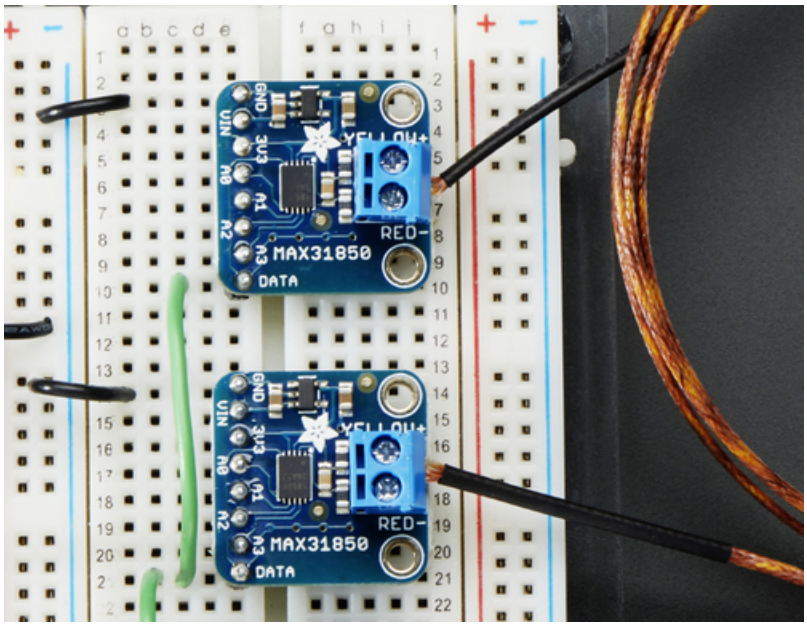
adafruit learning system

Adafruit 1-Wire Thermocouple Amplifier - MAX31850K

Created by lady ada



Last updated on 2018-08-22 03:40:09 PM UTC

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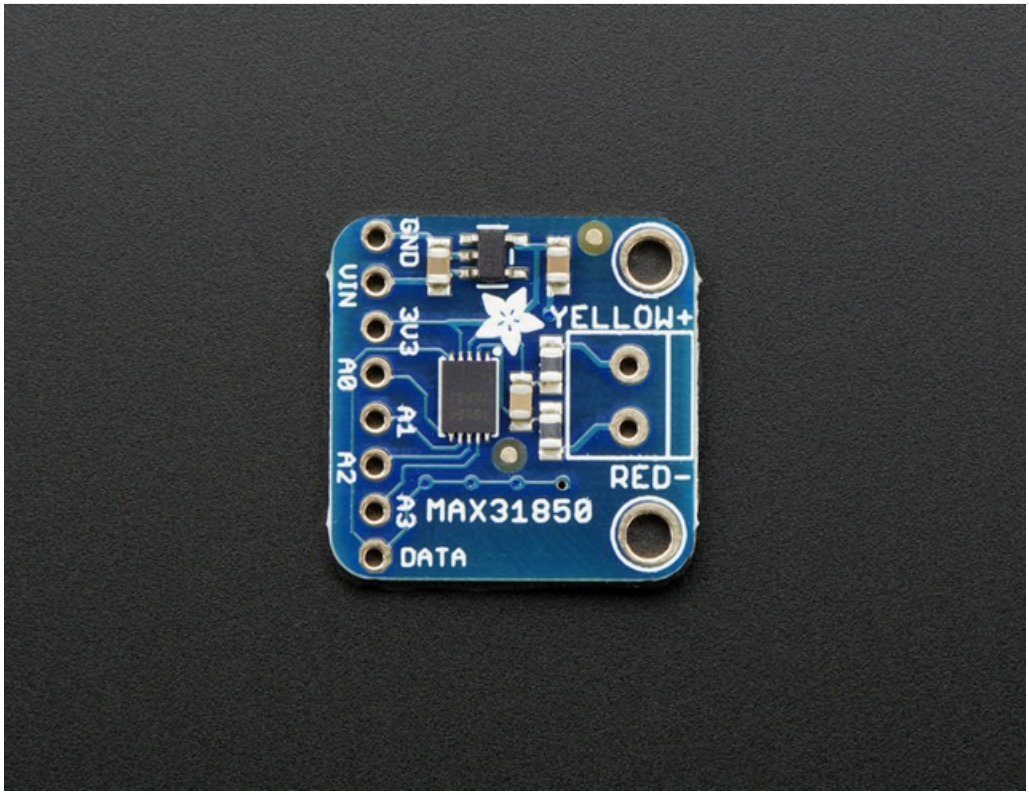
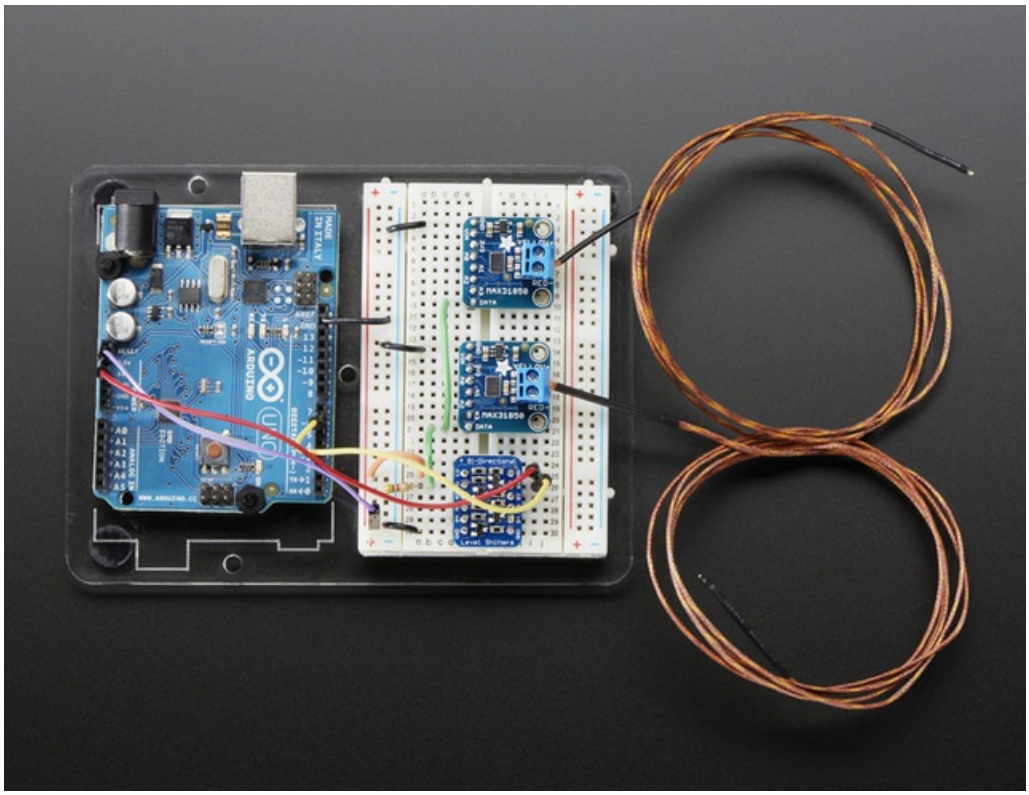
Overview

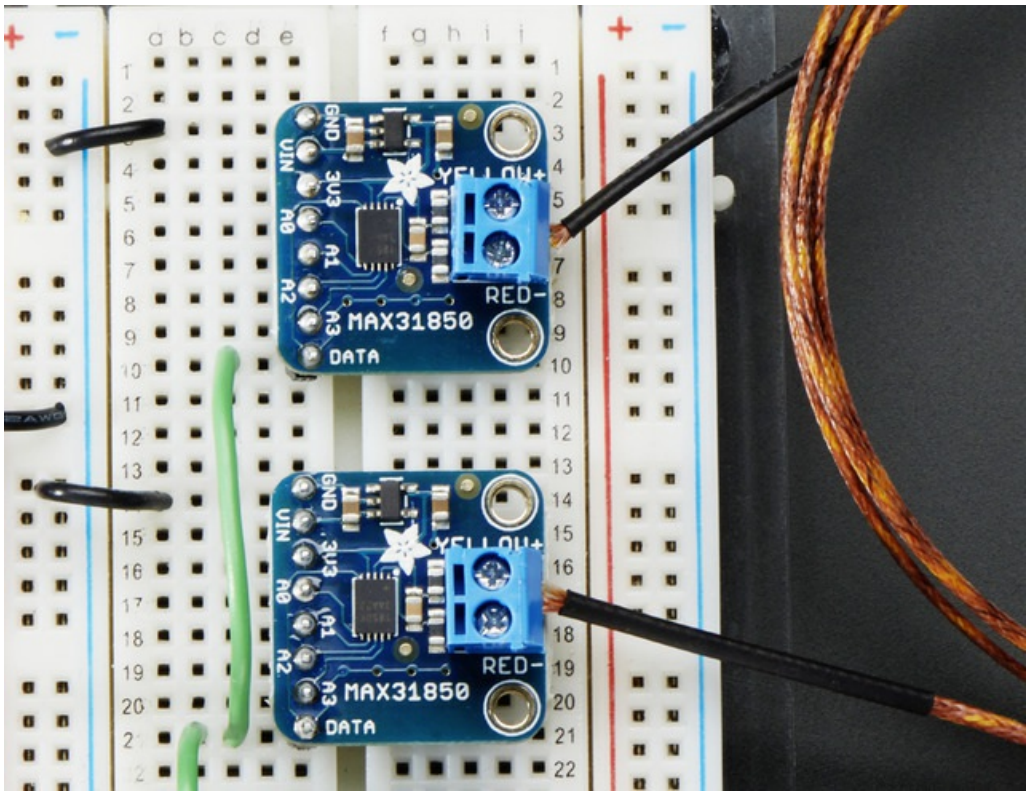


Thermocouples are very sensitive, requiring a good amplifier with a cold-compensation reference. So far we've carried the very nice MAX31855 which is an SPI interface thermocouple amplifier. The '855 is great but if you have a lot of thermocouples to measure it isn't terribly easy to use. That's why we are also carrying the new '850 model from Maxim - it's a "1-Wire" thermocouple amp which can have any number of breakouts on a single shared I/O line.

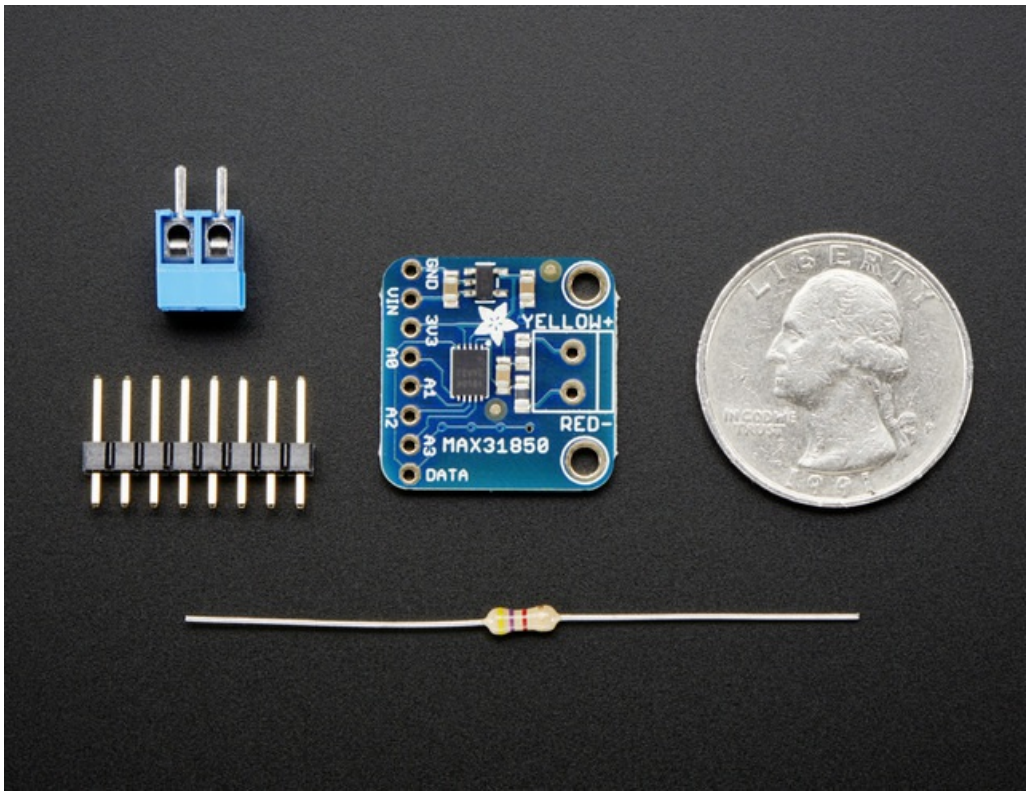


The MAX31850K does everything for you, and can be easily interfaced with any microcontroller that has 1-Wire support. This breakout board has the chip itself, a 3.3V regulator with 10uF bypass capacitors all assembled and tested. This board can be used with 'parasitic power' - where the power is on the data line - or with 'local power' where the power for the converter comes in on the Vin Pin.

Please note: this board does not have level shifting on the 3V Data line - we did this on purpose so that it can be used in parasitic mode. The data line must be level shifted to 3V - our 4-channel shifter works wonderfully for level shifting 1-Wire (http://adafru.it/757) and you only need one at the '1-Wire host' for all thermocouples on the shared data line.



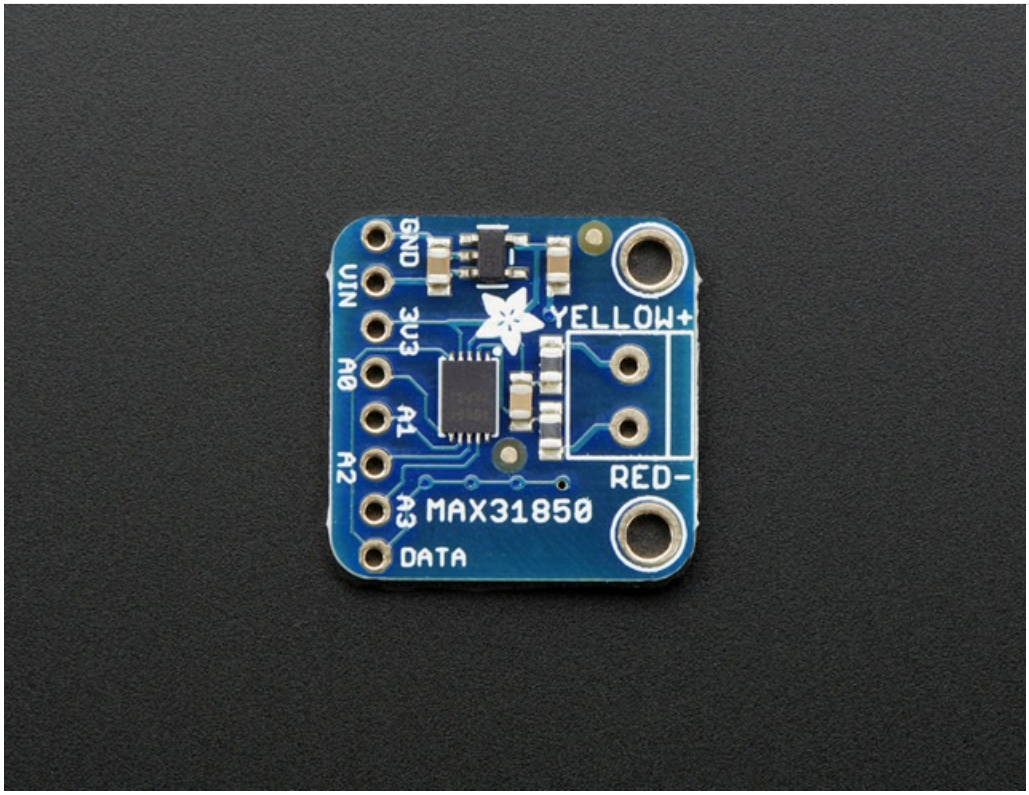
The MAX31850K data format is very similar to that of the well known 1-Wire DS18B20 temp sensor but it is *not drop in compatible* without code changes to check for the new '1 Wire family' type. We have adapted the classic Arduino OneWire (https://adafru.it/dal) and DallasTemp (https://adafru.it/dam) libraries to be MAX31850 compatible, so please click on those links to grab our libraries.



Comes with a 2 pin terminal block (for connecting to the thermocouple), 4.7K data line pullup resistor, and pin header (to plug into any breadboard or perfboard). Goes great with our 1m K-type thermocouple (http://adafru.it/270). Not for use with any other kind of thermocouple, K type only!

- Works with any K type thermocouple
- Will not work with any other kind of thermocouple other than K type
- **-270°C to +1370°C output in 0.25 degree increments**
- Internal temperature reading
- 3.3 to 5v power supply. Data line is 3V only
- 1-Wire interface allows any number of thermocouple amps on a single data line

Pinouts



The MAX31850K breakout is not too complicated, we'll go thru all the pins so you can be familiar with them! There's two breakout sides, the left side has the power and data lines. On the right side, theres a terminal block breakout for connecting up a thermocouple wireset.

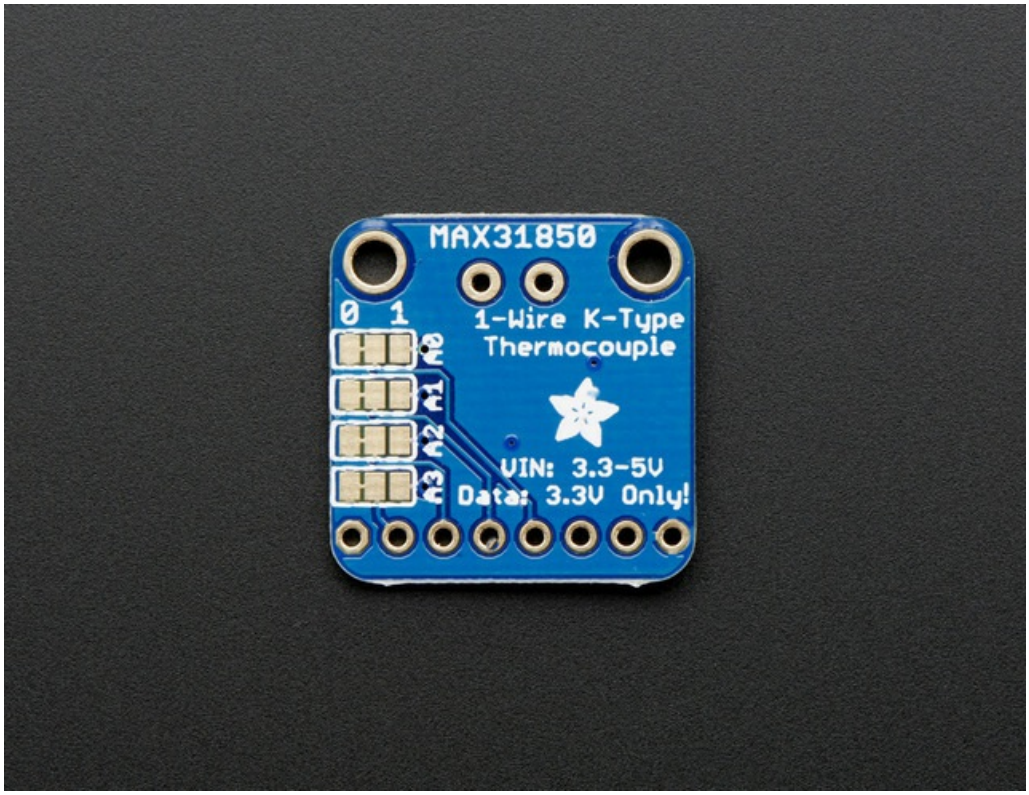
Power Pins

There are three power pins: **VIN GND 3V3**

- **GND** is the common ground line. You will need to connect this to both your power ground and microcontroller 'data reference' ground. If you are using '1-Wire' parasitic power you still need to connect this to your microcontroller
- **VIN** is 3-5V power in if you are *not* using parasitic power. If you want to power the sensor, connect up 3-5V DC power here, the MAX31850 will automagically switch to external power instead of parasitic power
- **3V3** This is the 3.3V output from the onboard regulator - you can get up to 100mA from it. It is only used if you are externally powering. In parasitic mode, it is unused and there will be no voltage available

Address Pins

The **A0 A1 A2 A3** pins are address pins. **Please note** these do not affect the 1-Wire 'fixed address'! These pins set bits that can be read from the 'configuration' register. These are used in case you have up to 16 different boards and you want to identify which is which without having to look up which has what address since the 1Wire address is burned into ROM. They are by default shorted to ground. You can tie them to 3.3V by cutting the back traces between the 3-way jumpers and then soldering the jumper the 'other' way or tying the pins to 3V or GND.



Data Pin

Ah finally the data pin. This is a '1-Wire' device so all data is **transmitted** and **received** on a single pin which is pretty cool. It is also possible for the microcontroller to **provide power** to the sensor on this line - triple duty! This pin is 3V logic level, and must be connected to a 3V output pin. Arduino's are not 3V, they're 5V so a level shifter is required, see the next pages for details.

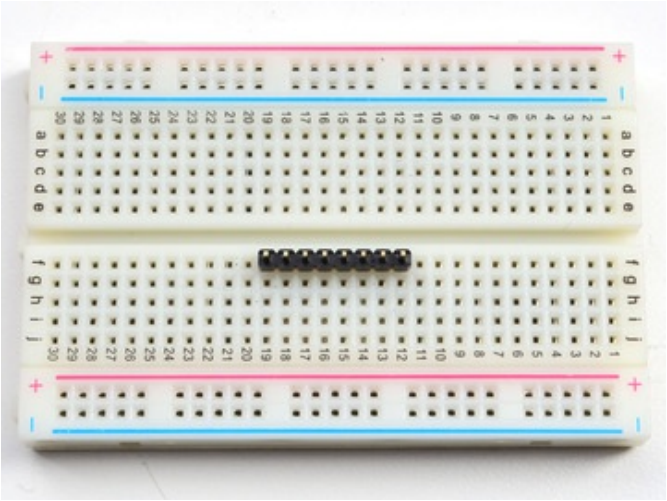
A 4.7K resistor must be connected between this pin and 3V3 power. For parasitic power, the resistor lives over on the microcontroller side of the data line. For external-power it can be on either side of the data line.

Themocouple Breakout

The other side of the board has a breakout for a 3.5mm terminal block, included in the mini kit. Use the screw terminal to connect to the thermocouple as thermocouple wires *cannot* be soldered to!

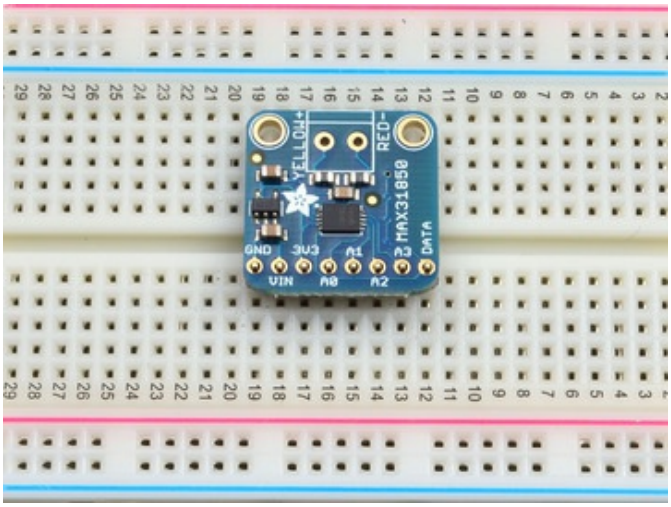
Remember, this kit is for K-type thermocouples only!

Assembly



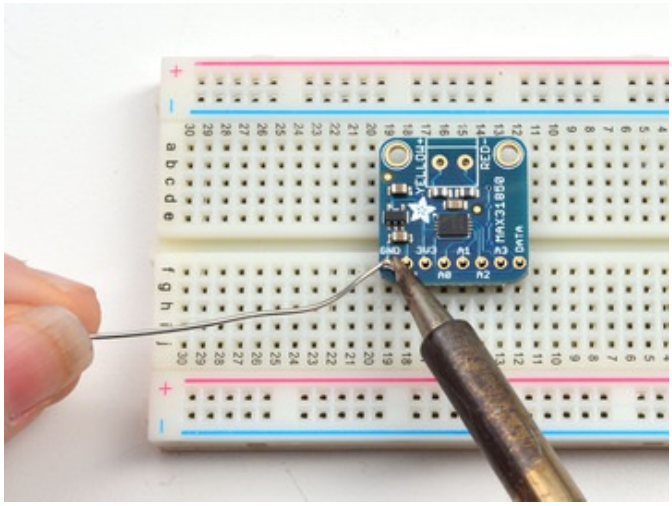
Prepare the header strip:

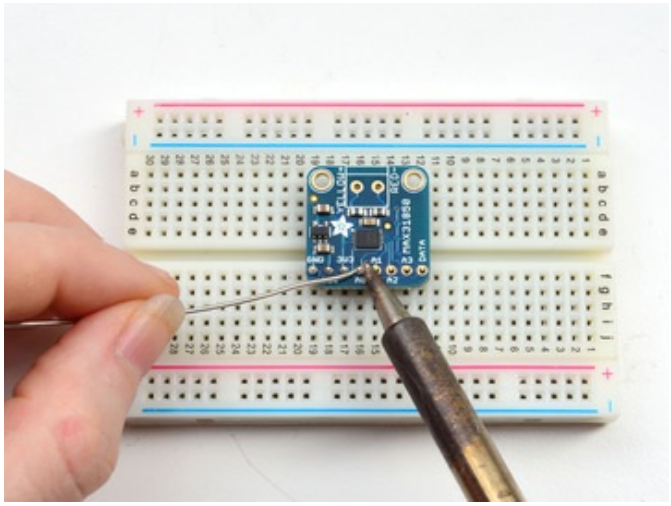
Cut the strip to length if necessary. It will be easier to solder if you insert it into a breadboard - **long pins down.**

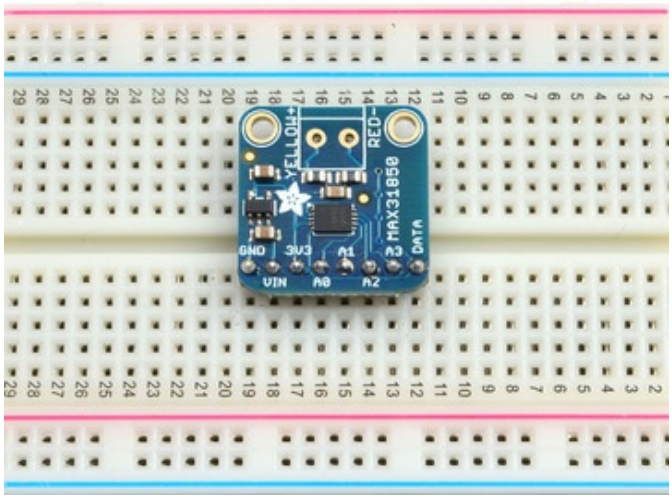


Add the breakout board:

Place the breakout board over the pins so that the short pins poke through the breakout pads



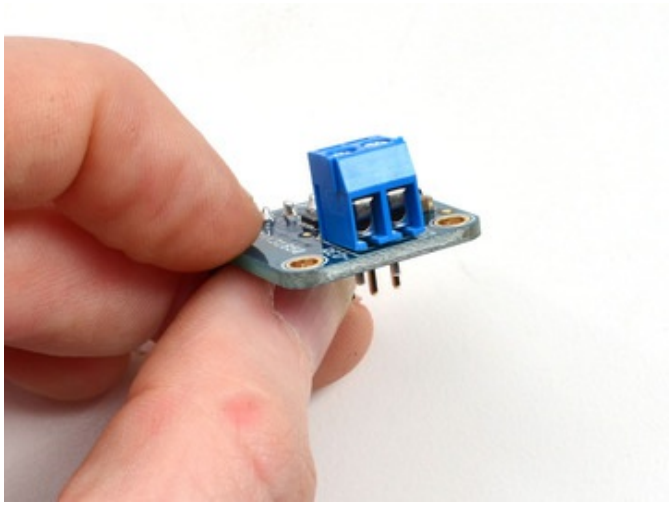




And Solder!

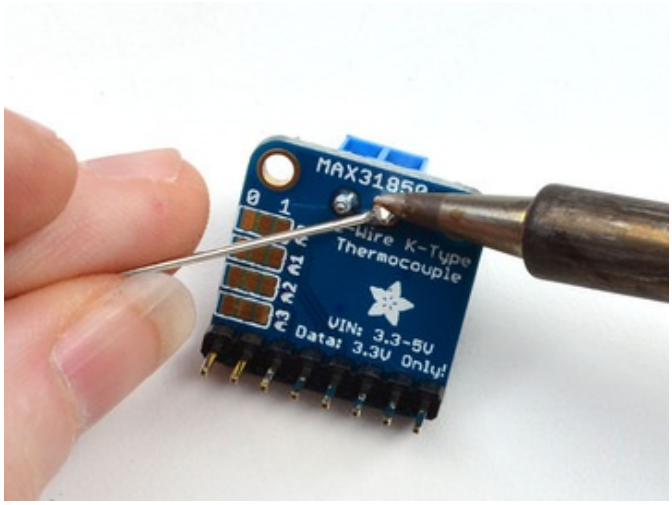
Be sure to solder all 5 pins for reliable electrical contact.

(For tips on soldering, be sure to check out our Guide to Excellent Soldering (https://adafru.it/aTk).

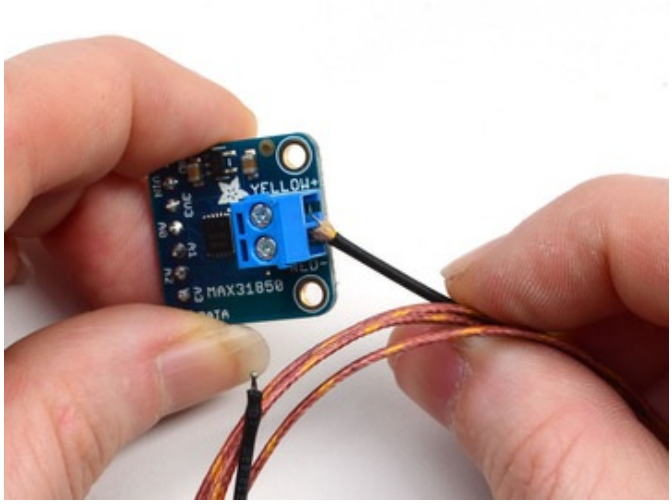


Now you can do the terminal block, this is what you'll use to attach the thermocouple since you cannot solder to thermocouples

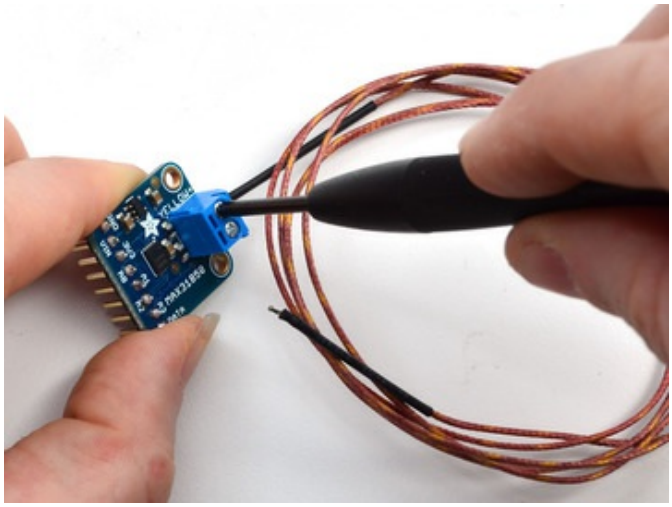
The terminal block goes on the top with the open ends pointing out

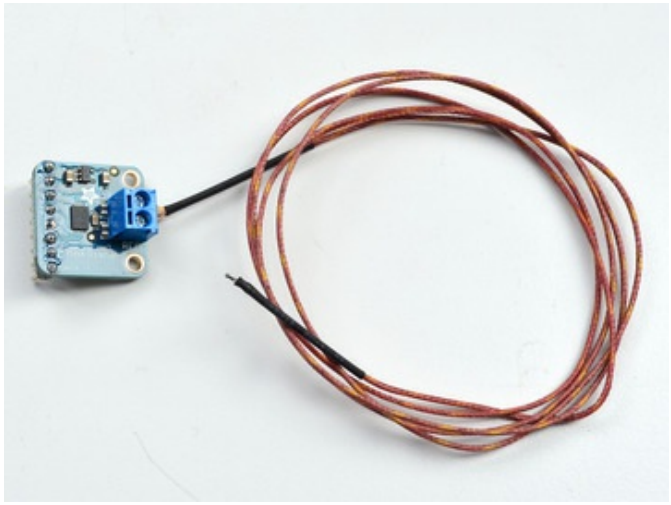


Solder the two pads as you did with the plain header. They're quite large and require a lot of solder



Insert the thermocouple wires and tighten down the clamps with a small Phillips or flat screwdriver





That's it! you are now ready to wire and test

Wiring and Test

In this step we'll wire up the assembled breakout board to an Arduino. Any 1-Wire capable microcontroller can be used but we have example code for Arduino only.

You can wire up 1-Wire devices in two modes **parasitic powered** and **externally powered**

- **Parasitic power** lets you have all data and power on a single data line + ground wire. Its more minimal but we believe it is a little more sensitive to power fluctuations
- **Externally powered** has data on the single data line + ground wire, and then a separate power supply. It requires more wires but we think it is more stable in readings.

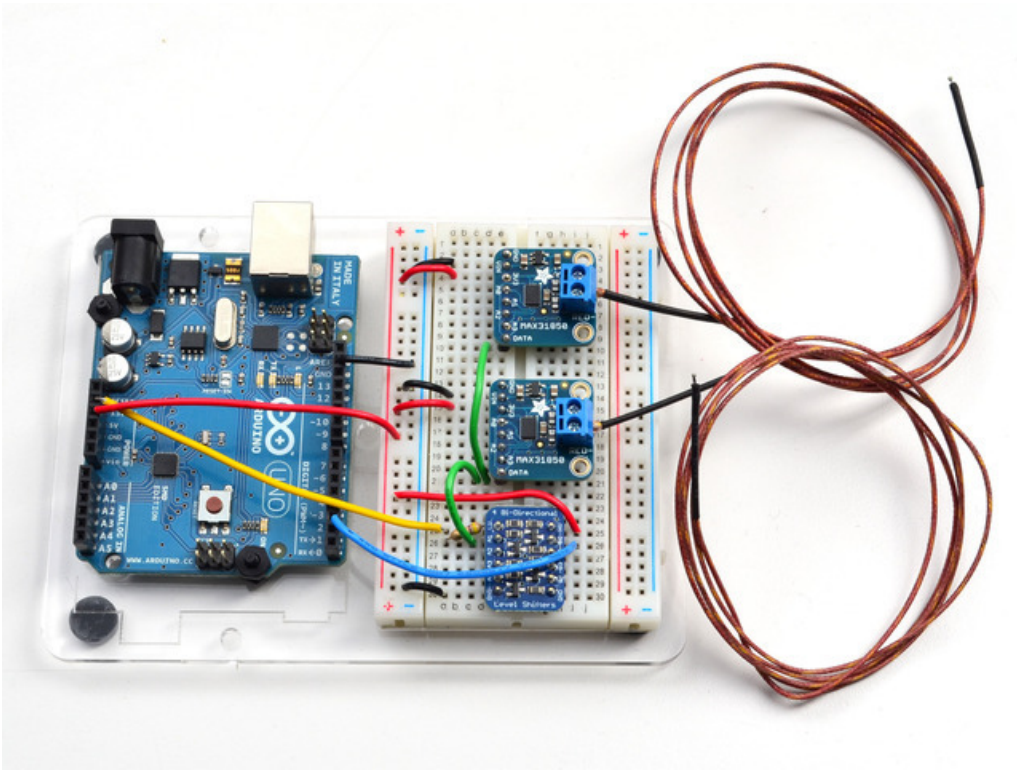
BOTH require level shifting on the data line if you are connecting up to a 5V microcontroller like an Arduino. If you are using a 3V logic microcontroller, you can skip the 4-channel level shifter we have in these images

We show 2 sensor boards in these photos, but you can connect as many as you like, 1-Wire supports any number of shared devices on a single data line.

External power

In this wiring style, each board is powered externally. Connect:

1. **GND** to the Arduino Ground pin (black wires)
2. **Vin** to the Arduino 5V pin (can also connect to an external battery of 3-5VDC) (red wires)
3. **Data** shared connection to **A1** on the level converter (green wire)
4. A single 4.7K resistor connects from the shared data line to 3V
5. **B1** of the level converter connects to Arduino **#2** (blue wire)
6. Level shifter **HV** connects to Arduino **5V** (red wire)
7. Level shifter **LV** connects to Arduino **3V** (yellow wire)



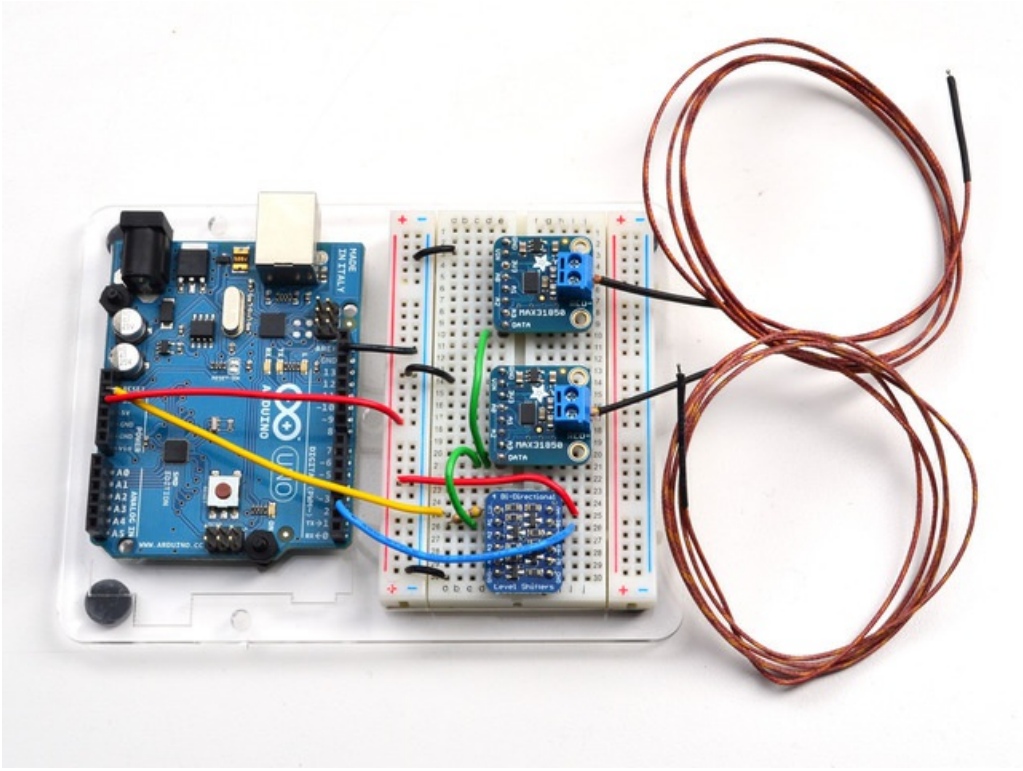
Click to see a bigger wiring photo

Parasitic Power

Alternatively you can use parasitic power to connect up MAX31850's - to do that basically follow the above except do not connect the **VIN** wires on the breakout boards

1. **GND** to the Arduino Ground pin (black wires)
2. **Vin** does not get connected
3. **Data** shared connection to **A1** on the level converter (green wire)
4. A single 4.7K resistor connects from the shared data line to 3V
5. **B1** of the level converter connects to Arduino **#2** (blue wire)
6. Level shifter **HV** connects to Arduino **5V** (red wire)
7. Level shifter **LV** connects to Arduino **3V** (yellow wire)

If you have the sensor far from the Arduino, you can extend the Data and GND lines going to each sensor by up to 10 meters!



Click to see a bigger wiring photo

Download Arduino libraries

For 1-Wire devices, we'll be using the **OneWire** library and a modified version of the **DallasTemp** library (Dallas was the name of the original company making 1-Wire devices, Maxim bought them later)

The original version of the **DallasTemp** library doesn't have support for the MAX31850, so we had to modify it! If you're having difficulty sensing the breakout sensors make sure you have completely removed any old copies of the libraries from your *libraries* and replaced them with ours

Start by downloading both OneWire (https://adafru.it/scg) and DallasTemp (https://adafru.it/dam) libraries from the GitHub repositories, or better yet, just click these buttons here:

https://adafru.it/sch

https://adafru.it/sch

Rename the uncompressed folder **OneWire**. Check that the **OneWire** folder contains **OneWire.cpp** and **OneWire.h** and an **examples** folder

Place the **OneWire** library folder your ***sketchbookfolder*/libraries/** folder. You may need to create the libraries subfolder if its your first library. Restart the IDE. You can figure out your ***sketchbookfolder*** by opening up the Preferences tab in the Arduino IDE.

If you're not familiar with installing Arduino libraries, please visit our tutorial: All About Arduino Libraries (https://adafru.it/aYM)!

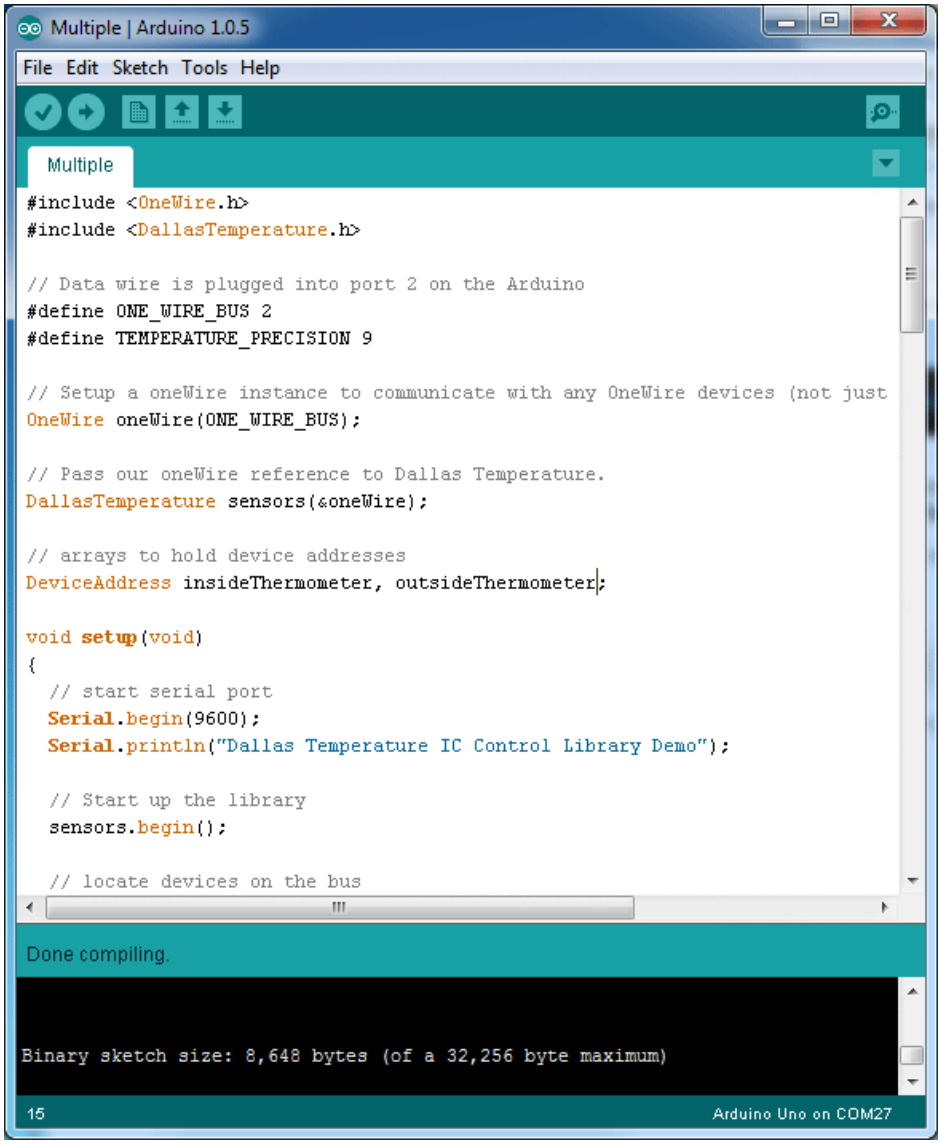
https://adafru.it/daq

https://adafru.it/daq

Rename the uncompressed folder **DallasTemp**. Check that the **DallasTemp** folder contains **DallasTemperature.cpp** and **DallasTemperature.h** and an **examples** folder (you can ignore other files in the archive).

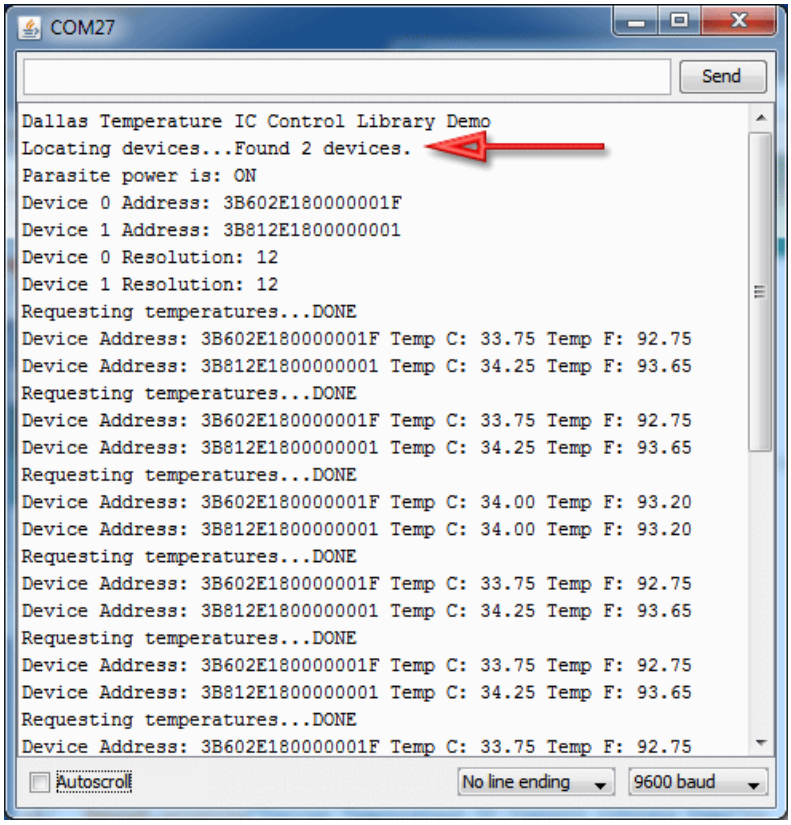
Place the **DallasTemp** library folder in your ***sketchbookfolder*/libraries/** folder like you did with **OneWire** - and restart the IDE

Now you are ready to run the **DallasTemp multiple** example from the **File->Examples->DallasTemp->multiple** menu. Upload this sketch to your Arduino

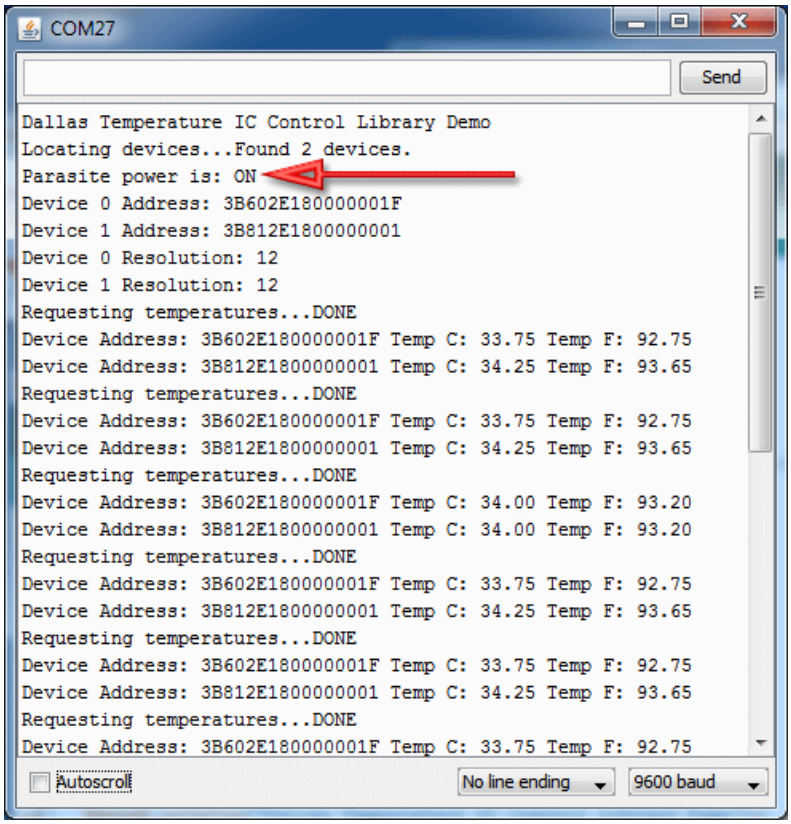


OK now open up the serial console

First up, you should see how many sensors were detected. In our case its 2

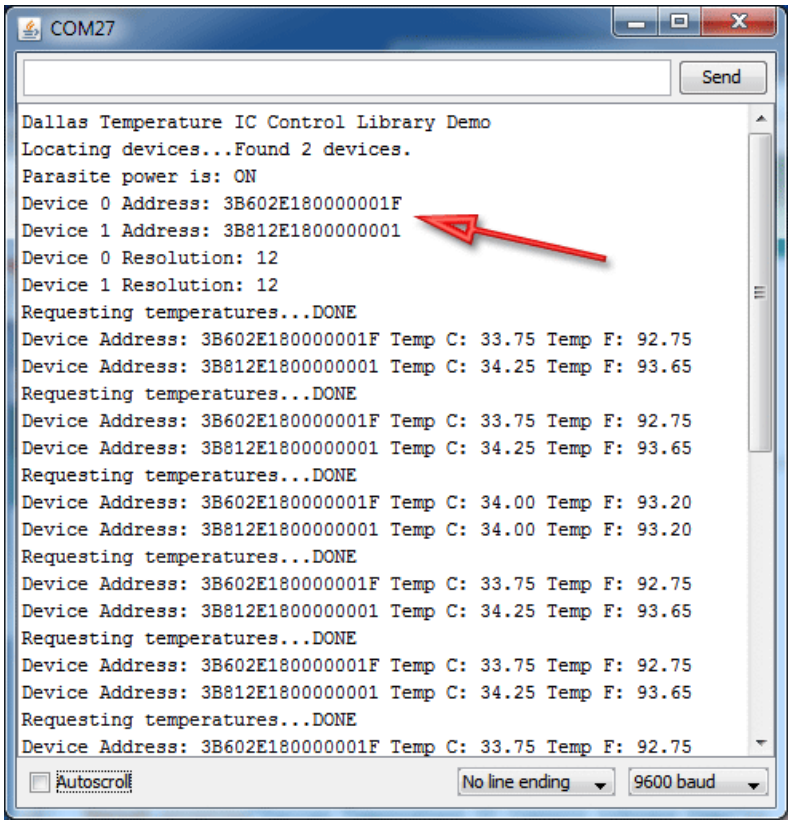


Also whether parasite power is being used or not, its on the third line



You'll also see the device addresses, these are the unique 64-bit addresses for each sensor. You have a promise from

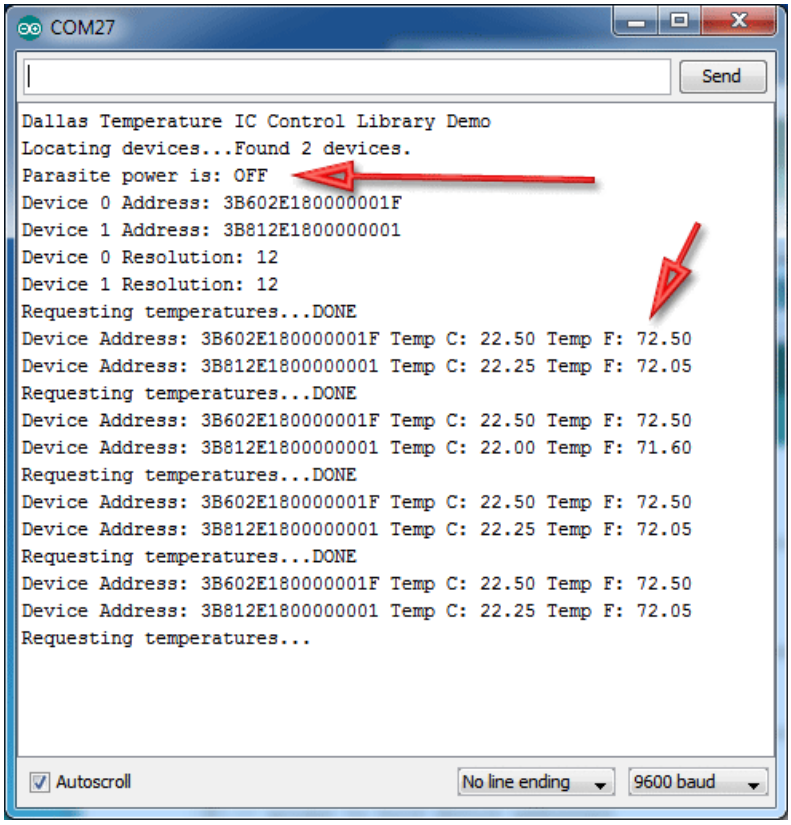
Maxim that they will never recycle these numbers! All **MAX31850** sensors start with **3B** which is the family address. You can see the temperature printed out afterwards



Note that this address is **not connected to the ADDR pins on the breakout!** those are *different* address pins. You cannot change the 64-bit address, its permanently burned into the chip!

External vs Parasite power

Here is the same setup under external power. The temperature is much closer to the true temp (room temp, about 72 degrees F) because the power supply is more stable. If you are using parasite power you may need to calculate the temperature offset (calibrating the sensor) to get the true sensor at the location.



Writing your own sketch

OneWire and DallasTemp are very powerful but for most people, they just want to get temperatures printed out in their project!
Here is some super-basic code based on the **Simple** example to handle any number of sensors, simply printing out the temperature and the last two bytes of the unique ID number. You can see we figure out how many sensors are attached with

> **sensors.getDeviceCount()**

which will let us know the # of connected sensors, and then can get the temperature from each one starting from index #0 up with

> **sensors.getTempCByIndex(*index #)***

The index #'s will always be sorted by address number so every time you start, the index #0 sensor will be the same as last time you started up. If you swap the sensors with another breakout, the index # may change so that's when you would have to check the code to figure out whether the index #'s are different

```
#include <OneWire.h>
#include <DallasTemperature.h>

// Data wire is plugged into port 2 on the Arduino
#define ONE_WIRE_BUS 2

// Setup a oneWire instance to communicate with any OneWire devices (not just Maxim/Dallas temperature IC
OneWire oneWire(ONE_WIRE_BUS);

// Pass our oneWire reference to Dallas Temperature.
DallasTemperature sensors(&oneWire);
DeviceAddress addr;

void setup(void)
{
  // start serial port
  Serial.begin(9600);
  Serial.println("Dallas Temperature IC Control Library Demo");

  // Start up the library
  sensors.begin();
}

void loop(void)
{
  // call sensors.requestTemperatures() to issue a global temperature
  // request to all devices on the bus
  Serial.print("Requesting temperatures...");
  sensors.requestTemperatures(); // Send the command to get temperatures
  Serial.println("DONE");

  for (uint8_t s=0; s < sensors.getDeviceCount(); s++) {
    // get the unique address
    sensors.getAddress(addr, s);
    // just look at bottom two bytes, which is pretty likely to be unique
    int smalladdr = (addr[6] << 8) | addr[7];

    Serial.print("Temperature for the device #"); Serial.print(s);
    Serial.print(" with ID #"); Serial.print(smalladdr);
    Serial.print(" is: ");
    Serial.println(sensors.getTempCByIndex(s));
  }
}
```

The Address pinouts

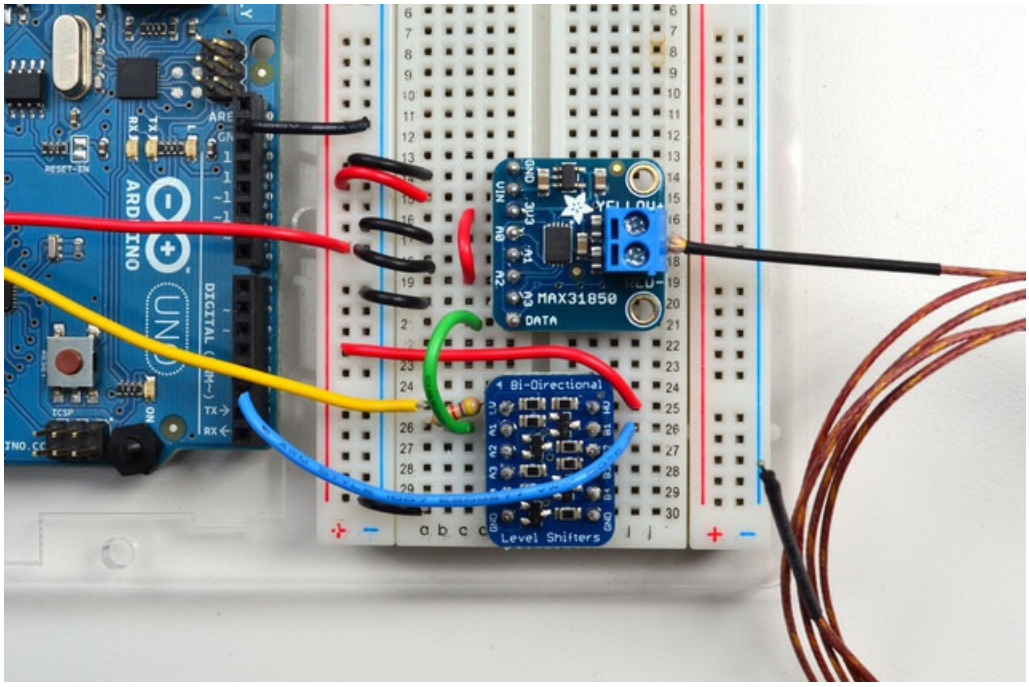
So if you're wondering how you can read those address pins, you can do so but the DallasTemp library doesn't support it, instead, you'll have to go with the lower-level **OneWire** library.

Open up the **OneWire->MAX31850_Temperature** example and load it into your Arduino.

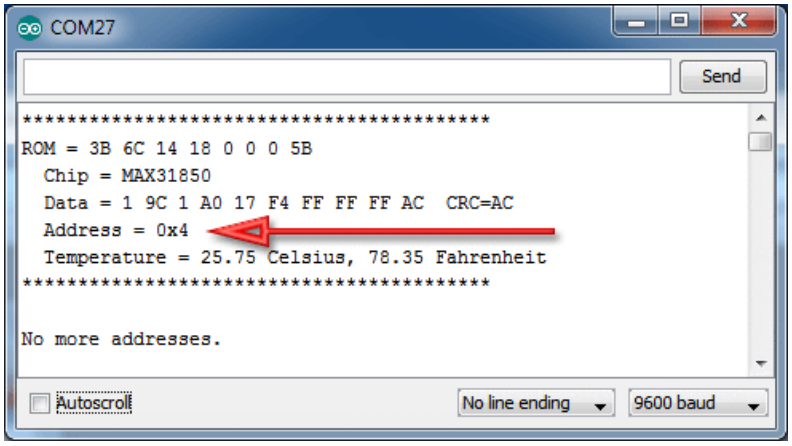
> Please Note - this example uses pin 10 instead of pin 2, for consistancy with the other OneWire examples. Either change OneWire ds(10); to OneWire ds(2); or switch your wiring

On the back of your MAX31850 breakout, cut the pads between the jumpers

. You can solder the jumpers on the back but we'll be showing wiring with colored wires. In this case, we connect **A2** to 3V and the rest to ground, That will make a binary address of **0100** = 0x4



Now if you open up the serial console you should see the OneWire example code print out the data, address and temperature of the sensor. If you mess with the **Ax** wires you'll see this address value change from 0x00 to 0x0F. This can be a good way to deal with 'hot-swapping' in sensors with unique ROM addresses



More about OneWire and DallasTemp

Arduino Playground has some good resources on OneWire at http://playground.arduino.cc/Learning/OneWire (https://adafru.it/dar) and PJRC has documented it as well over at http://www.pjrc.com/teensy/td_libs_OneWire.html (https://adafru.it/das)

Downloads

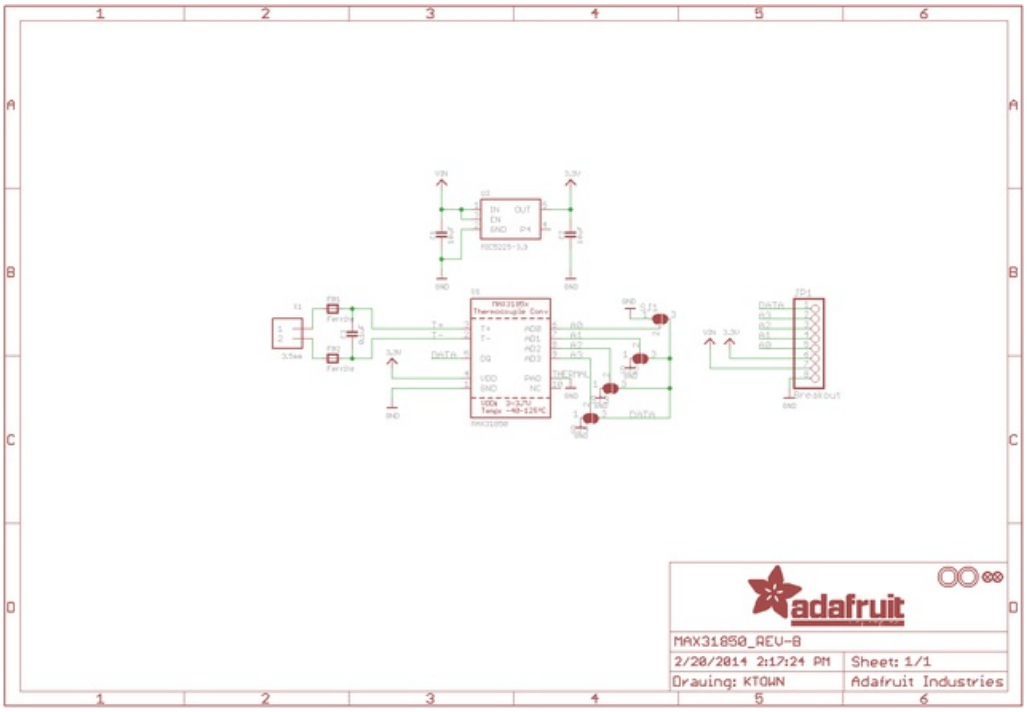
More Reading!

- Maxim has some great notes on running 1-Wire devices over long distances http://www.maximintegrated.com/app-notes/index.mvp/id/148 (https://adafru.it/dat)
- Arduino Playground has some good resources on OneWire at http://playground.arduino.cc/Learning/OneWire (https://adafru.it/dar) and PJRC has documented it as well over at http://www.pjrc.com/teensy/td_libs_OneWire.html (https://adafru.it/das)

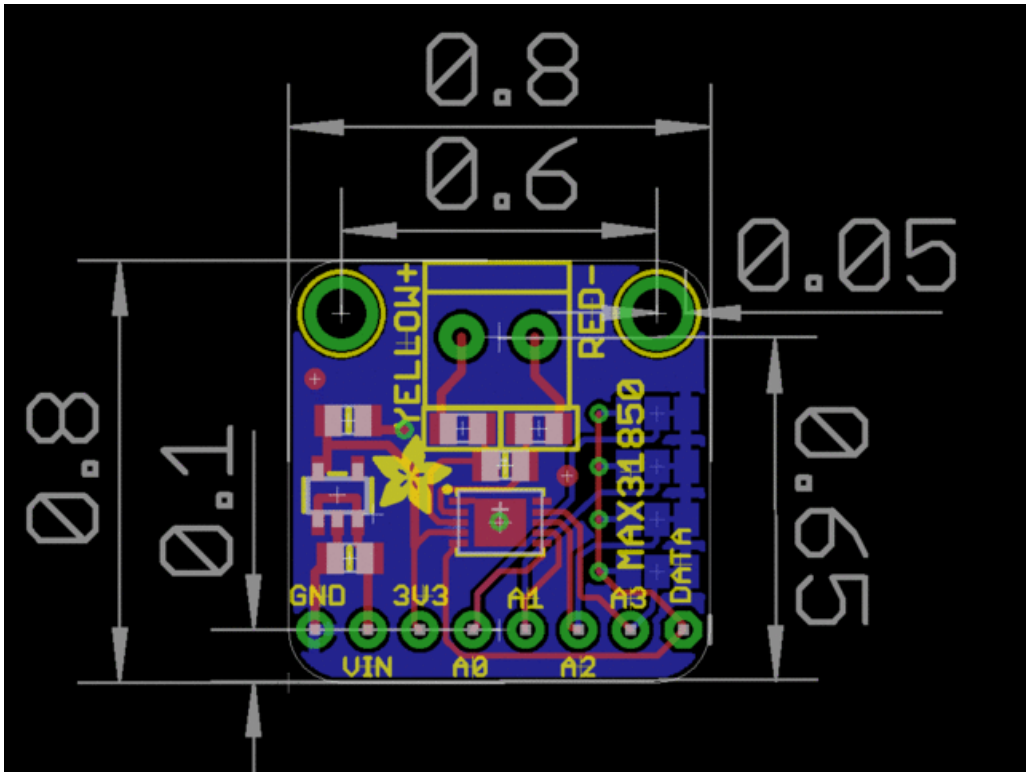
Datasheets & Files

- MAX31850 datasheet (https://adafru.it/dau)
- Fritzing object in the Adafruit Fritzing library (https://adafru.it/aP3)
- EagleCAD PCB files on GitHub (https://adafru.it/rpc)

Schematic



Fabrication Print


0.8
0.6
0.05
0.8
0.1
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YELLOW+
RED-
MAX31850
GND
3V3
A1
A3
DATA
VIN
A0
A2

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