# Silicon diffused power transistors — BUT12; BUT12A

High-voltage, high-speed, glass-passivated npn power transistors in a TO220 envelope intended for use in converters, inverters, switching regulators, motor control systems, etc.

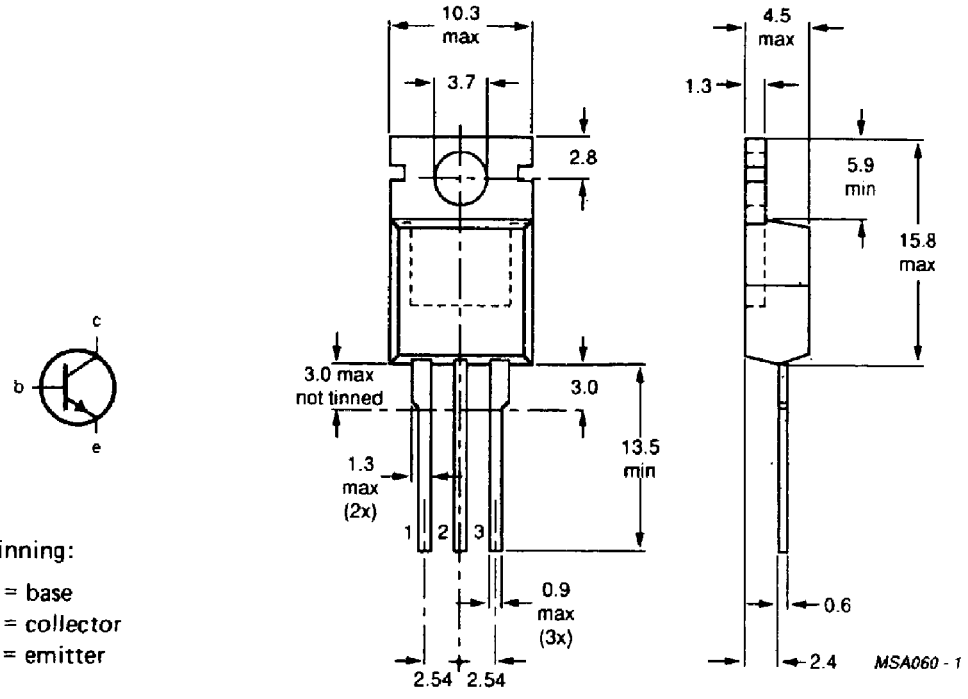
## QUICK REFERENCE DATA

| | | | BUT12 | BUT12A | |
|---|---|---|---|---|---|
| Collector-emitter voltage | | | | | |
| peak value; $V_{BE}$ = 0 | $V_{CESM}$ | max. | 850 | 1000 | V |
| open base | $V_{CEO}$ | max. | 400 | 450 | V |
| Collector-emitter saturation voltage | $V_{CEsat}$ | max. | 1.5 | 1.5 | V |
| Collector current | | | | | |
| saturation | $I_{Csat}$ | max. | 6.0 | 5.0 | A |
| DC | $I_C$ | max. | 8 | | A |
| peak value | $I_{CM}$ | max. | 20 | | A |
| Total power dissipation | | | | | |
| up to $T_{mb}$ = 25 °C | $P_{tot}$ | max. | 125 | | W |
| Fall time | $t_f$ | max. | 0.8 | | μs |

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO220AB.




Pinning:

1 = base
2 = collector
3 = emitter

Collector connected to mounting base.

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## RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

| | | | BUT12 | BUT12A | |
|---|---|---|---|---|---|
| Collector-emitter voltage | | | | | |
| peak value; $V_{BE}$ = 0 | $V_{CESM}$ | max. | 850 | 1000 | V |
| open base | $V_{CEO}$ | max. | 400 | 450 | V |
| Collector current | | | | | |
| saturation | $I_{Csat}$ | | 6.0 | 5.0 | A |
| DC | $I_C$ | max. | 8 | | A |
| peak value | $I_{CM}$ | max. | 20 | | A |
| Base current | | | | | |
| DC | $I_B$ | max. | 4.0 | | A |
| peak value | $I_{BM}$ | max. | 6.0 | | A |
| Total power dissipation | | | | | |
| up to $T_{mb}$ = 25 °C | $P_{tot}$ | max. | 125 | | W |
| Storage temperature range | $T_{stg}$ | | −65 to +150 | | °C |
| Junction temperature | $T_j$ | max. | 150 | | °C |

## THERMAL RESISTANCE

| | | | |
|---|---|---|---|
| From junction to mounting base | $R_{th\ j\text{-}mb}$ | = | 1.0 K/W |

## CHARACTERISTICS

$T_j$ = 25 °C unless otherwise specified

| | | | | |
|---|---|---|---|---|
| Collector cut-off currents* | | | | |
| $V_{CE} = V_{CESmax}$; $V_{BE}$ = 0 | $I_{CES}$ | max. | 1.0 | mA |
| $V_{CE} = V_{CESmax}$; $V_{BE}$ = 0; $T_j$ = 125 °C | $I_{CES}$ | max. | 3.0 | mA |
| Emitter cut-off current | | | | |
| $V_{EB}$ = 9 V; $I_C$ = 0 | $I_{EBO}$ | max. | 10 | mA |

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

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|---|---|---|---|---|
| **Saturation voltages** | | | | |
| $I_C$ = 6 A; $I_B$ = 1.2 A | $V_{CEsat}$ | max. | 1.5 | – V |
| | $V_{BEsat}$ | max. | 1.5 | – V |
| $I_C$ = 5 A; $I_B$ = 1.0 A | $V_{CEsat}$ | max. | – | 1.5 V |
| | $V_{BEsat}$ | max. | – | 1.5 V |
| **DC current gain** | | | | |
| $I_C$ = 10 mA; $V_{CE}$ = 5 V | $h_{FE}$ | min. | 10 | |
| | $h_{FE}$ | typ. | 18 | |
| | $h_{FE}$ | max. | 35 | |
| $I_C$ = 1 A; $V_{CE}$ = 5 V | $h_{FE}$ | min. | 10 | |
| | $h_{FE}$ | typ. | 20 | |
| | $h_{FE}$ | max. | 35 | |
| **Collector-emitter sustaining voltage** (Figs 2 and 3) | | | | |
| $I_C$ = 100 mA; $I_{B\,off}$ = 0; L = 25 mH | $V_{CEOsust}$ | min. | 400 | 450 V |
| **Switching times resistive load** (Figs 4 and 5) | | | | |
| $I_{C\,on}$ = 6 A; $I_{B\,on}$ = $-I_{B\,off}$ = 1.2 A | | | | |
| Turn-on time | $t_{on}$ | max. | 1.0 | — µs |
| Turn-off; | | | | |
| storage time | $t_s$ | max. | 4.0 | – µs |
| fall time | $t_f$ | max. | 0.8 | – µs |
| $I_{C\,on}$ = 5 A; $I_{B\,on}$ = $-I_{B\,off}$ = 1.0 A | | | | |
| Turn-on time | $t_{on}$ | max. | – | 1.0 µs |
| Turn-off; | | | | |
| storage time | $t_s$ | max. | – | 4.0 µs |
| fall time | $t_f$ | max. | – | 0.8 µs |
| **Switching times inductive load** (Figs 5 and 6) | | | | |
| $I_{C\,on}$ = 6 A; $I_{B\,on}$ = 1.2 A; $V_{CL}$ = 250 V; $T_c$ = 100 °C | | | | |
| Turn-off; | | | | |
| storage time | $t_s$ | typ. | 1.9 | – µs |
| | $t_s$ | max. | 2.5 | – µs |
| fall time | $t_f$ | typ. | 200 | – ns |
| | $t_f$ | max. | 300 | – ns |
| $I_{C\,on}$ = 5 A; $I_{B\,on}$ = 1.0 A; $V_{CL}$ = 300 V; $T_c$ = 100 °C | | | | |
| Turn-off; | | | | |
| storage time | $t_s$ | typ. | – | 1.9 µs |
| | $t_s$ | max. | – | 2.5 µs |
| fall time | $t_f$ | typ. | – | 200 ns |
| | $t_f$ | max. | – | 300 ns |

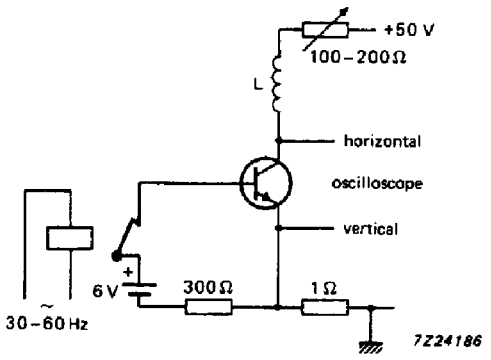
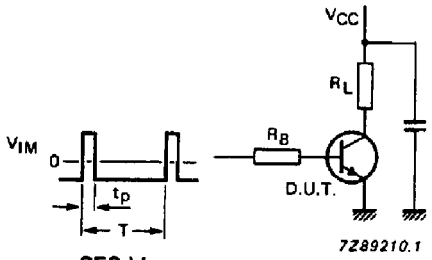


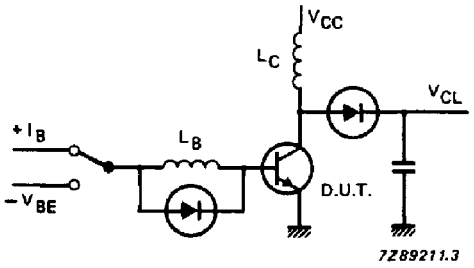

Fig. 2 Test circuit for $V_{CEOsust}$.




$V_{CC}$ = 250 V
$t_p$ = 20 μs
$V_{IM}$ = −6 to +8 V
$\frac{t_p}{T}$ = 0.01

The values of $R_B$ and $R_L$ are selected in accordance with $I_{C\,on}$ and $I_B$ requirements.

Fig. 4 Test circuit resistive load.




$V_{CL}$ = up to 1000 V
$V_{CC}$ = 30 V
$-V_{BE}$ = 1 to 5 V
$L_B$ = 1.0 μH
$L_C$ = 200 μH

Fig. 6 Test circuit inductive load and reverse bias SOAR.

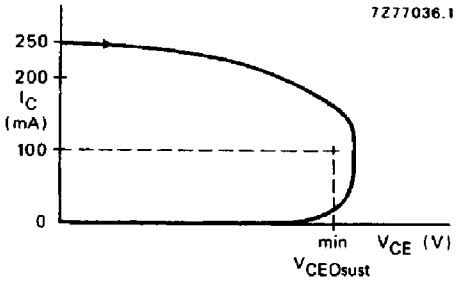



Fig. 3 Oscilloscope display for sustaining voltage.

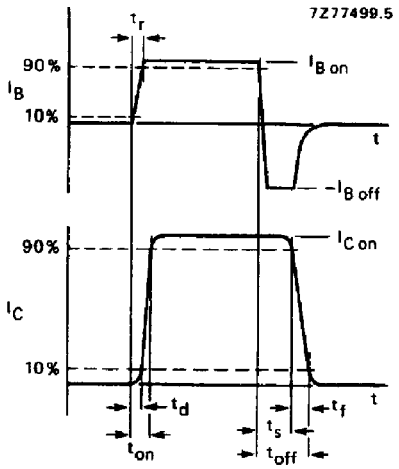



Fig. 5 Switching times waveforms with resistive load; $t_r \leqslant 20$ ns.

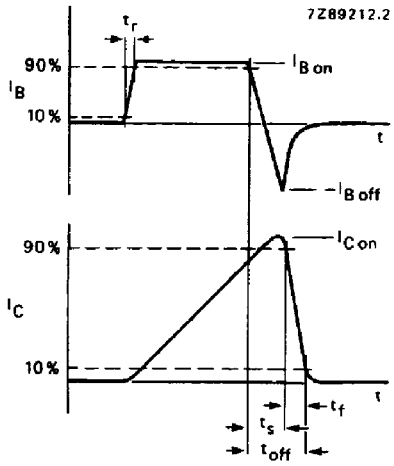
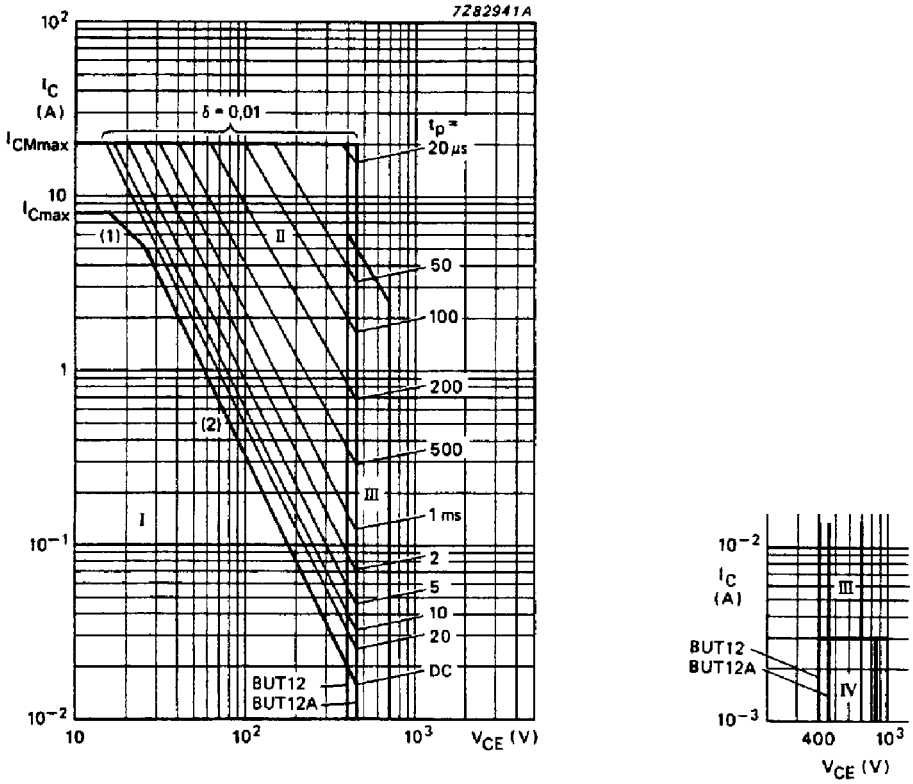



Fig. 7 Switching times waveforms with inductive load.




(1) $P_{tot\ max}$ and $P_{tot\ peak\ max}$ lines.
(2) Second-breakdown limits.

I Region of permissible DC operation
II Permissible extension for repetitive pulse operation

Fig. 8 Safe operating area at $T_{mb} < 25\ ^oC$.

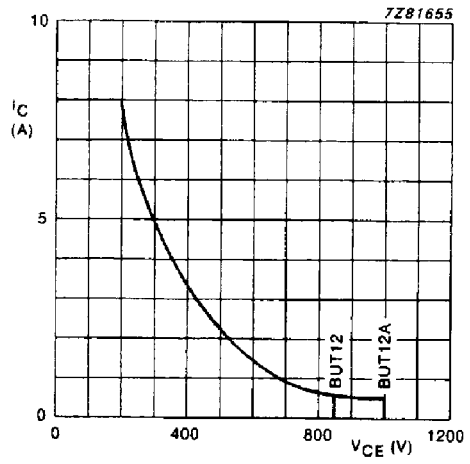



Fig. 9 Reverse bias SOAR; $T_C$ = 100 °C; $V_{BE}$ = −1 V to −5 V.

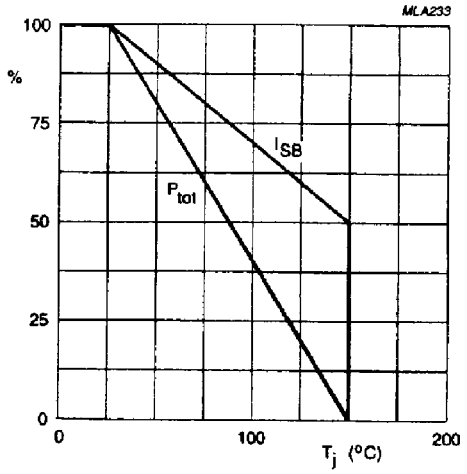



Fig. 10 Total power dissipation and second breakdown current derating curve.

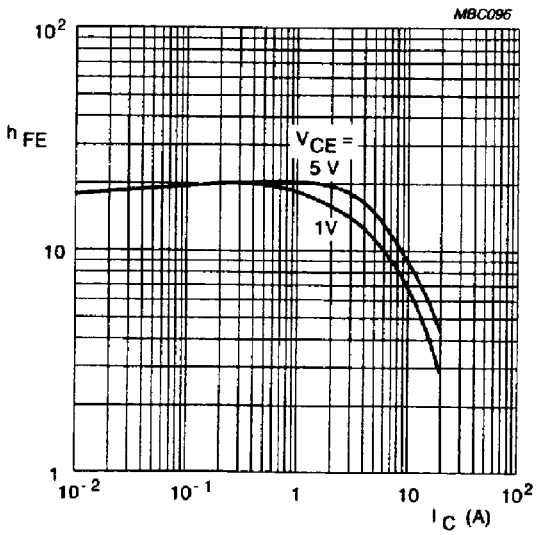



Fig. 11 Typical values DC current gain.

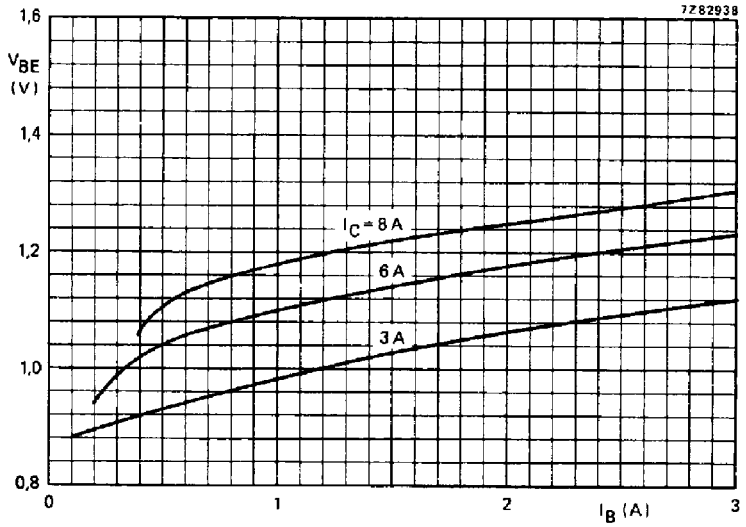



Fig. 12 Base-emitter voltage as a function of base current at $T_j$ = 25 °C.

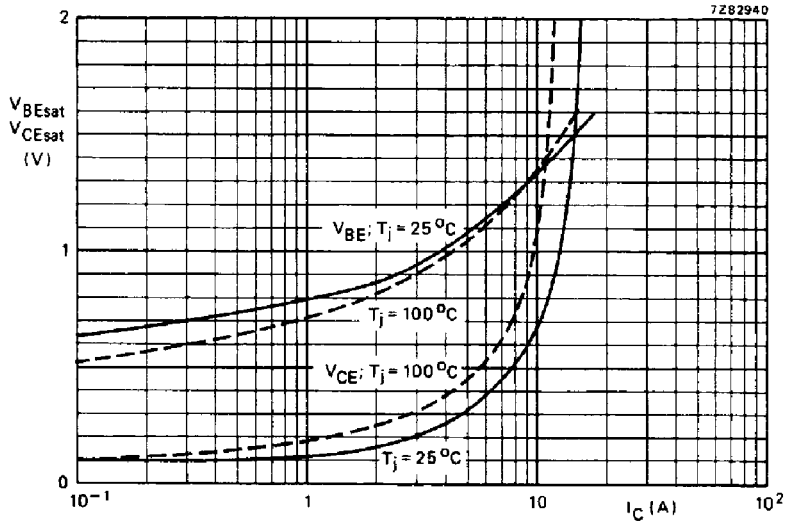



Fig. 13 Typical values base and collector voltage at $I_C/I_B$ = 5.

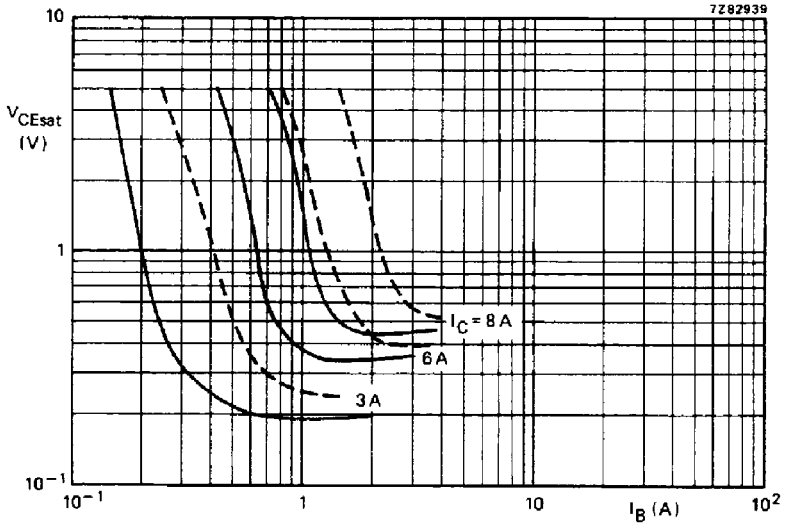



Fig. 14 Typical (——) and max. (– – –) values collector emitter saturation voltage at $T_j$ = 25 °C.

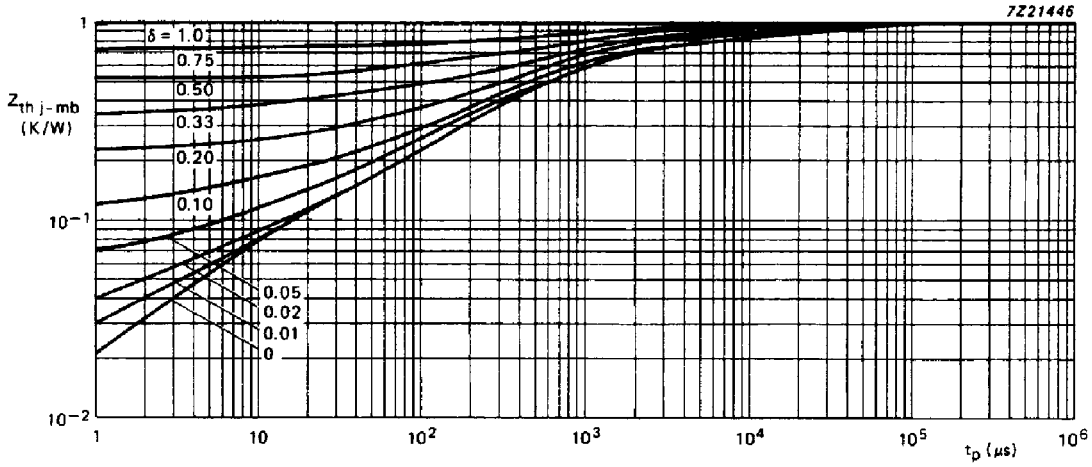



Fig. 15 Thermal response at pulse power conditions.