Electric
Power
Systems

G S I Darmstadt

User Manual

Adaptive Control Unit

(ACU)

Firmware from Version 07.00.00

Software from Version 007.0004

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Version from: Thursday, 2. June 2022, 10:10:00

Content

1   Table of alterations

Date	Name	Comment
01.08.2019	D. Schupp	Switching to Office 2016, font "Universe" replaced by "Calibri" and the associated reformatting performed.
06.03.2020	D. Schupp	MFU menu supplemented by 'flow rates'
10.02.2020	D. Schupp	ICM electrical switching outputs and PSS added
01.06.2022	D. Schupp	Extensively revised and supplemented

2   Abbreviations

To keep this manual short and well-arranged, several names and expressions will be shortened:

ACU   *Adaptive Control Unit* - all components belonging to the control and monitoring unit of a power supply

ADC   *Analog Digital Converter*

DCCT   *DC Current Transformer*

FPGA   *Field Programmable Gate Array* - a programmable logic module that contains the functionalities of an ACU module

ICM   *Interlock-and Control Module*

MFU   *Multi Function Unit* - Central basic unit of an ACU system

NIOSII   Microprocessor in the MFU that provides the user interface.

FW   *Firmware* – the necessary programming of the FPGA. A distinction is made between application and factory image. The application image is usually replaceable by the end user. The factory image, however, only by the support team.

SW   *Software* - Operating software of the NIOSII/VNC2 microprocessors within the MFU. Here too, a distinction is made between application and factory image. The application image is usually replaceable by the end user. The factory image, however, only by the support team.

SVE/PSU   *Strom-Versorgungs-Einheit* (*Power Supply Unit*)

USI   *Universal Serial Interface*

PCA   *Power Config Advanced* (Software)

PPS   *Personal Protection System*

Quench   Sudden transition from superconducting to normal condition**s**

3 Introduction

This document describes the operation as well as the configuration of each component (module) of the Adaptive Control Unit (ACU), including all specific details.

The first chapters contain substantial information for the user and service personnel of the ACU, for both operation and configuration.

The appendix contains information about the physical properties of all interfaces and modules.

Please note that this manual is specific to the standard GSI configuration of all used ACU modules and their components.

4 The Multi-Function Unit (FG660.014 and FG660.024)

4.1 Front view of the MFU
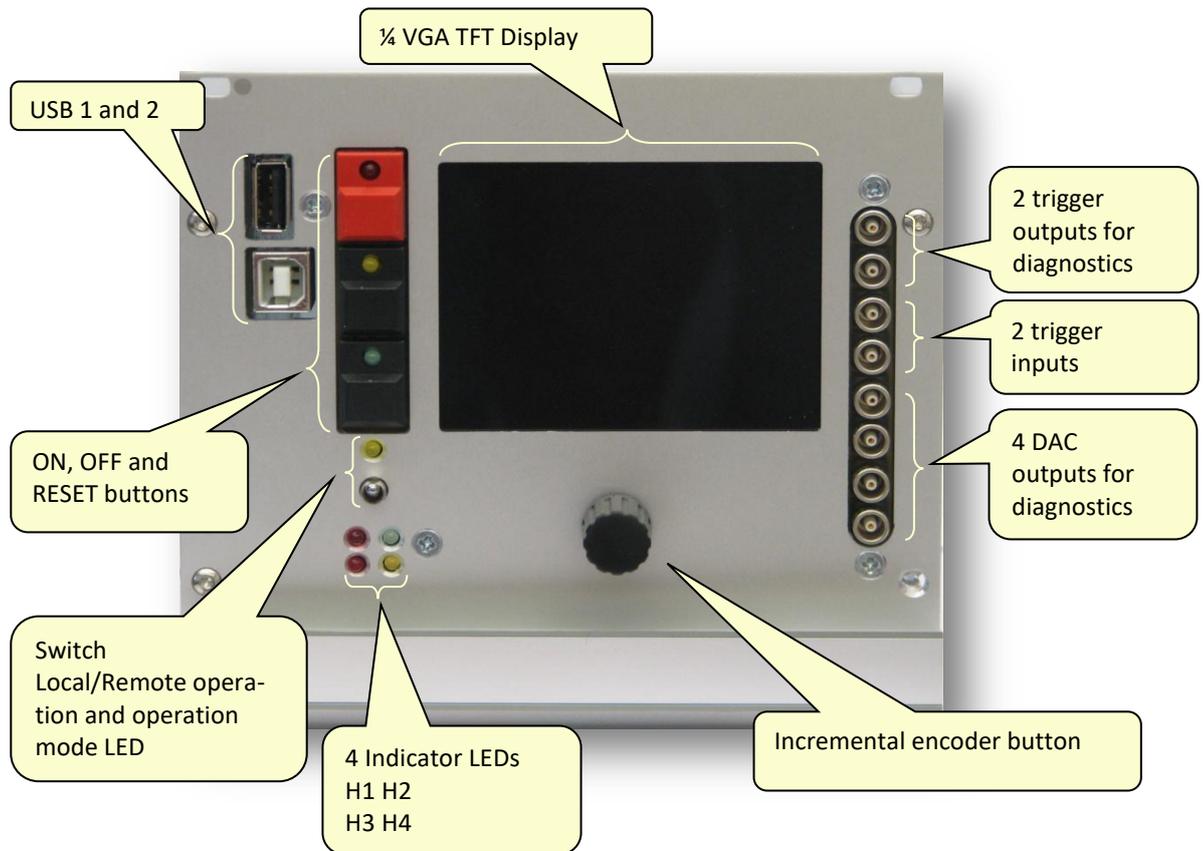
Figure 4-1: Front view for the MFU

4.1.1 USB 1 and 2

USB ports 1 and 2 are used for the communication between the MFU and its different user interfaces.

The MFU internally uses a USB host controller, which operates USB 1. USB 2 serves as slave and has to be operated by a host.

4.1.1.1 USB 1

USB 1 operates the MFU as a host, which means that devices like USB mass storages can be connected here to back up MFU data or provide new data for it. Furthermore, software updates can be applied to the MFU or other modules that are connected to the ACU system.

USB 1 can also provide power for other connected devices.

4.1.1.2 USB 2

USB 2 serves as slave for the MFU, which means that the host PC gets connected to the ACU operation software "PowerConfigAdvanced".

With this software, the ACU system can be parameterized, analyzed and operated remotely.

4.1.2 ON, OFF, RESET and related LEDs

These buttons switch the ACU system on and off or can reset present interlocks.

The related LEDs indicate status information.

After switching on the power supply all LEDs initially start flashing red.

Once device parameters are loaded, the blinking LEDs may change as follows:

No change (still flashing red) means that the loaded device parameters are not matching and/or connected modules could not be verified.

If the loaded device parameters are partially not matching, the LEDs of the ON and OFF buttons go out, the operating mode LED shows the operating status and the RESET button keeps on flashing red.

If incorrect device parameters are loaded and there are still interlocks present which need to be cleared by pressing the RESET button, the ON and OFF button LEDs will go out, the operating mode LED shows the operating status, while the RESET button will be glowing red constantly.

4.1.2.1   ON button

The LED flashes red if the criteria of 4.1.2 are not matched.

The LED is off and after the button is pressed, it starts flashing red if the PSU is switched on and the intermediate circuit bank is loaded.

The LED flashes green, if the intermediate circuit is loaded, but the controller is not cleared yet or has been locked externally.

The LED glows green if the intermediate circuit is loaded, the PSU is switched ON and the controller is cleared.

4.1.2.2   OFF button

The LED is off when the PSU is ON, currently being switched ON or interlocks are present.

The LED glows green when the PSU is ready to be switched ON.

The LED flashes red when the criteria of 4.1.2 are not matched or the PSU is being switched OFF and the timer to prevent immediate resetting is running.

4.1.2.3   RESET button

The LED is switched OFF, if the PSU is switched on and is ready to operate. That means valid parameters have been loaded and no interlocks are present.

The LED flashes red if the criteria of 4.1.2 are not matched.

The LED glows red while the reset button is being pressed and the PSU is ready to operate.

The LED glows red permanently if the criteria of 4.1.2 are matched, but unresolved interlocks are still present. The frame of the display will glow red as well. Once the RESET button is pressed, all present interlocks of the system are being cleared. Then the frame color changes to green and the LED of the OFF button changes to green. In case interlocks are still present, the OFF button LED goes out again and the frame color changes back to red. These changes occur right after the RESET button has been pressed.

4.1.2.4   Switch Local/Remote

This switches the authority to operate between the local user (switch up) and the control system (switch down).

4.1.2.5   Operation mode LED

Glows red: local authority to operate
Glows green: authority to operate is set to remote of comes from the control system
Flashes red: criteria from 4.1.2 are not matched

4.1.3   Indicator LEDs

The 4 LEDs show status information of the MFU to the user.

4.1.3.1   H1

If data is transferred between MFU and PC via USB 2, H1 flashes to indicate the data transfer. Red flashing stands for data being sent from the PC to the MFU, while green flashing shows data from the MFU being read by the PC.

4.1.3.2   H2

If data is transferred between the MFU and an external control system via the backplane, H2 flashes to optically signal the data transfer. If H2 flashes red, data is being written from the control system to the MFU; if it flashes green, the control system is reading data from the MFU.

4.1.3.3   H3

Up to MFU FW 7.4.x:

Lights up red when the internal oscilloscope of the MFU has been activated and is waiting for a trigger event. Flashes green when a trigger event has occurred and data is ready to be read.

From MFU FW 7.5.0:

Lights up red when the internal oscilloscope of the MFU has been activated and a trigger event is being waited for. Lights up orange when a trigger event occurs. Lights up green when a trigger event has occurred and data is ready to be read.

4.1.3.4   H4

If a checksum error occurs, H4 flashes orange. This also happen when data is being transferred or no parameters have been loaded yet, since the checksum is always calculated at the end of each data transfer.

If the null field control is active, H4 glows red.

If the current control is active, H4 glows green.

4.1.4   Incremental encoder with button

The incremental encoder has different tasks, depending on what is shown on the display. Please refer to chapter 4.3: "The MFU menu".

In general, the incremental encoder is used to navigate the menu or modify system parameters.

During menu navigation, a short press of the button brings the user to a submenu, in case one exists. A long press of the button brings the user back to the previous menu.

4.1.5   Trigger outputs for diagnostics

To synchronize external procedures with internal events, internal trigger signals from the MFU can be put out via the trigger outputs.

Please also refer to chapter 4.3.4.6.1: "(61) Trigger Out (X1-X2)".

4.1.6   Trigger inputs

To synchronize internal procedures with external events, external trigger signals can be supplied to the MFU via the trigger inputs.

4.1.7   DAC outputs for diagnostics

4 different internal signals can be put out as voltages from the MFU via the 4 DAC (Digital Analogue Converter) outputs. With the oscilloscope or the multi-meter, they can be displayed for diagnosis.

Please also refer to chapter 4.3.4.6.2: "(62) DAC Out (X5-X8)".

4.1.8   ¼ VGA display with 320x240 pixel

The TFT display is used as optical user interface of the ACU system. It shows status information or the MFU menu and it signals the current system status with changing frame colors.

Please refer to chapter 4.3.1.3 „Frame color".

4.2   *The boot process*

Upon being switched on, the MFU starts a boot process, which looks as follows:

1. The start-up logo is shown.

2. The MFU is initialized.

3. A USI search process is started. All USI interfaces are checked for connected modules. This search can take several seconds, depending on the number of attached modules.

4. The TFT display is cleared. Since this is also controlled by the USI, the display stays inoperable in case the USI search fails.

5. A quick overview about the USI interfaces appears which always shows the module that was found first.

Numbers of USI modules:

```
01:18Bits Analog to Digital Module     AI HS
02:Off, No Modules
03:Interlock- and Controlunit          AI HS
04:Off, No Modules
05:Off, No Modules
06:Off, No Modules
07:Off, No Modules
08:Off, No Modules
09:Off, No Modules
10:Off, No Modules
11:TFT Display Controller              AI
```

The exact meaning of this can be found in chapter 4.3.4.2: "USI".

6. After approx. 1 second the display is cleared and the version numbers of the software, FPGA firmware and theVNC1L USB-Controller are shown.

Example:

```
MultiFunctionUnit

Module HW  :001.00000
           01.01.17
FPGA SW/FW:007.00000
           29.03.17
           14:25:47
Nios SW    :007.00000
            Mar 29 2017
            12:28:47
VNC2       :testing…
```

7. IF the VNC2 (USB host controller for USB1) is programmed, instead of "testing", the following is shown after about 2 seconds:

```
VNC2        :MAIN V2.0.2 SP2.R1 RPRG 1.00R
```

If it's not programmed, the user will see

```
VNC2        :not programmed
```

8. After approx.. 1 second the display is cleared again and the saved interlock texts are checked for consistency with the modules that are attached to the USI.

```
Testing and loading
Testing interlock texts...
USI: u, Mod.:m
```

The result is shows as follows:

```
Interlock texts ok.
```

or

```
Interlock texts not ok.
```

In this case the USI shows:

```
Check texts for Mod.: m connected to USI: u
```

Which stands for the first USI and the first module number for which no interlocks had been saved.

9. The found modules will be parameterized with data stored in the internal flash of the MFU, in case there are parameters present:

```
Loading system parameters...
```

The result is shown as follows:

```
Loaded successfully
```

or

```
Missing system parameters
```

If no parameters are present or contain errors or are not consistent with the found modules:

```
Mismatch system parameters!
```

10. After another second the display is cleared once more. USB 1 is checked for any attached USB mass storages.

```
Updating system
Preparing system for updates...
Looking for USB flash device
```

If a mass storage is found which contains a file called `update.txt`, the update will be applied.

11. At the end of the boot process, the display changes to the default screen

.

4.3   The MFU menu

If the display stays inactive for a longer period of time and the incremental encoder button is not used, it automatically changes back to the default screen.

This default screen shows status information about the ACU system and allows a simple setting of a manual current target value.

To exit the default screen, the incremental encoder has to be pushed.

Once the user is back in the menu, turning, short press (one menu item forward) or long press (one menu backwards) of the incremental encoder button can be used to navigate.

4.3.1   The default screen

4.3.1.1   Displayed content (textual)
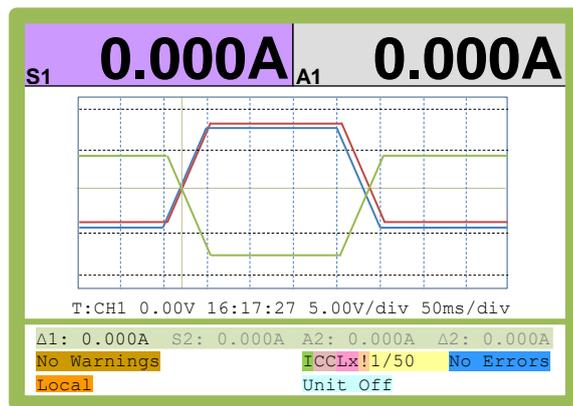
Figure 4-2: The default screen

Shows the current set value (here current in ampere).

Shows the current actual value (here current in ampere).

Shows the current control difference 1 ($\Delta1$) between set value 1 and current value 1(here in ampere). Is there a second ADC module connected this line additionally shows set value 2, current value 2 and the control difference 2 ($\Delta2$).

Shows possible system warnings.

An "E" indicates that external parameters (from USB, control system, …) have overwritten the internal ones of the MFU. A "I" indicates that the internal parameters of the MFU are being used.

Shows the controller mode. CC = Current Control, FC=Field Control.

In case a LoadSwitchModule (Load switch) is present in the ACU System, the currently chosen load is shown here.

Indicates that a USB mass storage has been found. An "*" stands for a mass storage with complete access, while a "!" stands for a mass storage with limited access.

Shows the current step width for the manual target value (local) as a fraction of the nominal current.

Shows possible system errors. Error codes can be found at the menu item "Errors".

Shows the current operation status, local or remote.

Shows the current system status.

4.3.1.2   Displayed content (graphical)

The modality of the shown graphical elements on the default screen depends on different factors.

4.3.1.2.1   Oscilloscope with completely functional range

The completely functional range is only visible when there is no connection between MFU and PC and the local/remote switch (4.1.2.4: "Switch Local/Remote") is set to Remote. In addition, the internal scope must have been configured by using the user menu or PCA.

The user will see a three-channel oscillogram. Normally, the three channels are configured as set point 1, current value 1 and control difference 1, but can also be connected with other sources

`T:CH1`	defined trigger channel, here channel 1.
`0.00V`	defined trigger level, here 0,00 Volt.
`16:17:27`	shows the time of the last trigger event, if no trigger event happens `Not Trig` will be displayed.
`5.00V/div`	shows the y axis scaling, here 5,00 Volt/div
`50ms/div`	shows the x axis scaling, here 50ms/div

4.3.1.2.2   Oscilloscope with limited functional range

At least the limited functional range is always visible if one or more conditions for the complete functional range (4.3.1.2.1: „Oscilloscope with completely functional range") are not fulfilled.

At the center of the default screen the actual value and its chronological sequence are shown graphically. The dotted x-axis will be placed at the center of the y-axis for bi-polar devices or at the bottom end of the y-axis for unipolar devices.

If the ACU system is set to local mode, by turning the incremental encoder button, a target value can be modified in steps of 1/50 of the nominal value. This is the rough setting of a target value. By pressing and holding the RESET button, the step width can be changed to 1/200 of the nominal value. This is the fine setting of a target value.

The target value can be set to zero at any point by long pressing of the incremental encoder button. Another long pressing of the incremental encoder button restores the previous target value.

4.3.1.3   Frame color

The shown frame color of the TFT can change. Please note that:

green   The ACU system is operational, no error or warnings are present, all interlocks have been resolved.

red   At least one error and/or interlock is present, which prevents the activation of the ACU system. These errors have to be removed or the interlocks need to be reset (by pressing the reset button). Once everything is resolved, the frame color changes to green or yellow.

blue   In addition to the frame color the text "Recording parameters…" shows that all following parameters of the MFU are recorded and stored. As soon as this recording is stopped, the frame color changes back to the previous one.

yellow   Warnings are present that might prevent the power converter from being turned on.

4.3.2   The main menu

By a quick press of the incremental encoder button while being at the default screen, the user can switch to the main menu.


```
0 Main
► 1 System Overview
  2 USI
  3 FSP Contents
  4 Save/Load
  5 Update
  6 Settings
```
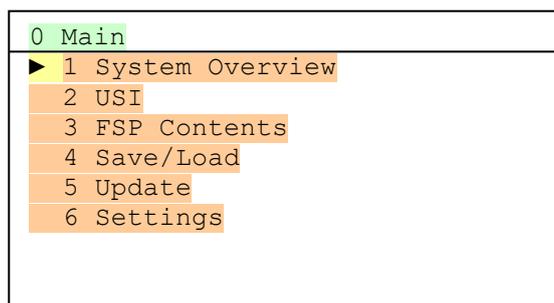
Figure 4-3: The main menu

The name/title of the current menu

This shows the selected menu item, which will be chosen by a short press of the incremental encoder button.

These are the available menu items.

4.3.3 The sub-menus

Sub-menus are accessible by selecting the desired menu item with the incremental encoder button.

To return to the previous menu, a long press of the incremental encoder button has to be done.

4.3.4 The menu tree

At the moment the menu is structured as follows:

0 Main				
1 System Overview	11 Interlocks	111 Interlocks dynamical		Shows present Interlocks
		112 Interlock early bird		Shows the trip line that was drawn first and additionally the order in which the interlocks occurred on this trip line. (preferably, usually the first 3-5 interlocks)
		113 Interlock sequence		Shows interlocks in the order of their occurrence for the individual trip lines. (preferably, usually the first 3-5 interlocks/each tripline)
	12 Errors			Shows error codes
	13 Warnings			Shows present warnings
	14 Status	141 Supplies		Shows the voltages of modules graphically and in decimal
		142 Temperatures	1421 Temperatures	Shows module temperatures in decimal
			1422 Temperature Graphs	Shows module temperatures graphically
		143 Interlocktexts		Checks stored interlock texts
		144 Real Time Clock		Shows the internal real time clock
		145 Flow Rates	1415 USI uu Module m Flow Rates Details	Displays flow rates of water monitors/ flow meters (if available)
		146 MFU Selftest		Starts several self-tests of the MFU
		147 SCU Debugging		Test routines for the SCU interface.
	15 Parameter and Configuration Info			Show the configuration of the MFU
	16 Logbook			Shows the logbook
	17 Operating Hours			Counter for operating hours
	18 Release time/date			Shows the current software release
2 USI	21 USI Module Quick Overview			Gives a quick overview of the first module at each USI
	22 USI Module Details	211 USI Module Details		Shows recognized modules with details
	23 USI Rescan			Checks all USIs once more
	24 USI Diagnosis			Does USI diagnosis
3 MFU FSP Contents				Shows several FSP contents
4 Save/Copy/Load	41 Parameters	411 Reload int. Parameters		Reloads the internal system parameters
		412 Copy Parameters TO USB Flash Drive		Stores system parameters on USB mass storage device
		413 Copy Parameters FROM USB Flash Drive	4131 Copy Parameters into internal Flash	Loads system parameters from USB mass storage device and saves them into nonvolatile internal flash
			4132 Load Parameters into RAM	Loads system parameters from USB mass storage device and saves them into volatile internal RAM
	42 Interlock texts	421 Copy Interlock Texts to USB Flash Drive		Stores interlock texts on USB mass storage device
		422 Copy Interlock Texts from USB Flash Drive		Loads interlock texts from USB mass storage device into nonvolatile flash
	43 All/Clone	431 Copy All USB Flash Drive		Stores system parameters and interlock texts on USB mass storage device
		432 Copy All from USB Flash Drive		Loads system parameters and interlock texts from USB mass storage device into nonvolatile flash
5 Update				Firm-/Software update of MFU internal components and peripheral modules
6 Settings	61 Trigger Out (X1-X2)			Allocation of trigger output signals
	62 DAC Out (X5-X8)			Allocation of the DAC output signals
	63 Load Switches			Manual operation of the load switch (if available)
	64 Controller Parameters			Local change of controller 1 P and I parts
	65 Controller Mode			Gives the possibility to switch between current or field control
	66 Internal Scope			Local change of internal scope settings

Figure 4-4: Menu tree

4.3.4.1 System overview

4.3.4.1.1 (11) Interlocks

Display interlocks either dynamically or in the order of their occurrence.

4.3.4.1.1.1 *(111) Interlocks dynamical*

Here the currently present and/or saved interlocks of the ACU system can be found. As longs as no in-interlock texts have been modified, the naming convention is the following:

`<*><U><M><XX> No named Interlock`

`*`   The asterisk indicates that an interlocks is still present. Without it, the interlock is only saved and can be removed by pressing the RESET button.

`U`   USI number (1..11) at which the module with the following interlock can be found.

`M`   Module number (1..8) for which the following interlock is present.

`XX`   Interlock number (00..99).

The bottom line of the screen shows the following information:

`Sum Mem` Amount of all interlocks currently saved in the ACU system.

`Act`   Amount of all interlocks currently present in the ACU system.

`n/m`   Page `n` of `m`. If m > 1, the incremental encoder button can be used to navigate through the available screen pages.

4.3.4.1.1.2 *(112) Interlock early bird*

Shows which trip line was pulled first. In addition, the interlocks on this trip line are shown in the order of their appearance. The nomenclature is as follows:

`<U><M><XX> No named Interlock`

`U`   USI number (1..11) where the module with the following interlock can be found.

`M`   Module number (1..8) on which the interlock shown below can be found.

`XX`   Interlock number (00..99) of the interlock.

The bottom line of the screen shows the following information:

`n/m`   USI n of m. The incremental encoder can be used to switch between the individual USIs.

4.3.4.1.1.3 *(113) Interlock sequence*

Displays interlocks in the ACU system in the order of their occurrence. This applies to each USI individually. If no interlock texts have been edited and saved, the nomenclature is as follows:

`<U><M><XX> No named Interlock`

`U`   USI number (1..11) where the module with the following interlock can be found.

`M`   Module number (1..8) on which the interlock shown below can be found.

`XX`   Interlock number (00..99) of the interlock.

The bottom line of the screen shows the following information:

`n/m`   USI n of m. The incremental encoder can be used to switch between the individual USIs.

4.3.4.1.2 *(12) Errors*

This part displays the last 24 errors that occurred at the MFU, showing 12 errors per page. Again the incremental encoder button is used to navigate between the pages. On page 3/3 the user is able to delete all errors by pressing the incremental encoder briefly.

The error codes are displayed as follows:

Nr.	USI	Mod.	Error	Day	Date	Time

with

`Nr.`   Sequential number

`USI`   Possibly USI number at which the error occurred

`Mod.`   Possibly module number with which the error occurred

`Error`   Error code (refer to the appendix, chapter 15.3: "Error codes".)

```
Day        Weekday at which the error occurred
Date       Date on which the error occurred
Time       Time at which the error occurred
```

The shown error codes are used primarily to detect issues with the software, but can also give information about problems with the ACU system.

The error codes given out by the MFU (shown in the error menu or via USB in PowerConfigAdvanced or another terminal program) are listed in the appendix, chapter 15.3: "Error codes".

4.3.4.1.3   (13) Warnings

This shows the 32bit warnings word. This is primarily for information. Warning bits are also shown in clear text below the 32 bit warnings word, on the default screen and inside the logbook. In case more than one warning is present, the display will switch periodically between each of them. The meanings of the warning bits can be found in the appendix in chapter 15.4: "Warnings".

4.3.4.1.4   (14) Status

This menu item shows status information of the MFU.

4.3.4.1.4.1   (141) Supplies

This expresses the 6 operation voltages of the MFU decimally as a graph.

The values of the internal MFU voltages 1,2V, 2,5V, 3,3V, 5,0V and ± 12,0V are being acquired each minute and are recorded and displayed in a graph over 24 hours. The display covers the range at ± 10% of the nominal voltage. The 6 operation voltages are being written over each other in the graph. The oldest value is found to the left.
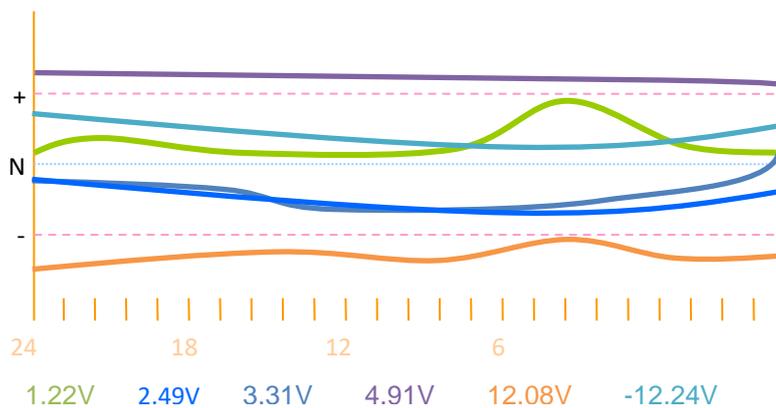
Figure 4-5: Supplies

x-axis shows the time over 24 hours.

Nominal voltage (N)

Tolerance band ±5% of the nominal voltage (+/-)

4.3.4.1.4.2   (142) Temperatures

4.3.4.1.4.2.1   (1421) Temperatures

The actual values of the internal MFU temperatures close to the FPGA, the linear regulator and the center of the module are displayed decimally in comparison to the maximal value.

4.3.4.1.4.2.2   (1422) Temperature Graphs

This temperature values are acquired each minute over 24 hours, recorded and shown as a graph. The display covers the range between +15°C and +95°C. By turning of the incremental encoder button the user can switch between each of the temperatures.

FPGA : 37 C / 60 C   1/3
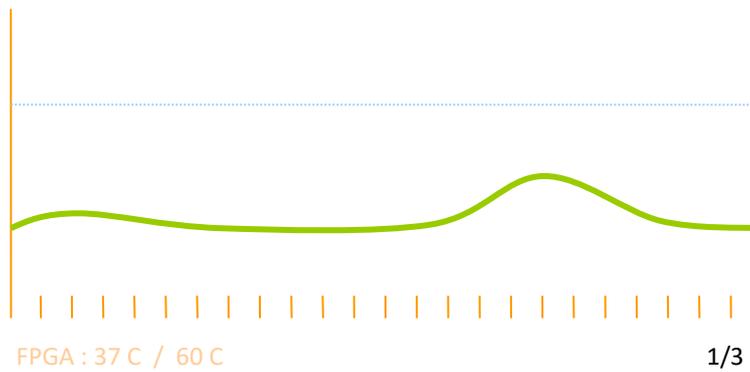
Figure 4-6: Temperatures

x-axis shows the time over 24 hours.

Permitted maximum of the temperature

Temperature curve of the last 24 hours, with the oldest value being to the left.

Measuring point with current temperature / max. temperature.

4.3.4.1.4.3 *(143) Interlock texts*

This checks the internally stored interlock texts for consistency with the present modules.

4.3.4.1.4.4 *(144) Real Time Clock*

Time/date of the internal real-time clock (RTC) of the MFU.

```
                 Day   Date        Time

Current Time    Tue   27.01.15    09:16:20    Current Date/time

Battery to Vdd --    01.02.--    17:12:28    last power down time

Vdd to Battery --    27.01.--    15:41:09    last power up time
```

Power up and power down can be cleared by pressing the incremental encoder briefly. The power up Time needs to be cleared before a new value can be recorded.

4.3.4.1.4.5 *(145) Flow Rates*

If available, shows the flow rates of water monitors or flow meters. The USI is selected on the first screen.

```
USI xx is Off with 115kBit
   No modules available
```

or

```
USI xx is On with 20MBit HS
   M <module designation>
```

xx   USI number
HS   only appears if this USI is in high-speed mode
M   module number + module name in plain text

You can switch between all USIs using the incremental encoder.

If on a USI a module has been identified that supports the connection of a water monitor or flow meter, this can be selected for further details.

```
Green modules support flow meter visualization,
red one do not.
```

To do this, press the incremental encoder (OK). The selection arrow appears. Use the incremental encoder to select the module from which details have to be displayed and confirm again with OK.

```
No.  Idx  Type       Min.   (Max.)   Cur.   PG(us)
01   00   FT/Ilck    0.00    0.00    0.00   999999
02   05   RRI_36l    5.00   10.00    7.40   006666
.
.
09   07   RRI120l   80.00  120.00   71.44   003333
10   00   Custmzd    0.00   00.00   00.00   999999
(…)
```

with

`No.`	consecutive number of the water monitor/flow meter
`Idx`	index of the water monitor/flow meter
`Type`	type of water monitor/flow monitor (refer to [*] No flow rate can be displayed for the

Customized type, since the information pulses/litre, which is necessary for calculating the same, cannot be made known within the MFU.

Table 4.1)

`Min.`	minimum permissible flow in liters/minute
`Max.`	maximum permissible flow in liters/minute
`Cur.`	currently measured flow in liters/minute
`PG(us)`	time in µseconds between two measuring pulses
(…)	additional water monitors/flow meters (turn incremental encoder)

grey	no flow can be displayed for this type of water monitor/flow meter
green	the measured flow is within the permissible limits
red	the measured flow is outside the permissible limits

manufacturer	type	display `Idx`	display `Type`
-	Float_Type_or_norm_Interlock	0	FT/Ilck
	Customized_Values[*]	1	Custmzd
GHM-Hornsberg	RRI_010xxx020_2l	2	RRI__2l
	RRI_010xxx050_12l	3	RRI_12l
	RRI_010xxx070_14l	4	RRI_14l
	RRI_025xxx180_36l	5	RRI_36l
	RRI_025xxx120_72l	6	RRI_72l
	RRI_010xxx160_120l	7	RRI120l
Kobold	DRS_9250XXF300	8	DRS

[*] No flow rate can be displayed for the Customized type, since the information pulses/litre, which is necessary for calculating the same, cannot be made known within the MFU.

Table 4.1: available water monitors/flow meters for display on the TFT

4.3.4.1.4.6 (146) MFU Selftest

Performs a series of MFU self-tests.

4.3.4.1.4.7 (147) SCU Debugging

Enables SCU interface diagnostics.

4.3.4.1.5 (15) Parameter and Configuration Info

4.3.4.1.5.1 (15 page 1) Parameter Info String

If available in the parameters, the following is displayed here

`File Name`	filename of the PSU parameters on the PC
`PSU Name`	PSU Name
`Date`	date of the parameters
`Time`	time of the parameters
`PCA Version`	the used PCA version for generating the parameters

Is there no parameter string available the display shows `No parameter info string available`.

4.3.4.1.5.2 *(15 page 2) First incorrect parameter string*

If parameter from the internal flash are being loaded into the ACU system (during system start-up or via 4.3.4.4.1.1:"(411) Reload internal Parameters") or copied into internal RAM from a USB mass storage device (chapter 4.3.4.4.1.3.2: "(4132) Load parameters into RAM") and an error occurs, this error can be analyzed here.

During this process the first incorrect parameter string and the related error number are being displayed.

Is there no incorrect parameter string the display shows `No incorrect parameters found`.

4.3.4.1.5.3 *(15 page 3) Controller Deviation Multiplier*

Displays the controller deviation multiplicand. If the deviation is outputted to a DAC or on the internal oscilloscope the value of the signal is first multiplied with this multiplicand.

4.3.4.1.6 *(16) Log book*

The log book shows the last 54 (6 per page) log book entries of the MFU. The latest entry comes first. The incremental encoder button is used to navigate between the pages.

The log book can hold up to 16384 entries. As soon as this number is exceeded, the oldest 8192 entries are deleted.

The first line of each entry displays the following information

`Number: Date Time Specification Log entry`

with

`Number`	consecutive number of logbook entries
`Date`	date of the entry
`Time`	time of the entry
`Specification`	specifies the type of the entry
`Log entry`	the real logbook entry

The second line displays the `Specification` und `Log entry` in plain text.

The footer displays `Overall xxxxx entries` which is the sum of all logbook entries.

To view the entire log book it has to be transferred to the PC using PowerConfigAdvanced.

The meaning of the log book entries is described in the appendix chapter 10.5 "Log book entries".

4.3.4.1.7 *(17) Operating Hours*

This shows the three different operation time counters. They are divided into days (Days), hours (H), minutes (M) and seconds (S).

`Energ.`(ized)	amount of time during which the MFU is supplied with power. This counter for the operating hours is saved in the internal flash.
`Uptime`	Time span since the operation voltage has been switched off the last time. This counter is non-retentive. Once the operation voltage is turned off, the value is lost.
`Runtime`	Time span that the ACU system is/was switched on. This counter is non-retentive. Once the operation voltage is turned off, the value is lost.

4.3.4.1.8 *(18) Release Time/Date*

This shows the name of the module along with date and time of the last software and hardware compilation.

If the Vinculum USB controller is programmed, its firmware version is also shown.

4.3.4.2   *(2) USI*

4.3.4.2.1   *(21) USI Module Quick Overview*

This show a quick overview of the first module connected to each USI.

USI	Module name	AI/FI	*optional * *	*optional* HS

with

USI   consecutive USI number
Module name   Module name
AI/FI   Application/Factory Image
*   Module is not part of the module definition.
                            If this module is in high-speed mode, its received data will not be made
                            available in the MFU. In order to use high-speed data from this module, the
                            module must be defined using PCA and must be part of the parameter set.
HS   Module in HighSpeed

4.3.4.2.2   *(22) USI Module Details*

On the first screen, the USI is chosen.

```
USI xx is OFF with 115kBit
   No modules available
```

or

```
USI xx is ON with 20MBit
   M <module description>
```

xx USI number
HS only displayed if USI is in HighSpeed mode
M   module number + module description in clear text

Using the incremental encoder button, the user can switch between all available USIs.

Once at least one module has been recognized at a USI, it's possible to select further details. To do so, the user has to press the incremental encoder button, select the module and press again to confirm.

On the first page the details of the MDS (Module Description Structure) are being displayed:

Module Class   Module class
Module Sub Class   Module sub class
Module Serial Number   Module serial number
Vendor ID   Module manufacturer number (GSI = 1)
Product ID   Module product number
Hardware Release   Module hardware version
Hardware Release Date   Module hardware release date
Firmware Release   Module firmware version
Firmware Rel. Date   Module firmware release date
USI Specification   USI specification supported by the module
Maximum USI Speed   Max bit rate of the module
Attributes   Module attributes
Module Maximum Power   Max current consumption of the module

It can be switched between the FSPs using the incremental encoder button.

If the reset button is being pressed and held during turning of the incremental encoder button, the FSPs are browsed by steps of 5.

The bottom line shows:

```
FSPNo.: xxx(d)/yy(h) Depth: zzz byte(s) act page/nmb pages
```

With

```
xxx        currently displayed FSP number (decimal)
yy         currently displayed FSP number (hexadecimal)
zzz        depth of the FSP
```

In case an FSP is not present, this display is skipped.

The representation of the FSP content can be changed between hexadecimal (`hex`), binary (`bin`) and decimal (`SDec/UDec`) using the incremental encoder button and it depends on the FSP depth.

4.3.4.2.2.1 Hexadecimal display

It's always a display of 5x8 nibble per line.

For example: FSP with a depth of 58 Byte

```
            0                     x_pos                 32

            |                                           |
0-    MSB -> 0000 00000000 00000000 00000000 00000000
y_pos       00000000 00000000 00000000 00000000 00000000
2-          00000000 00000000 00000000 00000000 00000000 <- LSB
```

4.3.4.2.2.2 Binary display

It's always a display of 8 nibbles (4 bytes) per line.

For example: FSP with a depth of 11 Byte

```
                              x_pos

            |                                       |
0-          MSB -> 0000 0000 0000 0000 0000 0000
y_pos       0000 0000 0000 0000 0000 0000 0000 0000
2-          0000 0000 0000 0000 0000 0000 0000 0000 <- LSB
```

4.3.4.2.2.3 Signed decimal display

FSPs with a depth of 3 bytes are displayed signed within a nominal range the acquisition between +/- 11 volts.

4.3.4.2.2.4 Unsigned decimal display

FSPs with a depth of up to 3 bytes are displayed unsigned within a nominal range the acquisition between 0 and 22 volts.

4.3.4.2.3 (23) USI Rescan

This scans again for USI modules. The module descriptors in the MFU up to this point are being deleted and replaced with the ones for the newly found modules. After the scan the ACU system continues to operate normally.

Requirement: The power supply has to be turned off.

4.3.4.2.4 (24) USI Diagnosis

The LCD display depends on the USI status and shows

```
USI xx is ON/OFF with yyBit HS
```

with

```
xx  USI number (1..11)
yy  bit rate (115,2k...20M)
HS  this USI is in operation and runs in HighSpeed mode
```

Then the 32bit HighSpeed-Word follows which was sent from the module.

```
HighSpeed Data snapshot
```

Finally there is the content of the USI response register in binary and hexadecimal form.

```
            The USI response register is as follows (bin/hex)


// USI_RESPONSE_PIO        Explanation of each bit:
// xxxx|xxxx|xxxx|xxxx
// |||| |||| |||| ||||
// |||| |||| |||| |||\----TxFIFOnEmpty
// |||| |||| |||| ||\-----TxFIFOAlmostFull
// |||| |||| |||| |\------TxFIFIFull
// |||| |||| |||| \-------TxFIFOOverflow
// |||| |||| |||\---------RxFIFOnEmpty
// |||| |||| ||\----------RxFIFOAlmostFull
// |||| |||| |\-----------RxFIFOFull
// |||| |||| \------------RxFIFOOverflow
// |||| |||\--------------RxCollision
// |||| ||\---------------RxError
// |||| |\----------------RxDataReady - ISR Trigger
// |||| \-----------------TxIdle
// |||\-------------------RxIdle
// ||\--------------------RatesValid
// |\---------------------n.u.
// \----------------------n.u.
```

4.3.4.3   (3) MFU FSP Contents

The current content of the internal hardware FSP 1..125 of the MFU are shown here.

The user can switch between each of the FSP using the incremental encoder button.

If the reset button is being pressed and held during turning of the incremental encoder button, the FSPs are browsed by steps of 5.

The bottom line shows:

`FSPNr.: xxx(d)/yy(h) Depth: zzz byte(s) act page/nmb pages`

with

xxx   currently displayed FSP number (decimal)
      yy   currently displayed FSP number (hexadecimal)
      zzz   depth of the FSP

In case an FSP doesn't exist, `it is skipped in the display.`

The way of representing the contents of the FSP depends on the FSP depth and can be switched between hexadecimal (hex), binary (bin) and decimal (`SDez/UDez`) by pressing the incremental encoder button.

4.3.4.3.1   Hexadecimal representation

Each line shows 54x8 nibble. Example: FSP with the depth of 58 bytes

```
        0                         x_pos                    32

        |                                                  |
0-    MSB -> 0000 00000000 00000000 00000000 00000000
y_pos       00000000 00000000 00000000 00000000 00000000
2-          00000000 00000000 00000000 00000000 00000000 <- LSB
```

4.3.4.3.2   Binary display

It's always a display of 8 nibbles (4 bytes) per line.

For example: FSP with a depth of 11 Byte

```
                        x_pos

        |                                 |
0-          MSB -> 0000 0000 0000 0000 0000 0000
```

```
y_pos       0000 0000 0000 0000 0000 0000 0000 0000
2-          0000 0000 0000 0000 0000 0000 0000 0000 <- LSB
```

4.3.4.3.3   *Signed decimal display*

FSPs with a depth of 3 bytes are displayed signed within a nominal range the acquisition between +/-11 volts.

4.3.4.3.4   *Unsigned decimal display*

FSPs with a depth of up to 3 bytes are displayed unsigned within a nominal range the acquisition between 0 and 22 volts.

4.3.4.4   *(4) Save/Copy/Load*

This menu item allows reading and writing of data on USB mass storages.

<u>Caution:</u>   Loading data from a USB mass storage is only possible, if the USB device has been authorized for that. This authorization is done by the LOEP department of GSI. In case a device does not meet all the requirements, the TFT display will show `"The USB Flash Drive does not meet all the requirements. Please check USB flash drive"`. Saving data can generally be done with every USB mass storage device.

4.3.4.4.1   *(41) Parameters*

4.3.4.4.1.1   *(411) Reload internal Parameters*

To reload system parameters that are stored in the MFU, this menu item is used. They are loaded automatically (if present) during the boot process. This is indicated on the default screen by the letter "I", for "internal parameters in use". In case these parameters are overwritten, for example by "PowerConfigAdvanced", an "E" indicates that "external parameters in use". If the internal MFU parameters are loaded again via this menu item, the display changes back to "I".

4.3.4.4.1.2   *(412) Copy Parameters to USB Flash Drive*

This allows saving the system parameters to a USB mass storage device. This has to be connected to the MFU via USB1. The parameters are saved in `"acu_para.txt"`.

4.3.4.4.1.3   *(413) Copy Parameters from USB Flash Drive*

4.3.4.4.1.3.1   *(4131) Copy parameters into internal flash*

This allows loading the system parameters from a USB mass storage device and saving them into the internal flash. This has to be connected to the MFU via USB1 and has to contain the necessary system parameter file `"acu_para.txt"`.

4.3.4.4.1.3.2   *(4132) Load parameters into RAM*

This allows loading the system parameters from a USB mass storage device into the volatile RAM. The parameters stored in the internal flash are not erased during this process.
This state is also volatile, which means if the MFU is being reset or 4.3.4.4.1.1:"(411) Reload internal Parameters" is executed. The parameters again have to be loaded from the internal flash. Therefore, the USB mass storage device has to be connected to MFU USB1 and contain the necessary system parameter file `"acu_para.txt"`.

4.3.4.4.2   *(42) Interlock texts*

4.3.4.4.2.1   *(421) Copy Interlock Texts to USB Flash Drive*

This menu item allows the user to save interlock texts on a USB mass storage. Again, the USB device has to be connected to the MFU via USB1. The interlock texts are saved in `"acu_intl.txt"`.

4.3.4.4.2.2 (422) Copy Interlock Texts from USB Flash Drive

This menu item allows the user to load interlock texts from a USB mass storage. Again, the USB device has to be connected to the MFU via USB1 and the required interlock texts file "`acu_intl.txt`" has to be present.

4.3.4.4.3 (43) All/Clone

4.3.4.4.3.1 (431) Copy All to USB Flash Drive

This menu item allows the user to store both interlock texts and system parameters on a USB mass storage all at once. The USB device has to be connected to the MFU via USB1. Parameters are stored in "`acu_para.txt`", interlock texts in "`acu_intl.txt`".

4.3.4.4.3.2 (432) Load All from USB Flash Drive

This menu item allows the user to load both interlock texts and system parameters at once from a USB mass storage. The USB device has to be connected to the MFU via USB1 and needs to contain the parameter file "`acu_para.txt`" and the interlock texts file "`acu_intl.txt`".

4.3.4.5 (5) Update

Caution   Update processes from a USB mass storage is only possible, if the USB device has been authorized for that. This authorization is done by the LOEP department of GSI. In case a device does not meet all the requirements, the TFT display will show **"`The USB Flash Drive does not meet all the requirements. Please check USB flash drive`"**. Saving data can generally be done with every USB mass storage device.

Furthermore, any update can only be executed as long as the ACU system is not turned on (controller is locked). Otherwise the display will show:

```
Unit is switched on. Please switch OFF go back and try
again.
```

The update menu item allows for firmware and software updates of MFU internal components as well as for all modules connected to the MFU. For this process a USB mass storage device has to be connected via USB1 and has to contain "`update.txt`" and the files necessary to program/update the modules and/or MFU components.

For further information about the update process and the "`update.txt`" file, please refer to the "ACU-Update" manual.

4.3.4.6 (6) Settings

This menu item allows modification of the system settings directly at the device.

4.3.4.6.1 (61) Trigger Out (X1-X2)

This item shows the source signals of both LEMO trigger outputs X1 and X2.

The desired trigger output can be selected using the incremental encoder button. "`Please se-lect`" will appear and the source can be changed by turning the incremental encoder button. Changes are immediately in effect. A long press of the button brings the user back to the selection.

4.3.4.6.2 (62) DAC Out (X5-X8)

The output signals of the 4 DAC channels at the Lemo sockets X5 to X8 are shown here.

The DACs can be selected using the incremental encoder button. The source can be changed by turning the incremental encoder button. Changes are immediately in effect. A long press of the button brings the user back to the selection.

4.3.4.6.3 (63) Load Switches

Specific PSUs have a load switch. The "Load Switches" menu item is used to operate these switches, if a "LoadSwitchModule" was found. In case none is present, the following message is displayed:

```
No Load Switch Module available!
```

If the PSU is turned on:

```
Unit is switched ON. Please switch OFF and try again.
```

If the PSU's operating mode is 'Remote':

```
Unit is remote. Switch to local and try again.
```

In both cases the problem should be solved before the user navigates back in the menu and `Load Switches` can be selected again.

If all requirements are met:

```
Select Load and press OK to confirm.
Current Load: x
Target Load: x/y
```

With

x   : currently selected load
y   : total number of all available loads

The incremental encoder button is used to select the load. OK confirms that. The display will show:

```
Switching, please wait.
```

As soon as the switching process is completed (takes about 4 seconds), the display changes to show the current load and

```
Selected
```

In case no response from the selected load comes in for about 9 seconds, the user sees the following information:

```
Load not available!
```

Important: In case the PSU is set to ‚`Remote`' and the load is changed remotely, the new load **won't** be shown in this menu. Please use the menu item „`Configuration`" for that.

4.3.4.6.4   (64) Controller Parameters

This displays the P and I parameter of controller 1.

Select the desired parameter with the incremental encoder and press it shortly.

"`Please change value`" appears. Change the source by rotation g the incremental encoder left or right. High step are possible by pressing and holding the RESET button at the same time. Changes are immediately in effect. A long press of the incremental encoder brings the user back to the selection.

4.3.4.6.5   (65) Controller Mode

Allows the user to switch between current or field-controlled operation. This changeover can only be carried out by trained personnel and is therefore blocked in the normal case.

4.3.4.6.6   (66) Internal Scope

This displays the parameters of the internal scope.

The internal scope records 500 values of up to 8 channels within a scalable time period which is definable via `Time Scale` and `Time Base`. For this the trigger condition must fulfill the `Trigger Level` of the `Trigger Channel` in `Trigger Mode`.

```
Time Scale        scaling of the time axis (ns, us, ms, s)
Time Base         time base of the time axis
Trigger Channel   trigger channel
Trigger Level     trigger level in volts
Trigger Offset    trigger offset along the time axis (0..500)
Trigger Mode      trigger mode       bottom-up              rising signal
```

	`equal`	signal = trigger level
	`top down`	falling signal
	`rising edge`	over external trigger source
	`falling edge`	over external trigger source
`TFT Channel (bl)`	channel is shown in blue on default screen	
`TFT Channel (rd)`	channel is shown in red on default screen	
`TFT Channel (gn)`	channel is shown in green on default screen	
`TFT Scaling`	scaling of the scope view on default screen	
	`1 times`	UmaxIn$_{SS}$
	`2 times`	½ UmaxIn$_{SS}$
	`4 times`	¼ UmaxIn$_{SS}$
	`8 times`	1/8 UmaxIn$_{SS}$
	`16 times`	1/16 UmaxIn$_{SS}$
	`32 times`	1/32 UmaxIn$_{SS}$ (only unipolar)
`Scope enable`	`no view`	in every case the default screen shows the classical scope
	`yes`	default screen show the full featured scope view as long as all conditions from chapter 4.3.1.2: "Displayed content (graphical)" are fulfilled.

5   The interlock and control module (FG660_055)

The present description in this chapter is for the hardware release mentioned in the headline. Older or newer versions of this module can have different markings regarding connectors, plugs, components and so on. In most cases the functions are identical. In case there are any doubts, please refer to the images or contact support.

5.1   View of the interlock and control module
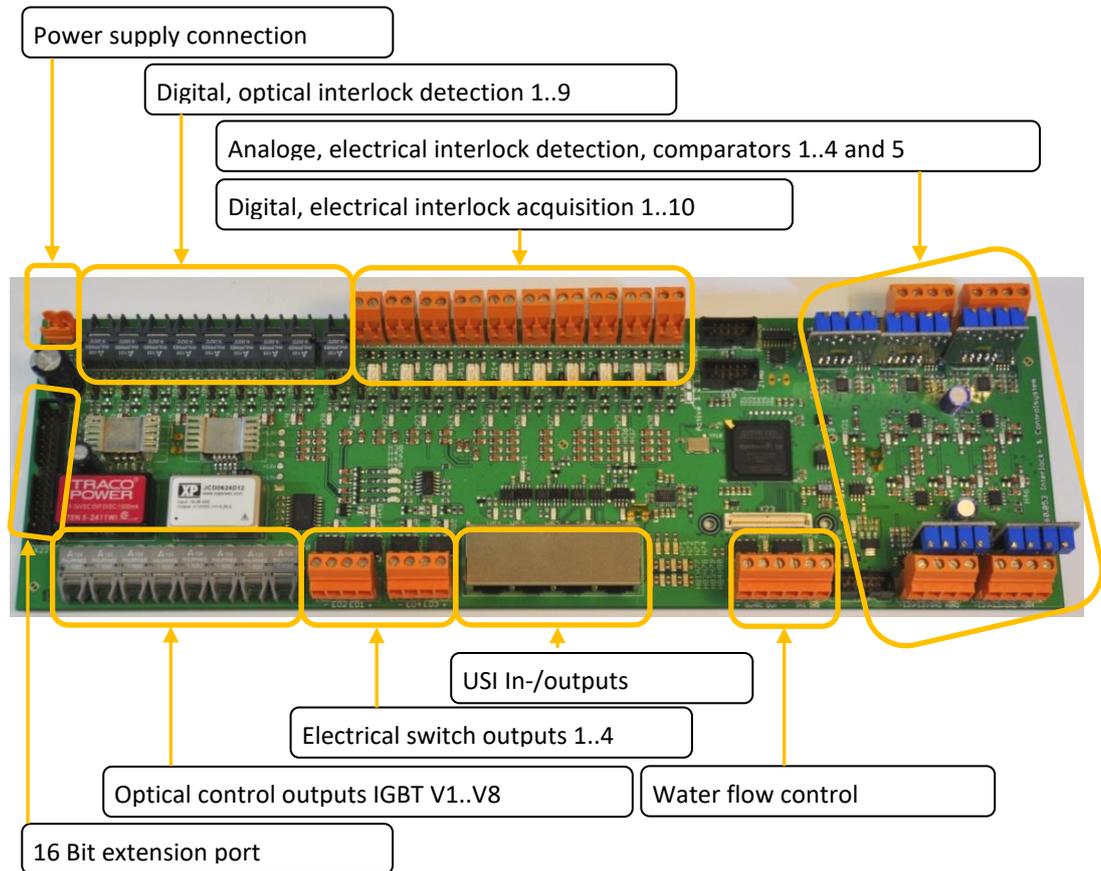
Figure 5-1: Front view of the interlock and control module

5.2   Configuration and operation

5.2.1   Numbering of the interlocks in the interlock and control module

The interlock and control module supports four interlock bytes, which means 32 interlock bits. The hardware can work with only up to 31 different interlock sources. These are arranged sequentially:

Interlock Bit 0...7   Analogue electrical interlock acquisition, bipolar comparators 1...4

Interlock Bit 8   Analogue electrical interlock acquisition, unipolar comparator

Interlock Bit 9...16   Digital optical interlock acquisition 1...8

Interlock Bit 17   Analogue electrical interlock acquisition Quench 1

Interlock Bit 18...27   Digital electrical interlock acquisition 1...10

Interlock Bit 28..29   water flow measurement

Interlock Bit 30   USI HighSpeed

Interlock Bit 31   not present, this bit is never used and always set to ‚1'

5.2.2   Current GSI default distribution of interlocks

When an interlock and control module is setup for the first time, all interlocks are distributed as follows. The distribution can be changed according to the actual requirements at any point using the PowerConfigAdvanced software.

Bit	Type	Name	Monitoring	Default text
0	Analogue, electrical	um00	Load voltage (p)	U_{Load} Pos
1		um01	Load voltage (n)	U_{Load} Neg
2		um02	Primary voltage (p)	$I_{Primary}$ Pos
3		um03	Primary voltage (n) unused	-
4		um04	Intermediate circuit (p)	U_d Pos
5		um05	Intermediate circuit (n) unused	-
6		um06	Earth fault (p)	I_{Earth}
7		um07	Earth fault (n) unused	-
8		um08	Oscillation monitoring (p)	Anti-Oscillation
9	Digital, optical	um09	IGBT1	IGBT V1
10		um10	IGBT2	IGBT V2
11		um11	IGBT3	IGBT V3
12		um12	IGBT4	IGBT V4
13		um13	IGBT5	IGBT V5
14		um14	IGBT6	IGBT V6
15		um15	-	UNUSED
16		um16	-	UNUSED
17		um17	Quench Detection	Quench Detection
18	Digital, electrical	um18	Main protection	Main contactor
19		um19	Emergency shut-down	Fast OFF
20		um20	-	Cooling H2O PSE
21		um21	Power supply	Main Voltage
22		um22	Safeties	Fuses
23		um23	Temperature power supply (cooling bank)	PSU Temperature
24		um24	Water magnet	Magnet H2O
25		um25	Temperature magnet	Magnet Temperature
26		um26	Temperature transformer	Transformer Temperature
27		um27	Water power supply (cooling bank)	PSU H2O
28	Water flow control	um28	Water flow monitoring 1	WaterFlow01
29		um29	Water flow monitoring 2	WaterFlow02
30	USI HighSpeed	um30	Abort USI HighSpeed	USI Highspeed
31	-	-	-	Unused

(p) Positive threshold of the comparator exceeded
(n) Negative threshold of the comparator exceeded

Table 5.1: Default layout of the interlocks of a new interlock and control module

With symbols:

<u> :   USI number
<m> :   Module number

5.2.3   Special functions of the interlock acquisition

5.2.3.1   The main contactor

If a main contactor is used, its status feedback can be assigned to any interlock. Normally one will use a digital electrical interlock. This feedback of the main contactor status is usually an open contact as long as the main contactor is not switched on. However, since the open contact signals that an interlock is pending, the SVE cannot be switched on. For this reason, this interlock detection must initially

be ignored and only activated when the main contactor has been switched on via the electrical switching output [1] (see chapter 5.2.10: "Electrical switch outputs 1...4"). Since the interlock detection takes place in two ways, care must be taken to ensure that these ways are configured correctly in advance.

5.2.3.1.1 Acquisition via the hardware

The acquisition via the hardware usually takes place via configuration diodes, which connect the interlock input with the up to 4 pull cords of the module.

To deactivate the detection, it is necessary to remove these diodes.

For the digital electrical interlock 1 (interlock bit 18) these are usually not mounted.

5.2.3.1.2 Capture via firmware

The FPGA also receives the interlock information. In order to prevent the interlock status from being recorded by the FPGA firmware when the device is switched off, the mode of the associated interlock bit in the module configuration must be set to "Conditional Mode" using the PCA.

This ensures that the FPGA only detects the interlock after the controller has been enabled.

Furthermore, the main contactor bit must be selected in the ICM's interlock configuration so that the switching module can provide the firmware with a correct status and a controller enable.
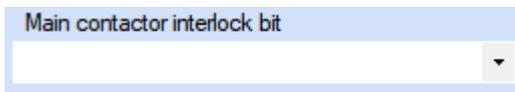
Figure 5-2: Main contactor bit selection box in PCA on form of ICM

5.2.3.2 Personal Protection System

If a PSS (Personal Protection System) is installed and feedback about its activation is required, the switching contact of the PSS must be connected to any interlock detection. Normally you will use a digital electrical interlock. If the PSS trips (e.g. the input voltage of the interlock becomes 0 volts), the electrical switching output [3] (see chapter: 5.2.10: "Electrical switch outputs 1...4") is also set to 0 volts. The (digital electrical) interlock input at which the PSS reports the status can be configured within the module configuration using PCA. After the reset/system start, the PSS is on interlock bit 31_D or $1F_H$ and is therefore deactivated because this bit is not used. If a PSS is to be used, it can be placed on any interlock.

Since the interlock detection takes place in two ways, it must be ensured that these paths are correctly configured in advance as described in Chapters 5.2.3.1.1: "Acquisition via the hardware" and 5.2.3.1.2: "Capture via firmware".

The following must also be observed:

-   The PSS status is not displayed on the MFU TFT.
-   If another interlock triggers, which acts on the trip line 1, the 5-volt supply voltage of the electrical switching outputs is switched off, which means that all 4 electrical switching outputs no longer supply any voltage.

5.2.3.3 External Control Lock

If an external controller lock is to be used, this is possible by using any interlock input. Normally one will use a digital electrical interlock. If the external controller lock is activated (status of an interlock at the detecting interlock input), the PI controller is locked, but the PSU remains in operation. This status is signaled at the electrical switching output [3] (see chapter 5.2.10: "Electrical switch outputs 1...4"). The (digital electrical) interlock input to which an external controller lock is connected can be configured within the module configuration using PCA. After the reset/system start, the external controller lock is on interlock bit 31_D or $1F_H$ and is therefore deactivated because this bit is not used. If an external controller lock is to be used, this can be placed on any interlock.

If the device is switched on, an external controller lock is displayed on the TFT of the MFU with "Contr. disabling FPGA internal." is displayed. In addition, the LED of the ON button flashes green.

Since the interlock detection takes place in two ways, care must be taken to ensure that these ways are configured correctly in advance.

5.2.3.3.1 Acquisition via the hardware

As a rule, the controller lock should not trigger an interlock and switch off the device.

The acquisition via the hardware usually takes place via configuration diodes, which connect the interlock input with the up to 4 trip lines of the module.

To deactivate the detection, it is necessary to remove these diodes.

5.2.3.3.2 Acquisition via the firmware

The FPGA also receives the interlock information. To prevent the interlock status of the device from being captured by the FPGA firmware, the two interlock masks of the associated interlock bit in the module configuration must be set to "do not capture..." using PCA.

5.2.4 Analogue electrical interlock acquisition

5.2.4.1 Bipolar comparators 1...4

The ICM contain 4 bipolar comparators with adjustable switch thresholds of +/- 11V. These allow the acquisition of electrical interlock sources, like for example load voltages, the primary current acquisition, earth faults and so on.

The default distribution of the comparators is as follows:

Comparator 1 (X2)   : Load voltage (U_{Load})

Comparator 2 (X31)   : Primary current (I_{Prim})

Comparator 3 (X3)   : intermediate circuit voltage (U_d)

Comparator 4 (X32)   : earth fault monitoring (I_{Earth})

Comparator 5 (X15)   : Oscillation monitoring (AOsc)
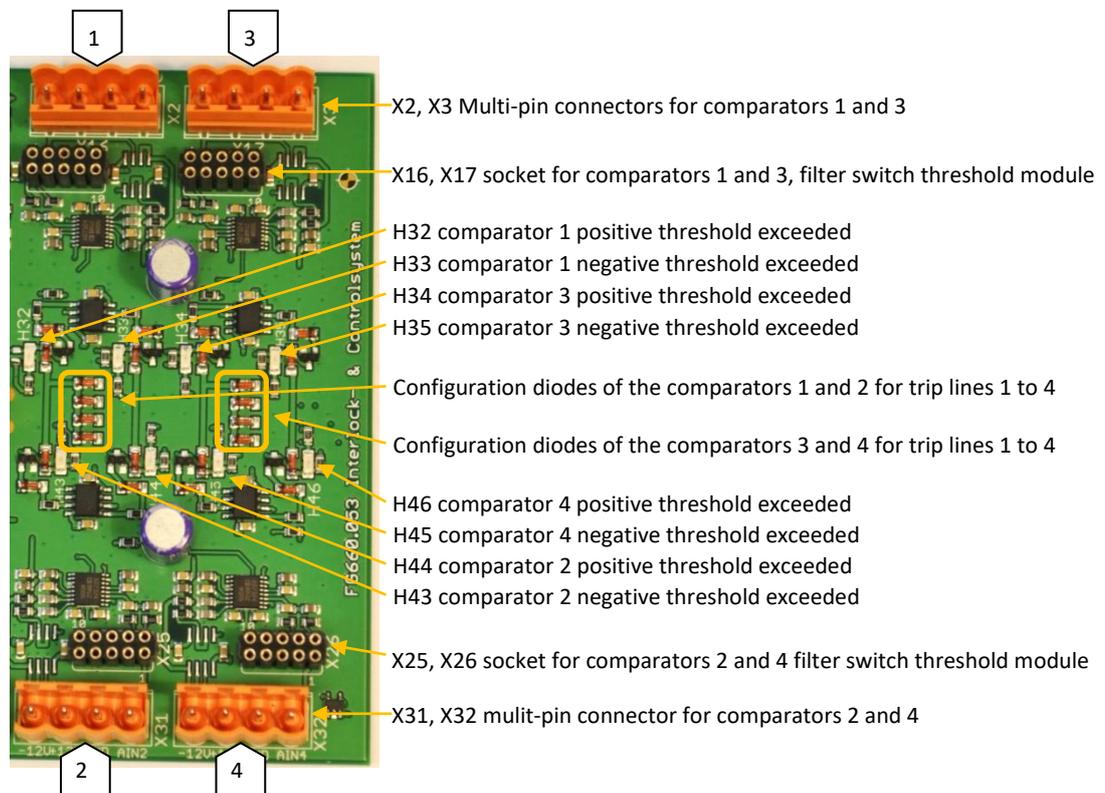
Figure 5-3: Analogue, electrical interlock acquisition

NOTE!!: The analog value used to generate the interlock signal is the filtered one. Between the RC filter in the Comparator Config Module and the operational amplifier in the ICM (used as comparator between the analogue filtered value and the positive/negative threshold) there is a resistor of 100K connected to ground (it is used to avoid a floating input when the Comparator Config Module is unplugged). On this resistor part of the analog signal to monitor will be dissipated. the ammount of voltage dissipated depends on the RC resistor value on the Comparator Config Module. Usually it is 10K so the voltage drop will be 10%, but sometime (i.e. I_Earth Comparator Config Module) it is also 100K and the voltage drop in that case is 50%.

In order to protect the power converter properly, it is necessary to set the positive and negative thresholds in relation to the voltage drop (i.e. 10% / 50% less than the computed value).
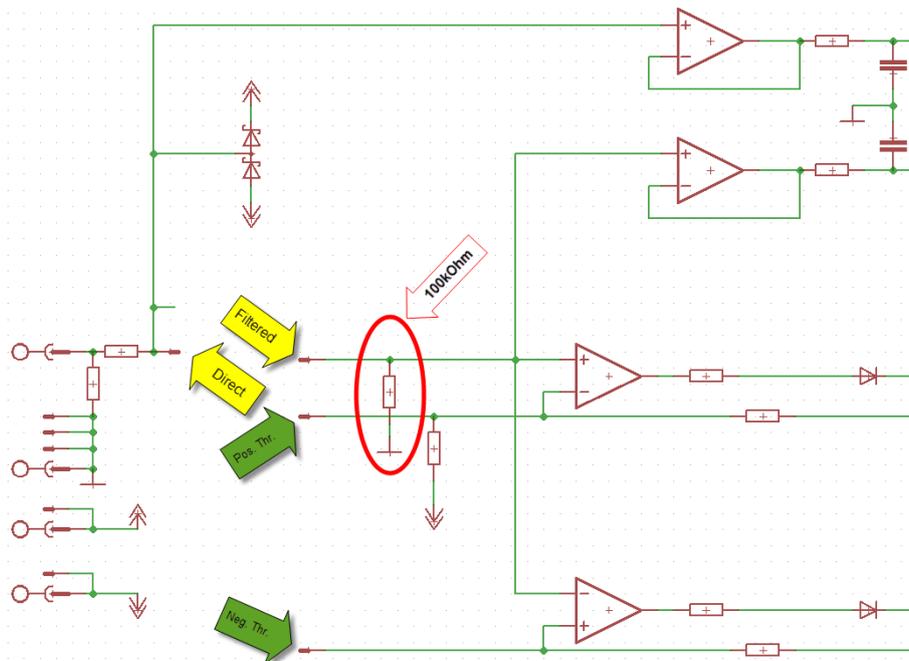
Figure 5-4: Error of the analog, electrical interlock acquisition

5.2.4.1.1 *Connection layout of the multi-pin connector*
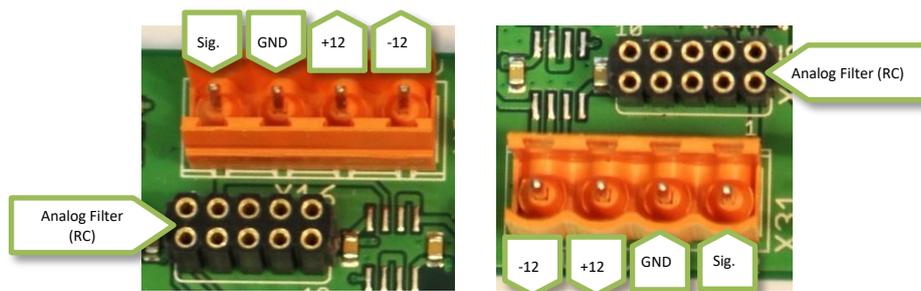
Figure 5-5: Multi-pin connector of the analog, electrical interlock acquisition

From left to right

1. Comparator input
2. Ground
3. +12V output
4. -12V output

5.2.4.1.2 *LEDs*

The LEDs H32..H35 or H43..H46 glow in case of an error of the respective comparator.

5.2.4.1.3   Filter-/Comparator threshold modules of the analogue, electrical interlock acquisition

The configuration of the electrical interlocks is realized with a filter-/comparator threshold module.

There are 3 different single Filter-/Comparator threshold modules: FG660.180, FG660.181 and FG660.182.

As well as a double (FG660.523) and a triple module (FG660.513) which can replace the 5 single modules starting from ICM FG660.057

To set or test the comparator thresholds, operating voltages and filter properties (of the filter-/comparator threshold modules) directly on the ICM, it is recommended to use the CCM test adapter which is placed between the contacts on the ICM and the filter-/comparator threshold module.
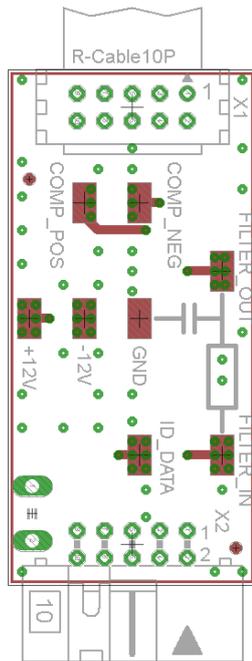
Figure 5-6: CCM test adapter

5.2.4.1.3.1   FG660.180
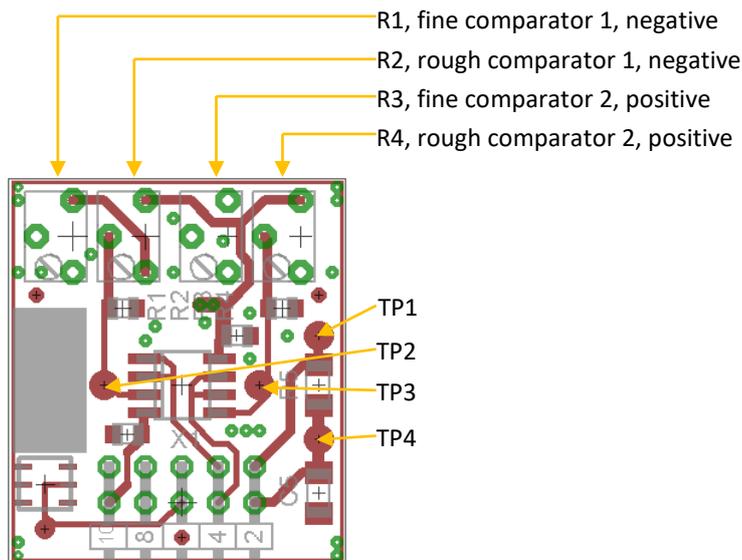
Figure 5-7: Filter-/comparator threshold module FG660.180

5.2.4.1.3.1.1   Pin assignment of the filter-/threshold module FG660.180
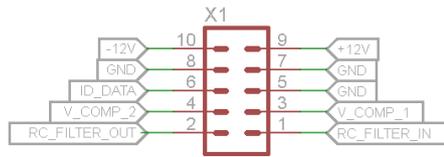
Figure 5-8: Pin assignment of the filter-/comparator threshold module FG660.180

V_Comp_2 determines the positive comparator threshold

V_Comp_1 determines the negative comparator threshold

5.2.4.1.3.1.2   Analogue filter FG660.180
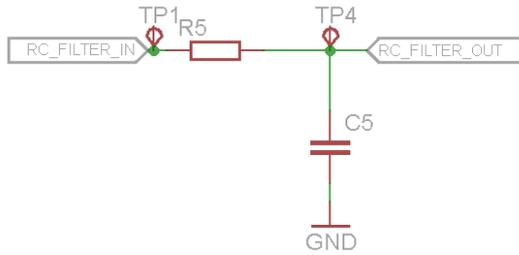
Figure 5-9: Analogue filter FG660.180

By configuring the RC part the behavior of the comparator can be changed. Default is R_5 = 10kΩ, C_5 = 1µF

5.2.4.1.3.1.3   Potentiometer for comparator thresholds of FG660.180
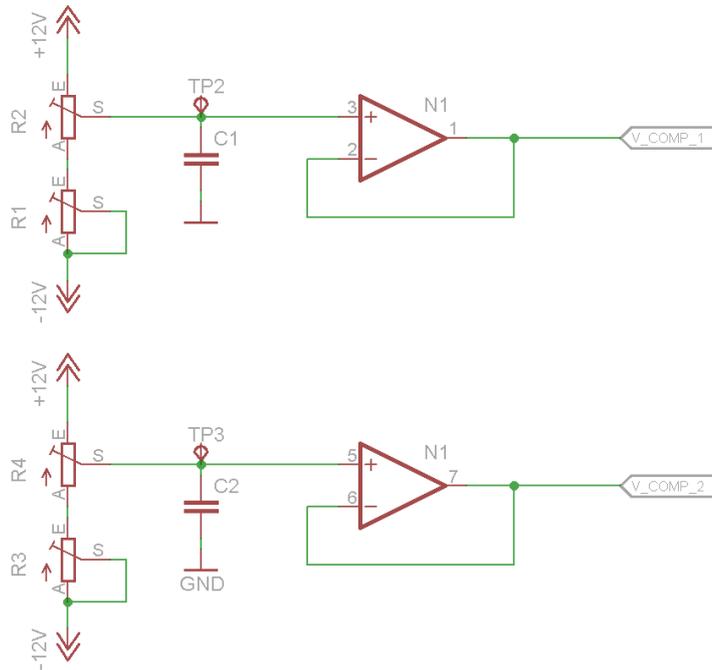
Figure 5-10: Potentiometer for comparator thresholds FG660.180

V_Comp_2 determines the positive comparator threshold

V_Comp_1 determines the negative comparator threshold

5.2.4.1.3.2   FG660.181

The comparator thresholds are further adjustable using fixed resistances in this module.

Poti R5, above: R1, fine comparator 1, negative
Poti R6, above: R2, rough comparator 1, negative
Poti R7, above: R3, fine comparator 2, positive
Poti R8, above: R4, rough comparator 2, positive

TP1
TP3
TP2
TP4
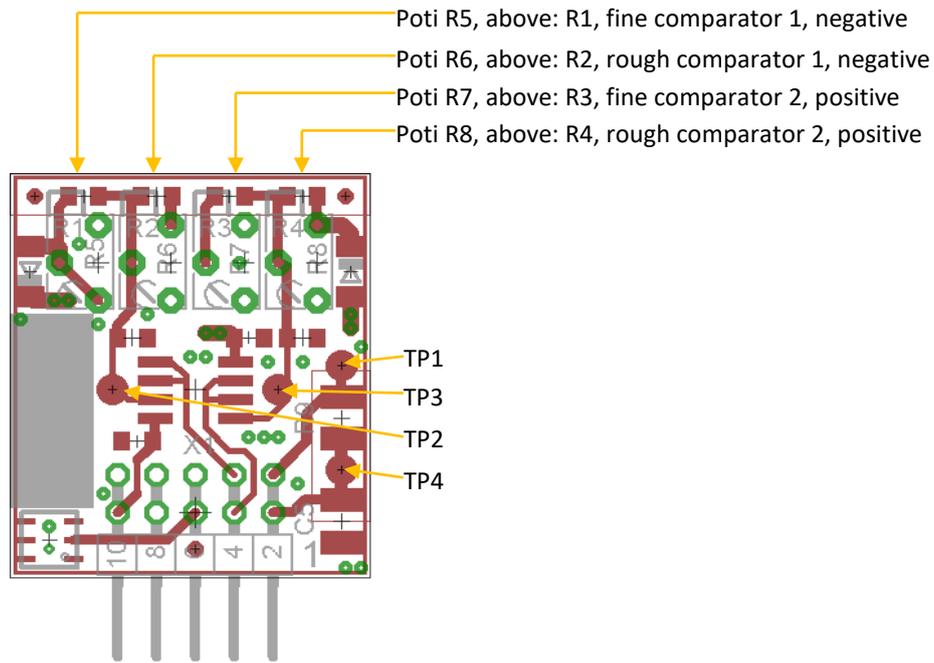
Figure 5-11: Filter-/comparator threshold module FG660.181

5.2.4.1.3.2.1   Pin assignment of the filter-/comparator module FG660.181
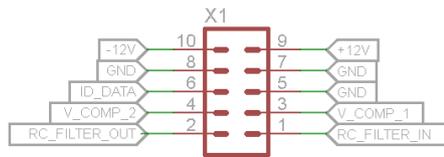
Figure 5-12: Pin assignment of the filter-/comparator module FG660.181

V_Comp_2 determines the positive comparator threshold

V_Comp_1 determines the negative comparator threshold

5.2.4.1.3.2.2   Analogue filter FG660.181
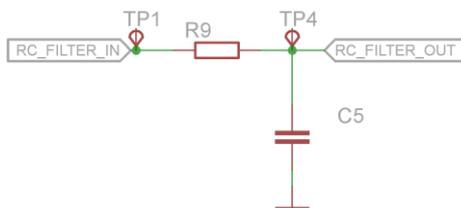
Figure 5-13: Analogue filter FG660.181

By configuring the RC part, the behavior of the comparator can be changed.

Default is $R_5 = 10k\Omega$, $C_5 = 1\mu F$

5.2.4.1.3.2.3   Potentiometer for comparator thresholds of FG660.181
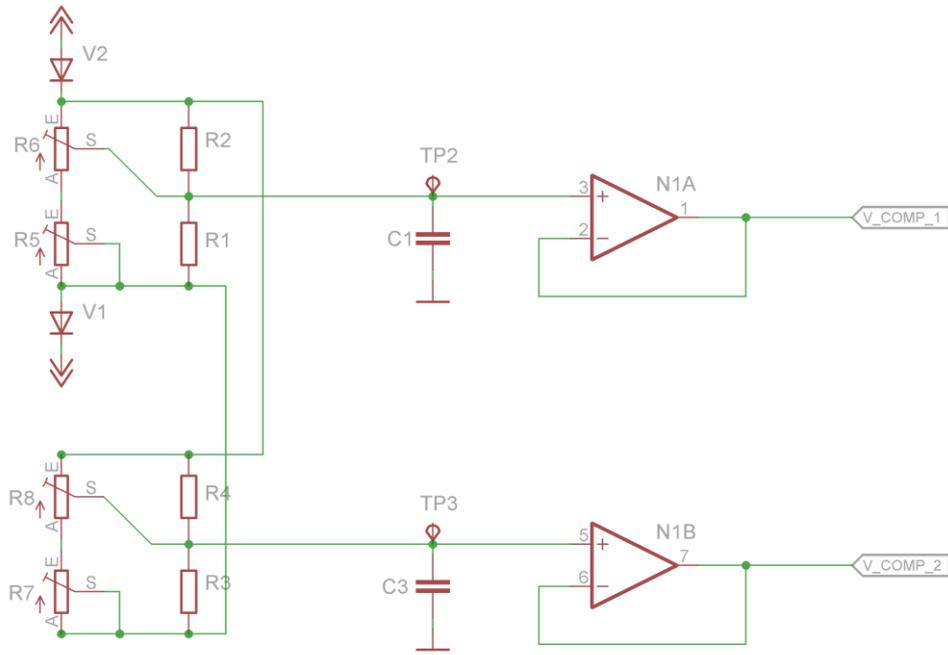
Figure 5-14: Potentiometer for comparator thresholds FG660.181

V_Comp_2 determines the positive comparator threshold

V_Comp_1 determines the negative comparator threshold

5.2.4.1.3.2.4   FG660.182

The difference between this module and FG660.181 is mainly the use of reverse voltage protection for the connectors.

Poti R_8, above: R_9, fine comparator 1, negative

Poti R_6, above: R_7, rough comparator 1, negative

Poti R_4, above: R_5, fine comparator 2, positive

Poti R_1, above: R_3, rough comparator 2, positive
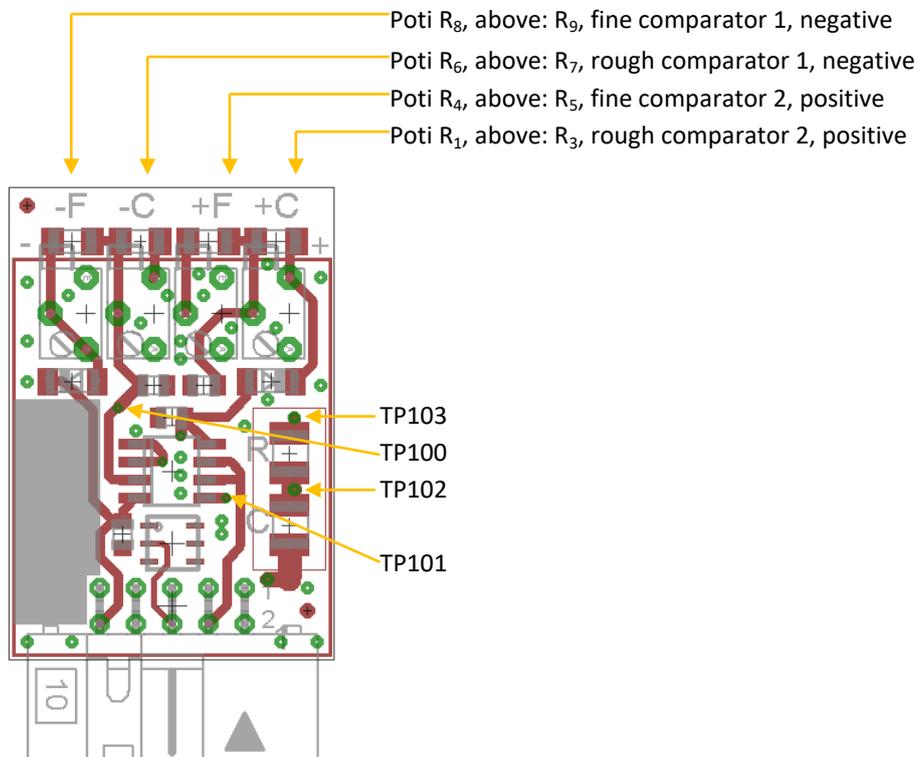
Figure 5-15: Filter-/comparator module FG660.182

5.2.4.1.3.2.5   Pin assignment of the filter-/comparator threshold module FG660.182
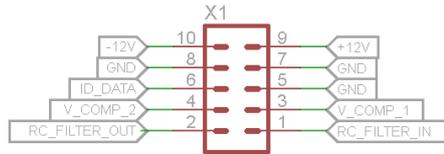
Figure 5-16: Pin assignment of the filter-/comparator threshold module FG660.182

V_Comp_2 determines the positive comparator threshold

V_Comp_1 determines the negative comparator threshold

5.2.4.1.3.2.6   Analogue filter FG660.182
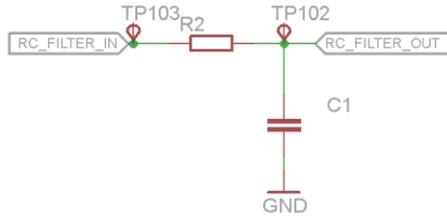
Figure 5-17: Analogue filter FG660.182

By configuring the RC part, the behavior of the comparator can be changed. Default is $R_2 = 10k\Omega$, $C_1 = 1\mu F$

5.2.4.1.3.2.7   Potentiometer for comparator threshold of FG660.182
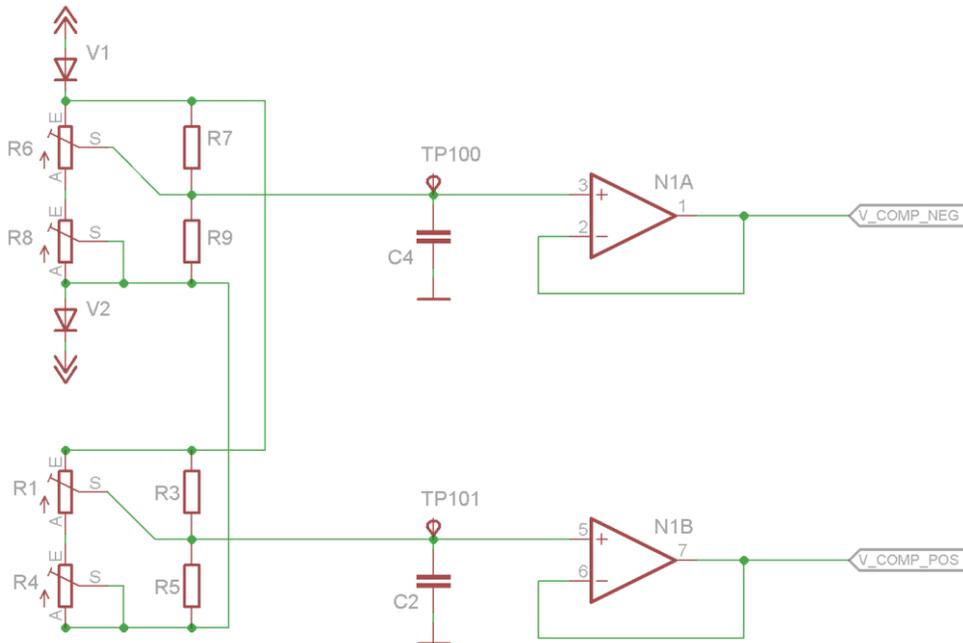
Figure 5-18: Potentiometer for comparator threshold of FG660.182

V_Comp_2 determines the positive comparator threshold

V_Comp_1 determines the negative comparator threshold

5.2.4.1.3.3   FG660.513 Tripple modul

As of ICM FG660.057, the triple module replaces the three individual modules for threshold detection for comparators 1, 3 and 5. By default, they are not equipped with all potentiometers (n.a.). Each

comparator has usually 2 potentiometers, one for coarse and one for fine adjustment.

Poti R8, R23, comparator 5 AOsc (n.a.)
Poti R9, R24, comparator 1 ULoad pos.
Poti R10, R25, comparator 1 ULoad neg.
Poti R11, R26, comparator 3 Ud pos.
Poti R12, R27, comparator 3 Ud neg. (n.a)
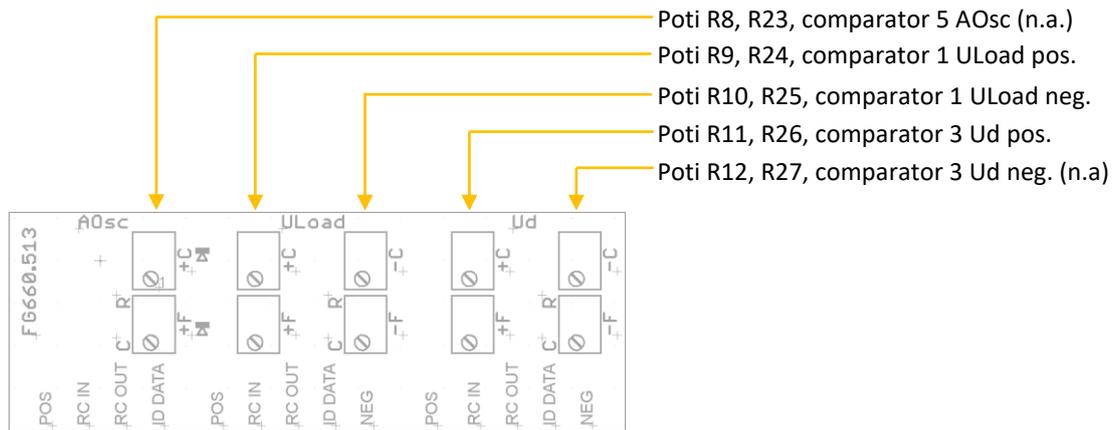
Figure 5-19: Triple Filter-/Comparator-Threshold module FG660.513

5.2.4.1.3.4 FG660.523 Double module

As of ICM FG660.057, the double module replaces the two individual modules for threshold detection for comparators 2 and 4. By default they are not equipped with all potentiometers (n.a.). Each comparator has usually 2 potentiometers, one for coarse and one for fine adjustment.

Poti R27, R12, comparator 2 Iprim neg. (n.a.)
Poti R26, R11, comparator 2 Iprim pos.
Poti R25, R10, comparator 4 IEarth neg (n.a.)
Poti R24, R9, comparator 4 IEarth pos.
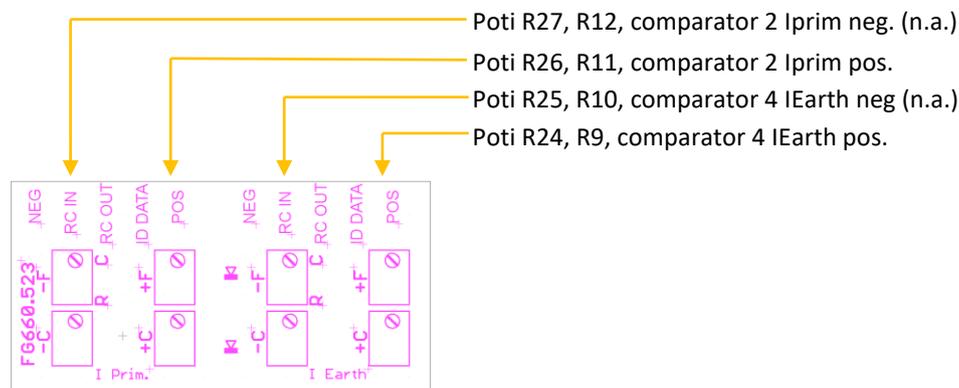
Figure 5-20: Double Filter-/Comparator-Threshold module FG660.523

5.2.4.1.4 Interlock active/inactive

If no filter-/comparator threshold module is present for a comparator, its interlocks are automatically active. So, such a module has to be present all the time and the threshold needs to be configured properly so the comparator does not trigger any interlocks.

5.2.4.1.5 Trip line

The analogue electrical interlock acquisitions (comparators) 1 to 4 affect trip lines 1 to 4. To configure these trip lines, please refer to chapter 5.2.4.3: "Trip line configuration of the comparators 1 to 4 and 5".

5.2.4.2 Unipolar comparator 5

The ICM contains a unipolar comparator with adjustable switch threshold from 0 to 11V. This comparator has no own multi-pin connector to receive signals. It gets its signals via the multi-pin connector of the first bipolar comparator.

If the load voltage gets measured at comparator 1, the oscillation monitoring is realized via comparator 5.
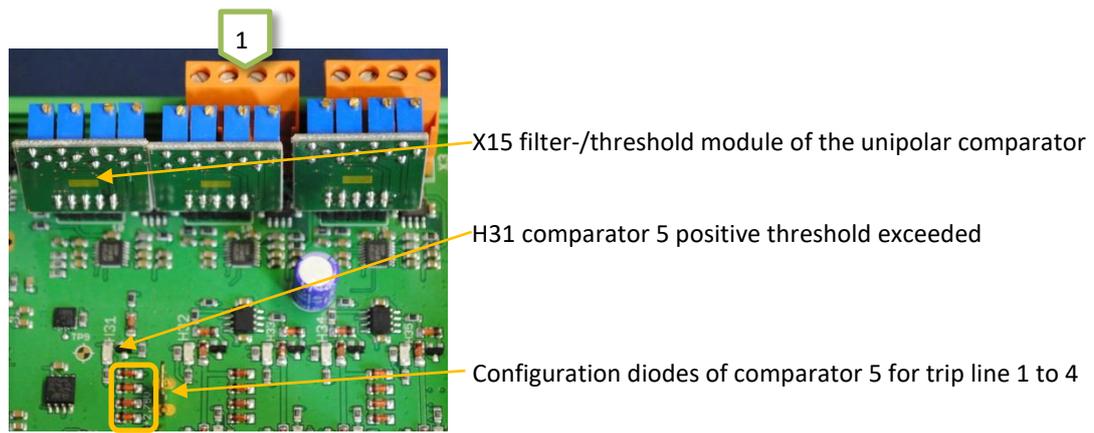
Figure 5-21: unipolar comparator 5

For further information, refer to chapter 5.2.4.1.

5.2.4.2.1   LED

The LED H31 glows in case of an error of comparator 5.

5.2.4.3   Trip line configuration of the comparators 1 to 4 and 5

The comparators affect all 4 trip lines. This can be configured using 4 diodes.

Figure 5-22: Trip line configuration of the comparators

In Figure 5-22 the comparators are specific to trip lines 1 to 4. If any trip lines should be excluded from the system, their respective diodes have to be removed.

5.2.5   Digital electrical interlock acquisition 1...10

10 galvanically isolated ports for digital, electrical interlocks, like for example door switches, water or temperature monitoring.

Important: In theory, all 10 interlock acquisitions can be considered equal. The first electrical, digital interlock input (green) is configured for responses of the main protection after a reset. Refer to the chapter 5.2.3: "Special functions of the interlock acquisition". This configuration can be modified.
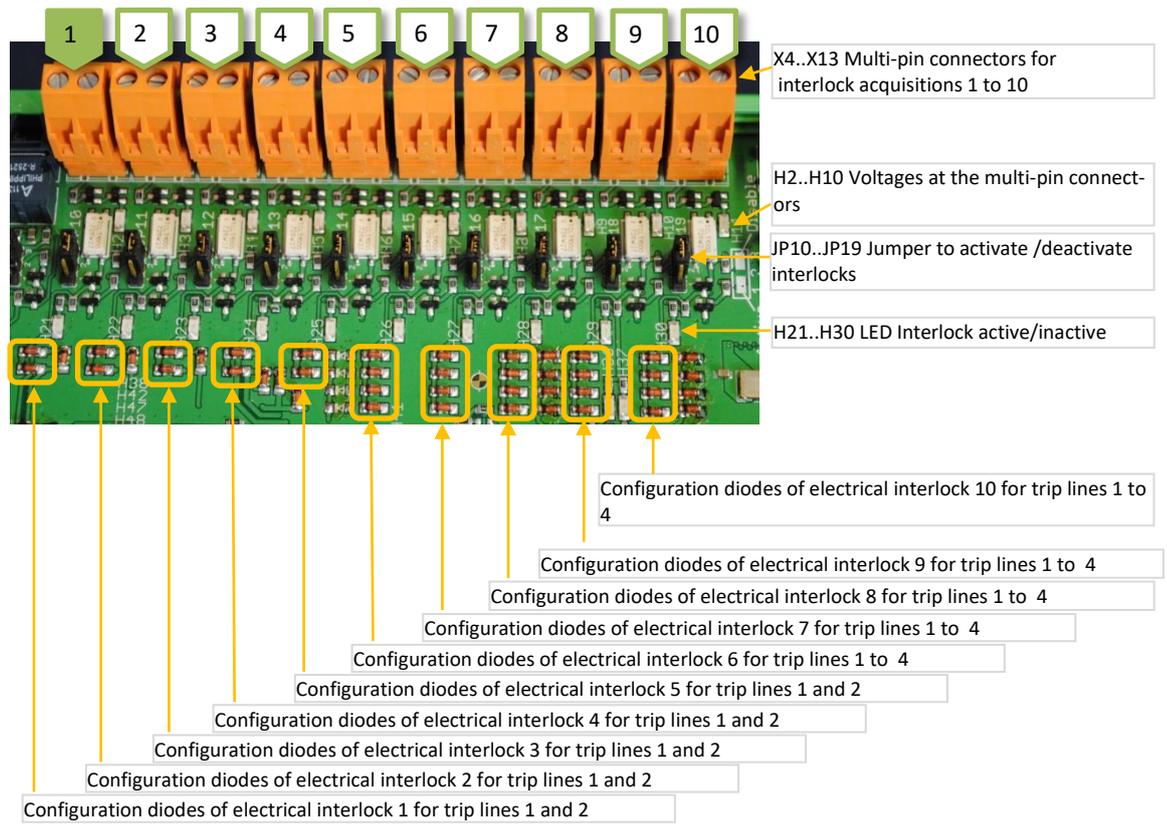
Figure 5-23: Digital, electrical interlock acquisition
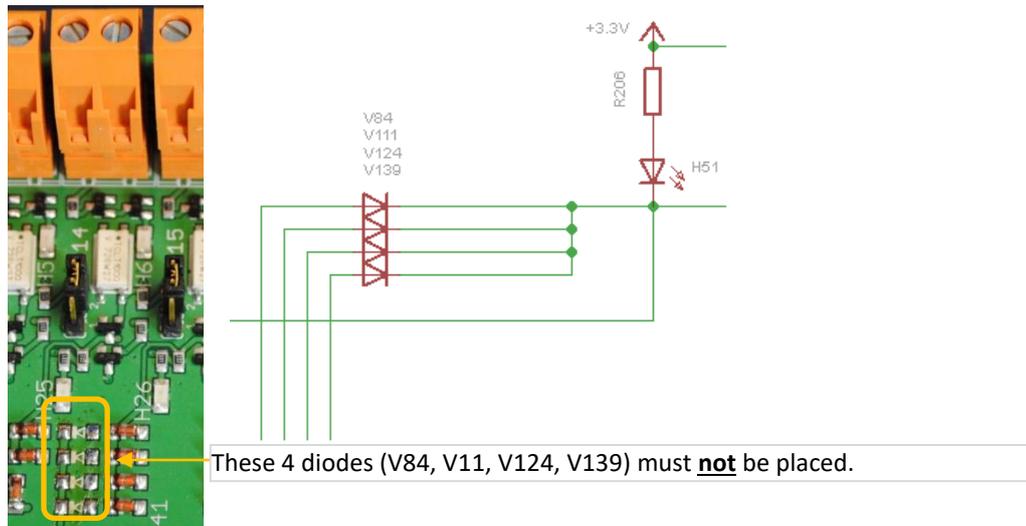
Figure 5-24: Basic trip line configuration

5.2.5.1 LEDs

The LEDs H2..H10 indicate voltage at the respective digital, electrical interlock port.

The LEDs H2w1..H30 glow in case of an error at the respective digital, electrical interlock port.

5.2.5.2 Channel configuration

Each channel requires an external 24V direct voltage at its terminal clips. Every interlock is active if this voltage is interrupted.

1= +24V

2= GND
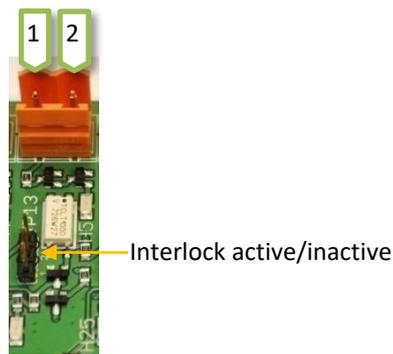
Figure 5-25: Terminal clip of an electrical interlock

5.2.5.3   *Activate/deactivate interlocks*

This jumper activates/deactivates the channel to be used as electrical, digital interlock.

Pins 1-2   channel is active
Pins 2-3   channel is inactive

5.2.5.4   *Trip line configuration of the digital, electrical interlocks 1 to 10*

The digital, electrical interlocks 1 to 5 affect trip lines 1 and 2. Interlocks 6 to 10 belong to trip lines 1 to 4.

This can be configured used 2 or 4 diodes.

Figure 5-26: Trip line configuration of digital, electrical interlocks 1 to 5

In Figure 5-26 the digital, electrical interlocks 1 to 5 belong to trip lines 1 and 2. If these trip lines are not supposed to be used, the respective diodes have to be removed.

Figure 5-27: Trip line configuration of digital, electrical interlocks 6 to 10

In Figure 5-27 the digital, electrical interlocks 6 to 10 belong to trip lines 1 to 4. If these trip lines are not supposed to be used, the respective diodes have to be removed.

5.2.6   Digital, optical interlock acquisition 1...8 and 9

D3..D11 optical interlock ports

JP1..JP9 activate/deactivate interlocks

H12..H20 LED Interlock active/inactive

Configuration diodes for digital, optical interlock 9 (Quench Detection) for trip lines 1 to 4

Configuration diodes for digital, optical interlocks 1 to 8, for trip lines 1 to 4
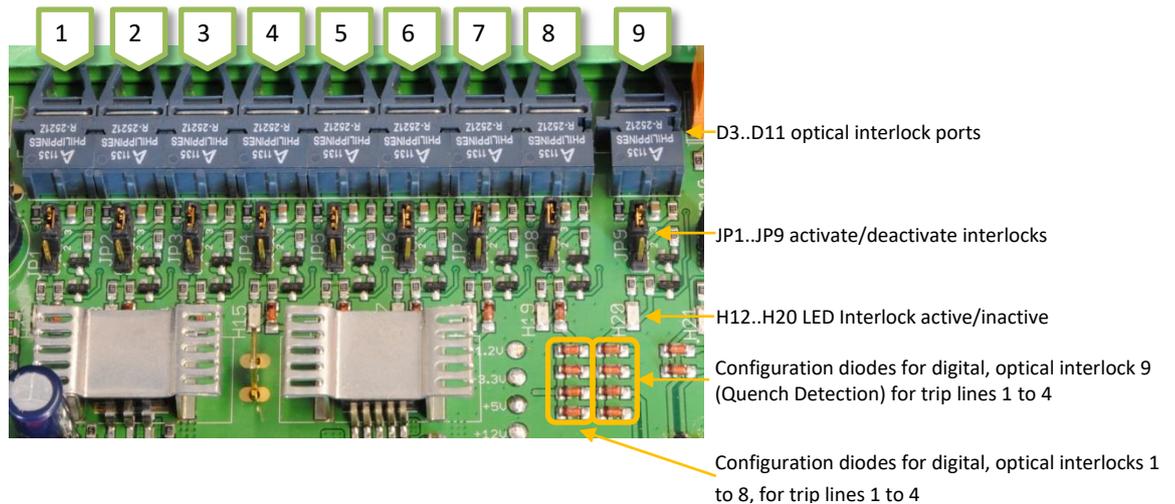
Figure 5-28: Digital, optical interlock acquisition

8 digital acquisitions for optical interlock sources, like for example messages of the IGBT driver. In addition to that, there is a 9th digital acquisition for Quench detection.

5.2.6.1   Activate/deactivate interlocks

This jumper activates/deactivates the channel for digital, optical interlocks.

1-2   Channel is active
2-3   Channel is inactive

5.2.6.2   LEDs

The LEDs H12..H20 glow in case of an error at the respective digital, optical interlock port.

5.2.6.3   Trip line configuration of digital, optical interlock acquisitions 1..8

The digital, optical interlock acquisitions 1 to 8 affect trip lines 1 to 4. The can be configured using 4 diodes.

Trip line 1
Trip line 2
Trip line 3
Trip line 4
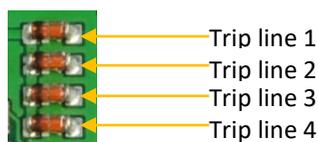
Figure 5-29: Trip line configuration of the digital, optical interlock acquisitions 1..8

In Figure 5-29 the digital, optical interlock acquisitions 1 to 8 belong to trip lines 1 to 4. If these trip lines are not supposed to be used, the respective diodes have to be removed.

5.2.6.4   Trip line configuration of the Quench Detection

The Quench detection interlock acquisition affects trip lines 1 to 4. This can be configured using 4 diodes.

Trip line 1
Trip line 2
Trip line 3
Trip line 4
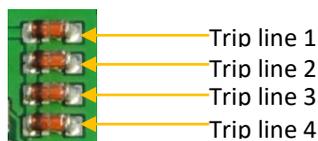
Figure 5-30: Trip line configuration of the Quench Detection

In Figure 5-30 the Quench Detection belongs to trip lines 1 to 4. If these trip lines are not supposed to be used, the respective diodes have to be removed.

5.2.7 16 Bit Extension port

Figure 5-31: 16 Bit Extension port

The extension port allows connecting extension boards to the ICM, for example to increase to amount of interlock ports or outputs for additional control pulses or signals.

Please note: If no extension module is used, a jumper needs to be set on pins 9 and 10.

5.2.8 Water flow control and regulation

The ICM has a separated input / output for the connection of 2 water flow monitors to control and regulate water flow by means of control valves.

The module can operate either with variable area flow meters or turbine flow meters. If no flow rates are configured, the connections of the water flow monitors are automatically defined for area flow meters. Here no pulses are counted and the flow is not calculated. Only the state at the terminals is recorded. Is the voltage between 12 and 24 volts, then the input is considered to be valid, otherwise an interlock is generated. If, however, flow rates for the water detector are parameterized, then pulses of turbine flow meter are counted on the monitored terminals and converted into flow rates according to the parameterization.

On the basis of the calculated flow rate a valve for flow rate control can be controlled via the two Schmitt trigger outputs.
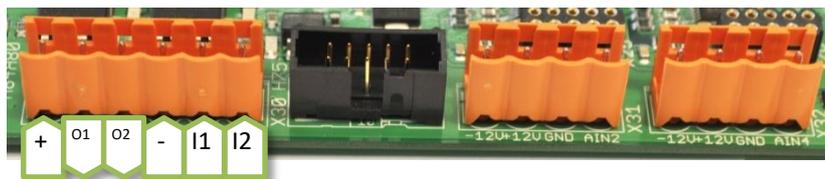
Figure 5-32: Water flow control

+   Power supply of the Output Schmitt-Trigger and for
      the pulse measurement I1 and I2 (usually +24 volts)

O1   Output Schmitt-Trigger 1 (RC)

O2   Output Schmitt-Trigger 2

-      Power supply of the Output Schmitt-Trigger (usually GND)

I1   Pulse entry 1

I2   Pulse entry 2

5.2.8.1 O1 Schmitt-Trigger Output 1 (RC)

Provides the delayed "Open" command for a connected solenoid valve. In this case, the RC filter is not to be fitted (see Figure 5-33). For the control of a valve with an analog control voltage, the RC filter for smoothing the PWM square-wave voltage is used. The output O2 is not used.

Figure 5-33: O1 Schmitt-Trigger 1 Output (RC)

5.2.8.2   O2 Schmitt-Trigger Output 2

Provides a not delayed "Close" command for a connected solenoid valve.

5.2.8.3   I1 and I2 pulse measurement

Up to 2 area flowmeters and / or turbine flow meters can be connect optionally here. Pulse measurement I1 takes place via X30-5, pulse measurement I2 via X30-6.

Please note that the power supply for pulse measurement is X30-1. Thus, the pulse measurement connections are in fact not inputs, but rather are connected via a flowmeter with NC / NO switches to ground.

Figure 5-34: I1 and I2 pulse measurement up to and including FG660.058

Figure 5-35: I1 and I2 pulse measurement from FG660.059

5.2.8.3.1   NPN or PNP turbine monitor

When using turbine monitors, care must be taken to use an NPN type (because they are connected to the cathode of the optocoupler LED).

If a PNP type is used, an additional pull-down on the cathode of the optocoupler LED is required.

Alternatively, the following connection diagrams can be used for turbine monitors of type RRIxx from (GHM) Honsberg.

Figure 5-36: Connect RRIxx NPN and PNP turbine monitors from (GHM) Honsberg to the ICM

5.2.9   External temperature sensors
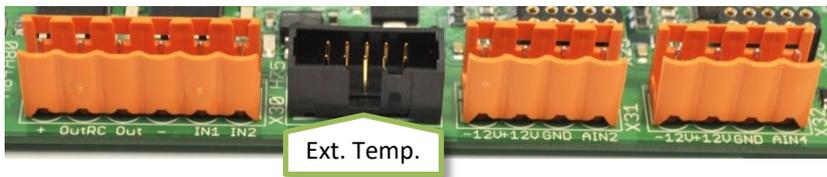
Figure 5-37: Sockets for external temperature sensors

X27 allows the connection of external ADT7410 temperature sensors via I²C.

Pin	Function
1	SCLK
2	GND
3	SDA
4	GND
5	3V3
6	3V3
7	GND
8	GND
9	-
10	-

Table 5-2: X27 pin assignment for external ADT7410 temperature sensors

5.2.10   Electrical switch outputs 1...4

Figure 5-38: Electrical switch output

4 electrical switch outputs for i.e. main and/or load contactor.

5.2.10.1 LEDs

In case an electrical switch output is active, its respective LED is glowing.

LED	Ausgang
H56	1 (EO1)
H57	2 (EO2)
H58	3 (EO3)
H59	4 (EO4)

Table 5-3: Allocation of the LEDs of the electrical outputs

5.2.10.2 Pin assignment of the multi-pin connector

Two switch outputs share one multi-pin connector regarding the power supply.
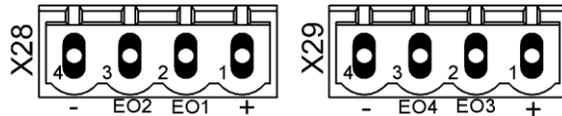
Figure 5-39: View of the electrical switching outputs from above

From left to right

4. Ground (-)
3. Switch output (2) (4)
2. Switch output (1) (3)
1. Power supply input (+) (usually +24V)

5.2.10.3 Pin assignment of the electrical switch outputs

Output	Function
1 (E01)	Load Contactor
2 (E02)	Main Contactor
3 (E03)	Personal Protection System (if PPS is active, the switch output is open)
4 (E04)	External control lock (if the control is locked, the switch output is open)

Table 5-4: Pin assignment of the electrical switch output

5.2.10.3.1 Peculiarity of the PSS

A personal protection system can be implemented via the electrical switching output 3.

Unfortunately, there is a layout error in this regard on the ICM. If the PSS is to be used, there are 2 options:

1. Fix the layout error
2. Use the optional ICM SPI Hub and the SPI I/O Extension Module.

The locking signal for personal protection is output via electrical output 3. In the event of an interlock, there should be an active signal here. Unfortunately, this is not possible due to a layout error, since the supply voltage of the optocoupler driver LED is switched off in the event of a locking.

It is therefore necessary to add a solder bridge. This connects JP20 (top solder pad, permanent +5V) and the anode of H58. H58 must be installed vertically to leave only the cathode connected to the ICM PCB.
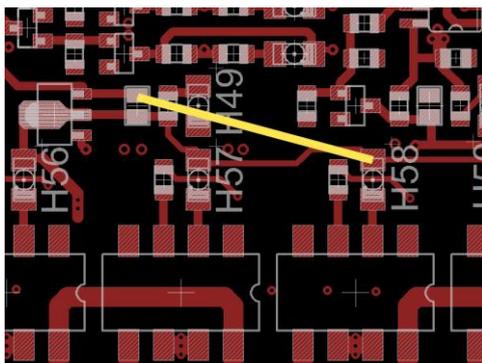
Figure 5-40: Installation of a solder bridge in the ICM when using the PSS on the electrical switching output
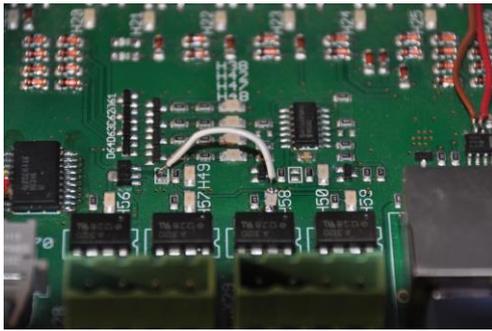
Figure 5-41: Realization on the printed circuit board

Alternatively, you can use the optional ICM SPI hub and an SPI I/O extension module for the PSS.

5.2.11   *Pulse logic outputs IGBT V1...V8*

Figure 5-42: Pulse logic outputs for IGBTs

8 optical switch outputs for IGBT pulse logic.

2 outputs are electrically isolated from each other, which means that output 1 and output 2 can't get light at the same time. This prevents 2 IGBTs of a bridge are connected through at the same time.

5.2.12   *USI In-/Outputs*

H51 USI Slave 1 status via external trip line

Configuration diodes of USI Slave 1 and 2 inputs for trip lines 1 to 4

H41 USI Slave 1 and 2 statuses for trip lines clearance at the module

H52 USI Slave 1 status for external trip line

H53 USI Slave 2 status for external trip line

Configuration diodes USI Master 1 for trip lines 1 to 4

H54 USI Master 1 status for external trip lines

Configuration diodes USI Master 2 for trip lines 1 to 4

H55 USI Master 2 status for external trip line

H77..H80, H81..H84 communication LEDs

Figure 5-43: USI In-/Outputs

4 USI ports

5.2.12.1 USI Slave

USI S1 and S2 are USI Slaves. USI S1 realizes the connection to the MFU.

5.2.12.2 USI Master

USI M1 and M2 are USI Masters and are used for optional system extensions.

5.2.12.3 Communication LEDs (H77..H80, H81..H84)

These 8 LEDs belong to 4 USI channels and show status information about the communication. If the USI is in normal mode the LEDs glow red during sending and receiving of data. If the USI in in High-speed mode the LEDs glow green and briefly switch off when data is "tunneled".

H77..H80 Module receives data

H81..H84 Module sends data

USI Master 2

USI Master 1

USI Slave 2

USI Slave 1

LED flashes/glows red　　: USI normal mode

LED flashes/glows green　: USI HighSpeed mode
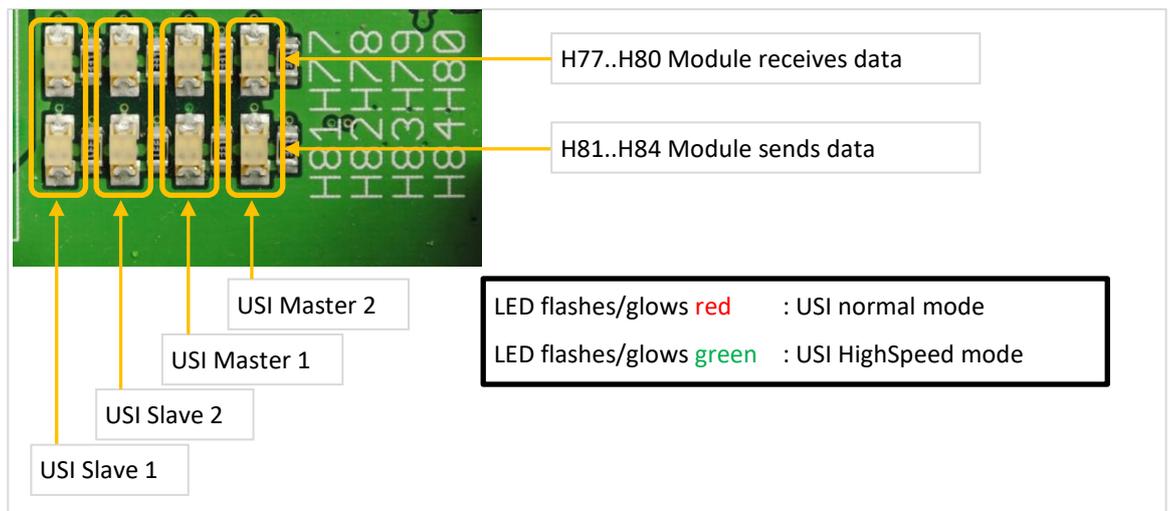
Figure 5-44: USI communication LEDs

5.2.12.4 Trip lines

The USI ports S1, M1 and M2 affect trip lines 1 to 4.

5.2.12.5 Trip lines configuration of USI Slave inputs 1 und 2

The USI Slave inputs 1 and 2 together affect trip lines 1 to 4. This can be configured using 4 diodes.

Trip line 1
Trip line 2
Trip line 3
Trip line 4
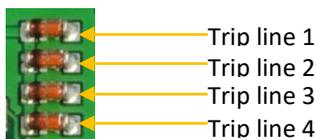
Figure 5-45: Trip line configuration of the USI Slave inputs

In Figure 5-45 the USI Slave inputs belongs to trip lines 1 to 4. F these trip lines are not supposed to be used, these diodes have to be removed.

5.2.12.6 Trip line configuration of USI Master 1 and 2

The USI Master 1 and 2 affect the trip lines 1 to 4 separately. This can be configured using 4 diodes.

Trip line 1
Trip line 2
Trip line 3
Trip line 4
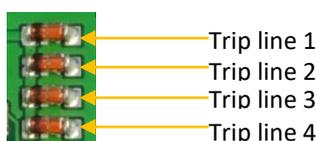
Figure 5-46: Trip line configuration of USI Master 1 and 2

In Figure 5-46 the USI Master 1 or 2 respectively, belong to trip lines 1 to 4. If these trip lines are not supposed to be used, the respective diodes have to be removed.

5.2.13 Trip line sum LEDs

If a trip line is pulled from any interlock source, the related trip line sum LED is turned off.

H38 Trip line sum 1
H42 Trip line sum 2
H47 Trip line sum 3
H48 Trip line sum 4

H50 Error memory Trip line sum 2
H49 Error memory Trip line sum 1
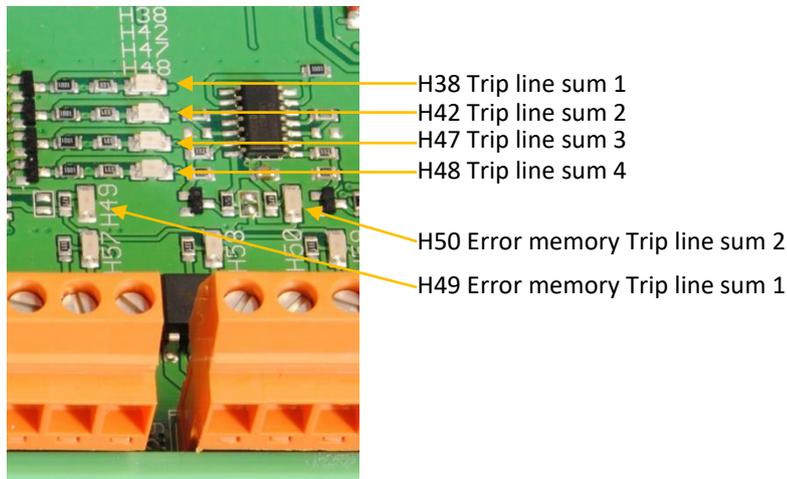
Figure 5-47: Trip line sum LEDs

5.2.14 Error storage LEDs

The trip line sums 1 and 2 each contain an error memory flip-flop. This flip-flop is set in case of an error and the related LED (H49 → trip line sum 1, H50 → trip line sum 2) goes off (refer to Figure 5-47). Once an error is removed, the related LED goes back on in case no further error is present.

5.2.15 Status LEDs

4 Status LEDs (H71..H74) show status information about the ICM.

Status control release

Status trigger line

Status sum interlock

Heartbeat LED
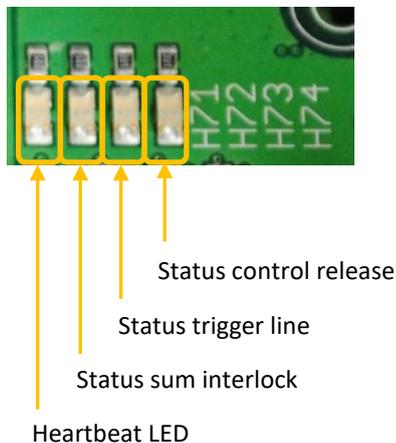
Figure 5-48: Status LEDs

5.2.15.1 Status controller release:

glows red:　Controller is locked

glows green:　Controller is released

5.2.15.2 Status trigger line:

glows red:　Hardware trigger line is open

glows green:　Hardware trigger line is closed

5.2.15.3 Status sum interlock:

glows red: A sum interlock is present

glows green: No sum interlock

5.2.15.4 Heartbeat:

Flashes green to indicate that a hardware configuration was loaded for the FPGA.

6   Water-Flow-Interlock- and Control Module (FG660.151)

The present description in this chapter is for the hardware release mentioned in the headline. Older or newer versions of this module may have different markings regarding connectors, plugs, components and so on. In most cases the functions are identical. In case there are any doubts, please refer to the images or contact support.

6.1   Overview

This module serves as an interface for up to 10 water flow monitors. In addition, external temperature sensors and a valve can be connected to control the cooling water flow or to measure external temperature conditions.

The module can operate either with variable area flow meters or turbine flow meters. If no flow rates are configured, the connections of the water flow monitors are automatically defined for area flow meters.

The default interlock names and controls given in Table 6-1: are for turbine flow meters.

Here no pulses are counted and the flow is not calculated. Only the state at the terminals is recorded. Is the voltage between 12 and 24 volts, then the input is considered to be valid, otherwise an interlock is generated. In this configuration an interlock always fires both to the port assigned interlock bits.

If, however, flow rates for the water detector are parameterized, then pulses of turbine flow meter are counted on the monitored terminals and converted into flow rates according to the parameterization.

6.2   View of the WICM

8 connectors for (turbine) flow meters

USI interface

Module supply

Outputs for valve control and 2 inputs for additional flow meters

Connector for external temperature sensors

16 bits extension connector
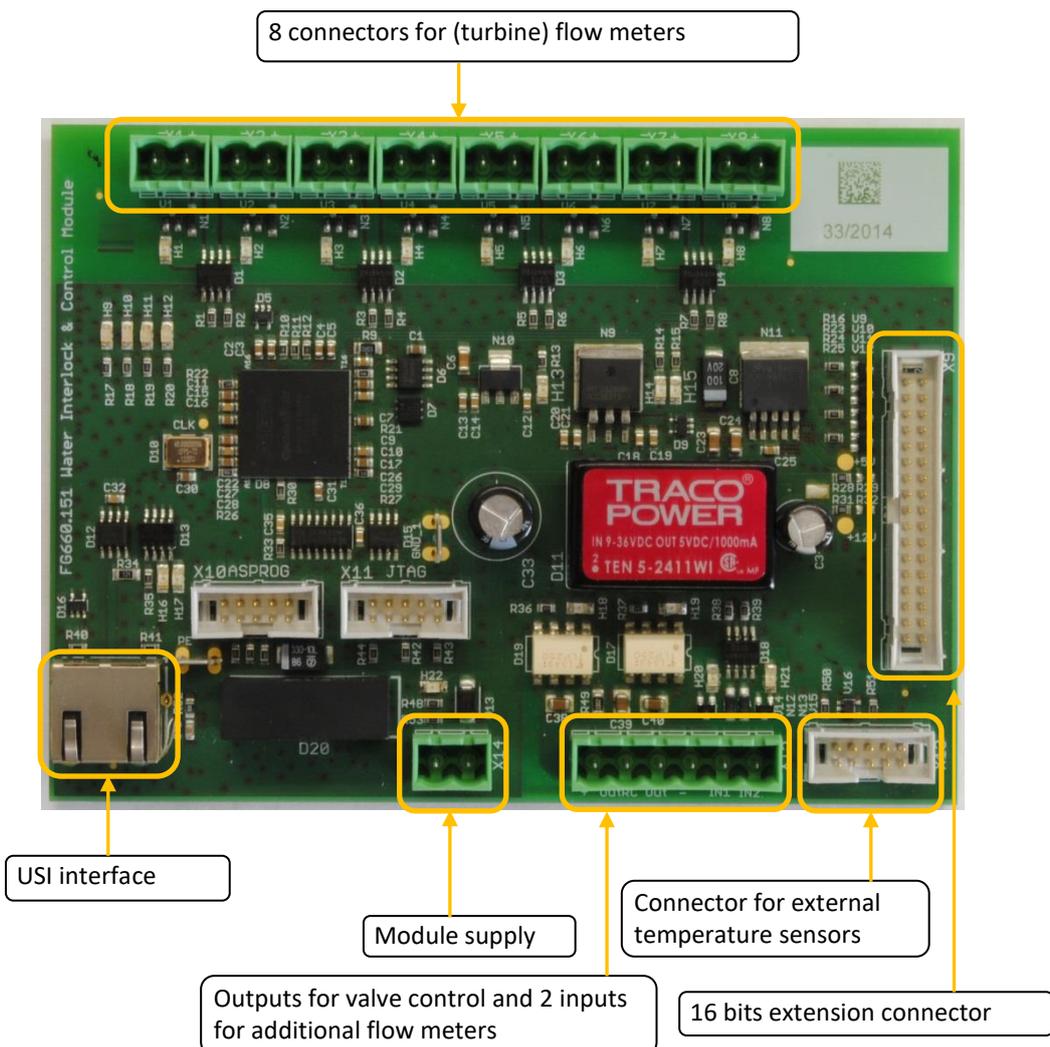
Figure 6-1: Top view of the WICM

6.3   Configuration and Control

6.3.1   Current GSI default distribution of interlocks

Refer to chapter 6.1: "Overview" with notes about the interlock texts.

The WICM can handle up to 20 different interlock sources. These sources are as follows:

Bit	Type	Name	Monitoring	Default text
0	Digital electrical	um00	Flow meter 1 flow to low	H2OFlowToLow_01
1	pulse monitoring	um01	Flow meter 1 flow to high	H2OFlowToHigh_01
2	in case of tur-	um02	Flow meter 2 flow to low	H2OFlowToLow_02
3	bine flow meter	um03	Flow meter 2 flow to high	H2OFlowToHigh_02
4	or input condi-	um04	Flow meter 3 flow to low	H2OFlowToLow_03
5	tion in case of	um05	Flow meter 3 flow to high	H2OFlowToHigh_03
6	variable area	um06	Flow meter 4 flow to low	H2OFlowToLow_04
7	flow meter.	um07	Flow meter 4 flow to high	H2OFlowToHigh_04
8		um08	Flow meter 5 flow to low	H2OFlowToLow_05
9		Um09	Flow meter 5 flow to high	H2OFlowToHigh_05
10		um10	Flow meter 6 flow to low	H2OFlowToLow_06
11		um11	Flow meter 6 flow to high	H2OFlowToHigh_06
12		um12	Flow meter 7 flow to low	H2OFlowToLow_07
13		um13	Flow meter 7 flow to high	H2OFlowToHigh_07
14		um14	Flow meter 8 flow to low	H2OFlowToLow_08
15		um15	Flow meter 8 flow to high	H2OFlowToHigh_08
16		um16	Flow meter 9 flow to low	H2OFlowToLow_09
17		um17	Flow meter 9 flow to high	H2OFlowToHigh_09
18		um18	Flow meter 10 flow to low	H2OFlowToLow_10
19		um19	Flow meter 10 flow to high	H2OFlowToHigh_10
20	-	−	-	Unused20
21	-	−	-	Unused21
22	-	−	-	Unused22
23	-	−	-	Unused23

Table 6-1: Default interlocks definition for the WICM

with:

<u> :   USI number
<m> :   module number

6.3.2   Flow meter 1..8

Here up to 8 flow meters can be connected. Depending on the parameterization either classical area flow meter or turbine flow meter that generate measuring pulses that can be counted internally.
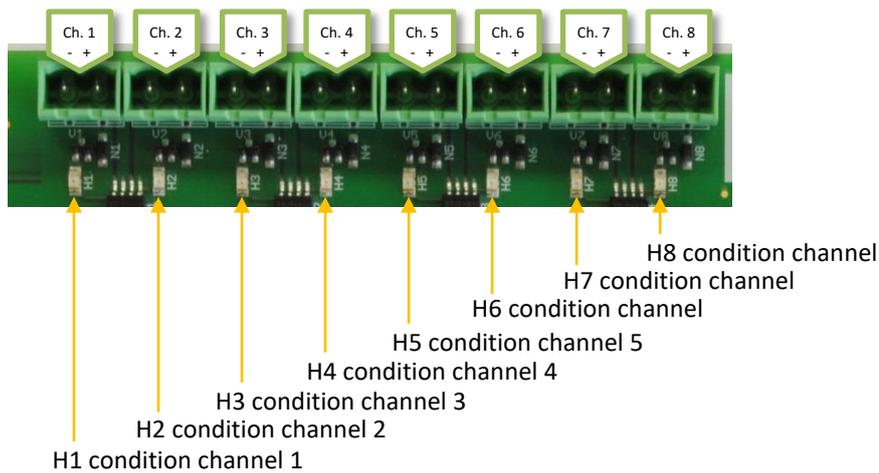
Figure 6-2: Flow meter 1..8

6.3.2.1 *LEDs H1..H8*

Indicate the channel related input condition. If the input is set to '1' the LED glows, otherwise the LED is off.

6.3.3 *Flow meter 9 and 10 and valve control*

The WICM has separated inputs / outputs to connect up to 2 additional water flow meters and to control the water flow by means of connected valves.

The module can operate either with variable area flow meters or turbine flow meters. If no flow rates are configured, the connections of the water flow monitors are automatically defined for area flow meters. Here no pulses are counted and the flow is not calculated. Only the state at the terminals is recorded. Is the voltage between 12 and 24 volts, then the input is considered to be valid, otherwise an interlock is generated. If, however, flow rates for the water detector are parameterized, then pulses of turbine flow meter are counted on the monitored terminals and converted into flow rates according to the parameterization.

Based on the calculated flow rate a valve for flow rate control can be controlled via the two Schmitt trigger outputs.
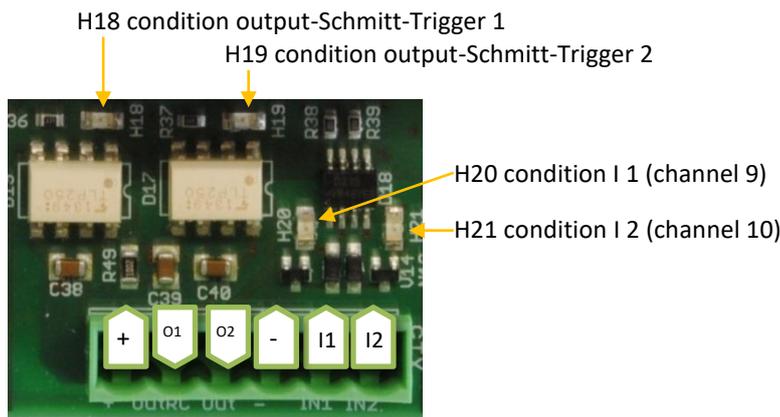
Figure 6-3: water flow control

+   Power supply of the Output Schmitt-Trigger (usually +24 volts)

O1   Output Schmitt-Trigger 1 (RC)

O2   Output Schmitt-Trigger 2

-     Power supply of the Output Schmitt-Trigger (usually GND)

I1   Pulse entry 9

I2   Pulse entry 10

6.3.3.1   O1 output Schmitt-Trigger 1 (RC)

Provides the delayed "Open" command for a connected solenoid valve. In this case, the RC filter is not to be fitted (see Figure 5-33). For the control of a valve with an analog control voltage, the RC filter for smoothing the PWM square-wave voltage is used. The output O2 is not used.
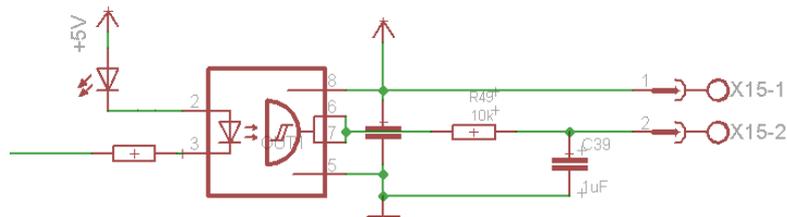
Figure 6-4: O1 output Schmitt-Trigger 1 (RC) for valve control

6.3.3.2   O2 Schmitt-Trigger Output 2

Provides a not delayed "Close" command for a connected solenoid valve.

6.3.3.3   I1 and I2 pulse inputs

Here up to 2 area flowmeters and / or turbine flow meters can be connect optionally.

6.3.4   External temperature sensors

Figure 6-5: Sockets for external temperature sensors

X13 allows the connection of external ADT7410 temperature sensors via I²C.

Pin	Function
1	SCLK
2	GND
3	SDA
4	GND
5	3V3
6	3V3
7	GND
8	GND
9	-
10	-

Table 6-2: X27 pin assignment for external ADT7410 temperature sensors

6.3.5   Spannungsversorgung

The needed module supply is +24 volts DC and has to be connected to X14.
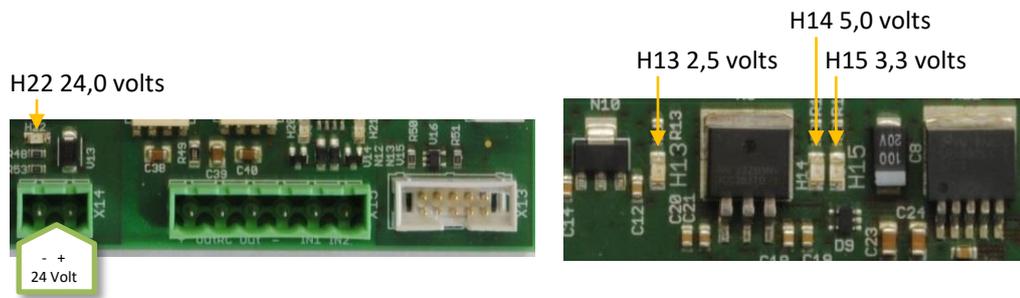
Figure 6-6: Module supply and related control LEDs

6.3.6   *Status LEDs*

4 status LEDs (H17..H20) indicate status information about the WICM.
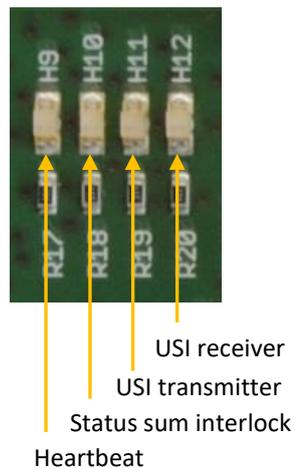
Figure 6-7: Status LEDs

6.3.6.1   *Status USI receiver:*

glows red: in USI standard mode when data is received

glows green: in USI high-speed mode and turns off shortly when data is tunneled

6.3.6.2   *Status USI transmitter:*

glows red: in USI standard mode when data is transmitted

glows green: in USI high-speed mode and turns off shortly when data is tunneled

6.3.6.3   *Status sum interlock:*

glows red: A sum interlock is present

glows green: No sum interlock

6.3.6.4   *Heartbeat:*

It flashes green to indicate that a hardware configuration was loaded for the FPGA.

7   Static Current Converter Module (FG660_091)

7.1   Communication LEDs (H78..H81, H82..H85)

The eighth LEDs are assigned to the 4 USI Master and 4 USI Slave channels and show status information about the communication. Is a USI in normal mode the belonging led always lights up red when data is received or transmitted. Is a USI in high-speed mode the belonging led lights up always green and turns of for a short moment when data is tunneled over HighSpeed.

USI Master: the static converter module is the master module the connected modules are slave modules.

USI slave: the static converter module is the slave module. The connected modules have to work here as Master (eg MFU or PC)

H78..H81 USI Master 1 to 4

H82..H85 USI Slave 1 to 4

LED flashes/glows red   : USI normal mode

LED flashes/glows green   : USI HighSpeed mode
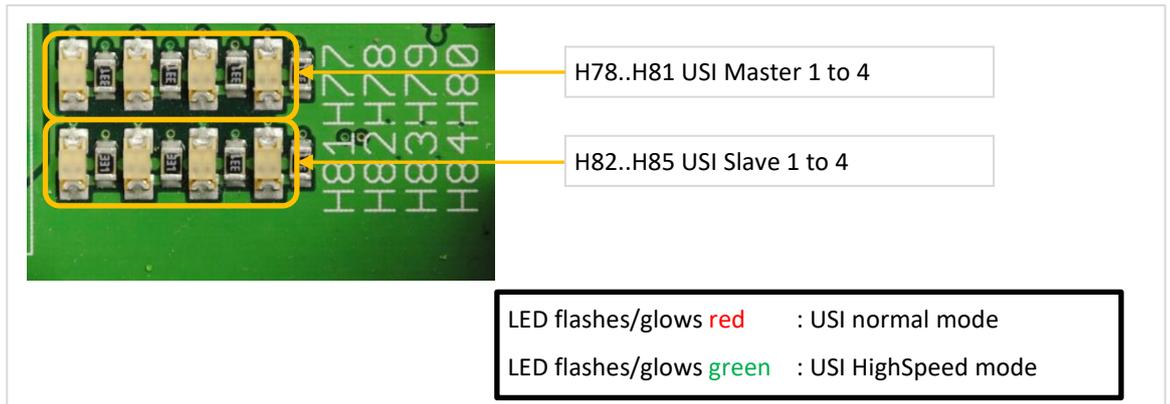
Figure 7-1: USI communication LEDs

7.2   Status LEDs

4 status LEDs (H54..H57) show status information of the current converter module.

Status controller enabled/disabled

Status USI Master Trip Line

Status Sum Trip Line

Heartbeat
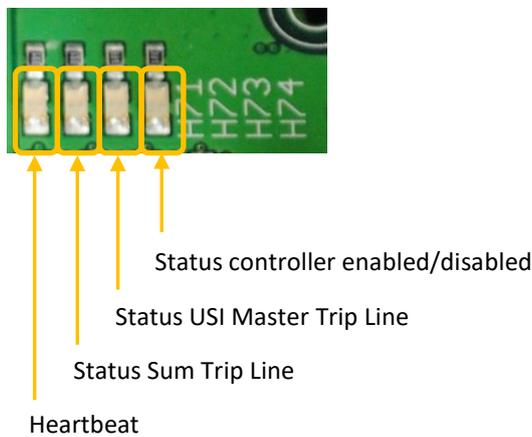
Figure 7-2: Status LEDs

7.2.1   Status controller enabled/disabled

glows red: controller disabled

glows green: controller enabled

7.2.2   Status USI Master Trip Line

glows red: Master hardware trip line is open

glows green: Master Hardware trip line is closed

7.2.3   Status Sum Trip Line

glows red: pending sum interlock

glows green: no interlocks

7.2.4   Heartbeat

It flashes green to indicate that a hardware configuration was loaded for the FPGA.

8 ADC-DAC-IO Module (FG660_10x)

The ADC-DAC-IO module is a multifunctional printed circuit board that combines a wealth of different functions.

- 18-bit ADC with comparator (positive, negative threshold selectable)
- 4 independent bipolar voltage acquisitions with user-definable gain
- 4 16-bit DAC outputs
- 16 freely definable I/O ports (each in groups of 4) for interlock acquisition or switching outputs
- USI interface

This means that universal use can be implemented.

8.1 View of the module

Figure 8-1: ADC-DAC-IO-Modul

PIN		Assignment		Assignment		Assignment
1	A	+5V In	B	+5V In	C	+5V In
2	A	GND	B	GND	C	GND
3	A	ICJX VB1 I/O 1	B	VB1	C	ICJX VB1 I/O 2
4	A	ICJX VB1 I/O 3	B	GND	C	ICJX VB1 I/O 4
5	A	ICJX VB2 I/O 5	B	VB2	C	ICJX VB2 I/O 6
6	A	ICJX VB2 I/O 7	B	GND	C	ICJX VB2 I/O 8
7	A	ICJX VB3 I/O 9	B	VB3	C	ICJX VB3 I/O 10
8	A	ICJX VB3 I/O 11	B	GND	C	ICJX VB3 I/O 12
9	A	ICJX VB4 I/O 13	B	VB4	C	ICJX VB4 I/O 14
10	A	ICJX VB4 I/O 15	B	GND	C	ICJX VB4 I/O 16
11	A	GND	B	GND	C	GND
12	A	Trip Line Input	B	GND	C	Trip Line Output
13	A	GND	B	GND	C	GND
14	A	FPGA PIN AA17	B	GND	C	FPGA PIN AA16
15	A	FPGA PIN AA15	B	GND	C	FPGA PIN AA14
16	A	FPGA PIN AA13	B	GND	C	FPGA PIN AA10
17	A	FPGA PIN AA9	B	GND	C	FPGA PIN AA8
18	A	GND	B	GND	C	GND

19	A	USI RxA	B	GND	C	USI RxB
20	A	USI TxZ	B	GND	C	USI TxY
21	A	GND	B	GND	C	GND
22	A	GND	B	GND	C	GND
23	A	GND	B	ADC Input	C	GND
24	A	GND	B	GND	C	GND
25	A	GND	B	D7 DAC VOUTA	C	GND
26	A	GND	B	D7 DAC VOUTB	C	GND
27	A	GND	B	D7 DAC VOUTC	C	GND
28	A	GND	B	D7 DAC VOUTD	C	GND
29	A	GND	B	GND	C	GND
30	A	+15V In	B	+15V In	C	+15V In
31	A	GND	B	GND	C	GND
32	A	-15V In	B	-15V In	C	-15V In

Table 8-1: Assignment of the rear VG96 bar
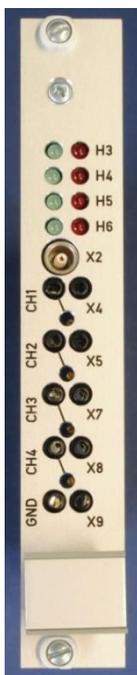
Figure 8-2: Front view of the ADC-DAC-IO module (here still ADC because picture is missing!)

8.2   LED

The 8 LEDs on the front show status information of the ADC-DAC-IO module.

After switching on the operating voltage or if the module carries out a reset due to a remote update, all 8 LEDs flash for approx. 3 seconds.

8.2.1   Left Column LEDs

The LEDs are connected to the module status.

8.2.1.1   H13

Lights when data is being transferred from the MFU to the ADC DAC IO module. In high-speed mode, this LED is therefore always on, since data is continuously being sent from the MFU to the ADC DAC IO module.

8.2.1.2   H15

Lights up when data is being transferred from the ADC-DAC-IO module to the MFU. In high-speed mode, this LED is therefore always on, as data is continuously being sent from the ADC DAC IO module to the MFU.

8.2.1.3   H16

Flashes when there are no parameters (gain, offset) for the module's own 18-bit ADC (flash empty) or have not been loaded.

8.2.1.4   H17

Flashes as a "heartbeat" to show the function of the ADI module. If H17 does not flash, there is a problem in the ADC-DAC-IO module, e.g. no valid firmware is available.

8.2.2   Right Column LEDs

Indicate interlocks on the ADC DAC IO module

8.2.2.1   H13

Flashes when interlock .... was triggered and is still pending. Lights up permanently when interlock ... has been triggered and is no longer pending.

8.2.2.2   H15

Flashes when interlock .... was triggered and is still pending. Lights up permanently when interlock ... has been triggered and is no longer pending.

8.2.2.3   H16

Flashes when interlock .... was triggered and is still pending. Lights up permanently when interlock ... has been triggered and is no longer pending.

8.2.2.4   H17

Flashes when interlock .... was triggered and is still pending. Lights up permanently when interlock ... has been triggered and is no longer pending.

8.2.2.5   H13 and H17, H15 and H6 alternating flashing

…

8.3   Numbering of the interlocks on the ADC-DAC-IO module

The ADC-DAC-IO module can... process different interlock sources, these are arranged sequentially as follows:

Bit	Art	Name	Überwachung	Standardtexte
0		umA01		
1		umA02		
2		umA03		
3		umA04		
4	Digital elektrisch	umE01		

Table 8-2: Standard assignment of the interlocks in an ADC-DAC-IO module

With meaning:

<u> :	USI number
<m> :	module number

8.4   Lemo sockets

8.4.1   X5

Outputs the voltage fed via the backplane (B23) fed to the ADC on the ADC DAC IO module.

8.4.2   X1

Outputs the DAC output voltage VOUTA, which can also be measured on the backplane at pin B25.

8.4.3   X3

Outputs the DAC output voltage VOUTB, which can also be measured on the backplane at pin B26.

8.4.4   X6

Outputs the DAC output voltage VOUTC, which can also be measured on the backplane at pin B27.

8.4.5   X7

Outputs the DAC output voltage VOUTD, which can also be measured on the backplane at pin B28.

8.5   Voltage Measurements

The ADC-DAC-IO module has 4 voltage acquisitions with differential inputs whose gains (G) are individually user-definable via solder bridges. The signals are fed to the voltage detections via socket X4.

Pin (X4)	Function	Solder bridges (A1, A0)
1	voltage detections 1 IN+	SJ4,SJ8
2	voltage detections 1 IN-	
3	voltage detections 2 IN+	SJ3,SJ7
4	voltage detections 2 IN-	
5	voltage detections 3 IN+	SJ2, SJ6
6	voltage detections 3 IN-	
7	voltage detections 4 IN+	SJ1, SJ5
8	voltage detections 4 IN-	
9	GND	
10	GND	

Table 8-3: Pin assignment X4 for voltage measurements and associated solder bridges

A1	A0	Gain
open	open	1
open	closed	2
closed	closed	5
closed	closed	10

Table 8-4: Solder bridge definition for gain

9   The ADC-DAC-IO-II-Module (FG660_46x)

The ADC-DAC-IO-II module is a multifunctional circuit board that combines a wealth of different functions.

- 18-bit main ADC with comparator (positive, negative threshold selectable)
- 4 independent bipolar voltage acquisitions using generic 13-bit ADC, with user-definable comparator thresholds and user-definable gain
- 4 16-bit DAC outputs
- 16 freely definable I/O ports (each combined in groups of 4) for interlock detection or switching outputs
- 3 USI interfaces

This means that universal use can be implemented.

9.1   View of the module
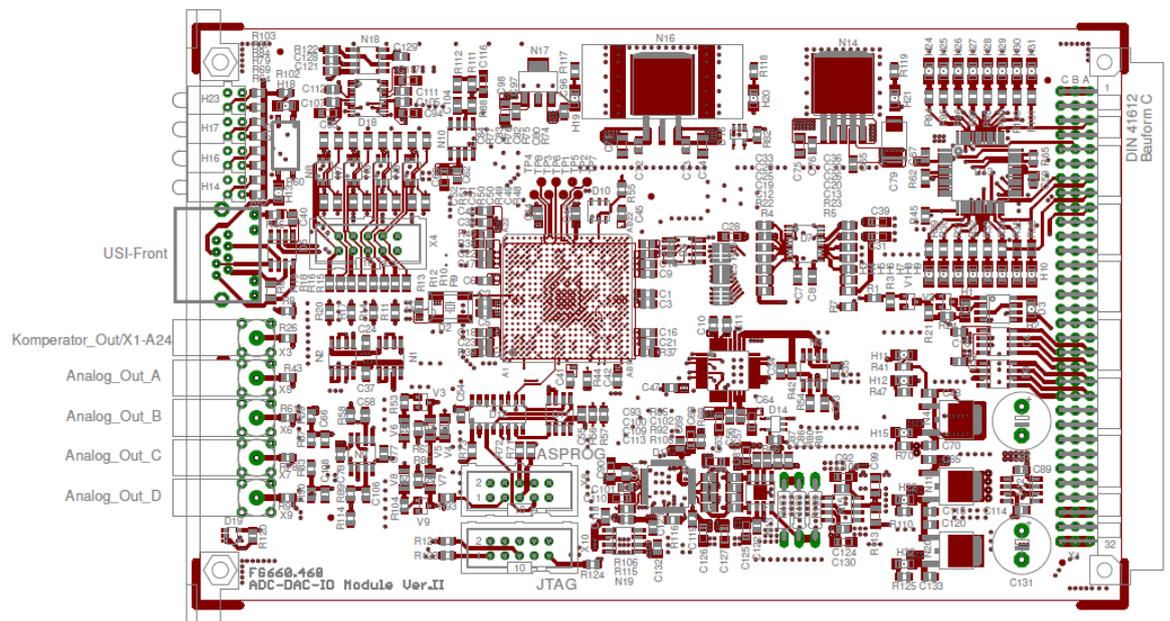
Figure 9-1: Side view of the ADC-DAC-IO-II module
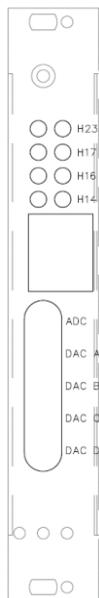
Figure 9-2: Front view of the ADC-DAC-IO-II module

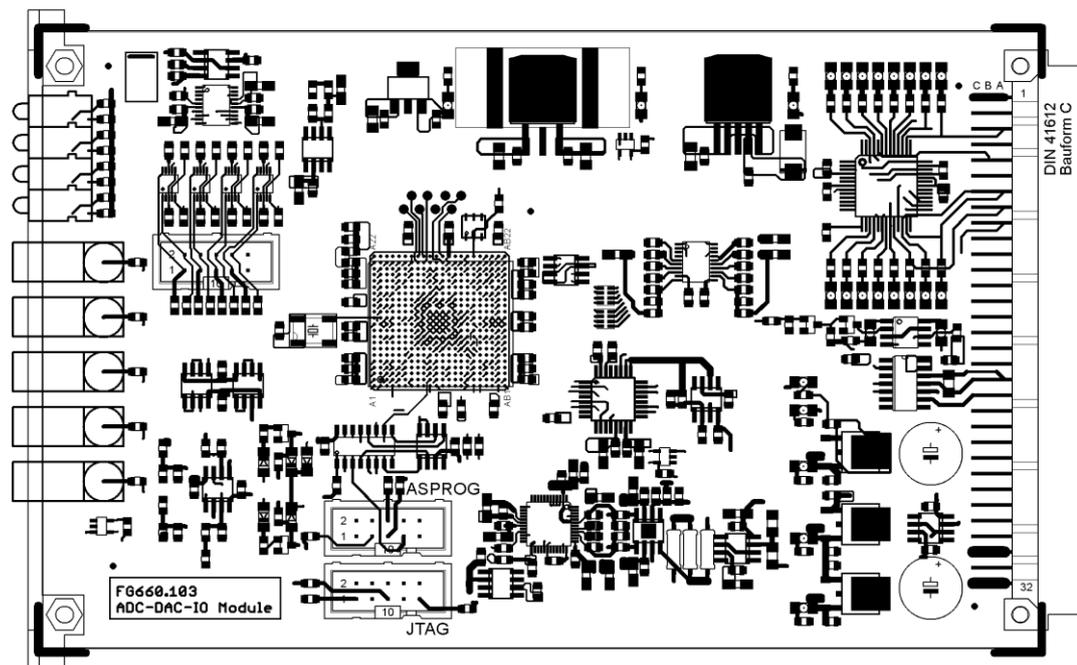| PIN		Assignment		Assignment		Assignment
1	A	+5V In	B	+5V In	C	+5V In
2	A	GND	B	GND	C	GND
3	A	ICJX VB1 I/O 1	B	VB1	C	ICJX VB1 I/O 2
4	A	ICJX VB1 I/O 3	B	GND	C	ICJX VB1 I/O 4
5	A	ICJX VB2 I/O 5	B	VB2	C	ICJX VB2 I/O 6
6	A	ICJX VB2 I/O 7	B	GND	C	ICJX VB2 I/O 8
7	A	ICJX VB3 I/O 9	B	VB3	C	ICJX VB3 I/O 10
8	A	ICJX VB3 I/O 11	B	GND	C	ICJX VB3 I/O 12
9	A	ICJX VB4 I/O 13	B	VB4	C	ICJX VB4 I/O 14
10	A	ICJX VB4 I/O 15	B	GND	C	ICJX VB4 I/O 16
11	A	GND	B	GND	C	GND
12	A	FPGA_PIN Y17	B	GND	C	FPGA_PIN Y15
13	A	FPGA_PIN Y14	B	GND	C	FPGA_PIN Y13
14	A	FPGA PIN AA17	B	GND	C	FPGA PIN AA16
15	A	FPGA PIN AA15	B	GND	C	FPGA PIN AA14
16	A	FPGA PIN AA13	B	GND	C	FPGA PIN AA10
17	A	FPGA PIN AA9	B	GND	C	FPGA PIN AA8
18	A	GND	B	GND	C	GND
19	A	USI 1 RxA	B	GND	C	USI 1 RxB
20	A	USI 1 TxZ	B	Trip Line Input	C	USI 1 TxY
21	A	USI 2 RxA	B	Trip Line Output	C	USI 2 RxB
22	A	USI 2 TxZ	B	GND	C	USI 2 TxY
23	A	ADC Input GND	B	GND	C	ADC Input GND
24	A	ADC Input Signal	B	ADC Input GND	C	GND
25	A	Generic ADC ch. A	B	D7 DAC VOUTA (X5)	C	GND
26	A	Generic ADC ch.B	B	D7 DAC VOUTB (X6)	C	GND
27	A	Generic ADC ch.C	B	D7 DAC VOUTC (X7)	C	GND
28	A	Generic ADC ch.D	B	D7 DAC VOUTD (X9)	C	GND
29	A	GND	B	GND	C	GND
30	A	+15V In	B	+15V In	C	+15V In
31	A	GND	B	GND	C	GND
32	A	-15V In	B	-15V In	C	-15V In

Table 9-1: Assignment of the rear VG96 bar

9.2   Information about the USIs

USIs 1 and 2 are served via the backplane. USI3 can be found on the front of the module.

USI3 does not have a trip line, so it cannot provide quick information about the shutdown of the device. USI3 is used exclusively for fast data transfer.

USI2 signals its data transfer with the LEDs on the RJ45 socket on the front of the module. I.e. data transfer to USI3 is not displayed optically.

9.3   LED

9.3.1   Front

The 8 LEDs on the front show status information of the ADC-DAC-IO-II module.

After switching on the operating voltage or if the module carries out a reset due to a remote update, all 8 LEDs flash for approx. 3 seconds.

9.3.2   Left Column LEDs

The LEDs in the left column indicate the module status.

9.3.2.1   H23

Lights up when data is being transferred from the MFU to the ADC-DAC-IO-II module. Consequently, in high-speed mode, this LED is always on since data is continuously being sent from the MFU to the ADC-DAC-IO-II module.

9.3.2.2   H17

Lights up when data is being transferred from the ADC-DAC-IO-II module to the MFU. Consequently, in high-speed mode, this LED is always on since data is continuously being sent from the ADC-DAC-IO-II module to the MFU.

9.3.2.3   H16

Flashes when there are no parameters (gain, offset) for the module's own 18-bit main ADC (flash is empty) or has not been loaded.

9.3.2.4   H14

Flashes as a "heartbeat" to show the function of the ADC-DAC-IO-II module. If H14 does not flash, there is a problem in the ADC-DAC-IO-II module, e.g. no valid firmware is available.

9.3.3   Right Column LEDs

Indicate interlocks on the ADC-DAC-IO-II module.

9.3.3.1   H23

Flashes when an interlock has been triggered and is still pending via an ICJX I/O pin that is defined as an input. Lights up permanently when the previously triggered interlock is no longer pending.

9.3.3.2   H17

Flashes when one of the comparator thresholds of the 18-bit main ADC is above (interlock bit[15]) or below (interlock bit[14]) and an interlock has been triggered and is still pending. Lights up permanently when the previously triggered interlock is no longer pending.

9.3.3.3   H16

Flashes when one of the comparator thresholds of the generic ADC channel A or B is above (interlock[17], [19]) or below (interlock bit[16], [18]) and an interlock has been triggered and is still pending. Lights up permanently when the previously triggered interlock is no longer pending.

9.3.3.4   H14

Flashes when one of the comparator thresholds of the generic ADC channel C or D is above (interlock[21], [23]) or below (interlock bit[20], [22]) and thus an interlock has been triggered and is still pending. Lights up permanently when the previously triggered interlock is no longer pending.

9.3.4   Module-side

9.3.4.1   Interlocks
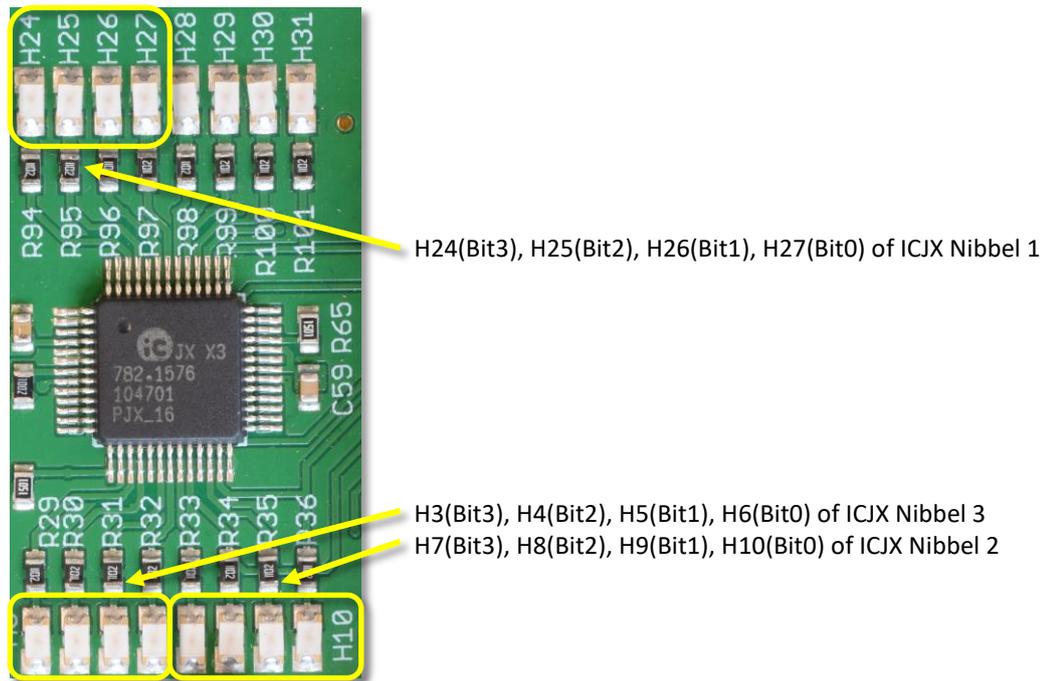
Figure 9-3: Interlock LEDs of the ADC-DAC-IO-II module

If the associated interlock LED does <u>not</u> light up, then an active interlock is pending.

Interlock bit	LED
0	H3
1	H4
2	H5
3	H6
4	H7
5	H8
6	H9
7	H10
8	H24
9	H25
10	H26
11	H27

Table 9-2: Interlock bits and associated LEDs

9.3.4.2   Switching outputs
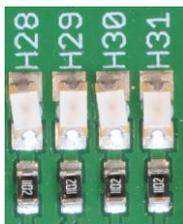
Figure 9-4: LEDs of the switching outputs of the ADC-DAC-IO-II module

Switching output	LED	Description
Contactor 1	H28	Becomes '1' when the module receives an ON command and the

		Val_Timer1 (PCA: `Charging time for the capacitor bank`) starts.
Contactor 2	H29	Becomes '1' when Val_Timer1 has expired and Val_Timer2 (always 1s, fixed) starts.
Controller Enable	H30	Becomes '1' when both Val_Timer2 and the subsequent Val_Timer3 (PCA: `Blocking time before controller enables`) have expired and the controller has been enabled.
Reset	H31	Always becomes '1' when the module receives a `RESET` command.

Table 9-3: Switching outputs and associated LEDs

9.3.4.3 Trip lines

H1 Status trip line module-internal
H2 Status trip line module-external
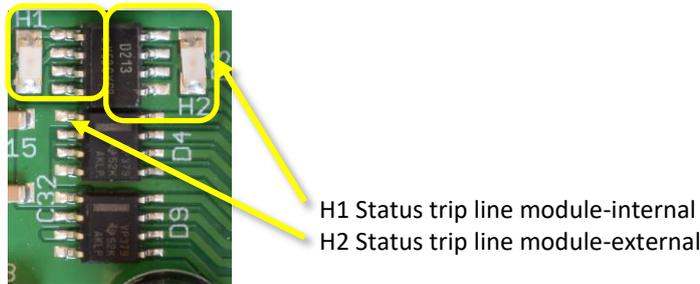
Figure 9-5: Trip line LEDs

H1 lights up when the trip line is <u>not</u> pulled on the module side.

H2 lights up when the trip line is <u>not</u> pulled outside of the module.

To switch on, it is necessary that both LEDs light up.

9.4 Numbering of the interlocks on the ADC-DAC-IO-II module

The ADC_DAC-IO-II module can process up to 32 different interlock sources, which are arranged sequentially as follows:

Bit	Art	Name	monitoring	Standard text
0	n.u.	um00	none, always ‚1‘.	
1	digital electric	um01	Interlock[1]	Digital Interlock 01
2		um02	Interlock[2]	Digital Interlock 02
3		um03	Interlock[3]	Digital Interlock 03
4		um04	Interlock[4]	Digital Interlock 04
5		um05	Interlock[5]	Digital Interlock 05
6		um06	Interlock[6]	Digital Interlock 06
7		um07	Interlock[7]	Digital Interlock 07
8		um08	Interlock[8]	Digital Interlock 08
9		um09	Interlock[9]	Digital Interlock 09
10		um10	Interlock[10]	Digital Interlock 10
11		um11	Interlock[11]	Digital Interlock 11
12		um12	Former main contactor. This interlock bit is obsolete. A main contactor reports back via any interlock source as a "conditional" interlock.	Main Contactor Closed Failure
13	n.u.	um13	none, always ‚1‘.	
14	Analog	um14	Below the negative comparator threshold of the 18-bit MainADC.	Negative comparator 01
15		um15	Positive comparator threshold of the 18-bit MainADC exceeded.	Positive comparator 01
16	Analog Software	um16	Negative comparator threshold of channel A (Ch5) of the generic 13-	Negative comparator 02

			bit ADC undershot.	
17		um17	Positive comparator threshold of channel A (Ch5) of the generic 13-bit ADC exceeded.	Positive comparator 02
18		um18	Negative comparator threshold of channel B (Ch6) of the generic 13-bit ADC undershot.	Negative comparator 03
19		um19	Positive comparator threshold of channel B (Ch6) of the generic 13-bit ADC exceeded.	Positive comparator 03
20		um20	Negative comparator threshold of channel C (Ch7) of the generic 13-bit ADC undershot.	Negative comparator 04
21		um21	Positive comparator threshold of channel C (Ch7) of the generic 13-bit ADC exceeded.	Positive comparator 04
22		um22	Negative comparator threshold of channel D (Ch8) of the generic 13-bit ADC undershot.	Negative comparator 05
23		um23	Positive comparator threshold of channel D (Ch8) of the generic 13-bit ADC exceeded.	Positive comparator 05
24	Digital Software	um24	USI_Slave_1_IsHighSpeed	USI Highspeed 01
25		um25	USI_Slave_2_IsHighSpeed	USI Highspeed 02
26		um26	USI_Slave_3_IsHighSpeed	USI Highspeed 03
27	n.u.	um27	none, always ‚1'.	
28	n.u.	um28	none, always ‚1'.	
29	n.u.	um29	none, always ‚1'.	
30	n.u.	um30	none, always ‚1'.	
31	n.u.	um31	none, always ‚1'.	

Table 9-4: Standard assignment of the interlocks in an ADC-DAC-IO-II module

Mit Bedeutung:

<u>:   USI number
<m>:   Module number

9.5   Lemo sockets

9.5.1   X3 (ADC)

Outputs the voltage fed via the backplane (A24), which is fed to the 18-bit main ADC on the ADC-DAC-IO-II module.

9.5.2   X5 (DAC A)

Outputs the DAC output voltage VOUTA, which can also be measured on the backplane at pin B25.

9.5.3   X6 (DAC b)

Outputs the DAC output voltage VOUTB, which can also be measured on the backplane at pin B26.

9.5.4   X7 (DAC C)

Outputs the DAC output voltage VOUTC, which can also be measured on the backplane at pin B27.

9.5.5   X9 (DAC D)

Outputs the DAC output voltage VOUTD, which can also be measured on the backplane at pin B28.

9.6   Voltage detections

The ADC-DAC-IO-II module has 4 voltage acquisitions with differential inputs whose gains (G) are individually user-definable via solder bridges. The signals are fed to the voltage detections via socket X4.

Pin (X4)	Function	Solder bridge (A1, A0)
1	voltage detection 1 IN+	SJ4,SJ8
2	voltage detection 1 IN-	
3	voltage detection 2 IN+	SJ3,SJ7
4	voltage detection 2 IN-	
5	voltage detection 3 IN+	SJ2, SJ6
6	voltage detection 3 IN-	
7	voltage detection 4 IN+	SJ1, SJ5
8	voltage detection 4 IN-	
9	GND	
10	GND	

Table 9-5: Pin assignment X4 for voltage measurements and associated solder bridges

A1	A0	Gain
open	open	1
open	closed	2
closed	open	5
closed	closed	10

Table 9-6: Solder bridge definition for gain

10 Load Switch Module - LSM (FG660_051)

This module is no longer supported. Please contact GSI if you have any questions.

11   ADC module (FG660_044)

The present description in this chapter is for the hardware release mentioned in the headline. Older or newer versions of this module can have different markings regarding connectors, plugs, components and so on. In most cases, the functions are identical. In case there are any doubts, please refer to the images or contact support.

11.1   *View of the module*

The module is used for the acquisition of the analogue/digital conversion of the actual value of the current that is collected by the DCCT.
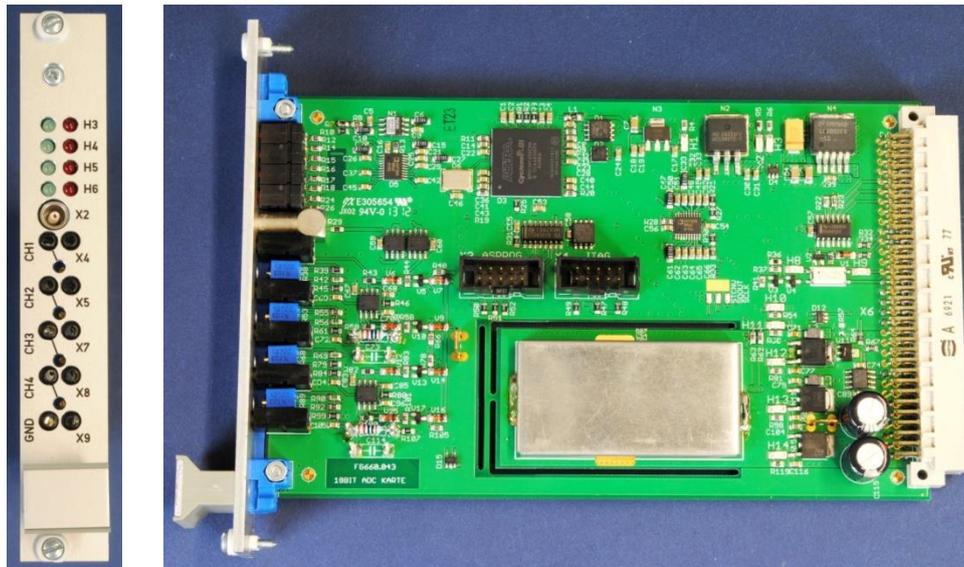
Figure 11-1: Front and side view of the (old) ADC module

11.2   *LEDs*

The 8 front side LEDs show status information about the ADC module. There are green (only status of the module) and red LEDs (status of interlocks).

After turning on the power supply or after a reset due to a remote update, all 8 LEDs flash for approx. 3 seconds.

11.2.1   *Green LEDs*

The green LEDs show the module status.

11.2.1.1 *H3 green*

In standard USI mode, the LED glows briefly when data is transferred from the host (i.e. MFU) to the ADC module. It is always on during High-speed mode, since data is sent continuously. Upon sending of USI tunnel data in High-speed mode, the LED goes out shortly.

11.2.1.2 *H4 green*

In standard USI mode, the LED glows briefly when data is transferred from the ADC module to the host (i.e. MFU). It is always on during High-speed mode, since data is sent continuously. Upon sending of USI tunnel data in High-speed mode, the LED goes out shortly.

11.2.1.3 *H5 green*

H5 flashes when ADC parameters (gain, offset) are not present or have not been loaded. Usually the module can load these data from an internally non-volatile flash device. Therefore, the ADC module

has to be calibrated previously and the necessary data needs to be saved inside flash device. Alternatively, the parameters can be sent to the module by the host after switching on.

11.2.1.4 H6 green

H6 serves as "Heartbeat" to indicate that the ADC module working properly. If there is no heartbeat, a problem occurred with the ADC module or a valid firmware is missing.

11.2.2 Red LEDs

Red LEDs indicate interlocks on the ADC module.

11.2.2.1 H3 red

H3 flashes once the interlock "Comparator: positive voltage exceeded" has been triggered and is still present. The LED glows permanently if this interlock had been triggered, is not present anymore, but is still in the memory.

11.2.2.2 H4 red

H4 indicates that the negative comparator voltage average was not okay and an interlock occurred. It flashes if this interlock is still present. If glows permanently if this interlock has been resolved and is only still in the memory.

11.2.2.3 H5 red

H5 indicates that the negative comparator voltage average was not okay and an interlock occurred. It flashes if this interlock is still present. If glows permanently if this interlock has been resolved and is only still in the memory.

11.2.2.4 H6 red

H6 indicates that the negative comparator voltage average was not okay and an interlock occurred. It flashes if this interlock is still present. If glows permanently if this interlock has been resolved and is only still in the memory.

11.2.2.5 H4 red-H7 red, H5 red-H6 red flashing alternately

Either the plug monitoring of the DCCT connection on the backplane is open or the DCCT does not have a working power supply or has a defect.

11.3 Numbering of interlocks on the ADC module

The ADC module can process 5 different interlock sources. They are arranged sequentially as follows:

Bit	Type	Name	Monitoring	Default texts
0	Analogue, electrical	um00	Comparator negative voltage average	I Neg average >
1		um01	Comparator negative voltage	I Neg >
2		um02	Comparator positive voltage average	I Pos average >
3		um03	Comparator positive voltage	I Pos >
4	Digital, electrical	um04	DCCT error	DCCT Error
5	-	–	-	-
6	-	–	-	-
7	-	–	-	-

Table 11-1: Default assignment of interlock on an ADC module

With the symbols:

<u> :   USI number
<m> :   Module number

11.4 Lemo socket

11.4.1 X1 (formerly X2)

X1 puts out the voltage of the actual current value that comes in via the Backplane.

11.5 Comparator threshold voltage

Each channel has a comparator to which a trigger threshold can be added using a potentiometer. In case the comparator should be deactivated, the trigger threshold at CH1 and CH2 has to be set to the maximal voltage or respectively.

NOTE!: The threshold values set via potentiometers have to be adjusted checking the value with a multi meter.

DON'T TAKE INTO CONSIDERATION THE VALUE DISPLAYED IN PowerConfigAdvance; it is affected by an error due to the ADC reference voltage. It should be 2,75V but (for a wrong resistor choice) it is 2,66V.

11.5.1 CH1 – X4 – left, right

The left hand socket puts out the positive voltage threshold for the interlock comparator. This voltage can be set with the potentiometer below, R38.

At the right hand socket, the comparator voltage at the input is put out.

11.5.2 CH2 – X5 – left, right

The left hand socket puts out the average of the positive voltage threshold for the interlock comparator. This voltage can be set with the potentiometer below, R53.

At the right hand socket, the comparator voltage at the input is put out.

11.5.3 CH3 – X7 – left, right

The left hand socket puts out the negative voltage threshold for the interlock comparator. This voltage can be set with the potentiometer below, R68.

At the right hand socket, the comparator voltage at the input is put out.

11.5.4 CH4 – X8 – left, right

The left hand socket puts out the average of the negative voltage threshold for the interlock comparator. This voltage can be set with the potentiometer below, R89.

At the right hand socket, the comparator voltage at the input after the RC filter is put out.

11.5.5 GND – X9

This is the ground for CH1 to CH4.

12   Analog Interlock Module AIM (FG660_560)

The present description in this chapter is for the hardware release mentioned in the headline. Older or newer versions of this module can have different markings regarding connectors, plugs, components and so on. In most cases, the functions are identical. In case there are any doubts, please refer to the images or contact support.

12.1   Description

The following chapter describes the Analog Interlock Module (AIM) board.

This board was designed in order to increase the normal number of analog interlock input signals in those standard boards as the Interlock and control module.

The board contains 4+6 analog interlock inputs signals. Four of them (X7,X8,X32 and X33) have the comparator thresholds settings and the RC filter developed with the external card (Comparator_Config_Module), instead for the last six inputs (X1 to X6), the RC filter is directly implemented on AIM board and the comparator thresholds are via FSP configured.

As in the AIM, the High Speed channel is used only to send commands from the MFU to this module and there is not a value back to the MFU.

It is possible to consider this board as an analog interlock extension module without any controller or switching actions inside.

The board is provided with a four channels DAC with the outputs RC filtered (X17 to X20) and directly connected to the terminals (X27 to X30).

There are also three temperature sensors in order to monitor the temperature in three different spots in the board: Power (D15), FPGA (D17) and Ambient (D25) temperature.

In addition it is possible to connect an external temperature sensor via connector (X25).

12.2   Module view
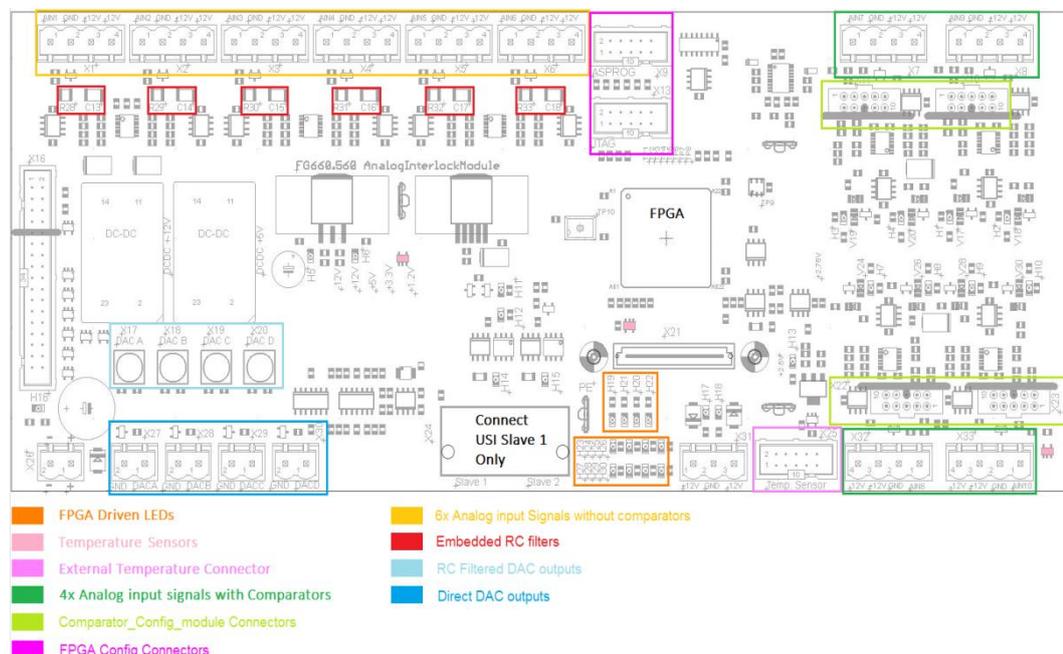
Figure 12-1: Top view of the AIM

12.3   LEDs

It is possible to divide them in three groups:

- Status LEDs

- USI Transmitting LEDs
- USI Receiving LEDs
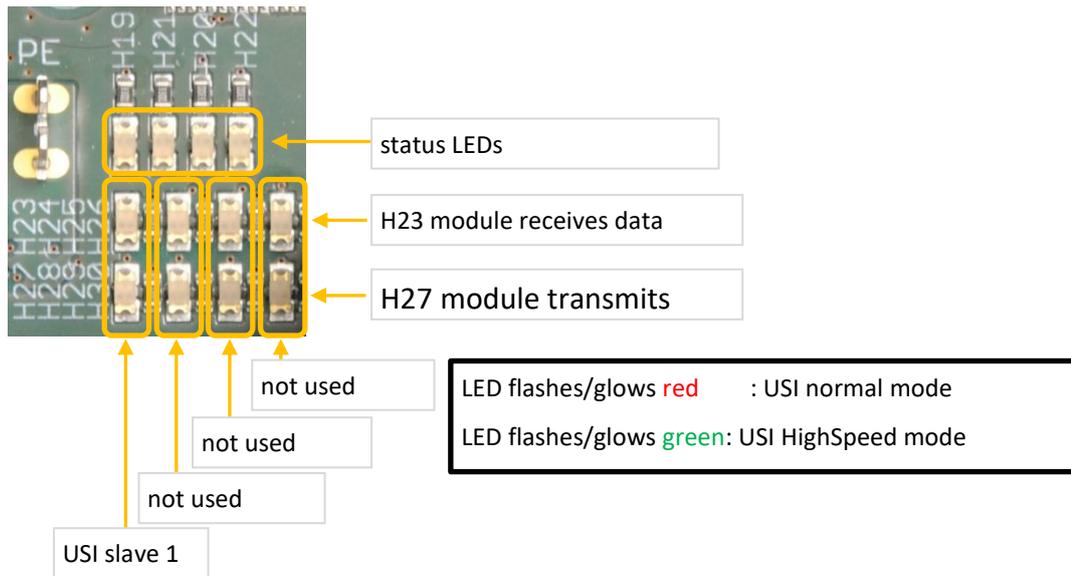
Figure 12-2: Status and communication LEDs of the AIM

12.3.1　Status LEDs

4 status LEDs (H19..H22) indicate status information of the AIM.

LED	Designation	Function	
		Green	Red
H19	HeartBeatSystem	Flashes green, indicates that the FPGA is loaded with a hardware configuration.	-
H20	SumInterlock	No sum interlock	There is a sum interlock
H21	HeartBeatRU	Flashes green, indicates the fact that the PLL concatenated to the reconfiguration of the module is running.	-
H22	n.u.	Always green	-

Table 12-1: Meaning of the status LEDs

12.3.2　Communication LEDs (H23..H26, H27..H30)

Currently only 2 of the 8 LEDs are assigned to the USI channel and indicate communication status information. If the USI is in normal mode, the corresponding LEDs are always red when data is received or sent. If a USI is in high-speed mode, the corresponding LEDs are always green and are switched off briefly when tunneling data.

LED	Designation	Function	
		Green	Red
H23	USI Slave 1	RX Data is transferred in High Speed	RX Data is transferred in normal USI mode
H24	Not used	-	-
H25	Not used	-	-
H26	Not used	-	-

Table 12.2: Meaning of the communication receiving LEDS

LED	Designation	Function	
		Green	**Red**
H27	USI Slave 1	TX Data is transferred in High Speed	TX Data is transferred in normal USI mode
H28	Not used	-	-
H29	Not used	-	-
H30	Not used	-	-

Table 12-3: Meaning of the communication transmitting LEDS

12.4   *Current standard distribution of interlocks*

Bit	Function
0	Analog signal connected to X7 exceeds positive threshold limit
1	Analog signal connected to X7 exceeds negative threshold limit
2	Analog signal connected to X32 exceeds positive threshold limit
3	Analog signal connected to X32 exceeds negative threshold limit
4	Analog signal connected to X8 exceeds positive threshold limit
5	Analog signal connected to X8 exceeds negative threshold limit
6	Analog signal connected to X33 exceeds positive threshold limit
7	Analog signal connected to X33 exceeds negative threshold limit
8	Analog signal connected to X1 is out of thresholds limits
9	Analog signal connected to X2 is out of thresholds limits
10	Analog signal connected to X3 is out of thresholds limits
11	Analog signal connected to X4 is out of thresholds limits
12	Analog signal connected to X5 is out of thresholds limits
13	Analog signal connected to X6 is out of thresholds limits
14	not used
15	not used
16	not used
17	not used
18	not used
19	not used
20	not used
21	not used
22	not used
23	not used

Table 12-4: Current standard distribution of interlocks

13   TS1_MU1_Module

TS1_MU1_Module is implemented on the SR FG660.093 board, the same used for the Static Converter and the parallel feeder. This because it is necessary, for this application, to have more than 5 analog comparators (the ICM board is not useful for this application).

13.1   *Description*

The firmware structure is not so much different from the one implemented in the Static converter, excluding the controller part.

It implements all the modules necessary to drive the chips on the PCB (ADCs, DAC, temperature sensors, Interlocks, etc.) and it has two USI slave connections. The first (USI_Slave_1) is the only one strictly necessary; USI_Slave_3 is the "Dummy" one and it can be used for extra High Speed data transfer with the MFU. On the USI_Slave_1 the MFU drives the difference (delta) between controller 1 SetValue on the higher 14 bits, the ActualValue on the lower 14 bits and the commands (4 bits). How these High Speed data are used in the controller part, will be discussed in the next chapter.

13.2   *Controller Part*

The controller part is implemented with two standard PI controller in cascade connected. That means that the output of the PI controller 1 is the input of the PI controller 2. As displayed in the Figure 13-1: Controller Part below, between the PI controllers there is a slope limiter.
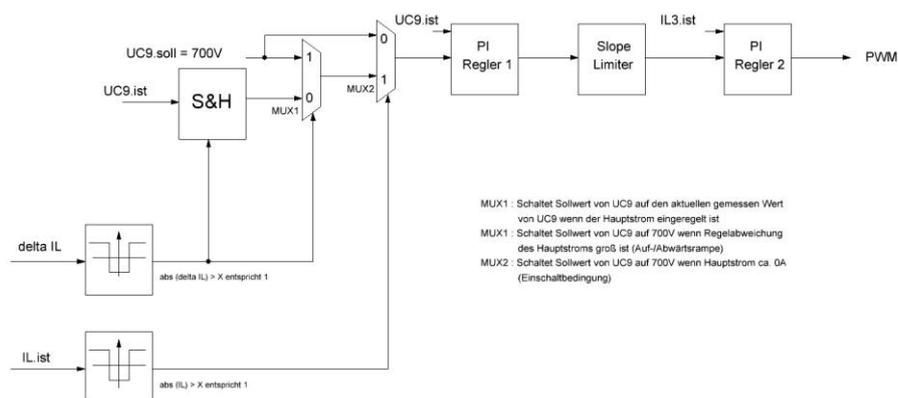
Figure 13-1: Controller Part

Please note how the PI controller 1 Set Value is generated. It is something very different from the standard PI Controller set value: It can switch between two static values; one coming from the internal FSPs set value (FSP30_SetVal_A, FSP31_SetVal_B, FSP32_SetVal_C and FSP33_SetVal_D) and the other is one of the ADCs the sampled and held signals. In order to do that, a new VHDL block was generated (ACU_TS1MU1_SetValue). The switching criteria are fully described in the ACU_TS1MU1_SetValue.docx file.

14   Zero Field Controller

The Zero Field Controller firmware is implemented in the FG660_460_ADC_DAC_IO_Module_VerII card and it is used to control the zero field power converter.

The zero-field-power-converter is used in combination with a standard power converter (main power converter) on the same magnet. It reduces to zero the residual magnetic field in a magnet when the main power converter drives the current to zero. The residual magnetic field stored in the magnet is the effect of the magnet hysteresis.
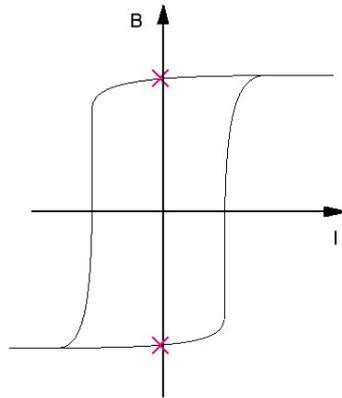
Figure 14-1: Hysteresis

Below there is a generic block diagram where is possible to see how the two power converter work on the same magnet.
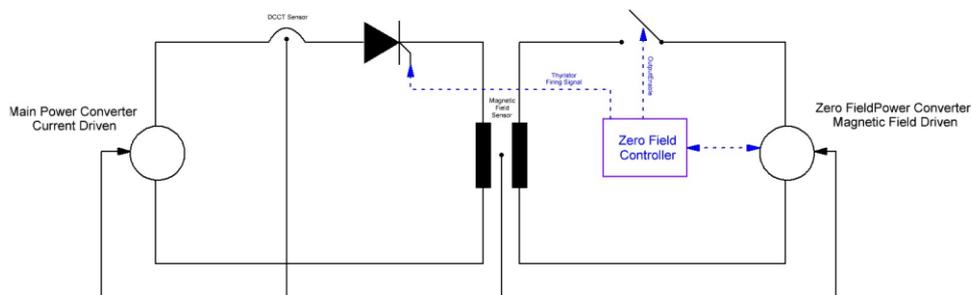
Figure 14-2: Main power supply and zero field power supply on the same magnet

15   Appendix

15.1   *The USI interface*

Communication between single modules in the ACU system is realized via USI. The assignment of the RJ45 plugs/sockets is the following:

PIN	Description	I/O	Explanation
1	TX +	O	Send line USI + (Data from master to slave)
2	TX -	O	Send line USI - (Data from master to slave)
3	RX +	I	Receive line USI + (Data from slave to master)
4	USI_TRIP_OUT	O	USI trip line (from master to slave)
5	USI_TRIP_IN	I	USI trip line response (from slave to master)
6	RX-	I	Receive line USI - (Data from slave to master)
7	GND		Ground
8	+12	I	+ 12V (provides the slave module)

Table 15-1: Pin assignment of the RJ45 USI connection (MFU - Master)

PIN	Description	I/O	Explanation
1	RX +	I	Receive line USI + (Data from master to slave)
2	RX -	I	Receive line USI - (Data from master to slave)
3	TX +	O	Send line USI + (Data from slave to master)
4	USI_TRIP_IN	I	USI trip line (from master to slave)
5	USI_TRIP_OUT	O	USI trip line response (from slave to master)
6	TX-	O	Send line USI - (Data from slave to master)
7	GND		Ground
8	+12	O	+ 12V (provides the slave module)

Table 15-2: Pin assignment of the RJ45 USI connection (Slave module)

To ensure a clean galvanic separation between master and slave module, the slave modules have to provide a +12V DC power supply via pin 8. This voltage supplies power to the secondary side of the USI driver component of the MFU at the MFU/FAIRBus backplane (FG660_034).

1:1 network cables (not crossed) are to be used for the master/slave connection.

15.2   Module description

15.2.1   The Multi-Function Unit (FG660.014 and FG660.024)

Figure 15-1: MFU with and without case

The central device, the Multi-Function Unit (MFU) is the host of the ACU system. The MFU contain a mainboard (FG660.014) and a perpendicularly placed operation and display board.

There is an Altera Cyclone II FPGA on mainboard, that is used for communication with the interface card / SCU (interface to the control system) and for controlling the power supply. Up to 10 USI on the MFU/FAIRBus backplane (FG660_034) are planned as interface to sensors and actors of the device.

To operate the device, the operation and display board contains the following: a graphical ¼ VGA TFT display, three buttons (ON, OFF, reset), an incremental encoder (+/-), a switch (local/remote), 8 one-pole Lemo sockets, 4 analogue DAC signal outputs (selectable via software), 2 digital inputs (i.e. trigger), 2 digital outputs (i.e. trigger).

Furthermore, the operation and display board contains 2 USB 2.0 interfaces. One is a master, the other on the client. Port 2 (client) is used to connect the system to a PC and the installed PCA software. USB port 1 (host) is operated by the MFU and can be used to connect USB mass storage devices for data transfer and/or software updates.

The MFU internal user interface controls a NiosII IP core that is implemented on the FPGA. The FPGA also serves as a logic array for the process control, the PI-Controller, the Multiplexer and other critical tasks.

The 4 DAC outputs are used for diagnosis and can put out several signals from the controller structure.

Additionally, an expansion interface to adapt to future requirements is planned on the mainboard, in form of a 64 pin SMD connector.

Usually the MFU will be installed with the ACU/FAIRBus Backplane (refer to chapter 15.2.2: „The ACU/FAIRBus Backplane (FG660_034)") in a 19" rack (refer to chapter 15.2.8: „The 19" rack").

15.2.1.1   Dimensions

The dimensions of the installation frame are 138 x 109 mm, with a front plate measuring 147 x 128 mm, which means 29 HP space in a 19" frame.

15.2.1.2   Power supply

The MFU require a 5V DC power supply, usually provided by the backplane (refer to chapter 15.2.2: „The ACU/FAIRBus Backplane (FG660_034)").

The backplane itself needs a 12V DC power supply and will generate the 5V DC supply for the MFU.

15.2.1.3   Connections and interfaces of the MFU

The connection between MFU and backplane is realized with a VG96 multi-pin connector.

In Figure 15-2 the back view of the module is shown, assembly side facing upwards.
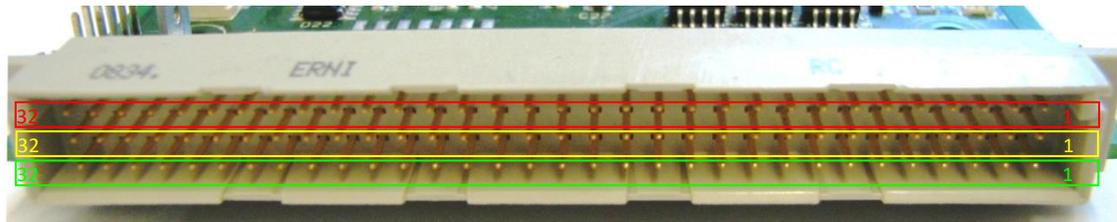
Figure 15-2: MFU VG96 multi-pin connector

Rail A: green (bottom)

Rail B: yellow (middle)

Rail C: red (up)

Pin assignment is the following:

15.2.1.3.1   Rail A

PIN	Description	I/O	Explanation
A1	+5V	I	+5V power supply
A2	n.u.		
A3	DGND		Digital ground
A4	BP_USI_RX1	I	USI 1 Receiver input
A5	BP_USI_RX2	I	USI 2 Receiver input
A6	BP_USI_RX3	I	USI 3 Receiver input
A7	BP_USI_RX4	I	USI 4 Receiver input
A8	BP_USI_RX5	I	USI 5 Receiver input
A9	BP_USI_RX6	I	USI 6 Receiver input
A10	BP_USI_RX7	I	USI 7 Receiver input
A11	BP_USI_RX8	I	USI 8 Receiver input
A12	BP_USI_RX9	I	USI 9 Receiver input
A13	BP_USI_RX10	I	USI 10 Receiver input
A14	DGND		Digital ground
A15	BP_R/W	I	Read/Write signal
A16	Res		
A17	BP_nEvent-Str		
A18	BP_nReset		
A19	DGND		Digital ground
A20	BP_A14	I	Address line 14
A21	BP_A12	I	Address line 12
A22	BP_A10	I	Address line 10
A23	BP_A8	I	Address line 8
A24	BP_A6	I	Address line 6
A25	BP_A4	I	Address line 4
A26	BP_A2	I	Address line 2
A27	BP_A0	I	Address line 0
A28	BP_D6	I/O	Data line 6
A29	BP_D4	I/O	Data line 4
A30	BP_D2	I/O	Data line 2
A31	BP_D0	I/O	Data line 0
A32	DGND		Digital ground

Table 15-3: Pin assignment of rail A

15.2.1.3.2   Rail B

PIN	Description	I/O	Explanation
B1	+5V	I	+5V power supply
B2	AGND		Analogue ground

B3	DGND		Digital ground
B4	USI1_TRIP_IN	I	USI 1 trigger line current input (sink)
B5	USI1_TRIP_IN	I	USI 2 trigger line current input (sink)
B6	USI2_TRIP_IN	I	USI 3 trigger line current input (sink)
B7	USI3_TRIP_IN	I	USI 4 trigger line current input (sink)
B8	USI4_TRIP_IN	I	USI 5 trigger line current input (sink)
B9	USI5_TRIP_IN	I	USI 6 trigger line current input (sink)
B10	USI6_TRIP_IN	I	USI 7 trigger line current input (sink)
B11	USI1_TRIP_IN	I	USI 8 trigger line current input (sink)
B12	USI1_TRIP_IN	I	USI 9 trigger line current input (sink)
B13	USI1_TRIP_IN	I	USI 10 trigger line current input (sink)
B14	DGND		Digital ground
B15	BP_nDS		
B16	Res		
B17	BP_D15	I/O	Data line 15
B18	BP_D14	I/O	Data line 14
B19	BP_D13	I/O	Data line 13
B20	BP_D12	I/O	Data line 12
B21	BP_D11	I/O	Data line 11
B22	BP_D10	I/O	Data line 10
B23	BP_D9	I/O	Data line 9
B24	BP_D8	I/O	Data line 8
B25	DGND		Digital ground
B26	DGND		Digital ground
B27	DGND		Digital ground
B28	DGND		Digital ground
B29	DGND		
B30	DGND		
B31	BP_USI_TRIPLINE_RESET		
B32	DGND		Digital ground

Table 15-4: Pin assignment rail B

15.2.1.3.3 Rail C

PIN	Description	I/O	Explanation
C1	+5V	I	+5V power supply
C2	n.u.		
C3	DGND	I	Digital ground
C4	BP_USI_TX1	O	USI 1 Sender output
C5	BP_USI_TX2	O	USI 2 Sender output
C6	BP_USI_TX3	O	USI 3 Sender output
C7	BP_USI_TX4	O	USI 4 Sender output
C8	BP_USI_TX5	O	USI 5 Sender output
C9	BP_USI_TX6	O	USI 6 Sender output
C10	BP_USI_TX7	O	USI 7 Sender output
C11	BP_USI_TX8	O	USI 8 Sender output
C12	BP_USI_TX9	O	USI 9 Sender output
C13	BP_USI_TX10	O	USI 10 Sender output
C14	DGND	I	Digital ground
C15	BP_nBoardsel-SL		
C16	Res		
C17	BP_nDtack		
C18	BP_nSRQ		
C19	DGND	I	Digital ground
C20	BP_A15	I	Address line 15
C21	BP_A13	I	Address line 13
C22	BP_A11	I	Address line 11

C23	BP_A9	I	Address line 9
C24	BP_A7	I	Address line 7
C25	BP_A5	I	Address line 5
C26	BP_A3	I	Address line 3
C27	BP_A1	I	Address line 1
C28	BP_D7	I/O	Data line 7
C29	BP_D5	I/O	Data line 5
C30	BP_D3	I/O	Data line 3
C31	BP_D1	I/O	Data line 1
C32	DGND		Digital ground

Table 15-5: Pin assignment rail C

15.2.2 The ACU/FAIRBus Backplane (FG660_034)

The ACU/FAIRBus backplane consist of up to 2 small expansion modules (AFBUSIExt) that are connected by a flat ribbon cable.

The backplane is the interface between the ACU and the control system. This will either be a GSI interface card or an SCU.

Figure 15-3: ACU/FAIRBus backplane with expansion module (AFBUSIExt)

These expansion modules are used to connect slave modules, like ICM and/or ADC, to the MFU using a RJ45 cable. Depending on the requirement, one or two of the modules are connected to the backplane (see Figure 15-3).
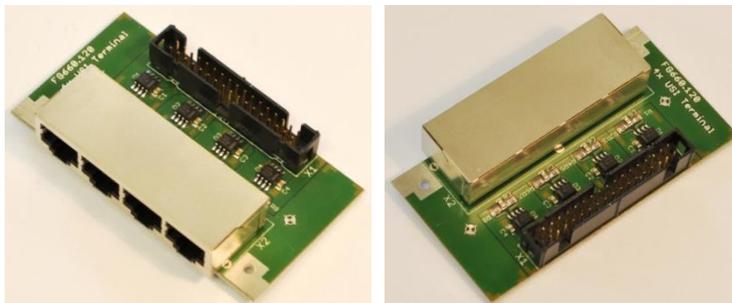
Figure 15-4: AFBUSIExt Module

The ACU/FAIRBus backplane usually gets installed in a 19" rack (refer to chapter 15.2.8: „The 19" rack"). This ensures it is possible to include more modules, like the MFU, interface card, SCU and so on.

The AFBUSIExt modules are installed at the back side of the 19" rack.

15.2.2.1 Dimensions

The dimensions of the ACU/FAIRBus backplane are 128 x 163 mm.

15.2.2.2 Power supply

The ACU/FAIRBus backplane requires a 12V power supply.

15.2.2.3   Connections and interfaces on the backside
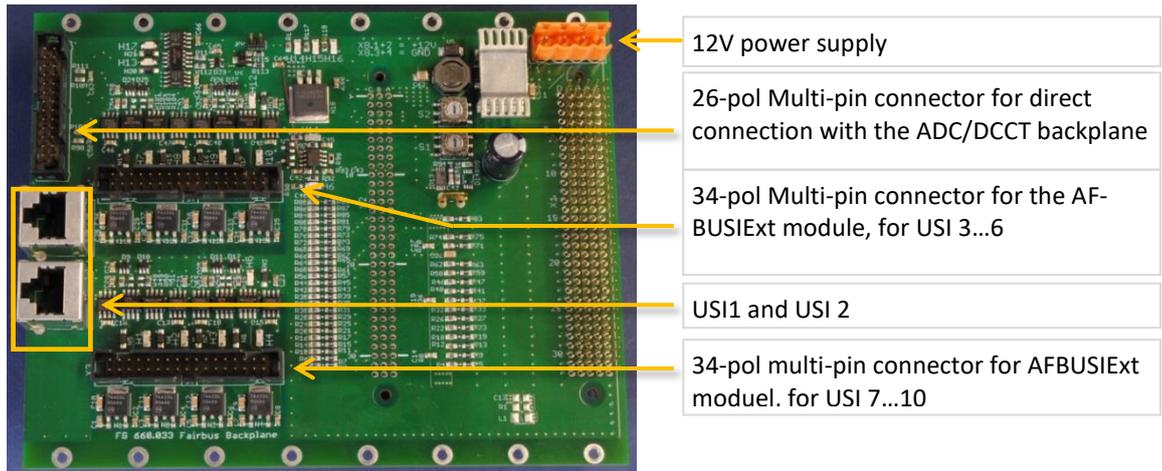
Figure 15-5: Backside of the ACU / FAIRBus backplane

Soldering bridges are needed in case USIs are not used. If the USI terminals are used (3..6 & 7..10), all unused USI have to be deactivated by placing the corresponding soldering bridges.

15.2.2.3.1   Supply to other modules

+5V DC are being generated on the backplane itself from the 12V power supply.

15.2.2.3.2   26-pol multi-pin connector

This one is used for the direct connection of the ACU/FAIRBus backplane with the ADC/DCCT back-plane (refer to chapter 15.2.5: „The ADC/DCCT backplane (FG660.072)").

USI 1 and 2 also communicate via this direct connection, which means that USI 1 and 2 have to remain free for that kind of connection (refer to chapter 15.2.2.3.4: „USI1 and USI2").

15.2.2.3.3   34-pol multi-pin connector

This connector is used for an AFBUSIExt module which provides the RJ45 sockets (USI interfaces) for connection external slave modules to the MFU.

The upper multi-pin connector provides for USI 3..6 and the bottom one for USI 7..10.

15.2.2.3.4   USI1 and USI2

USI 1 and 2 are connected directly at the RJ45 sockets and not at the Multi-pin connectors.

15.2.2.4   Connections and interfaces at the front side
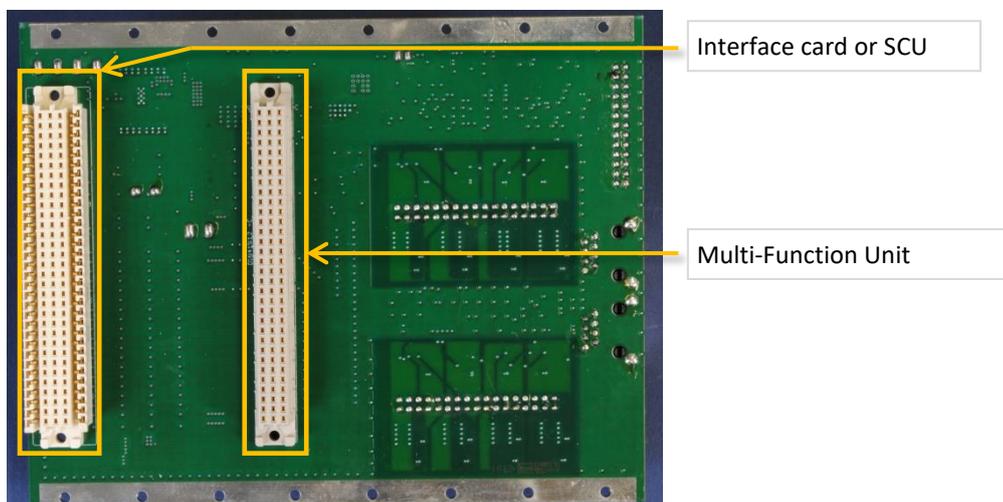
Figure 15-6: Front view of the ACU / FAIRBus backplane

15.2.2.4.1 Interface cards or the SCU rail

At this lug-in strip, the GSI interface card or the SCU can be connected for the communication between ACU and GSI control system.

15.2.2.4.2 MFU rail

At this plug-in strip, the MFU is plugged in. The assignment of the rail is described in chapter 15.2.1.3: „Connections and interfaces of the MFU".

15.2.3   *The interlock and control module (FG660_055)*
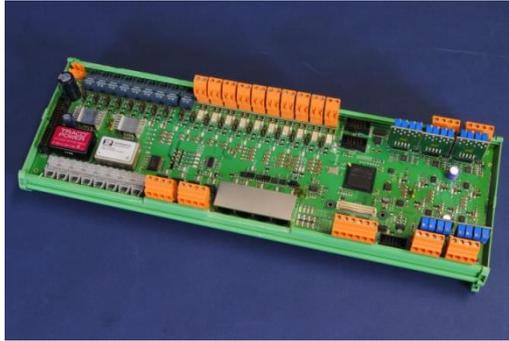
Figure 15-7: Front view of the ICM

The ICM is used to control the IGBT drivers, relays and protections, as well as the acquisition of inter-locks, the link voltage, earth faults and oscillation monitoring.

For this, it contains a number of in- and outputs, which are distributed as follows:

- 8 optical signal outputs for transistor control, using external IGBT drivers for i.e. transistors V1..V6

- 9 optical monitoring inputs for acquisition of errors of the external IGBT drivers. Usually this is the collector monitoring of the transistors V1..V6 and quench detection.

- 5 analogue monitoring inputs realized as comparators for acquisition of the primary current monitoring, the earth fault monitoring, the U_{d1} voltage monitoring and the U_{Load} voltage monitoring. All comparators are capable of grading using plug-in filters.

- 10 electrical monitoring inputs (+24V) for acquiring interlocks like DCCT saturation, main protection, main voltage too small, cooling water magnet, temperature magnet, temperature transformer, temperature cooling banks, cooling water IGBT bank, protection switch, emergency shut-down, door contact or PPS-Interlock.

- 4 electrical switch outputs (+24V via TLP optocoupler) to control main protection, load protection and PPS response.

- 4 USI RJ45 sockets, two as USI slave reserve and two as master reserve, to be used for possible expansion modules.

Usually this is the ICM, like shown in Figure 15-7, mounted on a hat rail.

15.2.3.1   *Dimensions*

The dimensions of the interlock and control module (without the hat rail) are 355 x 108 mm.

15.2.3.2   *Power supply*

The module needs a 24V DC power supply at the X1 socket. Please refer to chapter 5.1: „View of the interlock and control module".

15.2.3.3   *Connections and interfaces*

All electrical connections of the ICM are done via multi-pin connectors, type Phoenix Contact Series MSTBVA, pitch 5,08mm.
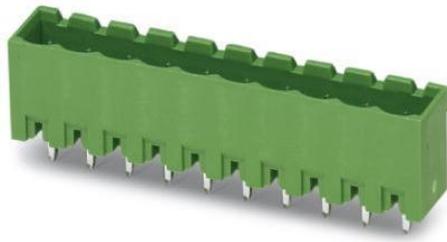
Figure 15-8: 10-pol version of the Phoenix multi-pin Series MSTBVA

All optical connections of the ICM are done via AVAGO Series HFBR-0500Z plugs.

Figure 15-9: Example for plugs of the AVAGO Series HFBR

15.2.3.3.1   Digital, optical interlock acquisition

The AVAGO Series HFBR-0500Z – R2521Z requires a light signal via fiber optic cable. If the signal is interrupted and the port is active, this will be recognized as an interlock. For further information refer to chapter 5.2.6: „Digital, optical interlock acquisition 1...8 and 9".

15.2.3.3.2   Digital, electrical interlock acquisitions

A +24V signal power supply is needed, so that no interlock will occur. If the voltage gets interrupted and the port is active, this will be recognized as an interlock. For further information refer to chapter 5.2.5: „Digital electrical interlock acquisition 1...10".

15.2.3.3.3   Analogue, electrical interlock acquisitions as comparators

Unipolar and bipolar comparators are used with filters to define switch threshold and response behavior. If they are activated for interlocks, exceeding or falling below the comparator voltage will be recognized as an interlock. For further information please refer to chapter 5.2.4.1: "Bipolar comparators 1...4" and chapter 5.2.4.2: „Unipolar comparator 5".

The comparators are configured with plug-in filter modules. These modules have 4 potentiometers for setting the comparator thresholds as well as a user definable RC filter.
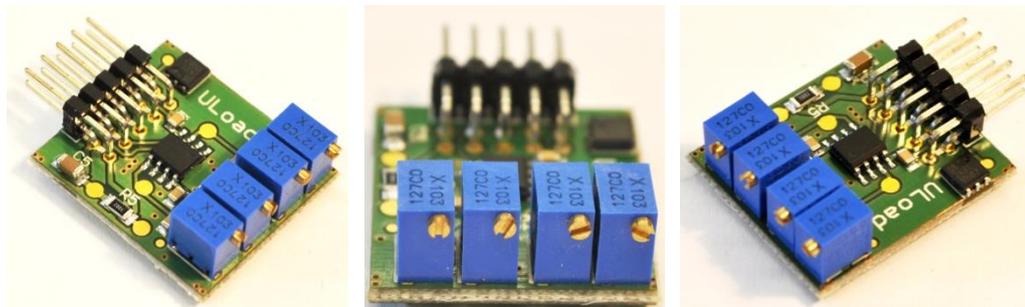
Figure 15-10: Plug-in filter modules of the ICM

15.2.3.3.4   Optical pulse logic outputs

They provide a light signal to optically control i.e. IGBT drivers for example via fibre optic cables. Refer to chapter 5.2.11: „Pulse logic outputs IGBT V1...V8" for further information.

15.2.3.3.5 Electrical switch outputs

These outputs provide a voltage signal to control electrical switch devices (like protections). Here, the voltage that is put out has to be fed externally. For more information refer to chapter 5.2.10: „Electrical switch outputs 1...4".

15.2.3.3.6 Water flow control

Water flow control allows the connection of 2 water flow guards. For further information refer to chapter 5.2.8: "Water flow control".

15.2.3.3.7 External temperature sensor

This connector allows connecting external temperature sensors via I²C Bus.

15.2.3.3.8 16 Bit expansion port

This multi-pin connector is used to connect an expansion module to the ICM for additional functions. For more information refer to chapter 5.2.7: „16 Bit Extension port".

PIN	Description	I/O	Explanation
1	Trip line 1	I	Trip line 1
2	GND		Ground
3	Trip line 2	I	Trip line 2
4	GND		Ground
5	Trip line 3	I	Trip line 3
6	GND		Ground
7	Trip line 4	I	Trip line 4
8	ID	I/O	1-wire ID
9*)	Trip line Pull-up Supply	O	+5V DC for Trip lines
10*)	Trip line Pull-up	I	Head point of the Trip line resistors
11	Trip line Status 2	O	Status of trip line 2 is stored using a hardware flip-flop
12	Switched 5V_1	O	Status of trip line 1 is stored using a hardware flip-flop
13	+5 Volt	O	+5V DC output
14	+5 Volt	O	+5V DC output
15	+12 Volt	O	+12V DC output
16	-12 Volt	O	-12V DC output
17	GND		Ground
18	GND		Ground
19	Extension Bus 0	I/O	Bus wire from/to FPGA
20	Extension Bus 1	I/O	Bus wire from/to FPGA
21	Extension Bus 2	I/O	Bus wire from/to FPGA
22	Extension Bus 3	I/O	Bus wire from/to FPGA
23	Extension Bus 4	I/O	Bus wire from/to FPGA
24	Extension Bus 5	I/O	Bus wire from/to FPGA
25	Extension Bus 6	I/O	Bus wire from/to FPGA
26	Extension Bus 7	I/O	Bus wire from/to FPGA
27	Extension Bus 8	I/O	Bus wire from/to FPGA
28	Extension Bus 9	I/O	Bus wire from/to FPGA
29	Extension Bus 10	I/O	Bus wire from/to FPGA
30	Extension Bus 11	I/O	Bus wire from/to FPGA
31	Extension Bus 12	I/O	Bus wire from/to FPGA
32	Extension Bus 13	I/O	Bus wire from/to FPGA
33	Extension Bus 14	I/O	Bus wire from/to FPGA
34	Extension Bus 15	I/O	Bus wire from/to FPGA

*) Pins 9 and 10 have to be connected by a short-circuit bridge, if no expansion module is present, to disable the trip lines to the expansion module. Otherwise, it is not possible to delete or acknowledge these trip lines.

Table 15-6: Pin assignment of the ICM 16 Bit expansion port

15.2.4   The ADC module (FG660_044)

The present description in this chapter is for the hardware release mentioned in the headline. Older or newer versions of this module can have different markings regarding connectors, plugs, components and so on. In most cases, the functions are identical. In case there are any doubts, please refer to the images or contact support.

Figure 15-11: ADC module

This is an 18-bit analogue/digital converter module, which is used for fast actual value acquisition. This actual value usually comes from the analogue output of the DCCT and is acquired through the ADC/DCCT backplane (see also chapter 15.2.5: „The ADC/DCCT backplane (FG660.072)") and passed on to the ACU/FAIRBus Backplane (chapter 15.2.2: „The ACU/FAIRBus Backplane (FG660_034)") via a flat ribbon cable.

The ADC module has 4 comparators for monitoring of i.e. positive and/or negative over-current and average over-current. On the front side, measurement sockets (2mm) can be found. They are used for normal and graded analogue signals of the comparators.

The module can do several different calculations for an average and has to be calibrated.

The ADC module is usually installed in a 19'' rack (chapter 15.2.8: „The 19" rack") with according ADC/DCCT Backplane (chapter 15.2.5: „The ADC/DCCT backplane (FG660.072)").

15.2.4.1   Dimensions

The ADC module is a Eurocard PCB (printed circuit board) with the dimensions 160 x 100 mm. The front plate of the card (left hand side in Figure 15-11), with which it is installed in the 19'' rack, measures 128 x 20 mm.

15.2.4.2   Power supply

The module requires a 5V and +/- 15V DC power supply, which usually is provided by the proper ADC/DCCT backplane (chapter 15.2.5: "The ADC/DCCT backplane (FG660.072)").

15.2.4.3   Connections and interfaces

All three multi-pin connectors are wired the same way, which means that pin with the same number are wired in the same way on all rails.

PIN	Description	I/O	Explanation
ABC1	+5V	I	+5V power supply
ABC2	GNDD		Digital ground
ABC3	GNDD		Digital ground

ABC4	RxA	I	Differential USI Receiver input A
ABC5	RxB	I	Differential USI Receiver input A
ABC6	TxZ	O	Differential USI Sender input Z
ABC7	TxY	O	Differential USI Sender input Z
ABC8	GNDD		Digital ground
ABC9	GNDD		Digital ground
ABC10	PMO	O	+5V output for plug monitoring
ABC11	PMI	I	Input for plug monitoring
ABC12	GNDD		Digital ground
ABC13	GNDD		Digital ground
ABC14	TLI	I	Trigger line input
ABC15	TLO	O	Trigger line output
ABC16	I/O1	I/O	free I/O for diagnostics and development
ABC17	I/O2	I/O	free I/O for diagnostics and development
ABC18	I/O3	I/O	free I/O for diagnostics and development
ABC19	I/O4	I/O	free I/O for diagnostics and development
ABC20	GNDA		Analogue ground
ABC21	GNDA		Analogue ground
ABC22	GNDA		Analogue ground
ABC23	GNDA		Analogue ground
ABC24	Analogue signal	I	Analogue input signal
ABC25	GNDA		Analogue ground
ABC26	GNDA		Analogue ground
ABC27	GNDA		Analogue ground
ABC28	GNDA		Analogue ground
ABC29	GNDA		Analogue ground
ABC30	+15V	I	+15V power supply
ABC31	GNDA		Analogue ground
ABC32	-15V	I	-15V power supply

Table 15-7: Pin assignment of the ADC modules A, B and C

15.2.5   *The ADC/DCCT backplane (FG660.072)*

The backplane is used for up to 4 plug-in units. This is one with 2 VG96 rails to take two ADC modules for current or field acquisition, one plug-in rail for the DCCT electronics card made by HITEC and one plug-in rail for the DCCT power supply.

The DCCT measuring head is connected with a 15-pol Sub-D socket. The field probe uses a 9-pol SUB-D socket.

Using a flat ribbon cable at a 26-pol multi-pin connector, the ADC/DCCT backplane is connected to ACU/SCU backplane (refer to chapter 15.2.2: „The ACU/FAIRBus Backplane (FG660_034)"). This way the acquired measuring data is communicated to MFU.

The ADC/DCCT backplane is usually installed in a 19'' rack (refer to chapter 15.2.8: „The 19" rack"). This allows adding ADC modules, the DCCT electronic and DCCT power supply.

If an ADC card slot is not used, the associated RJ45 plug on the ACU/FAIRBus backplane must be bridged in order to close the pull cord.

If only one ADC card is on X1 (field), X5 on the ACU/FAIRBus backplane must be bridged; if it is on X2 (power), X4 is bridged. X10 pin 9 and 23 ripcords receive the signal from the ACU/FAIRBus backplane that all ripcords are OK (+12V DC) when RESET is pressed.

This signal is generated for about 1 second by the N555 on the A-CU/FAIRBus backplane.

15.2.5.1   *Dimensions*

The dimensions of the ADC/DCCT backplane are 135 x 128 mm.

15.2.5.2   *Connections and interfaces of the backside*
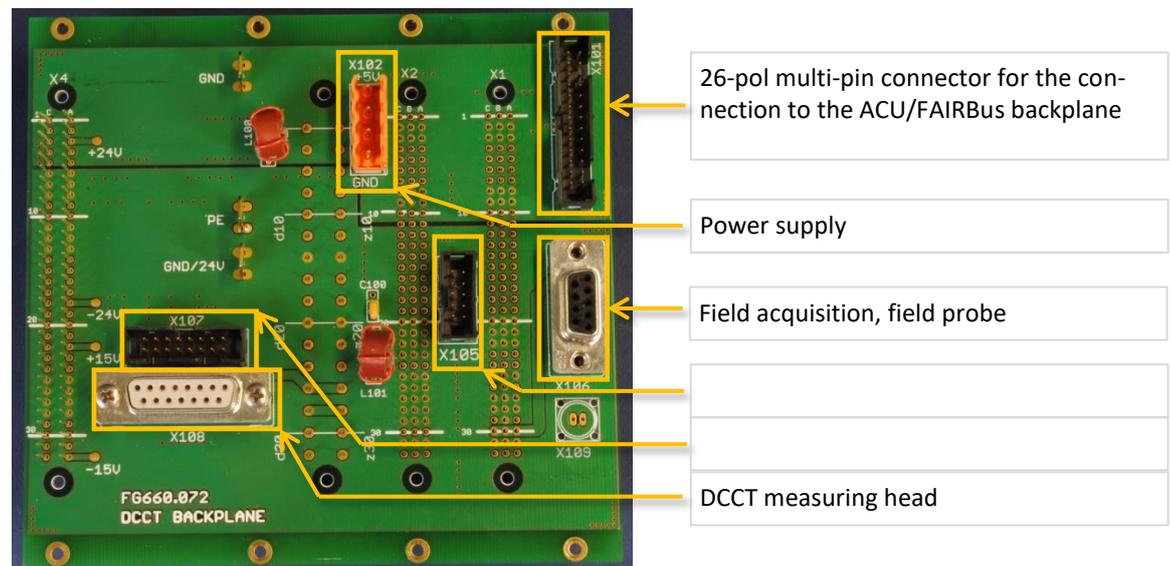
Figure 15-12: Backside of the ADC/DCCT backplane

26-pol multi-pin connector for the connection to the ACU/FAIRBus backplane

Power supply

Field acquisition, field probe

DCCT measuring head

15.2.5.2.1   *Power supply*

The backplane must be supplied with +5 volts DC via this connection. This voltage supplies any plugged-in ADC modules. The ribbon cable from the ACU/FAIRBus backplane on the X101 also supplies +5 volts. This means that if there is a direct connection, no additional +5V feed is required.

The +/- 15 volts DC also required for the ADC modules and the +24 volts DC for the DCCT electronics are supplied by the DCCT three-phase power supply (see Chapter 15.2.7: "The DCCT three phase current power supply").

Starting with FG660.073 the three-phase power supply has been omitted and replaced by two single-phase power supplies for gaining +/-15 volts and +/-24 volts.

These are no longer connected to the printed circuit board via an FABC strip, but via Phoenix MSTB connectors.

15.2.5.2.2   DCCT Measuring head Sub-D socket

The DCCT measuring head is connected here.

PIN	Description	I/O	Explanation
1			(at Z30/X3)
2			(at D30/X3)
3			(at Z32/X3)
4			(at D32/X3)
5			(over L101 at Z2/X3)
6			(at D2/X3)
7			(at Z4,D4/X3)
8			(at Z26, D26/X3)
9	-		unused
10	-		unused
11	-		unused
12	-		unused
13	-		unused
14	-		unused
15	-		unused

Table 15-8: Pin assignment of the Sub-D DCCT

15.2.5.2.3   Field acquisition Sub-D socket

For the optional possibility to acquire actual field values via field probe and run the PSU field-controlled, pins 6 and 9 in the plug have to be bridged. If this connection is open, the plug monitoring sets in.

PIN	Description	I/O	Explanation
1	-15V	O	-15V power supply
2	Analogue signal	I	Analogue input signal
3	GNDA		Analogue ground
4	GNDA		Analogue ground
5	+15V	O	+15V power supply
6	PMI	I	Input for plug monitoring
7	-		Unused
8	-		Unused
9	PMO	O	+5V output for plug monitoring

Table 15-9: Pin assignment of the Sub-D field acquisition

15.2.5.3   Connections and interfaces of the front view

Optional 2nd ADC module for field acqui-sition

ADC module for conversion of the DCCT output voltage

DCCT power supply

DCCT electronic
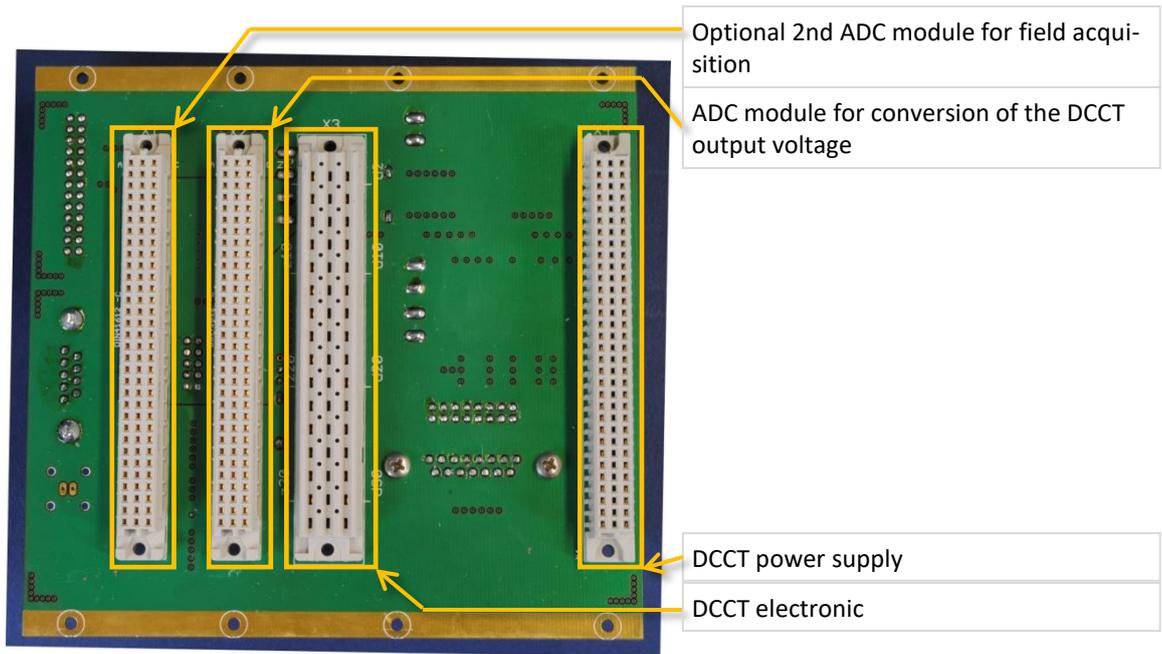
Figure 15-13: Front side of the ADC/DCCT backplane

15.2.5.3.1   ADC module VG96 rail

The ADC/DCCT backplane has two sockets for ADC module. X2 is the one for an ADC module to ac-quire and convert the DCCT output voltage. X1 is an optional socket for a second ADC module to ac-quire field values to control the field of the PSU.

The pin assignment of the multi-pin connector of both sockets is mostly identical and can be found in chapter 15.2.4.3: "Connections and interfaces". It is to be noted though that the analogue input signal (ABC24) and the plug monitoring (ABC10, ABC11) of socket X2 are connected with the Sub-D socket X107. The analogue input signal (ABC24) and the plug monitoring (ABC10, ABC11) of socket X1 are connected with the Sub-D socket X106.

The connection between the ADC module and backplane is realized using a VG96 multi-pin connector.

15.2.5.3.2   DCCT electronics rail

The connection between DCCT electronic and backplane is realized using a MZBD32 multi-pin con-nector.

Rail Z is on the left hand side when viewed from the front.

PIN	Description	I/O	Explanation
Z2	DCCT head		(over L101 at 5/X101)
Z4	DCCT head		(at 7/X101)
Z6	+24V		+24V (positive power supply)
Z8	-		Unused
Z10	-		Unused
Z12	-		Unused
Z14	GNDA		Analogue ground
Z16	-		Unused
Z18	-		Unused
Z20	GNDA		Analogue ground
Z22	GNDA		Analogue ground
Z24	-		Unused
Z26	DCCT head		(at 8/X101)
Z28	-24V		-24V power supply
Z30	DCCT head		(at 1/X101)

PIN	Description	I/O	Explanation
Z32	DCCT head		(at 3/X101)

Table 15-10: Pin assignment of the DCCT Electronic rail Z

Rail D is on the right hand side when viewed from the front.

PIN	Description	I/O	Explanation
D2	DCCT head		(at 6/X101)
D4	DCCT head		(at 7/X101)
D6	+24V		+24V (negative power supply)
D8	-		Unused
D10	PMI	I	+5V Input for plug monitoring (at ABC10/X2)
D12	PMO	O	Output for plug monitoring (at ABC11/X2)
D14	GNDA		Analogue ground
D16	-		Unused
D18	-		Unused
D20	GNDA		Analogue ground
D22	Analogue signal	O	Analogue output signal of the DCCT (at ABC24/X2)
D24	-		Unused
D26	DCCT head		(at 8/X101)
D28	-24V		-24V power supply
D30	DCCT head		(at 2/X101)
D32	DCCT head		(at 4/X101)

Table 15-11: Pin assignment of the DCCT electronics rail D

15.2.5.3.3 DCCT power supply rail

The multi-pin connectors A and C of the DCCT power supply are wired identically, which means that pins with the same number are wired the same way on both lists.

Rail B is not used.

The pin assignment is the following:

PIN	Description	I/O	Explanation
AC1	+24V/2	I	+24V input voltage
AC2	+24V/2	I	+24V input voltage
AC3	+24V/2	I	+24V input voltage
AC4	PE		Three phase current PE
AC5	PE		Three phase current PE
AC6	+24V/2 GND	I	Ground of the +24V input voltage
AC7	+24V/2 GND	I	Ground of the +24V input voltage
AC8	+24V/2 GND	I	Ground of the +24V input voltage
AC9	PE		Three phase current PE
AC10	PE		Three phase current PE
AC11	+24V/1	I	+24V input voltage
AC12	+24V/1	I	+24V input voltage
AC13	+24V/1	I	+24V input voltage
AC14	PE		Three phase current PE
AC15	PE		Three phase current PE
AC16	+24V/1 GND	I	Ground of the +24V input voltage
AC17	+24V/1 GND	I	Ground of the +24V input voltage
AC18	+24V/1 GND	I	Ground of the +24V input voltage
AC19	PE		Three phase current PE
AC20	PE		Three phase current PE
AC21	+15V	I	+15 Volt input voltage
AC22	+15V	I	+15 Volt input voltage
AC23	PE		Three phase current PE
AC24	PE		Three phase current PE
AC25	+15V GND	I	Ground of the +15V input voltage

AC26	+15V GND	I	Ground of the +15V input voltage
AC27	-15V GND	I	Ground of the -15V input voltage
AC28	-15V GND	I	Ground of the -15V input voltage
AC29	PE		Three phase current PE
AC30	PE		Three phase current PE
AC31	-15V	I	-15V input voltage
AC32	-15V	I	-15V input voltage

Table 15-12: Pin assignment of the DCCT power supply rails A and C

15.2.6   The ADC/DCCT backplane (FG660.075)

Beginning with FG660.073, the three-phase power supply has been omitted and replaced by two single-phase power supplies for gaining +/-15 volts and +/-24 volts. replaced.

These are no longer connected to the printed circuit board via an FABC strip, but via Phoenix MSTB connectors.

15.2.7   The DCCT three phase current power supply

The DCCT three-phase current power supply is a unit consisting of 2 euro format boards with a 15TE, 3HE front plate.

It is usually installed in a 19'' rack refer to chapter 15.2.8: „The 19" rack") with ADC/DCCT backplane (see chapter 15.2.5: „The ADC/DCCT backplane (FG660.072)").
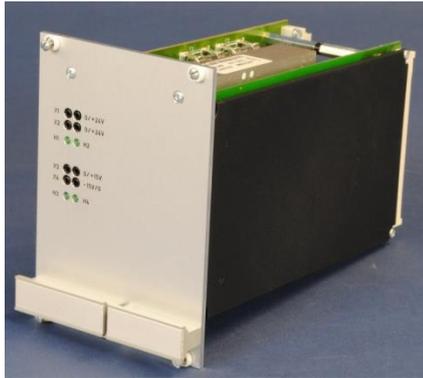
Figure 15-14: DCCT three-phase current power supply

15.2.7.1   Dimensions

The dimensions of the DCCT three phase power supply are 128 x 178 x 71 mm.

15.2.7.2   Power supply

The DCCT power supply requires a 400V three-phase power supply system with 0,1A.

15.2.7.3   Connections and interfaces

The DDCT three-phase current power supply has two connection rails. One is used to connect the three phase current contact. The other is the output rail for providing the created output voltages. It's usually mounted on the ADC/DCCT backplane (see chapter 15.2.5: „The ADC/DCCT backplane (FG660.072)"). The output voltages if the DCCT power supply are 2x 24V DC, +15V DC and -15V DC.

The connection rail of the power supply is a "Harting DIN 41 612 Bauform H15", Order. No. 09 06 115 293 2

Z20 Phase 1

Z24 Phase 2

Z28 Phase 3

Z32 PE

15.2.8   The 19" rack

Most modules and backplanes are installed in a 19'' rack. This ensures simple handling of the whole system.

The rack has a 3HE.
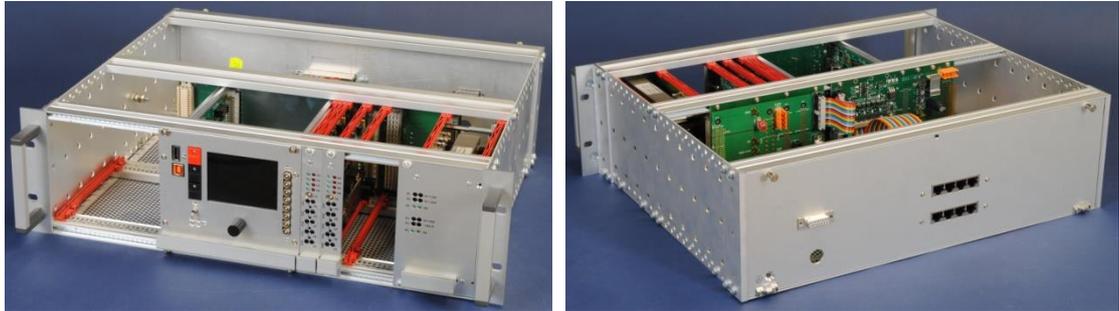
Figure 15-15: The 19'' rack

15.2.8.1   Power supply for the rack

The whole 19'' ACU rack requires a 400V three phase power supply system with max. 0,7A.

15.2.8.2   Digital power supply

Provides 12V power supply for MFU and SCU.

15.2.8.3   MFU

On the MFU backplane, the 5V power supply for the two USI slots is generated from the 12V of the digital power supply.

15.2.8.4   ADC USI 1 & 2

The +5V power supply for both ADC cards comes from the ACU/FAIRBus backplane.

15.2.8.5   DCCT

The DCCT module gets its power from the 3 phase, 400V analogue power supply.

15.2.8.6   3 phase, analogue power supply

The 3 phase, analogue power supply provides ±15V and ±24V for the DCT and the ADC modules.

15.3   Error codes

The following error codes are dated June 2nd 2022.

Code	#define	Description
0	ERR_NONE	No error
1	ERR_FT245_USI_NOT_AVAILABLE	selected USI not present
2	ERR_FT245_MOD_NOT_AVAILABLE	selected module not present
3	ERR_FT245_FSP_NOT_AVAILABLE	selected FSP not present
4	ERR_FT245_PID_UNKNOWN	PID unknown (same for mUSIC
5	ERR_FT245_DATA_LENGTH_MISSMATCH	Data length wrong
6	ERR_FT245_NO_SYNC_ERROR	no STX/ETX found
7	ERR_FT245_RX_BUF_EMPTY	FT245-CPU receive buffer is empty
8	ERR_FT245_TX_BUF_FULL	FT245-CPU Send buffer is full
9	ERR_FT245_FSP_WRITE_ONLY	This FSP is write-only
10	ERR_FT245_WHILE_WRITING_FSP	Error while writing on FSP over ft245
11	ERR_FT245_COLLECT	Error while getting data from ft245
12	ERR_FT245_CHECKSUM_ERR	Checksum wrong (same for mUSIC)
…		
14	ERR_USI_OFF	Error while USI is off and cannot be used
15	ERR_USI_INIT	Error while initializing USI
16	ERR_USI_RESET	Error during USI reset
17	ERR_USI_CHECK_IDLE	USI not ready
18	ERR_USI_BIT_RATE	USI has wrong bit rate
19	ERR_USI_CFG_BIT_RATE	Error while configuring bit rate of a USI
20	ERR_USI_RXBUF_NEMPTY	USI-CPU SW RxBuffer not empty
21	ERR_USI_RXBUF_EMPTY	USI-CPU SW RxBuffer is empty
22	ERR_USI_TX_TIME_OUT	Timeout while sending data via USI
23	ERR_USI_RX_TIME_OUT	Timeout while reading data via USI
24	ERR_USI_DECODE_MISSING_SYNC	STX not found
25	ERR_USI_DECODE_WRONG_FSP	FSP not found
26	ERR_USI_DECODE_WRONG_MOD_NUM	Module not present
27	ERR_USI_DECODE_MOD_MAILED_NAK	Module sent a NoAcknowledge
28	ERR_USI_DECODE_GENERAL_ERROR	general error while decoding USI communication
29	ERR_USI_SEND_STRING	Error while sending USI Strings
30	ERR_USI_SCAN_USI	Error during scanning for USI
31	ERR_USI_SETUP_HIGHSPEED	Error while turning High-speed mode on/off

32	ERR_USI_ENA_HSPEED_MOD_NO_HS_SUPPORT	Module does not support HS communication
…		
37	ERR_MDS_DECODE_VALUE_NOT_ASCII_OR_RxBUFFER_EMPTY	Error while decoding the received module descriptor
38	ERR_MDS_DECODE_MISSING_EOT	No EOT was found in MDS, end of descriptor not recognized
39	ERR_MDS_INTERPRET_DESCRIPTOR	Error while interpreting the module descriptor
40	ERR_MD_TUNNEL_SELECT	Error while selecting a tunnel
41	ERR_MD_TUNNEL_SEND_VALUE	Error during sending a value through a tunnel
42	ERR_MD_TUNNEL_SEND_STRING	Error during sending a string through a tunnel
43	ERR_MD_TUNNEL_RECEIVE_VALUE	Error during receiving a value through a tunnel
44	ERR_MD_TUNNEL_RX_BUF_EMPTY	Tunnel-CPU receiver buffer is empty
45	ERR_SPI_TRANSMIT_OVERRUN	Overflow during SPI sending to external flash
…		
50	ERR_EXT_FLASH_PROT_AREA	The sector of the serial flash is protected and write
51	ERR_EXT_FLASH_PAGE_PROG	Error occurred while writing one side of the serial flash
52	ERR_EXT_FLASH_SECTOR_ERASE	The desired sector of the serial flash could not be deleted
53	ERR_EXT_FLASH_BULK_ERASE	The serial flash could not be deleted completely
54	ERR_EXT_FLASH_GET_INTERLOCKTEXT	The interlock texts could not be loaded
55	ERR_EXT_FLASH_WRONG_DATA_FORMAT	Data length/format error while writing data into flash sector
56	ERR_EXT_FLASH_SECTOR_FULL	Sector is full, no more data writable
57	ERR_SERIAL_FLASH_SECTOR_EMPTY	Sector is empty, no meaningful data can be read from it
…		
60	ERR_VNC2_RX_FIFO_EMPTY	The VNC2 RxBuffer is empty
61	ERR_VNC2_RX_FIFO_FULL	The VNC2 RxBuffer is full
62	ERR_VNC2_BOOT_SYNC	The VNC2 has not reached the BootSync mode
63	ERR_VNC2_FIRMWARE_UPDATE	The VNC2 could not be refreshed
64	ERR_VNC2_NOT_PROGRAMMED	The VNC2 is not programmed
65	ERR_VNC2_FILE_HANDLE	The VNC2 produced an error while processing data
66	ERR_VNC2_RX_TIMEOUT	While receiving data the VNC2 timed out
67	ERR_VNC2_TX_TIMEOUT	While transmitting data the VNC2 timed out
68	ERR_VNC2_CMD_OR_ACCESS_DENIED	The VNC2 denies command or general
69	ERR_VNC2_CHAR_NOT_FOUND	Within a VNC2 file the desired char wasn't found
70	ERR_VNC2_FILE_EMPTY	A file on a USB memory is 0 bytes in size
75	ERR_CONV_ATOH_NO_VALID_ASCII_VALUE	Error while converting ASCII value into hex (same f. mUSIC)
76	ERR_CONV_HTOA_NO_HEX_VALUE	Error while converting hex value into ASCII
77	ERR_CONV_FSP_DATA	An error occured while running 'usi_convert_data()' or 'music_convert_data()'

78	ERR_EPCS_TIMEOUT	The serial programming component EPCS does not respond
79	ERR_MUX_CONTROL	Error while setting/reading the DAC/Trigger Multiplexer
80	ERR_FSP_NO_DATA_PERMITTED	FSP should be read -> no sending of data allowed (same for mUISC)
81	ERR_FSP_WRONG_FSP	Wrong FSP addressed
82	ERR_FSP_DATA_CONTENT	Wrong data, expected others
83	ERR_FSP_READ_ONLY	FSP is read-only (same for mUSIC)
84	ERR_FSP_WRITE_ONLY	FSP is write-only
85	ERR_FSP_DATA_LENGTH_MISMATCH	Sent FSP data has wrong length (same for mUSIC)
86	ERR_FSP_DECODE_MISSING_SYNC	Start of Transfer not found
87	ERR_FSP_NOT_AVAILABLE	this FSP is unknown (same for mUSIC)
88	ERR_FSP_BIT_MAN	Error FSP bit manipulation
...		
91	ERR_VERFICATION_USB_DEVICE	USB flash device not valid (need to check with LOEP)
92	ERR_CPU_STATUS_CHECK	Expected system configuration is wrong
93	ERR_INVALID_FONT	Invalid font for displaying on the TFT
94	ERR_NO_MEM_SPACE_AVILABLE	No RAM available
95	ERR_MODULE_NOT_AVAIL_ACCORD_USI_DESC	According to the USI descriptor, the module is not available
96	ERR_I2C_NO_ACKNOWLEDGE	no I2C response of temperature sensors
97	ERR_LOADING_OPHRS	Error while loading operating hours counter
98	ERR_UPDATE_MFU	Error during MFU update
99	ERR_TC74_COMMUNICATION_ERROR	Error while communicating with temperature sensors
100	ERR_SUPPLY	one or more operating voltages are outside of tolerance
101	ERR_MUSIC_RX_BUF_EMPTY	Receive Buffer of mUSIC is empty
102	ERR_CHECKSUM_ERROR	Check sum error of USI and mUSIC
103	ERR_MEMORY_FULL	No more free memory
104	ERR_MODULE_VERFICATION	Error while validating module (FSP243)
105	ERR_PARSE_AND_PROG_FLASH	Error while parsing and programming the flash component
106	ERR_UPDATE_ERR	Error during update
107	ERR_COLLECT_INTERLOCKS_IN_FSP66	Error while collecting interlocks & writing them in FSP66
108	ERR_PIGGY_NOT_READY	Piggy data is not available
109	ERR_VERIFICATION_FAILED	Verification of a programmed EPCS file failed
110	ERR_EPCS_NOT_ENOUGH_MEMORY	The EPCS does not have enough memory available
111	ERR_EPCS_ERROR_WHILE_READING	The reading of the EPCS failed
112	ERR_CFI_FLASH_TOGGLE_FAIL	The toggle bit of the CFI Flash does not toggle during programming

113	ERR_CFI_FLASH_TIME_OUT	While writing the CFI Flash a TimeOut occured
114	ERR_NOT_ALL_RECORDED_DATA_READ	Not all data was read from a 'DataStorage' module
115	ERR_TIMEOUT_WHILE_WAITING_FOR_DATA	There was a timeout on receiving "what-ever-data"
116	ERR_FKT_NOT_SUPPORTED	This function is not supported, probably the FW does not fit
117	ERR_NEEDED_PARAMETERS_NOT_SET	Necessary parameters have not been set previously (for example, in the case of read functions of the int. FSP)
118	ERR_USI_AUTO_RECONNECT	Auto-reconnect is active but no module/USI lost in alerts reported.
119	ERR_PROG_RAM	

Table 15-13: Error codes

15.4   Warnings

The following warnings are dated June 2nd 2022.

Code	#define	Description
0x00000001	WARNING_USI_1_LOST_CONNECTION	USI lost connection (time out)
0x00000002	WARNING_USI_2_LOST_CONNECTION	
0x00000004	WARNING_USI_3_LOST_CONNECTION	
0x00000008	WARNING_USI_4_LOST_CONNECTION	
0x00000010	WARNING_USI_5_LOST_CONNECTION	
0x00000020	WARNING_USI_6_LOST_CONNECTION	
0x00000040	WARNING_USI_7_LOST_CONNECTION	
0x00000080	WARNING_USI_8_LOST_CONNECTION	
0x00000100	WARNING_USI_9_LOST_CONNECTION	
0x00000200	WARNING_USI_10_LOST_CONNECTION	
0x00000400	WARNING_USI_11_LOST_CONNECTION	
0x00000800	-	
0x00001000	-	
0x00002000	WARNING_AUTO_RECONNECT_RUNNING	'AutoReconnect' attempts to reconnect an interrupted USI
0x00004000	WARNING_UNAUTHORIZED_USB_DEVICE	connected USB memory is not authorized (write YES, read NO)!
0x00008000	WARNING_CHECK_TRIPLINE_CONFIG	Interlocks are pending, but there is NO tripline pulled (circuit on the backplane?)
0x00010000	WARNING_CHECK_MODULES	Modules are inconsistent with provided system configuration
0x00020000	WARNING_CHECK_SUPPLIES	Check main power supply
0x00040000	WARNING_CHECK_PARAMETERS	Parameters are incorrect or contain errors
0x00080000	WARNING_CHECK_TEMPERATURE	at least one temp. sensor reports too high temperature
0x00100000	WARNING_TRIPLINE_PULLED	at least one trigger line has been pulled
0x00200000	WARNING_USI_1_LOST_MODULE	at least one of the modules connected to this USI lost connection
0x00400000	WARNING_USI_2_LOST_MODULE	
0x00800000	WARNING_USI_3_LOST_MODULE	
0x01000000	WARNING_USI_4_LOST_MODULE	
0x02000000	WARNING_USI_5_LOST_MODULE	
0x04000000	WARNING_USI_6_LOST_MODULE	
0x08000000	WARNING_USI_7_LOST_MODULE	
0x10000000	WARNING_USI_8_LOST_MODULE	
0x20000000	WARNING_USI_9_LOST_MODULE	

0x40000000	WARNING_USI_10_LOST_MODULE
0x80000000	WARNING_USI_11_LOST_MODULE

Table 15-14: Warnings

15.5 Log book entries

The following log book entries are dated June 2nd 2022:

The bytes [0] to [4] contain RTC information

The byte [5] specifies the entry.

Code	#define	Description
0x00	LOGBOOK_SPECIFY_ENTRY_AS_DEFAULT	Entry is a regular log book entry
0x01	LOGBOOK_SPECIFY_ENTRY_AS_ERROR	Entry is an error code
0x02	LOGBOOK_SPECIFY_ENTRY_AS_WARNING	Entry is a result
0x03	LOGBOOK_SPECIFY_ENTRY_AS_INTERLOCK	Entry is an interlock

Table 15-15: Logbook Specification

Byte [6] and [7] are the real logbook entries. In case of „LOGBOOK_SPECIFY_ENTRY_AS_DEFAULT"the meanings are as follows:

Code	#define	Decription
0x0001	LOGBOOK_ENTRY_ENERGIZED	control voltage provided to device
0x0002	LOGBOOK_ENTRY_DE_ENERGIZED	device separated from control voltage
0x0003	LOGBOOK_ENTRY_SWITCHED_ON	device turned on
0x0004	LOGBOOK_ENTRY_SWITCHED_OFF	device turned off
0x0005	LOGBOOK_ENTRY_INTERLOCKED	device turned off by interlock
0x0006	LOGBOOK_ENTRY_RESET_PRESSED	Reset button was pushed
0x0007	LOGBOOK_ENTRY_SWITCH_LOCAL	device set to local mode
0x0008	LOGBOOK_ENTRY_SWITCH_REMOTE	device set to remote mode
0x0009	LOGBOOK_ENTRY_USB_FLASH_DRIVE_INSERTED	USB Stick plugged in and recognized
0x000A	LOGBOOK_ENTRY_USB_FLASH_DRIVE_PERMITTED	plugged in USB Stick fully accepted
0x000B	LOGBOOK_ENTRY_USB_FLASH_DRIVE_RESTRICTED	plugged in USB Stick limitedly accepted
0x000C	LOGBOOK_ENTRY_USB_FLASH_DRIVE_REMOVED	USB Stick removed
0x000D	LOGBOOK_ENTRY_PC_CONNECTION_ESTABLISHED	Connection with PC established via USB
0x000E	LOGBOOK_ENTRY_PC_CONNECTION_TERMINATED	Connection with PC terminated
0x000F	LOGBOOK_ENTRY_RECORDING_SYSPARAMETERS_ENABLED	Recording of system parameters possible
0x0010	LOGBOOK_ENTRY_RECORDING_SYSPARAMETERS_DISABLED	Recording of system parameters not possible
0x0011	LOGBOOK_ENTRY_START_RECEIVING_PARAMETERS_FROM_PC	Receive parameters from PC started (RAM or Flash)
0x0012	LOGBOOK_ENTRY_INTERNAL_PARAMETERS_RE_LOADED	internal parameter loaded/refreshed
0x0013	LOGBOOK_ENTRY_PERFORMING_USI_SCAN	USI search is being performed
0x0014	LOGBOOK_ENTRY_PARAMETERS_RECEIVED_FROM_USB_FLASH_DRIVE	Parameter received via USB stick

0x0015	LOGBOOK_ENTRY_ACU_UPDATE_PROCESS_SUCCESSFUL	ACU System updated
0x0016	LOGBOOK_ENTRY_ERRORS_CLEARED	Error memory deleted
0x0017	LOGBOOK_ENTRY_LOGBOOK_READOUT	Log book read
0x0018	LOGBOOK_ENTRY_LOGBOOK_CLEARED	Log book deleted
0x0019	LOGBOOK_ENTRY_EXCEED_TEMPERATURE_LIMIT	Temperature of at least one sensor too high
0x001A	LOGBOOK_ENTRY_FINISH_RECEIVING_PARAMETERS_FROM_PC	Parameter received from PC (RAM or Flash)
0x001B	LOGBOOK_ENTRY_ACU_UPDATE_PROCESS_STARTED	ACU update process started
0x001C	LOGBOOK_ENTRY_ACU_UPDATE_PROCESS_ABORTED	ACU update process interrupted (because of an error)
0x001D	LOGBOOK_ENTRY_WARNINGS_CLEARED	Warnings memory deleted (if possible)
0x001E	LOGBOOK_ENTRY_LOST_USI_AUTO_RECONNECTED	A lost USI was automatically reconnected
0x001F	LOGBOOK_ENTRY_RESET_CMD_EXECUTED	RESET command executed
0x0020	LOGBOOK_ENTRY_COPY_PARAMETERS_FROM_USB_TO_RAM	Parameters copied from USB memory to RAM
0x0021	LOGBOOK_ENTRY_COPY_PARAMETERS_FROM_USB_TO_FLASH	Parameters copied from USB memory to FLASH

Table 15-16: Logbook entries in case of „LOGBOOK_SPECIFY_ENTRY_AS_DEFAULT"

If the logbook entry is specified as "LOGBOOK_SPECIFY_ENTRY_AS_ERROR" the upper nibble of byte [6] contains the USI number (0x1 ... 0xB), the lower nibble the module number (0x1 0x8 ...) and byte [7] the error code (refer to Table 15-13: Error codes). All entries are in hexadecimal. If the error is not generated by a module connected to an USI but from the MFU itself, this is signaled by USI number = 0x0 and module number = 0x0.

If the logbook entry is specified as "LOGBOOK_SPECIFY_ENTRY_AS_WARNING" byte [6] and [7] contain the bit position of the warning (refer to Table 15-14: Warnings) All entries are in hexadecimal.

If the logbook entry is specified as "LOGBOOK_SPECIFY_ENTRY_AS_INTERLOCK" the upper nibble of byte [6] contains the USI number (0x1 ... 0xB), the lower nibble the module number (0x1 0x8 ...) and byte [7] the interlock bit of the module. All entries are in hexadecimal.