



## Philips Semiconductors B.V.

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## IMPROVED IP3 BEHAVIOUR OF THE 900MHz LOW NOISE AMPLIFIER WITH THE BFG425W

*UPDATE OF REPORT RNR-T45-96-B-771*

### **Abstract:**

This application note contains an example of a Low Noise Amplifier with the new BFG425W Double Poly RF-transistor. The LNA is designed for a frequency  $f=900\text{MHz}$ ,  $V_{\text{SUP}}\sim 3.8\text{V}$ ,  $I_{\text{SUP}}=10\text{mA}$ . *Measured* performance at  $f=900\text{MHz}$ : Noise Figure  $\text{NF}\sim 1.7\text{dB}$ , gain  $S_{21}\sim 17\text{dB}$  and the *input*  $\text{IP3}=+3\text{dBm}$ .

**Appendix I:** 900MHz LNA circuit

**Appendix II:** Printlayout and list of used components & materials

**Appendix III:** Results of simulations and measurements



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### Introduction:

With the new Philips silicon bipolar double poly BFG400W series, it is possible to design low noise amplifiers for high frequency applications with a low current and a low supply voltage. These amplifiers are well suited for the new generation low voltage high frequency wireless applications. In this note an example of such an amplifier will be given. This amplifier is designed for a working frequency of 900MHz.

### Designing the circuit:

The circuit is designed to show the following performance:

transistor: BFG425W

$V_{ce}=2V$ ,  $I_c=10mA$ ,  $V_{SUP}\sim 3.5V$

freq=900MHz

Gain~18dB

NF<=1.6dB

IP3>0dBm (input)

VSWR<sub>i</sub><1:2

VSWR<sub>o</sub><1:2

In the simulations the effect of extra RF-noise caused by the SMA-connectors was omitted, so in the practical situation the NF is ~0.1 dB higher. This LNA is also optimised for the highest IP3. The IP3 can be optimised by:

- I. an extra series C-decoupling of the base to the ground
- II. increasing  $I_c$

With the solution I. an extra component is necessary, and with solution II, the Noise Figure of the LNA increases and the optimum source impedance also.

The in- and output matching is realised with a LC-combination. Also extra emitter-inductance on both emitter-leads ( $\mu$ -strips) are used to improve the matching and the Noise Figure.

### Designing the layout:

A lay-out has been designed with HP-MDS. Appendix II contains the print layout.

### Measurements:

Simulations (with realistic RF-models of all used parts) and measurements of the total circuit (epoxy PCB) are done (Appendix III).

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### Appendix I: Schematic of the circuit

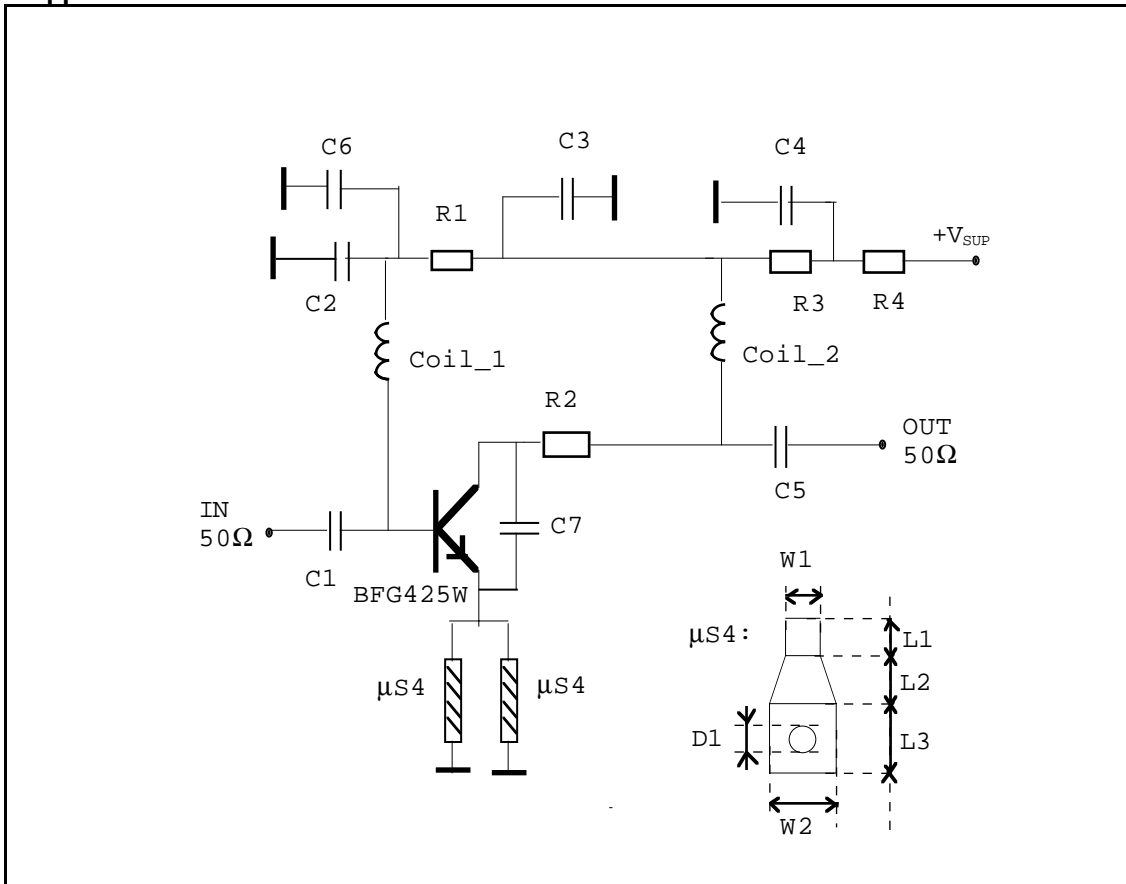


Figure 1: LNA circuit

#### 900MHz LNA Component list: 900MHz LNA Component list:

Component	Value	Purpose, comment
R1	8.2 kΩ	Bias (coll.-base)
R2	10 Ω	in series with coll. for better S22, stability and reducing gain.
R3	22 Ω	RF blocking
R4	150 Ω	Bias, series with coll., canceling hFE spread
C1	8.2 pF	Input match (input to base)
C2	27 pF	900 MHz short (L1 to ground)
C3	27 pF	900 MHz short (L2 to ground)
C4	100 nF	RF decoupling collector bias
C5	22 pF	Output match (collector to output)
C6	100 nF	To improve IP3 (by decoupling LF IP3 products)
C7	3.3 pF	Output match, stability (collector to emitter)
Coil_1	22 nH	Input match (base-bias)
Coil_2	12 nH	Output match (collector-bias)
μs4	(see next table)	μ-stripline Emitter-induction



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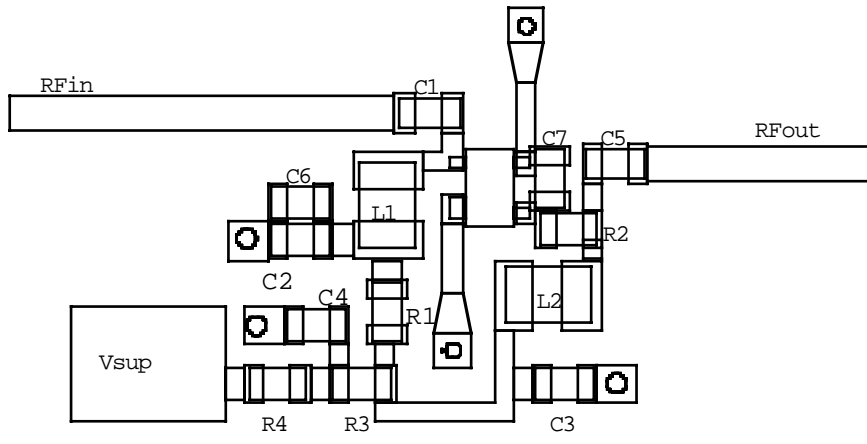
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$\mu$ S4 Emitter inductance of  $\mu$ -stripline and via-hole (see on formerpage: Schematic of the circuit):

Name	Dimension	Description
L1	2.5mm	length $\mu$ -stripline; $Z_0 \sim 48\Omega$ (PCB: $\epsilon_r \sim 4.6$ , $H=0.5\text{mm}$ )
L2	1.0mm	length interconnect stripline and via-hole area
L3	1.0mm	length via-hole area
W1	0.5mm	width $\mu$ -stripline
W2	1.0mm	width via-hole area
D1	0.4mm	diameter of via-hole

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### Appendix II: Printlayout and list of used components & materials



900MHz LOW NOISE AMP.

Figure 2: Printlayout

#### 900MHz LNA Component list:

Component:	Value:	size:
PCB	FR4: $\epsilon_r \sim 4.6$	H=0.5mm
R1	8.2 k $\Omega$	0603 Philips
R2	10 $\Omega$	0603 Philips
R3	22 $\Omega$	0603 Philips
R4	150 $\Omega$	0603 Philips
C1	8.2 pF	0603 Philips
C2	27 pF	0603 Philips
C3	27 pF	0603 Philips
C4	100 nF	0805 Philips
C5	22 pF	0603 Philips
C6	100 nF	0805 Philips
C7	3.3 pF	0603 Philips
L1	22 nH	0805CS Coilcraft
L2	12 nH	0805CS Coilcraft



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### Appendix III: Results of simulations and measurements

Conditions:  $V_{SUP}=3.7V$ ,  $I_C=10mA$ ,  $f=900MHz$

	Simulation (HP-MDS):	Measurements PCB:	Comment:
$ S_{21} ^2$ [dB]	17.2	17.3	
$ S_{12} ^2$ [dB]	-28.0	-28.3	
VSWR <sub>i</sub>	2.2	2.5	
VSWR <sub>o</sub>	1.7	1.8	
Noise Figure [dB]	1.6	1.7	note 1
IP3 [dBm] (input)	+1.3	+3	$\Delta f=200KHz$ , note 2

note 1: The Noise Figure of the PCB is higher than the simulations (~0.1 dB). This is caused by the influence of the SMA-connectors and the microstrips on the epoxy PCB.

note 2: The IP3 of the PCB is higher than the simulations. This can be explained by the deviation of the Spice parameters, used in the IP3 simulations, from the sample transistor-parameters used in the LNA.

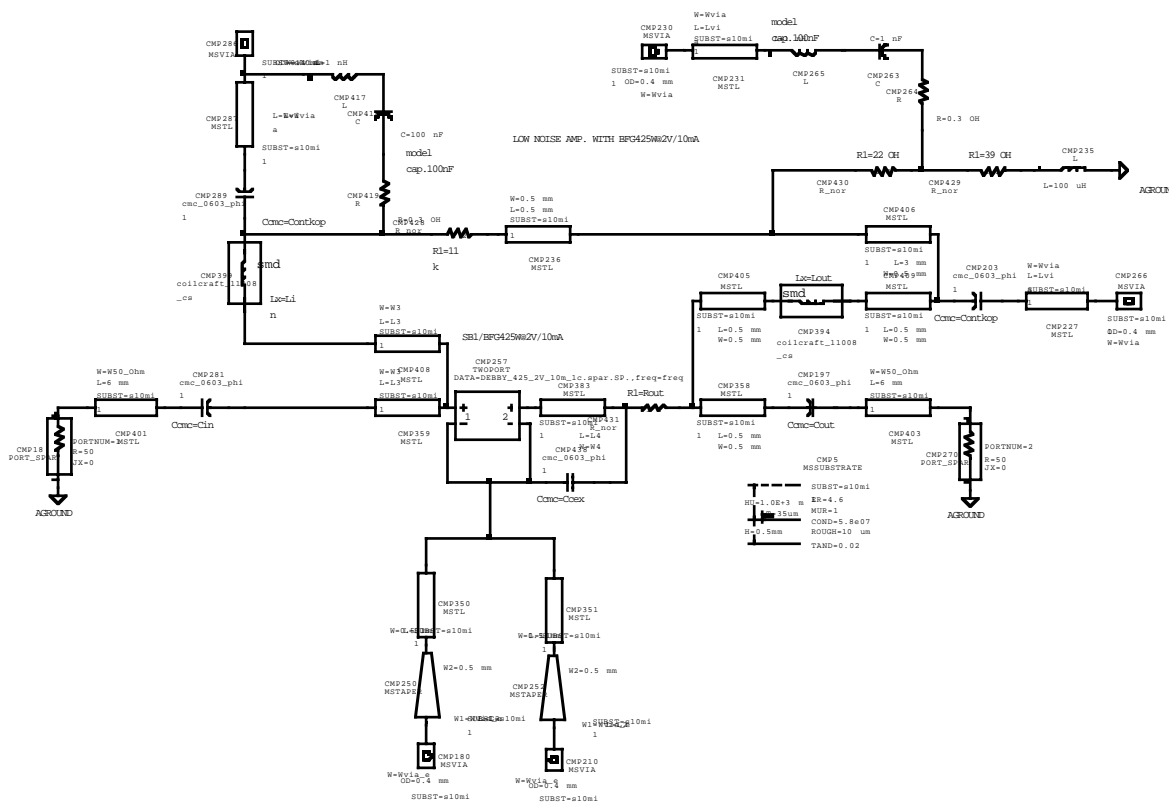


Figure 3: HP-MDS simulation circuit

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