IEC 61800-5-3

Edition 1.0 2021-02

INTERNATIONAL STANDARD

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Adjustable speed electrical power drive systems – Part 5-3: Safety requirements – Functional, electrical and environmental requirements for encoders

Entraînements électriques de puissance à vitesse variable – Partie 5-3: Exigences de sécurité – Exigences fonctionnelle, électrique et environnementale pour codeurs

IEC 61800-5-3:2021-02(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 13.110; 29.130.99; 29.200

ISBN 978-2-8322-9400-0

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS –

Part 5-3: Safety requirements – Functional, electrical and environmental requirements for encoders

FOREWORD

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The text of this International Standard is based on the following documents:

FDIS	Report on voting
22G/431/FDIS	22G/434/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

Terms in *italics* are defined in Clause 3.

A list of all parts in the IEC 61800 series, published under the general title *Adjustable speed electrical power drive systems*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
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INTRODUCTION

As a result of automation, demand for increased production and reduced operator physical effort, control systems of machinery and plant items play an increasing role in the achievement of overall safety. These control systems increasingly employ complex electrical/electronic/programmable electronic devices and systems.

Prominent amongst these devices and systems are *encoder* which are for example applied to measure angle and position of machine parts for use in safety-related applications (*Encoder(SR)*). Based on the *Encoder(SR)'s* output signals, *PDS(SR)* or other *evaluation units* calculate for example speed, acceleration, absolute position, etc., to perform their safety sub-functions SLS, SLA, SLP and others (see IEC 61800-5-2:2016, Clause 4). The *signal processing* necessary to perform some of these *safety sub-functions* may also be included in the *Encoder(SR)*.

Examples of industrial applications are:

- machine tools, robots, production test equipment, test benches;
- papermaking machines, textile production machines, calendars in the rubber industry;
- plastics processing lines, chemicals or metal production lines, rolling-mills;
- cement crushing machines, cement kilns, mixers, centrifuges, extrusion machines;
- drilling machines;
- conveyors, materials handling machines, hoisting equipment (cranes, gantries, etc.);
- pumps, fans, etc.

This document can also be used as a reference for developers using *Encoder(SR)* for other applications, for example in wind power plants.

Users of this document should be aware that some type C standards for machinery currently refer to ISO 13849-1 for safety-related control systems. In this case, *Encoder(SR)* manufacturers may be requested to provide further information (e.g. category and *performance level PL*) to facilitate the integration of an *Encoder(SR)* into the safety-related control systems of such machinery. This has been considered during development of this document and corresponding indications are included where appropriate.

NOTE "Type C standards" are defined in ISO 12100 [1] as machine safety standards dealing with detailed safety requirements for a particular machine or group of machines.

There are many situations where control systems that incorporate *Encoder(SR)* are employed, for example as part of safety measures that have been provided to achieve risk reduction. A typical case is reducing the speed during start-up in order to protect personnel from hazards arising by unexpected fast movements of machine parts. This document gives a methodology to identify the contribution made by an *Encoder(SR)* to identified safety *sub-functions* and to enable the appropriate design of the *Encoder(SR)* and verification that it achieves the required performance.

Measures are given to co-ordinate the safety performance of the *Encoder(SR)* with the intended risk reduction taking into account the probabilities and consequences of its random and systematic *faults*.

ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS –

Part 5-3: Safety requirements – Functional, electrical and environmental requirements for encoders

1 Scope

This part of IEC 61800, which is a product standard, specifies requirements and makes recommendations for the design and development, integration and validation of safety-related *encoder* (*Encoder(SR)*) in terms of their *functional safety* considerations, electrical safety and environmental conditions. It applies to *Encoder(SR)*, being sensors as part of a *PDS(SR)*.

NOTE 1 The term "integration" refers to the *Encoder(SR)* itself, not to its incorporation into the safety-related application.

This document can also be referred to and used for *Encoder(SR)* in any other safety-related application, for example safety-related position monitoring.

NOTE 2 This document specifies only complementary *functional safety*, electrical safety and environmental condition requirements that are not clearly provided by other parts of the IEC 61800 series.

This document is applicable where *functional safety* of an *encoder* is claimed and the *Encoder(SR)* is operating mainly in the high demand or continuous mode.

NOTE 3 While low demand mode operation is possible for an *Encoder(SR)*, this document concentrates on high demand and continuous mode. *Safety sub-functions* implemented for high demand or continuous mode can also be used in low demand mode. Requirements for low demand mode are given in IEC 61508 (all parts) [2]. Some guidance for the estimation of average probability of *dangerous failure* on demand (PFD_{avg}) value is provided in IEC 61800-5-2:2016, Annex F.

The requirements of IEC 61800-5-2:2016 for *PDS(SR)* apply to *Encoder(SR)* as applicable. This document includes additional or different requirements for *Encoder(SR)*. It sets out safety-related considerations of *Encoder(SR)* in terms of the framework of IEC 61508 (all parts), and introduces requirements for *Encoder(SR)* as subsystems of a safety-related system. It is intended to facilitate the realisation of the electrical/electronic/programmable electronic (E/E/PE) and mechanical parts of an *Encoder(SR)* in relation to the safety performance of *safety sub-function*(s) of an *Encoder(SR)*.

Manufacturers and suppliers of *Encoder(SR)* will, by using the normative requirements of this document, indicate to users (system integrator, original equipment manufacturer) the safety performance of the *Encoder(SR)*. This will facilitate the incorporation of *Encoder(SR)* into safety-related control systems using the principles of IEC 61508 (all parts), and possibly its specific sector implementations (for example IEC 61511 (all parts) [3], IEC 61513 [4], IEC 62061 [5] or ISO 13849-1 and ISO 13849-2 (see Clause 2).

By applying the requirements from this document, the corresponding requirements of IEC 61508 (all parts) that are necessary for an *Encoder(SR)* are fulfilled.

This document does not specify requirements for:

- the functional properties of an *Encoder(SR)* without any safety relevance;
- the *hazard* and risk analysis of a particular application;
- the identification of *safety sub-functions* for that application;
- the initial allocation of *SIL*s to those *safety sub-functions*;
- the driven equipment except for interface arrangements;

- secondary *hazard*s (for example from failure in a production or manufacturing process);
- the *Encoder(SR)* manufacturing process;
- the validity of signals and commands to the *Encoder(SR)*; and
- security aspects (e.g. cyber security or *Encoder(SR)* security of access).

NOTE 4 The *functional safety* requirements of an *Encoder(SR)* are dependent on the application, and can be considered as a part of the overall risk assessment of the installation. Where the supplier of the *Encoder(SR)* is not responsible for the driven equipment, the installation designer is responsible for the risk assessment, and for specifying the functional and safety integrity requirements of the *Encoder(SR)*.

This document applies to *Encoder(SR)* implementing *safety sub-functions* with a *SIL* not greater than *SIL* 3.

This document provides additional information for *Encoder(SR)* claiming conformity with ISO 13849-1:2015.

Figure 1 shows the installation and the functional parts of a *PDS(SR)* including the *Encoder(SR)* (sensor) which is considered in this document.

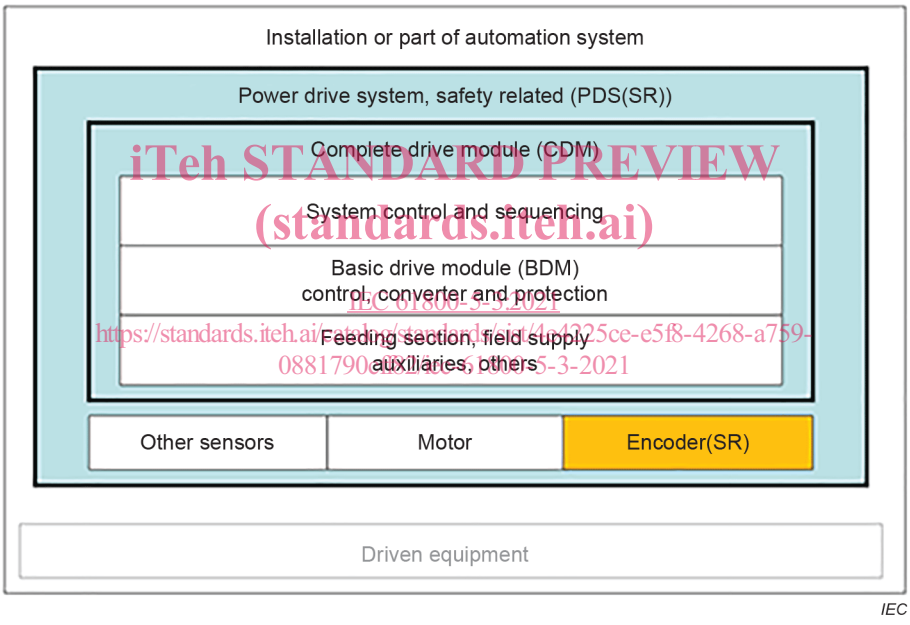

Figure 1 – Context of *Encoder(SR)*

Figure 1 shows a logical representation of a *PDS(SR)* rather than its physical description.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-47, *Environmental testing – Part 2-47: Tests – Mounting of specimens for vibration, impact and similar dynamic tests*

IEC 60335-1, *Household and similar electrical appliances – Safety – Part 1: General requirements*

IEC 60947-5-2:2019, *Low-voltage switchgear and controlgear – Part 5-2: Control circuit devices and switching elements – Proximity switches*

IEC 61000-6-7:2014, *Electromagnetic compatibility (EMC) – Part 6-7: Generic standards – Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations*

IEC 61508-2:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems*

IEC 61800-1:1997, *Adjustable speed electrical power drive systems – Part 1: General requirements – Rating specifications for low voltage adjustable speed d.c. power drive systems*

IEC 61800-5-1:2007, *Adjustable speed electrical power drive systems – Part 5-1: Safety requirements – Electrical, thermal and energy*
IEC 61800-5-1:2007/AMD1:2016

IEC 61800-5-2:2016, *Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional*

IEC 62368-1:2018, *Audio/video, information and communication technology equipment – Part 1: Safety requirements*

ISO 13849-1:2015, *Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design*

ISO 13849-2:2012, *Safety of machinery – Safety-related parts of control systems – Part 2: Validation*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

Table 1 shows a list of terms and definitions.

Table 1 – List of terms

3.1	*encoder*	3.19	*functional safety* *FS*
3.2	*Encoder(SR)*	3.20	*safety function*
3.3	*interface unit*	3.21	*safety sub-function*
3.4	*evaluation unit*	3.22	*fault*
3.5	*PDS(SR)*	3.23	*dangerous failure*
3.6	*tolerance range*	3.24	*hardware fault tolerance* *HFT*
3.7	*interpolation*	3.25	*single-fault tolerance*
3.8	*solid measure*	3.26	*safety integrity level* *SIL*
3.9	*mechanical fastening*	3.27	*SIL capability*
3.10	*mechanical connecting element*	3.28	*performance level* *PL*
3.11	*shaft-rotor coupling*	3.29	*diagnostic coverage* *DC*
3.12	*stator coupling*	3.30	*safe failure fraction* *SFF*
3.13	*bearing blockage*	3.31	*average frequency of a dangerous failure* *PFH*
3.13.1	*spontaneous bearing blockage*	3.32	*mean time to dangerous failure* *$MTTF_D$*
3.13.2	*gradual bearing blockage*	3.33	*process safety time*
3.14	*measurement point for working temperature*	3.34	*ideal fault detection*
3.15	*working temperature range*	3.35	*quantitative FMEDA*
3.16	*extra low voltage* *ELV*	3.36	*qualitative FMEDA*
3.17	*protective ELV circuit* *PELV circuit*	3.37	*signal evaluation*
3.18	*decisive voltage class* *DVC*	3.38	*signal processing*

3.1
encoder
electromechanical device that generates an analogue or digital output signal in response to the position of a moveable part

Note 1 to entry: Within this document, the definition of "*encoder*" includes resolvers and all types of motor feedback sensors.

Note 2 to entry: Annex A includes examples of type of *encoder*.

3.2
Encoder(SR)
encoder providing *safety sub-function(s)*

Note 1 to entry: The *safety sub-function(s)* of the *Encoder(SR)* allow(s) execution of safety sub-functions of a *PDS(SR)* or any other safety application.

Note 2 to entry: This definition has been derived from IEC 61800-5-2:2016, 3.16.

3.3
interface unit
separate electronic subassembly of the *Encoder(SR)* for signal conversion