

# BGB741L7ESD

Robust Low Noise Broadband RF Amplifier MMIC

## Data Sheet

Revision 2.0, 2012-09-10

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**BGB741L7ESD, ESD-Robust and Easy-To-Use Broadband LNA MMIC**
**Revision History: 2012-09-10, Rev. 2.0**

Page	Subjects (major changes since last revision)
	This datasheet replaces the version from 2009-04-17. Neither the wafer production nor the package assembly have been changed. Only the product description and information available in the datasheet has been expanded and adjusted to the typical production.

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Last Trademarks Update 2011-11-11

## Table of Contents

	<b>Table of Contents</b> .....	4
	<b>List of Figures</b> .....	5
	<b>List of Tables</b> .....	6
<b>1</b>	<b>Product Brief</b> .....	7
<b>2</b>	<b>Features</b> .....	7
<b>3</b>	<b>Pin Configuration</b> .....	8
<b>4</b>	<b>Application Circuit</b> .....	9
<b>5</b>	<b>Operating Conditions</b> .....	9
<b>6</b>	<b>Maximum Ratings</b> .....	10
<b>7</b>	<b>Thermal Characteristics</b> .....	11
<b>8</b>	<b>Electrical Characteristics</b> .....	12
8.1	DC Characteristics .....	12
8.2	DC Characteristics Under Varying Bias Conditions .....	13
8.3	AC Characteristics .....	15
<b>9</b>	<b>Package Information</b> .....	21

## List of Figures

Figure 3-1	Pin Configuration	8
Figure 4-1	Functional Block Diagram	9
Figure 7-1	Maximum Total Power Dissipation $P_{tot}$ as Function of Temperature $T_S$ at Soldering point	11
Figure 8-1	$I_{CC}$ as a Function of $R_{ext}$ , $V_{Ctrl} = 3\text{ V}$ , $V_{CC}$ as Parameter	13
Figure 8-2	$I_{CC}$ as a Function of $V_{CC}$ , $V_{Ctrl} = 3\text{ V}$ , $R_{ext}$ as Parameter	13
Figure 8-3	$I_{CC}$ as a Function of $V_{Ctrl}$ , $V_{CC} = 3\text{ V}$ , $R_{ext}$ as Parameter	14
Figure 8-4	$I_{CC}$ as a Function of Temperature, $V_{CC} = 3\text{ V}$ , $V_{Ctrl} = 3\text{ V}$ , $R_{ext} = \text{open}$	14
Figure 8-5	Testing Setup	15
Figure 9-1	Package Outline of TSLP-7-1	21
Figure 9-2	Foot Print of TSLP-7-1	21
Figure 9-3	Marking Layout of TSLP-7-1	21
Figure 9-4	Tape of TSLP-7-1	21

## List of Tables

Table 3-1	Pinning Table . . . . .	8
Table 5-1	Operation Conditions . . . . .	9
Table 6-1	Maximum Ratings at TA = 25°C (unless otherwise specified) . . . . .	10
Table 7-1	Thermal Resistance . . . . .	11
Table 8-1	DC characteristics at TA = 25 °C . . . . .	12
Table 8-2	AC Characteristics, VC = 3 V, $f = 150$ MHz. . . . .	15
Table 8-3	AC Characteristics, VC = 3 V, $f = 450$ MHz. . . . .	16
Table 8-4	AC Characteristics, VC = 3 V, $f = 900$ MHz . . . . .	16
Table 8-5	AC Characteristics, VC = 3 V, $f = 1500$ MHz. . . . .	17
Table 8-6	AC Characteristics, VC = 3 V, $f = 1900$ MHz . . . . .	17
Table 8-7	AC Characteristics, VC = 3 V, $f = 2400$ MHz. . . . .	18
Table 8-8	AC Characteristics, VC = 3 V, $f = 3500$ MHz. . . . .	19
Table 8-9	AC Characteristics, VC = 3 V, $f = 5500$ MHz . . . . .	19

## 1 Product Brief

The BGB741L7ESD is a high performance low noise amplifier (LNA) MMIC based on Infineon's reliable high volume silicon germanium carbon (SiGe:C) bipolar technology. Its integrated feedback provides a broadband pre-match to  $50 \Omega$  at input and output up to 3.5 GHz and improves the stability against parasitic oscillations. These measures simplify the design of arbitrary LNA application circuits. The integrated active biasing reduces the external parts count and stabilizes the bias current against temperature- and process-variations. The integrated protection elements make the device robust against electrostatic discharge (ESD) and high RF input power levels. The device is highly flexible because the bias current is adjustable and the device works with a broad supply voltage range. The BGB741L7ESD comes in a Pb-free and halogen-free low profile TSLP-7-1 package.

## 2 Features

- High-performance broadband LNA MMIC for applications between 50 MHz and 5 GHz
- Integrated ESD protection: 2 kV HBM at all pins
- High RF input power robustness of 20 dBm
- Supply voltage range  $V_{CC} = 1.8 - 4.0 \text{ V}$
- Adjustable current between 5.5 mA to 30 mA by an external resistor
- Power-off function
- Excellent noise figure for a broadband LNA:  
 $NF_{50} = 1.15 \text{ dB}$  at 6 mA, 3 V, 2.4 GHz
- Very small, leadless, Pb-free (RoHS compliant) and halogen-free package TSLP-7-1, 2.0 x 1.3 x 0.4 mm
- Qualification report according to AEC-Q101 available



TSLP-7-1



### Applications

Mobile TV, DAB, RKE, AMR, Cellular, ZigBee, WiMAX, SDARs, WiFi, Cordless phone, UMTS, WLAN

### 3 Pin Configuration

Type	Package	Marking
BGB741L7ESD	TSLP-7-1	AY

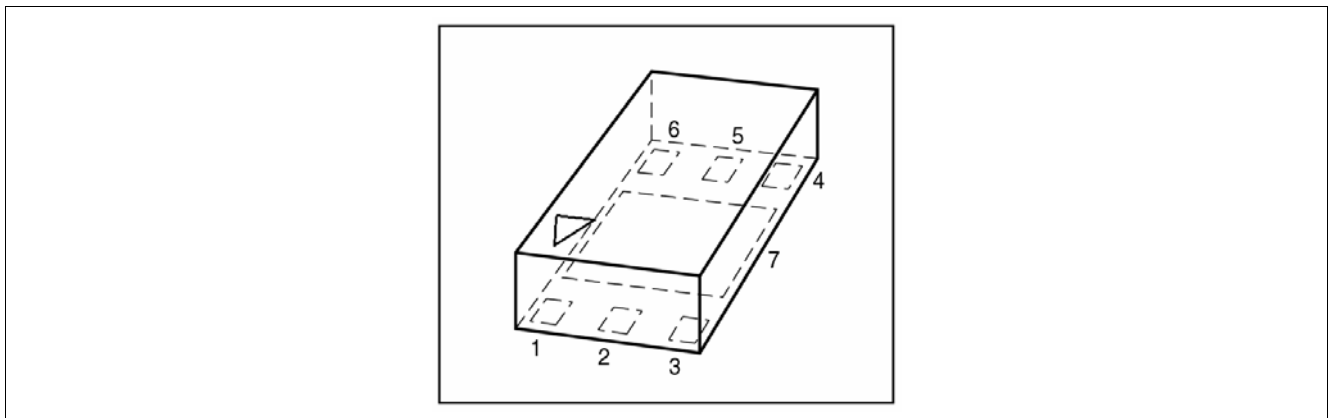


Figure 3-1 Pin Configuration

Table 3-1 Pinning Table

Pin	Function
1	$V_{CC}$
2	Bias-Out
3	RF-In
4	RF-Out
5	Control On/Off
6	Current Adjust
7	GND



## 4 Application Circuit

The following diagram shows the principal schematic how the BGB741L7ESD is used in a circuit. The power On/Off function is used by applying  $V_{Ctrl}$ . By applying an external resistor  $R_{ext}$  the pre-set minimum current of 5.5mA (which is adjusted by the integrated biasing when  $R_{ext}$  is omitted) can be increased. Base- and collector voltages are applied to the respective RFin- and RFout-pins by external inductors.

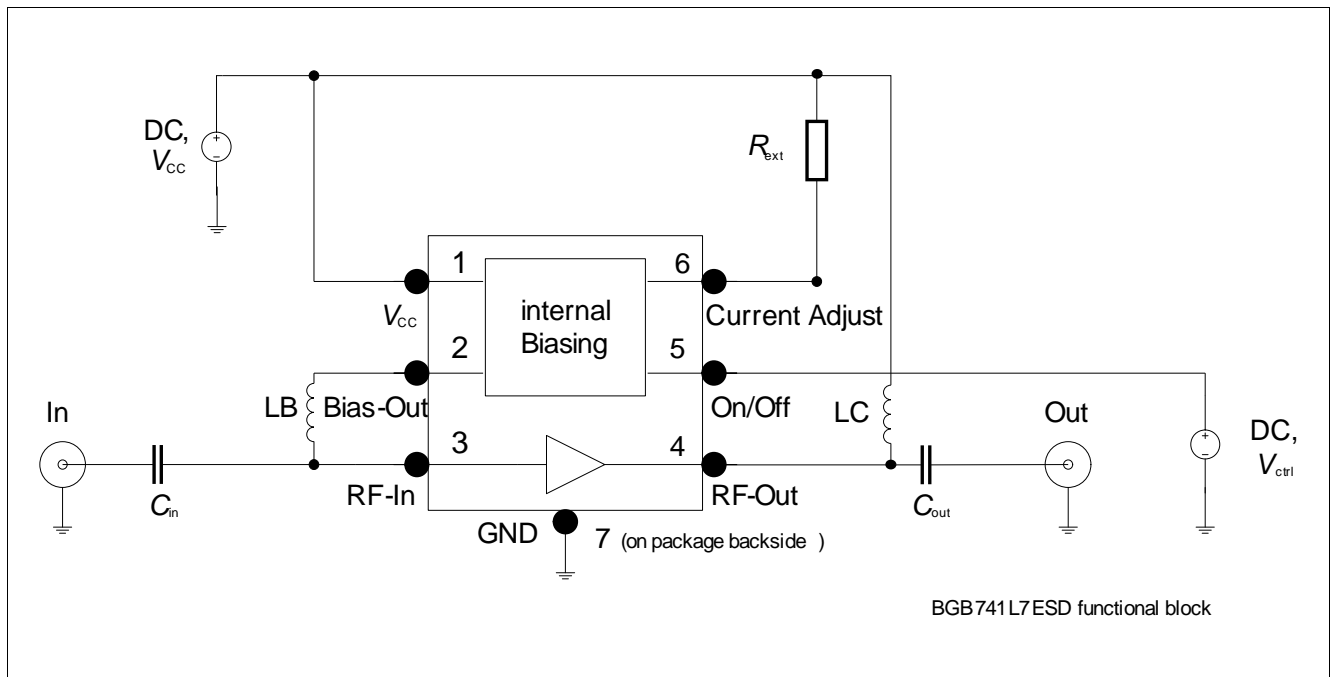


Figure 4-1 Functional Block Diagram

## 5 Operating Conditions

Table 5-1 Operation Conditions

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Supply voltage	$V_{CC}$	1.8	3.0	4.0	V	
Voltage Control On/Off pin in On mode	$V_{Ctrl-on}$	1.2	–	$V_{CC}$		
Voltage Control On/Off pin in Off mode	$V_{Ctrl-off}$	-0.3	–	0.3	V	

## 6 Maximum Ratings

**Table 6-1 Maximum Ratings at  $T_A = 25^\circ\text{C}$  (unless otherwise specified)**

Parameter	Symbol	Value	Unit
Supply voltage	$V_{CC}$	4.0	V
$T_A = -55^\circ\text{C}$		3.5	
Supply current at $V_{CC}$ pin	$I_{CC}$	30	mA
DC current at RF In pin	$I_B$	3	mA
Voltage at Control On / Off pin	$V_{Ctrl}$	$V_{CC}$	
ESD stress pulse (HBM)	$V_{ESD}$	+/-2	kV
RF input power	$P_{RF,in}$	20	dBm
Total power dissipation <sup>1)</sup>	$P_{tot}$	120	mW
$T_S < 117^\circ\text{C}$			
Junction temperature	$T_J$	150	$^\circ\text{C}$
Storage temperature	$T_{Stg}$	-55...150	$^\circ\text{C}$

1) The soldering point temperature  $T_S$  measured at the GND pin (7) at the soldering point to the pcb

*Note: Exceeding only one of the above maximum rating limits even for a short moment may cause permanent damage to the device. Even if the device continues to operate, its lifetime may be considerably shortened. Maximum ratings are stress ratings only and do not mean unaffected functional operation and lifetime at others than standard operating conditions*

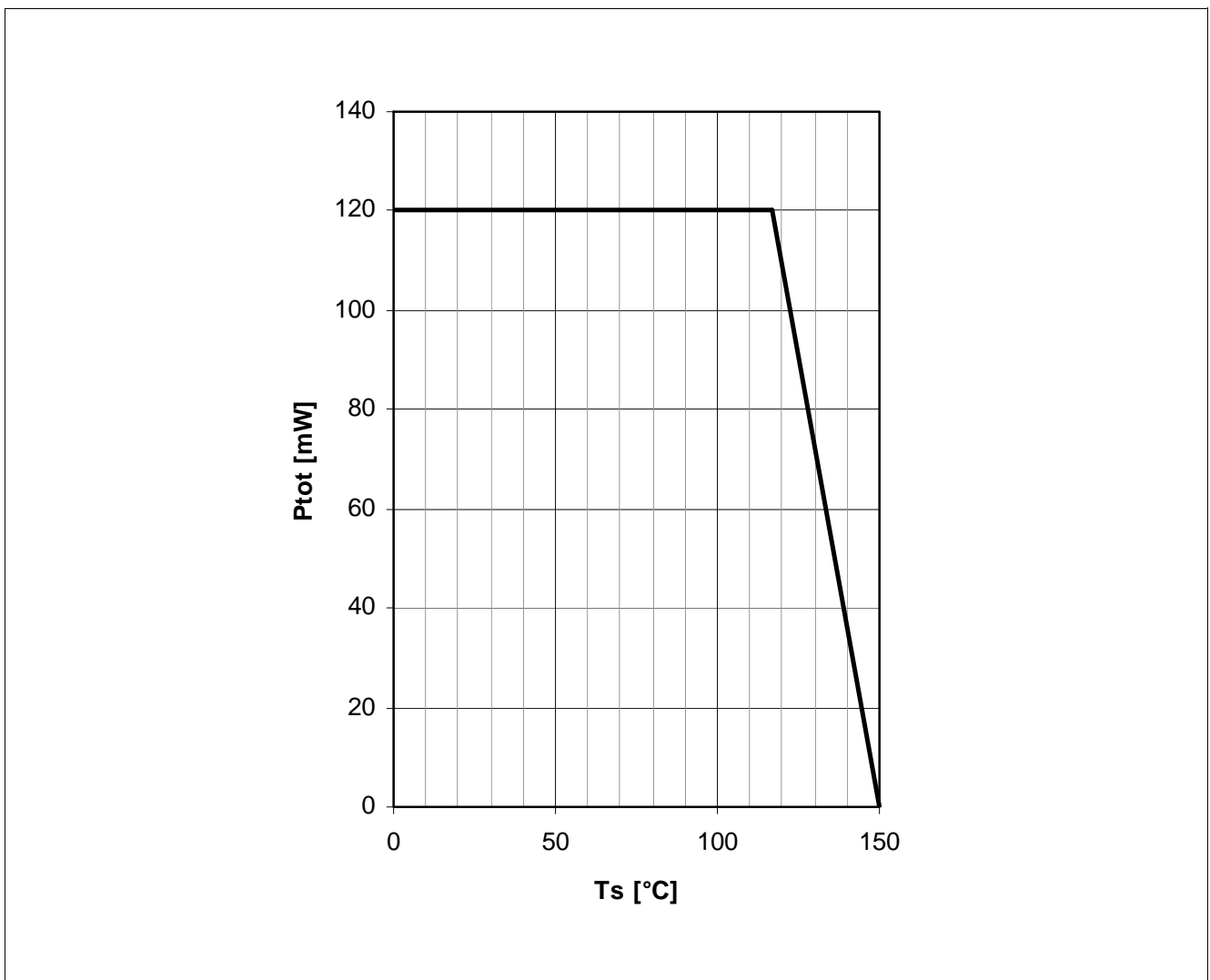
**Attention: ESD (Electrostatic Discharge) sensitive device, observe handling precautions.**

## 7 Thermal Characteristics

**Table 7-1 Thermal Resistance**

Parameter	Symbol	Value	Unit
Junction - soldering point <sup>1)</sup>	$R_{thJS}$	275	K/W

1) For calculation of  $R_{thJA}$  please refer to Application Note AN077 (Thermal Resistance Calculation)



**Figure 7-1 Maximum Total Power Dissipation  $P_{tot}$  as Function of Temperature  $T_s$  at Soldering point**

## 8 Electrical Characteristics

### 8.1 DC Characteristics

 Table 8-1 DC characteristics at  $T_A = 25\text{ °C}$ 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Supply current in On-mode	$I_{CC}$	5.0 – –	5.5 6 10	6.5 – –	mA	$R_{ext} = \text{open}$ $R_{ext} = 30\text{ k}\Omega$ $R_{ext} = 3\text{ k}\Omega$ $V_{CC} = 3.0\text{ V}$ $V_{Ctrl} = 3.0\text{ V}$ (Small signal operation)
Supply current in Off mode	$I_{CC-off}$	–	–	6.0	$\mu\text{A}$	$V_{CC} = 3.0\text{ V}$ $V_{Ctrl} = 0\text{ V}$
Current into Control On/Off pin in On-mode	$I_{Ctrl-on}$	–	14	20	$\mu\text{A}$	$V_{CC} = 3.0\text{ V}$ $V_{Ctrl} = 3.0\text{ V}$
Current into Control On/Off pin in Off-mode	$I_{Ctrl-off}$	–	–	0.1	$\mu\text{A}$	$V_{CC} = 3.0\text{ V}$ $V_{Ctrl} = 0\text{ V}$

### 8.2 DC Characteristics Under Varying Bias Conditions

The measurement setup is an application circuit according to [Figure 4-1 “Functional Block Diagram” on Page 9](#) using the integrated biasing.

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

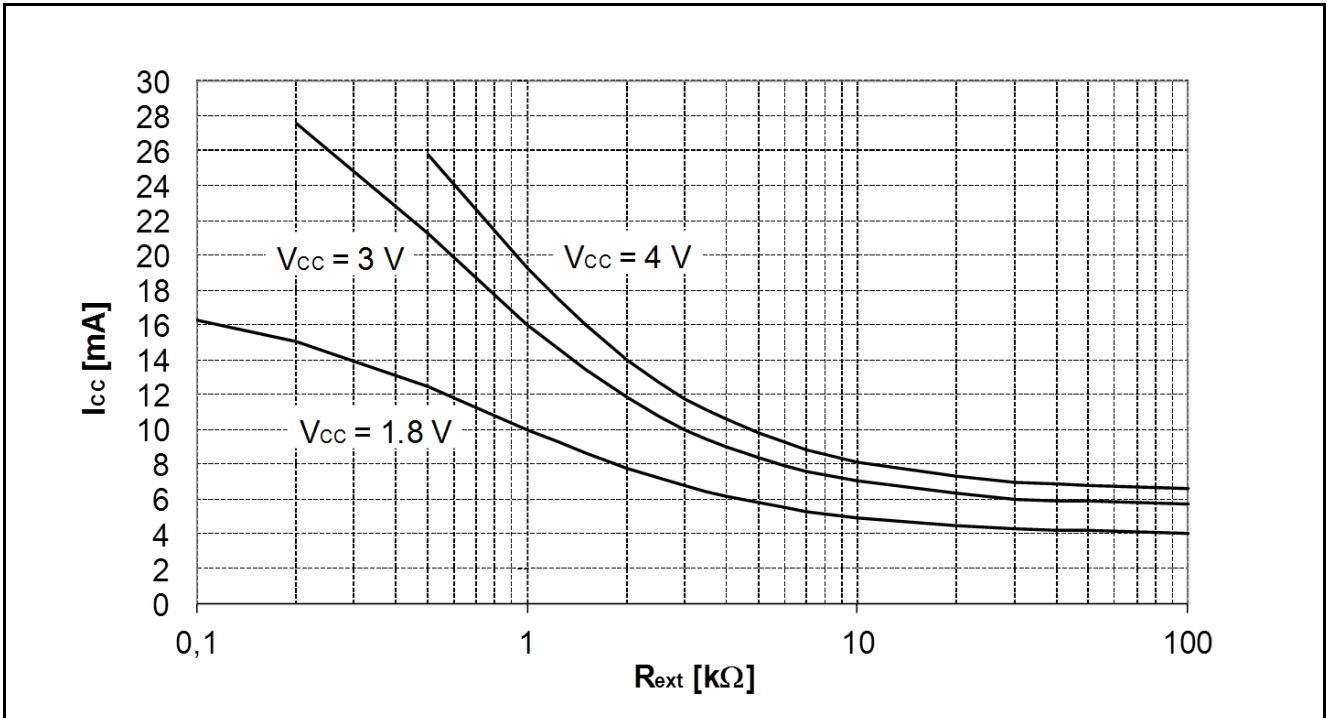


Figure 8-1  $I_{CC}$  as a Function of  $R_{ext}$ ,  $V_{Ctrl} = 3\text{ V}$ ,  $V_{CC}$  as Parameter

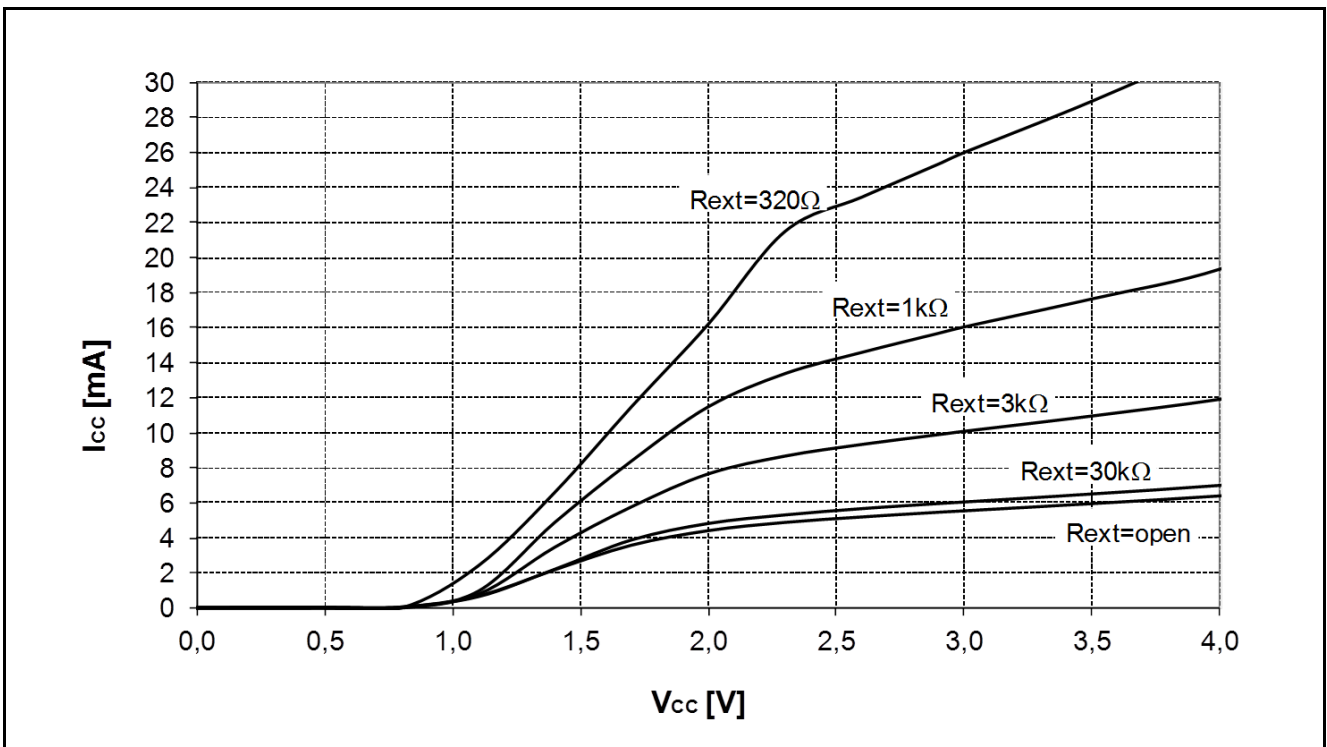


Figure 8-2  $I_{CC}$  as a Function of  $V_{CC}$ ,  $V_{Ctrl} = 3\text{ V}$ ,  $R_{ext}$  as Parameter

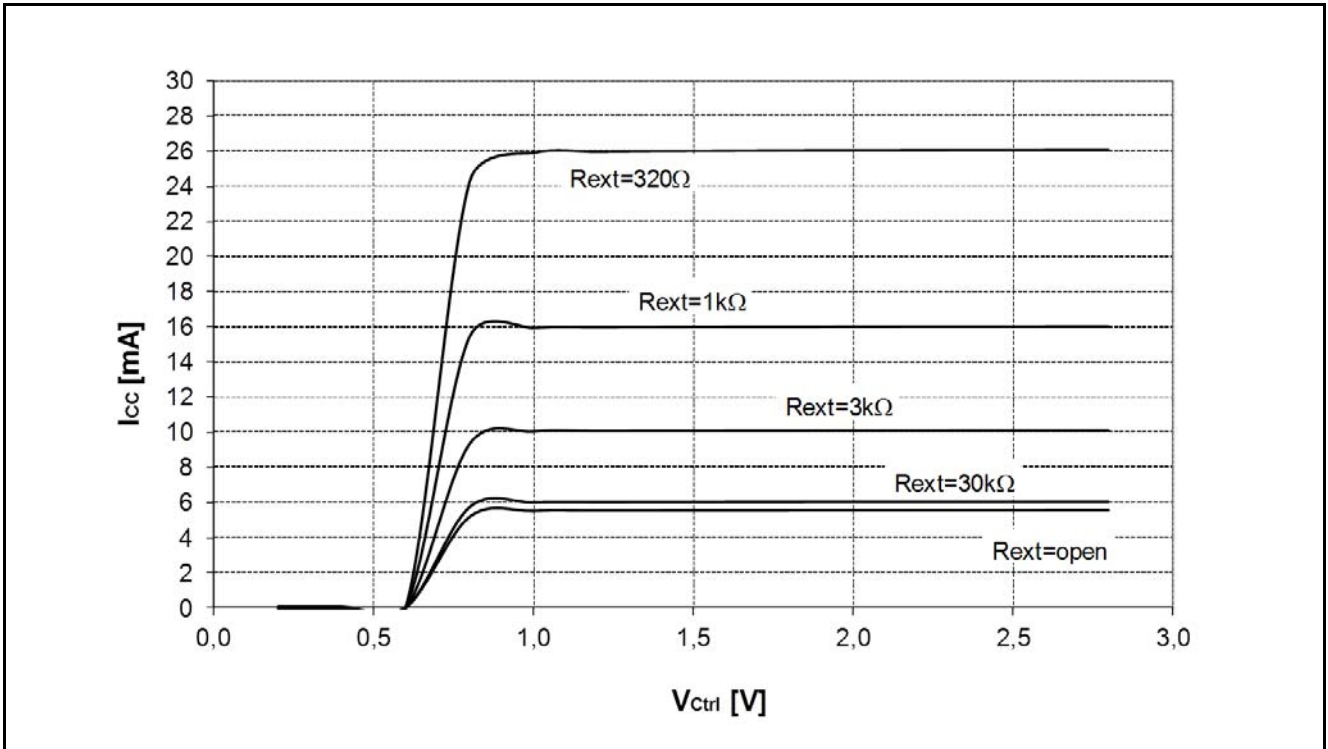


Figure 8-3  $I_{CC}$  as a Function of  $V_{Ctrl}$ ,  $V_{CC} = 3 V$ ,  $R_{ext}$  as Parameter

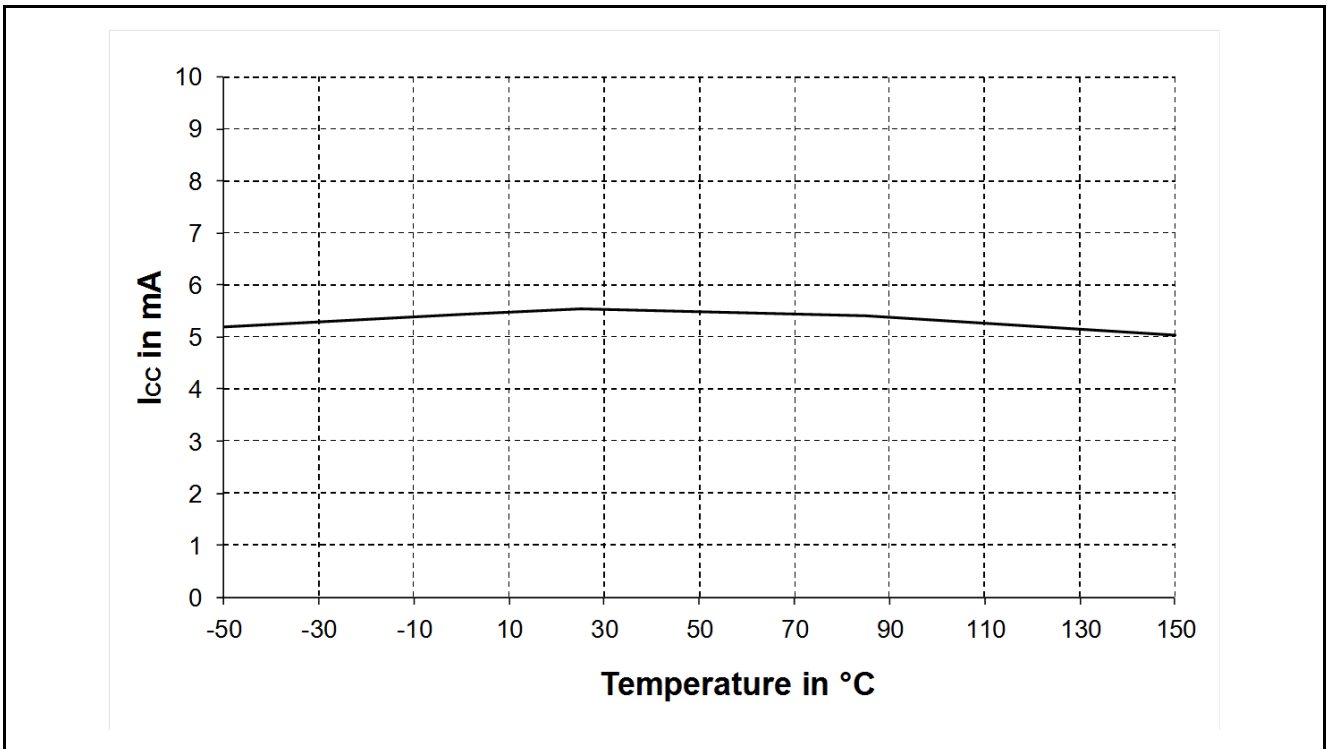
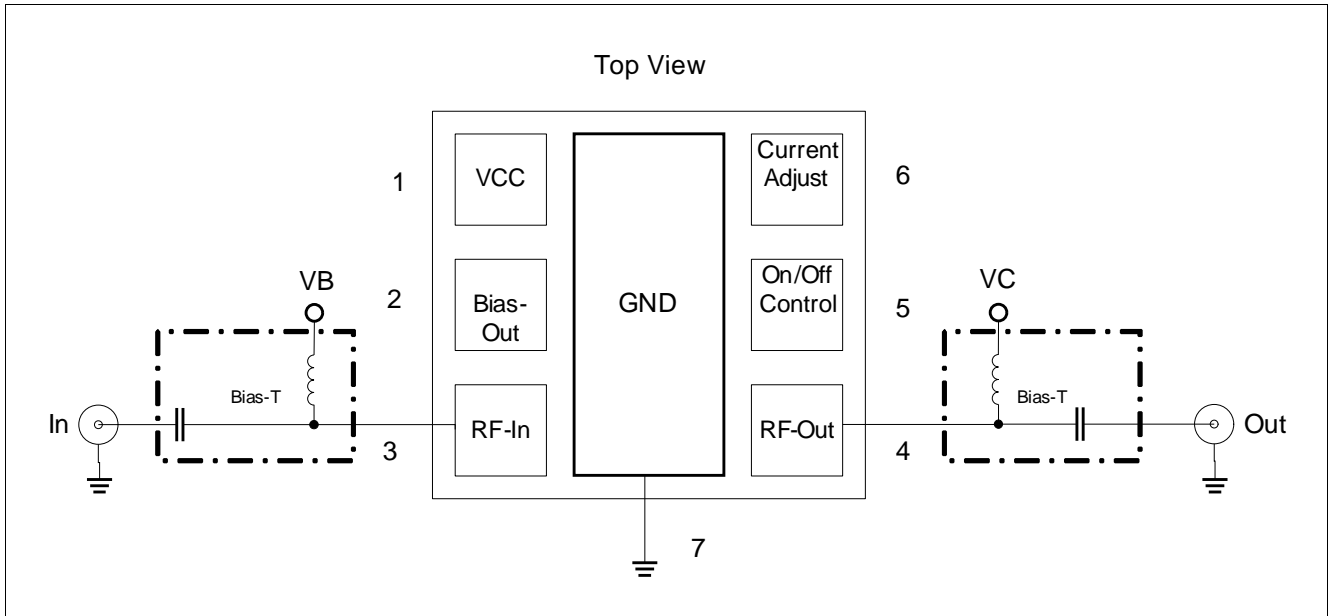


Figure 8-4  $I_{CC}$  as a Function of Temperature,  $V_{CC} = 3 V$ ,  $V_{Ctrl} = 3 V$ ,  $R_{ext} = open$

### 8.3 AC Characteristics

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



**Figure 8-5 Testing Setup**

**Table 8-2 AC Characteristics,  $V_C = 3\text{ V}$ ,  $f = 150\text{ MHz}$**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Minimum Noise Figure <sup>1)</sup>	$NF_{\min}$	–	1.05	–	dB	$Z_S = Z_{\text{Sopt}}$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Noise Figure in 50Ω System <sup>1)</sup>	$NF_{50}$	–	1.1	–	dB	$Z_S = Z_L = 50\Omega$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Transducer Gain	$ S_{21} ^2$	–	19	–	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Maximum Stable Power Gain	$G_{\text{ms}}$	–	20	–	dB	$Z_L = Z_{\text{Lopt}}, Z_S = Z_{\text{Sopt}}$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Input 1 dB Gain Compression Point <sup>2)</sup>	$IP_{1\text{dB}}$	–	-5.5	–	dBm	$I_{Cq} = 6\text{ mA}$ $I_{Cq} = 10\text{ mA}$
Input 3 <sup>rd</sup> Order Intercept Point	$IIP_3$	–	5.5	–	dBm	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Input Return Loss	$RL_{\text{in}}$	–	14	–	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Output Return Loss	$RL_{\text{out}}$	–	12.5	–	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$

**Electrical Characteristics**
**Table 8-3 AC Characteristics,  $V_C = 3\text{ V}$ ,  $f = 450\text{ MHz}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Minimum Noise Figure <sup>1)</sup>	$NF_{\min}$	–	1.05	–	dB	$Z_S = Z_{\text{Sopt}}$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	0.95	–		
Noise Figure in 50Ω System <sup>1)</sup>	$NF_{50}$	–	1.1	–	dB	$Z_S = Z_L = 50\Omega$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	1.05	–		
Transducer Gain	$ S_{21} ^2$	–	18.5	–	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	20.5	–		
Maximum Available Power Gain	$G_{\text{ma}}$	–	19	–	dB	$Z_L = Z_{\text{Lopt}}, Z_S = Z_{\text{Sopt}}$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	20.5	–		
Input 1 dB Gain Compression Point <sup>2)</sup>	$IP_{1\text{dB}}$	–	-5	–	dBm	$I_{\text{Cq}} = 6\text{ mA}$ $I_{\text{Cq}} = 10\text{ mA}$
		–	-7.5	–		
Input 3 <sup>rd</sup> Order Intercept Point	$IIP_3$	–	4	–	dBm	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	2.5	–		
Input Return Loss	$RL_{\text{in}}$	–	15.5	–	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	21	–		
Output Return Loss	$RL_{\text{out}}$	–	14.5	–	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	28	–		

**Table 8-4 AC Characteristics,  $V_C = 3\text{ V}$ ,  $f = 900\text{ MHz}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Minimum Noise Figure <sup>1)</sup>	$NF_{\min}$	–	1.05	–	dB	$Z_S = Z_{\text{Sopt}}$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	0.95	–		
Noise Figure in 50Ω System <sup>1)</sup>	$NF_{50}$	–	1.1	–	dB	$Z_S = Z_L = 50\Omega$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	1.05	–		
Transducer Gain	$ S_{21} ^2$	–	18.5	–	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	20	–		
Maximum Available Power Gain	$G_{\text{ma}}$	–	19	–	dB	$Z_L = Z_{\text{Lopt}}, Z_S = Z_{\text{Sopt}}$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	20.5	–		
Input 1 dB Gain Compression Point <sup>2)</sup>	$IP_{1\text{dB}}$	–	-5	–	dBm	$I_{\text{Cq}} = 6\text{ mA}$ $I_{\text{Cq}} = 10\text{ mA}$
		–	-7	–		
Input 3 <sup>rd</sup> Order Intercept Point	$IIP_3$	–	3	–	dBm	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	1.5	–		



**Electrical Characteristics**
**Table 8-4 AC Characteristics,  $V_C = 3\text{ V}$ ,  $f = 900\text{ MHz}$  (cont'd)**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input Return Loss	$RL_{in}$	–	15.5	–	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	19	–		
Output Return Loss	$RL_{out}$	–	14.5	–	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	28.5	–		

**Table 8-5 AC Characteristics,  $V_C = 3\text{ V}$ ,  $f = 1500\text{ MHz}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Minimum Noise Figure <sup>1)</sup>	$NF_{min}$	–	1.05	–	dB	$Z_S = Z_{Sopt}$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	1.0	–		
Noise Figure in 50Ω System <sup>1)</sup>	$NF_{50}$	–	1.1	–	dB	$Z_S = Z_L = 50\Omega$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	1.05	–		
Transducer Gain	$ S_{21} ^2$	–	18	–	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	19.5	–		
Maximum Available Power Gain	$G_{ma}$	–	18.5	–	dB	$Z_L = Z_{Lopt}$ , $Z_S = Z_{Sopt}$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	20	–		
Input 1 dB Gain Compression Point <sup>2)</sup>	$IP_{1dB}$	–	-4.5	–	dBm	$I_{Cq} = 6\text{ mA}$ $I_{Cq} = 10\text{ mA}$
		–	-6.5	–		
Input 3 <sup>rd</sup> Order Intercept Point	$IIP_3$	–	2.5	–	dBm	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	1	–		
Input Return Loss	$RL_{in}$	–	14.5	–	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	16	–		
Output Return Loss	$RL_{out}$	–	14	–	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	23	–		

**Table 8-6 AC Characteristics,  $V_C = 3\text{ V}$ ,  $f = 1900\text{ MHz}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Minimum Noise Figure <sup>1)</sup>	$NF_{min}$	–	1.05	–	dB	$Z_S = Z_{Sopt}$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	1.05	–		
Noise Figure in 50Ω System <sup>1)</sup>	$NF_{50}$	–	1.15	–	dB	$Z_S = Z_L = 50\Omega$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	1.1	–		
Transducer Gain	$ S_{21} ^2$	–	17.5	–	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
		–	19	–		

**Electrical Characteristics**
**Table 8-6 AC Characteristics,  $V_C = 3\text{ V}$ ,  $f = 1900\text{ MHz}$  (cont'd)**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Maximum Available Power Gain	$G_{ma}$	– –	18 19.5	– –	dB	$Z_L = Z_{Lopt}$ , $Z_S = Z_{Sopt}$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Input 1 dB Gain Compression Point <sup>2)</sup>	$IP_{1dB}$	– –	-4 -6	– –	dBm	$I_{Cq} = 6\text{ mA}$ $I_{Cq} = 10\text{ mA}$
Input 3 <sup>rd</sup> Order Intercept Point	$IIP_3$	– –	2.5 1	– –	dBm	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Input Return Loss	$RL_{in}$	– –	13.5 15	– –	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Output Return Loss	$RL_{out}$	– –	13.5 21	– –	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$

**Table 8-7 AC Characteristics,  $V_C = 3\text{ V}$ ,  $f = 2400\text{ MHz}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Minimum Noise Figure <sup>1)</sup>	$NF_{min}$	– –	1.1 1.05	– –	dB	$Z_S = Z_{Sopt}$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Noise Figure in 50Ω System <sup>1)</sup>	$NF_{50}$	– –	1.15 1.1	– –	dB	$Z_S = Z_L = 50\Omega$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Transducer Gain	$ S_{21} ^2$	– –	17 18.5	– –	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Maximum Available Power Gain	$G_{ma}$	– –	17.5 19	– –	dB	$Z_L = Z_{Lopt}$ , $Z_S = Z_{Sopt}$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Input 1 dB Gain Compression Point <sup>2)</sup>	$IP_{1dB}$	– –	-3.5 -5.5	– –	dBm	$I_{Cq} = 6\text{ mA}$ $I_{Cq} = 10\text{ mA}$
Input 3 <sup>rd</sup> Order Intercept Point	$IIP_3$	– –	3 1	– –	dBm	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Input Return Loss	$RL_{in}$	– –	12.5 13.5	– –	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Output Return Loss	$RL_{out}$	– –	12.5 18	– –	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$

**Electrical Characteristics**
**Table 8-8 AC Characteristics,  $V_C = 3\text{ V}$ ,  $f = 3500\text{ MHz}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Minimum Noise Figure <sup>1)</sup>	$NF_{\min}$	– –	1.25 1.2	– –	dB	$Z_S = Z_{\text{Sopt}}$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Noise Figure in 50Ω System <sup>1)</sup>	$NF_{50}$	– –	1.35 1.25	– –	dB	$Z_S = Z_L = 50\Omega$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Transducer Gain	$ S_{21} ^2$	– –	15 16.5	– –	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Maximum Available Power Gain	$G_{\text{ma}}$	– –	16 17.5	– –	dB	$Z_L = Z_{\text{Lopt}}, Z_S = Z_{\text{Sopt}}$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Input 1 dB Gain Compression Point <sup>2)</sup>	$IP_{1\text{dB}}$	– –	-2.5 -4.5	– –	dBm	$I_{\text{Cq}} = 6\text{ mA}$ $I_{\text{Cq}} = 10\text{ mA}$
Input 3 <sup>rd</sup> Order Intercept Point	$IIP_3$	– –	3.5 1.5	– –	dBm	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Input Return Loss	$RL_{\text{in}}$	– –	10 10.5	– –	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Output Return Loss	$RL_{\text{out}}$	– –	10 13.5	– –	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$

**Table 8-9 AC Characteristics,  $V_C = 3\text{ V}$ ,  $f = 5500\text{ MHz}$** 

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Minimum Noise Figure <sup>1)</sup>	$NF_{\min}$	– –	1.8 1.75	– –	dB	$Z_S = Z_{\text{Sopt}}$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Noise Figure in 50Ω System <sup>1)</sup>	$NF_{50}$	– –	1.95 1.85	– –	dB	$Z_S = Z_L = 50\Omega$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Transducer Gain	$ S_{21} ^2$	– –	12 13	– –	dB	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Maximum Available Power Gain	$G_{\text{ma}}$	– –	14 15	– –	dB	$Z_L = Z_{\text{Lopt}}, Z_S = Z_{\text{Sopt}}$ $I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$
Input 1 dB Gain Compression Point <sup>2)</sup>	$IP_{1\text{dB}}$	– –	-1 -3	– –	dBm	$I_{\text{Cq}} = 6\text{ mA}$ $I_{\text{Cq}} = 10\text{ mA}$
Input 3 <sup>rd</sup> Order Intercept Point	$IIP_3$	– –	8.5 4	– –	dBm	$I_C = 6\text{ mA}$ $I_C = 10\text{ mA}$

**Table 8-9 AC Characteristics,  $V_C = 3\text{ V}$ ,  $f = 5500\text{ MHz}$  (cont'd)**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input Return Loss	$RL_{in}$	–	7	–	dB	$I_C = 6\text{ mA}$
		–	8	–		$I_C = 10\text{ mA}$
Output Return Loss	$RL_{out}$	–	7	–	dB	$I_C = 6\text{ mA}$
		–	8.5	–		$I_C = 10\text{ mA}$

- 1) Test fixture losses extracted
- 2) Measured on an application board according to [Figure 4-1 “Functional Block Diagram” on Page 9](#) presenting a  $50\ \Omega$  system to the device.  $I_{Cq}$  is the quiescent current, that is at small RF input power level.  $I_C$  increases as RF input power level approaches P1dB.

## 9 Package Information

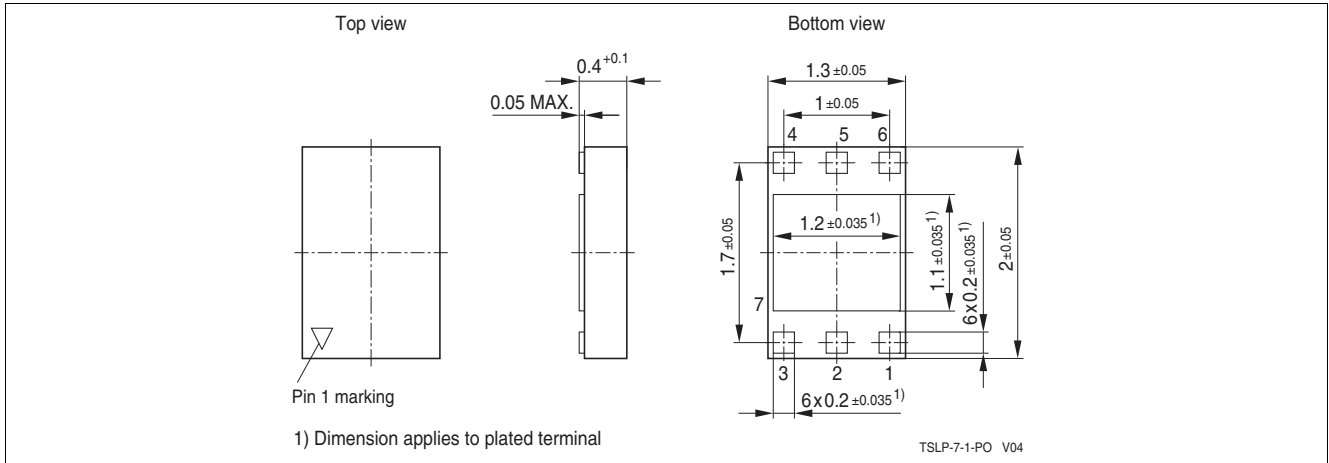


Figure 9-1 Package Outline of TSLP-7-1

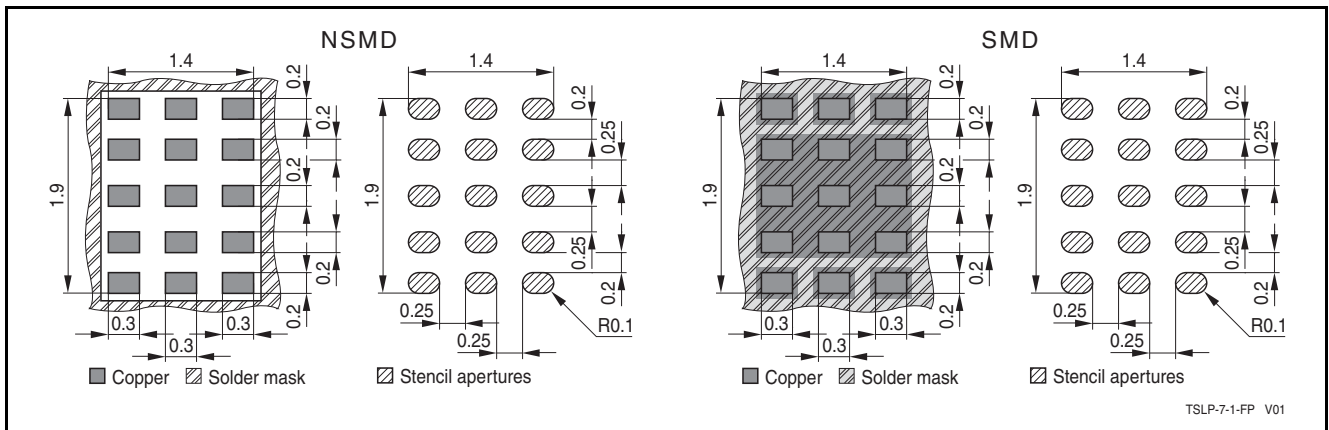


Figure 9-2 Foot Print of TSLP-7-1

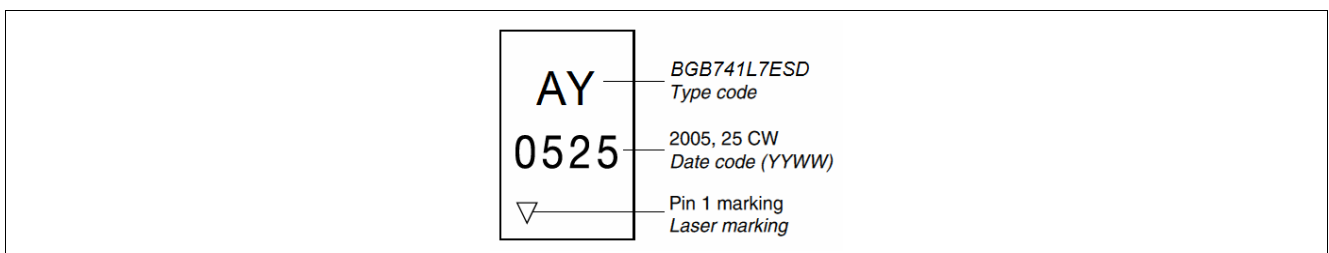


Figure 9-3 Marking Layout of TSLP-7-1

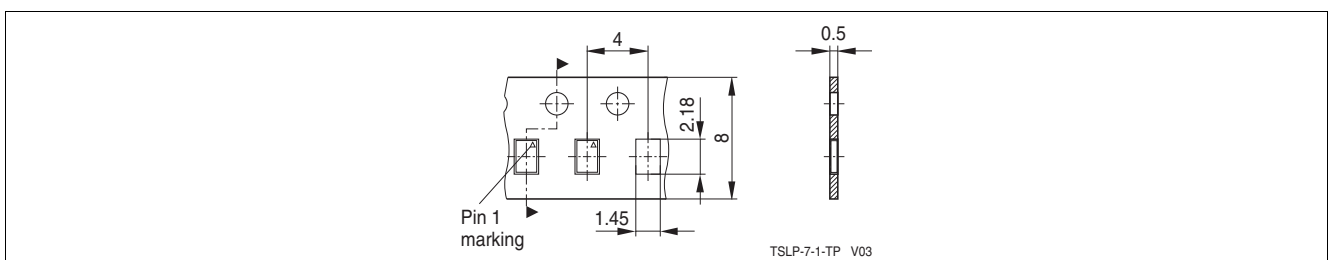


Figure 9-4 Tape of TSLP-7-1

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