# F 5220: Counter Module

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

- 2 channels for connecting to safety proximity switches and proximity switches in accordance with EN 60947-5-6 (NAMUR) or input signals with 5 V or 24 V.

- Counting range 0…1 MHz, for pulse counting, gate time measuring via adjustable gate time, with detection of rotation direction.

- 2 fast switching outputs up to 12 W, independent from the PES cycle time.

- For HIQuad X (SILworX) and HIQuad (ELOP II, HF-CNT-3 or HF-CNT-4 function block required).
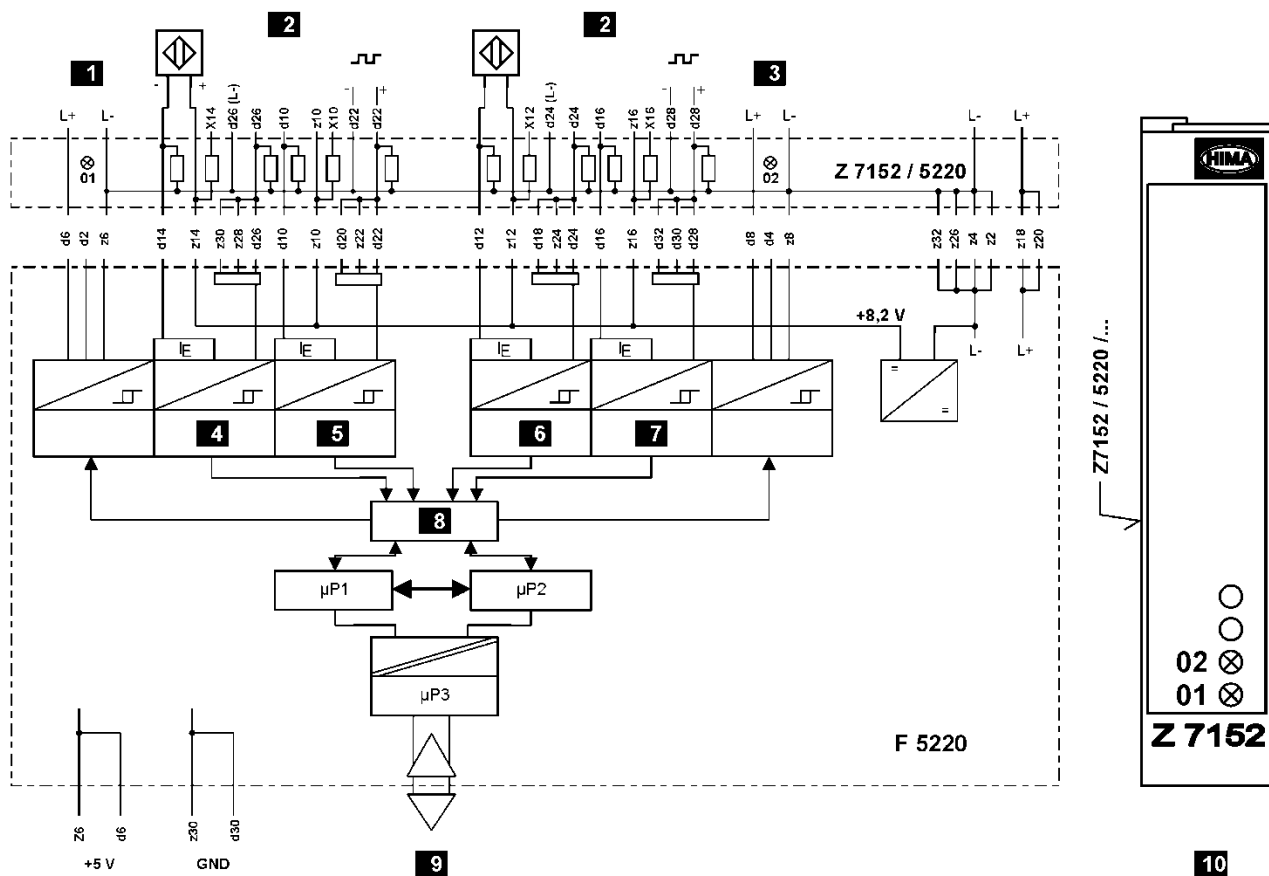
1 Channel 1: Switching output	**6**	Channel 2: Counter input
2 Proximity switch or 5/24 VDC pulse	**7**	Channel 2: Input for rotation direction
3 Channel 2: Switching output	**8**	Decoder
4 Channel 1: Input for rotation direction	**9**	I/O bus
5 Channel 1: Counter input	**10**	Cable plug, front view

Figure 1:   Module Block Diagram and Cable Plug Front View

Specifications

General information	
Resolution	24-bit
Accuracy	Gate time measuring: ±0.5 % over the entire range
	Pulse measuring: without pulse loss
Gate time	n x 50 ms (n = 0…65 535)
Min. pulse length	500 ns
Cable length	500 m, shielded, twisted pair (at 100 kHz)
Space requirement	4 HP
Current consumption	200 mA at 5 VDC (via backplane)
	500 mA at 24 VDC plus load (via cable plug)

Input (pulse)	
1-signal	5 VDC (high switching level: 3 V), 6 mA
	24 VDC, max. 8 mA
Count frequency	Max. 1 MHz (5 VDC)
Edge steepness	Min. 1 V/µs

Input (proximity switch)	
Count frequency	Max. 50 kHz

Outputs	
Number	2, with integrated safety shutdown
	Switchable independently from the PES cycle time
	Evaluation of short-circuits and open-circuits
	SIL 1…SIL 2 (evaluation for used signals only)
Output load	500 mA, 24 VDC
Internal voltage drop	Max. 2 V at 500 mA load
Admissible line resistance (in + out)	Max. 11 Ω
Short-circuit switching threshold	0.75…1.5 A
Open-circuit switching threshold	0.5…9.5 mA
Output leakage current	Max. 350 µA
Output voltage during deactivation	Max. 1.5 V
Monitored switching time (ELOP II)	Max. 200 µs (without latency due to the function block extension)
Monitored switching time (SILworX)	Max. 250 µs
	(if the maximum test pulse duration is 0)
Response time	
Gate time measuring:	typ. 50 ms
	(depending on the application: change rate of the rotational speed)
Pulse measurement:	< 100 µs, verified within the counter module's safety time

Wiring

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

- Cable plug Z 7152/5220/Cx/PU5/P2 for signals with 5 VDC input voltage (Table 1)
- Cable plug Z 7152/5220/Cx/PU24/P2 for signals with 24 VDC input voltage (Table 2).
- Cable plug Z 7152/5220/Cx/PSW/P2 for proximity switch signals (Table 3)

i   Cable plug Z 7152/5220/Cx/PU5/P2 (5 VDC) must **not** be used for 24 V input signals since the cable plugs differ in the resistor equipment.

Channel	Pin	Color	Connection
1 Counter	d22	WH	Cable: LiYCY 6 x 2 x 0.5 mm² (shielded)
	d22 (L-)	BN	
1 Rotation direction	d26	GN	
	d26 (L-)	YE	
1 Switching output	d6	BK	
	z6	VT	
2 Counter	d24	GY	
	d24 (L-)	PK	
2 Rotation direction	d28	BU	
	d28 (L-)	RD	
2 Switching output	d8	GYPK	
	z8	RDBU	
L+ (24 VDC)	z18	RD	Female connector 2.8 x 0.8 mm² q = 1 mm², l = 750 mm
L- (24 VDC)	z2	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 7152/5220/Cx/PU5/P2 for 5 V

Channel	Pin	Color	Connection
1 Counter	d22	WH	
	d22 (L-)	BN	
1 Rotation direction	d26	GN	
	d26 (L-)	YE	
1 Switching output	d6	BK	
	z6	VT	Cable: LiYCY 6 x 2 x 0.5 mm² (shielded)
2 Counter	d24	GY	
	d24 (L-)	PK	
2 Rotation direction	d28	BU	
	d28 (L-)	RD	
2 Switching output	d8	GYPK	
	z8	RDBU	
L+ (24 VDC)	z18	RD	Female connector 2.8 x 0.8 mm²
L- (24 VDC)	z2	BK	q = 1 mm², l = 750 mm
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 7152/5220/Cx/PU24/P2 for 24 V

Channel	Pin	Color	Connection
1 Counter	z10	WH	
	d10	BN	
1 Rotation direction	z14	GN	
	d14	YE	
1 Switching output	d6	BK	
	z6	VT	Cable: LiYCY 6 x 2 x 0.5 mm² (shielded)
2 Counter	z12	GY	
	d12	PK	
2 Rotation direction	z16	BU	
	d16	RD	
2 Switching output	d8	GYPK	
	z8	RDBU	
L+ (24 VDC)	z18	RD	Female connector 2.8 x 0.8 mm²
L- (24 VDC)	z2	BK	q = 1 mm², l = 750 mm
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 7152/5220/Cx/PSW/P2 for Proximity Switches
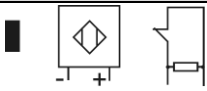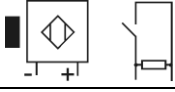
Function Table

Proximity switch inputs	Input current I_E in mA	Signal	State
	2.9…4.5	TRUE	OK
	0.35…2.1	FALSE	OK
Short-circuit activation range	> 5.1	FALSE	Short-circuit
Open-circuit activation range	< 0.2	FALSE	Open-circuit

Table 4:   Function Table

General Configuration Notes

- The input wiring with safety proximity switches such as P+F (... SN) includes monitoring of proximity switch circuits for short-circuits and open-circuits.
- If safety proximity switches are used, the manufacturer's specifications and notices must be observed.
- Use of non-safety-related proximity switches based on DIN EN 60947-5-6 requires series resistors of 390 Ω (0.25 W).
- If redundant wiring and proximity switches are used, the shunts must be removed from one of the two cable plugs Z 7152/5220/Cx/PU5/PSW.
- Unused inputs for rotation direction (proximity switches) must be terminated with a 6 kΩ resistor.

A wired mechanical contact may be used instead of the proximity switch:
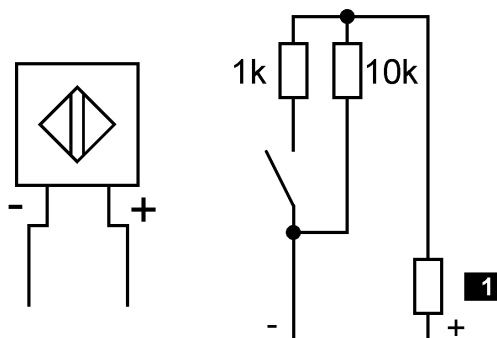
1 Connection of wired mechanical contact to X10, X12, X14 or X16 via cable plug (internal 390 Ω resistor). Without cable plug, a separate 390 Ω resistor must be connected in series.

Figure 2:   Wired Mechanical Contacts as an Alternative for Proximity Switches

i The module may only be operated with forced cooling through fans K 9203A or K 9212.
Systems without forced cooling must be retrofitted with fans as soon as an F 5220 is used.

To ensure forced cooling, the M 7201 air deflector (1 RU) must be installed above the K 9203A
fan or above the H 41q kit.

The M 7201 air deflector deflects the warm air backwards to avoid temperature increase of the
racks and modules installed one above the other.

Configuration Notes for ELOP II

- The error codes for the modules appear on the display of the corresponding central unit. For
  further information, refer to the HIQuad operating system manual (HI 800 105 E).
- The **HF-CNT-4** block is equipped with an additional output per counter for reporting channel
  faults.
- To configure the module, use the operating system functions manual specific to the used
  operating system version. Pay particular attention to the section about noise blanking.

Modes of Operation

- Pulse Count
- Gate Time Measuring
- Cycle-Independent Output Operation with Comparison Functions
- Detection of Rotation Direction

Pulse Count

The pulses entering the counter input are added up. The counter on the module has 24-bit
resolution. If the limits are overrun, the counter is reset to 0.

Gate Time Measuring

During the gate time measuring, the module counts all the pulses entering a previously set gate
time (n * 50 ms).

The gate time can be set in 50 ms increments.

Cycle-Independent Output Operation with Comparison Functions

The module outputs are independent from the PES cycle. The outputs are switched off if the
following conditions are met:

- If, during pulse counting, the limit value configured for the maximum counter reading (range
  of values: 0…16 500 000) is achieved.
- If, during gate time measuring, the required number of pulses is not achieved within the
  gate time.

Detection of Rotation Direction

During the detection of rotation direction, there must be a phase shift between counter input and direction input:

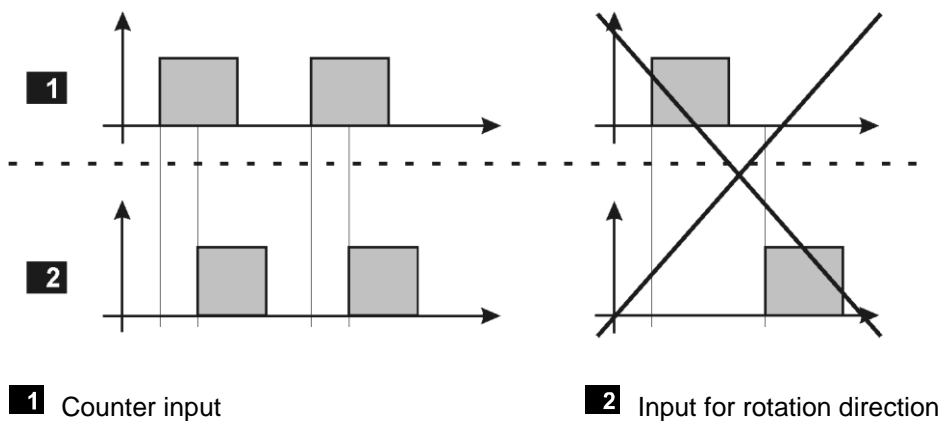| | 1 | Counter input | | 2 | Input for rotation direction |

Figure 3:   Phase Shift for Detection of Clockwise Rotation Direction

If the rotation direction pulse is leading, counter-clockwise rotation is displayed. If the rotation direction pulse is lagging, clockwise rotation is displayed. The *Count Mode* can be used to configure whether all pulses or only those of a specific rotation direction are to be detected.

Use of the Module with EMC Filters and Ex Isolation Amplifiers

To suppress electromagnetic interference, EMC filters can be used on connection cables. The filters must be connected as close as possible to the module. The filters' efficacy depends on the system installation and conditions.

The Ex isolation amplifiers from HIMA, H 4011 and H 4012, can be used to galvanically separate the proximity switches from the module's L+/L- potentials. HIMA recommends this in interference loaded systems. When using Ex isolation amplifiers, the HIMA mains filters, Z 6015, H 7013 or H 7034 must be additionally installed. The filters dampen or eliminate interference (interfering pulses) in the supply lines of the isolation amplifiers. This avoids effects on the module counters caused by interfering pulses.

The following types of interference between ground, L- and L+ are dampened by using EMC filters, Ex isolation amplifiers or both:

- Wideband, low-energy switching voltage interferences (burst) in accordance with EN 61000-4-4 up to 4 kV.
- Wideband, high-energy overvoltage (surge) in accordance with EN 61000-4-5 up to 4 kV (common mode) and 1 kV (differential mode) on a 24 V power supply.

Each interference is discharged to ground.

1 Configuration in SILworX

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

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.

- Noise blanking is always active. Pulses occurring during noise blanking are not counted. For safety-related operation, the *Lock Restart [BOOL] ->* parameter must be set to TRUE!

- Test mode is configured in the Hardware Editor and is only permitted during start-up or for test purposes! The following parameters are intended for test mode and must not be used in the user program during normal operation:
  - *Test Mode [BOOL] ->*
  - *Maximum Test Mode Time [ms]* **>** 0
  - *-> Remaining Time Test Mode [s] [UDINT]*
  - *Force Value Active [BOOL] ->*

- Test mode terminates as soon as the time set in *Maximum Test Mode Time [ms]* has expired.

- If a module or channel fault occurs or the connection to the I/O processing module (F-IOP) is lost, the test mode is immediately aborted, regardless of the time set in *Maximum Test Mode Time [ms].*

- Line monitoring is only active in *Proximity Switch Pulse* mode. If a short-circuit or an open-circuit is detected on the counter inputs, the corresponding parameter *-> SC [BOOL]* or *-> OC [BOOL]* is set to TRUE.

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.	
Input Signal Type		Y	W	Options for the type of input signal selectable for all counter channels: ▪ 5 V Pulse ▪ 24 V Pulse ▪ Proximity Switch Pulse	
				Default setting: 24 V Pulse	
				The parameter must match the cable plug in use.	
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.

System parameter	Data type	S [1]	R/W	Description
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 5:   The **Module** Tab in the Hardware Editor

1.2 The F 5220: Channels Tab

The **F 5220: 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.
Scaling Factor	REAL	Y	W	Counter scaling factor. Default value: 0.0
-> Counter Reading, Scaled [REAL]	REAL	Y	R	Counter reading (scaled) = counter scaling factor x counter reading. If a fault occurs or the connection is lost, the value displayed is the last fault-free detected scaled counter reading (with pulse count) or 0 (with frequency measurement). 0 is diplayed in the STOP state.
-> Counter Reading [UDINT]	UDINT	Y	R	24-bit counter reading for the channel.
-> Process Value OK [BOOL]	BOOL	Y	R	<table><tr><td>TRUE</td><td>Fault-free channel. No internal fault nor fault on the field side detected. Module initialization successfully completed.</td></tr><tr><td>FALSE</td><td>▪ 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.</td></tr></table>
-> Channel OK [BOOL]	BOOL	Y	R	<table><tr><td>TRUE</td><td>Fault-free channel.</td></tr><tr><td>FALSE</td><td>▪ Faulty channel. ▪ Module in the STOP state. ▪ Connection loss.</td></tr></table> -> *Channel OK [BOOL]* is neither affected by the line diagnosis on the digital output nor by an external short-circuit or open-circuit. Observe the statuses -> *OC [BOOL]* and -> *SC [BOOL]* and -> *SC/OC Switching Output [BOOL]*!
-> OC [BOOL]	BOOL	Y	R	<table><tr><td>TRUE</td><td>Open-circuit.</td></tr><tr><td>FALSE</td><td>▪ No open-circuit. ▪ Module in the STOP state. ▪ Connection loss.</td></tr></table> Only active in *Proximity Switch Pulse* mode.
-> SC [BOOL]	BOOL	Y	R	<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> Only active in *Proximity Switch Pulse* mode.
Count Mode	---	Y	W	By connecting two pulse generators per channel, the F 5220 can detect the rotation direction. This input is used to define whether all pulses or only those of a specific rotation direction are to be detected. ▪ Leading and Lagging (any rotation direction) ▪ Lagging (= clockwise rotation) ▪ Leading (= counter-clockwise rotation) Default setting: Leading and Lagging

System parameter	Data type	S[1]	R/W	Description
Gate Time [ms]	---	Y	W	Defines the channel mode of operation (pulse count or frequency measurement).
				When the frequency is measured, the measuring period (gate time) during which the recurring pulses are added up, is displayed.
				0: Pulse count.
				50…3 276 750: Gate time in ms for measuring the frequency with a granularity of 50 ms.
				When the frequency is measured, 24-bit counter reading overflows occurred during the gate time are not detected. By selecting an appropriate gate time, the users must ensure that the maximum frequency occurring in the application does not cause a counter reading overflow.
Maximum Test Mode Time [ms]	UDINT	Y	W	Defines the maximum duration of the test mode in ms.
				0: Test mode is not allowed.
				1000…21 474 830 000: Maximum duration of the test mode with a granularity of 1000 ms.
				Default value: 0
				Parameter > 0 is only permitted during start-up or for test purposes!
-> Channel Active [BOOL]	BOOL	Y	R	<table><tr><td>TRUE</td><td>▪ The channel output parameters provide their values in accordance with the channel configuration. ▪ Module fault. ▪ Module in the STOP state. ▪ Connection loss.</td></tr><tr><td>FALSE</td><td>The channel configuration has changed and the channel output parameters provide their values in accordance with the configuration that was previously valid.</td></tr></table> The following actions affect the -> *Channel Active [BOOL]* parameter: ▪ Change of the *Counter Upper Limit [UDINT]* -> parameters ▪ Change of the *Input Signal Type*, *Count Mode* or *Gate Time [ms]* parameter through reload.
-> Rotation Direction, Lagging [BOOL]	BOOL	Y	R	Boolean value as indication of the last pulse's rotation direction: <table><tr><td>TRUE</td><td>▪ The pulse on the rotation direction input was detected as lagging with respect to the counter input (clockwise rotation). ▪ Module in the STOP state.</td></tr><tr><td>FALSE</td><td>The pulse on the rotation direction input was detected as leading with respect to the counter input (counter-clockwise rotation).</td></tr></table> If a fault occurs or the connection is lost, the signal displayed is the last fault-free detected rotation direction.

System parameter	Data type	S[1]	R/W	Description	
Reset Counter [BOOL] ->	BOOL	Y	W	TRUE	Counter channel reset. The counter reading is reset to 0 incoming pulses are lost.
				FALSE	Normal operation. Incoming pulses are included in the counter reading.
				The counter reset does not affect the time-monitored test mode.	
Stop Counter [BOOL] ->	BOOL	Y	W	TRUE	The counter is halted. No new pulses are added to the counter reading, incoming pulses are lost.
				FALSE	Normal operation. Incoming pulses are added to the counter reading.
				Halting the counter does not affect the time-monitored test mode.	
Lock Restart [BOOL] ->	BOOL	Y	W	TRUE	The automatic restart of the channel is not activated, a user intervention is required.
				FALSE	The automatic restart of the channel is activated. This is the default setting.
				The parameter must be set to TRUE for safety-related operation.	
-> Overflow [BOOL]	BOOL	Y	R	TRUE	24-bit counter reading overflow occurred.
				FALSE	▪ No overflow or mode of operation Frequency Measurement ▪ Module fault. ▪ Module in the STOP state. ▪ Connection loss.
-> Output on [BOOL]	BOOL	Y	R	State of the digital outputs.	
				TRUE	The output is switched on.
				FALSE	▪ The output is switched off (safe state). ▪ Module fault. ▪ Module in the STOP state. ▪ Connection loss.
				Default setting: FALSE.	
				Since the output is operated independently of the CPU cycle, only the status at the CPU sampling time is displayed. The current state may already have changed.	
-> Remaining Time Test Mode [s] [UDINT]	UDINT	Y	R	Residual time left for the test mode in seconds.	
				If a module fault occurs, the module enters the STOP state and 0 is indicated for connection loss. Only use this parameter during start-up or for test purposes!	
Test Mode [BOOL] ->	BOOL	Y	W	Activate the time-monitored test mode.	
				TRUE	Test mode active for this channel.
				FALSE	Test mode not active for this channel. This is the default setting.
				This parameter is only permitted during start-up or for test purposes!	

System parameter	Data type	S[1]	R/W	Description
Force Value Active [BOOL] ->	BOOL	Y	W	Activate the force value for the test mode of this channel.
				TRUE — Force value active for this channel (high level).
				FALSE — Force value not active for this channel (safe state, low level). This is the default setting.
				This parameter is only permitted during start-up or for test purposes!
Counter Upper Limit [UDINT] ->	UDINT	Y	W	Limits for the process value of the counter channel. If the limit value is exceeded, the corresponding digital output is switched off.
				Range of values: 0…16 500 000
				0: No threshold monitoring active.
				1…65 535: Valid 16-bit limit value in connection with mode of operation Frequency Measurement. Threshold monitoring active.
				1…16 500 000: Valid 24-bit limit value in connection with mode of operation Pulse Count. Threshold monitoring active.
				Default value: 0
-> SC/OC Switching Output [BOOL]	BOOL	Y	R	Line diagnostics on the digital output.
				TRUE — Line fault on the digital output.
				FALSE — ▪ No line fault on the digital output. ▪ Module in the STOP state. ▪ Connection loss.

[1] The operating system handles the system parameter in a safety-related manner, yes (Y) or no (N).

Table 6: Tab **F 5220: Channels** in the Hardware Editor

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.
2	0x00000004	Error when configuring the system safety times. Workaround: Set the valid values for the module by performing a download, a reload or an online change.
3	0x00000008	Module's component fault.
4	0x00000010	
…	…	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 7:   Diagnostic Entry Coding

1.3.1   Channel Status

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

Bit	Coding [1]	Description
0	0x00000001	Hardware channel fault. Workaround: Check the channel wiring. F-IOP indicator: Continuous light of the channel LED.
1	0x00000002	Short-circuit (SC) in the input circuit of the counter channel. Workaround: Check the channel wiring. F-IOP indicator: Blinking1 of the channel LED.
2	0x00000004	Open-circuit (OCS) in the input circuit of the counter channel. Workaround: Check the channel wiring. F-IOP indicator: Blinking1 of the channel LED.
3	0x00000008	Short-circuit (SC) or open-circuit (OC) on the digital switching output of the counter channel. Workaround: Check the channel wiring in the external output circuit. F-IOP indicator: Blinking1 of the channel LED.
4	0x00000010	Invalid values for the system parameters. Probable cause: *Counter Upper Limit [UDINT] ->* is too high. Workaround: Set valid values for the system parameters.
5	0x00000020	
…	…	Hardware channel fault (the error code is for internal purposes only). F-IOP indicator: Continuous light of the channel LED.
15	0x00008000	
[1]	The status may consist of several codings, e.g.: Channel status = 0x00008001 (0x00000001 + 0x00008000).	

Table 8:   Channel Status of the F 5220