BFQ790

High linearity RF medium power transistor

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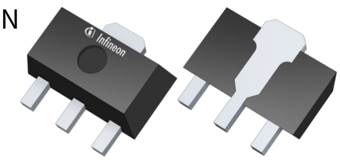
Product description

The BFQ790 is a single stage high linearity and high gain driver amplifier based on NPN silicon germanium technology.



Feature list

- OIP_3 = 38.5 dBm at 900 MHz, 5 V, 250 mA
- OP_{1dB} = 27 dBm at 900 MHz, 5 V, 250 mA corresponding to 40% collector efficiency
- High gain G_{ms} = 23 dB at 900 MHz, 5 V, 250 mA
- High maximum RF input power $P_{RFin,max}$ = 18 dBm

Product validation

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

Potential applications

- Commercial and industrial wireless infrastructure
- ISM band medium power amplifiers and drivers
- Automated test equipment
- UHF television, CATV and DBS

Device information

Table 1 Part information

Product name / Ordering code	Package	Pin configuration			Marking	Pieces / Reel
BFQ790 / BFQ790H6327XTSA1	SOT89	1 = B	2 = E	3 = C	R3	1000

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

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1 Absolute maximum ratings

Table 2 Absolute maximum ratings at T_A = 25 °C (unless otherwise specified)

Parameter	Symbol	Values		Unit	Note or 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}	–	18	V	–
Instantaneous total base emitter reverse voltage	v_{BE}	-2	–	V	DC + RF swing
Instantaneous total collector current	i_C	–	600	mA	DC + RF swing
DC collector current	I_C	–	300	mA	–
DC base current	I_B	–	10	mA	–
RF input power	P_{RFin}	–	18	dBm	In- and output matched
Mismatch at output	$VSWR$	–	10:1		In compression, over all phase angles
ESD stress pulse	V_{ESD}	-500	500	V	HBM, all pins, acc. to ANSI / ESDA / JEDEC JS-001-2012
Dissipated power	P_{diss}	–	1500	mW	$T_S \leq$ 112.5 °C [1], regard derating curve in ***Figure 1***.
Junction temperature	T_J	–	150	°C	–
Operating case temperature	T_A	-40	105 [2]	°C	–
Storage temperature	T_{Stg}	-55	150	°C	–

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 component.***

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 $T_{J,max}$.

2 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 it may increases failure rate and reduces lifetime. For further information refer to the quality report available on the BFQ790 internet page.

Table 3 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	250	1250	500 (27)	40	750	45	110
Final stage	55	200	1000	250 (24)	25	750	45	110
High T_A	85	120	600	50 (17)	8.5	550	20	110
Maximum T_A	105	50	250	100 (20)	40	150	30	110
Linear	55	150	750	50 (17)	7	700	50	110
Very linear	55	250	1250	50 (17)	4	1200	20	110

1 Is the operating case temperature respectively of the heat sink.

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 25 K/W for BFQ790, see **Chapter 3**.

3 Thermal characteristics

Table 4 Thermal resistance

Parameter	Symbol	Values			Unit	Note or test condition
		Min.	Typ.	Max.		
Junction - soldering point	R_{thJS}	–	25	–	K/W	–

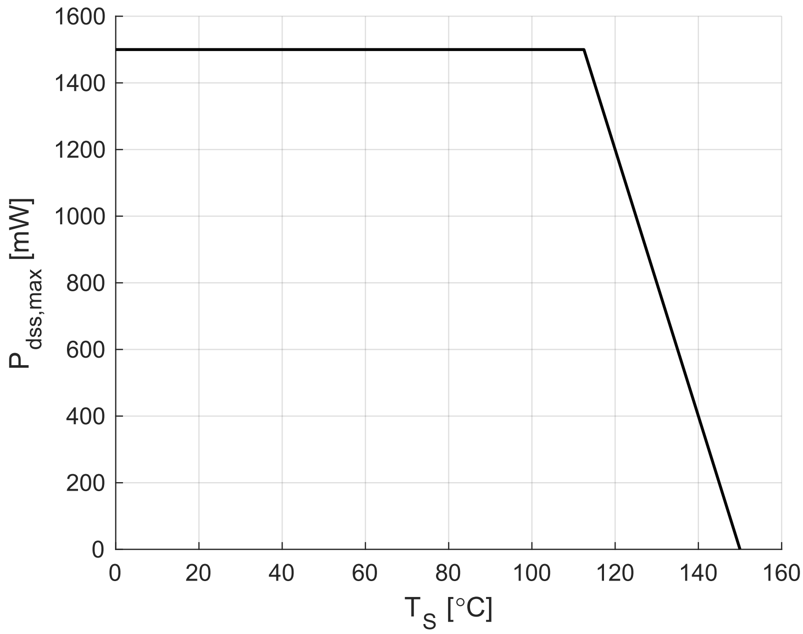

Figure 1 Absolute maximum power dissipation $P_{diss,max}$ = f(T_S)

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 $T_{J,max} = T_S + P_{diss,max} * R_{thJS}$.*

4 Electrical performance in test fixture

4.1 DC parameter table

Table 5 DC characteristics at $T_A = 25\ °C$

Parameter	Symbol	Values			Unit	Note or test condition
		Min.	Typ.	Max.		
Collector emitter breakdown voltage	$V_{(BR)CEO}$	6.1	6.7	–	V	$I_C = 1$ mA, open base
Collector emitter leakage current	I_{CES}	– –	1 0.1	40 [1] 3	nA µA	$V_{CE} = 8$ V, $V_{BE} = 0$ V $V_{CE} = 18$ V, $V_{BE} = 0$ V, E-B short circuited
Collector base leakage current	I_{CBO}	–	1	40 [1]	nA	$V_{CB} = 8$ V, $I_E = 0$, open emitter
Emitter base leakage current	I_{EBO}	–	1	40 [1]	µA	$V_{EB} = 0.5$ V, $I_C = 0$, open collector
DC current gain	h_{FE}	60	120	180		$V_{CE} = 5$ V, $I_C = 250$ mA, pulse measured [2]

4.2 AC parameter tables

Table 6 General AC characteristics at $T_A = 25\ °C$

Parameter	Symbol	Values			Unit	Note or test condition
		Min.	Typ.	Max.		
Transition frequency	f_T	–	20	–	GHz	$V_{CE} = 5$ V, $I_C = 250$ mA, $f = 0.5$ GHz
Collector base capacitance	C_{CB}	–	1.1	–	pF	$V_{CB} = 5$ V, $V_{BE} = 0$ V, $f = 1$ MHz, emitter grounded
Collector emitter capacitance	C_{CE}	–	2.2	–	pF	$V_{CE} = 5$ V, $V_{BE} = 0$ V, $f = 1$ MHz, base grounded
Emitter base capacitance	C_{EB}	–	9.4	–	pF	$V_{EB} = 0.5$ V, $V_{CB} = 0$ V, $f = 1$ MHz, collector grounded

1 Upper spec value not limited by the device but by the short cycle time of the 100% test.
2 Pulse width is 1 ms, duty cycle 10%. 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 to *Table 3*. Hence the h_{FE} specified in this datasheet must not be the same as in the application. It is highly recommended to apply circuit design techniques to make the collector current I_C independent on the h_{FE} production variation and temperature effects.

Electrical performance in test fixture

Measurement setup for the AC characteristics shown in ***Table 7*** to ***Table 10*** is a test fixture with Bias-T's and tuners to adjust the source and load impedance in a 50 Ω system, T_A = 25 °C.

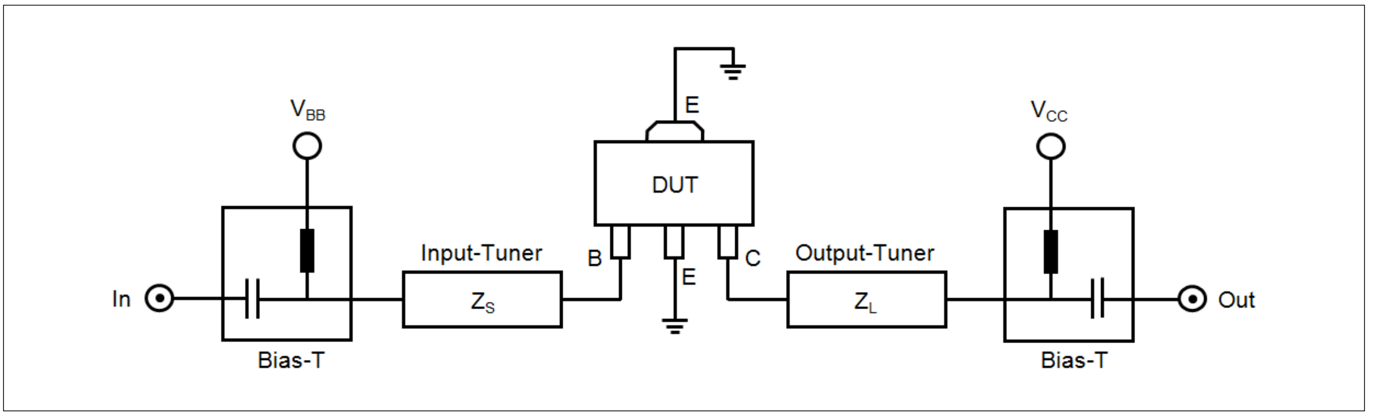

Figure 2 **BFQ790 testing circuit**

Table 7 **AC characteristics, V_{CE} = 5 V, f = 0.9 GHz**

Parameter	Symbol	Values			Unit	Note or test condition
		Min.	Typ.	Max.		
Power gain					dB	
Maximum power gain	G_{ms}	–	23	–		I_C = 250 mA
Transducer gain	$\|S_{21}\|^2$	–	13	–		
Minimum noise figure					dB	
Minimum noise figure	NF_{min}	–	2.5	–		$Z_S = Z_{S,opt}$, I_C = 70 mA
Linearity					dBm	
1 dB compression point at output	OP_{1dB}	–	27	–		$Z_L = Z_{Lopt}$, I_C = 250 mA
3rd order intercept point at output	OIP_3	–	38.5	–		

Table 8 **AC characteristics, V_{CE} = 5 V, f = 1.8 GHz**

Parameter	Symbol	Values			Unit	Note or test condition
		Min.	Typ.	Max.		
Power gain					dB	
Maximum power gain	G_{ma}	–	18.5	–		I_C = 250 mA
Transducer gain	$\|S_{21}\|^2$	–	7.5	–		
Minimum noise figure					dB	
Minimum noise figure	NF_{min}	–	2.6	–		$Z_S = Z_{S,opt}$, I_C = 70 mA
Linearity					dBm	
1 dB compression point at output	OP_{1dB}	–	27	–		$Z_L = Z_{Lopt}$, I_C = 250 mA
3rd order intercept point at output	OIP_3	–	38.5	–		

Electrical performance in test fixture

Table 9 AC characteristics, V_{CE} = 5 V, f = 2.6 GHz

Parameter	Symbol	Values			Unit	Note or test condition
		Min.	Typ.	Max.		
Power gain					dB	
Maximum power gain	G_{ma}	–	16	–		I_C = 250 mA
Transducer gain	$\|S_{21}\|^2$	–	5.5	–		
Minimum noise figure					dB	
Minimum noise figure	NF_{min}	–	3	–		$Z_S = Z_{S,opt}$, I_C = 70 mA
Linearity					dBm	
1 dB compression point at output	OP_{1dB}	–	27	–		$Z_L = Z_{Lopt}$, I_C = 250 mA
3rd order intercept point at output	OIP_3	–	38.5	–		

Table 10 AC characteristics, V_{CE} = 5 V, f = 3.5 GHz

Parameter	Symbol	Values			Unit	Note or test condition
		Min.	Typ.	Max.		
Power gain					dB	
Maximum power gain	G_{ma}	–	13	–		I_C = 250 mA
Transducer gain	$\|S_{21}\|^2$	–	3	–		
Minimum noise figure					dB	
Minimum noise figure	NF_{min}	–	3.4	–		$Z_S = Z_{S,opt}$, I_C = 70 mA
Linearity					dBm	
1 dB compression point at output	OP_{1dB}	–	27	–		$Z_L = Z_{Lopt}$, I_C = 250 mA
3rd order intercept point at output	OIP_3	–	38.5	–		

4.3 Characteristic DC diagrams

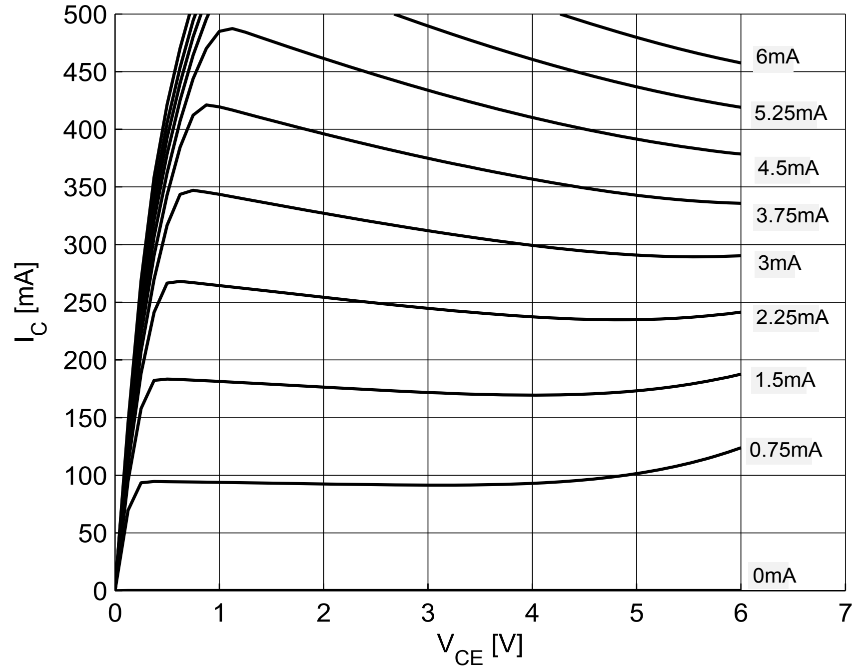

Figure 3 **Collector current vs. collector emitter voltage I_C = f(V_{CE}), I_B = parameter**

Note: *Refer to absolute maximum ratings for I_C, V_{CE} and P_{diss}.*

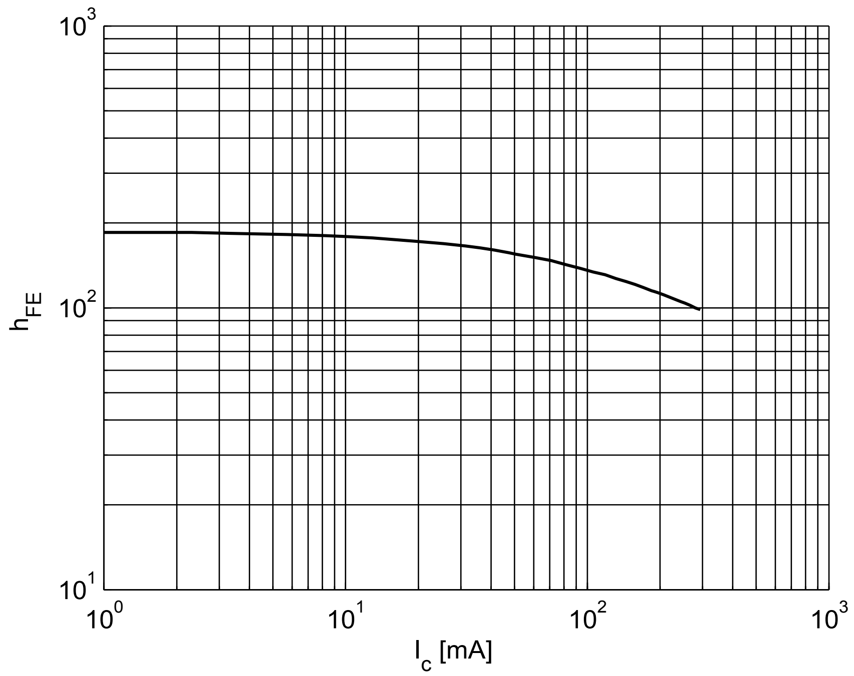

Figure 4 **DC Current gain h_{FE} = f(I_C), V_{CE} = 5 V**

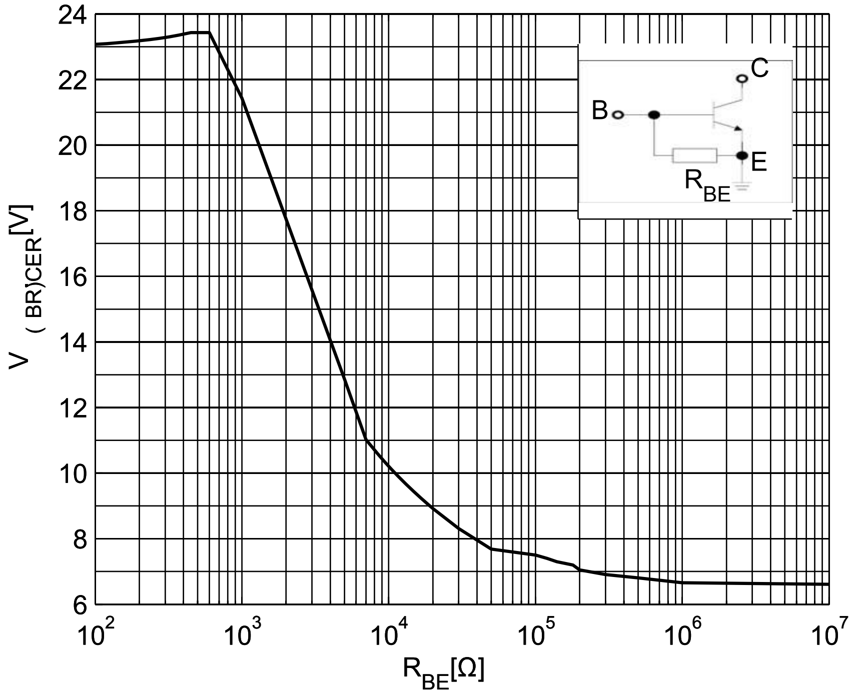

Figure 5 **Collector emitter breakdown voltage $V_{(BR)CER}$ = f(R_{BE})**

Note: *The above figure shows the collector-emitter breakdown voltage $V_{(BR)CER}$ with a resistor R_{BE} between base and emitter. Only for very high R_{BE} values ("open base") the breakdown voltage $V_{(BR)CER}$ is as low as $V_{(BR)CEO}$ (here 6.6 V). With decreasing R_{BE} values $V_{(BR)CER}$ increases, e.g. at R_{BE} = 10 kΩ to $V_{(BR)CEO}$ = 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 $V_{(BR)CEO}$, without clipping. Due to this effect the transistor can be biased at V_{CE} = 5 V and still high RF output powers achieved, see the OP_{1dB} values reported in* ***Chapter 4.2***.

4.4 Characteristic AC diagrams

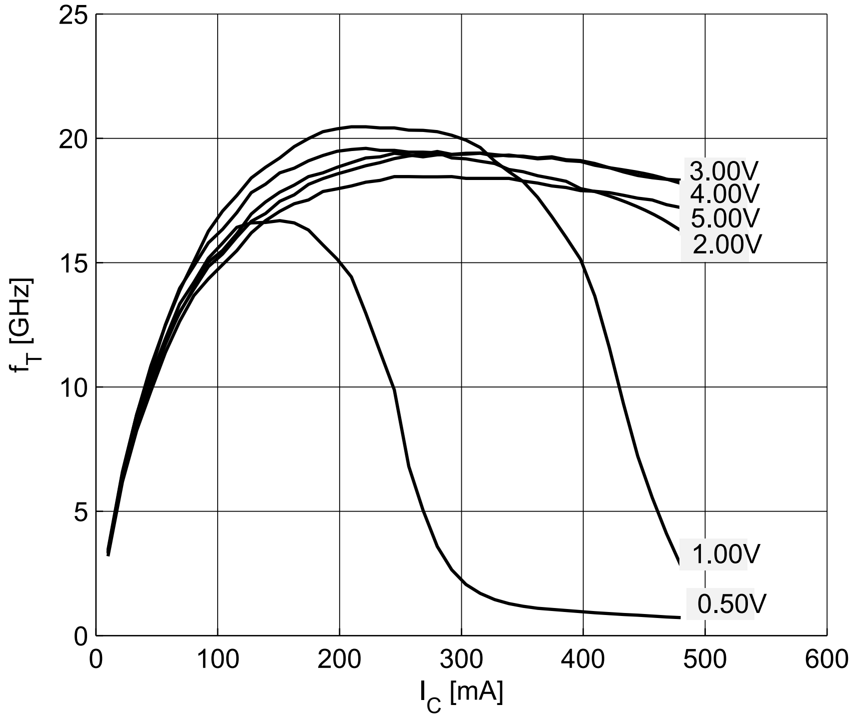

Figure 6 **Transition frequency $f_T = f(I_C)$, f = 1 GHz, V_{CE} = parameter**

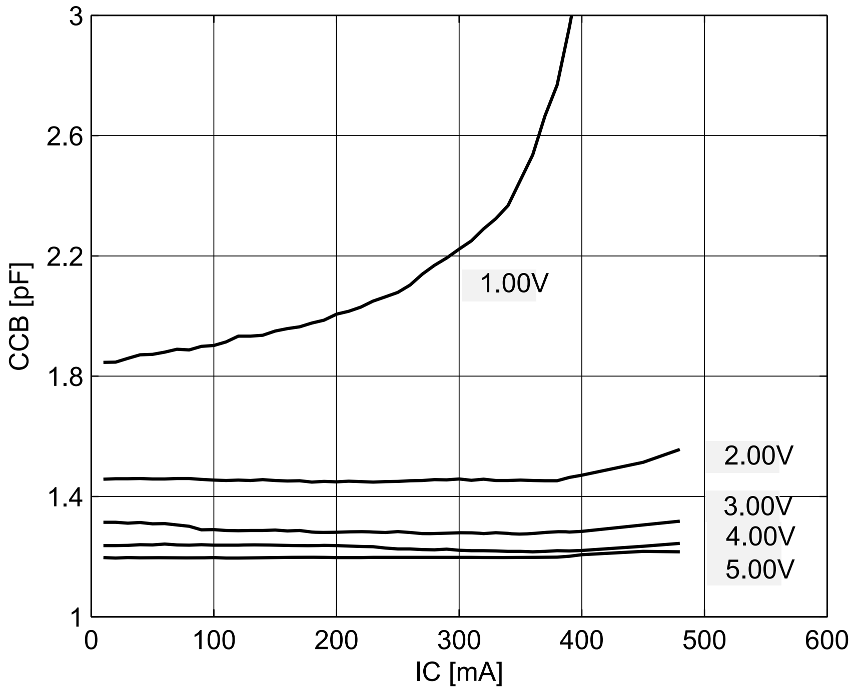

Figure 7 **Collector base capacitance $C_{CB} = f(I_C)$, f = 30 MHz, V_{CB} = parameter**

Electrical performance in test fixture

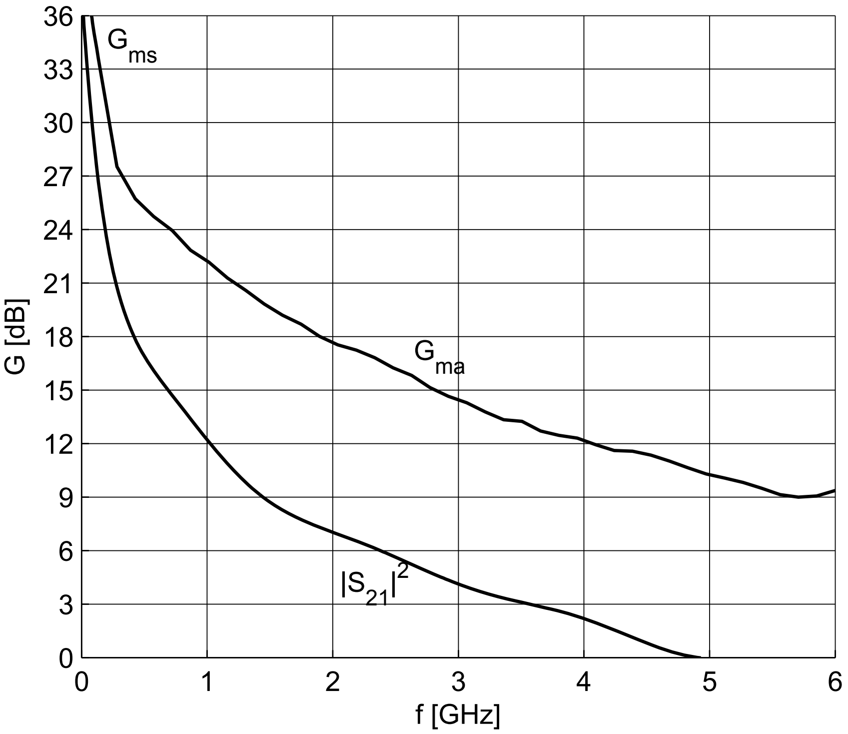

Figure 8 **Gain G_{ms}, G_{ma}, $|S_{21}|^2$ = f(f), V_{CE} = 5 V, I_C = 250 mA**

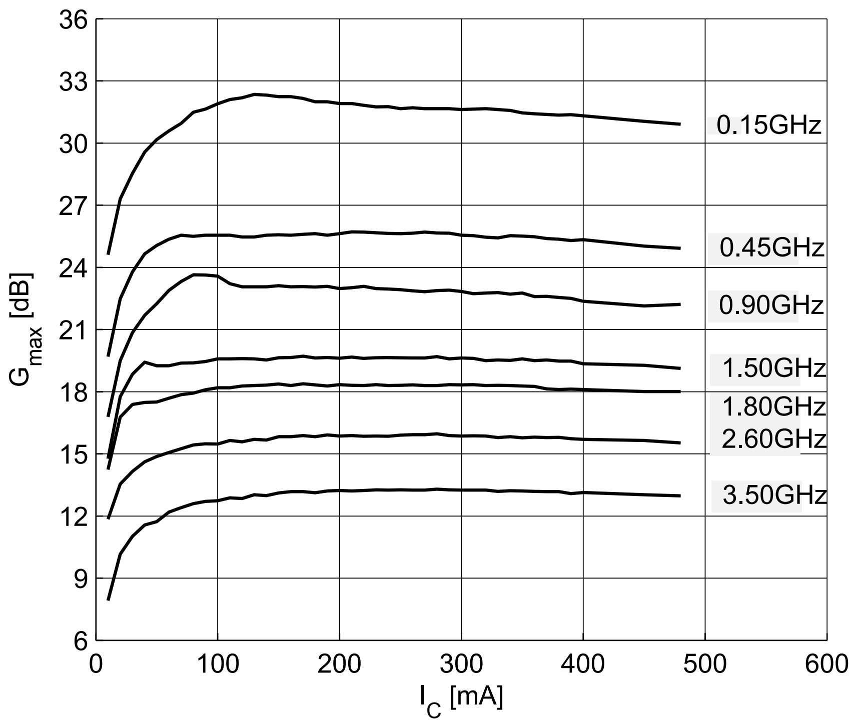

Figure 9 **Maximum power gain G_{max} = f(I_C), V_{CE} = 5 V, f = parameter**

Electrical performance in test fixture

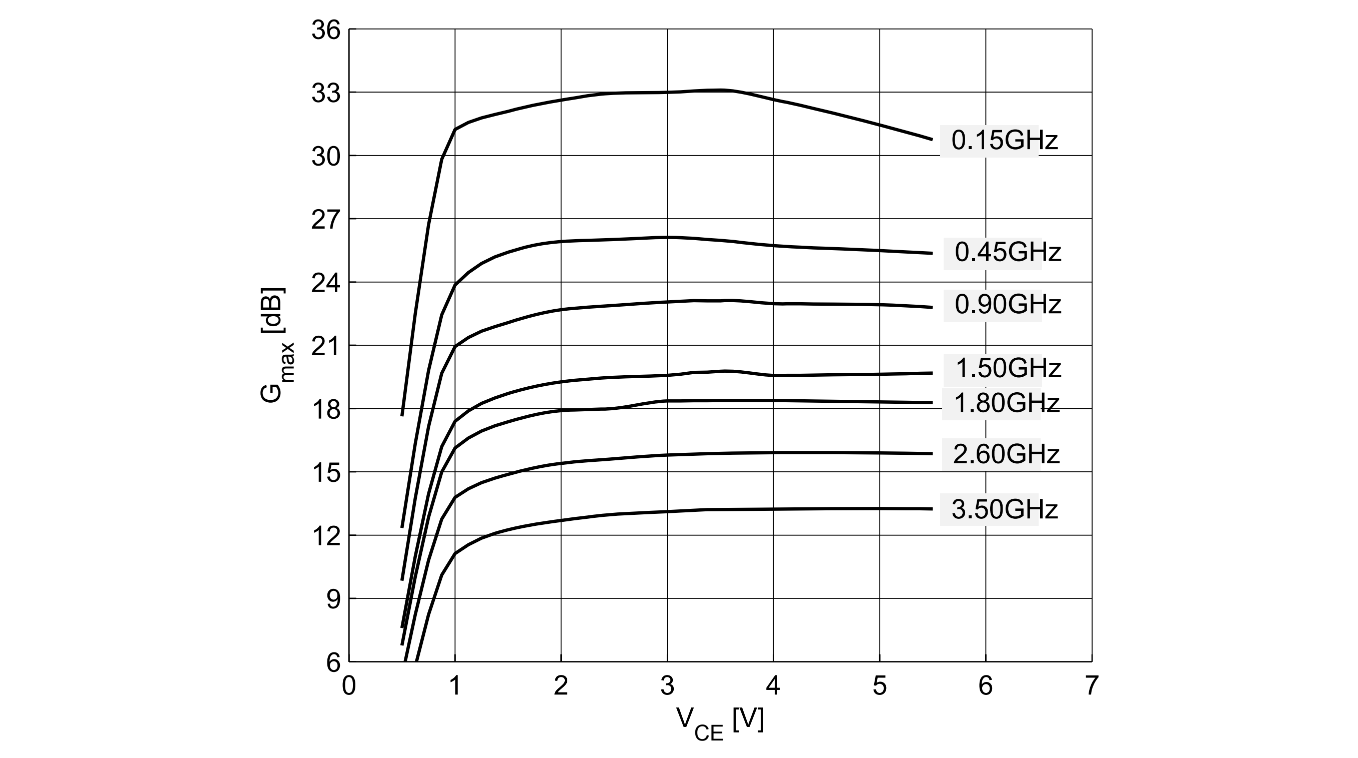

Figure 10 **Maximum power gain G_{max} = f(V_{CE}), I_C = 250 mA, f = parameter**

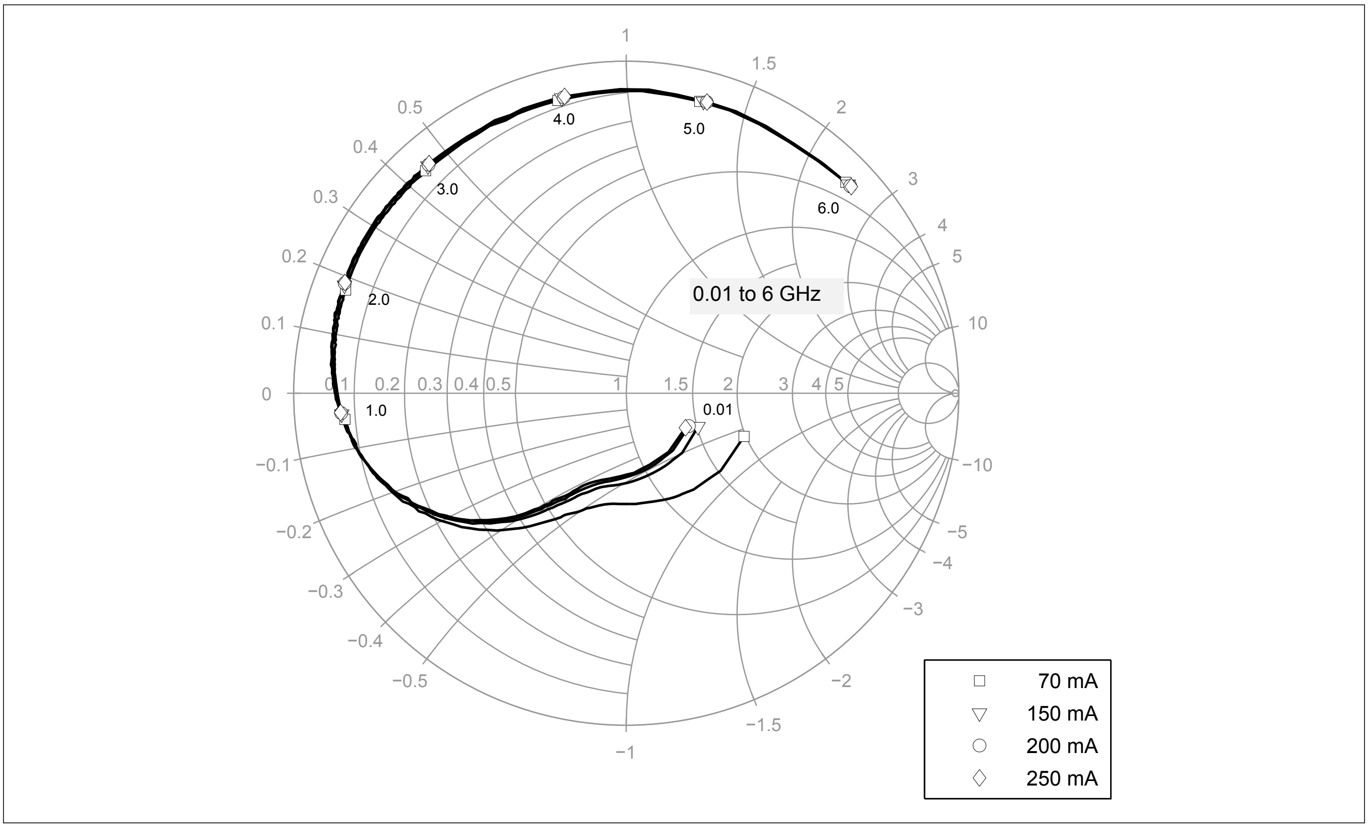

Figure 11 **Input reflection coefficient S_{11} = f(f), V_{CE} = 5 V, I_C = parameter**

Electrical performance in test fixture

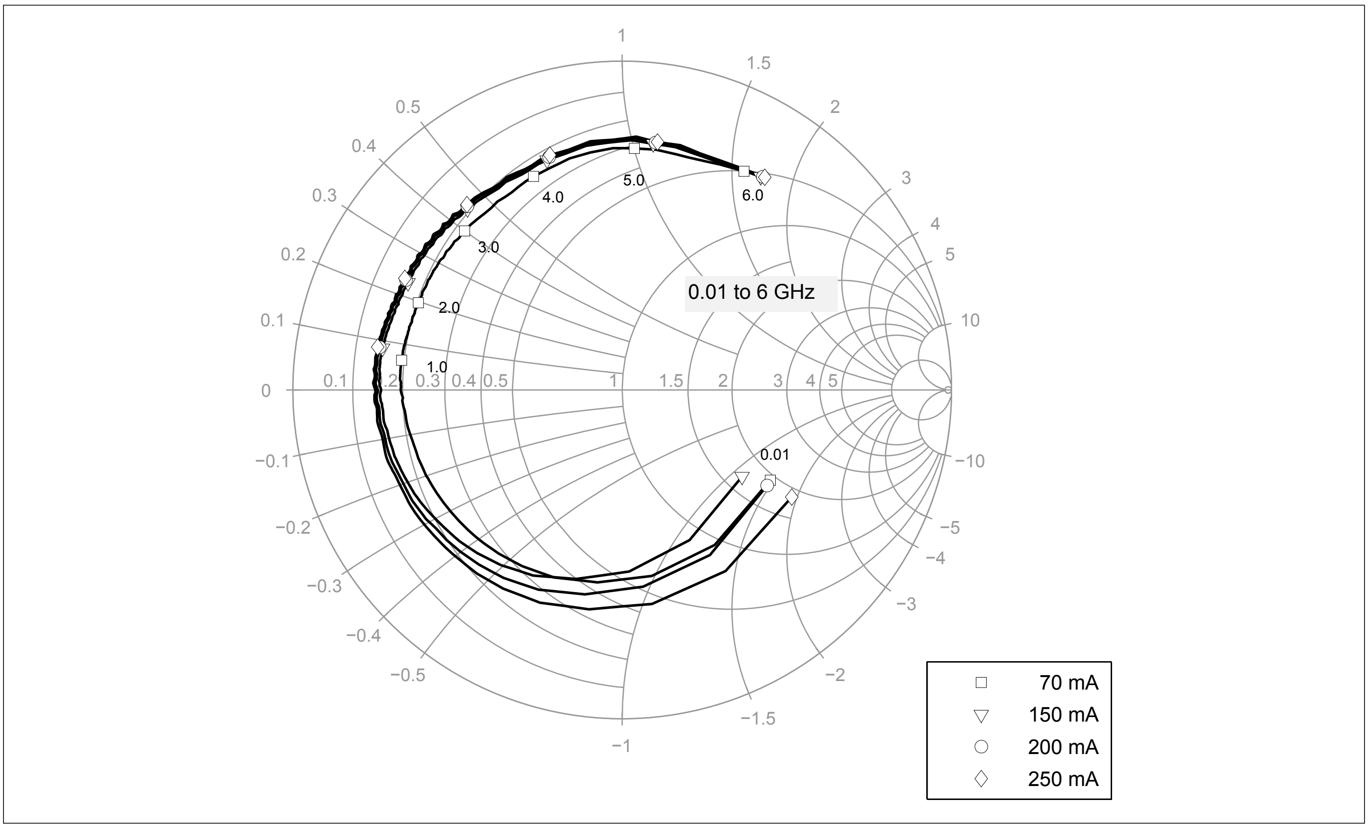

Figure 12 **Output reflection coefficient S_{22} = f(f), V_{CE} = 5 V, I_C = parameter**

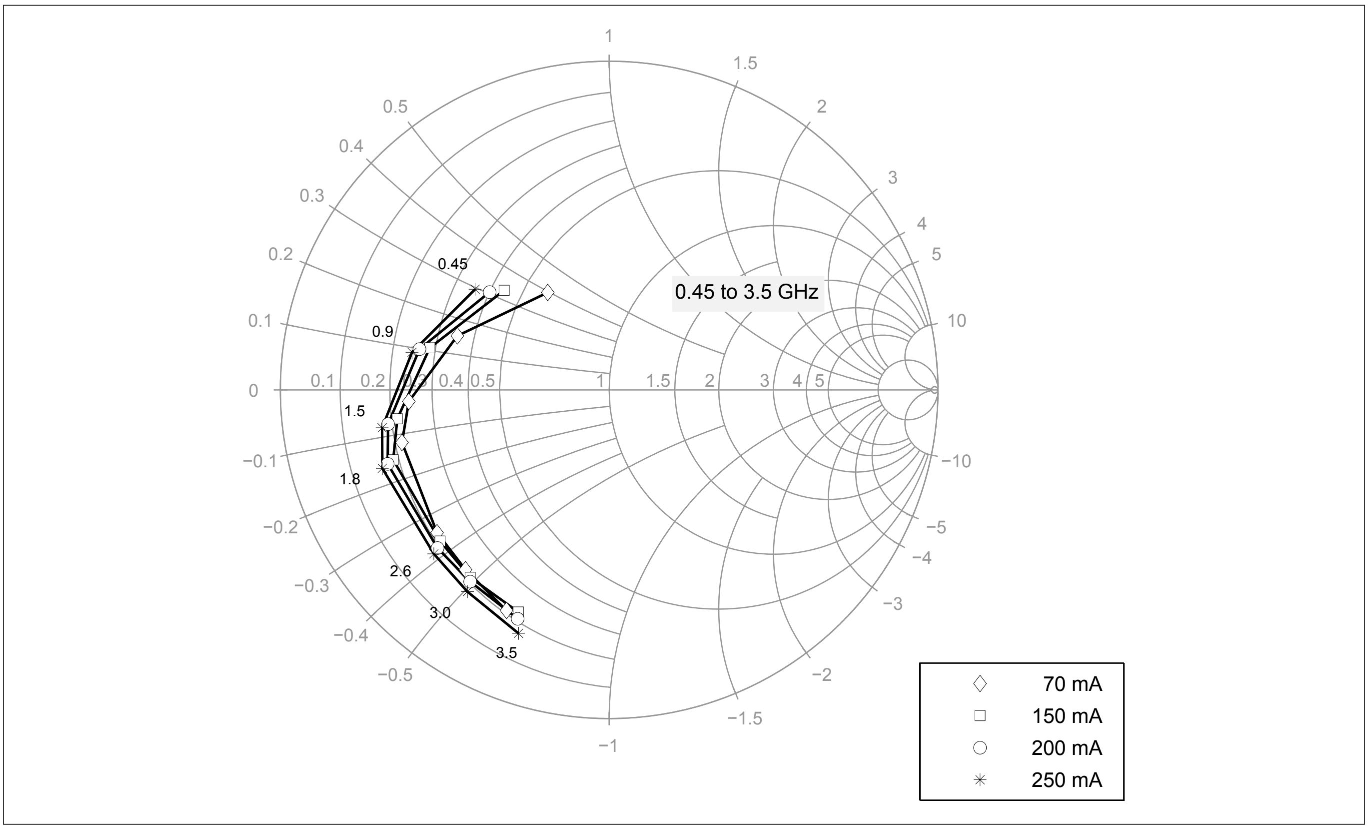

Figure 13 **Source impedance for minimum noise figure $Z_{S,opt}$ = f(f), V_{CE} = 5 V, I_C = parameter**

Electrical performance in test fixture

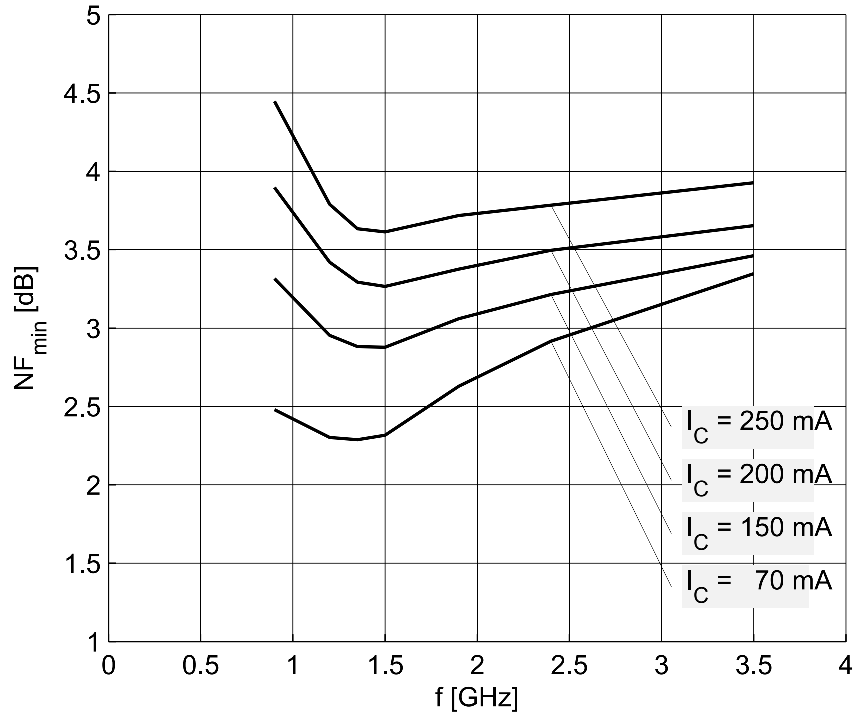

Figure 14 **Noise figure NF_{min} = f(f), V_{CE} = 5 V, $Z_S = Z_{S,opt}$, I_C = parameter**

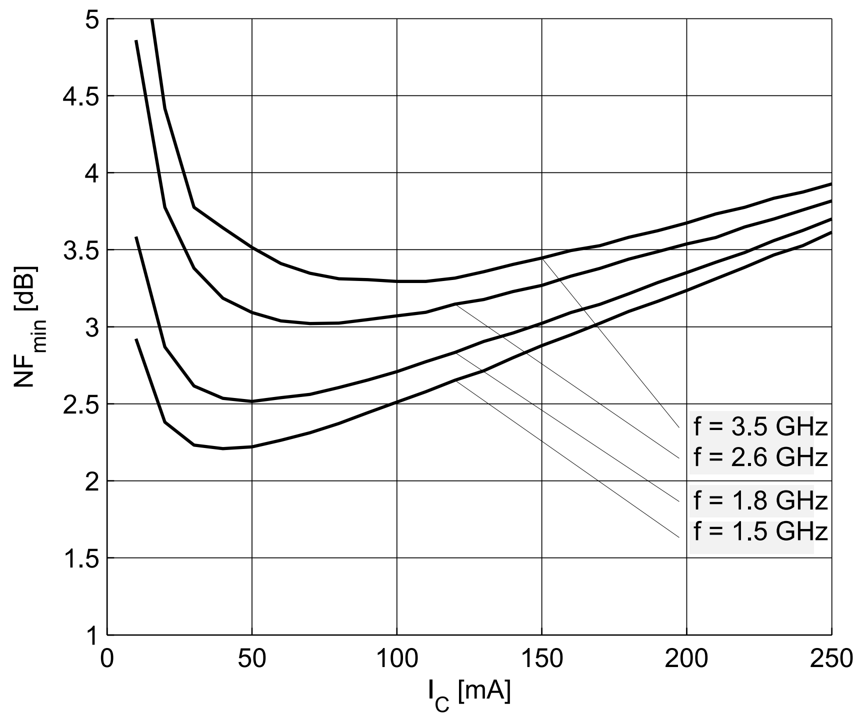

Figure 15 **Noise figure NF_{min} = f(I_C), V_{CE} = 5 V, $Z_S = Z_{S,opt}$, f = parameter**

Electrical performance in test fixture

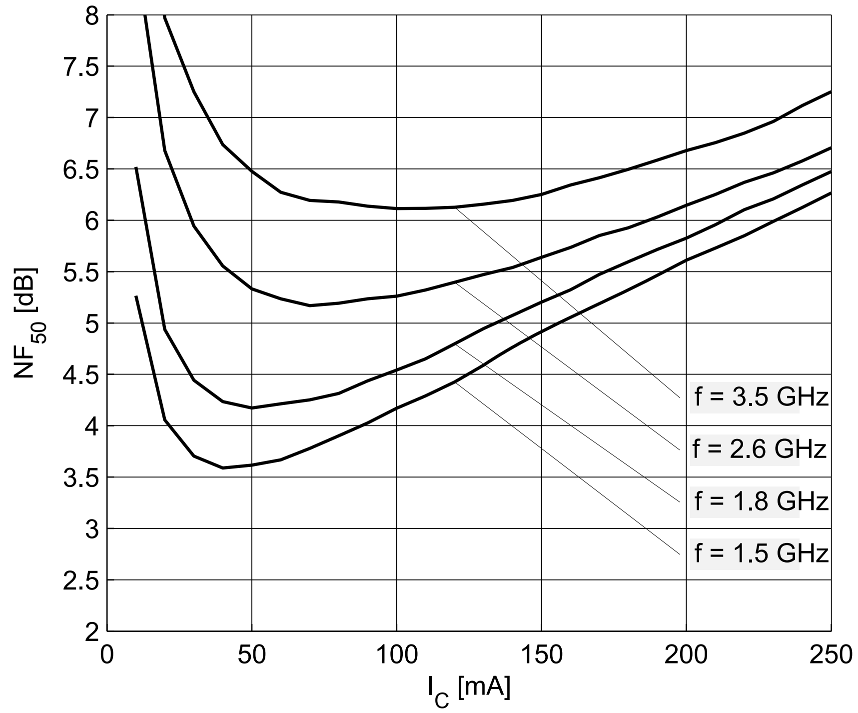

Figure 16 **Noise figure NF_{50} = f(I_C), V_{CE} = 5 V, Z_S = 50 Ω, f = parameter**

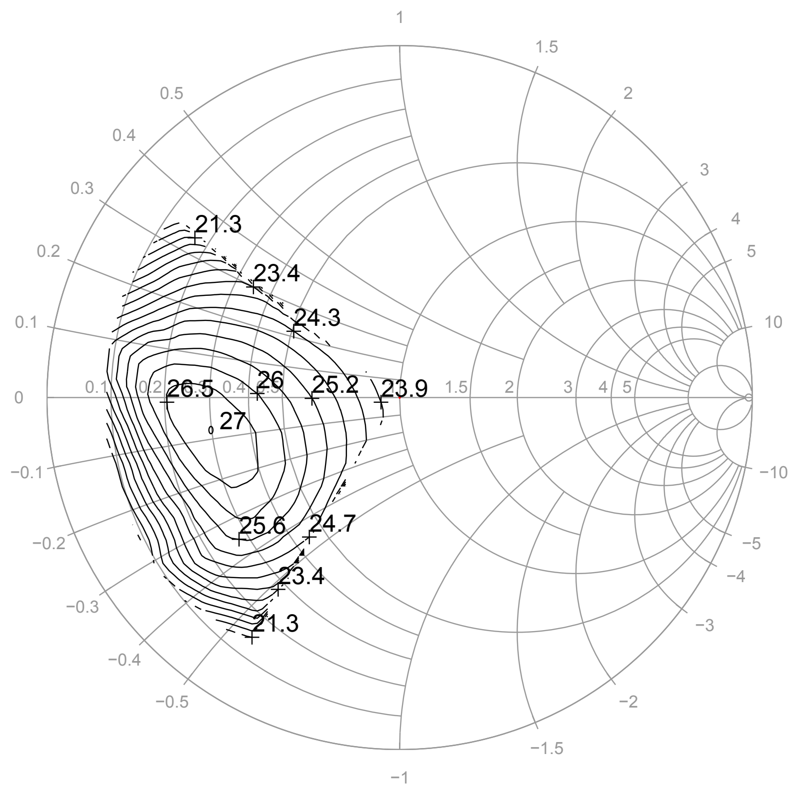

Figure 17 **Load pull contour OP_{1dB} [dBm], V_{CE} = 5 V, I_C = 250 mA, f = 900 MHz**

Electrical performance in test fixture

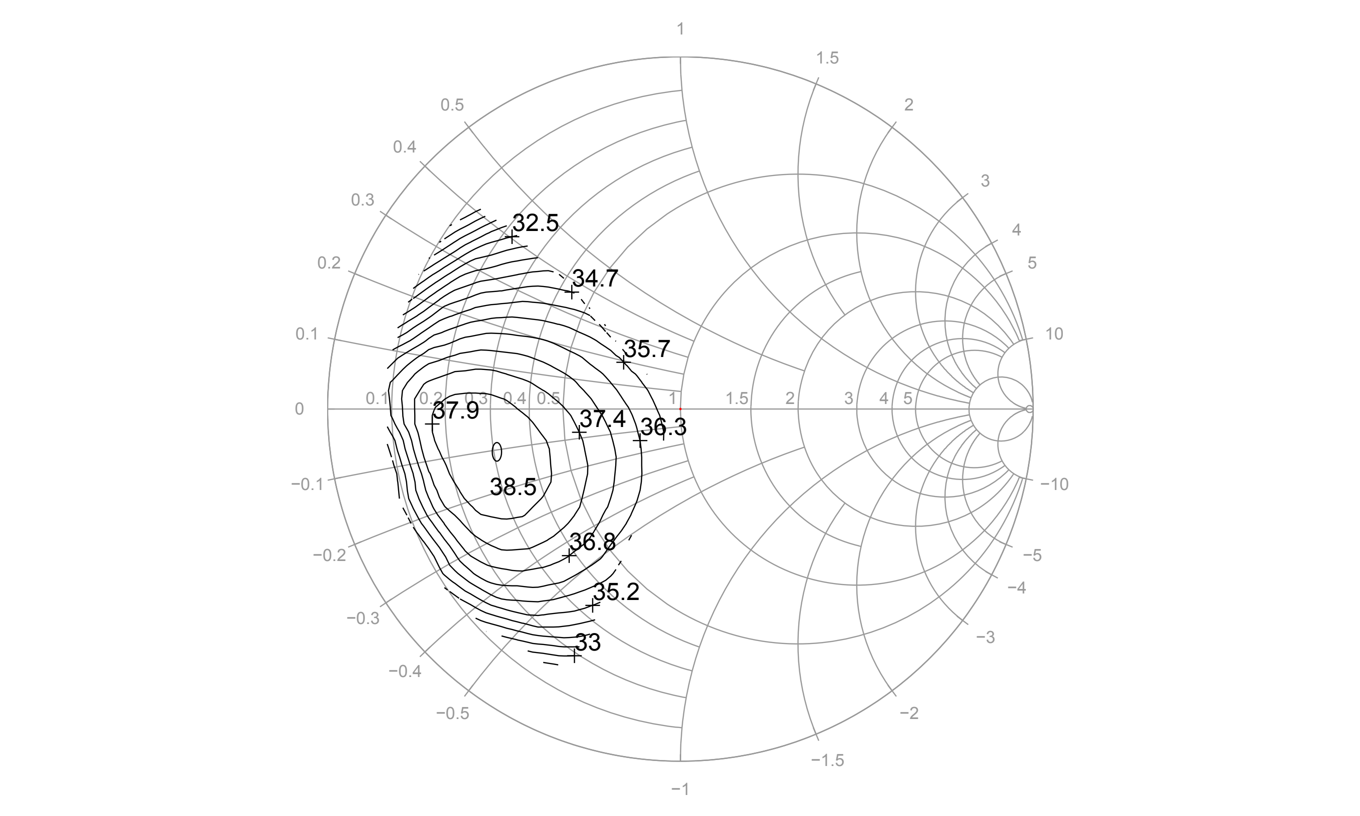

Figure 18 **Load pull contour OIP_3 [dBm], V_{CE} = 5 V, I_C = 250 mA, f = 900 MHz**

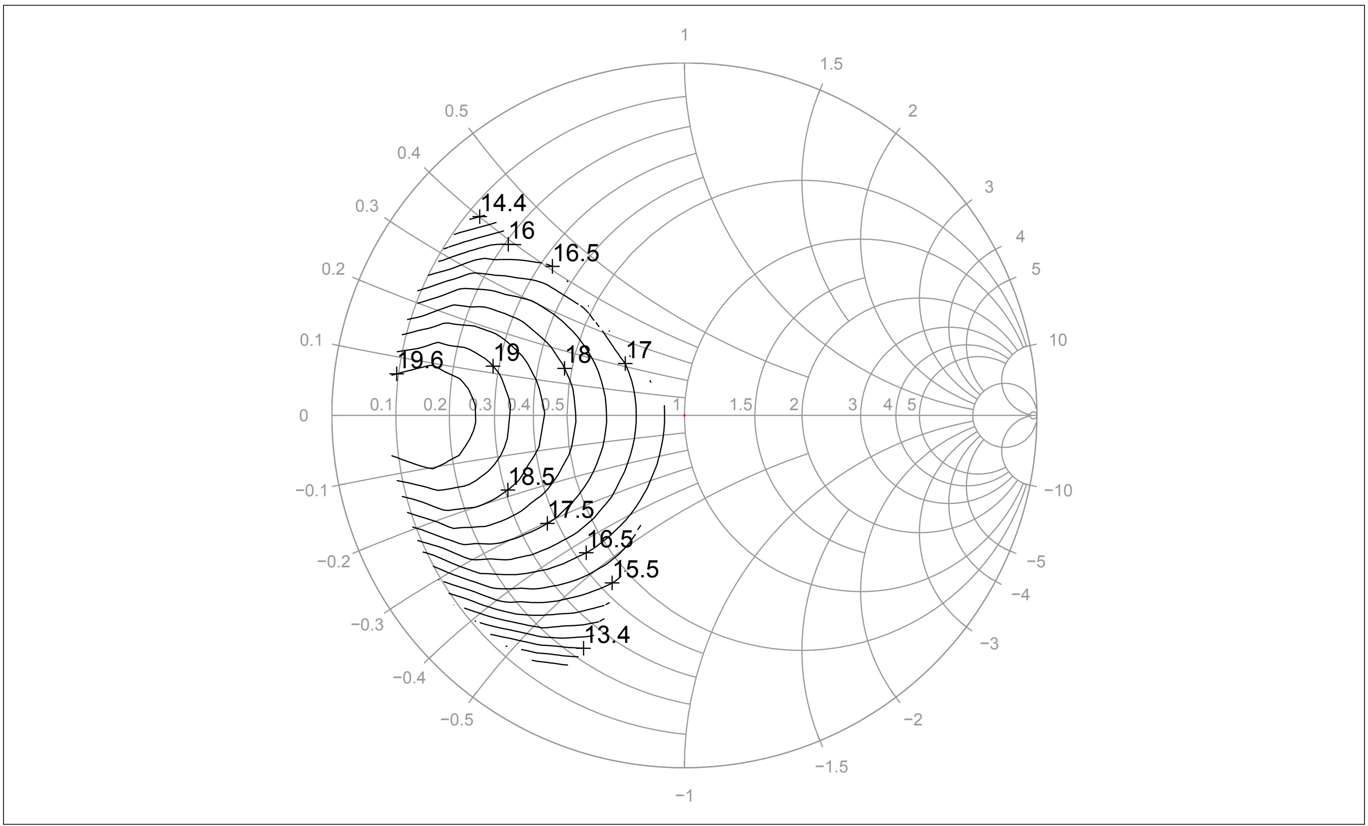

Figure 19 **Load pull contour gain G [dB], V_{CE} = 5 V, I_C = 250 mA, f = 900 MHz**

Electrical performance in test fixture

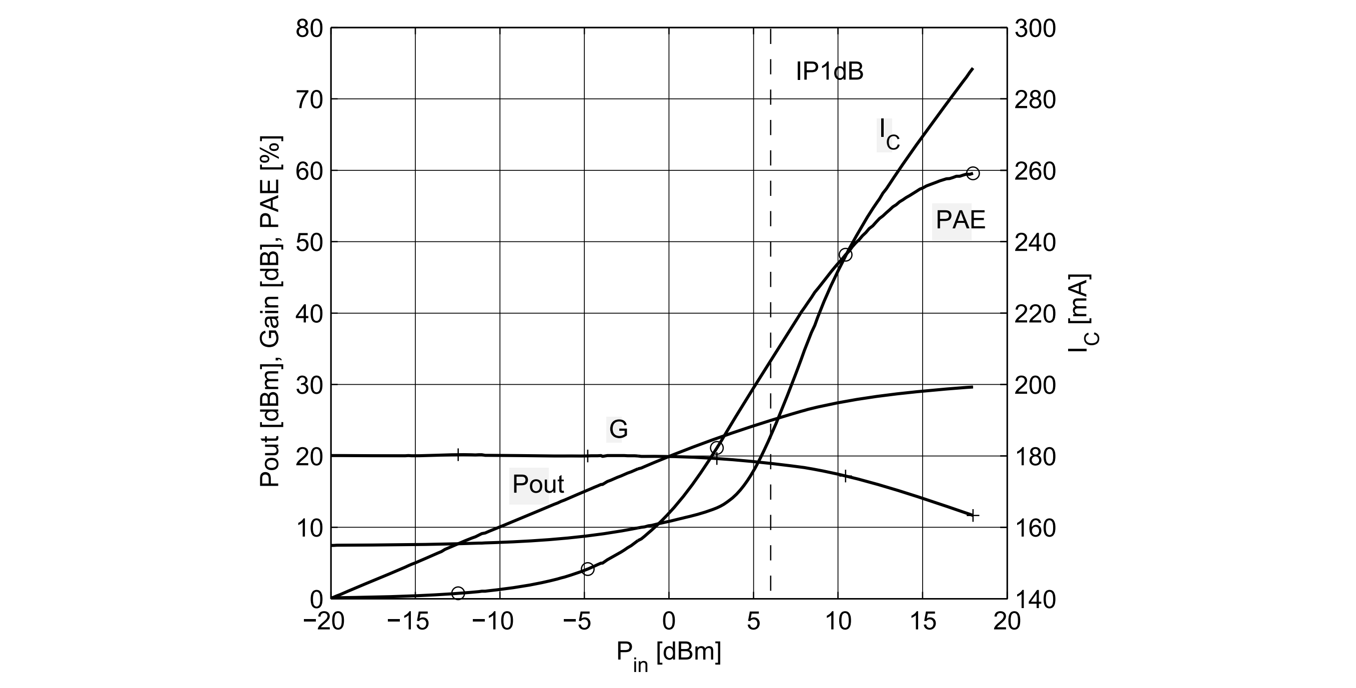

Figure 20 P_{out}, *Gain*, I_C, *PAE* = f(P_{in}), V_{CE} = 5 V, I_{Cq} = 155 mA, *f* = 900 MHz, $Z_L = Z_{L,opt}$ (P_{out})

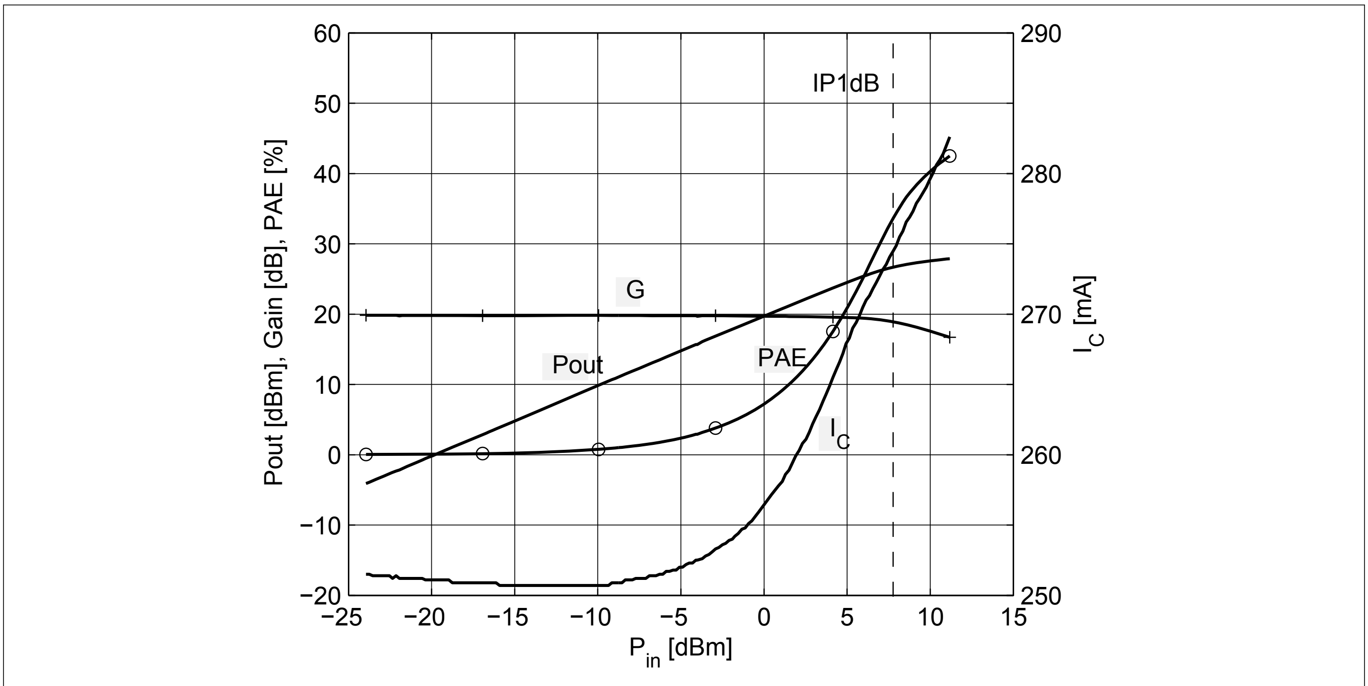

Figure 21 P_{out}, *Gain*, I_C, *PAE* = f(P_{in}), V_{CE} = 5 V, I_{Cq} = 250 mA, *f* = 900 MHz, $Z_L = Z_{L,opt}$ (P_{out})

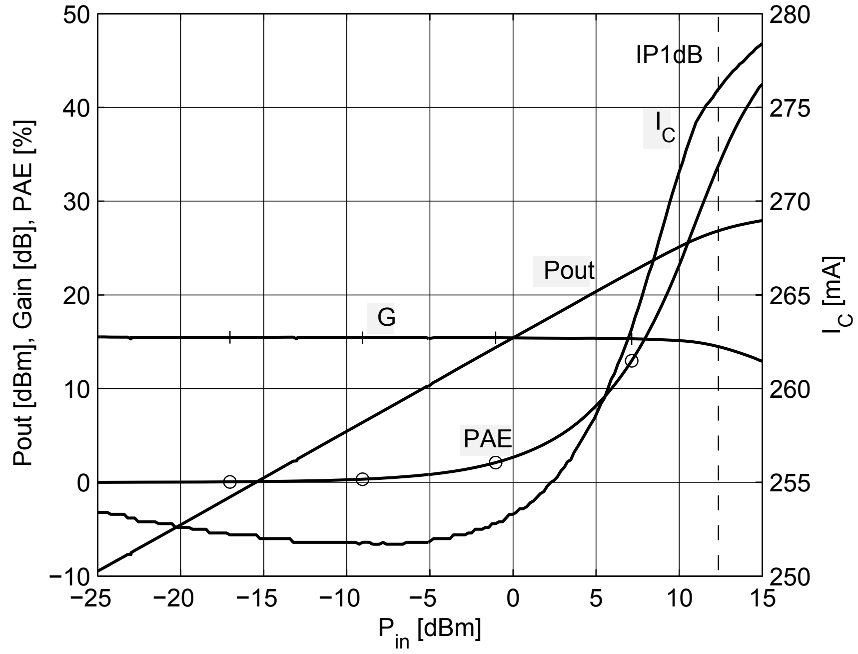

Figure 22 P_{out}, *Gain*, I_C, *PAE* = f(P_{in}), V_{CE} = 5 V, I_{Cq} = 250 mA, *f* = 2.6 GHz, $Z_L = Z_{L,opt}$ (P_{out})

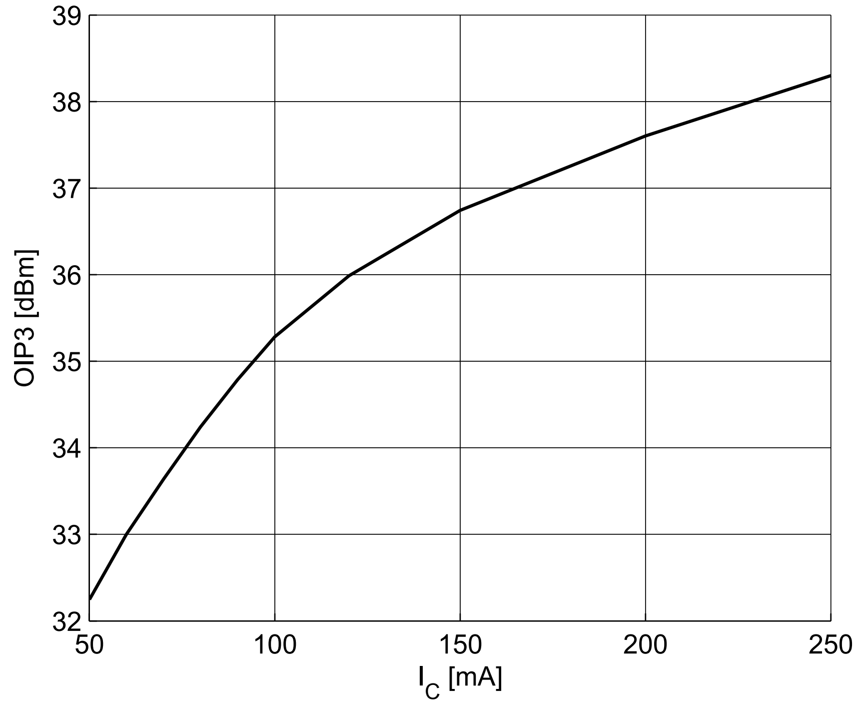

Figure 23 OIP_3 = f(I_C), V_{CE} = 5 V, *f* = 900 MHz, $Z_L = Z_{L,opt}$ (P_{out})

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.

5 Package information SOT89

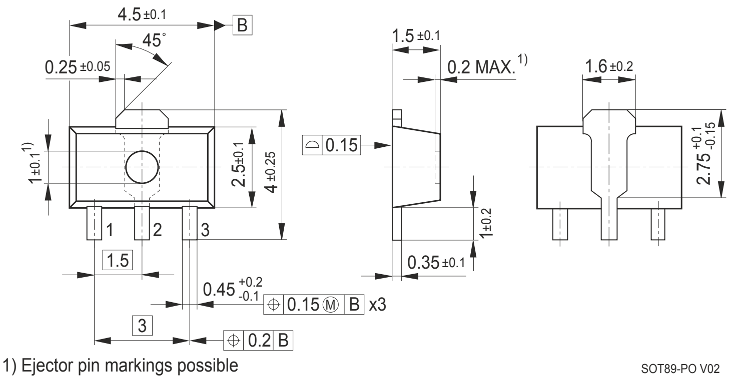

Figure 24 Package outline (dimensions in mm)

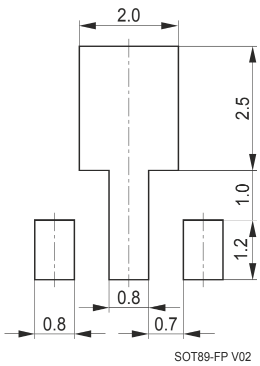

Figure 25 Foot print (dimension in mm)

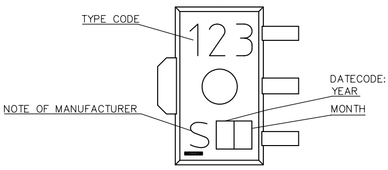

Figure 26 Marking layout example

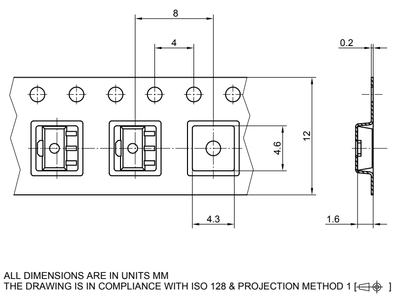

Figure 27 Tape information

Revision history

Document version	Date of release	Description of changes
3.0	2018-09-26	New datasheet layout.

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