

# BFP640F

Low Noise Silicon Germanium Bipolar RF Transistor

## Data Sheet

Revision 2.0, 2015-03-13

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**BFP640F, Low Noise Silicon Germanium Bipolar RF Transistor**
**Revision History: 2015-03-13, Revision 2.0**

Page	Subjects (major changes since last revision)
	This data sheet replaces the revision from 2007-05-31. The reason for the new revision is to increase the information content for the circuit designer. The performance parameters are now enlisted in a table containing many relevant application frequencies. The measurements of typical devices have been repeated and the device description has been expanded by adding several new characteristic curves. For customers who bought the product prior to the issue of the new revision the old specifications remain valid.

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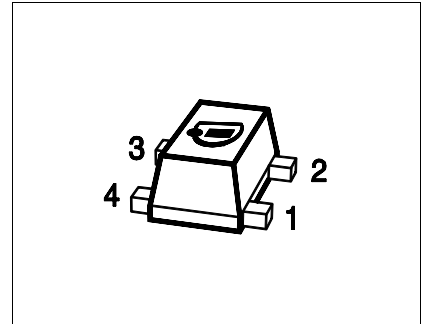
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## 1 Product Brief

The BFP640F is linear very low noise 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  $V_{CE} = 4.1$  V and currents up to  $I_C = 50$  mA. With its high linearity at currents as low as 10 mA (see Fig. 5-8) the device supports energy efficient designs. The typical transition frequency is approximately 40 GHz, hence the device offers high power gain at frequencies up to 8 GHz in amplifier applications. The device is housed in a thin small flat plastic package with visible leads.

## 2 Features

- Linear low noise amplifier based on Infineon’s reliable, high volume SiGe:C technology
- High linearity  $OIP3 = 27.5 \text{ dBm @ } 5.5 \text{ GHz, } 3 \text{ V, } 25 \text{ mA}$
- High transition frequency  $f_T = 42 \text{ GHz @ } 3 \text{ V, } 30 \text{ mA}$
- $NF_{\min} = 0.75 \text{ dB @ } 3.5 \text{ GHz, } 3 \text{ V, } 6 \text{ mA}$
- Maximum power gain  $G_{ma} = 16.5 \text{ dB @ } 3.5 \text{ GHz, } 3 \text{ V, } 25 \text{ mA}$
- Low power consumption, ideal for mobile applications
- Very common as GPS low noise amplifier, see respective application notes on Infineon internet page
- Easy to use Pb-free (RoHS compliant) and halogen-free standard package with visible leads
- Qualification report according to AEC-Q101 available



### Applications

As Low Noise Amplifier (LNA) in

- Satellite communication systems: Navigation systems (GPS, Glonass), satellite radio (SDARs, DAB) and C-band LNB
- Mobile, portable and fixed connectivity applications: WLAN 802.11a/b/g/n/ac, WiMAX 2.5/3.5/5.5 GHz, UWB, Bluetooth
- Multimedia applications such as mobile/portable TV, CATV, FM Radio
- 3G/4G UMTS/LTE mobile phone applications
- ISM applications like RKE, AMR and Zigbee, as well as for emerging wireless applications

As discrete active mixer, amplifier in VCOs and buffer amplifier

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

Product Name	Package	Pin Configuration				Marking
BFP640F	TSFP-4-1	1 = B	2 = E	3 = C	4 = E	R4s



### 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	$V_{CEO}$	– –	4.1 3.6	V	Open base $T_A = 25\text{ °C}$ $T_A = -55\text{ °C}$
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	$I_C$	–	50	mA	–
Base current	$I_B$	–	3	mA	–
Total power dissipation <sup>1)</sup>	$P_{tot}$	–	200	mW	$T_S \leq 92\text{ °C}$
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 <sup>1)</sup>	$R_{thJS}$	–	–	290	K/W	–

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

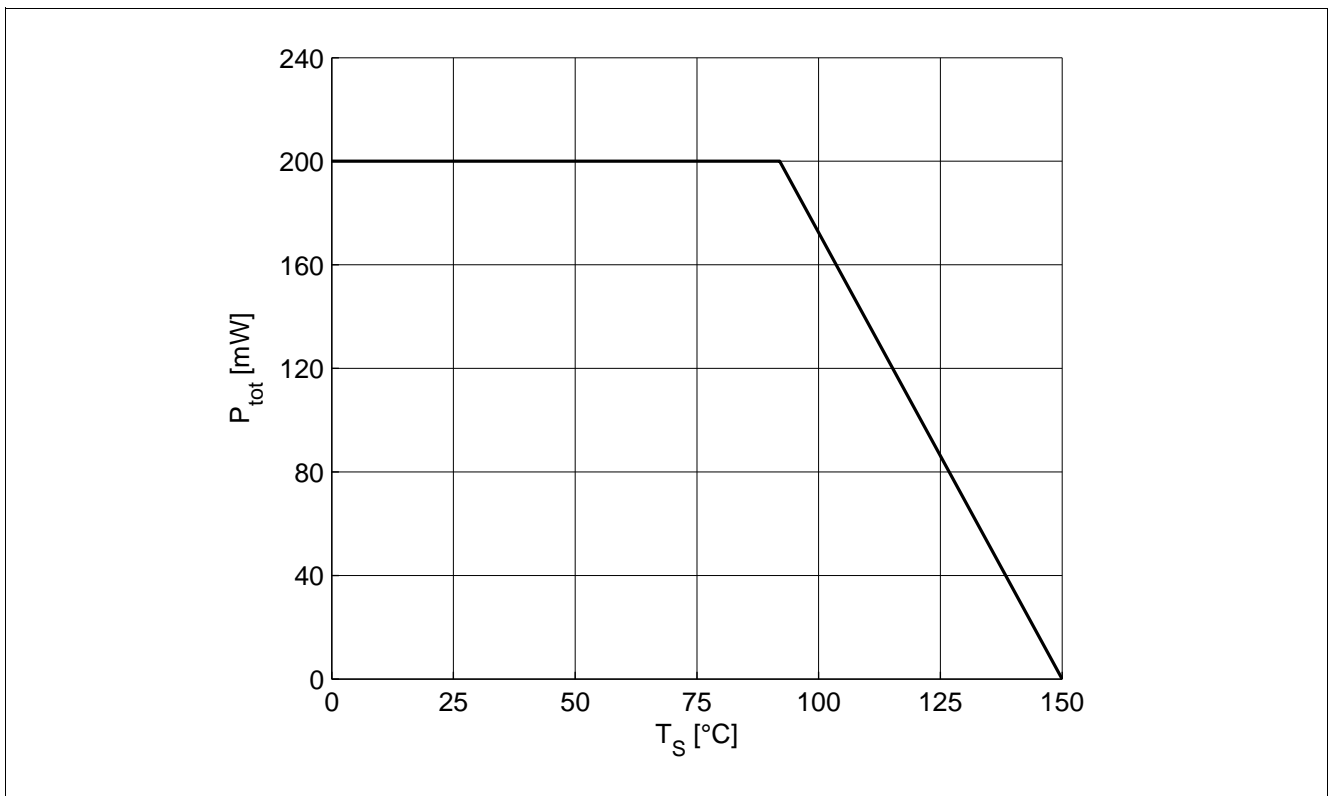


Figure 4-1 Total Power Dissipation  $P_{tot} = f(T_s)$

## 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	$V_{(BR)CEO}$	4.1	4.7	–	V	$I_C = 1\text{ mA}$ , $I_B = 0$ Open base
Collector emitter leakage current	$I_{CES}$	–	1 1	400 <sup>1)</sup> 40 <sup>1)</sup>	nA	$V_{CE} = 13\text{ V}$ , $V_{BE} = 0$ $V_{CE} = 5\text{ V}$ , $V_{BE} = 0$ E-B short circuited
Collector base leakage current	$I_{CBO}$	–	1	40 <sup>1)</sup>	nA	$V_{CB} = 5\text{ V}$ , $I_E = 0$ Open emitter
Emitter base leakage current	$I_{EBO}$	–	1	40 <sup>1)</sup>	nA	$V_{EB} = 0.5\text{ V}$ , $I_C = 0$ Open collector
DC current gain	$h_{FE}$	110	180	270		$V_{CE} = 3\text{ V}$ , $I_C = 30\text{ mA}$ Pulse measured

1) Maximum values not limited by the device but by the short cycle time of the 100% test

### 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	$f_T$	–	42	–	GHz	$V_{CE} = 3\text{ V}$ , $I_C = 30\text{ mA}$ $f = 1\text{ GHz}$
Collector base capacitance	$C_{CB}$	–	0.09	–	pF	$V_{CB} = 3\text{ V}$ , $V_{BE} = 0$ $f = 1\text{ MHz}$ Emitter grounded
Collector emitter capacitance	$C_{CE}$	–	0.2	–	pF	$V_{CE} = 3\text{ V}$ , $V_{BE} = 0$ $f = 1\text{ MHz}$ Base grounded
Emitter base capacitance	$C_{EB}$	–	0.47	–	pF	$V_{EB} = 0.5\text{ V}$ , $V_{CB} = 0$ $f = 1\text{ MHz}$ Collector grounded

### 5.3 Frequency Dependent AC Characteristics

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

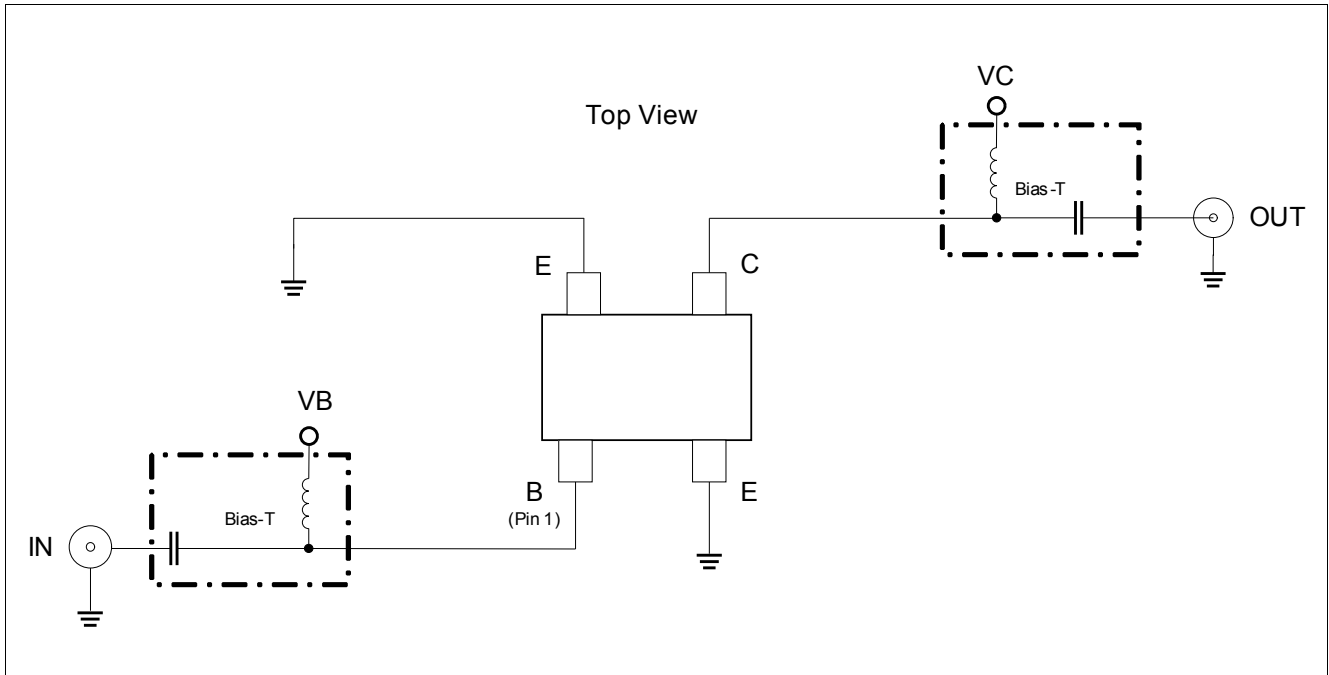


Figure 5-1 BFP640F Testing Circuit

**Electrical Characteristics**
**Table 5-3 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 0.45\text{ GHz}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
<b>Power Gain</b>						
Maximum power gain	$G_{ms}$	–	33	–	dB	$I_C = 25\text{ mA}$
Transducer gain	$ S_{21} ^2$	–	31	–		
<b>Minimum Noise Figure</b>						
Minimum noise figure	$NF_{min}$	–	0.55	–	dB	$I_C = 6\text{ mA}$
Associated gain	$G_{ass}$	–	26	–		
<b>Linearity</b>						
1 dB compression point at output	$OP_{1dB}$	–	10.5	–	dBm	$Z_S = Z_L = 50\ \Omega$ $I_C = 25\text{ mA}$
3rd order intercept point at output	$OIP3$	–	23.5	–		

**Table 5-4 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 0.9\text{ GHz}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
<b>Power Gain</b>						
Maximum power gain	$G_{ms}$	–	28.5	–	dB	$I_C = 25\text{ mA}$
Transducer gain	$ S_{21} ^2$	–	26.5	–		
<b>Minimum Noise Figure</b>						
Minimum noise figure	$NF_{min}$	–	0.55	–	dB	$I_C = 6\text{ mA}$
Associated gain	$G_{ass}$	–	23.5	–		
<b>Linearity</b>						
1 dB compression point at output	$OP_{1dB}$	–	12.5	–	dBm	$Z_S = Z_L = 50\ \Omega$ $I_C = 25\text{ mA}$
3rd order intercept point at output	$OIP3$	–	26	–		

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

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
<b>Power Gain</b>						
Maximum power gain	$G_{ms}$	–	25	–	dB	$I_C = 25\text{ mA}$
Transducer gain	$ S_{21} ^2$	–	22.5	–		
<b>Minimum Noise Figure</b>						
Minimum noise figure	$NF_{min}$	–	0.6	–	dB	$I_C = 6\text{ mA}$
Associated gain	$G_{ass}$	–	20.5	–		
<b>Linearity</b>						
1 dB compression point at output	$OP_{1dB}$	–	12	–	dBm	$Z_S = Z_L = 50\ \Omega$ $I_C = 25\text{ mA}$
3rd order intercept point at output	$OIP3$	–	26	–		

**Electrical Characteristics**
**Table 5-6 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 1.9\text{ GHz}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
<b>Power Gain</b>						
Maximum power gain	$G_{ms}$	–	23	–	dB	$I_C = 25\text{ mA}$
Transducer gain	$ S_{21} ^2$	–	20.5	–		$I_C = 25\text{ mA}$
<b>Minimum Noise Figure</b>						
Minimum noise figure	$NF_{min}$	–	0.6	–	dB	$I_C = 6\text{ mA}$
Associated gain	$G_{ass}$	–	19	–		$I_C = 6\text{ mA}$
<b>Linearity</b>						
1 dB compression point at output	$OP_{1dB}$	–	12.5	–	dBm	$Z_S = Z_L = 50\ \Omega$ $I_C = 25\text{ mA}$
3rd order intercept point at output	$OIP3$	–	27	–		$I_C = 25\text{ mA}$

**Table 5-7 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 2.4\text{ GHz}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
<b>Power Gain</b>						
Maximum power gain	$G_{ma}$	–	20	–	dB	$I_C = 25\text{ mA}$
Transducer gain	$ S_{21} ^2$	–	18.5	–		$I_C = 25\text{ mA}$
<b>Minimum Noise Figure</b>						
Minimum noise figure	$NF_{min}$	–	0.65	–	dB	$I_C = 6\text{ mA}$
Associated gain	$G_{ass}$	–	17	–		$I_C = 6\text{ mA}$
<b>Linearity</b>						
1 dB compression point at output	$OP_{1dB}$	–	12.5	–	dBm	$Z_S = Z_L = 50\ \Omega$ $I_C = 25\text{ mA}$
3rd order intercept point at output	$OIP3$	–	28	–		$I_C = 25\text{ mA}$

**Table 5-8 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 3.5\text{ GHz}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
<b>Power Gain</b>						
Maximum power gain	$G_{ma}$	–	16.5	–	dB	$I_C = 25\text{ mA}$
Transducer gain	$ S_{21} ^2$	–	15.5	–		$I_C = 25\text{ mA}$
<b>Minimum Noise Figure</b>						
Minimum noise figure	$NF_{min}$	–	0.75	–	dB	$I_C = 6\text{ mA}$
Associated gain	$G_{ass}$	–	14	–		$I_C = 6\text{ mA}$
<b>Linearity</b>						
1 dB compression point at output	$OP_{1dB}$	–	12	–	dBm	$Z_S = Z_L = 50\ \Omega$ $I_C = 25\text{ mA}$
3rd order intercept point at output	$OIP3$	–	27.5	–		$I_C = 25\text{ mA}$

**Table 5-9 AC Characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 5.5\text{ GHz}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
<b>Power Gain</b>						
Maximum power gain	$G_{ma}$	–	12.5	–	dB	$I_C = 25\text{ mA}$
Transducer gain	$ S_{21} ^2$	–	11.5	–		
<b>Minimum Noise Figure</b>						
Minimum noise figure	$NF_{min}$	–	1.0	–	dB	$I_C = 6\text{ mA}$
Associated gain	$G_{ass}$	–	11	–		
<b>Linearity</b>						
1 dB compression point at output	$OP_{1dB}$	–	12.5	–	dBm	$Z_S = Z_L = 50\ \Omega$ $I_C = 25\text{ mA}$
3rd order intercept point at output	$OIP3$	–	27.5	–		

Note:  $OIP3$  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

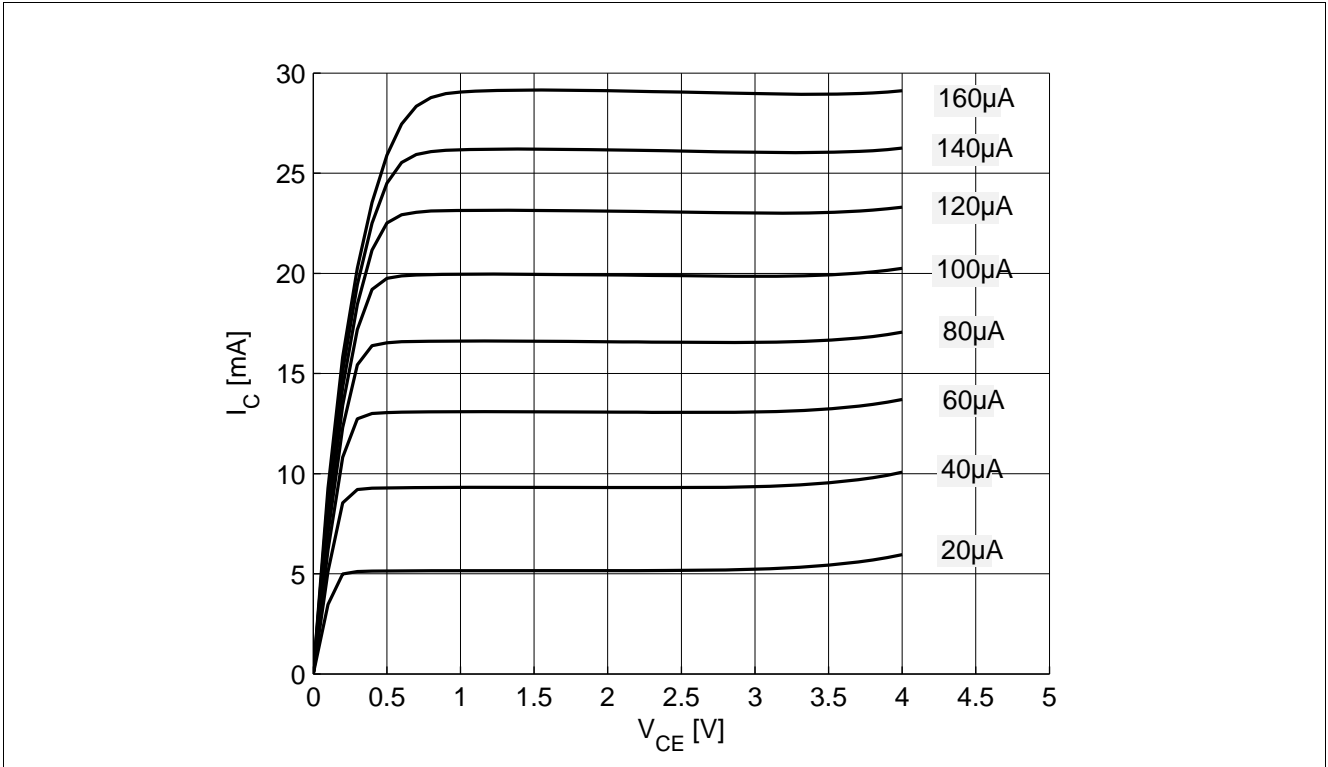


Figure 5-2 Collector Current vs. Collector Emitter Voltage  $I_C = f(V_{CE})$ ,  $I_B = \text{Parameter in } \mu\text{A}$

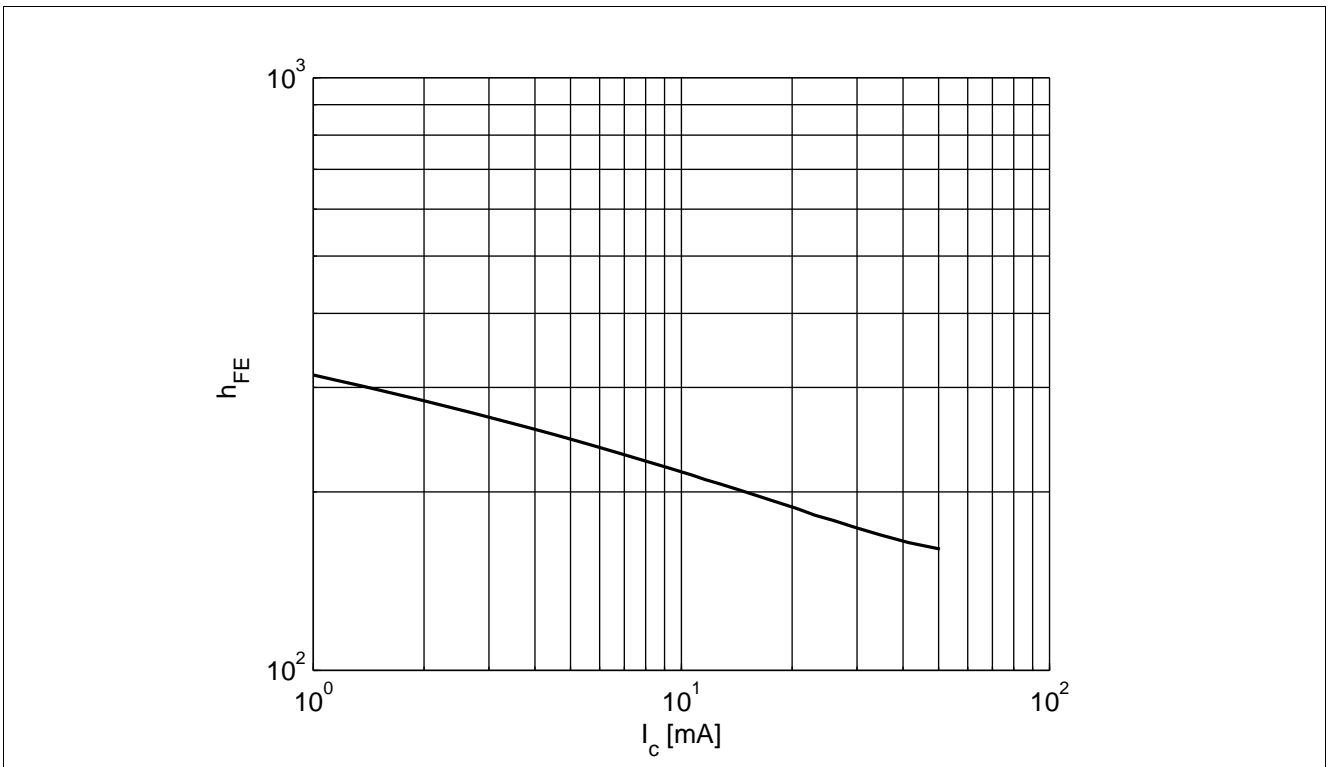


Figure 5-3 DC Current Gain  $h_{FE} = f(I_C)$ ,  $V_{CE} = 3 \text{ V}$



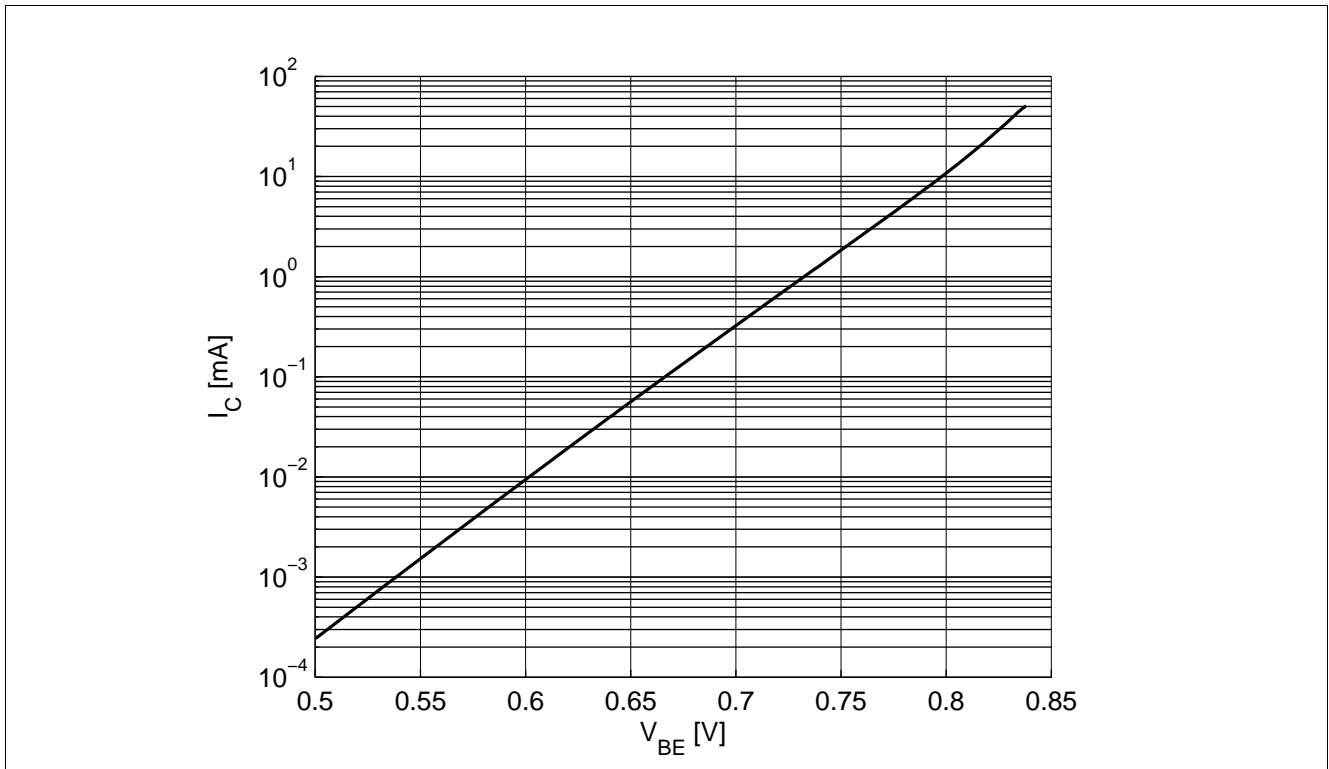


Figure 5-4 Collector Current vs. Base Emitter Forward Voltage  $I_C = f(V_{BE})$ ,  $V_{CE} = 2\text{ V}$

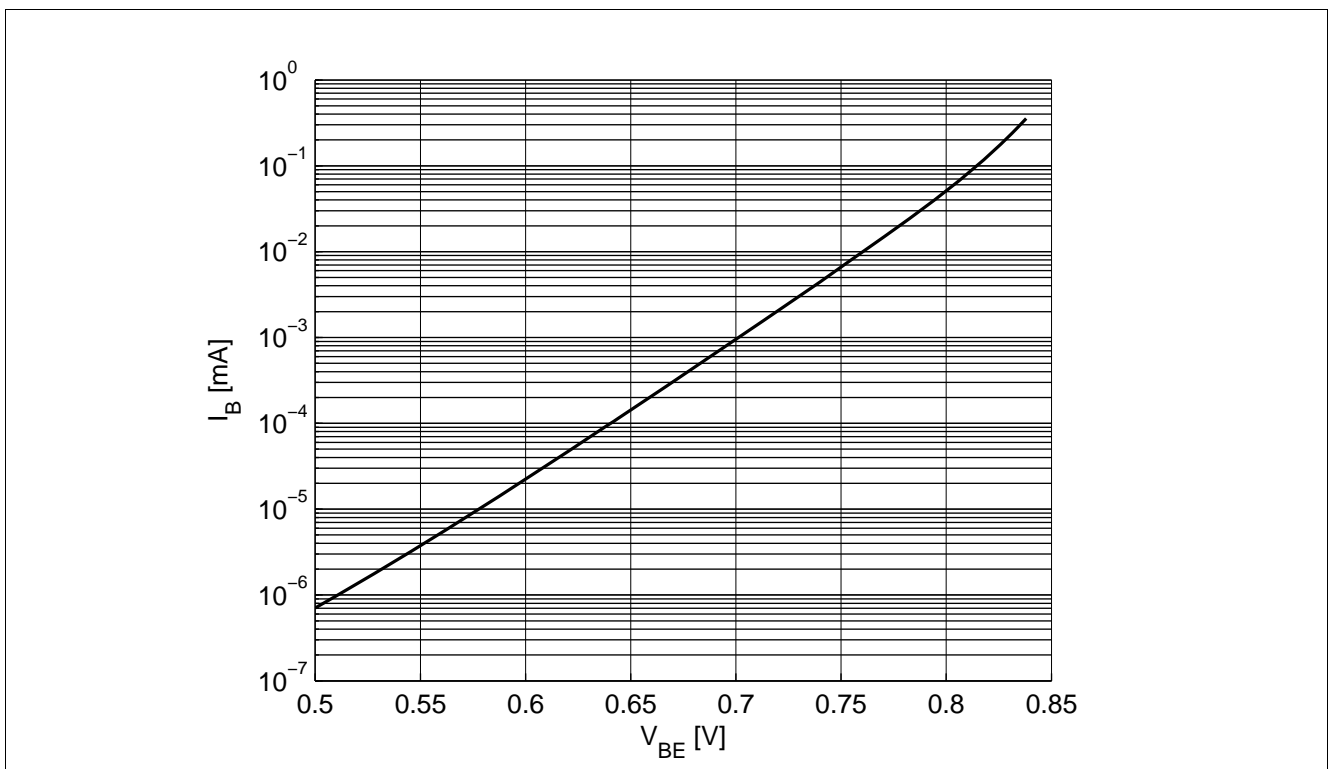


Figure 5-5 Base Current vs. Base Emitter Forward Voltage  $I_B = f(V_{BE})$ ,  $V_{CE} = 2\text{ V}$

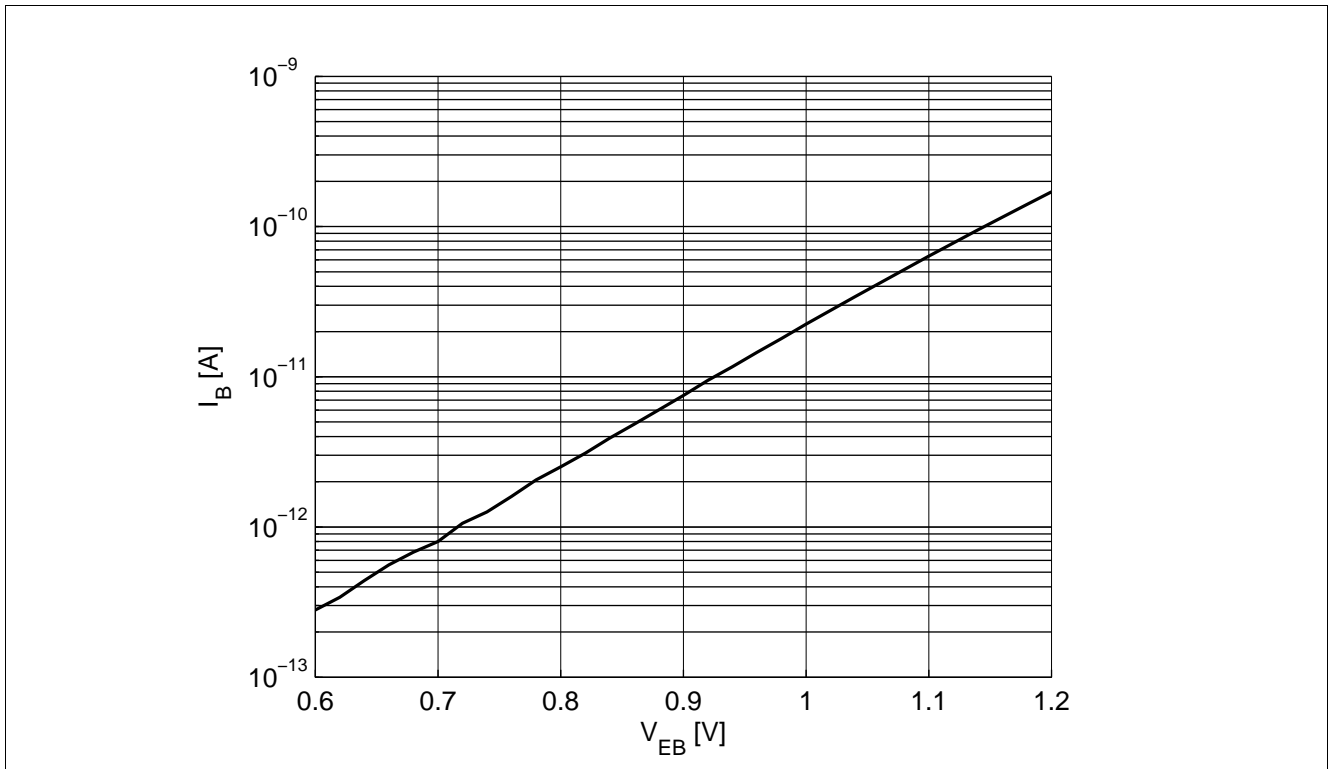


Figure 5-6 Base Current vs. Base Emitter Reverse Voltage  $I_B = f(V_{EB}), V_{CE} = 2\text{ V}$

### 5.5 Characteristic AC Diagrams

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

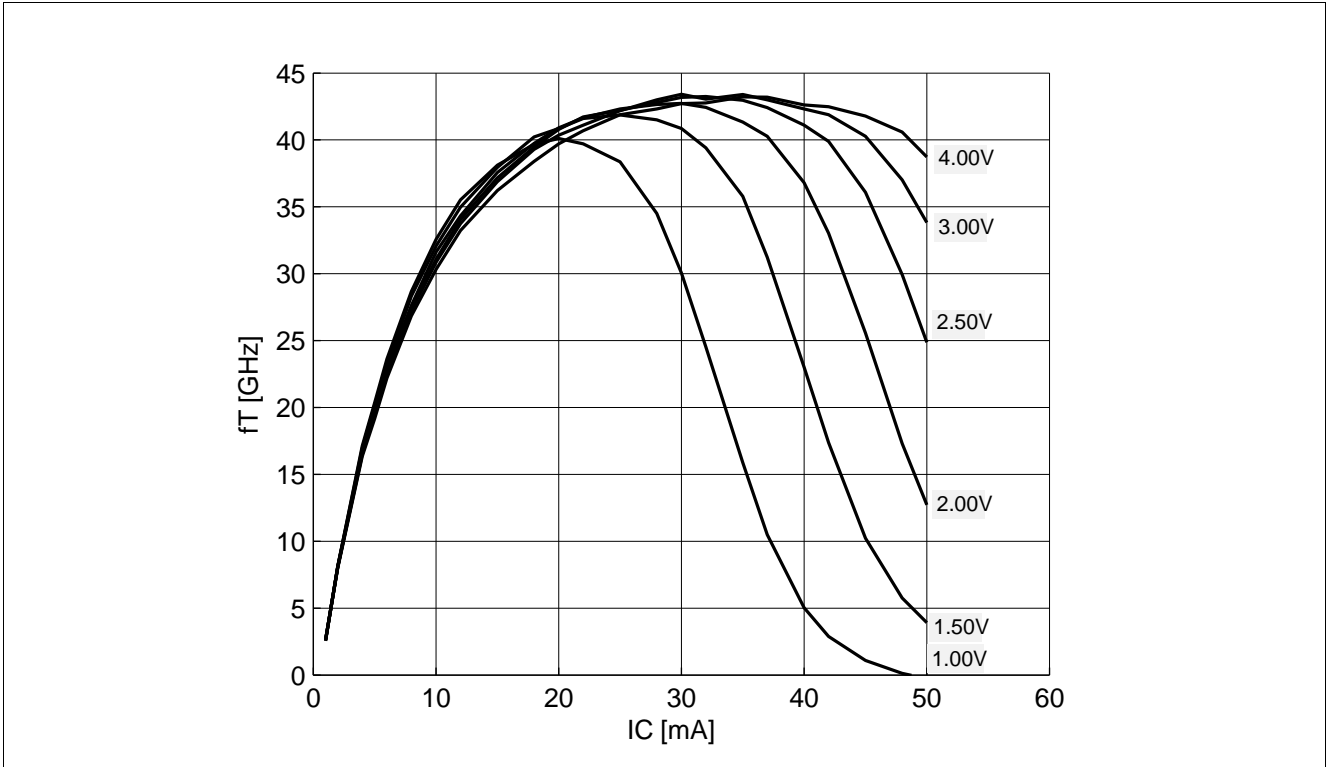


Figure 5-7 Transition Frequency  $f_T = f(I_C)$ ,  $f = 1\text{ GHz}$ ,  $V_{CE} = \text{Parameter in V}$

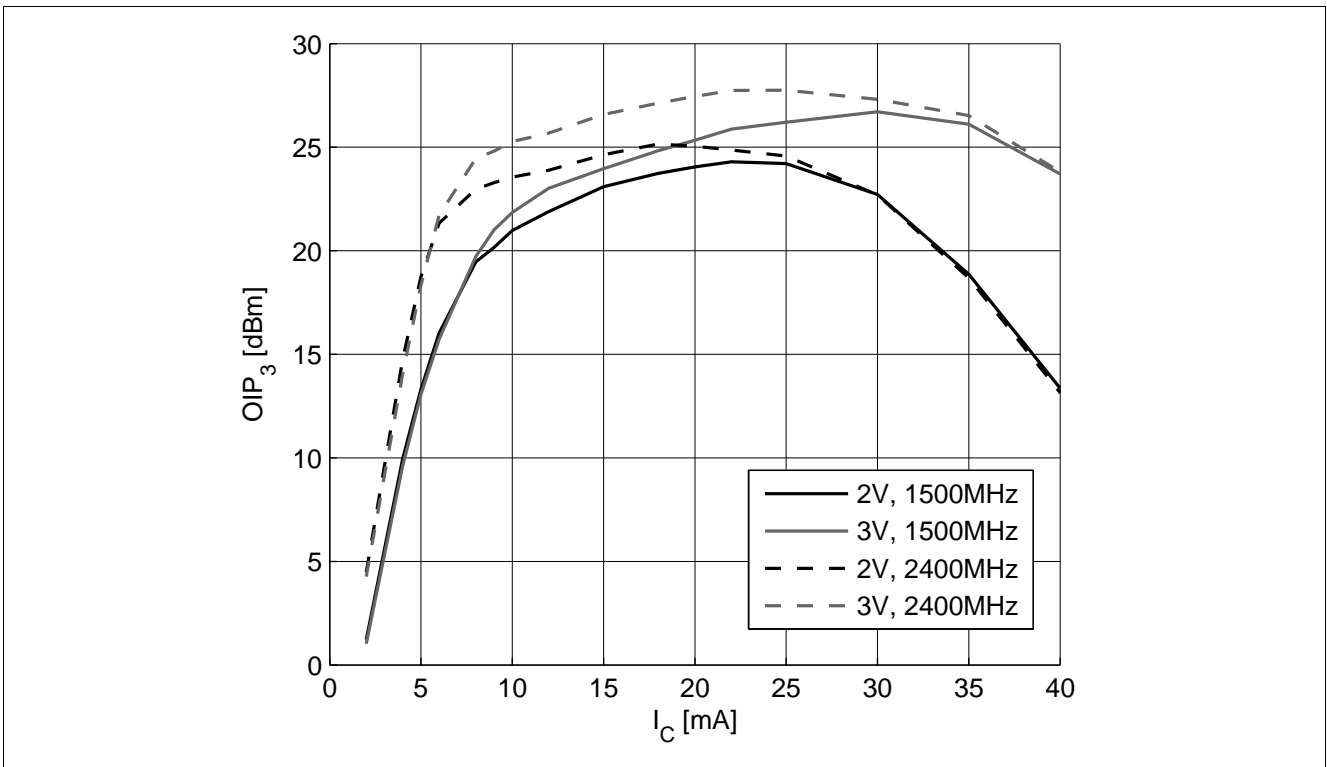


Figure 5-8 3rd Order Intercept Point at output  $OIP3 = f(I_C)$ ,  $Z_S = Z_L = 50\text{ }\Omega$ , Parameters:  $V_{CE}$  in V,  $f$  in MHz

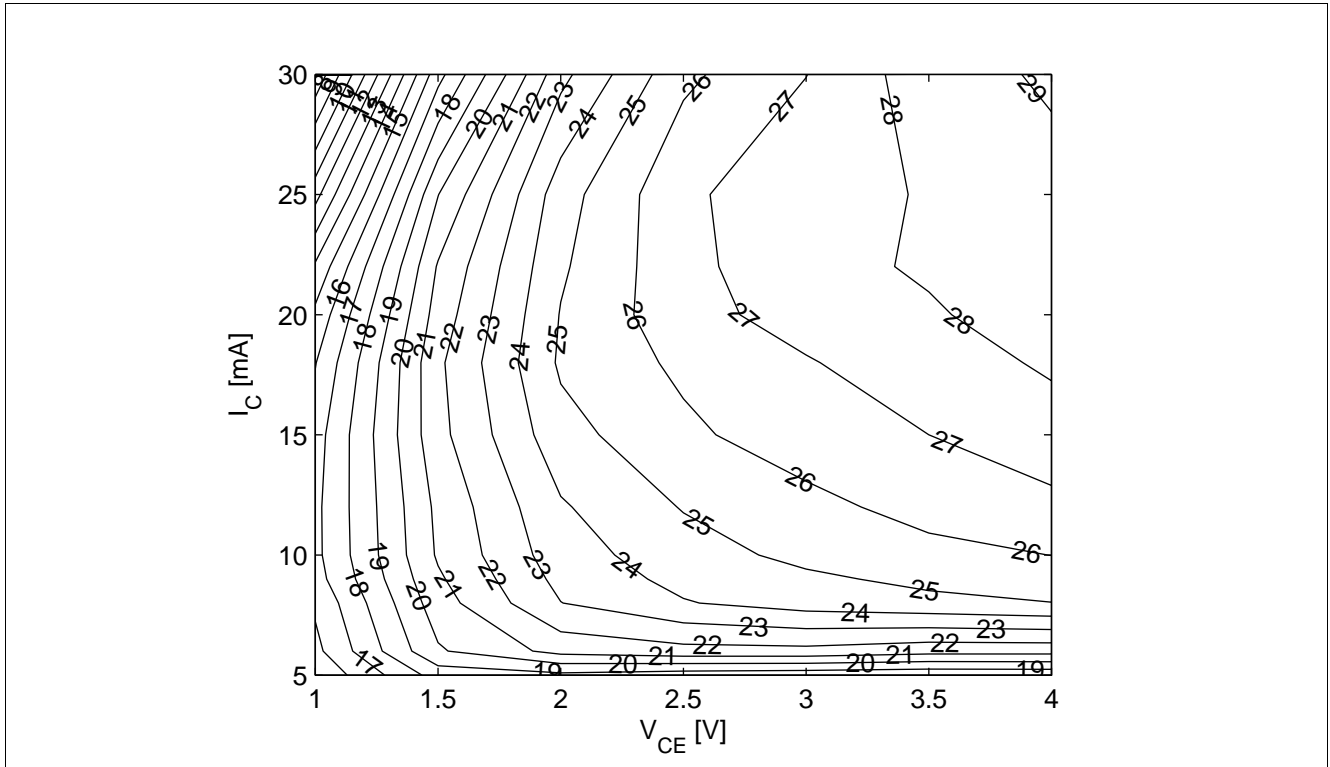


Figure 5-9 3rd Order Intercept Point at output  $OIP3$  [dBm] =  $f(I_C, V_{CE})$ ,  $Z_S = Z_L = 50 \Omega$ ,  $f = 2.4$  GHz

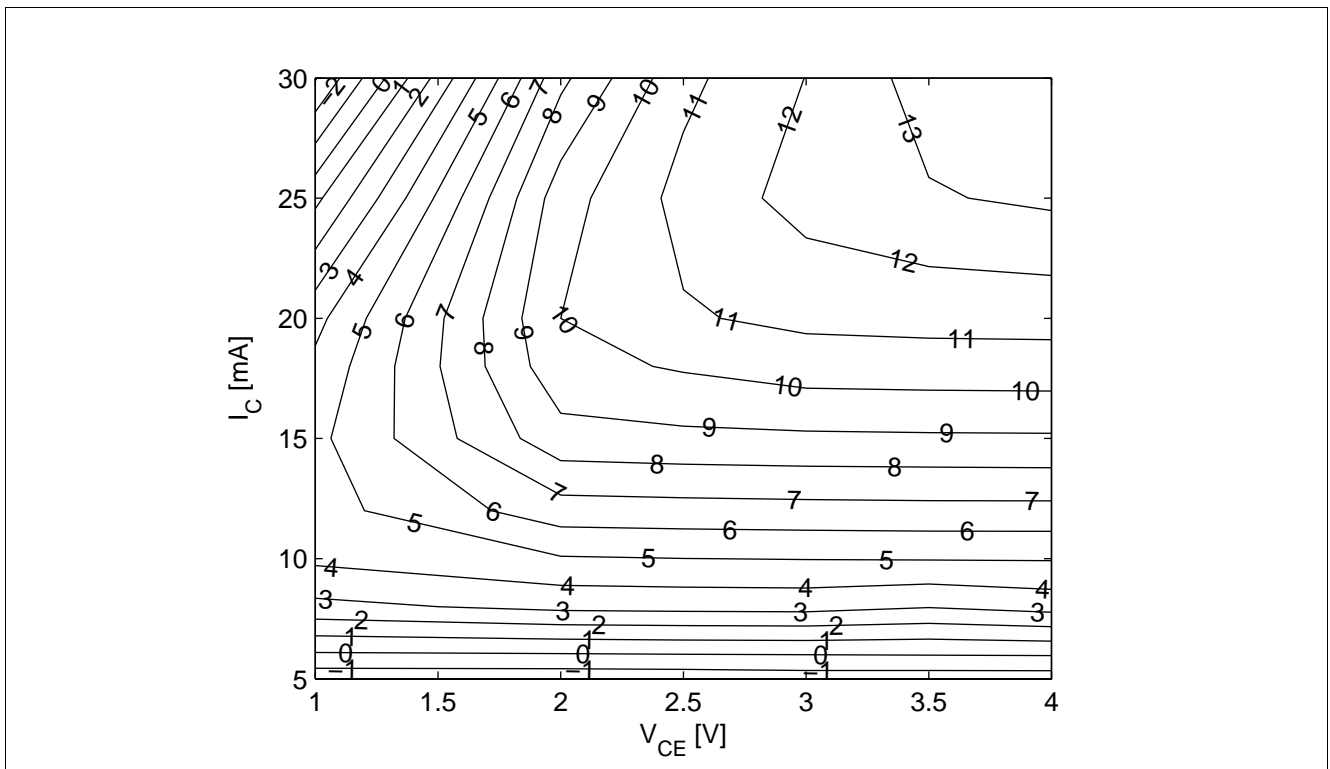


Figure 5-10 Compression Point at output  $OP_{1dB}$  [dBm] =  $f(I_C, V_{CE})$ ,  $Z_S = Z_L = 50 \Omega$ ,  $f = 2.4$  GHz

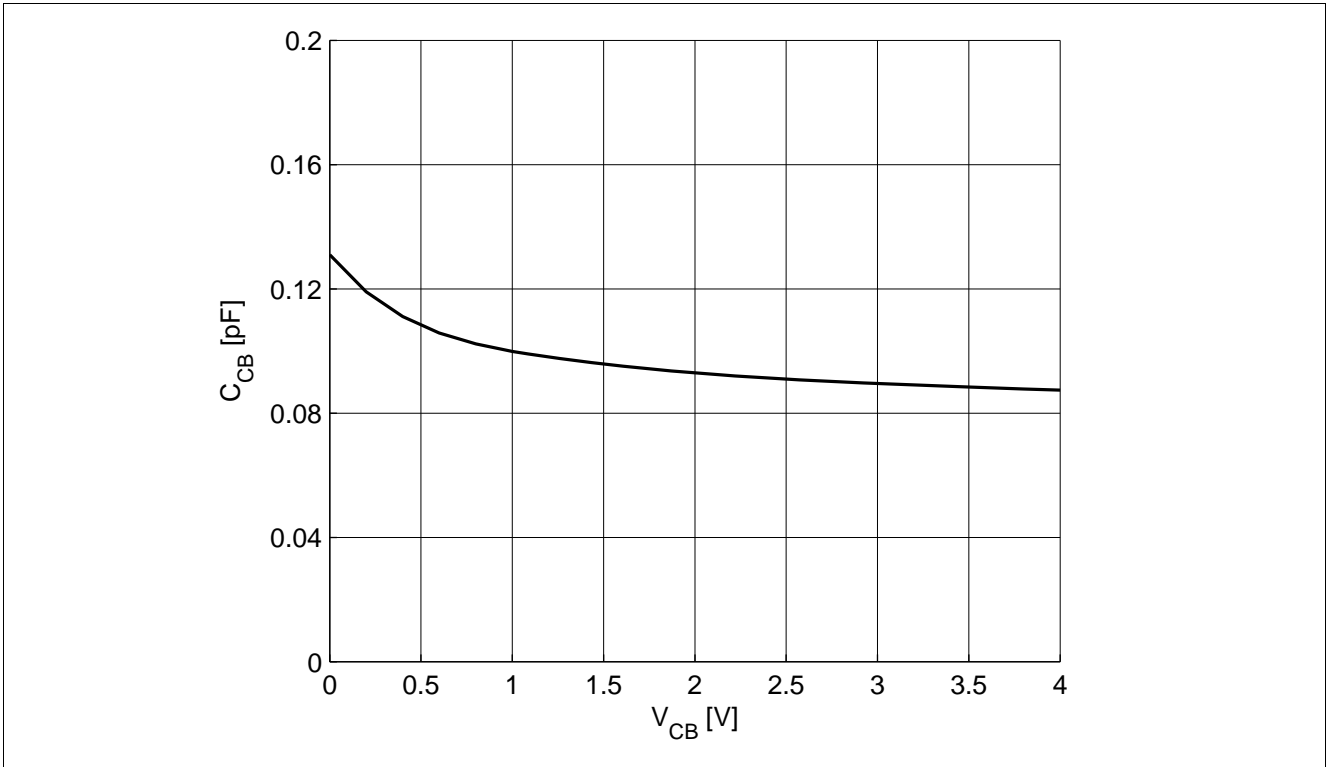


Figure 5-11 Collector Base Capacitance  $C_{CB} = f(V_{CB}), f = 1$  MHz

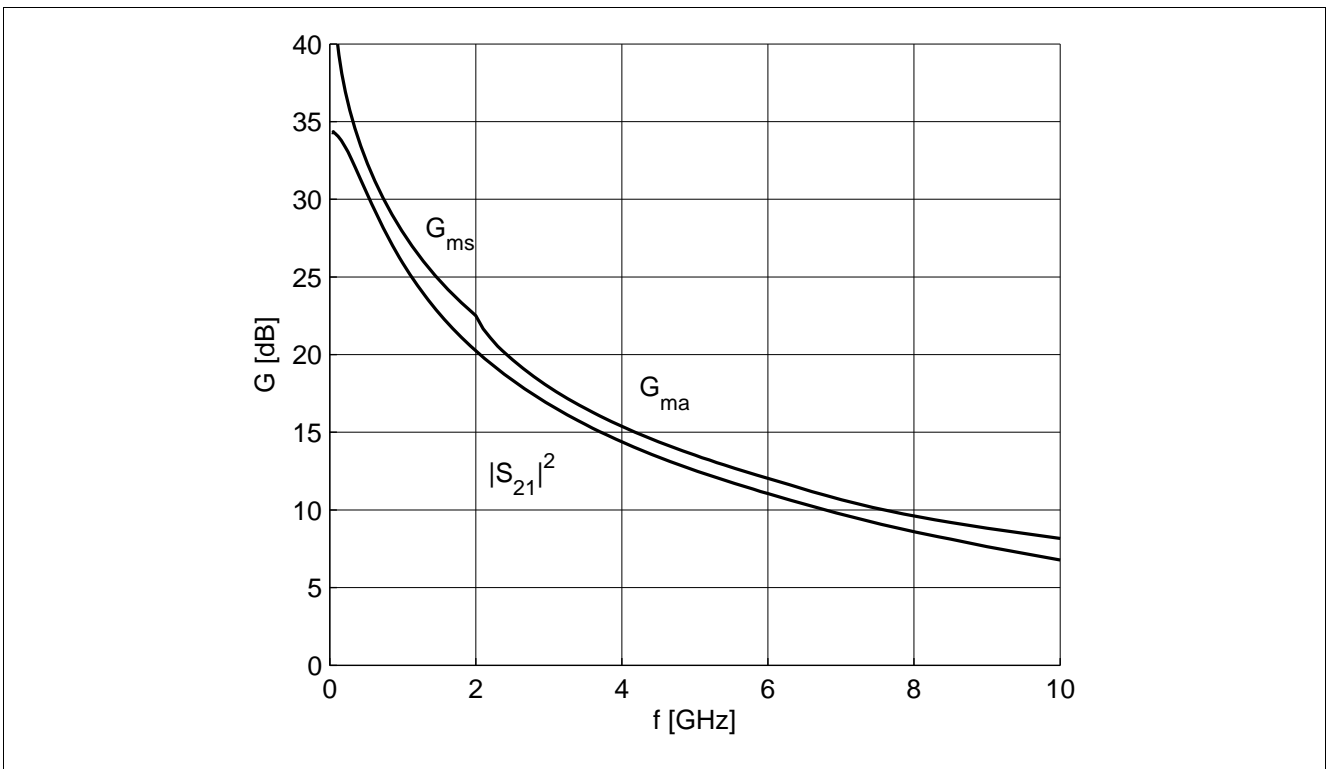


Figure 5-12 Gain  $G_{ma}, G_{ms}, |S_{21}|^2 = f(f), V_{CE} = 3$  V,  $I_C = 25$  mA

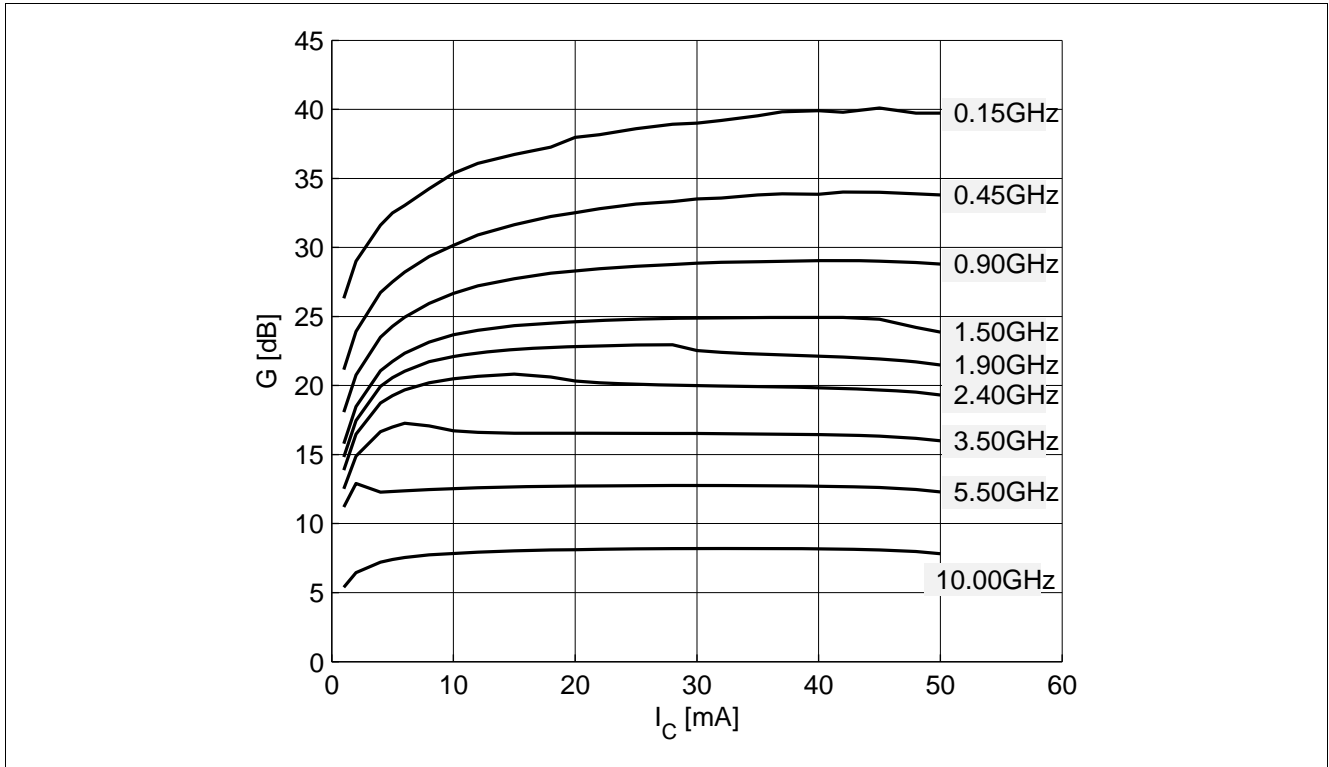


Figure 5-13 Maximum Power Gain  $G_{max} = f(I_C)$ ,  $V_{CE} = 3$  V,  $f =$  Parameter in GHz

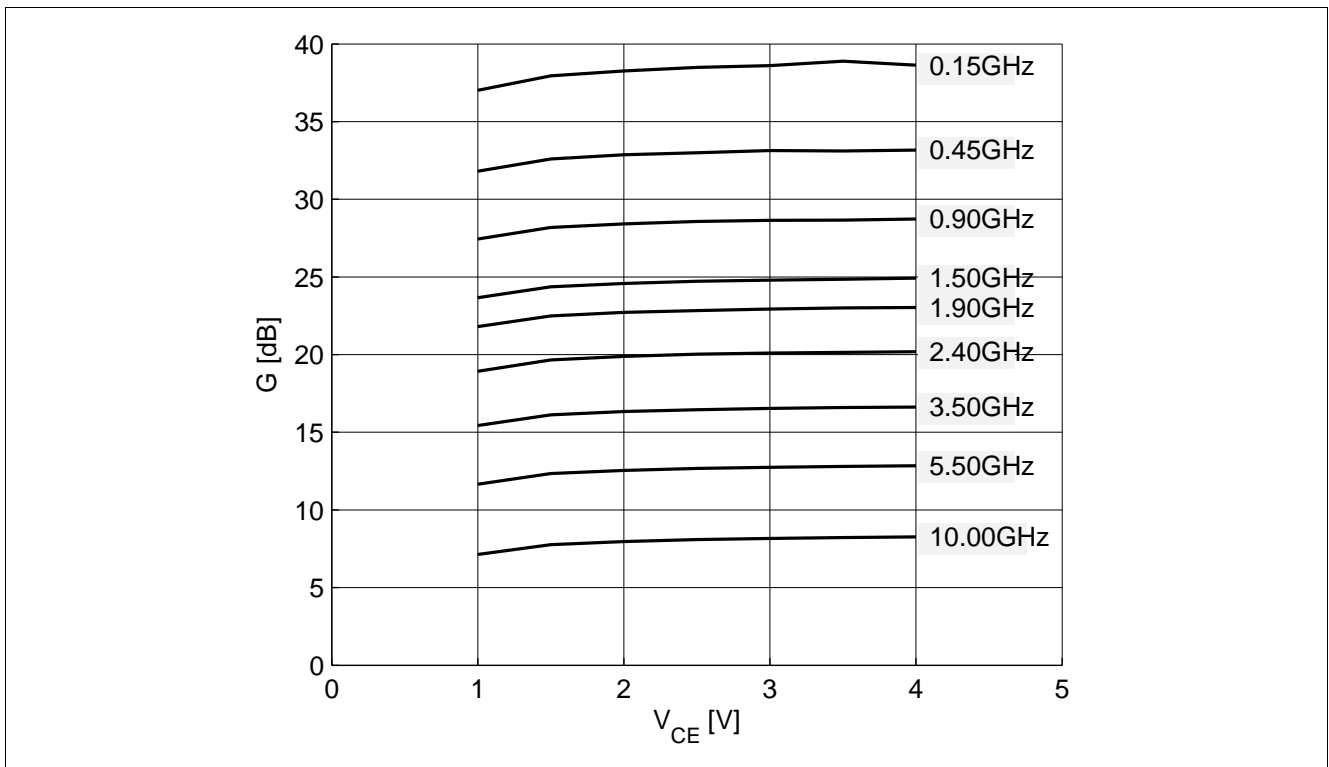


Figure 5-14 Maximum Power Gain  $G_{max} = f(V_{CE})$ ,  $I_C = 25$  mA,  $f =$  Parameter in GHz

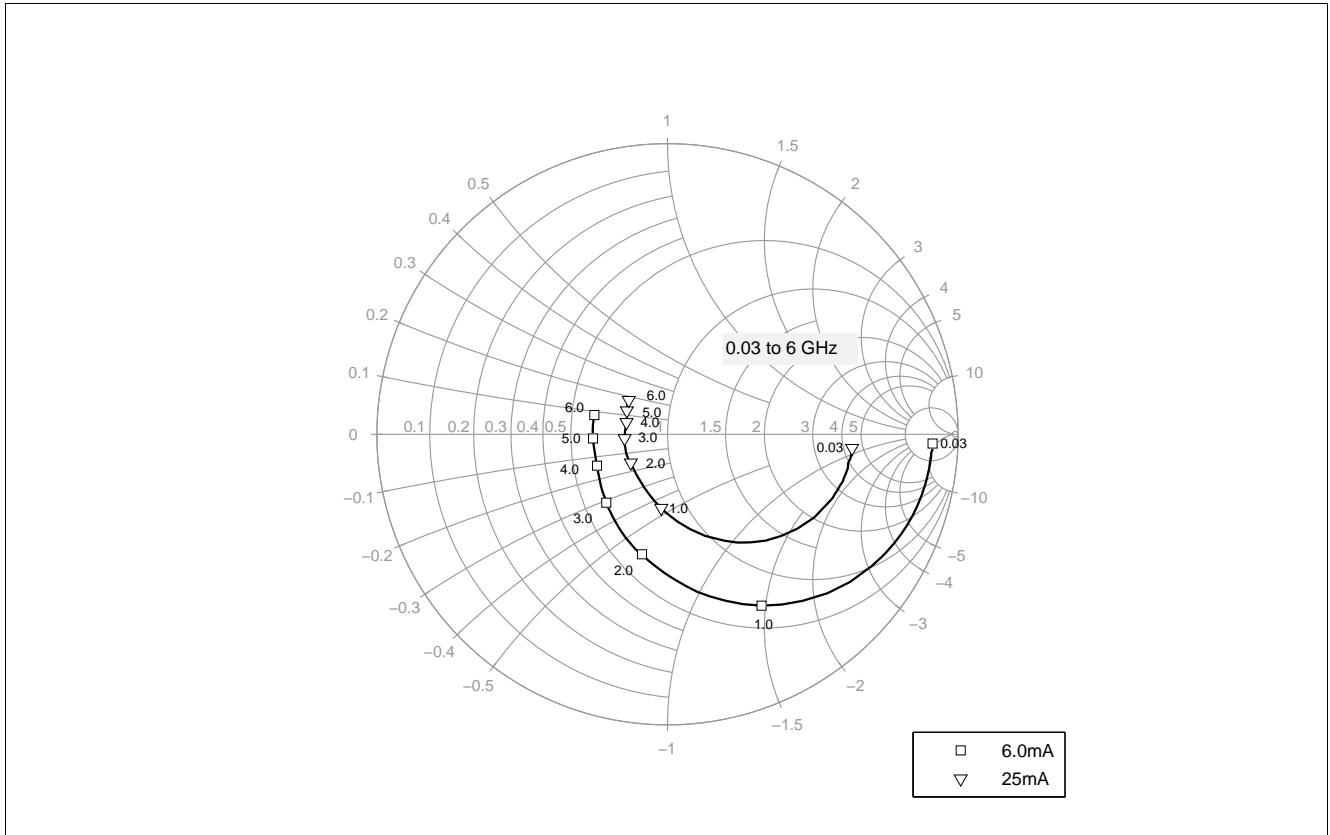


Figure 5-15 Input Matching  $S_{11} = f(f)$ ,  $V_{CE} = 3\text{ V}$ ,  $I_C = 6 / 25\text{ mA}$

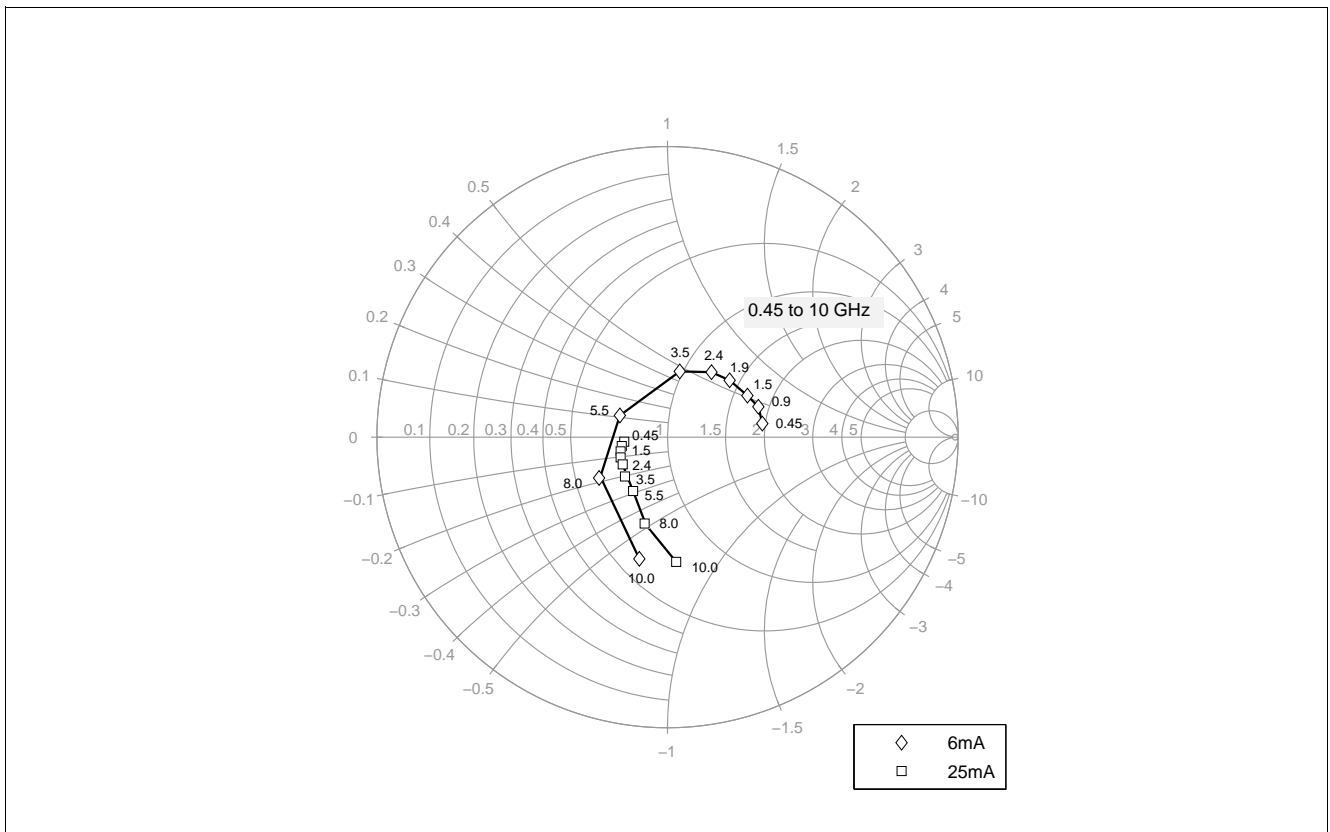


Figure 5-16 Source Impedance for Minimum Noise Figure  $Z_{opt} = f(f)$ ,  $V_{CE} = 3\text{ V}$ ,  $I_C = 6 / 25\text{ mA}$

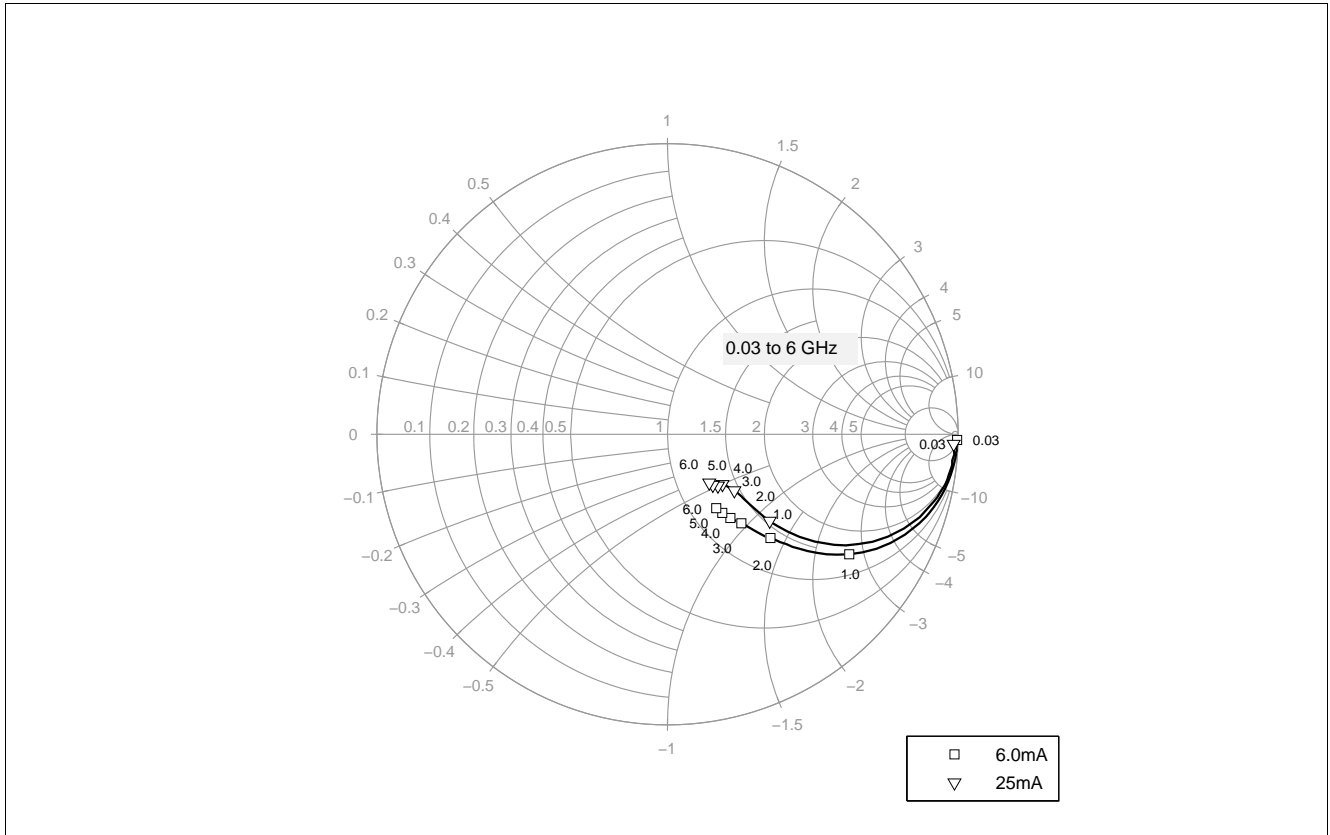


Figure 5-17 Output Matching  $S_{22} = f(f)$ ,  $V_{CE} = 3\text{ V}$ ,  $I_C = 6 / 25\text{ mA}$

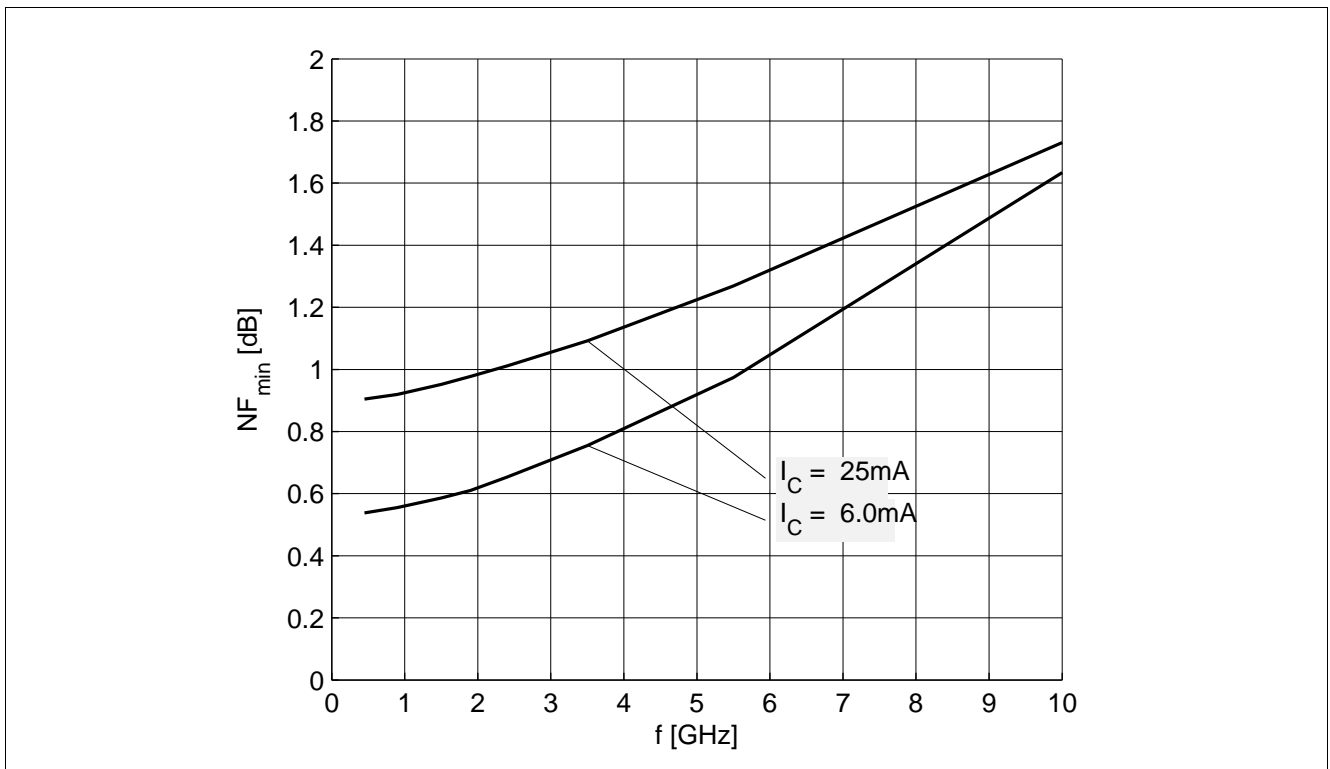


Figure 5-18 Noise Figure  $NF_{min} = f(f)$ ,  $V_{CE} = 3\text{ V}$ ,  $I_C = 6 / 25\text{ mA}$ ,  $Z_S = Z_{opt}$



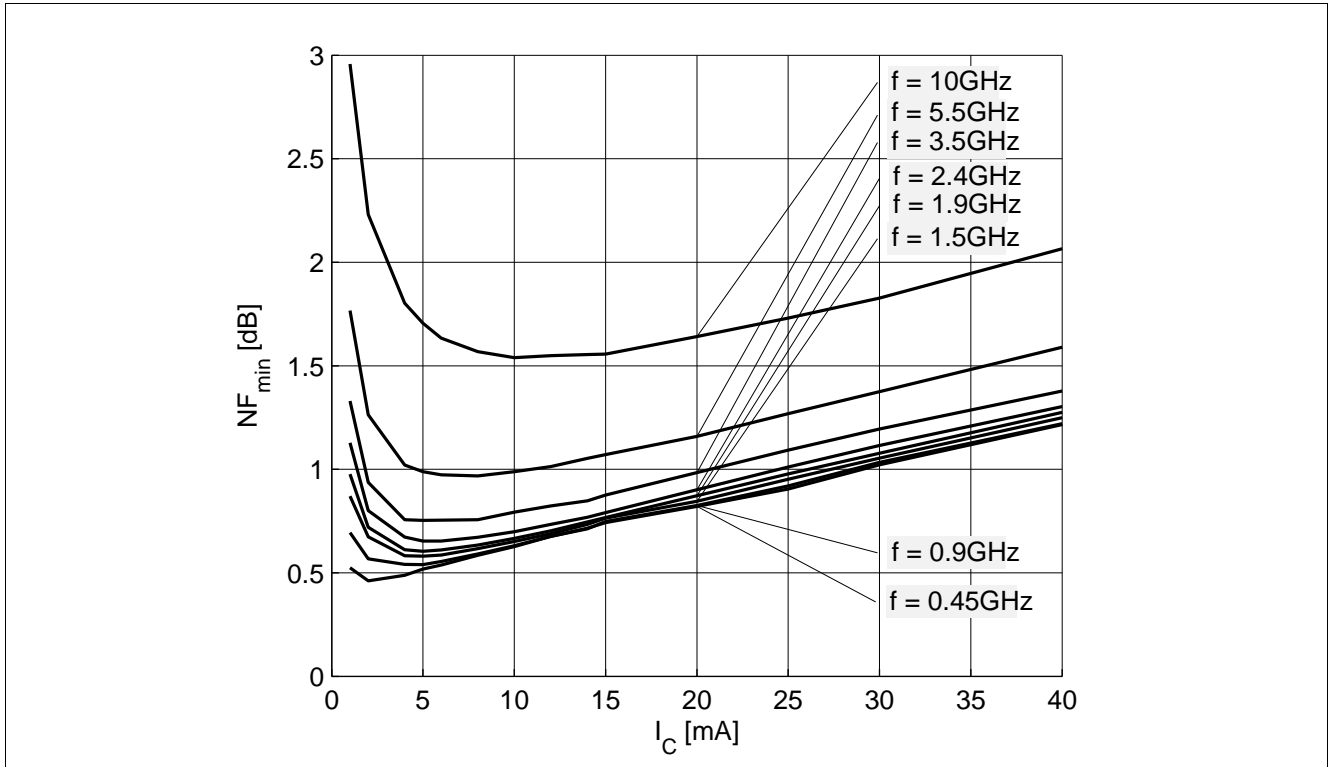


Figure 5-19 Noise Figure  $NF_{min} = f(I_C)$ ,  $V_{CE} = 3\text{ V}$ ,  $Z_S = Z_{opt}$ ,  $f = \text{Parameter in GHz}$

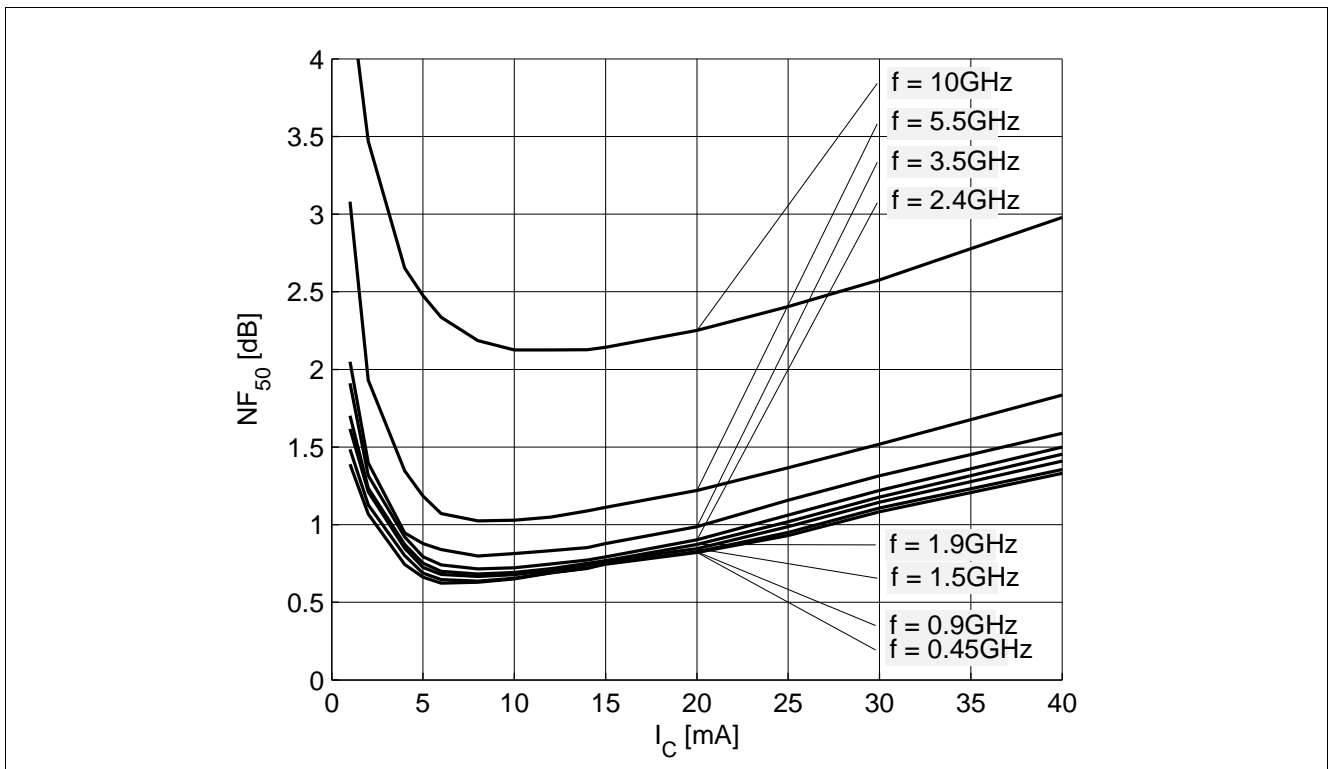


Figure 5-20 Noise Figure  $NF_{50} = f(I_C)$ ,  $V_{CE} = 3\text{ V}$ ,  $Z_S = 50\ \Omega$ ,  $f = \text{Parameter in GHz}$

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.

## 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. Please consult our website and download the latest versions before actually starting your design.

You find the BFP640F 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 6 GHz using typical devices. The BFP640F SPICE GP model reflects the typical DC- and RF-performance within the limitations which are given by the SPICE GP model itself. Besides the DC characteristics all S-parameters in magnitude and phase, as well as noise figure (including optimum source impedance, equivalent noise resistance and flicker noise) and intermodulation have been extracted.

## 7 Package Information TSFP-4-1

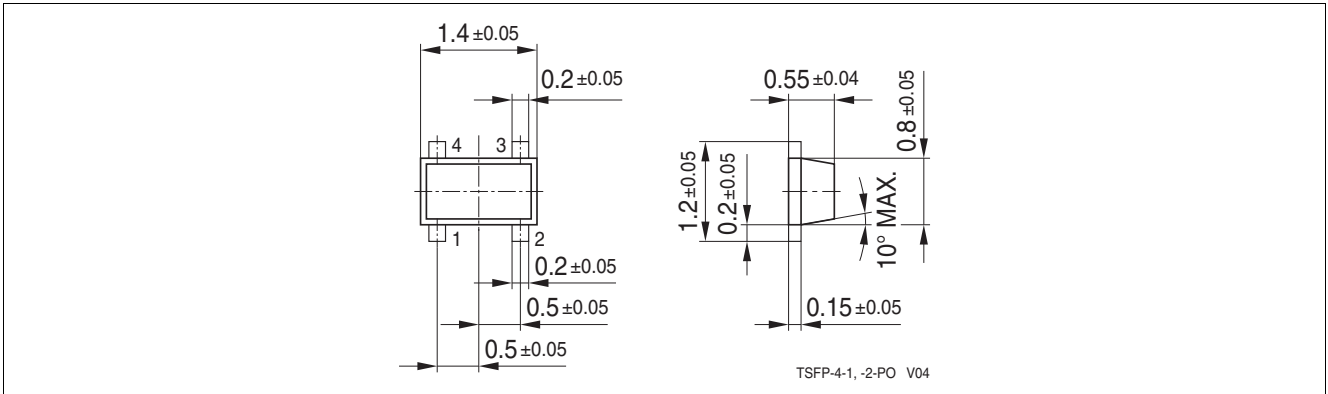


Figure 7-1 Package Outline

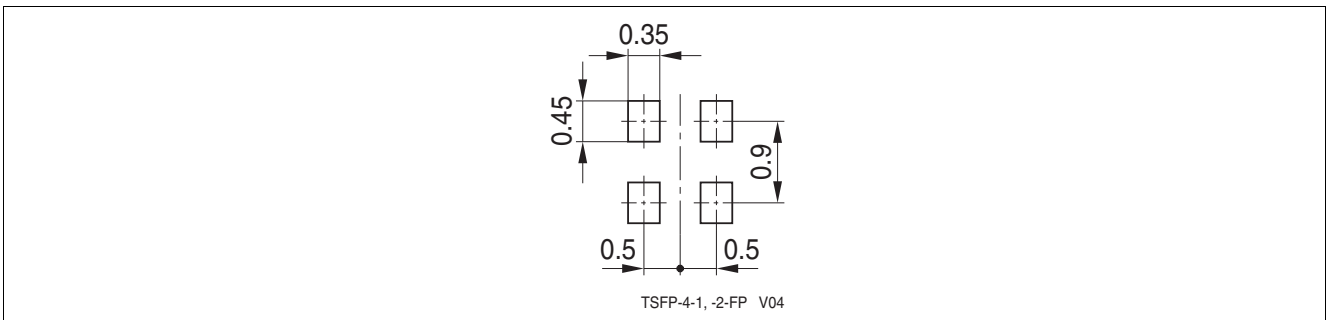


Figure 7-2 Package Footprint

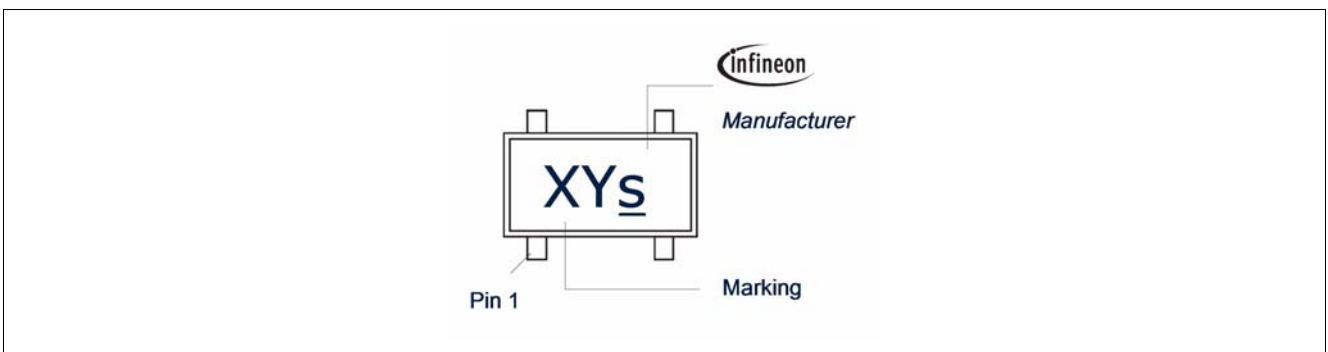


Figure 7-3 Marking Description (Marking BFP640F: R4s)

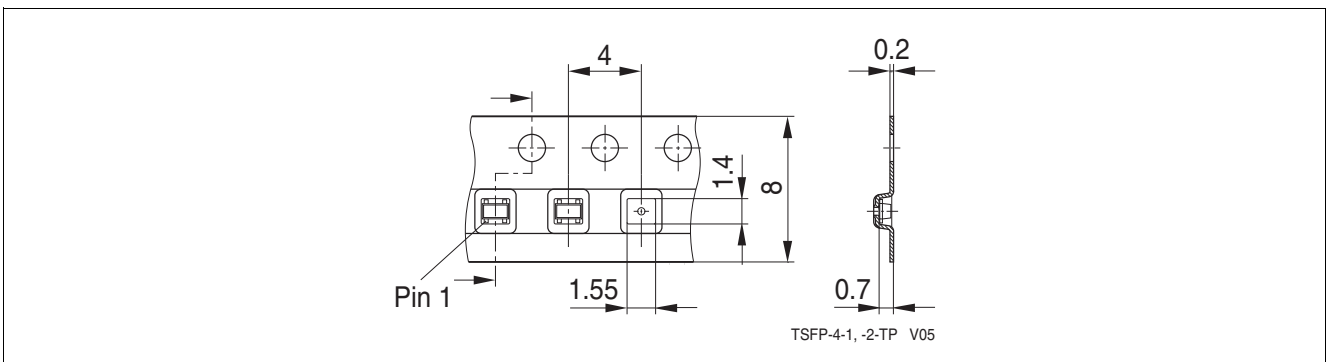


Figure 7-4 Tape Dimensions

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