Course info — E7009E

Joakim Nilsson

September 25, 2017

1 Introduction

This course presents advanced topics in electrical engineering. These include Fourier transform, electrical noise, SPICE simulators, distortion, feedback, A/D and D/A converters, power supplies, DC-DC converters, heat and reliability, see Table 2. The topics are presented in the form of lectures which teach the student the necessary skills to pass the laboratory and project parts of the course. The laboratory part consists of three laboratory assignments, see Table 3, and a project. The lectures, labs and project sessions are organised as in Table 1. We start with all five lectures and all three labs in the first three weeks and then begin working on the project in which we build an audio power amplifier.

1.1 Lab 2

Lab 2 is quite extensive and you will need to prepare your simulations before the lab session, so that you can start with the lab measurements right away.

2 Project

The goal of the project is to build an audio power amplifier. You will work in groups of two students per group (with one exception with a three-student group if there are an odd number of students).

The specifications for your amplifier are presented in Table 4 while the available components are presented in Table 5.

Table 1: Course organisation

week	**activities**
1	lecture 1
2	lectures 2 and 3, lab 1
3	lectures 4, labs 2 and 3
4	lecture 5, 1 spare lecture, 2 project sessions
5	2 project sessions
6	2 project sessions
7	2 project sessions
8	1 project session, project presentation

Table 2: Lectures

lecture no.	**activities**
1	course introduction, Fourier transform, electrical noise, SPICE simulators
2	audio amplifiers, distortion
3	feedback
4	power supplies, DC-DC converters, heat, reliability
5	analogue-to-digital and digital-to-analogue converters
hline	

Table 3: Labs

lab no.	**activities**
1	hierarchical design and SPICE syntax
2	electrical noise
3	PCB design in KiCad

Starting from course week 4, there are 2 scheduled project sessions with lab assistant(s) each week. There is, however, a super high probability (>99.95 %) that you will need to put more time into it during unscheduled hours.

You are required to make a project plan which are to be discussed with me (Joakim Nilsson) before the first project session. My recommendation is to start booking (send an email to joanil@ltu.se) no later than course week 2 and have the meeting either during course week 2 or 3. The plan is to be followed up through 4 weekly reports in the form of **short** texts that are uploaded to canvas. In these reports which you state what has been done, and by whom, during the week and if there are deviations from the project plan.

In the last week of the course, you will hold a 10-minute presentation were you demonstrate what you have done, discuss measured and simulated results, let us listen to your amplifier and talk about eventual problems that arose.

You are required to send in a report summarising measured and simulated results, eventual deviations as well as schematics, plots and motivations for design decisions. Deadline the 27$^{\text{th}}$ of October.

In regards to manufacture of circuit boards, you should upload gerber files on Canvas before Thursday, the 28$^{\text{nd}}$ of September 23:59 (hard deadline). If you do not meet this deadline, we will not have your PCB manufactured and you will have to do your design on breadboard or with nails on a wooden piece, which is much more tedious and will reduce the performance of your amplifier. An alternative would be to manufacture your own PCB at XP-el, but we highly recommend that you follow this deadline because much time will be needed to build and debug your amplifier. We also recommend that the designs be done a little earlier than this date, so we can have a look at it and point out potential problems with the design. The maximum dimensions for your PCB is 35 cm.

The available components are all those present in the electronics lab and the components presented in Table 5. The corresponding data sheets are available at elfa.se.

Table 4: Audio amplifier specifications

property	**value**	Sim	Meas
sensitivity	1 V (RMS)	1V +	1.44Vpp +
input impedance	47 kΩ	47k	47k
output power	30 W	30W	28.8W
bandwidth	20 Hz - 20 kHz (±1.5 dB)	19.7Hz - 21.2kHz	5.3Hz - 140kHz
slew rate	>5 V/µs	6.3V/us	4 V/us
SNR	>100 dB		60.1 dB
supply voltages	±24 V		
THD, 1 kHz, 1 W	<0.008 %		
THD, 1 kHz, 10 W	<0.02 %		
THD, 1 kHz, 30 W	<0.1 %		

Table 5: Available components, E = Elfa, F = Farnell

part no.	**description**
E: 143-49-926	C14 plug
E: 175-59-248	heat sink, 0.51 K/W
E: 175-59-881	heat conductive disc
F: 1675073	transformer, 230 V to 2×18 V
E: 167-54-147	electrolytic capacitor, 22 000 µF, 35 V DC
E: 170-00-173	bridge rectifier, KBPC604
E: 160-63-937	power resistor, 0.22 Ω, 5 W
E: 160-32-875	power resistor (to simulate speaker), 6.8 Ω, 50 W
E: 164-74-233	potentiometer, 1 kΩ
E: 171-14-929	power NMOS, IRF530NPBF
E: 171-16-353	power PMOS, IRF9530NPBF
E: 171-04-102	power NPN, BD135G
E: 171-04-094	power PNP, BD136G
E: 171-01-460	NPN, BC546B
E: 171-00-034	PNP, BC556B
E: 142-70-088	audio jack socket
E: 142-20-388	RCA sockets

Table 6: Reading recommendation

chapter	
1-5	introductory chapters — interesting, but not essential
6	the input stage
7	the VAS
9-11	the output stage

3 Recommended reading

The course literature for this course is "Audio Amplifier Design, 6^{th}" by Douglas self. The initial chapters are interesting, but not essential if you attend the lectures. I recommend that you at least skim a bit in them. Chapters that are more essential when designing the different stages are presented in Table 6.

For the interested student, here are some further reading recommendations:

- For an introduction to JFETs: Bonus topics pdf availible on the CD accompanying "Microelectronic circuits" by Sedra and Smith
- The noise chapter in "The art of electronics" by Horowitz and Hill

4 Summary

In summary, in order to pass the course, you shall:

- Pass all three laboratory assignments.
- Build and an audio amplifier with the specifications outlined in Table 4.
- Hold a presentation about your amplifier.
- Send in 4 weekly progress reports.
- Send in a report about your amplifier.

Note that the grading is carried out on an individual level, so it must be stated in the weekly reports who has done what.