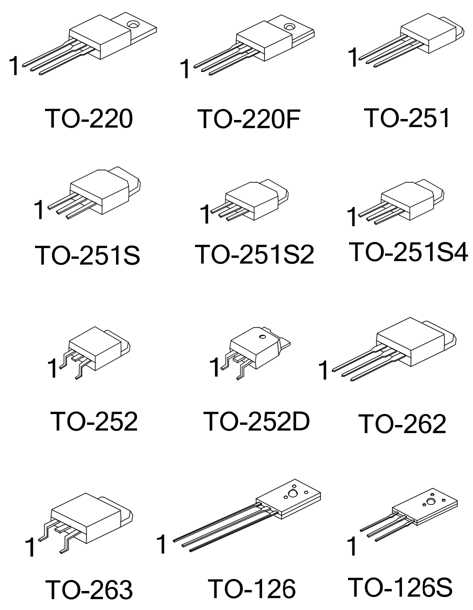
NPN SILICON POWER TRANSISTORS



■ 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

* $V_{CEO(SUS)}$= 400 V
* Reverse bias SOA with inductive loads @ T_C = 100°C
* Inductive switching matrix 2 to 4 Amp, 25 and 100°C
  t_C @ 3A, 100°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

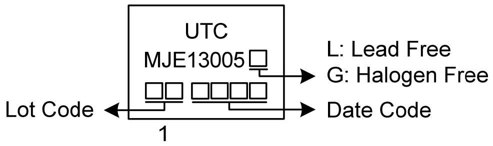
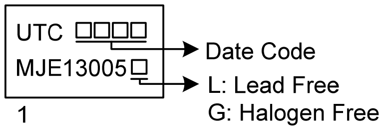
■ ORDERING INFORMATION

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-TMS-T	MJE13005G-x-TMS-T	TO-251S	B	C	E	Tube
MJE13005L-x-TMS2-T	MJE13005G-x-TMS2-T	TO-251S2	B	C	E	Tube
MJE13005L-x-TMS4-T	MJE13005G-x-TMS4-T	TO-251S4	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

Note: Pin Assignment: B: Base C: Collector E: Emitter

MJE13005G-x-TA3-T (1)Packing Type (2)Package Type (3)Rank (4)Green Package	(1) T: Tube, K: Bulk, R: Tape Reel (2) TA3: TO-220, TF3: TO-220F,TM3: TO-251, TMS: TO-251S, TMS2: TO-251S2, TMS4:TO-251S4, TN3: TO-252, TND: TO-252D, T2Q: TO-262, TQ3: TO-263, T60: TO-126, T6S: TO-126S (3) x: refer to Classification of h_{FE1} (4) G: Halogen Free and Lead Free, L: Lead Free

■ MARKING

PACKAGE		MARKING
TO-220 TO-220F TO-251 TO-251S TO-251S2	TO-251S4 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_C=25°C	TO-126/TO-126S TO-220F	P_D	40	W
	TO-251/TO-251S TO-251S2/TO-251S4 TO-252/TO-252D		50	
	TO-220/TO-263 TO-262		75	
Derate above 25°C	TO-126/TO-126S TO-220F		320	mW/°C
	TO-251/TO-251S TO-251S2/TO-251S4 TO-252/TO-252D		400	
	TO-220/TO-263 TO-262		600	
Operating and Storage Junction Temperature		T_J , T_{STG}	-65 ~ +150	°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	θ_{JA}	89	°C/W
	TO-251/TO-251S TO-251S2/TO-251S4 TO-252/TO-252D		80	
	TO-220/TO-263 TO-262/TO-220F		62.5	
Junction to Case	TO-126/TO-126S TO-220F	θ_{JC}	3.125	°C/W
	TO-251/TO-251S TO-251S2/TO-251S4 TO-252/TO-252D		2.5	
	TO-220/TO-263 TO-262		1.67	

■ ELECTRICAL CHARACTERISTICS (T_C=25°C, unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
OFF CHARACTERISTICS (Note 1)						
Collector-Emitter Sustaining Voltage	$V_{CEO(SUS)}$	I_C=10mA , I_B=0	400			V
Collector Cutoff Current	I_{CBO}	V_{CBO}=Rated Value, $V_{BE(OFF)}$=1.5V			1	mA
		V_{CBO}=Rated Value, $V_{BE(OFF)}$=1.5V, T_C=100°C			5	mA
Emitter Cutoff Current	I_{EBO}	V_{EB}=9V, I_C=0			1	mA
SECOND BREAKDOWN						
Second Breakdown Collector Current with bass forward biased	$I_{S/B}$			See Fig. 11		
Clamped Inductive SOA with Base Reverse Biased	RBSOA			See Fig. 12		
ON CHARACTERISTICS (Note 1)						
DC Current Gain	h_{FE1}	I_C=0.5A, V_{CE}=5V	20		40	
	h_{FE2}	I_C=1A, V_{CE}=5V	10		60	
	h_{FE3}	I_C=2A, V_{CE}=5V	8		40	
Collector-Emitter Saturation Voltage	$V_{CE(SAT)}$	I_C=1A, I_B=0.2A			0.5	V
		I_C=2A, I_B=0.5A			0.6	V
		I_C=4A, I_B=1A			1	V
		I_C=2A, I_B=0.5A, Ta=100°C			1	V
Base-Emitter Saturation Voltage	$V_{BE\ (SAT)}$	I_C=1A, I_B=0.2A			1.2	V
		I_C=2A, I_B=0.5A			1.6	V
		I_C=2A, I_B=0.5A, T_C=100°C			1.5	V
DYNAMIC CHARACTERISTICS						
Current-Gain-Bandwidth Product	f_T	I_C=500mA, V_{CE}=10V, f=1MHz	4			MHz
Output Capacitance	C_{OB}	V_{CB}=10V, I_E=0, f=0.1MHz		65		pF
SWITCHING CHARACTERISTICS						
Resistive Load (Table 1)						
Delay Time	t_D	V_{CC}=125V, I_C=2A, I_{B1}=I_{B2}=0.4A, t_P=25μs, Duty Cycle≤1%		0.025	0.1	μs
Rise Time	t_R			0.3	0.7	μs
Storage Time	t_S			1.7	4	μs
Fall Time	t_F			0.4	0.9	μs

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

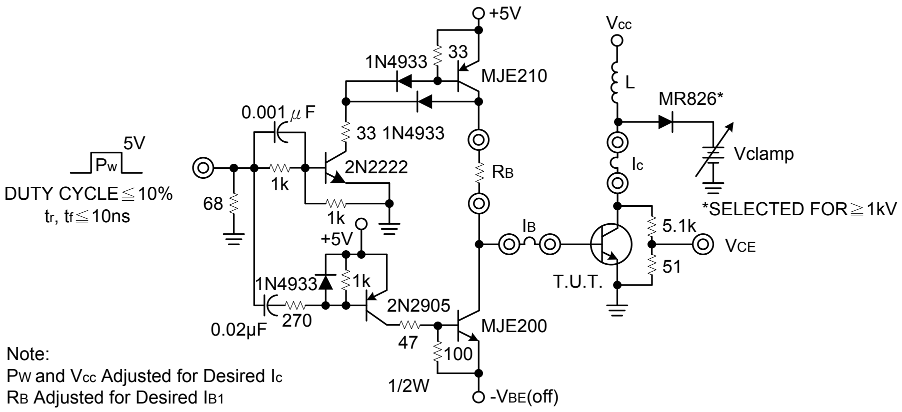
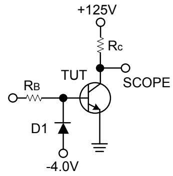
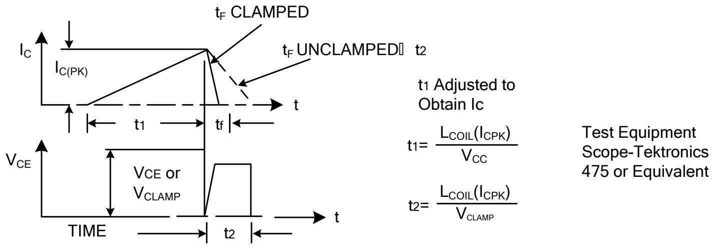
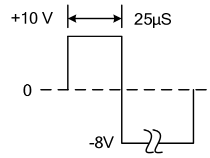
2. Pulse Test: P_W=300μs, Duty Cycle≤2%

■ CLASSIFICATION OF h_{FE1}

RANK	B	C	D
RANGE	20 ~ 25	25 ~ 30	30 ~ 40

■ APPLICATION INFORMATION

Table 1.Test Conditions for Dynamic Performance

<table>
<tr><th></th><th>Reverse Bias Safe Operating Area and Inductive Switching</th><th>Resistive Switching</th></tr>
<tr><td>Test Circuits</td><td>
</td><td>
</td></tr>
<tr><td>Circuit Values</td><td>Coil Data :
V_{CC}=20V
FERROXCUBE core #6656
Full Bobbin (~ 16 Turns) #16
GAP for 200μH/20 A
L_{COIL}=200μH
V_{CLAMP}=300V</td><td>V_{CC}=125V
R_C=62Ω
D1=1n5820 or Equiv.
RB=22Ω</td></tr>
<tr><td>Test Waveforms</td><td>OUTPUT WAVEFORMS

</td><td>

t_R, t_F<10ns
Duty Cycly=1.0%
R_B and R_C adjusted for desired I_B and I_C</td></tr>
</table>

■ RESISTIVE SWITCHING PERFORMANCE

Fig. 1 Turn-On Time

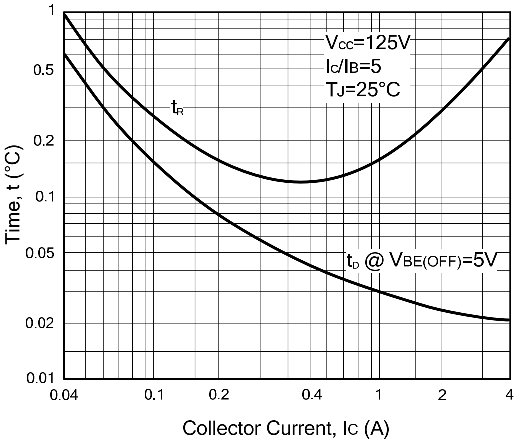


Fig. 2 Turn-Off Time

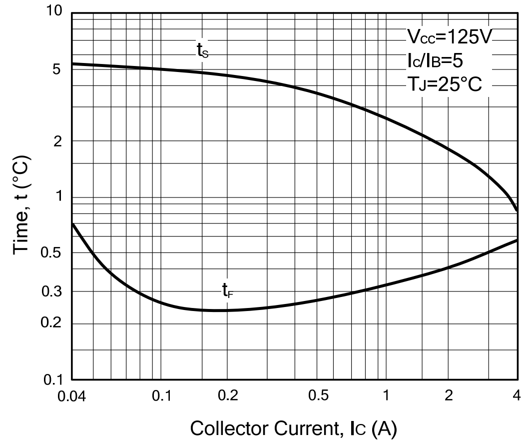


Fig. 3 Typical Thermal Response [ZθJC(t)]

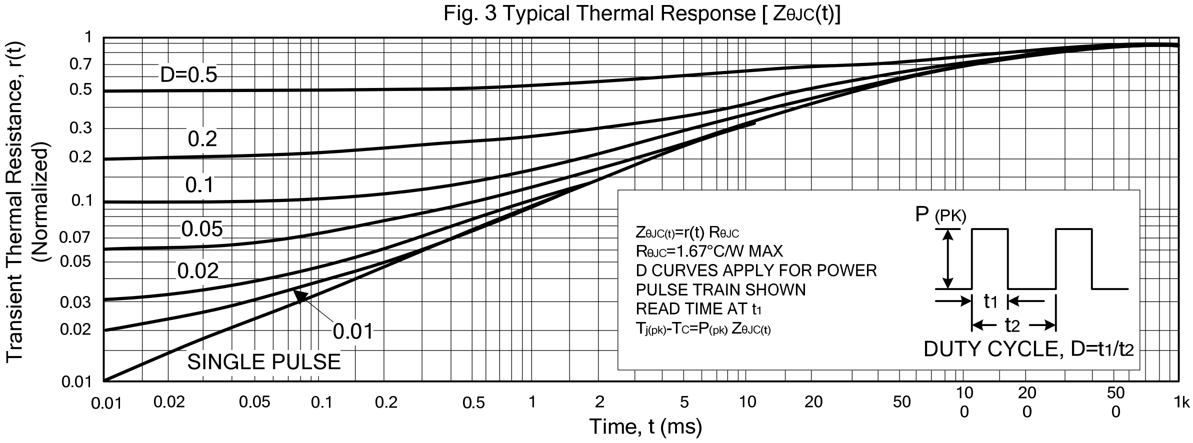


Fig. 4 Forward Bias Safe Operating Area

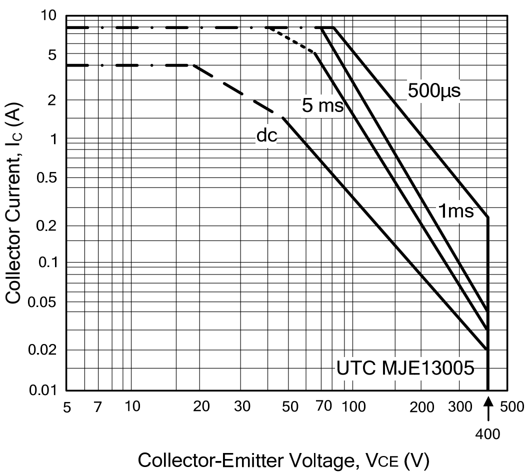
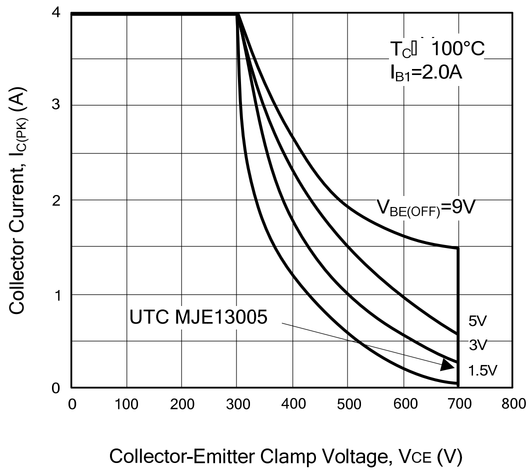
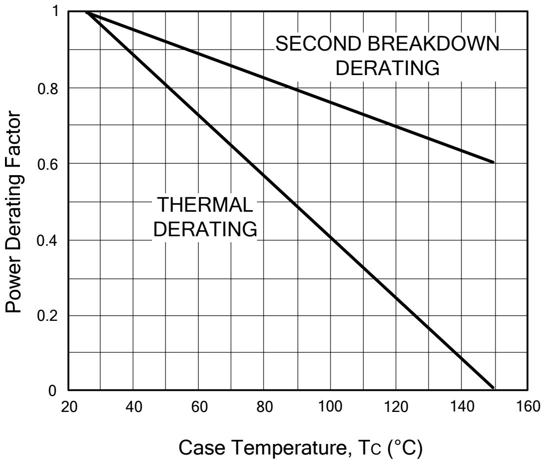


Fig. 5 Reverse Bias Switching Safe Operating Area



■ RESISTIVE SWITCHING PERFORMANCE(Cont.)

Fig. 6 Forward Bias Power Derating



■ 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°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≥25°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

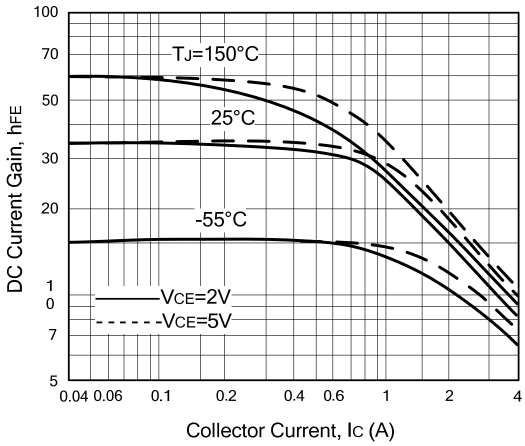


Figure 8. Collector Saturation Region

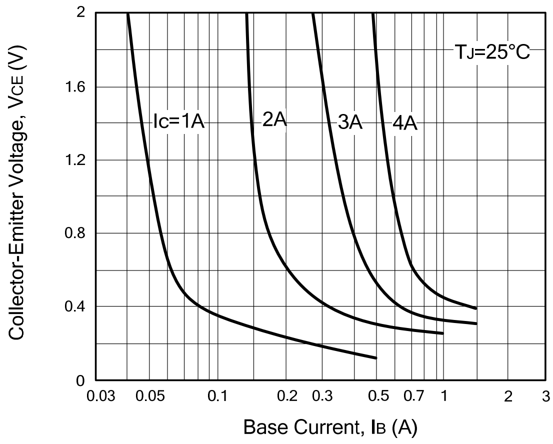


Figure 9. Base-Emitter Voltage

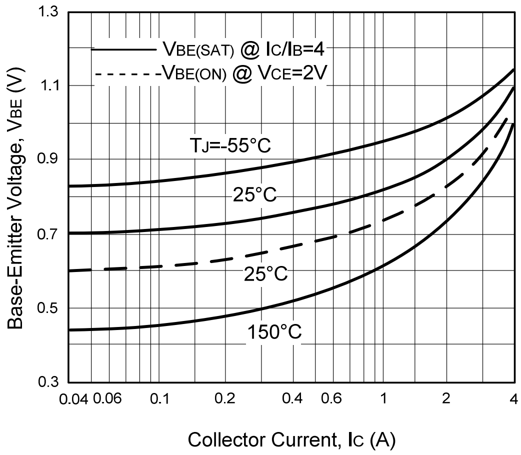


Figure 10. Collector-Emitter Saturation Voltage

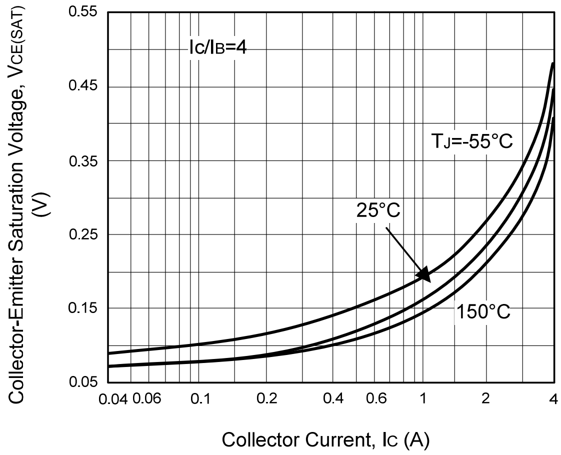


Figure 11. Collector Cutoff Region

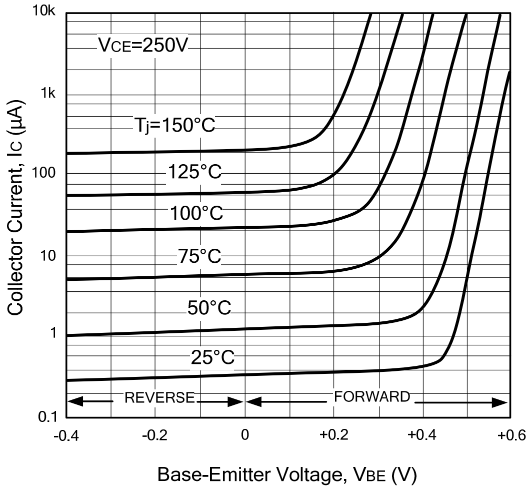


Figure 12. Capacitance