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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Semiconductor devices –
Part 1: General

Dispositifs à semiconducteurs –
Partie 1: Généralités

IEC 60747-1:2006

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SEMICONDUCTOR DEVICES –

Part 1: General

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.
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International Standard IEC 60747-1 has been prepared by IEC technical committee 47: Semiconductor devices.

This second edition of IEC 60747-1 cancels and replaces the first edition (1983) and its amendments 1 (1991), 2 (1993) and 3 (1996).

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

a) The terminology which is now given in the IEV (or which was in conflict with the IEV) has been omitted.
b) There has been a general revision of guidance on essential ratings and characteristics.
c) The distinction between general and reference methods of measurement has been removed.
d) A clause on product discontinuation notice has been added.

This bilingual version, published in 2009-11, corresponds to the English version.

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

FDIS	Report on voting
47/1841/FDIS	47/1848/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.

A list of all the parts in the IEC 60747 series, under the general title *Semiconductor 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.

The contents of the corrigendum of September 2008 have been included in this copy.

SEMICONDUCTOR DEVICES –

Part 1: General

1 Scope

This part of IEC 60747 gives the general requirements applicable to the discrete semiconductor devices and integrated circuits covered by the other parts of IEC 60747 and IEC 60748 (see Annex A).

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 60027 (all parts), *Letter symbols to be used in electrical technology*

IEC 60050-521, *International Electrotechnical Vocabulary (IEV) – Part 521: Semiconductor devices and integrated circuits*

IEC 60050-702, *International Electrotechnical Vocabulary (IEV) – Part 702: Oscillations, signals and related devices*

IEC 60068 (all parts), *Environmental testing*

IEC 60191-2, *Mechanical standardization of semiconductor devices – Part 2: Dimensions*

IEC 60747 (all parts), *Semiconductor devices*

IEC 60748 (all parts), *Semiconductor devices – Integrated circuits*

IEC 60749-26, *Semiconductor devices – Mechanical and climatic test methods – Part 26: Electrostatic discharge (ESD) sensitivity testing – Human body model (HBM)*

IEC 61340 (all parts), *Electrostatics*

QC 001002 (all parts), *IEC Quality Assessment Systems for Electronic Components (IECQ) – Rules of procedure*

ISO 9000, *Quality management systems – Fundamentals and vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-521 and IEC 60050-702, as well as the following, apply.

3.1 Device structure

3.1.1
pad
area on a chip (die) to which a connection to the chip (die) can be made

3.1.2
bonding wire
wire that is bonded to a chip (die) bonding pad in order to connect the chip (die) to any other point within the device package

3.1.3
base (of a package**)**

part of the package on which a chip (die) can be mounted

3.1.4
cap, can, lid, plug
part of a cavity package that completes its enclosure

NOTE The particular term used depends on the package design.

3.1.5
anode terminal (of a semiconductor diode, excluding current-regulator diodes)
terminal connected to the P-type region of the PN junction or, when more than one PN junction is connected in series with the same polarity, to the extreme P-type region

NOTE For voltage-reference diodes; if temperature-compensating diodes are included, these are ignored in the determination of the anode terminal.

3.1.6
cathode terminal (of a semiconductor diode, excluding current-regulator diodes**)**
terminal connected to the N-type region of the PN junction or, when more than one PN junction is connected in series with the same polarity, to the extreme N-type region

NOTE For voltage-reference diodes; if temperature-compensating diodes are included, these are ignored in the determination of the cathode terminal.

3.1.7
anode terminal (of a current-regulator diode)
terminal to which current flows from the external circuit when the diode is biased to operate as a current regulator

3.1.8
cathode terminal (of a current-regulator diode)
terminal from which current flows into the external circuit when the diode is biased to operate as a current regulator

3.2 Elements and circuits

3.2.1
passive circuit element
circuit element primarily contributing resistance, capacitance, inductance, ohmic inter-connection, wave-guiding, or a combination of these, to a circuit function

NOTE For example, resistors, capacitors, inductors, passive filters, interconnections.

3.2.2
active circuit element
circuit element that contributes other qualities to a circuit function than a passive circuit element, for example, rectification, switching, gain, conversion of energy from one form to another

NOTE 1 Examples for devices with active circuit elements are diodes, transistors, active integrated circuits, light-sensing or light-emitting devices.

NOTE 2 Active physical circuit elements may also be used to act as passive physical circuit elements only, for example, to contribute resistance and/or capacitance to a circuit function temperature.

3.2.3
reference-point temperature
temperature at a specified point on, near or within a device

3.2.4
case temperature
temperature of a reference point, on or near the surface of the case

NOTE For smaller devices, if the specified reference point is not located on the case but somewhere else on the device (for example, on one of the terminals), then the temperature at this place may be called the "reference-point temperature". However, devices rated with reference to this temperature are still called "case-rated devices".

3.2.5
storage temperature
temperature at which the device may be stored without any voltage being applied

3.3 Thermal characteristics

3.3.1
thermal derating factor
factor by which the power dissipation rating must be reduced with increase of reference point temperature

3.3.2
equivalent thermal network
theoretical equivalent circuit that simulates the thermal resistances, thermal capacitances and sources of heat flow of a semiconductor device (or integrated circuit), which gives a representation of thermal conditions and temperature behaviour under electrical load and which may be used for temperature calculations

NOTE 1 It is assumed that the total heat flow, caused by the power dissipation, is flowing through this equivalent thermal network.

NOTE 2 Where heat is generated at more than one point in a device, the equivalent thermal networks will need to include each source if the heat flow is to correspond to the total power dissipation occurring in the semiconductor device (or integrated circuit).

3.3.3
transient thermal impedance
quotient of

a) the change in temperature difference between two specified points or regions at the end of a time interval, and

b) the step-function change in power dissipation beginning at that time interval which causes the change in temperature difference

NOTE The term used in practice must indicate the two specified points or regions, for example, as in "junction-case transient thermal impedance". The use of the shortened term "transient thermal impedance" is permitted only if no ambiguity is likely to occur.

3.3.4
thermal impedance under pulse conditions
quotient of

a) the difference between the maximum virtual temperature caused by the pulse power and the temperature of a specified external reference point, and

b) the amplitude of the power dissipation in the device produced by a specified periodic sequence of rectangular pulses

NOTE 1 The initial transient phenomena are ignored and zero continuous power dissipation is assumed.

NOTE 2 The thermal impedance under pulse conditions is given as a function of the duration of the pulses with the duty factor as a parameter.

3.4 Noise

3.4.1
reference-noise temperature
absolute temperature (in kelvins) to be assumed as a noise temperature at the input ports of a network when calculating certain noise parameters, and for normalizing purposes

NOTE It has not been possible to achieve a consensus on a single standard reference noise temperature, although no values below 290 K or above 300 K were found to be in use.

3.4.2
overall average noise figure (of a mixer diode and an I.F. amplifier)
average noise figure of the cascaded combination of a mixer and an I.F. amplifier

3.4.3
standard overall average noise figure (of a mixer diode and an I.F. amplifier)
overall average noise figure, when the average noise figure of the I.F. amplifier is a specified standard value (usually 1,5 dB) and the passband of the I.F. amplifier is sufficiently narrower than that of the mixer so that the mixer conversion loss and output noise temperature are essentially constant over the I.F. passband

3.4.4
output noise ratio
ratio of the noise temperature of an output port to the reference noise temperature, when the noise temperature of all input terminations is at the reference noise temperature at all frequencies that contribute to the output noise

3.4.5
equivalent input noise voltage (of a two-port)
voltage of an ideal voltage source (having an internal impedance equal to zero) in series with the input terminals of the device that represents the part of the internally generated noise that can properly be represented by a voltage source

NOTE In the definition, the equivalent input noise current, which would be needed for a complete and precise description of the device noise, is neglected. If the external source impedance is zero, the noise voltage represents the total noise.

3.4.6
equivalent input noise current (of a two-port)
current of an ideal current source (having an internal impedance equal to infinity) in parallel with the input terminals of the device that represents the part of the internally generated noise that can properly be represented by a current source

NOTE In this definition, the equivalent input noise voltage, which would be needed for a complete and precise description of the device noise, is neglected. If the external source impedance is infinite, the noise current represents the total noise.

3.5 Conversion loss

3.5.1
conversion loss (of a mixer, mixer diode or harmonic generator)
ratio of available input power at a single-signal frequency to the available single-signal frequency output power, not including intrinsic mixer noise or power converted from other than the signal-input frequency

3.5.2
conversion insertion loss (of a mixer, mixer diode or harmonic generator)
ratio of available input power at a single-signal frequency to the delivered single-signal frequency output power, not including intrinsic mixer noise or power convened from other than the signal-input frequency

3.6 Stability of characteristics

3.6.1
drift
difference between the final value of a characteristic at the end of a specified long period and the initial value, all other operating conditions being held constant

NOTE The use of the term "drift" to refer to the immediate change of a characteristic in direct response to changed operating conditions (for example, temperature) is deprecated.

3.6.2
relative drift
ratio of

– drift of the characteristic, to
– initial value of the characteristic

NOTE See note to 3.6.1.

3.6.3
instability range
difference between the extreme values of the characteristic observed either continuously or repeatedly during a specified period, all other operating conditions being held constant

3.6.4
relative instability range
quotient of

– the instability range of the characteristic, and
– the initial value of the characteristic

4 Letter symbols

4.1 General

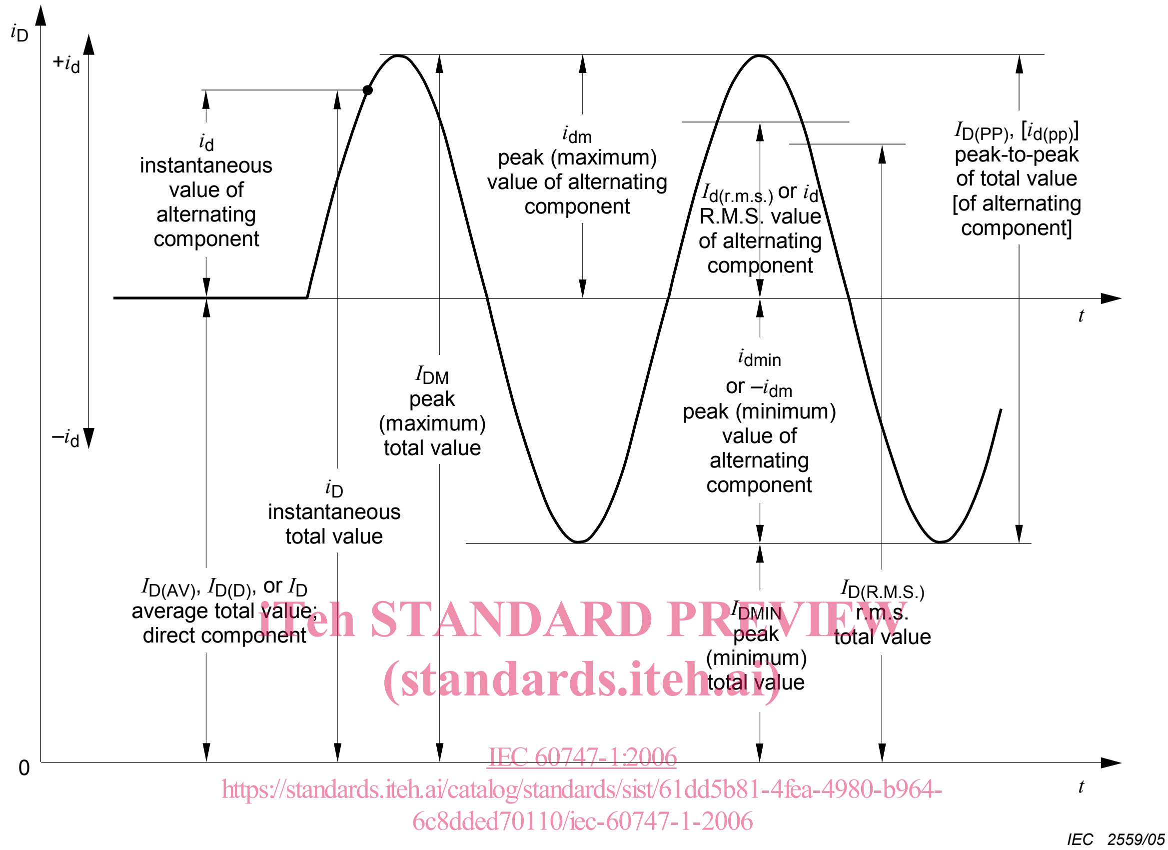
This clause provides a system of letter symbols for the properties used in the field of discrete devices and integrated circuits. Additional letter symbols, for specific categories may be given in Clause 4 of the other parts of IEC 60747 and IEC 60748. Where there is any conflict, the symbols given in the latter parts apply within the part.

The general standards given in IEC 60027 are applicable, except where this clause differs, in which case this clause should be followed. Some letter symbols or rules for composing complex letter symbols have been specifically approved for the purposes of IEC 60747 and IEC 60748.

NOTE Definitions of the terms used in this clause can be found in Clause 3 of this or the other parts of IEC 60747 and IEC 60748.

4.2 Letter symbols for currents, voltages and powers

4.2.1 Use of upper-case or lower-case letters and subscripts



NOTE D,d = Drain terminal

Figure 1 – Example of the application of the rules to a periodic current

Where both upper- and lower-case letters and subscripts are shown for currents, voltages or powers, upper-case letters shall be used for the representation of the total value (the large signal value), and lower-case letters shall be used for values related to the alternating component (the small signal value). If more than one subscript is used, subscripts for which both styles exist shall either be all upper-case or all lower-case.

Exceptionally, cases are used in combination to save otherwise necessary parentheses, for example, V_{CEsat}

Figure 1 gives an example. It represents the drain current of an FET that consists of a direct component (the average value) and an alternating component.

4.2.2 Basic letters

The basic letters to be used are:

I, i = current

V, v = voltage

P, p = power

NOTE IEC 60027 recommends the letters *V* and *v* only as reserve symbols for voltage; however, in the field of semiconductor devices, these are so widely used that in this publication they are preferred to *U* and *u*.

4.2.3 List of subscripts

(AV)	=	average value
(BR)	=	breakdown
(cr), cr	=	critical
(D)	=	direct
F, f	=	forward
M, m	=	peak (maximum) value with respect to time
MIN, min	=	peak (minimum) value with respect to time (see note 3)
n		noise
O, o	=	open circuit
(OV)	=	overload
(PP), (pp)	=	peak-to-peak, value
R, r	=	repetitive, recovery, reverse
(R.M.S.), (r.m.s.)	=	root-mean-square value
S,s	=	short-circuit, surge
(tot), tot	=	total value

NOTE 1 Where no ambiguity arises, subscripts may be omitted, for example:

I_B or $I_{B(D)}$ = direct base current.

I_b or $I_{b(rms)}$ = instantaneous root-mean-square value base current.

NOTE 2 For other recommended subscripts, see Clause 4 in the other relevant parts of these publications.

NOTE 3 "MIN, min" should be used with caution, as it can be confused with the lower limit of a ranges of values.

4.2.4 Subscripts denoting terminals

Where it is necessary to indicate the terminal carrying a current after which the current is named or to indicate the voltage at that terminal, this shall be done by a single subscript.

The terminal relative to which the voltage is measured or, if required, out of which the current flows (the reference terminal) shall be indicated by a second subscript.

A third subscript may be used to indicate the external connection between a third (input) terminal and the reference terminal, for example:

I_{CES} collector current of a transistor with the base short-circuited to the emitter;

$V_{(BR)CEO}$ collector-emitter breakdown voltage of a transistor with base open-circuit.

4.2.5 Subscripts for supply voltages or supply currents

Repeating the appropriate terminal subscript shall indicate supply voltages and supply currents, for example: V_{CC}, I_{EE}.

If it is necessary to indicate a reference terminal, this should be done by a third subscript, for example: V_{CCE}.

4.2.6 Subscripts for devices having more than one terminal of the same kind

If a device has more that one terminal of the same kind, the subscript is formed by the appropriate letter for the terminal followed by a number. In the case of multiple subscripts, hyphens may be necessary to avoid misunderstandings, for example:

I_{B2} = continuous (d.c.) current flowing in the second base terminal;

V_{B2-E} = continuous (d.c.) voltage between the second base terminal and the emitter terminal.

4.2.7 Subscripts for multiple devices

For multiple devices, the subscripts are modified by a number preceding the letter subscript. In the case of multiple subscripts, hyphens may be necessary to avoid misunderstandings, for example:

I_{2C} = continuous (d.c.) current flowing into the collector terminal of the second transistor;

V_{1C-2C} = continuous (d.c.) voltage between the collector terminals of the first and the second transistors.

4.2.8 Indication of the polarity of currents and voltages

4.2.8.1 Unsigned letter symbol

When neither the letter symbol nor the value is preceded by a minus, this denotes either a voltage that has a positive value with respect to a reference terminal, or a conventional current that has a positive value and which flows from the external circuit into the device terminal, for example:

V_{XY} = voltage applied to terminal X is positive with respect to terminal Y;

I_X = conventional current flowing into terminal X from an external source.

4.2.8.2 Negated letter symbol

The negation sign may precede either the letter symbol or the value, for example, $-V_{XY}$, $-I_X$ denote values that are of the opposite polarity to V_{XY}, I_X. It follows, by the application of algebraic rules, that V_{XY} = –5 V can be expressed as $-V_{XY}$ = 5 V.

Where the definition itself denotes a reversal of the polarity and there is no ambiguity, the negation may be omitted, for example, V_F = 2 V, V_R = 10 V.

4.3 Letter symbols for signal ratios expressed in dB

dB = the logarithm to the base of ten of the ratio of two powers multiplied by 10.

dB(V) = the logarithm to the base of ten of the ratio of two voltages multiplied by 20

dB(I) = the logarithm to the base of ten of the ratio of two currents multiplied by 20

Examples:

$n = 10 \log (P_1/P_2)$ dB

$n = 20 \log (V_1/V_2)$ dB (V)

$n = 20 \log (I_1/I_2)$ dB (I)

In the latter two cases, when, **and only when**, the resistances appertaining to V_1 and V_2 (or I_1 and I_2) are equal or of negligible difference, the numerical value of n will be the same as that of the first case, and the subscripts (V) and (I) may be omitted.