

January 1990  
Edition 1.1

FUJITSU

## PRODUCT PROFILE

**2SC3178, 2SC3059, 2SC3060, 2SC3061****Silicon High Speed Power Transistor****DESCRIPTION**

This series are silicon NPN planer general purpose, high power switching transistors fabricated with Fujitsu's unique Ring Emitter Transistor (RET) technology. RET devices are constructed with multiple emitters connected through ballast resistors which provide uniform current density. This structure permits the design of high power transistors with superior switching characteristics and frequency response in high current applications.

This series are especially well-suited for high speed/high voltage switching systems or other applications where large SOA is required.

**Features**

- High voltage
- Ultra-fast switching
- Large safe operating area

**Applications**

- Switching regulators
- Motor controls
- Ultrasonic oscillators
- Class C and D amplifiers
- Deflection circuits

**Outline of the Series**

Item	Symbol	2SC3178	2SC3059	2SC3060	2SC3061	Unit
Collector to Base Breakdown Voltage	$V_{CBO}$	1200				V
Collector to Emitter Breakdown Voltage	$V_{CEO}$	850				V
Emitter to Base Breakdown Voltage	$V_{EBO}$	7				V
Collector Current (continuous)	$I_C$	2		5	10	A
Collector Current (pulsed)	$I_{CP}$	4		8	20	A
Collector Power Dissipation	$P_C$	60	100	150	200	W
Reverse Bias Safe Operating Area @ 900V	RBSOA	2.5		5	7	A
Rise Time (Typ.)	$t_r$	0.20				$\mu s$
Storage Time (Typ.)	$t_{stg}$	2.50				$\mu s$
Fall Time (Typ.)	$t_f$	0.07				$\mu s$
Collector to Emitter Saturation Voltage (Typ.)	$V_{CE(sat)}$	0.3				V
Base to Emitter Saturation Voltage (Typ.)	$V_{BE(sat)}$	1.0				V
Package	—	TO-220	TO-3			—

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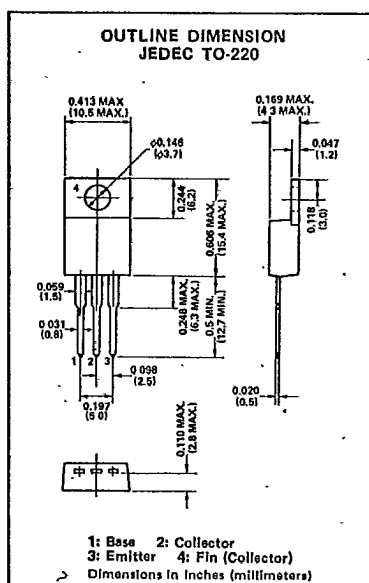


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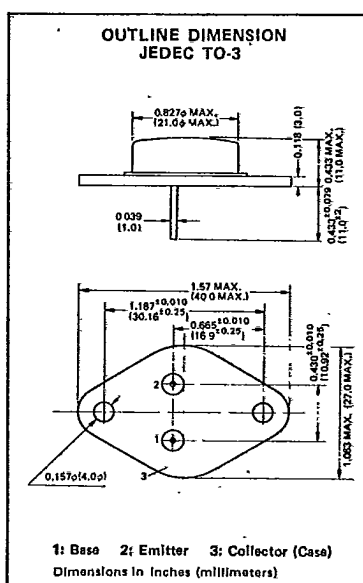
2SC3178, 2SC3059, 2SC3060, 2SC3061

OUTLINE DIMENSION

2SC3178



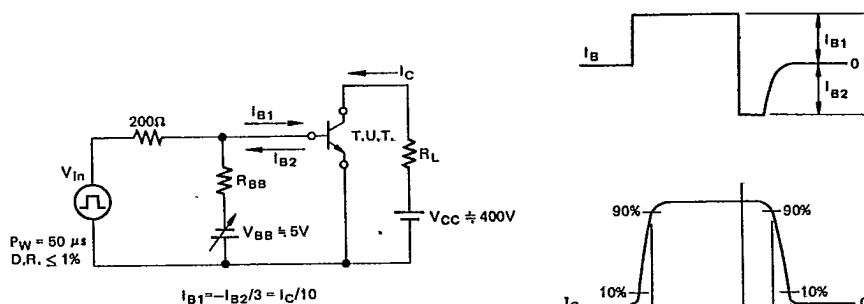
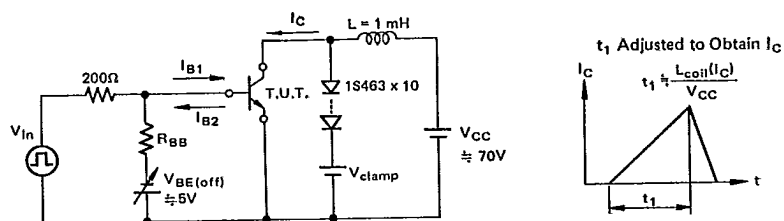
2SC3059  
2SC3060  
2SC3061



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2SC3178, 2SC3059, 2SC3060, 2SC3061

## TEST CIRCUIT USED FOR MEASUREMENT OF SWITCHING TIME (RESISTIVE)


TEST CIRCUIT USED FOR MEASUREMENT OF  $V_{CEX}(SUS)$  AND REVERSE BIAS SAFE OPERATING AREA

 $V_{CEX}(SUS)$ 

Type No.	$I_C$ (A)	$I_{B2}$ (A)	$R_{BB}(\Omega)$
2SC3178	2.5	-0.3	20
2SC3059	5.0	-0.6	10
2SC3060	7.0	-1.2	5

 $V_{clamp} = 900V$ 

## REVERSE BIAS SAFE OPERATING AREA

Type No.	$I_{B2}$ (A)	$R_{BB}(\Omega)$
2SC3178	-0.3	20
2SC3059	-0.6	10
2SC3060	-1.2	5

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2SC3178

Silicon High Speed Power Transistor

## ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector to Emitter Voltage	$V_{CEO}$	850	V
Collector to Base Voltage	$V_{CBO}$	1200	V
Emitter to Base Voltage	$V_{EBO}$	7	V
Collector Current-Continuous	$I_C$	2	A
Collector Current-Pulsed $P_W \leq 25 \mu s$ , $DR \leq 50\%$	$I_{CP}$	4	A
Base Current-Continuous	$I_B$	1	A
Collector Power Dissipation ( $T_C = 25^\circ C$ )	$P_C$	60	W
Junction Temperature	$T_J$	+150	$^\circ C$
Storage Temperature Range	$T_{stg}$	-55 ~ +150	$^\circ C$

ELECTRICAL CHARACTERISTICS ( $T_a = 25^\circ C$ )

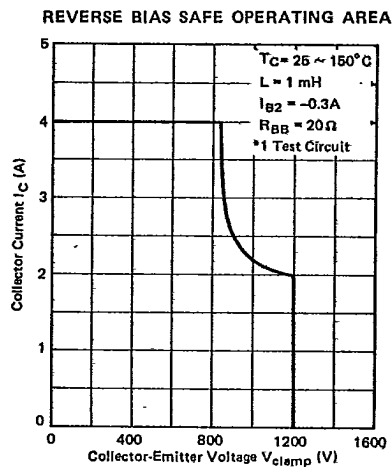
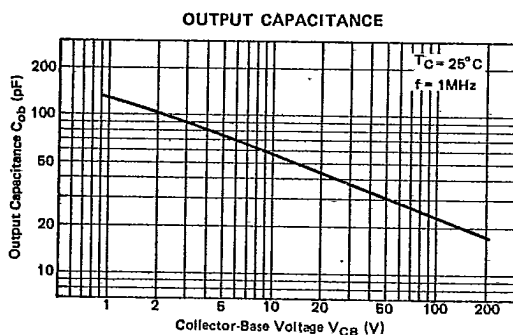
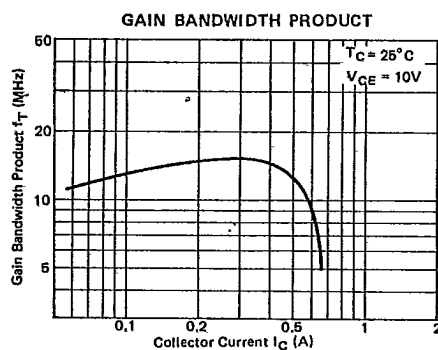
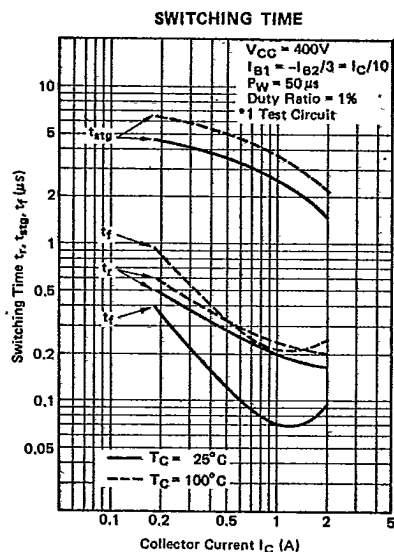
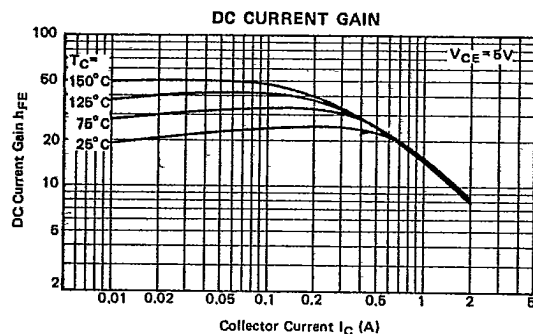
Parameter	Symbol	Test Conditions	Limit			Unit
			Min.	Typ.	Max.	
Collector to Base Breakdown Voltage	$V_{(BR)CBO}$	$I_C = 1mA, I_E = 0$	1200	—	—	V
Emitter to Base Breakdown Voltage	$V_{(BR)EBO}$	$I_E = 1mA, I_C = 0$	7	—	—	V
Collector to Emitter Sustaining Voltage	$V_{(BR)CEO}$	$I_C = 10mA, R_{BE} = \infty \Omega$	850	—	—	V
Collector to Emitter Sustaining Voltage	$V_{CEX(SUS)}$	$I_C = 2.5A, I_{B2} = -0.3A, L = 1mH(*1)$	900	—	—	V
Collector Cutoff Current	$I_{CBO}$	$V_{CB} = 1000V, I_E = 0$	—	—	100	$\mu A$
Collector Cutoff Current	$I_{CBO}$	$V_{CB} = 1000V, I_E = 0, T_C = 100^\circ C$	—	—	1	mA
Emitter Cutoff Current	$I_{EBO}$	$V_{EB} = 6V, I_C = 0$	—	—	100	$\mu A$
DC Current Gain	$h_{FE}$	$V_{CE} = 5V, I_C = 1A(*2)$	10	15	30	—
Collector to Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C = 1A, I_B = 0.2A(*2)$	—	0.3	1.5	V
Base to Emitter Saturation Voltage	$V_{BE(sat)}$		—	1.0	2.0	V
Output Capacitance	$C_{ob}$	$V_{CB} = 10V, I_E = 0, f = 1MHz$	—	60	—	pF
Gain Bandwidth Product	$f_T$	$V_{CE} = 10V, I_C = 0.2A$	—	15	—	MHz
Rise Time	$t_r$	$V_{CC} = 400V(*1)$ $I_C = 1A, 3I_{B1} = -I_{B2} = 0.3A$	—	0.2	0.5	$\mu s$
Storage Time	$t_{stg}$		—	2.5	3.5	$\mu s$
Fall Time	$t_f$		—	0.07	0.3	$\mu s$

\*1 Test Circuit    \*2 Pulse  $P_W \leq 300 \mu s$ , Duty Ratio  $\leq 6\%$ 

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2SC3178

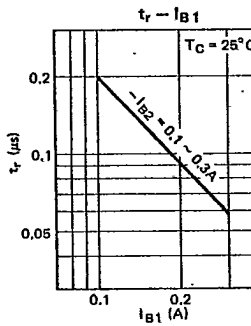
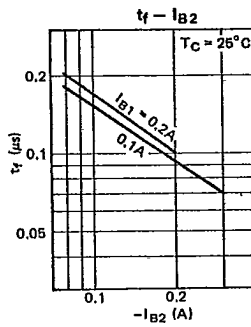
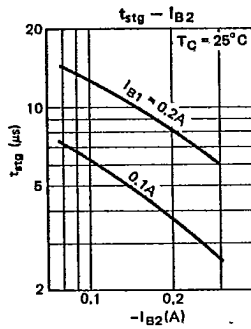


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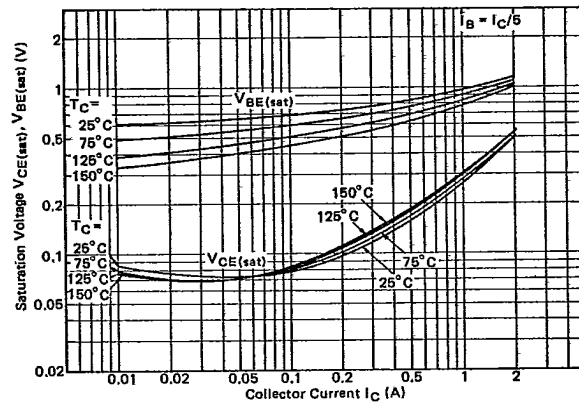
2SC3178

SWITCHING TIME

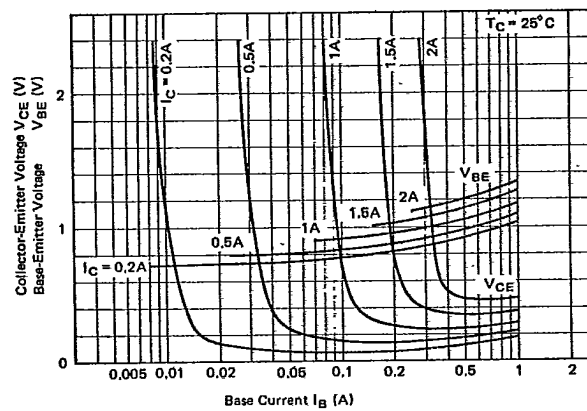
$V_{CC} = 400V$   
 $I_C = 1A$   
 $P_W = 60 \mu s$   
 Duty ratio = 1%



SATURATION VOLTAGE



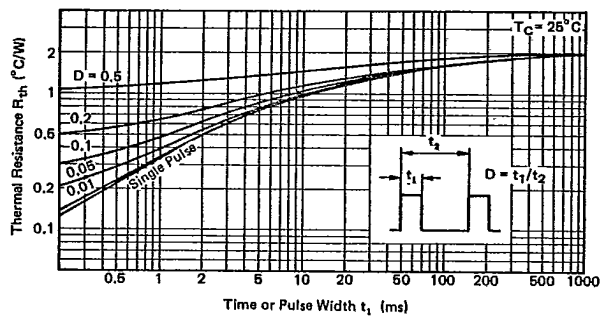
COLLECTOR SATURATION REGION



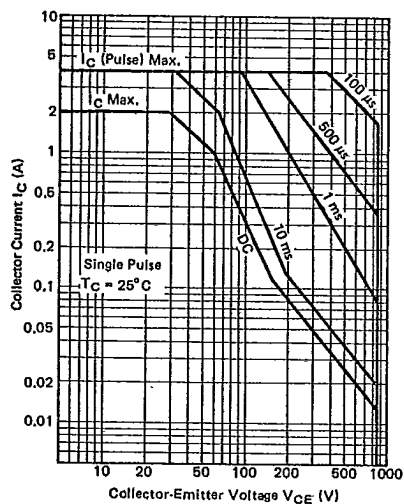
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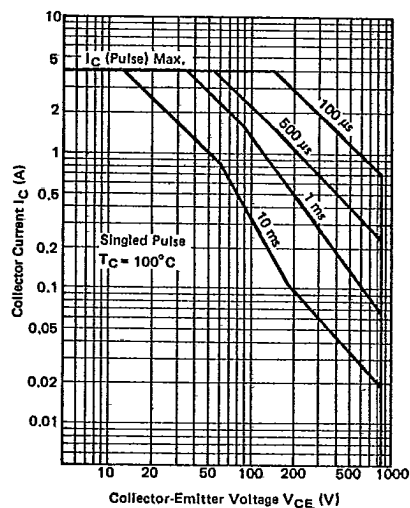
## THERMAL RESPONSE



## FOWARD BIAS SAFE OPERATING AREA



## FOWARD BIAS SAFE OPERATING AREA





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PRODUCT PROFILE

**2SC3059****T-33-01****Silicon High Speed Power Transistor**

## ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector to Emitter Voltage	$V_{CE0}$	850	V
Collector to Base Voltage	$V_{CBO}$	1200	V
Emitter to Base Voltage	$V_{EBO}$	7	V
Collector Current-Continuous	$I_C$	2	A
Collector Current-Pulsed $P_W \leq 25 \mu s$ , D.R. $\leq 50\%$	$I_{CP}$	4	A
Base Current-Continuous	$I_B$	1	A
Collector Power Dissipation ( $T_C = 25^\circ C$ )	$P_C$	100	W
Junction Temperature	$T_J$	+175	$^\circ C$
Storage Temperature Range	$T_{stg}$	-65 ~ +175	$^\circ C$

ELECTRICAL CHARACTERISTICS ( $T_a = 25^\circ C$ )

Parameter	Symbol	Test Conditions	Limit			Unit
			Min.	Typ.	Max.	
Collector to Base Breakdown Voltage	$V_{(BR)CBO}$	$I_C = 1mA, I_E = 0$	1200	—	—	V
Emitter to Base Breakdown Voltage	$V_{(BR)EBO}$	$I_E = 1mA, I_C = 0$	7	—	—	V
Collector to Emitter Sustaining Voltage	$V_{(BR)CEO}$	$I_C = 10mA, R_{BE} = \infty \Omega$	850	—	—	V
Collector to Emitter Sustaining Voltage	$V_{CEX(SUS)}$	$I_C = 2.5A, I_{B2} = -0.3A, L = 1mH(*1)$	900	—	—	V
Collector Cutoff Current	$I_{CBO}$	$V_{CB} = 1000V, I_E = 0$	—	—	100	$\mu A$
Collector Cutoff Current	$I_{CBO}$	$V_{CB} = 1000V, I_E = 0, T_C = 100^\circ C$	—	—	1	mA
Emitter Cutoff Current	$I_{EBO}$	$V_{EB} = 6V, I_C = 0$	—	—	100	$\mu A$
DC Current Gain	$h_{FE}$	$V_{CE} = 5V, I_C = 1A(*2)$	10	15	30	—
Collector to Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C = 1A, I_B = 0.2A(*2)$	—	0.3	1.5	V
Base to Emitter Saturation Voltage	$V_{BE(sat)}$		—	1.0	2.0	V
Output Capacitance	$C_{ob}$	$V_{CB} = 10V, I_E = 0, f = 1MHz$	—	60	—	PF
Gain Bandwidth Product	$f_T$	$V_{CE} = 10V, I_C = 0.2A$	—	15	—	MHz
Rise Time	$t_r$	$V_{CC} = 400V(*1)$ $I_C = 1A, 3I_{B1} = -I_{B2} = 0.3A$	—	0.2	0.5	$\mu s$
Storage Time	$t_{stg}$		—	2.5	3.5	$\mu s$
Fall Time	$t_f$		—	0.07	0.3	$\mu s$

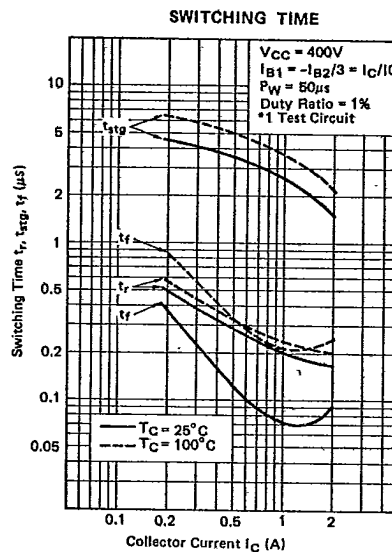
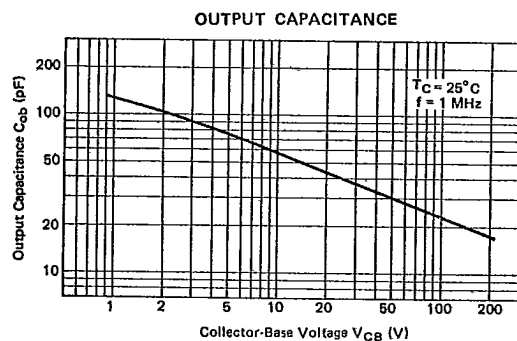
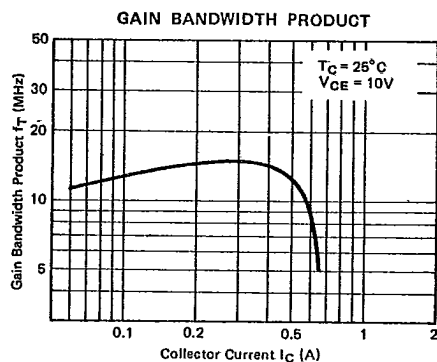
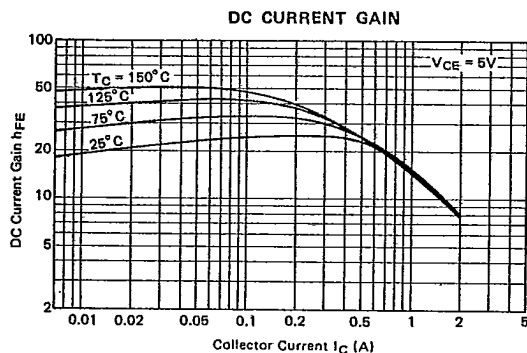
\*1 Test Circuit

\*2 Pulsed  $P_W \leq 300 \mu s$ , Duty Ratio  $\leq 6\%$ 

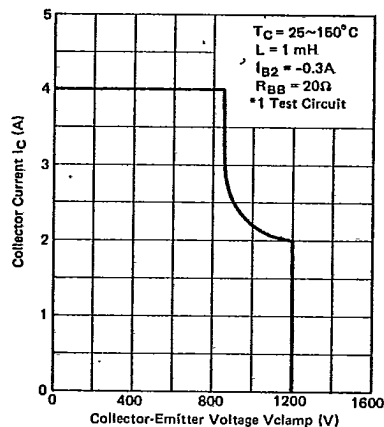
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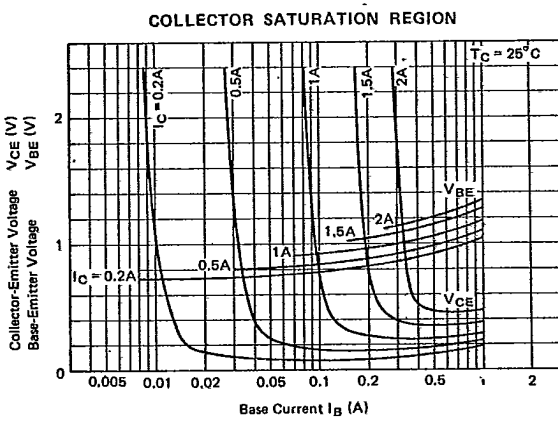
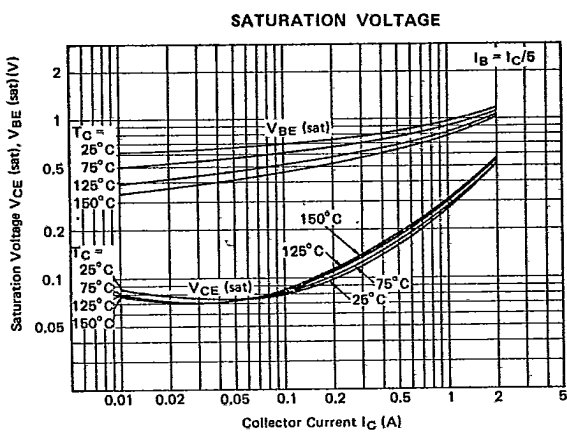
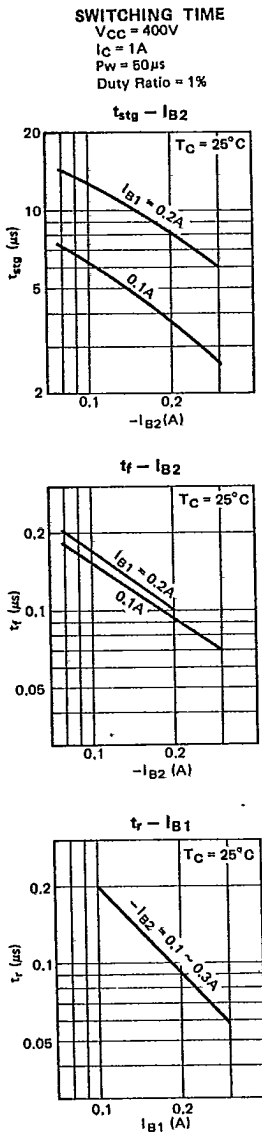


# REVERSE BIAS SAFE OPERATING AREA



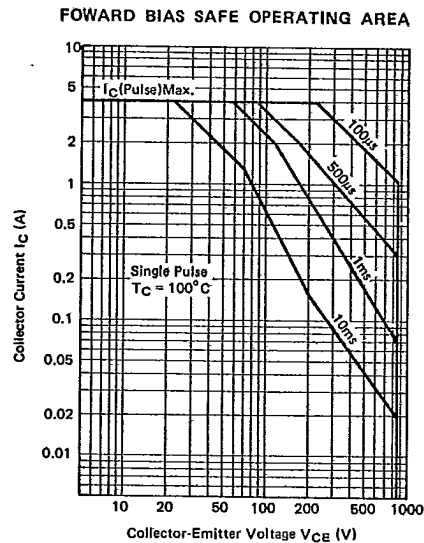
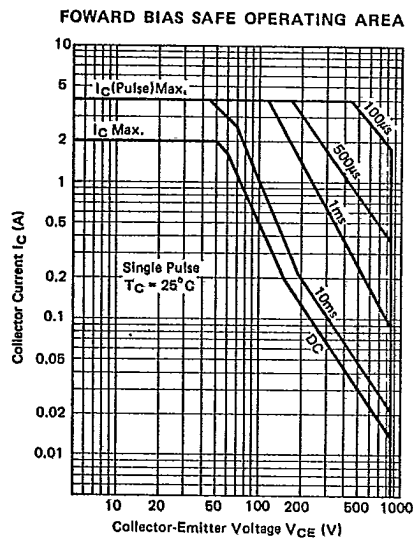
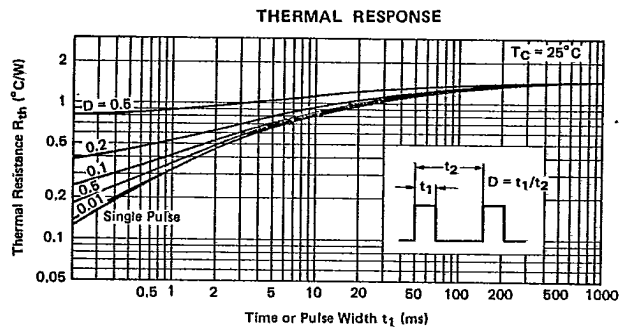
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2SC3059



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## PRODUCT PROFILE

**2SC3060****Silicon High Speed Power Transistor**

## ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector to Emitter Voltage	$V_{CEO}$	850	V
Collector to Base Voltage	$V_{CBO}$	1200	V
Emitter to Base Voltage	$V_{EBO}$	7	V
Collector Current-Continuous	$I_C$	5	A
Collector Current-Pulsed $P_W \leq 25 \mu s$ , D.R. $\leq 50\%$	$I_{CP}$	8	A
Base Current-Continuous	$I_B$	3	A
Collector Power Dissipation ( $T_C = 25^\circ C$ )	$P_C$	150	W
Junction Temperature	$T_J$	+175	$^\circ C$
Storage Temperature Range	$T_{stg}$	-65 ~ +175	$^\circ C$

ELECTRICAL CHARACTERISTICS ( $T_a = 25^\circ C$ )

Parameter	Symbol	Test Conditions	Limit			Unit
			Min.	Typ.	Max.	
Collector to Base Breakdown Voltage	$V_{(BR)CBO}$	$I_C = 1mA, I_E = 0$	1200	—	—	V
Emitter to Base Breakdown Voltage	$V_{(BR)EBO}$	$I_E = 1mA, I_C = 0$	7	—	—	V
Collector to Emitter Sustaining Voltage	$V_{(BR)CEO}$	$I_C = 10mA, R_{BE} = \infty \Omega$	850	—	—	V
Collector to Emitter Sustaining Voltage	$V_{CEX(SUS)}$	$I_C = 5A, I_{B2} = -0.6A, L = 1mH(*1)$	900	—	—	V
Collector Cutoff Current	$I_{CBO}$	$V_{CB} = 1000V, I_E = 0$	—	—	100	$\mu A$
Collector Cutoff Current	$I_{CBO}$	$V_{CB} = 1000V, I_E = 0, T_C = 100^\circ C$	—	—	1	mA
Emitter Cutoff Current	$I_{EBO}$	$V_{EB} = 6V, I_C = 0$	—	—	100	$\mu A$
DC Current Gain	$h_{FE}$	$V_{CE} = 5V, I_C = 2A(*2)$	10	15	30	—
Collector to Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C = 2A, I_B = 0.4A(*2)$	—	0.3	1.5	V
Base to Emitter Saturation Voltage	$V_{BE(sat)}$		—	1.0	2.0	V
Output Capacitance	$C_{ob}$	$V_{CB} = 10V, I_E = 0, f = 1MHz$	—	120	—	PF
Gain Bandwidth Product	$f_T$	$V_{CE} = 10V, I_C = 0.5A$	—	15	—	MHz
Rise Time	$t_r$	$V_{CC} = 400V(*1)$ $I_C = 2A, 3I_{B1} = -I_{B2} = 0.6A$	—	0.2	0.5	$\mu s$
Storage Time	$t_{stg}$		—	2.5	3.5	$\mu s$
Fall Time	$t_f$		—	0.07	0.3	$\mu s$

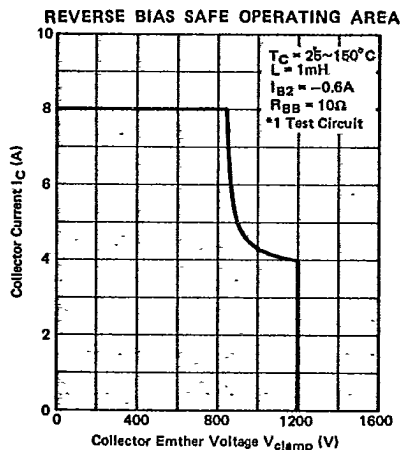
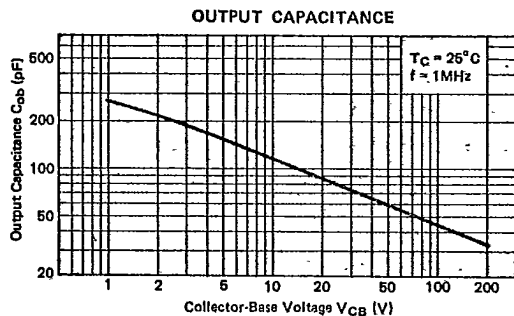
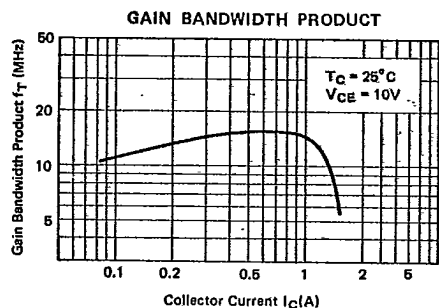
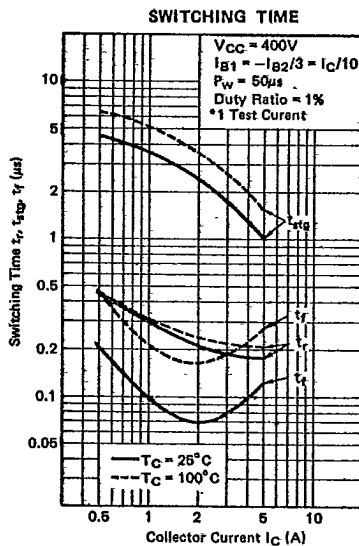
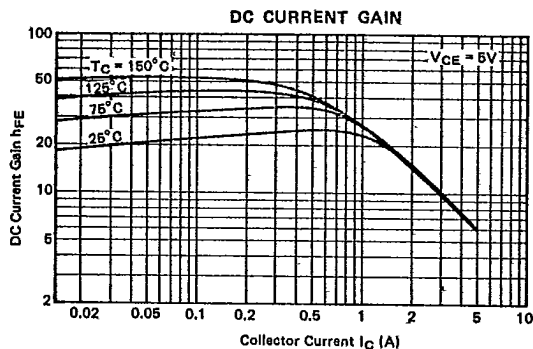
\*1 Test Circuit

\*2 Pulsed  $P_W \leq 300 \mu s$ , Duty Ratio  $\leq 6\%$ 

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## 2SC3060



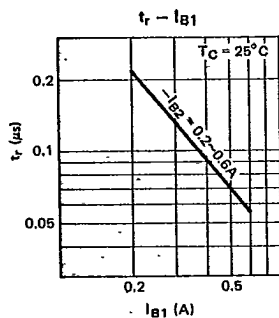
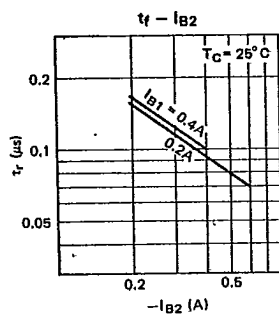
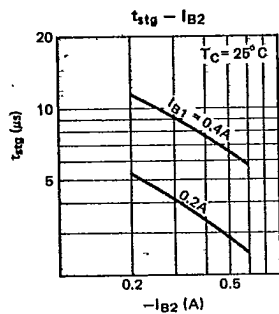
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2SC3060

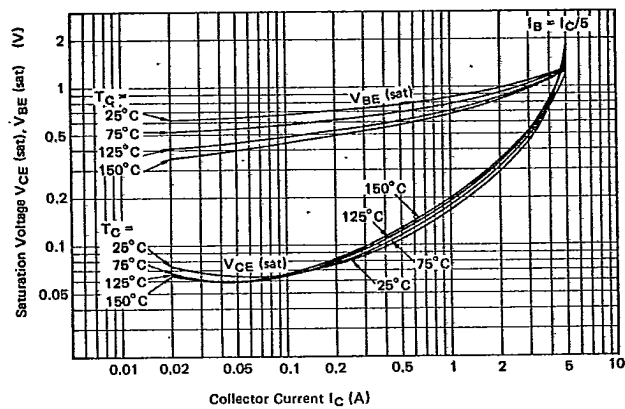
## SWITCHING TIME

 $V_{CC} = 400V$  $I_C = 2A$  $P_W = 60\mu s$ 

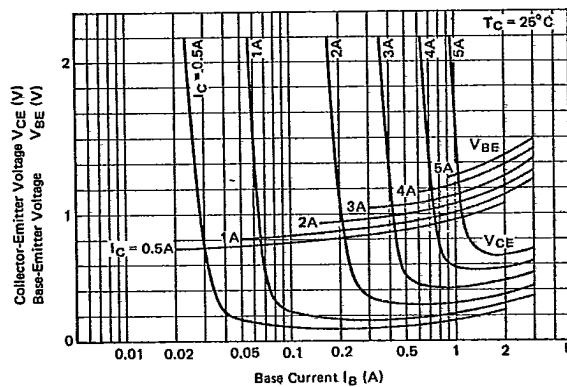
Duty Ratio = 1%



## SATURATION VOLTAGE



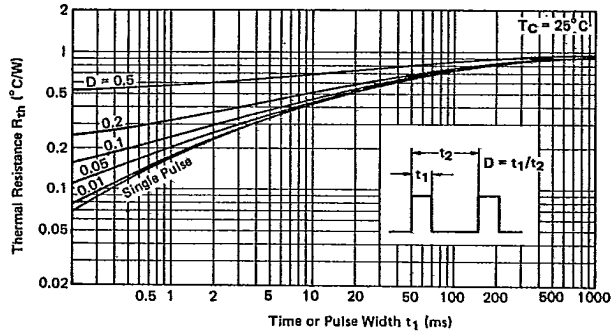
## COLLECTOR SATURATION REGION



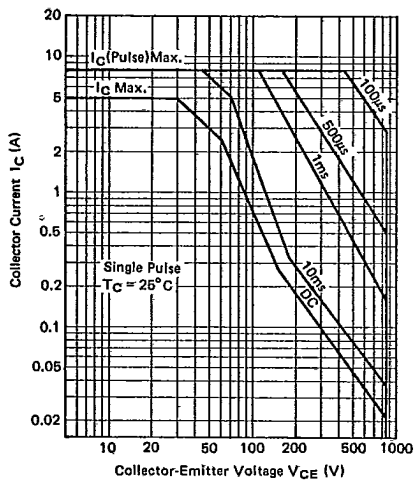
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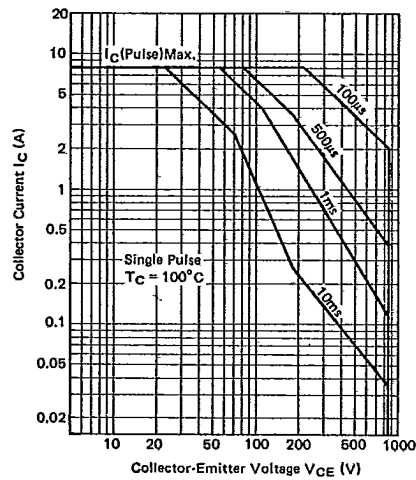
THERMAL RESPONSE



FORWARD BIAS SAFE OPERATING AREA



FORWARD BIAS SAFE OPERATING AREA





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Edition 1.1T-33-01  
FUJITSU

PRODUCT PROFILE

**2SC3061****Silicon High Speed Power Transistor****ABSOLUTE MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector to Emitter Voltage	$V_{CEO}$	850	V
Collector to Base Voltage	$V_{CBO}$	1200	V
Emitter to Base Voltage	$V_{EBO}$	7	V
Collector Current-Continuous	$I_C$	10	A
Collector Current-Pulsed $P_W \leq 25 \mu s$ , $DR \leq 50\%$	$I_{CP}$	20	A
Base Current-Continuous	$I_B$	5	A
Collector Power Dissipation ( $T_C = 25^\circ C$ )	$P_C$	200	W
Junction Temperature	$T_J$	+175	$^\circ C$
Storage Temperature Range	$T_{stg}$	-65 ~ +175	$^\circ C$

**ELECTRICAL CHARACTERISTICS ( $T_a = 25^\circ C$ )**

Parameter	Symbol	Test Conditions	Limit			Unit
			Min.	Typ.	Max.	
Collector to Base Breakdown Voltage	$V_{(BR)CBO}$	$I_C = 1mA, I_E = 0$	1200	—	—	V
Emitter to Base Breakdown Voltage	$V_{(BR)EBO}$	$I_E = 1mA, I_C = 0$	7	—	—	V
Collector to Emitter Sustaining Voltage	$V_{(BR)CEO}$	$I_C = 10mA, R_{BE} = \infty \Omega$	850	—	—	V
Collector to Emitter Sustaining Voltage	$V_{CEX(sus)}$	$I_C = 7A, I_{B2} = -1.2A, L=1mH(*1)$	900	—	—	V
Collector Cutoff Current	$I_{CBO}$	$V_{CB} = 1000V, I_E = 0$	—	—	100	$\mu A$
Collector Cutoff Current	$I_{CBO}$	$V_{CB} = 1000V, I_E = 0, T_C = 100^\circ C$	—	—	1	mA
Emitter Cutoff Current	$I_{EBO}$	$V_{EB} = 6V, I_C = 0$	—	—	100	$\mu A$
DC Current Gain	$h_{FE}$	$V_{CE} = 5V, I_C = 4A(*2)$	10	15	30	—
Collector to Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C = 4A, I_B = 0.8A(*2)$	—	0.3	1.5	V
Base to Emitter Saturation Voltage	$V_{BE(sat)}$		—	1.0	2.0	V
Output Capacitance	$C_{ob}$	$V_{CB} = 10V, I_E = 0, f = 1MHz$	—	220	—	PF
Gain Bandwidth Product	$f_T$	$V_{CE} = 10V, I_C = 1A$	—	15	—	MHz
Rise Time	$t_r$	$V_{CC} = 400V(*1)$ $I_C = 4A, 3I_{B1} = -I_{B2} = 1.2A$	—	0.2	0.5	$\mu s$
Storage Time	$t_{stg}$		—	2.5	3.5	$\mu s$
Fall Time	$t_f$		—	0.07	0.3	$\mu s$

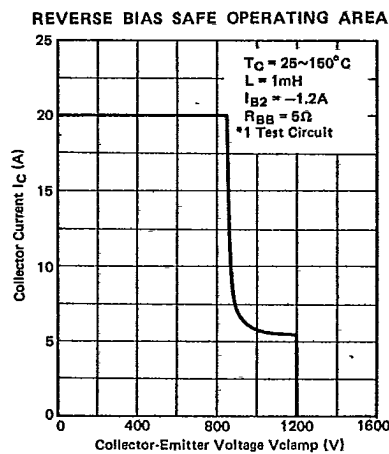
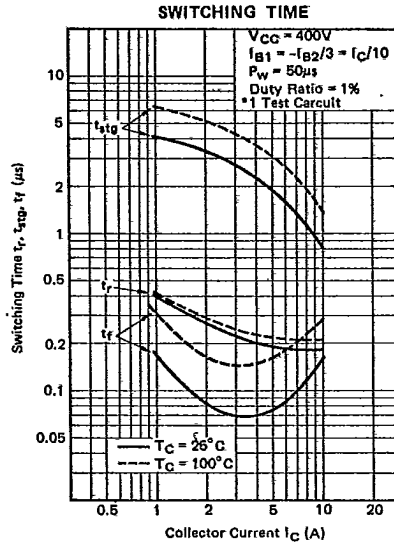
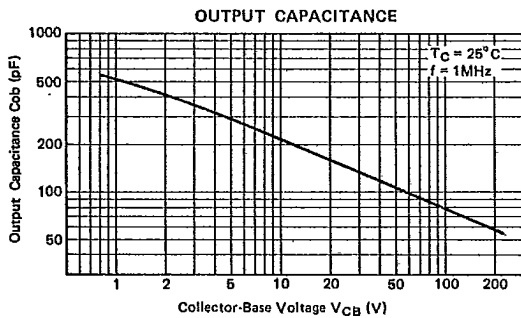
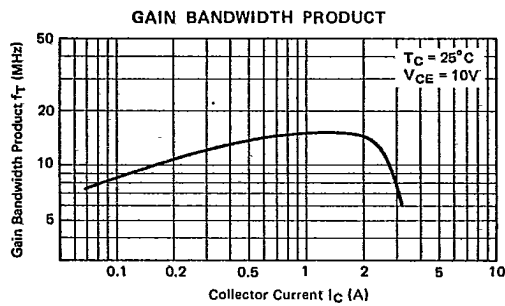
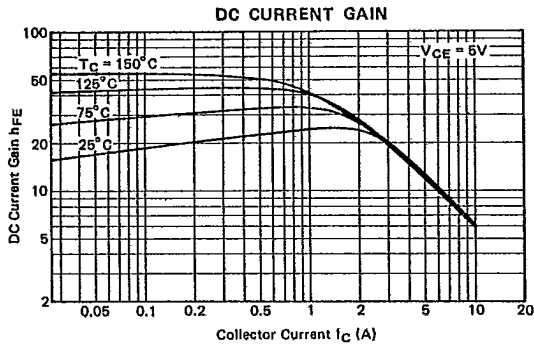
\*1 Test Circuit

\*2 Pulsed  $P_W \leq 300 \mu s$ , Duty Ratio  $\leq 6\%$ 

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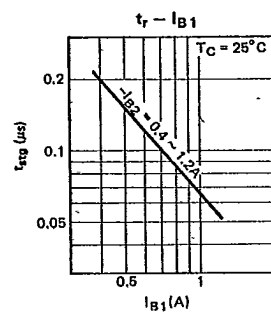
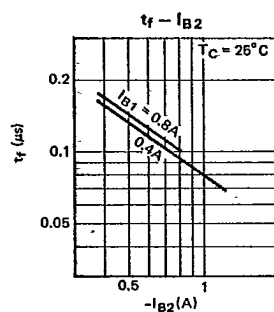
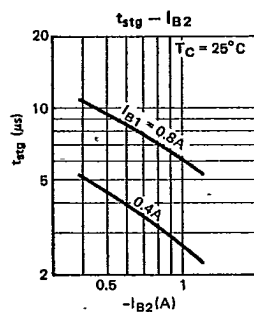


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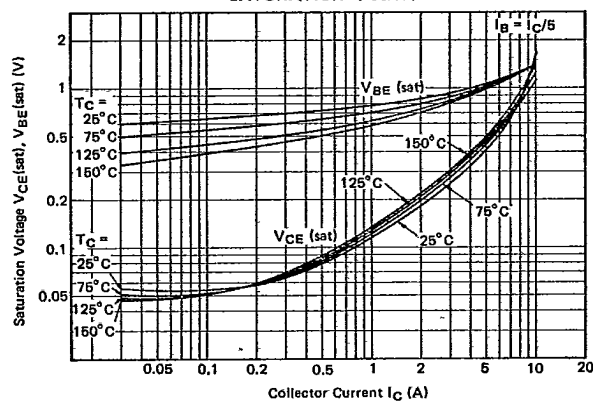
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## SWITCHING TIME

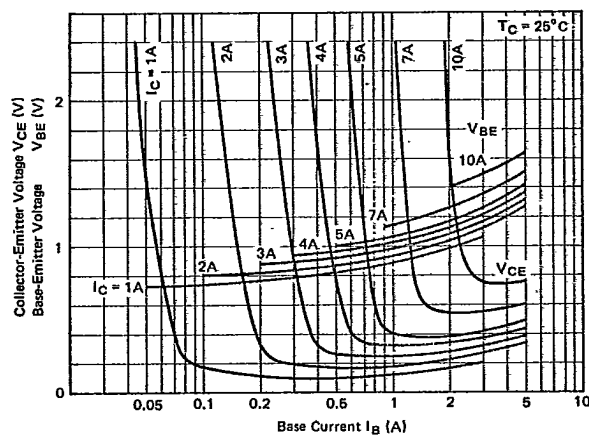
$V_{CC} = 400V$   
 $I_C = 4A$   
 $P_W = 60\mu s$   
Duty Ratio = 1%



## SATURATION VOLTAGE



## COLLECTOR SATURATION REGION



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