Microelectronics ECSE 335

Laboratory No. 4

Design, Simulation and Validation of a Class AB Output Stage

Purpose:

Design, simulate and validate the operation of a class AB output amplifier using a discrete prototype involving commercially available BJT transistors.

Equipment Required:

a. Computer
b. SPICE Simulator (student choice)
c. Test Bench: DC Voltage supplies, Function Generator and Oscilloscope
d. Components:
    i. Student decision but must be available from the parts-master on the 4th floor service counter in the Trottier building.
    ii. It is suggested to assemble some of the circuit components prior to entering the laboratory to save time.

Write-Up Requirements:

A good laboratory report should contain a **brief** description of what the experiment was about, including circuit diagrams, and what you did, your data, your results, and anything else called for in the assignment, such as questions inserted in the laboratory description. Answers to these questions require observations that need to be made at the time you do the experiment.

While not always explicitly spelled out in any one laboratory, the use of SPICE should be used by the

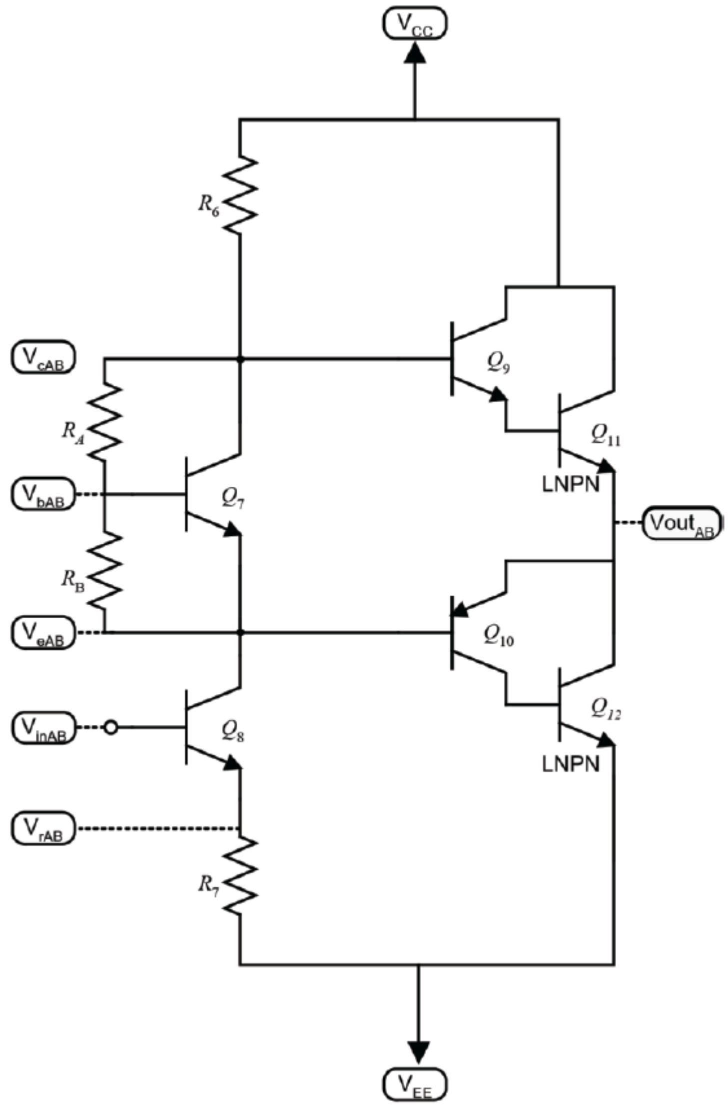

Figure 4.1: Class AB Output Stage

student to predict the experimental outcomes. SPICE results should be compared to that obtained by measurement, and any differences explained or justified.

The laboratory report should be written using the IEEE paper style consisting of a **double-column single-space format**, and must adhere to the following when necessary:

1. Title page - Title of the assignment/project, authors' name, and course name.
2. Abstract - Abstract of the assignment/project report.
3. Introduction
4. Main body of the assignment/project report including figures.
6. Conclusions

Table 4.1: Resistor components used.

Component	Value
R_6	
R_7	
R_A	
R_B	

7. References
8. Appendices

Class AB Output Stage

The circuit shown in Figure 4.1 is a quasi-complementary (uses a compound PNP-NPN) Class AB output stage, which is designed to provide high currents to a small output load, while remaining linear for large input signals. It also features a built-in gain that is provided by transistor Q_8. In addition, it uses a VBE multiplier circuit to bias the output transistor pairs correctly. If the two terminals of the VBE multiplier are shorted together, the circuit becomes a Class B output stage, as shown in Figure 4.2. Figure 4.3 shows the biasing circuit you will need to use when testing the output stage as standalone circuit. Another biasing approach will be used later on, when the circuit will be incorporated into the op-amp configuration.

Preparation

The student should make use of hand analysis and/or a circuit simulation tool such as SPICE to answer the following questions.

1. Get familiar with Chapter 12 in Sedra and Smith, 8th Ed.

2. Considering this circuit will be used as an output stage in an operational amplifier, what are the main characteristics that it must have?

3. Design the Class AB output stage circuit in Figure 4.1 by selecting the values of the resistors seen listed in Table 4.1. Check that the following specifications are met: the quiescent current (zero input signal) is 0.5 mA, and that the output stage is capable of supplying 6 Vp-p to a 330 Ω load without significant **visible** distortion, and the output stage provides a unloaded (disconnected load) gain of 10 V/V. Remember that when the circuit is tested alone, the biasing stage in Figure 4.3 needs to be used to interface the signal source to the amplifier input.

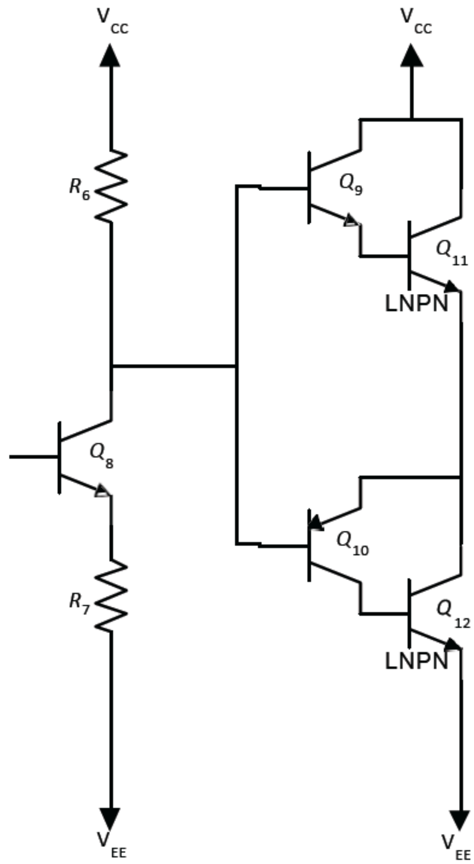

Figure 4.2: Modified Class-B Output Stage

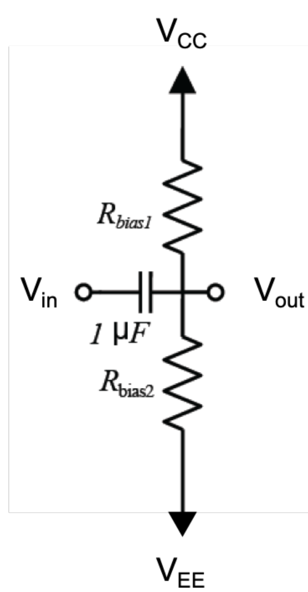

Figure 4.3: Input biasing network used for standalone output stage testing.

4. Determine the input resistance. Comment on how it is different compared to a small-signal amplifier.

5. Plot the frequency response and comment. Remember to include 5 pF parasitic capacitors to ground for each pin, and account for the parasitics of the oscilloscope.

6. Plot the voltage transfer characteristic, and then perform a transient analysis of both designed circuits. Document the maximal output range.

7. In summary, what are the advantages and limitations of the class AB output stage?

8. What is the purpose of transistor Q12?

9. What are the advantages and disadvantages of having an internal gain to the Class AB output stage, compared to having the bulk of the gain provided only by the differential pair?

Experiment

For the differential setup, perform the following in succession (make sure to use a 10X probe when required!):

Note: To avoid damage, observe the maximum power ratings of the transistors and set the current limits on the DC supply accordingly. The load of any circuit must have the capacity to dissipate the 'maximum' expected output power. Most resistors in the labs are rated at 250 mW at 25ºC. You may have to combine several resistors in parallel to meet the power dissipation specifications for the load.

For the Class AB output stage circuits, perform the following in succession with a 330 Ω load:

1. Assemble the circuit shown in Figure 4.1.

2. For the Class AB stage only, make note of the output DC offset with no input signal, and trim the resistors in the VBE multiplier to make the offset be as close to 0 V as possible (within 10 mV). Make sure to comment on the reasons of the discrepancy and why this correction is important both on the local output stage level, and then on the operational amplifier level.

3. Measure all DC voltages and infer the DC currents where possible. As for all results in this experiment, compare with expected (simulations and calculations) values.

4. Plot the transient response for a 6 Vp-p output. Comment on the output and maximum output

range.

5. Plot the voltage transfer characteristic of the circuit.

6. Plot the frequency response and find the 3-dB points. Use the 10X probe.

7. Measure the input resistance of the circuit.

This concludes this lab.