APPLICATION INFORMATION

Demoboard 900 MHz LNA with the BGA2003

Application Note

Philips Semiconductors

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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 applications present a low noise amplifier at 900 MHz at 3 V supply voltage and 4 mA supply current with matching components.
- **Main results**
  An amplifier has been designed and tested with minimum component count with 15.4 dB gain, IIP3 = –6.7 dBm, $VSWR_{in}$ = 1.5, $VSWR_{out}$ = 1.8, 1.8 dB Noise Figure at 900 MHz, 3 V and 4 mA supply.

THE INTERNAL BGA2003 CIRCUIT

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

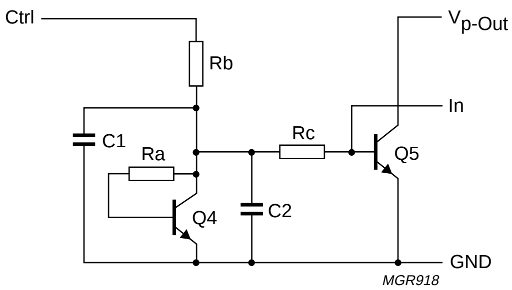

Fig.1 Internal circuit diagram.

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 to bias this circuit. Rc, and C2 in parallel with C1 decouple the bias circuit from the RF input signal.

SIMULATION OF THE BGA2003 DEMOBOARD

S-parameters of the BGA2003 MMIC were measured at $V_{p\text{-}Out}$ = 2.5 V, IC = 4 mA.

Table 1 Measured S-parameters

FREQ. MHz	MAG S_{11}	PHASE S_{11}	MAG S_{21}	PHASE S_{21}	MAG S_{12}	PHASE S_{12}	MAG S_{22}	PHASE S_{22}
800	0.5039	–45.05	7.2572	132.84	0.03984	73.68	0.7980	–26.81
900	0.4774	–47.83	6.7996	128.60	0.04393	72.61	0.7751	–28.52
1000	0.4523	–50.23	6.3946	125.36	0.04564	72.24	0.7520	–30.12

Table 2 Measured NF-parameters

FREQ. MHz	FMIN dB	GAMMA-OPT MAGNITUDE	GAMMA-OPT PHASE [DEG]	RN [Ω]
800	1.685	0.160	26.57	0.276
900	1.703	0.182	28.86	0.275
1000	1.700	0.153	31.56	0.261

An additional emitter inductance of 2.0 nH was added in the MDS simulation. The emitter inductance on the Printed Circuit Board (PCB) is beneficial for achieving good noise match, for stability and easier impedance match.

Optimization of the matching components was done for the parameters $VSWR_{in}$ and $VSWR_{out}$ (<1 : 1.5), resulting in component values, which were rounded up to nearby practical values. These values have been used on the PCB (see Table 1).

Important remarks

Available samples were made with ‘worst case’ processing. Optimal noise matching and use of typical products are expected to result in an improvement of the noise figure.

APPLICATION CIRCUIT

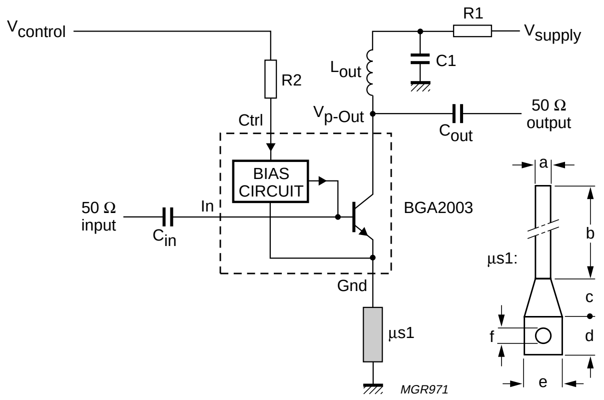

Fig.2 Schematic of the BGA2003 demoboard.

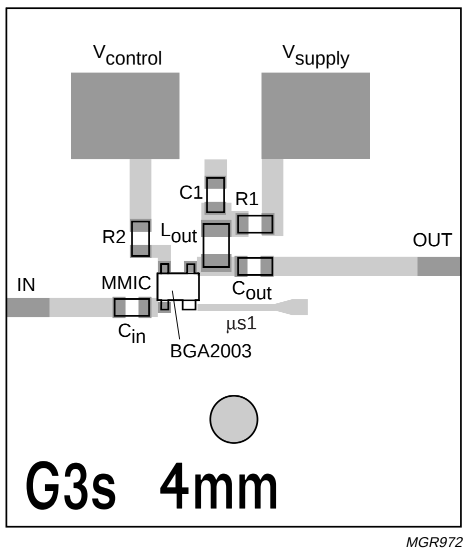

Fig.3 900 MHz amplifier print layout.

Table 3 Used components for the BGA2003 demoboard

COMPONENT	VALUE	UNIT	SIZE - MANUFACTURER	PURPOSE, COMMENT
R1	120	Ω	0603 Philips	DC-bias
R2	5.1	kΩ	0603 Philips	DC-bias
C1	27	pF	0603 Philips NP0	RF-short to ground
C_{in}	1	nF	0603 Philips X7R	input match, DC-decoupling
L_{out}	18	nH	0603 TDK	output match
C_{out}	1.2	pF	0603 Philips NP0	output match
μs 1	–	–	PCB-stripline 50 Ω, via	a = 0.5 mm, b = 4 mm, c = d = e = 1 mm, f = 0.4 mm
MMIC	BGA2003	–	Philips SOT343R1	
PCB	–	–	FR4	ε_R ~ 4.6, H = 0.5 mm

Table 4 Measured values

PCB number 24: I_{supply} = 4.04 mA, V_{supply} = 3.0 V; see note 1.

S-PARAMETERS	800 MHz	900 MHz	1000 MHz	UNIT
V_{ctrl} = 3 V				
NF	1.82	1.81	1.70	dB
IIP3	–	–6.755; see note 2	–	dBm
S_{11}	–6.701	–15.456	–13.286	dB
S_{21}	16.014	15.359	13.707	dB
S_{12}	–22.851	–21.755	–21.472	dB
S_{22}	–10.829	–10.924	–5.441	dB
V_{ctrl} = 0 V				
S_{11}	–1.012	–1.137	–1.178	dB
S_{21}	–22.052	–24.122	–26.088	dB
S_{12}	–22.221	–24.258	–26.802	dB
S_{22}	–8.362	–3.293	–1.703	dB

Notes

1. S-parameters measured at –30 dBm input level.
2. 2-tone –26 dBm at 900 and 900.1 MHz.

COMMENTS ON THE PRINTED CIRCUIT BOARD

This Printed Circuit Board (PCB) is developed for a LNA with the BGA2003, with minimum component count. C_{in} is for DC-decoupling the input to the circuit. L_{out} and C_{out} matches 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 $V_{control}$ determines the control current and thereby the collector current. With R2 = 5.1 kΩ and $V_{control}$ 3.0 V a supply current of 4 mA was set (see Figs 4 and 5).

Typical $I_{supply} = 10 \times I_{ctrl}$. Also I_{bias} can be estimated by calculation with formula: $I_{supply} = \frac{10 \times (V_{control} - 0.83)}{(R2 + 152)}$

C_{in} can be omitted in some applications when the input signal is not DC-coupled.

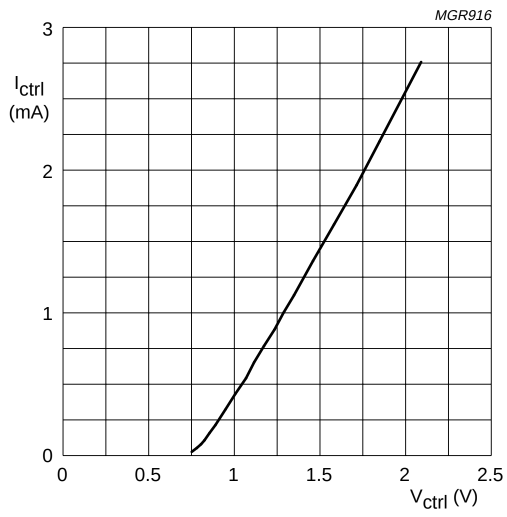

Fig.4 I_{ctrl} as function of voltage on I_{ctrl}-pin.

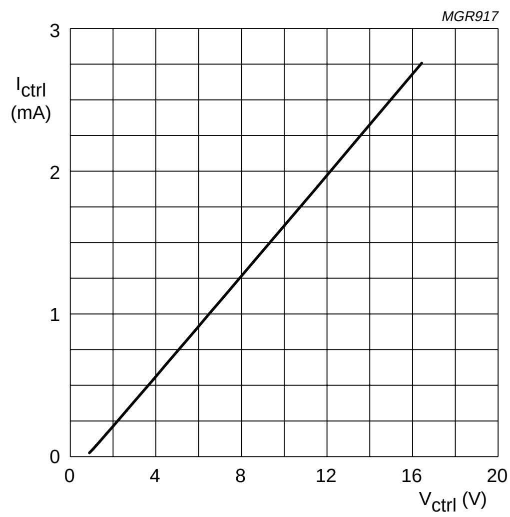

Fig.5 I_{ctrl} as function of control voltage with R2 = 5.1 k.

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