BFP780

200 mW High Gain RF Driver Amplifier

Data Sheet

Revision 3.0, 2015-07-08

RF & Protection Devices

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BFP780, 200 mW High Gain RF Driver Amplifier

Revision History: 2015-07-08, Revision 3.0

Page	Subjects (major changes since last revision)
	Final data sheet Rev. 3.0 replaces preliminary data sheet Rev. 2.0

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1 Product Brief

The BFP780 is a single stage 200 mW high gain driver amplifier. The device is not internally matched and hence provides flexibility to be used for any application where high linearity is key. There are several application notes available, most of them for LTE frequencies. The device is based on Infineon's reliable and cost effective NPN silicon germanium technology running in very high volume. The technology comprises low ohmic substrate contacts so that emitter bond wires can be omitted. Thereby the emitter inductance is minimized and the power gain optimized.

The data sheet describes the device mainly at 90 mA collector current IC, operated in Class A mode. Under these conditions the BFP780 provides 200 mW RF power and highest linearity. If energy efficiency is in the focus it is recommended to operate the device in class AB mode. That means to adjust a quiescent current Icq lower than 90 mA and use the self biasing effect to get high linearity and efficiency when the input RF power is high. Please refer to figure 7-18, where as an example an Icq of 70 mA is adjusted.

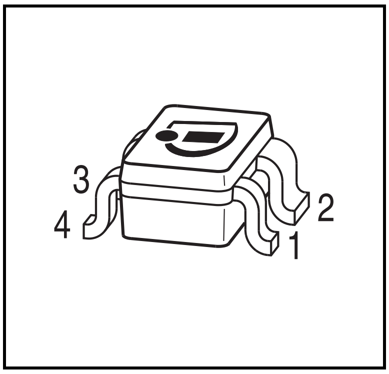
For the BFP780 a large signal compact model in SGP format is available. Further information please find in chapter 8.

The BFP780 is very rugged. The special design of the emitter-base diode makes the input robust and yields a high maximum RF input power. The maximum RF input power is 20 dBm (matched condition). The collector design allows safe operation with a single 5 V supply.

The chip is housed in a halogen free industry standard package SOT343. The high thermal conductivity of the silicon substrate and the low thermal resistance of the package add up to a thermal resistance of only 95 K/W, what leads to moderate junction temperatures even at high dissipated DC power values. Recommended operating conditions can be found in chapter 4. The proper die attach with good thermal contact is tested 100%, so that there is a minimum variation of thermal properties. The devices are 100% DC and RF tested

2 Features

- High 3rd order intercept point OIP3 of 34.5 dBm @ 5 V, 90 mA
- High compression point OP1dB of 23 dBm @ 5 V, 90 mA corresponding to 45 % collector efficiency
- Low minimum noise figure of 1.2 dB @ 900 MHz, 5 V, 30 mA
- Single stage, intended for external matching
- High maximum RF input power PRFinmax of 20 dBm
- Safe operation with single 5 V supply
- 100% test of proper die attach for reproducible thermal contact
- 100% DC and RF tested
- Easy to use large signal compact model available
- Cost effective NPN SiGe technology running in very high volume
- Easy to use Pb-free (RoHS compliant) and halogen-free industry standard package SOT343, low RTHJS of 95 K/W



RoHS HAL

Applications

As

- High linearity driver or pre-driver in the transmit chain
- 2nd or 3rd stage LNA in the receive chain
- IF or LO buffer amplifier

In

- Commercial / industrial wireless infrastructure / basestations
- Repeaters
- Automated test equipment

For

- Cellular, PCS, DCS, UMTS, LTE, CDMA, WCDMA, GSM, GPRS
- WLAN, WiMAX, WLL and MMDS
- ISM, AMR
- UHF television, CATV, DBS

Attention: ESD-class 1a (Electrostatic discharge) sensitive device, observe handling precautions

Product Name	Package	Pin Configuration				Marking
BFP780	SOT343-4-2	1 = B	2 = E	3 = C	4 = E	R1s

3 Absolute Maximum Ratings

Table 3-1 Absolute Maximum Ratings at T_A = 25 °C (unless otherwise specified)

Parameter	Symbol	Values		Unit	Note / Test Condition
		Min.	Max.		
Collector emitter voltage	V_{CE}		6.1 5.1	V	T_A = 25 °C T_A = -40 °C
Collector base voltage	V_{CB}		15	V	T_A = 25 °C
Instantaneous total collector current	i_C	–	240	mA	DC + RF swing
DC collector current	I_C	–	120	mA	
DC base current	I_B	-1	5	mA	
RF input power	P_{RFin}	–	20	dBm	In- and output matched
Dissipated power	P_{diss}	–	600	mW	$T_S \leq$ 93°C[1], regard derating curve in **Figure 5-1**
Junction temperature	T_J	–	150	°C	
Operating case temperature	T_A	-40	105[2]	°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.

2) At the same time regard $T_{J,max}$.

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 Recommended Operating Conditions

This following table shows examples of recommended operating conditions. As long as maximum ratings are regarded operation outside these conditions is permitted, but increases failure rate and reduces lifetime. For further information refer to the quality report available on the BFP780 internet page.

Table 4-1 Recommended Operating Conditions

Operating Mode	Ambient Temperature[1]	Collector Current	DC Power[2]	RF Output Power[3]	Efficiency[4]	Dissipated Power[5]	Thermal Resistance of pcb[6]	Junction Temperature[7]
	T_A [°C]	I_C [mA]	P_{DC} [mW]	P_{RFout} [mW] (dBm)	η [%]	P_{diss} [mW]	R_{THSA} [K/W]	T_J [°C]
Compression	55	90	450	200 (23)	45	250	120	110
Final stage	55	90	450	115 (20.5)	25	340	70	110
High T_A	85	50	250	75 (19)	30	175	35	110
Maximum T_A	105	20	100	45 (16.5)	45	55	35	110
Linear	55	50	250	20 (13)	8	230	120	110
Very Linear	55	90	450	23 (13.5)	5	430	35	110

1) Is the operating case temperature respectively of the heatsink.
2) $P_{DC} = V_{CE} * I_C$ with V_{CE} = 5 V.
3) RF power delivered to the load, $P_{RFout} = \eta * P_{DC}$.
4) Efficiency of the conversion from DC power to RF power, $\eta = P_{RFout} / P_{DC}$ (collector efficiency).
5) $P_{diss} = P_{DC} - P_{RFout}$. The RF output power P_{RFout} delivered to the load reduces the power P_{diss} to be dissipated by the device. This means a good output match is recommended.
6) R_{THSA} is the thermal resistance of the pcb including heat sink, that is between the soldering point S and the ambient A. Regard the impact of R_{THSA} on the junction temperature T_J, see below. The thermal design of the pcb, respectively R_{THSA}, has to be adjusted to the intended operating mode.
7) $T_J = T_A + P_{diss} * R_{THJA}$. $R_{THJA} = R_{THJS} + R_{THSA}$.
R_{THJA} is the thermal resistance between the transistor junction J and the ambient A.
R_{THJS} is the combined thermal resistance of die and package, which is 95 K/W for the BFP780, see **Chapter 5**.

5 Thermal Characteristics

Table 5-1 Thermal Resistance

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Junction - soldering point	R_{THJS}	–	95	–	K/W	–

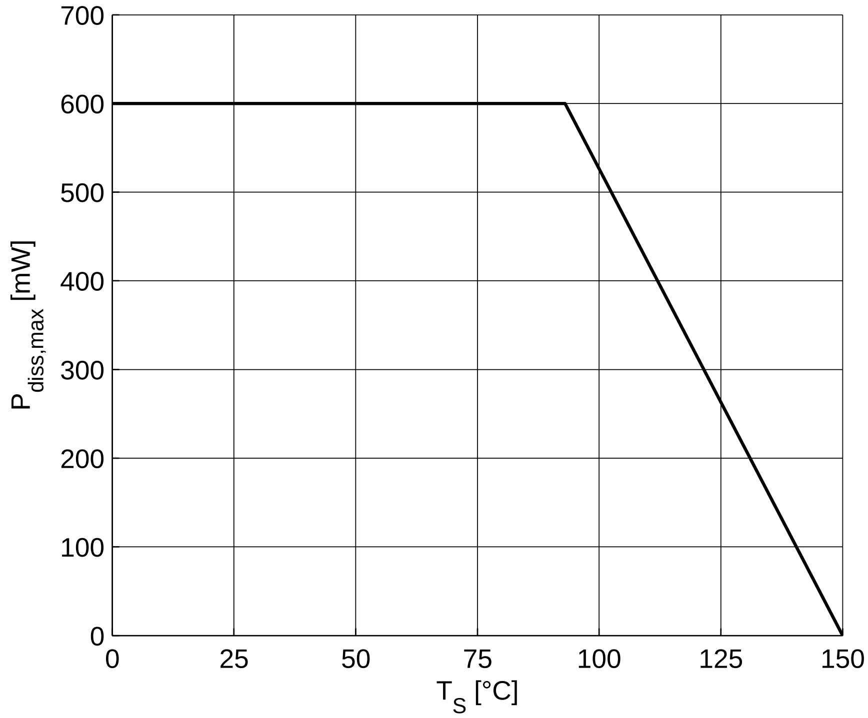


Figure 5-1 Absolute Maximum Power Dissipation $P_{diss,max}$ vs. T_s

Note: In the horizontal part of the derating curve the maximum power dissipation is given by $P_{diss,max} \approx V_{CE,max} * I_{C,max}$. In this part the junction temperature T_J is lower than $T_{J,max}$. In the declining slope it is $T_J = T_{J,max}$, $P_{diss,max}$ has to be reduced according to the curve in order not to exceed $T_{J,max}$. It is $T_{J,max} = T_S + P_{diss,max} * R_{THJS}$.

6 Electrical Performance in Application

The table shows the most important results of the application notes available for the BFP780. The matching is approximately 10 dB, the isolation is better than 20 dB and the stability factor is above 1 at V_{CC} = 5 V. For more detailed informations please refer to the BFP780 internet page. Application notes for Class AB operating mode respectively lower quiescent currents I_{Cq} are in development.

Table 6-1 Application Notes

Application Note	Frequency	OP1dB	OIP3	Gain	Operating Mode	I_{Cq}
#	[MHz]	[dBm]	[dBm]	[dB]		[mA]
AN410	2600	22	34.7	14.4	Class A	80
AN390	1805 - 1880	22	34	18	Class A	90
AN413	900	23	34.7	22	Class A	80

7 Electrical Performance in Test Fixture

7.1 DC Parameter Table

Table 7-1 DC Characteristics at T_A = 25 °C

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Collector emitter breakdown voltage	$V_{(BR)CEO}$	6.1	6.6	–	V	I_C = 1 mA, open base
Collector emitter leakage current	I_{CES}	–	1[1] 0.1	40 3	nA µA	V_{CE} = 8 V, V_{BE} = 0 V_{CE} = 18 V, V_{BE} = 0 E-B short circuited
Collector base leakage current	I_{CBO}	–	1[1]	40	nA	V_{CB} = 8 V, I_E = 0 Open emitter
Emitter base leakage current	I_{EBO}	–	–	10	µA	V_{EB} = 0.5 V, I_C = 0 Open collector
DC current gain	h_{FE}	85	160	230		V_{CE} = 5 V, I_C = 90 mA Pulse measured[2]

1) Accuracy of typcial value limited by the cycle time of the 100% test.

2) Test duration 14 ms, duty cycle 46%. Regard that the current gain h_{FE} depends on the junction temperature T_J and T_J amongst others from the thermal resistance R_{THSA} of the pcb, see notes on **Table 4-1**. Hence the h_{FE} specified in this data sheet must not be the same as in the application. It is recommended to apply circuit design techniques to make the collector current I_C independent on the h_{FE} production variation and temperature effects.

7.2 AC Parameter Tables

Table 7-2 General AC Characteristics at T_A = 25 °C

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Transition frequency	f_T	–	20	–	GHz	V_{CE} = 5 V, I_C = 90 mA
Collector base capacitance	C_{CB}	–	0.37	–	pF	V_{CB} = 5 V, V_{BE} = 0 f = 1 MHz Emitter grounded
Collector emitter capacitance	C_{CE}	–	1.4	–	pF	V_{CE} = 5 V, V_{BE} = 0 f = 1 MHz Base grounded
Emitter base capacitance	C_{EB}	–	3.3	–	pF	V_{EB} = 0.5 V, V_{CB} = 0 f = 1 MHz Collector grounded

Measurement setup for the AC characteristics shown in Table 7-3 to Table 7-6 is a test fixture with Bias T's and tuners to adjust the source and load impedances in a 50 Ω system, T_A = 25 °C.

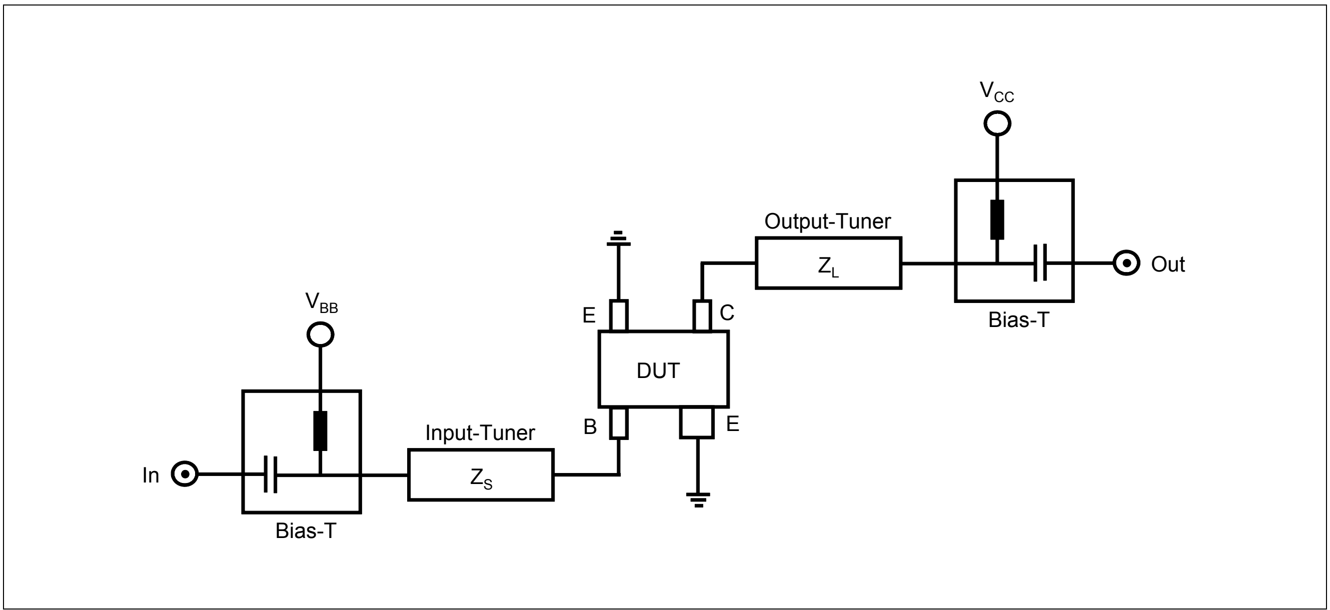


Figure 7-1 BFP780 Testing Circuit

Table 7-3 AC Characteristics, V_{CE} = 5 V, f = 0.9 GHz

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Power gain					dB	
Maximum power gain	G_{ms}	–	27	–		I_C = 90 mA
Transducer gain	$\|S_{21}\|^2$	–	21.5	–		I_C = 90 mA
Minimum Noise Figure					dB	$Z_S = Z_{Sopt}$
Minimum noise figure	NF_{min}	–	1.2	–		I_C = 30 mA
Linearity					dBm	$Z_L = Z_{Lopt}$
1 dB compression point at output	$OP1dB$	–	23	–		I_C = 90 mA
3rd order intercept point at output	$OIP3$	–	34.5	–		I_C = 90 mA

Table 7-4 AC Characteristics, V_{CE} = 5 V, f = 1.8 GHz

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Power gain					dB	
Maximum power gain	G_{ma}	–	22	–		I_C = 90 mA
Transducer gain	$\|S_{21}\|^2$	–	15	–		I_C = 90 mA
Minimum Noise Figure					dB	$Z_S = Z_{Sopt}$
Minimum noise figure	NF_{min}	–	1.4	–		I_C = 30 mA

Table 7-4 AC Characteristics, V_{CE} = 5 V, f = 1.8 GHz (cont'd)

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Linearity					dBm	$Z_L = Z_{Lopt}$
1 dB compression point at output	$OP1dB$	–	22	–		I_C = 90 mA
3rd order intercept point at output	$OIP3$	–	34	–		I_C = 90 mA

Table 7-5 AC Characteristics, V_{CE} = 5 V, f = 2.6 GHz

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Power gain					dB	
Maximum power gain	G_{ma}	–	18	–		I_C = 90 mA
Transducer gain	$\|S_{21}\|^2$	–	12	–		I_C = 90 mA
Minimum Noise Figure					dB	$Z_S = Z_{Sopt}$
Minimum noise figure	NF_{min}	–	1.7	–		I_C = 30 mA
Linearity					dBm	$Z_L = Z_{Lopt}$
1 dB compression point at output	$OP1dB$	–	22	–		I_C = 90 mA
3rd order intercept point at output	$OIP3$	–	34	–		I_C = 90 mA

Table 7-6 AC Characteristics, V_{CE} = 5 V, f = 3.5 GHz

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Power gain					dB	
Maximum power gain	G_{ma}	–	15	–		I_C = 90 mA
Transducer gain	$\|S_{21}\|^2$	–	8.5	–		I_C = 90 mA
Minimum Noise Figure					dB	$Z_S = Z_{Sopt}$
Minimum noise figure	NF_{min}	–	2.4	–		I_C =30 mA
Linearity					dBm	$Z_L = Z_{Lopt}$
1 dB compression point at output	$OP1dB$	–	22	–		I_C = 90 mA
3rd order intercept point at output	$OIP3$	–	33.5	–		I_C = 90 mA

7.3 Characteristic DC Diagrams

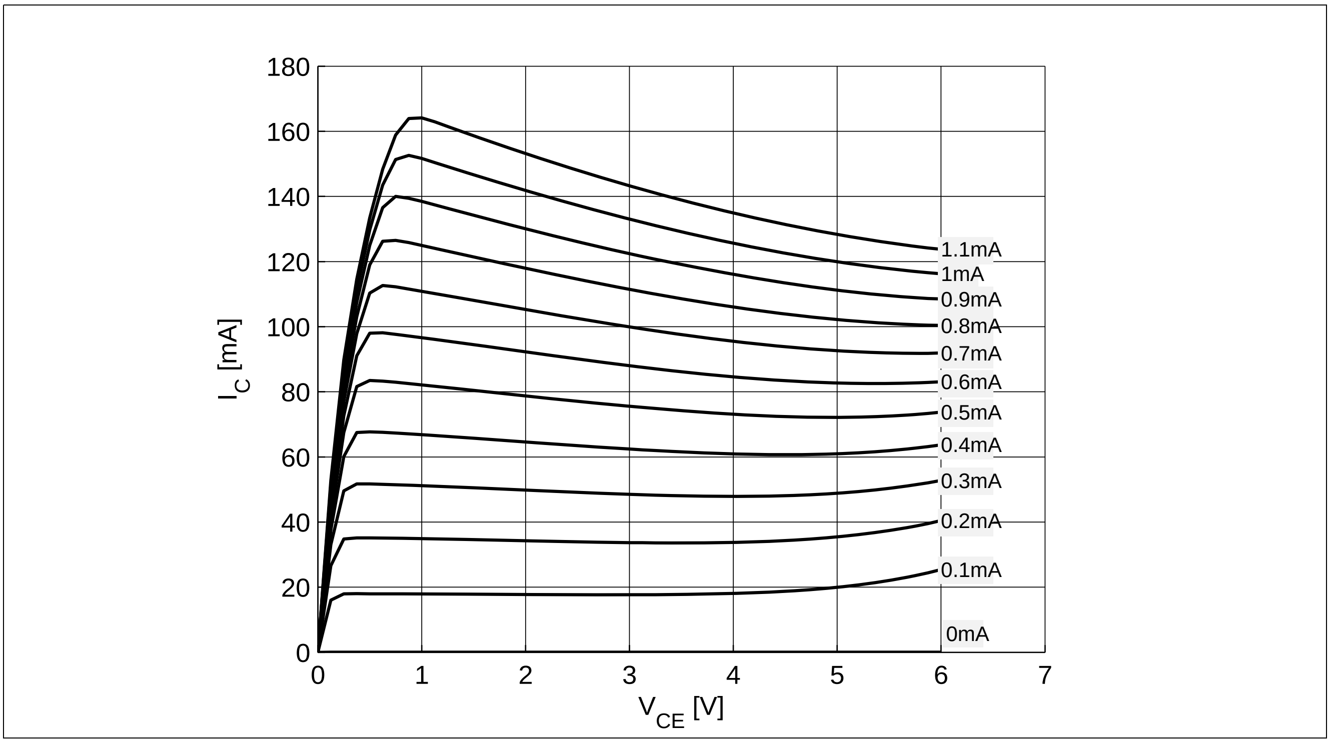


Figure 7-2 Collector Current I_C vs. V_{CE}, I_B = Parameter

Note: Regard absolute maximum ratings for I_C, V_{CE} and P_{diss}

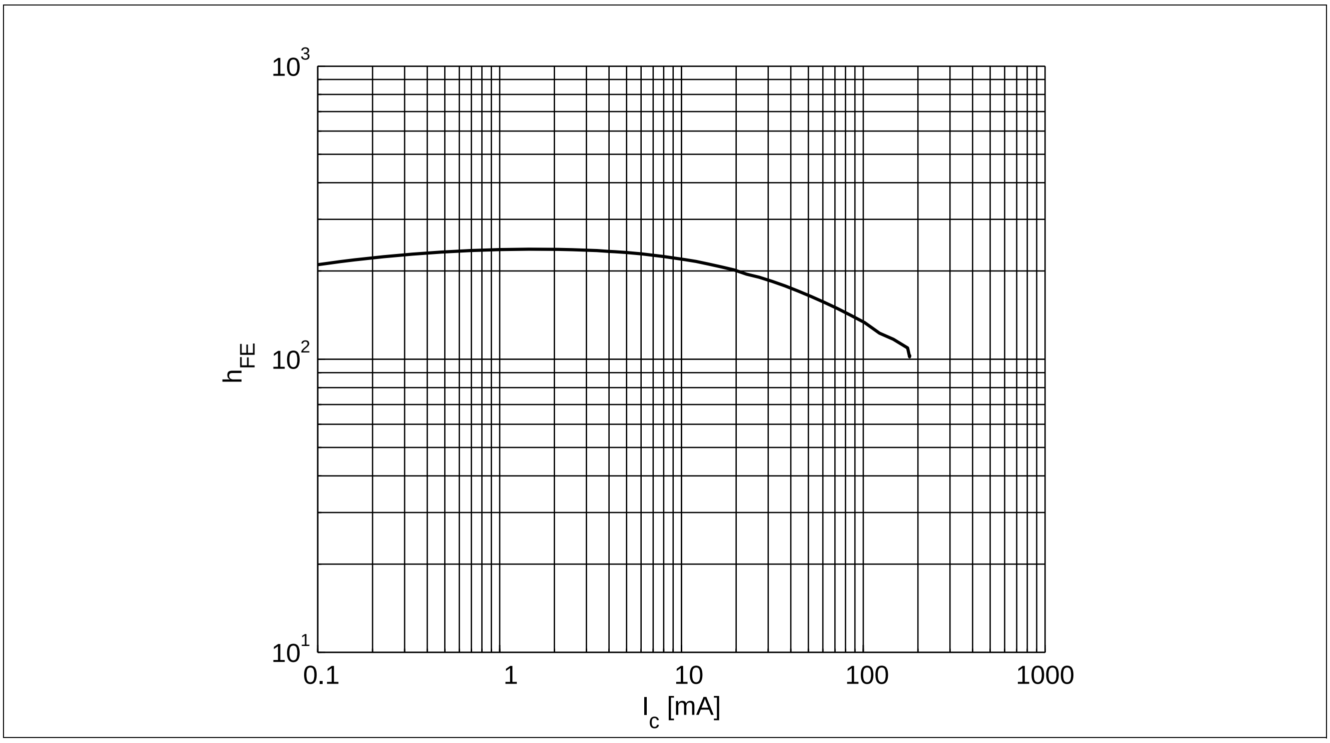


Figure 7-3 DC Current Gain h_{FE} vs. I_C at V_{CE} = 5 V

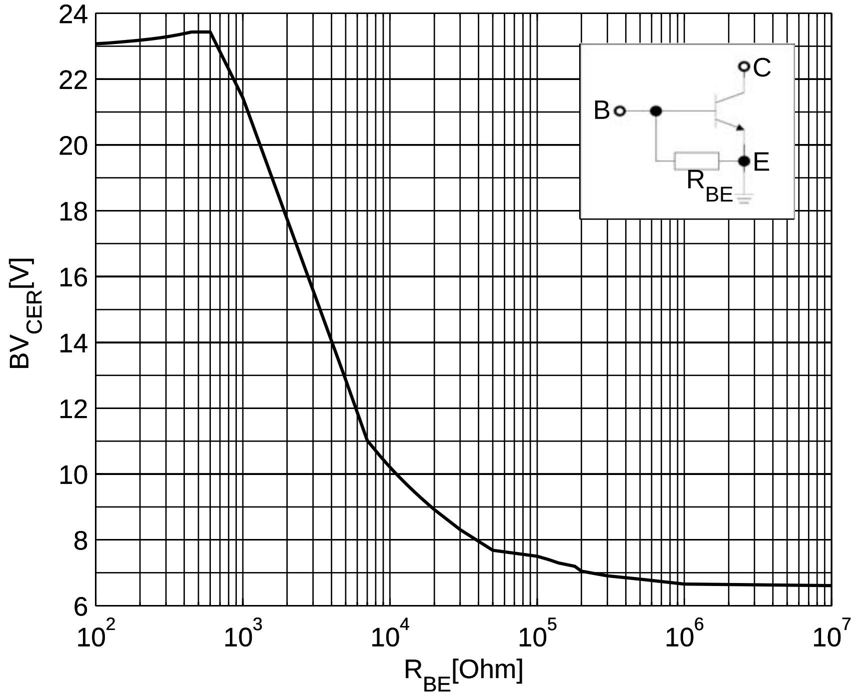


Figure 7-4 Collector Emitter Breakdown Voltage BV_{CER} vs. Resistor R_{BE}

Note: The above figure shows the collector-emitter breakdown voltage BV_{CER} with a resistor R_{BE} between base and emitter. Only for very high R_{BE} values ("open base") the breakdown voltage BV_{CER} is as low as BV_{CEO} (here 6.6 V). With decreasing R_{BE} values BV_{CER} increases, e.g. at R_{BE} = 10 kOhm to BV_{CER} = 10 V. In the application the biasing base resistance together with block capacitors take over the function of R_{BE} and allows the RF voltage amplitude to swing up to voltages much higher than BV_{CEO}, no clipping occurs. Due to this effect the transistor can be biased at V_{CE} = 5 V and still high RF output powers achieved, see the OP1dB values reported in ***Chapter 7.2****.*

7.4 Characteristic AC Diagrams

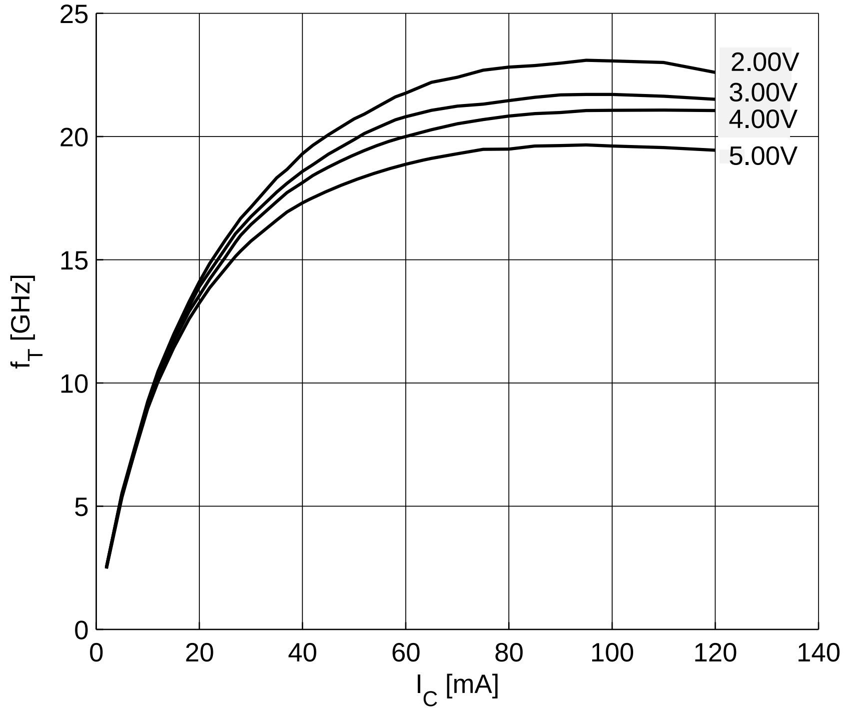


Figure 7-5 Transition Frequency f_T vs. I_C, V_{CE} = Parameter

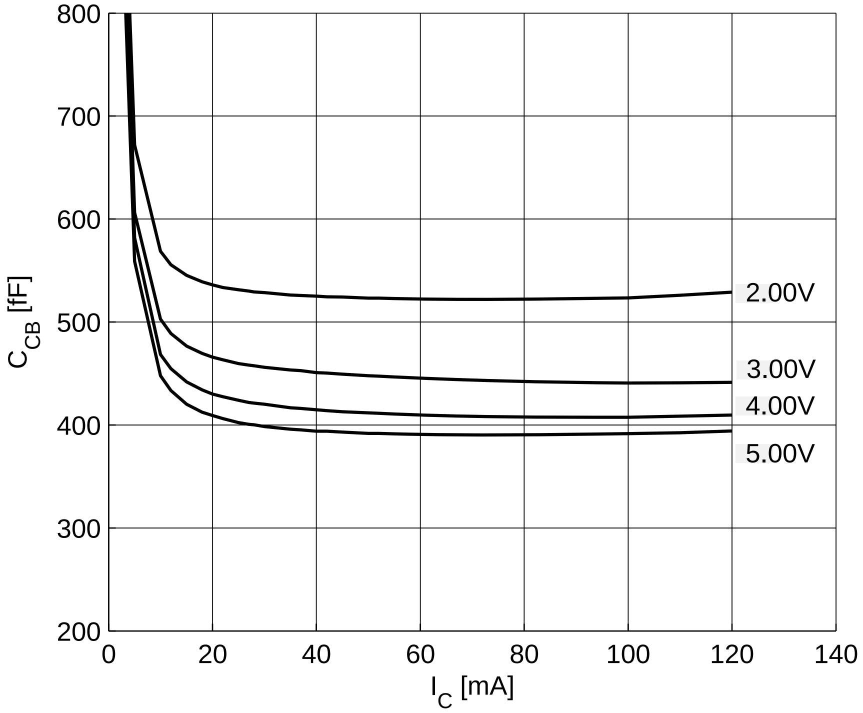


Figure 7-6 Collector Base Capacitance C_{CB} vs. I_C at f = 1 GHz, V_{CE} = Parameter

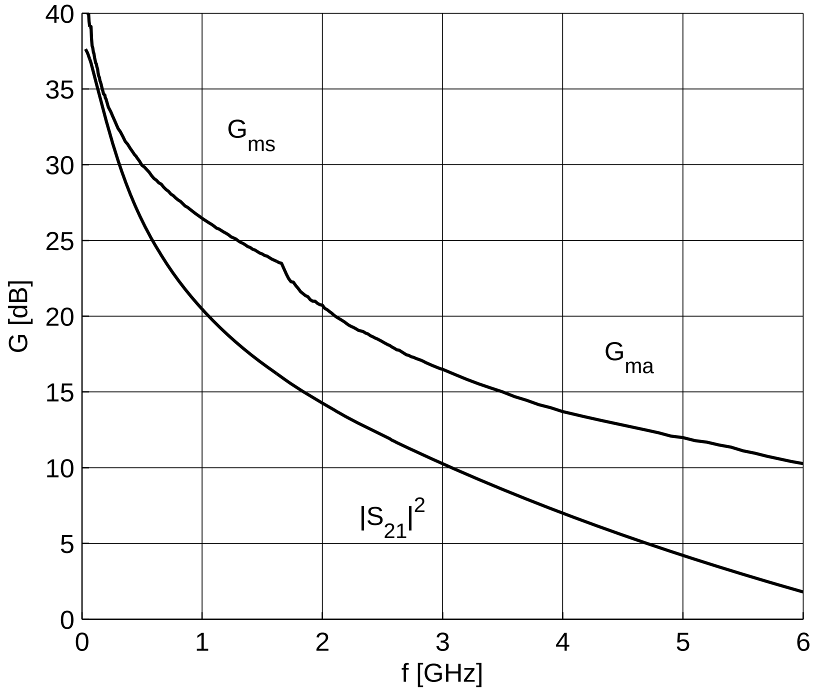


Figure 7-7 Gain G_{ms}, G_{ma}, $|S_{21}|^2$ vs. f at V_{CE} = 5 V, I_C = 90 mA

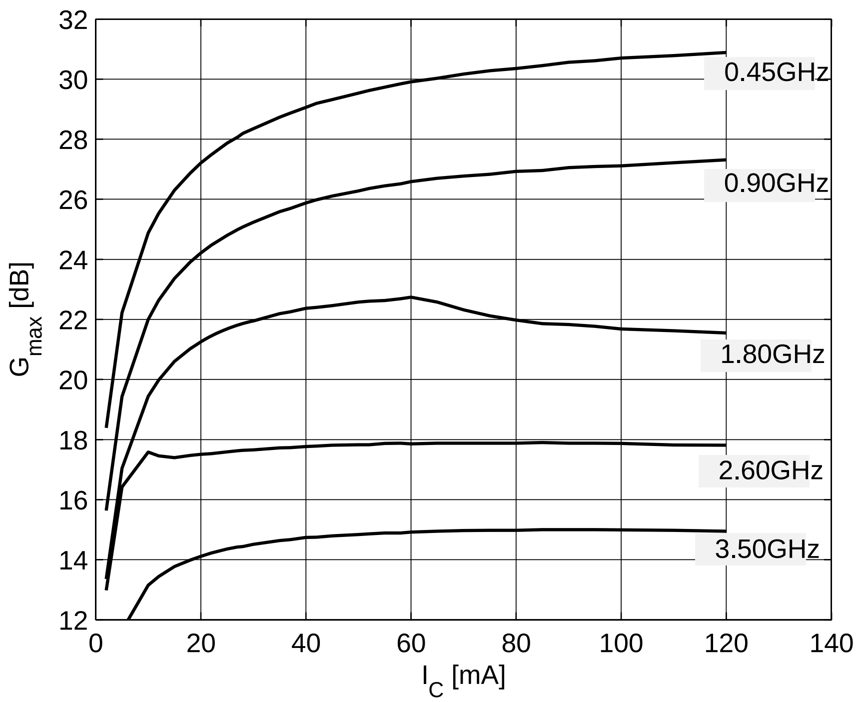


Figure 7-8 Maximum Power Gain G_{max} vs. I_C at V_{CE} = 5 V, f = Parameter

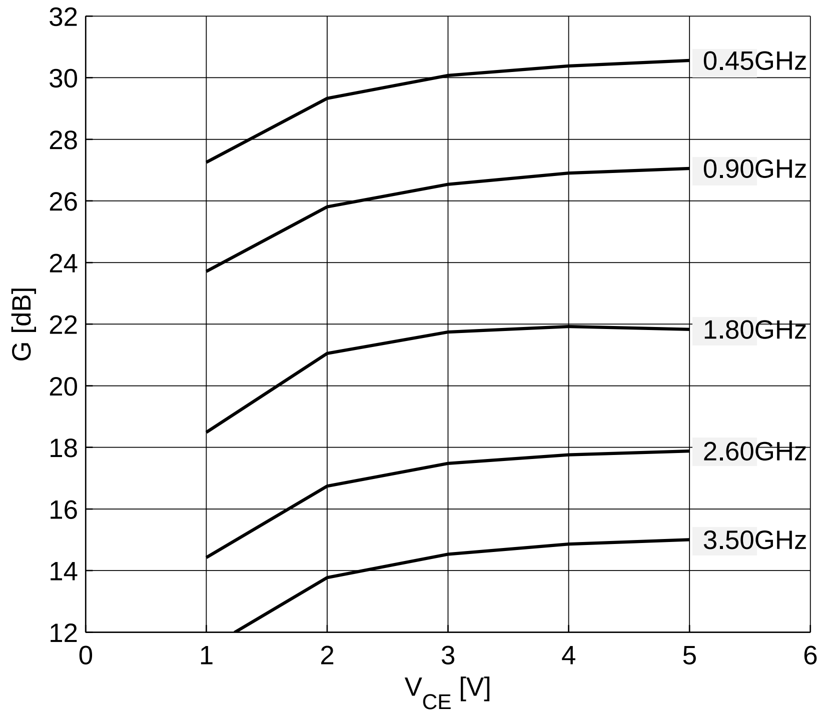


Figure 7-9 Maximum Power Gain G_{max} vs. V_{CE} at I_C = 90 mA, f = Parameter

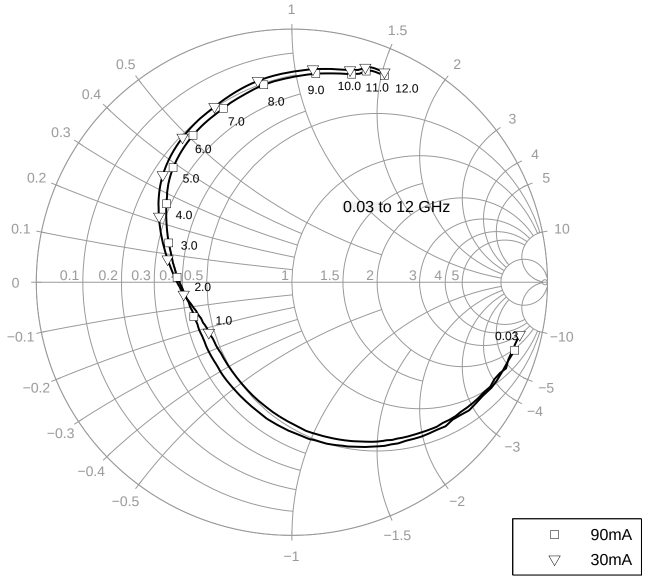


Figure 7-10 Output Reflection Coefficient S_{22} vs. f at V_{CE} = 5 V, I_C = Parameter

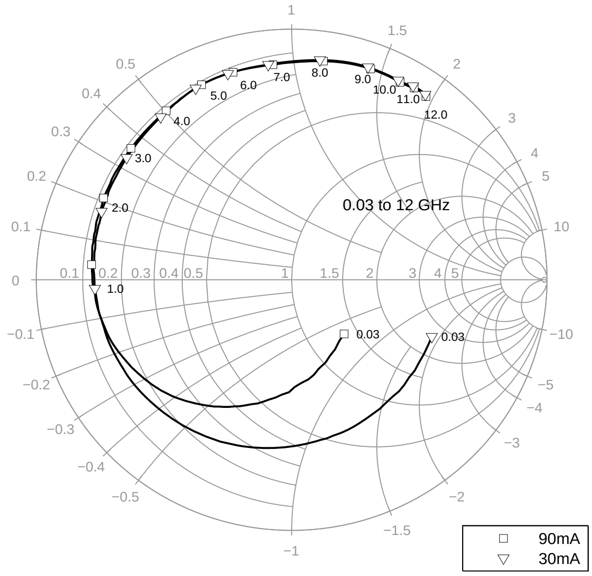


Figure 7-11 Input Reflection Coefficient S_{11} vs. f at V_{CE} = 5 V, I_C = Parameter

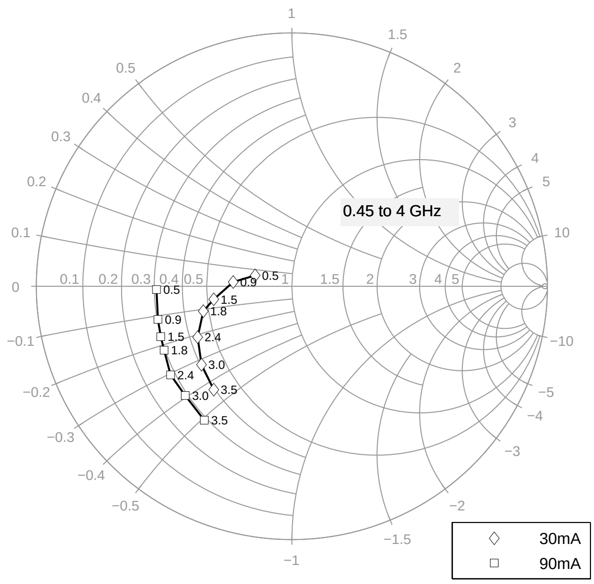


Figure 7-12 Source Impedance Z_{Sopt} for Minimum Noise Figure vs. f at V_{CE} = 5 V, I_C = Parameter

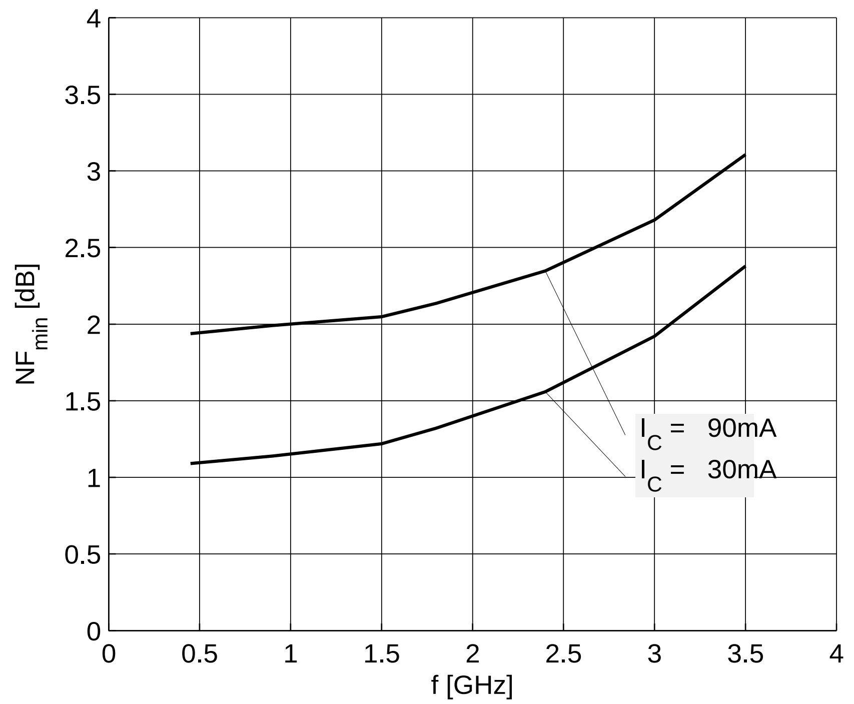


Figure 7-13 Noise Figure NF_{min} vs. f at V_{CE} = 5 V, Z_S = Z_{Sopt}, I_C = Parameter

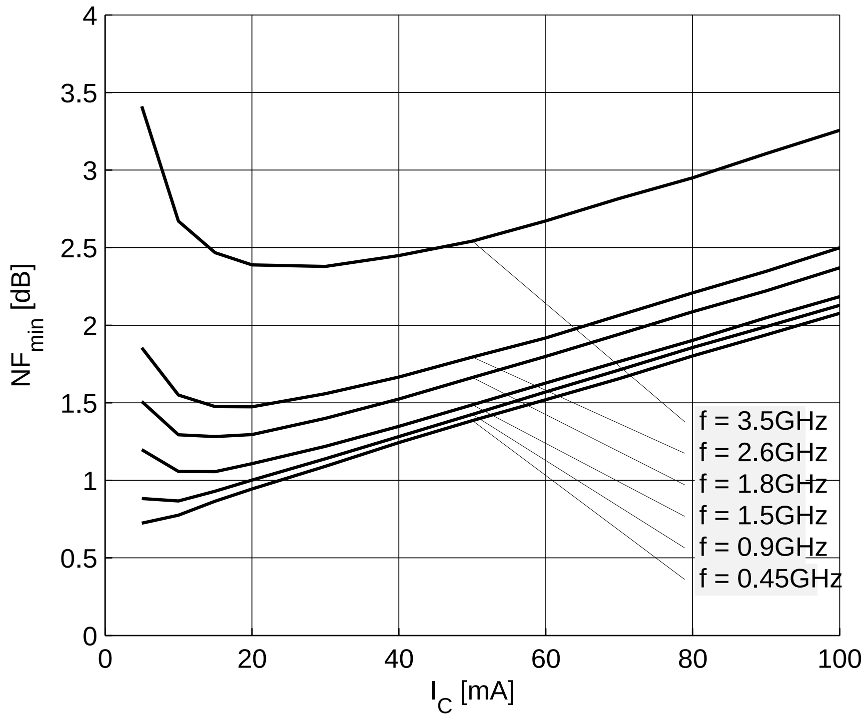


Figure 7-14 Noise Figure NF_{min} vs. I_C at V_{CE} = 5 V, Z_S = Z_{Sopt}, f = Parameter

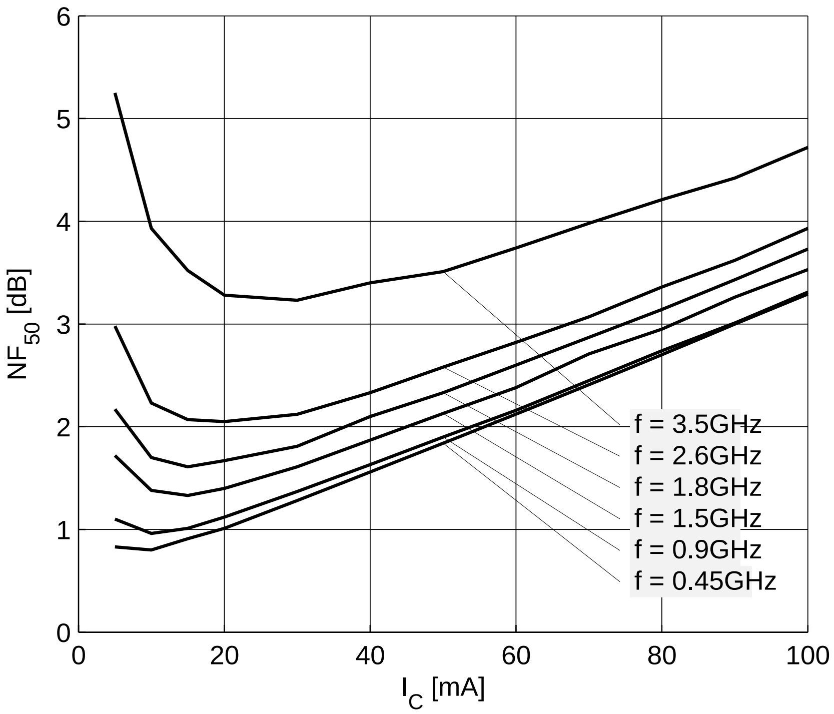


Figure 7-15 Noise Figure NF_{50} vs. I_C at V_{CE} = 5 V, Z_S = 50 Ω, f = Parameter

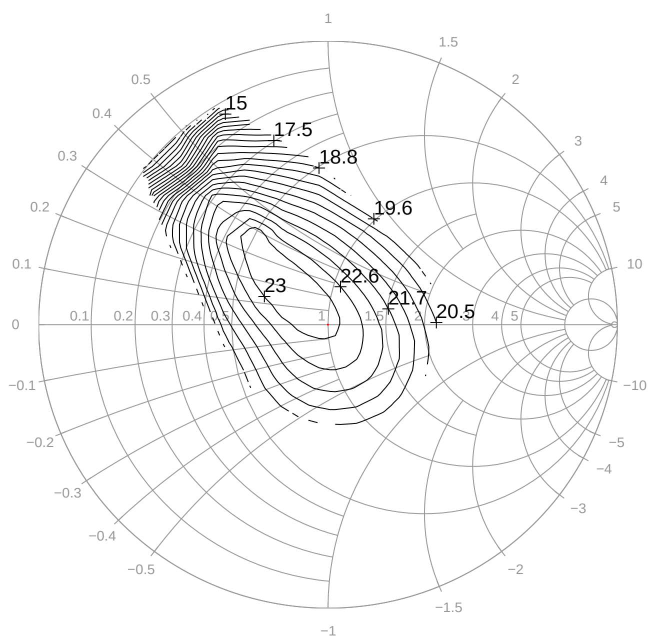


Figure 7-16 Load Pull Contour OP_{1dB} [dBm] at V_{CE} = 5 V, I_C = 90 mA, f = 0.9 GHz, Z_l = Z_{opt}

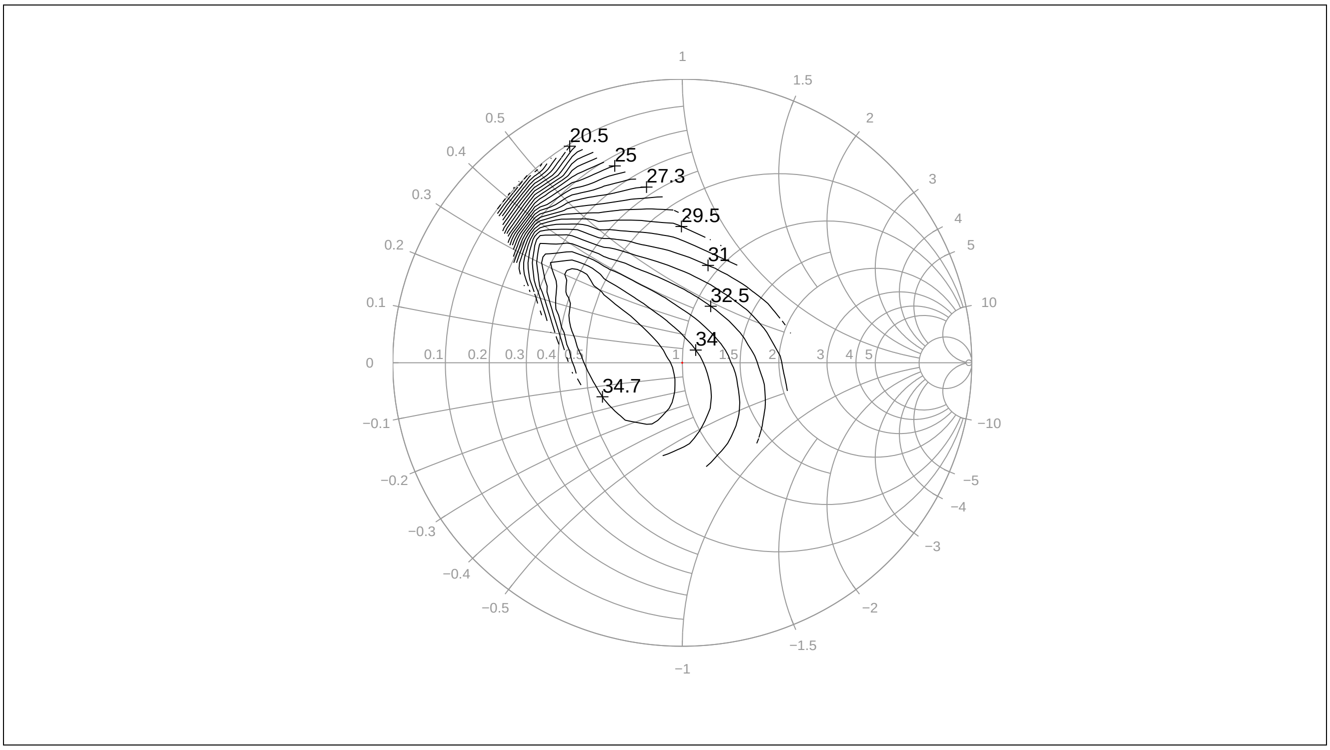


Figure 7-17 Load Pull Contour *OIP*3 [dBm] at V_{CE} = 5 V, I_C = 90 mA, *f* = 0.9 GHz, $Z_l = Z_{opt}$

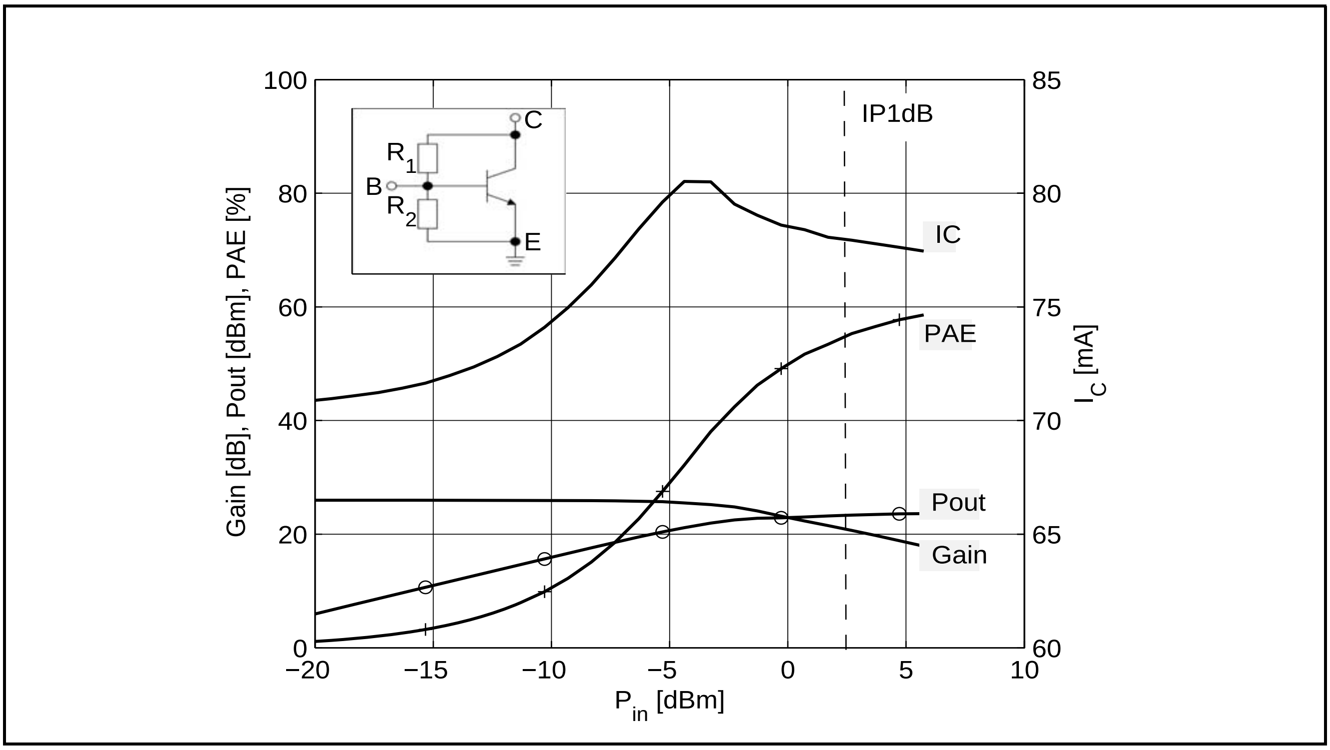


Figure 7-18 P_{out}, Gain, I_C, PAE vs. P_{in} at V_{CE} = 5 V, *f* = 0.9 GHz, $Z_l = Z_{opt}$, R_1 = 270 Ω, R_2 = 8 kΩ

Note: The curves shown in this chapter have been generated using typical devices but shall not be understood as a guarantee that all devices have identical characteristic curves. T_A = 25 °C.

8 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 BFP780 SPICE GP model in the internet in the section Development Support / Simulation Data, from where you can download the circuit simulation data 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 BFP780 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 parameters (including NFmin, optimum source impedance and equivalent noise resistance) and intermodulation have been extracted.

9 Package Information SOT343-4-2

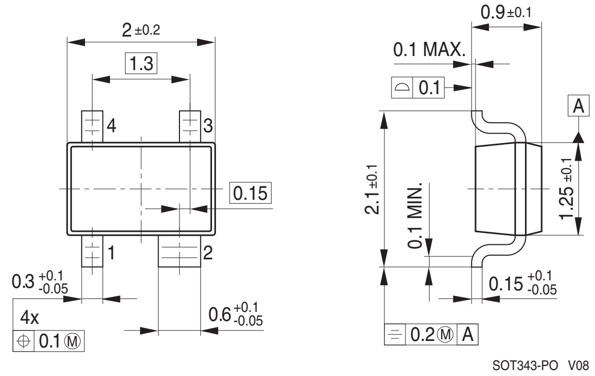


Figure 9-1 Package Outline

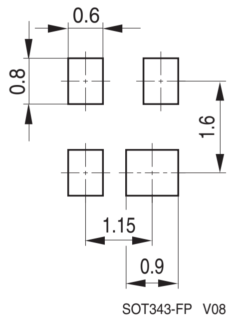


Figure 9-2 Package Footprint

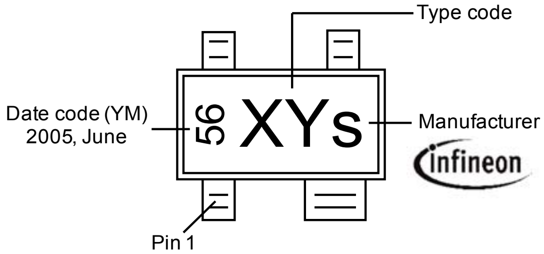


Figure 9-3 Marking Example (Marking BFP780: R1s)

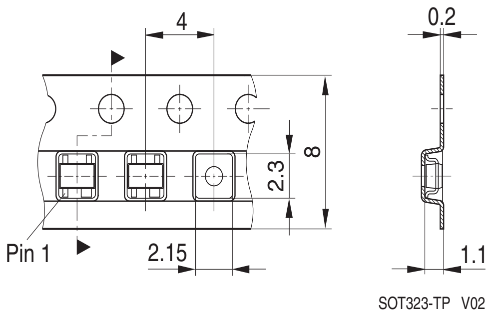


Figure 9-4 Tape Dimensions

w w w . i n f i n e o n . c o m

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Стандарт Электрон Связь

Мы молодая и активно развивающаяся компания в области поставок электронных компонентов. Мы поставляем электронные компоненты отечественного и импортного производства напрямую от производителей и с крупнейших складов мира.

Благодаря сотрудничеству с мировыми поставщиками мы осуществляем комплексные и плановые поставки широчайшего спектра электронных компонентов.

Собственная эффективная логистика и склад в обеспечивает надежную поставку продукции в точно указанные сроки по всей России.

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Минимальные сроки поставки, гибкие цены, неограниченный ассортимент и индивидуальный подход к клиентам являются основой для выстраивания долгосрочного и эффективного сотрудничества с предприятиями радиоэлектронной промышленности, предприятиями ВПК и научно-исследовательскими институтами России.

С нами вы становитесь еще успешнее!

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