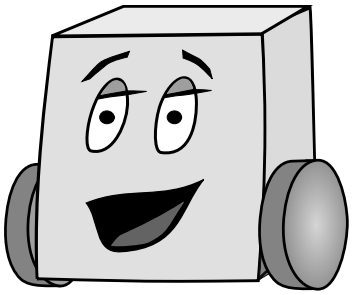


E11: Autonomous Vehicles

Fall 2011

Harris & Harris

Lab 4: Robot Assembly

Introduction

In this lab, you'll make your very own robot! You should have a Mudduino and a chassis, as well as your kit of parts. Now it's time to put them all together.

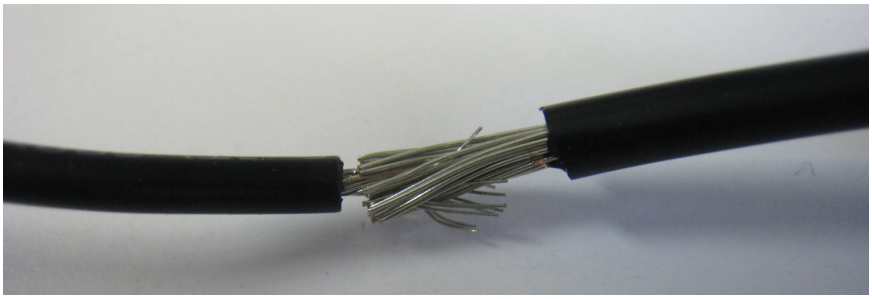
Preparing the Battery

The robot is powered by a 7.2V RC car battery. Before it can be used, you need to solder a barrel jack to the battery wires. The barrel jack has two leads that will be soldered to the battery wires.

WARNING: The battery is designed for high current output. If you accidently create a direct path between power and ground, the battery will start smoking in about four seconds. There is also the possibility of sparking between power and ground, which can cause small burns. If you take care to keep power and ground separated, you won't have any problems.

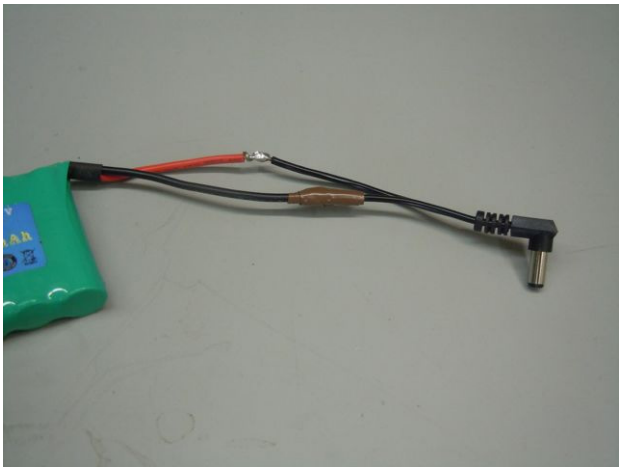
Now that we've gotten the scary warnings out of the way, here's how to attach the connector. Cut the wires so that about 4" emerge from the battery, and 3" emerge from the barrel jack leads (clip one of the leads about half an inch shorter than the other to prevent electrical contact between the wires). If you leave too much wire, it will drag behind your robot and might get caught on things.

Strip about 1/2” off of the black wire from the battery and barrel jack leads (not to be confused with the black wire with the white stripe on the barrel jack leads). Intertwine the wires, as shown below. Make sure you have a good mechanical connection before you solder.



Heat the junction, and apply copious amounts of solder. Make sure that the solder is actually soaking into the connection, rather than just wetting the surface (if this isn’t happening, keep heating the wires). You should also flip over the wires and solder the other side. You want to make a very strong electrical and mechanical connection.

Once you’re satisfied, clean up any stray wires with the cutters and wrap electrical tape around the junction. Then, do the same thing with the red wire from the battery pack and the black wire with the white stripe on the barrel jack leads. Remember that it is very important the two solder joints do not make contact or else power will be shorted to ground. You should end up with the following:



Write your initials on your battery pack.

Preparing the Battery Charger

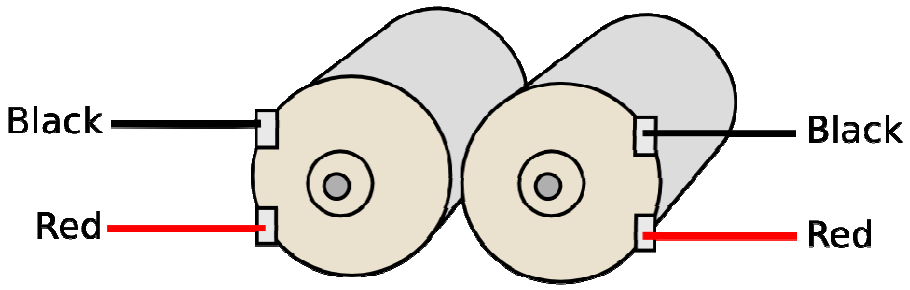
Connect the large round jack to the battery charger in the same fashion. Chop the incompatible connectors off of the battery charger so that you can solder on the round jack instead. The red wire on the charger goes to the black and white wire on the jack. The black and red wire on the charger goes to the solid black wire on the jack.

Plug your battery pack into the charger and the charger into the wall. You should see a red light on the charger indicating that the battery pack is charging. The light will turn green when the battery is fully charged. It is a good idea to recharge your battery before each of the future labs so that it remains at full strength.

Preparing the Motors

You will find two pairs of motors in your kit. They look deceptively similar and are important not to mix up. The motors that come with the gear box kit are only rate for 3-6 V and could burn out if connected to your 7.2 V battery pack. Discard them or mark them with a sharpie and set them aside in a way that you will not mix them. Instead, you'll be using the other pair of motors in your kit rated for 3-12 V.

Cut off two 6" pieces each of red and black wire to connect the 3-12 V motors to the Mudduino board. Strip 1/3" of insulation off the ends and solder a red and black wire to each of the motors. Twist the wires together to keep them neat. Note that since the motors are driving wheels on opposite sides of the bot, you will want the wire colors to be mirror images:



This will make programming the robot's driving more intuitive.

Be careful with your wires; if they bend too much, they may snap off.

Assembling the Gearbox

The robot's gearbox can be assembled in different ways depending on the desired speed and torque. For the purposes of this lab, we will assembly it in the lowest-speed configuration with a 344.2:1 gear ratio. Follow the directions in the gearbox kit.

The directions contain a scale that will help you place the parts at the right position on the shaft. Be sure to tighten down the grub screw forcefully against a flat edge of the hex shaft so that the gear hub does not slip when the motors apply full torque. If the hub does slip later, you'll have to disassemble your gear box and rebuild it. Keep the spare parts in case you want to rebuild your gearbox with a different gear ratio at a later time.

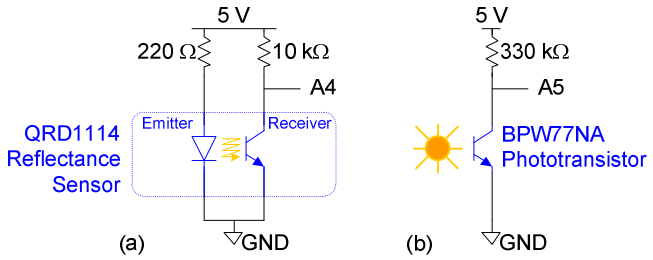
Plug the motors into the gearbox. For the sake of consistency between robots, put the red wires on the bottom. Bolt the gear box to the chassis using the nuts and bolts from the gear kit.

Put tires on your two wheels and mount them to the gear box using the hex shaft plates.

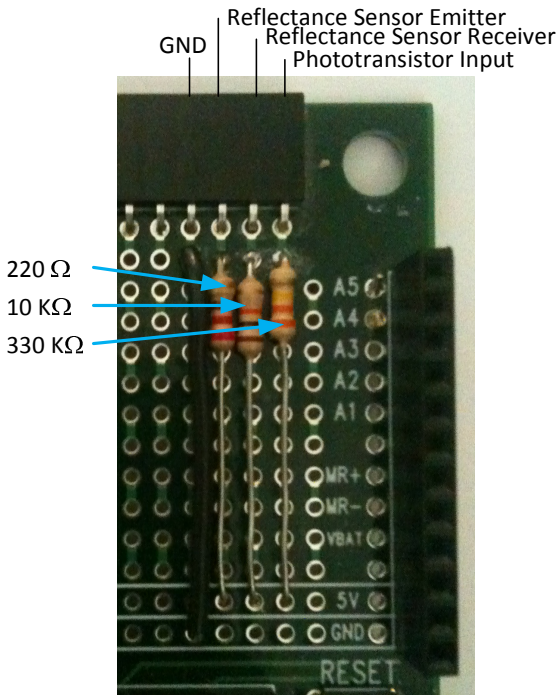
Bolt your gear box to your chassis using two machine screws and nuts that came with the gear box.

Wiring up the Sensors

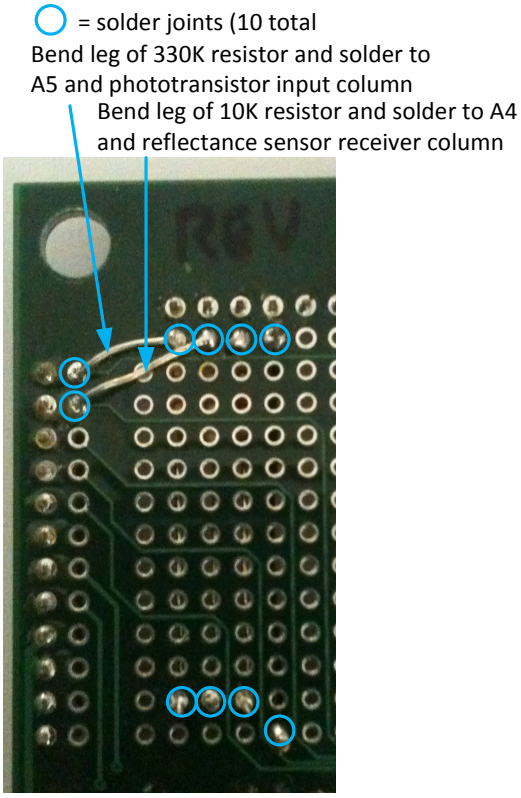
The standard robot is equipped with two different sensors: a phototransistor, and a reflectance sensor. The sensors require supporting circuitry to operate. The circuit diagrams of the phototransistor and reflectance sensor are shown below:



The required resistors will be soldered onto the perfboard on the top half of the Mudduino board. While there are many ways to do this, we recommend the layout below because it can be done with only three resistors and one wire by cleverly bending the resistor legs. Study the wiring diagram and relate it to the schematic so you see how each connection is made. Cut a piece of wire to make the ground connection. Take your time and get it right the first time; it's easy to goof up and fairly time consuming to redo if you make the wrong connections.



Component Side View

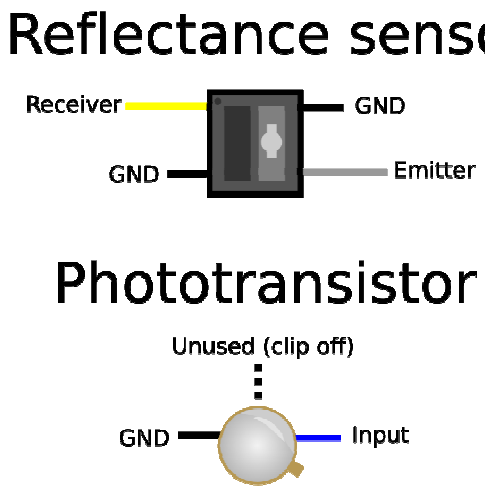


Solder Side View

Remember that the resistor codes are:

- 220 Ω: red-red-brown
- 10 KΩ: brown-black-orange
- 330 KΩ: orange-orange-yellow

You will need to make a 4-wire cable with four male header pins at one end that connects to the female right angle connector at the front of the robot. The following diagram shows which pins on the sensors connect to the slots on the Mudduino. The short pins on the reflectance sensor are GND. A common mistake is to wire the reflectance sensor incorrectly. The middle pin of the phototranisistor is the base terminal. It will interfere with the transistor's operation if it touches the other terminals, so snip it off close to the package to prevent such problems.



It's up to you to decide how to arrange these wires. You may wish to use some electrical tape to prevent pins from shorting. Again, it is much better to get this right on the first try. Talk to your instructor if you have any questions.

Attaching the Servo Motor

Notice how the circuit board has a notch in the back of the robot for mounting the servo motor. Place the servo in the notch, such that the gear is closer to the power jack. Secure the servo motor to the board using a pair of 2-56 x 3/16" nylon machine screws. The screws should enter from the back of the board and hold to the flanges on the servo so that you do not need nuts. The nylon screws prevent you from shorting the power to ground planes inside your circuit board.

The servo motor female header pins should mate with the corresponding male header pins on the circuit board. Polarity matters! The brown wire should connect to the GND pin, red to VDD, and yellow to SIG.

Mounting the Distance Sensor

Attach your distance sensor assembly to your servo motor. The distance sensor assembly includes the distance sensor, the mounting bracket, and the double horn arm. Place the arm on the servo with the sensor facing forward (toward the bumper in the front of the robot). Use a small pan-head screw in the servo kit to affix the arm to the servo.

Connect the distance sensor wire to the female header pins. One end of the wires connects to a socket on top of the distance sensor. Solder or crimp three male header pins onto the other end of the wire and insert the header into the female distance sensor header. Polarity matters; the red wire should go to 5V, the black to GND, and the white to signal.

Make sure that no wires or other parts can get in the view of the distance sensor or it will interfere with the distance readings.

Robot Assembly

You can think of the robot as a delicious sandwich: crunchy gearboxes and tangy batteries squished in between the chassis and the Mudduino. The entire thing is bolted together, with standoffs preventing you from smashing the sandwich.

Attach the ball caster to the front of the robot. Place the thicker black plastic standoff between the caster and the chassis to level the robot. The chassis holes are slightly too small for the screws, so the process of screwing them in will tap threads into the chassis.

Mount the sensor tower on the chassis with an 8-32 ½" machine screw.

Place the phototransistor in the sensor tower facing forward. Place the reflectance sensor in the square hole in the chassis.

The battery pack could be damaged if the sharp pins on the bottom of the Mudduino board were to pierce the pack. To prevent this risk, attach two 3" strips of foam tape to the side of the battery pack with no label.

Add the battery (foam side up) and Mudduino. Make sure that the battery cable is coming out in a convenient location.

There should be 4 metal standoffs, one in each corner that will hold the entire thing together. Secure the standoffs by fastening 8-32 machine screws on top through the holes in the Mudduino and on the bottom through the chassis. The standoffs are threaded inside so the screws should screw in place.

Connect the 4-wire cable from the sensors to the right-angle headers on the front of the Mudduino. Plug the battery wires into the MR+/- and ML+/- header pins on the sides of the Mudduino.

Congratulations! You have just made your delicious robot sandwich!