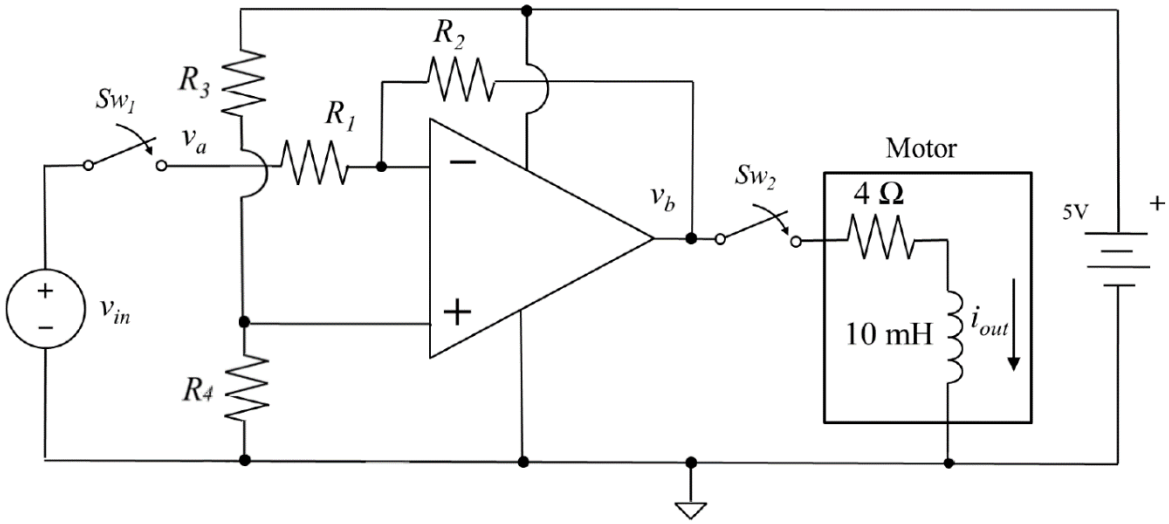
School of Electrical Engineering & Telecommunications

ELEC1111 Tutorial 6

1. Design of a motor driver for a wheeled mobile robot

The circuit below is a motor driver for a wheeled mobile robot. The motor driver is designed as an inverting amplifier to drive the motor in the opposite direction of the input voltage. A switch (Sw1) is used to disconnect the motor driver input signal (v_{in}) from the circuit and a motor protection switch (Sw2) is used to disconnect the motor from the amplifier when the motor is not used. A simplified model of a DC motor has been used, made up of a resistor and inductor in series. The DC motor generates a torque proportional to the current (i_{out}) through the inductor.



Q1. *(Design question)* Design an inverting amplifier by choosing suitable resistor values for R1 and R2 to produce a gain of 5 when both switches, Sw1 and Sw2, are open.

Answer: Many different combinations of R1 and R2 can be used to obtain the desired gain. They can be verified via simulation. If unsure, contact your lecturer to organise an appointment.

Q2. (*Design question*) Design the bias input circuit by choosing suitable resistors R3 and R4 such that the voltage v_b will be 0.5V. Note that switches Sw1 and Sw2 are still open.

Answer: Many different combinations of R3 and R4 can be used to obtain the desired v_b. They can be verified via simulation. If unsure, contact your lecturer to organise an appointment.

Q3. Consider that Sw1 is open and the amplifier is turned on for enough time, such that the voltages stabilise. The motor is connected by closing Sw2 and it starts to move. Find the current i_{out} resulting from the transient response of the motor circuit. Assume that the amplifier output resistance is negligible and does not limit the current, and the motor inductor is de-energised prior to close Sw2.

Answer: $i_{out}(t) = 0.125(1 - e^{-400t})\ A$

Q4. (*Design question*) Since the Op Amp has only a positive voltage, the motor voltage can only vary from +5V to 0V and the robot can only go forwards. If you have a second 5V battery, redraw the circuit to allow the motor voltage to vary from +5V to -5V as v_{in} varies from 0V to 3V, respectively. Note that you need to change both the op-amp gain and the bias voltage at the non-inverting input.

Answer: The new battery has to be connected from ground to the negative power supply pin of the Op Amp. Many different combinations of R1, R2, R3 and R4 can be used to obtain the desired behaviour. They can be verified via simulation. If unsure, contact your lecturer to organise an appointment.

2. Analysis of circuit to measure gauge strain[1]

A 120Ω strain gauge bridge consists of four identical 120Ω resistors arranged in a Wheatstone bridge. When the gauge experiences a positive strain of 0.5%, the resistances of the individual resistor elements change as shown in the figure below. The Op Amp circuit shown has been designed to amplify these small changes in resistance into a larger change in voltage for measurement.

Q5. Calculate the voltages v_a and v_b at the output of the strain gauge.

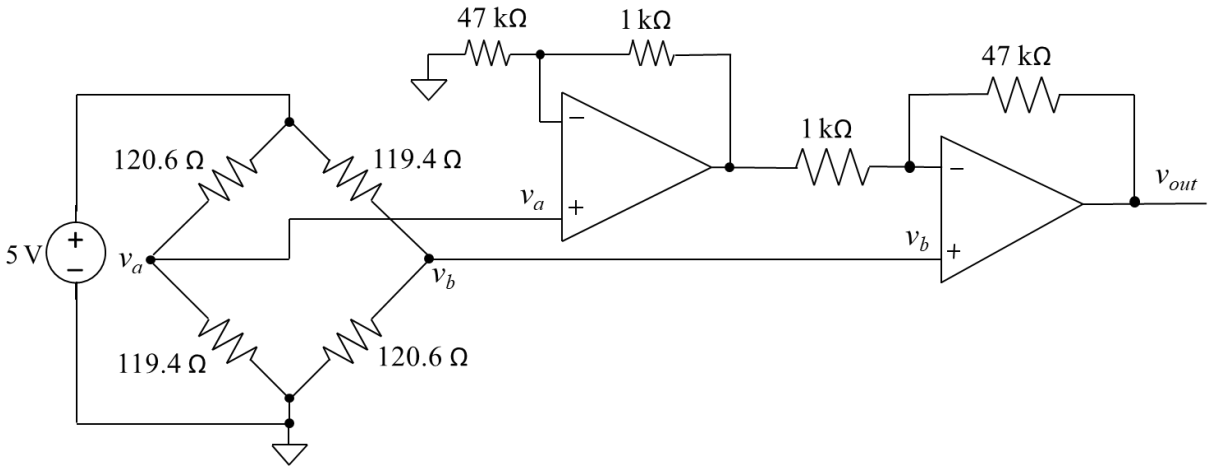
Answer: $v_a = 2.4875\ V, v_b = 2.5125\ V$

Q6. Derive an expression for the op-amp output voltage v_{out} in terms of the input voltages v_a and v_b to demonstrate that it is a difference amplifier. Note: DO NOT substitute the values of v_a and v_b from Q5 so that you can find a general expression rather than a voltage value.

Answer: $v_{out} = 48(v_b - v_a)$

Q7. Substitute the values of v_a and v_b from Q5 to calculate the voltage value at the output of the Op Amp.

Answer: $v_{out} = 1.2\ V$



[1] This problem is from the final exam in Semester 2, 2018 (full solution will be provided under Final exam -> Supplementary material in Moodle)