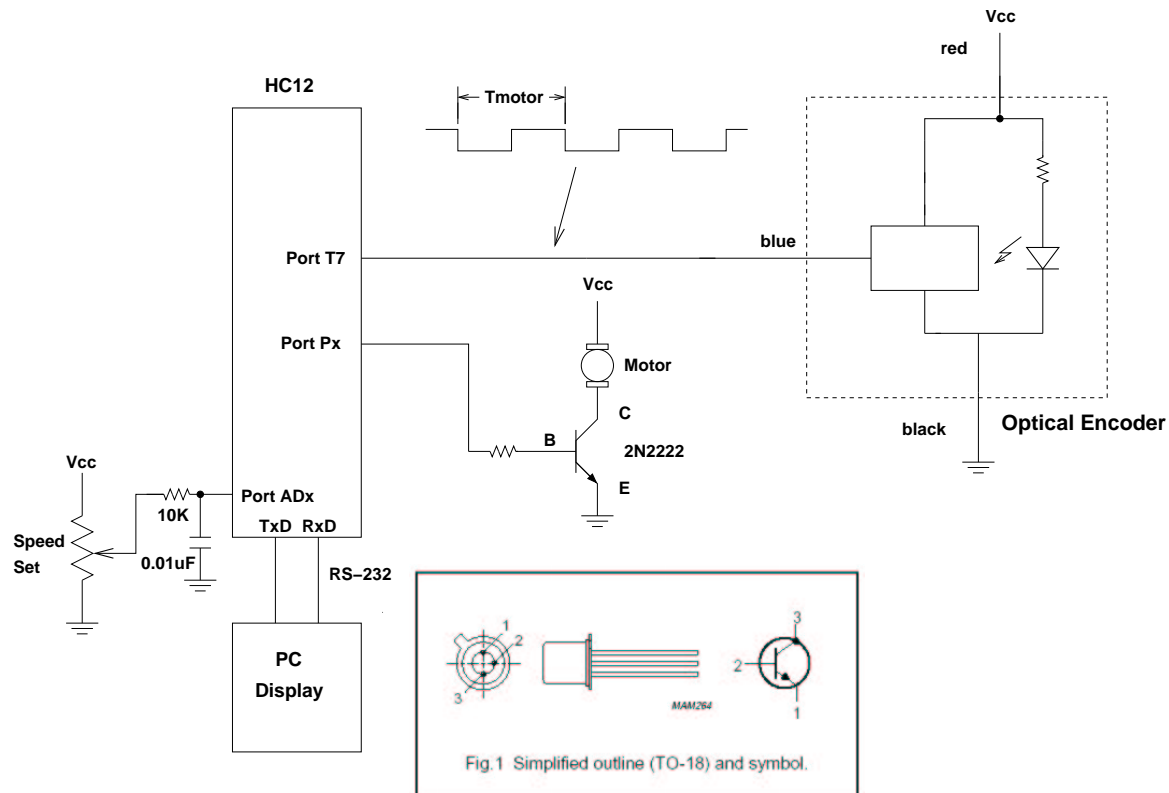


## EE 308 – LAB 12

### 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 HCS12. You will measure the speed of the motor using an input capture pin, and display the desired and actual speeds on the terminal.



1. Build the circuit shown in Figure 1. The 2N2222 is a transistor switch.
2. Set up the RTI to generate an interrupt once every 8 ms. In the interrupt service routine, increment LEDs connected to 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 the eight most significant bits to 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 50 kHz PWM signal on one of the four PWM channels. Set it up for high polarity. It will be easiest to set PWPERx to 255.  
Verify that the PWM works. In the RTI ISR, write the eight most significant bits of 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.

5. Measure the speed of the motor. Set up an Input Capture interrupt to determine the time between two falling edges of the optical encoder. In your main program write this time difference to the terminal.
6. Measure the speed for several different duty cycles by varying the voltage with the pot. Plot speed vs. duty cycle.
7. Implement closed-loop speed control. The desired speed  $S_d$  should be

$$S_d = (0.2 + 0.8 \frac{AD}{AD_{max}}) S_{max}$$

where  $S_{max}$  is the motor speed at 100% duty cycle,  $AD$  is the A/D converter reading, and  $AD_{max}$  is the maximum A/D converter reading. In this way you will be able to vary the speed between 20% and 100% of  $S_{max}$ . (Note: you cannot do floating point calculations with the HCS12. You will need to approximate the above calculation using integer arithmetic.)

To set the motor at the desired speed you can use a simple equation such as:

$$DC_{new} = DC_{old} + k(S_d - S_m)$$

where  $S_m$  is the measured speed. Do this calculation inside the RTI ISR, and write the new value to PWDTYx. 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.

8. Measure the motor speed for various values of input voltage. Take about 10 equally-spaced measurements for input voltage between 0 and 5 V.
9. With the pot set at about mid-range, vary the voltage of the voltage powering the motor (say between 8 V and 14 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 time difference between two falling edges to speed in RPM.