



Certificate No. FS 36235

Magna Park, Coventry Road, Lutterworth  
Leicestershire LE17 4JB, England  
Sales telephone: 01455 554711  
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BD646; 648  
BD650; 652

## SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; TO-220 plastic envelope. N-P-N complements are BD645, BD647, BD649 and BD651.

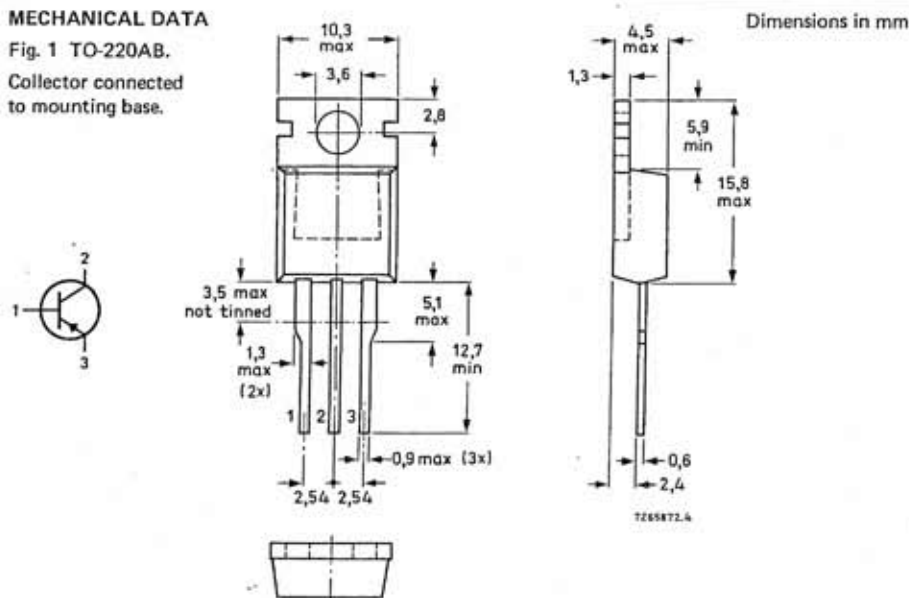
### QUICK REFERENCE DATA

|                                                           |                 | BD646 | 648 | 650  | 652              |
|-----------------------------------------------------------|-----------------|-------|-----|------|------------------|
| Collector-base voltage (open emitter)                     | $-V_{CBO}$ max. | 60    | 80  | 100  | 120 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 $T_{mb} = 25^\circ\text{C}$ | $P_{tot}$ max.  |       |     | 62,5 | W                |
| Junction temperature                                      | $T_j$ max.      |       |     | 150  | $^\circ\text{C}$ |
| D.C. current gain:                                        |                 |       |     |      |                  |
| $-I_C = 0,5\text{ A}; -V_{CE} = 3\text{ V}$               | $h_{FE}$ typ.   |       |     | 2700 |                  |
| $-I_C = 3,0\text{ A}; -V_{CE} = 3\text{ V}$               | $h_{FE} >$      |       |     | 750  |                  |
| Cut-off frequency:                                        |                 |       |     |      |                  |
| $-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$                 | $f_{hfe}$ typ.  |       |     | 100  | kHz              |

### MECHANICAL DATA

Fig. 1 TO-220AB.

Collector connected  
to mounting base.



See also chapters Mounting Instructions and Accessories.

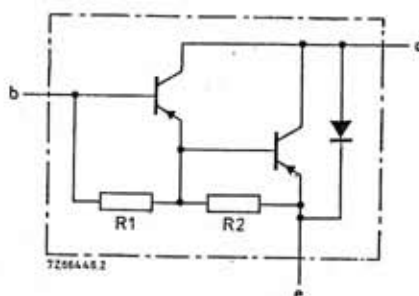


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$R_1$  typ. 4 k $\Omega$   
 $R_2$  typ. 80  $\Omega$

Fig. 2 Darlington circuit diagram.

**RATINGS**

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

|                                                           |                 | BD646        | 648  | 650 | 652              |
|-----------------------------------------------------------|-----------------|--------------|------|-----|------------------|
| Collector-base voltage (open emitter)                     | $-V_{CBO}$ max. | 60           | 80   | 100 | 120 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 $T_{mb} = 25^\circ\text{C}$ | $P_{tot}$ max.  |              | 62,5 |     | W                |
| Storage temperature                                       | $T_{stg}$       | -65 to + 150 |      |     | $^\circ\text{C}$ |
| Junction temperature *                                    | $T_j$           | 150          |      |     | $^\circ\text{C}$ |

**THERMAL RESISTANCE \***

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

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

Collector cut-off current

$I_E = 0; -V_{CB} = -V_{CB0\text{max}}$

BD646:  $-V_{CB} = 40\text{ V}$

BD648:  $-V_{CB} = 50\text{ V}$

$I_E = 0; -V_{CB} = 60\text{ V}; T_j = 150^\circ\text{C}$

BD650:  $-V_{CB} = 60\text{ V}$

BD652:  $-V_{CB} = 70\text{ V}$

$I_B = 0; -V_{CE} = \frac{1}{2} V_{CE0\text{max}}$

Emitter cut-off current

$I_C = 0; -V_{EB} = 5\text{ V}$

D.C. current gain (note 1)

$-I_C = 0,5\text{ A}; -V_{CE} = 3\text{ V}$

$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$

$-I_C = 8\text{ A}; -V_{CE} = 3\text{ V}$

Base-emitter voltage (notes 1 and 2)

$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$

Saturation voltages (note 1)

$-I_C = 3\text{ A}; -I_B = 12\text{ mA}$

$-I_C = 5\text{ A}; -I_B = 50\text{ mA}$

Collector capacitance at  $f = 1\text{ MHz}$

$I_E = I_B = 0; -V_{CB} = 10\text{ V}$

Cut-off frequency

$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$

Small-signal current gain

$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}; f = 1\text{ MHz}$

Diode, forward voltage

$I_F = 3\text{ A}$

Second-breakdown collector current

$-V_{CE} = 50\text{ V}; t_p = 0,1\text{ s}$

Switching times (between 10% and 90% levels) (Fig. 3)

$-I_{Con} = 3\text{ A}; -I_{Bon} = I_{Boff} = 12\text{ mA}; V_{CC} = -10\text{ V}$

Turn-on time

Turn-off time

$-I_{CBO} < 0,2\text{ mA}$

$-I_{CBO} < 2\text{ mA}$

$-I_{CEO} < 0,5\text{ mA}$

$-I_{EBO} < 5\text{ mA}$

$h_{FE}$  typ. 2700

$h_{FE} > 750$

$h_{FE}$  typ. 200

$-V_{BE} < 2,5\text{ V}$

$-V_{CEsat} < 2\text{ V}$

$-V_{CEsat} < 2,5\text{ V}$

$-V_{BEsat} < 3\text{ V}$

$C_c$  typ. 75 pF

$f_{hfe}$  typ. 100 kHz

$h_{fe} > 10$  ←

$V_F$  typ. 1,8 V

$-I_{(SB)} > 1,25\text{ A}$

$t_{on}$  typ. 1  $\mu\text{s}$

$t_{on} < 2\text{  $\mu\text{s}$$

$t_{off}$  typ. 5  $\mu\text{s}$

$t_{off} < 10\text{  $\mu\text{s}$$

## Notes

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



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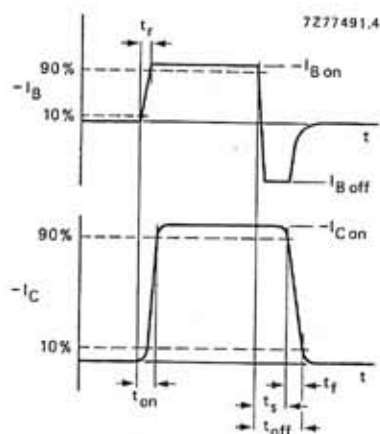


Fig. 3 Switching times waveforms.

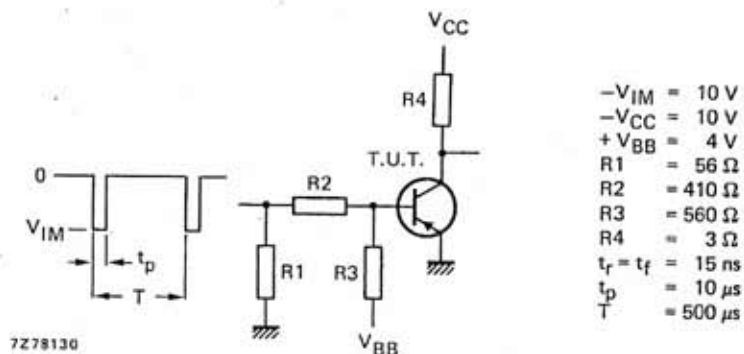


Fig. 4 Switching times test circuit.



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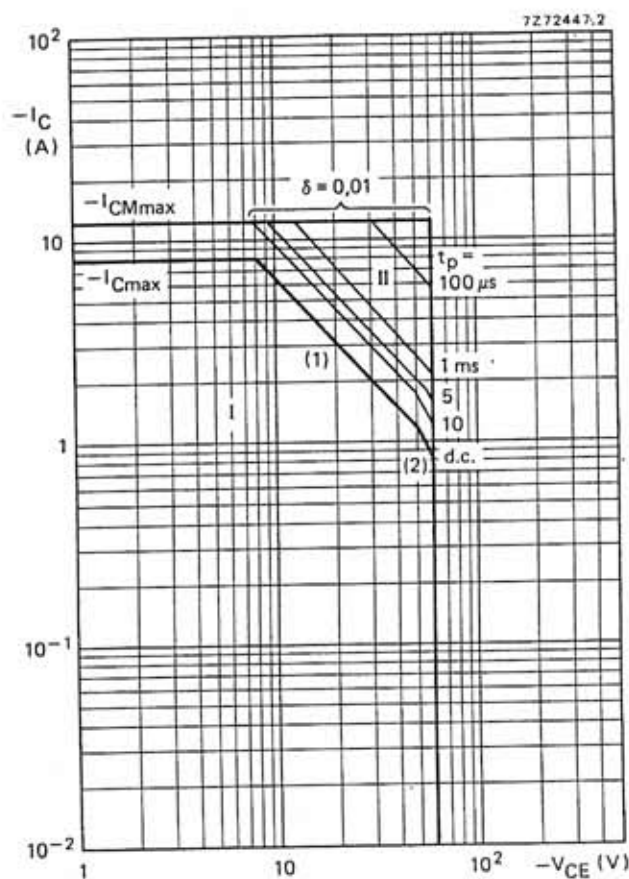


Fig. 5 Safe Operating Area transistor BD646 at  $T_{mb} = 25^\circ\text{C}$ .

- 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).



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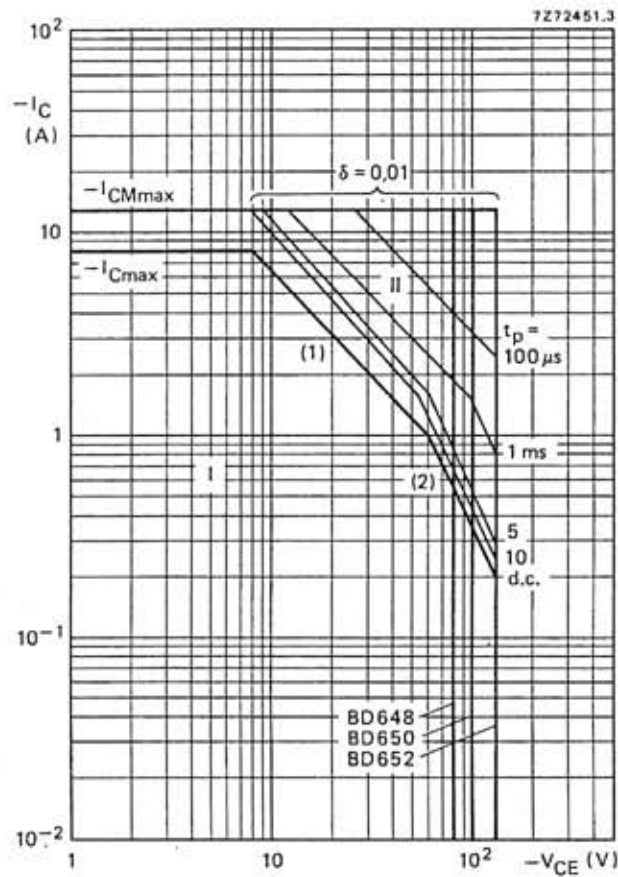


Fig. 6 Safe Operating Area.  $T_{mb} = 25^\circ\text{C}$

- 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).



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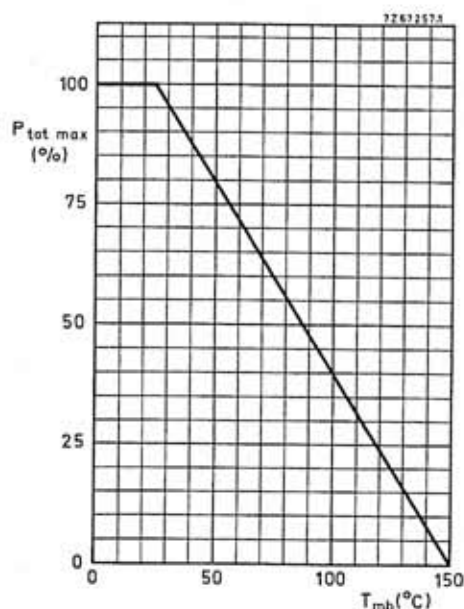


Fig. 7 Power derating curve.

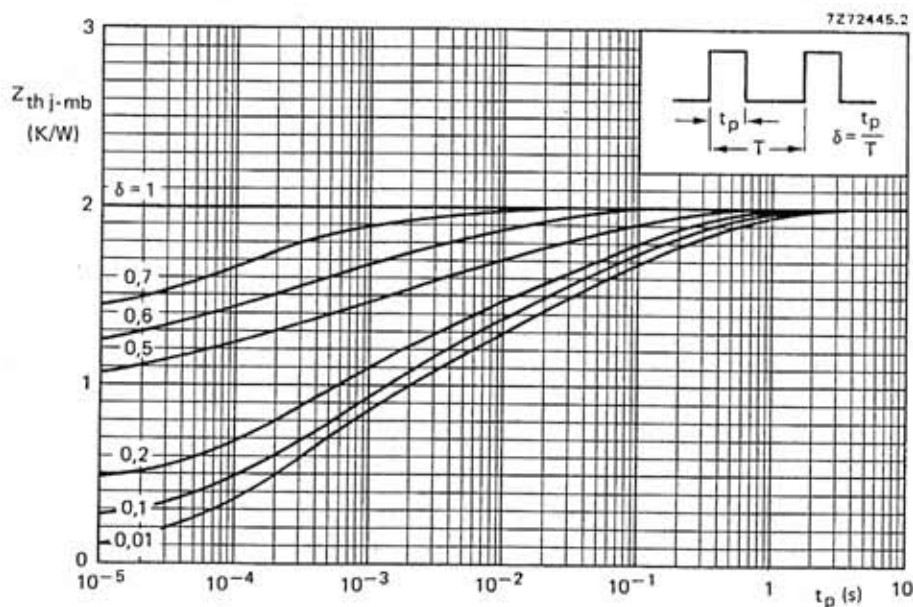


Fig. 8 Pulse power rating chart.



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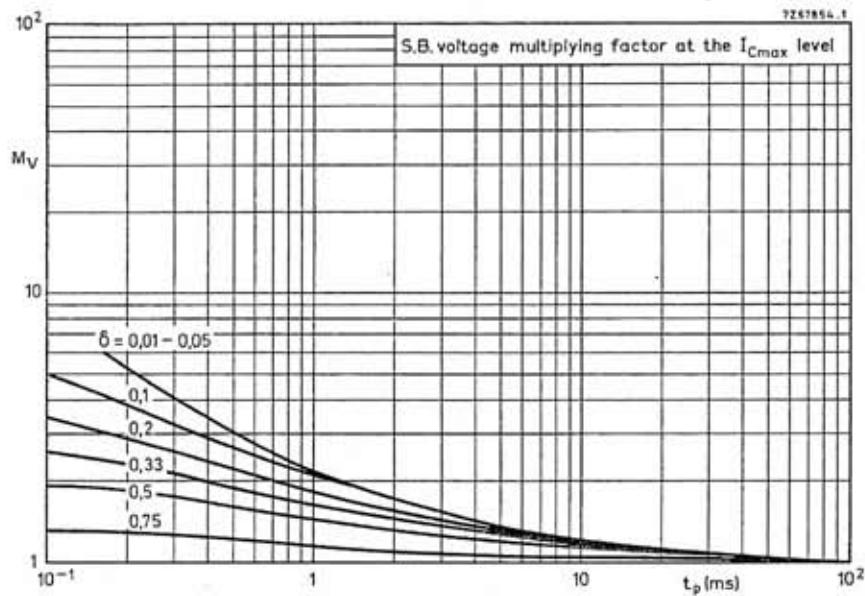


Fig. 9 S.B. voltage multiplying factor at the  $I_{Cmax}$  level.

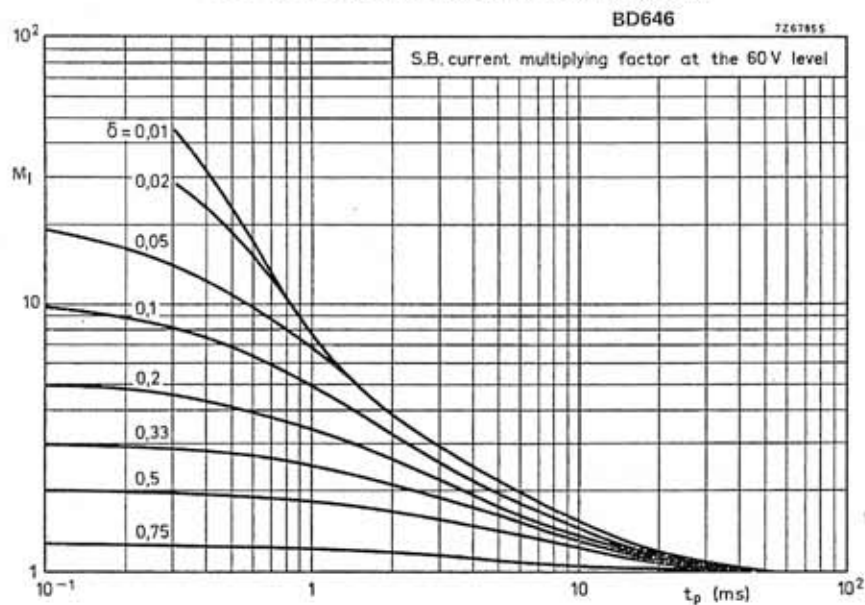


Fig. 10 S.B. current multiplying factor at 60 V level.





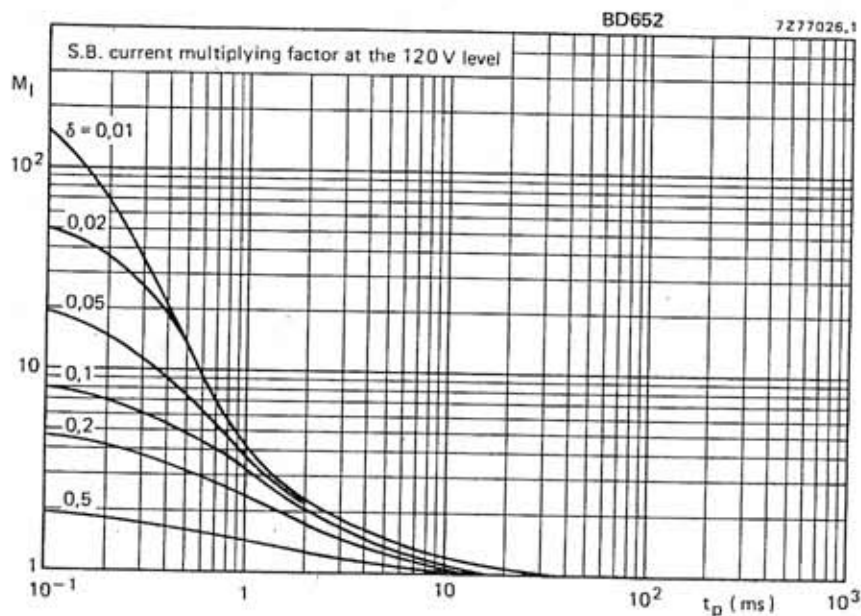
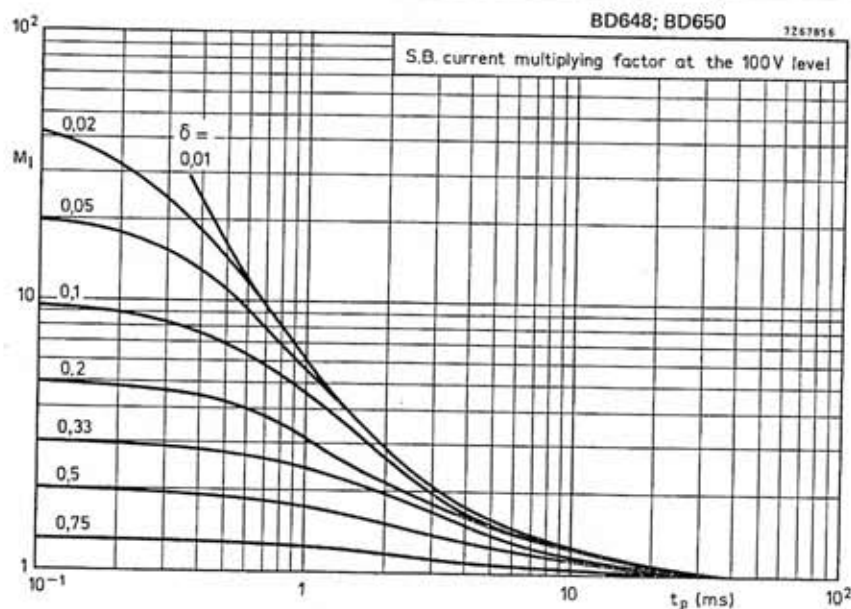
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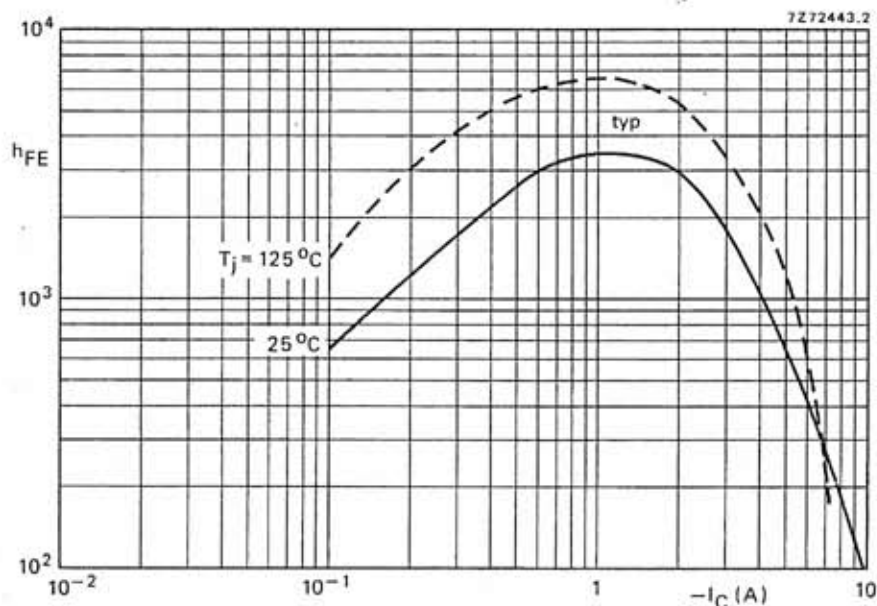


Fig. 13 D.C. current gain at  $-V_{CE} = 3$  V.

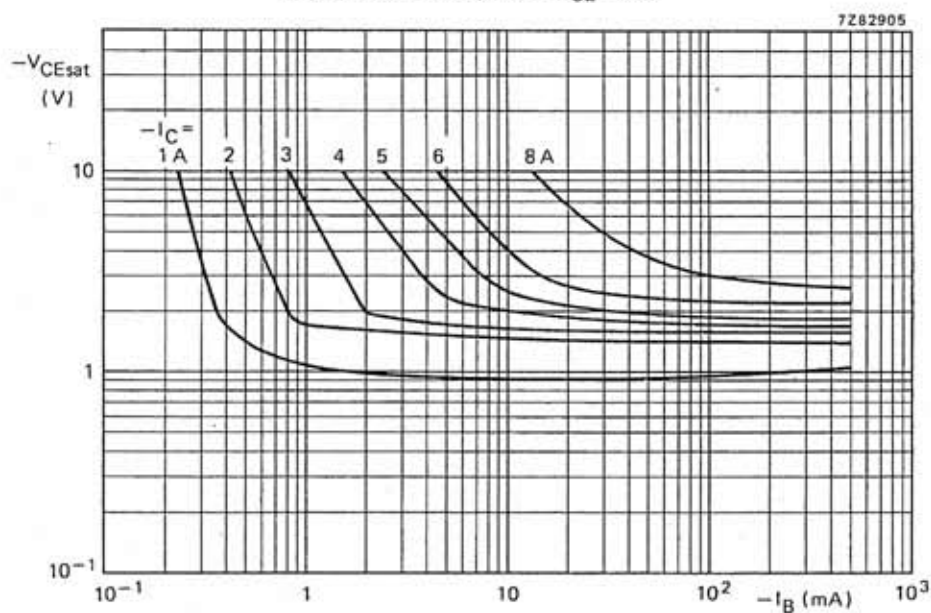


Fig. 14 Typical collector-emitter saturation voltage at  $T_j = 25$  °C.



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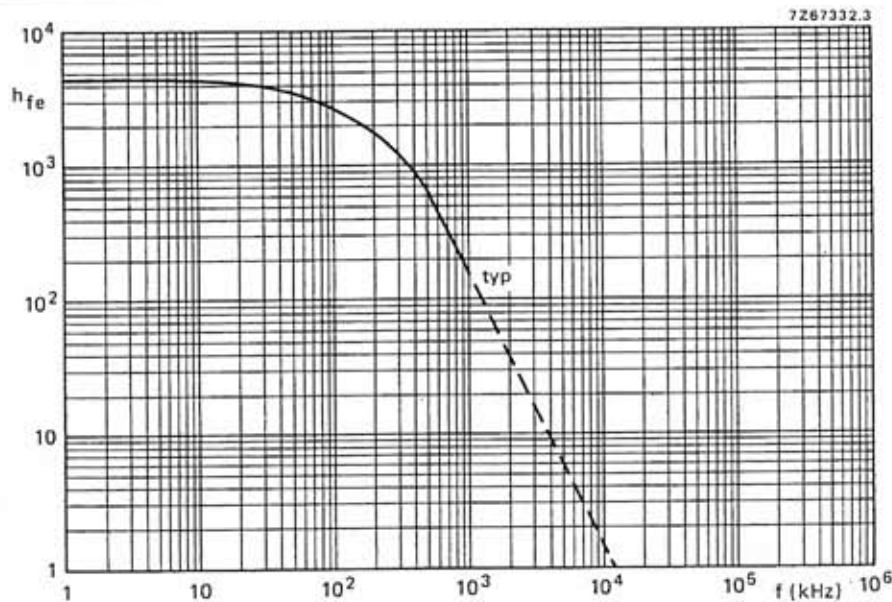


Fig. 15 Small signal current gain at  $-I_C = 3\text{ A}$ ;  $-V_{CE} = 3\text{ V}$ .

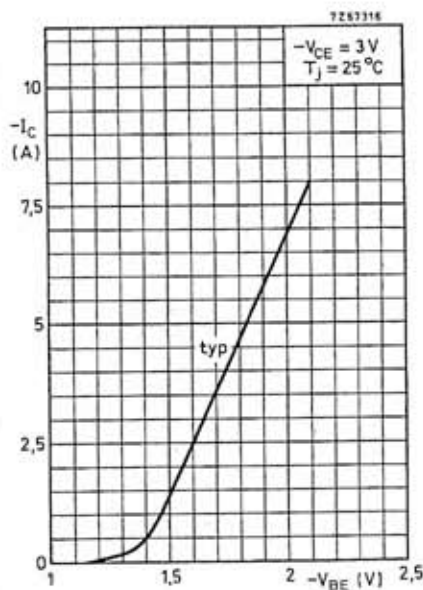


Fig. 16 Collector current.