EN Manual

BENDER
The Power in Electrical Safety©

ISOMETER® iso165C
iso165C-1

Insulation Monitoring Devices (IMDs) for unearthed DC drive systems (IT systems) in electric vehicles

iso165C_D00154_02_M_XXEN/11.2016

READ THIS MANUAL AND ALL ACCOMPANYING DOCUMENTS CAREFULLY AND RETAIN FOR FUTURE REFERENCE.

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1. How to use this document effectively

1.1 About the operating manual

This operating manual is intended for qualified experts in electrical engineering and communication technology.
To make it easier for you to understand and revisit certain sections of text and instructions in the manual, we have used symbols to identify important instructions and information. The meaning of these symbols is explained below:

DANGER

*The signal word indicates that there is a **high risk** danger that **will** result in **electrocution or serious injury** if not avoided.*

WARNING

*This signal word means that there is a **medium** risk of danger that can lead to **death or serious injury**, if not avoided.*

CAUTION

*This signal word indicates a **low level risk** that can result in **minor or moderate injury** or **damage to property** if not avoided .*

*This symbol denotes information intended to assist the user to make **optimum use** of the product.*

*This manual is intended for **qualified personnel** working in electrical engineering and electronics!*

1.2 Technical suport: Service abd support

For commissioning and troubleshooting Bender offers you:

1.2.1 First level support

Technical support by phone or e-mail for all Bender products

- Questions concerning specific customer applications
- Commissioning
- Troubleshooting

Telephone:		+49 6401 807-760*
Fax:		+49 6401 807-259
In Germany only:		0700BenderHelp (Tel. and Fax)
E-mail:		support@bender-service.de

1.2.2 Repair service

Repair, calibration, update and replacement service for Bender products

- Repairing, calibrating, testing and analysing Bender products
- Hardware and software update for Bender devices
- Delivery of replacement devices in the event of faulty or incorrectly delivered Bender devices
- Extended warranty for Bender devices with in-house repair service or replacement device at no extra cost

Telephone:		+49 6401 807-780** (technical issues)
		+49 6401 807-784**, -785** (sales)
Fax:		+49 6401 807-789
E-mail:		repair@bender-service.de

1.2.3 Field service

On-site service for all Bender products

- Commissioning, parameter setting, maintenance, troubleshooting for Bender products
- Analysis of the electrical installation in the building (power quality test, EMC test, thermography)
- Training courses for customers

Telephone:		+49 6401 807-752**, -762 **(technical issues)
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E-mail:		fieldservice@bender-service.de
Internet:		www.bender-de.com

How to use this document effectively

*Available from 7.00 a.m. to 8.00 p.m. 365 days a year (CET/UTC+1)
**Mon-Thurs 7.00 a.m. - 8.00 p.m., Fr 7.00 a.m. - 13.00 p.m.

1.3 Training courses

Bender is happy to provide training regarding the use of test equipment.
The dates of training courses and workshops can be found on the Internet at www.bender-de.com -> Know-how -> Seminars.

1.4 Delivery conditions

Bender sale and delivery conditions apply. For software products, the "Softwareklausel zur Überlassung von Standard-Software als Teil von Lieferungen, Ergänzung und Änderung der Allgemeinen Lieferbedingungen für Erzeugnisse und Leistungen der Elektroindustrie" (software clause in respect of the licensing of standard software as part of deliveries, modifications and changes to general delivery conditions for products and services in the electrical industry) set out by the ZVEI (Zentralverband Elektrotechnik- und Elektronikindustrie e.V.) (German Electrical and Electronic Manufacturers' Association) also applies.
Sale and delivery conditions can be obtained from Bender in printed or electronic format.

1.5 Inspection, transport and storage

Inspect the dispatch and equipment packaging for damage, and compare the contents of the package with the delivery documents. In the event of damage in transit, please contact Bender immediately.
The devices must only be stored in areas where they are protected from dust, damp, and spray and dripping water, and in which the specified storage temperatures can be ensured.

1.6 Warranty and liability

Warranty and liability claims in the event of injury to persons or damage to property are excluded if they can be attributed to one or more of the following causes:
Improper use of the device.

- Incorrect mounting, commissioning, operation and maintenance of the device.
- Failure to observe the instructions in this operating manual regarding transport, commissioning, operation and maintenance of the device.
- Unauthorised changes to the device made by parties other than the manufacturer.
- Non-observance of technical data.
- Repairs carried out incorrectly and the use of replacement parts or accessories not approved by the manufacturer.
- Catastrophes caused by external influences and force majeure.
- Mounting and installation with device combinations not recommended by the manufacturer.
- This operating manual, especially the safety instructions, must be observed by all personnel working on the device. Furthermore, the rules and regulations that apply for accident prevention at the place of use must be observed.

1.7 Disposal

Abide by the national regulations and laws governing the disposal of this device. Ask your supplier if you are not sure how to dispose of the old equipment.
The directive on waste electrical and electronic equipment (WEEE directive) and the directive on the restriction of certain hazardous substances in electrical and electronic equipment (RoHS directive) apply in the European Community. In Germany, these policies are implemented through the "Electrical and Electronic Equipment Act" (ElektroG). According to this, the following applies:

- Electrical and electronic equipment are not part of household waste.
- Batteries and accumulators are not part of household waste and must be disposed of in accordance with the regulations.
- Old electrical and electronic equipment from users other than private households which was introduced to the market after 13th August 2005 must be taken back by the manufacturer and disposed of properly.

For more information on the disposal of Bender devices, refer to our homepage at www.bender.de -> Service & support.

2.1 General safety instructions

Part of the device documentation in addition to this manual is the enclosed "Safety instructions for Bender products".

DANGER

Risk of electrocution due to electric shock!

Touching live parts of the system carries the risk of:

- *An electric shock*
- *Damage to the electrical installation*
- *Destruction of the device*

Before installing and connecting the device, make sure that the installation has been de-energised. Observe the rules for working on electrical installations.

If the device is used outside the Federal Republic of Germany, the applicable local standards and regulations must be complied with. The European standard EN 50110 can be used as a guide.

2.2 Intended use

Only skilled persons are permitted to carry out the work necessary to install, commission and run a device or system.

The ISOMETER® iso165C and ISOMETER® iso165C-1 monitor the high-voltage (HV) insulation resistance between the car chassis and the active HV components of an unearthed DC drive system (IT system) in electric vehicles with supply voltages of DC 0 V...600 V. The insulation condition is monitored on the DC side as well as on the AC motor side of the electrical drive system. Existing insulation faults will be reliably signaled even under high system interferences, which can be caused by motor control processes, acceleration or energy recovery for example.

Both ISOMETER®s feature a CAN bus interface and can be easily integrated into an existing CAN environment in hybrid or fully electric vehicles.

Ensure the correct rated input voltage and supply voltage is applied. For insulation or voltage tests, the ISOMETER® must be separated from the IT system for the duration of the test. To check that the device has been properly connected, perform a functional test before commissioning the system. It is necessary to examine whether the initial settings meet the requirements of the IT system.

With reference to the general application of an IMD in IT systems, only one active IMD in a galvanically interconnected system is permitted. If IT systems are to be interconnected via a coupling switch, it must be ensured via a controller that all other IMDs are separated from the IT system and switched to inactive. IT systems coupled via capacitors or diodes can also influence the insulation monitoring system. For this reason, central control of the various IMDs must be implemented.

In the event of an ISOMETER® alarm message, the insulation fault should be eliminated as quickly as possible.

2.2.1 ISOMETER® iso165C and ISOMETER® iso165C-1 comparison

While the ISOMETER® iso165C and ISOMETER® iso165C-1 are similiar in many aspects (refer to the features list on page 8) the main differences between the two are shown in the table below:

Feature	iso165C	iso165C-1
Contains an output driver	No	Yes. Error and Warning signals are available on the separated high-side driver
Coupling relays at power on	The HV coupling relays of the HV1 voltage path are, by default, open and therefore no valid voltage and insulation resistance measurements are possible until these relays are closed, which must be carried out using an external command	The HV coupling relays of the HV1 voltage path are automatically closed at power on
Baud rate	250 kBaud	500 kBaud
Terminating resistance	124 Ω internally	None

3.1 Device features

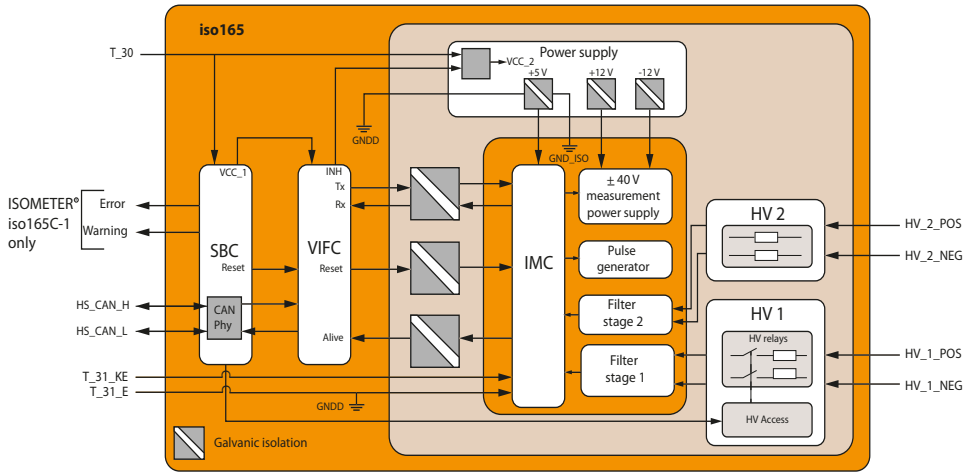
- Insulation monitoring of AC and DC insulation faults for unearthed systems (IT systems) from 0 V…600 V peak
- Power supply for all internal voltages
- Continuous measurement of insulation resistance from 0 Ω…50 MΩ
- Response time of ≤ 20 s for measured insulation resistance (using Direct Current Pulse (DCP))
- Automatic adaptation to the existing system leakage capacitance (≤ 1 µF)
- Detection of ground faults and lost ground line
- Measurement of a second voltage
- The device works when:
  - HV is unstable
  - HV is powered off
  - There are symmetric or asymmetric insulation faults
  - Faults exist between HV lines and the supply voltage
- Galvanic insulation of all signals from the HV side
- HV coupled network
- CAN bus interface
- Light weight: < 220 g (including housing and connection frame)
- **iso165C-1 only**: The iso165C-1 variant features **Error** and **Warning** signals on the separated high-side driver

3.2 Product description

The ISOMETER® monitors the insulation resistance between the active HV components of an electrical drive system (Un = DC 0 V…600 V) and the reference earth (chassis ground). The patented measurement technology is used to monitor the condition of the insulation on the DC side as well as on the AC motor side of the electrical drive system.

The ISOMETER® is assembled with three connectors. To achieve internal galvanic separation, connector 1 is connected to low-voltage (LV) areas and connectors 2 and 3 are connected to the HV areas in the car environment.

Due to its space saving design and optimized measurement technology, the device is optimized for use in hybrid or fully electric vehicles. The device meets the increased automotive requirements with regard to environmental conditions (e.g. temperatures and vibration, EMC). The ISOMETER® CAN bus interface allows it to integrate seamlessly into an existing CAN environment.



3.3 Function description

The ISOMETER® iso165C and iso165C-1 consist of two main components, the Vehicle Interface Controller (VIFC) and the Insulation Monitoring Controller (IMC). The VIFC consists of a microcontroller with a UART communication interface that translates and forwards requests from the HS-CAN bus transparently to the IMC. The corresponding IMC responses are returned to the requesting instance via the HS-CAN bus. The VIFC supervises the running state of the IMC via a signal known as "Alive", and internally and cyclically requests the insulation value and the running state of the IMC. The results are cyclically sent as an informal message via the HS-CAN bus.

The IMC consists of the HV connectors with HV coupling relays, the measurement circuit and a microcontroller to analyse the measurement results. It generates internal alarm information from the measurement results, which is coded to produce the "Alive" signal mentioned previously. This signal is transmitted in parallel with the measurements and status information to the VIFC and from there over the HS-CAN bus. The IMC is galvanically separated from the car environment.

Function

At initial power on, the ISOMETER® **iso165C** does not carry out any measurements until communication between the VIFC and IMC has been established. In addition, the HV coupling relays of the HV1 voltage path are, by default, open and therefore no valid measurement of voltage HV1 and the insulation resistance is possible until these relays are closed by an external command. Once these conditions have been satisfied, the ISOMETER® iso165C can immediately start measuring voltages HV1, HV2 and the insulation resistance.

In the ISOMETER® **iso165C-1**, however, the HV coupling relays of the HV1 voltage path are automatically closed at power on.

The initial measurement values after power up are:

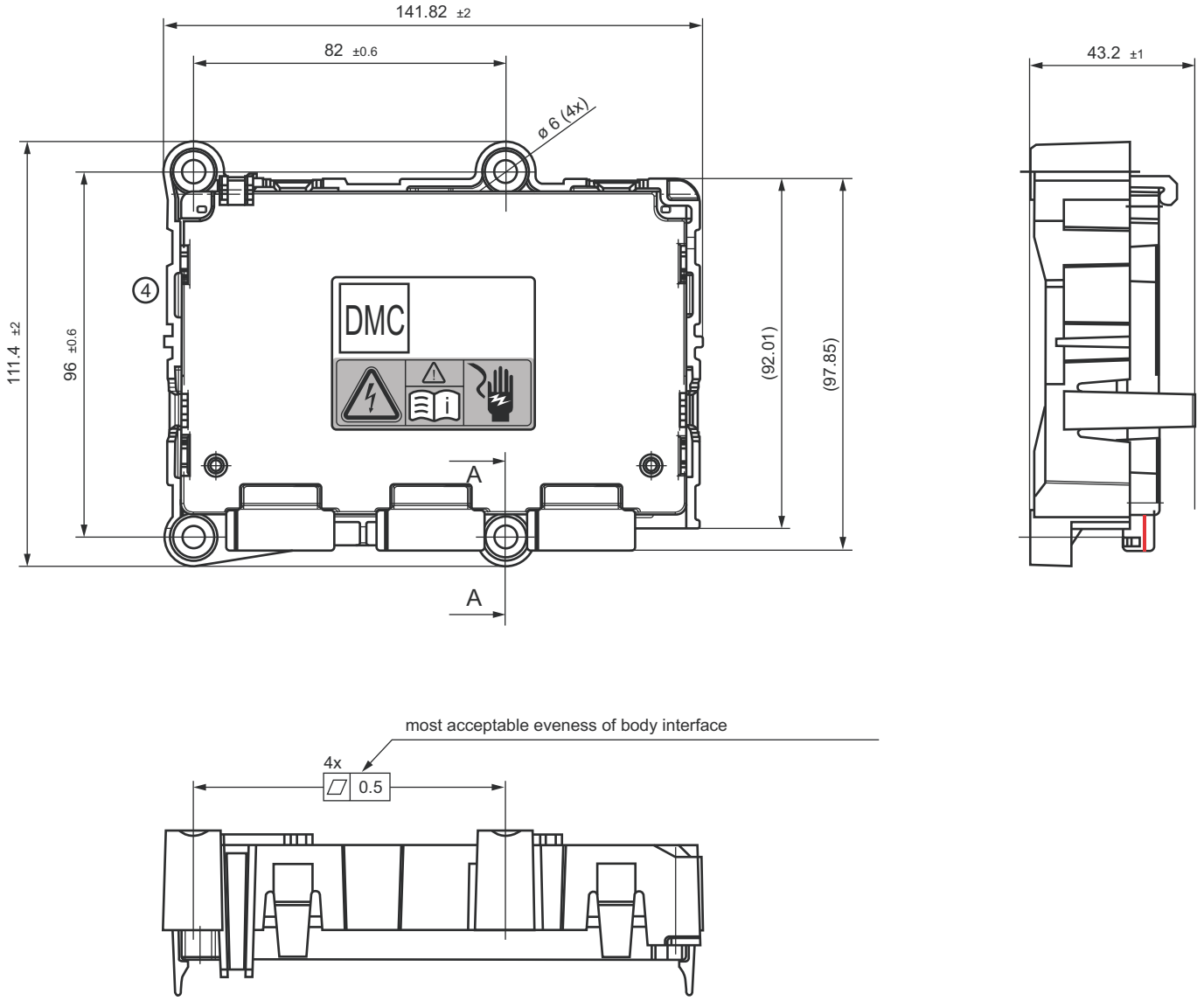
	HV relays open	**HV relays closed**
Insulation resistance	50,000 kΩ	Value in kΩ
Voltage of HV1	0V	Value in V
Voltage of HV2	Value in V	Value in V

The ISOMETER® generates a pulsed measuring voltage that is superimposed on the IT system by terminals T_31_E/KE (chassis). Because the connection between the terminals E/KE and the chassis ground (T_31) is continuously monitored, it is necessary to install two separated conductors from terminals T_31_E/KE to chassis ground.

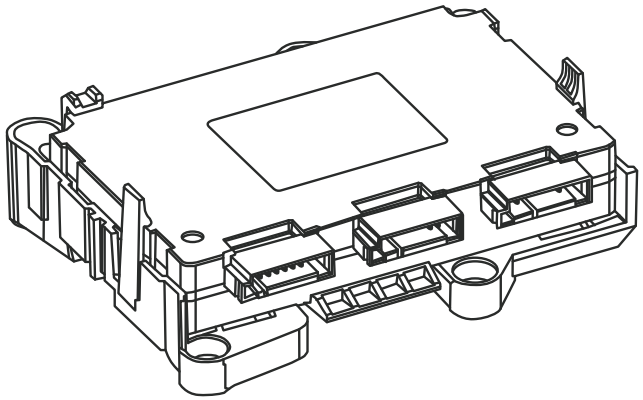
3.4 Self test

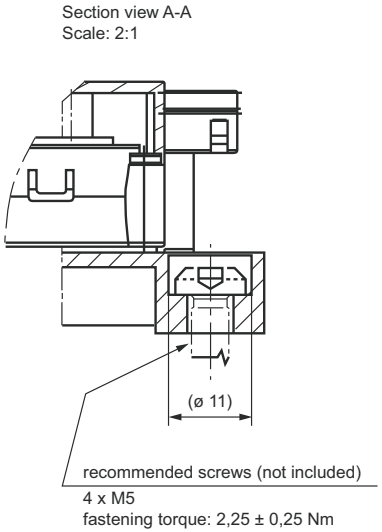
To optimize the start-up time, the ISOMETER® does not automatically execute a self test during boot up. Instead the execution of a self test is the responsibility of the external supervising system and has to be triggered via the CAN interface. A self test must be requested and can only be carried out when the coupling relays are open. The self test can be long (approximately 10 seconds) or short (approximately 1-2 seconds), and during this time the ISOMETER® is not able to perform insulation monitoring.

4.1 Device dimensions



4.2 Component housing and mounting





Position	Component	Properties
1	Housing	PBT GF30 black UL Standard: UL94 V0
2	Cover	PBT GF30 black UL Standard: UL94 V0
3	Connector pin	Cu-alloy, tin plated
4	Label	White Polyester foil
5	Bracket	PBT GF30 black UL Standard: UL94 V0

5.1 Connection conditions

DANGER

Risk of electric shock!
*The terminals HV1 ± / HV2 ± may have nominal voltages measuring up to 600 V. Touching live parts of the system carries the **risk of electric shock**. Therefore, the device is only to be operated with mounted and locked terminal covers.*

CAUTION

In order to check that the device is properly connected, a function test must be carried out before system commissioning by measuring a ground fault using a suitable resistance .

CAUTION

Terminals T_31_E and T_31_KE must be connected separately to the chassis.

CAUTION

Risk of injury from sharp-edged terminals. Handle housing and terminals with care .

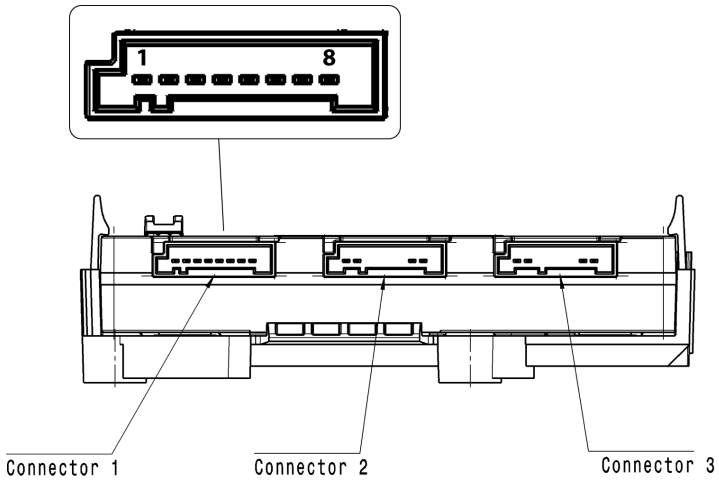
CAUTION

In every conductively connected system only one IMD may be connected. When performing insulation and dielectric tests on the system, the IMD must be disconnected by opening the HV relays for the duration of the test.

When a monitored AC system contains galvanically coupled DC circuits, the following applies: an insulation fault can only be accurately detected if a minimum current of > 10 mA flows through the rectifier valves.

The wiring should be carried out in a way that prevents a short circuit from happening.

5.2 Connectivity



Connector*)	Type	Code	Colour
1	1719183-1	A	Black
2	1719183-2	B	White
3	1719183-3	C	Blue

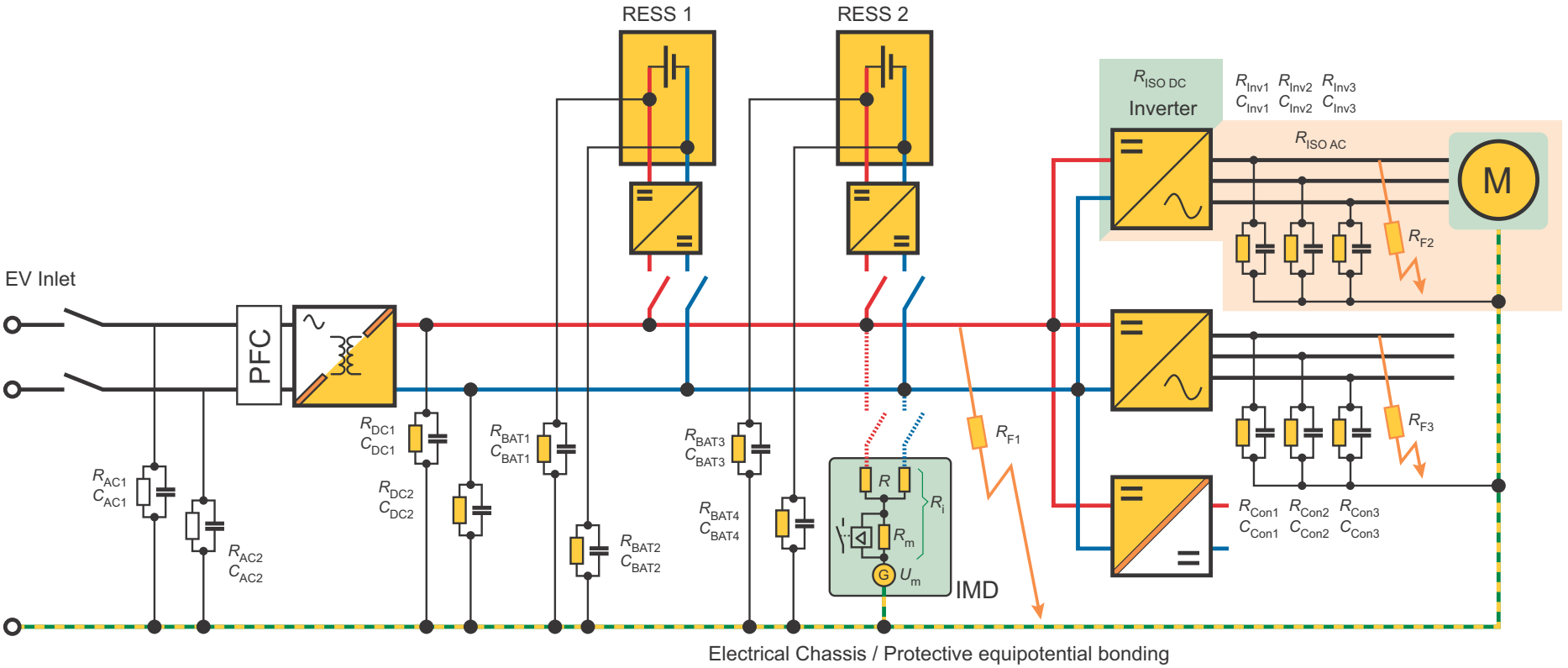
**) Please refer to "Data" on page 29 for detailed connector information.*

Connection

5.2.1 Connector pin arrangement

Connector/function	Pin no.	Signal
Connector 1 (LV) for: • Power supply • CAN Interface • High-side driver • Ground loop	1	T_31_KE_2 (vehicle internal earthing structure)
	2	reserved
	3	HST_2 (High-side driver 2, iso Warning) - **iso165C-1 only**
	4	HST_1 (High-side driver 1, iso Error) - **iso165C-1 only**
	5	HS-CAN_L
	6	HS-CAN_H
	7	T_31_E_2 (vehicle internal earthing structure)
	8	T_30 - 12V switched supply (5A fuse, Ignition and Charging FET)
Connector 2 (HV1) for: • Insulation monitoring • Voltage measurement HV1	1	HV1_POS
	2	reserved
	3	reserved
	4	reserved
	5	reserved
	6	reserved
	7	reserved
	8	HV1_NEG
Connector 3 (HV2) for: • Voltage measurement HV2	1	HV2_NEG
	2	reserved
	3	reserved
Connector 3 (HV2) for: Voltage measurement HV2 (continued)	4	reserved
	5	reserved
	6	reserved
	7	reserved
	8	HV2_POS

5.3 Typical application



5.3.1 Special application notes:

- If terminals HV2 are connected in parallel to terminals HV1 (i.e. a galvanically connected HV system), the measured insulation resistance will be monitored including a +10 % offset to the real insulation value.
- The HV2 terminals could be used for voltage monitoring at disconnected HV sections (e.g. voltage monitoring of a charging plug)

6.1 Messages

Communication between a requesting instance in the vehicle environment and the ISOMETER® takes place over the HS-CAN bus. The ISOMETER® can handle the following HS-CAN messages:

Message	CAN-ID	Direction	cyclic
IMD_Info	0x37	Tx	1 s
IMD Request	0x22	Rx	-
IMD_Response	0x23	Tx	-

The messages contain either DataByte or DataWord values. The byte order for the DataWord values is:

Byte order	DataByte
	7.....0

Byte order	DataWord	
	LowByte	HighByte
	7.....0	15.....8

6.2 IMD_Info

IMD_Info is cyclically sent once per second from the ISOMETER® and contains data values that represent the insulation resistance and the internal operating states of the VIFC and IMC.

Byte no.	0	1	2	3	4	5	6	7
	D_IMC_R_ISO		D_IMC_STATUS		D_VIFC_STATUS		Unused	Unused

Data value descriptions can be found in Chapter 7.3 on page 22.

The following example contains IMC status information:

CAN-ID (Info)	DLC*	Data1	Data2	Data3	Data4	Data5	Data6
0x37	0x6	dc	dc	IMC_STATUS_LSB	IMC_STATUS_MSB	dc	dc

DLC = **Data **L**ength **C**ode*

6.3 IMD_Request

IMD_Request is a request to the ISOMETER® and will always generate an answer message IMD_Response. It can handle Control(CTL), SET and GET commands.
A request has the following format:

Byte	0	1	2	3	4	5	6	7
	CMD	Data1	Data2	Data3	Data4	Unused	Unused	Unused
		DataWord1		DataWord2				

Definitions of DataWord1 and DataWord2 for different commands an be found in "Command descriptions" on page 17.

For synchronous processing of the asynchronously received IMD_Request commands, the VIFC implements a queue which operates on the First In, First Out (FIFO) principle. If the queue is full, an error response is generated and the request is dropped by the ISOMETER®. The queue full error response is not generated for every single request and may be generated only after a certain number of requests have been made.
To avoid processing commands that could mistakenly modify the system configuration during standard operation, the ISOMETER® has implemented a locking mechanism. The locking state can be changed with the command S_VIFC_CTL_LOCK.

Control (CTL) commands		
CMD	**DBC command description**	**Locked**
0x21	S_IMC_CTL_SELFTEST	
0xC8	S_VIFC_CTL_IMC_RESET	
0xCA	S_VIFC_CTL_LOCK	
0xCB	S_VIFC_CTL_MEASUREMENT	

SET commands		
CMD	**DBC command description**	**Locked**
0x28	S_IMC_SET_R_ISO_ERR_THR	X
0x29	S_IMC_SET_R_ISO_WRN_THR	X
0x2B	S_IMC_SET_MEAN_FACTOR	X
0xD2	S_VIFC_SET_HV_RELAIS	

GET commands		
CMD	**DBC command description**	**Locked**
0x0	S_VIFC_DUMMY	
0x37	S_IMC_GET_STATUS	
0x35	S_IMC_GET_R_ISO	
0x32	S_IMC_GET_R_ISO_ERR_THR	
0x39	S_IMC_GET_R_ISO_WRN_THR	
0x3C	S_IMC_GET_MEAN_FACTOR	
0x36	S_IMC_GET_HV_1	
0x3A	S_IMC_GET_HV_2	
0x33	S_IMC_GET_VERSION	
0xDC	S_VIFC_GET_STATUS	
0xDD	S_VIFC_GET_HV_RELAIS	
0xDE	S_VIFC_GET_VERSION	
0x5A	S_IMC_GET_TEST_CNT	
0x3D	S_IMC_GET_MANUFACTURER	

Command descriptions can be found in Chapter 7.2 on page 17.

6.3.1 Example

The example shown below is a request to unlock the device.

CAN-ID (Request)	DLC*	CMD	Data1	Data2	Data3	Data4
0x22	0x5	0xCA	0x00	0x00	0x00	0x00

DLC = **Data **L**ength **C**ode is always 0x5. Only IMD_Info has a DLC of 0x6.*

6.4 IMD_Response

IMD_Response is generated exclusively as an answer to the IMD_Request command. The system guarantees that every request is answered with a response if the IMD_Request is accepted by the queue implementation. The response can have one of two frame formats: a valid response is returned in the event the request can be successfully answered. Otherwise an error response is returned, the format of which contains an error code that specifies the reason.

Valid response format:

Byte	0	1	2	3	4
	CMD	Data1	Data2	Data3	Data4
		DataWord1		DataWord2	

Error response format:

Byte	0	1	2	3	4
	0xFF	D_IMD_ERROR_CODE		D_IMD_FAILED_CMD	0x00

7.1 Naming convention

7.1.1 Signal naming

Prefix	Description
S_	Command
D_	Data Value
P_	Physical Interface

7.1.2 DBC signal naming

The data value identifier "D_" is not included in DBC signal naming due to redundancy. Instead an identifier is added that allows the same data value identifier to be used in different messages and which avoids any naming conflict in the DBC. The DBC identifier identifies the sender of the message (Master or IMD) and the command type, i.e. Control (CTL), SET or GET. **Replace the DBC identifier with the data value identifier "D_" to obtain all valid data values for this DBC signal**.

Prefix	Description
MC_	Master control request data value
MS_	Master set request data value
MG_	Master get request data value

IC_	IMD control response data value
IS_	IMD set response data value
IG_	IMD get response data value

II_	IMD info data value

7.2 Command descriptions

The message parameters are coded in bytes 2 to 5 and provide the possibility to enhance the request or response with additional information. If no additional message parameters are listed in this chapter the parameter should be initialized with '0'. Parameters in response commands not described here have no concrete meaning in the system.

7.2.1 Control (CTL) commands

7.2.1.1 S_IMC_CTL_SELFTEST

This command is a request to start the IMC self test.

	IMD_Request	IMD_Response
CMD	0x21	0x21
DataWord1	D_IMC_SELFTEST_SCR	D_IMC_SELFTEST_SCR
DataWord2	0	0

7.2.1.2 S_VIFC_CTL_IMC_RESET

This command is a request to reset the IMC subsystem.

	IMD_Request	IMD_Response
CMD	0xC8	0xC8
DataWord1	0	0
DataWord2	0	0

7.2.1.3 S_VIFC_CTL_LOCK

This command is a request to lock or unlock the device against changes made by mistake.

	IMD_Request	IMD_Response
CMD	0xCA	0xCA
DataWord1	D_VIFC_LOCK_MODE	D_VIFC_LOCK_MODE
DataWord2	D_VIFC_LOCK_PWD	0

7.2.1.4 S_VIFC_CTL_MEASUREMENT

This command is a request to select the IMD measurement mode.

	IMD_Request	IMD_Response
CMD	0xCB	0xCB
DataWord1	D_VIFC_MEASURE_MODE	D_VIFC_MEASURE_MODE
DataWord2	0	0

7.2.2 SET commands

7.2.2.1 S_IMC_SET_R_ISO_ERR_THR

This command is a request to set the insulation error threshold.

IMD_Request	IMD_Response	
CMD	0x28	0x28
DataWord1	D_IMC_R_ISO_ERR_THR	D_IMC_R_ISO_ERR_THR
DataWord2	0	0

7.2.2.2 S_IMC_SET_R_ISO_WRN_THR

This command is a request to set the insulation warning threshold.

	IMD_Request	IMD_Response
CMD	0x29	0x29
DataWord1	D_IMC_R_ISO_WRN_THR	D_IMC_R_ISO_WRN_THR
DataWord2	0	0

7.2.2.3 S_IMC_SET_MEAN_FACTOR

This command is a request to set the mean factor of the insulation resistance averaging algorithm.

IMD_Request	IMD_Response	
CMD	0x2B	0x2B
DataWord1	D_IMC_MEAN_FACTOR	D_IMC_MEAN_FACTOR
DataWord2	0	0

7.2.2.4 S_VIFC_SET_HV_RELAIS

This command is a request to change the state of the HV relays in the HV coupling network.

	IMD_Request	IMD_Response
CMD	0xD2	0xD2
DataWord1	D_VIFC_HV_RELAIS	D_VIFC_HV_RELAIS
DataWord2	D_VIFC_HV_RELAIS_STATE	D_VIFC_HV_RELAIS_STATE

7.2.3 GET commands

7.2.3.1 S_VIFC_DUMMY

This command requests a dummy response with no functionality (ping).

	IMD_Request	IMD_Response
CMD	0x0	0x00
DataWord1	0	0
DataWord2	0	0

7.2.3.2 S_IMC_GET_STATUS

This command requests the internal status of the IMC.

	IMD_Request	IMD_Response
CMD	0x37	0x37
DataWord1	0	D_IMC_STATUS
DataWord2	0	D_IMC_STATUS_EXT

7.2.3.3 S_IMC_GET_R_ISO

This command requests the insulation resistance.

	IMD_Request	IMD_Response
CMD	0x35	0x35
DataWord1	0	D_IMC_R_ISO
DataWord2	0	Data3: D_IMC_R_ISO_BIAS Data4: D_IMC_R_ISO_CNT

7.2.3.4 S_IMC_GET_R_ISO_ERR_THR

This command requests the insulation error threshold.

	IMD_Request	IMD_Response
CMD	0x32	0x32
DataWord1	0	D_IMC_R_ISO_ERR_THR
DataWord2	0	0

Command and data value descriptions

7.2.3.5 S_IMC_GET_R_ISO_WRN_THR

This command requests the insulation warning threshold.

	IMD_Request	IMD_Response
CMD	0x39	0x39
DataWord1	0	D_IMC_R_ISO_WRN_THR
DataWord2	0	0

7.2.3.6 S_IMC_GET_MEAN_FACTOR

This command requests the mean factor of the insulation resistance mean algorithm.

	IMD_Request	IMD_Response
CMD	0x3C	0x3C
DataWord1	0	D_IMC_MEAN_FACTOR
DataWord2	0	0

7.2.3.7 S_IMC_GET_HV_1

This command requests the HV value between HV1_POS and HV1_NEG.

	IMD_Request	IMD_Response
CMD	0x36	0x36
DataWord1	0	D_IMC_HV_1
DataWord2	0	0

Command and data value descriptions

7.2.3.8 S_IMC_GET_HV_2

This command requests the HV value between HV2_POS and HV2_NEG.

	IMD_Request	IMD_Response
CMD	0x3A	0x3A
DataWord1	0	D_IMC_HV_2
DataWord2	0	0

7.2.3.9 S_IMC_GET_VERSION

This command requests the software version of the IMC.

	IMD_Request	IMD_Response
CMD	0x33	0x33
DataWord1	D_IMC_VERSION_INDEX	D_IMC_VERSION_INDEX
DataWord2	0	D_IMC_VERSION

7.2.3.10 S_IMC_GET_TEST_CNT

This command requests the communications counter value.

	IMD_Request	IMD_Response
CMD	0x5A	0x5A
DataWord1	0	D_IMC_TEST_CNT
DataWord2	0	0

7.2.3.11 S_IMC_GET_MANUFACTURER

This command requests manufacturer information.

	IMD_Request	IMD_Response
CMD	0x3D	0x3D
DataWord1	D_IMC_MANUFACT_INDEX	D_IMC_MANUFACT_INDEX
DataWord2	0	D_IMC_MANUFACT_DATA

7.2.3.12 S_VIFC_GET_STATUS

This command requests the internal status of the VIFC.

	IMD_Request	IMD_Response
CMD	0xDC	0xDC
DataWord1	0	D_VIFC_STATUS
DataWord2	0	0

7.2.3.13 S_VIFC_GET_HV_RELAIS

This command requests the state of the HV relays in the HV coupling network.

	IMD_Request	IMD_Response
CMD	0xDD	0xDD
DataWord1	D_VIFC_HV_RELAIS	D_VIFC_HV_RELAIS
DataWord2	0	D_VIFC_HV_RELAIS_STATE

7.2.3.14 S_VIFC_GET_IMC_ALIVE

This signal requests the alive state of the IMC.

	IMD_Request	IMD_Response
CMD	0xE2	0xE2
DataWord1	0	D_VIFC_IMC_ALIVE
DataWord2	0	0

7.2.3.15 S_VIFC_GET_VERSION

This command requests the software version of the VIFC.

	IMD_Request	IMD_Response
CMD	0xDE	0xDE
DataWord1	D_IMC_VERSION_INDEX	D_VIFC_VERSION_INDEX
DataWord2	0	D_IMC_VERSION

7.2.3.16 S_VIFC_GET_LOCK

This signal requests the locking state of the ISOMETER® iso165C.

	IMD_Request	IMD_Response
CMD	0xE0	0xE0
DataWord1	0	D_VIFC_LOCK_MODE
DataWord2	0	0

Command and data value descriptions

7.2.4 Reserved Commands

These commands are reserved for internal use.

CMD	ID
S_IMC_CTL_CALIB	0x22
S_IMC_SET_EEPROM	0x2A
S_IMC_GET_EEPROM	0x3B

Command and data value descriptions

7.3 Data value descriptions

7.3.1 D_IMC_SELFTEST_SCR

This data value represents the self test scenario.

Value	Description
0	No Action
1	OverAll scenario
2	ParameterConfig scenario

7.3.2 D_IMC_R_ISO_ERR_THR

This data value represents the threshold that causes an insulation error when the insulation resistance is lower than this value.

Unit	kΩ
Default	100
Resolution	1
Range	30…1,000

7.3.3 D_IMC_R_ISO_WRN_THR

This data value represents the threshold that causes an insulation warning when the insulation resistance is lower than this value.

Unit	kΩ
Default	200
Resolution	1
Range	40…2,000

7.3.4 D_IMC_MEAN_FACTOR

This data value represents the mean factor of the insulation resistance averaged algorithm.

Unit	Samples
Default	10
Resolution	1
Range	1…20

7.3.5 D_IMC_STATUS

This data value represents the internal status of the IMC.

Bit	Description	Status
0	Insulation failure	0 = NoError 1 = Error
1	Ground failure	0 = NoError 1 = Error
2	System failure	0 = NoError 1 = Error
3	Calibration running	0 = NotRunning 1 = Running
4	Self test running	0 = NotRunning 1 = Running
5	Insulation warning	0 = NoWarning 1 = Warning
6	Reserved	
7	Reserved	
8	Reserved	
9	Reserved	
10	Reserved	

Bit	Description	Status
11	Reserved	
12	Reserved	
13	Reserved	
14	Reserved	
15	Reserved	

7.3.6 D_IMC_STATUS_EXT

This data value represents the self test result flags of the IMC.

Bit	Description	Status
0	Calibration parameter failure	0 = NoError 1 = Error
1	Hardware failure	0 = NoError 1 = Error
2	EEPROM Parameter failure	0 = NoError 1 = Error
3	FLASH Parameter failure	0 = NoError 1 = Error
4	RAM Parameter failure	0 = NoError 1 = Error
5	Stack overflow	0 = NoError 1 = Overflow
6	Reserved	
7	Parameter value failure	0 = NoError 1 = Error
8	Test pulse voltage / ARef failure	0 = NoError 1 = Error
9	+12V voltage failure	0 = NoError 1 = Error

Command and data value descriptions

Bit	Description	Status
10	-12V voltage failure	0 = NoError 1 = Error
11	FuseBits invalid	0 = NoError 1 = Error
12	HV1 voltage failure	0 = NoError 1 = Error
13	HV2 voltage failure	0 = NoError 1 = Error
14	Manufacturer string invalid	0 = NoError 1 = Error
15	Reserved	

7.3.7 D_IMC_R_ISO

This data value represents the mean insulation resistance measured by the IMC.

Unit	kΩ
Default	0
Resolution	1
Range	0…50,000

7.3.8 D_IMC_R_ISO_BIAS

This data value represents the bias/tendency to the location of the insulation error. This value is only written when an insulation error exists and the measured voltage is ≥ 200 V.

Value	Description
0	Unknown
1	Failure on HV1_NEG
2	Failure on HV1_POS

Command and data value descriptions

7.3.9 D_IMC_R_ISO_CNT

This data value represents an 8-bit counter that is incremented on every successful calculation of a new insulation resistance value.

Unit	Sample
Default	0
Resolution	1
Range	0…255

7.3.10 D_IMC_MANUFACT_INDEX

This data value represents an index to a character from the manufacturer's string.

Unit	Sample
Default	0
Resolution	1
Range	0…60

7.3.11 D_IMC_MANUFACT_DATA

This data value represents the ASCII code of a character from the manufacturer's string.

Unit	Sample
Default	0
Resolution	1
Range	0…255

7.3.12 D_IMC_HV_1

This data value represents the HV between HV_1_POS and HV_1_NEG.

Unit	V
Default	0
Resolution	1
Range	0…600

7.3.13 D_IMC_HV_2

This data value represents the HV between HV_2_POS and HV_2_NEG.

Unit	V
Default	0
Resolution	1
Range	0…600

7.3.14 D_IMC_VERSION_INDEX

This data value represents the index to the software version of the IMC.

Value	Description
0	IMC bootloader
1	IMC firmware
2	IMC firmware ID
3	IMC firmware Hash

7.3.15 D_IMC_VERSION

This data value represents the software version of the IMC.

Value	Description
Data3	Minor version
Data4	Major version

7.3.16 D_IMC_TEST_CNT

This data value represents a 16-bit counter that is incremented on every request of S_IMC_GET_TEST_CNT.

Unit	Sample
Default	0
Resolution	1
Range	0…65,535

7.3.17 D_VIFC_HV_RELAIS

This data value represents the selected HV relay.

Value	Description
0	HV_1_NEG relay
1	HV_1_POS relay
100	Unknown

Command and data value descriptions

7.3.18 D_VIFC_MEASURE_MODE

This data value represents the state of the insulation measurement and the IMC activity status.

Value	Description
0	Disabled
1	Enabled
100	Unknown

7.3.19 D_VIFC_LOCK_MODE

This data value represents the current state of the ISOMETER® iso165C locking mode.

Value	Description
0	Unlocked
1	Locked
100	Unknown

7.3.20 D_VIFC_LOCK_PWD

This data value represents the password needed to change the locking state of the ISOMETER® iso165C.

Value	Description
0x0000	Unlock
0xFFFF	Lock

7.3.21 D_VIFC_HV_RELAIS_STATE

This data value represents the switching state of the HV relay.

Value	Description
0	Open
1	Closed
100	Unknown

7.3.22 D_VIFC_VERSION_INDEX

This data value represents the index to the software version of the VIFC.

Value	Description
0	VIFC bootloader
1	VIFC firmware
100	Unknown

7.3.23 D_VIFC_VERSION

This data value represents the software version of the VIFC.

Value	Description
Data3	Minor version
Data4	Major version

Command and data value descriptions

7.3.24 D_VIFC_IMC_ALIVE

This data value represents the alive state of the IMC.

Value	Description
0	Running The IMC is up and running without any failure. • Initialization • Idle • Isolation warning • Self test • Calibration
1	Error The IMC is up and running but has detected a failure. • System failure • Isolation failure • Ground failure
2	Performance error The VIFC has received the analog "Alive" signal but was not able to evaluate it correctly.
100	Unknown The VIFC is not receiving the analog "Alive" signal from the IMC.

7.3.25 D_VIFC_STATUS

This data value represents the status state of the VIFC.

Bit	Description	Status
0	Insulation measurement	0 = Activated 1 = Deactivated
1	IMC connectivity failure *)	0 = OK 1 = Failure
2	IMC alive status detection	0 = OK 1 = Failure
3	Reserved	
4	VIFC command error *)	0 = NoError 1 = Error
5	Reserved	
6	Reserved	
7	Reserved	
8	Outdated insulation resistance value	0 = Valid 1 = Outdated
9	Reserved	
10	Reserved	
11	Reserved	
12	IMC self test (OverAll scenario)	0 = Executed 1 = NotExecuted
13	IMC self test (ParameterConfig scenario)	0 = Executed 1 = NotExecuted
14	Reserved	
15	Reserved	

**) Currently not implemented*

Command and data value descriptions

7.3.26 D_IMD_ERROR_CODE

This data value represents the IMC and VIFC error codes in the error frame.

IMC error codes	
Value	**Description**
32	Timeout 10 ms (incomplete frame)
33	Checksum error detect in frame
34	Invalid parameter
35	Unknown command
36	Error in EEPROM access
37	Repeated or missing frame

VIFC error codes	
Value	**Description**
1000	Command locked
1001	Queue full (Command rejected)
1002	Command unavailable (Measurement Off)
1032	Timeout 10 ms (incomplete frame)
1033	Checksum error detect in frame
1034	Invalid parameter
1035	Unknown command
1037	Repeated or missing frame
1038	No response (Timeout 60 ms)
1039	Communication error
1040	Invalid IMC response command

Command and data value descriptions

7.3.27 D_IMD_FAILED_CMD

This data value represents the frame command ID of a failed IMC command.

Value	Description
0 ... 255	Every CMD sent in a request to the IMD

8.1 Technical data

Supply voltage

Supply voltage U_S ..... DC 9 V - 16 V
Nominal supply voltage ..... DC 12 V
Max operational current I_S ..... 300 mA (typ. 185 mA)
Max current I_K ..... 5 A
Power dissipation P_S ..... < 2.5 W

Supervised IT system

Rated voltage range U_n ..... DC 0 V . . . 600 V
Tolerance ..... +15%
Frequency range ..... 10 Hz . . . 1 kHz
System leakage capacity C_e ..... ≤ 1 µF
Withstand voltage test ..... 1.9 kV AC / 1 min.

Measuring circuit

Measurement method ..... Bender DCP technology
Measuring voltage U_m ..... ± 40 V
Measuring current I_m at $R_F = 0$ ..... ± 33 µA
Impedance Z_i at 50 Hz (HV1) ..... ≥ 1.2 MΩ (≥ 2.4 MΩ each line, high resistance in off state)
Internal resistance R_i (HV1) ..... ≥ 1.2 MΩ (≥ 2.4 MΩ each line, high resistance in off state)
Impedance Z_i at 50 Hz (HV2) ..... ≥ 10.5 MΩ (≥ 21 MΩ each line)
Internal resistance R_i (HV2) ..... ≥ 10.5 MΩ (≥ 21 MΩ each line)

Measuring ranges

Insulation resistance range ..... 0 Ω . . . 50 MΩ
Insulation resistance duration/Pulse (normal operation) ..... ~ 1.6 s (≤ 1 µF / 0 MΩ)
..... ~ 6 s (≤ 1 µF / 10 MΩ)
Relative error (DCP) ..... 100 kΩ....5 MΩ, ±15 %
Absolute error (DCP) ..... 0 Ω . . . 100 kΩ, ±15 kΩ
High-voltage range ..... 0 V . . . 600V
High-voltage tolerance ..... 0 V . . . 100 V, ±5 V
..... 100 V . . . 600 V, ±5 %

High-side driver output (iso165C-1)

HST_1* ..... High-side driver 1, iso Error
Maximum current, I_{out_max} ..... 80 mA
HST_2* ..... High-side driver 2, iso Warning
Maximum current, I_{out_max} ..... 80 mA
*External 2.2 kΩ pull-down resistor to chassis ground (KL.31) is required.
Not protected against a short circuit in the event that KL.31 is missing. Therefore, a 100 Ω resistor is required on each driver output.

Response Values

iso165C:

Response Alarm 1 (Error) ..... 30 kΩ . . . 1 MΩ (default 100 KΩ)
Response Alarm 2 (Warning) ..... 40 kΩ . . . 2 MΩ (default 200 KΩ)

iso165C-1:

Response Alarm 1 (Error) ..... 30 kΩ . . . 1 MΩ (default 200 KΩ)
Response Alarm 2 (Warning) ..... 40 kΩ . . . 2 MΩ (default 400 KΩ)

iso165C and iso165C-1:

Response uncertainty (according to IEC 61557-8) ..... ±15 %
Hysteresis ..... +25 %
Factor averaging F_{ave} 10 (default:10)
Response time tan (DCP)
(Changeover R_F: 10 MΩ - R_{an}/2; at $C_e = 1$ µF; $U_n = 600$ V DC) ..... $t_{an} \leq 20$ s (at $F_{ave} = 10$*)
..... during self test t_{an} + 10 s
Measurement time after power on (and after HV relays are closed) ..... ≤ 3 s (<1 µF / 150 kΩ)
Switch-off time tab (DCP)
(Changeover R_F:R_{an}/2 - 10 MΩ; at $C_e = 1$ µF; $U_n = 600$ V DC) ..... $t_{ab} \leq 40$ s (at $F_{ave} = 10$)
..... during self test t_{ab} + 10 s

* $F_{ave} = 10$ is recommended for electric vehicles

Interface

Protocol ..... HS-CAN

iso165C:

Data rate ..... 250 kBaud
Termination resistance ..... 124 Ω internally

iso165C-1:

Data rate ..... 500 kBaud
Termination resistance ..... None

Environment/EMC

EMC ..... IEC 61326-2-4
Overvoltage category/degree of pollution II/2
Temperature range ..... -40. . . +85 °C
Range of application ..... 5,000 m above sea level

Connectors (Tyco)

Receptor housing type ..... 1719183-1, 1719183-2, 1719183-3 (black, white, blue)
Receptor drawing number C-1719183
Contact type (tin plated) 5-963715-1
Contact wire range ..... 0.50 - 0.75 mm^2
Contact drawing number 929454
Crimp hand tool 539635-1

Other

Operating mode ..... Continuous operation
Degree of protection IP5K0

Software version:

iso165C ..... V1.0 - Release S010 (VIFC: V5.0 , IMC V5.0)
iso165C-1 ..... V2.0 - Release S010 (VIFC: V10.0 , IMC V5.0)

Mounting

Recommended screws for mounting ..... 4 x M5 (not included)
Max. tightening torque ..... 2.25 ± 0.25 Nm(XX lbs-in)

8.2 Ordering data

Type	Response value range	Nominal voltage	Supply voltage	Art. No.
iso165C	Alarm1 (Error): 30 kΩ…1 MΩ (default 100 kΩ); Alarm2 (Warning): 40 kΩ…2 MΩ (default 200 kΩ)	DC 0…600 V	DC 12 V	B 9106 8175
iso165C	Alarm1 (Error): 30 kΩ…1 MΩ (customer setting XXX kΩ); Alarm2 (Warning): 40 kΩ…2 MΩ (customer setting XXX kΩ)	DC 0…600 V	DC 12 V	B 9106 8175 C
iso165C-1	Alarm1 (Error): 30 kΩ…1 MΩ (default 200 kΩ); Alarm2 (Warning): 40 kΩ…2 MΩ (default 400 kΩ)	DC 0…600 V	DC 12 V	B 9106 8176
iso165C-1	Alarm1 (Error): 30 kΩ…1 MΩ (customer setting XXX kΩ); Alarm2 (Warning): 40 kΩ…2 MΩ (customer setting XXX kΩ)	DC 0…600 V	DC 12 V	B 9106 8176 C

8.2.1 Accessories

Type	Art. No.
iso165C connecting kit	B 9106 8503

CE

8.3 Standards - corresponding norms and regulations

8.3.1 General

IEC 61557-8 2007-01; IEC 60664-1 2004-04; ISO 6469-3 2001-11; ISO 23273-3 2006-11

8.3.2 EMC

CISPR 25
ISO 7637-2
ISO 11452-4
ISO 11452-2
ISO 11452-8
ISO 10605
IEC 61326-2-4
IEC 61000-4-4
e1 acc. 72/245/EWG/EEC (in progress)
ISO 16750-2

8.3.3 Environmental

ISO 16750-1
ISO 20653
ISO 16750-3
IEC 60068-2-14
IEC 60068-2-27
IEC 60068-2-32
IEC 60068-2-64
ISO 16750-4
IEC 60068-2-1
IEC 60068-2-2
IEC 60068-2-38
IEC 60068-2-60
IEC 60068-2-78

Normative exclusion

The device has gone through an automotive test procedure in accordance with multi customer requirements as outlined by reg. ISO 16750-x. IEC 61557-8 will be fulfilled by creating an LED warning function and test button at the customer site if necessary.

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