

# Low-voltage switchgear and controlgear —

Part 5-7: Control circuit devices and  
switching elements — Requirements for  
proximity devices with analogue output

The European Standard EN 60947-5-7:2003 has the status of a  
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## National foreword

This British Standard is the official English language version of EN 60947-5-7:2003. It is identical with IEC 60947-5-7:2003. It supersedes BS EN 50319:1999 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee PEL/17, Switchgear, controlgear and HV-LV co-ordination, to Subcommittee PEL/17/2, Low-voltage switchgear and controlgear, which has the responsibility to:

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**Low-voltage switchgear and controlgear**  
**Part 5-7: Control circuit devices and switching elements -**  
**Requirements for proximity devices with analogue output**  
(IEC 60947-5-7:2003)

Appareillage à basse tension  
Partie 5-7: Appareils et éléments  
de commutation pour circuits  
de commande -  
Prescriptions pour les détecteurs  
de proximité à sortie analogique  
(CEI 60947-5-7:2003)

Niederspannungsschaltgeräte  
Teil 5-7: Steuergeräte und Schaltelemente -  
Anforderungen an Näherungssensoren  
mit Analogausgang  
(IEC 60947-5-7:2003)

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Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

**Central Secretariat: rue de Stassart 35, B - 1050 Brussels**

### Foreword

The text of document 17B/1277/FDIS, future edition 1 of IEC 60947-5-7, prepared by SC 17B, Low-voltage switchgear and controlgear, of IEC TC 17, Switchgear and controlgear, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60947-5-7 on 2003-09-01.

This standard should be used in conjunction with EN 60947-5-2:1998.

This European Standard supersedes EN 50319:1999.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2004-06-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2006-09-01

Annexes designated "normative" are part of the body of the standard.  
Annexes designated "informative" are given for information only.  
In this standard, annex ZA is normative and annex G is informative.  
Annex ZA has been added by CENELEC.

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### Endorsement notice

The text of the International Standard IEC 60947-5-7:2003 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

- |             |      |  |
|-------------|------|--|
| IEC 60381-1 | NOTE | Harmonized as HD 452.1 S1:1984 (not modified). |
| IEC 60770-1 | NOTE | Harmonized as EN 60770-1:1999 (not modified).  |

## CONTENTS

INTRODUCTION.....	4
1 General .....	5
1.1 Scope and object.....	5
1.2 Normative references .....	5
2 Definitions .....	5
2.1 Basic definitions .....	5
2.3 Operation of a proximity device .....	6
2.4 Output element characteristics .....	6
3 Classification.....	7
3.7 Classification according to analogue output.....	7
4 Characteristics .....	7
4.3 Rated and limiting values for the proximity device and output elements.....	7
5 Product information .....	8
7 Constructional and performance requirements.....	8
8 Tests .....	9
8.6 Verification of the electromagnetic compatibility .....	10
 Annex G (informative) Example of the determination of the conformity of an ultrasonic sensor, nominal sensing distance 60 ... 500 mm with linear output characteristic .....	11
 Annex ZA (normative) Normative references to international publications with their corresponding European publications .....	15
 Bibliography.....	16
 Figure G.1 – Error curve plots.....	14
 Table 9 – Range of analogue voltage signals.....	7
Table 10 – Range of analogue current signals .....	8
Table G.1 – Error tabulation for travel 1 .....	11
Table G.2 – Error tabulation for travel 2.....	12
Table G.3 – Error tabulation for travel 3.....	12
Table G.4 – Computation of the errors .....	13

## INTRODUCTION

This part of IEC 60947 modifies the relevant requirements of IEC 60947-5-2, dealing with the requirements for proximity switches with semiconductor switching elements, to make them applicable to proximity devices with analogue output.

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## LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

### Part 5-7: Control circuit devices and switching elements – Requirements for proximity devices with analogue output

#### 1 General

##### 1.1 Scope and object

This part of IEC 60947 states the requirements for proximity devices with analogue output. They may consist of one or more parts.

The requirements of IEC 60947-5-2 (proximity switches) apply with the additions or modifications as stated in this standard. The clause numbering in this standard follows the clause numbering of IEC 60947-5-2, modified where necessary.

##### 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 60947-5-2:1997, *Low-voltage switchgear and controlgear – Part 5-2: Control circuit devices and switching elements – Proximity switches*  
Amendment 1 (1999)

#### 2 Definitions

##### 2.1 Basic definitions

###### 2.1.2

###### **proximity device with analogue output**

device producing an output signal which varies continuously depending on the distance between the sensing face of the proximity device and its target object

###### 2.1.3

###### **lower distance**

minimum stated distance above which the output signal varies continuously

###### 2.1.4

###### **upper distance**

maximum stated distance below which the output signal varies continuously

###### 2.1.5

###### **distance range**

range of distances between and including the lower and upper distances

## 2.3 Operation of a proximity device

### 2.3.7

#### **distance/output characteristic of the proximity device**

relationship of the output signal (current or voltage value) in the steady state to the distance between the sensing face of the proximity device and its target object

### 2.3.8

#### **conformity**

maximum deviation including the manufacturing tolerances between the nominal distance/output characteristic curve and the measured value of five defined distances

### 2.3.9

#### **repeatability**

value of variation of the output signal under specified conditions expressed as a percentage of the upper limit

### 2.3.10

#### **upscale error**

arithmetic mean of the errors at each value of each measurement cycle with increasing distance

### 2.3.11

#### **downscale error**

arithmetic mean of the errors at each value of each measurement cycle with decreasing distance

### 2.3.12

#### **average error**

arithmetic mean of all upscale and downscale readings at each distance value

## 2.4 Output element characteristics

NOTE Analogue proximity devices are not necessarily linear devices.

### 2.4.8

#### **analogue current signal**

current signal which varies in a continuous manner within its range

### 2.4.9

#### **analogue voltage signal**

voltage signal which varies in a continuous manner within its range

### 2.4.10

#### **range of an analogue signal**

all values of the signal between and including defined limits

### 2.4.11

#### **lower limit**

specified minimum value of the range

NOTE The lower limit may be either zero or a finite value; when zero is used, this is called "true zero"; when a finite value is used, this is called "live zero".

### 2.4.12

#### **upper limit**

specified maximum value of the range



#### 2.4.13

##### **load impedance**

impedance or impedances for which the output characteristics of the proximity device are specified

#### 2.4.14

##### **ripple content**

ratio between the peak-to-peak value of the a.c. component and the upper limit of the signal value

#### 2.4.15

##### **recovery time**

time taken, following the removal of an external influence for the output signal to return to its previous value within the limits of repeatability as defined in 2.3.9

### 3 Classification

Classification shall be in accordance with Table 1 of IEC 60947-5-2, with the following addition.

#### 3.7 Classification according to analogue output

A proximity device with analogue output shall be designated by a capital A placed in the fifth position. If other outputs also exist, they shall be designated by a second digit in accordance with Table 1, fifth position.

### 4 Characteristics

Characteristics shall be in accordance with Clause 4 of IEC 60947-5-2 with the following additions.

#### 4.3 Rated and limiting values for the proximity device and output elements

##### 4.3.1 Voltages

##### 4.3.1.5 Range of analogue voltage signals

The range of analogue voltage signals shall be one of the ranges given in Table 9.

**Table 9 – Range of analogue voltage signals**

Lower limit	Upper limit
V	V
+1	+5
0	+10

##### 4.3.1.6 Ripple content of the output voltage

The maximum ripple content shall be stated by the manufacturer.

### 4.3.2 Currents

#### 4.3.2.1 Range of analogue current signals

The range of analogue current signals shall be one of the ranges given in Table 10.

Table 10 – Range of analogue current signals

Lower limit mA	Upper limit mA
0	20
10	20

#### 4.3.2.2 Ripple content of the output current

The maximum ripple content shall be stated by the manufacturer.

#### 4.3.7 Conformity

The conformity shall be within  $\pm 10\%$  of the upper limit (see 2.3.8).

## 5 Product information

### 5.1.1 Identification

Subclause 5.1.1 of IEC 60947-5-2 applies with the following additions:

- aa) Output type and range (voltage or current).
- bb) Distance range.
- cc) Ripple content.
- dd) Distance/output characteristic.
- ee) Recovery time.

## 7 Constructional and performance requirements

### 7.2.1.4 Repeat accuracy

Subclause 7.2.1.4 of IEC 60947-5-2 applies with the following modification.

It shall be measured at the lower distance, at the upper distance and at the median value of the distance range, and shall not exceed 5 %.

#### 7.2.1.16 Upper limit of the output signal

The output signal of an analogue proximity device shall not decrease when the target is moved beyond the maximum distance stated by the manufacturer.

NOTE This requirement is intended to ensure that there cannot be two or more distances corresponding to the same output signal.

## 8 Tests

### 8.4.1.6 Conformity

#### 8.4.1.6.1 Method of measurement

A proximity device in new condition is mounted in accordance with the manufacturer's instructions and the target is moved towards and away from the sensing face of the proximity device in an axial direction. The test points to determine the performance characteristics of a device shall be equidistant over the distance range. At least five points are necessary.

The output values for each given distance shall be recorded for at least three full distance traverses in each axial direction of movement of the target.

An example is given in Annex C.

#### 8.4.1.6.2 Error tabulation

The difference between each recorded output value and its corresponding nominal output value shall be determined. These differences are the errors and shall be expressed as a percentage of the upper distance. A positive error denotes that the observed output value is greater than the nominal output value.

The following shall be calculated:

a) **average upscale error**

- arithmetic mean of the errors at each value of each measurement cycle with increasing distance;

b) **average downscale error**

- arithmetic mean of the errors at each value of each measurement cycle with decreasing distance;

c) **average error**

- arithmetic mean of all upscale and downscale readings at each distance value.

When the distance/output characteristic is adjustable, then the manufacturer shall state the characteristic used to measure the conformity.

#### 8.4.1.6.3 Error curves

The following error curves shall be plotted against percentage of upper distance:

- average upscale error;
- average downscale error;
- average error.

#### 8.4.1.6.4 Maximum error

The maximum value (positive or negative) of error determined from the curve of average upscale error or the curve of average downscale error shall be stated as the maximum error.

#### 8.4.1.6.5 Determination of conformity

Conformity shall be determined either by calculation or as follows.

The stated output characteristic shall be drawn so that it coincides with the average error curve at the upper and the lower distance range values.

Conformity is the maximum deviation between the average error curve and the stated output characteristic. It is expressed as a positive or negative percentage of the upper limit.

The manufacturer shall give information on the behaviour of the output outside the distance range.

#### 8.6 Verification of the electromagnetic compatibility

The provisions regarding emission and immunity given in 8.6 of IEC 60947-5-2 apply with the following addition.

After the removal of the test influence in accordance with 8.6.1, 8.6.2 and 8.6.3 of IEC 60947-5-2, the output signal shall return to its nominal value with the stated conformity, within the recovery time stated by the manufacturer.

## Annex G (informative)

### Example of the determination of the conformity of an ultrasonic sensor, nominal sensing distance 60 ... 500 mm with linear output characteristic

Method of measurement: in accordance with 8.4.1.6.1, using 14 test points and three full distance traverses.

Error tabulation (see Tables G.1, G.2 and G.3): in accordance with 8.4.1.6.2.

Table G.1 – Error tabulation for travel 1

Distance mm	Theoretical output value V	Travel 1			
		Decreasing distance	Error	Increasing distance	Error
		V	%	V	%
60	0,000	0,006	0,062	0,006	0,061
80	0,455	0,461	0,065	0,465	0,105
100	0,909	0,926	0,169	0,924	0,149
120	1,364	1,360	-0,036	1,400	0,364
140	1,818	1,850	0,318	1,830	0,118
160	2,273	2,310	0,373	2,310	0,373
180	2,727	2,780	0,527	2,760	0,327
200	3,182	3,230	0,482	3,250	0,682
250	4,318	4,410	0,918	4,390	0,718
300	5,455	5,520	0,655	5,520	0,655
350	6,591	6,660	0,691	6,720	1,291
400	7,727	7,840	1,127	7,820	0,927
450	8,864	8,970	1,064	9,000	1,364
500	10,000	10,000	0,000	10,000	0,000

Table G.2 – Error tabulation for travel 2

Distance mm	Theoretical output value V	Travel 2			
		Decreasing distance V	Error %	Increasing distance V	Error %
60	0,000	0,006	0,062	0,006	0,061
80	0,455	0,462	0,075	0,464	0,095
100	0,909	0,927	0,179	0,923	0,139
120	1,364	1,400	0,864	1,360	-0,036
140	1,818	1,860	0,418	1,820	0,018
160	2,273	2,300	0,273	2,320	0,473
180	2,727	2,790	0,627	2,750	0,227
200	3,182	3,210	0,282	3,270	0,882
250	4,318	4,500	1,818	4,300	-0,182
300	5,455	5,510	0,555	5,530	0,755
350	6,591	6,680	0,891	6,700	1,091
400	7,727	7,850	1,227	7,810	0,827
450	8,864	8,980	1,164	8,980	1,164
500	10,000	10,200	2,000	9,800	-2,000

Table G.3 – Error tabulation for travel 3

Distance mm	Theoretical output value V	Travel 3			
		Decreasing distance V	Error %	Increasing distance V	Error %
60	0,000	0,006	0,061	0,006	0,062
80	0,455	0,466	0,115	0,460	0,055
100	0,909	0,920	0,109	0,930	0,209
120	1,364	1,370	0,064	1,390	0,264
140	1,818	1,800	-0,182	1,880	0,618
160	2,273	2,280	0,073	2,340	0,673
180	2,727	2,720	-0,073	2,820	0,927
200	3,182	3,200	0,182	3,280	0,982
250	4,318	4,380	0,618	4,420	1,018
300	5,455	5,500	0,455	5,540	0,855
350	6,591	6,710	1,191	6,670	0,791
400	7,727	7,800	0,727	7,860	1,327
450	8,864	8,950	0,864	9,010	1,464
500	10,000	9,900	-1,000	10,100	1,000

Table G.4 gives the result of computation of

- average upscale error,
- average downscale error.
- average error.

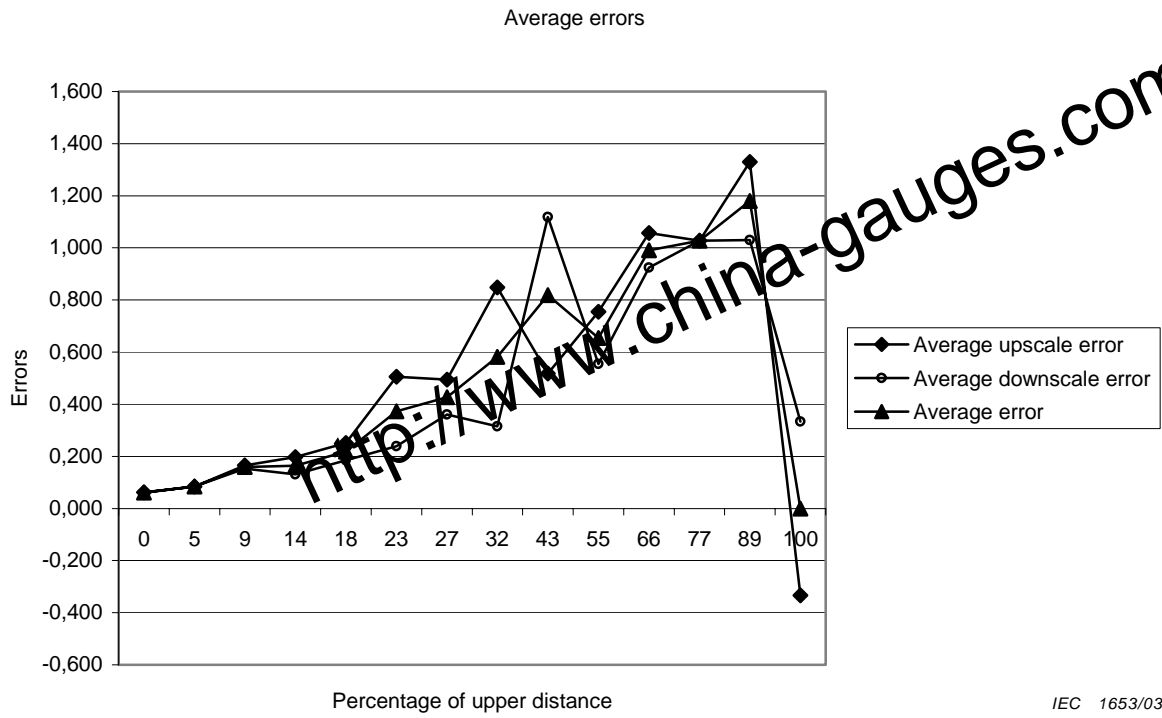
**Table G.4 – Computation of the errors**

Distance mm	Average upscale error	Average downscale error	Average error
60	0,062	0,061	0,061
80	0,085	0,085	0,085
100	0,166	0,152	0,159
120	0,197	0,130	0,164
140	0,252	0,185	0,218
160	0,506	0,239	0,373
180	0,494	0,361	0,427
200	0,848	0,315	0,582
250	0,518	1,118	0,818
300	0,755	0,555	0,655
350	1,058	0,924	0,991
400	1,027	1,027	1,027
450	1,330	1,030	1,180
500	-0,333	0,333	0,000

Error curves: in accordance with 8.4.1.6.3.

Error curves (see Figure G.1): plotted against percentage of upper distance:

- average upscale error;
- average downscale error;
- average error.



Maximum error: in accordance with 8.4.1.6.4.

Maximum error: 1,33 %.

Conformity: in accordance with 8.4.1.6.5.

Conformity: 1,33 %.

**Figure G.1 – Error curve plots**



**Annex ZA**  
(normative)

**Normative references to international publications  
with their corresponding European publications**

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60947-5-2 (mod)	1997	Low-voltage switchgear and controlgear Part 5-2: Control circuit devices and switching elements - Proximity switches	EN 60947-5-2	1998
A1	1999		A1	1999

### **Bibliography**

IEC 60381-1:1982, *Analogue signals for process control systems – Part 1: Direct current signals*

IEC 60381-2:1978, *Analogue signals for process control systems – Part 2: Direct voltage signals*

IEC 60770-1:1999, *Transmitters for use in industrial-process control systems – Part 1: Methods for performance evaluation*

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