Push Pull Amplifiers

ECE 321: Electronics II

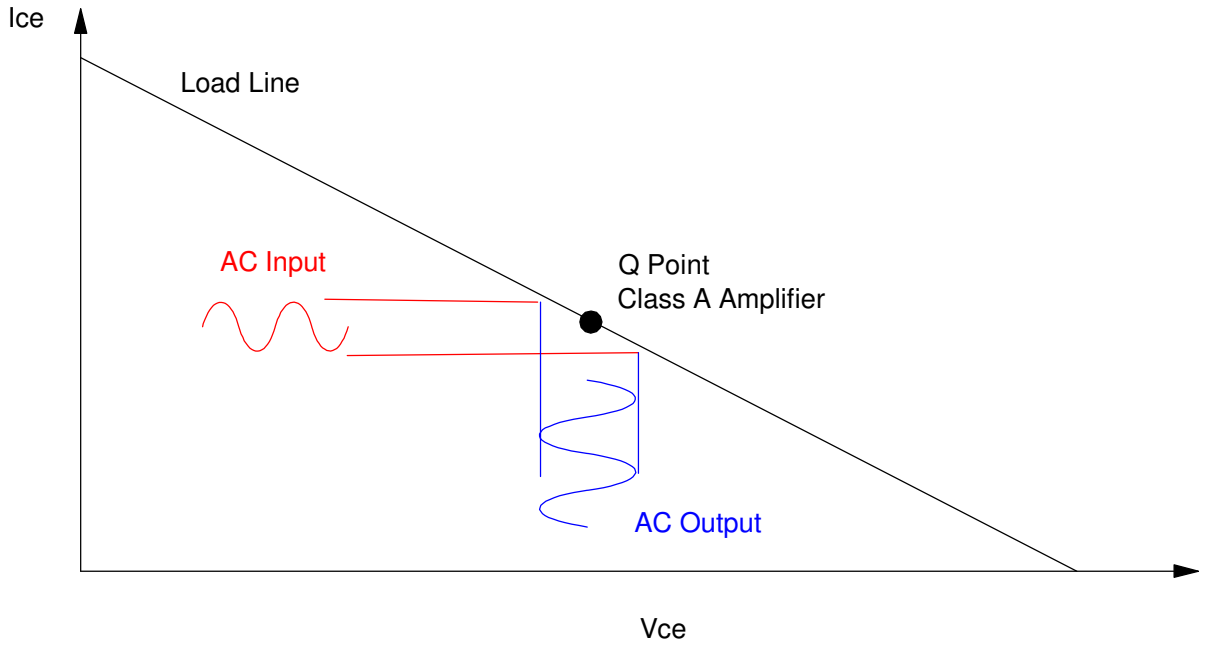
Lecture #3

Please visit Bison Academy for corresponding lecture notes, homework sets, and solutions

Class-A Amplifiers

Bias the transistors in the active region

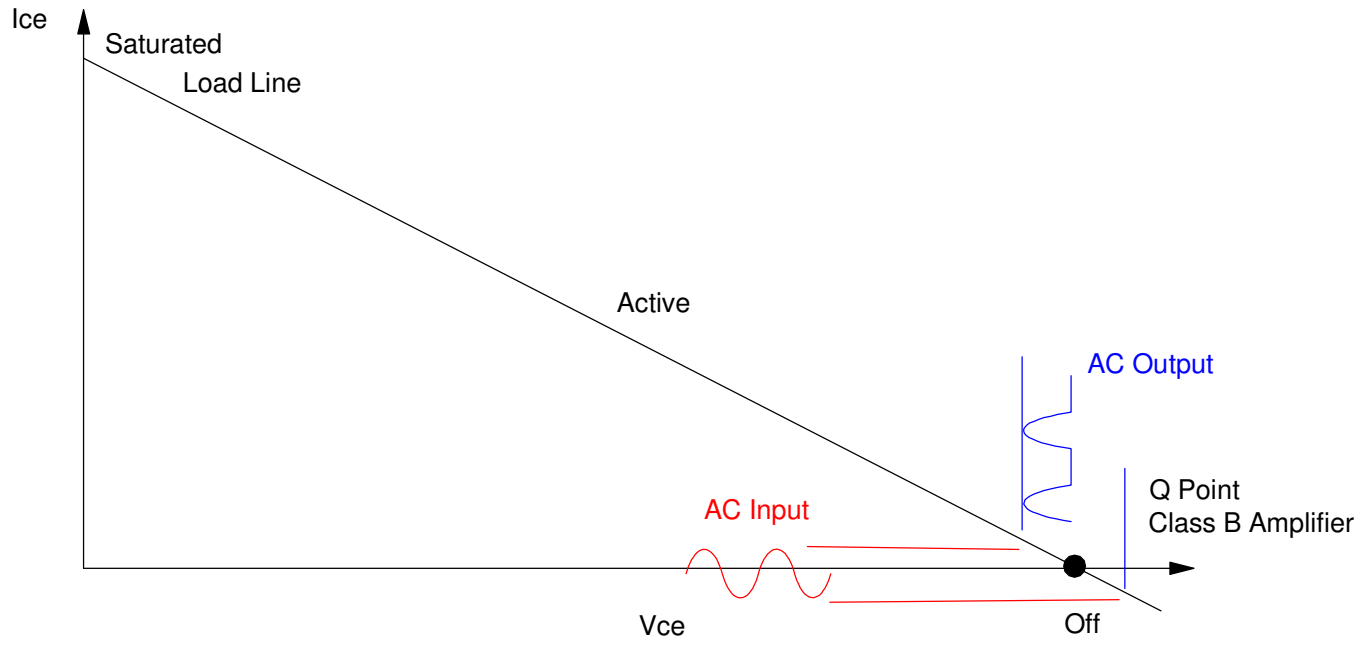
- Results in a large power drain even when there is no audio signal



Class-B Amplifiers (Push-Pull)

Biases the transistor so that it is off when there is no AC input.

- Less power consumption for small signals
- Results in clipping



Example: Drive an 8-Ohm Speaker

Input:

- 0..10V analog signal
- Capable of 20mA (i.e. a function generator)

Output:

- 8 Ohm speaker

Relationship:

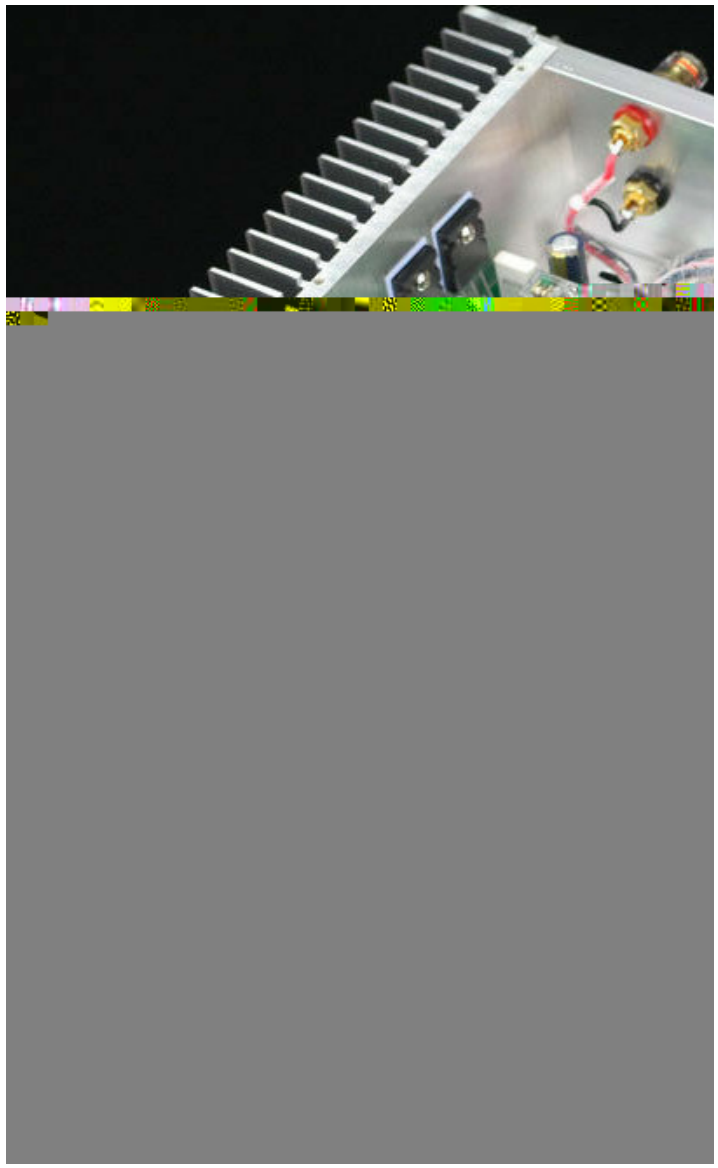
- Y = X

Option 1: Use an op-amp capable of 1.25A

- OPA2544: $18 each
- AMT 30A8T: $200 each

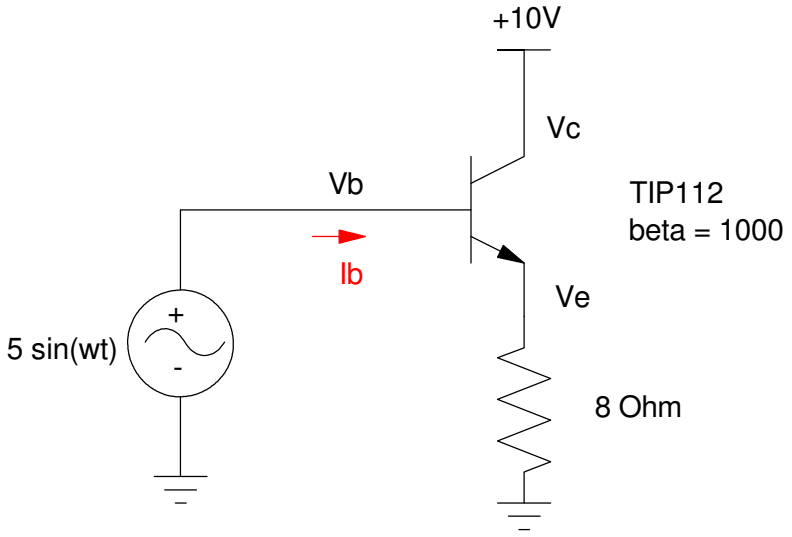
Option 2: Use a push-pull amplifier

- TIP112 or 6411 (NPN)
- TIP117 (PNP)
- $1 solution



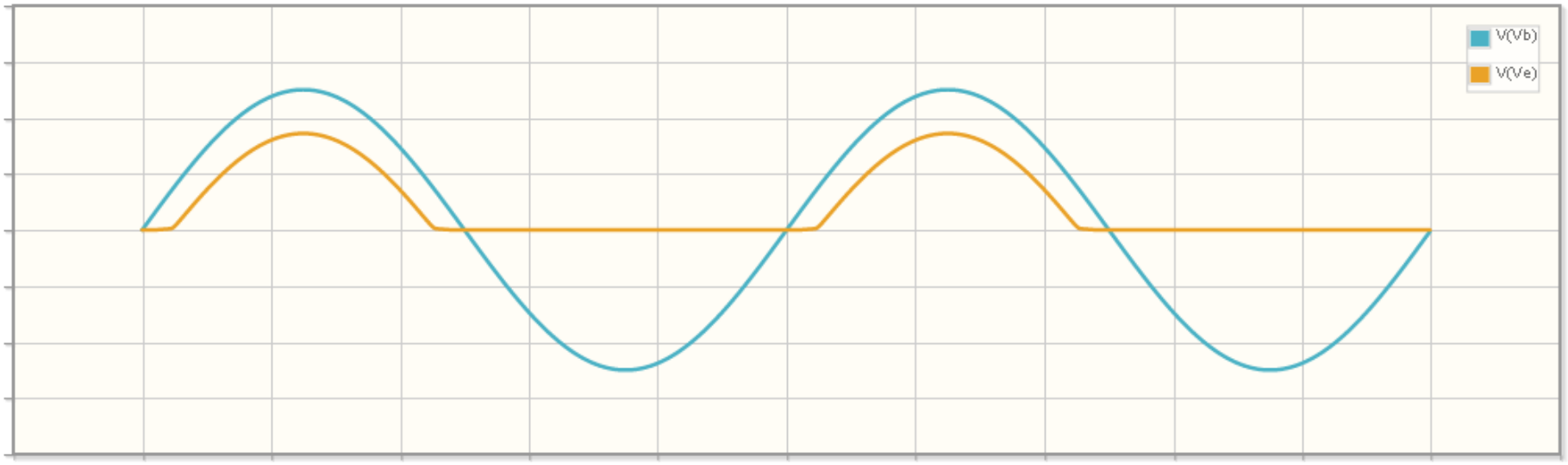
Solution (push):

- Use a transistor to amplify the current
- Place the load at the emitter

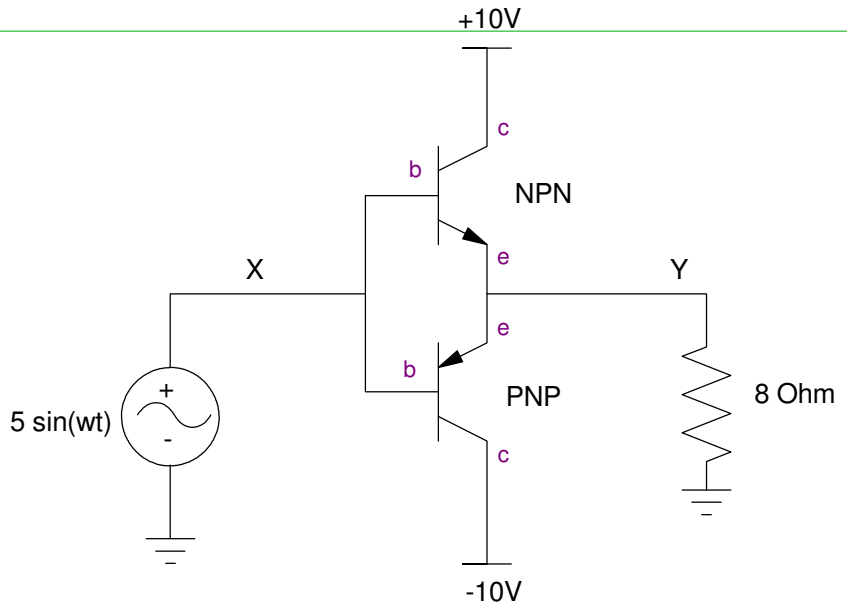


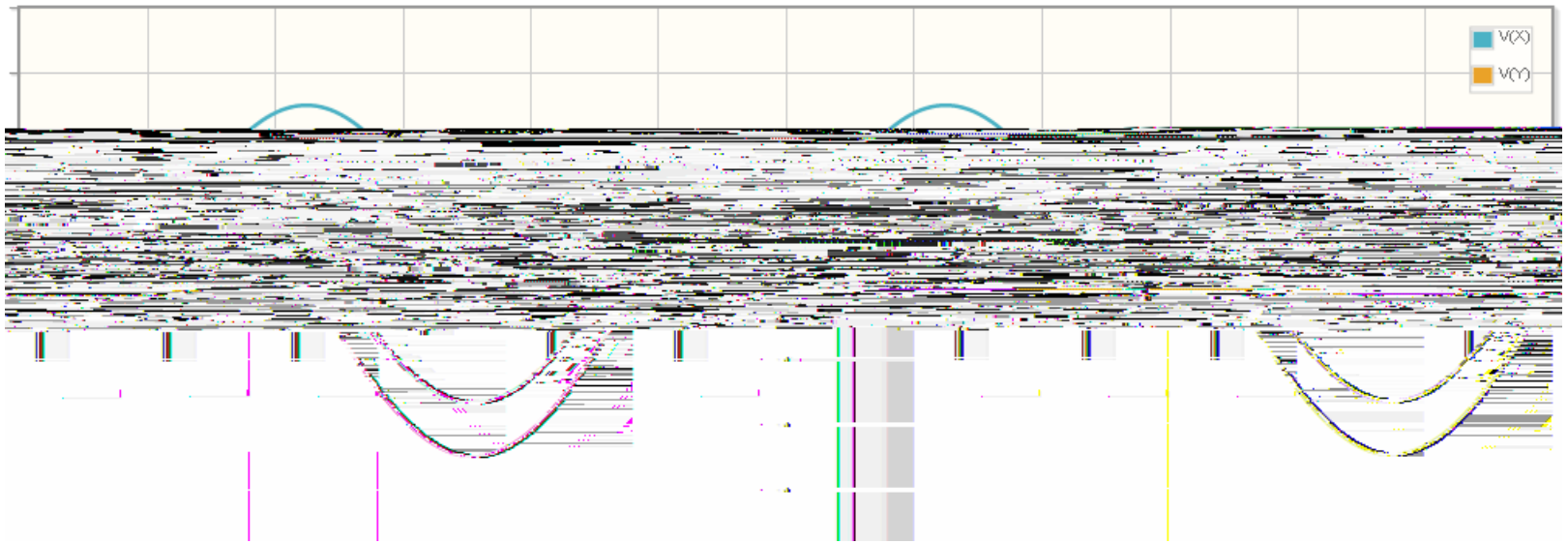
What this does is

- When Vb > 0, Ve follows Vb
- When Vb < 0, the diode turns off and Ve = 0.

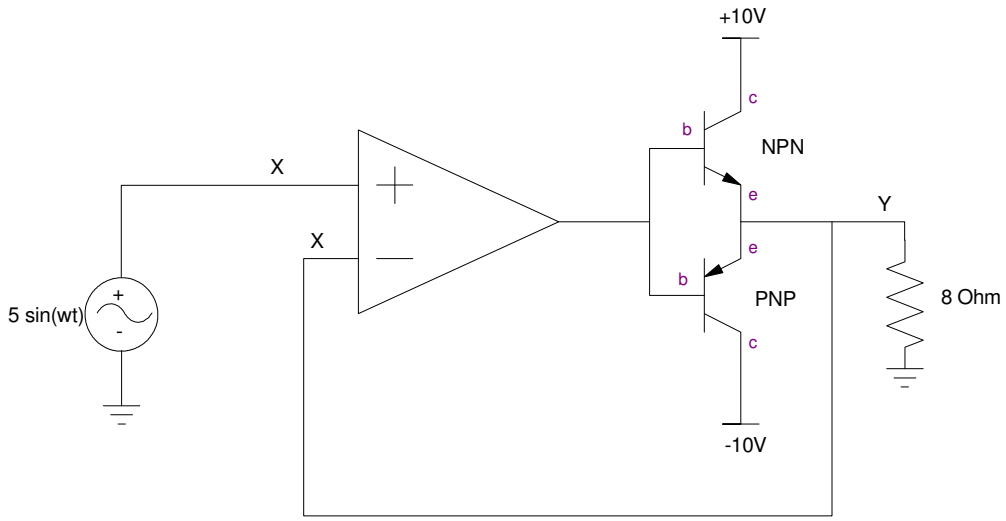


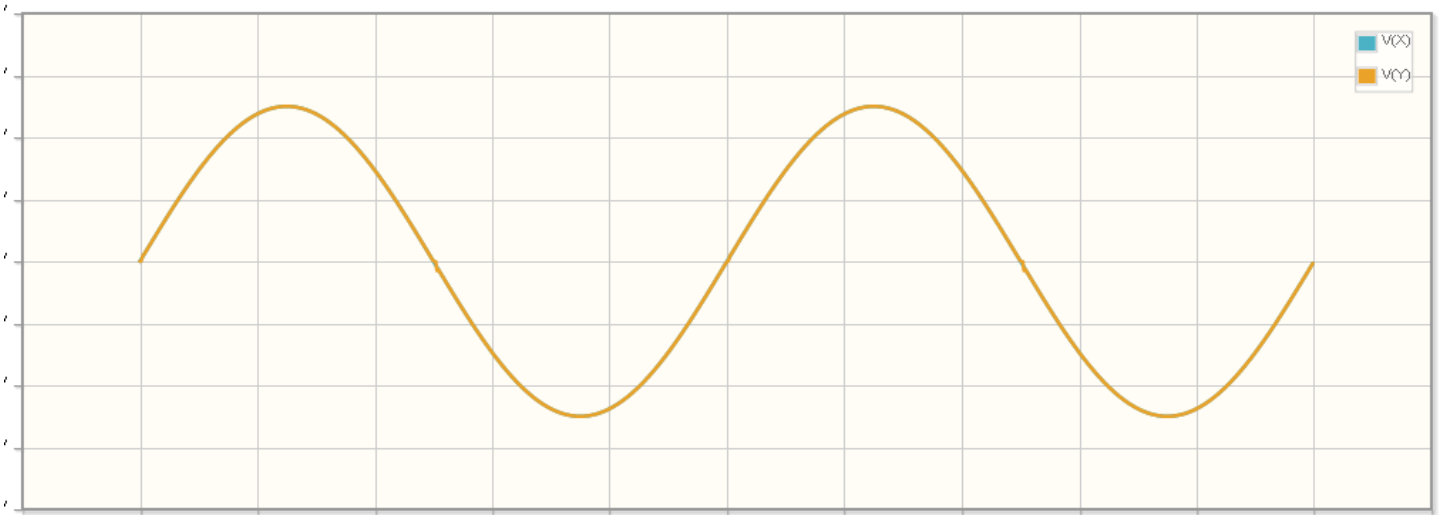
Solution: Push-Pull





Solution: Remove the cross-over distortion





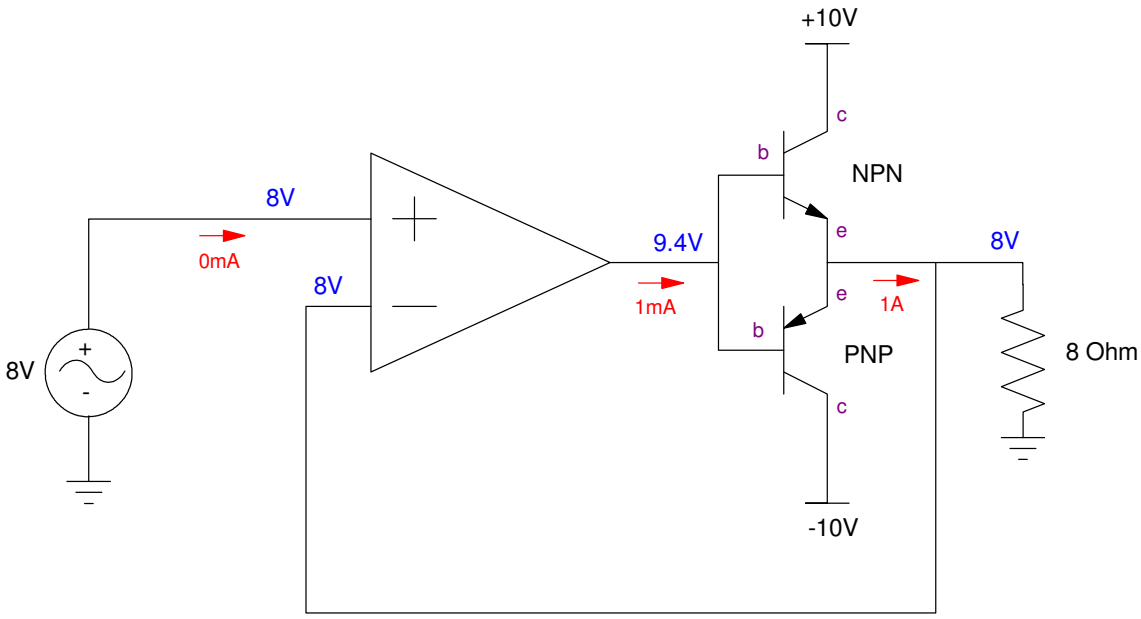
Result: Power Amplifier

Voltage: Asume X = 8V

$$Y = X$$

Current:

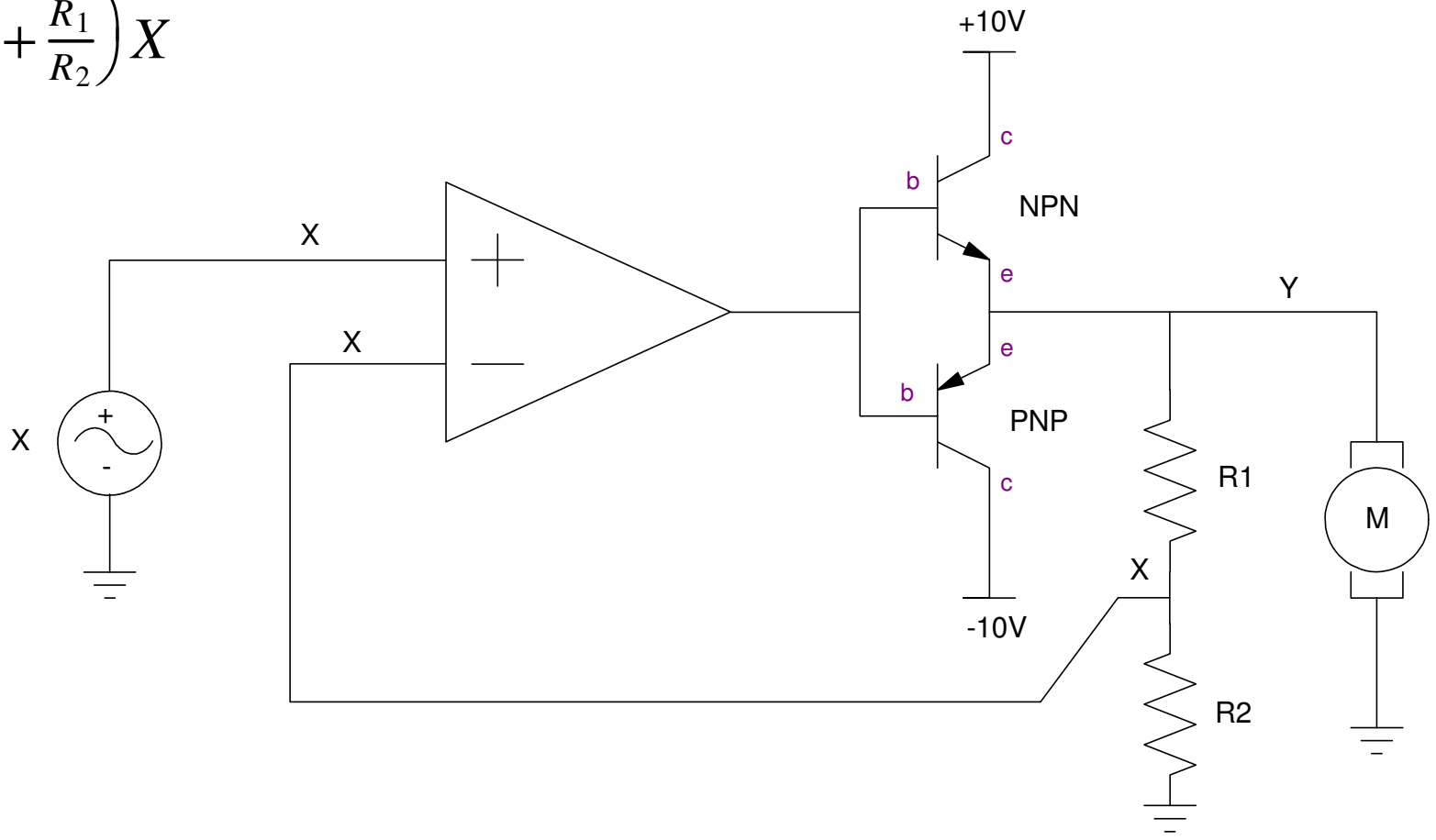
- I3 = 1.00A (8V @ 8 Ohms)
- I2 = 1.00 mA (β = 1000)
- I1 = 0.00 mA (ideal op amp)



Variation: Voltage Output

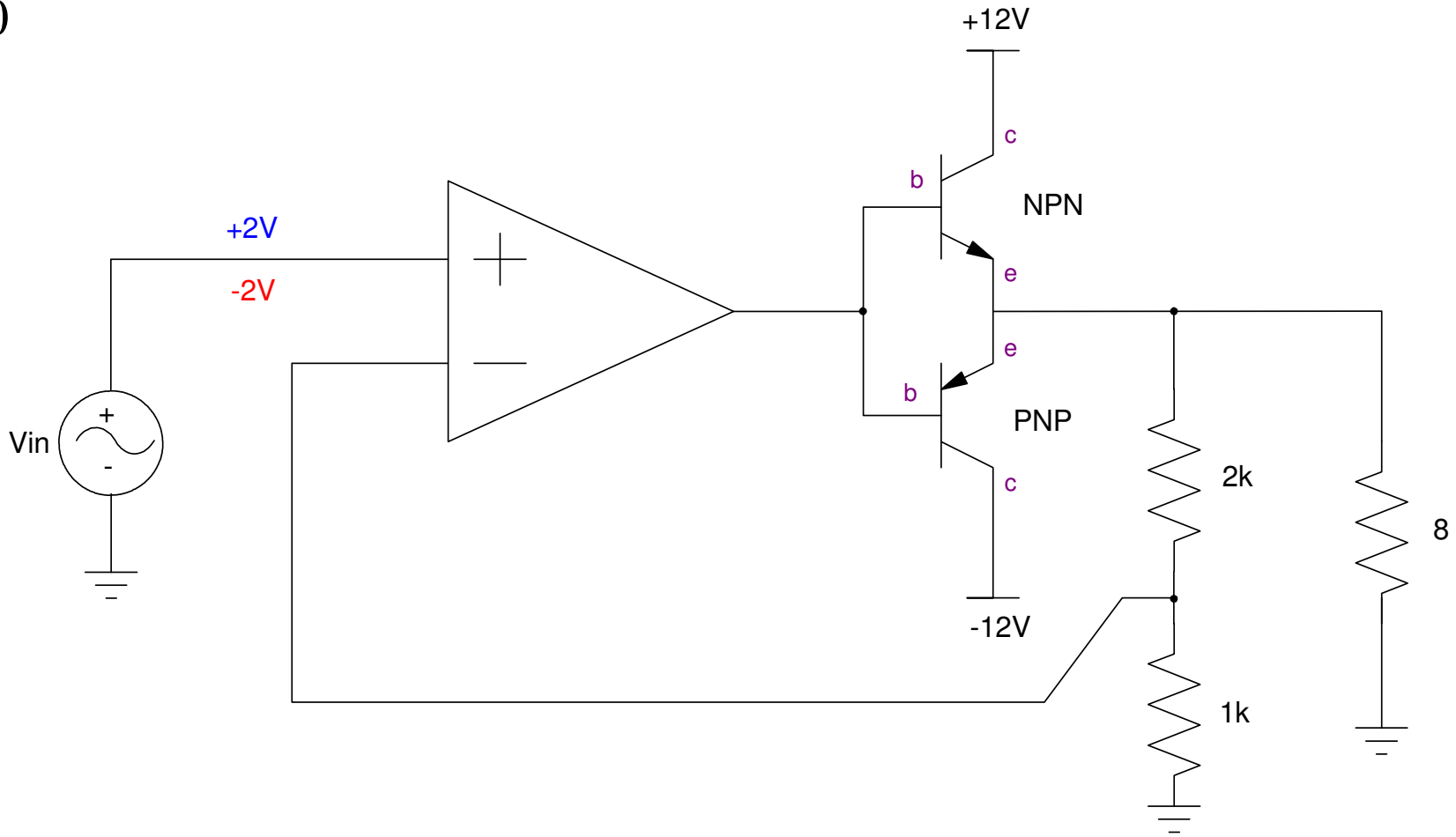
For DC motors, voltage is speed (approximately).

$$Y = \left(1 + \frac{R_1}{R_2}\right) X$$

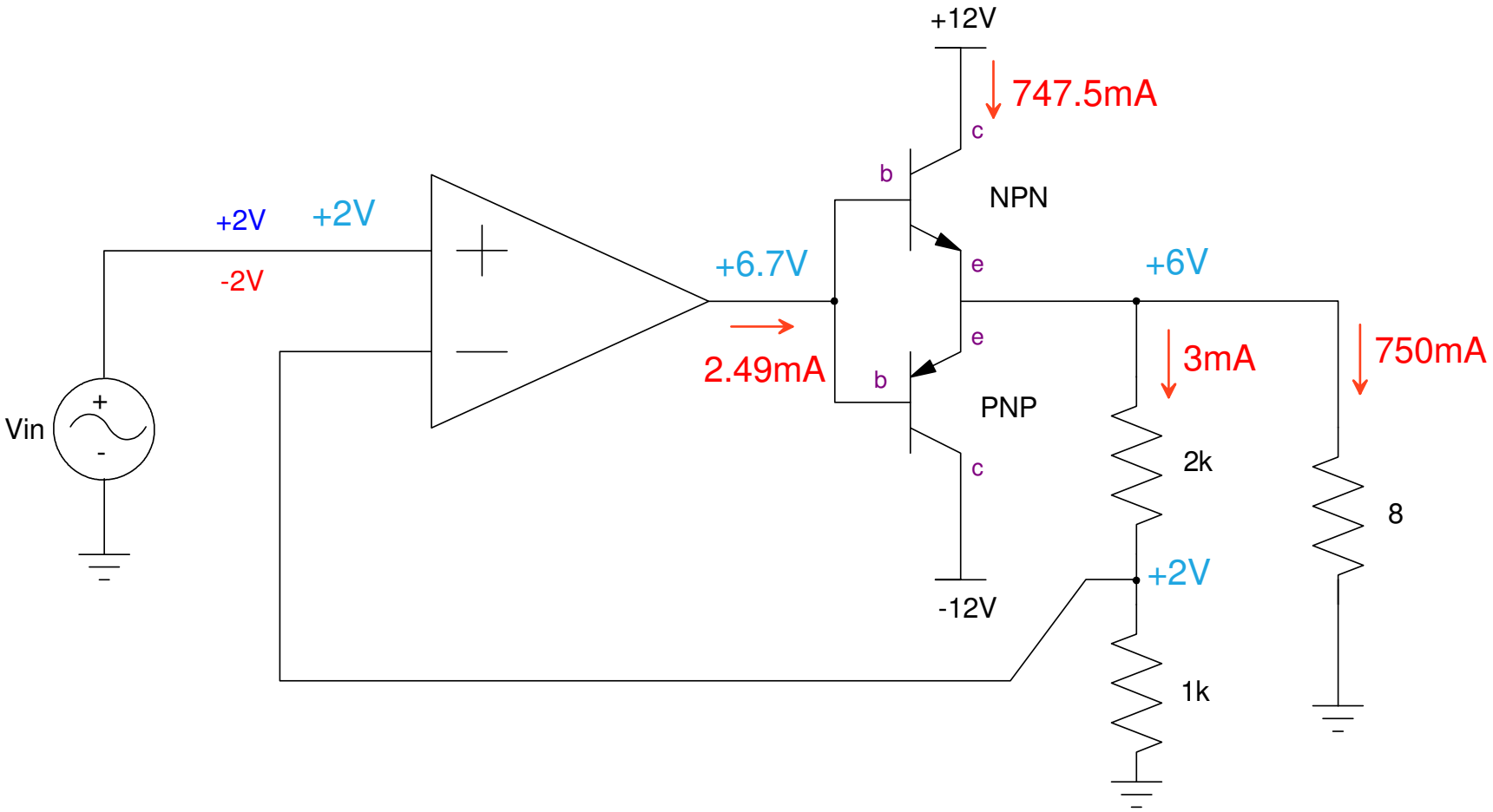


Handout: Determine the voltges and currents

- | Vbe| = 0.7V
- β = 300



Solution

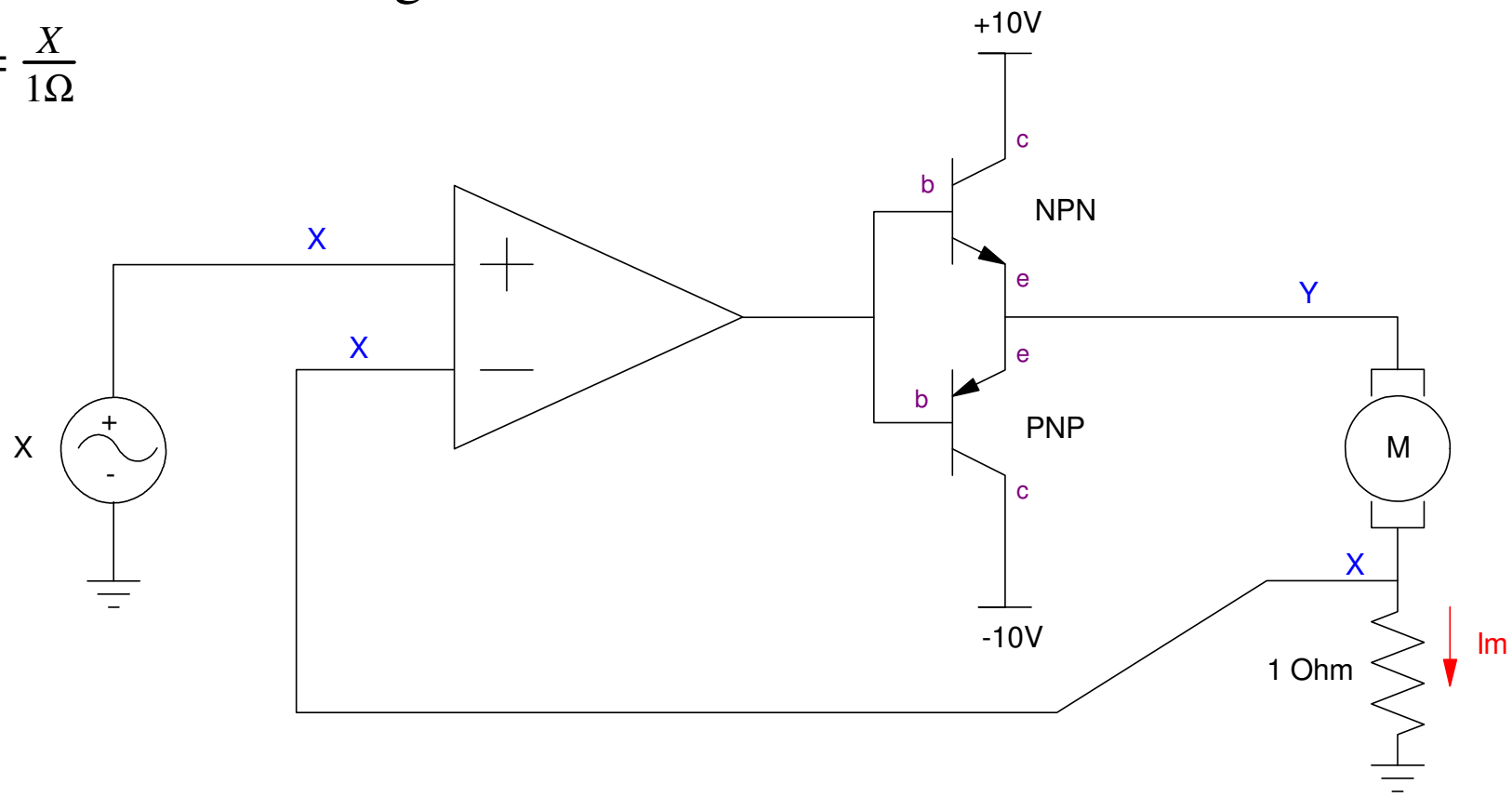

+12V
747.5mA
c
b
NPN
+2V
+2V
-2V
+6.7V
e
+6V
e
2.49mA
b
PNP
3mA
750mA
Vin
+
-
c
2k
8
+2V
-12V
1k

Variation: Current Output

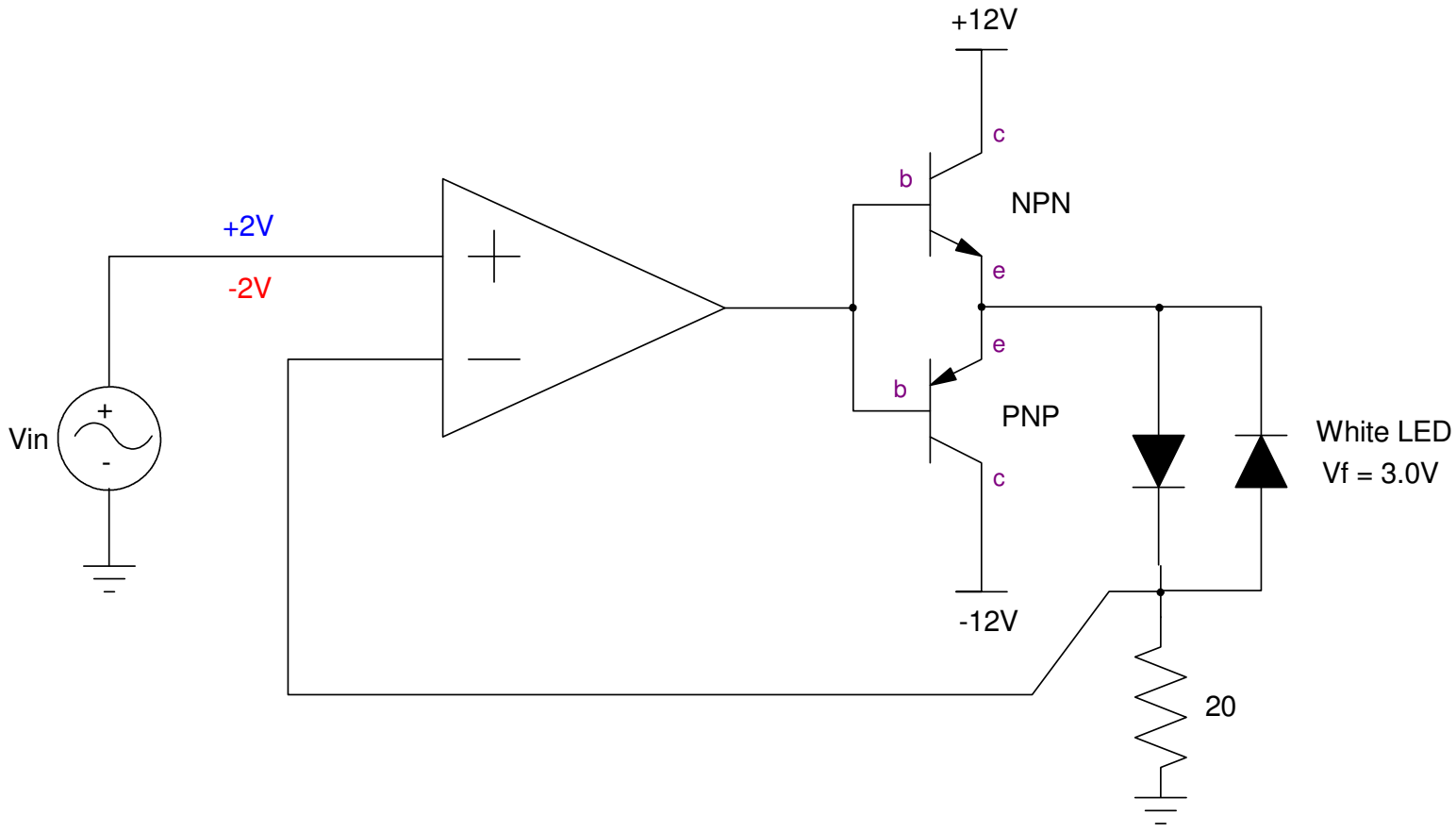
For DC motors, current is torque.

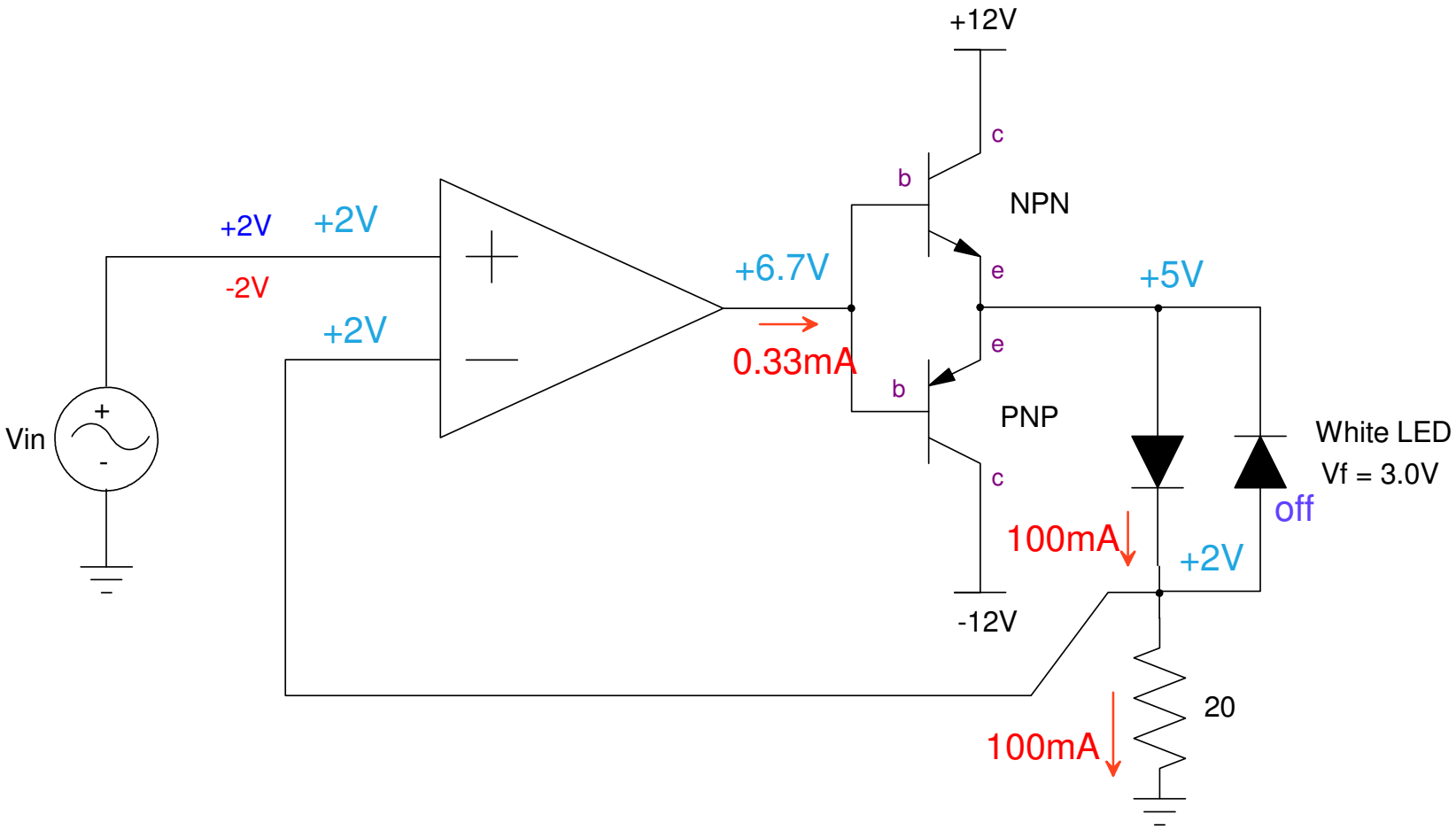
For LED's, current is brightness.

$$I_m = \frac{X}{1\Omega}$$



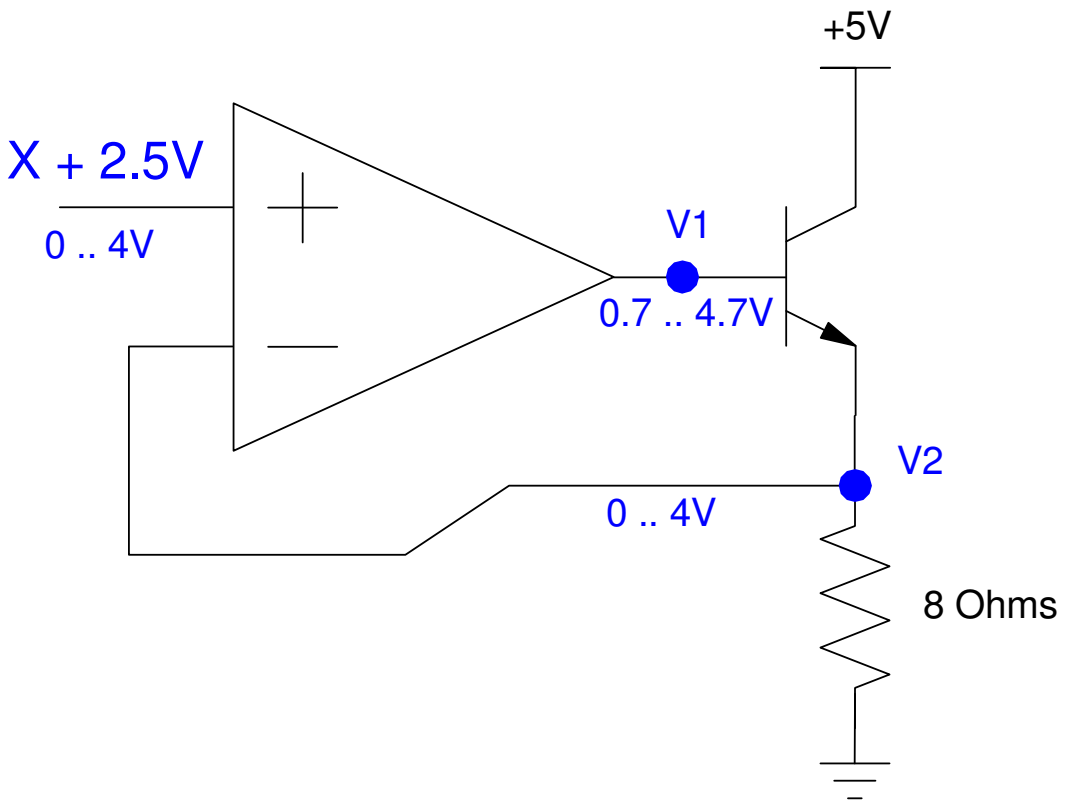
Handout: Determine the voltages and currents




+12V
c
b
NPN
+2V
+2V
-2V
+6.7V
e
+5V
+2V
0.33mA
e
b
PNP
Vin
+
-
White LED
Vf = 3.0V
c
off
100mA
+2V
-12V
20
100mA

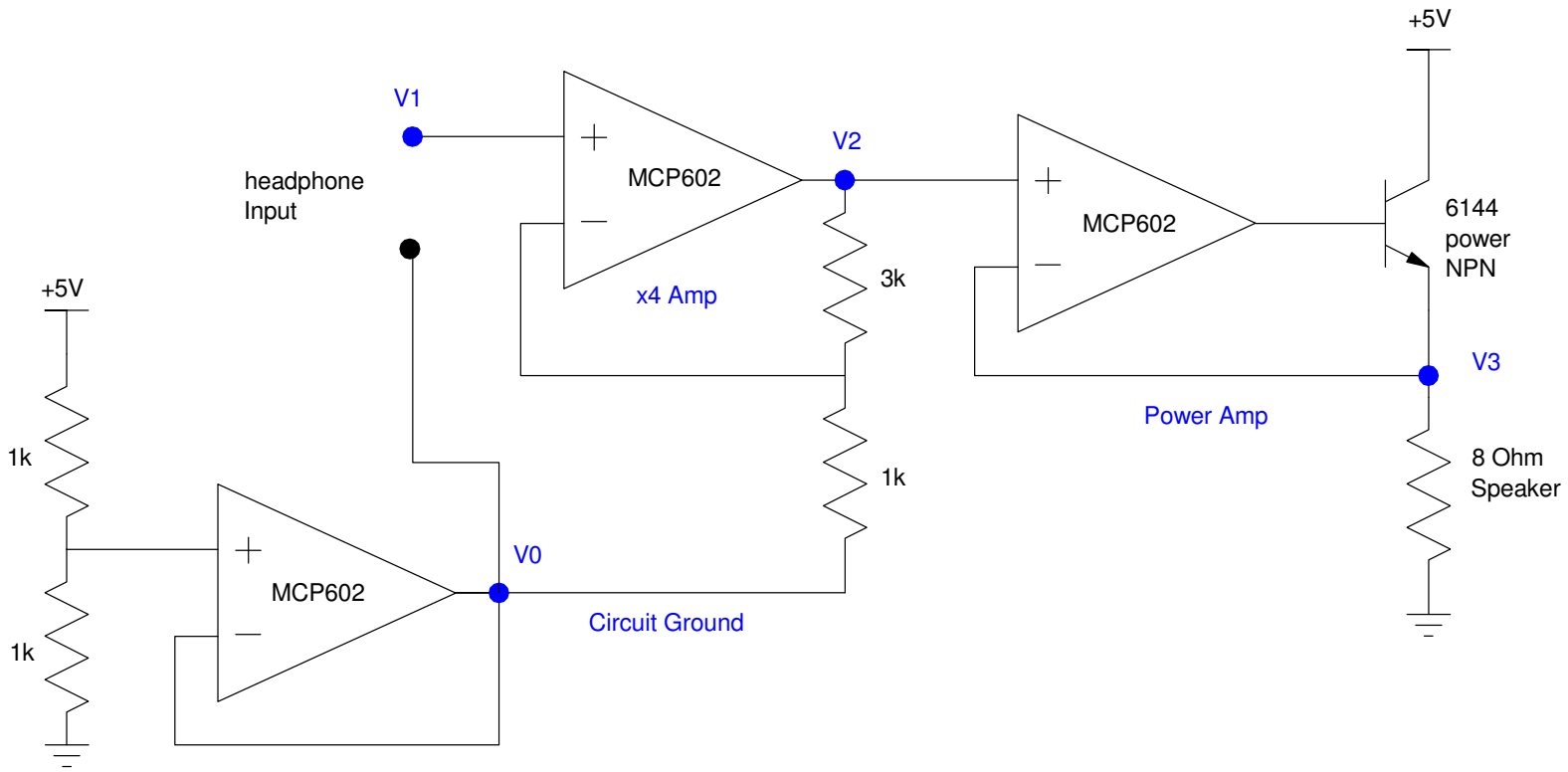
Variation: Single Sided Supply

- 0 .. +4V Out
- Class A Amplifier (inefficient)

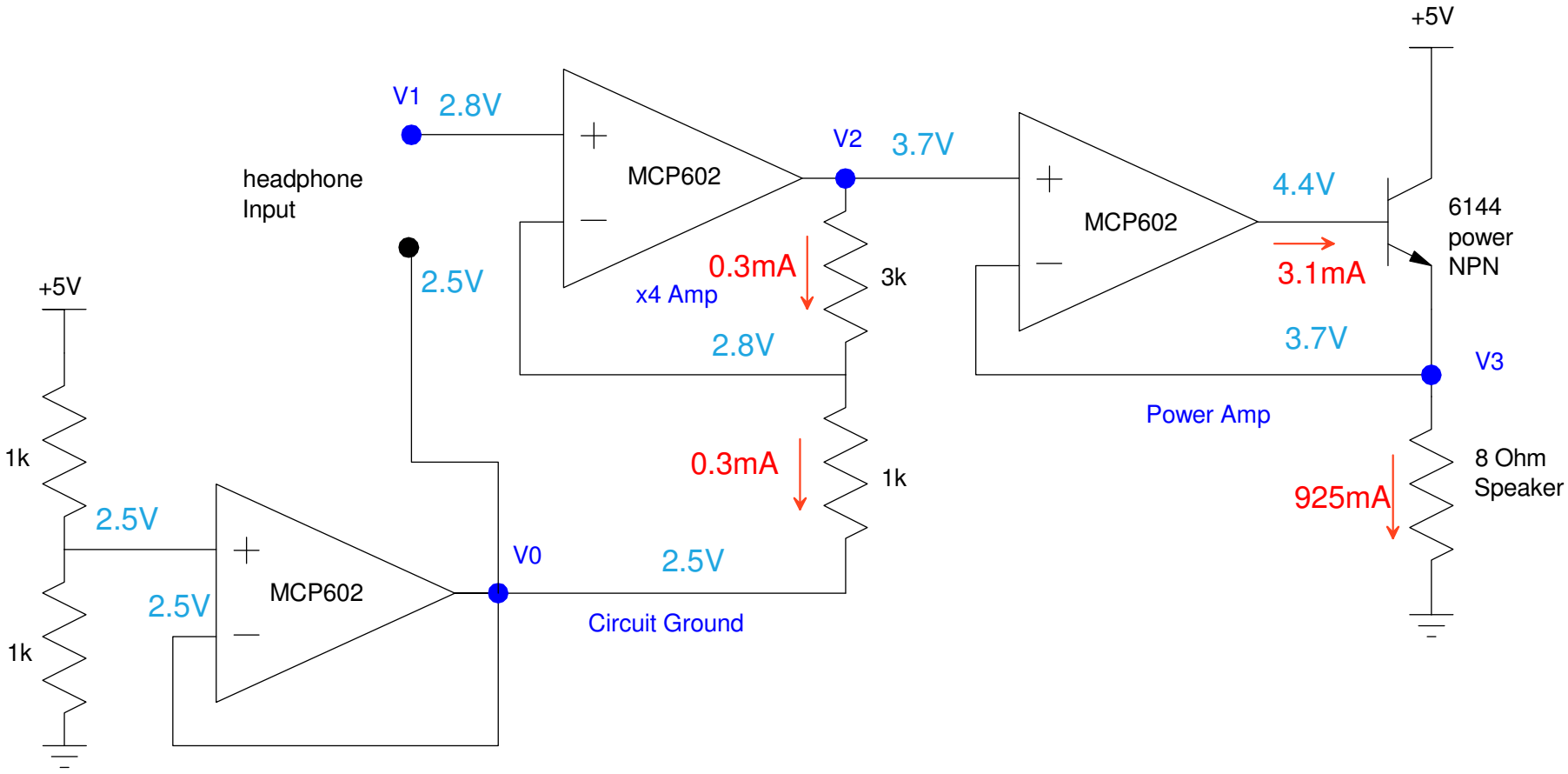


Handout: Determine the voltages and Currents

- V1 = 2.8V (circuit ground + 0.3V)

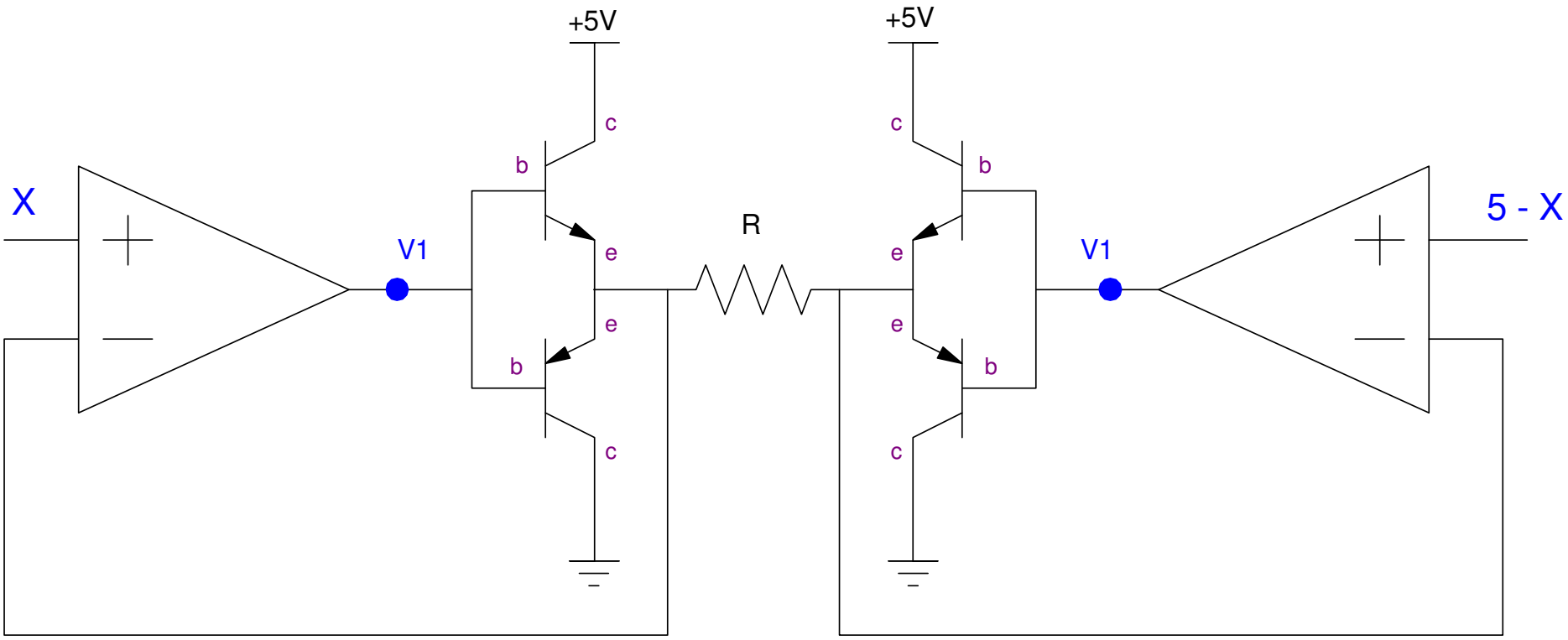


Solution

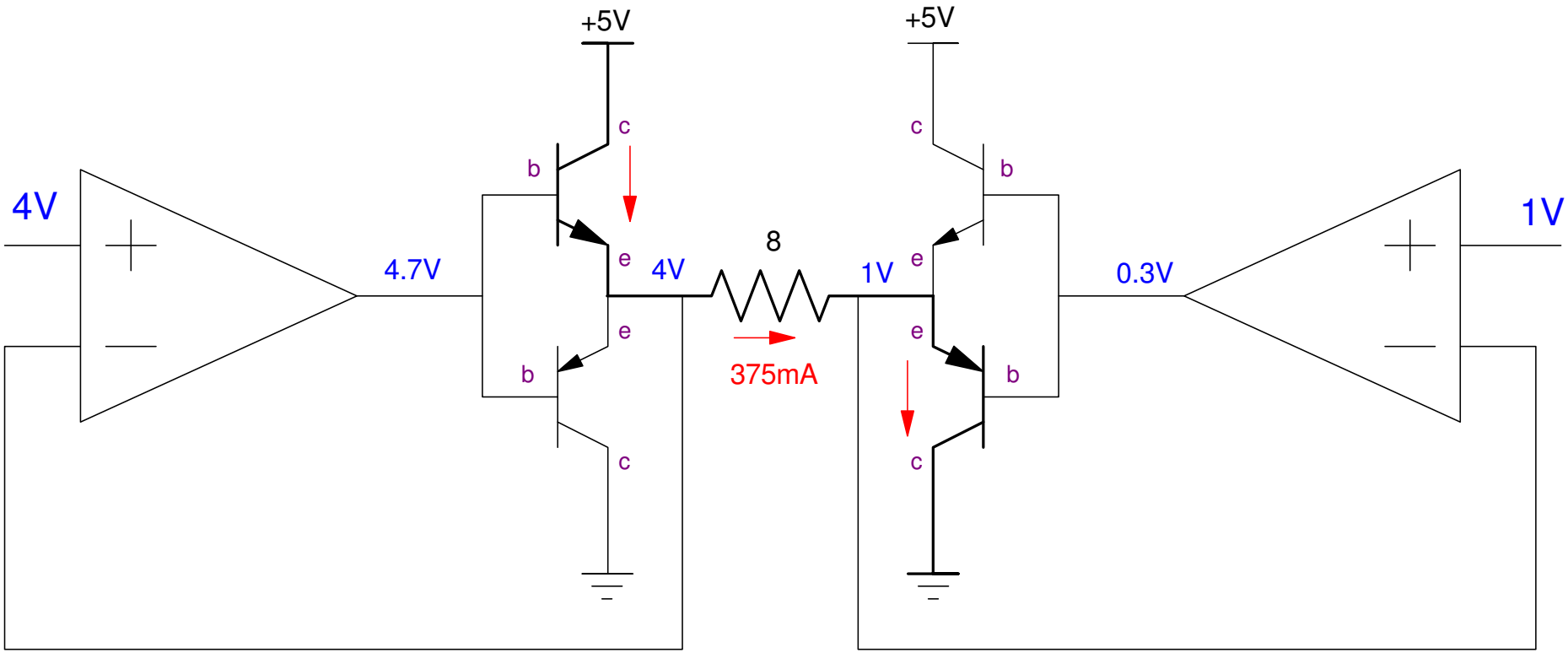

+5V
V1
2.8V
headphone
Input
MCP602
V2
3.7V
MCP602
4.4V
6144
power
NPN
+5V
2.5V
0.3mA
3k
x4 Amp
2.8V
3.1mA
3.7V
V3
Power Amp
1k
0.3mA
1k
8 Ohm
Speaker
925mA
2.5V
V0
2.5V
MCP602
2.5V
1k
Circuit Ground

Variation: Single-Sided Supply

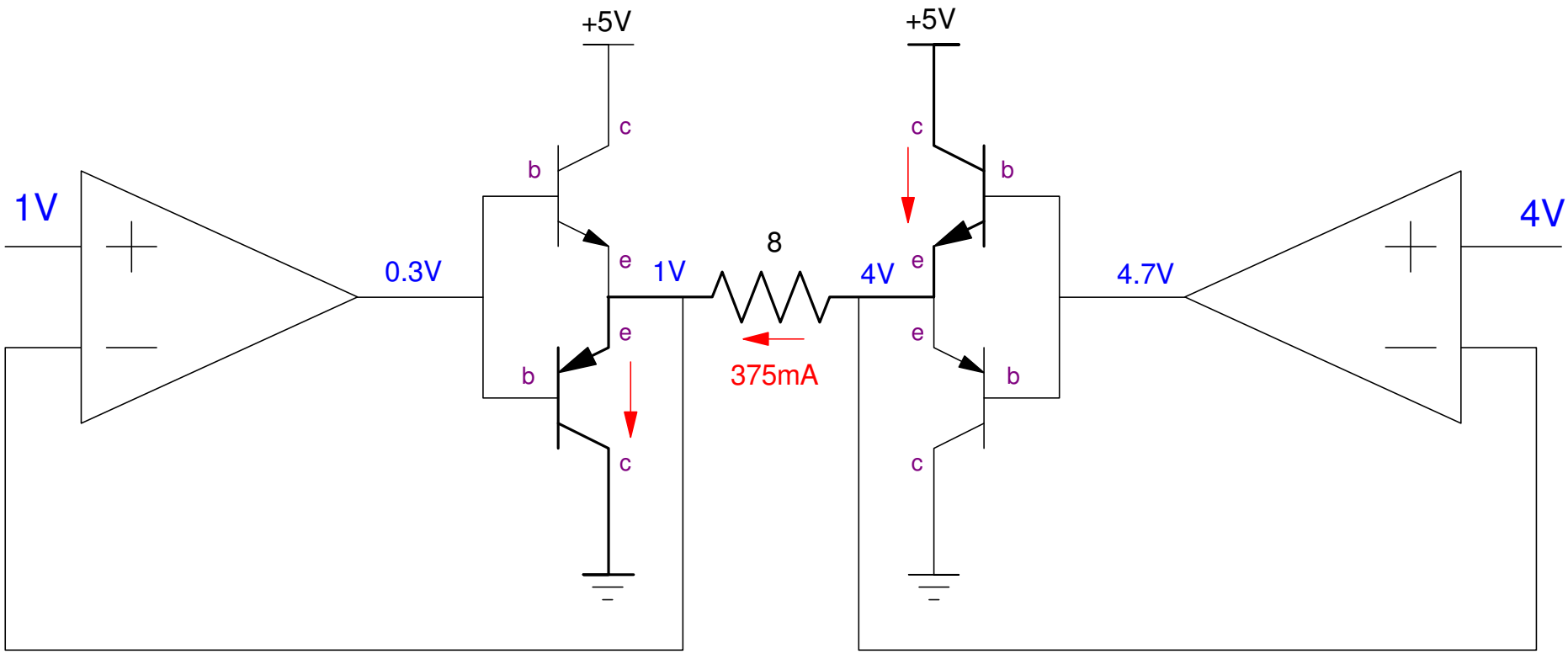
- +3V .. -3V Out
- Class AB Amplifier (more efficient)



+3V Out



-3V Out



Summary

A push-pull amplifier allows an op-amp circuit to drive a low-impedance load

- DC motor
- Speaker

Voltage Amplifier:

- Drive a speaker
- Control the speed of a DC motor

Current Amplifier

- Drive a power LED
- Control the torque of a DC motor