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# DATA SHEET

## BFG94
## NPN 6 GHz wideband transistor

Product specification

September 1995

# NPN 6 GHz wideband transistor BFG94

## FEATURES

- High power gain
- Low noise figure
- Low intermodulation distortion
- Gold metallization ensures excellent reliability.

## DESCRIPTION

NPN transistor mounted in a plastic SOT223 envelope. It is primarily intended for use in communication and instrumentation systems.

## PINNING

| PIN | DESCRIPTION |
|---|---|
| 1 | emitter |
| 2 | base |
| 3 | emitter |
| 4 | collector |

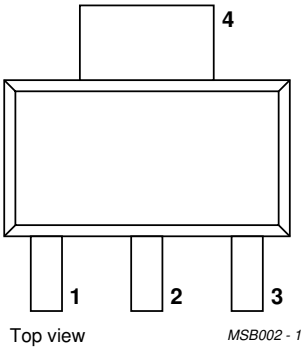



Fig.1 SOT223.

## QUICK REFERENCE DATA

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| $V_{CBO}$ | collector-base voltage | open emitter | – | – | 15 | V |
| $V_{CEO}$ | collector-emitter voltage | open base | – | – | 12 | V |
| $I_C$ | DC collector current | | – | – | 60 | mA |
| $P_{tot}$ | total power dissipation | up to $T_s$ = 140 °C (note 1) | – | – | 700 | mW |
| $C_{re}$ | feedback capacitance | $I_C$ = 0; $V_{CE}$ = 10 V; f = 1 MHz | – | – | 0.8 | pF |
| $f_T$ | transition frequency | $I_C$ = 45 mA; $V_{CE}$ = 10 V; f = 1 GHz; $T_{amb}$ = 25 °C | 4 | 6 | – | GHz |
| $G_{UM}$ | maximum unilateral power gain | $I_C$ = 45 mA; $V_{CE}$ = 10 V; f = 1 GHz; $T_{amb}$ = 25 °C | 11.5 | 13.5 | – | dB |
| $V_O$ | output voltage | $I_C$ = 45 mA; $V_{CE}$ = 10 V; $d_{im}$ = −60 dB; $R_L$ = 75 Ω; f = 800 MHz; $T_{amb}$ = 25 °C | – | 500 | – | mV |
| $P_{L1}$ | output power at 1 dB gain compression | $I_C$ = 45 mA; $V_{CE}$ = 10 V; f = 1 GHz; $T_{amb}$ = 25 °C | – | 21.5 | – | dBm |

**Note**

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

## LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134).

| SYMBOL | PARAMETER | CONDITIONS | MIN. | MAX. | UNIT |
|---|---|---|---|---|---|
| $V_{CBO}$ | collector-base voltage | open emitter | – | 15 | V |
| $V_{CEO}$ | collector-emitter voltage | open base | – | 12 | V |
| $V_{EBO}$ | emitter-base voltage | open collector | – | 2 | V |
| $I_C$ | DC collector current | | – | 60 | mA |
| $P_{tot}$ | total power dissipation | up to $T_s$ = 140 °C (note 1) | – | 700 | mW |
| $T_{stg}$ | storage temperature | | −65 | 150 | °C |
| $T_j$ | junction temperature | | – | 175 | °C |

## THERMAL RESISTANCE

| SYMBOL | PARAMETER | CONDITIONS | THERMAL RESISTANCE |
|---|---|---|---|
| $R_{th\ j\text{-}s}$ | thermal resistance from junction to soldering point | up to $T_s$ = 140 °C (note 1) | 50 K/W |

**Note**

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

## CHARACTERISTICS

$T_j$ = 25 °C unless otherwise specified.

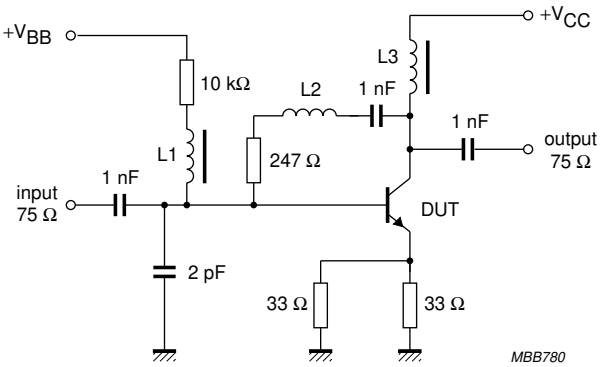
| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| $I_{CBO}$ | collector cut-off current | $I_E$ = 0; $V_{CB}$ = 10 V | – | – | 100 | nA |
| $h_{FE}$ | DC current gain | $I_C$ = 30 mA; $V_{CE}$ = 5 V | 45 | 90 | – | |
| | | $I_C$ = 45 mA; $V_{CE}$ = 10 V | – | 100 | – | |
| $C_c$ | collector capacitance | $I_E = i_e$ = 0; $V_{CB}$ = 10 V; f = 1 MHz | – | 0.9 | 2 | pF |
| $C_e$ | emitter capacitance | $I_C = i_e$ = 0; $V_{EB}$ = 0.5 V; f = 1 MHz | – | 2.9 | 4.5 | pF |
| $C_{re}$ | feedback capacitance | $I_C = i_c$ = 0; $V_{CE}$ = 10 V; f = 1 MHz | – | 0.5 | 0.8 | pF |
| $f_T$ | transition frequency | $I_C$ = 45 mA; $V_{CE}$ = 10 V; f = 1 GHz; $T_{amb}$ = 25 °C | 4 | – | – | GHz |
| | | $I_C$ = 30 mA; $V_{CE}$ = 5 V; f = 1 GHz; $T_{amb}$ = 25 °C | 4 | 6 | – | GHz |
| $G_{UM}$ | maximum unilateral power gain (note1) | $I_C$ = 45 mA; $V_{CE}$ = 10 V; f = 1 GHz; $T_{amb}$ = 25 °C | 11.5 | 13.5 | – | dB |
| F | minimum noise figure | $\Gamma_s = \Gamma_{opt}$; $I_C$ = 45 mA; $V_{CE}$ = 10 V; f = 500 MHz | – | 2.7 | – | dB |
| | | $\Gamma_s = \Gamma_{opt}$; $I_C$ = 45 mA; $V_{CE}$ = 10 V; f = 1 GHz | – | 3 | – | dB |
| $V_O$ | output voltage | note 2 | – | 500 | – | mV |
| $d_2$ | second order intermodulation distortion | note 3 | – | –51 | – | dB |
| $P_{L1}$ | output power at 1 dB gain compression | $I_C$ = 45 mA; $V_{CE}$ = 10 V; $R_L$ = 50 Ω; $T_{amb}$ = 25 °C; measured at f = 1 GHz | – | 21.5 | – | dBm |
| ITO | third order intercept point | note 4 | – | 34 | – | dBm |

**Notes**

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. $d_{im}$ = –60 dB (DIN 45004B, par 6.3: 3-tone); $I_C$ = 45 mA; $V_{CE}$ = 10 V; $R_L$ = 75 Ω; $T_{amb}$ = 25 °C;
   $V_p = V_O$ at $d_{im}$ = –60 dB; $f_p$ = 795.25 MHz;
   $V_q = V_O$ –6 dB; $V_r = V_O$ –6 dB;
   $f_q$ = 803.25 MHz; $f_r$ = 805.25 MHz;
   measured at $f_{(p+q-r)}$ = 793.25 MHz.
3. $I_C$ = 45 mA; $V_{CE}$ = 10 V; $R_L$ = 75 Ω; $T_{amb}$ = 25 °C;
   $V_q = V_O$ = 280 mV;
   $f_p$ = 250 MHz; $f_q$ = 560 MHz;
   measured at $f_{(p+q)}$ = 810 MHz.
4. $I_C$ = 45 mA; $V_{CE}$ = 10 V; $R_L$ = 50 Ω; $T_{amb}$ = 25 °C;
   $f_p$ = 1000 MHz; $f_q$ = 1001 MHz;
   measured at $f_{(2p-q)}$ and $f_{(2q-p)}$.




L1 = L3 = 5 μH micro-choke.
L2 = 1 turn copper wire (0.4 mm), internal diameter 4 mm.

Fig.2 Test circuit for second and third order intermodulation distortion.

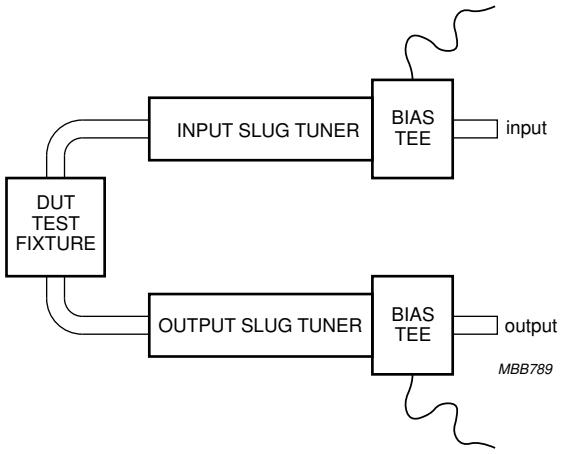



Fig.3 Measurement set-up for third order intercept point and 1 dB gain compression.

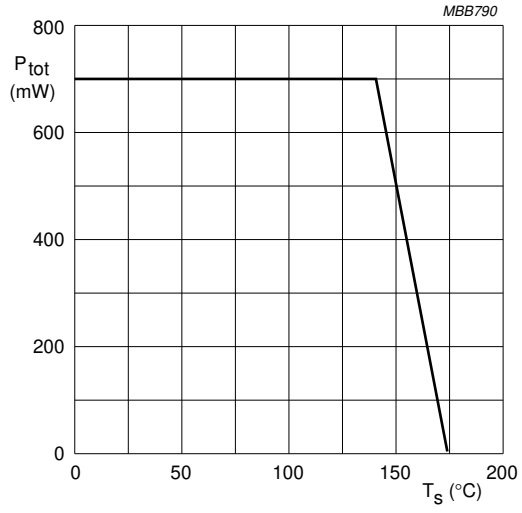
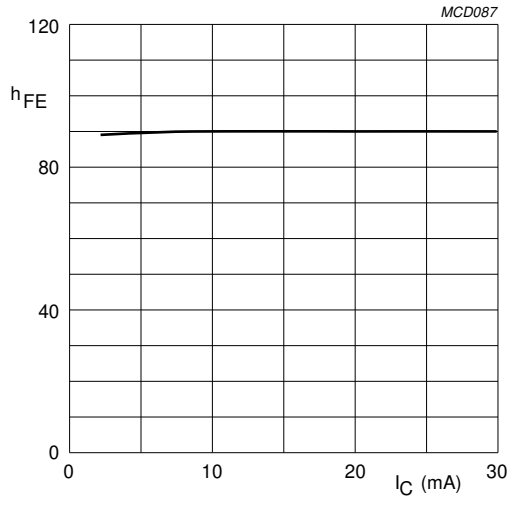
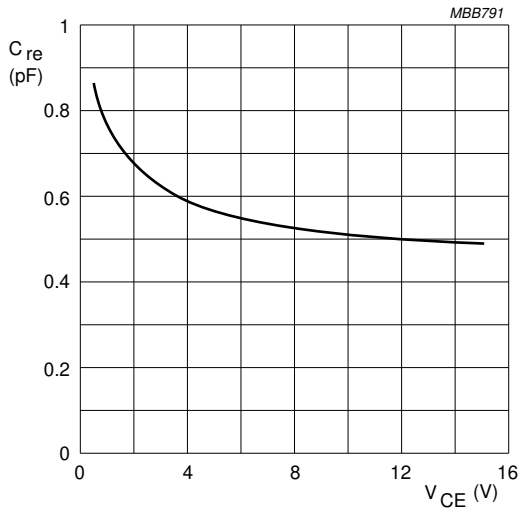



Fig.4 Power derating curve.



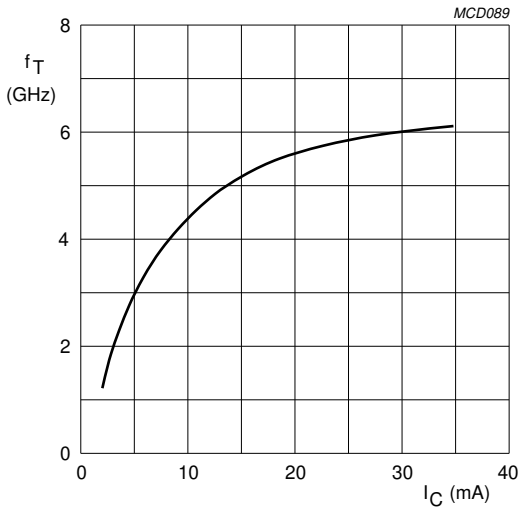

$V_{CE}$ = 10 V; $T_j$ = 25 °C

Fig.5 DC current gain as a function of collector current.



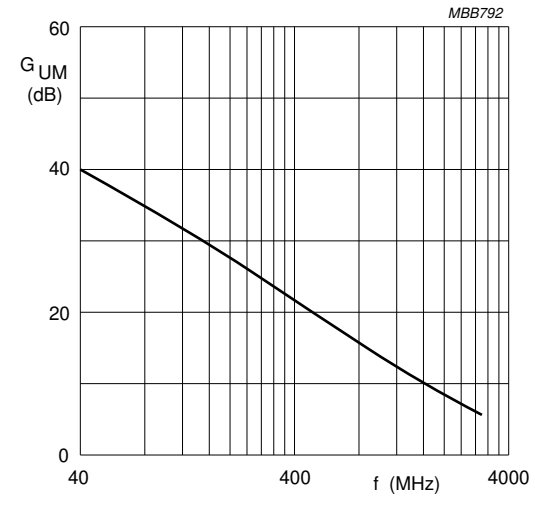

$I_C = i_c = 0$; f = 1 MHz.

Fig.6 Feedback capacitance as a function of collector-emitter voltage.



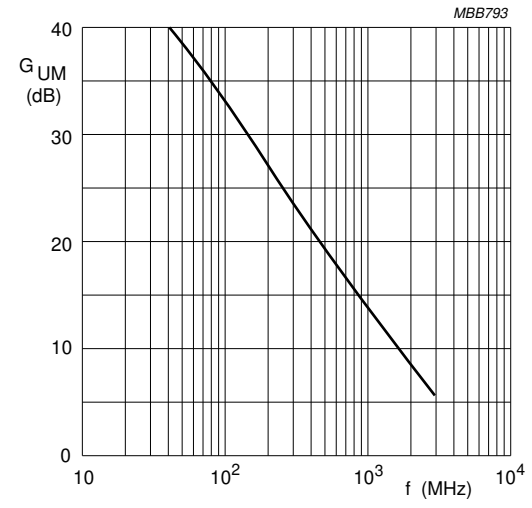

$V_{CE}$ = 10 V; f = 1 GHz.

Fig.7 Transition frequency as a function of collector current.



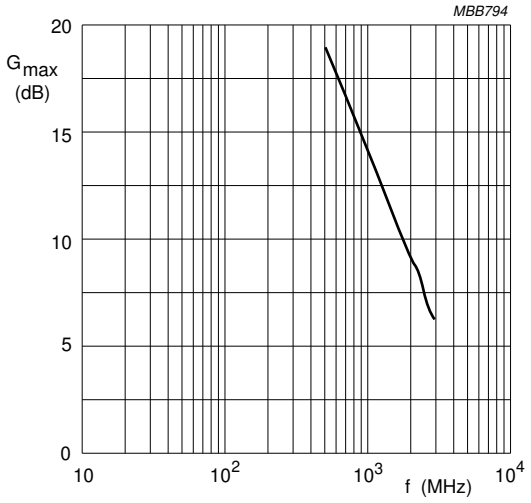

$I_c$ = 45 mA; $V_{CE}$ = 10 V.

Fig.8 Maximum unilateral power gain as a function of frequency.



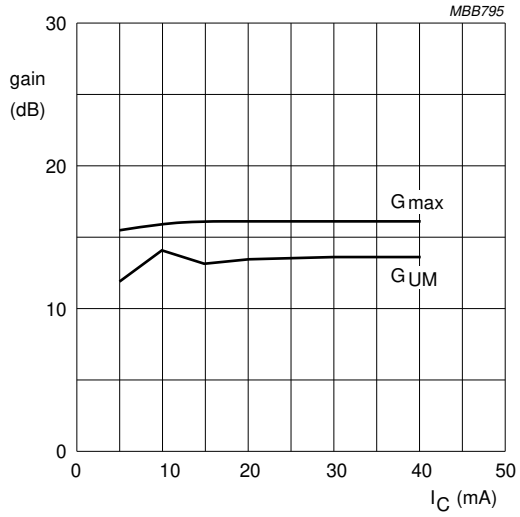

$I_c$ = 20 mA; $V_{CE}$ = 8 V.

Fig.9 Maximum unilateral power gain as a function of frequency.



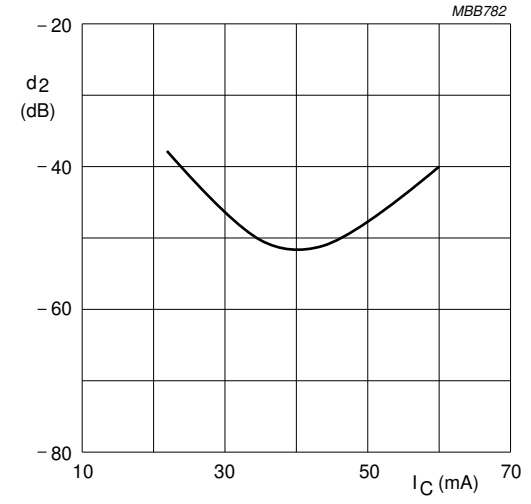

$I_c$ = 20 mA; $V_{CE}$ = 8 V.

Fig.10 Maximum available stable gain as a function of frequency.



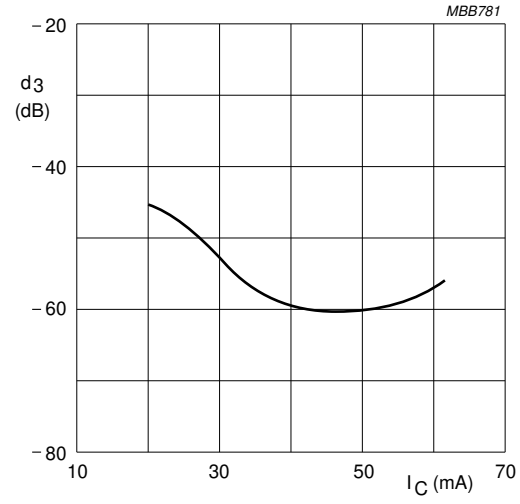

$V_{CE}$ = 8 V; f = 1 GHz.
$G_{max}$ = maximum available stable gain.
$G_{UM}$ = maximum unilateral power gain.

Fig.11 Gain as a function of collector current.



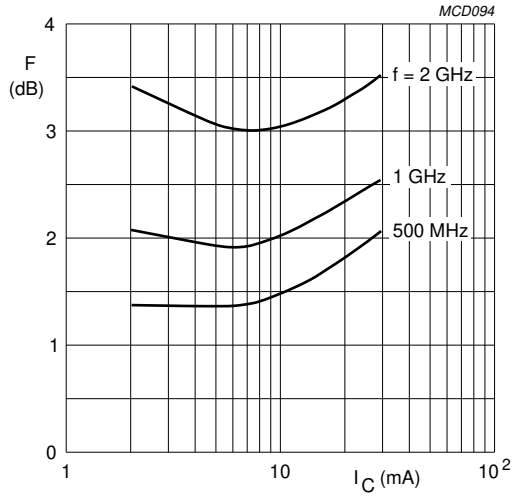

$I_c$ = 45 mA; $V_{CE}$ = 10 V; $f_{(p+q)}$ = 810 MHz.
See test circuit, Fig.2

Fig.12 Second order intermodulation distortion as a function of collector current.



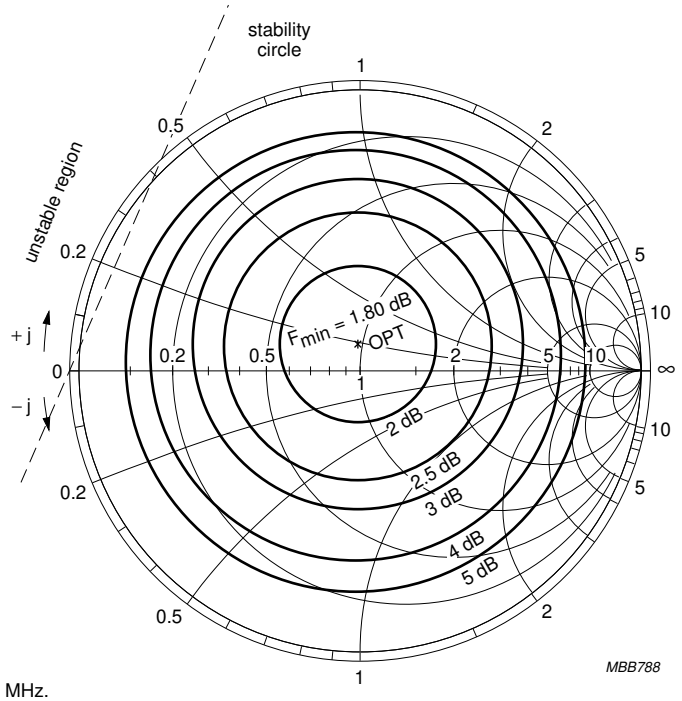

$I_c$ = 45 mA; $V_{CE}$ = 10 V; $f_{(p+q-r)}$ = 793.25 MHz.
See test circuit, Fig.2

Fig.13 Third order intermodulation distortion as a function of collector current.



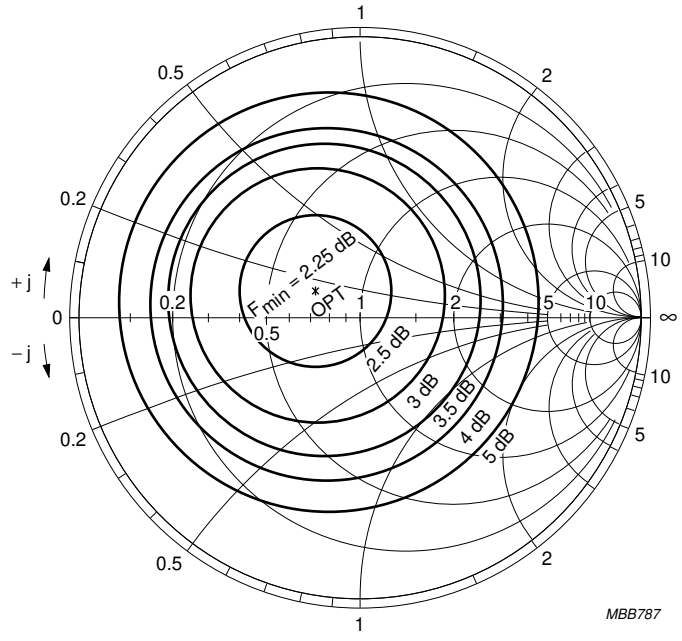

$V_{CE}$ = 8 V.

Fig.14 Minimum noise figure as a function of collector current.



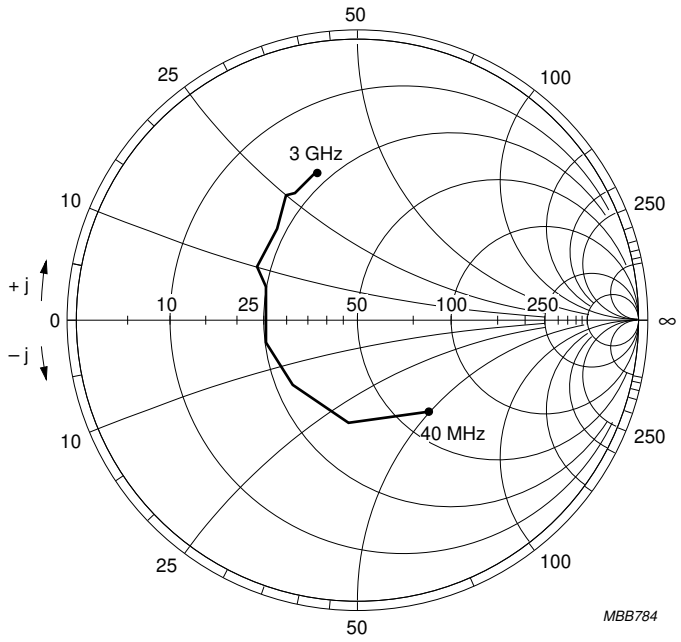

$I_c$ = 15 mA; $V_{CE}$ = 10 V; f = 500 MHz.

Fig.15 Noise circle.



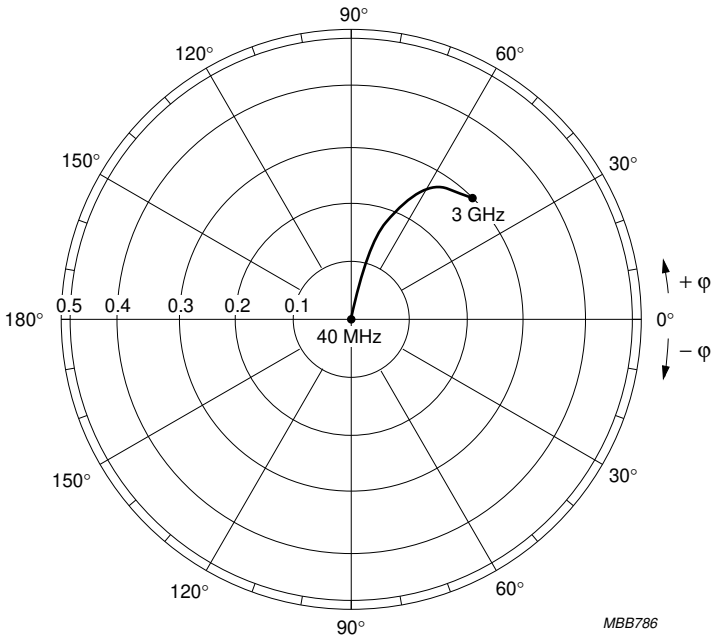

$I_c$ = 15 mA; $V_{CE}$ = 10 V; f =1 GHz.

Fig.16 Noise circle.



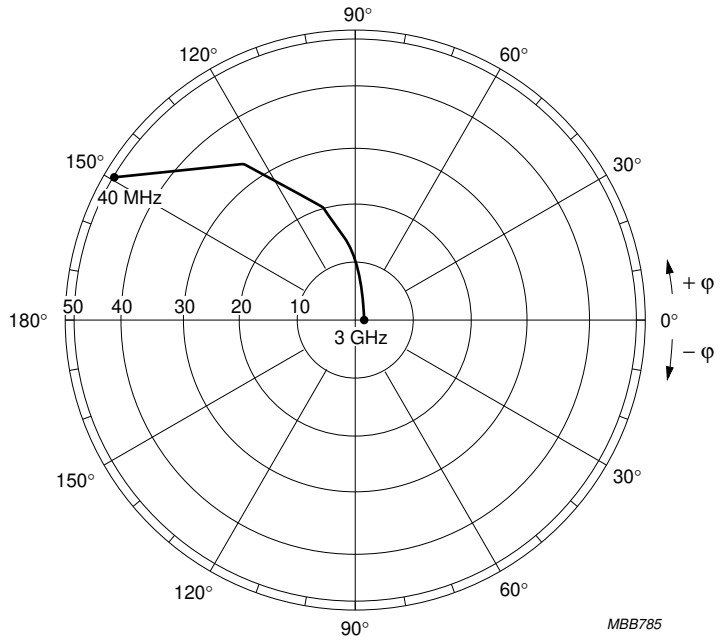

$I_C$ = 45 mA; $V_{CE}$ = 10 V.
$Z_O$ = 50 Ω.

Fig.17 Common emitter input reflection coefficient ($S_{11}$).



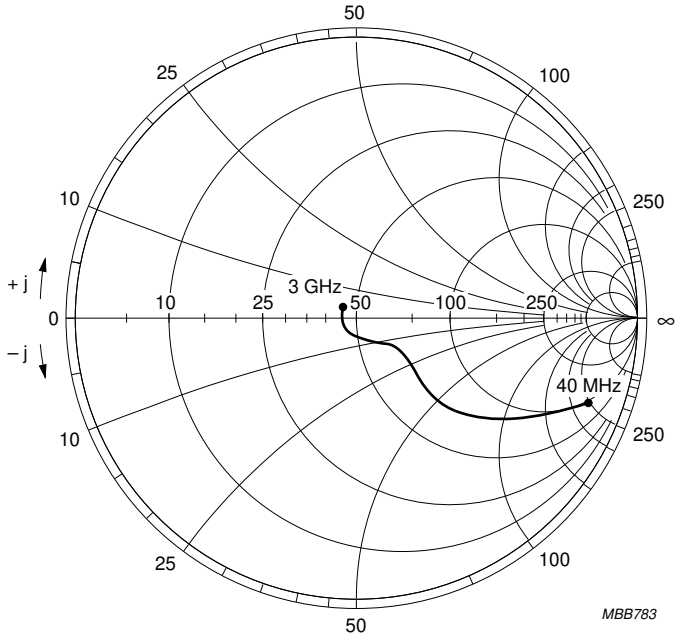

$I_C$ = 45 mA; $V_{CE}$ = 10 V.

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




$I_C$ = 45 mA; $V_{CE}$ = 10 V.

Fig.19 Common emitter reverse transmission coefficient ($S_{12}$).

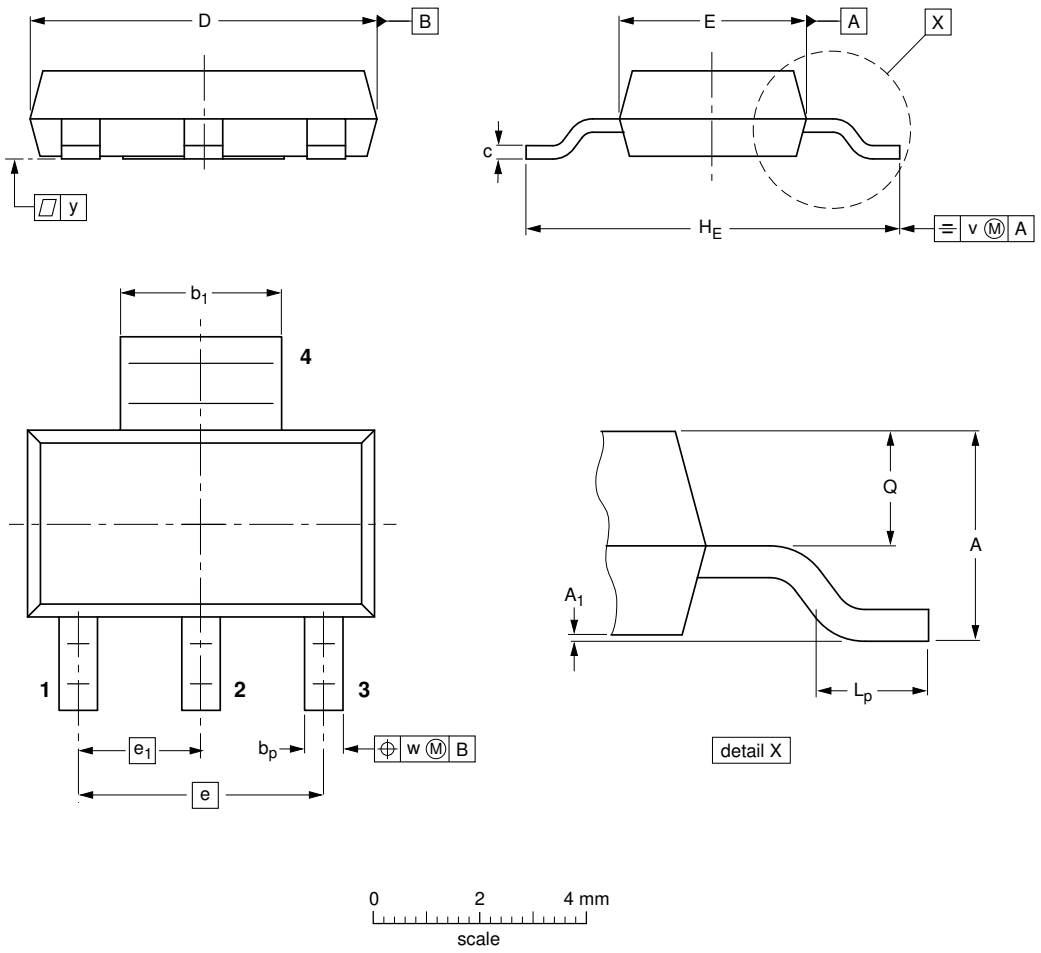



$I_C$ = 45 mA; $V_{CE}$ = 10 V.
$Z_O$ = 50 Ω.

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

## PACKAGE OUTLINE

**Plastic surface-mounted package with increased heatsink; 4 leads** **SOT223**




**DIMENSIONS (mm are the original dimensions)**

| UNIT | A | $A_1$ | $b_p$ | $b_1$ | c | D | E | e | $e_1$ | $H_E$ | $L_p$ | Q | v | w | y |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 1.8<br>1.5 | 0.10<br>0.01 | 0.80<br>0.60 | 3.1<br>2.9 | 0.32<br>0.22 | 6.7<br>6.3 | 3.7<br>3.3 | 4.6 | 2.3 | 7.3<br>6.7 | 1.1<br>0.7 | 0.95<br>0.85 | 0.2 | 0.1 | 0.1 |

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | JEITA | | | |
| SOT223 | | | SC-73 | | | ~~04-11-10~~<br>06-03-16 |

**DATA SHEET STATUS**

| DOCUMENT STATUS[1] | PRODUCT STATUS[2] | DEFINITION |
|---|---|---|
| Objective data sheet | Development | This document contains data from the objective specification for product development. |
| Preliminary data sheet | Qualification | This document contains data from the preliminary specification. |
| Product data sheet | Production | This document contains the product specification. |

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