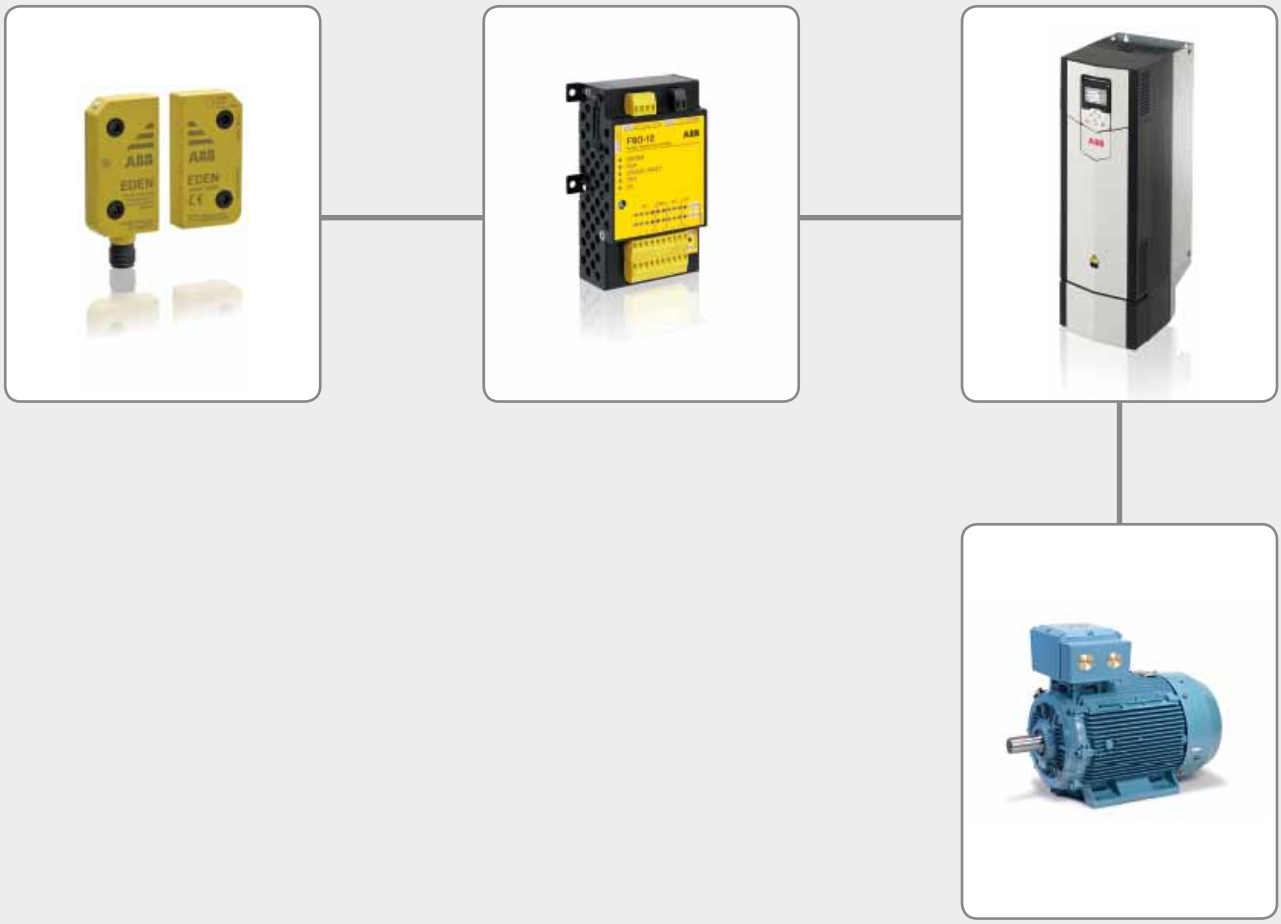
Technical description
How to implement an encoderless safely-limited speed function, with an ACS880-01 and the safety functions module



This document presents details how a safely-limited speed (SLS) safety function can be designed and implemented using an ACS880-01 drive and a safety functions module together with other ABB safety devices. The safety function is implemented according to EN/IEC 62061, EN ISO 13849-1, EN/IEC 60204-1 and EN/IEC 61800-5-2 machinery standards. Necessary SIL/PL calculations are presented using ABB's Functional safety design tool.

Safer machines with drive-based functional safety

Drive-based safety functions are used in applications that require risk reduction from eg. unexpected and hazardous movement. The aim is to design machines that are safe to use. This safety function example can be implemented with ACS880 series drives only.

ACS880-01 industrial drives, together with the safety functions module, provides an encoderless safely-limited speed (SLS) safety function. The function ensures that the speed of the motor does not exceed a specified limit while allowing machine interaction to be performed eg. at slow speed without stopping the drive. The SLS function is pre-programmed in the safety functions module. Only application specific parameter configuration is necessary to commission the function in addition to electrical connections.

ACS880-01 R5 drive

Eden OSSD non-contact safety sensor

Safety functions module, FSO-12

Effective and reliable encoderless safely-limited speed function for drive applications

Encoderless safely-limited speed function details	
Requirements according to EN/IEC 60204-1 and EN/IEC 61800-5-2	**Safely-limited speed (SLS)** The SLS function prevents the motor from exceeding the specified speed limit.
Safety integrity level	SIL 3 (EN/IEC 62061), PL e (EN ISO 13849-1)

Overview of the safety function

The SLS function (Figure 1) ensures that the motor speed does not exceed a specified speed limit. In ABB drive solutions, the SLS function can automatically decelerate the motor speed below the defined speed limit when SLS is activated. Both time delay and ramp monitoring can be used during the deceleration. The SLS function is suitable for ensuring that machine runs safely at the defined speed and that it does not accelerate during eg. maintenance or cleaning operations.

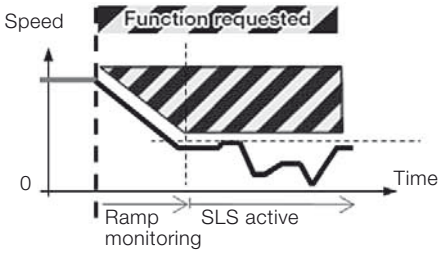


Figure 1: Safely-limited speed safety function using the ramp monitoring method.

Design of the safety function

The design of the encoderless safely-limited speed (SLS) function consists of an Eden non-contact safety sensor as an activating switch, the safety functions module and a safe torque off (STO) -circuit inside the ACS880-01 drive as an actuator to stop the drive if the speed of the motor exceeds the specified speed limit. There is no need for a separate encoder when the safety functions module is used (only for applications that do not have active loads). See circuit diagram (Figure 2) for connection details.

Operation of the safety function

When the Eden sensor is activated, the safety functions module detects the sensor signal and activates the SLS function. If the motor speed is higher than the specified SLS speed limit at the time SLS is activated, the drive decelerates the motor speed first below the SLS speed limit, while the safety functions module monitors the transition ramp. When the motor speed is below the SLS speed limit, the module begins monitoring the SLS to ensure that the motor speed does not exceed the specified level. Monitoring will continue until the SLS function is deactivated.

Returning the Eden sensor to the standby position deactivates the SLS function. The drive system will automatically resume operation or it will be reset manually, depending on the application requirements. If SLS trips (activates STO due to overspeed), a manual reset is required.

Ensuring the required safety performance

The safety function has to fulfil the required safety performance determined by a risk assessment. ABB's Functional safety design tool (FSDT-01) is used to design the desired safety function. This is carried out according to the following steps:

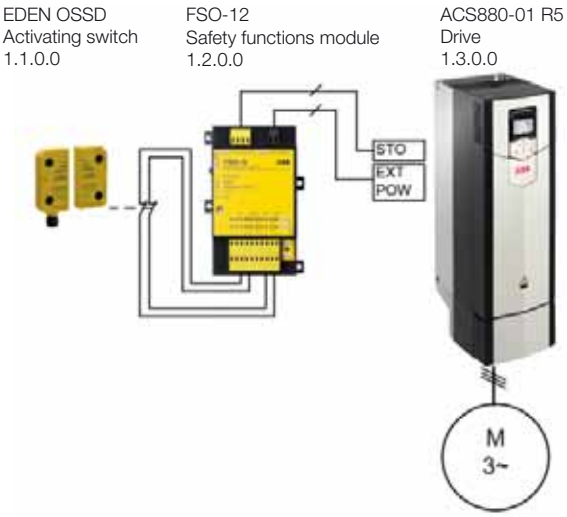
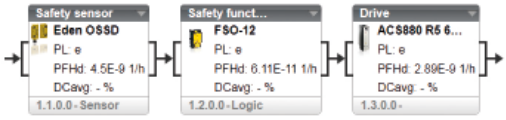


Figure 2: Connection example of the encoderless safely-limited speed (SLS) function with ACS880-01 drive.



Properties of: Safely-limited speed with FSO-12

Target PL: e Current PL: e Total PFHd: 7.45E-9 1/h

Breakdown by subsystems:

Component ID	Name	PL	PFHd	Cat	MTTFd	DCavg	Contribution to total PFHd	Lifetime
1.1.0.0	Safety sensor	e	4.5E-9 1/h	4	-	-	60.39 %	20 years
1.2.0.0	Safety functions module	e	6.11E-11 1/h	3	-	-	0.82 %	20 years
1.3.0.0	Drive	e	2.89E-9 1/h	3	-	-	38.79 %	20 years

Figure 3: Safety calculation and design for the SLS safety function according to EN ISO 13849-1 (can also be made according to EN/IEC 62061). The design is made with the Functional safety design tool.

1. **Evaluate the risks** to establish target safety performance (SIL/PL level) for the safety function.

2. **Design** the safety function loop and **verify** the achieved performance level (PL) or safety integrity level (SIL) for the safety function loop (according to EN ISO 13849-1 or EN/IEC 62061, respectively), utilizing the device safety data and the application specific characteristics.

3. **Generate the report** for the machine documentation. The report should contain all the calculation results as well as all assumptions made during the application design.

Figure 3 shows the design of the encoderless safely-limited speed safety function with the ACS880-01 drive. The function in this document achieves PL e (SIL 3). Safety calculation is made using the default safety data available for the safety devices.

Safety function verification and validation

In addition to the safety calculations for the achieved safety performance (SIL/PL), the safety function needs to be functionally verified as well.

Finally, the implemented safety function is validated against the risk assessment to ensure that the implemented safety function actually reduces the targeted risk.

General considerations

Achieving machinery safety requires a systematic approach beyond the physical implementation of a safety function. The overall machinery safety generally covers the following areas:

- **Planning** for and managing functional safety during the lifecycle of the machine
- **Assuring compliance** to local laws and requirements (such as the Machinery directive/CE marking)
- **Assessing machine risks** (analysis and evaluation)
- **Planning the risk reduction** and establishing safety requirements
- **Designing** the safety functions
- **Implementing and verifying** the safety functions
- **Validating** the safety functions
- **Documenting** the implemented functions and results of risk assessment, verification and validation

For more information concerning functional safety and the Functional safety design tool, see **www.abb.com/safety** and ABB's Technical Guide no. 10.

Abbreviations

Abbr.	Reference	Description
DC_{avg}	EN ISO 13849-1	Diagnostic coverage
$MTTF_d$	EN ISO 13849-1	Mean time to dangerous failure
PFH_d	EN/IEC 62061	Probability of dangerous failures per hour
PL	EN ISO 13849-1	Performance level: corresponds to SIL, Levels a-e
SIL	EN/IEC 62061	Safety integrity level

Note: This is an indicative example. Relevant installation, design and safety calculations need to be specifically completed for each system implementation according to machinery safety standards (EN/IEC 62061, EN ISO 13849-1, EN/IEC 60204-1 and EN/IEC 61800-5-2). ABB does not take any responsibility of the accuracy of the data used in this document and reserves right to make changes without further notice. For detailed safety function implementation please contact your local ABB representative.

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Drive-based functional
safety web page

3AUA0000172917 REV A EN 14.1.2015 #17364

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