Clodbuster Robot Building Documentation

Multiple Autonomous Robots
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Contents

Chassis Construction

Assembling the Tamiya RC model truck out of the box can be completed in approximately 2 days with two people working on it. Assembly will be much smoother if you have ALL of the parts that you will need before you start. Here are some instructions and modifications that need to be made to the given directions. Prior to assembly, organize all parts and label the various groups by letter. It is best to find a large desk where everything will be spread out in front of you and there is plenty of room to work. The following numbers coincide with the steps given in the instructions.

1. Notation:
    a. MA1 refers to part #1 in the small bag labeled 'A'
    b. A1 refers to the plastic part labeled 1 in the large bag containing the A parts. (If you look in the back of the instruction manual, you will find a parts listing. You should label all of the large part bags according to this listing.)

   Use needle-nose pliers to attach e-rings as shown in picture.
   Apply ceramic grease liberally.

2. Squeeze Liquid Thread-lock tube gently, as the blue gel will continue to slowly ooze from the tube even when you are not squeezing.

3. The allen-key needed for this step is included in the kit.

4. Follow instructions as given.

5. Follow instructions as given.

6. **DO NOT** attach any of the plastic parts; only attach the MF1 screws to the frame.

7. **N**ote: motors to do not sit on the MS7 shaft. (picture is deceiving)

8. Pay attention to which screws are used where, if done incorrectly, it is difficult to fix.

9. Apply liberal amounts of ceramic grease to parts.

10. Apply excessive amounts of grease to all parts. You should use approximately half a tube of grease between the two parts assembled in the step. When this piece is assembled, work the grease into the parts by rotating them.

11. Follow instructions as given.

12. Note orientation of differential gear.

13. Follow instructions as given.

14. Note there are two pictures given in the instructions. They are showing two different orientations of the axle guards. You are to make two of each.

15. Follow instructions as given.

16. On the rear tie-rod, insert the ball connector that is on the right-hand side so that the ball is on the bottom and the nut is on the top. (Reverse what is in picture.) Attach the tie-rod to the two bottom ball connectors. Refer to instructions next to step 18 on how to fasten tie rod to ball connectors.

17. Do not make any of the threaded shaft pieces. You will not need them.

18. Leave the ball connectors for the push rods empty.

19. Follow instructions as given.

20. Attach propeller joint before the lower arms.

21. Do not assemble the pushrods and again leave the ball connectors for these empty.

22. Same as step 20.

23. Use black clamps instead of nylon bands.

24. Follow instructions as given.

25. Use the clear, hard, #900 oil that has been previously purchased. Do not use the oil that comes with the car, it viscosity is too low.

26. The suspension of the car has been completely modified to fit our needs. **DO NOT** use the instructions given with the car. Modifications are explained below.

27. Skip this step.

28. Do not use the servo saver that comes in the kit because it does not have sufficient torque. Use any other higher torque model. Making whatever modifications necessary to the servo saver, screw in the ball connector and attach the necessary insert to connect the servo

29. Follow instructions as given.

30. Use MS9 instead of ML5 to construct the threaded shaft. DO NOT attach the ball connector to the plastic under guard, instead screw it into the servo saver. You will then attach the threaded shaft to the servo saver and the "double-sided" ball connector. When attaching the F7 plastic pieces, holes 2 and 3 should be used. The plastic under guard may need to be "forced" on by gently bending it into position while it is screwed on.

36. Do not use MT2 pieces. Insert foam into tires by pulling off tire from wheel halfway and inserting the foam. Replace tire and attach wheel as shown.

Assembly and Connection of Wires

I. <u>Power Connector Cable Assembly</u>:

The power connector cable provides power from either an AC adapter or a battery to the SPack board and to the camera on the Clodbuster. The cable must be properly connected to ensure the proper supply of power to each component.

- Splice one end of the power cord wire and splice the ends of two 20 AWG wires (one red and one black).

- Solder together the exposed metal tips of the red wire and the power lead of the power cord. Also solder together the black wire and the ground lead of the power cord.

- Crimp the soldered ends of the wires into a socket terminal connector (Digikey part # WM2311-ND, Molex mfg. part # 357-28-0201) and insert into the plug housing (Digikey part # WM2308-ND, Molex mfg. part # 351-43-0201)

- Crimp the other ends of the red and black wire into the proper size crimping terminator (Digikey part # WM2311-ND, Molex mfg. part # 43030-0009) and insert into the square connector.

- Use a small piece of wire with crimping terminators on each end as a jumper between the two remaining slots of the square connector.

- Ensure that wires are securely fastened and in the proper order.

WARNING: Improper wiring may damage board.

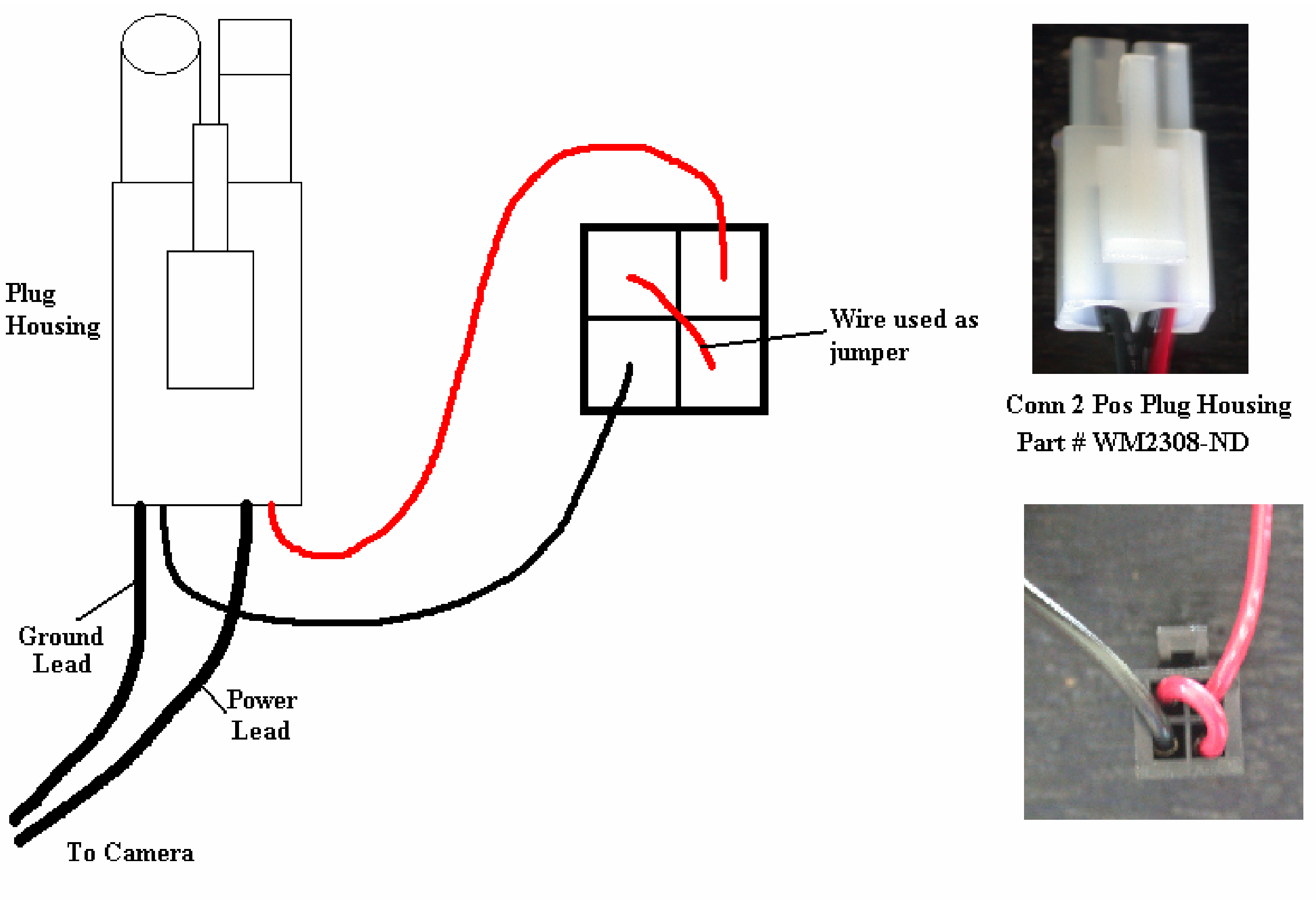


Figure 1 – Power Connector Cable

II. Serial Input Cable Assembly:

The serial cable interfaces with the notebook USB->Serial Adapter and the SPack. It is constructed from a three wire ribbon cable with an RS232 DB9 Connector on one end and a Tyco-Amp 3-pin connector on the other end (see Figure 4 below).

When assembling the cable, the Receive Data (RD), Transmitted Data (TX) and Signal Ground (GND) terminals on both connectors must properly be connected using a three wire ribbon cable. The remaining pins on the serial port connector are not used.

- Separate and splice one end of the ribbon cable. Solder the exposed metal ends of the wires into the serial port connector. Use heat shrink tubing (polyolefin) and electrical tape to provide support for the connection.

- Separate and splice the other end of the ribbon cable. Insert each wire into one slot of the Tyco-Amp connector by either using the proper crimping tool or using an exacto knife. Ensure that the wires are properly arranged so as to connect the RD, TX and GND terminals on both terminals. Use heat shrink tubing (polyolefin) to strengthen the connection.

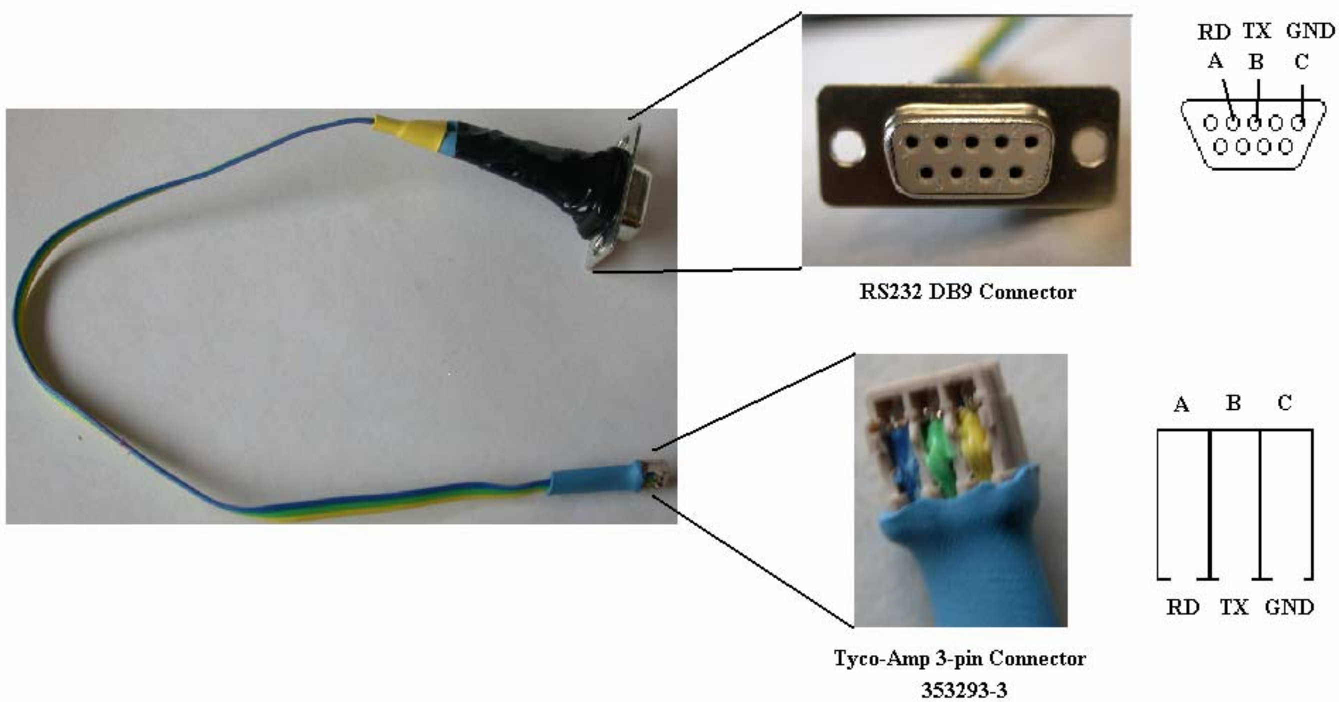


Figure 2 – Serial Input Cable

III. Soldering Firewire Cables:

You will be using 4 → 4 and 6 → 6 cables.

1. Cut the cables in half and you will find pairs of twisted cables for data transmission within the wire under a lot of shielding. The pairs are color-coded red-green and blue-orange for the 4 → 4 cable and there is an additional pair of black-white in the 6 → 6 cable. The black and white pair is used for camera power (Refer to Figure 3).

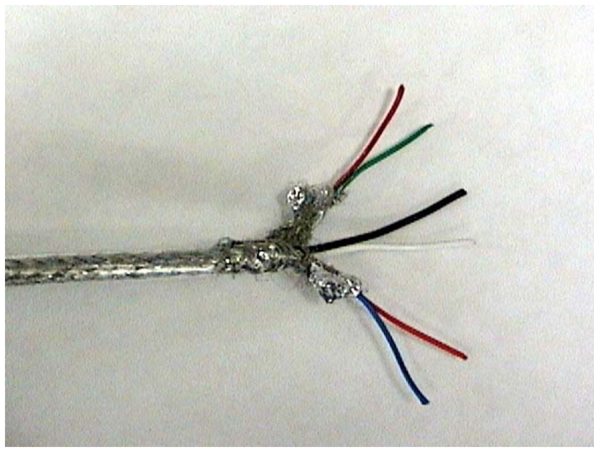


Figure 3

2. Splice out the two power wires for connection to the circuit board.
3. Solder and shrink wrap the four pairs of cables: R→R, G→G, B→B, and O→O.
4. Restore as much of the shielding as much as possible and then shrink wrap the two sections of cable together.
5. Ensure continuity is <u>exclusive</u>. (e.g. pin 1 to pin 1 <u>only</u>) Use the continuity tester for this.

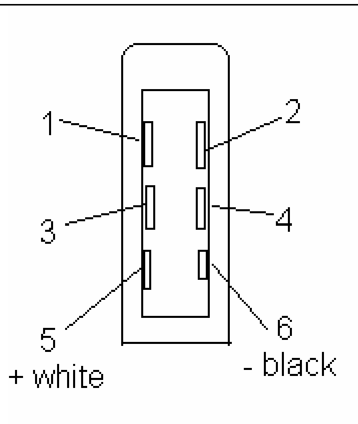
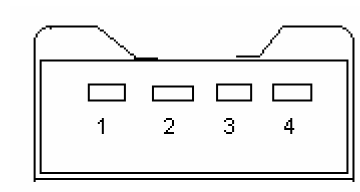
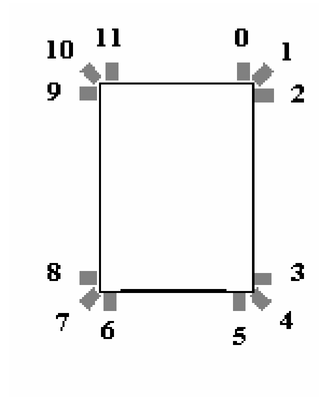
Port into Camera	Port into computer
	

Figure 4

IR Cable Assembly:

The SPack contains interfaces for up to 16 IR sensors, though only sensors 0-11 are used in the current Clodbuster implementation. Note in Figure 2 that connectors 7 and 8 on the SPack board are reversed and do not follow the regular order.

The Clodbuster uses 12 IR sensors to detect surrounding objects. 3 sensors are located in each corner of the robot in the arrangement shown to the right. All the sensors simultaneously fire out an infrared pulse every 70ms and measure the time taken to receive the pulse back. The sensors return values between 0 and 255 with higher values corresponding to smaller distances. The values for each sensor are individually calibrated to the corresponding distance and a lookup table is generated for values corresponding to the range of 10cm – 70cm.



A four-wire ribbon cable with a 353293-4 connector and a ZHR4J21 connector is used to construct the cable interfacing the IR sensors with the SPack board. To assemble this cable:

- Separate and splice one end of the ribbon cable. Insert each of the four wires into a slot of 353293-4 connector by either using the proper crimping tool or using an exacto-knife. Ensure that the wires are securely inserted into the connector.
- Separate and splice the other end of the ribbon cable. Using metal fasteners insert wires into the ZHR4J21 Connector

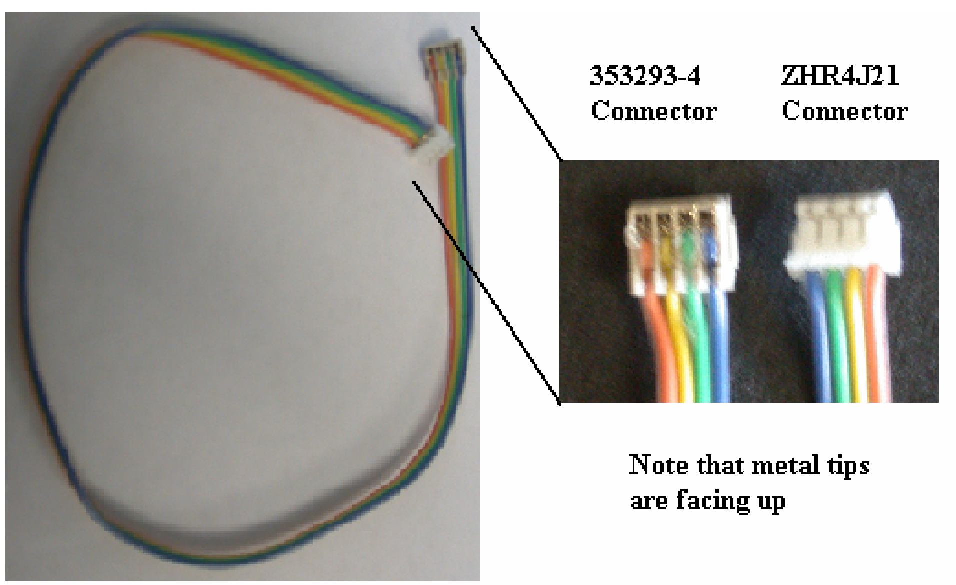


Figure 5 – IR Cable

IV. Servos:

There are eight servo inputs numbered 0-7 as outlined above in Figure 2. When connecting the servo cables to the board, the red and black wires must be flipped. The red wire is towards the outside of the board, as shown in Figure 3. This is in anomaly in the board manufacture.

WARNING: Failure to swap these wires will result in failures to the servo and speed controller.

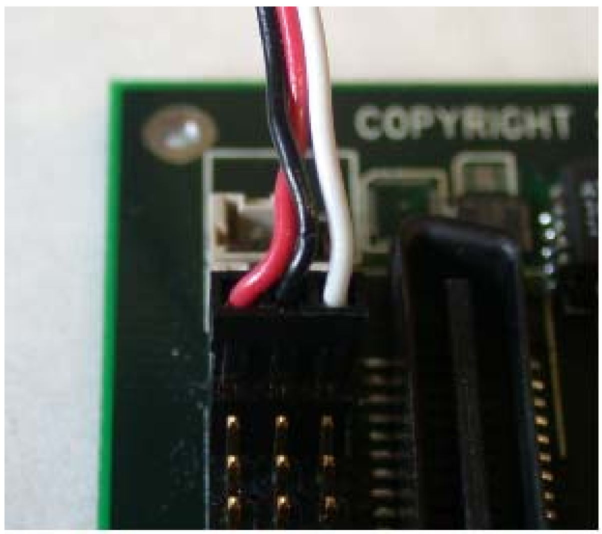


Figure 6

By convention, the steering controller uses input 0, and the speed controller input 1 (Refer to Figure 2 above).

SPack Integration

The SPack is a FPGA based sensor board for use on the GRASP Clodbuster Robots. It provides support for servo-controllers and IR sensors, in addition to an on-board 2-axis accelerometer. The SPack interfaces with the host computer via a RS232 Serial interface.

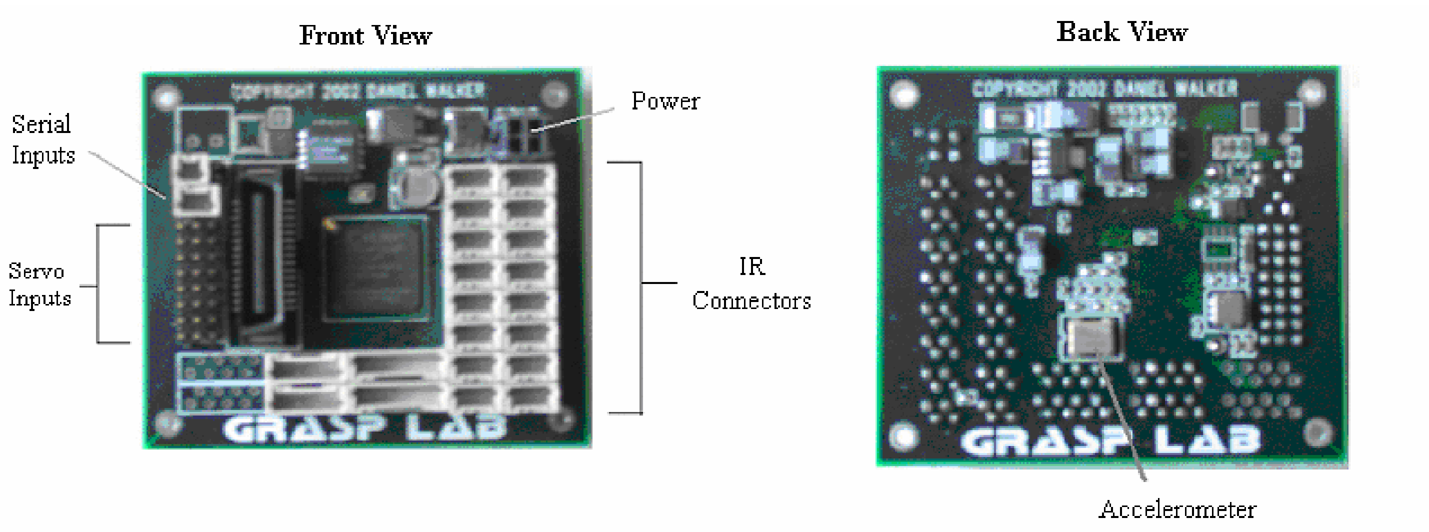


Figure 7 – SPack Board

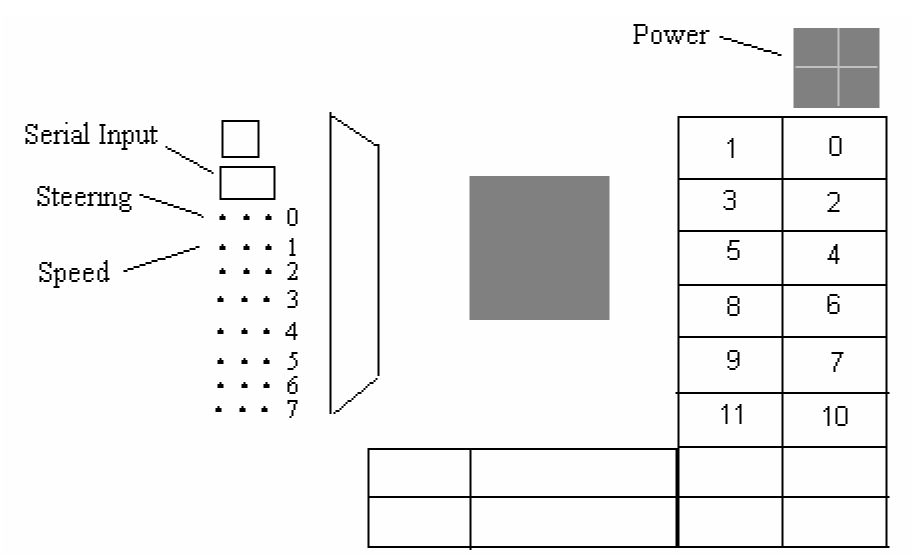


Figure 8 – SPack Board Diagram

Infrared Sensor Calibration

With the current Sharp IR sensors that we are using, each individual sensor will need to be calibrated. We have found a method to do this on the robots without taking up too much time; this method is best completed with two people working together. One person will be reading the computer and writing down the numbers the sensors give, the other person will be moving the robot to the seven different distances.

1. Set up the robot with computer onboard and all power and IR connections in place.

2. Place the robot on a slab of cardboard, or something equivalent that can easily slide along the floor. (Testing should take place against the same type of walls the robot will be running near and with the similar lighting.) Place a meter stick and one side of the robot perpendicular to the wall. (See Fig A)

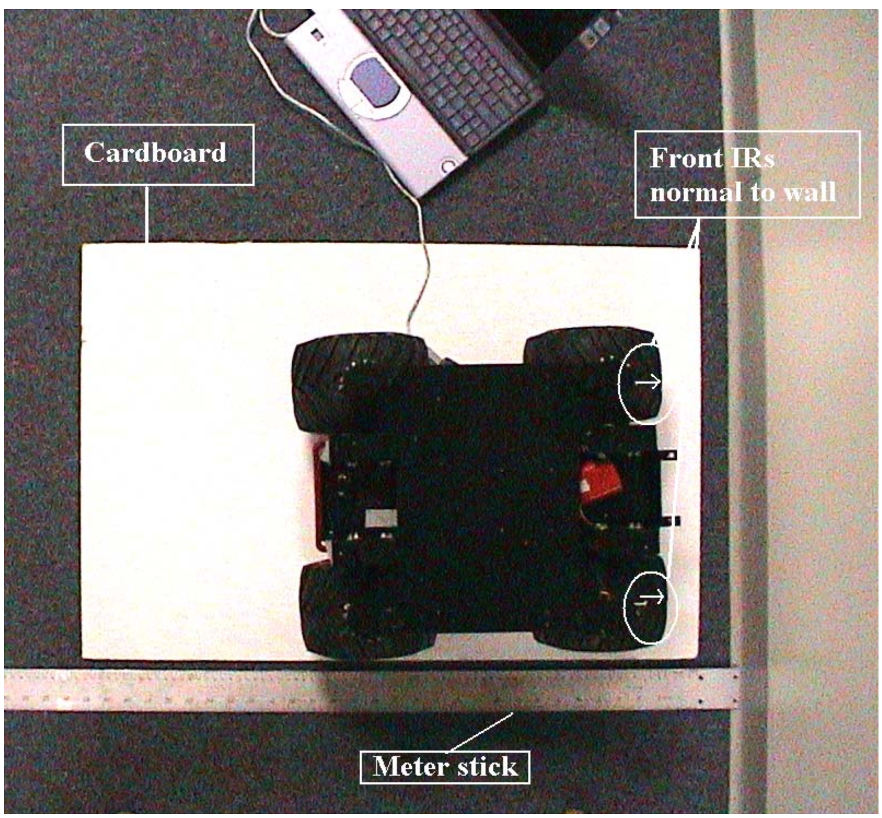


Figure 9 – IR Calibration Setup

3. Making sure that the IR sensors to be tested are normal to the wall, begin with the sensors at 10 centimeters away from the wall and write down the numbers the computer displays corresponding to the IR number you are calibrating. (You can calibrate two IRs at one time in this manner) Your chart should look similar to Figure 8.

IR Numbers	0	1	2	3	4	5	6	7	8	9	10	11
Distance(cm)												
10												
20												
30												
40												
50												
60												
70												

Figure 10 – IR Calibration Table

4. There are a total of 12 sensors; the computers first column of numbers corresponds to ‘0’, the second ‘1’, and so on. To make things easier you should stick numbers on all the sensors following the number scheme shown in previous figures (and like the previous robots made).

5. It is recommended that you do all of the normal sensors first and then proceed to the angled sensors.

6. For the angled sensors your method of calibration is almost the exact same, the only changes you will make is to sit the robot on your cardboard so that the sensors will also be normal to the wall.

7. Proceed as before.

8. When you have your completed IR chart, you can use a MATLAB code that has already been written to input your chart as an IR matrix. If, for any reason, you have a different number of columns/rows as above, the code will not work. It is set for 11 columns and 7 rows, but it can easily be modified. Use the MARS directory on the network and once you define your IR matrix in MATLAB, you can then run the code and it will give you 12 graphs showing the interpolation and it will also generate a look up table.

9. Lastly, in order to run these tests, you have a choice of what power options you would like to use. The computer will be okay to have it run on its own battery power. You will also need to add power to the circuit board; you can do this via a batter pack or an adapter.

Additional Design Thoughts

This section is included just to give you an idea of some mistakes that were previously made so you will not have to make them again in order to learn from them.

- Circuit board placement
  - Needs to be easily accessible
  - Should be protected
- IR placement
  - With the current IRs that are used, objects up to 10 cm directly in front of each IR can not be read accurately
  - If the sensors are placed approx 10 cm away from its edges, the IRs can sense the perimeter of the robot
- Computer Safety
  - The computer needs to be secure with the ports that are needed easily accessible
  - The notebook may be sensitive to overheating because of the conditions we run it in; make sure there is sufficient circulation around the computer
- Camera Stability
  - In the case you are using an omni-camera, information is best processed with a picture that is not vibrating, make the camera mount as sturdy as possible
- Ease of Assembly/Disassembly
  - The testing phase of making the robots will call for a lot of assembly and re-assembling the robot
- Design Flexibility
  - If your design is flexible to small changes (i.e. computer size change) you will not have to completely redesign the hardware to accommodate these changes