DATA SHEET

BLW60C
VHF power transistor

Product specification

March 1993
VHF power transistor

**DESCRIPTION**
N-P-N silicon planar epitaxial transistor intended for use in class-A, B and C operated mobile, industrial and military transmitters with a nominal supply voltage of 12.5 V. The transistor is resistance stabilized and is guaranteed to withstand severe load mismatch conditions with a supply over-voltage to 16.5 V.

Matched $h_{FE}$ groups are available on request.

It has a 3/8" capstan envelope with a ceramic cap. All leads are isolated from the stud.

**QUICK REFERENCE DATA**
R.F. performance up to $T_h = 25$ °C

<table>
<thead>
<tr>
<th>MODE OF OPERATION</th>
<th>$V_{CC}$ V</th>
<th>$f$ MHz</th>
<th>$P_L$ W</th>
<th>$G_L$ dB</th>
<th>$\eta$ %</th>
<th>$\bar{z}_i$ $\Omega$</th>
<th>$Z_L$ $\Omega$</th>
<th>$\Delta_3$ dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>c.w. (class-B)</td>
<td>12.5</td>
<td>175</td>
<td>45</td>
<td>&gt; 5.0</td>
<td>&gt; 75</td>
<td>$1.2 + j1.4$</td>
<td>2.6 – $j1.2$</td>
<td>–</td>
</tr>
<tr>
<td>s.s.b. (class-AB)</td>
<td>12.5</td>
<td>1.6-28</td>
<td>3-30</td>
<td>(P.E.P.)</td>
<td>typ. 19.5</td>
<td>typ. 35</td>
<td>–</td>
<td>–</td>
</tr>
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</table>

**PIN CONFIGURATION**

**PINNING - SOT120A.**

<table>
<thead>
<tr>
<th>PIN</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>collector</td>
</tr>
<tr>
<td>2</td>
<td>emitter</td>
</tr>
<tr>
<td>3</td>
<td>base</td>
</tr>
<tr>
<td>4</td>
<td>emitter</td>
</tr>
</tbody>
</table>

Fig.1 Simplified outline. SOT120A.

**PRODUCT SAFETY** This device incorporates beryllium oxide, the dust of which is toxic. The device is entirely safe provided that the BeO disc is not damaged.
RATINGS
Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-emitter voltage ($V_{BE} = 0$)
  - peak value
Collector-emitter voltage (open base)
Emitter-base voltage (open collector)
Collector current (average)
Collector current (peak value); $f > 1$ MHz
R.F. power dissipation ($f > 1$ MHz); $T_{mb} = 25 \ ^\circ C$
Storage temperature
Operating junction temperature

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Max. Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector-emitter voltage</td>
<td>$V_{CESM}$</td>
<td>36 V</td>
</tr>
<tr>
<td>Collector-emitter voltage</td>
<td>$V_{CEO}$</td>
<td>16 V</td>
</tr>
<tr>
<td>Emitter-base voltage</td>
<td>$V_{EBO}$</td>
<td>4 V</td>
</tr>
<tr>
<td>Collector current (average)</td>
<td>$I_{C(AV)}$</td>
<td>9 A</td>
</tr>
<tr>
<td>Collector current (peak)</td>
<td>$I_{CM}$</td>
<td>22 A</td>
</tr>
<tr>
<td>R.F. power dissipation</td>
<td>$P_{rf}$</td>
<td>100 W</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>$T_{stg}$</td>
<td>-65 to +150 °C</td>
</tr>
<tr>
<td>Operating junction temperature</td>
<td>$T_{j}$</td>
<td>200 °C</td>
</tr>
</tbody>
</table>

**Fig. 2** D.C. SOAR.

**Fig. 3** R.F. power dissipation; $V_{CE} \leq 16.5$ V; $f >$ MHz.

THERMAL RESISTANCE
(dissipation = 40 W; $T_{mb} = 88 \ ^\circ C$, i.e. $T_{h} = 70 \ ^\circ C$)

From junction to mounting base (d.c. dissipation)
From junction to mounting base (r.f. dissipation)
From mounting base to heatsink

\[
R_{th \ j-mb(dc)} = 2.8 \ \text{K/W}
\]
\[
R_{th \ j-mb(rf)} = 2.05 \ \text{K/W}
\]
\[
R_{th \ mb-h} = 0.45 \ \text{K/W}
\]
CHARACTERISTICS

$T_j = 25 \, ^\circ C$

**Breakdown voltage**

Collector-emitter voltage

$V_{BE} = 0; \ I_C = 50 \, mA$

$V_{(BR)CES} > 36 \, V$

Collector-emitter voltage

open base; $I_C = 100 \, mA$

$V_{(BR)CEO} > 16 \, V$

Emitter-base voltage

open collector; $I_E = 25 \, mA$

$V_{(BR)EBO} > 4 \, V$

**Collector cut-off current**

$V_{BE} = 0; \ V_{CE} = 15 \, V$

$I_{CES} < 25 \, mA$

**Transient energy**

$L = 25 \, mH; \ f = 50 \, Hz$

open base

$E > 8 \, ms$

$-V_{BE} = 1,5 \, V; \ R_{BE} = 33 \, \Omega$

$E > 8 \, ms$

**D.C. current gain**

$I_C = 4 \, A; \ V_{CE} = 5 \, V$

$h_{FE} \quad \text{typ} \quad 50$

$10 \, \text{to} \quad 80$

**D.C. current gain ratio of matched devices**

$I_C = 4 \, A; \ V_{CE} = 5 \, V$

$h_{FE1}/h_{FE2} < 1,2$

**Collector-emitter saturation voltage**

$I_C = 12,5 \, A; \ I_B = 2,5 \, A$

$V_{CEsat} \quad \text{typ} \quad 1,5 \, V$

**Transition frequency**

at $f = 100 \, MHz$

$I_C = 4 \, A; \ V_{CE} = 12,5 \, V$

$f_T \quad \text{typ} \quad 650 \, MHz$

$I_C = 12,5 \, A; \ V_{CE} = 12,5 \, V$

$f_T \quad \text{typ} \quad 600 \, MHz$

**Collector capacitance**

$I_E = I_e = 0; \ V_{CB} = 15 \, V$

$C_c \quad \text{typ} \quad 120 \, pF$

$< 160 \, pF$

**Feedback capacitance**

at $f = 1 \, MHz$

$I_C = 200 \, mA; \ V_{CE} = 15 \, V$

$C_{re} \quad \text{typ} \quad 80 \, pF$

$C_{cs} \quad \text{typ} \quad 2 \, pF$

**Note**

1. Measured under pulse conditions: $t_p \leq 200 \, \mu s; \ \delta \leq 0,02$. 

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March 1993 4
Fig. 4 DC current gain as a function of collector current.

Fig. 5 Collector capacitance as a function of collector-base voltage.

Fig. 6 Transition frequency as a function of collector current.
**APPLICATION INFORMATION**

R.F. performance in c.w. operation (unneutralized common-emitter class-B circuit); $T_h = 25 ^\circ C$

<table>
<thead>
<tr>
<th>$f$ (MHz)</th>
<th>$V_{CC}$ (V)</th>
<th>$P_L$ (W)</th>
<th>$P_S$ (W)</th>
<th>$G_p$ (dB)</th>
<th>$I_C$ (A)</th>
<th>$\eta$ (%)</th>
<th>$\bar{Z}_i$ (Ω)</th>
<th>$\bar{Z}_L$ (Ω)</th>
</tr>
</thead>
<tbody>
<tr>
<td>175</td>
<td>12,5</td>
<td>45</td>
<td>$&lt; 14,2$</td>
<td>$&gt; 5,0$</td>
<td>$&lt; 4,8$</td>
<td>$&gt; 75$</td>
<td>1,2 + j1,4</td>
<td>2,6 − j1,2</td>
</tr>
<tr>
<td>175</td>
<td>13,5</td>
<td>45</td>
<td>−</td>
<td>typ. 6,0</td>
<td>−</td>
<td>typ. 75</td>
<td>−</td>
<td>−</td>
</tr>
</tbody>
</table>

Test circuit for 175 MHz

**List of components:**

- $C1 = 2,5$ to $20 \text{ pF}$ film dielectric trimmer (cat. no. 2222 809 07004)
- $C2 = C8 = 4$ to $40 \text{ pF}$ film dielectric trimmer (cat. no. 2222 809 07008)
- $C3a = C3b = 47 \text{ pF}$ ceramic capacitor (500 V)
- $C4 = 120 \text{ pF}$ ceramic capacitor
- $C5 = 100 \text{ nF}$ polyester capacitor
- $C6a = C6b = 8,2 \text{ pF}$ ceramic capacitor (500 V)
- $C7 = 5$ to $60 \text{ pF}$ film dielectric trimmer (cat. no. 2222 809 07011)
- $L1 = 1$ turn Cu wire (1,6 mm); int. dia. 9,0 mm; leads 2 × 5 mm
- $L2 = 100 \text{ nH}$; 7 turns closely wound enamelled Cu wire (0,5 mm); int. dia. 3 mm; leads 2 × 5 mm
- $L3 = L8 = \text{Ferroxcube wide-band h.f. choke, grade 3B (cat. no. 4312 020 36640)}$
- $L4 = L5 = \text{strip (12 mm × 6 mm)}$; taps for $C3a$ and $C3b$ at 5 mm from transistor
- $L6 = 2$ turns enamelled Cu wire (1,6 mm); int. dia. 5,0 mm; length 6,0 mm; leads 2 × 5 mm
- $L7 = 2$ turns enamelled Cu wire (1,6 mm); int. dia. 4,5 mm; length 6,0 mm; leads 2 × 5 mm
- $L4$ and $L5$ are strips on a double Cu-clad printed-circuit board with epoxy fibre-glass dielectric, thickness 1/16”.
- $R1 = 10 \Omega$ (±10%) carbon resistor
- $R2 = 4,7 \Omega$ (±5%) carbon resistor

Component layout and printed-circuit board for 175 MHz test circuit: Fig.8.
The circuit and the components are situated on one side of the epoxy fibre-glass board, the other side being fully metallized to serve as earth. Earth connections are made by means of hollow rivets, whilst under the emitter leads Cu straps are used for a direct contact between upper and lower sheets.

Fig.8 Component layout and printed-circuit board for 175 MHz class-B test circuit.
Conditions for R.F. SOAR

\[ f = 175 \text{ MHz} \]
\[ T_h = 70 \degree \text{C} \]
\[ R_{th \ mb-h} = 0.45 \text{ K/W} \]
\[ V_{CCnom} = 12.5 \text{ V or 13.5 V} \]
\[ P_S = P_{Snom} \text{ at } V_{CCnom} \text{ and } VSWR = 1 \]
measured in circuit of Fig.7.

The transistor has been developed for use with unstabilized supply voltages. As the output power and drive power increase with the supply voltage, the nominal output power must be derated in accordance with the graph for safe operation at supply voltages other than the nominal. The graph shows the permissible output power under nominal conditions (VSWR = 1), as a function of the expected supply over-voltage ratio with VSWR as parameter.

The graph applies to the situation in which the drive \( (P_S/P_{Snom}) \) increases linearly with supply over-voltage ratio.
VHF power transistor  

**BLW60C**

**Fig. 12**  Input impedance (series components).

Typical values; $V_{CE} = 12.5 \, \text{V}$; $P_L = 45 \, \text{W}$; class-B operation; $T_h = 25 \, \text{°C}$.

**Fig. 13**  Load impedance (series components).

Typical values; $V_{CE} = 12.5 \, \text{V}$; $P_L = 45 \, \text{W}$; class-B operation; $T_h = 25 \, \text{°C}$.

**Fig. 14**
VHF power transistor

BLW60C

R.F. performance in s.s.b. class-AB operation

\( V_{CE} = 12.5 \text{ V} ; T_h \text{ up to } 25 \degree \text{C} ; R_{th \text{ mb-h}} \leq 0.45 \text{ K/W} \)

\( f_1 = 28,000 \text{ MHz} ; f_2 = 28,001 \text{ MHz} \)

**OUTPUT POWER**

<table>
<thead>
<tr>
<th>( W )</th>
<th>( G_p ) dB</th>
<th>( \eta_{dt} ) %</th>
<th>( d_3 ) dB (1)</th>
<th>( d_5 ) dB (1)</th>
<th>( I_{C(ZS)} ) mA</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 to 30 (P.E.P.)</td>
<td>typ 19,5</td>
<td>typ 35</td>
<td>typ –33</td>
<td>typ –36</td>
<td>25</td>
</tr>
</tbody>
</table>

**Note**

1. Stated intermodulation distortion figures are referred to the according level of either of the equal amplified tones. Relative to the according peak envelope powers these figures should be increased by 6 dB.

Fig.15  S.S.B. class-AB test circuit.
VHF power transistor

List of components:

TR1 = TR2 = BD137
C1 = 100 pF air dielectric trimmer (single insulated rotor type)
C2 = 27 pF ceramic capacitor
C3 = 180 pF ceramic capacitor
C4 = 100 pF air dielectric trimmer (single non-insulated rotor type)
C5 = C7 = 3,9 nF polyester capacitor
C6 = 2 x 270 pF polystyrene capacitors in parallel
C8 = C15 = C16 = 100 nF polyester capacitor
C9 = 2,2 µF moulded metallized polyester capacitor
C10 = 2 x 385 pF film dielectric trimmer
C11 = 68 pF ceramic capacitor
C12 = 2 x 82 pF ceramic capacitors in parallel
C13 = 47 pF ceramic capacitor
C14 = 385 pF film dielectric trimmer
L1 = 88 nH; 3 turns Cu wire (1,0 mm); int. dia. 9 mm; length 6,1 mm; leads 2 x 5 mm
L2 = L5 = Ferroxcube choke coil (cat. no. 4312 020 36640)
L3 = 68 nH; 3 turns enamelled Cu wire (1,6 mm); int. dia. 8 mm; length 8,3 mm; leads 2 x 5 mm
L4 = 96 nH; 3 turns enamelled Cu wire (1,6 mm); int. dia. 10 mm; length 7,6 mm; leads 2 x 5 mm
R1 = 27 Ω (± 5%) carbon resistor
R2 = 4,7 Ω (±5%) carbon resistor
R3 = 1,5 kΩ (±5%) carbon resistor
R4 = 10 Ω wirewound potentiometer (3 W)
R5 = 47 Ω wirewound resistor (5,5 W)
R6 = 150 Ω (±5%) carbon resistor

Measuring conditions for Figs 16 and 17:

V_{CC} = 12,5 V
f_1 = 28,000 MHz
f_2 = 28,001 MHz
T_h = 25 °C
R_{th mb-h} ≤ 0,45 ° K/W
I_{C(ZS)} = 25 mA
typical values

Measuring conditions for Figs 18 and 19:

V_{CC} = 13,5 V
f_1 = 28,000 MHz
f_2 = 28,001 MHz
T_h = 25 °C
R_{th mb-h} ≤ 0,45 ° K/W
I_{C(ZS)} = 25 mA
typical values
VHF power transistor

**BLW60C**

* Stated intermodulation distortion figures are referred to the according level of either of the equal amplified tones. Relative to the according peak envelope powers these figures should be increased by 6 dB.
S.S.B. class-AB operation

Conditions for Figs 20 and 21:

\[
\begin{align*}
V_{CC} &= 12.5 \text{ V} & V_{CC} &= 13.5 \text{ V} \\
P_L &= 30 \text{ W (P.E.P.)} & P_L &= 35 \text{ W (P.E.P.)} \\
T_h &= 25 ^\circ \text{C} & T_h &= 25 ^\circ \text{C} \\
R_{th \text{ mb-h}} &\leq 0.45 \text{ K/W} & R_{th \text{ mb-h}} &\leq 0.45 \text{ K/W} \\
I_{C(ZS)} &= 25 \text{ mA} & I_{C(ZS)} &= 25 \text{ mA} \\
Z_L &= 1.9 \Omega & Z_L &= 1.9 \Omega
\end{align*}
\]

The typical curves (both conditions) hold for an unneutralized amplifier.
**PACKAGE OUTLINE**

Studded ceramic package; 4 leads  
SOT120A

**DIMENSIONS** (millimetre dimensions are derived from the original inch dimensions)

<table>
<thead>
<tr>
<th>UNIT</th>
<th>A</th>
<th>b</th>
<th>c</th>
<th>D</th>
<th>D₁</th>
<th>D₂</th>
<th>H</th>
<th>L</th>
<th>M</th>
<th>M₁</th>
<th>N</th>
<th>N₁</th>
<th>N₂</th>
<th>Q</th>
<th>W</th>
<th>W₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>5.97</td>
<td>5.90</td>
<td>0.18</td>
<td>9.73</td>
<td>9.47</td>
<td>8.39</td>
<td>9.66</td>
<td>9.39</td>
<td>27.44</td>
<td>9.00</td>
<td>3.41</td>
<td>2.92</td>
<td>1.66</td>
<td>12.83</td>
<td>1.60</td>
<td>3.31</td>
</tr>
<tr>
<td>inches</td>
<td>0.232</td>
<td>0.232</td>
<td>0.007</td>
<td>0.383</td>
<td>0.373</td>
<td>0.330</td>
<td>0.380</td>
<td>0.370</td>
<td>1.080</td>
<td>0.354</td>
<td>0.134</td>
<td>0.069</td>
<td>0.065</td>
<td>0.505</td>
<td>0.063</td>
<td>0.130</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>OUTLINE VERSION</th>
<th>REFERENCES</th>
<th>EUROPEAN PROJECTION</th>
<th>ISSUE DATE</th>
</tr>
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<tbody>
<tr>
<td>SOT120A</td>
<td>IEC</td>
<td>JEDEC</td>
<td>EIAJ</td>
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March 1993
DEFINITIONS

<table>
<thead>
<tr>
<th>Data Sheet Status</th>
<th>Description</th>
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<tbody>
<tr>
<td>Objective specification</td>
<td>This data sheet contains target or goal specifications for product development.</td>
</tr>
<tr>
<td>Preliminary specification</td>
<td>This data sheet contains preliminary data; supplementary data may be published later.</td>
</tr>
<tr>
<td>Product specification</td>
<td>This data sheet contains final product specifications.</td>
</tr>
</tbody>
</table>

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.

LIFE SUPPORT APPLICATIONS

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