

A.C. supplied electronic ballasts for tubular fluorescent lamps — Performance requirements

The European Standard EN 60929:2004 has the status of a British Standard

ICS 29.140.30

National foreword

This British Standard is the official English language version of EN 60929:2004. It is identical with IEC 60929:2003. It supersedes BS EN 60929:1992 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee CPL/34, Lamps and related equipment, which has the responsibility to:

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- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
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**A.C. supplied electronic ballasts for tubular fluorescent lamps -
Performance requirements
(IEC 60929:2003)**

Ballasts électroniques alimentés
en courant alternatif pour lampes
tubulaires à fluorescence -
Prescriptions de performances
(CEI 60929:2003)

Wechselstromversorgte elektronische
Vorschaltgeräte für röhrenförmige
Leuchtstofflampen -
Anforderungen an die Arbeitsweise
(IEC 60929:2003)

This European Standard was approved by CENELEC on 2004-03-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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CENELEC

European Committee for Electrotechnical Standardization
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Foreword

The text of document 34C/618/FDIS, future edition 2 of IEC 60929, prepared by SC 34C, Auxiliaries for lamps, of IEC TC 34, Lamps and related equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60929 on 2004-03-01.

This European Standard Supersedes EN 60929:1992 + A1:1995 + A2:1996.

In this new edition digital signal control of electronic ballasts has been introduced.

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) 2004-12-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2007-03-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60929:2003 was approved by CENELEC as a European Standard without any modification.

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INTRODUCTION

This International Standard covers performance requirements for electronic ballasts for use on a.c. supplies up to 1 000 V at 50 Hz or 60 Hz with operating frequencies deviating from the supply frequency, associated with tubular fluorescent lamps as specified in IEC 60081 and IEC 60901, and other tubular fluorescent lamps for high frequency operation, still to be standardized.

These ballasts are intended to operate lamps at various frequencies including high frequencies, and at various lamp powers. Attention is drawn to the fact that operating frequencies below 20 kHz may cause audio noise disturbance, whereas frequencies above 50 kHz may increase radio interference problems.

Some lamps may be specifically designed for high-frequency operation on high-frequency ballasts. Two starting modes, preheat and non-preheat, are described.

NOTE The possibility exists for operation of lamps designed for preheat starting on circuits of the non-preheat type. Lamps specified for operation on both types of circuits may appear in IEC 60081, or lamp manufacturers can authorize such operation of their lamps.

In order to obtain satisfactory performance of fluorescent lamps and electronic ballasts, it is necessary that certain features of their design be properly coordinated. It is essential, therefore, that specifications for them be written in terms of measurement made against some common baseline of reference, which must be reasonable, permanent and reproducible.

These conditions may be fulfilled by reference ballasts. Moreover, the testing of ballasts for fluorescent lamps will, in general, be made with reference lamps and, in particular, by comparing results obtained on such lamps with ballasts to be tested and with a reference ballast.

Whereas the reference ballast for frequencies of 50 Hz or 60 Hz is a self-inductive coil, the high-frequency reference ballast is a resistor because of its independency of frequency and the lack of influence of parasitic capacitance.

AC-SUPPLIED ELECTRONIC BALLASTS FOR TUBULAR FLUORESCENT LAMPS – PERFORMANCE REQUIREMENTS

1 Scope

This International Standard specifies performance requirements for electronic ballasts for use on a.c. supplies up to 1 000 V at 50 Hz or 60 Hz with operating frequencies deviating from the supply frequency, associated with tubular fluorescent lamps as specified in IEC 60081 and IEC 60901 and other tubular fluorescent lamps for high frequency operation.

NOTE Tests in this standard are type tests. Requirements for testing individual ballasts during production are not included.

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 60081, *Double-capped fluorescent lamps – Performance specifications*

IEC 60410:, *Sampling plans and procedures for inspection by attributes*

IEC 60669-2-1, *Switches for household and similar fixed electrical installations – Part 2-1: Particular requirements – Electronic switches*

IEC 60901, *Single-capped fluorescent lamps – Performance specifications*

IEC 61000-3-2:2000, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*
Amendment 1 (2001)

IEC 61347-1, *Lamp controlgear – Part 1: General and safety requirements*

IEC 61347-2-3, *Lamp controlgear – Part 2-3: Particular requirements for a.c. supplied electronic ballasts for fluorescent lamps*

IEC 61547, *Equipment for general lighting purposes – EMC immunity requirements*

3 Terms and definitions

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

3.1

starting aid

aid that can be either a conductive stripe affixed to the outer surface of a lamp, or a conductive plate which is spaced within an appropriate distance from a lamp.

NOTE A starting aid can only be effective when it has an adequate potential difference from one end of the lamp.

3.2

ballast lumen factor

ratio of the light output of the lamp when the ballast under test is operated at its rated voltage, compared with the light output of the same lamp operated with the appropriate reference ballast supplied at its rated voltage and frequency

3.3

reference ballast

special ballast designed for the purpose of providing comparison standards for testing ballasts and for selecting reference lamps

NOTE It is essentially characterized by the fact that at its rated frequency it has a stable voltage/current ratio which is relatively uninfluenced by variations in current, temperature and magnetic surroundings, as outlined in this standard.

3.4

reference lamp

lamp selected for testing ballasts which, when associated with a reference ballast under specified conditions, has electrical characteristics which are close to the nominal values as stated in the relevant lamp standard for that particular type of lamp

3.5

calibration current of a reference ballast

value of the current on which are based the calibration and functioning of the ballast

3.6

total circuit power

total power dissipated by ballast and lamp in combination, at rated voltage and frequency of the ballast

3.7

circuit power factor

λ

power factor of the combination of a ballast and the lamp or lamps for which the ballast is designed

3.8

high power factor ballast

ballast having a circuit power factor of at least 0,85

NOTE 1 The value of power factor takes into account the effect of the distortion of the current waveform.

NOTE 2 For North America, high power factor is defined as a power factor of at least 0,9.

3.9

high audio-frequency impedance ballast

ballast of which the impedance in the frequency range 250 Hz to 2 000 Hz exceeds the values specified in Clause 14 of this standard

3.10

low-distortion type ballast

ballast of which the harmonic content complies with the more severe requirements of 12.1 of this standard

3.11

preheat starting

type of circuit in which the lamp electrodes are brought to emission temperature before the lamp actually ignites

3.12**non-preheat starting**

type of circuit which utilizes a high open-circuit voltage causing field emission from electrodes

3.13**pre-start time**

for ballasts according to 3.12, period after switching on the supply voltage during which the lamp current is ≤ 10 mA

4 General notes on tests**4.1** Tests according to this standard are type tests.

NOTE The requirements and tolerances permitted by this standard are based on the testing of a type test sample submitted by the manufacturer for that purpose. In principle this type test sample should consist of units having characteristics typical of the manufacturer's production and be as close to the production centre point values as possible.

It may be expected with the tolerances given in this standard that products manufactured in accordance with the type test sample will ensure compliance with the standard for the majority of the production. However, due to the production spread, it is inevitable that there will sometimes be products outside the specified tolerances. For guidance on sampling plans and procedures for inspection by attributes, see IEC 60410.

4.2 The tests are carried out in the order of the clauses, unless otherwise specified.**4.3** One ballast is submitted to all tests.**4.4** In general, all tests are made on each type of ballast or where a range of similar ballasts is involved for each rated wattage in the range or on a representative selection from the range, as agreed with the manufacturer.**4.5** The tests are made under the conditions specified in Annex A. Lamp data sheets not published in an IEC publication shall be made available by the lamp manufacturer.**4.6** All ballasts specified in this standard shall comply with the requirements of IEC 61347-1 and IEC 61347-2-3.**5 Marking****5.1** Ballasts shall be clearly marked with the following mandatory marking:

a) Circuit power factor, for example 0,85.

If the power factor is less than 0,95 leading, it shall be followed by the letter C, for example 0,85 C.

The following markings shall also be added, if appropriate:

b) The symbol $Z_{\approx}$ which indicates that the ballast is designed to comply with the conditions for audio-frequency impedance.c) The symbol H which indicates that the ballast is not of the low distortion type.**5.2** In addition to the above mandatory markings, the following information shall either be given on the ballast or be made available in the manufacturer's catalogue or the like:

- a) a clear indication regarding the type of starting, viz. preheat or non-preheat;
- b) indication whether a ballast needs a starting aid.

5.3 Non-mandatory information, which may be made available by the manufacturer:

- a) rated output frequency at rated voltage, with and without lamp operating;
- b) limits of the ambient temperature range within which the ballast will operate satisfactorily at the declared voltage (range);
- c) ballast lumen factor and total circuit power in combination.

6 General statement

It may be expected that ballasts complying with this standard, when associated with lamps which comply with IEC 60081 or IEC 60901 or other fluorescent lamps for high-frequency operation, will provide satisfactory starting of the lamp at an air temperature immediately around the lamp between 10 °C and 35 °C and operation between 10 °C and 50 °C at voltages within 92 % and 106 % of the rated voltage.

NOTE The electrical characteristics as given on the lamp data sheets of IEC 60081 and IEC 60901, and applying to operation on a reference ballast at rated voltage with a frequency of 50 Hz or 60 Hz, may deviate when operating on a high frequency ballast and the conditions of item b) of 5.3 above.

7 Starting conditions

Ballasts shall start lamps without adversely affecting the performance of the lamp when operated according to intended use. An explanation of the starting conditions is given in Annex D.

Compliance is checked by the tests according to 7.1 to 7.4, as appropriate, with the ballast operating at any supply voltage between 92 % and 106 % of its rated value.

NOTE Preheat current or voltage requirements also apply to controllable ballasts in any dimming position.

7.1 Ballasts for current-controlled preheat starting mode

For ballasts of this category, the following requirements apply. The tests shall be carried out in accordance with the requirements of Clause A.4.

7.1.1 With a non-inductive substitution resistor of the value specified on the relevant lamp data sheet, substituted for each lamp cathode, the ballast shall deliver a minimum total effective heating current according to the time/current limits specified on the relevant lamp data sheets (see Figure 1).

The absolute minimum preheat time shall be at least 0,4 s, unless otherwise specified on the relevant lamp data sheet.

The maximum effective heating current shall not exceed the limits specified on the relevant lamp data sheet at any time t .

7.1.2 The open-circuit voltage between any pair of substitution resistors representing a lamp shall not exceed the maximum values specified on the lamp data sheets, during the preheat period. After the preheat period it shall be, or rise to a value, not less than the minimum value for lamp starting, as specified on the lamp data sheet.

If the current through the substitution resistor, as specified in 7.1.1, is interrupted before the minimum specified voltage for lamp starting has been reached, the voltage rise to minimum starting voltage shall take place within not more than 0,1 s (see Figure 2a).

If the voltage rise takes more than 0,1 s, the current through the substitution resistor shall not fall below the absolute minimum value specified (see Figure 2b).

The crest factor of the open-circuit voltage shall not exceed 1,8. Even very narrow voltage peaks which do not influence the r.m.s. value shall not occur during the minimum preheat period.

7.2 Ballasts for voltage-controlled preheat starting mode

Ballasts of this type shall provide proper cathode preheating voltage, cathode operating voltage, and lamp starting voltage. Limiting values and appropriate substitution resistors are specified on the relevant lamp data sheets in IEC 60081 and IEC 60901.

Lamps with either low resistance cathodes or high resistance cathodes may be operated by this method.

7.2.1 Ballasts shall deliver r.m.s. cathode heating voltage, within the limits specified on the relevant lamp data sheet, to the specified substitution resistors, when rated supply voltage is applied.

It is permitted to exceed the maximum cathode voltage limit provided the maximum cathode current is in accordance with the requirements for current-controlled preheating.

The minimum application time of the cathode heating voltage shall be 0,4 s.

Dependent upon lamp data sheet requirements, the cathode heating voltage after 0,4 s may be:

- a) applied continuously during operation;
- b) reduced to a lower level;
- c) reduced to zero.

7.2.2 Ballasts shall provide the lamp starting voltages specified on the relevant lamp data sheet for:

- a) r.m.s. voltage across the lamp, and
- b) peak voltage to starting aid, if required.

Starting requirements for various series circuits may be specified. For operation of lamps in parallel circuits, the relevant single lamp requirement shall be provided for each lamp.

The starting voltages may be available simultaneously with the cathode preheating voltage or they may be elevated to those levels after 0,4 s elapsed time. Any voltage applied before 0,4 s shall be lower than the level that would cause starting of the lamp or shall be in accordance with the values given for current-controlled preheating.

7.3 Ballasts for non-preheat starting mode

Ballasts in accordance with definition 3.12 shall be so designed that the cumulative glow discharge periods during starting do not exceed 100 ms when measured with a reference lamp and without any earthed metal parts close by which might act as a starting aid. The glow discharge period is deemed to have finished if the lamp current is at least 80 % of the nominal lamp current.

A ballast is deemed to conform with the above requirements when the following conditions are fulfilled.

7.3.1 Open-circuit voltage

Measurement is made with an oscilloscope. With a non-inductive substitution resistor R_c of the value specified on the relevant lamp data sheet, substituted for each lamp cathode (see Figure 3a), the open-circuit voltage shall comply with the value specified on the relevant lamp data sheet.

Where two lamps are operated in series, the open-circuit voltage delivered to each lamp shall be determined in turn, by substituting a reference lamp in one lamp position and substitution resistors, of the value specified on the relevant lamp data sheet, in place of the electrodes in the other lamp position.

The open-circuit voltage is measured between the substitution resistors and shall comply in both cases with the value specified on the relevant lamp data sheet for one lamp.

NOTE In the case of additional cathode heating during the starting process, lower values may be sufficient provided the glow discharge period does not exceed 100 ms.

7.3.2 Ballast impedance test

With a non-inductive lamp substitution resistor R_L of the value specified on the relevant lamp data sheet, substituted for the lamp and a non-inductive resistor R_c of the value specified on the relevant lamp data sheet, substituted for each lamp cathode, (see Figure 3b), and at 92 % of the rated voltage, the ballast shall deliver a current not less than the minimum value specified on that data sheet.

7.3.3 Cathode current

Ballasts of the non-preheat start type may supply some cathode heating during the starting process.

The cathode current, if any, shall not exceed the maximum value specified on the relevant lamp data sheet.

The measurement is carried out with a substitution resistor R_i (see Figure 3c), the value of which is calculated as follows:

$$R_i = 11 (2,1 I_n)^{-1}$$

where I_n is the nominal value of the lamp operating current.

7.4 Starting aid and distances

Lamps operated with electronic ballasts complying with this standard may require a starting aid as specified in IEC 60081. The open-circuit voltage and voltage to starting aid (if required), during preheat and starting, shall be within the limits specified in the information for ballast design on the relevant lamp data sheet.

8 Operating conditions

8.1 At rated voltage, the ballast lumen factor shall not be less than 95 % of the value declared by the manufacturer.

If the declared lumen factor of the ballast is less than 0,9, evidence shall be given that the performance of lamps operated on that ballast is not impaired. A relevant test is under consideration.

8.2 At rated voltage, the total circuit power shall be not more than 110 % of the value declared by the manufacturer, when the ballast is operated with (a) reference lamp(s).

8.3 Requirements for dimming

8.3.1 Lamp cathode heating

When operating lamps at lower lumen levels than the optimum design point, care shall be taken that the ballast provides cathode heating continuously to the lamp(s) so that the lamp life is not degraded.

8.3.2 Lamp power control

Requirements are specified in Annex E.

There are presently also other non-standardized interfaces, which can lead to problems of interchangeability between interfaces. These have to be tested according to the manufacturers' specifications. The type of interface shall be marked on the ballast.

8.4 Unless otherwise specified on the relevant lamp data sheet, the ballast shall limit the current delivered to a reference lamp to a value not exceeding 115 % of that delivered to the same lamp when it is operated with a reference ballast.

Measurement is made in the circuit of Figure 4.

9 Circuit power factor

The measured circuit power factor shall not differ from the marked value by more than 0,05 when the ballast is operated with one or more reference lamp(s) and the whole combination is supplied at its rated voltage and frequency.

For controllable ballasts, the power factor is measured at full power.

10 Supply current

At rated voltage, the supply current shall not differ by more than ± 10 % from the value marked on the ballast or declared in the manufacturer's literature, when the ballast is operated with (a) reference lamp(s).

For controllable ballasts, the supply current shall not exceed the value marked on the ballast by more than 10 % in any dimming position.

11 Maximum current in any lead to a cathode

In normal operation at any supply voltage between 92 % and 106 % of the rated value, the current flowing in any one of the cathode terminations shall not exceed the value given on the relevant lamp data sheet.

The measurement is made with an oscilloscope or another suitable device. The measurements shall be made with a reference lamp at all contacts to the cathodes.

12 Current waveform

12.1 Supply current waveform

The harmonics of the input current for luminaires shall comply with IEC 61000-3-2.

NOTE The above requirements apply to luminaires or ballasts which are intended to be connected to supplies prescribed in Clause 4 of IEC 61000-3-2.

If separate tests with reference lamps have proved that ballasts for fluorescent lamps comply with the requirements as specified in the relevant table of IEC 61000-3-2, the luminaire is deemed to comply with these requirements and need not be checked. Manufacturers shall indicate whether or not the ballast under test shall be subjected to the following test.

Where these components have not been approved separately or do not comply, the luminaire itself is tested and shall comply.

The test is carried out in accordance with the requirements of Clause A.2. The ballast shall be operated at its rated voltage with a reference lamp or lamps. After lamp stabilization, the waveform of the supply current shall be such that the harmonics shall not exceed the limits given in the relevant table of IEC 61000-3-2.

12.2 Lamp operating current waveform

The test is carried out in accordance with the requirements of Clause A.2.

The ballast shall be operated with a reference lamp or lamps at its rated voltage. After lamp stabilization, the waveform of the lamp current shall comply with the following conditions:

- a) In every successive half-cycle, the enveloping wave of the lamp current shall not differ by more than 4 % at the same time after phase zero passage of the mains supply voltage.

NOTE 1 The purpose of this requirement is to avoid the inconsistency of the wave shape of the enveloping wave from half mains cycle to half mains cycle.

- b) The maximum ratio of peak value to r.m.s. value shall not exceed 1,7 individual high-frequency crest factor.

In the case where the high frequency is modulated at mains frequency, the maximum lamp current crest factor for the modulated envelope should not exceed 1,7¹⁾.

NOTE 2 High frequency current crest factor is equal to peak current of the modulated or unmodulated envelope divided by the r.m.s. current.

13 Magnetic screening

Ballasts shall be effectively screened against magnetic influence of adjacent ferromagnetic materials.

Compliance is checked by the following test.

The ballast shall be operated at rated voltage with an appropriate lamp. After stabilization, a steel plate 1 mm thick and of length and breadth greater than those of the ballast under test is successively placed in direct contact with the bottom plate of the ballast and at a distance of 1 mm from each face of the latter. During this operation, the lamp current is measured and this shall not change by more than 2 % due to the presence of the steel plate.

14 Impedance at audio frequencies

Ballasts marked with the audio-frequency symbol (see 5.1) are tested in accordance with Clause A.3.

For every signal frequency between 400 Hz and 2 000 Hz, the impedance of the ballast when operated with a reference lamp supplied at its rated voltage and frequency shall be inductive in characteristic. Its impedance in ohms shall be at least equal in value to the resistance of the resistor which would dissipate the same power as the lamp/ballast combination in question when it is supplied at its rated voltage and frequency. The ballast impedance is measured with a signal voltage equal to 3,5 % of the rated supply voltage of the ballast.

Between 250 Hz and 400 Hz, the impedance shall be at least equal to half the minimum value required for frequencies between 400 Hz and 2 000 Hz.

NOTE Radio interference suppressors consisting of capacitors of less than 0,2 μF (total value) which may be incorporated in the ballast may be disconnected for this test.

15 Mains transient overvoltages

Mains transients of either polarity, randomly phased and superimposed on the mains voltage, as specified in Clause A.5, shall not disturb the intended functioning of the equipment or lead to damage. Direct influence of lightning on the mains distribution has not been taken into account.

The test shall be carried out in accordance with the requirements of Clause A.5.

¹⁾ In Japan, a crest factor of 2,1 maximum is permitted.

16 Operational tests for abnormal conditions

16.1 Removal of lamp(s)

During the operation of the ballast at rated voltage +10 % and in association with (an) appropriate lamp(s), the lamp(s) shall be disconnected for 1 h from the ballast without switching off the supply voltage. At the end of this period, the lamp(s) is (are) reconnected and shall start and operate normally at least after line re-switch on.

16.2 Lamp fails to start

With an appropriate dummy cathode resistor as specified on the relevant data sheet connected in place of each lamp cathode, the ballast shall be operated at rated voltage +10 % for 1 h. At the end of this period, the resistor shall be removed; (an) appropriate lamp(s) is (are) connected and shall start and operate normally at least after line re-switch on.

17 Endurance

17.1 Before the test, the ballast shall be subjected to a temperature cycling and an open-circuit switching test, as follows:

a) Temperature cycle test

The ballast is stored firstly at the lower limit of the ambient temperature for 1 h. The temperature is then raised to t_c for 1 h. Five such temperature cycles are carried out. If a lower limit is not declared, a value of +10 °C shall be used.

b) Switching cycle test

At rated supply voltage, the ballast is switched on and off each for 30 s. This cycle is repeated 1 000 times with the output terminals open.

17.2 The ballast shall then be operated with an appropriate lamp at rated supply voltage and in an ambient temperature which produces t_c , until a test period of 200 h has elapsed. At the end of this time, and after cooling down to room temperature, the ballast shall correctly start and operate an appropriate lamp for 15 min. During this test, the lamps are placed outside the test enclosure at an ambient temperature of 25 °C ± 5 °C.

17.3 The mentioned t_c is the t_c measured at the most onerous dimming position. This dimming position may be given by consultation with the manufacturer.

NOTE When testing the t_c temperature within the luminaire, the same onerous dimming position applies.

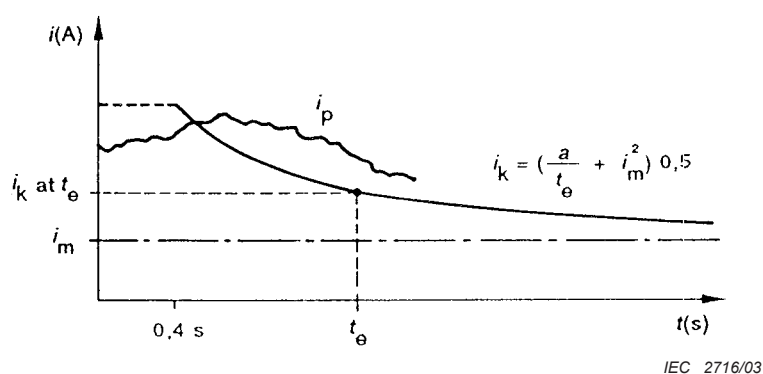


Figure 1a

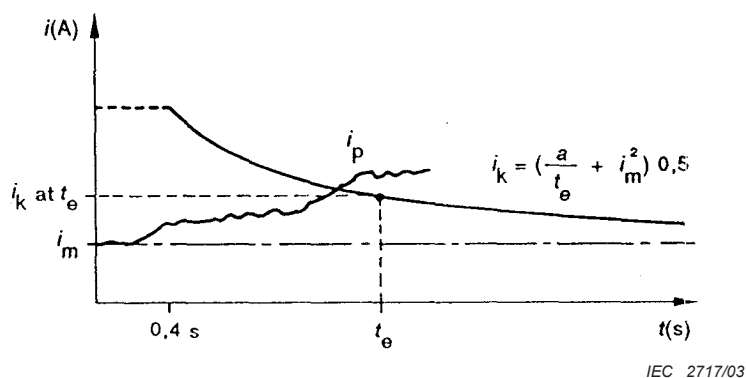


Figure 1b

Figure 1a: Ballast complies with 7.1.1. Varying r.m.s. current i_p never falls below steady state r.m.s. current i_k (at t_e), therefore the r.m.s. envelope of current i_p can be used to show

$$\int_0^{t_e} i_p^2 dt > \int_0^{t_e} i_k^2 dt$$

Figure 1b: Ballast does not comply with 7.1.1. Varying r.m.s. current i_p only reaches the level of steady state r.m.s. current i_k (at t_e) just before time t_e , therefore the r.m.s. envelope of current i_p can be used to show

$$\int_0^{t_e} i_p^2 dt < \int_0^{t_e} i_k^2 dt$$

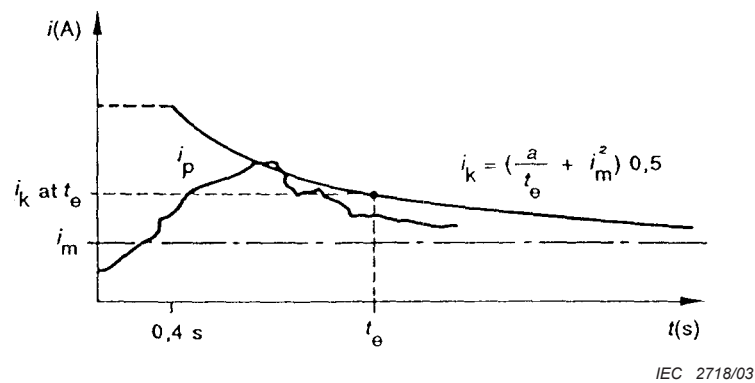


Figure 1c

Figure 1c: Ballast may or may not comply with 7.1.1. The varying r.m.s. current i_p only exceeds the steady state r.m.s. current i_k (at t_e) for part of the time period to t_e . Energy measurements or calculations are necessary to determine whether

$$\int_0^{t_e} i_p^2 dt \geq \int_0^{t_e} i_k^2 dt$$

The total heating effect of the varying heating current to time t_e shall not be less than the equivalent of the steady state r.m.s. current i_k (at t_e) for the same heating effect.

Possible instances are shown in the three figures.

Figure 1 – Interpretation of effective heating current

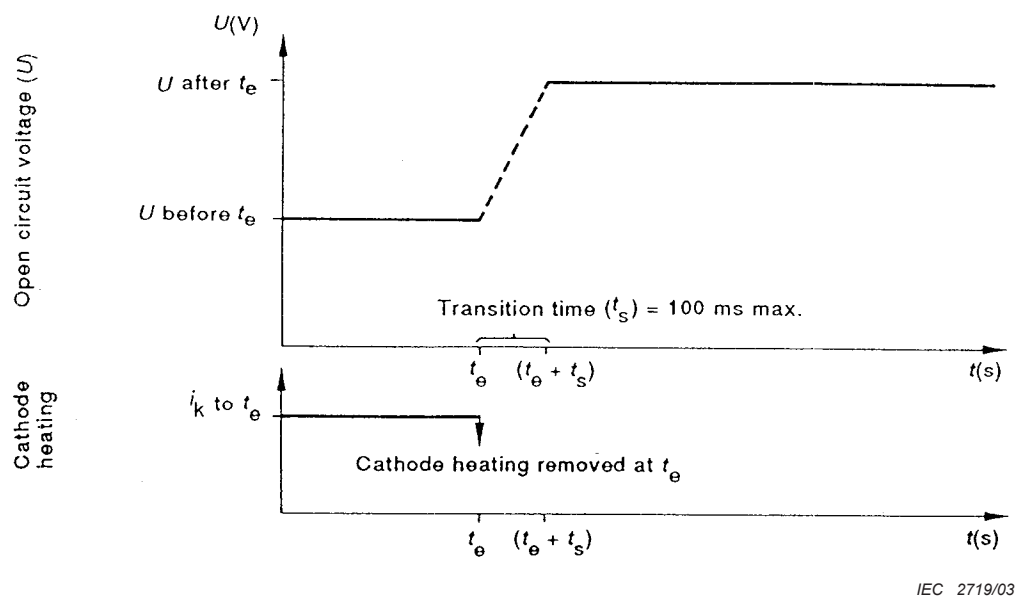


Figure 2a – Ballasts which remove preheating current when open-circuit voltages are elevated

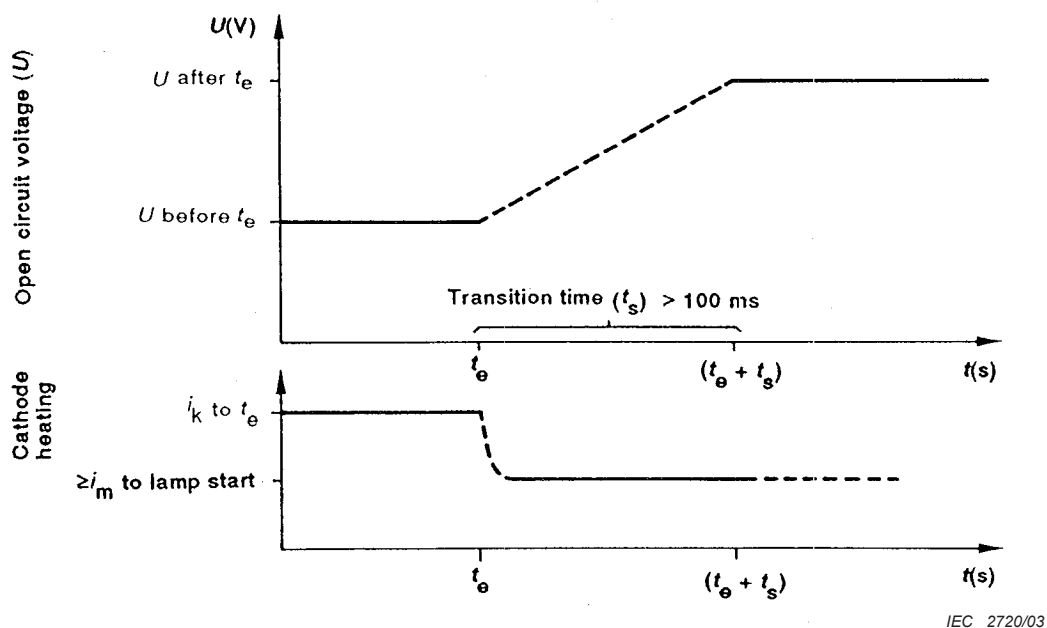
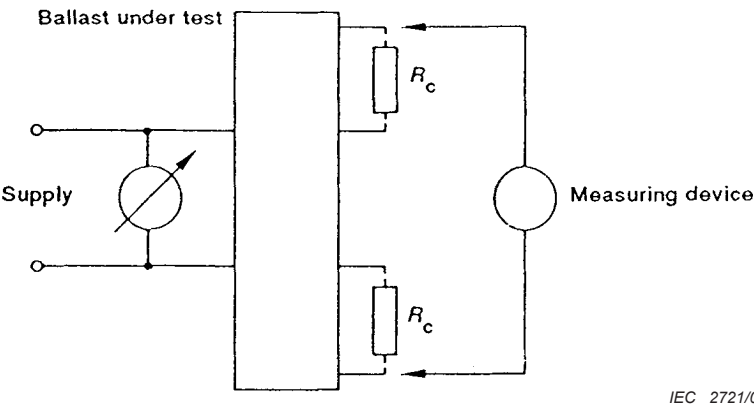


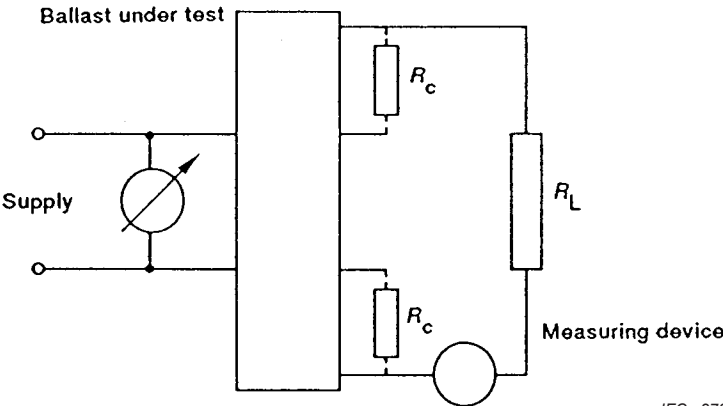
Figure 2b – Ballasts which have open-circuit voltage transition time > 100 ms

Figure 2 – Open-circuit voltage requirements for ballasts with current-controlled preheating



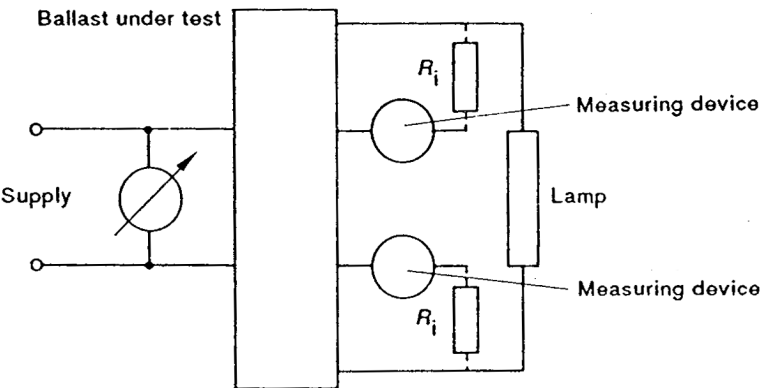
IEC 2721/03

Figure 3a – Test circuit for open-circuit voltage



IEC 2722/03

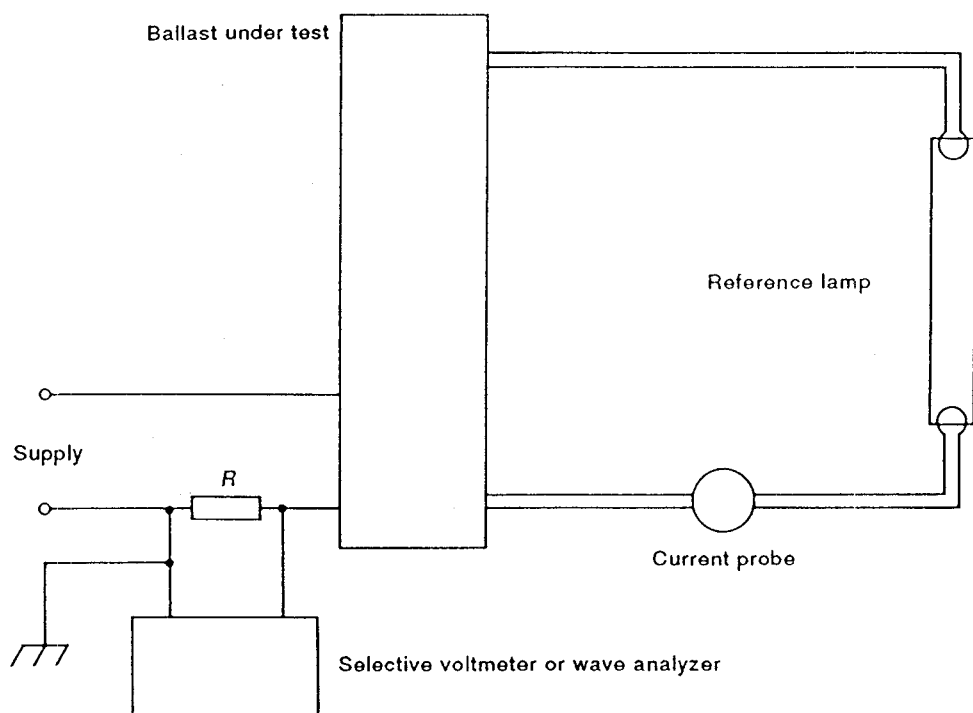
Figure 3b – Test circuit for ballast impedance



IEC 2723/03

Figure 3c – Test circuit for cathode current

Figure 3 – Test circuit for non-preheat starting mode

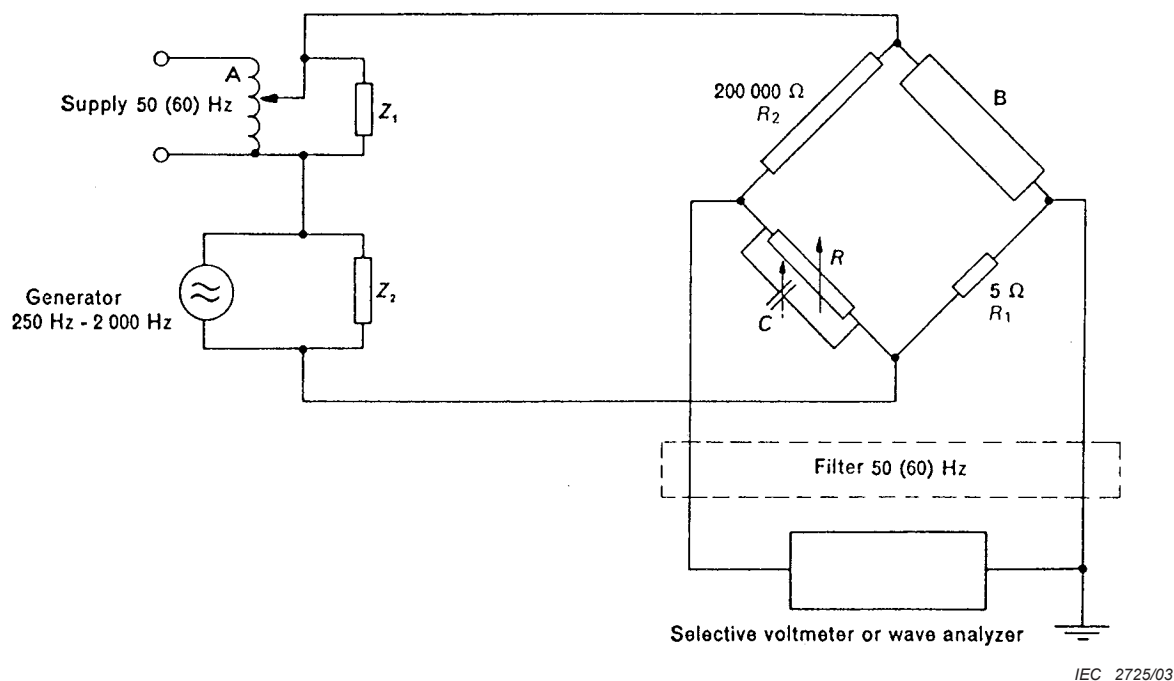


IEC 2724/03

The measuring device is connected to the output which is nearest to earth potential.

Earthing of any output circuit is not necessary.

Figure 4 – Measurement of current waveform



NOTE The value of 200 000 Ω for one branch of the bridge is not critical.

Figure 5 – Measurement of impedance at audio frequencies

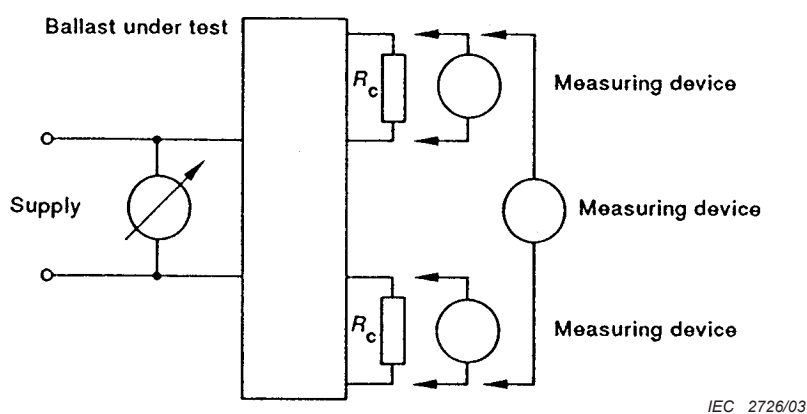
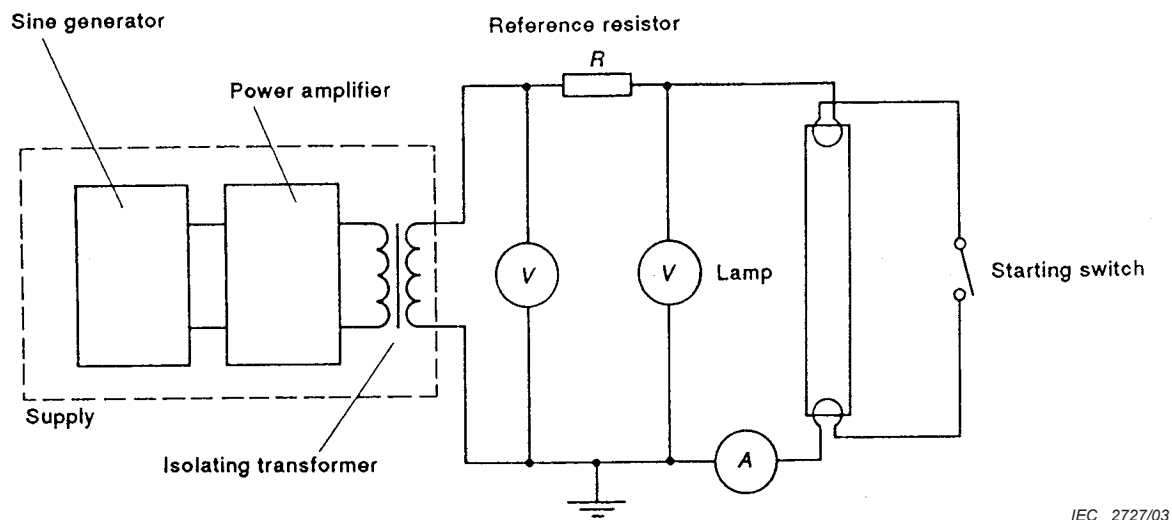
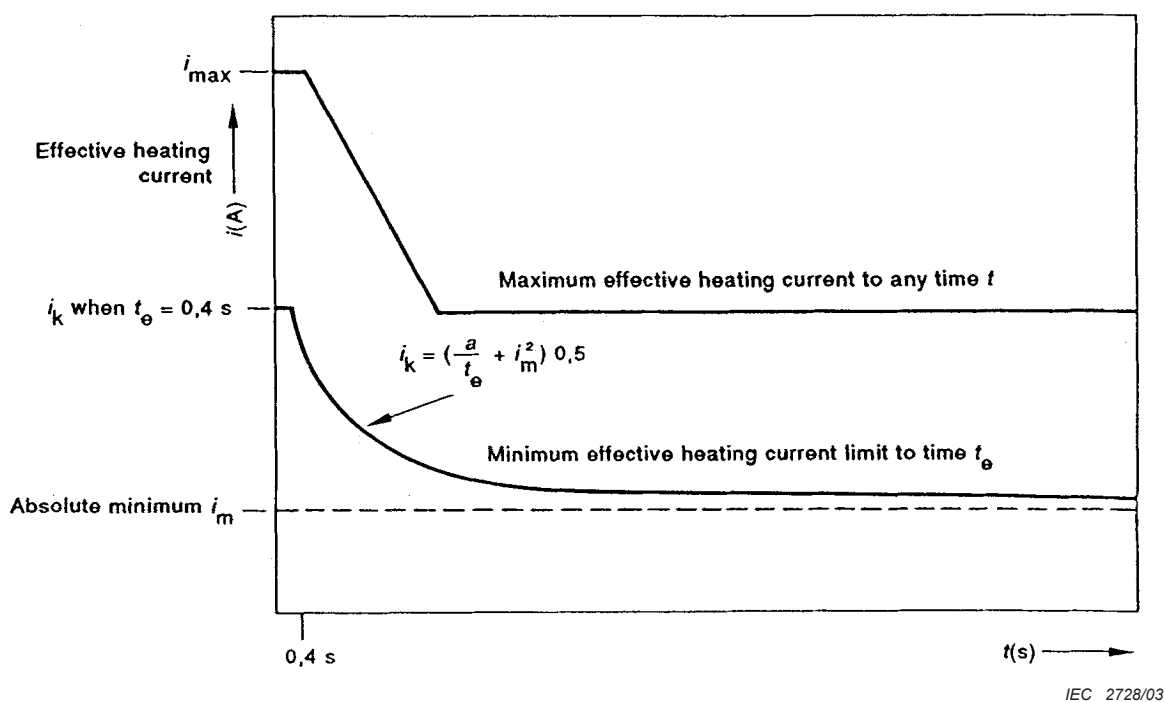


Figure 6 – Test circuit for ballasts for current-controlled preheat starting mode



IEC 2727/03

Figure 7 – HF reference circuit



IEC 2728/03

Figure 8 – Cathode heating current requirements for current-controlled ballasts

Annex A **(normative)**

Tests

A.1 General requirements

Tests are type tests. One sample shall be submitted to all tests.

A.1.1 Ambient temperature

Tests shall be made in a draught-free room and at an ambient temperature within the range 20 °C to 27 °C.

For those tests which require constant lamp performance, the ambient temperature around the lamp shall be within the range 23 °C to 27 °C and shall not vary by more than 1 °C during the test.

A.1.2 Supply voltage and frequency

A.1.2.1 Test voltage and frequency

Unless otherwise specified, the ballast to be tested shall be operated at its rated voltage and the reference ballast at its rated voltage and frequency.

When a ballast is marked for use on a range of supply voltages or has different separate rated supply voltages, any voltage for which it is intended may be chosen as the rated voltage.

A.1.2.2 Stability of supply and frequency

For most of the tests, the supply voltage and, where appropriate for the reference ballasts, the frequency shall be maintained within $\pm 0,5$ %. However, during the actual measurement, the voltage shall be adjusted to within $\pm 0,2$ % of the specified testing value.

A.1.2.3 Supply voltage waveform

The total harmonic content of the supply voltage shall not exceed 3 %; harmonic content is defined as the root-mean-square (r.m.s.) summation of the individual components using the fundamental as 100 %.

A.1.3 Magnetic effects

Unless otherwise specified, no magnetic object shall be allowed within 25 mm of the face of the reference ballast or the ballast under test.

A.1.4 Mounting and connection of reference lamps

In order to ensure that the electrical characteristics of the reference lamps are consistent, they shall be mounted as indicated on the relevant lamp data sheet. Where no mounting instructions are given on the relevant lamp data sheet, lamps shall be mounted horizontally.

It is recommended that lamps are allowed to remain permanently undisturbed in their test lampholders.

A.1.5 Reference lamp stability

A.1.5.1 A lamp shall be brought to a condition of stable operation before carrying out measurements. No swirling shall be present.

A.1.5.2 The characteristics of a lamp shall be checked immediately before and immediately after each series of tests in accordance with Annex C.

A.1.6 Reference ballast

The reference ballast used shall be that indicated on the relevant lamp data sheet.

A.1.7 Measuring instrument characteristics

a) Potential circuits

Potential circuits of instruments connected across the lamp shall not pass more than 3 % of the nominal running current.

b) Current circuits

Instruments connected in series with the lamp shall have a sufficiently low impedance such that the voltage drop does not exceed 2 % of the objective lamp voltage.

Where measuring instruments are inserted into parallel heating circuits, the total impedance of the instruments shall not exceed 0,5 Ω .

c) R.M.S. measurements

Instruments shall be essentially free from errors due to waveform distortion and shall be suitable for the operating frequencies.

Care shall be taken to ensure that the earth capacitance of instruments does not disturb the operation of the unit under test. It may be necessary to ensure that the measuring point of the circuit under test is at earth potential.

A.2 Measurement of the current waveform

The harmonic components in the mains current shall be determined by means of a selective voltmeter or wave analyzer and the resistor R introduced in the circuit shall be in accordance with A.1.7 (see Figure 4).

The selective voltmeter or wave analyzer should ensure that measurements being made on any given harmonic are not significantly affected by other harmonics.

The supply voltage distortion of maximum 3 % (see A.1.2.3) shall be taken into account when evaluating the test results, in case of doubt a distortion-free supply shall be used.

A.3 Measurement of impedance at audio frequencies

The circuit in Figure 5 illustrates a bridge for the determination of the audio-frequency impedance Z of the lamp/ballast assembly.

Let R' and R'' represent the values of the resistors shown in the circuit diagram by the values of $5\ \Omega$ and $200\ 000\ \Omega$, respectively (the latter at least not being critical). When by adjustments of R and C a balance is obtained for a given audio frequency selected on the wave-analyzer (or any other suitable selective detector), we have, in general:

$$Z = R' R'' \left(\frac{1}{R} + j\omega C \right)$$

If the resistors R' and R'' have precisely the indicated values, the equation becomes:

$$Z = 10^6 \left(\frac{1}{R} + j\omega C \right)$$

where (see Figure 5)

A is the supply transformer 50 Hz or 60 Hz;

B is the lamp ballast assembly under test;

Z_1 is the impedance of value sufficiently high for 50 Hz or 60 Hz, sufficiently low for 250 Hz to 2 000 Hz (for example resistance $15\ \Omega$ + capacitance $16\ \mu\text{F}$);

Z_2 is the impedance of value sufficiently low for 50 Hz or 60 Hz, sufficiently high for 250 Hz to 2 000 Hz (for example inductance $20\ \text{mH}$).

NOTE The impedances Z_1 and/or Z_2 are not necessary if the corresponding source has a low internal impedance for the currents of the other.

A.4 Measurement of current-controlled preheat starting

A.4.1 Test equipment

The test circuit shall be arranged to contain the ballast under test, the cathode substitution resistors (R_c) specified on the relevant lamp data sheet and a measuring device. The measuring device may be an oscilloscope provided with a voltage and/or current probe (see Figure 6).

If a ballast is intended for operating more than one lamp in parallel circuits, cathode substitution resistors shall be connected to all relevant contacts and measurements shall be taken at each substitution resistor, respectively at each pair of substitution resistors, representing a lamp successively.

If a ballast is intended for operating two lamps in series circuits, the measurement is carried out with the lamp cathodes of both lamps being replaced by cathode substitution resistors.

If applicable, connect the secondary output winding of the isolating transformer to ground at one side. If no isolating transformer is included in the ballast, then an isolating transformer shall be inserted at the input side.

The total open-circuit voltage is then measured across both lamps.

During preheat, the open-circuit voltage shall be equal to or less than the specified voltage for one lamp.

During ignition, the open-circuit voltage shall be greater than the minimum voltage specified on the lamp data sheet for two lamps in series.

The voltage to the starting aid, if any, shall comply with the specified voltage.

A.4.2 Measurement

With the aid of the measuring device the heating current and open-circuit voltage are determined in relation to time.

For a steady state r.m.s. current, the effective value of the heating current is determined by observation of one single HF period from which the effective value and the crest factor are determined.

A direct measurement of the effective value might be possible with suitable instrumentation.

For a varying current, the effective value of the heating current is defined as such value which is equivalent to a steady state r.m.s. current of the same heating effect (see Figure 1).

With the aid of the formula given on the lamp data sheets, the time to emission is calculated (see D.5.1.1.1).

The determination of the effective value of the open-circuit voltage is carried out in analogy with the determination of the effective value of the current.

A.5 Test transient overvoltages (see Table A.1)

A.5.1 For application, consult the manuals of the test equipment.

Table A.1 – Test transient overvoltages

Amplitude	Rise time	Pulse width	Source impedance	Pulse repetition maximum	Energy available maximum
V	ns	μs	Ω		J
Slow high energy					
Asymmetric 2 500	300	50	45	1/8 mains frequency ^a	1
Symmetric 1 000	300	50	5	1/8 mains frequency ^a	1
Fast low energy					
Asymmetric 2 500	5	0,10	50	1/5 ^e mains frequency	0,002
^a Minimum pulse repetition rate: 1/10 Hz.					

Voltages apply to the unloaded generator.

Pulses are to be applied in symmetrical, differential or series mode (that is from phase to neutral or from phase to phase) and in asymmetrical or common mode (that is from phase and neutral or phase to system ground and/or protective earth).

A.5.2 Test of slow high energy pulses

The pulse test is carried out in accordance with the relevant characteristics specified in A.5.1 as follows:

- pulse phase position: pulse phase is continuously changed from 80° to 460° by slowly moving the knob from one extreme phase position to the other and slowly back during 1 min;
- pulse polarity: + and –;
- equipment to be tested with most unfavourable control settings and,
- if possible, automatic programs to be selected.

Check the proper functioning and integrity of the components of the mains part of the equipment such as the filter and the transformer.

NOTE 1 Since a fast succession of high energy pulses can overload components in the mains part of the equipment, it is sometimes expedient to enlarge the pulse repetition time to at most 10 s.

NOTE 2 Since this test can degrade some components, for example VDRs used as mains transients suppressors and triacs, the test report should state the repetition time used and the number of pulses actually applied.

The components of which it is known that they are affected by this test are replaced.

A.5.3 Test of fast low energy pulse

The pulse test is carried out in accordance with the relevant characteristics specified in A.5.1, as follows:

- pulse phase position: pulse phase is continuously changed from 80° to 460° by slowly moving the knob from one extreme phase position to the other and slowly back during 1 min;
- pulse polarity: + and –.

Check the proper functioning and integrity of the components of the mains part of the equipment such as the filter and the transformer.

Annex B (normative)

Reference ballasts

B.1 Marking

The reference ballast shall be provided with durable legible marking as follows:

- a) the words "reference ballast" or "HF reference ballast" as applicable, in full;
- b) identification of the responsible vendor;
- c) serial number;
- d) rated lamp wattage and calibration current;
- e) rated supply voltage and frequency.

B.2 Design characteristics

B.2.1 General design for frequencies of 50 Hz or 60 Hz

A reference ballast is a self-inductive coil, with or without an additional resistor, designed to give the operating characteristics of Clause B.3.

It may be used either in a circuit employing a starter or, where applicable, in a circuit including separate power sources to heat the lamp cathodes.

B.2.2 HF reference ballast for frequencies of 25 kHz

An HF reference ballast is a resistor or choke-coil designed to give the operating characteristics of Clause B.4.

Since the type of HF reference ballast is intended to serve as a permanent baseline of reference, it is vitally important that the ballast be so constructed as to provide permanence of impedance under normal conditions of use.

For this purpose, it may be provided with suitable means of restoring the reference resistance.

An HF reference ballast shall be enclosed in a case for mechanical and electrical protection. Care should however be taken for proper conduction of the dissipated wattage losses.

B.2.3 Protection

The ballast shall be protected, for example by means of a suitable steel case, against magnetic influence in such a way that its ratio of voltage to current for the calibration current is not changed by more than 0,2 % when a 12,5 mm thick plate of ordinary mild steel is placed at 25 mm from any face of the ballast enclosure.

Moreover, the ballast shall be protected against mechanical damage.

B.3 Operating characteristics for frequencies of 50 Hz or 60 Hz

B.3.1 Rated supply voltage and frequency

The rated supply voltage and frequency of a reference ballast shall be in accordance with the values given in IEC 60081 or IEC 60901 on the relevant lamp data sheets.

B.3.2 Ratio of voltage to current

The ratio of voltage to current of a reference ballast shall have the value given in IEC 60081 or IEC 60901 on the relevant lamp data sheet, subject to the following tolerances:

- a) $\pm 0,5$ % at the calibration current value;
- b) ± 3 % at any other value of current from 50 % to 115 % of the calibration current.

B.3.3 Power factor

The power factor of the reference ballast determined at the calibration current shall be as shown in IEC 60081 or IEC 60901 on the relevant lamp data sheets, subject to a tolerance of $\pm 0,005$.

B.3.4 Temperature rise

When the reference ballast is operated in an ambient air temperature of between 20 °C and 27 °C, at calibration current and rated frequency, and after thermal stabilization, the temperature rise of the ballast winding shall not exceed 25 K, when measured by the "change in resistance" method.

B.4 Operating characteristics for frequencies of 25 kHz

B.4.1 General

The following specifications apply to measurements made at rated input voltage and rated frequency of the HF reference ballast and with a room temperature of $25\text{ °C} \pm 5\text{ °C}$ and with stabilized temperature of the reference ballast.

B.4.2 Impedance

The impedance of a HF reference ballast shall have the value given on the relevant lamp data sheets in IEC 60081 or IEC 60901, subject to the following tolerances:

- a) $\pm 0,5$ % at the calibration current value;
- b) ± 1 % at any other value of current between 50 % and 115 % of the calibration current.

B.4.3 Series inductance and parallel capacitance

The series inductance of a reference resistor shall be less than 0,1 mH and its parallel capacitance shall be less than 1 nF.

B.5 Circuit for frequencies of 25 kHz (see Figure 7)

B.5.1 Cathode heating

HF reference ballasts may be used in a circuit employing separate power sources to heat the lamp cathodes for proper starting of the lamp. These power sources shall be disconnected when measuring a lamp.

B.5.2 Power supply

The HF voltage supply used for the adjustment of or test with the HF reference ballast shall be such that at full load, the r.m.s. summation of the harmonic contents shall not exceed 3 % of the fundamental component.

This supply shall be as steady and free from sudden changes as possible. For best results, the voltage should be regulated to within 0,2 %.

For resistor type reference ballasts the frequency shall be within 2 %; for choke type reference ballasts, the frequency shall be within 0,5 %.

B.5.3 Instruments

All instruments used in HF reference ballast measurements should be suitable for high frequency operation.

Details are under consideration.

B.5.4 Wiring

Connecting cables should be as short and straight as possible to avoid parasitic capacitance.

The parasitic capacitance parallel to the lamp shall be less than 1 nF.

Annex C (normative)

Reference lamps

A lamp which has been aged for at least 100 h is considered to be a reference lamp if, when associated with a reference ballast under the conditions defined in Annex A and operating in an ambient temperature of 25 °C, the lamp wattage, voltage at lamp terminals or lamp running current do not deviate by more than 2,5 % from the corresponding objective or nominal values, as appropriate, given in IEC 60081 and IEC 60901.

For lamps operated without starter, it is also required that the resistance of the cathodes does not differ from the objective values for the type of lamp by more than 10 %. If the resistance is higher, it may be reduced by using a shunt resistor.

A reference lamp of a type suitable for the ballast under test shall always be used.

The waveform of the current passed by a stabilized reference lamp associated with a reference ballast shall show substantially the same waveform in successive half-cycles.

NOTE This limits the possible generation of even harmonics by any rectifying effect.

Annex D (informative)

Explanation of starting conditions

D.1 Introduction

The requirements for starting conditions given in Clause 7 and the associated data given in lamp data sheets in IEC publications have been specified to encompass the different lamp starting methods which can be employed by electronic ballasts.

As these starting methods can be more complex than those of conventional 50 Hz or 60 Hz circuits, this annex is provided to assist the interpretation of the requirements of this standard and the data specified on lamp data sheets.

D.2 Characteristics which affect lamp starting

There are five main physical characteristics which influence the starting mechanism of a fluorescent lamp:

- a) Cathode heating: Preheat current and time of application.
- b) Open circuit voltage: Voltage across lamp and to starting aid both during preheating and at the moment of lamp ignition.
- c) Environmental conditions: Ambient temperature, relative humidity.
- d) Lamp physical conditions: Type of filling gas and its pressure, lamp dimensions, the inclusion of an internal conducting film.
- e) Supply and luminaire conditions: Operating frequency, starting aid dimensions and spacing.

All of these characteristics interact with each other in a complex manner and if the correct combination is not obtained for a chosen method of starting, poor lamp performance can result (for example reduced lamp life, reduced number of starting cycles for a given lamp life, excessive end blackening of the lamp).

D.3 Principal methods of lamp starting

Traditionally, there have been two principal methods of starting fluorescent lamps associated with 50 Hz or 60 Hz ballasts: preheated cathode starting and non-preheated cathode starting.

Both of these methods can be used with electronic ballasts, but due to the higher technological features that can be built into electronic ballasts, revised methods of specifying, measuring and assessing the starting characteristics often have to be adopted.

Although electronic ballasts may produce lamp starting conditions in a more complex way than conventional 50 Hz or 60 Hz ballasts, the same principles apply if good lamp performance is to be obtained.

D.4 Particular methods of lamp starting

D.4.1 Preheat starting

Two basic methods of providing preheated cathode lamp starting are normally used, these being either:

- the cathode current control of preheating;
- the cathode voltage control of preheating.

With both of these methods, the following requirements must be satisfied during the starting period if satisfactory lamp performance is to be obtained.

- a) Prior to cathodes reaching emission, open-circuit voltages across the lamp and/or from lamp to starting aid must be kept below the level which causes cathode-damaging lamp glow currents.
- b) After cathodes have reached emission, open-circuit voltages must be adequate to start the lamp quickly and without repeated starting attempts.
- c) If open-circuit voltages have to be elevated to achieve lamp starting, once cathodes have reached emission, the transition from low to high open-circuit voltage must occur whilst the cathodes are still at emission temperature.
- d) During the cathode preheating period the heating current or voltage must not be so excessive that the emissive material on the cathodes is damaged by overheating.

As the required open-circuit voltages for preheat starting are relatively low, multilamp series circuits can be utilized for some types of lamps.

In such a scheme, starting capacitor(s) are sometimes employed to shunt part of the combination of lamps while full open-circuit voltage is applied to the unshunted lamp. The size of the starting capacitor relates to the potentially troublesome glow current during the initial phase of starting. Attention is necessary to balance starting capacitor size with ease of starting and other lamp and ballast performance attributes.

D.4.2 Non-preheat starting

This method of lamp starting takes advantage of the field emission that occurs at the unheated cathodes of a lamp when a high open-circuit voltage is instantaneously applied across the lamp.

The level of open-circuit voltage and the source impedance of the ballast determines the time it takes for the lamp to pass through the glow current stage of the discharge to the full arc state.

One of the major reasons for excessive lamp end blackening and subsequent early lamp failure is due to unduly high and/or long-lasting glow discharge currents during the starting process. To minimize the damaging effects of the glow discharge current it is necessary to ensure that a minimum value of open-circuit voltage is provided and that the ballast has the ability to "drive" the lamp rapidly through this phase without making repeated attempts at lamp starting which extend for greater than 100 ms.

Some ballasts may make use of currents in the lamp cathodes for purposes other than adequate cathode heating (for example for supporting starting with reduced starting voltages). In such instances, the limitations on maximum cathode current must be observed to avoid cathode overheating.

D.5 Interpretation of the requirements of Clause 7 and the information given on lamp data sheets

D.5.1 Preheat starting

D.5.1.1 Ballasts using current-controlled preheating

D.5.1.1.1 Effective heating current and emission time (t_e) and minimum values of effective heating current

The amount of heat necessary to bring a given cathode type to the minimum emission temperature can be stated in terms of time, current and a constant which is determined by the physical properties of the given cathode type.

This relationship can be expressed by the following equation:

$$t_e = a (i_k^2 - i_m^2)^{-1}$$

where

t_e is the time to emission (s);

NOTE Emission time less than 0,4 s is normally not acceptable because experience has shown that satisfactory cathode preheating is not always achievable in practice.

a is a constant for a specific cathode type;

i_k is the minimum effective heating current necessary to time t_e (A);

i_m is the absolute minimum value of effective heating current (A) to achieve emission if application time is of sufficiently long duration (for example ≥ 30 s from cold).

The values of constant "a" and the absolute minimum current (i_m) are given on each relevant lamp data sheet, together with the value of the cathode substitution resistor.

The minimum value of effective heating current (i_k) can be calculated by substituting the measured value of t_e into the equation given on each lamp data sheet.

Empirical evidence has shown that a relatively high effective heating current can be applied for a short time ($\leq 0,4$ s) without cathode damage occurring, but that this high level of current must be progressively reduced for times greater than 0,4 s. At 2 s and longer, the level should not exceed a value which is significantly different from those values already established for 50 Hz or 60 Hz glow starter circuit practice.

Maximum levels of effective heating current are given on relevant lamp data sheets together with the value of the substitution resistor required for the test.

A schematic representation of these conditions is given in Figure 8.

D.5.1.1.2 Open-circuit voltages and transition time (t_s)

The data in the relevant lamp data sheets is given for systems that require the use of a starting aid and for systems that do not require a starting aid.

It is essential that the correct system is identified before testing commences.

When open-circuit voltages are elevated at time t_e , the transition time t_s must be kept below 100 ms if cathode heating is terminated at time t_e .

Transition times of more than 100 ms are acceptable provided cathodes are kept at emission during the transition time.

Since the lamp cathodes will have been brought to emission during time t_e , it is only necessary to ensure that the effective heating current does not fall below the absolute minimum value (i_m) during the transition/lamp-starting phase.

The maximum value of open-circuit voltage prior to time t_e being reached, and the minimum value of open-circuit voltage after t_e is reached are specified on the relevant lamp data sheets.

For some lamp types, the relevant lamp data sheets specify values of maximum open-circuit voltage prior to time t_e being reached which are higher than, or the same as, the minimum values of open-circuit voltage specified after time t_e has been reached. Ballasts designed for these lamp types do not necessarily have to elevate the open-circuit voltage to start these lamps correctly.

A schematic representation of these conditions is given in Figure 2.

D.5.1.2 Ballasts using voltage-controlled preheating

D.5.1.2.1 RMS voltage and application time

Although the control of current is the fundamental method of controlling cathode preheating conditions, the voltage method is simple to specify and easy to measure.

For the voltage control method, appropriate cathode voltages, both to achieve emission temperature and to avoid excessive temperature, can be determined empirically.

It has been shown that the emission temperature of a cathode occurs when cathode voltage levels exceed the following and are applied for a minimum time of 0,4 s:

- low resistance cathodes: 3,0 V r.m.s.;
- high resistance cathodes: 6,0 V r.m.s.

To avoid excessive cathode temperatures other limits are imposed.

Transverse arcing occurs across all cathodes when the applied voltage exceeds 10 V r.m.s., and for low resistance cathodes, a limit on the maximum applied voltage has been determined experimentally in relation to other lamp performance criteria. This limiting value is usually set below the transverse arcing level, but it is permissible to allow transverse arcing if precautions are taken to ensure that excessive currents do not flow in the cathode heating circuits which will damage the cathodes or ballasts.

There are different lamp operating modes for lamps using low resistance cathodes. It is permissible to use a value of preheating cathode voltage which is maintained during lamp operation. However, alternative systems may reduce this voltage after lamp starting.

Data which cover all of these requirements are given on the relevant lamp data sheets.

D.5.1.2.2 Open-circuit voltages

If the value of the lamp open-circuit voltage, before the time of cathode thermal emission is reached, is lower than the value where cold starting is possible, then simultaneous application of cathode preheat and lamp voltage is allowable. Although electronic ballast circuits may offer several voltage control options, the principle of keeping lamp voltage below the cold starting level until thermal emission is achieved still applies.

For these ballasts, only the maximum and minimum values of open-circuit voltage have to be observed. These values are shown on the relevant lamp data sheets under "prestarting conditions – voltage preheating of cathodes".

For ballasts where open-circuit voltages are elevated after cathode emission is attained, the values of open-circuit voltage shown on the relevant lamp data sheets under "pre-starting conditions – current preheating of cathodes" shall be observed. In this case, t_e is taken as 0,4 s.

Starting by this method usually requires the presence of an electrical earth (ground) plane, the starting aid, for all lamps except internal starting aid lamps. A minimum value of peak voltage (V_p) must be developed between the cathode and the starting aid as well as the necessary voltage across the lamp (V_a). Circuit operating frequency affects these voltage values as increasing frequency lowers the V_p requirement and increases the V_a requirement in most cases. Use of an internal conductive coating on the lamp can significantly increase the V_a value at high frequency. The proximity of the external starting aid to the lamp affects both V_p and V_a . In general, increasing starting aid distance increases starting voltage requirements. A minimum starting aid distance should be observed to avoid high starting aid currents.

D.5.2 Non-preheat starting

Open-circuit voltage measurement alone does not necessarily ensure that a ballast will start a lamp cleanly and with the required minimal glow current period. Some ballasts are initially unable to supply the current necessary to drive the lamp quickly through the glow state and into the arc state.

To avoid this situation, a ballast impedance test is made with a lamp substitution resistor.

The values of the lamp substitution resistor and the minimum current level which must be obtained in this resistor are shown on the relevant lamp data sheet.

D.6 Measurement requirements

As the prestart and starting characteristics of electronic ballasts do not necessarily provide steady state voltages and currents, it is necessary to apply measuring devices and techniques which will cope with these conditions.

The term "effective heating current" has been used to describe the heating effect to time t which would result from a varying current and which is equivalent to a steady state r.m.s. current of the same heating effect (see Figure 1).

Specialized measuring equipment is now readily available which will give instant read-out of the required information, or more conventional equipment can be used together with manual computation of the data.

Annex E (normative)

Control interface for controllable ballasts

E.1 Overview

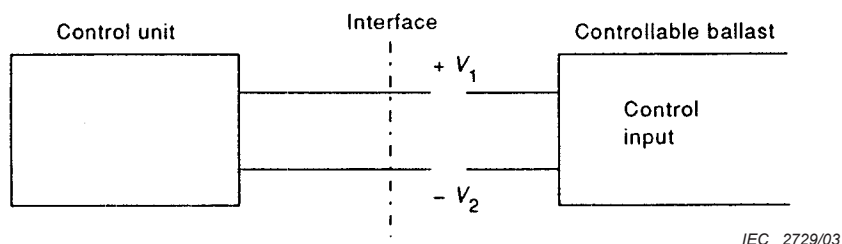
This annex specifies the control interface for controllable ballasts. The arc power of the electronic ballast is controlled between minimum/off and maximum values by the control signal applied to the control terminals of the ballast.

If the control signal is not connected, the ballast shall give the maximum value of arc power as defined in IEC 61347-1 and IEC 61347-2-3 or the system failure level, if applicable.

This annex does not cover any requirements for the control unit.

E.2 Control by d.c. voltage

E.2.1 Circuit diagram; functional specification for d.c. voltage control



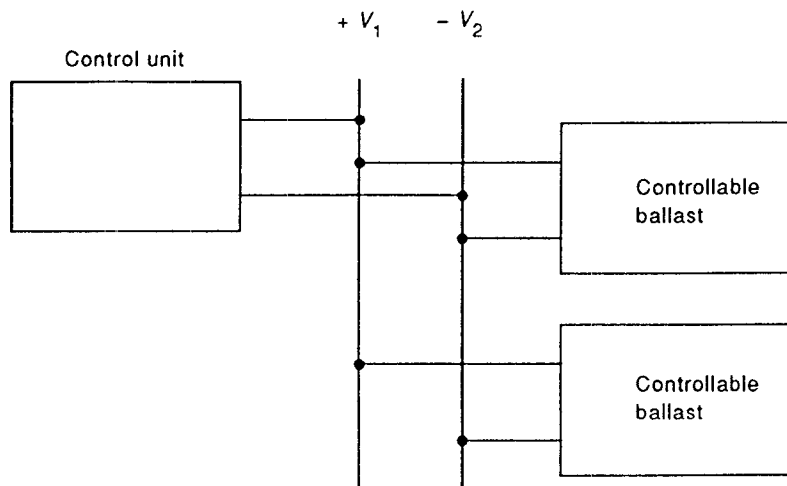
The arc power of a controllable ballast is controlled by the d.c. voltage on the control input of the controllable ballast. The d.c. voltage has the following characteristics:

Control signal range

$V_{1,2}$ = between 10 V and 11 V:	maximum value of arc power
$V_{1,2}$ = between 0 V and 1 V:	minimum value of arc power / minimum light output
$V_{1,2}$ = between 1 V and 10 V:	arc power rising from minimum to maximum value
$V_{1,2}$ = between 0 V and 11 V:	stable lamp operation with stable light output

E.2.2 Connection diagram

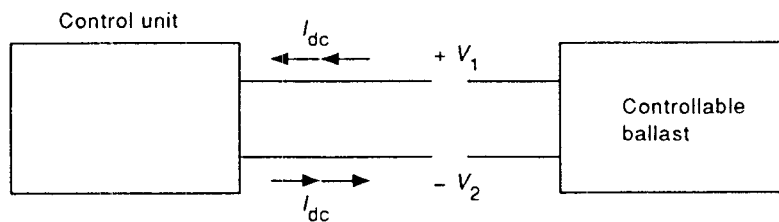
Depending on current-carrying capacity, several controllable ballasts can be connected to one control unit in the following way:



IEC 2730/03

E.2.3 Electrical specifications

E.2.3.1 The controllable ballast is current sourcing.



IEC 2731/03

E.2.3.2 Control input voltage limits

The ballast shall not be damaged when the control input voltage $V_{1,2}$ is between -20 V and $+20\text{ V}$.

The ballast shall not produce voltages that exceed the limiting values for the control unit and under no circumstances shall exceed the following:

$V_{1,2}$ between -20 V and $+20\text{ V}$.

The control terminals shall be reverse polarity protected. In that case, the ballast shall operate with minimum light output or shall not operate.

At control input voltages between 0 V and 11 V , there shall be stable light output.

This shall be tested by visual inspection.

E.2.3.3 Control input current limits

Limits for the control input current, to be supplied to the control unit, are 10 μ A minimum and 2 mA maximum.

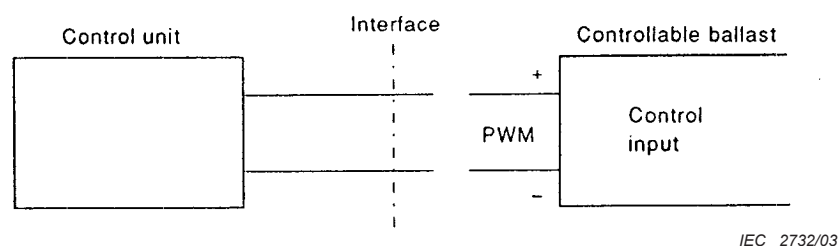
The value of the control input current shall be declared or stated on the ballast.

E.2.3.4 Switch-on

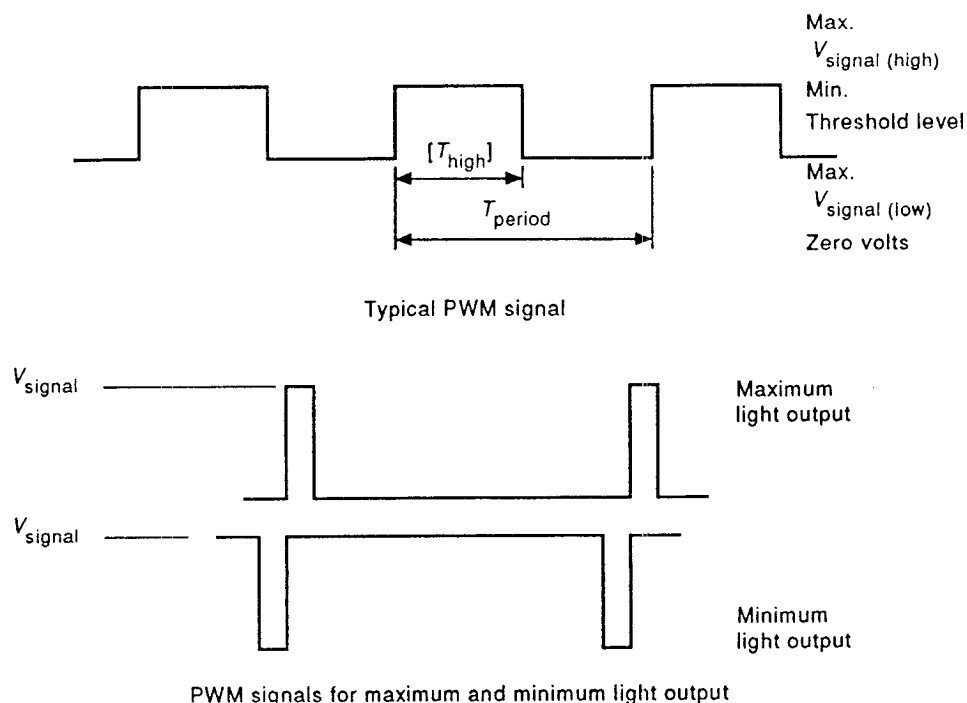
Switch-on is allowed at any dimming position.

E.3 Control by pulse width modulation (PWM)

E.3.1 Circuit diagram; functional specification for PWM control



The arc power of a controllable ballast is controlled by the PWM signal on the control input of the controllable ballast. The arc power is changed by varying the percentage of time for which the PWM signal is at V_{signal} . The PWM signal has the following characteristics:



The voltage of the signal is between $V_{\text{signal}}(\text{low})$ and $V_{\text{signal}}(\text{high})$, where:

$V_{\text{signal}}(\text{low})$ minimum is 0 V

$V_{\text{signal}}(\text{low})$ maximum is 1,5 V

$V_{\text{signal}}(\text{high})$ minimum is 10 V

$V_{\text{signal}}(\text{high})$ maximum is 25 V

$T_{\text{period}}(\text{cycle time})$ is 1 ms minimum and 10 ms maximum.

Full light output when signal width - $T(\text{high})$ - is 0 % to 5 % $\pm$ 1 %.

1 % or minimum light output when signal width - $T(\text{high})$ - is 95 % $\pm$ 1 %.

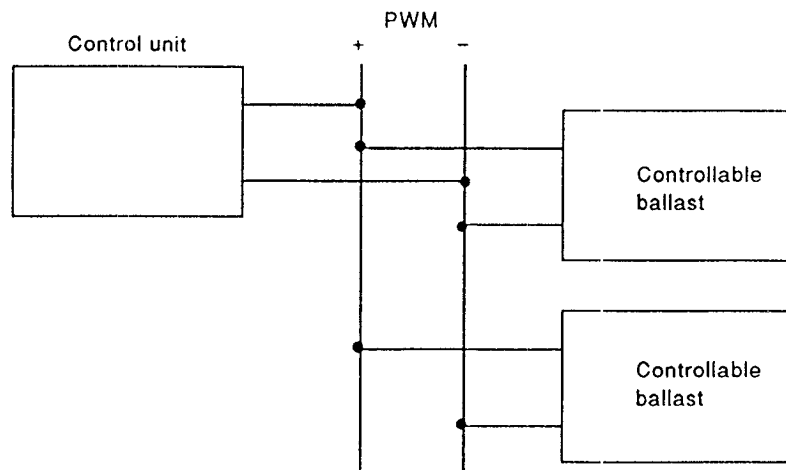
Switch-off when signal width - $T(\text{high})$ - is >95 %.

NOTE This part of the signal is reserved for switch-off. However, if a ballast does not possess this feature its output should remain at minimum.

No switch-off when signal width - $T(\text{high})$ - is <95 %.

E.3.2 Connection diagram

Depending on current-carrying capacity, several controllable ballasts can be connected to one control unit in the following way:



IEC 2734/03

E.3.3 Electrical specifications

The control unit is current-sourcing and the ballast is current-sinking.

E.3.3.1 Signal voltage limits

The ballast shall not be damaged when the signal voltage V_{signal} is below 25 V.

The control terminals shall be reverse polarity protected. In that case, the ballast shall not operate.

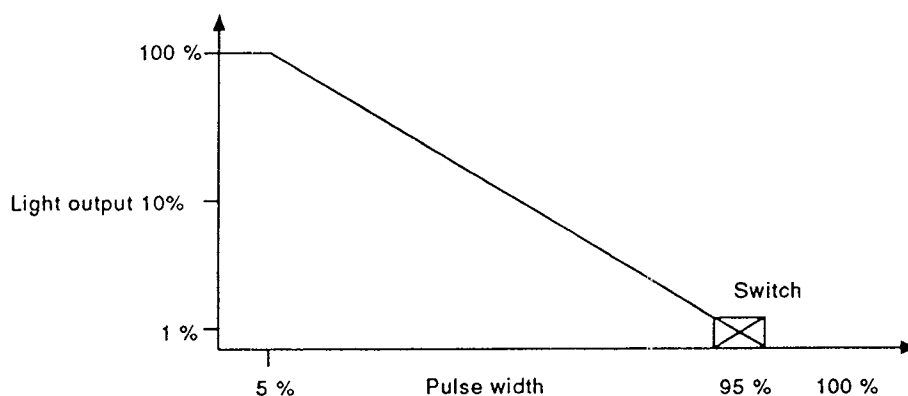
E.3.3.2 Control terminals impedance

The control terminal impedance shall be between 1 k Ω and 10 k Ω .

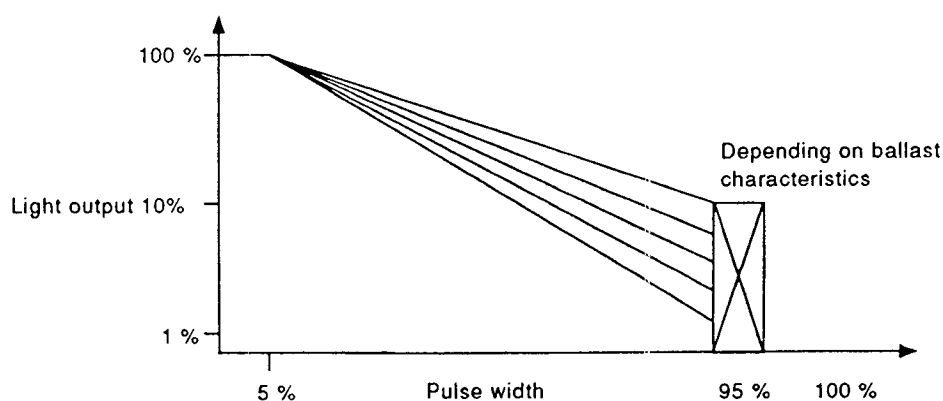
E.3.3.3 Input current

The value of the input current at 12 V stable shall be declared or stated on the ballast.

E.3.4 Examples of control characteristics



Dimming curve for ballast with minimum light output 1 %



Dimming curve for ballast with minimum light output higher than 1 %

IEC 2735/03

E.4 Control by digital signals

The standardization of the control interface for "Control by digital signals" of electronic ballasts is intended to reach interoperable multi-vendor operation between electronic ballasts and lighting controller, below the level of building management systems using multi-master control.

Therefore, this interface has a robust but limited specification to have a low threshold for the application as well in ballast cost-price as in fast implementation. The direct benefits in the application are mainly: easy loop through control wiring and no use of mains switching relays.

NOTE This interface for digital signals is a working example of which the good operation is proven in practice. Other interfaces are also possible.

Short specification:

Maximum 64 individual addressable ballasts within one system

The ballast can not act as a master controller

Multiple ballast groups

Bi-phase coding for error detection (see E.4.3.6, Pulse diagram)

Asynchronous start-stop transmission protocol

Low information rate: 1 200 bit/s

Allowed cable voltage drop: 2 V

No ground-loops because of isolation in the ballast

The tolerance at all mentioned timing specifications in this document shall be $\pm 10\%$ if minimum/maximum are not specified.

Impedance control terminals (see Figure E.1): $R_{in} \geq 8\text{ K}\Omega$ static at typical high input voltage

$$C_{in} \leq 1\text{ nF}$$

$$L_{in} \leq 1\text{ mH}$$

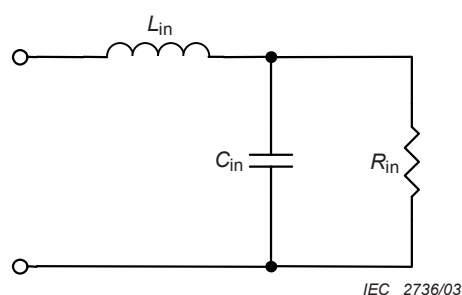


Figure E.1 – Replacement diagram at ballast's control terminals

The robustness can be increased with the optional implementation of:

- polarity insensitive interface input;
- overvoltage protection for accidental mains voltage between the control wires.

Transmission characteristics

The transmission rate, expressed in bandwidth, is specified with 1 200 Hz for the forward channel and for the backward channel.

All specified voltage and current levels refer to the terminals of the electronic ballast.

A forward message frame consists of 19 bits (see E.4.3.6: Pulse Diagram):

- 1 start bit
- 1 address byte: 1 individual or group address bit, 6 address bits, 1 select bit
- 1 data byte: 8 data bits
- 2 stop bits

A backward message frame consists of 11 bits (see E.4.3.6: Pulse Diagram):

- 1 start bit
- 1 data byte: 8 data bits
- 2 stop bits

Test conditions

The test conditions of the ballast are according to IEC 61547 and for mains power interrupts (0,2 s) according to IEC 60669-2-1.

To assure interoperability of ballasts from different manufacturers, test procedures are introduced testing the correct interpretation of parameters and commands specified in this standard.

The following test procedures are defined (see Annex G) and described in form of flow charts:

- G.1. Test sequences "Physical operational parameters"
- G.2. Test sequences "Configuration commands"
- G.3. Test sequences "Arc power control commands"
- G.4. Test sequences "Physical address allocation"
- G.5. Test sequences "Random address allocation"
- G.6. Test sequences "Queries and reserved commands"

Terminals marking

Both interface terminals shall be marked with "DA" for data.

If the interface is polarity sensitive, the terminals shall be marked with "+" and "-" respectively.

General Comment

In this draft, "lamp" is used for applications where a ballast operates one or multiple lamps.

If a ballast is "switched off", it shall be assumed that the ballast is still supplied by the mains but is in the stand-by mode.

Reserved commands shall not be used without an official change of this document; restricted to DEVICE TYPE 0; see Command 272.

E.4.1 Electrical specification

E.4.1.1 Voltage rating

The signal levels specified in Figure E.2 are considered to be reasonable for reliable operation of an electronic ballast over the specified operating temperature of the ballast.

In general, the interface voltage is high if there is no communication (idle state).

The slopes of the received and transmitted data signal shall be $10\ \mu\text{s} \leq t_{\text{fall}} \leq 100\ \mu\text{s}$ and $10\ \mu\text{s} \leq t_{\text{rise}} \leq 100\ \mu\text{s}$ at the ballast terminals of the digital interface.

The specified t_{fall} and t_{rise} are achievable under all configurations of types of wires and cable lengths.

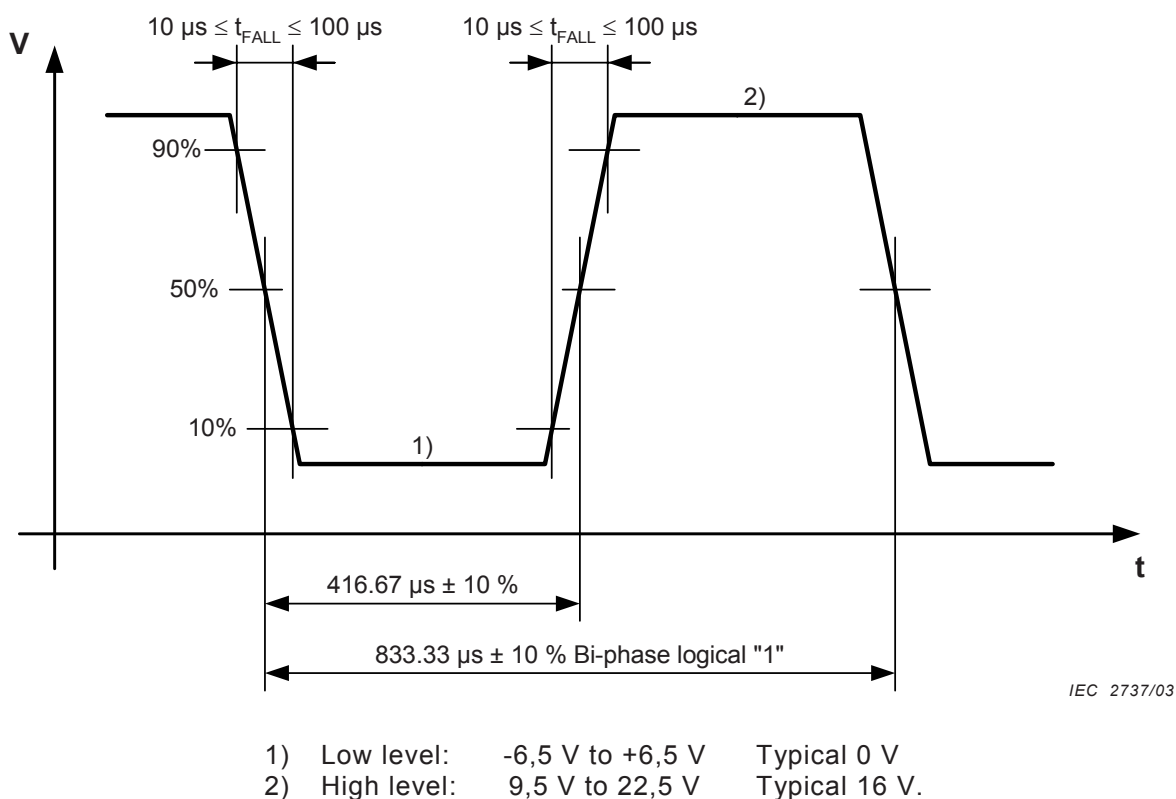


Figure E.2 – Required timing at the ballast terminals of the digital interface

The voltage range shall be between 9,5 V and 22,5 V for "high level" and between -6,5 V and +6,5 V for "low level" respectively. Between 6,5 V and 9,5 V, the level is undefined.

E.4.1.2 Current rating

In non-active state, the sink current of the ballast shall not exceed 2 mA at $\leq 22,5$ V because of the actual maximum number of ballasts per control unit. This shall be guaranteed by each ballast manufacturer.

The ballast shall be able to sink at least 250 mA at $\leq 4,5$ V at active state. The ballast shall keep the interface voltage lower than 4,5 V.

The interface power supply shall limit the supply current to max. 250 mA under all circumstances. This current limiter circuit has to react faster than 10 μ s

The interface specification at the ballast terminals shall be:

- active state: low voltage level $\leq 4,5$ V; high current level ≤ 250 mA (lim. by the power supply);
- non-active state: high voltage level $\leq 22,5$ V, low voltage level $\leq 6,5$ V; high current ≤ 2 mA.

See E.4.3.9 and Figure E.3: Voltage ratings.