

# INVEOR M / MP

Functional safety

Short manual



Distributor for:

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## EPA Drives

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Sales department:

**EPA** GmbH

Fliederstraße 8, D-63486 Bruchköbel  
Deutschland / Germany

Telefon / Phone: +49(0)6181 9704-0

Telefax / Fax: +49(0)6181 9704-99

E-Mail: [info@epa.de](mailto:info@epa.de)

Internet: [www.epa.de](http://www.epa.de)

Author:

**KOSTAL Industrie Elektrik GmbH**

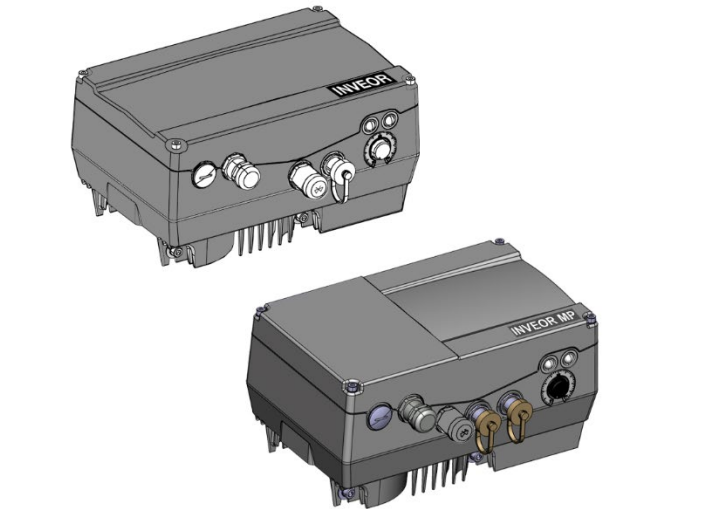
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Smart connections.

SIL3  
PLe

Functional safety

Short manual

INVEOR M / MP

Functional Safety


EN

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Legal notice

Direct link to operating manual

KOSTAL Industrie Elektrik GmbH  
An der Bellmerlei 10  
58513 Lüdenscheid  
Germany  
Phone +49 (0)2351 16-0  
Fax + 49 (0)2351 16-2400  
info-industrie@kostal.com



EN


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KOSTAL Industrie Elektrik GmbH is aware of the importance of language with regard to the equality of women and men and always makes an effort to reflect this in the documentation. Nevertheless, for the sake of readability we are unable to use non-gender-specific terms throughout and use the masculine form instead.

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The chapters marked with this symbol form part of the complete operating manual.  
Please read and note the information provided there.

Complete operating manual

You will find a detailed operating manual on “Functional safety”, including application examples, online at  
[http://www.kostal-industrie-elektrik.com/INVEOR\\_M\\_Functional\\_Safety](http://www.kostal-industrie-elektrik.com/INVEOR_M_Functional_Safety)

Proper use



■ Proper use

!

IMPORTANT INFORMATION

■ Using drive controllers in equipment that is not fixed is considered as an exceptional environmental condition and is only permitted if allowed by the standards and guidelines applicable on site.

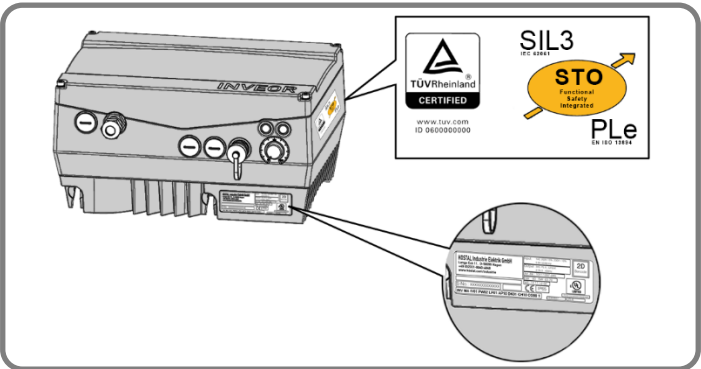
■ Only allow appropriately qualified staff to undertake assembly and disassembly.

■ Only use staff who are trained in mounting, installation, commissioning and handling.





■ Do not modify the drive controller.


■ Observe general and national safety and accident prevention regulations

Labels on the drive controller



Signs and labels are applied to the housing of the drive controller.  
These signs and labels may not be altered or removed.

Symbol	Meaning
	Danger due to electrical shock and discharge
	Danger due to electrical shock and discharge. Wait two minutes (discharge time of the capacitors) after shut-down
	Additional earth connection
	Observe and read operating manual



■ Qualified staff

■ Proper use

■ Responsibility

■ CE marking

■ Abbreviations used

■ Certificate

Contact details and service

If you have any technical questions, please contact our service hotline.

Country	Phone	E-mail
Germany and other countries	+49 (0)2331 80 40-848	INVEOR-service@kostal.com

1 | SAFETY INSTRUCTIONS



■ General safety instructions


STO safety instructions

The safety instructions listed in the following are to be observed and obeyed strictly.

!

IMPORTANT INFORMATION

No protection from electric shock is ensured by the STO status.



**DANGER!**

Risk of death due to electrical shock!  
Death or serious injury!  
De-energise drive controller and secure it against being restarted.  
The following terminals may lead to dangerous currents even when the motor is not running:

- Supply terminals X1: L1, L2, L3
- Motor connection terminals X2: U, V, W

Connecting terminals X6, X7: Relay contacts for relays 1 and 2

PTC terminals T1/T2

!

IMPORTANT INFORMATION

With open housing, contamination degree 2 must be observed in order to ensure the safety function.

!

IMPORTANT INFORMATION

The STO connection line must be shielded in order to allow the elimination of errors with regard to external voltage coupling to be applied. The EMC screw connection provided must be used for the cable inlet into the INVEOR housing.

!

IMPORTANT INFORMATION

With reference to the STO connection line, the “elimination of errors with regard to short circuit” is achieved in accordance with DIN EN 13849-2 in that a separate, shielded cable is used for each channel. Shielding is to be applied at both ends. The EMC screw connections provided must be used for this purpose.  
  
If only one shielded cable is used for both STO channels, a safety switch must be used to detect possible crossovers between the channels to qualify for observation of the “elimination of errors short circuit” in accordance with DIN EN 13849-2.

!

IMPORTANT INFORMATION

Permanent 24 V voltage to the STO inputs results in the loss of the safety function.

!

IMPORTANT INFORMATION

■ The process for the shut-down of the machine drive elements described under “Stop category-1” (SS1) can only be realised in connection with an additional external safety module!

■ “Stop category-2” (SS2) is not supported by the drive controller.

Classification IEC 61800-5-2

The following definitions describe the three types of safe stop function.

**STO (Safe Torque Off)**

No power is supplied to the motor that could cause rotation (or movement in the case of a linear motor). The drive controller supplies no power to the motor that could generate torque (or force in the case of a linear motor). This safety function corresponds to an uncontrolled shut-down according to IEC 60204-1, stop category 0.

!

IMPORTANT INFORMATION

■ This safety function can be used when it is necessary to shut off power in order to prevent an unexpected start.

■ Where there are external influences (e.g. falling of suspended loads), additional measures (e.g. mechanical braking), which must be designed to fail safe, may be necessary to prevent hazards.

■ In the STO status, the drive is not separated from the energy supply, as only the activation of the IGBTs is securely switched off.

**Safe Stop 1 SS1**

The SS1 safety function corresponds to an uncontrolled shut-down according to IEC 602,04-1, stop category 1. In this case the drive controller does not securely monitor the motor delay or the motor speed.

!

IMPORTANT INFORMATION

Secure monitoring of the motor delay is only possible with the use of an external safety module.

**Classification of two-channel EN 62061 without external diagnosis**

The classification of the two-channel STO function without external diagnosis meets the following requirements:

Designation	Value	Explanation
Safety measure	Pulse block	---
SIL	3	Safety integrity level
PFH	1.81e-08	Probability of hazardous failures per hour
DC	60 [%]	Diagnosis coverage
SFF	99.24 %	Proportion of safe failures
T	20 years	Duration of usage

Table: Classification two-channel EN 62061, without external testing

**Classification of two-channel EN 62061 with external diagnosis**

The classification of the two-channel STO function with external diagnosis meets the following requirements:

Designation	Value	Explanation
Safety measure	Pulse block	---
SIL	3	Safety integrity level
PFH	2.16e-09	Probability of hazardous failures per hour
DC	90 [%]	Diagnosis coverage
SFF	99.92 %	Proportion of safe failures
T	20 years	Duration of usage

Table: Classification of two-channel EN 62061 with external testing

**Classification of two-channel EN 62061 with dynamic testing**

The classification of the two-channel STO function with dynamic testing meets the following requirements:

Designation	Value	Explanation
Safety measure	Pulse block	---
SIL	3	Safety integrity level
PFH	1.45e-10	Probability of hazardous failures per hour
DC	99 [%]	Diagnosis coverage
SFF	99.99 %	Proportion of safe failures
T	20 years	Duration of usage

Table: Classification of two-channel EN 62061, with enhanced external testing

**Classification of two-channel EN ISO 13849-1 without external diagnosis**

The classification of the two-channel STO function without external diagnosis meets the following requirements:

Designation	Value	Explanation
Safety measure	Pulse block	---
PL	e	Performance level
Category	3	---
MTTFd	167 [a]	Mean time to failure (dangerous)
DC	60 [%]	Diagnosis coverage
T	20 years	Duration of usage
Max. diagnosis test interval	Once every 3 months	

Table: Classification of two-channel EN 13849-1, without external testing

The precise way in which a diagnosis test interval works is described in chapter 7 and in the “Functional safety” operating instructions.  
In accordance with ISO 13489-1, the category 3 MTTFd is restricted to 100 years.

!

IMPORTANT INFORMATION

Cat.3 with DC = 60% actually limits the performance level to d. However, the increased failure-safety present in this case and documented in the context of the FMEA is of equal value, and PL e is thus achieved.

**Classification of two-channel EN ISO 13849-1 with external diagnosis**

The classification of the two-channel STO function with external diagnosis meets the following requirements:

Designation	Value	Explanation
Safety measure	Pulse block	---
PL	e	Performance level
Category	3	---
MTTFd	167 [a]	Mean time to failure (dangerous)
DC	90 [%]	Diagnosis coverage
T	20 years	Duration of usage
Max. diagnosis test interval	Once every 3 months	

Table: Classification two-channel EN ISO 13849-1 with external diagnosis

The precise way in which a diagnosis test interval works is described in chapter 7 and in the “Functional safety” operating instructions.  
In accordance with ISO 13489-1, the category 3 MTTFd is restricted to 100 years.



Classification two-channel EN ISO 13849-1 with dynamic testing

The classification of the two-channel STO function with dynamic testing meets the following requirements:

Designation	Value	Explanation
Safety measure	Pulse block	---
PL	e	Performance level
Category	4	---
MTTFd	167 [a]	Mean time to failure (dangerous)
DC	99 [%]	Diagnosis coverage
T	20 years	Duration of usage
Max. diagnosis test interval	Daily	

Table: Classification of two-channel EN ISO 13849-1, with dynamic testing

The precise way in which a diagnosis test interval works is described in chapter 7 and in the “Functional safety” operating instructions.

Classification one-channel (reduced SIL and PL)

The one-channel classification is the result of parallel connection of the two STO inputs. The safety classification is thus reduced to the following values.

!

IMPORTANT INFORMATION

■

The classification may be reduced due to false connection technology (e.g. one-channel) during installation/planning!

■

An external 1-channel structure, bridged to both STO inputs, means that the safety level no longer meets SIL3 or PL<sub>e</sub>.

Designation	Value	Explanation
Safety measure	Pulse block	---
SIL	1	Safety Integrity Level
PFH	1.81e-08	Probability of hazardous failures per hour
SFF	99.24 %	Proportion of safe failures
T	20 years	Duration of usage
PL	c	Performance Level
Category	1	---
MTTFd	56 years	Mean time to failure (dangerous)
DC	60 [%]	Diagnosis coverage

Table: Classification one-channel IEC 61508 and EN ISO 13849

!

IMPORTANT INFORMATION

When an external control system carries out a test of the connection in the application 100 times more often than a “sharp” requirement of the STO function, SIL 2 and PL d are achieved.

2 | Type key/scope of application

The INVEOR line of drive controllers contains variants with and without STO safety function. These variants are clearly recognisable by the product key. The STO safety function cannot be retrofitted

Type key/scope of application

Item designation KOSTAL „INVEOR“ M

INV MA IV01 PW02 LP01 **AP10** DK01 GH10 CO00 1

The following table provides an overview of devices with STO function: INVEOR M

INV	Mx	IV01	PWxx	LPxx	<b>AP10</b>	GHxx	DKxx	COxx
INV	Mx	IV01	PWxx	LPxx	<b>AP2x</b>	GHxx	DKxx	COxx
INV	Mx	IV01	PWxx	LPxx	<b>AP5x</b>	GHxx	DKxx	COxx

Item designation KOSTAL „INVEOR“ MP

INV MPA IV01 PW02 LP01 **AP10** DK01 OA00 CO00

INVEOR MP

INV	MPx	VS01	IV01	PWxx	LPxx	<b>AP10</b>	GHxx	DKxx	OAxx	COxx
INV	MPx	VS01	IV01	PWxx	LPxx	<b>AP2x</b>	GHxx	DKxx	OAxx	COxx
INV	MPx	VS01	IV01	PWxx	LPxx	<b>AP5x</b>	GHxx	DKxx	OAxx	COxx

3 | Technical data

Technical data, general

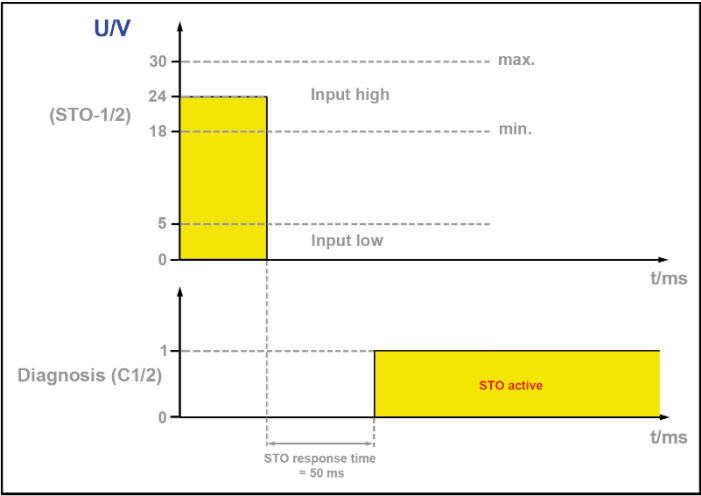
■ Technical data, general

Technical data STO

Designation	Value	Unit
STO max. response time	50	ms
PELV/SELV power supply for STO input voltage (rating)	24	VDC
PELV/SELV tolerance for STO input voltage (referring to rating)	± 25	%
Current consumption per STO channel with rated voltage	typ. 65	mA
Start-up peak current (2.5 ms)	400	mA
Compatibility: Max. OSSD pulse	1	ms
Compatibility: Min. OSSD pulse period time	10	ms
STO Input Low	0..5	V
STO Input High	18..30	V
STO Input High when operating with OSSD signals	19.2..30	V

Table: Technical data STO

The STO response team is the time between the deactivation of the STO input signal to the definite fail-safe pulse block.



STO input

!

IMPORTANT INFORMATION

The maximum STO response time of 50 ms is to be taken into account when using the machine

4 | Safety functions

STO function (Safe Torque Off)

After the STO function is triggered, the drive is switched off (impulse block) and the drive control runs down without braking (when no brake has been activated).

!

IMPORTANT INFORMATION

The shut-down time must be considered in this application.

5 | Application instructions - Safety

Restarting protection

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IMPORTANT INFORMATION

In the event of dangerous loads having an external effect, a hazard can originate from the STO status when no further measures are taken.

In addition to the switching examples, the instructions on the subject of “Restarting” from the standards DIN EN ISO 13849-1 (BGIA Report 2/2008) and IEC 60204 are to be considered.

The resetting of a safety requirement alone may not automatically result in the restarting of the drive. Restarting may only be made possible through a fault acknowledgement (manual reset) at the safety switching device.

!

IMPORTANT INFORMATION

Depending on the parameters set, it is possible for the drive controller to start up automatically.

Internal auxiliary voltage

The 24 V supply of the application PCB is found in accordance with the SELV/PELV requirement on terminal X5 and can be used as supply voltage for the STO channels. In this application case, a max. of 30 mA is available for additional external components.

6 | Parameterisation

We recommend deactivating the “auto acknowledgement“ of a fault (Parameter 1.181), as otherwise an immediate restart can occur as soon as the fault is no longer present.

STO

The restart protection (not safety-related, parameter 1.132) should under no circumstances be deactivated, as otherwise an immediate restart can occur when the STO voltage is activated.

7 | Diagnosis

The status of the STO function is signalled with the help of a potential-free diagnosis contact that is locked in the safe status. The two-channel, deactivated impulse block is thus displayed. This contact can be used as a response to a higher level control unit.

Diagnosis safety function

STO 1	STO 2	Contact	Note
Off	Off	closed	Neither STO channel is supplied: STO active
On	Off	open	Status implausible: Channels show unequal result
Off	On	open	Status implausible: Channels show unequal result
On	On	open	Both STO channels are supplied: Operation possible

!

IMPORTANT INFORMATION

■

The maximum delay time between the activation of the safety function by the input-side safety device and the closing of the contact is 50 ms.

■

This reaction time is to be observed when using the machine and configured in accordance with the external fault diagnosis.

External dynamic test

An external dynamic test is necessary in order to achieve diagnosis coverage of 99% and the resulting safety parameters. The STO channels are supplied with all possible logical statuses and the expected status of the diagnosis relay is queried before each motor activation is enabled.

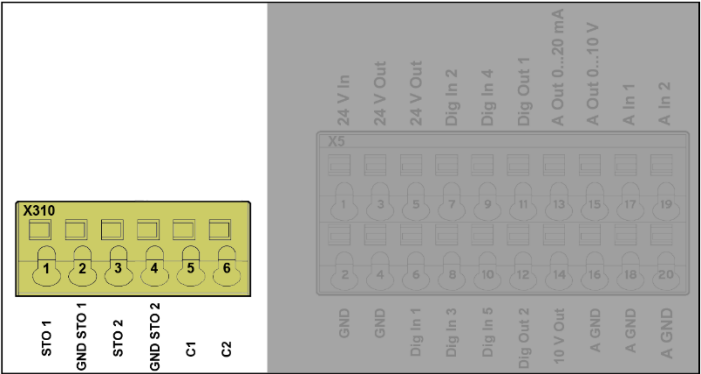
8 | Terminal assignment

The input terminal X310 serves the purpose of input-side connection of electromechanical and electronic safety switching devices.

In addition to the safety-related inputs, the response contacts are available on terminals X310.5 and X310.6 (diagnosis).

Terminal assignment X310

Control connections for functional safety



Terminal assignment X310

Terminal no.	Designation	Assignment
1	STO 1	Control input 1 for the STO function (0 V/24 V)
2	GND STO 1	Reference potential STO 1 (0 V)
3	STO 2	Control input 2 for the STO function (0 V/24 V)
4	GND STO 2	Reference potential STO 2 (0 V)
5	C1	Normally open contact for response of STO to external control system (diagnosis)
6	C2	Normally open contact for response of STO to external control system (diagnosis)

9 | Installation/disassembly/commissioning

The installation and disassembly instructions, as well as the information concerning commissioning refer in this document only to the subject area of “functional safety”.

Installation

■ Installation

STO connection cable

With reference to the STO connection line, the “elimination of errors with regard to short circuit“ is achieved in accordance with DIN EN 13849-2 in that a separate, shielded cable is used for each channel. Shielding is to be applied at both ends.

If only one shielded cable is used for both STO channels, a safety switch must be used to detect possible crossovers between the channels to qualify for observation of the “elimination of errors short circuit”.

The maximum cable length for the connection of the STO channels is 30m.

The cable cross-section is to be designed in such a way to ensure the required minimum input voltage of 18 V or 19.2 V during operation with OSSD signals.

Wiring instructions for control terminals X5 and X310:

Sizes A - D	
Terminals:	Plug terminal clamp with activation button (slot screwdriver, max. width 2.5 mm)
Connection cross-section:	0.5 to 1.5 mm <sup>2</sup> , single-wire, AWG 20 to AWG 14
Connection cross-section:	0.75 to 1.5 mm <sup>2</sup> , fine-wired, AWG 18 to AWG 14
Connection cross-section:	0.5 to 1.0 mm <sup>2</sup> , fine-wired (core end sleeves with and without plastic collars)
Length of stripped insulation:	9 to 10 mm

■ Disassembly

■ Commissioning

STO validation

In the context of commissioning, it is absolutely necessary to request the STO function of the drive controller in order to ensure problem-free function.

To this purpose the STO function is requested with running motor. The motor must then run down.

The diagnosis function must also be checked. Refer to operating manual for more details.

SS1 Validation

The INVEOR drive controller is not equipped with a safety-related input which provides the SS1 function.

The SS1 validation thus contains the check of the STO safety function of the drive controller and the check of the external safety switching device, which requests the STO function upon expiry of the set time.

10 | Dealing with malfunctions

■ Error detection and troubleshooting

■ Malfunction overview

■ Fault display

■ Fault-finding and troubleshooting

11 | Maintenance

■ Maintenance

■ Maintenance checklist

SS1 Validation

The STO function is requested when the motor is running. The motor must then run down.

In accordance with the selected safety application (refer to operating manual for more details), the correct functioning of the diagnosis or of the dynamic test must also be documented.