Operator's Manual

CAN-Interface

Multi-Channel High Voltage Power Supply Module EHQ xxx

Note

The information in this manual is subject to change without notice. We take no responsibility for any error in the document. We reserve the right to make changes in the product design without reservation and without notification to the users.

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1 General information

The EHQ multi-channel high voltage devices are power supplies in 6U Euro-card format. Each single channel is independently controllable. They are made ready for mounting into a crate. The powered system crate ECH xx8 (19“ rack) carries up to 8 modules. It is also possible to supply the modules separately with the necessary power. The unit is software controlled via CAN-Interface directly through a PC or a similar controller.

2 General settings and options

Please note that there are additional hardware features for these devices in this manual called **OPTION**. The use of an access without the hardware implementation will be described under **OPTION** in manual.

It is strictly forbidden to change the optional hardware limits via potentiometer if at minimum one of the channels is in HV mode ON.

Devices with different settings of bit rate do not work on the same bus.

The permanent storage of a write access exists only if it is described as mode in the manual.

The refresh of actual channel values is made in each program cycle of the module – approximately every second.

The refresh of actual values of module is made in each 2nd program cycle – approximately every 2nd second.

The refresh of actual board temperature value is made approximately every 5 minutes.

3 Operating Elements

3.1 Front panel

LED **CHANNEL 0 –** *(max channel-1)* **OK**

After power on and if no errors occurs the LED will be switched on.

If there is an Error such as: safety loop is not closed

power supplies are out of tolerance

exceed the threshold of V_{max}, I_{max}, I_{set} or I_{trip} (see description below) has been exceeded the LED will be switched off until the error has been corrected and the corresponding status bit has been erased via interface.

HV Connector There are different options which corresponds to V_{max}, application etc.(see Technical data).

Connector **SL** Two pin Socket for safety loop current I_{SL} (2mA<I_{SL}<20mA)

An *"active safety loop"* means that an output voltage is present only if a current is driven through PIN c 4 at the 96-pin connector on the back panel (see next chapter), the internal voltage drop is ca. 5 V and the pins of connector SL are connected together (i.e. safety loop closed). OPTION REDEL-connector SL-contact Pin 22 and PIN 30 are also connected together.

If the safety loop is open during operation then the output voltages are shut off without ramp and the corresponding bit in the 'Status module' will be cancelled. After the loop will be closed again the channels must be switched 'ON' and a new set voltage must be given before the unit is able to offer an output voltage.

The contacts of the safety loop are not isolated from ground. Coming from the factory the safety loop is not active. Remove of the internal jumper makes the loop active. (s. Appendix C).

OPTION **V_{max}** Potentiometer to adjust the global hardware voltage limit (for all channels) and the corresponding female connector to measure the monitor voltage 0V - 2.5V for the limited output voltage (100 % Vmax corresponds to 2,5 V).

OPTION **I_{max}** Potentiometer to adjust the global hardware current limit (for all channels) and the corresponding female connector to measure the monitor voltage 0V - 2.5V for the limited output current (100 % Imax corresponds to 2,5 V).

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3.2 Back panel

The supply voltages and the CAN interface are connected to the module via a 96-pin connector on the rear side of the module.

Pin assignment 96-pin connector according to DIN 41612:

PIN		PIN		PIN		Data
a1 a3 a5		b1 b3 b5		c1 c3 c5		+5V +24V GND
				c4		OPTION: Supply voltage (24 V, max. current 10 mA) for Safety loop
a11		b11		c11		@CAN_GND @CANL @CANH } potential free
a13		b13				RESET OFF with ramp (e.g. 10s after power fail)
a30 a31 a32	A4 A2 A0	b30 b31 b32	A5 A3 A1	c30 c31 c32	GND GND GND	} Address field module address (A0 ... A5)

The hardware signal “OFF with ramp” (Pulse High-Low-High, pulse width ≤ 100 µs) on pin b13 will shut off the output voltage for all channels with a ramp analogue to the Group access “Channel ON/OFF”. The ramp speed is defined to $V_{O\ max}$ / 50 s. This is the actual module ramp speed after “OFF with ramp”.

With help of the Group access “Channel ON/OFF” all channels are switched “ON” again.

With the address field a30, b30, a31, b31, a32 and b32 the module address will be coded. (see item 4.4, description 11bit-Identifier).

Connected to GND ⇒ A(n) = 0 ; contact open ⇒ A(n) = 1

4 Communication via Interface

4.1 Device Control Protocol DCP

The communication between the controller and the module is working according to the Device Control Protocol DCP, which has been designed for the use of multi-level-hierarchy systems for instruments. This protocol is working according to the master slave principle. Therefore, the controllers which are on higher hierarchy always are masters while devices, which are in lower hierarchy are slaves. In case of the control of the HV device through a controller this is the master in this system, while the module (as a Front-end device with intelligence) is the slave.

The data exchange between the controller and the Front-end (FE) device is working with help of data frames. These data frames are made out of one direction bit DATA_DIR, one identifier bit DATA_ID and further data bytes. The direction bit DATA_DIR defines whether the data frame is a write or read-write access. The DATA_ID is characterized through the first byte of the data frame with bit7=1. Bit6=0 is an access to a single channel (single access). Bit6=1 is an access to the total group of channels (group access). If the type of the data frame is a single access it will be defined with help of the symbol **S** and the corresponding channel multiplex information with help of the symbol M or if it is a group access with help of the symbol **G.**

Access	EXT_ INSTR	DATA _DIR	DATA_ID Bit							
			7	6	5	4	3	2	1	0
No DATA_ID		x	**0**	x	x	x	x	x	x	x
Write access on one channel of Front-end device	0/1	**0**	1	0	S1	S0	M3	M2	M1	M0
Read-write access on one channel of Front-end device (Request at Write)	0/1	**1**	1	0	S1	S0	M3	M2	M1	M0
Write access on Front-end device as group of channels	0/1	**0**	1	1	G3	G2	G1	G0	R1	R0
Read-write access on Front-end device as group of channels (Request at Write)	0/1	**1**	1	1	G3	G2	G1	G0	R2	R0

R reserved

These data frames correspond to a transfer into layer 3 (Network Layer) and layer 4 (Transport Layer) of the OSI model of ISO. The transmission medium is the CAN Bus according to specification 2.0A, related to level1 (Physical Layer) and level 2 (Data Link Layer).

The Device Control Protocol DCP has been matched to the CAN Bus according to specification CAN 2.0A. Therefore specials of layer 1 and 2 are mentioned only if absolutely necessary and if misunderstandings of functions between the Transport Layer and functions of the Data Link Layer may be possible. The communication between the controller and a module on the same bus segment can be described as follows.

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4.2 CAN-Bus Implementation

The data frame structure is matched to the message frame of the standard-format according to CAN specification 2.0A, whereas looking from the point of view of the CAN protocol a pure data transmission will be done, which is not applying to the protocol.

The data frame of the DCP will be transferred as data word with n bytes length in the data field of the CAN frame according to the specific demand of the related access. Therefore this results into a Data Length Code (DLC) of the CAN-protocol of n.

It is possible to transfer 8 data bytes that apply to the DLC field with decreasing values.

The addressing of the Front-end device is also made using the 11 bit identifier of the CAN protocol.

In order to keep the CAN segment open also for other protocols, the addressing room was limited to 64 nodes.

ID10 is dominant.

ID9 is always dominant for modules that have no Active-CAN message function.

is recessive for modules that have an Active-CAN message function by receiving or sending write- or read-write-accesses and is dominant, if the module is sending an active error message. If the module has been configured as a CAN-node with an Active-CAN message function and the sum status-, safety loop- or voltage supplies-bit in the group access “General status module” has been set, then the module will send this group access as an active error message with higher priority (ID9 = 0) before normal messages can be transmitted.

ID8 to ID3

allow the addressing of 64 Front-end devices (ID3: A0 = 2^0 ;...; ID8: A5 = 2^5), see *3.2 Back Panel* also.

ID2 is used for a special network management service (NMT).

ID1 is used for an extended instruction set.

ID0 is used for defining the direction of the data transfer (DATA_DIR). The controller therefore will start a read-write access for data with DATA_DIR = 1 and will send data with DATA_DIR=0. The Front-end device responds to the data request by sending the corresponding data with DATA_DIR = 0.

That means all “even” CAN-ports (Identifier) are interpreted as ‘Write ports’ all “odd” CAN ports as ‘ Read ports’.

Only if the Front-end device is not registered at the controller or if it does not receive valid data during a longer time period (ca. 1 min), then it will actively send the registration frame with DATA_DIR = 1 (see also item 4.3).

In one CAN segment only modules with unequal identifier and equal bit rate are allowed. The factory fixed bit rate is written on the sticker of the 96-pin connector.

The RTR Bit is always set to zero.

Following data frame is valid for the control of the Front-end device in this lowest CAN segment.

S O F	Identifier	R T R	0	0	DLC	n – data bytes				CRC	ack F.
					(n=1-8)	DATA_ID	DATA_(n-2)≥ 0	DATA_(n-3)≥ 0	DATA_ ...		
	b10 b0		Reserve		b3 b0	b7 =1 b0	b7 b0	b7 b0	b7 b0	15 bit	

ID10	ID9	ID8	ID7	ID6	ID5	ID4	ID3	ID2	ID1	ID0
0	0	0	0	0	0	0	0	1	EXT_INSTR	DATA_DIR

1. Acceptance-Filter of the used CAN-Controller is set to NMT service identifier

ID10	ID9	ID8	ID7	ID6	ID5	ID4	ID3	ID2	ID1	ID0
0	P	A5	A4	A3	A2	A1	A0	0	EXT_INSTR	DATA_DIR

2. Acceptance-Filter of the used CAN-Controller is set to Front-end-address A0 - A5

The Front-end device must do:

- Processing of NMT services via broadcast messages inside of the CAN segment
- Processing of the single accesses with direct channel values.
- Processing of group information of the module.
- Self-registration in the higher level through sending the module address.
- Building of status information.
- Send an active error message with higher priority if one of the bits - sum status, supply voltages or safety loop - in the group access “General status module” has not been set (the module must be configured as a CAN-node with an Active-CAN message function).

4.3 Summary of CAN data frame accesses via the NMT service identifier

Access	EXT_INSTR	DATA_DIR	DATA_ID Bit								read / write / active	DATA-Bytes	Page
	ID1	ID0	7	6	5	4	3	2	1	0			
No DATA_ID	x	x	**0**	x	x	x	x	x	x	x			
NMT service CAN segment:	**0**	**0**	**1**	**1**	**N3**	**N2**	**N1**	**N0**	**R1**	**R0**			
NMT Start	0	0	1	1	0	0	0	1	x	x	w	1	-
NMT Stop	0	0	1	1	0	0	1	0	x	x	w	1	-
NMT Reset CAN	0	0	1	1	0	0	1	1	x	x	w	1	-
NMT Reset hardware	0	0	1	1	0	1	0	0	x	x	w	1	-
NMT set of Bit rate	0	0	1	1	0	1	0	1	x	x	w	3	32
NMT set of temperature	0	0	1	1	0	1	1	0	x	x	w	3	11
N_i: NMT access													
R_i: reserved													

NMT Start — The state of all Front-end devices is going to OPERATIONAL (see Appendix D)

NMT Stop — The state of all Front-end devices is going to PREPARED
This is necessary before storing any information permanently in EEPROM or execute one of the following NMT services

NMT Reset CAN — reinitialize all connected iseg Multi-Channel CAN devices

NMT Reset hardware — execute a hardware reset of all connected CAN devices

NMT set of Bit rate — set a new bit rate for all connected iseg Multi-Channel CAN devices (DATA_1 / DATA_0 see group access Bit rate)

NMT set of an offset for the calculation of the temperature of all modules

all devices

DATA_1 to DATA_0 measured temperature in tenth parts of °C UI2

DATA_ID	DATA_1	DATA_0
0xd8	MSB	LSB

4.4 Summary of CAN data frame accesses via the Front-end-address identifier

Multi-channel High Voltage CAN modules are made out of one or two PCBs (in order to double the number of HV channels) and one digital CAN Interface per PCB.
Each module board has to be controlled separately via its own CAN nodes identifier (see chapter above).

4.4.1 Device classes

The information of the device class will be sent active from the device via the group instruction 'Log-on Front-end device at superior layer'.

device class	description	associated serial numbers
0	16 channel >1kV standard (resolution 50000)	471xxx
1	8 channel <=1kV standard (resolution 10E6)	472xxx
2	8 channel <=1kV high precision (resolution 10E6)	472xxx
3	8 channel <=1kV standard (resolution 10E6), mix	472xxx
6	8 channel >1kV standard (resolution 50000)	473xxx
7	8 channel, standard, floating (resolution 10E6), current feedback controlled	474xxx

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4.4.2 List to access of the DCP made for 16 channel HV boards (device class 0)

Access	EXT_INSTR	DATA_DIR	DATA_ID Bit								read / write / active	DATA-Bytes	Page
	ID1	ID0	7	6	5	4	3	2	1	0			
No DATA_ID	x	x	**0**	x	x	x	x	x	x	x			
Single access CHANNEL:	**1/0**	**1/0**	**1**	**0**	**S1**	**S0**	**M3**	**M2**	**M1**	**M0**			
Actual voltage	0	1	1	0	0	0	M3	M2	M1	M0	r	3	21
Actual current	0	1	1	0	0	1	M3	M2	M1	M0	r	3	22
Set voltage	0	1/0	1	0	1	0	M3	M2	M1	M0	r/w	3	23
Status channel	0	1	1	0	1	1	M3	M2	M1	M0	r	3	25
Set software current trip	1	1/0	1	0	0	0	M3	M2	M1	M0	r/w	3	26
Group access MODULE:	**1/0**	**1/0**	**1**	**1**	**G3**	**G2**	**G1**	**G0**	**R1**	**R0**			
General status	0	1/0	1	1	0	0	0	0	x	x	r/w a	1/2 3	27
GroupStatus1 - Voltage limits has been exceeded at least of one single channel	0	1	1	1	0	0	0	1	x	x	r/w	3	29
GroupStatus2 - Hardware current limits has been exceeded at least of one single channel	0	1	1	1	0	0	1	0	x	x	r/w	3	29
GroupStatus3 – Current trips Set current trip has been exceeded at least of one single channel	0	1	1	1	1	1	1	0	x	x	r/w	3	30
GroupStatus4 - Fast regulation error Voltage or Hardware current limit were exceeded at least of one single channel	1	1	1	1	1	01	0	0	x	x	r/w	3	30
Channel ON / OFF	0	1/0	1	1	0	0	1	1	x	x	r/w	3	31

Access	EXT_INSTR	DATA_DIR	DATA_ID Bit								read / write / active	DATA-Bytes	Page
	ID1	ID0	7	6	5	4	3	2	1	0			
Ramp speed	0	1/0	1	1	0	1	0	0	x	x	r/w	3	31
Emergency cut-off	0	0	1	1	0	1	0	1	x	x	w	3	31
Log-on Front-end device in superior layer	0	1	1	1	0	1	1	0	x	x	a	3	32
Log-off superior layer at Front-end device	0	0	1	1	0	1	1	0	x	x	w	2	32
Bit rate	0	1/0	1	1	0	1	1	1	x	x	r/w	3	33
Serial number, software release and CAN message configuration	0	1/0	1	1	1	0	0	0	x	x	r/w	6/2	33
Set voltage of all channels	0	0	1	1	1	0	0	1	x	x	w	3	34
Set current trip of all channels	1	0	1	1	1	0	0	1	x	x	w	3	34
Actual hardware current limit	0	1	1	1	1	0	1	0	x	x	r	3	35
Actual hardware voltage limit	1	1	1	1	1	0	1	0	x	x	r	3	35
KILL-enable	0	1/0	1	1	1	0	1	1	x	x	r/w	3	36
Set ADC filter frequency	0	1/0	1	1	1	1	0	0	x	x	r/w	3	36
Nominal values	0	1	1	1	1	1	0	1	x	x	r	5	36
Supply voltages and board temperature	1	1	1	1	0	0	0	0	x	x	r	8	37
Discharge relay configuration	1	1/0	1	1	0	1	0	1	x	x	r/w	2	37
Threshold to arm error detection	1	1/0	1	1	0	1	1	0	x	x	r/w	3	38
Access (for information only)													
Flash programming (is allowed only by SW from iseg Spezialelektronik GmbH)	0	1/0	1	1	1	1	1	1	x	x	r/w a	2/3	-
Calibration of HV (don't use, only factory)	1	0	1	1	0	1	1	1	x	x	w	1	-

S_i: Single access
M_i 0 to 15: Channel 0 to 15
G_i: Group access
R_i: reserved

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4.4.3 List to access of the DCP made for 8 channel HV boards (device class 1, 2, 3)

Access	EXT_INSTR	DATA_DIR	DATA_ID Bit								read/write/active	DATA-Bytes	Page
	ID1	ID0	7	6	5	4	3	2	1	0			
No DATA_ID	x	x	0	x	x	x	x	x	x	x			
Single access CHANNEL:	**1/0**	**1/0**	**1**	**0**	**S1**	**S0**	**M3**	**M2**	**M1**	**M0**			
Actual voltage	0	1	1	0	0	0	0	M2	M1	M0	r	4	21
Actual voltage time traced	1	1/0	1	0	1	0	0	M2	M1	M0	r/w	6	21
Actual current	0	1	1	0	0	1	0	M2	M1	M0	r	4	22
Actual current time traced	1	1/0	1	0	1	1	0	M2	M1	M0	r/w	6	22
Nominal values of channel	1	1	1	0	0	1	0	M2	M1	M0	r	5	22
Set voltage	0	1/0	1	0	1	0	0	M2	M1	M0	r/w	4	23
Status channel	0	1	1	0	1	1	0	M2	M1	M0	r	3	24
Set software current trip	1	1/0	1	0	0	0	0	M2	M1	M0	r/w	4	26
Group access module	**1/0**	**1/0**	**1**	**1**	**G3**	**G2**	**G1**	**G0**	**R1**	**R0**			
General status module	0	1/0	1	1	0	0	0	0	x	x	r/w a	1/2 3	27
GroupStatus1 - Voltage limits has been exceeded at least of one single channel	0	1	1	1	0	0	0	1	x	x	r/w	3	29
GroupStatus2 - Hardware current limits has been exceeded at least of one single channel	0	1	1	1	0	0	1	0	x	x	r/w	3	29
GroupStatus3 – Current trips Set current trip has been exceeded at least of one single channel	0	1	1	1	1	1	1	0	x	x	r/w	3	30
GroupStatus4 - Fast regulation error Voltage or Hardware current limit were exceeded at least of one single channel	1	1	1	1	1	01	0	0	x	x	r/w	3	30
Channel ON / OFF	0	1/0	1	1	0	0	1	1	x	x	r/w	3	31
Ramp speed	0	1/0	1	1	0	1	0	0	x	x	r/w	3	31

Access	EXT_INSTR	DATA_DIR	DATA_ID Bit								read/write/activ	DATA-Bytes	Page
	ID1	ID0	7	6	5	4	3	2	1	0			
Emergency cut-off	0	0	1	1	0	1	0	1	x	x	w	3	31
Log-on Front-end device in superior layer	0	1	1	1	0	1	1	0	x	x	a	3	32
Log-off superior layer at Front-end device	0	0	1	1	0	1	1	0	x	x	w	2	32
Bit rate	0	1/0	1	1	0	1	1	1	x	x	r/w	3	33
Serial number, software release, CAN message configuration and number of channels	0	1/0	1	1	1	0	0	0	0	0	r/w	7/2	33
Set voltage of all channels	0	0	1	1	1	0	0	1	x	x	w	4	34
Set current trip of all channels	1	0	1	1	1	0	0	1	x	x	w	3	34
Actual hardware current limit	0	1	1	1	1	0	1	0	x	x	r	3	35
Actual hardware voltage limit	1	1	1	1	1	0	1	0	x	x	r	3	35
KILL-enable	0	1/0	1	1	1	0	1	1	x	x	r/w	3	36
Set ADC filter frequency	0	1/0	1	1	1	1	0	0	x	x	r/w	3	36
Nominal values	0	1	1	1	1	1	0	1	x	x	r	5	36
Supply voltages and board temperature	1	1	1	1	0	0	0	0	x	x	r	8	37
Discharge relay configuration	1	1/0	1	1	0	1	0	1	x	x	r/w	2	37
Threshold to arm error detection	1	1/0	1	1	0	1	1	0	x	x	r/w	3	38
Equipped hardware channels	1	1	1	1	0	0	1	0	x	x	r	3	38
Channels working according control	1	1	1	1	0	0	1	1	x	x	r	3	38
Access (for information only)													
Flash programming (is allowed only by software from iseg Spezialelektronik GmbH)	0	1/0	1	1	1	1	1	1	x	x	r/w a	2/3	-

S_i: Single access
M_i 0 to 15: Channel 0 to 15
G_i: Group access
R_i: reserved

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4.4.4 List to access of the DCP made for 8 channel HV board (device class 6)

Access	EXT_INSTR	DATA_DIR	DATA_ID Bit								read / write / active	DATA-Bytes	Page
	ID1	ID0	7	6	5	4	3	2	1	0			
No DATA_ID	x	x	**0**	x	x	x	x	x	x	x			
Single access CHANNEL:	**1/0**	**1/0**	**1**	**0**	**S1**	**S0**	**M3**	**M2**	**M1**	**M0**			
Actual voltage	0	1	1	0	0	0	0	M2	M1	M0	r	3	21
Actual current	0	1	1	0	0	1	0	M2	M1	M0	r	3	22
Nominal values of channel	1	1	1	0	0	1	0	M2	M1	M0	r	5	22
Set voltage	0	1/0	1	0	1	0	0	M2	M1	M0	r/w	3	23
Set current	1	1/0	1	0	1	0	0	M2	M1	M0	r/w	3	24
Status channel	0	1	1	0	1	1	0	M2	M1	M0	r	3	25
Group access MODULE:	**1/0**	**1/0**	**1**	**1**	**G3**	**G2**	**G1**	**G0**	**R1**	**R0**			
General status module	0	1/0	1	1	0	0	0	0	x	x	r/w a	1/2 3	27
GroupStatus1 - Voltage limits has been exceeded at least of one single channel	0	1	1	1	0	0	0	1	x	x	r/w	3	29
GroupStatus2 - Hardware current limits has been exceeded at least of one single channel	0	1	1	1	0	0	1	0	x	x	r/w	3	29
GroupStatus3 – Current trips Set current has been exceeded at least of one single channel	0	1	1	1	1	1	1	0	x	x	r/w	3	30
Channel ON / OFF	0	1/0	1	1	0	0	1	1	x	x	r/w	3	31
Ramp speed	0	1/0	1	1	0	1	0	0	x	x	r/w	3	31

Access	EXT_INSTR	DATA_DIR	DATA_ID Bit								read / write / active	DATA-Bytes	Page
	ID1	ID0	7	6	5	4	3	2	1	0			
Emergency cut-off	0	0	1	1	0	1	0	1	x	x	w	3	31
Log-on Front-end device in superior layer	0	1	1	1	0	1	1	0	x	x	a	3	32
Log-off superior layer at Front-end device	0	0	1	1	0	1	1	0	x	x	w	2	32
Bit rate	0	1/0	1	1	0	1	1	1	x	x	r/w	3	33
Serial number, software release, CAN message configuration and number of channels	0	1/0	1	1	1	0	0	0	x	x	r/w	6/2	33
Set voltage of all channels	0	0	1	1	1	0	0	1	x	x	w	3	34
Set current of all channels	1	0	1	1	1	0	0	1	x	x	w	3	34
Actual hardware current limit	0	1	1	1	1	0	1	0	x	x	r	3	35
Actual hardware voltage limit	1	1	1	1	1	0	1	0	x	x	r	3	35
Set ADC filter frequency	0	1/0	1	1	1	1	0	0	x	x	r/w	3	36
Nominal values	0	1	1	1	1	1	0	1	x	x	r	5	36
Supply voltages and board temperature	1	1	1	1	0	0	0	0	x	x	r	8	37
Threshold to arm error detection	1	1/0	1	1	0	1	1	0	x	x	r/w	3	38
Access (for information only)													
Flash programming (is allowed only by software from iseg Spezialelektronik GmbH)	0	1/0	1	1	1	1	1	1	x	x	r/w a	2/3	-

S_i: Single access
M_i 0 to 15: Channel 0 to 15
G_i: Group access
R_i: reserved

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4.4.5 List to access of the DCP made for 8 channel HV boards (device class 7)

Access	EXT_INSTR	DATA_DIR	DATA_ID Bit								read/write/active	DATA-Bytes	Page
	ID1	ID0	7	6	5	4	3	2	1	0			
No DATA_ID	x	x	0	x	x	x	x	x	x	x			
Single access CHANNEL:	**1/0**	**1/0**	**1**	**0**	**S1**	**S0**	**M3**	**M2**	**M1**	**M0**			
Actual voltage	0	1	1	0	0	0	0	M2	M1	M0	r	4	21
Actual current	0	1	1	0	0	1	0	M2	M1	M0	r	4	22
Nominal values of channel	1	1	1	0	0	1	0	M2	M1	M0	r	5	22
Set voltage	0	1/0	1	0	1	0	0	M2	M1	M0	r/w	4	23
Set current	1	1/0	1	0	1	0	0	M2	M1	M0	r/w	3	24
Status channel	0	1	1	0	1	1	0	M2	M1	M0	r	3	25
Group access module	**1/0**	**1/0**	**1**	**1**	**G3**	**G2**	**G1**	**G0**	**R1**	**R0**			
General status module	0	1/0	1	1	0	0	0	0	x	x	r/w a	1/2 3	27
GroupStatus1 - Voltage limits has been exceeded at least of one single channel	0	1	1	1	0	0	0	1	x	x	r/w	3	29
GroupStatus2 - Hardware current limits has been exceeded at least of one single channel	0	1	1	1	0	0	1	0	x	x	r/w	3	29
GroupStatus3 – Current trips Set current has been exceeded at least of one single channel	0	1	1	1	1	1	1	0	x	x	r/w	3	30
Channel ON / OFF	0	1/0	1	1	0	0	1	1	x	x	r/w	3	31
Ramp speed	0	1/0	1	1	0	1	0	0	x	x	r/w	3	31
Emergency cut-off	0	0	1	1	0	1	0	1	x	x	w	3	31
Log-on Front-end device in superior layer	0	1	1	1	0	1	1	0	x	x	a	3	32
Log-off superior layer at Front-end device	0	0	1	1	0	1	1	0	x	x	w	2	32

Access	EXT_INSTR	DATA_DIR	DATA_ID Bit								read/write/activ	DATA-Bytes	Page
	ID1	ID0	7	6	5	4	3	2	1	0			
Bit rate	0	1/0	1	1	0	1	1	1	x	x	r/w	3	33
Serial number, software release, CAN message configuration and number of channels	0	1/0	1	1	1	0	0	0	0	0	r/w	7/2	33
Set voltage of all channels	0	0	1	1	1	0	0	1	x	x	w	4	34
Set current of all channels	1	0	1	1	1	0	0	1	x	x	w	3	34
Actual hardware current limit	0	1	1	1	1	0	1	0	x	x	r	3	35
Actual hardware voltage limit	1	1	1	1	1	0	1	0	x	x	r	3	35
ADC filter frequency	0	1/0	1	1	1	1	0	0	x	x	r	3	36
Nominal values	0	1	1	1	1	1	0	1	x	x	r	5	36
Supply voltages and board temperature	1	1	1	1	0	0	0	0	x	x	r	8	37
Equipped hardware channels	1	1	1	1	0	0	1	0	x	x	r	3	38
Channels working according control	1	1	1	1	0	0	1	1	x	x	r	3	38
Access (for information only)													
Flash programming (is allowed only by software from iseg Spezialelektronik GmbH)	0	1/0	1	1	1	1	1	1	x	x	r/wa	2/3	-

S_i: Single access
M_i 0 to 15: Channel 0 to 15
G_i: Group access
R_i: reserved

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4.5 Description of data information per DATA_ID in DCP

4.5.1 Single Access

4.5.1.1 Actual voltage (single read-write access) with additional example

device classes 0, 6

DATA_1 to DATA_0 actual voltage, resolution $V_{O\,max}$ / 50000 UI2

Access	EXT_INSTR	DATA_DIR	DATA_ID	DATA_1	DATA_0
master read -	0	1	0x80 + M_x	-	-
HV board write access	0	0	0x80 + M_x	MSB	LSB

M_x Channel 0 ... 15

device classes 1, 2, 7

DATA_2 to DATA_0 actual voltage, resolution $V_{O\,max}$ / 10E6 UI3

Access	EXT_INSTR	DATA_DIR	DATA_ID	DATA_2	DATA_1	DATA_0
master read -	0	1	0x80 + M_x	-	-	-
HV board write access	0	0	0x80 + M_x	MSB		LSB

M_x Channel 0 ... 15

Example: HV module $V_{O\,max}$=2.5kV, SN.471458, read-write access to actual voltage V_{meas} of channel 1

access	identifier	length code	DATA_ID	DATA_1	DATA_0
master read -	0x381	1	0x81	-	-
HV board write access	0x380	3	0x81	0x27	0x10

V_{meas}=0x2710*2.5kV/50000=500V

4.5.1.2 Actual voltage time traced (single read-write access)

device classes 1, 2

DATA_4 to DATA_2 actual voltage, resolution $V_{O\,max}$ / 10E6 UI3

DATA_1 to DATA_0 time trace [ms] between ADC sampling and CAN request UI2

Access	EXT_ INSTR	DATA_ DIR	DATA_ID	DATA_4	DATA_3	DATA_2	DATA_1	DATA_0
master read -	1	1	0xa0 + M_x	-	-	-		-
HV board write access	1	0	0xa0 + M_x	act. voltage MSB		act. voltage LSB	time trace MSB	time trace LSB

M_x Channel 0 ... 8

4.5.1.3 Actual current (single read-write access)

device classes 0, 6

DATA_1 to DATA_0 actual current, resolution $I_{O\ max}$ / 50000 UI2

Access	EXT_INSTR	DATA_DIR	DATA_ID	DATA_1	DATA_0
master read -	0	1	0x90 + M_x	-	-
HV board write access	0	0	0x90 + M_x	MSB	LSB

M_x Channel 0 ... 15

device classes 1, 2, 7

DATA_2 to DATA_0 actual current, resolution $I_{O\ max}$ / 10E6 UI3

Access	EXT_INSTR	DATA_DIR	DATA_ID	DATA_2	DATA_1	DATA_0
master read -	0	1	0x90 + M_x	-	-	-
HV board write access	0	0	0x90 + M_x	MSB		LSB

M_x Channel 0 ... 15

4.5.1.4 Actual current time traced (single read-write access)

device classes 1, 2

DATA_4 to DATA_2 actual voltage, resolution $V_{O\ max}$ / 10E6 UI3

DATA_1 to DATA_0 time trace [ms] between ADC sampling and CAN request UI2

Access	EXT_ INSTR	DATA_ DIR	DATA_ID	DATA_4	DATA_3	DATA_2	DATA_1	DATA_0
master read -	1	1	0xb0 + M_x	-	-	-		-
HV board write access	1	0	0xb0 + M_x	act. current MSB		act. current LSB	time trace MSB	time trace LSB

M_x Channel 0 ... 8

4.5.1.5 Nominal values of the channel (extended single read-write access) DATA_ID=0xF4

device classes 3, 6 and 7

DATA_3 to DATA_0 mantissa UI1, exponent SI1 2 (UI1, SI1)

DATA_3	DATA_2	DATA_1	DATA_0
Mantissa V_{max}	Exponent V_{max}	Mantissa I_{max}	Exponent I_{max}

Example:

DATA_3	DATA_2	DATA_1	DATA_0
0x19	0x02	0x02	0xFC

$V_{O\ max}$=25E02V=2.5kV
$I_{O\ max}$=2E-4A=200µA

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4.5.1.6 Set voltage (single write- / read-write access) with additional example

device classes 0, 6

DATA_1 to DATA_0 set voltage, resolution $V_{O\,max}$ / 50000 UI2

Access	EXT_INSTR	DATA_DIR	DATA_ID	DATA_1	DATA_0
master write access	0	0	0xa0 + M_x	MSB	LSB
master read -	0	1	0xa0 + M_x	-	-
HV board write access	0	0	0xa0 + M_x	MSB	LSB

M_x Channel 0 ... 15

device classes 1, 2, 7

DATA_2 to DATA_0 set voltage, resolution $V_{O\,max}$ / 10E6 UI3

Access	EXT_INSTR	DATA_DIR	DATA_ID	DATA_2	DATA_1	DATA_0
master write access	0	0	0xa0 + M_x	MSB		LSB
master read-	0	1	0xa0 + M_x	-	-	-
HV board write access	0	0	0xa0 + M_x	MSB		LSB

M_x Channel 0 ... 15

If the channel is switched 'ON' then the voltage will be ramped to the set value after the receipt of this access. Otherwise the set value will just be stored and only used for ramping to the set voltage after the channel will be switched 'ON'.

Set voltages higher than the maximum module voltage will be ignored and the bit 'Input error' of the 'Status channel' will be set.

Example: HV module $V_{O\,max}$=0.6kV, serial number 472163, write- and read-write access to set voltage V_{set} channel 3, $V_{set=}$550V

access	identifier	length code	DATA_ID	DATA_2	DATA_1	DATA_0
master write access	0x380	4	0xa3	0x8b	0xdf	0x4b
master read-	0x381	1	0xa3	-		-
HV board write access	0x380	4	0xa3	0x8b	0xdf	0x4b

DATA2..DATA_0[UI3] = 550V/600*10E6 = 0x8bdf4b

4.5.1.7 Set current (extended single write- / read-write access)

device class 6

DATA_1 to DATA_0 set current, resolution IO max / 50000 UI2

Access	EXT_INSTR	DATA_DIR	DATA_ID	DATA_1	DATA_0
master write access	1	0	0xa0 + M_x	MSB	LSB
master read-	1	1	0xa0 + M_x	-	-
HV board write access	1	0	0xa0 + M_x	MSB	LSB

M_x Channel 0 ... 8

device class 7

DATA_1 to DATA_0 set current, resolution IO max / 50000 UI2

Access	EXT_INSTR	DATA_DIR	DATA_ID	DATA_2	DATA_1	DATA_0
master write access	1	0	0xa0 + M_x	MSB		LSB
master read-	1	1	0xa0 + M_x	-		-
HV board write access	1	0	0xa0 + M_x	MSB		LSB

M_x Channel 0 ... 8

If the channel is in ‘ON’ and the output current will exceed the programmed set current checked by the hardware, then following will happen in dependence on the kill enable bit of general status:

killena=0 ⇒ The flag t in ‘Status channel’ and the flag sum in ‘General status module’ will be set. The green LED on front panel will be switched off.

killena=1 ⇒ The flag t in ‘Status channel’ and the flag sum in ‘General status module’ will be set - additional the voltage will be switched off permanently without ramp (Bit o = 0 in ‘Status channel’). The green LED on front panel will be switched off.
The flag t in ‘Status channel’ and sum bit in ‘General status module’ have to be resets by a write of ‘GroupStatus3 - Current trips’ (see GroupStatus3) before the concerning channel can be switched ON with help of the ‘Group access’ ‘Switch ON /OFF’ again.

Function will be switched off with write ‘Current trip = 0’.

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4.5.1.8 Status channel (single read-write access)

all devices

Access	EXT_INSTR	DATA_DIR	DATA_ID	DATA_1	DATA_0
master read-	0	1	0xb0 + M_x	-	-
HV board write access	0	0	0xb0 + M_x	MSB	LSB

M_x Channel 0 ... 15

device classes 0, 1, 2

DATA_1 to DATA_0 bool array UI2

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
v	c	k	e	r	o	i	x	x	x	x	x	x	x	s	t

device class 6

DATA_1 to DATA_0 bool array UI2

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
v	c	x	e	r	o	i	x	x	x	x	x	x	x	s	t

device class 7

DATA_1 to DATA_0 bool array UI2

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
v	c	x	e	r	o	i	x	x	x	x	x	x	x	x	x

current trip t = 0 ⇒ channel is ok
t = 1 ⇒ V_O shut of 0V because software current trip has been exceeded

sum error s = 0 ⇒ channel is ok
s = 1 ⇒ detection of a sum error - consist of an OR between current and voltage limit error in time slots of 1ms

no information

input-error I = 0 ⇒ no input-error
I = 1 ⇒ wrong message to control the module

switch channel to o = 0 ⇒ channel OFF
o = 1 ⇒ channel ON

ramping r = 0 ⇒ voltage is stable
r = 1 ⇒ voltage ramps

emergency cut-off e = 0 ⇒ channel works
e = 1 ⇒ cut-off V_O shut off to 0V without ramp

kill function k = 0 ⇒ disable (see hardware current limit and software current trip)
k = 1 ⇒ enable (see hardware current limit and software current trip)

current limit error c = 0 ⇒ channel is ok
c = 1 ⇒ V_O shut off 0V because hardware current limit has been exceeded

voltage limit error v = 0 ⇒ channel is ok
v = 1 ⇒ V_O shut of permanently because voltage limit has been exceeded

For detection of a current or voltage limit error flag the firmware must evaluate the channel voltage at first.

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4.5.1.9 Set software current trip (extended single write- / read-write access)

device classes 0

DATA_1 to DATA_0 current trip, resolution $I_{O\ max}$ / 50000 UI2

Access	EXT_INSTR	DATA_DIR	DATA_ID	DATA_1	DATA_0
master write access	1	0	0x80 + M_x	MSB	LSB
master read-	1	1	0x80 + M_x	-	-
HV board write access	1	0	0x80 + M_x	MSB	LSB

M_x Channel 0 ... 15

device classes 1, 2

DATA_2 to DATA_0 current trip, resolution $I_{O\ max}$ / 10E6 UI3

Access	EXT_INSTR	DATA_DIR	DATA_ID	DATA_2	DATA_1	DATA_0
master write access	1	0	0x80 + M_x			
master read-	1	1	0x80 + M_x			
HV board write access	1	0	0x80 + M_x	MSB		LSB

M_x Channel 0 ... 15

If the channel is in ‘ON’ and the measured output current will exceed the programmed current trip, then following will happen in dependence on the kill enable bit of status channel:

k=0 ⇒ The flag t in ‘Status channel’ and the flag sum in ‘General status module’ will be set. The green LED on front panel will be switched off.

k=1 ⇒ The flag t in ‘Status channel’ and the flag in ‘General status module’ will be set - additional the voltage will be switched off permanently without ramp (Bit o = 0 in ‘Status channel’). The green LED on front panel will be switched off.
The t bit in ‘Status channel’ and sum bit in ‘General status module’ have to be resets by a write of ‘GroupStatus3 - Current trip’ (see GroupStatus3) before the concerning channel can be switched ON with help of the ‘Group access’ ‘Switch ON /OFF’ again.

Function will be switched off with write ‘Current trip = 0’.

4.5.2 Group access

4.5.2.1 General status (group write- / read-write / active access)

all devices

Access	EXT_INSTR	DATA_DIR	DATA_ID	DATA_0
master read-	0	1	0xc0	-
HV board write access	0	0	0xc0	MSB LSB

DATA_0 bool array (read-write access) UI1

b7	b6	b5	b4	b3	b2	b1	b0
save	killena / HwVL2Low	vsup	avad	stbl	sloop	nramp	sum

sum error flag	sum = 0	voltage limit, current limit or trip has been exceeded in at least one of the channels (error)
	sum = 1	status channel flags v & c & t = 0 for all channels (no errors)
ramping flag	nramp = 0	V_O is ramping in at least one channel
	nramp = 1	no channel is ramping
safety loop flag	sloop = 0	safety loop is broken -V_O bas been shut off, reset by a write of the ‘General status’ with sloop flag is set to “1”
	sloop = 1	safety loop is closed
stable	stbl = 0	all channels are stable with programmable ADC filter frequency f_N. (ADC conversion time =1/f_N, see ‘Set ADC filter frequency‘, default f_N=50 Hz)
	stbl = 1	at least one channel is ramping Vo or not yet stable after ramping (ramping - with ADC filter frequency f_N=100 Hz)
average adjust	avad = 0	fine adjustment OFF for *device classes 0, 6 and 7* average of voltage and current measurement OFF for *device classes 1, 2 and 7*
	avad = 1	fine adjustment ON for *device classes 0, 6 and 7* average of voltage and current measurement ON for *device classes 1, 2 and 7*
supply voltages	vsup = 0	supply voltages are out of range or module temperature > 55°C
	vsup = 1	supply voltages are in range and module temperature <=55°C

for device classes 6 and 7 only

kill enable	killena = 0	kill function disable
	killena = 1	kill function enable

for device classes 0 only

HW Vlimit to low	HwVLToLow = 0	HW Vlimit voltage limit is to low, it is not possible to switch on the HV, reset by write with HwVLToLow flag is set to “1”
	HwVLToLow = 1	HW Vlimit in proper range
save set values	save=0	no write access to EEPROM
	save=1	store all set values to EEPROM (time to save ca. 10s)

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all devices

Access	EXT_INSTR	DATA_DIR	DATA_ID	DATA_0
master write access	0	0	0xc0	MSB LSB

DATA_0 bool array (write access) UI1

b7	b6	b5	b4	b3	b2	b1	b0
save	killena / HwVL2Low	x	avad	x	sloop	x	x

x no information

If a safety loop error occurs or the HW V_{limit} is too low the write access in order to cancel the corresponding bit has to be set to “1”. (see read-write access of “General status” also)

The module has been configured as a CAN-node with an Active-CAN message function (see **Group access: Serial number, software release and CAN message configuration**). If one of the bits - sum status, supply voltages or safety loop - in the group access “General status module” has not been set, the module will send this group access as an active error message with higher priority (ID9=0).

all devices

Access	EXT_INSTR	DATA_DIR	DATA_ID	DATA_1	DATA_0
HV board active access	0	0	0xc0	MSB	LSB

DATA_1 to DATA_0 bool array (active access) UI2

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
x	killena / HwVL2Low	vsup	avad	fN	sloop	ramp	sum	x	temp	x	x	VErr	CLimit	SErr	trip

The 2nd data byte offers more information about the sum error flag of the first byte.

trip software current trip in at least one of the channels

S_{Err} regulation error in at least one of the channels

C_{Limit} hardware current limit in at least one of the channels

V_{Err} voltage error in at least one of the channels

temp module temperature > 55°C, HV has been switched off

For bits b8 to b15 see description of general status.

Example of an active error message

access	identifier	length code	DATA_ID	DATA_1	DATA_0
HV board active access	0x180	3	0xc0	0x57	0x01

identifier comes with high priority, sum error flag in DATA_1 = 0 with precision by the trip bit in DATA_0 ⇒ superior layer should start a write-read access of software current trip group status 3

4.5.2.2 GroupStatus1 - Voltage limits (group write- / read-write access)

DATA_ID=0xC4

all devices

DATA_1 to DATA_0 bool array UI2

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Ch15	Ch14	Ch13	Ch12	Ch11	Ch10	Ch9	Ch8	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0

Ch_m=0 Channel ok

Ch_m=1 Voltage limit was exceeded of the corresponding Channel

Device class 7: The voltage will be limited only and the green LED on front panel is off.

All other devices: If an external over voltage occurs at the channel output (i.e. Output voltage > Set voltage) then the channel will be switched off and the according bit will be set. The error bits will be cancelled and the voltage of the corresponding channel can be switched on again only after writing 'GroupStatus1' with the bits, which are corresponding to the channel errors are set to "1".
(see Threshold to arm the errors detection)

4.5.2.3 GroupStatus2 - Hardware current limits (group write- / read-write access)

DATA_ID=0xc8

all devices

DATA_1 to DATA_0 bool array UI2

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Ch15	Ch14	Ch13	Ch12	Ch11	Ch10	Ch9	Ch8	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0

Ch_m=0 Channel ok

Ch_m=1 Voltage limit was exceeded of the corresponding Channel

The module responds to the exceeding of the hardware current limit which has been set in the channel in dependence on the according KILL-enable bit (see also Group access 'KILL-enable') as follows:

KILL-enable = 1: Voltage will be switched off permanently without ramp, green LED on front panel is off until a write of 'GroupStatus2' with the bits, which are corresponding to the channel errors set to "1". The error bits will be cancelled and the voltage of the corresponding channels can be switched on again.

KILL-enable = 0:

Device classes 0, 1 and 2: The Voltage will be switched off without ramp, green LED on front panel is off. If the output voltage arrives at 0 V the ramping to set voltage will be started automatically again. The green LED again flash only after writing the 'GroupStatus2' with the respective bits.

Device class 6 and 7: The voltage will be not switched off, green LED on front panel is off. The output current will be limited. The green LED flashes only after writing of 'GroupStatus2' with the respective bits and removing of the limitation of current before.

(see Threshold to arm the errors detection)

4.5.2.4 GroupStatus3 - Current trips (group write- / read-write access)

DATA_ID=0xF8

devices classes 0, 1 and 2 Software current trip

device classes 6 and 7 software controlled hardware current trip

DATA_1 to DATA_0 bool array UI2

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Ch15	Ch14	Ch13	Ch12	Ch11	Ch10	Ch9	Ch8	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0

$Ch_m=0$ Channel ok

$Ch_m=1$ Channel tripped

If the output current exceeds the programmed current trip value then the corresponding bits will be set.

KILL-enable = 1: Voltage will be switched off permanently without ramp, green LED on front panel is off until a write of ‘GroupStatus3’ with the bits, which are corresponding to the channel errors are set to “1”. The error bits will be cancelled and the voltage of the corresponding channels can be switched on again.

KILL-enable = 0:

Device classes 0, 1, 2, 3 and 6: The Voltage will be not switched off, green LED on front panel is off. The green LED again flash only after writing of ‘GroupStatus3’ with the respective bits and removing of the cause of current trip before.

Device class 7: The current will be limited only and the green LED on front panel is off. The green LED flashes only after writing of ‘GroupStatus3’ with the respective bits and removing of the limitation of current before.

A programmed current limit with value zero has no effect to the current flow.

After a write access which will cancel all error flags makes following:

clear bit t in ‘Status channel’, set sum error flag in ‘General status’ and reset the setting bits in

DATA_1 - DATA_0 of ‘GroupStatus3’

4.5.2.5 GroupStatus4 - Fast regulation error (extended group write- / read-write access)

DATA_ID=0xE0

device classes 0, 1, 2

DATA_1 to DATA_0 bool array UI2

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Ch15	Ch14	Ch13	Ch12	Ch11	Ch10	Ch9	Ch8	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0

$Ch_m=0$ Channel ok

$Ch_m=1$ Channel signaled an error in regulation

Voltage will be switched off permanently without ramp, green LED on front panel is off until a write of ‘GroupStatus4’ with the bits, which are corresponding to the channel errors are set to “1”. The error bits will be canceled and the voltage of the corresponding channels can be switched on again.

4.5.2.6 Channels ON / OFF (group write- / read-write access)

DATA_ID=0xCC

all devices

DATA_1 to DATA_0 bool array UI2

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Ch15	Ch14	Ch13	Ch12	Ch11	Ch10	Ch9	Ch8	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0

Ch_m = 1 Channel ON

Chm = 0 Channel OFF

4.5.2.7 Ramp speed (group write- / read-write access)

DATA_ID=0xD0

devices classes 0, 6 and 1, 2, 7

DATA_1 to DATA_0 ramp speed resolution is $V_{O\ max}$ / 50000s UI2

DATA_1	DATA_0
MSB	LSB

device classes 1, 2, 7

DATA_2 to DATA_0 ramp speed resolution is $V_{O\ max}$ / 10E6s UI3

DATA_2	DATA_1	DATA_0
MSB		LSB

device classes 0 and 6: Ramp speed range: $V_{O\ max}$ / 12500s ≤ Ramp speed ≤ $V_{O\ max}$ / 10s

device classes 1, 2, 3 and 7: Ramp speed range: $V_{O\ max}$ / 2500s ≤ Ramp speed ≤ $V_{O\ max}$ / 10s

Ramp speed higher than the maximum module specific ramp speed will be ignored and the bit ‘Input error’ in the ‘Status channel’ will be set.

4.5.2.8 Emergency cut-off (group write access)

DATA_ID=0xD4

all devices

DATA_1 to DATA_0 bool array UI2

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Ch15	Ch14	Ch13	Ch12	Ch11	Ch10	Ch9	Ch8	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0

Ch_m = 1 Channel cut-off without ramp, set voltage of the corresponding channel is setting to zero

Ch_m = 0 Channel will not be changed in any way

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4.5.2.9 Log-on Front-end device at superior layer (group active access)

After POWER ON the Front-end device - up to a number of two per module - will give this group access cyclically on the bus (ca. 1 sec). If a controller of superior layer identifies this access then it is able to register this as a Front-end device and is able to address it with FE_ADR. (see also description 11bit-Identifier)

DATA_ID=0xD8

all devices

DATA_1 equal to DATA_0 of general status

DATA_0 information of device class of module

DATA_1	DATA_0
see general status	device class

471xxx	device class = 0	16 channel >1kV standard (resolution 50000)
472xxx	device class = 1	8 channel <=1kV standard (resolution 10E6)
472xxx	device class = 2	8 channel <=1kV high precision (resolution 10E6)
472xxx	device class = 3	8 channel <=1kV standard (resolution 10E6), mix
473xxx	device class = 6	8 channel >1kV standard (resolution 50000)
474xxx	device class = 7	8 channel >1kV standard (resolution 10E6), floating

4.5.2.10 Log-on/off superior layer at Front-end device (group write access)

After the successful registration the Front-end device will not send further ‘Log-on” accesses as long as:

- it receives accesses from the external CAN Bus in periods shorter than one minute or
- until the superior controller will send a ‘Log-off” access to the Front-end device.

DATA_ID=0xD8

all devices

DATA_0=1 superior layer send “Log-on” at Front-end device to registration

DATA_0=0 superior layer send “Log-off” to Front-end device

4.5.2.11 Bit rate (group write- / read-write access)

DATA_ID=0xDC

all devices

DATA_1 to DATA_0 20, 50, 100, 125, 250 kbit/s UI2

DATA_1	DATA_0
MSB	LSB

(500 and 1000 kbit/s on request)

The new bit rate gets active after RESET or POWER OFF/ON. The bit rate of all modules in the system must be the same before a RESET or POWER/ON is made.

- The bit rate prefixed at factory is signed on a sticker of the 96 pin connector.
- Invalid bit rates will be ignored and the bit 'Input error' of the 'Status channel 0' will be set.
- A correct write access stores the information permanently if there was sent a NMT stop before.

4.5.2.12 Serial number, software release and CAN message configuration (group write / read-write access)

DATA_ID=0xE0

device classes 0

DATA_4 to DATA_0 read-write access 10 BCD

DATA_4		DATA_3		DATA_2		DATA_1		DATA_0	
BCD8	BCD7	BCD6	BCD5	BCD4	BCD3	p/a	BCD2	BCD1	BCD0

BCD8 to BCD3 serial number in 6 BCD e.g. '471212'

p/a passive or active error mode (see active group access general status)

2 passive error mode

4 active error mode

BCD2 to BCD0 firmware release 3 BCD e.g. 310 for '3.10'

all other device classes

DATA_5 to DATA_0 read-write access 11 BCD

DATA_5		DATA_4		DATA_3		DATA_2		DATA_1		DATA_0	
BCD9	BCD8	BCD7	BCD6	BCD5	BCD4	p/a	BCD3	BCD3	BCD1	-	BCD0

BCD9 to BCD4 serial number in 6 BCD e.g. '472112'

p/a passive or active error mode (see active group access general status)

2 passive error mode

4 active error mode

BCD3 to BCD1 firmware release 3 BCD e.g. 310 for '3.10'

BCD0 number of channels

all devices

DATA_0 write access to change the CAN message configuration BCD

DATA_0
p/a

A correct write access is storing the information permanently if it were sent a NMT stop before.

p/a = 2 passive CAN

p/a = 4 active CAN

4.5.2.13 Set voltage of all channels (group write access)

DATA_ID=0xE4

device classes 0 and 6

DATA_1 to DATA_0 set voltage, resolution $V_{O\ max}$ / 50000 UI2

DATA_1	DATA_0
MSB	LSB

device classes 1, 2, 7

DATA_2 to DATA_0 set voltage, resolution $V_{O\ max}$ / 10E6 UI3

DATA_2	DATA_1	DATA_0
MSB		LSB

(see also Set voltage single access)

4.5.2.14 Set current (– trip) of all channels (extended group write access)

DATA_ID=0xE4

device class 0 *software current trip*

device class 6 *software controlled hardware current trip*

DATA_1 to DATA_0 current, resolution $I_{O\ max}$ / 50000 UI2

DATA_1	DATA_0
MSB	LSB

device class 1, 2 *software current trip*

DATA_1 to DATA_0 current, resolution $I_{O\ max}$ / 10E6 UI3

DATA_1	DATA_1	DATA_0
MSB		LSB

device class 7 *hardware current limit*

DATA_1 to DATA_0 current, resolution $I_{O\ max}$ / 10E6 UI3

DATA_1	DATA_1	DATA_0
MSB		LSB

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4.5.2.15 Actual hardware current limit – OPTION (group read-write access)

DATA_ID=0xe8

device classes 0, 6

DATA_1 to DATA_0 actual hardware current limit I_{max}, resolution $I_{O\ max}$ / 50000 UI2

DATA_1	DATA_0
MSB	LSB

device classes 1, 2, 7

DATA_2 to DATA_0 actual hardware current limit I_{max}, resolution $I_{O\ max}$ / 10E6 UI3

DATA_2	DATA_1	DATA_0
MSB		LSB

It is forbidden to change the limit via potentiometer if not all channels are in state HV Off and not all set current values are equal to 0.

Modules without this OPTION deliver $I_{O\ max}$.

The module responds after the hardware current limit has been exceeded:

KILL-enable = 1: Voltage will be switched off permanently without ramp, green LED on front panel is off.

KILL-enable = 0: Voltage will be switched off without ramp, green LED on front panel is off. If the output voltage arrives at 0 V the ramping to set voltage will be started automatically again.

4.5.2.16 Actual hardware voltage limit – OPTION (extended group read-write access)

DATA_ID=0xE8

device classes 0, 6

DATA_1 to DATA_0 actual hardware voltage limit $\mathbf{V_{max}}$, resolution $V_{O\ max}$ / 50000 UI2

DATA_1	DATA_0
MSB	LSB

device classes 1, 2, 7

DATA_2 to DATA_0 actual hardware voltage limit $\mathbf{V}_{max}$, resolution $V_{O\ max}$ / 10E6 UI3

DATA_2	DATA_1	DATA_0
MSB		LSB

It is forbidden to change the limit via potentiometer if not all channels are in state HV Off and not all set voltage values are equal to 0.

Modules without this OPTION deliver $V_{O\ max}$.
The exceeding of the hardware voltage limit results in a limitation of the voltage.

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4.5.2.17 Kill enable (group write- / read write access)

DATA_ID=0xEC

device classes 0, 1, 2

DATA_1 to DATA_0 bool array UI2

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Ch15	Ch14	Ch13	Ch12	Ch11	Ch10	Ch9	Ch8	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0

Ch_m = 1 KILL - enable: V_O shuts off permanently if hardware or software current limit was exceeded

Ch_m = 0 KILL-disable: V_O shuts off if current limit was exceeded and then V_O is ramping from 0 V to V_{SET} again

V_O shuts not off if software current limit was exceeded

4.5.2.18 Set ADC filter frequency (group write / read-write access)

DATA_ID=0XF0

all devices

DATA_1 to DATA_0 UI2

DATA_1	DATA_0
MSB	LSB

Device class 0 and 6:
DATA_1 to DATA_0 = 19200 / ADC filter frequency f_N [Hz] 5 Hz $\leq f_N \leq$ 100 Hz
(invalid f_N will be ignored and the bit ‘Input-error’ in ‘Status channel’ is set).

Device class 1 and 2:
DATA_1 to DATA_0 = 2457600/512 / ADC filter frequency f_N [Hz] 5 Hz $\leq f_N \leq$ 100 Hz
(invalid f_N will be ignored and the bit ‘Input-error’ in ‘Status channel 0’ is set).

Device class 7 (read only):
DATA_1 to DATA_0 = samples per second

Further measurements are made with this filter frequency if all channels arrived at V_{set} and are in stable state (see group access general status). If V_O is ramping in at least one channel then f_N=100Hz

Factory setting: f_N = 50 Hz

4.5.2.19 Nominal values (group read-write access)

DATA_ID=0xF4

all devices

DATA_3 to DATA_0 mantissa UI1, exponent SI1 2 (UI1, SI1)

DATA_3	DATA_2	DATA_1	DATA_0
Mantissa V_{max}	Exponent V_{max}	Mantissa I_{max}	Exponent I_{max}

Example:

DATA_3	DATA_2	DATA_1	DATA_0
0x19	0x02	0x02	0xFC

$V_{O\ max}$=25E02V=2.5kV
$I_{O\ max}$=2E-4A=200µA

4.5.2.20 Supply voltages and board temperature (extended group read-write access)

DATA_ID=0xC0

all devices

DATA_6 to DATA_0 5 UI1, 1 UI2

DATA_6	DATA_5	DATA_4	DATA_3	DATA_2	DATA_1	DATA_0
Vp24	Vp15	Vp5	Vn15 / 0	Vn5 / 0	TempH	TempL

Vp24 external supply voltage +24V (resolution 100mV)

Vp15 internal supply voltage +15V (resolution 100mV)

Vp5 external supply voltage +5V (resolution 100mV)

Vn15 internal supply voltage -15V (resolution 100mV) *not at device classes 1, 2, 7 (value is 0x00)*

Vn5 internal supply voltage -5V (resolution 100mV) *not at device classes 1, 2, 7 (value is 0x00)*

TempH to TempL board temperature (resolution 0,1K)

An ‘out of range error’ (see group access: General status) will be generated if deviation of voltage is more than ± 5%.

4.5.2.21 Discharge relay configuration – OPTION (extended group write- /read-write access)

The relay contacts will discharge capacities connected to the output with help of an integrated load resistor (see Appendix B). The group access “Discharge relay configuration” configures the conditions of how this does work.
A correct write access stores the information permanently.

DATA_ID=0xD4

device class 0, 1, 2

DATA_0 bool array UI1

b7	b6	b5	b4	b3	b2	b1	b0
x		CACO	CRErr	CSLoop	CTrip	CVErr	CILimit

CILimit discharge if the hardware current limit was exceeded at least one channel

CVErr discharge if the hardware voltage limit was exceeded at least one channel

CTrip discharge if the software current trip was exceeded at least one channel

CSLoop discharge if the safety loop was active

CRErr discharge if the regulation was out of order at least one channel of (reaction >= 1ms)

CACO discharge if all channels set to “OFF”(Group access module “Channel ON/OFF” or “Emergency cut-off”)

Under the setting of one of these conditions and the corresponding error occurs following will happen:

- shut off the HV without ramp in all channels and the set voltage in all channels to 0V by software.
- close contact of discharge relay.

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4.5.2.22 Threshold to arm the errors detection (extended group write / read- write access)

DATA_ID=0xD8

device class 0, 6

DATA_1 to DATA_0 voltage threshold, resolution $V_{O\ max}$ / 50000 UI2

DATA_1	DATA_0
MSB	LSB

Factory setting is $V_{O\ maxl}$ / 10 (e.g. $V_{O\ max}$ = 2.5kV ⇒ Error threshold=250V)

devices classes 1, 2, 7

DATA_2 to DATA_0 voltage threshold, resolution $V_{O\ max}$ / 10E6 UI3

DATA_2	DATA_1	DATA_0
MSB		LSB

Factory setting is $V_{O\ max}$ / 25.

The arming of the error detection is started while the actual voltage exceeds these value which has been stored before.

Exception: At the start of a ramp from zero the firmware evaluates that the feedback control will look in. If not, because the channel has a short or the hardware current limit is near to zero, than the channel will be switched off and a current error will be generated before the actual voltage exceeds these threshold.

4.5.2.23 Equipped hardware channels (extended read-write access)

DATA_ID=0xC8

device classes 1, 2, 7

DATA_1 to DATA_0 bool array UI2

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Ch15	Ch14	Ch13	Ch12	Ch11	Ch10	Ch9	Ch8	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0

Ch_m = 1 channel in placed on HV board

Ch_m = 0 channel is not placed on HV board

4.5.2.24 Channels working according control (extended group read- write access)

DATA_ID=0xCC

device classes 1, 2, 7

DATA_1 to DATA_0 bool array UI2

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Ch15	Ch14	Ch13	Ch12	Ch11	Ch10	Ch9	Ch8	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0

Ch_m = 1 channel is working according to internal control (i.e. channel works properly)

Ch_m = 0 channel doesn't work according to internal control (i.e. channel is defect)

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Appendix A – Shortcuts

BCD	binary coded decimal format
CAN	controller area network
Ch_m	channel m=0..15
DCP	device control protocol
DATA_ID	data identifier of DCP
f_N	first filter notch frequency
HV	High voltage
HW	hardware
I_{meas}	Actual current
I_{max}	Hardware current limit
$I_{O\ max}$	Nominal current
I_{set}	Set current
I_{trip}	Trip current
ISO	International Standard Organization
LSB	least significant bit
MSB	most significant bit
NMT	network management service
OSI	Open System Interconnect
PCB	printed circuit board
p/a	passive / active
SN.	serial number
UI1	unsigned character
SI1	signed character
UI2	unsigned short integer (16 bit)
UI3	unsigned integer (24 bit)
V_{meas}	Actual voltage
V_{max}	Hardware voltage limit
$V_{O\ max}$	Nominal voltage
V_{set}	Set voltage
SW	software

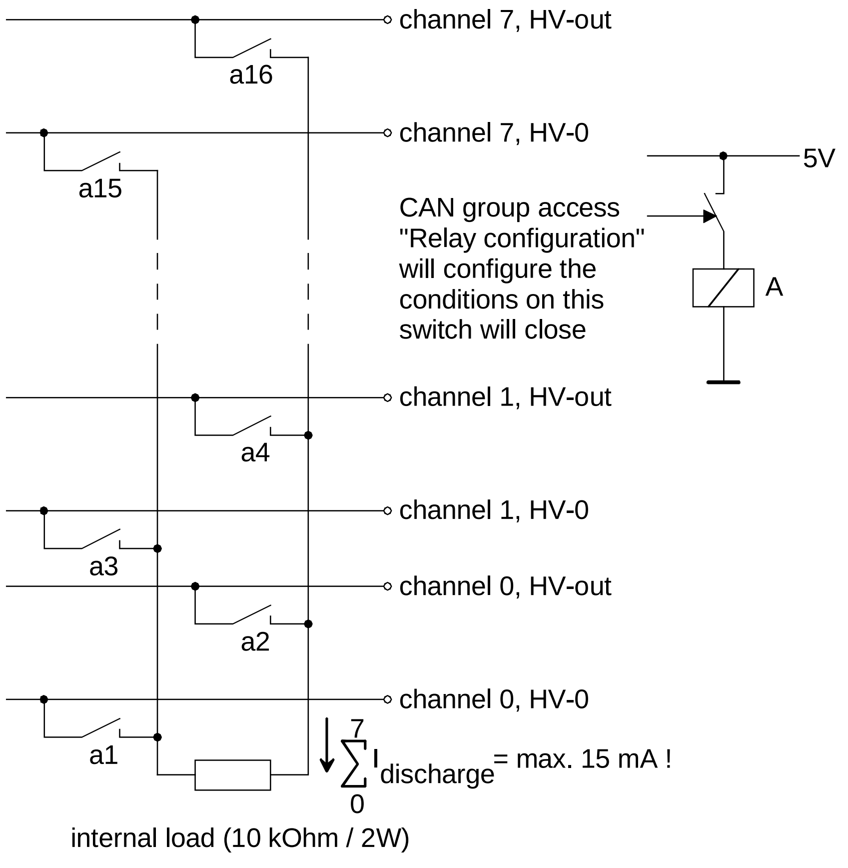
Appendix B – OPTION relay

Note! If one of the contacts must close

- all channels will discharge at the same time,
- HV-GND and HV-out will interlink of all channels and
- the floating HV-GND will cancelled for each channel.

The max. discharge current (sum for all channels) is 15 mA ! Please limit the discharge current with external resistors in series from HV-out $_{0\ to\ 7}$ to the capacity load!

Schematic of discharge a capacity load



Note! No external resistors are needed in series from HV-out to the capacity load for 0 V ≤ HV-out 0 to 7 ≤ 150 V but for different voltages HV-out 0 , HV-out 1 ... to HV-out 7 you must apply an external resistor of min. 2 kΩ in series from HV-out 0 to 7 to the capacity load!

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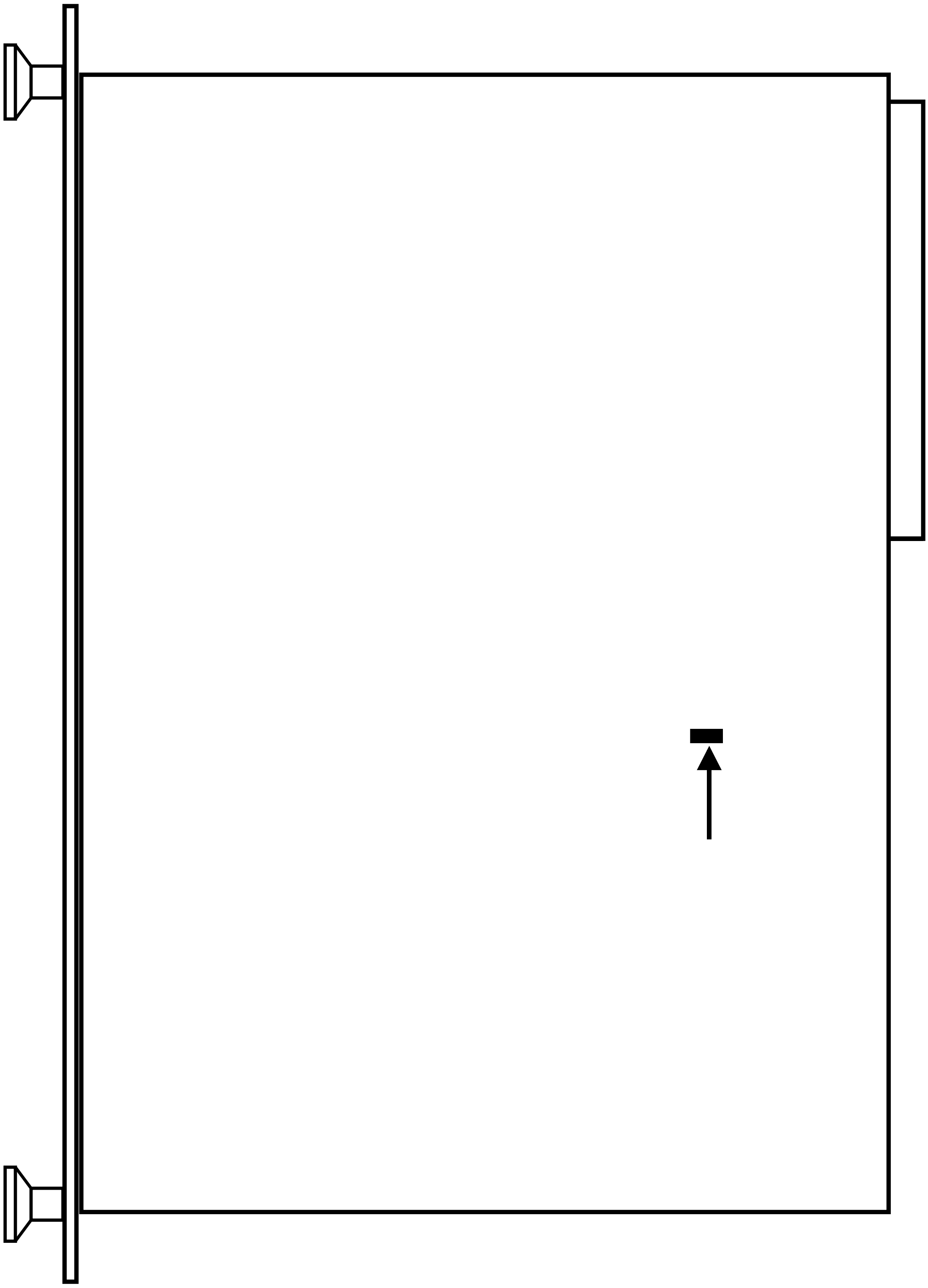
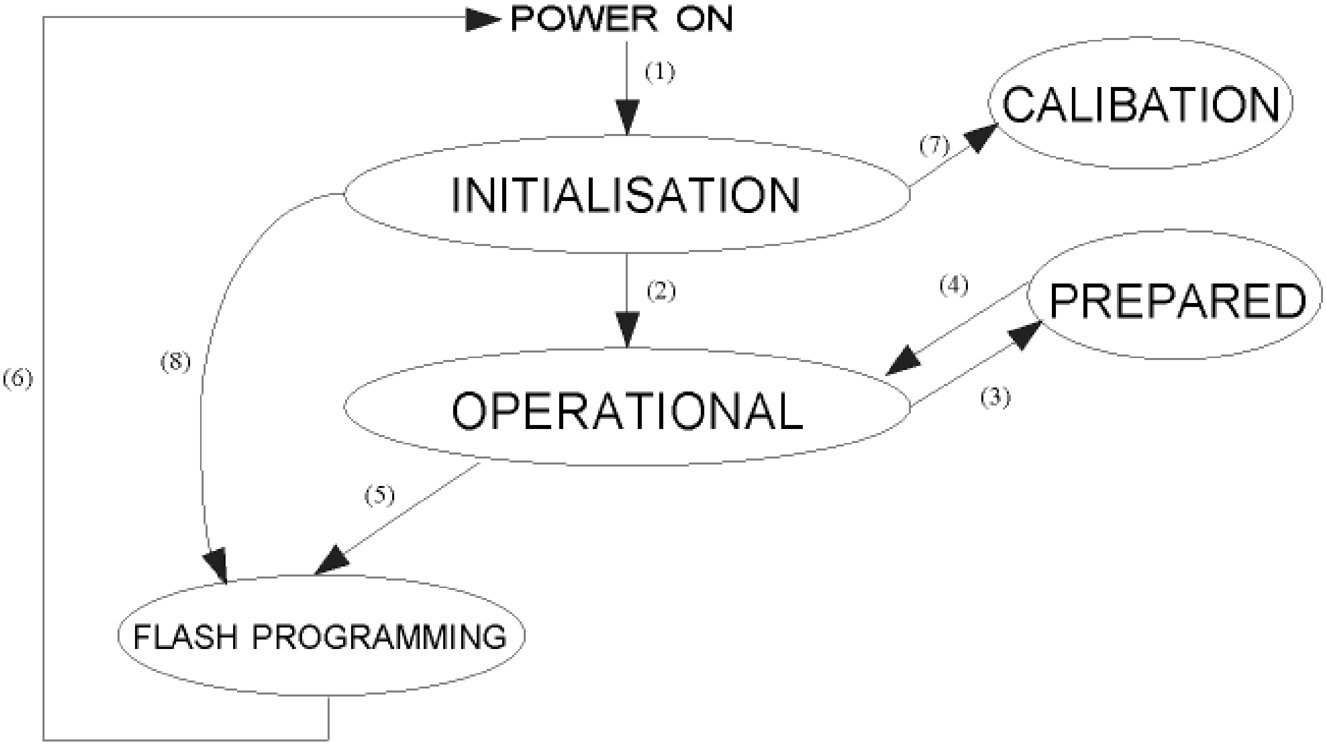
Appendix C – Side view



Desk open, jumper for safety-loop

Appendix D – Diagram of operating modes



(1) The INITIALIZATION follows after the POWER ON reset of the device hardware:
device classes 0, 6 ca. 2 seconds
device classes 1, 2 ca. 8 seconds
device class 7 ca. 7 seconds

(2) The state OPERATIONAL will be obtained by the device itself if all initializations are ready or the state PREPARED runs in time out.

(3) NMT Stop switches the devices of the CAN segment into the state PREPARED. In this state the permanent settings of the devices can be changed (per device *Bit rate, Set voltage, Set current, Ramp speed, General status, Threshold to arm the errors detection, Discharge relay configuration, CAN message configuration* and additional the *Bit rate* as a broadcast massage).

(4) NMT Start takes the devices of the CAN segment back to the OPERATIONAL state.

(5) With the special *Flash programming* access the device runs into the state FLASH PROGRAMMING. The high voltage will be switched off automatically before.

(6) The device will execute a POWER ON reset itself at the end of FLASH PROGRAMMING.

(7) The state CALIBRATION will be obtained by setting of the corresponding switches at the Calibration Crate.

(8) The state FLASH Programming will be obtained also if the corresponding switch at the Calibration Crate / Flash Programming Slot are set.

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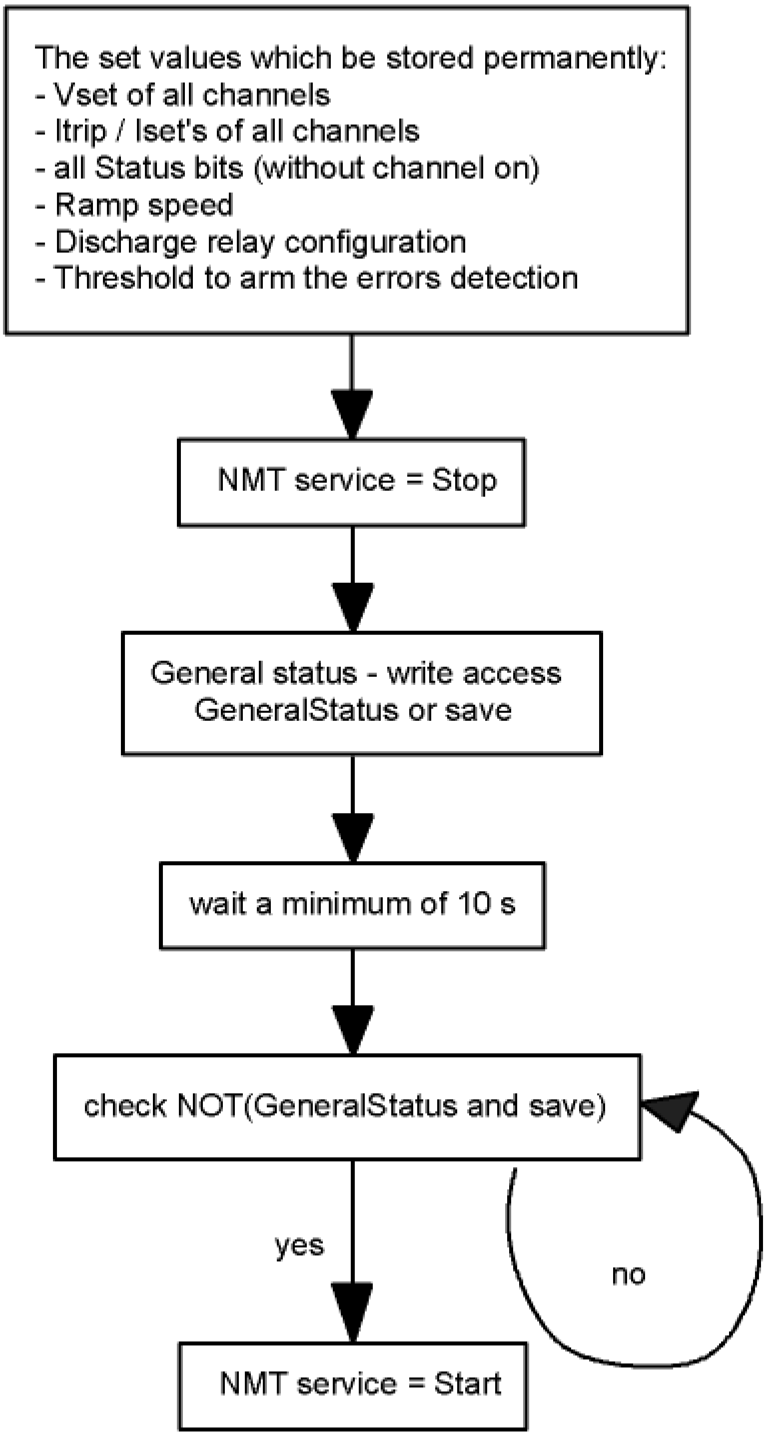
Appendix E – Programming flowchart to store the settings permanently with help of General state save bit



Appendix F – Programming flowchart to store the configurations of the module permanently with help of General state save bit