

UNIVERSITY OF UTAH
ELECTRICAL ENGINEERING DEPARTMENT

ECE 3110

LAB EXPERIMENT NO. 4
CLASS AB POWER OUTPUT STAGE

Objective: In this laboratory exercise you will build and characterize a class AB power output stage. This stage uses a complementary pair of bipolar transistors in the usual "push-pull" configuration. You are also to simulate this circuit using SPICE and compare your results with actual measurements.

Pre-Lab

Build and simulate each circuit below(there are 3) using PSpice. Use a 1V, 1kHz sinusoidal input signal when using the 1k load resistor and a 5V signal when using the 100 ohm load resistor. Print waveforms with the output and input on the same plot. Show at least 1 complete cycle. Also Print plots of the frequency response of the last amplifier from 10Hz to 1MHz. Use VSIN for the input voltage source when simulating time domain(transient) waveforms and VAC(or VSRC) for the AC sweep.

Required Parts for Part 1

- A complementary pair of bipolar transistors with higher power ratings. Those packaged in metal cans allow for higher heat dissipation. One such pair is the 2N2222A and the 2N2907 in TO-18 metal cans. For even more power handling, you can try the 2N2219 and 2N2905 in TO-39 metal cans.
- A standard 1k resistor to act as a load during initial testing and a 1 watt 100 ohm resistor for high power measurements.
- A 1uF capacitor

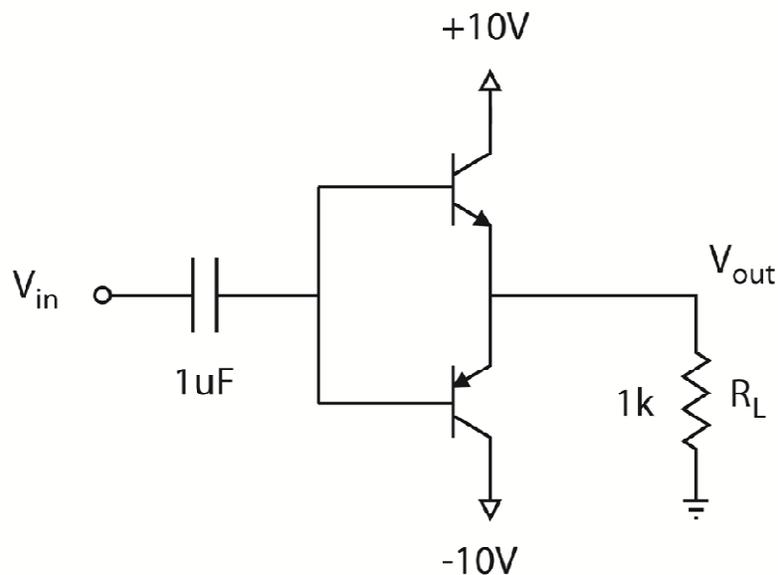


Fig. 1
Class B amplifier

Part 1

1. Construct the circuit as depicted in Fig. 1. Apply a 1V, 1kHz sinusoidal signal to the input and observe the output on the oscilloscope. Measure the peak voltage and sketch the waveform in your lab notebook. Based on the fact that the transistors are connected in the common collector layout, what would you expect V_{out} to be? How much smaller is the output voltage from the input?
2. Measure the average voltage across the load resistor and use this value to calculate the corresponding power dissipated in the load.
3. Now measure the total current drawn by the circuit while operating (be sure to measure the current for both + and - voltages) You can usually read this right off the power supply.
4. Increase the input voltage to 5 volts and replace the 1k load resistor with the 1 watt 100 ohm resistor. Repeat steps 2 and 3 for the new values.
5. Calculate the power efficiency of the amplifier using the values from 2 and 3. Then again with those obtained from 4. What is the efficiency of the Class B amplifier? Does it go up or down with voltage?

Additional Parts for Part 2

- 2 standard diodes such as the 1N4001. Any two will work, however make sure they have matching part numbers.
- Another 1 μ F capacitor
- 2 standard 1k resistors

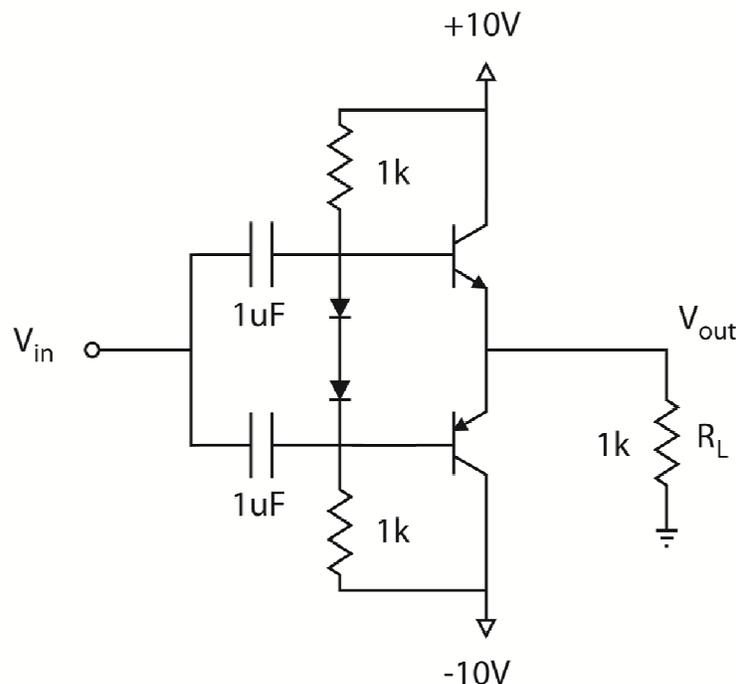


Fig. 2

Class AB amplifier

Part 2

In Part 1 you built a simple class B amplifier. Although simple and more power efficient than the rest of the amplifiers in this lab, Class B amplifiers suffer from severe cross-over distortion. This is due to the fact that the signal voltage must rise above a certain threshold before the transistors will even turn on. We can minimize this effect relative to the overall by increasing the voltages used. However this may not always be desirable. The other option is to bias the transistors slightly on so that the input signal does not have to overcome the base-emitter threshold voltage V_{be} . This can be done using a series of resistors forming a voltage divider network, or you can use diodes which have roughly the same voltage drop.

1. Construct the circuit as depicted in Fig. 2. Apply a 1V, 1kHz sinusoidal signal to the input and observe the output on the oscilloscope. Measure the peak voltage and sketch the waveform. How does the output compare to that of the class B? With a 1V signal in, what do you get out? Explain possible reasons for any distortion that may still be present.
2. Increase the input voltage to 5 volts and replace the 1k load resistor with the 100 ohm load resistor. Measure the average voltage across the load and compute the power dissipated.
3. Measure the total current drawn by the circuit.
4. Calculate the power efficiency of the amplifier.
5. How does it compare with Part 1?

Additional Parts for Part 3

- 2 matching general purpose pnp transistors for use in the current mirror
- 2 matching general purpose npn transistors to replace the diode
- A 5k potentiometer wired as a variable resistor.
- A standard 5k resistors

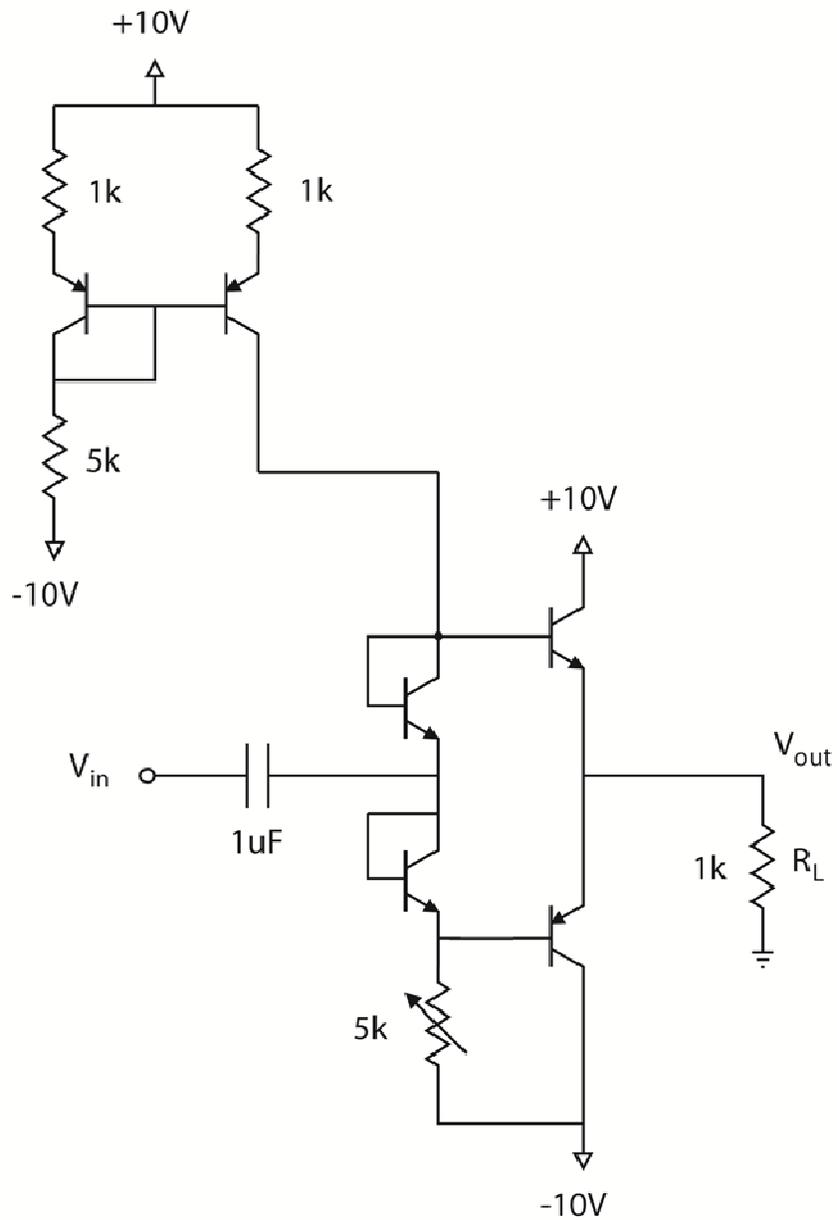


Fig. 3
Class AB amplifier with current mirror for biasing

Part 3

Although the Class AB amplifier in Part 2 will work just fine for many applications, it is sometimes desirable to build amplifiers using only transistors. Such is often the case when designing integrated circuits. We are not going to do so here, but we are going to apply some integrated circuit practices, using diode connected transistors and current mirrors.

1. Construct the circuit as depicted in Fig. 3. Apply a 1V sinusoidal signal to the input and observe the output on the oscilloscope. You may notice the presence of a DC offset. If not, be sure your oscilloscope is set to DC coupling. Adjust the 5k variable resistor to get rid of this DC offset.
2. Once everything is working properly, replace the load resistor with the 100 ohm resistor and increase the input voltage to 5V.
3. Do a frequency sweep from 10Hz up to 1MHz and plot the frequency response of the amplifier. Do as many points per decade as you need to get a good idea of the response. Compare this with your PSpice simulations from the prelab. How close do they compare? List some reasons for any discrepancy?
4. **OPTIONAL EXTRA CREDIT (5 points):** As an additional SPICE exercise, do a Fourier analysis of the output for the high power conditions of the last part of this experiment. What is the simulated total harmonic distortion?