



# BFR540

NPN 9 GHz wideband transistor

Rev. 05 — 1 September 2004

Product data sheet

## 1. Product profile

### 1.1 General description

The BFR540 is an NPN silicon planar epitaxial transistor in a SOT23 plastic package.

### 1.2 Features

- High power gain
- Low noise figure
- High transition frequency
- Gold metallization ensures excellent reliability.

### 1.3 Applications

- RF front end wideband applications in the GHz range
  - ◆ Analog and digital cellular telephones
  - ◆ Cordless telephones (CT1, CT2, DECT, etc.)
  - ◆ Radar detectors
  - ◆ Satellite TV tuners (SATV)
  - ◆ MATV/CATV amplifiers
  - ◆ Repeater amplifiers in fiber-optic systems.

### 1.4 Quick reference data

Table 1: Quick reference data

| Symbol    | Parameter                     | Conditions   | Min | Typ | Max | Unit |
|-----------|-------------------------------|--|-----|-----|-----|------|
| $V_{CBO}$ | collector-base voltage        | open emitter   | -   | -   | 20  | V    |
| $V_{CES}$ | collector-emitter voltage     | $R_{BE} = 0 \Omega$  | -   | -   | 15  | V    |
| $I_C$     | collector current (DC)        |  | -   | -   | 120 | mA   |
| $P_{tot}$ | total power dissipation       | $T_{sp} \leq 70 \text{ }^\circ\text{C}$  | [1] | -   | 500 | mW   |
| $h_{FE}$  | DC current gain               | $I_C = 40 \text{ mA}; V_{CE} = 8 \text{ V}$                                      | 100 | 120 | 250 |      |
| $C_{re}$  | feedback capacitance          | $I_C = i_c = 0 \text{ A}; V_{CB} = 8 \text{ V}; f = 1 \text{ MHz}$               | -   | 0.6 | -   | pF   |
| $f_T$     | transition frequency          | $I_C = 40 \text{ mA}; V_{CE} = 8 \text{ V}; f = 1 \text{ GHz}$                   | -   | 9   | -   | GHz  |
| $G_{UM}$  | maximum unilateral power gain | $I_C = 40 \text{ mA}; V_{CE} = 8 \text{ V}; T_{amb} = 25 \text{ }^\circ\text{C}$ |     |     |     |      |
|           |                               | $f = 900 \text{ MHz}$  | -   | 14  | -   | dB   |
|           |                               | $f = 2 \text{ GHz}$  | -   | 7   | -   | dB   |

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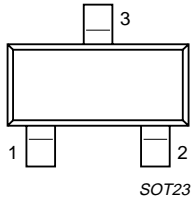
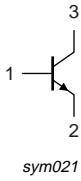
**Table 1: Quick reference data ...continued**

| Symbol       | Parameter            | Conditions  | Min | Typ | Max | Unit |
|--------------|----------------------|---|-----|-----|-----|------|
| $ s_{21} ^2$ | insertion power gain | $I_C = 40 \text{ mA}; V_{CE} = 8 \text{ V};$<br>$T_{amb} = 25 \text{ }^\circ\text{C};$<br>$f = 900 \text{ MHz}$ | 12  | 13  | -   | dB   |
| NF           | noise figure         | $\Gamma_s = \Gamma_{opt}; V_{CE} = 8 \text{ V};$<br>$T_{amb} = 25 \text{ }^\circ\text{C}$                       |     |     |     |      |
|              |                      | $I_C = 10 \text{ mA};$<br>$f = 900 \text{ MHz}$   | -   | 1.3 | 1.8 | dB   |
|              |                      | $I_C = 40 \text{ mA};$<br>$f = 900 \text{ MHz}$   | -   | 1.9 | 2.4 | dB   |
|              |                      | $I_C = 10 \text{ mA};$<br>$f = 2 \text{ GHz}$   | -   | 2.1 | -   | dB   |

[1]  $T_{sp}$  is the temperature at the soldering point of the collector tab.

## 2. Pinning information

**Table 2: Pinning**

| Pin | Description | Simplified outline   | Symbol  |
|-----|-------------|--|---|
| 1   | base        |  <p>SOT23</p> |  <p>sym021</p> |
| 2   | emitter     |  |   |
| 3   | collector   |  |   |

## 3. Ordering information

**Table 3: Ordering information**

| Type number | Package |  |         |
|-------------|---------|--|---------|
|             | Name    | Description                              | Version |
| BFR540      | -       | plastic surface mounted package; 3 leads | SOT23   |

## 4. Marking

**Table 4: Marking**

| Type number | Marking code [1] |
|-------------|------------------|
| BFR540      | 33*              |

[1] \* = p: Made in Hong Kong  
 \* = t: Made in Malaysia  
 \* = W: Made in China.

## 5. Limiting values

**Table 5: Limiting values**

In accordance with the Absolute Maximum Rating System (IEC 60134).

| Symbol    | Parameter                 | Conditions                              | Min | Max  | Unit             |
|-----------|---------------------------|---|-----|------|------------------|
| $V_{CBO}$ | collector-base voltage    | open emitter                            | -   | 20   | V                |
| $V_{CES}$ | collector-emitter voltage | $R_{BE} = 0 \Omega$                     | -   | 15   | V                |
| $V_{EBO}$ | emitter-base voltage      | open collector                          | -   | 2.5  | V                |
| $I_C$     | collector current (DC)    |   | -   | 120  | mA               |
| $P_{tot}$ | total power dissipation   | $T_{sp} \leq 70 \text{ }^\circ\text{C}$ | [1] | 500  | mW               |
| $T_{stg}$ | storage temperature       |   | -65 | +150 | $^\circ\text{C}$ |
| $T_j$     | junction temperature      |   | -   | 175  | $^\circ\text{C}$ |

[1]  $T_{sp}$  is the temperature at the soldering point of the collector tab.

## 6. Thermal characteristics

**Table 6: Thermal characteristics**

| Symbol         | Parameter   | Conditions | Typ | Unit    |
|----------------|---|------------|-----|---------|
| $R_{th(j-sp)}$ | thermal resistance from junction to soldering point |            | [1] | 260 K/W |

[1]  $T_{sp}$  is the temperature at the soldering point of the collector tab.

## 7. Characteristics

**Table 7: Characteristics**

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

| Symbol       | Parameter                     | Conditions   | Min | Typ | Max | Unit |
|--------------|-------------------------------|--|-----|-----|-----|------|
| $I_{CBO}$    | collector cut-off current     | $I_E = 0 \text{ A}; V_{CB} = 8 \text{ V}$  | -   | -   | 50  | nA   |
| $h_{FE}$     | DC current gain               | $I_C = 40 \text{ mA}; V_{CE} = 8 \text{ V}$  | 100 | 120 | 250 |      |
| $C_e$        | emitter capacitance           | $I_C = i_c = 0 \text{ A}; V_{EB} = 0.5 \text{ V};$<br>$f = 1 \text{ MHz}$                                  | -   | 2   | -   | pF   |
| $C_c$        | collector capacitance         | $I_E = i_e = 0 \text{ A}; V_{CB} = 8 \text{ V};$<br>$f = 1 \text{ MHz}$                                    | -   | 0.9 | -   | pF   |
| $C_{re}$     | feedback capacitance          | $I_C = 0 \text{ A}; V_{CB} = 8 \text{ V};$<br>$f = 1 \text{ MHz}$  | -   | 0.6 | -   | pF   |
| $f_T$        | transition frequency          | $I_C = 40 \text{ mA}; V_{CE} = 8 \text{ V};$<br>$f = 1 \text{ GHz}$  | -   | 9   | -   | GHz  |
| $G_{UM}$     | maximum unilateral power gain | $I_C = 40 \text{ mA}; V_{CE} = 8 \text{ V};$<br>$T_{amb} = 25 \text{ }^\circ\text{C}$                      | [1] |     |     |      |
|              |                               | $f = 900 \text{ MHz}$  | -   | 14  | -   | dB   |
|              |                               | $f = 2 \text{ GHz}$  | -   | 7   | -   | dB   |
| $ S_{21} ^2$ | insertion power gain          | $I_C = 40 \text{ mA}; V_{CE} = 8 \text{ V};$<br>$T_{amb} = 25 \text{ }^\circ\text{C}; f = 900 \text{ MHz}$ | 12  | 13  | -   | dB   |

**Table 7: Characteristics ...continued**  
*T<sub>j</sub> = 25 °C unless otherwise specified.*

| Symbol       | Parameter                             | Conditions  | Min | Typ | Max | Unit |
|--------------|---------------------------------------|---|-----|-----|-----|------|
| NF           | noise figure                          | $\Gamma_s = \Gamma_{opt}$ ; $V_{CE} = 8\text{ V}$ ;<br>$T_{amb} = 25\text{ °C}$   |     |     |     |      |
|              |                                       | $I_C = 10\text{ mA}$ ; $f = 900\text{ MHz}$   | -   | 1.3 | 1.8 | dB   |
|              |                                       | $I_C = 40\text{ mA}$ ; $f = 900\text{ MHz}$   | -   | 1.9 | 2.4 | dB   |
|              |                                       | $I_C = 10\text{ mA}$ ; $f = 2\text{ GHz}$   | -   | 2.1 | -   | dB   |
| $P_{L(1dB)}$ | output power at 1 dB gain compression | $I_C = 40\text{ mA}$ ; $V_{CE} = 8\text{ V}$ ;<br>$R_L = 50\ \Omega$ ; $T_{amb} = 25\text{ °C}$ ;<br>$f = 900\text{ MHz}$ | -   | 21  | -   | dBm  |
| ITO          | third order intercept point           |   | [2] | 34  | -   | dBm  |
| $V_O$        | output voltage                        | $I_C = 40\text{ mA}$ ; $V_{CE} = 8\text{ V}$ ;<br>$Z_L = Z_S = 75\ \Omega$ ;<br>$T_{amb} = 25\text{ °C}$                  | [3] | 550 | -   | mV   |

[1]  $G_{UM}$  is the maximum unilateral power gain, assuming  $s_{12}$  is zero and

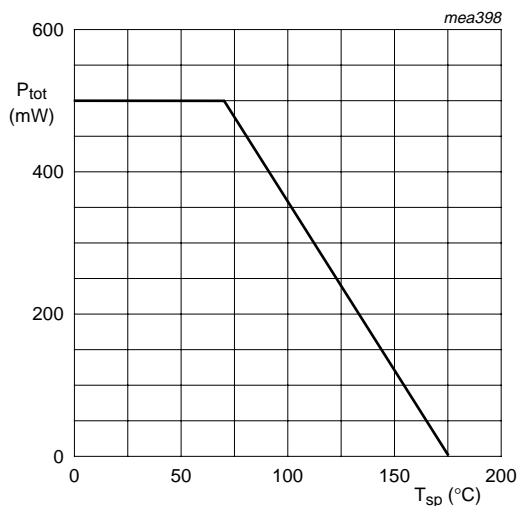
$$G_{UM} = 10 \log \frac{|s_{21}|^2}{(1 - |s_{11}|^2)(1 - |s_{22}|^2)} \text{ dB.}$$

[2]  $I_C = 40\text{ mA}$ ;  $V_{CE} = 8\text{ V}$ ;  $R_L = 50\ \Omega$ ;  $T_{amb} = 25\text{ °C}$ ;  $f = 900\text{ MHz}$ ;  $f_p = 900\text{ MHz}$ ;  $f_q = 902\text{ MHz}$ .

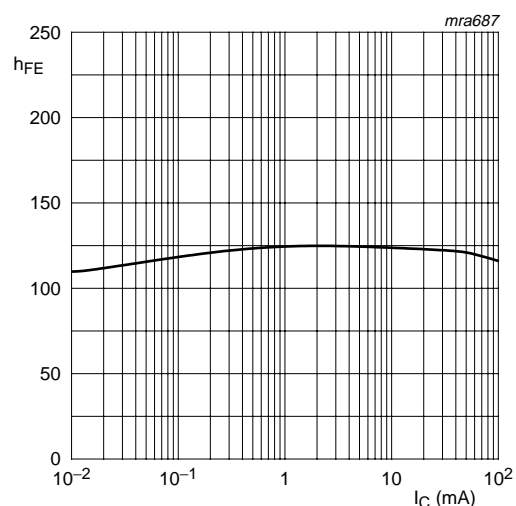
Measured at  $f_{(2p-q)} = 898\text{ MHz}$  and  $f_{(2q-p)} = 904\text{ MHz}$ .

[3]  $d_{im} = -60\text{ dB}$  (DIN 45004B);  $V_p = V_O$ ;  $V_q = V_O - 6\text{ dB}$ ;  $f_p = 795.25\text{ MHz}$ ;  $V_R = V_O - 6\text{ dB}$ ;  $f_q = 803.25\text{ MHz}$ ;  $f_r = 805.25\text{ MHz}$ .

Measured at  $f_{(p+q-r)} = 793.25\text{ MHz}$ .

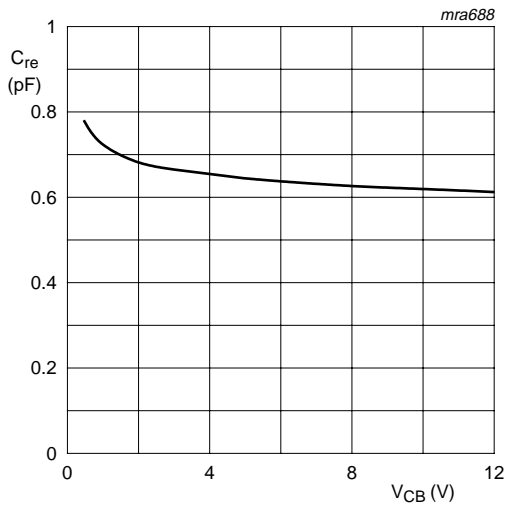


**Fig 1. Power derating curve.**



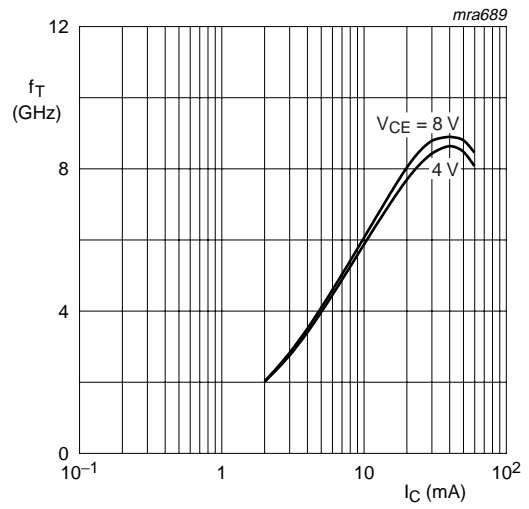
$V_{CE} = 8\text{ V}$ .

**Fig 2. DC current gain as a function of collector current.**



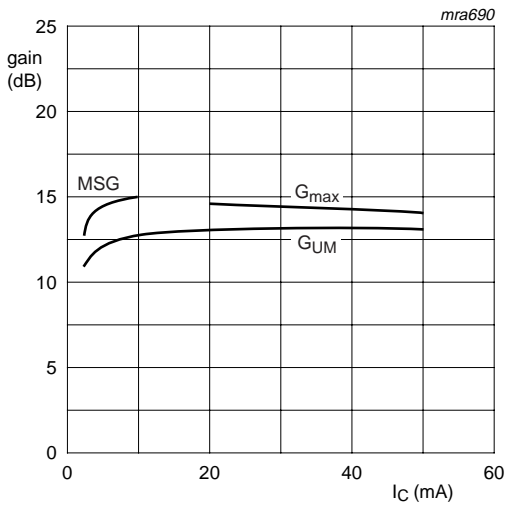
$I_C = 0$  A;  $f = 1$  MHz.

**Fig 3. Feedback capacitance as a function of collector-base voltage.**



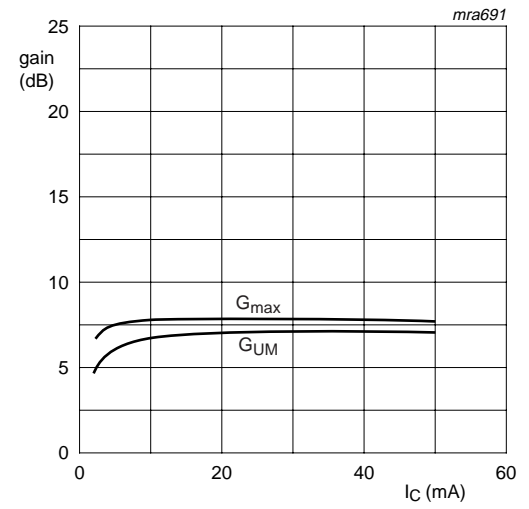
$T_{amb} = 25$  °C;  $f = 1$  GHz.

**Fig 4. Transition frequency as a function of collector current.**



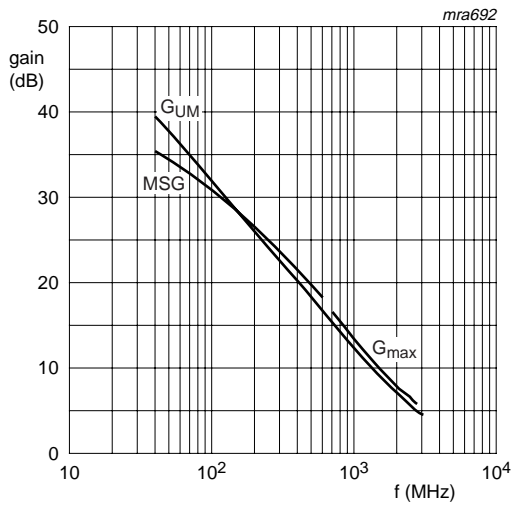
$V_{CE} = 8$  V;  $f = 900$  MHz.

**Fig 5. Gain as a function of collector current.**



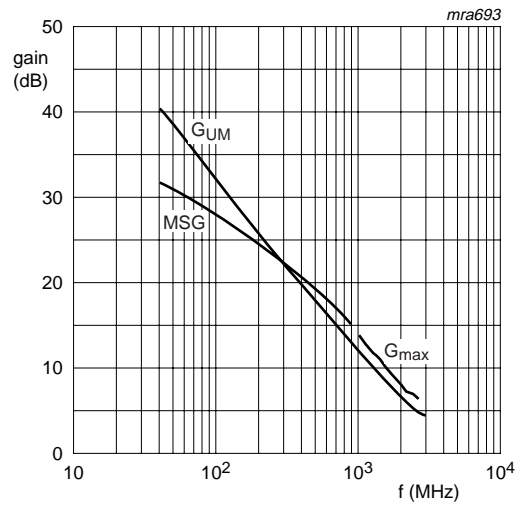
$V_{CE} = 8$  V;  $f = 2$  GHz.

**Fig 6. Gain as a function of collector current.**



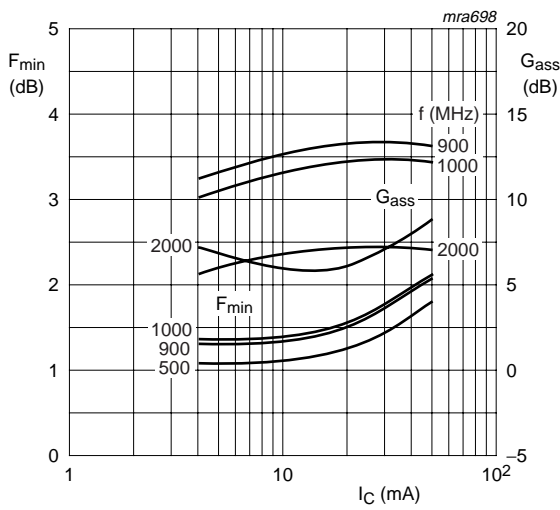
$V_{CE} = 8\text{ V}; I_C = 10\text{ mA}.$

**Fig 7. Gain as a function of frequency;  $I_C = 10\text{ mA}.$**



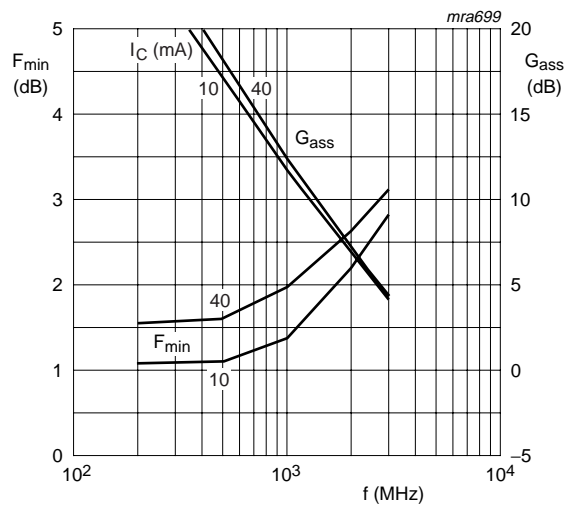
$V_{CE} = 8\text{ V}; I_C = 40\text{ mA}.$

**Fig 8. Gain as a function of frequency;  $I_C = 40\text{ mA}.$**



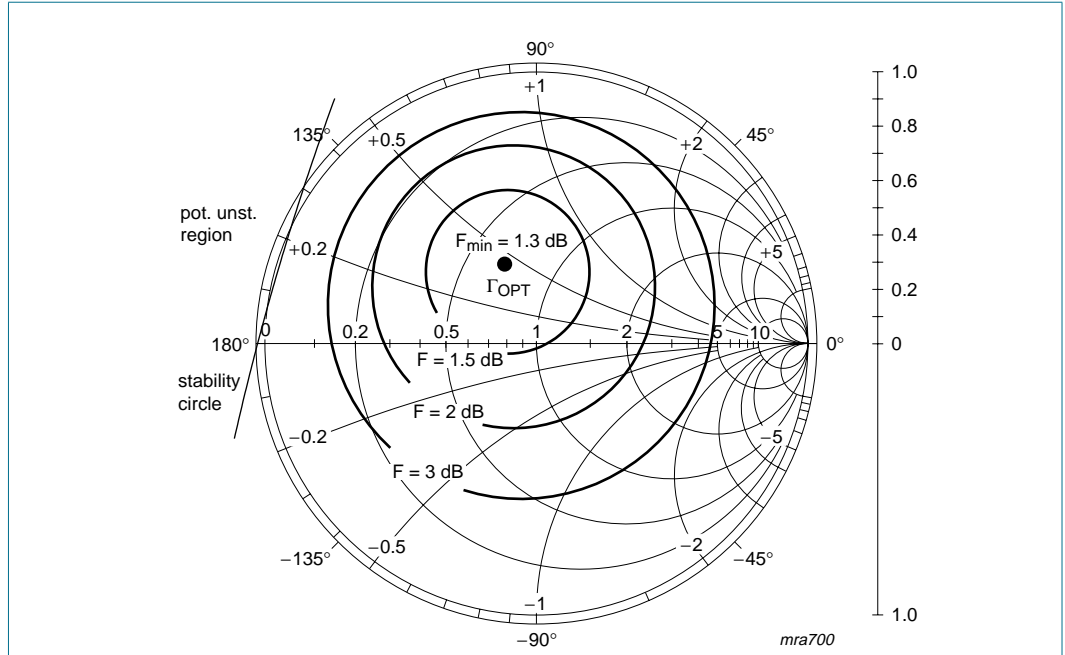
$V_{CE} = 8\text{ V}.$

**Fig 9. Minimum noise figure and associated available gain as a function of collector current.**



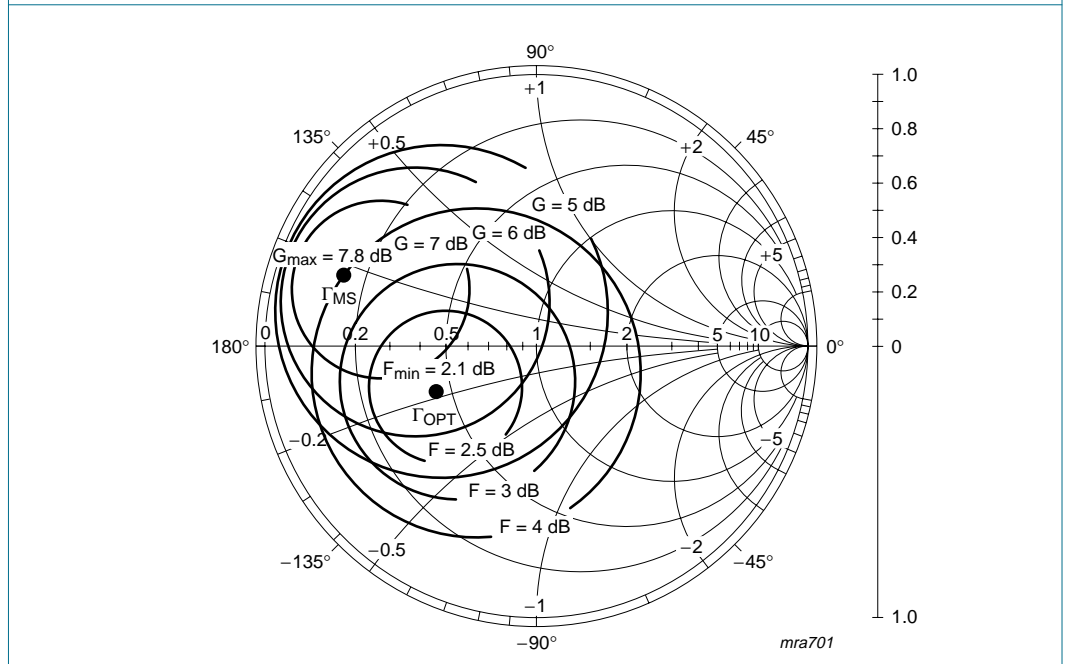
$V_{CE} = 8\text{ V}.$

**Fig 10. Minimum noise figure and associated available gain as a function of frequency.**



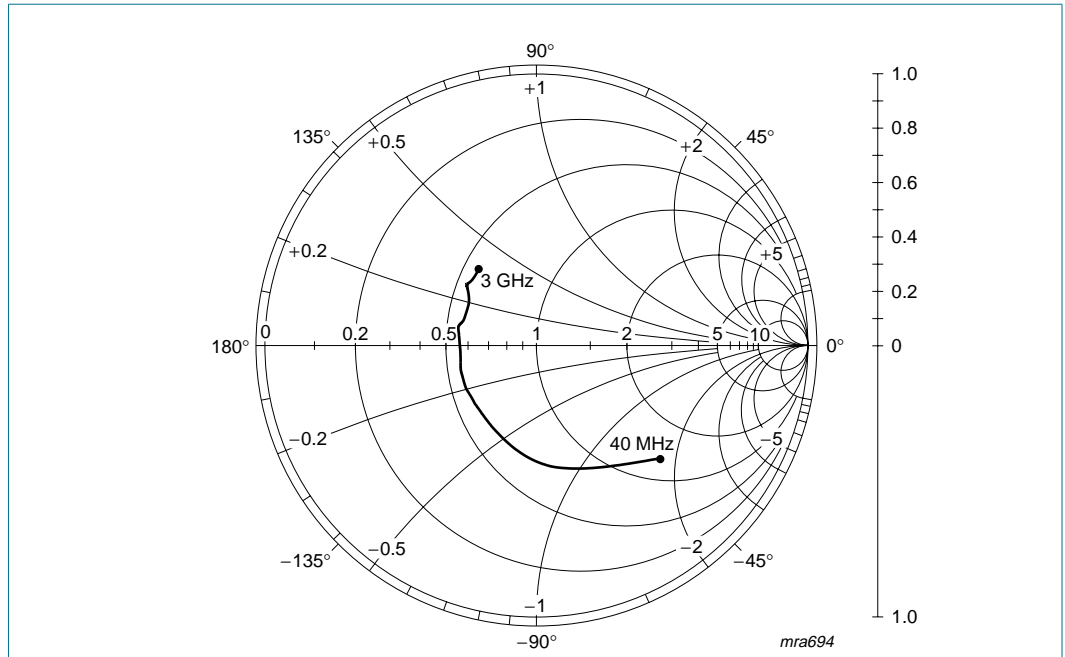
$Z_o = 50 \Omega$ ;  $V_{CE} = 8 \text{ V}$ ;  $I_C = 10 \text{ mA}$ ;  $f = 900 \text{ MHz}$ .

**Fig 11. Noise circle figure;  $f = 900 \text{ MHz}$ .**



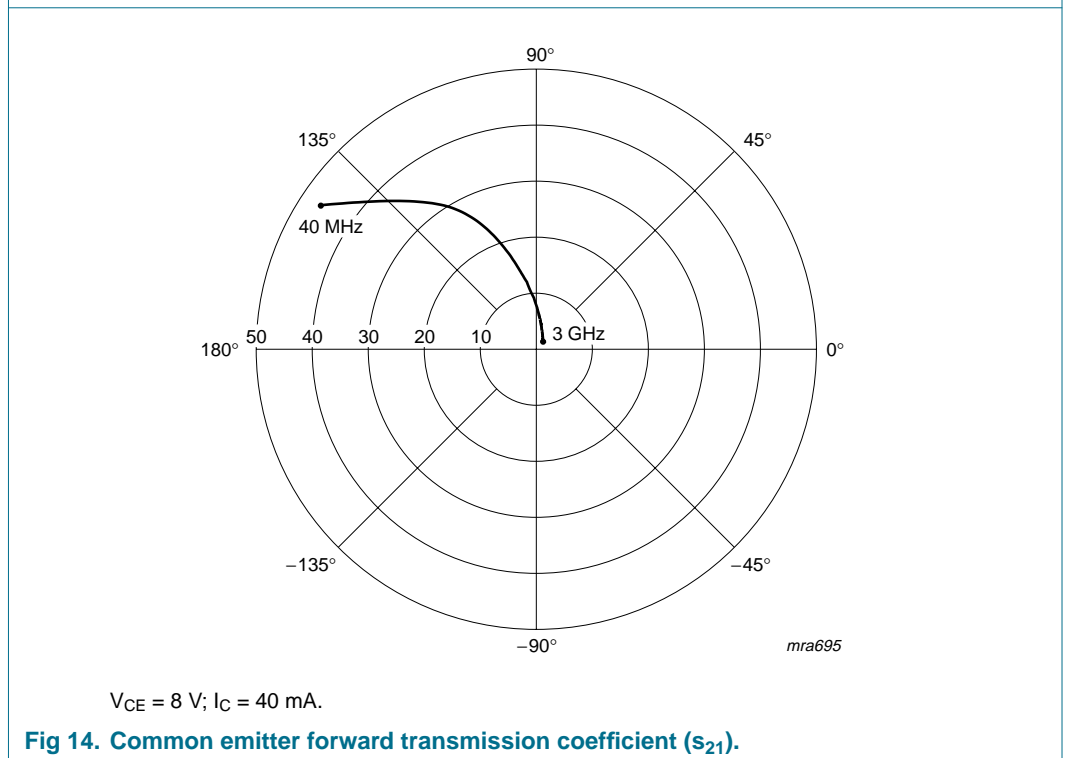
$Z_o = 50 \Omega$ ;  $V_{CE} = 8 \text{ V}$ ;  $I_C = 10 \text{ mA}$ ;  $f = 2000 \text{ MHz}$ .

**Fig 12. Noise circle figure;  $f = 2000 \text{ MHz}$ .**



$V_{CE} = 8\text{ V}; I_C = 40\text{ mA}; Z_o = 50\ \Omega.$

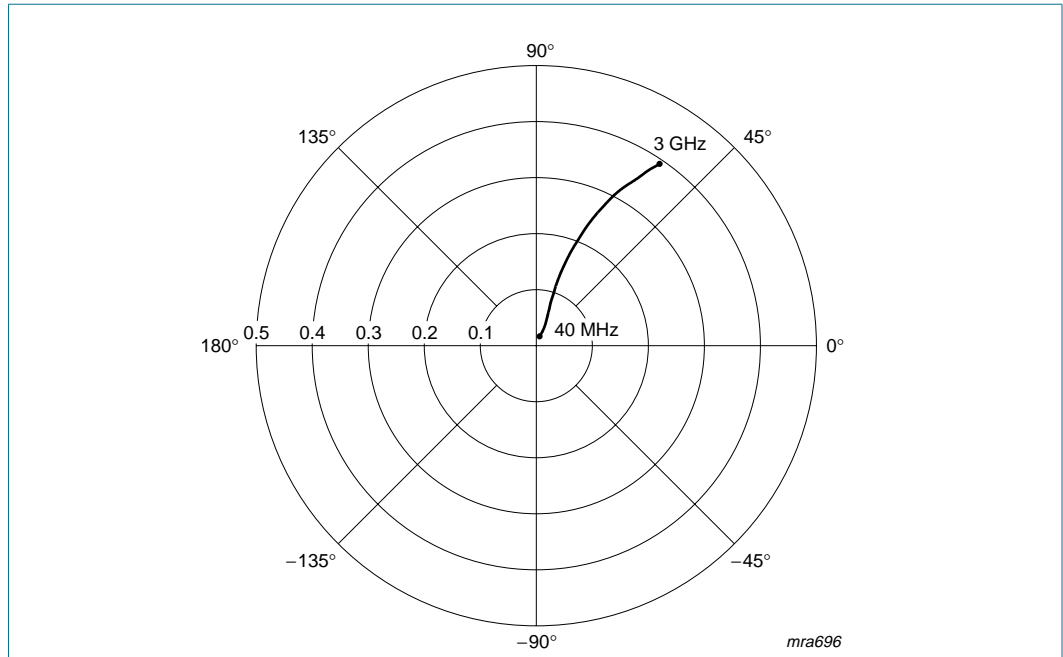
**Fig 13. Common emitter input reflection coefficient ( $s_{11}$ ).**



$V_{CE} = 8\text{ V}; I_C = 40\text{ mA}.$

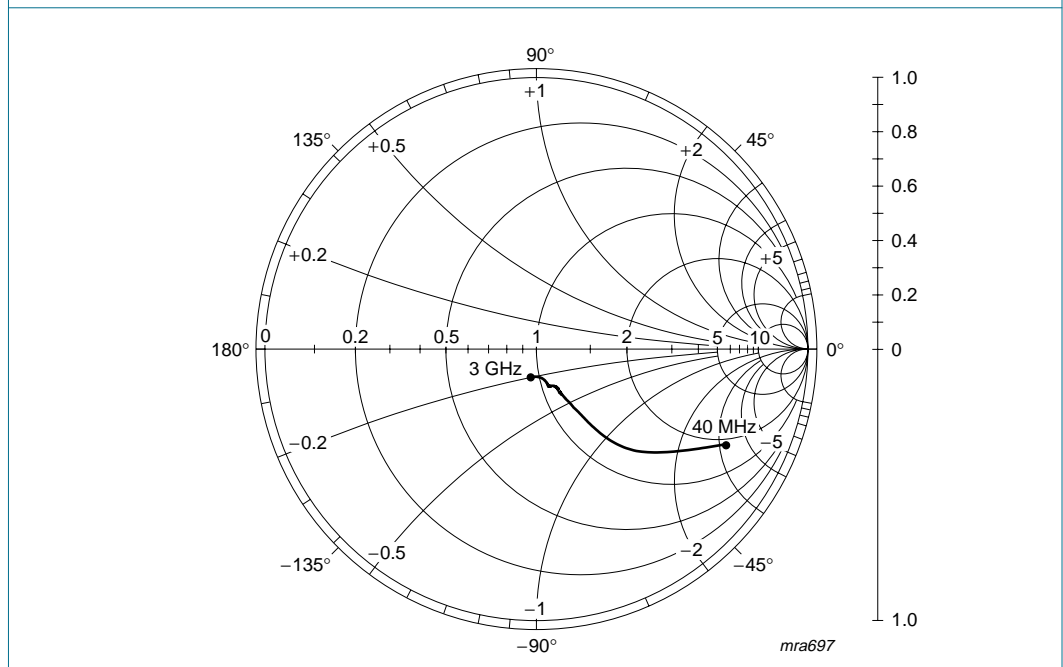
**Fig 14. Common emitter forward transmission coefficient ( $s_{21}$ ).**





$V_{CE} = 8\text{ V}; I_C = 40\text{ mA}$ .

**Fig 15. Common emitter reverse transmission coefficient ( $s_{12}$ ).**



$V_{CE} = 8\text{ V}; I_C = 40\text{ mA}; Z_o = 50\ \Omega$ .

**Fig 16. Common emitter output reflection coefficient ( $s_{22}$ ).**

8. Package outline

Plastic surface mounted package; 3 leads

SOT23

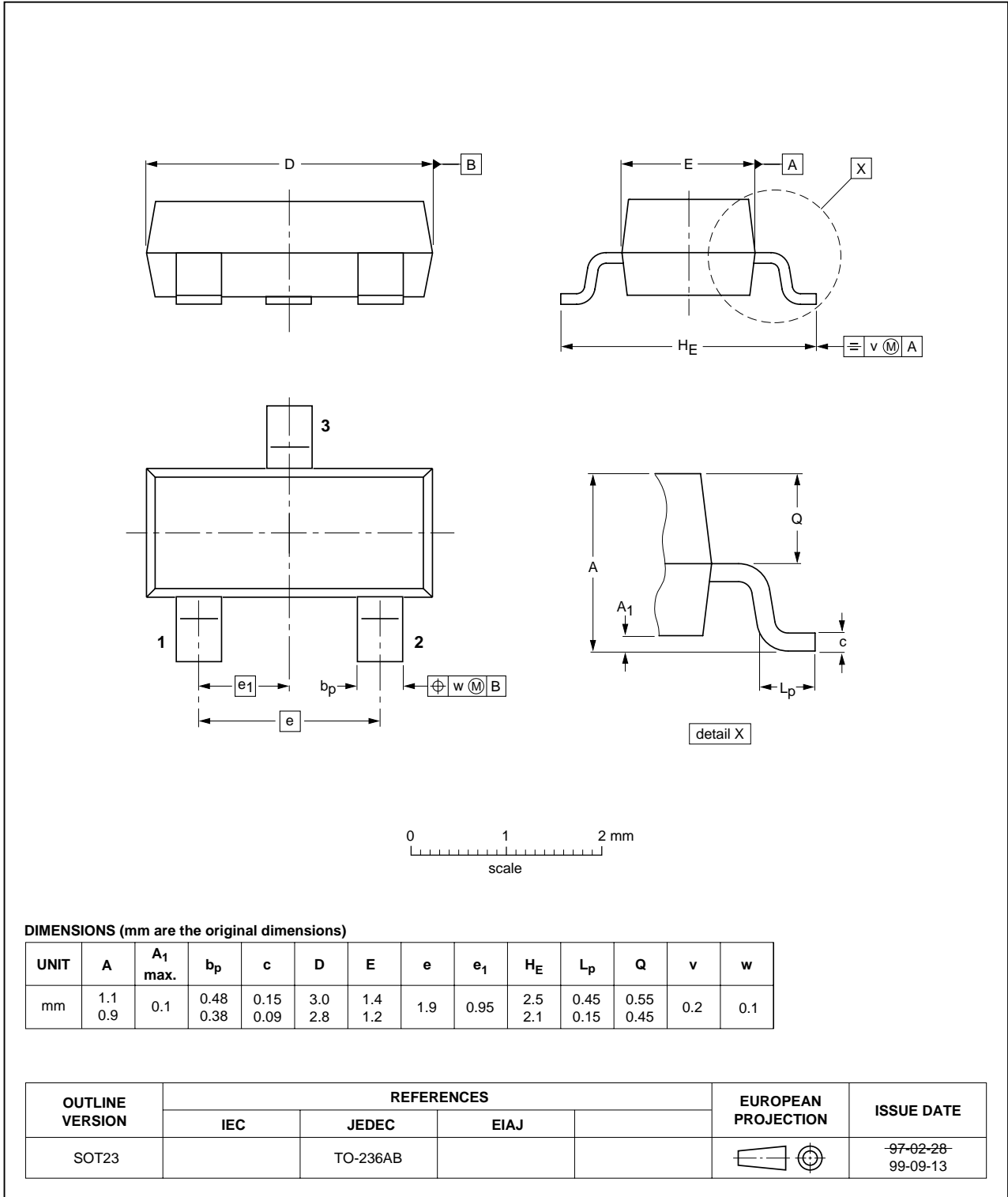


Fig 17. Package outline SOT23 (T0-236AB).

## 9. Revision history

Table 8: Revision history

| Document ID    | Release date | Data sheet status     | Change notice  | Doc. number    | Supersedes   |
|----------------|--------------|-----------------------|--|----------------|--------------|
| BFR540_5       | 20040901     | Product data sheet    | -  | 9397 750 13398 | BFR540_4     |
| Modifications: |              |                       | <ul style="list-style-type: none"><li>The format of this data sheet has been redesigned to comply with the new presentation and information standard of Philips Semiconductors.</li><li><a href="#">Table 4 "Marking"</a>: Format of marking code changed.</li></ul> |                |              |
| BFR540_4       | 20000530     | Product specification | -  | 9397 750 07062 | BFR540_3     |
| BFR540_3       | 19990823     | Product specification | -  | 9397 750 06338 | BFR540_CNV_2 |
| BFR540_CNV_2   | 19971204     | Product specification | -  | not applicable | -            |

## 10. Data sheet status

| Level | Data sheet status <sup>[1]</sup> | Product status <sup>[2]</sup> <sup>[3]</sup> | Definition   |
|-------|----------------------------------|--|--|
| I     | Objective data                   | Development                                  | This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.  |
| II    | Preliminary data                 | Qualification                                | This data sheet contains data from the preliminary specification. Supplementary data will be published at a later date. Philips Semiconductors reserves the right to change the specification without notice, in order to improve the design and supply the best possible product.             |
| III   | Product data                     | Production                                   | This data sheet contains data from the product specification. Philips Semiconductors reserves the right to make changes at any time in order to improve the design, manufacturing and supply. Relevant changes will be communicated via a Customer Product/Process Change Notification (CPCN). |

[1] Please consult the most recently issued data sheet before initiating or completing a design.

[2] The product status of the device(s) described in this data sheet may have changed since this data sheet was published. The latest information is available on the Internet at URL <http://www.semiconductors.philips.com>.

[3] For data sheets describing multiple type numbers, the highest-level product status determines the data sheet status.

## 11. Definitions

**Short-form specification** — The data in a short-form specification is extracted from a full data sheet with the same type number and title. For detailed information see the relevant data sheet or data handbook.

**Limiting values definition** — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 60134). 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.

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