

Notices

- Introductory Mobile Robotics Class - 10:00AM - 12:00PM
- Business Meeting - 12:30 - 1:00
- General Meeting - 1:00 - 3:00

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Inside this Issue

A Circular Navigation System1
 Robotic House 5
 Basics of Soldering 6

A Circular Navigation System [Part 2]

Jim Ubersetzig

Introduction

Have you ever wanted your robot to navigate accurately? Reliably moving to locations within a room is difficult for most robots. Usually they are not aware of their location. In this series of articles, I will show you how to solve the problem for indoor robots.

Part one was the theory document, and you should refer to it when you have questions about the mathematics (see Sept 99 issue of the "Robot Builder"). This month we will build the sensor assembly and get it working.

Parts and Cost

You will need these parts. Costs given are approximate.

Qty	PN	Desc	Src	Cost
1	3 x 3 inch	Perf. Board	-	1.00
1	0.01 uF	Capacitor	A	0.10
2	330 ohm	Resistor	A	0.05
2	CS-51	Servo w/futaba J connector.	B	15.00
1	Quarton VLM-670-01L	Laser Module eye safe.	C	32.08
1	SPST	power switch	-	2.50
3	L14P1QT	Phototranstr	C	1.80
1	35mm	film can,	D	free
?	corrugated	cardboard box		free
?	Scotch 411	Mounting Tape	E	2.19
1	V493KR	Reflectors	F	5.69
1	7805T	5 Volt Regulator	A	0.50
2	3.3uF, 10V	Capacitor	A	0.20
2	SHS-40	3 pin header,	A	0.50
1	BS2-IC	Basic Stamp 2	G	50.00
1	9 volt	Battery	A	2.25
total				132.71

Note: To load the software in this article into the Basic Stamp, you need a PC. The stamp also uses the PC to display test results.

ID	Name	Web site
A	All Electronics	www.allelectronics.com
B	Hobbico	
C	DigiKey	www.digikey.com
D	any photoshop	
E	paint dept at hardware store	
F	Pep Boys	
G	Parallax	www.parallaxinc.com

Skills Required

You will need certain minimum skills to complete the device described in this article:

- Soldering, electronic grade.
- Cutting plastic sheet.
- Safety skills to avoid injuries.
- Drilling holes.

Building the Sensor Head

Begin by finding a packing box and cut off a piece of corrugated cardboard. Photocopy figure 1 and glue it to the cardboard. The photocopied figure must be 1-9/16 inch square. Adjust the photocopy machine until you achieve this size.

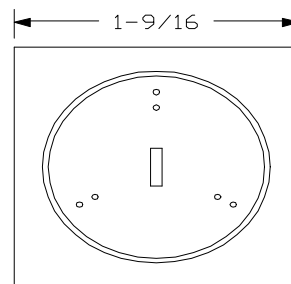


Figure 1 - Sensor Pattern

Using the glued paper pattern, trim the cardboard to proper size. Completely cover the other side of the cardboard with mounting tape, leaving the cover film in place. Cut a slot 1/16 inch wide where indicated and punch 6 holes using a needle for the emitter and collector

(see *Circular Navigation* on page 2)

Circular Navigation from Page 1

leads of the phototransistors.

Next remove the cover film from the mounting tape. Be careful to avoid getting fingerprints on the exposed sticky tape. Insert the wires of the laser module through the slot and press it firmly in place on the sticky tape. Use figure 2 to identify the base wire on the phototransistors. Cut off the base wire.

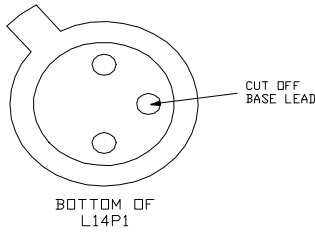


Figure 2 - Phototransistor leads

Use figure 3 to determine the orientation of the tab for the three phototransistors. This figure shows the sticky tape and the components that are stuck to the tape. After sliding the wires through the holes, press all phototransistors firmly into the sticky tape.

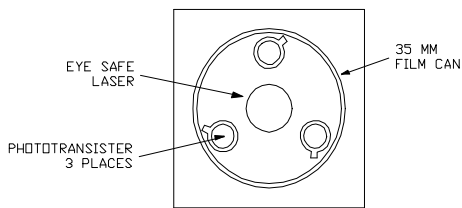


Figure 3 - Parts placement

Prepare the 35 mm film can by removing the lid and cutting off the bottom. Firmly press the rim of the film can into the sticky tape. Make sure that the laser is centered inside the film can.

Bend a paper clip or a resistor lead into a circle and solder to the outer leads of all three phototransistors. Also solder the black wire of the laser module to this connection.

Bend another resistor lead in a smaller circle and solder it to the inner lead of all the phototransistors.

Prepare a cable of three insulated stranded wires. Attach the cable to the cardboard with mounting tape. Wire the cable per figure 4.

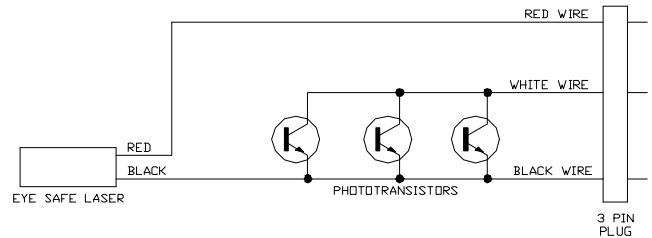


FIGURE 4
WIRING OF SENSOR HEAD

Testing the Sensor Head

Connect a regulated 5 volt power supply to the red and black wires of the sensor head. **DO NOT** look directly at the laser. You should see a dot of red light on the wall. If not, check the wiring.

Connect a 10K ohm resistor between the red and white wires. Connect a voltmeter between the black and white wires. Tape a retroreflector to the wall. You should see a drop in the voltage when the laser spot hits the retroreflector. If not, check the wiring - the phototransistor emitters should be grounded to the black wire, the collectors should go to the white wire. make sure that the optical axis of the laser and all phototransistors point in the same direction.

Adding the Servos

Turn the disk on both servos to the center of its range of motion. Mark these so you can return them to the center position if they accidentally move.

Put mounting tape on the top of the disks and on the bottoms of both servos. Determine the balance point of the sensor head and stick the side of the film can to the disk of a servo. The balance is important to prevent the sensor head from wobbling as it rotates.

Now find the center of balance of the assembly (servo and sensor head) and center it as you stick it to the tape on the disk of the other servo. Attach wiring as shown in figure 5. The wire lengths stated

(see Circular Navigation on page 3)

are critical to allow one full rotation of the sensor head.

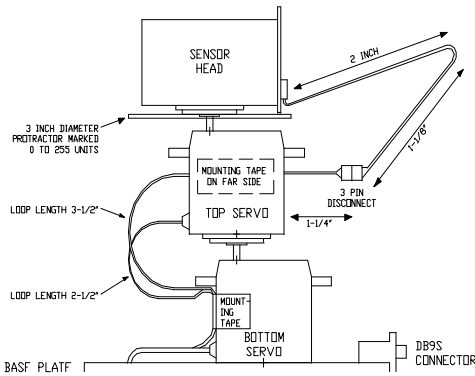


Figure 5 - System layout and wiring

Adding the Electronics

Now install the rest of the parts and wires on a piece of perforated board. To save time - the author substituted a stamp 2 carrier board for the perforated board. The carrier board already has a socket for the Basic Stamp 2, the connector for your desktop PC and also has clips for the 9 volt battery. Using perforated board is less expensive.

Wire the remaining parts per the schematic diagram in figure 6.

Note that the three pin headers are for plugging in the two servos. It's wise to mark the polarity of these to avoid plugging the servos in backwards.

The laser power switch turns off the laser. When your sensor head is down near the floor, this minimizes the chance of annoying people with the laser. If you place the sensor head on a table, turn the laser power switch off, because the moving laser beam annoys people.

Theory of Operation

For a complete description of the theory of operation see the author's 1993 theory paper (reprinted in the Sept 99 issue of the "Robot Builder")

Alignment Procedure

On your PC type stamp2 <enter> and the stamp development system will come up. If you don't have this file (stamp2.exe approx 15K bytes), it's a free download from the parallax web site. It also comes with the developer's kit, along with the cable. If you don't have the cable, instructions for building one are on the web site.

(see Circular Navigation on page 4)

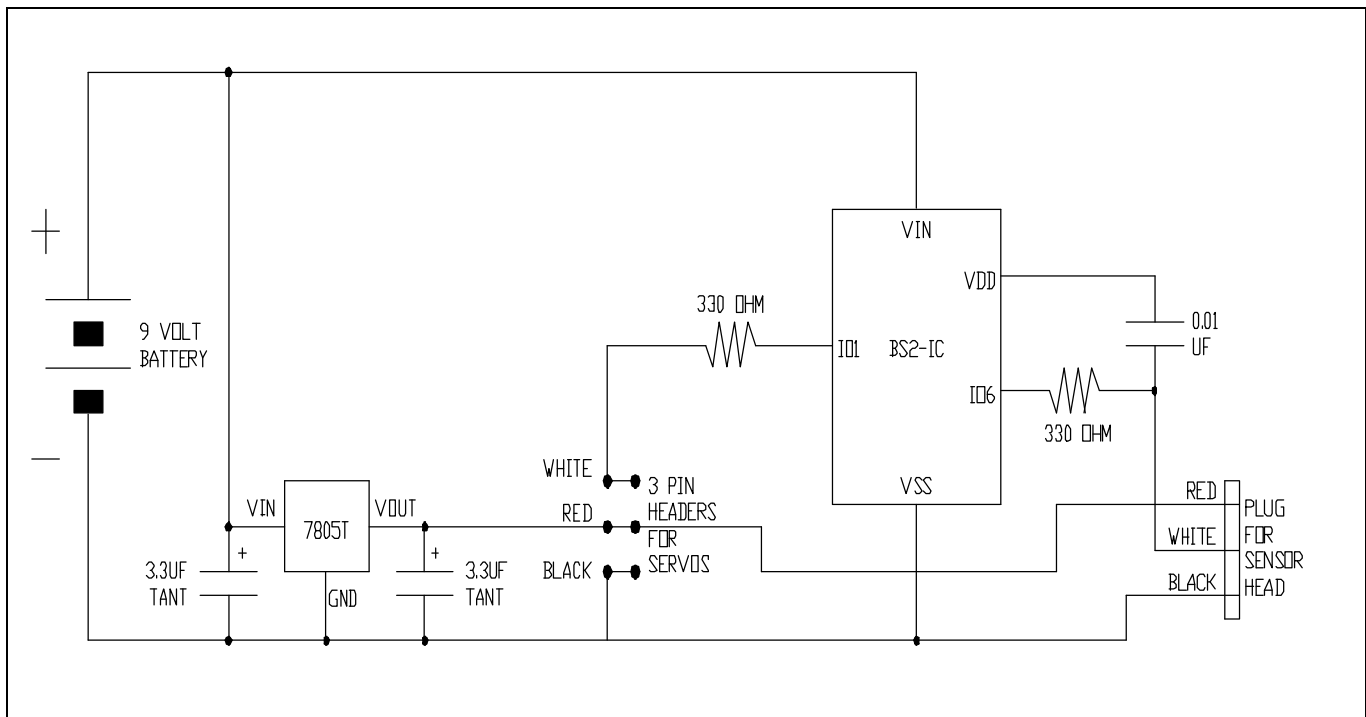


Figure 6 - Electronics schematic

On your PC you should see a screen for editing software. For servo alignment type in this software, then ALT-R to load and run it.

```
angle var word
angle = 800
loop: pulsout 1, angle: pause 18: goto loop
```

Change the angle to other numbers and ALT-R to see the resulting rotation of the sensor head. Keep trying other numbers until you have determined the exact limits of rotation of the sensor assembly. Both servos should turn to achieve slightly more than one complete rotation of the sensor head. Use the information to correct the values for cw_limit and ccw_limit in the main software listing.

Next clear the PC screen and type in the main software listing (see above). Press ALT-S to save the software in a file. Type in a suitable file name, then <enter>.

Tape some retroreflectors to nearby objects. Delete the ' mark at the beginning of the ' debug ? reflection ' statement. Run the software with ALT-R. The idea here is to look for:

- 1) The average of the higher numbers.
- 2) The low number when the laser beam strikes a retroreflector target.

You can pause the display with the space bar to make this process easier.

Once you find these numbers, use them to update the values in the software for threshold and thresholdh.

Replace ' mark at the beginning of the ' debug ? reflection ' statement. Press ALT-S to save the software in a file. Type in a suitable file name, then <enter>.

Demonstration

Place three retroreflective targets where the laser beam will strike them. Press ALT-R on the PC.

After the laser sweeps in a complete circle, you should see a report on the PC display screen.

Hit_index should be three (the number of targets found) and hit(0), hit(1) and hit(2) will be the measured angles to those targets.

Examine the software carefully and note: the software takes hundreds of readings from the sensor head - but saves only those few sensor readings which have meaning. This illustrates an important principle of robotics: Identify useless data as early as possible.

Jim Ubersetzig
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Note: This construction article describes the project demonstrated by the author at the April, 99 RSSC meeting.

```
' Software to locate three wall mounted retroreflective targets
' and to measure the angle to each one. Software runs on a
' Stamp 2.
' By Jim Ubersetzig
' April 99

' I/O pins
sensor con 6
servo con 1

' Variables and Constants
reflection var word ' reading from the phototransistors.
Threshold con 1500 ' greater than this is past target
thresholdh con 700 ' less than this means target is found.
lit var bit ' 1 -> reflection has been seen.

Angle var word ' current angle of the sensor assembly.
ccw_limit con 410 ' counter clockwise limit of rotation.
cw_limit con 1270 ' clockwise limit of sensor rotation.

Hit var byte(5) ' measured angles to targets.
hit_index var nib ' number of targets found.

scan: ' perform a complete laser scan of the room
' and measure the angles to the target beacons.
lit=0: hit_index=0
low servo
for angle = cw_limit to ccw_limit step 5
pulsout servo, angle: pause 18: next ' rewind the sensor.

for angle = ccw_limit to cw_limit ' 360 degrees rotation.
pulsout servo, angle: pause 18 ' move the sensor.
high sensor: pause 1: rctime sensor, 1, reflection
debug ? reflection ' the sensor reading.
if (lit=0) or (reflection < threshold) then aaa
lit = 0
hit(hit_index)=(hit(hit_index)+((angle-ccw_limit)/4)/2)
hit_index=(hit_index+1) // 5: goto bbb
aaa: if (lit=1) or (reflection > thresholdh) then bbb
lit = 1: hit(hit_index)=(angle-ccw_limit)/4
bbb: next
low servo ' shut down the servo motor.
debug ? hit_index ' and show the results.
debug ? hit(0)
debug ? hit(1)
debug ? hit(2)
return

' End of the software
```

Robotic House

by Ralph Irwin

What we all want – a house that takes care of its self. I built a house controller that takes care of all the basic functions of a house. To start with a house should know:

- The time of day and date (minute, hour, day, month and year)
- When to turn off and on certain lights
- When to use the sprinkler system
- Handle the motion sensors
- Other necessary information

After much searching I bought an Axiom board 68HC11 with about 56k of memory and a LynX-10 coprocessor for bi-directional control of any thing in the house using the house wiring (X-10). I wrote a controller program using ImageCraft C. It has a full clock and date in the 32k RAM. It has been running for about three years.

I use the minutes since midnight to key all events during the day. Each day at midnight I compute the exact time the event will happen (this allows me to randomize the events). I also compute the approximate time of the sunrise and sunset - based on the day of year. The time of every event is logged in (x-10, motion, watering, etc.).

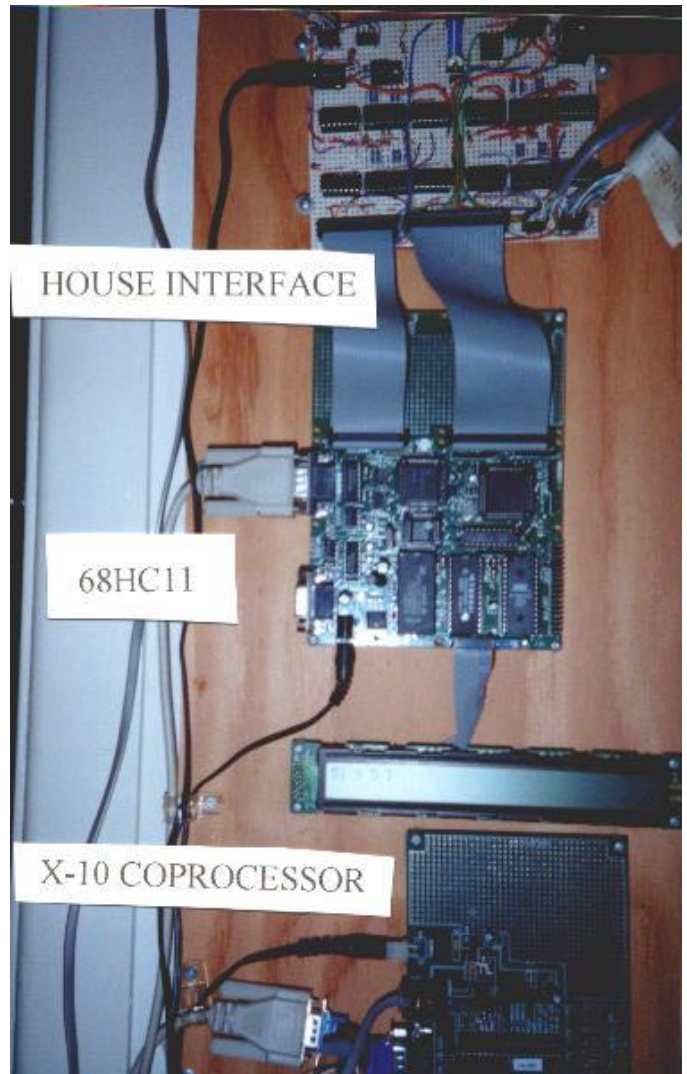
There are four motion detectors located around the outside of the house. They are connected to the controller each with separate wiring. When one detects motion, only during the night, a signal is sent out over the x-10 system to turn on up to three lights. A short time later it turns them off.

The watering system is something else again. I have a subsystem for the front and back yards. I use one whole output port just for the sprinkler system – four bits for the front yard and four for the back yard. This gives me control of up to 15 watering circuits each. At the appropriate time the output port just sets the number (between 1 and 15) and times the event. You can water the circuits at as often wish. You can water multiple times per day (for example: misters in the green house) all the way

down to once every two weeks.

The temperature and rain fall is measured each hour. The average, highest and lowest values are computed for each day and for the last three days. The temperature for the last three days is used to adjust the watering times up or down. The rain fall was supposed to be used also but it didn't work.

In case of a power outage there is an UPS to back just the 68HC11 computer. It will sense the power dropout and go into a special mode – it will keep a log of every thing it did during the power outage. When power comes back on, it will reissue those events.



Basics of Soldering

by Arthur Ed LeBouthillier

Soldering is the use of a low-melting point, conducting alloy in order to create a mechanical and electrical joint. Notice that there are two important connection aspects: mechanical AND electrical; a good solder joint provides both.

Solder is an alloy composed usually of tin and lead but can also sometimes contain silver. Because of the unique properties of these elements, the melting point of solder is lower than the individual melting points of each constituent material. For soldering electronic components, you should use a 40/60 or 60/40 solder. You should also use a flux compound, which reduces oxidation and helps apply heat. Rosin flux or rosin flux core solder is best. Never use acid-core flux.

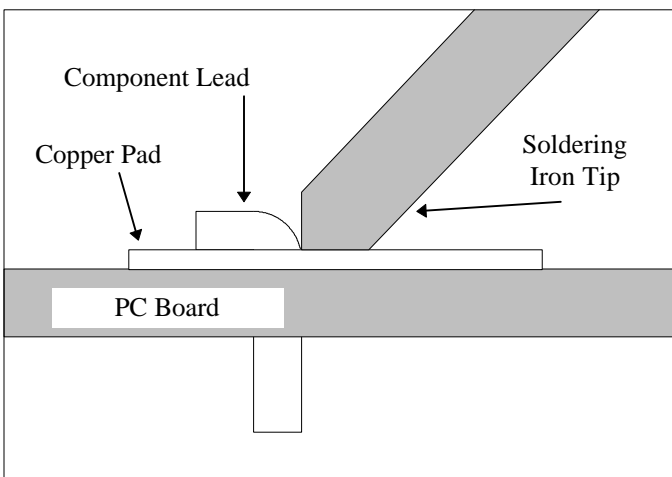


Figure 1 - Placing the soldering iron

Use a 25 to 40 Watt soldering iron with a good clean tip. Cleanliness of the tip and area to be soldered is vital to a successful solder joint. To ensure a clean tip, you should use a damp solder sponge regularly during your soldering session.

Bend the leads of the components so that they fit neatly into the whole. Trim away the excess lead. For the best mechanical and electrical connection, you should have a little bend on the pad side as figure 1 shows.

The basic idea behind soldering is to heat both elements to the melting point of the solder. Apply your soldering iron as shown in figure 1. You

should apply the soldering iron so as to quickly heat both the component lead and the copper pad to the solder melting point, while applying small amounts of solder. When the solder melts, let it flow around the component lead as shown in figure 2.

You need to be careful about applying either too much solder or too much heat. Too much solder creates opportunities for shorts. Too much heat can destroy the component, the board, or break the bond between the copper pad and the circuit board. A little practice will help you identify how to apply heat properly. Do not allow the component to move while the solder is fluid since it will create a weak solder joint.

A cold solder joint is a bad solder joint where the solder did not bond completely to both the component lead and the solder pad. As its name implies, it is caused by the components being too cold when the solder was applied. Because of this, the solder could not flow properly before it solidified. Cold joints are bumpy, grainy, and dull gray rather than smooth, shiny and silvery.

A perfect solder joint will be smooth and shiny. The solder will have flown evenly between the component and the pad and will not bulge out. In a good solder joint, the solder will have an inward slope and will spread evenly out onto the copper pad of the circuit board.

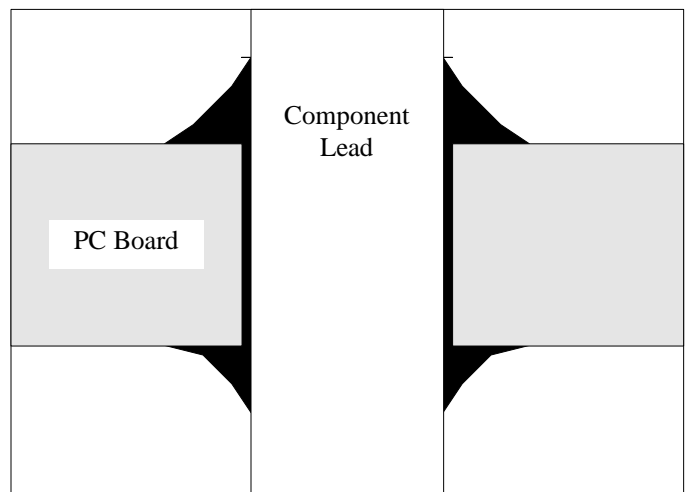


Figure 2 - A good solder joint

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Manuscripts, drawings and other materials submitted for publication that are to be returned must be accompanied by a stamped, self-addressed envelope or container. However, RSSC is not responsible for unsolicited material.

We accept a wide variety of electronic formats but if you are not sure, submit material in ascii or on paper. Electronic copy should be sent to:

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Arthur Ed LeBouthillier - editor

The Robotics Society of Southern California was founded in 1989 as a non-profit experimental robotics group. The goal was to establish a cooperative association among related industries, educational institutions, professionals and particularly robot enthusiasts. Membership in the society is open to all with an interest in this exciting field.

The primary goal of the society is to promote public awareness of the field of experimental robotics and encourage the development of personal and home based robots.

We meet the 2nd Saturday of each month at California State University at Fullerton in the electrical engineering building room EE321, from 12:30 until 3:00.

The RSSC publishes this monthly newsletter, The Robot Builder, that discusses various Society activities, robot construction projects, and other information of interest to its members.

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