

1 Functional description

The digital output module XI241202 is used to output pulse-width-modulated binary 24 V control signals in a ctrlX I/O station. It has two channels in a 2-wire technique. The signal state is shown at the channel LED on the removable peripheral connector. The parent control specifies the clock and pulse/pause ratio.

The digital outputs are fed via the 24 V supply from U_P .

The logic and peripheral voltage supply as well as the EtherCAT-based module communication are routed through the module.



For an application manual of the ctrlX I/O modules, refer to the media directory www.boschrexroth.com/mediadirectory and enter the search term ["R911423458"](http://www.boschrexroth.com/mediadirectory).

Ensure that the current documentation is consulted. For the current documentations, go to www.boschrexroth.com/mediadirectory and enter the module type as search term.

For the integration into the parent system, the respective ESI files are available. For the ESI files, go to <http://www.boschrexroth.com/electrics>, search term ["ESI-Files"](http://www.boschrexroth.com/electrics).

2 Ordering data

Type	Part number	Description
XI241202	R911421644	Digital output module 2-channel, DC 24 V, 0.5 A, 2-wire, pulse width modulation (PWM)

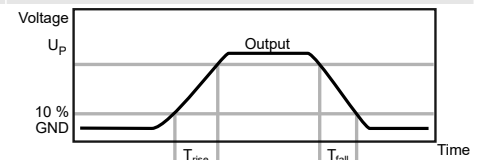
For further ordering data (accessories), refer to the application manual for the ctrlX I/O modules, see media directory www.boschrexroth.com/mediadirectory. Use the search term ["R911423458"](http://www.boschrexroth.com/mediadirectory).

3 Technical data

3.1 General technical data

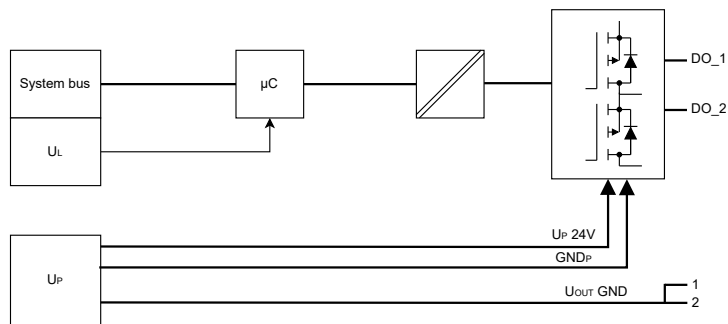
Number of outputs	2
Connection method	Push-in terminal

Connection technique	2-wire technique
PWM frequency	1 Hz to 100 kHz
PWM Duty Cycle	0 to 100%
Minimum pulse width (t_{ON} , t_{OFF})	2 μ s
Nominal output voltage	DC 24 V
Output current max.	0.5 A per channel
Total current of channels	1 A max.
Nominal load	Ohmic, 12 W max. (48 Ω ; at nominal voltage)
Minimum load	10 k Ω



Rising time (T_{Rise})	Without load: 300 ns on digital input Ohmic nominal load: 330 ns at 48 Ω , 500 mA
Fall time (T_{FALL})	Without load: 300 ns on digital input Ohmic nominal load: 30 ns at 48 Ω , 500 mA
Inductive switch-off energy	150 mJ max. per channel
Overload response	Granular switch-off with automatic restart
Feedback voltage resistance	Not resistant to feedback, external measures required
Nominal voltage (U_L/U_P)	DC 24 V (19.2 V to 30 V, including tolerance and residual ripple) PELV/SELV (safety extra-low voltage)
Current consumption U_L	35 mA
Current consumption U_P	50 mA + load
Max. power consumption of the module	1.8 W
Data width of output data in the process image	12 bytes (configurable)
Data width of input data in the process image	6 bytes (configurable)
Configuration	No address or configuration setting required
Dimensions	12 mm \times 105 mm \times 99 mm (Width \times height \times depth)
Weight	90 g (module including connector)
Electrical isolation	1200 V DC U_P to U_L , 707 V DC U_P/U_L to FE, tested for 60 s each (not evaluated by UL)
EMC resistance	Acc. to EN 61000-6-2 and EN 61000-6-4
Mounting position	Vertical, on a horizontal mounting rail
Labeling, approvals	CE, UKCA, UL

3.2 Internal schematic diagram



3.3 Ambient conditions

Ambient temperature	
≤ 2,000 m	-25 to +55 °C
2,000 m to 3,000 m	-25 to +50 °C
3,000 m to 4,000 m	-25 to +45 °C
4,000 m to 5,000 m	-25 to +40 °C
Maximum operating altitude	
Acc. to DIN 60204	5,000 m
Ambient temperature (storage and transport)	-40 to +70 °C
Permitted air humidity according to DIN EN 61131-2	
(Operation, storage, transport)	10 to 95 %
Degree of protection	IP20
Acc. to DIN EN 60 529	(not evaluated by UL)
Protection class	III
Acc. to DIN EN 61010-2-201	
Overvoltage category	2
Acc. to IEC 60664-1	
Contamination level	2, no condensation
Acc. to EN 61010-1	

NOTICE

Defective device due to contaminated air!

- The ambient air must not contain acids, alkaline solutions, corrosive agents, salts, metal vapors and other electrically conductive contaminants in high concentrations.
- The devices to be installed into the housings and installation compartments must at least comply with the degree of protection IP 54 according to DIN EN 60529.
- The device shall be provided in a suitable fire enclosure in the end-use application.

NOTICE

Defective device due to gases jeopardizing functions

Due to the risk of corrosion, avoid sulphureous gases (e.g. sulphur dioxide (SO₂) and hydrogen sulphide (H₂S)). The device is not resistant against these gases.

NOTICE

Defective device due to overheating

To avoid overheating and to ensure a trouble-free operation of the device, the ambient air has to circulate. Also refer to the section "Installation notes".

3.4 Mechanical tests

Vibration resistance	Oscillations, sinusoidal in all three axes, 5 Hz - 8,4 Hz with 3.5 mm amplitude
Acc. to DIN EN 60068-2-6	8.4 Hz -150 Hz with 1 g peak acceleration
Shock test	Shock stress: Shock resistance in all three axes
Acc. to DIN EN 60068-2-27	

11 ms semi-sinusoidal 15 g

Broadband noise	20-500 Hz with 1.22 g RMS
Acc. to DIN EN 60068-2-64	(Root Mean Square), 30 min in all three axes

For the current approvals, go to www.boschrexroth.com/electrics.

4 For your safety

4.1 Intended use

Use the module only as specified in the data sheet.

4.2 User qualification

The product use described in this data sheet is only intended for qualified electricians and staff trained by these qualified electricians. The user has to be familiar with the known safety concepts on automation technology, applicable standards and other guidelines.

4.3 Electrical safety

NOTICE

Loss of electric safety

Unintended handling can affect the device safety! Observe the notes in the present data sheet during installation, commissioning and operation.

5 Signal processing

5.1 General information on signal processing

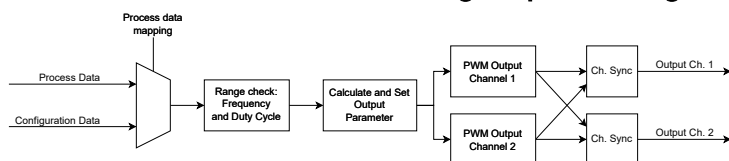


Fig. 1: Overview on signal processing

The frequency and the duty cycle ("Duty Cycle") are set individually for each channel via the process data.

These values are used in the module to calculate the period and the on and off times of the PWM with a minimum resolution of 10 ns.

If the set Frequency or the duty cycle are beyond the permitted range, a diagnostics is generated: The "Value Invalid" bit is set, the message "6830(hex) Configuration not allowed at channel x: {Frequency / Duty Cycle}" is sent and the status LED of the module flashes yellow. The values are not applied and the last valid PWM is still output.

Channels can be synchronized. One channel outputs the same signal as the other channel, also inverted depending on the setting. This can be set in the "PreOP" state via the "80x0:03(hex)" object.

To disable channels, see Chapter 7.2 "Disabling channels" on page 4.

5.2 Distinctive values and data format

5.2.1 Frequency

Frequency in Hz	Process datum	Note
0	0	Channel switched off permanently
0.01 to 0.99	1 to 99	Non-permissible range
1.00	100	1 Hz: Lower range limit
100 000.00	10000000	100 kHz: Upper range limit
> 100 000.00	> 10000000	Non-permissible range

The frequency can be specified up to 2 decimal places between 1 Hz and 100 kHz.

5.2.2 Duty cycle

Duty Cycle in %	Process datum	Note
0.00	0	Channel switched off permanently
50.00	5000	-
100.00	10000	Channel switched on permanently
>100.00	>10000	Non-permissible range

The duty cycle ("Duty Cycle") can be specified up to 2 decimal places between 0 and 100 %.

5.3 Synchronizing the application

The application is synchronized in the mode "SM synchronous".

5.4 Command value transfer

New process data values are applied to the module with each EtherCAT cycle. The new values are only applied at the output upon the start of the next PWM cycle. If the PWM cycle lasts longer than the process data cycle, new process data can overwrite older data before it was applied.

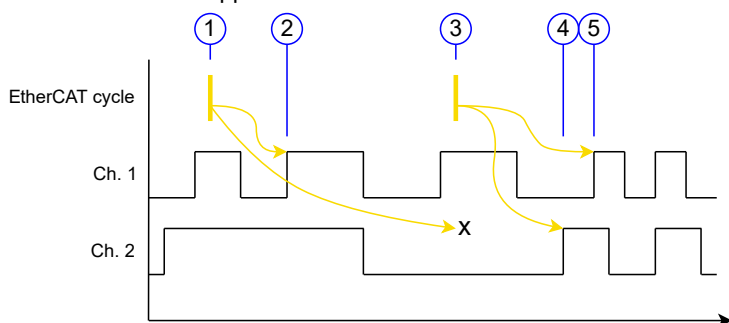


Fig. 2: Process data storage

- ① New values are transferred via EtherCAT.
- ② New values for channel 1 are applied upon the start of the next PWM cycle.
- ③ New values are transferred with the EtherCAT cycle, old values are overwritten.
- ④ New values from step 3 are applied for channel 2 upon the start of the next PWM cycle.
- ⑤ New values from step 3 are applied for channel 1 upon the start of the next PWM cycle.

5.5 Error detection and error response

The module is provided with a protection against excessive output currents, not only when switching the 24 V (high side) but also when switching GND (low side).

There are two different mechanisms that protect the output driver.

5.5.1 Limiting the edge steepness

If the output driver detects a current at a channel that is too high, the edge steepness is limited to protect the hardware. The output driver regularly checks whether the error state is still present, but requires an active PWM signal with switching edges. If the driver no longer detects an overcurrent, the regular mode is enabled again.

5.5.2 Switching off the channel in case of thermal overload

If the output current is permanently too high and the maximum temperature of the output driver is exceeded, it switches off the channel. After cooling down, the channel is automatically switched on again.

5.5.3 Diagnostics

When an overcurrent is detected, the following diagnostics are triggered:

- Send diagnostic message: "2310(hex) Warning: Continuous overcurrent at channel x".
- Overcurrent bit in process data and in CoE object 60x0:01(hex) is set.
- The channel LED is red.
- The module status LED flashes yellow.

If the overcurrent bit is pending permanently, follow the procedure below:

1. Set the machine to a safe state.
2. Disconnect the module from the voltage source. If this is not possible, switch at least to the "Safe-OP" state (the output driver is reset after an error).
3. Eliminate the cause of the overcurrent.
4. Connect the voltage again or switch back to "OP".

5.6 Minimum on/off pulse times

The minimum on/off pulse times of the module are 2 μ s. If the frequency and duty cycle result in shorter pulse times, these are rounded to valid values.

For pulse widths $0 \text{ ns} < t_{\text{ON}} < 1 \text{ } \mu\text{s}$ results in $t_{\text{ON, rounded}}$ of 0 μ s (output remains permanently off), for pulse widths $1 \text{ } \mu\text{s} \leq t_{\text{ON}} < 2 \text{ } \mu\text{s}$ results in $t_{\text{ON, rounded}}$ of 2 μ s. The same applies to t_{OFF} , whereby the output remains permanently on for $t_{\text{OFF}} < 1 \text{ } \mu\text{s}$.

6 Object directory

6.1 CoE standard objects

The object directory of the module contains objects that can be triggered via SDO services. These are defined in the ETG standards:

Index (hex)	Name
1000	Device type
1001	Error register
1008	Device name
1009	Hardware version
100A	Software version
1018	Identify
10F1	Error settings
10F3	Diagnosis history
10F8	Timestamp object
16nn	PDO mapping RxPDO
1Ann	PDO mapping TxPDO
1C00	Sync manager type
1C12	Sync manager 2 assignment
1C13	Sync manager 3 assignment
1C32	SM output parameter
1C33	SM input parameter
F000	Modular device profile
F100	Device state

6.2 Module-specific CoE objects

Objects with a module-specific design are described in the following table.

Index (hex)	Object name	Data type	Access	Description
A000	ModuleIdentification			
A000:0	Material number	String(20)	RO	Part number of the module
A010:0	Full serial number	String(20)	RO	Complete serial number of the module
F100	Module diagnostics and information			
F100:01	Periphery voltage OK	BIT1	RO	Indicates the peripheral voltage state, 1 = OK; 0 = Not OK
F100:02	Error	BIT1	RO	General module error

6.3 COE objects for parameterization

The module can be parameterized using these objects. Each channel can be freely parameterized.

ⓘ The module does not remanently store the parameter values. To automatically load the settings required upon each bus start, set the values in the start parameters of the Engineering.

Index (hex)	Object name	Data type	Access	Description	Default (hex)
8000	Channel 1, 2 settings				
8010					
80x0:01	Operation Mode	BIT16, ENUM	RW	Channel mode: 0: PWM 1: Invert other channel 2: Follow other channel	0 = PWM

The object for parameterization can only be written in the "PreOP" state.

7 Process data

7.1 Process data of the module

The module is provided with data that is included into the cyclic process data image.

Diagnostic information can also be retrieved via acyclic services using CoE. Additionally, the process data of each channel as well as the diagnostic data can be shown and hidden in the Engineering. This can reduce the amount of data in the application.

Index (hex)	Object name	Data type	Access	Description	Default (hex)
6000	Channel 1, 2 state				
6010					
60x0:01	Overcurrent	BOOL	RO	Overcurrent detected at output	0
60x0:02	Value invalid	BOOL	RO	Duty cycle or frequency for the PWM are not within the specified range 0: Specified values OK 1: Specified values beyond the specified range	0
60x0:03	Pulse width limit	BOOL	RO	The pulse width set via Duty Cycle and Frequency is smaller than the minimum permissible value of 2 µs 0: Specified values OK 1: Specified values beyond the specified range	0
60x0:04		BIT13		Fill bits	

Table 1: Input process data

The input process data contains status and diagnostic information for the respective channels.

The output process data contains the specified values for the PWM. If one of the values of a channel is 0, the output is switched off.

Index (hex)	Object name	Data type	Access	Description	Default (hex)
7000	Channel 1, 2				
7010					
70x0:01	Duty cycle	UINT16	RW	Duty ratio in percent Specification with 2 decimal places: 47.11 % = 4711 Value range: 0.00 % to 100.00 %	0
70x0:02	Frequency	UINT32	RW	PWM base frequency Specification with 2 decimal places: 47.11 Hz = 4711 Value range: 0 Hz; 1.00 Hz to 100000.00 Hz	0

Table 2: Output process data

7.2 Disabling channels

The individual objects of the process data can be disabled individually. If the output data of a channel, i.e. object 7000(hex) or 7010(hex) or respectively PDO assignment 1600(hex) or 1601(hex) are disabled, the channel is no longer refreshed. Thus, the other channel data in the process data and in the CoE objects are no longer up-to-date.

8 Diagnostic strategy

8.1 Mechanisms

Different mechanisms are used for the diagnostics of the module.

Mechanism	Diagnostics
EtherCAT state machine	EtherCAT system diagnostics
EtherCAT hardware watchdog	
Diagnostic objects in the CoE object directory	Extended diagnostics, e.g. peripheral errors
10F1(hex)	Error settings
Diagnosis history object	20 diagnostic messages can be stored
10F3(hex)	Diagnosis history
Module status LED	Shows the general module status
Channel status LED	Signals the channel status or the error states

8.2 Diagnosis history

The object 10F3(hex) is implemented as ring memory into the "Overwrite mode". The latest 20 diagnostic messages are stored. Older messages are deleted.

The following table shows the structure of the Diagnosis History object.

Index (hex)	Sub-index	Object name	Data type	Rights	Meaning
10F3		Diagnosis history			Diagnostic statistics
	01	Maximum messages	UINT8	R	Maximum number of messages
	02	Newest message	UINT8	R	Latest message
	03	Newest acknowledged message	UINT8	R/W	Latest confirmed message. Writing "0" deletes the messages in the ring memory.
	04	New messages available	Boolean	R	New message available
	05	Flags	UINT16	R/W	Setting of the object response. Refer to ETG.1020
	06 - 26	Diagnosis message	String	R	Diagnostic message according to ETG.1020

8.3 Status codes

Error, warning, information	Text ID (hex)	Text
E	1000	Module error <opt. info>
W	1020	Error during update, data corrupted, please update again
W	2310	Continuous overcurrent at channel <Channel no.>
E	3400	Periphery supply voltage (U _P) missing <opt. info>
W	6830	Value not allowed at channel <Channel no.> <text>

The <text> in angle brackets indicates the value: "Duty Cycle" or "Frequency".

8.4 Module status LED (diagnostic and device status)

Device state	LED flashing pattern
Booting or firmware update	BU BU BU BU BU -- -- -- -- -- ↷
Initialization or firmware update completed	BU BU BU BU BU BU BU BU BU BU BU ↷
It is currently configured. Module not yet ready.	GN GN GN GN GN -- -- -- -- -- ↷
Process data transmission, outputs inactive.	GN GN GN GN GN GN GN GN GN GN -- ↷
Module in "Run" state	GN GN GN GN GN GN GN GN GN GN ↷
Error and warning states	
Logic or peripheral voltage error	RD RD RD RD RD RD RD RD RD RD ↷
Communication or configuration error	RD RD RD RD RD -- -- -- -- -- ↷
Channel error	YE YE YE YE YE -- -- -- -- -- ↷

ⓘ One square corresponds to a period of 200 ms. The arrow represents the end of a cycle.

– LED is not on.

BU LED is blue.

GN LED is green.

RD LED is red.

YE LED is yellow.

ⓘ A new status is only displayed after the previous flashing cycle has elapsed. A change in status can thus be delayed up to two seconds.

8.5 Channel status LED

Each input channel of the module is provided with a channel status LED at the plug. Refer to .

LED	Meaning
Off	No output signal (PWM off)
Green	PWM active
Red	Signal error: Overcurrent

9 Installation

9.1 Clamping point assignment

Clamping point	Signal	LED	Pusher
1	DO channel 1	Green, red	Grey
2	U _{OUT} GND	None	Dark blue
3	DO channel 2	Green, red	Grey
4	U _{OUT} GND	None	Dark blue

ⓘ Connection notes:

- Use the U_{OUT} GND outputs only as reference potential to the respective output.
- These outputs may not be used as peripheral supply GND.
- To supply the connected actuators, use the potential distribution terminals, e.g. XI821116.

NOTICE

Electronic damage due to parallel channel switching

The output channels of the module must not be connected in parallel, as this can cause short circuits in the module and thus to the destruction of the module.

9.2 Switching off inductive loads

Negative voltages are generated when inductive loads are switched off. If the switch-off energies are greater than specified in the technical data, these switch-off energies can cause damage to the electronics of the module.

NOTICE

Electronic damage due to overload

Use a suitable external freewheeling circuit to protect the module from high voltages when switching off inductive loads.

9.3 Connection instructions

9.3.1 Cable and shielding

NOTICE

Electronic damage and measuring faults due to insufficient shielding

Unshielded cables can cause that tolerance limits are exceeded in an environment prone to interferences. Using shielded cables is recommended. Also note the cable routing for the installation.

Connect the cable shielding to the functional earth immediately after entering the control cabinet. Route the cable with its shielding up to the module. The signal cables should only be routed the shortest possible without shielding.

For the best connection directly in front of the module, the shield connection set (R911173030) is provided together with the busbar (R911173283).

9.4 Connection example

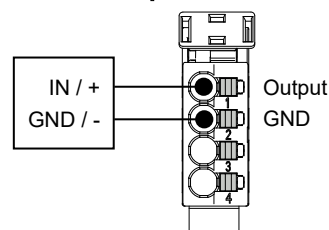


Fig. 3: Connection example of PWM module

9.5 Mounting and installation

The application manual for the ctrlX I/O modules contains notes on installation, mounting and dismounting. For the application description, go to:

- ↗ www.boschrexroth.com/MediaDirectory, Search term: ↗ "R911423458"
- or
- ↗ <https://docs.automation.boschrexroth.com/doc/4126711705/ctrlx-i-o-anwendungsbeschreibung/latest/en/>.

NOTICE

Destruction of the device due to non-compliance with the application manual

Follow the mounting instructions in the application manual to ensure a correct mounting and to prevent damage to the device.

10 Firmware update via FoE

⚠ WARNING

Risk of injury due to unsafe machine states

The machine has to be in a safe state before updating.

The firmware of the module can be updated via FoE. For new firmware files, go to ↗ www.boschrexroth.com/mediadirectory and search for the type code of the module.


A firmware module can be updated with all EtherCAT masters supporting the file download via FoE. The module has to be in the BOOTSTRAP state. Entering a password or a file name is not required.

If the update has been completed successfully, the module is restarted as soon as the module state changes from BOOTSTRAP to another state. The reloaded firmware is started.

ⓘ Do not disconnect the voltage supply of the module during the file transfer.

Please note that the logic voltage supply is temporarily interrupted for the following modules when completing the firmware update of the bus coupler and a subsequent restart.

ⓘ If switching to INIT is not possible, disconnect the ctrlX I/O from the power supply and connect it again.

 The new firmware version might require an updated description file in the Engineering to use new functions. For details, refer to the release notes.

Check whether the latest version of the description file is installed.

10.1 ctrlX I/O Engineering

Within the ctrlX I/O Engineering, the required user interface is only displayed for modules supporting a firmware update.

1. Switch the EtherCAT master of the ctrlX CORE to the "INIT" state.
2. First change to the active state in the ctrlX I/O Engineering by enabling "Show online data".
 - ➔ This is the requirement to update the firmware. The corresponding user interface tab is only displayed if the requirement is met.
3. To open the device editor, double-click on the module in the ctrlX I/O Engineering device tree and select the "FoE" tab.
4. In the "Download" section, select the firmware file (*.EFW) under "Local file name". Ensure that this is the correct file for the module to be updated.
5. Check that the option "Required state" is active under "Details" and that "BOOTSTRAP" is selected.
6. Use the "Download" button to start the firmware update.

11 License information

11.1 EtherCAT®



The ctrlX I/O modules use EtherCAT® technology. "EtherCAT®" is a registered trademark and patented technology licensed by the Beckhoff Automation GmbH, Germany. EtherCAT is an open, internationally standardized standard and developed further by the "EtherCAT Technology Group" (ETG).

11.2 Libhydrogen

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11.3 Ring-buffer

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