# DATA SHEET

# BUT11; BUT11A
## Silicon diffused power transistors

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

1997 Aug 13

Philips
Semiconductors

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# Silicon diffused power transistors BUT11; BUT11A

## DESCRIPTION

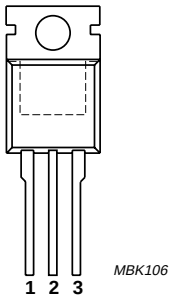
High-voltage, high-speed, glass-passivated NPN power transistor in a TO-220AB package.

## APPLICATIONS

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

## PINNING

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



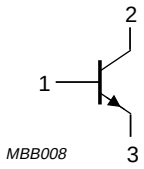




Fig.1 Simplified outline (TO-220AB) and symbol.

## 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 | $T_{mb} \leq 25$ °C; see Fig.3 | 100 | W |
| $t_f$ | fall time | resistive load; see Figs 11 and 12 | 0.8 | µs |

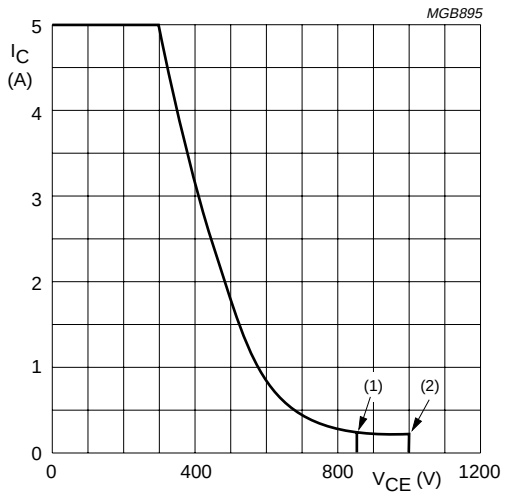
## THERMAL CHARACTERISTICS

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

**LIMITING VALUES**

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

| SYMBOL | PARAMETER | CONDITIONS | MIN. | 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 |
| $I_C$ | collector current (DC) | see Figs 2 and 4 | – | 5 | A |
| $I_{CM}$ | collector current (peak value) | $t_p$ < 2 ms; see Fig. 4 | – | 10 | A |
| $I_B$ | base current (DC) | | – | 2 | A |
| $I_{BM}$ | base current (peak value) | $t_p$ < 2 ms | – | 4 | A |
| $P_{tot}$ | total power dissipation | $T_{mb} \leq 25$ °C; see Fig.3 | – | 100 | W |
| $T_{stg}$ | storage temperature | | –65 | +150 | °C |
| $T_j$ | junction temperature | | – | 150 | °C |




(1) BUT11.
(2) BUT11A.

Fig.2 Reverse bias SOAR.

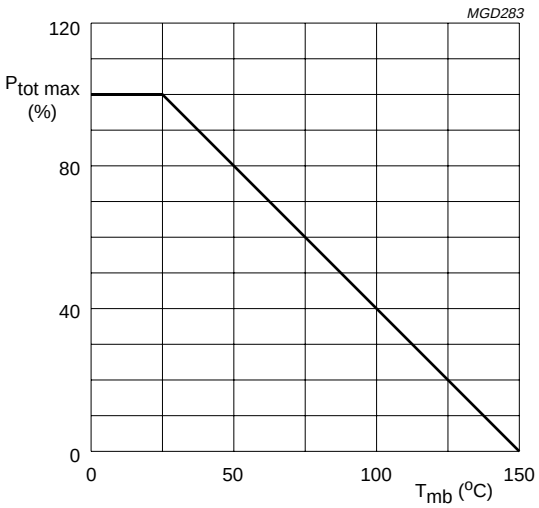



Fig.3 Power derating curve.

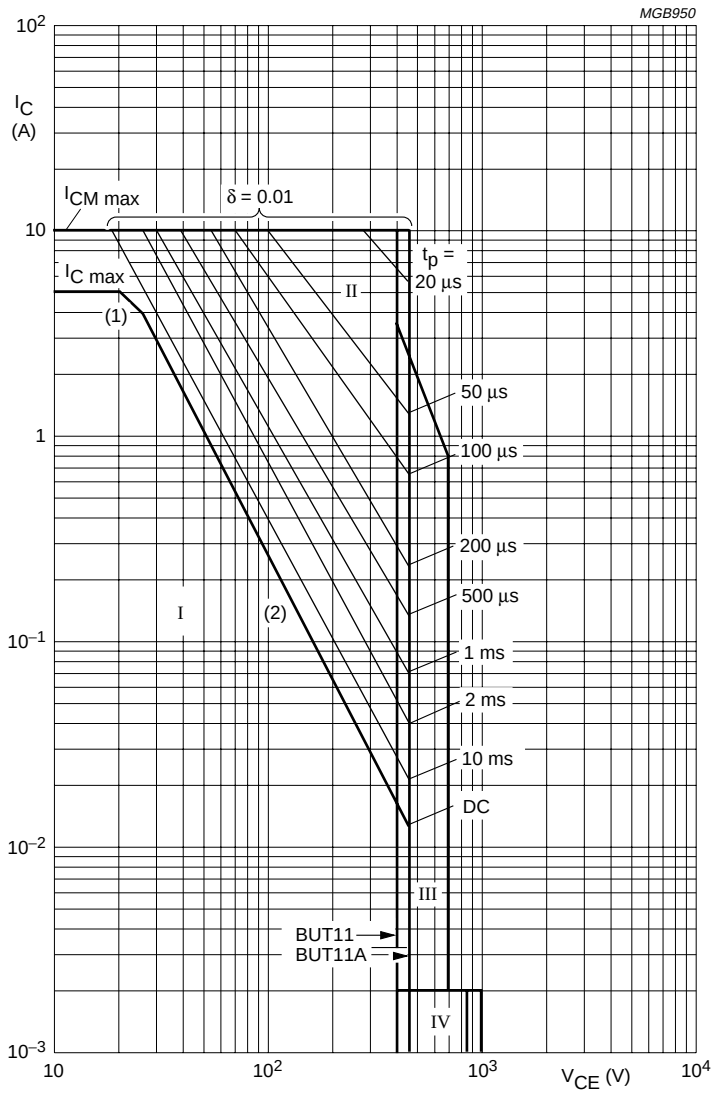
## CHARACTERISTICS

$T_j$ = 25 °C unless otherwise specified.

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

**Note**

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




$T_{mb} \leq 25$ °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 $t_p \leq 0.6$ µs.

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

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

(2) Second breakdown limits.

Fig.4 Forward bias SOAR.

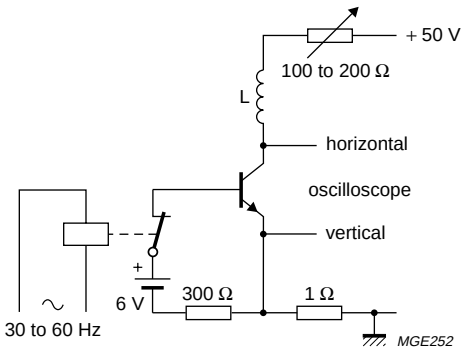



Fig.5 Test circuit for collector-emitter sustaining voltage.

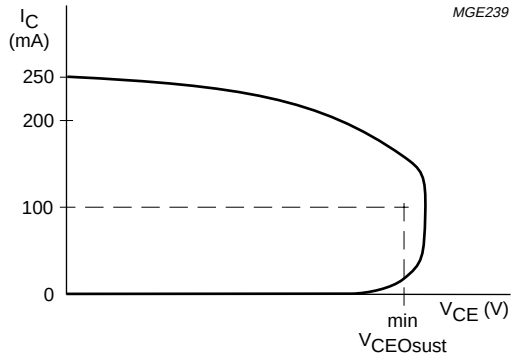
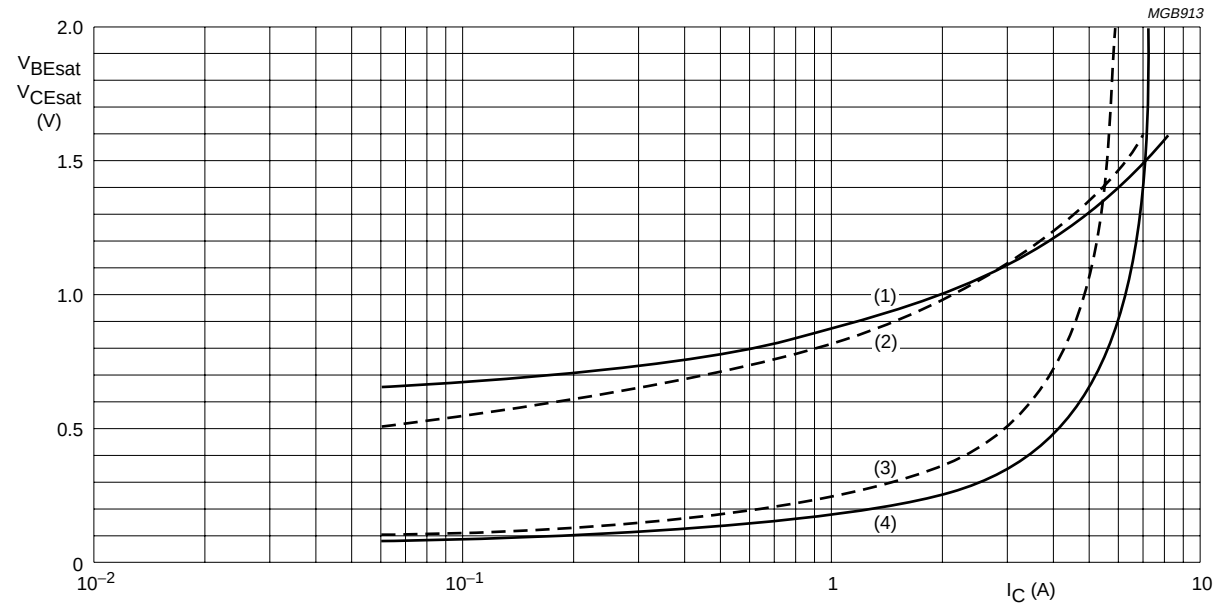


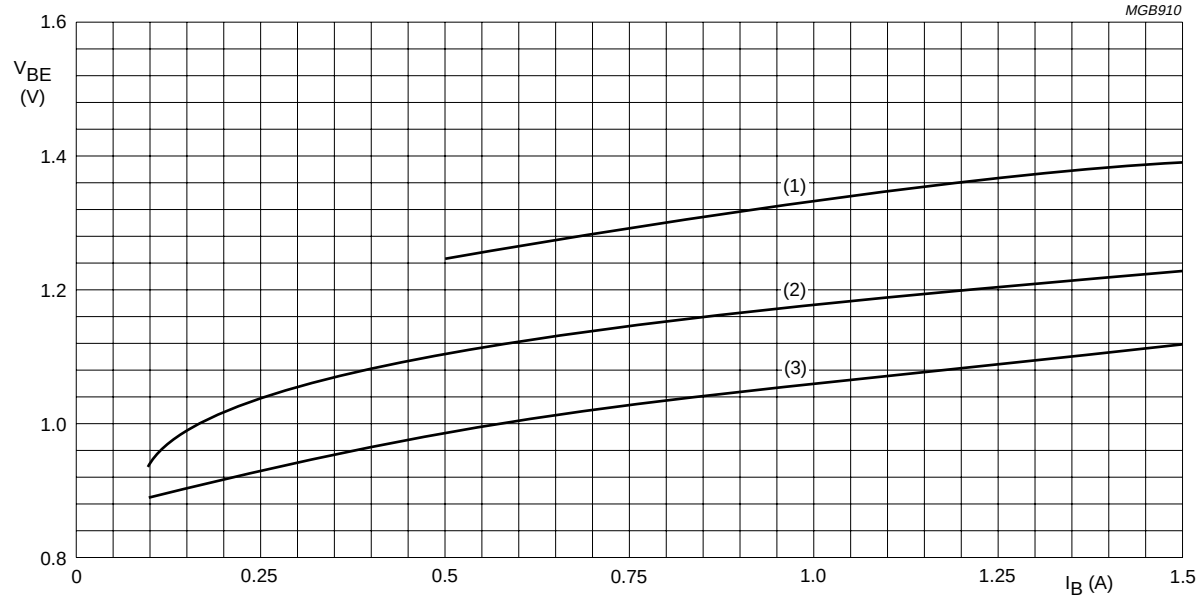

Fig.6 Oscilloscope display for collector-emitter sustaining voltage.




$I_C/I_B$ = 5.

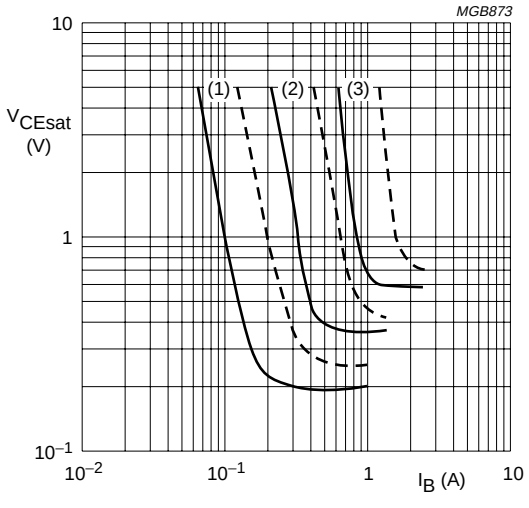
(1) $V_{BE}$; $T_j$ = 25 °C.
(2) $V_{BE}$; $T_j$ = 100 °C.
(3) $V_{CE}$; $T_j$ = 100 °C.
(4) $V_{CE}$; $T_j$ = 25 °C.

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




$T_j$ = 25 °C.
(1) $I_C$ = 5 A.
(2) $I_C$ = 3 A.
(3) $I_C$ = 1.5 A.

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




(1) $I_C$ = 1.5 A.
(2) $I_C$ = 3 A.
(3) $I_C$ = 5 A.
$T_j$ = 25 °C; solid line: typical values; dotted line: maximum values.

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

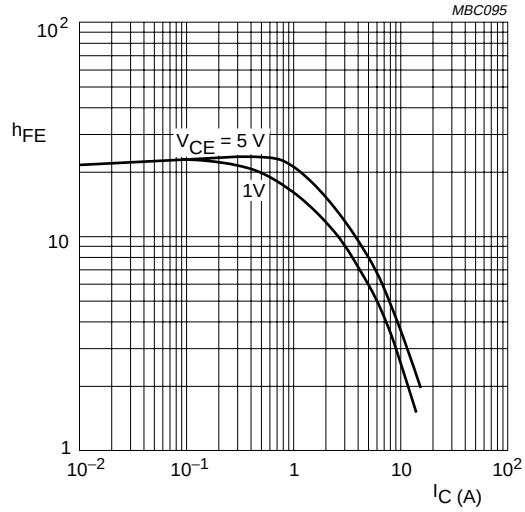
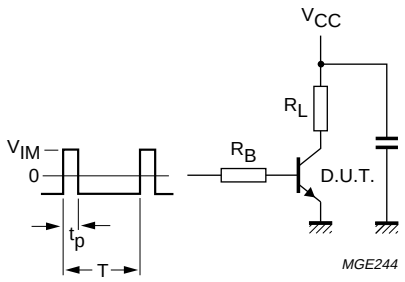



Fig.10 DC current gain; typical values.




$V_{CC}$ = 250 V; $t_p$ = 20 µs; $V_{IM}$ = −6 to +8 V; $t_p/T$ = 0.01.
The values of $R_B$ and $R_L$ are selected in accordance with $I_{Con}$ and $I_{Bon}$ requirements.

Fig.11 Test circuit resistive load.

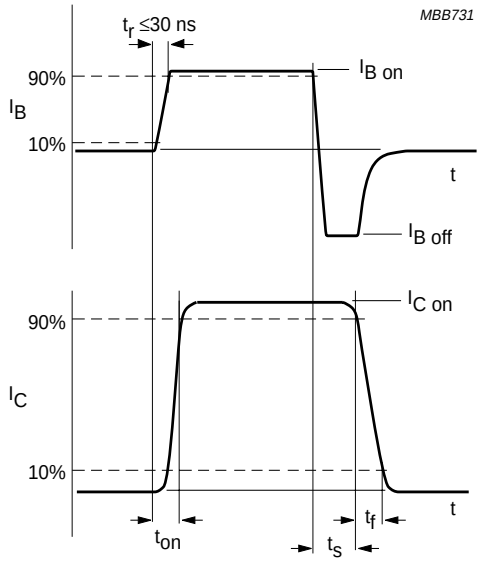
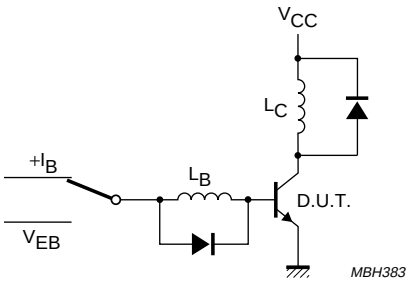



Fig.12 Switching time waveforms with resistive load.




$V_{CC}$ = 300 V; $V_{EB}$ = 5 V; $L_B$ = 1 µH.

Fig.13 Test circuit inductive load.

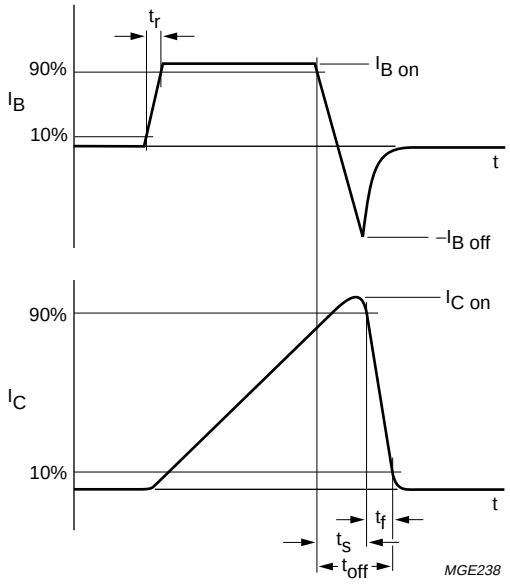
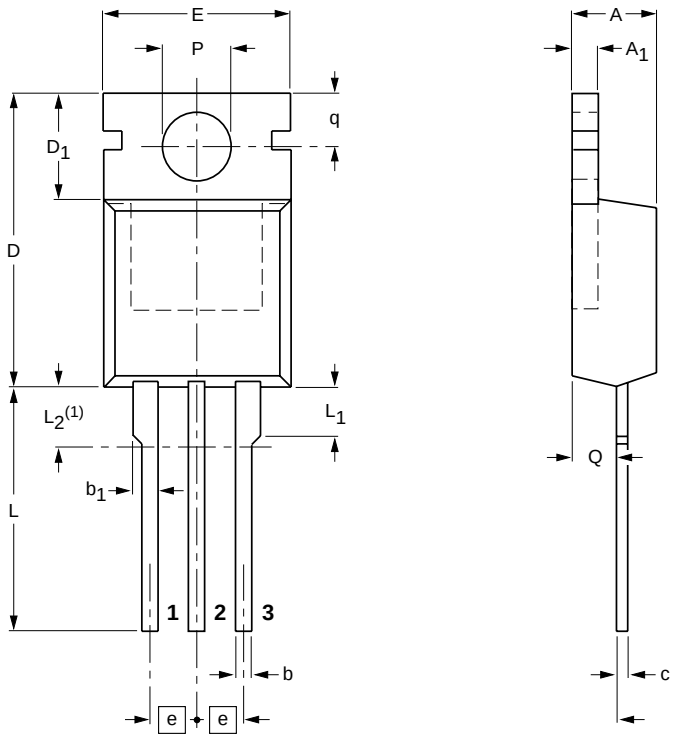
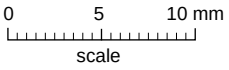



Fig.14 Switching time waveforms with inductive load.

## PACKAGE OUTLINE

**Plastic single-ended package; heatsink mounted; 1 mounting hole; 3-lead TO-220** **SOT78**




**DIMENSIONS (mm are the original dimensions)**

| UNIT | A | $A_1$ | b | $b_1$ | c | D | $D_1$ | E | e | L | $L_1$ | $L_2^{(1)}$ max. | P | q | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 4.5<br>4.1 | 1.39<br>1.27 | 0.9<br>0.7 | 1.3<br>1.0 | 0.7<br>0.4 | 15.8<br>15.2 | 6.4<br>5.9 | 10.3<br>9.7 | 2.54 | 15.0<br>13.5 | 3.30<br>2.79 | 3.0 | 3.8<br>3.6 | 3.0<br>2.7 | 2.6<br>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 |

## DEFINITIONS

| **Data sheet status** | |
|---|---|
| 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. |
| **Limiting values** | |
| 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. | |
| **Application information** | |
| Where application information is given, it is advisory and does not form part of the specification. | |

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