

Massachusetts Institute of Technology
Department of Mechanical Engineering
2.12 Introduction to Robotics
Laboratory No. 1

Objective

The objectives of today's laboratory are:

- Set up a robot control system and check basic functions of the controller,
- Drive a DC motor using a PWM power amplifier, and
- If time permits, download a user C-code to the robot controller.

Lab Report

You are expected to turn in the questions/check sheet. Each group turns in one report at the end of lab session.

SAFETY

The hardware and motor that you will be using for 2.12 this semester use considerable current. The Robot controller uses up to 1.5A continuously and the motor draws up to 4A of current. These currents are dangerous and please use common sense when operating the equipment. Most importantly, when you are wiring make sure all the power is turned off.

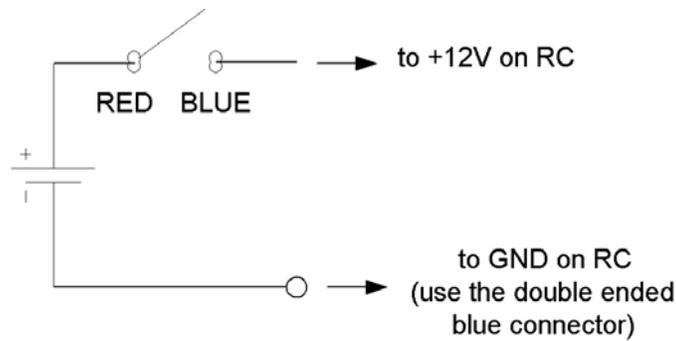
READING

1. Read materials from the Innovation First website.
 - a. 2004 Control System Overview
 - b. 2004 Operator Interface (OI) Reference Guide
 - c. 2004 Full-Size Robot Controller (RC) Reference Guide
 - d. 2004 Full-Size Control System Quick Start Guide

You have a half hour to skim these materials.

INITIAL SET UP

2. Turn on your laptop and click on 'Usern'. The password is: "[password removed]". Next, you should change your password. Open the control panel, click on User Accounts, and click your section again. Here you will be able to change your password. Write down the new password and give it to the laboratory instructor with your names and laptop number.
3. Retrieve switches for the 12 V power supply (the big one). Use the SPST switch (single pole single throw) and connect it as shown in the diagram below. Before connecting to the RC, check with a multi-meter that when the switch is toggled, 12 V and ground are read. Keep the switch OFF for the time being. Also, plug in the backup battery. NOTE: If you ever turn the switch off, power will be drained from the backup battery to keep the system functioning. This is a nice feature but not now. You must press the RESET button on the RC to stop the backup battery from being drained.



4. Use the tether cable (RED) to connect the Robot Controller (RC) to the Operator Interface (OI). NOTE: The tether cable (RED) will provide power to the OI from the RC when it is tethered: you do not need the AC Adapter when it is connected. However, the AC adapter must be used when you are using the radios.
5. Plug in the joystick to port 1.

PWM

6. Connect the PWM Extension cable (the black-red-white flat cable) to the PWM output 1 on the RC and connect the other end to a breadboard. Connect oscilloscope probes to the GND (Black) and the signal (White).
7. Connect a black DB9 connector from the DASHBOARD on the OI to the serial port on your laptop.
8. Before turning the power ON, ask the lab instructor to check your wiring.
9. Ensure that the Robot Controller Jumper is set to RC (see P.12 of Operator Interface Reference Guide).
10. Open the Dashboard program on the laptop.
11. Look at the PWM values on the Dashboard interface as you move the joystick horizontally and vertically.
 - a. What PWM numbers (there are sixteen of them) on the dashboard do X and Y motion correspond to?
 - b. What is the maximum value? Minimum? What is the value when the joystick is in the neutral setting? How many bits is the signal?
 - c. What variables in the dashboard program do the buttons on the joystick correspond to? What lights are illuminated on the OI when the joystick buttons are pressed?
 - d. As you move the joystick what lights are illuminated on the OI and under what circumstances?

12. Turn on the oscilloscope and observe the waveform. As you move the joystick, the duty cycle should vary.
 - a. What is the frequency of the PWM signal?
 - b. What is the maximum duty cycle? Minimum? What about at the neutral position? Is this what you expected? Any hypotheses why these are like this?
 - c. What is the voltage the PWM signal operates at?
 - d. What is the risetime? Falltime?

DC MOTOR

13. Turn off the power and setup one axis of the DC motor with PWM amplifier (Victor 884) referring to page 1 of the Victor 884 User Manual. You can connect the PWM Extension cable (the black-red-white flat cable) that was in the breadboard into the Victor 884. Also, you can connect the power to the Victor 884 by fastening the circle lug to the power of the RC (this is called daisy chaining). Before turning on the power, have the laboratory instructor check your wiring.
14. Send a command from the joystick and verify that you can drive the motor in both directions.
15. Using a multi-meter, look at the voltage that drives the motor (DO NOT use the oscilloscope for this: it has a world ground that will spark when attached to the floating motor load. If you want a further explanation talk to the lab instructor).
 - a. What is the voltage range?
 - b. Is the voltage the motor sees linear with position of the joystick?
 - c. Does this correspond to what you saw the PWM signal you saw earlier?Optional: You can calibrate the motor by following the directions on page 2 of the Victor 884 Manual.
16. Refer to page 2 of the Victor 884 User Manual to switch between Brake/Coast configurations. How does this change the behavior of the motor? Observe the time for stopping the motor after the joystick command turns to zero.

DIGITAL INPUT

17. The RC makes Digital I/O very easy. Connect a different PWM extension cable to DIGITAL IN/OUT (DIO) pin 1 and connect the other end to a breadboard. Note that the +5V and ground are already provided for you.
 - a. As you go between +5V and GND to the logic input to the DI pin, what lights on the OI are illuminated? When it turns ON, are you grounding the pin or giving +5V?
 - b. When you move the PWM extension cable to DIO pin 2 and 3 what lights are illuminated on the OI.
 - c. Looking at the Dashboard on the laptop, what variables represent the assertion and disassertion of these logic pins?

RADIO LINK

18. Now you will connect to the RC wirelessly. The RC will eventually be remote on the robot that you will be controlling. Follow the directions on page 5 of the Quick Start Guide. When you choose a team number, choose a unique number and write it on the white board with your names next to it (this is just temporary). Any redundant team numbers will cause interference. Note: Your team number is set by changing the 12 bits on the OI with the MSB (Most Significant Bit) on the far left.
19. After you connect wirelessly, turn off the power and disassemble all your parts to how you received them.

The remaining of this lab is optional although if you have time the first is strongly recommended. It involves downloading a program to the RC that you will be doing in the next lab.

1. The RC is able to capture analogue inputs. Connect a PWM extension cable to analogue input 1 and the end on the breadboard. Connect a variable resistor such that you can get a range from 0 to 5 V. Unfortunately, neither the dashboard nor the OI have any easy way to look at the signal you are changing. In order to do this we have to download a file to the RC. Although you program in the C language, it had to be in the .hex format in order to download the program. We have made a program for you to download. Disconnect the dashboard connection on the RC and connect it to the Program connection. Open the IFI Loader program and download "Lab1_Code.hex". After the program is successfully downloaded a text window pops up with three different items: X axis, Y axis, and analogue input. As you change the potentiometer, the analogue input should change between 0 and 255. This number is easily retrieved for use in programming. You can also move the joystick to see the X axis and Y axis numbers change. **IF YOU DOWNLOADED THE .HEX FILE, PLEASE REDOWNLOAD THE DEFAULT CODE "FRC_default.hex".**
2. Try connecting the joystick to other three ports and finding what variables the joystick movement and buttons correspond to on both the Dashboard and OI. Also, it is interesting to see a new Dashboard interface if you switch the jumper near the Dashboard to the other setting. If you do this, please switch it back after you are done.
3. See what happens when you have 2 identical team numbers.

Items Needed for the Lab

Laptop and AC Adapter
Robot Controller
Operator Interface
Both Radios
3 DB9 connectors (BLACK)
1 Tether cable (RED)
Joystick
Switch with soldered ends
12 V Battery or Power Supply
Backup Battery
Multimeter (we only have 2 of them currently)
Motor
PWM Amplifier (Victor 884)
Variable Resistor – **Ask TA**
Breadboard Wires (Communal) – **Ask TA**
Oscilloscope
2 PWM extension cables (black, red, white)
Philips screwdriver – **Ask TA**
Small flat-head screwdriver – **Ask TA**
1 Black wire with a blue circle lugs on the end.
1 dual black wire with Red/Blue circle lugs and Red/Blue U lugs on the ends