

# BFP650

## High linearity wideband silicon NPN RF bipolar transistor



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Simulation



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## Product description

The BFP650 is a RF bipolar transistor based on SiGe:C technology that is part of Infineon's established sixth generation transistor family. Its transition frequency  $f_T$  of 42 GHz and high linearity characteristics at low currents make the device suitable for energy efficiency designs at frequency as high as 5 GHz. It remains cost competitive without compromising on ease of use.



## Feature list

- Minimum noise figure  $NF_{min} = 1$  dB at 2.4 GHz, 3 V, 30 mA
- High gain  $G_{ma} = 17.5$  dB at 2.4 GHz, 3 V, 70 mA
- $OIP_3 = 30$  dBm at 2.4 GHz, 3 V, 70 mA

## Product validation

Qualified for industrial applications according to the relevant tests of JEDEC47/20/22.

## Potential applications

- Low noise, high linearity amplifiers in SDARS receivers
- Low noise, high linearity amplifiers for ISM band applications
- Low noise, high linearity amplifiers for multimedia applications such as CATV

## Device information

**Table 1** Part information

Product name / Ordering code	Package	Pin configuration				Marking	Pieces / Reel
BFP650 / BFP650H6327XTSA1	SOT343	1 = B	2 = E	3 = C	4 = E	R5s	3000

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

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**Absolute maximum ratings**

**1 Absolute maximum ratings**

**Table 2 Absolute maximum ratings at  $T_A = 25\text{ °C}$  (unless otherwise specified)**

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

**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. Exceeding only one of these values may cause irreversible damage to the integrated circuit.*

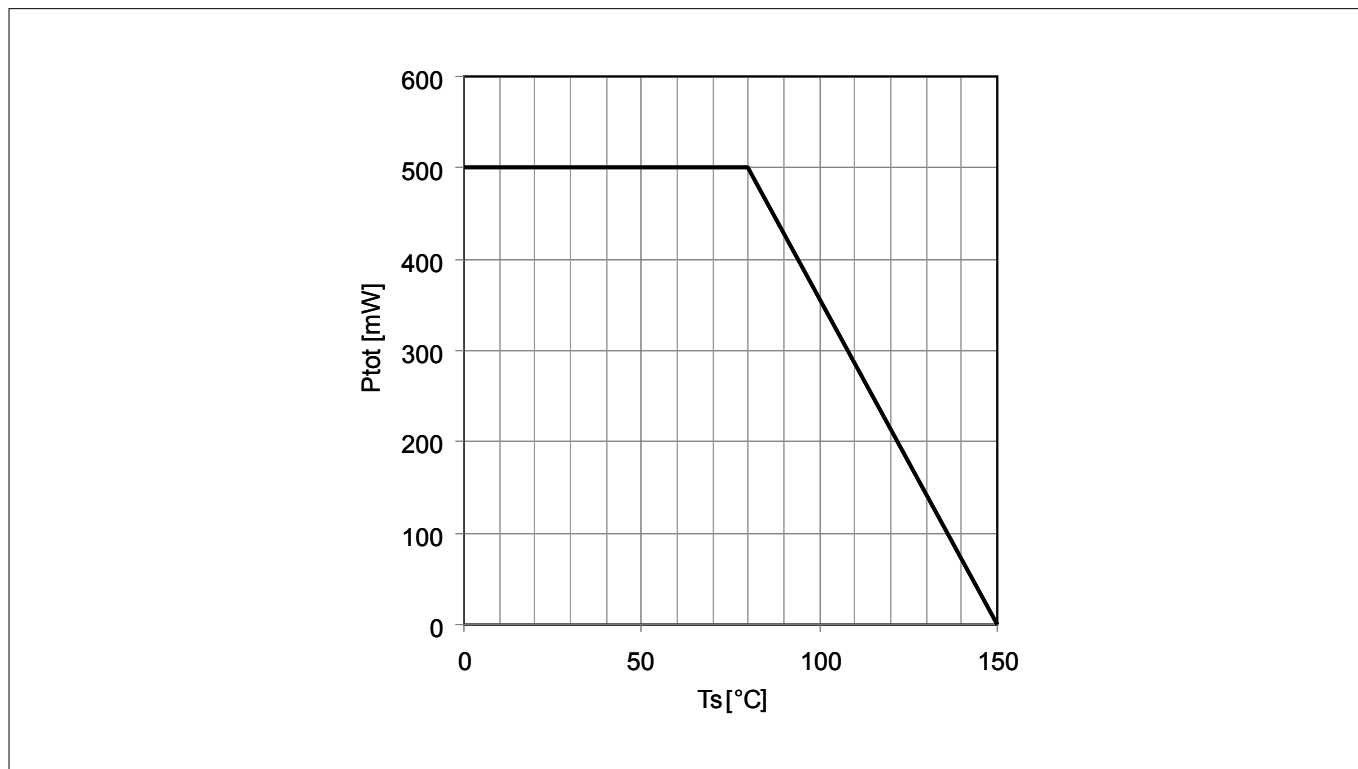
<sup>1</sup>  $T_S$  is the soldering point temperature.  $T_S$  is measured on the emitter lead at the soldering point of the PCB.

Thermal characteristics

## 2 Thermal characteristics

**Table 3 Thermal resistance**

Parameter	Symbol	Values			Unit	Note or test condition
		Min.	Typ.	Max.		
Junction - soldering point	$R_{thJS}$	-	140	-	K/W	-



**Figure 1 Total power dissipation  $P_{tot} = f(T_s)$**

**Electrical characteristics**

**3 Electrical characteristics**

**3.1 DC characteristics**

**Table 4 DC characteristics at  $T_A = 25\text{ °C}$**

Parameter	Symbol	Values			Unit	Note or 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 <sup>2)</sup>	$\mu\text{A}$	$V_{CE} = 13\text{ V}$ , $V_{BE} = 0$ , E-B short circuited
			1	40 <sup>2)</sup>	nA	$V_{CE} = 5\text{ V}$ , $V_{BE} = 0$ , E-B short circuited
Collector base leakage current	$I_{CBO}$		1	40 <sup>2)</sup>	nA	$V_{CB} = 5\text{ V}$ , $I_E = 0$ , open emitter
Emitter base leakage current	$I_{EBO}$		10	500 <sup>2)</sup>	nA	$V_{EB} = 0.5\text{ V}$ , $I_C = 0$ , open collector
DC current gain	$h_{FE}$	100	170	250		$V_{CE} = 3\text{ V}$ , $I_C = 5\text{ mA}$ , pulse measured

**3.2 General AC characteristics**

**Table 5 General AC characteristics at  $T_A = 25\text{ °C}$**

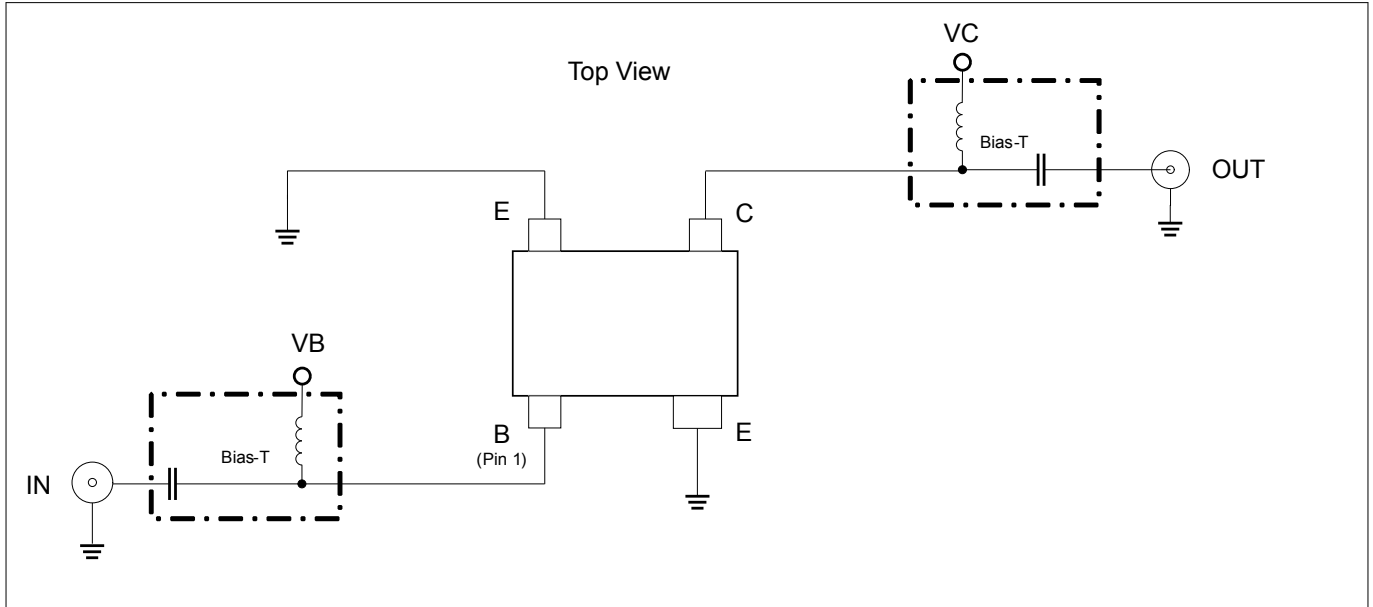
Parameter	Symbol	Values			Unit	Note or test condition
		Min.	Typ.	Max.		
Transition frequency	$f_T$	31	42	–	GHz	$V_{CE} = 3\text{ V}$ , $I_C = 70\text{ mA}$ , $f = 1\text{ GHz}$
Collector base capacitance	$C_{CB}$	–	0.26	0.4	$\mu\text{F}$	$V_{CB} = 3\text{ V}$ , $V_{BE} = 0$ , $f = 1\text{ MHz}$ , emitter grounded
Collector emitter capacitance	$C_{CE}$		0.45	–		$V_{CE} = 3\text{ V}$ , $V_{BE} = 0$ , $f = 1\text{ MHz}$ , base grounded
Emitter base capacitance	$C_{EB}$		1.3	–		$V_{EB} = 0.5\text{ V}$ , $V_{CB} = 0$ , $f = 1\text{ MHz}$ , collector grounded

<sup>2</sup> Maximum values not limited by the device but by the short cycle time of the 100% test.

**Electrical characteristics**

**3.3 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 Testing circuit**

**Table 6 AC characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 150\text{ MHz}$**

Parameter	Symbol	Values			Unit	Note or test condition
		Min.	Typ.	Max.		
Power gain		-		-	dB	$I_C = 70\text{ mA}$
<ul style="list-style-type: none"> <li>Maximum power gain</li> <li>Transducer gain</li> </ul>	$G_{ms}$ $ S_{21} ^2$		38 37.5			
Noise figure					dB	$I_C = 30\text{ mA}$
<ul style="list-style-type: none"> <li>Minimum noise figure</li> <li>Associated gain</li> </ul>	$NF_{min}$ $G_{ass}$		0.75 32			
Linearity					dBm	$I_C = 70\text{ mA}$ , $Z_S = Z_L = 50\text{ }\Omega$
<ul style="list-style-type: none"> <li>3rd order intercept point at output</li> <li>1 dB gain compression point at output</li> </ul>	$OIP_3$ $OP_{1dB}$		29.5 16.5			

**Electrical characteristics**

**Table 7 AC characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 450\text{ MHz}$**

Parameter	Symbol	Values			Unit	Note or test condition
		Min.	Typ.	Max.		
Power gain	$G_{ms}$ $ S_{21} ^2$	-	31.5	-	dB	$I_C = 70\text{ mA}$
• Maximum power gain			29.5			
• Transducer gain						
Noise figure	$NF_{min}$ $G_{ass}$		0.75		dB	$I_C = 30\text{ mA}$
• Minimum noise figure			29.5			
• Associated gain						
Linearity	$OIP_3$ $OP_{1dB}$		30		dBm	$I_C = 70\text{ mA}$ , $Z_S = Z_L = 50\ \Omega$
• 3rd order intercept point at output			16.5			
• 1 dB gain compression point at output						

**Table 8 AC characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 900\text{ MHz}$**

Parameter	Symbol	Values			Unit	Note or test condition
		Min.	Typ.	Max.		
Power gain	$G_{ms}$ $ S_{21} ^2$	-	26.5	-	dB	$I_C = 70\text{ mA}$
• Maximum power gain			24			
• Transducer gain						
Noise figure	$NF_{min}$ $G_{ass}$		0.8		dB	$I_C = 30\text{ mA}$
• Minimum noise figure			24.5			
• Associated gain						
Linearity	$OIP_3$ $OP_{1dB}$		31		dBm	$I_C = 70\text{ mA}$ , $Z_S = Z_L = 50\ \Omega$
• 3rd order intercept point at output			17			
• 1 dB gain compression point at output						

**Table 9 AC characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 1.5\text{ GHz}$**

Parameter	Symbol	Values			Unit	Note or test condition
		Min.	Typ.	Max.		
Power gain	$G_{ms}$ $ S_{21} ^2$	-	22.5	-	dB	$I_C = 70\text{ mA}$
• Maximum power gain			19.5			
• Transducer gain						
Noise figure	$NF_{min}$ $G_{ass}$		0.85		dB	$I_C = 30\text{ mA}$
• Minimum noise figure			20.5			
• Associated gain						
Linearity	$OIP_3$ $OP_{1dB}$		31		dBm	$I_C = 70\text{ mA}$ , $Z_S = Z_L = 50\ \Omega$
• 3rd order intercept point at output			17			
• 1 dB gain compression point at output						

**Electrical characteristics**

**Table 10 AC characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 1.9\text{ GHz}$**

Parameter	Symbol	Values			Unit	Note or test condition
		Min.	Typ.	Max.		
Power gain	$G_{ms}$ $ S_{21} ^2$	-	20	-	dB	$I_C = 70\text{ mA}$
<ul style="list-style-type: none"> <li>Maximum power gain</li> <li>Transducer gain</li> </ul>			17.5			
Noise figure	$NF_{min}$ $G_{ass}$		0.95			$I_C = 30\text{ mA}$
<ul style="list-style-type: none"> <li>Minimum noise figure</li> <li>Associated gain</li> </ul>			17.5			
Linearity	$OIP_3$ $OP_{1dB}$		30.5		dBm	$I_C = 70\text{ mA}$ , $Z_S = Z_L = 50\ \Omega$
<ul style="list-style-type: none"> <li>3rd order intercept point at output</li> <li>1 dB gain compression point at output</li> </ul>			17			

**Table 11 AC characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 2.4\text{ GHz}$**

Parameter	Symbol	Values			Unit	Note or test condition
		Min.	Typ.	Max.		
Power gain	$G_{ms}$ $ S_{21} ^2$	-	17.5	-	dB	$I_C = 70\text{ mA}$
<ul style="list-style-type: none"> <li>Maximum power gain</li> <li>Transducer gain</li> </ul>			15			
Noise figure	$NF_{min}$ $G_{ass}$		1			$I_C = 30\text{ mA}$
<ul style="list-style-type: none"> <li>Minimum noise figure</li> <li>Associated gain</li> </ul>			15			
Linearity	$OIP_3$ $OP_{1dB}$		30		dBm	$I_C = 70\text{ mA}$ , $Z_S = Z_L = 50\ \Omega$
<ul style="list-style-type: none"> <li>3rd order intercept point at output</li> <li>1 dB gain compression point at output</li> </ul>			17			

**Table 12 AC characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 3.5\text{ GHz}$**

Parameter	Symbol	Values			Unit	Note or test condition
		Min.	Typ.	Max.		
Power gain	$G_{ms}$ $ S_{21} ^2$	-	14.5	-	dB	$I_C = 70\text{ mA}$
<ul style="list-style-type: none"> <li>Maximum power gain</li> <li>Transducer gain</li> </ul>			11.5			
Noise figure	$NF_{min}$ $G_{ass}$		1.2			$I_C = 30\text{ mA}$
<ul style="list-style-type: none"> <li>Minimum noise figure</li> <li>Associated gain</li> </ul>			11.5			
Linearity	$OIP_3$ $OP_{1dB}$		30		dBm	$I_C = 70\text{ mA}$ , $Z_S = Z_L = 50\ \Omega$
<ul style="list-style-type: none"> <li>3rd order intercept point at output</li> <li>1 dB gain compression point at output</li> </ul>			17			



**Electrical characteristics**

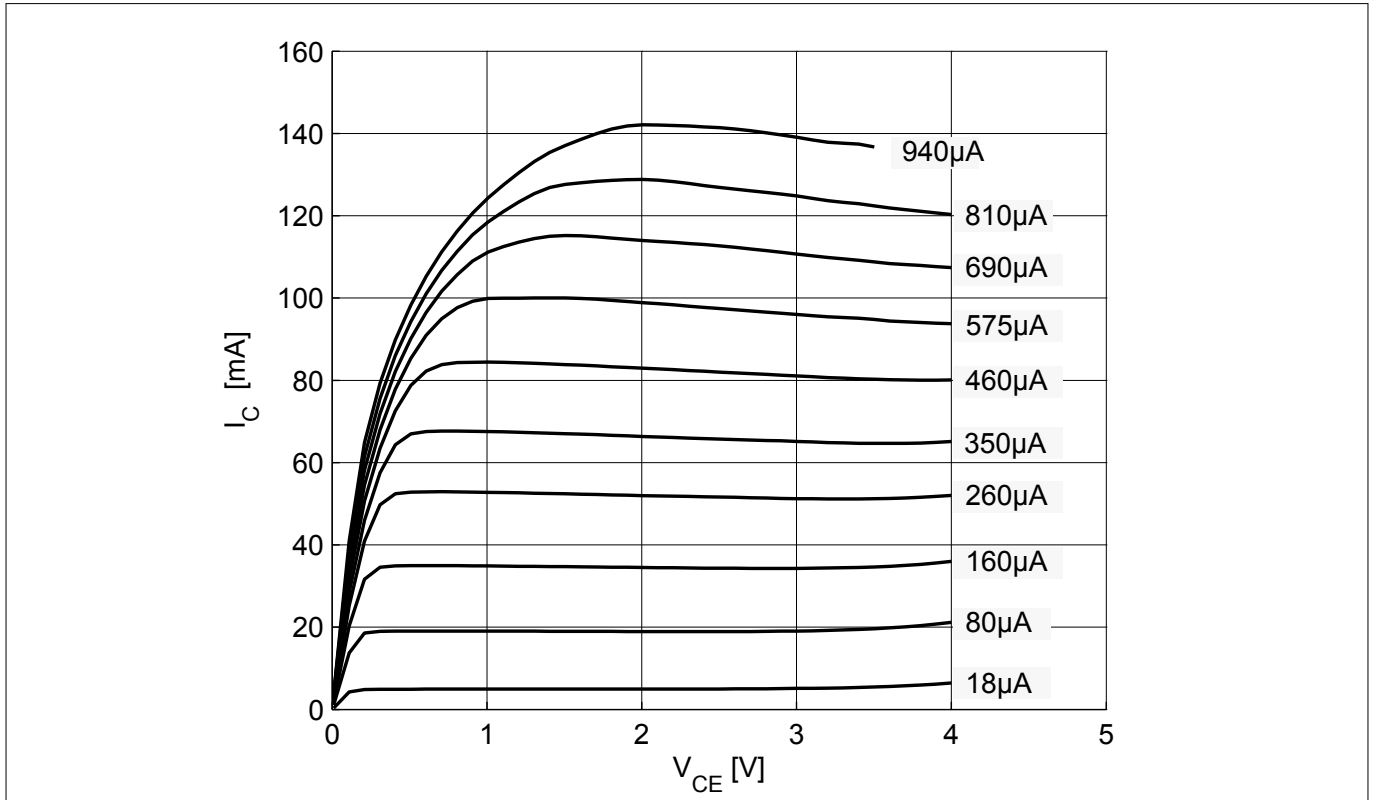
**Table 13 AC characteristics,  $V_{CE} = 3\text{ V}$ ,  $f = 5.5\text{ GHz}$**

Parameter	Symbol	Values			Unit	Note or test condition	
		Min.	Typ.	Max.			
Power gain		-		-	dB	$I_C = 70\text{ mA}$	
<ul style="list-style-type: none"> <li>Maximum power gain</li> <li>Transducer gain</li> </ul>	$G_{ms}$ $ S_{21} ^2$		10.5 7				
Noise figure						dB	$I_C = 30\text{ mA}$
<ul style="list-style-type: none"> <li>Minimum noise figure</li> <li>Associated gain</li> </ul>	$NF_{min}$ $G_{ass}$		1.6 8.5				
Linearity				dBm	$I_C = 70\text{ mA}$ , $Z_S = Z_L = 50\ \Omega$		
<ul style="list-style-type: none"> <li>3rd order intercept point at output</li> <li>1 dB gain compression point at output</li> </ul>	$OIP_3$ $OP_{1dB}$	29.5 16.5					

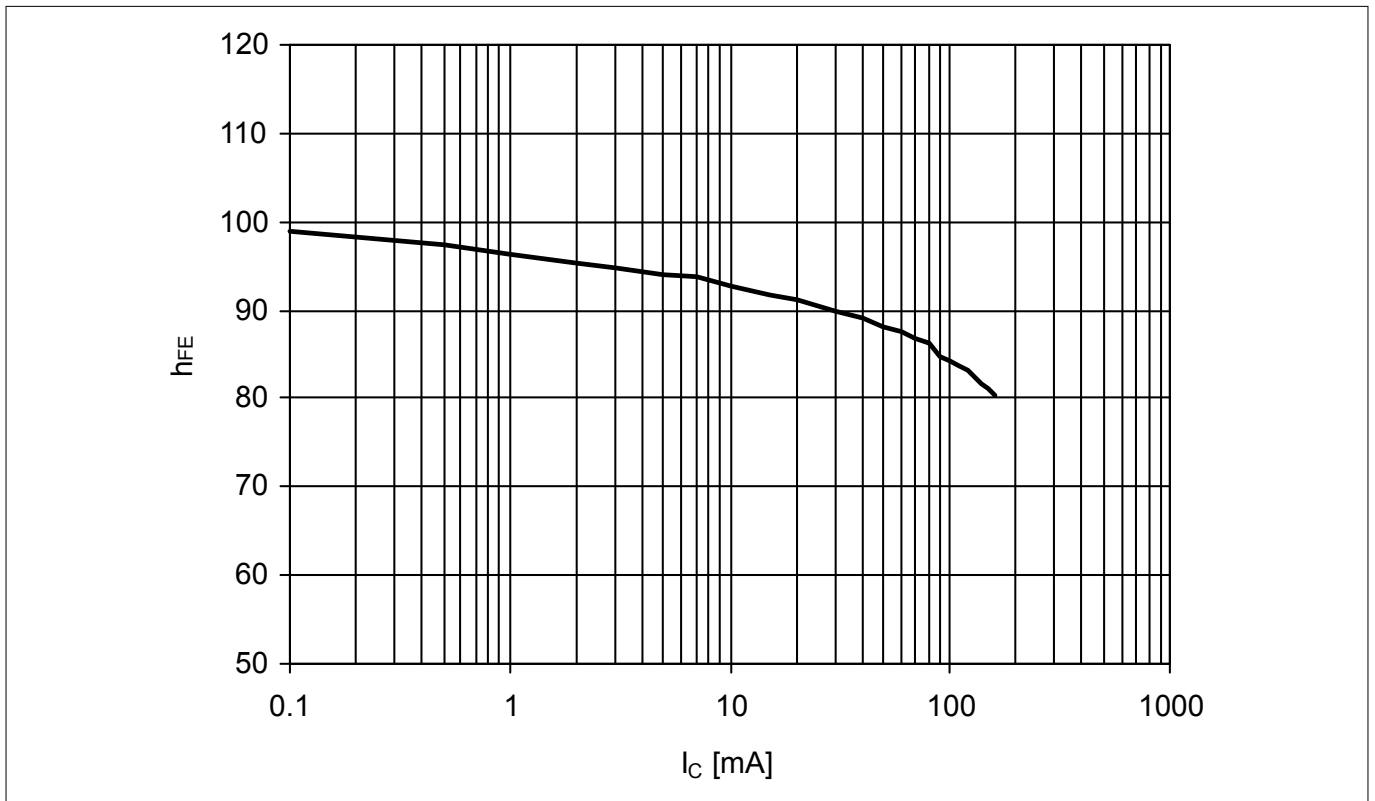
Note:  $G_{ms} = |S_{21}/S_{12}|$  for  $k < 1$ ;  $G_{ma} = |S_{21}/S_{12}|(k-(k^2-1)^{1/2})$  for  $k > 1$ . In order to get the  $NF_{min}$  values stated in this chapter, the test fixture losses have been subtracted from all measured results.  $OIP_3$  value depends on termination of all intermodulation frequency components. Termination used for this measurement is  $50\ \Omega$  from 0.2 MHz to 12 GHz.

**Electrical characteristics**

**3.4 Characteristic DC diagrams**

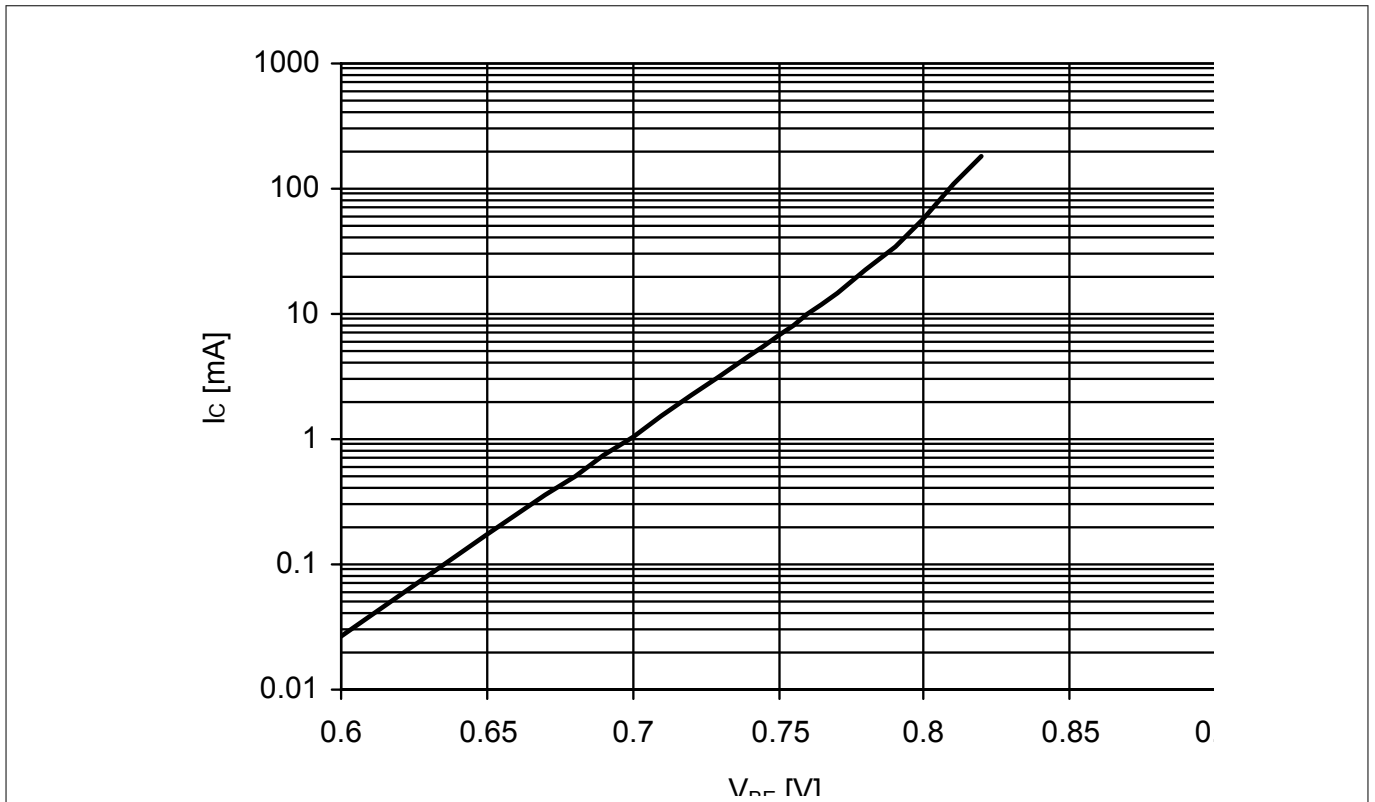


**Figure 3** Collector current vs. collector emitter voltage  $I_C = f(V_{CE})$ ,  $I_B = \text{parameter}$

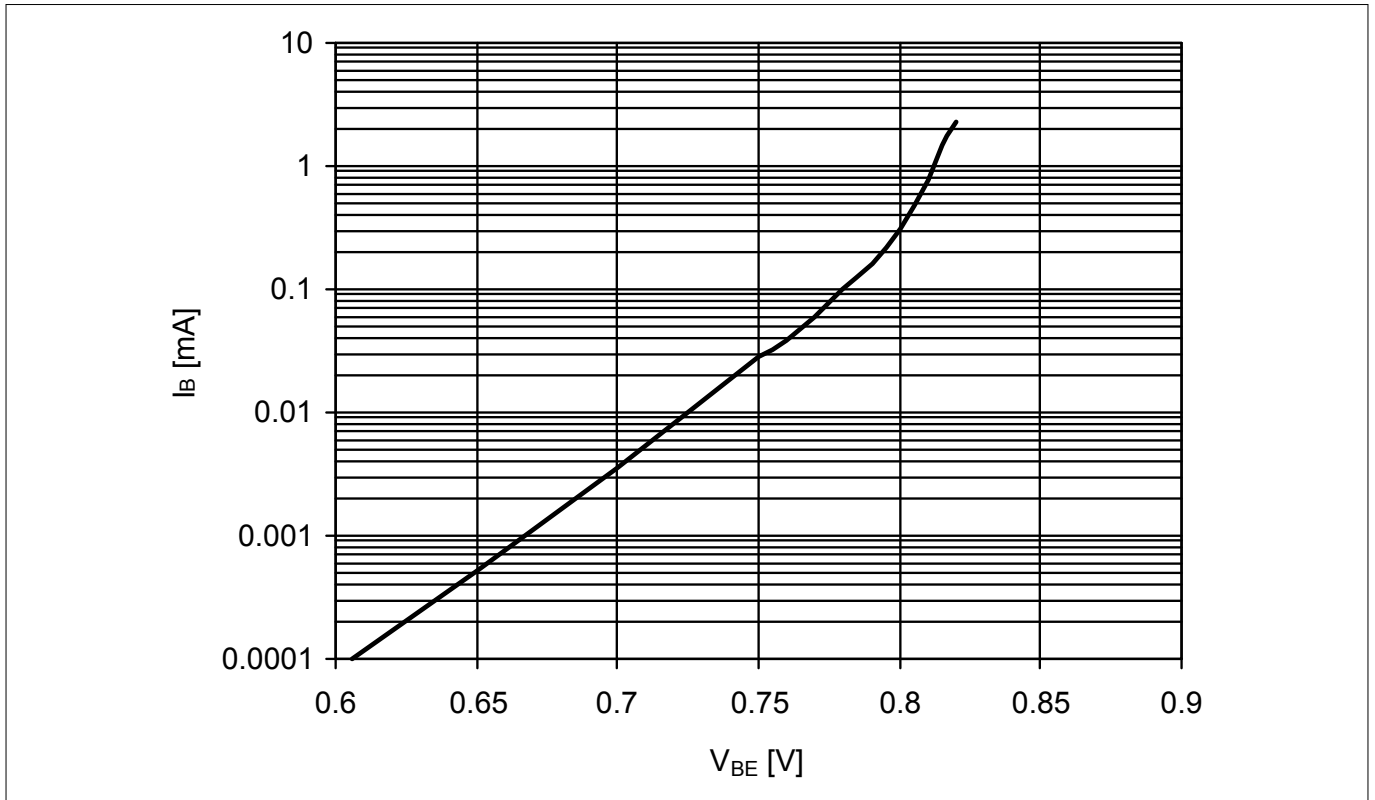


**Figure 4** DC current gain  $h_{FE} = f(I_C)$ ,  $V_{CE} = 3 \text{ V}$

**Electrical characteristics**

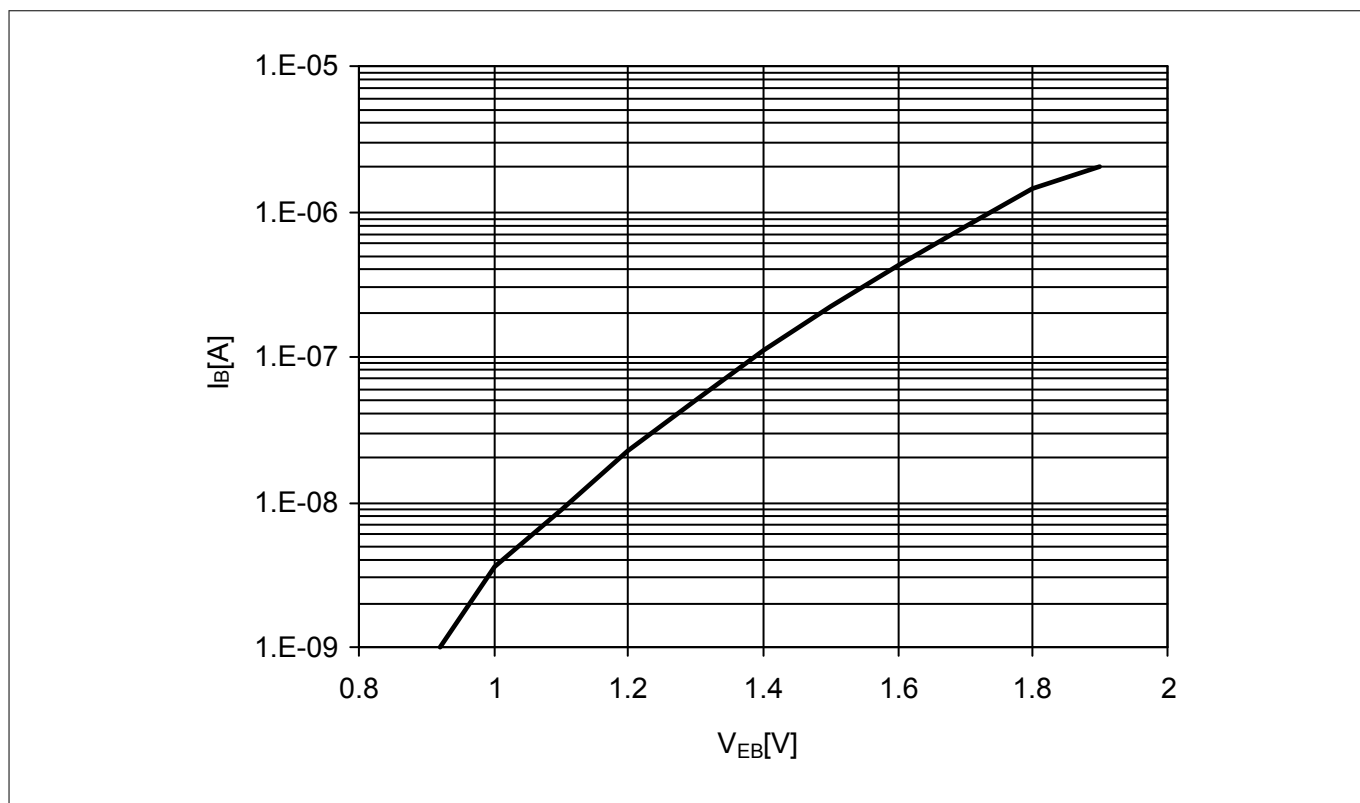


**Figure 5** Collector current vs. base emitter forward voltage  $I_C = f(V_{BE}), V_{CE} = 2\text{ V}$



**Figure 6** Base current vs. base emitter forward voltage  $I_B = f(V_{BE}), V_{CE} = 2\text{ V}$

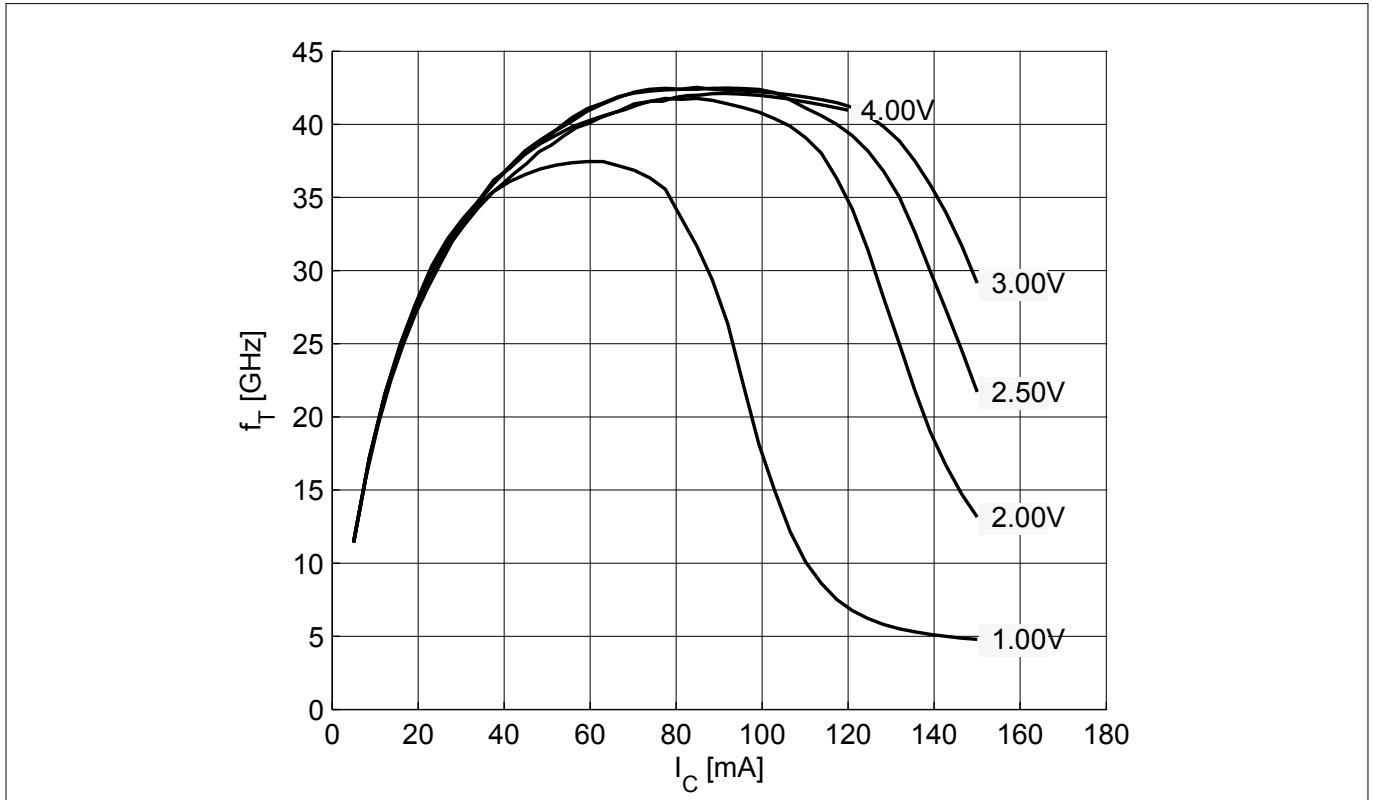
**Electrical characteristics**



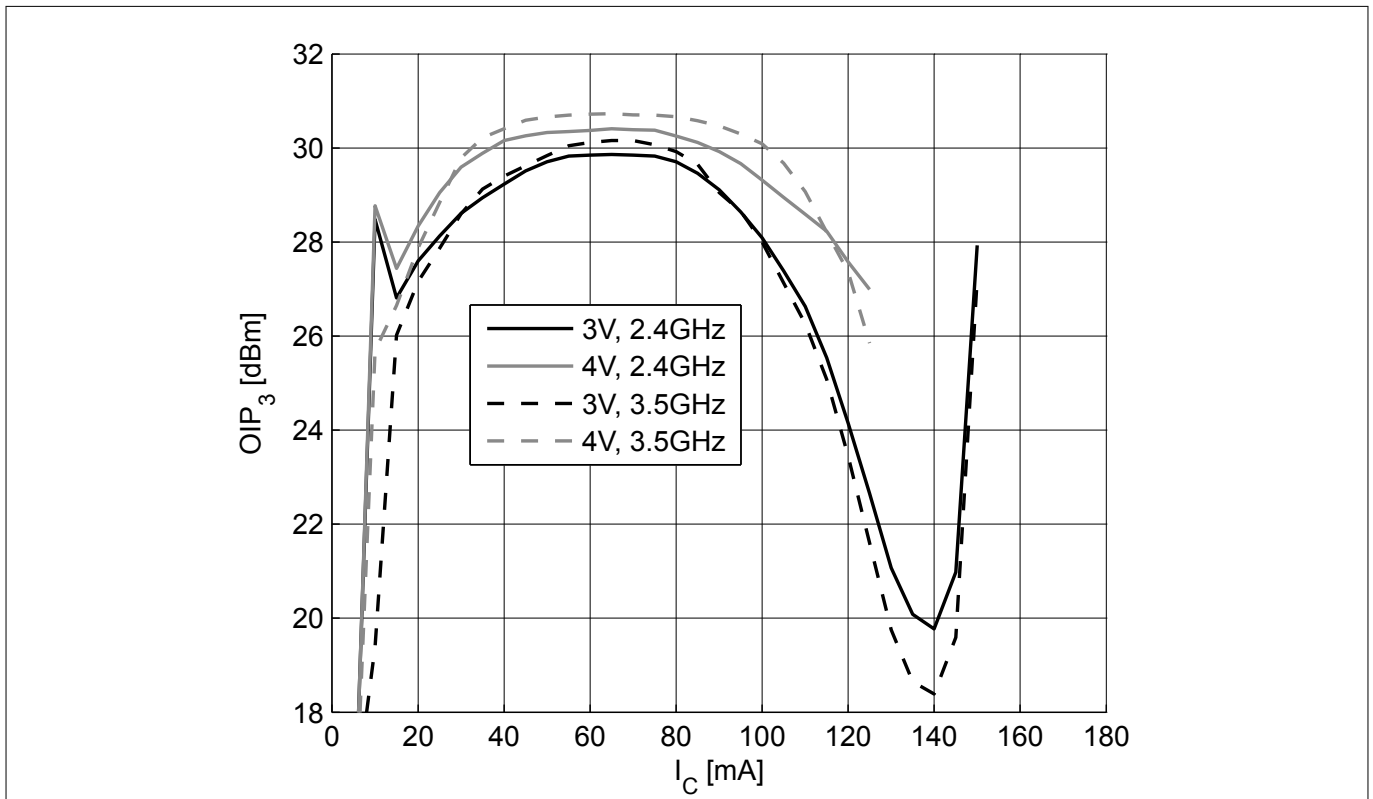
**Figure 7** Base current vs. base emitter reverse voltage  $I_B = f(V_{EB})$ ,  $V_{CE} = 2\text{ V}$

**Electrical characteristics**

**3.5 Characteristic AC diagrams**

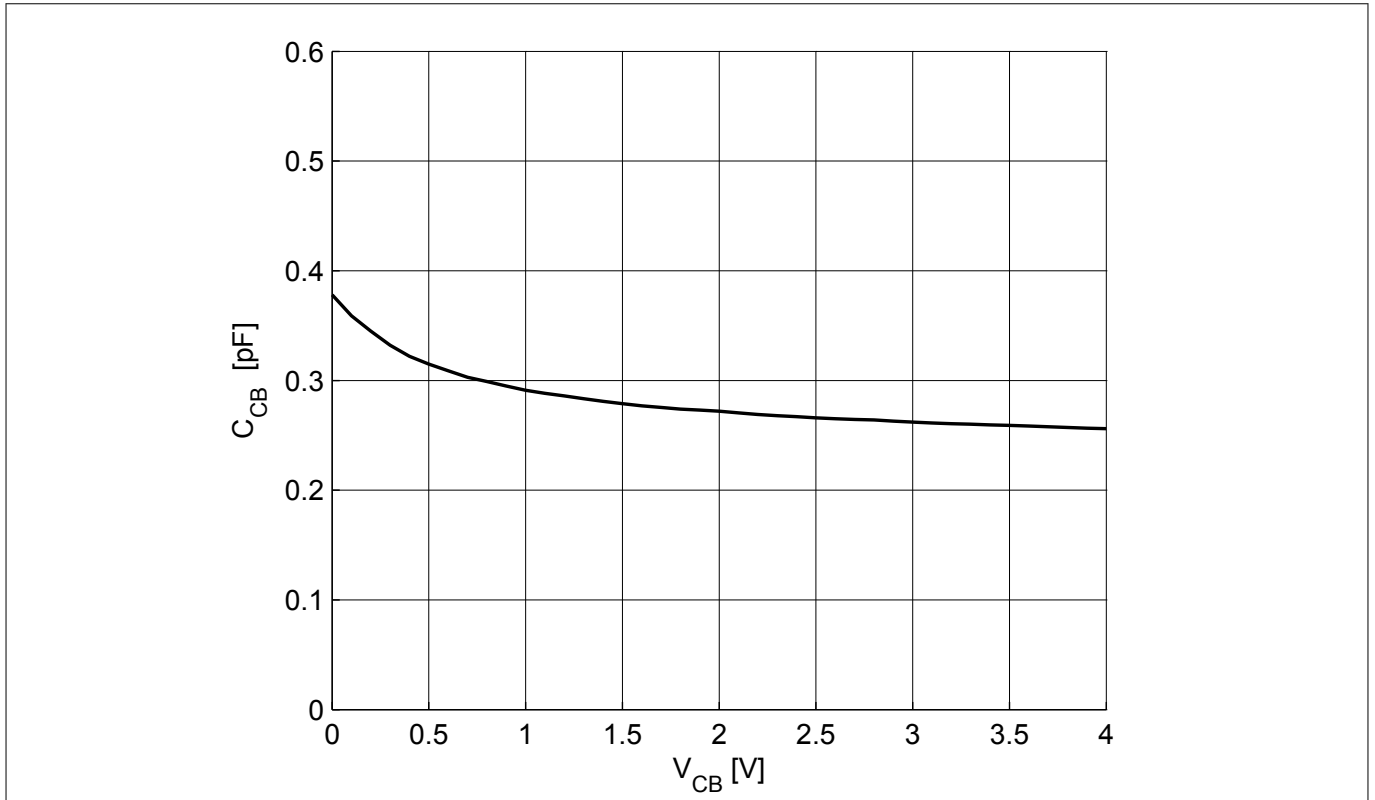


**Figure 8** Transition frequency  $f_T = f(I_C)$ ,  $f = 1 \text{ GHz}$ ,  $V_{CE} = \text{parameter}$

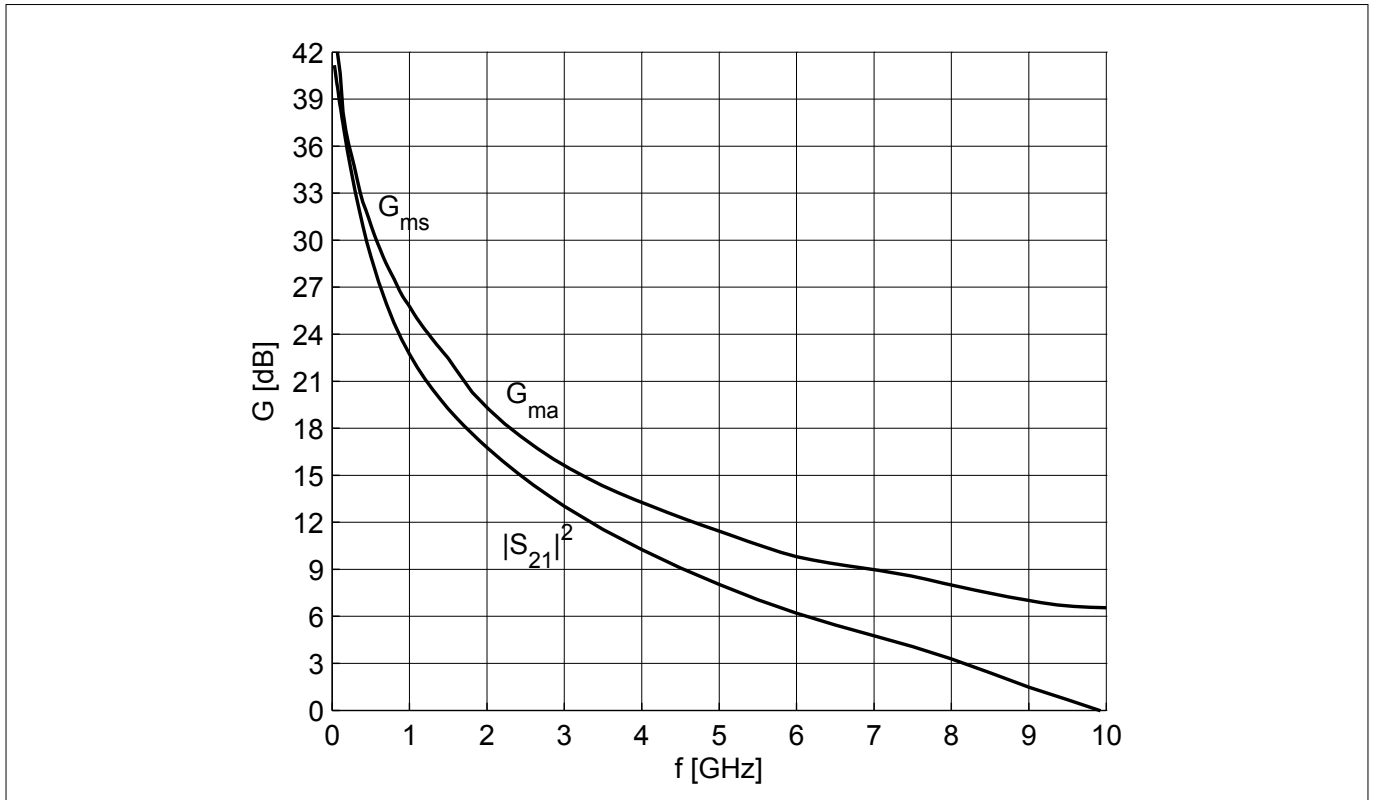


**Figure 9** 3rd order intercept point  $OIP_3 = f(I_C)$ ,  $Z_S = Z_L = 50 \Omega$ ,  $V_{CE}$ ,  $f = \text{parameters}$

**Electrical characteristics**

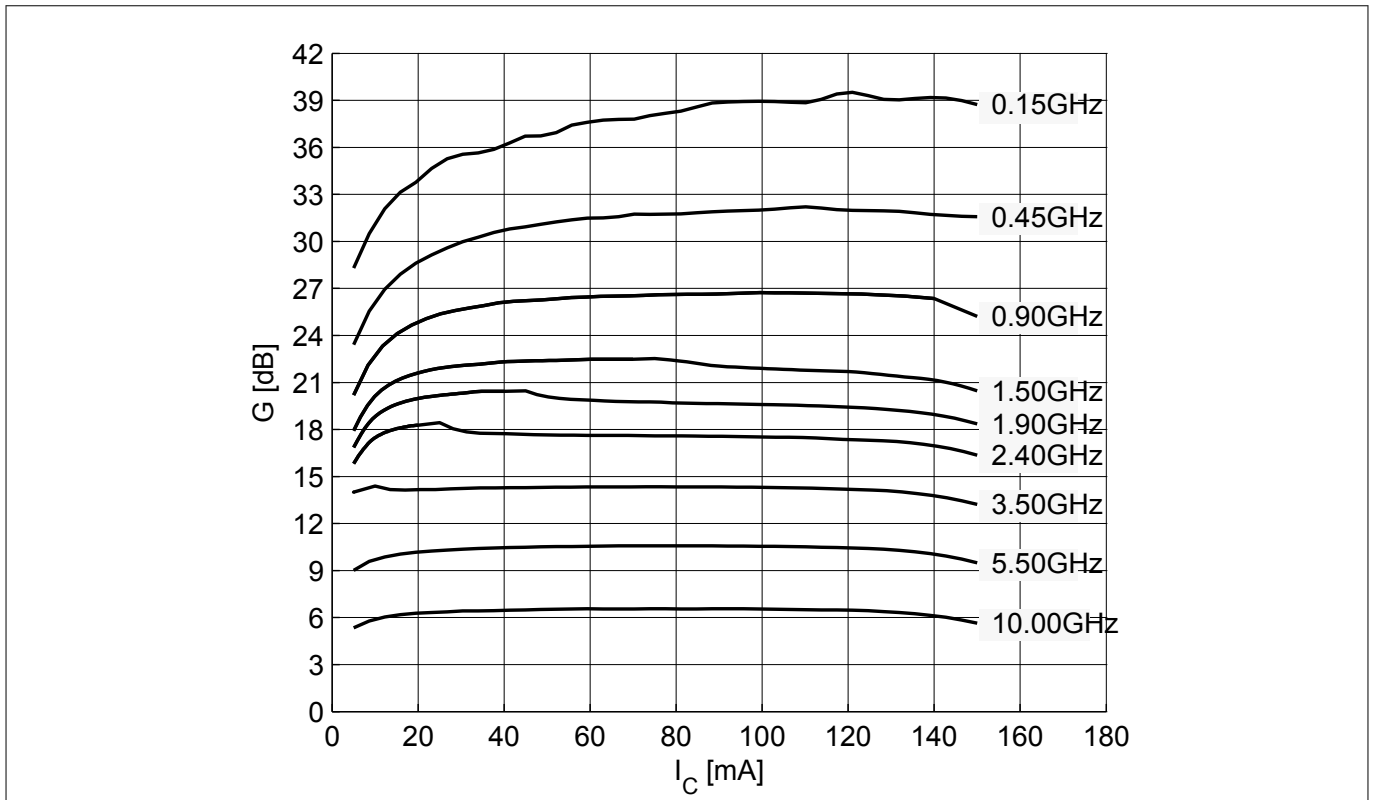


**Figure 10** Collector base capacitance  $C_{CB} = f(V_{CB})$ ,  $f = 1$  MHz

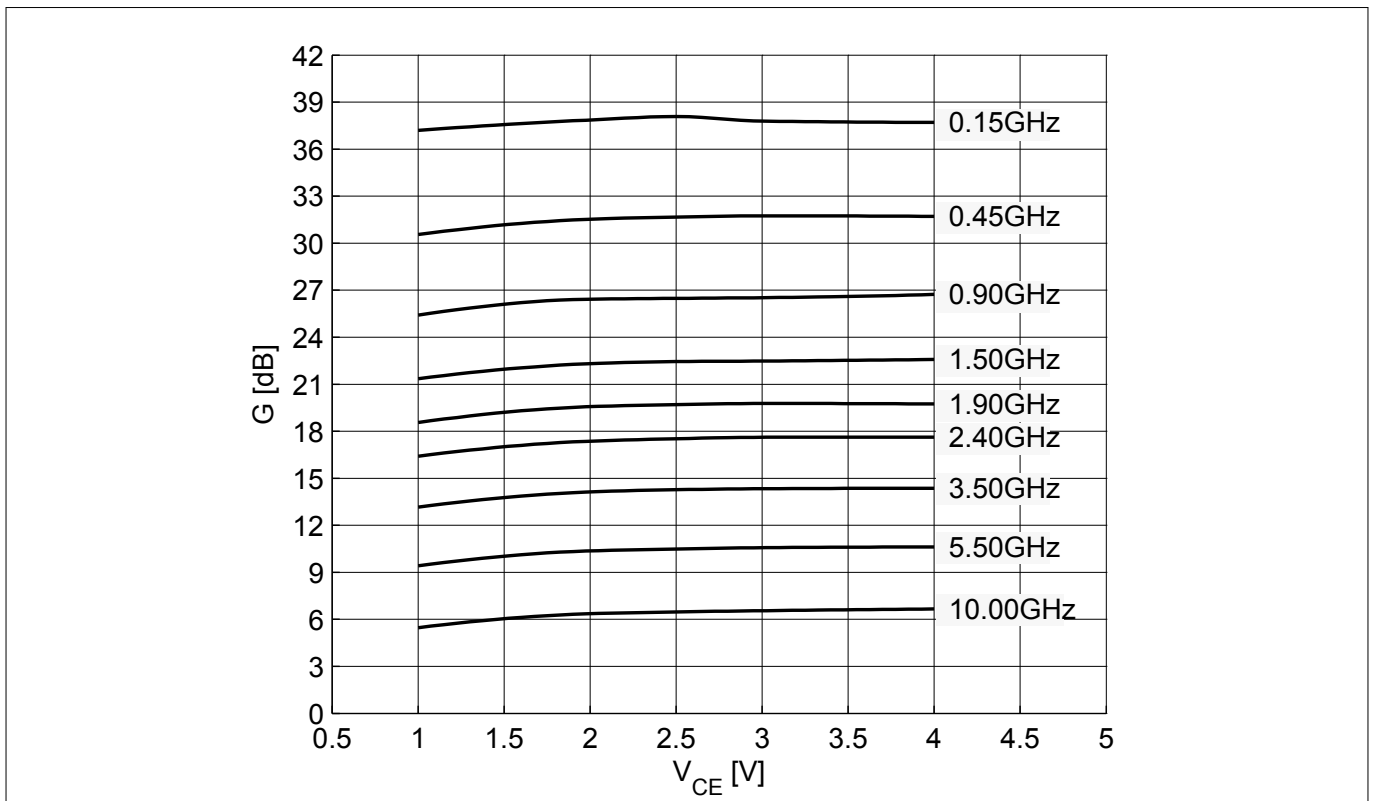


**Figure 11** Gain  $G_{ma}$ ,  $G_{ms}$ ,  $|S_{21}|^2 = f(f)$ ,  $V_{CE} = 3$  V,  $I_C = 70$  mA

**Electrical characteristics**

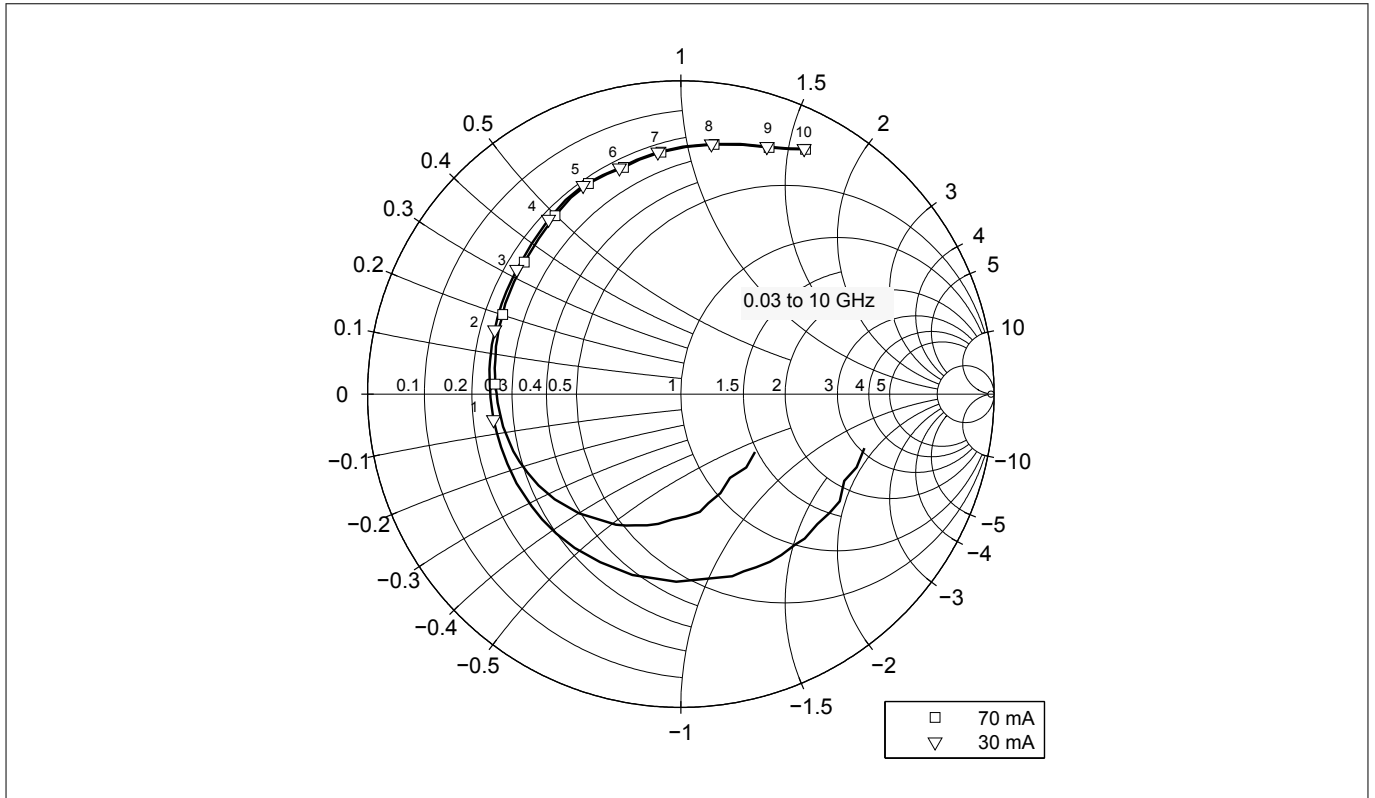


**Figure 12** Maximum power gain  $G_{max} = f(I_C)$ ,  $V_{CE} = 3\text{ V}$ ,  $f = \text{parameter in GHz}$

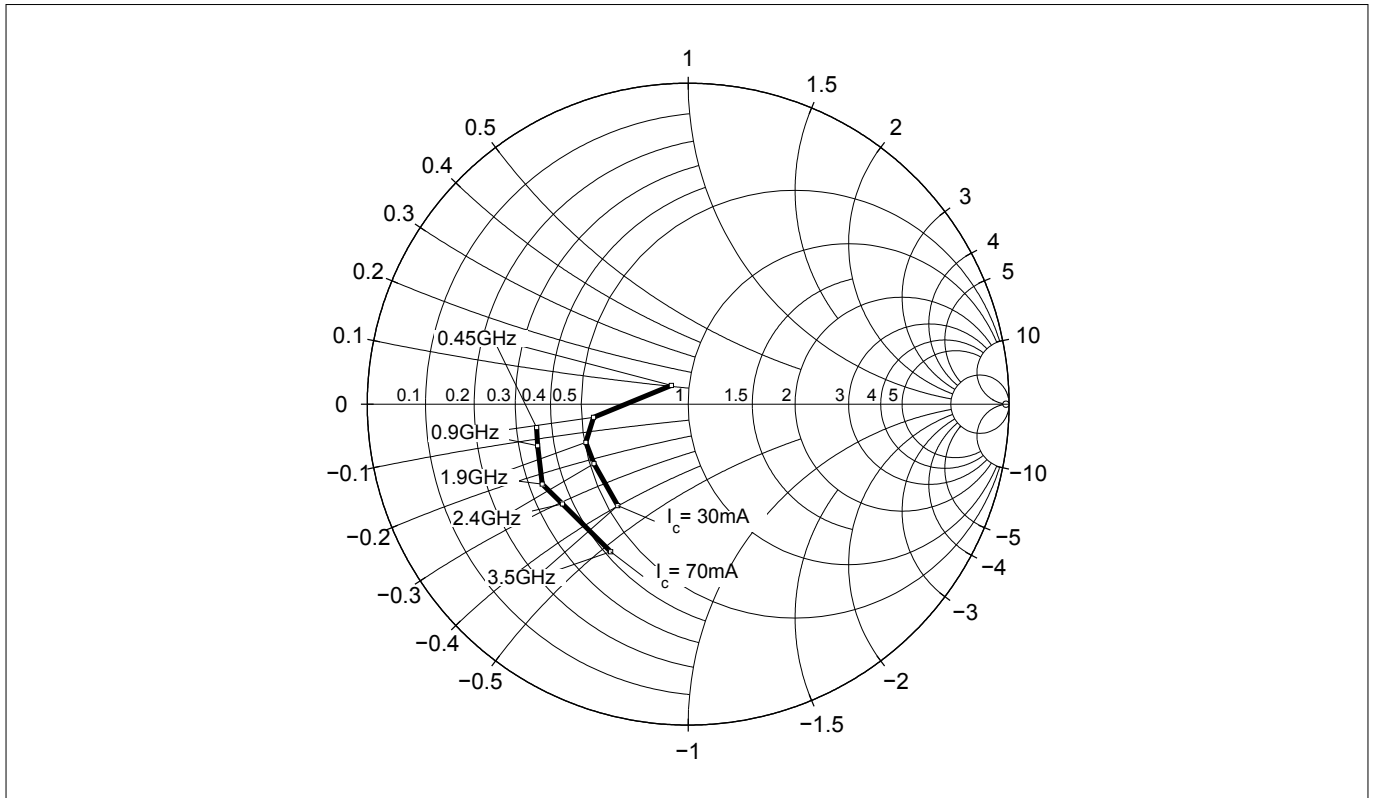


**Figure 13** Maximum power gain  $G_{max} = f(V_{CE})$ ,  $I_C = 70\text{ mA}$ ,  $f = \text{parameter in GHz}$

**Electrical characteristics**



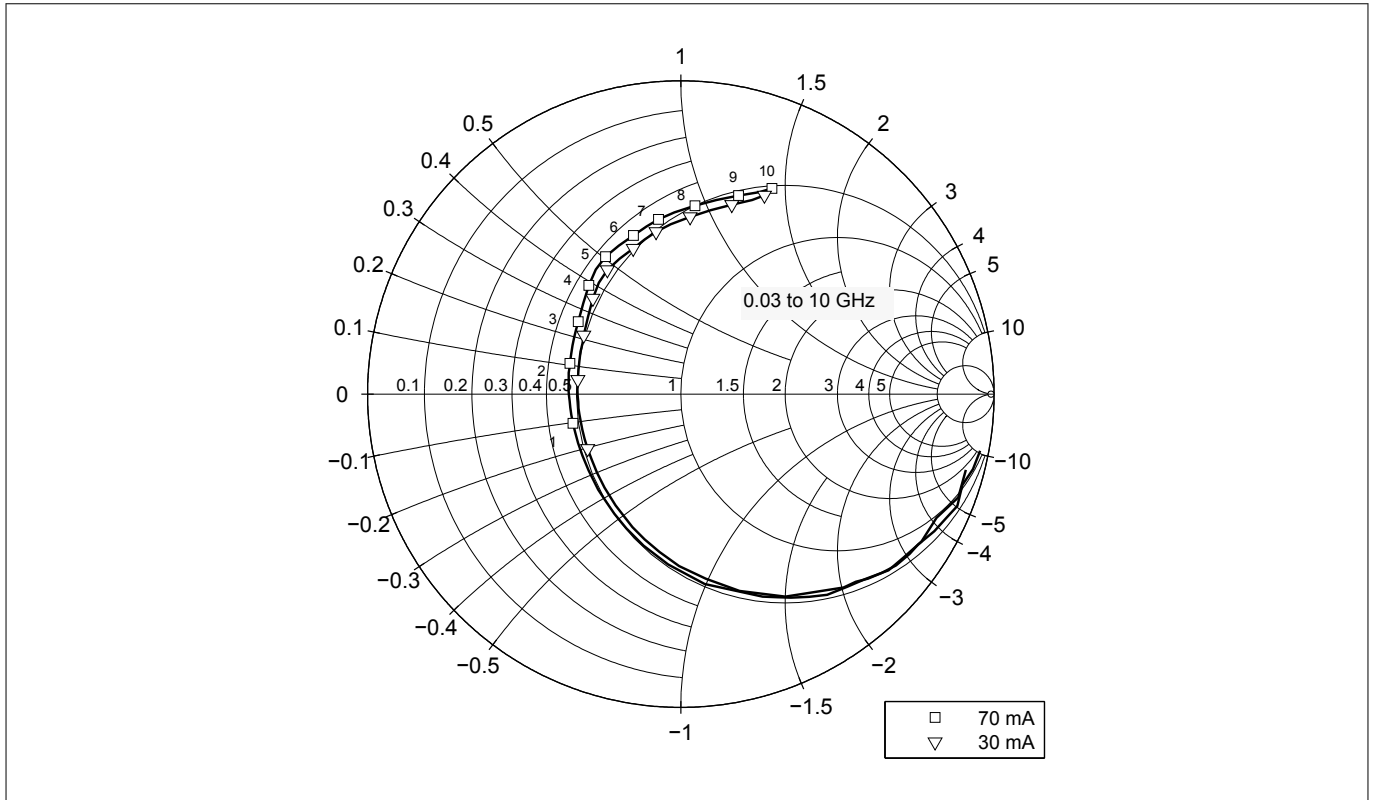
**Figure 14** Input reflection coefficient  $S_{11} = f(f)$ ,  $V_{CE} = 3$  V,  $I_C = 30 / 70$  mA



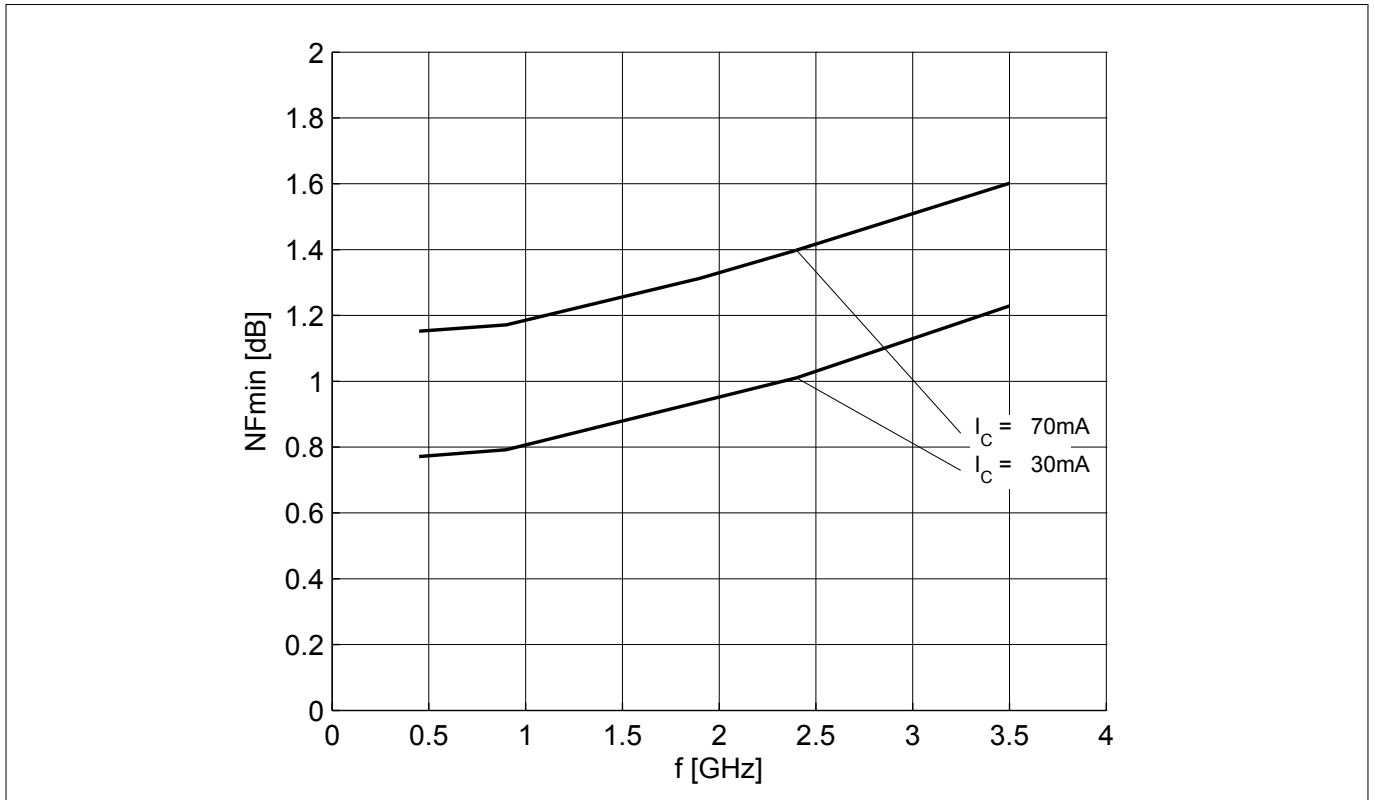
**Figure 15** Source impedance for minimum noise figure  $Z_{s,opt} = f(f)$ ,  $V_{CE} = 3$  V,  $I_C = 30 / 70$  mA



**Electrical characteristics**

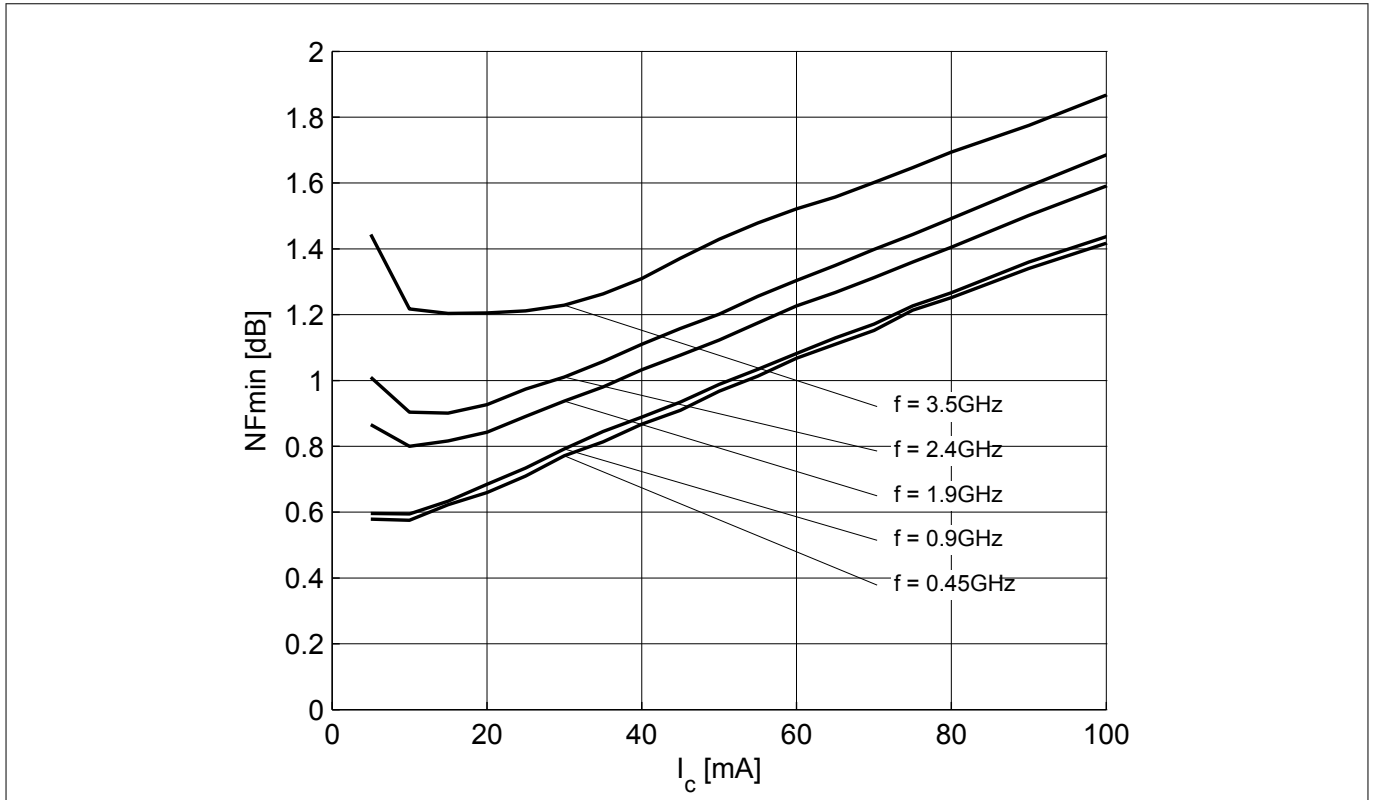


**Figure 16** Output reflection coefficient  $S_{22} = f(f)$ ,  $V_{CE} = 3\text{ V}$ ,  $I_C = 30 / 70\text{ mA}$

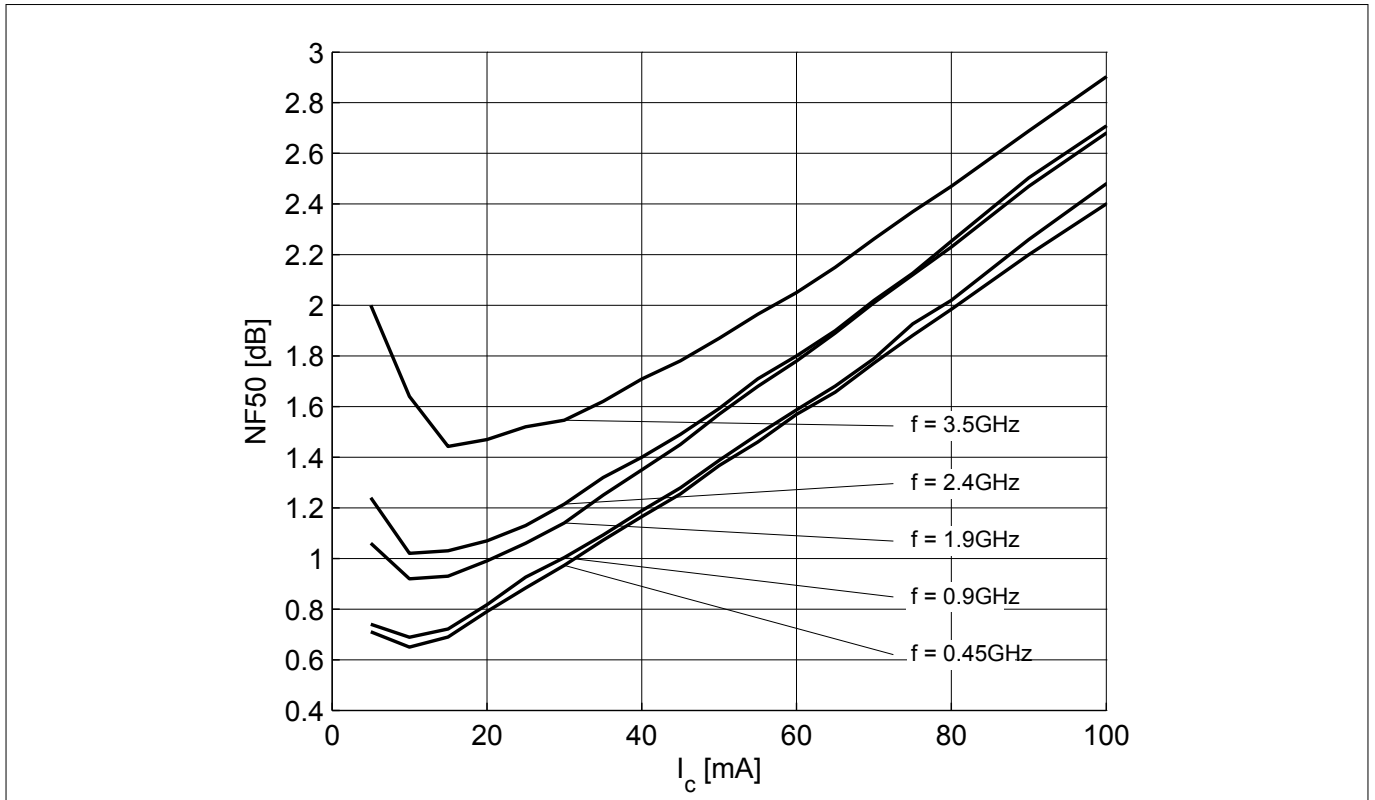


**Figure 17** Noise figure  $NF_{min} = f(f)$ ,  $Z_S = Z_{S,opt}$ ,  $V_{CE} = 3\text{ V}$ ,  $I_C = 30 / 70\text{ mA}$

**Electrical characteristics**

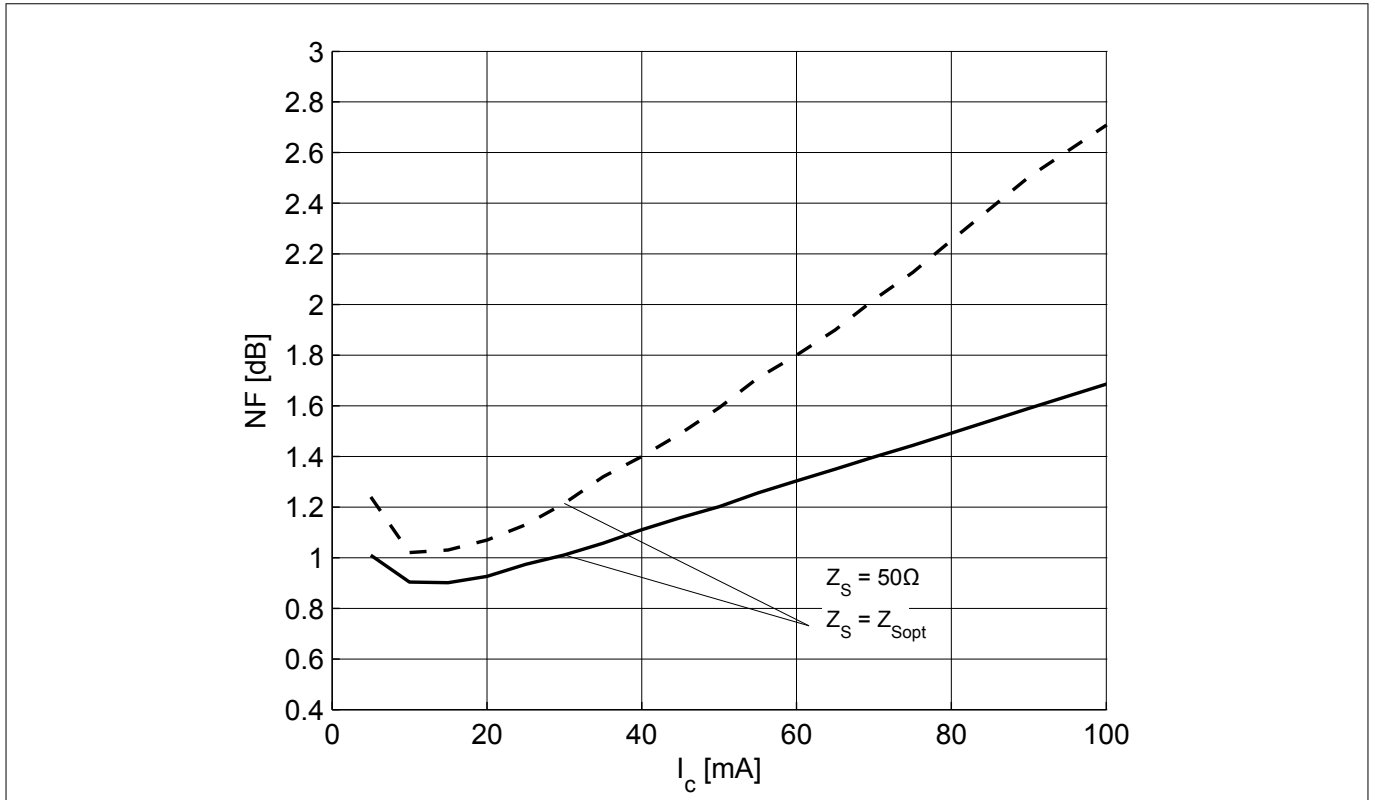


**Figure 18** Noise figure  $NF_{min} = f(I_C), Z_S = Z_{S,opt}, V_{CE} = 3\text{ V}, f = \text{parameter in GHz}$



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

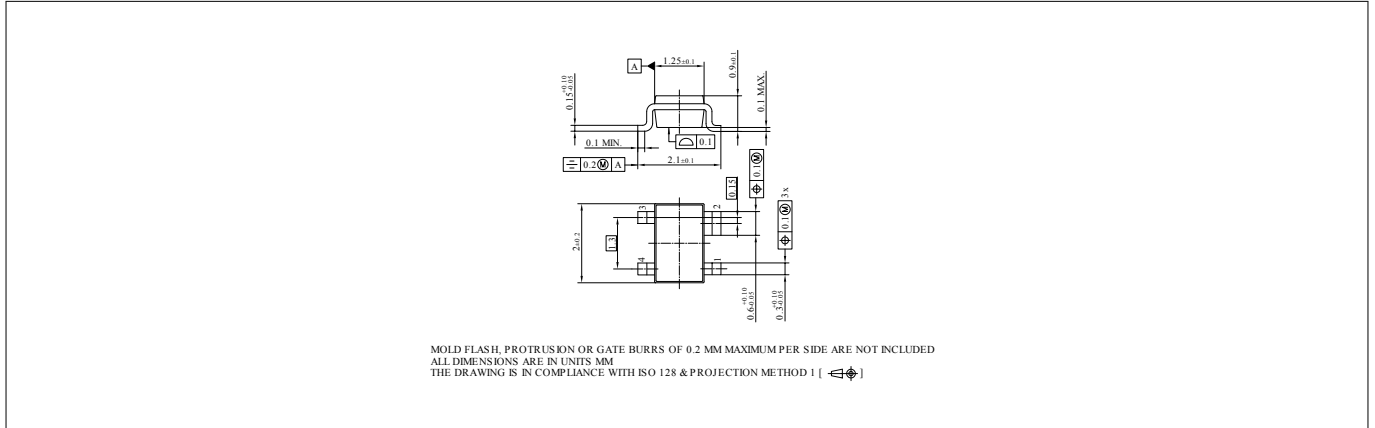
**Electrical characteristics**



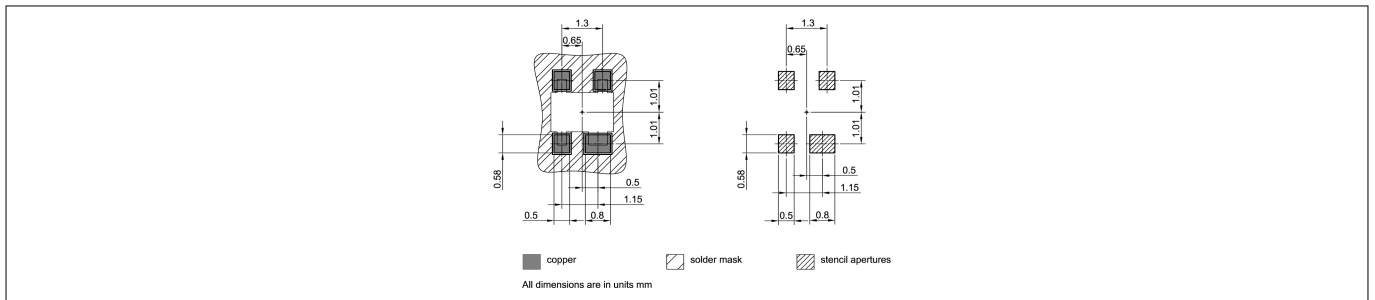
**Figure 20** Noise figure  $NF_{50} = f(I_C)$ ,  $Z_S = 50\Omega$ ,  $NF_{min} = f(I_C)$ ,  $Z_S = Z_{S,opt}$ ,  $V_{CE} = 3V$ ,  $f = 2.4GHz$

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.  $T_A = 25^\circ C$ .

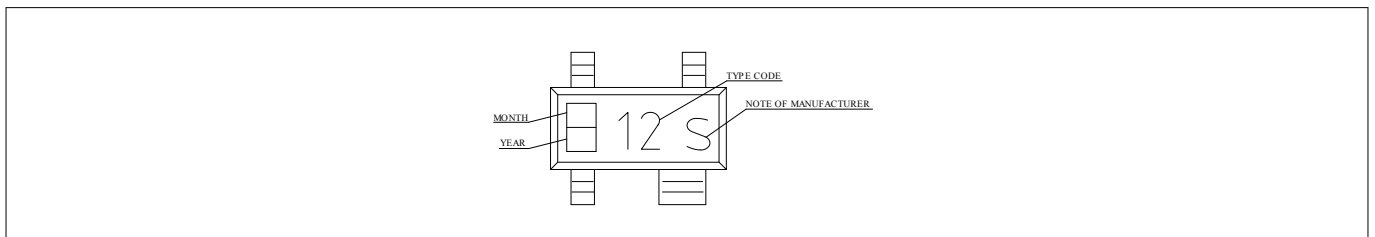
## 4 Package information SOT343



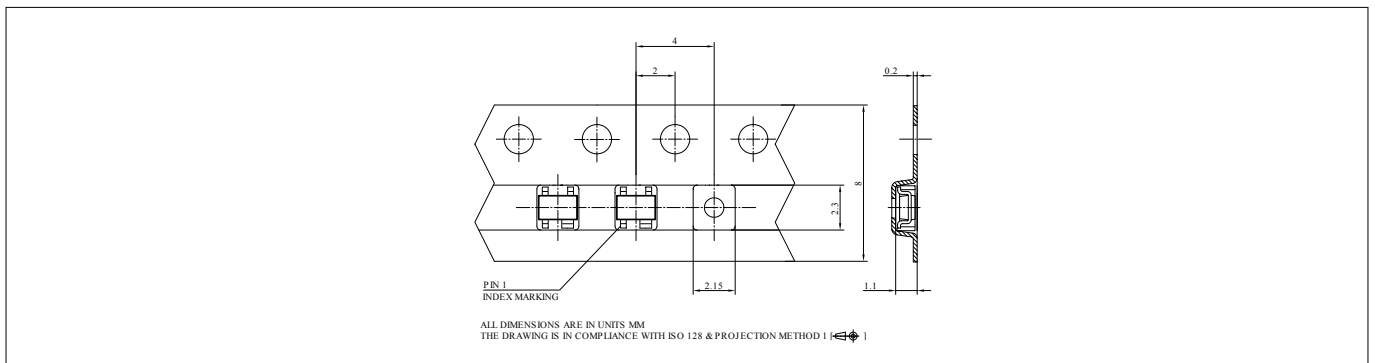
**Figure 21** Package outline



**Figure 22** Foot print



**Figure 23** Marking layout example



**Figure 24** Tape dimensions

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Revision history

## Revision history

Document version	Date of release	Description of changes
Revision 2.0	2019-01-25	New datasheet layout.

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