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Semiconductor devices –
Discrete devices –

Part 7-5:
Bipolar transistors for power switching applications

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SEMICONDUCTOR DEVICES – DISCRETE DEVICES –

Part 7-5: Bipolar transistors for power switching applications

FOREWORD

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International Standard IEC 60747-7-5 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/279/FDIS	47E/283/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 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- withdrawn;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.

A bilingual version of this standard may be issued at a later date.

SEMICONDUCTOR DEVICES – DISCRETE DEVICES –

Part 7-5: Bipolar transistors for power switching applications

1 Scope

This part of IEC 60747 gives requirements for bipolar switching transistors used for power switching application above 1 A.

NOTE Requirements concerning bipolar transistors in general can be found in IEC 60747-7.

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

IEC 60747-1:1983, *Semiconductor devices – Discrete devices and integrated circuits – Part 1: General*

3 Terms and definitions

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

3.1
switching times
$t_{d(on)}$, t_r, t_s and t_f
as described in IEC 60747-1, but here the input waveform is the base current and the output waveform is the collector current

3.2
collector-emitter sustaining voltage
$V_{CE\_(SUS)}$
the 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
turn-on energy (per pulse)
E_{on}
energy dissipated in transistor during turn-on

3.4
turn-off energy (per pulse)
E_{off}
energy dissipated in transistor during turn-off

4 Letter symbols – Energies

See IEC 60747-7.

Name and designation	Letter symbol	Remarks
Turn-on energy	E_{on}	Energy is always per pulse
Turn-off energy	E_{off}	

5 Essential ratings and characteristics

5.1 Ratings (limiting values)

Ratings shall be valid for the whole range of operating conditions as stated for the particular device, with reference to a curve where appropriate.

5.1.1 Temperatures

5.1.1.1 Minimum and maximum of operating temperatures, ambient or case or virtual junction (T_a or $T_{c\ or}$ Tvj)

5.1.1.2 Minimum and maximum of storage temperatures (T_{stg})

5.1.2 Currents

The ratings must cover the operation of the device over the range of operating temperatures. Where such ratings are temperature dependent, this dependence should be indicated.

5.1.2.1 Maximum continuous collector current (I_C)

5.1.2.2 Where appropriate, maximum peak repetitive collector current, under specified conditions (I_{CRM}).

5.1.2.3 Maximum continuous base current (I_B)

5.1.2.4 Where appropriate, maximum peak repetitive base current, under specified conditions (I_{BRM}).

5.1.2.5 Where appropriate, maximum emitter current, continuous and/or peak repetitive, under specified conditions (I_E, I_{ERM}).

5.1.3 Voltages

5.1.3.1 Maximum collector-base voltage with zero emitter current (V_{CBO})

5.1.3.2 Maximum collector-emitter voltage, either with zero base current or with a specified emitter-base reverse voltage (V_{CEO} or V_{CEX}).

5.1.3.3 Maximum emitter-base voltage with zero collector current (V_{EBO}).

5.1.3.4 Collector-emitter sustaining voltage (V_{CEXsus}).

Maximum rated value at specified collector current and specified base-emitter (reverse) voltage

5.1.4 Power dissipation

5.1.4.1 Maximum total power dissipation (without additional cooling for ambient-rated devices) up to ambient or case temperature of 25 °C (P_{tot}).

5.1.4.2 Derating factor above 25 °C or, for case-rated devices, derating curve

5.1.5 Safe operating areas

5.1.5.1 Forward biased safe operating area (FBSOA)

Diagram showing the area of collector currents (I_C) and collector-emitter voltages (V_{CE}) which the transistor will sustain simultaneously without being damaged by thermal overload or by the first or second breakdown, for d.c. and pulse operation.

Conditions to be specified:

– case temperature (T_c);

– pulse time (t_P);

– duty cycle (δ).

5.1.5.2 Reverse biased safe operating area (RBSOA)

Diagram showing the area of collector currents (I_C) and collector-emitter voltages (V_{CE}) which the transistor will sustain simultaneously for a short period of time during turn-off without being damaged

Conditions to be specified:

– case temperature (T_c);

– reverse base current (I_{B2});

– conditions in the drive circuit.

5.1.5.3 Short-circuit safe operating area (SCSOA)

The SCSOA is given by a pair of values of short-circuit duration ($t_{p(sc)}$) and collector-emitter voltage (V_{CE}) that may not be exceeded under the load short circuit conditions. The device may be turned on and turned off again for shorting a voltage source without failure.

5.2 Characteristics

5.2.1 Cut-off currents

NOTE One or more of these currents should be stated.

5.2.1.1 Collector-base current (I_{CBO})

– Maximum value at 25 °C, preferably at the maximum rated value of the collector-base voltage and with the emitter open-circuited.

– Maximum value at a high operating temperature, at a voltage preferably between 65 % and 85 % of the maximum rated collector-base voltage, and with the emitter open-circuited.

5.2.1.2 Collector-emitter current (I_{CEX})

– Maximum value at 25 °C, preferably at the maximum rated value of collector-emitter voltage and under specified base-emitter bias conditions.

– Maximum value at a high operating temperature, at a voltage preferably between 65 % and 85 % of the maximum rated collector-emitter voltage and under specified base-emitter bias conditions.

5.2.1.3 Collector-emitter current (I_{CES})

– Maximum value at 25 °C, preferably at the maximum rated value of the collector-emitter voltage and with the base short-circuited to the emitter.

– Maximum value at a high operating temperature, at a voltage preferably between 65 % and 85 % of the maximum rated collector-emitter voltage and with the base short-circuited to the emitter.

5.2.1.4 Collector-emitter current (I_{CER})

– Maximum value at 25 °C, preferably at the maximum rated collector-emitter voltage and with a specified base-emitter resistance.

– Maximum value at a high operating temperature, at a voltage preferably between 65 % and 85 % of the maximum rated collector-emitter voltage and with a specified base-emitter resistance.

5.2.1.5 Emitter-base current (I_{EBO})

– Maximum value at 25 °C at a specified high value of the emitter-base voltage and with the collector open-circuited.

– Maximum value at a high operating temperature and at a specified emitter-base voltage, and with the collector open-circuited.

5.2.2 Static value of common-emitter forward current transfer ratio *(h_{FE})*

Minimum value at 25 °C, at specified collector current and collector-emitter voltage.

5.2.3 Collector-emitter saturation voltage (V_{CEsat})

Maximum value at 25 °C, for at least one specified collector current and specified base current

5.2.4 Base-emitter saturation voltage (V_{BEsat})

Maximum value at 25 °C, at specified collector and base currents.

5.2.5 Turn-on energy (E_{on})

Maximum value per pulse with inductive load under specified conditions of T_a or T_c or T_{vj}, high V_{CE} , high I_C and I_B .

5.2.6 Turn-off energy (E_{off})

Maximum value per pulse with inductive load under specified conditions of T_a or T_c or T_{vj},high V_{CE} , high I_C and I_B.

5.2.7 Switching times

5.2.7.1 Turn-on delay time ($t_{d(on)}$)

Maximum value for resistive load under specified conditions.

5.2.7.2 Rise time (t_r)

Maximum value, at nominal values of collector current (I_C) and base forward current (I_{B1}).

5.2.7.3 Turn-on time (t_{on})

Maximum value, at nominal values of collector current (I_C), base forward current (I_{B1}) and base-emitter voltage (V_{BE}) prior to turn-on pulse.

5.2.7.4 Storage time (t_s)

Maximum value, at nominal values of collector current (I_C) and base forward and reverse currents (I_{B1} and I_{B2}).

5.2.7.5 Fall time (t_f)

Maximum value for resistive load under specified conditions.

5.2.7.6 Turn-off time (t_{off})

Maximum value, at nominal values of collector current (I_C) and base forward and reverse currents (I_{B1} and I_{B2}).

5.2.8 Thermal resistance junction to case ($R_{th(j-c)}$)

Maximum value for case-rated transistors.

5.2.9 Thermal resistance junction to ambient ($R_{th(j-a)}$)

Maximum value for ambient-rated transistors.

5.2.10 Transient thermal impedance junction to case ($Z_{th(j-c)}$)

For case-rated transistors, diagram showing the maximum value against the time which has elapsed after a step change in power dissipation.

5.2.11 Transient thermal impedance junction to ambient ($Z_{th(j-a)}$)

For ambient-rated transistors, diagram showing the maximum value against the time which has elapsed after a step change in power dissipation.

6 Measuring methods

6.1 Verification of ratings (limiting values)

Table 1 – Failure defining characteristics and failure criteria

Failure-defining Characteristics	Failure criteria	Measurement conditions
I_{CES}	I_{CES}> USL	Specified V_{CE}
V_{CEsat}	V_{CEsat}>USL	I_C specified for V_{CEsat}
USL: upper specified limit.		

6.1.1 Voltages and currents

6.1.1.1 Collector current (I_C)

6.1.1.1.1 Purpose

To verify that the collector current capability of a transistor is not less than the maximum rated value I_C under specified conditions.