

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Semiconductor devices – Discrete devices –
Part 5-5: Optoelectronic devices – Photocouplers**

**Dispositifs à semiconducteurs – Dispositifs discrets –
Partie 5-5: Dispositifs optoélectroniques – Photocoupleurs**

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CONTENTS

FOREWORD.....	6
1 Scope.....	8
2 Normative references	8
3 Photocoupler	9
3.1 Semiconductor material	9
3.2 Details of outline and encapsulation	9
3.2.1 IEC and/or national reference number of the outline drawing	9
3.2.2 Method of encapsulation: glass/metal/plastic/other	9
3.2.3 Terminal identification and indication of any connection between a terminal and the case	9
3.3 Type of photocouplers	9
3.3.1 DC input photocoupler	9
3.3.2 AC input photocoupler	9
3.3.3 Phototransistor photocoupler	9
3.3.4 Photodarlington photocoupler	9
3.3.5 Photothyristor photocoupler	9
3.3.6 Phototriac photocoupler	10
3.3.7 IC photocoupler	10
3.3.8 FET photocoupler	10
3.3.9 Photodiode photocoupler	10
3.3.10 IC input photocoupler	10
3.3.11 Solid state opto relay	10
4 Terms related to ratings and characteristics for photocouplers	10
4.1 Current transfer ratio	10
4.1.1 Static value of the (forward) current transfer ratio $h_{F(ctr)}$	10
4.1.2 Small-signal short-circuit (forward) current transfer ratio $h_{f(ctr)}$	10
4.2 Cut-off frequency f_{co}	10
4.3 Input-to-output capacitance C_{IO}	10
4.4 Isolation resistance R_{IO}	10
4.5 Isolation voltage	10
4.5.1 DC isolation voltage V_{IO}	11
4.5.2 Repetitive peak isolation voltage V_{IORM}	11
4.5.3 Surge isolation voltage V_{IOSM}	11
4.6 Terms related to photocouplers with phototriac output and/or solid state opto-relay with triac output	11
4.6.1 Repetitive peak voltage	11
4.6.2 Repetitive peak off-state voltage V_{DRM}	11
4.6.3 Repetitive peak reverse voltage V_{RRM}	11
4.6.4 RMS on-state current $I_{T(RMS)}$	11
4.6.5 Peak off-state current I_{DRM}	11
4.6.6 Peak on-state voltage V_{TM}	11
4.6.7 DC off-state current I_{BD}	11
4.6.8 DC on-state voltage V_T	11
4.6.9 Holding current I_H	11
4.6.10 Critical rate of rise of off-state voltage dV/dt	11

4.6.11	Trigger input current I_{FT}	12
4.7	Common mode transient immunity CMTI	12
5	Terms for photocoupler providing protection against electrical shock	12
5.1	Safety ratings of a photocoupler for reinforced isolation	12
5.2	Electrical safety requirements of a photocoupler for reinforced isolation	12
5.2.1	Partial discharge p_d	12
5.2.2	Apparent charge q_{pd} , q	12
5.2.3	Threshold apparent charge $q_{pd(TH)}$, q_{TH}	12
5.2.4	Test voltages for the partial-discharge test of a photocoupler	12
5.2.5	Test voltage $V_{pd(t)}$, V_t	12
5.2.6	Partial discharge test voltage $V_{pd(t)}$	13
5.2.7	Initial test voltage $V_{pd(ini)}$, V_{ini}	13
5.2.8	Apparent charge measuring voltage $V_{pd(m)}$, V_m	13
5.2.9	Partial-discharge inception voltage $V_{pd(i)}$, V_i	13
5.2.10	Partial-discharge extinction voltage $V_{pd(e)}$, V_e	13
5.2.11	Time intervals of the test voltage	13
5.3	Isolation voltages and isolation test voltages for photocouplers providing protection against electrical shock	16
5.3.1	Rated isolation voltage	16
5.4	Limiting values (absolute maximum system) over the operating temperature range, unless otherwise stated	16
5.4.1	Minimum and maximum storage temperatures T_{stg}	16
5.4.2	Minimum and maximum ambient or reference-point operating temperatures T_{amb} or T_{ref}	16
5.4.3	Maximum soldering temperature T_{sld}	16
5.4.4	Maximum continuous (direct) reverse input voltage V_R	16
5.4.5	Maximum collector-emitter voltage, with the base open-circuited V_{CEO}	16
5.4.6	Maximum collector-base voltage, where an external base connection is present, with the emitter open-circuited V_{CBO}	16
5.4.7	Maximum emitter-base voltage, where an external base connection is present, with the collector open-circuited V_{EBO}	16
5.4.8	Maximum emitter-collector voltage, where no external base connection is present V_{ECO}	16
5.4.9	Maximum continuous (direct) or repetitive peak isolation voltage V_{IO} or V_{IORM}	16
5.4.10	Where appropriate, maximum surge isolation voltage V_{IOSM}	16
5.4.11	Maximum continuous collector current I_C	17
5.4.12	Maximum continuous forward input current I_F at an ambient or reference-point temperature of 25 °C and derating curve or derating factor	17
5.4.13	Maximum peak forward input current I_{FM} at an ambient or reference-point temperature of 25 °C and under specified pulse conditions	17
5.4.14	Maximum power dissipation P_{trn} of the output transistor at an ambient or reference-point temperature of 25 °C and a derating curve or derating factor	17
5.4.15	Maximum total power dissipation of the package P_{tot} at an ambient or reference-point temperature of 25 °C and derating curve or derating factor	17

6	Electrical characteristics	17
6.1	Phototransistor output photocoupler	17
6.2	Phototriac output photocoupler or solid state opto-relay	19
7	Photocouplers providing protection against electrical shock.....	19
7.1	Type.....	19
7.2	Ratings (have to be mentioned in a special section in the manufacturer's data sheet).....	19
7.2.1	Safety ratings	19
7.2.2	Functional ratings	19
7.2.3	Rated isolation voltages	19
7.3	Electrical safety requirements	20
7.4	Electrical, environmental and/or endurance test information (supplementary information).....	20
8	Measuring methods for photocouplers	27
8.1	Current transfer ratio $h_{F(ctr)}$	27
8.2	Input-to-output capacitance C_{IO}	28
8.3	Isolation resistance between input and output R_{IO}	29
8.4	Isolation test.....	30
8.5	Partial discharges of photocouplers.....	31
8.6	Collector-emitter saturation voltage $V_{CE(sat)}$ of a photocoupler	34
8.6.1	Collector-emitter saturation voltage (d.c. method).....	34
8.6.2	Collector-emitter saturation voltage (pulse method)	35
8.7	Switching times t_{on} , t_{off} of a photocoupler	36
8.8	Peak off-state current I_{DRM}	37
8.9	Peak on-state voltage V_{TM}	39
8.10	DC off-state current I_{BD}	41
8.11	DC on-state voltage V_T	42
8.12	Holding current I_H	43
8.13	Critical rate of rise of off-state voltage dV/dt	43
8.14	Trigger input current I_{FT}	46
8.15	Measuring methods of common mode transient immunity (CMTI) for photocoupler	47
9	Testing methods of electrical rating for phototriac coupler	49
9.1	Repetitive peak off-state voltage V_{DRM}	49
9.2	DC off-state voltage V_{BD}	50
	Annex A (normative) Input/output safety test	51
	Bibliography.....	52
	Figure 1a – Time intervals for method a).....	14
	Figure 1b – Time intervals for method b).....	15
	Figure 1 – Time intervals of the test voltage.....	15
	Figure 2 – Test voltage	17
	Figure 3 – Measurement circuit.....	27
	Figure 4 – Measurement circuit for input to output capacitance	29
	Figure 5 – Measurement circuit for isolation resistance.....	29

Figure 6 – Test circuit for withstanding isolation voltage	30
Figure 7 – Partial discharge test circuit	31
Figure 8 – Complete test arrangement connections for calibration	32
Figure 9 – DC measurement circuit	34
Figure 10 – Pulse measurement circuit	35
Figure 11 – Switching time measurement circuit	36
Figure 12 – Switching times	37
Figure 13 – Measurement circuit for peak off-state current	38
Figure 14 – Waveforms of the peak off-state voltage and current	39
Figure 15 – Measurement circuit for peak on-state voltage	40
Figure 16 – Waveforms of the peak on-state voltage and current	41
Figure 17 – Measurement circuit for d.c. off-state current	41
Figure 18 – Measurement circuit for d.c. on-state voltage	42
Figure 19 – Measurement circuit for holding current	43
Figure 20 – Measurement circuit for critical rate of rise of off-state voltage	44
Figure 21 – Exponential waveform of the off-voltage (V_D)	45
Figure 22 – Linear pulse form of the off-voltage (V_D)	45
Figure 23 – Measurement circuit for the trigger input current	46
Figure 24 – Output terminal voltage versus input forward current	46
Figure 25 – Common mode transient immunity (CMTI) measurement circuit for photocoupler	47
Figure 26 – Typical waveforms of the common mode pulse (V_{CM}) and optocoupler output (V_O)	49
Figure A.1 – Circuit diagram	51
Table 1 – Datasheet characteristics	20
Table 2 – Tests and test sequence for photocoupler providing protection against electrical shock	26
Table 3 – Test conditions	27

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SEMICONDUCTOR DEVICES – DISCRETE DEVICES –

Part 5-5: Optoelectronic devices – Photocouplers

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International Standard IEC 60747-5-5 has been prepared by subcommittee 47E: Discrete semiconductor devices, of IEC technical committee 47: Semiconductor devices.

This standard replaces the clauses for photocouplers (or optocouplers) described in IEC 60747-5-1, IEC 60747-5-2 and IEC 60747-5-3, including their amendments.

The contents for phototransistors and photothyristors in IEC 60747-5-1, IEC 60747-5-2 and IEC 60747-5-3, including their amendments, will be considered obsolete as of the effective date of publication of this standard.

NOTE Photocouplers that are certified to the previous version of the photocoupler standard, namely IEC 60747-5-1/2/3, are to be considered in compliance with the requirements and provisions of IEC 60747-5-5.

The text of this standard is based on the following documents:

FDIS	Report on voting
47E/332/FDIS	47E/340/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

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

A list of the parts in the IEC 60747 series, under the general title *Semiconductor devices – Discrete devices*, can be found on the IEC website.

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- replaced by a revised edition, or
- amended.

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SEMICONDUCTOR DEVICES – DISCRETE DEVICES –

Part 5-5: Optoelectronic devices – Photocouplers

1 Scope

This part of IEC 60747 gives the terminology, essential ratings, characteristics, safety tests as well as the measuring methods for photocouplers (or optocouplers).

NOTE The word “optocoupler” can also be used instead of “photocoupler”.

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 60065:2001, *Audio, video and similar electronic apparatus – Safety requirements*

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-1:2007, *Environmental testing – Part 2: Tests – Tests A: Cold*

IEC 60068-2-2:2007, *Environmental testing – Part 2: Tests – Tests B: Dry heat*

IEC 60068-2-78:2001, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60068-2-6:—, *Environmental testing – Part 2: Tests – Test Fc: Vibration (sinusoidal)*¹

IEC 60068-2-14:1984, *Environmental testing – Part 2: Tests – Test N: Change of temperature*

IEC 60068-2-17:1994, *Basic environmental testing procedures – Part 2: Tests – Test Q: Sealing*

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

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

IEC 60068-2-58:2005, *Environmental testing – Part 2-58: Tests – Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

IEC 60112:2003, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

¹ To be published (replacing the sixth edition)

² To be published (replacing the third edition)

IEC 60216-1:2001, *Electrical insulating materials – Properties of thermal endurance – Part 1: Ageing procedures and evaluation of test results*

IEC 60216-2:2005, *Electrical insulating materials – Thermal endurance properties – Part 2: Determination of thermal endurance properties of electrical insulating materials – Choice of test criteria*

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60672-2:1999, *Ceramic and glass insulating materials – Part 2: Methods of test*

IEC 60695-11-5:2004, *Fire hazard testing – Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance*

3 Photocoupler

Optoelectronic device designed for the transfer of the electrical signals by utilizing optical radiation to provide coupling with electrical isolation between the input and the output

NOTE Different types of photocouplers include ambient-rated or case-rated photocouplers, for signal-isolation applications.

3.1 Semiconductor material

- Input diode: Gallium Arsenide, Gallium Aluminium Arsenide, etc.
- Output: Silicon, etc.

3.2 Details of outline and encapsulation

3.2.1 IEC and/or national reference number of the outline drawing

3.2.2 Method of encapsulation: glass/metal/plastic/other

3.2.3 Terminal identification and indication of any connection between a terminal and the case

3.3 Type of photocouplers

3.3.1 DC input photocoupler

Photocoupler consisting at the input of a photoemitter to which d.c. current is applied

3.3.2 AC input photocoupler

Photocoupler consisting at the input of antiparallel photoemitters to which a.c. current is applied

3.3.3 Phototransistor photocoupler

Photocoupler whose photo sensitive element is a phototransistor

NOTE Phototransistor is a transistor in which the current produced by the photoelectric effect in the neighbourhood of the emitter-base junction acts as base current, which is amplified.

3.3.4 Photodarlington photocoupler

Photocoupler whose photo sensitive element is a Darlington phototransistor

NOTE A base terminal may or may not be provided.

3.3.5 Photothyristor photocoupler

Photocoupler whose photo sensitive element is a photothyristor

NOTE 1 Photothyristor is a thyristor that is designed to be triggered by optical radiation.

NOTE 2 Gate terminal may or may not be provided.

3.3.6 Phototriac photocoupler

Photocoupler whose photo sensitive element is a phototriac.

NOTE A phototriac is a triac that is designed to be triggered by optical radiation.

3.3.7 IC photocoupler

Photocoupler whose photo-sensitive element is a photodiode/phototransistor and an integrated circuit

3.3.8 FET photocoupler

Photocoupler with one or more field-effect transistors (FETs) in the output stage

NOTE A FET is activated by photo emitter by direct optical radiation.

3.3.9 Photodiode photocoupler

Photocoupler whose photosensitive element is a photodiode

3.3.10 IC input photocoupler

Photocoupler whose input element consists of an integrated circuit and an photoemitter.

3.3.11 Solid state opto relay

Photocoupler whose photo sensitive element is phototriac and output is triac.

4 Terms related to ratings and characteristics for photocouplers

4.1 Current transfer ratio

4.1.1 Static value of the (forward) current transfer ratio $h_{F(ctr)}$

The ratio of the d.c. output current to the d.c. input current, the output voltage being held constant.

NOTE The abbreviation CTR (d.c.) is sometimes used instead of a symbol.

4.1.2 Small-signal short-circuit (forward) current transfer ratio $h_{f(ctr)}$

The ratio of the a.c. output current to the a.c. input current, the output being short-circuited to a.c.

NOTE The abbreviation CTR (a.c.) is sometimes used instead of a symbol.

4.2 Cut-off frequency f_{co}

The frequency at which the modulus of the small-signal current transfer ratio has decreased to $1/\sqrt{2}$ of its low-frequency value.

4.3 Input-to-output capacitance C_{IO}

The total capacitance between all input terminals connected together and all output terminals connected together.

4.4 Isolation resistance R_{IO}

The resistance between all input terminals connected together and all output terminals connected together.

4.5 Isolation voltage

The voltage between any specified input terminal and any specified output terminal.

4.5.1 DC isolation voltage V_{IO}

The value of the constant isolation voltage

4.5.2 Repetitive peak isolation voltage V_{IORM}

The highest instantaneous value of the isolation voltage including all repetitive transient voltages, but excluding all non-repetitive transient voltages.

NOTE A repetitive transient voltage is usually a function of the circuit. A non-repetitive transient voltage is usually due to an external cause and it is assumed that its effect has completely disappeared before the next non-repetitive voltage transient arrives.

4.5.3 Surge isolation voltage V_{IOSM}

The highest instantaneous value of an isolation voltage pulse of specified wave shape with short time duration

4.6 Terms related to photocouplers with phototriac output and/or solid state opto-relay with triac output**4.6.1 Repetitive peak voltage****4.6.2 Repetitive peak off-state voltage V_{DRM}**

Maximum applicable repetitive peak forward voltage between anode and cathode in off-state under specified gate conditions.

NOTE The repetitive voltage has a slew rate of less than the specified critical rate of rise of off-state voltage (dv/dt).

4.6.3 Repetitive peak reverse voltage V_{RRM}

Maximum applicable repetitive peak reverse voltage between anode and cathode in off-state under specified gate conditions.

4.6.4 RMS on-state current $I_{T(RMS)}$

Maximum applicable root-mean-square forward current between anode and cathode in on-state under specified gate conditions.

4.6.5 Peak off-state current I_{DRM}

Forward leakage current between the off-state output terminals under specified conditions

4.6.6 Peak on-state voltage V_{TM}

Peak forward voltage between on-state output terminals under specified conditions

4.6.7 DC off-state current I_{BD}

Forward leakage current between off-state output terminals under specified conditions

4.6.8 DC on-state voltage V_T

The d.c. forward voltage between on-state output terminals under specified conditions, when the specified forward current is applied between on-state output terminals

4.6.9 Holding current I_H

The minimum on-state current in output to maintain the on-state under specified conditions

4.6.10 Critical rate of rise of off-state voltage dV/dt

The rate of rise of off-state voltage just before the transition from off-state to on-state under the specified operating conditions

4.6.11 Trigger input current I_{FT}

The minimum input forward current to switch from off-state to on-state in output under specified conditions

4.7 Common mode transient immunity CMTI

The common mode transient immunity (CMTI), also sometimes referred to as the common mode rejection (CMR) or the common mode rejection ratio (CMRR), is the maximum tolerable rate-of-rise (or fall) of a common mode voltage (V_{CM}). The CMTI specification or the CMR or CMRR specification should include the amplitude of the common mode pulse (V_{CM}). This common mode pulse (V_{CM}) that is applied across the two grounds across the optocoupler should not exceed the maximum rated transient isolation voltage specification of the photocoupler as defined by the V_{IOTM} .

5 Terms for photocoupler providing protection against electrical shock

This clause covers terms for a photocoupler after it has been subjected to operating conditions (safety ratings) that exceed the specified ratings (limiting values) for normal operation.

5.1 Safety ratings of a photocoupler for reinforced isolation

Electrical, thermal, and mechanical operating conditions that exceed the specified ratings (limiting values) for normal operation, and to which the specified safety requirements refer.

5.2 Electrical safety requirements of a photocoupler for reinforced isolation

Electrical requirements that have to be met and maintained after the photocoupler has been subjected to specified safety ratings, to ensure protection against electrical shock.

NOTE The photocoupler may become permanently inoperative when safety ratings are applied.

5.2.1 Partial discharge p_d

Localized electrical discharge which occurs in the insulation between input and output terminals of the photocoupler

5.2.2 Apparent charge q_{pd} , q

Electrical charge caused by a partial discharge in the photocoupler

5.2.3 Threshold apparent charge $q_{pd(TH)}$, q_{TH}

A specified value of apparent charge that is as small as technically feasible and to which measured values of the partial-discharge inception voltage or extinction voltage, respectively, refer.

NOTE 1 A threshold apparent charge of 5 pC was found to be a practicable criterion for photocouplers. Otherwise it should be defined on each individual device design. Smaller values are desirable but are not viable at this time.

NOTE 2 In actual tests, this criterion applies to the apparent charge pulse with the maximum value.

NOTE 3 The term "specified discharge magnitude" (see 3.18.2 of IEC 60664-1) is synonymous with threshold apparent charge.

5.2.4 Test voltages for the partial-discharge test of a photocoupler

See Figure 1a and Figure 1b. All voltages used are a.c. peak voltages.

5.2.5 Test voltage $V_{pd(t)}$, V_t

The voltage applied during the test period between the input terminals (connected together) and the output terminals (connected together) of the photocoupler under test

5.2.6 Partial discharge test voltage $V_{pd(t)}$

The isolation voltage applied during the partial discharge test period.

NOTE 1 Specified values of this voltage may be expressed as multiple of the specified value of the maximum working isolation voltage or maximum repetitive peak isolation voltage: $V_{pd(t)} = F \times V_{IOWM}$ if $V_{IOWM} \geq V_{IORM}$.

($V_{pd(m)} = F \times V_{IOWM}$ or $V_{pd(m)} = F \times V_{IORM}$, whichever is higher. Refer to 5.2.8 for $V_{pd(m)}$.)

Refer 5.2.7 item c) multiplying factor.

NOTE 2 Test voltage, where the apparent charge has to be equal or less than the specified value.

5.2.7 Initial test voltage $V_{pd(ini)}$, V_{ini}

The test voltage applied during the initial test time t_{ini} .

- a) Initial voltage: $V_{pd(ini),a}$; $V_{ini,a}$ (see Table F.1 of IEC 60664-1 for minimum voltages, interpolation is also possible.)

The value of the voltage applied at the beginning of the measurement, for a specified time t_{ini} , which is intended to simulate the occurrence of a transient overvoltage.

- b) Initial test voltage: $V_{pd(ini),b}$; $V_{ini,b}$

The isolation test voltage applied between the short-circuited input and the short-circuited output terminals at routine test (method b). A withstand voltage equal to the manufacturer's rating with a maximum of V_{IOTM} .

NOTE 1 The initial test voltage is higher than or equal to the test voltage in the second part of the test period in which partial discharge characteristics are measured, see Subclause 5.2.10.

NOTE 2 For method a), the specified value for the initial test voltage is equal to the specified value of the maximum transient isolation voltage V_{IOTM} .

NOTE 3 For method b), the specified value for the initial test voltage (isolation voltage) is equal to or lower than the specified value of the maximum transient isolation voltage V_{IOTM} .

NOTE 4 The equivalent r.m.s. value of an a.c. test voltage may also be used.

- c) Multiplying factor: F

At routine test stage: $F = 1,875$

At sample test stage and after life tests, subgroup 1: $F = 1,6$

After endurance tests, subgroups 2 and 3: $F = 1,2$

NOTE When the test result using the above F factors is certainly affected by testability on, for example, the device package size, package leads or the test system, the following F factors can be chosen instead by manufacturer's decision; $F = 1,6$, $F = 1,2$ and $F = 1,0$ respectively.

5.2.8 Apparent charge measuring voltage $V_{pd(m)}$, V_m

The test voltage at which apparent charge is measured

5.2.9 Partial-discharge inception voltage $V_{pd(i)}$, V_i

The lowest peak value of an a.c. test voltage at which the apparent charge is greater than the specified threshold apparent charge, if the test voltage is increased from a lower value where no partial discharge occurs.

NOTE The equivalent r.m.s. value of an a.c. test voltage may also be used.

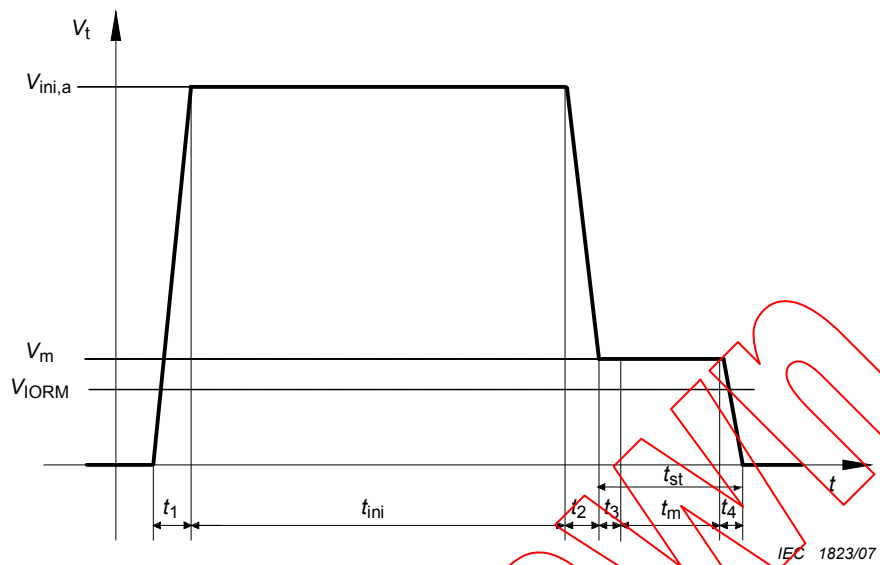
5.2.10 Partial-discharge extinction voltage $V_{pd(e)}$, V_e

The lowest peak value of an a.c. test voltage at which the apparent charge is smaller than the specified threshold apparent charge, if the test voltage is reduced from a higher value where such discharge occurs.

NOTE The equivalent r.m.s. value of an a.c. test voltage may also be used.

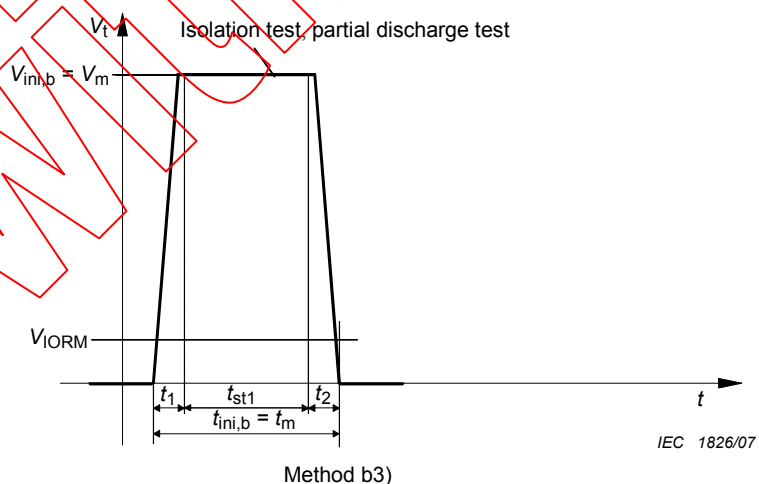
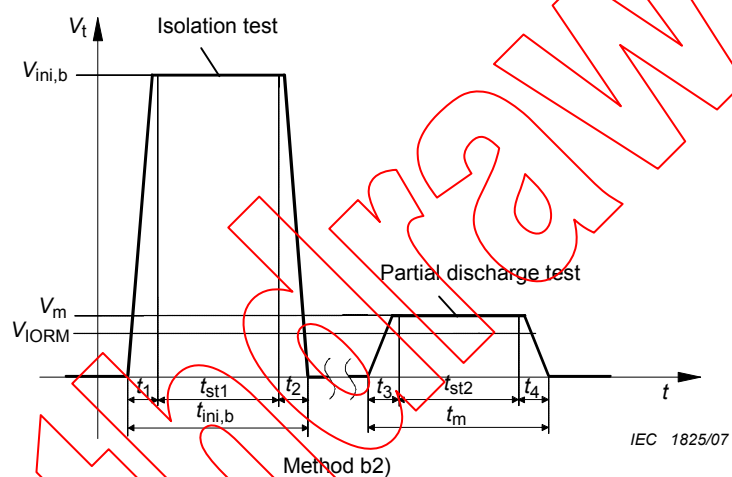
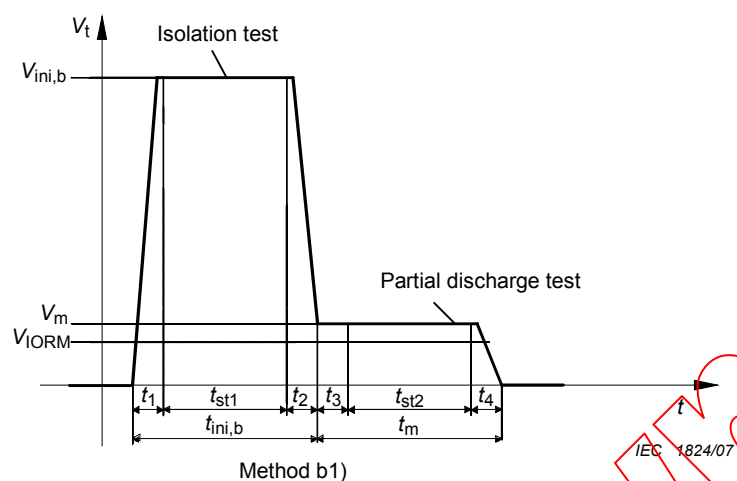
5.2.11 Time intervals of the test voltage

See the terms and letter symbols indicated in Figure 1a and 1b.



- t_{ini} initial time (method a) only
- t_{st} (partial-discharge) stress time
- t_m (partial-discharge) measuring time
- t_1, t_2, t_3, t_4 settling times

Figure 1a – Time intervals for method a)



$t_{ini,b}$	isolation test time (method b) only)	t_{st1}	isolation test stress time (method b) only)
t_{st2}	(partial-discharge) stress time	t_m	(partial-discharge) measuring time
t_1, t_2, t_3, t_4	settling times		

Figure 1b – Time intervals for method b)

Figure 1 – Time intervals of the test voltage

5.3 Isolation voltages and isolation test voltages for photocouplers providing protection against electrical shock

5.3.1 Rated isolation voltage

The maximum voltage between all input terminals (connected together) and all output terminals (connected together)

a) Maximum working isolation voltage V_{IOWM}

An r.m.s. value of withstand voltage assigned by the manufacturer of the photocoupler, characterizing the specified (long term or the working voltage) withstand capability of its isolation.

NOTE The r.m.s. voltage includes equivalent d.c. voltage.

b) Maximum repetitive peak isolation voltage V_{IORM}

A repetitive peak value of withstand voltage assigned by the manufacturer of the photocoupler, characterizing the specified withstand capability of its isolation against repetitive peak voltages.

NOTE This is the peak value of the waveform indicated in a) above, if the waveform is sinusoidal.

c) Maximum transient isolation voltage V_{IOTM}

A value of impulse withstand voltage assigned by the manufacturer of the photocoupler, characterizing the specified withstand capability of its isolation against transient overvoltages.

d) Maximum withstanding isolation voltage V_{ISO}

Maximum withstanding isolation a. c. (r.m.s.) voltage for 1 min

NOTE The r.m.s. voltage includes equivalent d.c. voltage.

5.4 Limiting values (absolute maximum system) over the operating temperature range, unless otherwise stated

Indicate any qualifications such as time, frequency, pulse duration, humidity, etc.

5.4.1 Minimum and maximum storage temperatures T_{stg}

5.4.2 Minimum and maximum ambient or reference-point operating temperatures T_{amb} or T_{ref}

5.4.3 Maximum soldering temperature T_{sld}

Maximum soldering time and minimum distance to case should be specified.

5.4.4 Maximum continuous (direct) reverse input voltage V_R

5.4.5 Maximum collector-emitter voltage, with the base open-circuited V_{CEO}

5.4.6 Maximum collector-base voltage, where an external base connection is present, with the emitter open-circuited V_{CBO}

5.4.7 Maximum emitter-base voltage, where an external base connection is present, with the collector open-circuited V_{EBO}

or:

5.4.8 Maximum emitter-collector voltage, where no external base connection is present V_{ECO}

5.4.9 Maximum continuous (direct) or repetitive peak isolation voltage V_{IO} or V_{IORM}

The waveshape and repetition rate should be specified.

5.4.10 Where appropriate, maximum surge isolation voltage V_{IOSM}

This should be specified for pulses of both polarities having the waveshape shown in Figure 2.

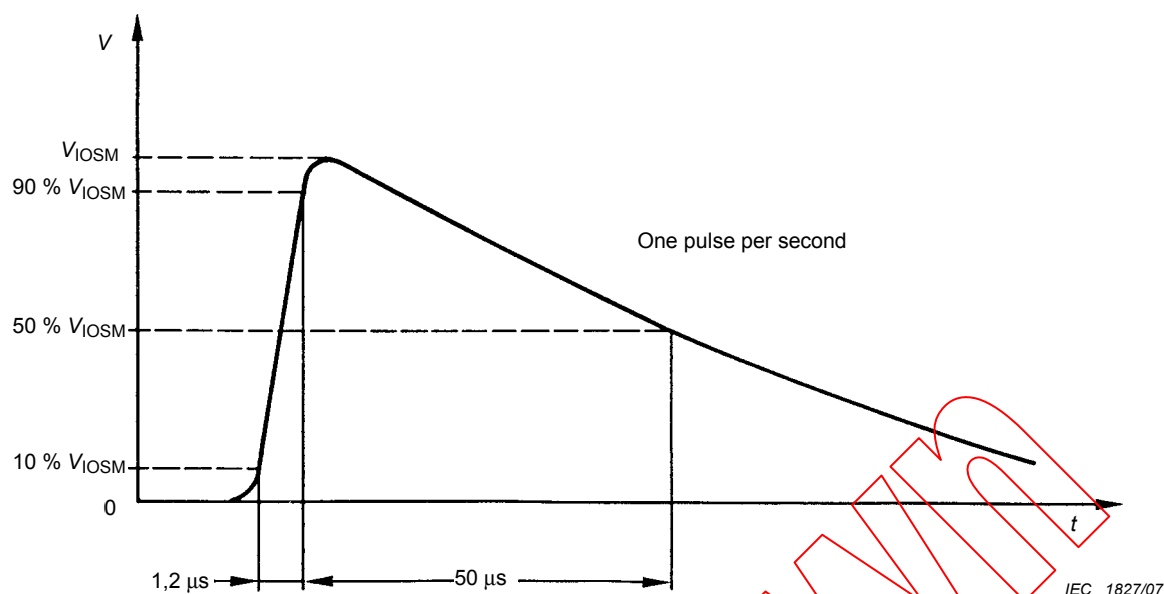


Figure 2 – Test voltage

- 5.4.11 Maximum continuous collector current I_C
- 5.4.12 Maximum continuous forward input current I_F at an ambient or reference-point temperature of 25 °C and derating curve or derating factor
- 5.4.13 Maximum peak forward input current I_{FM} at an ambient or reference-point temperature of 25 °C and under specified pulse conditions
- 5.4.14 Maximum power dissipation P_{trn} of the output transistor at an ambient or reference-point temperature of 25 °C and a derating curve or derating factor
- 5.4.15 Maximum total power dissipation of the package P_{tot} at an ambient or reference-point temperature of 25 °C and derating curve or derating factor

6 Electrical characteristics

6.1 Phototransistor output photocoupler

	Characteristics	Conditions at T_{amb} or $T_{case} = 25\text{ °C}$, unless otherwise stated	Notes	Symbols	Requirements	
6.1.1	Input diode forward voltage	I_F specified		V_F		Max.
6.1.2	Input diode reverse current	V_R specified		I_R		Max.
6.1.3	Collector-emitter dark current	V_{CE} specified, $I_F = 0$, $I_B = 0$ (base open-circuit)		I_{CEO}		Max.
	or, where appropriate*, collector-base dark current	V_{CB} specified, $I_F = 0$, $I_E = 0$		I_{CBO}		Max.

	Characteristics	Conditions at T_{amb} or $T_{case} = 25\text{ }^{\circ}\text{C}$, unless otherwise stated	Notes	Symbols	Requirements	
6.1.4	Collector-emitter dark current or, where appropriate*, collector base dark current	V_{CE} specified, $I_F = 0$, $I_B = 0$, T_{amb} or T_{ref} specified V_{CB} specified, $I_F = 0$, $I_E = 0$, T_{amb} or T_{ref} specified		I_{CEO} I_{CBO}		Max. Max.
6.1.5	Collector-emitter saturation voltage or, where appropriate*, collector-base voltage	I_F and I_C specified, $I_B = 0$ I_F and I_C specified, $I_B = 0$		V_{CEsat} V_{CB}		Max. Max.
6.1.6	Current transfer ratio	I_F or I_C and V_{CE} specified, $I_B = 0$		h_F or CTR (d.c.)	Min.	Max.
6.1.7	Where appropriate, differential current transfer ratio	I_F or I_C and V_{CE} specified, $I_B = 0$, frequency specified		h_F or CTR (a.c.)	Min.	Max.
6.1.8	Isolation resistance between input and output	V_{IO} specified	1	R_{IO}	Min.	
6.1.9	Where appropriate, input-to-output capacitance	$f = 1\text{ MHz}$, $I_F = 0$, $I_C = 0$	1	C_{IO}		Max.
6.1.10	Where appropriate, switching times: turn-on time and turn-off time or: rise time and fall time	Specified V_{CC} , I_F and R_L , and nominal I_C , test circuit specified Specified V_{CC} , I_F and R_L , and nominal I_C , test circuit specified		t_{on} t_{off} t_r t_f		Max. Max. Max. Max.
6.1.11	Where appropriate, cut-off frequency	I_F or I_C and V_{CE} specified, $I_B = 0$	2	f_{ctr}	Min.	
* For operation in the diode mode. NOTE 1 All input terminals should be connected together and all output terminals should be connected together. NOTE 2 The cut-off frequency is the lowest frequency at which the magnitude of the a.c. current transfer ratio is 0,707 times its value at very low frequency.						

6.2 Phototriac output photocoupler or solid state opto-relay

6.2.1	Peak off-state current	Peak off-state voltage (V_{DRM}) and T_{amb} specified		I_{DRM}		Max.
6.2.2	Peak on-state voltage	Peak on-state current (I_{TM}), input forward current (I_{F}) and T_{amb} specified		V_{TM}		Max.
6.2.3	d.c. off-state current	d.c. off-state voltage (V_{BD}) and T_{amb} specified		I_{BD}		Max.
6.2.4	d.c. on-state voltage	d.c. on-state current (I_{T}), $I_{\text{B}} = 0$, T_{amb} specified		V_{T}		Max.
6.2.5	Holding current	T_{amb} specified		I_{H}		Max.
6.2.6	Critical rate of rise of off-state voltage	Off voltage (V_{D}) and T_{amb} specified		dV/dt	Min.	Max.
6.2.7	Trigger input current	Supply voltage (V_{D}), load resistance, output terminal voltage and T_{amb} specified		I_{FT}	Min.	Max.
6.2.8	Isolation resistance between input and output	V_{IO} specified	NOTE	R_{IO}	Min.	

NOTE All input terminals should be connected together and all output terminals should be connected together.

7 Photocouplers providing protection against electrical shock

All requirements contained in this section are valid for photocouplers whatever the configuration of the input and/or the output (e.g. phototransistor, IC output, phototriac, etc.).

7.1 Type

Ambient-rated or case-rated photocoupler, designed to provide protection against electrical shock, when bridging double or reinforced isolation.

7.2 Ratings (have to be mentioned in a special section in the manufacturer's data sheet)

7.2.1 Safety ratings

- Maximum ambient safety temperature T_{s}
- Maximum input current or maximum input power dissipation I_{SI} or P_{SI}
- Maximum output current or maximum output power dissipation I_{SO} or P_{SO}

7.2.2 Functional ratings

Package related values: temperatures, total power dissipation

Input and output related values: voltages, currents, power dissipation

7.2.3 Rated isolation voltages

- Maximum working isolation voltage V_{IOWM}
- Maximum repetitive peak isolation voltage V_{IORM}
- Maximum transient isolation voltage V_{IOTM}
- Maximum withstanding isolation voltage V_{ISO}

7.3 Electrical safety requirements

The following characteristics as shown in Table 1 have to be mentioned in the manufacturer's datasheet, in addition to those listed in Clause 7.

Table 1 – Datasheet characteristics

Characteristics	Conditions	Notes	Symbol	Requirements
Apparent charge (method a)	See 8.5		q_{pd}	Max.
Apparent charge (method b)			q_{pd}	Max.
Isolation resistance	$100\text{ }^{\circ}\text{C} \leq T_{amb} \leq T_{amb\text{ max.}}$ $V_{IO} = 500\text{ V}$		R_{IO}	Min.
Isolation resistance (under fault conditions)	$T_{amb} = T_S$ (see Subclause 8.3)) $V_{IO} = 500\text{ V}$		R_{IO}	Min.
External clearance, External creepage distance	See IEC 60664-1, Tables F.2 and F.4 or equivalent for minimum requirements (inhomogeneous field) Refer to related equipment standards for further requirements		Symbols under consideration	Min. Min.
Comparative tracking index			CTI	Min.
Maximum withstanding isolation voltage	AC voltage with commercial frequency for 1 min Routine test for 1 s or 2 s is at 100 % or maximum 120 % of 1 min rating.		V_{ISO}	Max.

7.4 Electrical, environmental and/or endurance test information (supplementary information)

Refer to Tables 2 and 3.

7.4.1 At the routine test stage (method b) an isolation test according to Subclause 8.4 must be performed followed by a partial discharge test according to Subclause 8.5. Both tests may be performed either on the same test equipment without delay (method b1) or on different test equipment with delay (method b2). The isolation test can be omitted, if the partial discharge test is performed at $V_{ini,b}$ (method b3).

Any isolation tests either by the equipment or photocoupler manufacturer can be performed with voltages greater than or equal to test voltages defined in equipment standards (e.g. 4 kV r.m.s.), but have to be equal to or lower than $V_{pd(ini),b}$.

7.4.2 Sample test shall be performed once per quarter. See 2) in Table 2. A minimum sample of 20 devices shall be picked from a random production lot for each package type.

NOTE Package types must be significantly different in terms of package outline dimensions. The lead form option is not construed as a significant difference.

A production lot is defined here as the number of devices which have been produced using the same production line and production conditions. Examples of different package types are: DIP-4,-6,-8,...SOP-4,-6,-8,...etc. Thus, if a manufacturer has five different package types then 20 samples each would be pulled for this sample test for a total of $(5 \times 20 = 100)$ photocoupler) per quarter. Multiple channels do not make a package type difference.

The purpose of this random testing per quarter is to monitor the quality of the manufacturing with respect to selected criteria.

The minimum sampling size of the total is $n = 80$. The failures shall be $c = 0$, i.e. there shall be no failures.

7.4.3 A type test shall be performed with the different package types in one or more of the following items:

- Package materials relevant for insulation

Mold materials, silicone gels, foils, etc.

- Leadframe

If the new lead frame affects the external creepage distance or external clearance or the thermal resistance of the package and thereby making I_{si} or P_{si} or I_{so} or P_{so} affected.

- Package construction

EXAMPLE Change from single mold coplanar to a double mold coplanar package

Any changes of one or more of those items are considered major changes, which require a new type test.

Number of channels is not a consideration in determining a unique package platform.

The difference of a chip size is not considered for the type test as long as the safety limiting values are not affected.

Periodic testing shall be carried out at the latest 5 years after type testing and shall be repeated at the latest every 5 years.

Type tests and periodic tests shall include at least the following subgroups (7.4.3.1 to 7.4.3.8), with the following conditions:

- zero failure shall be achieved,
- if one failure occurs out of the 130 devices, further quantities of devices shall be subjected to the subgroup (in which the failure occurred), with no more failures.

NOTE Safety limiting values (I_{si} , P_{si} , I_{so} , P_{so} , T_s)

For components to provide safe electrical isolation the requirements for satisfactory isolation have the first priority.

The safety limiting values are the maximum input current (I_{si}), or maximum input power (P_{si}), or maximum output current (I_{so}), or maximum output power (P_{so}), or the maximum ambient safety temperature (T_s) that are defined by the manufacturer for an optocoupler device that can be allowed in the event of a fault or a failure without causing the insulation of the device to breakdown.

The safety limiting values determine the maximum range of input or output power dissipations allowed over which, although the function of the coupling elements may be destroyed, the isolation specification of the optocoupler device remains intact. The maximum ambient safety temperature (T_s) is the highest enclosure temperature permitted in the event of a fault.

The requirement for isolation remains even when the operation of the optocoupler is no longer in existence due to the external electrical thermal stress, when for example

- 1) the emitter diode becomes damaged,
- 2) the detector is damaged,
- 3) operation of optocoupler is impeded by an external heat source (e.g. resistor).

The safety limiting values are governed by the materials and circuit design parameters adopted by the manufacturer, and the user should ensure that the safety limiting values are not exceeded, to make certain that the isolation resistance or insulation of the optocoupler remains intact. The user will ensure the safety limiting values are not exceeded through adequate safety arrangements in the circuit design and application conditions of the optocoupler, e.g.:

- a) current limitation of the input/output circuit
- b) voltage limitation of the input/output circuit
- c) thermal management of the circuit, which ensures absolute maximum junction temperatures or absolute maximum operating temperature as specified in the manufacturer's data sheet is not exceeded
- d) the surrounding circuit to be ignition-resistant
- e) in the event of a fault or failure, the external current or voltage limiting safety mechanisms or methods will ensure that the safety limiting values are not exceeded.

7.4.3.1 Preconditioning

Visual inspection according to manufacturer's specification

Resistance to soldering heat $260\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$, $5\text{ s} \pm 1\text{ s}$

For photocouplers in SMT versions, the conditions according to IEC 60068-2-58 are applied.

Apparent charge

method b1

$$V_{pd(m)} = F \times V_{IORM} (V_{IOWM}),$$

(see 5.2.7.c)

$V_{ini,b}$ (according to manufacturer's specification) $\leq$

$V_{ini,a}$

$$q_{pd} \leq 5\text{ pC}$$

Parametric test

according to manufacturer's specification

Isolation resistance

$$R_{IO} \geq 10^{11}\text{ }\Omega \text{ at } V_{IO} = 500\text{ V, } t = 1\text{ min, } T_{amb} \text{ max}$$

7.4.3.2 Subgroup 1: 20 samples

7.4.3.2.1 Tests

Preconditioning: see 7.4.3.1

Rapid change of temperature:

see IEC 60068-2-14

T_{stgmin} , T_{stgmax} , 10 cycles, dwell time 3 h

Vibration:

see IEC 60068-2-6

Axis: 3

Frequency area: between 10 Hz and 500 Hz

Transition frequency: 58 Hz

Amplitude: 75 mm, 98 m/s^2 dependent on stress level

Cycles: 10 cycles

Criteria: no damage

Shock:

see IEC 60068-2-27

Axis: 3

Wave form: Half sine wave,

Acceleration: 980 m/s^2

Shock duration: 6 ms
 Numbers: 3 shocks/axis
 Criteria: no damage

Sealing (not for plastic):

see IEC 60068-2-17
 Pressure: 200 kPa
 Duration: 6 h
 Recover time: 0,5 h
 Maximum pressure: depending on manufacturer's specification

Dry heat:

see IEC 60068-2-2
 $V \geq V_{IORM}$ (min. 700 V), $T_{amb} = T_{amb\max}$ (min. = 100 °C)
 Duration = 16 h

Accelerated damp heat:

see IEC 60068-2-30
 Method: 1
 Temperature: 55 °C
 Cycles: 1

Temperature storage:

see IEC 60068-2-1 2 h at T_{stgmin}

Damp heat (steady state):

see IEC 60068-2-78 85 % R.H. at 85 °C, duration = 21 days

7.4.3.2.2 Final measurements

At least dry samples for 1 h to 2 h before doing final measurements.

Apparent charge

method a) $F = 1,6$ or $1,2$ (see 5. 2. 7c)
 $q_{pd} \leq 5$ pC

Isolation resistance

$R_{IO} \geq 10^{12} \Omega$ at $V_{IO} = 500$ V, $t = 1$ min, $T_{amb} = 25$ °C

Surge test (type test only)

see 10.1 of IEC 60065
 Number of discharge: 50
 Voltage: 10 kV
 Cycles: maximum 12 discharges/minute

Isolation resistance

$R_{IO} \geq 10^9 \Omega$ at $V_{IO} = 500$ V, $t = 1$ min, $T_{amb} = 25$ °C

7.4.3.3 Subgroup 2: 30 samples

7.4.3.3.1 Tests or examination:

Preconditioning

see 7.4.3.1

Input safety test

(see Annex A)

At limiting values under fault conditions:

Maximum input current or maximum input power dissipation, $T_{amb} = T_s$, duration: 72 h

7.4.3.3.2 Final measurements:

Apparent charge

Method a) $F = 1,2$ or $1,0$ (see 5.3.1 a); $q_{pd} \leq 5$ pC

Isolation resistance

$R_{IO} \geq 10^9 \Omega$ at $V_{IO} = 500$ V, $t = 1$ min, $T_{amb} = 25^\circ\text{C}$

7.4.3.4 Subgroup 3: 30 samples

7.4.3.4.1 Tests or examination

Preconditioning

see 7.4.3.1

Output safety test

(see Annex A)

At limiting values under fault conditions:

At maximum output current or maximum output power dissipation;

$T_{amb} = T_s$, duration: 72 h

7.4.3.4.2 Final measurements: see 7.4.3.3.2

7.4.3.5 Subgroup 4: 40 samples

7.4.3.5.1 Examinations

Isolation resistance at

a) T_{amb} max (min. 100°C),

$R_{IO} \geq 10^{11} \Omega$ at $V_{IO} = 500$ V, $t = 1$ min

b) T_s

$R_{IO} \geq 10^9 \Omega$ at $V_{IO} = 500$ V, $t = 1$ min

7.4.3.6 Subgroup 5: 10 samples

7.4.3.6.1 Examinations

External clearance see IEC 60664-1

External creepage distance see IEC 60664-1

Flammability test see IEC 60695-11-5

(type test only)

Time of application of the test flame

$t = 10$ s

After burning time ≤ 30 s

7.4.3.7 Testing of insulating materials

7.4.3.7.1 Tracking resistance

The insulating materials employed and their tracking resistance are important factors in determining the rated insulation voltage for optocouplers. For evaluation of insulating materials and determination of the comparative tracking index (CTI), IEC 60112 shall be used.

$CTI \geq 175$

7.4.3.7.2 Limit temperature of insulating materials

The limit temperature of insulating materials is determined in accordance with IEC 60216-1 and IEC 60216-2.

It shall be greater than the maximum storage temperature T_{stgmax} but lower than or equal to the glass transition temperature T_g .

7.4.3.7.3 Ceramic materials

If ceramic materials are employed, IEC 60672-2 shall be complied with.

7.4.3.8 Marking, labels, information in datasheets

If it is not possible, for reasons of space, to accommodate the data in accordance with 7.4.3.8.1 on the component, the data may be given on the packing. The component shall, however, incorporate at least a mark, which gives a clear reference to the datasheet.

7.4.3.8.1 Data on the optocoupler

The following data shall be applied in a durable manner to the optocoupler, in the priority shown:

1. Type identification which gives a clear reference to the datasheet
2. Manufacturer's mark
3. Terminal markings
4. Date Code

7.4.3.8.2 Information in datasheets

The datasheet shall include the following information:

- ratings, see 7.2
- electrical safety requirements, see 7.3
- characteristics
- properties of the package (sealing)
- terminal arrangement
- datasheet imprint:

"This optocoupler is suitable for 'safe electrical insulation' only within the safety ratings. Compliance with the safety ratings shall be ensured by means of suitable protective circuits."

Table 2 – Tests and test sequence for photocoupler providing protection against electrical shock

1) Routine test (non-destructive), see 7.4.1																																																								
1.1	Apparent charge magnitude at 1,6 V_{IORM} , method b1), b2) or b3), $q_c \leq 5 \text{ pC}$, $V_{ini'b} \leq V_{ini'a}$ See 5.2.7 c), 5.2.11																																																							
1.2	Parametric test according to manufacturer's specification, see 7.4.3.1																																																							
2) Sample test (destructive), $n = 20/\text{platform}$, with minimum $n = 80$ in total, $c = 0$, see 7.4.2																																																								
2.1	Visual inspection according to manufacturer's specification see 7.4.3.1																																																							
2.2	Resistance to soldering heat see 7.4.3.1																																																							
2.3	Apparent charge magnitude at $1,2 \times V_{IORM}$, method a), $q_c \leq 5 \text{ pC}$, $V_{ini'a}$, see 5.2.7 c)																																																							
2.4	Parametric test according to manufacturer's specification see 7.4.3.1																																																							
2.5	Isolation resistance see 7.4.3.6.1																																																							
2.6	External creepage distance and clearance, $n = 10$, $c = 0$, see 7.4.3.6.1																																																							
2.7	Isolation resistance at high temperatures, $n = 40$, $c = 0$, see 7.4.3.5.1 a) T_{amb} max, min 100°C b) T_s																																																							
3) Type test, periodic test (every 5 years), destructive, $n = 130$, $c = 0$, see 7.4.3																																																								
<table><tr><td>Subgroup 1 7.4.3.2 $n = 20$</td><td>Subgroup 2 7.4.3.3 $n = 30$</td><td>Subgroup 3 7.4.3.4 $n = 30$</td><td>Subgroup 4 7.4.3.5 $n = 40$</td><td>Subgroup 5 7.4.3.6 $n = 10$</td></tr><tr><td>Preconditioning 7.4.3.1</td><td>Preconditioning 7.4.3.1</td><td>Preconditioning 7.4.3.1</td><td>Isolation resistance T_{amb} max. $>100^\circ\text{C}$, T_s</td><td>Ext. creepage distance Ext. clearance</td></tr><tr><td>Rapid change of temperature</td><td>Input safety test</td><td>Output safety test</td><td></td><td>Flammability</td></tr><tr><td>Vibration</td><td>Final measurement</td><td>Final measurement</td><td></td><td></td></tr><tr><td>Shock</td><td></td><td></td><td></td><td></td></tr><tr><td>Sealing</td><td></td><td></td><td></td><td></td></tr><tr><td>Dry heat</td><td></td><td></td><td></td><td></td></tr><tr><td>Accelerated damp heat</td><td></td><td></td><td></td><td></td></tr><tr><td>Temperature storage</td><td></td><td></td><td></td><td></td></tr><tr><td>Damp heat</td><td></td><td></td><td></td><td></td></tr><tr><td>Final measurements</td><td></td><td></td><td></td><td></td></tr></table>		Subgroup 1 7.4.3.2 $n = 20$	Subgroup 2 7.4.3.3 $n = 30$	Subgroup 3 7.4.3.4 $n = 30$	Subgroup 4 7.4.3.5 $n = 40$	Subgroup 5 7.4.3.6 $n = 10$	Preconditioning 7.4.3.1	Preconditioning 7.4.3.1	Preconditioning 7.4.3.1	Isolation resistance T_{amb} max. $>100^\circ\text{C}$, T_s	Ext. creepage distance Ext. clearance	Rapid change of temperature	Input safety test	Output safety test		Flammability	Vibration	Final measurement	Final measurement			Shock					Sealing					Dry heat					Accelerated damp heat					Temperature storage					Damp heat					Final measurements				
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Testing of insulating materials (type test only) see 7.4.3.7																																																								
Marking, labels, information in datasheets see 7.4.3.8																																																								

Table 3 – Test conditions

Method a)	Parameter	Method b)
$t_{ini} = 60 \text{ s}$ $V_{ini,a}$ $*) V_{pd} = F \times V_{IORM} \text{ or } V_{IOWM}$ $t_m = 10 \text{ s}$ $t_{st} \text{ typ. } 12 \text{ s}$ $dV/dt \text{ during } t_1, t_2 = 100 \text{ V/s to } 1\,000 \text{ V/s}$ $t_3, t_4 \text{ typ. } 1 \text{ s}$ $T_{amb} = 15 \text{ }^\circ\text{C to } 35 \text{ }^\circ\text{C}$ $150 \text{ kHz} \leq f_o \leq 5 \text{ MHz}$ $\Delta f \leq 15 \text{ kHz}$ $q_o = 5 \text{ pC}$ $q_{min} = 1 \text{ pC}$ $q_{pd} = 5 \text{ pC}$ $C_C \geq 1 \text{ nF}$	Initial time Initial voltage Apparent charge test voltage Apparent charge measuring time Specified test time Rate of rise/fall (V_{ini}) Transient recovery time Ambient temperature Centre frequency Bandwidth Calibration value Smallest measurable value Apparent charge test limit Coupling capacitor	$t_{ini,b} = 1 \text{ s}$ $V_{ini,b} \leq V_{ini,a}$ $V_{pd} = 1,875 (*) \times V_{IORM} \text{ or } V_{IOWM}$ $t_m = 1 \text{ s}$ $t_{st} \text{ typ. } 1,2 \text{ s}$ $t_{st2} \text{ typ. } 1,2 \text{ s}$ - - $T_{amb} = 15 \text{ }^\circ\text{C to } 35 \text{ }^\circ\text{C}$ $150 \text{ kHz} \leq f_o \leq 5 \text{ MHz}$ $\Delta f \leq 15 \text{ kHz}$ $q_o = 5 \text{ pC}$ $q_{min} = 1 \text{ pC}$ $q_{pd} = 5 \text{ pC}$ $C_C \geq 1 \text{ nF}$
$*) V_{pd} = F \times V_{IORM} \text{ or } V_{IOWM}$ $*) F = 1,875$ in accordance with test method b) only for routine test and initial measurement of the type test $*) F = 1,6$ in accordance with test method a) for final measurement after environmental tests subgroup 1) $*) F = 1,2$ in accordance with test method a) for final measurement after input or safety test (subgroup 2 or 3) NOTE $*)$, $*)$, $*) F = 1,6$, $F = 1,2$ and $F = 1,0$ may be used respectively. See 5.2.7 c).		

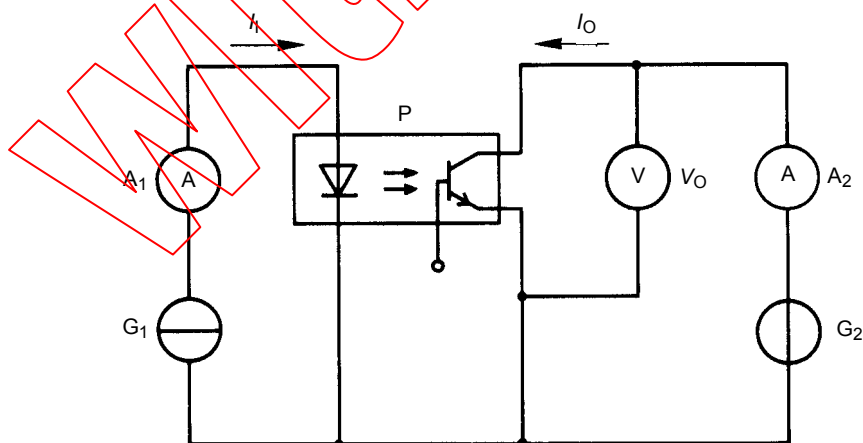
8 Measuring methods for photocouplers

8.1 Current transfer ratio $h_{F(ctr)}$

a) Purpose

To measure the static value of the forward current transfer ratio of photocouplers under specified conditions.

b) Circuit diagram



IEC 1828/07

P photocoupler being measured

Figure 3 – Measurement circuit

c) Circuit description and requirements

- I_I input current = forward current I_F of the photoemitter
- I_O output current = reverse current I_R of the photodiode or collector current I_C of the phototransistor
- V_O output voltage = reverse voltage V_R of the photodiode or collector-emitter voltage V_{CE} of the phototransistor
- A_1, A_2 = ammeters
- G_1 = current source
- G_2 = voltage source

d) Measurement procedure

The measurement shall be performed under standard atmospheric conditions, unless otherwise specified.

The constant current source G_1 is adjusted to obtain the specified input current through the photoemitter.

The voltage source G_2 is adjusted to the specified value V_R or V_{CE} . The output current I_R or I_C is measured with the ammeter A_2 .

The current transfer ratio is calculated by the following formula:

$$h_{F(ctr)} = \frac{I_O}{I_F} \quad (1)$$

hence, for a photocoupler with photodiode output,

$$h_{F(ctr)} = \frac{I_R}{I_F} \quad (2)$$

and, for a photocoupler with transistor output,

$$h_{F(ctr)} = \frac{I_C}{I_F} \quad (3)$$

e) Precautions to be observed

If the photocoupler is sensitive to external radiation, the precautions to be taken in measurement should be stated and observed.

f) Specified conditions

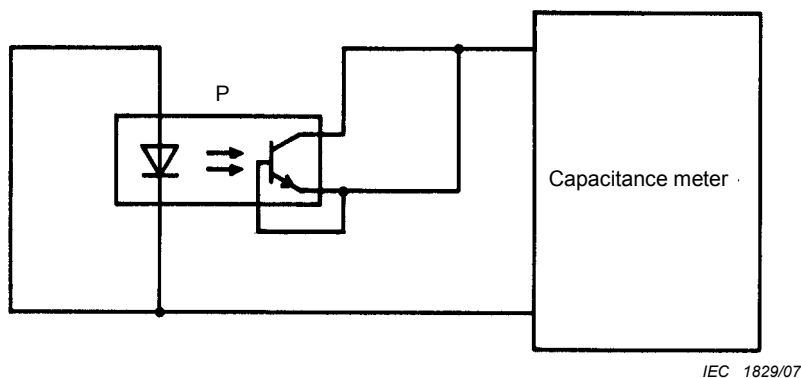
- Ambient temperature
- Input or output current, d.c. or pulse
- Output voltage (V_R or V_{CE})
- When appropriate, the atmospheric conditions

8.2 Input-to-output capacitance C_{IO}

a) Purpose

To measure the capacitance between the input and output terminals of a photocoupler under specified conditions.

b) Circuit diagram



IEC 1829/07

P photocoupler being measured

Figure 4 – Measurement circuit for input to output capacitance

c) Measurement procedure

The photoemitter terminals as well as the photodetector terminals are connected together. The capacitance between the photoemitter and the photodetector terminals is measured at a frequency of 1 MHz (unless otherwise specified), using a suitable capacitance meter.

d) Precautions to be observed

Allowance should be made for the stray capacitance of the test fixture and the leads.

e) Specified conditions

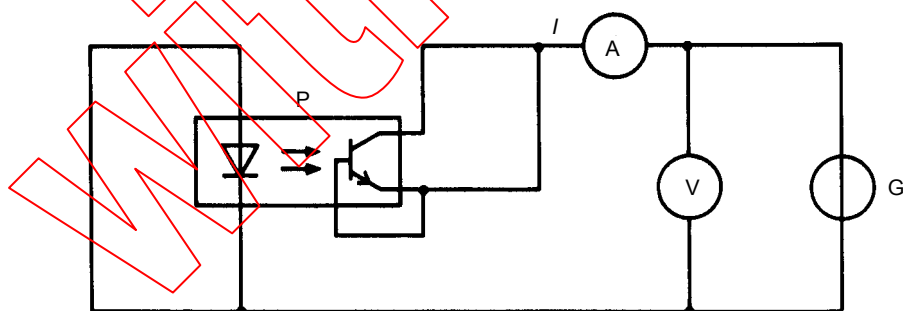
- Ambient temperature
- Measurement frequency, if different from 1 MHz

8.3 Isolation resistance between input and output R_{IO}

a) Purpose

To measure the isolation resistance between the input and output terminals of a photocoupler when subjected to d.c. voltage, under specified conditions.

b) Circuit diagram



IEC 1830/07

P photocoupler being measured

G voltage source

Figure 5 – Measurement circuit for isolation resistance

c) Precautions to be observed

Allowance should be made for the leakage current of the test fixture and the leads.

d) Measurement procedure

The photoemitter terminals, as well as the photodetector terminals, are connected together.

The specified measurement voltage between the photoemitter and photodetector terminals is applied for 60 s. The isolation resistance is calculated as V/I .

e) Specified conditions

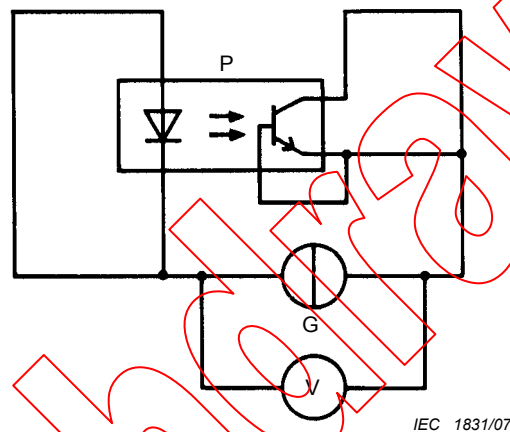
- Ambient temperature
- Measurement voltage
- Time after which the measurement is performed, if different from 60 s

8.4 Isolation test

a) Purpose

To verify the ability of the device to withstand the isolation test voltage (V_{ISO} or V_{IORM}) under specified conditions.

b) Circuit diagram



P photocoupler under test
G voltage source

Figure 6 – Test circuit for withstanding isolation voltage

c) Test procedure

The test should be carried out under the standard atmospheric conditions in 5.3.1 of IEC 60068-1.

The device is inserted into the test socket. The photoemitter terminals, as well as the photodetector terminals, are connected together.

The d.c. or a.c. test voltage is increased from zero to the specified value.

The voltage is maintained for 1 min for type testing, and 1 s or 2 s at maximum 120 % of the type testing voltage for routine testing.

d) Requirements

External or internal flash-over shall not occur during the test.

The device shall pass the post-test measurements.

e) Specified conditions

- Isolation voltage (V_{ISO})
- Test time (if different from 1 min)

- Post-test measurements

8.5 Partial discharges of photocouplers

a) Purpose

To verify the performance of insulation between input and output of a photocoupler by measuring the partial discharge level under specified conditions.

This test is non-destructive.

NOTE 1 For the definition of partial discharge, see 3.1 of IEC 60270. For convenience, this definition is repeated hereafter:

"Partial discharge

A partial discharge, within the terms of this standard, is an electric discharge that only partially bridges the insulation between conductors. Such discharges may, or may not, occur adjacent to a conductor."

NOTE 2 Partial discharges in gases around a conductor are sometimes referred to as "corona". This term should not be applied to other forms of partial discharges.

The general term "ionisation" should not be used to denote the particular case of partial discharges.

b) Circuit diagram

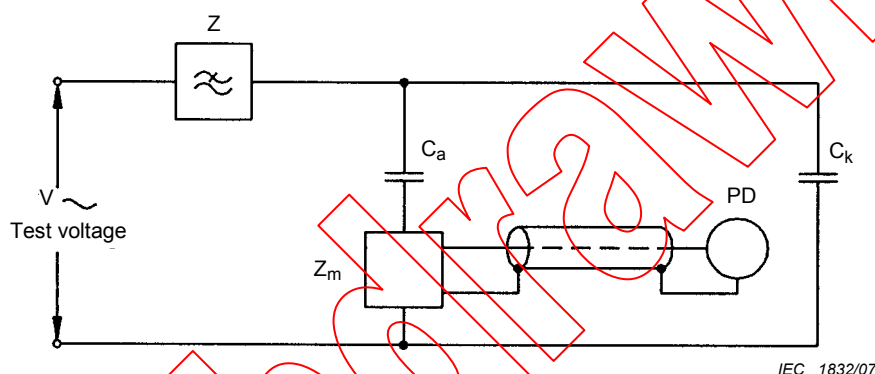


Figure 7 – Partial discharge test circuit

c) Description of the test circuit and requirements

(see also NOTES 3, 4 and 5)

1) Test circuit

The circuit consists mainly of

C_a photocoupler under test which can be regarded as a capacitance

C_k coupling capacitor bypassing partial discharge current

Z_m measuring circuit consisting of the measuring impedance, the connecting lead, the surge limiting device and the measuring instrument

PD partial discharge measuring instrument

Z a low-pass filter to reduce interference from the source (see also NOTE 3)

2) Equipment characteristics

The peak value of the test voltage shall be measured. An r.m.s. measuring instrument may be used provided that the distortion of the sine wave of the test voltage is less than 5 %.

The bandwidth of the partial discharge measuring equipment shall be less than 15 kHz.

The centre frequency shall be between 150 kHz and 2 MHz.