

SIEMENS



## Safety Integrated for Drives and Motion Control

Standard and safety technology in one system

Brochure

Edition  
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Answers for industry.

# Safety Integrated in automation and drive technology

Today, machines and systems are becoming increasingly flexible and productive. Nevertheless, the machines must satisfy the safety requirements of the respective country and they must not pose risks to the operating personnel.

Conventional safety technology is at its limits here. With integrated safety technology, you can satisfy today's requirements. With integrated safety functions, entirely new safety concepts can be cost-effectively implemented thanks to the short response times and the low wiring complexity. This means that safety and productivity can both be increased at the same time. Siemens offers a comprehensive range of products for this, which can be used to create a coherent overall concept for safety.

Integrated safety technology from Siemens is characterized by:

- An extensive range of products, from safety sensors, switching devices, controllers and communication to drive technology, all from a single source
- Integration of safety technology into the standard automation and drive technology
- Uniform engineering as well as
- Reliable communication via standard fieldbus systems

## Benefits

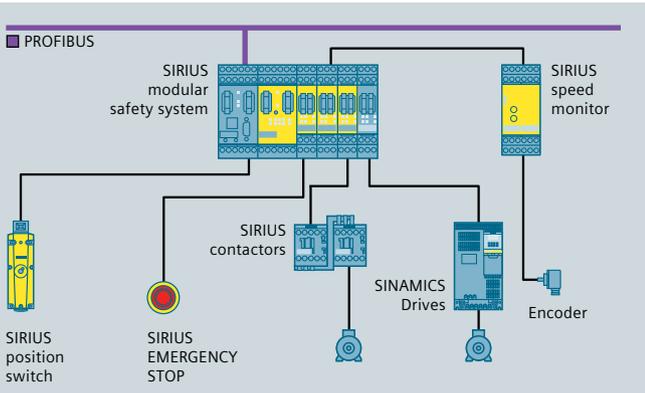
- **Highly effective safety:**  
integrated, from the sensor and evaluation unit all the way to the actuator
- **Extremely cost-effective:**  
thanks to reduced hardware and installation costs
- **Easy system coupling:**  
by means of safety-related communication via standard fieldbuses
- **Effective and fast diagnostics:**  
for a high level of availability of machines and plants
- Products, systems, solutions, and service:  
everything from a single source
- **Increased productivity:**
  - Fast troubleshooting and comprehensive diagnostics functions reduce downtimes
  - The products are certified according to the applicable safety standards (see tables on pages 20 to 22)
  - Rapid restart of systems after operator interventions

Detect safely	Evaluate safely	Respond safely
 <ul style="list-style-type: none"> <li>■ SIRIUS position switches</li> <li>■ SIRIUS signaling columns</li> <li>■ SIRIUS EMERGENCY STOP pushbutton</li> <li>■ SIRIUS standstill monitor</li> <li>■ ASIsafe modules</li> </ul>	 <ul style="list-style-type: none"> <li>■ SIRIUS safety relays</li> <li>■ SIRIUS MSS modular safety system</li> <li>■ ASIsafe safety monitor</li> <li>■ SIMATIC fail-safe controllers</li> <li>■ SIMATIC fail-safe I/Os</li> <li>■ ET 200</li> <li>■ SINUMERIK 840D sl</li> <li>■ SINUMERIK 828D</li> </ul>	 <ul style="list-style-type: none"> <li>■ SIRIUS contactors</li> <li>■ SIRIUS motor starters</li> <li>■ SIRIUS compact starters</li> <li>■ SINAMICS G110D/G120/G120D/G130/G150</li> <li>■ SINAMICS S110</li> <li>■ SINAMICS S120/S150</li> </ul>
<h3 style="text-align: center;">Communicate safely</h3> <ul style="list-style-type: none"> <li>■ PROFIBUS and PROFINET with PROFIsafe (PROFINET also wireless), AS-interface with ASIsafe</li> </ul>		

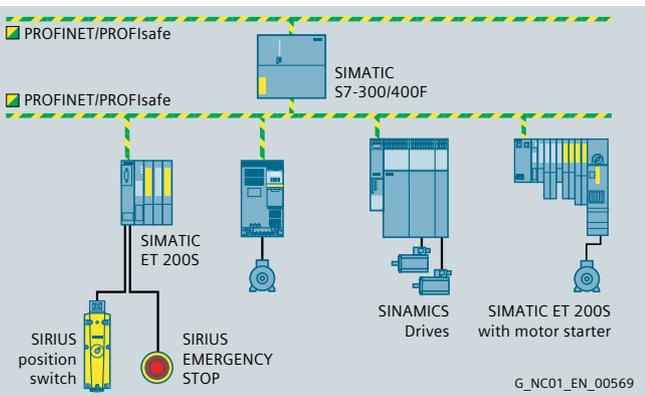
# Safety Integrated

## Customized safety solutions for any automation task

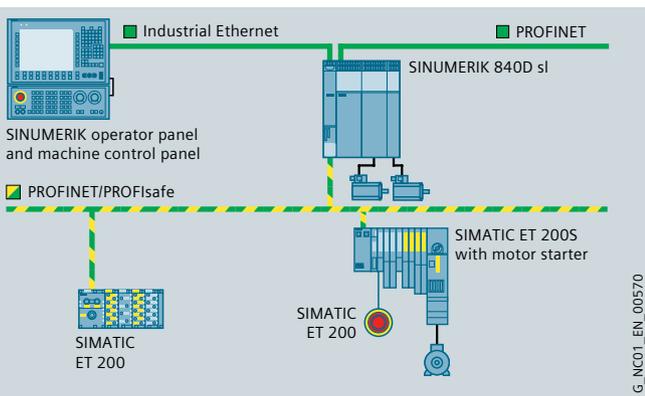
With its range of safety components, Siemens is able to offer a customized safety solution for almost any application: this includes both stand-alone solutions in simple automation tasks and integrated solutions with a higher-level controller in comprehensive automation applications.



Stand-alone solution



Integrated safety solution with SIMATIC



Integrated safety solution with SINUMERIK

### Stand-alone safety solutions for small to medium-sized automation tasks

For small automation solutions, it is often sufficient to hardwire a limited number of safety-related components to an evaluation unit. To do this, you can use either the SIRIUS 3SK1 safety relays or a modular SIRIUS 3RK3 safety system. The SIRIUS 3TK28 with special functions such as downtime or speed monitoring can be used for monitoring applications with drives without safety functions. For an extensive plant, the AS-i safety monitor is suitable for the evaluation of safety-related signals via an AS-interface.

### Integrated safety solutions for production automation with SIMATIC

The SIMATIC automation system plays a central role in processing and coordinating safety-related processes in industrial automation and it is now the standard in many instances. The Safety Integrated portfolio is harmonized along these lines so that applications can be integrally designed: A SIMATIC system operates without any problems in conjunction with the drive technology (SINAMICS, SIMATIC ET 200), low-voltage controls and distribution (SIRIUS), and sensors from Siemens. Communication is established via PROFIBUS or PROFINET using the PROFIsafe standard.

### Integrated safety solutions for machine tools with SINUMERIK

The integrated safety functions of SINUMERIK Safety Integrated are used in the machine tools sector. They are redundantly integrated in NC<sup>1)</sup>, the drive and the internal PLC and are used to monitor speed, standstill, and position. Such monitoring is necessary if the danger zone of the machines and systems is not blocked off. However, even in test mode or production mode, it provides effective operator protection as well as protection of tools, materials, and machines.

<sup>1)</sup> NC: Numerical Control

*In machines and systems, automated movements present huge potential risks. For this reason, drives always play a central role in safety solutions, regardless of the complexity of an automation task. Siemens drives are designed in such a way that they can be easily integrated into any of the safety solutions shown. With their integrated safety functions, they provide the basis for implementing highly effective safety concepts.*

# Advantages of drive-integrated safety functions

Electrically driven assemblies and machine components often pose a huge potential risk. Rotating units such as saws, rollers, and spindles can cause serious or even fatal injuries. The same applies to machine units that have a linear motion such as handling axes and machine slides. The measures for guaranteeing the safety of the operating personnel are governed by country-specific regulations.

When drives without integrated safety technology are used, operator protection was previously implemented through the use of additional hardware components such as contactors and safety relays, and interlock circuits. In danger situations, the systems are shut down and have to be restarted later. This sometimes leads to long downtimes and has a negative impact on productivity. In the worst case scenario, the operator is tempted to manipulate the safety devices.

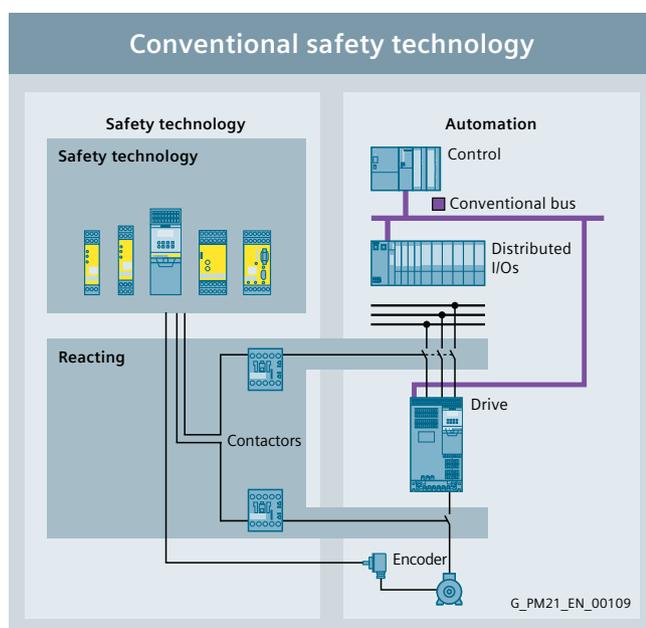
In modern drives, safety functions are becoming increasingly integrated. Using drives with integrated safety technology can mean that previously required electromechanical components and their associated wiring can be omitted. Even safety-relevant signals can be transmitted via standard fieldbuses, reducing the complexity and

expense of wiring. This considerably simplifies the implementation of safety concepts. The system costs can be reduced through fewer components and minimized wiring complexity. Furthermore, space can also be saved in the control cabinet.

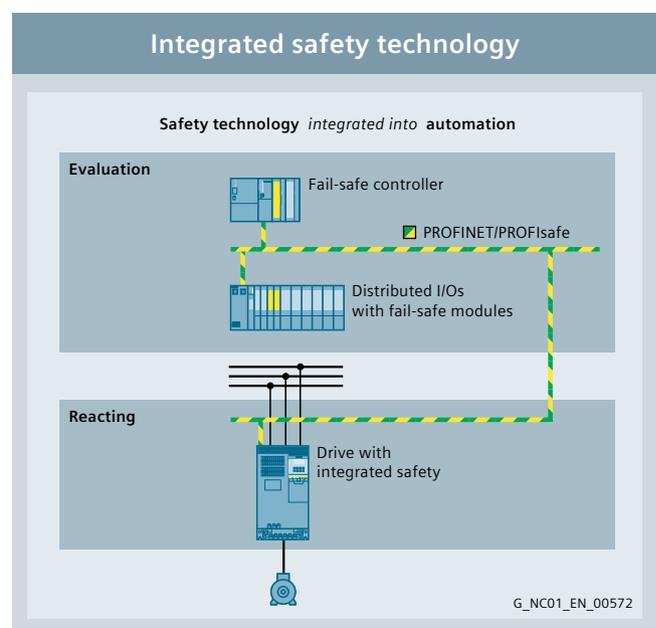
Integrated safety functions enable significantly more efficient safety concepts, in which the machine remains active, while safely monitored. The resulting shorter downtimes often produce increases in productivity. The integrated safety technology offers a considerably higher level of protection against accidents due to a reduced risk of tampering.

The use of certified integrated safety functions simplifies the certification of the safety category required for a machine. The certified functions support faster installation and commissioning.

The safety evaluation tool approved by the German Technical Inspectorate offers users support when evaluating safety functions of the machine (see [www.siemens.com/safety-evaluation-tool](http://www.siemens.com/safety-evaluation-tool)).



Integrated safety technology reduces the costs for components and wiring



# The most important integrated safety functions for drives

## Description of possible application areas and advantages for the customer

The implementation of safety concepts is based on the idea that safety-relevant events will first be recorded, then evaluated, and then responded to accordingly. An overview of the Siemens components available for this purpose can be found in the table on page 2. Fail-safe drives are characterized by their “integrated safety functions,” which they provide to the user as possible responses to

safety-relevant events. The most important integrated safety functions available for Siemens drives are described in the following pages. The functional safety of all the functions satisfies the requirements defined in Part 5-2 of the international standard IEC 61800 for variable-speed drive systems.

The drive-integrated safety functions can be roughly divided into three categories:

Functions for **safely stopping the drive** without having to disconnect the connection to the mains. This includes the following functions:

- **Safe Torque Off (STO):**  
This function prevents any further release of a torque on the motor shaft.
- **Safe Stop 1 (SS1):**  
This function actively brakes a drive before the STO function is activated. In the event of danger, drives with a high kinetic energy can be brought to a standstill extremely quickly using this function.
- **Safe Stop 2 (SS2):**  
Similarly to the SS1 function, the SS2 function actively brakes the drive. In a standstill, however, the SOS function is used instead of STO. Just as with SS1, drives with a high kinetic energy can be brought to a standstill extremely quickly in a hazardous situation.
- **Safe Operating Stop (SOS):**  
As an alternative to STO, you can use the SOS function. Unlike STO, the motor does not completely cease to exert torque. Instead, the drive remains in position control, holds its position, and it is monitored to detect zero speed.
- **Safe brake management (SBC/SBT):**  
Safe brake management consists of a safe brake control (SBC) and a safe brake test (SBT). The safely controlled and tested brake, in combination with the safely monitored drive, results in a stopping system for fall protection on vertical axes.

Functions for **safely monitoring the motion** of a drive:

- **Safely Limited Speed (SLS):**  
This function monitors the drive for exceeding of one or more specified maximum speeds.

- **Safe Speed Monitor (SSM):**  
This function reports the failure to reach a specified speed. No drive-autonomous response occurs.
- **Safe Direction (SDI):**  
This function monitors adherence to the selected direction of motion/rotation of the drive.

Functions for **safely monitoring the position** of a drive:

- **Safely Limited Position (SLP):**  
This function prevents a specified position from being exceeded. It facilitates the axis-specific realization of working area / protection zone delimitation or traversing range limitation.
- **Safe Position (SP):**  
This function transfers the safe position actual values of the drive to the higher-level controller (F-SPS). For example, the Safe Cam (SCA) function can be implemented there. The SCA outputs a safe signal if the drive is within a specified position range. This function can be used to implement a reliable range recognition for specific axes. The SP function can be used to implement cross-axis safety concepts in the F controller.

Further additional safety functions are available specially for safety solutions in machine tools in connection with the SINUMERIK computerized numerical control.

- **Safe programmable logic:**  
Using safe programmable logic, it is possible to connect safety-related sensors and actuators directly to the control unit's I/O, without external evaluation units, and to evaluate them using software.

# The most important integrated safety functions for drives

Description of possible application areas and advantages for the customer

## Safe Torque Off (STO)

The STO function is the most common and basic drive-integrated safety function. It ensures that no torque-generating energy can continue to act upon a motor and prevents unintentional starting.

### Effect

This function is a mechanism that prevents the drive from restarting unexpectedly, in accordance with EN 60204-1, Section 5.4. The Safe Torque Off function safely clears the pulses of the drive. The drive is reliably torque-free. This state is monitored internally in the drive.

### Applications

STO has the immediate effect that the drive cannot supply any torque-generating energy. STO can be used wherever the drive will be brought to a standstill in a sufficiently short time by the load torque or friction or where coasting down of the drive is not relevant to safety.

STO enables safe working when the protective door is open (restart interlock) and has a wide range of use in machines/systems with moving axes, e.g. handling, conveyor technology.

### Customer benefits

The advantage of the integrated STO safety function compared with standard safety technology using electromechanical switchgear is the elimination of separate components and the effort that would be required to wire and service them. Because of the rapid electronic switching times, the function has a shorter switching time than the electromechanical components in a conventional solution.

## Safe Stop 1 (SS1)

The SS1 function causes a motor to stop rapidly and safely and switches the motor to exert no torque at all after coming to a standstill, i.e. STO is activated.

### Effect

The Safe Stop 1 function can safely stop the drive in accordance with EN 60204-1, Stop Category 1. When the SS1 function is selected, the drive brakes along a quick stop ramp autonomously and automatically activates the Safe Torque Off and Safe Brake Control functions (if enabled) when the configured safety delay timer expires.

### Applications

The SS1 function is used when, in the event of a safety-related incident, the drive must stop as quickly as possible and then enter the STO state (e.g. in the case of an EMERGENCY STOP).

It is thus used to bring large centrifugal masses to a stop as quickly as possible for the safety of operating personnel, or to brake motors at high speeds as quickly as possible.

Typical applications include, for example:

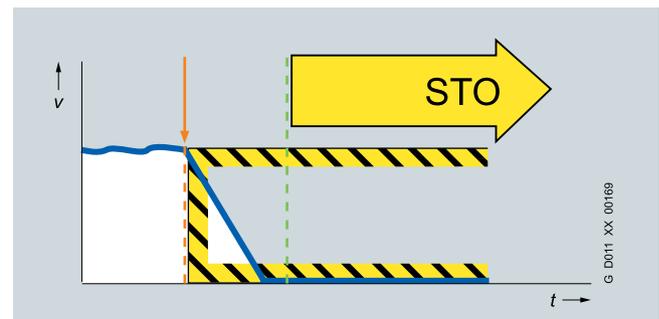
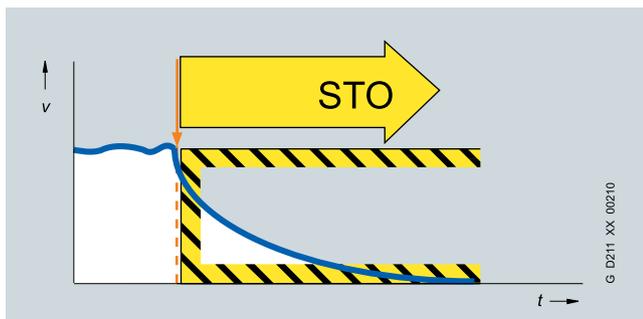
- Saws, grinding machine, centrifuges, stacker cranes, winders

### Customer benefits

The targeted stopping of a drive by means of SS1 reduces the risk of danger, increases the productivity of a machine, and allows safety clearances in a machine to be reduced.

The reason is the active stopping of the drive as compared with the use of the STO function only.

Complex, wear-prone mechanical brakes for stopping the motor are usually not required.



## Safe Operating Stop (SOS)

With the SOS function, the stopped motor is brought into position and monitored by a drive control.

### Effect

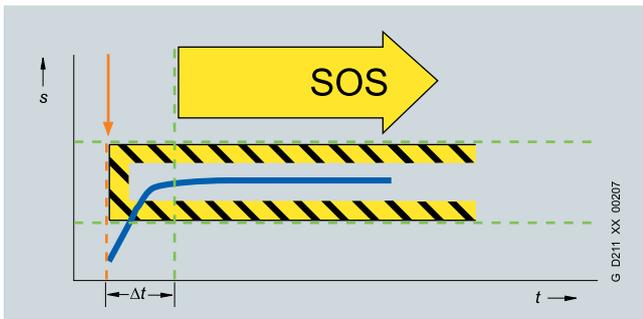
The Safe Operating Stop function represents safe standstill monitoring. The drive control remains in operation. The motor can therefore deliver the full torque to hold the current position. The actual position is reliably monitored. In contrast to safety functions SS1 and SS2, the speed setpoint is not influenced automatically. After SOS has been activated, the higher-level control must bring the drive to a standstill within a parameterized time and then hold the position setpoint.

### Applications

SOS is an ideal solution for all applications in which the machine or parts of the machine must be safely at standstill for certain machining steps, but in which the drive must also provide a holding torque. It is ensured that the drive remains in its current position despite the load torque. In contrast to SS1 and SS2, the drive does not brake automatically in this case. It expects the higher-level controller to coast down the relevant axes as a coordinated group within an adjustable delay time. This can be used to prevent any damage to the machine or product. SOS is widely used, for example, in winders, converting and packaging machines, and machine tools.

### Customer benefits

No mechanical components are necessary to keep the axis in position despite any counterforce that might appear. Because switching times are short and the position control always remains active, setup and downtimes are reduced. Recalibration of the axis after exiting the SOS function is not necessary. The axis can immediately be moved again after deactivation of the SOS function.



## Safe Stop 2 (SS2)

The SS2 function shuts down a motor quickly and safely and then activates the SOS function after coming to a standstill.

### Effect

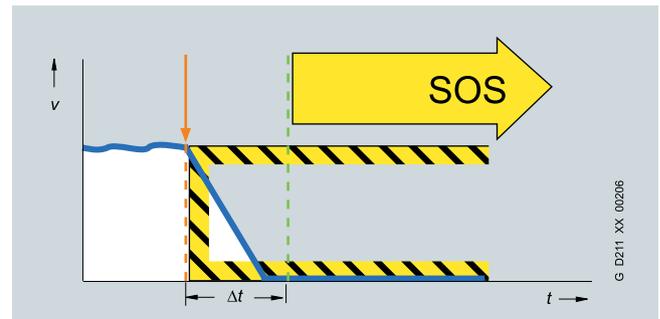
The Safe Stop 2 function can safely stop the drive in accordance with EN 60204-1, Stop Category 2. When the SS2 function is selected, the drive brakes autonomously along a quick-stop ramp. Unlike SS1, the automatic speed control remains operational afterward, i.e. the motor can provide the full torque required to maintain zero speed. Standstill is safely monitored (Safe Operating Stop function).

### Applications

As with SS1, the SS2 function ensures the quickest possible deceleration of the motor. However, the motor power is then not switched off, but prevented by a control system from leaving the standstill position even if external forces are applied to it. SS2 has a wide range of applications, for instance in production machines, machine tools.

### Customer benefits

The SS2 function ensures a rapid axis stop. Because the control remains active, after the safety function is deselected, productive operation can continue without referencing. This ensures short setup and standstill times and high productivity.



# The most important integrated safety functions for drives

Description of possible application areas and advantages for the customer

## Safe Brake Control (SBC)

The SBC function permits the safe control of a holding brake. The SBC function is always activated in parallel with STO.

### Effect

A holding brake which is active in a de-energized state is controlled and monitored using safe two-channel technology. Due to the two-channel control, the brake can still be operated if an insulation fault occurs in the control cable. Errors of this kind are detected early by means of test pulses.

### Applications

The SBC function is used in conjunction with the functions STO or SS1 to prevent the movement of an axis in the torque-free state, e.g. because of gravity.

### Customer benefits

Again, the function saves the use of external hardware and the associated wiring.

## Safe Brake test (SBT)

The SBT function performs a test of the brake function at cyclical intervals.

### Effect

The intended function of wear-prone brakes is safely tested by increasing torque against the closed brake. Two brakes can be tested with different test torques on each drive, e.g. motor brake and external brake.

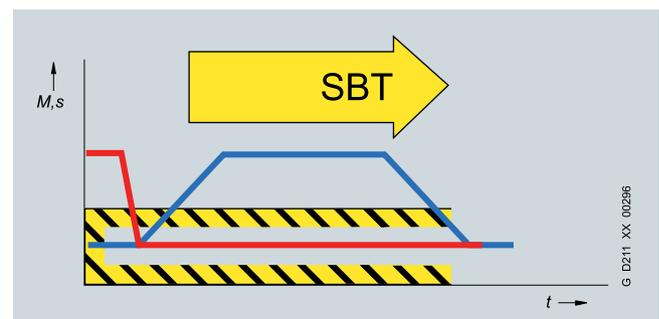
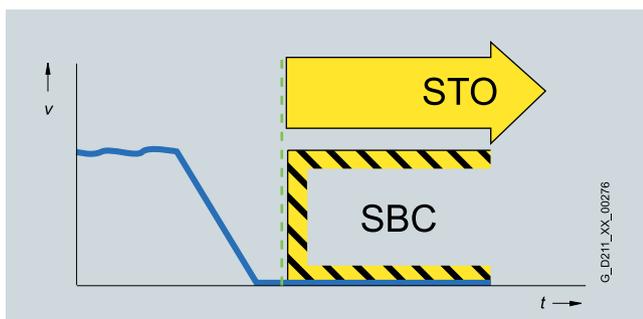
### Applications

The SBT function is suitable for implementing a safe brake combined with the SBC function.

### Customer benefits

The function identifies faults or wear in the brake mechanics. Automatically testing the effectiveness of brakes reduces maintenance costs and increases the safety and availability of plants/machines.

The SBT function goes beyond the safety functions named in IEC 61800-5-2.



## Safely Limited Speed (SLS)

The SLS function ensures that the drive does not exceed a defined speed limit.

### Effect

The drive reliably monitors the speed and activates a fault response defined by the configuration if the set speed limit is exceeded.

### Applications

The SLS function is used if people are in the danger zone of a machine and their safety can only be guaranteed by reduced speed. First, therefore, the speed is reduced, then safe monitoring is activated using the SLS function so that accidental exceeding of the set speed limit is prevented. Typical examples are cases in which an operator must enter the danger zone of the machine for maintenance or setup. A typical use of SLS is a winder, in which the material is manually threaded by the operator. To prevent injury to the operator, the roller may only spin at a safe reduced speed. SLS is often also used as part of a two-stage safety concept. While a person is in a less critical zone, the SLS function is activated, and the drives are only stopped in a smaller area with higher potential risk. SLS can be used not only for operator protection, but also for machinery protection, e.g. if a maximum speed must not be exceeded.

### Customer benefits

The SLS function can contribute to a significant reduction in downtime, or greatly simplify or even accelerate setup. The overall effect achieved is a higher availability of a facility. Moreover, external components such as speed monitors can be omitted.

## Safe Speed Monitor (SSM)

The SSM function warns when the drive is working below a specified speed/feed speed. As long as it remains below the threshold, the function issues a safety signal.

### Effect

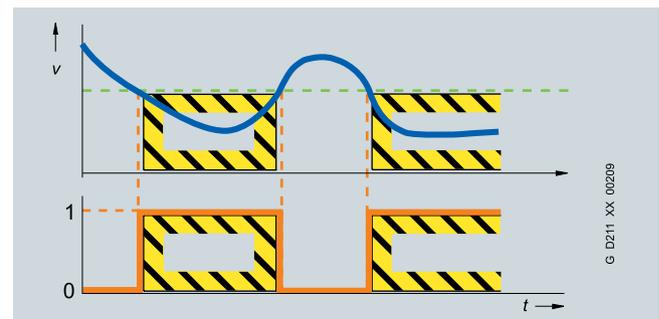
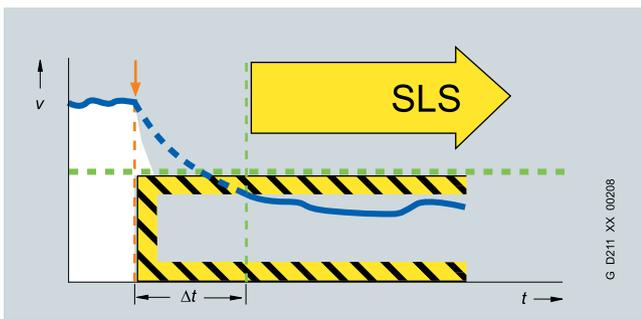
If a speed value drops below a parameterized level, a safety signal is generated. This can be processed, for example, in a safety controller to respond to the event by programming, depending on the situation.

### Applications

With the SSM function, in the simplest case, a safety door can be unlocked if the speed drops below a non-critical level. Another example is a centrifuge that must be filled only below a configured speed.

### Customer benefits

Unlike SLS, there is no drive-independent fault reaction when the speed limit is exceeded. The safe feedback can be evaluated in a safety control unit, allowing the user to respond appropriately to the situation.



# The most important integrated safety functions for drives

Description of possible application areas and advantages for the customer

## Safe Direction (SDI)

The SDI function ensures that the drive can only rotate in the selected direction.

### Effect

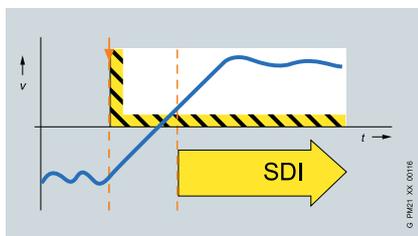
Deviation from the direction of motion/rotation currently being monitored is detected reliably and the configured drive-independent fault reaction is initiated. As an option, it is possible to monitor one or two directions of motion.

### Applications

The SDI function is used when the drive may only move in one direction. A typical application is to make a danger area accessible to the operator, provided the machine is moving in the safe direction, i.e. away from the operator. In this status, the operator can safely feed material into or remove it from the work area.

### Customer benefits

The function saves the use of external components e.g. speed monitors and the associated wiring. Release of a danger zone while the machine is moving away from the operator thereby increases productivity. Without the SDI function, the machine would have to be stopped safely while material was fed in or removed.



## Safely Limited Position (SLP)

The SLP function monitors the axis to ensure that it remains within the permissible traversing range.

### Effect

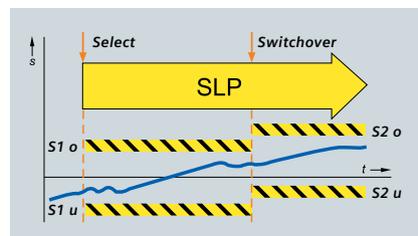
When SLP is activated, the traversing range limited by the configured software limit switch is safely monitored. If the permitted traversing range is exited, a configurable fault response is initiated. It is possible to toggle between two traversing ranges, even during operation.

### Applications

SLP is used for applications in which machine operators have to enter a protection area, e.g. for feeding in and removing material. Safe monitoring of the axis position ensures that the axis cannot move into the protection area released for operators, placing them in danger, e.g. for stacker cranes, gantry cranes, production centers.

### Customer benefits

SLP can be used for highly-effective protection area monitoring. The function eliminates the use of external components such as hardware limit switches and the associated wiring complexity. Because the response time following a limit overshoot is short, safety clearances can be reduced.



## Safe Position (SP)

The SP function transfers the safely determined actual position values in the drive to a safety controller via safe PROFIsafe communication.

### Effect

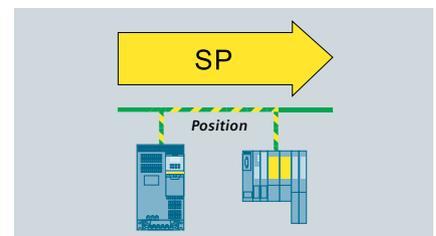
Unlike the SLP function, which monitors the current actual position value against a limit within the drive and initiates an autonomous fault response by the drive to an overshoot, SP communicates the current actual position values to the safety control. Monitoring functions can be implemented in a flexible manner in this case.

### Applications

Tailored safety concepts can be developed with the SP function. The function is particularly suitable for machines where flexible safety functions are required. It can be used in a wide range of applications, e.g. to implement safe, axis-specific range recognition via safe cams (SCA). The SP function can also be used to design cross-axis safety concepts, multi-dimensional protection areas and zone concepts.

### Customer benefits

Additional sensors or external safe encoders, their installation and evaluation are not necessary to monitor protection areas. The SP function goes beyond the safety functions stated in IEC 61800-5-2.



# Drives and motion control systems with integrated safety functions

In practice a very wide variety of components is used to control and power motors, depending on the required motion profile.

With this in mind, Siemens offers a comprehensive product portfolio with integrated safety features, which enables effective safety concepts for each application profile to be implemented economically:

- Frequency converters for variable-speed operation of motors

- Drives for precise and dynamic positioning and motion control tasks
- Numerical controls for path control in machine tools and production machines.

The following table provides an overview of which products are available for which applications. More information about the individual products is provided in the following chapters.

	Applications with variable speed	High-performance and motion control applications	Numeric control in production machines
<b>Fields of application</b>	Conveyor systems, pumps, extruders, mixers, mills, aggregates	Production machines General mechanical and plant engineering	Machine tools/ production machines
<b>Operating mode</b>	On/off operation with acceleration/braking ramp, continuous duty with variable speeds	Continuous duty with high speed accuracy or cyclic operation with frequent accelerations/slowdowns, positioning, motion control	Interpolating operation of multiple feed axes, spindle speed control
<b>Dynamic/speed accuracy</b>	Medium	High to very high	High to very high
<b>Open-/closed-loop control</b>	V/f control, vector control	V/f control, vector control, servo control	Servo control, interpolation
<b>Products</b>	Frequency converters <ul style="list-style-type: none"> <li>• SINAMICS G110D</li> <li>• SINAMICS G120C</li> <li>• SINAMICS G120</li> <li>• SINAMICS G120D</li> <li>• SINAMICS G130</li> <li>• SINAMICS G150</li> </ul>	Positioning drives <ul style="list-style-type: none"> <li>• SINAMICS S110</li> </ul> Drive for high-performance and motion control applications <ul style="list-style-type: none"> <li>• SINAMICS S120</li> <li>• SINAMICS S150</li> </ul>	Automation system for machine tools/ production machines <ul style="list-style-type: none"> <li>• SINUMERIK 840D sl</li> <li>• SINUMERIK 828D</li> </ul>
<b>Integrated safety functions</b>	See table section on pages 20 – 22		

Additional information:  
[www.siemens.com/sinamics](http://www.siemens.com/sinamics)  
[www.siemens.com/sinumerik](http://www.siemens.com/sinumerik)

# Fail-safe frequency converters for applications with variable speed



The integrated safety functions comply with the requirements of Category 3, performance level (PL) d according to ISO 13849-1, and Safety Integrity Level (SIL) 2 to IEC 61508 or IEC 61800-5-2. This allows essential requirements of functional safety to be implemented easily and economically.

## Customer benefits:

- High level of safety: Drive-integrated safety functions support flexible safety concepts and provide very short response times.
- Low validation effort: Certified components simplify validation of machine safety.
- Great economic efficiency: Integrated safety functions reduce hardware and save space and installation costs.
- Enhanced availability: Electromagnetically susceptible and wearing electromechanical components are no longer required.

Frequency converters are used to operate motors with variable speed. Typical areas of application are standard applications in which the operation of motors with variable speed is desired: pumps, fans, compressors, conveyor applications; but frequency converters are also used in the operation of extruders, mixers, mills and hoists. Siemens offers a comprehensive range of frequency converters in various forms for different key applications. They not only have the basic integrated safety features such as Safe Torque Off, but are also characterized by high-quality integrated safety functions. All SINAMICS G120 frequency converters offer STO as standard. The fail-safe control units offer an extensive range of safety functions for operation without an encoder.

The SINAMICS G130/G150 frequency converters offer STO, SS1, and SBC as standard. Further comprehensive safety functions are enabled via a software license.

The safety functions are controlled via PROFIBUS DP or PROFINET using the PROFIsafe profile. For data exchange with the higher-level controller, message frames are available that provide an easy way for the controller to trigger safety functions in the frequency converter and for frequency converter to report the status of safety functions back to the controller. The safety functions can also be controlled locally via the onboard fail-safe inputs. A fail-safe input for STO is provided on the standard control units for this purpose. The fail-safe control units feature fail-safe inputs. With these, several safety functions can be controlled directly.





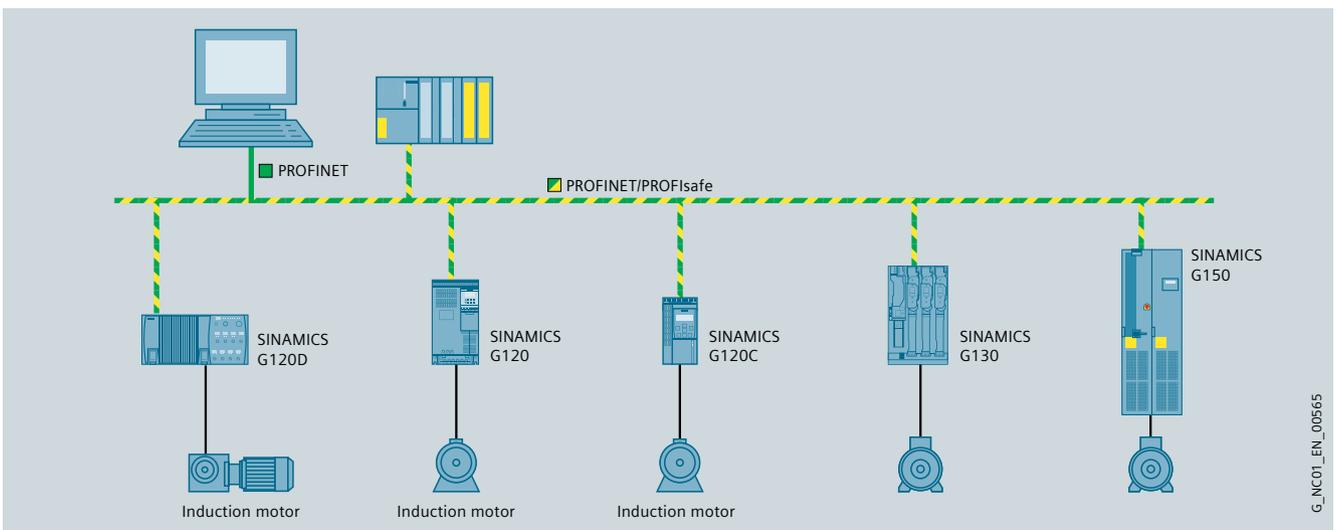
SINAMICS G120C, G120 (central frequency converters) and SINAMICS G120D (distributed frequency converter)



SINAMICS G130/SINAMICS G150 – frequency converters for medium to high power

- **SINAMICS G120D**  
the frequency converter for single drives with a low power of 0.37 to 7.5 kW with a high degree of protection for distributed use
- **SINAMICS G120**  
the modular, flexible frequency converter for single drives with low to medium power of 0.37 to 250 kW as a built-in unit for use in the control cabinet
- **SINAMICS G120 C**  
the compact frequency converter for individual drives with power from 0.55 to 18.5 kW as a built-in device

- **SINAMICS G130**  
the modular frequency converter as a built-in unit for single drives with medium to high power of 75 to 800 kW
- **SINAMICS G150**  
the ready-to-use converter cabinet for medium to high power of 75 to 2700 kW



PROFINET/PROFIsafe with SINAMICS configuration example

# Fail-safe high-performance drives for demanding single and multi-axis applications



Siemens offers drives with integrated safety functions for every kind of demanding application. Given the often rapid movement sequences, the great forces, and the sometimes large dynamic masses, the short response times of integrated safety functions also offer a much higher level of protection against personal injury and material damage than conventional safety concepts. Moreover, completely new, hitherto hardly feasible safety functions permit low-cost implementation of innovative safety concepts. SINAMICS S drives can be used in any application with the most stringent requirements for processes involving dynamic and reproducible operations, such as:

- Metalworking, wood, glass, ceramics industries
- Printing machines
- Tool changers, positioning axes
- Solar panel tracking
- Packaging machines
- Plastics processing machines
- Textile machinery
- Paper machines
- Handling and assembly systems
- Rolling mills
- Test bays
- Centrifuges
- Hoists, elevators and cranes
- Cross cutters and shears
- Conveyor belts
- Presses
- Cable winches

The integrated safety functions comply with the requirements of Category 3, performance level (PL) d according to ISO 13849-1, and Safety Integrity Level (SIL) 2 to IEC 61508 or IEC 61800-5-2. This allows essential requirements of functional safety to be implemented easily and economically.

## Customer benefits:

- High level of safety: Drive-integrated safety functions support flexible safety concepts and provide very short response times.
- Low validation effort: Certified components simplify validation of machine safety.
- Great economic efficiency: Integrated safety functions reduce hardware and save space and installation costs.

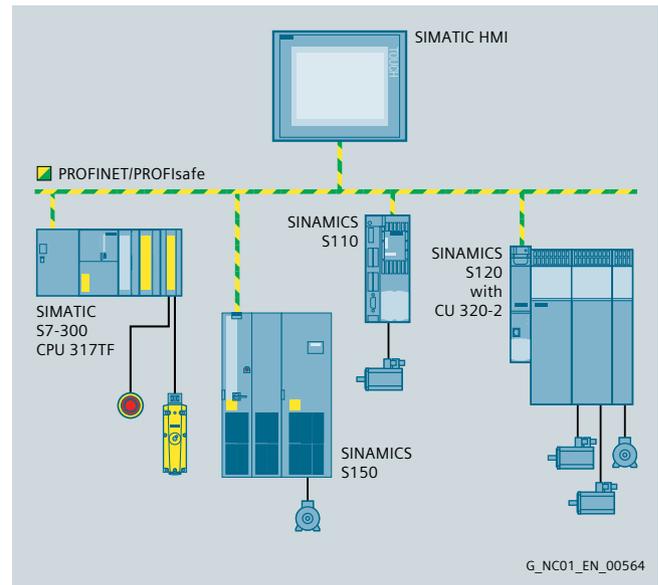
Enhanced availability: Electromagnetically susceptible and wearing electromechanical components are no longer required.





SINAMICS S110, S120 and S150

Together with other safety components, SINAMICS drives can be integrated in automation solutions that satisfy the highest safety requirements either by hardwiring or, simpler still, with a standard fieldbus using the PROFINET/PROFIsafe profile. The drives can also be controlled via fail-safe inputs/outputs.



SINAMICS S110/S120/S150 configuration example

The following drives are available:

- **SINAMICS S110**  
The single-axis drive for simple positioning tasks in the output range 0.12 to 90 kW
- **SINAMICS S120**  
The modular drive system for demanding and high-performance single and multi-axis applications in the output range 0.12 to 4500 kW
- **SINAMICS S150**  
The converter cabinet for demanding, variable-speed single drives in the output range 75 to 1200 kW

# High-performance motion control applications



SIMOTION is the tried and tested controller for all motion control tasks in machines for the widest range of industries:

- Packaging industry
- Plastics industry
- Glass industry
- Wood processing
- Metal forming technology
- Textiles industry
- Printing industry
- Converting
- General machine construction, etc.

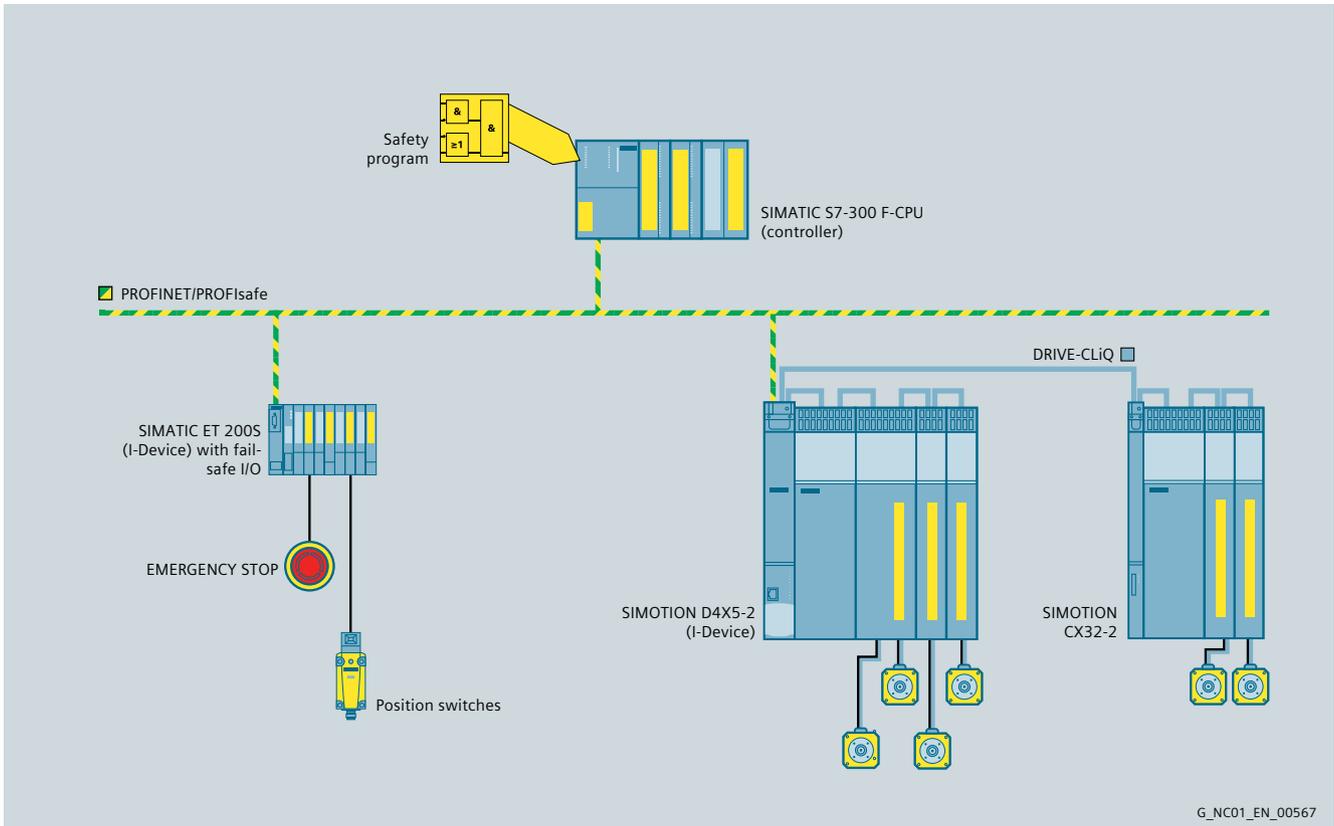
SIMOTION is available in three different platforms:

- **SIMOTION P**  
Open PC-based motion control system
- **SIMOTION C**  
A modular controller-based system with SIMATIC S7-300 design
- **SIMOTION D**  
A compact drive-based system in SINAMICS S120 booksized format.

SIMOTION offers maximum flexibility and enables central or distributed machine concepts. Thanks to the various performance versions, SIMOTION offers a high degree of scalability and therefore makes it easier to tailor the automation to the requirements of the machine.

SIMOTION's new system approach perfectly combines motion control with PLC and technology functions in one controller. In the case of SIMOTION D, the drive control of SINAMICS S120 is also integrated. As such, all safety functions of SINAMICS S120 are also available for SIMOTION D:

- Functions for stopping a drive safely and for monitoring the standstill
- Functions for reliable motion monitoring
- Functions for reliable position monitoring



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Typical configuration of an automation solution based on SIMOTION D with integrated safety functions

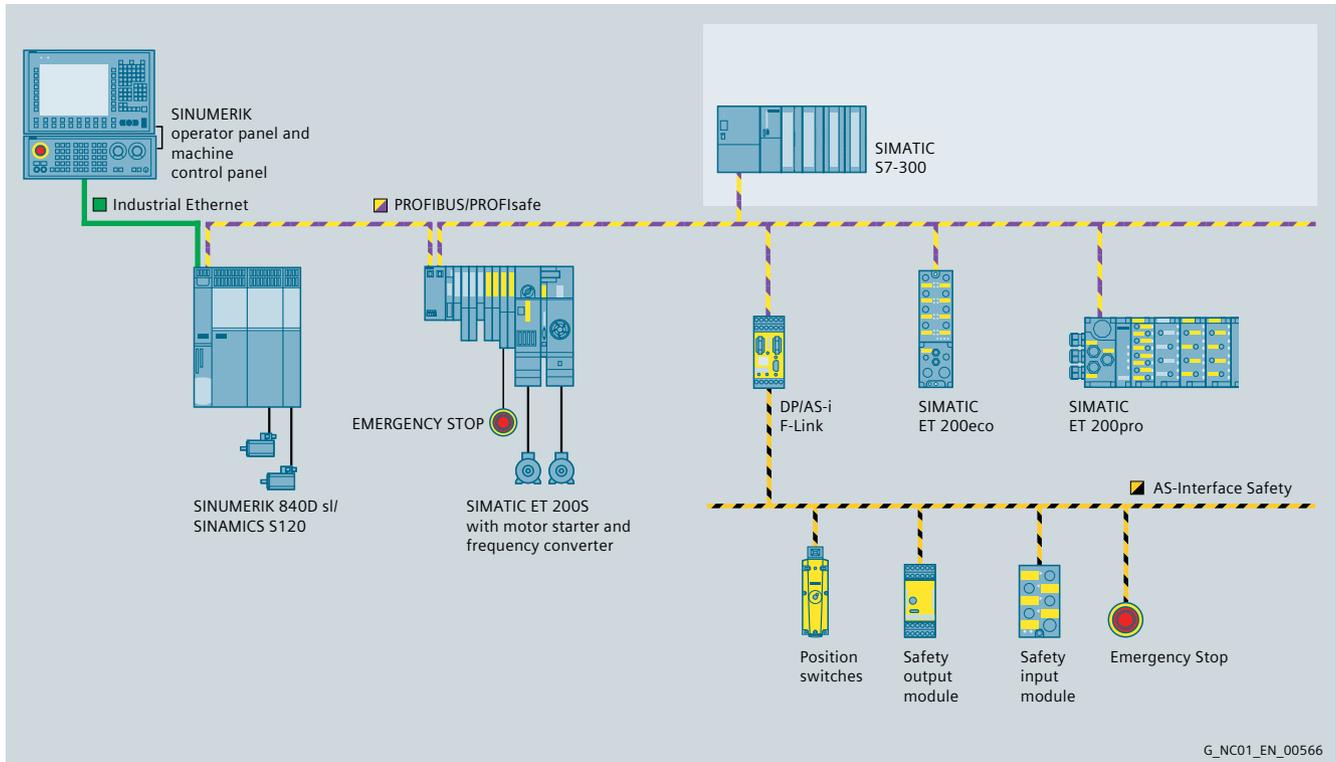
The safety functions can be controlled via safe I/Os or the PROFIsafe safe communication profile based on PROFINET or PROFIBUS. In this case, SIMOTION supports communication of underlying SINAMICS drives with a SIMATIC F-CPU, by routing through PROFIsafe message frames.

The integrated safety functions comply with the requirements of Category 3, performance level (PL) d according to ISO 13849-1, and Safety Integrity Level (SIL) 2 to IEC 61508 or IEC 61800-5-2. This allows essential requirements of functional safety to be implemented easily and economically.

#### Customer benefits:

- High level of safety: Drive-integrated safety functions support flexible safety concepts and provide very short response times.
- Low validation effort: Certified components simplify validation of machine safety.
- Great economic efficiency: Integrated safety functions reduce hardware and save space and installation costs.
- Enhanced availability: Electromagnetically susceptible and wearing electromechanical components are no longer required.

# Fail-safe CNC systems for machine tools and production machines



Typical configuration of an automation solution based on SINUMERIK 840D sl with integrated safety features

For machine tool and production machines, user input is particularly frequent due to the individual production of workpieces. Situations in which a tool or workpiece is damaged after a long processing time because of the response to a safety-related incident are to be avoided. Often this involves considerable financial and time losses. For these reasons, powerful safety concepts are particularly important here.

With SINUMERIK Safety Integrated, the integrated package of safety functions for our SINUMERIK machine tool control, it is particularly easy to implement innovative safety concepts that provide maximum protection to people and machines.

SINUMERIK Safety Integrated is a comprehensive safety package that helps to protect people as well as machines and this is achieved very efficiently and economically thanks to complete integration of safety functions into the control and drive technology. Moreover, it makes your machine safe and practical to operate under all required operating conditions. For example, with the protective door open during setup and test operation.



SINUMERIK 840D sl

**SINUMERIK Safety Integrated is available for the following systems:**

■ **SINUMERIK 840D sl**

The universal machine tool control with the SINAMICS S120 drive system

■ **SINUMERIK 828D**

The compact universal machine tool control for standard turning and milling machines

The function scope includes, e.g.:

- Functions for safely monitoring speed and standstill
- Functions for establishing safe boundaries in work spaces and protected spaces, and for range recognition
- Direct connection and internal logic combination of all safety-related signals



The integrated safety functions comply with the requirements of Category 3, Performance Level PL d according to EN ISO 13849-1, and Safety Integrity Level SIL 2 according to EN 61508. This enables essential requirements of functional safety to be implemented easily and economically. SINUMERIK Safety Integrated is extremely flexible in terms of communication with other safety-redundant components:

• **Safety-related communication via standard bus**

Connection of distributed I/Os for process and safety signals via PROFIBUS/PROFINET with PROFIsafe.

• **Safe communication between several F controllers**

(e.g. SINUMERIK 840D sl, SIMATIC) via the PROFIBUS and PROFINET standard.

• **Safe network transition between AS-i and PROFIBUS**

Using the DP/AS-i F-Link, a safe gateway from ASIsafe to PROFIsafe can be implemented.

The safety-related signals are collected via the AS-i bus.

**Customer benefits**

• **High safety:**

Full implementation of safety features in Category 3/SIL 2/PL d

• **High flexibility:**

Practical safety and operating concepts can be implemented

• **Very economical:**

Reduction of hardware and installation costs

• **High availability:**

Electromagnetically susceptible electromechanical switching elements are no longer required

	Drive applications with variable speed		
	SINAMICS G120C	SINAMICS G120	SINAMICS G120D
			
<b>Description</b>	Compact frequency converter for variable-speed individual drives with low outputs	Modular frequency converters for variable-speed individual drives with low to medium output	Modular, distributed frequency converter for variable-speed Single drives with high degree of protection
<b>Main applications</b>	For mechanical engineers and distributors in the industrial and commercial sector (auxiliary drives in mechanical engineering, for single production machines, pumps, fans, mixers)	Machines and plants for industrial and commercial applications (mechanical engineering, automotive, textiles, chemicals, printing, steel)	Machines and plants for industrial applications, particularly automotive, but also in airports (wet area without surfactants), the food and beverage industry, and distribution logistics (e.g. overhead monorail conveyors)
<b>Application examples</b>	<ul style="list-style-type: none"> <li>• Conveyor systems</li> <li>• Handling devices</li> <li>• Extruders, mixers</li> <li>• Pumps and fans</li> <li>• Compressors</li> </ul> in production and process industries	<ul style="list-style-type: none"> <li>• Conveyor systems</li> <li>• Handling devices</li> <li>• Extruders, mixers</li> <li>• Pumps and fans</li> <li>• Compressors</li> </ul> in production and process industries	<ul style="list-style-type: none"> <li>• Conveyor systems, primarily for high-performance solutions</li> </ul>
<b>Performance range</b>	0.55 – 18.5 kW	0.37 – 250 kW	0.75 – 7.5 kW
<b>Degree of protection</b>	IP20	IP20	IP65
<b>Line regeneration</b>	No	Yes, optional	Yes
<b>Control method</b>			
– V/f control	Yes	Yes	Yes
– Vector control with/without	–/Yes	Yes <sup>2)</sup> /Yes	Yes/Yes
– Servo control	–	–	–
<b>Motors</b>	Induction motors	Induction motors	Induction motors
<b>Fail-safe communication</b>	PROFIBUS/PROFINET with PROFI-safe profile	PROFIBUS/PROFINET with PROFI-safe profile	PROFIBUS/PROFINET with PROFI-safe profile
<b>Integrated safety functions</b>			
– Safe Torque Off (STO)	Yes	Yes	Yes
– Safe Stop 1 (SS1) (w/ w/o encoder)	–	–/Yes	–/Yes
– Safe Brake Control (SBC)	–	Yes <sup>2)</sup>	–
– Safe Brake Test (SBT)	–	–	–
– Safely Limited Speed (SLS) (with/without encoder)	–/–	–/Yes	–/Yes
– Safe Direction (SDI) (with/without encoder)	–/–	–/Yes	–/Yes
– Safe Speed Monitor (SSM) (with/without encoder)	–/–	–/Yes	–/Yes
– Safe Operating Stop (SOS) (with encoder)	–	–	–
– Safe Stop 2 (SS2) (with encoder)	–	–	–
– Safe Position (SP) (with encoder) <sup>1)</sup>	–	–	–
– Safely Limited Position (SLP) (with encoder)	–	–	–
<b>Approvals</b>	SIL 2 according to IEC 61508, Cat. 3 or PL d according to EN ISO 13849-1		

<sup>1)</sup> for the application of further safety functions to be implemented e.g. Safe Cam (SCA)

High-performance and motion control applications			
SINAMICS G130/G150	SINAMICS S110	SINAMICS S120	SINAMICS S150
			
Frequency converters for variable-speed single drives in the mid to upper performance range	Single-axis positioning drive	Modular drive system for demanding single or multiple-axis applications	Frequency converter for complex variable-speed single drives
Machines and plants for industrial applications, wherever solid, liquid, or gas substances must be moved, transported, pumped, or compressed	Simple positioning tasks with synchronous servo motors and asynchronous motors	Continuous motion control, motion control tasks (including highly dynamic and coordinated positioning tasks) in multi-axis drives with a common, central power supply and intermediate DC circuit	Machines and plants for industrial applications with the most stringent requirements for processes with dynamic and reproducible procedures
<ul style="list-style-type: none"> <li>• Pumps and fans</li> <li>• Compressors</li> <li>• Extruders and mixers</li> <li>• Mills</li> </ul>	<ul style="list-style-type: none"> <li>• Handling devices</li> <li>• Feed/extraction equipment</li> <li>• Assembly machines</li> <li>• Positioning axes</li> <li>• Tool changers</li> </ul>	<ul style="list-style-type: none"> <li>• Production machines: Machinery, equipment, and process lines in the packaging, textile, printing, paper, wood, glass, ceramics, and plastics industries</li> <li>• Presses</li> <li>• Converting applications</li> <li>• Handling devices</li> <li>• Paper machines, rolling mills, marine applications</li> </ul>	<ul style="list-style-type: none"> <li>• Test bay drives</li> <li>• Centrifuges</li> <li>• Elevators and cranes</li> <li>• Cross cutters and shears</li> <li>• Conveyor belts</li> <li>• Presses</li> <li>• Cable winches</li> </ul>
G130: 75 – 800 kW / G150: 75 – 2700 kW IP20/optional up to IP54 for SINAMICS G150	0.12 – 90 kW	1.6 – 4500 kW	75 – 1200 kW
No	IP20	IP20/optional up to IP54 for cabinet modules	IP20 / optional up to IP54
No	No	Yes, optional	Yes
Yes	No	Yes	Yes
Yes/Yes	No	Yes	Yes
–	Yes	Yes	Yes
Induction/ synchronous motors	Induction/ synchronous motors	Induction/synchronous/ torque/linear motors	Induction/synchronous motors Torque motors
PROFIBUS/PROFINET with PROFIsafe profile	PROFIBUS/PROFINET with PROFIsafe profile	PROFIBUS/PROFINET with PROFIsafe profile	PROFIBUS/PROFINET with PROFIsafe profile
Yes	Yes	Yes	Yes
–/Yes	Yes/Yes	Yes/Yes	Yes/Yes
Yes	Yes	Yes	Yes
–	–	Yes	Yes
Yes/Yes	Yes <sup>3)</sup> /Yes	Yes <sup>4)</sup> /Yes	Yes <sup>4)</sup> /Yes
Yes/Yes	Yes <sup>3)</sup> /Yes	Yes <sup>4)</sup> /Yes	Yes <sup>4)</sup> /Yes
Yes/Yes	Yes <sup>3)</sup> /Yes	Yes <sup>4)</sup> /Yes	Yes <sup>4)</sup> /Yes
–	Yes <sup>3)</sup>	Yes <sup>4)</sup>	Yes <sup>4)</sup>
–	Yes <sup>3)</sup>	Yes <sup>4)</sup>	Yes <sup>4)</sup>
–	–	Yes	Yes
–	–	Yes	Yes
SIL 2 according to IEC 61508, Cat. 3 or PL d according to EN ISO 13849-1	SIL 2 according to IEC 61508, Cat. 3 or PL d according to EN ISO 13849-1, NFPA 79, NRTL listed <sup>5)</sup>		SIL 2 according to IEC 61508, Cat. 3 or PL d according to EN ISO 13849-1

<sup>2)</sup> Only applies for CU 250S-2

<sup>3)</sup> In conjunction with sin/cos encoder or absolute value encoder EnDat

<sup>4)</sup> In conjunction with sin/cos encoder, absolute value encoder EnDat or HTL/TTL with 2-encoder system

<sup>5)</sup> Applies only to SINAMICS S120 booksize

	Numerical control in machine tools	
	SINUMERIK 840D sl	SINUMERIK 828D
		
<b>Description</b>	Automation solution for machine tools	
<b>Main applications</b>	Controller and drive system for machine tools and production machines based on the SINAMICS S120 drive system	Controller and drive system for machine tools and production machines based on the SINAMICS S120 drive system
<b>Application examples</b>	<ul style="list-style-type: none"> <li>Machine tools: Milling, turning, grinding, nibbling, ...</li> </ul>	<ul style="list-style-type: none"> <li>Machine tools: Milling, turning</li> </ul>
<b>Performance range</b>	1.6 – 107 kW	1.6 – 107 kW
<b>Degree of protection</b>	IP20	IP20
<b>Line regeneration</b>	No	Yes
<b>Control method</b>		
– V/f control	Yes	Yes
– Vector control with/without	Yes	Yes
– Servo control	Yes	Yes
<b>Motors</b>	Induction/synchronous/torque/linear motors	Induction/synchronous/torque motors
<b>Fail-safe communication</b>	PROFIBUS/PROFINET with PROFIsafe profile	–
<b>Integrated safety functions</b>		
– Safe Torque Off (STO)	Yes	Yes
– Safe Stop 1 (SS1) (with/without encoder)	Yes/Yes	Yes/Yes
– Safe Brake Control (SBC)	Yes	Yes
– Safe Brake Test (SBT)	Yes	Possible with an application
– Safely Limited Speed (SLS)	Yes	Yes
– Safe Direction (SDI)	–	Yes
– Safe Speed Monitor (SSM)	Yes	Yes
– Safe Operating Stop (SOS)	Yes	Yes
– Safe Stop 2 (SS2)	Yes	Yes
– Safe Cam (SCA)	Yes	–
– Safely Limited Position (SLP)	Yes	–
– Safe programmable logic (SPL)	Yes	–
<b>Approvals</b>	SIL 2 according to EN 61508, Cat. 3 or PL d according to EN ISO 13849-1	

# Risk analysis through specifying and evaluating risk elements

The risk elements (S, F, W and P) serve as input variables for both standards, but are evaluated differently by them. According to IEC 62061, a demanded Safety Integrity Level (SIL) is determined, according to EN ISO 13849-1, a Performance Level (PL).

Risk related to the identified danger

=

Severity of damage  
**S**

and

Frequency and/or exposure time to hazard	<b>F</b>
Probability of occurrence	<b>W</b>
Possibility of avoiding the hazard or limiting the damage	<b>P</b>

## IEC 62061 Determination of the required SIL (through SIL assignment)

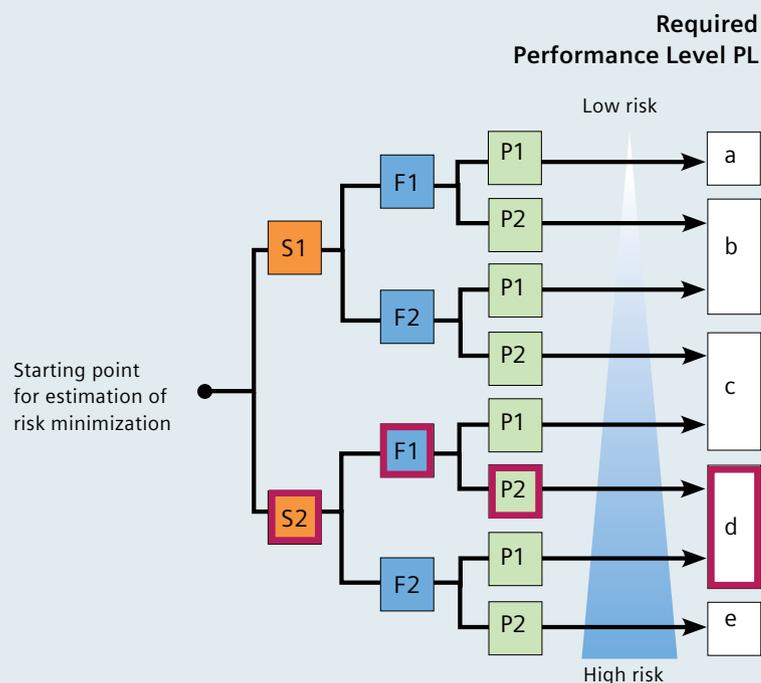
Frequency and/or exposure time to hazard <b>F</b>		Probability of hazard incident occurrence <b>W</b>		Possibility of avoidance <b>P</b>	
≤ 1 hour	5	Frequent	5		
> 1 hour to ≤ 1 day	5	Probable	4		
> 1 day to ≤ 2 weeks	4	Possible	3	Impossible	5
> 2 weeks to ≤ 1 year	3	Rare	2	Possible	3
> 1 year	2	Negligible	1	Probable	1

Effects (severity of injury)	Severity of harm <b>S</b>	Class $K = F + W + P$					Example calculation
		3-4	5-7	8-10	11-13	14-15	
Death, loss of an eye or arm	4	SIL 2	SIL 2	SIL 2	SIL 3	SIL 3	
Irreversible, loss of fingers	3	Other actions			SIL 1	SIL 2	SIL 3
Reversible, medical treatment	2	Other actions				SIL 1	SIL 2
Reversible, first aid	1	Other actions					SIL 1

## ISO 13849-1: Determination of the required PL (using risk graph)

The risk is estimated on the basis of identical risk parameters:

Risk parameters
<b>S = Severity of injury</b>
S1 = slight (usually reversible) injury
S2 = serious (usually irreversible) injury, including death
<b>F = Frequency and/or duration of exposure to hazard</b>
F1 = rare to often and/or short exposure to hazard
F2 = frequent to continuous and/or exposure time is long
<b>P = Possibility of avoiding the hazard or limiting the damage</b>
P1 = possible under certain conditions
P2 = hardly possible
<b>a, b, c, d, e = targets of the safety-related performance level</b>



*“The prevention of accidents must not merely be regarded as a requirement under the law – it is also a humanitarian imperative and a dictate of economic common sense.”*

Werner von Siemens, 1880

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