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# Adafruit DS3231 Precision RTC Breakout

Created by lady ada

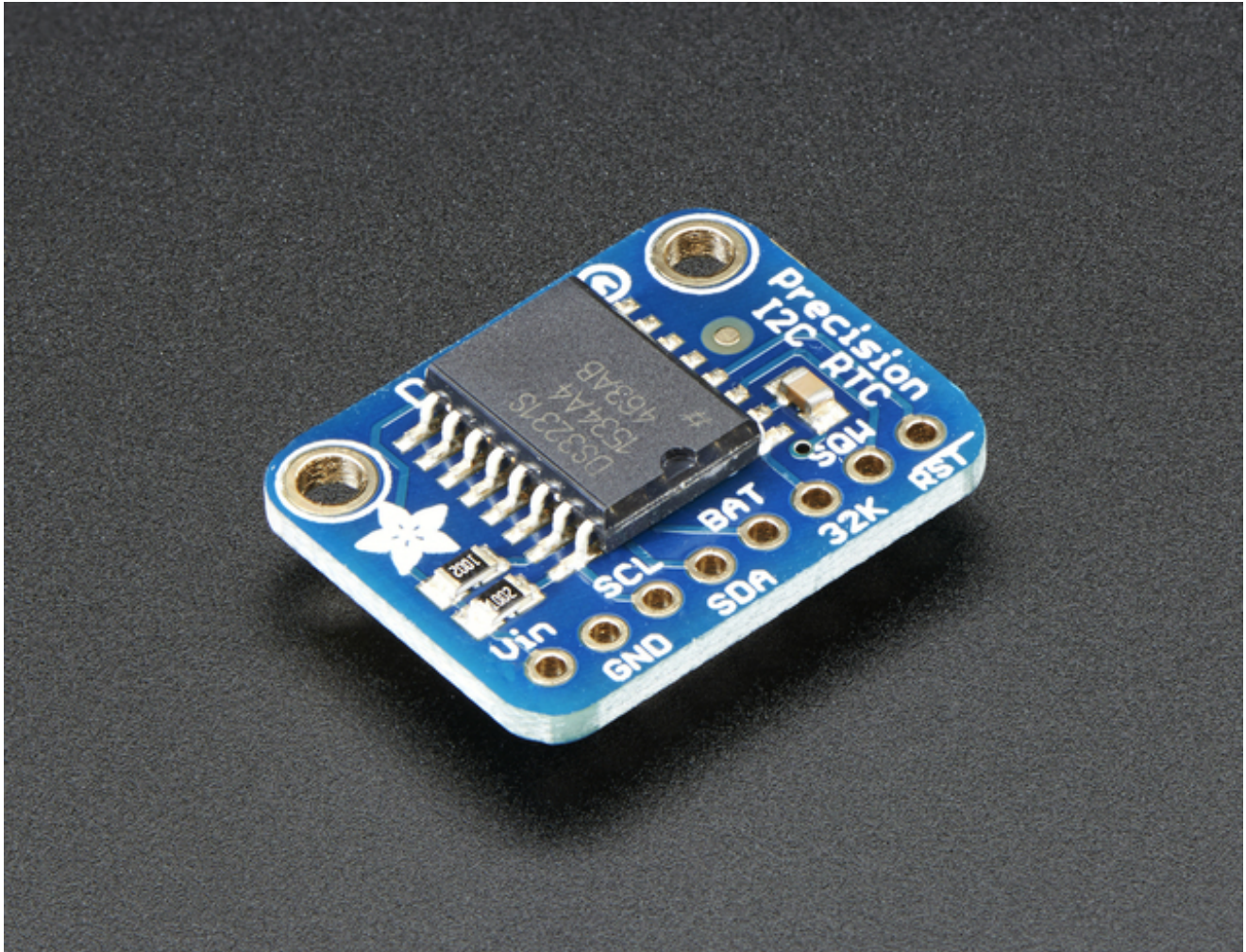


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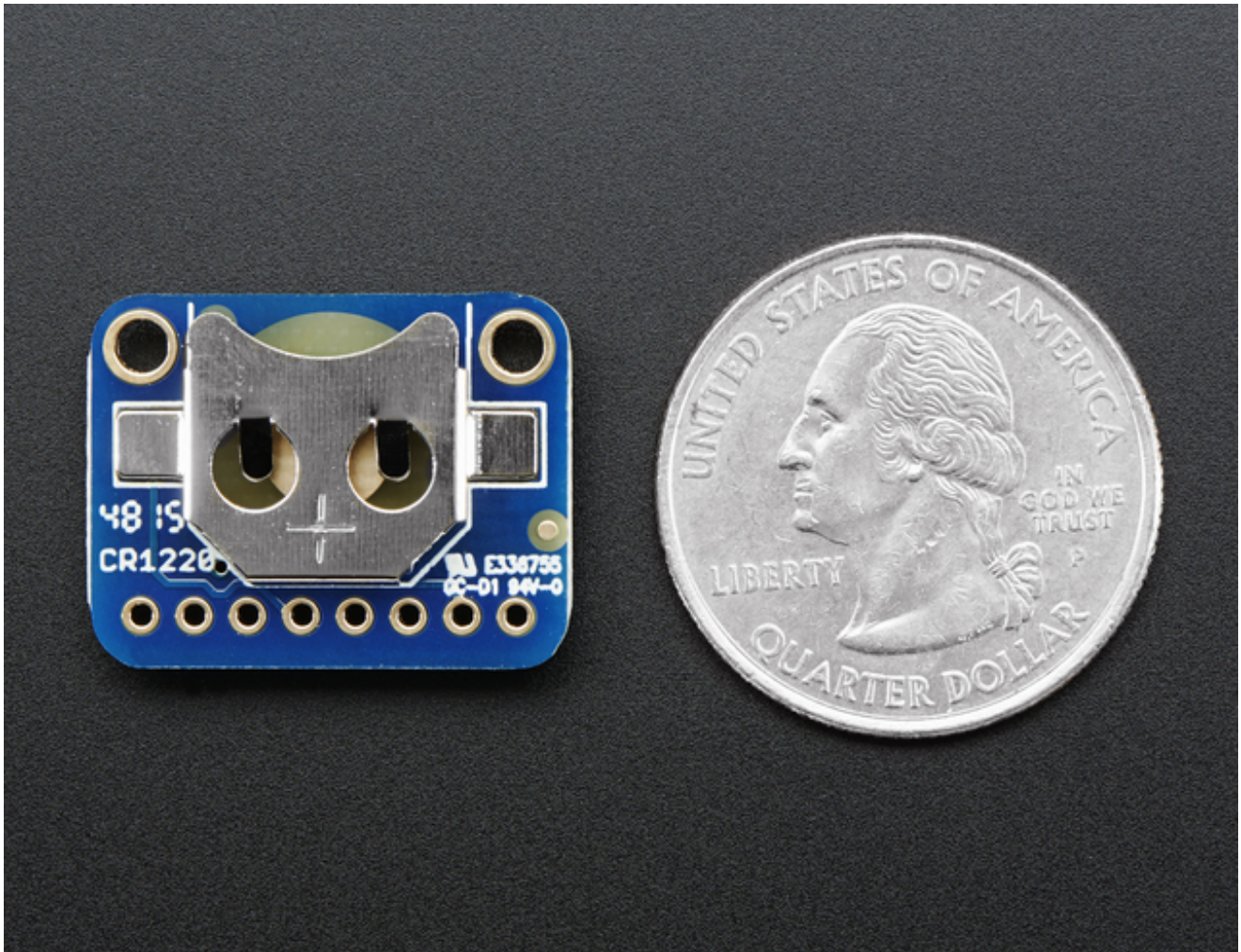
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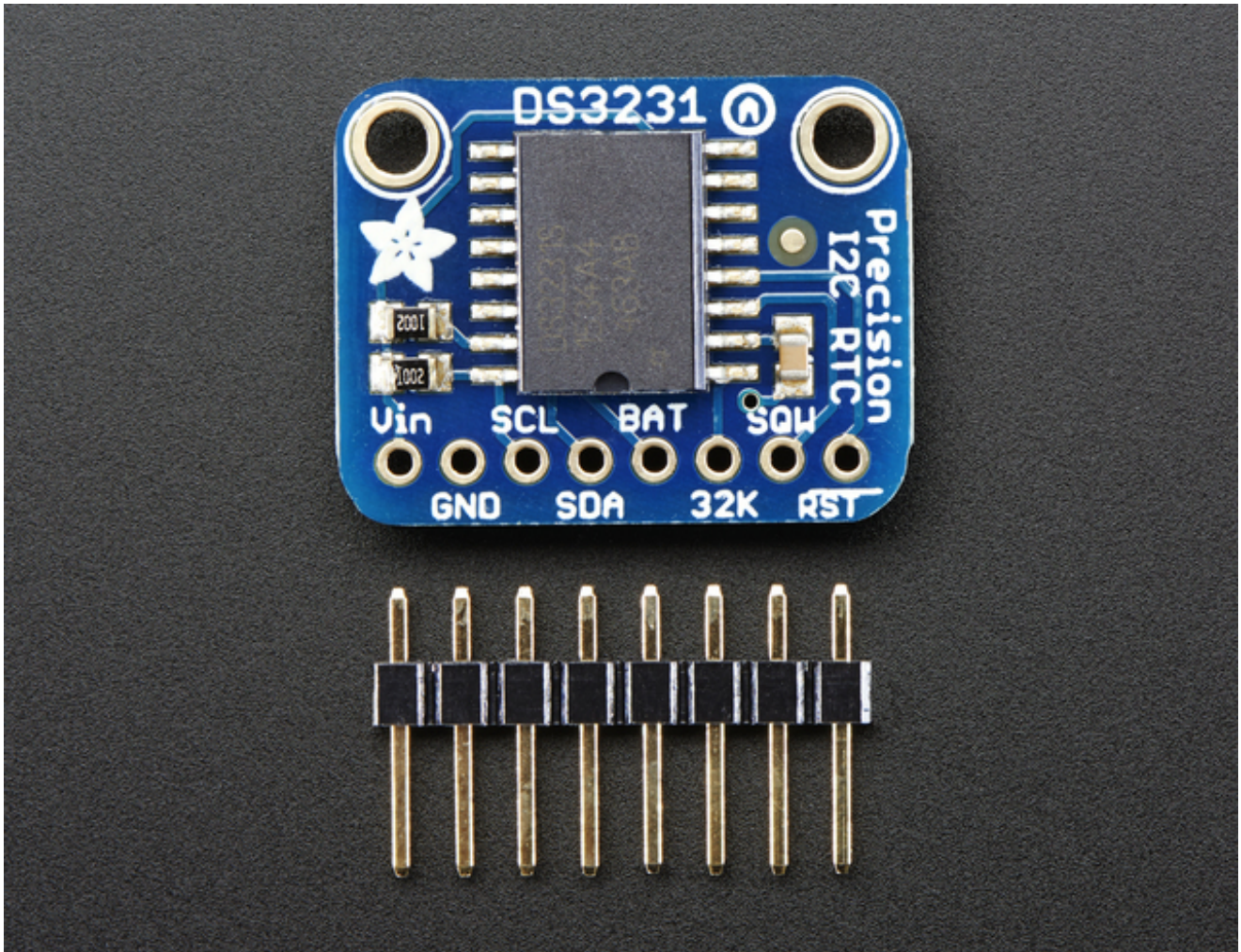
# Overview



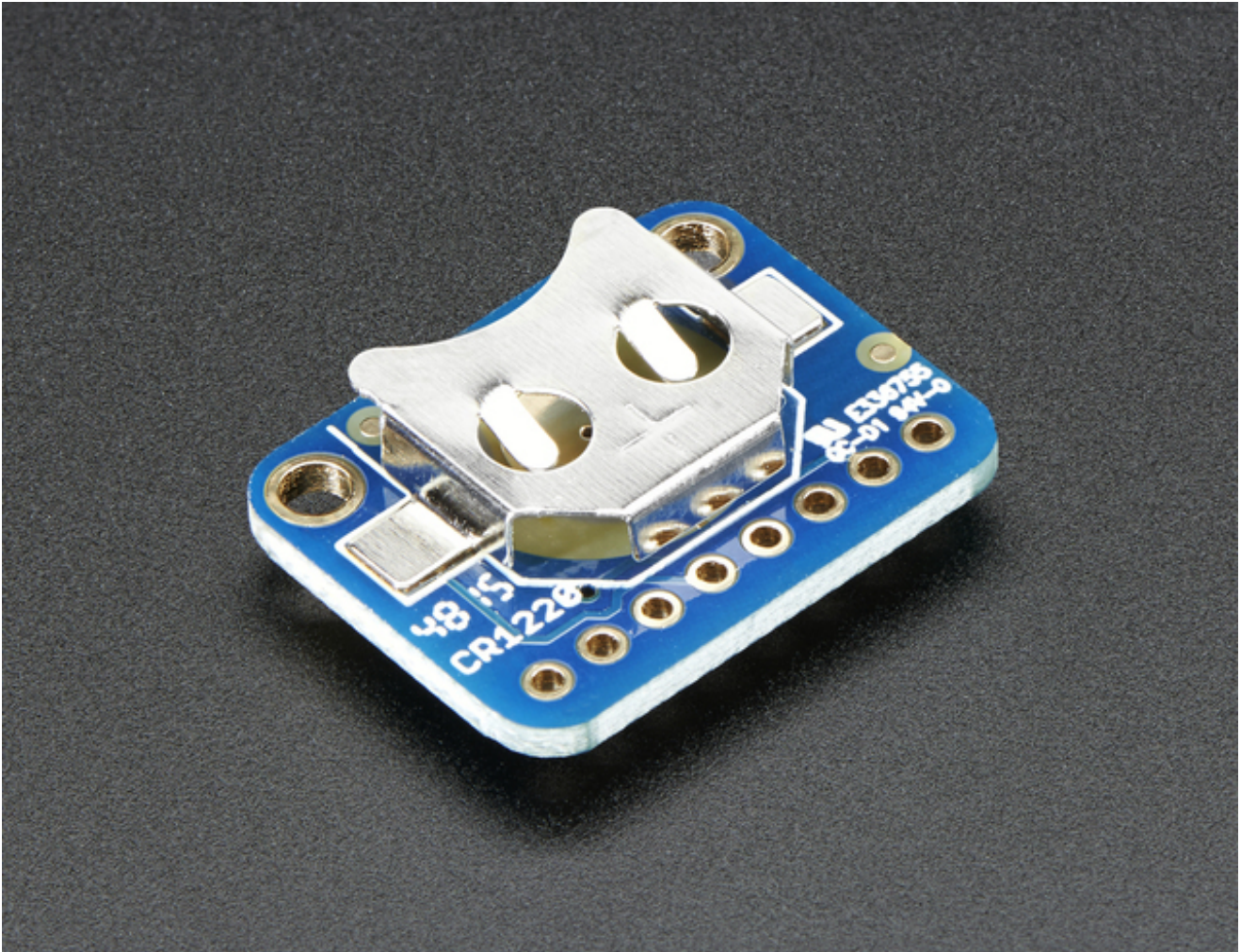
The datasheet for the DS3231 explains that this part is an "Extremely Accurate I<sup>2</sup>C-Integrated RTC/TCXO/Crystal". And, hey, it does exactly what it says on the tin! This Real Time Clock (RTC) is the most precise you can get in a small, low power package.



Most RTC's use an external 32kHz timing crystal that is used to keep time with low current draw. And that's all well and good, but those crystals have slight drift, particularly when the temperature changes (the temperature changes the oscillation frequency very very very slightly but it does add up!) This RTC is in a beefy package because the crystal is *inside* the chip! And right next to the integrated crystal is a temperature sensor. That sensor compensates for the frequency changes by adding or removing clock ticks so that the timekeeping stays on schedule



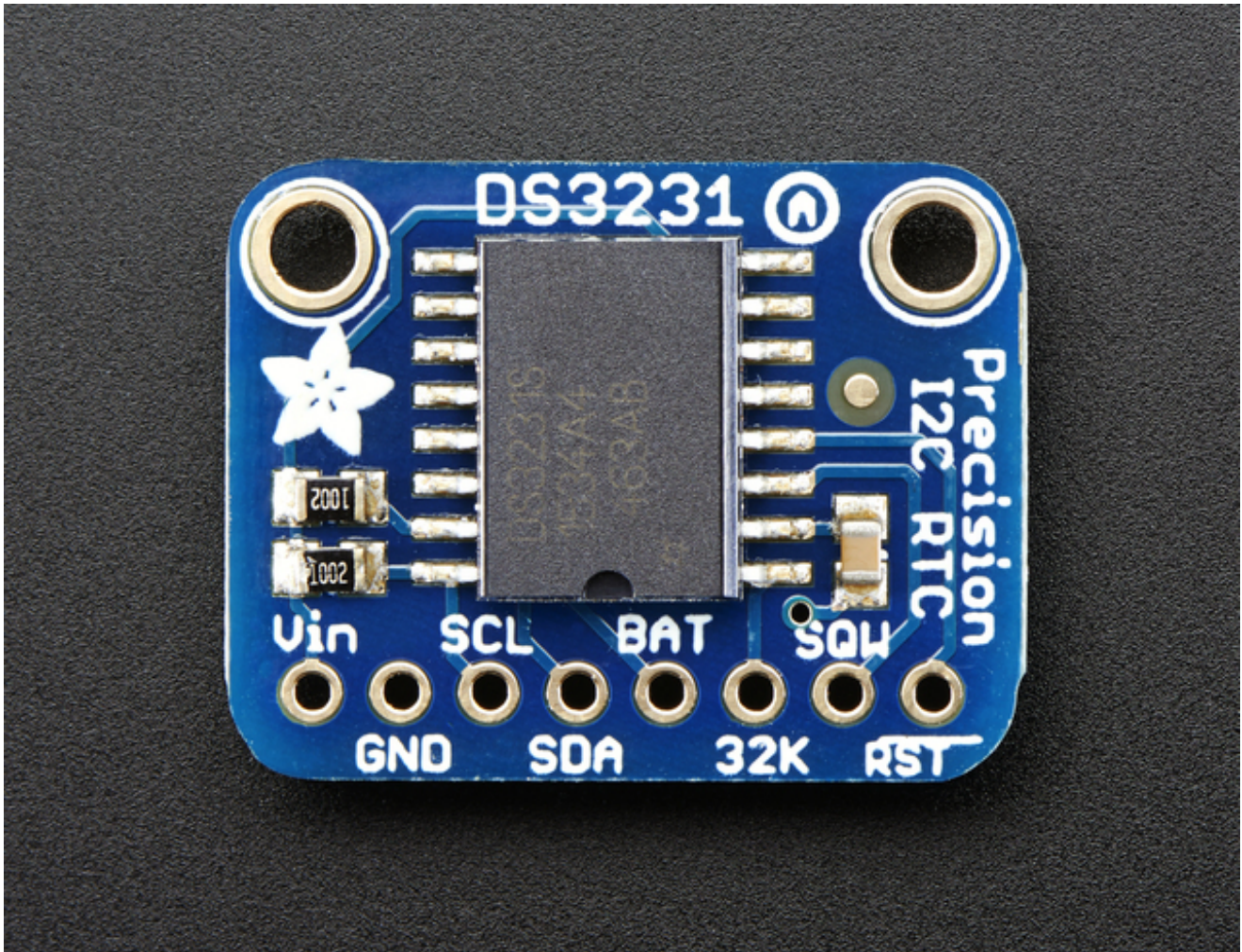
This is the finest RTC you can get, and now we have it in a compact, breadboard-friendly breakout. With a coin cell plugged into the back, you can get years of precision timekeeping, even when main power is lost. Great for datalogging and clocks, or anything where you need to really know the time.



Comes as a fully assembled and tested breakout plus a small piece of header. You can solder header in to plug it into a breadboard, or solder wires directly.

A coin cell is required to use the battery-backup capabilities! We don't include one by default, to make shipping easier for those abroad, [but we do stock them so pick one up or use any CR1220 you have handy.](#) (<http://adafru.it/380>)

# Pinouts



## Power Pins:

- **Vin** - this is the power pin. Since the RTC can be powered from 2.3V to 5.5V power, you do not need a regulator or level shifter for 3.3V or 5V logic/power. To power the board, give it the same power as the logic level of your microcontroller - e.g. for a 5V micro like Arduino, use 5V
- **GND** - common ground for power and logic

## I2C Logic pins:

- **SCL** - I2C clock pin, connect to your microcontrollers I2C clock line. This pin has a

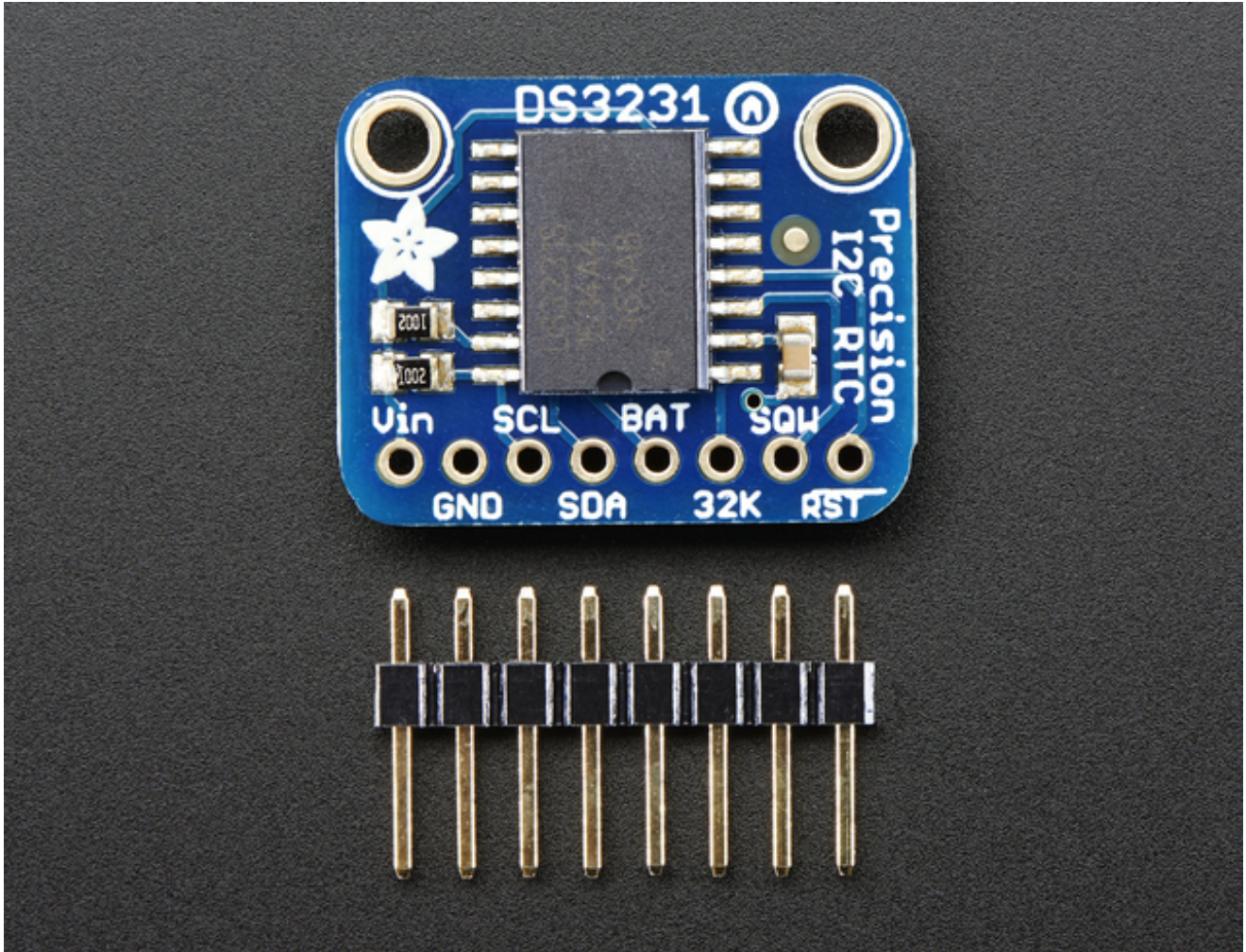


- 10K pullup resistor to Vin
- **SDA** - I2C data pin, connect to your microcontrollers I2C data line. This pin has a 10K pullup resistor to Vin

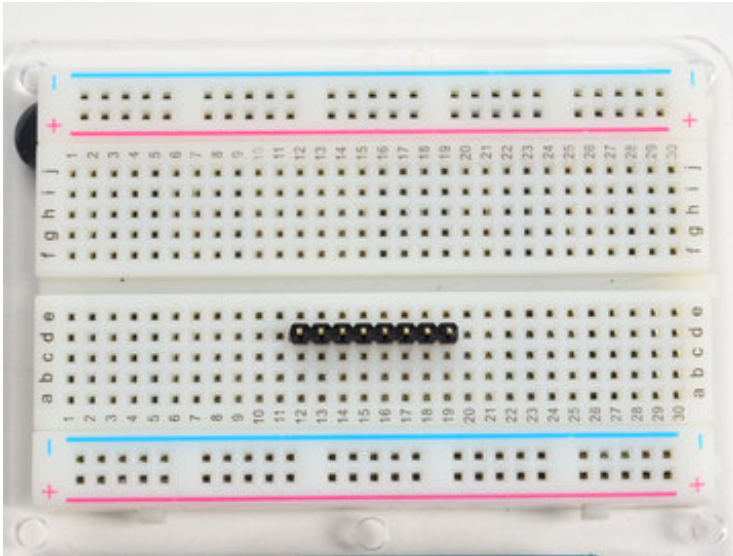
## Other Pins:

- **BAT** - this is the same connection as the positive pad of the battery. You can use this if you want to power something else from the coin cell, or provide battery backup from a different separate battery. VBat can be between 2.3V and 5.5V and the DS3231 will switch over when main Vin power is lost
- **32K** - 32KHz oscillator output. Open drain, you need to attach a pullup to read this signal from a microcontroller pin
- **SQW** - optional square wave or interrupt output. Open drain, you need to attach a pullup to read this signal from a microcontroller pin
- **RST** - This one is a little different than most RST pins, rather than being just an input, it is designed to be used to reset an external device or indicate when main power is lost. Open drain, but has an internal 50K pullup. The pullup keeps this pin voltage high as long as Vin is present. When Vin drops and the chip switches to battery backup, the pin goes low.

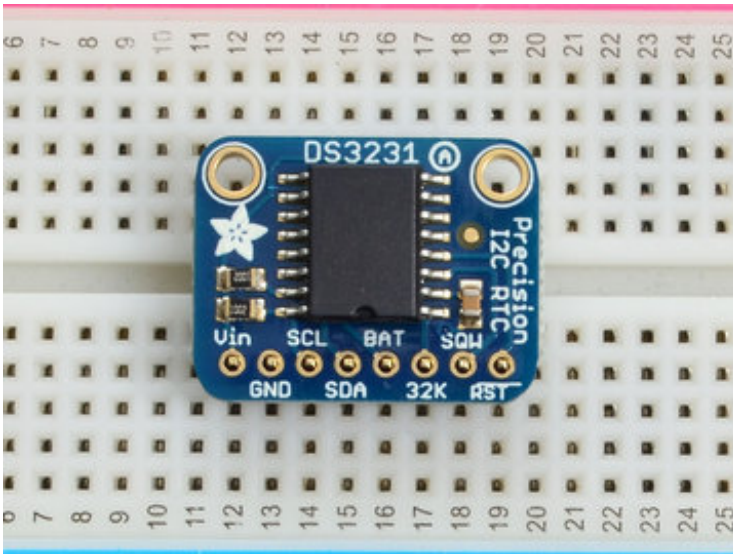
# Assembly



**Prepare the header strip:**

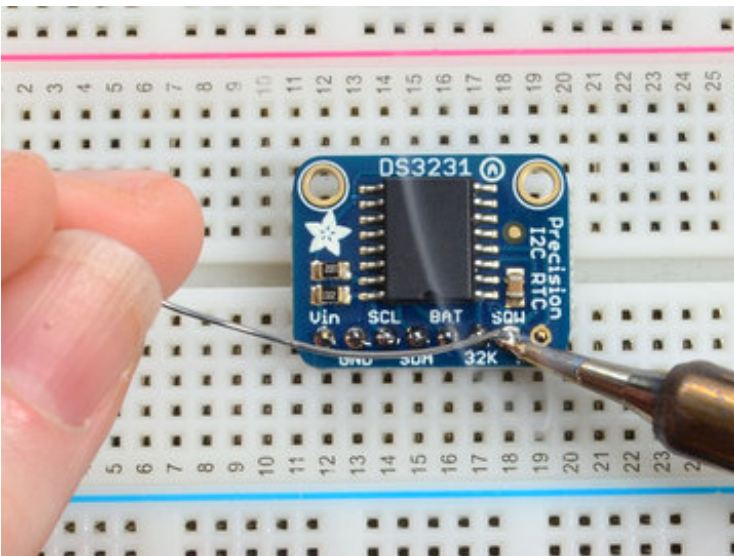
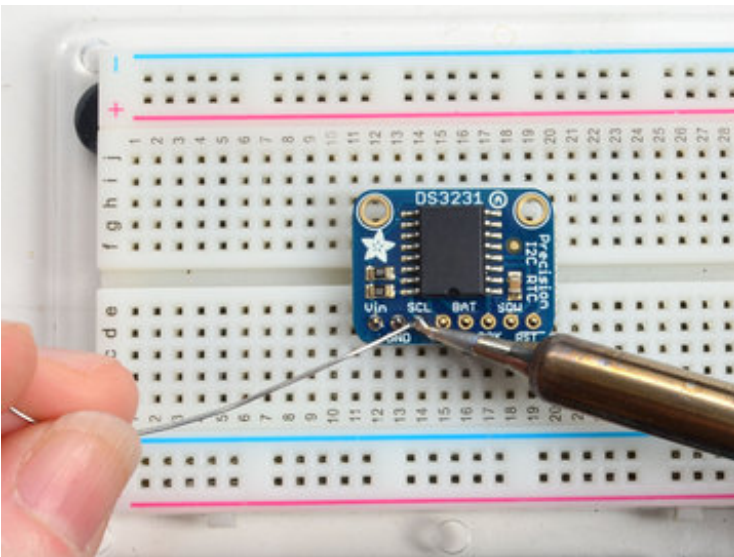
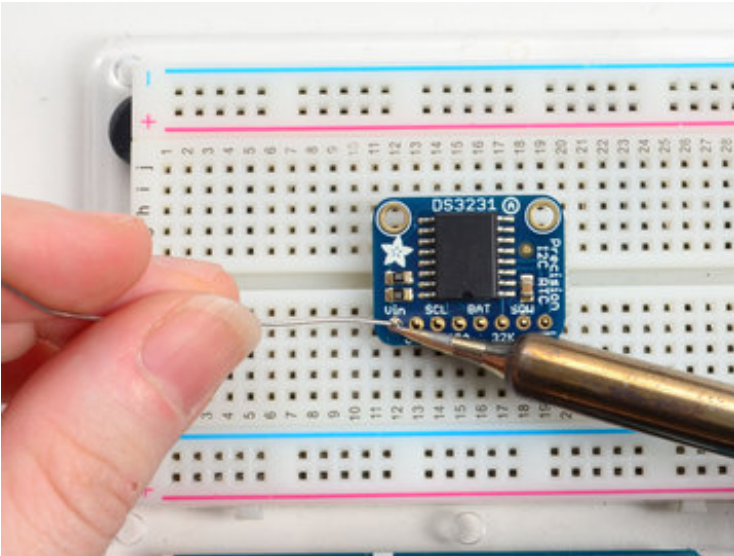


Cut the strip to length if necessary. It will be easier to solder if you insert it into a breadboard - **long pins down**



**Add the breakout board:**

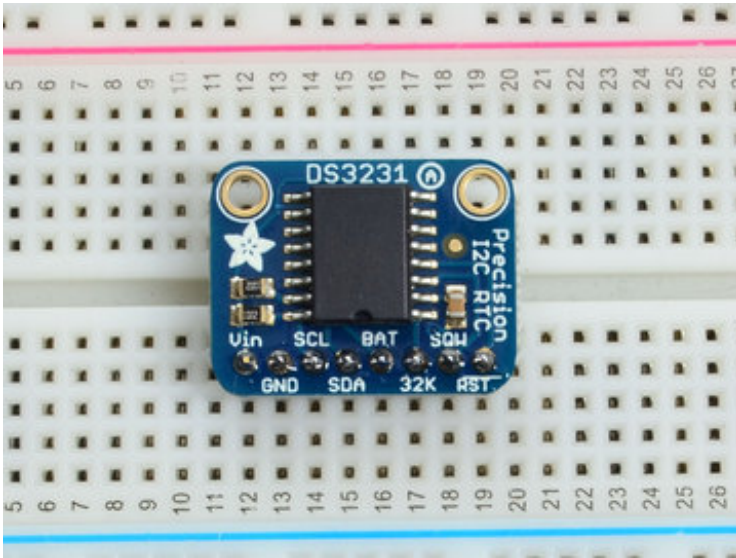
Place the breakout board over the pins so that the short pins poke through the breakout pads



## And Solder!

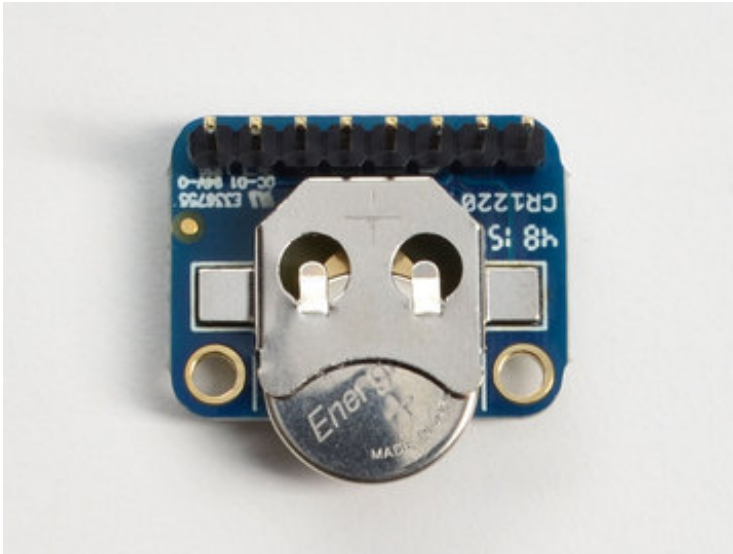
Be sure to solder all pins for reliable electrical contact.

(For tips on soldering, be sure to check out our [Guide to Excellent Soldering](http://adafruit.it/aTk) (<http://adafruit.it/aTk>)).

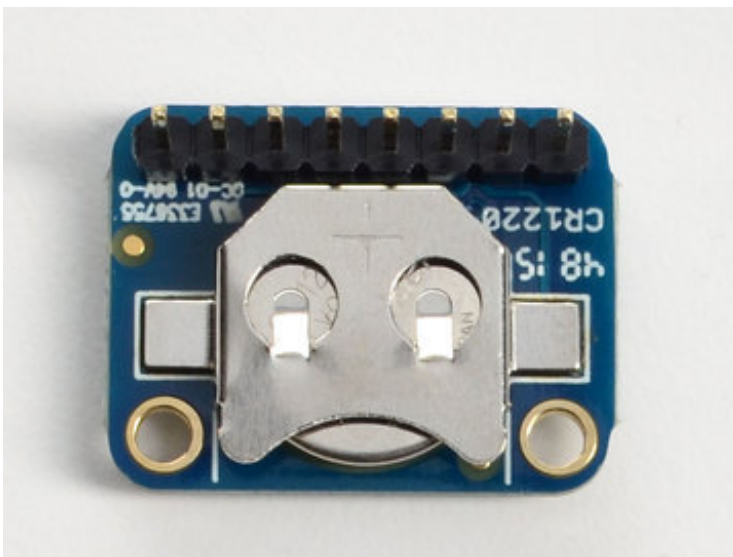


You're done! Check your solder joints visually and continue onto the next steps

Don't forget that the Real Time Clock requires a battery backup. A CR1220 size battery goes in the back, make sure the + symbol on the battery is visible when you insert!



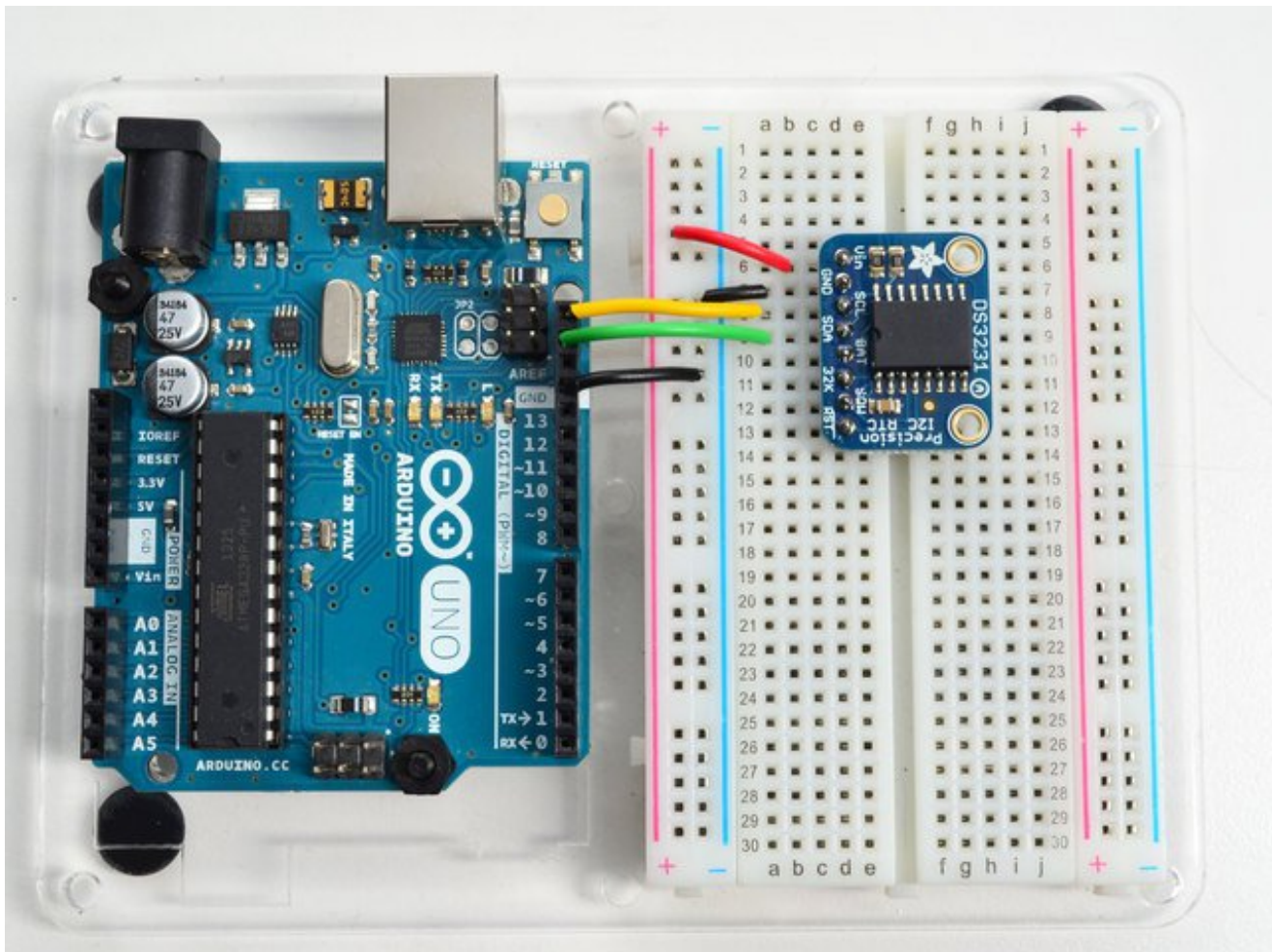
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# Wiring & Test

You can easily wire this breakout to any microcontroller, we'll be using an Arduino. For another kind of microcontroller, just make sure it has I2C, then port the code - its pretty simple stuff!



Oops i removed the Power wire from 5V to the Vin rail before taking this pic, don't forget it!

- Connect **Vin** to the power supply, 3-5V is fine. Use the same voltage that the microcontroller logic is based off of. For most Arduinos, that is 5V
- Connect **GND** to common power/data ground
- Connect the **SCL** pin to the I2C clock **SCL** pin on your Arduino. On an UNO & '328 based Arduino, this is also known as **A5**, on a Mega it is also known as **digital 21** and on a Leonardo/Micro, **digital 3**
- Connect the **SDA** pin to the I2C data **SDA** pin on your Arduino. On an UNO & '328 based Arduino, this is also known as **A4**, on a Mega it is also known as **digital 20** and

on a Leonardo/Micro, **digital 2**

The DS3231 has a default **I2C address of 0x68** and cannot be changed

## Download RTCLib

For the RTC library, we'll be using a fork of JeeLab's excellent RTC library [RTCLib](http://adafru.it/aX2) (<http://adafru.it/aX2>) - a library for getting and setting time from an RTC (originally written by JeeLab, our version is slightly different so please **only use ours** to make sure its compatible!)

To begin reading data, you will need to [download Adafruit's RTCLib from our github repository](http://adafru.it/c7r) (<http://adafru.it/c7r>). You can do that by visiting the github repo and manually downloading or, easier, just click this button to download the zip

[Download RTCLib](http://adafru.it/cxm)  
<http://adafru.it/cxm>

Rename the uncompressed folder **RTCLib** and check that the **RTCLib** folder contains **RTCLib.cpp** and **RTCLib.h**

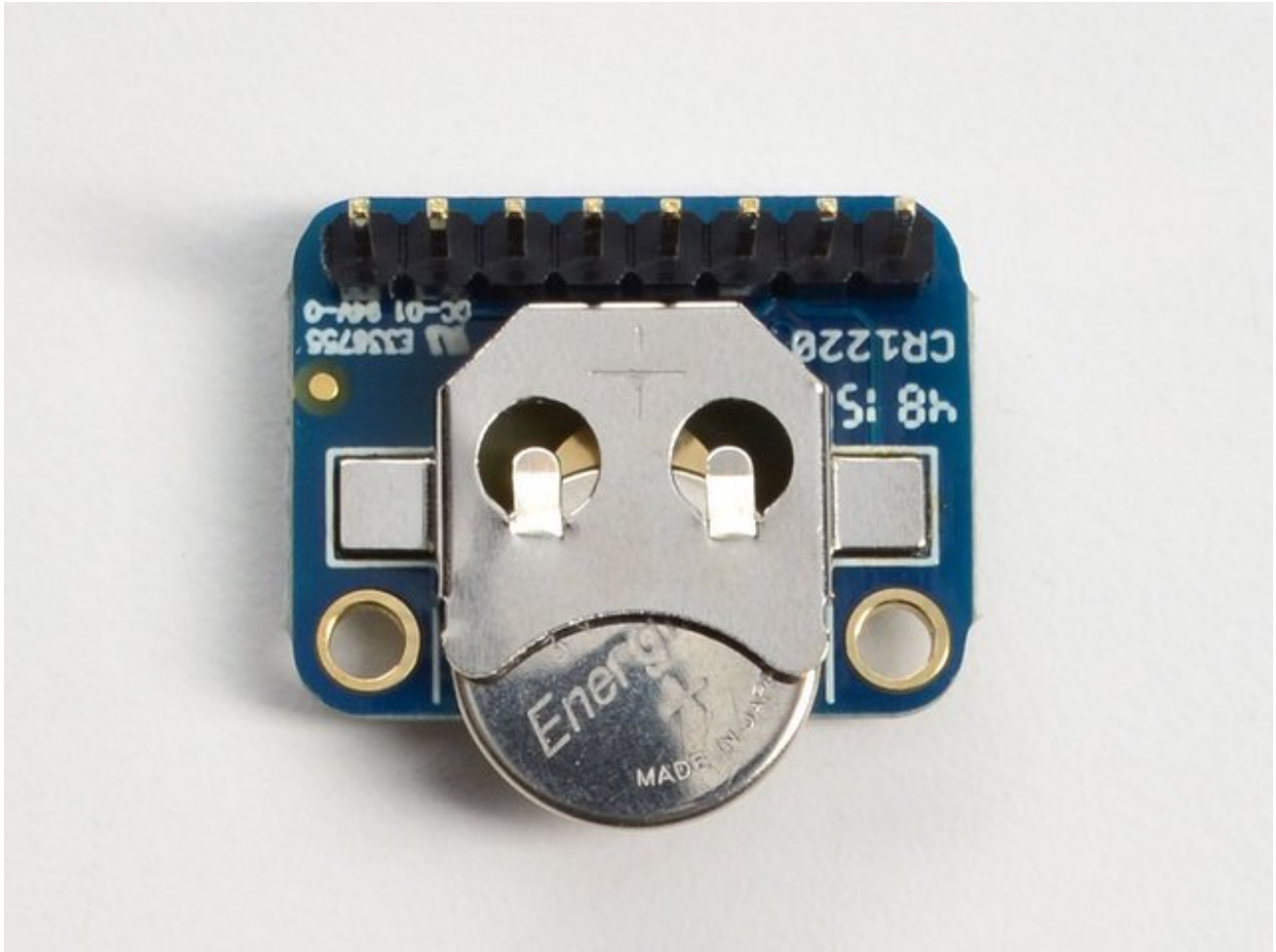
Place the **RTCLib** library folder your **arduinofolder/libraries/** folder. You may need to create the **libraries** subfolder if its your first library. Restart the IDE.

We also have a great tutorial on Arduino library installation at: <http://learn.adafruit.com/adafruit-all-about-arduino-libraries-install-use> (<http://adafru.it/aYM>)

## First RTC Test

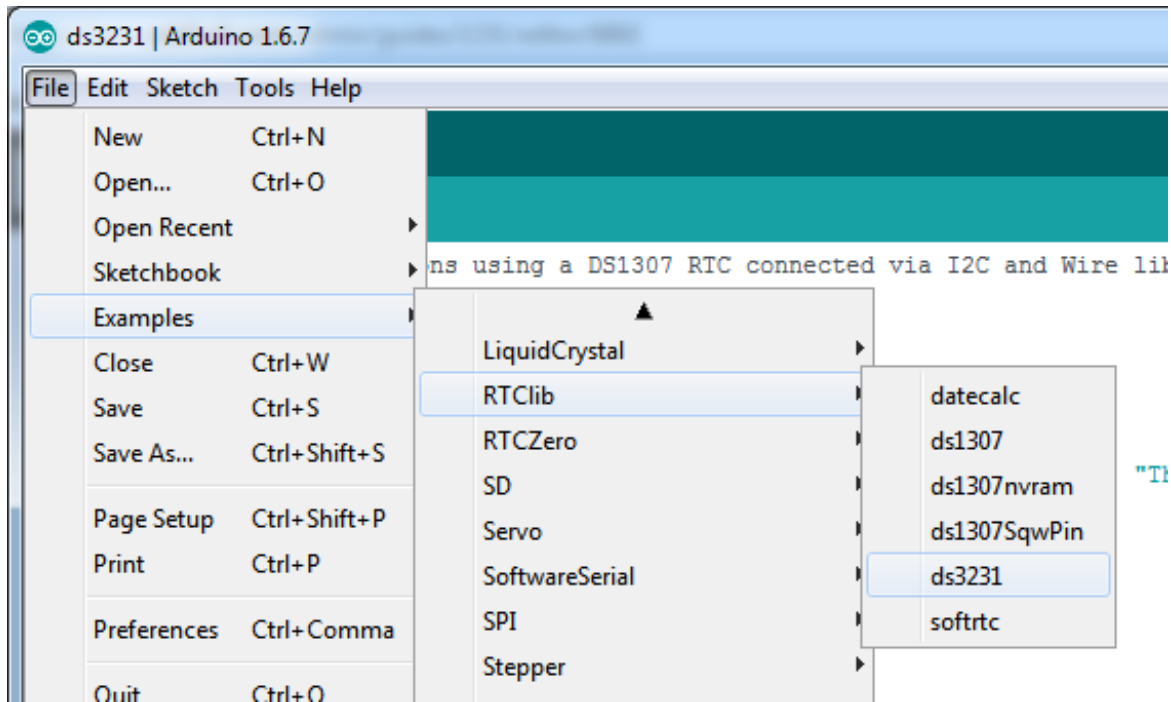
The first thing we'll demonstrate is a test sketch that will read the time from the RTC once per second. We'll also show what happens if you remove the battery and replace it since that causes the RTC to halt. So to start, remove the battery from the holder while the Arduino is not powered or plugged into USB. Wait 3 seconds and then replace the battery. This resets the RTC chip.



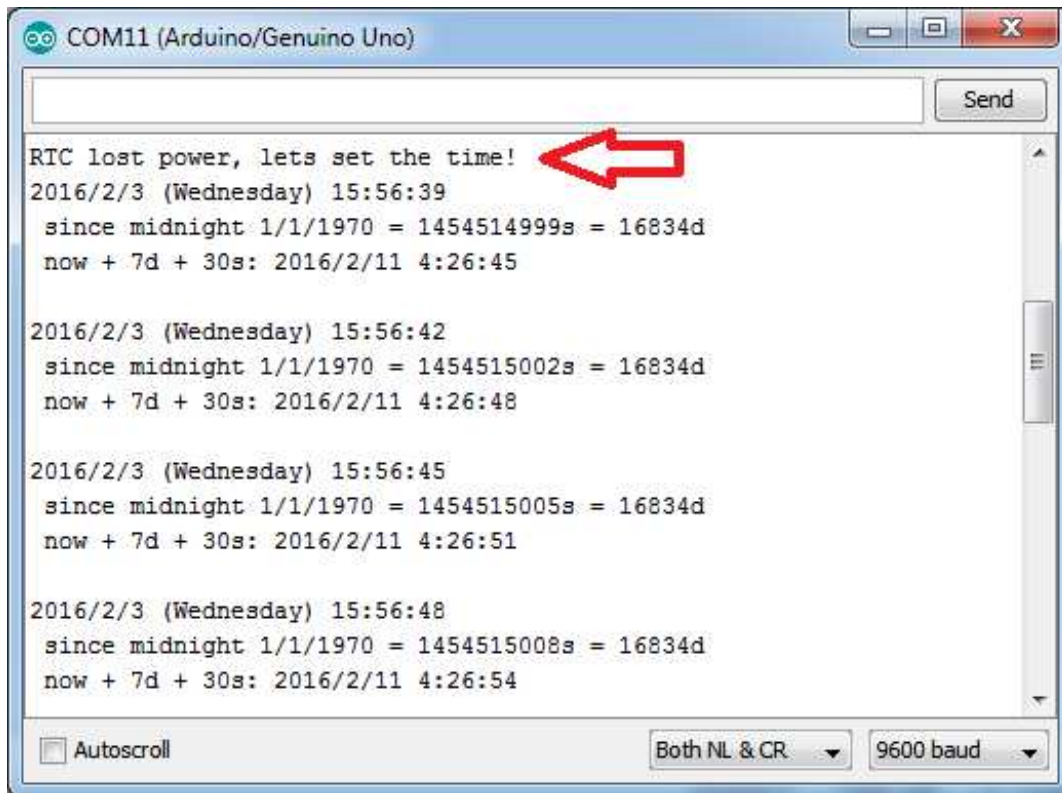


## Load Demo

Open up **File->Examples->RTClib->ds3231** and upload to your Arduino wired up to the RTC

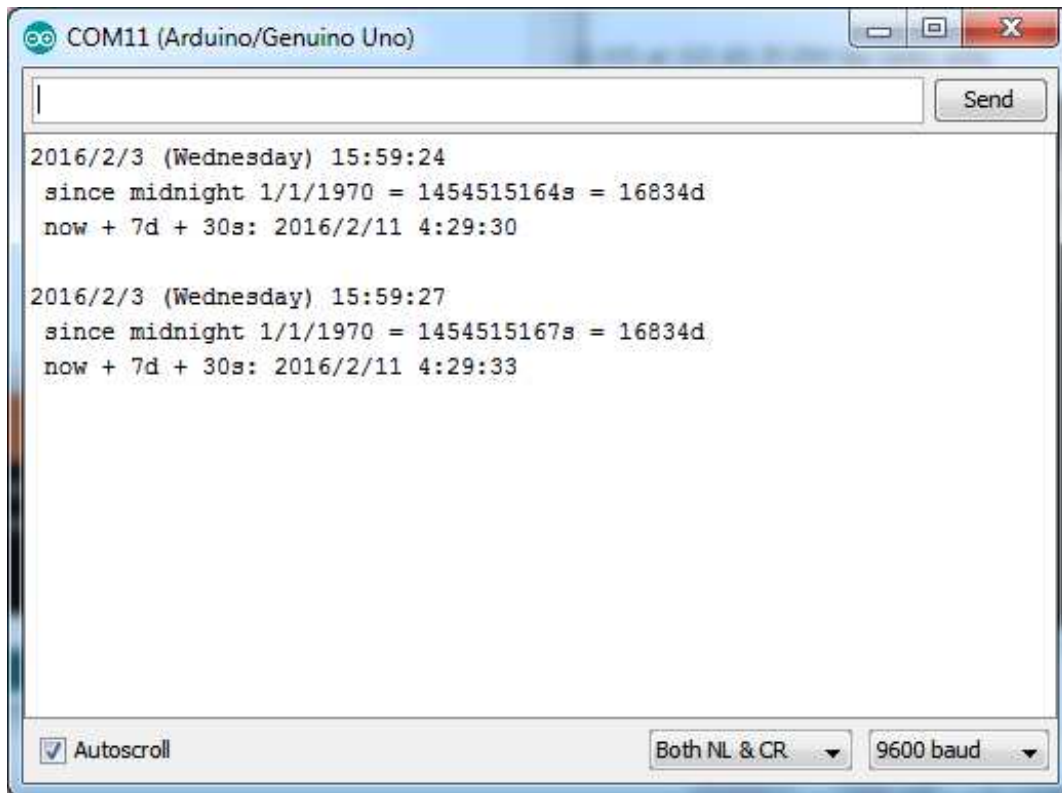


Upload to your Arduino and check the serial console @ 9600 baud. After a few seconds, you'll see the report that the Arduino noticed this is the first time the DS3231 has been powered up, and will set the time based on the Arduino sketch.



Unplug your Arduino plus RTC for a few seconds (or minutes, or hours, or weeks) and plug back in.

Next time you run it you won't get the same "RTC lost power" message, instead it will come immediately and let you know the correct time!



The screenshot shows the serial monitor window for COM11 (Arduino/Genuino Uno). The window title is "COM11 (Arduino/Genuino Uno)". The output text is as follows:

```
2016/2/3 (Wednesday) 15:59:24
  since midnight 1/1/1970 = 1454515164s = 16834d
  now + 7d + 30s: 2016/2/11 4:29:30

2016/2/3 (Wednesday) 15:59:27
  since midnight 1/1/1970 = 1454515167s = 16834d
  now + 7d + 30s: 2016/2/11 4:29:33
```

At the bottom of the window, there are controls: a checked "Autoscroll" checkbox, a dropdown menu set to "Both NL & CR", and a dropdown menu set to "9600 baud".

From now on, you won't have to ever set the time again: the battery will last 5 or more years.

## Reading the Time

Now that the RTC is merrily ticking away, we'll want to query it for the time. Let's look at the sketch again to see how this is done.

```
void loop () {
  DateTime now = rtc.now();

  Serial.print(now.year(), DEC);
  Serial.print('/');
  Serial.print(now.month(), DEC);
  Serial.print('/');
  Serial.print(now.day(), DEC);
  Serial.print(" (");
  Serial.print(daysOfTheWeek[now.dayOfTheWeek()]);
  Serial.print(") ");
  Serial.print(now.hour(), DEC);
  Serial.print(':');
  Serial.print(now.minute(), DEC);
```

```
Serial.print(':');  
Serial.print(now.second(), DEC);  
Serial.println();
```

There's pretty much only one way to get the time using the RTCLib, which is to call **now()**, a function that returns a `DateTime` object that describes the year, month, day, hour, minute and second when you called **now()**.

There are some RTC libraries that instead have you call something like **RTC.year()** and **RTC.hour()** to get the current year and hour. However, there's one problem where if you happen to ask for the minute right at **3:14:59** just before the next minute rolls over, and then the second right after the minute rolls over (so at **3:15:00**) you'll see the time as **3:14:00** which is a minute off. If you did it the other way around you could get **3:15:59** - so one minute off in the other direction.

Because this is not an especially unlikely occurrence - particularly if you're querying the time pretty often - we take a 'snapshot' of the time from the RTC all at once and then we can pull it apart into **day()** or **second()** as seen above. It's a tiny bit more effort but we think it's worth it to avoid mistakes!

We can also get a 'timestamp' out of the `DateTime` object by calling **unixtime** which counts the number of seconds (not counting leapseconds) since midnight, January 1st 1970

```
Serial.print(" since midnight 1/1/1970 = ");  
Serial.print(now.unixtime());  
Serial.print("s = ");  
Serial.print(now.unixtime() / 86400L);  
Serial.println("d");
```

Since there are  $60*60*24 = 86400$  seconds in a day, we can easily count days since then as well. This might be useful when you want to keep track of how much time has passed since the last query, making some math a lot easier (like checking if it's been 5 minutes later, just see if **unixtime()** has increased by 300, you don't have to worry about hour changes).

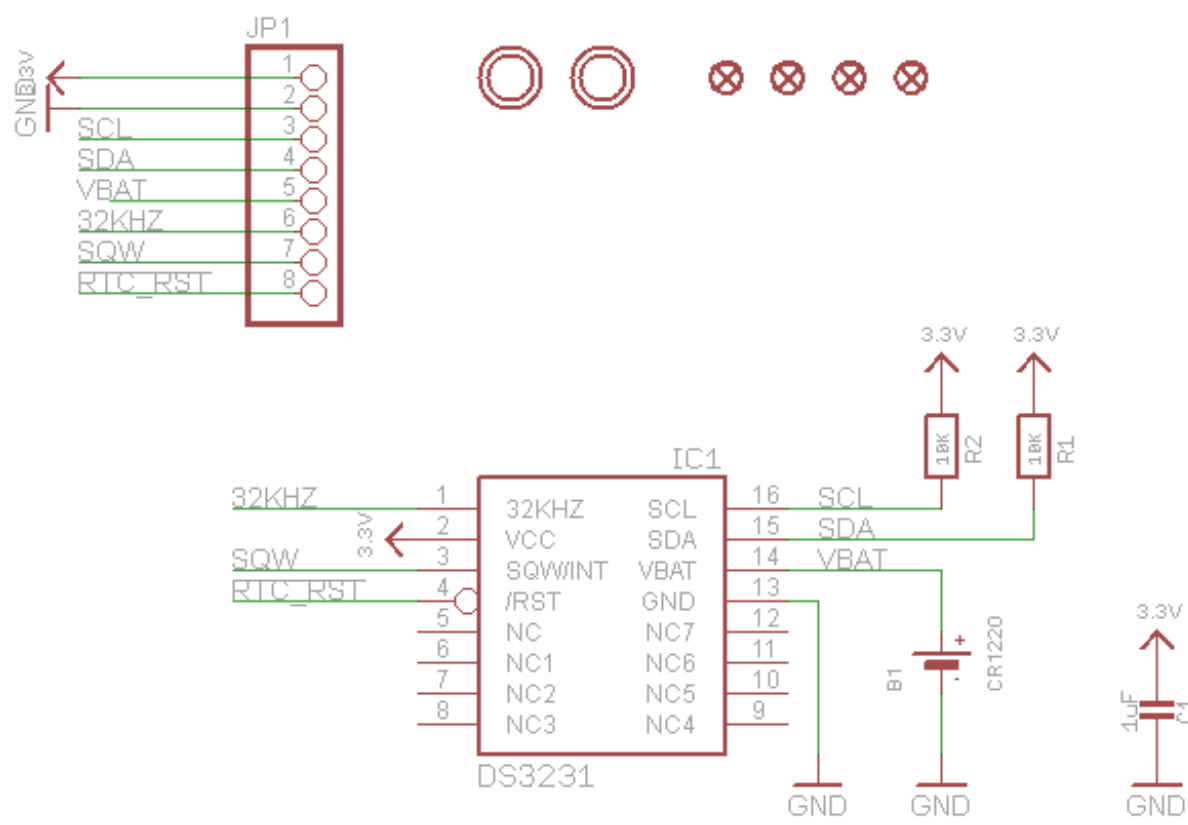


# Downloads

# Datasheets &c

- [Maxim product page for the DS3231](http://adafru.it/ldy) (http://adafru.it/ldy)
- [Datasheet](http://adafru.it/ldA) (http://adafru.it/ldA)
- [EagleCAD PCB files on GitHub](http://adafru.it/ohE) (http://adafru.it/ohE)
- [Fritzing object available in the Adafruit Fritzing Library](http://adafru.it/aP3)(http://adafru.it/aP3)

# Schematic



# Fabrication Print

Dims in inches

