Philips Semiconductors B.V.

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900MHz LOW NOISE AMPLIFIER WITH THE BFG410W

Abstract:
This application note contains an example of a Low Noise Amplifier with the new BFG410W Double Poly RF-transistor. The LNA is designed for a frequency f=900MHz. The Noise Figure NF~1.4dB at f=900MHz and the gain S_{21} ~14dB.

Appendix I: 900MHz LNA circuit

Appendix II: Printlayout and list of used components & materials

Appendix III: Results of simulations and measurements

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 a first study 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: BFG410W

V_{ce}=2V, I_c=2mA, V_{SUP}~3.3V
freq=900MHz
Gain~15dB
NF<=1.3dB
VSWRi<1:2
VSWRo<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 ~0.1dB higher. This LNA is not optimised for the highest IP3. The IP3 can be optimised by:

I. an extra series RC-decoupling of the base to the ground
II. increasing I_C

With the solution I. two extra components are necessary, and with solution II, the Noise Figure of the LNA increases and the optimum source impedance also.

The in- and outputmatching is realised with a LC-combination. Also extra emitter-inductance on both emitter-leads (µ-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 printlayout.

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

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Appendix I: Schematic of the circuit

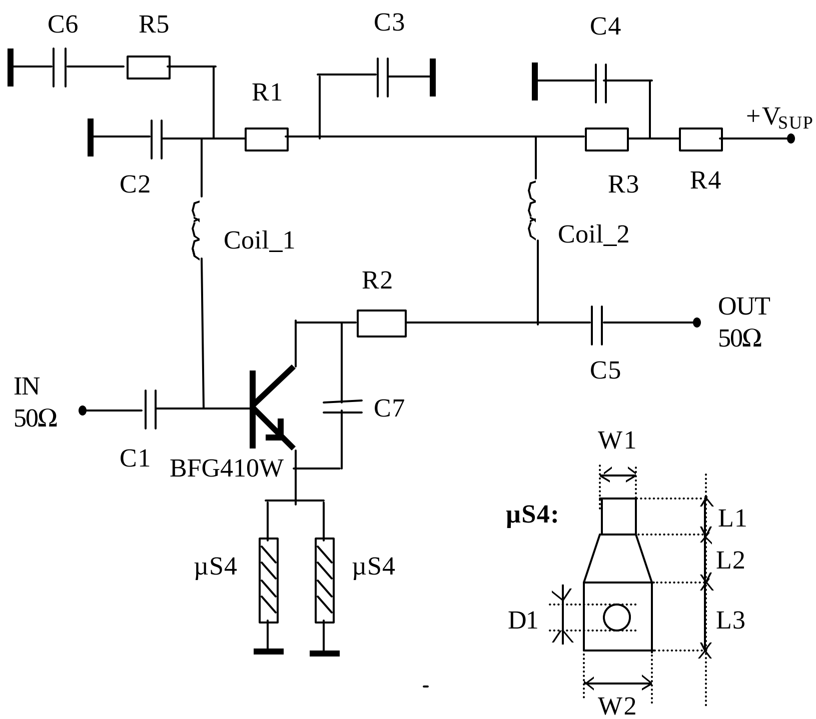

Figure 1: LNA circuit

900MHz LNA Component list:

Component:	Value:	Comment:
R1	47 KΩ	Bias.
R2	120 Ω	Better RF-stability (K>1).
R3	22 Ω	RF-block.
R4	560 Ω	Cancelling H_{FE}-spread.
R5	100 Ω	To improve IP3-performance
C1	2.2 pF	Input match.
C2	27 pF	900MHz short.
C3	27 pF	900MHz short.
C4	1 nF	RF-short
C5	1.5 pF	Output match.
C6	100 nF	To improve IP3-performance
C7	0.47 pF	Better RF-stability (K>1).
Coil_1	12 nH	Input match.
Coil_2	15 nH	Output match.
µs4	(next table)	Emitter induction: µ-stripline + via

μS4 Emitter induction (μ-stripline + via):

Name	Dimension	Description
L1	2.0mm	length μ-stripline; Z_0~48Ω (PCB: ε_r ~4.6, H=0.5mm)
L2	1.0mm	length interconnect stripline and via-hole area
L3	1.0mm	length via-hole area
W1	0.5mm	width μ-stripline
W2	1.0mm	width via-hole area
D1	0.4mm	diameter of via-hole

Appendix II: Printlayout and list of used components & materials

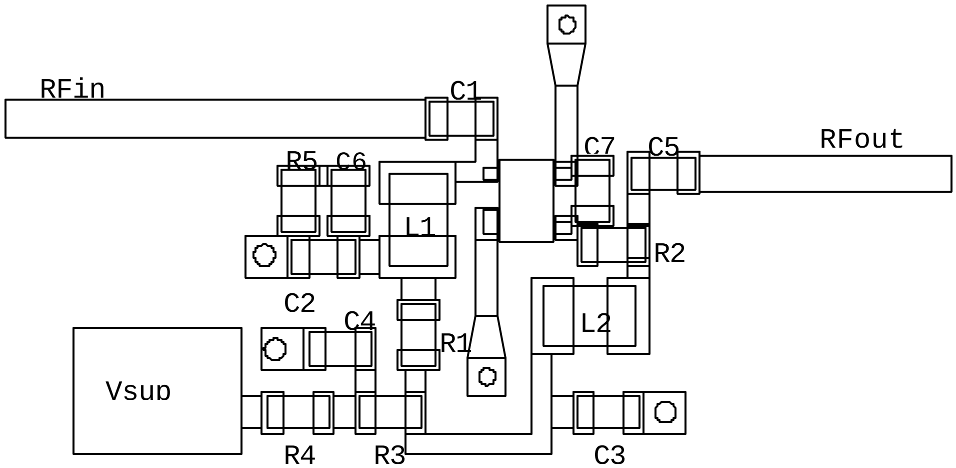

Figure 2: 900MHz LOW NOISE AMP. PRINT LAYOUT

Component list:

Component:	Value:	size:
R1	47 KΩ	0603 Philips
R2	120 Ω	0603 Philips
R3	22 Ω	0603 Philips
R4	560 Ω	0603 Philips
R5	100 Ω	**0805 Philips**
C1	2.2 pF	0603 Philips
C2	27 pF	0603 Philips
C3	27 pF	0603 Philips
C4	1 nF	0603 Philips
C5	1.5 pF	0603 Philips
C6	100 nF	**0805 Philips**
C7	0.47 pF	0603 Philips
L1	12 nH	0805CS Coilcraft
L2	15 nH	0805CS Coilcraft
PCB	ε_r~4.6, H=0.5mm	FR4

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Appendix III: Results of simulations en measurements

BFG410W, V_{CE}=2V, I_C=2mA:

	Simulation (HP-MDS):	Measurements PCB:	Comment:
$\|S21\|^2$ [dB]	14.6	14.0	
VSWRi	2.0	1.9	
VSWRo	2.4	2.3	
Noise Figure [dB]	1.3	1.4 *)	
IP3 [dBm] (input)	-	-9	Δf=100KHz

*) : 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 epoxi PCB.