

# DATA SHEET

## **BUT11; BUT11A** Silicon diffused power transistors

Product specification  
Supersedes data of February 1996  
File under Discrete Semiconductors, SC06

1997 Aug 13

Silicon diffused power transistors

BUT11; BUT11A

DESCRIPTION

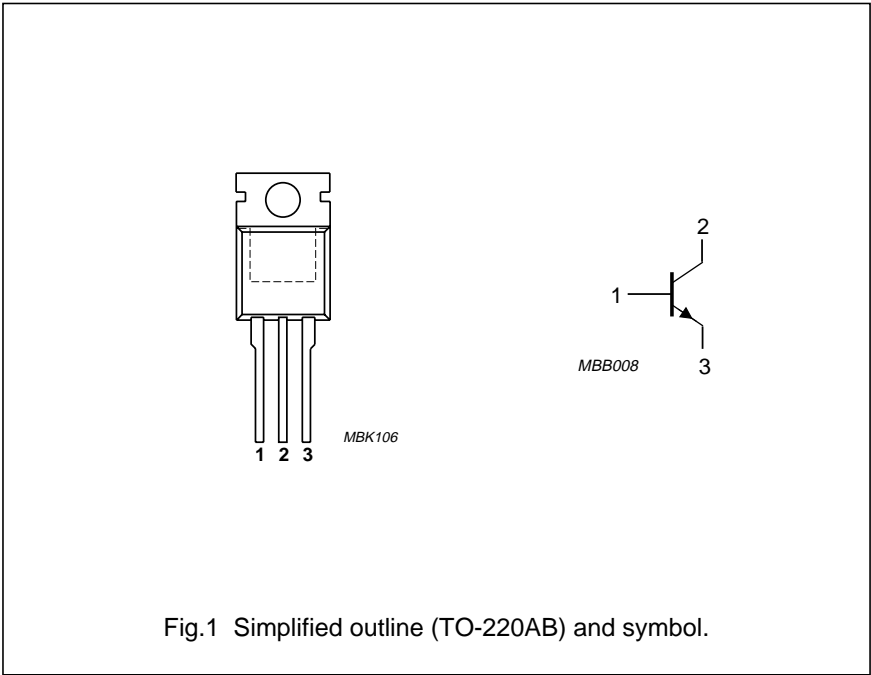
High-voltage, high-speed, glass-passivated NPN power transistor in a TO-220AB package.

APPLICATIONS

- Converters
- Inverters
- Switching regulators
- Motor control systems.

PINNING

PIN	DESCRIPTION
1	base
2	collector; connected to mounting base
3	emitter



QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MAX.	UNIT
$V_{CESM}$	collector-emitter peak voltage	$V_{BE} = 0$		
	BUT11		850	V
	BUT11A		1000	V
$V_{CEO}$	collector-emitter voltage	open base		
	BUT11		400	V
	BUT11A		450	V
$V_{CEsat}$	collector-emitter saturation voltage	see Figs 7 and 9	1.5	V
$I_C$	collector current (DC)	see Figs 2 and 4	5	A
$I_{CM}$	collector current (peak value)	see Fig. 4	10	A
$P_{tot}$	total power dissipation	$T_{mb} \leq 25\text{ }^{\circ}\text{C}$ ; see Fig.3	100	W
$t_f$	fall time	resistive load; see Figs 11 and 12	0.8	$\mu\text{s}$

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	VALUE	UNIT
$R_{th\ j-mb}$	thermal resistance from junction to mounting base	1.25	K/W

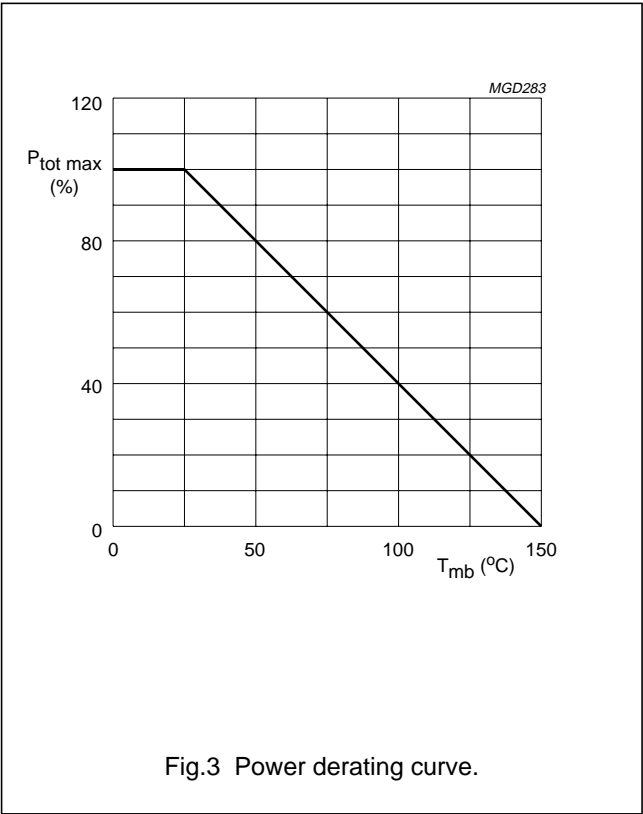
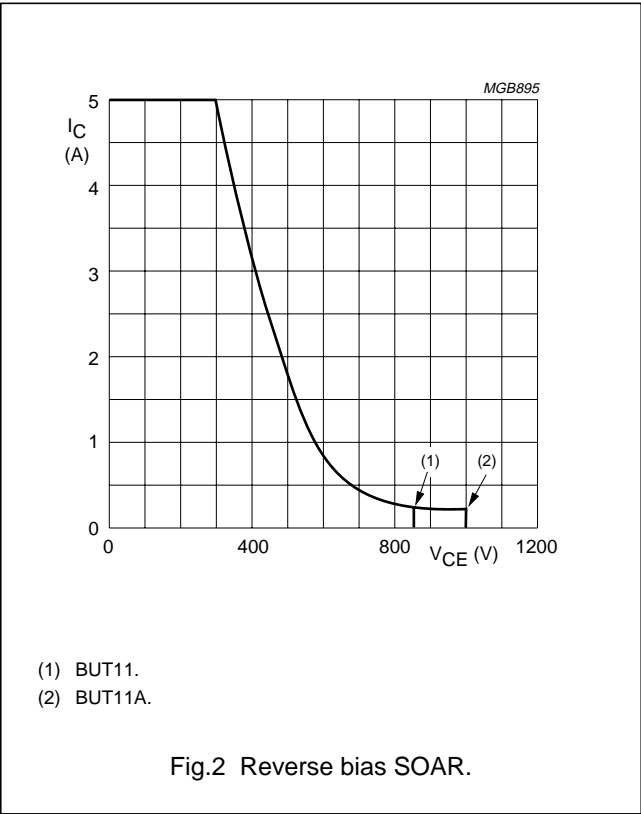
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LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V <sub>CESM</sub>	collector-emitter peak voltage	V <sub>BE</sub> = 0			
	BUT11		–	850	V
	BUT11A		–	1000	V
V <sub>CEO</sub>	collector-emitter voltage	open base			
	BUT11		–	400	V
	BUT11A		–	450	V
I <sub>C</sub>	collector current (DC)	see Figs 2 and 4	–	5	A
I <sub>CM</sub>	collector current (peak value)	t <sub>p</sub> < 2 ms; see Fig. 4	–	10	A
I <sub>B</sub>	base current (DC)		–	2	A
I <sub>BM</sub>	base current (peak value)	t <sub>p</sub> < 2 ms	–	4	A
P <sub>tot</sub>	total power dissipation	T <sub>mb</sub> ≤ 25 °C; see Fig.3	–	100	W
T <sub>stg</sub>	storage temperature		–65	+150	°C
T <sub>j</sub>	junction temperature		–	150	°C



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## CHARACTERISTICS

$T_j = 25\text{ }^{\circ}\text{C}$  unless otherwise specified.

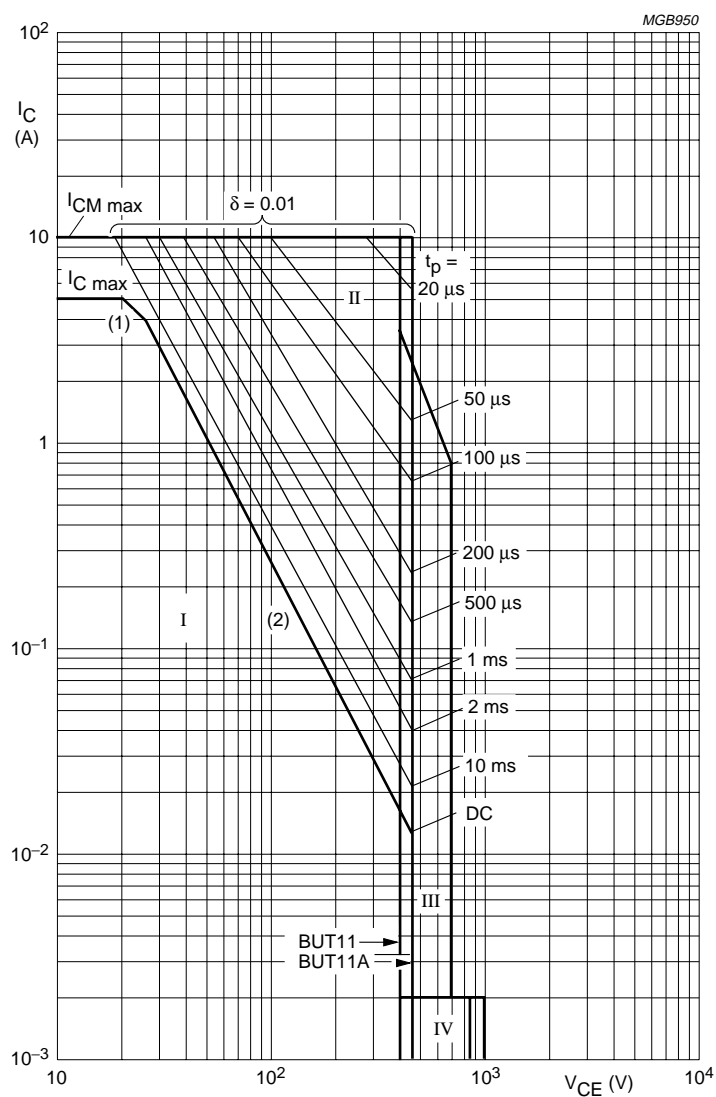
SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$V_{CEOsust}$	collector-emitter sustaining voltage BUT11 BUT11A	$I_C = 100\text{ mA}$ ; $I_{Boff} = 0$ ; $L = 25\text{ mH}$ ; see Figs 5 and 6	400	—	—	V
			450	—	—	V
$V_{CEsat}$	collector-emitter saturation voltage BUT11 BUT11A	$I_C = 3\text{ A}$ ; $I_B = 600\text{ mA}$ ; see Figs 7 and 9	—	—	1.5	V
		$I_C = 2.5\text{ A}$ ; $I_B = 500\text{ mA}$ ; see Figs 7 and 9	—	—	1.5	V
$V_{BEsat}$	base-emitter saturation voltage BUT11 BUT11A	$I_C = 3\text{ A}$ ; $I_B = 0.6\text{ A}$ ; see Fig.7	—	—	1.3	V
		$I_C = 2.5\text{ A}$ ; $I_B = 0.5\text{ A}$ ; see Fig.7	—	—	1.3	V
$I_{CES}$	collector-emitter cut-off current	$V_{CE} = V_{CESMmax}$ ; $V_{BE} = 0$ ; note 1	—	—	1	mA
		$V_{CE} = V_{CESMmax}$ ; $V_{BE} = 0$ ; $T_j = 125\text{ }^{\circ}\text{C}$ ; note 1	—	—	2	mA
$I_{EBO}$	emitter-base cut-off current	$V_{EB} = 9\text{ V}$ ; $I_C = 0$	—	—	10	mA
$h_{FE}$	DC current gain	$V_{CE} = 5\text{ V}$ ; $I_C = 5\text{ mA}$ ; see Fig.10	10	18	35	
		$V_{CE} = 5\text{ V}$ ; $I_C = 500\text{ mA}$ ; see Fig.10	10	20	35	
Switching times resistive load (see Fig.12)						
$t_{on}$	turn-on time BUT11 BUT11A	$I_{Con} = 3\text{ A}$ ; $I_{Bon} = -I_{Boff} = 600\text{ mA}$	—	—	1	$\mu\text{s}$
		$I_{Con} = 2.5\text{ A}$ ; $I_{Bon} = -I_{Boff} = 500\text{ mA}$	—	—	1	$\mu\text{s}$
$t_s$	storage time BUT11 BUT11A	$I_{Con} = 3\text{ A}$ ; $I_{Bon} = -I_{Boff} = 600\text{ mA}$	—	—	4	$\mu\text{s}$
		$I_{Con} = 2.5\text{ A}$ ; $I_{Bon} = -I_{Boff} = 500\text{ mA}$	—	—	4	$\mu\text{s}$
$t_f$	fall time BUT11 BUT11A	$I_{Con} = 3\text{ A}$ ; $I_{Bon} = -I_{Boff} = 600\text{ mA}$	—	—	0.8	$\mu\text{s}$
		$I_{Con} = 2.5\text{ A}$ ; $I_{Bon} = -I_{Boff} = 500\text{ mA}$	—	—	0.8	$\mu\text{s}$
Switching times inductive load (see Fig.14)						
$t_s$	storage time BUT11	$I_{Con} = 3\text{ A}$ ; $I_{Bon} = 600\text{ mA}$	—	1.1	1.4	$\mu\text{s}$
		$I_{Con} = 3\text{ A}$ ; $I_{Bon} = 600\text{ mA}$ ; $T_j = 100\text{ }^{\circ}\text{C}$	—	1.2	1.5	$\mu\text{s}$
	BUT11A	$I_{Con} = 2.5\text{ A}$ ; $I_{Bon} = 500\text{ mA}$	—	1.1	1.4	$\mu\text{s}$
		$I_{Con} = 2.5\text{ A}$ ; $I_{Bon} = 500\text{ mA}$ ; $T_j = 100\text{ }^{\circ}\text{C}$	—	1.2	1.5	$\mu\text{s}$
$t_f$	fall time BUT11	$I_{Con} = 3\text{ A}$ ; $I_{Bon} = 600\text{ mA}$	—	80	150	ns
		$I_{Con} = 3\text{ A}$ ; $I_{Bon} = 600\text{ mA}$ ; $T_j = 100\text{ }^{\circ}\text{C}$	—	140	300	ns
	BUT11A	$I_{Con} = 2.5\text{ A}$ ; $I_{Bon} = 500\text{ mA}$	—	80	150	ns
		$I_{Con} = 2.5\text{ A}$ ; $I_{Bon} = 500\text{ mA}$ ; $T_j = 100\text{ }^{\circ}\text{C}$	—	140	300	ns

## Note

1. Measured with a half-sinewave voltage (curve tracer).

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$T_{mb} \leq 25^\circ\text{C}$ .

I - Region of permissible DC operation.

II - Permissible extension for repetitive pulse operation.

III - Area of permissible operation during turn-on in single transistor converters, provided  $R_{BE} \leq 100 \Omega$  and  $t_p \leq 0.6 \mu\text{s}$ .

IV - Repetitive pulse operation in this region is permissible provided  $V_{BE} \leq 0$  and  $t_p \leq 5 \text{ ms}$ .

(1)  $P_{tot max}$  and  $P_{tot peak max}$  lines.

(2) Second breakdown limits.

Fig.4 Forward bias SOAR.

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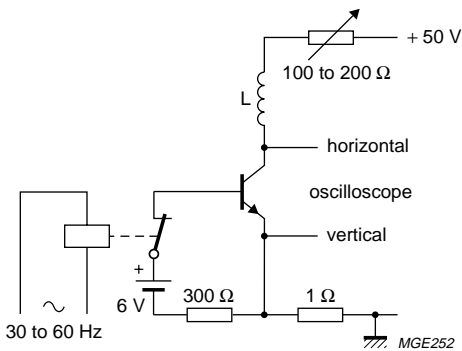


Fig.5 Test circuit for collector-emitter sustaining voltage.

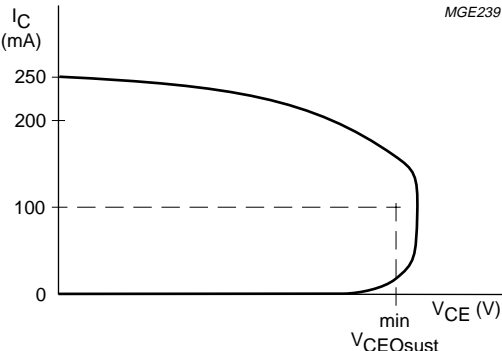


Fig.6 Oscilloscope display for collector-emitter sustaining voltage.

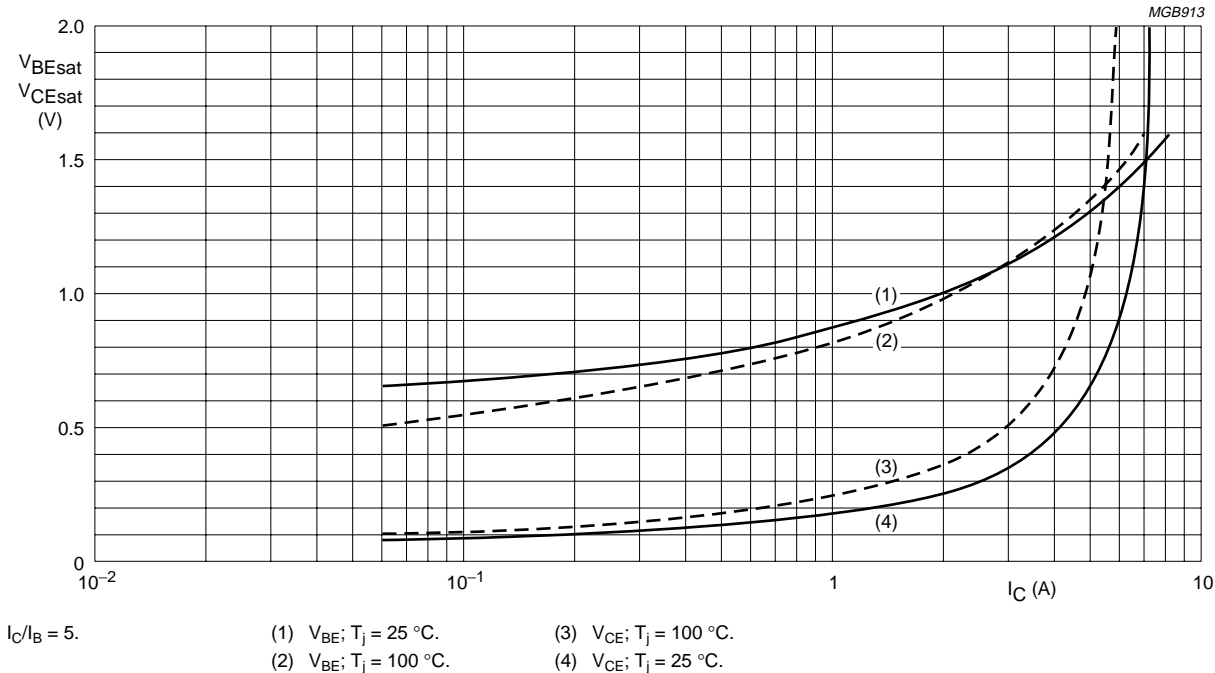


Fig.7 Base-emitter and collector-emitter saturation voltages as functions of collector current; typical values.

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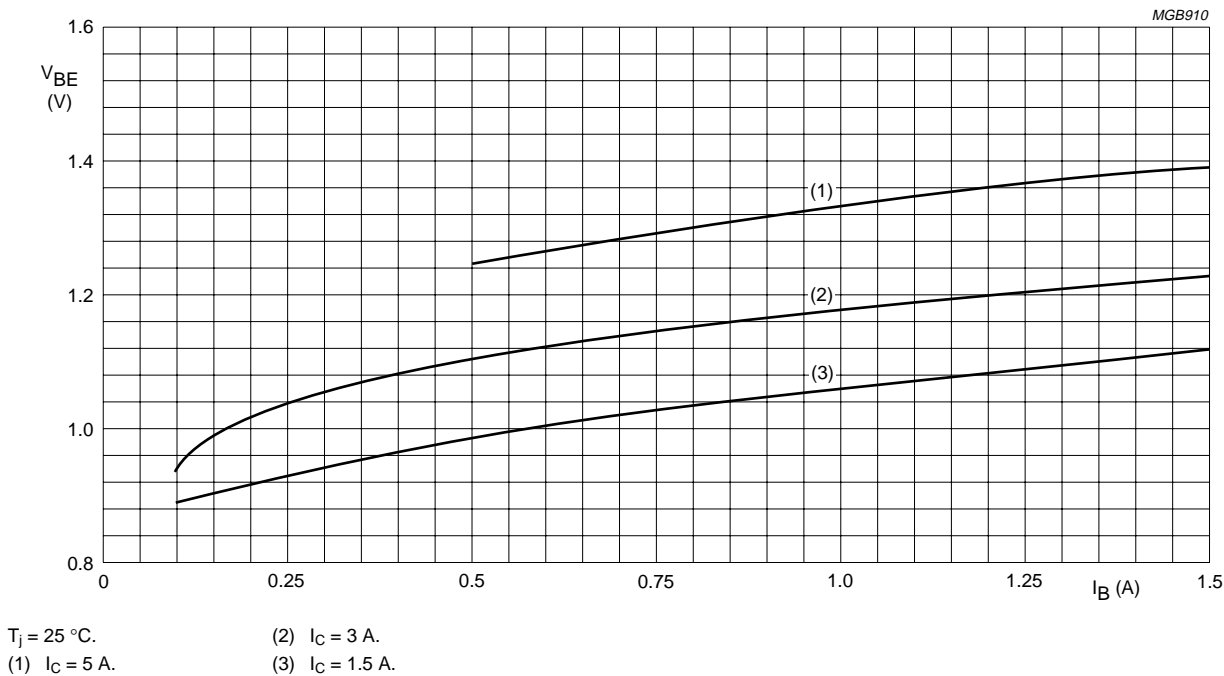


Fig.8 Base-emitter voltage as a function of base current.

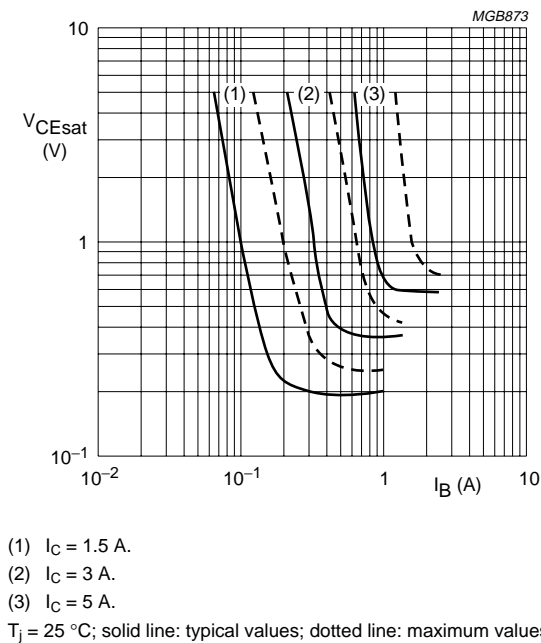


Fig.9 Collector-emitter saturation voltage as a function of base current.

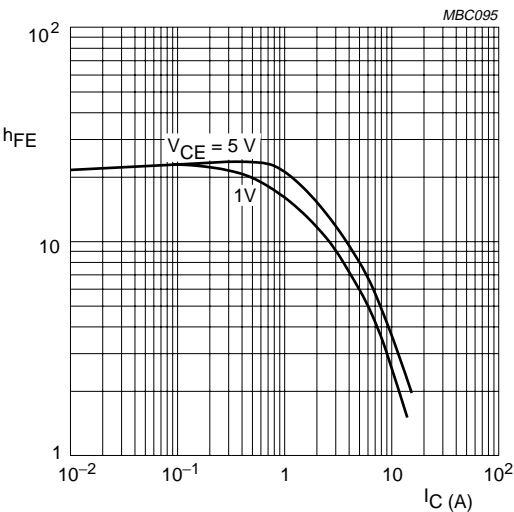
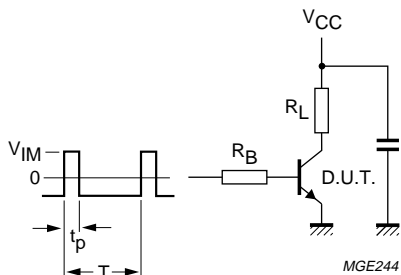


Fig.10 DC current gain; typical values.

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$V_{CC} = 250\text{ V}$ ;  $t_p = 20\text{ }\mu\text{s}$ ;  $V_{IM} = -6\text{ to }+8\text{ V}$ ;  $t_p/T = 0.01$ .  
The values of  $R_B$  and  $R_L$  are selected in accordance with  $I_{C\text{on}}$  and  $I_{B\text{on}}$  requirements.

Fig.11 Test circuit resistive load.

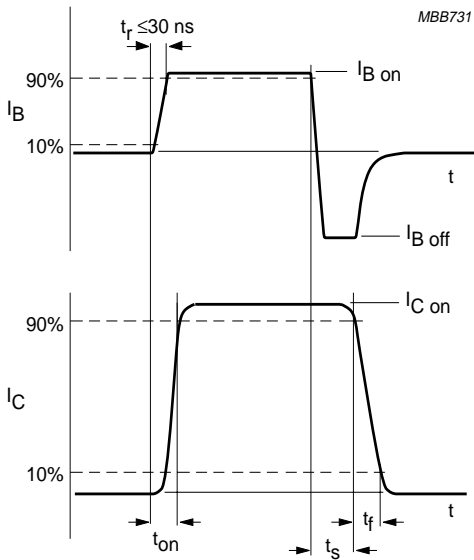
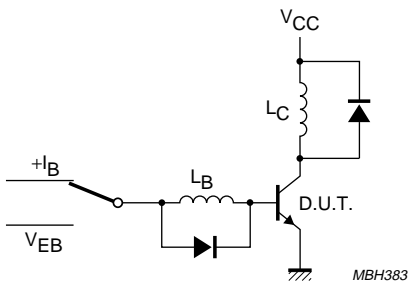


Fig.12 Switching time waveforms with resistive load.



$V_{CC} = 300\text{ V}$ ;  $V_{EB} = 5\text{ V}$ ;  $L_B = 1\text{ }\mu\text{H}$ .

Fig.13 Test circuit inductive load.

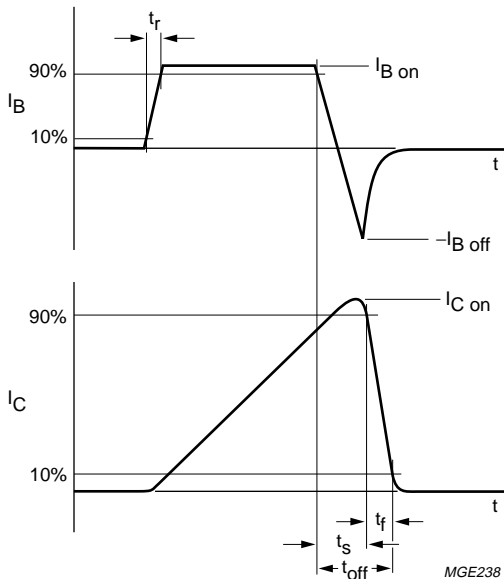


Fig.14 Switching time waveforms with inductive load.



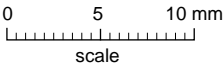
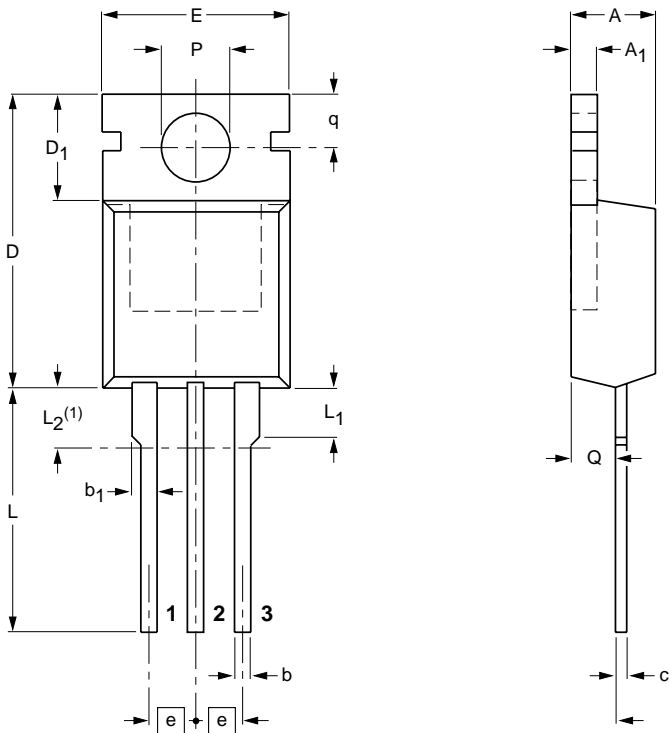
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PACKAGE OUTLINE

Plastic single-ended package; heatsink mounted; 1 mounting hole; 3-lead TO-220

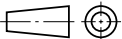
SOT78



DIMENSIONS (mm are the original dimensions)

UNIT	A	A <sub>1</sub>	b	b <sub>1</sub>	c	D	D <sub>1</sub>	E	e	L	L <sub>1</sub>	L <sub>2</sub> <sup>(1)</sup> max.	P	q	Q
mm	4.5 4.1	1.39 1.27	0.9 0.7	1.3 1.0	0.7 0.4	15.8 15.2	6.4 5.9	10.3 9.7	2.54	15.0 13.5	3.30 2.79	3.0	3.8 3.6	3.0 2.7	2.6 2.2

Note  
1. Terminals in this zone are not tinned.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT78		TO-220				97-06-11

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**DEFINITIONS**

<b>Data sheet status</b>	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
<b>Limiting values</b>	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.	
<b>Application information</b>	
Where application information is given, it is advisory and does not form part of the specification.	

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