

ELECTRONICS 365 PRACTICAL 1 – DIFFERENTIAL AMPLIFIER

17 – 20 AUGUST 2020

INTRODUCTION:

Practical 1 is due on the 20th August at 17:00. This practical has both a spice submission and a practical report. These two submissions must be called 12345678.cir and 12345678.pdf respectively (replacing 12345678 with your student number).

For this practical you will need to use Ngspice version 3.2 which can be downloaded from SUNLearn. The necessary spice files provided for this practical are:

- models.cir – contains 5 different BJT transistor models.
- Prac1Test1.cir – Testbench for MODEL 1.
- Prac1Test2.cir – Testbench for MODEL 2.
- Prac1Test3.cir – Testbench for MODEL 3.
- Prac1Test4.cir – Testbench for MODEL 4.
- Prac1Test5.cir – Testbench for MODEL 5.
- Diffamp_ex.cir – Template for the spice submission.

AIM & REQUIREMENTS:

The aim of this practical is to design and simulate a BJT differential amplifier (including current source) that meets certain Common-Mode gain, Differential-Mode gain and Common-Mode Rejection Ratio requirements. You may use any of the BJT current sources covered in this course for your design.

There are five variations of this practical with different requirements. Each variation requires the use of a different model from the models.cir file and has a different testbench. You may only use the transistor model assigned to you for your design. The variation you are assigned is determined by the last number in your student number according to the table below.

Table 1: Practical Requirements

STUDENT NO. ENDING IN	MODEL	TESTBENCH	MINIMUM A_{CM}	MINIMUM A_d	MINIMUM $CMRR_{dB}$
0 OR 6 OR 8	MODEL 1	Prac1Test1.cir	-5×10^{-5}	19	111.6
1 OR 7	MODEL 2	Prac1Test2.cir	-6×10^{-5}	15.8	108.4
2 OR 3	MODEL 3	Prac1Test3.cir	-8×10^{-5}	13.5	104.5
4 OR 9	MODEL 4	Prac1Test4.cir	-1×10^{-4}	11.7	101.4
5	MODEL 5	Prac1Test5.cir	-2×10^{-4}	10.0	94.7

EXAMPLE: Student number 12368095 will use MODEL 5 from models.cir and the testbench Prac1Test1.cir. They must design their differential amplifier to achieve a minimum A_{CM} of -2×10^{-4} , a minimum A_d of 10.0 and a minimum $CMRR_{dB}$ of 94.7 dB.

All necessary information about the transistors is included in the .model statements in the models.cir file (no datasheets are required for the design of the circuit). The testbench provides power supplies of $V_{CC} = 10$ V and $V_{EE} = -10$ V to the circuit as well as all other voltages necessary to determine A_d , A_{CM} and $CMRR_{dB}$. You may not include any voltage sources of any type in your design.

SPICE SUBMISSION & TESTBENCH:

A template for the spice file submission is given on SUNLearn (Diffamp_ex). Please use this template and replace only the highlighted sections with your own code:

```
-----
* SPICE model for differential amplifier
* -----
* Surname: Your surname
* First name: Your first name
* Student number: Your student number
* -----
.include models.cir

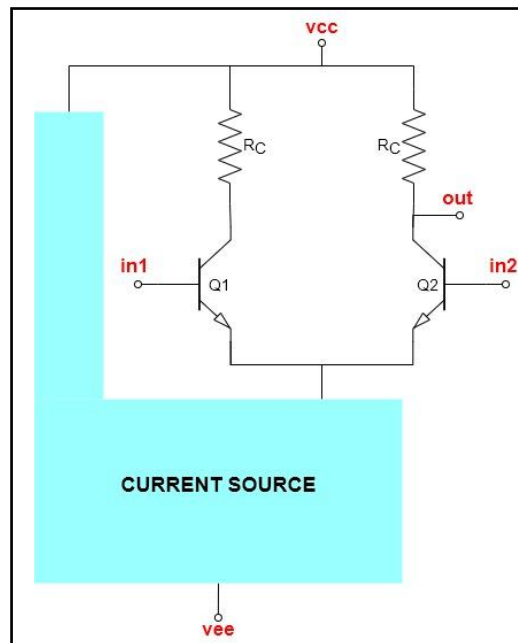
* Define differential amplifier as a subcircuit
.subckt diffamp in1 in2 out vcc vee

* ----- Start of student code -----

* Differential Stage
RC1 vcc nvc1 100
RC2 vcc out 100
Q1 nvc1 in1 nve MODEL1
Q2 out in2 nve MODEL1

* Current source
R1 nve vee 40k

* ----- End of student code -----
.ends
-----
```



The testbench requires certain nodes in your circuit to have specific names. These nodes are shown in red on the diagram above. If the nodes are not named correctly, the testbench will fail to run. The testbench includes the line “.include yourstudentnumber.cir”. In order to test your circuit, replace

“yourstudentnumber” with your student number (the name of your spice file) and run the testbench in Ngspice.

REPORT

The practical report must include:

- All theoretical calculations. Include calculations of the differential and common-mode input resistances
- A discussion on any fine tuning of theoretical values to meet the requirements.
- A comprehensive comparison of all theoretical and simulated results. Where results differed from the expected values, discuss why they may have differed.
- Include a plot of the voltage transfer curve (v_{out} against v_d) from spice simulation. Discuss this plot.

Your theoretical calculations may be handwritten, however, they must be neat and logically laid out. All other sections of the report must be typed.

MARKS

There are 10 marks available for this practical. Five marks are available for the SPICE submission:

- 2 marks for achieving the required Differential Gain.
- 2 marks for achieving the required Common-Mode Gain.
- 1 mark for achieving the required Common-Mode Rejection Ratio.

Five marks are available for the practical report:

- 2 marks for the theoretical calculations.
- 2 marks for the results comparison.
- 1 mark for the voltage transfer curve and discussion.

IMPORTANT NOTES:

- If your spice submission does not run through the testbench you will receive 0 for it.
- DO NOT INCLUDE ANY VOLTAGE SOURCES IN YOUR SUBMISSION. The required voltages will be supplied by the testbench. You will receive 0/5 for the spice submission if you include your own voltage sources.
- DO NOT INCLUDE THE .MODEL STATEMENT IN YOUR SUBMISSION. The necessary models are provided in the separate models.cir file that is included in your submission with the line “.include models.cir”. You will receive 0/5 for the spice submission if you include the .model statement.
- If the spice submission does not correspond with the report – specifically if differences between theoretical values and spice values aren’t addressed – then the report mark will be penalized.
- PLEASE ENSURE YOU USE THE CORRECT MODEL AND TESTBENCH. The spice marking is automated and if you use the incorrect model or testbench then your submission will not be marked correctly.
- START EARLY. You are unlikely to finish the practical report to a high-enough standard if you only start during Thursday’s practical session.