Fossil-Free MIT | Solar USB Phone Charger SOP | February 27, 2014

Estimated time: 2 hours and 20 minutes
Tools and supplies: Soldering iron (flat and point tips), multimeter, bright lamp for testing, wire-strippers, scissors, needle-nose pliers, aluminum foil, hot glue gun
Ingredients: Silicon solar cells (6, 2"x3"), tabbing wire (~5" of wide, ~32" of narrow), solder (fine and thick), wire (solid-core, ~20 AWG, ~6" each of red and black is preferable), voltage step-up converter (~3V input, 5V output) with USB female output (example), acrylic sheets (2, 7"x8", UV-resistant), hot glue sticks
Output: USB out, ~5V/1.5A under peak sunlight (standard iPhone charger is 5V/1A)

Safety considerations

- Never work alone!
- Never rush. Think and work deliberately.
- Be careful not to touch the soldering iron except on the handle. It will be hot. Very hot.
- Don't pick up any equipment by the electrical cord.
- Remove conductive metal jewelry and watches prior to working with exposed circuits.
- Make sure your hands are dry before using any electrical equipment.
- If anything seems unsafe or you're not sure what to do next, stop and ask for help.

Instructions

At steps with asterisks (***), please have a volunteer check your progress before proceeding.

(1) Connect 6 solar cells in series to get ~3V output (~80 minutes)

(a) ***Choose 6 2"x3" cells: Make sure each set of 3 has the wafer corner cut in the same orientation
(b) Prepare 8 tabs—strips of narrow tabbing wire (Ag-plated Cu)—each a bit longer than 4”
(c) Attach a tab to the back side of each of the 6 cells
  (i) Solder 1 tab to the back (gray) side of each cell, starting at one end of the tabbing wire (should have just over 2” hanging off the edge of each cell)
  (ii) Apply flux to the silver contact (white strip) using flux pen before soldering
  (iii) Test the power output of each individual cell using a multimeter
    (1) 2” x 3” = 5cm x 7.5cm = 37.5cm^2 * 100mW/cm^2 * 10% PCE = ~375mW$_p$
    (2) Under bright sunlight, you should measure an output voltage of ~0.5V and output current of ~750mA
    (3) Under a lamp in the lab, you may see much a lower current (100-300mA)
(d) Cover the back side of each cell with transparent packing tape (just under 2" wide) for extra mechanical support on the tabs
(e) Make 2 series-connected strings with 3 cells each
  (i) Solder the overhanging tab from the back side of one cell (V+) onto the front side of the next (V-)
  (ii) ***Check the order of the 3-cell strings for proper matching with the step-up polarity
  (iii) Solder a narrow tab onto each of the two cells that have an untabbed side
(f) Connect the 2 strings in series, side-by-side (in U-shape), using extra-wide tabbing wire
  (i) Fold the wide tabbing wire over the leads at the ends and use thick solder to secure them together
(g) ***Illuminate the cells and test the output voltage and current of the complete string using a multimeter: Should be ≥ 3V at open circuit

(i) When testing voltage, make sure not to short device through underlying Al foil
(ii) If illumination is not uniform, output current will be lower than expected (below 100mA)
(iii) Note the polarity of the string! Which end is positive?

(2) Connect the output of the PV string to the input of the step-up converter (~20 minutes)

(a) Cut and strip ends of ~6" long red and black wires
(b) Solder red and black wires onto V+ and V- pins of step-up converter
(c) ***Solder the free end of the red wire (from V+) to the positive end of the cell string
(d) Solder the free end of the black wire (from V-) to the negative end of the cell string
(e) ***Illuminate the module and test the voltage output of the step-up converter with a multimeter: You should measure clean 5V between V+ and GND, 2V between D- and GND, 2.7V between D+ and GND

(3) Encapsulate the entire PV string to complete the module (~40 minutes)

(a) Cut acrylic sheets into 2 rectangles (~7"x8")
(b) Place the cells face up onto one sheet with output wires extending out from shorter edge
(c) ***Check that the second sheet lies flat on top and will not crack the cells when applied (no protruding high-stress points)
(d) Use hot glue to secure key joints to the bottom acrylic sheet: mid-string connection (should be taped already), V+ and V- PV-wire joints, V+ and V- wires
(e) Apply hot glue around the edges of the bottom sheet, then quickly place and align the top sheet
(f) Fill in all the gaps between the sheets and seal all edges with hot glue
(g) Attach the step-up converter to the top corner of the module using hot glue
(h) ***Blanket all wires and step-up converter with hot glue, making sure not to shade any of the cells

(4) Solarize!