IV Swinger 2

Optional Environmental Sensors

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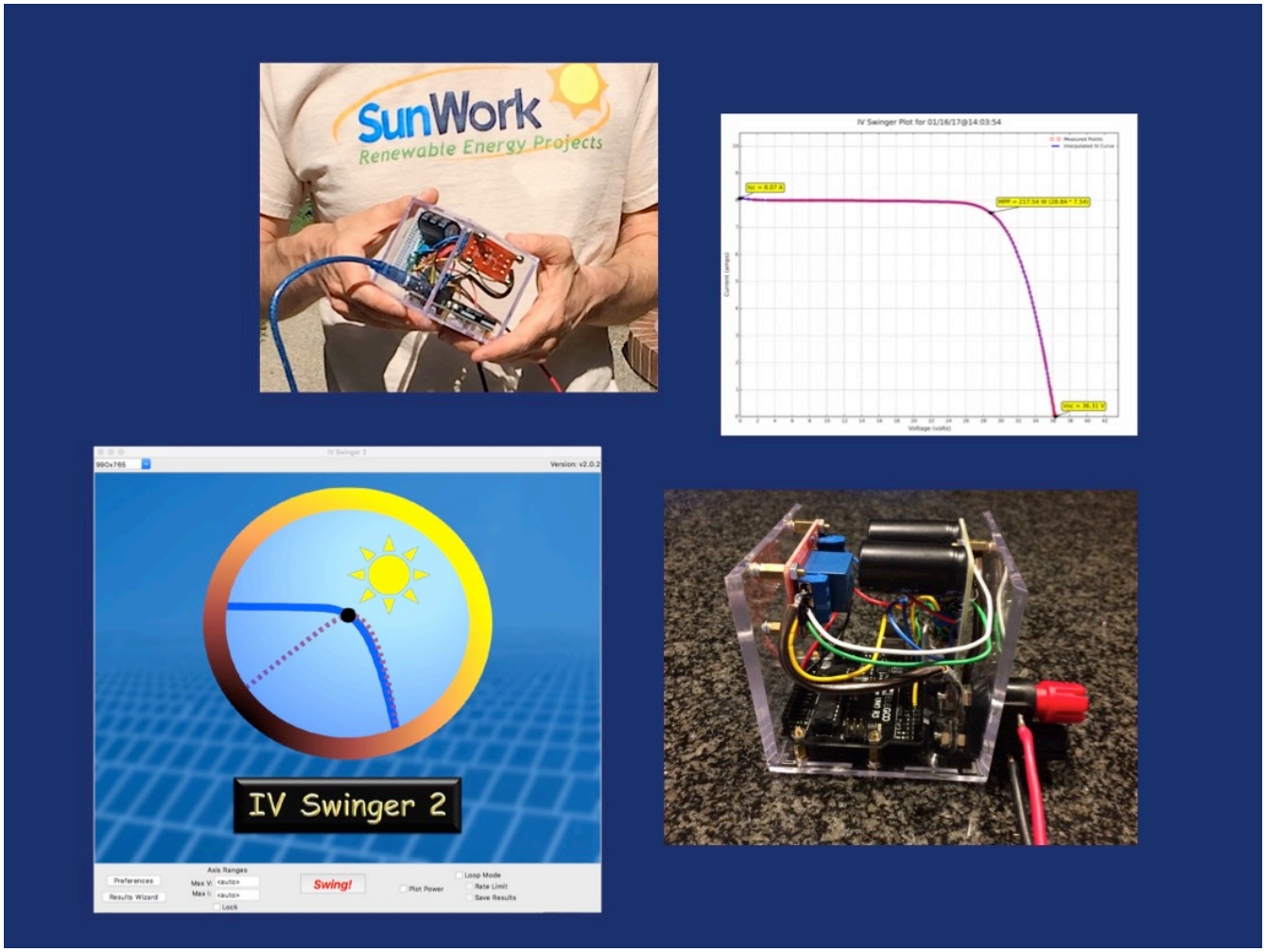

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1 Introduction

This document describes how to build and add optional environmental sensors to the IV Swinger 2 curve tracer.

As of this first writing, the only supported sensors are DS18B20 temperature sensors. However, the hope is eventually also to add support for an inexpensive DIY irradiance sensor (pyranometer).

2 DS18B20 Temperature Sensors

The DS18B20 is an inexpensive temperature sensor that can be purchased for less than $2 on Amazon, eBay, and other places. It comes in a TO-92-3 package that looks just like a discrete transistor as seen in Figure 2-1 below.

Figure 2-1: DS18B20 Sensor

It may also be purchased encapsulated in a waterproof enclosure with a 1-meter, 2-meter or 3-meter cable for not much more money than the device alone. These are abundant on Amazon and eBay. See Figure 2-2 below.

Figure 2-2: DS18B20 Waterproof Probe with Cable

In addition to being inexpensive and readily available, the DS18B20 has the following desirable characteristics:

- Only one Arduino signal pin is needed
- Multiple temperature sensors may be connected to the same one-wire interface
- Arduino library code is available
- Accuracy is more than adequate

2.1 Connections

2.1.1 Connecting One DS18B20 to IV Swinger 2

The connections that must be made in order for one DS18B20 to be detected and its temperature read by the IV Swinger 2 software are shown in Figure 2-3 below.

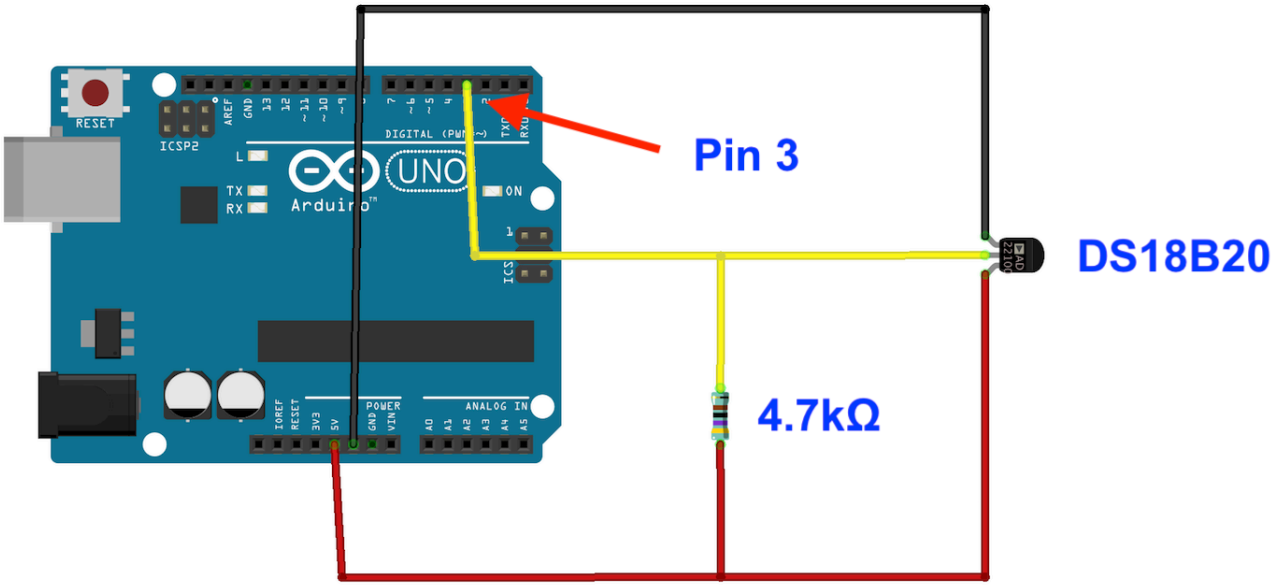


Figure 2-3: Connections for a Single DS18B20

The data (yellow) wire must connect directly to Pin 3 on the Arduino.

The power (red) wire can connect anywhere that is connected to the +5V pin on the Arduino, e.g. it can be soldered to the +5V rail on the PermaProto board. Optionally, it may be connected to the +3.3V pin on the Arduino.

The ground (black) wire can connect anywhere that is connected to the GND pin(s) on the Arduino, e.g. it can be soldered to the ground rail on the PermaProto board. Or it can connect directly to the unused GND pin on the Arduino itself.

The 4.7kΩ resistor must be connected between the data (yellow) wire and the power (red) wire. This resistor may be soldered to the PermaProto board, but that is not necessary. If you are adding the DS18B20 to an already-built IV Swinger 2, it will be easier to just solder this resistor to the two wires themselves – just make sure it is protected from shorting to anything (electrical tape, shrink tubing, etc.).

2.1.2 Connecting Multiple DS18B20s to IV Swinger 2

A nice feature of the DS18B20 is that each one has a unique ROM code, which allows multiple sensors to be connected to the same data wire. The software can identify which sensor is which, and read each

of their temperatures. This could be useful if you want to measure the temperature at multiple places on the module, for example.

Figure 2-4 below shows the addition of a second DS18B20.

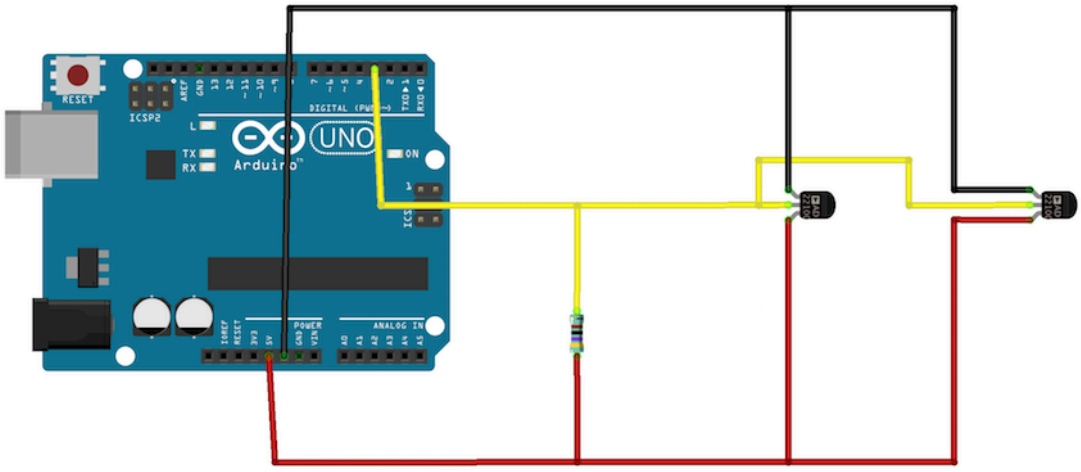


Figure 2-4: Connecting Additional DS18B20s

Note that there is only one 4.7kΩ resistor regardless of how many DS18B20s there are.

2.2 Software Installation

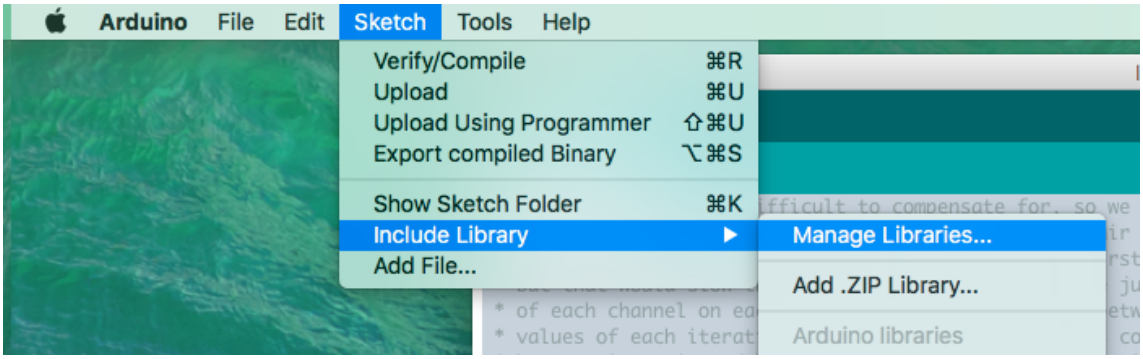
The latest releases of the IV Swinger 2 Arduino sketch and laptop application have support for the DS18B20. However, the Arduino sketch makes use of the OneWire and DallasTemperature libraries, which must be installed. Also, the IV_Swinger2.ino file must be edited to uncomment one line.

2.2.1 Installing Arduino Libraries

Two Arduino libraries must be installed:

- OneWire
- DallasTemperature

To do this from the Arduino IDE, use Sketch->Include Library->Manage Libraries…



Search for “OneWire”. Click on the one with the name “OneWire” and then click on the Install button.

Search for “DallasTemperature”. Click on the one with the name “DallasTemperature” and then click on the Install button.

2.2.2 Modifying IV_Swinger2.ino

Since temperature sensing is an optional feature, it was decided not to burden all users with having to install the OneWire and DallasTemperature libraries. The tradeoff is that users who do want to use this feature need to modify one line in the IV Swinger2 Arduino sketch.

You must manually change (“uncomment”) this line in IV_Swinger2.ino:

```
//#define DS18B20_SUPPORTED
```

to:

```
#define DS18B20_SUPPORTED
```

You may make this change using any text editor before starting up the Arduino IDE, or you may use the editor built into the Arduino IDE. If you have installed the OneWire and DallasTemperature libraries, the sketch should upload without errors.

Note that running code with this line uncommented will work fine even if there are no DS18B20s connected.

2.3 Swinging IV Curves with Temperature Sensors

When you have one or more DS18B20s connected as described in Section 2.1 above and you have uploaded IV_Swinger2.ino with `#define DS18B20_SUPPORTED` uncommented, you don’t need to do anything else to get temperature readings.

2.3.1 Temperature Scale

Temperatures are reported in degrees Celsius. There is no option to report in degrees Fahrenheit.

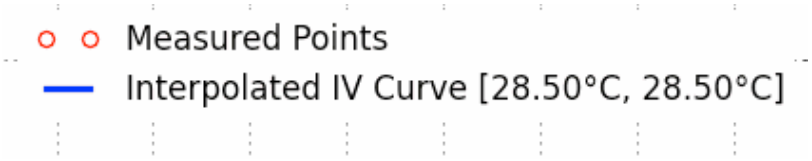
2.3.2 Precision

Temperatures are reported in **increments of 0.25˚C**. The DS18B20 supports programmable precisions from 9 to 12 bits, and this is 10-bit precision. 12-bit precision readings take 3/4 second for each device, which is too slow. 10-bit readings take less than 1/4 second. This is currently hardcoded in the Arduino sketch, and there are no plans to make it configurable.

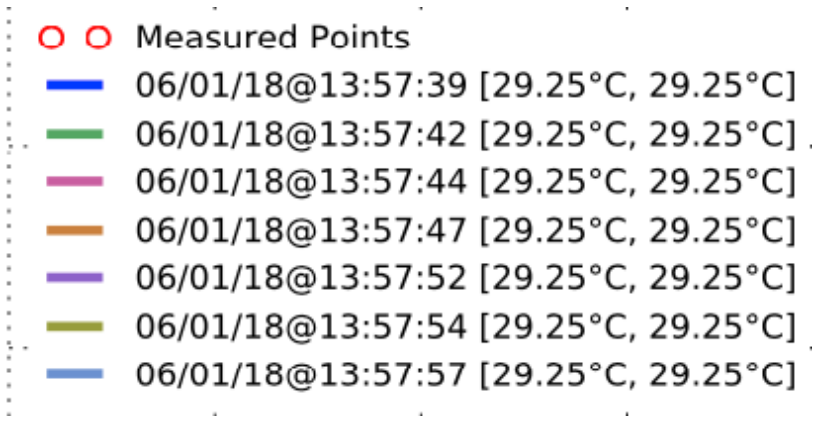
2.3.3 Where Are the Temperatures recorded?

The laptop application records the temperature(s) in a “sensor info” file (which will also contain values from other environmental sensors if they exist). There is a sensor info file saved for each run and it is saved in the same directory/folder as the CSV, PDF and other files for the run.

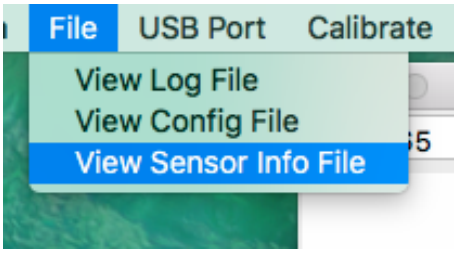
The temperature or temperatures are also included on the graph itself, in the legend. Here is an example with two temperature sensors:



Each curve on an overlay will have the temperature(s) for that run:



If you have only one sensor, that is all the information you need. But if you have more than one, you need to know which temperature is from which sensor. The File menu in the laptop application has an entry, “View Sensor Info File”:



The contents of the sensor info file might look like:

```
ROM code of DS18B20 temp sensor #1 is 0xEF000007F9CE1628
ROM code of DS18B20 temp sensor #2 is 0xBF000007F8D09328
Temperature at sensor #1 is 29.25 degrees Celsius
Temperature at sensor #2 is 29.25 degrees Celsius
```

The ROM codes uniquely identify each sensor, but that is unlikely to be of much help. Probably the best way to identify which sensor is which is to use freeze spray, an ice cube, cold drink, or something like that to artificially cool one sensor at a time to see which one it is. Fortunately, the sensors will always be in the same order, so you only have to go through this identification process once.

The temperatures recorded in the legend entries on the graph are listed in order [#1, #2, …]