



SWD[®]

SAFETY DRIVE & WHEEL DRIVE

User Manual

Version 2.0.3 - 04/04/2024 – Translated from French

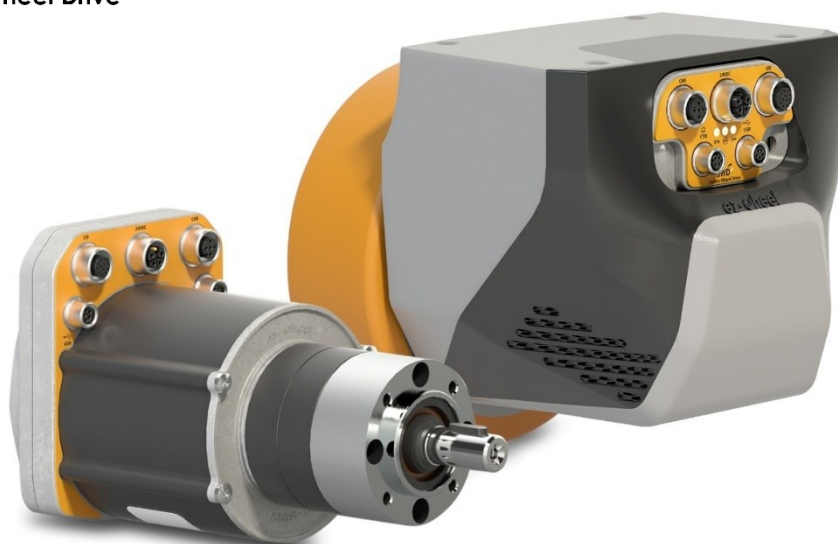


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 **Please read this document carefully before using the product for the first time.**

1. Introduction

1.1. Who is this manual intended for?

This manual is intended for industrial machine integrators.

Knowledge and understanding of power drive systems is necessary for implementing **SWD®** technology.

1.2. Terms of use

The terms used in this manual relate to the technical field of industrial machines and more specifically to fieldbus-controlled drive systems.

For an accurate reading of the manual, a good knowledge of the following reference systems is recommended:

- Machinery Directive (2006/42/CE)
- Safety of machinery – Electrical equipment of machines (EN 60204-1)
- Safety requirements – Adjustable speed electrical power drive systems (EN 61800-5)
- CANopen protocol (EN 50325 et CiA/DS 301) et CANopen Safety (CiA 304)
- CANopen device profile for drives and motion control (CiA 402)

1.3. Additional resources

The following documents relating to the **SWD®** product are available from ez-Wheel:




- Datasheets of **SWD®** products
- General **SWD® Safety Wheel Drive** range brochure
- 2D and 3D mechanical drawings for **SWD®** products

1.4. Declarations of conformity

SWD® products are developed in accordance with the regulatory requirements for commercialization.

The declarations of conformity for **SWD® products have been drawn up by ez-Wheel with the certification authority INERIS** for the certified safety functions.

1.5. Important information about the manual

| | |
|---|--|
|  | Important information – Read carefully |
|  | Configurable value |
|  | Additional information |

1.6. Disclaimer

The technical information included in this manual is subject to change. No responsibility is accepted for the completeness, up-to-dateness or accuracy of the data and illustrations provided.

Texts and visuals included in this manual are the property of **ez-Wheel SAS**.

ez-Wheel and *SWD Safety Wheel Drive* are registered trademarks.


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« USER MANUAL »

English Version 2024, translated from French
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FIRST EDITION, FEBRUARY 2022

EZ-WHEEL SAS
LE MOULIN DE L'ABBAYE - 135 ROUTE DE BORDEAUX
16400 LA COURONNE - FRANCE

2. Safety instructions – Precautions regarding usage of SWD® products

| | |
|---|--|
|  | <p>Do not open. Do not expose to a heat source. Do not expose to fire. Do not insert metal pieces in the connectors. In any case, the product cannot be modified without explicit authorization of ez-Wheel. Do not attempt to modify technical performances. Product use must remain within technical performance range specified by ez-Wheel. Improper use and opening the product invalidates the warranty.</p> |
|---|--|

3. Description

Warning message applicable to SWD® products fitted with the parking brake option.

⚠ The surface of the brake is subject to high temperatures approaching 100°C. There is a risk of burn while handling the product after use.

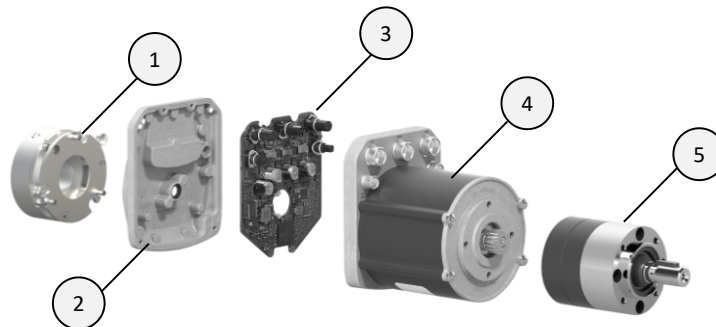
A pictogram "Danger hot surface" is located on the technical label to locate the hazardous area:



3.1. Presentation and main characteristics

SWD® Core

Presentation:



| | |
|----------|---|
| 1 | Brake option |
| 2 | Electronic cover |
| 3 | Safety driver |
| 4 | BLDC Motor with PM (Permanent Magnet) |
| 5 | Planetary gearbox 1, 2 or 3 stage(s) |

Key features:

| | |
|---------------------------|------------------------------------|
| Motor shaft output | keyed shaft, Ø 14 mm |
| Typical use | Safety conveying or safety lifting |
| IP index | IP66 (Electronic cover) |
| Nominal voltage | 24 VDC |
| Motor | BLDC PM |
| Nominal power | Up to 250 W (S1) |
| Transmission | Without, 1, 2 or 3-stages |
| Option(s) | Parking brake /B |

Available transmissions:

| Commercial Ref. | Stage(s) | Ratio | Nominal speed (rpm) | Nominal torque (Nm) |
|-------------------------|----------|-----------|---------------------|---------------------|
| ezSWDcore.0x/C | 0 | 1 | 1400 | 1.7 |
| ezSWDcore.4x/C | 1 | 4 | 370 | 5.0 |
| ezSWDcore.14x/C* | 2 | 14 | 100 | 17 |
| ezSWDcore.25x/C | | 25 | 56 | 25 |
| ezSWDcore.50x/C | 3 | 50 | 28 | 25 |
| ezSWDcore.100x/C | | 100 | 14 | 25 |

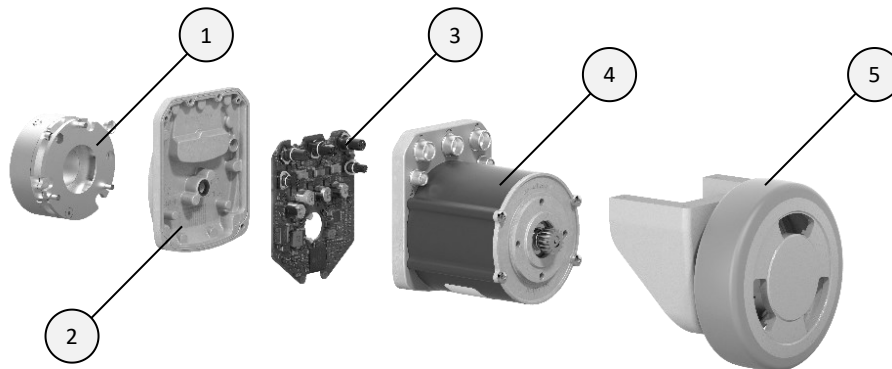
* Standard commercial reference

Key features for standard reference ezSWDcore.14x/C:

| | |
|----------------------------|---|
| Speed | 0 to 130 rpm |
| Nominal performance | 17 Nm at 100 rpm |
| Peak torque | 37 Nm |
| Transmission | Planetary gearbox – 2 stages ratio 14:1 – exact value $(63/17)^2$ |

SWD® 125

Presentation:



| | |
|----------|--|
| 1 | Brake option |
| 2 | Electronic cover |
| 3 | Safety driver |
| 4 | BLDC Motor with PM (Permanent Magnet) |
| 5 | Ø125 mm wheel, with integrated gearbox |

Key features:

| | |
|---------------------------|--|
| Wheel diameter | Ø125 mm |
| Type of tyre | PU 80 sh. A – Flat profile |
| Max. vertical load | 250 kg |
| Typical use | Mobile robot, up to 500 kg at 2m.s ⁻¹ |

| | |
|----------------------|-------------------------|
| IP index | IP66 (Electronic cover) |
| Motor | BLDC PM |
| Nominal power | Up to 200 W (S1) |
| Transmission | 1 or 2-stages |
| Option(s) | Parking brake /B |

Available transmissions:

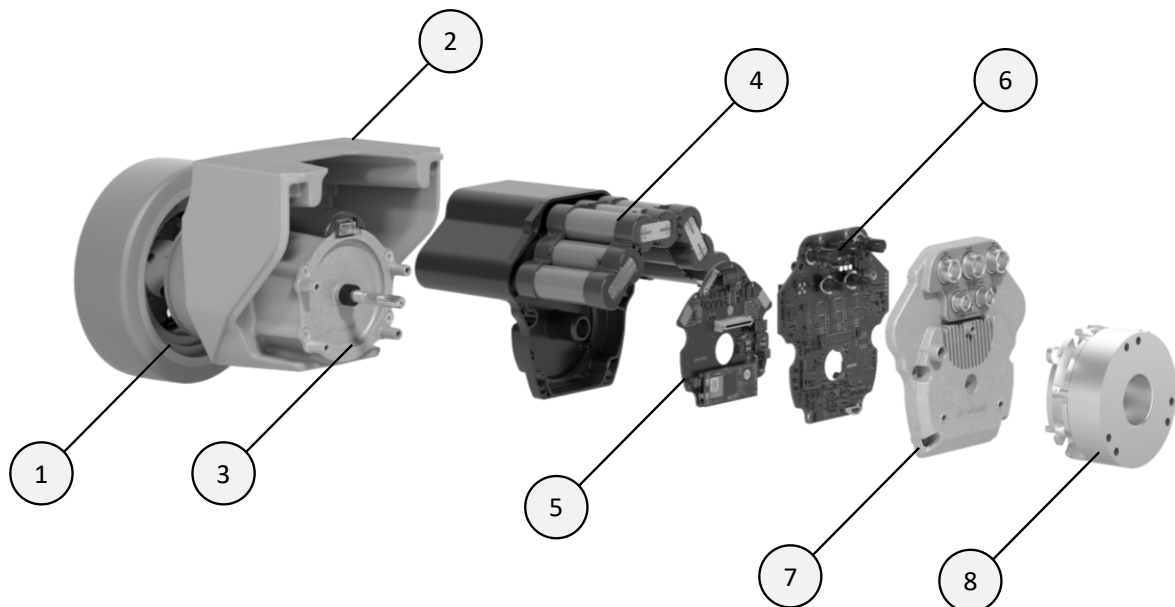
| Commercial Ref. | Stage(s) | Ratio | Nominal speed (rpm) | Nominal torque (Nm) |
|-------------------------|----------|----------|---------------------|---------------------|
| <i>ezSWD125IM.4x/C*</i> | 1 | 4 | 380 | 7.9 |
| ezSWD125IM.14x/C | 2 | 14 | 100 | 27 |

* Standard commercial reference

Key features for standard reference **ezSWD125IM.4x/C**:

| | |
|----------------------------|---|
| Speed | 0 to 11 km/h |
| Pushing force | 20 daN – Moves 500 kg |
| Nominal performance | 7.9 Nm at 380 rpm |
| Peak torque | 13 Nm |
| Transmission | Planetary – 1 stage ratio 4:1 – exact value (62/17) |

SWD® 150



| | |
|----------|---|
| 1 | Ø 150 mm wheel, with integrated gearbox |
| 2 | Cast iron hub |
| 3 | Motor BLDC PM |
| 4 | Battery cells |
| 5 | BMS (Battery Management System) |
| 6 | Safety driver |

| | |
|----------|------------------|
| 7 | Electronic cover |
| 8 | Brake option |

Key features:

| | |
|---------------------------|--|
| Wheel diameter | Ø 150 mm |
| Type of tyre | PU 92 sh. A – Flat profile |
| Max. vertical load | 700 kg |
| Typical use | Mobile robots, up to 1.500 kg /motor at 1m.s ⁻¹ |
| IP index | IP66 (Electronic cover) |
| Nominal voltage | 24 VDC |
| Motor | BLDC PM |
| Nominal power | 185 W (S1) |
| Transmission | 2-stages |
| Option(s) | Internal battery 100 Wh Parking brake/B |

Available transmissions:

| Commercial Ref. | Stages | Ratio | Nominal speed (rpm) | Nominal torque (Nm) |
|---------------------------|----------|-----------|---------------------|---------------------|
| <i>ezSWD150IH.14x/Cx*</i> | 2 | 14 | 100 | 23 |
| ezSWD150IH.25x/Cx | | 25 | 56 | 42 |

* Standard commercial reference


Key features for standard reference **ezSWD150IH.14x/Cx**:

| | |
|----------------------------|---|
| Speed | 0 to 3,7 km/h |
| Pushing force | 60 daN – moves 1 500 kg |
| Nominal performance | 23 daN at 100 rpm |
| Peak torque | 45 Nm |
| Transmission | Planetary gearbox - 2 stages ratio 14:1 exact value $(63/17)^2$ |

3.2. Safety functions

| | |
|-----------------------------------|--|
| Motor torque disconnection | STO (Safe Torque Off) - up to SIL3/PLe/Cat4 |
| Motor control | SMS (Safe Maximum Speed), SLS (Safe Limited Speed), SLSa ¹ ,SDI - (Safe Direction) up to SIL2/PLd/ Cat3 |

¹ SLSa, Safe asymmetrical speed, ez-Wheel specific, not specified by CEI 61800-5-2 norm.

| | | |
|------------------|--|---|
| Braking | SBC (Safe Brake Control) up to SIL2/PLd/Cat3, SBU ² - (Safe Brake Unlock) up to SIL2/PLd/Cat3 | |
| Encoder | 30 ppr (motor shaft, before reduction) - SIL2/PLd/Cat3 | |
| Interface | CANopen Safety® Safety Inputs, OSSDs compliant |  |

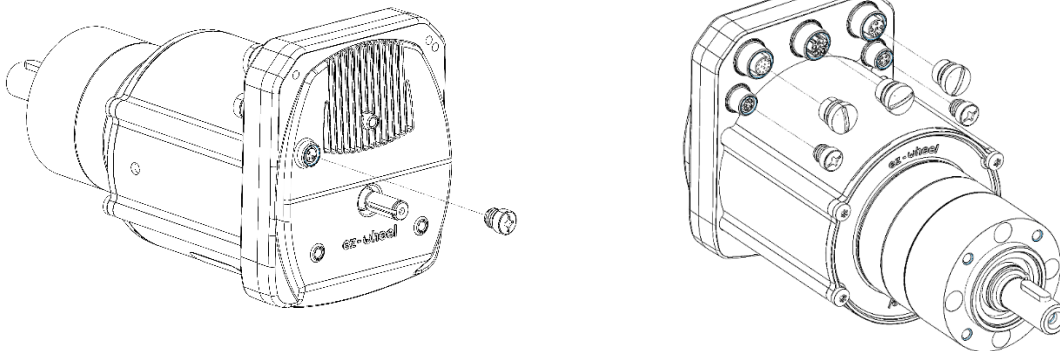
3.3. Terms of use

| | |
|---------------------------|-------------------------|
| Temperatures | 0 to +40°C |
| IP index | IP66 (Electronic cover) |
| Maintenance period | 5 years ³ |

⚠ The product is designed to be integrated into a machine. It is recommended to cover the machine to avoid direct access to the motorization by end-users.

Product sealing

To guarantee **SWD®** product life, we recommend using caps on unused connectors. Compliant caps are available on ez-Wheel catalogue.

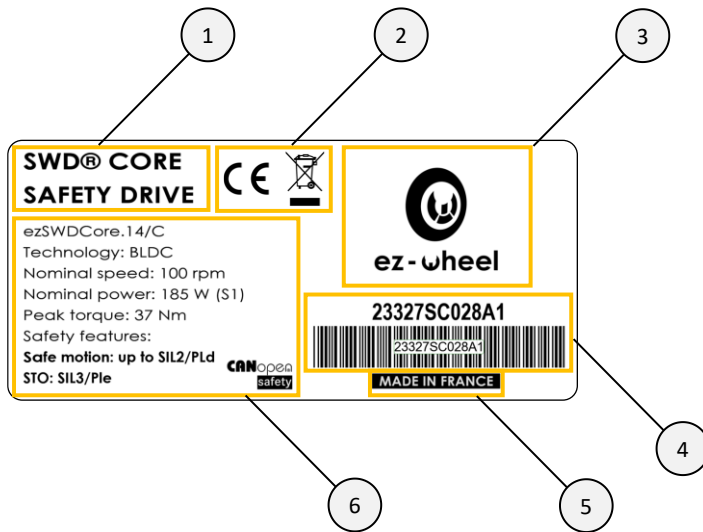


² SBU, Safe release of the brake, ez-Wheel specific, not specified by CEI 61800-5-2 norm.

³ Reference value, based on standard test condition, may differ according to specific use.

3.4. Product label

Product label example for SWD® Core ezSWDcore.14/C:

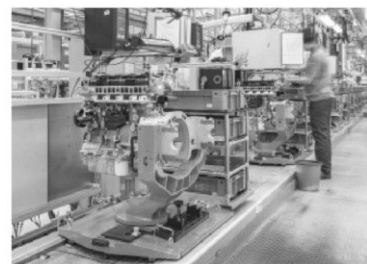
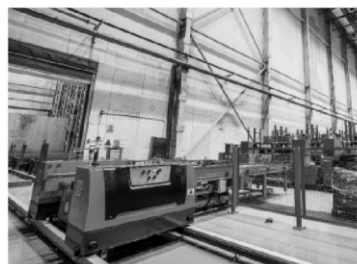
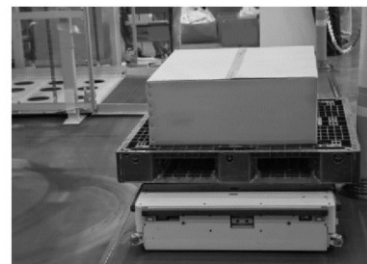


| | |
|---|--|
| 1 | Commercial identification of the product |
| 2 | Regulatory pictograms |
| 3 | Manufacturer identification |
| 4 | Item code |
| 5 | Geographic origin of the product |
| 6 | Motor performance, Safety functions |

3.5. Applications

SWD® products are designed for speed-controlled moving applications, where risk assessment justifies the implementation of safe movement supervision.

- Mobile robots
- Pallet shuttle
- Lifting cart
- Conveyors



4. Synoptic

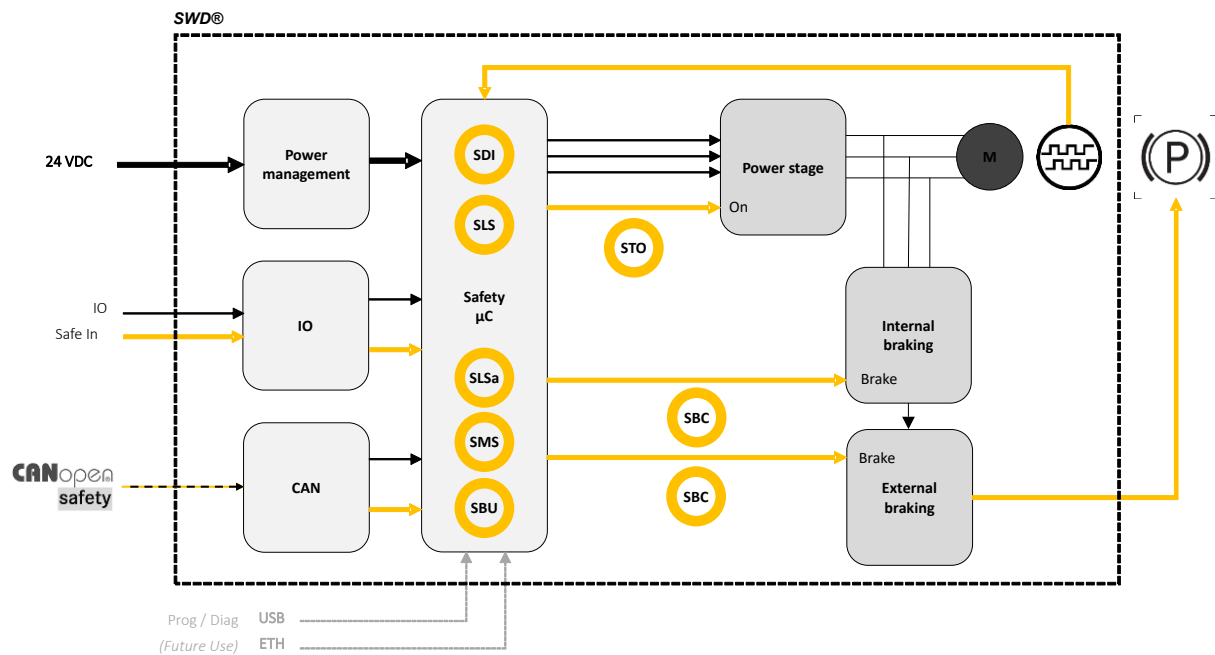


Figure 1 – General product overview

⚠ Functions SBC, SLSa, SMS and SBU are implemented from firmware version 'Firmware 2.0.1'

| | |
|--|-----------------------|
| | Motor et gearbox |
| | Safety encoder |
| | Safety external brake |

5. Interfaces

5.1. Overview

Mechanical assemblies' identification

SWD® Core

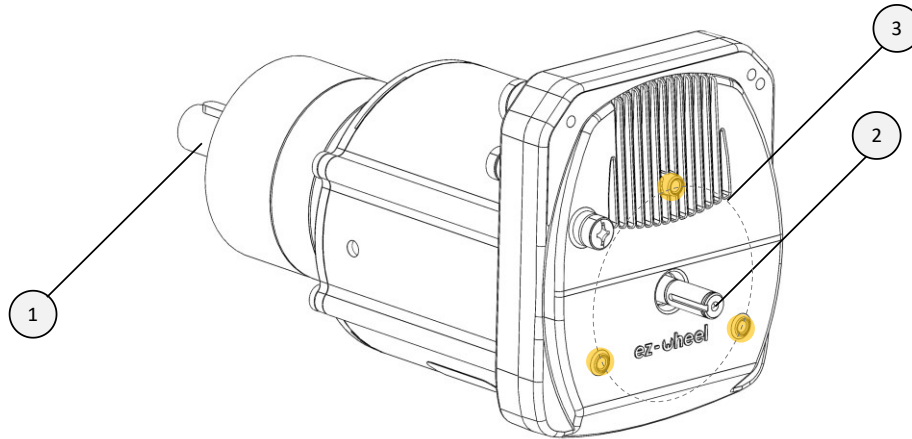


Figure 2 – Overview of mechanical interfaces– SWD® Core

| | |
|----------|-------------------------|
| 1 | Gearbox mounting flange |
| 2 | Brake mounting shaft |
| 3 | Brake mounting pins |

SWD® 125

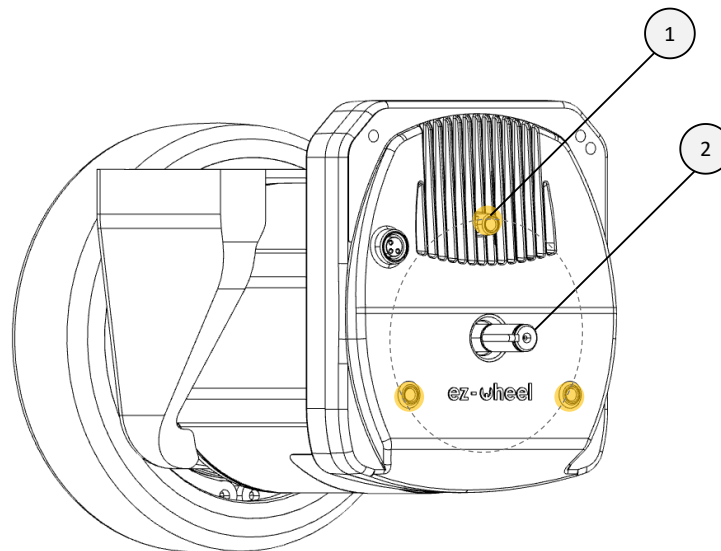


Figure 3 – Overview of mechanical interfaces – SWD® 125

| | |
|----------|----------------------|
| 1 | Brake mounting pins |
| 2 | Brake mounting shaft |

SWD® 150

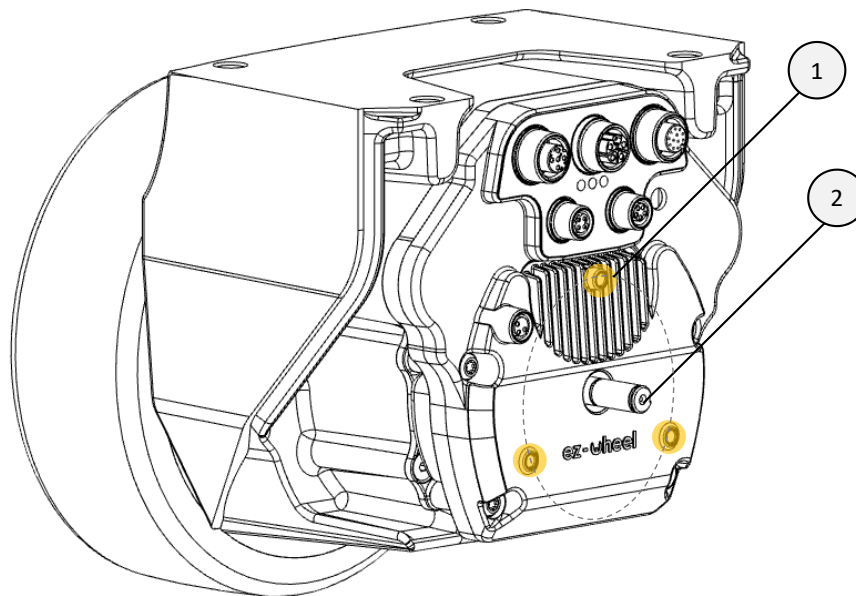


Figure 4 – Overview of mechanical interfaces – SWD® 150

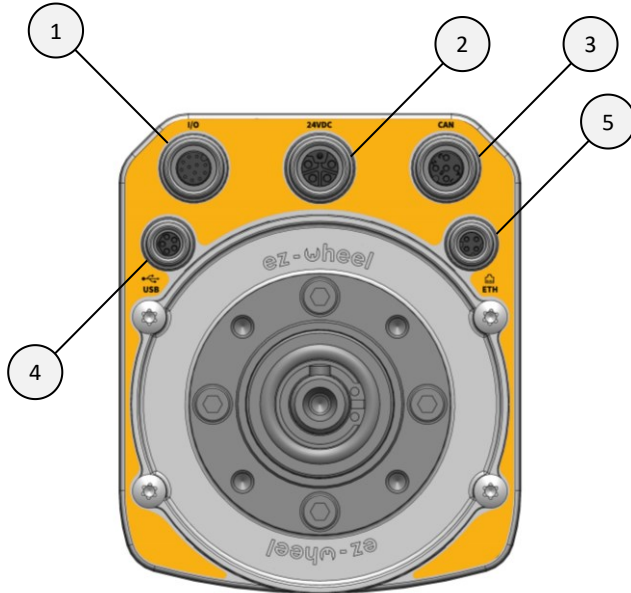
| | |
|----------|----------------------|
| 1 | Brake mounting pins |
| 2 | Brake mounting shaft |

Connectors and LEDs identification

SWD® Core

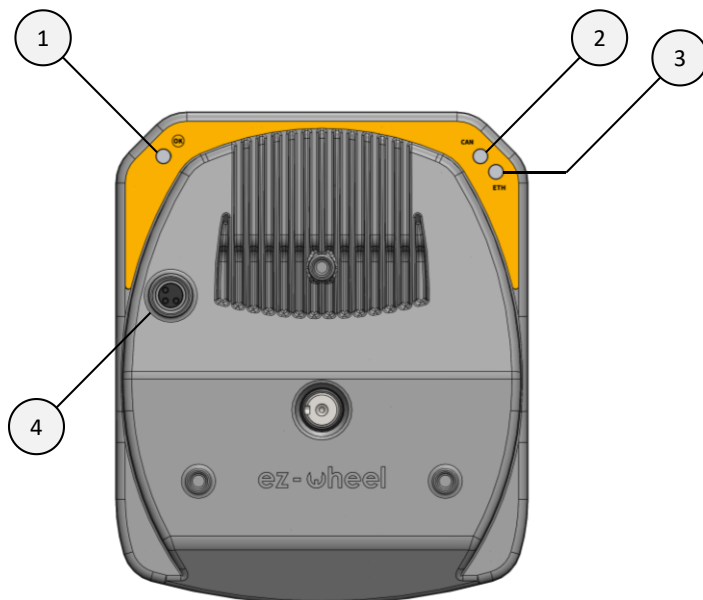
And,

SWD® 125



| | |
|----------|---|
| 1 | Connector I/O |
| 2 | Connector 24VDC |
| 3 | Connector CAN |
| 4 | Connector USB |
| 5 | Connector ETH <i>(Reserved for future use)</i> |

Figure 5 – Connectors identification



| | |
|----------|---|
| 1 | LED Status |
| 2 | LED CAN |
| 3 | LED ETH <i>(Reserved for future use)</i> |
| 4 | Connector brake |

Figure 6 – Connector brake and LEDs identification

SWD® 150

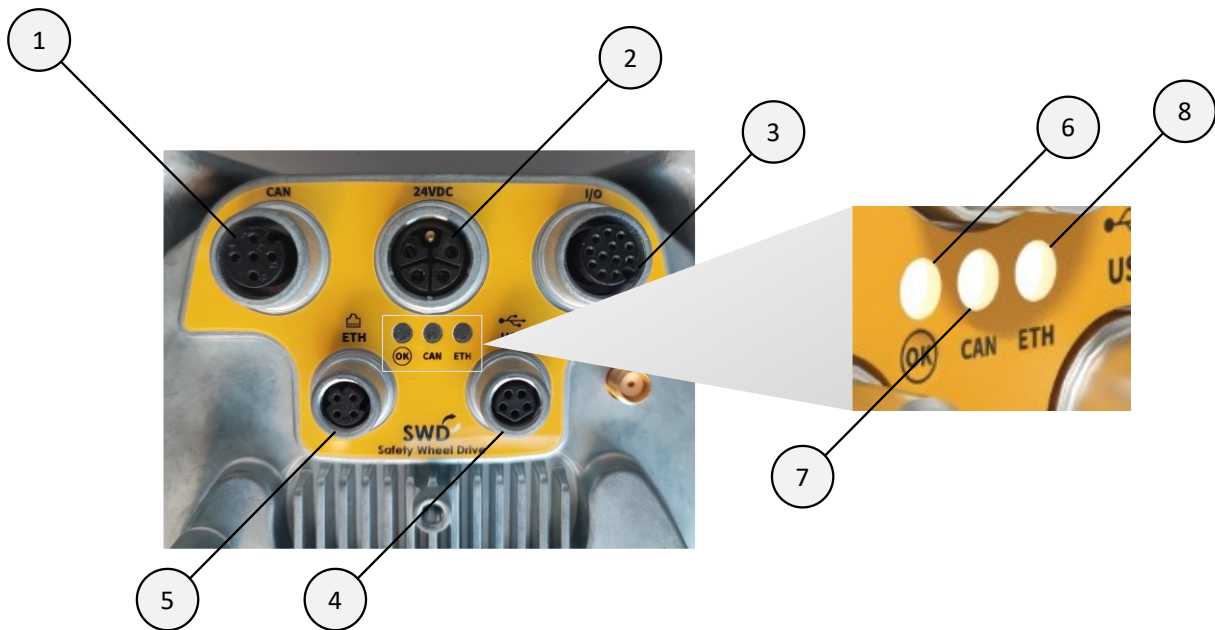


Figure 7 – Connectors and LEDs identification – SWD® 150

| | |
|----------|---|
| 1 | Connector CAN |
| 2 | Connector 24VDC |
| 3 | Connector I/O |
| 4 | Connector USB |
| 5 | Connector ETH <i>(Reserved for future use)</i> |
| 6 | LED Status |
| 7 | LED CAN |
| 8 | LED ETH <i>(Reserved for future use)</i> |

5.2. Connectors

The use of shielded cables is strongly recommended, as well as a total length of less than 30 meters for the CAN bus.

Connector layout plan

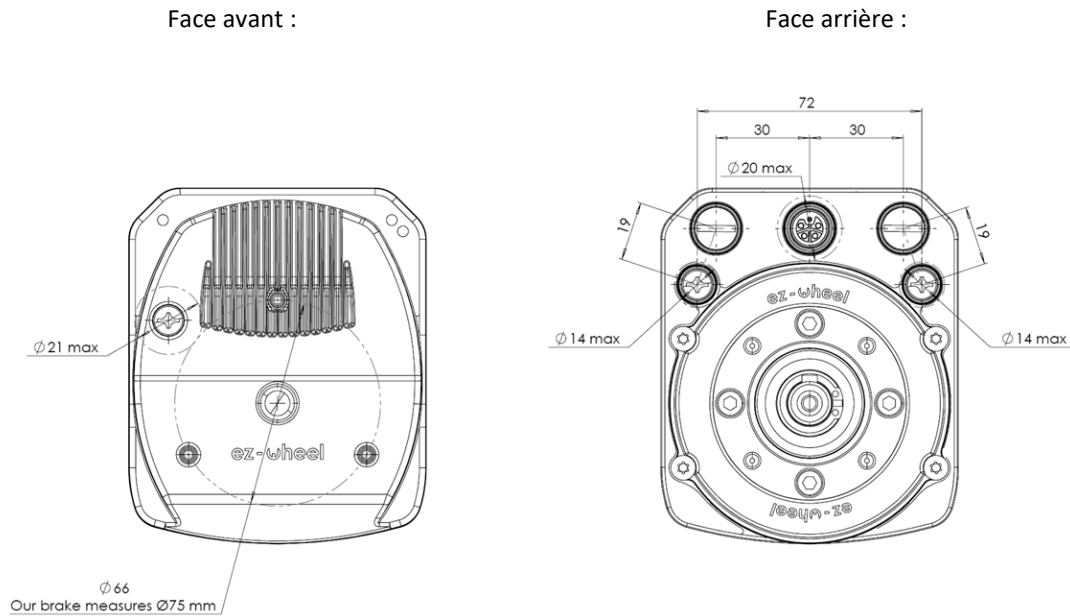


Figure 8 – Connector layout plan

I/O Connector

The I/O connector is M12, 12-pin, A-coded, female. It groups together the safety (INSafe) and product start-up (STO) inputs. It can also be used as a CAN interface (in addition to the dedicated CAN connector), and as a 24V power offset for third-party peripherals.

| Pin # | Designation |
|-------|--|
| 1 | CAN H |
| 2 | INSafe_4 |
| 3 | CAN L |
| 4 | 24 VDC output power supply (2A) – if activated = |
| 5 | STO_1: (0V: Safe State / 24 VDC: Drive enable) |
| 6 | GND output power supply (2A) |
| 7 | INSafe_1 |
| 8 | STO_2: (0V: Safe State / 24 VDC: Drive enable) |
| 9 | INSafe_3 |
| 10 | INSafe_2 |
| 11 | GND IN (From external device) |
| 12 | ON: Pull to GND to turn it ON (Reserved for future use) |

⚠ This connector cannot be used as a power supplier for the SWD®

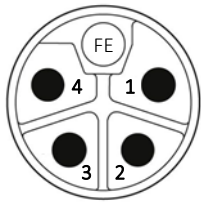
The following cables can be used to interface with the I/O connector:

- Compatible cables available in the ez-Wheel product guide

24 VDC Connector

The 24 VDC power supply connector is M12 Power, 5-pin, L-coded (4+FE), female. We recommend placing the power source as close as possible to the **SWD®**, to limit power dissipation in the cables. A maximum length of five meters between the power source and the **SWD®** is recommended.

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




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

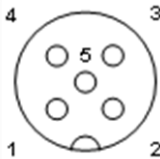
- Compatible cables available in the ez-Wheel product guide
- Phoenix Contact SAC-5P-M12MSL/ 1,5-280 FE SH – 1414884, 1.5m
- Phoenix Contact SAC-5P-M12MRL/ 1,5-280 FE SH - 1414851, 1.5m (*Only for ezSWD150IH.x/C-x*)


CAN Connector

The CAN connector is M12, 5-pole, A-coded, female. It can be used as a CANopen interface and as a 24V power supply for external devices, such as additional sensors.

Implementation complies with CiA 303-1 standard for standardized CAN interfaces.

| Pin # | Designation |
|-------|--|
| 1 | Mechanical mass |
| 2 | 24 VDC output power supply (4A) – if activated =  |
| 3 | GND output power supply (4A) |
| 4 | CAN H |
| 5 | CAN L |



 This connector cannot be used as a power supplier for the **SWD®**

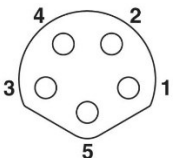
The following cables can be used to interface with the CAN connector:

- Compatible cables available in the ez-Wheel product guide
- Phoenix Contact SAC-5P-MR/ 2,0-923 CAN SCO – 1419044, 2m
- TE Connectivity 2273100, 1.5m

USB Connector

The USB connector is M8, 5-pin, B-coded, female. It is only used for updating and diagnosing the product. It must only be used with the explicit agreement of ez-Wheel for safety reasons, otherwise all warranties will be voided.

| 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 product guide
- Phoenix Contact SAC-5P-M 8MSB/ 1,5-115 – 1404461, 1.5m
- Phoenix Contact SAC-5P-M 8MS/ 2,0-920 – 1575712, 2.0m
- Phoenix Contact SAC-5P-M 8MR/920/... – 1575903 ‘Made to order.’

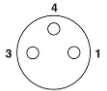
ETH Connector

⚠ *ETH connector is reserved for future use, it must not be connected.*

External brake connector

The external brake connector is M8, 3-pole, A-coded, female. It is used to connect an electromechanical brake, actuated by the SBC (Safe Brake Control)⁴ output.

| Pin # | Designation |
|----------|-------------|
| 1 | Command SBC |
| 3 | V_SBC |
| 4 | GND_SBC |



Consult ez-Wheel for a brake compatible with your product.

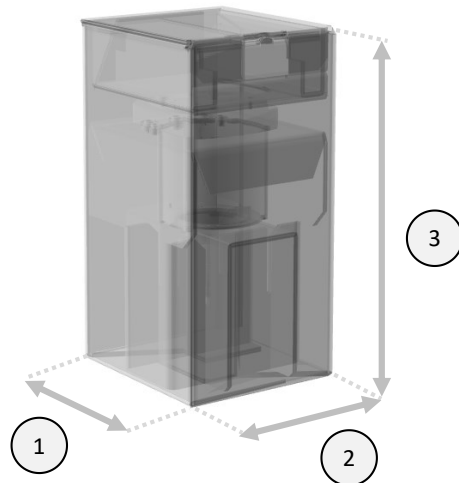
⁴ Implemented from firmware version ‘Firmware (2.0.x)’

6. Information and mechanical assembly

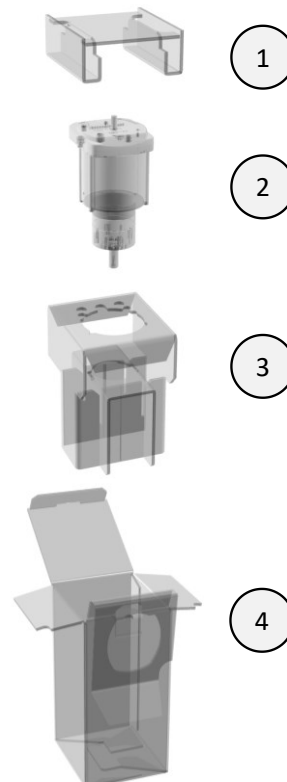
6.1. Dimensions, packaging, and pack contents

SWD® Core

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



| | |
|---|--------------------------|
| 1 | Upper wedge |
| 2 | Product SWD® Core |
| 3 | Lower wedge |
| 4 | Conditioning |



⚠ For engine-only logistics operations, use the original packaging.

SWD® 125

Definition ongoing.

SWD® 150

Definition ongoing.

6.2. Overall dimensions and weight⁵

SWD® Core

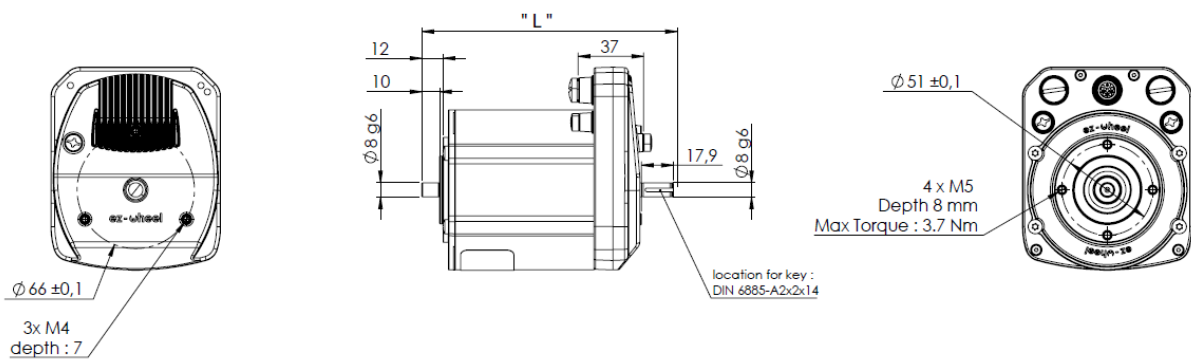


Figure 9 – Overall dimensions – SWD® Core without gearbox

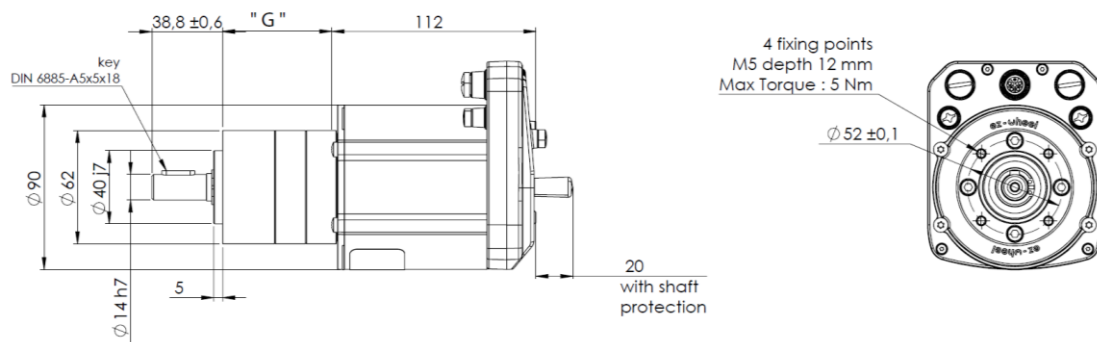


Figure 10 – Overall dimensions – SWD® Core with gearbox(es)

⁵ Indicative values +/- 10%

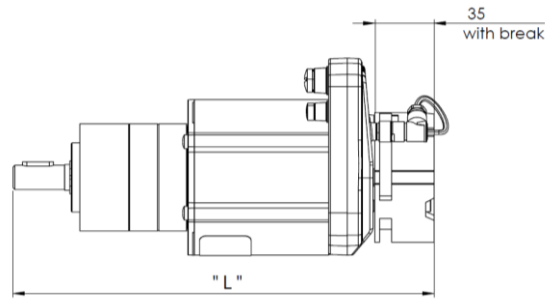


Figure 11 – Overall dimensions - SWD® Core – with external brake

| Gearbox Dim "G" ± 0.3 (mm) | | | With external brake | Dim "L" ± 2 (mm) | Weight ± 10% (kg) |
|----------------------------|----------|----------|---------------------|------------------|-------------------|
| 1-stage | 2-stages | 3-stages | | | |
| - | - | - | ✗ | 144 | 2.7 |
| 42.9 | - | - | ✗ | 214 | 3.3 |
| 42.9 | - | - | ✓ | 229 | 4.1 |
| - | 59.8 | - | ✗ | 231 | 3.6 |
| - | 59.8 | - | ✓ | 246 | 4.4 |
| - | - | 76.8 | ✗ | 248 | 3.9 |
| - | - | 76.8 | ✓ | 263 | 4.7 |

SWD® 125

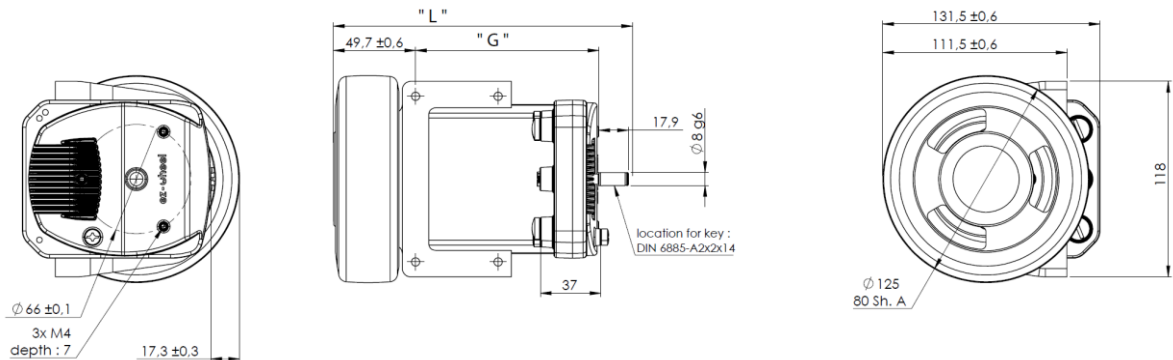


Figure 12 – Overall dimensions – 'SWD® 125 1-stage'

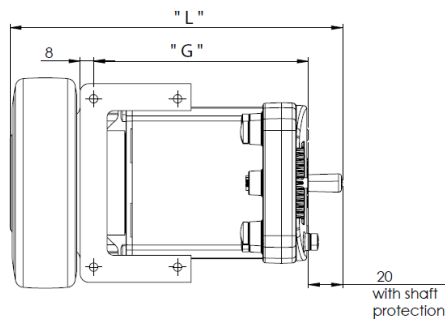


Figure 13 – Overall dimensions – 'SWD® 125 2-stages'

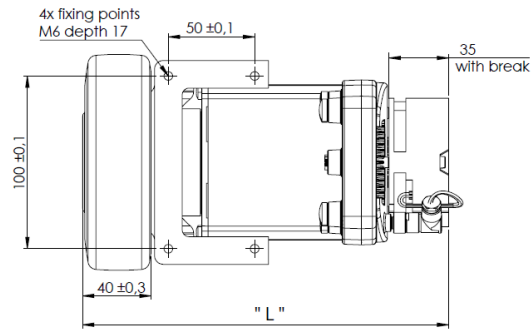
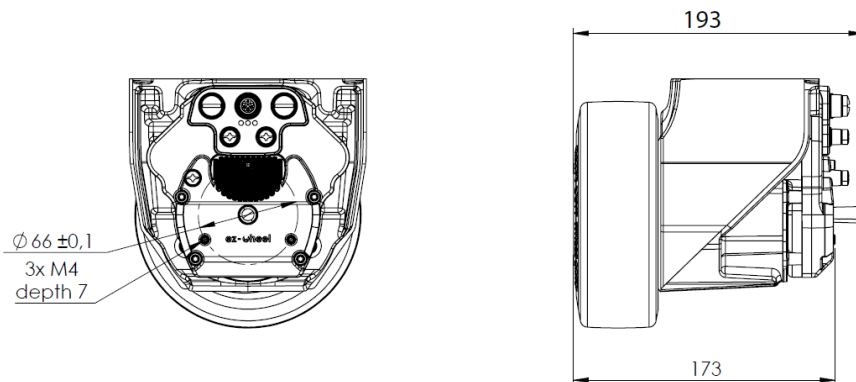


Figure 14 – Overall dimensions – ‘SWD® 125 2-stages and external brake

| Gearbox Dim "G" ± 0.3 (mm) | | With external brake | Dim "L" ± 2 (mm) | Weight ± 10% (kg) |
|----------------------------|----------|---------------------|------------------|-------------------|
| 1-stage | 2-stages | | | |
| 111 | - | ✗ | 181 | 6.2 |
| 111 | - | ✓ | 196 | 7 |
| - | 128 | ✗ | 198 | 6.5 |
| - | 128 | ✓ | 213 | 7.3 |

SWD® 150



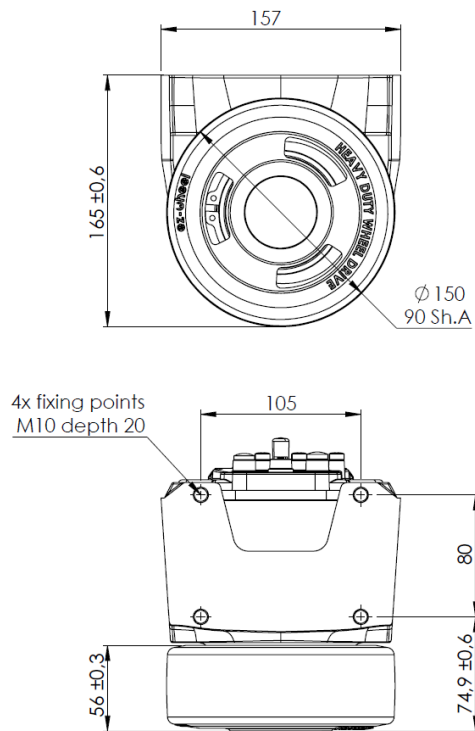


Figure 15 – Overall dimensions – ‘SWD® 150 2-stages’

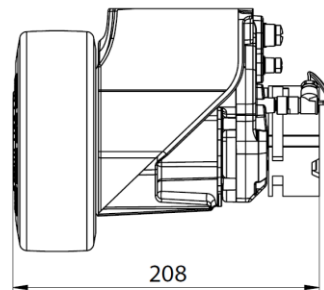


Figure 16 – Overall dimensions – ‘SWD® 150 2-stages’ with external brake

| SWD® 150 versions | Weight ± 10% (kg) |
|--|--------------------------|
| SWD® 150 with gearbox 2-stages | 10.5 |
| SWD® 150 with gearbox 2-stages and external brake | 11.3 |

6.3. Mechanical assembly drawing

SWD® Core

SWD® Core naked - Mounting recommendation (without gearbox)

For any specific mounting on the motor shaft, please contact us.

- i** **NEVER** tap or knock on the axle!
- i** **NEVER** exert forces more than the values indicated in paragraph 6.4 Restrictions on use.
 - CAUTION: fitting helical shafts may result in additional axial forces!
- i** **NEVER** make any mechanical changes to the shaft or bearing.
- i** **NEVER** tighten screws to the stop (blind holes).
- i** **NEVER** exceed the maximum tightening torque.
- i** The axial position of the motor shaft may vary slightly during operation (see *plan below).

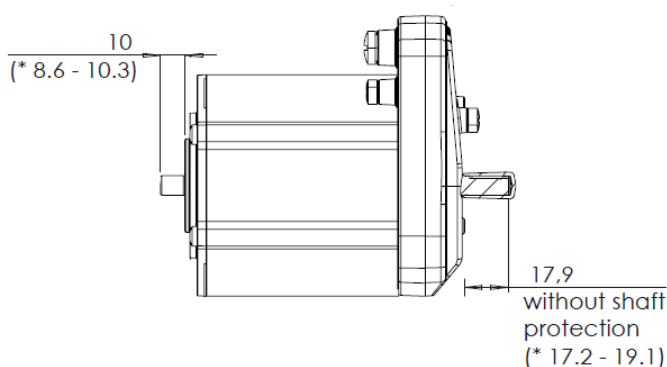


Figure 17 – Motor shaft tolerance - SWD® Core (naked)

Output characteristics

| | |
|---|------------------|
| Max. radial load (<i>median of output shaft</i>) | 330 N |
| Max. axial load (<i>in operation</i>) | 220 N |
| Max. axial force on shaft when mounted | Consult ez-Wheel |

Depending on how the motor shaft is mounted, special tools may be required.

Consult ez-Wheel for more information.

Special cases:

Please consult us for the maximum permissible loads for cases not defined above.

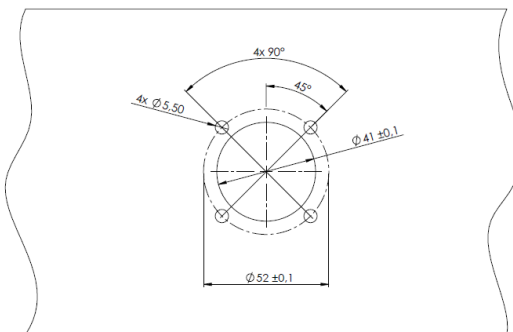
For example:

- Radial load not centred
- Combined axial and radial load

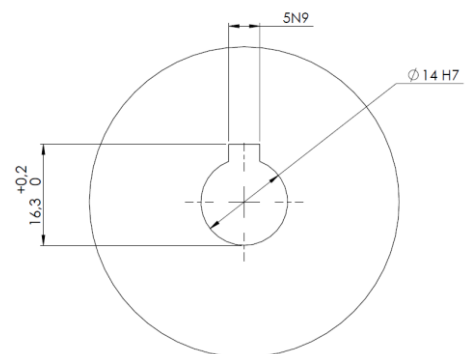
⚠ The front of the motor has an **IP20** protection rating



SWD® Core - Machine layout recommendation



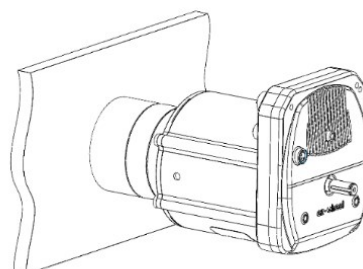
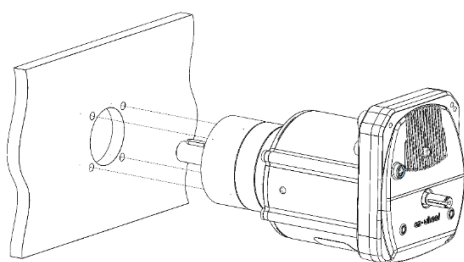
SWD® Core interface

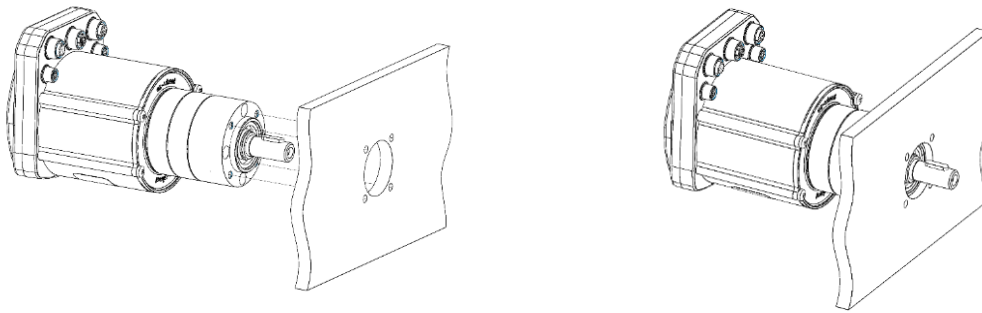


Motor transmission interface

Present the **SWD® Core** product on the machine interface until it stops on the flat surface. Using 4 M5 screws (not supplied), tighten the product on the machine interface.

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





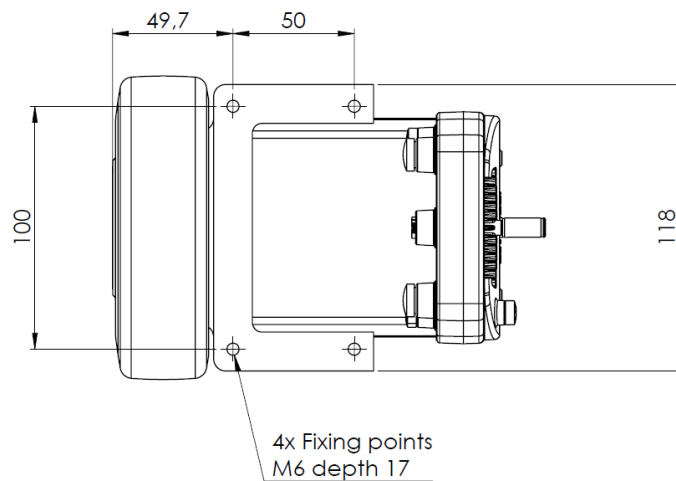
Installation requirements:

- Tightening torque for 4 - M5 screws (not supplied): 5 Nm.
- Length of thread engaged in the product: 8 to 10 mm.
- Use of thread lock and/or lock washers (not supplied).

For sealing higher than IP53, seal the shaft bearing by applying a gasket between the machine interface (x4) and the **SWD® Core** product (**SWD® Core** side) and between the customer interface and the customer application (customer side). As this sealing is different for each application, we leave it up to each integrator to implement the solutions required for his application.

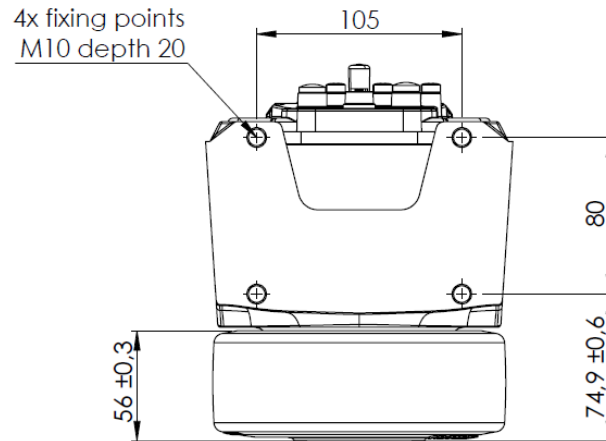
SWD® 125

SWD® 125 - Machine layout recommendation



SWD® 150

SWD® 150 - Machine layout recommendation



7. SWD® Status indicator

7.1. SWD® indicator display mode

The LEDs lights up according to the display states standardized in CiA 303-3.

| LED state | Description |
|----------------------------|--|
| LED on | LED is on |
| - | LED is off |
| LED scintillating | LED blinks at 10 Hz (50 ms on / 50 ms off) |
| LED blinking | LED blinks at 2,5 Hz (200 ms on / 200 ms off) |
| LED single flash | LED flashes 1 time, followed by a long pause (200 ms on / 1000 ms off) |
| LED double flash | LED flashes 2 times, followed by a long pause (200 ms on / 200 ms off 200 ms on / 1000 ms off) |
| LED triple flash | LED flashes 3 times, followed by a long pause (200 ms on / 200 ms off 200 ms on / 200 ms off 200 ms on / 1000 ms off) |
| LED quadruple flash | LED flashes 4 times, followed by a long pause (200 ms on / 200 ms off 200 ms on / 200 ms off 200 ms on / 200 ms off 200 ms on / 1000 ms off) |

During **SWD®** firmware updates, CAN LED is disabled.

7.2. Status LED display

SWD® Status LED is a two-color red or green LED, which indicates the status given by the CiA 402 standard status machine:

| CiA 402 State | | LED green | LED red |
|-------------------------------|------------------------|---------------------|---------------------|
| Not Ready to switch on | (On going) | LED flashes 1 time | - |
| Not Ready to switch on | (Initialisation error) | - | LED flashes 1 time |
| Switch on disabled | | LED flashes 2 times | - |
| Ready to switch on | | LED flashes 3 times | - |
| Switched on | | LED blinks | - |
| Operation enabled | | LED on | - |
| Operation enabled | (STO active) | - | LED on |
| Quick stop active | | LED on | LED flashes 2 times |
| Fault reaction active | | LED scintillating | LED scintillating |
| Fault | | - | LED blinking |

During **SWD®** firmware updates, Status LED is orange fixed (green + red), and red if the upload has failed⁶.

⁶ Only for SWD® products manufactured since October 2023

7.3. CAN LED display

The CAN bus status LED (CAN LED) is a two-color red or green LED, which indicates the operational status of the SWD® CANopen bus:

| CANopen state | | LED green | LED red |
|------------------------|------------------------|------------------|--------------|
| Bus Off | | - | - |
| Initialisation | (Ongoing) | - | - |
| Initialisation | (Initialisation error) | - | LED blinking |
| Pre-Operational | | LED blinking | - |
| Operational | | LED on | - |
| Stopped | | LED single flash | - |

8. Power supply

8.1. 32A Power supply

A two times 16 amps power supply (32A) is possible via the 24 VDC connector. This transmits the power required to operate the SWD®.

Various causes of power supply errors are possible. For instance, if the voltage is too high or too low. Or due to an excessive current.

Warning thresholds must be exceeded for a certain period before they are triggered (timeout). Error thresholds, on the other hand, are triggered immediately, followed by an STO command.

According to the configuration of the 'error behaviour' object (1029h), an error changes the NMT state of the node, unlike an alert, which does not.

Thresholds values are as follow:

| Type | Level | Limits | Timeout | EMCY message |
|----------------------|-------|----------|---------|--------------|
| Under-voltage | Alert | 16 Volts | 1000 ms | ✓ |
| | Error | 14 Volts | - | ✓ |
| Over-voltage | Alert | 32 Volts | 1000 ms | ✓ |
| | Error | 34 Volts | - | ✓ |
| Over-current | Alert | 25 Amps | 1000 ms | ✗ |
| | Error | 30 Amps | - | ✗ |

Some of these errors send an emergency message on the bus of type EMCY, as described in the table above. When the error level is reached, an STO is activated, and the NMT state can be assigned according to the configuration of the 'error behaviour' object (1029h), by default, the motor switches to pre-operational state.

8.2. 2A and 4A Power supply

A 24 VDC power supply on CAN connector of 4A and on I/O connector of 2A, are configurable. This can be used to supply power to third-party peripherals, via a single cable between the peripheral and the SWD®.

The 'control_ext_can_alim' (2400 01h) and 'control_ext_canio_alim' (2400 02h) objects are used to configure the 24V power supply on these connectors.



| 2400: 01-02h: control_ext | Deactivated | Activated |
|---------------------------|-------------|-----------|
| Value | 0 | 1 |

It is possible that an error blocks the correct operation of the power supply, for example a current requested too high. Objects 'status_ext_can_alim' (2401 01h) and 'status_ext_canio_alim' (2401 02h) are used to find out the status of the power supply on these connectors.

| 2401: 01-02h: status_ext | Deactivated | Activated |
|--------------------------|-------------|-----------|
| Value | 0 | 1 |

The object returns '0' if an error has occurred, otherwise '1' if the power supply is working properly.

| Index | Sub-index | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes |
|-------|-----------|-----------------------|-----------|---------------|-------------|-------------|------|-------------|-------------|---------------|
| 2400h | 01h | control_ext_can_alim | U8 | 0h | RW | - | - | 0 | 255 | 1 |
| 2400h | 02h | control_ext_can_alim | U8 | 1h | RW | - | - | 0 | 255 | 1 |
| 2401h | 01h | status_ext_can_alim | U8 | 0h | RW | - | - | 0 | 255 | 1 |
| 2401h | 02h | status_ext_canio_alim | U8 | 0h | RW | - | - | 0 | 255 | 1 |

-  By default, the power supply on the CAN IO connector is activated at start-up.
-  If the configuration is saved, it will be applied after a reboot, and the power supply configuration will be activated on this/these connector(s).

9. CAN bus and CANopen protocol

9.1. Bus specification

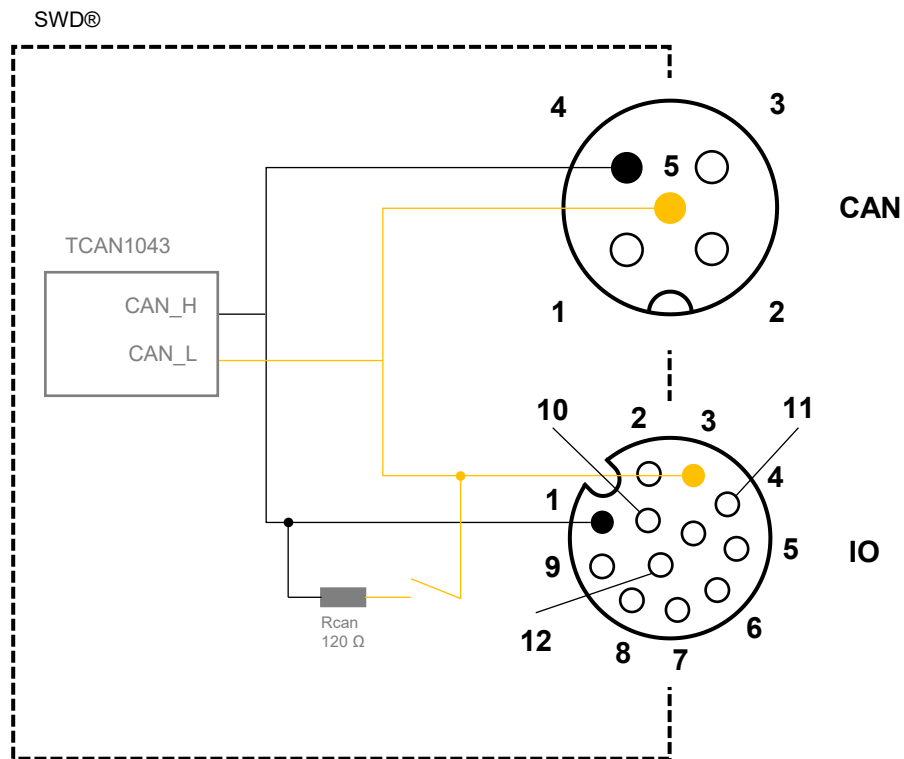


Figure 18 – CAN bus internal wiring diagram

9.2. Baudrate of the CAN node (Baudrate)

SWD® default baud rate is 1,000,000 bps. This value is configurable.

Baud rate configuration can be achieved using two different methods (in NMT Pre-Op mode):

- With **SWD®** dictionary object 'Configure Bit Timing Parameters', 2100 :00h
- With LSS⁷ protocol (Layer Settings Services)

Configuration with **SWD®** object dictionary is performed in 3 steps:

- Write the corresponding value to the selected Baudrate to the 'Configure Bit Timing Parameters' dictionary object 2100 :00h
- Save configuration of communication parameters (cf. 9.10)
- Load new configuration using NMT command 'Reset communication'

When saved, **SWD®** CANopen identifier is persistent to power loss, and will be used at next start-up.

⁷ Implemented from software version 'Firmware' (1.2.x)

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes |
|-------------------|-----|---------------------------------|-----------|----------------|-------------|-------------|------|-------------|-------------|---------------|
| 2100 _h | 0 | Configure Bit Timing Parameters | U8 | 0 _h | RW | - | - | 0 | 4 | 1 |

| 2100 _h : Configure Bit Timing Parameters | Value | Baudrate (bps) |
|--|-------|----------------|
| | 0 | 1.000.000 |
| | 1 | 800.000 |
| | 2 | 500.000 |
| | 3 | 250.000 |
| | 4 | 125.000 |

9.3. CAN node identifier (Node-ID)

The CANopen node identifier identifies a device on the bus. Each node identifier is associated with default CAN message identifiers.

Default **SWD**® identifier is 10_h, this value is configurable.

Node-ID configuration can be achieved using two different methods (in NMT Pre-Op mode):

- With **SWD**® dictionary object 'Node ID', 2101 :00_h
- With LSS⁸ protocol (Layer Settings Services)

Configuration with **SWD**® object dictionary is performed in 3 steps:

- Write the new node-ID value in object dictionary 'Node ID', 2101 :00_h
- Save configuration of communication parameters (cf. 9.10)
- Load new configuration using NMT command 'Reset communication'

When saved, **SWD**® CANopen identifier is persistent to power loss, and will be used at next start-up.

| 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 | - | - | 1 | 127 | 1 |

⚠ Changing the **SWD**® identifier has no impact on message configuration. When configuring the **SWD**®, the user must ensure that the communication parameters (PDO, SDO, etc.) are reconfigured.

⚠ Only the Heartbeat and SDO server 1 identifiers are updated automatically when the Node Id is reconfigured.

9.4. Termination resistor

When the drive is located at the end of the CAN bus, a termination resistor is required. The value of this resistor must be determined in relation to the application's bus topology.

The termination resistor can be set up in 2 simple ways:

- Add a terminating resistor to one of the CAN bus connectors between CAN H and CAN L.
- By activating **SWD**® internal termination resistor

⁸ Implemented from software version 'Firmware' (1.2.x)

SWD® includes an internal termination resistor whose activation is configurable by software.

- ⚠ *The internal resistor is activated in the default configuration.*
- ⚠ *During motor drive start-up or reset, the resistor is deactivated until the configuration is applied.*

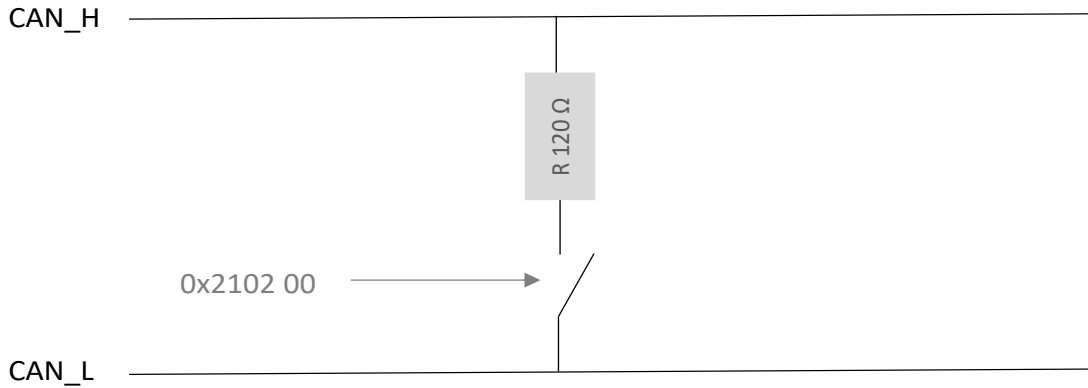


Figure 19 – Internal termination resistor activation

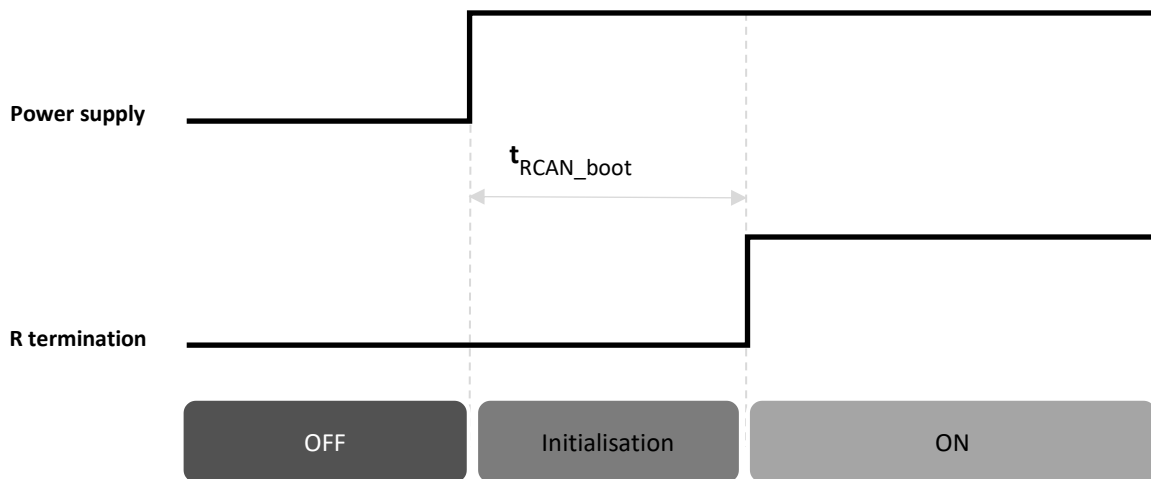


Figure 20 – CAN bus initialisation

| | | Min | Max | Value | Unit |
|------------------------------|---|-----|------|-------|------|
| R_{can} | Internal termination resistor | | | 120 | Ω |
| t_{RCAN_boot} | Time for setting up the internal resistance configuration at start-up | | <500 | | ms |

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes |
|-------------------------|-----------------------|---------------|-----------|-----------------|-------------|-------------|------|-------------|-------------|---------------|
| 2102_h | 00_h | R Termination | BOOL | 01 _h | RW | NO | - | 0 | 1 | 1 |

| | | |
|-----------------------------|-------------|-----------|
| 2102h: R Termination | Deactivated | Activated |
| Value | 0 | 1 |

9.5. SWD® Identity object

SWD® identification data is described in object 1018h in this format:

| Index | Sub-index | Name | Value | Data type |
|--------------|-----------|-------------------|-----------------|------------|
| 1018h | 00h | Number of entries | 04h | Unsigned8 |
| | 01h | Vendor-ID | 0000 0515h | Unsigned32 |
| | 02h | Product code | _ ⁹ | Unsigned32 |
| | 03h | Revision number | _ ¹⁰ | Unsigned32 |
| | 04h | Serial number | _ ¹¹ | Unsigned32 |

9.6. NMT protocol (Network Management) and state machine

A CANopen node respects a state machine, which corresponds to its start-up and operating states. State transitions can be performed automatically, or in response to a request from the CANopen Master node.

The NMT (Network Management) protocol allows this state machine to react, and to get NMT status of a CANopen node:

⁹ Specific ID according to the SWD® device used (e.g. ezSWDcore.14/C has ID 3). Refer to the product itself.

¹⁰ Bit 31-16 is the major revision number. Bit 15-0 the minor revision number. Cf. release notes.

¹¹ Specific serial number, refer to the product itself. Caution encoded format differs from the sticker.

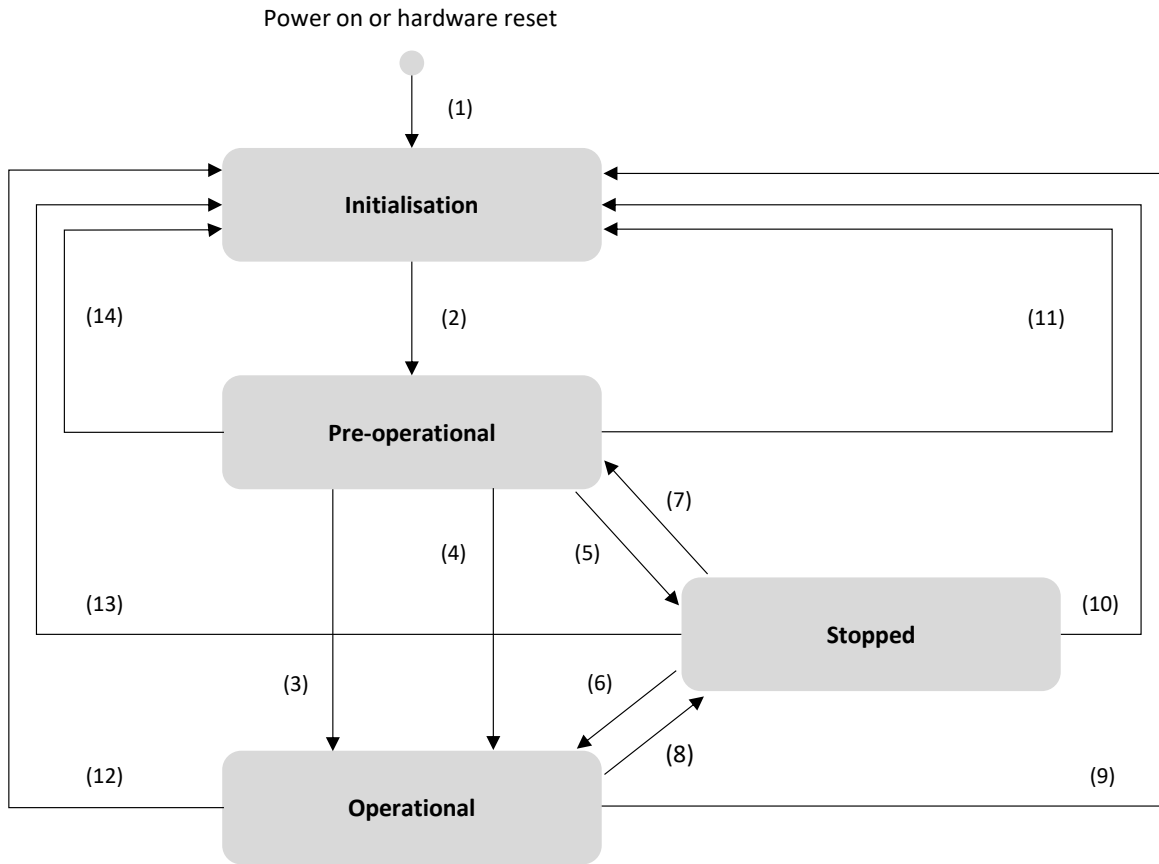


Figure 21 – NMT state machine diagram of a CANopen device

| | |
|-------------------------|---|
| (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 |

The availability of the protocols depends on the state of the node, the table below presents this availability:

| | Pre-operational | Operational | Stopped |
|------------------|-----------------|-------------|---------|
| PDO | | ✓ | |
| SDO | ✓ | ✓ | |
| NMT | ✓ | ✓ | ✓ |
| EMCY | ✓ | ✓ | |
| SRDO | | ✓ | |
| SYNC | ✓ | ✓ | |
| Heartbeat | ✓ | ✓ | ✓ |
| Timestamp | Not supported | | |

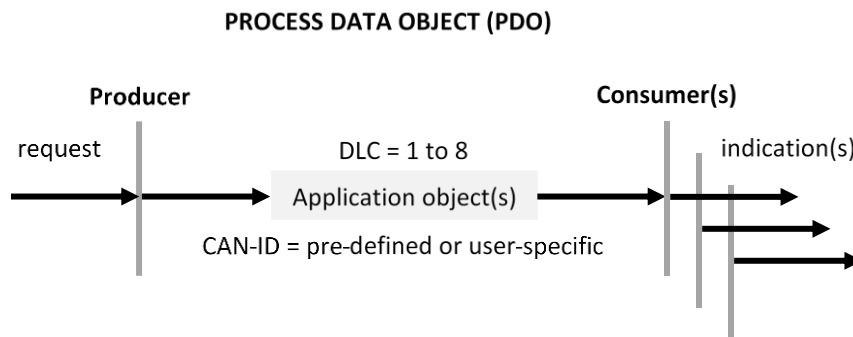
9.7. PDO (Process Data Object)

PDOs are messages used to exchange data in producer/consumer mode. A producer CANopen node sends a message which will be consumed by one or more consumer nodes. For the producer: the PDO is a TPDO (T: Transmitted), the same message is an RPDO (R: Received) for the consumer(s).

A PDO message is characterised by communication parameters including:

- Its identifier on the CAN bus (CAN-ID)
- Its transmission or reception modes
- Its activation

And mapping parameters, describing all the data carried by the message.



SWD® supports up to 8 transmit PDOs (TPDO) and 8 receive PDOs (RPDO).

Communication parameters

PDO communication parameters define whether a message is activated, its identity on the bus (CAN-ID), and its transmission or reception conditions.

For each of a node's messages, a CANopen dictionary lists its communication parameters. RPDO communication parameters are accessible from indexes 1400_h to 1407_h, and TPDO communication parameters from indexes 1800_h to 1807_h.

The configuration structure for communication parameters has the following format:

| Index | Sub-index | Description | Data type |
|---|-----------------|-------------------|------------|
| RPDOs: 1400 _h to 1407 _h | 00 _h | Number of entries | Unsigned8 |
| | 01 _h | COB-ID | Unsigned32 |
| | 02 _h | Transmission type | Unsigned8 |
| TPDOs: 1800 _h to 1807 _h | 03 _h | Inhibit time | UNSIGNED16 |
| | 05 _h | Event timer | UNSIGNED16 |

COB-ID (:01_h)

The COB-ID input can be used to specify:

- CAN-ID identity of the message on the bus
- Validity of the message

⚠ **SWD®** supports 11-bit CAN-ID ('CAN base frame') message identifiers and does not implement the sending of TPDOs on RTR request.

For RPDOs, the COB-ID format is:

| | | | | | | |
|--------------|----------|-------------------------|--------------------|----------------------|----|-----|
| 31 | 30 | 29 | 28 | 11 | 10 | 0 |
| Valid | RTR - | Frame 0 _h | 29-bit CAN-ID - | 11-bit CAN-ID | | |
| MSB | | | | | | LSB |

| Bit(s) | Value | Description |
|----------------------|----------------|---|
| Valid | 0 _b | PDO exists / is valid. |
| | 1 _b | PDO does not exist / is not valid |
| <i>RTR</i> | - | <i>Ignored</i> |
| <i>Frame</i> | 0 _b | <i>11-bit CAN-ID valid (CAN base frame)</i> |
| 29-bit CAN-ID | - | <i>Ignored</i> |
| 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 | 29-bit CAN-ID - | 11-bit CAN-ID | | |
| MSB | | | | | | LSB |

| Bit(s) | Value | Description |
|----------------------|----------------|--|
| Valid | 0 _b | PDO exists / is valid. |
| | 1 _b | PDO does not exist / is not valid |
| <i>RTR</i> | 1 _b | <i>No RTR allowed on TPDO (RTR shall not be used with CANopen)</i> |
| <i>Frame</i> | 0 _b | <i>11-bit CAN-ID valid (CAN base frame)</i> |
| 29-bit CAN-ID | - | <i>Ignored</i> |
| 11-bit CAN-ID | x | 11-bit CAN-ID of the CAN base frame |

Transmission type (:02_h)

The transmission type parameter of a PDO specifies the transmission mode, and the triggering mode. The **SWD®** supports synchronous message triggering (SYNC) only.

Message transmission is triggered by reception of the synchronization message (SYNC). The trigger condition can be configured according to the number of (SYNC) messages received before transmission.

| Value | Description | Supported |
|-----------------|--|-------------------------------------|
| 00h | Acyclic synchronous: <i>Triggered when the SYNC message is received and one of the mapped process data has changed its value after the last transmission.</i> | <input type="checkbox"/> |
| 01h | Cyclic synchronous (every sync) | <input checked="" type="checkbox"/> |
| 02h | Cyclic synchronous (every 2 nd SYNC) | |
| 03h | Cyclic synchronous (every 3 rd SYNC) | |
| 04h | Cyclic synchronous (every 4 th SYNC) | |
| (...) | (...) | |
| F0h | Cyclic synchronous (every 240 th SYNC) | |
| F1h | Reserved | |
| (...) | | |
| FBh | | |
| FC _h | | |
| FD _h | Asynchronous RTR only: <i>not recommended anymore</i> | |
| FE _h | Asynchronous: <i>Triggered by an internal event (e.g., change-of-state of one of the mapped process data or elapsing of the event-timer or any other event). The device manufacturer specifies the internal event triggering the TPDO transmission.</i> | |
| FF _h | Asynchronous: <i>As before, but the CiA profile specifies the internal event triggering the TDPO transmission.</i> | |

The transmission type specifies the transmission speed, based on the transmission period of the synchronisation message (SYNC).

- A transmission type equal to '00h', means that the message must be transmitted after the SYNC occurs, but acyclically (non-periodically), only if a data item mapped in a PDO has changed between two synchronization messages (SYNC).
- A transmission type equal to '01h', means that the message must be transmitted after reception of each synchronization message (SYNC).
- A transmission type between '01h' et 'F0h' (N), means that the message must be transmitted after every Nth SYNC object.

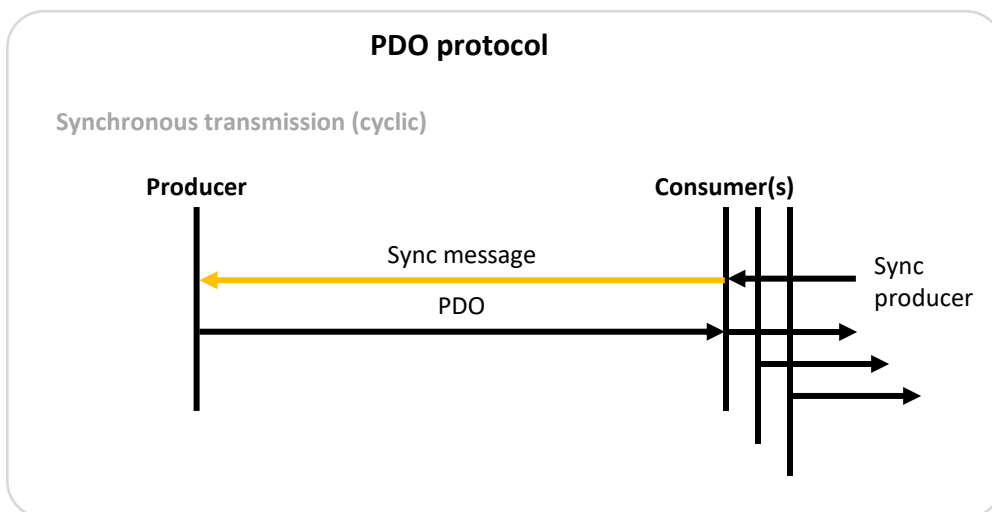


Figure 22 – PDO description

Inhibit time (:03)

The inhibit-time sub-parameter provides the time in ms, when this TPDO is allowed sending it again. The null value disables the inhibit time. It is not allowed to change the value while the PDO exists (bit 31 of sub-index 01_h is set to 0_b)

Event timer (:05)

The event timer sub-parameter specifies the period in ms of the TPDO transmission respectively the time-out (missing) of a RPDO. The null value disables the event-timer.

A RPDO uses this timer for deadline monitoring. If the timers expire before receiving a newer RPDO, it triggers an emergency message (EMCY), with error code: ‘8206: PDO_event_timer’, and the node goes into error state.

Mapping parameters

PDO mapping configuration allows data included in a PDO to be pointed to an object in the dictionary, either on the transmit or receive side.

SWD® supports user reconfiguration of PDO mapping.

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

- In reception mode (RPDO), mapping is used to decode the data received in the RPDO, and therefore to update the data in the SWD® dictionary. RPDO mapping is configured in objects 1600_h to 1607_h.
- In emission mode (TPDO), mapping is used to encode the data to be transmitted in the TPDO, which has been updated in the SWD® dictionary. TPDO mapping is configured in objects 1A00_h to 1A07_h.

The configuration structure for mapping parameters has the following format:

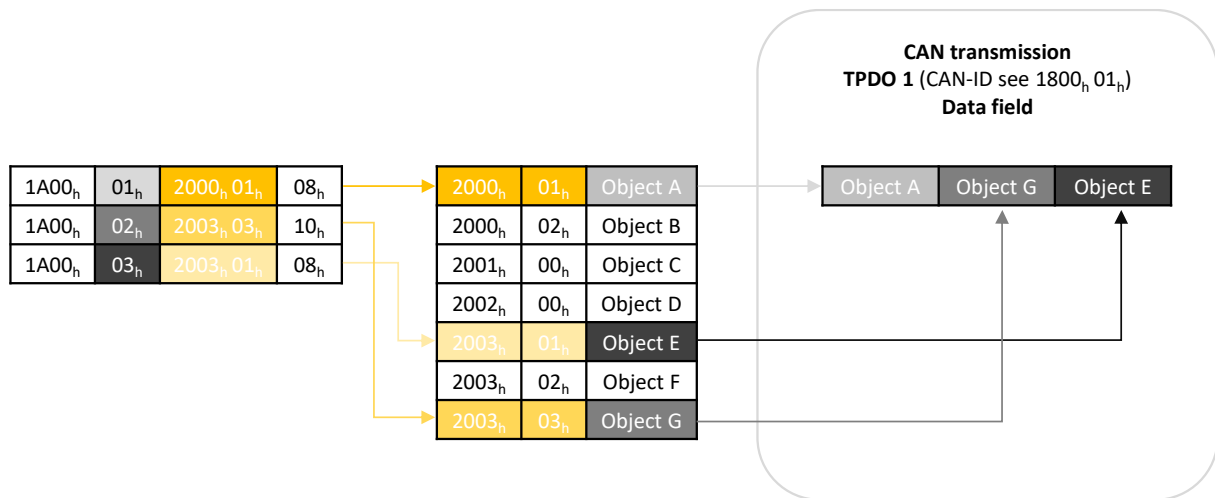


Figure 23 – TPDO mapping

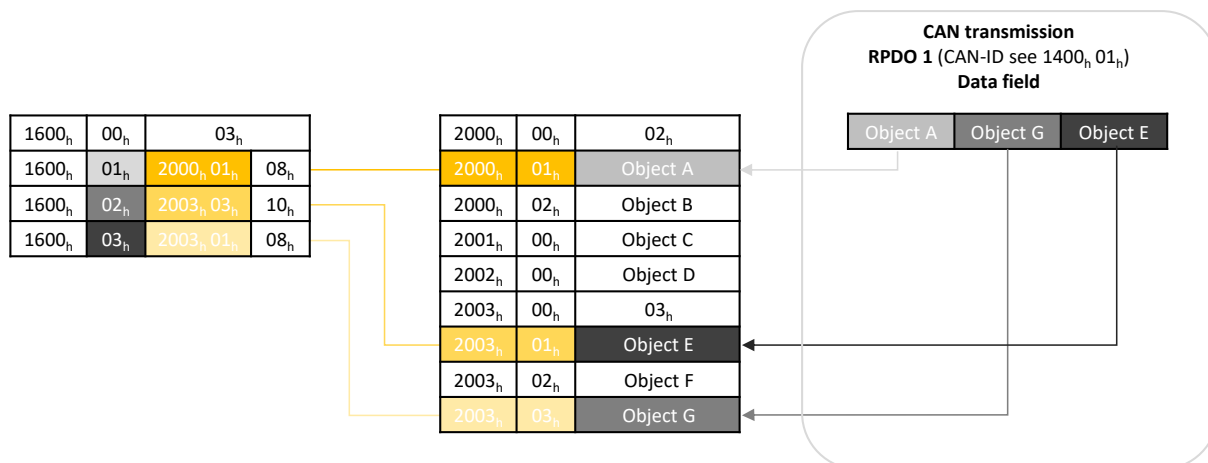


Figure 24 – RPDO mapping











Default values

| Valid (COB-ID bit 31) | RPDOs | Mapping |
|-------------------------------------|-------|----------------------------------|
| <input checked="" type="checkbox"/> | 1 | Controlword |
| <input type="checkbox"/> | 2 | - |
| <input type="checkbox"/> | 3 | - |
| <input checked="" type="checkbox"/> | 4 | Controlword & vl target velocity |
| <input type="checkbox"/> | 5 | - |
| <input type="checkbox"/> | 6 | - |
| <input type="checkbox"/> | 7 | - |
| <input type="checkbox"/> | 8 | - |













| Valid (COB-ID bit 31) | TPDOs | Mapping |
|-------------------------------------|-------|------------------------------------|
| <input checked="" type="checkbox"/> | 1 | Statusword |
| <input type="checkbox"/> | 2 | Statusword |
| <input checked="" type="checkbox"/> | 3 | Statusword & position value |
| <input checked="" type="checkbox"/> | 4 | Statusword & velocity actual value |
| <input type="checkbox"/> | 5 | Statusword |
| <input type="checkbox"/> | 6 | Statusword |
| <input type="checkbox"/> | 7 | Statusword |
| <input type="checkbox"/> | 8 | Statusword |

RPDO 1 : Controlword

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes |
|---------------------------------|-----------------|-------------------|-----------|------------------------|-------------|-------------|------|------------------|------------------|---------------|
| Communication parameters | | | | | | | | | | |
| 1400 _h | 00 _h | Number of entries | U8 | 02 _h | RO | NO | - | 02 _h | 02 _h | 1 |
| | 01 _h | COB-ID | U32 | 0000 0210 _h | RW | NO | - | 200 _h | 27F _h | 4 |
| | 02 _h | Transmission type | U8 | 01 _h | RW | NO | - | 0 _h | 0FF _h | 1 |
| | 03 _h | Inhibit time | U16 | 00 _h | RO | NO | - | 00 _h | 00 _h | 2 |












| | | | | | | | | | | |
|---------------------|-----------------|------------------|-----|---------------------------------------|---|----|----|-----------------|-------------------|---|
| | 05 _h | Event timer | U16 | 00 _h | RW  | NO | ms | 00 _h | FFFF _h | 2 |
| Data mapping | | | | | | | | | | |
| 1600 _h | 00 _h | Number of mapped | U8 | 01 _h | RW  | NO | - | 00 _h | 08 _h | 1 |
| | 01 _h | Mapping Entry 1 | U32 | 6040 0010 _h Controlword | RW  | NO | - | - | - | 4 |
| | 02 _h | Mapping Entry 2 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 03 _h | Mapping Entry 3 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 04 _h | Mapping Entry 4 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 05 _h | Mapping Entry 5 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 06 _h | Mapping Entry 6 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 07 _h | Mapping Entry 7 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 08 _h | Mapping Entry 8 | U32 | 00 _h | 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 parameters | | | | | | | | | | |
| 1403 _h | 00 _h | Number of entries | U8 | 02 _h | RO | NO | - | 02 _h | - | 1 |
| | 01 _h | COB-ID | U32 | 000 0510 _h | RW  | NO | - | 500 _h | 57F _h | 4 |
| | 02 _h | Transmission type | U8 | 01 _h | RW  | NO | - | 0 _h | 0FF _h | 1 |
| | 03 _h | Inhibit time | U16 | 00 _h | RO | NO | - | 00 _h | 00 _h | 2 |
| | 05 _h | Event timer | U16 | 00 _h | RW  | NO | ms | 00 _h | FFFF _h | 2 |
| Data mapping | | | | | | | | | | |
| 1603 _h | 00 _h | Number of mapped | U8 | 02 _h | RW  | NO | - | 01 _h | 08 _h | 1 |
| | 01 _h | Mapping Entry 1 | U32 | 6040 0010 _h Controlword | RW  | NO | - | - | - | 4 |
| | 02 _h | Mapping Entry 2 | U32 | 6042 0010 _h VI target velocity | RW  | NO | - | - | - | 4 |
| | 03 _h | Mapping Entry 3 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 04 _h | Mapping Entry 4 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 05 _h | Mapping Entry 5 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 06 _h | Mapping Entry 6 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 07 _h | Mapping Entry 7 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 08 _h | Mapping Entry 8 | U32 | 00 _h | 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 parameters | | | | | | | | | | |
|--------------------------|-----------------|-------------------|-----|--------------------------------------|---|----|---|------------------|------------------------------------|---|
| 1800 _h | 00 _h | Number of entries | U8 | 02 _h | RO | NO | - | 02 _h | - | 1 |
| | 01 _h | COB-ID | U32 | 4000 0190 _h | RW  | NO | - | 180 _h | 180 _h + 7F _h | 4 |
| | 02 _h | Transmission type | U8 | 01 _h | RW  | NO | - | 00 _h | OFF _h | 1 |
| Data mapping | | | | | | | | | | |
| 1A00 _h | 00 _h | Number of mapped | U8 | 01 _h | RW  | NO | - | 00 _h | 08 _h | 1 |
| | 01 _h | Mapping Entry 1 | U32 | 6041 0010 _h Statusword | RW  | NO | - | - | - | 4 |
| | 02 _h | Mapping Entry 2 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 03 _h | Mapping Entry 3 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 04 _h | Mapping Entry 4 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 05 _h | Mapping Entry 5 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 06 _h | Mapping Entry 6 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 07 _h | Mapping Entry 7 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 08 _h | Mapping Entry 8 | U32 | 00 _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 parameters | | | | | | | | | | |
| 1802 _h | 00 _h | Number of entries | U8 | 02 _h | RO | NO | - | 02 _h | - | 1 |
| | 01 _h | COB-ID | U32 | 4000 0390 _h | RW  | NO | - | 380 _h | 380 _h + 7F _h | 4 |
| | 02 _h | Transmission type | U8 | 01 _h | RW  | NO | - | 00 _h | OFF _h | 1 |
| Data mapping | | | | | | | | | | |
| 1A02 _h | 00 _h | Number of mapped | U8 | 02 _h | RW  | NO | - | 00 _h | 08 _h | 1 |
| | 01 _h | Mapping Entry 1 | U32 | 6041 0010 _h Statusword | RW  | NO | - | - | - | 4 |
| | 02 _h | Mapping Entry 2 | U32 | 6064 0020 _h position value | RW  | NO | - | - | - | 4 |
| | 03 _h | Mapping Entry 3 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 04 _h | Mapping Entry 4 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 05 _h | Mapping Entry 5 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 06 _h | Mapping Entry 6 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 07 _h | Mapping Entry 7 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 08 _h | Mapping Entry 8 | U32 | 00 _h | 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 parameters | | | | | | | | | | |
|--------------------------|-----------------|-------------------|-----|--|---|----|---|------------------|---------------------------------------|---|
| 1803 _h | 00 _h | Number of entries | U8 | 02 _h | RO | NO | - | 02 _h | - | 1 |
| | 01 _h | COB-ID | U32 | 4000 0490 _h | RW  | NO | - | 480 _h | 480 _h + 7F _h | 4 |
| | 02 _h | Transmission type | U8 | 01 _h | RW  | NO | - | 00 _h | OFF _h | 1 |
| Data mapping | | | | | | | | | | |
| 1A03 _h | 00 _h | Number of mapped | U8 | 02 _h | RW  | NO | - | 00 _h | 08 _h | 1 |
| | 01 _h | Mapping Entry 1 | U32 | 6041 0010 _h Statusword | RW  | NO | - | - | - | 4 |
| | 02 _h | Mapping Entry 2 | U32 | 606C 0020 _h Velocity actual value | RW  | NO | - | - | - | 4 |
| | 03 _h | Mapping Entry 3 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 04 _h | Mapping Entry 4 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 05 _h | Mapping Entry 5 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 06 _h | Mapping Entry 6 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 07 _h | Mapping Entry 7 | U32 | 00 _h | RW  | NO | - | - | - | 4 |
| | 08 _h | Mapping Entry 8 | U32 | 00 _h | RW  | NO | - | - | - | 4 |

Mapping configuration method

The following method is used to change the mapping or communication parameters of PDOs in the pre-operational NMT state:

1. Set node to pre-operational state (Pre-Op) by sending NMT command 'Enter Pre-Op'.
2. Disable PDO by setting COB-ID bit 31 'valid' to 1_b (sub-index 01_h, PDO communication parameter).
3. Disable mapping by setting sub-index 00_h of the mapping parameters to 00_h.
4. Modify mapping by changing the values of the corresponding sub-indices.
5. Enable mapping by setting sub-index 00_h to the number of mapped objects.
6. Create the PDO by setting bit 31 'valid' to 0_b in the associated COB-ID.
7. Save configuration of communication parameters (cf. 9.10).
8. Load new configuration via NMT command 'Reset communication'.
9. Start node by sending NMT 'Start' command.

9.8. Emergency (EMCY)

Presentation

The emergency message service (EMCY) is based on the producer/consumer principle. When the **SWD®** detects an error, it acts as a producer, transmitting a message on the CAN bus indicating the error code. Other nodes can act as consumers, by reading the message containing the error code.

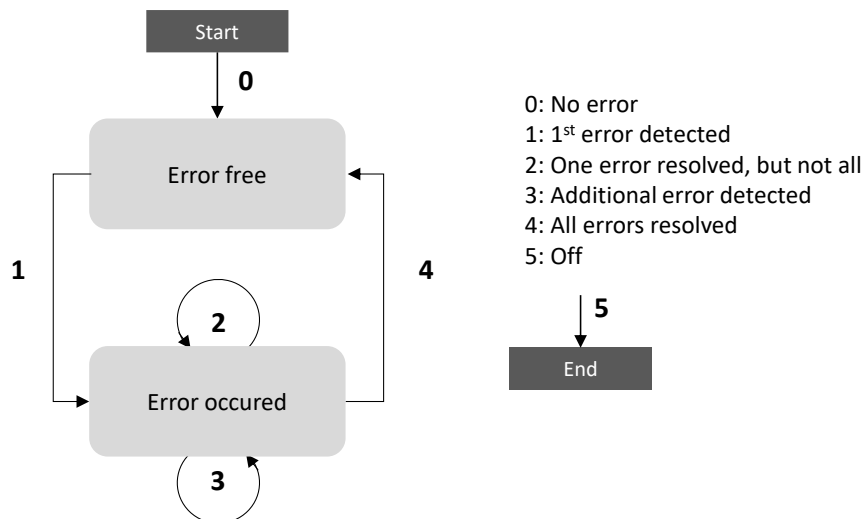


Figure 25 – EMCY error state machine

| | |
|---|--|
| 0 | After initialisation, The SWD® goes into error-free state. No emergency message is sent. |
| 1 | The SWD® detects a 1 st error. It goes into error state. An emergency message can be sent with the error code and associated error register. The error code corresponds to the first two bytes of the message, and the error register to the third byte. The error code is set in the object '1003 _h : Predefined error field'. The error register is set in object '1001 _h : Error Register'. |
| 2 | An error disappears, but one or more errors are still present. An emergency message containing error code 0000 _h (error reset) may be transmitted together with the remaining errors in the error register and in the manufacturer-specific error field. |
| 3 | A new error appears. The SWD® remains in error state and can transmit an emergency message with error code and associated error register. |
| 4 | All errors have disappeared. The SWD® goes into error-free state and transmits an emergency object with the error code "reset error / no error". |
| 5 | Reset or power off. |

The list of errors causing an emergency/no message (EMCY) to be sent, are listed below in the error code table.

The link between error state (EMCY) and CANopen node state (NMT) is defined by the 'Error behavior' object (1029_h). If an error or alert is detected in 'Operational' mode, it can be configured to switch the machine to 'pre-Operational', 'Stopped' or to maintain its NMT state. An error can occur in CAN bus communication, and an error or alert can appear in the application.

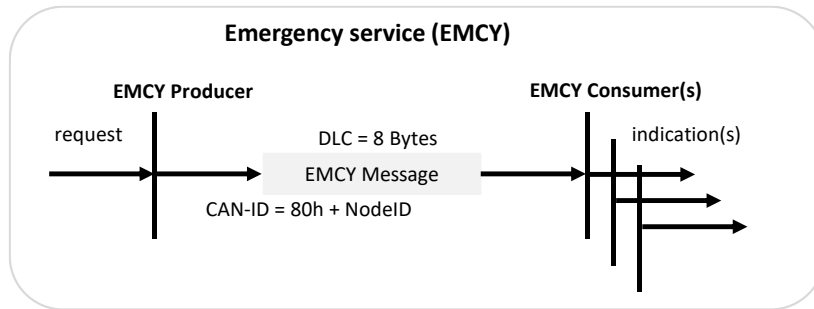
⚠ When using multiple devices, it is strongly recommended to set the 'Application error' object to 1. In this case, an application error will not cause the node to enter the NMT 'pre-Operational' state and will not stop the emission of SRDOs safety messages.

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes |
|-------------------|-----------------|---------------------|-----------|-----------------|-------------|-------------|------|-------------|-------------|---------------|
| 1029 _h | 00 _h | Number of entries | U8 | 03 _h | RO | NO | - | - | - | 1 |
| 1029 _h | 01 _h | Communication error | U8 | 00 _h | RW | NO | - | - | - | 1 |

| | | | | | | | | | | |
|-------------------------|-----------------|---------------------|----|-----------------|---|----|---|---|---|---|
| 1029_h | 02 _h | Application error | U8 | 01 _h | RW  | NO | - | - | - | 1 |
| 1029_h | 03 _h | Application warning | U8 | 01 _h | RW  | NO | - | - | - | 1 |

| | | |
|--------------|-----------------|---|
| Value | 00 _h | When this error occurs: the node enters the NMT 'pre-Operational' state |
| | 01 _h | When this error occurs: no change in NMT state of the node |
| | 02 _h | When this error occurs: the node enters the NMT 'Stopped' state |

Emergency messages (EMCY) are transmitted in the following format:



| EMCY Message | | |
|--------------|----------------|-----------------------|
| Error code | Error register | Manufacturer-specific |
| 2 Bytes | 1 Byte | 5 Bytes |

Error code

| Reset | Description | EMCY |
|-------------------------|-------------------------|--------------------------|
| 0000_h | Reset error or no error | <input type="checkbox"/> |

| Generic | Description | EMCY |
|-------------------------|---------------|--------------------------|
| 1000_h | Generic error | <input type="checkbox"/> |

| Current | Description | EMCY |
|-------------------------|---|--------------------------|
| 2221_h | Motor overcurrent error - Error level | <input type="checkbox"/> |
| 2222_h | Motor overcurrent error - Warning level | <input type="checkbox"/> |

| Voltage | Description | EMCY |
|-------------------------|---------------------------------------|-------------------------------------|
| 3211_h | DC overvoltage error - Error level | <input checked="" type="checkbox"/> |
| 3212_h | DC overvoltage fault - Warning level | <input checked="" type="checkbox"/> |
| 3221_h | DC undervoltage error - Error level | <input checked="" type="checkbox"/> |
| 3222_h | DC undervoltage error - Warning level | <input checked="" type="checkbox"/> |

| Temperature | Description | EMCY |
|-------------------------|---|-------------------------------------|
| 4000_h | Internal error temperature too high | <input type="checkbox"/> |
| 4210_h | Internal error Power stage temperature too high | <input checked="" type="checkbox"/> |
| 4310_h | Internal error Drive temperature too high | <input checked="" type="checkbox"/> |

| Software | Description | EMCY |
|-------------------------|--|-------------------------------------|
| 6000_h | CANopen software error | <input checked="" type="checkbox"/> |
| 6020_h | CANopen software error: CRC safety mapping / configuration | <input checked="" type="checkbox"/> |

| Manufacturer | Description | EMCY |
|--------------|---|-------------------------------------|
| 7100h | Power supply error on CAN or IO connector | <input checked="" type="checkbox"/> |
| 7121h | Motor blocked error | <input checked="" type="checkbox"/> |

| Monitoring | Description | EMCY |
|------------|---|-------------------------------------|
| 8001h | Fault on safety input STO_1 | <input checked="" type="checkbox"/> |
| 8002h | Fault on safety input STO_2 | <input checked="" type="checkbox"/> |
| 8003h | INSafe_1 safety input failure | <input checked="" type="checkbox"/> |
| 8004h | INSafe_2 safety input failure | <input checked="" type="checkbox"/> |
| 8005h | INSafe_3 safety input failure | <input checked="" type="checkbox"/> |
| 8006h | INSafe_4 safety input failure | <input checked="" type="checkbox"/> |
| 8007h | Internal encoder coherence failure | <input checked="" type="checkbox"/> |
| 8008h | Internal failure switching-off driver | <input checked="" type="checkbox"/> |
| 8009h | STO signal consistency failure | <input checked="" type="checkbox"/> |
| 800Ah | Internal brake activation failure | <input checked="" type="checkbox"/> |
| 800Bh | Internal brake management failure | <input checked="" type="checkbox"/> |
| 800Ch | Internal failure disconnecting power supply to driver | <input checked="" type="checkbox"/> |
| 800Dh | Internal failure on DC power | <input checked="" type="checkbox"/> |
| 800Eh | Internal STO management failure | <input checked="" type="checkbox"/> |
| 8010h | Error external brake disconnected | <input checked="" type="checkbox"/> |
| 8011h | External brake overcurrent error | <input checked="" type="checkbox"/> |
| 8012h | SBU activated | <input checked="" type="checkbox"/> |
| 8013h | Error activating SBU | <input checked="" type="checkbox"/> |
| 8014h | Error inconsistent diagnosis on N_CC_STATE | <input checked="" type="checkbox"/> |
| 8015h | Error diagnosing MCU_NBRAKE | <input checked="" type="checkbox"/> |
| 8016h | Error diagnosing BRAKE_LOCK_CHECK | <input checked="" type="checkbox"/> |
| 8017h | Error in external brake activation command | <input checked="" type="checkbox"/> |
| 8018h | Error internal brake interrupt check | <input checked="" type="checkbox"/> |
| 8050h | Generic driver error | <input checked="" type="checkbox"/> |

| Communication | Description | EMCY |
|---------------|-------------------------------------|-------------------------------------|
| 8120h | CAN bus error - error passive | <input checked="" type="checkbox"/> |
| 8140h | CAN bus error - return from bus off | <input checked="" type="checkbox"/> |

| Protocol | Description | EMCY |
|----------|---|-------------------------------------|
| 8201h | SRDO protocol error - SCT not respected | <input checked="" type="checkbox"/> |
| 8202h | SRDO protocol error - SRVT not respected | <input checked="" type="checkbox"/> |
| 8203h | SRDO protocol error - data inconsistency | <input checked="" type="checkbox"/> |
| 8204h | SRDO protocol error - message missing | <input checked="" type="checkbox"/> |
| 8205h | SRDO protocol error - wrong message size | <input checked="" type="checkbox"/> |
| 8206h | RPDO protocol error – ‘Event timer’ timeout | <input checked="" type="checkbox"/> |

Error register

This object is an 8-bit field, indicating error classes. Each bit corresponds to a class:

| Bit | M/O | Signification |
|-----|-----|------------------------------|
| 0 | M | Generic error |
| 1 | O | Current |
| 2 | O | Voltage |
| 3 | O | Temperature |
| 4 | O | Communication error |
| 5 | O | <i>Device specific</i> |
| 6 | O | <i>Reserved</i> |
| 7 | O | <i>Manufacturer specific</i> |

Error class and history

Object 1001_h contains current error class.

| 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 | TPDO | - | 0 | FF _h | 1 |

Object 1003_h contains the list of errors. The oldest error is stored in the object with the highest sub-index. The most recent error is stored in the object with sub-index 1. The number of errors stored in the table corresponds to the value stored in sub-index 0.

| 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 |
| | 1..FE _h | Standard error field | U32 | - | RO | - | - | - | - | 4 |

EMCY COB-ID

The COB-ID value of the emergency message (EMCY) can be set from object 1014_h. The default value is (80h + NodeID):

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes |
|-------------------|-----|---------------------|-----------|---------------|-------------|-------------|------|-------------|-------------|---------------|
| 1014 _h | 0 | COB-ID EMCY message | U32 | 80h + NodeID | RW | - | - | - | - | 1 |

The COB-ID format is:

| 31 | 30 | 29 | 28 | 11 | 10 | 0 |
|-------|-----------------------|-------------------------|--------------------|----|---------------|-----|
| Valid | RTR 0 _h | Frame 0 _h | 29-bit CAN-ID - | | 11-bit CAN-ID | |
| MSB | | | | | | LSB |

EMCY COB-ID description table:

| Bit(s) | Value | Description |
|----------------------|----------------------|---|
| Valid | 0_b | EMCY exists / is valid. |
| | 1_b | EMCY does not exist / is not valid |
| <i>RTR</i> | <i>0_b</i> | <i>reserved</i> |
| <i>Frame</i> | <i>0_b</i> | <i>11-bit CAN-ID valid (CAN base frame)</i> |
| 29-bit CAN-ID | - | <i>Ignored</i> |
| 11-bit CAN-ID | x | 11-bit CAN-ID of the CAN base frame |

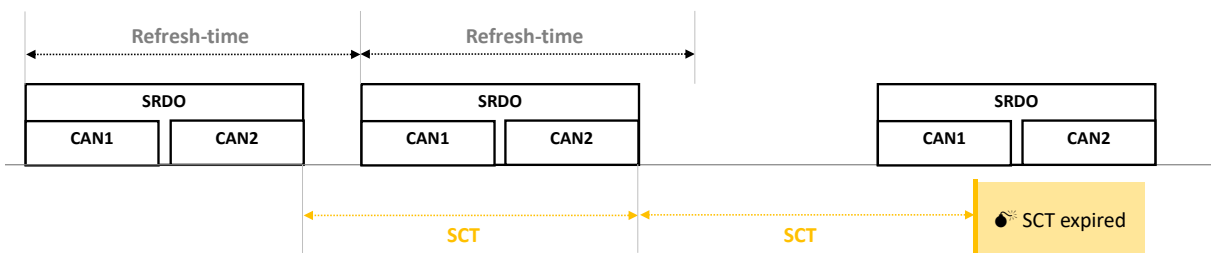
9.9. SRDO (Safety-Relevant Data Object)

The SRDO protocol included in CANopen Safety enables the transmission of safety-related data. Data exchange between two safety-related nodes using the CANopen Safety protocol is guaranteed up to Safety Integrity Level 3 (SIL 3). SRDOs consist of two CAN messages (CAN1 and CAN2). The second message contains the information of the 1st message, but inverted bit by bit.

Periodicity control between messages (SCT):

Cyclic transmission speed and refresh time are monitored. The SCT (Safe-guard Cycle Time) defines the maximum time between two periodic transmissions of an SRDO. If the time elapsed between two SRDO receptions exceeds the SCT, the SRDO consumer signals the SCT event. The SRLD (Safety-Related Logical Device) must then switch to a safe state.

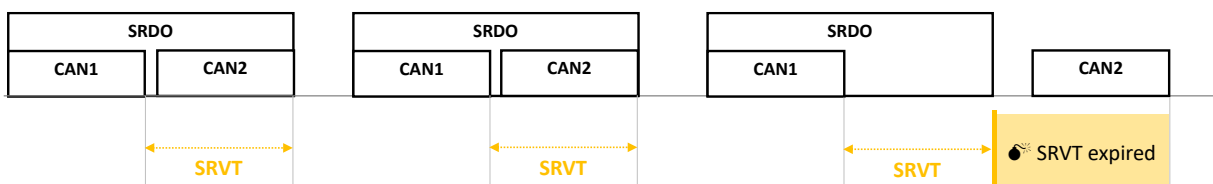
The figure below illustrates the SCT mechanism:



Time control between CAN frames (SRVT)

An SRDO message includes two CAN frames (CAN1 and CAN2) whose reception time between the two frames is also monitored. The SRVT (Safety-Related object Validation Time) defines this duration. If the time elapsed between two CAN frames (CAN1 and CAN2) is greater than the SRVT, the SRDO consumer signals the SRVT event. The SRLD (Safety-Related Logical Device) must then switch to the safe state.

The figure below illustrates the SRVT mechanism:



Data consistency checks

The data contained in the two CAN frames (CAN1 and CAN2) must be consistent with each other. The second message contains the bit-by-bit complement of this data.

Communication parameters

| Index | Sub-index | Description | Data type |
|--|-----------------|-------------------|------------|
| SRDO1: 1301_h SRDO2: 1302_h SRDO 9 à 16: 1309_h to 1310_h | 00 _h | Number of entries | Unsigned8 |
| | 01 _h | Direction | Unsigned8 |
| | 02 _h | SCT | Unsigned16 |
| | 03 _h | SRVT | Unsigned8 |
| | 04 _h | Transmission type | Unsigned8 |
| | 05 _h | COB-ID 1 | Unsigned32 |
| | 06 _h | COB-ID 2 | Unsigned32 |

Time (SCT et SRVT)

In transmission, the SCT value defines the period at which the SRDO message is to be sent.

At the receiving end, the SCT and SRVT times are used to configure monitoring. The default values are 50ms and 20ms respectively. Times are expressed in ms and the value 0 is forbidden.

⚠ SRVT must always be lower than SCT, otherwise an error will occur.

Message direction:

| Value | Description |
|-----------------|--------------------------|
| 00 _h | Invalid (does not exist) |
| 01 _h | (TX) Transmission |
| 02 _h | (RX) Reception |
| 03 _h | Reserved |
| (...) | |
| FF _h | |

Transmission type:

| Value | Description | Supported |
|-----------------|--|-------------------------------------|
| 00 _h | Acyclic synchronous (every sync if data has changed) | <input type="checkbox"/> |
| 01 _h | Cyclic synchronous (every sync) | <input type="checkbox"/> |
| 02 _h | Cyclic synchronous (every 2 nd SYNC) | <input type="checkbox"/> |
| 03 _h | Cyclic synchronous (every 3 rd SYNC) | <input type="checkbox"/> |
| 04 _h | Cyclic synchronous (every 4 th SYNC) | <input type="checkbox"/> |
| (...) | (...) | <input type="checkbox"/> |
| F0 _h | Cyclic synchronous (every 240 th SYNC) | <input type="checkbox"/> |
| FC _h | Reserved | |
| (...) | | |
| FD _h | | |
| FE _h | Asynchronous: <i>Triggered by an internal event</i> | <input checked="" type="checkbox"/> |
| FF _h | Asynchronous: <i>As before, but the CiA profile specifies the internal event SRDO transmission.</i> | <input type="checkbox"/> |

i Any change to the transmission type generates an 'abort code'.

Default values

| SRDO | Valid | Direction | Mapping |
|-------|-------------------------------------|-----------------------|--|
| 1 | <input checked="" type="checkbox"/> | RX (02 _h) | Safety control word 1 (6620 0108 _h) |
| 2 | <input checked="" type="checkbox"/> | TX (01 _h) | Safety status word 1 à 8 (6621 0108 _h -> 6621 0808 _h) |
| 3 | Reserved | | |
| (...) | | | |
| 8 | | | |
| 9 | | | |
| 10 | <input type="checkbox"/> | TX | Safe position actual value i32 (6611 0020 _h) + Safe velocity actual value i32 (6613 0020 _h) ¹² |
| 11 | <input type="checkbox"/> | RX | Safety control word 3 (6620 0308 _h) |
| 12 | <input type="checkbox"/> | RX | Safety control word 4 (6620 0408 _h) |
| 13 | <input type="checkbox"/> | RX | Safety control word 5 (6620 0508 _h) |
| 14 | <input type="checkbox"/> | RX | Safety control word 6 (6620 0608 _h) |
| 15 | <input type="checkbox"/> | RX | Safety control word 7 (6620 0708 _h) + Safety control word 8 (6620 0808 _h) |
| 16 | <input type="checkbox"/> | TX | Safety control word Safein 1 (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 parameter | | | | | | | | | | | |
| 1301 _h | 00 _h | Number of entries | U8 | 06 _h | RO | NO | - | - | - | 1 | |
| | 01 _h | Information direction | U8 | 2 (RX) | RW | NO | - | 0 / 2 (RX) | | 1 | |
| | 02 _h | 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 |
| Mapping | | | | | | | | | | | |
| 1381 _h | 00 _h | Number of entries | 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 | |


SRDO 2 TX

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes |
|--------------------------------|-----------------|-------------------|-----------|-----------------|-------------|-------------|------|-------------|-------------|---------------|
| Communication parameter | | | | | | | | | | |
| 1302 _h | 00 _h | Number of entries | U8 | 06 _h | RO | NO | - | - | - | 1 |

¹² Implemented from firmware version 1.1.4

| | | | | | | | | | | |
|-------------------------|------------------------------|------------------------------|------------------------|------------------------|---|----|----|-----------------|-----------------|---|
| | 01 _h | Information direction | U8 | 1 (TX) | RW  | NO | - | 0 / 1 (TX) | | 1 |
| | 02 _h | 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 |
| Mapping | | | | | | | | | | |
| 1382_h | 00 _h | Number of entries | 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 parameter | | | | | | | | | | |
| 1309_h | 00 _h | Number of entries | U8 | 06 _h | RO | NO | - | - | - | 1 |
| | 01 _h | Information direction | U8 | 0 (inactive) | RW  | NO | - | 0 / 2 (RX) | | 1 |
| | 02 _h | 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 |

| Mapping | | | | | | | | | | |
|-------------------|-----------------|------------------------------|-----|------------------------|----|----|---|-----------------|-----------------|---|
| 1389 _h | 00 _h | Number of entries | 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 parameter | | | | | | | | | | |
| 130A _h | 00 _h | Number of entries | U8 | 06 _h | RO | NO | - | - | - | 1 |
| | 01 _h | Information direction | U8 | 0 (inactive) | RW | NO | - | 0 / 1 (TX) | | 1 |
| | 02 _h | 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 |
| Mapping | | | | | | | | | | |
| 138A _h | 00 _h | Number of entries | 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 velocity actual 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 parameter | | | | | | | | | | |
| 130B _h | 00 _h | Number of entries | U8 | 06 _h | RO | NO | - | - | - | 1 |
| | 01 _h | Information direction | U8 | 0 (inactive) | RW | NO | - | 0 / 2 (RX) | | 1 |
| | 02 _h | 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 |
| Mapping | | | | | | | | | | |
| 138B _h | 00 _h | Number of entries | 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 parameter | | | | | | | | | | |
| 130C _h | 00 _h | Number of entries | U8 | 06 _h | RO | NO | - | - | - | 1 |
| | 01 _h | Information direction | U8 | 0 (inactive) | RW | NO | - | 0 / 2 (RX) | | 1 |
| | 02 _h | 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 |
| Mapping | | | | | | | | | | |
| 138C _h | 00 _h | Number of entries | 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 parameter | | | | | | | | | | |
| 130D _h | 00 _h | Number of entries | U8 | 06 _h | RO | NO | - | - | - | 1 |
| | 01 _h | Information direction | U8 | 0 (inactive) | RW | NO | - | 0 / 2 (RX) | | 1 |
| | 02 _h | 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 |
| Mapping | | | | | | | | | | |
| 138D _h | 00 _h | Number of entries | 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 parameter | | | | | | | | | | |
|-------------------------|-----------------|------------------------------|-----|------------------------|----|----|----|-----------------|-----------------|---|
| 130E _h | 00 _h | Number of entries | U8 | 06 _h | RO | NO | - | - | - | 1 |
| | 01 _h | Information direction | U8 | 0 (inactive) | RW | NO | - | 0 / 2 (RX) | | 1 |
| | 02 _h | 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 |
| Mapping | | | | | | | | | | |
| 138E _h | 00 _h | Number of entries | 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 parameter | | | | | | | | | | |
| 130F _h | 00 _h | Number of entries | U8 | 06 _h | RO | NO | - | - | - | 1 |
| | 01 _h | Information direction | U8 | 0 (inactive) | RW | NO | - | 0 / 2 (RX) | | 1 |
| | 02 _h | 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 |
| Mapping | | | | | | | | | | |
| 138F _h | 00 _h | Number of entries | 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 parameter | | | | | | | | | | |
| 1310 _h | 00 _h | Number of entries | U8 | 06 _h | RO | NO | - | - | - | 1 |
| | 01 _h | Information direction | U8 | 0 (inactive) | RW | NO | - | 0 / 1 (TX) | | 1 |

| | | | | | | | | | | |
|-------------------|-----------------|-----------------------------------|-----|------------------------|---|----|----|-----------------|-----------------|---|
| | 02 _h | 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 |
| Mapping | | | | | | | | | | |
| | 00 _h | Number of entries | U8 | 2 _h | RO | NO | - | 00 _h | 08 _h | 1 |
| 1390 _h | 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 |

9.10. Store and restore configurations

The **SWD**® supports saving user parameters and restoring factory settings. This is managed when the node is stopped (Stopped) or in pre-operational state (Pre-operational).

User parameters are saved when the 'save' command is received in the 'Store Parameter' object (1010_h):

| Store Parameters 1010 _h | | | | |
|------------------------------------|-----------------|-----------------|-----------------|-----------------|
| Signature | MSB | | LSB | |
| /ISO8859/ character | e | v | a | s |
| Value | 65 _h | 76 _h | 61 _h | 73 _h |

Saved parameters are divided into several groups. Saving is performed either for all product parameters, or for a specific group. This depends on which sub-index the 'save' command is written to:

| Sub-index | Group of data | Supported |
|-----------|--|-------------------------------------|
| 1 | Save all Parameters | <input checked="" type="checkbox"/> |
| 2 | Save Communication Parameters | <input type="checkbox"/> |
| 3 | Save Application Parameters | <input type="checkbox"/> |
| 4 | Save Manufacturer Parameters | <input type="checkbox"/> |
| 5 | Save LSS Parameters | <input type="checkbox"/> |
| 6 | Save Motor Calibration and Internal Parameters | <input type="checkbox"/> |
| 7 | Save Test Results | <input type="checkbox"/> |

The default configuration is restored by writing 'load' to the 'Restore Default parameters' object (1011_h):

| Restore Default Parameters 1011 _h | | | | |
|--|-----------------|-----------------|-----------------|-----------------|
| Signature | MSB | | LSB | |
| /ISO8859/ character | d | a | o | l |
| Value | 64 _h | 61 _h | 6F _h | 6C _h |

The parameters displayed are divided into several groups. Parameters are returned either for all product parameters, or for a specific group. This depends on which sub-index the 'load' command is written to:

| Sub-index | Group of data | Supported |
|-----------|---|-------------------------------------|
| 1 | Restore all Default Parameters | <input checked="" type="checkbox"/> |
| 2 | Restore Communication Default Parameters | <input checked="" type="checkbox"/> |
| 3 | Restore Application Default Parameters | <input checked="" type="checkbox"/> |
| 4 | Restore Manufacturer Parameters | <input type="checkbox"/> |
| 5 | Restore LSS Parameters | <input type="checkbox"/> |
| 6 | Restore Motor Calibration and Internal Parameters | <input type="checkbox"/> |
| 7 | Restore Test Results | <input type="checkbox"/> |

Communication parameters

| Communication segment | | |
|-----------------------|-----------------|--------------------------------------|
| | 1000h | Device Type |
| | 1001h | Error Register |
| | 1002h | Manufacturer status register |
| | 1003h | Predefined error field |
| | 1005h | COB ID SYNC message |
| | 1008h | Manufacturer device name |
| | 1009h | Manufacturer hardware version |
| | 100Ah | Manufacturer software version |
| | 1010h | Store Parameters |
| | 1011h | Restore Default Parameters |
| | 1014h | COB-ID EMCY message |
| | 1017h | Producer Heartbeat Time |
| | 1018h | Identity Object |
| 1029h | Error behaviour | |
| SDO | 1200h | SDO 1 server parameter |
| | 1201h | SDO 2 server parameter ¹³ |
| | 1202h | SDO 3 server parameter ¹⁴ |
| | 1203h | SDO 4 server parameter ¹⁵ |
| SRDO | 1301h | SRDO 1 communication parameter |
| | 1302h | SRDO 2 communication parameter |
| | 1309h | SRDO 9 communication parameter |
| | 130Ah | SRDO 10 communication parameter |
| | 130Bh | SRDO 11 communication parameter |
| | 130Ch | SRDO 12 communication parameter |

¹³ Configurations under development

¹⁴ Configurations under development

¹⁵ Configurations under development

| | | |
|------|-------------------------|---------------------------------|
| | 130D_h | SRDO 13 communication parameter |
| | 130E_h | SRDO 14 communication parameter |
| | 130F_h | SRDO 15 communication parameter |
| | 1310_h | SRDO 16 communication parameter |
| | 1381_h | SRDO 1 mapping parameter |
| | 1382_h | SRDO 2 mapping parameter |
| | 1389_h | SRDO 9 mapping parameter |
| | 138A_h | SRDO 10 mapping parameter |
| | 138B_h | SRDO 11 mapping parameter |
| | 138C_h | SRDO 12 mapping parameter |
| | 138D_h | SRDO 13 mapping parameter |
| | 138E_h | SRDO 14 mapping parameter |
| | 138F_h | SRDO 15 mapping parameter |
| | 1390_h | SRDO 16 mapping parameter |
| | 13FE_h | Configuration valid |
| | 13FF_h | Safety configuration signature |
| RPDO | 1400_h | RPDO 1 communication parameter |
| | 1401_h | RPDO 2 communication parameter |
| | 1402_h | RPDO 3 communication parameter |
| | 1403_h | RPDO 4 communication parameter |
| | 1404_h | RPDO 5 communication parameter |
| | 1405_h | RPDO 6 communication parameter |
| | 1406_h | RPDO 7 communication parameter |
| | 1407_h | RPDO 8 communication parameter |
| | 1600_h | RPDO 1 mapping parameter |
| | 1601_h | RPDO 2 mapping parameter |
| | 1602_h | RPDO 3 mapping parameter |
| | 1603_h | RPDO 4 mapping parameter |
| | 1604_h | RPDO 5 mapping parameter |
| | 1605_h | RPDO 6 mapping parameter |
| | 1606_h | RPDO 7 mapping parameter |
| | 1607_h | RPDO 8 mapping parameter |
| TPDO | 1800_h | TPDO 1 communication parameter |
| | 1801_h | TPDO 2 communication parameter |
| | 1802_h | TPDO 3 communication Parameter |
| | 1803_h | TPDO 4 communication Parameter |
| | 1804_h | TPDO 5 communication parameter |
| | 1805_h | TPDO 6 communication parameter |
| | 1806_h | TPDO 7 communication Parameter |
| | 1807_h | TPDO 8 communication Parameter |
| | 1A00_h | TPDO 1 mapping parameter |
| | 1A01_h | TPDO 2 mapping parameter |
| | 1A02_h | TPDO 3 mapping parameter |
| | 1A03_h | TPDO 4 mapping parameter |
| | 1A04_h | TPDO 5 mapping parameter |
| | 1A05_h | TPDO 6 Mapping Parameter |

| | | |
|--|--------------|--------------------------|
| | 1A06h | TPDO 7 Mapping Parameter |
| | 1A07h | TPDO 8 Mapping Parameter |

Manufacturer parameters

| Manufacturer segment | | |
|----------------------|--------------|---|
| | 2050 | cia402_use_intenal_brake |
| | 2064h | Accurate position value |
| | 208fh | Accurate position resolution |
| LSS (SDO) | 2100h | Configure Bit Timing Parameters |
| | 2101h | Node ID |
| | 2102h | R Termination |
| PID | 2155h | motctrl_speed_pid_p |
| | 2156h | motctrl_speed_pid_i |
| | 2157h | motctrl_speed_pid_d |
| | 2158h | motctrl_speed_pid_tw |
| | 2159h | motctrl_speed_pid_tn |
| | 2201h | Hardware version |
| | 2202h | Software version |
| | 2204h | Product ID |
| | 2205h | Software reference |
| | 2400h | Control_ext |
| | 2401h | Status_ext |
| | 2620h | Safety controlwords manufacturer |
| | 2621h | Safety statuswords manufacturer |
| | 2622h | Inverted Safety controlwords manufacturer |
| | 2623h | Inverted Safety statuswords manufacturer |
| | 2624h | ezw_safety_word_scw_mapping_permanent_cw1 |
| | 2625h | ezw_safety_word_scw_mapping_permanent_cw2 |
| | 2630h | Safety Function Output |
| | 2660h | Brake present |
| | 26F1h | ezw_safety_word_scw_mapping_safein |
| | 26F8h | ezw_safety_word_ssw_mapping_safeout |
| | 3040h | SBU command |
| | 3041h | SBU status |
| | 3050h | SLSa commands |
| | 3051h | SLSa time to positive velocity monitoring |
| | 3052h | SLSa positive velocity limit u32 |
| | 3053h | SLSa time for positive velocity in limits |
| | 3054h | SLSa time to negative velocity monitoring |
| | 3055h | SLSa negative velocity limit u32 |
| | 3056h | SLSa time for negative velocity in limits |
| | 3057h | SLSa error reactions |
| | 3058h | SLSa safety application configuration signature |

| | | |
|--|-------|---------------|
| | 3059h | SLSa statuses |
|--|-------|---------------|

Drive parameters

List of configurable data linked to the CiA 402 profile:

| Device profile segment | | |
|------------------------|-----------------------|-------------------------------|
| CiA 402 | 6007h | Abort_connection_option_code |
| | 603Fh | Error code |
| | 6040h | Controlword |
| | 6041h | Statusword |
| Velocity Mode | 6042h | vl_target_velocity |
| | 6043h | vl_velocity_demand |
| | 6044h | vl_velocity_actual_value |
| | 6046h | vl_velocity_min_max_amount |
| | 6048h | vl_velocity_acceleration |
| | 6049h | vl_velocity_deceleration |
| | 604Ah | vl_velocity_quick_stop |
| | 604Bh | vl_set_point_factor |
| CiA 402 | 604Ch | vl_dimension_factor |
| | 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 |
| | 6061h | modes_of_operation_display |
| | 6064h | position_value |
| | 606Ch | velocity_actual_value |
| | 607Eh | polarity |
| | 608F | position_encoder_resolution |
| | 6090 | velocity_encoder_resolution |
| | 6091h | gear_ratio |
| | 6092h | feed_constant ¹⁶ |
| | 6402h | motor_type |
| | 6403h | motor_catalogue_number |
| | 6404h | motor_manufacturer |
| | 6405h | http_motor_catalogue_address |
| | 6406h | motor_calibration_date |
| 6407h | motor_service_period | |
| 6502h | supported_drive_modes | |

¹⁶ Configuration under development

| | | |
|-----------------------------------|--|--|
| | 6503_h | drive_catalogue_number |
| | 6505_h | http_drive_catalogue_address |
| CiA 402-4 Safety functionality | 6600_h | Time unit |
| | 6601_h | Position unit |
| | 6602_h | Velocity unit |
| | 6603_h | Acceleration unit |
| | 6607_h | Safety application configuration valid |
| | 6608_h | Safety application configuration failed |
| | 6611_h | Safe position actual value i32 |
| | 6613_h | Safe velocity actual value i32 |
| | 661A_h | Inverted safe position actual value i32 |
| | 661C_h | Inverted safe velocity actual value i32 |
| | 6620_h | Safety controlwords |
| | 6621_h | Safety statuswords |
| | 6622_h | Inverted safety controlwords |
| | 6623_h | Inverted safety statuswords |
| | 6630_h | Restart acknowledge command |
| | 6631_h | Restart acknowledge status |
| | 6632_h | Error acknowledge command |
| | 6633_h | Error acknowledge status |
| | 6640_h | STO command |
| | 6641_h | STO restart acknowledge behaviour |
| | 6643_h | STO activate SBC |
| | 6644_h | STO status |
| | 6645_h | STO safety application configuration signature |
| | 6660_h | SBC commands |
| | 6661_h | SBC brake time delay |
| | 6662_h | SBC safety application configuration signature |
| | 6667_h | SBC statuses |
| | 6690_h | SLS commands |
| | 6691_h | SLS time to velocity monitoring |
| | 6693_h | SLS velocity limit u32 |
| | 6694_h | SLS time for velocity in limits |
| | 6698_h | SLS error reactions |
| | 6699_h | SLS safety application configuration signature |
| | 669F_h | SLS statuses |
| 66A8_h | SMS statuses | |
| 66AA_h | SMS velocity maximum positive u32 | |
| 66AC_h | SMS velocity maximum negative u32 | |
| 66AD_h | SMS error reactions | |
| 66AE_h | SMS safety application configuration signature | |
| 66D0_h | SDIp commands | |
| 66D1_h | SDIn commands | |

| | | |
|-------------------------|---------------------------------|--|
| | 66D3_h | SDI position zero window u32 |
| | 66D5_h | SDI velocity zero window u32 |
| | 66D6_h | SDI safety application configuration signature |
| | 66DE_h | SDIp statuses |
| | 66DF_h | SDIn statuses |
| | 66F0_h | ezw_safety_word_scw_mapping_cw1 |
| | 66F1_h | ezw_safety_word_scw_mapping_cw2 |
| | 66F2_h | ezw_safety_word_scw_mapping_cw3 |
| | 66F3_h | ezw_safety_word_scw_mapping_cw4 |
| | 66F4_h | ezw_safety_word_scw_mapping_cw5 |
| | 66F5_h | ezw_safety_word_scw_mapping_cw6 |
| | 66F6_h | ezw_safety_word_scw_mapping_cw7 |
| | 66F7_h | ezw_safety_word_scw_mapping_cw8 |
| | 66F8_h | ezw_safety_word_ssw_mapping_sw1 |
| | 66F9_h | ezw_safety_word_ssw_mapping_sw2 |
| | 66FA_h | ezw_safety_word_ssw_mapping_sw3 |
| | 66FB_h | ezw_safety_word_ssw_mapping_sw4 |
| | 66FC_h | ezw_safety_word_ssw_mapping_sw5 |
| | 66FD_h | ezw_safety_word_ssw_mapping_sw6 |
| 66FE_h | ezw_safety_word_ssw_mapping_sw7 | |
| 66FF_h | ezw_safety_word_ssw_mapping_sw8 | |
| CIA 406 | 6800_h | Operating parameters |
| | 6801_h | Measuring units per revolution |
| | 6802_h | Total measuring range in measuring units |
| | 6803_h | Preset value |
| | 6810_h | Preset values for multi sensor devices |
| | 6820_h | Position values for multi sensor devices |
| | 6830_h | Speed value |

10. CiA 402: Motor control unit profile

CiA profile 402 specifies a generic motor interface (PDS: Power Drive System). This interface handles various operating modes, such as position, speed, torque, etc.

An operating mode is associated with parameters that must be configured to start the state machine. State machine control depends on the chosen operating mode. It is used to control the motor.

The **SWD®** drive implements the *Velocity mode*.

10.1. State machine

The CiA 402 profile state machine is used to control the operation of the drive integrated into the **SWD®**:

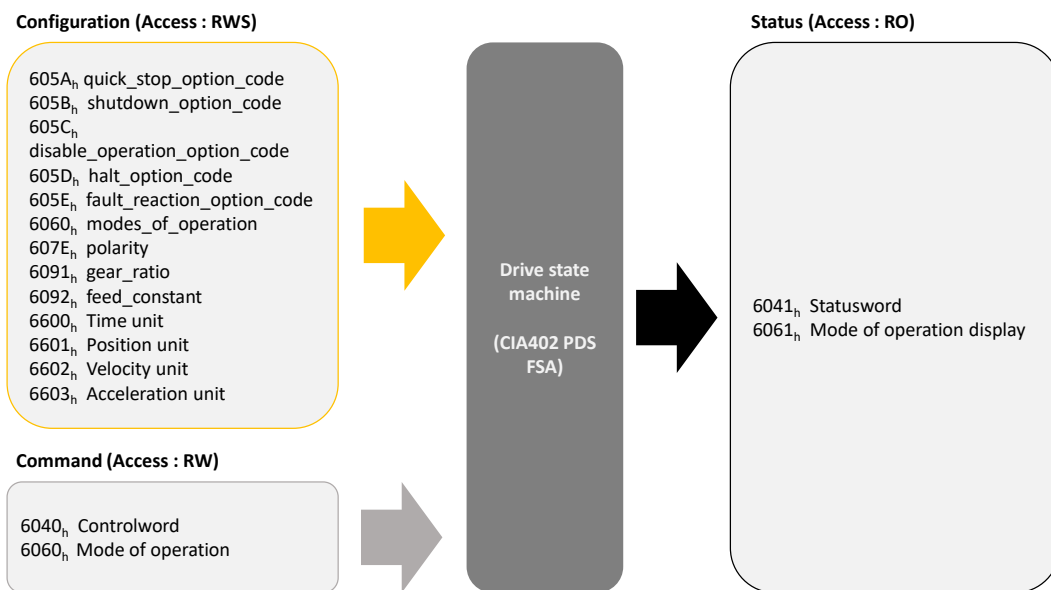


Figure 26 – Drive status management interface

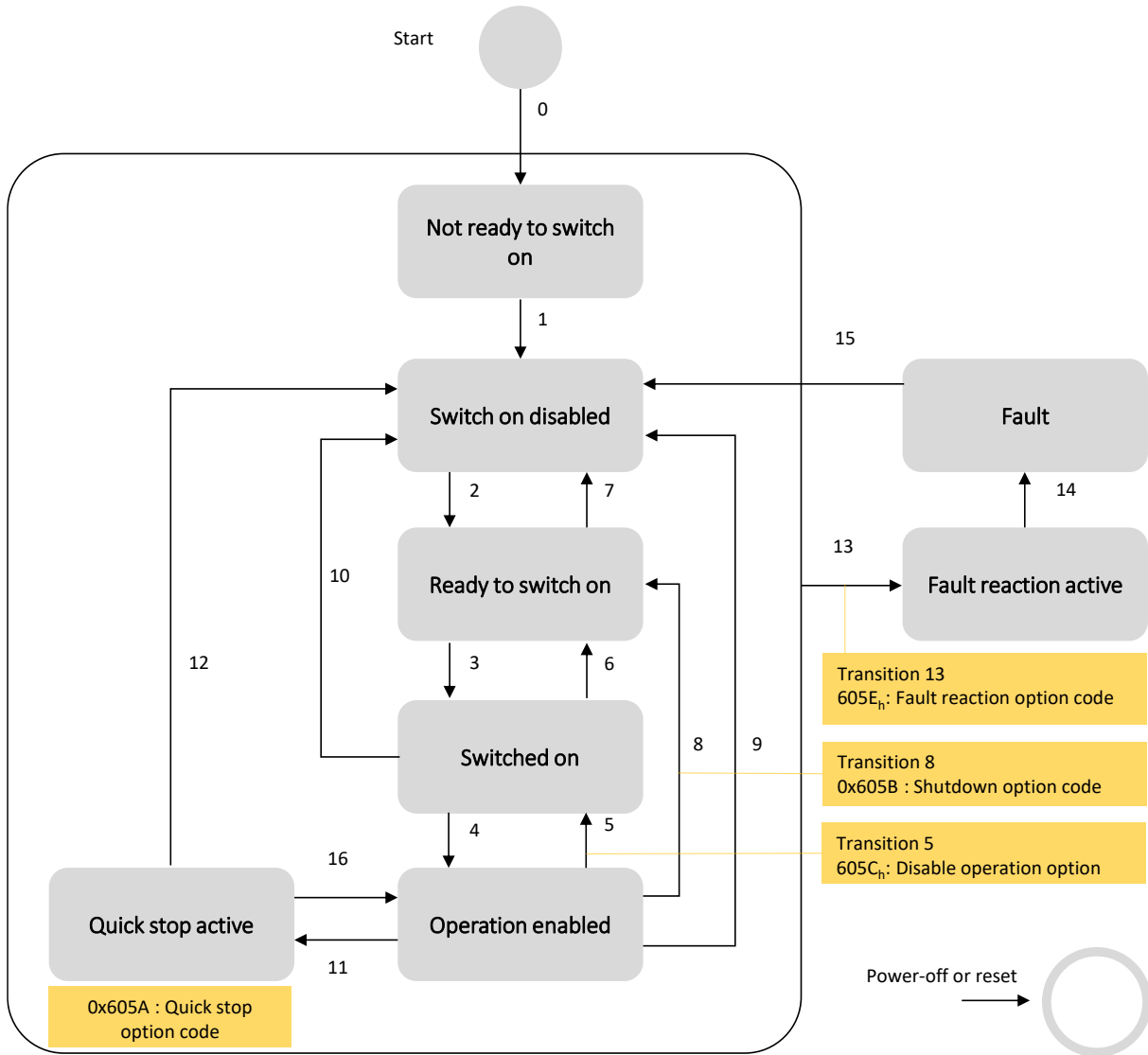


Figure 27 – CiA 402, state machine and transitions

⚠ Reading the CiA-402 object '6041_h: Statusword', provides the status of the state machine. This makes it possible to determine possible transitions.

| 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 |

CiA standard 402-2 defines a set of supported functions for controlling machine states. A summary table of supported function states for each machine stage is available below:

The following functions are supported:

- Active brake, (configurable with object 2050 00_h 'cia402_use_internal_brake'¹⁷).
- Electronic board under voltage
- Active engine control
- Configuration authorised

Their On/Off states are as follows:

| 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 | Yes | Yes | Yes | Yes | Yes/No | Yes/No | Yes | Yes |
| Card under voltage | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Active engine control | No | No | No | No | Yes | Yes | Yes | No |
| Authorised configuration | Yes | Yes | Yes | Yes | No | No | No | Yes |

Figure 28 – Configuration of functions according to CiA 402 state machine states

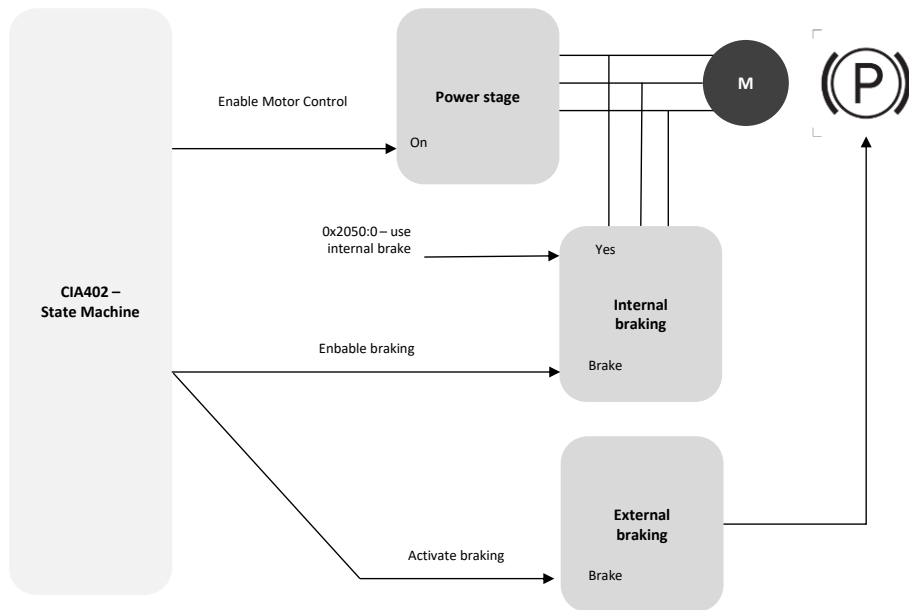


Figure 29 – Motor control overview

| | Brake present | Brake not present |
|------------------------------|--|---|
| Internal brake | 2050 00 _h cia402_use_internal_brake = true | 2050 00 _h cia402_use_internal_brake = false |
| External brake ¹⁸ | Mechanical assembly and connection to brake connector | Not mounted / connected |

¹⁷ Configuration possible under development, not active by default

¹⁸ An external brake can only be connected and activated as of software version 'Firmware 2.0.x'.

6040_h Controlword

The '6040_h Controlword' object is used to control the CiA 402 PDS state machine and request the transition from one state to another. The transition is made by writing the 'Controlword', or sometimes automatically, for example in the event of an error (if configured).

Some transitions can perform specific, configurable actions, such as a safe shutdown with automatic deceleration ramp.

| | | | | | | | | | | | |
|-----------|-----------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 15 | 11 | 10 | 9 | 8 | 7 | 6 | 4 | 3 | 2 | 1 | 0 |
| ms | | r | oms | h | fr | oms | | eo | qs | ev | 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 | Controlword bitfield | | | | | 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 | | oms | | ila | tr | rm | ms | w | sod | qs | ve | 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 enable |
| f | fault |
| oe | operation enabled |
| so | switched on |
| rtso | ready to switch on |

lla - internal limit active

The drive sets the 'lla' bit to 1 if the speed setpoint is outside the speed range authorized for the product (See 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 |

Start-up example

| SWD® state | Status word (typical) | Control word for 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 | |

NB: Controlword value for a fault reset is 00 80_h.

Operating modes

The SWD® drive implements the 'velocity' mode, which enables speed control of the motor. Supported operating modes are available by reading the "6502_h Supported drive mode" object.

| | | | | | | | | | | | | | | |
|------------------------------|----|----------|-------|-----|-----|-----|----|----|---|----|----|----|------------|---|
| 31 | 16 | 15 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Manufacturer-specific | | reserved | 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 | cyclic sync torque mode with commutation angle |
| r(eserved) | reserved |


The operating mode defines the behaviour when the **SWD®** is in the 'operation enable' state.

The object "Modes of operation" (6060_h) is used to select the operating mode. The object "Modes of operation display" (6061_h) displays the current **SWD®** operating mode. The value associated with the operating mode is shown below:

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

 By default, velocity mode is activated.

The default operating mode can be saved in 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 | Operating mode request | U32 | 2 | RW  | NO | Table | 0 | 2 | 4 |
| 6061 _h | 0 | Operating mode | U32 | 2 | RO | NO | Table | 0 | 2 | 4 |

10.2. 'Velocity mode' (vl) operation

Introduction

The 'velocity' operating mode controls the speed of the **SWD®** motor.

Speed is controlled by an acceleration or deceleration ramp, which limits the current load and mechanical stress on the motor.

Load-dependent force calculation is performed automatically, and a feedback loop ensures that the speed setpoint is followed without exceeding the acceleration or deceleration limits.

The velocity mode consists of a transfer function whose various stages produce internal or external values, some of which can be inspected by reading CANopen objects (described in the next subsection).

Configuration (Access : RWS)

vl velocity min/max amount (6046_h)
vl dimension factor (604C_h)

vl velocity acceleration (6048_h)
vl velocity deceleration (6049_h)
vl velocity quick stop (604A_h)

Command (Access : RW)

vl target velocity (6042_h)
controlword bit 4 (enable ramp)
controlword bit 5 (unlock ramp)
controlword bit 6 (reference ramp)
controlword bit 8 (halt)

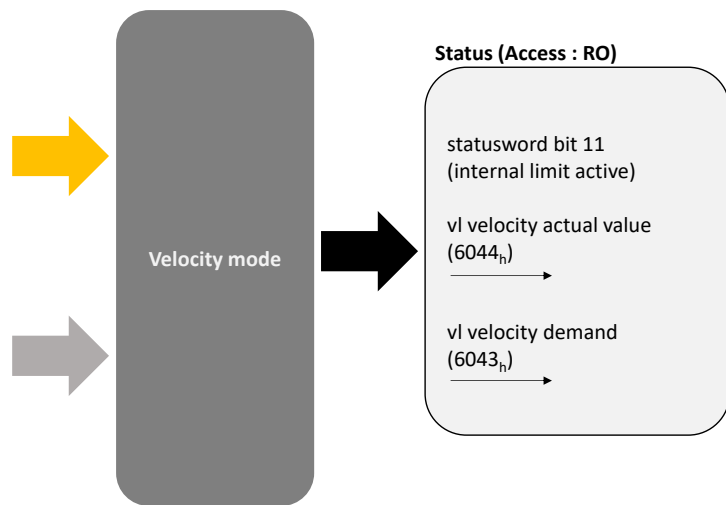


Figure 30 – 'Speed control' interface

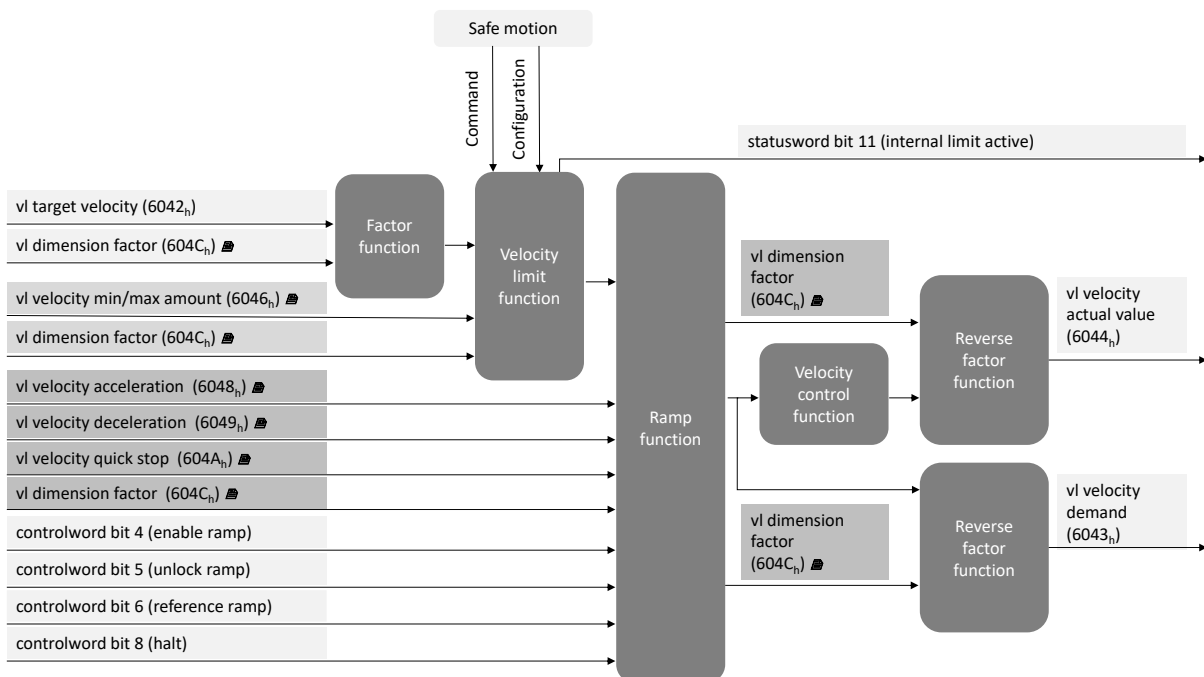


Figure 31 – 'Speed control' architecture

6042_h: Speed setpoint

The speed setpoint is transmitted via the dictionary input 'vl_target_velocity' (6042_h).

By default, speeds are expressed in revolutions per minute at the motor shaft, regardless of the mechanical gearbox ratio.

⚠ The speed unit used depends on the Dimension factor configuration (604C_h).

6064_h: Position

Position is expressed in motor encoder increments and is available in the dictionary entry 'position_value' (6064_h).

The **SWD®**'s built-in encoder resolution is 30 increments per motor revolution. Positive or negative counting direction can be configured via the 'polarity' object (607E_h).

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes | Non-volatile storage |
|-------------------|-----|----------------|-----------|---------------|-------------|-------------|------|-------------|-------------|---------------|----------------------|
| 6064 _h | 0 | position_value | I32 | - | R0 | TPDO | inc | | | 4 | Yes |

607E_h: Polarity

By configuration, it is possible to change the direction of motor rotation corresponding to a positive speed. Similarly, it is possible to change the direction in which position increments are incremented.

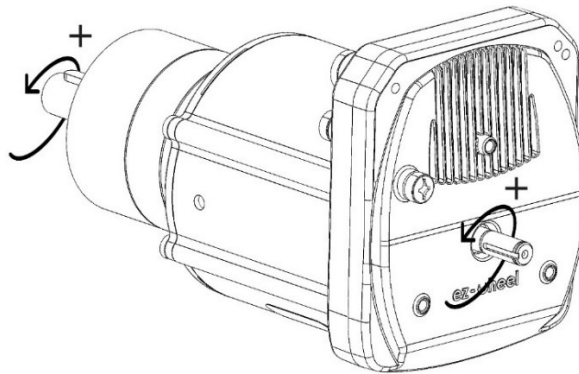


Figure 32 – Positive direction of rotation (+)

| | | | |
|--------------------------|-------------------|--------------|-----|
| 7 | 6 | 5 | 0 |
| Position polarity | Velocity polarity | Reserved (0) | |
| MSB | | | LSB |

Polarity bits are coded as follows: 0b = multiply by 1 and 1b = multiply by -1

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

⚠ The 'polarity' object has no impact on the positive direction of rotation used for the SDIp and SDIn safety functions.

604Ch: vl_dimension_factor

It is possible to apply a dimension factor to the expression of speeds, so that they are expressed in another unit. The dimension factor can be configured using the following objects:

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes |
|-------|-----|------------------------------------|-----------|---------------|-------------|-------------|------|----------------|-------------|---------------|
| 604Ch | 1 | vl_dimension_factor_or_numerator | I32 | 1 | RW | RPDO | - | I32 excepted 0 | | 4 |
| 604Ch | 2 | vl_dimension_factor_or_denominator | I32 | 1 | RW | RPDO | - | I32 excepted 0 | | 4 |

$$\text{Speed}_{\text{RPM}} = \frac{\text{Numerator}}{\text{Denominator}} \times \text{Speed}$$

When it is not equal to 1, the dimension factor applies to all the following parameters:

| | |
|------|------------------------------|
| 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 Limitations

The setpoint speed limitation block limits the speed range accessible in the setpoint. It acts symmetrically on positive and negative setpoints.

In the case of a setpoint greater in absolute value than the 'velocity_max_amount' setpoint, the limiting output setpoint will be equal to plus or minus 'velocity_max_amount'.

In the case of a setpoint lower in absolute value than the 'velocity_min_amount' setpoint, the limiting output setpoint will be equal to zero.

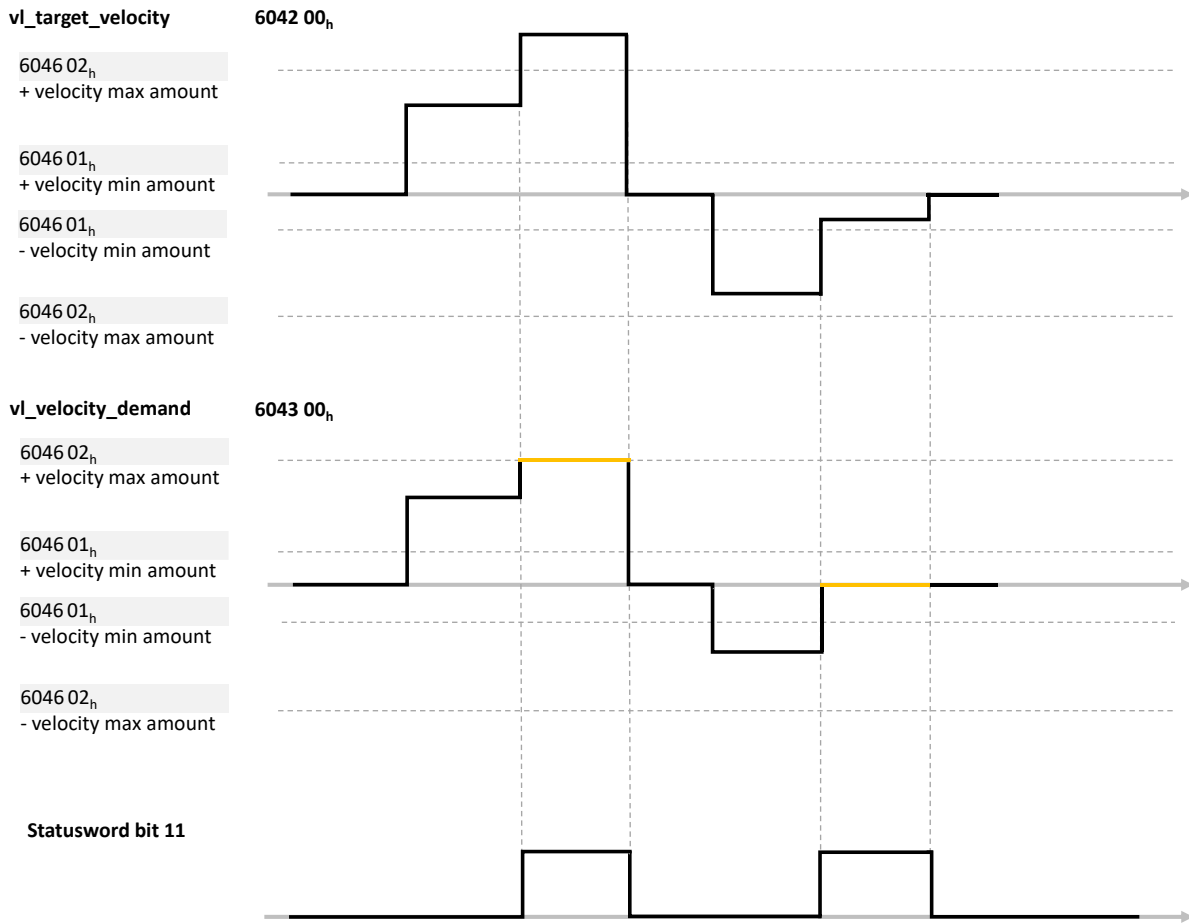


Figure 33 – Speed limit management

- ⚠ Limits are set in motor rpm, i.e., before the GearBox.
- ⚠ The speed unit used depends on the 'vl_dimension_factor' configuration (604Ch).

The user can modify the limits used by the drive:

- During runtime, limitation values are taken into consideration when switching to 'operation enable'.
- By configuration, by saving the limits to be used by default at product startup.

| 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 | RPDO | RPM | 30 | 1800 | 4 | Yes |
| 6046 _h | 2 | vl_velocity_max_amount | U32 | 1800 | RW | RPDO | RPM | 30 | 1800 | 4 | Yes |


Speed limitation and safety functions

Additional setpoint limitations are applied when safety functions are activated. This limitation of the setpoint is not in itself a safety function but provides an early way of dealing with the constraints associated with a safety function.

| Active function | Output command |
|-----------------|--|
| STO | Disconnection of motor torque |
| SMS | Maximum speed is set regardless of the requested safety-related functions |
| SLS | Speed is restricted below SLS speed set. Same behavior as 'velocity max amount'. |
| SLSa | Speed is restricted below SLSa speed independently for each direction. |
| SDI p | Positive speed commands above nZero_SDI are forced to null speed. |
| SDI n | Negative speed commands below -nZero_SDI are forced to null speed. |

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

The 11th bit of the Statusword is also set in the case of setpoint limitation related to a safety function.

 *Limiting the setpoint does not guarantee that the motor speed will remain within the limits imposed by the safety function, and that an error management response will not be triggered. A setpoint consistent with the active safety functions must be set at application level.*

Ramps

The ramp function smoothes the setpoint by limiting setpoint variations during acceleration or deceleration.

The output of the ramp function is the data used as motor control input.

There are 3 ramp configurations:

- An acceleration 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

Each ramp is configured by setting 2 variables in the dictionary:

- A speed variation 'delta_speed' expressed by default in rpm (Cf. 604C_h)
- A time variation delta_time expressed in seconds

The ramp is then calculated as follows:

$$Ramp = \frac{\Delta_{speed}}{\Delta_{time}}$$

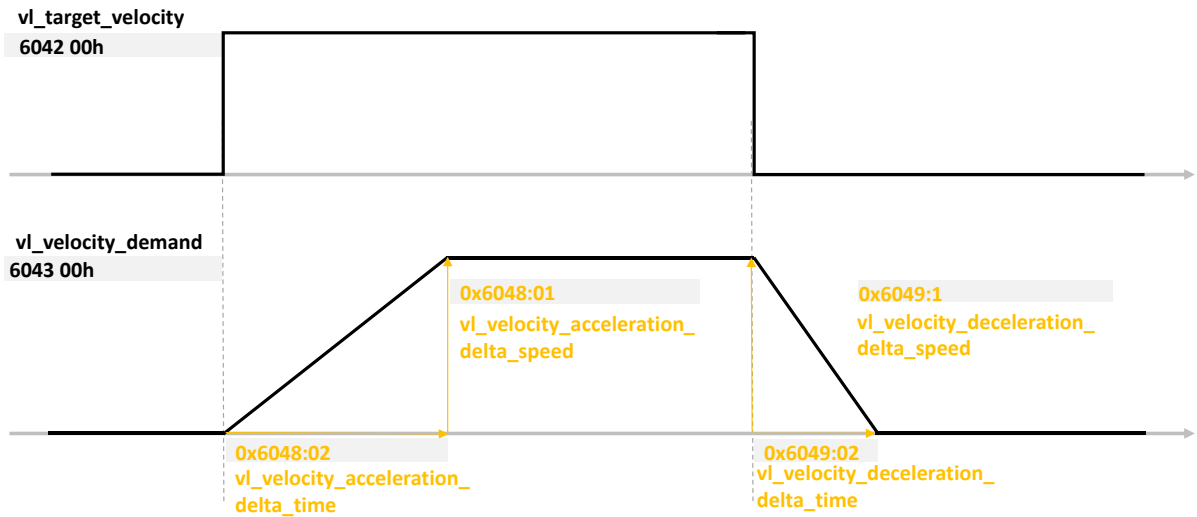


Figure 34 – Acceleration/deceleration ramp management (1/2)

When the setpoint direction is reversed, the nominal deceleration ramp is used to return to zero speed. The acceleration ramp is then used to reach the new setpoint.

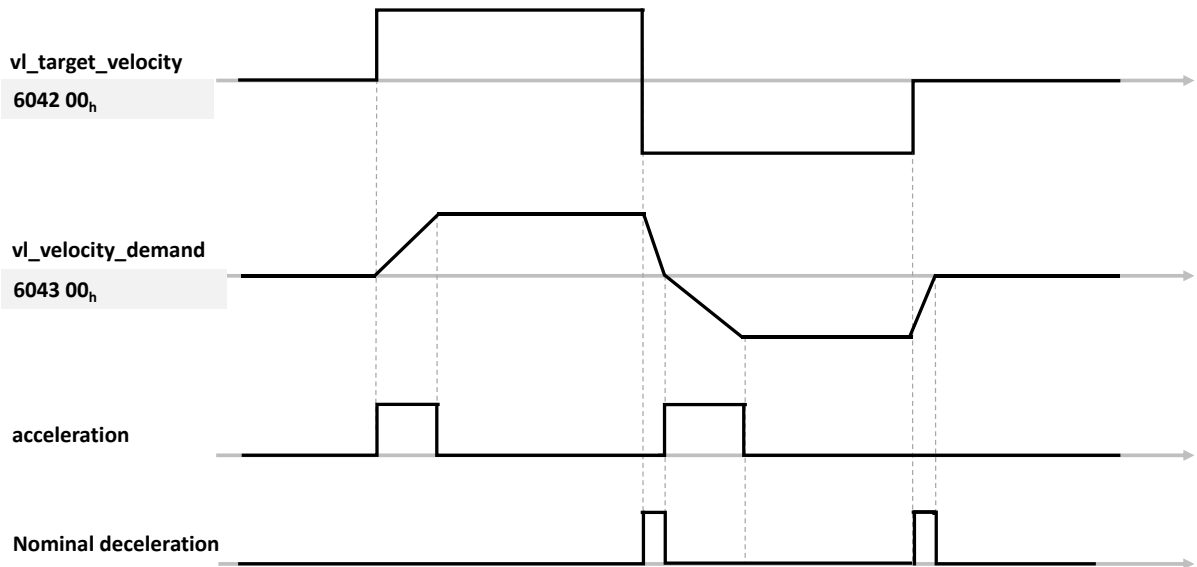


Figure 35 – Managing acceleration/deceleration ramps (2/2)

Ramp function control

The ramp function can be controlled via the controlword bit field.

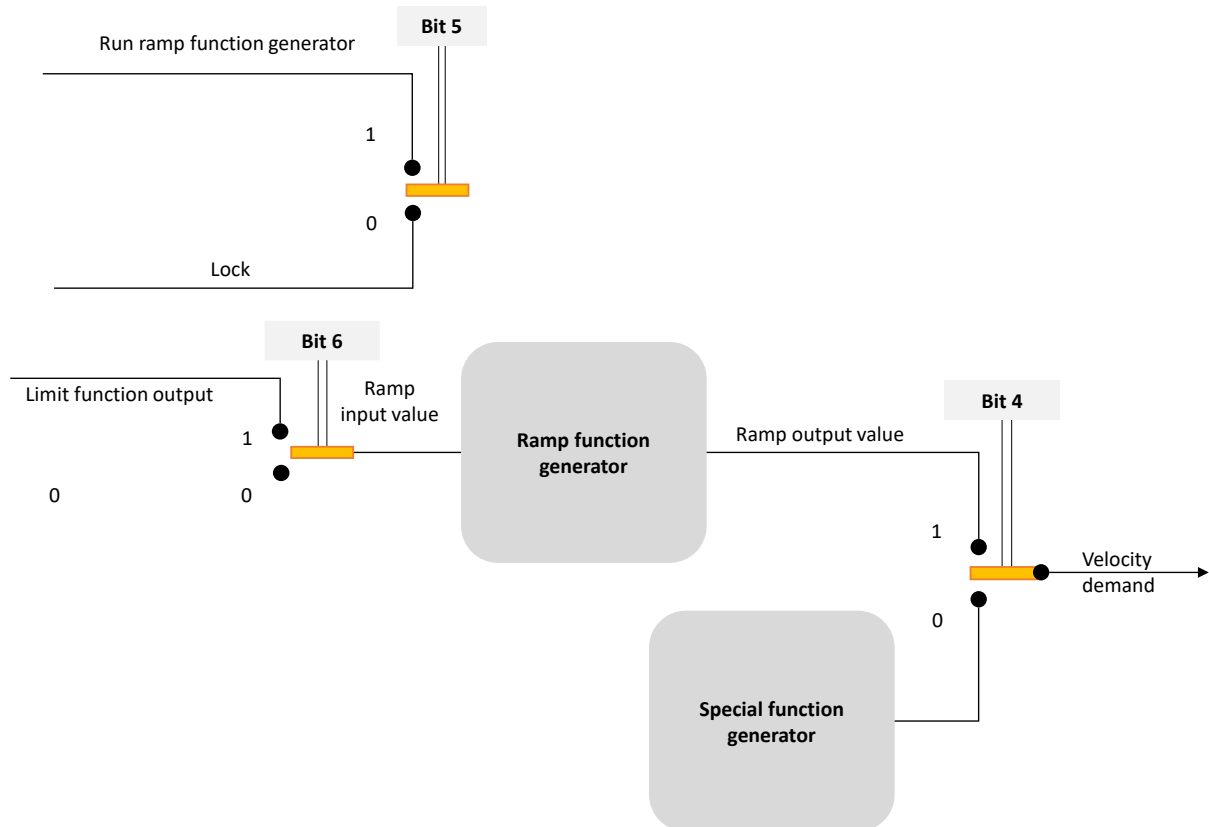


Figure 36 – Use of controlword bits in velocity mode

| Bit | Bitfield coding in velocity mode | |
|-----|----------------------------------|---|
| 4 | Activate ramp | 0: Ramp module is deactivated, bloc output is identical to the input 1: Ramp module is activated |
| 5 | Unlock ramp | 0: Ramp output bloc is fixed 1: Ramp output bloc follows the input applying ramps |
| 6 | Ramp reference | 0: Ramp input bloc is forced to null, only deceleration ramp is used 1: Ramp input bloc corresponds to the speed limitation bloc |
| 8 | Halt | 0: No command, nominal behaviour 1: Motor stops, used ramp 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 |
|-------------------|-----|--------------------------------------|-----------|---------------|-------------|-------------|-------------------|-------------|-------------|---------------|----------------------|
| 6048 _h | 1 | vl_velocity_acceleration_delta_speed | U32 | 500 | RW | RPDO | RPM ¹⁹ | 1 | 10000 | 4 | Yes |
| 6048 _h | 2 | vl_velocity_acceleration_delta_time | U16 | 1 | RW | RPDO | s | 1 | 100 | 2 | Yes |

Deceleration ramp

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes | Non-volatile storage |
|-------------------|-----|--------------------------------------|-----------|---------------|-------------|-------------|-------------------|-------------|-------------|---------------|----------------------|
| 6049 _h | 1 | vl_velocity_deceleration_delta_speed | U32 | 500 | RW | RPDO | RPM ²⁰ | 1 | 10000 | 4 | Yes |
| 6049 _h | 2 | vl_velocity_deceleration_delta_time | U16 | 1 | RW | RPDO | s | 1 | 100 | 2 | Yes |

Deceleration ramp in 'Quick stop' mode

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes | Non-volatile storage |
|-------------------|-----|------------------------------------|-----------|---------------|-------------|-------------|-------------------|-------------|-------------|---------------|----------------------|
| 604A _h | 1 | vl_velocity_quick_stop_delta_speed | U32 | 1000 | RW | RPDO | RPM ²¹ | 1 | 10000 | 4 | Yes |
| 604A _h | 2 | vl_velocity_quick_stop_delta_time | U16 | | RW | RPDO | s | 1 | 100 | 2 | Yes |

Speed control

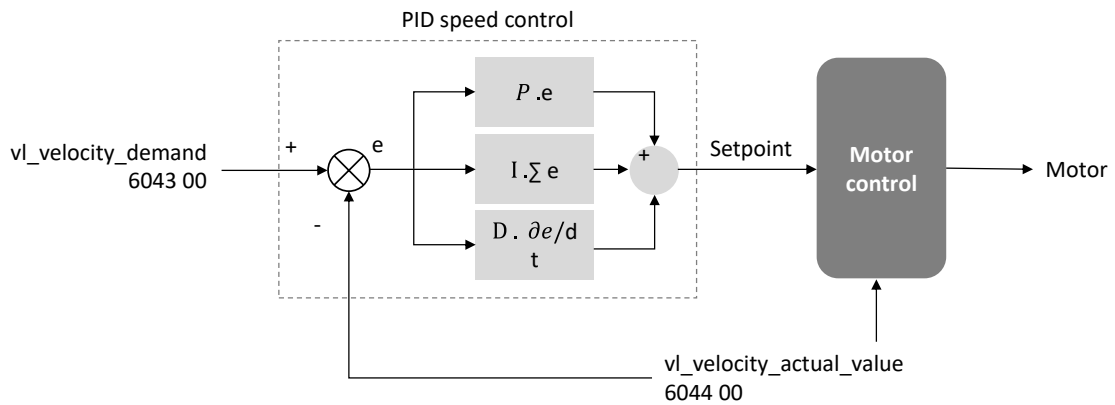
The 'speed control' block monitors the setpoint generated by the motor ramp block.

This block is based on a PID which aims to avoid speed error.

¹⁹ This unit depends on the configuration of object 'velocity_unit' (604C_h).

²⁰ This unit depends on the configuration of object 'velocity_unit' (604C_h).

²¹ This unit depends on the configuration of object 'velocity_unit' (604C_h).



The PID parameters are accessible in the CANopen dictionary and are updated when the CiA 402 state machine switches to the 'Operation Enable' state.

- ⚠ *Coefficients can be saved in non-volatile memory.*
- ⚠ *If a user configuration has been saved, it is used when the drive starts up.*

The error 'e' is expressed in the PID in $\text{mdeg}\cdot\text{s}^{-1}$ at the motor shaft before gearbox.

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes |
|-------------------|-----|----------------------|-----------|---------------|-------------|-------------|-----------|-------------|-------------|---------------|
| 2155 _h | 0 | motctrl_speed_pid_p | U32 | .22 | RW 🔒 | NO | 10^{-8} | 0 | 4294967295 | 4 |
| 2156 _h | 0 | motctrl_speed_pid_i | U32 | | RW 🔒 | NO | 10^{-8} | 0 | 4294967295 | 4 |
| 2157 _h | 0 | motctrl_speed_pid_d | U32 | | RW 🔒 | NO | 10^{-8} | 0 | 4294967295 | 4 |
| 2158 _h | 0 | motctrl_speed_pid_tw | U32 | | RW 🔒 | NO | 10^{-3} | 0 | 4294967295 | 4 |
| 2159 _h | 0 | motctrl_speed_pid_tn | U32 | | RW 🔒 | NO | 10^{-3} | 0 | 4294967295 | 4 |

In addition to the PID, the controller incorporates an "anti-windup" action on the integral action, and a time filter on the derivative action, both of which can be set using the 'motctrl_speed_pid_tw' and 'motctrl_speed_pid_tn' parameters.

The minimum speed setpoint is 5 RPM.

²² Default values differs according to the gearbox ratios of the SWD® products. Please refer directly to the product.

10.3. Configuration

The configuration data for the motor controller are considered when the 'Operation enable' state is reached.

Modifications in the dictionary are not possible in 'Operation enable', 'Quick stop active' and 'Fault reaction active' states.

6007_h Abort connection option code

You can define the action to be applied if the CANopen connection is lost. The SWD® considers a loss of the CAN bus in the following cases:

- Bus-off
- SWD® in *NMT STOPPED* and in *NMT INITIALISATION*

| 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 | 2 | RO ²³ | 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

You can define the action to be applied when a QuickStop command is received.

| 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 | 6 | RO ²⁴ | 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 |

²³ Configuration under development

²⁴ Configuration under development

605B_h Shutdown option code

You can define the action to be applied when a QuickStop command is received.

| 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 | l16 | 0 | RO ²⁵ | 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 action applied at 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 |
|-------------------|-----|----------------------|-----------|---------------|------------------|-------------|-------|-------------|-------------|---------------|----------------------|
| 605C _h | 0 | shutdown option code | l16 | 0 | RO ²⁶ | 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

You can define the action to be taken when a 'Halt' command is received.

| 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 | l16 | 1 | RO ²⁷ | 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 |

²⁵ Configuration under development

²⁶ Configuration under development

²⁷ Configuration under development

605E_h Fault reaction option code

You can define the action to be applied when a PDS (Power Drive System) internal error is detected.

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes |
|-------------------|-----|----------------------------|-----------|---------------|------------------|-------------|-------|-------------|-------------|---------------|
| 605E _h | 0 | fault_reaction_option_code | I16 | 0 | RO ²⁸ | NO | Table | - | - | 2 |

| 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 |

²⁸ Configuration under development

11. Safety functions

11.1. SWD® Safety functions

The **SWD®** includes safe motor shutdown functions, as well as advanced safe speed supervision functions. This exclusive, integrated solution developed by ez-Wheel simplifies machine architecture by removing the need for external supervision devices and safety logic.

The motor stop functions are as follows:

- STO (Safe Torque Off): safe disconnection of motor torque
- SBC²⁹ (Safe Brake Control): safe braking engagement
- SBU³⁰ (Safe Brake Unlock): freewheel mode, safe brake disengagement






Speed supervision functions are based on a safety encoder integrated into the **SWD®**. They are listed below:

- SDI (Safe Direction): safe control of direction of rotation
- SLS (Safely Limited Speed): safe speed limitation
- SLSa³¹ (Safely Limited Speed asymmetric): safe speed limitation, with different thresholds depending on the direction of the motor's rotation.
- SMS³² (Safe Maximum Speed): Maximum speed limitation independent of activated safety functions.



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





| | Safety functions | Possible settings |
|---|------------------------------------|---|
|  | Safe disconnection of motor torque | Rearm: <ul style="list-style-type: none"> ▪ automatic ▪ by request acknowledgment STO associated with braking, see SBC configuration |
|  | Safe braking engagement | Joint activation with STO: <ul style="list-style-type: none"> ▪ Internal SWD® braking ▪ External electromechanical brake ▪ Both brakes simultaneously |
|  | Safe braking disengagement | - |

²⁹ Implemented from 'Firmware' (2.0.x)

³⁰ Implemented from 'Firmware' (2.0.x)

³¹ Implemented from 'Firmware' (2.0.x)

³² Implemented from 'Firmware' (2.0.x)

| | | |
|---|---|---|
|  | Reliable control of direction of rotation | Direction of rotation prohibited: <ul style="list-style-type: none"> ▪ in positive or negative direction ▪ with a tolerance threshold |
|  | Safe speed limitation | Overtaking speed: <ul style="list-style-type: none"> ▪ 8 switchable thresholds ▪ adjustable triggering time |
|  | Safe speed limitation, in one direction only | Overtaking speed, in one direction only: <ul style="list-style-type: none"> ▪ 8 switchable thresholds ▪ adjustable triggering time |
|  | Safe limitation of maximum authorized speed, regardless of activated safety functions | Overtaking speed, regardless of safety functions triggered <ul style="list-style-type: none"> ▪ a threshold limit for positive maximum speeds ▪ a threshold limit for negative maximum speeds |

11.2. Typical use of the safety functions

SWD® safety functions are designed for speed-controlled load movement applications where risk assessment justifies the implementation of safe movement supervision.

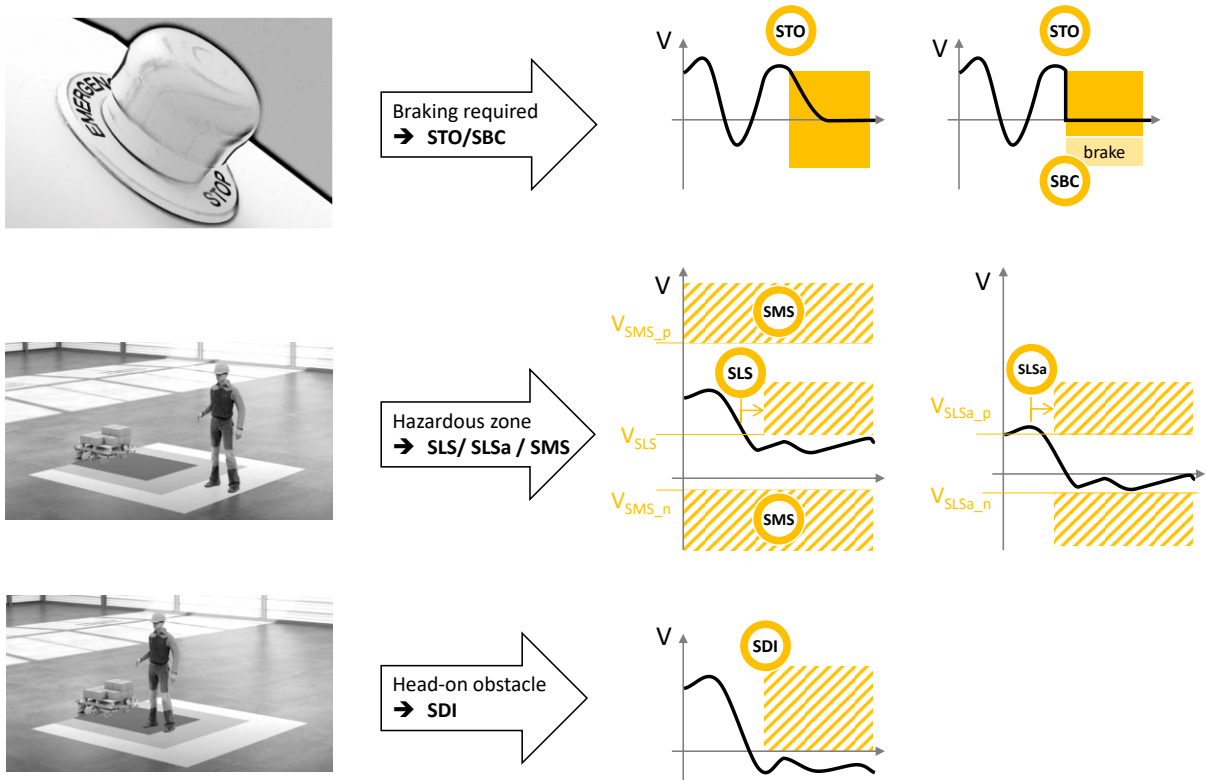


Figure 37 – Use of the safety functions

11.3. Safety level summary

| Safety function | ISO 13849-1:2015 | | | EN IEC 61508 ³³ | | | | IEC 62061 ³⁴ | IEC 61800-5-2 ³⁵ | NF EN 60204-1 ³⁶ |
|--|------------------|------|------------------------|----------------------------|-----------|-----------------------------|-------|-------------------------|-----------------------------|-----------------------------|
| | Category | PL | PFH _b /h | SIL | PFH /h | PFD _{AVG} /Year | SFF | SIL CL | SIL | Category |
| STOP safety functions | | | | | | | | | | |
| Safe Torque Off (STO) STO1 et STO2 inputs | Category 4 | PL e | 1,42E-9 | 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 | 99,6% | 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 | 99,6% | 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 | 99,6% | 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 | | | | | | | | | | |
| Safe Maximum speed (SMS) | Category 2 | PL d | 2,29E-7 | SIL 2 | 8,9E-9 | 3,9E-5 | 99,7% | SIL 2 | SIL 2 | NA |
| 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 | NA |
| Safely limited speed (SLS) SafeInput | Category 2 | PL d | 2,29E-7 | SIL 2 | 10,3E-9 | 4,5E-5 | 99,6% | SIL 2 | SIL 2 | NA |
| Safely limited speed (SLS) Pair of SafeInput | Category 3 | PL d | 2,29E-7 | SIL 2 | 11,6E-9 | 5,1E-5 | 99,6% | SIL 2 | SIL 2 | NA |
| Safely limited speed asymmetric (SLSa) CANopen Safety | Category 2 | PL d | 2,29E-7 | SIL 2 | 8,9E-9 | 3,9E-5 | 99,7% | SIL 2 | SIL 2 | NA |
| Safely limited speed asymmetric (SLSa) SafeInput | Category 2 | PL d | 2,29E-7 | SIL 2 | 10,3E-9 | 4,5E-5 | 99,6% | SIL 2 | SIL 2 | NA |

³³ EN IEC 61508: December 2001 and April 2010

³⁴ NF EN 62061 (July 2005) + NF EN 62061/A1 (2013-05-10) + NF EN 62061/A2 (2015-12-25)

³⁵ IEC 61800 part 5-2 ed1 2007 and ed2 2016: Adjustable speed electrical power drive systems

³⁶ NF EN 60204-1:2018 "Safety of machinery - Electrical equipment of machines - Part 1: General requirements" - IEC 60204-1:2016, modified

| | | | | | | | | | | |
|---|------------|------|---------|-------|---------|--------|--------|-------|-------|------------|
| Safely limited speed asymmetric (SLSa) Pair of SafeInput | Category 3 | PL d | 2,29E-7 | SIL 2 | 11,6E-9 | 5,1E-5 | 99,6% | SIL 2 | SIL 2 | NA |
| 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 | NA |
| Safe direction (SDI) SafeInput | Category 2 | PL d | 2,29E-7 | SIL 2 | 10,3E-9 | 4,5E-5 | 99,6% | SIL 2 | SIL 2 | NA |
| Safe direction (SDI) Pair of SafeInput | Category 3 | PL d | 2,29E-7 | SIL 2 | 11,6E-9 | 5,1E-5 | 99,6% | SIL 2 | SIL 2 | NA |
| Safe speed | Category 3 | PL d | 4,29E-8 | SIL 2 | 8,9E-9 | 3,9E-5 | 99,6 % | SIL 2 | SIL 2 | NA |
| Output safety functions | | | | | | | | | | |
| Safe Brake Control (SBC2) external STO1 et STO2 inputs | Category 2 | PL d | 2,29E-7 | SIL 3 | 9,2E-9 | 4,0E-5 | 99,7% | SIL 3 | SIL 3 | Category 0 |
| Safe Brake Control (SBC2) 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 |
| Safe Brake Control (SBC2) SafeInput | Category 2 | PL d | 2,29E-7 | SIL 2 | 10,3E-9 | 4,5E-5 | 99,6% | SIL 2 | SIL 2 | Category 0 |
| Safe Brake Control (SBC2) Pair of SafeInput | Category 2 | PL d | 2,29E-7 | SIL 2 | 11,6E-9 | 5,1E-5 | 99,6% | SIL 2 | SIL 2 | Category 0 |
| | | | | | | | | | | |
| Safe Brake Control (SBC3) internal STO1 et STO2 inputs | Category 2 | PL d | 2,29E-7 | SIL 3 | 10,8E-9 | 4,7E-5 | 99,6% | SIL 3 | SIL 3 | Category 0 |
| Safe Brake Control (SBC3) CANopen Safety | Category 2 | PL d | 2,29E-7 | SIL 2 | 10,5E-9 | 4,6E-5 | 99,6% | SIL 2 | SIL 2 | Category 0 |
| Safe Brake Control (SBC3) SafeInput | Category 2 | PL d | 2,29E-7 | SIL 2 | 11,8E-9 | 5,2E-5 | 99,6% | SIL 2 | SIL 2 | Category 0 |
| Safe Brake Control (SBC3) Pair of SafeInput | Category 2 | PL d | 2,29E-7 | SIL 2 | 13,2E-9 | 5,8E-5 | 99,5% | SIL 2 | SIL 2 | Category 0 |

STO functions are certified for **category 0** shutdown in compliance with standard **EN 60204-1**.

This mode corresponds to disconnection of the motor power supply for the STO function, which is then in freewheel mode.

A 14-year MTTFD is used for **SWD®-Core & SWD®-125**

A 12-year MTTFD is used for **SWD®-150**.

11.4. Activating a safety function

Safety functions can be triggered by:

- A safety input on the **SWD®** I/O connector (SafeIN).
- A safety controlword from the CANopen dictionary object (Safety controlwords).
- In reaction to the detection of an internal **SWD®** error.

i The control status of a safety function is read-only in the CANopen dictionary and is processed by the **SWD®**.

Types of sensors enabling activation

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

Safety functions configuration

Safety controlwords' are used to control a safety function from CANopen Safety. Safety status words are used to retrieve the status of a safety function from CANopen Safety.

It is necessary to map the desired safety functions to these 'Safety words'. Commands must be mapped in 'scw_mapping_' and 'status' in 'ssw_mapping'.

The list of 'commands' and 'status' that can be mapped are:

| Safety Function | Code Control | Code Status |
|-----------------|------------------------|------------------------|
| RESTART_ACK | 6630 0000 _h | 6631 0000 _h |
| ERROR_ACK | 6632 0000 _h | 6633 0000 _h |
| STO | 6640 0000 _h | 6644 0000 _h |
| SBC_1 | 6660 0100 _h | 6667 0100 _h |
| SBC_2 | 6660 0200 _h | 6667 0200 _h |
| SBC_3 | 6660 0300 _h | 6667 0300 _h |
| SBU | 3040 0000 _h | 3041 0000 _h |
| SMSp | 66AA 0100 _h | 66A8 0100 _h |
| SMSn | 66AC 0100 _h | 66A8 0100 _h |
| SLS [1] | 6690 0100 _h | 669F 0100 _h |
| SLS [2] | 6690 0200 _h | 669F 0200 _h |
| SLS [3] | 6690 0300 _h | 669F 0300 _h |
| SLS [4] | 6690 0400 _h | 669F 0400 _h |
| SLS [5] | 6690 0500 _h | 669F 0500 _h |
| SLS [6] | 6690 0600 _h | 669F 0600 _h |
| SLS [7] | 6690 0700 _h | 669F 0700 _h |
| SLS [8] | 6690 0800 _h | 669F 0800 _h |
| SLSa [1] | 3050 0100 _h | 3059 0100 _h |

| | | |
|-----------------|------------------------|------------------------|
| SLSa [2] | 3050 0200 _h | 3059 0200 _h |
| SLSa [3] | 3050 0300 _h | 3059 0300 _h |
| SLSa [4] | 3050 0400 _h | 3059 0400 _h |
| SLSa [5] | 3050 0500 _h | 3059 0500 _h |
| SLSa [6] | 3050 0600 _h | 3059 0600 _h |
| SLSa [7] | 3050 0700 _h | 3059 0700 _h |
| SLSa [8] | 3050 0800 _h | 3059 0800 _h |
| SDIp [1] | 66D0 0100 _h | 66DE 0100 _h |
| SDIp [2] | 66D0 0200 _h | 66DE 0200 _h |
| SDIn [1] | 66D1 0100 _h | 66DF 0100 _h |
| SDIn [2] | 66D1 0200 _h | 66DF 0200 _h |

Activation with CANopen Safety

i To update the value of controlwords in a security context, it is necessary to use SRDO safety messages.

To activate a safety function via CANopen, you need to use a safety control word(s). Each Safety Controlword can control up to 8 safety functions, with each bit corresponding to the activation of a command. It is also possible to retrieve the status of a safety function by using safety Statusword(s). Each Safety Statusword can be used to retrieve up to 8 safety function states, with each component bit corresponding to the activation state of a function.

Each Safety Controlword bit is associated with a command by means of a mapping configuration operation.

Each bit of the Safety Statusword is associated with a status by means of a configuration operation in this mapping.

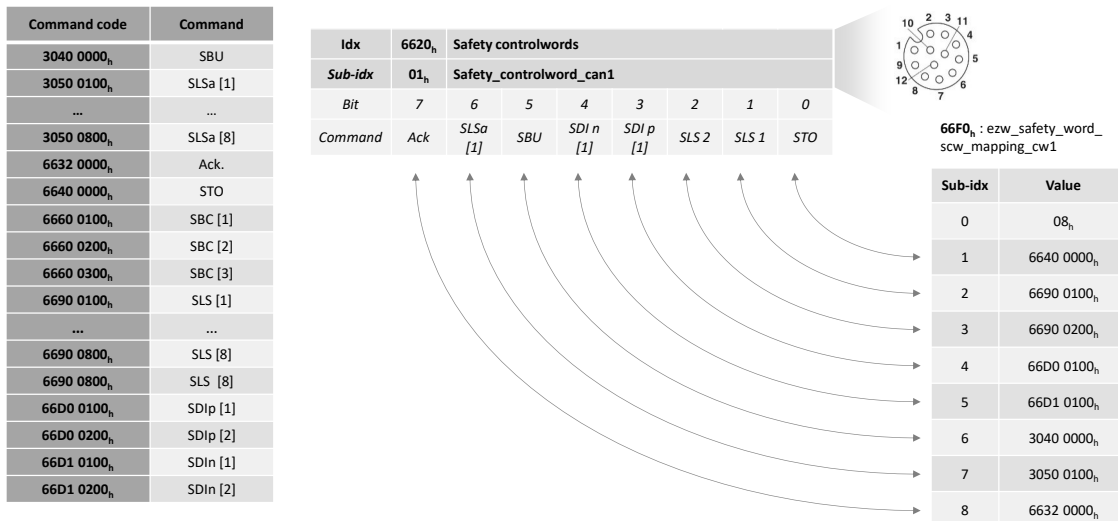


Figure 38 – Example of safety command configuration via CANopen

Activation with safety inputs

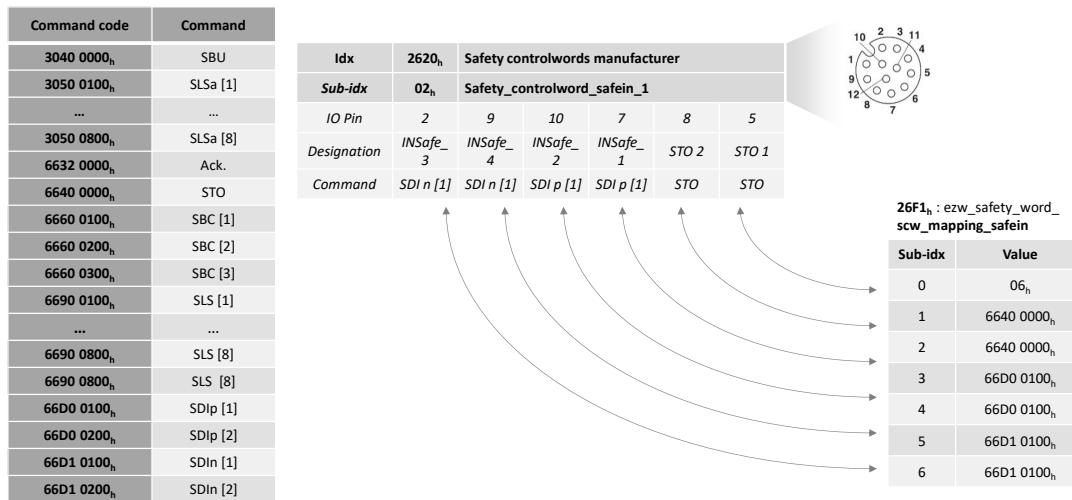


Figure 39 – Example of SafeInputs configuration of safety commands

Safety inputs can operate in pairs to achieve SIL2/PLd/Cat3 safety levels. The configuration must be carried out in such a way as to account for joint operation by associating the same safety function with the commands of both inputs.

The inputs are grouped as follows:

- INSafe_1 – INSafe_2
- INSafe_3 – INSafe_4









Permanent activation

It is possible to permanently activate a safety function. To do this, map the safety function you wish to activate permanently to one of the two sub-objects:

2624_h 'ezw_safety_word_scw_mapping_permanent_cw1':






| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes |
|-------------------|-----------------|-----------------------------|-----------|------------------------|-------------|-------------|------|-------------|-------------|---------------|
| 2624 _h | 00 _h | Number of entries | U8 | 08 _h | RO | NO | - | - | - | 1 |
| 2624 _h | 01 _h | scw_cw_permanent_can_1_bit0 | U32 | 0000 0000 _h | RW | NO | - | - | - | 4 |
| 2624 _h | 02 _h | scw_cw_permanent_can_1_bit1 | U32 | 0000 0000 _h | RW | NO | - | - | - | 4 |
| 2624 _h | 03 _h | scw_cw_permanent_can_1_bit2 | U32 | 0000 0000 _h | RW | NO | - | - | - | 4 |
| 2624 _h | 04 _h | scw_cw_permanent_can_1_bit3 | U32 | 0000 0000 _h | RW | NO | - | - | - | 4 |
| 2624 _h | 05 _h | scw_cw_permanent_can_1_bit4 | U32 | 0000 0000 _h | RW | NO | - | - | - | 4 |
| 2624 _h | 06 _h | scw_cw_permanent_can_1_bit5 | U32 | 0000 0000 _h | RW | NO | - | - | - | 4 |
| 2624 _h | 07 _h | scw_cw_permanent_can_1_bit6 | U32 | 0000 0000 _h | RW | NO | - | - | - | 4 |
| 2624 _h | 08 _h | scw_cw_permanent_can_1_bit7 | U32 | 0000 0000 _h | RW | NO | - | - | - | 4 |

2625_h 'ezw_safety_word_scw_mapping_permanent_cw2':




| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes |
|-------------------|-----------------|-----------------------------|-----------|------------------------|---|-------------|------|-------------|-------------|---------------|
| 2625 _h | 00 _h | Number of entries | U8 | 08 _h | RO | NO | - | - | - | 1 |
| 2625 _h | 01 _h | scw_cw_permanent_can_2_bit0 | U32 | 0000 0000 _h | RW  | NO | - | - | - | 4 |
| 2625 _h | 02 _h | scw_cw_permanent_can_2_bit1 | U32 | 0000 0000 _h | RW  | NO | - | - | - | 4 |
| 2625 _h | 03 _h | scw_cw_permanent_can_2_bit2 | U32 | 0000 0000 _h | RW  | NO | - | - | - | 4 |
| 2625 _h | 04 _h | scw_cw_permanent_can_2_bit3 | U32 | 0000 0000 _h | RW  | NO | - | - | - | 4 |
| 2625 _h | 05 _h | scw_cw_permanent_can_2_bit4 | U32 | 0000 0000 _h | RW  | NO | - | - | - | 4 |
| 2625 _h | 06 _h | scw_cw_permanent_can_2_bit5 | U32 | 0000 0000 _h | RW  | NO | - | - | - | 4 |
| 2625 _h | 07 _h | scw_cw_permanent_can_2_bit6 | U32 | 0000 0000 _h | RW  | NO | - | - | - | 4 |
| 2625 _h | 08 _h | scw_cw_permanent_can_2_bit7 | U32 | 0000 0000 _h | RW  | NO | - | - | - | 4 |






Default 'Safety words' mappings

Safety 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 | RO | 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 | 6630 0000 _h RESTART_ACK | RO | NO | - | - | - | 4 |
| 66F0 _h | 08 _h | Command 8 | U32 | 6632 0000 _h ERROR_ACK | RO | NO | - | - | - | 4 |

Safety 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 |






Safety Controlword Safein 1

In its default configuration, the safety inputs on the connector are not associated with a control. Configuration must be carried out by the machine manufacturer according to the architecture and safety functions to be assigned.









STO_1 and STO_2 inputs are read-only and cannot be modified 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 |

Safety 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 | RO | 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 | 6631 0000 _h RESTART_ACK | RO | NO | - | - | - | 4 |
| 66F8 _h | 08 _h | Status 8 | U32 | 6633 0000 _h ERROR_ACK | RO | NO | - | - | - | 4 |

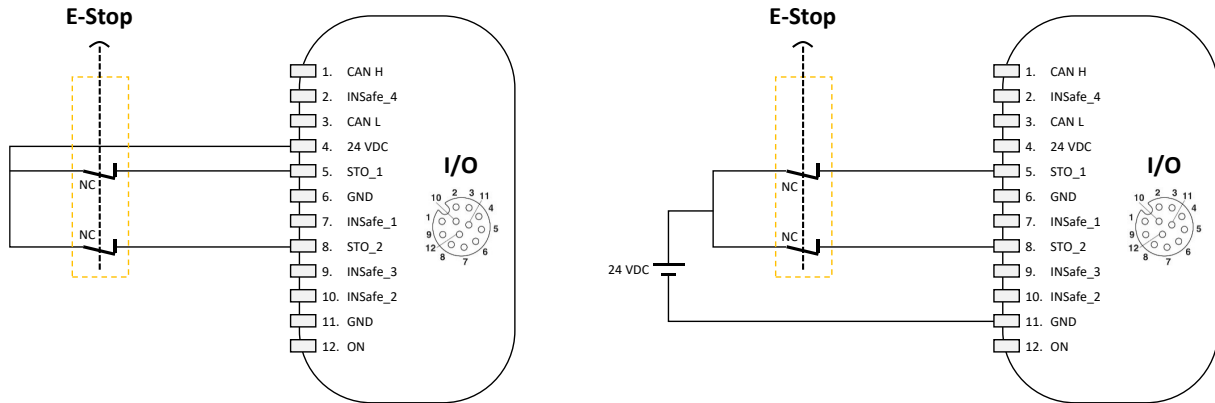
Safety Statusword 2 to 8

| 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 |

11.5. Recommendations for implementation

STO activation by emergency stop

STO activation by emergency stop via I/O connector interface, connected to input pair STO_1 and STO_2; SIL3 / Ple / Cat4 compliant.

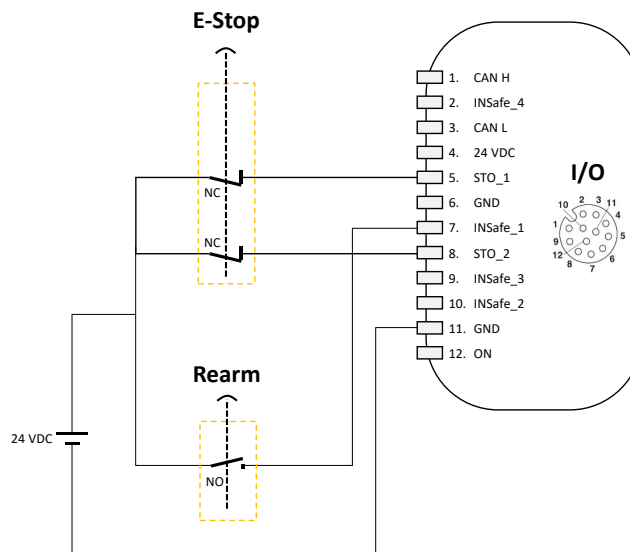


A switch conforming to ISO 13850, with positive opening as in accordance with IEC 60947-5-1, or a certified safety controller must be used as the actuating element.

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

STO rearmament

STO reset by pressing a normally open (NO) button via the I/O connector interface, connected to the INSafe_1 input; holds for up to 100 hours.



The single input INSafe_1 is configured as a reset input after STO engagement. A rising edge from 0 to 24 VDC on the INSafe_1 input resets the STO State to 0 and restores torque to the motor. Object 6641h 'STO restart acknowledge behavior' must be activated (value set to 1), and safety input 'INSafe 1' configured to STO restart acknowledge command 6630h.

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

The safety function is guaranteed to be maintained for a maximum of 100 hours.

STO activation and reset with a safety reset relay

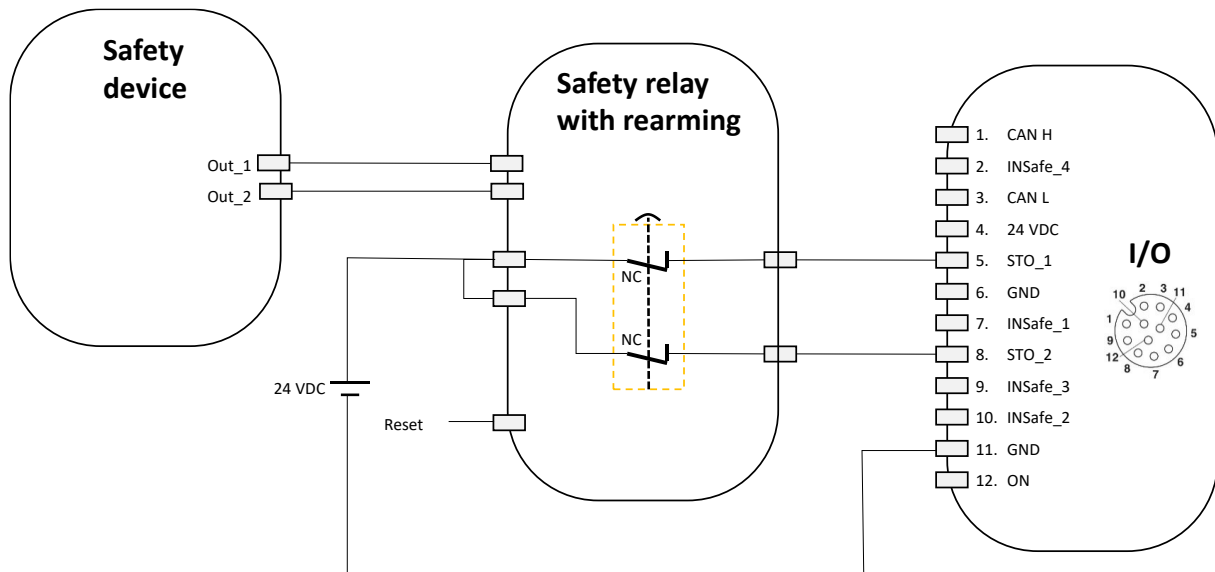
STO activation with compliance up to SIL3 / Ple, with reset, maintained beyond 100h using a safety relay.

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

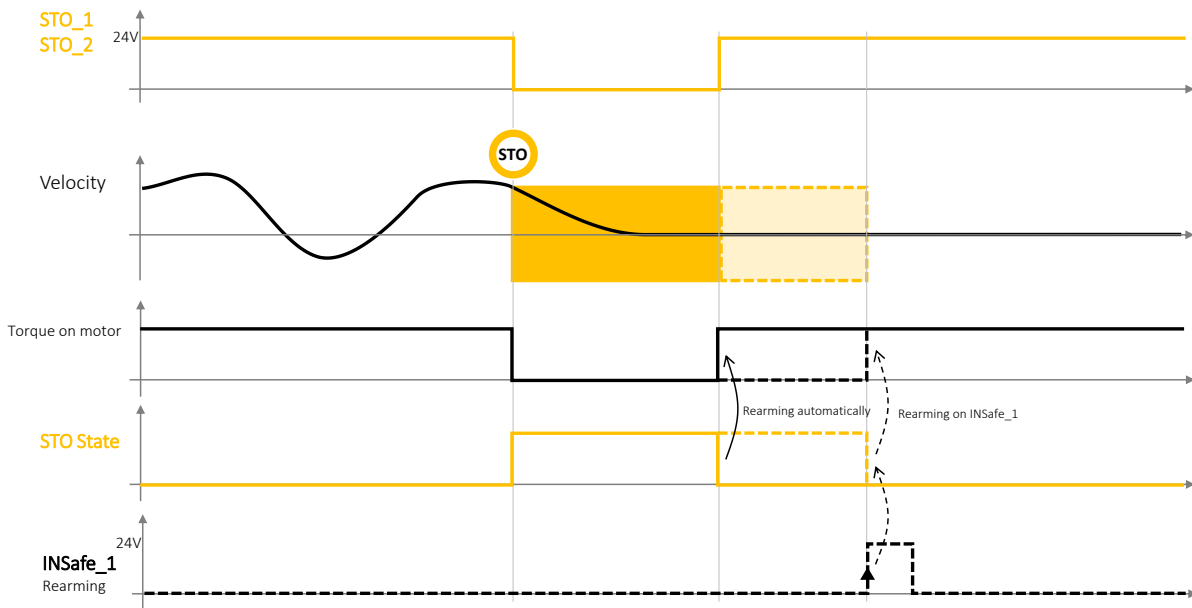
The performance levels of the safety functions and the STO position guarantee are guaranteed for a period of 100 hours.

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

After this period of 100 hours, 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.

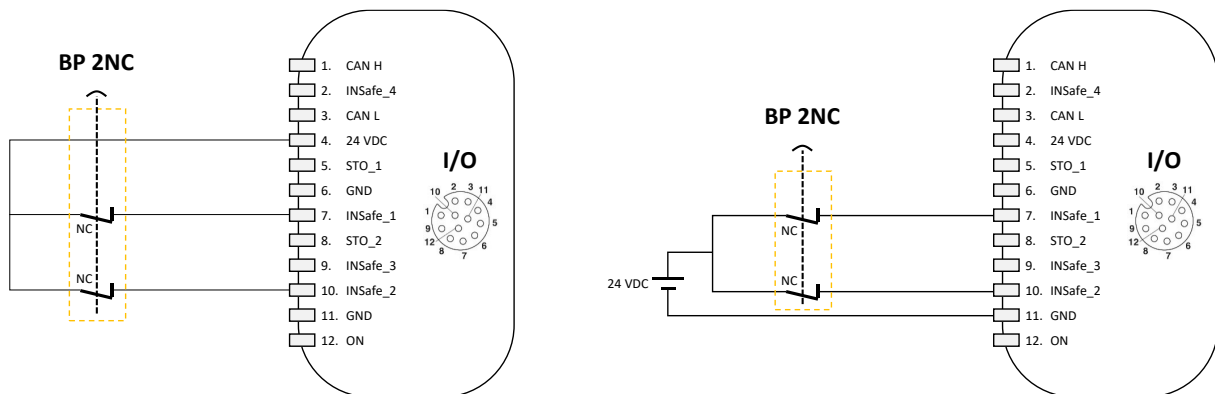


The input safety component must be chosen to satisfy the overall level of the safety function.



Activation of a safety function via a safety input pair

Activation of a software safety function with a 2-pole normally closed (2NC) switch; compliance up to SIL2 / PLd / Cat3.



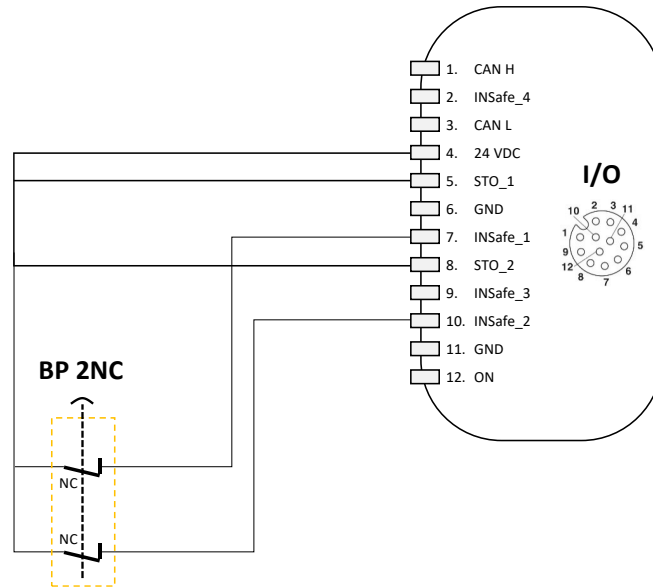
A switch according to ISO 13850, positive opening according to IEC 60947-5-1, or a certified safety controller must be used as the actuating element.

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

If a software safety function is activated by the I/O connector interface, the associated safety function must be configured for each safety inputs.

Permanent deactivation of STO and activation of a safety function

Permanent deactivation of STO and activation of another safety function by a 2-pole normally closed (2NC) switch, compliance up to SIL2 / PLd.

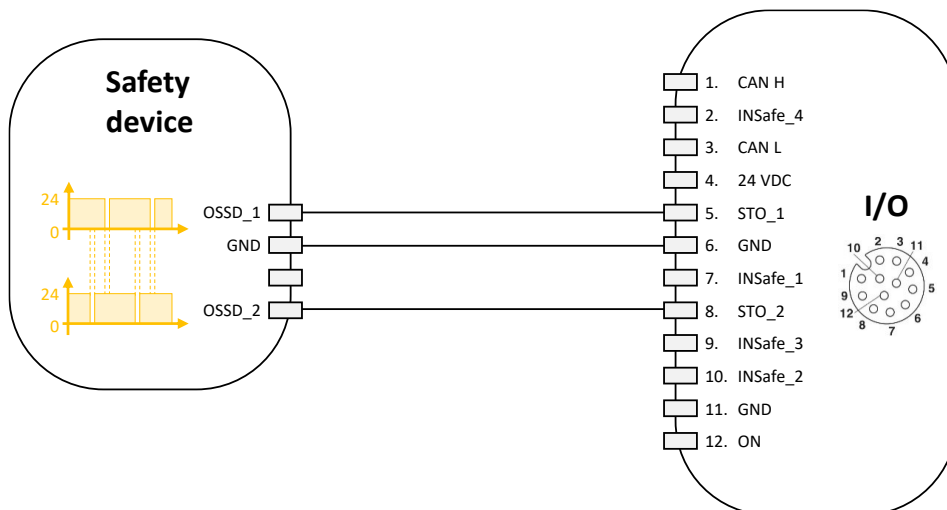


A switch according to ISO 13850, positive opening according to IEC 60947-5-1, or a certified safety controller must be used as the actuating element.

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

Activation of STO by OSSD outputs

Activation of STO by OSSD outputs, compliance up to SIL3 / PL_e.

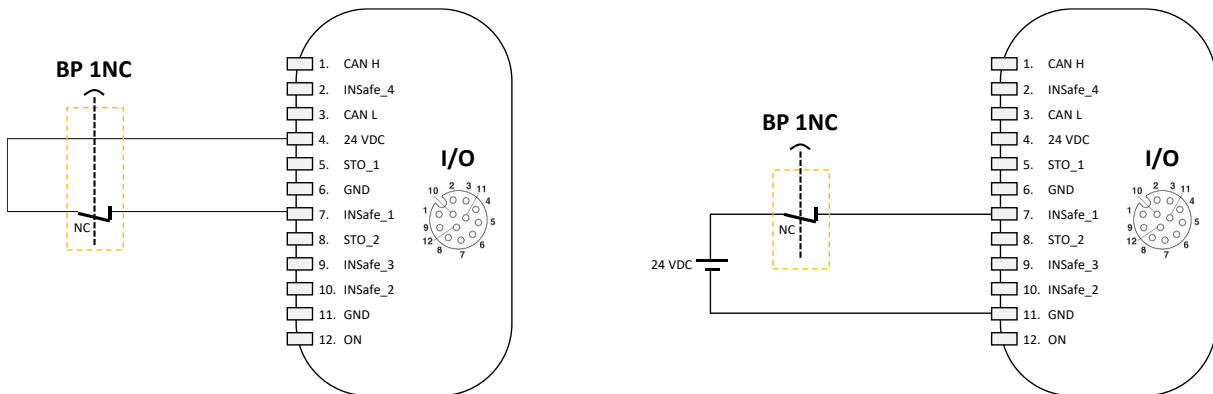


A certified sensor with a pair of OSSDs, a sensor, a safety controller.

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

Use of a single security entrance

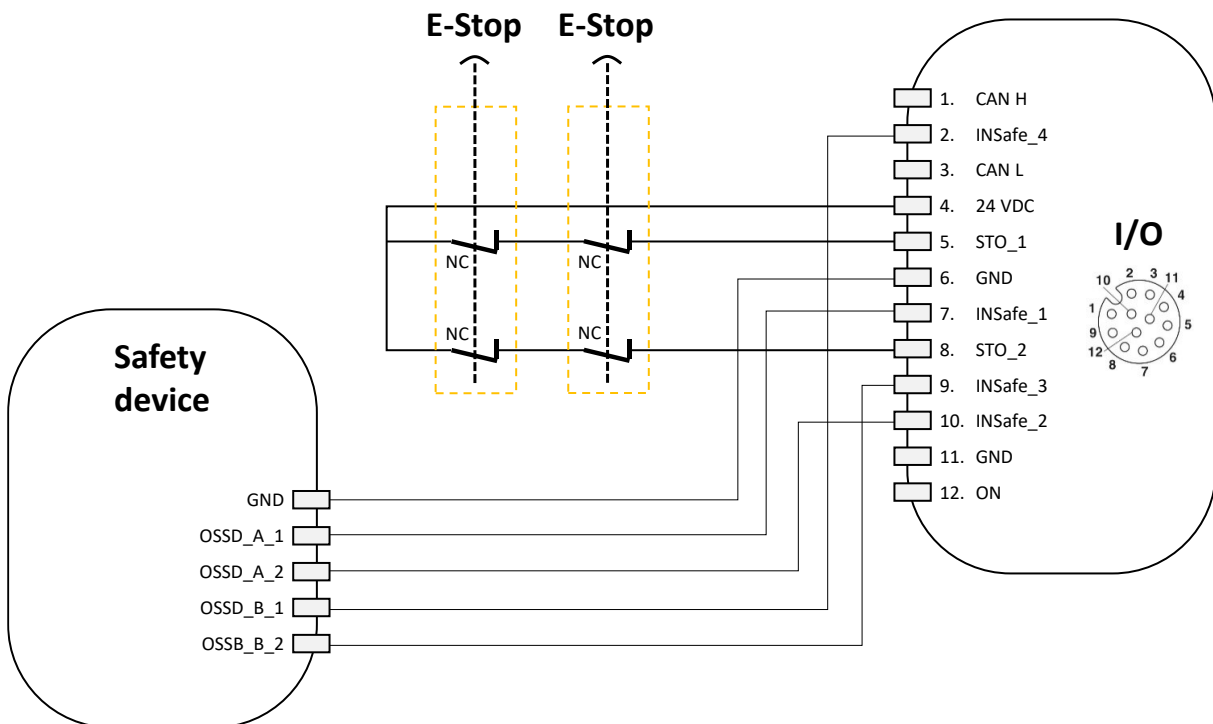
Use of a simple safety input; compliance up to SIL2 / PL_d / Cat2.



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

Activation of STO by two emergency stops

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



The input safety components must be chosen to satisfy the overall level of the safety function.

Exchanges of safety input status on the CANopen Safety bus

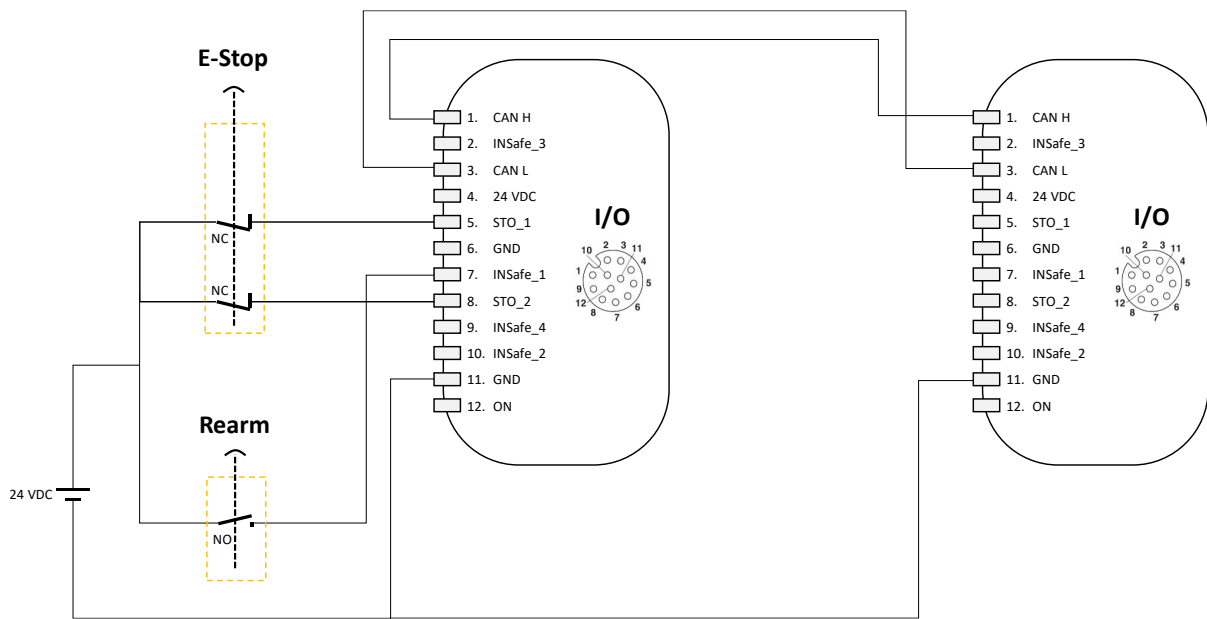
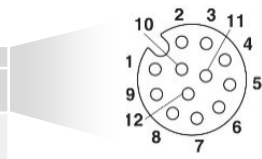
Information on the state of the safety inputs is exchanged on the CANopen Safety bus. So that any device connected to the CANopen bus can know the state of the safety inputs. This information is exchanged through a safety message on the CANopen Safety bus, called SRDO. This SRDO message contains a security object called 'Safe Control Word'. The **SWD®** on which the safety inputs are wired is, in this case of use, the transmitter of the SRDO containing the state of these safety inputs. The other **SWD®** consume the Safe Control Word contained in this SRDO. Thus, they can react to the state of a safety input of another peripheral, with a safety level SIL2 / PLd.

The configuration of the safety function commands must be carried out on each of the **SWD®**.

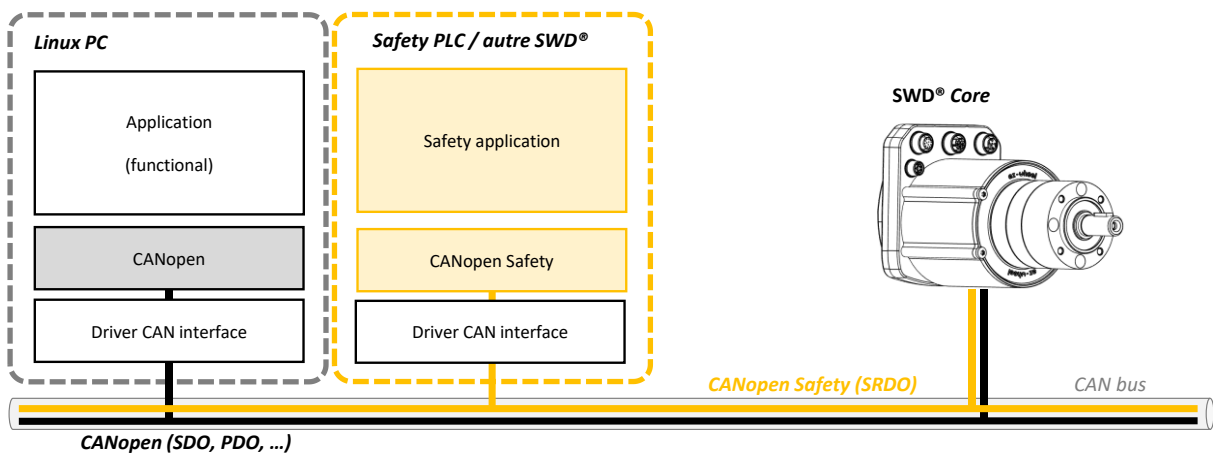
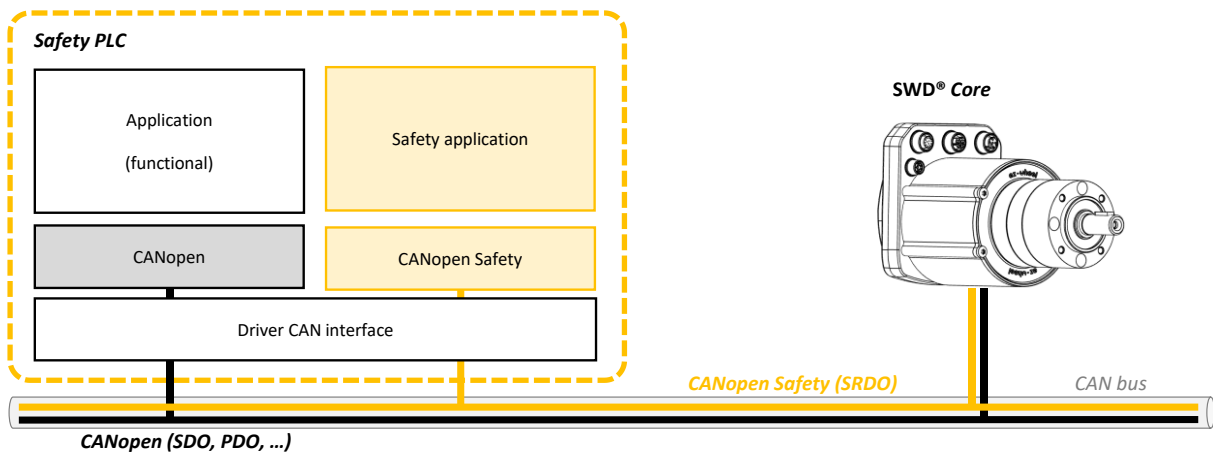
It is carried out by configuring the **safeIn control word** on which the safety inputs are wired and by configuring the **safe control word 'n'** received by CANopen safety on the other **SWD®**.

2620 00_n : 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 |



Connection to a CANopen safety controller



11.6. States of safety functions

The status of the activated safety function commands are available in the 'Safety Function Output' object (2630_h). This read-only object is configurable in TxPDO. It contains the following two sub-indexes:

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes |
|-------------------------------|-----------------|--------------------------|-----------|-----------------|-------------|-------------|------|-----------------|-------------------|---------------|
| Safety Function Output | | | | | | | | | | |
| 2630 _h | 00 _h | Number of entries | U8 | 02 _h | RO | NO | - | 02 _h | - | 1 |
| | 01 _h | safety_function_output_1 | U16 | - | RO | TPDO | - | 0 _h | FFFF _h | 2 |
| | 02 _h | safety_function_output_2 | U16 | - | RO | TPDO | - | 0 _h | FFFF _h | 2 |

| safety_function_output_1 | | | | | | | | | | | | | | | |
|---------------------------------|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |

| | | | | | | | | | | | | | | | |
|---------|---------|---------|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-----|
| SDI_N_2 | SDI_N_1 | SDI_P_2 | SDI_P_1 | SLS_8 | SLS_7 | SLS_6 | SLS_5 | SLS_4 | SLS_3 | SLS_2 | SLS_1 | SBC_3 | SBC_2 | SBC_1 | STO |
| MSB | | | | | | | | LSB | | | | | | | |

| safety_function_output_2 | | | | | | | | | | | | | | | |
|--------------------------|----|----|----|--------|--------|--------|--------|--------|--------|--------|--------|-----|-----|--------------|------------|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Not used | | | | SLSa_8 | SLSa_7 | SLSa_6 | SLSa_5 | SLSa_4 | SLSa_3 | SLSa_2 | SLSa_1 | SMS | SBU | RESTART_ ACK | ERROR_ ACK |
| MSB | | | | | | | | LSB | | | | | | | |

| | | |
|-----------------|-------------|-----------|
| Safety function | Deactivated | Activated |
| Bit value | 0 | 1 |

11.7. Safety function

STO Activation

STO is activated by command 0x6640, active low.

After engaging an STO, the motor is electrically disconnected and no longer exerts torque. The speed slows down, but in the case of activation of STO alone, the motor is not braked, and the speed deceleration depends on the inertia of the drive.

The STO state is available in the '0x6644 STO State' object. A high state means that it is active and remains active until reset.

Activating STO

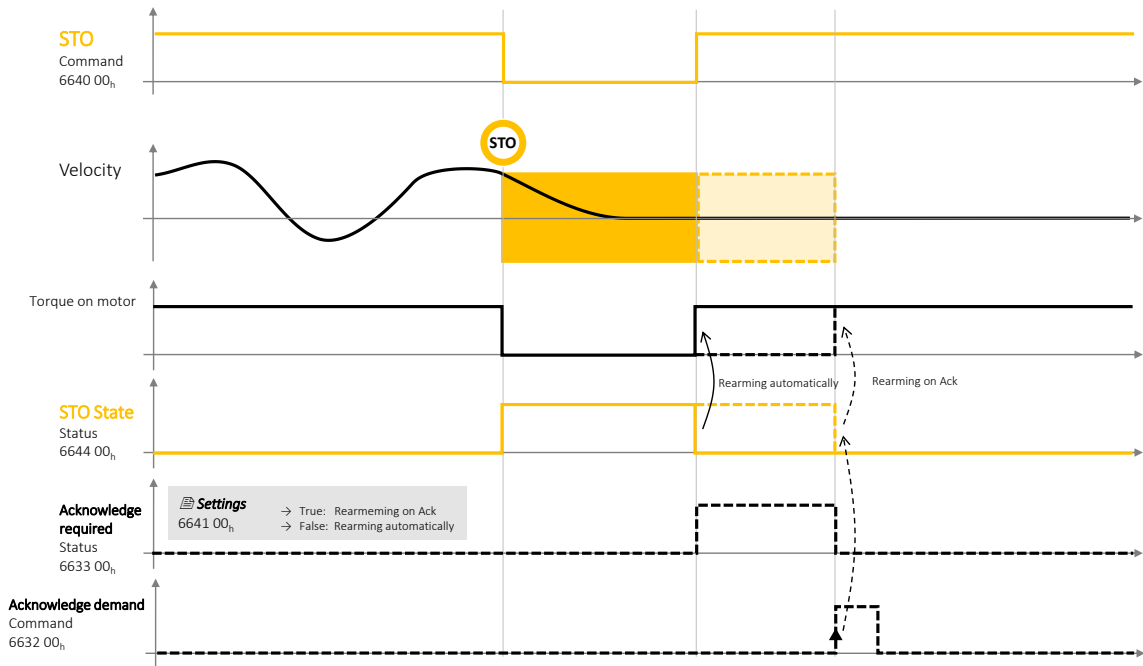


Figure 40 – STO activation and acknowledgment diagram

The restart mode is set by the '0x6641 STO restart acknowledge behavior' register. A 'False' value initiates automatic resetting on disappearance of the STO signal. A 'True' value requires an acknowledgment to be reset.

In the case of a reset by Acknowledge, the status is active in the high state as long as an acknowledgment is expected. The Acknowledge request must be made by switching the command to the high state, the rising edge triggering the acknowledgement.

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes |
|-------------------|-----|----------------------------------|-----------|---------------|-------------|-------------|------|--|-------------|---------------|
| 6630 _h | 00 | Restart acknowledge command | BOOLEAN | - | WO | NO | - | 0 | 1 | 1 |
| 6631 _h | 00 | Restart acknowledge status | BOOLEAN | - | RO | NO | - | 0 | 1 | 1 |
| 6640 _h | 00 | STO Command | BOOLEAN | - | RO | NO | - | 0 | 1 | 1 |
| 6641 _h | 00 | STO restart acknowledge behavior | BOOLEAN | 0 | RW | NO | - | 0 | 1 | 1 |
| 6643 _h | 00 | STO active SBC | U32 | 0x66600300 | RW | NO | - | 0000 0000 _h 6660 0100 _h 6660 0200 _h 6660 0300 _h | | 4 |
| 6644 _h | 00 | STO status | BOOLEAN | 0 | RO | NO | - | 0 | 1 | 1 |

SBC Activation

The SWD® manages two engine braking modes. Internal motor braking and external braking. Internal braking works by short-circuiting the motor phases. While the external brake works by lack of current. It is mounted on the motor shaft, at the rear of the product. The use or not of the internal brake is configurable³⁷ :

| Braking applied according to the configuration used | | |
|---|----------------|----------------|
| SBC commands | Internal brake | External brake |
| No SBC | | |
| SBC command 1 | ✓ | ✓ |
| SBC command 2 | | ✓ |
| SBC command 3 | ✓ | |

⚠ *If configured on 'SBC command 3', no external brake should be connected. If necessary, it will not be powered, and the SWD® will be braked by the external brake.*

When an external brake is fitted, the user must enter it in the dedicated field of the CANopen dictionary, 'Brake present' (2660_h).

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes |
|-------------------|-----------------|---------------|-----------|-----------------|-------------|-------------|------|-------------|-------------|---------------|
| 2660 _h | 00 _h | Brake present | BOOL | - ³⁸ | RW | NO | - | 0 | 1 | 1 |

| | | |
|--|---------------------------|------------------------|
| 2660_h: Brake present | No external brake mounted | External brake mounted |
| Value | 0 | 1 |

The external brake is present if it has been correctly mounted on the motor and if it is connected to the dedicated connector.

- i** If the configuration indicates that an external brake is fitted, but it is not detected, an error in the form of an EMCY message is sent, with the code 8016_h BLC (Brake Lock Check).
- i** If the configuration indicates that no external brake is fitted, but it is detected, an error in the form of an EMCY message is sent, with the code 8010_h (EXT_BRAKE_PRESENCE).

By default, the "SBC command 3" braking mode is activated on an STO signal, i.e., internal motor braking.

By default, the "SBC command 3" braking mode is activated on an STO signal, i.e., internal motor braking.

An SBC command can also be activated via a safety command, i.e., a 'Safety Controlword' (6620_h).

⚠ *If an SBC command mode incompatible with the hardware has been set, an error in the form of an EMCY message is sent, with the code 6020_h (CANOPEN_PARAMETER_ERROR).*

³⁷ Configuration possible from software version 'Firmware 2.0.x'. SBC command 3 by default otherwise.

³⁸ 'True' for products with external brake, 'False' for products without external brake.

The internal brake is maintained after disconnecting the power supply to the motors. Brake hold time is approximately three minutes.

Since software version 'Firmware 1.1.4', the internal brake remains disabled in the event of:

1. Driven by means external to the engine (towing)
2. Disconnection of a power source allowing energy storage, or that this one does not accept any more current in input.
3. 3. Detection of motor electronics overheating.

Towing is strongly discouraged and must remain within the nominal operating ranges of the engines.

SBU Activation

The **SWD®** provides a safe motor disengagement mode, to facilitate maintenance operations on mobile platforms. This SBU mode (Safe Brake Unlock) allows the brakes to be deactivated and the motor to be freewheeled.

This mode can be activated by a signal on a safety input of the **SWD®** or by reception of a safety message on the CANopen safety bus.

When this mode is activated, an EMCY emergency message is sent with the code 8012h "SBU_SET".

SBU activation is limited to SWITCHED_ON_DISABLED and READY_TO_SWITCH_ON modes of the motor drive state machine. Otherwise, the activation of this mode fails, and an EMCY emergency message is sent with the code 8013h "SBU_ACTIVATION_ERROR", causing the state machine to go into the 'Fault' state.

SDI Activation

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.

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

- 66D0 01h: SDI positive beyond threshold *+nZero_SDI*, value of sub-index 01
- 66D1 01h: SDI negative beyond threshold *-nZero_SDI*, value of sub-index 01
- 66D0 02h: SDI positive beyond threshold *+nZero_SDI*, value of sub-index 02
- 66D1 02h: SDI negative beyond threshold *-nZero_SDI*, value of sub-index 02

The *nZero_SDI* trigger thresholds can be configured by registers 66D5 01h and 66D5 02h.

Exceeding the threshold by the rotational speed of the motor when an SDI command is active leads to the violation of an SDI and the triggering of the STO.

The reset mode then works in the same way as for the activation of STO only (see Activation of STO).

SDI Activation

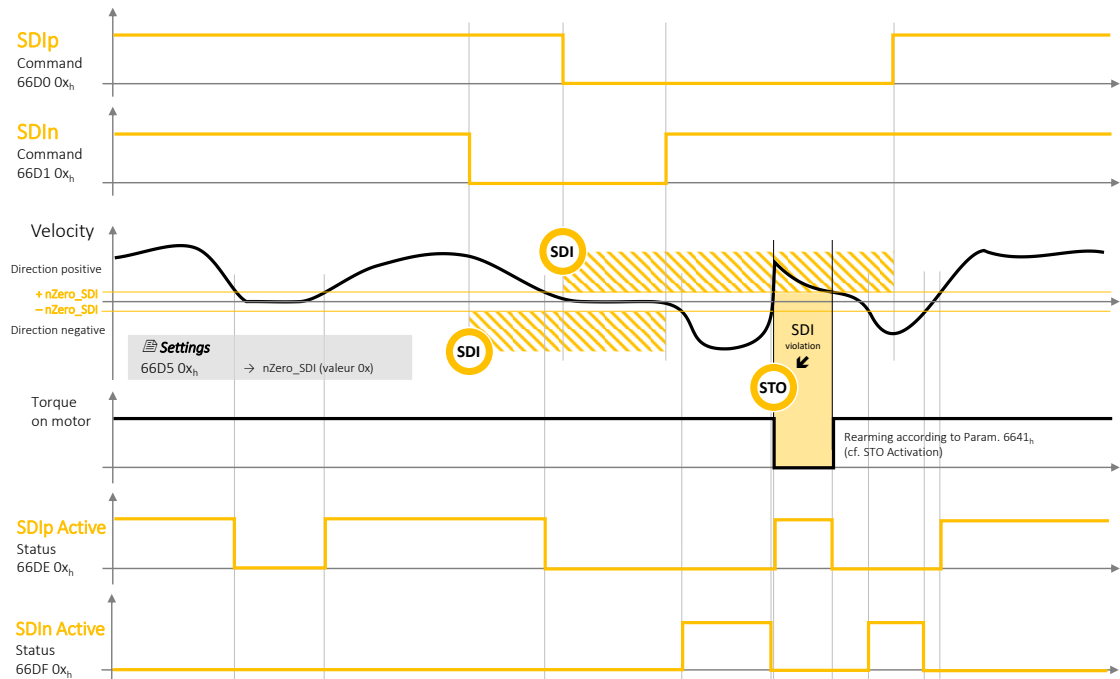


Figure 41 – SDI activation diagram

Two statuses SDIp Active and SDIn Active are available, even without activation of the SDI functions, to indicate if the rotation speed is beyond the nZero_SDI trigger threshold. The thresholds use the values of the two configured indexes, so there are a total of four rotation direction detection statuses that can be used to monitor motor activity:

- 66DE 01_h: rotation positive beyond threshold +nZero_SDI, value of sub-index 01
- 66DF 01_h: rotation negative beyond threshold -nZero_SDI, value of sub-index 01
- 66DE 02_h: rotation positive beyond threshold +nZero_SDI, value of sub-index 01
- 66DF 02_h: rotation negative beyond threshold -nZero_SDI, value of sub-index 01

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes |
|-------------------|------------------------------------|--------------------------|-----------|---------------|-------------|-------------|------|-------------|-------------|---------------|
| 66D0 _h | 00 _h to 02 _h | SDIp Commands | BOOLEAN | 1 | RO | NO | - | 0 | 1 | 1 |
| 66D1 _h | 00 _h to 02 _h | SDIn Commands | BOOLEAN | 1 | RO | NO | - | 0 | 1 | 1 |
| 66D5 _h | 00 | SDI velocity zero window | U32 | 0 | RW | NO | RPM | 0 | 1 | 1 |
| 66DE _h | 00 _h to 02 _h | SDIp statuses | BOOLEAN | 0 | RO | NO | - | 0 | 1 | 1 |
| 66DF _h | 00 _h to 02 _h | SDIn statuses | BOOLEAN | 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 are not guaranteed.

SLS Activation

Eight levels of SLS speed limitation can be activated by command 6690_h, index 01 to 08.

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

- The time t_{SLS} (in ms) elapsed since the activation of the SLS command
- The time t_{L_SLS} (in ms) elapsed after the speed passed through the authorized window

The authorized speed is limited by the n_{SLS} value (in rpm), in both directions of rotation.

For each of the eight actionable SLSs, the values can be configured using the registers:

- 6693 0_h: Speed n_{SLS} , value for index 0_x [01..08]
- 6691 0_h: Time t_{SLS} , value for index 0_x [01..08]
- 6694 0_h: Time t_{L_SLS} , value for index 0_x [01..08]

Exceeding the motor rotation speed threshold when an SLS command is active leads to the violation of an SLS. This can trigger an STO signal, depending on the configuration of the 'SLS error reactions' object 0x6698_h. In this case, the reset mode works in the same way as for the activation of STO alone (see Activation of STO).

SLS Activation

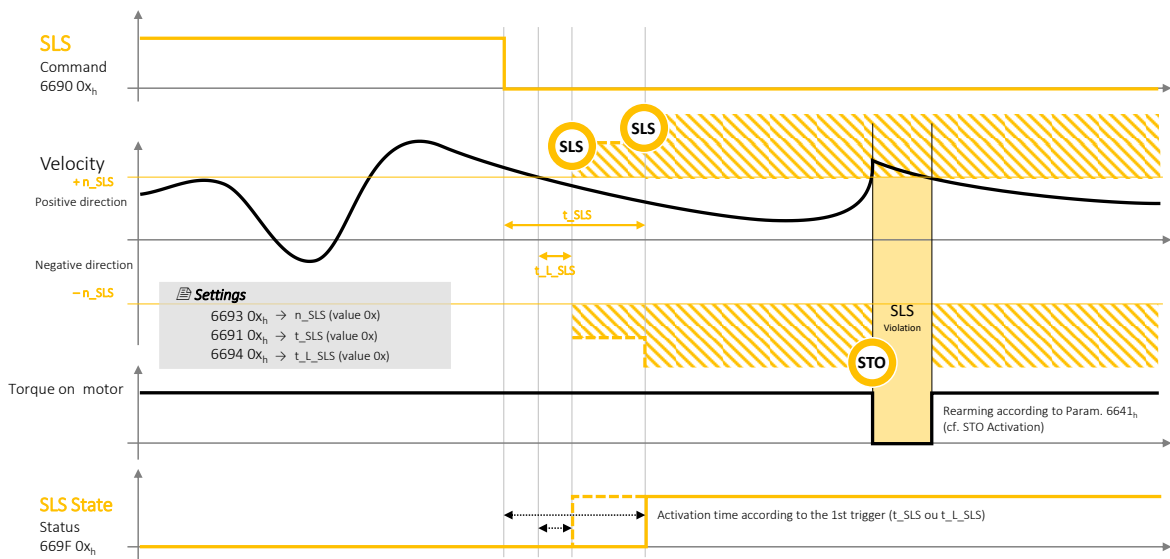


Figure 42 – SLS activation diagram

The status accessible in the SLS State 6697 0_h object, at sub-indexes [01...08], is active in the high state when the speed monitoring triggered by the SLS 6690 0_h 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 to Monitoring start | 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 to SLS start "within limit" | U16 | 0 | RW | NO | MS | 0 | U16 | 2 | YES |
| 6698 _h | 00 _h to 08 _h | SLS reactions in the 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 purpose. This configuration depends on the use case of the SWD® and is under 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 are not guaranteed.

Activation du SLSa

Eight levels of SLSa speed limit can be activated by command 3050_h, sub-index 01 to 08.

SLSa 3050_h 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_SLSa (in ms) elapsed since the activation of the SLSa command
- The time t_L_SLSa (in ms) elapsed after the speed passed through the authorized window

The authorized speed is limited by the n_SLSa value (in rpm), in a single direction of rotation.

For each of the eight actionable SLSa, the values can be configured with the objects:

- 3051_h: 01_h ... 08_h Positive Time t_SLSa+
- 3052_h: 01_h ... 08_h Positive speed n_SLSa+
- 3053_h: 01_h ... 08_h Positive limited time t_L_SLSa+
- 3054_h: 01_h ... 08_h Negative Time t_SLSa-
- 3055_h: 01_h ... 08_h Negative speed n_SLSa-
- 3056_h: 01_h ... 08_h Negative limited time t_L_SLSa-

Exceeding the motor rotation speed threshold when an SLSa command is active leads to the violation of an SLSa. This may trigger an STO signal, depending on the configuration of the 'SLSa error reactions' object 0x3057_h. In this case, the reset mode works in the same way as for the activation of STO alone (see Activation of STO).

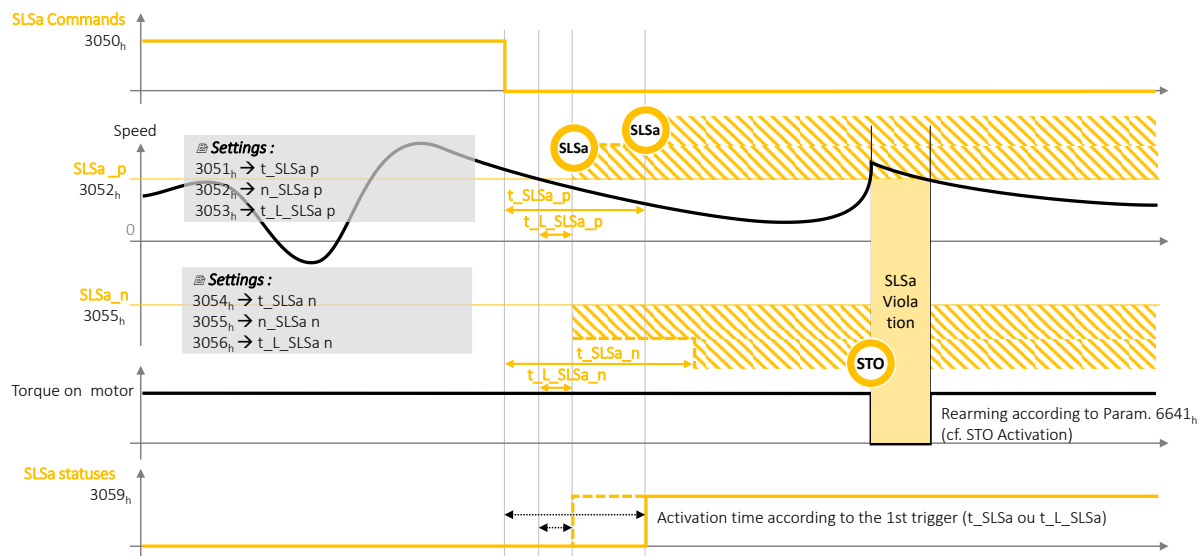


Figure 43 – SLSa activation diagram

The status accessible in the SLSa State 3059h object, at sub-index [01h ... 08h], is active in the high state when the speed monitoring triggered by the SLSa 3050h 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 |
|-------------------|------------------------------------|---|-----------|---------------|-------------|-------------|------|--|-------------|---------------|----------------------|
| 3050 _h | 00 _h to 08 _h | SLSa commands | BOOLEAN | - | RO | NO | - | 0 | 1 | 1 | - |
| 3051 _h | 00 _h to 08 _h | SLSa time to positive velocity monitoring | U16 | 0 | RW | NO | MS | 0 | U16 | 2 | YES |
| 3052 _h | 00 _h to 08 _h | SLSa positive velocity limit u32 | U32 | 0 | RW | NO | RPM | 0 | U32 | 4 | YES |
| 3053 _h | 00 _h to 08 _h | SLSa time for positive velocity in limits | U16 | 0 | RW | NO | MS | 0 | U16 | 2 | YES |
| 3054 _h | 00 _h to 08 _h | SLSa time to negative velocity monitoring | U16 | 0 | RW | NO | MS | 0 | U16 | 2 | YES |
| 3055 _h | 00 _h to 08 _h | SLSa negative velocity limit u32 | U32 | 0 | RW | NO | RPM | | U32 | 4 | YES |
| 3056 _h | 00 _h to 08 _h | SLSa time for negative velocity in limits | U16 | 0 | RW | NO | MS | | U16 | 2 | YES |
| 3057 _h | 00 _h to 08 _h | SLSa error reactions | U32 | 6640 0000 h | RW | NO | - | 0 = pas de reaction 6640 0000 = STO | | 4 | YES |
| 3058 _h | 00 _h to 08 _h | SLSa safety application configuration signature | U16 | - | RW | NO | - | 0 | 1 | 2 | YES |
| 3059 _h | 00 _h to 08 _h | SLSa statuses | BOOLEAN | - | RO | NO | - | 0 | 1 | 1 | YES |

- ⚠ The user can choose to deactivate the reaction if he wishes to use the 'status' of the SLSa for another purpose. This configuration depends on the use case of the **SWD®** and is under the responsibility of the machine manufacturer.
- ⚠ The SLSa 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 are not guaranteed.

SMS Activation

Two maximum positive and negative SMS velocity commands can be activated in the low state to prevent the exceeding of a speed threshold.

The two SMS functions each have indexes for activating the speed threshold not to be exceeded (RPM), for a positive speed and for a negative speed.

- 66AA 01_h: SMS maximum positive velocity, value of sub-index 01
- 66AC 01_h: SMS maximum negative velocity, value of sub-index 01

Exceeding the motor rotation speed threshold when the SMS is activated leads to the violation of the SMS and the triggering of a configurable reaction.

- 66AD 01_h: SMS error reaction, sub-index value 01

By default, the configured reaction mode is the activation of the STO command '6640 00h' (see Activation of STO). If no reaction is set, the speed will be reduced to the given speed range.

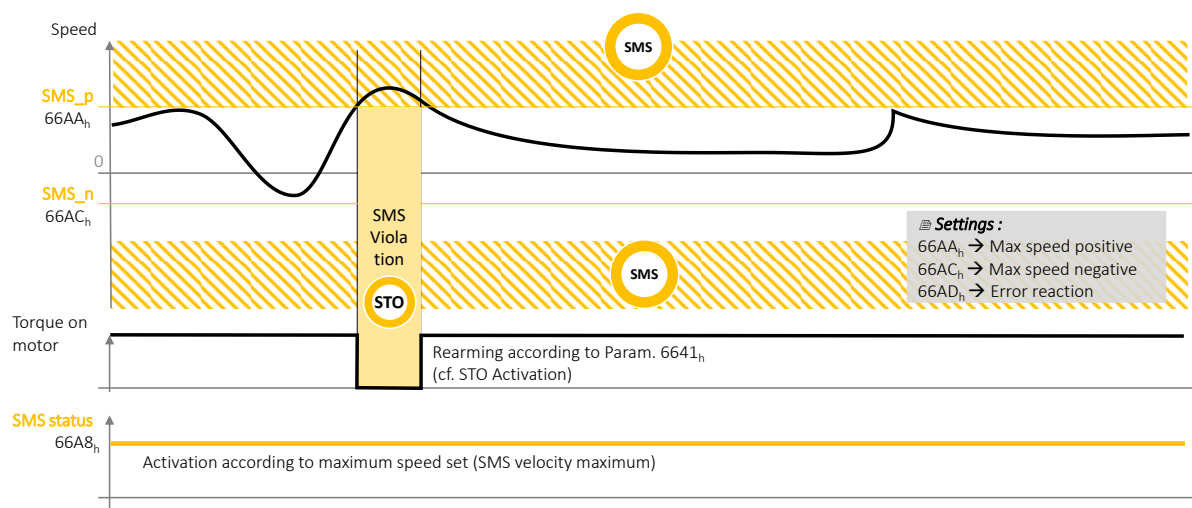


Figure 44 – SMS (Safe Maximum Speed) activation diagram

SMS status is available, indicating whether a maximum rotation speed has been set. If no speed threshold is configured (value of index 01 zero), then the SMS function is not activated.

- 66A8 01_h: SMS status, subindex value 01

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes |
|-------------------|------------------------------------|--|-----------|----------------------|-------------|-------------|------|-------------|-------------|---------------|
| 66A8 _h | 00 _h to 01 _h | SMS statuses | BOOLEAN | - | RO | NO | - | 0 | 1 | 1 |
| 66AA _h | 00 _h to 01 _h | SMS velocity maximum positive u32 | U32 | 0 | RW | NO | RPM | 0 | U32 | 4 |
| 66AC _h | 00 _h to 01 _h | SMS velocity maximum negative u32 | U32 | 0 | RW | NO | RPM | 0 | U32 | 4 |
| 66AD _h | 00 _h to 01 _h | SMS error reactions | U32 | 6640 00 _h | RW | NO | - | 0 | U32 | 4 |
| 66AE _h | 00 _h to 01 _h | SMS safety application configuration signature | U16 | - | RW | NO | - | 0 | U16 | 2 |

11.8. Signatures

Security configurations include a CRC-type signature to ensure their integrity. A signature error prevents the transition to the NMT operational state.

In the event of an error on the signature of one of the safety functions, the object '6607 00h Safety application configuration valid' is worth 00h, otherwise it is worth A5h. Signatures must be updated in NMT Pre-Operational mode.

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes | Non-volatile storage |
|-------------------|-----|--|-----------|---------------|-------------|-------------|------|-------------|-------------|---------------|----------------------|
| 6607 _h | 0 | Safety application configuration valid | U8 | - | RW | NO | - | 0 | 255 | 1 | Yes |

| Value | Definition |
|-----------------|------------------------------|
| 00 _h | Safety configuration invalid |
| A5 _h | Safety configuration valid |

Calculation method

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

Example of implementation:

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

Example of CRC calculation 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, 0xbfba u, 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);
}

```

SRDO Signatures

Security message configurations include a CRC type signature to ensure their integrity. A signature error prevents the transition to the operational NMT state.

In the event of an error on the signature of one of the safety functions, the '6607 00_h Safety application configuration valid' object takes the value 00_h, otherwise it is A5_h. Signatures must be updated in NMT Pre-Operational mode.

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes | Non-volatile storage |
|-------------------|-----|---------------------|-----------|---------------|-------------|-------------|------|-------------|-------------|---------------|----------------------|
| 13FE _h | 0 | Configuration valid | U8 | 0xA5 | RW | NO | - | 0 | 255 | 1 | Yes |

| Value | Definition |
|-----------------|------------------------------|
| 00 _h | Safety configuration invalid |
| A5 _h | Safety configuration valid |

As soon as the configuration of an SRDO has been modified, the object '13FE 00_h Configuration valid' automatically switches to the invalid state '00_h'.

There is a signature for each SRDO. The signatures are stored in the 'Safety configuration checksum' object 13FF_h at Each sub-index corresponds to the signature of an SRDO:

| Idx | Sub | Name | Data Type | Default Value | Access Type | PDO Mapping | Unit | Lower Limit | Upper Limit | Size in Bytes | Non-volatile storage |
|-------------------|-----------------|-------------------|-----------|-------------------|-------------|-------------|------|-------------|-------------|---------------|----------------------|
| 13FF _h | 00 _h | Number of entries | U8 | 16 | RO | NO | - | 0 | 255 | 1 | Yes |
| | 01 _h | SRDO 1 signature | U16 | 70AB _h | RW | NO | - | 0 | 65535 | 2 | Yes |
| | 02 _h | SRDO 2 signature | U16 | 8C5F _h | RW | NO | - | 0 | 65535 | 2 | Yes |

| | | | | | | | | | | |
|-----------------|-------------------|-----|-------------------|----|----|---|---|-------|---|-----|
| 09 _h | SRDO 9 signature | U16 | 6C9B _h | RW | NO | - | 0 | 65535 | 2 | Yes |
| 0A _h | SRDO 10 signature | U16 | 2274 _h | RW | NO | - | 0 | 65535 | 2 | Yes |
| 0B _h | SRDO 11 signature | U16 | 78AE _h | RW | NO | - | 0 | 65535 | 2 | Yes |
| 0C _h | SRDO 12 signature | U16 | 4052 _h | RW | NO | - | 0 | 65535 | 2 | Yes |
| 0D _h | SRDO 13 signature | U16 | 9968 _h | RW | NO | - | 0 | 65535 | 2 | Yes |
| 0E _h | SRDO 14 signature | U16 | 1BF6 _h | RW | NO | - | 0 | 65535 | 2 | Yes |
| 0F _h | SRDO 15 signature | U16 | 3A94 _h | RW | NO | - | 0 | 65535 | 2 | Yes |
| 10 _h | SRDO 16 signature | U16 | 9941 _h | RW | NO | - | 0 | 65535 | 2 | Yes |

The configurations for each SRDO are stored in the following objects:

| | Communication parameters index | Mapping parameters index |
|----------------|--------------------------------|--------------------------|
| SRDO 1 | 1301 _h | 1381 _h |
| SRDO 2 | 1302 _h | 1382 _h |
| SRDO 9 | 1309 _h | 1389 _h |
| SRDO 10 | 130A _h | 138A _h |
| SRDO 11 | 130B _h | 138B _h |
| SRDO 12 | 130C _h | 138C _h |
| SRDO 13 | 130D _h | 138D _h |
| SRDO 14 | 130E _h | 138E _h |
| SRDO 15 | 130F _h | 138F _h |
| SRDO 16 | 1310 _h | 1390 _h |

⚠ NB: SRDOs 3 to 8 do not exist.

The data to consider are, in order:

| Index | Sub | Name | Size (Bytes) |
|--|-----------------------------|--------------------------|------------------------------|
| <u>SRDO Communication Parameter:</u> 1301 _h ; 1302 _h ; 1309 _h ; 130A _h ; 130B _h ; 130C _h ; 130D _h ; 130E _h ; 130F _h ; 1310 _h | 01 | Information direction | 1 |
| | 02 | Refresh time or SCT | 2 |
| | 03 | SRVT | 1 |
| | 05 | COB-ID 1 | 4 |
| | 06 | COB-ID 2 | 4 |
| | Index of mapping parameters | 00 | Number of mapping parameters |
| For each object 'X' in the mapping: | | | |
| <u>SRDO Mapping Parameter:</u> 1381 _h ; 1382 _h ; 1389 _h ; 138A _h ; 138B _h ; 138C _h ; 138D _h ; 138E _h ; 138F _h ; 1390 _h | 00 | Number of mapped objects | 1 |
| | 0x | Mapped object entry | 4 |

STO signature

The STO configuration signature is stored in object 6645 00_h

The data to be considered are, in order:

| Index | Sub-Index | Name | Size (Bytes) |
|-------------------|-----------|--------------------------------|------------------------|
| 6641 _h | 00 | STO acknowledge behavior | 1 |
| 66F0 _h | 01 to 08 | Safety Controlword 1 | 4 (for each sub-index) |
| 66F1 _h | 01 to 08 | Safety Controlword 2 | 4 (for each sub-index) |
| 66F2 _h | 01 to 08 | Safety Controlword 3 | 4 (for each sub-index) |
| 66F3 _h | 01 to 08 | Safety Controlword 4 | 4 (for each sub-index) |
| 66F4 _h | 01 to 08 | Safety Controlword 5 | 4 (for each sub-index) |
| 66F5 _h | 01 to 08 | Safety Controlword 6 | 4 (for each sub-index) |
| 66F6 _h | 01 to 08 | Safety Controlword 7 | 4 (for each sub-index) |
| 66F7 _h | 01 to 08 | Safety Controlword 8 | 4 (for each sub-index) |
| 66F8 _h | 01 to 08 | Safety Statusword 1 | 4 (for each sub-index) |
| 66F9 _h | 01 to 08 | Safety Statusword 2 | 4 (for each sub-index) |
| 66FA _h | 01 to 08 | Safety Statusword 3 | 4 (for each sub-index) |
| 66FB _h | 01 to 08 | Safety Statusword 4 | 4 (for each sub-index) |
| 66FC _h | 01 to 08 | Safety Statusword 5 | 4 (for each sub-index) |
| 66FD _h | 01 to 08 | Safety Statusword 6 | 4 (for each sub-index) |
| 66FE _h | 01 to 08 | Safety Statusword 7 | 4 (for each sub-index) |
| 66FF _h | 01 to 08 | Safety Statusword 8 | 4 (for each sub-index) |
| 26F1 _h | 01 to 06 | Safety Controlword Safe_in | 4 (for each sub-index) |
| 26F8 _h | 01 to 04 | Safety Statusword Safe_out | 4 (for each sub-index) |
| 2624 _h | 01 to 08 | Permanent Safety Controlword 1 | 4 (for each sub-index) |
| 2625 _h | 01 to 08 | Permanent Safety Controlword 2 | 4 (for each sub-index) |

SBC / SBU signatures

There is a signature for each of the 3 SBC functions.

Signatures are stored in the object 6662 0x_h, with sub-index x corresponding to the SBC configuration number.

The data to be considered are, in order:

| Index | Sub-Index | Name | Size (Bytes) |
|-------------------|-----------|----------------------|------------------------|
| 6600 _h | 00 | Time unit | 4 |
| 6661 _h | 01 to 03 | SBC brake time delay | 2 |
| 2660 _h | 00 | Brake present | 1 |
| 66F0 _h | 01 to 08 | Safety Controlword 1 | 4 (for each sub-index) |
| 66F1 _h | 01 to 08 | Safety Controlword 2 | 4 (for each sub-index) |
| 66F2 _h | 01 to 08 | Safety Controlword 3 | 4 (for each sub-index) |
| 66F3 _h | 01 to 08 | Safety Controlword 4 | 4 (for each sub-index) |
| 66F4 _h | 01 to 08 | Safety Controlword 5 | 4 (for each sub-index) |
| 66F5 _h | 01 to 08 | Safety Controlword 6 | 4 (for each sub-index) |
| 66F6 _h | 01 to 08 | Safety Controlword 7 | 4 (for each sub-index) |
| 66F7 _h | 01 to 08 | Safety Controlword 8 | 4 (for each sub-index) |
| 66F8 _h | 01 to 08 | Safety Statusword 1 | 4 (for each sub-index) |
| 66F9 _h | 01 to 08 | Safety Statusword 2 | 4 (for each sub-index) |
| 66FA _h | 01 to 08 | Safety Statusword 3 | 4 (for each sub-index) |

| | | | |
|-------------------------|----------|--------------------------------|------------------------|
| 66FB_h | 01 to 08 | Safety Statusword 4 | 4 (for each sub-index) |
| 66FC_h | 01 to 08 | Safety Statusword 5 | 4 (for each sub-index) |
| 66FD_h | 01 to 08 | Safety Statusword 6 | 4 (for each sub-index) |
| 66FE_h | 01 to 08 | Safety Statusword 7 | 4 (for each sub-index) |
| 66FF_h | 01 to 08 | Safety Statusword 8 | 4 (for each sub-index) |
| 26F1_h | 01 to 08 | Safety Controlword Safe_in | 4 (for each sub-index) |
| 26F8_h | 01 to 08 | Safety Statusword Safe_out | 4 (for each sub-index) |
| 2624_h | 01 to 08 | Permanent Safety Controlword 1 | 4 (for each sub-index) |
| 2625_h | 01 to 08 | Permanent Safety Controlword 2 | 4 (for each sub-index) |

SLS Signatures

There is a signature for each of the 8 SLS functions.

Signatures are stored in object **6699 0x_h**, with sub-index x corresponding to the SLS configuration number.

The data to be considered are, in order:

| Index | Sub-Index | Name | Size to be considered |
|-------------------------|-----------|--|--|
| 6600_h | 00 | Time unit | 4 bytes |
| 6602_h | 00 | Velocity unit | 4 bytes |
| 6603_h | 00 | Acceleration unit | 4 bytes |
| 6691_h | 01 to 08 | SLS time to velocity monitoring | 2 bytes |
| 6692_h | 01 to 08 | SLS velocity limit u16 | 2 bytes (object does not exist, a null value 0000 _h must be used in the calculation) |
| 6693_h | 01 to 08 | SLS velocity limit u32 | 4 bytes |
| 6694_h | 01 to 08 | SLS time for velocity in limits | 2 bytes |
| 6695_h | 01 to 08 | SLS time delay deceleration monitoring | 2 bytes (object does not exist, a null value 0000 _h must be used in the calculation) |
| 6696_h | 01 to 08 | SLS deceleration limit u16 | 2 bytes (object does not exist, a null value 0000 _h must be used in the calculation) |
| 6697_h | 01 to 08 | SLS deceleration limit u32 | 4 bytes (object does not exist, a null value 0000 0000 _h must be used in the calculation) |
| 6698_h | 01 to 08 | SLS error reactions | 4 bytes |
| 66F0_h | 01 to 08 | Safety Controlword 1 | 4 bytes for each sub-index |
| 66F1_h | 01 to 08 | Safety Controlword 2 | 4 bytes for each sub-index |
| 66F2_h | 01 to 08 | Safety Controlword 3 | 4 bytes for each sub-index |
| 66F3_h | 01 to 08 | Safety Controlword 4 | 4 bytes for each sub-index |
| 66F4_h | 01 to 08 | Safety Controlword 5 | 4 bytes for each sub-index |
| 66F5_h | 01 to 08 | Safety Controlword 6 | 4 bytes for each sub-index |
| 66F6_h | 01 to 08 | Safety Controlword 7 | 4 bytes for each sub-index |
| 66F7_h | 01 to 08 | Safety Controlword 8 | 4 bytes for each sub-index |
| 66F8_h | 01 to 08 | Safety Statusword 1 | 4 bytes for each sub-index |
| 66F9_h | 01 to 08 | Safety Statusword 2 | 4 bytes for each sub-index |
| 66FA_h | 01 to 08 | Safety Statusword 3 | 4 bytes for each sub-index |
| 66FB_h | 01 to 08 | Safety Statusword 4 | 4 bytes for each sub-index |
| 66FC_h | 01 to 08 | Safety Statusword 5 | 4 bytes for each sub-index |

| | | | |
|-------------------------|----------|--------------------------------|----------------------------|
| 66FD_h | 01 to 08 | Safety Statusword 6 | 4 bytes for each sub-index |
| 66FE_h | 01 to 08 | Safety Statusword 7 | 4 bytes for each sub-index |
| 66FF_h | 01 to 08 | Safety Statusword 8 | 4 bytes for each sub-index |
| 26F1_h | 01 to 08 | Safety Controlword Safe_in | 4 bytes for each sub-index |
| 26F8_h | 01 to 08 | Safety Statusword Safe_out | 4 bytes for each sub-index |
| 2624_h | 01 to 08 | Safety Controlword permanent 1 | 4 bytes for each sub-index |
| 2625_h | 01 to 08 | Safety Controlword permanent 2 | 4 bytes for each sub-index |

SLSa Signatures

There is a signature for each of the 8 SLSa functions.

Signatures are stored in object **3058 0x_h**, with sub-index x corresponding to the SLSa configuration number.

The data to be considered are, in order:

| Index | Sub-Index | Name | Size to be considered |
|-------------------------|-----------|---|----------------------------|
| 6600_h | 00 | Time unit | 4 bytes |
| 6602_h | 00 | Velocity unit | 4 bytes |
| 3051_h | 01 to 08 | SLSa time to velocity monitoring | 2 bytes |
| 3052_h | 01 to 08 | SLSa positive velocity limit u32 | 4 bytes |
| 3053_h | 01 to 08 | SLSa time for positive velocity in limits | 2 bytes |
| 3054_h | 01 to 08 | SLSa time to negative velocity monitoring | 2 bytes |
| 3055_h | 01 to 08 | SLSa negative velocity limit u32 | 4 bytes |
| 3056_h | 01 to 08 | SLSa time for negative velocity in limits | 2 bytes |
| 3057_h | 01 to 08 | SLSa error reactions | 4 bytes |
| 66F0_h | 01 to 08 | Safety Controlword 1 | 4 bytes for each sub-index |
| 66F1_h | 01 to 08 | Safety Controlword 2 | 4 bytes for each sub-index |
| 66F2_h | 01 to 08 | Safety Controlword 3 | 4 bytes for each sub-index |
| 66F3_h | 01 to 08 | Safety Controlword 4 | 4 bytes for each sub-index |
| 66F4_h | 01 to 08 | Safety Controlword 5 | 4 bytes for each sub-index |
| 66F5_h | 01 to 08 | Safety Controlword 6 | 4 bytes for each sub-index |
| 66F6_h | 01 to 08 | Safety Controlword 7 | 4 bytes for each sub-index |
| 66F7_h | 01 to 08 | Safety Controlword 8 | 4 bytes for each sub-index |
| 66F8_h | 01 to 08 | Safety Statusword 1 | 4 bytes for each sub-index |
| 66F9_h | 01 to 08 | Safety Statusword 2 | 4 bytes for each sub-index |
| 66FA_h | 01 to 08 | Safety Statusword 3 | 4 bytes for each sub-index |
| 66FB_h | 01 to 08 | Safety Statusword 4 | 4 bytes for each sub-index |
| 66FC_h | 01 to 08 | Safety Statusword 5 | 4 bytes for each sub-index |
| 66FD_h | 01 to 08 | Safety Statusword 6 | 4 bytes for each sub-index |
| 66FE_h | 01 to 08 | Safety Statusword 7 | 4 bytes for each sub-index |
| 66FF_h | 01 to 08 | Safety Statusword 8 | 4 bytes for each sub-index |
| 26F1_h | 01 to 08 | Safety Controlword Safe_in | 4 bytes for each sub-index |
| 26F8_h | 01 to 08 | Safety Statusword Safe_out | 4 bytes for each sub-index |
| 2624_h | 01 to 08 | Safety Controlword permanent 1 | 4 bytes for each sub-index |
| 2625_h | 01 to 08 | Safety Controlword permanent 2 | 4 bytes for each sub-index |

SDI Signatures

There is a signature for each of the 2 SDI functions.

Signatures are stored in object **66D6 0x_n**, the sub-index x corresponding to the SDI configuration number.

The data to be considered are, in order:

| Index | Sub-Index | Name | Size to be considered |
|-------------------|-----------|--------------------------------|----------------------------|
| 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 |
| 66D3 _h | 01 to 02 | SDI position zero window u32 | 4 bytes |
| 66D4 _h | 01 to 02 | SDI velocity zero window u16 | 2 bytes |
| 66D5 _h | 01 to 02 | SDI velocity zero window u32 | 4 bytes |
| 66F0 _h | 01 to 08 | Safety Controlword 1 | 4 bytes for each sub-index |
| 66F1 _h | 01 to 08 | Safety Controlword 2 | 4 bytes for each sub-index |
| 66F2 _h | 01 to 08 | Safety Controlword 3 | 4 bytes for each sub-index |
| 66F3 _h | 01 to 08 | Safety Controlword 4 | 4 bytes for each sub-index |
| 66F4 _h | 01 to 08 | Safety Controlword 5 | 4 bytes for each sub-index |
| 66F5 _h | 01 to 08 | Safety Controlword 6 | 4 bytes for each sub-index |
| 66F6 _h | 01 to 08 | Safety Controlword 7 | 4 bytes for each sub-index |
| 66F7 _h | 01 to 08 | Safety Controlword 8 | 4 bytes for each sub-index |
| 66F8 _h | 01 to 08 | Safety Statusword 1 | 4 bytes for each sub-index |
| 66F9 _h | 01 to 08 | Safety Statusword 2 | 4 bytes for each sub-index |
| 66FA _h | 01 to 08 | Safety Statusword 3 | 4 bytes for each sub-index |
| 66FB _h | 01 to 08 | Safety Statusword 4 | 4 bytes for each sub-index |
| 66FC _h | 01 to 08 | Safety Statusword 5 | 4 bytes for each sub-index |
| 66FD _h | 01 to 08 | Safety Statusword 6 | 4 bytes for each sub-index |
| 66FE _h | 01 to 08 | Safety Statusword 7 | 4 bytes for each sub-index |
| 66FF _h | 01 to 08 | Safety Statusword 8 | 4 bytes for each sub-index |
| 26F1 _h | 01 to 08 | Safety Controlword Safe_in | 4 bytes for each sub-index |
| 26F8 _h | 01 to 08 | Safety Statusword Safe_out | 4 bytes for each sub-index |
| 2624 _h | 01 to 08 | Safety Controlword permanent 1 | 4 bytes for each sub-index |
| 2625 _h | 01 to 08 | Safety Controlword permanent 2 | 4 bytes for each sub-index |

SMS Signature

There is a signature for the SMS function.

The signature is stored in object **66AE 01_h**.

The data to be considered are, in order:

| Index | Sous-Index | Nom | Taille à prendre en compte |
|-------------------|------------|-----------------------------------|---|
| 6602 _h | 00 | Velocity unit | 4 octets |
| 66A9 _h | 01 | SMS velocity maximum positive u16 | 2 octets (objet inexistant, une valeur nulle 0000 _h doit être utilisée dans le calcul) |
| 66AA _h | 01 | SMS velocity maximum positive u32 | 4 octets |
| 66AB _h | 01 | SMS velocity maximum negative u16 | 2 octets (objet inexistant, une valeur nulle 0000 _h doit être utilisée dans le calcul) |

| | | | |
|--------------|----------|-----------------------------------|----------------------------|
| 66ACh | 01 | SMS velocity maximum negative u32 | 4 bytes |
| 66ADh | 01 | SMS error reactions | 4 bytes |
| 66F0h | 01 to 08 | Safety Controlword 1 | 4 bytes for each sub-index |
| 66F1h | 01 to 08 | Safety Controlword 2 | 4 bytes for each sub-index |
| 66F2h | 01 to 08 | Safety Controlword 3 | 4 bytes for each sub-index |
| 66F3h | 01 to 08 | Safety Controlword 4 | 4 bytes for each sub-index |
| 66F4h | 01 to 08 | Safety Controlword 5 | 4 bytes for each sub-index |
| 66F5h | 01 to 08 | Safety Controlword 6 | 4 bytes for each sub-index |
| 66F6h | 01 to 08 | Safety Controlword 7 | 4 bytes for each sub-index |
| 66F7h | 01 to 08 | Safety Controlword 8 | 4 bytes for each sub-index |
| 66F8h | 01 to 08 | Safety Statusword 1 | 4 bytes for each sub-index |
| 66F9h | 01 to 08 | Safety Statusword 2 | 4 bytes for each sub-index |
| 66FAh | 01 to 08 | Safety Statusword 3 | 4 bytes for each sub-index |
| 66FBh | 01 to 08 | Safety Statusword 4 | 4 bytes for each sub-index |
| 66FCh | 01 to 08 | Safety Statusword 5 | 4 bytes for each sub-index |
| 66FDh | 01 to 08 | Safety Statusword 6 | 4 bytes for each sub-index |
| 66FEh | 01 to 08 | Safety Statusword 7 | 4 bytes for each sub-index |
| 66FFh | 01 to 08 | Safety Statusword 8 | 4 bytes for each sub-index |
| 26F1h | 01 to 08 | Safety Controlword Safe_in | 4 bytes for each sub-index |
| 26F8h | 01 to 08 | Safety Statusword Safe_out | 4 bytes for each sub-index |
| 2624h | 01 to 08 | Safety Controlword permanent 1 | 4 bytes for each sub-index |
| 2625h | 01 to 08 | Safety Controlword permanent 2 | 4 bytes for each sub-index |

11.9. Periodic checks

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

The need for and frequency of this check must be indicated in the documentation for the machine or equipment incorporating a safety drive from the SWD® range.

The check verifies the ability of the safety functions to perform the associated safety function.

The frequency of testing depends on the safety level of the function. The test should be carried out once a year for SIL2 functions and once a month for the STO SIL3 function.

11.10. CANopen safety - SRDO

Engineers implementing this Part shall provide a safety manual containing at least the following information:

- a) The safety manual must inform users of the constraints involved in calculating the system's characteristics (see 9.4);
- b) The safety manual must inform users of their responsibilities regarding the correct configuration of the devices (6.4);
- c) The safety manual should include advice on calculating the maximum expected response time of the network.

Constraints linked to the calculation of system characteristics

SRDO Number

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

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

Calculations used to determine the residual probability of error of the SRDO.

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

The worst-case residual error probability for ADC according to [17], [18] and [19] is given in (4). This worst-case 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-case residual error probability is squared in accordance with GS-ET-26 for the use of Model III (see A.4) as shown in (5). Other models may be used but it must be demonstrated that the following formula is still valid.

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

- i** 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.
- i** 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 security.

User responsibilities

SRDOs are configured under the responsibility of the user, who is responsible for configuring the product to meet the needs of the application.

Reaction time

The Safety Function Response Time (SFRT) represents the worst-case time from an SR event, considered as an input to the system or as a fault within the system, until the system is in the safe state. To determine the worst-case SFRT of any SR control loop, the user must sum all the worst-case safety reaction times of each subsystem of the SR control loop (see definitions in EN 61784-3). An example of the range of reaction times is shown below:

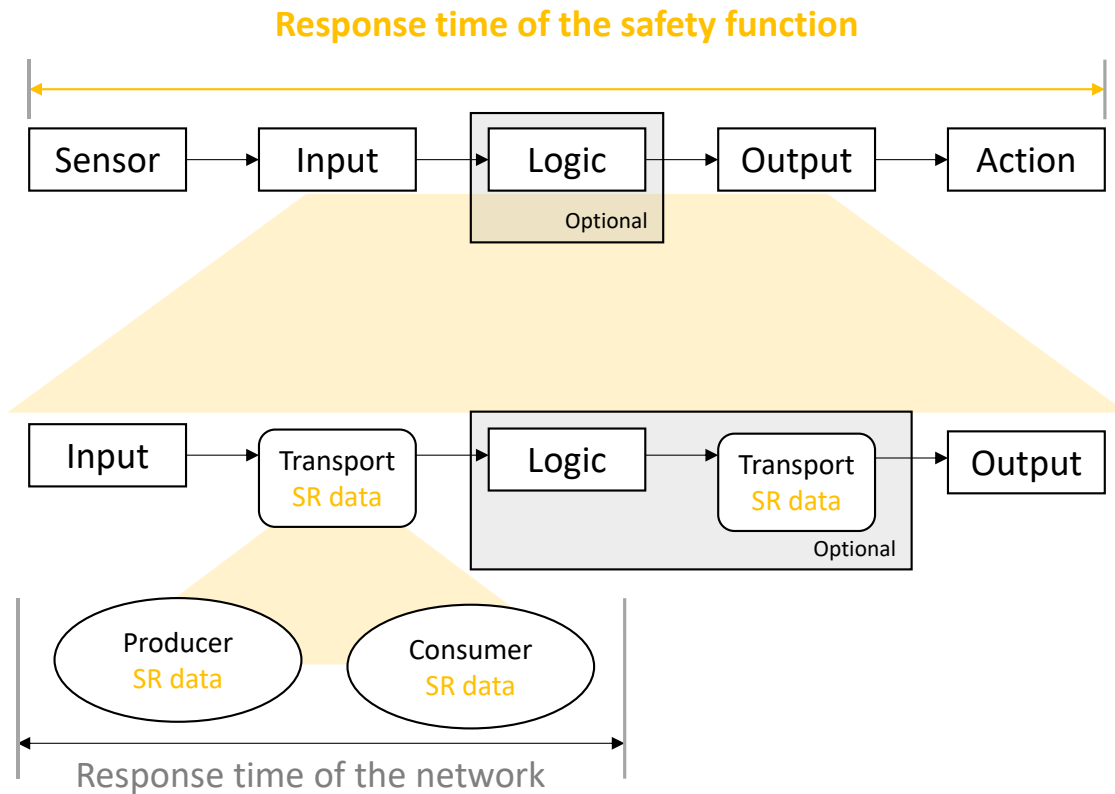


Figure 45 – example of the range of reaction times

Example:

The SFRT shown in the previous figure comprises the following elements:

- Detector response 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

The SFRT is then the sum of the worst-case reaction times mentioned above:

- + worst-case detector reaction time
 - + worst-case input reaction time
 - + worst-case network's reaction time
 - + worst-case manager's reaction time
 - + worst-case network response time
 - + worst-case output reaction time
 - + worst-case actuator response time
 - + worst-case time difference of a failed subsystem when the safety function is triggered
- = safety function response time**

Information & contact

For more information on SWD® technology and ez-Wheel:

| | |
|---|---|
|  | https://github.com/ezWheelSAS |
|  | https://ez-wheel.com/en |



ez-Wheel SAS

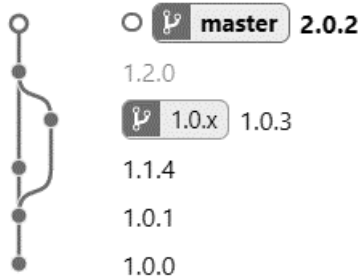
Moulin de l'Abbaye, 135 route de Bordeaux
16400 La Couronne – France

Phone: +33 (0)5 31 61 55 80

Appendices

- **Versions overview**
- **Release notes**
- **SWD® - Quick start**

Versions overview



| Version 'Firmware' | Release date | Content |
|--------------------|----------------|--|
| 2.0.2 | September 2023 | - Add safety fuctions SMS, SLSa, SBC et SBU |
| 1.2.0 | March 2023 | <ul style="list-style-type: none"> - Improve motor control - Support LSS protocol (NodeID, Baudrate) - Add TPDO revealing Safety commands states (STO, SDI, SLS, ...) - Speed measurement from 1 RPM |
| 1.1.4 | October 2022 | <ul style="list-style-type: none"> - Electronic protection in case of towing - Firmware update availbale with GUI - Implementation of SRDO 10 (Sending safety position and safety speed) |
| 1.0.3 | Decembre 2022 | <ul style="list-style-type: none"> - Improve speed information - Improve motor calibration |
| 1.0.1 | March 2022 | - 1 st release of SWD® |
| 1.0.0 | - | |

Release notes

Release note 'Firmware 1.0.3'

Implementation of improved motor calibration and, consequently, improved symmetry of motor behaviour. The motor control considers geometric variations in the position of the magnets on the rotor.

A new calculation method provides motor speed data with less noise. This data is available in the 'od_velocity_actual_value' CANopen object. It gives a smoother motor speed, making it more stable over a given time.

Release note 'Firmware 1.1.4'

Incorporation of an overvoltage protection mechanism. These are likely to occur when the motor is driven by an external means. And when a power source used to store energy is no longer connected or no longer accepts input current. Or when an overheated motor is detected.

This protection deactivates internal braking by short-circuiting the motor phases when the system is no longer powered, or when a fault is detected on the power supply. As a result, the motor will not apply internal braking in the event of a loss of power, detection of an internal overtemperature or detection of an external drive.

- ⚠ Warning: this modification removes braking on battery disconnection. An impact analysis is required in the machine risk analysis before using this update.
- ⚠ Drive from the outside is not recommended, for example when towing the system.

A mechanism for checking software and hardware compatibility has been added. This means that when a software version is updated, the version of electronic board used is checked. This also ensures that the update runs smoothly.

- ⚠ A compatibility or integrity error makes it impossible to use the **SWD®**. A new update will then be required.
- ⚠ For software updates, **SWD® Bootloader GUI** application must be used.

Safe speed and position information is now available in a CANopen Safety message. This information is sent in the SRDO 10 issued by the **SWD®**.

Release note 'Firmware 1.2.0'

Version 1.2.0 includes improved engine control:

- The integral action of the PID controller is given an "anti-windup" action to limit saturation of the integral action. The time constant can be set via the "motctrl_speed_pid_tw" CANopen object.
- - The derivative action of the PID controller incorporates a low-pass filter with a time constant that can be set from the "od_motctrl_speed_pid_tn" CANopen object. The gain of the derivative action is now considered and can be set from the "od_motctrl_speed_pid_d" CANopen object.
- The minimum speed setpoint is lowered to 5 rpm-1 motor (before gear reduction)

An improvement in speed measurements, with a speed that can be measured at up to 1 rpm (before gear reduction).

Implementation of the Layer Settings Service (LSS) protocol, in accordance with the CiA-305 standard. This service enables the Baudrate and NodeID of a CANopen node to be configured. Each node can be individually addressed using the parameters in its "Identity Object". This object contains the node's serial number. This method allows

a node to be configured without knowing its NodeID, or if several nodes connected to the CANopen bus have the same NodeID.

The addition of objects that can be used to find out the status of safety function commands. The "safety_function_output_1" and "safety_function_output_2" objects indicate whether a request to activate a safety function is in progress. If this is the case, the bit corresponding to the safety function is set to 1b. These objects are read-only and can be transmitted in a TPDO.

| Safety_function_output_1 | | | | | | | | | | | | | | | | |
|--------------------------|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|--------|--------|--------|
| Bit | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| Safety Function | STO | SBC_1 | SBC_2 | SBC_3 | SLS_1 | SLS_2 | SLS_3 | SLS_4 | SLS_5 | SLS_6 | SLS_7 | SLS_8 | SDIP_1 | SDIP_2 | SDIN_1 | SDIN_2 |

Bit = 0 → Safety Function command deactivated

Bit = 1 → Safety Function command activated

| Safety_function_output_2 | | | | | | | | | | | | | | | | |
|--------------------------|-----------|-------------|----------|---|---|---|---|---|---|---|----|----|----|----|----|----|
| Bit | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| Safety Function | ERROR_ACK | RESTART_ACK | Not used | | | | | | | | | | | | | |

Bit = 0 → Safety Function command deactivated

Bit = 1 → Safety Function command activated

The 'Hardware' and 'Firmware' versions and the commercial designation of the product are available in the CANopen dictionary objects, 'Hardware version', 'Software version' and 'Product ID'.

A fix for version 'Firmware 1.1.4' which caused the motor to enter a 'Fault' state when an external brake was connected.

Release note 'Firmware 2.0.2'

SMS, SLSa, SBC and SBU safety functions added.

SMS

The SMS safety function allows an overall speed limit to be imposed on the engine. The maximum forward and reverse speed can be set independently via two separate thresholds.

Depending on the configuration, the SMS can limit the motor speed to the thresholds or trigger an STO if a threshold is exceeded.

SLSa

The SLSa uses the same operating principle as the SLS but allows the thresholds for forward and reverse travel to be set independently.

SBC

It is now possible to configure motor braking via the SBC function.

4 modes are available:

- SBC NONE: freewheel
- SBC 1: application of the internal brake and the external brake
- SBC 2: application of the external brake only
- SBC 3: internal brake only

The availability of these modes depends on the object 2660_h 'brake_present':

- If an external brake is present: SBC NONE, SBC 1, or SBC 2
- If no external brake is present: SBC NONE or SBC 3.

Braking can be activated during an STO by configuring object 6643_h 'STO activate SBC'.

It is also possible to activate an SBC function on demand, via a controlword.

SBU

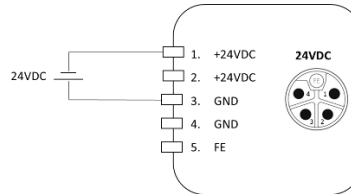
The SBU function enables the motor brakes to be disengaged for maintenance operations. This function can be activated via a controlword. Its activation is limited to the PDS states SWITCHED_ON_DISABLED and READY_TO_SWITCH_ON.

SWD® - Quick start

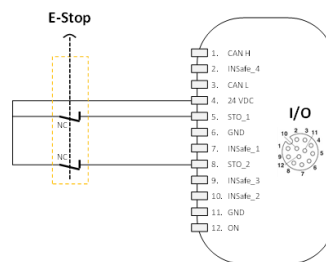
SWD® standalone without load

Hardware set-up:

1. Connect the power to the SWD® (~5A max. required):

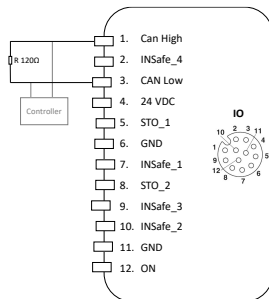


2. Connect SWD®'s STO inputs to 24V:

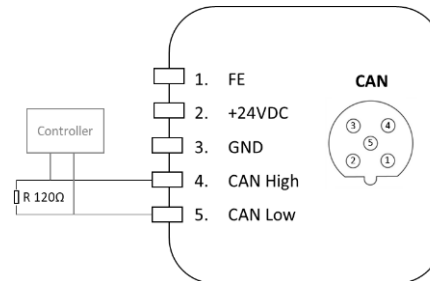


3. Connect you controller to the CAN bus

Either on SWD® IO connector:



Or on dedicated SWD® CAN connector:



You can add a resistor to avoid a passive bus in you don't have an internal resistor on your controller.

A configurable internal resistor is integrated within SWD® between CAN High and CAN Low.

Default CANopen bus parameters

- Node-ID = 0x10
- Baudrate = 1.000 kbits/s

If you need to change those parameters, report to the section CAN bus and CANopen protocol of the manual.

CANopen set-up:

4. Disable SRDO1 (RX), or send the safety message, i.e. SRDO1:

| Disable reception of SRDO1 on SWD®: | Or send the SRDO1 to the SWD® | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--|-------------------------------|-----------------------------|------|------|----|-----------------------------|--------|--------|------|------|----|-----------------------------|--------|--------|------|------|----|-----------------------------|---|--------|--------|------|------|----|-----|------|----|-----|
| <p>Set SRDO1 field direction 0x1301:01 to: Value = 0x00</p> <table border="1"> <thead> <tr> <th>CAN-ID</th> <th>Length</th> <th>Data</th> </tr> </thead> <tbody> <tr> <td>610h</td> <td>8h</td> <td>2F 01 13 01 00 00 00 00h</td> </tr> </tbody> </table> <p>Update SRDO1 safety signature 0x13FF:01 to: Value = 0xBABD</p> <table border="1"> <thead> <tr> <th>CAN-ID</th> <th>Length</th> <th>Data</th> </tr> </thead> <tbody> <tr> <td>610h</td> <td>8h</td> <td>2B FF 13 01 BD BA 00 00h</td> </tr> </tbody> </table> <p>Set SWD® safety configuration to valid by setting object 0x13FE:00 to: Value = 0xA5</p> <table border="1"> <thead> <tr> <th>CAN-ID</th> <th>Length</th> <th>Data</th> </tr> </thead> <tbody> <tr> <td>610h</td> <td>8h</td> <td>2F FE 13 00 A5 00 00 00h</td> </tr> </tbody> </table> | CAN-ID | Length | Data | 610h | 8h | 2F 01 13 01 00 00 00 00h | CAN-ID | Length | Data | 610h | 8h | 2B FF 13 01 BD BA 00 00h | CAN-ID | Length | Data | 610h | 8h | 2F FE 13 00 A5 00 00 00h | <p>Send the safety message on bus can with the following parameters:</p> <table border="1"> <thead> <tr> <th>CAN-ID</th> <th>Length</th> <th>Data</th> </tr> </thead> <tbody> <tr> <td>11Fh</td> <td>1h</td> <td>FFh</td> </tr> <tr> <td>120h</td> <td>1h</td> <td>00h</td> </tr> </tbody> </table> | CAN-ID | Length | Data | 11Fh | 1h | FFh | 120h | 1h | 00h |
| CAN-ID | Length | Data | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 610h | 8h | 2F 01 13 01 00 00 00 00h | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CAN-ID | Length | Data | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 610h | 8h | 2B FF 13 01 BD BA 00 00h | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CAN-ID | Length | Data | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 610h | 8h | 2F FE 13 00 A5 00 00 00h | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CAN-ID | Length | Data | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11Fh | 1h | FFh | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 120h | 1h | 00h | | | | | | | | | | | | | | | | | | | | | | | | | | |

5. Save configuration (*optional*)

Set the object 'Store Parameters', sub-object 'Save all Parameters' 1010:01h to value = 0x65 76 61 73. So that, the configuration will be saved after On-Off³⁹.

| CAN-ID | Length | Data |
|--------|--------|--------------------------|
| 610h | 8h | 23 10 10 01 73 61 76 65h |

Start NMT and PDS state machine.

Can be made in 2 different ways:

- **Method A: Use your own controller (e.g. PLC) > from point 6.a to point 8.a**
- **Method B: Use an IPC with swd-services Debian package > from point 6.b to point 10.b**

³⁹ Cf. Store and restore configurations

Method A: Use your own controller (e.g. PLC)

6.a Start CANopen node:

| Send NMT start to SWD node (0x10): | | | Or Broadcast NMT start to all nodes: | | |
|------------------------------------|----------------|--------------------|--------------------------------------|----------------|--------------------|
| CAN-ID | Length | Data | CAN-ID | Length | Data |
| 000 _h | 2 _h | 01 10 _h | 000 _h | 2 _h | 01 00 _h |

NB: SWD® CAN led should be solid green. SWD® heartbeat (CAN-ID 0x710_h) should display value 05_h

7.a Enable Power Drive System FSA⁴⁰, by sending relevant commands.

The 'Controlword' object 0x6040:00, is used for controlling the drive.

The 'Statusword' object 0x6041:00, is used to observe its state.

| Statusword value | State | Command | Controlword value: |
|--|--------------------------|-------------------------------|--------------------|
| 00 28 _h 00 08 _h | Fault | 'Reset Fault' (If necessary): | 00 80 _h |
| 00 40 _h 00 60 _h | Switch on disabled | Go to 'Ready to switch on' | 00 06 _h |
| 00 21 _h | Ready to switch on | Go to 'Switched on' | 00 07 _h |
| 00 23 _h | Switched on | Go to 'Operation enabled' | 00 0F _h |
| 00 27_h | Operation enabled | | |
| 00 07 _h | Quick stop | Go to 'Operation enabled' | 00 0F _h |

NB: SWD® Status led should be solid green. If it is red, a STO is activated. Release the emergency stop or check your STO wiring.

SDO request Statusword value:

| | CAN-ID | Length | Data |
|----------|------------------|----------------|---|
| Request | 610 _h | 8 _h | 40 41 60 00 00 00 00 00 _h |
| Response | 590 _h | 8 _h | 4B 41 60 00 XX 00 00 00 _h |

Where '**XX**' represents the first 8-bits value of the Statusword.

SDO write controlword object:

| Command | CAN-ID | Length | Data |
|----------------------------|------------------|----------------|--------------------------------------|
| 'Reset Fault' | 610 _h | 8 _h | 2B 40 60 00 80 00 00 00 _h |
| Go to 'Ready to switch on' | 610 _h | 8 _h | 2B 40 60 00 06 00 00 00 _h |
| Go to 'Switched on' | 610 _h | 8 _h | 2B 40 60 00 07 00 00 00 _h |
| Go to 'Operation enabled' | 610 _h | 8 _h | 2B 40 60 00 0F 00 00 00 _h |
| Halt | 610 _h | 8 _h | 2B 40 60 00 40 00 00 00 _h |

8.a Send velocity commands:

Write the desired target velocity in 0x6042:00 'vl_target_velocity':

| Speed (RPM on motor shaft) | CAN-ID | Length | Data |
|---------------------------------------|------------------|----------------|--------------------------------------|
| 012A _h = 298 _d | 610 _h | 8 _h | 2B 42 60 00 2A 01 00 00 _h |
| FED6 _h = -298 _d | 610 _h | 8 _h | 2B 42 60 00 D6 FE FF FF _h |
| 0578 _h = 1400 _d | 610 _h | 8 _h | 2B 42 60 00 78 05 00 00 _h |
| FA88 _h = 1400 _d | 610 _h | 8 _h | 2B 42 60 00 88 FA FF FF _h |

⁴⁰ Cf. CiA 402 *State machine*

Method B: Use an IPC with [swd-services](#) Debian package.

6.b Install the package, following the installation guide on our GitHub page :

<https://github.com/ezWheelSAS/swd-services/blob/main/docs/md/installation.md>

7.b Start using it, following the usage guide on our GitHub page:

<https://github.com/ezWheelSAS/swd-services/blob/main/docs/md/usage.md>

NB: You can create a symbolic link of the remote script in your home directory “~” (*Optional*):

```
In -s /opt/ezw/usr/sbin/remote.py ~
```

8.b Start the remote in a new terminal:

```
~/remote.py smc_drive
```

Keyboard commands are listed at the end.

NB: For further information, see our GitHub: <https://github.com/ezWheelSAS/>.