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

<table>
<thead>
<tr>
<th></th>
<th>BD646</th>
<th>648</th>
<th>650</th>
<th>652</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector-base voltage (open emitter)</td>
<td>$-V_{CBO}$ max.</td>
<td>60</td>
<td>80</td>
<td>100</td>
</tr>
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<td>Collector-emitter voltage (open base)</td>
<td>$-V_{CEO}$ max.</td>
<td>60</td>
<td>80</td>
<td>100</td>
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<tr>
<td>Collector current (peak value)</td>
<td>$I_{CM}$ max.</td>
<td>12</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Total power dissipation up to $T_{amb} = 25, ^\circ C$</td>
<td>$P_{tot}$ max.</td>
<td>82.5</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>Junction temperature</td>
<td>$T_{j}$ max.</td>
<td>150</td>
<td>$^\circ C$</td>
<td></td>
</tr>
<tr>
<td>D.C. current gain:</td>
<td>$-I_C = 0.5, A; \quad -V_{CE} = 3, V$</td>
<td>$h_{FE}$ typ.</td>
<td>2700</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$-I_C = 3.0, A; \quad -V_{CE} = 3, V$</td>
<td>$h_{FE}$ &gt;</td>
<td>750</td>
<td></td>
</tr>
<tr>
<td>Cut-off frequency:</td>
<td>$-I_C = 3, A; \quad -V_{CE} = 3, V$</td>
<td>$f_{bbe}$ typ.</td>
<td>100</td>
<td>kHz</td>
</tr>
</tbody>
</table>

MECHANICAL DATA

Fig. 1 TO-220AB.
Collector connected to mounting base.

Dimensions in mm

See also chapters Mounting Instructions and Accessories.

October 1985
BD646; 648
BD55C; 652

Fig. 2: Darlington circuit diagram.

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

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<td>Collector-emitter voltage (open base)</td>
<td>$-V_{CEO}$ max.</td>
<td>60</td>
<td>80</td>
<td>100</td>
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<tr>
<td>Emitter-base voltage (open collector)</td>
<td>$-V_{EBO}$ max.</td>
<td>6</td>
<td>6</td>
<td>5</td>
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<tr>
<td>Collector current (d.c.)</td>
<td>$I_C$ max.</td>
<td>8</td>
<td>A</td>
<td></td>
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<tr>
<td>Collector current (peak value)</td>
<td>$I_{CM}$ max.</td>
<td>12</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Base current (d.c.)</td>
<td>$I_B$ max.</td>
<td>150</td>
<td>mA</td>
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<tr>
<td>Total power dissipation up to $T_{mb} = 25 \degree C$</td>
<td>$P_{DOL}$ max.</td>
<td>62.5</td>
<td>W</td>
<td></td>
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<tr>
<td>Storage temperature</td>
<td>$T_{stg}$</td>
<td>$-65$ to $+150$</td>
<td>$^\circ$C</td>
<td></td>
</tr>
<tr>
<td>Junction temperature</td>
<td>$T_J$</td>
<td>150</td>
<td>$^\circ$C</td>
<td></td>
</tr>
</tbody>
</table>

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.
CHARACTERISTICS

Collector cut-off current

$I_C = 0 \Rightarrow V_{CB} = V_{CB}^{\text{max}}$

BD646: $V_{CB} = 40 \text{ V}$
BD648: $V_{CB} = 50 \text{ V}$
BD650: $V_{CB} = 60 \text{ V}$; $T_J = 150 \text{ °C}$
BD652: $V_{CB} = 70 \text{ V}$

$I_C = 0 \Rightarrow V_{CE} = \frac{1}{2} V_{CE}^{\text{max}}$

Emitter cut-off current

$-I_E = 0 \Rightarrow V_{BE} = 5 \text{ V}$

D.C. current gain (note 1)

$-I_C = 6.5 \text{ A}; -V_{CE} = 3 \text{ V}$

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

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

Base-emitter voltage (notes 1 and 2)

$-V_{BE} < 2.5 \text{ V}$

Saturation voltages (note 1)

$-V_{CE}^{\text{sat}} < 2 \text{ V}$

$-V_{CE}^{\text{sat}} < 2.5 \text{ V}$

$-V_{BE}^{\text{sat}} < 3 \text{ V}$

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

$I_E = I_C = 0; -V_{CE} = 10 \text{ V}$

$C_C < 75 \text{ pF}$

Cut-off frequency

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

$h_{fe} < 100 \text{ kHz}$

Small-signal current gain

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

$h_{fe} > 10$

Diode, forward voltage

$I_F = 3 \text{ A}$

$V_{F} < 1.8 \text{ V}$

Second-breakdown collector current

$V_{CE} = 50 \text{ V}; I_P = 0.1 \text{ s}$

$-I_{SB} < 1.25 \text{ A}$

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

$I_{ON} < 1 \text{ µs}$

Turn-off time

$I_{OFF} < 5 \text{ µs}$

Notes

1. Measured under pulse conditions: $I_P < 300 \mu\text{s}$, $I < 2\%$.
2. $-V_{BE}$ decreases by about $3.8 \text{ mV/K}$ with increasing temperature.
BD646; 648
BD650; 652

Fig. 3 Switching times waveforms.

Fig. 4 Switching times test circuit.

- $V_{IM} = 10\, V$
- $V_{CC} = 10\, V$
- $V_{BB} = 4\, V$
- $R_1 = 56\, \Omega$
- $R_2 = 410\, \Omega$
- $R_3 = 560\, \Omega$
- $R_4 = 3\, \Omega$
- $t_{r} = t_{f} = 15\, \text{ns}$
- $t_{p} = 10\, \mu\text{s}$
- $t_{f} = 500\, \mu\text{s}$
Fig. 5 Safe Operating Area transistor BD646 at $T_{mb} = 25^\circ C$.

I  Region of permissible d.c. operation.
II  Permissible extension for repetitive pulse operation.
(1)  $P_{ut\,max}$ and $P_{peak\,max}$ lines.
(2)  Second-breakdown limits (independent of temperature).
Fig. 6 Safe Operating Area. $T_{mb} = 25^\circ C$

1. Region of permissible d.c. operation.
2. Permissible extension for repetitive pulse operation.

(1) Plot $I_{CMmax}$ and $P_{peak max}$ lines.
(2) Second-breakdown limits (independent of temperature).
Silicon Darlington power transistors

Fig. 7 Power derating curve.

Fig. 8 Pulse power rating chart.

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Fig. 9 S.B. voltage multiplying factor at the $i_{C_{\text{max}}}$ level.

Fig. 10 S.B. current multiplying factor at 60 V level.
Silicon Darlington power transistors

BD648; BD650

Fig. 11.

S.B. current multiplying factor at the 100 V level

BD652

Fig. 12.

S.B. current multiplying factor at the 120 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 $-I_C = 3$ A; $-V_{CE} = 3$ V.

Fig. 16 Collector current.

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