MetaShunt V2 User Guide

User Guide Version 1.0, March 2025

NOTE: THIS IS THE USER GUIDE FOR METASHUNT V2, NOT VERSION 2 OF THE USER GUIDE FOR THE ORIGINAL METASHUNT

MetaShunt V2 is an electronic instrument designed for high-bandwidth, very high dynamic range measurements of the instantaneous current and power and accumulated energy use of low-power and IoT devices from 10s of nanoamps and 100s of milliamps.

MetaShunt V2 leverages a simple idea - by quickly and accurately measuring the voltage across a current shunt resistor and engaging additional shunt stages when needed, MetaShunt V2 ensures that it can provide accurate current measurement across a range of approximately 10,000,000:1 without providing significant voltage burden. This range of current is specifically targeted for use with ultra-low power and IoT systems. By measuring current rapidly over time, the total energy use during a given portion of your code can be determined. MetaShunt V2 acts as a virtual ground for your device, so that you can use your battery. MetaShunt V2 can also provide 3.3V or 5V to the device under test if desired.

A version of MetaShunt V2 includes an LCD screen on which long-term statistics about the DUT are shown, such as total on-time in seconds and the total “current x time” used over that time (e.g. mAh). The total “current x time” measurement is calculated and accumulated using the same high rate and high dynamic range measurements as MetaShunt V2 uses for short-term measurements when connected to an external computer over USB.

More information is available on the Hackaday.io page here:
https://hackaday.io/project/193628-metashunt-high-dynamic-range-current-measurement

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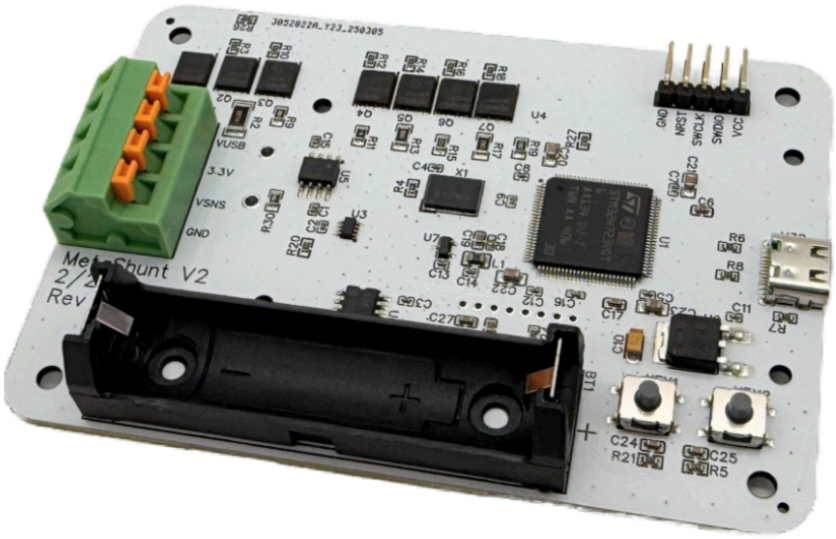
MetaShunt V2 Hardware Versions

MetaShunt V2 is currently sold in two versions, as described below. For all versions, you will need an Alkaline AA battery and a quality USB-C cable (both not included). Note that poor quality USB cables are prevalent and charging-only cables exist. MetaShunt V2 may not work as expected without a high-quality cable. As a general rule, if the cable came with your phone or other quality electronic device, it will probably work with MetaShunt V2.

Version A: Base MetaShunt V2

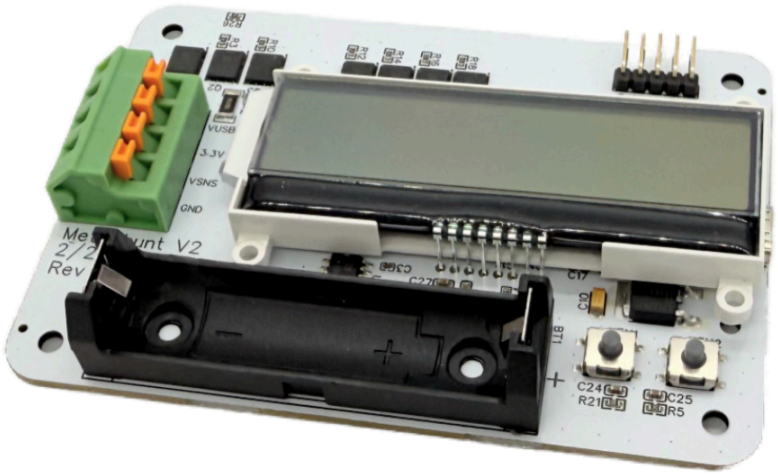
This version of MetaShunt comes as shown in the image below. Calibration has been performed so that MetaShunt V2 is ready to use “out-of-the-box.” While all efforts are made to ensure accurate calibration, no guarantees are made as to the accuracy of calibration. If you need more assurance of calibration, please reach out to discuss options.



Version B: MetaShunt V2 LT

This version of MetaShunt comes as shown in the image below. It includes all the features of the Base MetaShunt V2, but also includes a mounted LCD screen which provides a real-time readout of current and Long Term (LT) data such as total time of operation and total units of “current x time” used (e.g. mAh or nAh). This data can be reset using an onboard button. This version can be used for high-speed measurement of short events, where you would connect to your computer to measure current and optimize your DUT. It also can be used for long-term

monitoring of your DUT, over days, weeks, or months. When connected to your DUT, MetaShunt V2 LT measures current with the same high rate and accuracy as always, and accurately accumulates data about it over time. If you want to verify that your DUT is not locking up or occasionally consuming much more energy than expected, this version is right for you! It does not need to be connected to a computer when these measurements are occurring - a battery pack or USB-C wall adapter are acceptable. Calibration has been performed so that MetaShunt V2 is ready to use “out-of-the-box.” While all efforts are made to ensure accurate calibration, no guarantees are made as to the accuracy of calibration. If you need more assurance of calibration, please reach out to discuss options.



Specifications

Specification	Typical Value	Notes
Maximum Burden Voltage	35mV	This is the maximum voltage across the “shunt” in MetaShunt V2 before the gain stages change.
Continuous Data Output Rate	>5 kHz	
Maximum Burst Data Output Rate	127.5 kHz	Up to the maximum, in resolution of 500Hz. Not all rates may be met exactly, and MetaShunt V2 will bias towards providing burst measurements faster than requested if it cannot meet the requested rate exactly.

Burst Datapoints	37,500	This many measurements are recorded into a buffer on MetaShunt V2, then sent over the USB interface. This allows for faster measurements of key events and can be triggered immediately or on rising or falling current past a configured threshold. See the Use section for more information.
Control Loop Rate	>700 kHz	Rate at which burden voltage is measured and shunt gain stages are changed
Maximum Current Measured	500mA	Higher currents up to ~1A are not expected to damage MetaShunt but have not been tested. Proceed at your own risk.
Resolution	0.1nA from 0.5nA to 0.35uA 1nA from 0.35uA to 3.5uA 10nA from 3.5uA to 35uA 0.1uA from 35uA to 350uA 1uA from 350uA to 3.5mA 10uA from 3.5mA to 35mA 100uA from 35mA to 350mA 550uA above 350mA	All values are approximate based on expected values of resistors in the measurement stage of MetaShunt V2. For reference use. May vary.
Size	100x70mm	

Calibration

MetaShunt V2 is calibrated prior to shipping to customers. Care is taken to ensure this calibration is accurate, but cannot be guaranteed at this time. We encourage you to compare MetaShunt V2 measurements against other trustworthy tools, especially in steady state operation, in order to build up confidence in MetaShunt V2's performance.

High-Power Stage

The high power stages (for measurements of ~50mA or more) must be calibrated in a different way. Resistors are to be connected between the 5V and VSNS pins of MetaShunt V2. These resistors should be >2W rated. One should be about 22 Ohm, and the other about 11 Ohm, which can be made with two 22 Ohm resistors in parallel. With a multimeter, measure the resistance of each resistor or pair of resistors. Also measure the voltage between 5V and VSNS. First, configure the MetaShunt V2 with known resistances. If you choose, you may use the metashunt_v2_cfg.json file found on the repo.

Second, connect the 22 Ohm resistor, plug in MetaShunt V2, and read data for about 20 seconds. Record the average current. Next, follow the same process for the 11 Ohm Resistor (or pair of 22 Ohm resistors). Plug all of these values into the top of the "metashunt_v2_hp_calibrate.py" Python script on the MetaShunt Interface repository. Then, run the script, providing the JSON file you configured to the. This script will calculate updated values for R_FET and R1. In some cases, due to the lumping of resistance in different ways, R1 could be calculated to be negative. That is OK. Put those into the JSON file in the appropriate places, and run the "metashunt_v2_configure.py" script again. Now your MetaShunt V2 is fully calibrated and ready to use!

Use

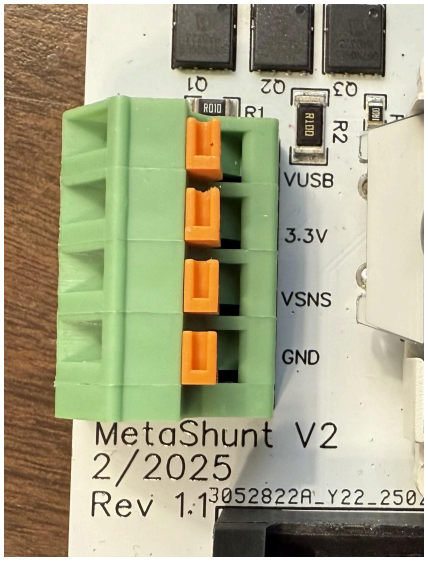
General Information and Recommendations

MetaShunt V2 is designed to be simple to use. First, insert the AA battery into its holder. This battery is required even if MetaShunt is powered by the USB cable. This battery does not power the device; it is used to provide a stable negative referenced voltage rail for an amplification circuit in MetaShunt V2's front end.

Please note that MetaShunt V2 is not isolated and the GND on the green connector is connected to the USB ground (and therefore, your computer). Do not use MetaShunt V2 on high voltage systems. All use of MetaShunt V2 is at your own risk. If connected the wrong way, your computer or other test equipment could be damaged. Always double check your connections. All responsibility for correct connection and use is on the user. MetaShunt V2 is not a dangerous device, but always be careful when working with electronics.

If you are powering your device from the 5V or 3.3V connectors on MetaShunt V2, connect your Device Under Test (DUT) to MetaShunt V2 before connecting MetaShunt V2 to your computer. The 5V rail comes directly from USB, which can typically range from 4.5-5.5V, so be aware that it may not be very close to 5V. The 3.3V (3V3) rail is regulated to 3.3V with a linear voltage regulator. Do not attempt to source more than 370mA from either the 5V or 3.3V rails. If more current is needed for the DUT, use MetaShunt V2 as a virtual ground with an external power supply or battery to provide the power.

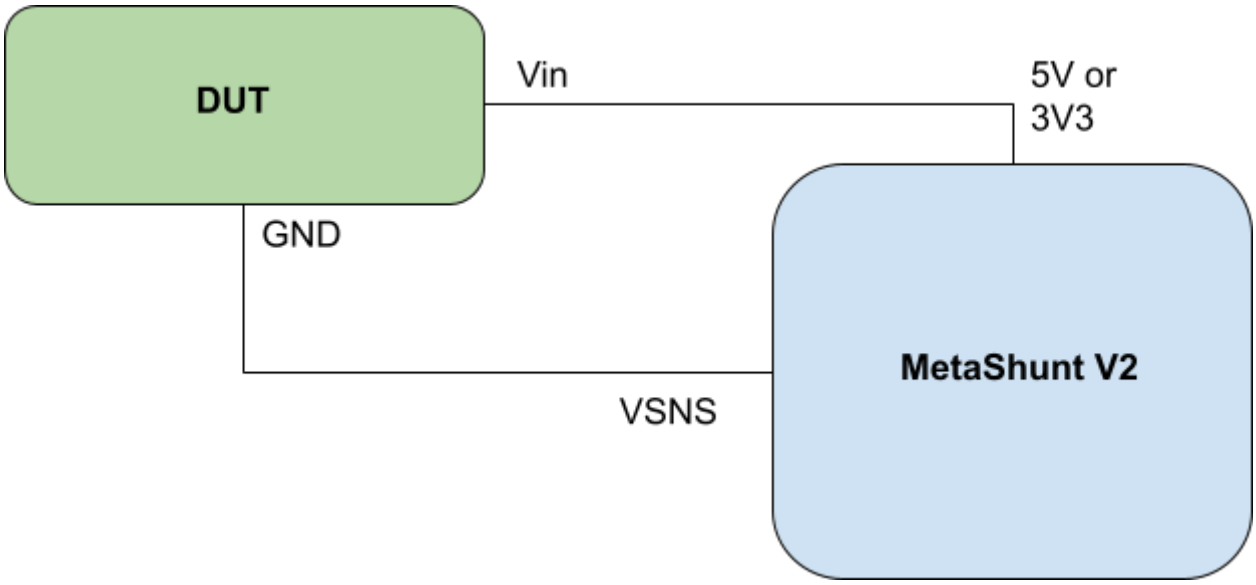
The VSNS pin on the green connector is the “virtual ground” that MetaShunt V2 provides. MetaShunt V2 maintains a small voltage between VSNS and GND, and uses this to measure the current of the DUT. Only positive current can be measured - negative current could damage MetaShunt V2. MetaShunt V2 is not intended for use with AC circuits.



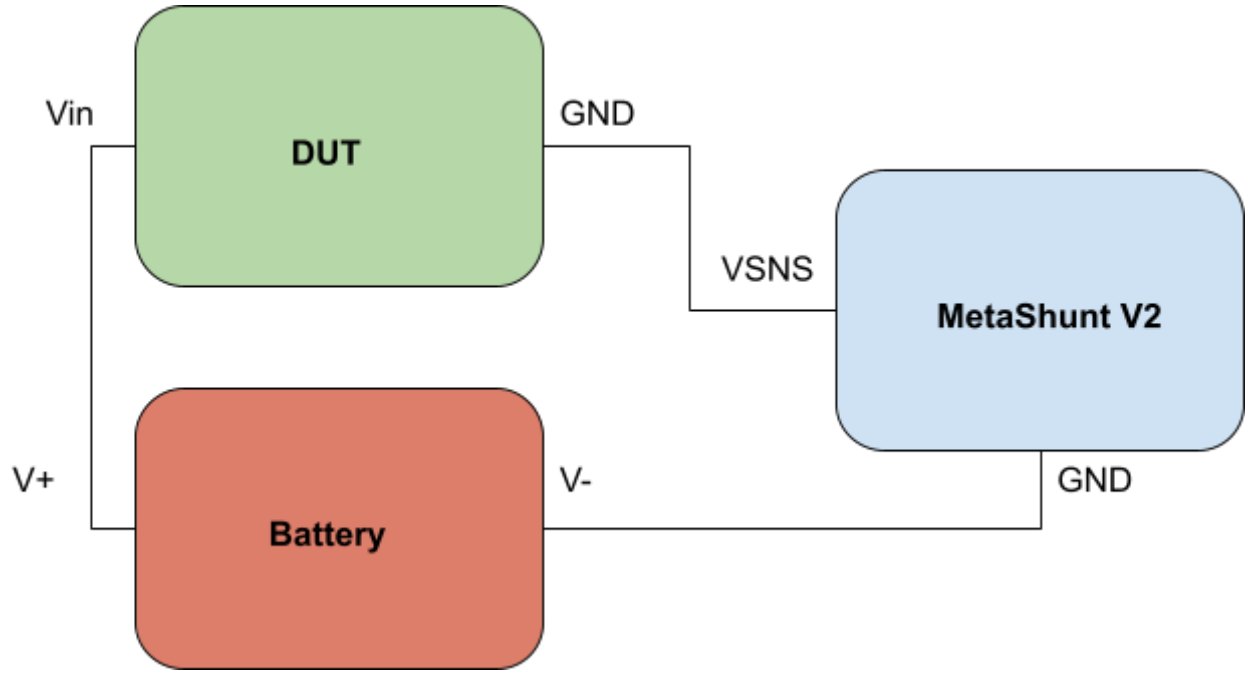
Connecting MetaShunt V2 to Your Device

There are several ways that MetaShunt V2 can be connected to your DUT.

First, if the DUT is powered by MetaShunt V2, connect the 5V or 3V3 output of MetaShunt V2 to the Vin of your DUT. Then, connect the GND of your DUT to the VSNS pin of MetaShunt V2.



Second, if your DUT is powered by a battery, the battery's negative terminal can be connected to MetaShunt V2 GND. The battery's positive terminal should be connected to the DUT Vin, and the DUT GND should be connected to MetaShunt V2 VSNS.



Taking Measurements

MetaShunt V2 communicates to your computer over USB serial using an open protocol. Open source, MIT licensed Python scripts for interfacing with MetaShunt are available on GitHub here:
https://github.com/jwachlin/metashunt_interface

To use, install Python and all required packages for the example. Connect MetaShunt V2 to your computer, and then use the scripts to collect data. For measurements (recording data and showing plots of the data), see the "metashunt_v2_realtime_interface.py" Python script in the "Realtime" Interface folder of the repository. To use, follow these rules:

python metashunt_v2_realtime_interface.py h --- Provides helpful information

python metashunt_v2_realtime_interface.py s [measurement_time_seconds] --- Get streaming data, by default for 10 seconds

python metashunt_v2_realtime_interface.py b rate_hz --- Burst reads 37,500 samples immediately

python metashunt_v2_realtime_interface.py b rate_hz r current_level_uA --- Burst reads 37,500 samples once current rises over the specified level

python metashunt_v2_realtime_interface.py b rate_hz f current_level_uA --- Burst reads 37,500 samples once current falls below the specified level

python metashunt_v2_realtime_interface.py b rate_hz s stage_index --- Burst reads 37,500 samples once system operates at specified stage index

python metashunt_realtime_v2_interface.py b rate_hz i --- Burst reads 37,500 samples once KEY2 button is pressed

For the MetaShunt V2 LT version, the KEY1 button is used to reset the “on time” and accumulated “current x time” data shown on the display. To reset both of those, simply press KEY1. For the Base version, the KEY1 button has no function at this time.

Version History

Version	Date	Changes
1.0	March 16, 2025	Initial version