

APPLICATION INFORMATION

Demoboard W-CDMA for the BGA2003

Application Note

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1 SUMMARY**• Description of products**

Monolithic Microwave Integrated Circuit (MMIC): RF transistor with internal bias circuit. The benefit is lower component count, low production spread and enabling function by I_{ctrl} with high isolation when shutoff.

• Application Area

Low noise amplifier for systems like GSM, DECT, DCS with low component count.

• Presented Application

The application presents a low noise amplifier for W-CDMA at 3400 MHz with matching components.

• Main results

An amplifier has been designed and tested for application in W-CDMA with minimum component count:

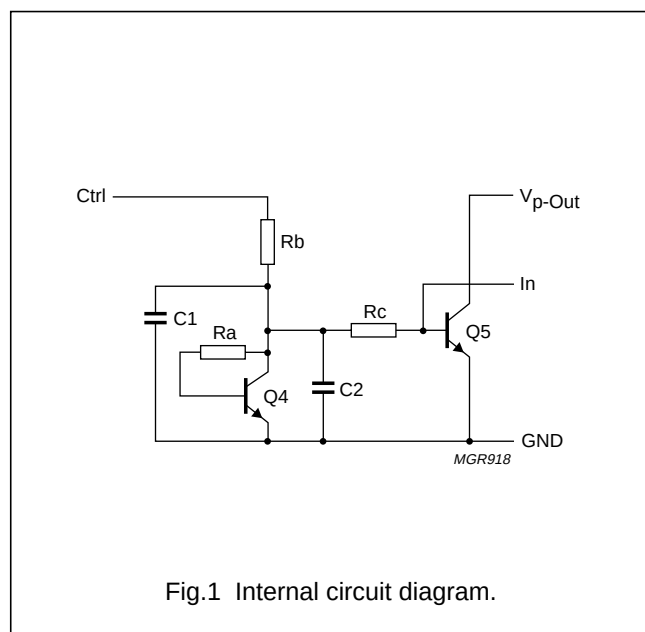
- Frequency is 3400 MHz; $I_{supply} = 4.7$ mA;
Gain = 9.4 dB; IIP3 = 2.1 dBm; Noise Figure (NF) = 2.7 dB;
 $VSWR_{in} = 1.4$; $VSWR_{out} = 1.6$
- Frequency is 3400 MHz; $I_{supply} = 10$ mA;
Gain = 10.3 dB; IIP3 = 9.2 dBm; Noise Figure = 3.1 dB;
 $VSWR_{in} = 1.2$; $VSWR_{out} = 1.6$.

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2 THE INTERNAL BGA2003 CIRCUIT

For understanding of the behaviour of the BGA2003 MMIC circuit the internal circuit diagram is given in Fig.1.



Q5 is the main RF transistor. Q4 forms a current mirror with Q5. The input current of this current mirror is determined by the current into pin Ctrl. Rb limits the current when a control voltage is applied directly to the Ctrl input. Rc, C1, and C2 decouple the bias circuit from the RF input signal.

3 SIMULATION OF THE BGA2003 DEMOBOARD

S-parameters of the BGA2003 MMIC were measured at $V_{p-Out} = 2.5\text{ V}$, $I_{supply} = 4\text{ mA}$ up to 3 GHz. HP-MDS simulation was used to extrapolate to 3.4 GHz and optimize component values for gain, noise and matching. These component values have been used as a starting point for finding the used practical component values (see Table 1).

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4 APPLICATION CIRCUIT

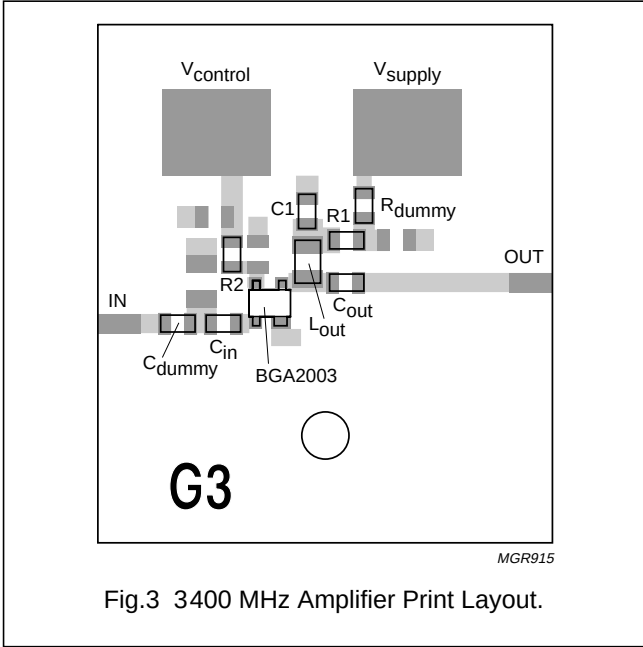
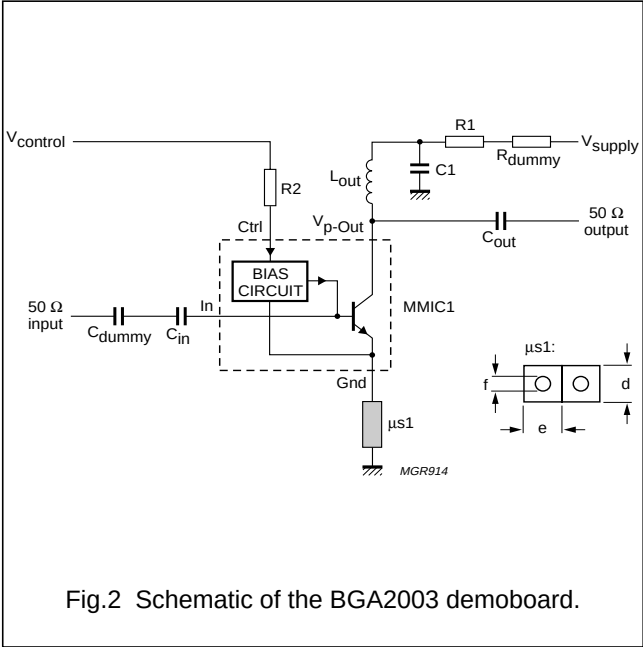


Table 1 Used components for the BGA2003 demoboard

COMPONENT	VALUE	UNIT	SIZE - MANUFACTURER	PURPOSE; COMMENT
C_{dummy}	150	pF	0603 Philips	connecting dummy (NP0); see Chapter 5
C_{in}	47	pF	0603 Philips	DC-decoupling; input match
C_{out}	0.82	pF	0603 Philips	output match
L_{out}	2.2	nH	0603 AVX type 1200	output match
$C1$	2.2	pF	0603 Philips	RF-short to ground
R_{dummy}	0	Ω	0603 Philips	connecting dummy, short; see Chapter 5
$R1$	120	Ω	0603 Philips	DC-bias; RF decoupling
$R2$	4.7	kΩ	0603 Philips	DC-bias; bias setting
$\mu s1$	–	–	PCB via	$d = e = 1\text{ mm}$; $f = 0.4\text{ mm}$
MMIC1	BGA2003	–	Philips SOT343R1	
PCB	–	–	FR4	$\epsilon_R \sim 4.6$; $H = 0.5\text{ mm}$

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Table 2 Measured values

$V_{\text{supply}} = 3.0 \text{ V}$; $V_{\text{control}} = 3.0 \text{ V}$; $I_{\text{supply}} = 4.66 \text{ mA}$; $f = 3400 \text{ MHz}$; see note 1.

S-PARAMETERS	CONDITION	TYP.	UNIT	VSWR
S_{11}		-16.4	dB	1.4
S_{21}		+9.4	dB	–
S_{12}		-15.2	dB	–
S_{22}		-13.1	dB	1.6
NF		+2.65	dB	–
Input IP3	at -30 dBm in; note 2	+2.1	dBm	–

Notes

1. S-parameters measured at -30 dBm input level.
2. IP3 -30 dBm in, f1 and f2 100 kHz separated.

Table 3 Measured values

$V_{\text{supply}} = 3.7 \text{ V}$; $V_{\text{control}} = 6.0 \text{ V}$; $I_{\text{supply}} = 10 \text{ mA}$; $f = 3400 \text{ MHz}$; note 1.

S-PARAMETERS	TYP.	UNIT	VSWR
Spars with $I_{\text{ctrl}} = 0$			
S_{11}	-3.85	dB	4.6
S_{21}	-19.1	dB	–
S_{12}	-19.3	dB	–
S_{22}	-5.27	dB	3.4

Note

1. Switch off isolation.

5 COMMENTS ON THE PRINTED CIRCUIT BOARD

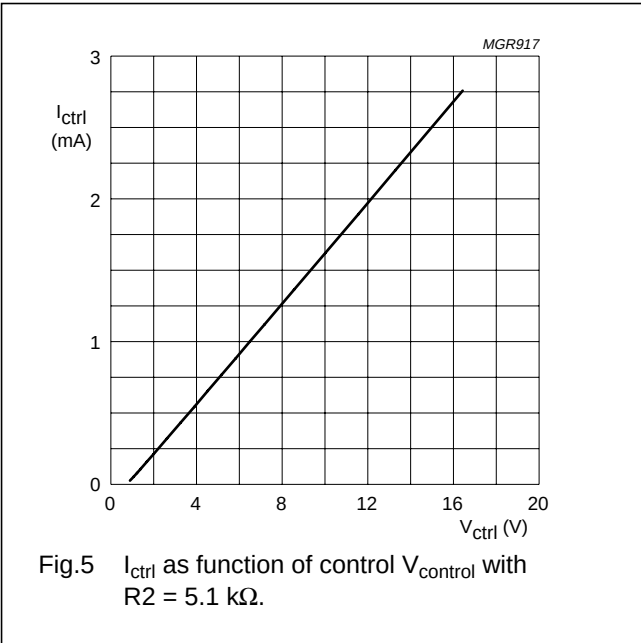
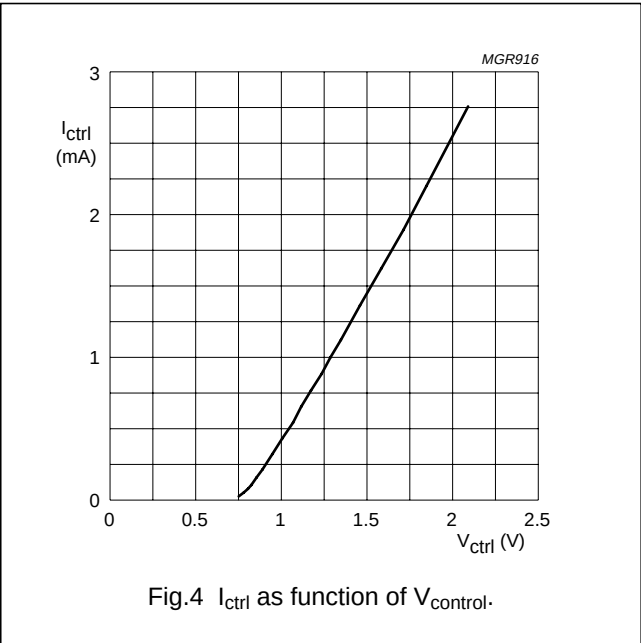
This Printed Circuit Board (PCB) is developed for a LNA with the BGA2003, with component positions for extra decoupling and matching. Although this application was designed for minimal component count, two extra components R_{dummy} and C_{dummy} were needed as interconnect on this PCB. With a new PCB these components can be left out. C_{in} is for DC-decoupling the input to the circuit and matching to 50 Ω . L_{out} and C_{out} match the circuit to the 50 Ω output. Decoupling the supply for high frequencies is done by R1 and C1. The value of R1 determines the voltage on $V_{\text{p-out}}$, which was designed to be 2.5 V with a supply current of 4 mA. The value of R2 and the value of V_{control} determine the control current and thereby the collector current. With 4.7 k Ω for R2 and V_{ctrl} 3.0 V a supply current of 4.66 mA was set (see Figs 4 and 5).

I_{supply} can also be estimated by calculation with formula:
$$I_{\text{supply}} = \frac{10 \times (V_{\text{control}} - 0.83)}{(R2 + 152)}$$

Coil L_{out} can be replaced by a stripline made on the PCB itself. C_{in} can be omitted in some applications when the input signal is not DC coupled.

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For higher IIP3 a supply current of 10 mA was set by applying larger V_{ctrl} (6 V). V_{supply} was raised to 3.7 V to compensate for the extra voltage drop across R1 to keep voltage on pin V_{p-Out} to 2.5 V. To get the same supply current of 10 mA at 3 V supply, and keep voltage on pin V_{p-Out} to 2.5 V, R1 should be changed from 120 Ω into 47 Ω .

Table 4 Measured values on the BGA2003 demoboard

$V_{supply} = 3.7\text{ V}$; $V_{control} = 6.06\text{ V}$; $I_{supply} = 10.0\text{ mA}$; 3400 MHz; see note 1

S-PARAMETERS	CONDITION	TYP.	UNIT	VSWR
S_{11}		-20.4	dB	1.2
S_{21}		+10.3	dB	—
S_{12}		-14.8	dB	—
S_{22}		-12.9	dB	1.6
NF		+3.10	dB	—
Input IP3	at -20 dBm in; note 2	+9.2	dBm	—

Notes

- 1. S-parameters measured at -30 dBm input level.
- 2. IP3: 2 $\times$ -20 dBm in; f1 and f2 100 kHz separated.

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