

Radar Transmitters

SITRANS LR250 (HART)

Functional Safety Manual · 08/2014



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Level Instruments

Functional safety for SITRANS LR250 (HART)

Product Information

SITRANS LR250 (HART):

7ML5431-xxx00-xxAx-Z C20
7ML5431-xxx00-xxBx-Z C20
7ML5431-xxx00-xxCx-Z C20
7ML5431-xxx00-xxDx-Z C20
7ML5431-xxx00-xxEx-Z C20
7ML5431-xxx20-xxAx-Z C20
7ML5431-xxx20-xxBx-Z C20
7ML5431-xxx20-xxCx-Z C20
7ML5431-xxx20-xxDx-Z C20
7ML5431-xxx20-xxEx-Z C20
7ML5432-xxx20-xxAx-Z C20
7ML5432-xxx20-xxBx-Z C20
7ML5432-xxx20-xxCx-Z C20
7ML5432-xxx20-xxDx-Z C20
7ML5432-xxx20-xxEx-Z C20
7ML5432-xxx20-xxKx-Z C20
7ML5432-xxx20-xxLx-Z C20
7ML5433-xxx20-xxAx-Z C20
7ML5433-xxx20-xxBx-Z C20
7ML5433-xxx20-xxCx-Z C20
7ML5433-xxx20-xxDx-Z C20
7ML5433-xxx20-xxEx-Z C20
7ML5433-xxx20-xxKx-Z C20
7ML5433-xxx20-xxLx-Z C20

Ordering Number: A5E32286471
03/2014

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Safety Guidelines

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.



Danger

indicates that death or severe personal injury **will** result if proper precautions are not taken.



Warning

indicates that death or severe personal injury **may** result if proper precautions are not taken.



Caution

with a safety alert symbol, indicates that minor personal injury can result if proper precautions are not taken.

Caution

without a safety alert symbol, indicates that property damage can result if proper precautions are not taken.

Notice

indicates that an unintended result or situation can occur if the corresponding information is not taken into account.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The device/system may only be set up and used in conjunction with this documentation. Commissioning and operation of a device/system may only be performed by **qualified personnel**. Within the context of the safety notes in this documentation qualified persons are defined as persons who are authorized to commission, ground and label devices, systems and circuits in accordance with established safety practices and standards.

Prescribed Usage

Note the following:



Warning

This device may only be used for the applications described in the catalog or the technical description and only in connection with devices or components from other manufacturers which have been approved or recommended by Siemens. Correct, reliable operation of the product requires proper transport, storage, positioning and assembly as well as careful operation and maintenance.

Trademarks

All names identified by ® are registered trademarks of the Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

Disclaimer of liability

While we have verified the contents of this manual for agreement with the hardware and software described, variations remain possible. Thus we cannot guarantee full agreement. The contents of this manual are regularly reviewed and corrections are included in subsequent editions. We welcome all suggestions for improvement.

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1

1 Introduction

1.1 Safety Manual Revision History

Revision*	Document Part Number	Release Date	Revision Comments
1.0	7ML19985MX01	03/2011	Initial Release
2.0	7ML19985MX02	08/2011	Approval options D and E added; Threaded PVDF antenna process connection added. Firmware Rev. 1.03.03 added.
2.1	7ML19985MX02	10/2011	Updated Section 3.4 Settings and Proof Test in Section 3.6 Maintenance/Testing.
3.0	7ML19985MX03	09/2012	Updated Section 3.4 Settings and 3.7 Safety Characteristics; Firmware Rev. 1.03.04 added.
AA	A5E32286471	01/2014	Updated cover page and section 1.2 to include new models with Flanged Encapsulated Antenna.
AB	A5E32286571	03/2014	Updated cover page and section 1.2 to include new models with Hygienic Encapsulated Antenna.

* See Operating Instructions for additional revision information.

1.2 General

The following table lists all available SITRANS LR250 HART, 4 to 20 mA HART models:

Product Number
7ML5431-xxx00-xxAx-Z C20
7ML5431-xxx00-xxBx-Z C20
7ML5431-xxx00-xxCx-Z C20
7ML5431-xxx00-xxDx-Z C20
7ML5431-xxx00-xxEx-Z C20
7ML5431-xxx20-xxAx-Z C20
7ML5431-xxx20-xxBx-Z C20
7ML5431-xxx20-xxCx-Z C20
7ML5431-xxx20-xxDx-Z C20
7ML5431-xxx20-xxEx-Z C20

7ML5432-xxx20-xxAx-Z C20
7ML5432-xxx20-xxBx-Z C20
7ML5432-xxx20-xxCx-Z C20
7ML5432-xxx20-xxDx-Z C20
7ML5432-xxx20-xxEx-Z C20
7ML5432-xxx20-xxKx-Z C20
7ML5432-xxx20-xxLx-Z C20
7ML5433-xxx20-xxAx-Z C20
7ML5433-xxx20-xxBx-Z C20
7ML5433-xxx20-xxCx-Z C20
7ML5433-xxx20-xxDx-Z C20
7ML5433-xxx20-xxEx-Z C20
7ML5433-xxx20-xxKx-Z C20
7ML5433-xxx20-xxLx-Z C20

The term LR250 HART is used in the following text for all device models.

1.3 Purpose of this document

This document contains information and safety instructions required when using the LR250 HART in safety-instrumented systems.

It is aimed at system planners, plant managers, service and maintenance engineers and personnel who will commission the device.

1.4 Required documentation

This document deals with the “Continuous Radar Measurement – SITRANS LR250 HART” exclusively as part of a safety function. This document only applies in conjunction with the following documentation:

Name	Order No*
Operating Instructions for LR250 HART/mA devices	A5E32220602 (English) A5E32376088 (German)

* Operating Instructions are located at the following web site:
<http://www.siemens.com/level>

1.5 History

This history establishes the correlation between the current documentation and the valid firmware of the device.

This edition of the documentation applies to the following firmware:

Safety Manual Edition	Firmware identification type plate
Rev. 1.0	Firmware Rev. 1.02.03 Firmware Rev. 1.03.02
Rev. 2.0	Firmware Rev. 1.02.03 Firmware Rev. 1.03.02 Firmware Rev. 1.03.03
Rev. 2.1	Firmware Rev. 1.02.03 Firmware Rev. 1.03.02 Firmware Rev. 1.03.03
Rev. 3.0	Firmware Rev. 1.02.03 Firmware Rev. 1.03.02 Firmware Rev. 1.03.03 Firmware Rev. 1.03.04

The most important changes in the documentation when compared with the respective previous edition are given in the following table:

Safety Manual Edition	Comment
Rev. 1.0	Safety manual order #: 7ML19985MX01
Rev. 2.0	Safety manual order #: 7ML19985MX02 Approval options D and E added; Threaded PVDF antenna process connection added Firmware Rev. 1.03.03 added.
Rev. 2.1	Updated Section 3.4 Settings and Proof Test in Section 3.6 Maintenance/Testing.
Rev. 3.0	Safety manual order #: 7ML19985MX03; Added firmware release 1.03.04.
Rev. AA	Added new models for Flanged Encapsulated Antenna.
Rev. AB	Added new models for Hygienic Encapsulated Antenna.

More information

Information

The contents of these instructions shall not become part of or modify any prior or existing agreement, commitment, or legal relationship. All obligations on the part of Siemens AG are contained in the respective sales contract which also contains the complete and solely applicable warranty conditions. Any statements contained herein do not create new warranties or modify the existing warranty.

The content reflects the technical status at the time of printing. We reserve the right to make technical changes in the course of further development.

Siemens regional offices

If you need more information or have particular problems which are not covered sufficiently by the operating instructions, contact your local Siemens Regional Office. You will find the address of your local Siemens Regional Office on the Internet at <https://www.siemens.com/processinstrumentation> under the tab **Contacts and Partners**.

Product information on the Internet

The Operating Instructions are on the supplied CD and are also available on the Siemens Level homepage on the Internet: www.siemens.com/level

On the supplied CD, you will also find the product catalog sheet containing the ordering data, the Device Install software for SIMATIC PDM for subsequent installation, and the generic station description (GSD).

See also

Siemens Regional Offices
(<https://www.siemens.com/processinstrumentation>) under the tab **Contacts and Partners**.

Product information and Operating Instructions on the Internet
(<https://www.siemens.com/level>)

2 General safety instructions

2.1 Safety-instrumented system (SIS)

Description

A safety-instrumented system used to implement one or more safety-instrumented functions. A SIS is composed of any combination of sensor, logic solvers or control systems (PLCs), and final elements.

Control system

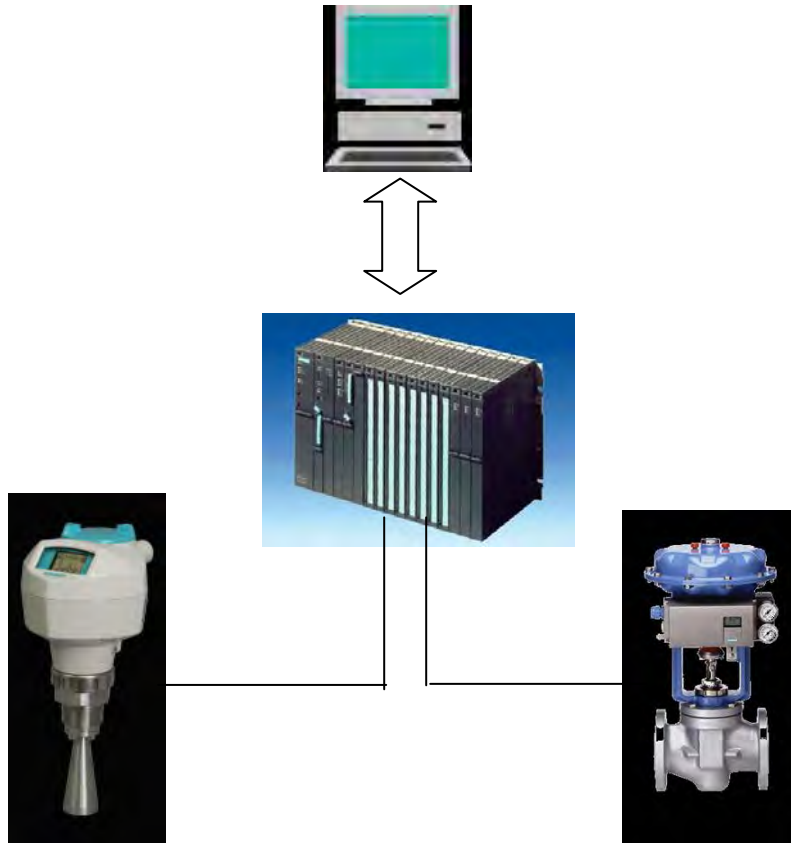


Figure 2-1: Example of a safety-instrumented system

Device operation

The LR250 (HART) is a 2-wire loop-powered, continuous level measuring instrument. The measured level is converted to a 4 to 20 mA signal. The safety PLC monitors the signal to perform a specified action based on the level measurement.

If the safety PLC detects a failure in the measurement device, it generates a failure signal, which brings the valve to the defined safe position.

2.2 Safety Integrity Level (SIL)

Definition: SIL

The international standard IEC 61508 defines four discrete Safety Integrity Levels (SIL) from SIL 1 to SIL 4. Each level corresponds to the probability range for the failure in a safety function.

The higher the level of safety integrity of the safety-related system, the lower the probability that the safety-related system will fail to carry out the required safety function.

The achievable SIL is determined by the following safety characteristics:

- Average probability of dangerous failure of a safety function in case of demand (PFD_{AVG})
- Hardware fault tolerance (HFT)
- Safe failure fraction (SFF)

Description

The following table shows the dependency of the SIL on the “average probability of dangerous failures of a safety function of the entire safety-instrumented system” (PFD_{AVG}). The table deals with “Low demand mode,” i.e. the safety function is required to act a maximum of once per year on average.

Table 2-1 Safety Integrity Level

SIL	PFD_{AVG}
4	$10^{-5} \leq PFD_{AVG} < 10^{-4}$
3	$10^{-4} \leq PFD_{AVG} < 10^{-3}$
2	$10^{-3} \leq PFD_{AVG} < 10^{-2}$
1	$10^{-2} \leq PFD_{AVG} < 10^{-1}$

The “average probability of dangerous failures of the entire safety instrumented system” (PFD_{AVG}) is normally split between the three subsystems in the following figure.

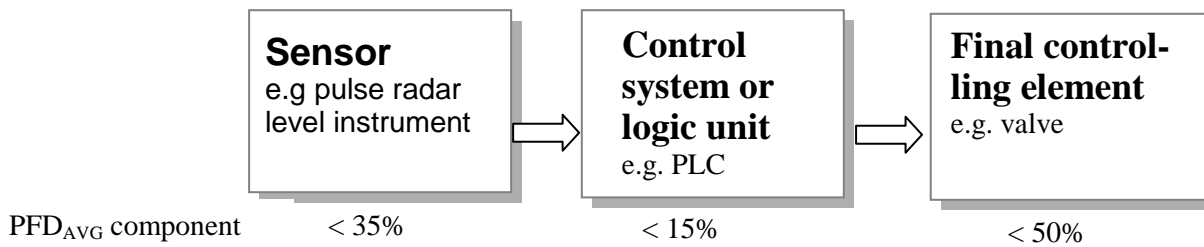


Figure 2-2 Example of PFD distribution

The following table shows the achievable Safety Integrity Level (SIL) for the entire safety-instrumented system for type B subsystems depending on the safe failure fraction (SFF) and the hardware fault tolerance (HFT). Type B subsystems include digital transmitters and shut-off valves with complex components, e.g. microprocessors (see also IEC 61508, *Section 2*).

SFF	HFT		
	0	1 (0) ¹	2 (1) ¹
< 60 %	Not permitted	SIL 1	SIL 2
60 to 90 %	SIL 1	SIL 2	SIL 3
90 to 99 %	SIL 2	SIL 3	SIL 4
> 99 %	SIL 3	SIL 4	SIL 4

¹ As per IEC 61511-1, Section 11.4.4.

According to IEC 61511-1, Section 11.4.4, the hardware fault tolerance (HFT) listed in the table above can be reduced by one (values in brackets) for sensor and final controlling elements with complex components if the following conditions are applicable for the device:

- The device is proven-in-use.
- The user can configure only the process-related parameters, e.g. control range, signal direction in case of a fault, limiting values, etc.
- The configuration level of the firmware is blocked against unauthorized operation.
- The function requires SIL of less than 4.

The device fulfils these conditions.

3 Device-specific safety instructions

3.1 Applications

The LR250 is suitable for use in a safety instrumented function of Safety Integrity Level (SIL) 2 with a low demand mode 1oo1 architecture.

The proven in-use-assessment was carried out by RISKNOLOGY according to IEC 61508 / IEC 61511. Product revisions will be carried out by the manufacturer in accordance with IEC 61508.

3.2 Safety function

Measuring Level is the Safety Function for the SITRANS LR250. The 4 to 20 mA analog output may be used as part of a safety instrumented function (SIF). In addition to the application specific measurement error, an additional safety accuracy of 2% of maximum measurement range (10 m or 20 m, depending on the antenna option) must be added.

Total tolerance (Safety Function) = ± [application specific measuring error + 2% safety accuracy]

Safety Accuracy of the level transmitter: the maximum effect of a single failure on the measured value, which is classified to have no effect.

Warning



The settings and conditions listed in the “*Settings*” and “*Safety characteristics*” sections of this document must be met for the safety function specification to be valid.

If the device detects a failure (by diagnosis), the system must be brought to a safe state, and the device shall be repaired within the Mean Time To Restoration (MTTR). The base of this PFD calculation is a MTTR of 72 hours.

The failure rates, SFF and PFD_{AVG} published in the SIL Declaration of Conformity are only valid for 10 years of operation.

Reference

Required documentation (Chapter 1.4)

See also

Settings (Chapter 3.4)

3.3 Application restrictions

Installation and configuration of the SITRANS LR250 (HART) must be completed following the instructions detailed in the device's Operating Instructions. All application limitations and restrictions described in that manual must be observed. False echo suppression must be enabled and properly configured.

Before being put into service, measurement by the SITRANS LR250 (HART) must be verified as accurate over the entire operating range, from empty to full. This will ensure that the device has been configured properly to avoid measurement error due to obstructions in the tank.

A high level trip point must be separated from the Near Range setting of the device by the "Total tolerance" as defined in section 3.2. If the material reaches the Near Range region an incorrect measurement may occur.

3.4 Settings

After assembly and commissioning in line with the device manual, the following parameter settings shall be made when the device is used as part of a SIF:

Safety parameters

Please enter following parameters via LR250 HART menu:

Parameter	Comment
2.5.2	The Fail-Safe Timer shall be set to $\leq 100s$
2.5.3	User-selected value (defined in 2.5.3 Level) for mA fail safe level. The output current shall be set to ≤ 3.6 mA or ≥ 22.6 mA.
2.6.1	Current Output Function must be set to one of Level, Distance, Space or Volume.
2.8.1	Near Range (defined in 2.8.1 Near Range), for Threaded PVDF antenna configurations 7ML5431-4xxx0-xxxx, FEA Antenna configurations 7ML5432-xxxxx-xxxx, and HEA antenna configurations 7ML5433-xxxxx-xxxx shall be set to ≥ 0.3 m.
2.8.7.1	Set Auto False Echo Suppression according to the Operating Instructions.
5.1	Device Address = 0

Reference

Required documentation (Chapter 1.4)

Protection against configuration changes

After configuration, the LR250 HART must be protected against unwanted and unauthorized changes/operation. Parameter 6.1.1 Access Control, must be set to Read Only (no changes permitted via remote communications) and 6.2.1 Write Protect must be set to “Lock on” (programming not permitted via the handheld programmer).”

Checking the safety function after installation

After installation of the SITRANS LR250 HART, a safety function proof test must be carried out (see *Chapter 3.6*).

When performing this test, measurement must be verified to be within the safety accuracy as defined in section 3.2 of this manual.

3.5 Behavior in case of faults

Fault

The procedure in case of faults is described in the device Operating Instructions.

Repairs

Defective devices should be sent to the Repair Department with details of the fault and the cause. When ordering replacement devices, please specify the serial number of the original device. The serial number can be found on the nameplate.

See also

Services & Support (<https://www.siemens.com/automation/services&support>)

Partner (<https://www.automation.siemens.com/partner>)

3.6 Maintenance/Testing

Interval

We recommend that the functioning of the level transmitter be checked at regular intervals of one year.

Functional test

To ensure the proper operation of the LR250 HART, we recommend that the basic functions of the LR250 HART are tested as described in the Operating Instructions.

Functional safety proof test

To reveal possible undetected faults of the safety function, the entire SIF shall be tested according to IEC 61508 or 61511.

To reveal dangerous undetected faults the LR250 HART analogue output shall be tested using the following procedure:

Step	Action
1	Bypass the safety PLC or take other appropriate action to avoid a false trip.
2	Inspect the product for signs of physical damage/defects or loose parts and replace/repair product as required.
3	Inspect the antenna of the device and verify that no build up of material has occurred. Clean the antenna if necessary according to the Operating Instructions.
4	Generate or simulate an alarm condition to force the LR250 HART to go to the high alarm current output and verify that the analog current reaches that value.
5	Generate or simulate an alarm condition to force the LR250 HART to go to the low alarm current output and verify that the analog current reaches that value.
6	Perform a reference measurement with the material level at minimum and maximum level. The expected result must not deviate from the expected input value by more than the Safety Accuracy as defined in section 3.2 of this manual.
7	Perform a reference measurement with at least one measuring point between min and max level. The expected result must not deviate from the expected input value by more than the Safety Accuracy as defined in section 3.2 of this manual.
8	Restore the loop to full operation.
9	Remove the bypass from the safety PLC or otherwise restore normal operation.

Table 3-1 Steps for Proof Test

The proof test interval (TI) is specified for the failure rate calculation of each individual SIF in a system (PFD_{AVG}). We recommend the Proof Test be performed at least once per year.

The Internet Product Page (www.siemens.com/lr250) will be used to communicate additional Safety Information, and should be checked regularly.

3.7 Safety characteristics

The safety characteristics necessary for use of the system are listed in the declaration of conformity. These values apply under the following conditions:

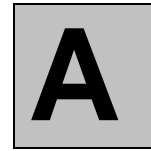
- The LR250 HART is only used in safety-related systems with a low demand mode for the SIF.
- The safety-related parameters/settings (see *Settings* section) have been entered by local operation and checked before commencing safety-instrumented operation.
- The LR250 HART is blocked against unwanted and unauthorized changes / operation.
- The average ambient temperature during the operating time is not greater than 40 °C.
- All used materials are compatible with process conditions.
- The MTTR after a device fault is 72 hours.
- The logic solver (PLC) has to be configured to detect over range (≥ 21 mA) and under range (≤ 3.6 mA) failure of the LR250 HART (Fail High and Fail Low) and will recognize these as internal failure of the device.

See also

Settings (Chapter 3.4)

SIL Declaration of Conformity on the Internet Product Page (www.siemens.com/lr250).
Go to Support > Approvals / Certificates.

A List of Abbreviations/Acronyms



A.1 Abbreviations

Abbreviation	Full term in English	Meaning
FIT	Failures in Time	Failure rates have the dimension one over time. Failure rates are specified in FIT (Failures in Time), ie. the number of failures in 10^9 component hours.
HFT	Hardware Fault Tolerance	Hardware fault tolerance: Capability of a function unit to continue executing a required function in the presence of faults or deviations.
MooN	"M out of N" voting	In terms of redundancy and the selection procedure used: A safety-instrumented system, or part of a system, that consists of "N" independent channels. The channels are connected to each other in such a way that "M" channels are in each case sufficient to perform the safety-instrumented function. Example: Pressure measurement: 1oo2 architecture. A safety instrumented system decides that a specified pressure limit has been exceeded if one out of two pressure sensors reaches this limit. In a 1oo1 architecture, there is only one pressure sensor.
MTBF	Mean Time Between Failures	Average period between two failures.
MTTR	Mean Time To Restoration	Average period between the occurrence of a fault on a device or system and the repair.
PFD	Probability of Failure on Demand	Probability of dangerous failures of a safety function on demand.
PFD _{AVG}	Average Probability of Failure on Demand	Average probability of dangerous failures of a safety function on demand.
PLC	Programmable Logic Controller	
SFF	Safe Failure Fraction	Proportion of safe failures: Proportion of failures without the potential to bring the safety instrumented system into a dangerous or not permissible functional status.
SIF	Safety Instrumented Function	A portion of a safety instrumented system consisting of a sensor, logic solver/PLC and final element used to reduce the risk of occurrence of one hazardous event.
SIL	Safety Integrity Level	The international standard IEC 61508 defines four discrete Safety Integrity Levels (SIL 1 to SIL 4). Each level corresponds to a range of probability for failure of a safety function. The higher the Safety Integrity Level of the safety-instrumented system, the lower the probability that it will not execute the required safety functions.
TI	Proof Test Interval	Interval at which the test to reveal undetected faults is performed.

Glossary

Dangerous failure

Failure with the potential to bring the safety-instrumented system into a dangerous or non-functional status.

Example:

The measurement device reports a value 10% below the actual value, preventing the safety function from acting on a value, which is too high.

Low Demand Mode

The frequency of demands for operation made on a safety related system is no greater than one per year and no greater than twice the proof-test frequency.

Safety function

Defined function of a device or system with the objective of achieving or maintaining a safe state of a system taking into account a defined dangerous occurrence.

Example:

Level/pressure/temperature measurement using 4 to 20 mA output.

Safety Integrity Level

→ SIL

Safety-instrumented system

A safety-instrumented system executes the safety functions that are required to achieve or maintain a safe status in a system. It consists of a sensor, logic solver/ control system (PLC) and final element.

Definition: Safety Instrumented Function (SIF)

A portion of a safety instrumented system consisting of a sensor, logic solver/ control system (PLC) and final element used to reduce the risk of occurrence of one hazardous event.

Example:

A safety PLC will close a valve if the measured value exceeds a specified value.

SIL

The international standard IEC 61508 defines four discrete Safety Integrity Levels (SIL) from SIL 1 to SIL 4. Each level corresponds to the probability range for the failure of a safety function. The higher the SIL of the safety-instrumented system, the higher the probability that the required safety function will work.

The achievable SIL is determined by the following safety characteristics:

- Average probability of dangerous failure of a safety function in case of demand (PFD_{AVG})
- Hardware fault tolerance (HFT)
- Safe failure fraction (SFF)

For more information

www.siemens.com/level

www.siemens.com/weighing

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