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PUBLICLY AVAILABLE SPECIFICATION

PRE-STANDARD

Semiconductor devices – Discrete devices –
Part 17: Magnetic and capacitive coupler for basic and reinforced isolation

IEC/PAS 60747-17:2011(E)

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SEMICONDUCTOR DEVICES – DISCRETE DEVICES –

Part 17: Magnetic and capacitive coupler for basic and reinforced isolation

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47E/412/PAS	47E/423/RVD

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SEMICONDUCTOR DEVICES – DISCRETE DEVICES –

Part 17: Magnetic and capacitive coupler for basic and reinforced isolation

1 Scope

This PAS gives the terminology, essential ratings, characteristics, safety test and the measuring methods of magnetic and capacitive couplers.

It specifies the principles of magnetic and capacitive coupling across an isolation barrier and the related requirements for basic isolation and reinforced insulation.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

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

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

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

IEC 60068-2-67, *Environmental testing – Part 2-67: Tests – Test Cy: Damp heat, steady state, accelerated test primarily intended for components*

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

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

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

IEC 60068-2-20, *Environmental testing – Part 2-20: Tests – Test T: Test methods for solderability and resistance to soldering heat of devices with leads*

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

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

IEC 60068-2-58:2004, *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, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

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

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

IEC 60270:2000, *High-voltage test techniques – Partial discharge measurements*

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

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

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

IEC 61000-4-5, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-8, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

IEC 61000-4-9, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 9: Pulse magnetic field immunity test*

IEC 62539, *Guide for the statistical analysis of electrical insulation breakdown data*

3 Magnetic and Capacitive Coupler

Magnetic and capacitive couplers consist of a transmitter stage and a receiver stage on either side of a galvanic insulation barrier. The device transmits a signal across the insulation boundary where a receiver stage is able to detect the transmitted signal and uses the information to generate the electrical output signal.

In this PAS, magnetic and capacitive couplers are referred to as “coupler”.

This PAS can only be applied to magnetic and capacitive couplers listed under 3.3 ‘Type of coupler’.

3.1 Semiconductor material

Input: Silicon, etc.

Output: Silicon, etc.

3.2 Details of outline and encapsulation

3.2.1 Outline drawing

For details, see the relevant IEC standards.

3.2.2 Method of encapsulation

The materials of encapsulation shall be given e.g. glass/metal/plastic/other

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

3.3 Type of coupler

Ambient-rated or case-rated coupler device for signal-isolation applications with input(s) and output(s) in one package.

3.3.1 SIO2 Isolators

Isolators with an internal insulation construction utilizing Silicon Dioxide or Silica based material.

3.3.2 Thin film Polymer Isolators

Isolators with an internal insulation construction, utilising a thin film polymer insulation layer spin coated onto a base substrate.

NOTE A package also may be a molded module.

4 Terms related to ratings and characteristics for a coupler

4.1 Isolation sides

All Terminals of the first side are isolated from all terminals of the second side by an isolation barrier forming a two-terminal device.

4.2 Isolation capacitance: C_{IO}

The total capacitance between the terminals on a first side of the isolation barrier connected together and the terminals on a second side of the isolation barrier connected together forming a two-terminal device.

4.3 Isolation resistance: R_{IO}

The resistance between the terminals on a first side of the isolation barrier connected together and all the terminals on a second side of the isolation barrier connected together forming a two-terminal device.

4.4 Isolation voltage

The voltage between any specified terminal on the first side of the isolation barrier and any terminal on the second side of the isolation barrier.

4.5 Logic state match

The condition in which an output logic state matches the associated input logic state.

4.6 Logic state transition match

The condition in which an output logic state change follows the associated input logic state change.

4.7 Common mode transient immunity (CMTI)

Common mode transient immunity (CMTI) is the maximum tolerable rate-of-rise (or fall) of a common-mode voltage. It is given in volts per second. CMTI should include the amplitude of the common-mode voltage that can be tolerated.

4.8 Magnetic field immunity (MFI)

4.8.1 Static magnetic field immunity (SMFI)

The maximum tolerable magnetic field density regardless of component orientation under which the coupler maintains its specified performance.

4.8.2 Variable magnetic field immunity (VMFI)

The maximum tolerable magnetic field density change or the maximum tolerable magnetic field amplitude at defined frequency regardless of component orientation under which the coupler maintains its specified performance.

4.9 Propagation Delay: t_{pLH} or t_{pHL}

The duration from the presence of an input signal to the time at which the output matches the associated state of the input signal.

4.10 Further terms and abbreviations

– V_{DD} or V_{CC} Supply voltage
– IC Input or output integrated circuit of a coupler
– I/O Input/Output terminal(s) of an integrated circuit
– GND Ground reference for an integrated circuits
– V_I Input voltage, either V_{IL} or V_{IH}
– V_O Output voltage, either V_{OL} or V_{OH}

5 Terms for couplers providing protection against electrical shock

Terms for a coupler designed to maintain protection against electrical shock 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 couplers for reinforced insulation

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 couplers for basic and reinforced insulation

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

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

Dielectric Strength

If an enclosure of material is depended upon to serve as electrical insulation, it shall have a dielectric strength in the use thickness at 16 Hz – 100 Hz:

in case of basic insulation:

of 1,3 × VIOSM, rms, 1 s, Tamb,max

in case of reinforced insulation

of at least 10 000 V, rms,1 s Tamb,max or 1,6 × VIOSM, rms, 1 s, Tamb,max respectively – if 1,6 × VIOSM, rms, is higher than 10 000V –

In both cases, after conditioning for 96 h to moist air having a relative humidity of 90 % ± 5 % at a temperature of 85,0 °C ± 2,0 °C.

Resistivity

The resistivity of the isolator material shall not be less than:

10^9 Ω at V_{IO} = 500 V for 1 min after conditioning for 40 h at 23,0 °C ± 2,0 °C and 50 % ± 5 % percent relative humidity.

5.2.1 Partial discharge (pd)

Localized electrical discharge which occurs in the insulation between all terminals of the first side and all terminals of the second side of the coupler.

5.2.2 Apparent charge: q_{pd}

Electrical discharge caused by a partial discharge in the coupler.

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

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 couplers. Otherwise it should be defined on each individual device design. Smaller values are desirable but are not viable.

NOTE 2 In actual testing, 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 60664-1:2007) is synonymous with "threshold apparent charge".

5.2.4 Test voltages and time intervals for the partial-discharge test of couplers

See Figures 1 and 2.

All applicable test voltages in this PAS are peak voltages, unless otherwise stated.

5.2.4.1 Test voltage: $V_{pd(t)}$

The voltage applied during the test period of the partial discharge test between all terminals of the first side (connected together) and all terminals of the second side (connected together) to the coupler under test.

5.2.4.2 Initial test voltage: $V_{pd(ini)}$

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

5.2.4.2.1 Initial test voltage: $V_{pd(ini),a}$

(See 4.3.3.3 and Table F.1 of IEC 60664-1:2007 for minimum voltages, interpolation is possible). The value of the voltage applied at the beginning of the measurement, for a specified time t_{ini}, is intended to simulate the occurrence of a transient over-voltage. Refer to Figure 1.

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

The isolation test voltage applied between all terminals of the first side (connected together) and all terminals of the second side (connected together) at routine test (method b). A withstand voltage equal to the manufacturer's rating with a maximum of V_{IOTM}. Refer to Figure 2.

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 5.2.4.6.

NOTE 2 For the method according to Figure 1, the specified value for the initial test voltage is equal to the specified value of the rated transient isolation voltage V_{IOTM}.

NOTE 3 For methods according to Figure 2, the specified value for the initial test voltage (isolation voltage) is equal to or lower than the specified value of the rated transient isolation voltage V_{IOTM}.

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

5.2.4.2.3 Multiplying factor: F for method a) and method b)

For basic insulation:

At routine test stage and initial measurement of the type test: F = 1,5

At sample test stage and after life tests, subgroup 1: F = 1,3

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

For reinforced insulation:

At routine test stage and initial measurement of the type test: 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

5.2.4.3 Apparent charge measuring voltage: $V_{pd(m)}$

The test voltage at which apparent charge is measured.

NOTE 1 Specified values of this voltage may be expressed as multiple of the specified value of the rated isolation voltage or rated repetitive peak isolation voltage: $V_{pd(m)} = F \times V_{IOWM}$ or $V_{pd(m)} = F \times V_{IORM}$, whichever is higher. Refer to 5.2.4.2.3 multiplying factor.

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

5.2.4.4 Partial-discharge inception voltage: $V_{pd(I)}$

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.

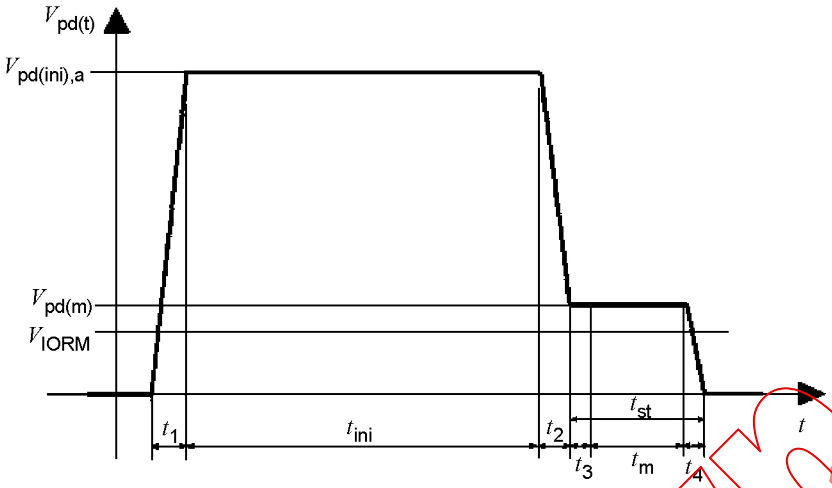
5.2.4.5 Partial-discharge extinction voltage: $V_{pd(e)}$

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.

5.2.4.6 Time intervals of the test voltage

See the terms and letter symbols indicated in Figures 1 and 2.



Key

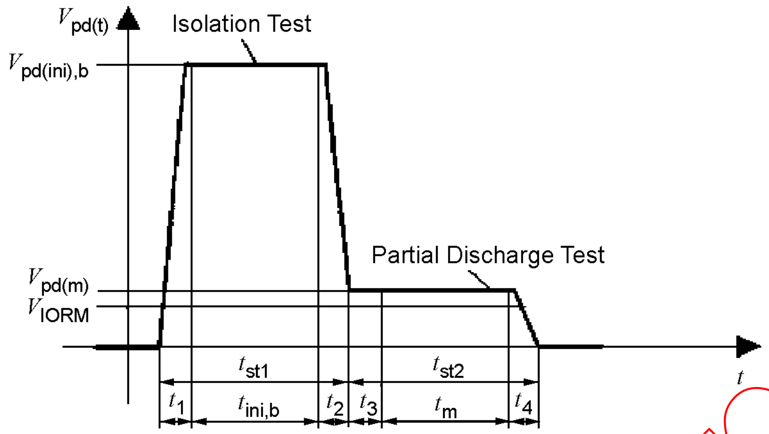
t_{ini} = initial time (method a) only)

t_{st} = (partial-discharge) stress time

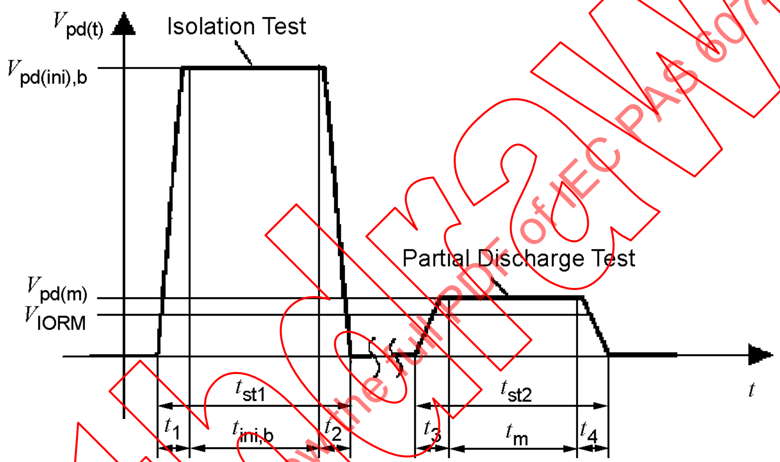
t_m = (partial-discharge) measuring time

t_1, t_2, t_3, t_4 = settling times

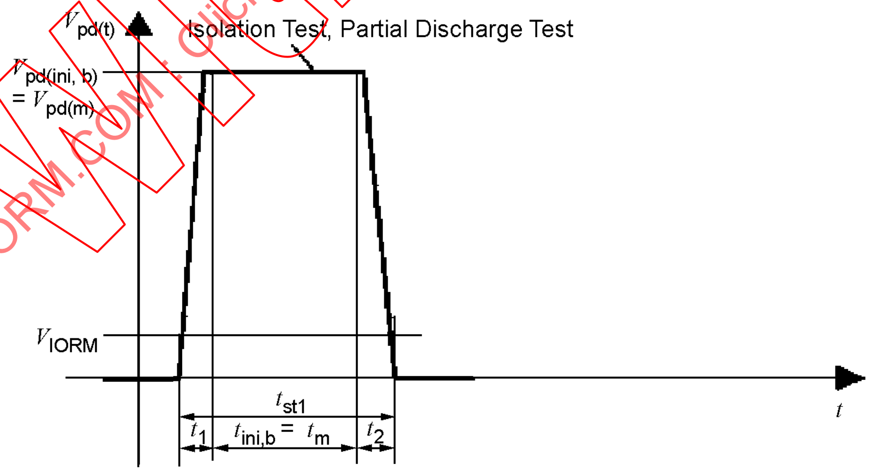
Figure 1 – Time intervals for method a) of the test voltage



Method b1)



Method b2)



Method b3)

Key

$t_{ini,b}$ = isolation test time (method b only)

t_{stl} = 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 2 – Time intervals for method b) of the test voltage

5.2.5 Lifetime (Lifetime)

Minimum years applied at statistical interpolation of lifetime in correlation with failure rate.

5.2.6 Failure Rate over Lifetime (FROL)

Maximum failure rate due to isolation break down using lifetime prediction.

5.2.7 Statistical model (model)

The type of curve fit shall be based on the material type as defined in 3.3.1 and 3.3.2.

In cases where the insulation material type is not defined by either of these definitions, the statistical modelling method specified in 5.2.7.1 shall be used.

5.2.7.1 Material types as defined in 3.3.1 shall use the exponential modelling method.

$$L = ce^{-kV}$$

where:

L = time-to-failure at test voltage *V*

V = voltage

c = constant

k = constant

5.2.7.2 Material types as defined in 3.3.2 shall use the following modeling method.

$$L = \frac{e^{-(E-E_t)^n}}{(E-E_t)^m}$$

where:

L = time-to-failure at test voltage *V*

E_t = threshold field where no charge injection will happen

E = stress field when test voltage V is applied

m = constant

n = constant

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

All applicable test voltages in this PAS are peak voltages, unless otherwise stated.

5.3.1 Rated isolation voltages

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

5.3.1.1 DC Isolation voltage: V_{IO}

The value of the constant isolation voltage.

5.3.1.2 Maximum rated isolation working voltage: V_{IOWM}

An r.m.s. value or an equivalent d.c. voltage of withstand voltage assigned by the manufacturer of the couplers, characterizing the specified (long term) withstand capability of its isolation.

5.3.1.3 Maximum rated repetitive peak isolation voltage: V_{IORM}

A repetitive peak value of withstand voltage assigned by the manufacturer of the couplers, characterizing the specified withstand capability of its isolation against repetitive peak voltages. This peak isolation voltage includes all repetitive transient voltages, but excludes 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.

5.3.1.4 Maximum rated transient isolation voltage: V_{IOTM}

A peak value of impulse withstand voltage assigned by the manufacturer of the couplers, characterizing the specified withstand capability of its isolation against transient over-voltages.

5.3.1.5 Withstanding isolation voltage: V_{ISO}

Maximum isolation withstanding a.c. r.m.s. voltage for one minute.

5.3.1.6 Surge isolation voltage: V_{IOSM}

The highest instantaneous value of an isolation voltage pulse with short time duration and of specified wave shape (see also: 5.4.6).

5.4 Absolute maximum ratings

Indicate any qualifications such as time, frequency, pulse duration, humidity, etc. Exceeding the maximum ratings can lead to damage of the isolation barrier.

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) over the operating temperature range

5.4.5 Maximum continuous (direct) or repetitive peak isolation voltage (V_{IO} or V_{IORM}) over the operating temperature range

The wave shape and repetition rate should be specified.

5.4.6 Maximum surge isolation voltage (V_{IOSM}) over the operating temperature range

In case of basic insulation all DUT shall pass $V_{IOSM} \times 1.3$.

In the case of reinforced insulation, all DUT shall pass the surge test with rated $V_{IOSM} \times 1,6$ but with a minimum of 10 kV. V_{IOSM} should be specified for pulses of both. Surge test method according to 10.1 of IEC 60065:2001 using test circuit with impedance shown in Figure 5a of IEC 60065:2001.

5.4.7 Maximum continuous input current (I_I) at an ambient or reference-point temperature of 25 °C and derating curve or derating factor

5.4.8 Maximum peak input current (I_{IM}) at an ambient or reference-point temperature of 25 °C and under specified pulse conditions

5.4.9 Maximum power dissipation (P_{trn}) of the output stage at an ambient or reference- point temperature of 25 °C and a derating curve or derating factor

5.4.10 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 Coupler logic and timing definitions

Table 1 – Overview of characteristics and symbols

No.	Characteristics	Conditions at T_{amb} or T_{case} = 25 °C unless otherwise stated	Notes	Symbols	Requirements	
6.1.1	First logic level input voltage (logic high Input voltage)	Defined load	1	V_{IH}	min	
6.1.2	Second logic level input voltage (logic low input voltage)		1	V_{IL}		max
6.1.3	First logic level output voltage (logic high output voltage)		1	V_{OH}	min	
6.1.4	Second logic level output voltage (logic low output voltage)		1	V_{OL}		max
6.1.5	Propagation delay input to output at change low to high Uin	Load conditions defined 10 % to 90 % or 50 % to 50 %		t_{pLH}		max
6.1.6	Propagation delay input to output at change low to high Uin			t_{pHL}		max
6.1.7	Pulse width distortion	As 6.1.5 & 6.1.6		$\lvert t_{pLH} - t_{pHL} \rvert$		max
6.1.8	Output rise time	10 % to 90 %, load defined		t_r		max
6.1.9	Output fall time	90 % to 10 %, load defined		t_f		max
6.1.10	Working frequency			f		max
6.1.11	Isolation resistance between input and output	V_{IO} specified		R_{IO}	Typ	
6.1.12	Barrier capacitance	As tested in section 8.1		C_{IO}	Typ	
6.1.13	First-side supply current	f = 0 Hz		ICC1	min	max
		$f = f_{max}$		ICC1	min	max
6.1.14	Second-side supply current	f = 0 Hz		ICC2	min	max
		$f = f_{max}$, Defined load		ICC2	min	max
6.1.15	Common mode transient immunity ICMHI	V_O defined in datasheet at common mode conditions	3	$\lvert CM_H \rvert$	min	
	Common mode transient immunity ICMLI			$\lvert CM_L \rvert$	min	

No.	Characteristics	Conditions at T_{amb} or T_{case} = 25 °C unless otherwise stated	Notes	Symbols	Requirements	
6.1.16	Static magnetic field immunity $\|H_H\|$	V_O defined in datasheet at common mode conditions	3	$\| H_H \|$		max
	Static magnetic field immunity $\|H_L\|$			$\| H_L \|$		max
6.1.17 a	Variable magnetic field immunity H_H peak at f spec	V_O defined in datasheet at common mode conditions, f = f spec.	2 & 3	H_H peak		max
	Variable magnetic field immunity H_L peak at f spec			H_L peak		max
6.1.17 b	Magnetic field change immunity $\|dH_H/dt\|$	V_O defined in datasheet at common mode conditions	2 & 3	$\|dH_H/dt\|$		max
	Magnetic field change immunity $\|dH_L/dt\|$			$\|dH_L/dt\|$		max
NOTE 1 3V and/or 5V TTL compatible logic						
NOTE 2 Specification required either according to 6.1.17a or 6.1.17b						
NOTE 3 Preferably consistent with datasheet specifications: minimum V_{OH} and maximum V_{OL}						

7 Coupler protection against electrical shock

All requirements contained in this clause are valid for couplers with a solid insulation in one package, whatever the configuration of the input and/or the output (e.g. IC input, output, etc.).

7.1 Type

Ambient-rated or case-rated couplers designed to provide protection against electrical shock with reinforced insulation or basic insulation.

It shall be clearly indicated on the datasheet whether the approval is for basic or reinforced insulation.

7.2 Ratings (shall be listed in a special section in the manufacturer's datasheet)

7.2.1 Safety Limiting Values

a) Maximum ambient safety temperature, T_S

b) Maximum input power dissipation, P_{S_I}

c) Maximum output current or maximum power dissipation, I_{S_O} or P_{S_O}

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

a) Maximum working isolation voltage, V_{IOWM}

b) Maximum repetitive isolation voltage, V_{IORM}

c) Maximum transient isolation voltage, V_{IOTM}

d) Maximum withstanding isolation voltage, V_{ISO}

e) Maximum surge isolation voltage, V_{IOSM}

7.3 Electrical safety requirements

The following characteristics as shown in Table 2 have to be mentioned in the manufacturer's datasheet, in addition to those listed in Clause 7:

Table 2 – Datasheet characteristics

Characteristics	Conditions	Symbols	Requirements
Apparent charge (method a)	Subclause 8.4	q_{pd}	max
Apparent charge (method b)		q_{pd}	max
Insulation resistance	100 °C ≤ $T_{amb} \leq T_{amb,\ max}$ V_{IO} = 500 Volts	R_{IO}	min
Insulation resistance	$T_{amb} = T_S$ V_{IO} = 500 Volts	R_{IO}	min
External clearance	See IEC 60664-1for measuring requirements Refer to related equipment standards for further requirements	CPG	min
External creepage		CLR	min
Comparative tracking index		CTI	min
Over-voltage category			
Climatic category			
Pollution degree			
Maximum isolation withstand voltage	a.c. voltage at commercial frequency for one min, Production test for 1 s at 120 % of V_{ISO}	V_{ISO}	
Maximum surge isolation voltage for reinforced insulation	Test according to 5.4.6	V_{IOSM}	1.6 × V_{IOSM}, min. 10 kV
Maximum surge isolation voltage for basic insulation	Test according to 5.4.6	V_{IOSM}	1.3 × V_{IOSM},

7.4 Electrical, environmental and/or endurance test information: (supplementary information if desired by the manufacturer)

See Tables 3 and 4 for reference.

7.4.1 Routine test

At the routine test stage (method b), an isolation test according to 8.3 must be performed followed by a partial discharge test according to 8.4. 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 the coupler manufacturer can be performed with voltages greater than or equal to the test voltages defined in equipment standards (e.g. 4 kV rms), but have to be equal to or lower than $V_{pd(ini),b}$.

7.4.2 Sample test

Partial discharge test (method a, destructive test) shall be performed on a sample basis once per quarter. A minimum sample of 20 devices will be picked from a random production lot for each package type.

NOTE Packages must be significantly different in terms of package outline dimensions. The lead form option will not be 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, SOIC-8, etc. Thus, if a manufacturer has five different package types, then 20 samples each would be pulled for this destructive partial discharge test for a total of (5 × 20 = 100 couplers) per quarter. Multiple channels does not constitute 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 is n = 80 of which the failures shall be c = 0, i.e. there shall be no failure.

7.4.3 Type Test

Type test has to be performed with the introduction of a new coupler, which differs from already tested couplers in one or more of the following items:

– Package or die materials relevant for insulation: mold materials, silicone gels, foils, etc.

– Lead frame: if the new lead frame affects the external creepage distance or external clearance or the thermal resistance of the package and thereby P_{S_I} or I_{S_O} or P_{S_O} are affected.

– Package or die construction relevant for isolation.

(Examples: 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 for an existing product.

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

– Zero failure must be achieved.

– If one failure occurs out of the 100 devices, further quantities of devices must be subjected to the subgroup (in which the failure occurred), with no more failures.

NOTE Safety Limiting Values (P_{S_I}, I_{S_O}, P_{S_O}, T_S)

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

The Safety Limiting Values to be defined by the manufacturer for a coupler device are the input power dissipation (P_{S_I}), maximum output current (I_{S_O}), maximum output power dissipation (P_{S_O}), or the maximum ambient safety temperature (T_S) 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 digital function of the isolating elements may be destroyed, the isolation specification of the device remains intact. The safety limit 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 coupler is no longer in existence due to external electrical or thermal stress, when for example:

1) The internal digital circuitry becomes faulted due to excessive current or input power.

2) Internal bond wires melt.

3) Operation of the coupler is impeded by an external heat source (e.g. a resistor).

The safety limiting values are governed by the materials and circuit design parameters adopted by the manufacturer, and the user must ensure that the safety limiting values are not exceeded, to ensure that the isolation resistance or insulation of the coupler 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 coupler, 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 datasheet 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	See IEC 60068-2-20, Test Tb, Method 1A
	260 °C ± 5 °C, 5 s ± 1 s
	For couplers in SMT packages, see conditions according to IEC 60068-2-58:2004 , Table 1
Apparent charge, method b1)	Basic insulation $V_{pd(m)} = 1{,}5 \times V_{IORM}$,
	Reinforced insulation $V_{pd(m)} = 1{,}875 \times V_{IORM}$,
	Temperature 15 °C to 35 °C
	$V_{ini,b}$ (acc. to manufacturer's specification) $\leq V_{ini,a}$, $V_{ini,a} = V_{IOTM}$
	$q_{pd} \leq 5$ pC
Parametric test	According to manufacturer's specification.
	Temperature 15 °C to 35 °C
Isolation resistance	$V_{IO} = 500$ V, $T_{amb} = T_{amb,\ max}$ $R_{IO} \geq 10^{11}$ Ω, $t = 1$ min.

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, Test Na
	$T_{stg,min}$, $T_{stg,max}$, 10 cycles , dwell time 3 h
Vibration	See IEC 60068-2-6, Test Fc
	Axis: 3
	Frequency:10 Hz to 500 Hz, Transition frequency: 58 Hz
	Amplitude: 0.75 mm / 10 g, dependent on stress level
	Cycles: 10 per axis
	Criteria: No damage
Shock	See IEC 60068-2-27
	Axis: 3
	Wave form: half sine wave,
	Acceleration: 100 g
	Shock duration: 6 ms
	Numbers: 3 shocks/axis
	Criteria: No damage
Sealing (not for plastic)	See IEC 60068-2-17, Test Q
	Test Qk according to Clause 6
	Pressure: 200 kPa
	Duration: 6 h
	Recover time: 0,5 h
	Test Qc, according to Clause 3
	$T_{stg,max}$, method 2
	Maximum pressure: depending on manufacturer's specification
Dry heat	See IEC 60068-2-2 , Test Ba
	$V \geq V_{IORM}$ (min 700 V), $T_{amb} = T_{amb,max}$ (min. 100 °C)
	Duration: 16 h
Damp heat, cyclic	See IEC 60068-2-30 , Method 1
	T_{amb} = + 55 °C
	Cycles: 1
Temperature storage (Cold)	See IEC 60068-2-1 2 h at $T_{stg,min}$
Damp heat (steady state)	See IEC 60068-2-67, Test Cy
	85 % r.H. at 85 °C
	Duration: 21 days

7.4.3.2.2 Final measurements for Subgroup 1: at least

Dry samples for 1 h to 2 h before doing final measurements. Final measurements made within the next 6h after drying.

Apparent charge, method a)	Reinforced insulation $V_{pd(m)}$ = 1,6 × V_{IORM}
	Basic insulation $V_{pd(m)}$ = 1,2 × V_{IORM},
	$V_{ini,a} = V_{IOTM}$
	$q_{pd} \leq$ 5 pC
Isolation resistance	V_{IO} = 500 V, T_{amb} = 25 °C, $R_{IO} \geq 10^{12}$ Ω, t = 1 min.
Surge test (type test only)	Number of discharge: 50
	Cycles: Maximum 12 discharges/min.
	Voltage for basic : 1,3 × V_{IOSM}
	Voltage for reinforced : 1,6 × V_{IOSM}, min 10 kV
Isolation resistance	V_{IO} = 500 V, T_{amb} = 25 °C, $R_{IO} \geq 10^{9}$ Ω, t = 1 min.

7.4.3.3 Subgroup 2: 15 samples

7.4.3.3.1 Tests or examination:

Preconditioning	See 7.4.3.1
Temperature change test	One cycle consists of the following temperature changes:
	Dwell time 68 h at T_{stgmax} or 125 °C (which is higher),
	Dwell time 1 h at 25 °C,
	Dwell time 2 h at 0 °C,
	Dwell time 1 h at 25 °C,
	Voltage: 500 VAC / 50 Hz applied during complete test
	Cycles: 10
Input safety test	At limiting safety values Maximum dissipation
power or maximum input current	
	$T_{amb} = T_S$ derated, duration = 72 h.

7.4.3.3.2 Final measurements for Subgroup 2: at least

Apparent charge , method a)	Basic insulation $V_{pd(m)} = 1{,}2 \times V_{IORM}$
	Reinforced insulation $V_{pd(m)} = 1{,}2 \times V_{IORM}$
	$V_{ini,a} = V_{IOTM}$
	$q_{pd} \leq 5$ pC
Isolation resistance	$V_{IO} = 500$ V, $T_{amb} = 25$ °C, $R_{IO} \geq 10^9\ \Omega$, $t = 1$ min.

7.4.3.4 Subgroup 3: 15 samples

7.4.3.4.1 Tests or examination:

Preconditioning	See 7.4.3.1
Temperature change test	See 7.4.3.3.1
Output safety test	At limiting safety values maximum output current or maximum output power dissipation $T_{amb} = T_S$ derated, duration = 72 h

7.4.3.4.2 Final measurements for Subgroup 3: see 7.4.3.3.2

7.4.3.5 Subgroup 4: 40 sample

Examinations

Isolation resistance at	a) $T_{amb,max}$ (min 100 °C), $V_{IO} = 500$ V, $R_{IO} \geq 10^{11}\ \Omega$, $t = 1$ min.
	b) T_S, $V_{IO} = 500$ V, $R_{IO} \geq 10^9\ \Omega$, $t = 1$ min.

7.4.3.6 Subgroup 5: 10 samples

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: $t \leq 30$ s.

7.4.3.7 End of life test

7.4.3.7.1

Data collection		See IEC 62539
Wear Out	Basic insulation	$1{,}3 \times V_{IORM}$
	Reinforced insulation	$2{,}0 \times V_{IORM}$

Failure criteria: isolation breakdown occurring either at the couplers rated transient voltage V_{IOTM} *or its working voltage applying the defined wear out safety factors.*

Wear out test voltage, e.g. d.c., a.c. bipolar and polarity shall be selected by the manufacturer reflecting the worst case stress conditions for the isolator type under test.

Lifetime	Min 35 years	
Model	See IEC 62539	
	For SIO2 Isolators	See 5.2.7.1
	For thin film Polymer Isolators	See 5.2.7.2
	For other not listed:	See 5.2.7
Failure rate	Basic insulation	FROL <= 10 PPM
	Reinforced insulation	FROL <= 0,01 PPM

Method of statistical interpolation, sample size and applied testing time has to support maximum failure rate prediction over lifetime.

7.4.3.8 Testing of insulating materials

7.4.3.8.1 Tracking resistance

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

Requirement: CTI ≥ 175

7.4.3.8.2 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 $T_{stg,max}$ but lower than or equal to the glass transition temperature T_g.

7.4.3.8.3 Ceramic materials

In case ceramic materials are used, IEC 60672-2 is applicable.

7.4.3.9 Marking, labels, information in datasheets

If it is not possible, for reasons of space, to accommodate the data in accordance with 7.4.3.9.1 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.

7.4.3.9.1 Data on the coupler

The following data shall be applied in a durable manner to the coupler, 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

7.4.3.9.2 Information in datasheets

The datasheet shall include the following information:

– Ratings, see 7.2
– Electrical safety requirements, see 7.3
– Electrical characteristics
– Properties of the package (sealing)
– Terminal arrangement (pin out)

Datasheet imprint:

In the case of reinforced insulation approval

“This coupler 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.”

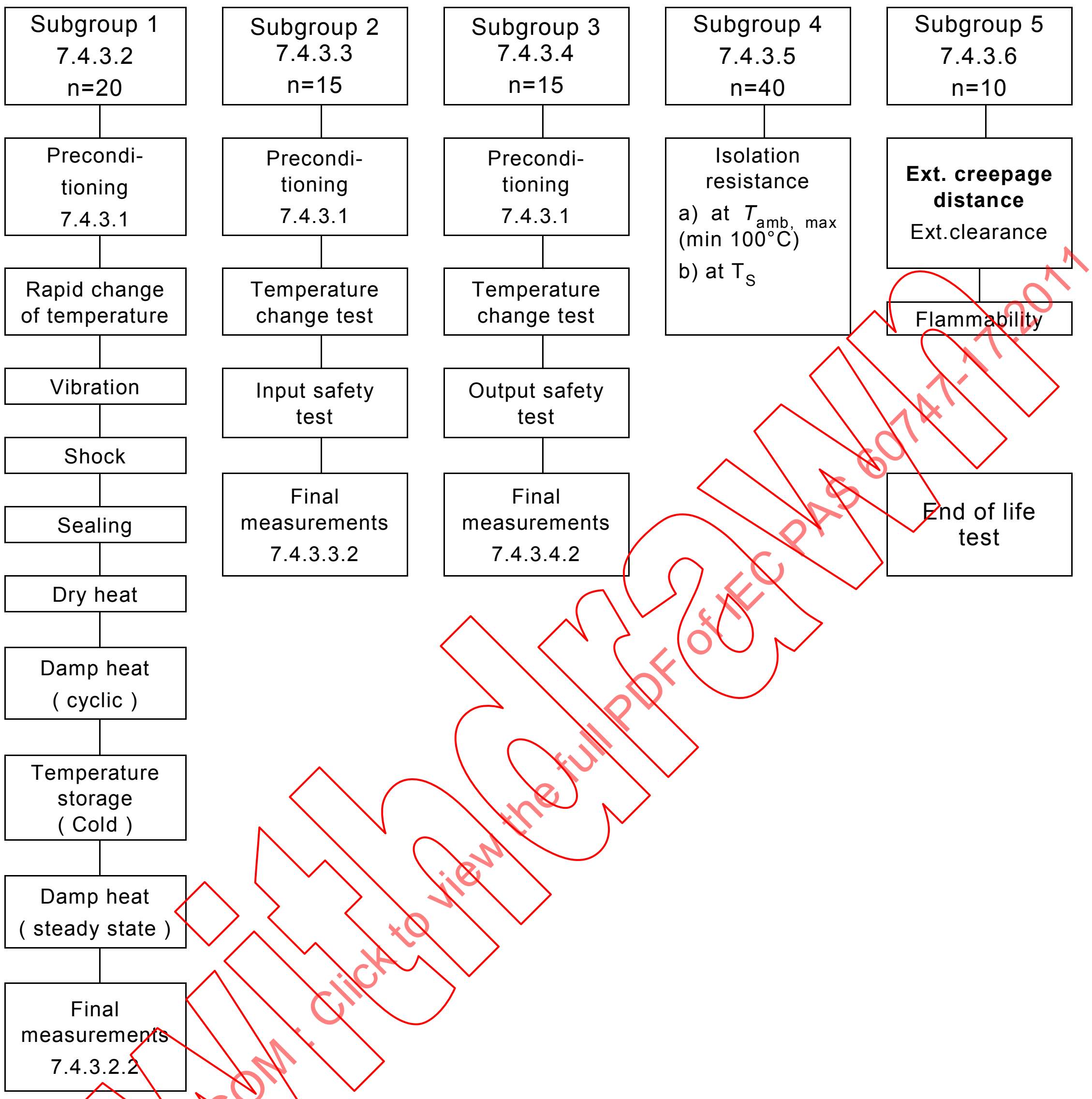
In the case of basic insulation approval

"This coupler is suitable for ´basic electrical insulation´ only within the maximum operating ratings. Compliance with the safety ratings shall be ensured by means of suitable protective circuits."

Table 3 – Tests and test sequence for coupler providing basic insulation and reinforced insulation for protection against electrical shock

1)	**Routine test (non-destructive) see 7.4.1**
1.1	Apparent charge magnitude at 1.875 × V_{IORM} for reinforced insulation and 1.5 × V_{IORM} for basic insulation method b1, b2, or b3, $q_c \leq 5$ pC, $V_{ini,b} \leq V_{ini,a}$ see 5.2.4.2 and 5.2.4.6
1.2	Parametric test according to manufacturer's specification, see 7.4.3.1
2)	**Sample test (destructive) n = 80, 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 1.6 × V_{IORM} for reinforced insulation and for basic insulation 1,3 × V_{IORM} method a, $q_c \leq 5$ pC, $V_{ini,a}$ see 5.2.4.2, 5.2.4.6
2.4	Parametric test according to manufacturer's specification, see 7.4.3.1
2.5	Isolation resistance, see 7.4.3.1
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 (Destructive), n = 120, c = 0 see 7.4.3



Testing of insulating materials, (Type test only) see 7.4.3.8

Marking, labels, information in datasheets see 7.4.3.9

End of life test based in statistical interpolation see 7.4.3.7

Table 4 – Test conditions

Method a)	Parameter	Method b)
t_{ini} = 60 s	Initial time	$t_{ini,b}$ = 1 s
$V_{ini,a}$	Initial voltage	$V_{ini,b} \leq V_{ini,a}$
*) $V_{pd} = F \times V_{IORM}$ or V_{IOWM}	Apparent charge test voltage	*) $V_{pd} = F \times V_{IORM}$ or V_{IOWM}
t_m = 10 s	Apparent charge measuring time	t_m = 1 s
t_{st} typ. 12 s.	Specified test time	t_{st} typ. 1.2 s, t_{st2} typ. 1.2 s.
dV/dt during t_1, t_2 = 100 V/s to 1 000 V/s	Rate of rise/fall (V_{ini})	Only for type test: dV/dt during t_1, t_2 = 100 V/s to 1 000 V/s
t_3, t_4 typ. 1 s.	Transient recovery time	Only for type test: t_3, t_4 typ. 1 s.
T_{amb} = 15 °C to 35 °C	Ambient temperature	T_{amb} = 15 °C to 35 °C
150 kHz $\leq f_o \leq$ 5 MHz	Center frequency	150 kHz $\leq f_o \leq$ 5 MHz
$\Delta f \leq$ 15 kHz	Bandwidth	$\Delta f \leq$ 15 kHz
q_o = 5 pC	Calibration value	q_o = 5 pC
q_{min} = 1 pC	Smallest measurable value	q_{min} = 1 pC
q_{pd} = 5 pC	Apparent charge test limit	q_{pd} = 5 pC
CC ≥ 1 nF	Coupling capacitor	CC ≥ 1 nF
*) In accordance with factors specified in 5.2.4.2.3		

8 Measuring methods for couplers

8.1 Input-to-output capacitance (C_{IO})

8.1.1 Purpose

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

8.1.2 Circuit diagram

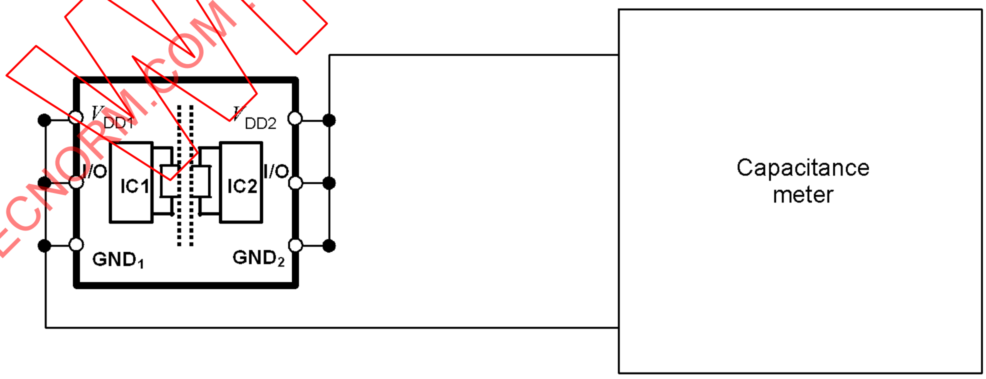


Figure 3 – Basic isolation capacitance measurement circuit

8.1.3 Measurement procedure

The primary side terminals as well as the secondary side terminals of the coupler are connected together forming a two-terminal device. The capacitance between the primary side and the secondary side is measured at a frequency of 1 MHz (unless otherwise specified), using a suitable capacitance meter.

8.1.4 Precautions to be observed

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

8.1.5 Special conditions

– Ambient temperature
– Measurement frequency, if different from 1 MHz
– Measurement voltage

8.2 Isolation resistance between input and output, R_{IO}

8.2.1 Purpose

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

8.2.2 Circuit diagram

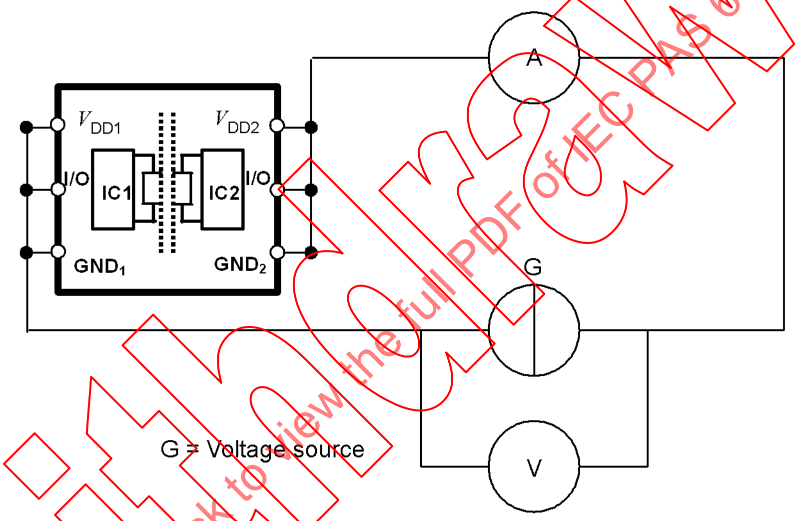


Figure 4 – Basic isolation resistance measurement circuit

8.2.3 Precautions to be observed

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

8.2.4 Measurement procedure

The primary side terminals as well as the secondary side terminals are connected together forming a two-terminal device. The specified measurement voltage between the primary and the secondary terminals is applied for 60 s. The isolation resistance is calculated as V/I.

8.2.5 Special conditions

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

8.3 Isolation test

8.3.1 Purpose

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

8.3.2 Circuit diagram

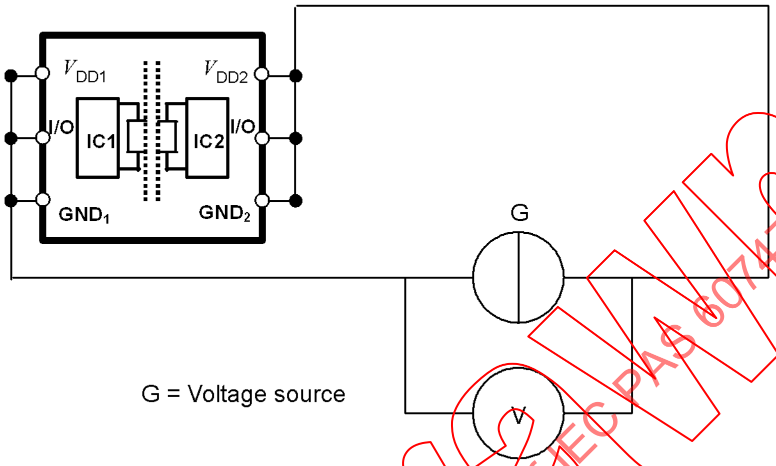


Figure 5 – Basic isolation voltage measurement circuit

8.3.3 Test procedure

The test should be carried out under the standard atmospheric conditions of 5.3.1 of IEC 60068–1:1988.

The device is inserted into the test socket. The primary side terminals, as well as the secondary side terminals, are connected together forming a two-terminal device.

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

The voltage is maintained for:

– Routine test for 1 second at 120 % of V_{ISO} or V_{IORM}
– Type test for 1 minute at V_{ISO} or V_{IORM}

8.3.4 Requirements

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

The device shall pass the post-test measurements.

8.3.5 Specified conditions

– Isolation voltage (V_{ISO} or V_{IORM})
– Test time (if different from 1 minute)
– Post-test measurements

8.4 Partial discharges of magnetic couplers

8.4.1 Purpose

To verify the performance of solid insulation between input and output of a coupler 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 60270:2000.

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 "ionization" should not be used to denote the particular case of partial discharges."

8.4.2 Circuit diagram

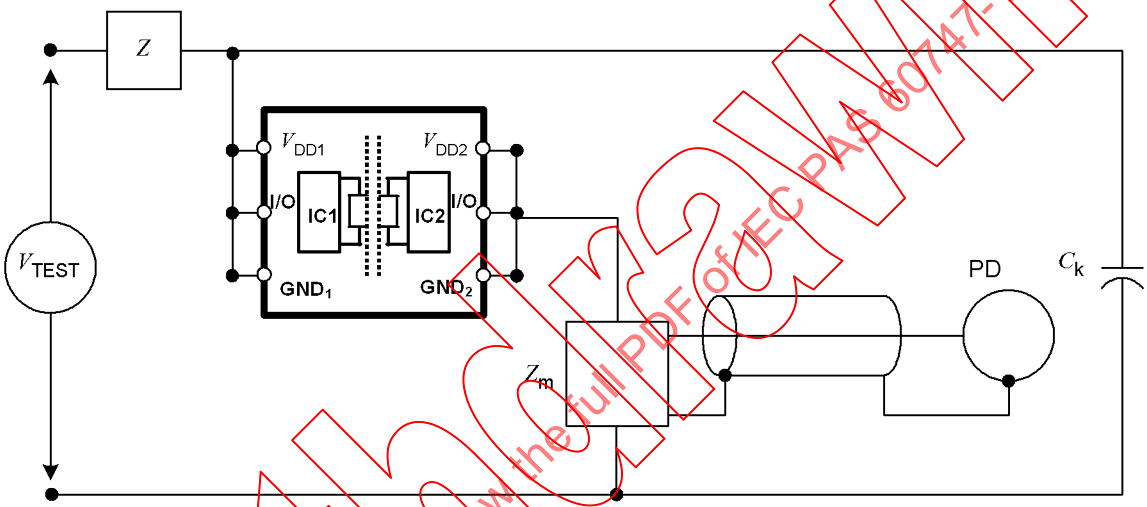


Figure 6 – Partial discharge test circuit

8.4.3 Description of the test circuit and requirements

(See also 8.4.5, Notes 1 to 3).

1) *Test circuit*

The circuit consists mainly of:

Ck = coupling capacitor bypassing partial discharge current.

Zm = 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 8.4.5, Note 1)

2) *Equipment characteristics*

The peak value of the test voltage shall be measured. An r.m.s. measuring instrument may be used provided 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. The resonance frequency of the test circuit shall be at least three times the center frequency used (see also 8.4.5, Note.2).

3) *Coupling capacitor*

The coupling capacitor shall be of a low-inductance design and shall not exhibit any partial discharges at the test voltage.

8.4.4 Test procedure

1) Calibration

Calibration involves two separate procedures: one is a complete determination of the characteristics of the measuring instrument itself including a detailed calibration and should be performed after major repairs or at least once per year; the other is a routine calibration of the instrument in the complete test circuit and should be performed before every test or, if many identical test objects are being tested, then it may be performed at suitable time to be determined by the user. The latter calibration should include a verification that the instrument, as used in the test circuit, shall be able to measure a partial discharge level of 1 pC (minimum).

1.1) Calibration of partial discharge measuring instrument

The partial discharge measuring instrument is calibrated according to the instructions of the manufacturer of the instrument.

1.2) Calibration of the instrument in the complete test arrangement

The complete test arrangement has to be calibrated.

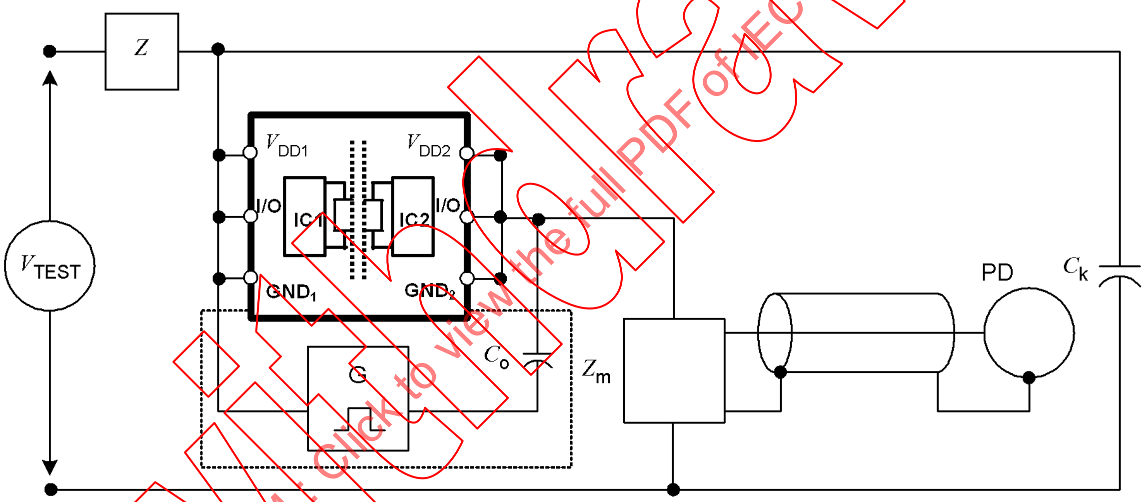


Figure 7 – Connections for the calibration of the complete test arrangement

The calibration shall be repeated every day and for each device with a different design. The pulse generator is adjusted so that the output pulse represents a charge of 5 pC.

The pulse of the calibration generator shall have a rise time of less than 50 *n*s. The delay time shall be between 100 μs and 1000 μs.

The reading of the instrument should be at least half of full scale.

The pulse generator shall be removed before energizing the test circuit.

The test voltage is set to the highest applicable level relevant to the device under test.

The measuring instrument shall enable the reading below. For this verification of the test circuit noise level, the DUT shall be free of partial discharge.

2) Test methods

The partial discharge basic noise level value may not be subtracted from the partial discharge value of a specimen. The partial discharge magnitude q_c is the instantaneous maximum read out value during the partial discharge measuring time interval t_p.

See 5.2.4.6 for time intervals and test voltages for test method a), b1), b2) and b3).

NOTE The apparent partial discharge magnitude q_c of 5 pC was found to be a practicable criterion for couplers. Otherwise, it should be defined on each individual device design.

2.1) Method a)

(See Figure 1) A voltage well below the expected inception value is applied to the test object and gradually increased to the specified value V_{ini} at which partial discharge is allowed. The initial test voltage is maintained for the specified time (t_{ini}).

Thereafter, the test voltage (V_t) is reduced to the value of the partial discharge measurement voltage (V_m).

The test voltage (V_m) is maintained for a specified time (t_{st}) and during this time the partial discharge magnitude is measured in a given time interval (f_p).

$V_{ini} = V_{IOTM}$ $\qquad\qquad$ $V_m = F \times V_{IORM}$ $(F > 1)$

2.2) Method b)

(See Figure 2) The partial discharge test voltage (V_t) is applied. This voltage is maintained for a specified time (t_{st}) and during this time the partial discharge magnitude is measured in a given time interval (t_p).

$$V_m = F \times V_{IORM}$$

8.4.5 Specified conditions

Table 5 – Specified conditions

Parameter	Method a)	Method b)
Initial time, t_{ini}	x	-
Initial voltage, V_{IOTM}	x	-
Partial discharge test voltage, V_m, V_m = F × V_{IORM}	x	x
Partial discharge measuring time, t_p	x	x
Stress time, t_{st}	x	x
Settling time, t_1, t_2, t_3, t_4	x	x
Ambient temperature, T_{amb}	x	x

NOTE 1 Partial discharges in the test object cause charge transfer in the test circuit giving rise to current pulses through the measuring impedance. This impedance, in combination with the test object and coupling capacitor, determines the duration and shape of the measured voltage pulses. These pulses are further shaped and amplified in order to supply to a measuring instrument a value proportional to the apparent charge quantity.

NOTE 2 Measuring impedance.

The measuring impedance usually acts as a four terminal network with a frequency response chosen to prevent the test supply frequency from reaching the instrument. This may be achieved in the case of a resistive impedance by connecting an inductor in parallel with the resistor, or by connecting a capacitor in series between the measuring resistor and the connecting lead to the instrument. The measuring impedance may consist of a resistor, a resistor in parallel with a capacitor, a tuned circuit or a more complex filter design.

NOTE 3 Instruments for the measurement of apparent charges q.

The current pulses due to partial discharges produce a signal at the terminals of the measuring impedance. For short-duration current pulses, the signal produced is a voltage pulse whose peak value is proportional to the apparent charge of the coupler under test. (See 3.2 of IEC 60270:2000).

The individual pulses shall be displayed on a cathode-ray oscilloscope and the magnitude of the apparent charge can be determined by calibration. The pulses are to be displayed on a linear time-base which is triggered, for example, by the discharge pulse or by the test voltage.

The oscillogram assists in distinguishing between different types of partial discharges and between the discharges to be measured and extraneous disturbances. The magnitude of the apparent charge which is measured during an actual test is generally understood to be that associated with the largest repeatedly occurring pulse.