

TECHNICAL REPORT



**Electrical interface specifications for self ballasted lamps and controlgear in
phase-cut dimmed lighting systems**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRICAL INTERFACE SPECIFICATIONS
FOR SELF BALLASTED LAMPS AND CONTROLGEAR IN PHASE-CUT
DIMMED LIGHTING SYSTEMS**

FOREWORD

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The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a Technical Report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC TR 63037, which is a Technical Report, has been prepared by IEC technical committee 34: Lamps and related equipment.

This second edition cancels and replaces the first edition published in 2016. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) emission of audible noise;
- b) ghosting caused by issues that are not related to the power supply of the dimmer or synchronization;
- c) stability of phase angle waveform (for the dimmer), including symmetry and stability tests;
- d) flicker of light loads;
- e) repetitive ring up voltage;
- f) dimming range; and
- g) number of switching cycles have been added.

The text of this Technical Report is based on the following documents:

Draft TR	Report on voting
34/517/DTR	34/583A/RVDTR

Full information on the voting for the approval of this Technical Report 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.

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- withdrawn,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
- amended.

A bilingual version of this publication may be issued at a later date.

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.

INTRODUCTION

This document describes the technical requirements for self-ballasted lamps and controlgear to work with phase-cut dimmers. For a complete picture of the technical requirements the user should also refer to IEC TR 63036 (see also IEC 60669-2-1:—, ¹ Annex EE), the companion document that contains technical requirements and testing methods for phase-cut dimmers.

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¹ Under preparation. Stage at the time of publication IEC AFDIS 60669-2-1:2019.

ELECTRICAL INTERFACE SPECIFICATIONS FOR SELF BALLASTED LAMPS AND CONTROLGEAR IN PHASE-CUT DIMMED LIGHTING SYSTEMS

1 Scope

~~This document specifies the electrical interface between phase-cut dimming equipment and lighting equipment, such as LED integrated lamps and light sources with external controlgear, with the intention of helping designers of both types of equipment to develop products that will work together properly.~~

~~This document describes both the dimming phase and the off phase. In addition to the specification of the interface, test procedures are given for testing the proper operation.~~

~~It may be expected that controlgear fulfilling the requirements of this document are also suited to be used with electronic switches that use a circuitry comparable with that of a phase-cut dimmer, but do not contain means for the adjustability of the phase-cut angle.~~

This document provides guidance to controlgear/integrated lamp designers for the development of products suitable to operate with future phase-cut dimmers. It describes the possible voltage signals and the expected response of the controlgear/integrated lamps.

This document describes the expected response of controlgear during all operation states of a phase-cut lighting system and provides a complete understanding of the requirements for phase-cut dimmers. The response of a phase-cut dimmer is described in IEC 60669-2-1:—, Annex EE.

This document specifies the system performance aspects and test procedures for the control by mains voltage phase-cut dimming of the brightness of mains operated electronic lighting equipment intended to be controlled by mains voltage phase-cut dimmers, such as LED integrated lamps and light sources with external controlgear.

Safety requirements are not covered by this document, but by respective product standards.

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 60050-845, *International Electrotechnical Vocabulary – Part 845: Lighting* (available at <http://www.electropedia.org>)

IEC 62504, *General lighting – Light emitting diode (LED) products and related equipment – Terms and definitions*

3 Terms, definitions, abbreviated terms and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-845 and IEC 62504 and the following 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>

3.1.1

phase-cut dimmed lighting system **lighting system**

combination of a phase-cut dimmer and one or more controlgear and light sources

Note 1 to entry: The term "lighting system" used in this document is an abbreviated form of "phase-cut dimmed lighting system".

3.1.2

off-state

state of a ~~phase-cut dimming~~ lighting system when no light is emitted

3.1.3

on-state

state of a ~~phase-cut dimming~~ lighting system when light is emitted

3.1.4

electrical interface

electrical parameters for supplying power and making exchange of information between the phase-cut dimmer and controlgear

3.1.5

phase-cut dimmer **dimmer**

electronic switch connected in series with a load, that changes the supply voltage waveform applied to the load from the ~~pure~~ mains voltage waveform to a leading edge (forward phase) or a trailing edge (reverse phase) AC voltage waveform ~~or is capable of switching between both waveforms~~

Note 1 to entry: Some phase-cut dimmers are capable of switching their output between leading edge and trailing edge waveforms.

Note 2 to entry: The output voltage waveform of a phase-cut dimmer is applied to one or more loads. The conduction angle of the voltage waveform is adjustable.

Note 3 to entry: Within this document, where the term "dimmer" is used, the term "phase-cut dimmer" is meant.

3.1.6

two-wire phase-cut dimmer

phase-cut dimmer connected in series with a load that has no connection to neutral

3.1.7

three-wire phase-cut dimmer

phase-cut dimmer connected in series with a load that has ~~in addition~~ an additional connection to neutral

3.1.8

controlgear

~~device~~ one or more components between the ~~phase-cut dimmer~~ supply and one or more lamps which may serve to transform the ~~AC mains power~~ supply voltage, limit the current of the lamp(s) to the required value, provide starting voltage and preheating current, prevent cold starting, correct power factor or reduce radio interference

Note 1 to entry: Lamps may have integrated controlgear such as an integrated LED lamp. Any references to controlgear will include any such integrated lamps.

3.1.9**load side**

connection from the output of the phase-cut dimmer to the supply input of one or more controlgear

3.1.10**conducting period**

time period during which the phase-cut dimmer supplies power to a controlgear

3.1.11**non-conducting period**

time period during which the phase-cut dimmer does not supply power to a controlgear

3.1.12**half-wave**

positive or negative 180° of an AC sine wave starting and ending at the zero crossing point

3.1.13**phase angle**

position within a half-wave expressed in degree, being in the range of 0° to 180°, referred to the beginning of the half-wave

3.1.14**reference minimum light output
RMLO**

light output (luminous flux) produced by a lamp operated by a controlgear that is connected to mains voltage via a phase-cut dimmer set to a conduction angle of 40° ± 1°

3.1.15**maximum light output
MLO**

light output (luminous flux) produced by a lamp operated by a controlgear that is directly connected to mains voltage

3.2 Abbreviated terms and symbols

To describe the electrical characteristics of the ~~phase-cut~~ electrical interface, the following ~~abbreviations~~ symbols are used:

α_x α	Angle where the test voltage starts rising with the given slew rate SR as shown in Figure A.1. Subscripts L and 1 (see Table 20) refer to leading and end-of-transition, respectively.
β_x β	Angle where the test voltage starts falling with the given slew rate SR as shown in Figure A.2. Subscripts T and 1 (see Table 20) refer to trailing and end-of-transition, respectively.
C_f	Filter capacitor to reduce high frequency disturbances
EC_CG	Equivalent circuit that represents a controlgear for phase-cut dimmer testing purposes
EC_D	Equivalent circuit that represents a phase-cut dimmer for controlgear testing purposes
I_{CG}	Current through the input terminals of the controlgear (see Figure 1)
I_{CG_pk}	Repetitive peak current of the controlgear in leading edge mode
I_{CG_SL}	Current-carrying capability of the controlgear with $V_{CG} \leq V_{SW}$ in leading edge mode
I_{CG_STH}	Current-carrying capability of the controlgear with $V_{CG} \leq V_{SW}$ in trailing edge mode

I_{CG_STL}	Current-carrying capability of the controlgear with $V_{CG} > V_{SW}$ in trailing edge mode
I_D	Current through the load side terminal of the phase-cut dimmer (see Figure 1)
I_{D_nc}	Maximum current through the phase-cut dimmer during the non-conducting period, limited by the phase-cut dimmer
I_{EC_CG}	Value of test current of EC_CG in the test circuit in Figure A.1
I_{PO}	Minimum current carrying capability of the controlgear during the electronic off-state
I_{trans}	Current sourced by the phase-cut dimmer during the transition from the conducting to the non-conducting state in trailing edge mode
n	Required minimum number of controlgear connected with one phase-cut dimmer (named in phase-cut dimmer installation sheet)
P_{CG}	Rated input power of the controlgear (as marked)
P_{max}	Maximum permissible nominal load of phase-cut dimmer (according to installation sheet)
P_{min}	Minimum nominal load required by the phase-cut dimmer (according to installation sheet)
R_R	Resistance value of resistive load R of the test circuit of Figure 5 (according to 8.3.3), dependent on maximum permissible load of phase-cut dimmer P_{max}
SR	Absolute value of the slew rate of the decrease of the voltage across the input terminals of a controlgear in trailing edge dimming mode when the phase-cut dimmer switches off at time t_{s1} (see Figure 3)
SR_L	Absolute value of the slew rate of the increase of the voltage across the input terminals of a controlgear in leading edge dimming mode when the phase-cut dimmer under test switches on (according to Clause 8)
SR_T	Absolute value of the slew rate of the decrease of the voltage across the input terminals of a controlgear in trailing edge dimming mode when the phase-cut dimmer under test switches off (according to Clause 8)
t_{HW}	Time related to previous zero crossing of the mains to the subsequent zero crossing of the mains (duration of a half-wave)
t_s	Time related to previous zero crossing of the mains when leading edge phase-cut dimmer reduces its impedance towards zero by activating its power switch
t_{s1}	Time related to previous zero crossing of the mains when the trailing edge phase-cut dimmer increases its impedance towards infinite by deactivating its power switch
t_{s2}	Time related to previous zero crossing of the mains when the voltage V_{CG} falls below V_{SW} in trailing edge method
t_{s3}	Time related to previous zero crossing of the mains when the transition from the conducting period to the non-conducting period is finished
t_{SW}	Time related to previous zero crossing of the mains when voltage V_{CG} crosses V_{SW}
t_t	Transition time for trailing edge mode, equals $t_{s2} - t_{s1}$
V_{CG}	Voltage across the input terminals of the controlgear (see Figure 1)
V_{CG_PK}	Repetitive peak voltage across the terminal of the controlgear
V_D	Voltage between the line side (L) and load side terminal of the phase-cut dimmer (see Figure 1)
V_M	Mains voltage (rated nominal value)
V_{ME}	Phase-cut voltage for testing purposes, sinusoidal part of the waveform (α 1 to t_{HW} , 0 to β) equivalent to mains voltage

V_{PO}	Lower limit for voltage across the input terminals of the controlgear to provide a current carrying capability I_{PO} during the electronic off-state
V_{SW}	Voltage across the input terminals of the controlgear at the time that leads to disabling ($V_M(t) > V_{SW}$) or enabling ($V_M(t) < V_{SW}$), a current path having a current carrying capability of I_{CG_SL} or I_{CG_STH}
V_{test}	Value of the test voltage of the test circuit in Figure 6 (according to 8.4)
$xx(t)$	Instantaneous values of current or voltage xx
Z_{CG}	Impedance across the input terminals of the controlgear
Z_D	Impedance between the line side (L) and the load side terminals of the phase-cut dimmer
Z_{D_max}	Maximum impedance between the line side (L) and load side terminal of the phase-cut dimmer, defined by the technical properties of the phase-cut dimmer
Z_{D_min}	Minimum impedance between the line side (L) and the load side terminal of the phase-cut dimmer, defined by the power properties of the phase-cut dimmer

4 General description

A phase-cut dimmer either cuts the mains voltage immediately after the zero crossing of the mains (leading edge) or towards the next projected zero crossing of the mains (trailing edge). The functionality of both methods can be implemented in one device (universal dimmers).

This document describes requirements for controlgear during the on-state of a ~~phase-cut dimming~~ lighting system. Specifications are provided dependent on the dimming method for the conducting period, the non-conducting period of the phase-cut dimmer and the transitions between the conducting and non-conducting period.

In addition, this document describes requirements for controlgear during the off-state of a ~~phase-cut dimming~~ lighting system. Specifications are provided independently from the dimming method.

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This document addresses the following issues previously reported by consumers and authorities such as:

- emission of audible noise;
- ghosting caused by issues that are not related to the power supply of the dimmer or synchronization;
- stability of phase angle waveform (for the dimmer), including symmetry and stability tests;
- flicker of light loads;
- repetitive ring up voltage;
- dimming range;
- number of switching cycles.

5 General requirements

5.1 Voltage rating

This document applies to one or more of the following mains voltages:

100 V, 120 V, 200 V, 230 V, 277 V, according to IEC 60038.

5.2 Frequency rating

This document applies to one or more of the following mains frequencies:

50 Hz or 60 Hz, according to IEC 60038.

5.3 Marking of controlgear

~~The following information should be provided by the manufacturer on the product or in the accompanying instruction sheets.~~

Controlgear suitable for operating with a phase-cut dimmer, should be marked either on the product or in the product documentation with the following:

DIM

Controlgear and lamps with integrated controlgear should be marked with the reference minimum light output (RMLO) value, or the value should be given in the manufacturer's documentation.

The RMLO value should be in the form "DIM xx %" where xx is the RMLO value.

6 Description of the lighting system and its components

6.1 Wiring method

The wiring of the devices is in accordance with the installation rules given in IEC 60364 (all parts) and also with the national wiring rules applicable in the country where the devices are installed.

6.2 Wiring diagram

The wiring of the lighting system uses the traditional method of connecting the phase-cut dimmer to the mains and to the controlgear. Figure 1 is an example of a lighting system with one phase-cut dimmer and one or two controlgear.

Regarding the connections of the phase-cut dimmer shown in Figure 1, the drawn lines represent a two-wire installation and the dashed line represents the direct connection of the phase-cut dimmer to the mains which is used in three-wire installations.

The direct connection of the phase-cut dimmer to neutral (dashed line in Figure 1) will have consequences on the power supply requirement and synchronization with the phase-cut dimmer.

This document defines requirements that enable compatibility between phase-cut dimmer and controlgear in two-wire installations. However, all predications are also valid for three-wire phase-cut dimmers to ensure proper operation of controlgear.