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# BFP840ESD

Robust low noise Silicon Germanium Bipolar RF Transistor

## Data Sheet

Revision 1.1, 2012-07-11

RF & Protection Devices

**Edition 2012-07-11**

**Published by**
**Infineon Technologies AG**
**81726 Munich, Germany**





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**BFP840ESD, Robust low noise Silicon Germanium Bipolar RF Transistor**

**Revision History: 2012-07-11, Revision 1.1**

| Page | Subjects (major changes since last revision) |
|---|---|
| p. 9 | RF input power changed from tbd to 20 dBm |
| p. 18 | Figure 6 updated |
| p. 26 | Chapter ´Simulation Data´ added |
| | |

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# 1 Product Brief

The BFP840ESD is a high performance HBT (Heterojunction Bipolar Transistor) specifically designed for 5-6 GHz WiFi applications. The device is based upon the reliable high volume SiGe:C technology of Infineon.

The BFP840ESD provides inherently good input and output power match as well as inherently good noise match at 5-6 GHz. The simultaneous noise and power match without lossy external matching components at the input leads to a low external parts count, to a very good noise figure and to a very high transducer gain in the WiFi application. Integrated protection elements at in- and output make the device robust against ESD and excessive RF input power.

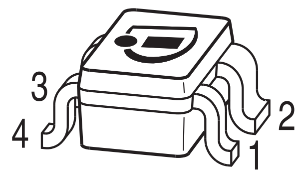
The device offers its high performance at low current and voltage and is especially well-suited for portable battery-powered applications in which energy efficiency is a key requirement. The device comes in an easy to use industry standard package with visible leads.

Robust very low noise SiGe:C Bipolar NPN RF Transistor in easy to use industry standard package

**BFP840ESD**

## 2 Features

- Robust very low noise amplifier based on Infineon´s reliable, high volume SiGe:C technology
- Unique combination of high end RF performance and robustness: 20 dBm maximum RF input power, 1.5 kV HBM ESD hardness
- Very high transition frequency $f_T$ = 80 GHz enables very low noise figure at high frequencies: $NF_{min}$ = 0.85 dB at 5.5 GHz, 1.8 V, 6 mA
- High gain $|S_{21}|^2$ = 18.5 dB at 5.5 GHz, 1.8 V, 10 mA
- $OIP3$ = 23 dBm at 5.5 GHz, 1.5 V, 6 mA
- Ideal for low voltage applications e.g. $V_{CC}$ = 1.2 V and 1.8 V (2.85 V, 3.3 V, 3.6 V requires corresponding collector resistor)
- Low power consumption, ideal for mobile applications
- Easy to use Pb free (RoHS compliant) and halogen free industry standard package with visible leads




RoHS

**Applications**

As Low Noise Amplifier (LNA) in

- Mobile and fixed connectivity applications: WLAN 802.11, WiMAX and UWB
- Satellite communication systems: satellite radio (SDARs, DAB), navigation systems (e.g. GPS, Glonass) and C-band LNB (1st and 2nd stage LNA)
- Ku-band LNB front-end (2nd stage or 3rd stage LNA and active mixer)
- Ka-band oscillators (DROs)

***Attention: ESD (Electrostatic discharge) sensitive device, observe handling precautions***

| Product Name | Package | Pin Configuration | | | | Marking |
|---|---|---|---|---|---|---|
| BFP840ESD | SOT343 | 1 = B | 2 = E | 3 = C | 4 = E | T8s |

# 3 Maximum Ratings

**Table 1 Maximum Ratings at $T_A$ = 25°C (unless otherwise specified)**

| Parameter | Symbol | Values | | Unit | Note / Test Condition |
|---|---|---|---|---|---|
| | | Min. | Max. | | |
| Collector emitter voltage | $V_{CEO}$ | – | 2.25<br>2.0 | V | $T_A$ = 25°C<br>$T_A$ = -55°C<br>Open base |
| Collector emitter voltage[1)] | $V_{CES}$ | – | 2.25<br>2.0 | V | $T_A$ = 25°C<br>$T_A$ = -55°C<br>E-B short circuited |
| Collector base voltage[2)] | $V_{CB0}$ | – | 2.9<br>2.6 | V | $T_A$ = 25°C<br>$T_A$ = -55°C<br>Open emitter |
| Base current | $I_B$ | -5 | 3 | mA | – |
| Collector current | $I_C$ | – | 35 | mA | – |
| RF input power | $P_{RFin}$ | – | 20 | dBm | – |
| ESD stress pulse | $V_{ESD}$ | -1.5 | 1.5 | kV | HBM, all pins, acc. to JESD22-A114 |
| Total power dissipation[3)] | $P_{tot}$ | – | 75 | mW | $T_S \leq$ 108°C |
| Junction temperature | $T_J$ | – | 150 | °C | – |
| Storage temperature | $T_{Stg}$ | -55 | 150 | °C | – |

1) $V_{CES}$ is identical to $V_{CEO}$ due to design
2) $V_{CBO}$ is similar to $V_{CEO}$ due to design
3) $T_S$ is the soldering point temperature. $T_S$ is measured on the emitter lead at the soldering point of the pcb.

***Attention: Stresses above the max. values listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Maximum ratings are absolute ratings; exceeding only one of these values may cause irreversible damage to the integrated circuit.***

# 4 Thermal Characteristics

Table 2 **Thermal Resistance**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Junction - soldering point[1)] | $R_{thJS}$ | – | 551 | – | K/W | – |

1) For calculation of $R_{thJA}$ please refer to Application Note Thermal Resistance AN 077

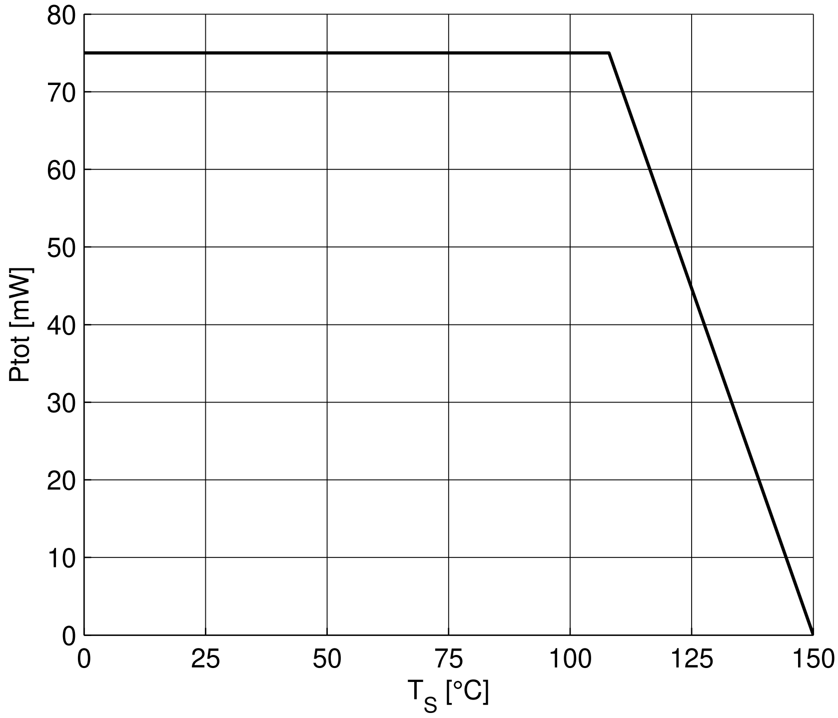



**Figure 1 Total Power Dissipation $P_{tot} = f(T_s)$**

# 5 Electrical Characteristics

## 5.1 DC Characteristics

**Table 3 DC Characteristics at $T_A$ = 25 °C**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Collector emitter breakdown voltage | $V_{(BR)CEO}$ | 2.25 | 2.6 | – | V | $I_C$ = 1 mA, $I_B$ = 0<br>Open base |
| Collector emitter leakage current | $I_{CES}$ | – | – | 400 | nA | $V_{CE}$ = 1.5 V, $V_{BE}$ = 0<br>E-B short circuited |
| Collector base leakage current | $I_{CBO}$ | – | – | 400 | nA | $V_{CB}$ = 1.5 V, $I_E$ = 0<br>Open emitter |
| Emitter base leakage current | $I_{EBO}$ | – | – | 10 | µA | $V_{EB}$ = 0.5 V, $I_C$ = 0<br>Open collector |
| DC current gain | $h_{FE}$ | 150 | 260 | 450 | | $V_{CE}$ = 1.8 V, $I_C$ = 10 mA<br>Pulse measured |

## 5.2 General AC Characteristics

**Table 4 General AC Characteristics at $T_A$ = 25 °C**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Transition frequency | $f_T$ | – | 80 | – | GHz | $V_{CE}$ = 1.8 V, $I_C$ = 25 mA<br>$f$ = 2 GHz |
| Collector base capacitance | $C_{CB}$ | – | 37 | – | fF | $V_{CB}$ = 1.8 V, $V_{BE}$ = 0<br>$f$ = 1 MHz<br>Emitter grounded |
| Collector emitter capacitance | $C_{CE}$ | – | 0.40 | – | pF | $V_{CE}$ = 1.8 V, $V_{BE}$ = 0<br>$f$ = 1 MHz<br>Base grounded |
| Emitter base capacitance | $C_{EB}$ | – | 0.41 | – | pF | $V_{EB}$ = 0.4 V, $V_{CB}$ = 0<br>$f$ = 1 MHz<br>Collector grounded |

## 5.3 Frequency Dependent AC Characteristics

Measurement setup is a test fixture with Bias T's in a 50 Ω system, $T_A$ = 25 °C

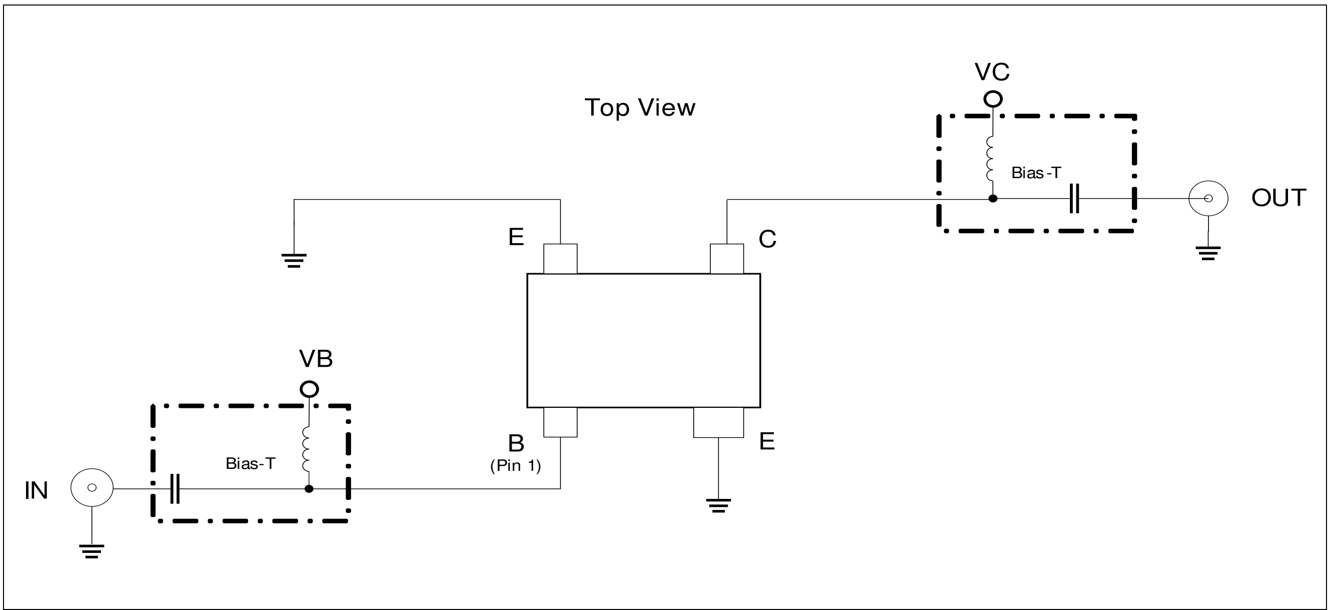



**Figure 2 BFP840ESD Testing Circuit**

**Table 5 AC Characteristics, $V_{CE}$ = 1.8 V, $f$ = 0.45 GHz**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| **Power gain** | | | | | dB | |
| Maximum power gain | $G_{ms}$ | – | 33.5 | – | | $I_C$ = 10 mA |
| Transducer gain | $\|S_{21}\|^2$ | – | 27.5 | – | | $I_C$ = 10 mA |
| **Minimum Noise Figure** | | | | | dB | |
| Minimum noise figure | $NF_{min}$ | – | 0.6 | – | | $I_C$ = 5 mA |
| Associated gain | $G_{ass}$ | – | 26.5 | – | | $I_C$ = 5 mA |
| **Linearity** | | | | | dBm | $Z_S = Z_L$ = 50 Ω |
| 1 dB compression point at output | $OP_{1dB}$ | – | 4 | – | | $I_C$ = 10 mA |
| 3rd order intercept point at output | $OIP3$ | – | 19.5 | – | | $I_C$ = 10 mA |

**Table 6 AC Characteristics, $V_{CE}$ = 1.8 V, $f$ = 0.9 GHz**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| **Power gain** | | | | | dB | |
| Maximum power gain | $G_{ms}$ | – | 30 | – | | $I_C$ = 10 mA |
| Transducer gain | $\|S_{21}\|^2$ | – | 27 | – | | $I_C$ = 10 mA |

**Table 6 AC Characteristics, $V_{CE}$ = 1.8 V, $f$ = 0.9 GHz** (cont'd)

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| **Minimum Noise Figure** | | | | | dB | |
| Minimum noise figure | $NF_{min}$ | – | 0.6 | – | | $I_C$ = 5 mA |
| Associated gain | $G_{ass}$ | – | 25.5 | – | | $I_C$ = 5 mA |
| **Linearity** | | | | | dBm | $Z_S = Z_L$ = 50 Ω |
| 1 dB compression point at output | $OP_{1dB}$ | – | 4 | – | | $I_C$ = 10 mA |
| 3rd order intercept point at output | $OIP3$ | – | 19.5 | – | | $I_C$ = 10 mA |

**Table 7 AC Characteristics, $V_{CE}$ = 1.8 V, $f$ = 1.5 GHz**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| **Power gain** | | | | | dB | |
| Maximum power gain | $G_{ms}$ | – | 28 | – | | $I_C$ = 10 mA |
| Transducer gain | $\|S_{21}\|^2$ | – | 25.5 | – | | $I_C$ = 10 mA |
| **Minimum Noise Figure** | | | | | dB | |
| Minimum noise figure | $NF_{min}$ | – | 0.65 | – | | $I_C$ = 5 mA |
| Associated gain | $G_{ass}$ | – | 24 | – | | $I_C$ = 5 mA |
| **Linearity** | | | | | dBm | $Z_S = Z_L$ = 50 Ω |
| 1 dB compression point at output | $OP_{1dB}$ | – | 4.0 | – | | $I_C$ = 10 mA |
| 3rd order intercept point at output | $OIP3$ | – | 19.5 | – | | $I_C$ = 10 mA |

**Table 8 AC Characteristics, $V_{CE}$ = 1.8 V, $f$ = 1.9 GHz**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| **Power gain** | | | | | dB | |
| Maximum power gain | $G_{ms}$ | – | 27 | – | | $I_C$ = 10 mA |
| Transducer gain | $\|S_{21}\|^2$ | – | 25 | – | | $I_C$ = 10 mA |
| **Minimum Noise Figure** | | | | | dB | |
| Minimum noise figure | $NF_{min}$ | – | 0.65 | – | | $I_C$ = 5 mA |
| Associated gain | $G_{ass}$ | – | 23 | – | | $I_C$ = 5 mA |
| **Linearity** | | | | | dBm | $Z_S = Z_L$ = 50 Ω |
| 1 dB compression point at output | $OP_{1dB}$ | – | 4.5 | – | | $I_C$ = 10 mA |
| 3rd order intercept point at output | $OIP3$ | – | 21 | – | | $I_C$ = 10 mA |

**Table 9 AC Characteristics, $V_{CE}$ = 1.8 V, $f$ = 2.4 GHz**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| **Power gain** | | | | | dB | |
| Maximum power gain | $G_{ms}$ | – | 26 | – | | $I_C$ = 10 mA |
| Transducer gain | $\lvert S_{21}\rvert^2$ | – | 24 | – | | $I_C$ = 10 mA |
| **Minimum Noise Figure** | | | | | dB | |
| Minimum noise figure | $NF_{min}$ | – | 0.7 | – | | $I_C$ = 5 mA |
| Associated gain | $G_{ass}$ | – | 22 | – | | $I_C$ = 5 mA |
| **Linearity** | | | | | dBm | $Z_S = Z_L$ = 50 $\Omega$ |
| 1 dB compression point at output | $OP_{1dB}$ | – | 4 | – | | $I_C$ = 10 mA |
| 3rd order intercept point at output | $OIP3$ | – | 21 | – | | $I_C$ = 10 mA |

**Table 10 AC Characteristics, $V_{CE}$ = 1.8 V, $f$ = 3.5 GHz**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| **Power gain** | | | | | dB | |
| Maximum power gain | $G_{ms}$ | – | 24.5 | – | | $I_C$ = 10 mA |
| Transducer gain | $\lvert S_{21}\rvert^2$ | – | 22 | – | | $I_C$ = 10 mA |
| **Minimum Noise Figure** | | | | | dB | |
| Minimum noise figure | $NF_{min}$ | – | 0.7 | – | | $I_C$ = 5 mA |
| Associated gain | $G_{ass}$ | – | 20 | – | | $I_C$ = 5 mA |
| **Linearity** | | | | | dBm | $Z_S = Z_L$ = 50 $\Omega$ |
| 1 dB compression point at output | $OP_{1dB}$ | – | 5 | – | | $I_C$ = 10 mA |
| 3rd order intercept point at output | $OIP3$ | – | 22.5 | – | | $I_C$ = 10 mA |

**Table 11 AC Characteristics, $V_{CE}$ = 1.8 V, $f$ = 5.5 GHz**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| **Power gain** | | | | | dB | |
| Maximum power gain | $G_{ma}$ | – | 22.5 | – | | $I_C$ = 10 mA |
| Transducer gain | $\lvert S_{21}\rvert^2$ | – | 18.5 | – | | $I_C$ = 10 mA |
| **Minimum Noise Figure** | | | | | dB | |
| Minimum noise figure | $NF_{min}$ | – | 0.85 | – | | $I_C$ = 5 mA |
| Associated gain | $G_{ass}$ | – | 17 | – | | $I_C$ = 5 mA |
| **Linearity** | | | | | dBm | $Z_S = Z_L$ = 50 $\Omega$ |
| 1 dB compression point at output | $OP_{1dB}$ | – | 5 | – | | $I_C$ = 10 mA |
| 3rd order intercept point at output | $OIP3$ | – | 22 | – | | $I_C$ = 10 mA |

**Table 12 AC Characteristics, $V_{CE}$ = 1.8 V, $f$ = 10 GHz**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| **Power gain** | | | | | dB | |
| Maximum power gain | $G_{ms}$ | – | 17 | – | | $I_C$ = 10 mA |
| Transducer gain | $\|S_{21}\|^2$ | – | 12 | – | | $I_C$ = 10 mA |
| **Minimum Noise Figure** | | | | | dB | |
| Minimum noise figure | $NF_{min}$ | – | 1.2 | – | | $I_C$ = 5 mA |
| Associated gain | $G_{ass}$ | – | 12.5 | – | | $I_C$ = 5 mA |
| **Linearity** | | | | | dBm | $Z_S = Z_L$ = 50 Ω |
| 1 dB compression point at output | $OP_{1dB}$ | – | 2.5 | – | | $I_C$ = 10 mA |
| 3rd order intercept point at output | $OIP3$ | – | 19.5 | – | | $I_C$ = 10 mA |

**Table 13 AC Characteristics, $V_{CE}$ = 1.8 V, $f$ = 12 GHz**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| **Power gain** | | | | | dB | |
| Maximum power gain | $G_{ms}$ | – | 15.5 | – | | $I_C$ = 10 mA |
| Transducer gain | $\|S_{21}\|^2$ | – | 9.5 | – | | $I_C$ = 10 mA |
| **Minimum Noise Figure** | | | | | dB | |
| Minimum noise figure | $NF_{min}$ | – | 1.45 | – | | $I_C$ = 5 mA |
| Associated gain | $G_{ass}$ | – | 11 | – | | $I_C$ = 5 mA |
| **Linearity** | | | | | dBm | $Z_S = Z_L$ = 50 Ω |
| 1 dB compression point at output | $OP_{1dB}$ | – | 1.5 | – | | $I_C$ = 10 mA |
| 3rd order intercept point at output | $OIP3$ | – | 18.5 | – | | $I_C$ = 10 mA |

*Note:*

1. *$OIP3$ value depends on the termination of all intermodulation frequency components. The termination used for this measurement is 50 Ω from 0.2 MHz to 12 GHz.*

## 5.4 Characteristic DC Diagrams

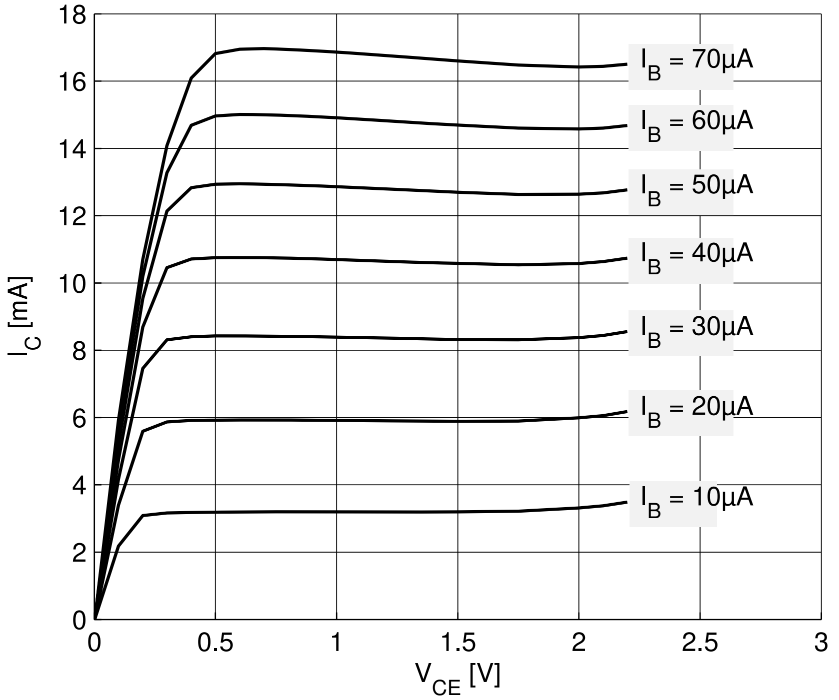



**Figure 3 Collector Current vs. Collector Emitter Voltage $I_C = f(V_{CE})$, $I_B$ = Parameter**

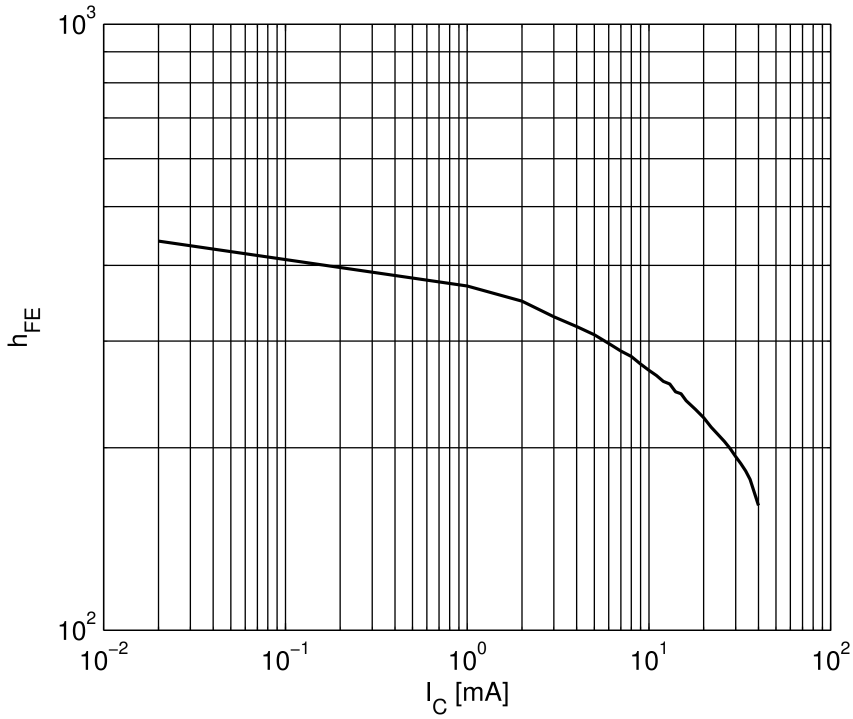



**Figure 4 DC Current Gain $h_{FE} = f(I_C)$, $V_{CE}$ = 1.8 V**

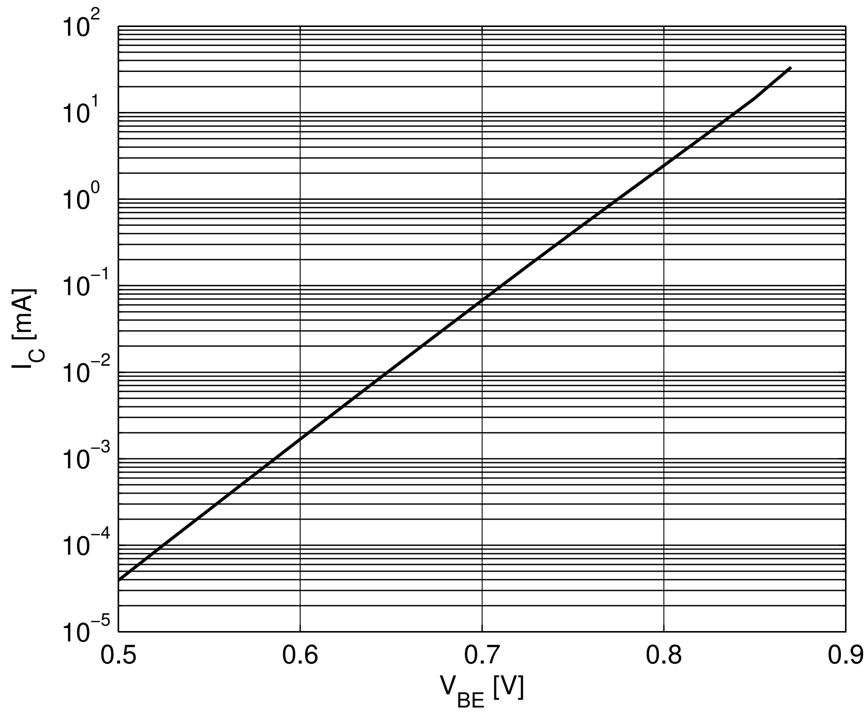



**Figure 5 Collector Current vs. Base Emitter Forward Voltage $I_C = f(V_{BE})$, $V_{CE}$ = 1.8 V**

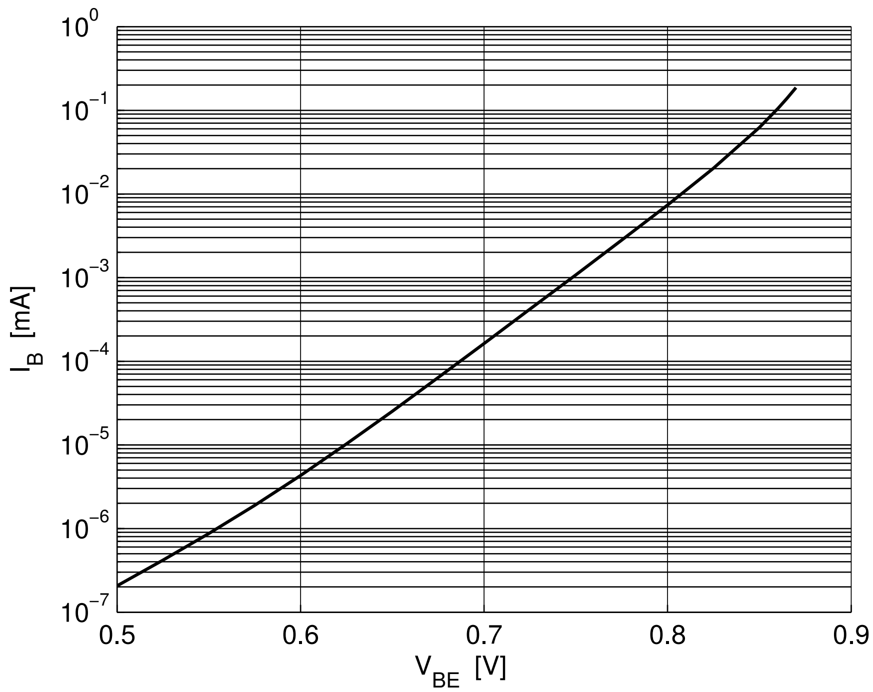



**Figure 6 Base Current vs. Base Emitter Forward Voltage $I_B = f(V_{BE})$, $V_{CE}$ = 1.8 V**

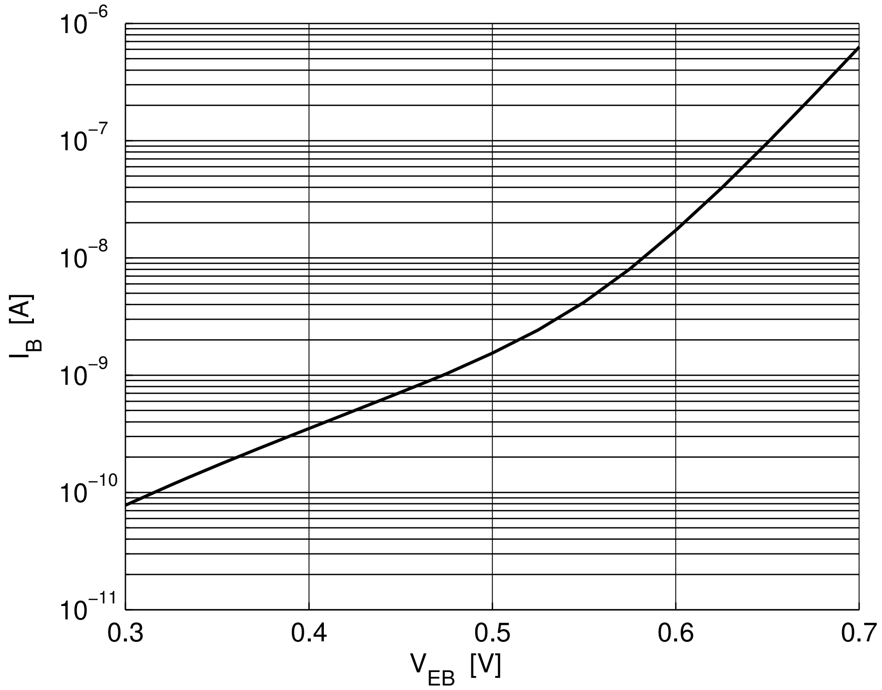



**Figure 7 Base Current vs. Base Emitter Reverse Voltage $I_B = f(V_{EB})$, $V_{CE}$ = 1.8 V**

## 5.5 Characteristic AC Diagrams

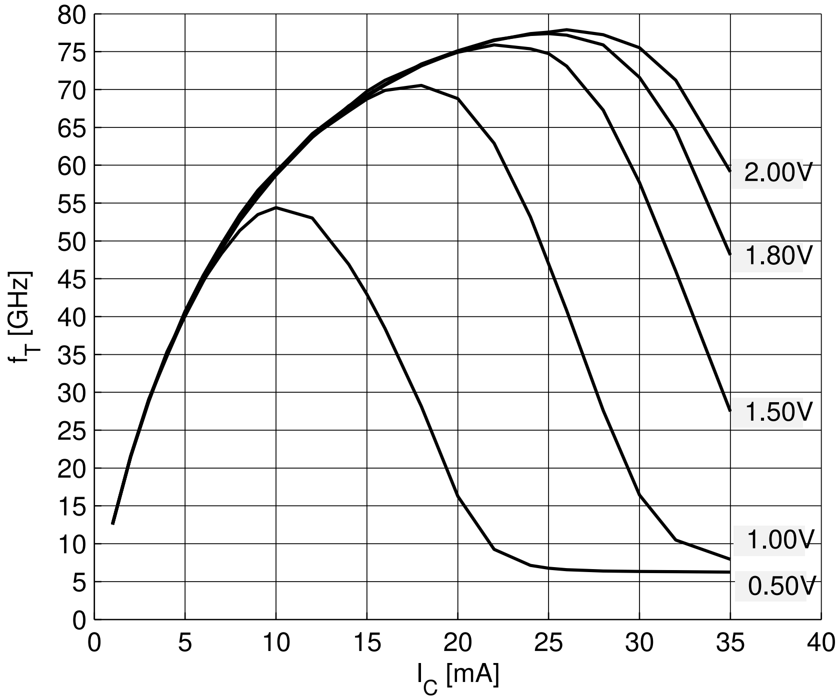



**Figure 8 Transition Frequency $f_T = f\,(I_C), f$ = 2 GHz, $V_{CE}$ = Parameter**

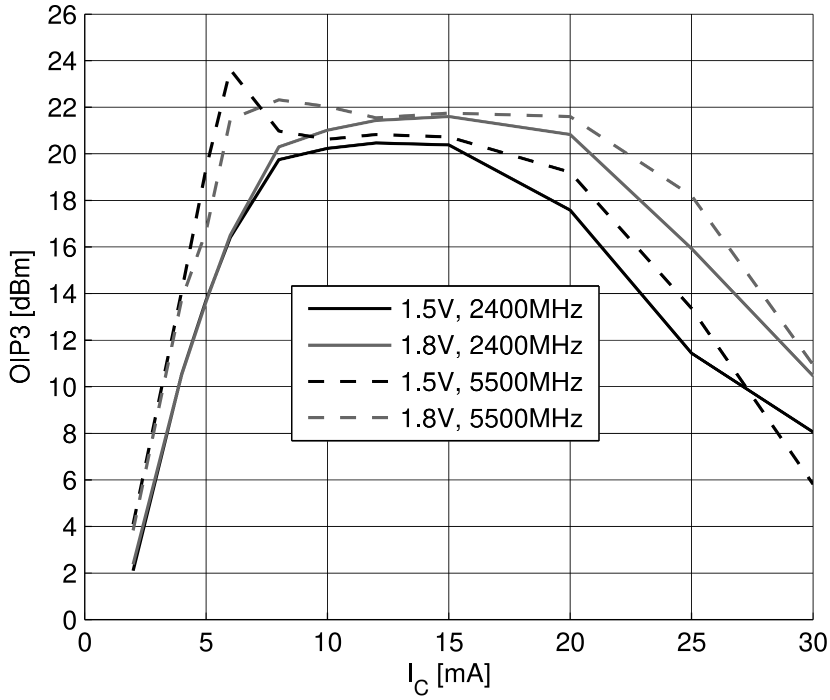



**Figure 9 3rd Order Intercept Point at output $OIP3 = f\,(I_C)$, $Z_S = Z_L$ = 50 Ω, $V_{CE}, f$ = Parameters**

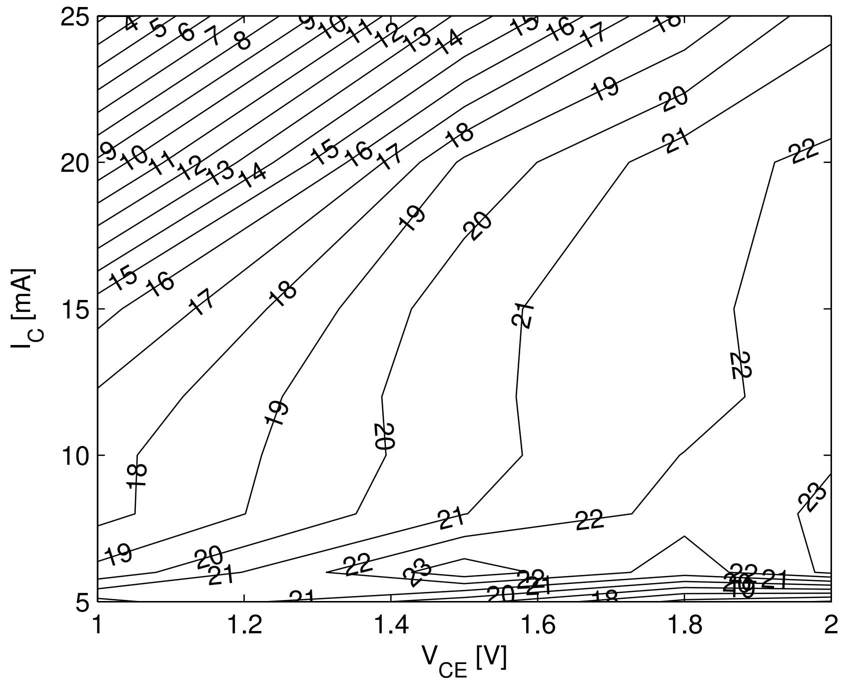



**Figure 10 3rd Order Intercept Point at output** $OIP3$ **[dBm]=** $f\,(I_C,\,V_{CE})$, $Z_S = Z_L = 50\ \Omega$, $f$ **= 5.5 GHz**

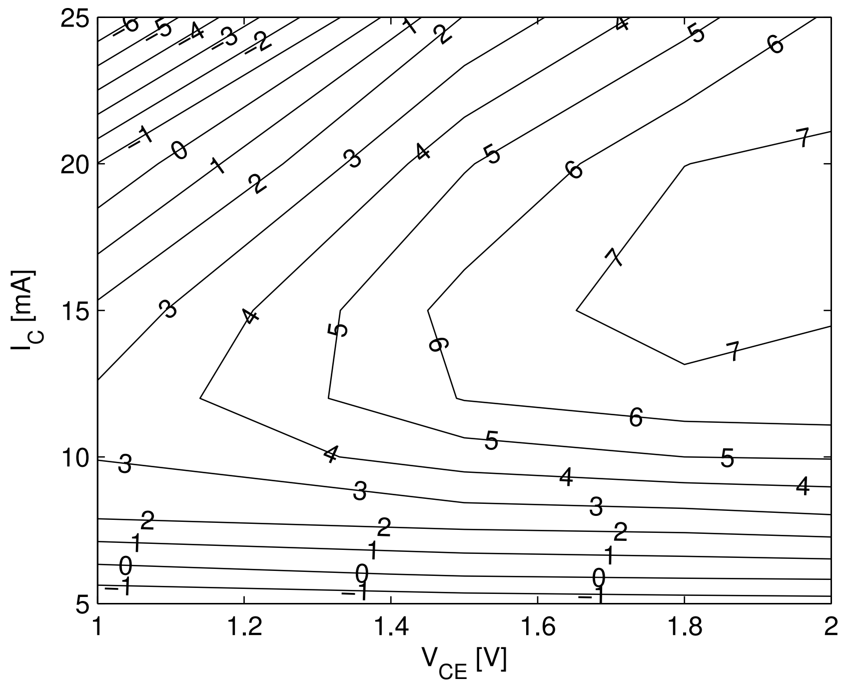



**Figure 11 Compression Point at output** $OP_{1dB}$ **[dBm]=** $f\,(I_C,\,V_{CE})$, $Z_S = Z_L = 50\ \Omega$, $f$ **= 5.5 GHz**

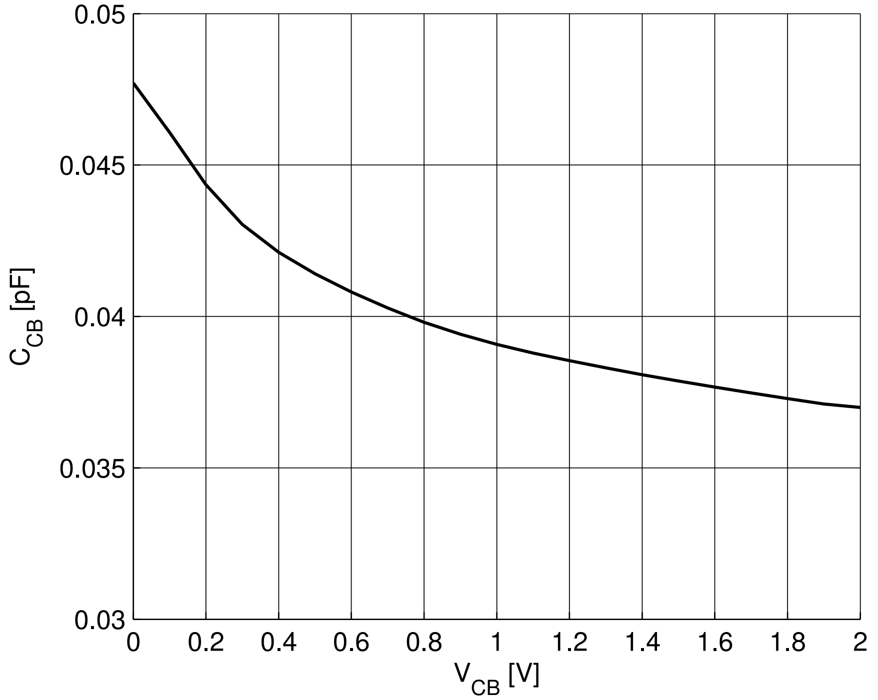



**Figure 12 Collector Base Capacitance $C_{CB} = f\,(V_{CB}), f$ = 1 MHz**

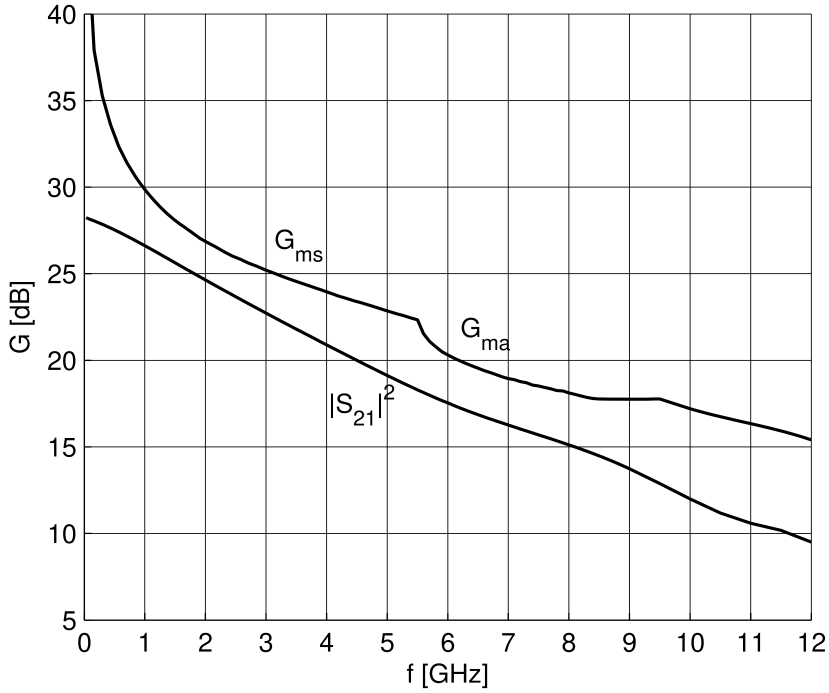



**Figure 13 Gain $G_{ma}$, $G_{ms}$, $|S_{21}|^2 = f\,(f)$, $V_{CE}$ = 1.8 V, $I_C$ = 10 mA**

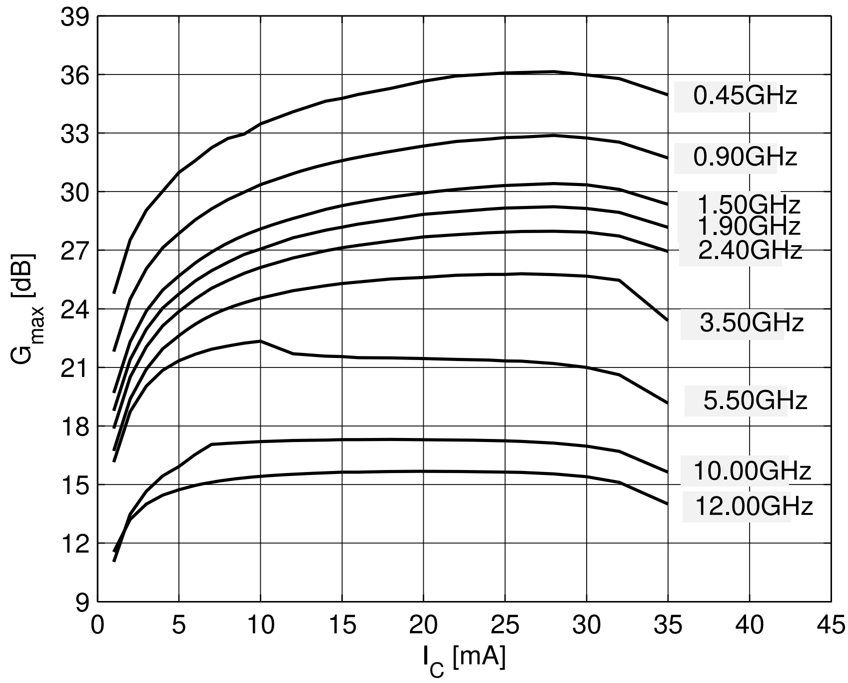



**Figure 14 Maximum Power Gain $G_{max} = f(I_C)$, $V_{CE}$ = 1.8 V, $f$ = Parameter in GHz**

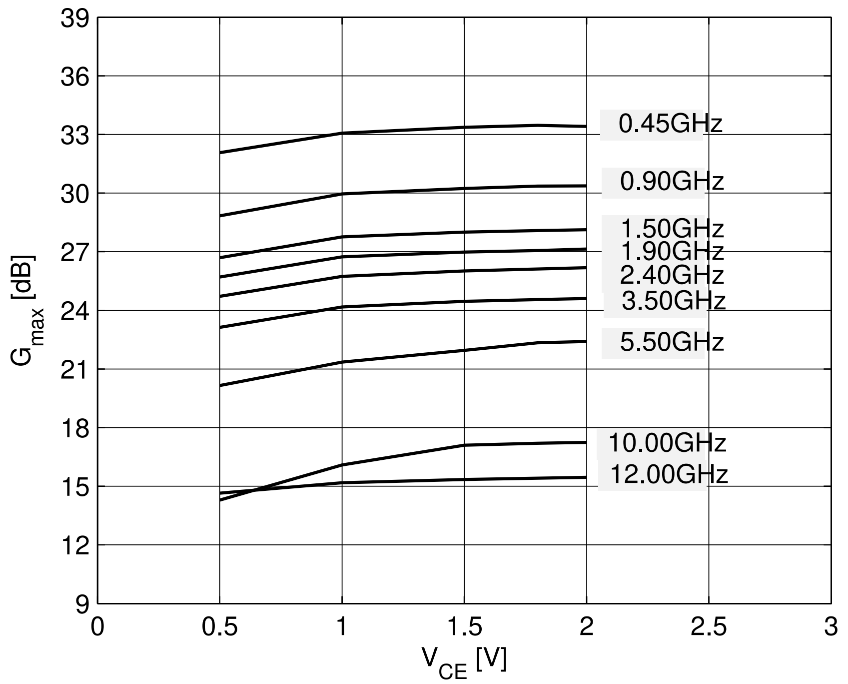



**Figure 15 Maximum Power Gain $G_{max} = f(V_{CE})$, $I_C$ = 10 mA, $f$ = Parameter in GHz**

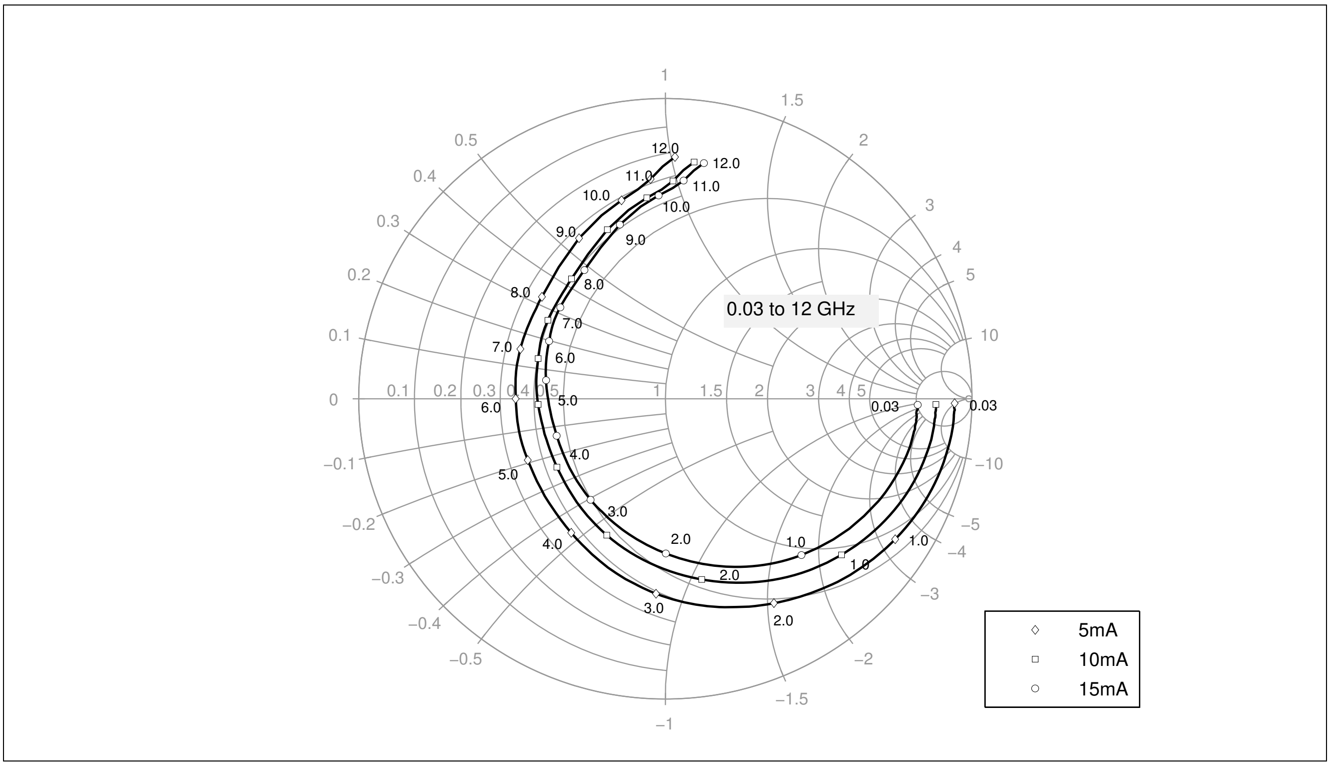



**Figure 16 Input Reflection Coefficient $S_{11} = f(f)$, $V_{CE}$ = 1.8 V, $I_C$ = 5 / 10 / 15 mA**

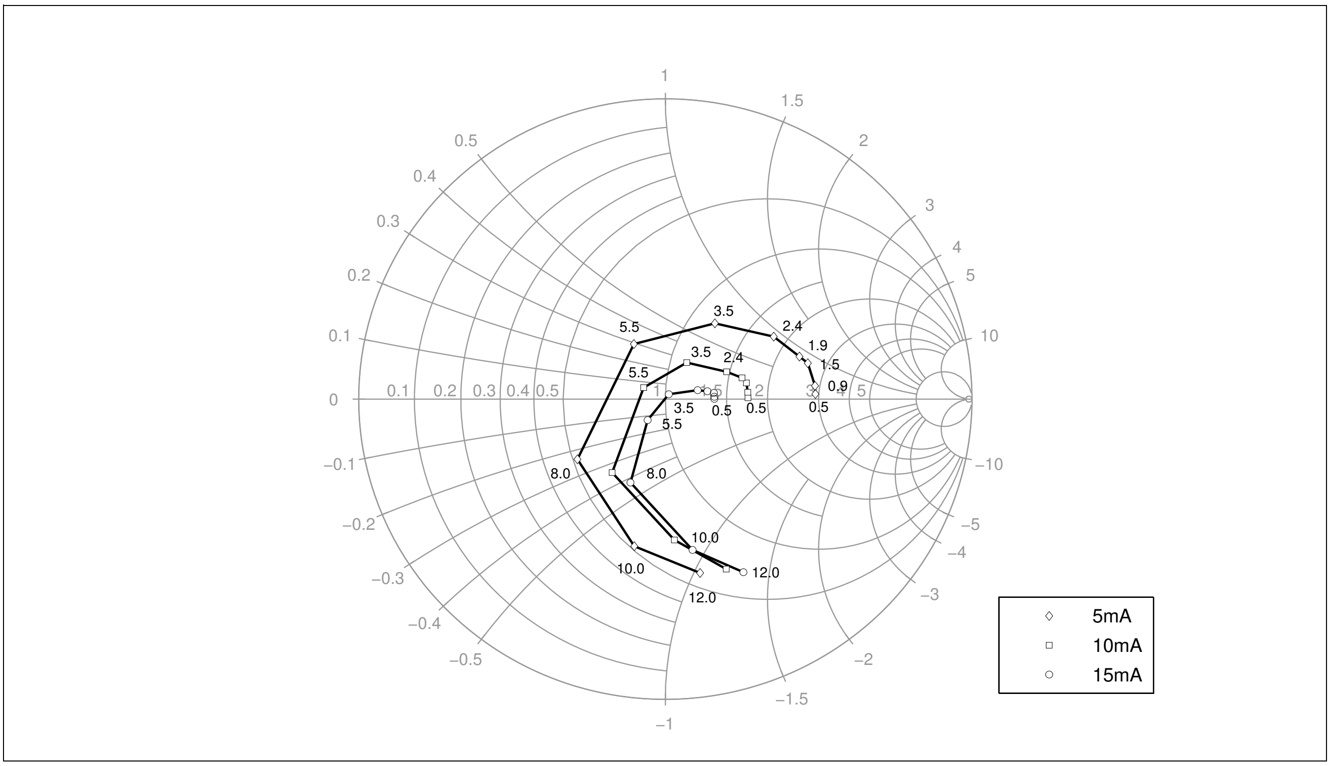



**Figure 17 Source Impedance for Minimum Noise Figure $Z_{opt} = f(f)$, $V_{CE}$ = 1.8 V, $I_C$ = 5 / 10 / 15 mA**

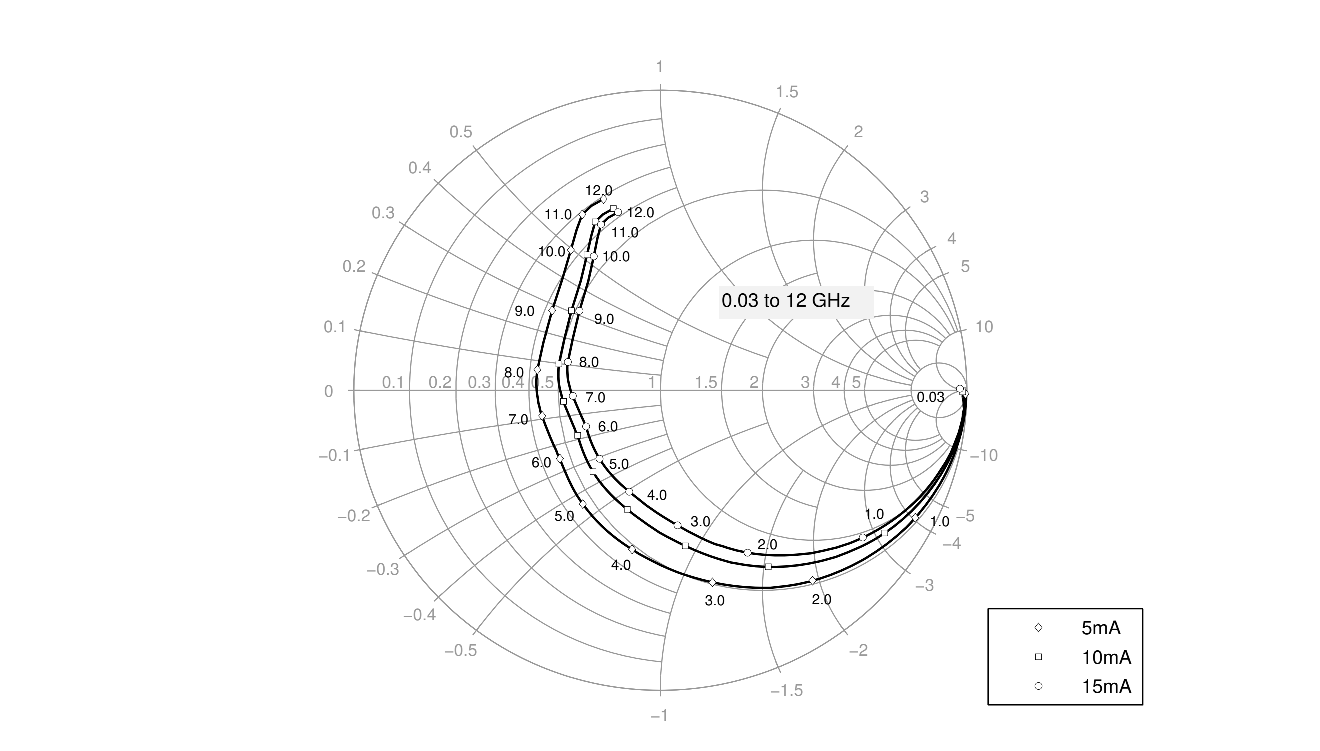



**Figure 18 Output Reflection Coefficient $S_{22} = f(f)$, $V_{CE}$ = 1.8 V, $I_C$ = 5 / 10 / 15 mA**

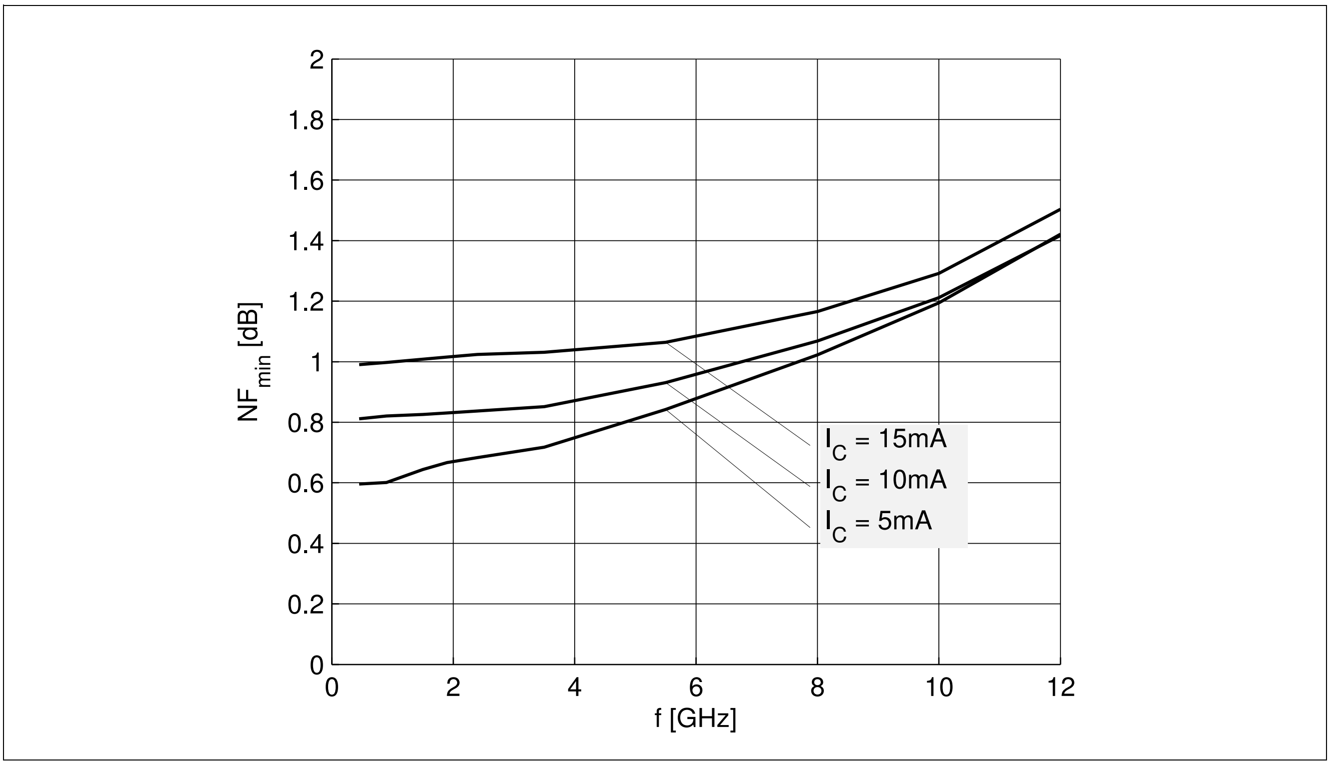



**Figure 19 Noise Figure $NF_{min} = f(f)$, $V_{CE}$ = 1.8 V, $I_C$ = 5 / 10 / 15 mA, $Z_S = Z_{opt}$**

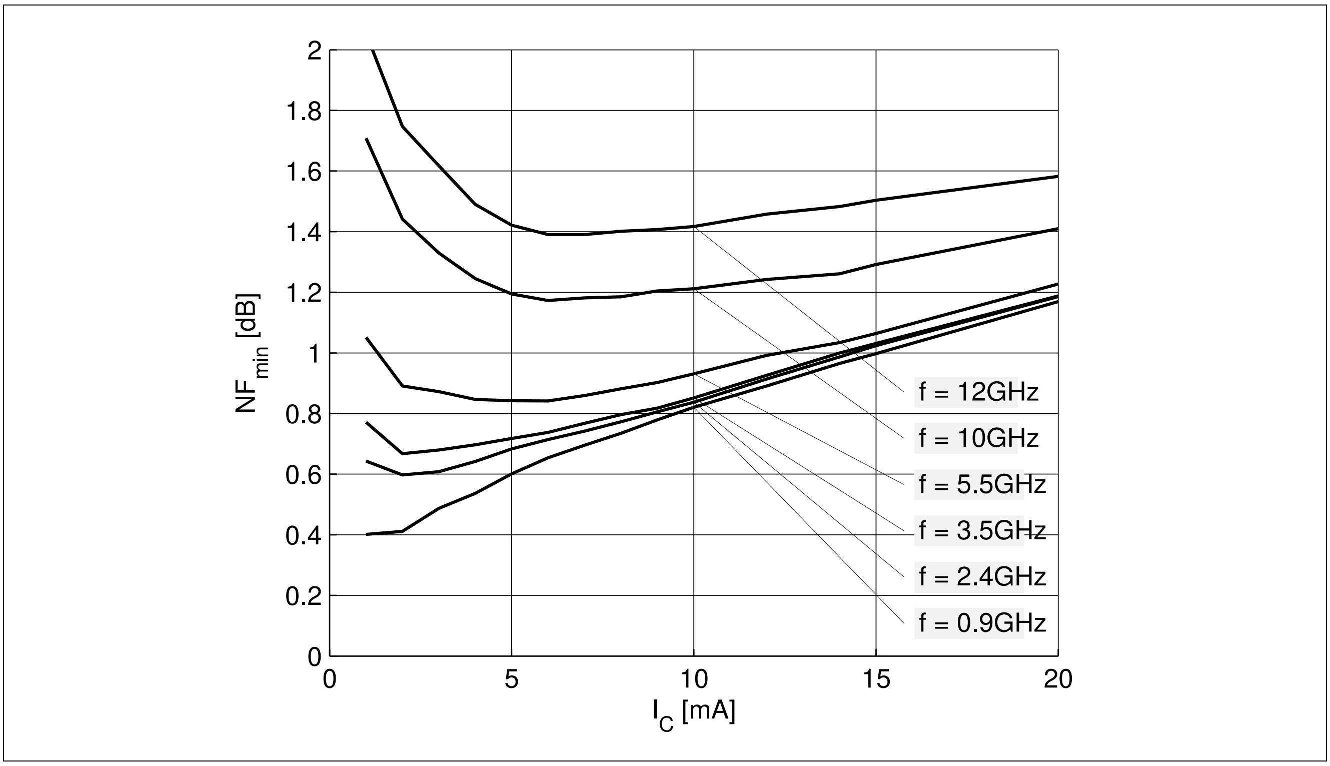



**Figure 20 Noise Figure $NF_{min} = f\,(I_C)$, $V_{CE}$ = 1.8 V, $Z_S = Z_{opt}$, $f$ = Parameter in GHz**

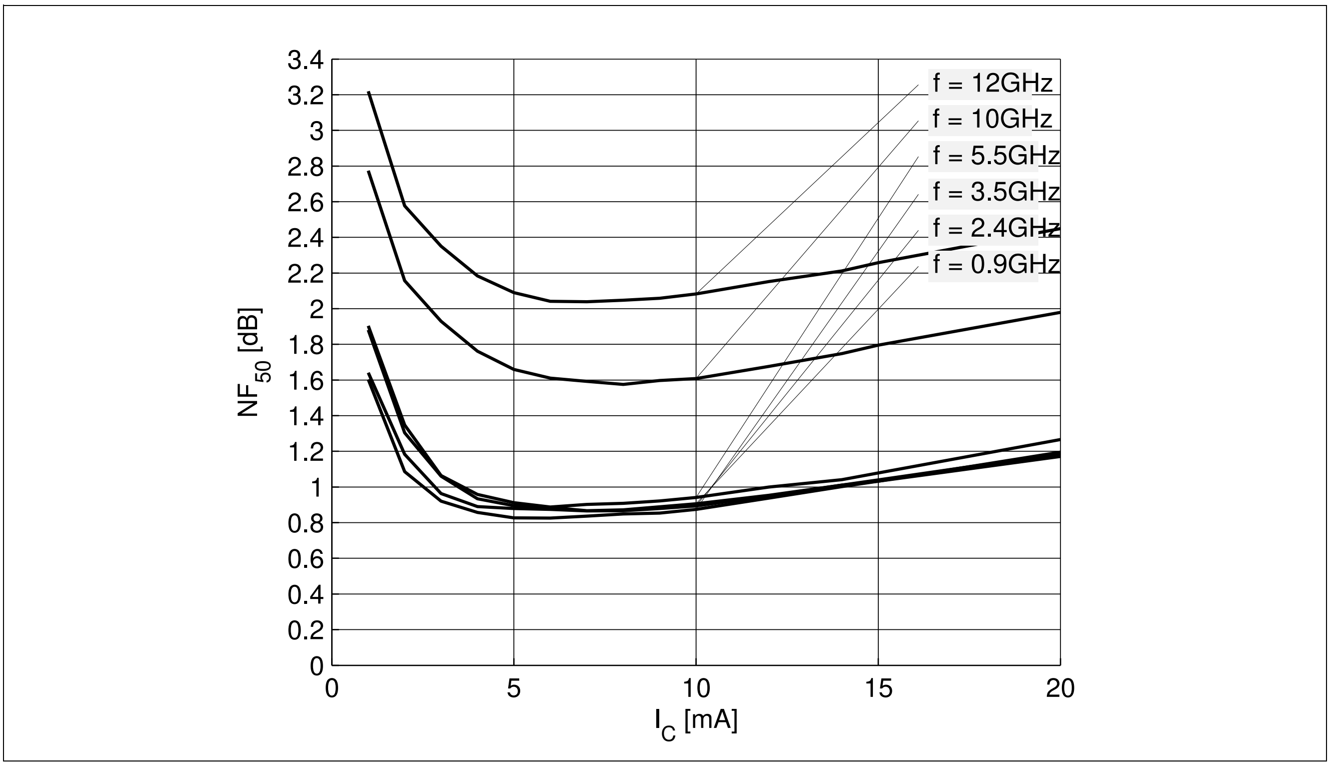



**Figure 21 Noise Figure $NF_{50} = f\,(I_C)$, $V_{CE}$ = 1.8 V, $Z_S$ = 50 $\Omega$, $f$ = Parameter in GHz**

*Note: The curves shown in this chapter have been generated using typical devices but shall not be considered as a guarantee that all devices have identical characteristic curves.* $T_A$ = 25 °C.