

BFP650

High Linearity Silicon Germanium Bipolar RF Transistor

Data Sheet

Revision 1.1, 2012-09-13

RF & Protection Devices

Edition 2012-09-13

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

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BFP650, High Linearity Silicon Germanium Bipolar RF Transistor

Revision History: 2012-09-13, Revision 1.1

| Page | Subjects (changes since previous revision) |
|------|--|
| | This data sheet replaces the revision from 2010-10-22. The product itself has not been changed and the device characteristics remain unchanged. Only the product description and information available in the data sheet have been expanded and updated. |
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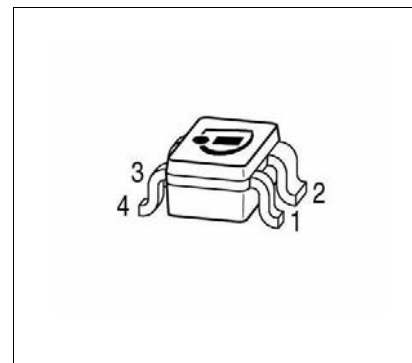
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1 Product Brief

The BFP650 is a high linearity wideband NPN bipolar RF transistor. The device is based on Infineon's reliable high volume silicon germanium carbon (SiGe:C) heterojunction bipolar technology. The collector design supports voltages up to $V_{CE0} = 4\text{ V}$ and currents up to $I_C = 150\text{ mA}$. With its high linearity at currents as low as 30 mA the device supports energy efficient designs. The typical transition frequency is approximately 42 GHz, hence the device offers high power gain at frequencies up to 5 GHz in amplifier applications. the device is housed in an easy to use plastic package with visible leads.

2 Features

- Linear low noise driver amplifier for RF frontends up to 5 GHz based on Infineon's reliable, high volume SiGe:C wafer technology
- Output compression point $OP_{1dB} = 17$ dBm at 70 mA, 3 V, 2.4 GHz, 50 Ω system
- Output 3rd order intermodulation point $OIP_3 = 30$ dBm at 70 mA, 3 V, 2.4 GHz, 50 Ω system
- Maximum available gain $G_{ma} = 17.5$ dB at 70 mA, 3 V, 2.4 GHz
- Minimum noise figure $NF_{min} = 1$ dB at 30 mA, 3 V, 2.4 GHz
- Easy to use Pb-free (RoHS compliant) and halogen-free standard package with visible leads
- Qualification report according to AEC-Q101 available



Application Examples

Driver amplifier

- ISM bands 434 and 868 MHz
- 1.9 GHz cordless phones
- CATV LNA

Transmitter driver amplifier

- 2.4 GHz WLAN / Bluetooth, 2.4 / 3.5 GHz WiMAX

Output stage LNA for active antennas

- TV, GPS, SDARS
- 2.4 / 5 GHz WLAN
- 2.4 / 3.5 / 5 GHz WiMAX, etc

Suitable for 5 - 10.5 GHz oscillators

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

| Product Name | Package | Pin Configuration | | | | Marking |
|--------------|---------|-------------------|-------|-------|-------|---------|
| BFP650 | SOT343 | 1 = B | 2 = E | 3 = C | 4 = E | R5s |

3 Maximum Ratings

Table 3-1 Maximum Ratings at $T_A = 25\text{ °C}$ (unless otherwise specified)

| Parameter | Symbol | Values | | Unit | Note / Test Condition |
|---------------------------------------|-----------|--------|------|------|-----------------------------------|
| | | Min. | Max. | | |
| Collector emitter voltage | V_{CEO} | — | 4.0 | V | Open base $T_A = 25\text{ °C}$ |
| | | — | 3.7 | V | $T_A = -55\text{ °C}$ |
| Collector emitter voltage | V_{CES} | — | 13 | V | E-B short circuited |
| Collector base voltage | V_{CBO} | — | 13 | V | Open emitter |
| Emitter base voltage | V_{EBO} | — | 1.2 | V | Open collector |
| Collector current | I_C | — | 150 | mA | — |
| Base current | I_B | — | 10 | mA | — |
| Total power dissipation ¹⁾ | P_{tot} | — | 500 | mW | $T_S \leq 78\text{ °C}$ |
| Junction temperature | T_J | — | 150 | °C | — |
| Storage temperature | T_{Stg} | -55 | 150 | °C | — |

1) 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 4-1 Thermal Resistance

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|--|------------|--------|------|------|------|-----------------------|
| | | Min. | Typ. | Max. | | |
| Junction - soldering point ¹⁾ | R_{thJS} | – | 140 | – | K/W | – |

1) For the definition of R_{thJS} please refer to Application Note AN077 (Thermal Resistance Calculation)

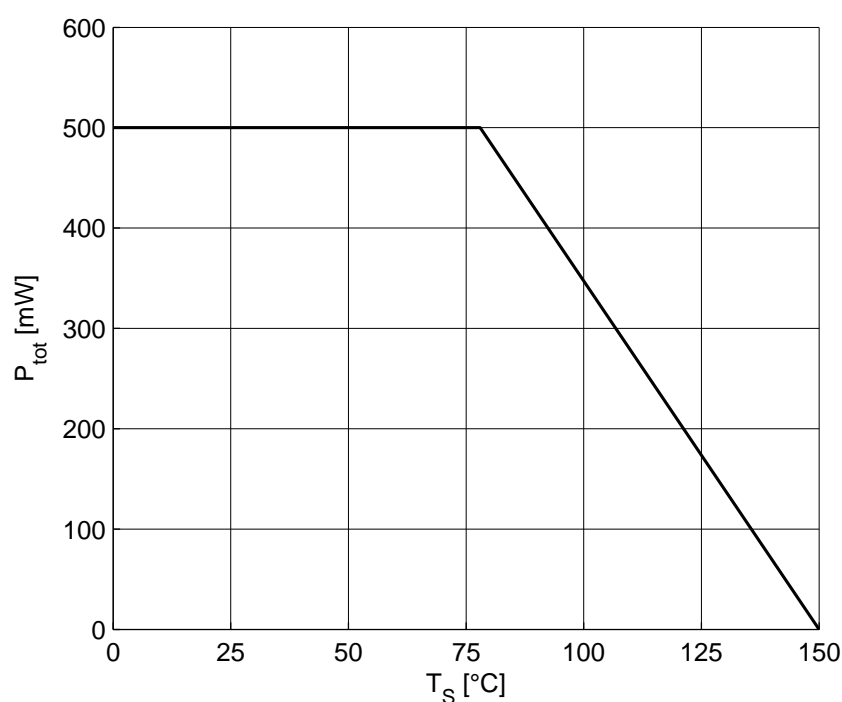


Figure 4-1 Total Power Dissipation $P_{tot} = f(T_s)$

5 Electrical Characteristics

5.1 DC Characteristics

Table 5-1 DC Characteristics at $T_A = 25\text{ °C}$

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|-------------------------------------|---------------|--------|------|------|---------------|--|
| | | Min. | Typ. | Max. | | |
| Collector emitter breakdown voltage | $V_{(BR)CEO}$ | 4 | 4.5 | – | V | $I_C = 3\text{ mA}$, $I_B = 0$ Open base |
| Collector emitter leakage current | I_{CES} | – | 0.1 | 1 | μA | $V_{CE} = 13\text{ V}$, $V_{BE} = 0$ |
| | | – | 1 | 40 | nA | $V_{CE} = 5\text{ V}$, $V_{BE} = 0$ E-B short circuited |
| Collector base leakage current | I_{CBO} | – | 1 | 40 | nA | $V_{CB} = 5\text{ V}$, $I_E = 0$ Open emitter |
| Emitter base leakage current | I_{EBO} | – | 10 | 500 | nA | $V_{EB} = 0.5\text{ V}$, $I_C = 0$ Open collector |
| DC current gain | h_{FE} | 100 | 170 | 250 | | $V_{CE} = 3\text{ V}$, $I_C = 70\text{ mA}$ Pulse measured |

5.2 General AC Characteristics

Table 5-2 General AC Characteristics at $T_A = 25\text{ °C}$

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|-------------------------------|----------|--------|------|------|------|---|
| | | Min. | Typ. | Max. | | |
| Transition frequency | f_T | 31 | 42 | – | GHz | $V_{CE} = 3\text{ V}$, $I_C = 70\text{ mA}$, $f = 1\text{ GHz}$ |
| Collector base capacitance | C_{CB} | – | 0.26 | 0.4 | pF | $V_{CB} = 3\text{ V}$, $V_{BE} = 0\text{ V}$ $f = 1\text{ MHz}$ Emitter grounded |
| Collector emitter capacitance | C_{CE} | – | 0.45 | – | pF | $V_{CE} = 3\text{ V}$, $V_{BE} = 0\text{ V}$ $f = 1\text{ MHz}$ Base grounded |
| Emitter base capacitance | C_{EB} | – | 1.3 | – | pF | $V_{EB} = 0.5\text{ V}$, $V_{CB} = 0\text{ V}$ $f = 1\text{ MHz}$ Collector grounded |

5.3 Frequency Dependent AC Characteristics

Measurement setup is a test fixture with Bias T's in a 50 Ω system, $T_A = 25\text{ }^{\circ}\text{C}$

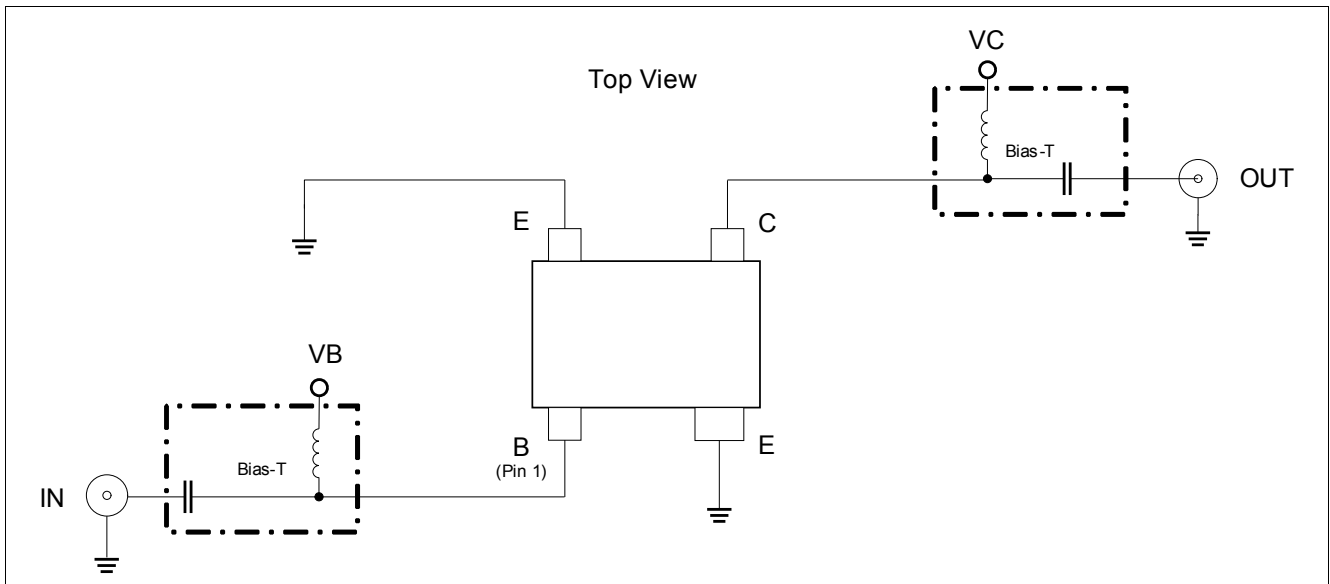


Figure 5-1 BFP650 Testing Circuit

Table 5-3 AC Characteristics, $V_{CE} = 3\text{ V}$, $f = 150\text{ MHz}$

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|--------------------------------|------------|--------|------|------|------|--------------------------------|
| | | Min. | Typ. | Max. | | |
| Maximum power gain | | | | | dB | |
| High linearity operation point | G_{ms} | – | 35.5 | – | | $I_C = 30\text{ mA}$ |
| Class A operation point | G_{ms} | – | 38 | – | | $I_C = 70\text{ mA}$ |
| Transducer gain | | | | | dB | $Z_S = Z_L = 50\text{ }\Omega$ |
| High linearity operation point | S_{21} | – | 35 | – | | $I_C = 30\text{ mA}$ |
| Class A operation point | S_{21} | – | 37.5 | – | | $I_C = 70\text{ mA}$ |
| Minimum noise figure | | | | | dB | $Z_S = Z_{opt}$ |
| Minimum noise figure | NF_{min} | – | 0.75 | – | | $I_C = 30\text{ mA}$ |
| Associated gain | G_{ass} | – | 32 | – | | $I_C = 30\text{ mA}$ |
| Linearity | | | | | dBm | $Z_S = Z_L = 50\text{ }\Omega$ |
| 1 dB gain compression point | OP_{1dB} | – | 16.5 | – | | $I_C = 70\text{ mA}$ |
| 3rd order intercept point | OIP_3 | – | 29.5 | – | | $I_C = 70\text{ mA}$ |

Electrical Characteristics

Table 5-4 AC Characteristics, $V_{CE} = 3\text{ V}$, $f = 450\text{ MHz}$

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|--------------------------------|------------|--------|------|------|------|--------------------------|
| | | Min. | Typ. | Max. | | |
| Maximum power gain | | | | | dB | |
| High linearity operation point | G_{ms} | – | 30 | – | | $I_C = 30\text{ mA}$ |
| Class A operation point | G_{ms} | – | 31.5 | – | | $I_C = 70\text{ mA}$ |
| Transducer gain | | | | | dB | $Z_S = Z_L = 50\ \Omega$ |
| High linearity operation point | S_{21} | – | 29 | – | | $I_C = 30\text{ mA}$ |
| Class A operation point | S_{21} | – | 29.5 | – | | $I_C = 70\text{ mA}$ |
| Minimum noise figure | | | | | dB | $Z_S = Z_{opt}$ |
| Minimum noise figure | NF_{min} | – | 0.75 | – | | $I_C = 30\text{ mA}$ |
| Associated gain | G_{ass} | – | 29.5 | – | | $I_C = 30\text{ mA}$ |
| Linearity | | | | | dBm | $Z_S = Z_L = 50\ \Omega$ |
| 1 dB gain compression point | OP_{1dB} | – | 16.5 | – | | $I_C = 70\text{ mA}$ |
| 3rd order intercept point | OIP_3 | – | 30 | – | | $I_C = 70\text{ mA}$ |

Table 5-5 AC Characteristics, $V_{CE} = 3\text{ V}$, $f = 900\text{ MHz}$

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|--------------------------------|------------|--------|------|------|------|--------------------------|
| | | Min. | Typ. | Max. | | |
| Maximum power gain | | | | | dB | |
| High linearity operation point | G_{ms} | – | 25.5 | – | | $I_C = 30\text{ mA}$ |
| Class A operation point | G_{ms} | – | 26.5 | – | | $I_C = 70\text{ mA}$ |
| Transducer gain | | | | | dB | $Z_S = Z_L = 50\ \Omega$ |
| High linearity operation point | S_{21} | – | 23.5 | – | | $I_C = 30\text{ mA}$ |
| Class A operation point | S_{21} | – | 24 | – | | $I_C = 70\text{ mA}$ |
| Minimum noise figure | | | | | dB | $Z_S = Z_{opt}$ |
| Minimum noise figure | NF_{min} | – | 0.8 | – | | $I_C = 30\text{ mA}$ |
| Associated gain | G_{ass} | – | 24.5 | – | | $I_C = 30\text{ mA}$ |
| Linearity | | | | | dBm | $Z_S = Z_L = 50\ \Omega$ |
| 1 dB gain compression point | OP_{1dB} | – | 17 | – | | $I_C = 70\text{ mA}$ |
| 3rd order intercept point | OIP_3 | – | 31 | – | | $I_C = 70\text{ mA}$ |

Electrical Characteristics

Table 5-6 AC Characteristics, $V_{CE} = 3\text{ V}$, $f = 1.5\text{ GHz}$

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|--------------------------------|------------|--------|------|------|------|--------------------------|
| | | Min. | Typ. | Max. | | |
| Maximum power gain | | | | | dB | |
| High linearity operation point | G_{ms} | – | 22 | – | | $I_C = 30\text{ mA}$ |
| Class A operation point | G_{ms} | – | 22.5 | – | | $I_C = 70\text{ mA}$ |
| Transducer gain | | | | | dB | $Z_S = Z_L = 50\ \Omega$ |
| High linearity operation point | S_{21} | – | 19 | – | | $I_C = 30\text{ mA}$ |
| Class A operation point | S_{21} | – | 19.5 | – | | $I_C = 70\text{ mA}$ |
| Minimum noise figure | | | | | dB | $Z_S = Z_{opt}$ |
| Minimum noise figure | NF_{min} | – | 0.85 | – | | $I_C = 30\text{ mA}$ |
| Associated gain | G_{ass} | – | 20.5 | – | | $I_C = 30\text{ mA}$ |
| Linearity | | | | | dBm | $Z_S = Z_L = 50\ \Omega$ |
| 1 dB gain compression point | OP_{1dB} | – | 17 | – | | $I_C = 70\text{ mA}$ |
| 3rd order intercept point | OIP_3 | – | 31 | – | | $I_C = 70\text{ mA}$ |

Table 5-7 AC Characteristics, $V_{CE} = 3\text{ V}$, $f = 1.9\text{ GHz}$

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|--------------------------------|------------|--------|------|------|------|--------------------------|
| | | Min. | Typ. | Max. | | |
| Maximum power gain | | | | | dB | |
| High linearity operation point | G_{ma} | – | 20.5 | – | | $I_C = 30\text{ mA}$ |
| Class A operation point | G_{ms} | – | 20 | – | | $I_C = 70\text{ mA}$ |
| Transducer gain | | | | | dB | $Z_S = Z_L = 50\ \Omega$ |
| High linearity operation point | S_{21} | – | 17 | – | | $I_C = 30\text{ mA}$ |
| Class A operation point | S_{21} | – | 17.5 | – | | $I_C = 70\text{ mA}$ |
| Minimum noise figure | | | | | dB | $Z_S = Z_{opt}$ |
| Minimum noise figure | NF_{min} | – | 0.95 | – | | $I_C = 30\text{ mA}$ |
| Associated gain | G_{ass} | – | 17.5 | – | | $I_C = 30\text{ mA}$ |
| Linearity | | | | | dBm | $Z_S = Z_L = 50\ \Omega$ |
| 1 dB gain compression point | OP_{1dB} | – | 17 | – | | $I_C = 70\text{ mA}$ |
| 3rd order intercept point | OIP_3 | – | 30.5 | – | | $I_C = 70\text{ mA}$ |

Electrical Characteristics

Table 5-8 AC Characteristics, $V_{CE} = 3\text{ V}$, $f = 2.4\text{ GHz}$

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|--------------------------------|------------|--------|------|------|------|--------------------------|
| | | Min. | Typ. | Max. | | |
| Maximum power gain | | | | | dB | |
| High linearity operation point | G_{ma} | – | 18 | – | | $I_C = 30\text{ mA}$ |
| Class A operation point | G_{ma} | – | 17.5 | – | | $I_C = 70\text{ mA}$ |
| Transducer gain | | | | | dB | $Z_S = Z_L = 50\ \Omega$ |
| High linearity operation point | S_{21} | – | 14.5 | – | | $I_C = 30\text{ mA}$ |
| Class A operation point | S_{21} | – | 15 | – | | $I_C = 70\text{ mA}$ |
| Minimum noise figure | | | | | dB | $Z_S = Z_{opt}$ |
| Minimum noise figure | NF_{min} | – | 1 | – | | $I_C = 30\text{ mA}$ |
| Associated gain | G_{ass} | – | 15 | – | | $I_C = 30\text{ mA}$ |
| Linearity | | | | | dBm | $Z_S = Z_L = 50\ \Omega$ |
| 1 dB gain compression point | OP_{1dB} | – | 17 | – | | $I_C = 70\text{ mA}$ |
| 3rd order intercept point | OIP_3 | – | 30 | – | | $I_C = 70\text{ mA}$ |

Table 5-9 AC Characteristics, $V_{CE} = 3\text{ V}$, $f = 3.5\text{ GHz}$

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|--------------------------------|------------|--------|------|------|------|--------------------------|
| | | Min. | Typ. | Max. | | |
| Maximum power gain | | | | | dB | |
| High linearity operation point | G_{ma} | – | 14 | – | | $I_C = 30\text{ mA}$ |
| Class A operation point | G_{ma} | – | 14.5 | – | | $I_C = 70\text{ mA}$ |
| Transducer gain | | | | | dB | $Z_S = Z_L = 50\ \Omega$ |
| High linearity operation point | S_{21} | – | 11 | – | | $I_C = 30\text{ mA}$ |
| Class A operation point | S_{21} | – | 11.5 | – | | $I_C = 70\text{ mA}$ |
| Minimum noise figure | | | | | dB | $Z_S = Z_{opt}$ |
| Minimum noise figure | NF_{min} | – | 1.2 | – | | $I_C = 30\text{ mA}$ |
| Associated gain | G_{ass} | – | 11.5 | – | | $I_C = 30\text{ mA}$ |
| Linearity | | | | | dBm | $Z_S = Z_L = 50\ \Omega$ |
| 1 dB gain compression point | OP_{1dB} | – | 17 | – | | $I_C = 70\text{ mA}$ |
| 3rd order intercept point | OIP_3 | – | 30 | – | | $I_C = 70\text{ mA}$ |

Table 5-10 AC Characteristics, $V_{CE} = 3\text{ V}$, $f = 5.5\text{ GHz}$

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|--------------------------------|------------|--------|------|------|------|--------------------------|
| | | Min. | Typ. | Max. | | |
| Maximum power gain | | | | | dB | |
| High linearity operation point | G_{ma} | – | 10.5 | – | | $I_C = 30\text{ mA}$ |
| Class A operation point | G_{ma} | – | 10.5 | – | | $I_C = 70\text{ mA}$ |
| Transducer gain | | | | | dB | $Z_S = Z_L = 50\ \Omega$ |
| High linearity operation point | S_{21} | – | 6.5 | – | | $I_C = 30\text{ mA}$ |
| Class A operation point | S_{21} | – | 7 | – | | $I_C = 70\text{ mA}$ |
| Minimum noise figure | | | | | dB | $Z_S = Z_{opt}$ |
| Minimum noise figure | NF_{min} | – | 1.6 | – | | $I_C = 30\text{ mA}$ |
| Associated gain | G_{ass} | – | 8.5 | – | | $I_C = 30\text{ mA}$ |
| Linearity | | | | | dBm | $Z_S = Z_L = 50\ \Omega$ |
| 1 dB gain compression point | OP_{1dB} | – | 16.5 | – | | $I_C = 70\text{ mA}$ |
| 3rd order intercept point | OIP_3 | – | 29.5 | – | | $I_C = 70\text{ mA}$ |

Notes

1. AC parameter limits verified by random sampling.
2. In order to get the NF_{min} values stated in this chapter the test fixture losses have been subtracted from all measured result.
3. OIP_3 value depends on termination of all intermodulation frequency components. Termination used for this measurement is $50\ \Omega$ from 0.2 MHz to 12 GHz.

5.4 Characteristic DC Diagrams

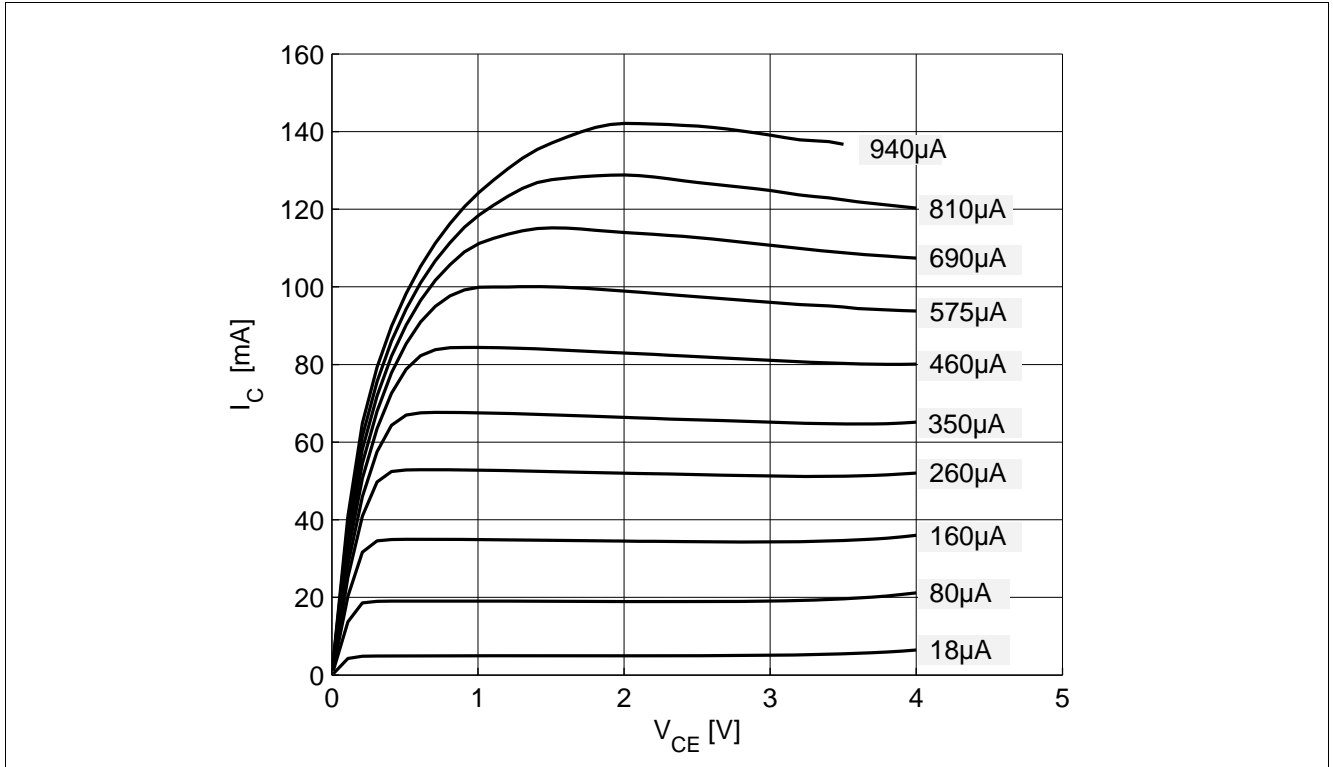


Figure 5-2 Collector Current vs. Collector Emitter Voltage $I_C = f(V_{CE})$, $I_B = \text{Parameter in } \mu\text{A}$

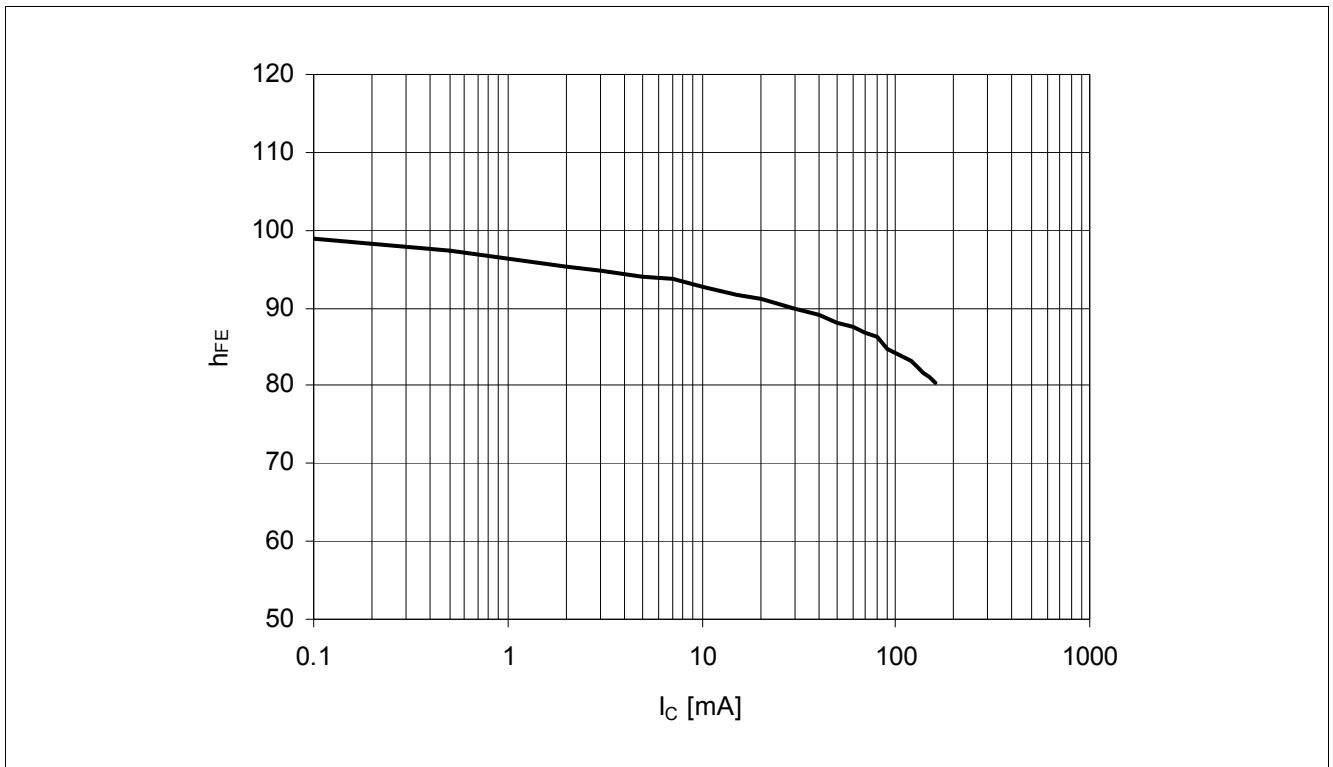


Figure 5-3 DC Current Gain $h_{FE} = f(I_C)$, $V_{CE} = 3 \text{ V}$

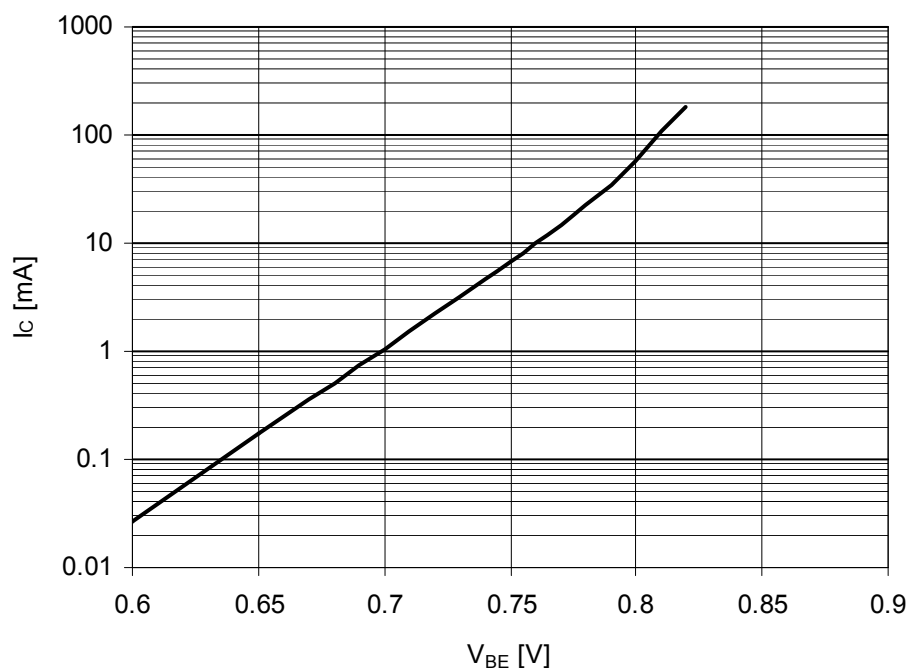


Figure 5-4 Collector Current vs. Base Emitter Voltage $I_C = f(V_{BE})$, $V_{CE} = 2\text{ V}$

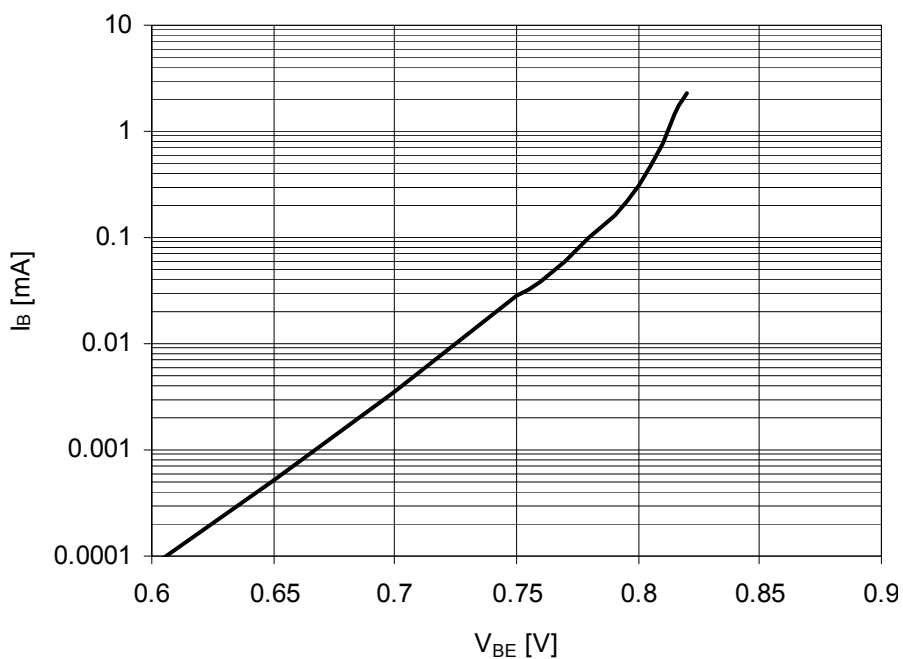


Figure 5-5 Base Current vs. Base Emitter Forward Voltage $I_B = f(V_{BE})$, $V_{CE} = 2\text{ V}$

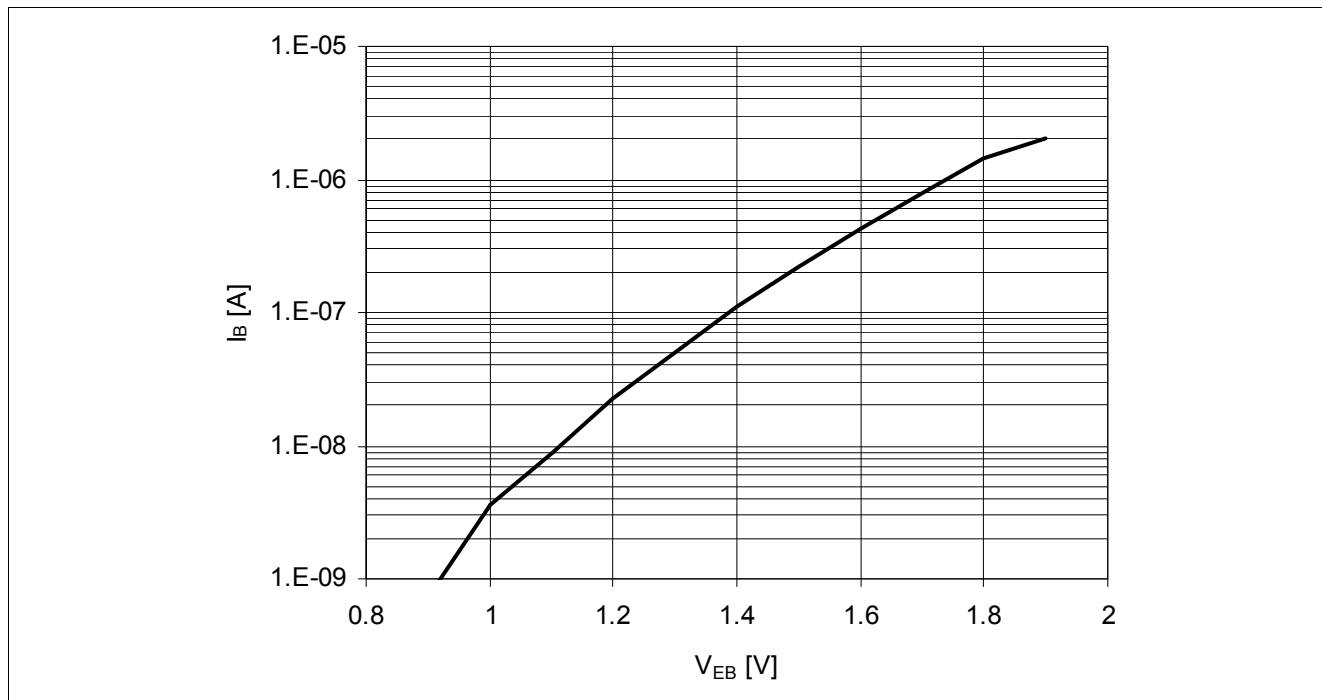


Figure 5-6 Base Current vs. Base Emitter Reverse Voltage $I_B = f(V_{EB})$, $V_{CE} = 2 \text{ V}$

5.5 Characteristic AC Diagrams

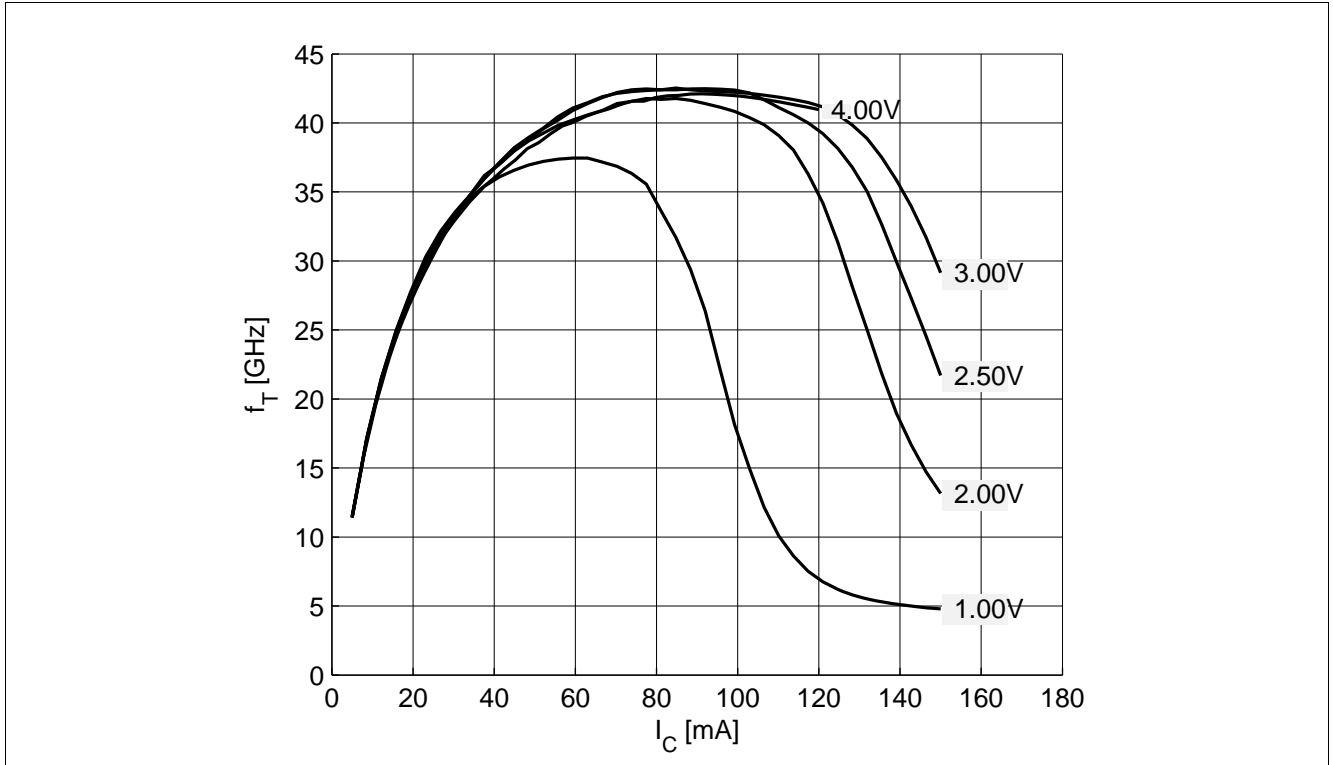


Figure 5-7 Transition Frequency $f_T = f(I_C)$, $f = 1 \text{ GHz}$, $V_{CE} = \text{Parameter in V}$

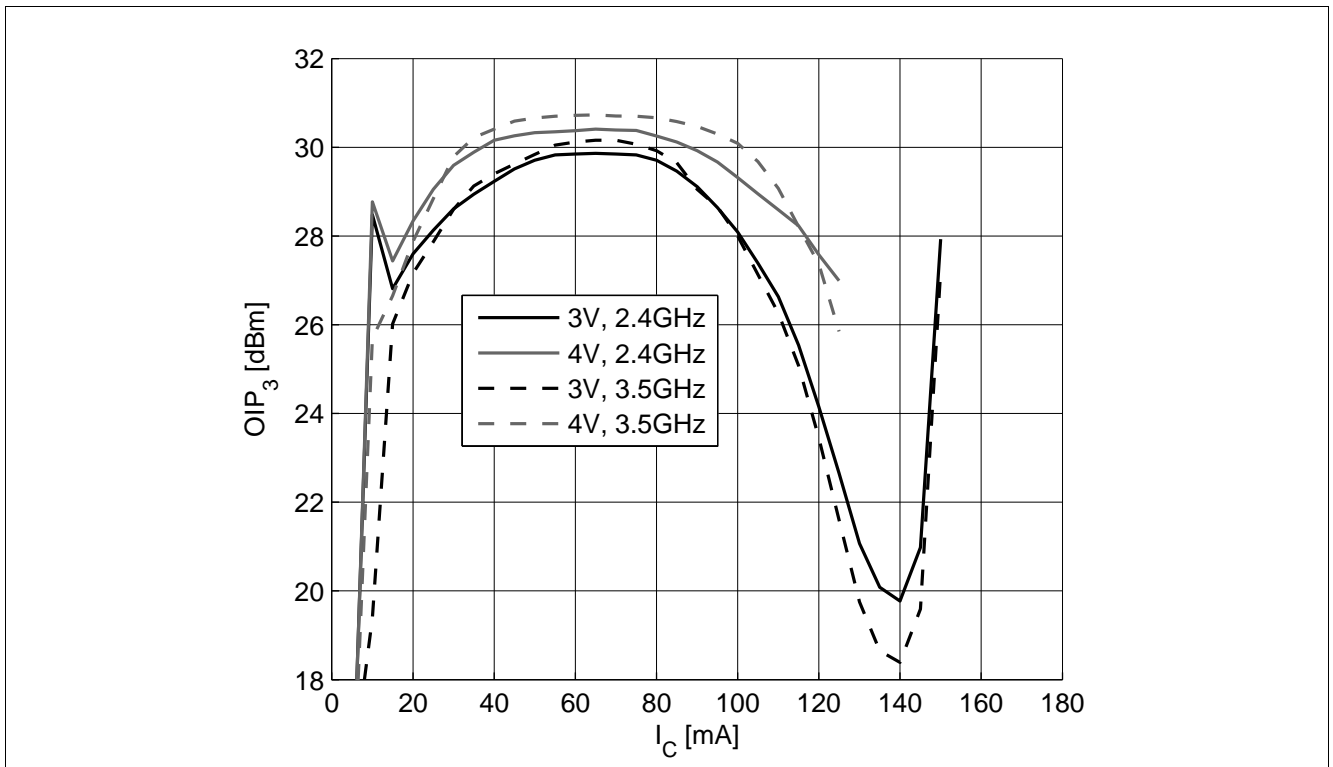


Figure 5-8 3rd Order Intercept Point $OIP_3 = f(I_C)$, $Z_S = Z_L = 50 \Omega$, $V_{CE}, f = \text{Parameters}$

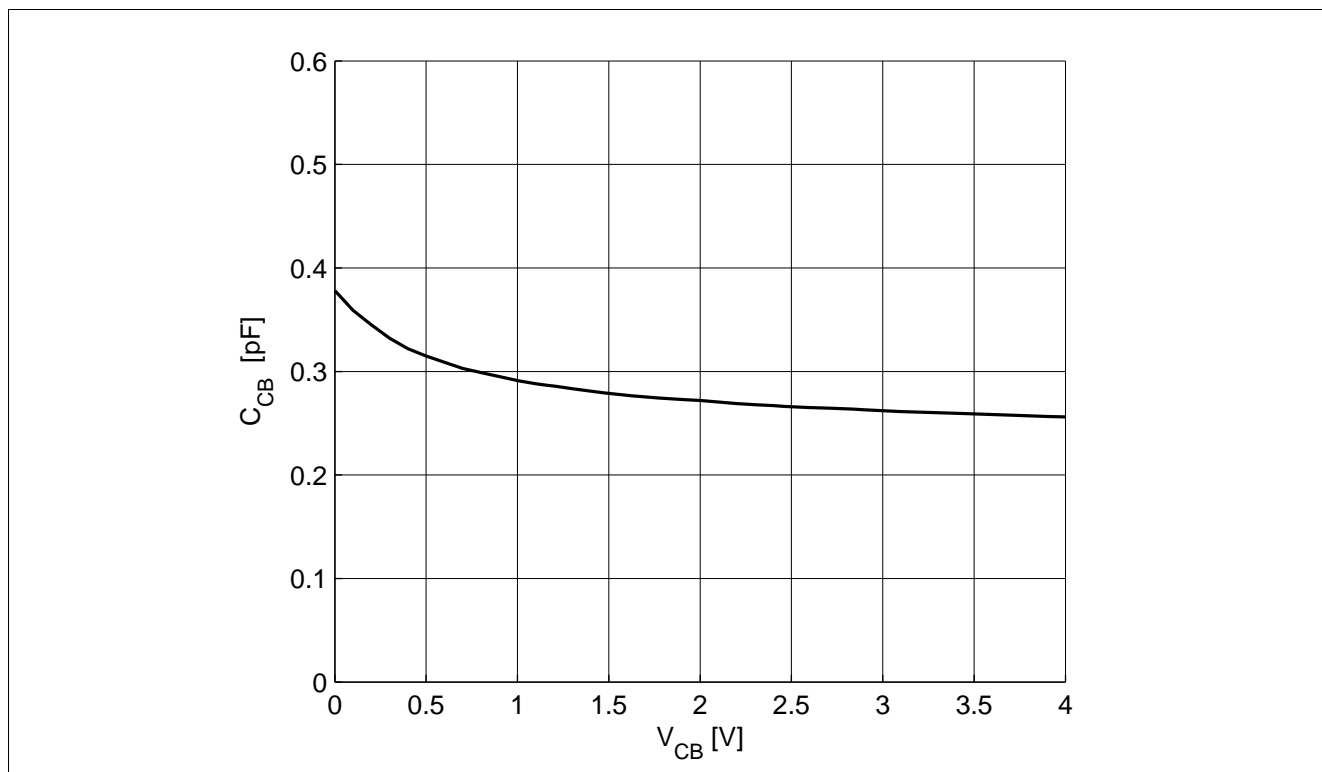


Figure 5-9 Collector Base Capacitance $C_{CB} = f(V_{CB})$, $f = 1$ MHz

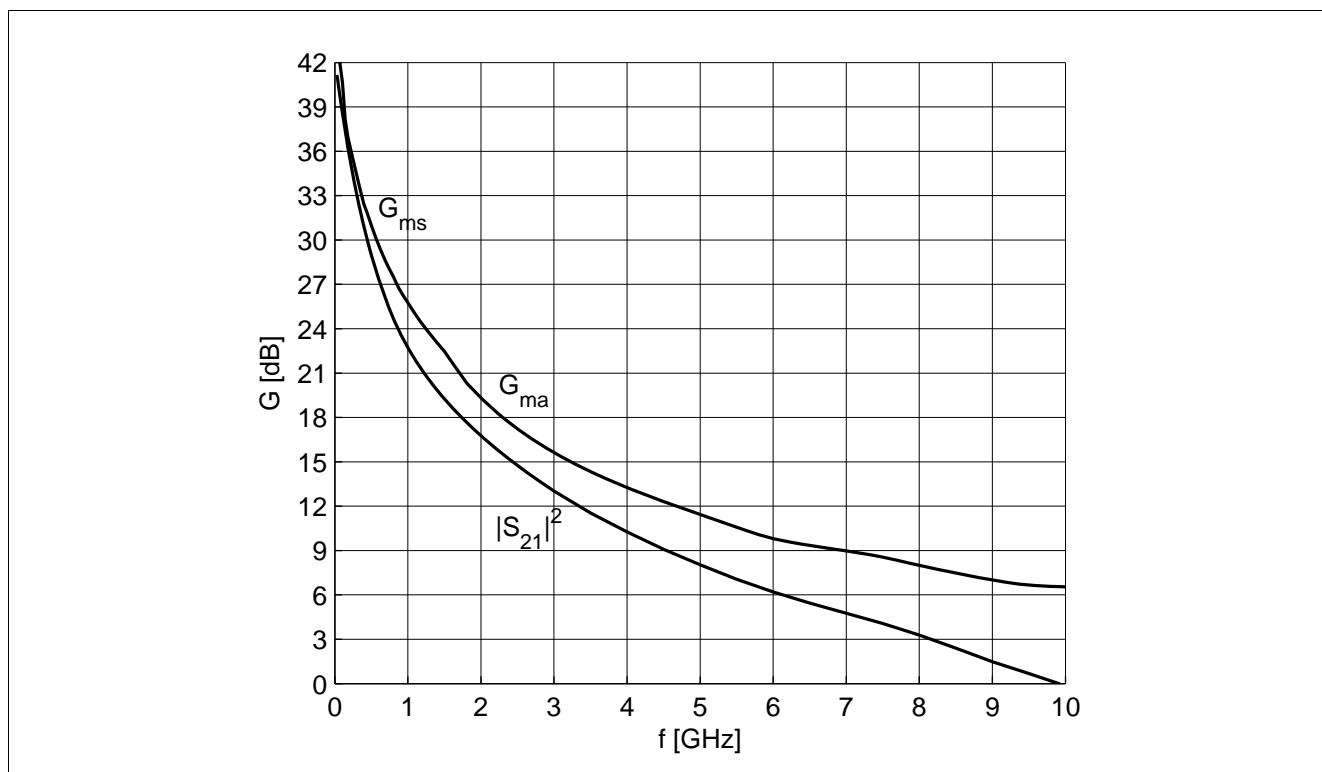


Figure 5-10 Gain G_{ma} , G_{ms} , $|S_{21}|^2 = f(f)$, $V_{CE} = 3$ V, $I_C = 70$ mA

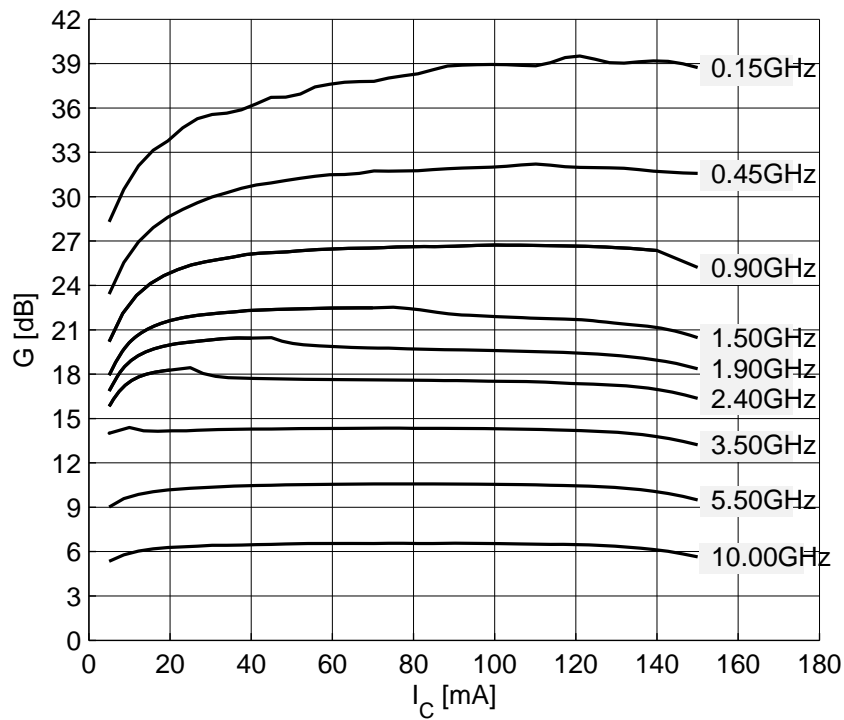


Figure 5-11 Maximum Power Gain $G_{max} = f(I_C)$, $V_{CE} = 3\text{ V}$, $f = \text{Parameter in GHz}$

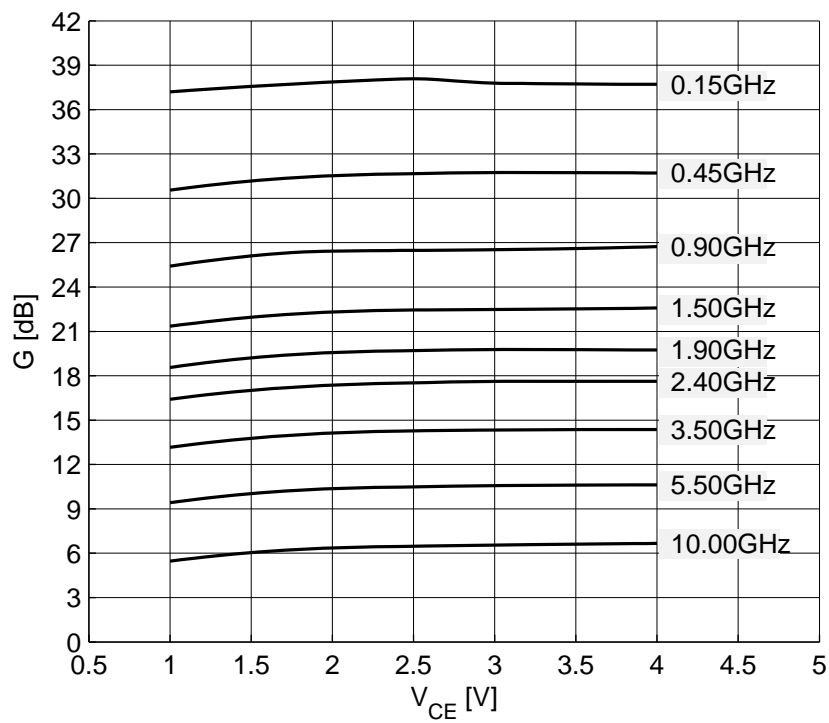


Figure 5-12 Maximum Power Gain $G_{max} = f(V_{CE})$, $I_C = 70\text{ mA}$, $f = \text{Parameter in GHz}$

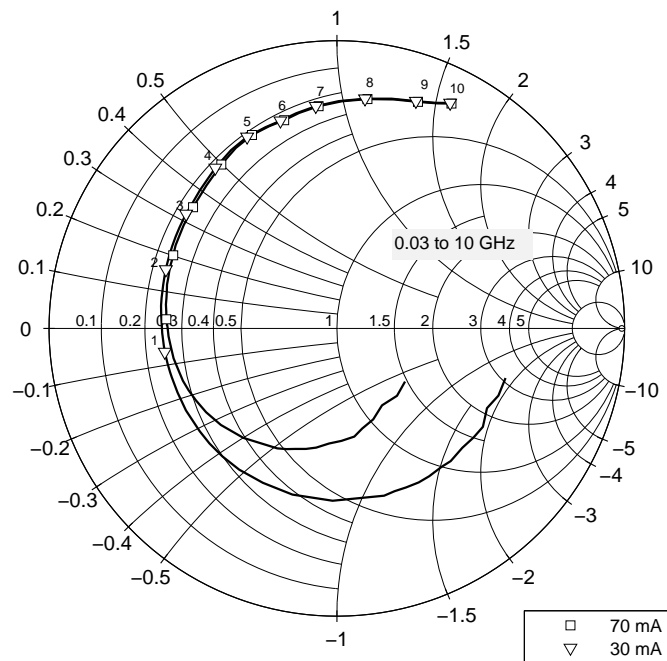


Figure 5-13 Input Matching $S_{11} = f(f)$, $V_{CE} = 3\text{ V}$, $I_C = 30 / 70\text{ mA}$

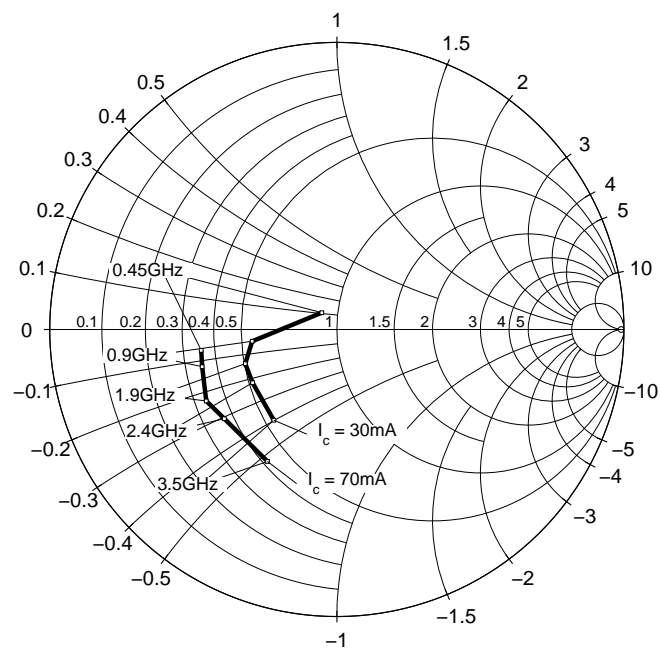


Figure 5-14 Source Impedance for Minimum Noise Figure $_{opt} = f(f)$, $V_{CE} = 3\text{ V}$, $I_C = 30 / 70\text{ mA}$

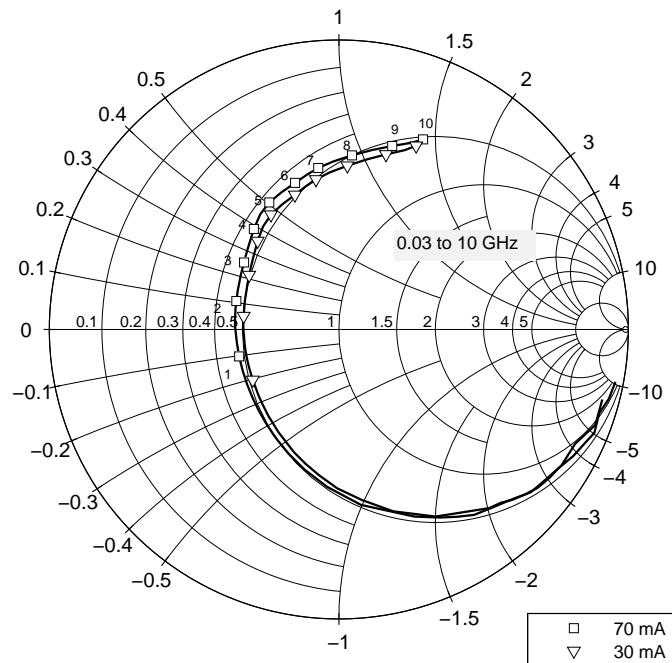


Figure 5-15 Output Matching $S_{22} = f(f)$, $V_{CE} = 3\text{ V}$, $I_C = 30 / 70\text{ mA}$

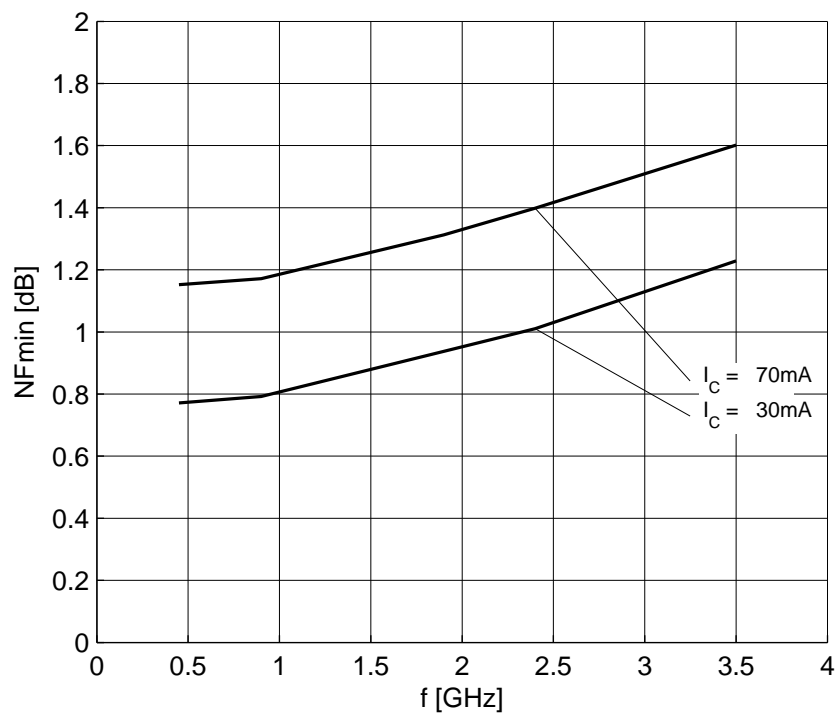


Figure 5-16 Noise Figure $NF_{min} = f(f)$, $V_{CE} = 3\text{ V}$, $I_C = 30 / 70\text{ mA}$, $Z_S = Z_{opt}$

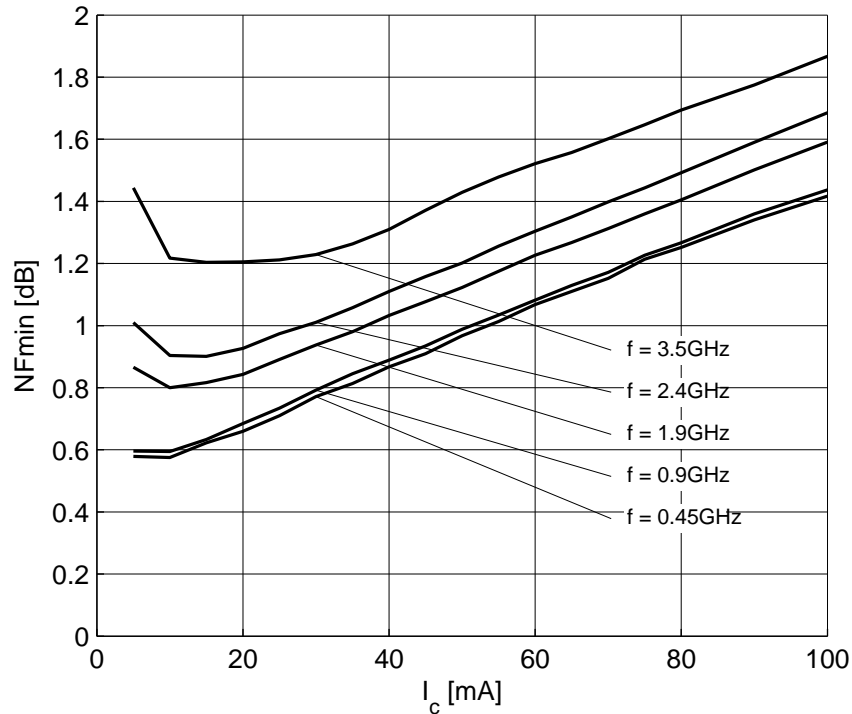


Figure 5-17 Noise Figure $NF_{min} = f(I_c)$, $V_{CE} = 3\text{ V}$, $Z_S = Z_{opt}$, f = Parameter in GHz

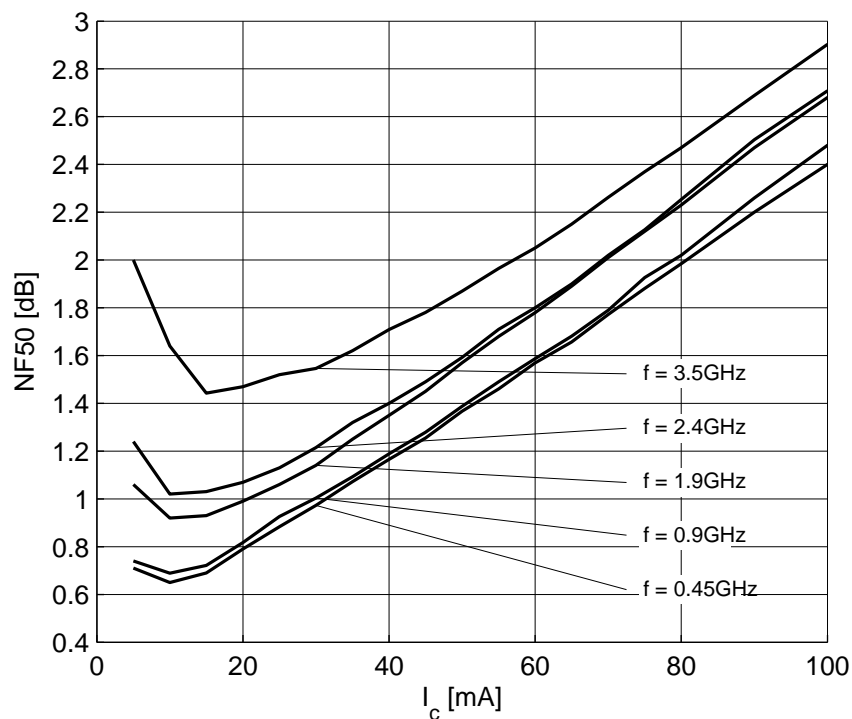


Figure 5-18 Noise Figure $NF_{50} = f(I_c)$, $V_{CE} = 3\text{ V}$, $Z_S = 50\ \Omega$, f = Parameter in GHz

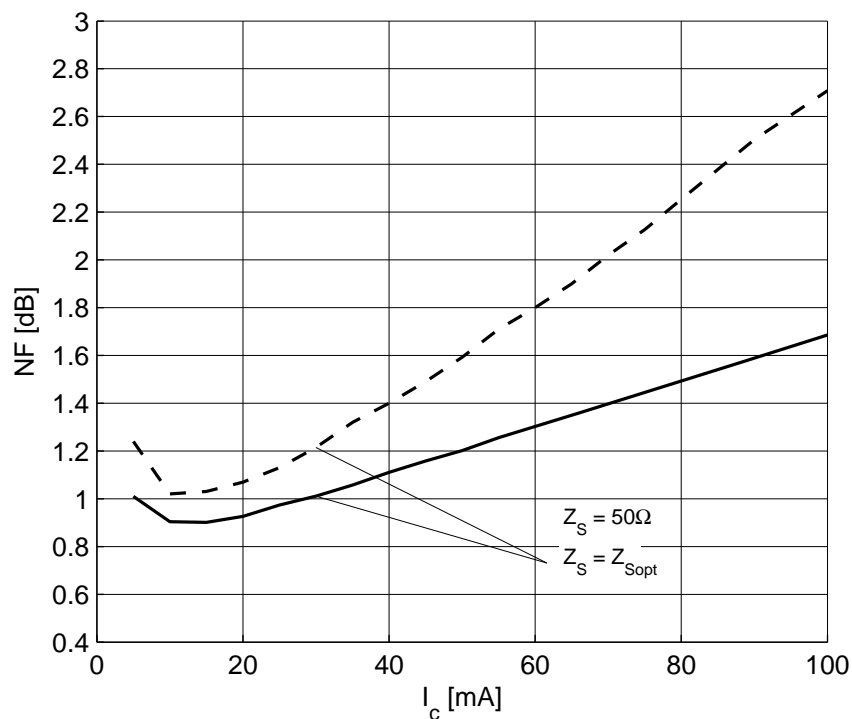


Figure 5-19 Comparison Noise Figure $NF_{50} / NF_{min} = f(I_c)$, $V_{CE} = 3\text{ V}$, $f = 2.4\text{ GHz}$

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. $T_A = 25\text{ }^\circ\text{C}$.

6 Simulation Data

For the SPICE Gummel Poon (GP) model as well as for the S-parameters (including noise parameters) please refer to our internet website: www.infineon.com/rf.models. Please consult our website and download the latest versions before actually starting your design.

You find the BFP650 SPICE GP model in the internet in MWO- and ADS-format, which you can import into these circuit simulation tools very quickly and conveniently. The model already contains the package parasitic and is ready to use for DC- and high frequency simulations. The terminals of the model circuit correspond to the pin configuration of the device.

The model parameters have been extracted and verified up to 10 GHz using typical devices. The BFP650 SPICE GP model reflects the typical DC- and RF-performance within the limitations which are given by the SPICE GP model itself.

7 Package Information SOT343

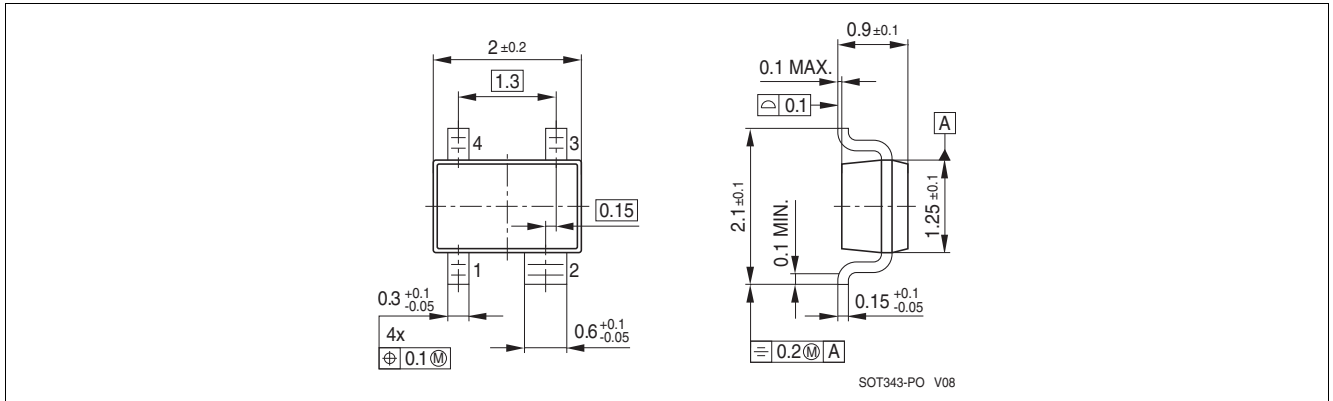


Figure 7-1 Package Outline

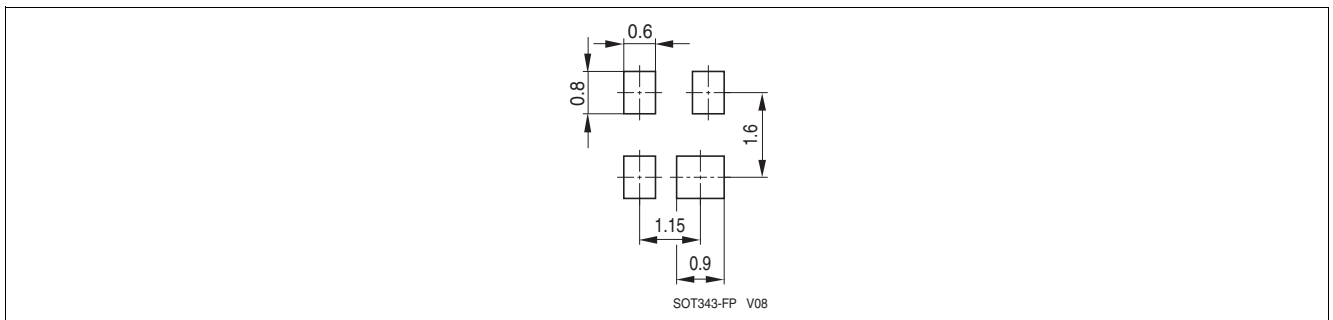


Figure 7-2 Package Footprint

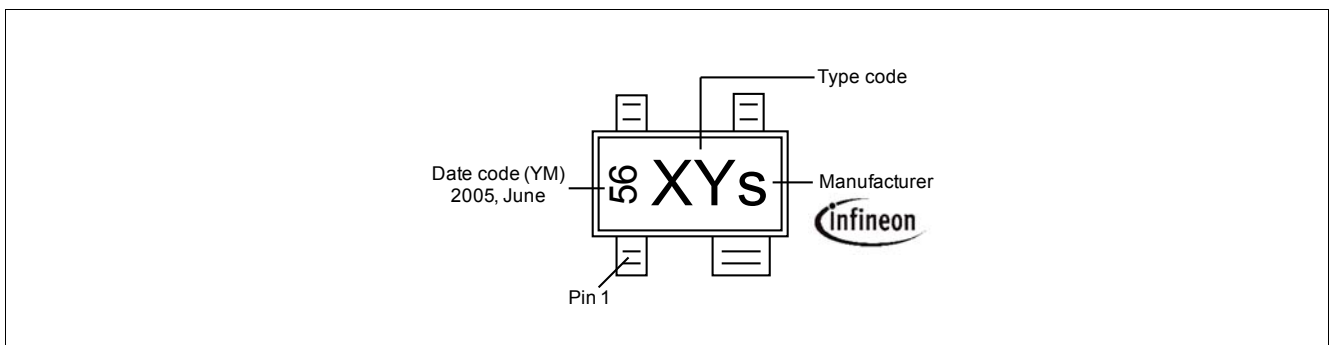


Figure 7-3 Marking Example (Marking BFP650: R5s)

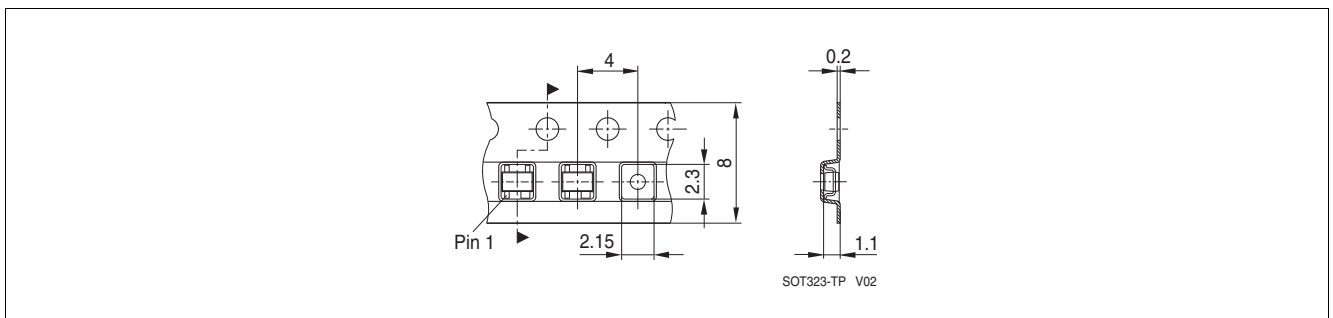


Figure 7-4 Tape dimensions

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