



## **Functional Safety and EMI**

**White Paper**

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## Electromagnetic Interference (EMI)

Electromagnetic Interference (EMI) is an important consideration for a Safety-Related System, and IEC 61508 lists two standards with the option of:

- a) testing to higher levels or
- b) specifying installation requirements.

As one of the environmental stresses that can stop a system from performing its safety function, it is important for a functional safety system to be immune from the EMI levels that are likely to be present. Unlike other environmental stresses, like temperature and vibration, EMI is more difficult to sense and is more likely to be transitory. Still, the effects can be catastrophic.

EMI can take many forms: motor switching, lightning strikes, and the use of handheld radios/cell phones. The standards for EMI use terms like surge, transient, and electromagnetic fields for these stresses.

## Immunity Requirements

IEC 61508-2 addresses EMI with electromagnetic immunity requirements. Clause 7.2.3.3.f states that the design requirements shall contain details about the required EMI levels. Clause 7.3.2.2.f states that the validation planning shall consider EMI performance criteria to be applied. Table A.16 lists techniques and measures to control systematic failures caused by environmental stress or influences and it has an entry about increasing interference immunity. For SIL2, low effectiveness measures are needed; for SIL3, medium effectiveness measures are needed. Guidance on the effectiveness of the measures to be used is listed in Table A.18. Both tables refer to IEC 61508-7 section A.11.3, where there is a note about two EMI standards for immunity requirements for safety-related systems and equipment performing safety-related functions. They are:

- IEC 61326-3-1, Functional Safety in General Industrial Applications
- IEC 61326-3-2, Functional Safety in Industrial Applications with Specified EMI Environment

Each of these two standards first requires meeting EMI standard IEC 61326-1, which applies to electrical equipment for measurement, control, and laboratory use. IEC 61326-1 deals with general requirements and the broader term Electromagnetic Compatibility (EMC). EMC includes limits on the emission of the interference, not just the immunity from the interference. When discussing Functional Safety, immunity is key.

## Electromagnetic Environment

The decision to use IEC 61326-3-1 or IEC 61326-3-2 depends on how much attention is given to the electromagnetic environment. Annex A of IEC 61326-3-1 explains the difference between IEC 61326-3-1 and 61326-3-2 as follows:

"There are basically two approaches on how to deal with the electromagnetic environments and to [determine] immunity requirements.

- (A) To consider a general electromagnetic environment with no specific restrictions, for example an industrial environment, and to take into account all the electromagnetic phenomena that can occur as well as their maximum amplitudes when deriving appropriate immunity levels for the system and the equipment. This approach has been used to determine the levels specified within [IEC 61326-3-1] leading to increased immunity levels for some electromagnetic phenomena compared to immunity levels which are derived without functional safety considerations.
- (B) To control the electromagnetic environment, for example by the application of particular installation and mitigation practices, in such a way that electromagnetic phenomena and their amplitudes could occur only to a certain extent. These phenomena and restricted amplitudes are then taken into account by appropriate immunity levels. These levels are not necessarily higher than those derived without functional safety considerations because it is ensured by corresponding means that higher amplitudes are not normally expected. This approach is considered in this part of IEC 61326-3-2."

Annex C in IEC 61326-3-2 has examples of criteria for specifying the environment. They include limiting the use of mobile transmitters, periodic maintenance to prevent corrosion of cable shields, and installation guidelines that explain shielding and ground bonding in detail. The test levels are lower for equipment used in a controlled electromagnetic environment. If IEC 61326-3-2 and the lower test levels are used, the Safety Manual must list the installation criteria that a user must follow.

## Performance Criteria

Performance Criteria DS is given for functions of the safety applications in section 6 of IEC 61326-3-1 and IEC 61326-3-2. Performance Criteria A, B and C are defined in IEC 61326-1, however IEC 61326-3-1 only applies criteria DS as appropriate for functional safety. IEC 61326-3-2 allows for criteria A or DS but states that criteria B and C are not appropriate for functional safety. This means that Performance Criteria DS must be defined for the system prior to testing (see item [2]) below). According to IEC 61326-3-1, performance criterion is listed in clause 6.1:

"a) the functions of the EUT (Equipment Under Test) intended for use in safety applications

- 1) Are not affected outside their specification, or
- 2) May be affected temporarily or permanently (even by destruction of components), if the EUT reacts to a disturbance in a way that a detectable and defined state(s) of the EUT is (are)
  - a. Maintained, or

b. Achieved within a stated time

b) The functions not intended for use in safety applications may be disturbed temporarily or permanently.

NOTE 1: It is possible for the defined state to be outside normal operating limits.”

EMI test criteria can be selected from the table below, however the appropriate standards should be the determining factor.

## Comparison of EMC Standards that Apply to Functional Safety, Sep-2019

Note: per CISPR and FCC Part 15 requirements, most industrial equipment will be in Class A; most residential equipment will be in Class B.

Standard --->	<b>IEC 61326-1:2012</b> General Requirements for Class A equip, Industrial environment	<b>IEC 61326-3-1:2017</b> Functional Safety Industrial Locations (must test per IEC 61326-1 first)	<b>IEC 61326-3-2:2017</b> Functional Safety Industrial Locations with Specified EM Environment (must test per IEC 61326-1 first)
Phenomenon —			
Electromagnetic Field Enclosure port 61000-4-3	CISPR 11:2009, Clause 5 is cited; however the latest version is CISPR 11:2015+A1:2016 +A2:2019  10 V/m (80 MHz to 1 GHz, 3 V/m (1.4 GHz to 2 GHz, 1 V/m (2 GHz to 2.7 GHz, (consider up to 6 GHz) at reduced levels  -use performance criteria A	20 V/m (80 MHz to 1 GHz, 1 kHz (80 % AM) ) <sup>c</sup> 10 V/m (1.4 GHz to 2 GHz, 1 kHz (80 % AM) ) <sup>c</sup> 3 V/m (2 GHz to 6 GHz, 1 kHz (80 % AM) ) <sup>c</sup>  -use performance criteria DS	10 V/m (80 MHz to 1 GHz, 1 kHz (80 % AM) ) 10 V/m (1.4 GHz to 2 GHz, 1 kHz (80 % AM) ) 3 V/m (2 GHz to 2.7 GHz, 1 kHz (80 % AM) )  3 V/m (2.7 GHz to 6 GHz, 1 kHz (80 % AM) ) if required by application  -use performance criteria A
Conducted RF Power & I/O signal ports 61000-4-6	Class A equip: CISPR 11:2009, Clause 5 is cited; however the latest version is: CISPR 11:2015+A1:2016 +A2:2019  -use performance criteria A	10 V (150 kHz to 80 MHz, 1 kHz (80% AM) ) <sup>d</sup>  -use performance criteria DS	Power ports, earth port, and signal lines > 3 meters long: 10 V (150 kHz to 80 MHz, 1 kHz (80% AM) ) <sup>d</sup>  -use performance criteria A
Power frequency magnetic field 61000-4-8 *only for applicable devices susceptible to magnetic fields	30 A/m  -use performance criteria A	30 A/m  -use performance criteria DS	100 A/m  -use performance criteria A
Electrostatic Discharge (ESD) 61000-4-2	Contact discharge @ ±4 kV Air discharge @ ±8 kV -use performance criteria B	Contact discharge @ ±6 kV <sup>a,b</sup> Air discharge @ ±8 kV <sup>a,b</sup> performance criteria DS	Contact discharge @ ±6 kV <sup>a,b</sup> Air discharge @ ±8 kV <sup>a,b</sup> performance criteria A or DS

a) applied with conditions in IEC 61000-4-2 on parts accessible by untrained persons, but not to equipment with limited access by trained persons.

- b) For equipment intended to be used in SIL 3 applications, the number of discharges at the highest level shall be increased by a factor of 3 compared to the number as given in the basic standard.
- c) These test values shall be applied in frequency ranges as given in IEC 61326-3-1 Table 8. ISM frequencies shall be taken into account on an individual basis.
- d) These test values shall be applied in frequency ranges as given in IEC 61326-3-1 Table 9. ISM frequencies shall be taken into account on an individual basis.
  - performance criteria A: during test, normal performance within specified limits
  - performance criteria B: during test temporary degradation, loss of function or performance; self-recovering after test
  - performance criteria DS: safety functions not affected outside their specification, or may be disturbed if reaction is a detectable, defined state within a stated time. (See IEC 61326-3-1 section 6.2 for complete definition. See Annex B for Allowed effects during immunity tests.)

## Revision History:

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## *exida – Who we are.*

exida is one of the world's leading accredited certification and knowledge companies specializing in automation system cybersecurity, safety, and availability. Founded in 2000 by several of the world's top reliability and safety experts, exida is a global company with offices around the world. exida offers training, coaching, project-oriented consulting services, standalone and internet-based safety and cybersecurity engineering tools, detailed product assurance and certification analysis, and a collection of online safety, reliability, and cybersecurity resources. exida maintains a comprehensive failure rate and failure mode database on electrical and mechanical components, as well as automation equipment based on hundreds of field failure data sets representing over 350 billion unit operating hours.

exida Certification is an ANSI (American National Standards Institute) accredited independent certification organization that performs functional safety (IEC 61508 family of standards) and cybersecurity (IEC 62443 family of standards) certification assessments.

exida Engineering provides the users of automation systems with the knowledge to cost-effectively implement automation system cybersecurity, safety, and high availability solutions. The exida team will solve complex issues in the fields of functional safety, cybersecurity, and alarm management, like unique voting arrangement analysis, quantitative consequence analysis, or rare event likelihood analysis, and stands ready to assist when needed.

### ***Training***

exida believes that safety, high availability, and cybersecurity are achieved when more people understand the topics. Therefore, exida has developed a successful training suite of online, on-demand, and web-based instructor-led courses and on-site training provided either as part of a project or by standard courses. The course content and subjects range from introductory to advanced. The exida website lists the continuous range of courses offered around the world.

### ***Knowledge Products***

exida Innovation has made the process of designing, installing, and maintaining a safety and high availability automation system easier, as well as providing a practical methodology for managing cybersecurity across the entire lifecycle. Years of experience in the industry have allowed a crystallization of the combined knowledge that is converted into useful tools and documents, called knowledge products. Knowledge products include procedures for implementing cybersecurity, the Safety Lifecycle tasks, software tools, and templates for all phases of design.

## **Tools and Products for End User Support**

- exSILentia® – Integrated Safety Lifecycle Tool
  - PHAx™ (Process Hazard Analysis)
  - LOPAx™ (Layer of Protection Analysis)
  - SILAlarm™ (Alarm Management and Rationalization)



excellence in dependable automation

- SILect™ (SIL Selection and Layer of Protection Analysis)
- Process SRS (PHA based Safety Requirements Specification definition)
- SILver™ (SIL verification)
- Design SRS (Conceptual Design based Safety Requirements Specification definition)
- Cost (Lifecycle Cost Estimator and Cost Benefit Analysis)
- PTG (Proof Test Generator)
- SILstat™ (Life Event Recording and Monitoring)
- exSILentia® Cyber- Integrated Cybersecurity Lifecycle Tool
  - CyberPHAx™ (Cybersecurity Vulnerability and Risk Assessment)
  - CyberSL™ (Cyber Security Level Verification)

### ***Tools and Products for Manufacturer Support***

- FMEDAx (FMEDA tool including the exida EMCRH database)
- ARCHx (System Analysis tool; Hardware and Software Failure, Dependent Failure, and Cyber Threat Analysis)

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