# BD645; 647
# BD649; 651

## SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; TO-220 plastic envelope. P-N-P complements are BD646, BD648, BD650 and BD652.

### QUICK REFERENCE DATA

| | | | BD645 | 647 | 649 | 651 | |
|---|---|---|---|---|---|---|---|
| Collector-base voltage (open emitter) | $V_{CBO}$ | max. | 80 | 100 | 120 | 140 | V |
| Collector-emitter voltage (open base) | $V_{CEO}$ | max. | 60 | 80 | 100 | 120 | V |

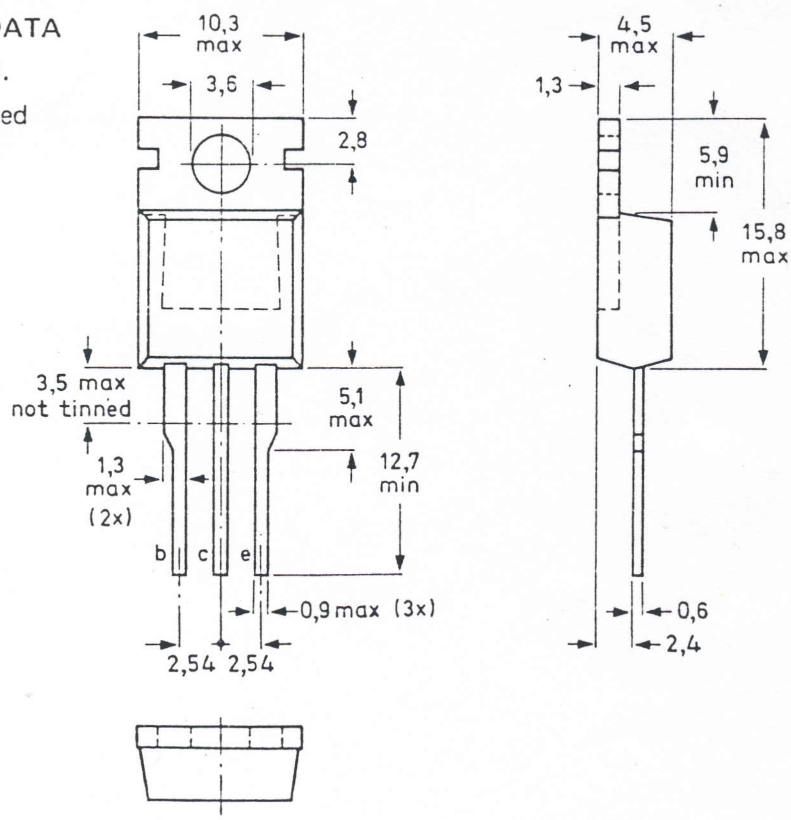
| | | | | |
|---|---|---|---|---|
| Collector current (peak value) | $I_{CM}$ | max. | 12 | A |
| Total power dissipation up to $T_{mb}$ = 25 $^oC$ | $P_{tot}$ | max. | 62,5 | W |
| Junction temperature | $T_j$ | max. | 150 | $^oC$ |
| D.C. current gain: | | | | |
| $I_C$ = 0,5 A; $V_{CE}$ = 3 V | $h_{FE}$ | typ. | 1900 | |
| $I_C$ = 3,0 A; $V_{CE}$ = 3 V | $h_{FE}$ | > | 750 | |
| Cut-off frequency: $I_C$ = 3 A; $V_{CE}$ = 3 V | $f_{hfe}$ | typ. | 50 | kHz |

### MECHANICAL DATA

Fig. 1 TO-220AB.

Collector connected to mounting base.

Dimensions in mm



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## CIRCUIT DIAGRAM

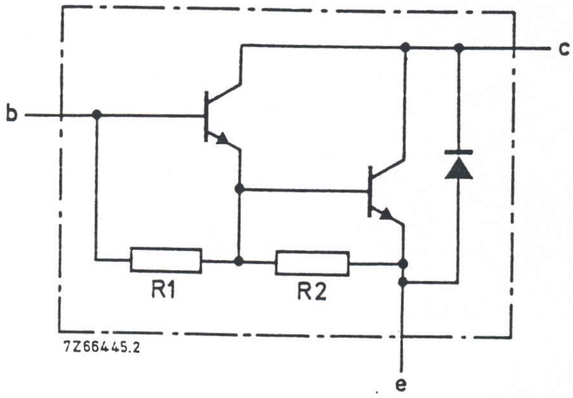


Fig. 2
$R_1$ typ. 4 kΩ
$R_2$ typ. 100 Ω

## RATINGS

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

| | | | BD645 | 647 | 649 | 651 | |
|---|---|---|---|---|---|---|---|
| Collector-base voltage (open emitter) | $V_{CBO}$ | max. | 80 | 100 | 120 | 140 | V |
| Collector-emitter voltage (open base) | $V_{CEO}$ | max. | 60 | 80 | 100 | 120 | V |
| Emitter-base voltage (open collector) | $V_{EBO}$ | max. | 5 | 5 | 5 | 5 | V |

| | | | | |
|---|---|---|---|---|
| Collector current (d.c.) | $I_C$ | max. | 8 | A |
| Collector current (peak value) | $I_{CM}$ | max. | 12 | A |
| Base current (d.c.) | $I_B$ | max. | 150 | mA |
| Total power dissipation up to $T_{mb}$ = 25 °C | $P_{tot}$ | max. | 62,5 | W |
| Storage temperature | $T_{stg}$ | | −65 to + 150 | °C |
| Junction temperature * | $T_j$ | max. | 150 | °C |

## THERMAL RESISTANCE *

| | | | | |
|---|---|---|---|---|
| From junction to mounting base | $R_{th\ j\text{-}mb}$ | = | 2 | K/W |
| From junction to ambient in free air | $R_{th\ j\text{-}a}$ | = | 70 | K/W |

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

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## CHARACTERISTICS

$T_j$ = 25 °C unless otherwise specified

| | | | |
|---|---|---|---|
| Collector cut-off current | | | |
| $I_E = 0$; $V_{CBO} = V_{CEOmax}$ | $I_{CBO}$ | < | 0,2 mA |
| $I_E = 0$; $V_{CB} = ½ V_{CBOmax}$; $T_j = 150$ °C | $I_{CBO}$ | < | 2 mA |
| $I_B = 0$; $V_{CE} = ½ V_{CEOmax}$ | $I_{CEO}$ | < | 0,5 mA |
| Emitter cut-off current | | | |
| $I_C = 0$; $V_{EB} = 5$ V | $I_{EBO}$ | < | 5 mA |
| D.C. current gain (note 1) | | | |
| $I_C = 0,5$ A; $V_{CE} = 3$ V | $h_{FE}$ | typ. | 1900 |
| $I_C = 3$ A; $V_{CE} = 3$ V | $h_{FE}$ | > | 750 |
| $I_C = 8$ A; $V_{CE} = 3$ V | $h_{FE}$ | typ. | 1800 |
| Base-emitter voltage (notes 1 and 2) | | | |
| $I_C = 3$ A; $V_{CE} = 3$ V | $V_{BE}$ | < | 2,5 V |
| Saturation voltages (note 1) | | | |
| $I_C = 3$ A; $I_B = 12$ mA | $V_{CEsat}$ | < | 2 V |
| $I_C = 5$ A; $I_B = 50$ mA | $V_{CEsat}$ | < | 2,5 V |
| | $V_{BEsat}$ | < | 3 V |
| Diode forward voltage | | | |
| $I_F = 3$ A | $V_F$ | typ. | 1,2 V |
| Collector capacitance at f = 1 MHz | | | |
| $I_E = I_e = 0$; $V_{CB} = 10$ V | $C_c$ | typ. | 75 pF |
| Cut-off frequency | | | |
| $I_C = 3$ A; $V_{CE} = 3$ V | $f_{hfe}$ | typ. | 50 kHz |
| Turn-off breakdown energy with inductive load | | | |
| $-I_{Boff} = 0$; $I_{CM} = 4,5$ A; $t_p = 1$ ms; T = 100 ms; see Fig. 3 | $E_{(BR)}$ | > | 50 mJ |
| Small signal current gain | | | |
| $I_C = 3$ A; $V_{CE} = 3$ V; f = 1 MHz | $\|h_{fe}\|$ | typ. | 50 |
| Second breakdown collector current | | | |
| $V_{CE} = 60$ V; $t_p = 0,1$ s | $I_{(SB)}$ | > | 1,04 A |
| Switching times (see Figs 4 and 5) | | | |
| $I_{Con} = 3$ A; $I_{Bon} = -I_{Boff} = 12$ mA | | | |
| turn-on time | $t_{on}$ | typ. | 1,0 µs |
| | | < | 2,5 µs |
| turn-off time | $t_{off}$ | typ. | 5 µs |
| | | < | 10 µs |

Notes
1. Measured under pulse conditions: $t_p < 300$ µs, $\delta < 2\%$.
2. $V_{BE}$ decreases by about 3,8 mV/K with increasing temperature.

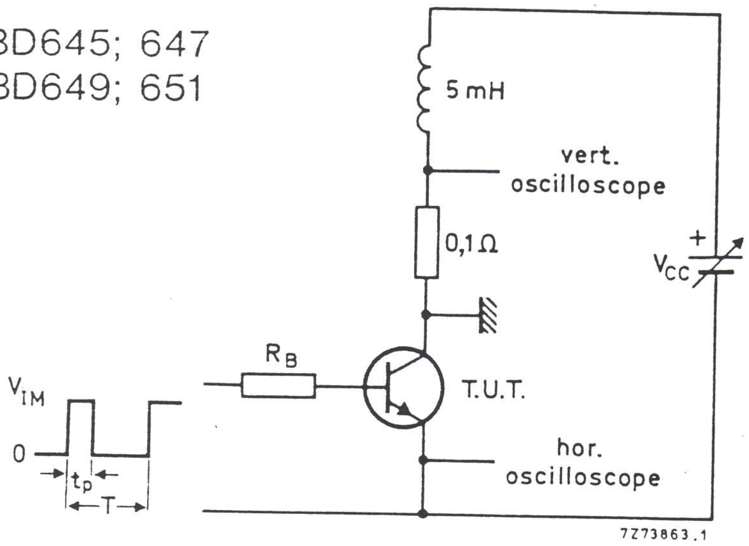



Fig. 3 Test circuit for turn-off breakdown energy.
$V_{IM}$ = 12 V; $R_B$ = 270 Ω;
$t_p$ = 1 ms; $\delta$ = 1%.

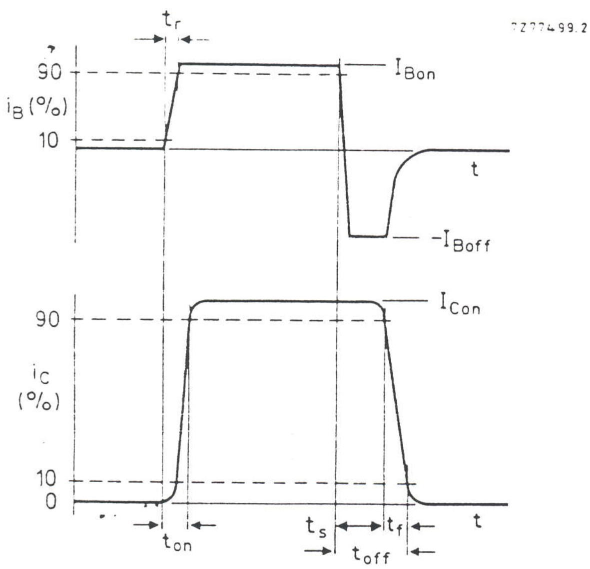
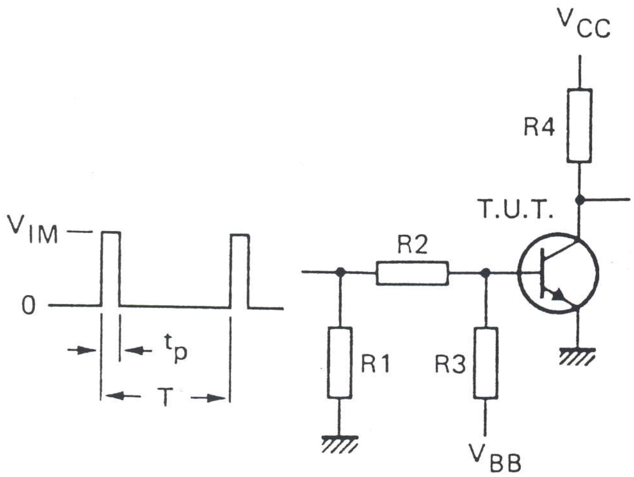



Fig. 4 Switching times waveforms.




$V_{CC}$ = 10 V
$V_{IM}$ = 10 V
$-V_{BB}$ = 4 V
R1 = 56 Ω
R2 = 410 Ω
R3 = 560 Ω
R4 = 3 Ω
$t_r = t_f$ = 15 ns
$t_p$ = 10 μs
T = 500 μs

Fig. 5 Switching times test circuit.

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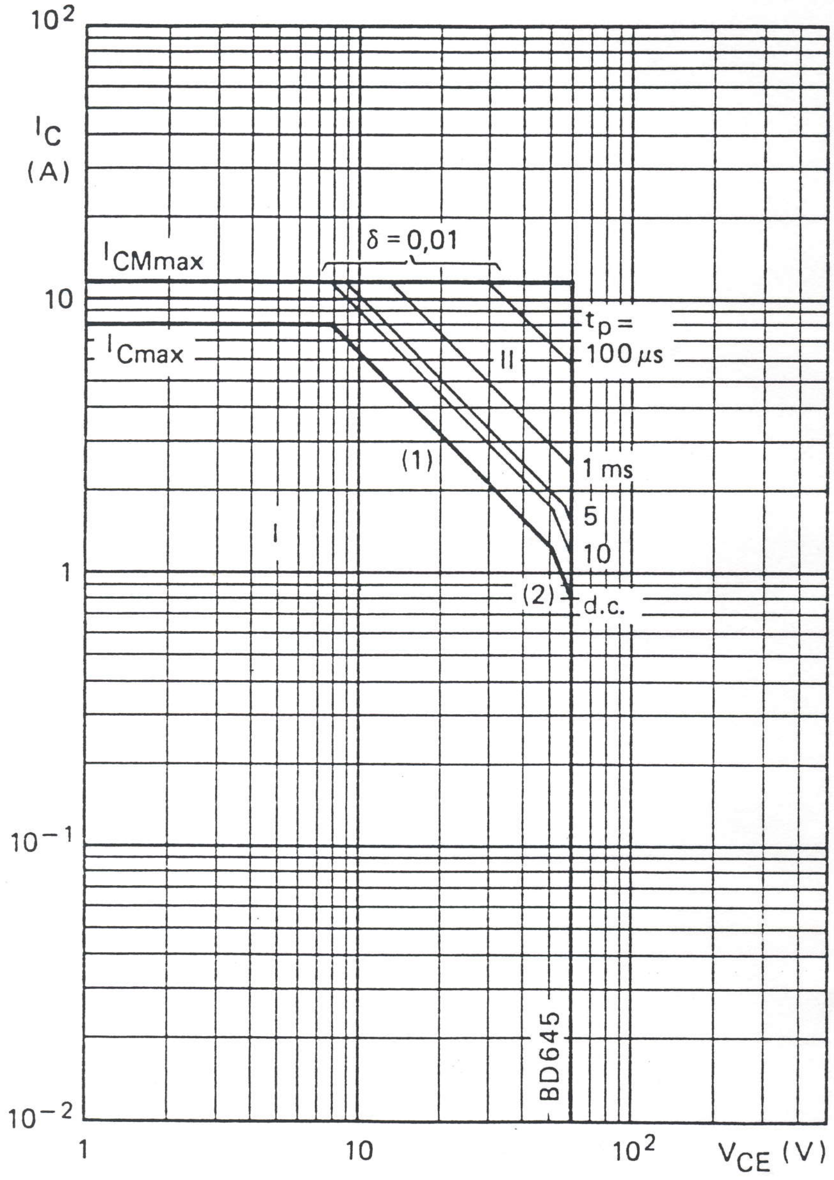


Fig. 6 Safe Operating ARea; $T_{mb}$ = 25 °C

I   Region of permissible d.c. operation.

II   Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits (independent of temperature).

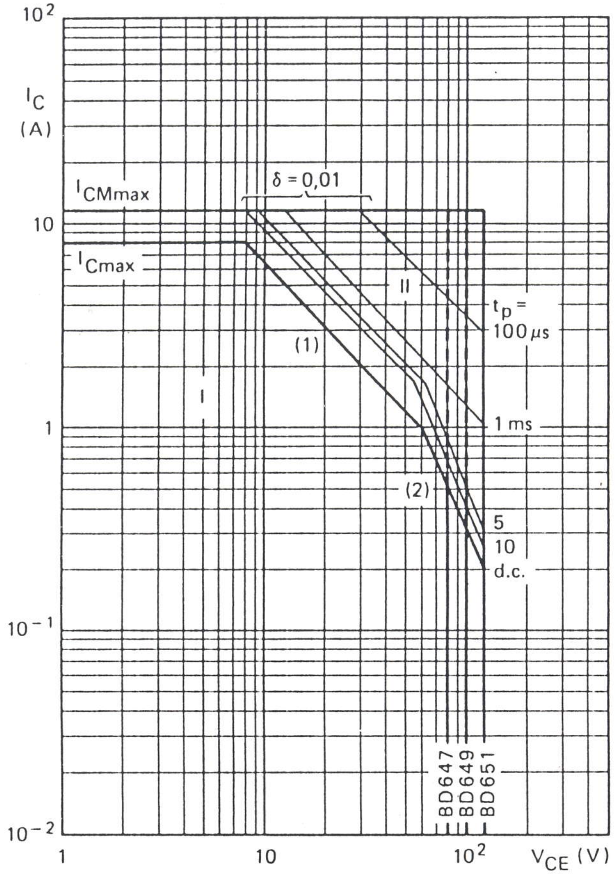


Fig. 7 Safe Operating ARea; $T_{mb}$ = 25 °C.
I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
(2) Second-breakdown limits (independent of temperature).

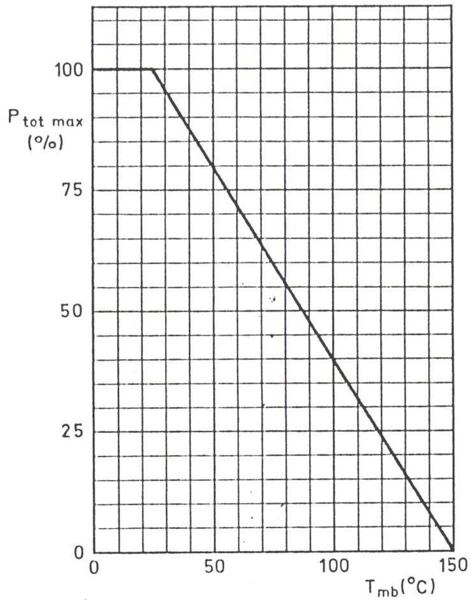


Fig. 8 Power derating curve.

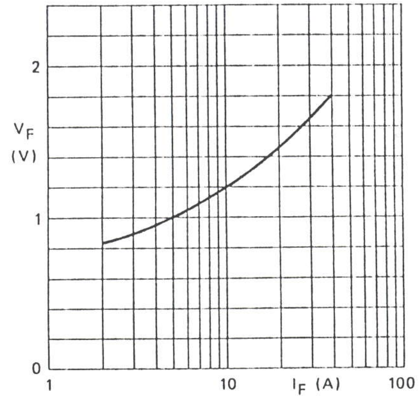


Fig. 8a Typical values forward voltage of collector-emitter diode (see Fig. 2) at $T_j$ = 25 °C.

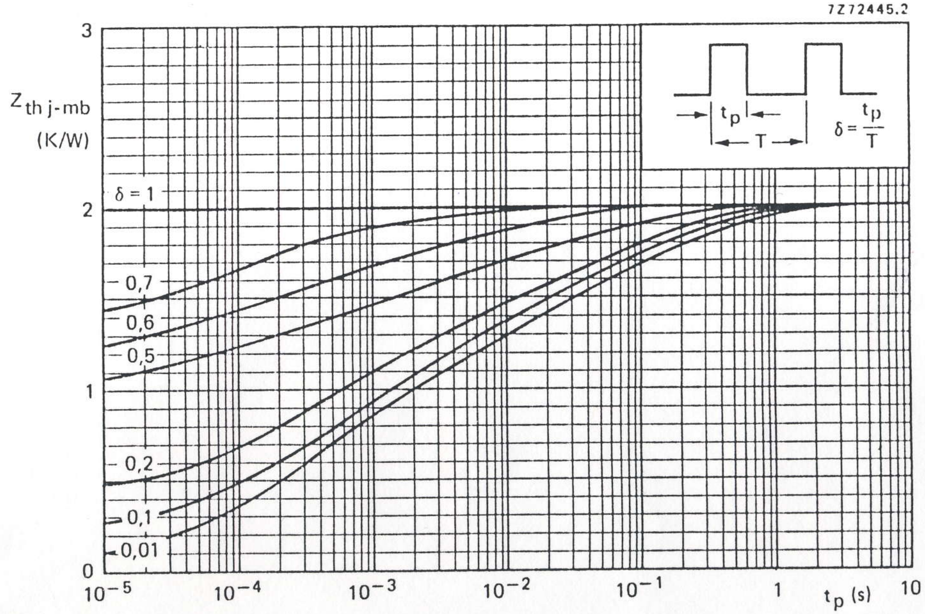


Fig. 9 Pulse power rating chart.

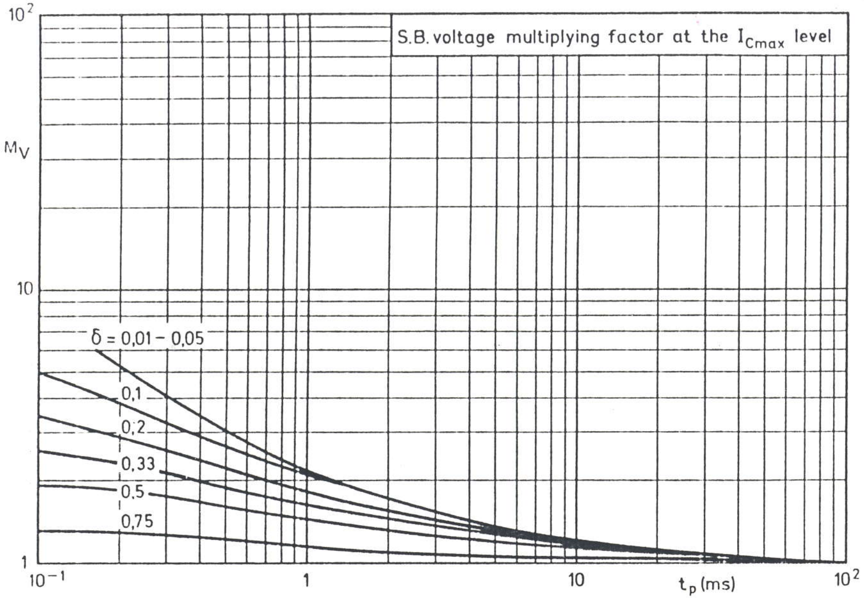


Fig. 10.

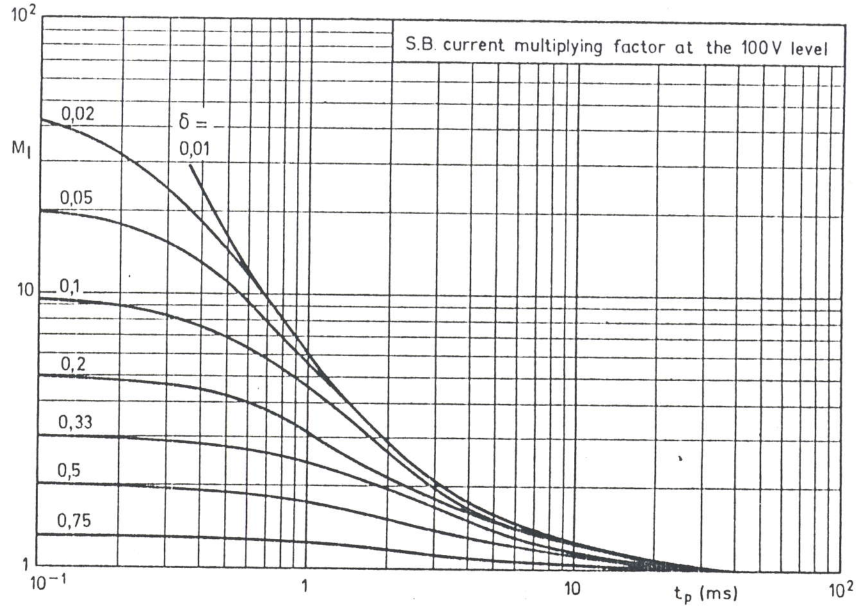


Fig. 12 Second breakdown current multiplying factor at the 100 V level.

BD645 7Z67855

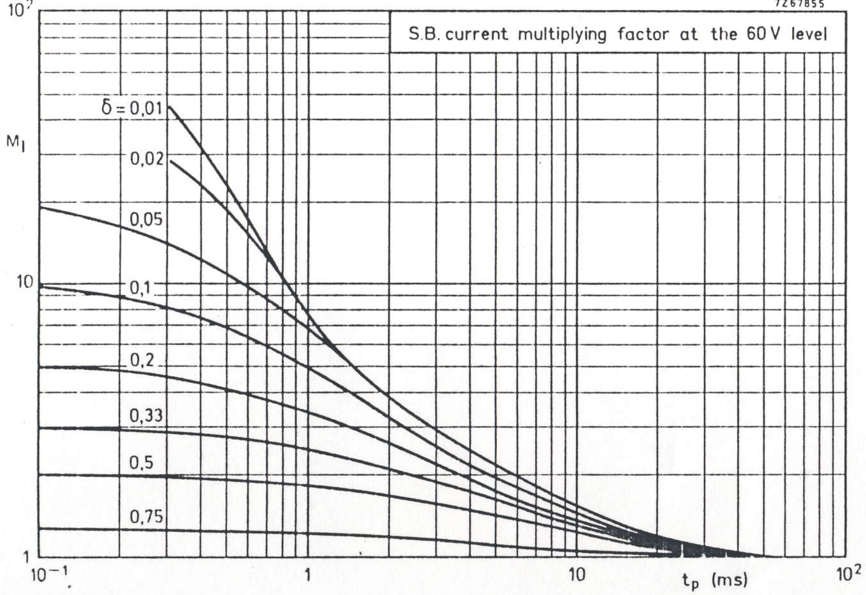


Fig. 11.

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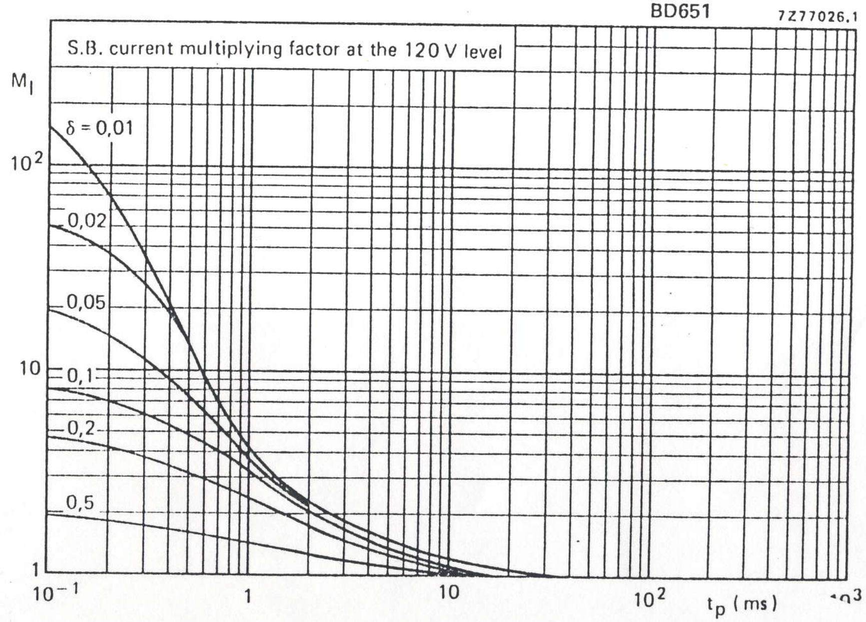


Fig. 13 Second breakdown current multiplying factor at the 120 V level.

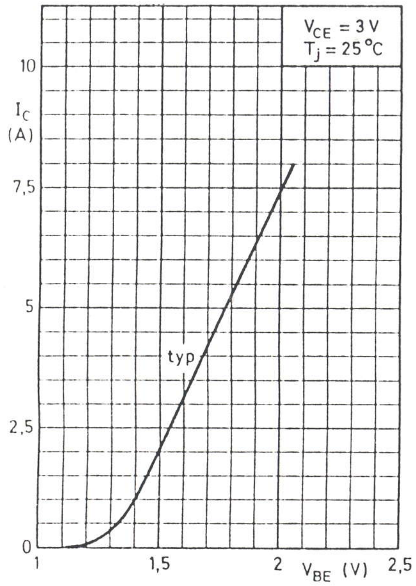


Fig. 14.

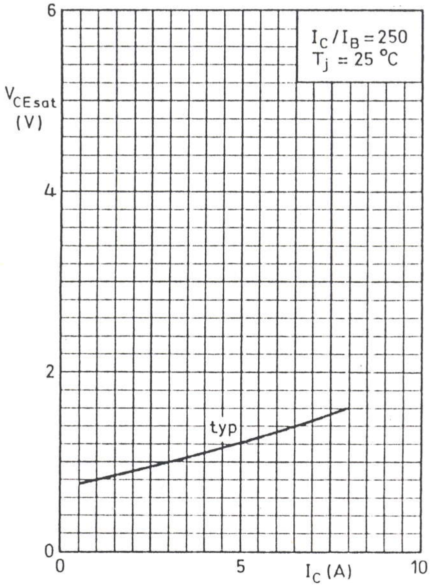


Fig. 15.

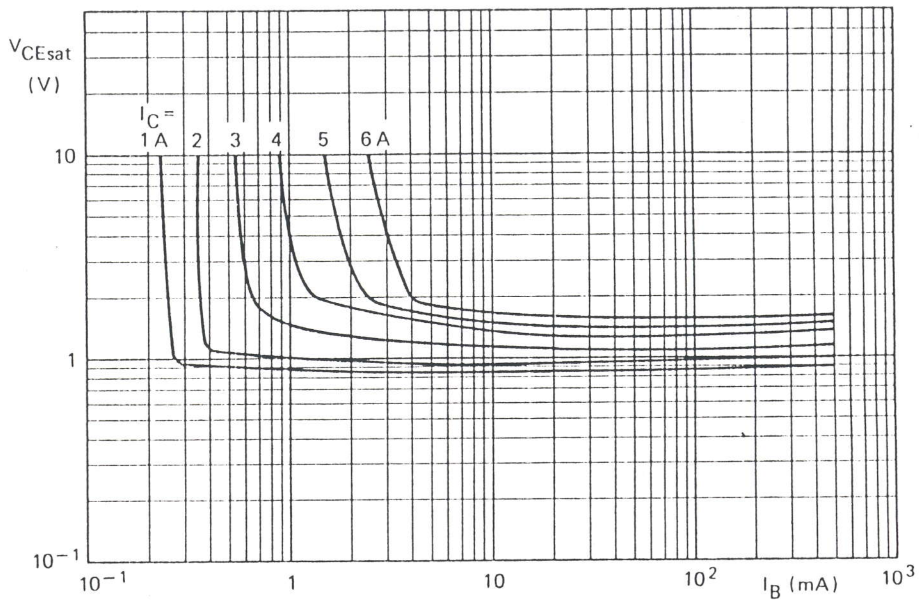


Fig. 17 Typical values collector-emitter saturation voltage. $T_j$ = 25 °C.

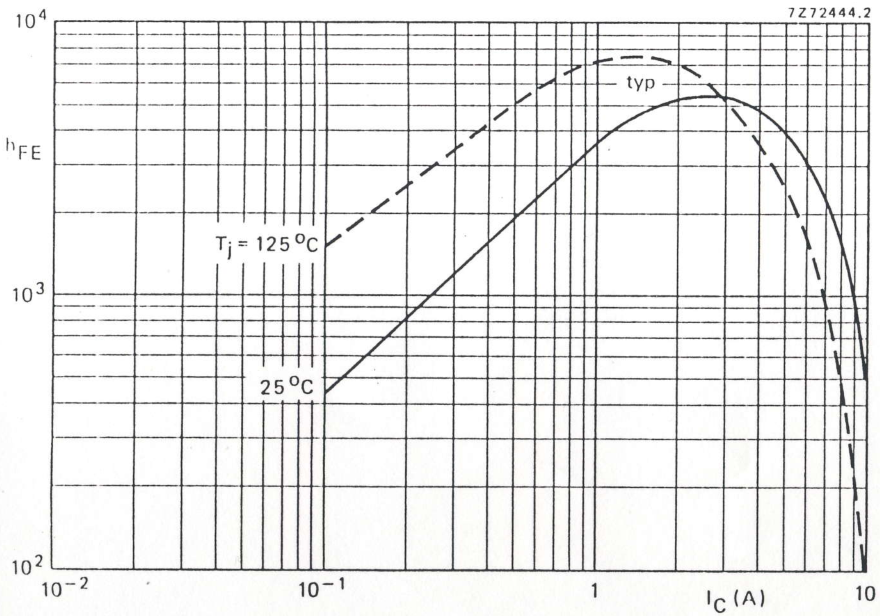


Fig. 16 Typical d.c. current gain. $V_{CE}$ = 3 V.

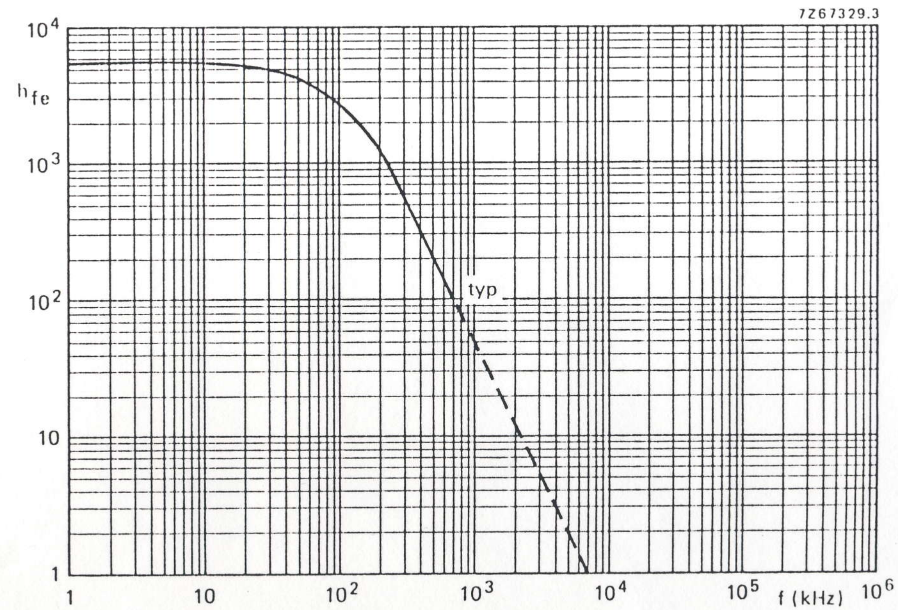


Fig. 18 Small signal current gain at $I_C$ = 3 A; $V_{CE}$ = 3 V.