ECE 651: Electronic Design II

Homework #4

Due: Wednesday, October 18th, 2023

Student Name: _____

Note: Please use this as a cover page for your paper submission.

Build the following 2-stage differential amplifier on Multisim and simulate the circuit to find the overall voltage gain (A_v). For input signal (v_{id}), use a sinusoidal voltage source with a frequency of 1 kHz and a voltage amplitude of 1 mV. For BJTs, use the NPN silicon transistor (model: 2N2222A) for Q_1 and Q_2, and use PNP transistor (2N3906) for Q_3.
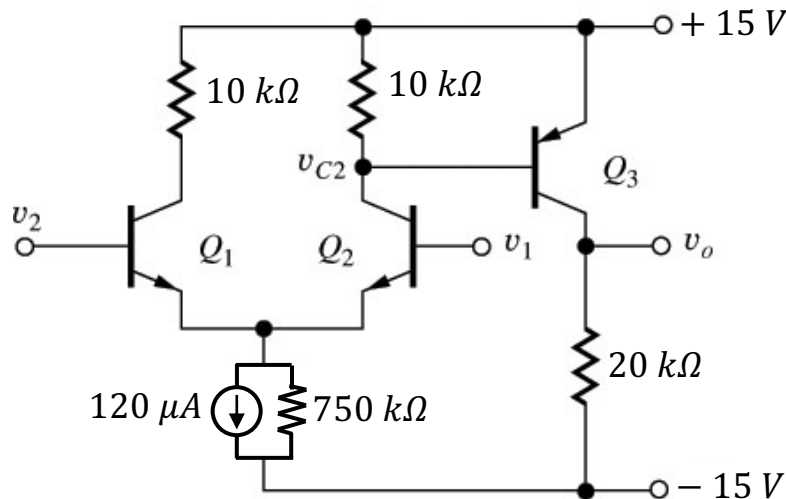

Figure 1. A 2-Stage Differential Amplifier.

(a) Apply a differential input to v_1 ($= + v_{id}/2$) and v_2 ($= - v_{id}/2$). Use the oscilloscope to display both input and output voltage waveforms for: (a) stage #1 only; and (b) stage #1 and #2 combined. Make sure to use different colors for the plots so that the two waveforms are distinguishable. Label each waveform accordingly. Use the waveforms to estimate the overall voltage gain ($A_{dm} = v_o/v_{id}$).

(b) Apply a common-mode input to both v_1 and v_2. Use the oscilloscope to display both input and output voltage waveforms for: (a) stage #1 only; and (b) stage #1 and #2 combined. Make sure to use different colors for the plots so that the two waveforms are

distinguishable. Use the waveforms to estimate the overall common-mode voltage gain $(A_{cm} = v_o/v_{ic})$.

(c) Inject a noise signal into the differential input using a Thermal Noise Voltage Source. First, display the noisy differential inputs (v_1 and v_2) on oscilloscope to confirm that the same noise has been added to both inputs. Then, use the oscilloscope to display both the input signal (v_1) and output (v_C) voltage waveforms for: (a) stage #1 only; and (b) stage #1 and #2 combined. Make sure to use different colors for the plots so that the two waveforms are distinguishable.

(d) Adjust the value of the 20 kΩ resistor at Stage #2 so that the output waveform is centered at 0 V. Display the oscilloscope waveforms to support your answer.

(e) What is the maximum amplitude of the input signal v_{id} (at 1 kHz) that can be amplified without signal distortion at the output (v_o)? Use the oscilloscope waveforms to support your answer.

Note:
- All plots and waveforms must be properly labeled with units provided.
- For submission, convert all your worksheets (including this cover page with your name, all handwritten work, schematics, plots, etc.) into a PDF format and submit electronically on Canvas.
- Also, submit your Multisim files (file extension: .ms14) along with your PDF worksheets.