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400MHz LOW NOISE AMPLIFIER WITH THE BFG540W/X

Abstract:

This application note contains an example of a Low Noise Amplifier with the BFG540W/X RF-transistor. The LNA is designed for a frequency $f=400\text{MHz}$, $V_{\text{SUP}}=3.0\text{V}$, $I_{\text{SUP}}\sim 7.5\text{mA}$.

Measured performance at $f=400\text{MHz}$: Noise Figure $\text{NF}\sim 1.0\text{dB}$, rf-Gain $S_{21}\sim 15.5\text{dB}$, Input_IP3 $\sim 2\text{dBm}$

Applications: LNA for a 400MHz CDMA system (Chinese market).

Appendix I: 400MHz LNA circuit

Appendix II: Printlayout and list of used components & materials

Appendix III: Results of simulations and measurements



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Introduction:

With Philips silicon wideband transistors, it is possible to design low noise amplifiers for UHF-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 400MHz.

Designing the circuit:

The circuit is designed to show the following performance (target):

transistor: BFG540W/X

$V_{ce}=2V$, $I_c<10mA$, $V_{SUP}=3.0V$.

freq=400MHz

Gain~15dB

NF<1.5dB

Input_IP3>+0dBm

VSWR_i<1:2

VSWR_o<1:2

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

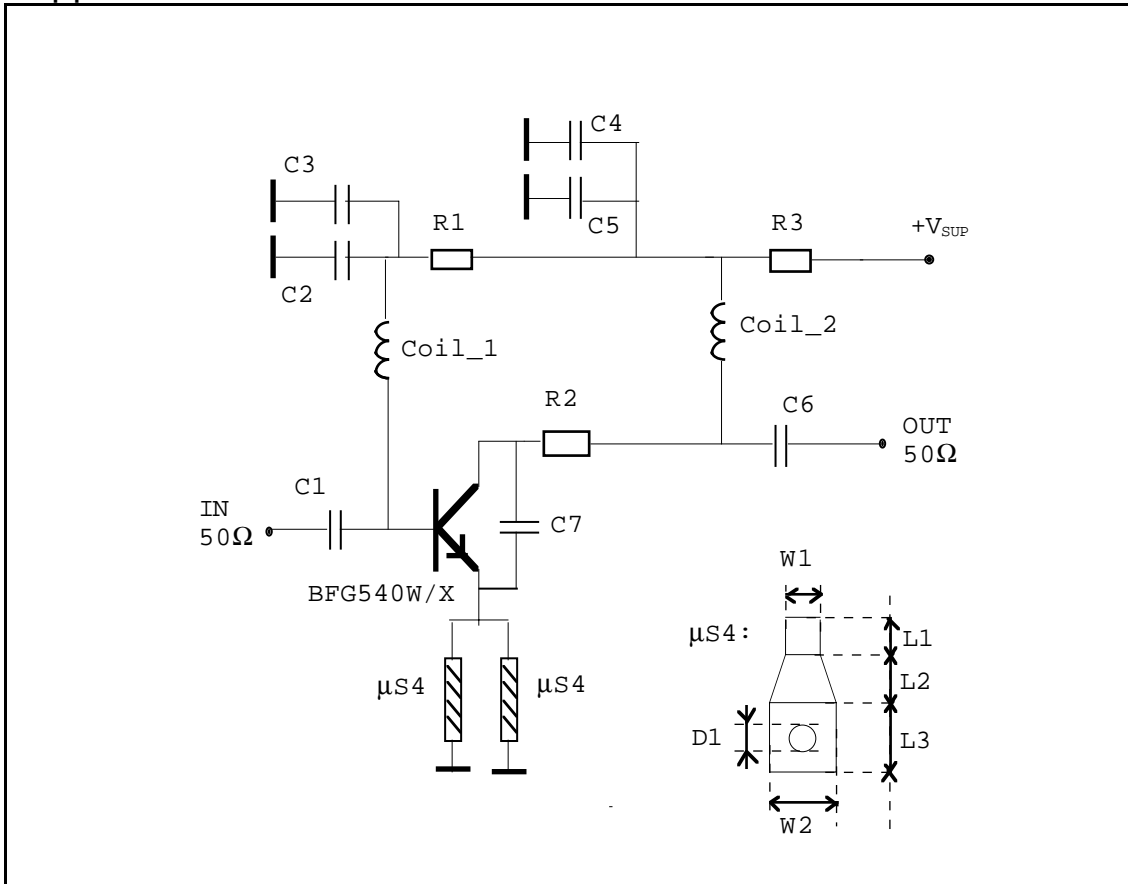


Figure 1: LNA circuit

400MHz LNA Component list: 400MHz LNA Component list:

Component	Value	Purpose, comment
R1	22 k Ω	Bias (coll.-base)
R2	22 Ω	in series with coll. for better S22, stability and reducing gain.
R3	100 Ω	Bias, series with coll., cancelling h_{FE} spread
C1	150 pF	Input match (input to base)
C2	150 pF	400MHz short (L1 to ground)
C3	22 nF	LF-short, improving IP3 performance
C4	22 nF	LF-short, improving IP3 performance
C5	150 pF	400MHz short (L2 to ground)
C6	8.2 pF	Output match (collector to output)
C7	4.7 pF	Output match, stability (collector to emitter)
Coil_1	22 nH	Input match (base-bias)
Coil_2	22 nH	Output match (collector-bias)
μ s4	(see next table)	μ -stripline Emitter-induction



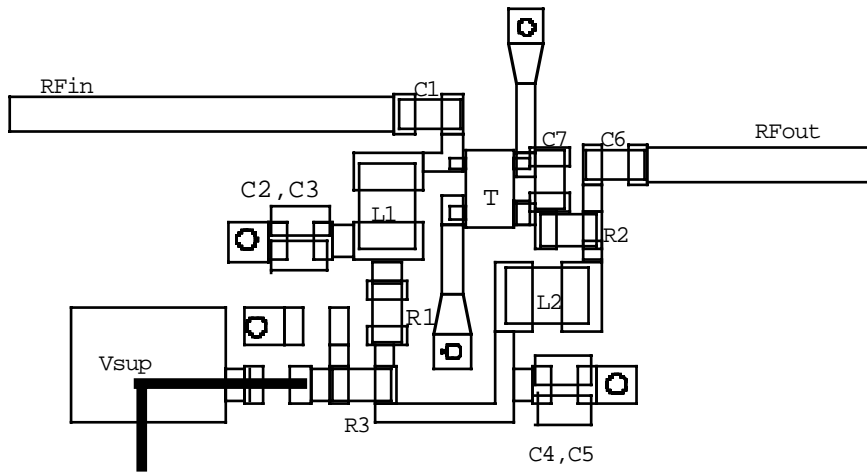
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μ S4 Emitter inductance of μ -stripline and via-hole (see on formerpage: Schematic of the circuit):

Name	Dimension	Description
L1	2.5mm	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



400MHz LOW NOISE AMP.

Figure 2: Printlayout

400MHz LNA Component list:

Component:	Value:	size:
PCB	FR4: $\epsilon_r \sim 4.6$	H=0.5mm
R1	22 k Ω	0603 Philips
R2	22 Ω	0603 Philips
R3	100 Ω	0603 Philips
C1	150 pF	0603 Philips NPO
C2	150 pF	0603 Philips NPO
C3	22 nF	0603 Philips X7R
C4	22 nF	0603 Philips X7R
C5	150 pF	0805 Philips NPO
C6	8.2 pF	0603 Philips NPO
C7	4.7 pF	0603 Philips NPO
Coil_1	22 nH	0805CS Coilcraft
Coil_2	22 nH	0805CS Coilcraft
T	BFG540W/X	SOT343



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Appendix III: Results of simulations and measurements

Conditions: $V_{SUP}=3.0V$, $I_{SUP}=8mA$, $f=400MHz$

	Simulation HP-MDS	Measured Performance	Comment:
f=400MHz	BFG540W/X SPICE model		
$ S_{21} ^2$ [dB]	15.5	15.6	note 1
$ S_{12} ^2$ [dB]	-26.2	-28	note 1
VSWRi	1.7	1.8	note 1
VSWRo	1.6	2.0	note 1
Noise Figure [dB]	1.3	1.0	note 2
Input_IP3 [dBm]	+6.7	+2	$\Delta f=1MHz$, note 3

note 1: Circuit is stable for all frequencies.

note 2: The Noise Figure of the PCB is lower than the simulations (~0.3 dB). This difference is caused by the SPICE-model of the BFG540W/X, which is not optimised for noise.

note 3: The Input_IP3 of the PCB is lower than the simulations (~4 dBm). This difference is caused by the SPICE-model of the BFG540W/X, which is not optimised for IP3.