SparkFun Qwiic Thermocouple Hookup Guide

Introduction

How many times have you asked yourself, "Self? How can I measure both the ambient temperature as well as that thing over there, AND set temperature limits to trigger interrupts so I don't have to constantly poll over I^{2}C? And how can I make it as easy as possible?" Well, we've got your answer. SparkFun has 2 new thermocouple amplifier boards - the SparkFun Qwiic Thermocouple - PCC and the SparkFun Qwiic Thermocouple - Screw Terminals; both of which do all of the above with a resolution of 0.0625°C, and an accuracy of ±1.5°C (worst-case). The boards come ready to accept a K-type thermocouple, which gives a temperature range of -200°C to 1350°C. Additionally, the MCP9600 has four onboard temperature alerts for those interrupt triggers as well as the ability to enter alternate operation modes in order to save power.

Let's dig in and see how all this works!

SparkFun Qwiic Thermocouple Amplifier - MCP9600
(PCC Connector)
◉ SEN-16294
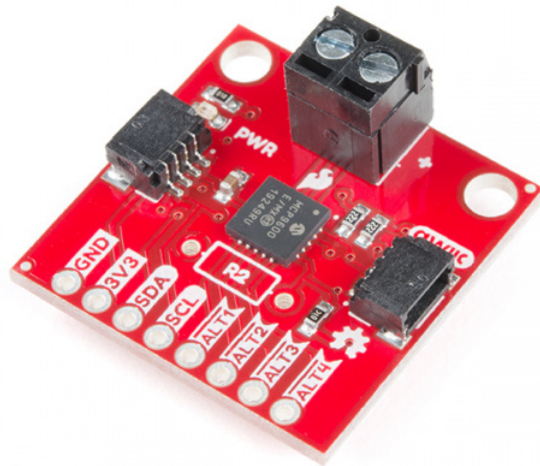
SparkFun Qwiic Thermocouple Amplifier - MCP9600 (Screw Terminals)
◉ SEN-16295

Product Showcase: SparkFun Qwiic Thermocouple Amplifier

Required Materials

To follow along with this tutorial, you will need the following materials. You may not need everything though depending on what you have. Add it to your cart, read through the guide, and adjust the cart as necessary.

SparkFun Qwiic Thermocouple Wish List SparkFun Wish List

Reversible USB A to Reversible Micro-B Cable - 0.3m
CAB-15429

|	SparkFun Qwiic Thermocouple Amplifier - MCP9600 (Screw Terminals) SEN-16295
	SparkFun Qwiic Thermocouple Amplifier - MCP9600 (PCC Connector) SEN-16294
	Qwiic Cable - 100mm PRT-14427
	SparkFun RedBoard Qwiic DEV-15123
	Thermocouple Type-K - Stainless Steel SEN-13715 This is a stainless steel, Type-K Thermocouple probe. A thermocouple works by taking two wires made of dissimila…

Suggested Reading

If you aren't familiar with the following concepts, we recommend checking out these tutorials before continuing. If you aren't familiar with the Qwiic system, we recommend reading here for an overview.
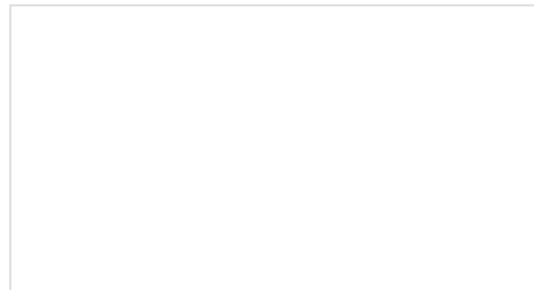

Qwiic Connect System
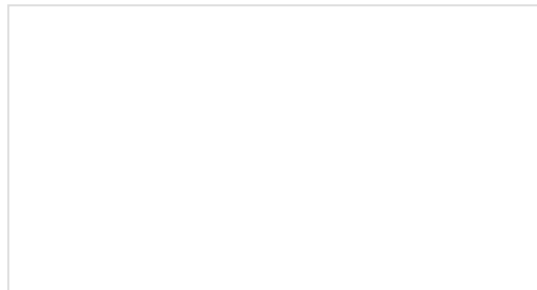
Serial Terminal Basics
This tutorial will show you how to communicate with your serial devices using a variety of terminal emulator applications.


Processor Interrupts with Arduino
What is an interrupt? In a nutshell, there is a method by which a processor can execute its normal program while continuously monitoring for some kind of event, or interrupt. There are two types of interrupts: hardware and software interrupts. For the purposes of this tutorial, we will focus on hardware interrupts.

A Brief Theory of Operation

Thermocouples are fairly ubiquitous, being used in everything from industrial kilns and diesel engines to pilot light sensors and thermostats in your home or office. Let's take a brief moment to go over how they work.

Roughly a couple hundred years ago, a man named Thomas Seebeck discovered the principal that thermocouples use. He noticed that if you take two wires made of dissimilar metals, connect them at the two ends, and make a temperature gradient between one end and the other, a voltage potential formed and current flowed. One junction is held in the environment where the temperature of interest exists. This is known as the hot junction. The other junction is referred to as the cold junction.
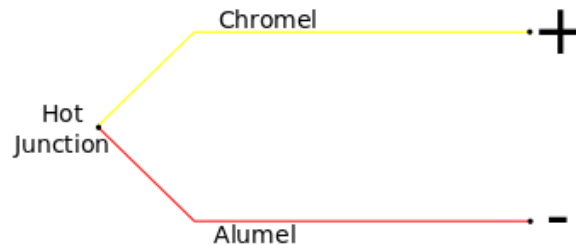
K-type thermocouple with cold junction spread for voltage measurement

There are many types of thermocouples, which mainly differ by the types of metals used in the two wires. The most common general purpose thermocouple is **type K**. They are made out of chromel and alumel. These two alloys produce a potential of approximately 41.276 µV/°C, and voltage out can be calculated using the equation below.

$$V_{OUT} = \frac{41.276\mu V}{°C} \times (T_{HOT} - T_{COLD})$$

K-type thermocouples can read between from −200 °C to +1350 °C (−330 °F to +2460 °F) and are fairly stable.

Hardware Overview

MCP9600

At the heart of this board is the MicroChip Technology Inc MCP9600 Thermocouple EMF to Temperature Converter. Inside this chip are two temperature sensors, one for the thermocouple itself (the hot junction) and one for the chip itself (the cold junction). In addition, the MCP9600 has four onboard temperature alerts that allow you to set a temperature limit to trigger an interrupt when the temperature reaches a certain value. This frees up your microcontroller and your I^{2}C bus. The MCP9600 can also be put into alternate operation modes in order to save power. The sensor supports a burst mode, where it will take a specifiable number of samples, return the results, and then go to sleep. More information can be found in the MCP9600 Datasheet (PDF).
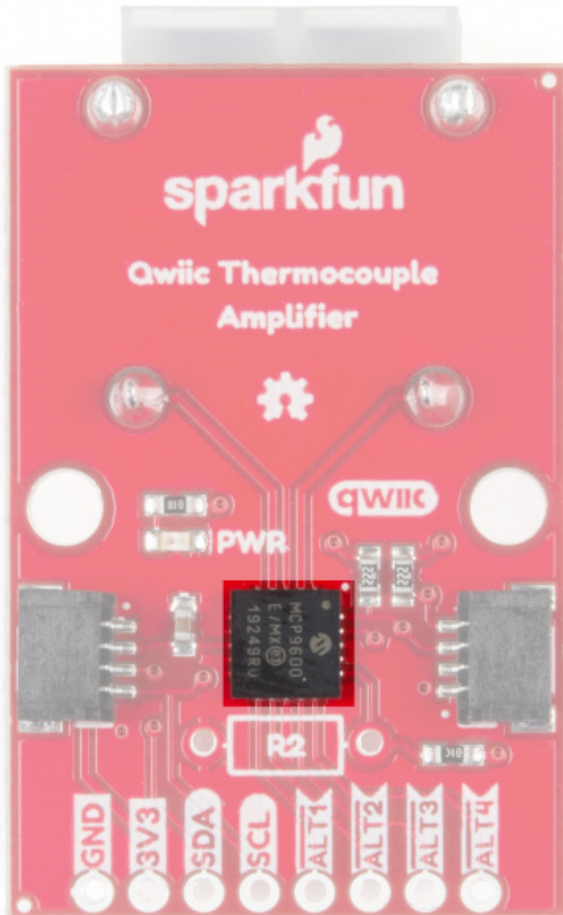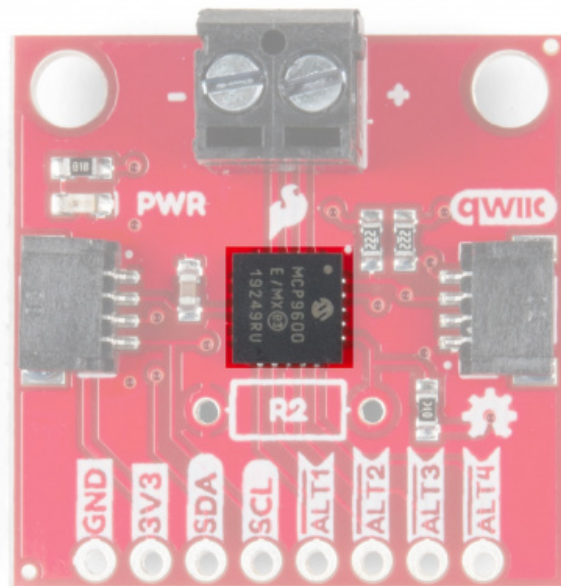
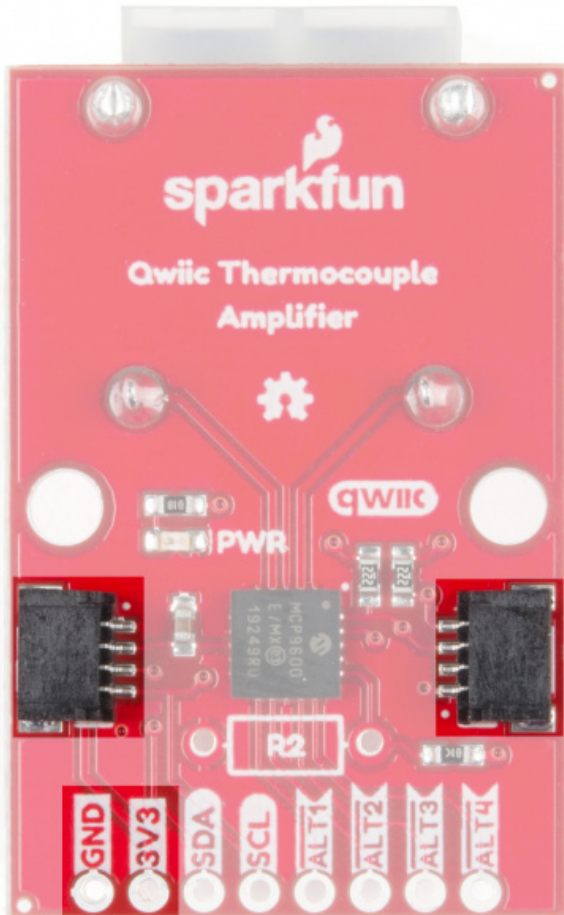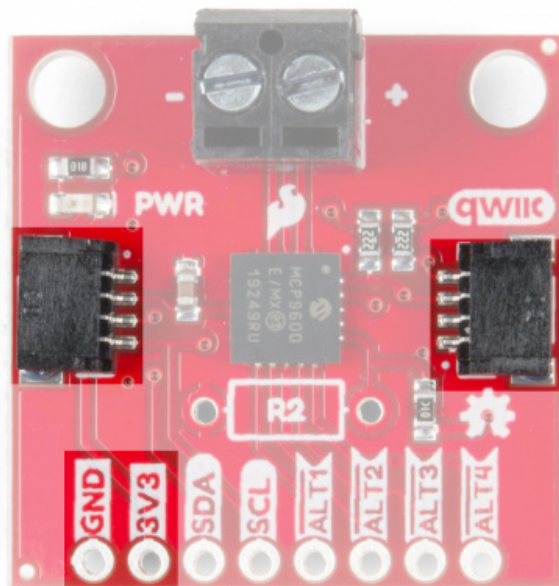*PCC Connector*   *Screw Terminal*

Power

Ideally, power will be supplied via the Qwiic connectors on either side of the board. Alternatively, power can be supplied through the header along the bottom side of the board labeled `3V3` and `GND`. The input voltage range should be between **2.7-5.5V**.

> ⚡ **Note:** There is no onboard voltage regulation on either of these boards. If you choose to provide power via the plated through holes, ensure that your voltage does not exceed **5.5V**.
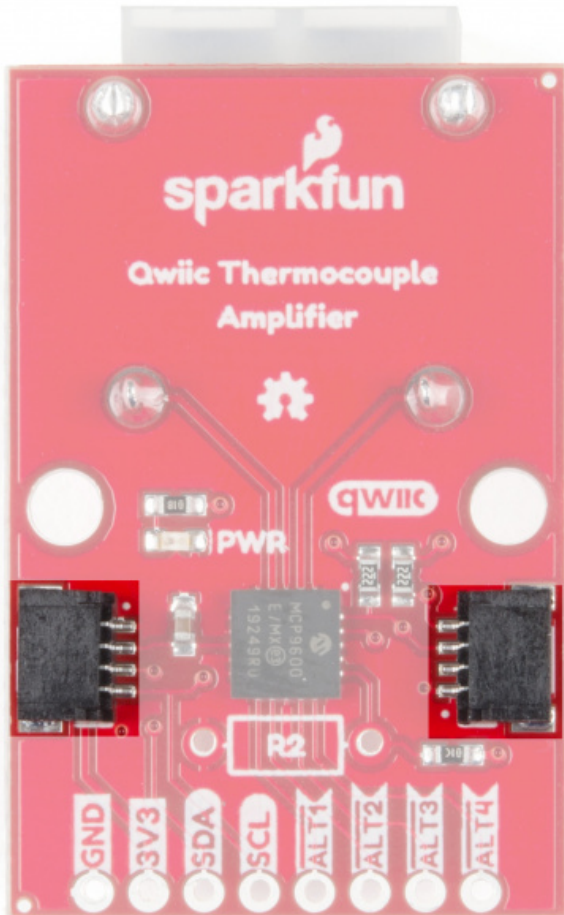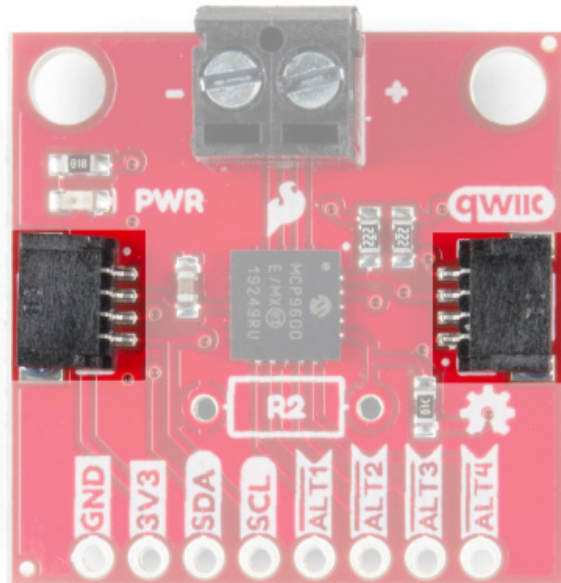
PCC Connector   *Screw Terminal*

Qwiic Connectors

There are two Qwiic connectors on either end of the SparkFun Qwiic Thermocouple boards to provide power and I^2C connectivity simultaneously. The I^2C address of the board is **0x60 by default**, but has 7 other address the board can be configured to use.
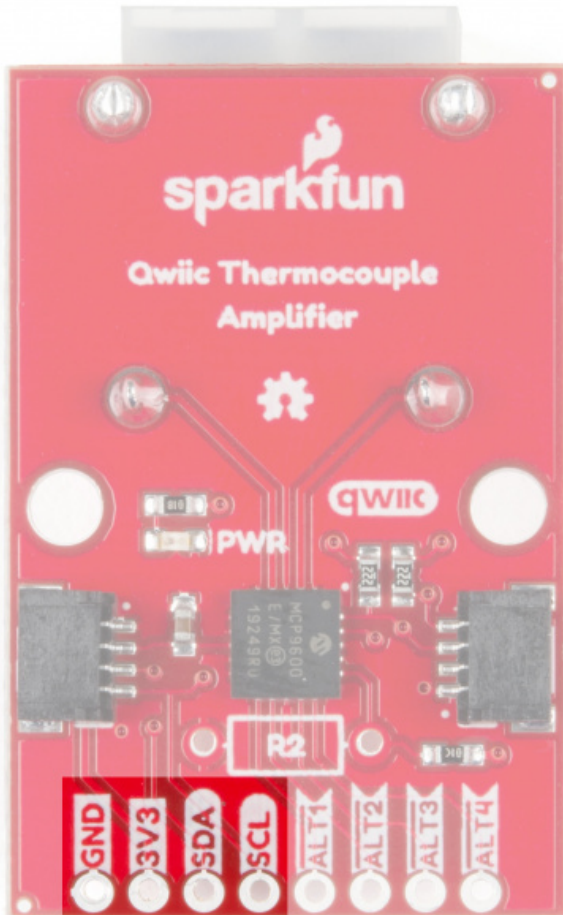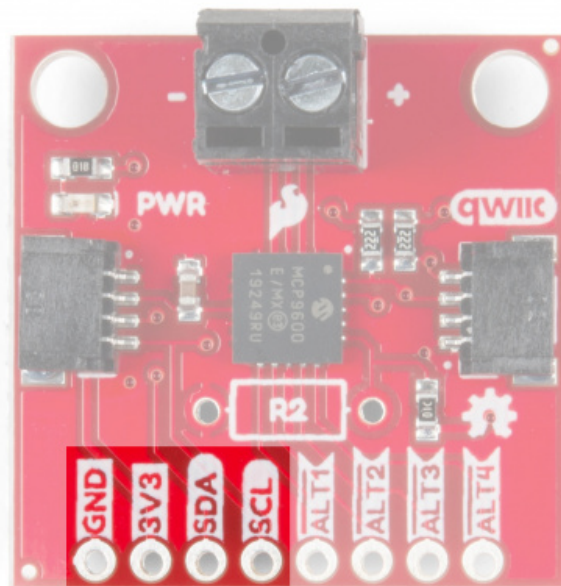
PCC Connector   *Screw Terminal*

I^{2}C Pins

The I^{2}C pins break out the functionality of the Qwiic connectors. Depending on your application, you can connect to these pins via the plated through holes for SDA and SCL.

PCC Connector

Screw Terminal

Jumpers

I^2C Jumper

These boards are both equipped with pull-up resistors. If you are daisy-chaining multiple Qwiic devices, you will want to cut this jumper; if multiple sensors are connected to the bus with the pull-up resistors enabled, the parallel equivalent resistance will create too strong of a pull-up for the bus to operate correctly. As a general rule of thumb, disable all but one pair of pull-up resistors if multiple devices are connected to the bus. To disable the pull up resistors, use an X-acto knife to cut the joint between the two jumper pads highlighted below.

PCC Connector   *Screw Terminal*

ADDR Jumper

The MCP9600 uses an analog voltage to set the I^{2}C address. By default, the ADDR jumper pulls the address pin low, which gives the board a **default address of 0x60**. Cutting the jumper pulls the address pin high through a 10K resistor, which will change the address to 0x67.
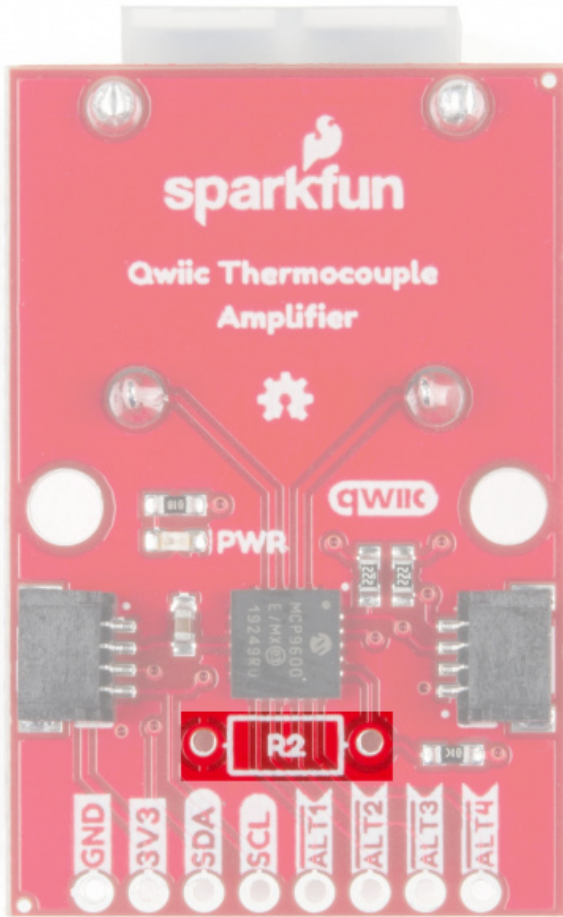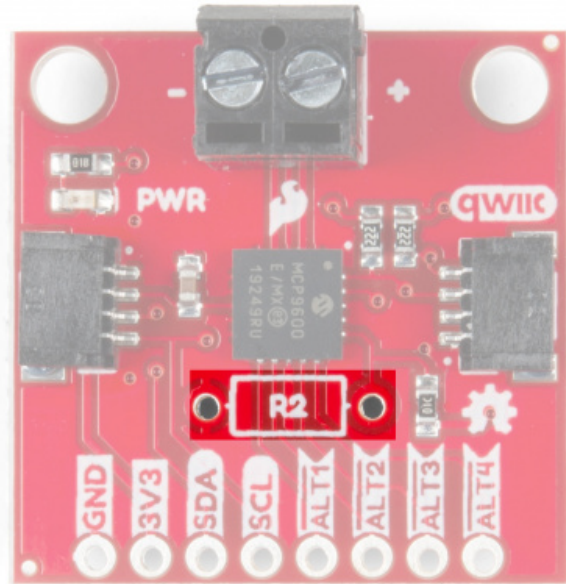
PCC Connector

Screw Terminal

For addresses other than 0x67, a resistor will need to be soldered. Refer to the table below for the resistor value and corresponding address.

Address	Resistor (kΩ)
0x60	0
0x61	2.2
0x62	4.3
0x63	7.5
0x64	13
0x65	22
0x66	43
0x67	N/A

Resistor location on each board:
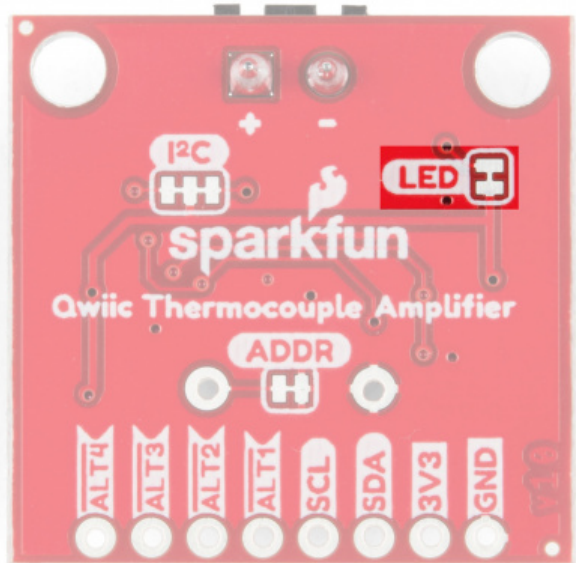

PCC Connector

Screw Terminal

LED Jumper

Wanna turn off that pesky power LED? Cut this jumper.
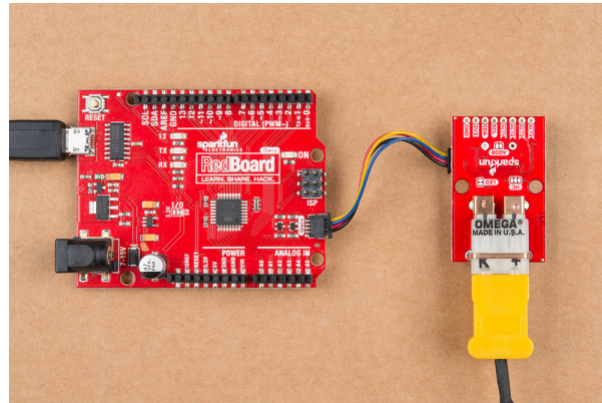
PCC Connector

Screw Terminal

Board Dimensions

Feel free to click on either of the images below for a closer look!

Qwiic Thermocouple Amplifier PCC

Qwiic Thermocouple Amplifier Screw Terminals

Hardware Hookup

For this tutorial, we'll use the Amplifier board with the PCC connector. Grab your Qwiic cable and plug one end into the RedBoard Qwiic and the other end into the Thermocouple Amplifier.

Then you can connect the K-type Thermocouple into the PCC connector as so:
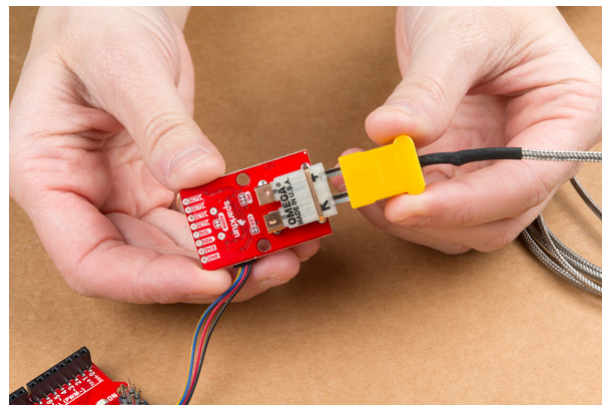
Click for a closer view.

Plug in the RedBoard Qwiic When you are all set up, you should have something that looks like this:
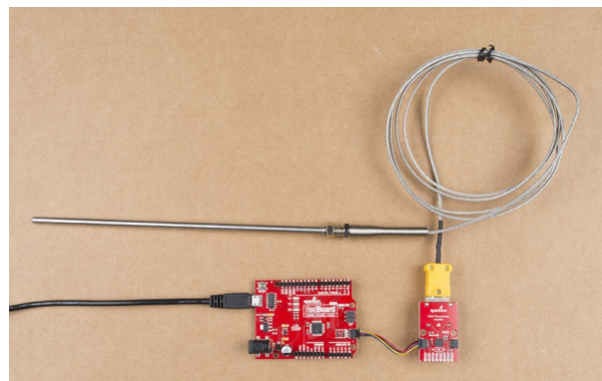
Click for a closer view.

Software Setup and Programming

Note: This code/library has been written and tested on Arduino IDE version 1.8.10. Otherwise, make sure you are using the latest stable version of the Arduino IDE on your desktop.

If this is your first time using Arduino, please review our tutorial on installing the Arduino IDE. If you have not previously installed an Arduino library, please check out our installation guide.

SparkFun has written a library to work with the Qwiic Thermocouple. You can obtain this library through the Arduino Library Manager by searching for **MCP9600**. Find the one written by **SparkFun Electronics** and install the latest version. If you prefer downloading libraries manually, you can grab them from the GitHub Repository.

<div style="text-align: center;">

DOWNLOAD THE SPARKFUN MCP9600 ARDUINO LIBRARY (ZIP)

</div>

Example Code

Once you've installed the library, you should be able to find the examples in Arduino under **File** > **Examples** > **SparkFun MCP9600 Thermocouple Library**.
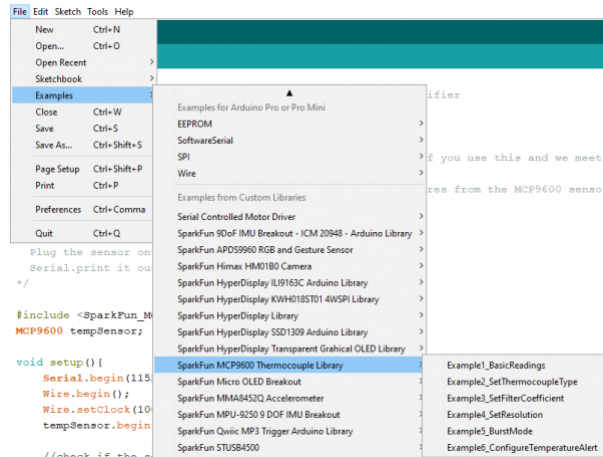
Example 1: Basic Readings

While all of the examples are well commented, let's quickly run through example 1 just to get your feet wet. The best part? It's pretty much plug and play. So go ahead and open up Example 1, or alternatively, copy and paste the code below into an Arduino window:

```
/*
  Temperature Measurements with the MCP9600 Thermocouple Amplifier
  By: Fischer Moseley
  SparkFun Electronics
  Date: July 8, 2019
  License: This code is public domain but you buy me a beer if you use this and we meet someday
 (Beerware License).

  This example outputs the ambient and thermocouple temperatures from the MCP9600 sensor.

  Hardware Connections:
  Attach the Qwiic Shield to your Arduino/Photon/ESP32 or other
  Plug the sensor onto the shield
  Serial.print it out at 115200 baud to serial monitor.
*/

#include <SparkFun_MCP9600.h>
MCP9600 tempSensor;

void setup(){
    Serial.begin(115200);
    Wire.begin();
    Wire.setClock(100000);
    tempSensor.begin();         // Uses the default address 0x60 for SparkFun
    //tempSensor.begin(0x66);   // Default address for SparkX

    //check if the sensor is connected
    if(tempSensor.isConnected()){
        Serial.println("Device will acknowledge!");
    }
    else {
        Serial.println("Device did not acknowledge! Freezing.");
        while(1); //hang forever
    }

    //check if the Device ID is correct
    if(tempSensor.checkDeviceID()){
        Serial.println("Device ID is correct!");
    }
    else {
        Serial.println("Device ID is not correct! Freezing.");
        while(1);
    }
}

void loop(){ //print the thermocouple, ambient and delta temperatures every 200ms if available
    if(tempSensor.available()){
        Serial.print("Thermocouple: ");
        Serial.print(tempSensor.getThermocoupleTemp());
        Serial.print(" °C    Ambient: ");
        Serial.print(tempSensor.getAmbientTemp());
        Serial.print(" °C    Temperature Delta: ");
        Serial.print(tempSensor.getTempDelta());
```
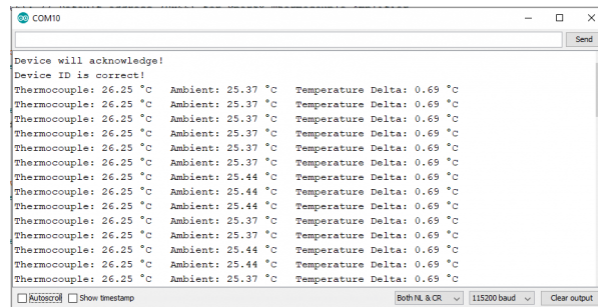
```
        Serial.print(" °C");
        Serial.println();
    }
    delay(20); //don't hammer too hard on the I2C bus
}
```

What You Should See

Open up the Serial Monitor and make sure your baud rate is 115200. You should see something like the image below. If you move the hot junction (ie, the thermocouple wand) closer to a heat source, you should see the Thermocouple temperature go up.

Troubleshooting

> **❷ Need help?**
>
> If your product is not working as you expected or you need technical assistance or information, head on over to the SparkFun Technical Assistance page for some initial troubleshooting.
>
> If you don't find what you need there, the SparkFun Forums are a great place to find and ask for help. If this is your first visit, you'll need to create a Forum Account to search product forums and post questions.

Resources and Going Further

Want more information on the Qwiic Thermocouple? Check out the links here:

Qwiic Thermocouple Amplifier PCC:

- Schematic (PDF)
- Eagle Files (ZIP)

Qwiic Thermocouple Amplifier Screw Terminals:

- Schematic (PDF)
- Eagle Files (ZIP)

Hardware and Library:

- GitHub Repo
- Arduino Library GitHub Repo
- MCP9600 Datasheet (PDF)

Need inspiration for more projects? We have loads of great Qwiic tutorials! Check 'em out!

CCS811/BME280 (Qwiic) Environmental Combo Breakout Hookup Guide

Sense various environmental conditions such as temperature, humidity, barometric pressure, eCO2 and tVOCs with the CCS811 and BME280 combo breakout board.
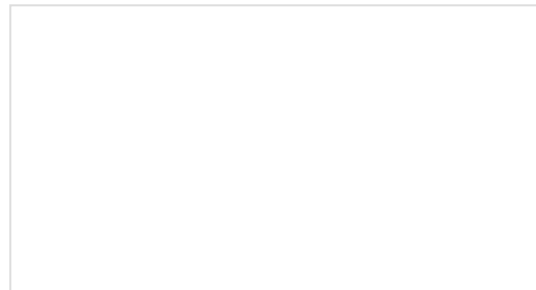
Qwiic MUX Hookup Guide

Have a bunch of sensors with the same I2C address? Put them on the Qwiic MUX (TCA9548A) to get them all talking on the same bus!
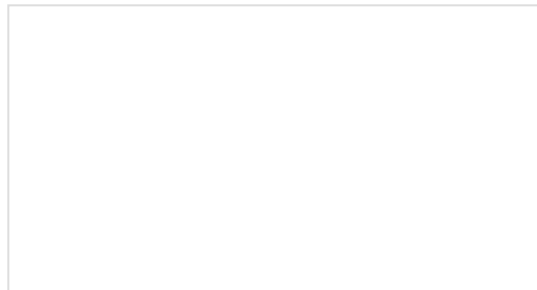
SparkFun Pro nRF52840 Mini Hookup Guide

A hardware overview and hookup guide for the SparkFun Pro nRF52840 Mini -- a breakout for Nordic's impossibly cool Bluetooth/ARM Cortex M4 SoC.

Pi Servo pHAT (v2) Hookup Guide

This hookup guide will get you started with connecting and using the Pi Servo pHAT on a Raspberry Pi.