Circuit Theory and Electronics Fundamentals

Lab 4: Audio Amplifier

Audio Amplifier Circuit

$R_s = 100\Omega$

12V Supply Voltage (Vcc)

Audio
IN
Max: 10mV

+

-

Gain
Stage

Output
Stage

Audio
OUT

8Ω Speaker
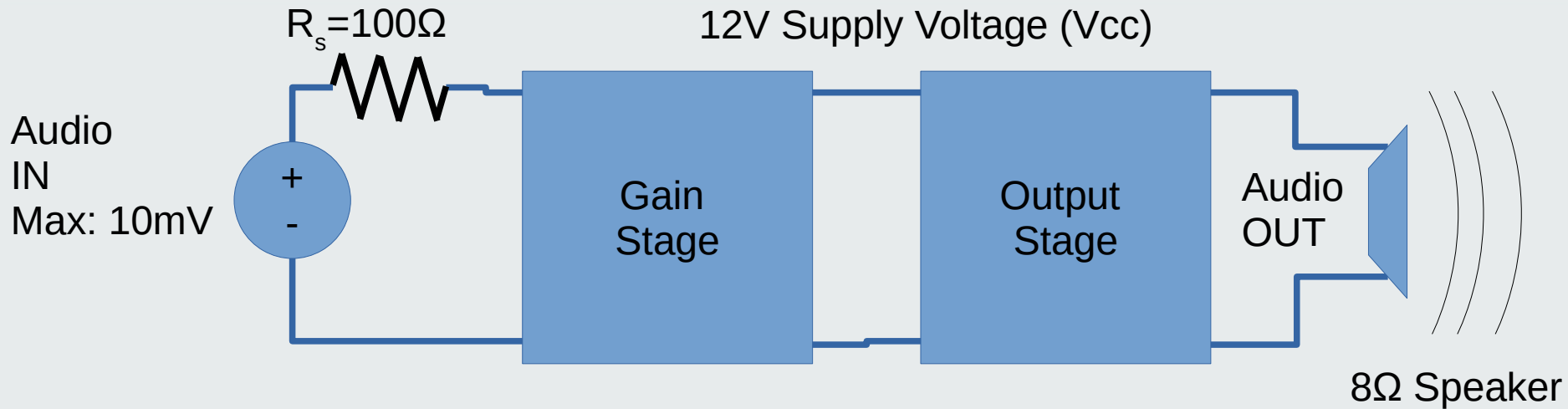
Based on Lectures 16 and 17, choose the architecture of the Gain and Output amplifier stages. Provided the output has no visible distortion of the input sine waves, the merit M of your work is given by

$$M = \frac{voltageGain * bandwidth}{cost * lowerCutoffFreq}$$

cost = cost of resistors + cost of capacitors + cost of transistors
cost of resistors = 1 monetary unit (MU) per kOhm
cost of capacitors = 1 MU/µF
cost of transistors = 0.1 MU per transistor

Simulation Analysis

- Write an Ngspice script to simulate the audio amplifier. Start with the provided script

- Use the provided transistor models: the gain stage must use the NPN transistor and the output stage must use the PNP transistor

- Measure the output voltage gain in the passband, the lower and upper 3dB cut off frequencies (the difference between them is the bandwidth), the input and output impedances

- Perform incremental modifications to improve the merit figure
  - Make sure the BJTs operate in the F.A.R. ($V_{CE} > V_{BE}$) by means of a suitable O.P. (For the PNP, $V_{EC} > V_{EB}$)
  - Understand the purpose of the coupling capacitors and their effect on the bandwidth
  - Understand the purpose of the bypass capacitor and its effect on the gain
  - Understand the effect of resistor R_C on the gain

Theoretical Analysis

1) Compute the OP using the theoretical DC model studied. Compare it to Ngspice's OP and explain.

2) Compute the gain, input and output impedances separately for the 2 stages, and explain why they can be connected without significant signal loss.

3) Compute the frequency response $V_o(f)/V_i(f)$, using the incremental circuit, solving the circuit for a frequency vector in log scale with 10 points per decade, from 10Hz to 100MHz.

Lab report

1) Produce all tables and plots required in the simulation and analysis sections
2) Compare Octave and Ngspice results <u>side by side</u> looking for accuracy or discrepancy, and explaining both. Read the repository's README file.
3) The results of interest are, obviously,

   - the gain's frequency response

   - input /output impedances to support the driver (input audio source) and load (speaker), respectively, adequately

   - the cost of the components used

Evaluation criteria

1) The instructor should *git pull* your repo, and run *make <u>flawlessly</u>*

2) The report should not have obvious mistakes in figures, tables, formulae, section titles or main sentences

3) 1 bonus point (mark can be 5 offsetting previous grade losses) for the 5% best merit figures

   - if your work is in the top 5%, expect a more thorough review