X20DO4613

Data sheet
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Version history

B&R makes every effort to keep documents as current as possible. The most current versions are available for download on the B&R website (www.br-automation.com).

1 General information

1.1 Other applicable documents

For additional and supplementary information, see the following documents.

Other applicable documents

Document name	Title
MAX20	X20 System user's manual
MAEMV	Installations / EMV guide

1.2 Order data

Order number	Short description	Figure
	Digital outputs	
X20DO4613	X20 digital output module, 4 triac coupler outputs, 48 to 240 VAC, 50 mA, zero-crossing detection, 240 V keyed	
	Required accessories	
	Bus modules	
X20BM12	X20 bus module, 240 VAC keyed, internal I/O power supply connected through	
	Terminal blocks	
X20TB32	X20 terminal block, 12-pin, 240 VAC keyed	

Table 1: X20DO4613 - Order data

1.3 Module description

The module is a digital output module that is equipped with 4 opto-triac outputs using phase-angle control. L and N are fed to the module for zero-crossing detection.

The 4 outputs are electrically isolated from one another and are used for controlling external power triacs or nonparallel thyristors.

Functions:

- Phase angle control
- Digital outputs
- OSP mode

Phase angle control

Phase angle control can be used to control resistive and inductive loads.

OSP mode

In mode "OSP" (Operator Set Predefined), the user defines a digital pattern. This OSP value is output as soon as the communication between the module and master is aborted.

Danger!

Risk of electric shock!

The terminal block is only permitted to conduct voltage when it is connected. It is not permitted to be disconnected or connected while voltage is applied or have voltage applied to it while it is removed under any circumstances!

This module is not permitted to be the last module connected on the X2X Link network. At least one subsequent X20ZF dummy module must provide protection against contact.

2 Technical description

2.1 Technical data

Order number	X20DO4613
Short description	
I/O module	4 digital outputs for controlling external power triacs or non-parallel thyristors
General information	
B&R ID code	0xAD05
Status indicators	I/O function per channel, operating state, module status
Diagnostics	
Module run/error	Yes, using LED status indicator and software
Outputs	Yes, using LED status indicator
Power consumption	
Bus	0.8 W
Internal I/O	-
External I/O	-
Additional power dissipation caused by actuators (resistive) [W] [1)]	+1 W
Certifications	
CE	Yes
UKCA	Yes
ATEX	Zone 2, II 3G Ex nA nC IIA T5 Gc IP20, Ta (see X20 user's manual) FTZÚ 09 ATEX 0083X
UL	cULus E115267 Industrial control equipment
HazLoc	cCSAus 244665 Process control equipment for hazardous locations Class I, Division 2, Groups ABCD, T5
KC	Yes
Digital outputs	
Variant	Opto-triac
Circuit	Normally open contact
Nominal voltage	48 to 240 VAC
Max. voltage	264 VAC
Rated frequency	47 to 63 Hz
Nominal current at 25°C	
Nominal output current	80 mA
Total nominal current	320 mA
Current over entire temperature range	
Output current	50 mA
Summation current	200 mA
Connection type	2-wire connections
Zero-crossing detection	Yes
Holding current	Max. 3.5 mA
Leakage current	Max. 1.5 mA (per channel)
Residual voltage (on-state voltage)	Max. 3 V
Phase-angle control	
Area	5 to 95%
Resolution	1%
Accuracy (60 to 240 VAC)	<100 µs
Voltage monitoring L - N	No
Recommended wiring	Twisted pair cabling to the terminal pairs
Line length	Max. 10 m
Overvoltage protection between L and N	Yes
Insulation voltages	
Channel - Bus	Tested at 2300 VAC
Channel - Channel	Tested at 2300 VAC
Protective circuit	
External	Generally fuse
Internal	Snubber circuit (RC element) and varistor
Electrical properties	
Electrical isolation	Channel isolated from channel, bus and I/O power supply

Table 2: X20DO4613 - Technical data

Order number	X20DO4613
Operating conditions	
Mounting orientation	
Horizontal	Yes
Vertical	Yes
Installation elevation above sea level	
0 to 2000 m	No limitation
>2000 m	Not permitted
Degree of protection per EN 60529	IP20
Ambient conditions	
Temperature	
Operation	
Horizontal mounting orientation	-25 to 60°C
Vertical mounting orientation	-25 to 50°C
Derating	-
Storage	-40 to 85°C
Transport	-40 to 85°C
Relative humidity	
Operation	5 to 95%, non-condensing
Storage	5 to 95%, non-condensing
Transport	5 to 95%, non-condensing
Mechanical properties	
Note	Order 1x terminal block X20TB32 separately. Order 1x bus module X20BM12 separately.
Pitch	12.5$^{+0.2}$ mm

Table 2: X20DO4613 - Technical data

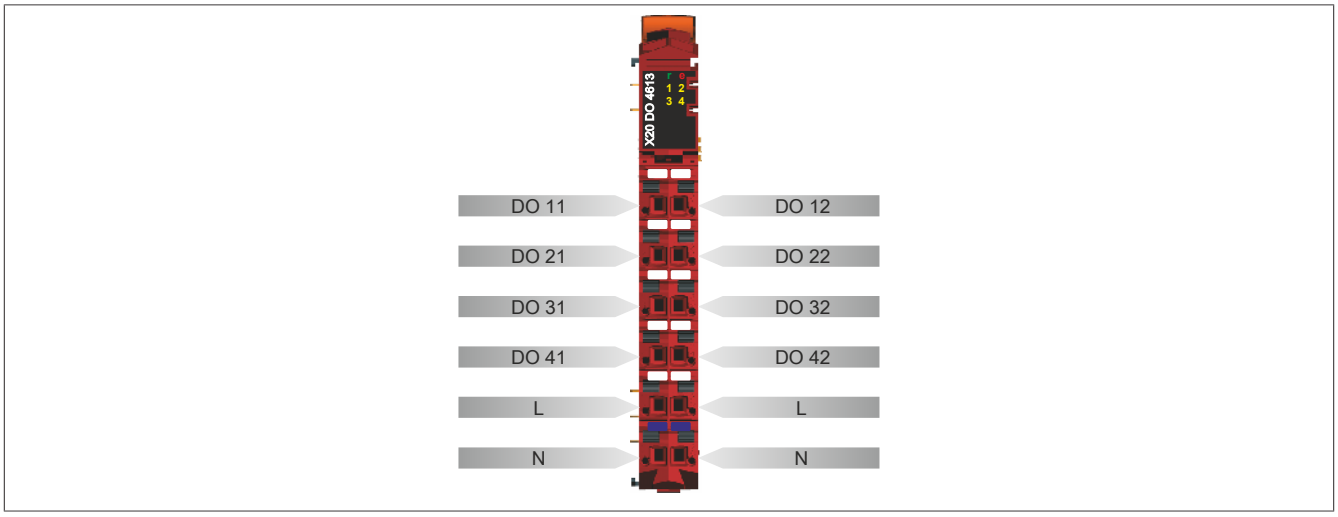
1) Number of outputs x Residual voltage (on-state voltage) x Nominal output current. For a calculation example, see section "Mechanical and electrical configuration" in the X20 system user's manual.

2.2 Status LEDs

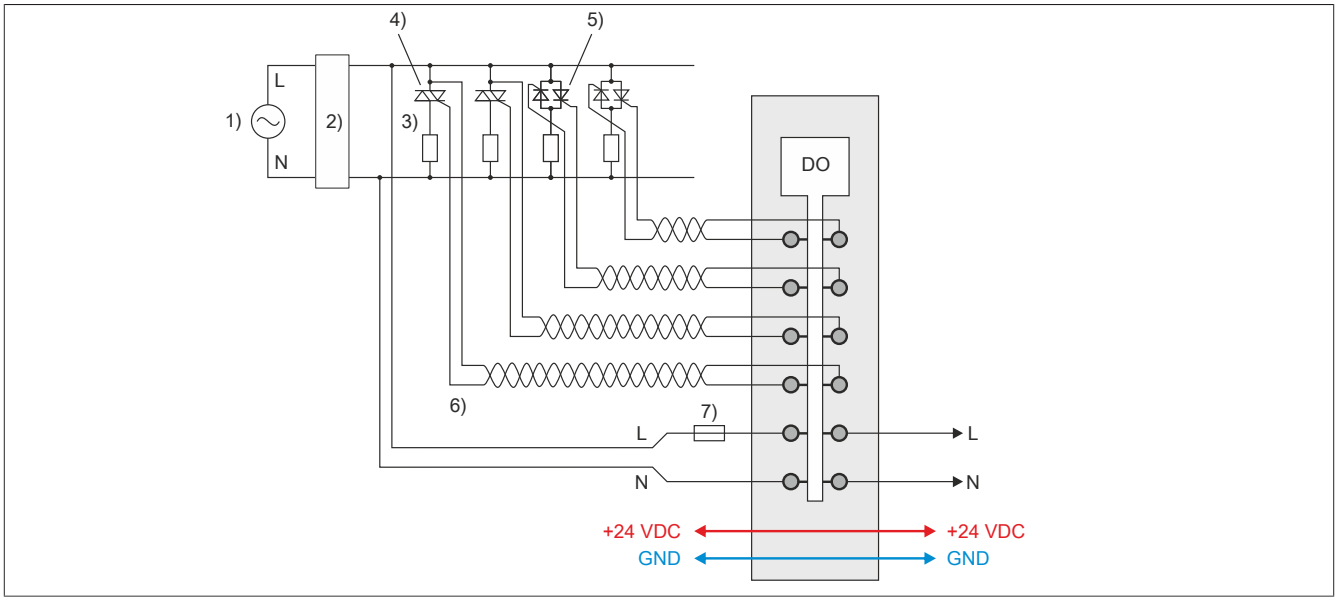
For a description of the various operating modes, see section "Additional information - Diagnostic LEDs" in the X20 System user's manual.

Figure	LED	Color	Status	Description
	r	Green	Off	Module supply not connected
			Single flash	RESET mode
			Blinking	PREOPERATIONAL mode
			On	RUN mode
			Flickering (approx. 10 Hz)	Module is in OSP state
	e	Red	Off	Module supply not connected or everything OK
			On	Error or reset status
			Single flash	Loss of zero-crossing signal (input voltage absent or too low)
	e + r	Red on / Green single flash		Invalid firmware
	1 - 4	Orange		Control status of the corresponding digital output

2.3 Pinout

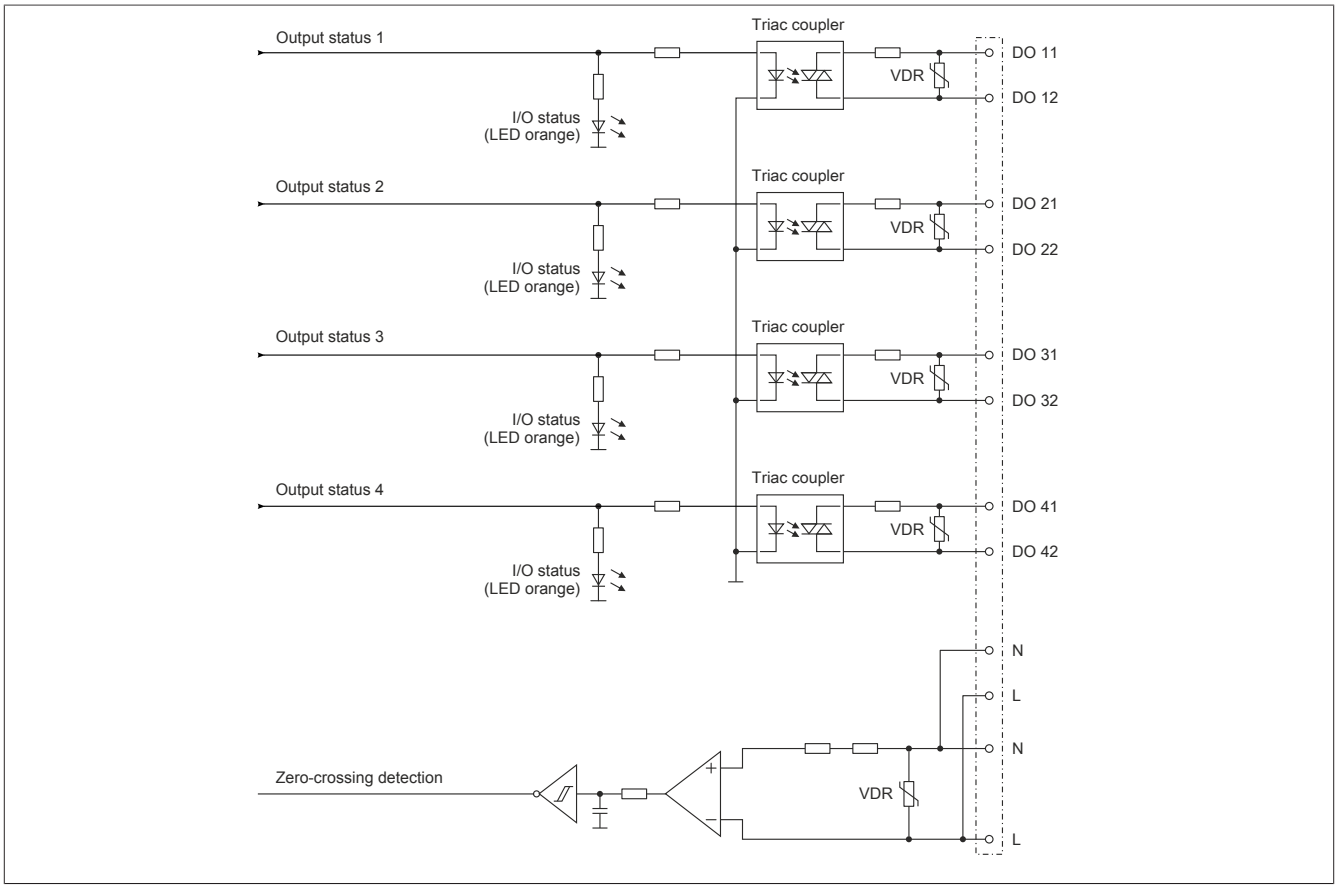


2.4 Connection example



1) 48 - 240 VAC
2) Line filter
3) Load
4) Power triac
5) Power thyristor
6) Twisted lines
7) Fuse, 0.5 A slow-blow

2.5 Output circuit diagram



3 Function description

3.1 Phase angle control

The digital output module was designed for phase angle control of resistive and inductive loads.

The module has internal zero-crossing detection. The zero-crossing detection forms the basis for a software PLL that generates 200 times the zero-crossing frequency. The output signal of the PLL forms the base clock for the PWM outputs in both digital and analog mode.

If a failure of periods or periods that are too short is detected, control of the outputs is deactivated until the PLL has settled correctly. The settling procedure can take several seconds. In addition, bit "ZeroCrossingStatus" is set, and LED Error is enabled (valid frequency range of the power supply is 45 to 65 Hz).

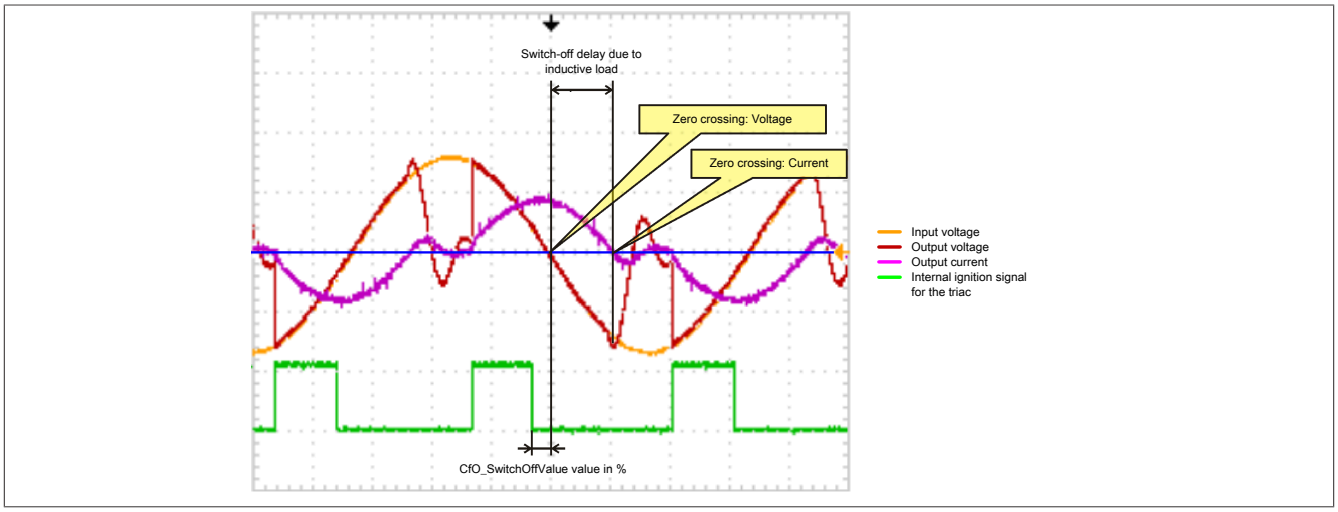
Information:

The jitter of the output signals generated by the PLL and communication can reach 0.5%.

Operation with inductive loads

By design, the triac output is switched off at the current zero crossing. Due to the delayed current zero crossing with inductive loads, the effect occurs that at higher output values (depending on the inductance of the load, between 50 and 100%) the triac is fired again even though it has not yet been switched off. A full wave is therefore output. This results in the available control range (0 to 100%) being changed.

The physically output value no longer changes if the activation goes beyond the point of full-wave control (up to 100%). However, this does not damage the module.



3.1.1 Output values

The output value of the outputs defined as analog (unit: percent) is switched through to the drive ports synchronously with the mains. The analog value is output to the triac drive port with a resolution of 1% in the range (Output value > SwitchOffValue) and (Output value ≤ 95%).

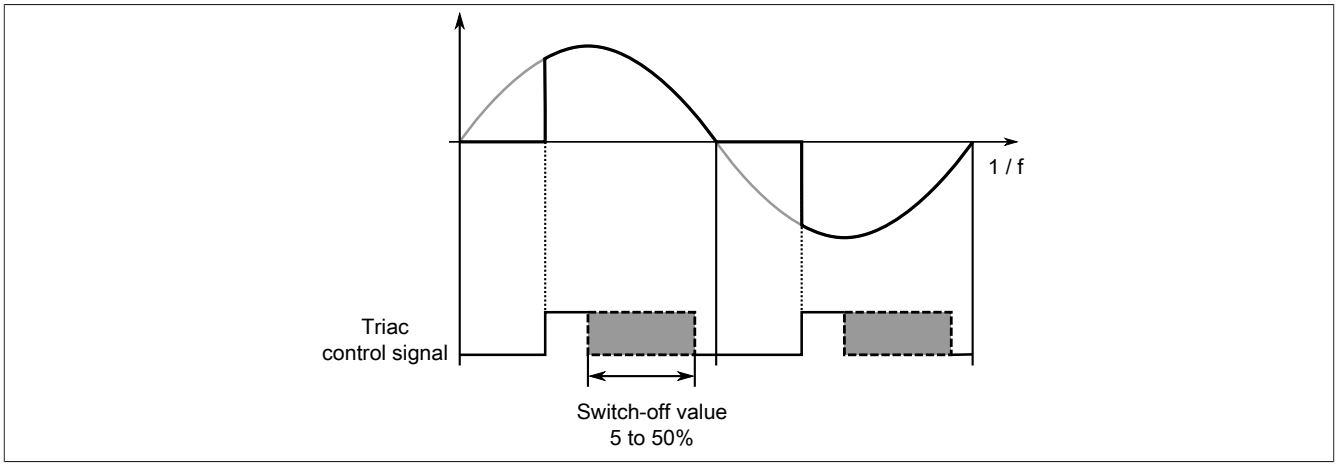
Changes to the output value are applied with the next positive half-wave.

3.1.2 Deactivation time

The deactivation time defines how far before the zero crossing the internal control signal for the triac is switched off. Adjusting this value may be necessary in order to avoid misfiring of the triac in the event of slight disturbances in the mains frequency.

For small loads, it is important to ensure that the switch-off value is not set too high (too early) in order to avoid premature deactivation.

The triac can naturally only be fired before the set deactivation time.



3.1.3 Behavior with zero-crossing faults

The switching behavior of the trigger can be adjusted. After a configured number of zero crossing errors, the output is switched off for at least 3 periods.

This is followed by one of the following possible synchronizations to the zero signal:

Quick adjustment

With this option, the trigger point of the firing is regulated after each individual zero crossing and input jitter.

- **Advantage:** Extended tolerance and faster response to mains frequency fluctuations
- **Disadvantage:** Increased switch-on jitter of the firing signal of ±100 µs to the zero-crossing signal

PLL adjustment

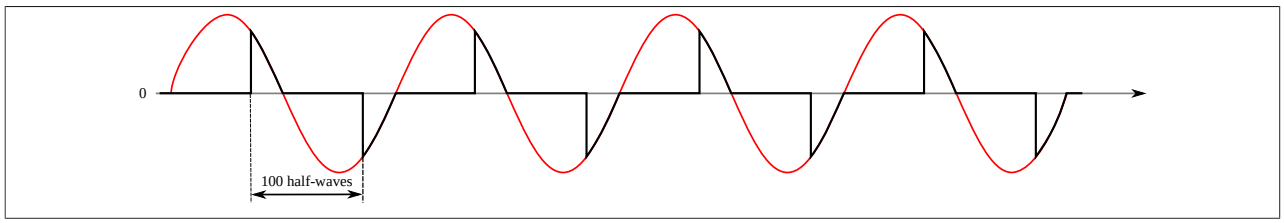
With this option, the intervals between the zero crossings are measured and the PLL frequency is adjusted according to this measurement.

- **Advantage:** Jitter-free firing signal
- **Disadvantage:** After switching off the output, additional measuring phases are required before the output can be switched on again.

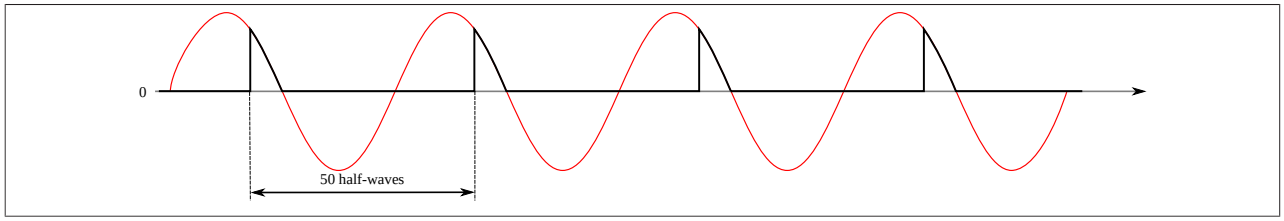
3.1.4 Setting the half-wave pattern

In "Function model 2 - Frequency mode", the output of half-wave patterns can be set in different frequencies. The commutation angle of the outputs is not affected by this. The following frequency patterns can be configured:

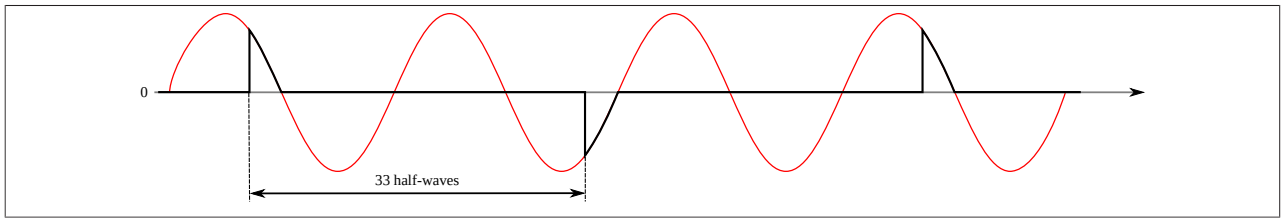
- 100 half-waves



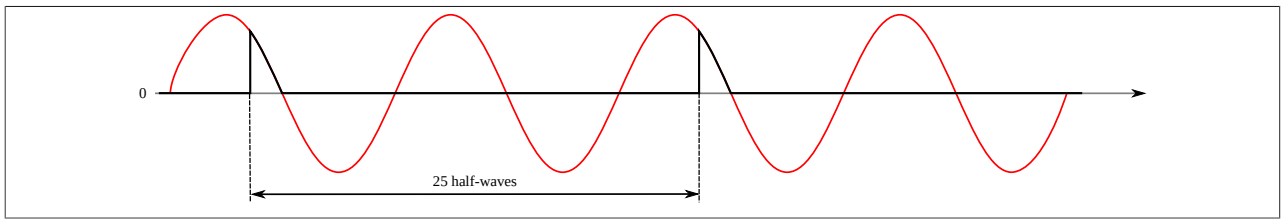
- 50 half-waves



- 33 half-waves



- 25 half-waves



In multi-channel operation, the different channels should be operated with delayed half-waves to ensure a more even load on the module.

3.2 Digital outputs

This module is equipped with 4 digital outputs.

The output state of the outputs defined as digital is transferred to the output ports of the drive circuit in synchronization with the connected mains. The switch-on state is applied at the voltage zero crossing of the positive half-wave and the switch-off state at the current zero crossing of each half-wave.

Packed outputs (only function model 0 - Standard)

Setting "Packed outputs" in the Automation Studio I/O configuration can be used to determine whether all bits of the register should be applied as individual data points in the Automation Studio I/O mapping (e.g. "DigitalOutput01 to DigitalOutputxx") or whether the register should be displayed as a single USINT data point (e.g. "DigitalOutput").

Information:

The register is described in "Switching state of digital outputs 1 to 4" on page 14.

3.3 OSP mode

In function model "OSP" (Operator Set Predefined), the user defines a digital pattern. This OSP value is output as soon as the communication between the module and master is aborted.

3.3.1 Hardware requirements

In order to use OSP mode sensibly, it should be ensured when setting up the application that the power supply of the output module and controller are designed to be independent of each other.

3.3.2 Functionality

The user has the choice between 2 OSP modes:

- Retain last valid value
- Replace with static value

In the first case, the module retains the last value recognized as a valid output status.

When selecting mode "Replace with static value", a plausible output value must be entered in the associated value register. When an OSP event occurs, this value is output instead of the value currently requested by the task.

If an OSP event occurs, e.g. communication between the module and master controller aborted, then bit OSPValid is reset on the module. The module enters the OSP state and output occurs according to the configuration in register OSPMode.

The following generally applies:

Even after regeneration of the communication channel, the OSP replacement value is still pending. The OSP state is only exited again when a set OSPValid bit is transferred.

When the master controller is restarted, bit OSPValid bit is reinitialized in the master controller. It must be set once more by the application and transferred via the bus.
In the event of brief communication errors between the module and master controller (e.g. due to EMC), the cyclic registers fail to refresh for several bus cycles. Within the module, bit OSPValid is reset; the set bit is retained in the controller, however. During the next successful transfer, the module-internal OSPValid bit is set again and the module automatically returns to normal mode.

If the task in the master controller needs the information about which output mode the module is currently in, bit ModulOK can be evaluated.

Warning!

If bit OSPValid bit is reset to "0" by the module, the output status no longer depends on the responsible task in the master controller. Nevertheless, output is made depending on the configuration of the OSP replacement value.

Information:

The registers are described in "Function model "OSP"" on page 18.

4 Commissioning

4.1 Using the module on the bus controller

Function model 254 "Bus controller" is used by default only by non-configurable bus controllers. All other bus controllers can use other registers and functions depending on the fieldbus used.

For detailed information, see section "Additional information - Using I/O modules on the bus controller" in the X20 user's manual (version 3.50 or later).

4.1.1 CAN I/O bus controller

The module occupies 1 analog logical slot on CAN I/O.

5 Register description

5.1 General data points

In addition to the registers described in the register description, the module has additional general data points. These are not module-specific but contain general information such as serial number and hardware variant.

General data points are described in section "Additional information - General data points" in the X20 System user's manual.

5.2 Function model 0 - Standard and Function model 2 - Frequency mode

The only difference between function model 2 and function model 0 is the possibility of generating half-wave patterns in various frequencies. Register 18 "CfO_Frequency" is an additional register for this.

Register	Name	Data type	Read		Write	
			Cyclic	Non-cyclic	Cyclic	Non-cyclic
Configuration - General						
2 + N * 2	AnalogOutput0N (Index N = 1 to 4)	USINT			•	
18	CfO_Frequency	UINT				•
18 + N * 2	ConfigOutput0N (Index N = 1 to 4)	USINT				•
28	ConfigOutput05	USINT				•
29	CfO_OutputTolerance	USINT				•
Communication						
2	DigitalOutput	USINT			•	
	DigitalOutput01	Bit 0				
	...	...				
	DigitalOutput04	Bit 3				
30	StatusInput01	USINT	•			
	ZeroCrossingInput	Bit 4				
	ZeroCrossingStatus	Bit 7				

5.3 Function model 1 - OSP

Register	Name	Data type	Read		Write	
			Cyclic	Non-cyclic	Cyclic	Non-cyclic
Configuration - General						
2 + N * 2	AnalogOutput0N (Index N = 1 to 4)	USINT			•	
18 + N * 2	ConfigOutput0N (Index N = 1 to 4)	USINT				•
28	ConfigOutput05	USINT				•
29	CfO_OutputTolerance	USINT				•
Configuration - OSP						
34	Enabling OPS output in the module	USINT			•	
	OSPValid	Bit 0				
32	CfgOSPMode	USINT				•
36	CfgOSPValue	USINT				•
36 + N * 2	CfgOSPValue0N (Index N = 1 to 4)	USINT				•
Communication						
2	Switching state of digital outputs 1 to 4	USINT			•	
	DigitalOutput01	Bit 0				
	...	...				
	DigitalOutput04	Bit 3				
30	Status of the outputs	USINT	•			
	ZeroCrossingInput	Bit 4				
	ZeroCrossingStatus	Bit 7				

5.4 Function model 254 - Bus controller

Register	Offset	Name	Data type	Read		Write	
				Cyclic	Non-cyclic	Cyclic	Non-cyclic
Configuration - General							
2 + N * 2	(N-1) * 2	AnalogOutput0N (Index N = 1 to 4)	USINT			•	
18 + N * 2	-	ConfigOutput0N (Index N = 1 to 4)	USINT				•
28	-	ConfigOutput05	USINT				•
29	-	CfO_OutputTolerance	USINT				•
Communication							
30	0	Status of the outputs	USINT	•			
		ZeroCrossingInput	Bit 4				
		ZeroCrossingStatus	Bit 7				

1) The offset specifies the position of the register within the CAN object.

5.5 Digital outputs

The output state of the outputs defined as digital is transferred to the output ports of the drive circuit in synchronization with the connected mains.

5.5.1 Switching state of digital outputs 1 to 4

Name:
DigitalOutput
DigitalOutput01 to DigitalOutput04

This register stores the switching state of digital outputs 1 to 4.

Data type	Values	Information[1)]
USINT	0 to 15	Packed outputs = On Data point: "DigitalOutput"
	See the bit structure.	Packed outputs = Off or function model ≠ 0 - Standard. Data points: "DigitalOutput01" to "DigitalOutput04"

1) See "Digital outputs" on page 10.

Bit structure:

Bit	Name	Value	Information
0	DigitalOutput01	0	Digital output 01 reset
		1	Digital output 01 set
...		...	
3	DigitalOutput04	0	Digital output 04 reset
		1	Digital output 04 set

Information:

The states in these registers are only applied if the configuration of the channels in "Configuration of the output channels" on page 17 is set to DIGITAL accordingly.

When using setting "Packed outputs", ALL channels must be set to DIGITAL. Mixed operation is not possible.

5.6 Phase angle control

5.6.1 Commutation angle for analog outputs 1 - 4

Name:
AnalogOutput01 to AnalogOutput04

These registers are used to set the commutation angle for phase angle control.

Values between 0 and 100 correspond to the output value for the respective channel in percent. Values above 100 correspond to 100%.

Data type	Value
USINT	0 to 100

Information:

The switch-on angles of the phase angle control set in these registers are only applied if the configuration of the channels in "ConfigOutput05" on page 17 is set to ANALOG accordingly.

5.6.2 Status of the outputs

Name:
ZeroCrossingInput
ZeroCrossingStatus
StatusInput01

The operating status of the outputs is mapped in this register.

Data type	Value	Information[1)]
USINT	0 to 17	Packed outputs = On Data point: "StatusInput01"
	See the bit structure.	Packed outputs = Off or function model ≠ 0 - Standard. Data points: "ZeroCrossingInput" and "ZeroCrossingStatus"

1) See "Digital outputs" on page 10.

Bit structure:

Bit	Name	Value	Information
0 - 3	Reserved	-	
4	ZeroCrossingInput	0	Zero cross signal during the negative half-wave
		1	Zero cross signal during the positive half-wave
5 - 6	Reserved	-	
7	ZeroCrossingStatus	0	Zero cross signal OK
		1	Zero cross signal has dropped out

5.6.3 Configuring the half-wave pattern

Name:
CfO_Frequency

This register can only be used in function model 2 - Frequency mode and makes it possible to configure the output of half-wave patterns in various frequencies. For details, see Setting the half-wave pattern.

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 3	Channel 1	0000	100 half-waves/second
		0001	50 half-waves/second
		0010	25 half-waves/second
		0011	33 half-waves/second
		0101	50 half-waves/second delayed by 1 half-wave
		0110	25 half-waves/second delayed by 2 half-waves
		0111	33 half-waves/second delayed by 1 half-wave
4 - 7	Channel 2	0000 to 0111	See channel 1.
8 - 11	Channel 3	0000 to 0111	See channel 1.
12 - 15	Channel 4	0000 to 0111	See channel 1

Information:

This function is only available with firmware version 940 or later. This can be installed starting with hardware variant 8.

5.6.4 Setting the switch-off time

Name:
ConfigOutput01 to ConfigOutput04

This register defines how far before the zero crossing the internal drive signal for the triac is switched off. Increasing this value may be necessary in order to avoid misfiring of the triac in the event of slight disturbances in the mains frequency. For details, see "Deactivation time" on page 9.

"SwitchOffValue" in the Automation Studio I/O configuration.

Data type	Value	Description
USINT	5 to 50	Switch-off time in %. Bus controller default setting: 0

5.6.5 Configuration of the output channels

Name:
ConfigOutput05

The configuration of the output channels is stored in this register.

"Output type digital/analog" and "Output type full/half wave" in the Automation Studio I/O configuration

Data type	Values	Bus controller default setting
USINT	See the bit structure.	15

Bit structure:

Bit	Description	Value	Information
0	Channel 1: Digital/Analog output	0	Output channel 1 is defined as a digital output. The output status is defined by bit 0 in registers "DigitalOutput 1 - 4" on page 14.
		1	Output channel 1 is defined as an analog output. The output status is defined by register "AnalogOutput01" on page 15 (bus controller default setting).
...		...	
3	Channel 4: Digital/Analog output	0	Output channel 4 is defined as a digital output. The output status is defined by bit 1 in registers "DigitalOutput 1 - 4" on page 14.
		1	Output channel 2 is defined as an analog output. The output status is defined by register "AnalogOutput04" on page 15 (bus controller default setting).
4	Channel 1: Full-wave/Half-wave control[1)]	0	Full-wave control on output channel 1 (bus controller default setting)
		1	Negative half-wave on output channel 1 is suppressed.
...		...	
7	Channel 4: Full-wave/Half-wave control[1)]	0	Full-wave control on output channel 4 (bus controller default setting)
		1	Negative half-wave on output channel 4 is suppressed.

1) Not available in function model 2 - Frequency mode.

5.6.6 Switching behavior for zero-crossing errors

Name:
CfO_OutputTolerance

This register can be used to set the switching behavior of the trigger. After the number of zero-crossing errors configured in Bit 0 to 4, the output is switched off for at least 3 periods. This is followed by synchronization with the zero signal according to Bit 7.

Data type	Values	Bus controller default setting
USINT	See the bit structure.	0

Bit structure:

Bit	Description	Value	Information
0 - 4	Trigger for Resync	0 to 30	Number of zero crossing errors. Bus controller default setting: 0
5 - 6	Reserved	-	
7	Fast settling	0	Quick adjustment (bus controller default setting)
		1	PLL adjustment

Information:

This function is available starting with Firmware version 928. This can be installed with hardware version 7 and hardware revision B4 or higher.

5.7 Function model "OSP"

In function model "OSP" (Operator Set Predefined), the user defines a digital pattern. This OSP value is output as soon as the communication between the module and master is aborted.

5.7.1 Enabling OPS output in the module

Name:
OSPValid

This data point makes it possible to start the output of the module and request the use of OSP during operation.

Bit OSPValid exists once on the module and is managed by the user task. It must be set to start the enabled channels. As long as bit OSPValid remains set in the module, the module behaves the same as in function model "Standard".

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	OSPValid	0	Request OSP operation (after initial startup or module in standby)
		1	Request normal operation
1 - 7	Reserved	0	

5.7.2 Setting OSP mode

Name:
CfgOSPMode

This register controls the behavior of a channel when using OSP.

Data type	Values	Explanation
USINT	0	Replace with static value
	1	Retain last valid value

5.7.3 Defining an OSP-digital output value

Name:
CfgOSPValue

This register contains the digital output value that is output in "Replace with static value" mode during OSP mode.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0		0 or 1	OSP output value for channel DigitalOutput00
...		...	
x		0 or 1	OSP output value for channel DigitalOutput0x

Warning!

"OSPValue" is only applied by the module if bit "OSPValid" has been set in the module.

5.7.4 Define the OSP analog output value

Name:
CfgOSPValue01 to CfgOSPValue04

This register contains the analog output value, which is output in "Replace with static value" mode during OSP operation.

Data type	Value
USINT	0 to 100

Warning!

"OSPValue" is only applied by the module if bit "OSPValid" has been set in the module.

5.8 Minimum cycle time

The minimum cycle time specifies how far the bus cycle can be reduced without communication errors occurring. It is important to note that very fast cycles reduce the idle time available for handling monitoring, diagnostics and acyclic commands.

	Minimum cycle time
All channels	250 µs

5.9 Minimum I/O update time

The minimum I/O update time specifies how far the bus cycle can be reduced so that an I/O update is performed in each cycle.

	Minimum I/O update time
All channels	150 µs