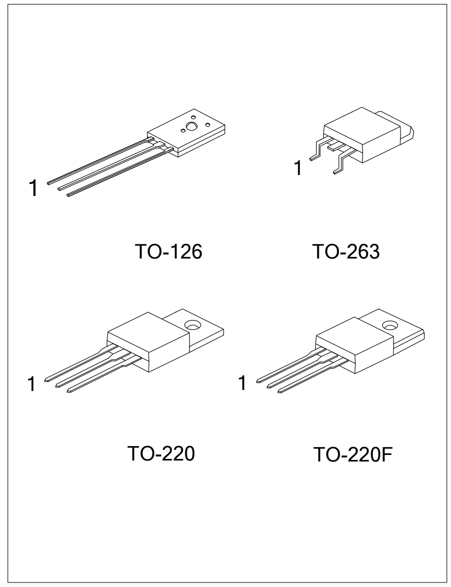
NPN SILICON POWER TRANSISTORS



*Pb-free plating product number: MJE13005L

■ 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
  . . . tc @ 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
Normal	Lead Free Plating		1	2	3	
MJE13005-T60-K	MJE13005L-T60-K	TO-126	B	C	E	Bulk
MJE13005-TA3-T	MJE13005L-TA3-T	TO-220	B	C	E	Tube
MJE13005-TF3-T	MJE13005L-TF3-T	TO-220F	B	C	E	Tube
MJE13005-TQ3-R	MJE13005L-TQ3-R	TO-263	B	C	E	Tape Reel
MJE13005-TQ3-T	MJE13005L-TQ3-T	TO-263	B	C	E	Tube

MJE13005L-T60-K
(1)Packing Type
(2)Package Type
(3)Lead Plating

(1)T: Tube, K: Bulk, R: Tape Reel
(2) T60: TO-126, TA3: TO-220, TF3: TO-220F, TQ3: TO-263
(3) L: Lead Free Plating, Blank: Pb/Sn

■ ABSOLUTE MAXIMUM RATINGS

PARAMETER		SYMBOL	RATINGS	UNIT
Collector-Emitter Voltage		$V_{CEO(SUS)}$	400	V
Collector-Emitter Voltage		V_{CBO}	700	V
Emitter Base Voltage		V_{EBO}	9	V
Collector Current	Continuous	Ic	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
Total Power Dissipation at Ta=25°C		P_D	2	W
Derate above 25°C			16	mW/°C
Total Power Dissipation at T_C=25°C		P_D	75	W
Derate above 25°C			600	mW/°C
Operating and Storage Junction Temperature Range		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	MAX	UNIT
Thermal Resistance, Junction to Ambient	θ_{JA}	62.5	°C/W
Thermal Resistance, Junction to Case	θ_{JC}	1.67	°C/W

(1) Pulse Test : Pulse Width=5ms,Duty Cycle≤10%

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

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
***OFF CHARACTERISTICS (1)**						
Collector-Emitter Sustaining Voltage	$V_{CEO(SUS)}$	Ic=10mA , I_B=0	400			V
Collector Cutoff Current	I_{CBO}	V_{CBO}=Rated Value, $V_{BE(OFF)}$=1.5 V			1	mA
		V_{CBO}=Rated Value, $V_{BE(OFF)}$=1.5V, Tc=100°C			5	
Emitter Cutoff Current	I_{EBO}	V_{EB}=9V, Ic=0			1	mA
SECOND BREAKDOWN						
Second Breakdown Collector Current with bass forward biased	Is/b			See Figure 11		
Clamped Inductive SOA with Base Reverse Biased	RBSOA			See Figure 12		
***ON CHARACTERISTICS (1)**						
DC Current Gain	h_{FE1}	Ic=1A, V_{CE}=5V	10		60	
	h_{FE2}	Ic=2A, V_{CE}=5V	8		40	
Collector-Emitter Saturation Voltage	$V_{CE(SAT)}$	Ic=1A, I_B=0.2A			0.5	V
		Ic=2A, I_B=0.5A			0.6	V
		Ic=4A, I_B=1A			1	V
		Ic=2A, I_B=0.5A, Ta=100°C			1	V
Base-Emitter Saturation Voltage	$V_{BE\ (SAT)}$	Ic=1A, I_B=0.2A			1.2	V
		Ic=2A, I_B=0.5A			1.6	V
		Ic=2A, I_B=0.5A, Tc=100°C			1.5	V
DYNAMIC CHARACTERISTICS						
Current-Gain-Bandwidth Product	f_T	Ic=500mA, V_{CE}=10V, f=1MHz	4			MHz
Output Capacitance	Cob	V_{CB}=10V, I_E=0, f=0.1MHz		65		pF

■ ELECTRICAL CHARACTERISTICS (Cont.)

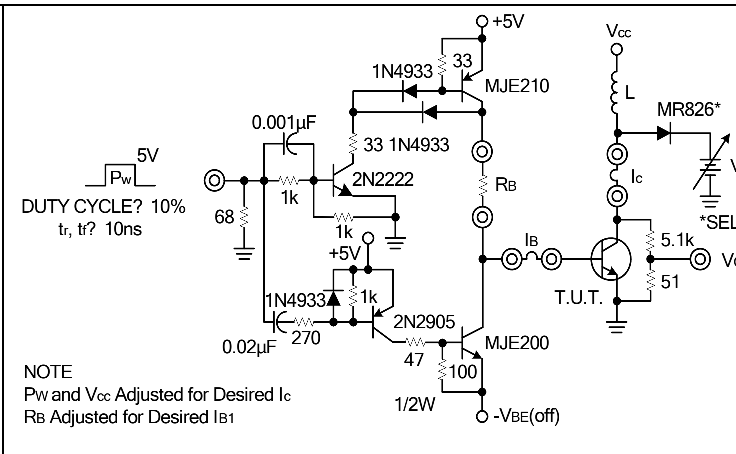
PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
SWITCHING CHARACTERISTICS						
Resistive Load (Table 1)						
Delay Time	t_D	V_{CC}=125V, I_C=2A, I_{B1}=I_{B2}=0.4A, t_P=25μs, Duty Cycle≤1%		0.025	0.1	μs
Rise Time	t_R			0.3	0.7	μs
Storage Time	t_S			1.7	4	μs
Fall Time	t_F			0.4	0.9	μs

* Pulse Test: Pulse Width=300μs, Duty Cycle≤2%

Table 1.Test Conditions for Dynamic Performance

REVERSE BIAS SAFE OPERATING AREA AND INDUCTIVE SWITCHING

TEST CIRCUITS

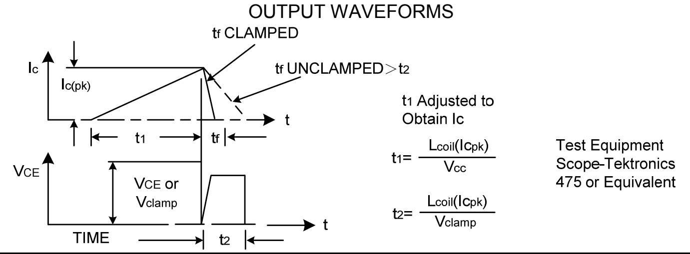


CIRCUIT VALUES

Coil Data	GAP	
Coil Data : FERROXCUBE core #6656 Full Bobbin (~ 16 Turns) #16	GAP for 200μH/20 A Lcoil=200μH	Vcc=20V Vclamp=300V

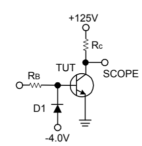
TEST WAVEFORMS

OUTPUT WAVEFORMS



RESISTIVE SWITHCING

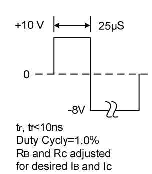
TEST CIRCUITS



CIRCUIT VALUES

Vcc=125V
Rc=62Ω
D1=1n5820 or Equiv.
RB=22Ω

TEST WAVEFORMS



■ RESISTIVE SWITCHING PERFORMANCE

Figure 1. Turn-On Time

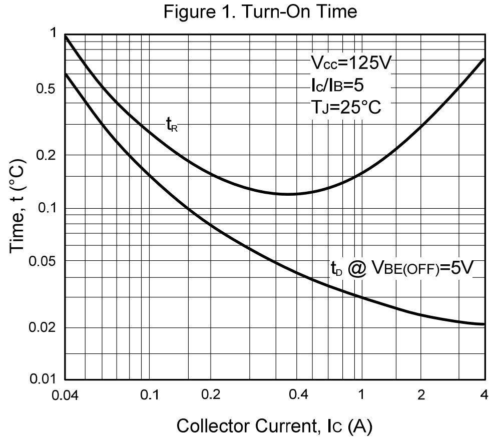


Figure 2. Turn-Off Time

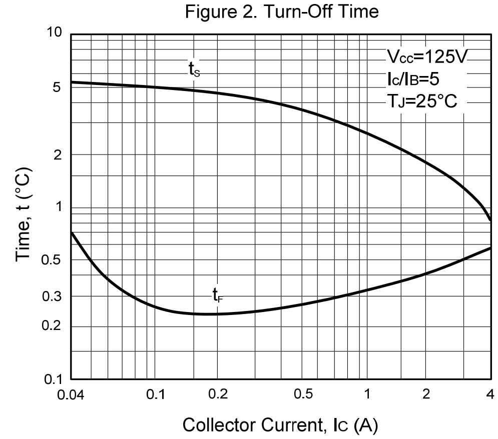


Figure 3. Typical Thermal Response [ZθJC(t)]

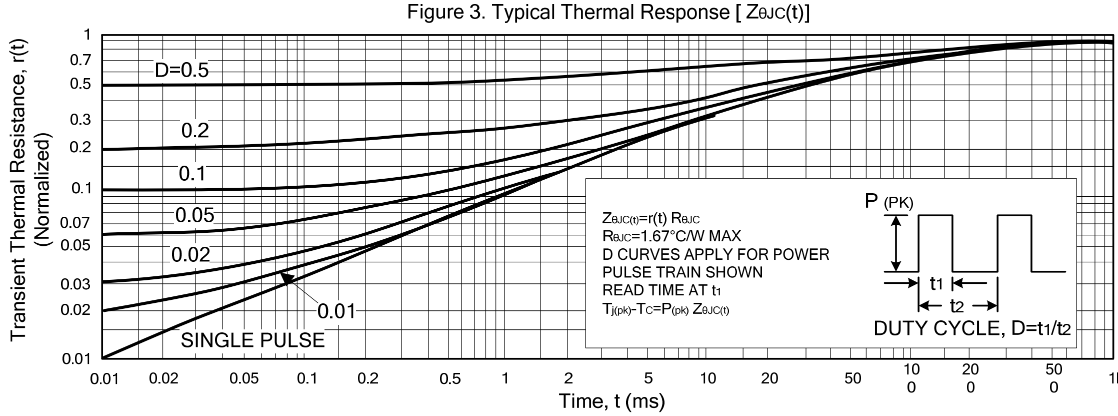


Figure 4. Forward Bias Safe Operating Area

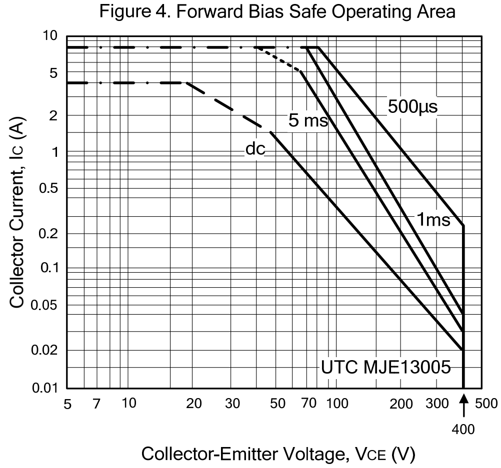
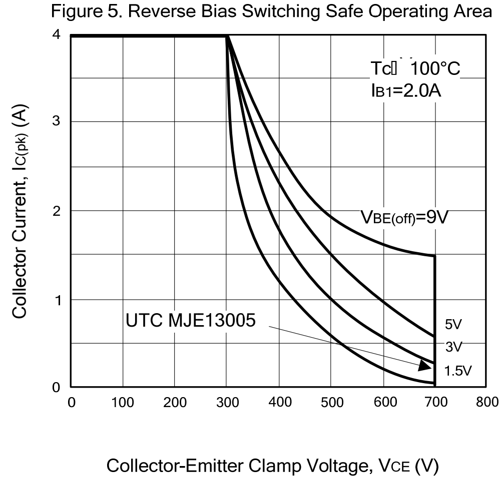
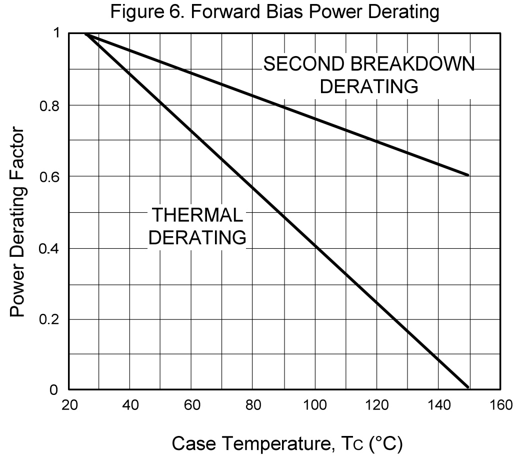


Figure 5. Reverse Bias Switching Safe Operating Area



■ RESISTIVE SWITCHING PERFORMANCE

Figure 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 Figure 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 Figure 4 may be found at any case temperature by using the appropriate curve on Figure 6.

T_J(pk) may be calculated from the data in Figure 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

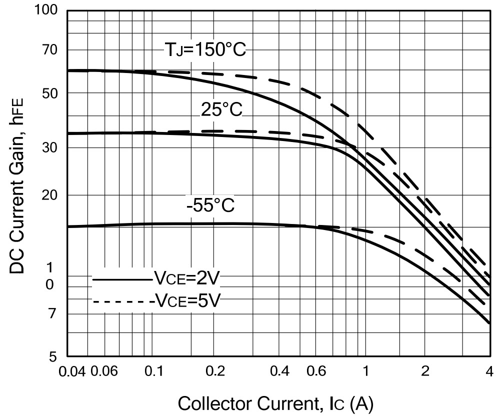


Figure 8. Collector Saturation Region

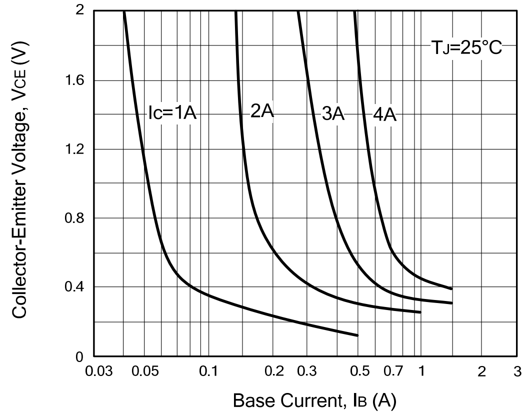


Figure 9. Base-Emitter Voltage

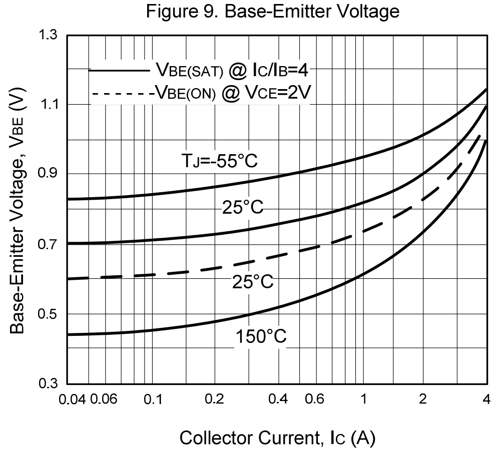


Figure 10. Collector-Emitter Saturation Voltage

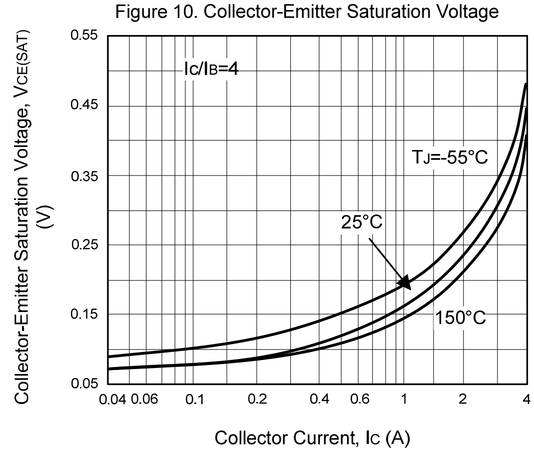


Figure 11. Collector Cutoff Region

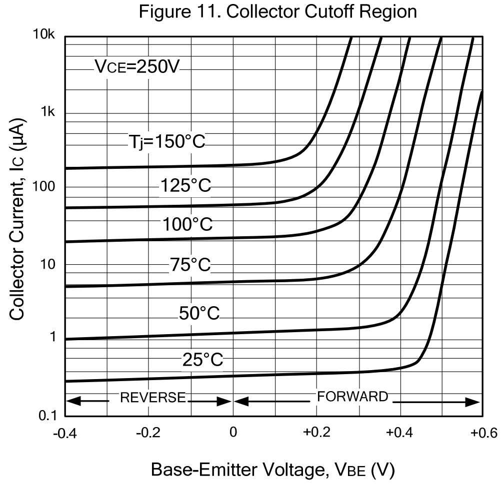


Figure 12. Capacitance