Bipolar Transistors
Terms used in data sheets

Description

This document describes the terms used in data sheets bipolar transistors.

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1. Glossary

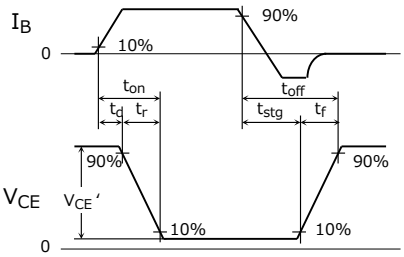
1.1. Absolute maximum ratings

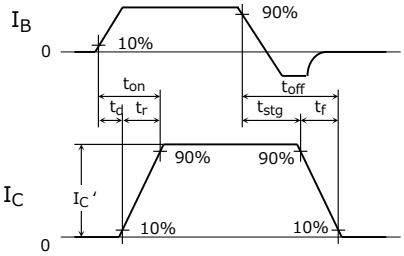
Term	Symbol	Description
Collector-base voltage	V_{CBO}	The maximum allowable voltage between the collector and base terminals when the emitter terminal is open-circuited
Collector-emitter voltage	V_{CEO}	The maximum allowable voltage between the collector and emitter terminals when the base terminal is open-circuited
	V_{CER}	The maximum allowable voltage between the collector and emitter terminals when a resistor is connected between the base and emitter terminals
	V_{CEX}	The maximum allowable voltage in the cut-off state between the collector and emitter terminals with reverse bias applied between the base and emitter terminals
	V_{CES}	The maximum allowable voltage between the collector and emitter terminals in the cut-off state when the base and emitter terminals are short-circuited
Emitter-base voltage	V_{EBO}	The maximum allowable voltage in the cut-off state between the emitter and base terminals when the collector terminal is open-circuited
Collector current (DC)	I_C	The maximum allowable continuous current into the collector terminal
Collector current (pulsed)	I_{CP}	The maximum allowable pulsed current into the collector terminal
Emitter current	I_E	The maximum allowable continuous current into the emitter terminal
Base current	I_B	The maximum allowable continuous current into the base terminal
Collector power dissipation	P_C	The maximum allowable power dissipated across the collector and emitter terminals
Junction temperature	T_j	The maximum allowable temperature at the junction of the transistor
Storage temperature	T_{stg}	The ambient temperature range over which the device, without any voltage applied, can be stored and transported

1.2. Electrical Characteristics

Term	Symbol	Description
Collector-base breakdown voltage	$V_{(BR)CBO}$	The breakdown voltage between the collector and base terminals under specified test conditions when the emitter terminal is open-circuited
Collector-emitter breakdown voltage	$V_{(BR)(CEO)}$	The breakdown voltage between the collector and emitter terminals under specified test conditions when the base terminal is open-circuited
	$V_{(BR)CER}$	The breakdown voltage between the collector and emitter terminals under specified test conditions when a resistor is connected between the base and emitter terminals
	$V_{(BR)CEX}$	The breakdown voltage between the collector and emitter terminals under specified test conditions when a reverse bias is applied between the base and emitter terminals
	$V_{(BR)CES}$	The breakdown voltage between the collector and emitter terminals under specified test conditions when the base and emitter terminals are short-circuited
Emitter-base breakdown voltage	$V_{(BR)EBO}$	The breakdown voltage between the emitter and base terminals under specified test conditions when the collector terminal is open-circuited
Collector-base cut-off current	I_{CBO}	The current in the cut-off state that flows into the collector terminal under specified test conditions when a voltage is applied across the collector and base terminals with the emitter terminal open-circuited
Collector-emitter cut-off current	I_{CEO}	The current in the cut-off state that flows into the collector terminal under specified test conditions when a voltage is applied between the collector and emitter terminals with the base terminal open-circuited
Emitter-base cut-off current	I_{EBO}	The current in the cut-off state that flows into the emitter terminal under specified test conditions when a voltage is applied between the emitter and base terminals with the collector terminal open-circuited
DC current gain	h_{FE}	The ratio of the collector current to the base current in a common-emitter configuration under specified test conditions DC current gain = collector current / base current

Term	Symbol	Description
Collector-emitter saturation voltage	$V_{CE(sat)}$	The voltage between the collector and emitter terminals in the saturation state under specified test conditions
Base-emitter saturation voltage	$V_{BE(sat)}$	The voltage between the base and emitter terminals in the saturation state under specified test conditions
Collector output capacitance	C_{ob}	The capacitance between collector and base at the specified collector-base voltage and frequency when the emitter terminal is open-circuited
Emitter input capacitance	C_{ib}	The capacitance value between emitter and base at the specified emitter-base voltage and frequency when the base terminal is grounded
Reverse capacitance	C_{re}	The capacitance value when the input is ac short-circuited and the emitter terminal is grounded
Transition frequency	f_T	The frequency at which the current gain is 1 (= 0 dB) when the emitter is grounded
Noise figure	NF	The ratio of the input signal-to-noise ratio to the output signal-to-noise ratio of a device. NF is calculated as: $NF=10\ \log\left[\frac{(S/N)_{in}}{(S/N)_{out}}\right]^2$

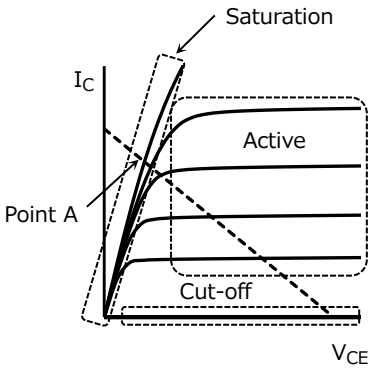
<table>
<tr><th>Term</th><th>Symbol</th><th colspan="2">Description</th></tr>
<tr><td>Delay time</td><td>t_d</td><td>The period of time from when the base current has reached 10% of its maximum amplitude to when the collector-emitter voltage has reached 90% of its maximum amplitude, or
the period of time required for the collector current to reach 10% of its maximum amplitude</td><td rowspan="2">Definition of collector-emitter voltage (V_{CE})
 

V_{CE}': Maximum amplitude of V_{CE}</td></tr>
<tr><td>Rise time</td><td>t_r</td><td>The period of time required for the collector-emitter voltage to decrease from 90% to 10% of its maximum amplitude, or
the period of time required for the collector current to increase from 10% to 90% of its maximum amplitude</td></tr>
<tr><td>Turn-on time</td><td>t_{on}</td><td>The period of time from when the base current has reached 10% of its maximum amplitude to when the collector-emitter voltage has reached 10% of its maximum amplitude, or
the period of time required for the collector current to reach 90% of its maximum amplitude</td><td rowspan="2">Definition of collector current (I_C)
 

I_C': Maximum amplitude of I_C</td></tr>
<tr><td>Storage time</td><td>t_{stg}</td><td>The period of time from when base current has dropped to 90% of its maximum amplitude to when the collector-emitter voltage has reached 10% of its maximum amplitude, or
the period of time from when the base current has dropped to 90% of its maximum amplitude to when the collector-emitter voltage has reached 90% of its maximum amplitude</td></tr>
</table>

Term	Symbol	Description
Fall time	t_f	The period of time required for the collector-emitter voltage to increase from 10% to 90% of its maximum amplitude, or the period of time required for the collector current to decrease from 90% to 10% of its maximum amplitude
Turn-off time	t_{off}	The period of time from when the base current has reached 90% of its maximum amplitude to when the collector-emitter voltage has reached 90% of its maximum amplitude, or the time required for the collector current to reach 10% of its maximum amplitude

1.3. Other terms

Term	Description	
Cut-off region	The region where almost no collector current flows when the base and emitter are open-circuited, short-circuited, or reverse-biased	
Active region	The region where the collector current changes in proportion to the base current applied	
Saturation region	In this region, even if the base current is increased or decreased, the collector current on the load line hardly changes (Point A in the figure) and the collector current changes only when the collector-emitter voltage is changed.	
Forward-bias safe operating area	The region specified by the collector current and collector-emitter voltage conditions where a transistor operates without self-damage when the base -emitter is forward-biased	
Reverse-bias safe operating area	The region bounded by the collector current and collector-emitter voltage conditions where a transistor can safely transition to the cut-off region from the “on” state without self-damage when the base-emitter is reverse-biased	

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