17.384 Microprocessors B
Lab 4
Spring 2011

Motor Control Using Pulse Width Modulation (PWM)

Lab Report

See separate report form located on the course webpage. This form should be completed during the performance of this lab.

Objectives

1) To interface the PIC24HJ32GP202 microcontroller and a DC Motor. Motor speed will be controlled by using Pulse Width Modulation (PWM).

Materials

PIC24 and Voltage Regulator Circuit (*Parts only needed if not previously constructed*)

☐ 1	Breadboard	
☐ 1	Oscilloscope	
☐ 1	Voltmeter	
☐ 1	PICkit ™ 2	
☐ 2	6x1 0.1" pitch R/A long-tail connector	S1132E-06-ND (DK)
☐ 1	PIC24HJ32GP202, microcontrollers - P/N PIC24HJ32GP202-I/SP-ND (DK)	
☐ 1	Wall transformer 6V, 1 A	T978-P7P-ND (DK)
☐ 1	Power connector	CP-2519-ND (DK)
☐ 1	9 volt battery (needed only if not using the Wall Transformer)	
☐ 1	9 volt battery clip (if using a 9 volt battery)	
☐ 1	LM2937-3.3 low-dropout regulator 3.3 V	LM2937ET-3.3-ND (DK)
☐ 1	Slide switch	EG1903-ND (DK)
☐ 1	500 mA fast-acting axial fuse	F2311-ND (DK)
☐ 3	0.1 microfarad capacitor	(104)
☐ 2	10 µF tantalum radial, < 5 ohms ESR	478-1839-ND (DK)
☐ 1	LED	
☐ 1	910 Ω axial resistors	(any supplier)
☐ 1	10 kΩ axial resistor	(brown black orange)
☐ 1	Pushbutton switch	P8009S-ND (DK)

Switch and LED Circuit (Figure 5) (*Parts only needed if not previously constructed*)

☐ 1	Pushbutton switch	P8009S-ND (DK)
☐ 1	LED	
☐ 1	470 Ω axial resistors	(yellow violet brown)

5 Volt Regulator (Figure 6)

□	1	LM7805 Voltage Regulator	
□	1	0.33 microfarad capacitor	(334)
□	1	0.1 microfarad capacitor	(104)

DC Motor - 5 volt Fan (Figure 7)

□	1	SN754410 Quad Half-H Driver	P/N 296-9911-5-ND
□	1	1 microfarad capacitor	(105)
□	1	Motor (fan)	P/N AD4505MX-G70-LF

WARNINGS AND PRECAUTIONS

1) Never remove the PIC24HJ32GP202 from an energized circuit

2) Do not construct circuits while energized

3) Follow electrical safety precautions

Source File Locations

1. Microchip PIC24 C compiler (C30 compiler)

LIB30 Archiver
C:|Program Files|Microchip|mplabc30|v3.25|bin|pic30-ar.exe

MPLAB ASM 30 Assembler
C:|Program Files|Microchip|mplabc30|v3.25|bin|pic30-as.exe

MPLAB C30 C Compiler
C:|Program Files|Microchip|mplabc30|v3.25|bin|pic30-gcc.exe

MPLAB Link30 Object Linker
C:|Program Files|Microchip|mplabc30|v3.25|bin|pic30-ld.exe

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Background Information

We shall utilize a 5 volt DC fan to demonstrate how to control motor speeds by using Pulse Width Modulation (PWM) module available on the PIC24HJ32GP202 microcontroller. Emphasis needs to be on configuring the PWM module of the microcontroller.

Pre-Lab Preparation

1. Download Lab # 4 from the course website. Read and understand the lab.

2. Read the various course reference materials (PIC24HJ32GP202 data sheet, PIC24 Family Reference Manual, Microchip PIC24 C Compiler manual, SN754410 Quad Half-H Driver, and review the PICkit ™ 2, etc). Datasheet links are located on the course webpage.

Procedure

Objective 1. INITIAL START-UP CIRCUIT (*Not required if accomplished in Lab #1*)

NOTE: This objective is only required if the circuit shown in Figure 1 has not been previously constructed on your breadboard. Skip to Objective 2 breadboard is wired properly.

a. Review lab Warnings and Precautions.

b. Pin-out for the PIC24HJ32GP202 is shown in Figure 1.

c. Pin-out for the LM2937-3.3 is shown in Figure 2a. 10µF capacitor terminals are shown in Figure 2b.

d. Review the "Prototyping Walkthrough for PIC24HJ32GP202 Startup Schematic" file located on the Class Webpage. This document provides additional guidance when constructing your circuit.

e. Construct the circuit shown in Figure 3 on your breadboard.

1. Locate your voltage regulator circuit in a corner of your board as this circuit will be required throughout the semester.

2. **DO NOT** install the PIC24HJ32GP202 at this time

f. Apply power (either a 9 volt wall transformer or a 9 volt battery) to the Power On/Off switch.

g. Using the voltmeter and an oscilloscope (if available), verify that +3.3 volts is at the output of the LM2937-3.3 regulator and is clean and free of interference.

h. Verify that L1 is on. This will be a visual aid in determining if voltage is present (when the LED is turned on).

i. Power down the circuit.

j. Install the PIC24HJ32GP202.

k. Add the components shown in Figure 5.

Objective 2. **VOLTAGE REGULATOR CIRCUIT (5 volts) … new circuit**

a. Review lab Warnings and Precautions.

b. LM7805 Voltage regulator that has the same pinout, Figure 2a, as the LM2937-3.3 V voltage regulator that you already have on your board.

c. Construct the schematic shown in Figure 6 on your breadboard. **DO NOT INCLUDE JP2.** Some guidelines for your construction follows:

1. Locate your voltage regulator circuit in a corner of your board as this circuit will be required throughout the semester.

d. Apply 9 volts to the VIN connection (same connection as your current output of your wall transformer power switch which feeds the 3.3 volt regulator circuit that was previously constructed). ***Care needs to be taken to ensure that the 3.3 volt supply and the 5 volt supply stay separate.***

e. Using the voltmeter and an oscilloscope (if available), verify that the +5V_REG port reads +5 volts and the output is clean and free of interference.

f. Power down the circuit.

Objective 3. MOTOR CIRCUIT CONSTRUCTION

a. Wire the schematic shown in Figure 7. Note the following …

1. In place of using two output pins (RBy pins) to connect to your H-bridge, we shall only control the motor in the forward direction, therefore, 1A will always equal zero (0) and 2A will always equal one (1). Therefore, hardwire these connections to either ground (1A) or 3.3 volts (2A).

   Future alterations to your circuit/code can control the motor in the Reverse, Break, and Coast Directions by utilizing the two pins (RBy pins). At this time we shall eliminate the added coding needed to control these features.

2. OC1 connection will be via remappable pin RB7 (RP7).

3. The TI SN754410 Quad Half-H Driver (VCC1 and VCC2) must be connected to your regulated 5 V power source that was constructed in Objective 2 of this lab. TI SN754410 Quad Half-H Driver pinout is shown in Figure 8. Ensure that pins 4, 5, 12, and 13 are grounded as indicated in Figure 8.

4. Connect the Motor (fan) as shown in Figure 7. Connect a 1 uF capacitor between the motor terminals to reduce noise.

5. Switch circuit, Figure 5, constructed in prior lab will be utilized in the performance of this lab. If needed, reconnect as indicated. The LED will not be used, however, you should keep it connected for future use.

Objective 4. MOTOR SPEED CONTROL USING PWM

a. Compose a program in "C" to perform the following tasks (see step 4.b. for some programming requirements and suggestions):

1. We shall only control the motor in the forward direction, therefore, 1A will always equal zero (0) and 2A will always equal one (1) as indicated in the chart contained in Figure 7. Objective 3.a.1 hardwired these values.

2. The switch connected to RB13 will be used to control the speed of the fan. Speeds will be as follows …

    a. Initial conditions … Fan Off

    b. First switch depression … Fan Fully rotating

    c. Second switch depression … Fan rotating at ¾ speed

    d. Third switch depression … Fan rotating at ¼ speed

    e. Fourth switch depression … Fan Off

    f. Next switch depression … Fan condition same as b

3. Use Pulse Width Modulation (PWM) to control fan speed. Use Timer2 as the timer source.

4. Verify that you can control the speed of the motor with the switch.

b. The following software requirements/suggestions need to be incorporated into your code (those labeled as "REQUIRED" *must* be in your code):

1. REQUIRED --- Include the required Class Required Header Code, Figure 4, in your software.

2. SUGGESTED --- review the textbook's "C" code. Incorporate required Code directly into your code vice utilizing header files as the textbook's code does.

3. REQUIRED --- Utilize the Pulse Width Modulation module of the PIC24HJ32GP202 microcontroller to varying the fan speed.

c. Save your program as Lab_4A.c

d. Program the PIC24HJ32GP202 using the PICkit ™ 2 connected to J1

e. Troubleshoot as required to correct all hardware and software issues.

f. Verify proper fan rotation.

g. Reverse 1A will equal one (1) and 2A now will equal zero (0) as indicated in the chart contained in Figure 7.

1. Does the fan rotate in the reverse direction?

2. Reinstall 1A and 2A to their original conditions (Objective 4.a.1.)

h. If required, have the instructor view your working circuit.

i. Insert a copy of your code, Lab_4A.c at the end of the lab report in the space provided as well as email a copy to the instructor.

SUMMARY:

You developed Code that utilizes the Pulse Width Modulation (PWM) feature of the PIC24HJ32GP202 microcontroller. We also saw how to vary fan speed and direction, which can be used in many future applications.

An addition to this lab would be to attach a variable resistor to an analog input of the PIC24HJ32GP202 microcontroller. Varying the resistor would cause the motor to change speeds. In addition, additional switches could be attached to control the direction of the motor. This would also require connecting 1A and 2A to the microcontroller (RBy pins) and adding control of these pins to your code.

Lab Notebook Requirements:

Ensure that you have recorded all the data requested during the lab in your lab notebook as well as your lab report.

Lab Report:

1. Use template provided on the Class Web Site.

Figure 1 – PIC24HJ32GP202 Pin-Out Diagram

28-Pin SDIP, SOIC

■ = Pins are up to 5V tolerant

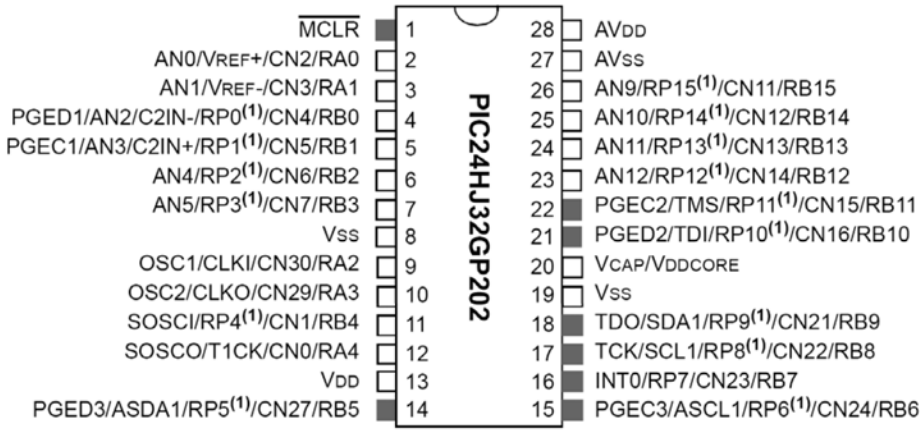


Figure 2a – Top View – LM2937-3.3 and LM7805 (5 volts)

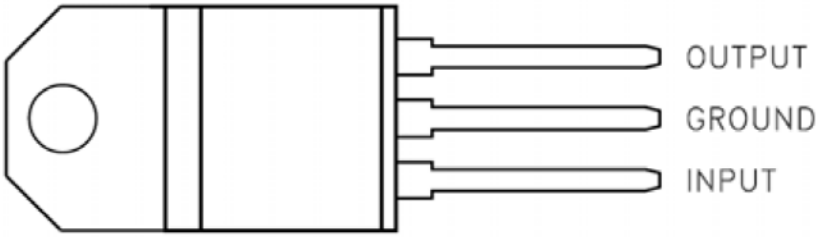


Figure 2b – 10µF Tantalum Capacitor P/N 478-1839-ND

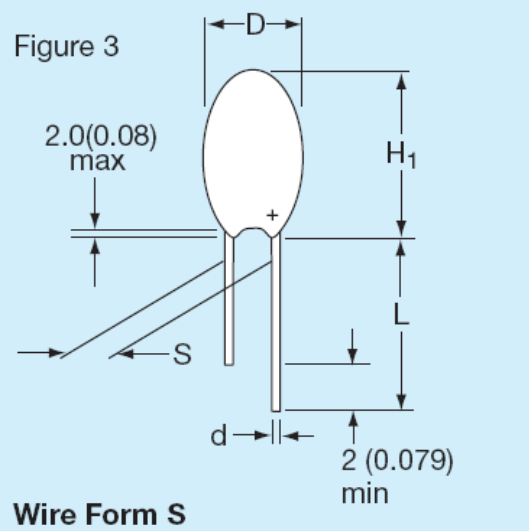
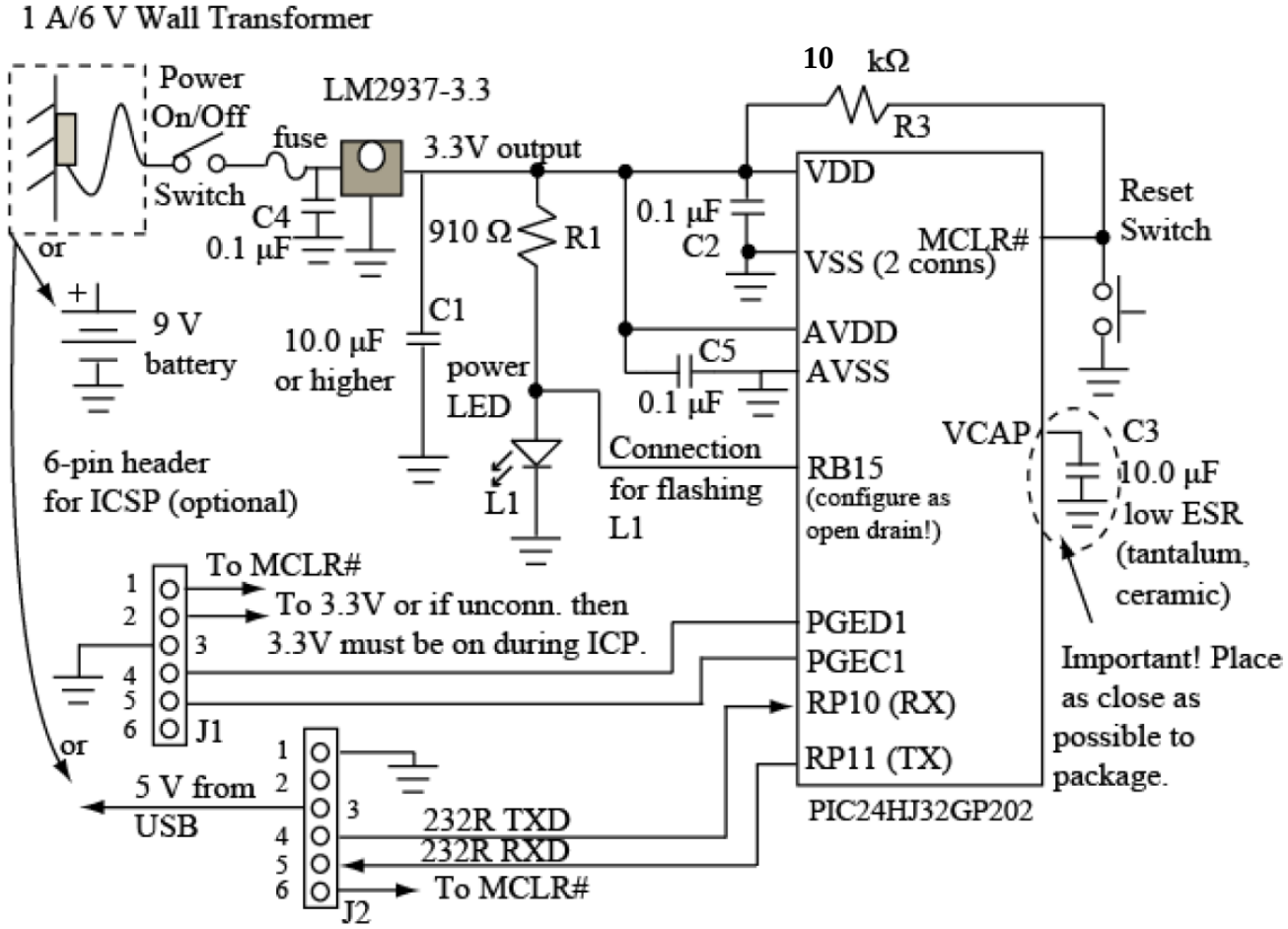


Figure 3 – PIC24HJ32GP202 Initial Start-up Schematic



6-pin header for FTDI TTL-232R-3.3V USB-to-TTL cable (PC serial communication link)

Figure 4 - Required Header Code

```
/*******************************************************
*
* Program Title:     xxxx
*
* Program File Name: Lab_XA.c
*
* Microprocessors B 17.384
*
* xxxxxxxx - Put in Semester (i.e. Spring 2011) here
*
* xxxxxxxx - Put in your name here
*
* xx/xx/xx - Put date here
*
*******************************************************/
```

Figure 5 – RB13 and RB14 Connections

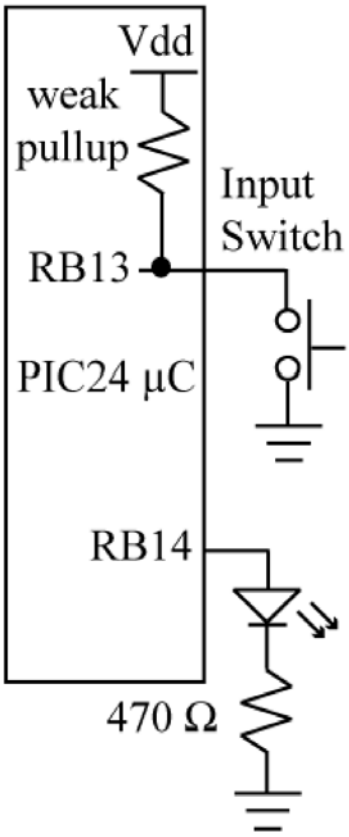


Figure 6 – Voltage Regulator Circuit (5 volts)

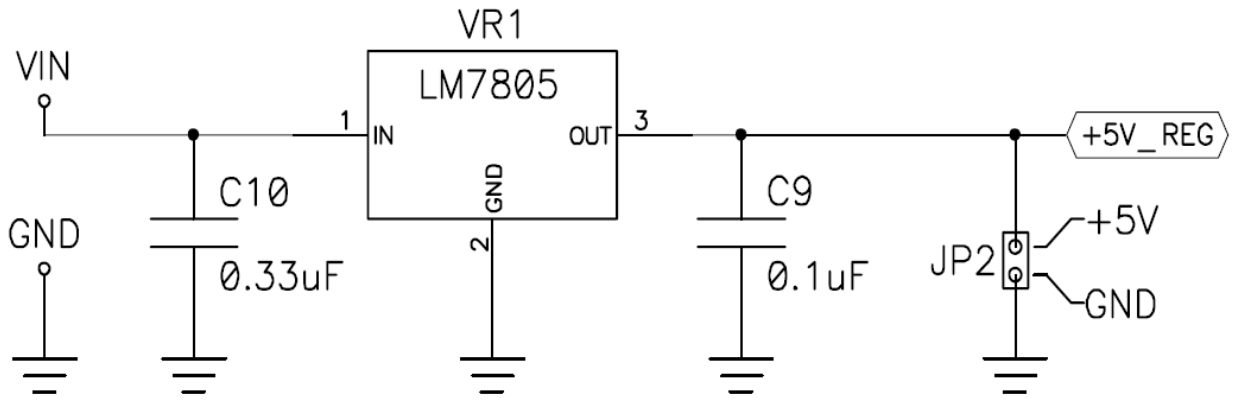
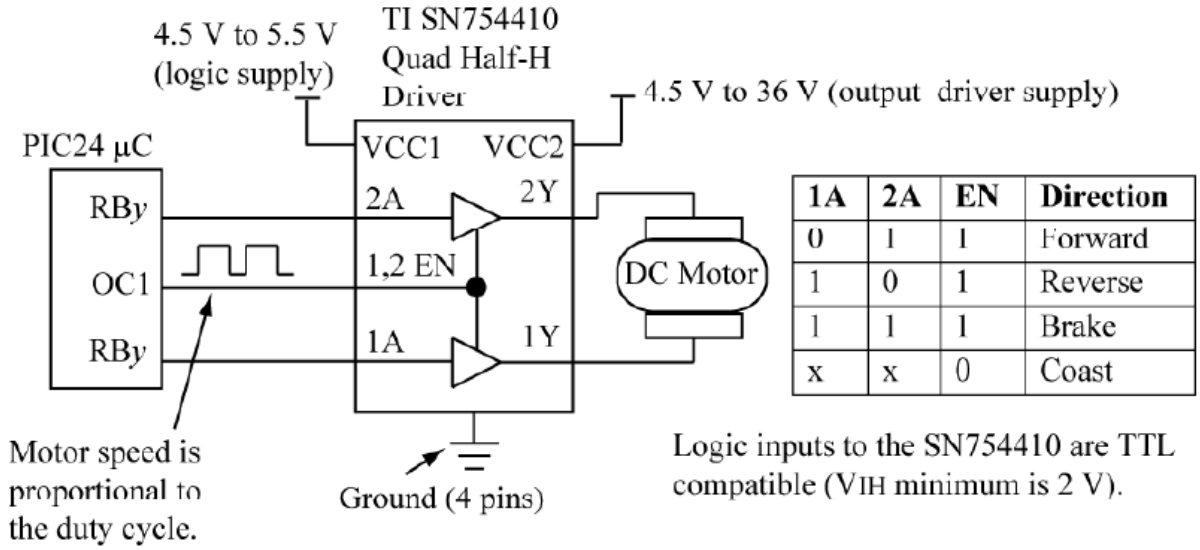


Figure 7 – Motor (5 volt Fan)



1A	2A	EN	Direction
0	1	1	Forward
1	0	1	Reverse
1	1	1	Brake
x	x	0	Coast

Integrates MOSFET/BJT drivers, protection diodes, switches.

Figure 8 – SN 754410 Quad Half-H Driver