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.

2 THE INTERNAL BGA2003 CIRCUIT

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

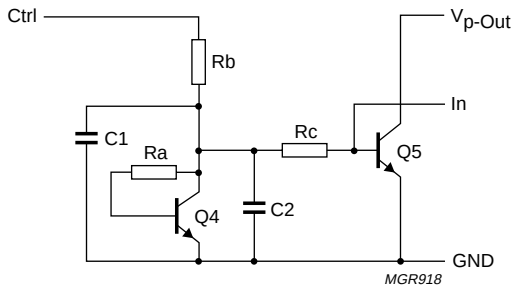

Fig.1 Internal circuit diagram.

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 $V_{p\text{-}Out}$ = 2.5 V, I_{supply} = 4 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).

4 APPLICATION CIRCUIT

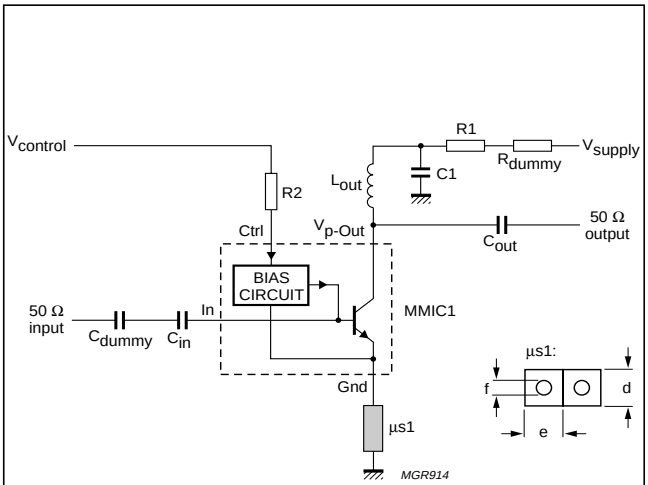

Fig.2 Schematic of the BGA2003 demoboard.

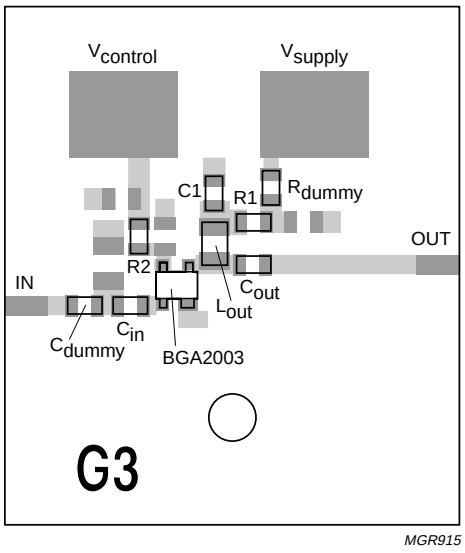

Fig.3 3400 MHz Amplifier Print Layout.

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
µs1	–	–	PCB via	d = e = 1 mm; f = 0.4 mm
MMIC1	BGA2003	–	Philips SOT343R1	
PCB	–	–	FR4	ε_R ~ 4.6; H = 0.5 mm

Table 2 Measured values

V_{supply} = 3.0 V; $V_{control}$ = 3.0 V; I_{supply} = 4.66 mA; f = 3400 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_{supply} = 3.7 V; $V_{control}$ = 6.0 V; I_{supply} = 10 mA; f = 3400 MHz; note 1.

S-PARAMETERS	TYP.	UNIT	VSWR
Spars with I_{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 $V_{p\text{-}out}$, 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 kΩ 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: $I_{supply} = \frac{10 \times (V_{control} - 0.83)}{(R2 + 152)}$

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.

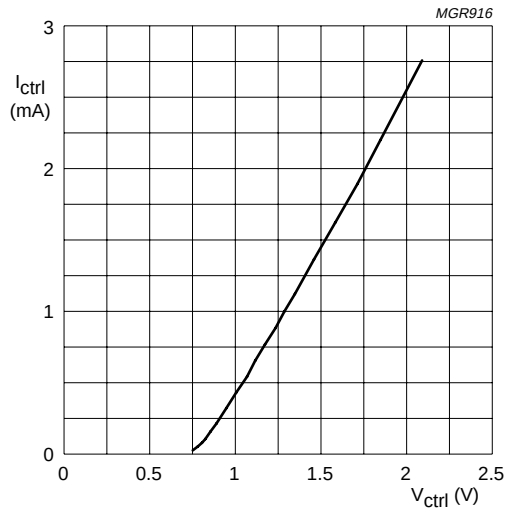

Fig.4 I_{ctrl} as function of $V_{control}$.

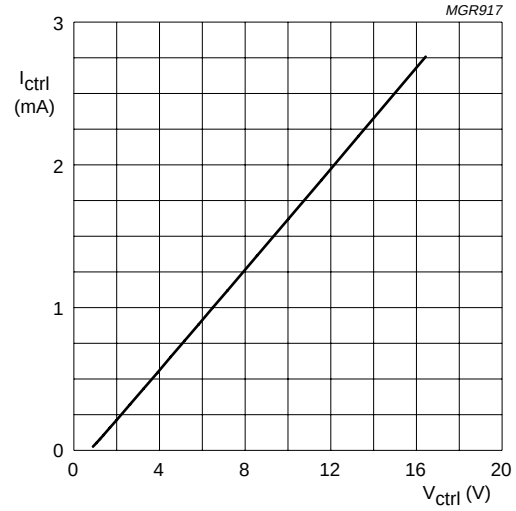

Fig.5 I_{ctrl} as function of control $V_{control}$ with R2 = 5.1 kΩ.

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 $V_{p\text{-}Out}$ to 2.5 V. To get the same supply current of 10 mA at 3 V supply, and keep voltage on pin $V_{p\text{-}Out}$ 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 V; $V_{control}$ = 6.06 V; I_{supply} = 10.0 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× −20 dBm in; f1 and f2 100 kHz separated.

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