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Edition 3.0 2010-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Semiconductor devices – Discrete devices –
Part 7: Bipolar transistors

Dispositifs à semiconducteurs – Dispositifs discrets –
Partie 7: Transistors bipolaires

IEC 60747-7:2010

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International Standard IEC 60747-7 has been prepared by subcommittee 47E: Discrete semiconductor devices, of IEC technical committee 47: Semiconductor devices.

This third edition cancels and replaces the second edition published in 2000 and IEC 60747-7-5 published in 2005.

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

a) Clause 1 was amended by adding an item that should be included.
b) Clauses 3, 4, 5, 6 and 7 were amended by adding terms, definitions, suitable additions and deletions those should be included.
c) The text of the second edition was combined with that of IEC 60747-7-5.

This standard is to be read in conjunction with IEC 60747-1:2006.

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

FDIS	Report on voting
47E/404/FDIS	47E/408/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 the parts in the IEC 60747 series, under the general title *Semiconductor devices – Discrete devices*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

The committee has decided that the contents of this publication will remain unchanged until the stability 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- withdrawn,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 7: Bipolar transistors

1 Scope

This part of IEC 60747-7 gives the requirements applicable to the following sub-categories of bipolar transistors excluding microwave transistors.

– Small signal transistors (excluding switching and microwave applications);
– Linear power transistors (excluding switching, high-frequency, and microwave applications);
– High-frequency power transistors for amplifier and oscillator applications;
– Switching transistors for high speed switching and power switching applications;
– Resistor biased transistors.

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 60050-521:2002, *International Electrotechnical Vocabulary – Part 521: Semiconductor devices and integrated circuits*

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

IEC 60747-4:2007, *Semiconductor devices – Discrete devices – Part 4: Microwave diodes and transistors*

3 Terms and definitions

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

3.1 Specific functional regions

3.1.1
functional collector region
collection region that acquires principal-current charge carriers from the functional base region through the (collecting) junction between it and the functional base region

NOTE In the normal operating mode, this functional region is located in the collector region and, in the inverse operating mode, in the emitter region.

3.1.2
functional emitter region
supply region that delivers principal-current charge carriers into the functional base region through the (emitting) junction between it and the functional base region.

NOTE In the normal operating mode, this functional region is located in the emitter region and, in the inverse operating mode, in the collector region.

3.1.3
functional base region
control region through which the principal current passes and in which the concentration of principal-current charge carriers is the result of an applied base current

3.1.4
collector(-base) space-charge region;
collector(-base) depletion layer
space-charge region between the functional collector region and the functional base region

3.1.5
emitter(-base) space-charge region;
emitter(-base) depletion layer
space-charge region between the functional emitter region and the functional base region

3.2 Resistor biased transistor

3.2.1

general description
bipolar junction transistors that incorporate with two bias resistors. One bias resistor is connected between the In terminal and the base region and the another between the base region and the common terminal. The resistor biased transistor is specified as a logic circuit element.

The graphical symbol as shown in Figure 1 is used in this standard for resistor biased transistors npn or pnp.

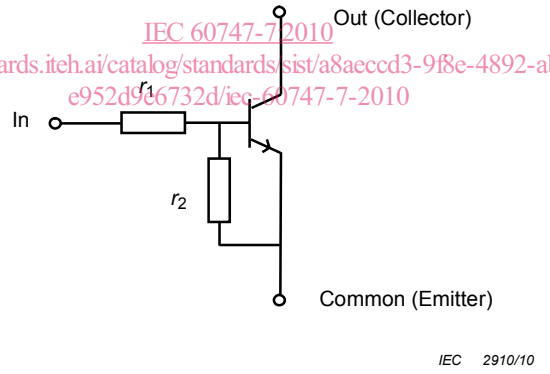

Figure 1 – Resistor biased transistor graphical symbol

3.2.2
input terminal
terminal connected to the bias resistor 1

3.2.3
output terminal
terminal connected to a collector

3.2.4
common terminal
terminal connected to an emitter

3.2.5
bias resistor 1
resistor connected between the input terminal and the internal base of the transistor

3.2.6
bias resistor 2
resistor connected between the internal base of the transistor and the common terminal

3.3 Terms related to ratings and characteristics

3.3.1
punch-through voltage
value of the collector-base voltage above which the open-circuit emitter-base voltage increases almost linearly with increasing collector-base voltage

NOTE 1 At this voltage, the collector depletion layer extends through the base to the emitter depletion layer.

NOTE 2 "Reach-through voltage" is a term also in the USA.

3.3.2
saturation voltages

3.3.2.1
collector-emitter saturation voltage
voltage between the collector and emitter electrodes under conditions of base current beyond which the collector current remains essentially constant as the base current increased.

NOTE This is the voltage between the collector and emitter electrodes when both the base-emitter and base-collector junctions are forward biased.

3.3.2.2
base-emitter saturation voltage

voltage between the base and emitter electrodes under conditions of emitter current or collector current and base current beyond which the collector current remains essentially constant as the base current increased.

NOTE This is the voltage between the base and emitter electrodes when both the base-emitter and base-collector junctions are forward biased.

3.3.3
cut-off current
reverse current
reverse current of the base-collector junction or base-emitter junction.

3.3.4
saturation resistance
resistance between collector and emitter terminals under specified conditions of base current and collector current when the collector current is limited by the external circuit

NOTE The saturation resistance may be determined either as the ratio of total voltage to total current or as the ratio of differential voltage to differential current; the method of determination should be specified.

3.3.5
emitter depletion layer capacitance
part of the capacitance across an emitter-base junction that is associated with its depletion layer

NOTE The emitter depletion layer capacitance is a function of the total potential difference across the depletion layer.

3.3.6
collector depletion layer capacitance
part of the capacitance across a collector-base junction that is associated with its depletion layer

NOTE The depletion layer capacitance is a function of the total potential difference across the depletion layer.

3.3.7
switching times
for bipolar transistors, the input waveform is the base current and the output waveform is the collector current. The lower and upper limits are usually 10% and 90% of the amplitude.

3.3.7.1
turn on delay time
rise time
carrier storage time
fall time
$t_{d(on)}$, t_r, t_s and t_f
see IEC 60050-521:2002,521-05-21, IEC 60050-521:2002,521-05-22, IEC 60050-521:2002, 521-05-23, IEC 60050-521:2002,521-05-24.

3.3.7.2
turn-on time
time interval between a step function change of the input signal level and the instant at which the magnitude of the signal at the output terminals reaches a specified upper limit when the semiconductor device is being switched from its non-conducting to its conducting state. The lower and upper limits are usually 10 % and 90 % of the amplitude.

3.3.7.3
turn-off time
time interval between a step function change of the input signal level and the instant at which the magnitude of the signal at the output terminals reaches a specified lower limit when the semiconductor device is being switched from its conducting to its non-conducting state. The lower and upper limits are usually 10 % and 90 % of the amplitude.

3.3.8
collector-emitter sustaining voltage
$V_{CE\ (SUS)}$

collector-emitter breakdown voltage at higher values of collector current where the breakdown voltage is relatively constant over decreasing collector current for a specified termination between base and emitter terminals

3.3.9
turn-on energy (per pulse)
E_{on}
energy dissipated in transistor during turn-on

3.3.10
turn-off energy (per pulse)
E_{off}
energy dissipated in transistor during turn-off

3.3.11
maximum frequency of oscillation
maximum frequency at which a transistor can be made to oscillate under specified conditions

NOTE This frequency approximates to the transition frequency.

3.3.12
transition frequency
f_T
frequency at which the modulus of the common-emitter small-signal short-circuit forward current transfer ratio $|h_{21e}|$ has decreased to unity

3.3.13
transfer ratio

3.3.13.1
small-signal short-circuit forward current transfer ratio
ratio between the alternating output current and the small sinusoidal input current producing it under small-signal conditions, the output being short-circuited to a.c.

3.3.13.2
static value of the forward current transfer ratio
ratio between the continuous (direct) output and the continuous (direct) input current, the output voltage being held constant

3.3.13.3
inherent (large-signal) forward current transfer ratio
difference between the continuous (direct) collector current and the collector-base cut-off current divided by the sum of the continuous (direct) base current and the collector-base cut-off current at a specified constant value of the collector-emitter voltage

3.3.13.4
small-signal open-circuit reverse voltage transfer ratio
ratio of the alternating voltage appearing at the input terminals, when they are a.c. open-circuited, to the alternating voltage applied to the output terminals, under small-signal conditions

3.3.13.5
transient current ratio in saturation (of a switching transistor)
quotient of the collector current suddenly demanded from a transistor and the minimum base current necessary to hold it in saturation

3.3.14
resistor ratio (of resistor biased transistor)
ratio of the values of bias resistor 2 and bias resistor 1

3.3.15
input voltage (of resistor biased transistor)
voltage between the input terminal and the common terminal of the device

3.3.16
off-state input voltage (of resistor biased transistor)
input voltage at which the output current has reached its defined off-state value

3.3.17
on-state input voltage (of resistor biased transistor)
input voltage at which the output current has reached its defined on-state value

3.3.18
output voltage (of resistor biased transistor)
voltage between the output terminal and the common terminal of the device

3.3.19
off-state output current (of resistor biased transistor)
current flowing into the output terminal in the off-state

3.3.20
on-state output voltage (of resistor biased transistor)
current flowing into the output terminal in the off-state output voltage with specified I_i and I_o in such a way that the transistor is in its specified on state

4 Letter symbols

4.1 General

Mostly, existing letter symbols are added to the terms in titles. When several distinct forms exist, the most commonly used form is given.

Subclause 4.2 of IEC 60747-1:2006 applies.

4.2 Additional subscripts

In addition to the list of recommended general subscripts given in Clause 4 of IEC 60747-1:2006, the following subscripts are recommended for bipolar transistors:

B,b	=	base
C,c	=	collector
E,e	=	emitter
fl	=	floating
pt	=	punch-through (penetration, reach-through)
R,r (not as a first subscript)	=	specified resistance
sat	=	saturation
X	=	specified circuit
s	=	storage
T	=	transition

4.3 Lists of letter symbols

4.3.1 General

The symbols contained in the following lists are recommended for use in the field of bipolar transistors. They have been compiled in accordance with the general rules in Clause 4 of IEC 60747-1:2006.