Lab 14 Optical Isolation and Pulse Width Modulation

This laboratory assignment accompanies the book, Embedded Microcomputer Systems: Real Time Interfacing, by Jonathan W. Valvano, published by Brooks-Cole, copyright © 2000.

Goals
- Interface a DC motor using a 6N139 or IL-5 digital isolation circuit,
- Implement variable duty cycle squarewave with output compare interrupts.

Review
- Chapter 13 of the M68HC812A4 Technical Summary, in particular look up output compare interrupts,
- Valvano Section 2.7 on device drivers,
- Valvano Section 6.2 about output compare,
- Valvano Section 8.5 concerning transistors, motors and optocouplers,
- 6N139 or IL-5 data sheets.

Starter files
- PWMOD.C, INTERP12.C

Background

One of the basic building blocks of many microcomputer systems is electrical isolation. This is particular important when the delicate microcomputer is used in conjunction with large EMF devices like motors. The interfaces developed in this lab will be used later in the digital control lab. Analog isolation devices, based on transformers or light, are available but expensive. Digital devices like the 6N139 or IL-5 are fast, cheap and accurate. The basic configuration for this lab is illustrated below. Notice the ADAPT812 and motor circuits have separate power and ground connections. The ADAPT812 ground is not connected to the motor ground between your protoboards. The Buehler motor coil resistance is about 12 Ω, costs about $5.00, and is rated at 6,800 rpm at 12 V. The red/blue wires are used to apply power to the motor, and the yellow/green wires are the tachometer output.

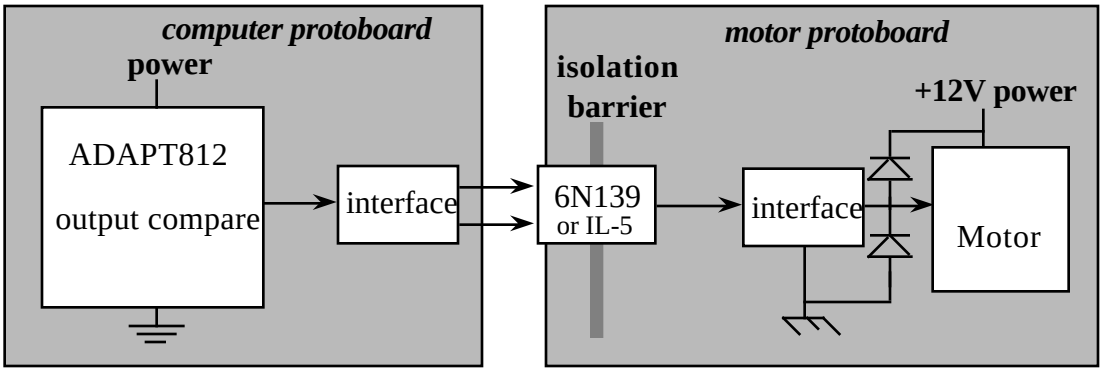

Figure 14.1. Block diagram of an isolated motor control circuit.

The output compare interrupts will continuously maintain a squarewave with variable period and variable duty cycle. The signal will pass across the electrical isolation to the external circuit. You should observe each signal on a scope. The motor speed will be controlled by the duty cycle. In a subsequent lab, you will interface the tachometer with a second isolation circuit in the other direction. In this other lab, the motor speed is fed back across the electrical isolation and into input capture. In this lab, no input capture is required. **No** `OutUDec` or `OutString` etc. should be called from the interrupt handler(s). The software main program will accept two commands. One command to set the duty cycle, and one command to set the period.

Preparation (do this before your lab period)

Design the digital isolation interfaces labeling all resistors and diodes. Include pin numbers and resistor/capacitor types and tolerances. Build the external circuit on a separate protoboard. Put the 6N139 or IL-5 on the receiver side of the interface. There should be 2 wires (2 wires in this lab, 4 when the tachometer is interfaced in a subsequent lab) between the external and ADAPT812 protoboards. Be sure the interface circuit you select can sink enough current to activate the LED within the 6N139 or IL-5. Too much current into the 6N139 or IL-5 input diode will destroy the chip. Make sure you have all the parts you need before lab starts. Include units in the numbers reported to the operator. E.g.,

```
OutString("Enter the period in usec (valid range is 500 to 65535):");
Period=InUDec();
```

or

```
OutString("Enter the duty in % (valid range is 0.5 to 99.5%):");
DutyCycle=InFDec();
```

A "syntax-error-free" hardcopy listing for the software is required as preparation. The TA will check off your listing at the beginning of the lab period. You are required to do your editing before lab. The debugging will be done during lab. Document clearly the operation of the routines.

Look ahead to the motor control lab to see how these routines will be used. In this way you can properly divide the software into separate files to facilitate their reuse.

Procedure (do this during your lab period)

Make sure your TA checks your hardware diagram before connecting it to the 6812. We do not have extra 6812 boards, so if you fry your board, you may not be able to finish. Build the 6N139 or IL-5 and motor interfaces on a separate protoboard from the 6812. I suggest you get a squarewave generator and connect it one by one to the digital controls (the place you will eventually connect the 6812). Use a scope to look at the voltages along the circuit. Please test the hardware before connecting it to the 6812. Then test the system with a fixed resistor in place of the motor. After all hardware and software parts are thoroughly debugged, then connect the motor with the 6812.

You can test your software by simply connecting output compare to a scope.

If the smallest pulse-width setting does not stop the motor, then a special case should be added that makes the output zero. No special case for 100% duty-cycle will be needed.

Checkout (show this to the TA)

You should be able to demonstrate correct operation of the interface:

- observe the signal path at each stage of the circuit,
- the motor speed is mostly independent of frequency,
- the motor speed is adjustable by the duty cycle.

You should be able to demonstrate correct operation of the interpreter:

- verify the proper handling of illegal formats,
- demonstrate your software does not crash.

Hints

1) Debug the lab in small steps.
2) Check for back EMF on the motor coil before connecting to the 6812. It can be huge!
3) The motor can be run at voltages other than +12. If you use a 24-volt supply, limit the duty cycle to 50%.
4) If you run more than 20 mA into the input diode of the 6N139, then you may damage it, 60mA for the IL-5. So don't forget the resistor on the input that limits the current well below these maximum values. Also it is easy to damage the 6N139 or IL-5 from back EMF, so connect the two snubber diodes properly. Since the 6N139 or IL-5 is easily damaged, it is good practice to test this chip separately before using it (last semester's students may have damaged your chip). Ask you TA about how to test it. Please let the lab staff know if you have a damaged 6N139 or IL-5.
5) A more detailed 6N139 or IL-5 data sheet is available on the web. Ask your TA about how to find data sheets.
6) See the INTERP12.C file on the web or included with the TExaS application for an example of a linked list interpreter.
7) The red and blue wires on the Bueller motor are to be used to deliver power to the motor. You will use the green and yellow wires from the tachometer in the next lab.