IEC 60747-9

Edition 2.0 2007-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Semiconductor devices – Discrete devices –
Part 9: Insulated-gate bipolar transistors (IGBTs)

Dispositifs à semiconducteurs – Dispositifs discrets –
Partie 9: Transistors bipolaires à grille isolée (IGBT)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: 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.

- Catalogue of IEC publications: www.iec.ch/searchpub

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 It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

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

- Electropedia: www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:
Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

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.

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm

Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,…). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: www.iec.ch/online_news/justpub

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

- Electropedia: www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.

- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:
Email: csc@iec.ch
Tél.: +41 22 919 02 11
Fax: +41 22 919 03 00

IEC 60747-9

Edition 2.0 2007-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Semiconductor devices – Discrete devices –
Part 9: Insulated-gate bipolar transistors (IGBTs)

Dispositifs à semiconducteurs – Dispositifs discrets –
Partie 9: Transistors bipolaires à grille isolée (IGBT)

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX XA

ICS 31.080.01; 31.080.30

ISBN 2-8318-9321-6

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SEMICONDUCTOR DEVICES –
DISCRETE DEVICES –

Part 9: Insulated-gate bipolar transistors (IGBTs)

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of 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, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). 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. 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 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 IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60747-9 has been prepared by subcommittee 47E: Discrete semiconductor devices, of IEC technical committee 47: Semiconductor devices.

This second edition of IEC 60747-9 cancels and replaces the first edition (1998) and its amendment 1 (2001).

The main changes with respect to the previous edition are listed below.

a) Clause 3 was amended by adding terms that should be included.
b) Clauses 4 and 5 were amended by suitable additions and deletions that should be included.
c) Clauses 6 and 7 in Amendment 1 were combined into Clause 6 with suitable additions and corrections that should be included.
d) Clause 8 in Amendment 1 was renumbered as Clause 7.

This standard is to be read in conjunction with IEC 60747-1.

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

FDIS	Report on voting
47E/333/FDIS	47E/341/RVD

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

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

A list of all parts of the IEC 600747 series, under the general title: *Semiconductor devices – Discrete devices*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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

SEMICONDUCTOR DEVICES –
DISCRETE DEVICES –

Part 9: Insulated-gate bipolar transistors (IGBTs)

1 Scope

This part of IEC 60747 gives product specific standards for terminology, letter symbols, essential ratings and characteristics, verification of ratings and methods of measurement for insulated-gate bipolar transistors (IGBTs).

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 60747-1:2006, *Semiconductor devices – Part 1: General*

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

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

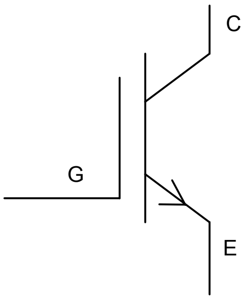
IEC 61340 (all parts), *Electrostatics*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 Graphical symbol of IGBT

The graphical symbol as shown below is used in this edition of IEC 60747-9.



Graphical symbol

NOTE Only the graphical symbol for N-channel IGBT is used in this standard. It equally applies for the measurement of P-channel devices. In the case of P-channel devices polarity must be adapted.

3.2 General terms

3.2.1

insulated-gate bipolar transistor
IGBT
transistor having a conduction channel and a PN junction. The current flowing through the channel and the junction is controlled by an electric field resulting from a voltage applied between the gate and emitter terminals
See IEV 521-04-05.

NOTE With collector-emitter voltage applied, the PN junction is forward biased.

3.2.2

N-channel IGBT
IGBT that has one or more N-type conduction channels
See IEV 521-05-06.

3.2.3

P-channel IGBT
IGBT that has one or more P-type conduction channels
See IEV 521-04-05.

3.2.4

collector current (of an IGBT)
I_C
direct current that is switched (controlled) by the IGBT

3.2.5

collector terminal, collector (of an IGBT)
C
for an N-channel (a P-channel) IGBT, the terminal to (from) which the collector current flows from (to) the external circuit
See IEV 521-07-05 and IEV 521-05-02.

3.2.6

emitter terminal, emitter (of an IGBT)
E
for an N-channel (a P-channel) IGBT, the terminal from (to) which the collector current flows to (from) the external circuit
See IEV 521-07-04.

3.2.7

gate terminal, gate (of an IGBT)
G
terminal to which a voltage is applied against the emitter terminal in order to control the collector current
See IEV 521-07-09.

3.3 Terms related to ratings and characteristics; voltages and currents

3.3.1

collector-emitter (d.c.) voltage
voltage between collector and emitter

3.3.2

collector-emitter voltage with gate-emitter short-circuited
V_{CES}
collector-emitter voltage at which the collector current has a specified low (absolute) value with gate-emitter short-circuited

3.3.3

collector-emitter sustaining voltage

$V_{\mathrm{CE*sus}}$

collector-emitter breakdown voltage at relatively high values of collector current where the breakdown voltage is relatively insensitive to changes in collector current, for a specified termination between gate and emitter terminals

NOTE 1 The specified termination between gate and emitter terminals is indicated in the letter symbol by the third subscript '*'; see 4.1.2 of IEC 60747-7.

NOTE 2 When necessary, a suitable qualifier is added to the basic term to indicate a specific termination between gate and emitter terminals.

Example: Collector-emitter sustaining voltage with gate and emitter terminals short-circuited V_{CESsus}.

NOTE 3 The basic term may be shortened if the meaning is clear from the letter symbol used.

Example: Collector-emitter sustaining voltage V_{CERsus}.

NOTE 4 This term is important for high-voltage devices, for example more than 4 kV.

3.3.4

collector-emitter breakdown voltage

$V_{\mathrm{(BR)CES}}$

voltage between collector and emitter above which the collector current rises steeply, with gate to emitter short-circuited

See IEV 521-05-06.

3.3.5

collector-emitter saturation voltage

V_{CEsat}

collector-emitter voltage under conditions of gate-emitter voltage at which the collector current is essentially independent of the gate-emitter voltage

3.3.6

gate-emitter (d.c.) voltage

voltage between gate and emitter

3.3.7

gate-collector (d.c.) voltage

voltage between gate and collector

3.3.8

gate-emitter threshold voltage

$V_{\mathrm{GE(th)}}$

gate-emitter voltage at which the collector current has a specified low (absolute) value

3.3.9

electrostatic discharge voltage

voltage that can be applied to the gate terminal without destruction of the isolation layer

See IEV 521-05-27

3.3.10

collector cut-off current

collector current at a specific collector-emitter voltage below the breakdown region and gate off-state

3.3.11

collector current

current through collector

3.3.12
tail current
I_{CZ}
collector current during the tail time

3.3.13
gate leakage current
I_{GES}
leakage current into the gate terminal at a specified gate-emitter voltage with the collector terminal short-circuited to the emitter terminal

3.3.14
safe operating area
SOA
collector current versus collector emitter voltage where the IGBT is able to turn-on and turn-off without failure

3.3.14.1
forward bias safe operating area
FBSOA
collector current versus collector emitter voltage where the IGBT is able to turn-on and is able to be on-state without failure

3.3.14.2
reverse bias safe operating area
RBSOA
collector current versus collector emitter voltage where the IGBT is able to turn-off without failure

3.3.14.3
short circuit safe operating area
SCSOA
short circuit duration and collector emitter voltage where the IGBT is able to turn-on and turn-off without failure

3.4 Terms related to ratings and characteristics; other characteristics

3.4.1
input capacitance
C_{ies}
capacitance between the gate and emitter terminals with the collector terminal short-circuited to the emitter terminal for a.c.

3.4.2
output capacitance
C_{oes}
capacitance between the collector and emitter terminals with the gate terminal short-circuited to the emitter terminal for a.c.

3.4.3
reverse transfer capacitance
C_{res}
capacitance between the collector and gate terminals

3.4.4
gate charge
Q_G
charge required to raise the gate-emitter voltage from a specified low to a specified high level

3.4.5
internal gate resistance

r_g

internal series resistance

3.4.6
turn-on energy (per pulse)

E_{on}

energy dissipated inside the IGBT during the turn-on of a single collector current pulse

NOTE The corresponding turn-on power dissipation under periodic pulse conditions is obtained by multiplying E_{on} by the pulse frequency.

3.4.7
turn-off energy (per pulse)

E_{off}

energy dissipated inside the IGBT during the turn-off time plus the tail time of a single collector current pulse

NOTE The corresponding turn-off power dissipation under periodic pulse conditions is obtained by multiplying E_{off} by the pulse frequency.

3.4.8
turn-on delay time

$t_{d(on)}$, t_d

time interval between the beginning of a voltage pulse across the input terminals which switches the IGBT from the off-state to the on-state and the beginning of the rise of the collector current

NOTE Usually, the time is measured between points corresponding to 10 % of the input and output pulse amplitudes.

3.4.9
rise time

t_r

time interval between the instants at which the rise of the collector current reaches specified lower and upper limits, respectively, when the IGBT is being switched from the off-state to the on-state

NOTE Usually the lower and upper limits are 10 % and 90 % of the pulse amplitude.

3.4.10
turn-on time

t_{on}

sum of the turn-on delay time and the rise time

3.4.11
turn-off delay time

$t_{d(off)}$, t_s

time interval between the end of the voltage pulse across the input terminals which has held the IGBT in its on-state and the beginning of the fall of the collector current when the IGBT is switched from the on-state to the off-state

NOTE Usually, the time is measured between points corresponding to 90 % of the input and output pulse amplitudes.

3.4.12
fall time

t_f

time interval between the instants at which the fall of the collector current reaches specified upper and lower limits, respectively, when the IGBT is switched from the on-state to the off-state

NOTE Usually, the upper and lower limits are 90 % and 10 % of the pulse amplitude.

3.4.13
turn-off time
t_{off}
sum of the turn-off delay time and the fall time

3.4.14
tail time
t_{z}
time interval from the end of the turn-off time to the instant at which the collector current has fallen to 2 % or lower specified value

4 Letter symbols

4.1 General

General letter symbols for IGBTs are defined in Clause 4 of IEC 60747-1.

4.2 Additional general subscripts

C,c	collector
E,e	emitter
G,g	gate
sat	saturation
th	threshold
Z,z	tail
S	termination with a short circuit
R	termination with a resistor
X	termination with specified gate emitter voltage
sus	sustaining