

# BFP650

High Linearity Low Noise SiGe:C NPN RF Transistor

## Data Sheet

Revision 1.0, 2010-10-22

**Edition 2010-10-22**

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

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**BFP650, High Linearity Low Noise SiGe:C NPN RF Transistor**
**Revision History: 2010-10-22, Revision 1.0**
**Previous Revision:**

Page	Subjects (changes since last revision)
	This datasheet replaces the revision from 16 Feb 2009. The product itself has not been changed and the device characteristics remain unchanged. Only the product description and information available in the datasheet have been expanded and updated. The old datasheet revision remains fully valid for those customers who have got the revision from 16 Feb 2009.
2	Typical values for leakage currents included, description of hFE updated.
3	Description of electrical parameters updated.
4, 5	Spice GP model parameters removed from datasheet, updated model parameters shifted to the internet simulation data section.
6	Pulse load curves removed.
7, 8	AC characteristic curves updated.

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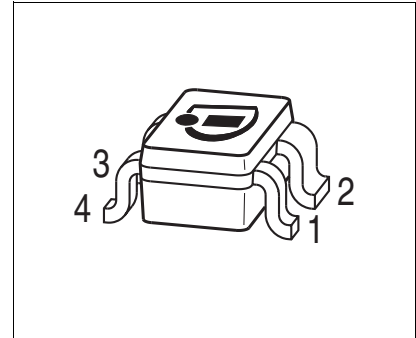
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## 1 Features

- Highly linear low noise driver amplifier for all RF frontends up to 4.5 GHz
- Output compression point  $OP_{1dB} = 17$  dBm at 70 mA, 3V, 2.4 GHz, 50Ω 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, 3V, 2.4 GHz
- Minimum noise figure  $NF_{min} = 1$  dB at 30 mA, 3V, 2.4 GHz
- Based on Infineon’s reliable, high volume SiGe:C wafer technology
- Easy to use Pb-free (RoHS compliant) standard package with visible leads
- Qualified according AEC Q101



### 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

## 2 Maximum Ratings

**Table 1** Maximum Ratings at  $T_A = 25^\circ\text{C}$  (unless otherwise specified)

Parameter	Symbol	Values		Unit	Note / Test Condition
		Min.	Max.		
Collector emitter voltage	$V_{\text{CEO}}$	–	4.0	V	Open base $T_A = 25^\circ\text{C}$
		–	3.7	V	$T_A = -55^\circ\text{C}$
Collector emitter voltage	$V_{\text{CES}}$	–	13	V	Emitter / base shortened
Collector base voltage	$V_{\text{CBO}}$	–	13	V	Open emitter
Emitter base voltage	$V_{\text{EBO}}$	–	1.2	V	Open collector
Collector current	$I_C$	–	150	mA	–
Base current	$I_B$	–	10	mA	–
Total power dissipation <sup>1)</sup>	$P_{\text{tot}}$	–	500	mW	$T_S \leq 80^\circ\text{C}$
Junction temperature	$T_J$	–	150	$^\circ\text{C}$	–
Storage temperature	$T_{\text{Stg}}$	-65	150	$^\circ\text{C}$	–

1)  $T_S$  is the soldering point temperature.  $T_S$  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.**

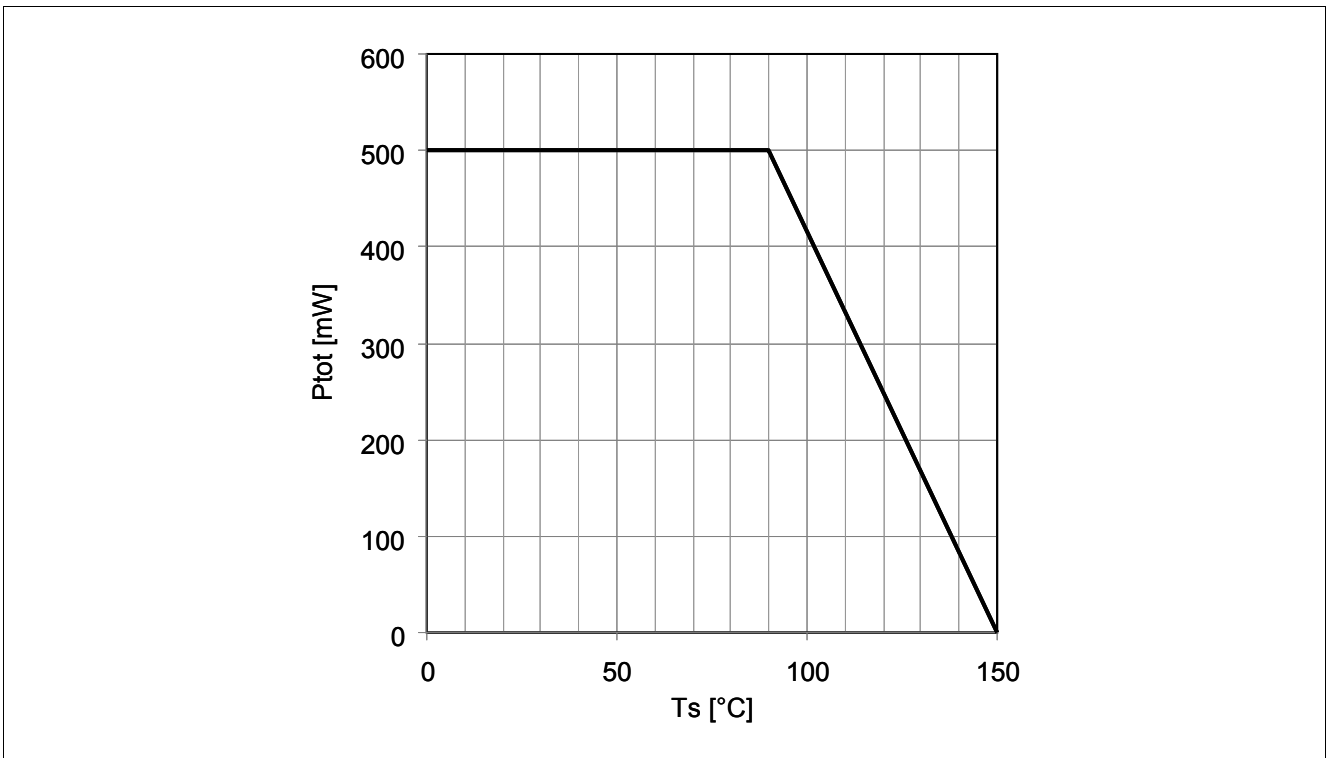


### 3 Thermal Characteristics

**Table 2 Thermal Resistance**

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

1) For calculation of  $R_{thJA}$  please refer to Application Note Thermal Resistance AN077



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

## 4 Electrical Characteristics

### 4.1 DC Characteristics

**Table 3 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	$I_{CES}$	–	–	100	$\mu\text{A}$	$V_{CE} = 13\text{ V}$ , $V_{BE} = 0$
		–	1	40	nA	$V_{CE} = 5\text{ V}$ , $V_{BE} = 0$ Emitter/base shortened
Collector base leakage current	$I_{CBO}$	–	1	40	nA	$V_{CB} = 5\text{ V}$ , $I_E = 0$ Open emitter
Emitter base leakage current	$I_{EBO}$	–	0.01	3	$\mu\text{A}$	$V_{EB} = 0.5\text{ V}$ , $I_C = 0$ Open collector
DC current gain	$h_{FE}$	100	170	250		$V_{CE} = 3\text{ V}$ , $I_C = 70\text{ mA}$ Pulse measured

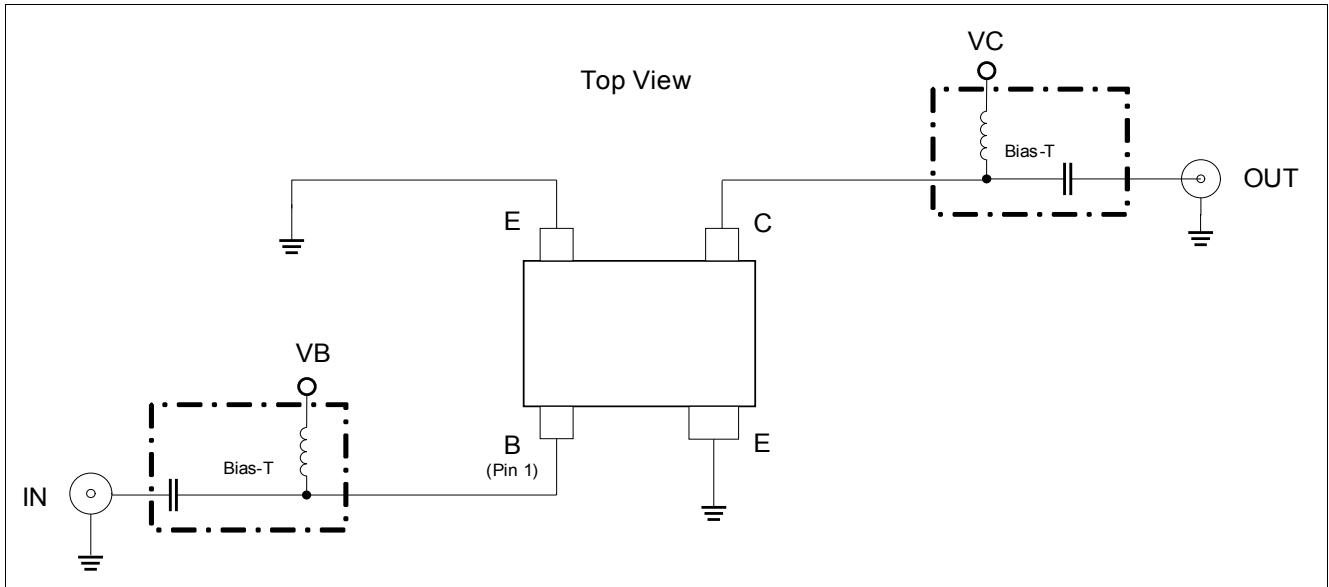
### 4.2 General AC Characteristics

**Table 4 General AC Characteristics at  $T_A = 25\text{ °C}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Transition frequency	$f_T$	31	41	–	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

### 4.3 Frequency Dependent AC Characteristics

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



**Figure 2 BFP650 Testing Circuit**

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

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
<b>Maximum power gain</b>					dB	
High linearity operation point	$G_{ms}$	–	35.5	–		$I_C = 30\text{ mA}$
Class A operation point	$G_{ms}$	–	38	–		$I_C = 70\text{ mA}$
<b>Transducer gain</b>					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	–		$I_C = 70\text{ mA}$
<b>Minimum noise figure</b>					dB	$Z_S = Z_{opt}$
Minimum noise figure	$NF_{min}$	–	0.75	–		$I_C = 30\text{ mA}$
Associated gain	$G_{ass}$	–	32	–		$I_C = 30\text{ mA}$
<b>Linearity</b>					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	–		$I_C = 70\text{ mA}$

**Table 6 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 450\text{ MHz}$**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
<b>Maximum power gain</b>					dB	
High linearity operation point	$G_{ms}$	–	30	–		$I_C = 30\text{ mA}$
Class A operation point	$G_{ms}$	–	31.5	–		$I_C = 70\text{ mA}$

**Table 6 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 450\text{ MHz}$  (cont'd)**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
<b>Transducer gain</b>					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	–		$I_C = 70\text{ mA}$
<b>Minimum noise figure</b>					dB	$Z_S = Z_{opt}$
Minimum noise figure	$NF_{min}$	–	0.75	–		$I_C = 30\text{ mA}$
Associated gain	$G_{ass}$	–	29.5	–		$I_C = 30\text{ mA}$
<b>Linearity</b>					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 7 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 900\text{ MHz}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
<b>Maximum power gain</b>					dB	
High linearity operation point	$G_{ms}$	–	25.5	–		$I_C = 30\text{ mA}$
Class A operation point	$G_{ms}$	–	26.5	–		$I_C = 70\text{ mA}$
<b>Transducer gain</b>					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	–		$I_C = 70\text{ mA}$
<b>Minimum noise figure</b>					dB	$Z_S = Z_{opt}$
Minimum noise figure	$NF_{min}$	–	0.8	–		$I_C = 30\text{ mA}$
Associated gain	$G_{ass}$	–	24.5	–		$I_C = 30\text{ mA}$
<b>Linearity</b>					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 8 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 1.5\text{ GHz}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
<b>Maximum power gain</b>					dB	
High linearity operation point	$G_{ms}$	–	22	–		$I_C = 30\text{ mA}$
Class A operation point	$G_{ms}$	–	22.5	–		$I_C = 70\text{ mA}$
<b>Transducer gain</b>					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	–		$I_C = 70\text{ mA}$
<b>Minimum noise figure</b>					dB	$Z_S = Z_{opt}$
Minimum noise figure	$NF_{min}$	–	0.85	–		$I_C = 30\text{ mA}$

**Electrical Characteristics**
**Table 8 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 1.5\text{ GHz}$  (cont'd)**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Associated gain	$G_{ass}$	–	20.5	–		$I_C = 30\text{ mA}$
<b>Linearity</b>					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 9 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 1.9\text{ GHz}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
<b>Maximum power gain</b>					dB	
High linearity operation point	$G_{ma}$	–	20.5	–		$I_C = 30\text{ mA}$
Class A operation point	$G_{ms}$	–	20	–		$I_C = 70\text{ mA}$
<b>Transducer gain</b>					dB	$Z_S = Z_L = 50\ \Omega$
High linearity operation point	$S_{21}$	–	17	–		$I_C = 30\text{ mA}$
Class A operation point	$S_{21}$	15	17.5	–		$I_C = 70\text{ mA}$
<b>Minimum noise figure</b>					dB	$Z_S = Z_{opt}$
Minimum noise figure	$NF_{min}$	–	0.95	–		$I_C = 30\text{ mA}$
Associated gain	$G_{ass}$	–	17.5	–		$I_C = 30\text{ mA}$
<b>Linearity</b>					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	–		$I_C = 70\text{ mA}$

**Table 10 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 2.4\text{ GHz}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
<b>Maximum power gain</b>					dB	
High linearity operation point	$G_{ma}$	–	18	–		$I_C = 30\text{ mA}$
Class A operation point	$G_{ma}$	–	17.5	–		$I_C = 70\text{ mA}$
<b>Transducer gain</b>					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	–		$I_C = 70\text{ mA}$
<b>Minimum noise figure</b>					dB	$Z_S = Z_{opt}$
Minimum noise figure	$NF_{min}$	–	1	–		$I_C = 30\text{ mA}$
Associated gain	$G_{ass}$	–	15	–		$I_C = 30\text{ mA}$
<b>Linearity</b>					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 11 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 3.5\text{ GHz}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
<b>Maximum power gain</b>					dB	
High linearity operation point	$G_{ma}$	–	14	–		$I_C = 30\text{ mA}$
Class A operation point	$G_{ma}$	–	14.5	–		$I_C = 70\text{ mA}$
<b>Transducer gain</b>					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	–		$I_C = 70\text{ mA}$
<b>Minimum noise figure</b>					dB	$Z_S = Z_{opt}$
Minimum noise figure	$NF_{min}$	–	1.2	–		$I_C = 30\text{ mA}$
Associated gain	$G_{ass}$	–	11.5	–		$I_C = 30\text{ mA}$
<b>Linearity</b>					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 12 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 5.5\text{ GHz}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
<b>Maximum power gain</b>					dB	
High linearity operation point	$G_{ma}$	–	10.5	–		$I_C = 30\text{ mA}$
Class A operation point	$G_{ma}$	–	10.5	–		$I_C = 70\text{ mA}$
<b>Transducer gain</b>					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	–		$I_C = 70\text{ mA}$
<b>Minimum noise figure</b>					dB	$Z_S = Z_{opt}$
Minimum noise figure	$NF_{min}$	–	1.6	–		$I_C = 30\text{ mA}$
Associated gain	$G_{ass}$	–	8.5	–		$I_C = 30\text{ mA}$
<b>Linearity</b>					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	–		$I_C = 70\text{ mA}$

Note:

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.

### 4.4 Characteristic DC Diagrams

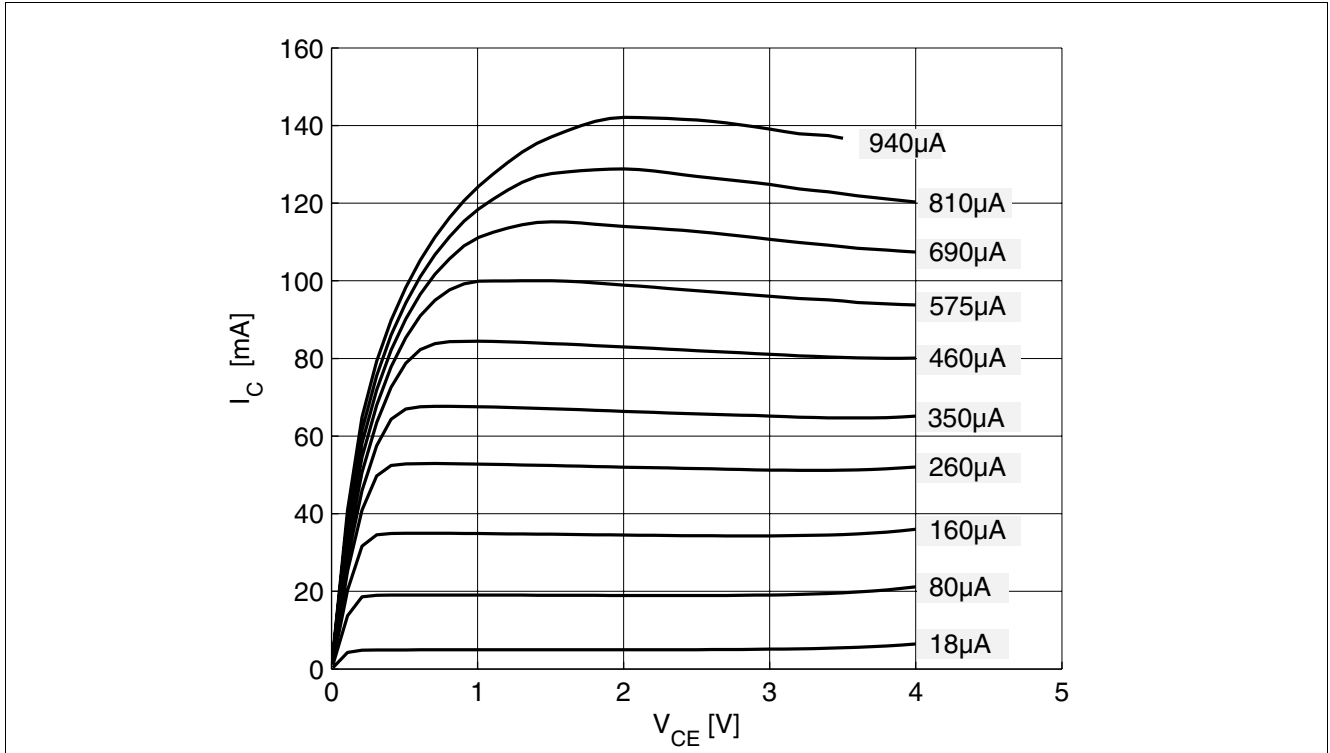


Figure 3 Collector Current vs. Collector Emitter Voltage  $I_C = f(V_{CE})$ ,  $I_B = \text{Parameter}$

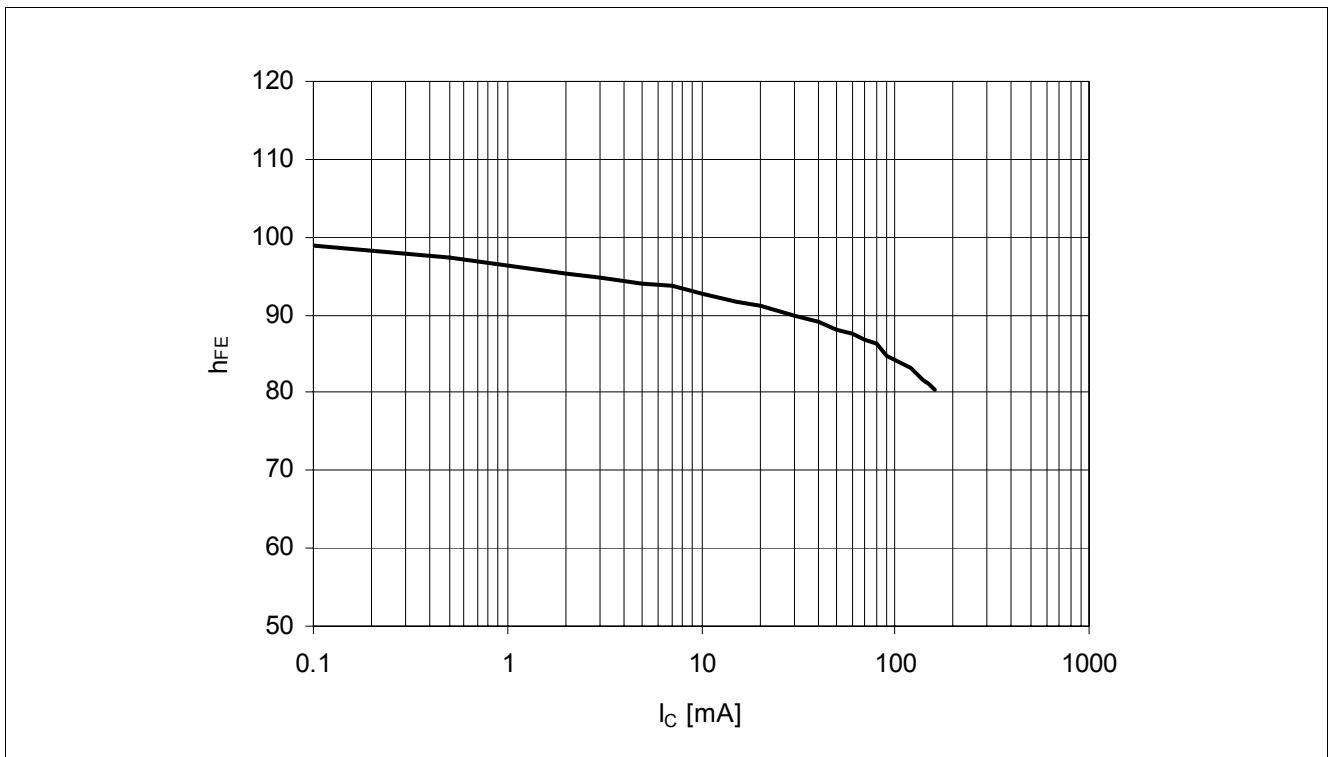


Figure 4 DC Current Gain  $h_{FE} = f(I_C)$ ,  $V_{CE} = 3 \text{ V}$

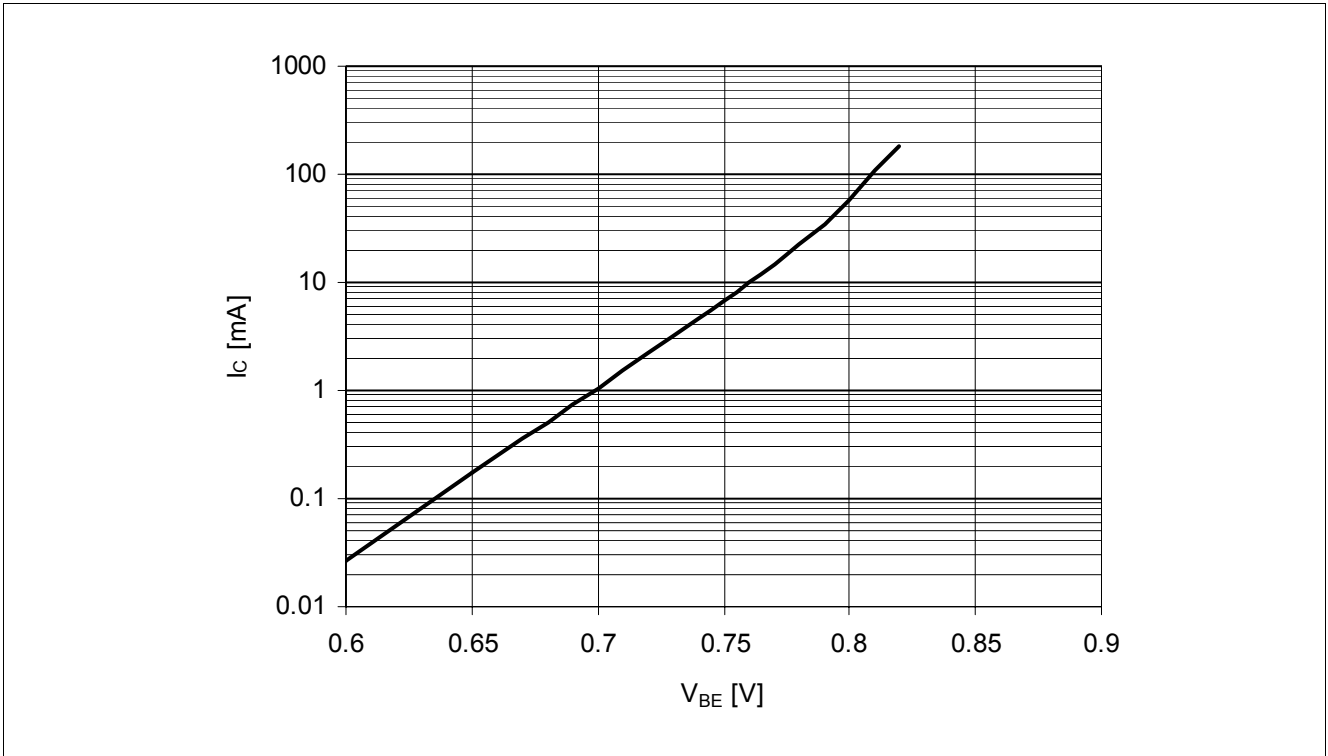


Figure 5 Collector Current vs. Base Emitter Voltage  $I_C = f(V_{BE})$ ,  $V_{CE} = 2\text{ V}$

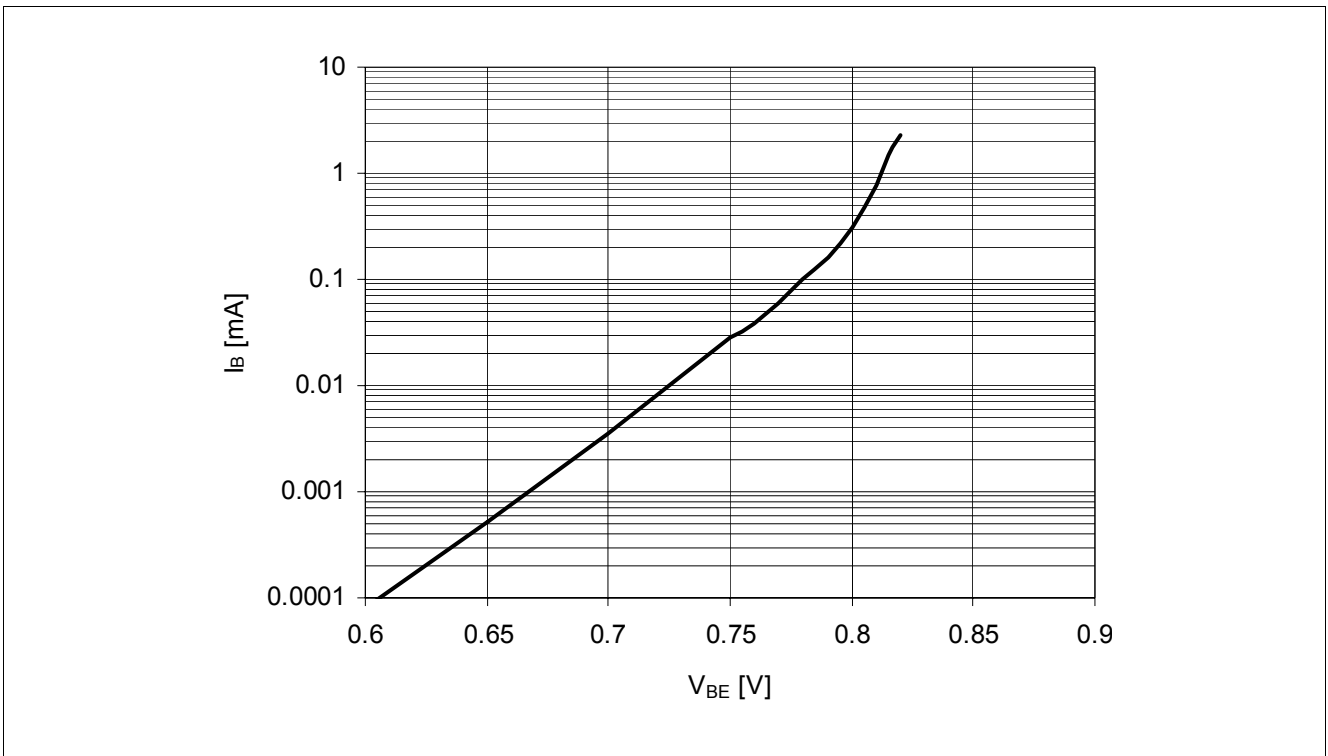


Figure 6 Base Current vs. Base Emitter Forward Voltage  $I_B = f(V_{BE})$ ,  $V_{CE} = 2\text{ V}$



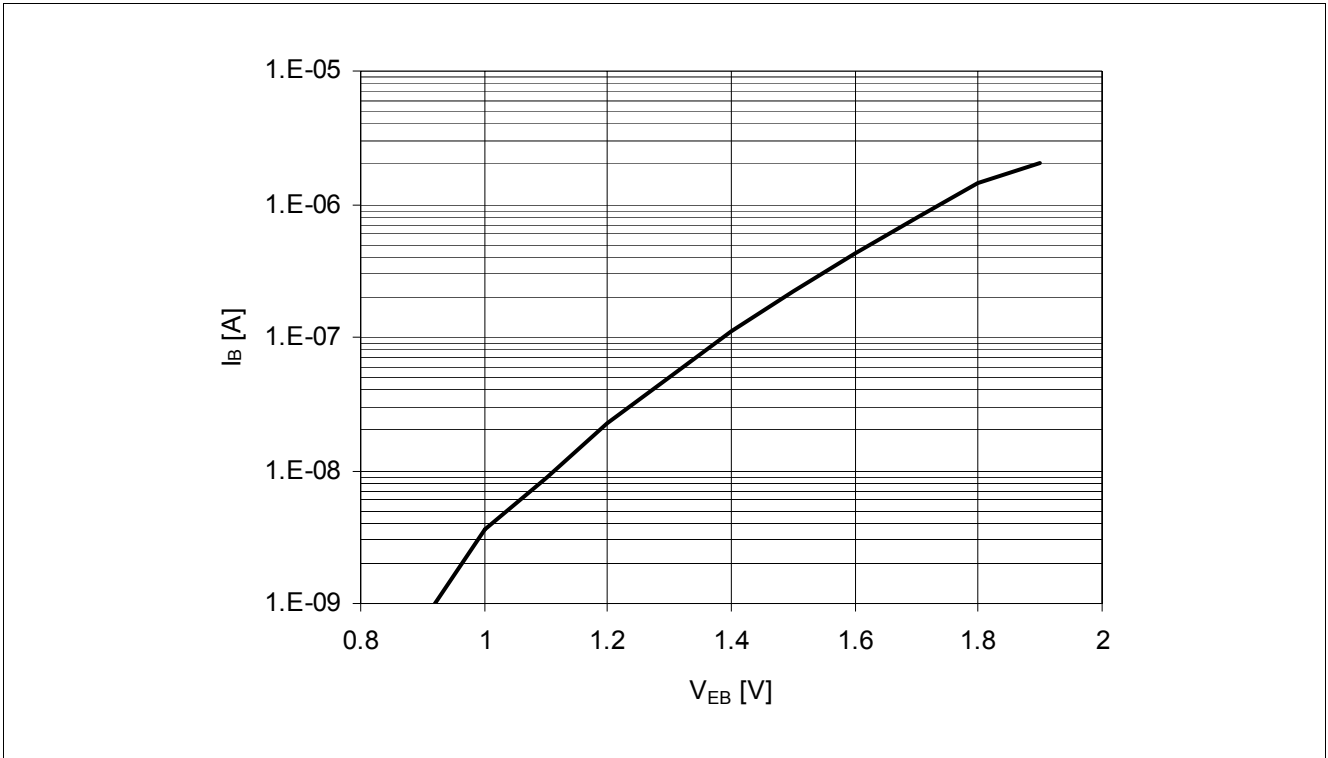


Figure 7 Base Current vs. Base Emitter Reverse Voltage  $I_B = f(V_{EB}), V_{CE} = 2\text{ V}$

### 4.5 Characteristic AC Diagrams

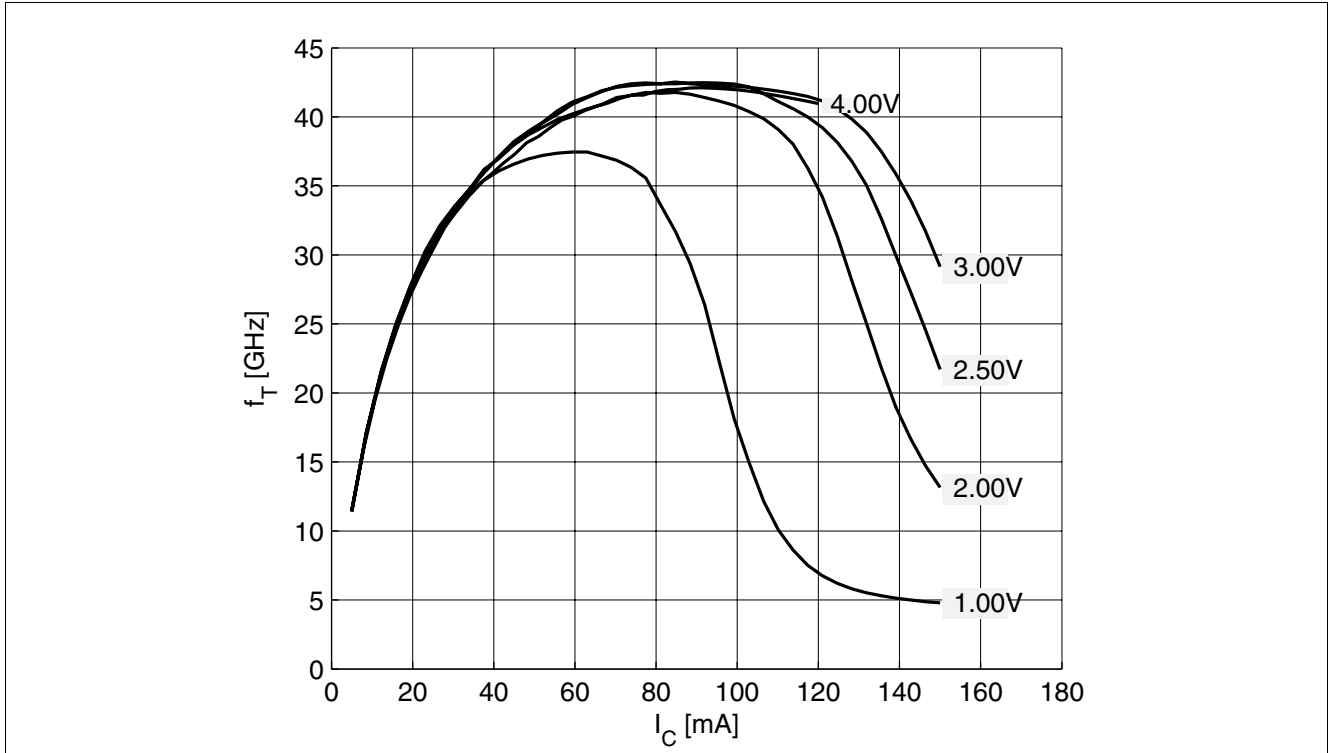


Figure 8 Transition Frequency  $f_T = f(I_C)$ ,  $f = 1 \text{ GHz}$ ,  $V_{CE} = \text{Parameter}$

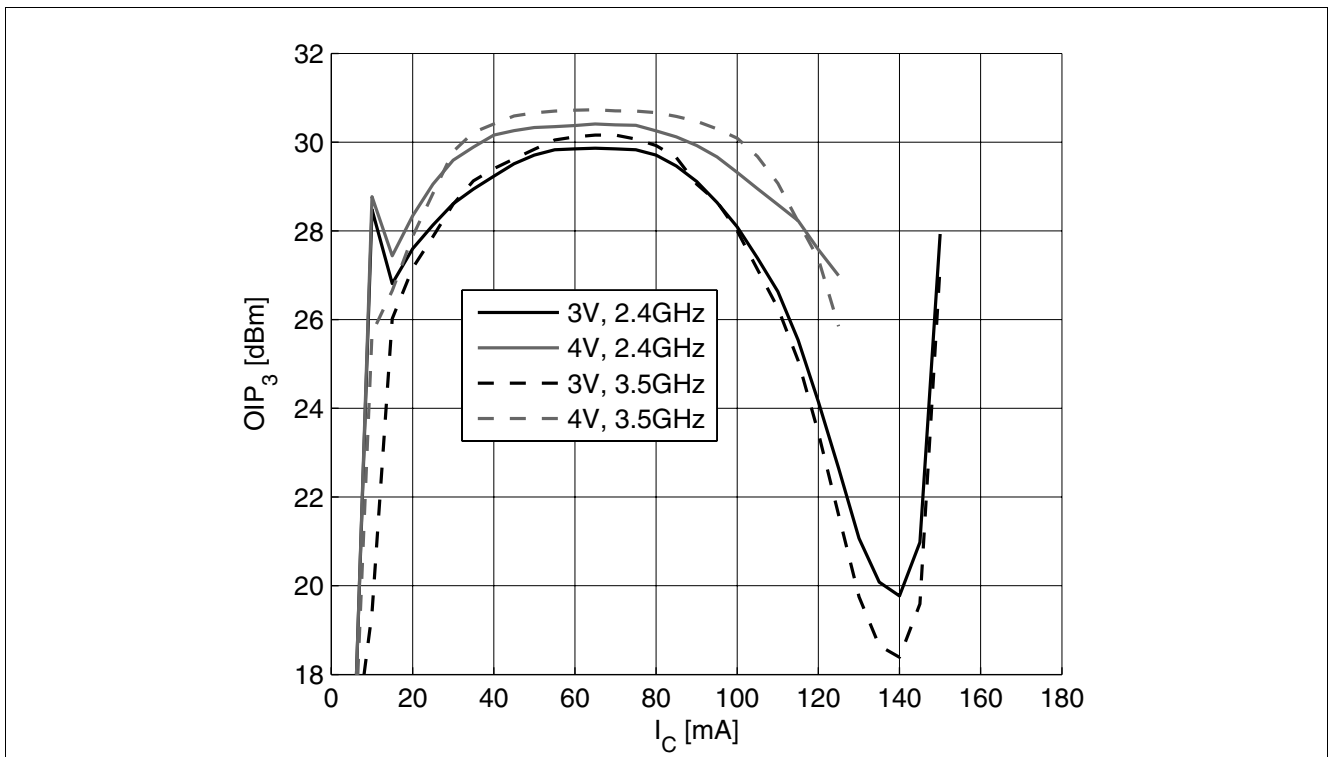


Figure 9 3rd Order Intercept Point  $OIP_3 = f(I_C)$ ,  $Z_S = Z_L = 50 \Omega$ ,  $V_{CE}, f = \text{Parameters}$

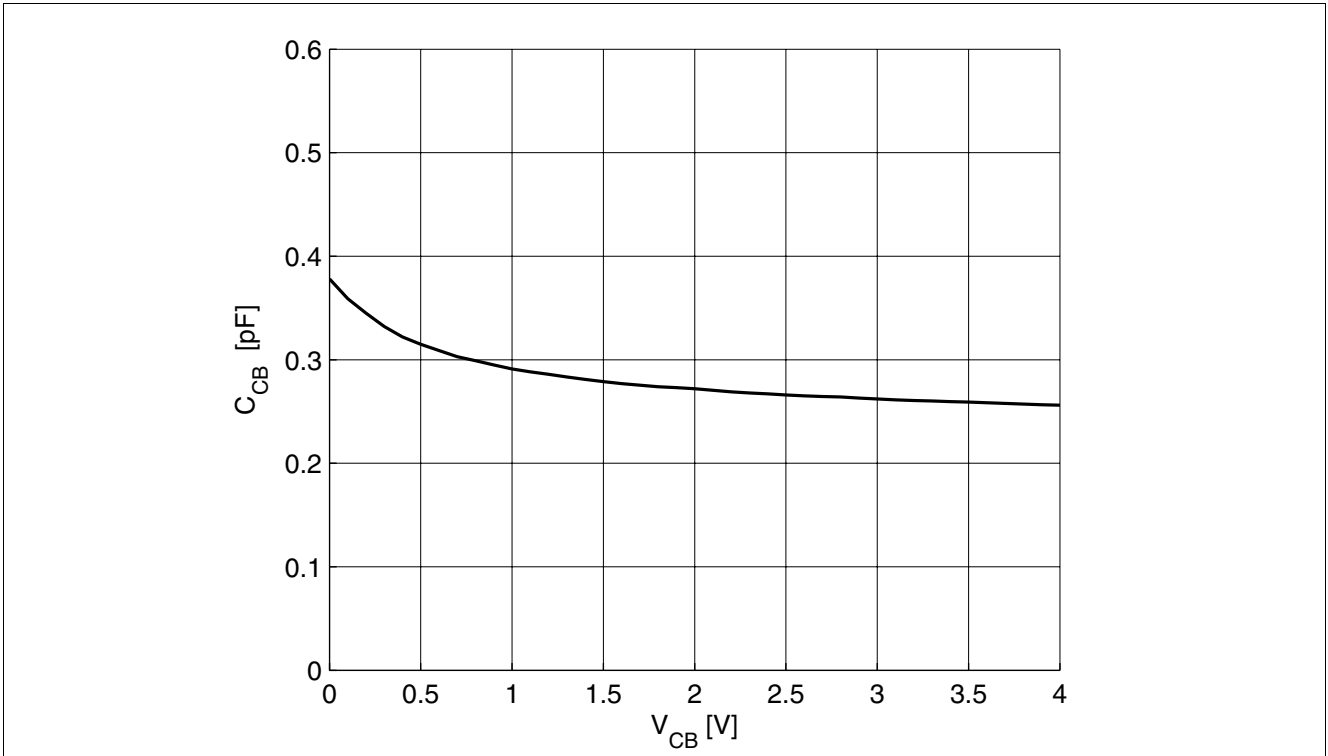


Figure 10 Collector Base Capacitance  $C_{CB} = f(V_{CB})$ ,  $f = 1$  MHz

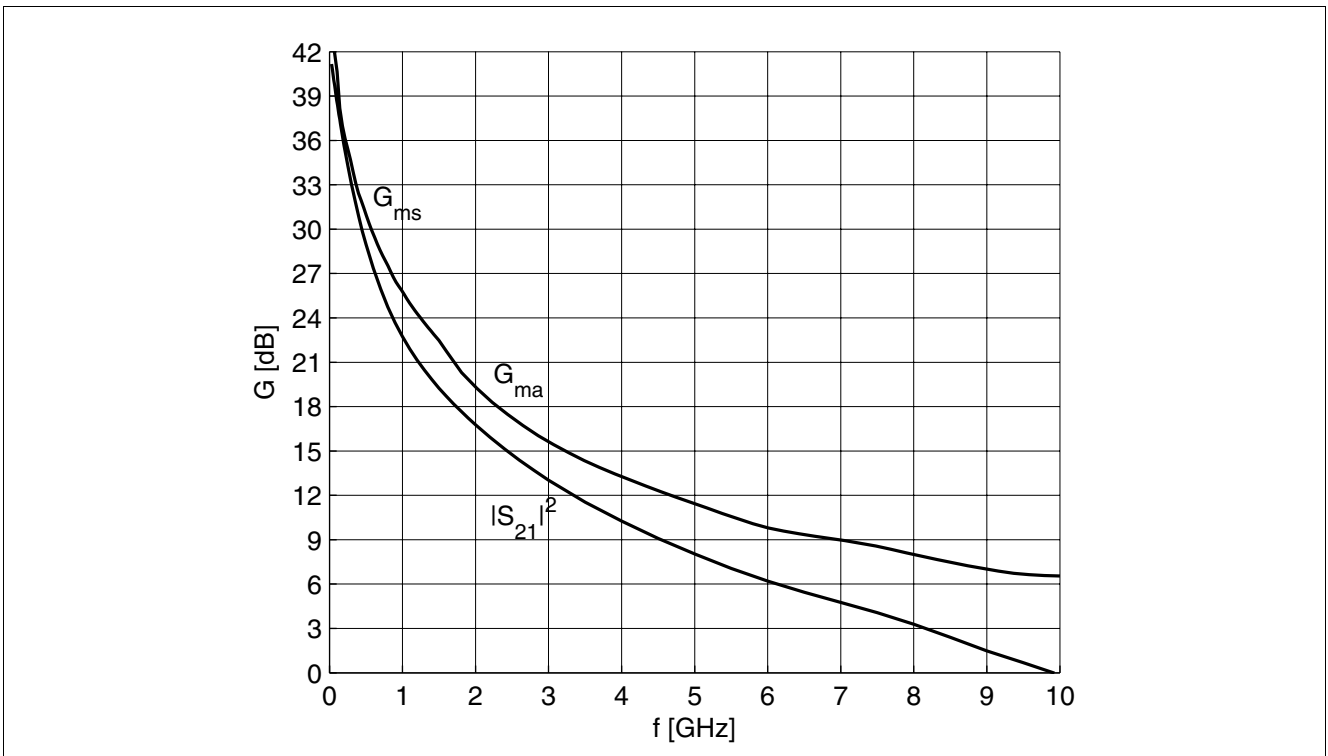


Figure 11 Gain  $G_{ma}$ ,  $G_{ms}$ ,  $|S_{21}|^2 = f(f)$ ,  $V_{CE} = 3$  V,  $I_C = 70$  mA

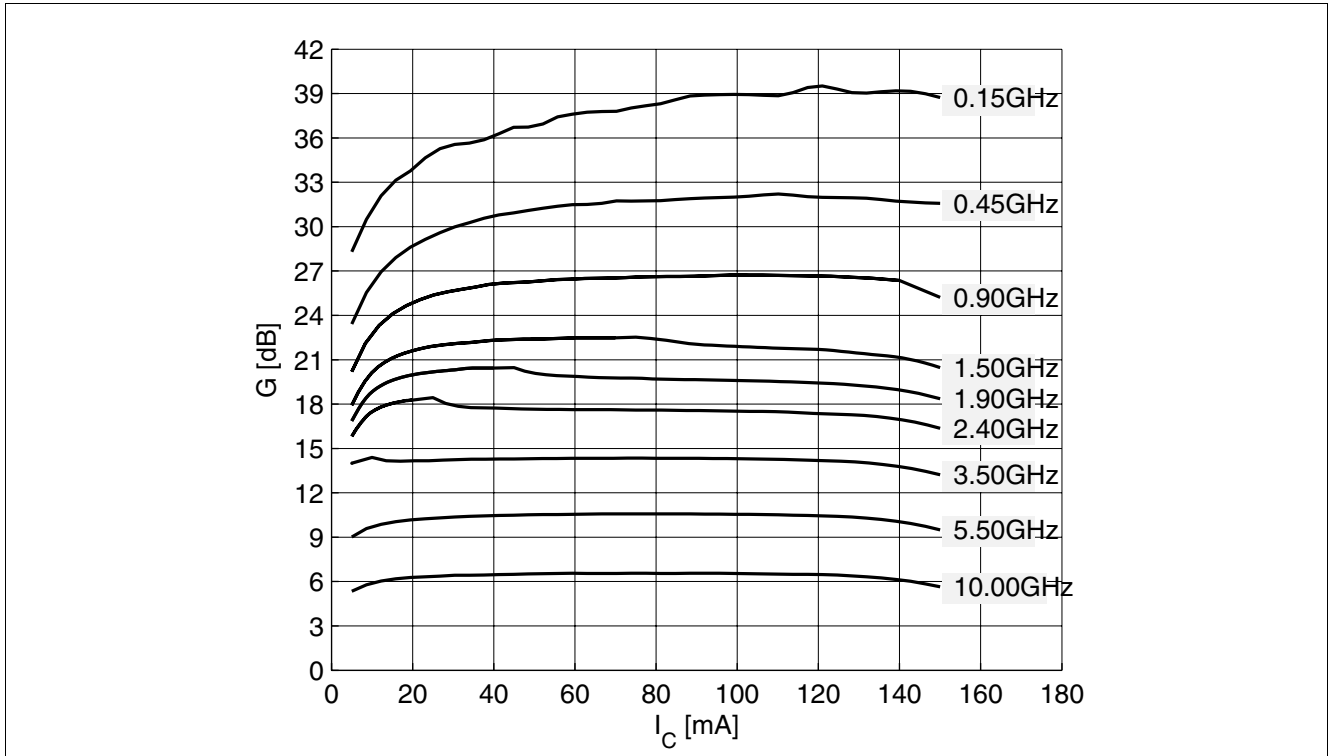


Figure 12 Maximum Power Gain  $G_{\max} = f(I_C)$ ,  $V_{CE} = 3\text{ V}$ ,  $f = \text{Parameter in GHz}$

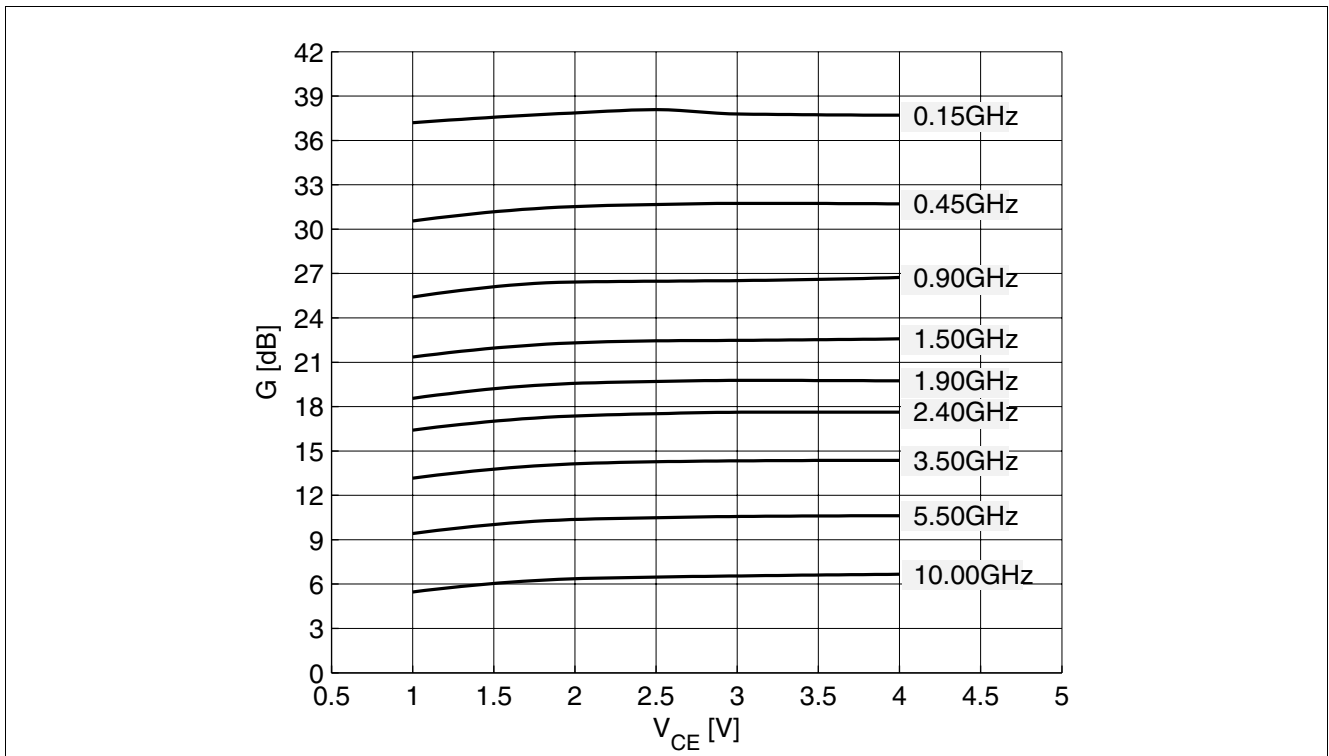


Figure 13 Maximum Power Gain  $G_{\max} = f(V_{CE})$ ,  $I_C = 70\text{ mA}$ ,  $f = \text{Parameter in GHz}$

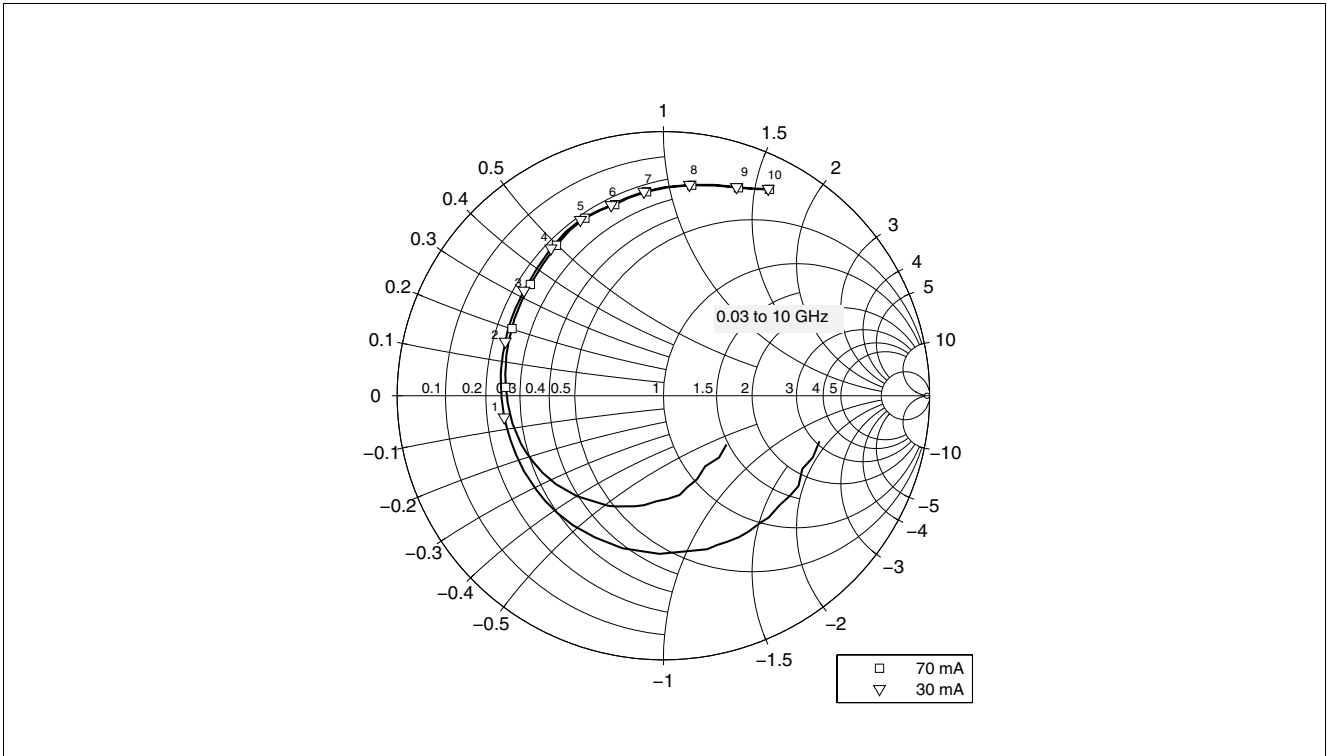


Figure 14 Input Matching  $S_{11} = f(f)$ ,  $V_{CE} = 3\text{ V}$ ,  $I_C = 30 / 70\text{ mA}$

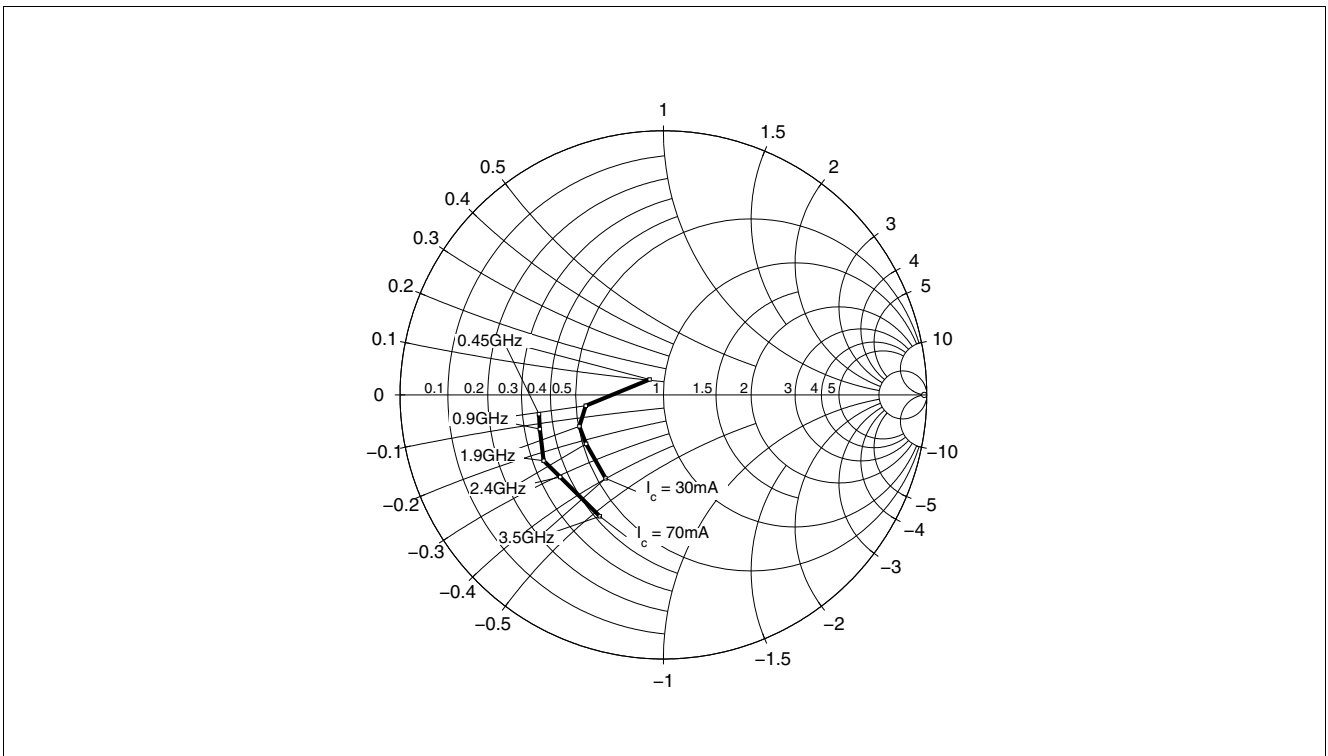


Figure 15 Source Impedance for Minimum Noise Figure  $Z_{opt} = f(f)$ ,  $V_{CE} = 3\text{ V}$ ,  $I_C = 30 / 70\text{ mA}$

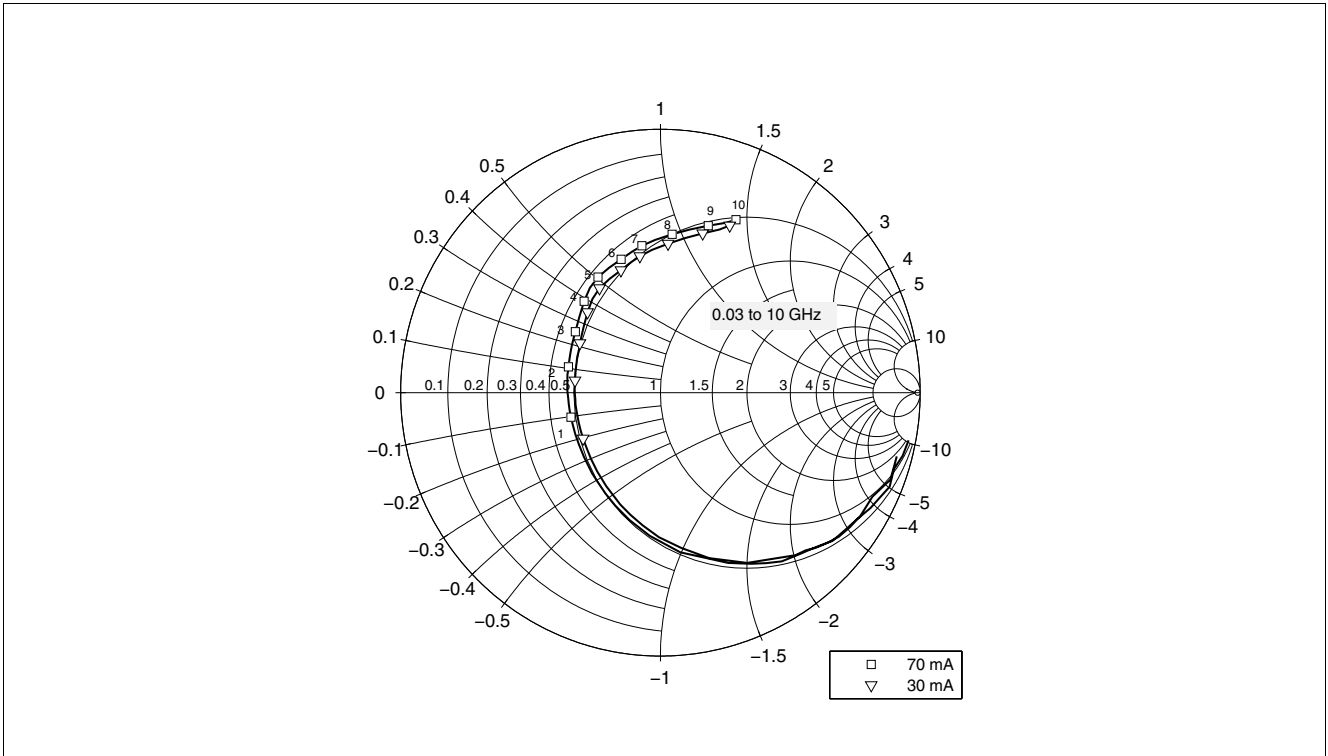


Figure 16 Output Matching  $S_{22} = f(f)$ ,  $V_{CE} = 3 \text{ V}$ ,  $I_C = 30 / 70 \text{ mA}$

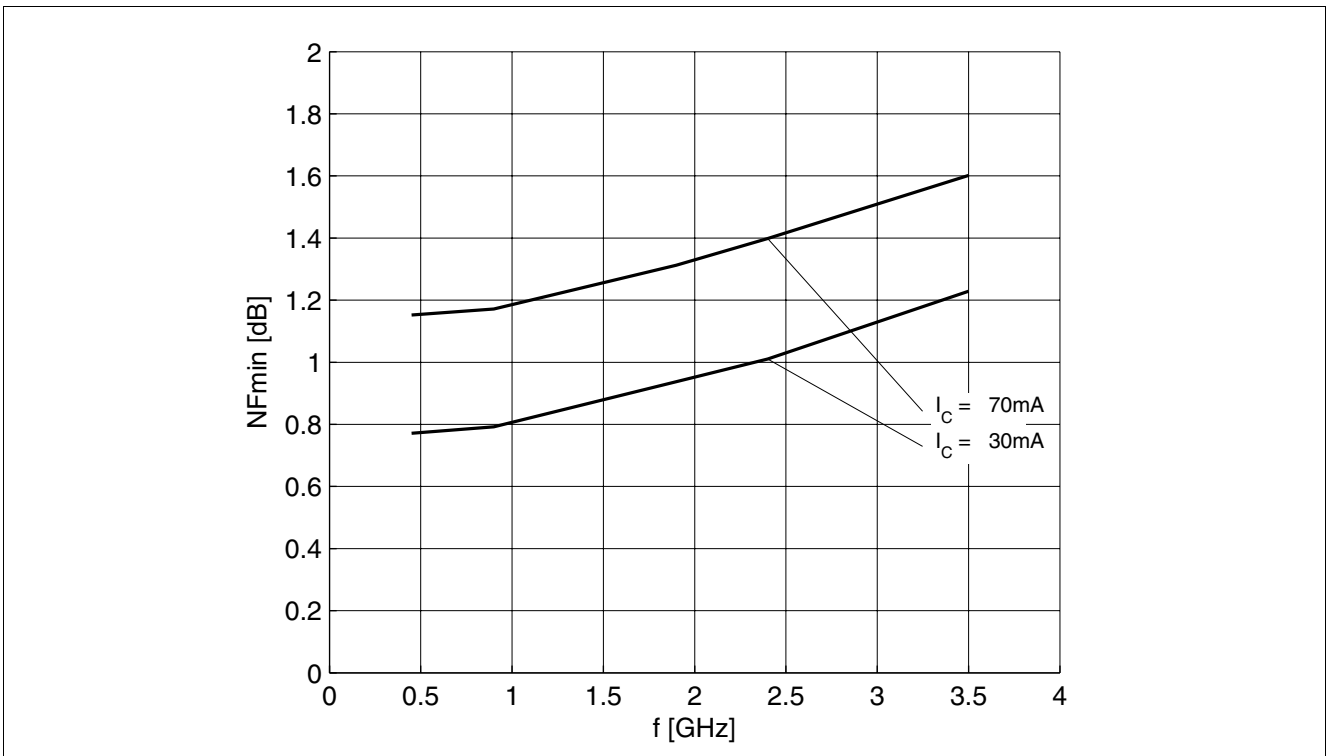


Figure 17 Noise Figure  $NF_{min} = f(f)$ ,  $V_{CE} = 3 \text{ V}$ ,  $I_C = 30 / 70 \text{ mA}$ ,  $Z_S = Z_{opt}$

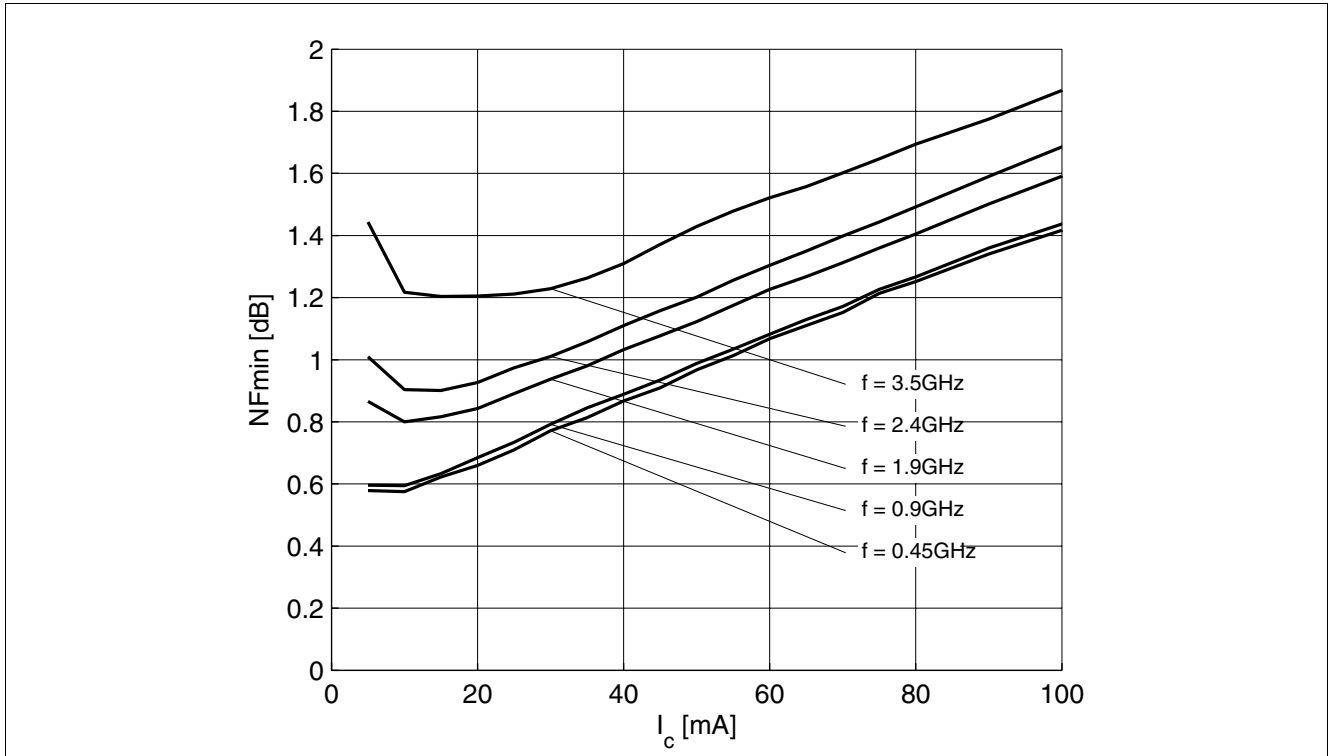


Figure 18 Noise Figure  $NF_{min} = f(I_C)$ ,  $V_{CE} = 3\text{ V}$ ,  $Z_S = Z_{opt}$ ,  $f = \text{Parameter in GHz}$

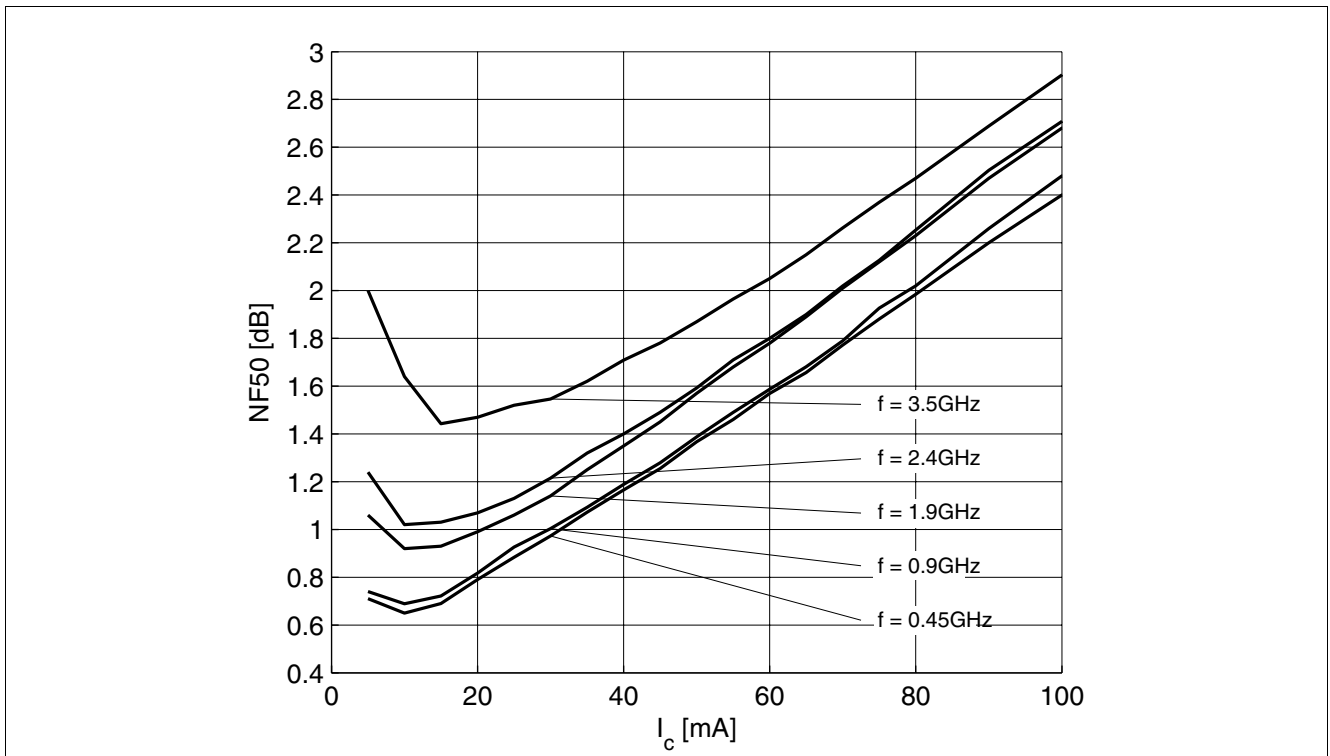


Figure 19 Noise Figure  $NF_{50} = f(I_C)$ ,  $V_{CE} = 3\text{ V}$ ,  $Z_S = 50\ \Omega$ ,  $f = \text{Parameter in GHz}$

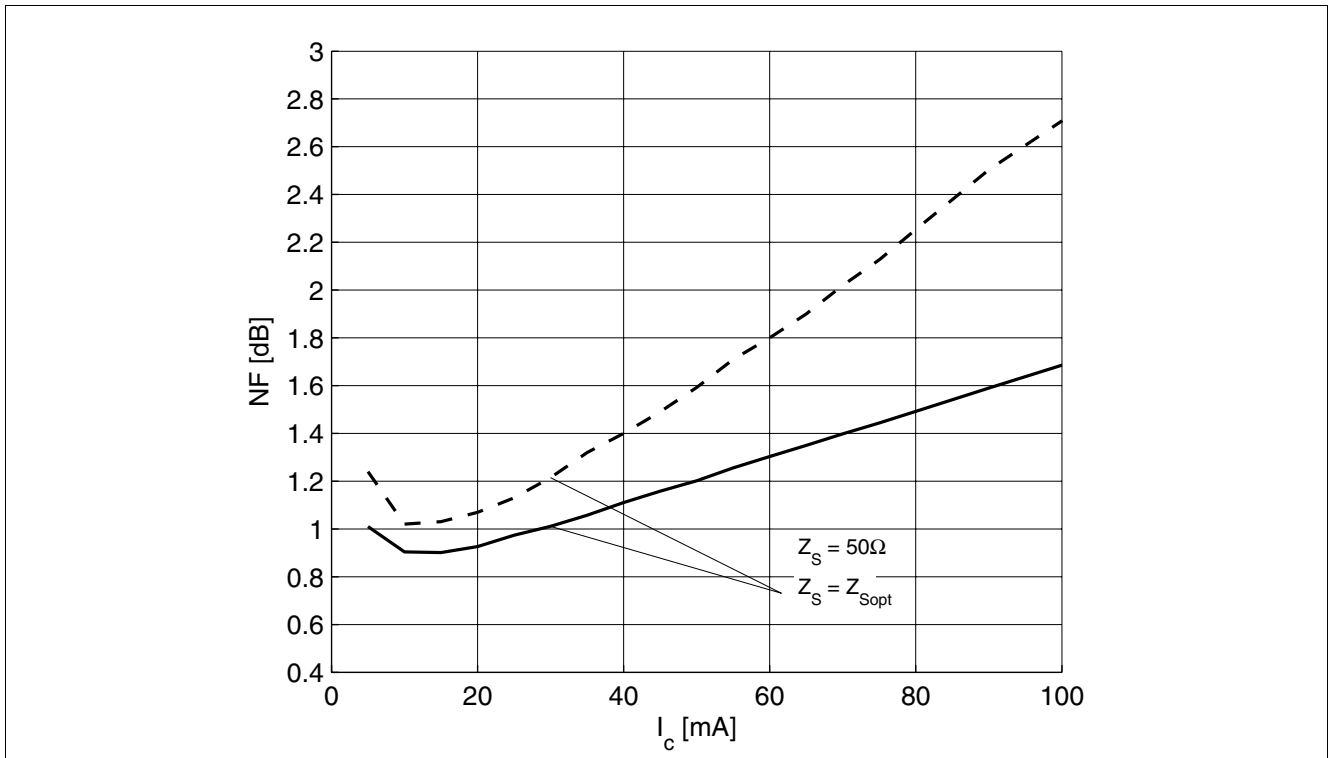


Figure 20 Comparison Noise Figure  $NF_{50} / NF_{min} = f(I_C)$ ,  $V_{CE} = 3\text{ V}$ ,  $f = 2.4\text{ GHz}$

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



## 5 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](http://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 parasitics 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.

## 6 Package Information SOT343

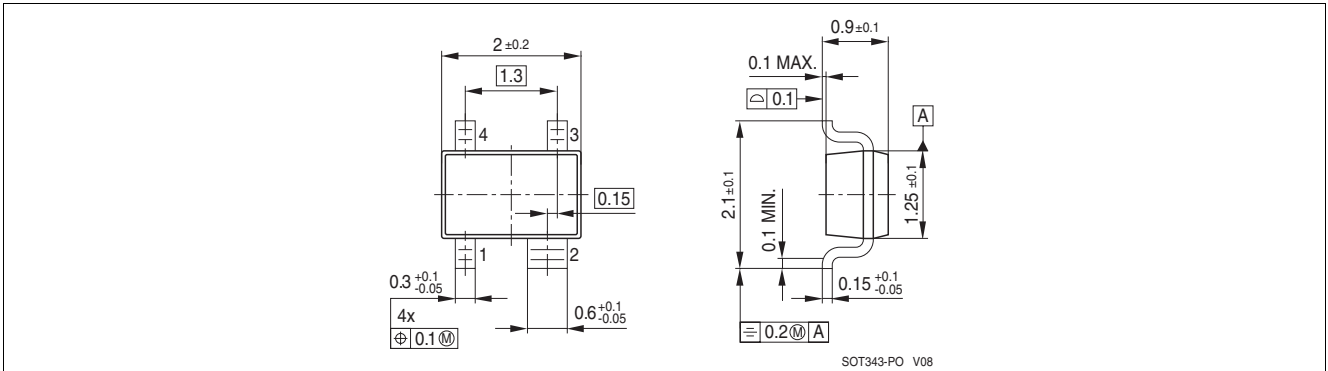


Figure 21 Package Outline

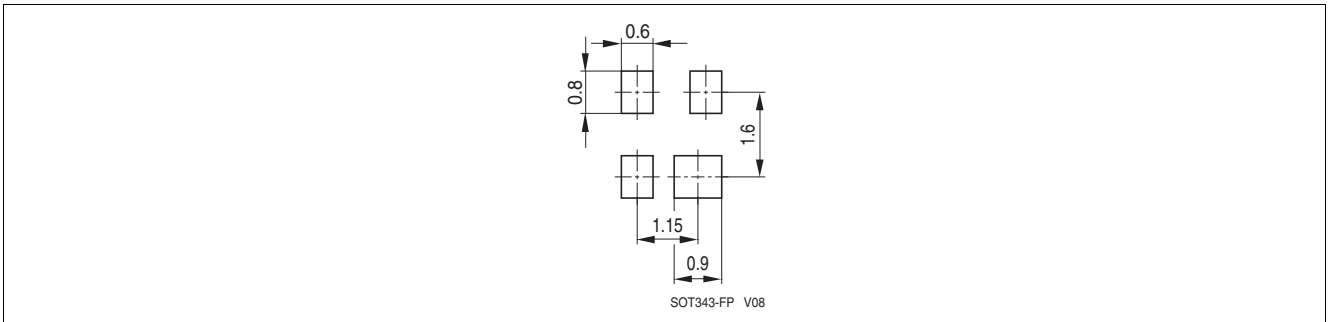


Figure 22 Package Foot Print

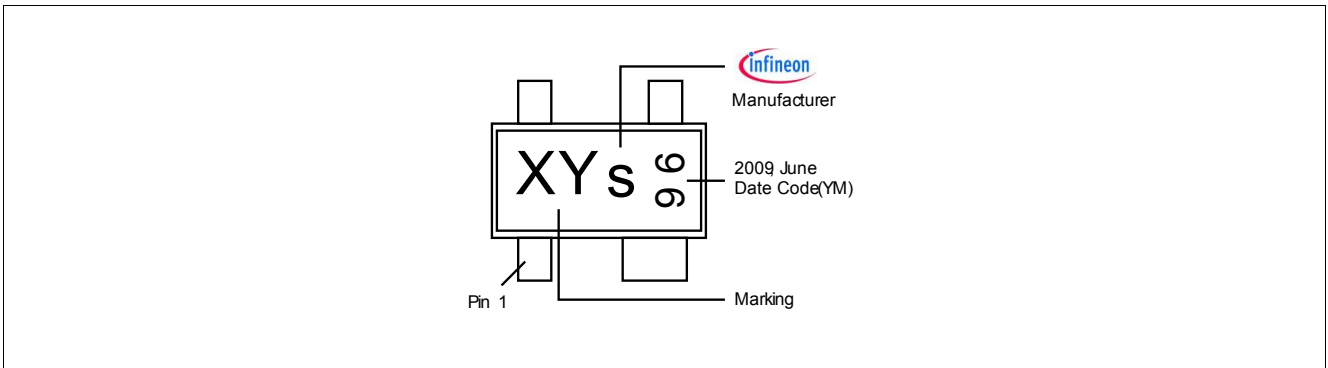


Figure 23 Marking Description (Marking BFP650: R5s)

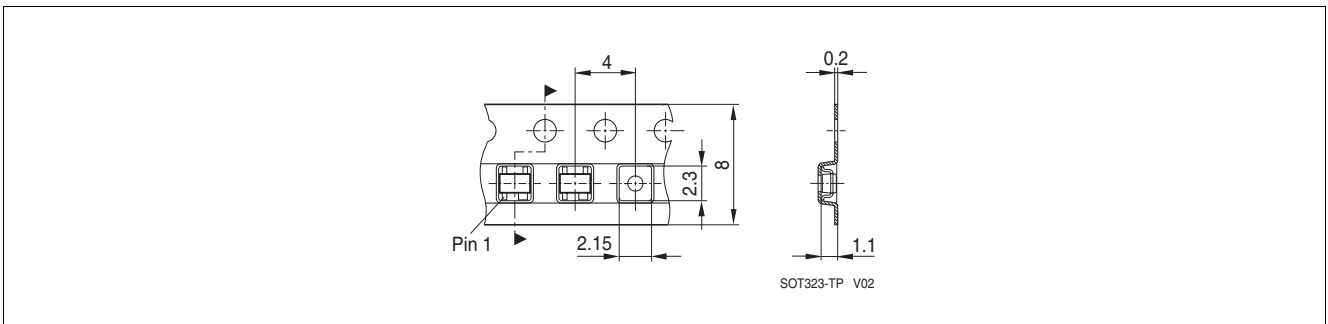


Figure 24 Tape Dimensions

[www.infineon.com](http://www.infineon.com)

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