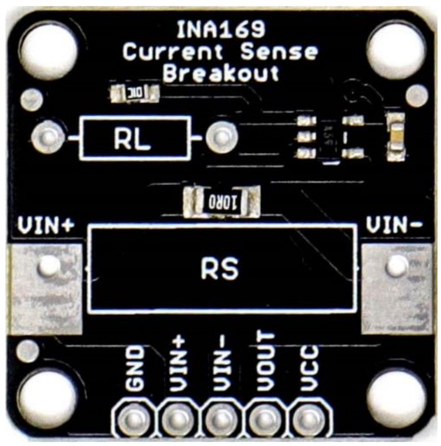
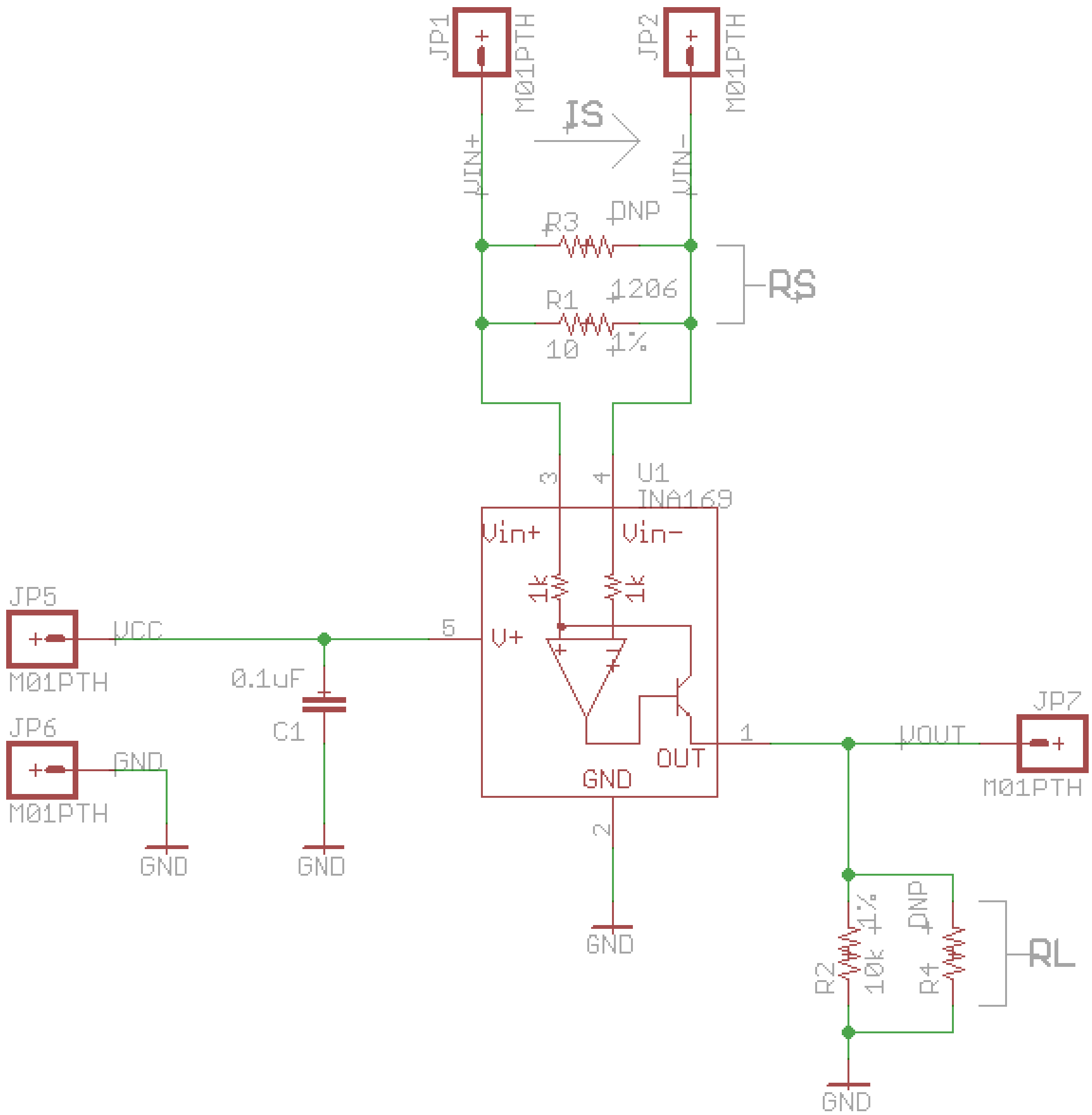
SmartElex Current Sensor Breakout - INA169



The INA169 is a "high-side current monitor," which means that you place a resistor (a "shunt resistor") on the positive power rail and the INA169 measures the voltage drop across that resistor. The INA169 outputs a small current based on the measured voltage drop. If you place a resistor from the output of the INA169 to ground, you can measure the voltage at the output. With some basic math, the output voltage gives you the current through the shunt resistor.

Board Overview

Take a look at the schematic, and you will notice that the breakout board consists of a shunt resistor (R_S), the INA169 chip, and an output resistor (R_L). While R_S and R_L might appear to have 2 resistors, only one is populated on the board. If you would like to change the values of the resistors, you can replace them or put another resistor in parallel.



INA169 Current Sensing Breakout Schematic

As current passes from V_{IN+} through R_S to V_{IN-}, it creates a voltage drop across R_S. The op-amp inside of the INA169 chip measures the difference between the V_{IN+} and V_{IN-} voltages and outputs a voltage based on that difference. The output of the op-amp is amplified through the internal transistor, which sources a current out of the INA169 chip. As that current passes through R_L to ground, a voltage level is generated at V_{OUT}.

IMPORTANT: The INA169 is configured to measure DC only. The VIN+ pin must be at a higher potential than the VIN- pin, which means that the INA169 cannot measure AC.

Measuring Current

The voltage at V_{OUT} can be measured using an oscilloscope or an analog-to-digital converter. A bit of math is needed to convert to the source current (I_S):

$$I_S = \frac{V_{OUT} \times 1k\Omega}{R_S \times R_L}$$

I_S is the current we want to measure.

V_{OUT} is the voltage we measured at the output of the INA169.

1kΩ is a constant resistance value we need to include due to the internals of the INA169.

R_S is the value of the shunt resistor. If you do not modify the board, then this is set at 10Ω.

R_L is the value of the output resistor. If you do not modify the board, then this is set at 10kΩ.

Example

For example, let's say that you hook up the board and you measure 2.8V at V_{OUT}. Plugging this into our equation, we would get:

$$I_S = \frac{2.8V \times 1k\Omega}{10\Omega \times 10k\Omega} = 0.028A$$

This shows that you have 0.028A (or 28mA) flowing through your line.

The Pinout

GND should be connected to ground of the circuit you are trying to measure

VIN+ needs to be connected to the positive side of the source (e.g. battery, output pin, etc.)

VIN- needs to be connected to the positive side of the load (e.g. VCC on Arduino, positive side of an LED, etc.)

VOUT is the measured output and should be connected to something that measures voltage levels, such as a multimeter, oscilloscope, or an Arduino ADC pin

VCC is the supply power to the INA169, which needs to be connected to 3.3V, 5V, etc. This can be anywhere from 0 to 75V. Note that the V_{OUT} range depends on the voltage supplied by VCC.

In addition to the pins on VIN+ and VIN-, the board also has two large pads around R_S, which are capable of taking alligator clips should you want to have a temporary hookup. Note that GND and VCC will still need to be connected for the board to function.

Modifying Functionality

The INA169 cannot sense any differences across R_S greater than 500mV, and the output error increases once the voltage across R_S dips below 35mV. If you include the voltage drop across the internal transistor, this means that the default setup of the breakout board is limited to measuring a current range of about 3.5mA to 35mA.

If you would like to change that range, R_S and R_L can be replaced with resistors of different values. R_S can be removed and replaced with another resistor fairly easily. R_L is a bit more difficult as it is a small, surface mount resistor. Changing either of the resistors changes the equation from above.

With R_L at 10kΩ, changing R_S gives us the following ranges:

R_S	Current Sense Range
10Ω	3.5mA - 35mA
1Ω	35mA - 350mA
0.1Ω	350mA - 3.5A

IMPORTANT: Be careful with the power rating on the resistor! If you choose a 0.1Ω resistor for R_S and expect to see 3.5A through it, this can result in 1.2W of heat being generated - way too much for your average ¼W resistor! You will need a resistor that can handle at least 2W. The following power resistors are recommended:

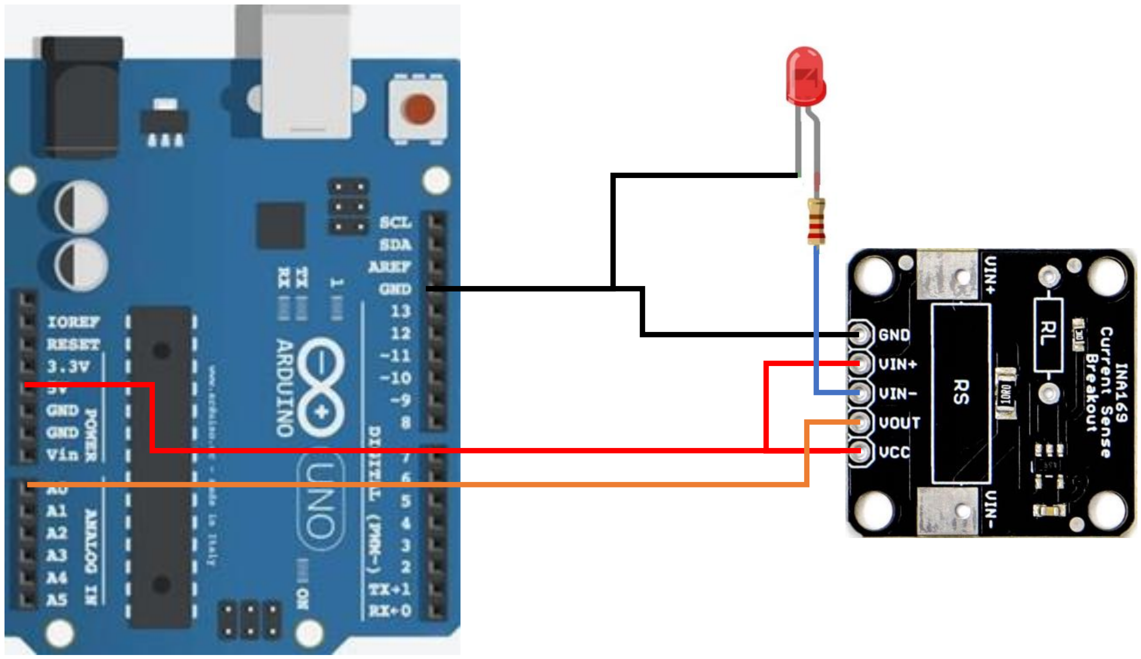
- Ohmite 1Ω 1% 3W
- Ohmite 0.1Ω 1% 3W

Hookup Example

Assembly

You will need to solder either wires or straight male headers to the 5 header holes on the board. If you need to measure over 35mA, you will need to desolder the RS resistor and solder a lower value (e.g. 1Ω), higher power (e.g. 3W) resistor to the holes around RS.

Connecting the INA169 Breakout Board



Arduino	INA169
5V	VCC & VIN+
GND	GND
A0	VOUT

As shown in the diagram, connect the Arduino 5V to the INA169 VCC and the Arduino GND to the INA169 GND. To read the output voltage level, we need to run a jumper cable from the Arduino A0 to the INA169 VOUT pin.

Use a jumper wire to connect the INA169 VCC and VIN+ pins, as we want to power the LED with the Arduino 5V. If you use a different power source (other than the Arduino 5V or 3.3V) through VIN+ and VIN-, make sure you connect the ground of the power source to the ground of the INA169 board. Just ensure that the voltage level as measured from VIN+ to ground does not exceed 60V. Bad things will happen to the board if you do.

Connect a 330Ω resistor from the INA169 VIN- to the anode of the LED and a jumper wire from the LED's cathode to GND.

If you want to measure the current going to something else, you can use alligator clips on the bare metal pads around RS. Make sure that the INA169 board is inline with the positive power rail and that the INA169 GND is connected to the target's GND.

Example Code:

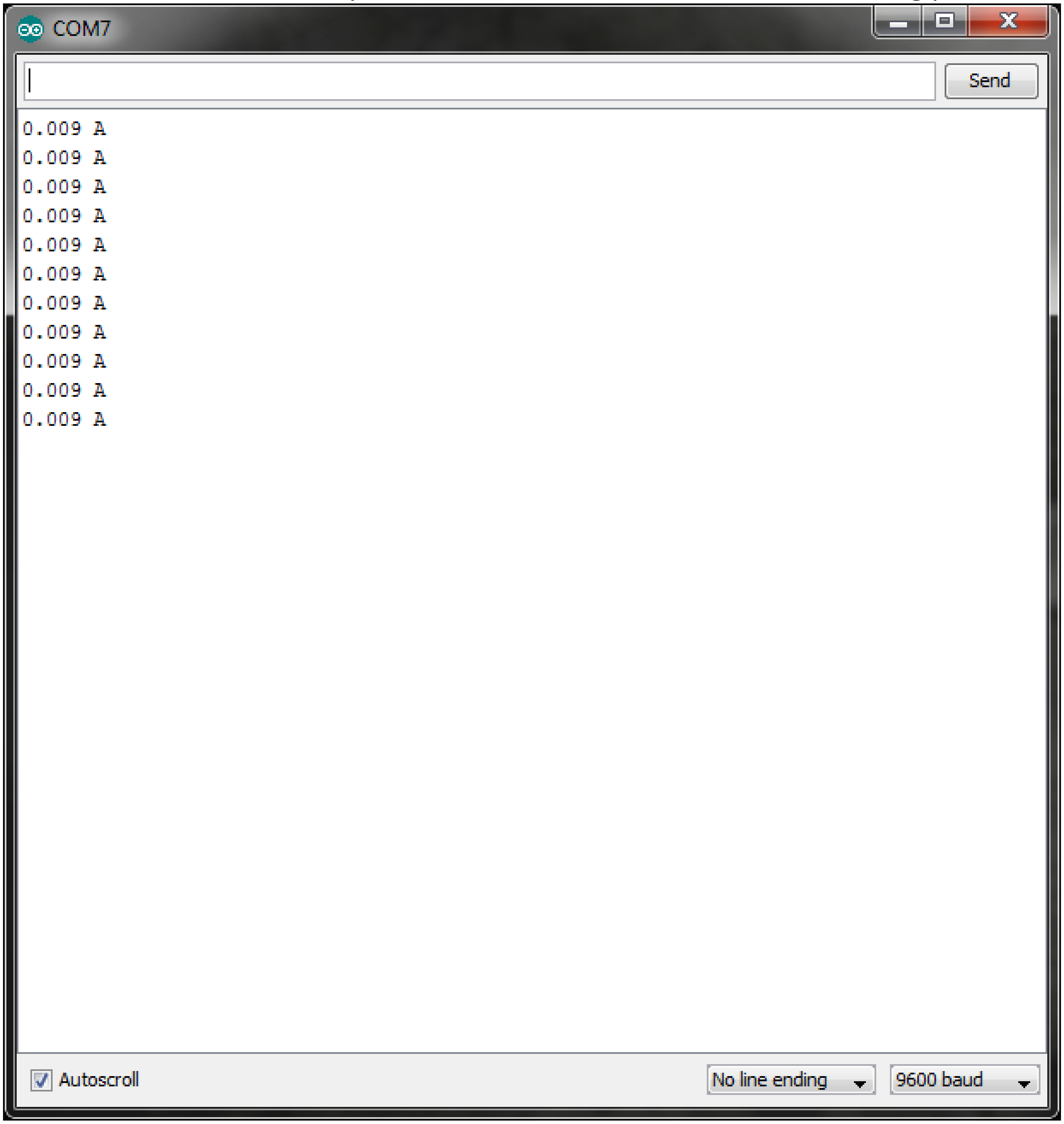
```
/*
 Description:

 This sketch shows how to use the SparkFun INA169 Breakout
 Board. As current passes through the shunt resistor (Rs), a
 voltage is generated at the Vout pin. Use an analog read and
 some math to determine the current. The current value is
 displayed through the Serial Monitor.

 Hardware connections:

 Uno Pin    INA169 Board    Function

 +5V        VCC             Power supply
 GND        GND             Ground
 A0         VOUT            Analog voltage measurement

 VIN+ and VIN- need to be connected inline with the positive
 DC power rail of a load (e.g. an Arduino, an LED, etc.).

 */

// Constants
const int SENSOR_PIN = A0;  // Input pin for measuring Vout
const int RS = 10;          // Shunt resistor value (in ohms)
const int VOLTAGE_REF = 5;  // Reference voltage for analog read

// Global Variables
float sensorValue;   // Variable to store value from analog read
float current;       // Calculated current value

void setup() {

  // Initialize serial monitor
  Serial.begin(9600);

}

void loop() {

  // Read a value from the INA169 board
```

```
  sensorValue = analogRead(SENSOR_PIN);

  // Remap the ADC value into a voltage number (5V reference)
  sensorValue = (sensorValue * VOLTAGE_REF) / 1023;

  // Follow the equation given by the INA169 datasheet to
  // determine the current flowing through RS. Assume RL = 10k
  // Is = (Vout x 1k) / (RS x RL)
  current = sensorValue / (10 * RS);

  // Output value (in amps) to the serial monitor to 3 decimal
  // places
  Serial.print(current, 3);
  Serial.println(" A");

  // Delay program for a few milliseconds
  delay(500);

}
////////////////////////////////////////END///////////////////////////////////////////
```

Plug in the Arduino and upload the code. You should see the LED light up as soon as you apply power.

Select the appropriate board (Arduino Uno in this case) from Tools->Board and the correct COM port from Tools->Serial Port. Click the upload button, and wait for the program to be compiled and uploaded to the Arduino. Open the Serial Monitor from

Tools->Serial Monitor and you should see current measurements being printed.



If you are using a basic red LED, a 330Ω resistor, and a 5V supply, you should see 0.009A (9mA) on the Serial Monitor.

If we want to verify this reading, we can use a multimeter to measure the voltage across the 330Ω resistor. You should see around 3V across the resistor. Using Ohm's Law, we can calculate the current flowing through the resistor and LED is 0.00909 A, which matches the reading from the INA169.