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Report nr. : RNR-T45-97-B-0789
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Date : 30th of September 97
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2GHz LOW NOISE AMPLIFIER WITH THE BFG410W

update of report RNR-T45-96-B-772

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 $f=2\text{GHz}$. The Noise Figure $NF\sim 1.7\text{dB}$ at $f=2\text{GHz}$ and the gain $S_{21}\sim 14\text{dB}$.

Appendix I: Schematic of the 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 a first study of such an amplifier will be given. This amplifier is designed for a working frequency of 2GHz.

Designing the circuit:

The circuit is designed to show the following performance:

transistor: BFG410W

$V_{ce}=2V$, $I_c=2mA$, $V_{SUP}\sim 3.3V$

freq=2GHz

Gain~14dB

NF<=1.7dB

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 output matching 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 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

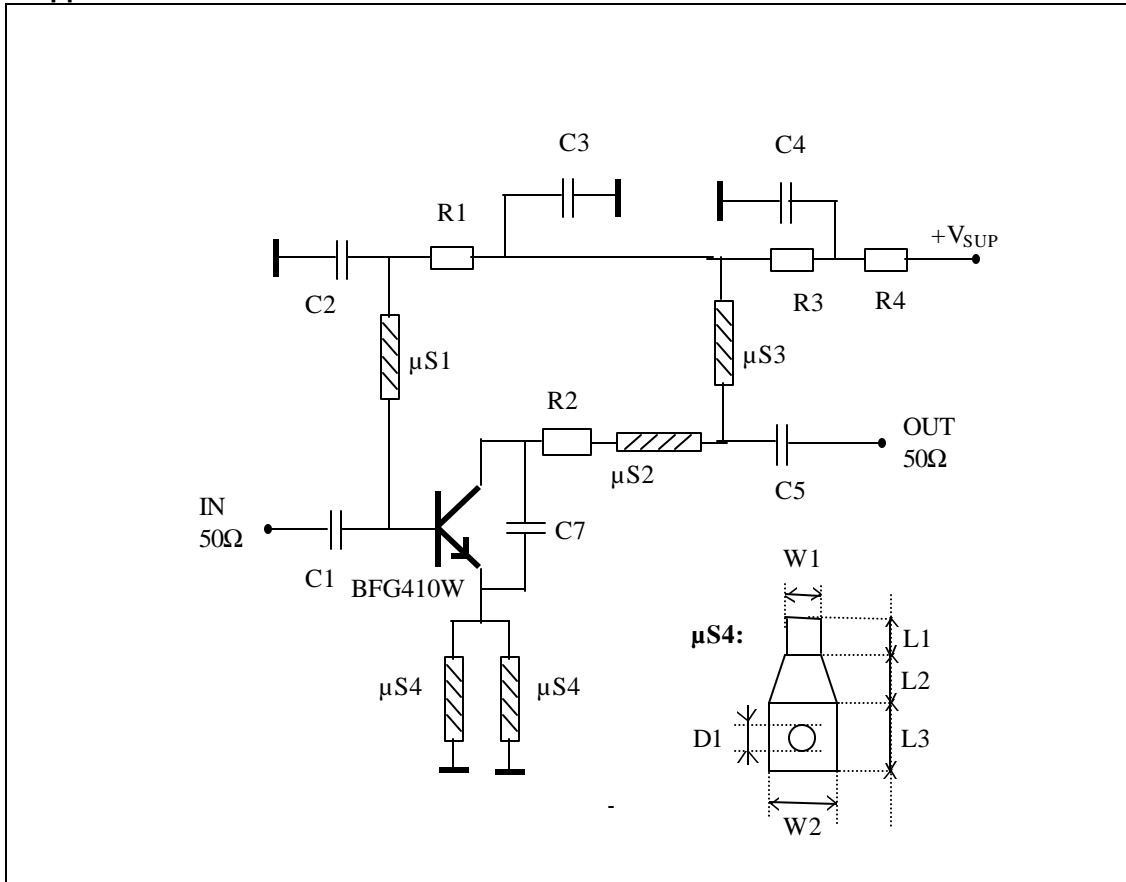


Figure 1: LNA circuit

2 GHz LNA Component list:

Component:	Value:	Comment:
R1	47 KΩ	Bias.
R2	10 Ω	Better RF-stability ($K > 1$).
R3	22 Ω	RF-block.
R4	560 Ω	Cancelling H _{FE} -spread.
C1	1 pF	Input match.
C2	5.6 pF	2GHz short.
C3	5.6 pF	2GHz short.
C4	1 nF	RF-short
C5	3.3 pF	Output match.
C7	0.47 pF	Better RF-stability ($K > 1$).
μs1	W=0.25mm	μ-stripline Z ₀ ~95Ω (PCB: ε _r ~4.6, H=0.5mm)
μs2	W=0.25mm	μ-stripline Z ₀ ~95Ω (PCB: ε _r ~4.6, H=0.5mm)
μs3	W=0.25mm	μ-stripline Z ₀ ~95Ω (PCB: ε _r ~4.6, H=0.5mm)
μs4	(next table)	Emitter induction: μ-stripline + via

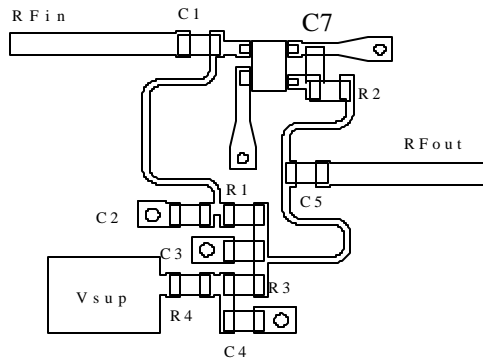
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μ S4 Emitter induction (μ -stripline + via):

Name	Dimension	Description
L1	2.0mm	length μ -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 μ -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



2 GHz LNA
BFG410W

Figure 2: Printlayout

2GHz LNA Component list:

Component:	Value:	size:
R1	47 K Ω	0603 Philips
R2	10 Ω	0603 Philips
R3	22 Ω	0603 Philips
R4	560 Ω	0603 Philips
C1	1 pF	0603 Philips
C2	5.6 pF	0603 Philips
C3	5.6 pF	0603 Philips
C4	1 nF	0603 Philips
C5	3.3 pF	0603 Philips
C5	0.47 pF	0603 Philips
PCB	$\epsilon_r \sim 4.6$, H=0.5mm	FR4

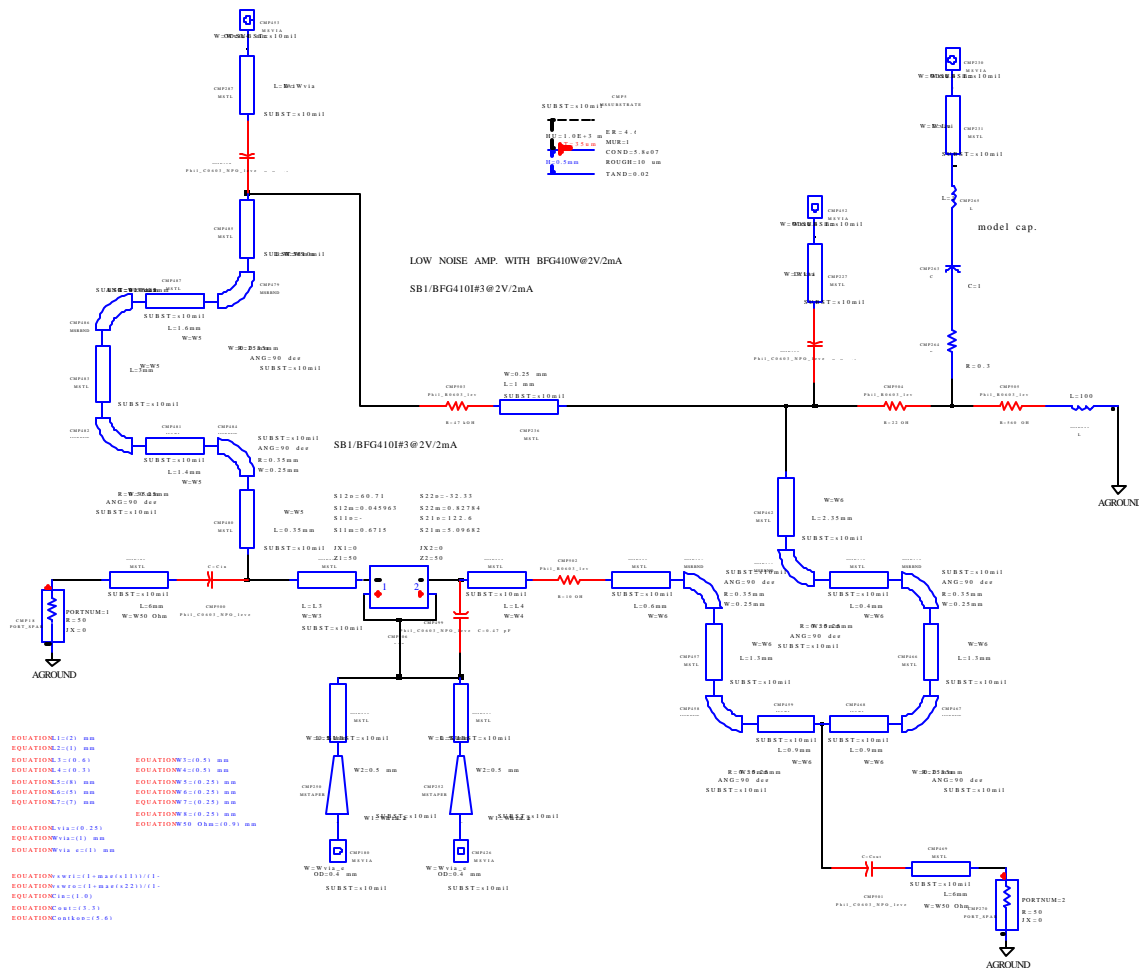
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Appendix III: Results of simulations and measurements:

BFG410W, $V_{sup}=3.3V$, $V_{CE}=2V$, $I_C=2mA$:

	HP-MDS Simulation: S-par.	HP-MDS Simulation: SPICE-model	Measurements PCB:	Comment:
$ S_{21} ^2$ [dB]	14.2	14.6	14.3	
$ S_{12} ^2$ [dB]	-24.6	-27.4	-29.5	
VSWRi	2.6	2.1	2.2	
VSWRo	1.3	1.3	2.1	
Noise Figure [dB]	1.6	1.8	1.7	
IP3 [dBm] (output)	-	-	-	not measured

Figure 3: HP-MDS simulation circuit



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