PD IEC/TR 63037:2016

BSI Standards Publication

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

bsi.

National foreword

This Published Document is the UK implementation of IEC/TR 63037:2016.

The UK participation in its preparation was entrusted to Technical Committee CPL/34, Lamps and Related Equipment.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2016

ISBN 978 0 580 92877 2
ICS 29.140.99

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 November 2016.

Amendments/corrigenda issued since publication

Date	Text affected

IEC TR 63037

Edition 1.0 2016-11

TECHNICAL REPORT

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.140.99

ISBN 978-2-8322-3711-3

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

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

FOREWORD

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.

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

Enquiry draft	Report on voting
34/305/DTR	34/325/RVC

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.

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 the companion document that contains technical requirements and testing methods for phase-cut dimmers (IEC TR 63036).

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.

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. 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 and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62504 and IEC 60050-845 as well as 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
combination of a phase-cut dimmer and one or more controlgear and light sources

3.1.2
off state
state of a phase-cut dimming system when no light is emitted

3.1.3
on state
state of a phase-cut dimming system when light is emitted

3.1.4
phase-cut dimmer
electronic switch which is connected in series with a load and 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: 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 2 to entry: Within this document, where the term “dimmer” is used the term “phase-cut dimmer” is meant.

3.1.5
two-wire phase-cut dimmer
phase-cut dimmer which is connected in series with the load and has no connection to neutral

3.1.6
three-wire phase-cut dimmer
phase-cut dimmer which is connected in series with the load and has in addition a connection to neutral

3.1.7
controlgear
device between the phase-cut dimmer and one or more lamps which may serve to transform the AC mains power, 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.

3.1.8
load side
connection from the output of the phase-cut dimmer to the supply input of one or more controlgear

3.1.9
conducting period
time period during which the phase-cut dimmer supplies power to a controlgear

3.1.10
non-conducting period
time period during which the phase-cut dimmer does not supply power to a controlgear

3.1.11
half-wave
positive or negative 180 degrees of an AC sine wave starting and ending at the zero crossing point

3.1.12
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

3.2 Abbreviated terms

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

α_x	Angle where the test voltage starts rising with the given slew rate SR as shown in Figure A.1
β_x	Angle where the test voltage starts falling with the given slew rate SR as shown in Figure A.2
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
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
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 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	The 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	The 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	The 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 the 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
V_D	Voltage between the line side (L) and load side terminal of the phase-cut dimmer
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 toβ) 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 test voltage of test circuit 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 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 system. Specifications are provided independently from the dimming method.

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 should be marked with the following indication:

DIM

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 controlgears.

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 to 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.

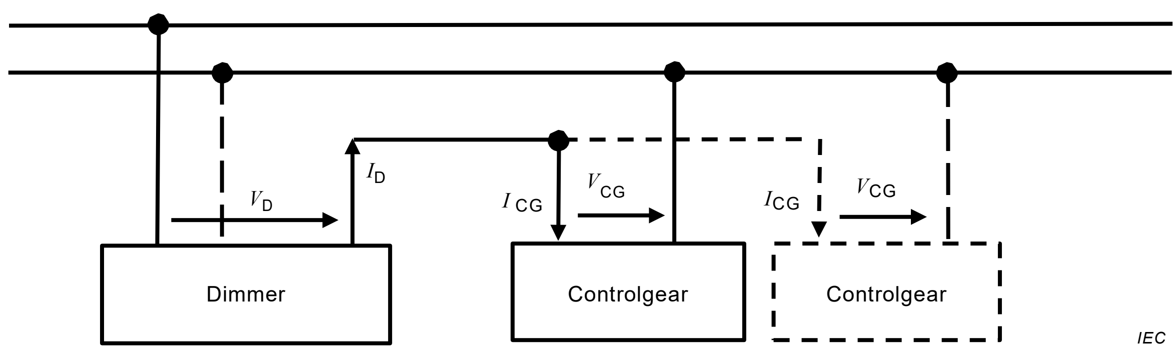

Figure 1 – Example of wiring diagram

7 Electrical specification

7.1 General

All information given in this document is related to a half-wave of the mains. Due to the polarity change between subsequent half-waves, all values have to be regarded as absolute values.

The phase-cut dimming system is either in on state or in off state.

In on state, light sources controlled by controlgear being part of the phase-cut dimming system emit light. In off state, light sources controlled by controlgear being part of the phase-cut dimming system do not emit light.

The off state may be realized as mechanical off state by opening the current loop of the phase-cut dimming system with mechanical means, for example a switch. For this case, no requirements need to be fixed.

Alternatively, the off state may be realized as electronic off state. In this case, the phase-cut dimmer increases its impedance (i.e. stops producing phase-cut) while continuing its operation, for example to keep its control interface activated. In this case, the connected controlgear are not energized sufficiently to operate a light source, but should provide a current path that allows the phase-cut dimmer to draw current continuously from the mains.

NOTE Applications that provide a connection to neutral allow using a three-wire device, enabling the usage of lamps that do not provide a current carrying capability according to 7.2 and 7.4.

During the on state and the electronic off state, it should be ensured that the phase-cut dimmer is supplied sufficiently with power and that the synchronization of phase-cut dimmer and controlgear with the mains is ensured.

7.2 Electrical characteristics during the on state of a phase-cut dimming system

7.2.1 General

For the on state of a phase-cut dimming system, specifications are dependent on the dimming method, leading edge or trailing edge.

Each half-wave is divided into two periods, the conducting period and the non-conducting period of the phase-cut dimmer.

During the conducting period of the phase-cut dimmer, the mains voltage is applied to the controlgear. During the non-conducting period, the voltage between terminals of the phase-cut dimmer is almost equal to the mains voltage ($V_D \approx V_M$).

7.2.2 Electrical characteristics for leading edge dimming method

7.2.2.1 General

Starting from the mains zero crossing, the phase-cut dimmer remains in non-conducting state until its timing element activates the power switch at t_s. Afterwards, the phase-cut dimmer is supplying power to the load for the entire remaining part of the mains half-wave (see Figure 2).

To achieve synchronization with the mains and to control the phase-cut angle correctly, leading edge phase-cut dimmers need to draw a current also during the non-conducting state.

Thus, the controlgear has to be able to conduct a current I_{CG_SL}, which allows synchronization of the phase-cut dimmer with the mains and ensures the supply of power to the phase-cut dimmer even in a two-wire installation.

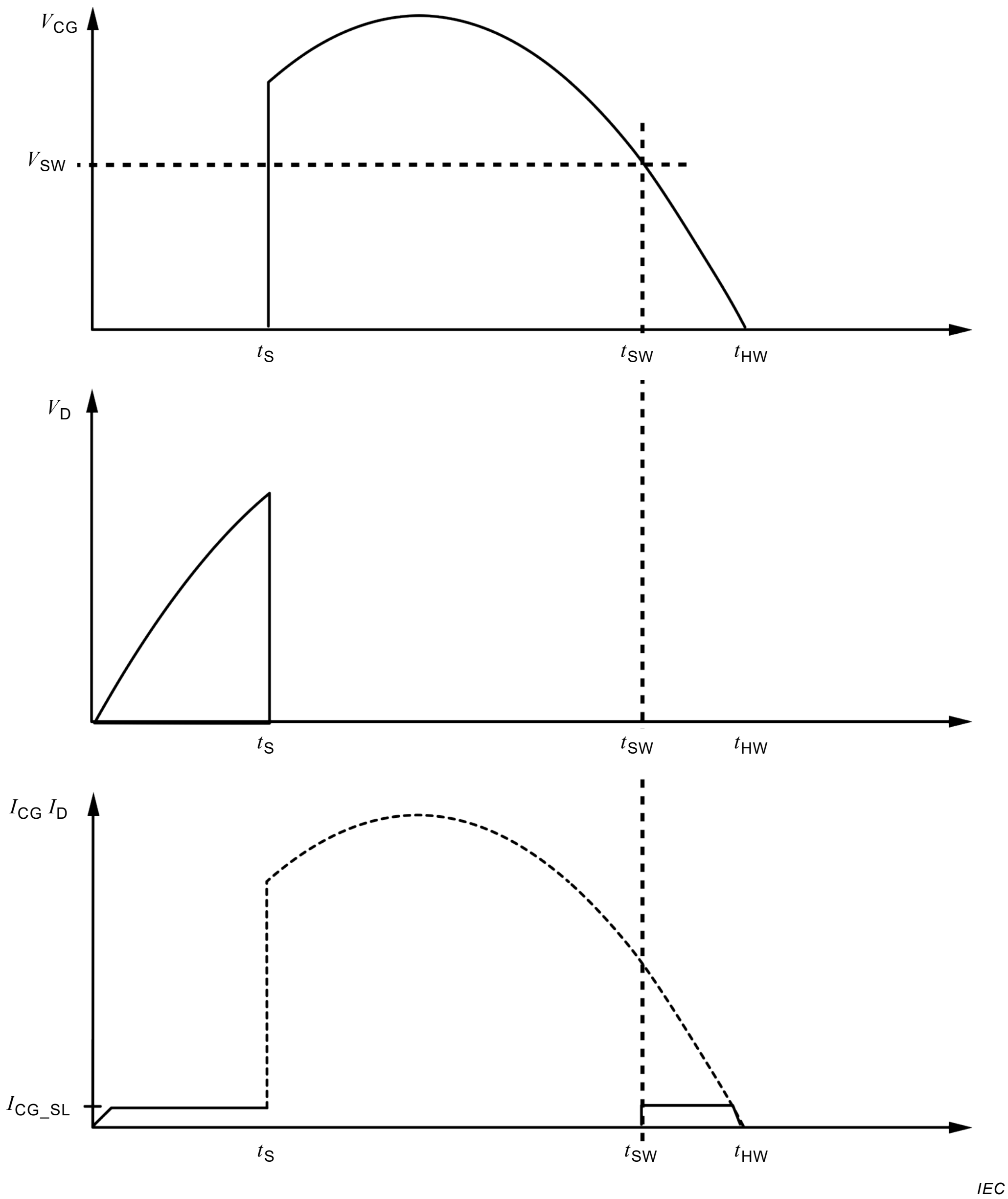

Figure 2 – Timing leading edge dimming method

7.2.2.2 Electrical characteristics during the non-conducting period

During the non-conducting period, the controlgear should comply with the electrical characteristics listed in Tables 1 to 5.

The non-conducting period starts at the zero crossing of the mains and ends at time t_s when the timing element of the phase-cut dimmer activates the power switch.

During this period, the controlgear should provide a current path with a minimum current-carrying capability of I_{CG_SL} as listed in Tables 1 to 5. At small input voltages of the controlgear when I_{CG_SL} cannot be reached due to the characteristics of its input circuitry (e.g. inrush current limiting elements), only its impedance Z_{CG} is defined as listed in Tables 1 to 5.

The controlgear may deactivate its current-carrying capability during the non-conducting period after it has not detected an input voltage waveform showing an unsteady waveform (leading edge characteristic) for 100 ms.

NOTE This is for reducing power losses in case a controlgear is used without a phase-cut dimmer.

Table 1 – Nominal mains voltage 100 V; frequency 50 Hz or 60 Hz

Time related to previous zero crossing of mains voltage	Controlgear: current, voltage and impedance limits
0 to t_S	$0\ V \le V_{CG} \le 3\ V$: Z_{CG} not defined $3\ V < V_{CG} \le 6\ V$: $Z_{CG} \le 1\ 200\ \Omega$ $6\ V < V_{CG} < V_{SW} = 22\ V$: $P_{CG} < 12\ W$: $I_{CG}(t) = I_{CG\_SL} \ge 13{,}8\ mA/W \cdot P_{CG}$ $P_{CG} \ge 12\ W$: $I_{CG}(t) = I_{CG\_SL} \ge 165{,}6\ mA$

Table 2 – Nominal mains voltage 120 V; frequency 50 Hz or 60 Hz

Time related to previous zero crossing of mains voltage	Controlgear: current, voltage and impedance limits
0 to t_S	$0\ V \le V_{CG} \le 3\ V$: Z_{CG} not defined $3\ V < V_{CG} \le 6\ V$: $Z_{CG} \le 1\ 200\ \Omega$ $6\ V < V_{CG} < V_{SW} = 26\ V$: $P_{CG} \ge 12\ W$: $I_{CG}(t) = I_{CG\_SL} \ge 138\ mA$

Table 3 – Nominal mains voltage 200 V; frequency 50 Hz or 60 Hz

Time related to previous zero crossing of mains voltage	Controlgear: current, voltage and impedance limits
0 to t_S	$0\ V \le V_{CG} \le 3\ V$: Z_{CG} not defined $3\ V < V_{CG} \le 6\ V$: $Z_{CG} \le 1\ 200\ \Omega$ $6\ V < V_{CG} < V_{SW} = 43\ V$: $P_{CG} < 12\ W$: $I_{CG}\ (t) = I_{CG\_SL} \ge 6{,}9\ mA/W \cdot P_{CG}$ $P_{CG} \ge 12\ W$: $I_{CG}(t) = I_{CG\_SL} \ge 82{,}8\ mA$

Table 4 – Nominal mains voltage 230 V; frequency 50 Hz or 60 Hz

Time related to previous zero crossing of mains voltage	Controlgear: current, voltage and impedance limits
0 to t_s	0 V ≤ V_{CG} ≤ 3 V: Z_{CG} not defined 3 V < V_{CG} ≤ 6 V: Z_{CG} ≤ 1 200 Ω 6 V < V_{CG} < V_{SW} = 40 V: P_{CG} < 12 W: $I_{CG}(t) = I_{CG\_SL}$ ≥ 6 mA/W · P_{CG} P_{CG} ≥ 12 W: $I_{CG}(t) = I_{CG\_SL}$ ≥ 72 mA

Table 5 – Nominal mains voltage 277 V; frequency 50 Hz or 60 Hz

Time related to previous zero crossing of mains voltage	Controlgear: current, voltage and impedance limits
0 to t_s	0 V ≤ V_{CG} ≤ 3 V: Z_{CG} not defined 3 V < V_{CG} ≤ 6 V: Z_{CG} ≤ 1 200 Ω 6 V < V_{CG} < V_{SW} = 60 V: P_{CG} < 12 W: $I_{CG}(t) = I_{CG\_SL}$ ≥ 5 mA/W · P_{CG} P_{CG} ≥ 12 W: $I_{CG}(t) = I_{CG\_SL}$ ≥ 60 mA

7.2.2.3 Electrical characteristics during the transition from the non-conducting to the conducting period

The transition from the non-conducting to the conducting state of the phase-cut dimmer starts at time t_s.

Starting from time t_s, the impedance Z_D of the phase-cut dimmer decreases until its minimum Z_{D_min} is reached. The voltage V_{CG} applied to the controlgear increases towards the instantaneous value $V_M(t)$ of the mains minus the voltage drop across the phase-cut dimmer.

The absolute value of the slew rate of the voltage change of V_D during the transition period does not exceed the values as listed in Table 6 when the phase-cut dimmer is connected to the marked maximum resistive load.

The slew rate should be calculated based on the measurement of the voltage slope of V_D by measuring the time (dt) between V_D= 0,8 · $V_D(t_s)$ and V_D = 0,1 · $V_D(t_s)$ and by calculating the differential voltage d V_D = 0,8 · $V_D(t_s)$ – 0,1 · $V_D(t_s)$.

When the voltage V_{CG} exceeds V_{SW}, the controlgear may deactivate its current carrying capability, thus possibly no current can flow through the controlgear.

NOTE Values for slew rate represent a compromise between EMC, repetitive peak current in the controlgear and switching losses in the phase-cut dimmer power semiconductors.

Table 6 – Slew rate for voltage decrease across the phase-cut dimmer

V_M [V]	100	120	200	230	277
dV_D/dt [V/µs]	≤ 6,5	≤ 300	≤ 6,5	≤ 6,5	≤ 300

7.2.2.4 Electrical characteristics during the conducting period

During the conducting period, the controlgear should comply with the electrical characteristics listed in Tables 7 to 11.

During this period, full power is applied continuously to the controlgear from the phase-cut dimmer to allow power to be supplied to the controlgear. The values of peak current in Table 7 to 11 apply at the maximum slew rate values given in Table 6.

Due to the low impedance of the phase-cut dimmer during the conducting period, the input voltage of the controlgear is almost equal to the mains voltage.

At time t_{SW}, the input voltage V_{CG} of the controlgear falls below V_{SW}.

From time t_{SW} to the end of the period, the controlgear should provide a current path with a minimum current-carrying capability of I_{CG_SL}.

Table 7 – Nominal mains voltage 100 V; frequency 50 Hz or 60 Hz

Time related to previous zero crossing of mains voltage	Controlgear: current, voltage and impedance limits
t_s to t_{SW}	Z_{CG} not defined I_{CG_pk} (P_{CG}) < 0,111 A/W
t_{SW} to t_{HW}	0 V ≤ V_{CG} ≤ 3 V: Z_{CG} not defined 3 V < V_{CG} ≤ 6 V: Z_{CG} ≤ 1 200 Ω 6 V < V_{CG} < V_{SW} = 22 V: $I_{CG}(t) = I_{CG\_SL} \geq (0,7 \cdot P_{CG})/V_M$ or $I_{CG}(t) = I_{CG\_SL}(t) \geq (0,7 \cdot V_{CG}(t))/(V_M^2/P_{CG})$

Table 8 – Nominal mains voltage 120 V; frequency 50 Hz or 60 Hz

Time related to previous zero crossing of mains voltage	Controlgear: current, voltage and impedance limits
t_s to t_{SW}	Z_{CG} not defined I_{CG_pk} (P_{CG}) < to be defined
t_{SW} to t_{HW}	0 V ≤ V_{CG} ≤ 3 V: Z_{CG} not defined 3 V < V_{CG} ≤ 6 V: Z_{CG} ≤ 1 200 Ω 6 V < V_{CG} < V_{SW} = 26 V: $I_{CG}(t) = I_{CG\_SL} \geq (0,7 \cdot P_{CG})/V_M$ or $I_{CG}(t) = I_{CG\_SL}(t) \geq (0,7 \cdot V_{CG}(t))/(V_M^2/P_{CG})$

Table 9 – Nominal mains voltage 200 V; frequency 50 Hz or 60 Hz

Time related to previous zero crossing of mains voltage	Controlgear: current, voltage and impedance limits
t_s to t_{SW}	Z_{CG} not defined I_{CG_pk} (P_{CG}) < 0,077 25 A/W
t_{SW} to t_{HW}	0 V ≤ V_{CG} ≤ 3 V: Z_{CG} not defined 3 V < V_{CG} ≤ 6 V: Z_{CG} ≤ 1 200 Ω 6 V < V_{CG} < V_{SW} = 43 V: $I_{CG}(t) = I_{CG\_SL} \geq (0{,}7 \cdot P_{CG})/V_M$ or $I_{CG}(t) = I_{CG\_SL}(t) \geq (0{,}7 \cdot V_{CG}(t))/(V_M{}^2/P_{CG})$

Table 10 – Nominal mains voltage 230 V; frequency 50 Hz or 60 Hz

Time related to previous zero crossing of mains voltage	Controlgear: current, voltage and impedance limits
t_s to t_{SW}	Z_{CG} not defined I_{CG_pk} (P_{CG}) < 0,077 25 A/W
t_{SW} to t_{HW}	0 V ≤ V_{CG} ≤ 3 V: Z_{CG} not defined 3 V < V_{CG} ≤ 6 V: Z_{CG} ≤ 1 200 Ω 6 V < V_{CG} < V_{SW} = 50 V: $I_{CG}(t) = I_{CG\_SL} \geq (0{,}7 \cdot P_{CG})/V_M$ or $I_{CG}(t) = I_{CG\_SL}(t) \geq (0{,}7 \cdot V_{CG}(t))/(V_M{}^2/P_{CG})$

Table 11 – Nominal mains voltage 277 V; frequency 50 Hz or 60 Hz

Time related to previous zero crossing of mains voltage	Controlgear: current, voltage and impedance limits
t_s to t_{SW}	Z_{CG} not defined I_{CG_pk} (P_{CG}) < to be defined
t_{SW} to t_{HW}	0 V ≤ V_{CG} ≤ 3 V: Z_{CG} not defined 3 V < V_{CG} ≤ 6 V: Z_{CG} ≤ 1 200 Ω 6 V < V_{CG} < V_{SW} = 60 V: $I_{CG}(t) = I_{CG\_SL} \geq (0{,}7 \cdot P_{CG})/V_M$ or $I_{CG}(t) = I_{CG\_SL}(t) \geq (0{,}7 \cdot V_{CG}(t))/(V_M{}^2/P_{CG})$

7.2.3 Electrical characteristics for trailing edge dimming method

7.2.3.1 General

Starting from the mains zero crossing, the phase-cut dimmer operates in conducting state until its timing element deactivates the power switch at time t_{s1}. Afterwards, the phase-cut dimmer is not significantly supplying power to the load for the entire remaining part of the mains half-wave (see Figure 3).

To achieve synchronization with the mains and to control the phase-cut angle correctly, trailing edge phase-cut dimmers need to draw a current also during the non-conducting state.

Thus, the controlgear has to be able to conduct a current I_{CG_STH}, which allows synchronization of the phase-cut dimmer with the mains and ensures the supply of power to the phase-cut dimmer even in a two-wire installation.

Since the negative voltage slope that is triggered by the switch-off of the power switch of the phase-cut dimmer is not only determined by the current I_{CG_STL} that is conducted by the controlgear, but also by the effective capacitance of the wiring and the capacitance being effective in parallel to the phase-cut dimmer, the sum of these capacitances has to be considered.

This document and all listed values are based on systems having a maximum capacitance of the wiring of 10 nF being effective in parallel to the controlgear.

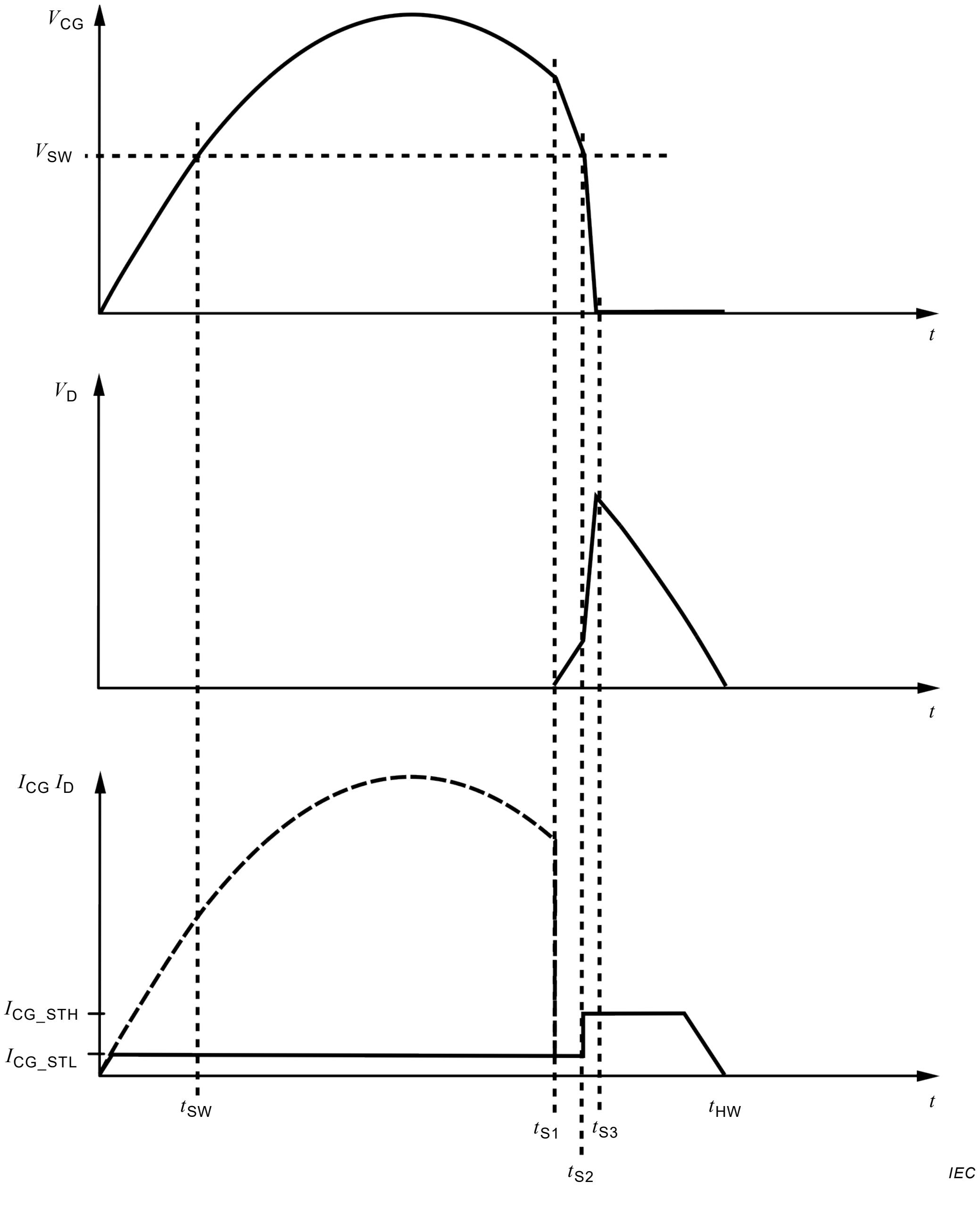

Figure 3 – Timing trailing edge dimming method

7.2.3.2 Electrical characteristics during the conducting period

The conducting period starts at the zero crossing of the mains and ends at time t_{s1} when the timing element of the phase-cut dimmer deactivates its power switch and the impedance of the phase-cut dimmer Z_D increases towards Z_{D_max}.

During the conducting period, the controlgear should comply with the electrical characteristics listed in Table 12.

During this period, the phase-cut dimmer continuously applies full power to the controlgear. Therefore, the impedance Z_D of the phase-cut dimmer remains continuously at its minimum value Z_{D_min}, independently from the current $I_D = I_{CG}$.

The impedance Z_D of the phase-cut dimmer is Z_{D_min} when the voltage $V_D(t)$ across the phase-cut dimmer is less than $0{,}1 \cdot V_M(t)$ during the entire conduction period.

Due to the low impedance of the phase-cut dimmer during the conducting period, the input voltage of the controlgear is almost equal to the instantaneous value of the mains voltage.

From the zero crossing of the mains to time t_{s1}, the controlgear should provide a current path with a minimum current-carrying capability of I_{CG_STL} as listed in Table 12.

Since the current I_{CG_STL} is based on nominal data of a controlgear, a factor of 0,7 is inserted to account for the fact that the current drawn by the controlgear will have some distortion or displacement and may not be a perfect sine-wave or rectangular shape. Therefore the factor 0,7 introduces some margin for this. Additionally, according to this document the controlgear may not operate with its nominal wattage even at the maximum conduction angle.

Table 12 – Nominal mains voltage from 100 V to 277 V; frequency 50 Hz or 60 Hz

Time related to previous zero crossing of mains voltage	Controlgear: current, voltage and impedance limits
0 to t_{s1}	$0\text{ V} \le V_{CG} \le 3\text{ V}$: Z_{CG} not defined $3\text{ V} < V_{CG} \le 6\text{ V}$: $Z_{CG} \le 1\,200\ \Omega$ $V_{CG} > 6\text{ V}$: $I_{CG}(t) = I_{CG\_STL} \ge (0{,}7 \cdot P_{CG})/V_M$ or $I_{CG}(t) = I_{CG\_STL}(t) \ge (0{,}7 \cdot V_{CG}(t))/(V_M^2/P_{CG})$

7.2.3.3 Electrical characteristics during the transition from the conducting to the non-conducting period

The transition from the conducting to the non-conducting state of the phase-cut dimmer starts at time t_{s1} and ends at time t_{s3}.

At the time t_{s1}, the impedance Z_D of the phase-cut dimmer starts to increase towards Z_{D_max}. From time t_{s1} to t_{s2}, the phase-cut dimmer limits the current I_D.

The minimum value for $t_t = t_{s2} - t_{s1}$ should be as listed in Tables 13 to 17.

Since the controlgear provides a minimum current-carrying capability of I_{CG_STL} (see Tables 13 to 17), the voltage across the input terminals of the controlgear decreases towards zero and falls below the voltage V_{SW} at t_{s2} (see Figure 3).

NOTE 1 This requirement is to ensure that parasitic capacities of the installation, the active capacity C_f between the terminals of the phase-cut dimmer (see Figure 3) and a capacitor that might be assembled inside the controlgear and which is connected directly with the mains terminals of the controlgear is discharged in a reasonable time to allow the phase-cut dimmer to supply itself sufficiently.

NOTE 2 The ratio between the values for the period t_{S2} to t_{HW} as given in Tables 13 to 17 for the different mains voltages is proportional to the ratio of the relevant mains voltages. The values for I_{CG_STH} scale inversely with the mains voltage. The value for V_{SW} scales directly with the mains voltage. The value for I_{D_nc} is always 10 % lower than the relevant I_{CG_STH}.

The slew rate SR should be calculated based on the measurement of the voltage slope of V_{CG} by measuring the time (dt) between V_{CG} = 0,8 · $V_{CG}(t_{s1})$ and $V_{CG} = V_{SW}$ and by calculating the differential voltage dV_{CG} = 0,8 · $V_{CG}(t_{s1}) - V_{SW}$.

When the voltage V_{CG} falls below V_{SW} (time t_{s2}), the controlgear should provide a minimum current-carrying capability of I_{CG_STH} as listed in Tables 13 to 17.

NOTE 3 The values for V_{SW} and I_{CG_STH} are selected to achieve a good compromise between the ability for the phase-cut dimmer to supply itself on one side and the appearing power loss in the controlgear on the other side.

NOTE 4 t_{s2} is defined by the time at which V_{CG} falls below V_{SW}. V_{CG} and I_D can be measured simultaneously with a 4-channel oscilloscope, and the value of I_D between t_{s1} and t_{s2} can be determined. The break in slope of V_D at t_{s2} (if such a break in slope exists) is not a criteria to define t_{s2}.

Table 13 – Nominal mains voltage 100 V; frequency 50 Hz or 60 Hz

Time related to previous zero crossing of mains voltage	Controlgear: current carrying capability
t_{s1} to t_{s2} $t_{s2} - t_{s1} \geq t_t$ $t_t = (1/SR) \cdot V_M(t_{s1})$	$t = t_{s1}$: $I_{CG}(t) = I_{CG\_STL} \geq (0,7 \cdot P_{CG})/V_M$ or $I_{CG}(t) = I_{CG\_STL}(t) \geq (0,7 \cdot V_{CG}(t))/(V_M^2/P_{CG})$ $t_{s1} < t \leq t_{s2}$: $SR = \lvert dV_{CG}/dt \rvert \geq$ 0,09 V/µs (50 Hz) $SR = \lvert dV_{CG}/dt \rvert \geq$ 0,108 V/µs (60 Hz) when the CG is supplied by a current source driving (2,8 mA · P_{CG})/W from t_{s1} to t_{s2}.
t_{s2} to t_{HW}	0 V ≤ V_{CG} ≤ 3 V: Z_{CG} not defined 3 V < V_{CG} ≤ 6 V: Z_{CG} ≤ 1 200 Ω 6 V < V_{CG} < V_{SW} = 22 V: P_{CG} < 12 W: $I_{CG}(t) = I_{CG\_STH} \geq$ 13,8 mA/W · P_{CG} P_{CG} ≥ 12 W: $I_{CG}(t) = I_{CG\_STH} \geq$ 165,6 mA

Table 14 – Nominal mains voltage 120 V; frequency 50 Hz or 60 Hz

Time related to previous zero crossing of mains voltage	Controlgear: current carrying capability
t_{s1} to t_{s2} $t_{s2} - t_{s1} \geq t_t$ $t_t = (1/SR) \cdot V_M(t_{s1})$	$t = t_{s1}$: $I_{CG}(t) = I_{CG\_STL} \geq (0{,}7 \cdot P_{CG})/V_M$ or $I_{CG}(t) = I_{CG\_STL}(t) \geq (0{,}7 \cdot V_{CG}(t))/(V_M^2/P_{CG})$ $t_{s1} < t \leq t_{s2}$: $SR = \|dV_{CG}/dt\| \geq 0{,}0105$ V/µs (50 Hz) $SR = \|dV_{CG}/dt\| \geq 0{,}126$ V/µs (60 Hz) when the CG is supplied by a current source driving (2,8 mA $\cdot P_{CG}$)/W from t_{s1} to t_{s2}.
t_{s2} to t_{HW}	0 V $\leq V_{CG} \leq$ 3 V: Z_{CG} not defined 3 V $< V_{CG} \leq$ 6 V: $Z_{CG} \leq$ 1 200 Ω 6 V $< V_{CG} < V_{SW}$ = 26 V: P_{CG} < 12 W: $I_{CG}(t) = I_{CG\_STH} \geq$ 11,5mA/W $\cdot P_{CG}$ $P_{CG} \geq$ 12 W: $I_{CG}(t) = I_{CG\_STH} \geq$ 138 mA

Table 15 – Nominal mains voltage 200 V; frequency 50 Hz or 60 Hz

Time related to previous zero crossing of mains voltage	Controlgear: current carrying capability
t_{s1} to t_{s2} $t_{s2} - t_{s1} \geq t_t$ $t_t = (1/SR) \cdot V_M(t_{s1})$	$t = t_{s1}$: $I_{CG}(t) = I_{CG\_STL} \geq (0{,}7 \cdot P_{CG})/V_M$ or $I_{CG}(t) = I_{CG\_STL}(t) \geq (0{,}7 \cdot V_{CG}(t))/(V_M^2/P_{CG})$ $t_{s1} < t \leq t_{s2}$: $SR = \|dV_{CG}/dt\| \geq 0{,}175$ V/µs (50 Hz) $SR = \|dV_{CG}/dt\| \geq 0{,}210$ V/µs (60 Hz) when the CG is supplied by a current source driving (2,8 mA $\cdot P_{CG}$)/W from t_{s1} to t_{s2}.
t_{s2} to t_{HW}	0 V $\leq V_{CG} \leq$ 3 V: Z_{CG} not defined 3 V $< V_{CG} \leq$ 6 V: $Z_{CG} \leq$ 1 200 Ω 6 V $< V_{CG} < V_{SW}$ = 43 V: P_{CG} < 12 W: $I_{CG}(t) = I_{CG\_STH} \geq$ 6,9 mA/W $\cdot P_{CG}$ $P_{CG} \geq$ 12 W: $I_{CG}(t) = I_{CG\_STH} \geq$ 82,8 mA

Table 16 – Nominal mains voltage 230 V; frequency 50 Hz or 60 Hz

Time related to previous zero crossing of mains voltage	Controlgear: current carrying capability
t_{s1} to t_{s2} $t_{s2} - t_{s1} \geq t_t$ $t_t = (1/SR) \cdot V_M(t_{s1})$	$t = t_{s1}$: $I_{CG}(t) = I_{CG\_STL} \geq (0{,}7 \cdot P_{CG})/V_M$ or $I_{CG}(t) = I_{CG\_STL}(t) \geq (0{,}7 \cdot V_{CG}(t))/(V_M^2/P_{CG})$ $t_{s1} < t \leq t_{s2}$: $SR = \|dV_{CG}/dt\| \geq 0{,}2$ V/µs (50 Hz) $SR = \|dV_{CG}/dt\| \geq 0{,}24$ V/µs (60 Hz) when the CG is supplied by a current source driving (2,8 mA $\cdot P_{CG}$)/W from t_{s1} to t_{s2}.
t_{s2} to t_{HW}	0 V $\leq V_{CG} \leq$ 3 V: Z_{CG} not defined 3 V $< V_{CG} \leq$ 6 V: $Z_{CG} \leq$ 1 200 Ω 6 V $< V_{CG} < V_{SW}$ = 40 V: P_{CG} < 12 W: $I_{CG}(t) = I_{CG\_STH} \geq$ 6 mA/W $\cdot P_{CG}$ $P_{CG} \geq$ 12 W: $I_{CG}(t) = I_{CG\_STH} \geq$ 72 mA

Table 17 – Nominal mains voltage 277 V; frequency 50 Hz or 60 Hz

Time related to previous zero crossing of mains voltage	Controlgear: current carrying capability
t_{s1} to t_{s2} $t_{s2} - t_{s1} \geq t_t$ $t_t = (1/SR) \cdot V_M(t_{s1})$	$t = t_{s1}$: $I_{CG}(t) = I_{CG\_STL} \geq (0{,}7 \cdot P_{CG})/V_M$ or $I_{CG}(t) = I_{CG\_STL}(t) \geq (0{,}7 \cdot V_{CG}(t))/(V_M^2/P_{CG})$ $t_{s1} < t \leq t_{s2}$: $SR = \|dV_{CG}/dt\| \geq 0{,}245$ V/µs (50 Hz) $SR = \|dV_{CG}/dt\| \geq 0{,}295$ V/µs (60 Hz) when the CG is supplied by a current source driving (2,8 mA $\cdot P_{CG}$)/W from t_{s1} to t_{s2}.
t_{s2} to t_{HW}	0 V $\leq V_{CG} \leq$ 3 V: Z_{CG} not defined 3 V $< V_{CG} \leq$ 6 V: $Z_{CG} \leq$ 1 200 Ω 6 V $< V_{CG} < V_{SW}$ = 60 V: P_{CG} < 12 W: $I_{CG}(t) = I_{CG\_STH} \geq$ 5 mA/W $\cdot P_{CG}$ $P_{CG} \geq$ 12 W: $I_{CG}(t) = I_{CG\_STH} \geq$ 60 mA

7.2.3.4 Electrical characteristics during the non-conducting period

During the non-conducting period, the controlgear should comply with the electrical characteristics listed in Tables 13 to 17.

The non-conducting period ends at the next zero crossing of the mains at time t_{HW}.

During this period, the controlgear should provide a minimum current-carrying capability of I_{CG_STH} as listed in Tables 13 to 17. At small input voltages of the controlgear when I_{CG_STH} cannot be reached due to the characteristics of its input circuitry (e.g. inrush current limiting elements), only its impedance Z_{CG} is defined as listed in Tables 13 to 17.

During this period, the phase-cut dimmer limits the current I_D to $n \cdot I_{D\_nc}$ as listed in IEC TR 63036, whereby I_{D_nc} is related to P_{min} of the phase-cut dimmer.

The controlgear may deactivate its current-carrying capability during the non-conducting period after it has not detected an input voltage waveform showing trailing edge characteristics for 100 ms.

NOTE This is for reducing power losses in case a controlgear is used without a phase-cut dimmer.

7.3 Electrical characteristics during the off state of a phase-cut dimming system

The off state of a phase-cut dimming system is when no lamp connected with a controlgear is emitting light.

To set a controlgear in the off state, the phase-cut dimmer increases its impedance Z_D until the controlgear is not sufficiently supplied with power to operate the lamp.

A phase-cut dimmer that needs no supply during the off state of all connected controlgear may open the current loop of the system, for example by means of a mechanical switch.

A phase-cut dimmer that needs a power supply also during the off state of all connected controlgear requires that the connected controlgear provide a current carrying capability, although no lamp is operated (electronic off state) in order to provide power to the electronic circuits within the dimmer to enable returning to the on-state when demanded.

If none of the connected controlgear is able to provide the current carrying capability due to insufficient power, the impedance Z_{CG} of the controlgear will increase.

The phase-cut dimmer may reduce its impedance Z_D to supply power to the connected controlgear in order to reestablish a current carrying capability that carries the needed supply current I_{D_nc}.

By reducing Z_D, the voltage V_D will decrease and the voltage V_{CG} will increase, thus all connected controlgear are energized and the requested current carrying capability is generated in the system to carry the required supply current I_D of the phase-cut dimmer.

The controlgear should provide a minimum current carrying capability of I_{PO} when the voltage V_{CG} is in the range of V_{PO} to V_{SW} (see Table 18). For voltages V_{CG} smaller than V_{PO} and higher than V_{SW}, the current carrying capability of the controlgear is not defined.

The controlgear should not operate the lamp when the voltage V_{CG} is below V_{SW}, so no light should be emitted.

The phase-cut dimmer limits the current to a level that ensures that the voltage V_{CG} that is applied to the controlgear does not exceed V_{SW}.

Table 18 – Currents and voltages for controlgear during the electronic off state

V_M [V]	100	120	200	230	277
V_{PO} [V]	15	15	30	30	30
I_{PO} [mA]	20	20	10	10	10
I_{PO_rms} [mA]	8	8	4	4	4

Values for voltages and currents are instantaneous values except I_{PO_rms}.

8 Test procedures

8.1 General

To simplify the description of the test setups and the test procedures, testing conditions for controlgear related to specific moments in time are defined in degree phase angle related to the mains zero crossings. Thus, a definition of different values for the moments in time such as t_{s1}, t_{s2} or t_{HW} is not necessary for different mains frequencies.

Table 19 – Parameters for testing purposes

V_M [V]	100	120	200	230	277
R_R	V_M^2 / P_max	V_M^2 / P_max	V_M^2 / P_max	V_M^2 / P_max	V_M^2 / P_max
V_{test} [V]	0 to 23	0 to 23	0 to 45	0 to 45	0 to 45
V_1 [V]	8	8	8	8	8
SR_L [V/µs]	Refers to Table 2				
α_L	90°				
β_L	120°				
SR_T [V/ms]	200	200	200	200	200
α_T	120°				

8.2 Tests for leading edge dimmable devices

8.2.1 General

Tests concerning the electrical characteristics should ensure compliance of devices with this document in terms of electrical behavior of controlgear during different periods of mains waveform according to 7.2.2.

A test circuit as shown in Figure 4 should be used to test the controlgear.

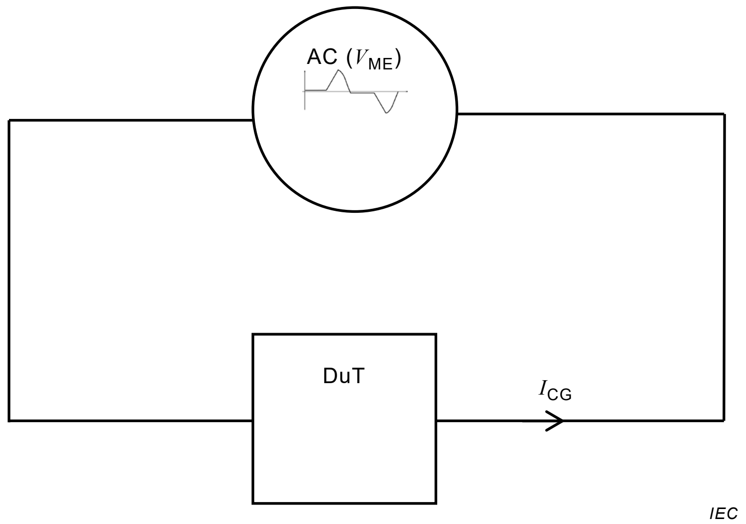

Figure 4 – Test setup for testing the conducting phase

8.2.2 Test related to the non-conducting phase

Pre-condition: Controlgear applied to an AC test voltage source (V_{ME}) providing the relevant mains voltage according to Clause A.2 with the values of V_1, α_L and SR_L given in Table 19.
Test: Measure the current I_{CG} of the controlgear. Measure I_{CG} from 0° until $V_{CG} > V_{SW}$
Expected results: 6 V ≤ $V_{CG} \leq V_{SW}$: $I_{CG} \geq I_{CG\_SL}$ as listed in Tables 1 to 5 NOTE The controlgear may deactivate its current-carrying capability during the non-conducting phase after it has not detected an input voltage waveform showing an unsteady waveform (leading edge characteristic) for one minute.

8.2.3 Test related to the transition from the non-conducting to the conducting phase and to the conducting phase

Pre-condition: Controlgear applied to an AC test voltage source (V_{ME}) providing the relevant mains voltage according to Clause A.2 with the values of V_1, α_L and SR_L given in Table 19.
Test: Measure the current I_{CG} of the controlgear Measure I_{CG} from t_s (α_L) to t_{SW} and Measure I_{CG} from t_{SW} to t_{HW}
Expected results: from t_s to t_{SW}: $I_{CG} \leq I_{CG\_pk}$ (P_{CG}) from t_{SW} to t_{HW}: 3 V < $V_{CG} \leq$ 6 V: $I_{CG} \geq V_{CG}/Z_{CG}$ with Z_{CG} as listed in Tables 7 to 11 6 V < $V_{CG} < V_{SW}$: $I_{CG} = I_{CG\_SL}$ as listed in Tables 7 to 11

8.3 Tests for trailing edge dimmable devices

8.3.1 General

Tests concerning the electrical characteristics should ensure compliance of devices with this document in terms of electrical behavior of controlgear during different periods of mains waveform according to 7.2.3.

8.3.2 Test related to the conducting phase

For an applicable test circuit, see Figure 4.

Pre-condition: Controlgear applied to an AC test voltage source (V_{ME}) providing the relevant mains voltage according to Clause A.3 with the values of V_1, α_T and SR_T given in Table 19
Time related to last zero crossing: 0 to $V(t) < V_{SW}$
Test: Measure I_{CG} in dependence of instantaneous value of applied voltage
Expected results: 3 V ≤ V_{CG} ≤ 6V: $I_{CG} \geq V_{CG}/Z_{CG}$ with Z_{CG} as listed in Table 12 V_{CG} ≥ 6 V: $I_{CG} = I_{CG\_SL} \geq (0,7 \cdot P_{CG})/V_M$ or $I_{CG} = I_{CG\_STL}(t) \geq (0,7 \cdot V_{CG}(t))/(V_M^2/P_{CG})$

8.3.3 Test related to the transition from the conducting phase to the non-conducting phase

For an applicable test circuit, see Figure 5.

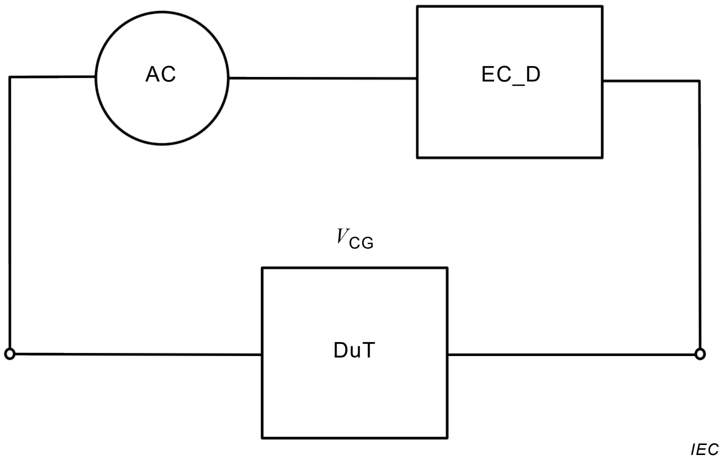

Figure 5 – Test setup for the transition from the conducting to the non-conducting phase

Pre-condition: Controlgear connected to the EC_D according to Annex B as shown in Figure 5, system powered with relevant mains voltage. Adjust the current I_D according to Annex B as given in Tables 13 to 17
Time related to last zero crossing: t_{s1} to t_{s2}
Test: Measure $\lvert dV_{CG}/dt \rvert$ with a conduction angle of the EC_D of 90°, repeat this measurement with conducting angles of the EC_D of 60° and 120°
Expected result: When the conduction angle of EC_D is terminated (t_{s1}), the voltage across the input terminals of the controlgear decreases with $\lvert dV_{CG}/dt \rvert \geq SR$, as listed in Tables 13 to 17.

The slew rate SR should be calculated based on the measurement of the voltage slope of V_{CG} by measuring the time (dt) between V_{CG}= 0,8 · $V_{CG}(t_{s1})$ and $V_{CG} = V_{SW}$ and by calculating the differential voltage $dV_{CG} = 0,8 \cdot V_{CG}(t_{s1}) - V_{SW}$.

8.3.4 Test related to the non-conducting phase

For an applicable test circuit, see Figure 6.

Pre-condition: Controlgear applied to an AC test voltage source (V_{ME}) providing the relevant mains voltage according to Clause A.2 with the values of V_1, α_L and SR_L given in Table 19.
Time related to last zero crossing: t_{s2} to t_{HW}
Test: Measure I_{CG} in dependence of instantaneous value of applied voltage
Expected results: 6V ≤ V_{CG} ≤ V_{SW}: $I_{CG} \geq I_{CG\_STH}$ 3V ≤ V_{CG} < 6V: $I_{CG} \geq V_{CG}/Z_{CG}$ with Z_{CG} as listed in Tables 13 to 17

8.4 Tests for characteristics during electronic off state

Tests concerning the electrical characteristics should ensure compliance of devices with this document in terms of electrical behavior of controlgear during the electronic off state of a phase-cut dimming system according to 7.3.

A test circuit as shown in Figure 6 should be used to test the controlgear.

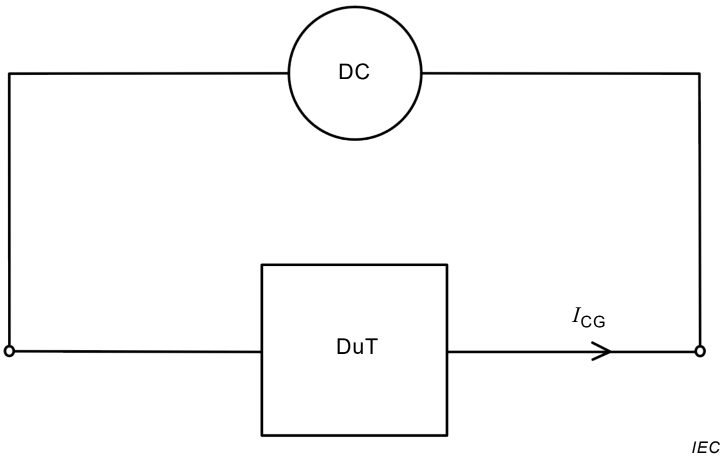

Figure 6 – Test setup for the non-conducting phase

Pre-condition: Controlgear connected to a controllable DC voltage source
Test: Vary the voltage of the DC source within the range for V_{test} as given in Table 19 for the relevant mains voltage. Measure I_{CG} and record at which voltages in the range of V_{test} the current carrying capability is activated
Expected results: Controlgear provides a current carrying capability I_{PO} at $V_{PO} \leq V_{PO} < V_{SW}$ as listed in Tables 1 to 5, 7 to 11, 13 to 17 Controlgear does not operate the lamp at $V_{CG} \leq V_{SW}$, no light is emitted

Annex A
(informative)

Voltage shapes to be used with the tests in IEC TR 63037

A.1 General

A test AC voltage source (V_{ME}) with the waveform as shown in Figure A.1 or Figure A.2 should be used as indicated in the defined tests. The detailed settings for time and voltage should be set with an accuracy of ≤ 1 %. The internal resistance of this voltage source should not exceed 1 Ω.

A.2 Waveform description

0° to α°: constant voltage with the value V_1

α° to α_1°: constant slew rate (SR)

α_1° to 180°: sinusoidal voltage according to V_M

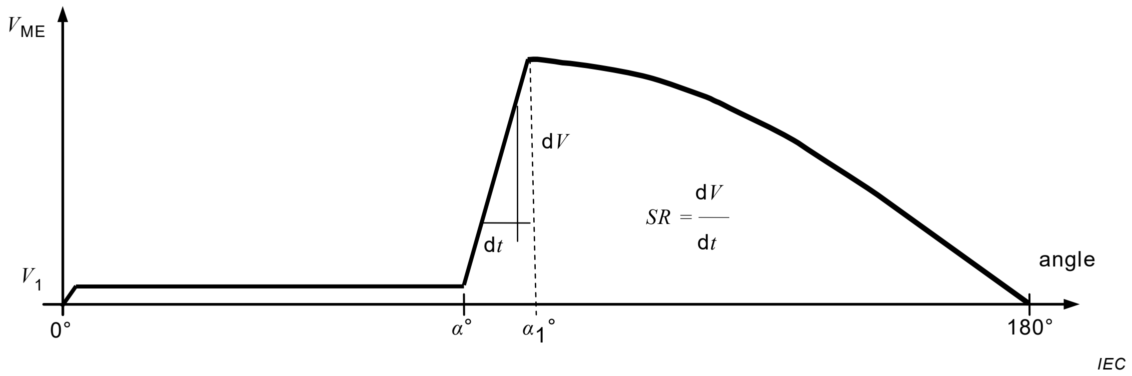

Figure A.1 – Waveform of AC voltage source

A.3 Waveform description

0° to β°: sinusoidal voltage according to V_M

β° to β_1°: constant slew rate (SR)

β_1° to 180°: constant voltage with the value V_1

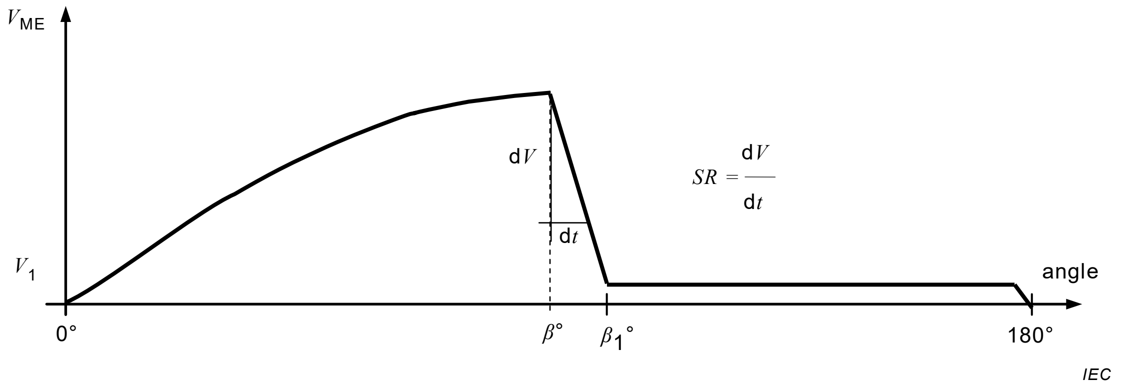

Figure A.2 – Waveform of AC voltage source

Annex B
(informative)

Equivalent phase-cut dimmer circuit

Figure B.1 shows the equivalent circuit EC_D for a phase-cut dimmer:

Components and values are only exemplary beside capacitance C2 which is mandatory, representing the maximum wiring capacitance.

V2 is a pulse generator that provides a control signal for the transistors T1 and T2 leading to conduction states of these two transistors in order that the correct phase angle is adjusted.

Adjust the current $I_D = (I_{trans} \cdot P_{min})$/W according to Tables 13 to 17 by varying R20.

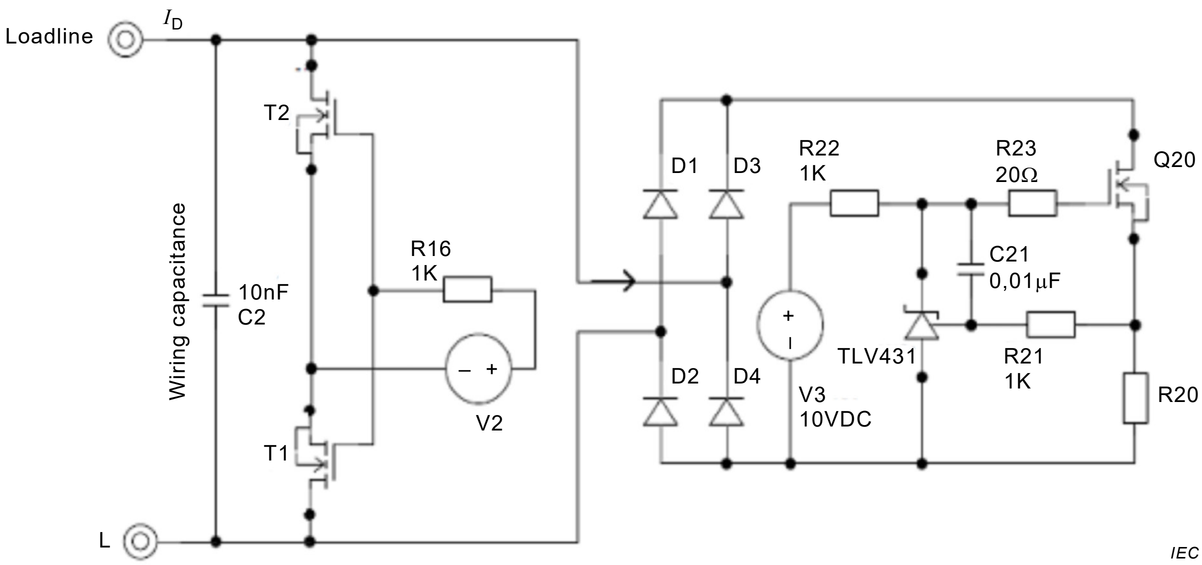

Figure B.1 – Scheme of the EC_D

Bibliography

IEC 60038, *IEC standard voltages*

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

IEC TR 63036, *Electrical interface specification for phase-cut dimmer in phase-cut dimmed lighting systems*

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Copyright in BSI publications

Storing and using standards

Standards purchased in soft copy format:

- A British Standard purchased in soft copy format is licensed to a sole named user for personal or internal company use only.
- The standard may be stored on more than 1 device provided that it is accessible by the sole named user only and that only 1 copy is accessed at any one time.
- A single paper copy may be printed for personal or internal company use only.

Standards purchased in hard copy format:

- A British Standard purchased in hard copy format is for personal or internal company use only.
- It may not be further reproduced – in any format – to create an additional copy. This includes scanning of the document.

If you need more than 1 copy of the document, or if you wish to share the document on an internal network, you can save money by choosing a subscription product (see 'Subscriptions').

Reproducing extracts

For permission to reproduce content from BSI publications contact the BSI Copyright & Licensing team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email subscriptions@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Useful Contacts

Customer Services
Tel: +44 345 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 345 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

bsi.