



UL 60947-5-2

STANDARD FOR SAFETY

Low-Voltage Switchgear and
Controlgear – Part 5-2: Control Circuit
Devices and Switching Elements –
Proximity Switches

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UL Standard for Safety for Low-Voltage Switchgear and Controlgear – Part 5-2: Control Circuit Devices and Switching Elements – Proximity Switches, UL 60947-5-2

Fourth Edition, Dated March 31, 2022

Summary of Topics

Adoption of Edition 3.1 of IEC 60947-5-2, Standard for Low-Voltage Switchgear and Controlgear – Part 5-2: Control Circuit Devices and Switching Elements – Proximity Switches, as the Fourth Edition of ANSI/UL 60947-5-2.

This standard is an adoption of IEC 60947-5-2, Edition 3.0, issued May 2007 and amendment 1, issued 2012. Please note that the National Difference document incorporates all of the U.S. national differences for UL 60947-5-2.

The requirements are substantially in accordance with Proposal(s) on this subject dated February 7, 2020 and September 27, 2021.

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CSA Group
CSA C22.2 No. 60947-5-2:22
Second Edition
(IEC 60947-5-2:2007+A1:2012, MOD)



Underwriters Laboratories Inc.
UL 60947-5-2
Fourth Edition

Low-Voltage Switchgear and Controlgear – Part 5-2: Control Circuit Devices and Switching Elements – Proximity Switches

March 31, 2022

This national standard is based on IEC 60947-5-2, edition 3 (2007), consolidated with amendment 1 (2012).

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ANSI/UL 60947-5-2:2022



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This ANSI/UL Standard for Safety consists of the Fourth Edition. The most recent designation of ANSI/UL 60947-5-2 as an American National Standard (ANSI) occurred on March 31, 2022. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface. The National Difference Page and IEC Foreword are also excluded from the ANSI approval of IEC-based standards.

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CONTENTS

Preface	7
NATIONAL DIFFERENCES	9
FOREWORD	11
1 General	13
1DV Modification of Clause 1 by adding the following:	13
1.1 Scope and object	13
1.1DV Modification of 1.1 by adding the following:	14
1.2 Normative references	14
1.2DV Modification of 1.2 by adding the following:	15
2 Definitions	15
2.1 Basic definitions	17
2.2 Parts of a proximity switch	19
2.3 Operation of a proximity switch	20
2.4 Switching element characteristics	23
3 Classification	27
3.1 Classification according to sensing means	27
3.2 Classification according to the mechanical installation	27
3.3 Classification according to the construction form and size	27
3.4 Classification according to switching element function	27
3.5 Classification according to type of output	27
3.6 Classification according to method of connection	27
4 Characteristics	27
4.1 Summary of characteristics	27
4.2 Operating conditions	28
4.3 Rated and limiting values for the proximity switch and switching element(s)	31
4.4 Utilization categories for the switching element	33
4.4DV Modification of 4.4 by replacing it with the following:	33
5 Product information	33
5.1 Nature of information – Identification	33
5.1DV Modification of 5.1 by adding the following:	34
5.2 Marking	35
5.3 Instructions for installation, operation and maintenance	36
6 Normal service, mounting and transport conditions	36
6.1 Normal service conditions	36
6.2 Conditions during transport and storage	37
6.3 Mounting	37
7 Constructional and performance requirements	37
7.1 Constructional requirements	37
7.2 Performance requirements	42
7.3 Physical dimensions	53
7.4 Shock and vibration	53
8 Tests	54
8.1 Kinds of tests	54
8.2 Compliance with constructional requirements	55
8.3 Performances	55
8.4 Testing of operating distances	67
8.5 Testing for the frequency of operating cycles	71
8.6 Verification of the electromagnetic compatibility	76
8.7 Test results and test report	78

Annex A (informative) Typical dimensions and operating distances of proximity switches

A.1	(IA) Dimensions	79
A.2	(IA) Rated operating distances	80
A.3	(IA) Installation (mounting)	80
A.4	(IA) Frequency of operating cycles (f) in operating cycles per second – Minimum requirements	81
A.1	(IB) Dimensions	82
A.2	(IB) Rated operating distances	82
A.3	(IB) Installation (mounting)	83
A.4	(IB) Frequency of operating cycles (f) in operating cycles per second – Minimum requirements	83
A.1	(IC) Dimensions	84
A.2	(IC) Rated operating distance	87
A.3	(IC) Installation (mounting)	87
A.4	(IC) Frequency of operating cycles (f) in operating cycles per second – Minimum requirements	89
A.1	(ID) Dimensions	90
A.2	(ID) Rated operating distance	90
A.3	(ID) Installation (mounting)	91
A.4	(ID) Frequency of operating cycles (f) in operating cycles per second – Minimum requirements	91
A.1	(CA) Dimensions	92
A.2	(CA) Rated operating distance (s_n)	93
A.3	(CA) Installation (mounting)	93
A.4	(CA) Frequency of operating cycles (f)	93
A.1	(CC) Dimensions	94
A.2	(CC) Rated operating distances (s_n)	95
A.3	(CC) Installation (mounting)	96
A.4	(CC) Frequency of operating cycles (f)	96
A.1	(CD) Dimensions	97
A.2	(CD) Rated operating distance (s_n)	97
A.3	(CD) Installation (mounting)	97
A.4	(CD) Frequency of operating cycles (f)	98
A.1	(UA) Dimensions	99
A.2	(UA) Sensing range	100
A.3	(UA) Installation (mounting)	100
A.4	(UA) Frequency of operating cycles (f)	100
A.1	(UC) Dimensions	101
A.2	(UC) Sensing range	101
A.3	(UC) Installation (mounting)	102
A.4	(UC) Frequency of operating cycles (f)	102
A.1	(UD) Dimensions	103
A.2	(UD) Sensing range	103
A.3	(UD) Installation (mounting)	104
A.4	(UD) Frequency of operating cycles (f)	104

Annex B (normative) Class II proximity switches insulated by encapsulation – Requirements and tests

B.1	General	105
B.2	Definitions	105
B.5	Marking	105
B.7	Constructional and functional requirements	106
	B.7.1 Choice of compound	106
	B.7.2 Adhesion of the compound	106

B.7.3 Dielectric properties.....	106
B.8 Tests.....	107
B.8.1 Kind of tests.....	107

Annex C (normative) Additional requirements for proximity switches with integrally connected cables

C.1 General.....	109
C.2 Definitions.....	109
C.7 Constructional and performance requirements.....	109
C.7.1 Constructional requirements.....	109
C.7.2 Performance requirements.....	111
C.8 Tests.....	111
C.8.1 Type tests.....	111
C.8.2 Results to be obtained.....	114
C.8.2DV Modification of C.8.2 by adding the following:.....	114

Annex D (normative) Integral connectors for plug-in proximity switches

Annex E (normative) Additional requirements for proximity switches suitable for use in strong magnetic fields

E.1 General.....	120
E.1.2 Scope and object.....	120
E.2 Definitions.....	120
E.3 Classification.....	120
E.3.7 Classification according to the type of the influencing magnetic field.....	120
E.7 Construction and performance requirements.....	121
E.8 Tests.....	121
E.8.9 Verification of immunity.....	121

Annex F (informative) Symbols for proximity switches

Annex DVA (normative) Normative and informative content

Annex DVA Addition: Add Annex DVA as follows:.....	127
--	-----

Annex DVB (normative) Standard references

Annex DVB Addition: Add Annex DVB as follows:.....	130
--	-----

Annex DVC (normative) Standards for components

Annex DVC Addition: Add Annex DVC as follows:.....	132
--	-----

Annex DVD (normative) Clearance and creepage distances for control circuit devices and switching elements

Annex DVD Addition:.....	133
--------------------------	-----

No Text on This Page

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Preface

This is the harmonized CSA Group and UL standard for Low-voltage switchgear and controlgear – Part 5-2: Control circuit devices and switching elements – Proximity switches. It is the second edition of CSA C22.2 No. 60947-5-2, and the fourth edition of UL 60947-5-2. This edition of CSA C22.2 No. 60947-5-2 supersedes the previous edition published in 2014 as CAN/CSA-C22.2 No. 60947-5-2.

This harmonized standard is based on IEC Publication 60947-5-2: Edition 3.1, Low-voltage switchgear and controlgear – Part 5-2: Control circuit devices and switching elements – Proximity switches, issued September 2012. IEC 60947-5-2 is copyrighted by the IEC.

This harmonized standard was prepared by CSA Group and Underwriters Laboratories Inc. (UL). The efforts and support of the Technical Harmonization Committee for Industrial Control Equipment, of the Council on the Harmonization of Electrotechnical Standards of the Nations of the Americas (CANENA), are gratefully acknowledged.

This standard is considered suitable for use for conformity assessment within the stated scope of the standard.

This standard was reviewed by the CSA Integrated Committee on Industrial Control, under the jurisdiction of the CSA Technical Committee on Industrial Products and the CSA Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committee. This standard has been developed in compliance with Standards Council of Canada requirements for National Standards of Canada. It has been published as a National Standard of Canada by CSA Group.

Application of Standard

Where reference is made to a specific number of samples to be tested, the specified number is considered a minimum quantity.

Note: Although the intended primary application of this Standard is stated in its scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.

CSA C22.2 No. 60947-5-2 is to be used in conjunction with the current edition of CSA C22.2 No. 60947-1. Requirements of this standard, where stated, amend the requirements of CSA C22.2 No. 60947-1.

UL 60947-5-2 is to be used in conjunction with the current edition of UL 60947-1. Requirements of this standard, where stated, amend the requirements of UL 60947-1.

Level of harmonization

This standard adopts the IEC text with national differences.

This standard is published as an identical standard for CSA Group and UL.

An identical standard is a standard that is exactly the same in technical content except for national differences resulting from conflicts in codes and governmental regulations. Presentation is word for word except for editorial changes.

All national differences from the IEC text are included in the CSA Group and UL versions of the standard. While the technical content is the same in each organization's version, the format and presentation may differ.

Reasons for differences from IEC

National differences from the IEC are being added in order to address safety and regulatory situations present in the US and Canada.

Interpretations

The interpretation by the standards development organization of an identical or equivalent standard is based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

IEC copyright

For CSA Group, the text, figures, and tables of International Electrotechnical Commission Publication 60947-5-2, Low-voltage switchgear and controlgear – Part 5-2: Control circuit devices and switching elements – Proximity switches, copyright 2012, are used in this Standard with the consent of the International Electrotechnical Commission. The IEC Foreword is not a part of the requirements of this Standard but is included for information purposes only.

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NATIONAL DIFFERENCES

GENERAL

National Differences from the text of International Electrotechnical Commission (IEC) Publication 60947-5-2, Low-voltage switchgear and controlgear – Part 5-2: Control circuit devices and switching elements – Proximity switches, copyright 2012, are indicated by notations (differences) and are presented in bold text. The national difference type is included in the body.

There are five types of National Differences as noted below. The difference type is noted on the first line of the National Difference in the standard. The standard may not include all types of these National Differences.

DR – These are National Differences based on the **national regulatory requirements**.

D1 – These are National Differences which are based on **basic safety principles and requirements**, elimination of which would compromise safety for consumers and users of products.

D2 – These are National Differences from IEC requirements based on existing **safety practices**. These requirements reflect national safety practices, where empirical substantiation (for the IEC or national requirement) is not available or the text has not been included in the IEC standard.

DC – These are National Differences based on the **component standards** and will not be deleted until a particular component standard is harmonized with the IEC component standard.

DE – These are National Differences based on **editorial comments or corrections**.

Each national difference contains a description of what the national difference entails. Typically one of the following words is used to explain how the text of the national difference is to be applied to the base IEC text:

Addition / Add - An addition entails adding a complete new numbered clause, subclause, table, figure, or annex. Addition is not meant to include adding select words to the base IEC text.

Modification / Modify - A modification is an altering of the existing base IEC text such as the addition, replacement or deletion of certain words or the replacement of an entire clause, subclause, table, figure, or annex of the base IEC text.

Deletion / Delete - A deletion entails complete deletion of an entire numbered clause, subclause, table, figure, or annex without any replacement text.

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FOREWORD

INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR – Part 5-2: Control circuit devices and switching elements – Proximity switches

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

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8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

This consolidated version of IEC 60947-5-2 consists of the third edition (2007) [documents 17B/1570/FDIS and 17B/1576/RVD] and its amendment 1 (2012) [documents 17B/1733/CDV and 17B/1774/RVC]. It bears the edition number 3.1.

The technical content is therefore identical to the base edition and its amendment and has been prepared for user convenience.

International Standard IEC 60947-5-2 has been prepared by subcommittee 17B: Low-voltage switchgear and controlgear, of IEC technical committee 17: Switchgear and controlgear.

The document 17B/1570/FDIS, circulated to the National Committees as Amendment 3, led to the publication of the new edition.

The main changes with respect to the previous edition are as follows:

- modification of Table 3;
- modifications of voltage dips and voltage interruptions immunity tests, in Table 8;
- modification of status of Annex A, now informative.

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

A list of all the parts in the IEC 60947 series, under the general title *Low-voltage switchgear and controlgear*, can be found on the IEC website.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The “colour inside” logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

DV.1 DE Modification of the IEC Foreword by adding the following:

The numbering system in the standard uses a space instead of a comma to indicate thousands and uses a comma instead of a period to indicate a decimal point. For example, 1 000 means 1,000 and 1,01 means 1.01.

DV.2 D2 Modification of the IEC Foreword by adding the following:

This standard shall be read in conjunction with Canadian and United States equivalent standards to the IEC 60947 series per [Table DVB.2](#). Where specifically called for, any reference to IEC 60947-5-2 or IEC 60947-1 shall be to the applicable clause – either the national difference “DV” clause or IEC clause, or a reference to the applicable standard listed in the Annex. The provisions of the general rules are applicable to this standard, where specifically called for.

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR – Part 5-2: Control circuit devices and switching elements – Proximity switches

1 General

The provisions of the general rules in IEC 60947-1 are applicable to this standard, where specifically called for. General rules clauses and subclauses thus applicable, as well as tables, figures and appendices, are identified by references to IEC 60947-1, e.g. subclause 7.1.9.3 of IEC 60947-1 or Annex C of IEC 60947-1.

Clauses [1](#) to [8](#) contain the general requirements. Specific requirements for the various types of proximity switches are given in Annex [A](#).

1DV D2 Modification of Clause 1 by adding the following:

Annex [DVA](#) defines the specific clauses, tables, and figures in this standard which are to be considered normative, informative, or not applicable. Compliance with the normative clauses, tables, and figures is mandatory; compliance with the informative clauses, tables, and figures is optional.

1.1 Scope and object

This part of IEC 60947 applies to inductive and capacitive proximity switches that sense the presence of metallic and/or non-metallic objects, ultrasonic proximity switches that sense the presence of sound reflecting objects, photoelectric proximity switches that sense the presence of objects and non-mechanical magnetic proximity switches that sense the presence of objects with a magnetic field.

These proximity switches are self-contained, have semiconductor switching element(s) and are intended to be connected to circuits, the rated voltage of which does not exceed 250 V 50 Hz/60 Hz a.c. or 300 V d.c. This Standard is not intended to cover proximity switches with analogue outputs.

The object of this standard is to state for proximity switches:

- definitions;
- classification;
- characteristics;
- product information;
- normal service, mounting and transport conditions;
- constructional and performance requirements;
- tests to verify rated characteristics.

1.1DV D2 Modification of 1.1 by adding the following:

This equipment is intended for use on industrial machinery or mass production industrial equipment as defined and installed in accordance with CSA C22.1, Canadian Electrical Code (CE Code, Part I), and CSA C22.2 No. 301 in Canada, and NFPA 70, National Electrical Code (NEC), and NFPA 79 in the USA.

1.2 Normative references

The following referenced documents are indispensable for the application 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 60050(441):1984, *International Electrotechnical Vocabulary (IEV) – Chapter 441: Switchgear, controlgear and fuses*
Amendment 1 (2000)

IEC 60068-2-6:2007, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14:2009, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-27:2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-30:2005, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60364 (all parts), *Low-voltage electrical installations*

IEC 60445:2010, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

IEC 60947-1:2007, *Low-voltage switchgear and controlgear – Part 1: General rules*
Amendment 1:2010

IEC 61000-3-2:2005, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*
Amendment 1:2008
Amendment 2:2009

IEC 61000-3-3:2008, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection*

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*
Amendment 1:2007
Amendment 2:2010

IEC 61000-4-4:2004, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-6:2008, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8:2009, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

IEC 61000-4-11:2004, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-4-13:2002, *Electromagnetic compatibility (EMC) – Part 4-13: Testing and measurement techniques – Harmonics and interharmonics including mains signalling at a.c. power port, low-frequency immunity tests*

Amendment 1:2009

IEC 61076-2 (all parts), *Connectors for electronic equipment – Product requirements – Part 2: Circular connectors*

IEC 61140:2001, *Protection against electric shock – Common aspects for installation and equipment*
Amendment 1 (2004)

CISPR 11:2009, *Industrial, scientific and medical equipment – Electromagnetic Radio-frequency disturbance characteristics – Limits and methods of measurement*
Amendment 1:2010

ISO 630 (all parts), *Structural steels*

1.2DV DC Modification of 1.2 by adding the following:

For a list of normative standards, see [Table DVB.1](#) and [Table DVB.2](#). See [Table DVC.1](#) for component standards.

2 Definitions

Clause 2 of part 1 applies with the following additions:

Alphabetical index of definitions

References

	A	
Adjuster of a proximity switch		2.2.15
Adjuster of a capacitive proximity switch		2.2.15.1
Adjuster of an ultrasonic proximity switch		2.2.15.2
Ambient light for a photoelectric proximity switch		2.4.7
Assured operating distance (s_a)		2.3.1.7
Axial approach		2.3.3
	B	

Blind zone		2.3.1.3
Break function		2.4.1.2
	C	
Capacitive proximity switch		2.1.1.2
Currents (I)		2.4.5
	D	
Damping material		2.2.5
Differential travel (H)		2.3.5
Direct operated proximity switch		2.1.1.6
	E	
Effective operating distance (s_r)		2.3.1.5
Embeddable proximity switch		2.2.9
Emitter		2.2.12
Excess gain for a photoelectric proximity switch		2.4.6
	F	
Free zone		2.2.4
Frequency of operating cycle (f)		2.4.3
	I	
Independent (snap) action		2.4.2
Indirect operated proximity switch		2.1.1.7
Inductive proximity switch		2.1.1.1
	L	
Lateral approach		2.3.2
	M	
Make function		2.4.1.1
Make-break, or changeover function		2.4.1.3
Maximum operating distance		2.3.1.2.2
Minimum operating distance		2.3.1.2.1
Minimum operational current (I_m)		2.4.5.2
	N	
Neutral density filters		2.1.1.8
No-load supply current (I_o)		2.4.5.3
Non-damping material		2.2.6
Non-embeddable proximity switch		2.2.10
Non-mechanical magnetic proximity switch		2.1.1.5
	O	
OFF-state current (I_r)		2.4.5.1
Operating distances (s)		2.3.1
Operating range (r_o)		2.3.1.8
Operation of a proximity switch		2.3

	P	
Parts of proximity switches		2.2
Photoelectric proximity switch		2.1.1.4
Photoelectric proximity switch – type D		2.1.1.4.1
Photoelectric proximity switch – type R		2.1.1.4.2
Photoelectric proximity switch – type T		2.1.1.4.3
Proximity switch (IEV 441-14-51)		2.1.1
	R	
Rated operating distance (s_n)		2.3.1.1
Receiver		2.2.13
Reference axis		2.2.2
Reflector		2.2.14
Repeat accuracy (R)		2.3.4
Response time proximity switch		2.4.1.4
	S	
Semiconductor switching element		2.2.1
Sensing face		2.2.11
Sensing range (s_d)		2.3.1.2
Sound absorbing material		2.2.8
Sound reflecting material		2.2.7
Standard target		2.2.3
Switching element characteristics		2.4
Switching element function		2.4.1
	T	
Time delay before availability (t_v)		2.4.4
Total beam angle		2.3.1.4
Turn off time for a photoelectric proximity switch		2.4.1.6
Turn on time for a photoelectric proximity switch		2.4.1.5
	U	
Ultrasonic proximity switch		2.1.1.3
Usable operating distance (s_u)		2.3.1.6

2.1 Basic definitions

2.1.1

proximity switch

a position switch which is operated without mechanical contact with the moving part

[IEV 441-14-51]¹⁾

¹⁾ See IEC 60050(441).

2.1.1.1

inductive proximity switch

a proximity switch producing an electromagnetic field within a sensing zone and having a semiconductor switching element

2.1.1.2

capacitive proximity switch

a proximity switch producing an electric field within a sensing zone and having a semiconductor switching element

2.1.1.3

ultrasonic proximity switch (see [Figure 2](#))

a proximity switch transmitting and receiving ultrasound waves within a sensing zone and having a semiconductor switching element

2.1.1.4

photoelectric proximity switch (see [Figure 1](#))

a proximity switch which senses objects that either reflect or interrupt visible or invisible light and having a semiconductor switching element

2.1.1.4.1

type D

diffuse reflective photoelectric proximity switch which is directly operated through lateral or axial approach to its reference axis by a defined object

2.1.1.4.2

type R

retroreflective photoelectric proximity switch which is indirectly operated through lateral approach to its reference axis between emitter-receiver and reflector by a defined object

2.1.1.4.3

type T

through beam photoelectric proximity switch which is indirectly operated through lateral approach of its reference axis between emitter and receiver by a defined object

2.1.1.5

non-mechanical magnetic proximity switch

proximity switch which senses the presence of a magnetic field and has a semiconductor switching element and no moving parts in the sensing element

2.1.1.6

direct operated proximity switch

proximity switch which detects its target without the use of an external means, e.g. a reflector

2.1.1.7

indirect operated proximity switch

proximity switch which detects its target with the use of an external means, e.g. a reflector

2.1.1.8

neutral density filters

filters which uniformly attenuate the intensity of light over a broad spectral range

NOTE Attenuation is accomplished by using either a light-absorbing glass or a thin-film metal coating that combines absorption and reflection.

2.2 Parts of a proximity switch

2.2.1

semiconductor switching element

an element designed to switch the current of an electric circuit by controlling conductivity of a semiconductor

2.2.2 Reference axis

2.2.2.1

reference axis for inductive, capacitive, non-mechanical magnetic and ultrasonic proximity switches

an axis perpendicular to the sensing face and passing through its centre

2.2.2.2

reference axis for types R and D photoelectric proximity switches

an axis located midway between the optical axis of the emitter and this of receiver elements or lenses (see [Figure 1](#))

2.2.2.3

reference axis for type T photoelectric proximity switches

an axis perpendicular to the centre of the emitter

2.2.3

standard target

a specified object used for making comparative measurements of the operating distances and sensing distances

2.2.4

free zone

a volume around the proximity switch which is kept free from any material capable of affecting the characteristics of the proximity switch

2.2.5

damping material

a material which has an influence on the characteristics of a proximity switch

2.2.6

non-damping material

a material which has negligible influence on the characteristics of a proximity switch

2.2.7

sound-reflecting material

a material which reflects the ultrasound waves and gives detectable echoes

2.2.8

sound-absorbing material

a material with negligible reflecting characteristics for ultrasound waves which gives no detectable echo

2.2.9

embeddable proximity switch

a proximity switch is "embeddable" when any damping material can be placed around the sensing face plane without influencing its characteristics

2.2.10

non-embeddable proximity switch

a proximity switch is "non-embeddable" when a specified free zone around its sensing face is necessary in order to maintain its characteristics

2.2.11 Sensing face

2.2.11.1

sensing face of an inductive proximity switch

a surface of the proximity switch through which the electromagnetic field emerges

2.2.11.2

sensing face of a capacitive proximity switch

a surface of the proximity switch through which the electric field emerges

2.2.11.3

sensing face of an ultrasonic proximity switch

a surface of the proximity switch where ultrasound is transmitted and received

2.2.11.4

sensing face of a non-mechanical magnetic proximity switch

a surface of the proximity switch through which the change in a magnetic field is detected

2.2.12

emitter

the light source, lens and necessary circuitry which provide the light beam

2.2.13

receiver

the detector, lens and necessary circuitry to monitor the presence of the light beam from the emitter

2.2.14

reflector

a specified device used to reflect light back to the receiver for type R photoelectric proximity switches

2.2.15 Adjuster

2.2.15.1

adjuster of a capacitive proximity switch

a part of capacitive proximity switch used to set the operating distance. Its use compensates for influence due to target material, transmission medium and installation (mounting) conditions

2.2.15.2

adjuster of an ultrasonic or a photoelectric proximity switch

a part of an ultrasonic or a photoelectric proximity switch used to set the operating distance within the sensing range

2.3 Operation of a proximity switch

2.3.1

operating distances (s)

a distance at which the target approaching the sensing face along the reference axis causes the output signal to change

2.3.1.1

rated operating distance (s_n)

the rated operating distance is a conventional quantity used to designate the operating distances. It does not take into account either manufacturing tolerances or variations due to external conditions such as voltage and temperature

2.3.1.2

sensing range (s_d)

the range within which the operating distance may be adjusted

2.3.1.2.1

minimum operating distance

the lower limit of the specified sensing range of an ultrasonic or photoelectric proximity switch

2.3.1.2.2

maximum operating distance

the upper limit of the specified sensing range of an ultrasonic or photoelectric proximity switch

2.3.1.3

blind zone

the zone between the sensing face and the minimum operating distance, where no object can be detected

2.3.1.4

total beam angle

the solid angle around the reference axis of an ultrasonic proximity switch, where the sound level drops by 3 dB

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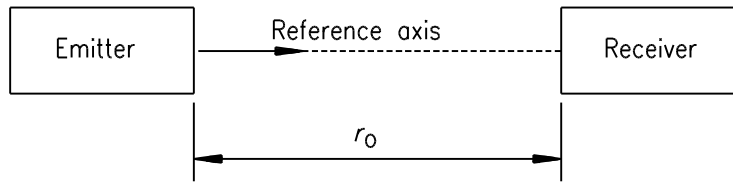


Figure 1a – Type T, emitter and receiver – Through beam photoelectric

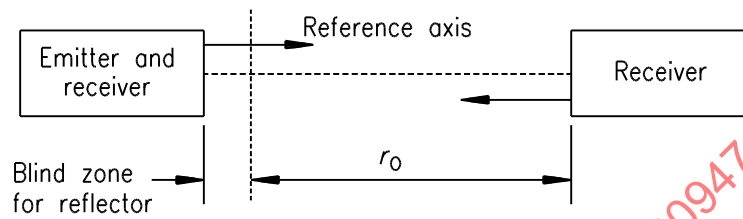


Figure 1b – Type R, emitter–receiver and reflector – Retroreflective photoelectric

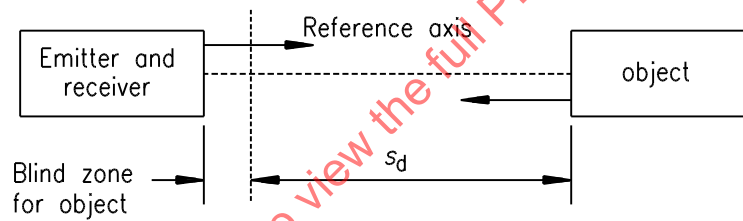


Figure 1c – Type D, emitter–receiver and object – Diffuse reflective photoelectric
S4985

Figure 1

Sensing range and operating range of photoelectric proximity switches

(see [7.2.1.3](#) and [8.4](#))

2.3.1.5

effective operating distance (s_r)

the operating distance of an individual proximity switch, measured at stated temperature, voltage and mounting conditions

2.3.1.6

usable operating distance (s_u)

the operating distance of an individual proximity switch, measured under specified conditions

2.3.1.7

assured operating distance (s_a)

the distance from the sensing face within which the correct operation of the proximity switch under specified conditions is assured

2.3.1.8 **operating range (r_o)**

range within which a lateral approach of the target causes the output signal of a through beam or retroreflective proximity switch to change

2.3.2

lateral approach

the approach of the target perpendicular to the reference axis

2.3.3

axial approach

the approach of the target with its centre maintained on the reference axis

2.3.4

repeat accuracy (R)

the value of variation of the effective operating distance (s_r) under specified conditions

2.3.5

differential travel (H)

the distance between the operating point when the target approaches the proximity switch and the release point when the target moves away

2.4 Switching element characteristics**2.4.1 switching element function**

2.4.1.1

make function

a make function causes load current to flow when a target is detected and load current not to flow when a target is not detected

2.4.1.2

break function

a break function causes load current not to flow when a target is detected and load current to flow when a target is not detected

2.4.1.3

make-break, or changeover function

a switching element combination which contains one make function and one break function