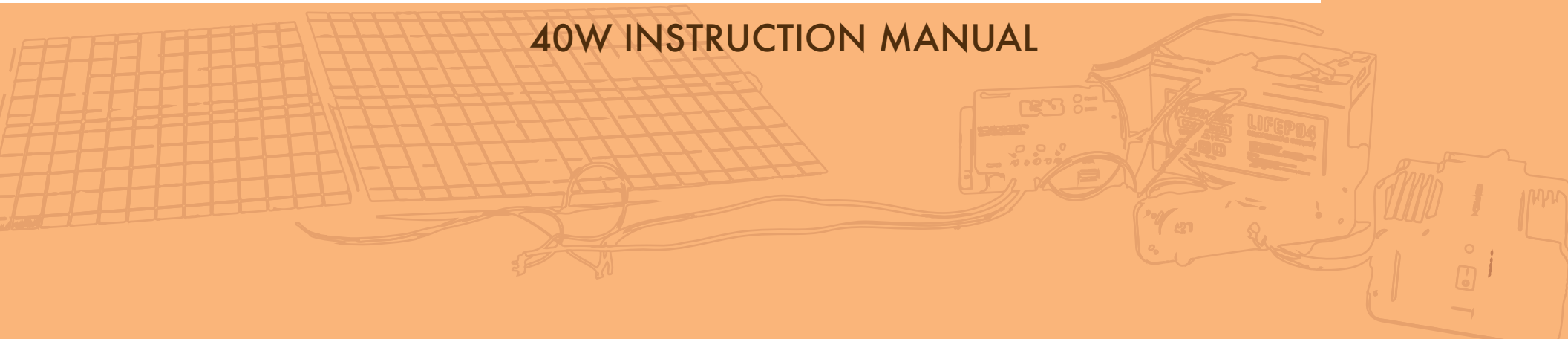
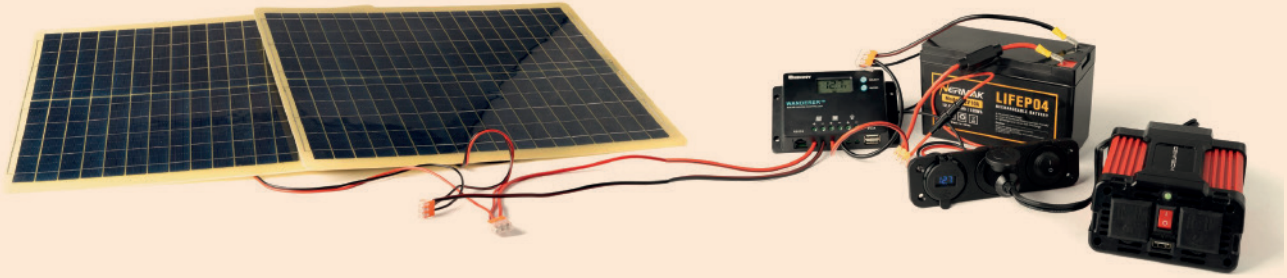
TO CATCH THE SUN

40W INSTRUCTION MANUAL

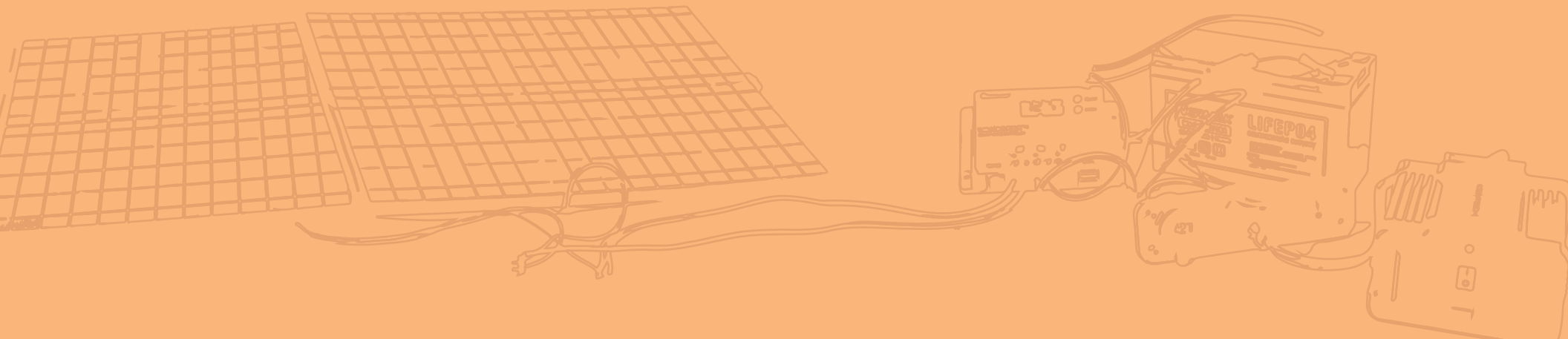


40W INSTRUCTION MANUAL

This guide provides instructions on how to create a 40 W solar power array with a 120 Wh energy capacity and the ability to supply power to both DC and AC loads. The total cost to build this system is around $200 USD (depending on sourcing) including the required tools.

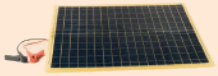


Content



1. Parts

Below are the list of parts, supplies, and tools you will need. Depending on sourcing, you will likely be buying slightly different components. Make sure to read the notes to make sure what you are purchasing will work. This system is purposely designed to be quite adaptable in your component selection.



Two 12 volt 20 watt solar panels

One 12 volt 10 amp hour $LiFePO_4$ Battery

One 12 volt 10 amp charge controller

One 200 watt inverter

One 12 Volt accessory plug

One 12 gauge fuse holder

One 25 amp blade fuse

A few feet of red and black 10 gauge wire

Four 12 gauge 3-way lever nuts

Two 12-10 gauge spade receptacle terminals

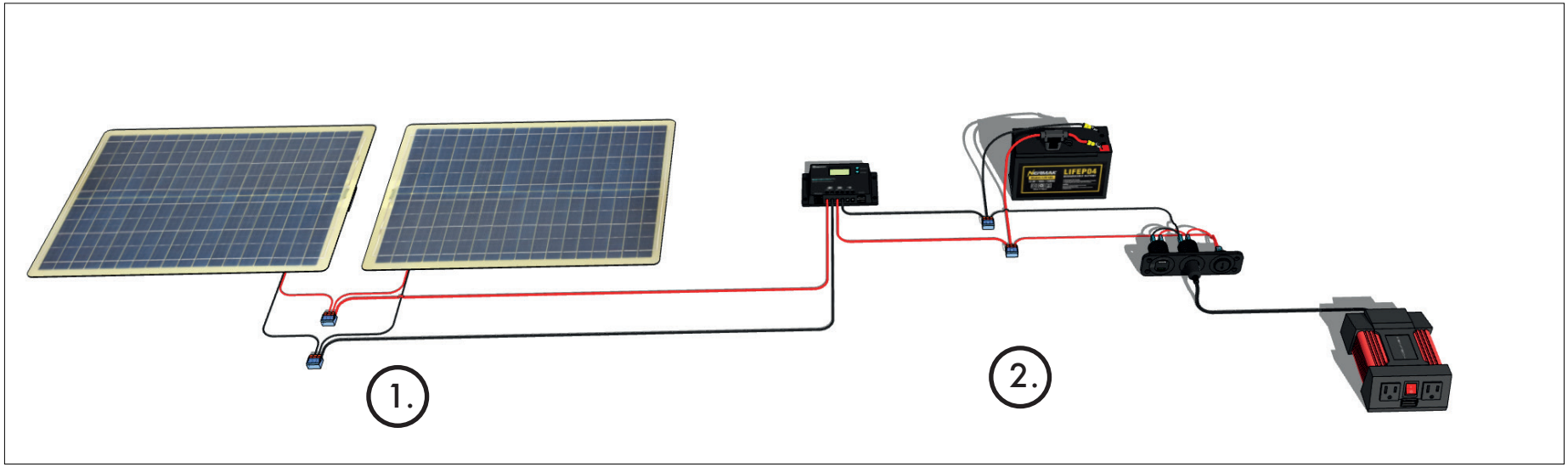
Wire cutter/stripper/crimper

Small screw driver

Optional - Multimeter

2. Assembly Instructions

The following section contains step-by-step instructions on how to assemble this 40 W photovoltaic system.



1. The section contains instructions on how to assemble the solar panels
2. The section contains instructions on how to assemble the battery
3. The section contains instructions on how to assemble all the sub-assemblies

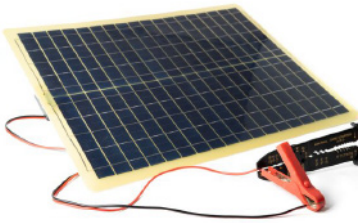
Assembly Instructions

1. The following section contains instructions on how to assemble the solar panels for this 40 W photovoltaic system.

1

Remove the alligator clips from both of the solar panels

Remove the alligator clips from the red and black wires that attach to the solar panels by using the wire cutter.

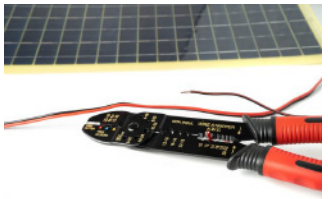


PARTS & TOOLS
- Two 12 volt 20 watt solar panels
- Wire cutter/stripper/crimper

2

Strip insulation from solar panel wires

Strip about 3/8 inch of insulation off the solar panel wires by using the 10 or 12-gauge wire stripper (whichever fits better)



PARTS & TOOLS
- Solar panel wires
- Wire cutter/stripper/crimper

3

Cut and strip the wire

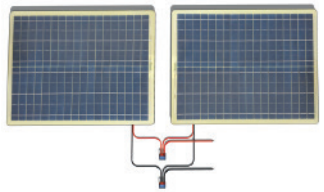
Cut 6 to 12 inches (depending on your desired distance of panels to charge controller) of red and black 10-gauge wire from the wire and strip 3/8 inch from all ends.

PARTS & TOOLS
- Red and black 10 gauge wire
- Wire cutter/stripper/crimper

4

Connect the panels in parallel

Connect the panels in parallel with the 10-gauge wires by connecting all three red wires with a 3-way lever nut connector. Note that three red wires include 1 red wire from one panel, 1 red wire from the other panel, and 1 loose red wire you stripped in the previous step. Then repeat the process with the three black wires.



Parallel wiring between two panels, using 3-way lever nuts.

PARTS & TOOLS
- Two 12 volt 20 watt solar panels
- 10-gauge wires

Assembly Instructions

2. The following section contains step-by-step instructions on how to assemble the battery section for this 40 W photovoltaic system.

5

Cut the fuse housing wire

Cut the wire for the blade fuse housing so that there is more wire length on one side than the other. You want to place the fuse housing close to the battery terminal by having a short section of wire. There is no direction for a fuse, so it does not matter which side is shorter, just that one side is.

PARTS & TOOLS
- 12 Gauge Fuse Holder
- Wire cutter/stripper/crimper

6

Insert a 25 A blade fuse

Push a 25 A blade fuse into the fuse housing. There is not direction to a fuse, so either way works fine.

PARTS & TOOLS
- 25 A blade fuse
- 12 Gauge Fuse Holder

7

Cut and strip a section of black wire and put on blade fuse receptacle terminals

Cut and strip a section of 10 gauge black wire similar in length to the red fuse housing wire. Strip this wire the same as done in a previous step.

Apply 1 yellow spade terminal receptacles to the short end of the red fuse housing wire and another yellow spade terminal receptacle to one end of the newly cut black wire.

To apply the yellow spade terminal receptacles, slide the stripped wire into the receptacle and use the yellow spot on the crimper to firmly press one the receptacle. Check to make sure terminal is on tight.

Wires cut and stripped with yellow spade terminal receptacles on one end each.

Image showing how to clamp on the spade terminal receptacles.

8

Attach 3-way lever nuts to one end and to the battery on the other end

Place 3-way lever nuts at the bare ends of the black wire and fuse holder wire.

Connect the spade terminal receptacle from the fuse housing wire to the positive blade (red) of the 12 V battery. REMEMBER the battery is the only dangerous thing here. Do not connect the two battery terminals together with anything conductive like metal..
Connect the spade terminal receptacle of the black wire to the negative blade (black) of the 12 V battery.

Assembly Instructions

2. The following section contains step-by-step instructions on how to assemble the battery section for this 40 W photovoltaic system.

9

Cut and strip another 10-gauge red and black wire

Cut another pair of 10-guage wire (red and black) and strip it at both ends. The length of the wires depends on the desired distance between the charge controller and the battery.

This wire in this image might be shorter than you need for your set up.

PARTS & TOOLS
- Two 12 volt 20 watt solar panels
- Wire cutter/stripper/crimper

10

Connect the bare wire to the battery hatch of the charge controller

Loosen the battery hatch terminal screws of the charge controller with a small (1/8 inch) flathead screwdriver and insert the newly cut pair of wires with red going to the positive hatch terminal (+), and black going to the negative hatch terminal (-). Close and secure the hatch terminals by tightening the overhead screws.

PARTS & TOOLS
- One 12 volt 10 amp charge controller
- Flat head screw driver (1/8 inch)

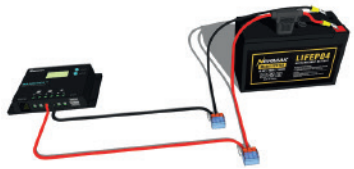
11

Connect the charge controller to the battery

Connect the open ends of the wires from the charge controller to the 3-way lever nuts attached to the battery, matching red with red and black with black. With this connection established, the LCD screen of the charge controller should turn on. Follow the instructions of the charge controller to set it up for your specific battery type (e.g. in this case $LiFePO_4$).

If you are using the same battery and charge controller as this how to manual, here are the steps to follow: Press the select key until the battery voltage (batt) is displayed. At this point, press and hold the enter button until the screen flashes with battery types. Cycle through the battery types by pressing the select key until "Li" is displayed, then press enter. Select 12 V as the battery voltage and press enter. In the last option, press select until 14.4 V is shown as the charge voltage, then press and hold the enter key to save and finish the setup.

Charge controller connected to battery (through the fuse on the positive wire).



3D model of charge controller connected to battery and fuse.

Assembly Instructions

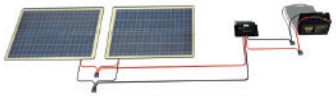
3. The following section contains step-by-step instructions on how to assemble all the sub-assemblies for this 40 W photovoltaic system.

12

Connect solar panel wires to charge controller

Connect the bare wires coming from the parallel solar panels (from Step 4) to the solar hatch terminal screws on the charge controller. Refer to the process described above to open and secure the hatch terminals on the charge controller.

Charge controller connected to battery and now the solar panels.



3D model of the charge controller connected to the parallel solar panels and the 12 V battery.

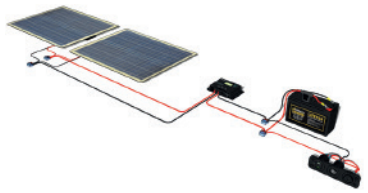
13

Insert a 25 A blade fuse

Connect the positive (red) wire of the 12 V accessory adapter by inserting it into the corresponding 3-way lever nut attached to the positive (red) wire of the battery (the wire with the fuse holder) and charge controller. For guidance, see the single remaining opening in the lever nut from Step 12 that is connected to the red wires.

12 V accessory adapter connected to the battery

Connect the negative (black) wire of the 12 V accessory adapter by inserting it into the corresponding 3-way lever nut attached to the negative (black) wire of the battery and charge controller. For guidance, see the single remaining opening in the lever nut from Step 12 that is connected to the black wires.



3D model of the 12 V accessory adapter connected to the battery.

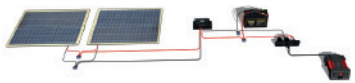
14

Connect the inverter

Plug the cigar style plug from the inverter into the accessory adapter receptacle for the cigar style plug.

Turn the switch on the accessory adapter to the on position. Turn the switch (if present) on the inverter to the on position.

Entire 40 W PV system including a charge controller with two solar panels in parallel and a 12 V battery running an inverter. Solar panels not pictured.



3D model of entire 40 W PV system including a charge controller with two solar panels in parallel and a 12 V battery running an inverter.

It is now ready to use!

3. Usage & Testing

Once the assembly steps have been completed, the PV system is ready to use. To charge the system, set the panels in an area that receives ample sunlight. To maximize the solar radiation absorbed by the panels, tilt them towards the sun.

To utilize the system to run a DC load via USB (such as to charge a phone) connect the device to the USB port on the 12 V accessory adapter. To power an AC load such as a fan or light fixture, plug the appliance into an outlet on the inverter. In both cases, ensure the switch on the 12 V accessory panel is in the on position. Flip the inverter switch into the on position when utilizing AC loads. You will need to make sure you don't pull more continuous power than the inverter can handle (in this case 200 W, and make sure that your DC accessory plug is rated for that much power as well).

This system can be utilized in a variety of different applications. To understand how long the battery will last, and how quickly it can charge, a low-power and high-power draw example system can be analyzed.

Example of the final system with panels tilted at 26 degrees to optimize their performance in Arcata, CA during summer months.

Low-power draw example

An example of a low-power draw system is a 10 W LED light bulb being run continuously. Given enough uninterrupted sunlight, the light can easily be powered without draining the battery due to the 40 W of power supplied by the solar panels. At night, when the solar panels no longer supply power, the light can run off of the battery for almost 12 hours[1]. To fully recharge an empty battery would take about 3 hours with the light off[2] or 4 hours with the light on[3]. A system like this could run with little to no downtime during the summer months.

High-power draw example

An example of a high-power draw system is an 80 W box fan. During periods of full sunlight, this system can run continuously for 3 hours[4] before the low voltage disconnect turns off the inverter and shuts down the fan. When no light reaches the solar panels, the system can run for 1.5 hours[5]. Because the power draw is higher than the power supplied by the solar panels, it is not possible to charge the battery while running the fan. With the fan shut off, the solar panels can fully recharge the battery in about 3 hours[6].

Intermediate power draw

Many intermittent loads can be powered by this system indefinitely.

[1] Because 120 Wh/10 W = 12 hours, but there are some inefficiencies which will make it a little less than 12 hours.
[2] Because 120 Wh/40 W = 3 hours.
[3] Because 120 Wh/30 W = 4 hours
[4] Because 120 Wh/(80 W draw - 40 W supply) = 3 hours.
[5] Because 120 Wh/80 W draw = 1.5 hours.
[6] Because 120 Wh/40 W = 3 hours.

4. Reasons to build

Once the assembly steps have been completed, the PV system is ready to use. To charge the system, set the panels in an area that receives ample sunlight. To maximize the solar radiation absorbed by the panels, tilt them towards the sun.

- ✓ You want to take more power into your own hands!
- ✓ You have a need for a 40W system, e.g. for laptop charging, emergency preparedness and battery charging, remote air data collection, gate opening, electric fencing, #vanlife, #glamping, or some power (e.g. for lighting) in an off grid home.
- ✓ You have a need for a custom system that is smaller or larger, but you want some practice building something specific.
- ✓ You are a teacher or a school and want a system that students can build.
- ✓ You read To Catch the Sun and want to build all types of solar, so here is a great start!
- ✓ You want to become an energy entrepreneur and are looking for a complete project to start with.
- ✓ You want a 40W system with 120Wh of storage that you can customize and adapt. This system would be easy to increase or decrease in size.

To Catch the Sun is the first book created from this much exclusive Appropedia content on photovoltaics. It is was successfully crowdfunded on Kickstarter. See http://tocatchthesun.com to get your own copy.

5. Safety and Disclaimer

This guide is provided as a free reference. Electricity is dangerous. Batteries have stored energy and can be very dangerous if you short them (i.e., connect the positive and negative terminal with something conductive like metal). You can even hurt yourself with a screwdriver if you try hard enough. Please proceed at your own risk. Appropedia (and any authors) shall not be held responsible for any damages as a result of any activities contained within this guide.

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