

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Semiconductor devices –
Part 17: Magnetic and capacitive coupler for basic and reinforced insulation**

**Dispositifs à semiconducteurs –
Partie 17: Coupleur magnétique et capacitif pour l'isolation principale et renforcée**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SEMICONDUCTOR DEVICES –

**Part 17: Magnetic and capacitive coupler
for basic and reinforced insulation**

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International Standard IEC 60747-17 has been prepared by subcommittee SC 47E: Discrete semiconductor devices, of IEC technical committee TC 47: Semiconductor devices.

This first edition cancels and replaces IEC PAS 60747-17:2011. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to IEC PAS 60747-17:2011:

- a) introduced lifetime safety factors for improved life time consideration, to comply with widely recognized aging mechanisms of silicone dioxide (TDDB) and thin film polymer isolation layers;
- b) significantly improved "end of life testing" paragraph and statistical life time consideration by adding detailed description on process, safety factors, methods of generating data points and respective lifetime interpolations as well as being specific on minimum amount of samples required;

- c) introduced concept of certification by similarity, including Annex A, giving guidance on qualification considerations and required certification process;
- d) alternative pulse shape allowed for surge pulse testing, to avoid issues due to surge tester availability;
- e) various improvements throughout the standard: definitions, for example type of coupler have been improved, introduction of surge impulse V_{IMP} rating, usage of glass transition temperature, pre-conditioning have been redefined for improved usability and better compatibility with today's design and functionality of couplers, available mold compounds, etc.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
47E/711/FDIS	47E/715/RVD

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

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

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

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

SEMICONDUCTOR DEVICES –

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

1 Scope

This part of IEC 60747 specifies the terminology, essential ratings, characteristics, safety test and the measuring methods of magnetic coupler and capacitive coupler.

It specifies the principles and requirements of insulation and isolation characteristics for magnetic and capacitive couplers for basic insulation and reinforced insulation.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

IEC 60068-2-14:2009, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-20:2008, *Environmental testing – Part 2-20: Tests – Test T: Test methods for solderability and resistance to soldering heat of devices with leads*

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

IEC 60068-2-58:2015, *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 60068-2-67:1995, *Environmental testing – Part 2: Tests – Test Cy: Damp heat, steady state, accelerated test primarily intended for components*

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

IEC 60216-1:2013, *Electrical insulating materials – Thermal endurance properties – 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 60695-11-5:2016, *Fire hazard testing – Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance*

IEC 62539:2007, *Guide for the statistical analysis of electrical insulation breakdown data*

3 Terms and definitions

3.1

details of outline and encapsulation

information related method of encapsulation and terminal connections within the coupler's isolation system

3.1.1

outline drawing

drawing or sketch restricted to line to describe the shape of objects or circuitry

3.1.2

method of encapsulation

encapsulating materials used forming part of the isolation system

3.1.3

terminal identification

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

3.2

type of coupler

internal construction and insulation method of coupler to achieve basic or reinforced insulation

3.2.1

SiO₂ isolator

isolator with an internal insulation construction utilizing silicon dioxide based material

3.2.2

thin film polymer isolator

isolator with an internal insulation construction, utilising a thin film polymer insulation

3.3

isolation

ability to reject electrical and magnetic interference or noise

3.4

insulation

part of an electromechanical product which galvanically separates the conducting parts at different electrical potentials

3.4.1

reinforced insulation

insulation of hazardous-live-parts which provides a degree of protection against electric shock equivalent to double insulation

Note 1 to entry: Reinforced insulation may comprise several layers which cannot be tested singly as basic insulation or supplementary insulation.

[SOURCE: IEC 60664-1:2007, 3.17.5]

3.4.2**basic insulation**

insulation providing a basic safeguard against electric shock

3.5**isolation side**

all terminals of side 1 which are isolated from all terminals of side 2 by an isolation barrier, forming a two-terminal device

3.6**isolation capacitance** C_{IO}

total capacitance between the terminals on side 1 of the isolation barrier connected together and the terminals on side 2 of the isolation barrier connected together forming a two-terminal device

Note 1 to entry: See IEC 60747-5-5:2007, 4.3.

3.7**isolation resistance** R_{IO}

resistance between the terminals on side 1 of the isolation barrier connected together and all the terminals on side 2 of the isolation barrier connected together forming a two-terminal device

3.8**isolation resistance at safety limiting temperature** R_{IO_S}

resistance at safety limiting temperature T_S between the terminals on side 1 of the isolation barrier connected together and all the terminals on side 2 of the isolation barrier connected together forming a two-terminal device which should be larger or equal to $1E9\ \Omega$

3.9**isolation voltage**

voltage between any specified terminals connected together on side 1 of the isolation barrier and any terminals connected together on side 2 of the isolation barrier

3.10**logic state match**

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

3.11**logic state transition match**

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

3.12**common mode transient immunity** $CMTI$

maximum tolerable rate-of-rise (or fall) of a common-mode voltage

Note 1 to entry: The common mode transient immunity is given in volts per second. CMTI should include the amplitude of the common-mode voltage that can be tolerated.

3.12.1**common mode transient immunity at logic high output** $|CM_H|$

common mode transient immunity of the coupler with logic at high output

3.12.2

common mode transient immunity at logic low output

$|CM_L|$

common mode transient immunity of the coupler with logic at low output

3.12.3

common mode transient immunity at logic dynamic output

$|CM_D|$

maximum slew rate of a common-mode voltage (V_{CM}) at which the coupler transmits the data without missing the transition or creating unexpected transitions for all combinations of slew rate polarity and data edges

Note 1 to entry: The data transition shall occur in the specified time frame, and invalid data in terms of delay times, transitions or number of transitions, or magnitude (not meeting minimum logic V_{OH} or maximum logic low V_{OL} specifications) will be construed as a failure.

3.12.4

CMTI performance

dV_{CM}/dt

maximum slew rate of a common mode voltage at which the output of the coupler remains at the specific logic level and at the specified timing

3.12.5

common mode voltage

V_{CM}

common mode voltage at which the slew rate is measured

3.13

propagation delay

t_{pLH} , t_{pHL}

time required for a change in the input state of a digital coupler to propagate to the corresponding output

Note 1 to entry: The propagation delay from LOW to HIGH is expressed by t_{pLH} .

Note 2 to entry: The propagation delay from HIGH to LOW is expressed by t_{pHL} .

3.14

pulse width distortion

$|t_{pLH} - t_{pHL}|$

PWD

unintentional and generally undesired change in the form of a signal causing the signal input pulse width to differ from signal output pulse width

3.15

supply voltage

V_{DD}

supply voltages supplied on input and output side of coupler

Note 1 to entry: The supply voltage is also commonly expressed by V_{CC} .

3.16

integrated circuit

IC

microcircuit in which all or some of the circuit elements are inseparably associated and electrically interconnected so that it is considered to be indivisible for the purpose of construction and commerce on side 1 and side 2

[SOURCE: IEC 60050-521:2002, 521-10-03, modified – The words "on side 1 and side 2" have been added.]

3.17**input and output terminal**

I/O

side 1 and side 2 terminals of an integrated circuit providing signal conditioning to the internal coupling element

3.18**ground potential**

GND

reference potential for any side of a coupler

3.19**input voltage** V_I

input voltage, either V_{IL} , V_{IH} or analog level

3.20**output voltage** V_O

output voltage, either V_{OL} , V_{OH} or analog level

3.21**maximum ambient operating temperature** $T_{op\ max}$

maximum ambient operating temperature allowed during operation of coupler

3.22**reference-point temperature** T_{REF}

temperature defined by the manufacturer to refer to a defined point such as junction temperature, case temperature, etc.

3.23**characteristic lifetime** t_{63}

refers to characteristic lifetime (t_{63} %) when applying Weibull distribution to determine the mean lifetime

Note 1 to entry: In general, lifetime reliability is defined as the mean lifetime (t_{50} %) at which cumulative failure rate reaches 50 %. When Weibull distribution is used, a characteristic lifetime (t_{63} %) is considered for the mean lifetime. This is referred to as t_{63} in the statistical lifetime consideration.

3.24**general safety ratings of couplers for basic and reinforced insulation**

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

Note 1 to entry: The couplers may become permanently inoperative when safety ratings are applied.

3.25**electrical safety ratings 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 1 to entry: The couplers may become permanently inoperative when safety ratings are applied.

[SOURCE: IEC 60747-5-5:2007, 5.2, modified – In the term, the word "requirements" has been replaced with "ratings", and "isolation" with insulation. In the definition, the word "photocoupler" has been replaced by "couplers".]

3.25.1

partial discharge

PD

localized electrical discharge which occurs in the insulation between all terminals of the side 1 and all terminals of side 2 of the coupler

3.25.2

apparent charge

q_{pd}

electrical discharge caused by a partial discharge in the coupler

3.25.3

threshold apparent charge

$q_{pd(TH)}$

specified value of apparent charge that is as small as technically feasible, which determines the partial-discharge extinction voltage

Note 1 to entry: 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 threshold values are desirable but not required if accurate measurement in a production environment is not practical. This threshold shall not be exceeded at any time.

Note 2 to entry: In actual testing, this criterion applies to the apparent charge pulse with the maximum value.

Note 3 to entry: The term "specified discharge magnitude" (see 6.1.3.5.4.1 of IEC 60664-1:2007) is synonymous with "threshold apparent charge".

3.26

test voltage

$V_{pd(t)}$

voltage applied during the test period of the partial discharge test between all terminals of side 1 (connected together) and all terminals of side 2 (connected together) to the coupler under test

3.26.1

initial test voltage for partial discharge

$V_{pd(ini)}$

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

3.26.2

initial test voltage for partial discharge, method a

$V_{pd(ini),a}$

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

Note 1 to entry: Refer to Figure 1, method a.

3.26.3

initial test voltage for partial discharge, method b

$V_{pd(ini),b}$

isolation test voltage applied between all terminals of side 1 (connected together) and all terminals of side 2 (connected together) at routine test (method b) which is equal or higher to the manufacturer's maximum transient voltage rating

3.27
multiplying factor F

multiplying factor applied for method a and method b

Note 1 to entry: See Table 5 for more information.

3.28
apparent charge measuring voltage $V_{pd(m)}$

test voltage at which apparent charge is measured

Note 1 to entry: Specified values of this voltage may be expressed as multiple of the specified value of the rated repetitive peak isolation voltage: $V_{pd(m)} = F \times V_{IORM}$. Refer to 3.27.

Note 2 to entry: This is a test voltage where the apparent charge shall be equal or less than the specified value.

3.29
partial-discharge inception voltage $V_{pd(I)}$

lowest peak value of an AC 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

3.30
partial-discharge extinction voltage $V_{pd(e)}$

lowest peak value of an AC 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

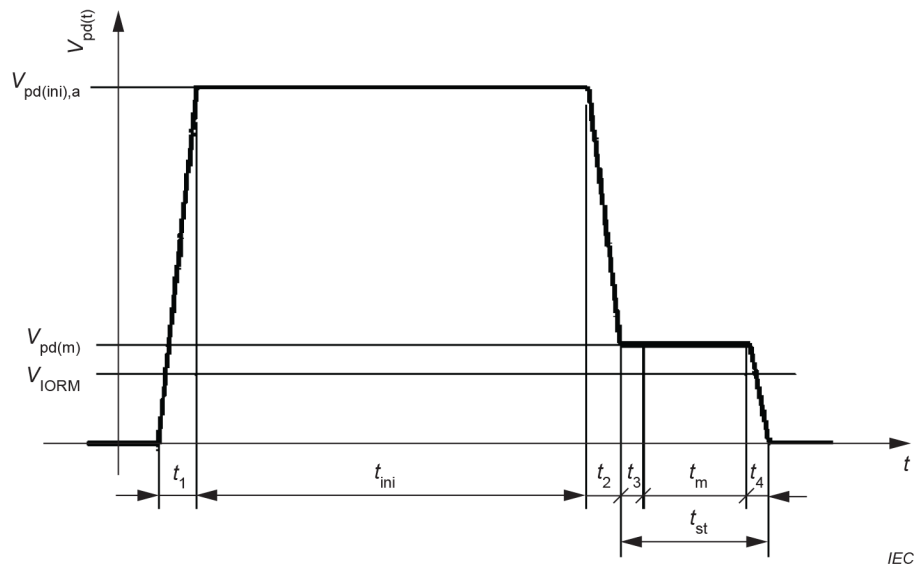
Note 1 to entry: The equivalent RMS value of an AC test voltage may also be used.

3.31
reference voltage for lifetime determination V_{REF}

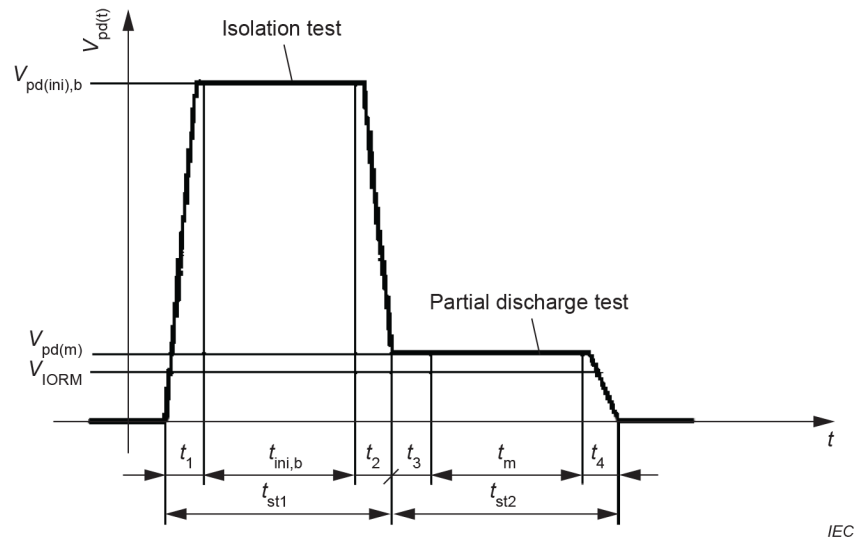
maximum predicated voltage which is determined by the end of life (EOL) test according 5.5.5.8

3.32
lifetime safety factorlifetime safety factor applied to V_{REF} to reflect safety consideration on coupler lifetime**3.33**
time intervals

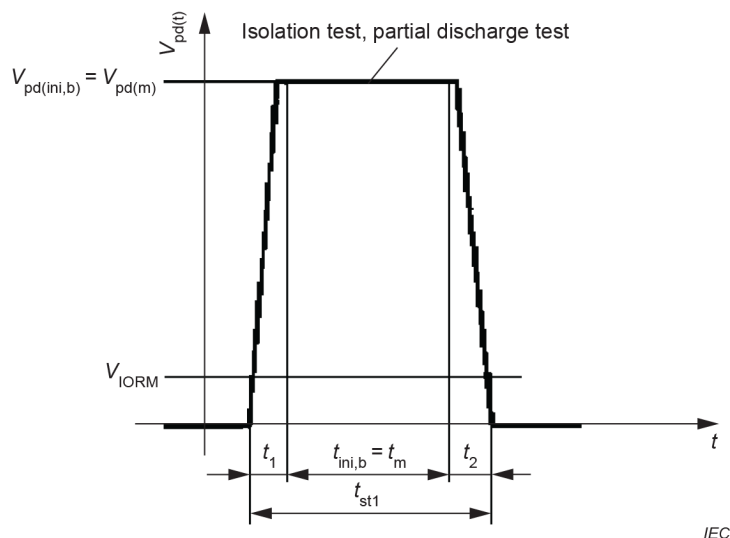
duration and sequence of test voltages for partial discharge measurements as shown in Figure 1



Time intervals for method a



Time intervals for method b1



Time intervals for method b2

Key

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

Figure 1 – Time intervals for methods a and b of the test voltage**3.34****lifetime**

minimum required time in years to failure based on an insulation grade correlated failure rate

3.35**SiO₂ time dependent dielectric breakdown**

SiO₂ TDDDB

aging effect observed in isolators using internal constructions utilizing SiO₂ based materials

3.36**thin film polymer space charge degradation**

aging effect observed in isolators using internal insulation constructions utilizing thin film polymer dielectric materials

Note 1 to entry: This constitutes test requirements to establish the maximum safe operating voltage at which space charge aging does not impact the safety related values V_{IORM} and V_{IOTM} .

3.37**failure rate over lifetime**

FROL

maximum allowed failure rate due to isolation break down using lifetime prediction

3.38**statistical model**

mathematical model that embodies a set of statistical assumptions concerning the generation of sample data

Note 1 to entry: The type of curve fit shall be based on the material type as defined in 3.2.1 and 3.2.2.

Note 2 to entry: In cases where the insulation material type is not compatible or defined with models in 3.38.1 and 3.38.2, such isolators may only be used in case the specific distinctiveness of such insulation material has been considered and properly addressed by the regulatory experts and has been added as into the standard.

3.38.1

exponential model

modelling method used for material types defined in 3.2.1 (SiO₂ isolators):

$$L = ce^{kV}$$

where

L is the time-to-failure at test voltage V ;

V is the test voltage;

c and k are the coefficients

Note 1 to entry: For the usage of $k \times V$ dependency, an adequate data set with sufficient measurement points shall be provided which clearly proves the $k \times V$ dependency according to IEC 62539:2007.

3.38.2

non linear model

modelling method used for material types defined in 3.2.2 (thin film polymer isolators):

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

where

L is the time-to-failure at test voltage V ;

V is the test voltage;

c , n and k are the coefficients

Note 1 to entry: For the usage of $k \times V^{-n}$ dependency, an adequate data set with sufficient measurement points shall be provided which clearly proves the $k \times V^{-n}$ dependency according to IEC 62539:2007.

3.38.3

rated isolation voltages

3.38.3.1

DC isolation voltage

V_{IO}

value of the constant isolation voltage

3.38.3.2

maximum rated isolation working voltage

V_{IOWM}

RMS value of isolation voltage V_{IORM} assigned by the manufacturer of the couplers, characterizing the specified (long term) withstand capability of its isolation

3.38.3.3

maximum rated repetitive peak isolation voltage

V_{IORM}

repetitive peak isolation voltage assigned by the manufacturer of the couplers, characterizing the specified withstand capability of its isolation against repetitive peak voltages

Note 1 to entry: This peak isolation voltage includes all repetitive transient voltages, but excludes all non-repetitive transient voltages.

Note 2 to entry: 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.

Note 3 to entry: Since the degradation of the galvanic isolation depends normally on the peak voltage, V_{IORM} is the repetitive peak value of the absolute envelope voltage over time.

Note 4 to entry: See IEC 60747-5-5:2007, 5.3, from which the description has been modified to define V_{IORM} as repetitive peak or equivalent DC value and state it includes all repetitive transient voltages.

3.38.3.4 maximum rated transient isolation voltage

V_{IOTM}
peak isolation voltage which includes all non-repetitive transient voltages and applies to the package clearance as well as internal insulation

Note 1 to entry: See IEC 60664-1:2007.

Note 2 to entry: See IEC 60747-5-5:2007, 5.3, from which the description has been modified to emphasize that V_{IOTM} includes all non-repetitive transient voltages and applies to package clearance as well as internal insulation.

3.38.3.5 withstanding isolation voltage

V_{ISO}
maximum isolation withstanding AC RMS voltage for one minute

3.38.3.6 surge isolation voltage

V_{IOSM}
highest instantaneous value of an isolation voltage pulse with short time duration and of specified wave form (1,2/50 μ s) applied across the internal insulation of the device

Note 1 to entry: Testing of required V_{IOSM} levels as specified in 5.5.4 may be conducted for example in oil to exclude arcing across the surface or in air.

Note 2 to entry: See IEC 60747-5-5:2007, 5.3, from which description has been modified to provide additional information on duration and wave form.

3.38.3.7 impulse voltage

V_{IMP}
highest peak value of impulse voltage without flashover and solid insulation breakdown

Note 1 to entry: Wave form and polarity are described in 6.1.2.2.1 of IEC 60664-1:2007.

3.39 absolute maximum ratings

qualifications such as time, frequency, pulse duration, humidity

Note 1 to entry: Exceeding the maximum ratings can lead to damage of the isolation barrier.

3.39.1 minimum and maximum storage temperatures

T_{stg}
temperatures in non-operation condition

3.39.2 minimum and maximum ambient temperatures

T_{amb}
temperatures of the air surrounding a component

3.39.3

maximum soldering temperature

T_{sld}

maximum soldering time and minimum distance to case which should be specified

3.39.4

maximum continuous input power

P_{SI}

maximum continuous input power at ambient or a reference point temperature of 25 °C and derating curve or derating factor

3.39.5

maximum output power dissipation

P_{SO}

maximum output power dissipation of the output stage at ambient or a reference point temperature of 25 °C and a derating curve or derating factor

3.39.6

maximum total power dissipation of the package

P_{tot}

maximum total power dissipation at ambient or reference-point temperature of 25 °C and derating curve or derating factor

3.39.7

maximum power transmission

P_{TR}

power transferred across isolation barrier during operation

3.40

F_{LT}

working voltage safety factor at applicable lifetime of coupler

3.41

maximum ambient safety temperature

T_{S}

highest ambient temperature permitted in the event of a fault

3.42

maximum output current

I_{SO}

current used for power dissipation considerations to determine safety limitation

4 Electrical characteristics – Coupler logic and timing definitions

Clause 4 relates to definitions and logic related coupler operation (see Table 1).

Table 1 – Overview on characteristics and symbols

No.	Characteristics	Conditions at T_{amb} or $T_{case} = 25\text{ °C}$ unless otherwise stated	Symbols	Requirements	
4.1.1	Input logic level voltage high (logic high input voltage) ^a		V_{IH}	min.	
4.1.2	Input logic level voltage low (logic low input voltage) ^a		V_{IL}		max.
4.1.3	Output logic level voltage high (logic high output voltage) ^a	Defined load	V_{OH}	min.	
4.1.4	Output logic level voltage (logic low output voltage) ^a		V_{OL}		max.
4.1.5	Propagation delay input to output at change low to high output voltage	Load conditions defined 10 % to 90 % or 50 % to 50 %	t_{pLH}		max.
4.1.6	Propagation delay input to output at change high to low output voltage		t_{pHL}		max.
4.1.7	Pulse width distortion	As defined in 3.14	$ t_{pLH} - t_{pHL} $		max.
4.1.8	Output rise time	10 % to 90 %, load defined	t_r		max.
4.1.9	Output fall time	90 % to 10 %, load defined	t_f		max.
4.1.10	Working frequency		f		max.
4.1.11	Isolation resistance between input and output	V_{IO} specified	R_{IO}	typ	
4.1.12	Isolation capacitance between input and output	As tested in 6.2	C_{IO}	typ	
4.1.13	Side 1 supply current	$f = 0\text{ Hz}$	I_{CC1}	min.	max.
		$f = f_{max}$	I_{CC1}	min.	max.
4.1.14	Side 2 supply current	$f = 0\text{ Hz}$	I_{CC2}	min.	max.
		$f = f_{max}$, defined load	I_{CC2}	min.	max.
4.1.15	Common mode transient immunity at logic high output ^b	V_O defined in datasheet at common mode conditions	$ CM_H $	min.	
	Common mode transient immunity at logic low output ^b		$ CM_L $	min.	
	Common mode transient immunity at logic dynamic output ^b		$ CM_D $	min.	
4.1.16	maximum total power dissipation of the package		P_{tot}		Max.

^a 3 V and/or 5 V TTL compatible logic.

^b Preferably consistent with datasheet specifications: minimum V_{OH} and maximum V_{OL} .

5 Coupler for protection against electrical shock

5.1 General

All requirements contained in Clause 5 are valid for couplers with a solid insulation in one package, whatever the configuration of the input and/or the output is (e.g. IC input, output, etc.).

5.2 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.

5.3 Ratings

5.3.1 General

The ratings shall be listed in a special section in the manufacturer's datasheet.

5.3.2 Safety limiting values

- a) Maximum ambient safety temperature, T_S .
- b) Maximum input power dissipation, P_{SI} .
- c) Maximum output current or maximum output power dissipation, I_{SO} or P_{SO} .

NOTE Safety limiting values are determined only by damage to the isolation barrier.

5.3.3 Functional ratings

Package related values: temperatures, total power dissipation

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

5.3.4 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}
- f) Maximum impulse voltage, V_{IMP}

5.4 Electrical safety requirements

The following characteristics as shown in Table 2 shall be mentioned in the manufacturer's datasheet, in addition to those listed in 5.3.

Table 2 – Datasheet characteristics

Characteristics	Conditions	Symbols	Requirements
Apparent charge method a	6.5	q_{pd}	max
Apparent charge method b		q_{pd}	max
Isolation resistance	$25\text{ °C} \leq T_{amb} \leq T_{amb,max.}$ Test voltage between side 1 and side 2 = 500 V DC	R_{IO}	min
Isolation resistance	$T_{amb} = T_s$ Test voltage between side 1 and side 2 = 500 V DC	R_{IO_s}	min
External clearance	See IEC 60664-1:2007 for measuring requirements Refer to related equipment standards for further requirements	CLR	min
External creepage		CRP	min
Comparative tracking index		CTI	min
Over-voltage category			
Climatic category			
Maximum rated transient isolation voltage		V_{IOTM}	
Maximum rated repetitive peak isolation voltage	V_{IORM} is based on the conditions in 5.5.5.8.4. For variances of V_{IORM} , see Note 1.	V_{IORM}	
Impulse voltage	Test according to 5.5.4 in air	V_{IMP}	max
Maximum surge isolation voltage for reinforced insulation	Test according to 5.5.4	V_{IOSM}	Test voltage is $\geq 1,3 \times V_{IMP}$, min. 10 kV
Maximum surge isolation voltage for basic insulation	Test according to 5.5.4	V_{IOSM}	Test voltage is $\geq 1,3 \times V_{IMP}$
NOTE 1 For additional V_{IORM} information, derating of the data generated in 5.5.5.8, reflecting different conditions such as lifetime or failure rates is acceptable if derating conditions are clearly stated and this information is provided in a separate table.			

5.5 Electrical, environmental and/or endurance test information

5.5.1 General

This information is supplementary information if desired by the manufacturer. See Table 3 and Table 4 for reference.

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 5.5.2																																									
1.1	Isolation test according 6.4 and 6.5 Apparent charge magnitude at $1,875 \times V_{IORM}$ for reinforced insulation and $1,5 \times V_{IORM}$ for basic insulation, method b1 or b2, $q_{pd} \leq 5$ pC See 3.30																																								
1.2	Parametric test according to manufacturer's specification, (see 5.5.5.2)																																								
2) Sample test (destructive) $n = 80$, zero failure (see 5.5.3)																																									
2.1	Visual inspection according to manufacturer's specification (see 5.5.5.2)																																								
2.2	Resistance to soldering heat (see 5.5.5.2)																																								
2.3	Apparent charge magnitude at $1,6 \times V_{IORM}$ for reinforced insulation and for basic insulation $1,3 \times V_{IORM}$, method a, $q_{pd} \leq 5$ pC, $V_{ini,a}$ (see 6.5)																																								
2.4	Parametric test according to manufacturer's specification (see 5.5.5.2)																																								
2.5	Isolation resistance (see 6.3)																																								
2.6	External creepage distance and clearance $n = 10$, zero failure (see 5.5.5.7)																																								
2.7	Isolation resistance at high temperatures $n = 40$, zero failure (see 5.5.5.6): a) $T_{amb,max}$, min. 100 °C; b) T_s .																																								
3) Type test (destructive), $n = 552$, zero failure (see 5.5.5.8)																																									
<table><tr><td>Subgroup 1 5.5.5.3 $n = 20$</td><td>Subgroup 2 5.5.5.4 $n = 15$</td><td>Subgroup 3 5.5.5.5 $n = 15$</td><td>Subgroup 4 5.5.5.6 $n = 40$</td><td>Subgroup 5 5.5.5.7 $n = 10$</td></tr><tr><td>Preconditionning 5.5.5.2</td><td>Preconditionning 5.5.5.2</td><td>Preconditionning 5.5.5.2</td><td>Isolation resistance a) at $T_{amb,max}$ (≥ 100 °C) b) at T_s</td><td>Ext. creepage distance Ext. Clearance</td></tr><tr><td>Rapid change of temperature</td><td>Temperature change test</td><td>Temperature change test</td><td></td><td>Flammability</td></tr><tr><td>Dry heat</td><td>Input safety test</td><td>Output safety test</td><td></td><td></td></tr><tr><td>Damp heat (cyclic)</td><td></td><td></td><td>Subgroup 6 5.5.5.8.2 $n = 432$</td><td>Subgroup 7 5.5.5.8.3 $n = 20$</td></tr><tr><td>Temperature storage (cold)</td><td></td><td></td><td>Preconditionning 5.5.5.2</td><td>Transient voltage V_{IOTM}</td></tr><tr><td>Damp heat (steady state)</td><td></td><td></td><td>Maximum repetitive peak isolation voltage V_{IORM}</td><td></td></tr><tr><td>Final measurements 5.5.5.3.2</td><td></td><td></td><td></td><td></td></tr></table>		Subgroup 1 5.5.5.3 $n = 20$	Subgroup 2 5.5.5.4 $n = 15$	Subgroup 3 5.5.5.5 $n = 15$	Subgroup 4 5.5.5.6 $n = 40$	Subgroup 5 5.5.5.7 $n = 10$	Preconditionning 5.5.5.2	Preconditionning 5.5.5.2	Preconditionning 5.5.5.2	Isolation resistance a) at $T_{amb,max}$ (≥ 100 °C) b) at T_s	Ext. creepage distance Ext. Clearance	Rapid change of temperature	Temperature change test	Temperature change test		Flammability	Dry heat	Input safety test	Output safety test			Damp heat (cyclic)			Subgroup 6 5.5.5.8.2 $n = 432$	Subgroup 7 5.5.5.8.3 $n = 20$	Temperature storage (cold)			Preconditionning 5.5.5.2	Transient voltage V_{IOTM}	Damp heat (steady state)			Maximum repetitive peak isolation voltage V_{IORM}		Final measurements 5.5.5.3.2				
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Damp heat (steady state)			Maximum repetitive peak isolation voltage V_{IORM}																																						
Final measurements 5.5.5.3.2																																									

IEC

IEC

Table 4 – Test conditions

Parameter	Method a	Method b
Initial time	$t_{ini} = 60 \text{ s}$	$t_{ini,b} = 1 \text{ s}$
Initial voltage	$V_{ini,a} = V_{IOTM}$	$V_{ini,b} \geq 1,2 \times V_{IOTM}$
Apparent charge test voltage	$V_{pd(m)} = F \times V_{IORM}$	$V_{pd(m)} = F \times V_{IORM}$
Apparent charge measuring time	$t_m = 10 \text{ s}$	$t_m = 1 \text{ s}$
Specified test time	$t_{st} \text{ typ. } 1,2 \text{ s.}$	$t_{st1} \text{ typ. } 1,2 \text{ s, } t_{st2} \text{ typ. } 1,2 \text{ s.}$
Rate of rise/fall (V_{ini})	dV/dt during t_1 , $t_2 = 100 \text{ V/s to } 1\,000 \text{ V/s}$	Only for type test: dV/dt during t_1 , $t_2 = 100 \text{ V/s to } 1\,000 \text{ V/s}$
Transient recovery time	$t_3, t_4 \text{ typ. } 1 \text{ s}$	Only for type test: $t_3, t_4 \text{ typ. } 1 \text{ s}$
Ambient temperature	$T_{amb} = 15 \text{ °C to } 35 \text{ °C}$	$T_{amb} = 15 \text{ °C to } 35 \text{ °C}$
Center frequency	$150 \text{ kHz} \leq f_o \leq 5 \text{ MHz}$	$150 \text{ kHz} \leq f_o \leq 5 \text{ MHz}$
Bandwidth	$\Delta f \leq 15 \text{ kHz}$	$\Delta f \leq 15 \text{ kHz}$
Calibration value	$q_o = 5 \text{ pC}$	$q_o = 5 \text{ pC}$
Smallest measurable value	$q_{min} = 1 \text{ pC}$	$q_{min} = 1 \text{ pC}$
Apparent charge test limit	$q_{pd} = 5 \text{ pC}$	$q_{pd} = 5 \text{ pC}$
Coupling capacitor	$C_C \geq 1 \text{ nF}$	$C_C \geq 1 \text{ nF}$
NOTE In accordance with safety multiplying factors specified in Table 5.		

5.5.2 Routine test

At the routine test stage (method b), an isolation test according to 6.4 and 6.5 shall be performed.

5.5.3 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. Packages shall be significantly different in terms of package outline dimensions. The lead form option will not be construed as a significant difference. All samples shall have passed routine test according 5.5.2 and therefore the regular production including high voltage partial discharge test.

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 ($5 \times 20 = 100$ coupler) per quarter. Multiple channels do 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 zero, i.e. there shall be no failures.

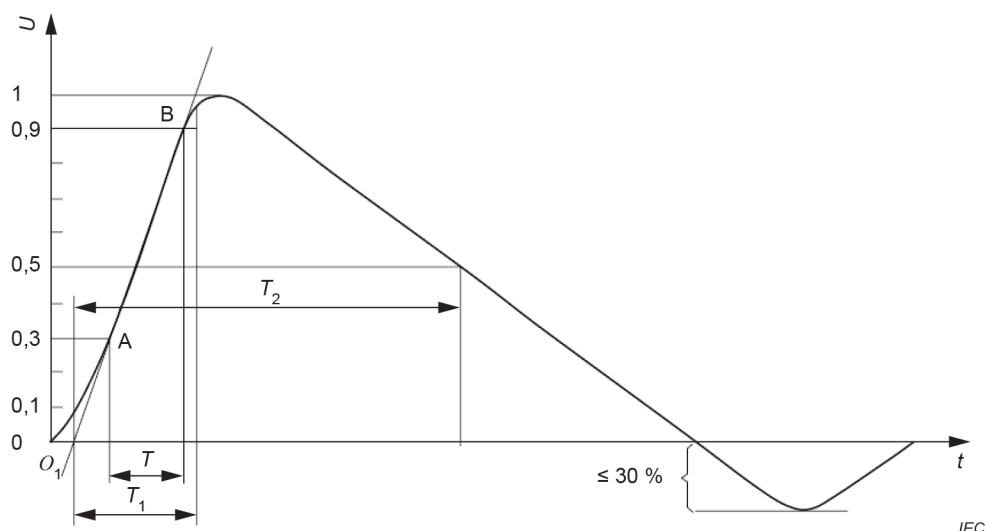
5.5.4 Maximum surge isolation voltage

Describes the highest surge isolation voltage applied, considering V_{IOSM} and V_{IMP} .

In case of basic insulation, all DUT shall pass $\geq V_{IMP} \times 1,3$.

In the case of reinforced insulation, all DUT shall pass the surge test with rated $V_{IMP} \times 1,3$ but with a minimum of 10 kV. V_{IOSM} should be specified in accordance with testing described in 5.5.5.3.2, subgroup 1. Recommended pulse shape is 1,2/50 μ S in accordance with IEC 61000-4-5:2014, Figure 2 (see Figure 2).

Alternative pulse shape is generated in accordance with IEC 62368-1:2018, Clause D.2, circuit 3.



Front time: $T_1 = 1,67 \times T = 1,2 \mu\text{s} \pm 30 \%$

Time to half-value: $T_2 = 50 \mu\text{s} \pm 20 \%$

**Figure 2 –1,2/50 μ s surge pulse according 61000-4-5:2014
allowed as equivalent impulse for isolation testing**

5.5.5 Type test

5.5.5.1 General

Type test shall 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.;
- if the new lead frame affects the external creepage distance or external clearance, or the thermal resistance of the package and thereby P_{SI} or I_{SO} or P_{SO} are affected;
- package or die construction relevant for isolation.

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

All samples shall have passed routine test according 5.5.2 and therefore the regular production including high voltage partial discharge test.

Type tests shall include at least the following subgroups (5.5.5.2 to 5.5.5.7), with the following conditions:

- zero failure shall be achieved;
- if one failure occurs out of the 100 devices, a full set of 100 new devices shall be subjected to the subgroup (in which the failure occurred), with no more failures.

NOTE Safety limiting values (P_{SI} , I_{SO} and/or P_{SO} , P_{TR} , T_S): for components providing safe electrical isolation, the requirements for satisfactory isolation have the first priority.

The safety limiting values of signal and power transmission, if applicable, which shall be individually defined by the manufacturer for a coupler device, are the input power dissipation (P_{SI}), maximum output current (I_{SO}), maximum output power dissipation (P_{SO}), maximum power transmission (P_{TR}), 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 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 ambient 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 circuitry becomes faulty due to excessive current or 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 shall 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, for example:

- 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 is 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.

5.5.5.2 Preconditioning

Visual inspection	According to manufacturer's specification
Resistance to soldering heat	See IEC 60068-2-20:2008, Test Tb, method 1 (260 ± 5) °C, (5 ± 1) s For couplers in SMT packages, see conditions according IEC 60068-2-58:2015, Table 1, three cycles
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 $V_{ini,b} = V_{IOTM}$ $q_{pd} \leq 5 \text{ pC}$
Parametric test	According to manufacturer's specification Temperature 15 °C to 35 °C
Isolation resistance	$R_{IO} > 10^{12} \Omega$, $t = 1 \text{ min}$; $V_{IO} = 500 \text{ V DC}$, $T_{amb} = 25 \text{ °C}$

5.5.5.3 Subgroup 1: 20 samples

5.5.5.3.1 Tests

Preconditioning	See 5.5.5.2
Rapid change of temperature	See IEC 60068-2-14:2009, Test Na $T_{\text{stg,min}}, T_{\text{stg,max}}, 10$ cycles, dwell time 3 h
Dry heat	See IEC 60068-2-2:2007, Test Bb $V \geq V_{\text{IORM}}$ (min. 700 V), $T_{\text{amb}} = T_{\text{amb,max}}$ (min. 100 °C) Duration: 16 h
Damp heat, cyclic	See IEC 60068-2-30:2005 $T_{\text{amb}} = 55$ °C Cycles: 1
Temperature storage (Cold)	See IEC 60068-2-1:2007, 2 h at $T_{\text{stg,min}}$
Damp heat (steady state)	See IEC 60068-2-67:1995, Test Cy 85 % RH at 85 °C, duration = 21 days

5.5.5.3.2 Final measurements for subgroup 1

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

Apparent charge, method a	Basic insulation $V_{\text{pd(m)}} = 1,3 \times V_{\text{IORM}}$ Reinforced insulation $V_{\text{pd(m)}} = 1,6 \times V_{\text{IORM}}$ $V_{\text{ini,a}} = V_{\text{IOTM}}$ $q_{\text{pd}} \leq 5$ pC
Isolation resistance	$V_{\text{IO}} = 500$ V DC, $T_{\text{amb}} = 25$ °C, $R_{\text{IO}} \geq 10^{12}$ Ω , $t = 1$ min
Surge test (type test only)	The applied test pulse shall be identified by the manufacturer in the datasheet. Recommended pulse shape is 1,2/50 μs in accordance with IEC 61000-4-5. Alternative pulse shape generated in accordance with IEC 62368-1:2018, Clause D.2, circuit 3. Number of discharge: 50 (25 discharges with polarity 1 followed by 25 discharges with polarity 2) Cycles: maximum 12 discharges/min Voltage for basic insulation: $\geq 1,3 \times V_{\text{IMP}}$ Voltage for reinforced insulation: $\geq 1,3 \times V_{\text{IMP, min}}$ 10 kV Samples shall be discharged before polarity changes for minimum of 1 h up to a maximum of 2 h by a resistor of 100 Ω . The 1 h minimum discharge time can be ignored upon manufacturer request.
Isolation resistance	$V_{\text{IO}} = 500$ V DC, $T_{\text{amb}} = 25$ °C, $R_{\text{IO}} \geq 10^9$ Ω , $t = 1$ min

5.5.5.4 Subgroup 2: 15 samples**5.5.5.4.1 Tests or examination**

Preconditioning	See 5.5.5.2
Temperature change test	One cycle consists of the following temperature changes: – dwell time 68 h at $T_{\text{stg,max}}$ or 125 °C (which is higher); – dwell time 1 h at 25 °C $\pm$ 2 °C; – dwell time 2 h at 0 °C $\pm$ 2 °C; – dwell time 1 h at 25 °C $\pm$ 2 °C. Voltage: 500 V RMS/50 Hz applied during complete test Cycles: 10
Input safety test	At limiting safety values: samples with power transmission shall allow maximum transmission power to be directly applied to the isolation barrier $T_{\text{amb}} = T_{\text{S}}$, duration = 72 h

5.5.5.4.2 Final measurements for subgroup 2

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

5.5.5.5 Subgroup 3: 15 samples**5.5.5.5.1 Tests or examination**

Preconditioning	See 5.5.5.2
Temperature change test	See 5.5.5.4.1
Output safety test	At limiting safety values Max. output current or max. output power dissipation $T_{\text{amb}} = T_{\text{S}}$, duration = 72 h

5.5.5.5.2 Final measurements for subgroup 3

See 5.5.5.4.2.

5.5.5.6 Subgroup 4: 40 sample**Examinations**

Isolation resistance at	a) $T_{\text{amb,max}}$ (min. 100 °C), $V_{\text{IO}} = 500 \text{ V DC}$, $R_{\text{IO}} \geq 10^{11} \Omega$, $t = 1 \text{ min}$ b) T_{S} , $V_{\text{IO}} = 500 \text{ V DC}$, $R_{\text{IO}} \geq 10^9 \Omega$, $t = 1 \text{ min}$
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5.5.5.7 Subgroup 5: 10 samples

Examinations

External clearance	See IEC 60664-1:2007
External creepage distance	See IEC 60664-1:2007
Flammability test	See IEC 60695-11-5:2016
(type test only)	Time of application of the test flame, $t = 10$ s, after burning time: $t \leq 30$ s

5.5.5.8 End of life test

5.5.5.8.1 General

Coupler lifetime under voltage stress has several independent degradation mechanisms: surface tracking, mold compound thermal degradation and primary insulation wear out. 5.5.5.8 will determine the maximum working voltage based on primary insulation degradation under voltage stress, and use that data to verify the isolation capabilities of the part under transient voltage stress at predicted end of life. Lifetime limitations of the packaging and mold compound are addressed in 5.5.5.9. In addition, the partial discharge measurements apply.

Expected lifetime, failure rates and test margins are specified based on the insulation grade "basic" or "reinforced". Maximum rated repetitive peak isolation voltage (V_{IORM}) can be determined through accelerated life testing to determine the voltage dependent time to failure at several test conditions. These data are applied to accepted models of voltage dependent degradation to extrapolate to the required lifetime and the required probability of failure. Additional margin factors are applied as specified.

End of lifetime verification shall be done by manufacturers. Supporting data and signed documentation shall be provided to test houses to prove these safety requirements are met.

5.5.5.8.2 Subgroup 6: 432 samples – End of life test/ V_{IORM}

Maximum rated repetitive peak isolation voltage (V_{IORM}) will be determined based on identified lifetime and insulation grade. It will be measured with the introduction of a new coupler which differs from already tested couplers in one or more criteria given in 5.5.5.8.6.

5.5.5.8.3 Subgroup 7: 20 samples – End of life test/ V_{IOTM}

Select a test condition from the 1 ppm¹ lifetime curve, determined in 5.5.5.8.4, within the interpolated span of the data as shown in Figure 4. Apply the selected stress voltage, under the same ambient conditions as the lifetime data was gathered, for 80 % of the predicted lifetime.

Example:

Select $V_{\text{stress}} = 1\,000$ V; $T_{\text{op}} = 100$ °C to determine the predicted lifetime of 1 500 h.

Apply the same ambient and voltage stress conditions for 1 200 h ($1\,500 \text{ h} \times 0,8$). Components in test shall show no failure during preconditioning and subsequent isolation test.

¹ ppm = parts per million

Subgroup 7 parts shall not be taken from subgroup 6.

Transient test: after preconditioning, a 50/60 Hz sine wave with $V_{\text{peak}} = V_{\text{IOTM}}$ is applied for 10 s.

Pass criteria

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

5.5.5.8.4 Manufacturer data collection for End of life test/ V_{IORM}

NOTE See IEC 62539:2007 and IEC 61649:2008 for right or single censoring.

Failure criteria: isolation breakdown occurring either at the couplers rated transient voltage V_{IOTM} or its maximum rated repetitive peak isolation voltage V_{IORM} applying the defined wear out safety factors. Failure point reached when insulation resistance has decreased below $2 \text{ M}\Omega$ at 500 V DC for basic insulation, $4 \text{ M}\Omega$ at 500 V DC for reinforced insulation (see IEC 62368-1:2018).

This procedure tests components to failure per the failure criterion. Time to failure data is analyzed per IEC 62539:2007 to determine the time to failure probability line and confidence interval for each data set. Multiple data sets are acquired at conditions specified below to ensure adequate sample size, span of test voltages and consistent extrapolation interval. Degradation models for the two primary insulation materials SiO_2 and polymer are specified in 3.38. Applying the data to the degradation model allows the best possible curve fit and reliable extrapolation of the lifetime to determine the reference working voltage (V_{REF}) for the insulation grade required.

The specified failure rate over the rated lifetime is 1 000 ppm for basic insulation, and 1 ppm for reinforced insulation. This is in keeping with the concept that reinforced insulation is equivalent to 2 instances of basic insulation in series. Two test margin factors are applied on top of this requirement. One is a required lifetime margin factor of $1,2 \times$ for basic, and $1,5 \times$ for reinforced. The second is a 20 % margin factor applied to the reference working voltage (V_{REF}) to reduce the final maximum working voltage.

Accelerated stress test conditions may exceed above defined test criteria.

The electric strength is influenced by the frequency of the applied voltage, so test data at 50Hz/60Hz may not be applicable to use condition. The influence of frequencies greater than 30 kHz on the electric strength is described in IEC 60664-4:2005, Clause 6.

Lifetime safety factor	Lifetime rated value 20 years	
	For basic insulation:	equivalent 24 years (factor 1,2)
	For reinforced insulation:	equivalent 30 years (factor 1,5)
Working voltage safety factor at applicable lifetime	For basic insulation:	$F_{\text{LT}} = 1,2$
	For reinforced insulation:	$F_{\text{LT}} = 1,2$
	Extrapolated lifetime voltage:	$V_{\text{IORM}} = V_{\text{REF}}/F_{\text{LT}}$
Model	See IEC 62539:2007	
	For SiO_2 isolators:	see 3.38.1
	For thin film polymer isolators:	see 3.38.2

Accumulated failure rate over rated lifetime (20 years)	For basic insulation:	FROL $\leq$ 1 000 ppm
	For reinforced insulation:	FROL $\leq$ 1 ppm
Test voltage frequency	Frequency of applied test voltage – sinusoidal with 0 V mean voltage shall be used:	50/60 Hz
	Maximum operating temperature as specified in datasheet:	-

The method of data acquisition and analysis requires the following sample size and applied testing time to support statistical interpolation of lifetime. It also determines a consistent extrapolation interval for a high confidence prediction of insulation lifetime in the extrapolation interval (see Figure 4 and Figure 5). These data points are used to determine V_{IORM} .

For samples and applied method to calculate life time, the following criteria should be met.

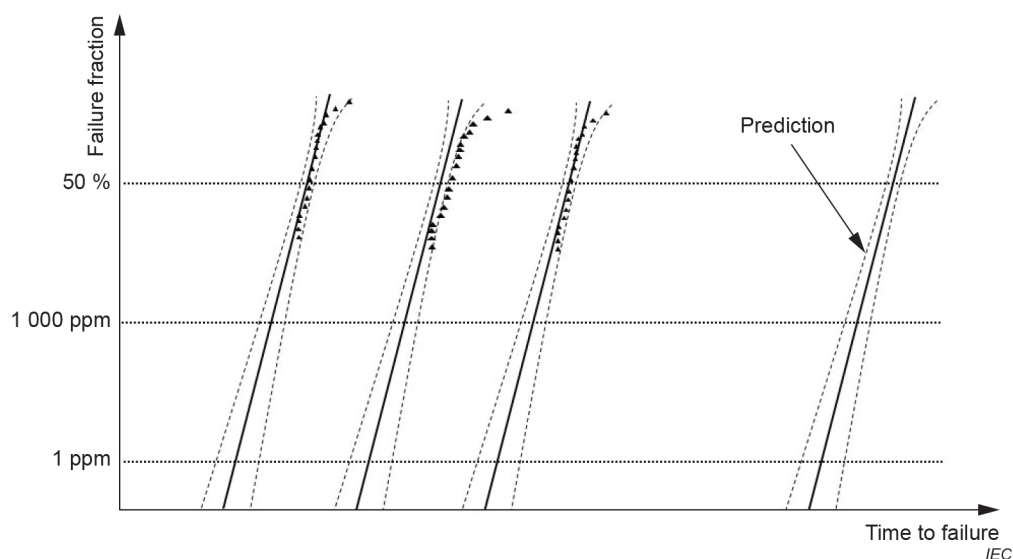
- 1) All samples shall be preconditioned per 5.5.5.2.
- 2) All samples shall pass routine test according 5.5.2.
- 3) For the determination of the V_{IORM} levels including safety factors, a minimum of three voltage stress points per specified temperature as stated below shall be taken as basis:
 - maximum operating temperature: minimum of 16 parts per lot, 3 lots total;
 - room temperature: minimum of 32 parts per lot, 3 lots total;
 - in total, 432 samples (288 at room temperature, 144 at high temperature).
- 4) The smallest to the largest mean-time-to-failure value at the three chosen voltage stress points used for the extrapolation shall span 2 orders of magnitude.
- 5) The lowest test voltage shall yield a t_{63} point > ten million seconds (1E7 s). This is demonstrated by testing to 1E7 s and observing failures in < 63 % of devices at that voltage.

Determination of 1 ppm and 1 000 ppm time to failure based on the lowest voltage requires failures in the greater of either 10 samples or 30 % of the tested sample size. Standard statistical analysis can be performed if sufficient data is gathered. An exception for the purposes of this document is when no failure is found after 1E7 s. The test can be stopped and the worst-case slope of the higher voltage (shorter duration) data sets, Weibull or log normal distribution, shall be applied with an assumed failure probability of $1/n$, where n is the sample size.

If the t_{63} point is below ten million seconds (1E7 s), stress shall continue until a minimum of 63 % devices have failed.

- 6) When extrapolating lifetime, the line of maximum likelihood (best fitting line) of the model curve fit shall be used for a working voltage prediction.
- 7) The slope of extrapolation can only be referenced to existing data sets of true failures.
- 8) Extrapolation over time shall follow the dependencies given for:
 - SiO₂ isolators (see 3.38.1);
 - thin film polymer isolators (see 3.38.2).
- 9) Censored data point shall be shared with test house.
- 10) Any early failures shall be verified to not be insulation material degradation related failures.

The procedure for data analysis is illustrated in Figure 3, and Figure 4 and Figure 5. This can be used as a general procedure to analyze insulation lifetime under different test conditions not mentioned in this document.



Key

Distribution trend ———

Confidence interval - - - - -

Failure fraction (dotted line)

Prediction based on fit to appropriate mode; included confidence interval

Figure 3 – Determination of time to failure (referring to method in 5.5.5.8)

Cumulative failures at a test voltage are analyzed using the procedures of IEC 62539:2007. Several commercial software packages are available to assist with generation of probability plots and estimates of confidence interval; however, the user is accountable for the accuracy of results. Time to failure at the failure rates required can be extracted from this plot.

Failure rate (ppm) as defined in 5.5.5.8.4, will depend on desired basic or reinforced isolation rating.