

Chapter 6

Lab 5: Independent Project: Motor Speed Controller

Objectives:

- Implement basic electronics building blocks in a circuit that is largely of your design.
- Understand the role of feedback in controlling the rotational speed of a DC motor.

6.1 Introduction

In the previous electronics labs you built many of the basic building blocks of electronic circuits using resistors, capacitors, op-amps, and transistors. For the most part, the circuits were pre-specified, requiring you to only choose the value of a resistor or two at most. In reality, you are likely to encounter applications where you must do much more substantial design of a circuit because the only information you will have are the performance requirements for the device. This lab attempts to prepare you for such a situation by having you construct and test a DC motor speed controller.

6.2 The Project

In Lab 3, you built an open-loop DC motor speed controller. The no-load speed of the motor was proportional to the voltage level of the input signal; however, application of a load reduced the speed of the motor. The speed controller that you will build in this activity utilizes a motor-tach in a feedback loop to measure and maintain the speed of the motor, even under load. Figure 6.1 contains a block diagram of the speed controller. A differential amplifier should be used for the summer (Σ), and because the loaded motor's current requirements exceed the capacity of the 3904 and 3906 transistors, you will require a Darlington pair configuration with power transistors. You will be required to assess the performance of your controller in both the open- and closed-loop configurations. To open the loop of Figure 6.1, break the signal at A and set the free input of the differential amplifier to ground.

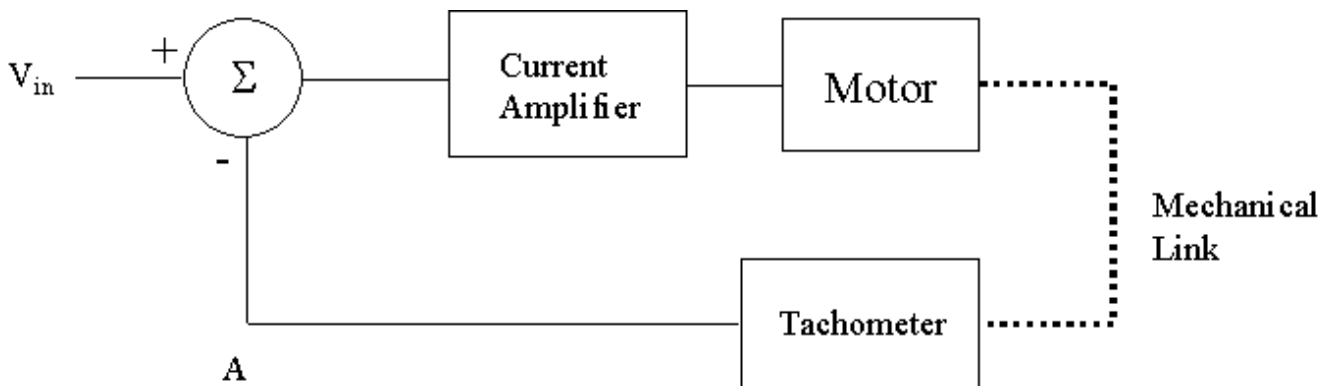


Figure 6.1: Block diagram of the motor speed controller

Initially, use a potentiometer to adjust the input voltage (V_{in}). You must demonstrate both forward and backward rotation of the motor when controlled with the pot. Later, you will replace the pot with a TTL input signal from your trainer's function generator. The TTL signal is just like the digital output that you created with LabVIEW in Lab 1. In this case it alternates (as a square wave) between 0V and 5V at the function generator frequency. **Set the function generator frequency to its minimum value when doing this test.**

With both the pot and TTL input signals, and for both open- and closed-loop configurations, observe both the op-amp and tach outputs on the oscilloscope, and note the effects of mechanically loading the motor shaft as it turns.

To summarize, your speed controller should have the following capabilities:

- Forward and backward motion with speed adjustable using a potentiometer.
- Voltage and current capacity to maintain constant speed while applying a load by squeezing motor shaft between fingers with moderate pressure. **Do not stall the motor. The high current drawn can cause damage.**
- These capabilities must be demonstrated to an instructor.

The reference sheet that you construct for this motor should contain the following:

- A schematic diagram of your circuit generated with Orcad
- Answers to the following questions:
 - How does the gain of the differential amplifier affect the controller's ability to keep the speed constant under load? How does the amplitude of the input signal affect your answer?
 - When driving with the TTL signal, how does the op-amp output signal and the tach output signal differ between the open- and closed-loop cases? Include sketches. Comment on what is going on.
 - How does the gain of the differential amplifier affect the outputs that you discussed in the previous question? What is the maximum practical gain with the TTL signal? Why?

Your pre-lab work is to design the motor controller that you will construct in the lab.

This assignment is due at the beginning of your first lab session following the mid-term break.