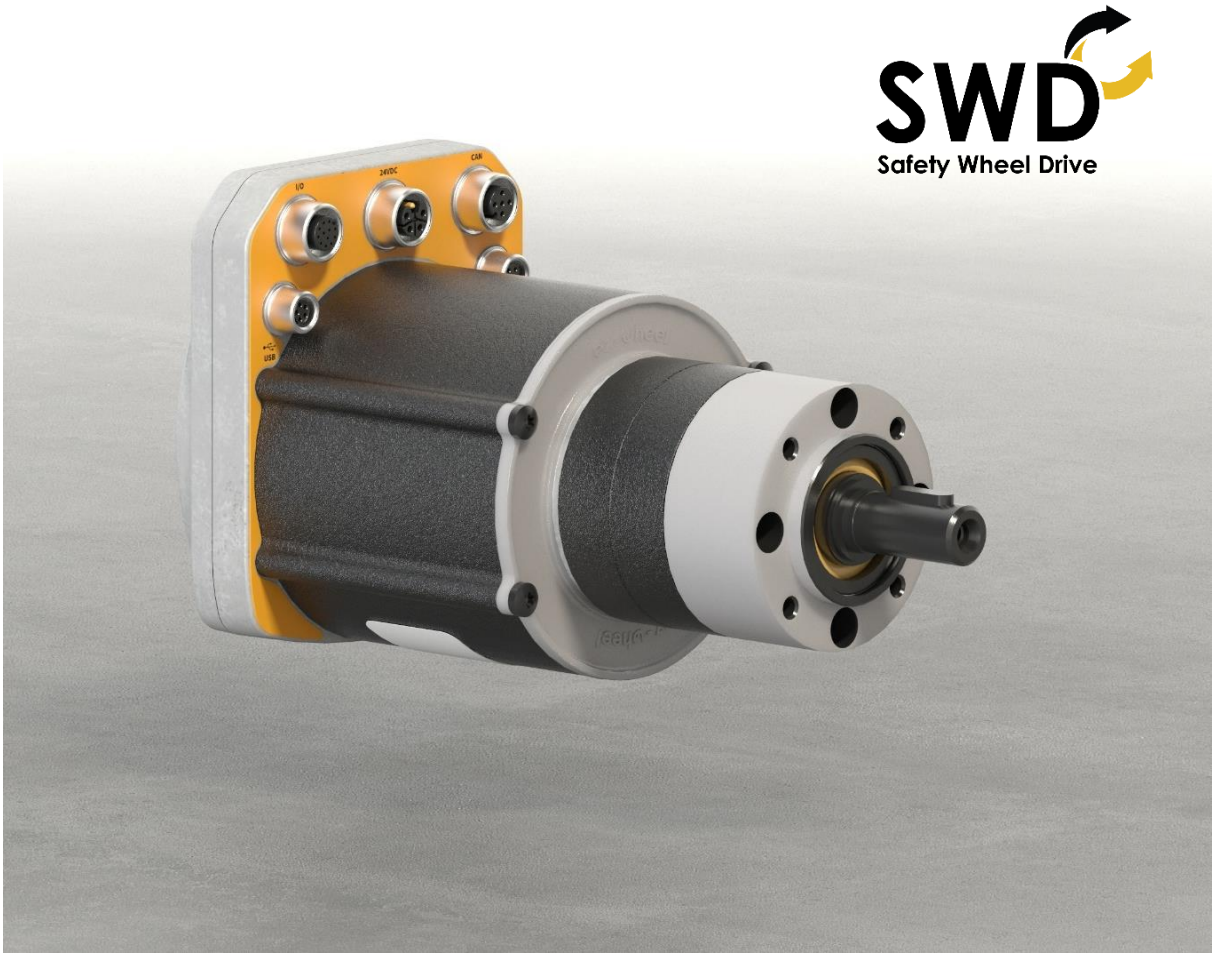
ez-wheel
The Electric Wheel

SWD® Core

SAFETY DRIVE

Instruction manual

Version 1.0.x - 19/04/2022 - Translated from French



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⚠ **This document should be read carefully before the first use of the product.**

1. Preamble

1.1. Who is this manual for?

This manual is intended for integrators of industrial machinery.
Knowledge and understanding of variable speed electrical drive systems is required for the implementation of the ***SWD® Core*** product.

1.2. Terminology

The terms used in this manual are related to the technical field of industrial machinery and more particularly to drive systems controlled by fieldbus.

For a precise reading of the manual, a good mastery of the following standards is recommended:

- Machinery Directive (2006/42/EC)
- General safety requirements for electrical equipment of machinery (EN 60204-1)
- Variable speed power electric drives (EN 61800-5)
- Description of the CANopen (EN 50325 and CiA/DS 301) and CANopen Safety (CiA 304) protocols
- CANopen Application Profile for Motor Drives (CiA 402)

1.3. Additional resources

The following ***SWD® Core*** documents are available from ez-Wheel:

- ***SWD® Core*** datasheet
- ***SWD® Safety Wheel Drive*** Range Overview Brochure
- 2D and 3D mechanical plans of the ***SWD® Core***

1.4. Declarations of conformity

The ***SWD® Core*** product is developed in accordance with regulatory requirements for marketing throughout the European Union.

The ***SWD® Core*** declarations of conformity ***have been drawn up by ez-Wheel with the INERIS certification body*** for certified safety features.

1.5. Important information about the manual

⚠	Important information – Read carefully
🖹	Parameterizable value
🛈	Additional information

1.6. Disclaimer

The technical information included in this manual is subject to change. No responsibility is assumed for the completeness, up-to-date or accuracy of the data and illustrations provided.
The textual and visual data included in this manual are the property of ez-Wheel SAS. The *trademarks ez-Wheel* and *SWD Safety Wheel Drive* are registered.
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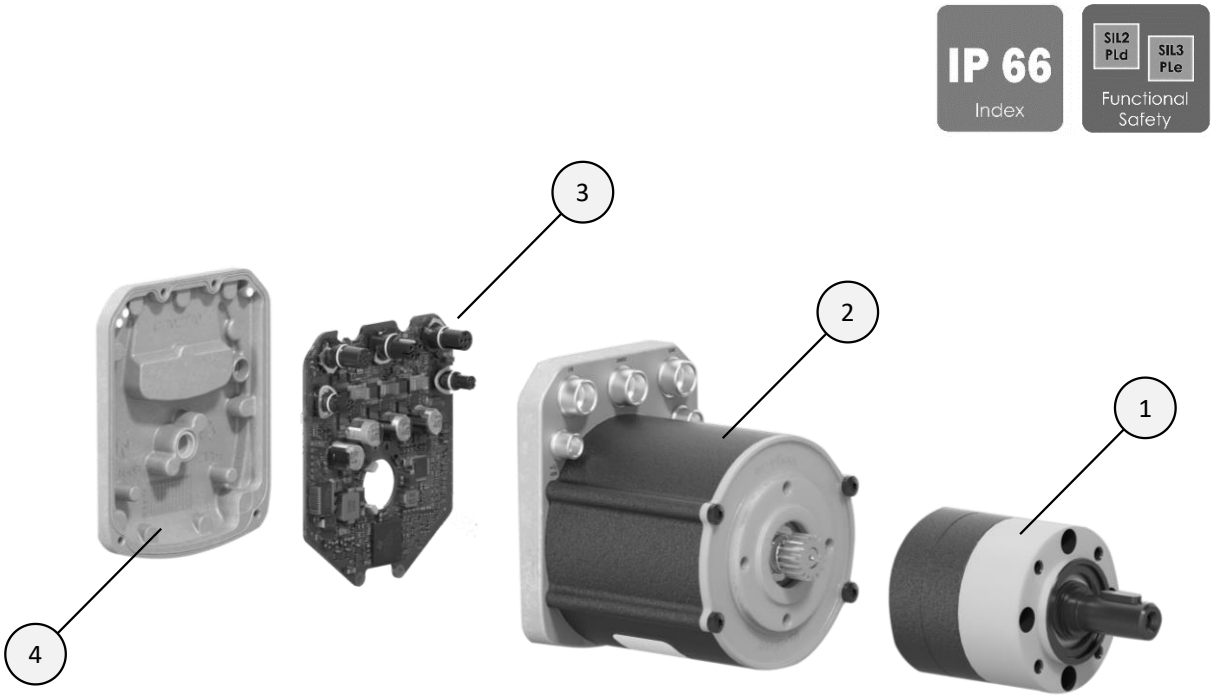
LE MOULIN DE L'ABBAYE - 135 ROUTE DE BORDEAUX
16400 LA COURONNE - FRANCE

2. Safety Instructions – *SWD® Core* Precautions

⚠	Do not open. Do not expose to a heat source. Do not expose to fire. Do not insert metal parts into the connectors. Under no circumstances shall the product undergo any modifications not authorized by ez-Wheel Do not attempt to modify the technical performance of the product. The product must not be used for use beyond the technical performance specified by ez-Wheel. Improper use results in the cancellation of the warranty. Opening the product results in the cancellation of the warranty.

3. Description

3.1. Presentation



1	Planetary reducer
2	BLDC engine
3	Safety Controller
4	Package

3.2. Technical characteristics of the engine

Engine data alone, without mechanical reduction:

Speed range	0 to 1800 rpm
Nominal performance	185 W (S1) at 1400 rpm
Starting torque	4,5 Nm

The following data is shown for the standard version of the ***SWD® Core*** equipped with the 14:1 ratio two-stage planetary gearbox.

Speed range	0 to 130 rpm
Nominal performance	20 Nm at 100 rpm
Maximum rolling speed	130 rpm
Option(s)	Parking brake **/B**

3.3. Specificities of the *SWD® Core*

The following data is shown for the standard version of the ***SWD® Core*** equipped with the 14:1 ratio two-stage planetary gearbox.

Technology	BLDC
Gearbox	2-stage planetary ratio 14:1 - exact value (63/17) per stage
Indicative lifespan[1]	5 000 h / 1 500 000 starts/stops
Nominal speed	100 rpm
Nominal power	185 watts (S1)
Starting torque	37 Nm

3.4. Security features

Motor disconnection	STO (Safe Torque Off) up to SIL3/PLe**/Cat4**	
Motion control	SLS (Safe Limited Speed), SDI (Safe Direction) up to SIL2/PLd/Cat3	
Braking	SBC (Safe Brake Control) up to SIL2/PLd/Cat3	
Encoder	30 ppr (motor axis) SIL2/PLd/Cat3	
Interface	CANopen Safety® OSSD-compatible security inputs	CANopen safety

3.5. Terms of Use

Temperatures	0 to +40°C
IP index	IP66
Maintenance period	5 years

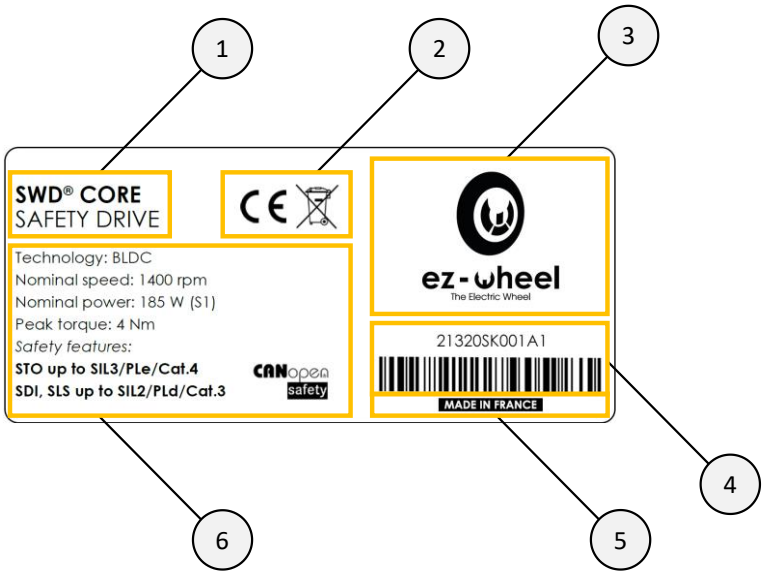
ⓘ The product is intended to be integrated into a machine. It is recommended to derail the machine to avoid direct access of end users to the engine.

3.6. Weight

Drive weight	3.7 kg

[1] Reference values, based on standard test conditions, may vary depending on different use cases

3.7. Product Label

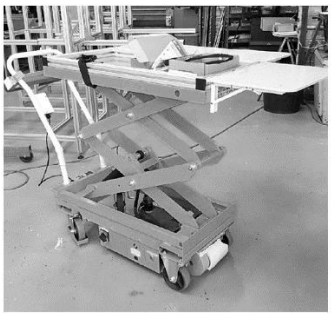


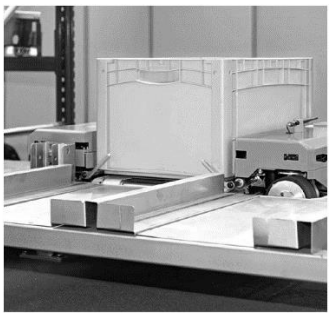
1	Commercial identification of the product
2	Regulatory pictograms
3	Identification of the manufacturer
4	Serial Number
5	Geographical origin of the product
6	Engine performance Safety features

3.8. Applications

The ***SWD® Core*** product is intended for speed-controlled charge movement applications, for which risk assessment justifies the implementation of safe movement monitoring.

- Mobile robots
- Pallet shuttles
- Lifting trolleys
- Conveyors





4. Synoptic

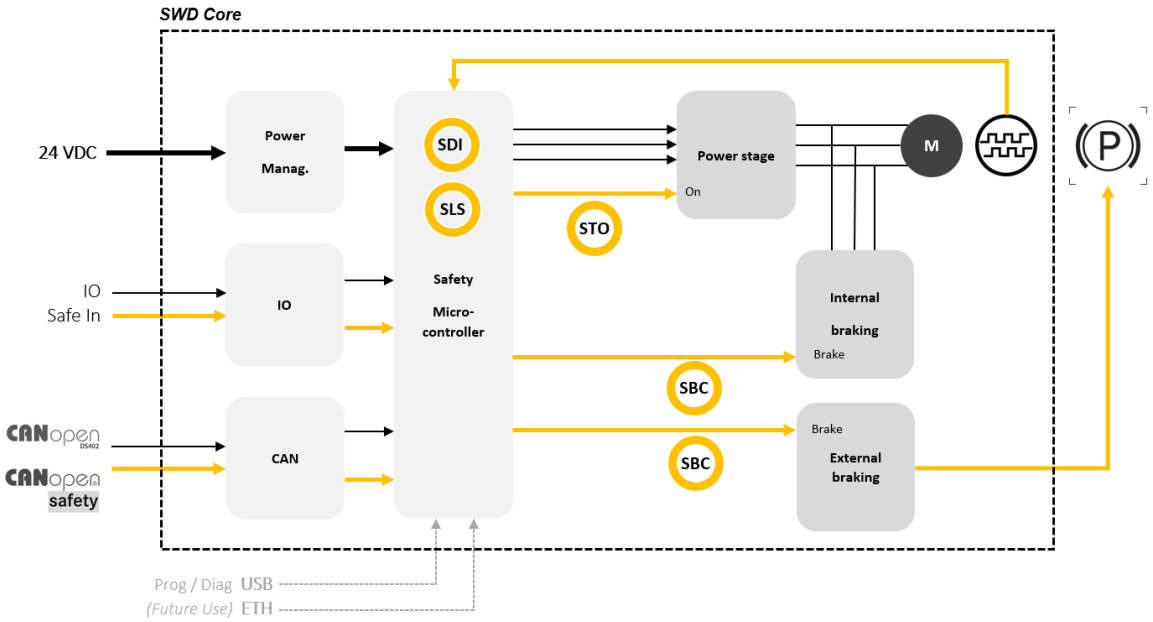


Figure 1 - General synoptic of the product

ℹ The SBC function is under development.

M	Motor and Gearbox
	Security Encoder
P	External safety brake

5. Interfaces

5.1. Overview

Identification of mechanical parts

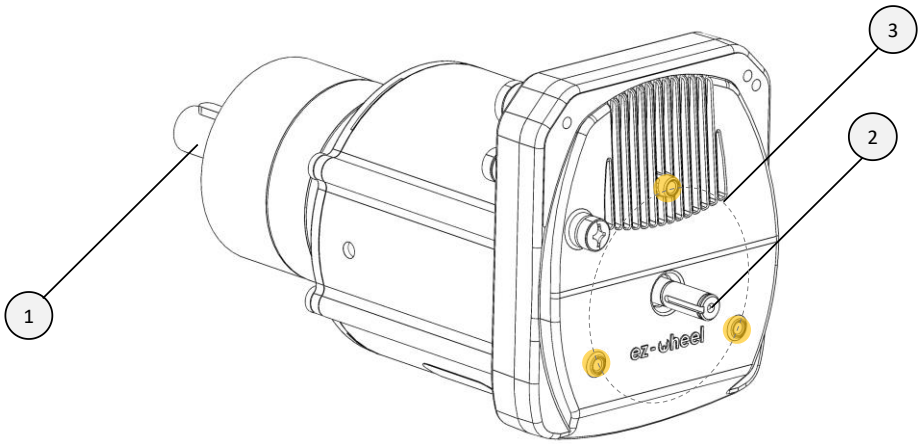
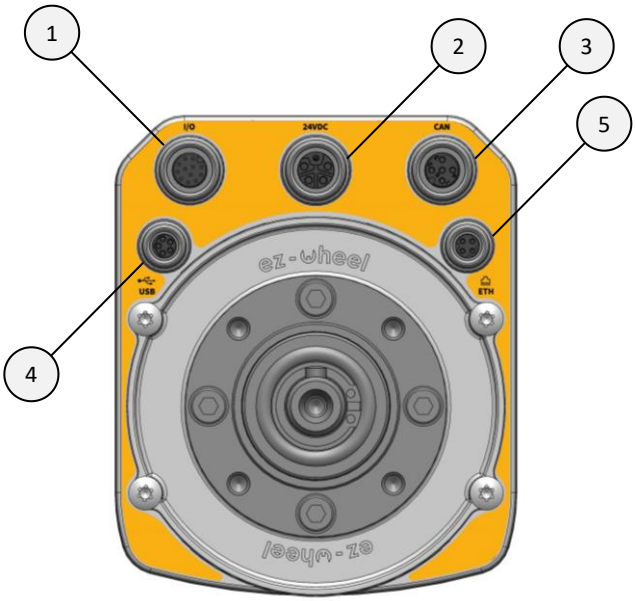


Figure 2 - Overview of mechanical interfaces

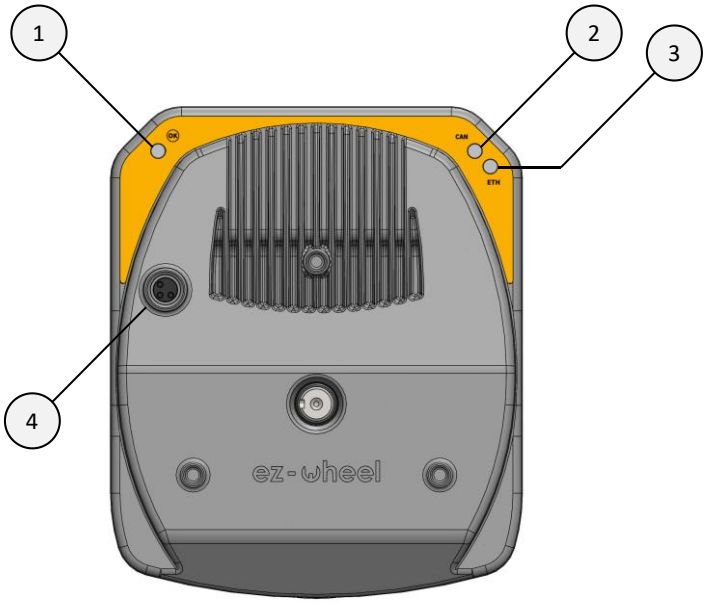
1	**Gearbox mounting flange**
2	Brake mounting axis
3	Brake mounting pads

Connectors and LEDs identification



1	I/O connector
2	24VDC connector
3	CAN connector
4	USB connector
5	ETH connector (for future use only)

Figure 3 - Connectors Identification



1	LED Status
2	LED CAN
3	LED ETH (reserved for future use)
4	Brake connector

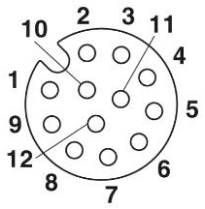
Figure 4 - Rear view, LEDs and brake connector identification

5.2. Connectors

I/O connector

The I/O connector is a M12, 12 poles, A-coding type. It bundles the product's safety and start-up inputs. It serves also as a CANopen interface and a 24V output power supply.

Pin #	Designation
1	CAN H
2	INSafe_3
3	CAN L
4	Power supply 24 VDC (2A) - if enabled =
5	STO_1 (GND: SafeState / 24 VDC: Drive enable)
6	GND Alimentation (2A)
7	INSafe_1
8	STO_2 (GND: SafeState / 24 VDC: Drive enable)
9	INSafe_4
10	INSafe_2
11	GND IN
12	ON: Shoot at GND to put on



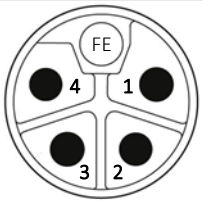
The following cables can be used to interface the I/O connector:

- Compatible cables available in the ez-Wheel catalog
- Phoenix Contact SAC-12P-MR/ 1,5-PUR SCO – 1430572
- Amphenol M12A-12BMMM-SR8AXX

24 VDC connector

The 24 VDC power connector is M12 Power, 5 poles, L-coding (4+FE) type.

Pin #	Designation
1	+ Power supply 24 VDC (16A)
2	+ Power supply 24 VDC (16A)
3	GND Alimentation (16A)
4	GND Alimentation (16A)
FE	Mechanical mass connected to the chassis



The following cables can be used to interface the 24 VDC connector:

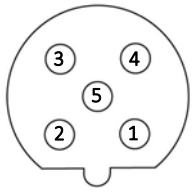
- Compatible cables available in the ez-Wheel catalog
- Phoenix Contact SAC-5P-M12MSL/ 1,5-280 FE SH – 1414884
- Phoenix Contact SAC-5P-M12MRL/ 1,5-280 FE SH - 1414851

CAN connector

The CAN connector is a M12, 5 poles, A-coding type. It is used as a CANopen interface and can be used as a 24V output power supply.

The implementation complies with the CiA 303-1 norm for standardized CAN interfaces.

Pin #	Designation
1	Mechanical mass
2	+ Power supply 24 VDC (4A) - if enabled =
3	GND Alimentation (4A)
4	CAN H
5	CAN L



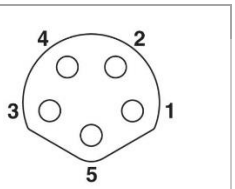
The following cables can be used to interface the CAN connector:

- Compatible cables available in the ez-Wheel catalog
- Phoenix Contact SAC-5P-MR/ 2,0-923 CAN SCO – 1419044
- YOUR 2273088 2273100
- Amphenol M12A-05BMMM-SR8A01

USB connector

The USB connector is a M8, 5 poles, B-coding type. It is only used for updating and diagnosing the product. Thus, it should only be used with the explicit agreement of ez-Wheel for security reasons, otherwise you will lose all warranty.

Pin #	Designation
1	V_USB
2	USB D+
3	USB D-
4	GND USB
5	USB Id (NC)



The following cables can be used to interface with the USB connector:

- Compatible cables available in the ez-Wheel catalog
- Phoenix Contact SAC-5P-M 8MSB/ 1,5-115 – 1404461
- Phoenix Contact SAC-5P-M 8MS/ 2,0-920 – 1575712
- Phoenix Contact SAC-5P-M 8MR/920/... – 1575903

ETH connector

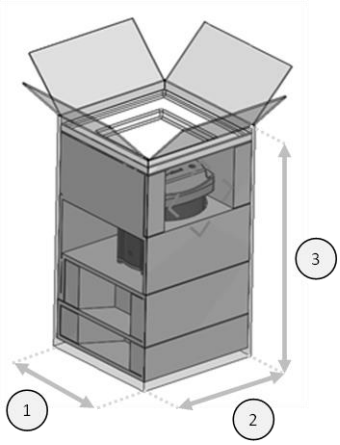
ℹ *The ETH connector is for future use only and should not be connected.*

External brake connector

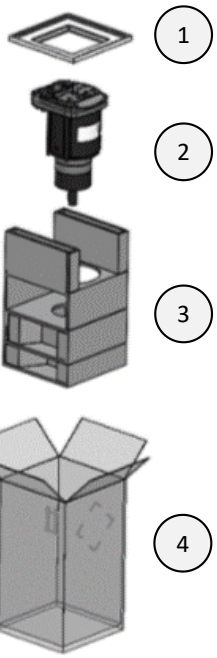
The external brake connector is used to connect an electromechanical brake, actuated by the SBC (Safe Brake Control) output.
Check ez-Wheel for a brake that is compatible with your product.

6. Mechanical assembly

6.1. Dimensions of the packaging and contents of the pack



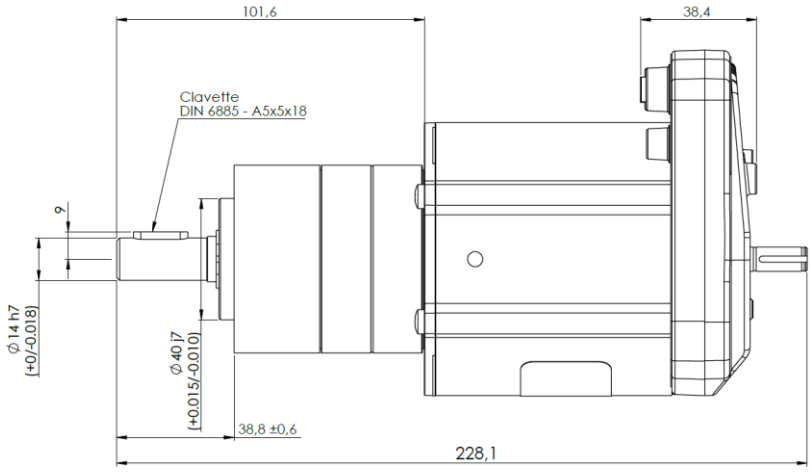
1	Depth: 170 mm
2	Width: 150 mm
3	Height: 306 mm



1	Upper wedge
2	***SWD® Core*** product
3	Lower hold
4	Conditioning

⚠ For all engine logistics operations alone, preferably use the original packaging.

6.2. Overall dimensions



*clavette = Parallel key

Figure 5 - Overall dimensions, side view

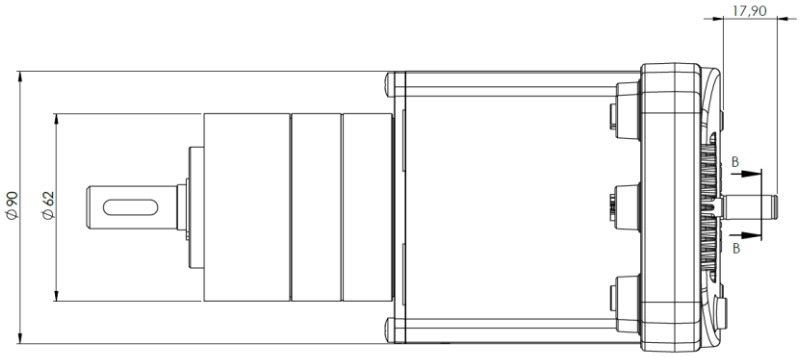


Figure 6 - Overall dimensions, top view

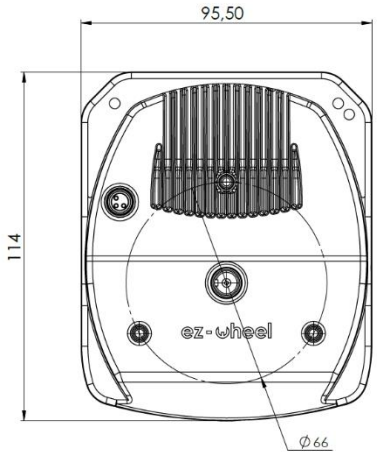
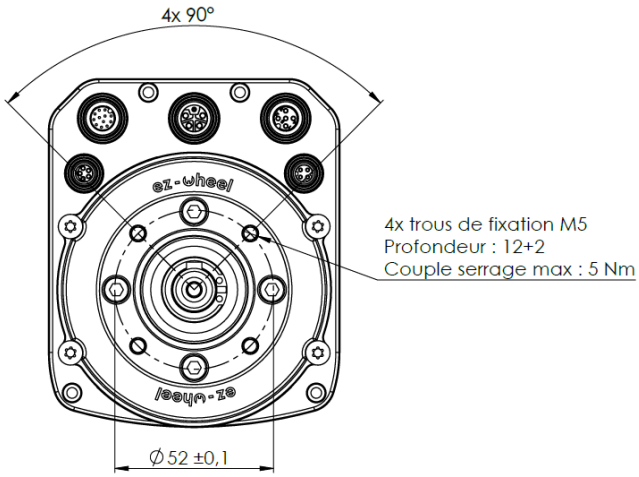


Figure 7 - Overall dimensions, front view

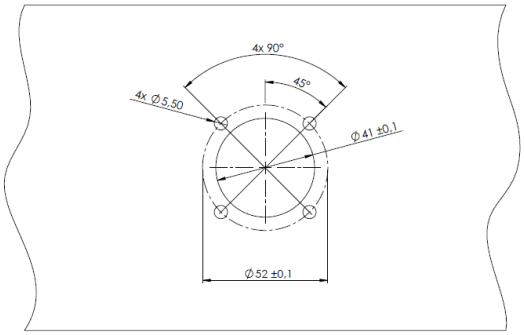


*4 mounting holes, depth 12 ±2mm, Max. tightening torque: 5 Nm

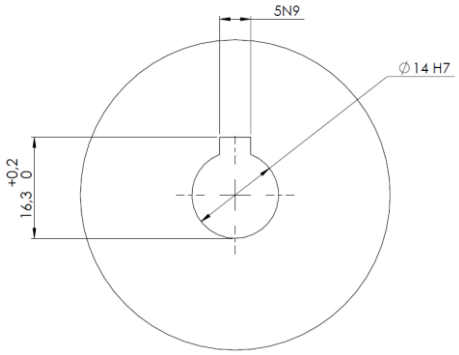
Figure 8 - Overall dimensions, rear view - connectors

6.3. Assembly plan

Machine implementation recommendations



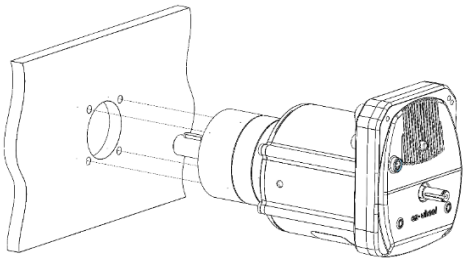
Interface ***SWD® Core***

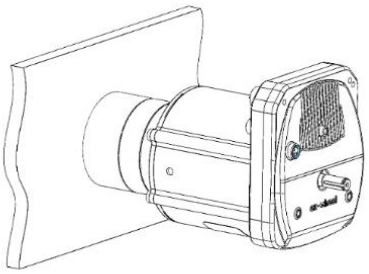


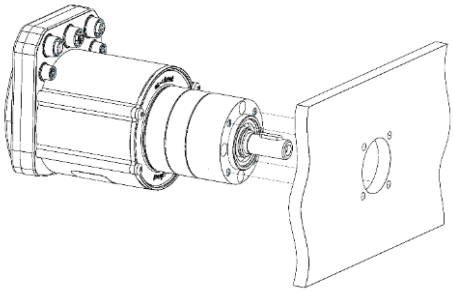
Engine transmission interface

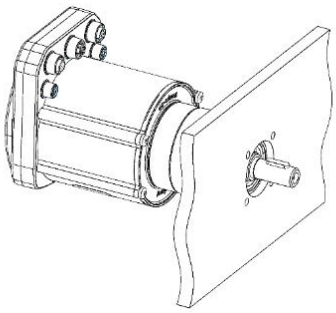
Place the ***SWD® Core*** product on the machine interface until it is stopped on the flat surface. Use four M5 screws (not supplied) to tighten the product on the machine interface.

⚠ **NEVER** use a hammer to set up the product!









Installation requirements:

- Tightening torque of the 4 M5 screws (not supplied): 5 Nm.
- Thread length in the product: 8 - 10 mm.
- Use of brake filet and/or brake washers (not supplied).

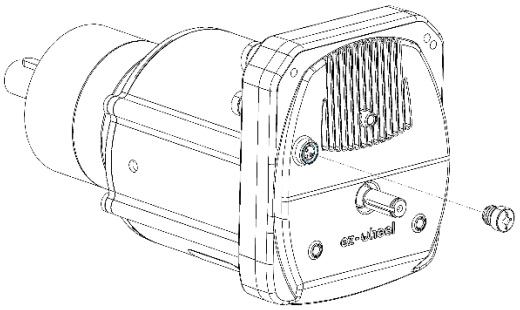
For waterproofing greater than IP53, seal the shaft bearing between the machine interface (x4) and the ***SWD® Core*** product (***SWD® Core*** side). Then, between the client interface and the client application (client side). This sealing is different for each application, so it is left it to each integrator to set up the required solution for its application.

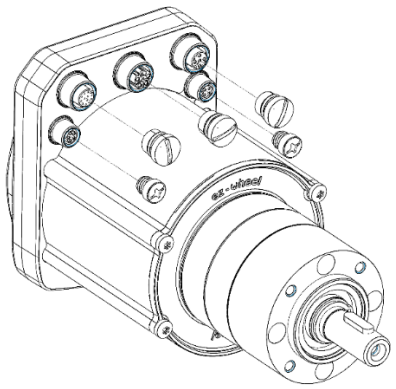
Restriction of use

Max. radial load (middle of the tree)	360 N
Max axial load	100 N
Max permanent mounting pressure	1,000 N

Sealing of the product

To ensure product's life, we recommend putting caps on unplugged connectors.
Compatible ones are available in ez-Wheel catalogue.





7. *SWD® Core* status LEDs

7.1. *SWD® Core* LED display mode

LEDs operate according to the CiA 303-3 standard. The display modes are as shown below:

LED Status	Description
LED on	The LED is constantly on
-	The LED is constantly turned off
Sparkling LED	The LED shows alternation at about 10 Hz (50 ms on / 50 ms off)
Flashing LED	The LED shows alternation at about 2.5 Hz (200 ms on / 200 ms off)
Single brightness LED	The LED shows a flash followed by a long stop (200 ms on / 1000 ms off)
Double brightness LED	The LED shows two flashes followed by a long stop (200 ms on / 200 ms off / 200 ms on / 1000 ms off)
Triple brightness LED	The LED shows three flashes followed by a long stop (200 ms on / 200 ms off / 200 ms on / 200 ms off / 200 ms on / 1000 ms off)
Quadruple brightness LED	The LED shows four flashes followed by a long stop (200 ms on / 200 ms off / 200 ms on / 200 ms off / 200 ms on / 200 ms off / 200 ms on / 1000 ms off)

7.2. Status LED Status LED Display

The STATUS® LED, is a two-tone red or green LED, that indicates the status set by the CiA 402 standard state machine:

Status CiA 402		LED beat	LED rouge
Not Ready to switch on	(Ongoing)	Single brightness LED	-
Not Ready to switch on	(Initialization error)	-	Single brightness LED
Switch on disabled		Double brightness LED	-
Ready to switch on		Triple brightness LED	-
Switched on		Flashing LED	-
Operation enabled		LED on	-
Operation enabled	(Active STO)	-	LED on
Quick stop active		LED on	Double brightness LED
Fault reaction active		Sparkling LED	Sparkling LED
Fault		-	Flashing LED

During the *SWD® Core* (bootloader) update, the led turns orange with the following indications:

Bootloader status	LED orange
Active	Flashing LED
Missing or invalid application	Single brightness LED
Program / Firmware loading	Triple brightness LED

7.3. CAN Bus LED Display

The CAN display is a two-tone red or green LED, that indicates the operational status of the *SWD® Core* CANopen bus:

Budget CANopen		LED beat	LED rouge
Bus Off		-	-
Initialization	(Ongoing)	-	-
Initialization	(Initialization error)	-	Flashing LED
Pre-Operational		Flashing LED	-
Operational		LED on	-
Stopped		Single brightness LED	-

During the ***SWD® Core*** (bootloader) update, the CAN LED is disabled.

8. CAN Bus and CANopen Protocol

8.1. Bus feature

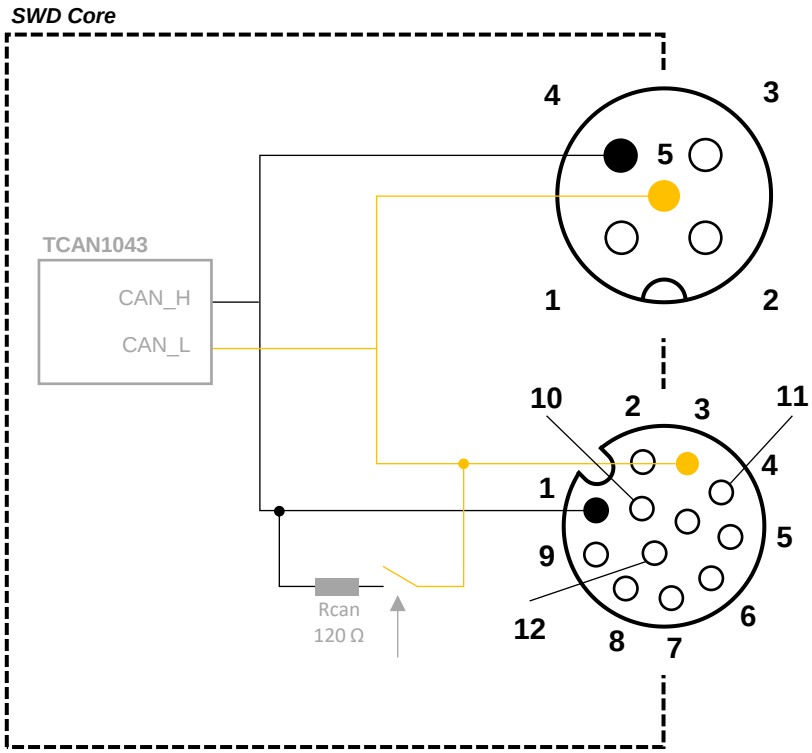


Figure 9 - Internal electrical diagram of the CAN bus

8.2. CAN Node IDENTIFIER

The CANopen node identifier (Node-ID), is used to identify the equipment on the bus. Each identifier is associated with default CAN identified messages.

The default ***SWD® Core*** Node-ID is 10_h, and it is configurable.

The configuration of the identifier can be carried-out by two different methods:

- Through the dictionary entry 0x2101 sub-index 0x00
- By the LSS protocol

The configuration method using the dictionary can be made within 3 steps:

- Writing the chosen Node-Id in the object 2101_h
- Saving the communication parameters configuration (see8.9)
- Loading the configuration with an NMT 'Reset communication' message

Thus, ***SWD® Core*** Node-ID is persistent, and a loss of power will not affect the configured Node-ID.

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
2101_h	0	Node Id	U8	10_h	RW	R	-	1	127	1

⚠ Changing the ***SWD® Core*** Node-ID has no impact on the configuration of the different messages. When configuring the ***SWD® Core***, the user must ensure that the reconfiguration of the communication parameters (PDO, SDO, ...) are relevant.

⚠ Only the *"heartbeat"* message and the SDO server 1 identifiers are updated automatically.

8.3. CAN bus termination resistance

When the ***SWD® Core*** is located at the end of the CAN bus, a termination resistor is necessary. The value of this resistor must be determined relatively to the topology of the bus in the application.

The implementation of the termination resistor can be done simply by 2 means:

- Connection of a terminating resistor on one of the connectors exposing the CAN bus.
- Enabling the internal termination resistor (120 ohms).

The ***SWD® Core*** drive includes a bus termination resistor whose activation is software configurable.

ℹ *Internal resistance is enabled in the default configuration.*

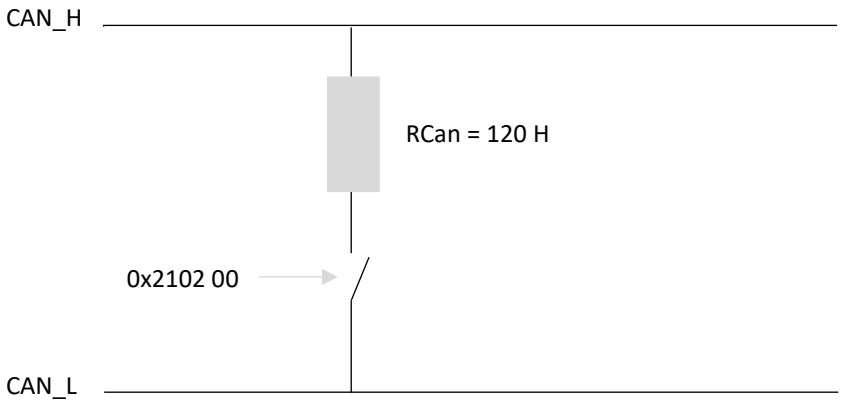


Figure 10 - Enabling the Internal Termination Resistor

ℹ *During the start-up phase of the motor* drive *or during a reset, the resistor is deactivated until the chosen configuration is applied.*

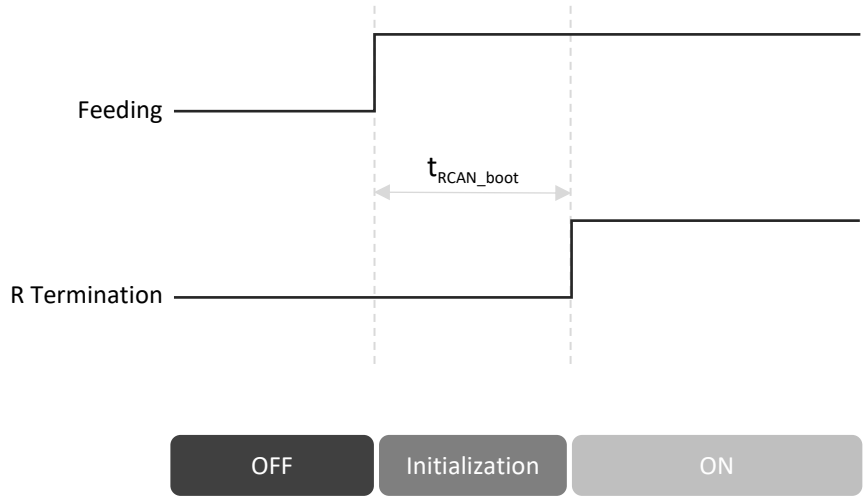


Figure 11 - CAN Bus Initialization Diagram

		min	Max	value	Unit
R_{can}	Internal termination resistor			120	Ohms
t_{RCAN_boot}	Setup time of the internal resistance configuration at startup		< 500 ms		ms

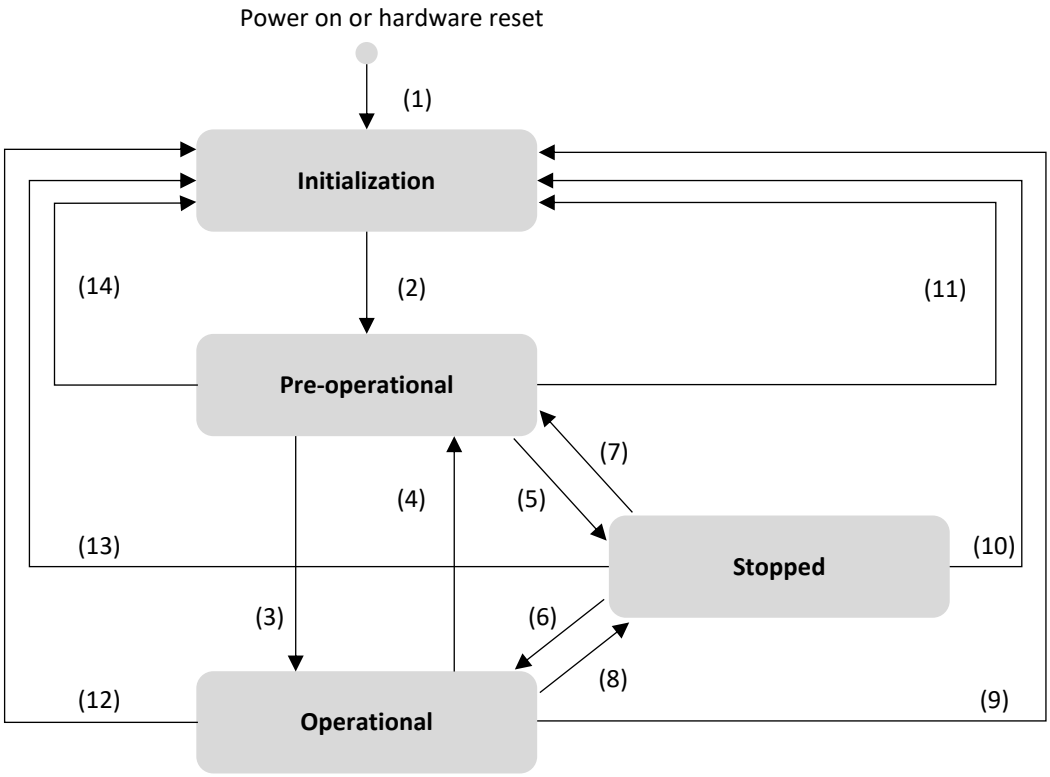
8.4. *SWD® Core* Product Identity

The identification data of the ***SWD® Core*** is described in the object 1018_h according to the following format:

Index	Sub-index	Name	Value	Data type
1018_h	00_h	Number of entries	04_h	Unsigned8
	01_h	Vendor-ID	$0000\ 0515_h$	Unsigned32
	02_h	Product code	$0001\ 0001_h$	Unsigned32
	03_h	Revision number	-	Unsigned32
	04_h	Serial number	-	Unsigned32

8.5. Network ManagemenT (NMT) protocol and State machine

A CANopen node respects a state machine, which corresponds to its startup and operating state. State transitions can be performed automatically, or in response to a NMT request from the master node.
The NMT (Network Management) protocol makes it possible to react to this state machine, and to know the current NMT state of a node.



(1)	At Power on the NMT state initialization is entered autonomously
(2)	NMT state initialization finished – enter NMT state Pre-Operational automatically
(3)	NMT service start remote node indication or by local control
(4), (7)	NMT service enter pre-operational indication
(5), (8)	NMT service stop remote node indication
(6)	NMT service start remote node indication
(9), (10), (11)	NMT service reset node indication
(12), (13), (14)	NMT service reset communication indication

Figure 12 - NMT State Machine Diagram of a CANopen Device

The availability of protocols depends on the state of the node, the following table shows this availability:

	Pre-operational	Operational	Stopped
PDO		x	
SDO	x	x	
NMT	x	x	x
EMCY	x	x	
SRDO		x	

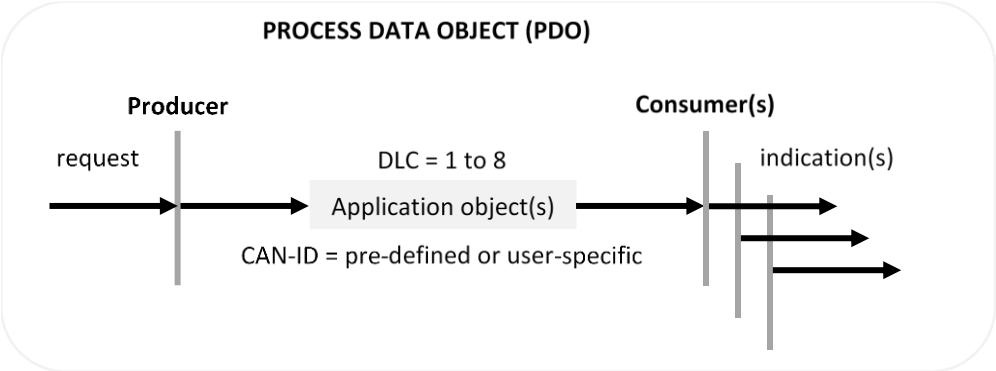
8.6. PDO (Process Data Object)

PDOs are messages sent by a producer to consumers for broadcasting high-priority data. For a producer: a PDO is considered as a TPDO (T: Transmitted), and as a RPDO (R: Received) for the consumer(s).

A PDO message is characterized by communication parameters that includes:

- its identifier on the CAN bus
- its methods of transmission or reception
- its activation
- Its mapping

"Mapping parameters", describe the data transported by the message.



SWD® Core supports up to 8 TRANSMIT PDOs (TPDO) and 8 Receive PDOs (RPDO).

Communication settings

The communication settings of the PDOs are used to define whether a message is activated or not, to identify it on the can bus (CAN-ID), and to define its conditions of transmission or reception.

For each messages, a CANopen dictionary object stores its communication parameters. The communication parameters for the RPDOs are accessible from the indexes 1400_h until 1407_h, and for those concerning the TPDOs, from the indexes 1800_h until 1807_h.

The configuration of the communication settings has the following format:

Index	Sub-index	Description	Data type
RPDOs: 1400_h to 1407_h **TPDOs: 1800_h to 1807_h**	00_h	Number of entries	Unsigned8
	01_h	COB-ID	Unsigned32
	02_h	Transmission type	Unsigned8
	03_h	Inhibit time	Unsigned16
	05_h	Event timer	Unsigned16

COB-ID

The COB-ID entry is used to specify:

- The CAN-ID identity of the message on the bus
- Whether or not to activate the message

ℹ ***SWD® Core*** *supports 11-bit message IDs and does not implement sending TPDOs on RTR request.*

For DPI, the COB-ID format is:

31	30	29	28	11	10	0
Valid	- 0_h	Frame 0_h	$0\ 0000_h$		11-bit CAN-ID	
MSB						LSB

Bit(s)	Value	Description
valid	0_b 1_b	PDO exists / is valid PDO does not exist / is not valid
reserved	x	Do not care
frame	0_b 1_b	11-bit CAN-ID valid (CAN base frame) 29-bit CAN-ID valid (CAN extended frame)
29-bit CAN-ID	x	29-bit CAN-ID of the CAN extended frame
11-bit CAN-ID	x	11-bit CAN-ID of the CAN base frame

For TPDOs, the cob-ID format is:

31	30	29	28	11	10	0
Valid	RTR 1_h	Frame 0_h	$0\ 0000_h$		11-bit CAN-ID	
MSB						LSB

Bit(s)	Value	Description
valid	0_b 1_b	PDO exists / is valid PDO does not exist / is not valid
RTR	0_b 1_b	RTR allowed on this PDO No RTR allowed on this PDO
frame	0_b 1_b	11-bit CAN-ID valid (CAN base frame) 29-bit CAN-ID valid (CAN extended frame)
29-bit CAN-ID	x	29-bit CAN-ID of the CAN extended frame
11-bit CAN-ID	x	11-bit CAN-ID of the CAN base frame

Transmission

The transmission type parameter of a PDO specifies the transmission mode, as well as the trigger mode.

There are three modes of triggering messages:

- **Requested remotely**

The transmission is triggered by a RTR (Remote Transmission Request), from a PDO consumer.

ℹ This mode is not supported by ***SWD® Core***.

- **Event-driven et timer-driven**

Message transmission is triggered by the occurrence of an application-specific event specified in the device profile, application profile, or manufacturer profile, or if a specified time (event time) has elapsed without an event occurring.

Event time is configured in the 5_h Event Timer sub indent. This duration corresponds to the maximum interval between PDO transmission if the type of transmission is FE_h or FF_h. The value is defined as a multiple of 1 ms. The value of 0 disables the event timer.

Event-Driven transmissions respond to the emission in the event of a change in the value of one of the data mapped in the PDO. Inhibit time (under index 03_h) is the minimum interval between two transmissions of the PDO if the type of transmission is FE_h or FF_h. The value is defined as a multiple of 100 µs. The value of 0 disables the inhibition time. The value should not be changed if the PDO exists (the 31st bit of the 01_h sub-index is set to 0_b).

- **Triggered synchronously**

The transmission of a message is triggered by the instance of the SYNC object. The trigger condition is the number of Syncs and possibly an internal event.

SWD® Core supports the following configurations:

Value	Description
00_h	Transmission type not supported
01_h	synchronous (acyclic every sync)
02_h	synchronous (cyclic every 2nd SYNC)
03_h	synchronous (cyclic every 3rd SYNC)
04_h	synchronous (cyclic every 4th SYNC)
(…)	(…)
$F0_h$	synchronous (cyclic every 240th SYNC)
$F1_h$	reserved
(…)	(…)
FB_h	reserved
FC_h	Transmission type not supported
FD_h	
FE_h	Transmission type not supported
FF_h	Transmission type not supported

For synchronous TPDOs (value from 0_h to FE_h), the transmission type also specifies the transmission speed as a factor based on the transmission period of the base SYNC object. A transmission type of 0 means that the message must be transmitted after sync appears but acyclically (not periodically), only if an event occurred before SYNC. Transmission type 1 means that the message must be transmitted after each SYNC message. A transmission type n (>1) means that the message must be transmitted with each n^{th} SYNC message. Event TPDOs are transmitted without any relation to the SYNC object.

Synchronous RPDO data are received after that the SYNC message was transmitted to the application, with the next SYNC instance (regardless of the transmission speed specified by the transmission type). Event RPDO data are transmitted directly to the application.

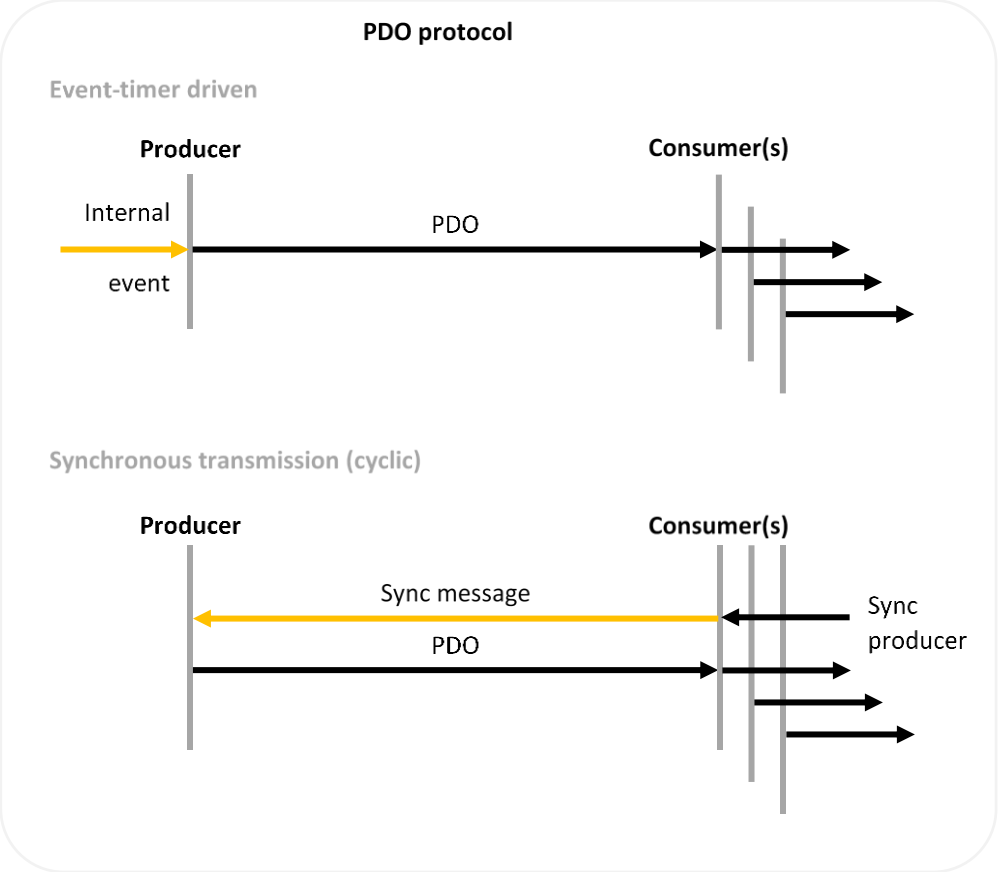


Figure 13 - Description des PDO

Mapping parameters

Configuring the mapping of a PDO is used to describe the data included in the PDO, in transmission or reception.

SWD® Core supports redefining PDO mapping by user configuration.

The data is concatenated in the data field of the CAN message:

- In reception (RPDO) the mapping allows the decoding of the data from the message and the update of the data in the ***SWD® Core*** dictionary. The configuration of the mapping of RPDO is carried out in objects 1600_h to 1607_h.

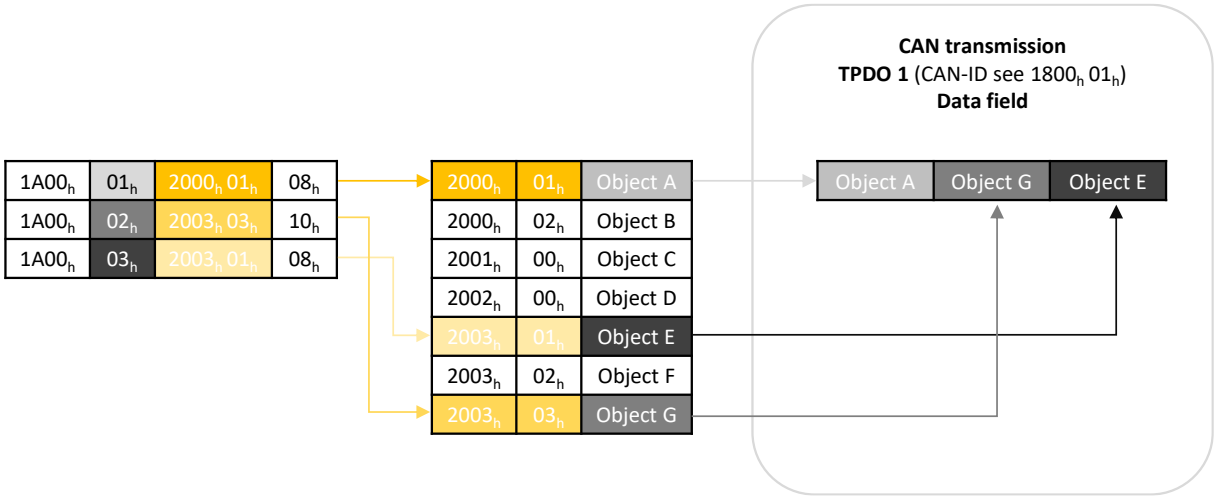


Figure 14 - TPDO mapping

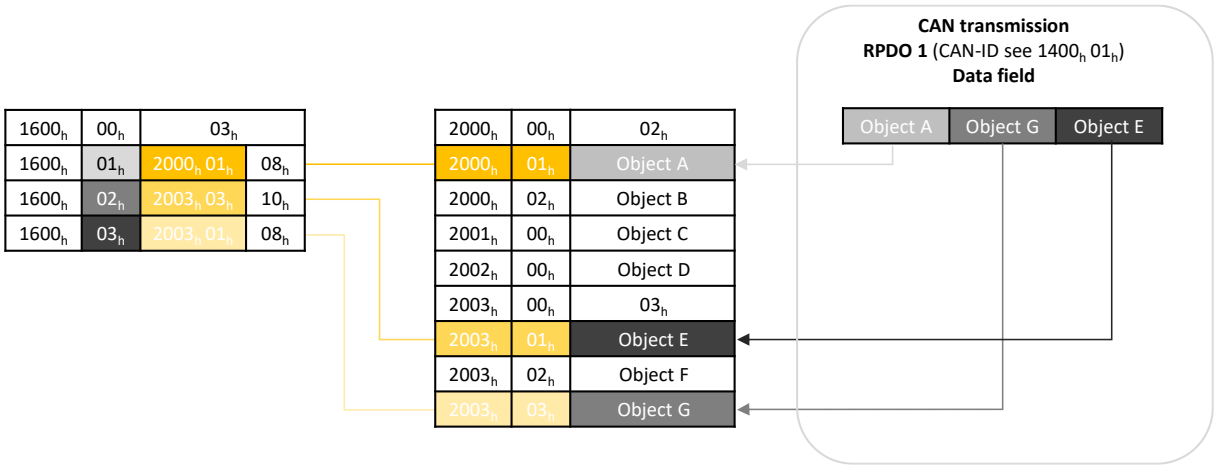


Figure 15 - RPDO mapping

Default values

Activated	RPDO	Default mapping
☑	1	Controlword
☐	2	*No data*
☐	3	*No data*
☑	4	Controlword & Target velocity
☐	5	*No data*
☐	6	*No data*
☐	7	*No data*
☐	8	*No data*

Activated	TPDO	Default mapping
☑	1	Statusword
☐	2	*No data*
☑	3	Statusword & Actual positon
☑	4	Statusword & Actual velocity
☐	5	*No data*
☐	6	*No data*
☐	7	*No data*
☐	8	*No data*

RPDO 1 : Controlword

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
Communication settings										
1400$_h$	00$_h$	Number of entries	U8	02$_h$	RO	NO	-	-	-	1
1400$_h$	01$_h$	COB-ID	U32	0000 0210$_h$	RW	NO	-	-	-	4
1400$_h$	02$_h$	Transmission type	U8	01$_h$	RW	NO	-	-	-	1
Data Mapping										
1600$_h$	00$_h$	Number of objects	U8	01$_h$	RW	NO	-	00$_h$	08$_h$	1
1600$_h$	01$_h$	1st Object	U32	6040 0010$_h$ Controlword	RW	NO	-	-	-	4

RPDO 4 : Controlword & Target velocity

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
Communication settings										
1403$_h$	00$_h$	Number of entries	U8	02$_h$	RO	NO	-	-	-	1
1403$_h$	01$_h$	COB-ID	U32	000 0510$_h$	RW	NO	-	-	-	4
1403$_h$	02$_h$	Transmission type	U8	01$_h$	RW	NO	-	-	-	1
Data Mapping										
1603$_h$	00$_h$	Number of objects	U8	02$_h$	RW	NO	-	00$_h$	08$_h$	1
1603$_h$	01$_h$	1st Object	U32	6040 0010$_h$ Controlword	RW	NO	-	-	-	4
1603$_h$	02$_h$	2nd object	U32	6042 0020$_h$ Target velocity	RW	NO	-	-	-	4

TPDO 1 : Statusword

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
Communication settings										
1800$_h$	00$_h$	Number of entries	U8	02$_h$	RO	NO	-	-	-	1
1800$_h$	01$_h$	COB-ID	U32	4000 0190$_h$	RW	NO	-	-	-	4
1800$_h$	02$_h$	Transmission type	U8	01$_h$	RW	NO	-	-	-	1
Data mapping										
1A00$_h$	00$_h$	Number of objects	U8	02$_h$	RW	NO	-	00$_h$	08$_h$	1
1A00$_h$	01$_h$	1st Object	U32	4000 0190$_h$	RW	NO	-	-	-	4

TPDO 3 : Statusword & current position

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
Communication settings										
1802$_h$	00$_h$	Number of entries	U8	02$_h$	RO	NO	-	-	-	1
1802$_h$	01$_h$	COB-ID	U32	4000 0390$_h$	RW	NO	-	-	-	4
1802$_h$	02$_h$	Transmission type	U8	01$_h$	RW	NO	-	-	-	1
Data mapping										
1A02$_h$	00$_h$	Number of objects	U8	02$_h$	RW	NO	-	00$_h$	08$_h$	1
1A02$_h$	01$_h$	1st Object	U16	6041 0010$_h$ Statusword	RW	NO	-	-	-	4
1A02$_h$	01$_h$	1st Object	U32	6064 0020$_h$ Current position	RW	NO	-	-	-	4

TPDO 4 : Statusword & current velocity

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
Communication settings										
1803$_h$	00$_h$	Number of entries	U8	02$_h$	RO	NO	-	-	-	1
1803$_h$	01$_h$	COB-ID	U32	4000 0490$_h$	RW	NO	-	-	-	4
1803$_h$	02$_h$	Transmission type	U8	01$_h$	RW	NO	-	-	-	1
Data Mapping										
1A03$_h$	00$_h$	Number of objects	U8	01$_h$	RW	NO	-	00$_h$	08$_h$	1
1A03$_h$	01$_h$	1st Object	U16	6041 0010$_h$ Statusword	RW	NO	-	-	-	4
1A03$_h$	01$_h$	1st Object	U32	606C 0010$_h$ Current velocity	RW	NO	-	-	-	4

Configuration

The following procedure is used for changing the mapping or communication parameters of PDOs, which takes place in the pre-operational NMT state and in the operational NMT state:

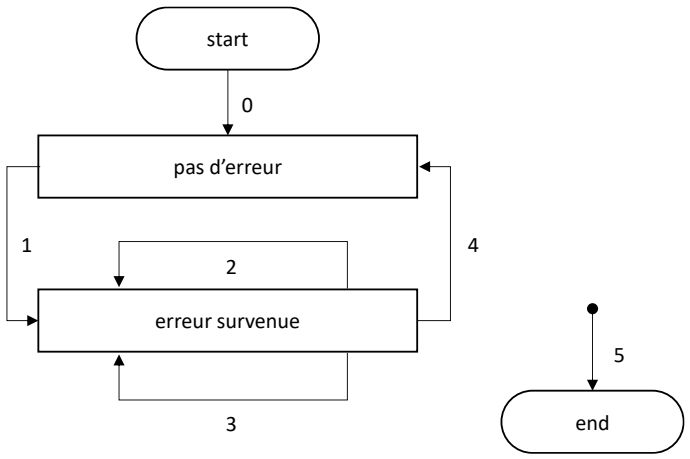
1. Destroy the TPDO by setting the 'valid' bit to 1$_b$ (sub-index 01$_h$, COB-ID)
2. Disable mapping by setting the 00$_h$ sub-index of the mapping settings to 00$_h$
3. Change the mapping by changing the values of the corresponding sub-indices
4. Enable mapping by setting the 00$_h$ sub-index to the number of mapped objects
5. Create TPDO by setting the 'valid' bit to 0$_b$

> *The configuration of PDO can be saved in non-volatile memory by writing to the 'store parameters' object for all parameters or communication parameters (see 8.9)*

8.7. EMCY (EMergenCY)

Presentation

The ***SWD® Core*** is in one of two states of emergency. Depending on the transition, emergency objects must be transmitted. The links between the error state machine and the NMT state machine are defined by object 1029$_h$.



0. After initialization, the ***SWD® Core*** enters the error-free state if no error is detected. No error messages are sent.

1. The ***SWD® Core*** detects an internal error indicated in the first three bytes of the emergency message (error code and error register). The ***SWD® Core*** goes into an error state. An emergency object with the error code and the appropriate error log is transmitted. The error code is populated at the location of the object 1003_h (predefined error field).

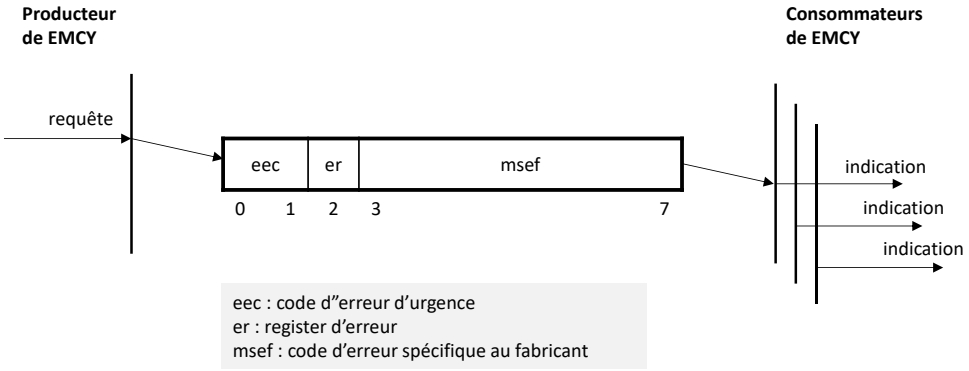
2. One, but not all, reason for error disappears. An emergency message containing the error code 0000_h (error reset) can be transmitted along with the remaining errors in the error register and in the manufacturer-specific error field.

3. A new error occurs on the CANopen device. The CANopen device remains in an error state and transmits an emergency object with the appropriate error code. The new error code is filled in at the top of the error code table (1003_h). The error codes are sorted: the oldest error with the highest sub-index (see object 1003_h).

4. All errors are repaired. The ***SWD® Core*** enters the error-free state and transmits an emergency object with the error code "reset error / no error".

5. Reset or power off.

EMCY emergency messages are issued in the following format:



Error codes
The ***SWD® Core*** may emit the following error codes:

	Description	FAULT
0000_h	Reset error or no error	☐

Generic	Description	FAULT
1000_h	Generic error	☐

Current	Description	FAULT
2221_h	Motor over-current error - Error	☑
2222_h	Motor Over-Current Error - Warning	☐

Tension	Description	FAULT
3211h	DC surge error – Error	☑
3212h	DC Surge Error – Warning	☐
3221h	DC Power On Error - Error	☑
3222h	DC Power On Error - Warning	☐
7100h	Power error on CAN or IO connector	☑

Temperature	Description	FAULT
4000h	Internal error temperature too high	☑
4210h	Internal error temperature too high power stage	☑
4310h	Internal error temperature too high driver	☑

Manufacturer	Description	FAULT
7121h	Engine error stuck	☑
8001h	Failure on STO_1 security input	☑
8002h	Failure on the security input STO_2	☑
8003h	Failure on the security input INSafe_1	☑
8004h	Failure on the security input INSafe_2	☑
8005h	Failure on the security input INSafe_3	☑
8006h	Failure on the security input INSafe_4	☑
8007h	Internal encoder consistency failure	☑
8008h	Internal failure put off driver	☑
8009h	Failure coherence STO signals	☑
800Ah	Internal failure activation braking	☑
800Bh	Internal failure brake management	☑
800Ch	Internal failure cut power driver	☑
800Dh	DC power error	☑
800Eh	Internal failure STO management	☑
8050h	Generic driver error	☑

Communication	Description	FAULT
6020h	CRC error on safety mapping or safety configuration	☑
8120h	CAN bus error - passive error	☑
8140h	CAN bus error - back from bus off	☑
8201h	SRDO protocol error - SCT non-compliance	☑
8202h	SRDO protocol error - SRVT non-compliance	☑
8203h	SRDO protocol error - data inconsistency	☑
8204h	SRDO protocol error - missing message	☑
8205h	SRDO protocol error - incorrect message size	☑
8206h	Rpdo's Event-Timer Timeout Error	🖹

1001_h: Error Register
This object indicates the error classes that are currently active.

Each bit corresponds to a class:

Bit	M/O	Meaning
0	M	Generic error
1	Or	Current
2	Or	Tension
3	Or	Temperature
4	Or	Communication error
5	Or	*Device specific*
6	Or	*Reserved*
7	Or	*Manufacturer-specific*

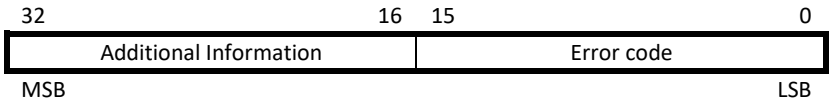
Refer to the error code table for the class of an error.

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
1001_h	0	Error register	U8	0	RO	-	-	-	-	1

1003_h: History of active errors
Object 1003_h contains the list of active errors. This list is presented in the form of a table. The most recent error is placed in sub-index 1, the oldest one occupies the highest sub-index of the table.

The number of errors stored in the table corresponds to the value stored in subindex 0.

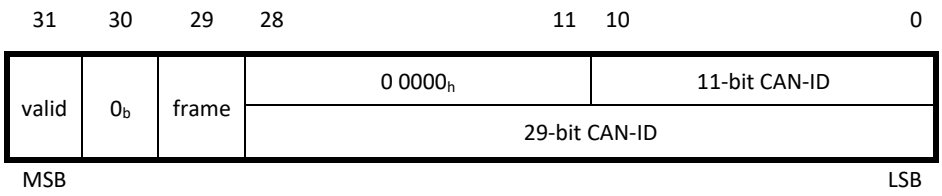
Each error is stored in the form:



Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
1003_h	0	Number of errors	U8	0	RO	-	-	0	FE_h	1
1003_h	1..FE	Errors	U32	0	RO					4

1014_h: COB-ID of the EMCY message
Use this object to set the default COB-ID used for issuing EMCY messages.

Structure of the EMCY *identifier*:



EMCY COB-ID description table:

Bit(s)	Value	Description
valid	0_b	Valid (or existing) EMCY
	1_b	Invalid (or non-existent) EMCY
30	0_b	Reserved (always 0_b)
frame	0_b	CAN-ID (base frame) on 11 valid bits
	1_b	CAN-ID (extended frame) on 29 valid bits
29-bit CAN-ID	x	CAN-ID of the 29-bit extended CAN frame
11-bit CAN-ID	x	CAN-ID of the base 11-bit CAN frame

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
1014_h	0	EMCY COB-ID	U32	0	RW	-	-	-	-	1

8.8. SRDO (Safety-Relevant Data Object)

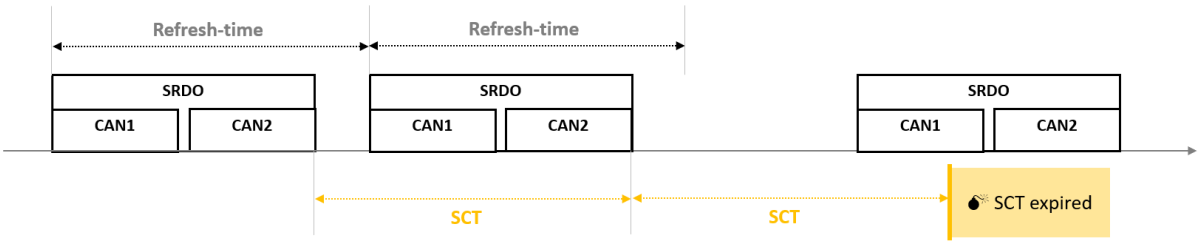
The SRDO protocol included in CANopen Safety provides a secure way to transmit operational safety data.

Data exchange takes place between two nodes performing safety functions in a system that operates with the CANopen Safety protocol.

Control of periodicity

Cyclic transmission speed is defined by refresh time and monitored according to safety cycle time (SCT). If the SCT has elapsed before receiving the corresponding SRDO, the SRDO consumer must report the *SCT event* to the SRLD and the SRLD must switch to the security state.

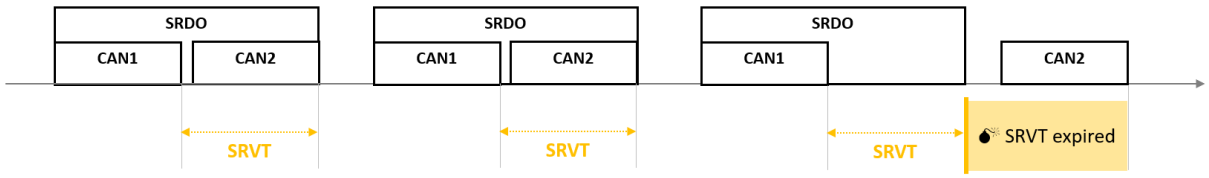
The figure below illustrates the timing relationship:



Time control between frames

The SRDO consists of two CAN frames transmitted consecutively and the reception is monitored. Receipt is monitored according to SR validation time (SRVT). If the SRVT elapsed before receiving the second CAN data frame, the SRDO consumer must report the *SRVT event* to the SRLD and the SRLD must switch to the security state.

The figure below illustrates the timing relationship:



Data consistency check
The data contained in the 2 messages of an SRDO must be consistent with each other.

- The first message contains the security data
- The second message contains the bit-to-bit add-in of this data.

Communication settings:

Index	Sub-index	Description	Data type
SRDO1 : 1301h **SRDO2 : 1302h** **SRDO 9 à 16 : 1309h to 1310h**	00h	Number of entries	Unsigned8
	01h	Information Directorate	Unsigned8
	02h	Refresh time / SCT	Unsigned16
	03h	SRVT	Unsigned8
	04h	Transmission type	Unsigned8
	05h	COB ID 1	Unsigned32
	06h	COB ID 2	Unsigned32

Time (SCT, refresh time, SVT)
In emission, only the Refresh Time parameter is used and its default value is 25ms.

In reception, the SCT and SRVT times are used to configure the monitoring. They are worth 50ms and 20ms respectively. The times are expressed in ms. The value 0 is prohibited.

Information Directorate

value	description
00h	Valid (or exists)
01h	Valid for transmission (tx)
02h	Valid for receipt (rx)
03h à FFh	reserved

Transmission type

value	description
00h	Synchronous
…	…
F0h	Synchronous
F1h	reserved
…	…
FDh	reserved
FEh	On event (manufacturer specific)
FFh	On event (device specific)

Default values

Activated	SRDO	Direction	Mapping
☑	1	RX	Safety control word 1 (6620 0108_h)
☑	2	*TX*	Safety status word 1 to 8 (6621 0108_h -> 6621 0808_h)
	3..8	-	*Reserved for future use CIA 402*
	9	*RX*	Safety control word 2 (6620 0208_h)
	10	*TX*	Safe position actual value i32 (6611 0020_h) + Safe velocity actual value i32 (6613 0020_h)[2]
	11	*RX*	Safety control word 3 (6620 0308_h)
	12	*RX*	Safety control word 4 (6620 0408_h)
	13	*RX*	Safety control word 5 (6620 0508_h)
	14	*RX*	Safety control word 6 (6620 0608_h)
	15	*RX*	Safety control word 7 (6620 0708_h) + Safety control word 8 (6620 0808_h)
	16	*TX*	Inputs Safety control word (2620 0208_h)

SRDO 1 RX

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
Communication settings										
1301_h	00_h	Number of entries	U8	06_h	RO	NO	-	-	-	1
	01_h	Information Directorate	U8	2 (RX)	RW	NO	-	0 or 2 (RX)		1
	02_h	Refresh time / SCT	U16	50	RW	NO	ms	1	U16	2
	03_h	SRVT	U16	20	RW	NO	ms	1	U16	2
	04_h	Transmission type	U8	FE_h	RW	NO		FE_h	FE_h	1
	05_h	COB ID 1	U32	0000 $00FF_h$ + (2 x node-ID)	RW	NO				4
	06_h	COB ID 2	U32	0000 0100_h + (2 x node-ID)	RW	NO				4
Data mapping										
1381_h	00_h	Number of objects	U8	02_h	RO	NO	-	00_h	08_h	1
	01_h	Safety Controword 1	U8	6620 0108_h SCW_1	RO	NO	-	-	-	4
	02_h	Safety Controword 1 inverted	U8	6622 0108_h SCW_1_inv	RO	NO	-	-	-	4

[2] *Development in progress*

SRDO 2 TX

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
Communication settings										
1302h	00_h	Number of entries	U8	06_h	RO	NO	-	-	-	1
	01_h	Information Directorate	U8	1 (TX)	RW	NO	-	0 ou 1 (TX)		1
	02_h	Refresh time / SCT	U16	25	RW	NO	ms	1	U16	2
	03_h	SRVT	U16	20	RW	NO	ms	1	U16	2
	04_h	Transmission type	U8	FE_h	RW	NO		FE_h	FE_h	1
	05_h	COB ID 1	U32	$0000\ 0103_h$	RW	NO				4
	06_h	COB ID 2	U32	$0000\ 0104_h$	RW	NO				4
Data mapping										
1382_h	00_h	Number of objects	U8	16_h	RO	NO	-	00_h	08_h	1
	01_h	Safety Statusword 1	U32	$6621\ 0108_h$	RO	NO	-	-	-	4
	02_h	Safety Statusword 1 inverted	U32	$6623\ 0108_h$	RO	NO	-	-	-	4
	03_h	Safety Statusword 2	U32	$6621\ 0208_h$	RO	NO	-	-	-	4
	04_h	Safety Statusword 2 inverted	U32	$6623\ 0208_h$	RO	NO	-	-	-	4
	05_h	Safety Statusword 3	U32	$6621\ 0308_h$	RO	NO	-	-	-	4
	06_h	Safety Statusword 3 inverted	U32	$6623\ 0308_h$	RO	NO	-	-	-	4
	07_h	Safety Statusword 4	U32	$6621\ 0408_h$	RO	NO	-	-	-	4
	08_h	Safety Statusword 4 inverted	U32	$6623\ 0408_h$	RO	NO	-	-	-	4
	09_h	Safety Statusword 5	U32	$6621\ 0508_h$	RO	NO	-	-	-	4
	$0A_h$	Safety Statusword 5 inverted	U32	$6623\ 0508_h$	RO	NO	-	-	-	4
	$0B_h$	Safety Statusword 6	U32	$6621\ 0608_h$	RO	NO	-	-	-	4
	$0C_h$	Safety Statusword 6 inverted	U32	$6623\ 0608_h$	RO	NO	-	-	-	4
	$0D_h$	Safety Statusword 7	U32	$6621\ 0708_h$	RO	NO	-	-	-	4
	$0E_h$	Safety Statusword 7 inverted	U32	$6623\ 0708_h$	RO	NO	-	-	-	4
	$0F_h$	Safety Statusword 8	U32	$6621\ 0808_h$	RO	NO	-	-	-	4
	10_h	Safety Statusword 8 inverted	U32	$6623\ 0808_h$	RO	NO	-	-	-	4

SRDO 9 RX (inactive)

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
Communication settings										
1309_h	00_h	Number of entries	U8	06_h	RO	NO	-	-	-	1
	01_h	Information Directorate	U8	0 (inactive)	RW	NO	-	0 or 2 (RX)		1
	02_h	Refresh time / SCT	U16	50	RW	NO	ms	1	U16	2
	03_h	SRVT	U16	20	RW	NO	ms	1	U16	2
	04_h	Transmission type	U8	FE_h	RW	NO		FE_h	FE_h	1
	05_h	COB ID 1	U32	0000 $00FF_h$ + (2 x node-ID)	RW	NO				4
	06_h	COB ID 2	U32	0000 0100_h + (2 x node-ID)	RW	NO				4
Data mapping										
1389_h	00_h	Nombre d'objets	U8	02_h	RO	NO	-	00_h	08_h	1
	01_h	Safety Controword 2	U32	6620 0208_h	RO	NO	-	-	-	4
	02_h	Safety Controword 2 inverted	U32	6622 0108_h	RO	NO	-	-	-	4

SRDO 10 TX (inactive)

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
Communication settings										
$130A_h$	00_h	Number of entries	U8	06_h	RO	NO	-	-	-	1
	01_h	Information Directorate	U8	0 (inactive)	RW	NO	-	0 ou 1 (TX)		1
	02_h	Refresh time / SCT	U16	25	RW	NO	ms	1	U16	2
	03_h	SRVT	U16	20	RW	NO	ms	1	U16	2
	04_h	Transmission type	U8	FE_h	RW	NO		FE_h	FE_h	1
	05_h	COB ID 1	U32	0000 0107_h	RW	NO				4
	06_h	COB ID 2	U32	0000 0108_h	RW	NO				4
Data mapping										
$138A_h$	00_h	Number of objects	U8	04_h	RO	NO	-	00_h	08_h	1
	01_h	Safe position actual value	U32	6611 0020_h	RO	NO	-	-	-	4
	02_h	Safe position actual value inverted	U32	661A 0020_h	RO	NO	-	-	-	4
	03_h	Safe velocityactual value inverted	U32	6613 0020_h	RO	NO	-	-	-	4
	04_h	Safe velocity actual value inverted	U32	661C 0020_h	RO	NO	-	-	-	4

SRDO 11 RX (inactive)

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
Communication settings										
$130B_h$	00_h	Number of entries	U8	06_h	RO	NO	-	-	-	1
	01_h	Information Directorate	U8	0 (inactive)	RW	NO	-	0 or 2 (RX)		1
	02_h	Refresh time / SCT	U16	50	RW	NO	ms	1	U16	2
	03_h	SRVT	U16	20	RW	NO	ms	1	U16	2
	04_h	Transmission type	U8	FE_h	RW	NO		FE_h	FE_h	1
	05_h	COB ID 1	U32	$0000\ 0109_h$	RW	NO				4
	06_h	COB ID 2	U32	$0000\ 010A_h$	RW	NO				4
Data mapping										
$138B_h$	00_h	Number of objects	U8	02_h	RO	NO	-	00_h	08_h	1
	01_h	Safety Controword 3	U32	$6620\ 0308_h$	RO	NO	-	-	-	4
	02_h	Safety Controword 3 inverted	U32	$6622\ 0308_h$	RO	NO	-	-	-	4

SRDO 12 RX (inactive)

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
Communication settings										
$130C_h$	00_h	Number of entries	U8	06_h	RO	NO	-	-	-	1
	01_h	Information Directorate	U8	0 (inactive)	RW	NO	-	0 or 2 (RX)		1
	02_h	Refresh time / SCT	U16	50	RW	NO	ms	1	U16	2
	03_h	SRVT	U16	20	RW	NO	ms	1	U16	2
	04_h	Transmission type	U8	FE_h	RW	NO		FE_h	FE_h	1
	05_h	COB ID 1	U32	$0000\ 010B_h$	RW	NO				4
	06_h	COB ID 2	U32	$0000\ 010C_h$	RW	NO				4
Data mapping										
$138C_h$	00_h	Number of objects	U8	02_h	RO	NO	-	00_h	08_h	1
	01_h	Safety Controword 4	U32	$6620\ 0408_h$	RO	NO	-	-	-	4
	02_h	Safety Controword 4 inverted	U32	$6622\ 0408_h$	RO	NO	-	-	-	4

SRDO 13 RX (inactive)

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
Communication settings										
$130D_h$	00_h	Number of entries	U8	06_h	RO	NO	-	-	-	1
	01_h	Information Directorate	U8	0 (inactive)	RW	NO	-	0 or 2 (RX)		1
	02_h	Refresh time / SCT	U16	50	RW	NO	ms	1	U16	2
	03_h	SRVT	U16	20	RW	NO	ms	1	U16	2
	04_h	Transmission type	U8	FE_h	RW	NO		FE_h	FE_h	1
	05_h	COB ID 1	U32	$0000\ 010D_h$	RW	NO				4
	06_h	COB ID 2	U32	$0000\ 010E_h$	RW	NO				4
Data mapping										
$138D_h$	00_h	Number of objects	U8	02_h	RO	NO	-	00_h	08_h	1
	01_h	Safety Controword 5	U32	$6620\ 0508_h$	RO	NO	-	-	-	4
	02_h	Safety Controword 5 inverted	U32	$6622\ 0508_h$	RO	NO	-	-	-	4

SRDO 14 RX (inactive)

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
Communication settings										
$130E_h$	00_h	Number of entries	U8	06_h	RO	NO	-	-	-	1
	01_h	Information Directorate	U8	0 (inactive)	RW	NO	-	0 or 2 (RX)		1
	02_h	Refresh time / SCT	U16	50	RW	NO	ms	1	U16	2
	03_h	SRVT	U16	20	RW	NO	ms	1	U16	2
	04_h	Transmission type	U8	FE_h	RW	NO		FE_h	FE_h	1
	05_h	COB ID 1	U32	$0000\ 010F_h$	RW	NO				4
	06_h	COB ID 2	U32	$0000\ 0110_h$	RW	NO				4
Data mapping										
$138E_h$	00_h	Number of objects	U8	02_h	RO	NO	-	00_h	08_h	1
	01_h	Safety Controword 6	U32	$6620\ 0608_h$	RO	NO	-	-	-	4
	02_h	Safety Controword 6 inverted	U32	$6622\ 0608_h$	RO	NO	-	-	-	4

SRDO 15 RX (inactive)

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
Communication settings										
130F$_h$	00$_h$	Number of entries	U8	06$_h$	RO	NO	-	-	-	1
	01$_h$	Information Directorate	U8	0 (inactive)	RW	NO	-	0 or 2 (RX)		1
	02$_h$	Refresh time / SCT	U16	50	RW	NO	ms	1	U16	2
	03$_h$	SRVT	U16	20	RW	NO	ms	1	U16	2
	04$_h$	Transmission type	U8	FE$_h$	RW	NO		FE$_h$	FE$_h$	1
	05$_h$	COB ID 1	U32	0000 0111$_h$	RW	NO				4
	06$_h$	COB ID 2	U32	0000 0112$_h$	RW	NO				4
Data mapping										
138F$_h$	00$_h$	Number of objects	U8	04$_h$	RO	NO	-	00$_h$	08$_h$	1
	01$_h$	Safety Controword 7	U32	6620 0708$_h$	RO	NO	-	-	-	4
	02$_h$	Safety Controword 7 inverted	U32	6622 0708$_h$	RO	NO	-	-	-	4
	03$_h$	Safety Controword 8	U32	6620 0808$_h$	RO	NO	-	-	-	4
	04$_h$	Safety Controword 8 inverted	U32	6622 0808$_h$	RO	NO	-	-	-	4

SRDO 16 TX (inactive)

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
Communication settings										
1310h	00$_h$	Number of entries	U8	06$_h$	RO	NO	-	-	-	1
	01$_h$	Information Directorate	U8	0 (inactive)	RW	NO	-	0 ou 1 (TX)		1
	02$_h$	Refresh time / SCT	U16	25	RW	NO	ms	1	U16	2
	03$_h$	SRVT	U16	20	RW	NO	ms	1	U16	2
	04$_h$	Transmission type	U8	FE$_h$	RW	NO		FE$_h$	FE$_h$	1
	05$_h$	COB ID 1	U32	0000 0113$_h$	RW	NO				4
	06$_h$	COB ID 2	U32	0000 0114$_h$	RW	NO				4
Data mapping										
1390$_h$	00$_h$	Number of objects	U8	2$_h$	RO	NO	-	00$_h$	08$_h$	1
	01$_h$	Safety Statusword INSafe	U32	2620 0208$_h$	RO	NO	-	-	-	4
	02$_h$	Safety Statusword INSafe inverted	U32	2622 0208$_h$	RO	NO	-	-	-	4

8.9. Backup and restore of configurations

SWD® Core supports saving user settings and restoring factory settings.

The backup of the user parameters is carried out when receiving the 'save' command in the object 'Store Parameter' (1010_h).

Signature	MSB			LSB
/ISO8859/ character	and	in	a	s
hex	65_h	76_h	61_h	73_h

The saved settings are divided into several groups. The backup is performed either for all the parameters of the product, or for a specific group.

The restitution of the default configuration is done by writing 'load' in the object 'Restore Default parameters' (1011_h)

Signature	MSB			LSB
/ISO8859/ character	d	a	or	l
Hex	64_h	61_h	$6F_h$	$6C_h$

Sub-Index	Configuration dataset
1	All data is backed up/returned

Communication settings

Communication parameters	
1005	COB ID SYNC message
1017	Producer Heartbeat Time
1200	SDO server parameter
1400	RPDO 1 communication parameter
1401	RPDO 2 communication parameter
1402	RPDO 3 communication parameter
1403	RPDO 4 communication parameter
1600	RPDO 1 mapping parameter
1601	RPDO 2 mapping parameter
1602	RPDO 3 mapping parameter
1603	RPDO 4 mapping parameter
1800	TPDO 1 communication parameter
1801	TPDO 2 communication parameter
1802	TPDO 3 Communication Parameter
1A00	TPDO 1 mapping parameter
1A01	TPDO 2 mapping parameter
1A02	TPDO 3 Mapping Parameter
LSS parameters (SDO access)	
2100	Configure Bit Timing Parameters
2101	Node ID
2102	R Termination
SRDO parameters	
1301	SRDO 1 communication parameter
1302	SRDO 2 communication parameter
1309	SRDO 9 communication parameter
130a	SRDO 10 communication parameter
130b	SRDO 11 communication parameter
130c	SRDO 12 communication parameter
130d	SRDO 13 communication parameter
130e	SRDO 14 communication parameter
130f	SRDO 15 communication parameter
1310	SRDO 16 communication parameter
1381	SRDO 1 mapping parameter
1322	SRDO 2 mapping parameter
1389	SRDO 9 mapping parameter
138a	SRDO 10 mapping parameter
138b	SRDO 11 mapping parameter
138c	SRDO 12 mapping parameter
138d	SRDO 13 mapping parameter
138e	SRDO 14 mapping parameter
138f	SRDO 15 mapping parameter
1390	SRDO 16 mapping parameter

Drive parameters
List of configurable data related to CiA 402:

Drive Configuration	
Velocity mode	
6046h	vl_velocity_min_max_amount
6048h	vl_velocity_acceleration
6049h	vl_velocity_deceleration
604Ah	vl_velocity_quick_stop
604Bh	vl_set_point_factor
604Ch	vl_dimension_factor
CiA 402	
6007h	Abort_connection_option_code
605Ah	quick_stop_option_code
605Bh	shutdown_option_code
605Ch	disable_operation_option_code
605Dh	halt_option_code
605Eh	fault_reaction_option_code
6060h	modes_of_operation
607Eh	polarity
6091h	gear_ratio
6092h	feed_constant
6600h	Time unit
6601h	Position unit
6602h	Velocity unit
6603h	Acceleration unit
CiA 402-4 - Configuring Security Features	
6641h	STO restart acknowledge behavior
6643h	STO activate SBC
6645h	STO safety application configuration signature
6661h	SBC brake time delay
6662h	SBC safety application configuration signature
6691h	SLS time to velocity monitoring
6693h	SLS velocity limit u32
6694h	SLS time for velocity in limits
6698h	SLS error reactions
6699h	SLS safety application configuration signature
66D5h	SDI velocity zero window u32
66D6h	SDI safety application configuration signature
66F0h	ezw_safety_word_scw_mapping_cw1
66F1h	ezw_safety_word_scw_mapping_cw2
66F2h	ezw_safety_word_scw_mapping_cw3
66F3h	ezw_safety_word_scw_mapping_cw4
66F4h	ezw_safety_word_scw_mapping_cw5

66F5h	ezw_safety_word_scw_mapping_cw6
66F6h	ezw_safety_word_scw_mapping_cw7
66F7h	ezw_safety_word_scw_mapping_cw8
66F8h	ezw_safety_word_ssw_mapping_sw1
66F9h	ezw_safety_word_ssw_mapping_sw2
66FAh	ezw_safety_word_ssw_mapping_sw3
66FBh	ezw_safety_word_ssw_mapping_sw4
66FCh	ezw_safety_word_ssw_mapping_sw5
66FDh	ezw_safety_word_ssw_mapping_sw6
66FEh	ezw_safety_word_ssw_mapping_sw7
66FFh	ezw_safety_word_ssw_mapping_sw8

Parameters *SWD Core®*

List of configurable data related to the ***SWD® Core*** product:

Configuration *SWD® Core*	
2050h	cia402_use_intenal_brake
2155h	motctrl_speed_pid_p
2156h	motctrl_speed_pid_i
2157h	motctrl_speed_pid_d

9. CiA 402: Engine Control Device Profile

The CiA 402 profile manages the motors (power, braking, ...) according to different modes of operation (position, velocity, torque, ...). This management involves selecting the expected mode, configuring the specific parameters, and then starting the CiA 402 profile state machine. According to the chosen mode, specific functions will carry out the controls and the commands of the engine.
The ***SWD® Core*** drive is managed with a state machine and implements the velocity mode.

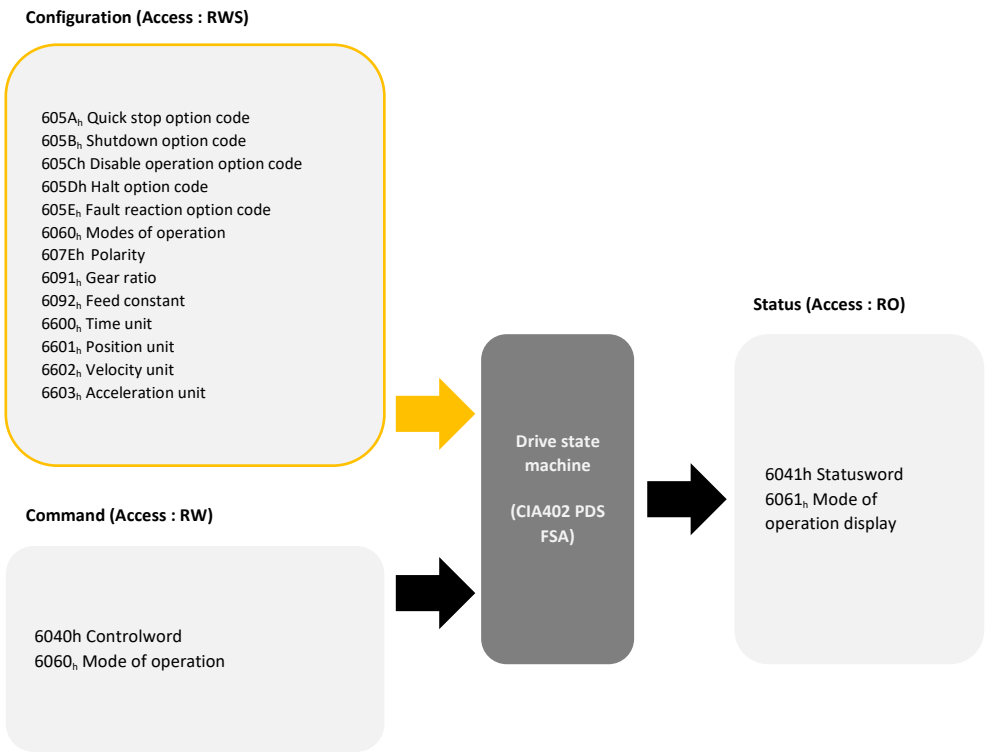


Figure 16 - Drive State Management Interface

9.1. State machine

The CiA 402 profile state machine allows you to control the operation of the drive integrated into the ***SWD® Core***.

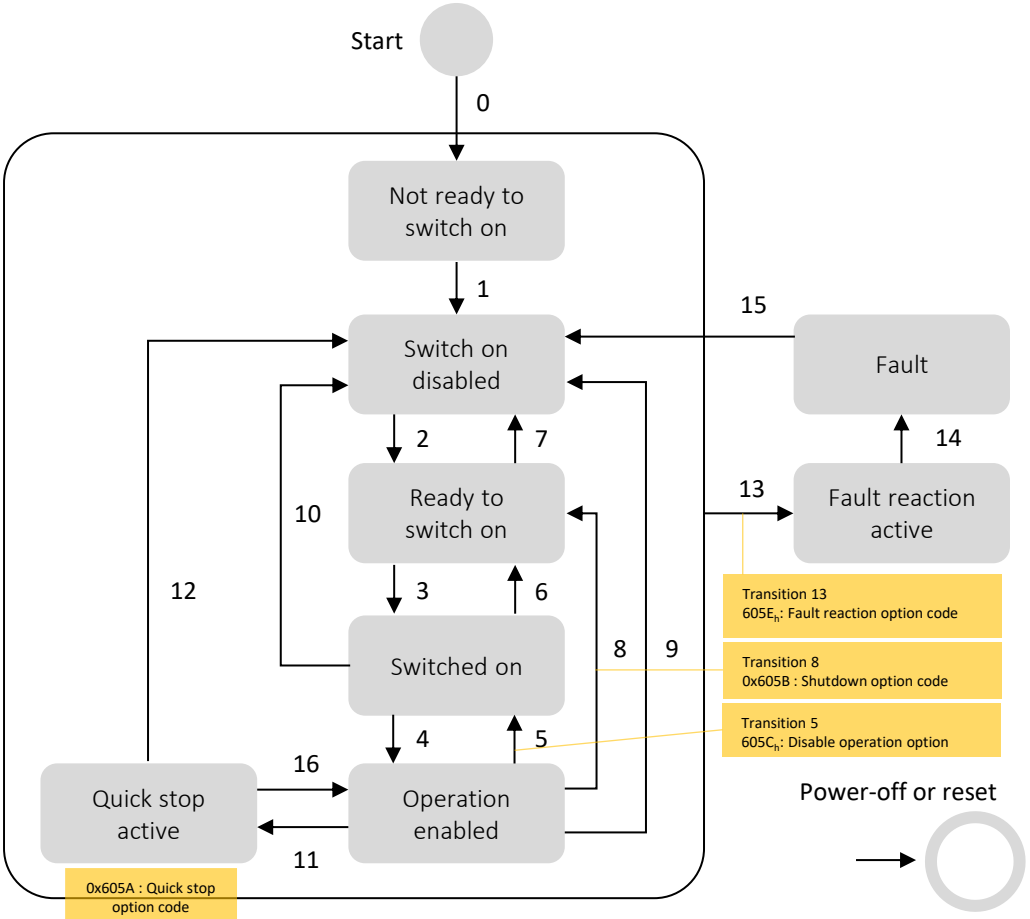


Figure 17 - CiA 402, State Machine and Transitions

ℹ *Reading a dedicated CiA 402 object to get the current state ('status_word', 0x6041) lets you know what transition can be made.*

Transition	Events	Actions
0	Automatic transition after power-on or reset application	Drive device self-test and/or self -initialization shall be performed.
1	Automatic transition	Communication shall be activated.
2	Shutdown command from control device or local signal	None
3	Switch on command received from control device or local signal	The high-level power shall be switched on, if possible.
4	Enable operation command received from control device or local signal	The drive function shall be enabled and all internal set-points cleared.
5	Disable operation command received from control device or local signal	The drive function shall be disabled.
6	Shutdown command received from control device or local signal	The high-level power shall be switched off, if possible.
7	Quick stop or disable voltage command from control device or local signal	None
8	Shutdown command from control device or local signal	The drive function shall be disabled, and the high-level power shall be switched off, if possible.
9	Disable voltage command from control device or local signal	The drive function shall be disabled, and the high-level power shall be switched off, if possible.
10	Disable voltage or quick stop command from control device or local signal	The high-level power shall be switched off, if possible.
11	Quick stop command from control device or local signal	The quick stop function shall be started.
12	Automatic transition when the quick stop function is completed and quick stop option code is 1, 2, 3 or 4, or disable voltage command received from control device (depends on the quick stop option code)	The drive function shall be disabled, and the high-level power shall be switched off, if possible.
13	Fault signal	The configured fault reaction function shall be executed.
14	Automatic transition	The drive function shall be disabled; the high-level power shall be switched off, if possible.
15	Fault reset command from control device or local signal	A reset of the fault condition is carried out, if no fault exists currently on the drive device; after leaving the fault state, the fault reset bit in the controlword shall be cleared by the control device.
16	Enable operation command from control device, if the quick stop option code is 5, 6, 7, or 8	The drive function shall be enabled.

The CiA 402-2 standard defines a set of supported functions, to control the machine states. The table below sums-up the supported function states, for each stage of the machine.

Supported functions include:

- *Active brake, according to config.*
- *Powered on board*
- *Active motor control*
- *Allowed configuration*

Their states will be either ON, OFF or ON/OFF if both states are possible.

Function	**FSA states**							
	Not ready to switch on	Switch on disabled	Ready to switch on	Switched on	Operation enabled	Quick stop active	Fault reaction active	Fault
Active brake according to config.	**Yes**	**Yes**	**Yes**	**Yes**	**Yes/No**	**Yes/No**	**Yes/No**	**Yes**
Map under tension	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Active motor control	**No**	**No**	**No**	**No**	**Yes**	**Yes**	**Yes**	**No**
Allowed configuration	**Yes**	**Yes**	**Yes**	**Yes**	**No**	**No**	**No**	**Yes**

Figure 18 - Configuring Functions according to the states of the CiA 402 state machine

6040h Controlword

The `Controlword` allows the management of the CiA 402 state machine and the request of transitions.

The transition from one state to another is controlled by writing to the dedicated CiA 402 object (*'control_word'*, 6040h) or automatically (e.g. in case of error, if configured). For some of these transitions, specific configurable actions can be carried out, especially in the context of a secure shutdown with an automatic deceleration ramp.

15 **11**	**10**	**9**	**8**	**7**	**6** **4**	**3**	**2**	**1**	**0**
ms	r	WHO	h	Fri	WHO	eo	qs	home	so
MSB									LSB

Key:

ms	manufacturer-specific
r	reserved
oms	operation mode specific
h	halt
fr	fault reset
eo	enable operation
qs	quick stop
ev	enable voltage
so	switch on

Command	Bits of the controlword					Transitions
	Bit 7	Bit 3	Bit 2	Bit 1	Bit 0	
Shutdown	0	X	1	1	0	2, 6, 8
Switch on	0	0	1	1	1	3
Switch on + enable operation	0	1	1	1	1	3 + 4 (NOTE)
Disable voltage	0	X	X	0	X	7, 9, 10, 12
Quick stop	0	X	X	1	X	7, 10, 11
Disable operation	0	0	1	1	1	5
Enable operation	0	1	1	1	1	4, 16
Fault reset	↑	X	X	X	X	15

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
6040_h	0	Controlword	U16	0	RW	R	-	-	-	2

6041_h Statusword

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ms		WHO		To	tr	rm	ms	in	sod	qs	and	f	oe	so	rtso
MSB															LSB

Key:

ms	manufacturer-specific
oms	operation mode specific
ila	internal limit active
tr	target reached
rm	remote
w	warning
sod	switch on disabled
qs	quick stop
ve	voltage enables
f	fault
oe	operation enabled
so	switched on
rtso	ready to switch on

Statusword	PDS FSA state
xxxx xxxx x0xx 0000_b	Not ready to switch on
xxxx xxxx x1xx 0000_b	Switch on disabled
xxxx xxxx x01x 0001_b	Ready to switch on
xxxx xxxx x01x 0011_b	Switched on
xxxx xxxx x01x 0111_b	Operation enabled
xxxx xxxx x00x 0111_b	Quick stop active
xxxx xxxx x0xx 1111_b	Fault reaction active
xxxx xxxx x0xx 1000_b	Fault

Ila - internal limit active
The drive sets the '*Ila*' bit to 1, if the speed setpoint is outside the speed range allowed for the product. (cf. 6046_h - vl_velocity_min_max_amount)

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
6041_h	0	Statusword	U16	0	RO	T	-	-	-	2

Startup example

SWD® Core state	Status word (typical)	Word control to move to the next state
Not ready to switch on	$00\ 00_h$	Automatic
Switch on disabled	$00\ 40_h$	$00\ 06_h$
Ready to switch on	$00\ 21_h$	$00\ 07_h$
Switched on	$00\ 23_h$	$00\ 0F_h$
Operation enabled	$00\ 27_h$	

Brake applied depending on configuration
The ***SWD® Core*** handles 2 engine braking modes.

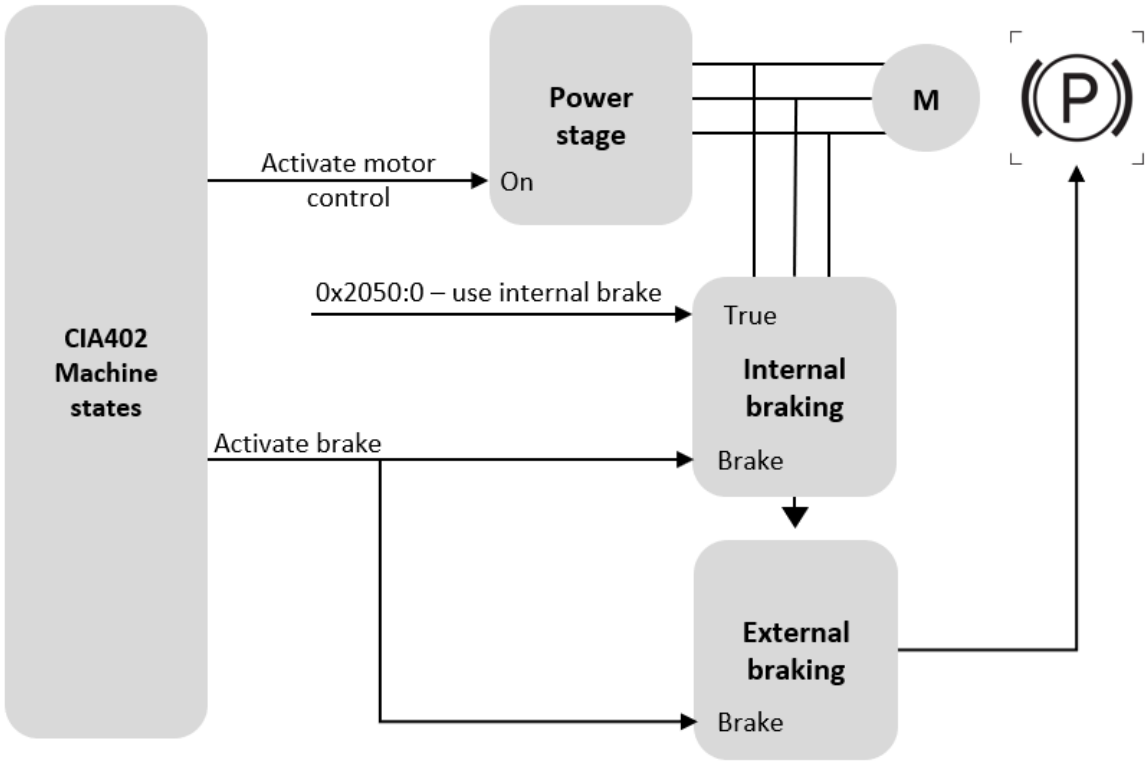


Figure 19 - Motor Control Synoptic

The ***SWD® Core*** handles 2 engine braking modes.
The use of the internal brake, by short-cutting the engine phases. This mode can be activated, by setting the corresponding value in the dictionary. The external brake (if present) has to be properly mounted on the engine and connected to the dedicated connector.

	Present	Not present
Brake by ENGINE DC 'if present' is a configurable	2050 00_h USE_INTERNAL_BRAKE = true[3]	2050 00_h USE_INTERNAL_BRAKE = false
External brake	Mechanical mounting and connection to the 'brake' connector	Brake not mounted or not connected

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
2050_h	0	USE_INTERNAL_BRAKE	U8	1	RW	NO	-	0	1	1

Modes of operation

The ***SWD® Core*** drive implements the 'velocity' mode which allows speed control of the motor. Supported operating modes are available by reading the object "6502h Supported drive mode".

31 16	15 11	10	9	8	7	6	5	4	3	2	1	0
Manufacturer-specific	r(eserved)	cstca	cst	csv	csp	ip	hm	r	tq	pv	vl	pp
MSB												LSB

Key:

pp profile position mode
vl velocity mode
pv profile velocity mode
tq torque profile mode
r reserved
hm homing mode
ip interpolated position mode
csp cyclic sync position mode
csv cyclic sync velocity mode
cst cyclic sync torque mode
cstca operation enabled
r(eserved) reserved

The following data may apply:

1 = mode is supported	0 = mode is not supported

The operating mode allows you to define the behavior when the ***SWD® Core*** is in the 'operation enable' state.

[3] *Development in progress*

The input "Request operating mode" (6060_h) allows the choice of mode, the input "Current operating mode" (6061_h) allows to know the mode in which the ***SWD® Core*** is located. The value of these objects is described in the table below:

Value	Definition
-128 to -1	Manufacturer-specific operation modes
0	No mode change/no mode assigned
+1	Profile position mode (pp)
+2	**Velocity mode (vl)**
+3	Profile velocity mode (pv)
+4	Torque profile mode (tq)
+5	Reserved (r)
+6	Homing mode (hm)
+7	Interpolated position mode
+8	Cyclic sync position mode
+9	Cyclic sync velocity mode
+10	Cyclic sync torque mode
+11	Cyclic sync torque mode with commutation angle
+12 to +127	Reserved

By default the 'velocity' mode is enabled. It is possible to change the default operating mode by saving it to non-volatile memory.

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
6502_h	0	Supported operating mode	U32	2	RO	NO	Table	2	2	4
6060_h	0	Request operating mode	U32	2	RW	NO	Table	0	2	4
6061_h	0	Operating Mode	U32	0	RO	NO	Table	0	2	4

9.2. How 'velocity mode' works (vl)

Presentation

The 'velocity' operating mode controls the speed (velocity) of the ***SWD® Core*** motor, but not its position. The selection of a new speed is carried out by an acceleration or a deceleration ramp. It limits the current load and the mechanical stress of the engine. The calculation of the force to be applied according to the load is carried out automatically. A feedback loop control makes sure to follow the speed instruction without exceeding the limits set for acceleration or deceleration.

The 'velocity' mode is composed of a transfer function whose different stages produce internal or external values, some of them can be read in CANopen objects dictionary (described in the next subsection).

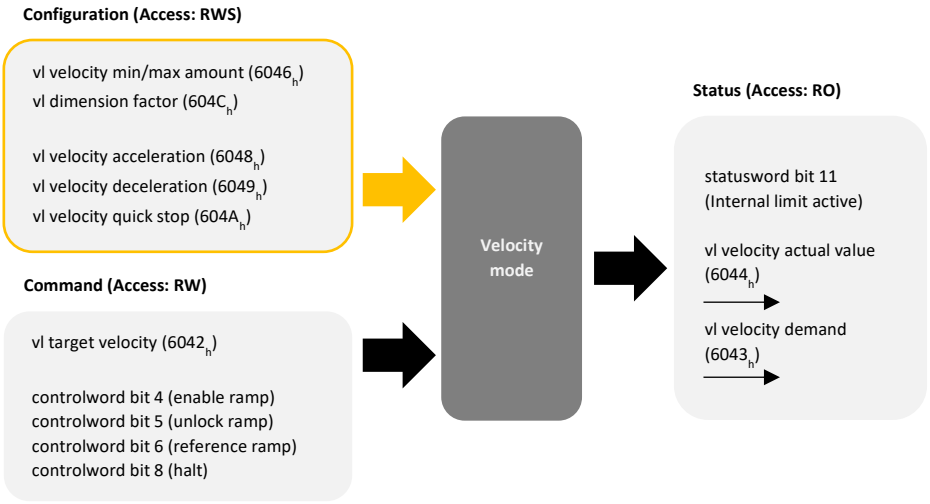


Figure 20 - 'Speed control' interface

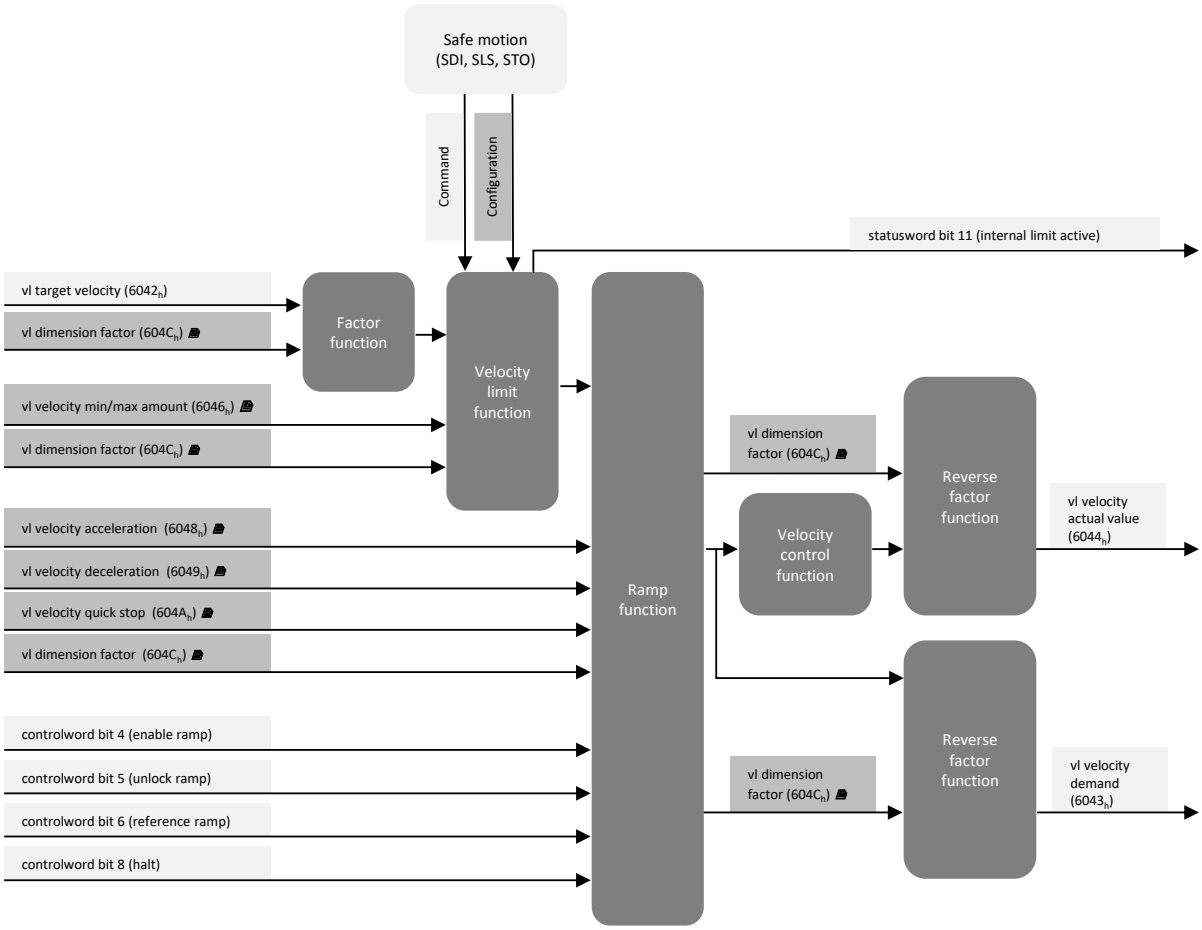


Figure 21 - 'speed control' architecture

6042h: Speed instruction

The speed instruction is stored in the dictionary object 'vl_target_velocity' (6042h).

By default, speeds are expressed at the motor shaft in RPM (Rotation Per Minute), regardless the mechanical reducer ratio.

ℹ The unit of speed used depends on the configuration of ' vl_dimension_factor' (604Ch).

6064h: Position

The position is expressed in motor encoder increments, and it is stored in the dictionary object 'position_value' (6064h).

The resolution of the native encoder into the ***SWD® Core,*** is 30 increments per motor shaft rotation, regardless the mechanical reducer ratio. The counting direction is influenced by the configuration of the object 'polarity' (607Eh).

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes	Non-volatile storage
6064h	0	position_ value	I32	0	R0	T	inc			4	Yes

607Eh: Direction of rotation

Direction of the motor rotation is configurable, according to a positive speed. Similarly, it is possible to change the counting position increments (to count positively or negatively), according to the motor direction.

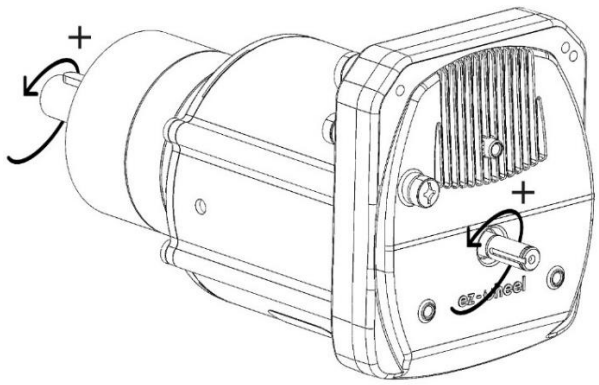


Figure 22 - Positive direction of rotation (+)

7	6	5	0
Position polarity	Velocity polarity	Reserved (0)	

MSB LSB

The polarity bits are encoded as follows: 0b = multiplies by one '1', and 1b = multiplies by minus one '–1'.

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
607Eh	0	Polarity	U8	0	RW	R	-	0	1	1

ℹ *The polarity object does not impact the positive direction of rotation used for the SDIp and SDIn security functions.*

604C$_h$: Conversions

It is possible to apply a dimension factor on the expression of velocities so that they are expressed in another unit. The dimension factor is configurable using the following objects:

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
604C$_h$	1	Dimension factor numerator	I32	1	RW	R	-	I32 excepted 0		4
604C$_h$	2	Dimension factor denominator	I32	1	RW	R	-	I32 excepted 0		4

$$Vitesse_{RPM} = \frac{Numérateur}{Dénominateur} \times Vitesse$$

When different from ‘1’, the dimension factor applies the following quantities:

6046	vl_velocity_min_max_amount
6048	vl_velocity_acceleration
6049	vl_velocity_deceleration
604A	vl_velocity_quick_stop
6693	SLS velocity limit u32
66D5	SDI velocity zero window u32

Speed limits

The set speed limit block limits the speed setpoint. It acts symmetrically on positive and negative instructions.

In the case the setpoint value is higher than the 'velocity_max_amount', it limits the output to plus or minus 'velocity_max_amount'.

In the case the setpoint value is lower than the 'velocity_min_amount', it sets the output to zero.

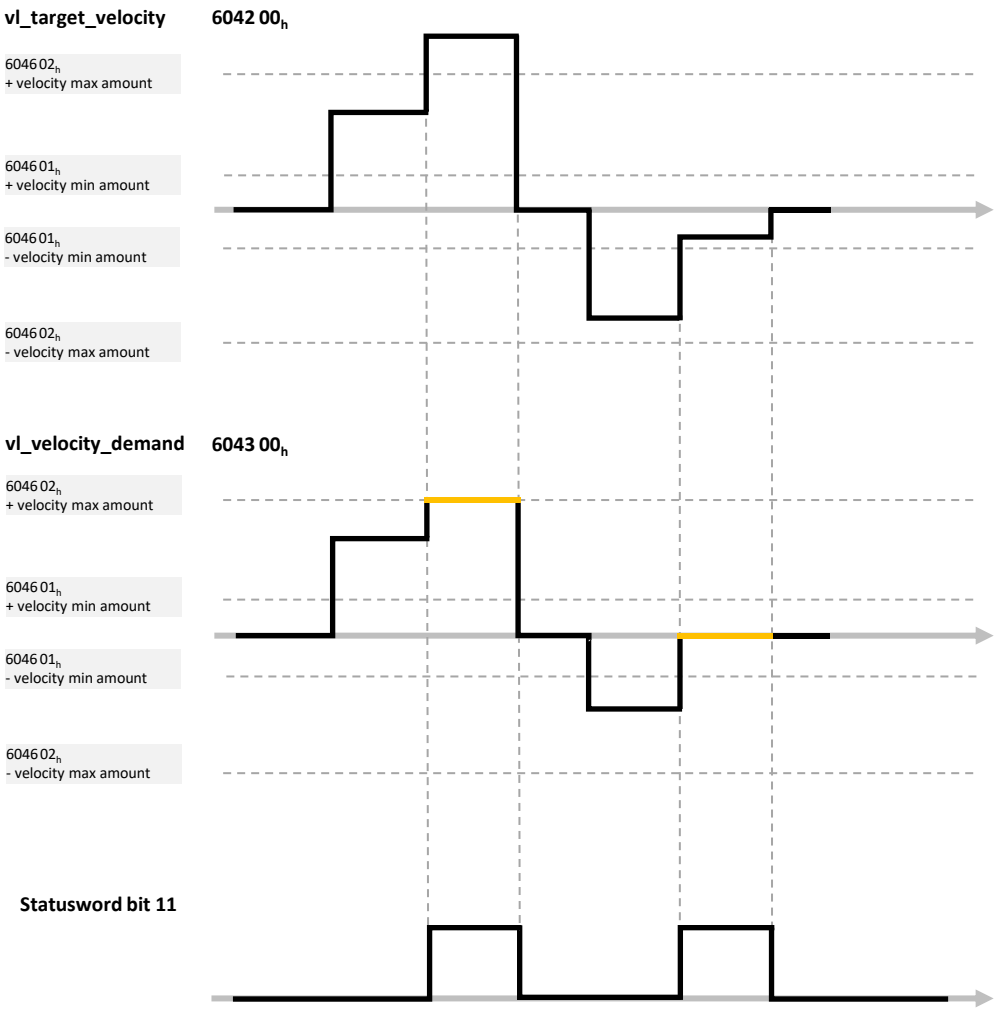


Figure 23 - Managing Speed Limits

- The configuration of the limits speed is carried out in rpm, i.e. before the reduction stage (GearBox)
- The speed unit used depends on the configuration of the `Dimension factor` (Cf. 604C$_h$).

The user can modify the limits used by the drive:

- In runtime, the limiting values are considered when switching to 'operation enable'
- By configuration, while saving the default limits to be used when starting the product.

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes	Non-volatile storage
6046$_h$	1	vl_velocity_min_amount	U32	30	RW	R	r.min-1	30	1800	4	Yes
6046$_h$	2	vl_velocity_max_amount	U32	1800	RW	R	r.min-1	30	1800	4	Yes

Speed limit and safety features
Additional limitations are applied to the setpoint because of the security features. The setpoint limitation is not a safety function itself, but takes into account the constraints related to the safety functions.

Active function	Throttling output policy
STO	The setpoint is forced to 0
SLS	The setpoint is saturated at the speed of SLS. Same behavior as 'velocity max amount'.
SDI p	Positive instructions greater than nZero_SDI are forced to 0.
SDI n	Negative instructions below -nZero_SDI are forced to 0.

The ramps used in the context of this limitation are the acceleration (6048_h) and deceleration (6049_h) ramps.

The 11th bit of the status word is also enabled as part of a limitation policy, related to security functions.

ℹ *The limitation on the setpoint does not guarantee that the engine speed will remain within the limits imposed by the safety function and that an error handling reaction will not be triggered. A consistent guideline with active safety features is required at the application level.*

Ramps
The ramp functions ensure smooth setpoints by limiting its variations, in acceleration or in deceleration.
The ramp function output, is the input of the motor control.

There are 3 ramp configurations:
- An accelerating ramp used when the setpoint increases in absolute value
- A nominal deceleration ramp used when the setpoint decreases in absolute value
- A fast deceleration ramp.

The configuration of each ramps is stored in two dictionary objects, object ($604C_h$):
- A speed variation ‘delta_speed’ expressed by default in RPM (Rotation Per Minute)
- A time variation ‘delta_time’ expressed in seconds.

The ramp is given by the following calculation:

$$ramp = \frac{delta\_speed}{delta\_time}$$

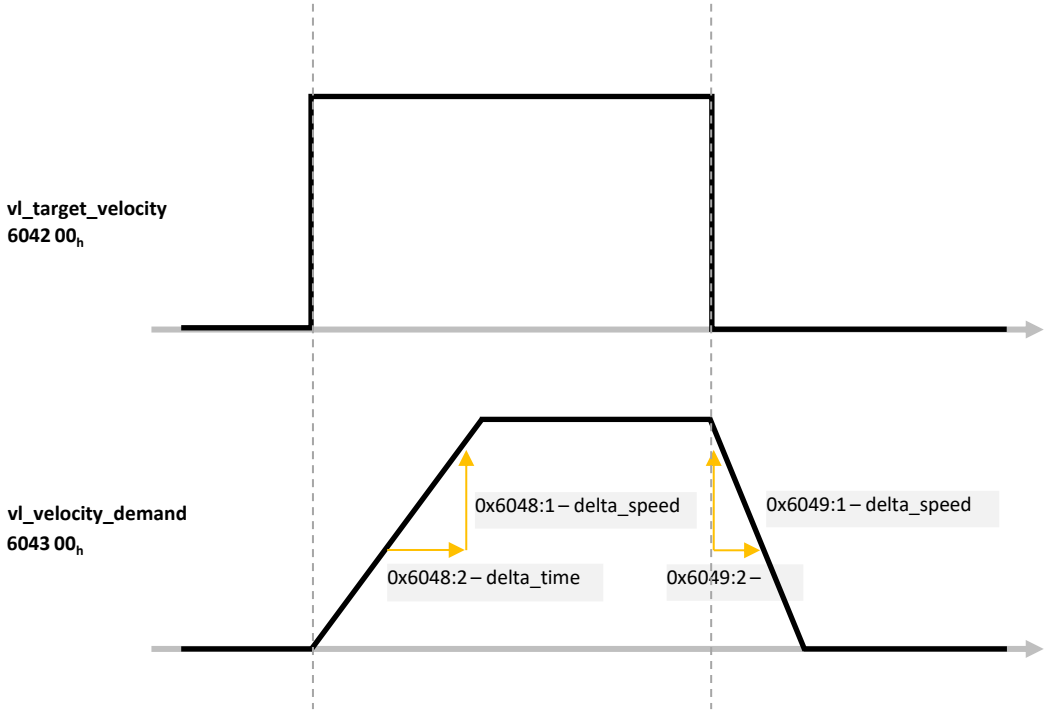


Figure 24 - Management of acceleration /deceleration ramps (1/2)

When inverting setpoint direction, the nominal ramp deceleration is used for returning to zero speed, then the acceleration ramp is used to reach the new setpoint.

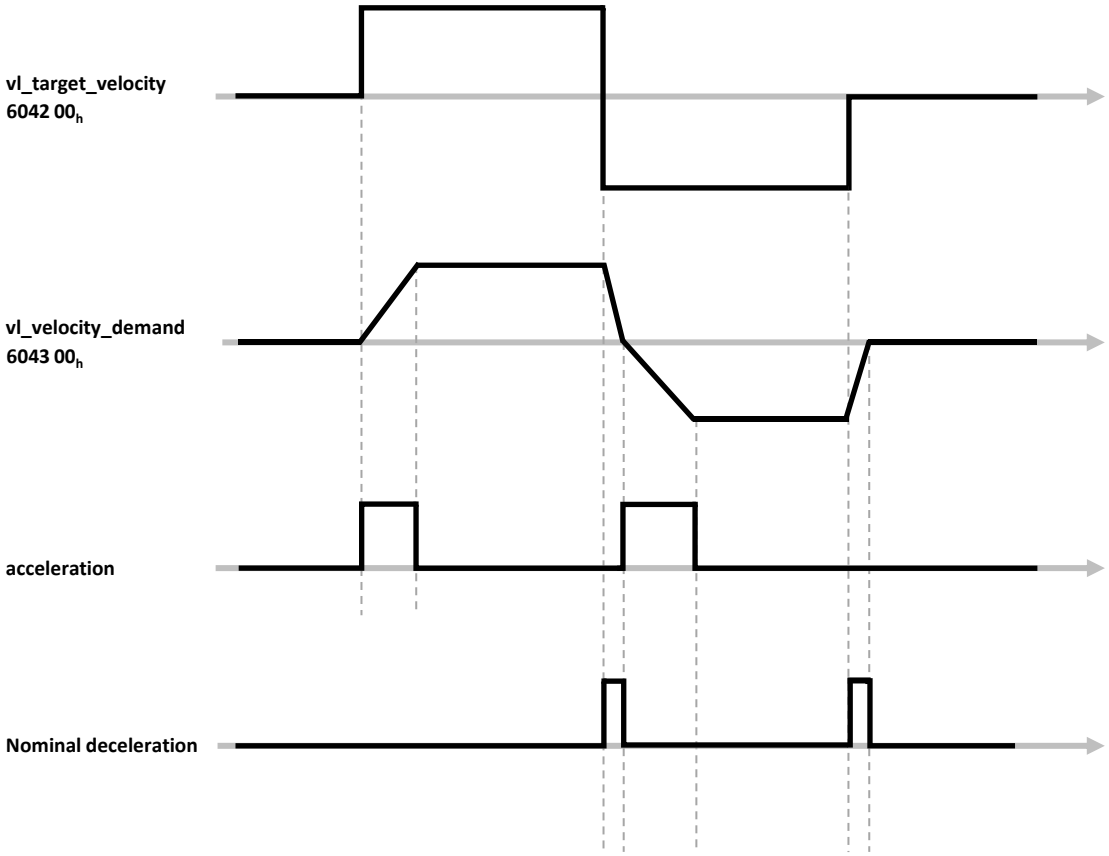


Figure 25 - Management of acceleration /deceleration ramps (2/2)

Ramp function control

Controlling function ramp is possible from given bits of the controlword.

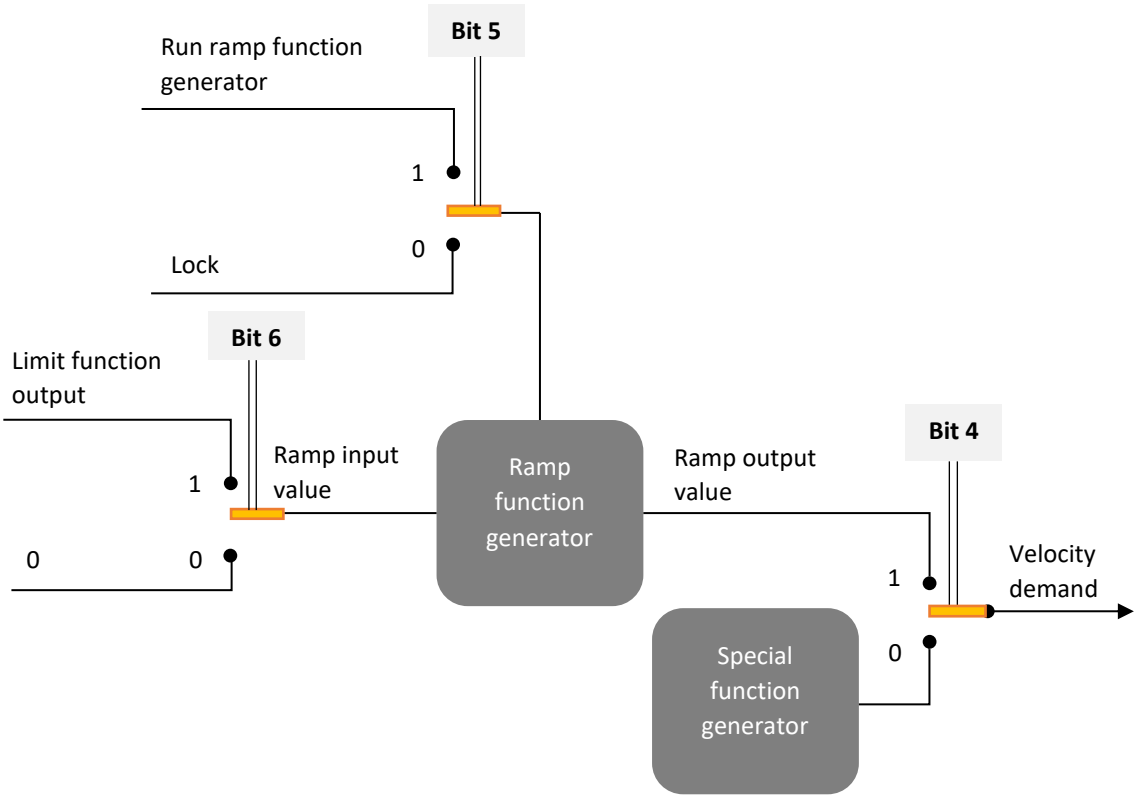


Figure 26 - Using controlword bits in velocity mode

Bit	Encoding controlword bits in velocity mode	
4	Enable ramp	0: The ramp module is disabled, the output of the block is identical to its input. 1: The ramp module is activated
5	Unlock ramp	0: The exit of the ramp block is frozen 1: The exit of the ramp block follows the entrance by applying the ramps
6	Reference rampe	0: The entrance to the ramp block is forced to 0, the ramp used is the deceleration ramp 1: The entrance of the ramp block corresponds to the exit of the speed limit block
8	Halt	0: No control, nominal operation 1: The engine stops, the ramp used depends on 605D Halt option code

Acceleration ramp

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes	Non-volatile storage
6048h	1	Acceleration_ delta_speed	U32	500	Rw	R	$r.min^{-1}$ (*4)	1	10000	4	Yes
6048h	2	Acceleration_ delta_time	U16	1	Rw	R	S	1	100	2	Yes

*4 This unit depends on the configuration of velocity_unit (604Ch)

Acceleration ramp

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes	Non-volatile storage
6049h	1	Deceleration_delta_speed	U32	500	Rw	R	r.min-1 (*)5	1	10000	4	Yes
6049h	2	Acceleration_delta_time	U16	1	Rw	R	s	1	100	2	Yes

Ramp deceleration 'Quick stop'

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes	Non-volatile storage
604Ah	1	QuickStop_delta_speed	U32	1000	Rw	R	r.min-1 (*)6	1	10000	4	Yes

Speed control

The 'speed control' block ensures the follow-up of the instruction elaborated by the ramp block of the engine. This block is based on a PID that seeks to cancel the speed error.

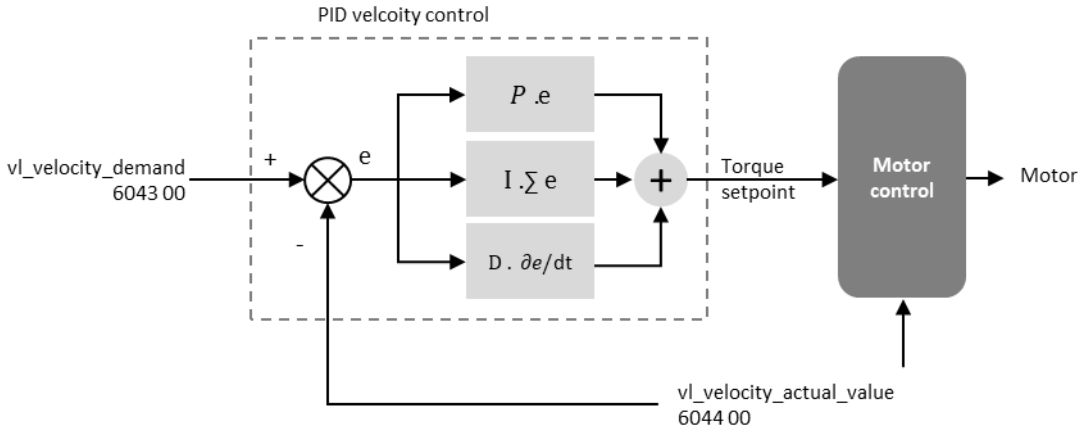


Figure 27 – Controller synoptic

PID parameters are accessible in the CANopen dictionary. They are updated during the transition to 'Operation Enable' state of the CiA 402 state machine.

- *Saving the coefficients is possible in non-volatile memory.*
- *If a user configuration exists, this is used when the drive starts.*

In the PID controller, the error 'e' is expressed in milli degrees per seconds, from the engine shaft.

*5 This unit depends on the configuration of velocity_unit (604Ch)
*6 This unit depends on the configuration of velocity_unit (604Ch)

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
2155	0	motctrl_speed_pid_p	U32	200	RW	R	10^{-10}	0	4294967295	4
2156	0	motctrl_speed_pid_i	U32	10	RW	R	10^{-10}	0	4294967295	4
2157	0	motctrl_speed_pid_d	U32	0	RW	R	10^{-10}	0	4294967295	4

9.3. Configuration

The configuration related to the motor drive is considered when switching to the 'Operation enable' state. Thus, in 'Operation enable', 'Quick stop active' and 'Fault reaction active' states, new configurations are not considered.

6007_h Abort connection option code
It is possible to define the action required when CANopen connection is lost.

SWD® Core considers that a loss of CANopen occurs in the following cases:

- *Bus-off*
- ***SWD® Core** in NMT STOPPED state*
- ***SWD® Core** in NMT BOOT state*

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
6007_h	0	Abort connection option code	I16	1	RW	NO	Table	0	3	2

Value	Definition
-32 768 to -1	Manufacturer-specific
0	No action
+1	Fault signal
+2	Disable voltage command
+3	Quick stop command
+4 to +32 767	Reserved

$605A_h$ Quick stop option code
It is possible to define the required action, after receiving a QuickStop order.

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
$605A_h$	0	Quick stop option code	I16	2	RW	NO	Table	0	6	2

Value	Definition
+1	Slow down on slow down ramp and transit into switch on disabled
+2	Slow down on quick stop ramp and transit into switch on disabled
+5	Slow down on slow down ramp and stay in quick stop active
+6	Slow down on quick stop ramp and stay in quick stop active

$605B_h$ Shutdown option code

It is possible to define the required action during transition 8: from 'operation enable' to 'ready to switch on'.

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes	Non-volatile storage
$605B_h$	0	shutdown option code	I16	0	RW	NO	Table	0	2	2	Yes

Value	Definition
0	Disable drive function (switch-off the drive power stage)
+1	Slow down with slow down ramp; disable of the drive function

$605C_h$ Disable operation option code

It is possible to define the required action during transition 8: from 'operation enable' to 'switched on state'.

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes	Non-volatile storage
$605B_h$	0	shutdown option code	I16	1	RW	NO	Table	0	1	2	Yes

Value	Definition
0	Disable drive function (switch-off the drive power stage)
+1	Slow down with slow down ramp; disable of the drive function

$605D_h$ Halt option code

It is possible to define the required action when receiving a 'Halt' order.

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
$605D_h$	0	Halt option code	I16	1	RW	NO	Table	1	2	2

Value	Definition
+1	Slow down on slow down ramp and stay in operation enabled
+2	Slow down on quick stop ramp and stay in operation enabled

605E$_h$ Fault reaction option code

It is possible to define the required action when detecting an internal error in the PDS (Power Drive System).

Value	Definition
0	Disable drive function, motor is free to rotate
+1	Slow down on slow down ramp
+2	Slow down on quick stop ramp

10. Security features

10.1. Overview of security features

Security features in the *SWD® Core*

The ***SWD® Core*** includes safe engine shutdown features, as well as advanced safe speed monitoring features. This exclusive integrated solution developed by ez-Wheel simplifies the machine architecture by avoiding the need for external supervisory bodies and safety logics.

The engine shutdown functions include:

- STO (Safe Torque Off): safe disconnection of engine torque
- SBC (Safe Brake Control): safe braking activation[7]

Speed monitoring functions are based on a security encoder integrated into the product and include:

- SDI (Safe Direction): safe control of the direction of rotation
- SLS (Safely Limited Speed): safe rotational speed limitation

These safety functions are implemented in accordance with IEC 61800-5-2 (functional safety requirements for the development of safety drives) and according to the CiA/DS 402-4 profile for the safety functions of engine controllers.

	Security features	Possible settings
STO	Safe disconnection of engine torque	Rearmament: ▪ automatic ▪ by request for acquittal Braking configuration associated with the STO (Cf. SBC)
SBC	Safe braking engagement	Joint activation of the STO: ▪ from internal braking to ***SWD® Core*** ▪ an external electromechanical brake ▪ of both brakes simultaneously
SDI	Safe control of the direction of rotation	Prohibition of the direction of rotation: ▪ positive or negative ▪ with two tolerance threshold levels
SLS	Safe rotational speed limitation	Prohibition of speeding: ▪ eight switchable throttling thresholds ▪ an adjustable trigger time

Typical use of security features

The safety functions of the ***SWD® Core*** are intended for speed-controlled load movement applications, for which risk assessment justifies the implementation of safe movement supervision.

[7] Development in progress

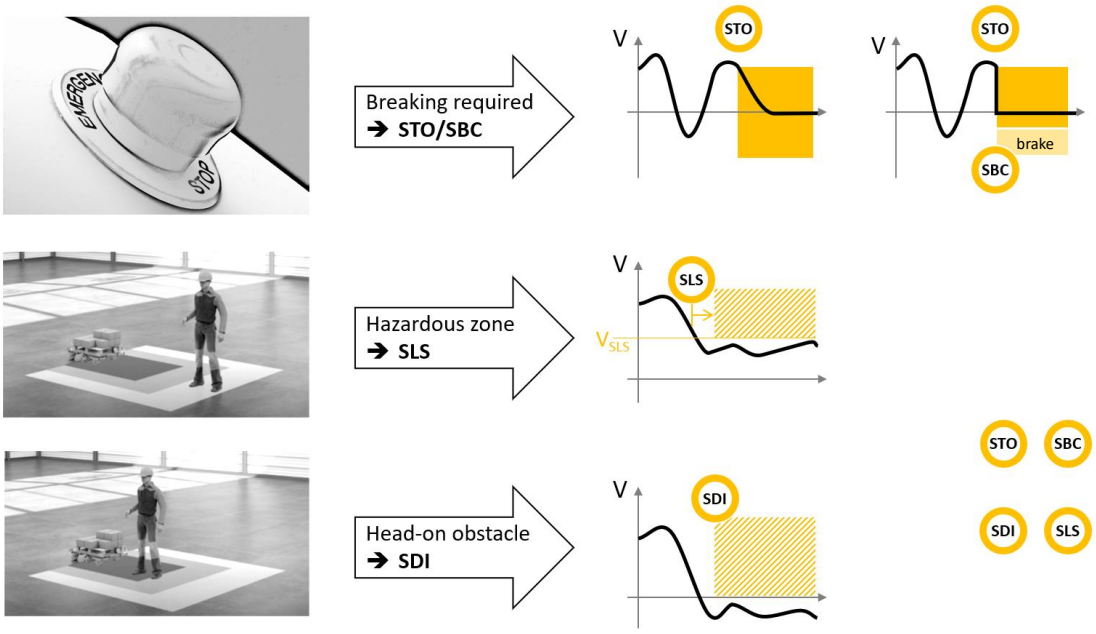


Figure 28 - Use of Security Features

10.2. Summary of security levels

	ISO 13849-1:2015			EN IEC 61508[8]				IEC 62061[9]	IEC 61800-5-2[10]	NF EN 60204-1[11]
Safety function	**Category**	**PL**	**PFHD /h**	**COAMING**	**PFH /h**	**PFDAVG / years**	**SFF**	**SIL CL**	**COAMING**	**Category**
STOP safety functions										
Safe Torque Off (STO) STO1 et STO2 inputs	Category 4	PL e	2.23E-8	SIL 3	8.9E-9	3.9E-5	100%	SIL3	SIL3	Category 0
Safe Torque Off (STO) CANopen Safety	Category 2	PL d	2.29E-7	SIL 2	8.9E-9	3.9E-5	99,7%	SIL 2	SIL 2	Category 0
Safety Safe Torque Off (STO) SafeInput	Category 2	PL d	2.29E-7	SIL 2	10.3E-9	4.5E-5	99,7%	SIL 2	SIL 2	Category 0
Safety Safe Torque Off (STO) Pair of SafeInput	Category 3	PL d	4.29E-8	SIL 2	11.6E-9	5.1E-5	99,7%	SIL 2	SIL 2	Category 0
Rearm of STO SafeInput	Category 2	PL d	2.29E-7	SIL 2	10.3E-9	4.5E-5	99,7%	SIL 2	SIL 2	Category 0
Rearm of STO CANopen safety	Category 2	PL d	2.29E-7	SIL 2	8.9E-9	3.9E-5	99,7%	SIL 2	SIL 2	Category 0
Monitoring safety functions										
Safely-limited speed (SLS) CANopen Safety	Category 2	PL d	2.29E-7	SIL 2	8.9E-9	3.9E-5	99,7%	SIL 2	SIL 2	ON
Safely-limited speed (SLS) SafeInput	Category 2	PL d	2.29E-7	SIL 2	10.3E-9	4.5E-5	99,7%	SIL 2	SIL 2	ON
Safely-limited speed (SLS) Pair of SafeInput	Category 3	PL d	4.29E-8	SIL 2	11.6E-9	5.1E-5	99,6%	SIL 2	SIL 2	ON
Safe direction (SDI) CANopen Safety	Category 2	PL d	2.29E-7	SIL 2	8.9E-9	3.9E-5	99,7%	SIL 2	SIL 2	ON
Safe direction (SDI) SafeInput	Category 2	PL d	2.29E-7	SIL 2	10.3E-9	4.5E-5	99,7%	SIL 2	SIL 2	ON
Safe direction (SDI) Pair of SafeInput	Category 3	PL d	4.29E-8	SIL 2	11.6E-9	5.1E-5	99,6%	SIL 2	SIL 2	ON

STO functions are certified for a **0 category stop** according to **EN 60204-1.**
This mode corresponds to the disconnection of the power supply from the motor for the STO function, which is then in free wheel.
A 114-year-old $MTTF_D$ is used for the entire drive.

[8] EN IEC 61508: December 2001 and April 2010

[9] NF EN 62061 (July 2005) + NF EN 62061/A1 (2013-05-10) + NF EN 62061/A2 (2015-12-25)

[10] IEC 61800 part 5-2 ed1 2007 and ed2 2016: Adjustable speed electrical power drive systems

[11] NF EN 60204-1:2018 “Safety of machinery - Electrical equipment of machines - Part 1: General requirements “ - IEC 60204-1:2016, modified

10.3. Control of security functions

The activation of safety functions results from an indirect mechanism of the CiA 402-4 norm. It synthesis several safety commands sent by the ***SWD® Core***.

Security functions are triggered by:

- The status of a security input on the I/O connector
- A security controlword in the CANopen dictionary
- A reaction from an internal error of the ***SWD® Core***.

⚠ *The status of a security function is accessible as read-only object in the CANopen dictionary, its development is carried out by the **SWD® Core**.*

Activation modes
The following options are available to control built-in safety features:

Function	Level	I/O connector	Autre *SWD® Core*	CANopen safety
STO	Up to SIL3	Yes	Not	Not
Software security feature:				
STO	Up to SIL2	Yes	Yes	Yes
SLS 1..8	Up to SIL2	Yes	Yes	Yes
SDI p/n	Up to SIL2	Yes	Yes	Yes

Types of sensors for activation

Sensors		Description
Electro-mechanical switch/safety switch	EMSS	Electromechanical switches with equivalent dual contacts / safety switches without signal processing element
Safety sensors with monitored semiconductor output	OSSD	Safety sensors with dual-channel semiconductor outputs for transverse short circuit monitoring
Safety sensors with test input	SCSD	Safety sensors with test input, signal processing element and test output

Configuring the activation of a security command via the CANopen

⚠ *To update control words value in a safe context, it is necessary to use safe messages, called SRDO.*

The activation of a security function by the CANopen must be carried out using safety controlword(s). Each *safety controlword,* allows you to command up to 8 security functions. Each bit of a safety control word, corresponds to the activation of a command.

The association of each bit of *the security controlword* to a command is carried out by configuring SRDO mappings.

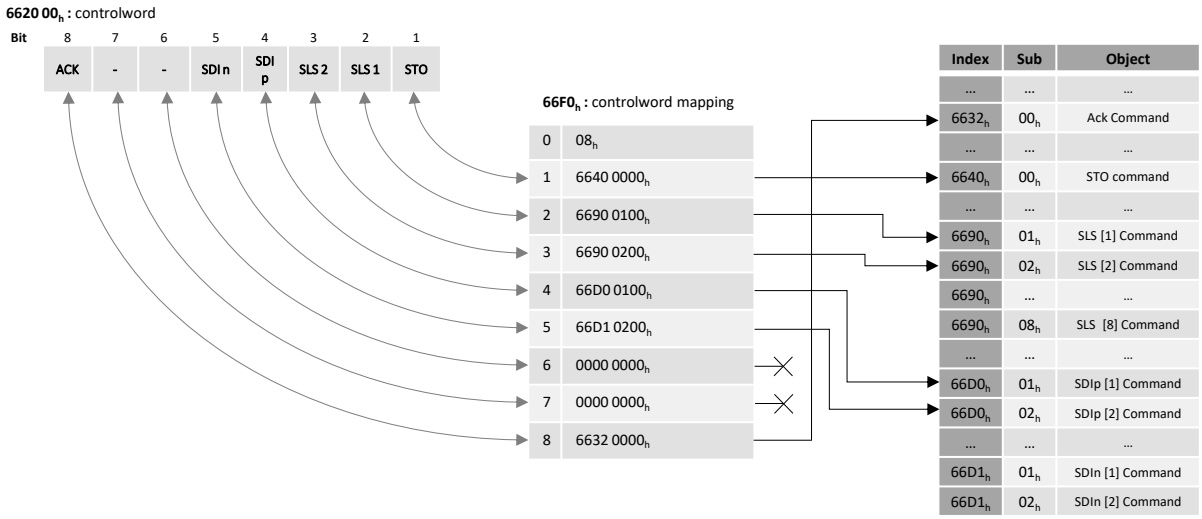


Figure 29 - Example of canopen configuration of safety controls

The list of commands that can be used in a mapping is:

Order code	Order
6632 0000h	Ack.STO
6640 0000h	STO
6690 0100h	SLS [1]
6690 0200h	SLS [2]
6690 0300h	SLS [3]
6690 0400h	SLS [4]
6690 0500h	SLS [5]
6690 0600h	SLS [6]
6690 0700h	SLS [7]
6690 0800h	SLS [8]
66D0 0100h	SDIp [1]
66D0 0200h	SDIp [2]
66D1 0100h	SDIn [1]
66D1 0200h	SDIn [2]

Default values

Safe controlword 1

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
66F0$_h$	00$_h$	Number of entries	U8	08$_h$	RO	NO	-	-	-	1
66F0$_h$	01$_h$	Command 1	U32	6640 0000$_h$ STO command	RW	NO	-	-	-	4
66F0$_h$	02$_h$	Command 2	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F0$_h$	03$_h$	Command 3	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F0$_h$	04$_h$	Command 4	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F0$_h$	05$_h$	Command 5	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F0$_h$	06$_h$	Command 6	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F0$_h$	07$_h$	Command 7	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F0$_h$	08$_h$	Command 8	U32	6632 0000$_h$ Error command	RW	NO	-	-	-	4

Safe controlword 2 to 8

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
66F1$_h$ to 66F8$_h$	00$_h$	Number of entries	U8	08$_h$	RO	NO	-	-	-	1
66F1$_h$ to 66F8$_h$	01$_h$	Command 1	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F1$_h$ to 66F8$_h$	02$_h$	Command 2	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F1$_h$ to 66F8$_h$	03$_h$	Command 3	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F1$_h$ to 66F8$_h$	04$_h$	Command 4	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F1$_h$ to 66F8$_h$	05$_h$	Command 5	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F1$_h$ to 66F8$_h$	06$_h$	Command 6	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F1$_h$ to 66F8$_h$	07$_h$	Command 7	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F1$_h$ to 66F8$_h$	08$_h$	Command 8	U32	0000 0000$_h$	RW	NO	-	-	-	4

Safe statusword 1

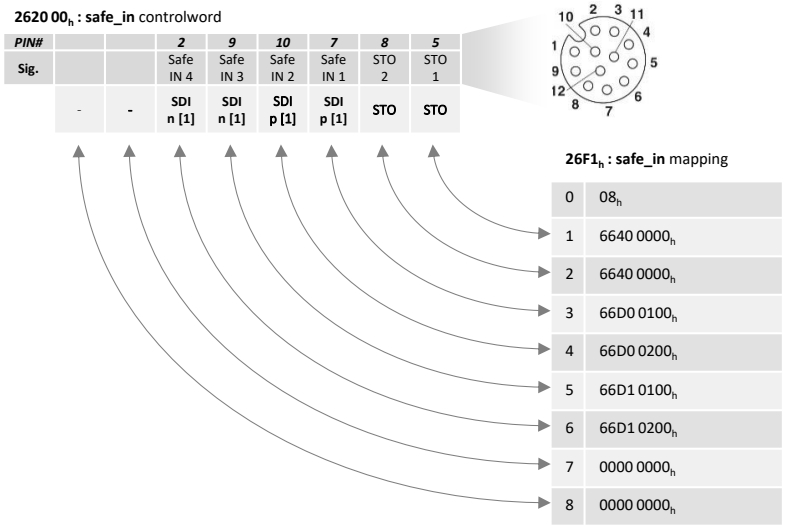
Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
66F8$_h$	00$_h$	Number of entries	U8	08$_h$	RO	NO	-	-	-	1
66F8$_h$	01$_h$	Status 1	U32	6644 0000$_h$ STO status	RW	NO	-	-	-	4
66F8$_h$	02$_h$	Status 2	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F8$_h$	03$_h$	Status 3	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F8$_h$	04$_h$	Status 4	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F8$_h$	05$_h$	Status 5	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F8$_h$	06$_h$	Status 6	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F8$_h$	07$_h$	Status 7	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F8$_h$	08$_h$	Status 8	U32	6633 0000$_h$ Error status	RW	NO	-	-	-	4

Safe statusword 2 to 8

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
66F9$_h$ to 66FF$_h$	00$_h$	Number of entries	U8	08$_h$	RO	NO	-	-	-	1
66F9$_h$ to 66FF$_h$	01$_h$	Status 1	U32	6644 0000$_h$ STO status	RW	NO	-	-	-	4
66F9$_h$ to 66FF$_h$	02$_h$	Status 2	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F9$_h$ to 66FF$_h$	03$_h$	Status 3	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F9$_h$ to 66FF$_h$	04$_h$	Status 4	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F9$_h$ to 66FF$_h$	05$_h$	Status 5	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F9$_h$ to 66FF$_h$	06$_h$	Status 6	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F9$_h$ to 66FF$_h$	07$_h$	Status 7	U32	0000 0000$_h$	RW	NO	-	-	-	4
66F9$_h$ to 66FF$_h$	08$_h$	Status 8	U32	6633 0000$_h$ Error status	RW	NO	-	-	-	4

Configuring commands associated with security entries

The list of the commands that can be used in a mapping is:



Code commande	Commande
6632 0000h	Ack.
6640 0000h	STO
6690 0100h	SLS [1]
6690 0200h	SLS [2]
6690 0300h	SLS [3]
6690 0400h	SLS [4]
6690 0500h	SLS [5]
6690 0600h	SLS [6]
6690 0700h	SLS [7]
6690 0800h	SLS [8]
66D0 0100h	SDIp [1]
66D0 0200h	SDIp [2]
66D1 0100h	SDIn [1]
66D1 0200h	SDIn [2]

Figure 30 - Example of how SafeInputs configure security commands

Order code	Order
6632 0000h	Ack.STO
6640 0000h	STO
6690 0100h	SLS [1]
6690 0200h	SLS [2]
6690 0300h	SLS [3]
6690 0400h	SLS [4]
6690 0500h	SLS [5]
6690 0600h	SLS [6]
6690 0700h	SLS [7]
6690 0800h	SLS [8]
66D0 0100h	SDIp [1]
66D0 0200h	SDIp [2]
66D1 0100h	SDIn [1]
66D1 0200h	SDIn [2]

The safe inputs work in pairs to achieve a SIL2/PLd/Cat3 security level. The configuration must be carried out to account for the joint operation by associating the same security function with the controls of the two inputs.

The entries are grouped as follows:

- INSafe_1 – INSafe_2
- INSafe_3 – INSafe_4

Default values

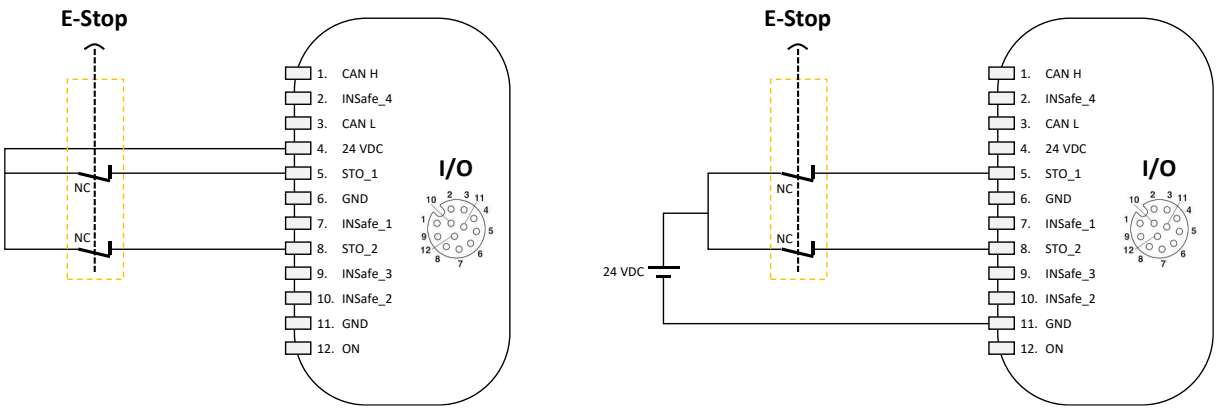
Safe_in controlword

In its default configuration, the security entries on the connector are not associated with a command. The configuration must be carried out by the manufacturer of the machine according to its architecture and the safety functions to be assigned.

The configuration of the STO_1 and STO_2 inputs is read-only and cannot be changed by configuration. These connector inputs are always associated with the STO function.

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
2620$_h$	00$_h$	Number of entries	U8	06$_h$	RO	NO	-	-	-	1
2620$_h$	01$_h$	Command STO_1	U32	6640 0000$_h$ STO command	RO	NO	-	-	-	4
2620$_h$	02$_h$	Command STO_2	U32	6640 0000$_h$ STO command $_h$	RO	NO	-	-	-	4
2620$_h$	03$_h$	Command INSafe_1	U32	0000 0000$_h$	RW	NO	-	-	-	4
2620$_h$	04$_h$	Command INSafe_2	U32	0000 0000$_h$	RW	NO	-	-	-	4
2620$_h$	05$_h$	Command INSafe_3	U32	0000 0000$_h$	RW	NO	-	-	-	4
2620$_h$	06$_h$	Command INSafe_4	U32	0000 0000$_h$	RW	NO	-	-	-	4

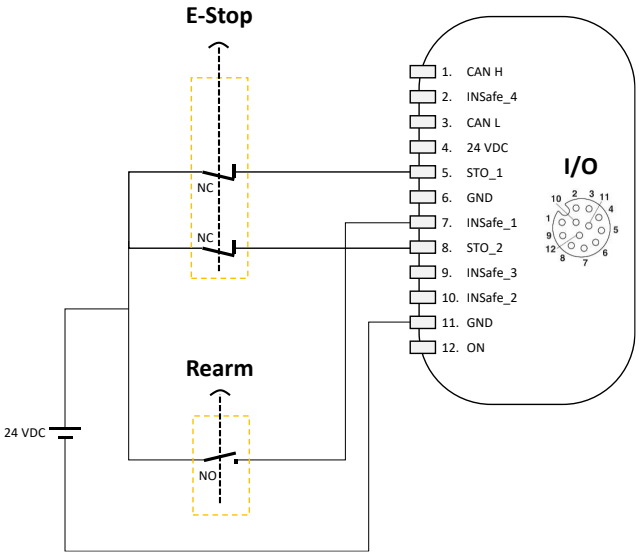
Activation of the STO by emergency stop via the I/O Connector interface, compliance up to SIL3 / PLe / Cat4



A switch in accordance with ISO 13850, with a positive opening according to CE 60947-5-1, or a certified safety controller must be used as an actuation element.

The input security component must be chosen to satisfy the overall level of the security function.

Rearming the STO by pressing the 1NO button connected to the INSafe_1 input, Holds up to 100h



The single input INSafe_1 is configured as a rearmament input after an STO engagement. A front rising from 0 to 24 VDC on the INSafe_1 inlet tilts the STO State to 0 and restores torque to the engine.

Input safety components must be chosen to meet the overall level of the security function.

The maintenance of the safety function before rearmament is ensured for a maximum of 100 hours.

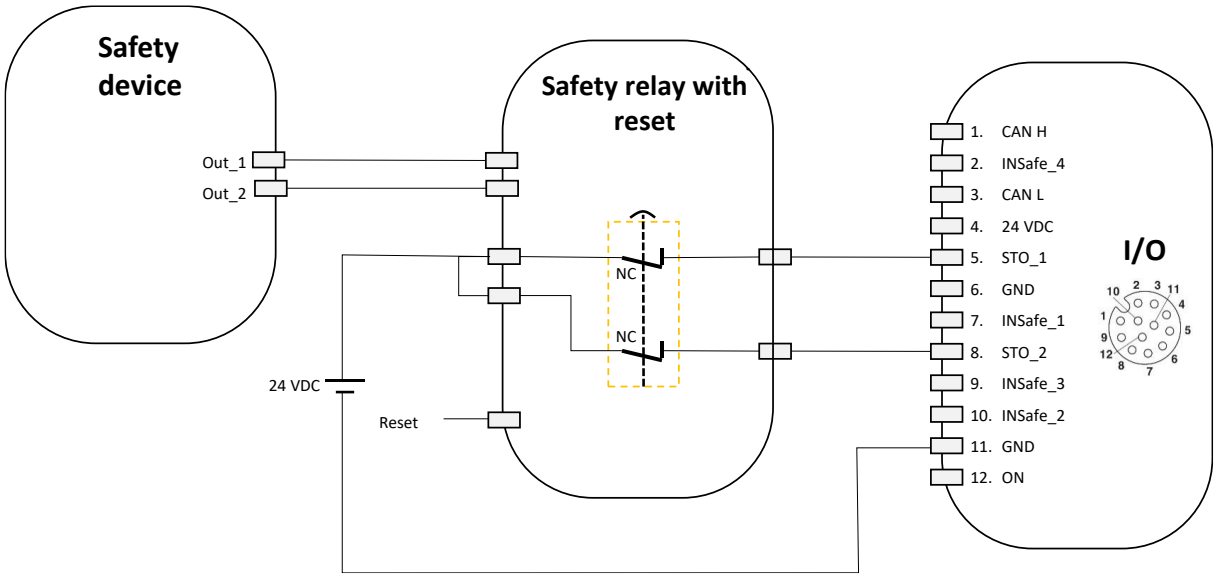
Activation of the STO by emergency stop, compliance up to SIL3 / Ple, and reset by NO button on single input, maintains beyond 100h using a safety relay

For the regulations of the Machinery Directive in Europe, the additional requirements of EN ISO 14118:2018 for non-restart must be considered.

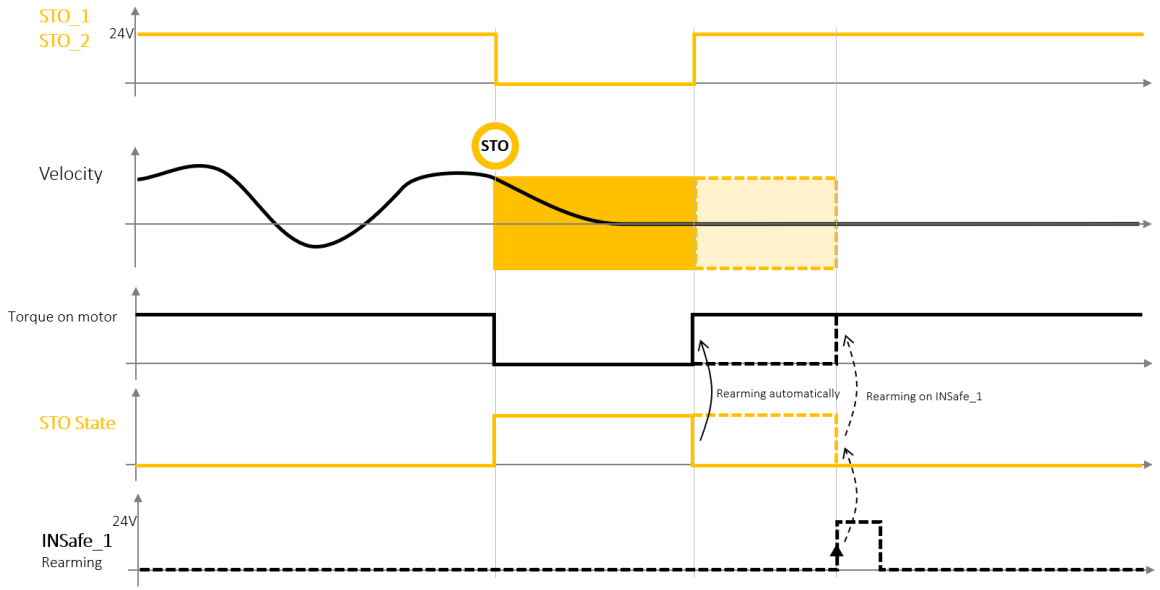
The performance levels of the safety functions and the STO position guarantee are guaranteed for a period of 100 hours.

In the event of a power cut, this periodicity of time is guaranteed, because in normal operation, the drive must be restarted after a physical action by the user.

After this 100-hour period, the drive can accumulate failures and, to avoid a dangerous situation, the addition of a safety relay is necessary to comply with EN ISO 14118:2018 for non-restart requirements.



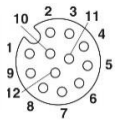
Input safety components must be chosen to meet the overall level of the security function.



In this configuration the controlword safe_in is configured as follows:

2620 00$_h$: safe_in controlword

PIN#			*2*	*9*	*10*	*7*	*8*	*5*
Sig.			Safe IN 4	Safe IN 3	Safe IN 2	Safe IN 1	STO 2	STO 1
	-	-	**SDI n [1]**	**SDI n [1]**	**SDI p [1]**	**SDI p [1]**	**STO**	**STO**

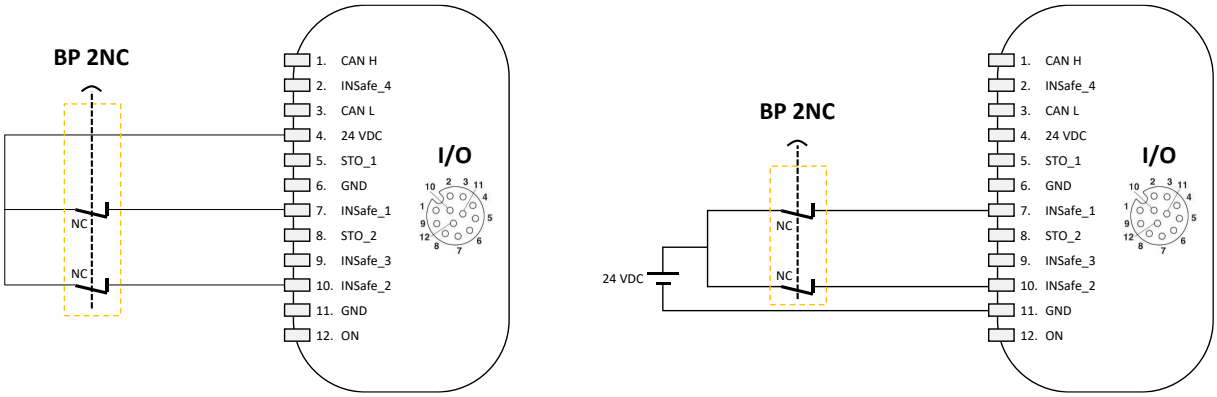


26F1$_h$: safe_in mapping

0	08$_h$
1	6640 0000$_h$
2	6640 0000$_h$
3	66D0 0100$_h$
4	66D0 0200$_h$
5	66D1 0100$_h$
6	66D1 0200$_h$
7	0000 0000$_h$
8	0000 0000$_h$

Code commande	Commande
6632 0000$_h$	Ack.
6640 0000$_h$	STO
6690 0100$_h$	SLS [1]
6690 0200$_h$	SLS [2]
6690 0300$_h$	SLS [3]
6690 0400$_h$	SLS [4]
6690 0500$_h$	SLS [5]
6690 0600$_h$	SLS [6]
6690 0700$_h$	SLS [7]
6690 0800$_h$	SLS [8]
66D0 0100$_h$	SDIp [1]
66D0 0200$_h$	SDIp [2]
66D1 0100$_h$	SDIn [1]
66D1 0200$_h$	SDIn [2]

Activation of a software safety function by 2 NC switch, compliance up to SIL2 / PLd / Cat3



A switch in accordance with ISO 13850, with a positive opening according to CE 60947-5-1, or a certified safety controller must be used as an actuation element.

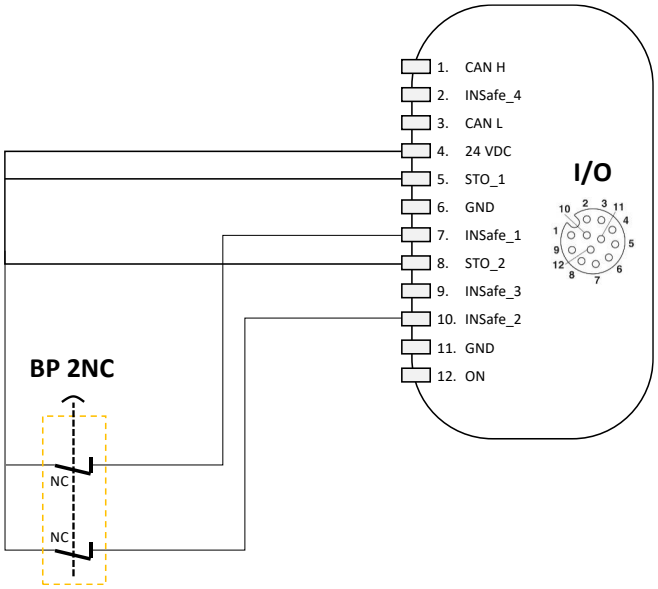
Input safety components must be chosen to meet the overall level of the security function.

In the case of enabling a software security feature by the I/O connector interface, it is necessary to configure the associated security function for each of the security entries.

Configuring the security features

Configuring commands associated with security entries.

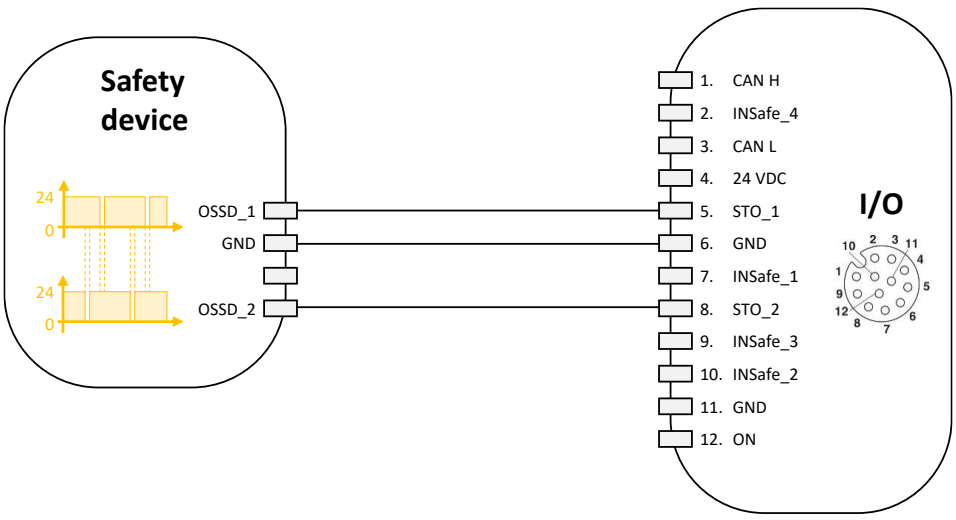
Permanent deactivation of the STO, activation of another function by 2NC switch, compliance up to SIL2 / PLd



A switch in accordance with ISO 13850, with a positive opening according to CE 60947-5-1, or a certified safety controller shall be used as an actuation element.

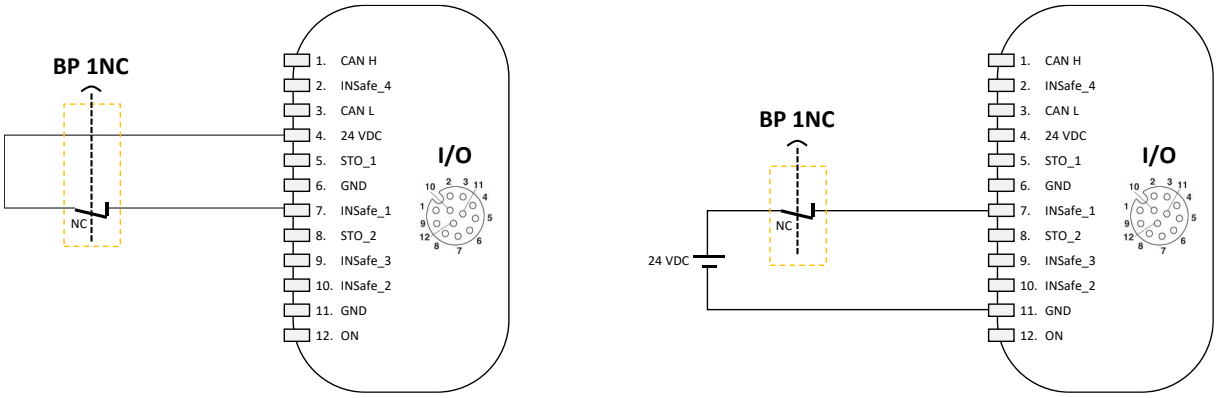
The input security component must be chosen to satisfy the overall level of the security function.

STO activation by OSSD outputs, compliance up to SIL3/PIe



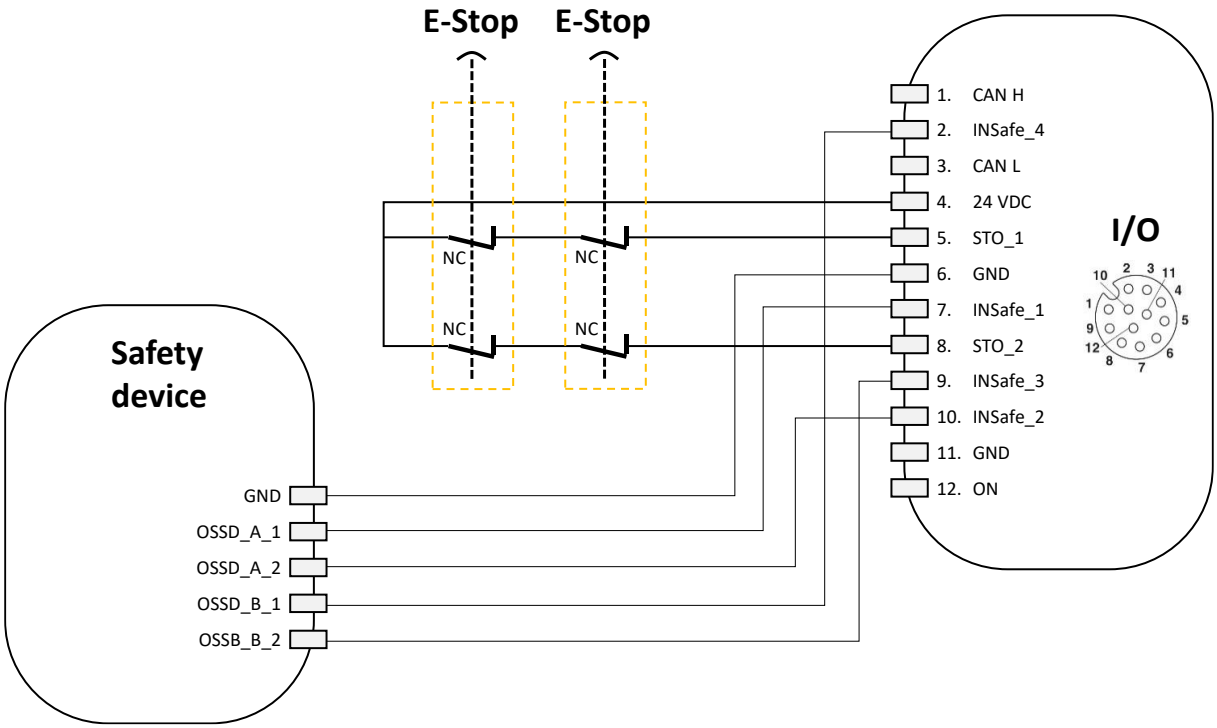
A certified sensor with a pair of OSSDs, a sensor, a safety controller.
The input security component must be chosen to satisfy the overall level of the security function.

Use of single inputs, compliance up to SIL2 / PLd



The input security component must be chosen to satisfy the overall level of the security function.

Activation of the STO by two emergency stops, compliance up to SIL3 / Ple, and activation of two other functions by OSSD signals, compliance up to SIL2 / PLd



Input safety components must be chosen to meet the overall level of the security function.

Deferring safety inputs in a system using multiple *SWD® Core drives*

The status information of the security entries is available in the CANopen dictionary. This information is stored in dictionary objects, in the form of an object and its inverse, allowing the use of an SRDO message as Safe Control Word.

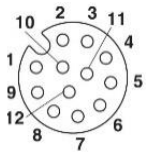
The ***SWD® Core*** on which the security inputs are wired is in this use case transmitter of the SRDO containing the status of these security inputs. Other ***SWD® Core*** consume the Safe Control Word contained in this SRDO.

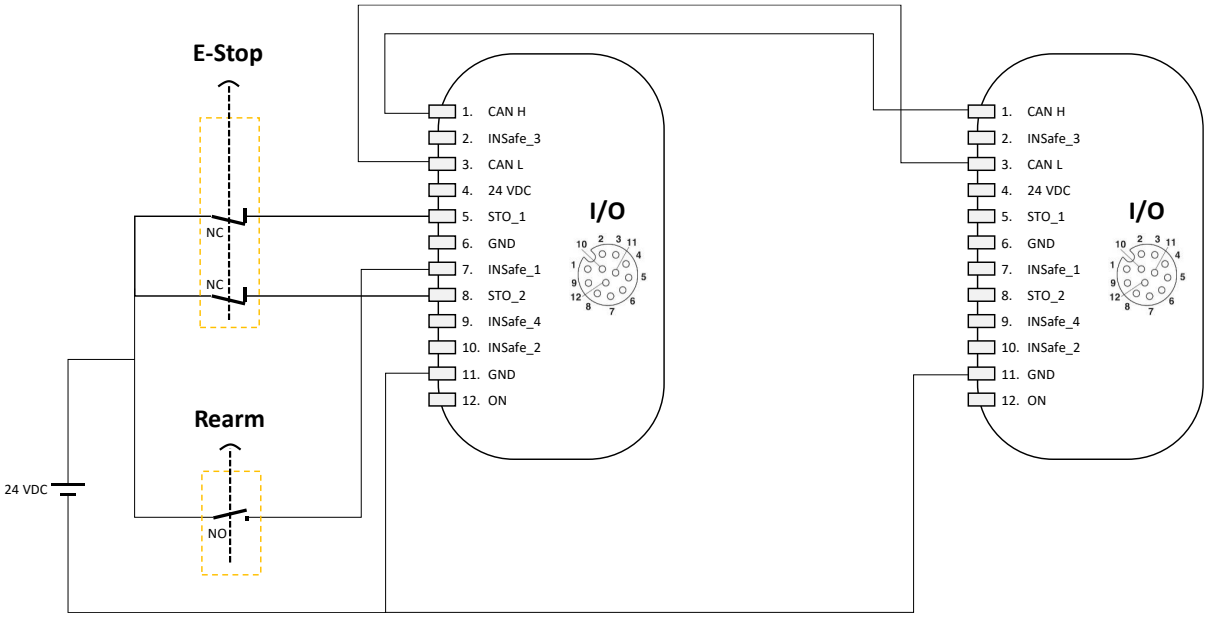
The configuration of the security function commands must be performed on each of the ***SWD® Core***.

It is done by configuring the ***safeIn control word*** for the first ***SWD® Core*** and by configuring the ***safe control word n*** received by CANopen safety on the second ***SWD® Core.***

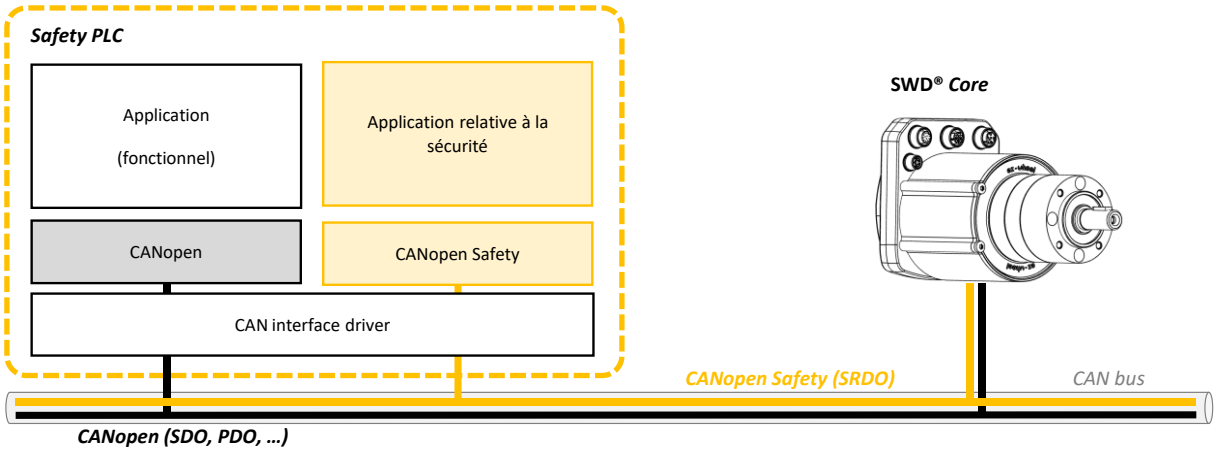
2620 00_h : safe_in controlword

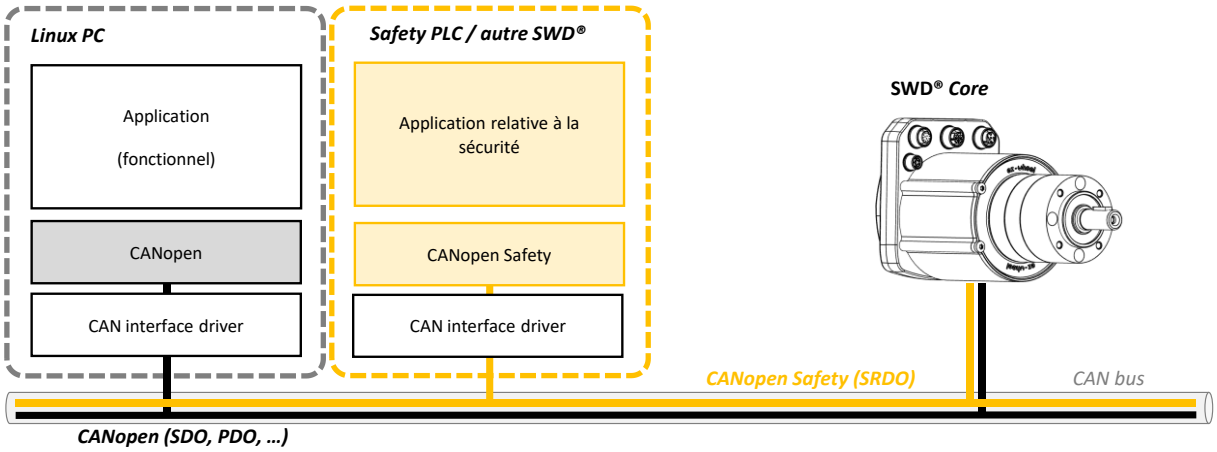
PIN#			*2*	*9*	*10*	*7*	*8*	*5*
Sig.			Safe IN 4	Safe IN 3	Safe IN 2	Safe IN 1	STO 2	STO 1
	-	-	**SDI n [1]**	**SDI n [1]**	**SDI p [1]**	**SDI p [1]**	**STO**	**STO**





Connecting to a CANopen safety calculator





10.4. Security features

Activating the STO

The STO is activated by the 0x6640 command, which is active in the low state.

After engagement of an STO, the motor is electrically disconnected and no longer applies torque. The speed slows down, but in the case of activating the STO alone, the motor is not braked, and the speed deceleration is a function of the inertia of the drive.

The STO State 0x6644 status is active in the high state after STO engagement and remains active until rearmament.

Activating STO

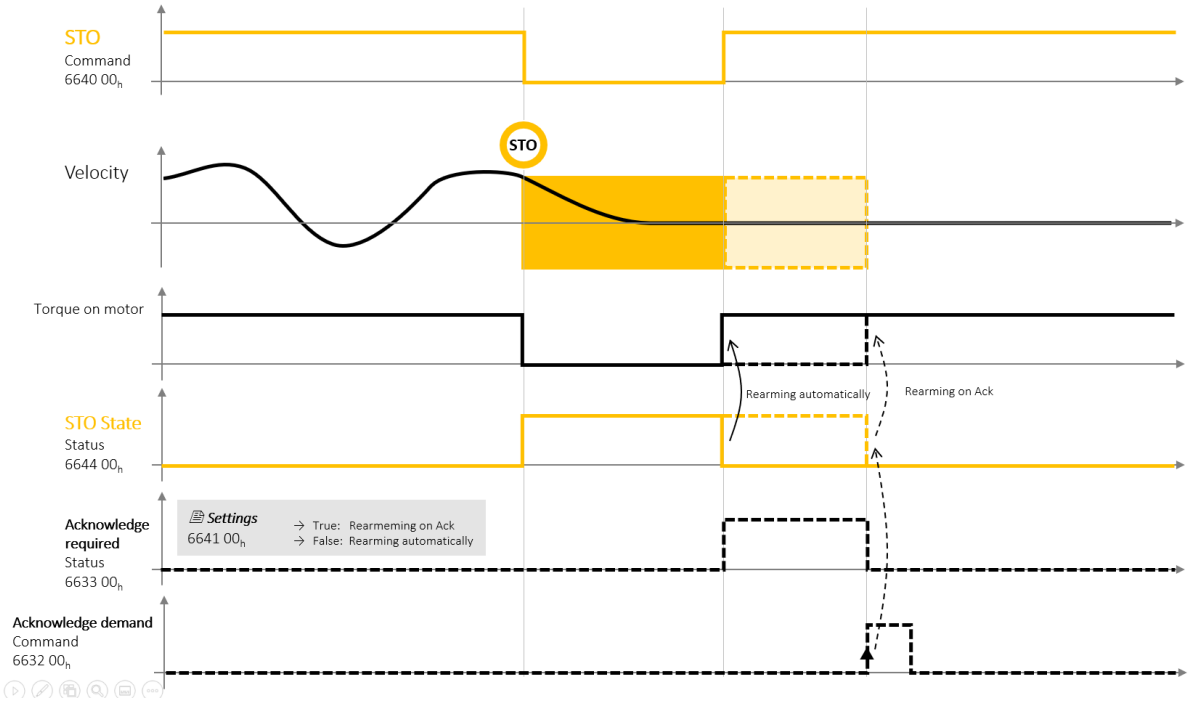


Figure 31 - STO Activation and Acquittal Diagram

The rearmament mode is set via the 0x6641 register, a *False* value engages an automatic rearmament when the STO signal disappears, and a *True* value requires an Acknowledge acknowledgment to rearm.

In the case of *acknowledge* rearmament, the status 0x6633 is active in the high state as long as an acquittal is expected. Acknowledge's request must be made by placing the order 0x6632 in the high state, the rising front triggering the payment.

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
6632h	00	Acknowledge	BOOLEAN	0	WHERE	NO		0	1	1
6633h	00	Acknowledge error required	BOOLEAN	0	RO	NO	-	0	1	1
6640h	00	STO Command	BOOLEAN	1	RO	NO	-	0	1	1
6641h	00	STO acknowledge behavior	BOOLEAN	0	RW	NO	-	0	1	1
6643h	00	STO active SBC	U32	0	RO	NO	-	0000 0000h 6660 0100h 6660 0200h 6660 0300h		4
6644h	00	STO status	BOOLEAN	0	RO	NO	-	0	1	1

Activating IDW

Two SDIp and SDIn commands can be activated in the low state to prohibit the positive and negative direction of rotation of the motor respectively (see Setting the direction of rotation).

The two commands each have two indexes to enable two different tolerance threshold levels *nZero_SDI* (speed in rpm) in the SDI trigger mechanism. A total of four controls are controllable:

- 66D0 01_h: Positive SDI above the *+nZero_SDI* threshold, index value 01
- 66D1 01_h: Negative SDI above the *-nZero_SDI* threshold, index value 01
- 66D0 02_h: Positive SDI above the *+nZero_SDI* threshold, index value 02
- 66D1 02_h: Negative SDI above the *-nZero_SDI* threshold, index value 02

The trigger thresholds *nZero_SDI* are configurable by the registers 66D5 01_h and 66D5 02_h.

Exceeding the threshold by the engine rotation speed when an SDI control is active results in the violation of an SDI and the triggering of the STO. The rearmament mode then works in the same way as for STO activation alone (see STO Activation).

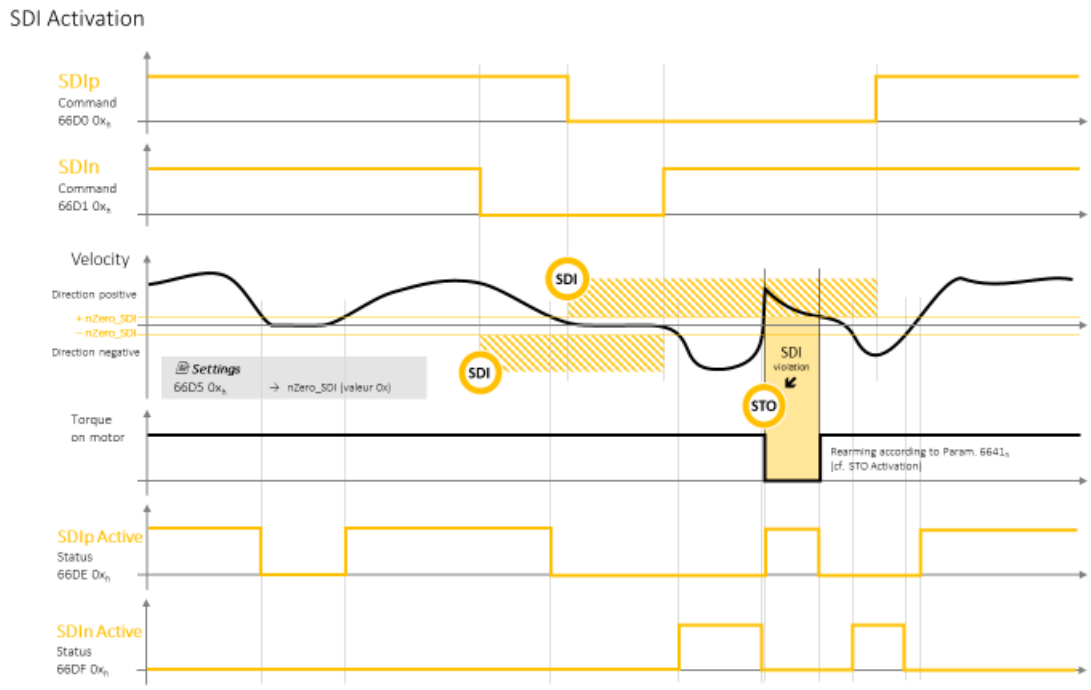


Figure 32 - CIU Activation Diagram

Two *SDIp Active* and *SDIn Active* statuses are available, even without enabling SDI functions, to indicate whether the rotation speed is above the trigger threshold *nZero_SDI*. The thresholds use the values of the two parameterized indexes, so a total of four rotational direction detection statuses can be used to monitor engine activity:

- 66DE 01_h: rotation positive direction beyond the threshold *+nZero_SDI*, index value 01
- 66DF 01_h: negative direction rotation beyond the threshold *-nZero_SDI*, index value 01
- 66DE 02_h: rotation positive direction beyond the threshold *+nZero_SDI*, index value 02
- 66DF 02_h: negative direction rotation beyond the threshold *-nZero_SDI*, index value 02

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes
66D0h	00h to 02h	SDIp Commands	BOOL EAN	1	RO	NO	-	0	1	1
66D1h	00h to 02h	SDIn Commands	BOOL EAN	1	RO	NO				
66D5h	00	SDI velocity zero window	U32	0	RW	NO	rpm	0	1	1
66DEh	00h to 02h	SDIp statuses	BOOL EAN	0	RO	NO	-	0	1	1
66DFh	00h to 02h	SDI statuses	BOOL EAN	0	RO	NO	-	0	1	1

⚠ The SDI safety function is guaranteed from 50 rpm (rotations per minute) at the motor shaft. Below this value, the SIL level and the associated criteria PL, category is not guaranteed.

Enabling SLS

Eight SLS speed limit levels can be activated by the 6690h control, index 01 to 08.

The SLS 6690h is active in the low state, and speed monitoring is activated after a trigger time defined by the first of these two events:

- The time t_SLS (in ms) since the SLS command was activated
- The time t_L_SLS (in ms) elapsed after the speed is shifted in the allowed window

The speed allowed is limited by the value n_SLS (in rpm), in both directions of rotation.
For each of the eight operable SLS, the values are configurable by the registers:

- 6693 0xh: Speed n_SLS, value for index 0x [01..08]
- 6691 0xh: Time t_SLS, value for index 0x [01..08]
- 6694 0xh: Time t_L_SLS, value for index 0x [01..08]

Exceeding these thresholds by the engine rotation speed when an SLS control is active results in the violation of an SLS and the triggering of the STO. The rearmament mode then works in the same way as for STO activation alone (see STO Activation).

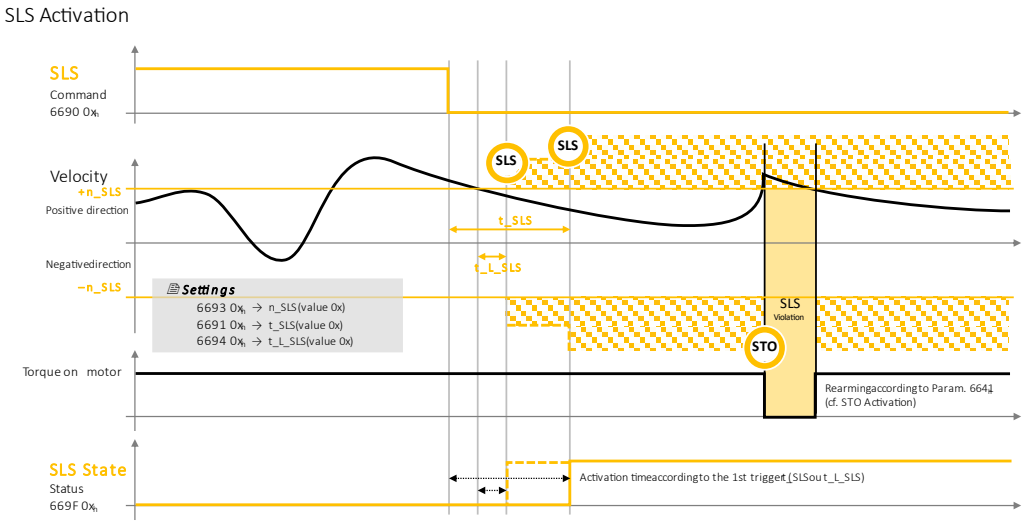


Figure 33 - SLS Activation Diagram

The *STATUS SLS State* 6697 0x$_h$, also according to the indexes [01..08], is active in the high state when the speed monitoring triggered by the SLS 6690 0xh command is activated.

Idx	Sub	Name	Data Type	Default Value	Access Type	PDO Mapping	Unit	Lower Limit	Upper Limit	Size in Bytes	Non-volatile storage
6690$_h$	00_h to 08_h	SLS Commands	BOOLEAN	-	RO	NO	-	0	1	1	-
6691$_h$	00_h to 08_h	Time before Monitoring starts	U16	0	RW	NO	MS	0	U16	2	YES
6693$_h$	00_h to 08_h	SLS speed limit	U32	0	RW	NO	rpm	100	U32	4	YES
6694$_h$	00_h to 08_h	Time before SLS startup "within the limit"	U16	0	RW	NO	MS	0	U16	2	YES
6698$_h$	00_h to 08_h	SLS reactions in case of error	U32	6640 0000$_h$	RW	NO	-	0: no reaction 6640 0000 STO		4	YES
669F$_h$	00_h to 02_h	SLS statuses	BOOLEAN	-	RO	NO	-	0	1	1	-

⚠ The user can choose to disable the reaction if he wishes to use the 'status' of the SLS for another use. This configuration depends on the use case of the ***SWD® Core*** and is the responsibility of the machine manufacturer.

⚠ The SLS safety function is guaranteed from 100 rpm (rotations per minute) at the motor shaft. Below this value, the SIL level and the associated criteria PL, category is not guaranteed.

10.5. Signature

Security configurations include a CRC-like signature to ensure their integrity.
A signature error prevents the transition to the operational NMT state.
In case of error on the signature of one of the safety functions, the object 660700$_h$ 'Safety application configuration valid' is worth 00_h, otherwise it is worth $A5_h$.

Calculation method
The calculation of the CRCs of the safety data groups is performed with the CRC-16-CCITT generation polynomial:
$G(x) = x^{16}+x^{12}+x^5+1$

Sample implementation:

```
UNSIGNED16   crc = 0u;
```
For each byte do:
```
      crc = CrcCalc(crc, octet);
```

Example of function CrcCalc():

```
UNSIGNED16 CrcCalc(
            UNSIGNED16        crc,              /* start value for CRC */
            UNSIGNED8         value             /* pointer to data for CRC */
      )
{
static const UNSIGNED16 crc_tabccitt[256] = {
 0x0000u, 0x1021u, 0x2042u, 0x3063u, 0x4084u, 0x50a5u, 0x60c6u, 0x70e7u,
 0x8108u, 0x9129u, 0xa14au, 0xb16bu, 0xc18cu, 0xd1adu, 0xe1ceu, 0xf1efu,
 0x1231u, 0x0210u, 0x3273u, 0x2252u, 0x52b5u, 0x4294u, 0x72f7u, 0x62d6u,
 0x9339u, 0x8318u, 0xb37bu, 0xa35au, 0xd3bdu, 0xc39cu, 0xf3ffu, 0xe3deu,
 0x2462u, 0x3443u, 0x0420u, 0x1401u, 0x64e6u, 0x74c7u, 0x44a4u, 0x5485u,
 0xa56au, 0xb54bu, 0x8528u, 0x9509u, 0xe5eeu, 0xf5cfu, 0xc5acu, 0xd58du,
```

```
 0x3653u, 0x2672u, 0x1611u, 0x0630u, 0x76d7u, 0x66f6u, 0x5695u, 0x46b4u,
 0xb75bu, 0xa77au, 0x9719u, 0x8738u, 0xf7dfu, 0xe7feu, 0xd79du, 0xc7bcu,
 0x48c4u, 0x58e5u, 0x6886u, 0x78a7u, 0x0840u, 0x1861u, 0x2802u, 0x3823u,
 0xc9ccu, 0xd9edu, 0xe98eu, 0xf9afu, 0x8948u, 0x9969u, 0xa90au, 0xb92bu,
 0x5af5u, 0x4ad4u, 0x7ab7u, 0x6a96u, 0x1a71u, 0x0a50u, 0x3a33u, 0x2a12u,
 0xdbfdu, 0xcbdcu, 0xfbbfu, 0xeb9eu, 0x9b79u, 0x8b58u, 0xbb3bu, 0xab1au,
 0x6ca6u, 0x7c87u, 0x4ce4u, 0x5cc5u, 0x2c22u, 0x3c03u, 0x0c60u, 0x1c41u,
 0xedaeu, 0xfd8fu, 0xcdecu, 0xddcdu, 0xad2au, 0xbd0bu, 0x8d68u, 0x9d49u,
 0x7e97u, 0x6eb6u, 0x5ed5u, 0x4ef4u, 0x3e13u, 0x2e32u, 0x1e51u, 0x0e70u,
 0xff9fu, 0xefbeu, 0xdfddu, 0xcffcu, 0xbf1bu, 0xaf3au, 0x9f59u, 0x8f78u,
 0x9188u, 0x81a9u, 0xb1cau, 0xa1ebu, 0xd10cu, 0xc12du, 0xf14eu, 0xe16fu,
 0x1080u, 0x00a1u, 0x30c2u, 0x20e3u, 0x5004u, 0x4025u, 0x7046u, 0x6067u,
 0x83b9u, 0x9398u, 0xa3fbu, 0xb3dau, 0xc33du, 0xd31cu, 0xe37fu, 0xf35eu,
 0x02b1u, 0x1290u, 0x22f3u, 0x32d2u, 0x4235u, 0x5214u, 0x6277u, 0x7256u,
 0xb5eau, 0xa5cbu, 0x95a8u, 0x8589u, 0xf56eu, 0xe54fu, 0xd52cu, 0xc50du,
 0x34e2u, 0x24c3u, 0x14a0u, 0x0481u, 0x7466u, 0x6447u, 0x5424u, 0x4405u,
 0xa7dbu, 0xb7fau, 0x8799u, 0x97b8u, 0xe75fu, 0xf77eu, 0xc71du, 0xd73cu,
 0x26d3u, 0x36f2u, 0x0691u, 0x16b0u, 0x6657u, 0x7676u, 0x4615u, 0x5634u,
 0xd94cu, 0xc96du, 0xf90eu, 0xe92fu, 0x99c8u, 0x89e9u, 0xb98au, 0xa9abu,
 0x5844u, 0x4865u, 0x7806u, 0x6827u, 0x18c0u, 0x08e1u, 0x3882u, 0x28a3u,
 0xcb7du, 0xdb5cu, 0xeb3fu, 0xfb1eu, 0x8bf9u, 0x9bd8u, 0xabbbu, 0xbb9au,
 0x4a75u, 0x5a54u, 0x6a37u, 0x7a16u, 0x0af1u, 0x1ad0u, 0x2ab3u, 0x3a92u,
 0xfd2eu, 0xed0fu, 0xdd6cu, 0xcd4du, 0xbdaau, 0xad8bu, 0x9de8u, 0x8dc9u,
 0x7c26u, 0x6c07u, 0x5c64u, 0x4c45u, 0x3ca2u, 0x2c83u, 0x1ce0u, 0x0cc1u,
 0xef1fu, 0xff3eu, 0xcf5du, 0xdf7cu, 0xaf9bu, 0xbfbau, 0x8fd9u, 0x9ff8u,
 0x6e17u, 0x7e36u, 0x4e55u, 0x5e74u, 0x2e93u, 0x3eb2u, 0x0ed1u, 0x1ef0u
};
	UNSIGNED16 tmp, x;

	x = (UNSIGNED16)value;
	x &= 0xffu;

	tmp = (crc >> 8) ^ x;
	crc = (UNSIGNED16)((crc & 0xffu) << 8) ^ crc_tabccitt[tmp];

	return(crc);
}
```

Signature of the SRDO

There is a signature for each of the SRDO configurations.

Signatures are stored in the 'Safety configuration checksum' $13FF_h$ object at the Sub-index corresponding to the SRDO:

	Sub for storing the signature in the object $13FF_h$	Index of communication parameters	Index of mapping parameters
SRDO 1	01_h	1301_h	1381_h
SRDO 2	02_h	1302_h	1382_h
SRDO 9	09_h	1309_h	1389_h
SRDO 10	$0A_h$	$130A_h$	$138A_h$
SRDO 11	$0B_h$	$130B_h$	$138B_h$
SRDO 12	$0C_h$	$130C_h$	$138C_h$
SRDO 13	$0D_h$	$130D_h$	$138D_h$
SRDO 14	$0E_h$	$130E_h$	$138E_h$
SRDO 15	$0F_h$	$130F_h$	$138F_h$
SRDO 16	10_h	1310_h	1390_h

⚠ Remarque: SRDO 3 to 8 do not exist.

The data to be considered are, in order:

Index	Sub	Name	Size to consider
Index of communication parameters	01	Information direction	1 octet
Index of communication parameters	02	Refresh time or SCT	2 bytes
Index of communication parameters	03	SRVT	1 octet
Index of communication parameters	05	COB-ID 1	4 bytes
Index of communication parameters	06	COB-ID 2	4 bytes
Index of mapping parameters	00	Number of mapping parameters	1 octet
For each X object in the mapping:			
Index of mapping parameters	X	Object number in mapping	1 octet
Index of mapping parameters	0x	Input given	4 bytes

Signature STO

The STO configuration signature is stored in object 6645 $_{00h}$

The data to be considered are, in order:

Index	Sub-Index	Name	Size to consider
6641_h	00	STO acknowledge behavior	1 bit
$66F0_h$	01 to 08	Security Controlword 1	4 bytes for each sub-index
$66F1_h$	01 to 08	Security Controlword 2	4 bytes for each sub-index
$66F2_h$	01 to 08	Security Controlword 3	4 bytes for each sub-index
$66F3_h$	01 to 08	Security Controlword 4	4 bytes for each sub-index
$66F4_h$	01 to 08	Security Controlword 5	4 bytes for each sub-index
$66F5_h$	01 to 08	Security Controlword 6	4 bytes for each sub-index
$66F6_h$	01 to 08	Security Controlword 7	4 bytes for each sub-index
$66F7_h$	01 to 08	Security Controlword 8	4 bytes for each sub-index
$66F8_h$	01 to 08	Security Statusword 1	4 bytes for each sub-index

66F9h	01 to 08	Security Statusword 2	4 bytes for each sub-index
66FAh	01 to 08	Security Statusword 3	4 bytes for each sub-index
66FBh	01 to 08	Security Statusword 4	4 bytes for each sub-index
66FCh	01 to 08	Security Statusword 5	4 bytes for each sub-index
66FDh	01 to 08	Security Statusword 6	4 bytes for each sub-index
66FEh	01 to 08	Security Statusword 7	4 bytes for each sub-index
66FFh	01 to 08	Security Statusword 8	4 bytes for each sub-index
26F1h	01 to 08	Security Controlword Safe_in	4 bytes for each sub-index
26F8h	01 to 08	Security Statusword Safe_out	4 bytes for each sub-index

Signature SLS

There is a signature for each of the 8 SLS functions.
Signatures are saved in entry **6699 0xh**, with the x subindex corresponding to the SLS configuration number.
The data to be considered are, in order:

Index	Sub-Index	Name	Size to consider
6600h	00	Time unit	4 bytes
6602h	00	Velocity unit	4 bytes
6603h	00	Acceleration unit	4 bytes
6691h	01 to 08	SLS time to velocity monitoring	2 bytes
6692h	01 to 08	SLS velocity limit u16	2 bytes (object does not exist, a null value 0000h must be used in the calculation)
6693h	01 to 08	SLS velocity limit u32	4 bytes
6694h	01 to 08	SLS time for velocity in limits	2 bytes
6695h	01 to 08	SLS time delay deceleration monitoring	2 bytes (object does not exist, a null value 0000h must be used in the calculation)
6696h	01 to 08	SLS deceleration limit u16	2 bytes (object does not exist, a null value 0000h must be used in the calculation)
6697h	01 to 08	SLS deceleration limit u32	4 bytes (object non-existent, a null value 0000 0000h must be used in the calculation)
6698h	01 to 08	SLS error reactions	4 bytes
66F0h	01 to 08	Security Controlword 1	4 bytes for each sub-index
66F1h	01 to 08	Security Controlword 2	4 bytes for each sub-index
66F2h	01 to 08	Security Controlword 3	4 bytes for each sub-index
66F3h	01 to 08	Security Controlword 4	4 bytes for each sub-index
66F4h	01 to 08	Security Controlword 5	4 bytes for each sub-index
66F5h	01 to 08	Security Controlword 6	4 bytes for each sub-index
66F6h	01 to 08	Security Controlword 7	4 bytes for each sub-index
66F7h	01 to 08	Security Controlword 8	4 bytes for each sub-index
66F8h	01 to 08	Security Statusword 1	4 bytes for each sub-index
66F9h	01 to 08	Security Statusword 2	4 bytes for each sub-index
66FAh	01 to 08	Security Statusword 3	4 bytes for each sub-index
66FBh	01 to 08	Security Statusword 4	4 bytes for each sub-index
66FCh	01 to 08	Security Statusword 5	4 bytes for each sub-index
66FDh	01 to 08	Security Statusword 6	4 bytes for each sub-index
66FEh	01 to 08	Security Statusword 7	4 bytes for each sub-index
66FFh	01 to 08	Security Statusword 8	4 bytes for each sub-index
26F1h	01 to 08	Security Controlword Safe_in	4 bytes for each sub-index
26F8h	01 to 08	Security Statusword Safe_out	4 bytes for each sub-index

Signature SDI
There is a signature for each of the 2 SDI functions.
Signatures are saved in entry **66D6 0x$_h$**, with the x subindex for the SDI configuration number.

The data to be considered are, in order:

Index	Sub-Index	Name	Size to consider
6601$_h$	00	Position unit	4 bytes
6602$_h$	00	Velocity unit	4 bytes
66D2$_h$	01 to 02	SDI position zero window u16	2 bytes (object does not exist, a null value 0000$_h$ must be used in the calculation)
66D3$_h$	01 to 02	SDI position zero window u32	4 bytes (object non-existent, a null value 0000 0000$_h$ must be used in the calculation)
66D4$_h$	01 to 02	SDI velocity zero window u16	2 bytes (object does not exist, a null value 0000$_h$ must be used in the calculation)
66D5$_h$	01 to 02	SDI velocity zero window u32	4 bytes
66F0$_h$	01 to 08	Security Controlword 1	4 bytes for each sub-index
66F1$_h$	01 to 08	Security Controlword 2	4 bytes for each sub-index
66F2$_h$	01 to 08	Security Controlword 3	4 bytes for each sub-index
66F3$_h$	01 to 08	Security Controlword 4	4 bytes for each sub-index
66F4$_h$	01 to 08	Security Controlword 5	4 bytes for each sub-index
66F5$_h$	01 to 08	Security Controlword 6	4 bytes for each sub-index
66F6$_h$	01 to 08	Security Controlword 7	4 bytes for each sub-index
66F7$_h$	01 to 08	Security Controlword 8	4 bytes for each sub-index
66F8$_h$	01 to 08	Security Statusword 1	4 bytes for each sub-index
66F9$_h$	01 to 08	Security Statusword 2	4 bytes for each sub-index
66FA$_h$	01 to 08	Security Statusword 3	4 bytes for each sub-index
66FB$_h$	01 to 08	Security Statusword 4	4 bytes for each sub-index
66FC$_h$	01 to 08	Security Statusword 5	4 bytes for each sub-index
66FD$_h$	01 to 08	Security Statusword 6	4 bytes for each sub-index
66FE$_h$	01 to 08	Security Statusword 7	4 bytes for each sub-index
66FF$_h$	01 to 08	Security Statusword 8	4 bytes for each sub-index
26F1$_h$	01 to 08	Security Controlword Safe_in	4 bytes for each sub-index
26F8$_h$	01 to 08	Security Statusword Safe_out	4 bytes for each sub-index

10.6. Periodic inspections

The correct operation of the safety functions must be checked periodically on the machine to ensure operation with a correct level of safety.

The need to carry out this control and the periodicity of this control must appear in the documentation of the machine or equipment that incorporates a safety drive of the ***SWD®*** range.

The check is used to verify the ability of the safety functions to perform the associated safety function.

The frequency of control depends on the level of safety of the function. The check is to be carried out once a year for the SIL2 functions, once a month for the STO SIL3 function.

10.7. CANopen safety - SRDO

Application engineers in this Part shall provide a safety manual containing at least the following information:

(a) the safety manual to inform users of the constraints associated with the calculation of system characteristics (see 9.4).

(b) the safety manual to inform users of their responsibilities for the correct parameterization of devices (6.4).

(c) the safety manual to include guidance on the calculation of the expected maximum reaction time of the network.

Constraints related to the calculation of system characteristics
SRDO Name

The number of SRDO producers is limited to 64 in an SR system. The number of SRDO consumers is not limited.

- The number of SRDO producers is limited due to compatibility with EN 50325-4 which specifies only 128 reserved high-priority CAN Identifiers, and limited available bandwidth. A greater number of SRDO producers increases the likelihood of excessive traffic on the CAN giving rise to SR reactions due to a simple overload.

Residual SRDO error probability

This paragraph describes the calculations used to determine the probability of residual error of the ODRS.

The most unfavorable residual error probability of the CAN according to [17], [18] and [19] is given in (4). This most unfavorable residual error probability applies because the data link layer is used as part of the white channel method which differs from the black channel method defined by the FSCPs specified in EN 61784-3-X.

$R(P_{CAN}) = 7 \times 10^{-9} \approx 1 \times 10^{-8}$

The worst probability of residual error is squared in accordance with GS-ET-26 for the use of Model Ill (see A.4) as shown in (5). The other models can be used but it must then be demonstrated that the following formula is still valid.

$R_{SL}(P) = R(P_{CAN})^2 = 4{,}9 \times 10^{-17}$

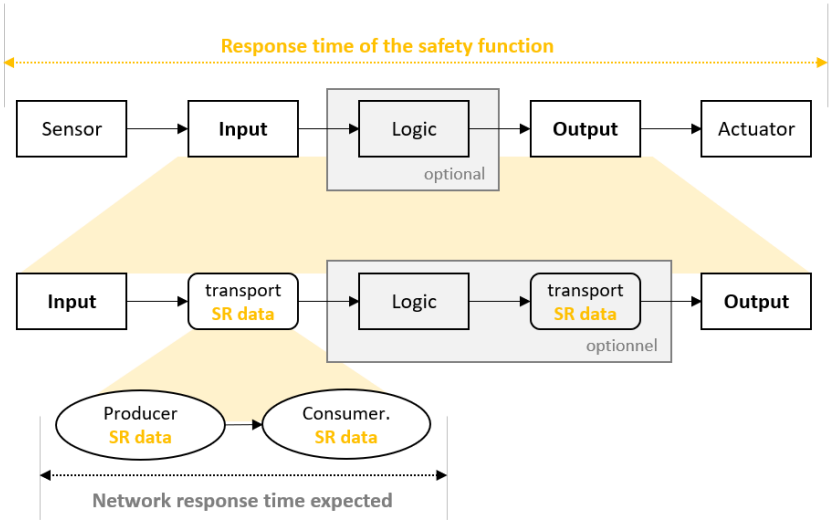
- The definition of the white channel (EN 61784-3) requires an evaluation of the complete solution with all possible errors and failures of the transmission channel in accordance with the EN 61508 series.

- The probability of residual error calculated in this paragraph and the formula used assume that the implementation of this SRCP uses redundant mechanisms or diversified methods to maintain safety

User Responsibilities
The configuration of the SRDO is carried out under the responsibility of the user who is responsible for the configuration of the product in relation to the need of the application.

Reaction time

The security function response time (SFRT) represents the most unfavorable time from an SR event, considered an input to the system or a defect within the system, until the moment the system is in the security state. To be able to determine the most unfavorable SFRT of any SR control loop, the user must sum up all the most unfavorable safety reaction times of each subsystem of the SR control loop (see definitions in EN 61784-3). An example of reaction time range is shown here:



Example:

The SFRT shown in Figure 11 includes the following:

- Sensor reaction time
- Input reaction time; Network reaction time
- Manager reaction time, if a manager is present; network reaction time, if a manager is present; output reaction time; and
- Actuator reaction time.

Then, the SFRT is the sum of the most adverse reaction times mentioned above:

+ most adverse reaction time of the sensor
+ worst input reaction time
+ worst reaction time in the network
+ manager's worst reaction time
+ worst reaction time in the network
+ worst exit reaction time
+ most adverse reaction time of the actuator
+ most unfavorable time difference of a failed subsystem when the safety function is triggered

= security function response time