IEC 60747-15

Edition 1.0 2003-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Discrete semiconductor devices – Part 15: Isolated power semiconductor devices

Dispositifs discrets à semiconducteurs – Partie 15: Dispositifs de puissance à semiconducteurs isolés

IEC 60747-15:2003

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

Useful links:

IEC publications search - www.iec.ch/searchpub

The advanced search enables you to find IEC publications by a variety of criteria (reference number, text, technical committee,…).
It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available on-line and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Liens utiles:

Recherche de publications CEI - www.iec.ch/searchpub

La recherche avancée vous permet de trouver des publications CEI en utilisant différents critères (numéro de référence, texte, comité d'études,…).
Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

Just Published CEI - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications de la CEI. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 30 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (VEI) en ligne.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

IEC 60747-15

Edition 1.0 2003-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour
inside

Discrete semiconductor devices –
Part 15: Isolated power semiconductor devices

Dispositifs discrets à semiconducteurs –
Partie 15: Dispositifs de puissance à semiconducteurs isolés

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX **X**

ICS 31.080.99

ISBN 978-2-83220-704-8

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

DISCRETE SEMICONDUCTOR DEVICES –

Part 15: Isolated power semiconductor devices

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60747-15 has been prepared by subcommittee 47E, Discrete semiconductor devices of IEC technical committee 47: Semiconductor devices.

This bilingual version (2013-05) corresponds to the monolingual English version, published in 2003-06.

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

FDIS	Report on voting
47E/236/FDIS	47E/238/RVD

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

The French version of this standard has not been voted upon.

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

The committee has decided that the contents of this publication will remain unchanged until 2006. At this date, the publication will be

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

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

DISCRETE SEMICONDUCTOR DEVICES –

Part 15: Isolated power semiconductor devices

1 Scope

This part of IEC 60747 gives the product specific standards, requirements and test methods for isolated power semiconductor devices. These requirements are added to those given in other parts of IEC 60747, IEC 60748 and IEC 60749 for the corresponding non-isolated power devices.

2 Normative references

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

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

IEC 60068-2-7, *Environmental testing – Part 2-7: Tests – Test Ga and guidance: Acceleration, steady state*

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

IEC 60068-2-20, *Environmental testing – Part 2-20: Tests – Test T: Soldering*

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

IEC 60068-2-47, *Environmental testing – Part 2-47: Test methods – Mounting of components, equipment and other articles for vibration, impact and other similar dynamic tests*

IEC 60068-2-48, *Environmental testing – Part 2-48: Test methods – Guidance on the application of the tests of IEC 60068 to simulate the effects of storage*

IEC 60068-3-4: *Environmental testing – Part 3-4: Supporting documentation and guidance – Damp heat tests*

IEC 60191-4:1999, *Mechanical standardization of semiconductor devices – Part 4: Coding system and classification into forms of package outlines for semiconductor device packages*

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

IEC 60319, *Presentation and specification of reliability data for electronic components*

IEC 60664-1:1992, *Insulation coordination for equipment within low-voltage systems – Principles, requirements and tests*

IEC 60721-3-3:1994, *Classification of environmental conditions – Part 3-3: Classification of groups of environmental parameters and their severities – Stationary use at weather-protected locations*

IEC 60747-1:1983, *Semiconductor devices – Discrete devices and integrated circuits – Part 1: General*
Amendment 1 (1991)
Amendment 3 (1996)

IEC 60747-2:2000, *Semiconductor devices – Discrete devices and integrated circuits – Part 2: Rectifier diodes*

IEC 60747-6:2000, *Semiconductor devices – Part 6: Thyristors*

IEC 60747-7:2000, *Semiconductor devices – Part 7: Bipolar transistors*

IEC 60747-8:2000, *Semiconductor devices – Part 8: Field effect transistors*

IEC 60747-9:1998, *Semiconductor devices – Discrete devices – Part 9: Insulated-gate bipolar transistors (IGBTs)*

IEC 60749-5: *Semiconductor devices – Mechanical and climatic test methods – Part 5: Steady-state temperature humidity bias life test*

IEC 60749-6: *Semiconductor devices – Mechanical and climatic test methods – Part 6: Storage at high temperature*

IEC 60749-10: *Semiconductor devices – Mechanical and climatic test methods – Part 10: Mechanical shock*

IEC 60749-12: *Semiconductor devices – Mechanical and climatic test methods – Part 12: Vibration, variable frequency*

IEC 60749-14: *Semiconductor devices – Mechanical and climatic test methods – Part 14: Robustness of terminations (lead integrity)*[1]

IEC 60749-15: *Semiconductor devices – Mechanical and climatic test methods – Part 15: Resistance to soldering temperature for through-hole mounted devices*[1]

IEC 60749-21: *Semiconductor devices – Mechanical and climatic test methods – Part 21: Solderability*[1]

IEC 60749-25: *Semiconductor devices – Mechanical and climatic test methods – Part 25: Rapid change of temperature (air, air)*[1]

IEC 60749-26: *Semiconductor devices – Mechanical and climatic test methods – Part 26: Rapid change of temperature (air, air)*[1]

IEC 60749-36: *Semiconductor devices – Mechanical and climatic test methods – Part 36: Acceleration, steady-state*

IEC 61287-1:1995, *Power convertors installed on board rolling stock – Part 1: Characteristics and test methods*[2]

ISO 1302:2002, *Geometrical Product Specifications (GPS) – Indication of surface texture in technical product documentation*

ISO 2768-2:1989, *General tolerances – Part 2: Geometrical tolerances for features without individual tolerance indications*

---

[1] In preparation.

[2] A new edition is being prepared.

3 Terms and definitions

For the purposes of this part of IEC 60747, the following definitions apply.

3.1
isolated power semiconductor device
semiconductor device that contains an integral electrical insulator between cooling surface or base plate (envelope) and any isolated circuit elements

NOTE 1 Included are solid-state relays (SSRs) incorporating opto-isolated driving units (see IEC 60747-5-1, IEC 60745-5-2 and IEC 60745-5-3), monolithically integrated ICs with power stages and isolated cooling surface, i.e. intelligent power devices and isolated discrete plastic encapsulated packages that have an isolated cooling surface.

NOTE 2 The surface of the package transferring the heat to a heat sink or ambient is referred to as “base plate”. The surface of the package not transferring the heat is referred to as “envelope”.

3.2
constituent parts of the isolated power semiconductor device

3.2.1
circuit element
any constituent part of a circuit that contributes directly to its operation and performs a definable function

NOTE Examples include rectifier diodes, thyristors, bipolar transistors, MOSFETs, IGBTs affixed on metallized isolator substrates and integrated driver and protection circuits.

3.2.2
interconnection
internal connection between circuit elements and between circuit elements and terminals (see subclause 3.7.2 of IEC 60747-1)

NOTE They are considered to be parts of their associated circuit elements.

3.2.3
base plate
metallic or metallized cooling surface part of the package that transfers the heat from inside to a heat sink outside

3.2.4
terminals
externally available points of connection, isolated from base plate

3.2.4.1
main terminals
terminals having the high potential of the power circuit and carrying the main current

3.2.4.2
control terminals
terminals having only low current capability for the purpose of control function to which the external control signals are applied or from which sensing parameters are taken

3.2.4.3
high-voltage control terminals
terminals having the high potential of the power circuit, but carrying only low current for control function

NOTE Examples include current shunts and collector sense terminals having the high potential of the main terminals.

3.2.4.4
low-voltage control terminals

terminals at a low potential against base plate having a control function, and isolated from the “main terminals” as well as from high voltage control terminals

NOTE Examples include the terminals of isolated temperature sensors and isolated gate driver inputs, etc.

3.3
classification of categories of isolated power devices

isolated power semiconductor devices are classified as follows:

3.3.1
chip content: types according to their main functional circuit elements

3.3.1.1
thyristor module

isolated power semiconductor device containing thyristor chips

3.3.1.2
diode module

isolated power semiconductor device containing diode chips

3.3.1.3
bipolar transistor module

isolated power semiconductor device containing bipolar transistor chips and their inverse diode chips

3.3.1.4
IGBT module

isolated power semiconductor device containing isolated gate bipolar transistor (IGBT) chips and their inverse diode chips

3.3.1.5
MOSFET module

isolated power semiconductor device containing MOSFET chips

3.3.2
circuit configuration: types according to their main functional circuit

3.3.2.1
single switch

one functional circuit element, the “semiconductor switch”, in one case (as the most simple functional device) (see Annex D, Figure D.2a)

NOTE 1 Examples include epoxy isolated discrete semiconductors with metallic cooling surface.

NOTE 2 “Switch” is here a commonly used synonym for “functional circuit elements”.

3.3.2.2
dual switch

two switches in one case, series connected, forming a “half bridge” circuit, a phase leg of a single-phase bridge or three-phase bridge circuit arrangement (see Annex D, Figure D.2b)

NOTE Examples include “brake chopper” circuit with a high side switch or a low side switch and the freewheeling diode on the other position, see Annex D, Figure D.2c and D.2d.

3.3.2.3
H – bridge

four switches in one case, two half bridges forming a “full bridge”, a single-phase bridge (see Annex D, Figure D.2e)

3.3.2.4
sixpack

six switches in one case, three half bridges forming a “three-phase bridge” (see Annex D, Figure D.2f)

3.3.2.5
sevenpack

seven switches in one case, three half bridges forming a three-phase bridge circuit and in addition a brake chopper circuit (see Annex D, Figures D.2g and D.2h)

NOTE Above circuit configurations are mainly used for transistor inverter circuits producing a.c. output of fixed or variable frequency from d.c. input voltage, using pulse width modulation (PWM), see Annex D, Figure D.2i (CIB-converter-inverter-brake chopper devices).

3.3.2.6
bridge rectifier

single-phase bridge converter circuit of 4 diodes in one case (see Annex D, Figure D.1: circuit B2U, two pulse bridge uncontrolled)

3.3.2.7
half controlled bridge rectifier

single-phase bridge converter circuit of 2 diodes and 2 thyristors in one case (see Annex D, Figure D.1: B2HK)

3.3.2.8
fully controlled bridge rectifier

single-phase bridge converter circuit of 4 thyristors in one case (see Annex D, Figure D.1: B2C, two pulse bridge controlled)

3.3.2.9
three phase bridge rectifier

three-phase bridge converter circuit of 6 diodes in one case (see Annex D, Figure D.1: B6U, six pulse bridge uncontrolled)

3.3.2.10
half controlled three phase bridge rectifier

three-phase bridge converter circuit of 3 diodes and 3 thyristors in one case (see Annex D, Figure D.1: B6HK)

3.3.2.11
fully controlled three phase rectifier

three-phase bridge converter circuit of 6 thyristors in one case (see Annex D, Figure D.1: B6C, six pulse bridge controlled)

3.3.2.12
a.c. controller

single-phase (or three-phase) proportional controller of two (or six) inverse-parallel connected thyristors producing a proportional a.c. output voltage from a.c. input voltage using phase angle control (see Annex D, Figure D.1: W1C or W3C)

NOTE 1 Above rectifier (or respectively controller) circuits are mainly used as input converters producing a fixed or – if thyristor controlled – proportional d.c. (or respectively a.c.) output voltage from a.c. input voltage, using phase-angle control. (See also JESD 14.)

NOTE 2 IEC 60971 provides details. Examples include circuits designated “B2U”,….. “B6C”,…… “W1C”, “W3C”.

3.3.3
other circuit configurations and combinations

for other circuit configurations and combinations for the above circuits, see Annex D

3.4
functionality: types according to additional functions

such as for measurement, protection and control, including SSRs:

circuits as in 3.2.3, but with enhanced functionality by:

- current shunts or sensors
- temperature sensors
- overcurrent or overvoltage protection
- driver with or without integrated power supply
- further control circuitry
- opto-coupler and auxiliary circuits
- other functions

NOTE Such devices are called intelligent power modules (IPM) on the market. IPM and SMART power devices are specific names of such specific products.

3.5
solid-state relays
SSRs

isolated power semiconductor devices that incorporate an opto-isolated electronic driving unit using an input section, fully isolated from the power output side and the metallic or metallized isolated cooling surface or base plate, performing a switch-on/switch-off function as an electronic relay producing a non-proportional output

NOTE For SSRs, IEC 60747-5-1, IEC 60747-5-2 and IEC 60747-5-3 also apply.

3.6
isolation voltage

V_{isol}

isolation breakdown withstand voltage between terminals and base plate (or external heat sink) over a specified time

NOTE Subclause 1.3.9.1 of IEC 60664-1 defines 'rated insulation voltage' as r.m.s. withstand voltage value assigned by the manufacturer to the equipment or to a part of it, characterizing the specified isolation voltage withstand capability of its insulation.

3.7
partial discharge inception voltage

V_{i}

voltage between main terminals and base plate at which partial discharges occur when the applied voltage is gradually increased from a lower value

NOTE 1 IEC 60270 defines inception voltage as greater than the extinction voltage.

NOTE 2 Subclause 1.3.18.4 of IEC 60664-1 defines 'partial discharge inception voltage', U_{i}, as the lowest peak value of the test voltage at which the apparent charge becomes greater than the specified discharge magnitude when the test voltage is increased above a low value for which no discharge occurs.

3.8
partial discharge extinction voltage

V_{e}

voltage between main terminals and base plate at which partial discharges disappear when the applied voltage is gradually decreased from a higher value

NOTE 1 IEC 60270 defines the extinction voltage as lower than the inception voltage.

NOTE 2 Subclause 1.3.18.5 of IEC 60664-1 defines 'partial discharge extinction voltage', U_{e}, as the lowest peak value of the test voltage at which the apparent charge becomes less than the specified discharge magnitude when the test voltage is reduced below a high level where such discharges have occurred.

3.9
creepage distance along surface

d_s

shortest distance along the surface of the insulating material between two conductive parts at different potentials

NOTE See subclause 1.3.3 of IEC 60664-1 (IEV 151-15-50).

3.10
clearance distance in air

d_a

shortest distance in air between two conductive parts at different potentials

NOTE See 1.3.2 of IEC 60664-1.

3.11
peak case non-rupture current

peak current that will not lead to a rupture of the package, ejecting plasma and massive particles under specified conditions

NOTE The value indicated depends on the type of the device, e.g. thyristor, diode, IGBT, and the packaging technology, e.g. whether wire bonded.

3.11.1
peak case non-rupture current for diodes and thyristors

I_RSMC

peak reverse current of a half sine wave, when the device has lost its reverse blocking capability, that should not be exceeded in order to avoid bursting of the case or emission of a plasma beam or massive particles under specified conditions

NOTE Specified in IEC 60747-2 for diode devices, respectively IEC 60747-6 for thyristor devices.

3.11.2
peak case non-rupture current for bipolar transistors, IGBT and MOSFETs

I_CNR

peak collector current that should not be exceeded in order to avoid bursting of the case or emission of a plasma beam or ejection of massive particles under specified conditions

3.12
parasitic stray inductance between main terminals

L_P

inner wiring stray inductance, effective in the main current path between the main terminals

NOTE 1 L_P of a half-bridge module (dual switch) is the effective parasitic stray inductance L_CE between the power terminal (+) (top collector) and power terminal (–) (bottom emitter).

NOTE 2 Parasitic stray inductance L_P will cause a voltage spike at switch-off (above the continuous d.c. voltage V_CC) on chip level, higher than the voltage, measured between the terminals.

3.13
parasitic stray capacitance between switching circuit elements and case

C_P

coupling capacitance between all terminals connected together and the base plate (or heat-sink surface)

NOTE This capacitance can serve as a bypass for parasitic high frequency currents that can cause electro-magnetic interference (EMI).

3.14
power cycling (load) capability

$N_\mathrm{f;p}$

number of power cycles $N_\mathrm{f;p}$ until failure of the cumulative percentage p (=percentile) of a device population