



Aalto University
School of Electrical
Engineering

S-26.3120 Radio Engineering, laboratory course
Spring 2014

Instructions for Lab 4:
Microwave transistor amplifier design

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Microwave transistor amplifier design

1. Introduction:

The design of a microwave transistor amplifier is the last part of the laboratory course in Radio Engineering (S-26.3120). The aim of this work is to design, build and test a single stage low-noise microwave amplifier (LNA), based on AVAGO's low-noise pseudomorphic HEMT (pHEMT) transistor, ATF-35143. The designing will be performed with the help of Agilent Technologies' Advanced Design System (ADS) software.

The work is done in a team of three students. Each group gets their own amplifier design specifications, which are for the parameters noise figure, operating frequency, and gain. For these individual parameters, see the course website in Noppa (introductory lecture slides). The course assistant supervises and if needed directs the progress of the work.

First, a pre-design of the amplifier is made and returned to the course assistant. After the assistant has approved the preliminary design, the next step is to realize the design with help of ADS, which is available in the school's computer class room F402. The pre-designed amplifier is simulated and optimized with ADS, and also with ADS a PCB layout is created for the optimized amplifier circuit. The layout is sent (by the assistant) to an external circuit board manufacturer who produces the individual circuit boards for each group. Once the PCB is manufactured, the students solder transistors, capacitors, connectors and other components onto the circuit board. This is done in the workshop of the Department of Radio Science and Engineering, room C328. The students then evaluate their ready amplifier by measuring the scattering or S-parameters, the 1-dB compression point, the 3rd order inter-modulation product and the noise. In the final report students summarize and comment the results from their final design and measurements.

Pre-study and the final report must be submitted separately, as they are scored separately. Each person submits an individual pre-study report and the final report is submitted for each group. Reports can be prepared with any word processing program/ LATEX.

2. Schedule:

Due to the tight schedules and the use of an external company, the student groups must proceed in accordance with the following time frame. (If changes should occur in the schedule, this will be informed by e-mail to students, on the course homepage in Noppa, and bulletin board.)

- ✓ Introductory briefing: **Room C124, Mon 03.03.2014 at 09:00.**
- ✓ Submission of pre-design, by **17.03.2014 at 1600 hrs.**
- ✓ Introduction with ADS Simulation: **Room F402, Fri 21.03.2014 at 1300 hrs.**
- ✓ Designing and complete layout (in Gerber format): **17.04.2014 at 1600 hrs.**
(→ Sent to PCB manufacturer)
-Two week time for manufacturing
- ✓ Building the amplifier (tentative): **05.05.2014 – 09.05.2014**
- ✓ Measurements (tentative): **08.05.2014 – 16.05.2014**
- ✓ The final report by **Fri 30.05.2014 at 1600 hrs.**

The time schedule is very strict and any delay by you will affect your grade!!

3. Designing consideration:

The preliminary stage of the amplifier design is carried out with text-book formulas and using the Smith chart. In this particular design the AVAGO's ATF-35143 pHEMT, FET transistor is used. The transistor data sheet and S-parameters are attached. The S-parameters for the given operating point of the frequency is used in the pre-design. The PCB material used is **RT-Duroid 5870** (Cu 1.0 oz/ft²), where $\epsilon_r = 2.33 \pm 0.02$, $h = 0.787 \pm 0.003$ mm, $t = 35$ μ m, and $\tan\delta = 0.0012$ up to 10 GHz, the smallest microstrip width that can be manufactured is 0.3 mm and the smallest through hole size diameter is 0.7 mm. Consider the manufacturing inaccuracy when selecting strip widths, the higher the impedance the narrower the strip and a larger the effect of inaccuracies. For this reason, avoid the use of very narrow lines (<0.4 mm). The size of the circuit board is 70×85 mm.

4. Pre-design

A pre-design report should be prepared answering the questions given in the pre-study document and should include the following things:

- ✓ Stability evaluation at the operating frequency
- ✓ Choice of appropriate reflection coefficients in the input and the output of the transistor
- ✓ Distributed element matching circuit (choice of suitable type).
- ✓ A preliminary sketch of the circuit diagram (see the introductory slides)

For detailed knowledge of transistor amplifier design please go through the reference [1] and files uploaded in Noppa. Before returning the pre-report it is possible to agree (by e-mail) on 1-2 meetings with the course assistant, so that he can guide the progress of the amplifier design and make sure that the project progresses correctly. The pre-report is returned to the course assistant, Sathya Venkatasubramanian (room C230) by email at sathya.venkatasubramanian@aalto.fi.

Reference:

- [1] David M. Pozar, "Microwave Engineering", 3rd edition, John Wiley & Sons, Inc., NY.
- [2] Guillermo Gonzalez, "Microwave Transistor Amplifiers : Analysis and Design", 2nd edition, Prentice Hall.