IV Swinger 2
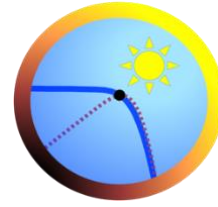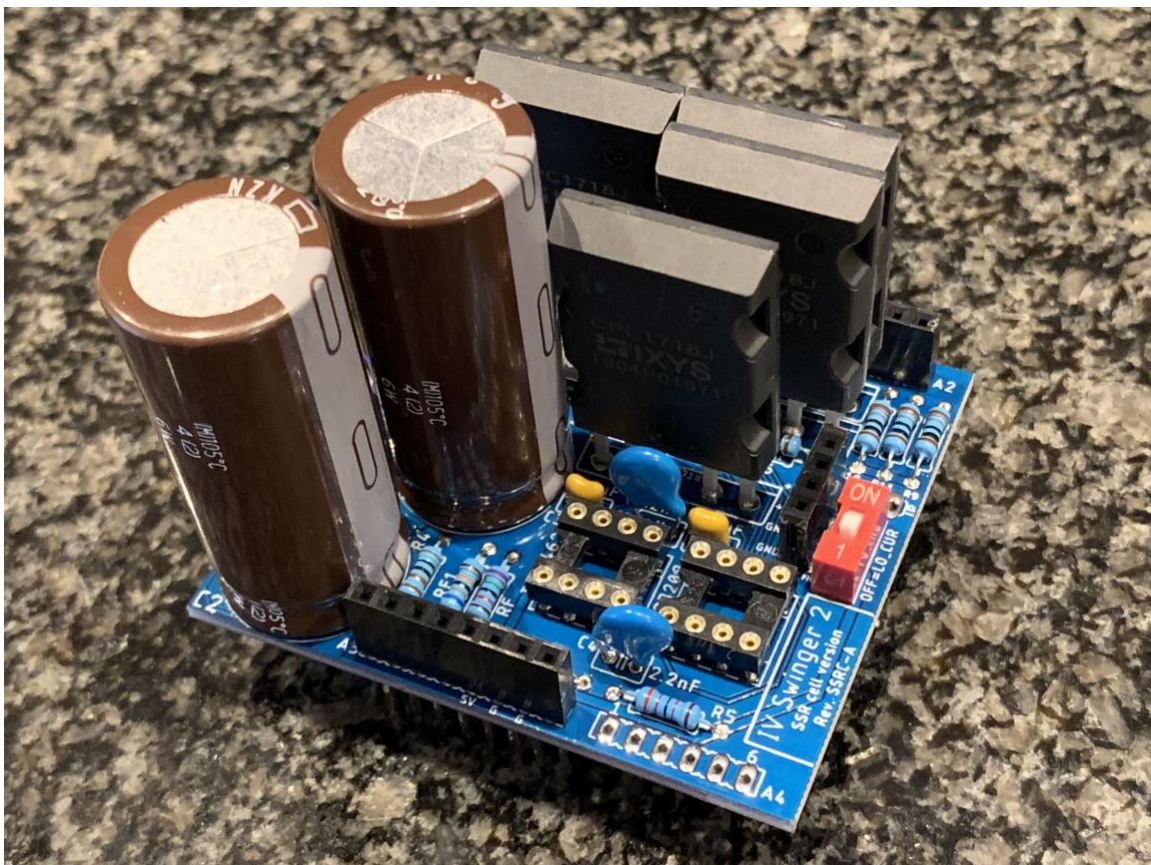
Step-by-step Construction:
Arduino Shield PCB Designs
SSR cell version

Document Revision: 1.03 (27-Feb, 2022)   Chris Satterlee

Intro

This document contains the step-by-step instructions to build the EMR cell variant of IV Swinger 2.

These are the same instructions that are on www.instructables.com but do not include any of the photos or videos. The purpose of this document is primarily so you can print it out and check off completed steps and make other notes as you work on the project. You should use the Instructable to take advantage of the visual aids.

https://www.instructables.com/id/IV-Swinger-2-a-50-IV-Curve-Tracer

Step 1:   Understand the HW design / Choose Variant

Please refer to the Instructable for this Step.

https://www.instructables.com/id/IV-Swinger-2-a-50-IV-Curve-Tracer

The remainder of this document assumes that you have chosen the following variant:

PV cell version, solid-state relay (SSR)

https://github.com/csatt/IV_Swinger/raw/master/PCB/IV_Swinger_2_ss_cell/PDF/IV_Swinger_2_ss_cell_sch.pdf

If this is not correct, please find the step-by-step construction document for the version you did choose. **Many of the steps are similar, but the details differ, so you need to use the correct document.**

Step 2:   Install software

Before spending time building the hardware, install the Arduino software and the IV Swinger 2 application on the laptop that you'll be using.

- **Install Arduino IDE:**
    https://www.arduino.cc/en/Main/Software

- **Install IV Swinger 2 app:**
    https://github.com/csatt/IV_Swinger/releases

- **Make sure both of the above come up before proceeding. If necessary, upgrade the OS on your computer**

Step 3:   Order PCB

Currently the PCB must be purchased from a manufacturing house that will actually fabricate it for your order. The

downside of this is that you'll probably have to buy more than you need. I have used the following two:

OSH Park:
	https://oshpark.com
	Made in USA
	Cost: $25 for 3 PCBs (includes shipping)
	Time: < 12 days to ship

PCBWay:
	https://www.pcbway.com
	Made in China
	Cost: $5 for 10 PCBs + shipping ($16 DHL to CA)
	Time: < 5 days to ship

Amazingly, I have put orders in to PCBWay on a Monday and had the boards in my hands in California on Friday.

I have shared this PCB design on PCBWay, and you can order it directly using the following link:

https://www.pcbway.com/project/shareproject/W112835ASR5_IV_Swinger_2_ss_cell_Rev_A_2019_01_06_546bb8c1.html

https://www.pcbway.com/project/shareproject/W112835ASR5_IV_Swinger_2_ss_cell_Rev_A_2019_01_06_546bb8c1.html

Alternately, you can order PCBs from OSH Park (or anywhere else) by uploading the ZIP archive of the Gerber files, which are found in the GitHub repository:

  IV_Swinger/PCB/IV_Swinger_2_ss_cell/Gerber/*.zip

Soon, I hope to find someone who wants to sell individual PCBs on eBay (possibly in kits, that include all the other parts too).

Step 4:   Buy other parts

The other necessary parts to build an IV Swinger 2 can all be purchased online from Amazon and Digi-Key.

SSR PV cell version BOM:

https://github.com/csatt/IV_Swinger/raw/master/PCB/BOM/ssr_cell_BOM.pdf

The BOM has an Amazon link and a Digi-Key link at the bottom. The Amazon link is a "wish list" that can be used to populate your cart. Some of the items come in quantities larger (in some cases much larger) than needed to build a single IV Swinger 2. You may of course choose to find equivalents that are offered in smaller quantities. Also, many of the items are things that you may already have, so don't necessarily just blindly order everything on the list.

The Digi-Key link is a pre-populated shopping cart. Again, you'll want to check if you already have any of the items before ordering.

In both cases, it is possible (or probable) that certain items will go out of stock or be discontinued, so you'll have to find suitable substitutions. Note that there are some of the Digi-Key items have ALT_n (e.g., ALT_1, ALT_2) in the "Customer Reference field. These should only be ordered if the primary version of the same part is marked as "backorder".

Alternately, the following CSV file may be used to order from Digi-Key, Mouser or possibly other suppliers that support uploading a BOM spreadsheet. It includes the manufacturer, manufacturer's part number, Digi-Key part number, and Mouser part number:

https://github.com/csatt/IV_Swinger/raw/master/PCB/BOM/DigiKeyMouser/ssr_cell_DigiKey_Mouser.csv

https://github.com/csatt/IV_Swinger/raw/master/PCB/BOM/DigiKeyMouser/ssr_cell_DigiKey_Mouser.csv

Also included below is the link to donate to the original Arduino developers. I donate $5 for each $10 Arduino clone that I buy. This is your choice, but I think it is the right thing to do.

Donate to Arduino.cc:
        https://www.arduino.cc/en/Main/Contribute

Step 5:   Gather / buy tools

- Holding:
    - Vise
    - 3rd hand tool with magnifying glass
    - Tape (preferably Kapton, but Scotch ok)
    - Long/needle-nosed pliers
- Soldering:
    - Soldering iron (preferably temp controlled solder station)
    - Tip cleaner
    - Rosin core solder
    - Solder sucker or solder wick
- Cutting:
    - Wire cutter (flush cut)
    - Wire stripper
- Drilling:
    - Drill
    - 1/16" bit (pilot for 9/64")
    - 9/64" bit (standoffs)
    - 11/64" bit (pilot for 13/64")
    - 13/64" bit (binding posts)
    - 3/8" Forstner bit (preferred - USB cable hole)
        - Alternate: 1/8", 3/16", 7/32", 1/4", 9/32", 5/16", 11/32", 3/8", and 25/64" normal bits
- Other:
    - Digital Multimeter (DMM)
    - Small Phillips screwdriver
    - 1.5V battery
    - Sharpie
    - Ruler
    - Water spray bottle

Step 6:   Prepare for Soldering

- **<u>Soldering NOTES:</u>**

    - If you don't have a lot of soldering experience, read this:

    https://learn.adafruit.com/adafruit-guide-excellent-soldering/common-problems

    - Soldering components to the PCB is pretty mistake-proof, but doing it in the order described is recommended (shortest -> tallest).

o Some components have a correct and an incorrect orientation and some don't matter. Pay attention to the instructions.

o I highly recommend using 63/37 0.031" (or 0.8mm) rosin core solder. Yes, it is 37% lead, but it is not a health risk for you (really), and environmentally insignificant when used by hobbyists. You'll solder like a pro.

Step 7:   1/4W resistors

Resistors can be inserted in either orientation. It is very important to use the correct value for each, however.

- **Solder 1/4W resistors to PCB:**

  o Insert all resistors before soldering. Tape down on front to hold in place OR bend leads slightly on back.

  PV cell version (SSR) – 20 joints:

  - R3   (1k):   _____

  - R4   (1k):   _____

  - R5   (22k):   _____

  - R6   (180Ω):   _____   (180 <u>ohms</u> not k!)

  - R9   (180Ω):   _____

  - R10 (180Ω):   _____

  - R11 (180Ω):   _____

  - RF   (75k):   _____

  - RF1 (680k):   _____

  - RG   (1k):   _____

o Flip board upside down and hold with vise or 3rd hand tool OR tape board to work surface. Solder all 20 leads _____

o Inspect with magnifying glass to make sure all joints are good and there are no solder bridges _____

   NOTE: A solder bridge is ok between the ends of RF and RG

o Trim all leads _____

- **Use multimeter to measure exact resistances of soldered resistors:**

With the PCB still upside down, measure the resistances with a DMM. The resistances (but unfortunately not the names) are marked on the back. Record the exact values of the ones marked with an asterisk (*) below – these values will be used later ("Step 27: Apply resistor calibration"). The others should just be close to their specified value (should be 1%, but don't worry as long as it is < 10%) – the main point is to catch any mistakes you might have made.

PV cell version (SSR):

▪ R3   (1k): _____

▪ R4   (1k): _____

▪ R5   (22k): _____

▪ R6   (180Ω): _____   (180 <u>ohms</u> not k!)

▪ R9   (180Ω): _____

▪ R10 (180Ω): _____

▪ R11 (180Ω): _____

▪ RF   (75k): _____   *

- RF1 (680k): _____   *

- RG   (1k): _____   *

Step 8:   IC sockets

- **Solder IC sockets to PCB – 16 joints:**

  o Insert both sockets before soldering. Tape down on front to hold in place.

  o Make sure notch is on the left end as marked on the PCB

  o Flip board upside down and hold with vise or 3rd hand tool OR tape board to work surface and solder all 16 pins _____

  o Inspect with magnifying glass to make sure all joints are good _____

If you have opted not to use sockets, solder the ICs directly to the PCB instead of the sockets. Make sure dot is on the left end of the TLV2462 (pin 1). Make sure notch and dot are on the left end of the MCP3202 (pin 1).

Step 9:   Horizontal shunt resistor

The shunt resistor lies flat on the PCB and should be soldered down at this point.

- **Solder horizontal shunt resistor to PCB – 2 joints:**

  o Insert 5mΩ shunt resistor (either way). Tape down to hold in place.

    • SHUNT: _____

o Flip board upside down and hold with vise or 3rd hand
  tool OR tape board to work surface and solder both
  leads _____

o Trim both leads _____

o Re-flow/add solder on both leads _____

  (This is because leads are thick, and may not have
  heated well before trimming)

o Inspect with magnifying glass to make sure joints are
  good
  _____

Step 10:   Stacking connectors and female header

- **Solder stacking connectors and female header to
  PCB – 30 joints:**

  o Insert stacking connectors A1, A2, and A3 and female
    header FH. These connectors are symmetrical, so
    there's no "backwards". Tape down to hold in place.

    • A1 (10 pin): _____

    • A2 (8 pin): _____

    • A3 (8 pin): _____

    • FH (4 pin): _____

    NOTE: Stacking connector A4 is not needed.

  o Flip board upside down and hold with vise or 3rd hand
    tool OR tape board to work surface and solder all pins
    _____

    NOTE: the pins on A1, A2, and A3 that are actually used
    on the PCB are circled on the back of the PCB.
    Soldering the others provides physical support only.

o Inspect with magnifying glass to make sure joints are
   good and there are no solder bridges
   _____

Step 11:   DIP switch or jumper header

The cell versions need either a x1 DIP switch or a 2-pin
jumper header. Both have the same purpose – to select
whether current measurements are multiplied by a factor of
approximately 10 (for lower power PV cells). Only one of
these should be installed.

- **Solder x1 DIP switch (or jumper header) to PCB –
  2 joints:**

  o Insert x1 DIP switch with the "ON" end toward the top
     of the board. Tape down to hold in place.

     • OFF=LO_CUR: _____

  -OR-

  o Insert 2-pin jumper header. Tape down to hold in
     place.

     • JP: _____

  o Flip board upside down and hold with vise or 3rd hand
     tool OR tape board to work surface and solder both
     pins   _____

  o Inspect with magnifying glass to make sure joints are
     good and there are no solder bridges
     _____

Step 12:   Screw terminal blocks

- **<u>Solder screw terminal blocks to PCB – 4 joints:</u>**

  o Insert screw terminal blocks with the openings facing left. Tape down to hold in place.

    - J1: _____

    - J2: _____

    NOTE: The screw terminal blocks <u>may</u> be omitted entirely, soldering the 18ga wire directly to the holes in the PCB (later).

  o Flip board upside down and hold with vise or 3rd hand tool OR tape board to work surface and solder all joints
  _____

  o Inspect with magnifying glass to make sure joints are good and there are no solder bridges
  _____

Step 13:   Filter capacitors

The small filter capacitors are not polarized, so it doesn't matter which lead goes in which hole.

- **<u>Solder 0.1uF capacitors to PCB - 4 joints:</u>**

  o Insert both capacitors before soldering. Bend leads on back to hold in place.

    - C3: _____

    - C6: _____

  o Flip board upside down and hold with vise or 3rd hand tool and solder all four joints
  _____

o Inspect with magnifying glass to make sure joints are
  good and there are no solder bridges
  _____

o Trim all 4 leads _____

- **Solder 2.2nF (2200pF) capacitors to PCB - 4
  joints:**

  o Insert both capacitors before soldering. Bend leads on
    back to hold in place.

    • C4: _____

    • C5: _____

  o Flip board upside down and hold with vise or 3rd hand
    tool and solder all four joints
    _____

  o Inspect with magnifying glass to make sure joints are
    good and there are no solder bridges
    _____

  o Trim all 4 leads _____

Step 14:   Bypass diode

The purpose of the bypass diode is to protect the
electronics in case the PV is connected to the IV Swinger 2
backwards.

The cell versions require one 15A, 45V bypass diode
(15SQ045).

- **Solder bypass diode(s) to PCB – 2 or 4 joints:**

  o Bend lead on striped end of diode around the diode so
    that it points in the same direction as the other
    lead.

o Insert leads as follows:

- Pad D1, striped end (top): _____
- Pad D2, non-striped end (bottom): _____

o Flip board upside down and hold with vise or 3rd hand tool and solder both (or all four) leads _____

o Trim leads _____

o Re-flow/add solder on both/all leads _____

   (This is because leads are thick, and may not have heated well before trimming)

o Inspect with magnifying glass to make sure joints are good _____

Step 15:   Solid-state relays

- <u>**Solder SSRs to PCB – 16 joints:**</u>

o Put two SSRs (SSR1 and SSR5) side-by-side in vise with leads pointing straight up. Try to make sure they are aligned so they will look nice. _____

o Lower the PCB over the leads. It is very important that the front of the SSRs is pointed toward the middle of the PCB. The front is the black side with the label. The back has the metal heat sink pad. Hold the PCB with the 3rd hand tool so the leads all extend the same amount as the stacking connector pins and are perpendicular to the PCB.

   The bodies of the SSRs should <u>not</u> be sitting flat on the PCB; there should be some separation (~1cm) for heat dissipation. _____

o Solder all 8 SSR1/SSR5 leads _____

o Trim all 8 SSR1/SSR5 leads _____

o Insert SSR6 in its position with its back against the
   front of SSR5 and tape it to SSR5.

   _____

o Flip board upside down and hold with vise or 3rd hand
   tool _____

o Solder all 4 SSR6 leads _____

o Trim all 4 SSR6 leads _____

o Insert SSR4 in the vise, pins up, with the SSR
   perpendicular to the vise jaws.

o Lower the PCB over the leads. It is very important
   that the front of the SSR is pointed toward the middle
   of the PCB. Hold the PCB with the 3rd hand tool so
   that the pins of SSR4 extend the same as the leads of
   the other SSRs and are perpendicular to the PCB.

   _____

o Solder all 4 SSR4 leads _____

o Trim all 4 SSR4 leads _____

o Re-flow/add solder on all 16 leads _____

o Inspect with magnifying glass to make sure joints are
   good
   _____

Step 16:   Load capacitors

- **Solder load capacitors to PCB:**

  Cell versions use 22000μF, 6.3V load capacitors.

  These are polarized electrolytic capacitors, so
  orientation is important.

- Insert load capacitors in position. **Stripe side (shorter lead) goes to the right – this is the negative lead.** Tape to hold in place.

  - C1   _____

  - C2   _____

- Flip board upside down and hold with vise or 3rd hand tool _____

- Solder all 4 leads   _____

- Trim all 4 leads _____

- Re-flow/add solder on all 4 leads   _____

  (This is because leads are thick, and may not have heated well before trimming)

- Inspect with magnifying glass to make sure joints are good
  _____

Step 17:   Optionally clean flux residue from PCB

Some people think it is important to clean off the flux residue from the PCB after soldering. It makes it looks nicer, but since the PCB sits on top of the Arduino, you don't see the back anyway.

Functionally, it shouldn't matter. The solder manufacturer Kester says this:

"Rosin flux residues are non-conductive and non-corrosive. Under normal circumstances they do not have to be removed from a printed circuit assembly. Rosin residue removal would be for cosmetic considerations. In an environment where the working temperature of the assembly will exceed 200°F the rosin residues will melt and become conductive, in these situations flux removal is required."

If you do want to clean it off, see this Instructable: https://www.instructables.com/id/Cleaning-up-your-PCB/

Step 18:   Check for shorts

Using the digital multimeter (DMM) set on the continuity check (beep), check that there is <u>no continuity</u> between the following:

Power to ground (mandatory):
- o Left IC socket, pin 8 to pin 4
     OR
- o Right IC socket, pin 8 to pin 4

Other (recommended):
- o All "neighbor" pins or solder joints. None should indicate continuity, except the pairs circled in the pictures.
- o The idea is to find solder bridges that you didn't see visually

Step 19:   Insert ICs

Static electricity can destroy ICs. Take off your shoes and touch something metal connected to ground before handling them, if possible.

- **Insert TLV2462 in left socket** _____

    o Make sure dot is on the left end (pin 1)

    o Legs may have to be bent inward slightly

- **Insert MCP3202 in right socket** _____

    o Make sure notch and dot are on the left end (pin 1)

    o Legs may have to be bent inward slightly

Step 20:   Prepare load circuit wires

- <u>**Prepare load circuit wires:**</u>

    o NOTE: This can be any stranded AWG 18 or AWG 16 insulated wire such as from a typical household

extension/lamp cord or heavier speaker wire. **AWG 18 solid core is fine too. If solid core is used, ignore the instructions to twist and "tin" the strands. And instead of the ring connectors, the end can just be bent into a loop (add 1 cm to length).**

- o **"BLK1"**: BLK1 (lower black) binding post to B1 screw terminal on PCB (J1)
  "RED1": RED1 (lower red) binding post to R1 screw terminal on PCB (J1)
  "BLK2": BLK2 (upper black) binding post to B2 screw terminal on PCB (J2)
  "RED2": RED2 (upper red) binding post to R2 screw terminal on PCB (J2)

  - ▪ Cut to length:
    BLK1 (7cm): _____
    RED1 (7cm): _____
    BLK2 (9cm): _____
    RED2 (9cm): _____

  - ▪ Strip 1 cm on each end and twist strands
    BLK1 _____
    RED1 _____
    BLK2 _____
    RED2 _____

  - ▪ Crimp cable ring connector on one end using pliers (or vise / ViseGrips / crimping tool)
    BLK1 _____
    RED1 _____
    BLK2 _____
    RED2 _____

  - ▪ Heat crimp with the soldering iron and flow solder into strands
    BLK1 _____
    RED1 _____
    BLK2 _____
    RED2 _____

  - ▪ Heat the strands of the other twisted end and flow solder into the strands (i.e. "tin" it)
    BLK1 _____
    RED1 _____

```
BLK2 _____
RED2 _____
```

Step 21:   Make load circuit connections

Refer to the drawings of off-PCB connections for this step.
These connections use the load circuit wires that were
prepared in the previous step.

- **<u>Make binding post connections:</u>**

  o Remove outer nuts and washers from threaded posts
    _____

  o Insert threaded post of black side through the cable
    ring connector on load circuit wire:
          "BLK1"

    _____

  o Insert threaded post of red side through the cable
    ring connector on load circuit wire:
          "RED1"

    _____

  o Insert threaded post of black side of <u>second binding
    post</u> through the cable ring connector on load circuit
    wire:
          "BLK2"

    _____

  o Insert threaded post of red side of <u>second binding
    post</u> through the cable ring connector on load circuit
    wire:
          "RED2"

    _____

  o Put washers back on
    _____

o Put nuts on and tighten

    _____

- **<u>Make PCB connections:</u>**

  o Loosen screw and insert the twisted/soldered end of
    the load circuit wire from the black binding post into
    the lower hole of screw terminal J1 and tighten down
    the screw.
        "BLK1"

    _____

  o Loosen screw and insert the twisted/soldered end of
    the load circuit wire from the red binding post into
    the adjacent hole of screw terminal J1 and tighten
    down the screw.
        "RED1"

    _____

  o Loosen screw and insert the twisted/soldered end of
    the load circuit wire from the second black binding
    post into the lower hole of screw terminal J2 and
    tighten down the screw.
        "BLK2

    _____

  o Loosen screw and insert the twisted/soldered end of
    the load circuit wire from the second red binding post
    into the upper hole of screw terminal J2 and tighten
    down the screw.
        "RED2"

    _____

Step 22:   Check all off-PCB connections

- **<u>Check all off-PCB connections:</u>**

o Use the drawing of off-PCB connections for the version
  you are building and double-check that all connections
  match the drawing.

  _____

o Tug all wires connected to screw-terminal blocks
  gently to make sure they are securely connected.

  _____

Step 23: Mate PCB with Arduino

- **Mate PCB with Arduino:**

  o Put tape on metal USB connector housing where PCB will
    touch it

    _____

  o Line up stacking connector pins on bottom of the PCB
    with the corresponding connectors on the top of the
    Arduino and press the boards together, taking care not
    to bend any of the pins.

    _____

  o For now, move the slider on the DIP switch that was
    installed in "Step 11: DIP switch or jumper header" above to
    the ON position. If you opted to install jumper header
    JP instead, slide the jumper over the pins to short
    them together.

    _____

Step 24:   Smoke test

- **Smoke test:**

  o Connect Arduino to laptop via USB

    ▪ Check for smoke ☺   _____

      Check that Arduino yellow LED is blinking once per second (assuming that it's still loaded with "Blink" sketch) _____

Step 25:   Load Arduino sketch

- **Load IV Swinger 2 Arduino sketch:**

  o Open Arduino application on your computer _____

  o Find where the Arduino software looks for sketches:

      Arduino->Preferences->Sketchbook location

  o Use your browser to go to:

      https://raw.githubusercontent.com/csatt/IV_Swinger/master/Arduino/IV_Swinger2/IV_Swinger2.ino

  o Right-click and use "Save As" to save IV_Swinger.ino to the Arduino sketchbook folder found above (make sure your browser doesn't add an extension like .txt to the file name)

  o Go back to the Arduino application and find the IV_swinger2.ino sketch using:

      File->Open

      The Arduino application will inform you that IV_Swinger2.ino must be in a folder named IV_Swinger2 and it will offer to do that for you. Accept its kind

offer.

- o Click on arrow button or select "Upload" from "Sketch" menu

   _____

- o Check Arduino LEDs: Yellow LED should be blinking. This is not the same yellow LED that the Blink sketch controls.

   _____

Step 26: Connect via IV Swinger 2 app

- **Connect via IV Swinger 2 application:**

   o Open the IV Swinger 2 application _____

   o Verify that "Swing!" button text changes to RED and the message below it changes from "Not connected" to "Connected" (briefly, then disappears). The yellow LED should no longer be on.

   _____

   If not, pull down the "USB Port" menu and select the correct port. If it isn't obvious which one to select:

   - Close the IV Swinger 2 application and disconnect the IV Swinger 2 USB cable from the laptop
   - Re-open the IV Swinger 2 application (leave the cable disconnected)
   - Pull down the USB Port menu and take note of the listed ports
   - Connect the USB cable from the IV Swinger 2 hardware to the laptop
   - Pull down the USB Port menu and select the port that is new to the list

Step 27: Apply resistor calibration

- **Apply resistor calibration:**

o   In the IV Swinger 2 app, select "Resistors" from the
    "Calibrate" menu _____

o   Enter the values you measured and recorded in "Step 7:
    1/4W resistors" above.

    ▪   Values are in ohms

    ▪   IMPORTANT: You must enter a value of 0.0 for R1
        (which does not exist on cell versions). Do not
        change the value for R2.

    ▪   Note that there is no RF1 value to enter. This is
        by design. Later (not now!), you will enter the
        value of RF+RF1 for RF if you set the DIP switch to
        the OFF position (or remove the jumper).

        _____

Step 28:   Sanity tests

-   **Sanity tests:**

o   "Nothing connected" test

    ▪   Click the "Swing!" button. You should see an error
        dialog saying "ERROR: Voc is zero volts"
        _____

o   Battery test

    Use 1.5V battery

    ▪   Strip both ends of two wires and screw one end of
        each into the side holes of the binding posts. If
        you happen to have a battery connector or holder
        with wires, use that. Use the RED1 and BLK1 binding
        posts. Leave RED2 and BLK2 unconnected.
        _____

- Connect the wire from the RED1 binding post to the positive terminal of the battery (you can either tape it or hold it with your thumb/finger) _____

- Connect the wire from the BLK1 binding post to the negative terminal of the same battery _____

- Click the "Swing!" button. You should get an IV curve that looks like the photo. _____

- If you get an error dialog that says: "ERROR: Voc is zero volts" check that you don't have the battery backwards and that the wires are making good contact with the terminals.

- If you get an error dialog that says: "ERROR: Timed out polling for stable Isc"

  o Click on Preferences, click on Arduino tab, change value of "Isc stable ADC" to 500, click OK

  o Retry the battery test; it should work

  o Click on Preferences, click on Arduino tab, click on "Restore Defaults", click OK

Step 29:   Prepare for case and final assembly

The acrylic baseball display case used for the IV Swinger 2 enclosure needs to have several holes drilled through it for attachments.

Case side definitions (see photo):

  o Front: side with the USB connector
  o Back: side opposite from front
  o Left: side with binding posts
  o Right: side opposite from left
  o Bottom: side with Arduino
  o Top: side above PCB

The case comes in two U-shaped halves:

- Base: Left / Bottom (with fins) / Right
- Lid: Front / Top / Back

All the attachments are made to the base half. The lid half has nothing attached to it, but does need a 3/8" hole in the front for the USB cable.

Care must be taken when drilling acrylic or else it will crack:

- Use a drill press if you have one
- Use vise (with rubber guards) to hold case
- Position so that the hole being drilled is close to the vise jaw
- Start with 1/16" pilot for all holes
- Drill slowly with light pressure
- Spray water on hole as it is being drilled to cool
- Use a Forstner bit to drill the 3/8" hole for the USB cable. Otherwise, you'll have to start with 1/16" pilot and drill incrementally larger holes until you get to 3/8" (actually 25/64")

Step 30: Mark holes for Arduino standoffs

IMPORTANT: For this step and the next three, look straight down with one eye when making the Sharpie dots (the plastic distorts/refracts if you look at an angle, and you'll miss the mark).

- **Mark holes for Arduino standoffs:**

  o Attach four 15mm standoffs to Arduino:

    - Unplug the USB cable from the Arduino
      _____

    - Carefully remove the PCB from the Arduino
      _____

- Insert threaded/male end of each standoff through
  its hole in the Arduino from the back

  _____

- Screw nuts onto the threaded ends of the standoffs
  on the front of the Arduino – hold the nut with your
  finger and turn the standoff to tighten it. Use
  pliers to tighten more.

  NOTE: The hole nearest the Arduino reset button
  doesn't have room for a nut

  _____

o Place the Arduino in position, standing on its
  standoffs (including the one without a nut). The
  Arduino should be touching the right side of the case,
  with the USB connector facing the front. The single
  fin should be facing toward you so the fins look like
  a "Y". See photo.

  _____

o PUT LID ON THE CASE. This is important because the fit
  is very tight!

  _____

o Turn the case over and look at it from the bottom. The
  Arduino will probably stay in place, but you can make
  sure by squeezing the front and back together with the
  hand you're holding it with. Use a Sharpie to mark the
  centers of the four holes.

  _____

o Remove the lid from the case and remove the Arduino

  _____

Step 31:   Mark holes for binding posts

- **Mark holes for binding posts:**

  o Remove top nuts, washers, cable rings, and bottom nuts
    from the binding posts. Remove the black plastic
    backing plate.

    _____

o Hold the plastic backing plate in position on the inside of the left side of the case. It should be about 1mm from the front inner edge of the case and about 1mm from the bottom.
    _____

o Use Sharpie to mark the centers of the two holes
    _____

o Repeat the above for the upper pair of binding posts, which goes immediately above the first pair, with the top of the backing plate 1mm from the top
    _____

Step 32: Drill marked holes

- **Drill 8 marked holes:**

  o Use something pointy to make an indentation in the middle of each of the Sharpie marks. The tip of the Forstner bit is perfect for this, but you can also use a needle or the tip of an X-acto blade (poke and twirl). This will keep the drill bit centered when you start drilling the hole.
      _____

  o Drill 1/16" pilot holes
      _____

  o Switch to 9/64" bit and re-drill all holes
      _____

- **Enlarge holes for binding posts:**

  o Switch to 11/64" bit and re-drill the binding post holes
      _____

  o Switch to 13/64" bit and re-drill the binding post holes one more time
      _____

- **Clean up case:**

  o Remove burrs around holes with X-acto knife or your
    fingernails
    _____

  o Wash case off and dry
    _____

Step 33:   Install binding posts

- **Install binding posts:**

  o Insert the binding posts through their holes with the
    RED terminals toward the TOP of the case
    _____

  o Slide backing plates over the posts on the inside of
    the case
    _____

  o Thread nuts on the posts and tighten down
    _____

Step 34:   Install Arduino and PCB

- **Install Arduino (without PCB) in case:**

  o Attach the one Arduino standoff that won't have a nut
    onto the bottom of the case with an M3 screw
    _____

  o Insert the Arduino, put the lid on the case, and screw
    down the other three standoffs with M3 screws. TIP:
    start all screws before tightening any of them.
    _____

  o Remove the lid
    _____

- **Mate PCB back onto Arduino:**

  o Load circuit wires should still be screwed to PCB. If
    not, insert them back to into their correct screw
    terminal block openings and tighten them down.
    _____

  o Line up stacking connector pins on bottom of the PCB
    with the corresponding connectors on the top of the
    Arduino and press the boards together, taking care not
    to bend any of the pins.
    _____

Step 35:   Restore binding post connections

- **Restore connections to binding posts:**

  o Restore connections as before, following the off-PCB
    connections drawing. Tighten nuts securely.
    _____

Step 36:   Drill USB connector hole

- **Drill USB connector hole:**

  o Put the lid on the case
    _____

  o Make indentation in the exact center of the USB
    connector using the tip of the Forstner bit (or
    whatever pointy thing you used for the other drill-
    starting indentations). **NOTE: it is very important
    that this hole is precisely centered.** You need to look
    at it from all four directions before making the
    indentation since the refraction through the plastic
    distorts the apparent position (you'll see what I mean
    as soon as you turn it 90 degrees).

_____

- o Use 3/8" Forstner bit to drill the hole

    - Drill slowly, spraying with water often
    - Reduce pressure when hole is getting close to "punching through"
    - Alternative to Forstner bit is to use following succession of normal bits:
        - o 1/16", 1/8", 3/16", 7/32", 1/4", 9/32", 5/16", 11/32", 3/8", 25/64"

        _____

- o Clean up the edge of the hole with X-acto knife or your fingernail

    _____

- o Wash lid off and dry _____

- o Put lid on and insert the USB cable to make sure it fits _____

    - If it doesn't, try loosening the Arduino standoff screws. This might give you enough "play" to get the connector in. Then, with the connector still in, re-tighten the screws
    - If that isn't enough, you may have to enlarge the hole with a round file or some other way

Step 37:   Final test

Your IV Swinger 2 is now complete!

Repeat the tests you did in "Step 28: Sanity tests" to make sure everything got hooked back up correctly.

You may now test it with a real PV cell. Refer to the IV Swinger 2 User Guide for information on how to build and connect a bias battery, which is necessary for typical high power PV cells.

If accuracy is important to you, see the IV Swinger 2 User Guide for instructions on how to perform a calibration. There is also a Help dialog available from the Calibrate menu in the application.