Current Meter Project

30-Jul-2023 TEP

I did this project to measure the current drawn by various electronics projects. While I have a nice multi-meter, it gives very erratic readings when measuring modest current in digital circuits. The meter I designed provides stable readings with 1mA resolution over a range of +/-2.5A. Stability is achieved with filtering on the analog from end and averaging hundreds of ADC readings on the digital side. The packaging includes binding post input connectors that are convenient for connection to a breadboard. Power can be provided from a 3.7V Lithium-Ion battery, with built in charger, or from USB. With USB power, common mode voltage can range from 0V to 30VDC, and when running from battery the common mode range is virtually unlimited.

The front end consists of an ON Semiconductor NCS199A2R current shunt monitor, which provides a voltage gain of 100, and a 0.010 Ohm shunt resistor. This combination provides a 1V/Amp transfer function. This voltage is digitized using an ADS1115 ADC module from Adafruit. When operated in differential input mode this gives a signed 16 bit output. I use a precision 2.5V reference to offset the ADC input which gives an input range of +/-2.5V. The ADC operates in continuous measurement mode, providing 860 measurements per second. I average 430 measurements to provide 2 readings per second.

Signal and display processing is done on an Arduino style Nano board with an Atmel/Microchip Technology ATMEGA328P processor. The display is an Adafruit 4 digit, 7 segment LED module with an additional custom LED module to provide the sign. The battery is a single 18650 Lithium-Ion battery with a generic charging module that includes a TP4056 charger IC and a DW01A battery protector IC. The 3.7V battery output is converted to 5V for the electronics using an MT3608 based DC-DC boost converter. The software is developed under the Arduino 1.8.19 IDE and is written using the Arduino C++ variant.

When connected to a computer via USB a serial console is available that provides functions to calibrate the meter and capture readings as text on the computer. The USB-Serial port operates at 115200 Baud. Available commands are as follows:

```
H - Display this help menu
G - Set gain (scale factor)
! (shift 1) - Set gain to 1.0
O - Capture offset
) (shift 0) - Set offset to 0
P - Display Parameters
S - Toggle serial logging
K - Kick the ADC if it's not running
```

G – Allows setting a gain multiplier that can be used to trim the current scaling. The default value is 1.000. On my system I think I soldered the sense wires to close to the shunt body so I need to use a gain of 1.050 to compensate.

O – Is used to adjust the offset parameter so the meter reads 0.000 with no input. This could also be used to make measurements relative to a reference current. For example, how much extra current does this LED use?

The gain and offset parameters are stored in the Nano's EEPROM memory so these only need to be set once.

K – This command will restart the ADC if it gets stuck. This command should not be needed and is only included as a digital talisman.

S – This will direct readings to the USB serial output twice per second. The log is formatted as a comma delimited record so it can easily be imported into a spreadsheet.

```
ADC nom,   Amps   ,   High   ,   Low    ,   Delta
=======,   ====   ,   ====   ,   ===    ,   =====
   185 ,   0.0243 ,   0.0247 ,   0.0241 ,   0.0007
   185 ,   0.0243 ,   0.0246 ,   0.0241 ,   0.0005
   185 ,   0.0243 ,   0.0246 ,   0.0241 ,   0.0005
   185 ,   0.0243 ,   0.0246 ,   0.0241 ,   0.0005
```

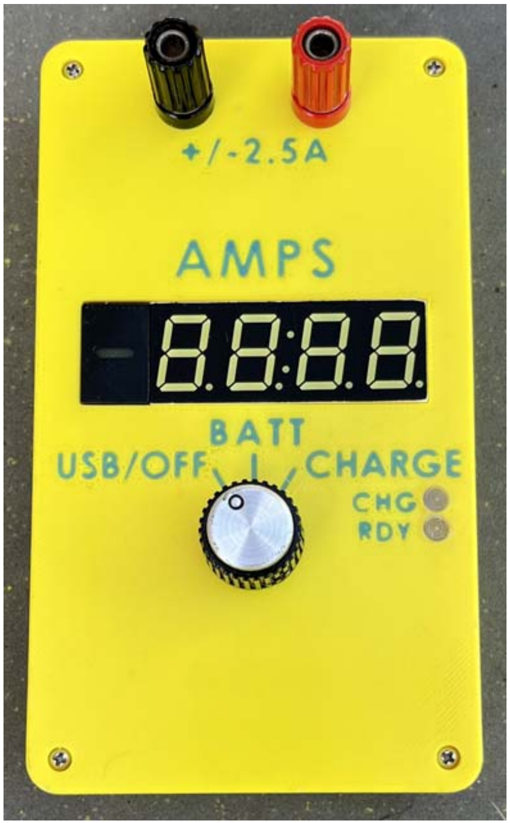
ADC nom is the average ADC value. This value is offset corrected but not gain corrected.

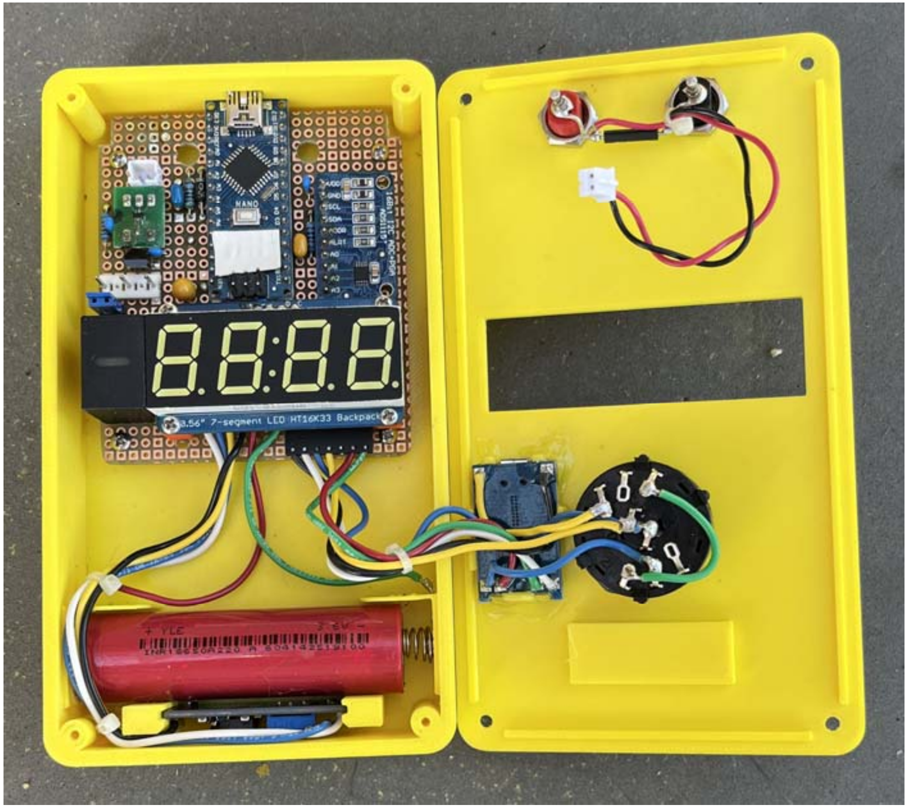
Amps is the measured current in Amps. This is the average of 430 readings over ½ second and is offset and gain corrected.

High is the highest current reading during the ½ second period and is gain and offset corrected.

Low is the lowest current reading during the ½ second period and is gain and offset corrected.

Delta is the difference between High and Low.





See https://imgur.com/gallery/Z087rDk for additional photos.