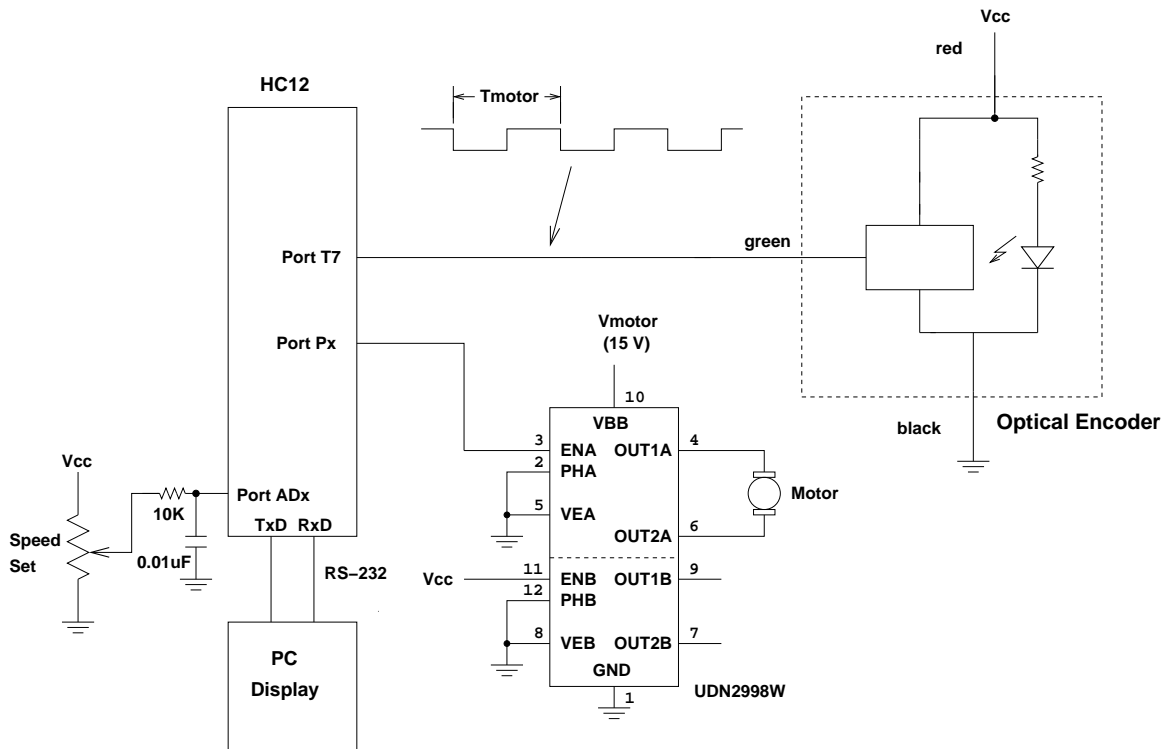


## EE 308 – LAB 13

## Motor Speed Control

In this lab you will control the speed of a motor. Figure 1 shows the hardware setup. You will use a pot to set the desired speed of the motor, and control the speed through the PWM output of the HC12. You will measure the speed of the motor using the pulse accumulator, and display the desired and actual speeds on the terminal.



1. Build the circuit shown in Figure 1. The UDN2998W is a dual H-bridge. We will use only section A. The OUT1A and OUT2A pins provide power for the motor. The PHA pin allows you to change direction of the motor. (We will tie it to ground so the motor will turn in one direction only.) The ENA pin is an active low enable — when ENA is low, the H-bridge powers the motor, and when ENA is high, the power is turned off. Both H-bridges are powered from VBB. The VEA pin is the low-voltage power pin for Section A; we will tie this to ground.
2. Set up the RTI to generate an interrupt once every 8 ms. In the interrupt service routine, increment LEDs connected to Expanded Port A. Verify from the rate at which the LEDs are incrementing that you are getting interrupts at a rate of 8 ms.
3. Program the A/D converter to read the value from the pot. Use 8-bit A/D mode. In your RTI ISR, read the A/D converter, and write this value to Expanded Port A. In the main program loop, print the value read from the A/D to the terminal. (Do not print inside the ISR — this will take more than 8 ms, and you will miss interrupts.) Verify that the A/D values change as expected as you use the pot to change the voltage.
4. Set up the PWM to generate a 5 kHz PWM signal on one of the four PWM channels. Set it up for low polarity (because the H-bridge is enabled with a low signal). It will be easiest to set PWPERx to 255.

Verify that the PWM works. In the RTI ISR, write the A/D value you read to PWDTYx. The motor speed should change as you use the pot to vary the voltage on the A/D.

Note: Writing 0xFF (255) to PWDTYx will turn off the PWM. Thus, the highest number you should write to PWDTYx is 254. If the A/D output is 255, write 254 to PWDTYx instead of 255.

5. Measure the speed of the motor. Set up the pulse accumulator to determine the number of pulses from the encoder between two RTI interrupts. In the main program loop print out the number of pulses accumulated in 8 ms, which will be directly related to the speed of the motor. Verify that the speed changes as you would expect as you vary the voltage with the pot.
6. Measure the speed for several different duty cycles by varying the voltage with the pot. Plot speed vs. duty cycle. Fit this to a straight line (use a ruler) to get the slope of the line. (It is okay to use number of pulses in 8 ms as a measure of speed, and PWDTYx+1 as a measure of duty cycle, for this part.)
7. With the pot set at about mid-range, vary the voltage from the power supply powering the motor (say between 10 V and 15 V). With this open-loop control the speed of the motor should change as you change the motor voltage. Verify that this is the case. Be sure to return the motor voltage to 15 V when done with this part.
8. Close the loop. The desired speed will be the input value from the pot times the inverse slope of the line from the Part 6. The duty cycle will be

$$DC = \frac{1}{\alpha} S_d + k(S_d - S_m)$$

where  $\alpha$  is the slope of the speed vs. duty cycle graph,  $S_d$  is the desired speed (in counts per 8 ms on the pulse accumulator) based on the input value from the pot, and  $S_m$  is the measured speed (in counts per 8 ms on the pulse accumulator). Do this calculation inside the RTI ISR, and write the new value to PWDTYx. (Be sure to limit the duty cycle to the range of 0 to 254 – if  $DC < 0$  set  $DC$  to 0, and if  $DC > 254$  set  $DC$  to 254.) Try different values of  $k$  to see how the motor responds. If  $k$  is too small, it will take a long time for the motor to get to its steady-state speed. If  $k$  is too large, the motor will be jerky as it tries to settle down to its steady-state speed.

Once you have found a good value for  $k$ , take several measurements of speed vs. input voltage to the A/D. These points should lie on a straight line with the same slope as you got in Part 6.

9. With the pot set at about mid-range, vary the voltage of the voltage powering the motor (say between 10 V and 15 V). With closed-loop control the speed of the motor should stay the same. Verify that this is the case.
10. Using the data from Part 8, plot the speed in RPM vs. the input voltage from the pot — i.e., convert the speed measured in pulses per 8 ms to speed in RPM.