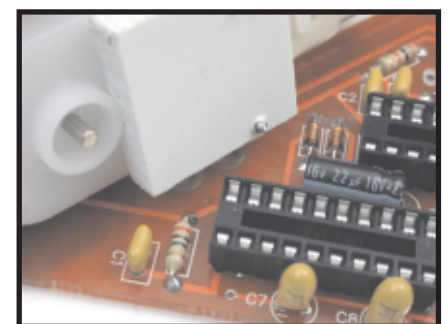
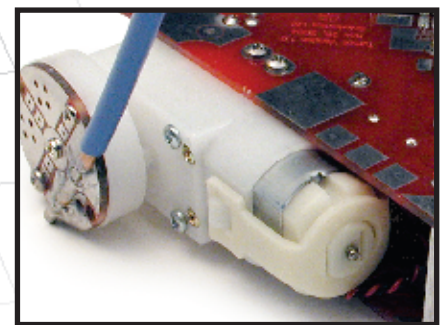
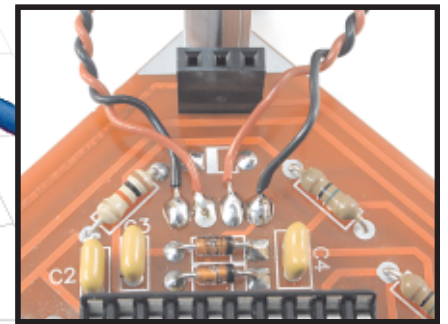
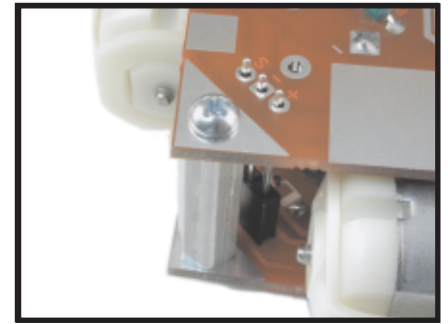
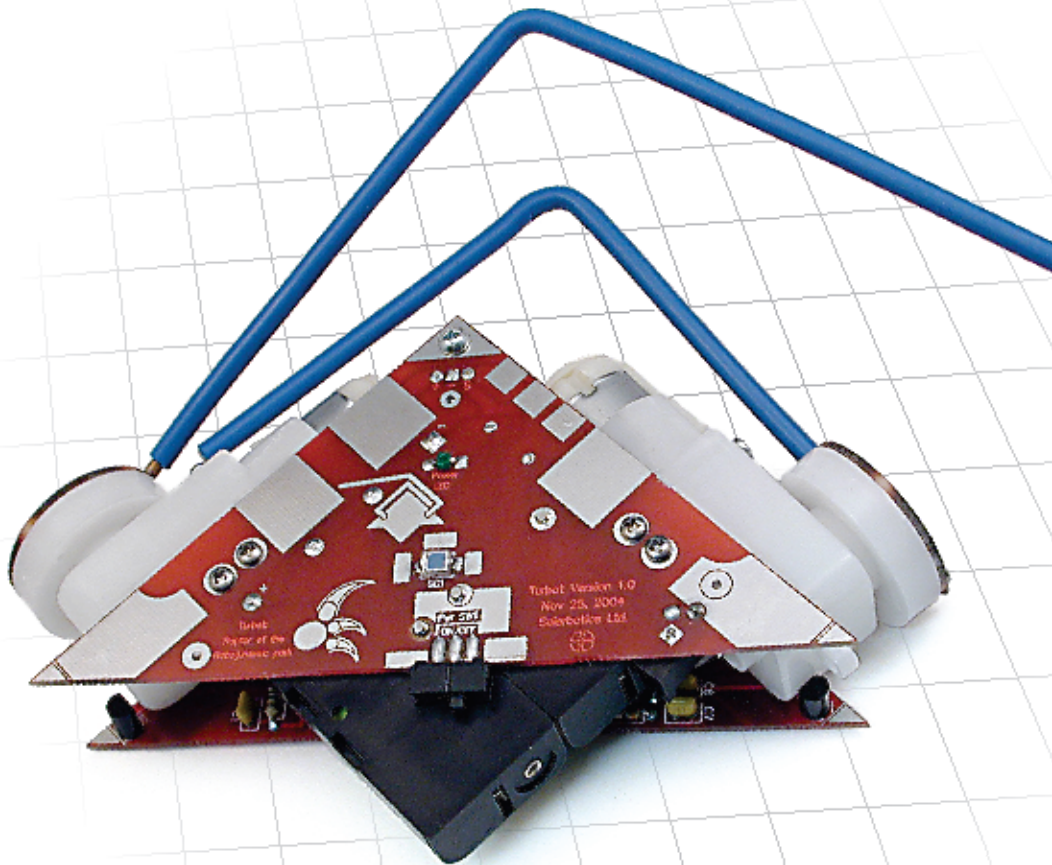


Turbot Tumbling Robot

The Velociraptor of the Robot Jurassic Park



The Xenomorphic Turbot is nothing like any robot you've ever seen before. Designed with no default sense of up or down, left or right, the Turbot scrambles over the landscape, easily tackling obstacles equal in height to itself!

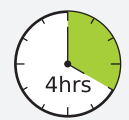
The two arms let Turbot reach, scrape, hook, and claw its way over any obstacle. If something does manage to become ensnared, Turbot releases its prize so it can continue on chasing the light!

Skill Level:



Intermediate
(Soldering
Req'd)

Build Time:



4hrs



www.solarbotics.com
1-866-276-2687

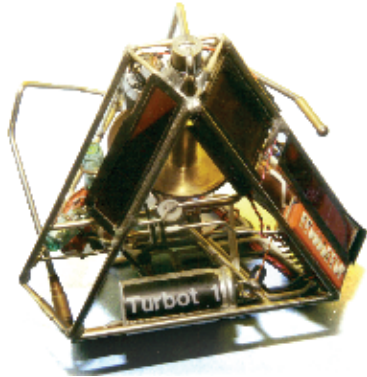
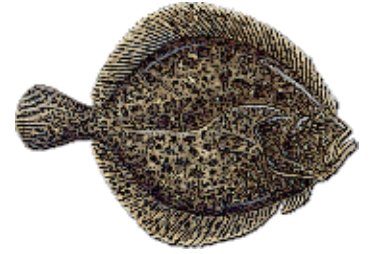
We strongly suggest you inventory the parts in your kit to make sure you have all the parts listed (c'mon - there's barely a handful of parts, so count them!). If anything is missing, contact Solarbotics Ltd. for replacement parts information.

Disclaimer of Liability

Solarbotics Ltd. is not responsible for any special, incidental, or consequential damages resulting from any breach of warranty, or under any legal theory, including lost profits, downtime, good-will, damage to or replacement of equipment or property, and any costs or recovering of any material or goods associated with the assembly or use of this product. We appreciate chocolate-chip oatmeal cookies, Dad's Root Beer, and Sunshine. Solarbotics Ltd. reserves the right to make substitutions and changes to this product without prior notice. Pat your dog, think nice thoughts, and have a nice day. Oh, and come any birthdays and holidays, think "Boy, a Solarbotics kit would be a good idea!"

TURBOT - INTRODUCTION

Mark Tilden built the first Turbot inspired by the theories of Turing machines, which are powerful abstract calculation engines. Really. It hasn't **anything** to do with a member of the Scophthalmidae family of flatfish, which are often found partially buried in the seabed in sand, gravel, rocks and sediment. Well other than that they're also an active predator that feeds almost exclusively off of other fish... Uh, not that the robot turbot feeds off of fish...

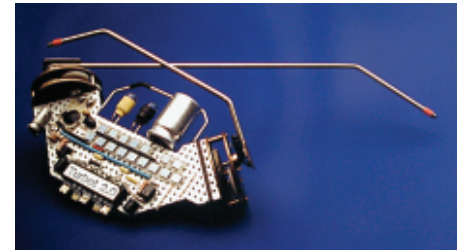


Turbot 1

penned with other solar-powered creatures. The slow pace of any confrontation would let the owner of the Robot Jurassic park watch the developments unfold over many hours, or days, or until it was obvious that it was time to rescue and repair the hapless prey.

The Solarbotics Turbot is a kinder, gentler robot than its forebearers. Although the original Turbot was a relatively tame truncated tetrahedron that followed light, Turbot 2 was particularly nasty. The Turbot's long arms sweep far ahead of it, pulling in potential prey. When closer, the arms apply more force, and could kill the prey by breaking vital solar cells or ripping out unprotected wires.

These "stone-age" Turbots were solar-powered and were often



Turbot 2

We've since tamed the Turbot somewhat, and also given it greater vitality through battery power. Instead of taking hours to scramble over a pile of books, it does so in seconds. Rather than trying to crumble its prey, it now releases and attempts new tactics to get around it.

As the Turbot uses its whole body to move, to make it respond to a stimulus was somewhat tricky, especially now that it is so active using battery power. It uses two pairs of light-sensitive sensors; one on each large flat surface (up / down) and one at each end of the hypotenuse of its body (left / right). Based on the intensity of light falling on these sensors, the Turbot directs the motors controlling the arms to either spin the body to the light, or run parallel to it (depending on which side of the Turbot body is up). Although counter-intuitive, this technique lets the Turbot follow light and scramble around complex terrain.

Additional to this behavior, we had to modify its natural tendency to trap obstacles in its arms. By adding a motor stall detection circuit, we tamed the Turbot so now that it will give up after a few seconds of bear-hugging, and try another tactic. After all, we couldn't produce a robot that was designed to maim any other robots around it....could we? (Nawwww...)

Our tests of this "gentler and tamer" Turbot showed great success in traveling across a room with a great number of chairs, tables and cables on the floor, getting wrapped up and untangled many times in the process. Success!

TURBOT - PARTS LIST

Mechanical Components

- 1 x Printed Circuit Board (comprised of two large triangles and two circles)
- 2 x Solarbotics GM3 Gearmotors
- 2 x GMW mounting wheels
- 1 x 51cm (20") length 12 gauge copper wire (for flagella-arm construction)
- 2 x 22mm (7/8") square x 6mm thick plastic mounting blocks
- 14 x #2 sheet metal screws, 1/4" long (pointy-tipped)
- 3 x #2 x 3/16" thread-forming screws (not pointy-tipped)
- 4 x #2 sheet metal screws, 1" long (for attaching motors to mounting blocks)
- 1 x 7/8" aluminum threaded hex stand-off
- 2 x #4-40 machine screws, 3/8" long (standoff attachment)

PCB Components

- 1 x SWT1 Power switch
- 2 x Dual AAA battery holders
- 1 x MPin3L Long triple-pin header
- 1 x Fpin3 Triple-socket header
- 2 x 20-pin DIP IC carrier
- 1 x 14-pin DIP IC carrier
- 2 x 10cm (4") length two-conductor wire

- 2 x 74AC240 Octal Inverting Buffer IC
- 1 x 74HC86 Quad 2-input "Exclusive-OR" IC

- 6 x 1N914 diodes - D1 to D6
- 2 x SCPD 1/8" square solar cell photodiodes - SC1, SC2
- 2 x IR1 Infrared wide-field photodiodes - IR1, IR2
- 1 x TLED-G Green Tiny LED (power indicator) - L1
- 1 x TLED-R Red Tiny LED (stalled motor indicator) - L2

- 1 x 2M Ω Resistor (Red / Black / Green) - R2
- 4 x 1M Ω Resistors (Brown / Black / Green) - R4, R6, R7, R8
- 2 x 300k Resistors (Orange / Black / Yellow) - R3, R9
- 2 x 1k Resistor (Brown / Black / Red) - R1, R5

- 7 x 0.47 μ F monolithic capacitors (labeled "474") - C1, C2, C3, C4, C5, C6, C7a
- 2 x 6.8 μ F tantalum capacitors - C7b, C8
- 2 x 22 μ F electrolytic capacitors - C9, C10

Optional Components

- 1 x Charging Jack (we like the 1.7mm barrel version)
- 2 x 10x10cm (4x4") Sintra, 3mm (1/8") thick for constructing Turbot "Jacket"
- 2 x Flagella/arm boots (or heat-shrink tubing)

Recommended Tools

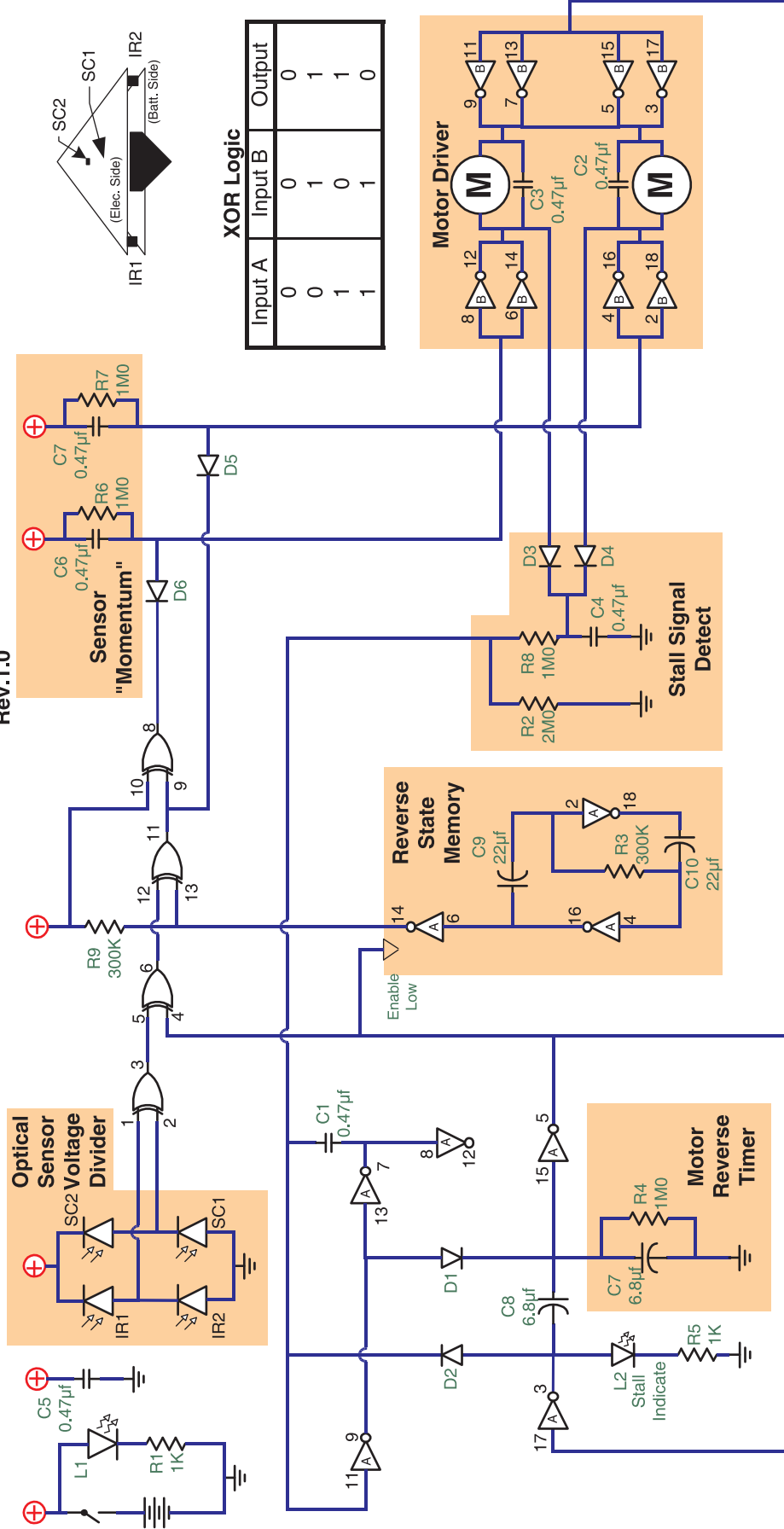
Soldering equipment
Heavy-duty soldering iron (for attaching flagella/arms)
Felt-tip marker

1/16 drill bit & drill
Phillips-tip Screwdriver
Pliers
File (optional, but nice for clean edges)

TURBOT - SCHEMATIC

Turbot Schematic

Rev.1.0



TURBOT - GEEK STUFF

The Solarbotics Turbot is based on a simple "finite state machine", which is augmented by a motor-stall detection circuit and multiplexor. The 3-state orientation logic (up/down/stalled motor) is sorted by the 2-input 'XOR' gates (see the logic chart on the schematic to figure out what the XOR gate does). Each set of eyes (up/down & left/right) are arranged as a voltage dividers feeding into the inputs of the XOR gate. These four eyes sort out the body's orientation at this first gate, and the signal cascades down the chain flipping logic states.

The Turbot is normally unidirectional, meaning the motors spin in only one direction, unless there is a stall condition (eg: it's attacking your ankle). This means that it can't move in an optimal manner in every orientation as it flips and rolls. If we simply cross-wired the eyes to the motors, it would simply run parallel to a light input, being neither attracted nor repelled by the light, but just simply being moth-like and keeping the light to one side. Fortunately, the Turbot uses an "Inverting Multiplexor" that makes the Turbot run parallel to the light while on one side, and phototropic while on the other side, which makes for a pretty darn good tumbling robot!

You may ask "Why not make both sides phototropic?". Besides being electronically more complex, we've found that adding a "side-step" motion to the Turbot's path makes it **very** adept at crossing complex terrain. It's like adding an extra bit of tenaciousness to it so that it tries something different rather than just a dumb charge-at-the-light, over and over again.

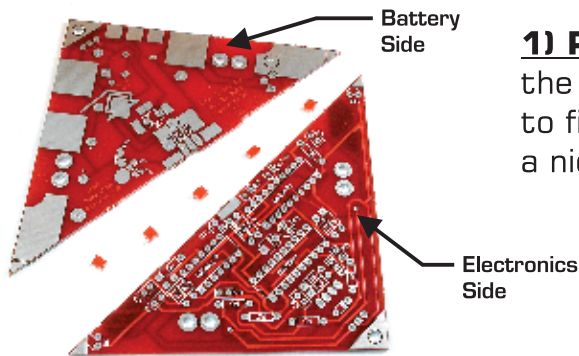
Let's revisit that stall-condition behaviour. It's a simple circuit that detects the increased motor load from either motor. When the motor load goes up, it looks like a lower resistance to the driver circuit. This lower voltage (from either motor) passes through the blocking diodes, and pulls the logic level down enough to trigger the "Motor Reverse Timer" and "Reverse State Memory" circuit. The function of the timer circuit is obvious - you don't want it to go in reverse **forever**. The "Reverse State Memory" ensures that the Turbot doesn't favour one motor over the other - it will alternately try one motor, then the other every time the circuit is activated, making for a robot with a real tenacity for getting untangled from a bad situation.

There's an interesting pair of circuits at the top of the schematic labeled "Sensor Momentum". As the Turbot flips over, the sensors send new signals to the control circuit. Without this "momentum" circuit, the Turbot would often be caught on edge where both sensors were both receiving equal light, and the Turbot couldn't tell which way to direct the motors. With this circuit, the Turbot has the time to properly flip over before the logic circuit starts giving it new information.

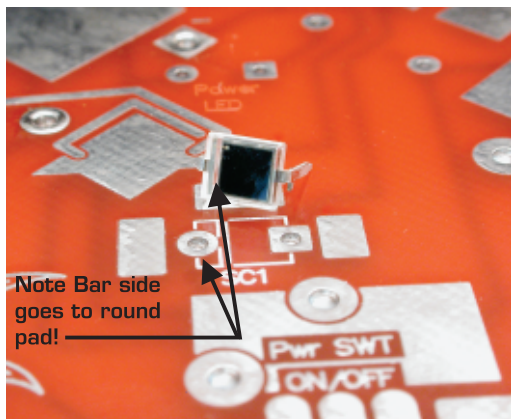
TURBOT - CONSTRUCTION


The Turbot is built like a sandwich, where most of the stuff is stuck on one side (like the peanut butter and bananas), and a little is put on the other side (like the pepper). Then you squish the two halves together, and have a tasty treat!

We'll call the two halves of the Turbot PCB the "battery" and "electronics" side. We'll start with the battery side.



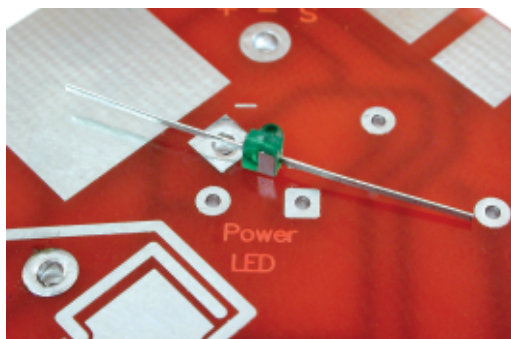
1) PCB Preparation: Snap the PCB in half, removing the little tabs that connected them together. We like to file down the little nubs that are left behind to make a nice, smooth edge.



2) SCPD Installation: Grab the half with the funky Turbot logo on it (), and put the other half away for now. Take one of the SCPDs, and mount it to the position marked 'SC1'. **Note** that it has to go in the right way! Make sure the side of the SCPD with **the line** in it (the anode) is inserted into the **round** pad.

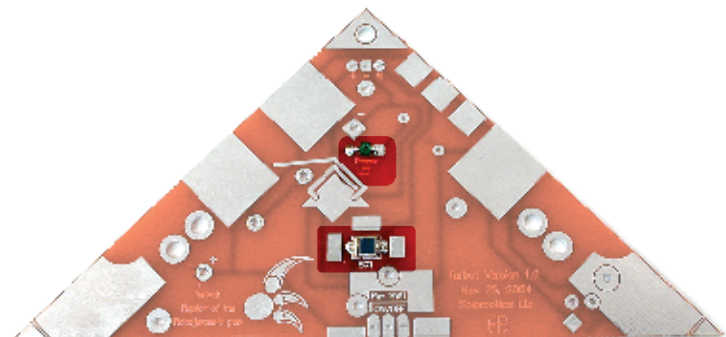


SCPD installed



3) L1 TLED (Green) Installation: Here's another part to stick on this side that is also position-sensitive - the green TLED (tiny LED).

See the little silver bar underneath? That's the side (the cathode) that has to be soldered into the **square pad**. This LED is the power indication LED.

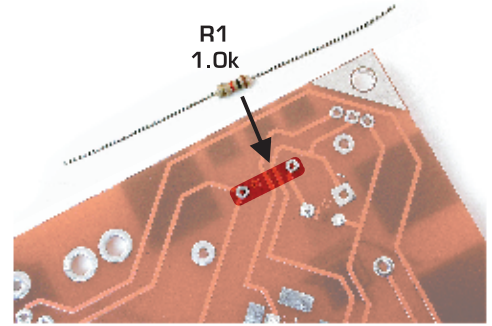


SCPD & Power LED (L1) installation complete!

TURBOT - CONSTRUCTION

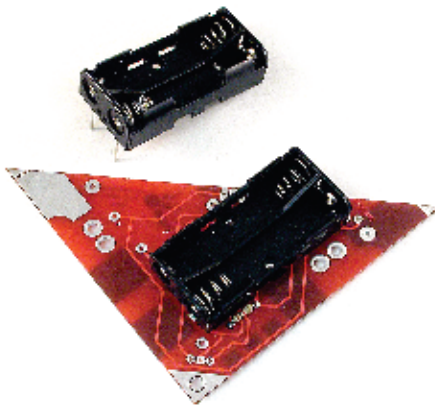
4) R1 - 1.0k Resistor (Brown / Black / Red):

R1 is the current-limiting resistor for the L1 power-indication green LED. As it's on the other side of the PCB, **Flip the PCB over** and install it across the location marked 'R1'.



We're going to start working on the battery holders next. If you're planning on using rechargeables, now would be a good time to put them in a charger, so you'll have them ready when it's time to test your Turbot!

5) 2 x AAA Battery Holders: The two double 'AAA' battery pack holders also are installed from *this* side of the PCB (opposite side to where the SCPD & LED are). The holders are then screwed down with the #2 x 3/16" (*not* the #2 x 1/4 pointy-tips).



5a) Install the two battery holders so their leads poke through the PCB, and solder them in place.

They sit snugly side-by-side when the leads are put in the holes in the PCB.

5b) Use the three #2 x 3/16 blunt-tip thread-forming screws to mount the battery holders to the PCB.

Don't mix the screws up with regular #2 screws, which have a pointy tip. You don't want your Turbot to have these viscous "teeth" poking out the other side of the PCB!

You'll need to use some force to get these screws in, so don't be wimpy here! You need to get the screws in far enough that the heads are down nice'n'low so they don't hit the batteries.

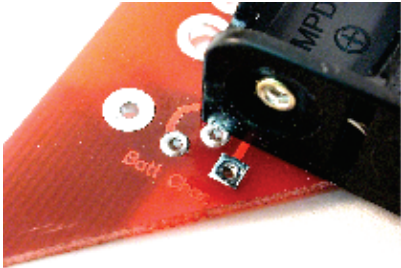


#2 x 1/4"
Sheet metals screws.
Pointy-tips! Ouch!

#2 x 3/16"
Thread-forming screws.
See? No pointy-tips!

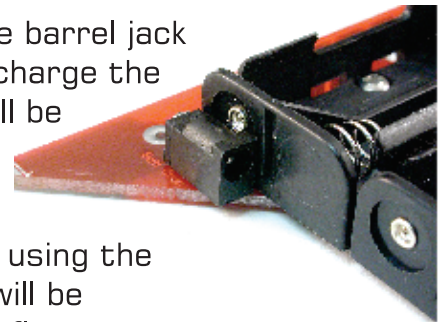
TURBOT - CONSTRUCTION

6) OPTIONAL Charging Jack Installation: If you're planning on installing non-rechargeable batteries, this step can be skipped. You'll just have to unscrew a few screws to replace the batteries occasionally. But if you're planning on going the rechargeable route, pick out your favourite charging jack and get soldering!

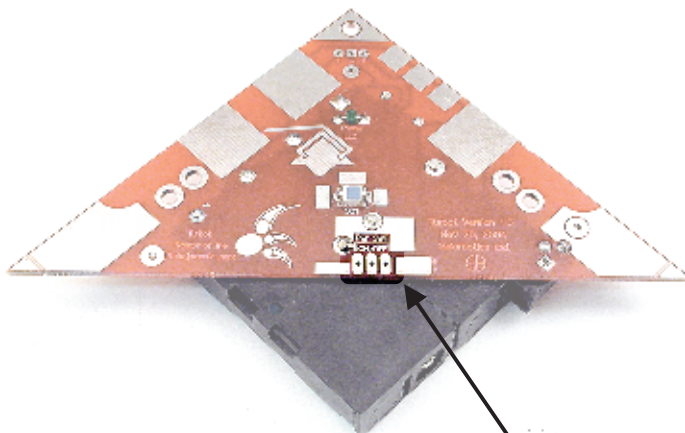


Charging jacks come in many sizes and styles, so we've created a fairly common triple-point mounting pad. The square pad is directly connected to ground (-), and the round one is directly connected to positive (+). The middle round pad isn't connected to anything, and can be used to modify the mount to suit your own charging jack.

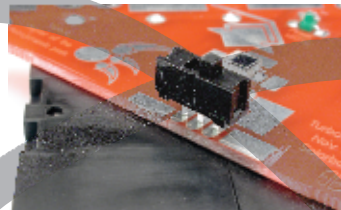
Here's our favourite barrel jack installed, ready to charge the nicad batteries we'll be using.



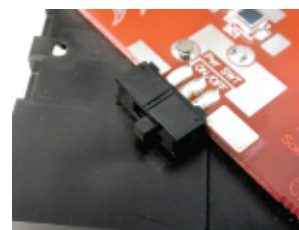
7) Power Switch: This is a bit counter-intuitive - you **won't** be using the holes in the PCB to mount your switch. If you do, your switch will be damaged almost immediately! You **have** to lay the switch down flat against the pads to solder it down, where it is protected against the battery holders



Switch installed flat at this position

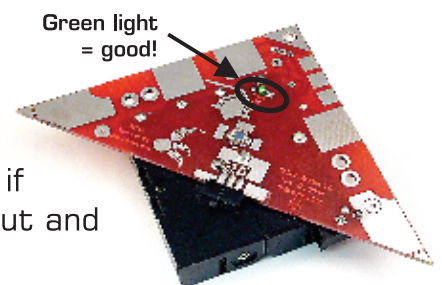


Do not install like this!



Switch installed properly

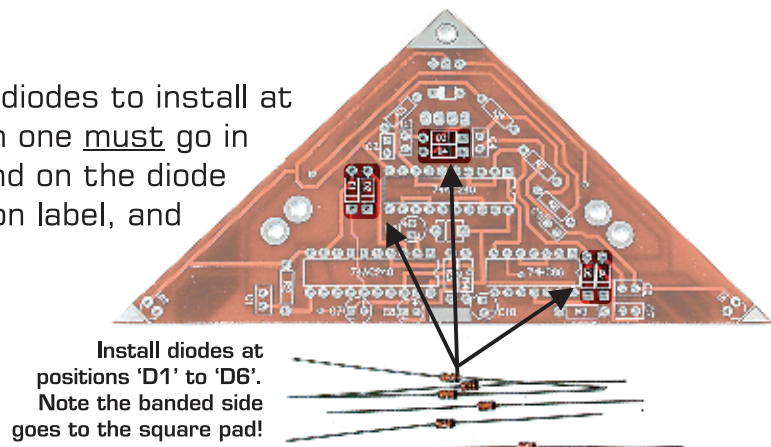
8) Power Check: Install the batteries, turn the PCB over, and flip the power switch to the left. If all is well, the green LED will light up! If not, quickly shut the switch off and check to see if the batteries are warming up - you don't want to short them out and cause damage!



TURBOT - CONSTRUCTION

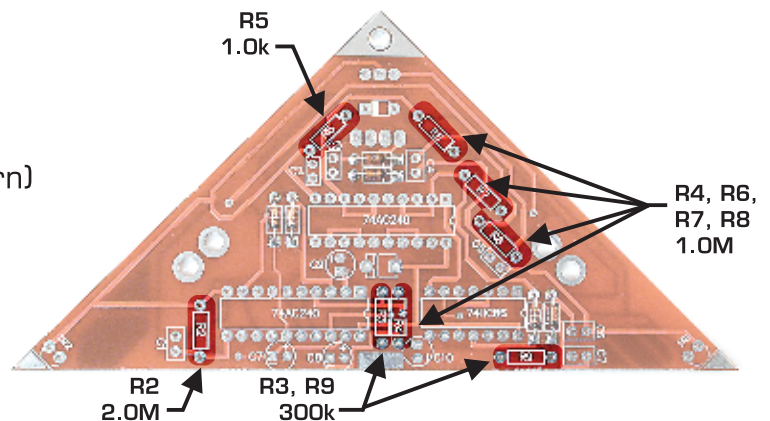
The Electronics Side - Let's get busy! Put the battery-side PCB away for now - we're going to start populating the serious brains of the Turbot!

9) The 1N914 Diodes: We've got six diodes to install at positions 'D1' through 'D6', and each one must go in the right way around. Position the band on the diode the same way as on each diode position label, and you'll do fine.



10) Resistor Installation: We've only got 4 values of resistors installed in 8 places, so let's do them all at once. Use the following list to figure out the color codes:

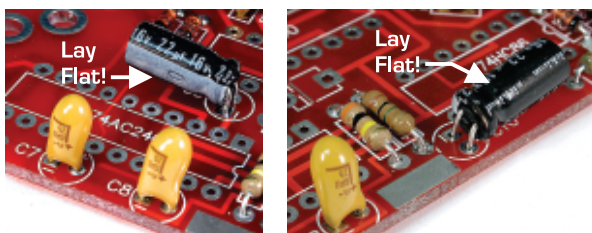
- R2 - 2.0M (Red / Blk / Grn)
- R3 & R9 - 300k (Org / Blk / Yel)
- R5 - 1.0k (Brn / Blk / Red)
- R4, R6, R7, R8 - 1.0M (Brn / Blk / Grn)



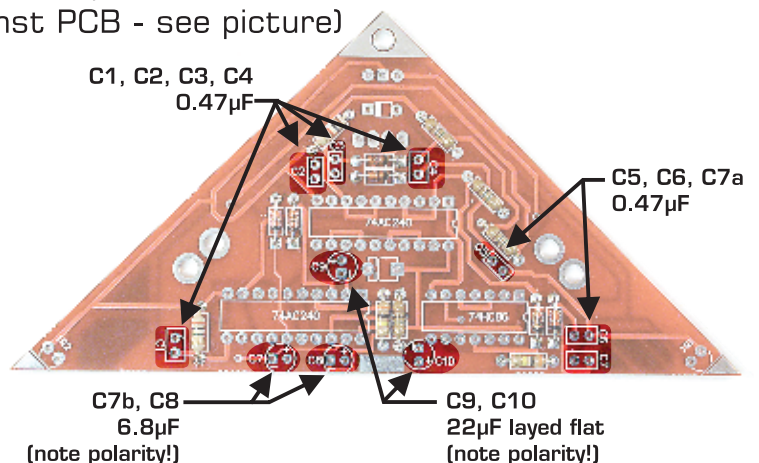
11) Capacitor Installation: Like the resistors, we don't have many types or places to put them, so we'll do them all in one step, okay? Watch for the '+' and '-' markers on the 6.8 μ F and 22 μ F electrolytic capacitors - they have to go in the right way around!

- C1 to C7a - 0.47 μ F (marked '474' on one side)
- C7b, C8 - 6.8 μ F (conveniently marked '6.8 μ F'...)
- C9, C10 - 22 μ F (installed **FLAT** against PCB - see picture)

Sorry about the duplicate 'C7' marker (that one slipped by QA).

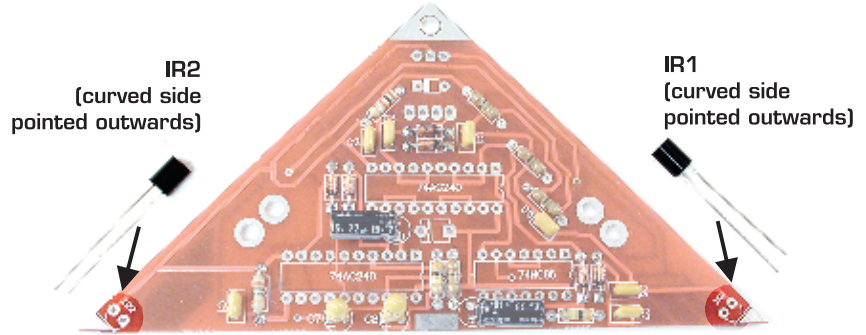


Note position of '+' on C7 & C8 and how 22 μ F caps are laid flat to PCB



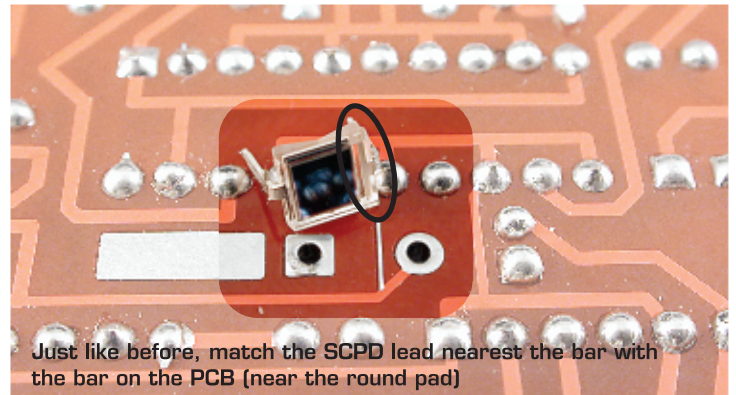
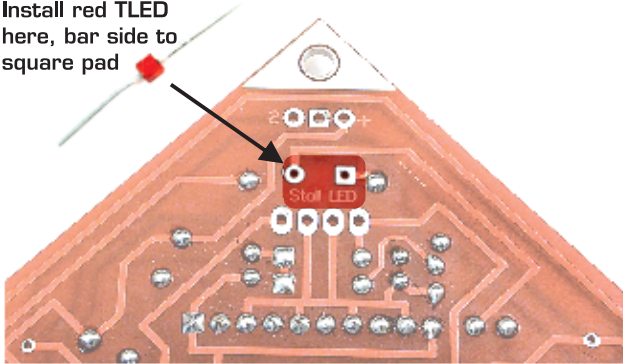
TURBOT - CONSTRUCTION

12) IR Sensors: The IR sensors are sensitive on the **curved** side, so make sure this side points outwards from the Turbot body, unless you think it'll find staring at its own innards fun!



13) Other-Side Components: Time to flip this PCB over and solder in the stall indicator LED and the other SCPD photodiode sensor. We have to finish giving this Turbot eyes and blinky lights!

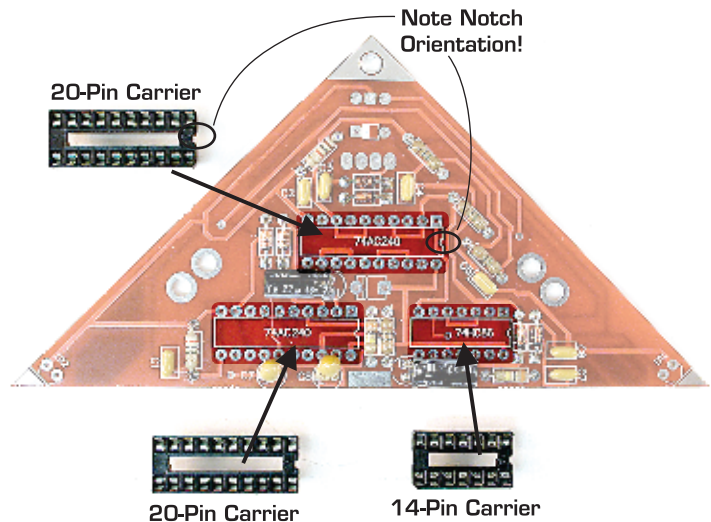
Install red TLED here, bar side to square pad



14) IC Chip Carriers: Now that we've got all the small niggly bits installed and out of the way, let's put in the IC chip carriers. We use carriers as an easy way to mount the chips and keep the chips out of harms way until they're needed (which is right at the end of assembly).

You've got two 20-pin carriers (for the two 74AC240s), and one 14-pin holder (for the 74HC86).

Although not crucial, it's wise to install the carriers with the front notch matching the notch on the PCB. Hey, you gotta keep track of where front is, right?

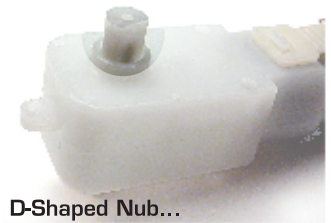


TURBOT - CONSTRUCTION

15) Gear Motor Preparation: It's getting close to time to assemble this beastly together, so let's prepare the gear motors and get them on the motor mounts.

Start by prying/pulling off the "D" nub off the backside of the motor. This will keep the nub from potentially rubbing on the battery packs, or snagging any foreign materials (like issues of Russia's PRAVDA).

Careful now! You may pull the metal shaft right out of the gear motor! If you do, it's no big deal to carefully reinsert it and tap it back in. Take the shaft and wiggle it back into the hole until it find the main gear, then force it back in. For each motor take two of the #2 x 1" screws and a piece of sintra.



D-Shaped Nub...



...Ba-leted! (removed)

16) Mounting Sintra Mount: This mount acts as the spacer between the two halves of the PCB, and as the motor mount. Multitasking parts are yummy!

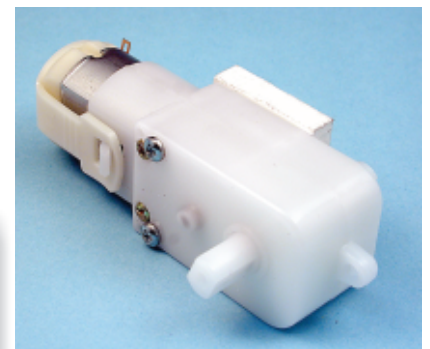
Align the spacer to the motor by laying the motor on its side and snugging up the sintra square to the motor body and the collar the 'D' shaft used to be in. Use the #2 x 1" long screws to attach the two together.



Aligning block to motor collar & tabletop. Put screws in through motor holes on the other side.

See? No problem. Do it again for the other motor, and we'll get to work joining the two halves together.

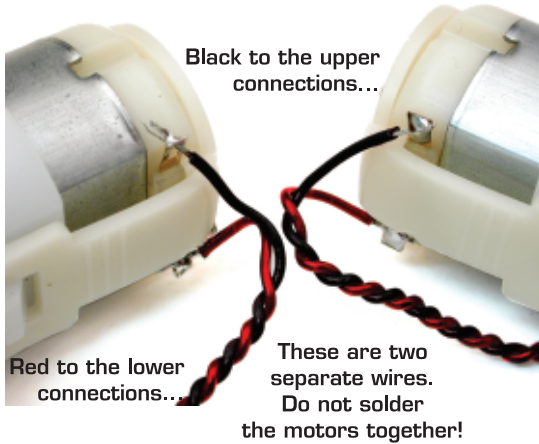
Note: The tips of the screws may poke out the back of the mount. You should file off these poking-out tips as they can interfere with installation later.



Finished motor on mount

TURBOT - CONSTRUCTION

17) Wiring the Motors: Something as simple as motor wiring isn't usually a big deal, but with a Turbot, you may finish it and not realize for a good long while that it isn't working properly because of a miswired motor.



The most common mistake is to reverse both motor wires, making your Turbot photophobic (or a lover of darkness. A "Sithbot?").

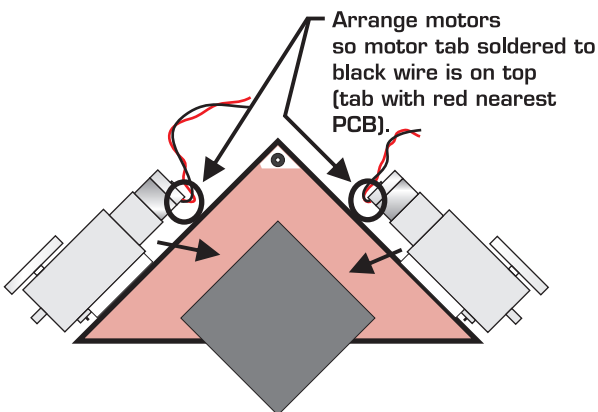
The trick is to wire the motors in a consistent way, so follow these directions precisely; exactly; unwavering; upon-threat-of-giving-your-pet-kitty-a-headshave. Got it? Good.

Arrange the motors so the ends are side-by-side (see picture at left). We want to have the wire colours connected to the motor contacts like this when we're done.

Take each twisted wire, and solder a **black** wire to each **top** motor connector. Solder a **red** wire to each **bottom** connector.

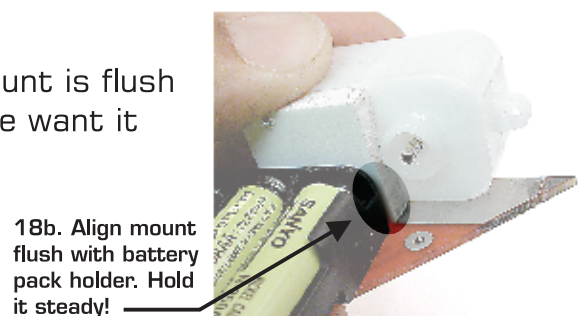
There. That wasn't too terrible so far, right? Stay tuned - when we mount the motors to the Turbot body, we'll re-threaten your kitty (and nobody loves a bald kitty...).

18) Installing the Motor: We're going to install the motors on the battery-side PCB. In order to make sure the wiring is correct, use the following illustration to arrange the motors to the PCB.



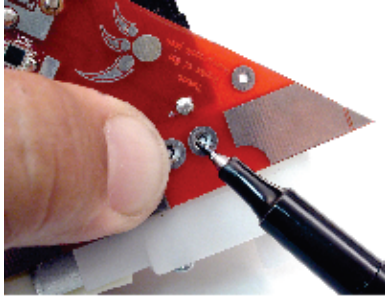
18a: Arrange the motors like on the illustration, so the motor tab soldered to the black wire is on top, and the motor tab soldered to the red wire is closest to the PCB. Very important!

18b: Take one motor, and line it up so the sintra mount is flush with the edge of the battery holder. This is where we want it ultimately to line up to when all is screwed down.



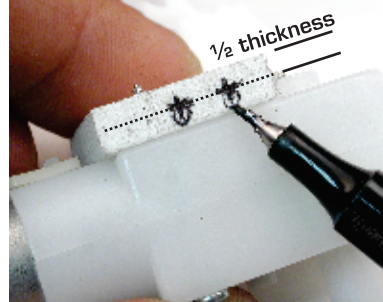
TURBOT - CONSTRUCTION

18c) While holding the motor steady, flip the works over, and mark the holes with your felt-tip pen.



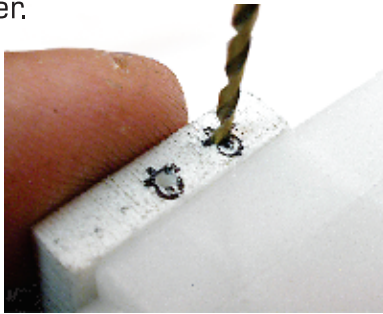
18c. Flip assembly, mark two screw holes

18d) Remove the motor, and inspect the hole marks. If they aren't located at about $\frac{1}{2}$ the mount thickness, shift the marks so they are.



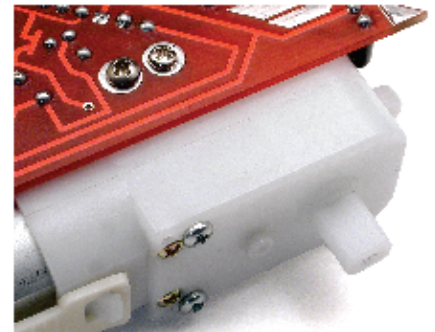
18d. Inspect / move hole marks

18e) Use your $\frac{1}{16}$ " drill to put a shallow 3mm ($\frac{1}{8}$ ") deep pilot hole at each of the marks. This will make adding the screws *much* easier.



18e. $\frac{1}{16}$ " Pilot holes

18f) Put the motor mount back under the holes you used in step 19c, and use two #2 x $\frac{1}{4}$ " screws to mount it on. **Don't** over-tighten and strip the holes in the mount!



18f. Screw motor mount to PCB! Repeat for other motor.

To strengthen the holes, **unscrew** the screws, and soak some thin CA (superglue) into the Sintra. It'll make it much harder.

If you need to repair a stripped hole, fill it with glue, or flip/rotate the mount so you can redrill on a fresh side.

Did it all go well? Good, then we won't need this shaver and kitty anymore. Repeat the procedure for the other motor!

19) Wiring the Motors to the Circuit Board: Here's the problem: We installed the motors to the **battery** side of the PCB (for easy alignment), but the electrical connections have to be connected to the other PCB - the **electronics** side.

Start by laying the two halves peak-to-peak, just like in the picture below.

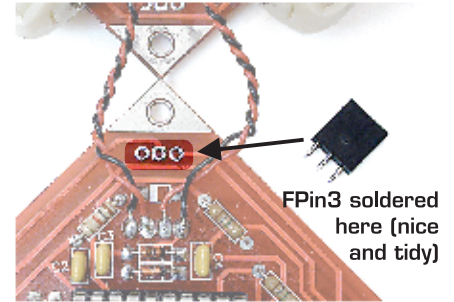
Solder the left motor to the left set of pads, and the right motor to the ("well, let's see what's left...") right set of pads.

Note: Make sure the red wires are on the middle pair of pads! Get it backwards, and you'll get funky Turbot behaviour! (You can decide if that's a bad thing...)



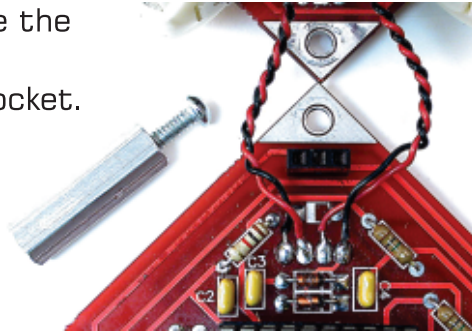
TURBOT - CONSTRUCTION

20) Install the 3-Pin Socket: Tuck the 3-position header into place, making sure it's sitting nice and flat to the PCB surface. It's soon going to be mated with another set of pins, and having this part sit up straight and purty will make the task easy.



21) Install Spacer Standoff: Use the bolt to mount the aluminum hex standoff right beside the 3-pin socket.

Make it nice and tight!

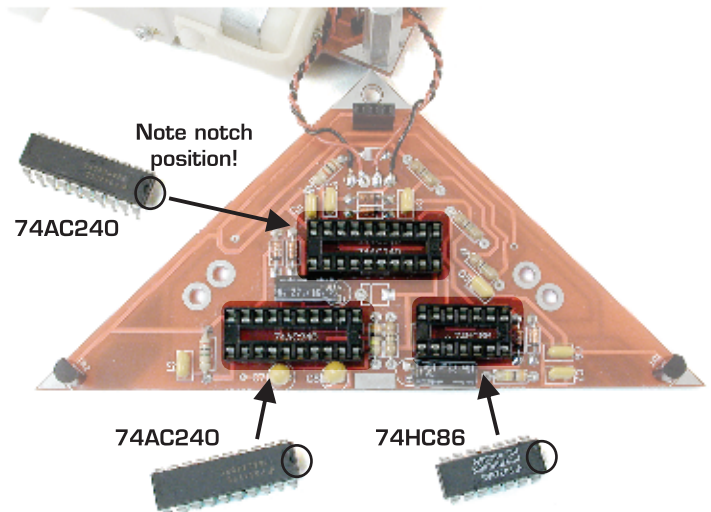


Didja know the difference between "bolts" and "screws"? "Bolts" mate only with nuts or other threaded holes, while "screws" are usually pointy and make their own threads.

22) Install the Chips!: Gasp! Put on your ceremonial chip-handling robe, strap on your gold-plated anti-static bracelet, and activate your anti-static air ionizer - it's time to give your Turbot **BRAINS!**

Ok, you don't have to go to such extremes as these chips are generally fairly robust, but don't comb your hair with them - they are still static sensitive. Plug the three chips where they're labeled to go, making sure the orientation notch is on the right

Chips installed backwards don't work!



TURBOT - CONSTRUCTION

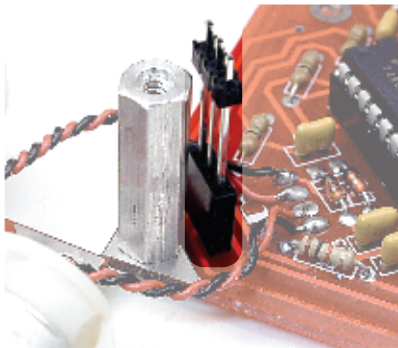
23) The Long 3-Pin Connector: The 3-pin connector is a *bit* on the long side, so we're going to have to use a bit of force to make it be height during assembly.

Insert the long 3-pin header so the **long** pins go into the sockets on the electronics side next to the aluminum spacer.

Lay the other PCB down on top, so the short-end of the pins poke through the right holes.

Insert the other bolt through the PCB and tighten it into the standoff. As you tighten the bolt, the PCB will auto-magically force the black pin mounts downward until they're **exactly** the same height as the standoff. If this just all confused you, simply put it together and screw the bolts down until everything is tight,

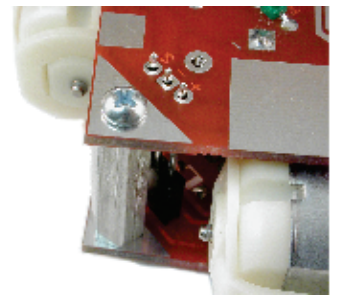
Solder the pins, add the four #2 x 1/4" screws to the mounting holes on the electronics side of the PCB, and you're done the Turbot body construction. Make sure the motor leads are tucked away nicely!



Insert 3-pin set into socket...



...Flip the PCB on, matching the holes for the pins, and screw together...



...So the screw pushes the pins down nice and even. Now solder the pins!

Now you can do an initial power-up test of the Turbot (yes, without the arms). You should be able to flip it around and **hear** the motors turning on and off as they respond the changing lighting conditions. If there aren't any sounds...it's time to troubleshoot!

TURBOT - CONSTRUCTION

24) Legs! Flagella! Arms! Things that spin around and clobber stuff!: Time to build the things that make the Turbot move - the "TSAACS". Uhhh, let's just call them arms, ok?

24a) Cut the arm wire so one length is 25cm long (10"), and strip 5cm (2" off the end of each length. You'll now have one arm a bit longer than the other, but that's ok - it's supposed to be that way.

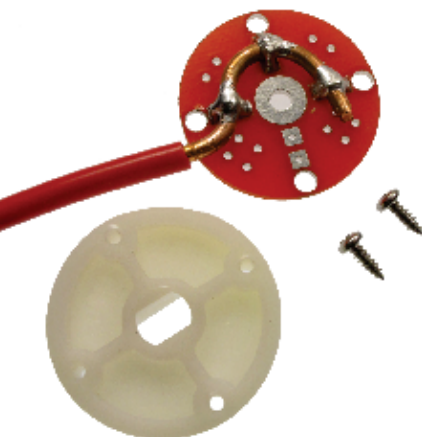
24b) Shape the bare copper so it makes this nice hook shape past three of the pads. We're going to solder **and** wire it down to these pads, so take some time and get it just right.

Also, get yourself those resistor clippings - it's time to put them to work!

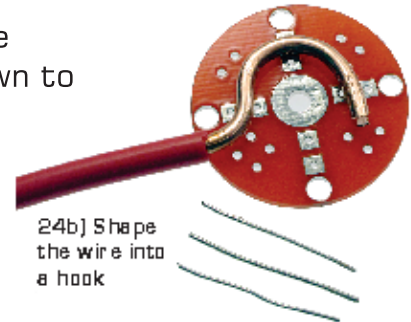
24c) Tie the copper ends down to the square pads with the clippings, twisting the clipping ends together on the bottom of the PCB.

When it's secure, crank up your soldering iron and generously solder the copper wire to the pads and the clippings. The copper will suck up heat, so be patient (and expect the copper to get **hot!**)

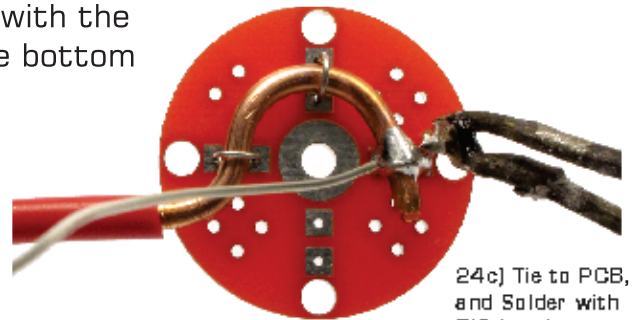
24d) All soldered up? Good! Flip it over, and snip off the clippings from the backside of the PCB.



24e) Secure to wheel



24b) Shape the wire into a hook



24c) Tie to PCB, and Solder with BIG heat!



24d) Trim off clippings from backside

24e) Mount the leg assembly to the white utility wheel with two #2 x 1/4" long screws.

Then install it to a gearmotor, using a 3rd screw in the center hole to lock it in place.

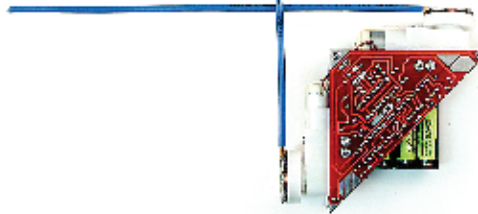
Excellent! Now do it all over again one more time for the other leg!

TURBOT - CONSTRUCTION

25) Arm Installation & Geometry! Now for the fun stuff - getting the arms to start flailing about! Take each of your arm/wheel combinations, and attach one to each motor using a #2 x 1/4" screw. It doesn't matter which side gets the slightly longer arm.

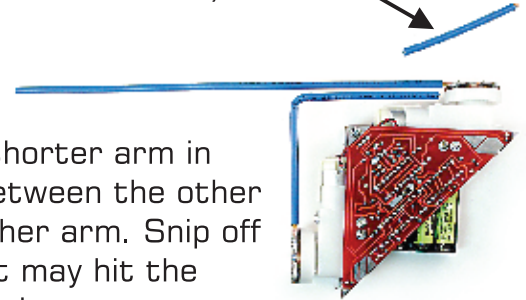
Dis one!
It's shorter!

25a) After screwing the legs to the motors, lay the arms out flat with the Turbot body, so they cross. Identify the shorter of the two.



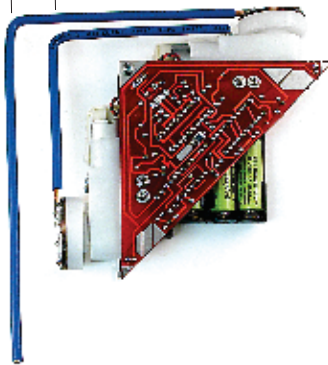
Fold over, and SNIP!

25b) Fold the shorter arm in 90° so it fits between the other motor & the other arm. Snip off any excess that may hit the other motors hub.



~12mm
(1/2")

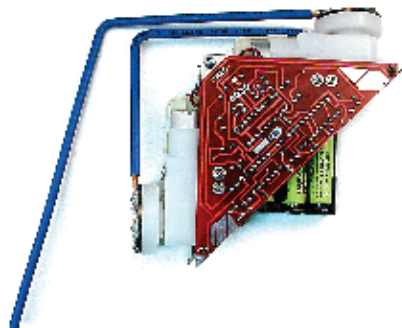
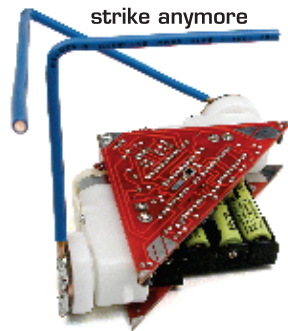
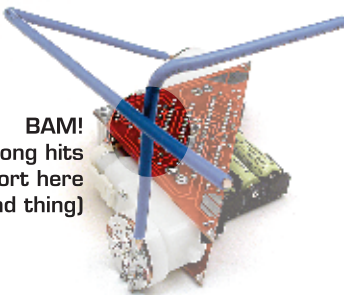
25c) Leaving about a 12mm gap (1/2"), fold the long leg 90° down parallel to the short leg motor. Don't worry about snipping the excess (leave that for after when you've experimented for a while!)



Bend longer arm
until it doesn't
strike anymore

25d) Try spinning the legs around, seeing where they may hit. Oh yes, they **will** hit! The trick is to bend the long arm outwards a bit so that it won't ever hit the shorter leg.

BAM!
Long hits
short here
(bad thing)



Final arm/leg/flagella shape for your Turbot. The extra length on the long arm is generally useful, but if you wish, bend/fold/cut it into a new shape. You can always get new mounts & wire from Solarbotics!

TURBOT - OPERATION

The Turbot has a pretty simple set of instructions:

- 1) Turn it on
- 2) Put it down
- 3) Watch to see what trouble it causes!

The Turbot will tumble around, looking for the strongest source of light it can find. When it finds it, Turbot will swing around and scurry back through the middle again until it detects the light levels falling off again. The net result is that it will continue exploring the “light pool”, beating the stuffing out of anything that gets close to it. Of course, this **could** be a beneficial thing depending on what you’re planning, but we’ll leave that up to you to decide!

As previously explained, the logic circuitry in the Turbot makes it phototropic when on one side, and parallel-phototropic (light-orbiting, like a moth) when on the other side. These behaviours are only obvious if you replace the legs with wheels. You’ll most often see it using both motors in sync, using them to tumble the body along in a fairly straight line. This is pretty amazing in itself, as it’s using a pair of arm that are different in length.

It will be in the turning around aspect that Turbot’s abilities are particularly fun to watch. Sometimes it will be a simple 90° flip, and that will be enough. Often, you’ll see it shuffle forward, then pirouette on one motor on edge, then plunk down. Watch it to see if you can detect when its sensor inputs cause the logic shift - it’s quick!

The Turbot has been successfully tested on asphalt, gravel, concrete, linoleum, hardwood, tight & loose-fill carpet, and even on some fluffy blankets. With the exception of the blankets (it wraps itself into an attractive ball, ideal for gift-giving), it is quite compatible with all these surroundings. If you want to run it in a particularly dusty or sandy environment, try to seal the rear vent holes on the motors. If you don’t, the particles will make short-work of the motor brushes, making the Turbot easy prey for the local bald kitty.

A neat experiment is to use a sealed-motor Turbot, and let it loose in a raked sandbox (or golf sandtrap? Hmmm...). You’ll end up with a very cool track being left on the surface. Another interesting experiment is putting your Turbot in a large box of packing peanuts/puffies. It will dig down and bury itself into the box - a self-packing robot!

In short, you now have a unique robot that has surprisingly high survivability in a small package. Further experiments we’d like to see done include building a large quadruple-sized version; a solar version; one with GPS-following capability; a high-strength, ultra-strong version that could be hurled overhand several hundred feet; and of course, one out of chocolate. Well, that’s just because we like chocolate here at Solarbotics. Any reason to get more chocolate is a good reason...

We hope you enjoy your Turbot as much as we did designing it!

TURBOT - TROUBLESHOOTING

The Turbot is really one of the easier kits Solarbotics has produced, so if you are having problems, start with these tips:

- Don't get frustrated, leave it and come back later with a clear mind. This is supposed to be fun.
- Re-solder any suspicious solder joints and repair any solder bridges (this fixes nearly 75% of the robots that we see in for repair).
- Clean the board off with rubbing alcohol and a used toothbrush. Clip any leads that are excessively long. It is easier to see any soldering problems on a clean board.
- Check over the documentation to see if all components are present and in the right spots, and in the right way around.
- **If** you have spare IC's then swap out the logic chips with new ones.
- Although troublesome (and rarely useful other than a last resort) use a continuity checker and going over each connection point to connection point to make sure that the circuit pathways are all intact. (Again, this has *rarely* even been needed)
- Hint: removing the legs makes troubleshooting easier!

Turbot does not turn on/ no green LED happiness: Check that the batteries are actually touching the battery pack tabs. If not, make the necessary adjustments with a screwdriver. Check the batteries - if dead, then change / recharge them.

Turbot seems to just go around in circles: Chances are that one of the motors is reversed. By default, both motors will come up over the top (power switch side) when you first turn it on. Reversing both motors makes the turbot photophobic, which is fine until it works its way deep under the couch and spends the last of its battery life killing dust-bunnies...

Turbot doesn't seem to be affected by light: The SCPDs can be a bit sensitive to overheating. Check the voltage across the SCPDs with the turbot off. Remember that the round pad is '+' and the square pad is '-'. Under a decently bright light (like 60cm/2' from an overhead 150W halogen desk lamp), you should read approximately 0.4V. You can also do this test with the photodiodes on the sides, which should read about the same. If there is no voltage present then the SCPD/photodiodes is either shorted out or dead - did you install it in reverse?

Turbot has only one motor working: This is most likely a problem with soldering the wires to the motors but **could** be a problem with the motor driver (74AC240). When the Turbot is in operation, one motor should always be moving. If the soldering looks good, swap out the logic chips for new ones. ICs can easily be blown by putting them in backwards then powering up, even if just for a split second.

Turbot never seems to go into "stall reverse"/ no red LED happiness: Could be low batteries (or high internal resistance batteries, like carbon cell types). It may be a much more complex problem (wrong resistors in wrong spots, hairline short between two pads, etc.).

TURBOT - TROUBLESHOOTING

Turbot is always in stall reverse/stall never times out: If everything else is correct, excess motor noise may be causing the stall detect circuitry to re-trigger. One thing to try would be adding power filter capacitors across the motor itself. A $0.01\mu\text{F}$ capacitor from each motor terminal to the motor body, and one across the terminals (3 total) is pretty effective.

Turbot ran away: Yeah, that happens. Just look around for the brightest source of light, or start walking South until you find it!

Turbot still does not work: Turbot hates you. Return it to us for a spanking.

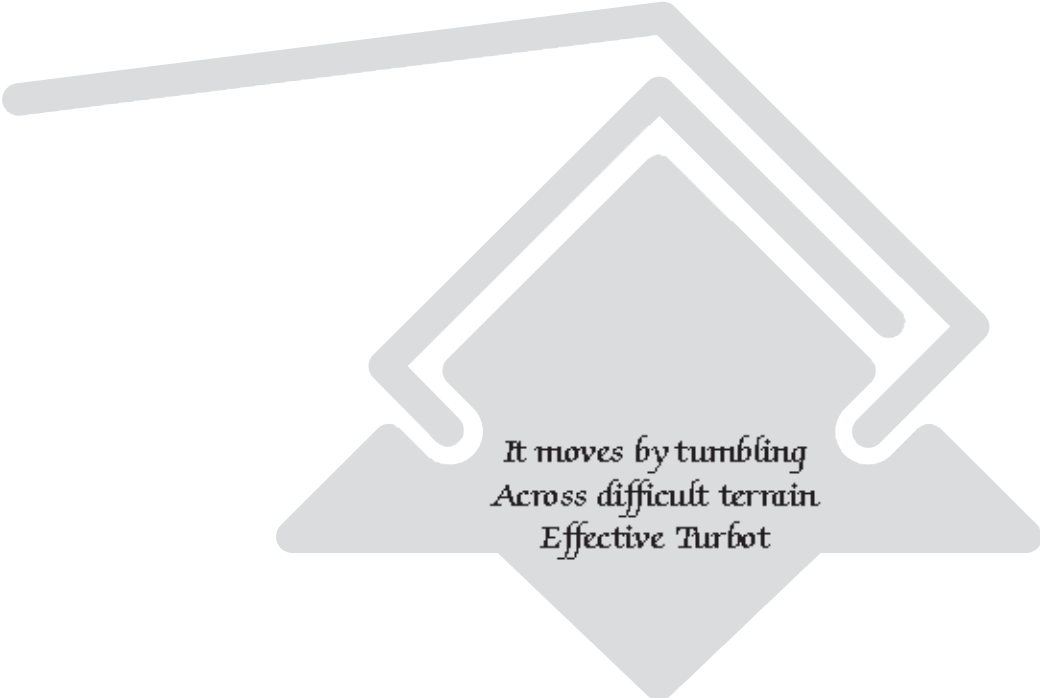
Failing all else, you can always return it to Solarbotics Ltd. for repairs:

Solarbotics Repairs
#101, 3740D - 11a Street NE,
Calgary, Alberta, Calgary
Canada T2E 6M6

A short note explaining what is not working (and some cookies...) can expedite the repair process.

Important: Please contact us first for a Repair Authorization First. We'll give it to you, but we need to process some paperwork first, ok?

In the meanwhile perhaps this Haiku (by Grant McKee, Solarbotics Designer) will cheer you up:



*It moves by tumbling
Across difficult terrain
Effective Turbot*

TURBOT - OPTIONS

Optional Stuff: We know, we know - you want to just get to *playing* with your Turbot, but if you ever will add the extras, now is the most likely time to do so.

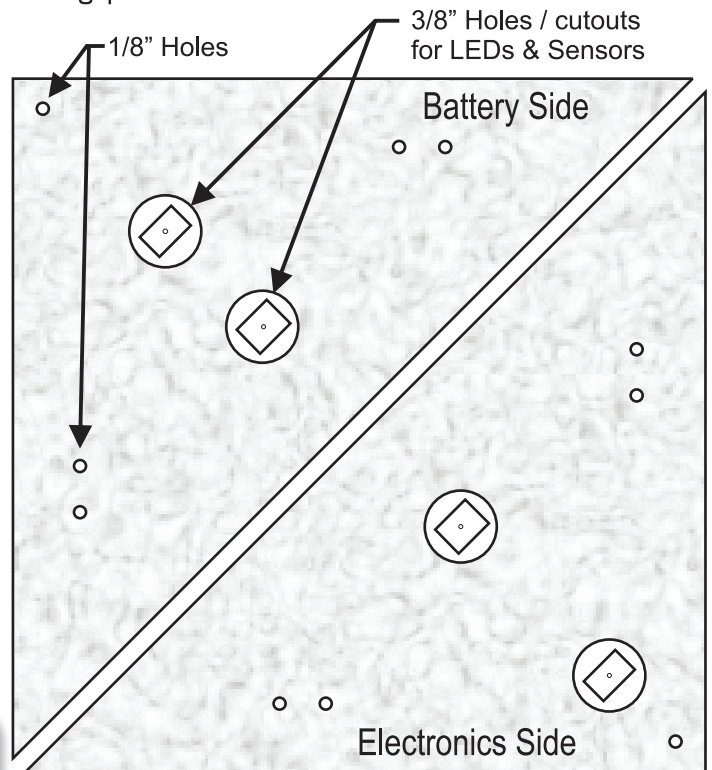
Arm Bands: Ok, it was too cute of a term to pass up. After building several Turbots, they start beginning to look alike. By using different colors of heat-shrink tubing, you can add "Arm Bands" to your Turbot for some decoration. The bands are especially useful at the tips of the arms where they see the most action and wear. Or get some "GRF - Gumby Rubber Feet" caps from Solarbotics for real strong protection.

The Turbot Jacket: Being a native of South American climate, the Turbot finds most indoor surroundings much too cold...

Seriously, the jacket protects the solder connections and sensors from the natural wear and tear that occurs while tumbling over the environment. We find that 3mm (1/8) sintra is an excellent jacket material, as it's inexpensive, colorful, and easy to form (and easily found at Solarbotics!).

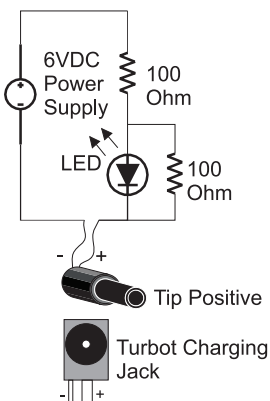
You should be able to build a Turbot jacket out of almost any non-conductive material (steel is a no-no!), Use this pattern to make the jacket.

You **will** have to replace the #2 screws with longer versions! #2 x 1/2" work well.

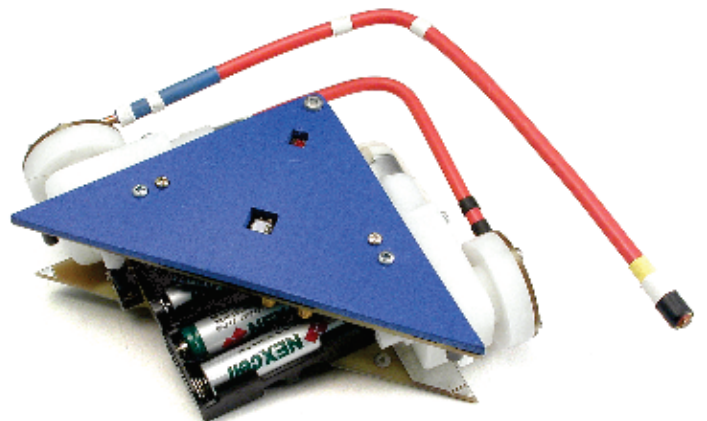


1:1 Drawing for making your own Turbot Jacket. Lay this over your jacket material, and poke pinholes to mark the geometry

Basic Battery Charger: Now that you have 4 AA rechargeables (well, some of you do) tucked in your Turbot, how to recharge them? Here's a basic slow charger circuit borrowed from our "Bicore Experimenters PCB". Hook it up to a 6V DC power supply (watch polarities!), attach it to your Turbot, and it'll always be ready for a tumble.



LED brightness is a good indication of charge condition. When LED turns off, the battery is practically at full charge.



One of Solarbotics' Prototype Turbots "with all the options"

Liked the Turbot? Want more?

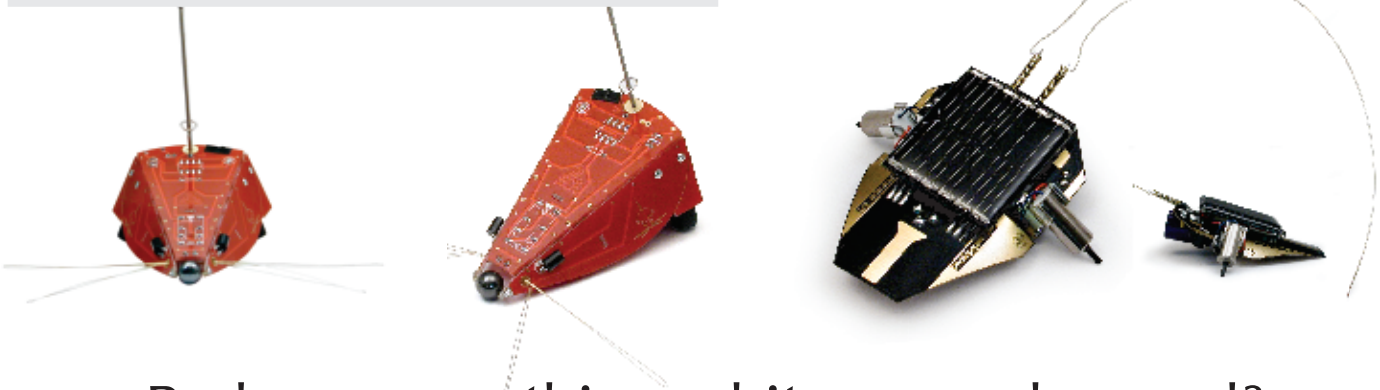
There are several more kits Solarbotics offers for any skill level!

Herbie the Mousebot is a 9-volt battery-powered robot that loves to chase flash light beams. If there are several Herbies in the same area, they can be configured to chase each other! These little robots are so quick, you have to run to keep up to them!

K HM Herbie the Mousebot \$39.95USD/CAD

Like the Mousebot, the *K PP Photopopper* seeks light and avoids obstacles but is solar powered! It's pretty quick, covering a meter per minute (that's 3.3 feet!). Newly upgraded with better electronics and gold circuit board!

K PP Photopopper \$45USD/CAD



Perhaps something a bit more advanced?

The Solarbotics Sumovore Kit is a strong, modular design with over 500 man-hours of development and 21 prototypes behind it. It has more power, speed, and is less expensive than the Junun Mark III, Parallax Mini-Sumo, and Tab SumoBot.

K SV Sumovore Mini-Sumo \$98.50USD/CAD



Visit us online for more info and cool stuff:

www.solarbotics.com

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