

# BFP720F

Low Noise Silicon Germanium Bipolar RF Transistor

## Data Sheet

Revision 1.1, 2012-10-25

RF & Protection Devices

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**BFP720F, Low Noise Silicon Germanium Bipolar RF Transistor**

**Revision History: 2012-10-25, Revision 1.1**

Page	Subjects (changes since previous revision)
	This data sheet replaces the revision from 2009-03-13. 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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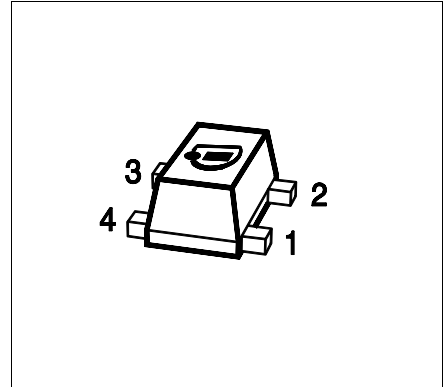
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## 1 Product Brief

The BFP720F 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  $V_{CE0} = 4.0$  V and currents up to  $I_C = 25$  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 12 GHz in amplifier applications. The device is housed in a thin small flat plastic package with visible leads.

## 2 Features

- High performance general purpose wideband LNA transistor
- Operation voltage: 1.0 V to 4.0 V
- Transistor geometry optimized for low current applications
- 26.5 dB maximum stable gain at 1.9 GHz and only 13 mA
- 15 dB maximum available gain at 10 GHz and only 13 mA
- 0.7 dB minimum noise figure at 5.5 GHz and 1.0 dB at 10 GHz
- High linearity  $OP_{1dB} = 7$  dBm and  $OIP_3 = 21$  dBm at 5.5 GHz and low current consumption of 13 mA
- Thin small flat Pb-free (RoHS compliant) and halogen-free package with visible leads
- Qualification report according to AEC-Q101 available



### Applications

FM Radio, Mobile TV, RKE, AMR, Cellular, ZigBee, GPS, WiMAX, SDARs, Satellite Radio, Bluetooth, WiFi, Cordless phone, UMTS, WLAN, UWB, LNB

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

Product Name	Package	Pin Configuration				Marking
		1 = B	2 = E	3 = C	4 = E	
BFP720F	TSFP-4-1	1 = B	2 = E	3 = C	4 = E	R9s



### 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.	Typ.	Max.		
Collector emitter voltage	$V_{CEO}$			4.0 3.5	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	$I_C$	–	–	25	mA	
Base current	$I_B$	–	–	2	mA	
Total power dissipation <sup>1)</sup>	$P_{tot}$	–	–	100	mW	$T_S \leq 109\text{ °C}$
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 to 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>	$R_{thJS}$	–	410	–	K/W	–

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

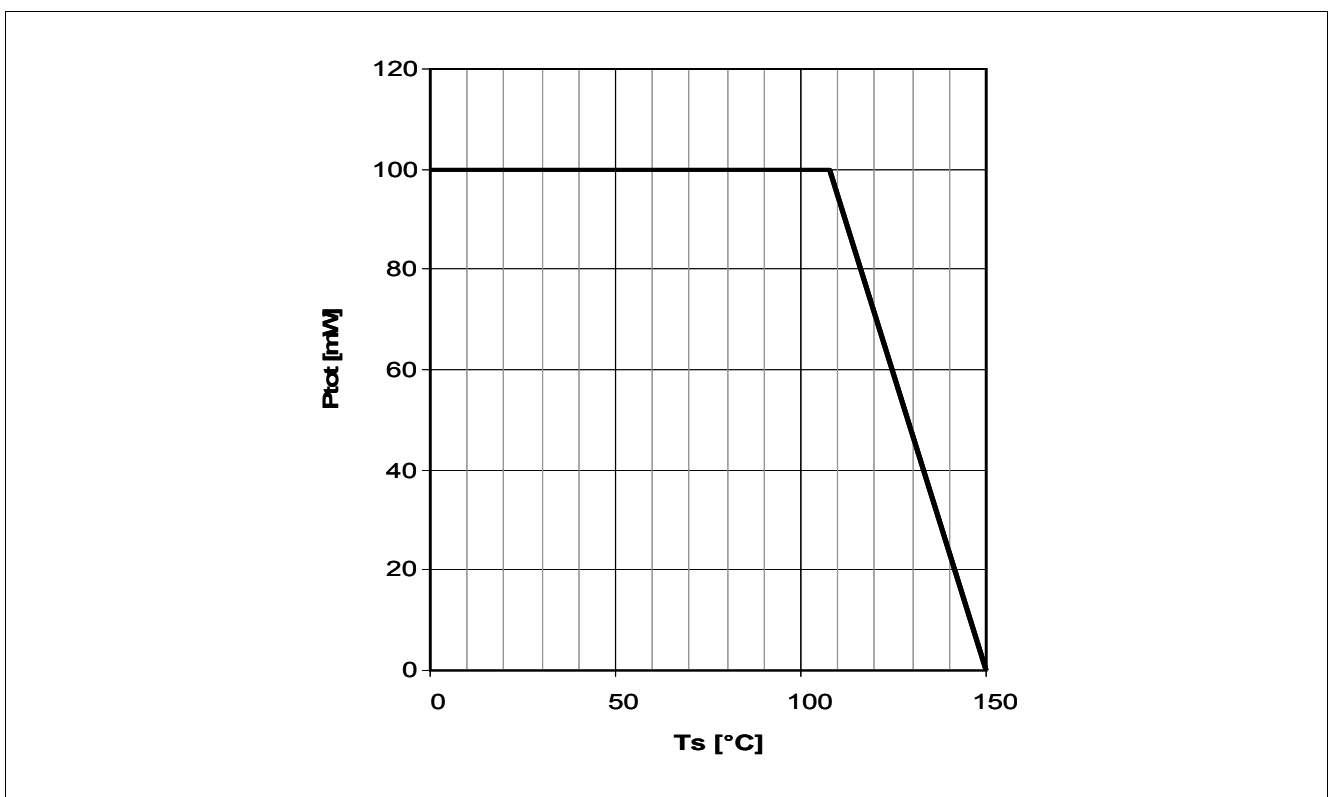


Figure 4-1 Total Power Dissipation  $P_{tot} = f(T_s)$

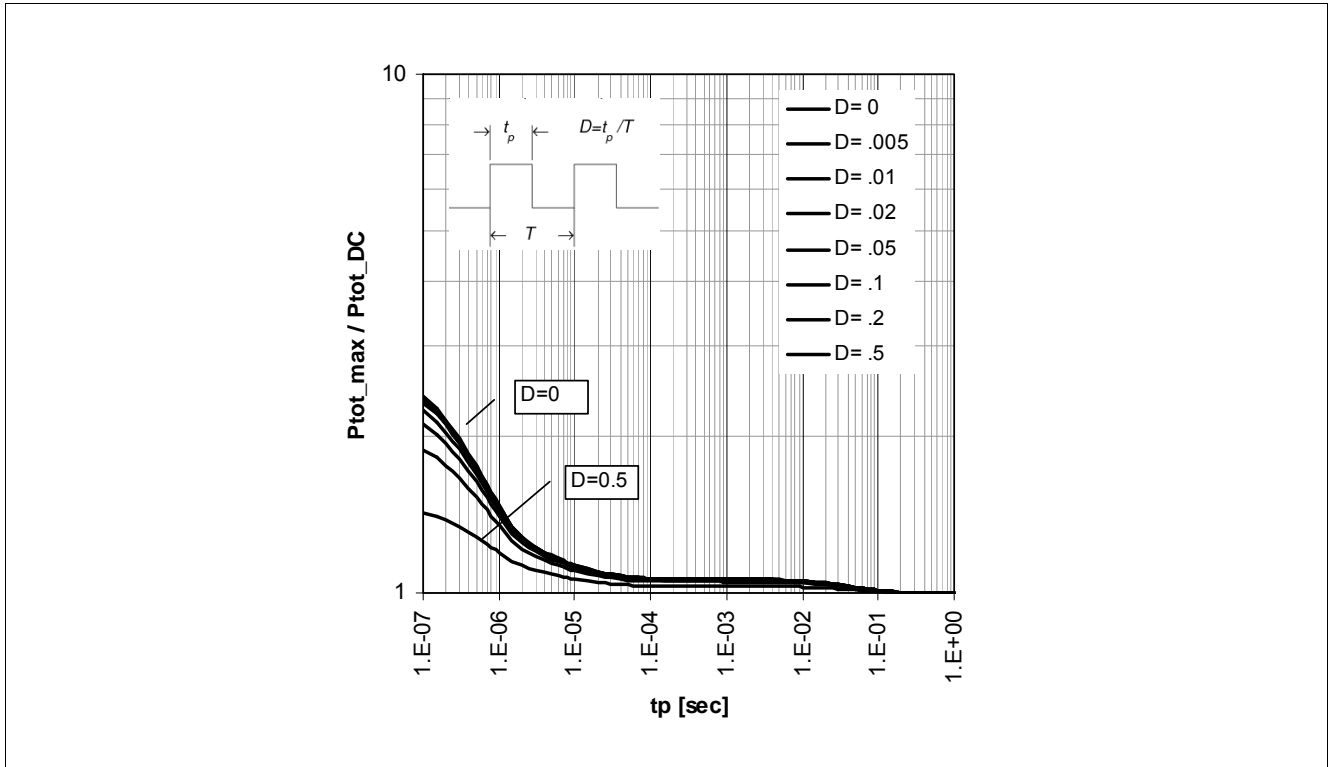


Figure 4-2 Permissible Pulse Load  $P_{tot\_max} / P_{tot\_DC} = f(t_p)$

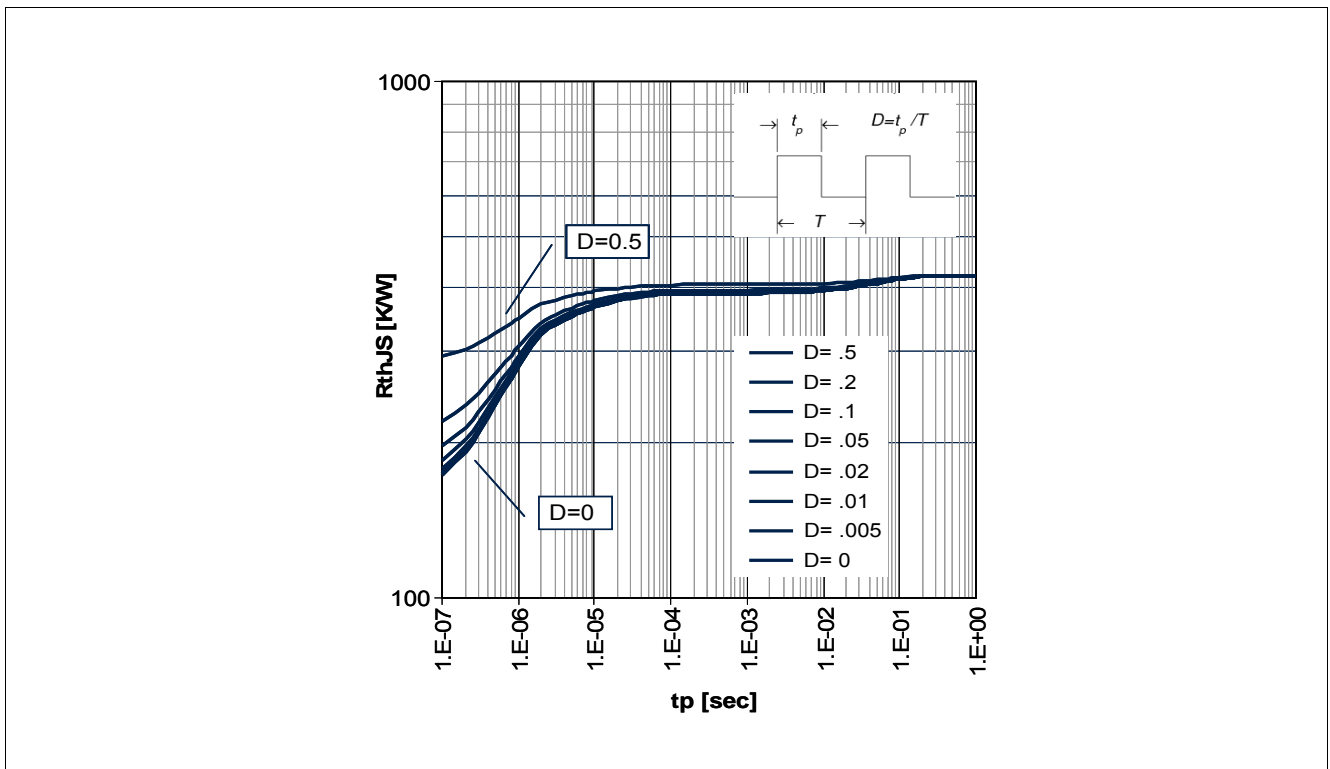


Figure 4-3 Permissible Pulse Load  $R_{thJS} = f(t_p)$

## 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	4.7	–	V	$I_C = 1\text{ mA}, I_B = 0\text{ mA}$
Collector emitter cutoff current	$I_{CES}$	–	–	30	$\mu\text{A}$	$V_{CE} = 13\text{ V}, V_{BE} = 0\text{ V}$
Collector base cutoff current	$I_{CBO}$	–	–	100	nA	$V_{CB} = 5\text{ V}, I_E = 0\text{ mA}$
Emitter base cutoff current	$I_{EBO}$	–	–	2	$\mu\text{A}$	$V_{EB} = 0.5\text{ V}, I_C = 0\text{ mA}$
DC current gain	$h_{FE}$	160	250	400		$I_C = 13\text{ mA}, V_{CE} = 3\text{ V}$ pulse measured

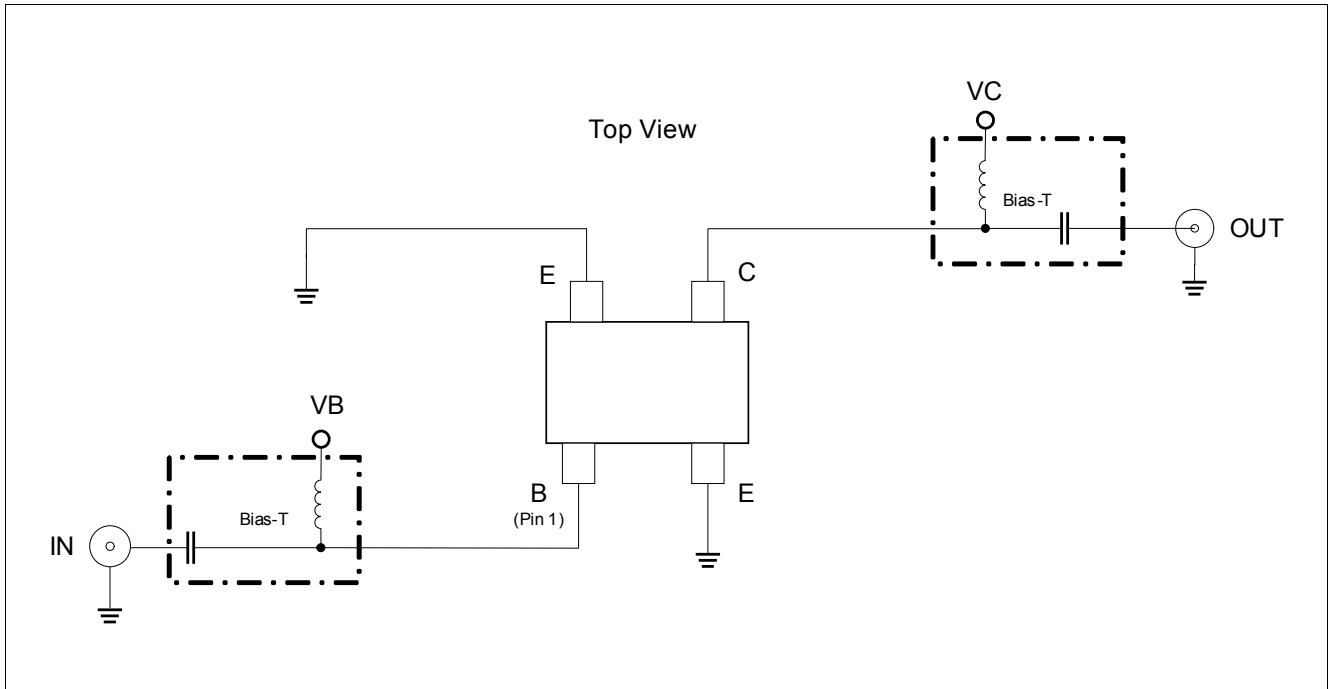
### 5.2 General AC Characteristics

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

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Transition frequency	$f_T$	–	45	–	GHz	$I_C = 13\text{ mA}, V_{CE} = 3\text{ V}$ $f = 1\text{ GHz}$
Collector base capacitance	$C_{CB}$	–	0.06	–	pF	$V_{CB} = 3\text{ V}, V_{BE} = 0\text{ V}$ $f = 1\text{ MHz}$ emitter grounded
Collector emitter capacitance	$C_{CE}$	–	0.3	–	pF	$V_{CE} = 3\text{ V}, V_{BE} = 0\text{ V}$ $f = 1\text{ MHz}$ base grounded
Emitter base capacitance	$C_{EB}$	–	0.3	–	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,  $T_A = 25\text{ °C}$



**Figure 5-1 BFP720F 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.		
<b>Maximum Power Gain</b>						
Low noise operation point	$G_{ms}$	–	34	–	dB	$I_C = 5\text{ mA}$
High linearity operation point	$G_{ms}$	–	37.5	–		$I_C = 13\text{ mA}$
<b>Transducer Gain</b>						
Low noise operation point	$S_{21}$	–	23	–	dB	$Z_S = Z_L = 50\text{ }\Omega$ $I_C = 5\text{ mA}$
High linearity operation point	$S_{21}$	–	29	–		$I_C = 13\text{ mA}$
<b>Minimum Noise Figure</b>						
Minimum noise figure	$NF_{min}$	–	0.4	–	dB	$Z_S = Z_{opt}$ $I_C = 5\text{ mA}$
Associated gain	$G_{ass}$	–	28	–		$I_C = 5\text{ mA}$
<b>Linearity</b>						
1 dB gain compression point	$OP_{1dB}$	–	6	–	dBm	$Z_S = Z_L = 50\text{ }\Omega$ $I_C = 13\text{ mA}$
3rd order intercept point	$OIP_3$	–	22.5	–		$I_C = 13\text{ mA}$

**Table 5-4 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	
Low noise operation point	$G_{ms}$	–	29	–		$I_C = 5\text{ mA}$
High linearity operation point	$G_{ms}$	–	32.5	–		$I_C = 13\text{ mA}$
<b>Transducer Gain</b>					dB	$Z_S = Z_L = 50\ \Omega$
Low noise operation point	$S_{21}$	–	22.5	–		$I_C = 5\text{ mA}$
High linearity operation point	$S_{21}$	–	28.5	–		$I_C = 13\text{ mA}$
<b>Minimum Noise Figure</b>					dB	$Z_S = Z_{opt}$
Minimum noise figure	$NF_{min}$	–	0.4	–		$I_C = 5\text{ mA}$
Associated gain	$G_{ass}$	–	27.5	–		$I_C = 5\text{ mA}$
<b>Linearity</b>					dBm	$Z_S = Z_L = 50\ \Omega$
1 dB gain compression point	$OP_{1dB}$	–	5.5	–		$I_C = 13\text{ mA}$
3rd order intercept point	$OIP_3$	–	21.5	–		$I_C = 13\text{ mA}$

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

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
<b>Maximum Power Gain</b>					dB	
Low noise operation point	$G_{ms}$	–	26.5	–		$I_C = 5\text{ mA}$
High linearity operation point	$G_{ms}$	–	29.5	–		$I_C = 13\text{ mA}$
<b>Transducer Gain</b>					dB	$Z_S = Z_L = 50\ \Omega$
Low noise operation point	$S_{21}$	–	22.5	–		$I_C = 5\text{ mA}$
High linearity operation point	$S_{21}$	–	27.5	–		$I_C = 13\text{ mA}$
<b>Minimum Noise Figure</b>					dB	$Z_S = Z_{opt}$
Minimum noise figure	$NF_{min}$	–	0.45	–		$I_C = 5\text{ mA}$
Associated gain	$G_{ass}$	–	25.5	–		$I_C = 5\text{ mA}$
<b>Linearity</b>					dBm	$Z_S = Z_L = 50\ \Omega$
1 dB gain compression point	$OP_{1dB}$	–	5.5	–		$I_C = 13\text{ mA}$
3rd order intercept point	$OIP_3$	–	20.5	–		$I_C = 13\text{ mA}$

**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.		
<b>Maximum Power Gain</b>						
Low noise operation point	$G_{ms}$	–	24	–	dB	$I_C = 5\text{ mA}$
High linearity operation point	$G_{ms}$	–	27.5	–		$I_C = 13\text{ mA}$
<b>Transducer Gain</b>						
Low noise operation point	$S_{21}$	–	21.5	–	dB	$Z_S = Z_L = 50\ \Omega$ $I_C = 5\text{ mA}$
High linearity operation point	$S_{21}$	–	26	–		$I_C = 13\text{ mA}$
<b>Minimum Noise Figure</b>						
Minimum noise figure	$NF_{min}$	–	0.45	–	dB	$Z_S = Z_{opt}$ $I_C = 5\text{ mA}$
Associated gain	$G_{ass}$	–	24	–		$I_C = 5\text{ mA}$
<b>Linearity</b>						
1 dB gain compression point	$OP_{1dB}$	–	6	–	dBm	$Z_S = Z_L = 50\ \Omega$ $I_C = 13\text{ mA}$
3rd order intercept point	$OIP_3$	–	21	–		$I_C = 13\text{ mA}$

**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.		
<b>Maximum Power Gain</b>						
Low noise operation point	$G_{ms}$	–	23	–	dB	$I_C = 5\text{ mA}$
High linearity operation point	$G_{ms}$	–	26.5	–		$I_C = 13\text{ mA}$
<b>Transducer Gain</b>						
Low noise operation point	$S_{21}$	–	21	–	dB	$Z_S = Z_L = 50\ \Omega$ $I_C = 5\text{ mA}$
High linearity operation point	$S_{21}$	–	24.5	–		$I_C = 13\text{ mA}$
<b>Minimum Noise Figure</b>						
Minimum noise figure	$NF_{min}$	–	0.5	–	dB	$Z_S = Z_{opt}$ $I_C = 5\text{ mA}$
Associated gain	$G_{ass}$	–	23	–		$I_C = 5\text{ mA}$
<b>Linearity</b>						
1 dB gain compression point	$OP_{1dB}$	–	6.5	–	dBm	$Z_S = Z_L = 50\ \Omega$ $I_C = 13\text{ mA}$
3rd order intercept point	$OIP_3$	–	21	–		$I_C = 13\text{ mA}$

**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.		
<b>Maximum Power Gain</b>						
Low noise operation point	$G_{ms}$	–	22	–	dB	$I_C = 5\text{ mA}$
High linearity operation point	$G_{ms}$	–	25.5	–		$I_C = 13\text{ mA}$
<b>Transducer Gain</b>						
Low noise operation point	$S_{21}$	–	20.5	–	dB	$Z_S = Z_L = 50\ \Omega$ $I_C = 5\text{ mA}$
High linearity operation point	$S_{21}$	–	23	–		$I_C = 13\text{ mA}$
<b>Minimum Noise Figure</b>						
Minimum noise figure	$NF_{min}$	–	0.55	–	dB	$Z_S = Z_{opt}$ $I_C = 5\text{ mA}$
Associated gain	$G_{ass}$	–	22	–		$I_C = 5\text{ mA}$
<b>Linearity</b>						
1 dB gain compression point	$OP_{1dB}$	–	6	–	dBm	$Z_S = Z_L = 50\ \Omega$ $I_C = 13\text{ mA}$
3rd order intercept point	$OIP_3$	–	21	–		$I_C = 13\text{ mA}$

**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.		
<b>Maximum Power Gain</b>						
Low noise operation point	$G_{ms}$	–	20.5	–	dB	$I_C = 5\text{ mA}$
High linearity operation point	$G_{ms}$	–	23.5	–		$I_C = 13\text{ mA}$
<b>Transducer Gain</b>						
Low noise operation point	$S_{21}$	–	18	–	dB	$Z_S = Z_L = 50\ \Omega$ $I_C = 5\text{ mA}$
High linearity operation point	$S_{21}$	–	20.5	–		$I_C = 13\text{ mA}$
<b>Minimum Noise Figure</b>						
Minimum noise figure	$NF_{min}$	–	0.6	–	dB	$Z_S = Z_{opt}$ $I_C = 5\text{ mA}$
Associated gain	$G_{ass}$	–	19.5	–		$I_C = 5\text{ mA}$
<b>Linearity</b>						
1 dB gain compression point	$OP_{1dB}$	–	6.5	–	dBm	$Z_S = Z_L = 50\ \Omega$ $I_C = 13\text{ mA}$
3rd order intercept point	$OIP_3$	–	21.5	–		$I_C = 13\text{ mA}$



**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.		
<b>Maximum Power Gain</b>	$G_{ms}$				dB	$I_C = 5\text{ mA}$ $I_C = 13\text{ mA}$
Low noise operation point	$G_{ms}$	–	19	–		
High linearity operation point	$G_{ms}$	–	21.5	–		
<b>Transducer Gain</b>					dB	$Z_S = Z_L = 50\ \Omega$ $I_C = 5\text{ mA}$ $I_C = 13\text{ mA}$
Low noise operation point	$S_{21}$	–	15	–		
High linearity operation point	$S_{21}$	–	16.5	–		
<b>Minimum Noise Figure</b>					dB	$Z_S = Z_{opt}$ $I_C = 5\text{ mA}$ $I_C = 5\text{ mA}$
Minimum noise figure	$NF_{min}$	–	0.7	–		
Associated gain	$G_{ass}$	–	15	–		
<b>Linearity</b>					dBm	$Z_S = Z_L = 50\ \Omega$ $I_C = 13\text{ mA}$ $I_C = 13\text{ mA}$
1 dB gain compression point	$OP_{1dB}$	–	7	–		
3rd order intercept point	$OIP_3$	–	21	–		

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

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
<b>Maximum Power Gain</b>					dB	$I_C = 5\text{ mA}$ $I_C = 13\text{ mA}$
Low noise operation point	$G_{ma}$	–	14	–		
High linearity operation point	$G_{ma}$	–	15	–		
<b>Transducer Gain</b>					dB	$Z_S = Z_L = 50\ \Omega$ $I_C = 5\text{ mA}$ $I_C = 13\text{ mA}$
Low noise operation point	$S_{21}$	–	9.5	–		
High linearity operation point	$S_{21}$	–	10.5	–		
<b>Minimum Noise Figure</b>					dB	$Z_S = Z_{opt}$ $I_C = 5\text{ mA}$ $I_C = 5\text{ mA}$
Minimum noise figure	$NF_{min}$	–	1.0	–		
Associated gain	$G_{ass}$	–	10.5	–		
<b>Linearity</b>					dBm	$Z_S = Z_L = 50\ \Omega$ $I_C = 13\text{ mA}$ $I_C = 13\text{ mA}$
1 dB gain compression point	$OP_{1dB}$	–	8	–		
3rd order intercept point	$OIP_3$	–	19.5	–		

**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 results

### 5.4 Characteristic Curves

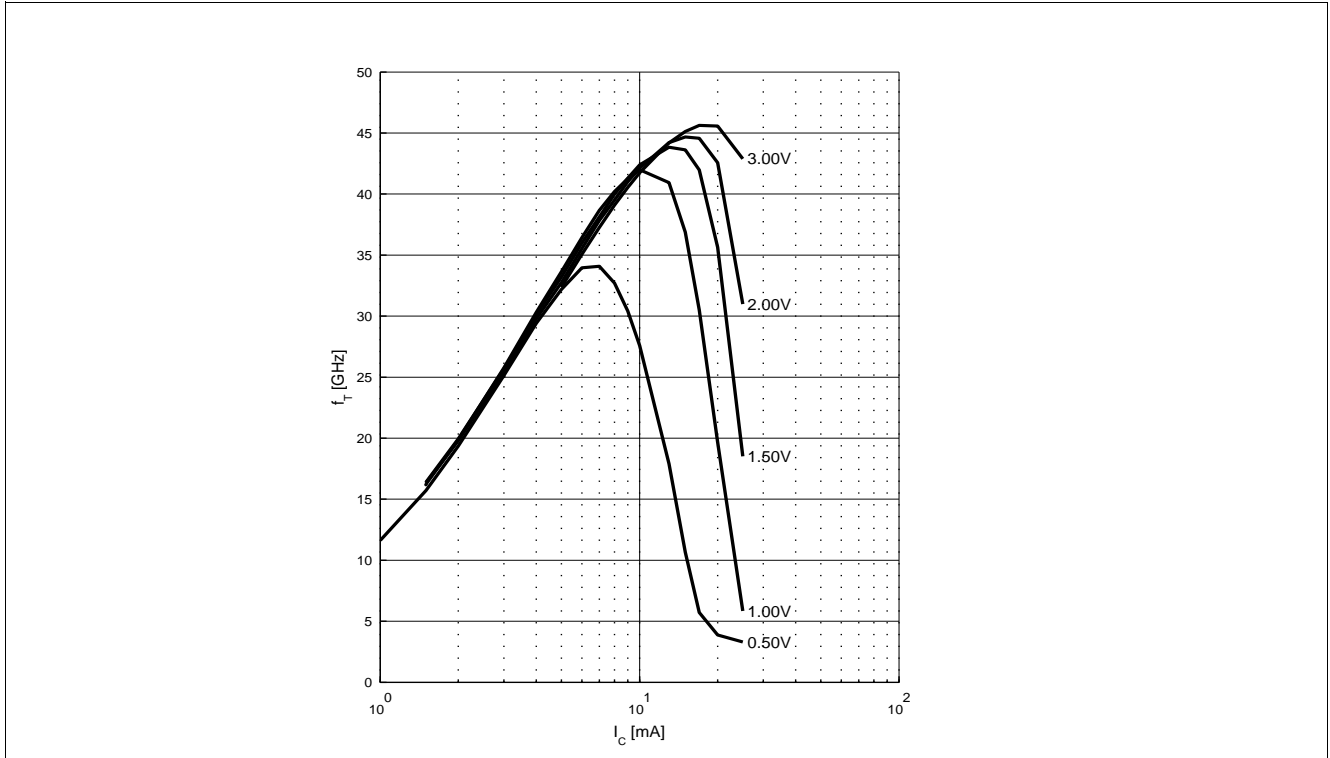


Figure 5-2 Transition Frequency  $f_T = f(I_C, V_{CE})$ ,  $f = 1 \text{ GHz}$ ,  $V_{CE}$  Parameter in V

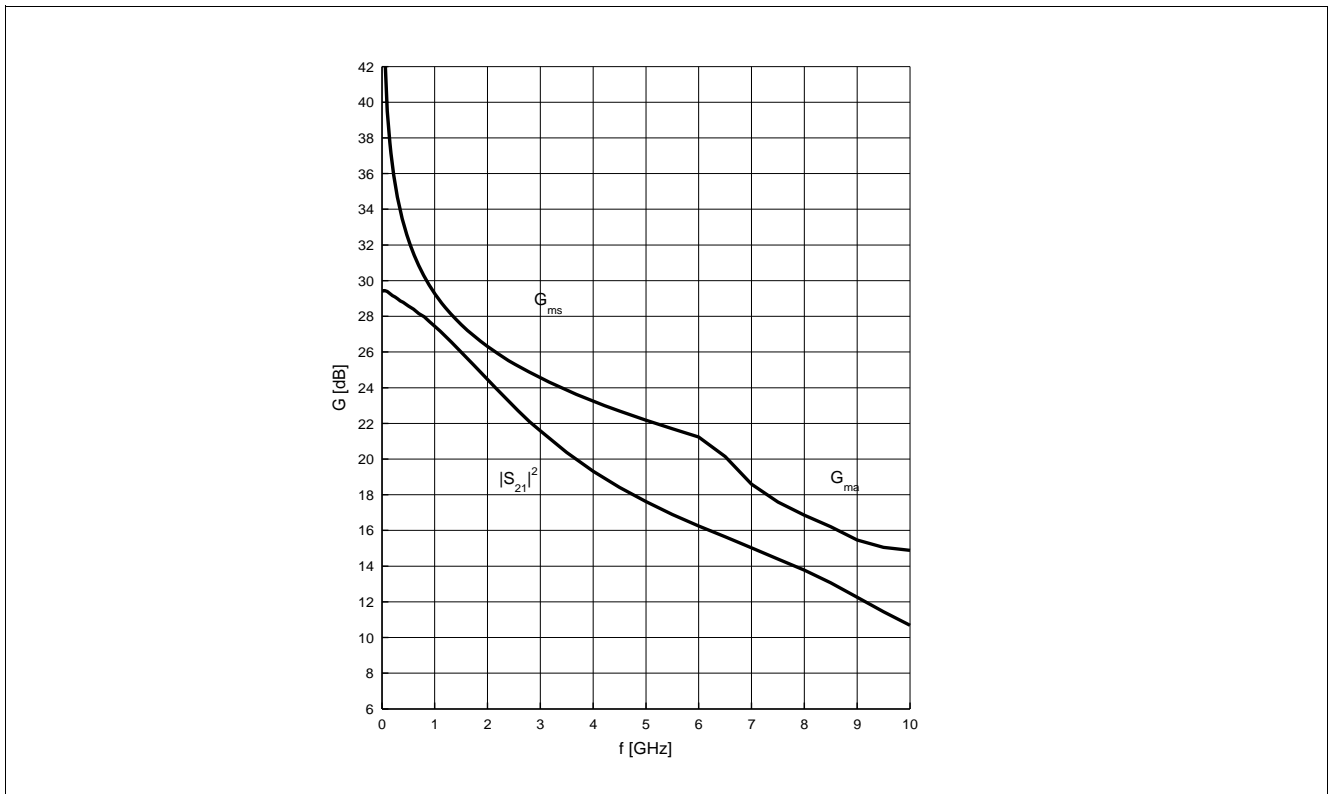


Figure 5-3 Power Gain  $G_{ma}$ ,  $G_{ms}$ ,  $IS_{21}^2 = f(f)$ ,  $V_{CE} = 3 \text{ V}$ ,  $I_C = 13 \text{ mA}$

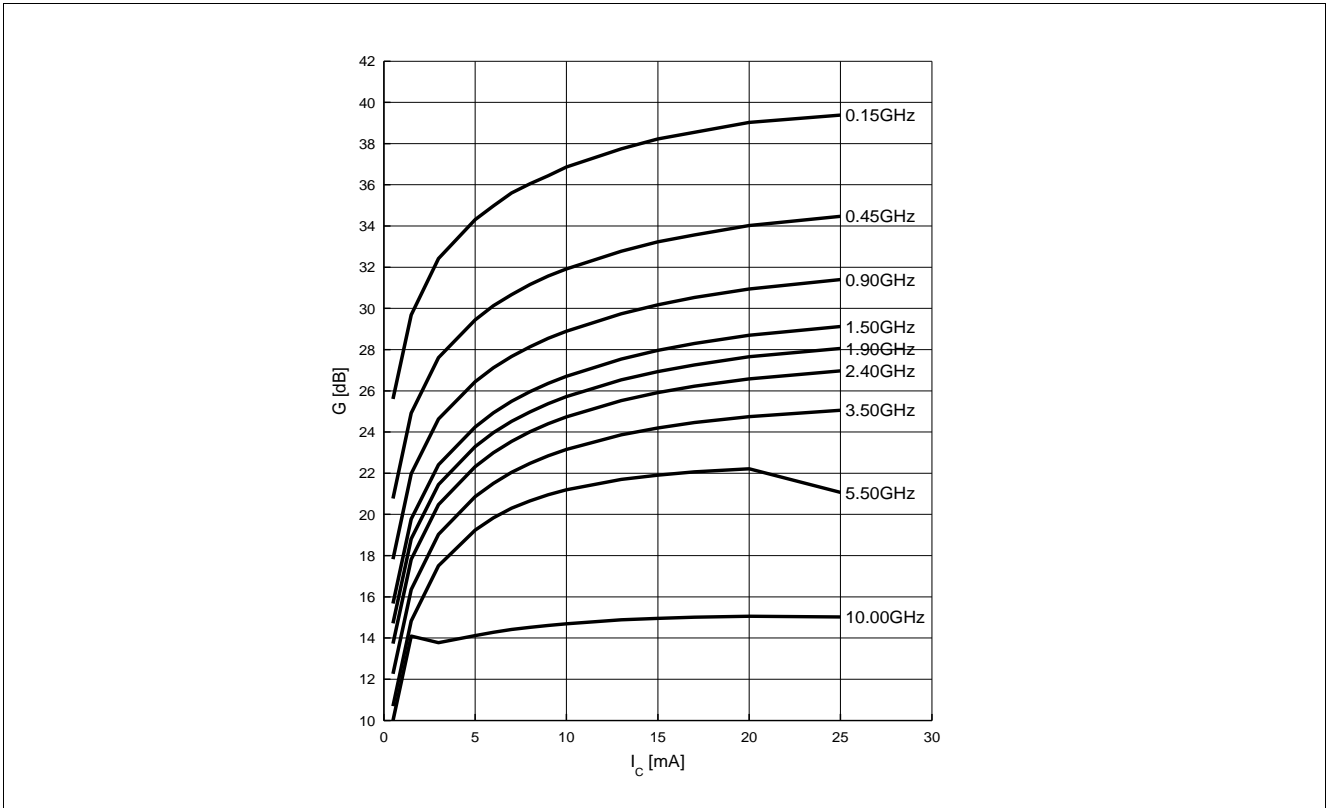


Figure 5-4 Power Gain  $G_{ma}$ ,  $G_{ms} = f(I_c)$ ,  $V_{CE} = 3\text{ V}$ ,  $f = \text{Parameter in GHz}$

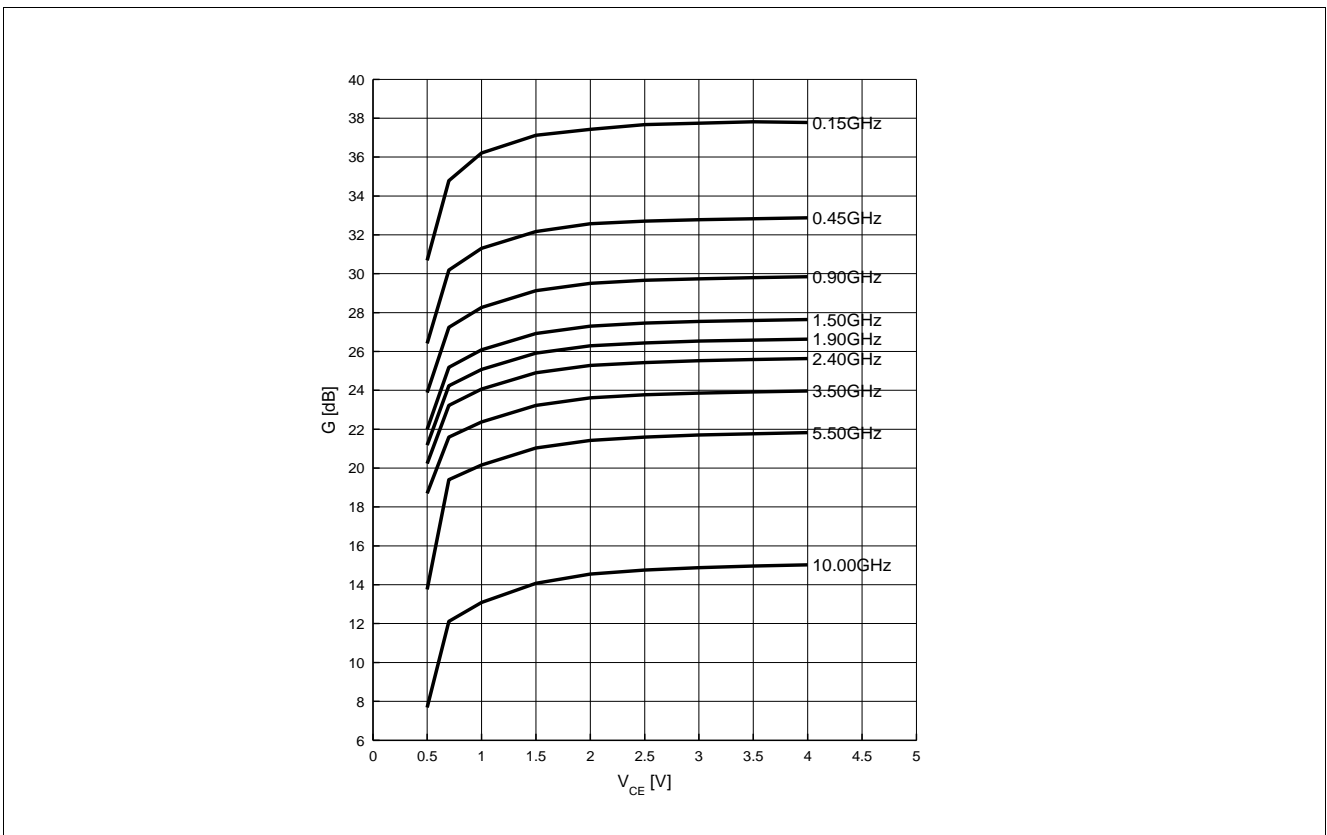


Figure 5-5 Power Gain  $G_{ma}$ ,  $G_{ms} = f(V_{CE})$ ,  $I_c = 13\text{ mA}$ ,  $f = \text{Parameter in GHz}$

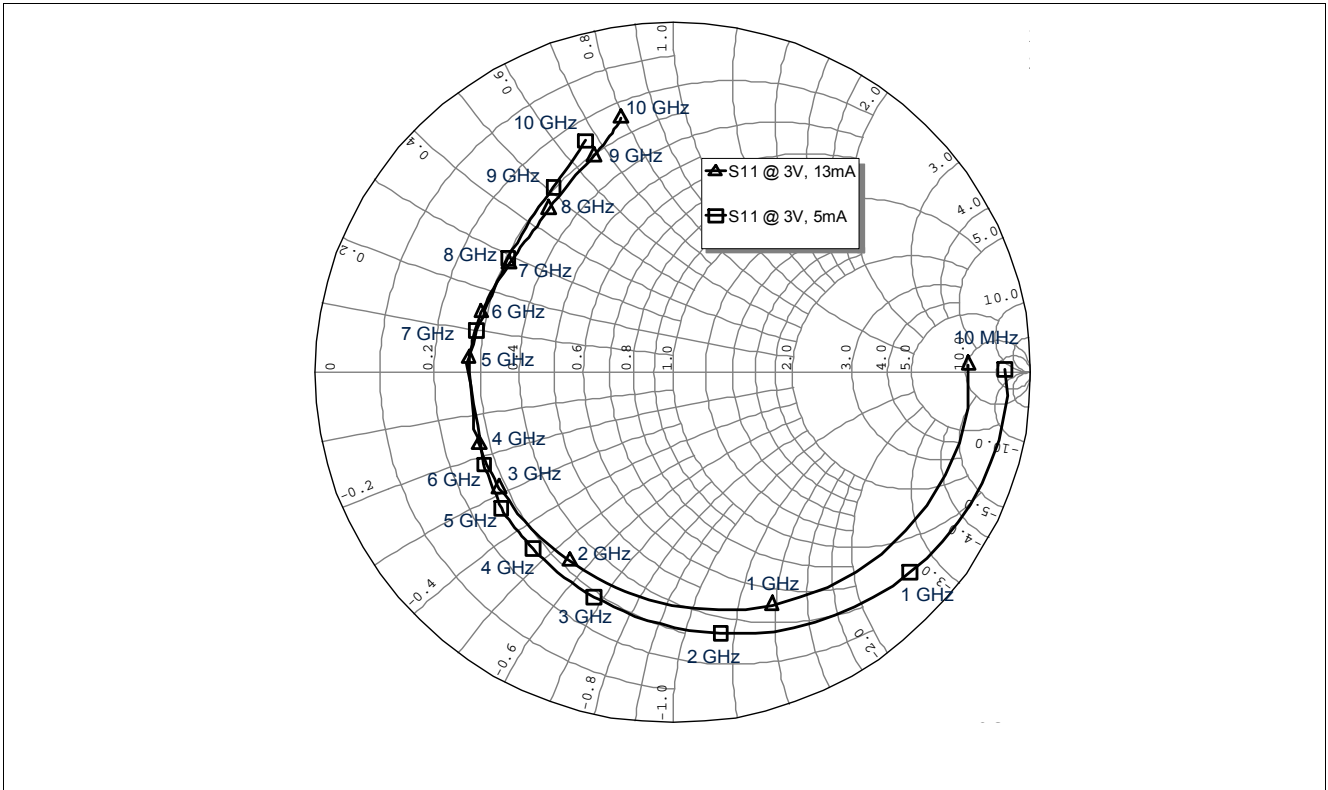


Figure 5-6 Input Matching  $S_{11} = f(f)$ ,  $V_{CE} = 3\text{ V}$ ,  $I_C = 5\text{ mA} / 13\text{ mA}$

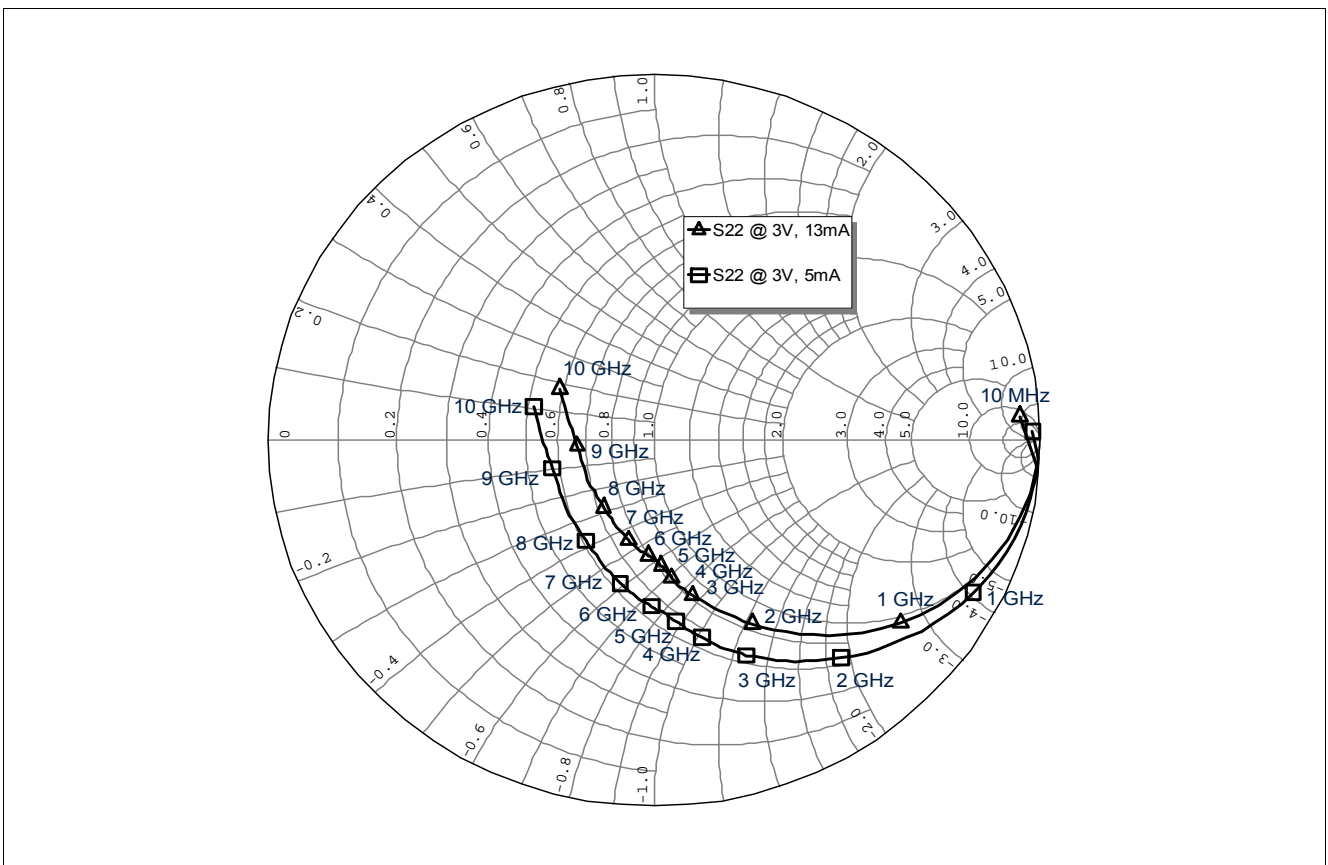


Figure 5-7 Output Matching  $S_{22} = f(f)$ ,  $V_{CE} = 3\text{ V}$ ,  $I_C = 5\text{ mA} / 13\text{ mA}$

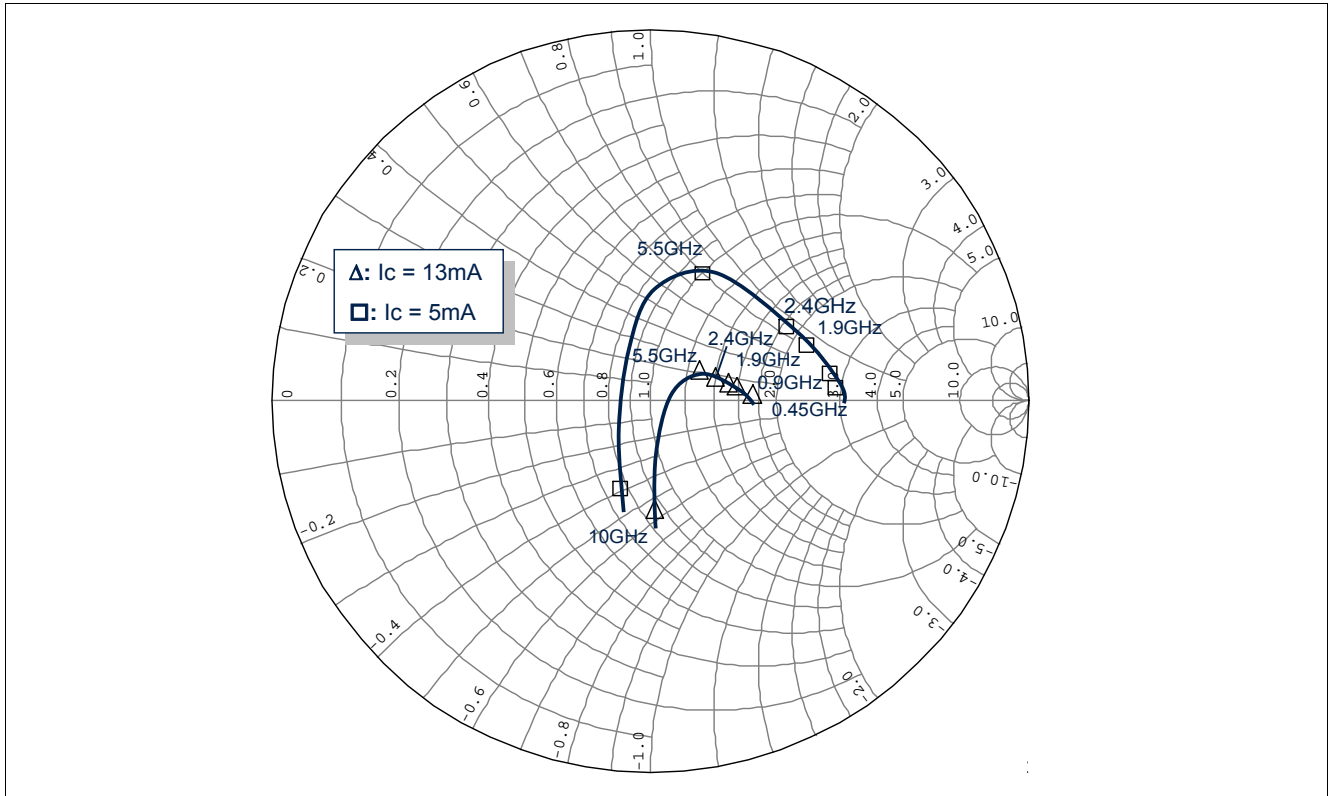


Figure 5-8 Source Impedance  $Z_{opt}$  for  $NF_{min} = f(f)$ ,  $V_{CE} = 3V$ ,  $I_C = 5mA / 13mA$

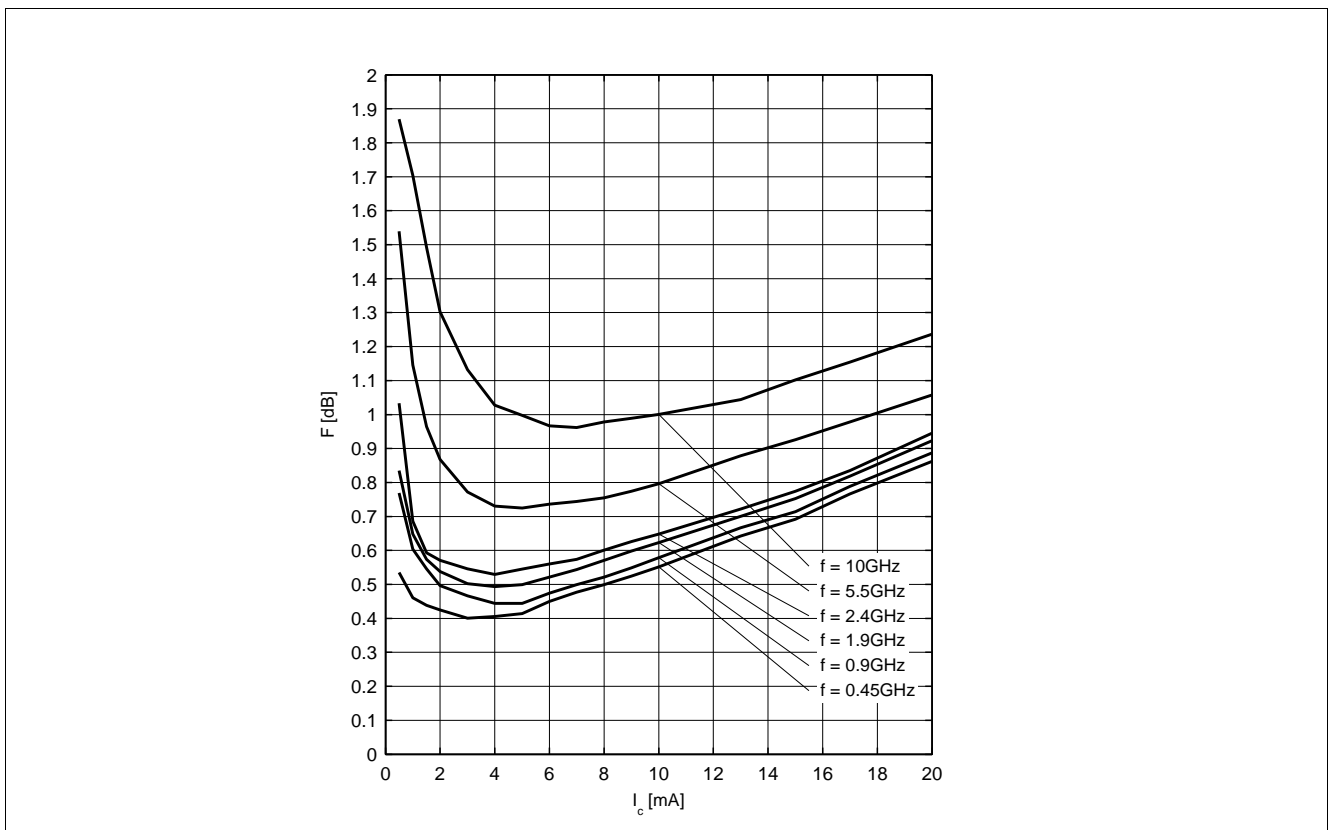


Figure 5-9 Noise Figure  $NF_{min} = f(I_C)$ ,  $V_{CE} = 3V$ ,  $Z_S = Z_{opt}$

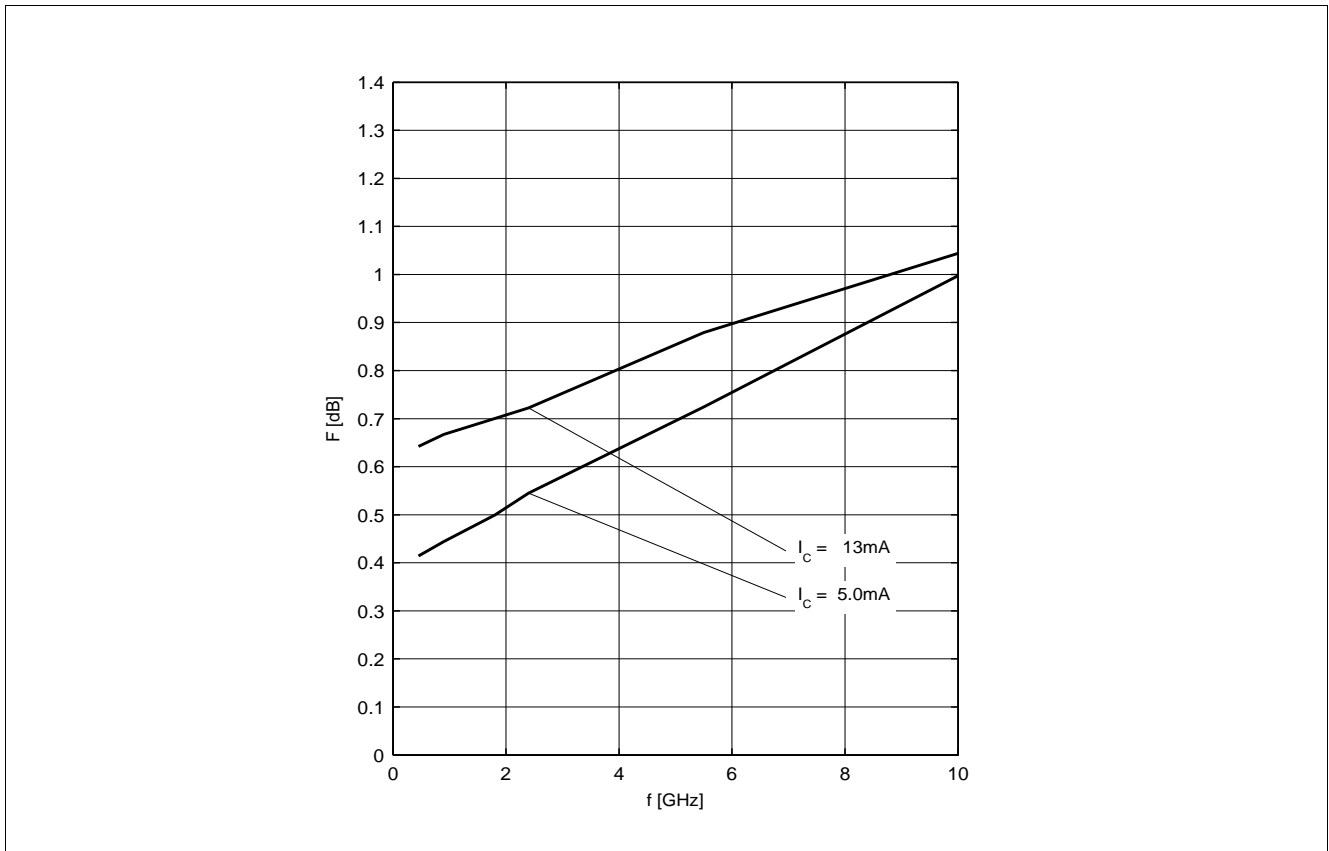


Figure 5-10 Noise Figure  $NF_{min} = f(f)$ ,  $V_{CE} = 3V$ ,  $Z_S = Z_{opt}$

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: [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 BFP720F 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 15 GHz using typical devices. The BFP720F 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 TSFP-4-1

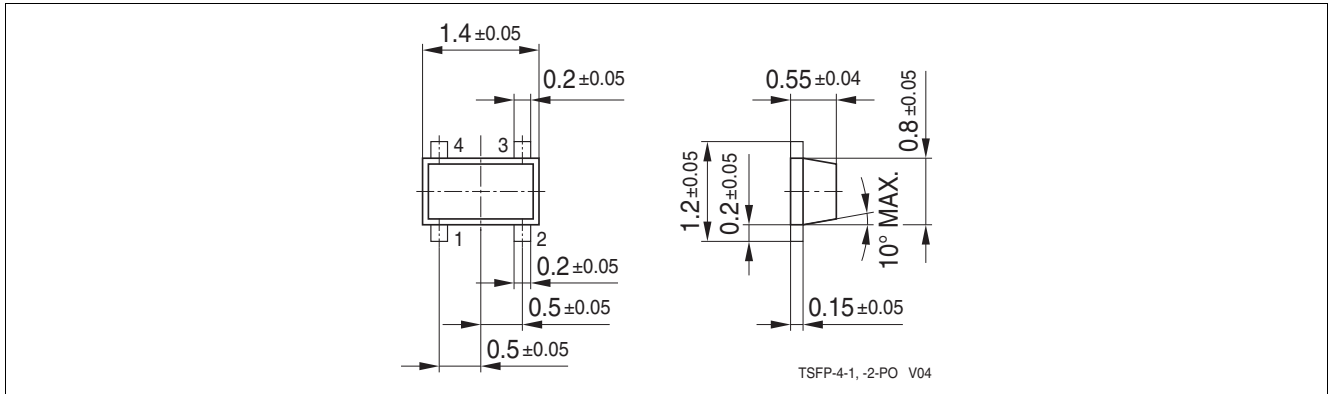


Figure 7-1 Package Outline

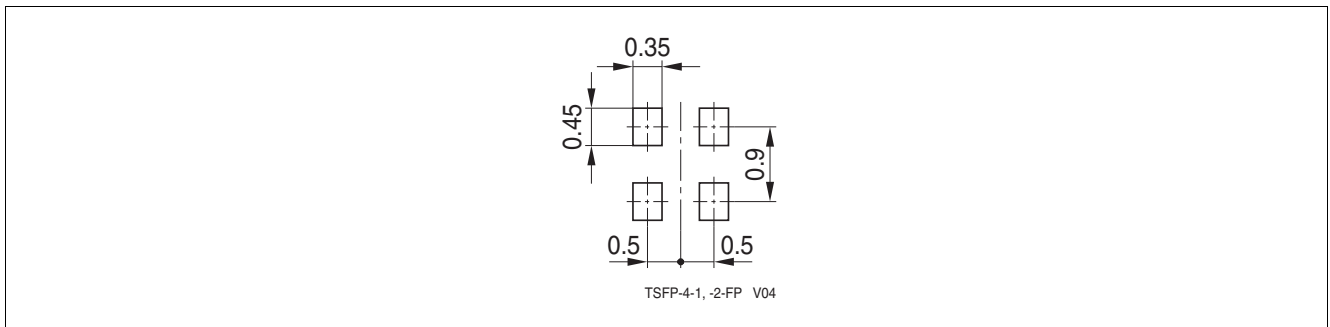


Figure 7-2 Footprint

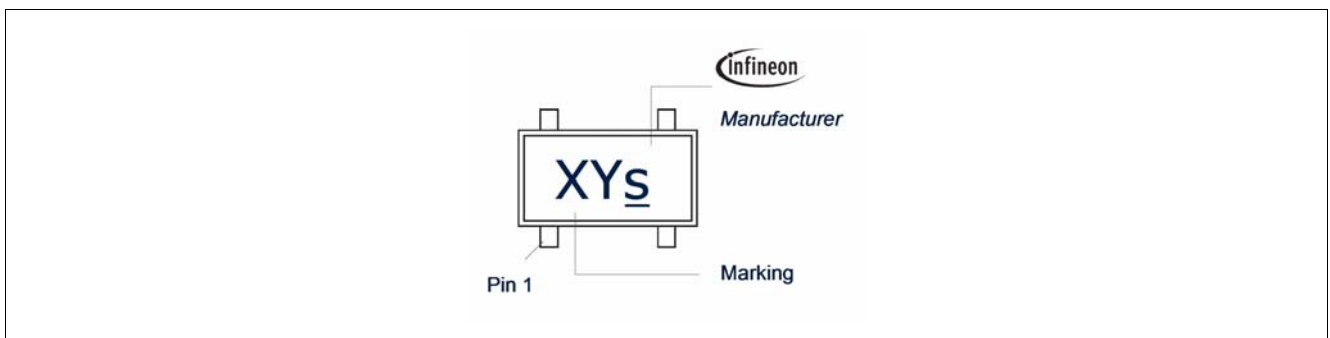


Figure 7-3 Marking Description (Marking BFP720F: R9s)

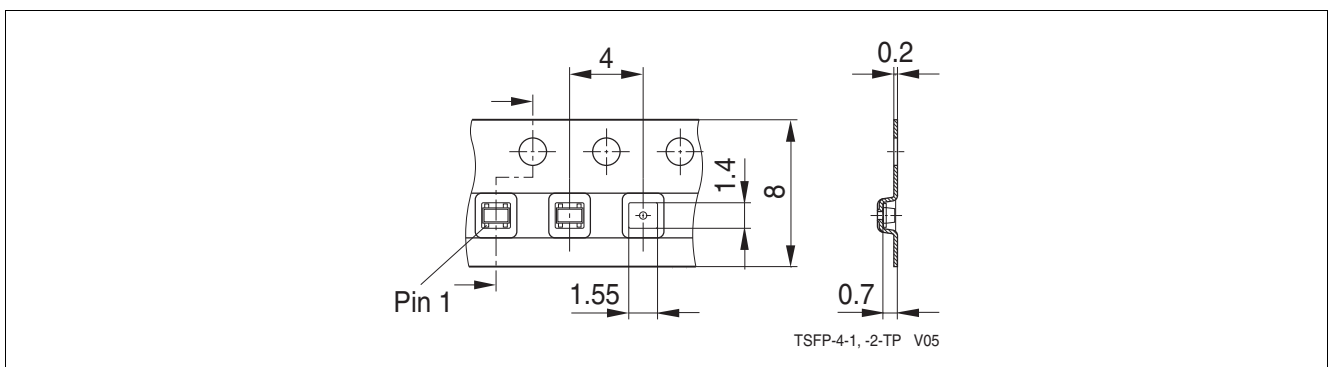


Figure 7-4 Tape Dimensions



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