How to Build This Dual Axis Tracker

for the All American Sun Oven
and other similar solar ovens

It is entirely solar powered and requires no controls, no complicated electronics, and no batteries. It will automatically follow the sun and keep your solar oven focused.

By Stan Wells

Parts and Materials

The most critical components are the solar panels and the motors. These components must be well matched for this to work. For just about everything else there are numerous options available and while there are undoubtably other options for motors and panels, any departure from the recommendations should

Sunnytech 1pc 2w 6v 330ma Mini Solar Panel Module DIY Polysilicon Solar Epoxy Cell Charger B031

Sold by: stirlingtechonline

$7.99

be thoroughly tested before construction.

There are four 6 volt/2 watt solar panels.
Please note that these panels come without wires. The ones that come with wires usually have a diode built in which will not work for this project.

The tracker has three 12 volt motors. The motor type used is available in different rpm speeds. Get motors that are either 2 or 3 rpm. (You could also use 5 or 6 rpm for the rotation but tilt requires the lower gearing).

Motor mounts are available for these motors but they cost about $8 each. I make them out of 65 cent construction brackets which I drill to match the motor.
Short M2 metric screws attach the motor to the bracket.

*Note that leads must be soldered onto the motors and panels.

High Torque Turbo Geared Motor Gearbox DC 12V Motor 2/3/5/6/10/20/30/40/62/100RPM (2 RPM)

Sold by: huhushop | Product question? Ask Seller

Return eligible through Oct 26, 2020

$14.21

Parts - Wheels

The flange shown below will attach to the motor shaft and various wheels can be attached to it. I use the wheels shown below. Note that I grind down the flange to a slightly smaller diameter and epoxy it into the rim of the wheel. The result is a solid wheel with good traction that can withstand the weight of the oven.

4Pcs 6mm Flange Coupling Connector, Rigid Guide Model Coupler Accessory, Shaft Axis Fittings for DIY RC Model Motors
Sold by: iloveam
Return window closed on Sep 16, 2020
$6.99

uxcell 2 Pcs RC Toy Car Robot Vehicle Rubber Cover Wheel DIY 43mm Dia Rims
Sold by: uxcell | Product question? Ask Seller
$4.82

Another option is to use a 6mm coupling made for RC car wheels. These can bolt right on to the motor shafts. Some tires must be glued onto their rims.

There are undoubtably other options not shown here. In addition to the two motorized wheels get two non swivel castors with 1 1/2” wheels.

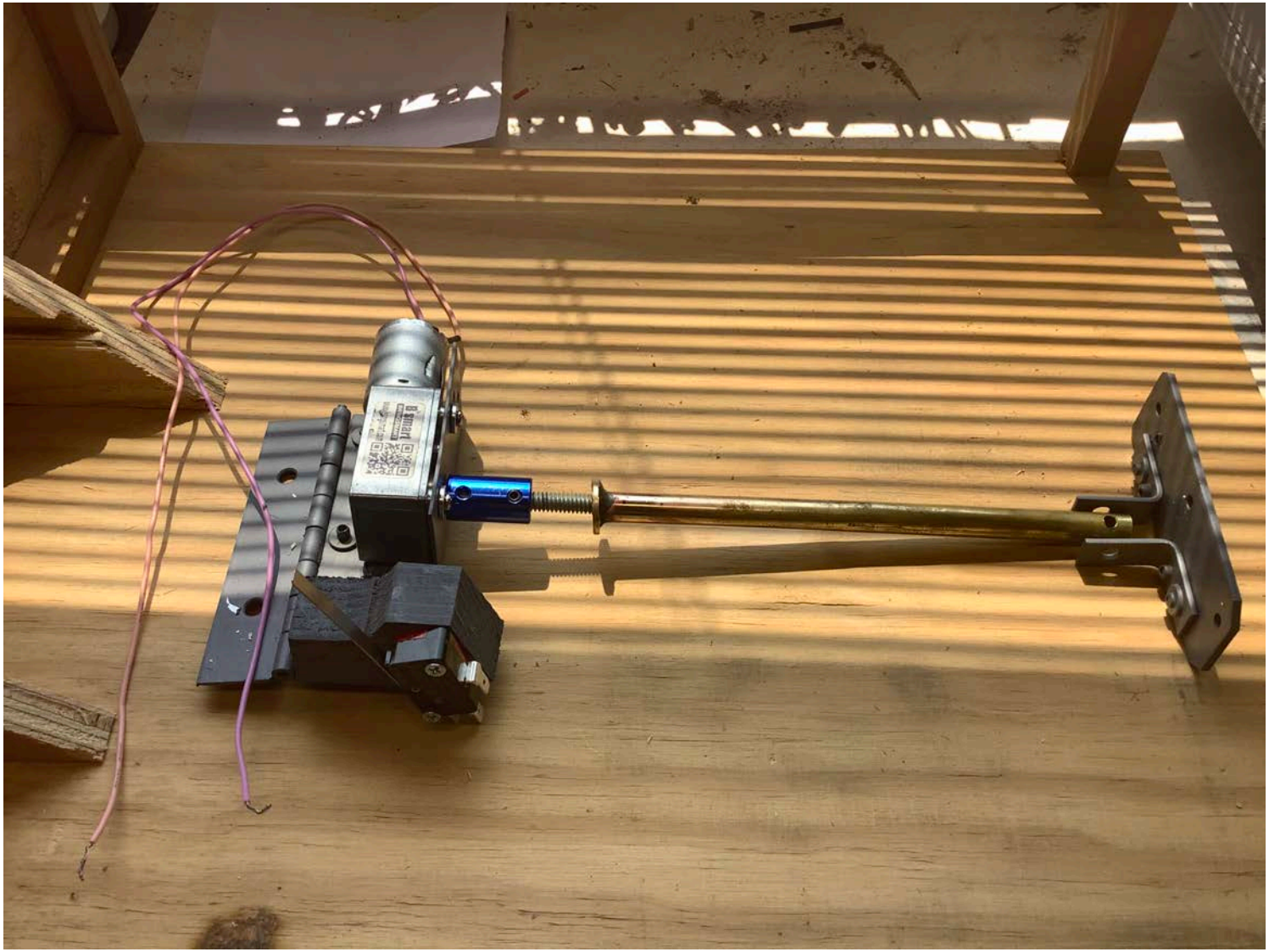
Parts - Linear actuator for tilt

6.5” of 1/4 20 threaded rod.
1 1/4 20 brass nut
6.5” 1/4” OD brass tubing
1   6 mm coupling

BQLZR Blue 6mm to 6mm Aluminum Shaft Coupling Rigid Coupling Coupler Motor Connector with Spanner Pack of 2
Sold by: BQLZR(7-20 days delivery,Fast and free shipping，great customer service) | Prod

2 small angle brackets, 1 metal construction strap tie, 1 3” hinge
2 normally open momentary push button switches (micro limit switches can also be used).
2 diodes. 1N4007 is a good one. Most any small blocking or switching diode should work but not zener diodes.

If soldering the nut to the brass tube is a problem get 7/16” diameter tube and a 1/4 20 barrel nut. Pound the nut into the tube and epoxy it in.



Linear actuator assembly.

Parts - Other misc.

Hinges or continuous piano hinge for tilting

Sensor &. Mast:

3 feet 3/4” dowel. 8” 2x2 for wooden mast or 4 ft 3/4” copper pipe, 2 90 degree elbows, 1 3/4” to 1/2” copper reducing coupling and one microphone screw for copper mast.

One mic holder clip, 4” of 7/8” dowel, and misc wood for sensor frame.

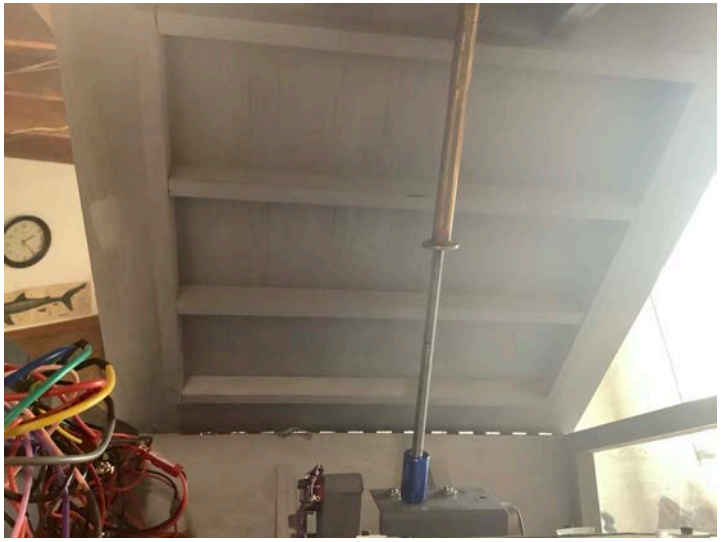
Order details | Ordered on September 9, 2020 (1 item)

Moukey Universal **Mic**rophone **Mic** Clip Holder for **Mic** Stand with 5/8" Male to 3/8" Female Adapter, 2-pack, MMc-2M2

Moukey

Sold by: Moukey

Parts - Wooden Box



2 pieces plywood 16”x18” Top can be 1/4” 3/8” or 1/2”. If 1/4” some reinforcement strips should be added under top to resist twisting and might be needed on bottom as well. (We want to minimize weight as much as possible).
I board 4”x16”x1/2”
2 boards 2”x16”x1/2”
1 board 4”x4”x4” cut diagonally in half for triangle supports.
1 board 16”x3/4”x1/2” (front lip).
8” x 3/4” dowel to hold oven in place.

Bottom view. Note shims under motor mounts to get all four wheels even. Brackets were ground down on bottom facing edge of motor mounts to improve ground clearance. Top view shows two styles of sensor mast.

Parts- Wiring

For wiring I highly recommend this wire because of its flexibility which works well with the connections to the solar panels. The multi colors are very helpful to keep track of the different circuits.

The sensor can be wired right into the box but I like to put a connector there so I can disconnect it and pack it up easier. For this you need a 4 wire connector male and female. You can get that at an auto parts store.

Construction

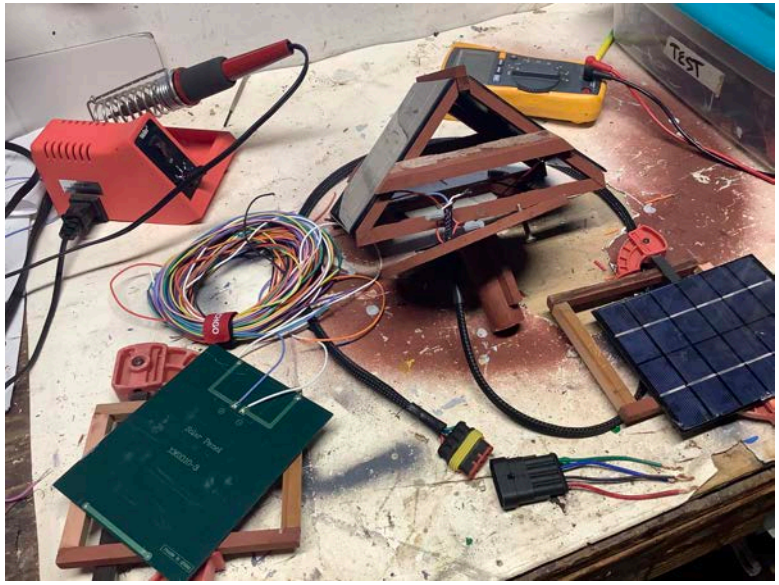
Build the box. Glue and screw all joints. Drill the lower 2” board for the lower limit switch or devise some other way to mount your switch. Attach top hinge(s). Attach front strip. Remove the Sun Oven’s rear leg and throw as far as you can. Insert the 8” dowel into the leg’s socket. Set oven in position and mark where the dowel hits the deck. Drill a shallow 3/4” hole and glue and screw the dowel in place.
Build the linear actuator assembly. Attach the motor mount to the 3” hinge by drilling 1/8” holes through both and fastening with pop rivets. The upper limit switch can be attached to one end of the hinge but save the final Installation of that till later. Build the bracket for the linear actuator extension arm using the flat plate, angle brackets and pop rivets.
Solder the nut onto the end of the brass tube. Drill a 1/8” hole in the other end of the tube across the diameter.

Attach the linear actuator extension bracket firmly to the underside of the top plywood at the end opposite the top hinge. Attach the brass tube end to the bracket with a screw or metal pin. Thread the rod into the tube, attach the coupler to the rod and tighten the set screws. Attach the motor to the motor

mount and attach the coupling to the motor. Later, use the coupler-to-motor connection to disconnect top from bottom whenever you need it open.

Close the top and, with the linear actuator fully contracted, mark on the bottom board where the hinge is located. Open the top, disconnect the coupler from the motor shaft and attach the hinge to the lower plywood.

Solder leads on all motors, solar panels and switches. For the solar panels, leads should only be about 6” long. On one lead from each switch insert a diode in line. It doesn’t matter which lead or which way you solder it in because the polarity will be reversing. Use two colors of lead wires on two of the solar panels and two different colors on the other two. (See wiring diagram).



Instal lower limit switch so that it is engaged and closes when the top is fully lowered.

Turn the tracker over and instal the casters and motor mounts. Make sure the axels of the two motors are both along the centerline. Shim motors so tires are even

with casters. Drill holes for motor leads through the bottom plywood.

Build frame for the sensor solar panels. There are lots of possible designs. The panels should be at a 45 degree angle. Adding panels of flashing or other material to help shade the PV panels can improve tracking.

Note the 7/8” dowel with rib that fits into the mic holder. The rib ensures the orientation of the sensor is correct. I use Gorilla wood glue to hold it all together. The panels are then glued on using Quick Hold contact adhesive. If the sensor takes a hard spill it might come apart but things aren’t as likely to break.

Wiring the Tracker

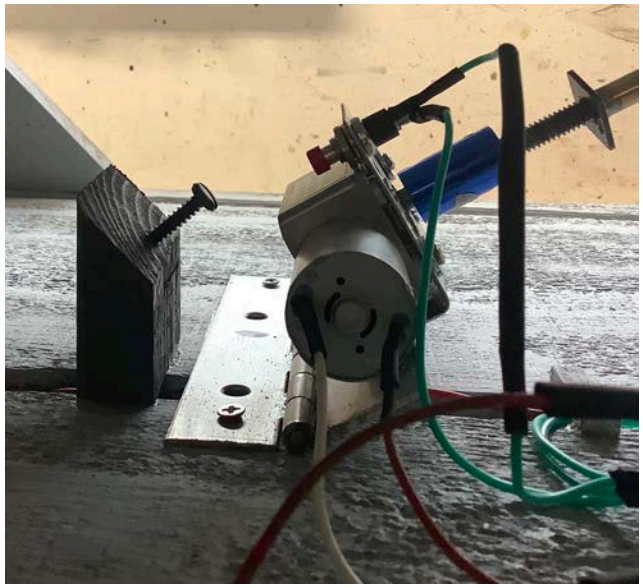
As you start to connect everything together leave the connections in the box just twisted together. Later, you can solder or crimp them or use wire nuts but leave them bare at first because polarity might be wrong and the tracker could be going the wrong way. To correct that you just have to reverse the wires going to

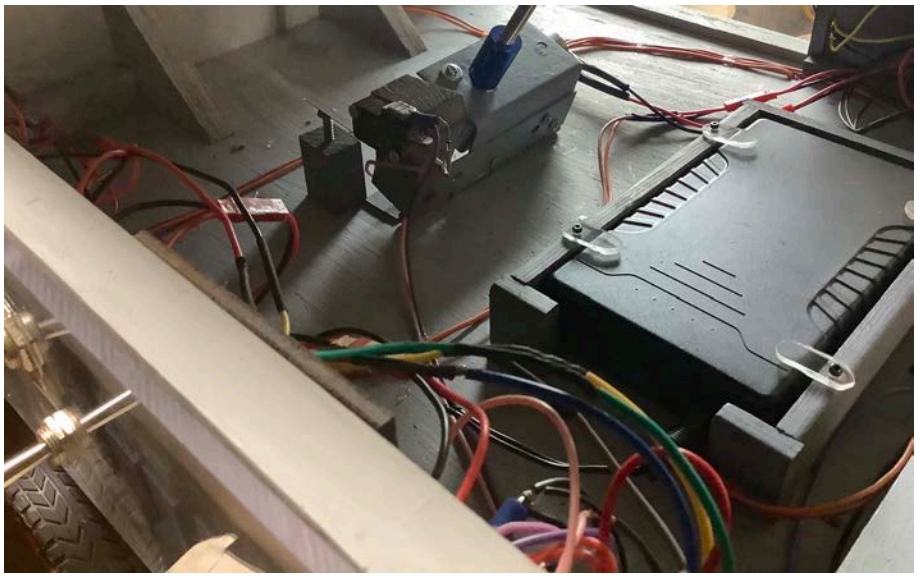
the motor. It's the same thing with the limit switches. It they don't work we have to reverse their wires as well.

The way this is wired is unique to a solar device like this. There are two completely independent circuits: rotation and tilting. The front and back panels control the tilt and the left and right panels control the rotation. The pairs of panels are wired together in parallel but opposite polarity. e.g. red wire to black wire and black wire to red wire. (The sort of thing that gives electricians nightmares). The limit switches are normally OPEN and are wired across the circuit e.g. between the red wire and the black wire. When pushed, the switch shorts out the solar panels to stop the motor. Since the short is created through a diode it stops shorting if the polarity is reversed enabling the tracker to go the other way after reaching its limit. Unlike an interrupting switch, which introduces resistance across its contacts, these solar panels are always directly connected to the motor which makes for less resistance and more power. That is the reason for shorting the panels instead of interrupting the circuit. Solar water pumping systems use this type of control as well. *A battery should not be used with this tracker.* However, for testing you can use any 12 volt power source before you connect the limit switches but take care not to exceed the intended range of travel.

The motors have one terminal marked with a red dot. When that connection receives positive polarity the motor turns clockwise. When the rotation motors turn CW the tracker turns CCW. When the linear actuator motor turns CW the tilt increases.
To get the polarity right make sure the positive terminal of a solar panel flows into the proper motor terminal. For example, the back panel should raise the oven when energized so the positive lead from that solar panel, which is connected to the negative lead from the front panel, should be connected to the positive motor terminal. As you look at the oven head on, if the panel on the right is energized the tracker should rotate CCW to the East so that positive wire goes to the positive terminals on the rotation motors. (The other method is to just guess and take it out in the sun and see what happens. Adjust as needed).

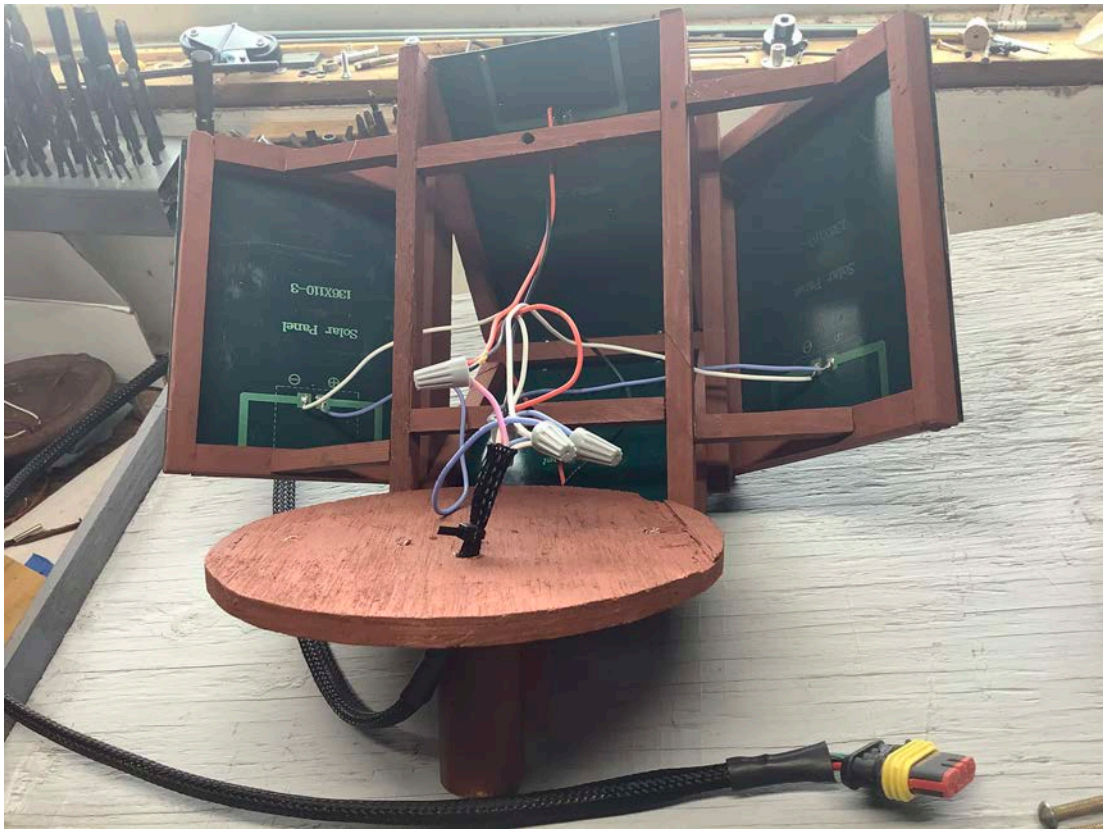
Once everything is working, instal, adjust and test the upper limit switch. Two examples are shown below. On the left is a push button mounted through a hole in the motor mount bracket. The screw in the wooden block allows for adjustment. On the right is a limit switch fastened to a block of wood that is attached to the hinge. Although it is capable of more, I recommend limiting the tilt to about 40 degrees.

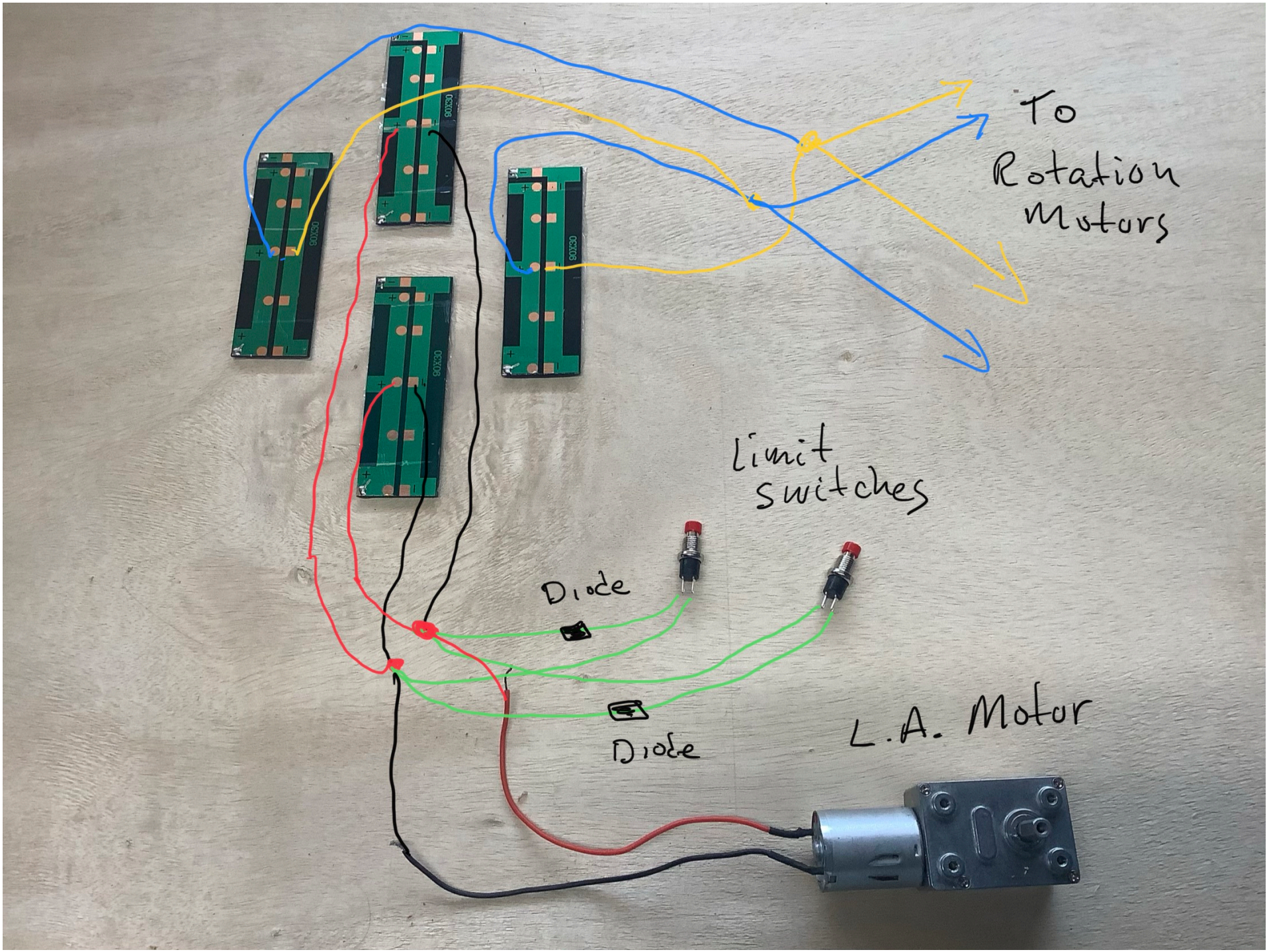




Between the sensor and the tracker you need about 43” of cable with four wires. I recommend the same wire as used for leads. The mast has three sections. The first is up 10” then it goes back 8” and then up 23”. You want the solar panels to just clear the oven’s reflectors. Take a block of wood and drill it 1 3/4” deep for your mast and attach it to the upper 2” board for the mast receptacle. You can add a set screw to hold it in position.

Be sure to provide strain relief on the wires coming out of the sensor to prevent them from being ripped off the solar panels. I used a wire tie for that.


Solar Panel


To
Rotation
Motors
Limit
switches
Diode
Diode
L.A. Motor

Using the Tracker

Place the tracker on a flat smooth surface.

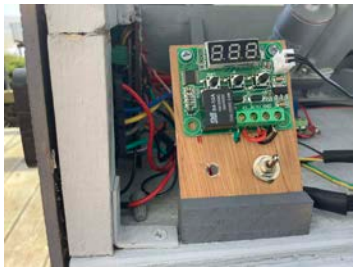
The sensor should be tilted to match the built in tilt of the sun oven's face. You can tweak its performance by adjusting that angle or rotating slightly. To stop tracking simply unplug the sensor cord if so equipped or place a bag over the sensor.

The tilt movement is very slow (but faster than the sun). If the tracker is all the way down in the morning, point it at the sun and let it start tilting before you put the oven on. It will get there faster that way. If you're not in a hurry go ahead and load the oven on and it can preheat while the tracker is slowly increasing the tilt. At the end of the cooking day you can just leave it tilted to get a head start next time or you can point the sensor head sharply down and watch the tracker slowly close while you eat.

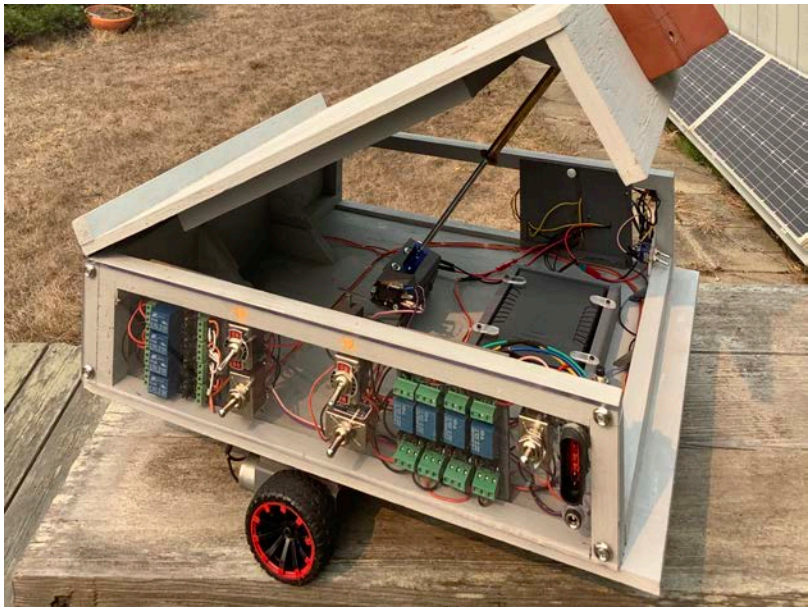
How this tracker evolved

My wife was making biscuits. I had thrown this tilt deck together by the time the batter was ready. We put it on a lazy Susan we and the tracker was born.

After several attempts I built a sensor, a motorized turntable and a motorized tilt. The tilt was the hard part and required a commercial linear actuator and a lot of power to operate.



I modified the turntable by moving the drive wheels under it to improve traction. That made me realize the turntable wasn't needed. By then we couldn't do without a tracker so I built another one with no turntable. Then I added



a thermostat and added low temperature baking. I decided to take all I had learned and build one more. I built my own linear actuator for this one and gave it four wheel drive.

I was outside testing this tracker and was surprised when I noticed it was operating even though the battery pack was shut off! My home made linear actuator didn't need as much power as the commercial one. This meant I could finally achieve my original goal of driving the motion directly from the sensor panels and creating a simple affordable solution. This eliminated the need for the 12 volt solar panel, the commercial linear actuator, 8 relay switches and all sorts of complicated wiring. It took me a while to find the right combination of motor and panel but it is now done. I built the new simple prototype out of the boards from the original tilt deck and part of the original turntable tracker. I like to reuse stuff.