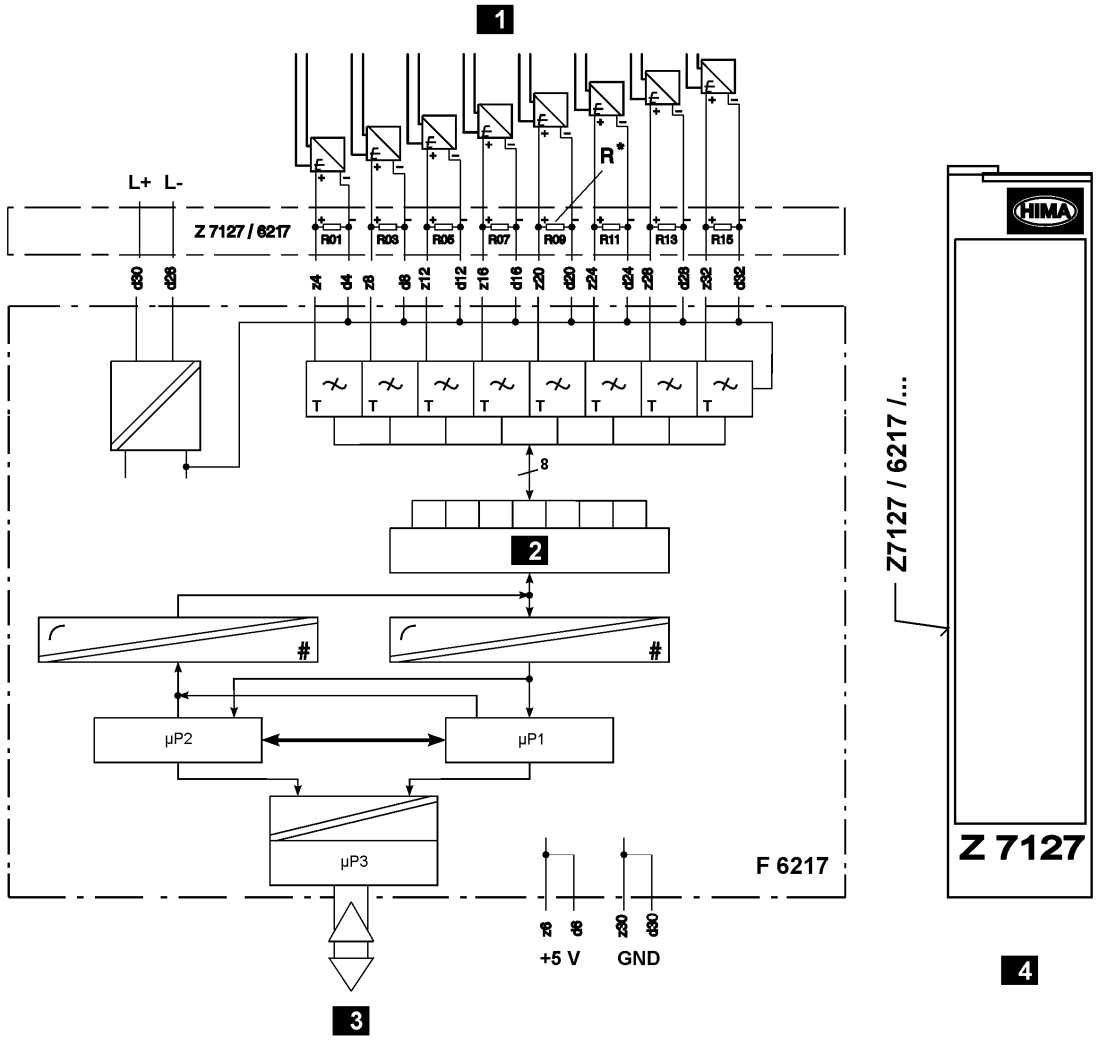
F 6217: Analog Input Module

Safety-related, TÜV-tested in accordance with IEC 61508 for applications up to SIL 3

- 8 channels for current inputs 0/4…20 mA, voltage inputs 0…5/10 V.
- Circuits with protective separation.
- Resolution: 12 bits.
- Short-circuit and open-circuit configurable in SILworX.
- For HIQuad X (SILworX) and HIQuad (ELOP II).



1 Transmitter supply
2 Multiplexer
3 I/O bus
4 Cable plug, front view

Figure 1: Module Block Diagram and Cable Plug Front View

HIMA Paul Hildebrandt GmbH, P.O. Box 1261, 68777 Brühl
English translation of the German original document: HI 803 067 D, F 6217, Rev.1.03 (2022)

The module includes a redundant, safety-related processor system, which allows all the tests to be directly performed on the module. The main test functions are:

- Linearity of the A/D converter.
- Overflow of the A/D converter.
- Cross-talk between the eight input channels.
- Input filter function.
- I/O bus communication function.
- Microcontroller self-test.
- Memory tests.

If a fault is detected, the channel error bit is set; its evaluation must be performed in the user program of the programming tool.

Specifications

Input voltage	0…5.5 V, max. 7.5 V
Input current	0…22 mA (via shunt), max. 30 mA
R*: Shunt for current measurement	250 Ω, 0.05 %, 0.25 W T < 10 ppm/K
Resolution	12-bit 0 mV = 0 5.5 V = 4095
Measured value refresh	50 ms
Safety time	< 450 ms
Input resistance	100 kΩ
Time constant for input filter	Approx. 10 ms
Intrinsic error limit	0.1 % at 25 °C
Operating error limit	0.3 % at 0…+60 °C
Withstand voltage	200 V against GND
Space requirement	4 HP
Current consumption	80 mA at 5 VDC (via backplane) 50 mA at 24 VDC (via cable plug)

Wiring

Refer to the corresponding tables for the wire color coding of the following cable plugs:

- Cable plug Z 7127/6217/Cx/I (U5V) for current or voltage connection (Table 1).
- Cable plug Z 7127/6217/Cx/U10V for voltage connection via voltage divider (Table 2).

Channel	Pin	Color	Connection
1	z4	BN	Cable: LiYCY 20 x 0.25 mm² (shielded)
	d4	WH	
2	z8	YE	
	d8	GN	
3	z12	PK	
	d12	GY	
4	z16	RD	
	d16	BU	
5	z20	VT	
	d20	BK	
6	z24	WHGN	
	d24	WHBN	
7	z28	WHGY	
	d28	WHYE	
8	z32	WHBU	
	d32	WHPK	
L+ (24 VDC)	d30	RD	Female connector 2.8 x 0.8 mm² q = 1 mm², l = 750 mm
L- (24 VDC)	d26	BK	
Shield		YEGN	Female connector 6.3 x 0.8 mm² q = 2.5 mm², l = 120 mm

Table 1: Wire Color Coding of the Cable Plug Z 7127/6217/Cx/I (U5V)

Channel	Pin	Color	Connection
1	x4	BN	Cable: LiYCY 20 x 0.25 mm² (shielded)
	d4	WH	
2	x8	YE	
	d8	GN	
3	x12	PK	
	d12	GY	
4	x16	RD	
	d16	BU	
5	x20	VT	
	d20	BK	
6	x24	WHGN	
	d24	WHBN	
7	x28	WHGY	
	d28	WHYE	
8	x32	WHBU	
	d32	WHPK	
L+ (24 VDC)	d30	RD	Female connector 2.8 x 0.8 mm² q = 1 mm², l = 750 mm
L- (24 VDC)	d26	BK	
Shield		YEGN	Female connector 6.3 x 0.8 mm² q = 2.5 mm², l = 120 mm

Table 2: Wire Color Coding of the Cable Plug Z 7127/6217/Cx/U10V

Current Inputs 0/4…20 mA

The measuring range for the current inputs is 0/4…20 mA.

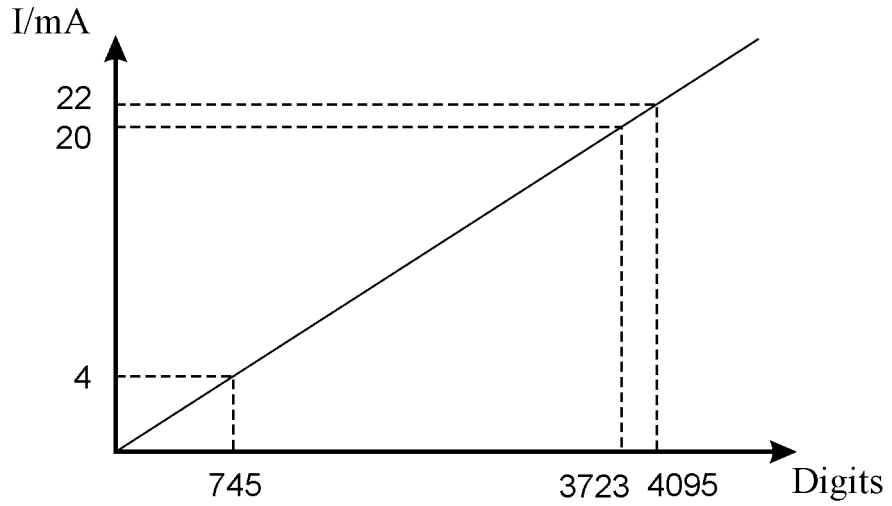
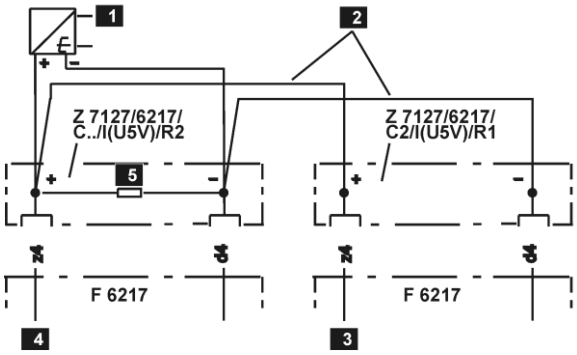


Figure 2: Current Inputs with 12 Bits = 4095 Digits = 22 mA

Redundant Current or Voltage Connection

The following figure shows the redundant current or voltage connection:

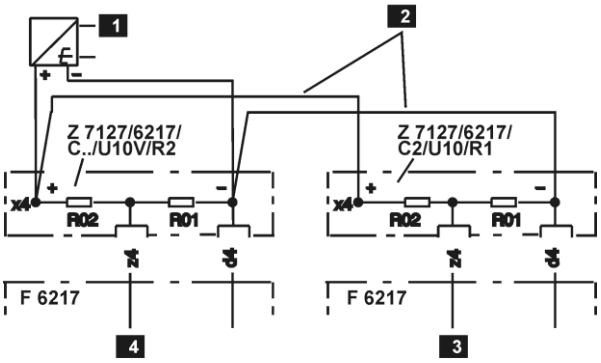


1 Transmitter supply
2 Not applicable for 1-channel connection
3 Module 2, channel 1
4 Module 1, channel 1
5 Cable plug Z 7126/6217/Cx/U5V, resistor not existing

Figure 3: Redundant Current or Voltage Connection

Redundant Connection via Voltage Divider up to 10 V

The following figure shows the redundant connection via voltage divider up to 10 V. The value of the voltage divider resistors, R01 and R02, is 1.96 kΩ. The internal resistance of the transmitter supply source must be taken into account for the redundant connection via voltage divider.

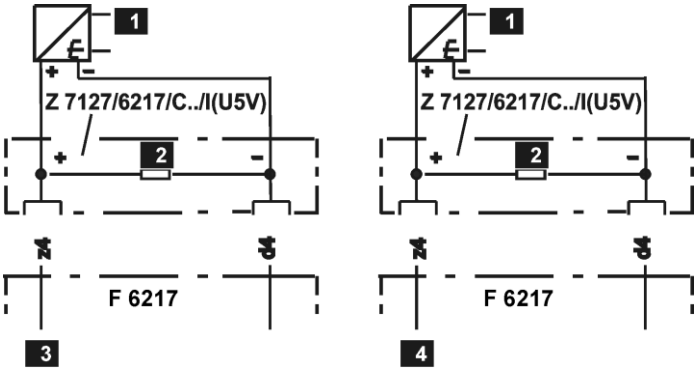


1 Transmitter supply
2 Not applicable for 1-channel connection
3 Module 2, channel 1
4 Module 1, channel 1

Figure 4: Redundant Connection via Voltage Divider

Current or Voltage Connection of Redundant Transmitters

The following figure shows the current or voltage connection of redundant transmitters. The redundant transmitter must be evaluated in the user program.

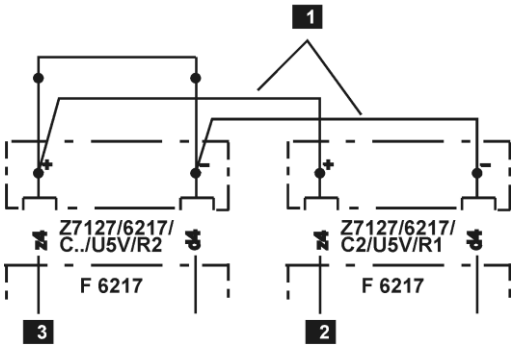


1 Transmitter supply
2 Cable plug Z 7126/6217/Cx/U5V, resistor not existing
3 Module 1, channel 1
4 Module 2, channel 1 or module 1, channel 2

Figure 5: Current or Voltage Connection of Redundant Transmitters

Wiring Unused Inputs

Unused voltage inputs 0…5 V must be short-circuited to terminals outside of the cable plug. This also applies for redundant connections, see Figure 6:



1 Not applicable for 1-channel connection

2 Module 2, channel 1

3 Module 1, channel 1

Figure 6 Voltage Supply 0…5 V

Unused current inputs are terminated through the shunt, while unused voltage inputs 0…10 V are terminated through the voltage divider in the cable plug.

Configuration Notes for ELOP II

Each input channel of the module has an analog value and a corresponding channel fault bit. If the channel fault is set, a safety-related reaction must be programmed in ELOP II for the corresponding analog input.

Safety Notices and Operating Requirements

The field lines of the input current circuits must be led with shielded cables, HIMA recommends using twisted pair wires.

If it is sure that the environment of the transmitter up to the module is free from interferences and the distance is rather short (e.g., within a control cabinet), shielded cables or twisted pair of wires are no longer necessary. The analog inputs, however, can only ensure immunity to interference if shielded cables are used.

Recommendations for Using the Modules in Accordance with IEC 61508, SIL 3

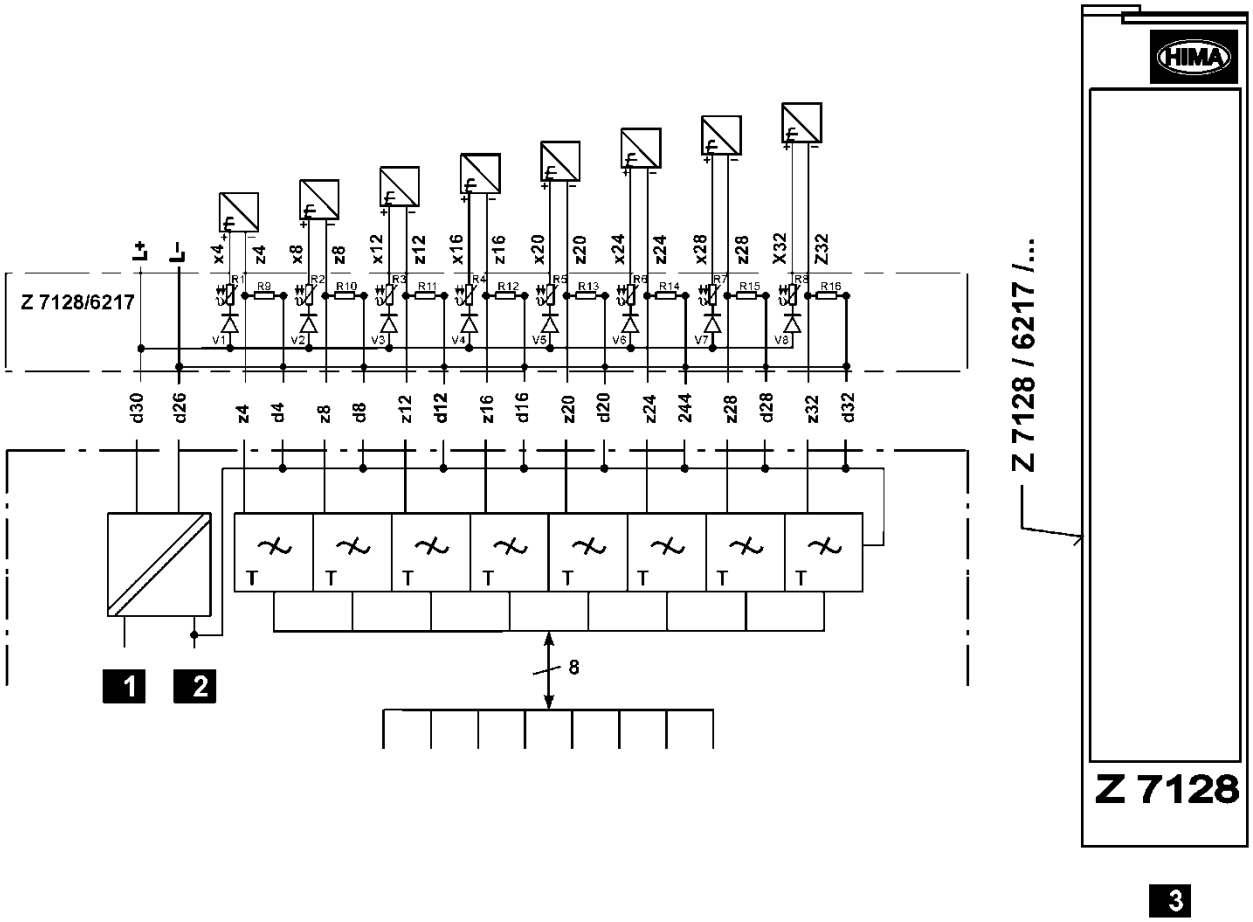
- Voltage supply lines must be physically separated from the input current circuits.
- Sufficient grounding must be ensured.
- Measures against temperature overrun must be taken outside the module, e.g., fans within the control cabinet.
- Logbook keeping for the entire operation and maintenance.

No specific maintenance is required for the module. If failures occur, the module is switched off. The defective module must be replaced.

Cable Plug Z 7128 with Transmitter Supply

The Z 7128 cable plug with transmitter supply is available for supplying transmitters (suitable only for 2-wire circuit).

i Cable plug Z 7128 cannot be used with Zener barriers!



1 Analog supply
2 Analog GND
3 Cable plug, front view

Figure 7: Wiring for Cable Plug Z 7128

Cable Plug with Transmitter Supply

Refer to the following table for the wire color coding of the cable plug Z 7128/6217/Cx/ITI with transmitter supply:

Channel	Pin	Color	Connection
1	z4	BN	Cable: LiYCY 24 x 0.14 mm² (shielded)
	x4	WH	
	d4	GN	
2	z8	GY	
	x8	YE	
	d8	PK	
3	z12	RD	
	x12	BU	
	d12	BK	
4	z16	WHBN	
	x16	VT	
	d16	WHGN	
5	z20	WHGY	
	x20	WHYE	
	d20	WHPK	
6	z24	WHRD	
	x24	WHBU	
	d24	WHBK	
7	z28	BNYE	
	x28	BNGN	
	d28	BNGY	
8	z32	BNBU	
	x32	BNPK	
	d32	BNRD	
L+ (EL+)	d30	RD	Female connector 2.8 x 0.8 mm² q = 1 mm², l = 750 mm
L-	d26	BK	
Shield		YEGN	Female connector 6.3 x 0.8 mm² q = 2.5 mm², l = 120 mm

Table 3: Wire Color Coding of the Cable Plug Z 7128/6217/Cx/ITI

If the transmitter Saab/Rosemount 3300 GWR is used with internal Zener diode, galvanic separation in the signal connection must be provided to prevent interference (signal peaks, undefined signal levels) at the analog inputs of an F 6217.

The analog repeater power supply from HIMA, H 6200A, can be used to this purpose.

Module Interference in Low Frequency Range (10 Hz)

External interference pulses of around 10 Hz, such as those occurring when measuring pressure near piston pumps, can cause temporary channel faults at the inputs. This noise level can have negative effects on internal hardware tests performed in the same rhythm. Input channels can be interpreted as being faulty and thus switched off.

Workaround

- Pressure sensors:
  - Interference pulses can be minimized or eliminated through adjustable digital filters within the sensor to apply internal damping.
- Use of the H 7017 low-pass filter:
  - The high time constant of the low-pass filter attenuates the level of the input current signals and removes low-frequency interference pulses.

i The low-pass filter may only be used in safety-related circuits with low switch-off because the input signal levels are damped. The filter's time delay must be taken into account when calculating the safety time.

Note: Additional transmitter feeds, such as via the Z 7128 front cable plug, have no disturbing effects on the F 6217 module operation.

1 Configuration in SILworX

The module is configured in the Hardware Editor of the SILworX programming tool.

To ensure safety-related use, the limit values for short-circuits and open-circuits must be configured in SILworX for each channel. HIMA recommends retaining the preset NAMUR values for open-circuits (3.6 mA) and short-circuits (21 mA).

A safety-related evaluation greater than 21 mA and less than 0 mA is not permitted, as the measuring accuracy in these ranges can no longer be ensured.

The *-> Process Value [REAL]* parameter automatically adopts the configured initial value if the limit values are violated or if an internal channel fault occurs. The users must adopt measures in the user program to ensure that this initial value causes the respective safety function to enter the safe state.

The *-> Raw Value [1 mA = 10 000] [DINT]* parameter may only be used under the following conditions:

1. Measuring range 0…21 mA.
2. Additional evaluation of the *-> Process Value OK [BOOL]* parameter within the user program. FALSE must cause the respective safety function to enter the safe state.
3. Evaluation of the limit values for open-circuits and short circuits as *-> Process Value OK [BOOL]* automatically changes to FALSE when the set limit values are exceeded. Alternatively, the thresholds can also be evaluated in the user program.
4. Programming of a substitute value (initial value) in the user program, which causes the respective safety function to enter the safe state.

Additionally, observe the following points when configuring the module:

- To diagnose the module and channels, both the statuses and the measured value can be evaluated within the user program. For further details on the statuses and parameters, refer to the tables in Chapter 1.1 and following chapters.
- Depending on the cable plug, the parameters *4 mA*, *20 mA* and *-> Process Value [REAL]* must be scaled as follows during voltage measurement:

  - Voltage measurement 5 V:
    Process value **x** scaling factor **=** 4 mA **x** 250.0 **=** 1000.0 corresponding to 1000.0 mV
    Process value **x** scaling factor **=** 20 mA **x** 250.0 **=** 5000.0 corresponding to 5000.0 mV
  - Voltage measurement 10 V:
    Process value **x** scaling factor **=** 4 mA **x** 500.0 **=** 2000.0 corresponding to 2000.0 mV
    Process value **x** scaling factor **=** 20 mA **x** 500.0 **=** 10000.0 corresponding to 10000.0 mV
- When scaling, the value range of the REAL data type must be taken into account to be able to represent the input values as REAL variables.
- If a redundancy group is created, its configuration is defined in the tabs. The tabs specific to the redundancy group differ from those of the individual modules, see the following tables.
- If 2 inputs are redundantly configured, the larger of the two scaled values is written to the redundant system parameter *-> Process Value [REAL].* This applies provided that both modules are in proper working order. If faults occur, only the value of the fault-free module is processed. This requires an identical signal source for both inputs, e.g., a measured value. Any deviation between the two measured values must be within the safety-related accuracy.

To evaluate the system parameters in the user program, they must be assigned to global variables. Perform this step in the Hardware Editor using the module's detail view.

The following tables present the system parameters for the module in the same order as in the SILworX Hardware Editor.

1.1 The Module Tab

The **Module** tab contains the following system parameters:

System parameter	Data type	S [1]	R/W	Description
Name	---	---	W	Module name.
Noise Blanking	BOOL	Y	W	Allow noise blanking performed by the system (Activated/Deactivated). After a transient fault, the system delays the fault response until the safety time. The user program retains its last valid process value. Default setting: Activated (not changeable). Refer to the system manual (HI 803 211 E) for further details on noise blanking.
The following statuses and parameters can be assigned global variables and used in the user program.				
Explicitly Triggered Restart Required	BOOL	Y	R	TRUE: The module must be explicitly required to restart. FALSE: ▪ Restart is necessary and the module performs it automatically. ▪ Module in the STOP state. ▪ Connection loss.
Background Test Noise Blanking Active	BOOL	Y	R	TRUE: Error detected by a background test. FALSE: ▪ No errors detected by the background tests. ▪ Module in the STOP state. ▪ Connection loss.
Initialization Active	BOOL	Y	R	TRUE: The module is performing initial tests. FALSE: ▪ The initial tests are complete. ▪ Module in the STOP state. ▪ Connection loss.
Module OK	BOOL	Y	R	TRUE: No internal fault detected by the system. FALSE: ▪ Internal fault detected by the system. ▪ Module in the STOP state. ▪ Connection loss.
Module Process Value OK	BOOL	Y	R	TRUE: No channel fault detected by the system. FALSE: ▪ At least one channel fault detected by the system. ▪ Module in the STOP state. ▪ Connection loss.
Restart on Error Suppressed	BOOL	Y	W	Automatic restart after errors can be suppressed by the user. To cause the automatic restart to be performed after an error, the system parameter must have been set to FALSE for longer than the F-CPU safety time (does not apply to field faults). TRUE: No automatic restart after a module or channel fault. FALSE: Automatic restart after a module or channel fault. Default setting: FALSE
[1] The operating system handles the system parameter in a safety-related manner, yes (Y) or no (N).				

Table 4: The **Module** Tab in the Hardware Editor

1.2 The F 6217: Channels Tab

The **F 6217: Channels** tab contains the following system parameters for each channel:

System parameter	Data type	S [1)]	R/W	Description
Channel no.	---	---	R	Channel number, preset and cannot be changed.
4 mA	REAL	Y	W	Data point used to calculate the process value at the lowest full scale (4 mA) of the channel. The parameter must be scaled for voltage measurement: Scaling factor 250.0 (5 V) Scaling factor 500.0 (10 V) Default value: 4.0
20 mA	REAL	Y	W	Data point used to calculate the process value at the upper full scale (20 mA) of the channel. The parameter must be scaled for voltage measurement: Scaling factor 250.0 (5 V) Scaling factor 500.0 (10 V) Default value: 20.0
-> Process Value [REAL]	REAL	Y	R	Process value determined using the data points 4 mA and 20 mA. Scaling factor 250.0 (5 V) Scaling factor 500.0 (10 V)
-> Raw Value [1 mA = 10 000] [DINT]	DINT	N	R	Unhandled value measured for the channel. The safety-related use of the parameter in HIQuad X is only permitted under the specified conditions.
-> Process Value OK [BOOL]	BOOL	Y	R	TRUE: Fault-free channel. No internal fault nor fault on the field side detected. Module initialization successfully completed. FALSE: ▪ Faulty channel. Internal fault or fault on the field side detected. ▪ The initial test has not been completely performed. ▪ Module in the STOP state. ▪ Connection loss.
-> Channel OK [BOOL]	BOOL	Y	R	TRUE: Fault-free channel. FALSE: ▪ Faulty channel. ▪ Module in the STOP state. ▪ Connection loss. An external SC or OC has no influence on *-> Channel OK [BOOL]*. Observe the statuses -> *OC* [BOOL] and -> *SC [BOOL]*!
OC Limit [1mA = 10000]	DINT	Y	W	Threshold in mA for detecting an open-circuit. If the process value falls under *OC Limit*, the module detects an open-circuit. Default value: 36 000
-> OC [BOOL]	BOOL	Y	R	TRUE: Open-circuit. FALSE: ▪ No open-circuit. ▪ Module in the STOP state. ▪ Connection loss.

<table>
<tr><th>System parameter</th><th>Data type</th><th>S [1)]</th><th>R/W</th><th>Description</th></tr>
<tr><td>SC Limit
[1 mA = 10000]</td><td>DINT</td><td>Y</td><td>W</td><td>Threshold in mA for detecting a short-circuit.
If the process value exceeds SC Limit, the module detects a short-circuit.
Default value: 210 000</td></tr>
<tr><td>-> SC [BOOL]</td><td>BOOL</td><td>Y</td><td>R</td><td><table><tr><td>TRUE</td><td>Short-circuit.</td></tr><tr><td>FALSE</td><td>▪ No short-circuit.
▪ Module in the STOP state.
▪ Connection loss.</td></tr></table></td></tr>
<tr><td>Redund.</td><td>BOOL</td><td>Y</td><td>R</td><td>Requirement: A redundant module must exist.<table><tr><td>TRUE</td><td>The channel redundancy for this channel is active.</td></tr><tr><td>FALSE</td><td>The channel redundancy for this channel is not active.</td></tr></table>Default setting: FALSE</td></tr>
<tr><td colspan="5">[1)] The operating system handles the system parameter in a safety-related manner, yes (Y) or no (N).</td></tr>
</table>

Table 5: Tab **F 6217: Channels** in the Hardware Editor

Global variables can be assigned to the system parameters with **->** and used in the user program. The values of the system parameters without **->** must be directly defined.

1.3 Description of Diagnostic Entry

The module is completely and automatically tested for safety-related errors during operation. The diagnostic entry is not 0 if one or more errors were detected in the module.

Defective modules must be replaced with a faultless module of the same type or with an approved replacement model.

Bit	Coding [1)]	Description
0	0x00000001	Hardware module fault.
1	0x00000002	The module in the slot was not deleted. The slot is either empty or equipped with incorrect module type.
4	0x00000010	CRC error.
5	0x00000020	Monotony error.
6	0x00000040	Invalid analog values.
7	0x00000080	Input module fault.
10	0x00000400	Transmitted data is obsolete. Probable cause: The cable plug is not be properly inserted or the 24 V power supply is not ensured. Workaround: Insert the cable plug, ensure the 24 V voltage supply.
16	0x00010000	Module defective (the error code is for internal purposes only).
…	…	
31	0x80000000	
[1)] The status may consist of several codings, e.g.: Module status = 0x80000001 (0x00000001 + 0x80000000).		

Table 6: Diagnostic Entry Coding

1.3.1 Channel Status

The channel status byte in the diagnostic entry shows the following status:

Bit	Coding [1)]	Description
Bit 0	0x0001	Internal hardware channel fault (i.e., not if short-circuits or open-circuits occur). F-IOP indicator: Continuous light of the channel LED.
Bit 1	0x0002	Short-circuit (SC). Workaround: Check the channel wiring and the limit values. F-IOP indicator: Blinking1 of the channel LED.
Bit 2	0x0004	Open-circuit (OC). Workaround: Check the channel wiring and the limit values. F-IOP indicator: Blinking1 of the channel LED.
Bit 3	0x0008	Overflow of the A/D converter. Workaround: Check the channel wiring, ensure that the value is within the measuring range. The input current may not exceed 22 mA. (The measured value is ≥ 4095 digits, the value is therefore outside the measuring range). F-IOP indicator: Blinking1 of the channel LED.
[1)] The status may consist of several codings, e.g.: Channel status = 0x8001 (0x0001 + 0x8000).		

Table 7: Channel Status of the F 6217