BFR93A
NPN 6 GHz wideband transistor

Product specification
Supersedes data of September 1995

1997 Oct 29
NPN 6 GHz wideband transistor BFR93A

FEATURES
- High power gain
- Low noise figure
- Very low intermodulation distortion.

APPLICATIONS
- RF wideband amplifiers and oscillators.

DESCRIPTION
NPN wideband transistor in a plastic SOT23 package. PNP complement: BFT93.

PINNING

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

QUICK REFERENCE DATA

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNIT</th>
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</thead>
<tbody>
<tr>
<td>V_{CBO}</td>
<td>collector-base voltage</td>
<td>open emitter</td>
<td>–</td>
<td>15</td>
<td>V</td>
</tr>
<tr>
<td>V_{CEO}</td>
<td>collector-emitter voltage</td>
<td>open base</td>
<td>–</td>
<td>12</td>
<td>V</td>
</tr>
<tr>
<td>I_{C}</td>
<td>collector current (DC)</td>
<td>–</td>
<td>35</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>P_{tot}</td>
<td>total power dissipation</td>
<td>T_s ≤ 95 °C</td>
<td>–</td>
<td>300</td>
<td>mW</td>
</tr>
<tr>
<td>C_{re}</td>
<td>feedback capacitance</td>
<td>I_{C} = 0; V_{CE} = 5 V; f = 1 MHz</td>
<td>0.6</td>
<td>–</td>
<td>pF</td>
</tr>
<tr>
<td>f_{T}</td>
<td>transition frequency</td>
<td>I_{C} = 30 mA; V_{CE} = 5 V; f = 500 MHz</td>
<td>6</td>
<td>–</td>
<td>GHz</td>
</tr>
<tr>
<td>G_{UM}</td>
<td>maximum unilateral power gain</td>
<td>I_{C} = 30 mA; V_{CE} = 8 V; f = 1 GHz; T_{amb} = 25 °C</td>
<td>13</td>
<td>–</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I_{C} = 30 mA; V_{CE} = 8 V; f = 2 GHz; T_{amb} = 25 °C</td>
<td>7</td>
<td>–</td>
<td>dB</td>
</tr>
<tr>
<td>F</td>
<td>noise figure</td>
<td>I_{C} = 5 mA; V_{CE} = 8 V; f = 1 GHz; T_{amb} = 25 °C</td>
<td>1.9</td>
<td>–</td>
<td>dB</td>
</tr>
<tr>
<td>V_{O}</td>
<td>output voltage</td>
<td>d_{in} = –60 dB; I_{C} = 30 mA; V_{CE} = 8 V; R_{L} = 75 Ω; T_{amb} = 25 °C; f_{p} + f_{q} – f_{s} = 793.25 MHz</td>
<td>425</td>
<td>–</td>
<td>mV</td>
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LIMITING VALUES
In accordance with the Absolute Maximum Rating System (IEC 134).

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN.</th>
<th>MAX.</th>
<th>UNIT</th>
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<tr>
<td>V_{CBO}</td>
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<td>–</td>
<td>15</td>
<td>V</td>
</tr>
<tr>
<td>V_{CEO}</td>
<td>collector-emitter voltage</td>
<td>open base</td>
<td>–</td>
<td>12</td>
<td>V</td>
</tr>
<tr>
<td>V_{EBO}</td>
<td>emitter-base voltage</td>
<td>open collector</td>
<td>–</td>
<td>2</td>
<td>V</td>
</tr>
<tr>
<td>I_{C}</td>
<td>collector current (DC)</td>
<td>–</td>
<td>35</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>P_{tot}</td>
<td>total power dissipation</td>
<td>T_s ≤ 95 °C; note 1</td>
<td>–</td>
<td>300</td>
<td>mW</td>
</tr>
<tr>
<td>T_{slg}</td>
<td>storage temperature</td>
<td>–65</td>
<td>+150</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>T_{j}</td>
<td>junction temperature</td>
<td>–</td>
<td>+175</td>
<td>°C</td>
<td></td>
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</tbody>
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Note
1. T_s is the temperature at the soldering point of the collector pin.

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THERMAL CHARACTERISTICS

<table>
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<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>VALUE</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{th,j-s}$</td>
<td>thermal resistance from junction to soldering point</td>
<td>$T_s \leq 95 , ^\circ\text{C}$; note 1</td>
<td>260</td>
<td>K/W</td>
</tr>
</tbody>
</table>

Note

1. $T_s$ is the temperature at the soldering point of the collector pin.

CHARACTERISTICS

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

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{CBO}$</td>
<td>collector cut-off current</td>
<td>$I_E = 0$; $V_{CB} = 5 , \text{V}$</td>
<td>–</td>
<td>–</td>
<td>50</td>
<td>nA</td>
</tr>
<tr>
<td>$h_{FE}$</td>
<td>DC current gain</td>
<td>$I_C = 30 , \text{mA}$; $V_{CE} = 5 , \text{V}$</td>
<td>40</td>
<td>90</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>$C_c$</td>
<td>collector capacitance</td>
<td>$I_C = I_e = 0$; $V_{CB} = 5 , \text{V}$; $f = 1 , \text{MHz}$</td>
<td>–</td>
<td>0.7</td>
<td>–</td>
<td>pF</td>
</tr>
<tr>
<td>$C_e$</td>
<td>emitter capacitance</td>
<td>$I_C = I_e = 0$; $V_{EB} = 0.5 , \text{V}$; $f = 1 , \text{MHz}$</td>
<td>–</td>
<td>1.9</td>
<td>–</td>
<td>pF</td>
</tr>
<tr>
<td>$C_{re}$</td>
<td>feedback capacitance</td>
<td>$I_C = I_e = 0$; $V_{CE} = 5 , \text{V}$; $f = 1 , \text{MHz}$; $T_{amb} = 25 , ^\circ\text{C}$</td>
<td>–</td>
<td>0.6</td>
<td>–</td>
<td>pF</td>
</tr>
<tr>
<td>$f_T$</td>
<td>transition frequency</td>
<td>$I_C = 30 , \text{mA}$; $V_{CE} = 5 , \text{V}$; $f = 500 , \text{MHz}$</td>
<td>4.5</td>
<td>6</td>
<td>–</td>
<td>GHz</td>
</tr>
<tr>
<td>$G_{UM}$</td>
<td>maximum unilateral power gain (note 1)</td>
<td>$I_C = 30 , \text{mA}$; $V_{CE} = 8 , \text{V}$; $f = 1 , \text{GHz}$; $T_{amb} = 25 , ^\circ\text{C}$</td>
<td>–</td>
<td>13</td>
<td>–</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_C = 30 , \text{mA}$; $V_{CE} = 8 , \text{V}$; $f = 2 , \text{GHz}$; $T_{amb} = 25 , ^\circ\text{C}$</td>
<td>–</td>
<td>7</td>
<td>–</td>
<td>dB</td>
</tr>
<tr>
<td>$F$</td>
<td>noise figure (note 2)</td>
<td>$I_C = 5 , \text{mA}$; $V_{CE} = 8 , \text{V}$; $f = 1 , \text{GHz}$; $\Gamma_s = \Gamma_{opt}$; $T_{amb} = 25 , ^\circ\text{C}$</td>
<td>–</td>
<td>1.9</td>
<td>–</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_C = 5 , \text{mA}$; $V_{CE} = 8 , \text{V}$; $f = 2 , \text{GHz}$; $\Gamma_s = \Gamma_{opt}$; $T_{amb} = 25 , ^\circ\text{C}$</td>
<td>–</td>
<td>3</td>
<td>–</td>
<td>dB</td>
</tr>
<tr>
<td>$V_O$</td>
<td>output voltage</td>
<td>notes 2 and 3</td>
<td>–</td>
<td>425</td>
<td>–</td>
<td>mV</td>
</tr>
<tr>
<td>$d_2$</td>
<td>second order intermodulation distortion</td>
<td>notes 2 and 4</td>
<td>–</td>
<td>–50</td>
<td>–</td>
<td>dB</td>
</tr>
</tbody>
</table>

Notes

1. $G_{UM}$ is the maximum unilateral power gain, assuming $S_{12}$ is zero and $G_{UM} = 10 \log \left( \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)} \right)$ dB.
2. Measured on the same die in a SOT37 package (BFR91A).
3. $d_{in} = -60 \, \text{dB}$ (DIN 45004B); $I_C = 30 \, \text{mA}$; $V_{CE} = 8 \, \text{V}$; $R_L = 75 \, \Omega$; $T_{amb} = 25 \, ^\circ\text{C}$;
   $V_p = V_O$ at $d_{in} = -60 \, \text{dB}$; $f_p = 795.25 \, \text{MHz}$;
   $V_q = V_O$ at $d_{in} = -6 \, \text{dB}$ at $f_q = 803.25 \, \text{MHz}$;
   $V_f = V_O$ at $d_{in} = -6 \, \text{dB}$ at $f_f = 805.25 \, \text{MHz}$;
   measured at $f_p + f_q - f_f = 793.25 \, \text{MHz}$.
4. $I_C = 30 \, \text{mA}$; $V_{CE} = 8 \, \text{V}$; $R_L = 75 \, \Omega$; $T_{Amb} = 25 \, ^\circ\text{C}$;
   $V_p = 200 \, \text{mV}$ at $f_p = 250 \, \text{MHz}$;
   $V_q = 200 \, \text{mV}$ at $f_q = 560 \, \text{MHz}$;
   measured at $f_p + f_q = 810 \, \text{MHz}$.
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**Fig. 2** Intermodulation distortion and second harmonic distortion MATV test circuit.

- $L1 = L3 = 5 \, \mu\text{H} $ choke.
- $L2 = 3 \text{ turns } 0.4 \, \text{mm copper wire; winding pitch } 1 \, \text{mm; internal diameter } 3 \, \text{mm.}$

**Fig. 3** Power derating curve.

- $V_{CE} = 5 \text{ V; } T_j = 25 \, ^\circ\text{C.}$

**Fig. 4** DC current gain as a function of collector current.
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Fig. 5  Collector capacitance as a function of collector-base voltage; typical values.

\[ V_{CB} (V) \]

\[ C_C (\text{pF}) \]

\[ I_C = i_e = 0; f = 1 \text{ MHz}; T_j = 25 \degree C. \]

Fig. 6  Transition frequency as a function of collector current; typical values.

\[ V_{CE} = 5 \text{ V}; f = 500 \text{ MHz}; T_j = 25 \degree C. \]

Fig. 7  Gain as a function of collector current; typical values.

\[ V_{CE} = 8 \text{ V}; f = 500 \text{ MHz}. \]

Fig. 8  Gain as a function of collector current; typical values.

\[ V_{CE} = 8 \text{ V}; f = 1 \text{ GHz}. \]
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Fig. 9  Gain as a function of frequency; typical values.

\( I_C = 10 \text{ mA}; \ V_{CE} = 8 \text{ V}. \)

Fig. 10  Gain as a function of frequency; typical values.

\( I_C = 30 \text{ mA}; \ V_{CE} = 8 \text{ V}. \)

Fig. 11  Circles of constant noise figure; typical values.

\( I_C = 4 \text{ mA}; \ V_{CE} = 8 \text{ V}; \ f = 800 \text{ MHz}; \ T_{amb} = 25 ^\circ \text{ C}. \)

Fig. 12  Circles of constant noise figure; typical values.

\( I_C = 4 \text{ mA}; \ V_{CE} = 8 \text{ V}; \ f = 800 \text{ MHz}; \ T_{amb} = 25 ^\circ \text{ C}. \)
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**Fig. 13** Minimum noise figure as a function of collector current; typical values.

**Fig. 14** Minimum noise figure as a function of frequency; typical values.

**Fig. 15** Intermodulation distortion; typical values.

**Fig. 16** Second order intermodulation distortion; typical values.

\[ V_{CE} = 8 \text{ V}; \ V_{O} = 425 \text{ mV (52.6 dBmV)}; \]

\[ f_{s} + f_{q} = 793.25 \text{ MHz}; \ T_{amb} = 25 \text{ °C}. \]

Measured in MATV test circuit (see Fig. 2)

\[ V_{CE} = 8 \text{ V}; \ V_{O} = 200 \text{ mV (46 dBmV)}; \]

\[ f_{s} + f_{q} = 810 \text{ MHz}; \ T_{amb} = 25 \text{ °C}. \]

Measured in MATV test circuit (see Fig. 2)
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**Fig. 17** Common emitter input reflection coefficient ($S_{11}$).

\[ I_C = 30 \text{ mA}; \ V_{CE} = 8 \text{ V}; \ Z_o = 50 \text{ } \Omega; \ T_{amb} = 25 \text{ } ^\circ\text{C}. \]

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**Fig. 18** Common emitter forward transmission coefficient ($S_{21}$).

\[ I_C = 30 \text{ mA}; \ V_{CE} = 8 \text{ V}; \ T_{amb} = 25 \text{ } ^\circ\text{C}. \]
Fig.19 Common emitter reverse transmission coefficient ($S_{12}$).

Fig.20 Common emitter output reflection coefficient ($S_{22}$).
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PACKAGE OUTLINE

Plastic surface-mounted package; 3 leads

SOT23

REPRESENTATIVE DIMENSIONS

DIMENSIONS (mm are the original dimensions)

<table>
<thead>
<tr>
<th>UNIT</th>
<th>A</th>
<th>A1</th>
<th>b_p</th>
<th>c</th>
<th>D</th>
<th>E</th>
<th>e</th>
<th>e1</th>
<th>H_E</th>
<th>L_p</th>
<th>Q</th>
<th>v</th>
<th>w</th>
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<tr>
<td>mm</td>
<td>1.1</td>
<td>0.9</td>
<td>0.48</td>
<td>0.15</td>
<td>3.0</td>
<td>1.4</td>
<td>1.9</td>
<td>0.95</td>
<td>2.5</td>
<td>0.45</td>
<td>0.55</td>
<td>0.2</td>
<td>0.1</td>
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REFERENCES

OUTLINE VERSION

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<th>IEC</th>
<th>JEDEC</th>
<th>JEITA</th>
<th>EUROPEAN PROJECTION</th>
<th>ISSUE DATE</th>
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TO-236AB

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DATA SHEET STATUS

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<td>Development</td>
<td>This document contains data from the objective specification for product development.</td>
</tr>
<tr>
<td>Preliminary data sheet</td>
<td>Qualification</td>
<td>This document contains data from the preliminary specification.</td>
</tr>
<tr>
<td>Product data sheet</td>
<td>Production</td>
<td>This document contains the product specification.</td>
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Notes

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This data sheet was changed to reflect the new company name NXP Semiconductors, including new legal definitions and disclaimers. No changes were made to the technical content, except for package outline drawings which were updated to the latest version.

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