BİLKENT UNIVERSITY
DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

EE 311 ELECTRONICS II

Experiment 6

Lab Report

Design of a Differential Amplifier Biased by a Current Source

Student Name:

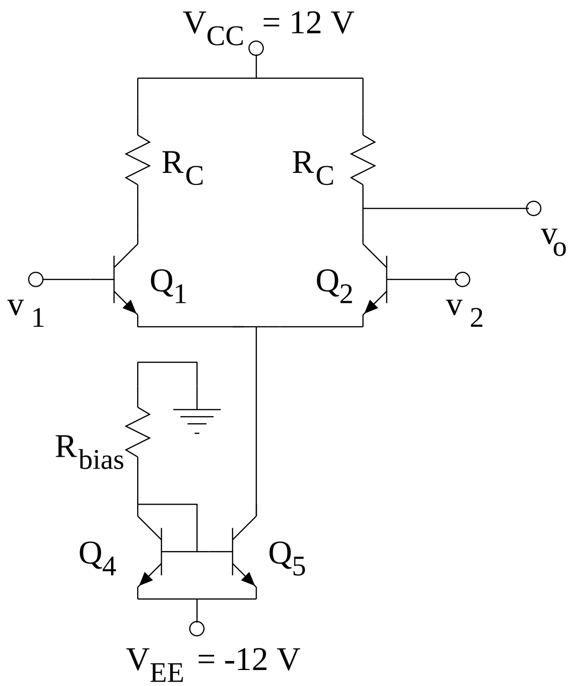
ID Number:

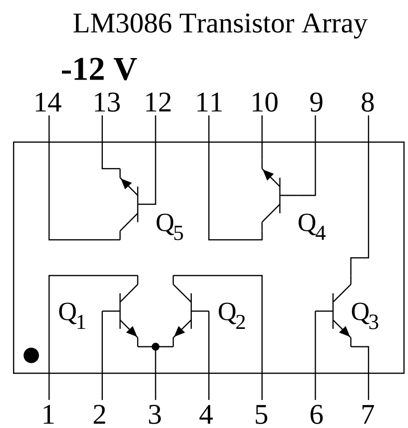
Date:

INTRODUCTION

In this experiment you will design, construct, and evaluate a differential amplifier biased by a current source.

PRELIMINARY WORK





1. Design a differential amplifier biased by a current source based on the circuit topology given in the figure. You will use the integrated circuit transistor array LM3086 whose connection diagram is shown in the same figure. For each transistor on this IC, you can assume that $\beta = 100$ and $V_A = 50$.

The following specifications must be satisfied by the circuit:

- One-sided differential voltage gain $A_d \geq 35$ dB.
- Differential-mode input resistance $R_{id} \geq 4$ kΩ.

Determine the values of R_C and R_{bias}. Use nominal 10% resistor values only. Try to leave some margin in meeting the above specifications.

Calculate the common-mode gain (A_{cm}) and the common-mode rejection-ratio (CMRR). Also determine the maximum peak-to-peak output voltage swing for which both transistors are guaranteed to be in the active region.

2. Perform the following tasks via SPICE simulations. Use a generic transistor model. Append the pages containing the input decks and the results of SPICE simulations to the end of this report.

(a) Determine the one-sided differential voltage gain.

(b) Determine the CMRR.

(c) Determine the differential-mode input resistance R_{id}.

(d) Determine the maximum allowable voltage swing at the input that will not push the transistors out of the active region.

(e) Determine the maximum peak-to-peak undistorted output swing.

EXPERIMENT:

Construct the differential amplifier that you designed in the preliminary work section and verify that your design meets the specs.

Use transistors Q1 and Q2 (on the circuit diagram of LM3086) as your differential pair and use transistors Q4 and Q5 as the transistors for the current source. Note that pin 13 of LM3086 should always be connected to the most negative voltage in your circuit (-12 V in this case).

To measure the common-mode gain, connect V_1 to V_2 and connect both of them to the signal generator V_{in}. Set the output of the signal generator to be a sine-wave with an amplitude of ~ 1 V peak-to-peak at a frequency of 2 kHz. Plot $V_o = V_{C2}$, V_{C1}, and V_{in} versus time on the same graph in this common-mode configuration. Calculate the one-sided common-mode gain $A_{cm} = V_o/V_{in}$. Compare this value with your calculations.

To measure the differential-mode gain, you would normally need two signal generators that are perfectly out of phase by π radians. Since this is difficult to do experimentally, you will measure the differential-mode gain by applying a signal to only one input. Set $V_2 = 0$ by grounding the base of Q2. Connect the signal generator to V_1. Set the output of the signal generator to be a sine-wave with an amplitude of 20 mV peak-to-peak at a frequency of 2 kHz. Plot $V_o = V_{C2}$, V_{C1} and V_{in} versus time on the same graph. Calculate the one-sided differential mode gain. Compare this value with your calculations.

Call the TA and demonstrate the performance of your circuit. Your circuit must meet the specs before you leave the lab room.