

BFP640ESD

Robust Low Noise Silicon Germanium Bipolar RF Transistor

Data Sheet

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BFP640ESD, Robust Low Noise Silicon Germanium Bipolar RF Transistor

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Page	Subjects (major changes since previous revision)
	This data sheet replaces the revision from 2010-06-29. 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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Table of Contents

	Table of Contents	4
	List of Figures	5
	List of Tables	6
1	Product Brief	7
2	Features	8
3	Maximum Ratings	9
4	Thermal Characteristics	10
5	Electrical Characteristics	11
5.1	DC Characteristics	11
5.2	General AC Characteristics	11
5.3	Frequency Dependent AC Characteristics	12
5.4	Characteristic DC Diagrams	17
5.5	Characteristic AC Diagrams	20
6	Simulation Data	26
7	Package Information SOT343	27

List of Figures

Figure 4-1	Total Power Dissipation $P_{\text{tot}} = f(T_s)$	10
Figure 5-1	BFP640ESD Testing Circuit	12
Figure 5-2	Collector Current vs. Collector Emitter Voltage $I_C = f(V_{\text{CE}})$, $I_B = \text{Parameter in } \mu\text{A}$	17
Figure 5-3	DC Current Gain $h_{\text{FE}} = f(I_C)$, $V_{\text{CE}} = 3 \text{ V}$	17
Figure 5-4	Collector Current vs. Base Emitter Voltage $I_C = f(V_{\text{BE}})$, $V_{\text{CE}} = 2 \text{ V}$	18
Figure 5-5	Base Current vs. Base Emitter Forward Voltage $I_B = f(V_{\text{BE}})$, $V_{\text{CE}} = 2 \text{ V}$	18
Figure 5-6	Base Current vs. Base Emitter Reverse Voltage $I_B = f(V_{\text{EB}})$, $V_{\text{CE}} = 2 \text{ V}$	19
Figure 5-7	Transition Frequency $f_T = f(I_C)$, $f = 1 \text{ GHz}$, $V_{\text{CE}} = \text{Parameter in V}$	20
Figure 5-8	3rd Order Intercept Point $OIP_3 = f(I_C)$, $Z_S = Z_L = 50 \Omega$, $V_{\text{CE}}, f = \text{Parameters}$	20
Figure 5-9	Collector Base Capacitance $C_{\text{CB}} = f(V_{\text{CB}})$, $f = 1 \text{ MHz}$	21
Figure 5-10	Gain $G_{\text{ma}}, G_{\text{ms}}, S_{21} ^2 = f(f)$, $V_{\text{CE}} = 3 \text{ V}$, $I_C = 30 \text{ mA}$	21
Figure 5-11	Maximum Power Gain $G_{\text{max}} = f(I_C)$, $V_{\text{CE}} = 3 \text{ V}$, $f = \text{Parameter in GHz}$	22
Figure 5-12	Maximum Power Gain $G_{\text{max}} = f(V_{\text{CE}})$, $I_C = 30 \text{ mA}$, $f = \text{Parameter in GHz}$	22
Figure 5-13	Input Matching $S_{11} = f(f)$, $V_{\text{CE}} = 3 \text{ V}$, $I_C = 6 / 30 \text{ mA}$	23
Figure 5-14	Source Impedance for Minimum Noise Figure $Z_{\text{opt}} = f(f)$, $V_{\text{CE}} = 3 \text{ V}$, $I_C = 6 / 30 \text{ mA}$	23
Figure 5-15	Output Matching $S_{22} = f(f)$, $V_{\text{CE}} = 3 \text{ V}$, $I_C = 6 / 30 \text{ mA}$	24
Figure 5-16	Noise Figure $NF_{\text{min}} = f(f)$, $V_{\text{CE}} = 3 \text{ V}$, $I_C = 6 / 30 \text{ mA}$, $Z_S = Z_{\text{opt}}$	24
Figure 5-17	Noise Figure $NF_{\text{min}} = f(I_C)$, $V_{\text{CE}} = 3 \text{ V}$, $Z_S = Z_{\text{opt}}$, $f = \text{Parameter in GHz}$	25
Figure 5-18	Noise Figure $NF_{50} = f(I_C)$, $V_{\text{CE}} = 3 \text{ V}$, $Z_S = 50 \Omega$, $f = \text{Parameter in GHz}$	25
Figure 7-1	Package Outline	27
Figure 7-2	Package Footprint.	27
Figure 7-3	Marking Description (Marking BFP640ESD: T4s)	27
Figure 7-4	Tape Dimensions	27

List of Tables

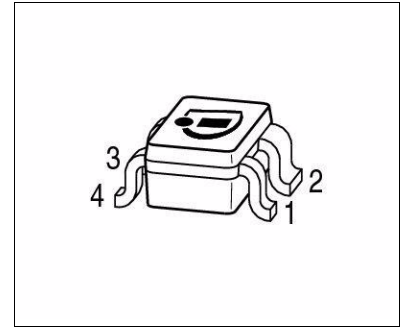
Table 3-1	Maximum Ratings at $T_A = 25\text{ °C}$ (unless otherwise specified)	9
Table 4-1	Thermal Resistance	10
Table 5-1	DC Characteristics at $T_A = 25\text{ °C}$	11
Table 5-2	General AC Characteristics at $T_A = 25\text{ °C}$	11
Table 5-3	AC Characteristics, $V_{CE} = 3\text{ V}$, $f = 150\text{ MHz}$	12
Table 5-4	AC Characteristics, $V_{CE} = 3\text{ V}$, $f = 450\text{ MHz}$	13
Table 5-5	AC Characteristics, $V_{CE} = 3\text{ V}$, $f = 900\text{ MHz}$	13
Table 5-6	AC Characteristics, $V_{CE} = 3\text{ V}$, $f = 1.5\text{ GHz}$	14
Table 5-7	AC Characteristics, $V_{CE} = 3\text{ V}$, $f = 1.9\text{ GHz}$	14
Table 5-8	AC Characteristics, $V_{CE} = 3\text{ V}$, $f = 2.4\text{ GHz}$	15
Table 5-9	AC Characteristics, $V_{CE} = 3\text{ V}$, $f = 3.5\text{ GHz}$	15
Table 5-10	AC Characteristics, $V_{CE} = 3\text{ V}$, $f = 5.5\text{ GHz}$	16
Table 5-11	AC Characteristics, $V_{CE} = 3\text{ V}$, $f = 10\text{ GHz}$	16

1 Product Brief

The BFP640ESD is a 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 $V_{CE0} = 4.1$ V and currents up to $I_C = 50$ mA. The device is especially suited for mobile applications in which low power consumption is a key requirement. The typical transition frequency is approximately 45 GHz, hence the device offers high power gain at frequencies up to 10 GHz in amplifier applications. The transistor is fitted with internal protection circuits, which enhance the robustness against electrostatic discharge (ESD) and high levels of RF input power. The device is housed in an easy to use plastic package with visible leads.

2 Features

- Robust very low noise amplifier based on Infineon’s reliable, high volume SiGe:C wafer technology
- 2 kV ESD robustness (HBM) due to integrated protection circuits
- High maximum RF input power of 21 dBm
- 0.65 dB minimum noise figure typical at 1.5 GHz, 0.7 dB at 2.4 GHz, 6 mA
- 26.5 dB maximum gain G_{ms} typical at 1.5 GHz, 23 dB G_{ms} at 2.4 GHz, 30 mA
- 27 dBm OIP_3 typical at 2.4 GHz, 30 mA
- 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

- Mobile portable and fixed connectivity applications: WLAN 802.11a/b/g/n, WiMAX 2.5 / 3.5 / 5 GHz, UWB, Bluetooth
- Satellite communication systems: Navigation systems (GPS, Glonass), satellite radio (SDARs, DAB) and C-band LNB
- 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
BFP640ESD	SOT343	1 = B	2 = E	3 = C	4 = E	T4s

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	V	Open base $T_A = 25\text{ °C}$
		–	3.6	V	$T_A = -55\text{ °C}$
Collector base voltage ¹⁾	V_{CBO}	–	4.8	V	Open emitter $T_A = 25\text{ °C}$
		–	4.3	V	$T_A = -55\text{ °C}$
Collector emitter voltage ²⁾	V_{CES}	–	4.1	V	E-B short circuited $T_A = 25\text{ °C}$
		–	3.6	V	$T_A = -55\text{ °C}$
Base current ³⁾	I_B	-10	6	mA	–
Collector current	I_C	–	50	mA	–
RF input power ⁴⁾	P_{RFIn}	–	21	dBm	–
ESD stress pulse ⁵⁾	V_{ESD}	-2	2	kV	HBM, all pins, acc. to JESD22-A114
Total power dissipation ⁶⁾	P_{tot}	–	200	mW	$T_S \leq 88\text{ °C}$
Junction temperature	T_J	–	150	°C	–
Storage temperature	T_{Stg}	-55	150	°C	–

- 1) Low V_{CBO} due to integrated protection circuits.
- 2) V_{CES} is identical to V_{CEO} due to integrated protection circuits.
- 3) Sustainable reverse bias current is high due to integrated protection circuits.
- 4) RF input power is high due to integrated protection circuits.
- 5) ESD robustness is high due to integrated protection circuits.
- 6) 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.

4 Thermal Characteristics

Table 4-1 Thermal Resistance

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Junction - soldering point ¹⁾	R_{thJS}	–	310	–	K/W	–

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

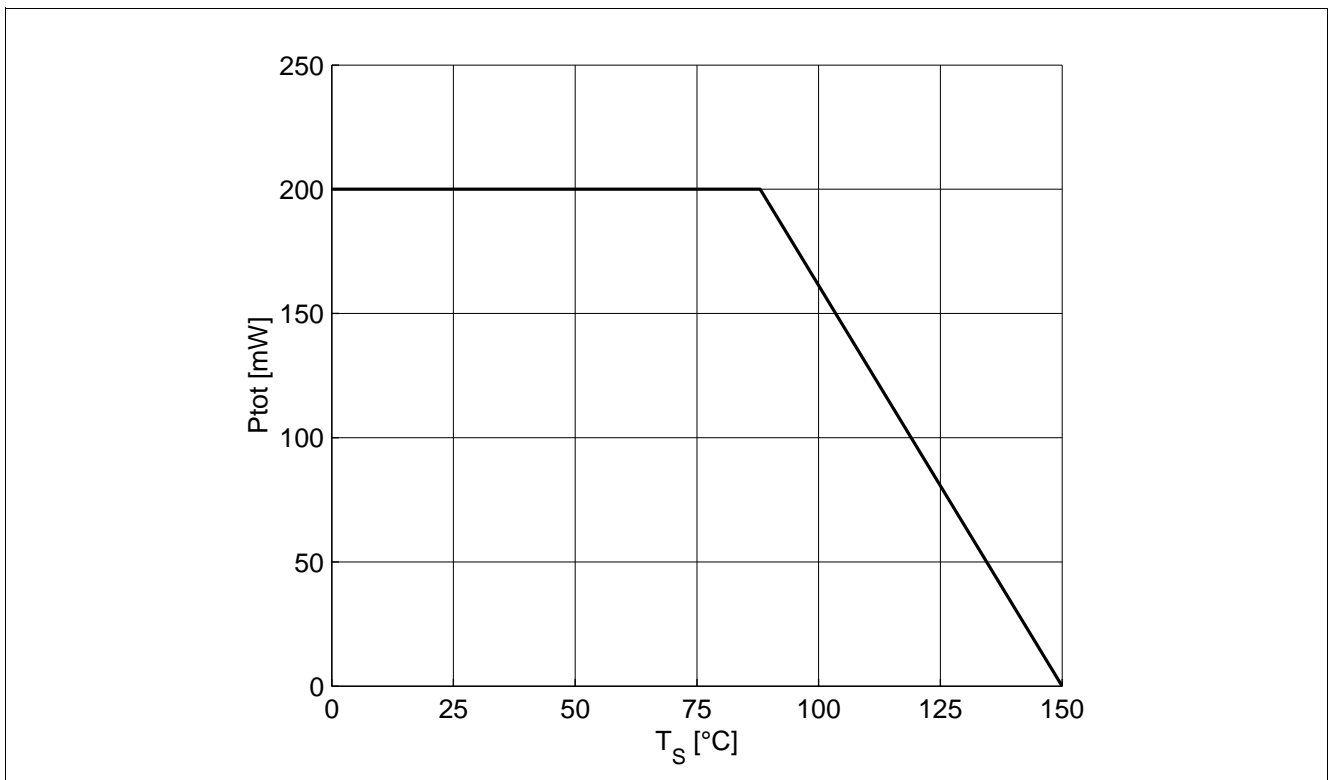


Figure 4-1 Total Power Dissipation $P_{tot} = f(T_s)$

5 Electrical Characteristics

5.1 DC Characteristics

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

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}	–	–	500	nA	$V_{CE} = 2\text{ V}$, $V_{BE} = 0$ E-B short circuited
Collector base leakage current	I_{CBO}	–	–	500	nA	$V_{CB} = 2\text{ V}$, $I_E = 0$ Open emitter
Emitter base leakage current	I_{EBO}	–	–	10	μA	$V_{EB} = 0.5\text{ V}$, $I_C = 0$ Open collector
DC current gain	h_{FE}	110	180	270		$V_{CE} = 3\text{ V}$, $I_C = 30\text{ mA}$ Pulse measured

5.2 General AC Characteristics

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

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Transition frequency	f_T	–	45	–	GHz	$V_{CE} = 3\text{ V}$, $I_C = 30\text{ mA}$, $f = 1\text{ GHz}$
Collector base capacitance	C_{CB}	–	0.08	–	pF	$V_{CB} = 3\text{ V}$, $V_{BE} = 0\text{ V}$ $f = 1\text{ MHz}$ Emitter grounded
Collector emitter capacitance	C_{CE}	–	0.4	–	pF	$V_{CE} = 3\text{ V}$, $V_{BE} = 0\text{ V}$ $f = 1\text{ MHz}$ Base grounded
Emitter base capacitance	C_{EB}	–	0.7	–	pF	$V_{EB} = 0.4\text{ V}$, $V_{CB} = 0\text{ V}$ $f = 1\text{ MHz}$ Collector grounded

5.3 Frequency Dependent AC Characteristics

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

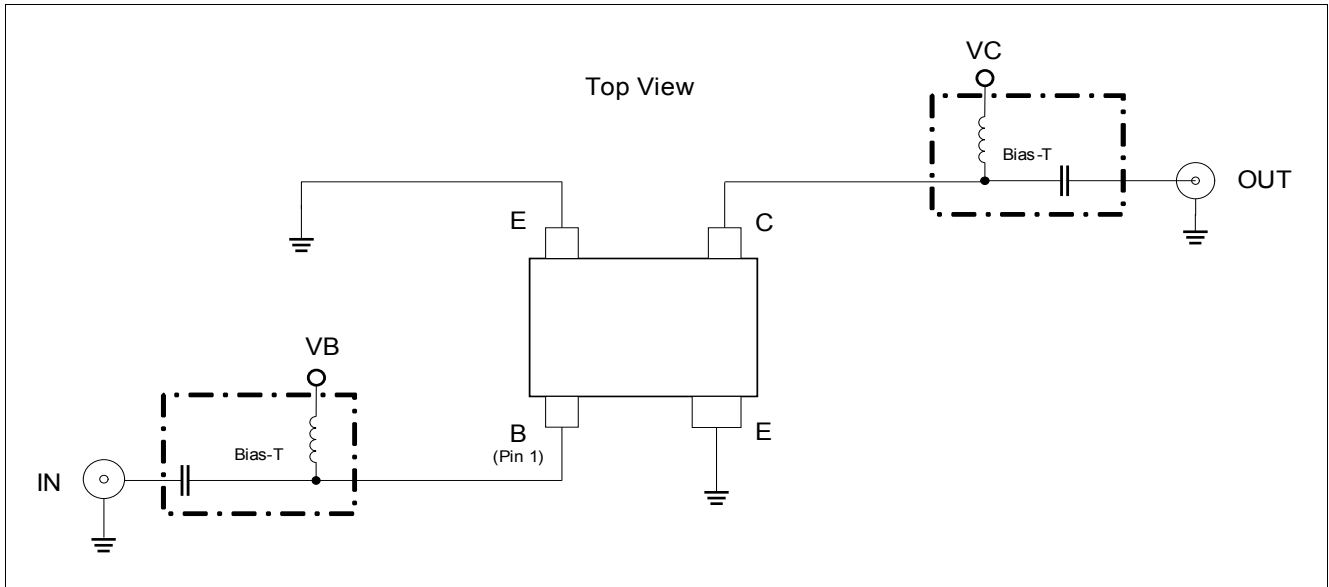


Figure 5-1 BFP640ESD Testing Circuit

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	
Low noise operation point	G_{ms}	–	34	–		$I_C = 6\text{ mA}$
High linearity operation point	G_{ms}	–	39.5	–		$I_C = 30\text{ mA}$
Transducer gain					dB	$Z_S = Z_L = 50\text{ }\Omega$
Low noise operation point	S_{21}	–	25	–		$I_C = 6\text{ mA}$
High linearity operation point	S_{21}	–	35	–		$I_C = 30\text{ mA}$
Minimum noise figure					dB	$Z_S = Z_{opt}$
Minimum noise figure	NF_{min}	–	0.6	–		$I_C = 6\text{ mA}$
Associated gain	G_{ass}	–	30	–		$I_C = 6\text{ mA}$
Linearity					dBm	$Z_S = Z_L = 50\text{ }\Omega$
1 dB gain compression point	OP_{1dB}	–	11	–		$I_C = 30\text{ mA}$
3rd order intercept point	OIP_3	–	25	–		$I_C = 30\text{ mA}$

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	
Low noise operation point	G_{ms}	–	29	–		$I_C = 6\text{ mA}$
High linearity operation point	G_{ms}	–	34.5	–		$I_C = 30\text{ mA}$
Transducer gain					dB	$Z_S = Z_L = 50\ \Omega$
Low noise operation point	S_{21}	–	24.5	–		$I_C = 6\text{ mA}$
High linearity operation point	S_{21}	–	32	–		$I_C = 30\text{ mA}$
Minimum noise figure					dB	$Z_S = Z_{opt}$
Minimum noise figure	NF_{min}	–	0.6	–		$I_C = 6\text{ mA}$
Associated gain	G_{ass}	–	28.5	–		$I_C = 6\text{ mA}$
Linearity					dBm	$Z_S = Z_L = 50\ \Omega$
1 dB gain compression point	OP_{1dB}	–	11	–		$I_C = 30\text{ mA}$
3rd order intercept point	OIP_3	–	25	–		$I_C = 30\text{ mA}$

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	
Low noise operation point	G_{ms}	–	26	–		$I_C = 6\text{ mA}$
High linearity operation point	G_{ms}	–	30.5	–		$I_C = 30\text{ mA}$
Transducer gain					dB	$Z_S = Z_L = 50\ \Omega$
Low noise operation point	S_{21}	–	23.5	–		$I_C = 6\text{ mA}$
High linearity operation point	S_{21}	–	28	–		$I_C = 30\text{ mA}$
Minimum noise figure					dB	$Z_S = Z_{opt}$
Minimum noise figure	NF_{min}	–	0.6	–		$I_C = 6\text{ mA}$
Associated gain	G_{ass}	–	26	–		$I_C = 6\text{ mA}$
Linearity					dBm	$Z_S = Z_L = 50\ \Omega$
1 dB gain compression point	OP_{1dB}	–	11.5	–		$I_C = 30\text{ mA}$
3rd order intercept point	OIP_3	–	26	–		$I_C = 30\text{ mA}$

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						
Low noise operation point	G_{ms}	–	23.5	–	dB	$I_C = 6\text{ mA}$
High linearity operation point	G_{ms}	–	26.5	–		$I_C = 30\text{ mA}$
Transducer gain						
Low noise operation point	S_{21}	–	21	–	dB	$Z_S = Z_L = 50\ \Omega$ $I_C = 6\text{ mA}$
High linearity operation point	S_{21}	–	24	–		$I_C = 30\text{ mA}$
Minimum noise figure						
Minimum noise figure	NF_{min}	–	0.65	–	dB	$Z_S = Z_{opt}$ $I_C = 6\text{ mA}$
Associated gain	G_{ass}	–	23.5	–		$I_C = 6\text{ mA}$
Linearity						
1 dB gain compression point	OP_{1dB}	–	12	–	dBm	$Z_S = Z_L = 50\ \Omega$ $I_C = 30\text{ mA}$
3rd order intercept point	OIP_3	–	26.5	–		$I_C = 30\text{ mA}$

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						
Low noise operation point	G_{ms}	–	22.5	–	dB	$I_C = 6\text{ mA}$
High linearity operation point	G_{ms}	–	25	–		$I_C = 30\text{ mA}$
Transducer gain						
Low noise operation point	S_{21}	–	19.5	–	dB	$Z_S = Z_L = 50\ \Omega$ $I_C = 6\text{ mA}$
High linearity operation point	S_{21}	–	22	–		$I_C = 30\text{ mA}$
Minimum noise figure						
Minimum noise figure	NF_{min}	–	0.65	–	dB	$Z_S = Z_{opt}$ $I_C = 6\text{ mA}$
Associated gain	G_{ass}	–	22	–		$I_C = 6\text{ mA}$
Linearity						
1 dB gain compression point	OP_{1dB}	–	12	–	dBm	$Z_S = Z_L = 50\ \Omega$ $I_C = 30\text{ mA}$
3rd order intercept point	OIP_3	–	27	–		$I_C = 30\text{ mA}$

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						
Low noise operation point	G_{ms}	–	21	–	dB	$I_C = 6\text{ mA}$
High linearity operation point	G_{ms}	–	23	–		$I_C = 30\text{ mA}$
Transducer gain						
Low noise operation point	S_{21}	–	18	–	dB	$Z_S = Z_L = 50\ \Omega$ $I_C = 6\text{ mA}$
High linearity operation point	S_{21}	–	20	–		$I_C = 30\text{ mA}$
Minimum noise figure						
Minimum noise figure	NF_{min}	–	0.7	–	dB	$Z_S = Z_{opt}$ $I_C = 6\text{ mA}$
Associated gain	G_{ass}	–	20	–		$I_C = 6\text{ mA}$
Linearity						
1 dB gain compression point	OP_{1dB}	–	12.5	–	dBm	$Z_S = Z_L = 50\ \Omega$ $I_C = 30\text{ mA}$
3rd order intercept point	OIP_3	–	27	–		$I_C = 30\text{ mA}$

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						
Low noise operation point	G_{ma}	–	19	–	dB	$I_C = 6\text{ mA}$
High linearity operation point	G_{ms}	–	19	–		$I_C = 30\text{ mA}$
Transducer gain						
Low noise operation point	S_{21}	–	15	–	dB	$Z_S = Z_L = 50\ \Omega$ $I_C = 6\text{ mA}$
High linearity operation point	S_{21}	–	17	–		$I_C = 30\text{ mA}$
Minimum noise figure						
Minimum noise figure	NF_{min}	–	0.8	–	dB	$Z_S = Z_{opt}$ $I_C = 6\text{ mA}$
Associated gain	G_{ass}	–	16	–		$I_C = 6\text{ mA}$
Linearity						
1 dB gain compression point	OP_{1dB}	–	12.5	–	dBm	$Z_S = Z_L = 50\ \Omega$ $I_C = 30\text{ mA}$
3rd order intercept point	OIP_3	–	26.5	–		$I_C = 30\text{ mA}$

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	
Low noise operation point	G_{ma}	–	14	–		$I_C = 6\text{ mA}$
High linearity operation point	G_{ma}	–	14.5	–		$I_C = 30\text{ mA}$
Transducer gain					dB	$Z_S = Z_L = 50\ \Omega$
Low noise operation point	S_{21}	–	11	–		$I_C = 6\text{ mA}$
High linearity operation point	S_{21}	–	12.5	–		$I_C = 30\text{ mA}$
Minimum noise figure					dB	$Z_S = Z_{opt}$
Minimum noise figure	NF_{min}	–	1.05	–		$I_C = 6\text{ mA}$
Associated gain	G_{ass}	–	11.5	–		$I_C = 6\text{ mA}$
Linearity					dBm	$Z_S = Z_L = 50\ \Omega$
1 dB gain compression point	OP_{1dB}	–	12.5	–		$I_C = 30\text{ mA}$
3rd order intercept point	OIP_3	–	26	–		$I_C = 30\text{ mA}$

Table 5-11 AC Characteristics, $V_{CE} = 3\text{ V}$, $f = 10\text{ GHz}$

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Maximum power gain					dB	
Low noise operation point	G_{ms}	–	10	–		$I_C = 6\text{ mA}$
High linearity operation point	G_{ms}	–	10.5	–		$I_C = 30\text{ mA}$
Transducer gain					dB	$Z_S = Z_L = 50\ \Omega$
Low noise operation point	S_{21}	–	4.5	–		$I_C = 6\text{ mA}$
High linearity operation point	S_{21}	–	6	–		$I_C = 30\text{ mA}$
Minimum noise figure					dB	$Z_S = Z_{opt}$
Minimum noise figure	NF_{min}	–	2	–		$I_C = 6\text{ mA}$
Associated gain	G_{ass}	–	7	–		$I_C = 6\text{ mA}$
Linearity					dBm	$Z_S = Z_L = 50\ \Omega$
1 dB gain compression point	OP_{1dB}	–	11	–		$I_C = 30\text{ mA}$
3rd order intercept point	OIP_3	–	25.5	–		$I_C = 30\text{ mA}$

Notes

- $G_{ms} = |S_{21} / S_{12}|$ for $k < 1$; $G_{ma} = |S_{21} / S_{12}| (k - (k^2 - 1)^{1/2})$ for $k > 1$.
- In order to get the NF_{min} values stated in this chapter the test fixture losses have been subtracted from all measured result.
- 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

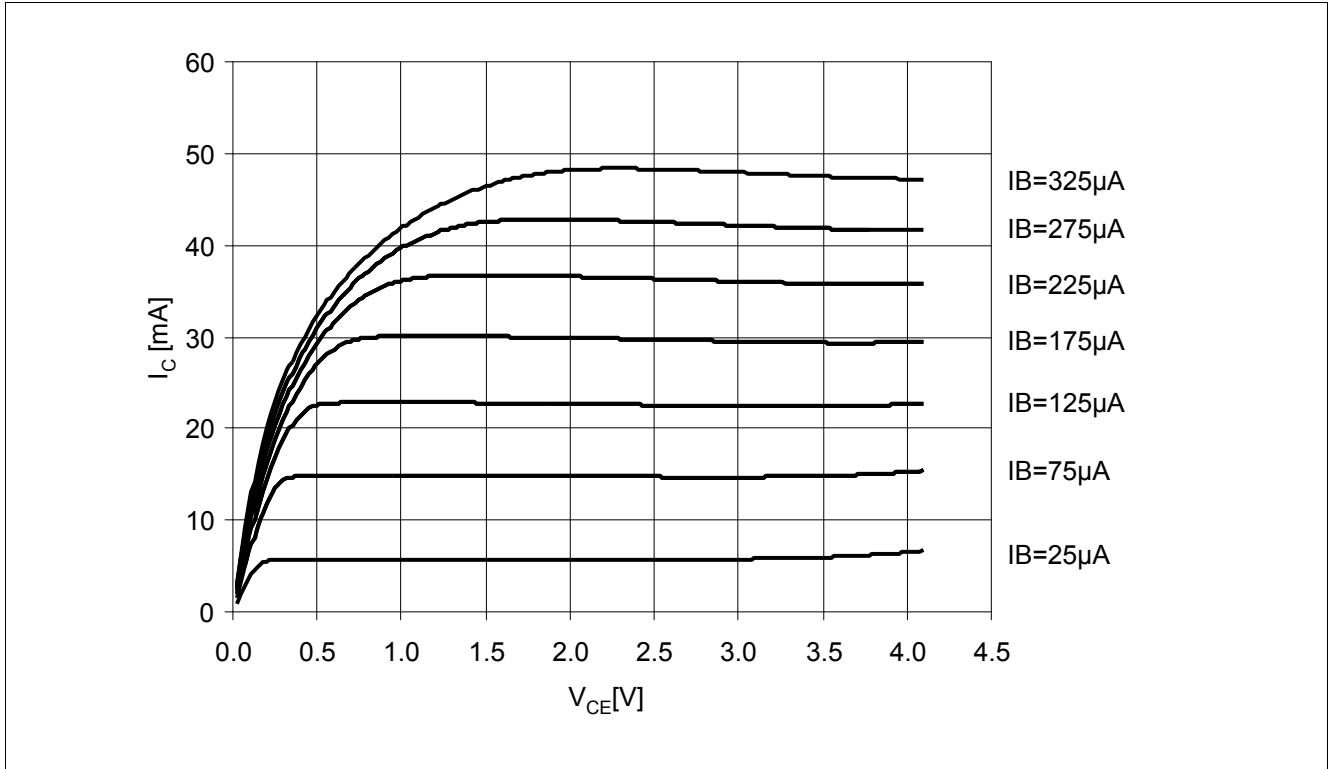


Figure 5-2 Collector Current vs. Collector Emitter Voltage $I_C = f(V_{CE})$, $I_B = \text{Parameter in } \mu A$

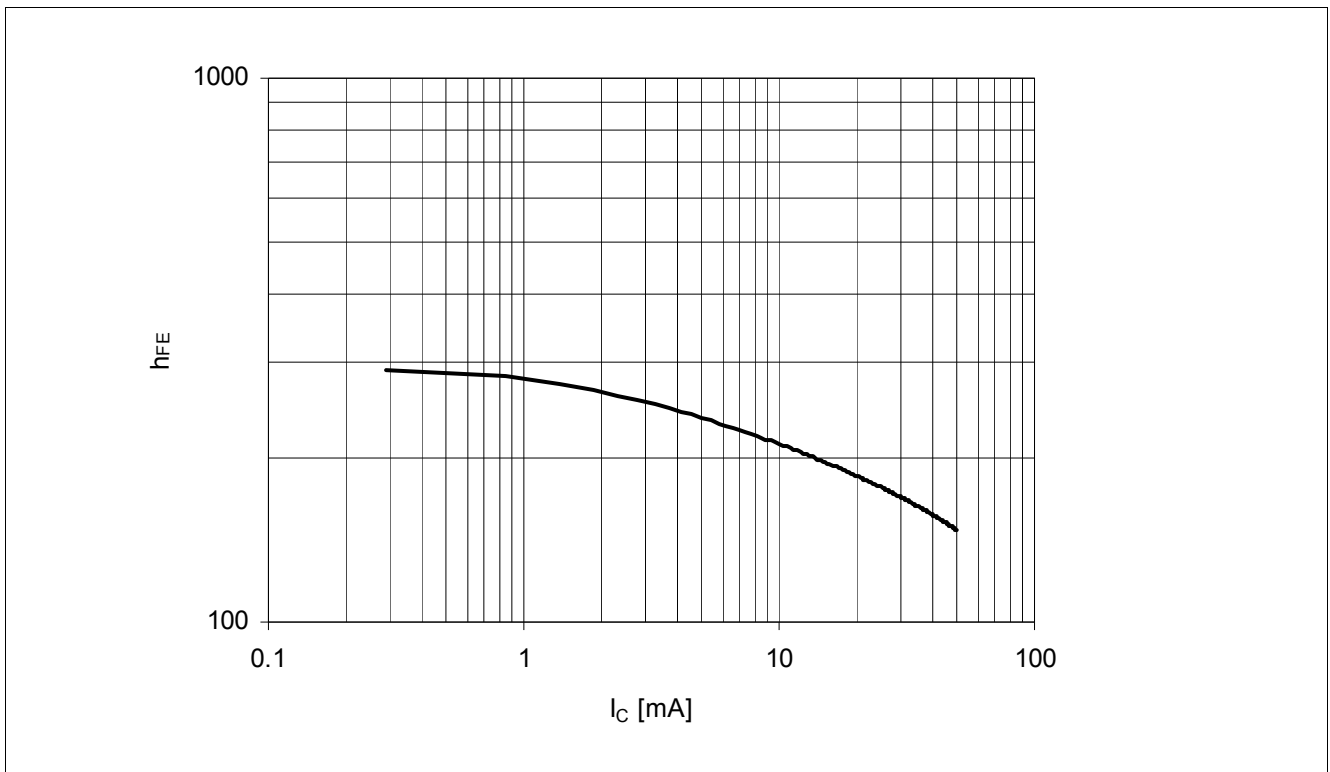


Figure 5-3 DC Current Gain $h_{FE} = f(I_C)$, $V_{CE} = 3 V$

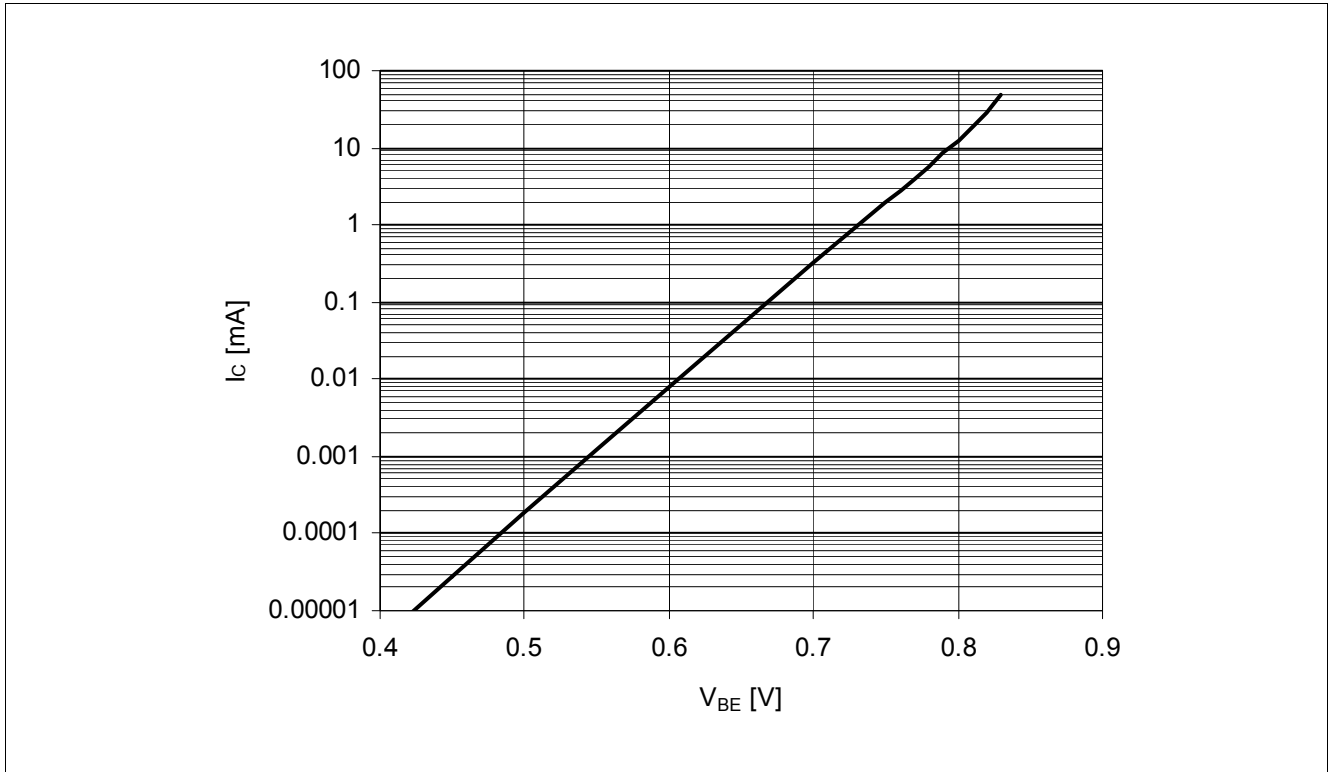


Figure 5-4 Collector Current vs. Base Emitter Voltage $I_C = f(V_{BE})$, $V_{CE} = 2\text{ V}$

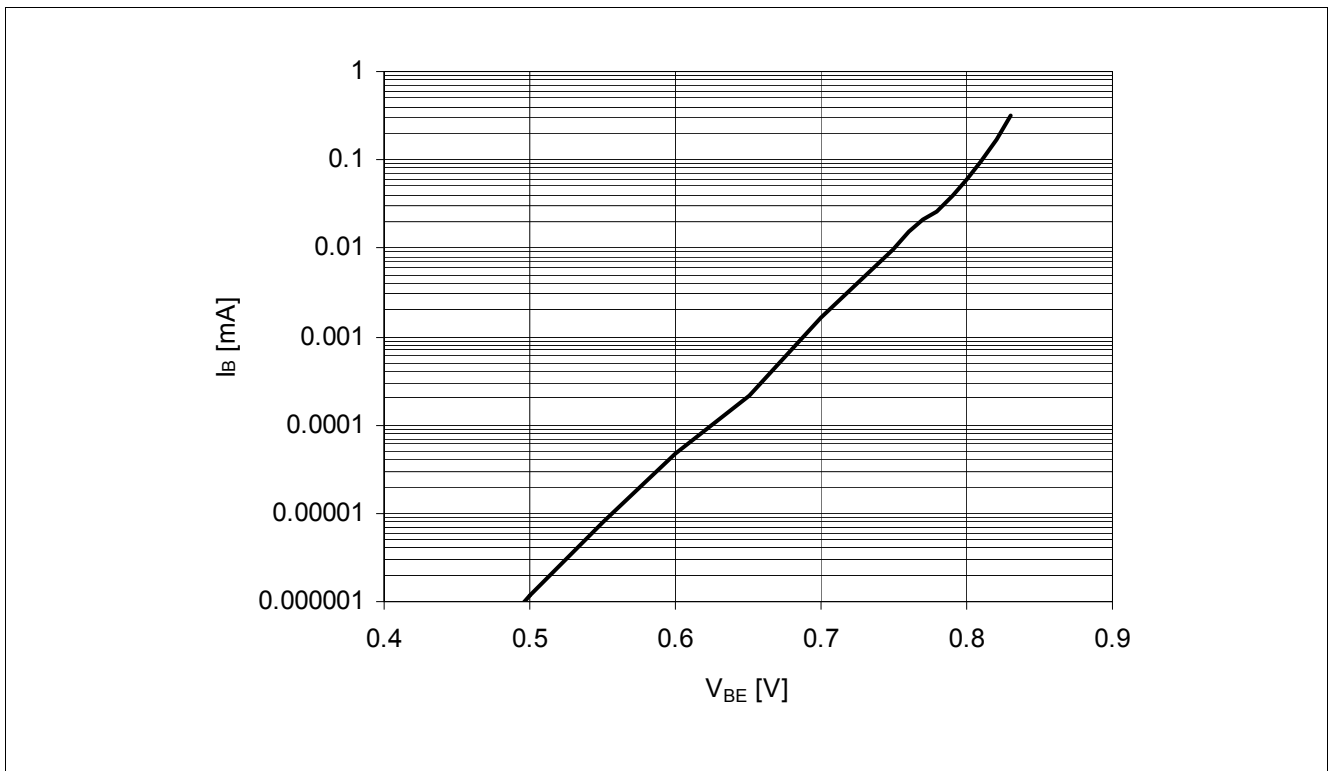


Figure 5-5 Base Current vs. Base Emitter Forward Voltage $I_B = f(V_{BE})$, $V_{CE} = 2\text{ V}$

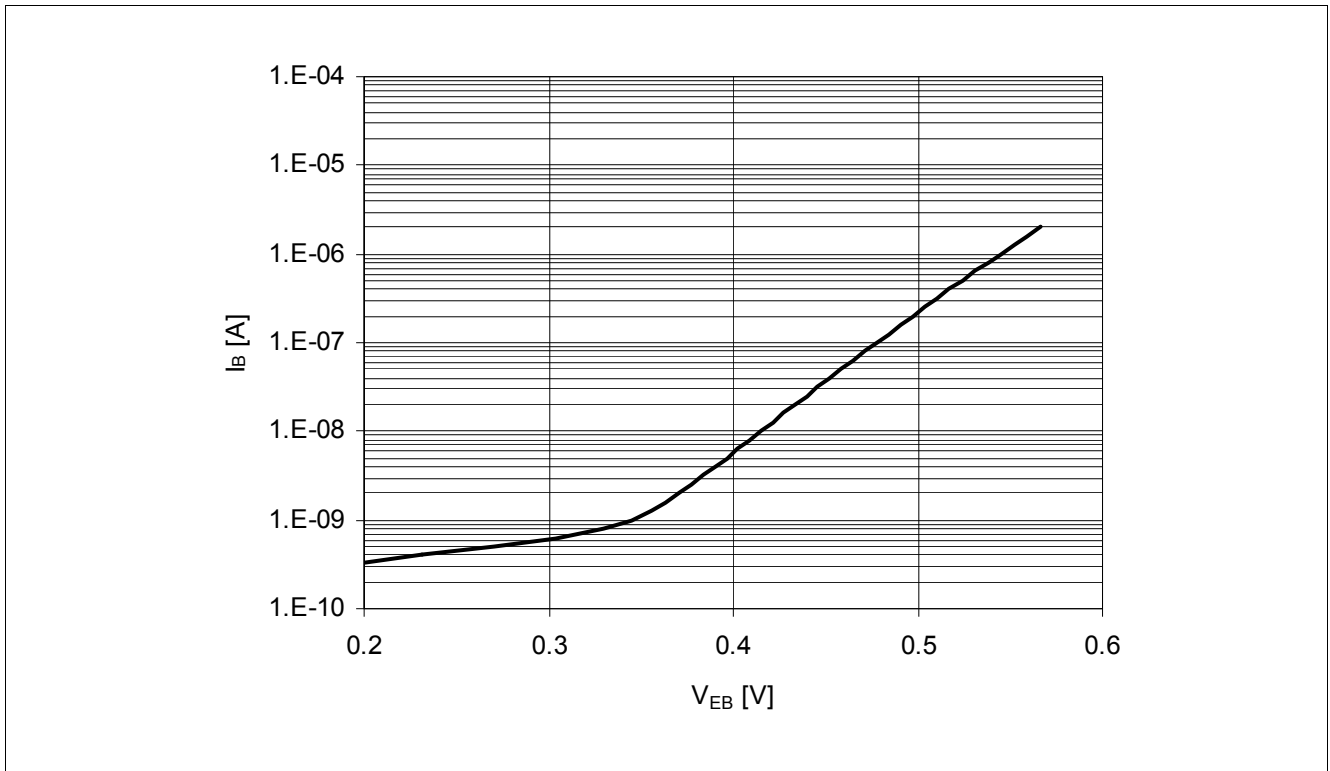


Figure 5-6 Base Current vs. Base Emitter Reverse Voltage $I_B = f(V_{EB})$, $V_{CE} = 2\text{ V}$

5.5 Characteristic AC Diagrams

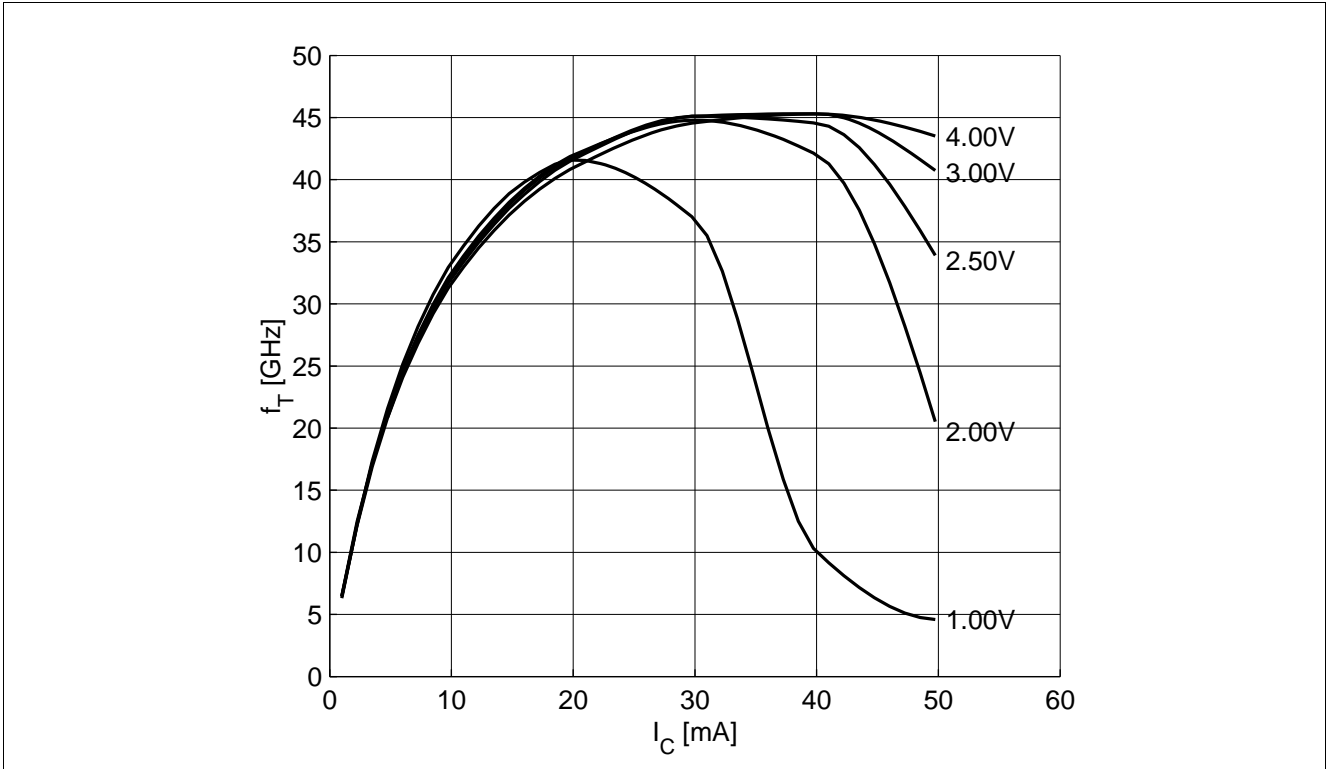


Figure 5-7 Transition Frequency $f_T = f(I_C)$, $f = 1 \text{ GHz}$, $V_{CE} = \text{Parameter in V}$

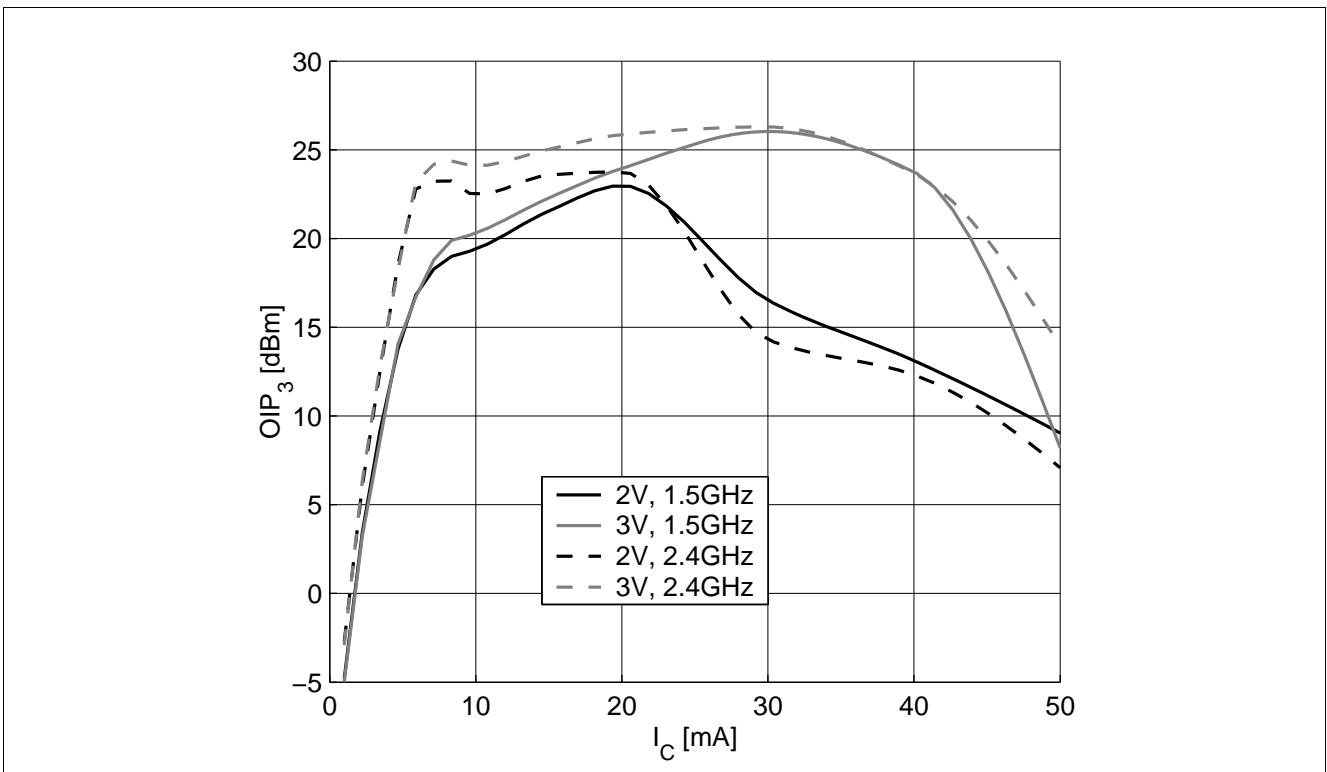


Figure 5-8 3rd Order Intercept Point $OIP_3 = f(I_C)$, $Z_S = Z_L = 50 \Omega$, $V_{CE}, f = \text{Parameters}$

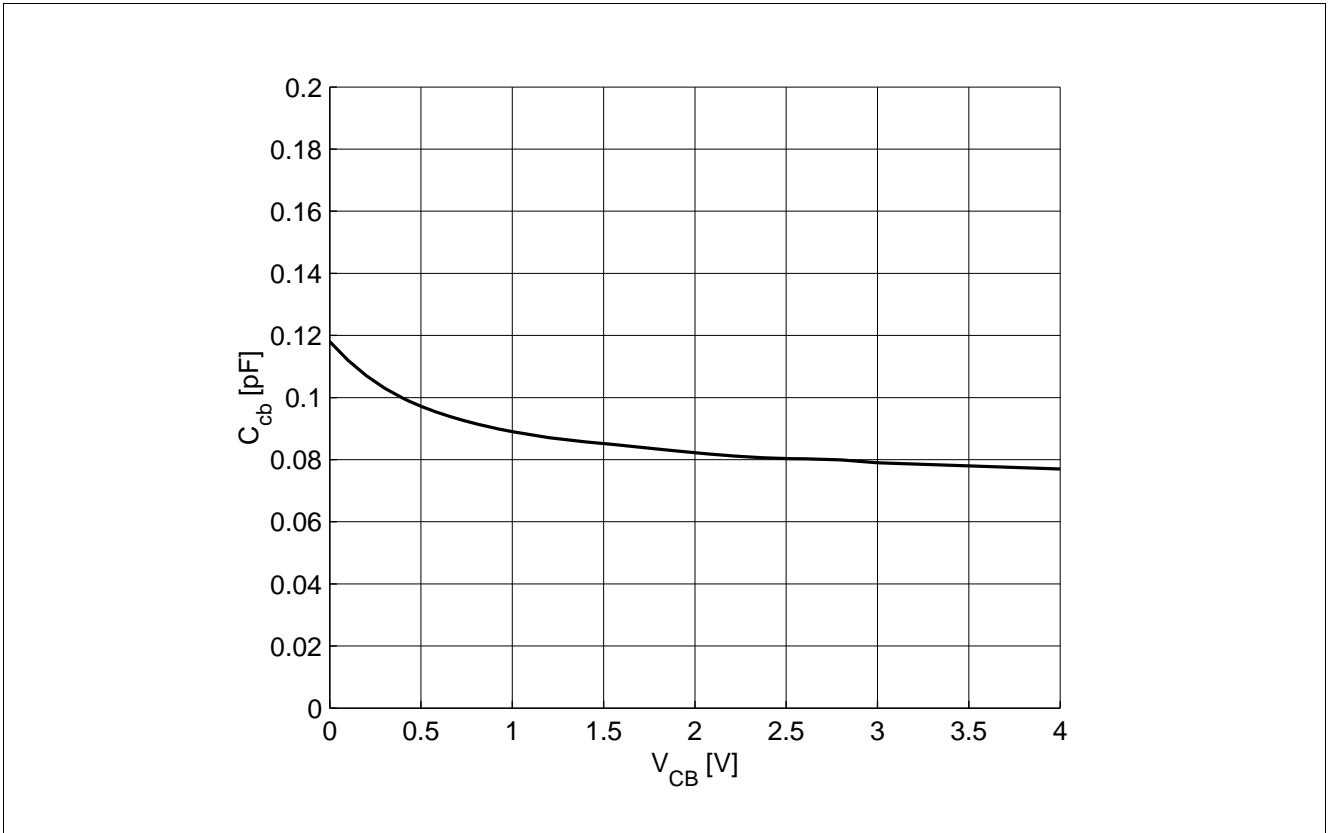


Figure 5-9 Collector Base Capacitance $C_{CB} = f(V_{CB})$, $f = 1$ MHz

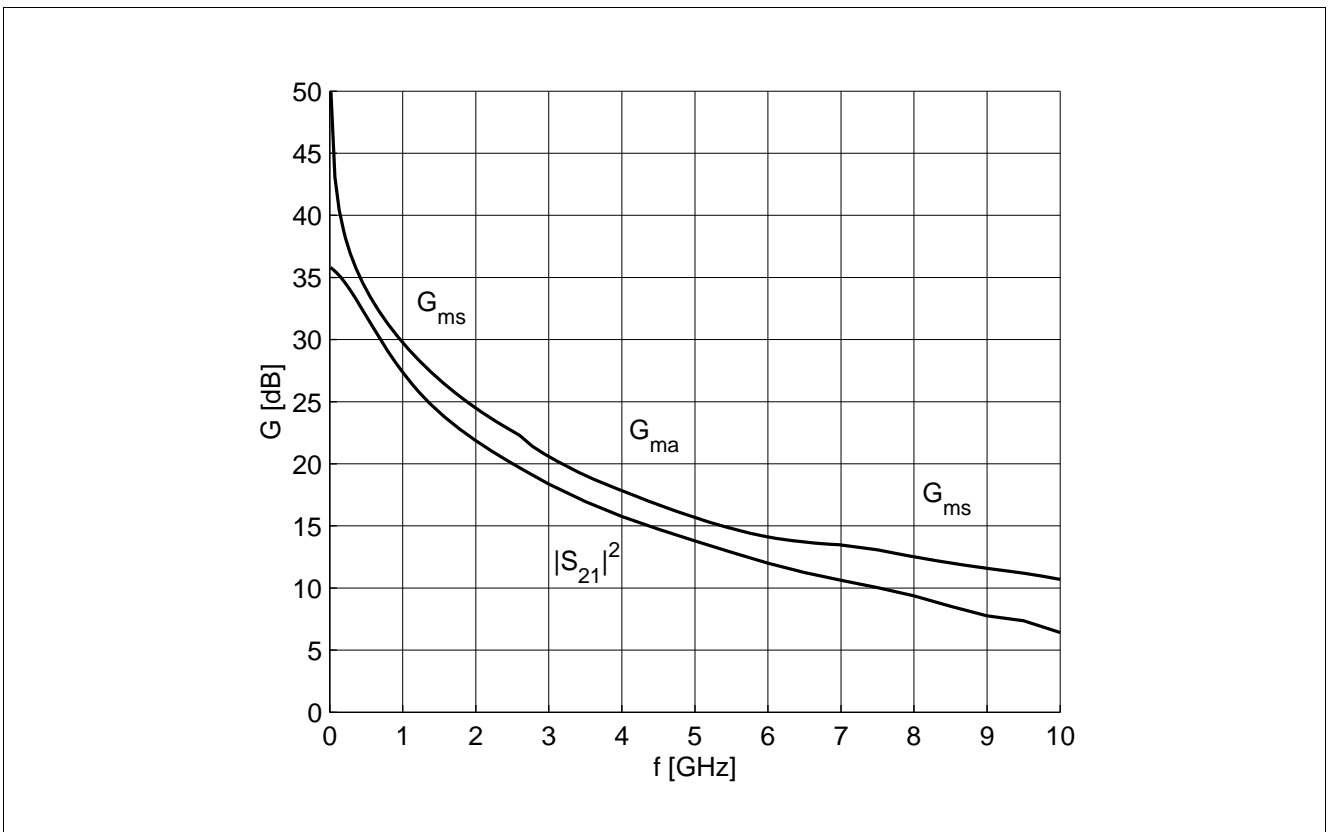


Figure 5-10 Gain G_{ma} , G_{ms} , $|S_{21}|^2 = f(f)$, $V_{CE} = 3$ V, $I_C = 30$ mA

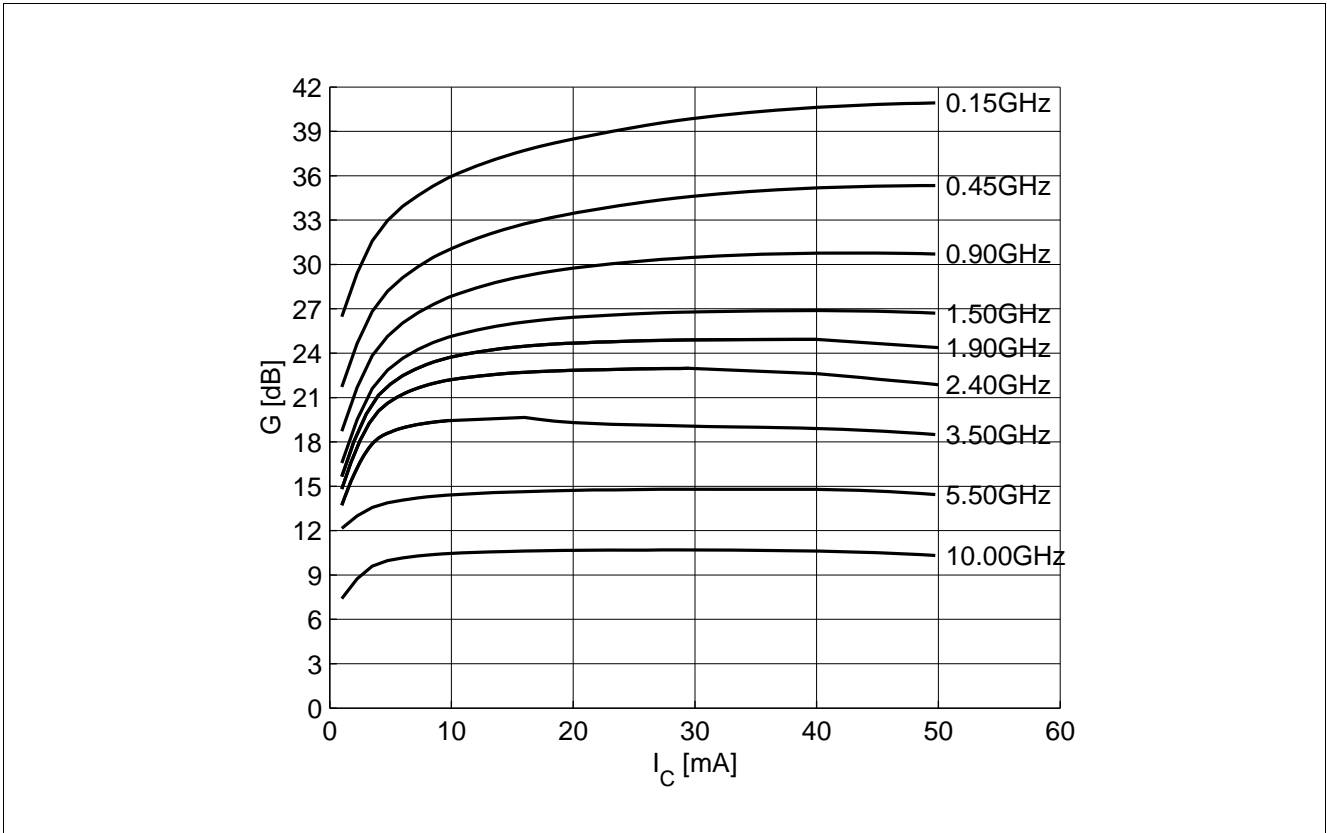


Figure 5-11 Maximum Power Gain $G_{max} = f(I_C)$, $V_{CE} = 3$ V, $f =$ Parameter in GHz

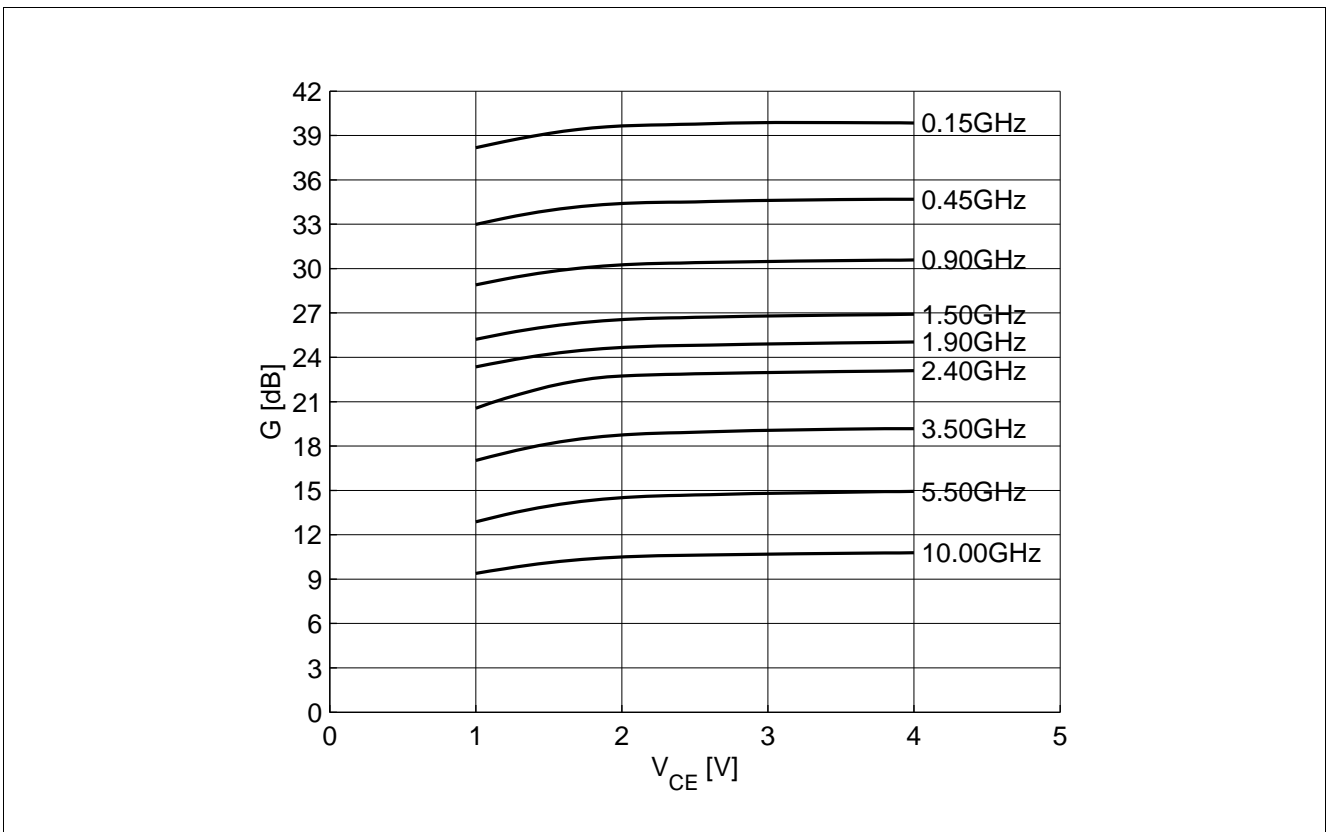


Figure 5-12 Maximum Power Gain $G_{max} = f(V_{CE})$, $I_C = 30$ mA, $f =$ Parameter in GHz

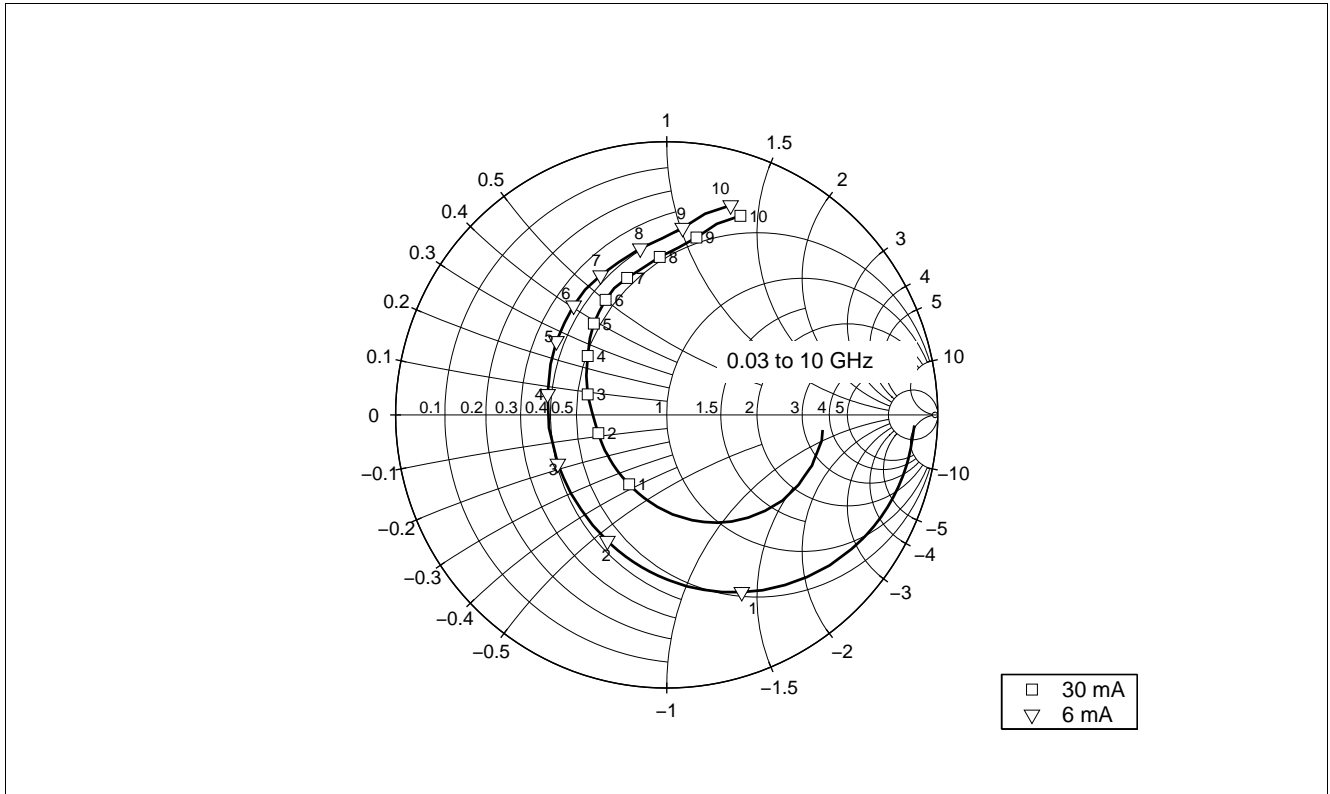


Figure 5-13 Input Matching $S_{11} = f(f)$, $V_{CE} = 3\text{ V}$, $I_C = 6 / 30\text{ mA}$

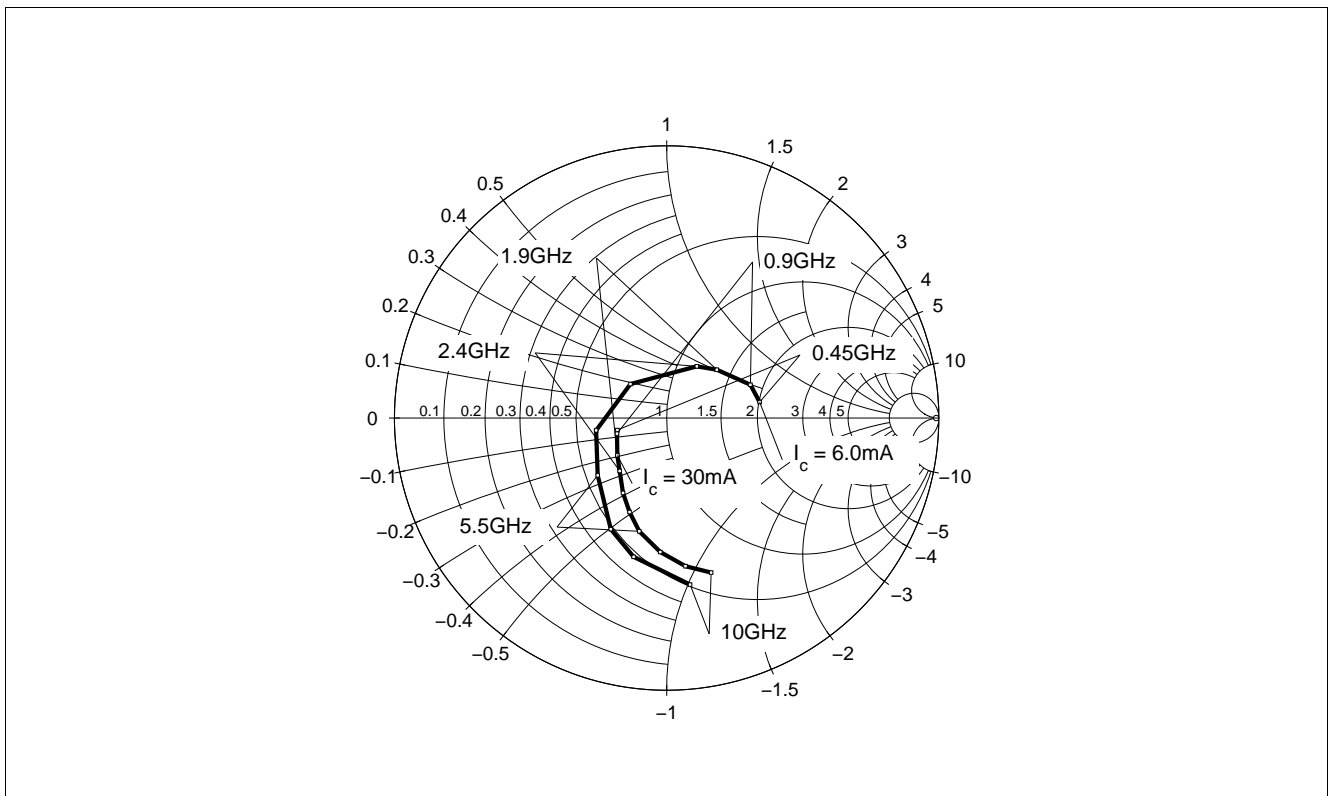


Figure 5-14 Source Impedance for Minimum Noise Figure $Z_{opt} = f(f)$, $V_{CE} = 3\text{ V}$, $I_C = 6 / 30\text{ mA}$

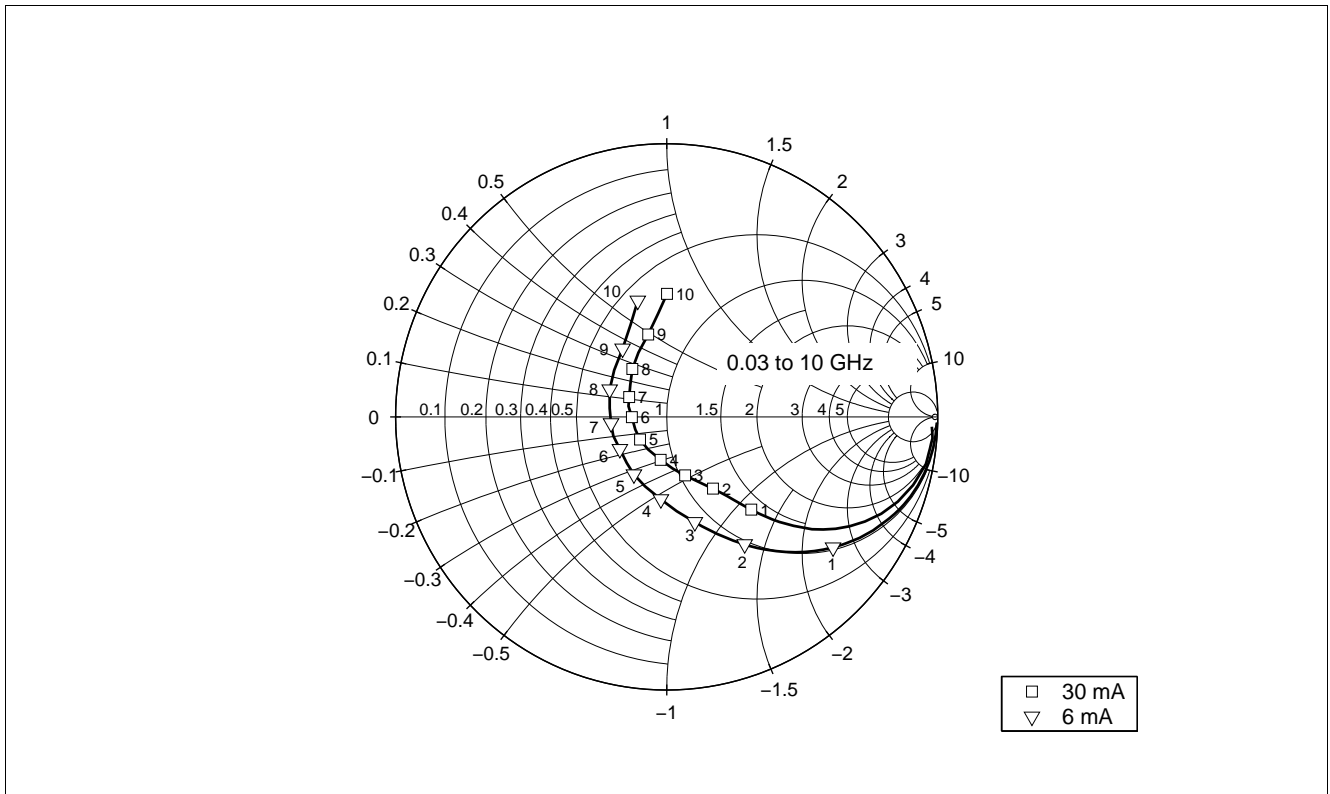


Figure 5-15 Output Matching $S_{22} = f(f)$, $V_{CE} = 3 \text{ V}$, $I_C = 6 / 30 \text{ mA}$

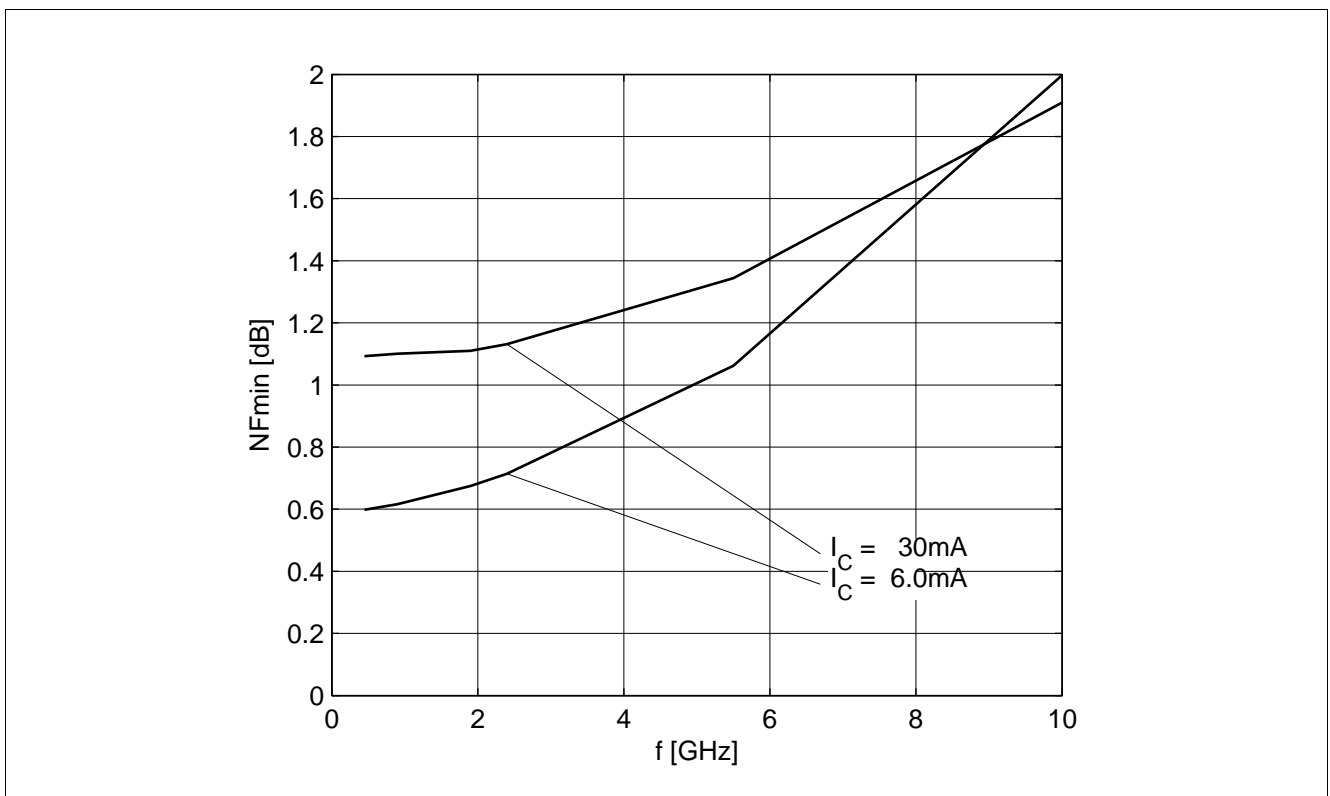


Figure 5-16 Noise Figure $NF_{min} = f(f)$, $V_{CE} = 3 \text{ V}$, $I_C = 6 / 30 \text{ mA}$, $Z_S = Z_{opt}$

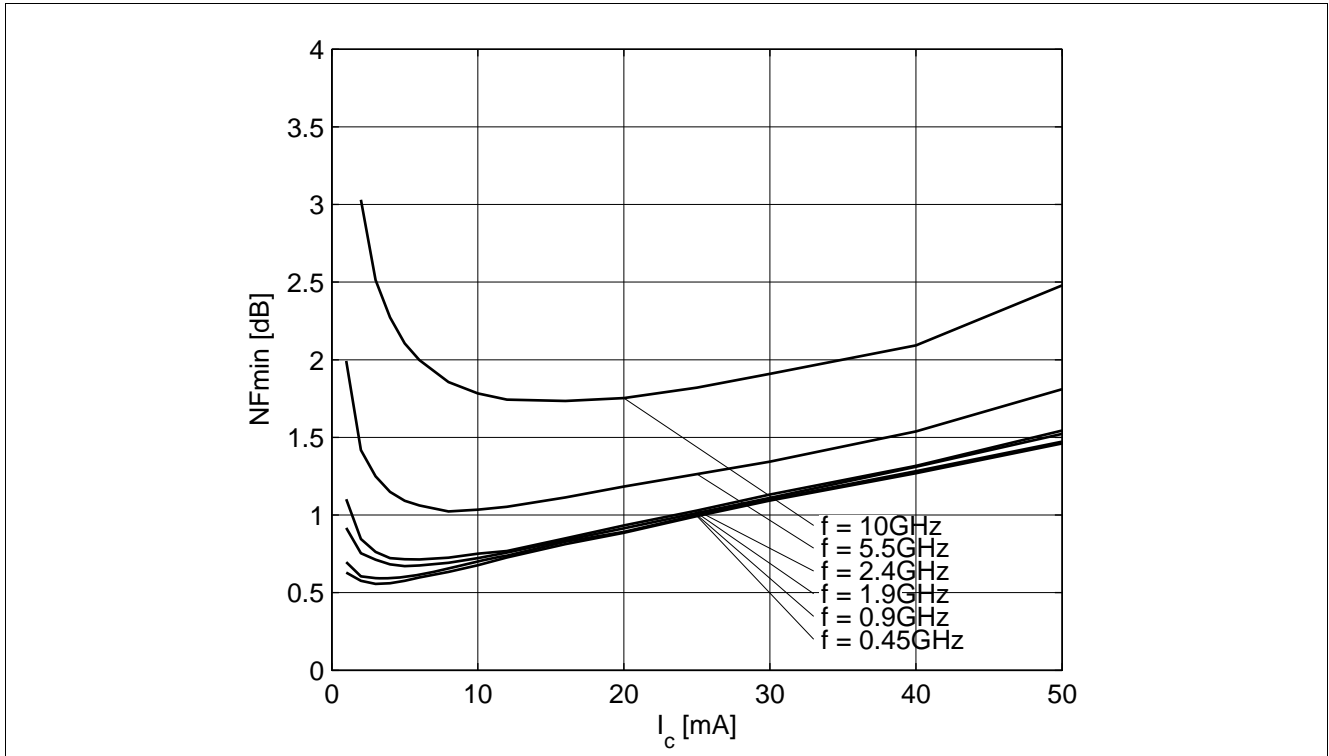


Figure 5-17 Noise Figure $NF_{min} = f(I_C)$, $V_{CE} = 3\text{ V}$, $Z_S = Z_{opt}$, $f = \text{Parameter in GHz}$

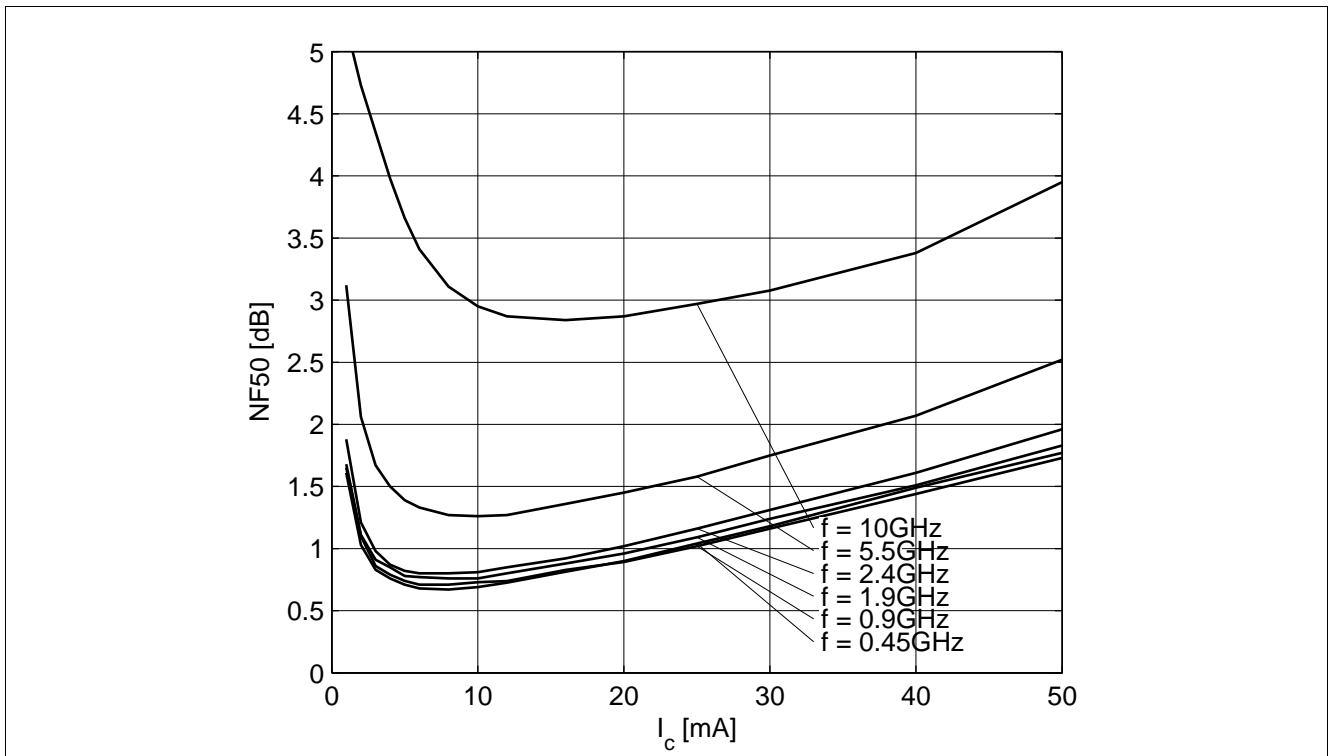


Figure 5-18 Noise Figure $NF_{50} = f(I_C)$, $V_{CE} = 3\text{ V}$, $Z_S = 50\ \Omega$, $f = \text{Parameter in GHz}$

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

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 BFP640ESD 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 BFP640ESD 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 SOT343

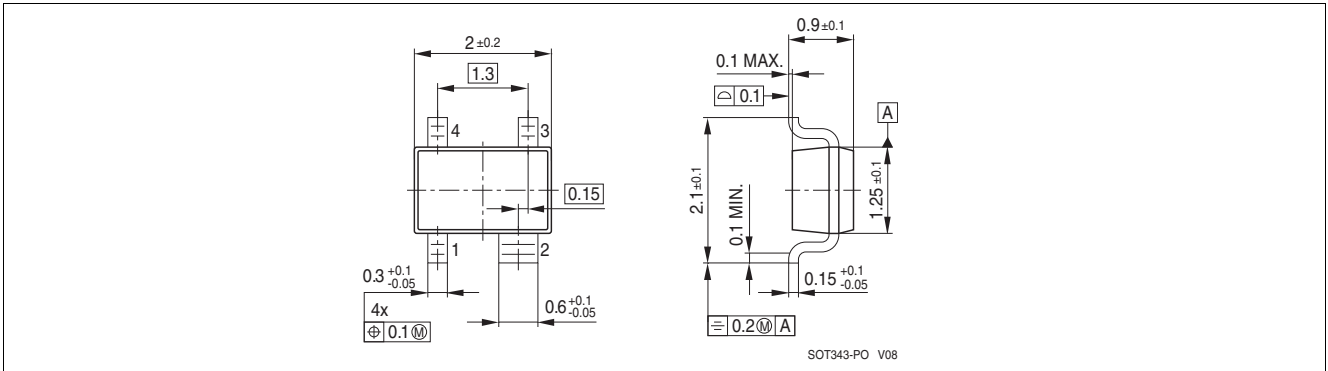


Figure 7-1 Package Outline

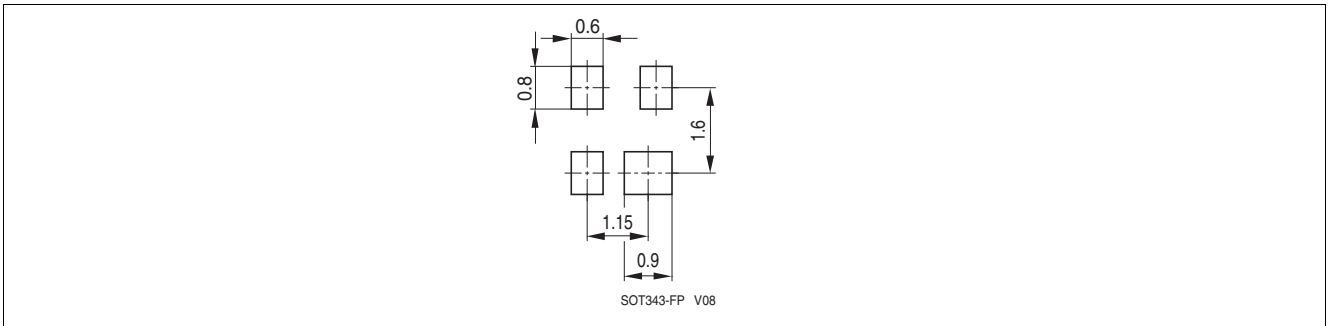


Figure 7-2 Package Footprint

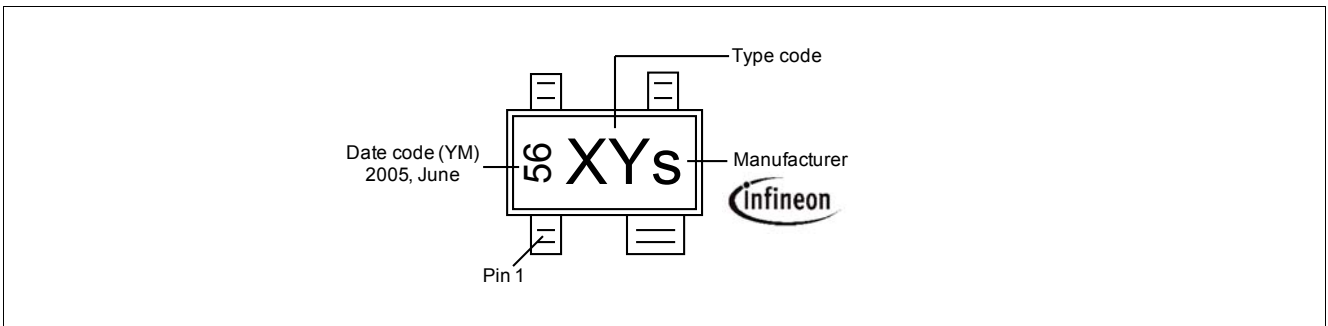


Figure 7-3 Marking Description (Marking BFP640ESD: T4s)

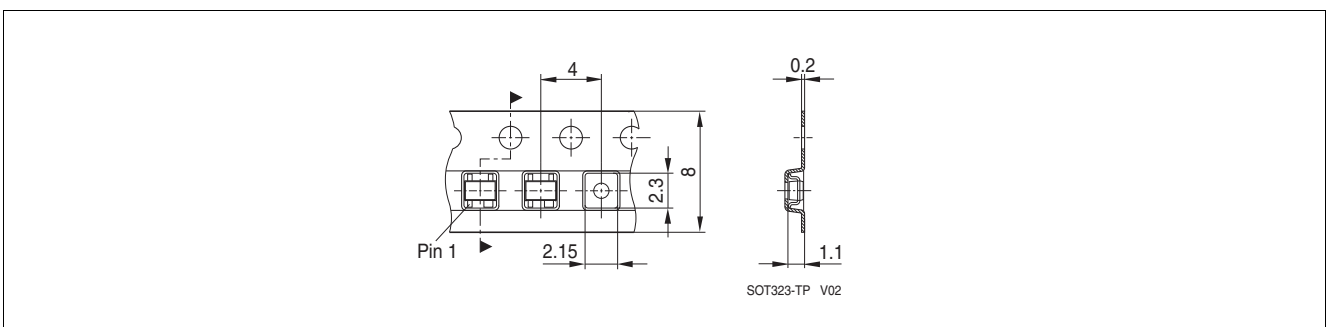


Figure 7-4 Tape Dimensions

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