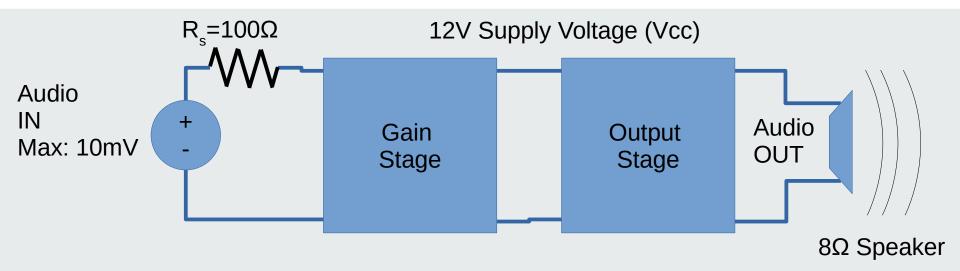


# Circuit Theory and Electronics Fundamentals

Lab 4: Audio Amplifier



### **Audio Amplifier Circuit**



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 =  $1 \text{ MU/}\mu\text{F}$ 

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<sub>c</sub> 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 V₀(f)/Vᵢ(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