Operators Manual

Multi-Channel CAN I/O

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 CIOF8m0_24 / CIOF8m0_12 is a Multi Channel CAN-I/O in 3U Euro card format with:

16 DAC´s (16-bit, V_{OUT-X}= 0 to 5 V) and

8 ADC´s (16-bit, V_{IN-X}= 0 to 5 V)

The CIOFFm0_24 / CIOFFm0_12 is a Multi Channel CAN-I/O in 3U Euro card format with:

16 DAC´s (16-bit, V_{OUT-X}= 0 to 5 V) and

16 ADC´s (16-bit, V_{IN-X}= 0 to 5 V)

The CIO20Fm0_24 / CIO20Fm0_12 is a Multi Channel CAN-I/O in 3U Euro card format with:

32 DAC´s (16-bit, V_{OUT-X}= 0 to 5 V) and

16 ADC´s (16-bit, V_{IN-X}= 0 to 5 V)

The CIO devises are made ready for mounting into a powered system crate ECH 128_CAN or ECH 12A_CAN (19“/3U rack). The unit is software controlled via CAN-Interface through a PC or similar controller.

2 Notes on Safety

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

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

The NMT-service identifier is reserved to configure of these CIO devices only. The use of the NMT-service identifier 0x004 should be with the program “canHVcontrol” only and only for CIO devices in your CAN-system.

The permanent storage of a write access exist 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 **Ready**

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

If there is an Error such as: power supplies are not in tolerance

exceed the threshold of I_{trip} (see description below)

the LED will be switched off until the error has been corrected and the corresponding status bit has been erased via interface.

3.2 Back panel

The supply voltages and the CAN interface is 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	Data	PIN	Data	PIN	Data	Remarks
a1	+5V	b1	+5V	c1	+5V	
a2	GND	b2	GND	c2	GND	
a3	+24V/+12V	b3	+24V/+12V	c3	+24V/+12V	CIO20(F)Fm0_**24**: +24V or xxx_**12**: +12V
a4	SET-V_Ch0	b4	SET-V_Ch1	c4	**IC**	Don´t connect "**IC**" !
a5	GND	b5	GND	c5	GND	SET-V_Chx with x = 0 to 7:
a6	SET-V_Ch2	b6	SET-V_Ch3	c6	SET-V_Ch4	Analog output voltage 0 to 5V / max. 2mA
a7	SET-V_Ch5	b7	SET-V_Ch6	c7	SET-V_Ch7	See command "Set voltage" (4.5.1.3.)
a8	SET-I_Ch8	b8	SET-I_Ch9	c8	**IC**	SET-I_Chx with x = 8 to 15:
a9	SET-I_Ch10	b9	SET-I_Ch11	c9	SET-I_Ch12	Analog output voltage 0 to 5V / max. 2mA
a10	SET-I_Ch13	b10	SET-I_Ch14	c10	SET-I_Ch15	See command "Set current" (4.5.1.3.)
a11	CAN_GND	a11	CANL	a11	CANH	CANbus connection, potential free
a12	**IC**	b12	GND	c12	ACT-V_Ch0	/INT interrupt non-maskable: LOW = active
a13	/RESET	b13	/INT	c13	**IC**	/RESET signal: LOW = active
a14	ACT-V_Ch1	b14	GND	c14	**IC**	ACT-V_Chx with x = 0 to 15:
a15	ACT-V_Ch2	b15	**IC**	c15	ACT-V_Ch3	Analog input voltage 0 to 5V
a16	ACT-V_Ch4	b16	**IC**	c16	**IC**	See command "Actual voltage" (4.5.1.1.)
a17	ACT-V_Ch5	b17	ACT-V_Ch6	c17	ACT-V_Ch7	
a18	ACT-I_Ch0	b18	ACT-I_Ch1	c18	ACT-I_Ch2	ACT-I_Chx with x = 0 to 15:
a19	ACT-I_Ch3	b19	**IC**	c19	GND	Analog input voltage 0 to 5V
a20	ACT-I_Ch4	b20	ACT-I_Ch5	c20	GND	See command "Actual current" (4.5.1.2.)
a21	ACT-I_Ch6	b21	ACT-I_Ch7	c21	ACT-V_Ch8	

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PIN	Data	PIN	Data	PIN	Data	Remarks
a22	ACT-V_Ch9	b22	ACT-V_Ch10	c22	ACT-V_Ch11	
a23	ACT-V_Ch12	b23	ACT-V_Ch13	c23	ACT-V_Ch14	
a24	ACT-V_Ch15	b24	ACT-I_Ch8	c24	ACT-I_Ch9	
a25	DB0	b25	DB1	c25	ACT-I_Ch10	DB0 to DB7: digital output signals
a26	DB2	b26	DB3	c26	ACT-I_Ch11	
a27	DB4	b27	DB5	c27	ACT-I_Ch12	
a28	DB6	b28	DB7	c28	ACT-I_Ch13	With the address field a30/b30 ..... a32/b32
a29	**IC**	b29	**IC**	c29	ACT-I_Ch14	the module address will be coded
a30	A4	b30	A5	c30	ACT-I_Ch15	(see item 3.2, description 11bit-Identifier).
a31	A2	b31	A3	c31	GND	Connected to GND ⇒ A(n) = 0 ;
a32	A0	b32	A1	c32	GND	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 characterised 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 by means of the symbol **S** and the corresponding channel multiplex information by means of the symbol M or if it is a group access by means 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 2.0B-passive, 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 will be described as follows.

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 frames according to the specific demands 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 with 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 which have no Active-CAN message function.

is recessive for module which 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-bit 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.

ID3 to ID8 allow the addressing of 64 Front-end devices (ID3: A0 = 2^0 ;...; ID8: A5 = 2^5),

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

ID1 is used for an extended instruction set.

ID 0 is used for 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 with DATA_DIR = 0. The Front-end device responds to the data request by sending the corresponding data with DATA_DIR = 0.

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). Therefore it follows that all “even” CAN-ports (Identifier) are interpreted as ‘Write ports’ all “odd” CAN ports as ‘ Read ports’.

In one CAN segment only modules are allowed with unequal identifier and equal bit rate. The factory fixed bit rate is written on the sticker of the 96-pin connector.
While at work without the NMT-service 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 b10 b0	R T R	0 0 Reserve	DLC (n=1-8) b3 b0	n – data bytes DATA_ID b7 =1 b0	 DATA_(n-2)≥ 0 b7 b0	 DATA_(n-3)≥ 0 b7 b0	 DATA_ ... b7 b0	CRC 15 bit	ack F.

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 device.
- 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 or supply voltages - 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	RTR	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	x	**0**	x	x	x	x	x	x	x			
NMT service CAN segment:	**0/1**	**0**	**0**	**1**	**1**	**N3**	**N2**	**N1**	**N0**	**R1**	**R0**			
NMT Address	0/1	0	0	1	1	0	0	0	0	x	x	w	0/2/3	10
NMT Start	0	0	0	1	1	0	0	0	1	x	x	w	1	-
NMT Stop	0	0	0	1	1	0	0	1	0	x	x	w	1	-
NMT Reset CAN	0	0	0	1	1	0	0	1	1	x	x	w	1	-
NMT Reset hardware	0	0	0	1	1	0	1	0	0	x	x	w	1	-
NMT set of Bit rate	0	0	0	1	1	0	1	0	1	x	x	w	3	-
N_i: NMT access														
R_i: reserved														

NMT Address RTR-/ read-/ write access to Front-end address

Access	RTR	EXT_INSTR	DATA_DIR	DATA_ID	DATA_1	DATA_0
NMT Address RTR access	1	0	0	-	-	-
NMT Address read access	0	0	0	0xc0	address	-
NMT write access	0	0	0	0xc0	old address	new address

NMT Start The state of all Front-end devices are going to OPERATIONAL (see Appendix C).

NMT Stop The state of all Front-end devices are going to PREPARED - **it is necessary before you can store any information permanently in EEPROM or execute one of the following NMT services.**

NMT Reset CAN reinitialise 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)

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

Following list describes the accesses of the DCP made for one CIOFFm0 /CIO20Fm0 module.

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	14
Actual current	0	1	1	0	0	1	M3	M2	M1	M0	r	3	1
Set voltage / Set current	0	1/0	1	0	1	0	M3	M2	M1	M0	r/w	3	15
Status channel	0	1	1	0	1	1	M3	M2	M1	M0	r	3	16
Current trip	1	1/0	1	0	0	0	M3	M2	M1	M0	r/w	3	16
Nominal values of channel	1	1	1	0	0	1	M3	M2	M1	M0	r/w	5	17
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	0	0	r/w a	1/2 3	18
Channel ON / OFF	0	1/0	1	1	0	0	1	1	0	0	r/w	3	20
Electronical polarity switch	1	1/0	1	1	0	0	1	1	0	0	r/w	2	20
Ramp speed	0	1/0	1	1	0	1	0	0	0	0	r/w	3	20
Emergency cut-off	0	1/0	1	1	0	1	0	1	0	0	r/w	3	20
General Emergency cut-off	1	1/0	1	1	0	1	0	1	0	0	r/w	2	21
Log-on Front-end device in superior layer	0	1	1	1	0	1	1	0	0	0	a	2	21
Log-off superior layer at Front-end device	0	0	1	1	0	1	1	0	0	0	w	2	21
Bit rate	0	1/0	1	1	0	1	1	1	0	0	r/w	3	22
Serial number, software release and CAN message configuration	0	1/0	1	1	1	0	0	0	0	0	r/w	6/2	22
Set voltage of all channels	0	0	1	1	1	0	0	1	0	0	w	3	23

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Access	EXT_INSTR	DATA_DIR	DATA_ID Bit								read / write / active	DATA-Bytes	Page
	ID1	ID0	7	6	5	4	3	2	1	0			
Set ADC filter frequency	0	1/0	1	1	1	1	0	0	0	0	r/w	3	23
Nominal values of module	0	1	1	1	1	1	0	1	0	0	r	5	23
Status3 Software current trip has been exceeded at single channel	0	1	1	1	1	1	1	0	0	0	r	3	24
Supply voltages and board temperature	1	1	1	1	0	0	0	0	0	0	r	8	24
Access only for information													
Flash programming (is allowed only by software from iseg Spezialelektronik GmbH)	0	1/0	1	1	1	1	1	1	0	0	r/w a	2/3	-
S_i: Single access													
G_i: Group access													
M_i 0 to 15: Channel 0 to 15													
R_i: reserved													

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

all devices

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

Example: HV module $V_{O\,max}$=2.5kV, 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 current (single read-write access)

all devices

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

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

all device

DATA_1 to DATA_0 set voltage/current, resolution V/$I_{O\,max}$ / 50000 [V]/[A] 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

For powered system crates ECH with the possibility to take place of more than 8 HV modules.

M_x Channel 0...15 depends of the number of channels (see **Group access: Serial number, software release and CAN message configuration**)

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

For powered system crates ECH with the possibility to take of less than or equal 8 HV modules.

M_x Channel 0...7

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

M_x Channel 8...15

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

If global INHIBIT is not active and 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’ or the global INHIBIT go to the not active state.

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 $V_{O\,max}$=5kV, write- and read-write access to set voltage V_{set} channel 3, $V_{set=}$550V

access	identifier	length code	DATA_ID	DATA_1	DATA_0
master write access	0x380	1	0xa3	0x15	0x7c
master read-	0x381	1	0xa1		-
HV board write access	0x380	3	0xa1	0x15	0x7c

DATA1..DATA_0[UI3] = 550V/5000*5E4 = 5500 = 0x157c

4.5.1.4 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

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
x	x	x	e	r	o	i	x	x	x	x	x	x	x	x	t

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

x no information

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

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

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

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

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

4.5.1.5 Current trip (extended single write- / read-write access)

all devices

DATA_1 to DATA_0 current trip, resolution IO max / 50000 [A] 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

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4.5.1.6 Nominal values of channel (extended single write- / read-write access)

all devices

DATA_ID=0x90 mantissa UI1, exponent SI1 2 (UI1, SI1)

Access	EXT_INSTR	DATA_DIR	DATA_ID	DATA_3	DATA_2	DATA_1	DATA_0
master write access	1	0	0x90 + M_x	Mantissa V_{max}	Exponent V_{max}	Mantissa I_{max}	Exponent I_{max}
master read-	1	1	0x90 + M_x	-	-	-	-
HV board write access	1	0	0x90 + M_x	Mantissa V_{max}	Exponent V_{max}	Mantissa I_{max}	Exponent I_{max}

M_x Channel 0 ... 15

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

A write access will the values permanently save into the CIO device.

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 UI1

b7	b6	b5	b4	b3	b2	b1	b0
save	killena	vsup	noramp	stbl	1	ramp	sum

sum	sum error flag	sum = 0	trip has been exceeded in at least one of the channels
		sum = 1	status channel flags v & c & t = 0 for all channels
ramp	ramping flag	ramp = 0	V_O is ramping in at least one channel
		ramp = 1	no channel is ramping
stbl	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)
noramp	change of Vset	noramp = 0	with a voltage ramp
		noramp = 1	without a voltage ramp
vsup	supply voltages	vsup=0	supply voltages are out of range
		vsup=1	supply voltages are in range
killena	kill enable	killena=0	kill function disable
		killena=1	kill function enable
save	save set values	save=0	no write access to EEPROM
		save=1	store all set values to EEPROM (time to save ca. 10s)

all devices

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

DATA_0 bool array (read-write access) UI1

b7	b6	b5	b4	b3	b2	b1	b0
x	killena	x	noramp	x	x	x	x

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 or supply voltages 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_0
HV board active access	0	0	0xc0	MSB LSB

DATA_0 active access (write access) UI1

b7	b6	b5	b4	b3	b2	b1	b0
x	killena	vsup	x	fN	x	ramp	sum

Example of an active error message

access	identifier	length code	DATA_ID	DATA_0
HV board active access	0x000	2	0xc0	0x28

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

4.5.2.2 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

$Ch_m = 0$ Channel OFF

4.5.2.3 Electronical polarity switch (extended group write- / read-write access)

DATA_ID=0xCC

device class 5

DATA_0 bool array UI1

b7	b6	b5	b4	b3	b2	b1	b0
Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0

$Ch_m = 1$ Channel polarity positive

$Ch_m = 0$ Channel polarity negative

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

DATA_ID=0xD0

all Devices

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

DATA_1	DATA_0
MSB	LSB

Ramp speed with resolution $V_{O\,max}$ / 50000s

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.

4.5.2.5 Emergency cut-off (group write- / read-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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4.5.2.6 General emergency cut-off (group write- / read-write access)

DATA_ID=0xD4

all Devices

DATA_0 bit 0 = 1 The inhibit line on the 96 PIN adapter/A29 will be switched to low level in order to switch the high voltage of all connected modules to off.

Additional all channels will cut-off without ramp and the set voltages are setting to zero.

bit 0 = 0 The inhibit line on the 96 PIN adapter/A29 will goes to high level in order to switch the high voltage on all connected modules on.

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

After POWER ON the Front-end device 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 of the 11 bit-Identifier)

DATA_ID=0xD8

all Devices

DATA_1 equal to DATA_0 of general status

DATA_0 information device class of module

DATA_1	DATA_0
see general status	device class

SN. 457xxx device class = 4 8 channel CIO with relay control

SN. 457xxx device class = 5 16 / 8 channel CIO 8V / 8I

SN. 457xxx device class = 8 16 / 8 channel CIO V/I mux normal

4.5.2.8 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.

all Devices

DATA_ID=0xD8

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

4.5.2.9 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 is prefixed from factory 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 is storing the information permanently.

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

DATA_ID=0xE0

all devices

DATA_5 to DATA_0 read-write access 11 BCD

DATA_5		DATA_4		DATA_3		DATA_2		DATA_1		DATA_0	
BCD9	BCD8	BCD 7	BCD6	BCD 5	BCD4	p/a	BCD3	BCD3	BCD 1	-	BCD 0

BCD9 to BCD4 serial number in 6 BCD e.g. '457001'

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

Master write access to change the CAN message configuration.

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

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4.5.2.11 Set voltage of all channels (group write access)

DATA_ID=0xE4

all Devices

DATA_1 to DATA_0 set voltage, resolution VO max / 50000 [V] UI2

DATA_1	DATA_0
MSB	LSB

(see also Set voltage single access)

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

DATA_ID=0XF0

all Devices

DATA_1 to DATA_0 19200 / ADC filter frequency f_N [Hz] UI2

DATA_1	DATA_0
MSB	LSB

5 Hz ≤ f_N ≤ 100 Hz
(invalid f_N will be ignored and the bit 'Input-error' in 'Status channel 0' is set).

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

4.5.2.13 Nominal values of module (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}

This instruction is useful only, if there are the same HV modules connected to the CIO device.

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

4.5.2.14 Software Current trip (group status3 read-write access)

DATA_ID=0xF8

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 Channel tripped

If the measured output current exceeds the programmed current trip then the corresponding bits will be set. Voltage will be switched off permanently without ramp, green LED on front panel is off until to this access.

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

After this access:

The corresponding bits in ‘Status channel’, ‘General status’ and the setting bits in DATA_1 - DATA_0 will be reset.

(clear bit t in ‘Status channel’, set sum error flag in ‘General status’ to one)

With help of the ‘Group access’ ‘Switch **ON** /OFF’ the concerning channels are switched ‘ON’ again.

4.5.2.15 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	Vn5	TempH	TempL

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

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

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

Vn15 don’t exist *at CIO*

Vn5 internal supply voltage -5V (resolution 100mV)

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

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

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Appendix A – Technical data

	CIOFFm0_24/ CIOFFm0_12	CIO20Fm0_24/ CIO20Fm0_12
Output current I_{OUT-X} per DAC channel	max. 500 µA 16 channels	max. 500 µA 16 channels
Output voltage V_{OUT-X} per DAC channel	0 to 5 V 16 channels	0 to 5 V 16 channels
Input voltage V_{IN-X} per ADC channel	0 to 5 V 16 channels	0 to 5 V 32 channels
Interface	CAN-Interface	
Voltage setting	via software, resolution 100 µV	
Voltage measurement	via software, resolution 100 µV	
Rate of change of output voltage via software	1 V/s to 125 V/s resolution 0,5 V/s 125 V/s to 250 V/s resolution 5 V/s	
Channel control via software	Status: channel emergency cut-off, ramp, channel on/off, input error, current trip	
Error signal	Green LED at ″Connection ready″	
Power requirements V_{IN}	_**24**: + 24 V / _**12**: +12 V	
Packing	3U Euro cassette (20,32 mm wide and 160 mm deep)	
Connector	96-pin connector according to DIN 41612	

Appendix B – 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
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 Organisation
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)
V_{meas}	Actual voltage
V_{max}	Hardware voltage limit
$V_{O\ max}$	Nominal voltage
V_{set}	Set voltage

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Appendix C – Diagram of operating modes

Fehler! Kein Thema angegeben.

(1) The INITIALISATION follow after the POWER ON reset of the device hardware:

471xxx ca. 2 seconds
472xxx ca. 8 seconds
473xxx ca. 2 seconds

(2) The state OPERATIONAL will obtained by the device oneself if all initialisations are ready or the state PREPARED goes in time out.

(3) NMT Stop switches the devices of the CAN segment to the state PREPARED within it can be changed the permanent settings of the devices (per device *Front-end address, Bit rate, Set voltage, Set current, Ramp speed, General status*, *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 goes the device to the state FLASH PROGRAMMING. The high voltage have to switched off before.

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