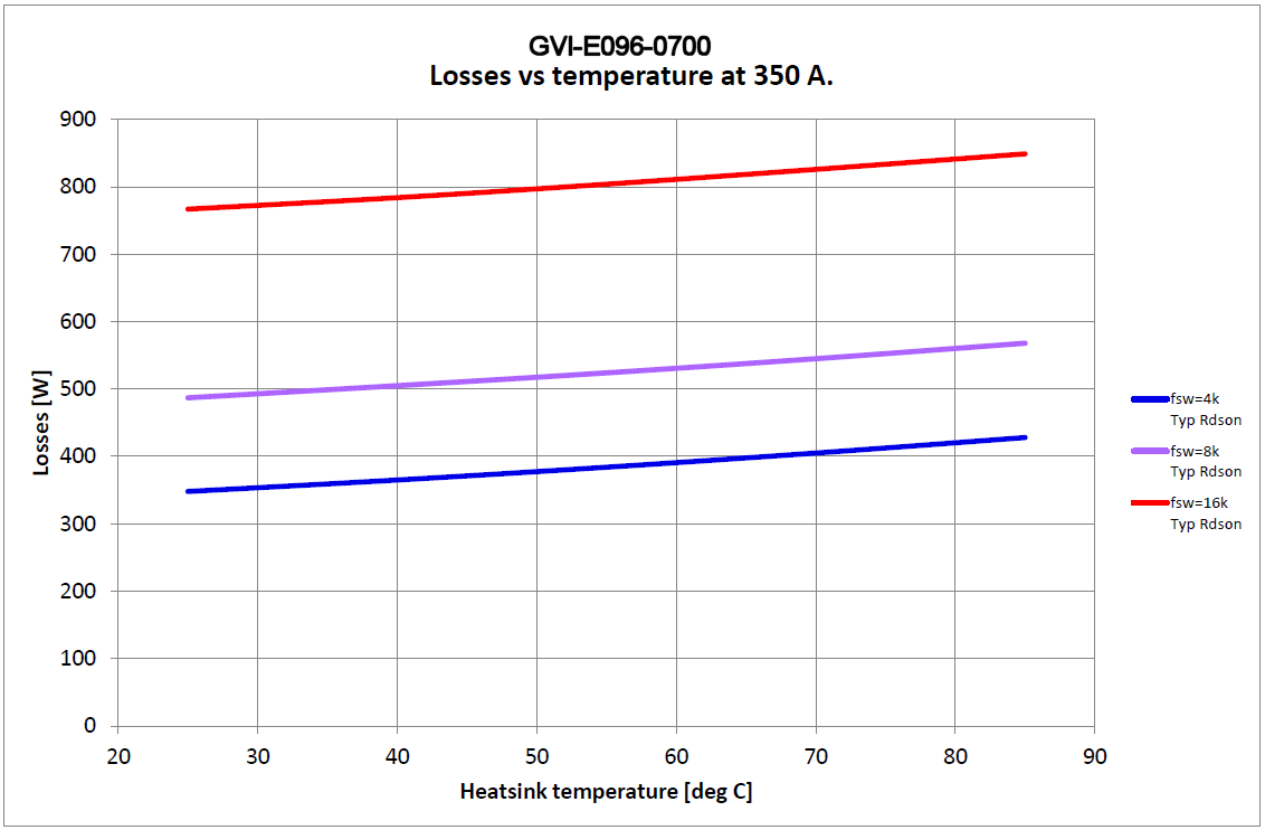

GVI-D096-0350 at 8kHz
Losses vs current at different temperatures (typ).
Losses [W]
1000
900
800
700
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
400
Phase current [Arms]
Temp=85 °C
Temp=25 °C


GVI-D096-0350
Losses vs temperature at 175 A.
Losses [W]
450
400
350
300
250
200
150
100
50
0
20
30
40
50
60
70
80
90
Heatsink temperature [deg C]
fsw=4k
Typ Rdson
fsw=8k
Typ Rdson
fsw=16k
Typ Rdson


GVI-E096-0500 at 8kHz
Losses vs current at different temperatures (typ).
Losses [W]
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
600
Phase current [Arms]
Temp=85 °C
Temp=25 °C


GVI-E096-0500
Losses vs temperature at 250 A.
Losses [W]
700
600
500
400
300
200
100
0
20
30
40
50
60
70
80
90
Heatsink temperature [deg C]
fsw=4k
Typ Rdson
fsw=8k
Typ Rdson
fsw=16k
Typ Rdson


GVI-E096-0700 at 8kHz
Losses vs current at different temperatures (typ).
Losses [W]
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
600
700
800
Phase current [Arms]
Temp=85 °C
Temp=25 °C


GVI-E096-0700
Losses vs temperature at 350 A.
Losses [W]
900
800
700
600
500
400
300
200
100
0
20
30
40
50
60
70
80
90
Heatsink temperature [deg C]
fsw=4k
Typ Rdson
fsw=8k
Typ Rdson
fsw=16k
Typ Rdson

12 Declaration of Incorporation

EU Declaration of Incorporation

(Original)

for partly completed machinery

Document No:	DOC-0003-14-A
Manufacturer:	Parker Hannifin Manufacturing Germany GmbH & Co.KG Electric Motion & Pneumatic Division
Authorized Representative:	Timothy Faillo
Address:	Robert-Bosch-Str. 22, 77656 Offenburg, Germany

Herewith we declare under our sole responsibility that the following products

Type of Product:	Mobile Inverter
Product Name:	GVI - Frame Sizes C, D & E
Further Details:	See appendix (which is part of this declaration, when attached)

comply with the essential requirements of following EU legislations including their amendments in force at the time of the declaration:

Reference	Name
2006/42/EC	Machinery Directive
2014/30/EU	EMC Directive

Following harmonized standards have been applied:

Reference	Edition	Title
EN 1175	2020	Safety of industrial trucks - Electrical/electronic requirements
EN 12895	2015+A1:2019	Industrial trucks – Electromagnetic compatibility

Notes:

Essential requirements in the directives that apply to the partially completed machinery are documented in a Technical Construction File (TCF) including references to all relevant technical documentation in accordance with part B of Annex VII. The TCF and all relevant documentation can, in response to a reasoned request by the national authorities, be sent in electronic or paper form.

The partly completed machinery must not be put into service until the final machinery, into which it is to be incorporated, has been declared in conformity with the provisions of the Machinery Directive 2006/42/EC.

Signed for and on behalf of:	Parker Hannifin Manufacturing Germany GmbH & Co.KG
Location, date of issue:	Offenburg, 2023-05-01

Raphael Wendling

Digital unterschrieben von Raphael Wendling
Datum: 2023.05.12 12:12:55 +02'00'

Raphael Wendling
Division Operational Manager EMPD

Timothy Faillo

Digital unterschrieben von Timothy Faillo
Datum: 2023.05.13 13:57:07 +02'00'

Timothy Faillo
Division Engineering Manager EMPD

(Übersetzung)

EU Einbauerklärung

für eine unvollständige Maschine

Dokument Nr:	DOC-0003-14-A
Hersteller:	Parker Hannifin Manufacturing Germany GmbH & Co.KG Electric Motion & Pneumatic Division
Bevollmächtigter:	Timothy Faillo
Anschrift:	Robert-Bosch-Str. 22, 77656 Offenburg, Germany

Wir erklären hiermit in unserer alleinigen Verantwortung, dass die nachfolgenden Produkte

Produkttyp:	Mobiler Inverter
Produktname:	GVI - Rahmengrößen C, D & E
Weitere Angaben:	Siehe Anhang (der Teil dieser Erklärung ist, sofern beigefügt)

die grundlegenden Anforderungen der nachfolgend aufgeführten EU-Richtlinien erfüllen, einschließlich ihrer zum Zeitpunkt der Erklärung geltenden Änderungen:

Referenz	Name
2006/42/EC	Maschinenrichtlinie
2014/30/EU	EMV - Richtlinie

Folgende harmonisierte Normen wurden angewandt:

Referenz	Ausgabe	Titel
EN 1175	2020	Sicherheit von Flurförderzeugen. Elektrische/elektronische Anforderungen.
EN 12895	2015+A1:2019	Flurförderzeuge - Elektromagnetische Verträglichkeit

Bemerkungen:

Die grundlegenden Anforderungen der Richtlinie, die für die unvollständige Maschine gelten, werden in einer technischen Dokumentation erfasst, die auch Verweise auf alle einschlägigen technischen Unterlagen gemäß Anhang VII Teil B enthält. Die technische Dokumentation und alle einschlägigen Unterlagen können auf begründeten Antrag der nationalen Behörden in elektronischer oder Papierform übermittelt werden.

Die unvollständige Maschine darf erst dann in Betrieb genommen werden, wenn die endgültige Maschine, in die sie eingebaut werden soll, für konform mit den Bestimmungen der Maschinenrichtlinie 2006/42/EG erklärt wurde.

Appendix: **Components List**
Anhang: *Komponentenliste*

Order Code

		1		2,3		4,5,6		7,8		9
Order Example		**GVI**	-	**C024**	-	**0350S1**	-	**S00**	-	**G0000**

1	**Product Familiy**	
	GVI	Global Vehicle Inverter
2	**Frame Size**	
	C	Frame Size C
	D	Frame Size D
	E	Frame Size E
3	**Nominal DC Supply**	
	024	24V DC
	048	48V DC
	080	80V DC
	096	96V DC
4	**Current Rating**	
	24VDC Nominal Voltage	
	0350	350A Frame C
	0550	550A Frame D
	48VDC Nominal Voltage	
	0280	280A Frame C
	0450	450A Frame D
	0550	550A Frame D
	0700	700A Frame E
	80VDC Nominal Voltage	
	0230	230A Frame D
	0350	350A Frame D
	0400	400A Frame D
	0500	500A Frame E
	0700	700A Frame E
	96VDC Nominal Voltage	
	0230	230A Frame D
	0350	350A Frame D
	0400	400A Frame D
	0500	500A Frame E
	0700	700A Frame E

5	**Package**	
	S	Single
6	**Series**	
	1	Series 1
7	**Feedback Type**	
	S	Sin/Cos Encoder
8	**Reserved**	
	00	
9	**Special Option**	
	G0000	Global Specification
	E0000	European Specification
	N0000	North American Specificatio

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