



# MJE13005

## NPN SILICON TRANSISTOR

### NPN SILICON POWER TRANSISTORS

■ DESCRIPTION

These devices are designed for high-voltage, high-speed power switching inductive circuits where fall time is critical. They are particularly suited for 115 and 220 V SWITCHMODE.

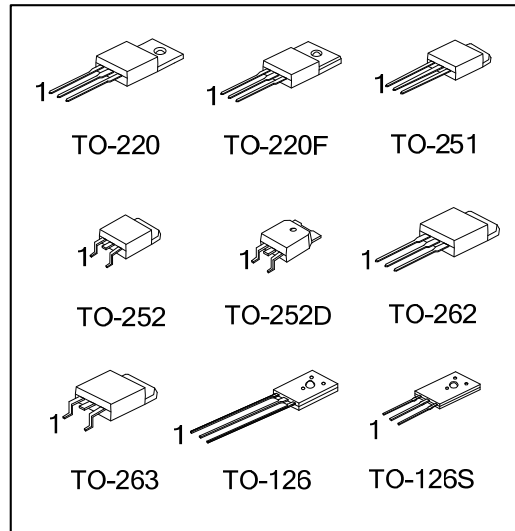
■ FEATURES

- \*  $V_{CE0(SUS)} = 400\text{ V}$
- \* Reverse bias SOA with inductive loads @  $T_C = 100^\circ\text{C}$
- \* Inductive switching matrix 2 to 4 Amp, 25 and  $100^\circ\text{C}$   
 $t_c @ 3\text{A}, 100^\circ\text{C}$  is 180 ns (Typ)
- \* 700V blocking capability
- \* SOA and switching applications information

■ APPLICATIONS

- \* Switching regulator's, inverters
- \* Motor controls
- \* Solenoid/Relay drivers
- \* Deflection circuits

■ ORDERING INFORMATION



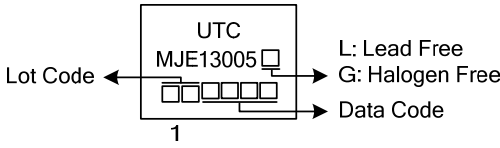
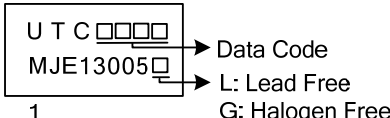
Ordering Number		Package	Pin Assignment			Packing
Lead Free	Halogen Free		1	2	3	
MJE13005L-x-TA3-T	MJE13005G-x-TA3-T	TO-220	B	C	E	Tube
MJE13005L-x-TF3-T	MJE13005G-x-TF3-T	TO-220F	B	C	E	Tube
MJE13005L-x-TM3-T	MJE13005G-x-TM3-T	TO-251	B	C	E	Tube
MJE13005L-x-TN3-R	MJE13005G-x-TN3-R	TO-252	B	C	E	Tape Reel
MJE13005L-x-TND-R	MJE13005G-x-TND-R	TO-252D	B	C	E	Tape Reel
MJE13005L-x-T2Q-T	MJE13005G-x-T2Q-T	TO-262	B	C	E	Tube
MJE13005L-x-TQ3-T	MJE13005G-x-TQ3-T	TO-263	B	C	E	Tube
MJE13005L-x-TQ3-R	MJE13005G-x-TQ3-R	TO-263	B	C	E	Tape Reel
MJE13005L-x-T60-K	MJE13005G-x-T60-K	TO-126	B	C	E	Bulk
MJE13005L-x-T6S-K	MJE13005G-x-T6S-K	TO-126S	B	C	E	Bulk

<p>MJE13005L-x-TA3-T</p> <p>(1)Packing Type</p> <p>(2)Package Type</p> <p>(3)Rank</p> <p>(4)Lead Free</p>	<p>(1) T: Tube, K: Bulk, R: Tape Reel</p> <p>(2) TA3: TO-220, TF3: TO-220F, TM3: TO-251, TN3: TO-252, TND: TO-252D, T2Q: TO-262, TQ3: TO-263, T60: TO-126, T6S: TO-126S</p> <p>(3) x: refer to Classification of <math>h_{FE1}</math></p> <p>(4) L: Lead Free, G: Halogen Free</p>
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## NPN SILICON TRANSISTOR

■ MARKING INFORMATION

PACKAGE	MARKING
TO-220 TO-220F TO-251 TO-252 TO-252D TO-262 TO-263	
TO-126 TO-126S	

### ■ ABSOLUTE MAXIMUM RATINGS

PARAMETER		SYMBOL	RATINGS	UNIT
Collector-Emitter Voltage		$V_{CEO(SUS)}$	400	V
Collector-Emitter Voltage ( $V_{BE}=0$ )		$V_{CES}$	700	V
Collector-Base Voltage		$V_{CBO}$	700	V
Emitter Base Voltage		$V_{EBO}$	9	V
Collector Current	Continuous	$I_C$	4	A
	Peak (1)	$I_{CM}$	8	A
Base Current	Continuous	$I_B$	2	A
	Peak (1)	$I_{BM}$	4	A
Emitter Current	Continuous	$I_E$	6	A
	Peak (1)	$I_{EM}$	12	A
Power Dissipation at $T_A=25^\circ\text{C}$	TO-126/TO-126S TO-220F	$P_D$	40	W
	TO-251/TO-252 TO-252D		50	
	TO-220/TO-263 TO-262		75	
Derate above $25^\circ\text{C}$	TO-126/TO-126S TO-220F		320	mW/ $^\circ\text{C}$
	TO-251/TO-252 TO-252D		400	
	TO-220/TO-263 TO-262		600	
Operating and Storage Junction Temperature		$T_J, T_{STG}$	-65 ~ +150	$^\circ\text{C}$

Note: Absolute maximum ratings are those values beyond which the device could be permanently damaged.  
 Absolute maximum ratings are stress ratings only and functional device operation is not implied.

### ■ THERMAL DATA

PARAMETER		SYMBOL	RATINGS	UNIT
Junction to Ambient	TO-126/TO-126S	$\theta_{JA}$	89	$^\circ\text{C/W}$
	TO-251/TO-252 TO-252D		110	
	TO-220/TO-263 TO-262/TO-220F		62.5	
	TO-126/TO-126S TO-220F		3.125	
Junction to Case	TO-251/TO-252 TO-252D	$\theta_{JC}$	2.5	$^\circ\text{C/W}$
	TO-220/TO-263 TO-262		1.67	

■ ELECTRICAL CHARACTERISTICS (T<sub>C</sub>=25°C, unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>OFF CHARACTERISTICS (Note 1)</b>						
Collector-Emitter Sustaining Voltage	V <sub>CEO(SUS)</sub>	I <sub>C</sub> =10mA, I <sub>B</sub> =0	400			V
Collector Cutoff Current	I <sub>CBO</sub>	V <sub>CBO</sub> =Rated Value, V <sub>BE(OFF)</sub> =1.5V			1	mA
		V <sub>CBO</sub> =Rated Value, V <sub>BE(OFF)</sub> =1.5V, T <sub>C</sub> =100°C			5	
Emitter Cutoff Current	I <sub>EBO</sub>	V <sub>EB</sub> =9V, I <sub>C</sub> =0			1	mA
<b>SECOND BREAKDOWN</b>						
Second Breakdown Collector Current with base forward biased	I <sub>S/B</sub>				See Fig. 11	
Clamped Inductive SOA with Base Reverse Biased	RBSOA				See Fig. 12	
<b>ON CHARACTERISTICS (Note 1)</b>						
DC Current Gain	h <sub>FE1</sub>	I <sub>C</sub> =0.5A, V <sub>CE</sub> =5V	15		50	
	h <sub>FE2</sub>	I <sub>C</sub> =1A, V <sub>CE</sub> =5V	10		60	
	h <sub>FE3</sub>	I <sub>C</sub> =2A, V <sub>CE</sub> =5V	8		40	
Collector-Emitter Saturation Voltage	V <sub>CE(SAT)</sub>	I <sub>C</sub> =1A, I <sub>B</sub> =0.2A			0.5	V
		I <sub>C</sub> =2A, I <sub>B</sub> =0.5A			0.6	V
		I <sub>C</sub> =4A, I <sub>B</sub> =1A			1	V
		I <sub>C</sub> =2A, I <sub>B</sub> =0.5A, T <sub>a</sub> =100°C			1	V
Base-Emitter Saturation Voltage	V <sub>BE(SAT)</sub>	I <sub>C</sub> =1A, I <sub>B</sub> =0.2A			1.2	V
		I <sub>C</sub> =2A, I <sub>B</sub> =0.5A			1.6	V
		I <sub>C</sub> =2A, I <sub>B</sub> =0.5A, T <sub>C</sub> =100°C			1.5	V
<b>DYNAMIC CHARACTERISTICS</b>						
Current-Gain-Bandwidth Product	f <sub>T</sub>	I <sub>C</sub> =500mA, V <sub>CE</sub> =10V, f=1MHz	4			MHz
Output Capacitance	C <sub>OB</sub>	V <sub>CB</sub> =10V, I <sub>E</sub> =0, f=0.1MHz		65		pF
<b>SWITCHING CHARACTERISTICS</b>						
Resistive Load (Table 1)						
Delay Time	t <sub>D</sub>	V <sub>CC</sub> =125V, I <sub>C</sub> =2A, I <sub>B1</sub> =I <sub>B2</sub> =0.4A, t <sub>P</sub> =25μs, Duty Cycle≤1%		0.025	0.1	μs
Rise Time	t <sub>R</sub>			0.3	0.7	μs
Storage Time	t <sub>S</sub>			1.7	4	μs
Fall Time	t <sub>F</sub>			0.4	0.9	μs

Note: 1. Pulse Test: Pulse Width=5ms, Duty Cycle≤10%

2. Pulse Test: P<sub>W</sub>=300μs, Duty Cycle≤2%

■ CLASSIFICATION OF h<sub>FE1</sub>

RANK	A	B	C	D	E
RANGE	15 ~ 20	20 ~ 25	25 ~ 30	30 ~ 40	40 ~ 50

## APPLICATION INFORMATION

Table 1. Test Conditions for Dynamic Performance

Reverse Bias Safe Operating Area and Inductive Switching		Resistive Switching
Test Circuits	<p>DUTY CYCLE <math>\leq 10\%</math> <math>t_r, t_f \leq 10\text{ns}</math></p> <p>Note: Pw and V<sub>cc</sub> Adjusted for Desired I<sub>c</sub> R<sub>B</sub> Adjusted for Desired I<sub>B1</sub></p> <p>*SELECTED FOR <math>\geq 1\text{kV}</math></p>	
Circuit Values	<p>Coil Data : V<sub>CC</sub>=20V FERROXCUBE core #6656 Full Bobbin ( ~ 16 Turns) #16</p> <p>GAP for 200μH/20 A L<sub>COIL</sub>=200μH V<sub>CLAMP</sub>=300V</p>	<p>V<sub>CC</sub>=125V R<sub>C</sub>=62Ω D1=1n5820 or Equiv. R<sub>B</sub>=22Ω</p>
Test Waveforms	<p>OUTPUT WAVEFORMS</p> <p><math>t_1</math> Adjusted to Obtain I<sub>c</sub></p> $t_1 = \frac{L_{COIL}(I_{CPK})}{V_{CC}}$ $t_2 = \frac{L_{COIL}(I_{CPK})}{V_{CLAMP}}$ <p>Test Equipment Scope-Tektronics 475 or Equivalent</p>	<p><math>t_r, t_f &lt; 10\text{ns}</math> Duty Cycle=1.0% R<sub>B</sub> and R<sub>C</sub> adjusted for desired I<sub>B</sub> and I<sub>C</sub></p>

## RESISTIVE SWITCHING PERFORMANCE

Fig. 1 Turn-On Time

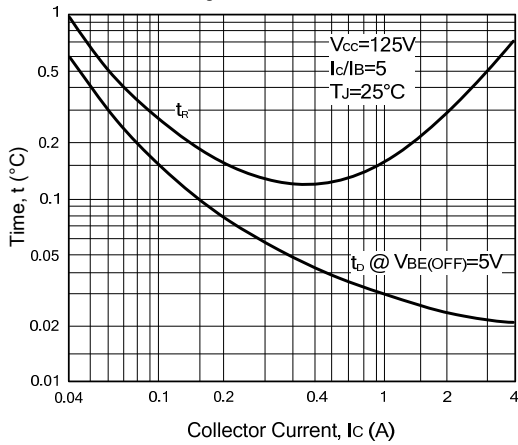


Fig. 2 Turn-Off Time

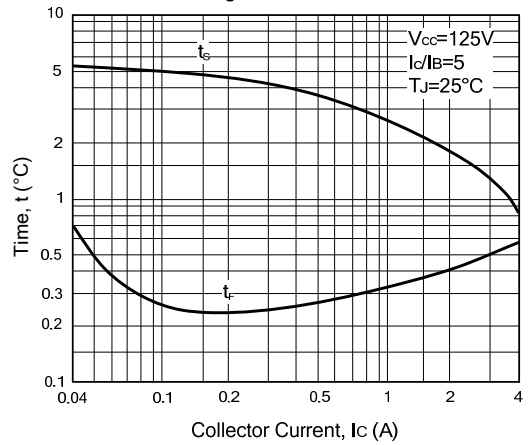


Fig. 3 Typical Thermal Response [ $Z_{\theta JC}(t)$ ]

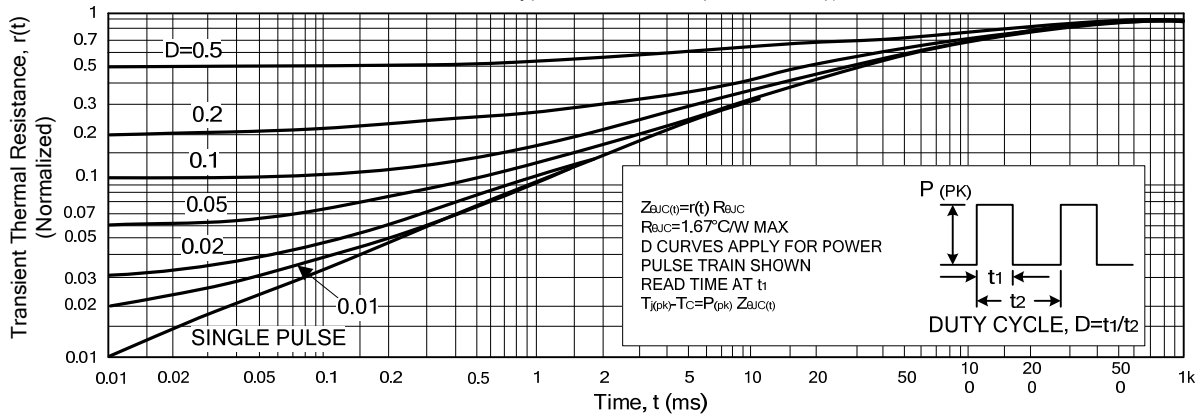


Fig. 4 Forward Bias Safe Operating Area

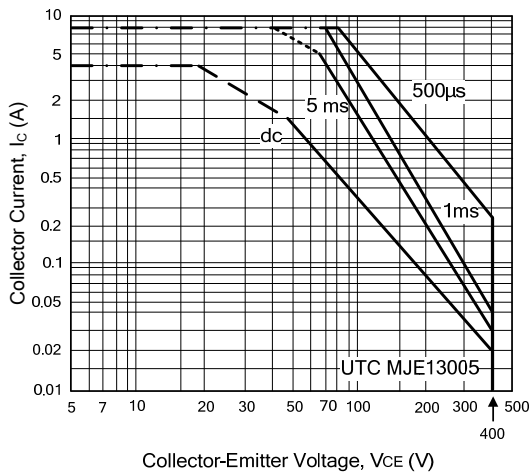
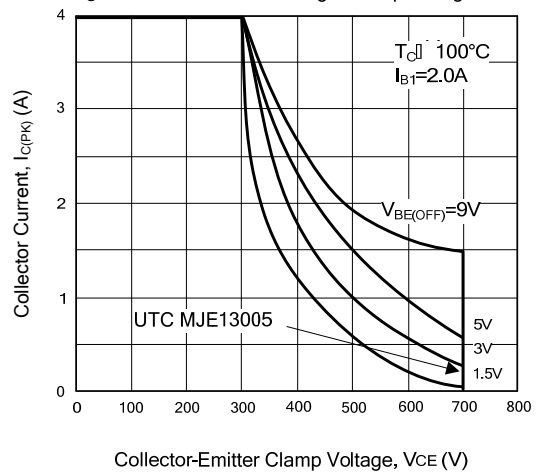
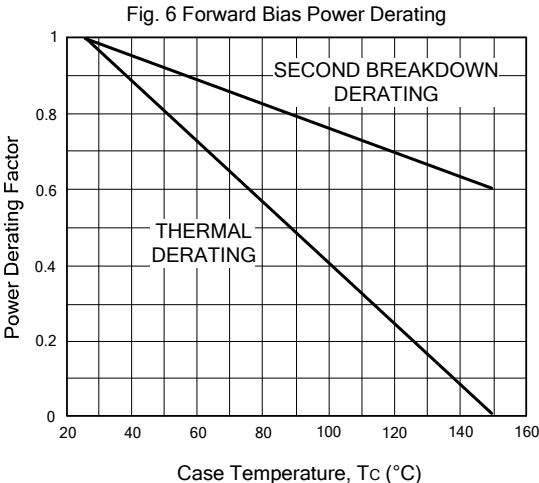


Fig. 5 Reverse Bias Switching Safe Operating Area



■ RESISTIVE SWITCHING PERFORMANCE(Cont.)



## ■ SAFE OPERATING AREA INFORMATION

### FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C$ - $V_{CE}$  limits of the transistor that must be observed for reliable operation; e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Fig. 4 is based on  $T_C = 25^\circ\text{C}$ ;  $T_{J(PK)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geq 25^\circ\text{C}$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Fig. 4 may be found at any case temperature by using the appropriate curve on Fig. 6.

$T_{J(PK)}$  may be calculated from the data in Fig. 10. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 5 gives the complete RBSOA characteristics.



## TYPICAL CHARACTERISTICS

Figure 7. DC Current Gain

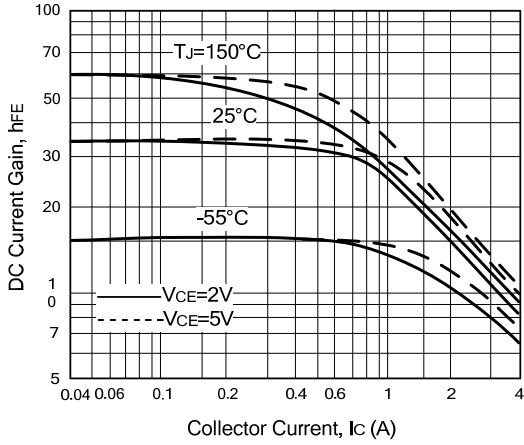


Figure 8. Collector Saturation Region

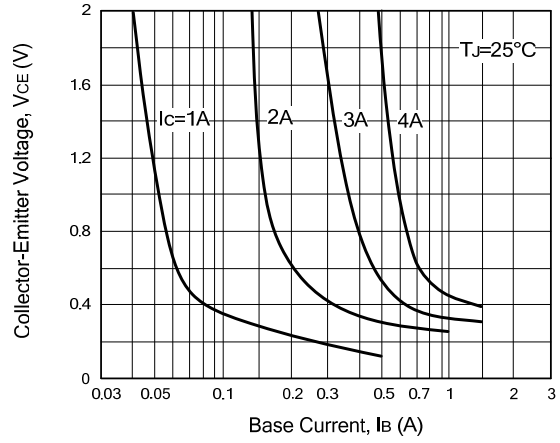


Figure 9. Base-Emitter Voltage

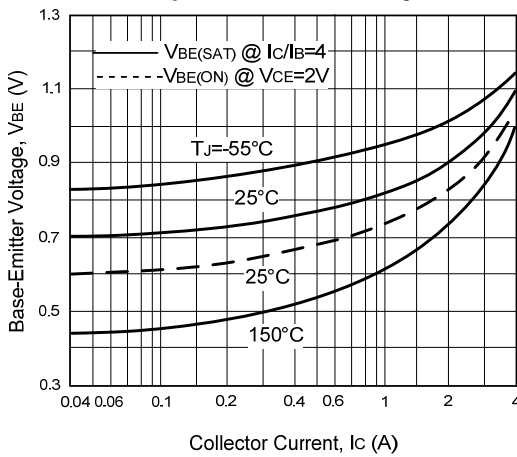


Figure 10. Collector-Emitter Saturation Voltage

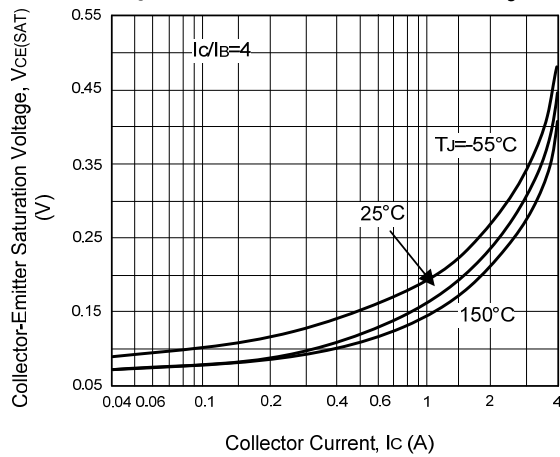


Figure 11. Collector Cutoff Region

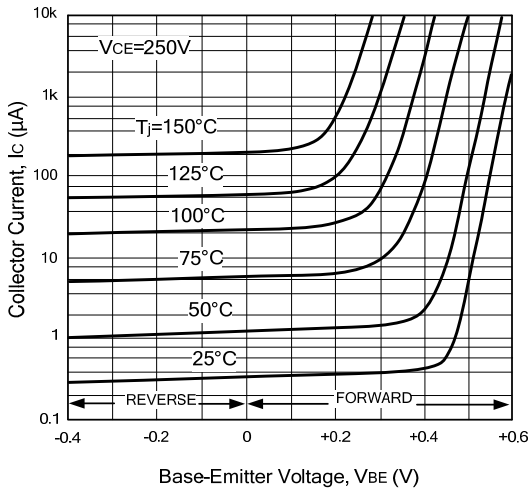
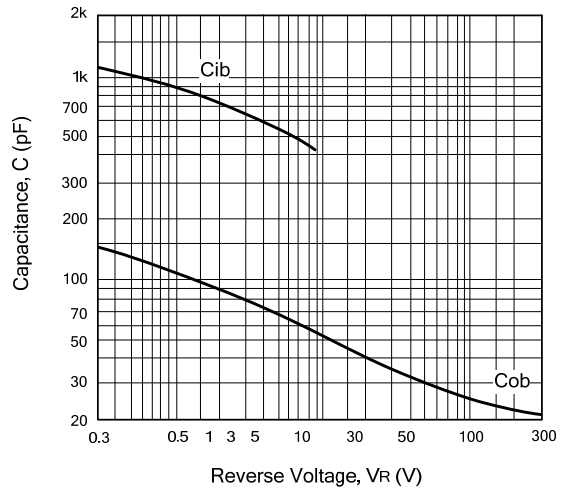


Figure 12. Capacitance



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