

UNISONIC TECHNOLOGIES CO., LTD

MJE13003-R

NPN SILICON TRANSISTOR

NPN SILICON POWER TRANSISTOR

DESCRIPTION

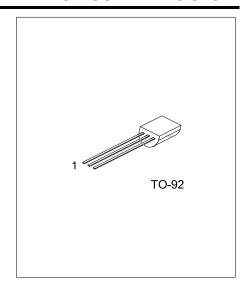
These devices are designed for high-voltage, high-speed power switching inductive circuits where fall time is critical. They are particularly suited for 115 and 220V applications in switch mode.

FEATURES

- * Reverse biased SOA with inductive load @ T_C=100°C
- * Inductive switching matrix 0.5 ~ 1.5 Amp, 25 and 100°C Typical t_C = 290ns @ 1A, 100°C.
- * 700V blocking capability

APPLICATIONS

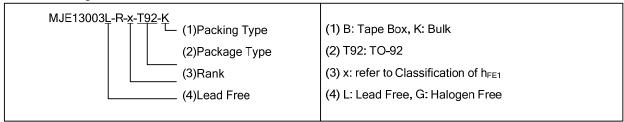
- * Switching regulator's, inverters
- * Motor controls
- * Solenoid/relay drivers
- * Deflection circuits



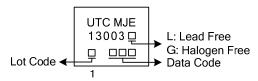
ORDERING INFORMATION

Ordering	Dookogo	Pin Assignment			Dooking	
Lead Free	Package	1	2	3	Packing	
MJE13003L-R-x-T92-B	MJE13003G-R-x-T92-B	TO-92	В	С	E	Tape Box
MJE13003-L-R-x-T92-K	MJE13003G-R-x-T92-K	TO-92	В	С	E	Bulk

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



MARKING



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■ ABSOLUTE MAXIMUM RATINGS

PARAMETER		SYMBOL	RATINGS	UNIT	
Collector-Emitter Voltage		V _{CEO(SUS)}	400	V	
Collector-Base Voltage		V_{CBO}	700	V	
Emitter Base Voltage		V_{EBO}	9	V	
Collector Current	Continuous	I _C	1.5	_	
Collector Current	Peak (1)	I _{CM}	3	Α	
Base Current	Continuous	I _B	0.75		
base Current	Peak (1)	I _{BM}	1.5	А	
Fraittan Cumant	Continuous	Ι _Ε	2.25	Δ.	
Emitter Current	Peak (1)	I _{EM}	4.5	Α	
Dawer Dissination	T _A =25°C	D	1.1	W	
Power Dissipation	T _C =25°C	P _D	1.5	W	
Junction Temperature		TJ	+150	°C	
Storage Temperature		T _{STG}	-55 ~ + 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.

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

Collector-Emitter Sustaining Voltage	PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT	
Collector Cutoff Current	OFF CHARACTERISTICS (Note)							
Cappaign Collector Cutoff Current Cappaign Capp	Collector-Emitter Sustaining Voltage	V _{CEO(SUS)}	I _C =10mA , I _B =0	400			V	
Tc=100°C See Very Second See Very Second See	Collector Cutoff Current		V _{CEO} =Rated Value,	1		mΛ		
Second Breakdown Collector Current with bass forward biased See Fig.5 See Fig.5	T _C =100°C	ICEO	V _{BE(OFF)} =1.5 V			5	шА	
Second Breakdown Collector Current with bass forward biased See Fig.5 See Fig.5	Emitter Cutoff Current	I _{EBO}	$V_{EB}=9V$, $I_{C}=0$			1	mA	
See Fig. 5 See Fig. 6	SECOND BREAKDOWN							
Clamped Inductive SOA with base reverse biased RB _{SOA} See Fig.6	Second Breakdown Collector Current with bass	ls/b		Soo Fig 5				
DC Current Gain	forward biased			See Fig.5				
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Clamped Inductive SOA with base reverse biased	RB _{SOA}	See Fig.6			.6		
Collector-Emitter Saturation Voltage	ON CHARACTERISTICS (Note)							
Collector-Emitter Saturation Voltage	DC Current Gain	h _{FE1}	I _C =0.5A, V _{CE} =5V			57		
Collector-Emitter Saturation Voltage $V_{CE(SAT)}$ V_{C	De current dani	h _{FE2}	I _C =1A, V _{CE} =5V	5		30		
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$			I _C =0.5A, I _B =0.1A			0.5		
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Collector Emitter Saturation Voltage	V	I _C =1A, I _B =0.25A			1		
Base-Emitter Saturation Voltage $V_{BE(SAT)}$ $I_{C}=0.5A, I_{B}=0.1A$ $I_{C}=1A, I_{B}=0.25A$ $I_{C}=100^{\circ}C$ $I_{C}=1A, I_{B}=0.25A$ $I_{C}=100^{\circ}C$ $I_{C}=1A, I_{B}=0.25A, I_{C}=100^{\circ}C$ $I_{C}=1A, I_{C}=1A, I_{C}=1A,$	Conector-Emitter Saturation voltage	V CE(SAT)	I _C =1.5A, I _B =0.5A			3	V	
Base-Emitter Saturation Voltage V _{BE(SAT)} I _C =1A, I _B =0.25A 1.2 V DYNAMIC CHARACTERISTICS Current-Gain-Bandwidth Product f _T I _C =100mA, V _{CE} =10V, f=1MHz 4 10 MHz Output Capacitance C _{OB} V _{CB} =10V, I _E =0, f=0.1MHz 21 pF SWITCHING CHARACTERISTICS Resistive Load (Table 1) Delay Time t _D 0.05 0.1 μs Rise Time t _R V _{CC} =125V, I _C =1A, B ₁ =I _{B2} =0.2A, 0.5 1 μs Storage Time t _F 0.4 0.7 μs Inductive Load, Clamped (Table 1) t _{STG} I _C =1A, V _{CLAMP} =300V, I _{B1} =0.2A, 0.29 1.7 4 μs Crossover Time t _C V _{REGUES} =5V _{DC} T _C =100°C 0.29 0.75 μs			I _C =1A, I _B =0.25A, T _C =100°C			1		
DYNAMIC CHARACTERISTICS Current-Gain-Bandwidth Product $ f_T I_C=100\text{mA}, V_{CE}=10\text{V}, f=1\text{MHz} 4 10 \text{MHz} $ Output Capacitance $ C_{OB} V_{CB}=10\text{V}, I_E=0, f=0.1\text{MHz} 21 \text{pF} $ SWITCHING CHARACTERISTICS Resistive Load (Table 1) Delay Time $ t_D V_{CC}=125\text{V}, I_C=1\text{A}, B_1=I_{B2}=0.2\text{A}, 0.5 1 \mu \text{s} $ Storage Time $ t_E V_{CC}=125\text{V}, I_C=1\text{A}, B_1=I_{B2}=0.2\text{A}, 0.5 1 \mu \text{s} $ Fall Time $ t_F I_C=100\text{mA}, V_{CE}=10\text{V}, f=10\text{MHz} 4 10 \text{MHz} $ $ 0.05 0.1 \mu \text{s} $ $ V_{CC}=125\text{V}, I_C=1\text{A}, B_1=I_{B2}=0.2\text{A}, 0.5 1 \mu \text{s} $ $ V_{CC}=125\text{V}, I_C=1\text{A}, B_1=I_{B2}=0.2\text{A}, 0.5 1 \mu \text{s} $ $ V_{CC}=125\text{V}, I_{C}=1\text{A}, B_1=I_{B2}=0.2\text{A}, 0.5 1 \mu \text{s} $ $ V_{CC}=125\text{V}, I_{C}=1\text{A}, B_1=I_{B2}=0.2\text{A}, 0.5 1 \mu \text{s} $ $ V_{CC}=125\text{V}, I_{C}=1\text{A}, I_{C}=1\text{A}, I_{C}=1\text{A}, I_{C}=1\text{A}, I_{C}=1\text{A} $ $ V_{CC}=125\text{V}, I_{C}=1\text{A}, I_{C}=1\text{A}, I_{C}=1\text{A} $ $ V_{CC}=125\text{V}, I_{C}=1\text{A}, I_{C}=1\text{A} $ $ V_{CC}=125\text{V}, I_{C$		V _{BE(SAT)}	I _C =0.5A, I _B =0.1A			1		
DYNAMIC CHARACTERISTICSCurrent-Gain-Bandwidth Product f_T $I_C=100$ mA, $V_{CE}=10$ V, $f=1$ MHz410MHzOutput Capacitance C_{OB} $V_{CB}=10$ V, $I_E=0$, $f=0.1$ MHz21pFSWITCHING CHARACTERISTICSResistive Load (Table 1) I_D I_D I_D I_D I_D I_D I_D I_D Delay Time I_D <	Base-Emitter Saturation Voltage		I _C =1A, I _B =0.25A			1.2	V	
Current-Gain-Bandwidth Product f_T I_C =100mA, V_{CE} =10V, f =1MHz 4 10 MHz Output Capacitance C_{OB} V_{CB} =10V, I_E =0, f =0.1MHz 2 1 pF SWITCHING CHARACTERISTICS Resistive Load (Table 1) Delay Time t_D Rise Time t_R Storage Time t_R Fall Time t_R Ic=100mA, V_{CE} =10V, f =1MHz 4 10 MHz t_R			I _C =1A, I _B =0.25A, T _C =100°C			1.1		
Output Capacitance C _{OB} V _{CB} =10V, I _E =0, f=0.1MHz 21 pF SWITCHING CHARACTERISTICS Resistive Load (Table 1) t _D 0.05 0.1 μs Paley Time t _B V _{CC} =125V, I _C =1A, B ₁ =I _{B2} =0.2A, 0.5 1 μs Storage Time t _B t _B =25μs, Duty Cycle≤1% 2 2 4 μs Inductive Load, Clamped (Table 1) t _B I _C =1A, V _{CLAMP} =300V, I _{B1} =0.2A, V _{BE} 1.7 4 μs Crossover Time t _C V _{BE} (OSE)=5V _{DC} T _C =100°C 0.29 0.75 μs	DYNAMIC CHARACTERISTICS			_	_	_		
SWITCHING CHARACTERISTICS Resistive Load (Table 1) Delay Time	Current-Gain-Bandwidth Product	f _T	I _C =100mA, V _{CE} =10V, f=1MHz	4	10		MHz	
Resistive Load (Table 1) Delay Time t_D t_D 0.05 0.1 μs Rise Time t_R V_{CC} =125V, I_C =1A, I_D = I_D =0.2A, I_D =0.2A, I_D =0.5 0.5 1 μs Storage Time t_D t_D =25μs, Duty Cycle≤1% 2 4 μs Inductive Load, Clamped (Table 1) t_D t_D =1.7 4 μs Storage Time t_D =1.7 t_D =2.2A, t_D =2.2A, t_D =3.00V, t_D =4.00V, t	Output Capacitance	Сов	V _{CB} =10V, I _E =0, f=0.1MHz		21		pF	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	SWITCHING CHARACTERISTICS							
Rise Time t _R V _{CC} =125V, I _C =1A, B ₁ =I _{B2} =0.2A, 0.5 1 μs Storage Time t _S t _P =25μs, Duty Cycle≤1% 2 4 μs Fall Time t _F 0.4 0.7 μs Inductive Load, Clamped (Table 1) t _{STG} I _C =1A, V _{CLAMP} =300V, I _{B1} =0.2A, U _{CLAMP} =300V, I _{B1} =0.2A, U _{CLAMP} =300V, I _C =100°C 1.7 4 μs Crossover Time t _C V _{CLAMP} =300V, I _C =100°C 0.29 0.75 μs	Resistive Load (Table 1)			_	_	_		
Storage Time t_S $t_P=25\mu s$, Duty Cycle≤1% 2 4 μs Fall Time t_F 0.4 0.7 μs Inductive Load, Clamped (Table 1) Storage Time t_{STG} $t_{C=1A}$, $V_{CLAMP}=300V$, $t_{B1}=0.2A$, $t_{C}=10.2A$, $t_$	Delay Time	t _D			0.05	0.1	μs	
Fall Time t_F 0.4 0.7 μs Inductive Load, Clamped (Table 1) Storage Time t_{C}	Rise Time	t _R	V _{CC} =125V, I _C =1A, _{B1} =I _{B2} =0.2A,		0.5	1	μs	
Inductive Load, Clamped (Table 1) Storage Time	Storage Time	ts	t _P =25µs, Duty Cycle≤1%		2	4	μs	
Storage Time t_{STG} $I_{C}=1A, V_{CLAMP}=300V, I_{B1}=0.2A,$ $0.29 \ 0.75 \ \mu s$ $V_{CLAMP}=300V, I_{C}=100^{\circ}C$	Fall Time	t _F			0.4	0.7	μs	
Crossover Time	Inductive Load, Clamped (Table 1)							
Crossover Time tc Ver(05)=5Vpc Tc=100°C 0.29 0.75 µs	Storage Time	t _{STG}	1 44 1/ 2001/ 1 2 24		1.7	4	μs	
Fall Time t_F $v_{BE(OFF)}=5v_{DC}, T_C=100 C$ 0.15 μs	Crossover Time	t _C			0.29	0.75	μs	
	Fall Time	t _F	VBE(OFF)=5VDC, IC=1UU-C		0.15		μs	

Note: Pulse Test: PW=300µs, Duty Cycle≤2%

■ CLASSIFICATION OF h_{FE1}

RANK	Α	В	С	D	E	F	G	Н
RANGE	14 ~ 22	21 ~ 27	26 ~ 32	31 ~ 37	36 ~ 42	41 ~ 47	46 ~ 52	51 ~ 57

APPLICATION INFORMATION

Table 1.Test Conditions for Dynamic Performance

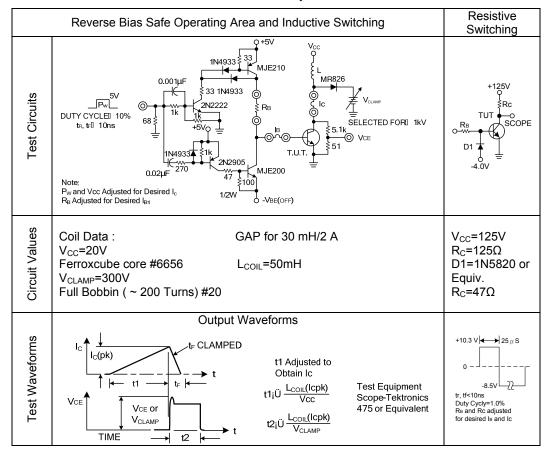


Table 2. Typical Inductive Switching Performance

Ic	Tc	t _{sv}	t _{RV}	t _{FI}	t _{TI} (µs)	tc
(A)	(°C)	(µs)	(µs)	(µs)		(µs)
0.5	25	1.3	0.23	0.30	0.35	0.30
	100	1.6	0.26	0.30	0.40	0.36
1	25	1.5	0.10	0.14	0.05	0.16
	100	1.7	0.13	0.26	0.06	0.29
1.5	25	1.8	0.07	0.10	0.05	0.16
	100	3	0.08	0.22	0.08	0.28

Note: All Data Recorded in the Inductive Switching Circuit in Table 1

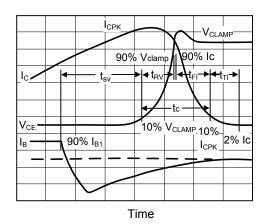


Fig.1 Inductive Switching Measurements

■ SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads, which are common to switch mode power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

 t_{SV} = Voltage Storage Time, 90% I_{B1} to 10% V_{CLAMP}

 t_{RV} = Voltage Rise Time, 10 ~ 90% V_{CLAMP}

 t_{FI} = Current Fall Time, 90 ~ 10% I_{C}

 t_{TI} = Current Tail, 10 ~ 2% I_{C}

 t_C = Crossover Time, 10% V_{CLAMP} to 10% I_C

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation:

$$P_{SWT} = 1/2 V_{CC}I_{C} (t_{C}) f$$

In general, $t_{RV} + t_{FI} \approx t_C$. However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this transistor are the inductive switching speeds (t_C and t_{SV}) which are guaranteed at $100^{\circ}C$.

RESISTIVE SWITCHING PERFORMANCE

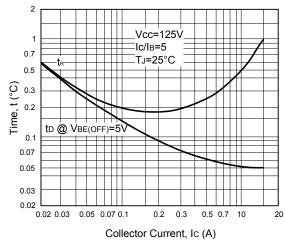


Fig.2 Turn-On Time

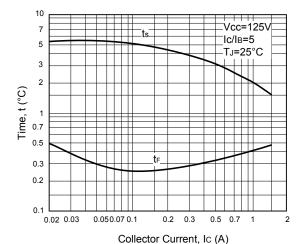


Fig.3 Turn-Off Time

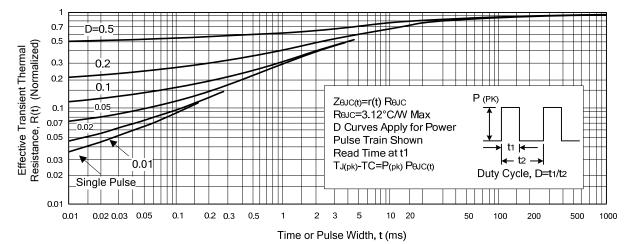


Fig.4 Thermal Response

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; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

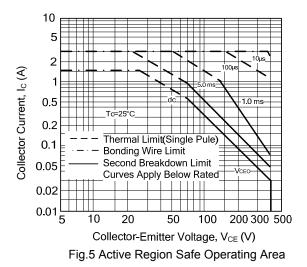
The data of Fig.5 is based on $T_C = 25^{\circ}C$; $T_{J(PK)}$ is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when $T_C \ge 25^{\circ}C$. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Fig.5.

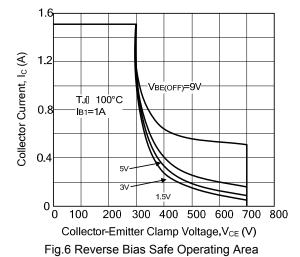
 $T_{J(PK)}$ may be calculated from the data in Fig.4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

REVERSE BIAS

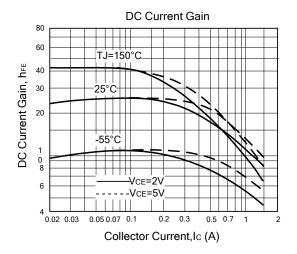
For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as RB_{SOA} (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. Fig.6 gives RB_{SOA} characteristics.

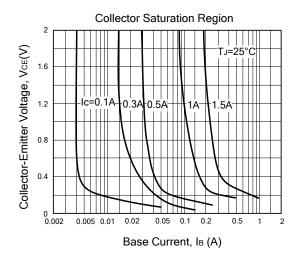
The Safe Operating Area of Fig.5 and 6 are specified ratings (for these devices under the test conditions shown.)

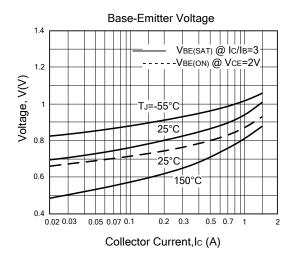


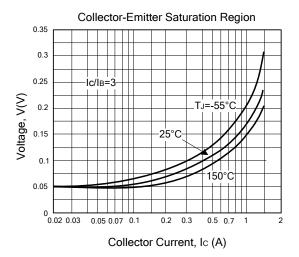


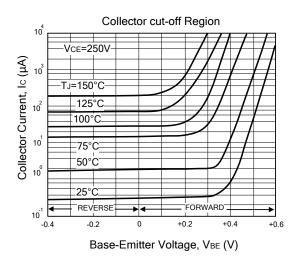
■ TYPICAL CHARACTERISTICS

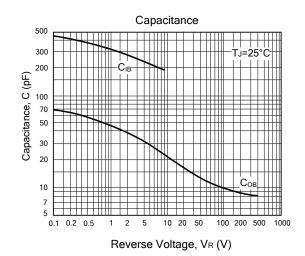




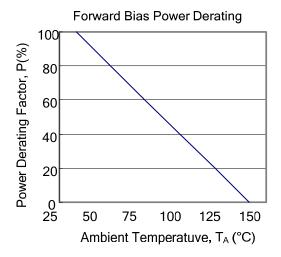








■ TYPICAL CHARACTERISTICS(Cont.)



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