INTERNATIONAL STANDARD

IEC 60747-15

First edition
2003-06

Discrete semiconductor devices –

Part 15:
Isolated power semiconductor devices

Dispositifs à semiconducteurs –

Partie 15:
Dispositifs à semiconducteurs de puissance isolés

Reference number
IEC 60747-15:2003(E)

Publication numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series. For example, IEC 34-1 is now referred to as IEC 60034-1.

Consolidated editions

The IEC is now publishing consolidated versions of its publications. For example, edition numbers 1.0, 1.1 and 1.2 refer, respectively, to the base publication, the base publication incorporating amendment 1 and the base publication incorporating amendments 1 and 2.

Further information on IEC publications

The technical content of IEC publications is kept under constant review by the IEC, thus ensuring that the content reflects current technology. Information relating to this publication, including its validity, is available in the IEC Catalogue of publications (see below) in addition to new editions, amendments and corrigenda. Information on the subjects under consideration and work in progress undertaken by the technical committee which has prepared this publication, as well as the list of publications issued, is also available from the following:

- **IEC Web Site (www.iec.ch)**

- **Catalogue of IEC publications**

  The on-line catalogue on the IEC web site (http://www.iec.ch/searchpub/cur_fut.htm) enables you to search by a variety of criteria including text searches, technical committees and date of publication. On-line information is also available on recently issued publications, withdrawn and replaced publications, as well as corrigenda.

- **IEC Just Published**

  This summary of recently issued publications (http://www.iec.ch/online_news/justpub/jp_entry.htm) is also available by email. Please contact the Customer Service Centre (see below) for further information.

- **Customer Service Centre**

  If you have any questions regarding this publication or need further assistance, please contact the Customer Service Centre:

  Email: custserv@iec.ch
  Tel: +41 22 919 02 11
  Fax: +41 22 919 03 00

INTERNATIONAL STANDARD

IEC 60747-15

First edition
2003-06

Discrete semiconductor devices –

Part 15:
Isolated power semiconductor devices

Dispositifs à semiconducteurs –

Partie 15:
Dispositifs à semiconducteurs de puissance isolés

International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch

Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE X

For price, see current catalogue

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

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.

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.

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

NOTE Subclause 7.4.6 of IEC 60747-2 (diodes) and 9.4.6 of IEC 60747-6 (thyristors) define “power cycling load test”. Subclause 10.1.3.3 of Amendment 1 to IEC 60747-9 (IGBT) defines “intermittent operating life tests”.

4 Letter symbols

4.1 General

IEC 60747-1 applies.

4.2 Additional subscripts/symbols

p = parasitic
ref = reference point (for measuring temperatures)
s = heat sink (subscript of heat-sink temperature T_s)
t = time (parameter) used for currents, voltages as function of time: in brackets: (t)
t = terminal (subscript of mounting torque to terminal M_t)
1 = primary side (of a transformer or control input)
2 = secondary side (power output side)

4.3 List letter symbols

4.3.1 Voltages and currents (see also IEC 60747-1)

Terminal current	I_{tRMS}
Isolation voltage	V_{isol}
Partial discharge inception voltage	V_i
Partial discharge extinction voltage	V_e
Isolation leakage current	I_{isol}
Peak case non-rupture current (for diode and thyristor devices)	I_{RSMC}
Peak case non-rupture current (for IGBT and MOSFET devices)	I_{CNR}

4.3.2 Mechanical terms

Mounting torque for screws to heat sink	M_s	see Note 1
Mounting torque for terminal screws	M_t	see Note 1
Mounting force for pressure mounted devices	F	
Maximum acceleration in all 3 axis (x, y, z)	a	
Mass	m	
Flatness of the case (base-plate, cooling surface)	e_c	see Note 2
Flatness of the cooling surface (heat sink)	e_s	
Roughness of the case (base plate)	R_{Zc}	see Note 3
Roughness of the cooling surface (heat sink)	R_{Zs}	see Note 3
Thickness of thermal compound grease (case – sink)	$D_{(c\text{-}s)}$	see Annex B

NOTE 1 Under given mounting instructions. In respect of thermal compound properties see mounting instructions.

NOTE 2 See for instance IEC 60191-2:1995, outline 191-IEC-080B (34 mm wide module) and 191-IEC-081B (62 mm wide module) deviation from flatness 100 µm – see Note 4.

NOTE 3 In USA: "R_a" is used instead, (R_z = about 3*R_a). There is no fixed factor between those two.

NOTE 4 Example: Seating plane. Deviation from flatness shall be <20 µm concave and <100 µm convex, the roughness <10 µm. Flatness and roughness are to be specified as, for instance, defined in the related publication IEC 60191-2.