Aalto University
School of Electrical
Engineering

S-26.3120 Radio Engineering, Laboratory Course
Lab IV: Microwave transistor amplifier design

Sathya Venkatasubramanian,
Clemens Icheln

03.03.2014

firstname.lastname@aalto.fi

Learning objective

- To design, fabricate and measure a single stage microwave transistor amplifier (LNA).
- At the end of the laboratory, the students will be able to
  - Understand the theory and mathematical background in designing microwave transistor amplifiers (also from RF & MW Engineering course).
  - Use software design tools (Agilent ADS) to design and simulate basic circuits.
  - Design the amplifier considering practical constraints and be able to generate the final design for fabrication.
  - Perform measurements and able to correlate the theory and practice.

Outline

- Project motivation and overview
- Time frame
- Group specification
- Work flow
- Pre-design
- Transistor amplifier design preview
- Simulation in Agilent Advanced Design System (ADS)
- Measurements
- Final Report

Laboratory overview

- Radio Engineering laboratory course – the last and most important assignment
  - Assignment weight - 33% of overall grading
  - Each group – 2/3 students

- Design, building and measurement of Field Effect Transistor (FET) low-noise amplifier (LNA)
  - Simulation software *Agilent Advanced Design System* (ADS)
  - Design of prototype LNA and evaluation.

- Pre-study and final report
  - Pre-study must be submitted to proceed with computer aided design (individual pre-study report) (submit via email to sathya.venkatasubramanian@aalto.fi).
  - Final report includes results of preliminary design, CAD simulations, prototype details and measurement results (1 report / group).
  - The final report should be in Master's thesis format

Time frame

Contact sessions	Schedule
Introductory lecture	Monday 03-03-2014 (9 – 10 AM)
ADS Demo (F402)	Friday 21-03-2014 (1 – 4 PM)

Deadlines/ measurements	Date
Pre study	17.03.2014 (16:00)
Design Layout	17.04.2014 (16:00)
Building in RAD workshop (tentative)	05.05 - 09.05
Measurement in RAD lab (tentative)	12.05 – 16.05
Final report	**Fri 30.05.14 (12:00)**

- **Be aware of the strict time schedule !!**

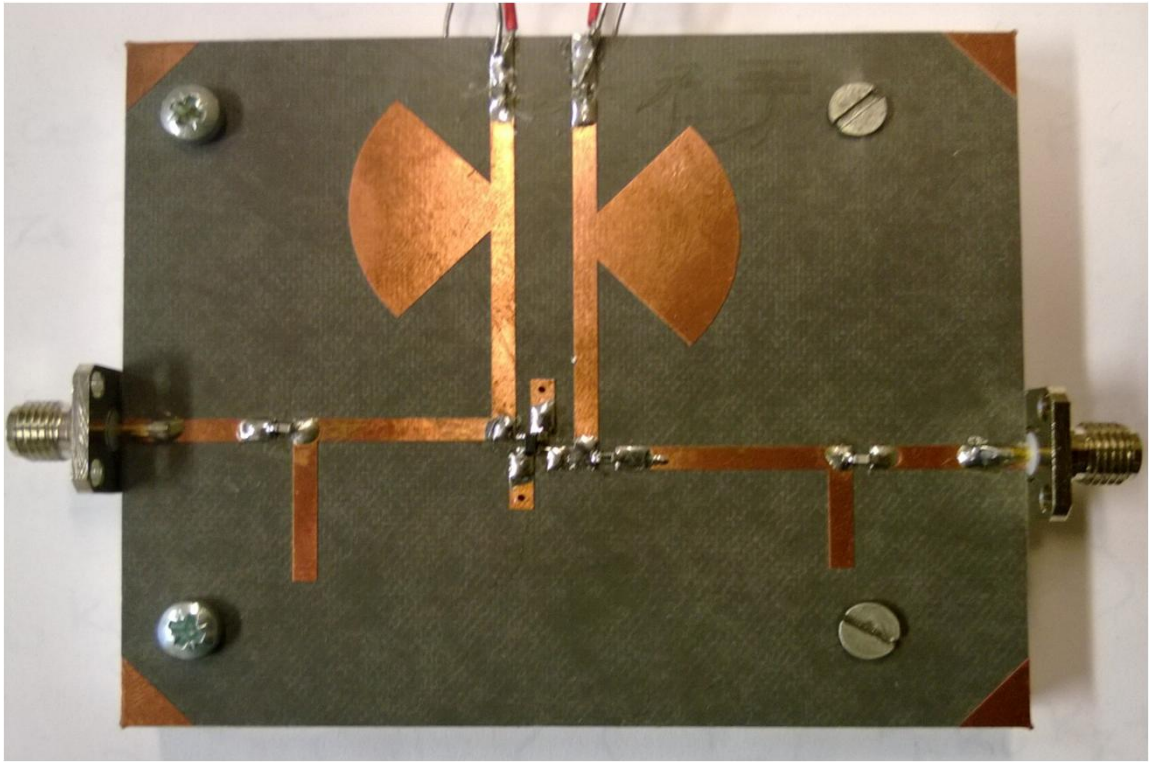
Design task

To design a single stage LNA at 2.5 GHz with the following specifications:
Transistor used: Avago Technologies ATF-35143 pHEMT
PCB : RT Duroid 5870, Height = .787 mm.

Group	Operating frequency (GHz)	Bias point (V_{DS}, I_{DS})	Gain (dB) Min.	Min. Noise figure (dB)	Return loss, S11 (dB) Min.
1	2.5	2V, 30 mA	13	0.8	15
2	2.5	2V, 15 mA	12	0.8	15
3	2.5	3V, 30 mA	14	1	15
4	2.5	3V, 15 mA	13	1	15

Note: The specifications indicate minimum requirements. Try to optimize your design to further improve gain/ decrease noise figure.
Detailed instructions available in lab manual uploaded in Noppa.

Sample amplifier



Work flow

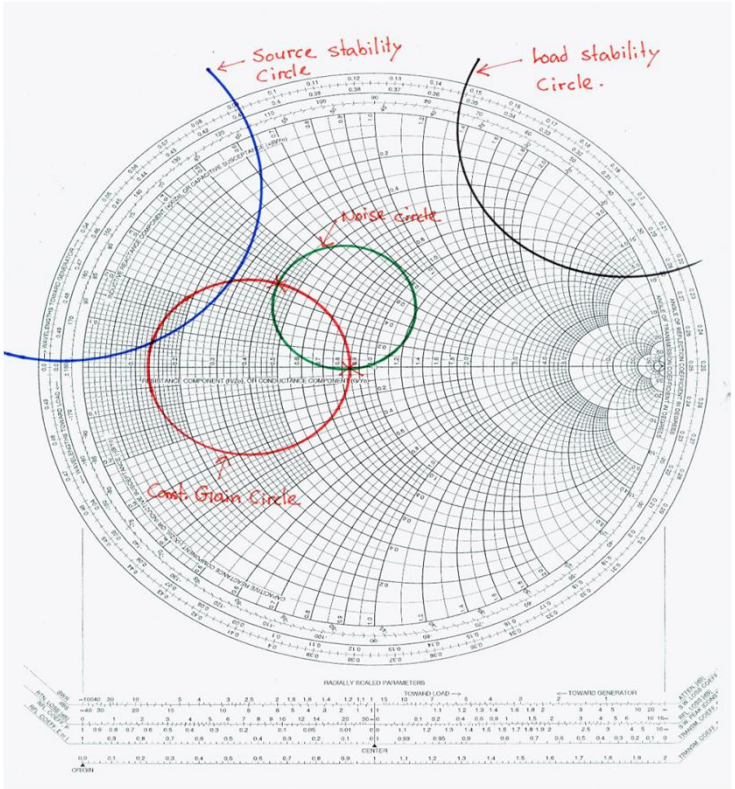
- Pre-design
- Using ADS
  - Circuit design
  - Simulation
  - Optimization
  - Layout
- Manufacturing
  - Export the layout in Gerber format
    (for PCB manufacturing outside Aalto, requires strict schedules)
- Measurement
  - S-parameters
  - 1 dB compression point
  - Third-order intercept point
  - Noise figure
- Final report

Pre-design

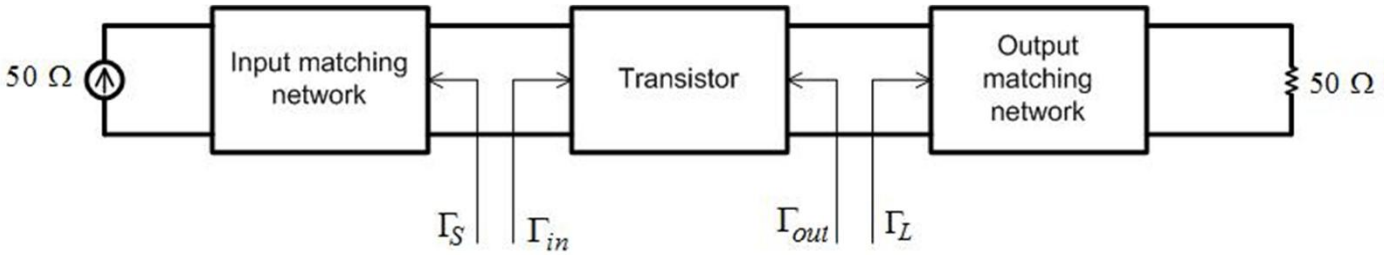
- Tasks (Detailed instructions available in Noppa)
  - Answer the questions given in the pre-study document.
  - Perform analytical calculations and design the matching network and draw the complete amplifier circuit.
    - Draw the input and output stability circles.
    - Draw the gain and noise circles.
    - Suitable choice of reflection coefficient at the input and the output for the given specification (Check the stability).
    - Design the input and output matching network.
    - Sketch of the tentative circuit diagram of the complete amplifier circuit (showing the matching circuitry).

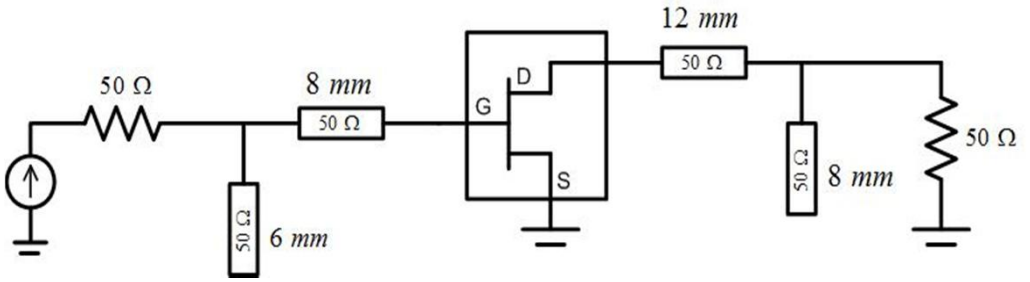
    (You can use MATLAB RF toolbox for drawing various circles)
- On agreement, meetings with the course assistant are possible during the preparation of the pre-design.

Sample stability, gain & noise circles

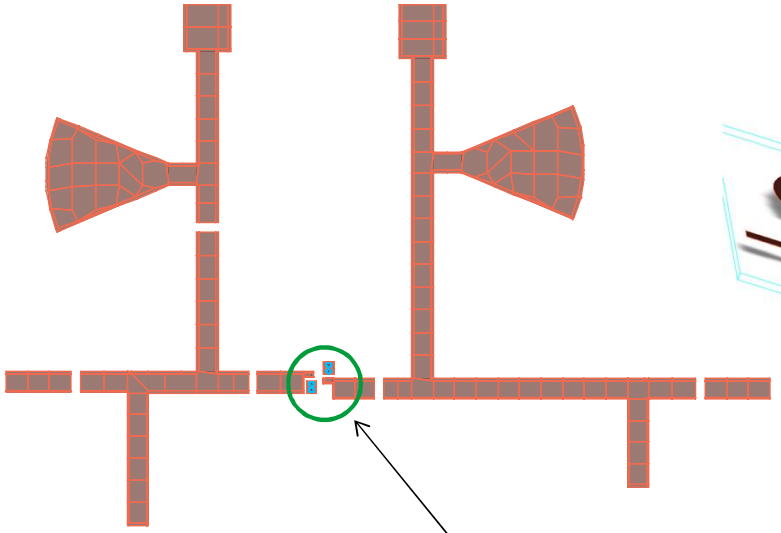


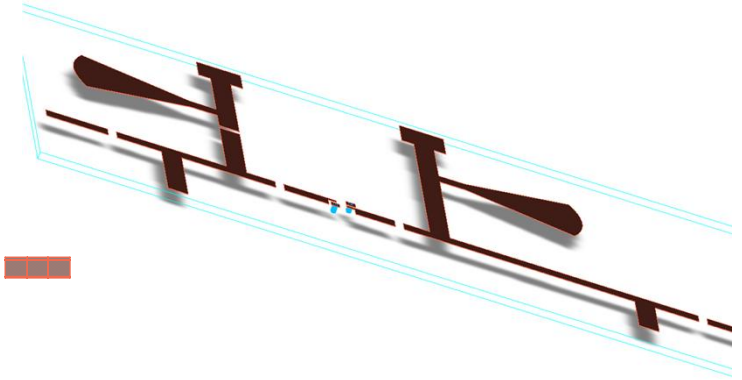
Transistor amplifier design preview





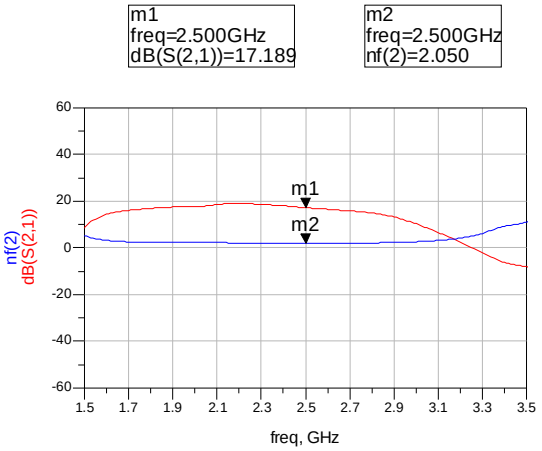
ADS: Final layout

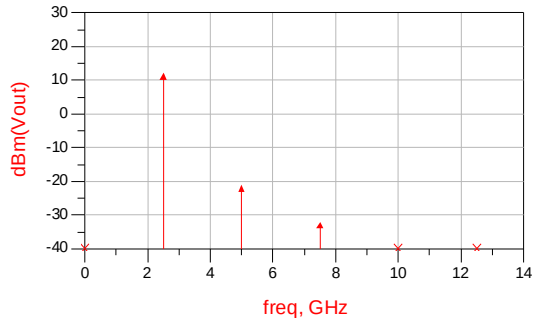


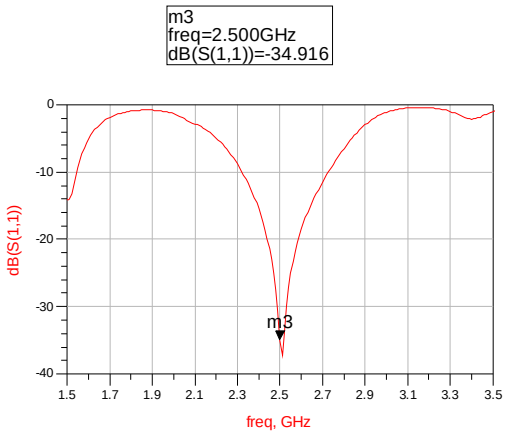


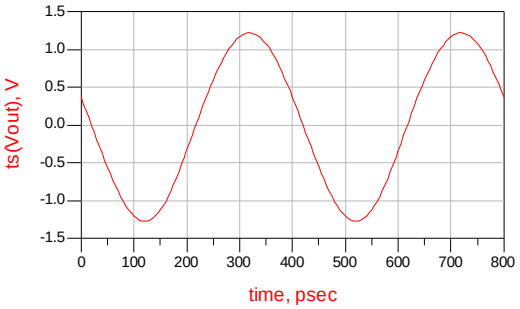
Transistor foot print

Simulation Results



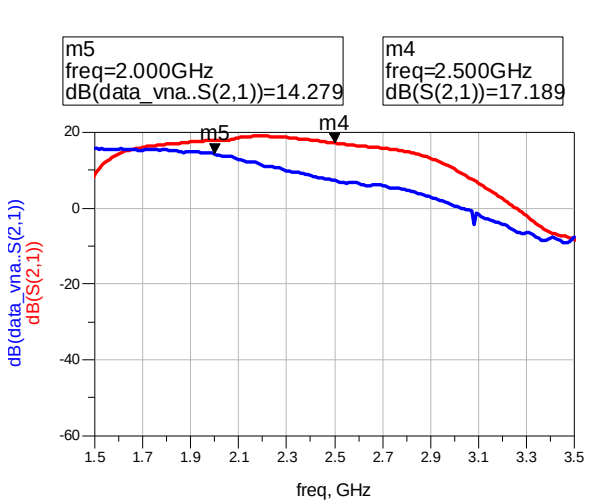


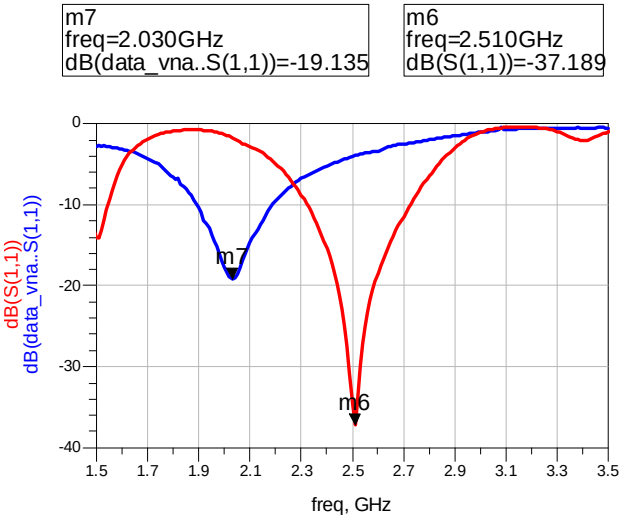




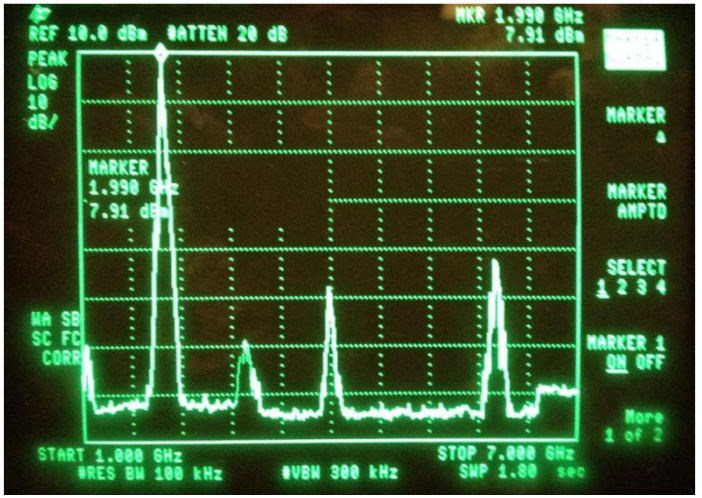
It is encouraged to perform HB simulation!!

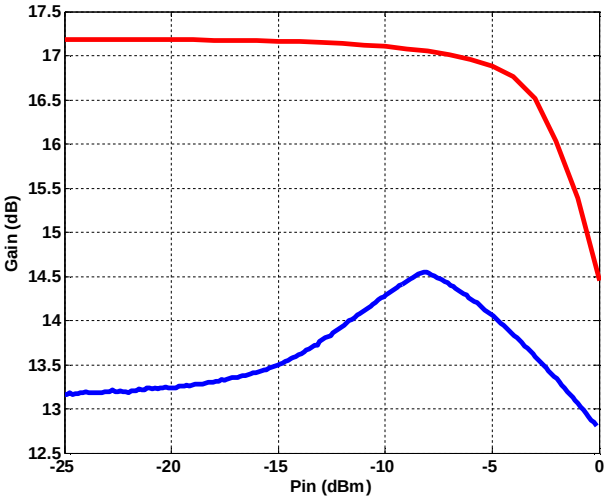
Comparison (Measurement and Simulation)





Comparison (Measurement and Simulation)





Final Report

- Final report should contain at least
  - Introduction
  - Brief theory of transistor amplifier
  - Pre-design (include smith chart)
  - Detail description of simulation work in ADS
  - Measurement procedure
  - Comparison between measurement and simulation results
  - Most important, comments on the results
  - Conclusions
  - Feedback