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1 Description

Powermon is a device built around the Texas Instruments INA219 chip, that can simultaneously measure DC voltage and current and therefore calculate power. Powermon also measures run time and which allows it to calculate capacity (mAh) and energy (mWh) for testing batteries. The accuracy of voltage and current measurements is 0.5%. The current accuracy depends of course on the tolerance of the shunt resistor. It uses an internal 0.1 Ohm 1% shunt but external shunts can be connected to extend the current range. Powermon allows voltage and current measurements to be calibrated to get better than 0.5% if a suitable reference is available and stores the calibration values for different shunts.

The voltage range is limited to 0..26V DC maximum (without protection diodes). With protection diodes shown in the schematic, the voltage is limited to 0..20V. The voltage must never get negative or exceed the maximum voltage or you will damage the INA219 chip.

Specs:

Table 1: Basic specs

Voltage	0..20VDC in 10 mV resolution	Voltage is internally measured and

		recorded in 4mV resolution but displayed in 10 mV resolution
Current	0..±400mA in 12.5uA resolution 0..±800mA in 25uA resolution 0..±1.6A in 50uA resolution 0..±3.2A in 100uA resolution	(0.1 Ohm shunt) Burden voltage: 100 mV/A

Powermon calculates the following parameters which can be selected for displayed

Table 2: Parameters that are measured (or calculated) and displayed or recorded

Measurement	Display	Snapshot recording	Recording
Voltage (bus or load, selectable)	Always: upper left	Yes	Yes
Current	Always: upper right	Yes	Yes
Power	Selectable field	Yes	Yes
Capacity	Selectable field	Yes	Yes
Energy	Selectable field	Yes	Yes
Run time	Selectable field	Yes	Yes
Highest voltage	Selectable field	Yes	-
Average voltage	Selectable field	Yes	-
Lowest voltage	Selectable field	Yes	-
Highest current	Selectable field	Yes	-
Average current	Selectable field	Yes	-
Lowest current	Selectable field	Yes	-
Highest power	Selectable field	Yes	-
Average power	Selectable field	Yes	-
Lowest power	Selectable field	Yes	-
INA219 shunt voltage	Selectable field	Yes	-
INA219 bus voltage	-	Yes	-
INA219 power	-	Yes	
Sample count	-	-	Yes

2 Usage

2.1 Scenarios

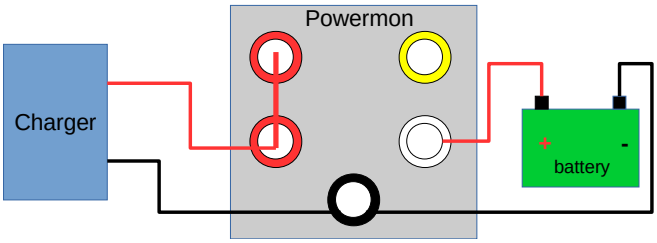

Figure 1: Measuring charge into a battery

Figure 1 shows the basic wiring to measure the charge flowing into a battery. The charge begins when the relay is (manually) activated. The LIMITS function allows the charge to be terminated when one of the thresholds is exceeded, for example run time.
To measure the voltage of the battery (and not the charger), SETUP-VOLTS must be set to V = LOAD

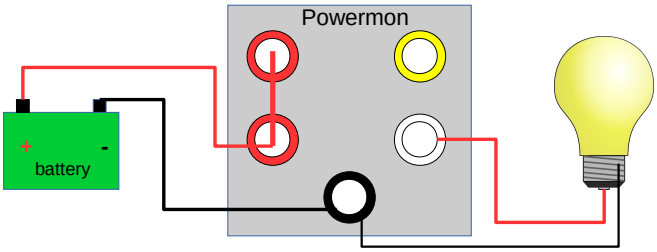

Figure 2: Measuring battery capacity

Figure 2 shows the basic setup to measure the capacity of a battery by discharging it into a load. The discharge begins when the relay is activated and can be automatically terminated when one of the LIMITS thresholds is reached, for example a minimum voltage. To measure the voltage of the battery (and not the load), SETUP-VOLTS must be set to V = SUPP.

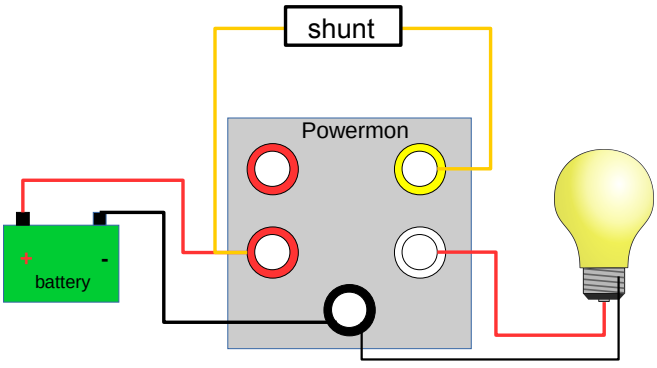

Figure 3: Using an external shunt

Figure 3 shows how to connect an external shunt resistor to extend the current range. The wire bridge between the two red terminals must be removed for this. The value of the external shunt must be selected in the SETUP-SHUNT menu and Powermon should have been calibrated before, using this external shunt.

Note that the max. current for the relay is 10A. For higher currents, the internal relay must be bypassed by connecting the load to the yellow terminal instead.

2.2 Run Menu

The standard display while doing measurements is the Run Menu. It also comes up automatically after power-up. While in the run menu, the display looks like Figure 4 below

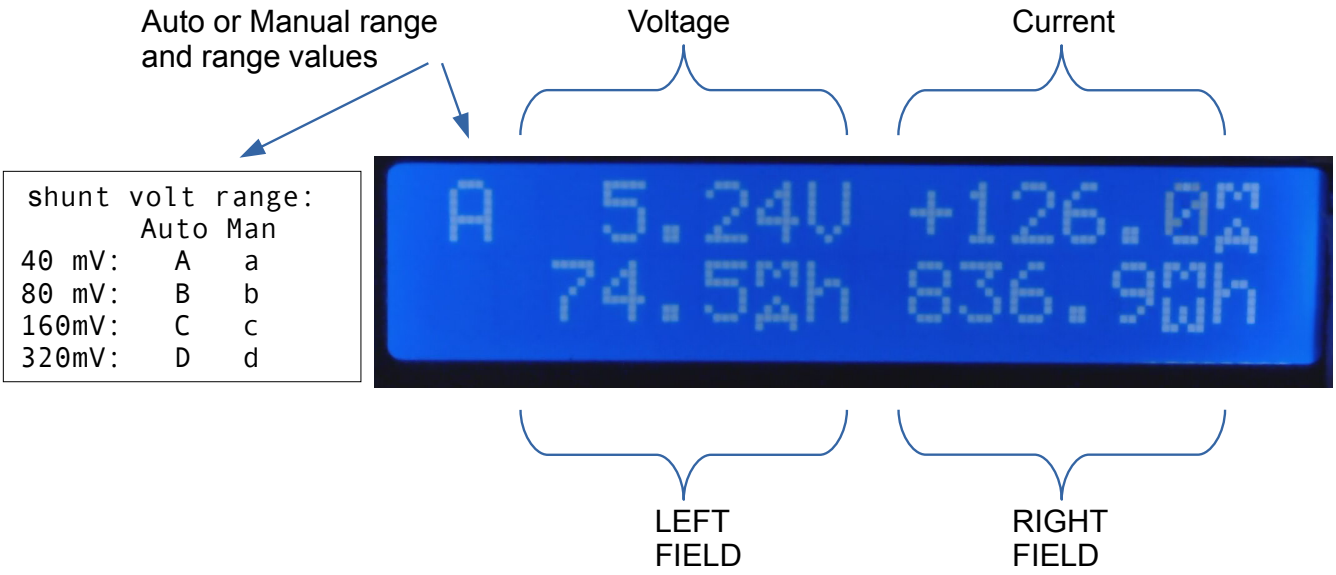

Figure 4: Run Menu display

The button assignments in the run menu are shown in Table 3

Table 3: Button assignments in the Run Menu

	PREV	SEL	NEXT	BACK
Short press	cycle through field options for the LEFT field	SNAPSHOT	cycle through field options for the RIGHT field	Return to main menu
Long press	In manual range: decrements range	Toggles between auto and manual range mode	In manual range: increments range in auto range: CLEAR	START

2.2.1 Fields:

Using short presses on the PREV or the NEXT buttons cycles the left or right fields through one of 16 options for display. These are:

(1) empty (nothing is shown)

(2) capacity (mAh)

(3) energy (mWh)

(4) power (W)

(5) Run time (hh:mm:ss)

(6) Highest voltage (V)

(7) Average voltage (V)

(8) Lowest voltage (V)

(9) Highest current (A)

(10) Average current (A)

(11) Lowest current (A)

(12) Highest power (W)

(13) Average power (W)

(14) Lowest power (W)

(15) Shunt voltage (mV)

(16) Status

2.2.2 Status:

An example of the status display selected in the left field is shown below:

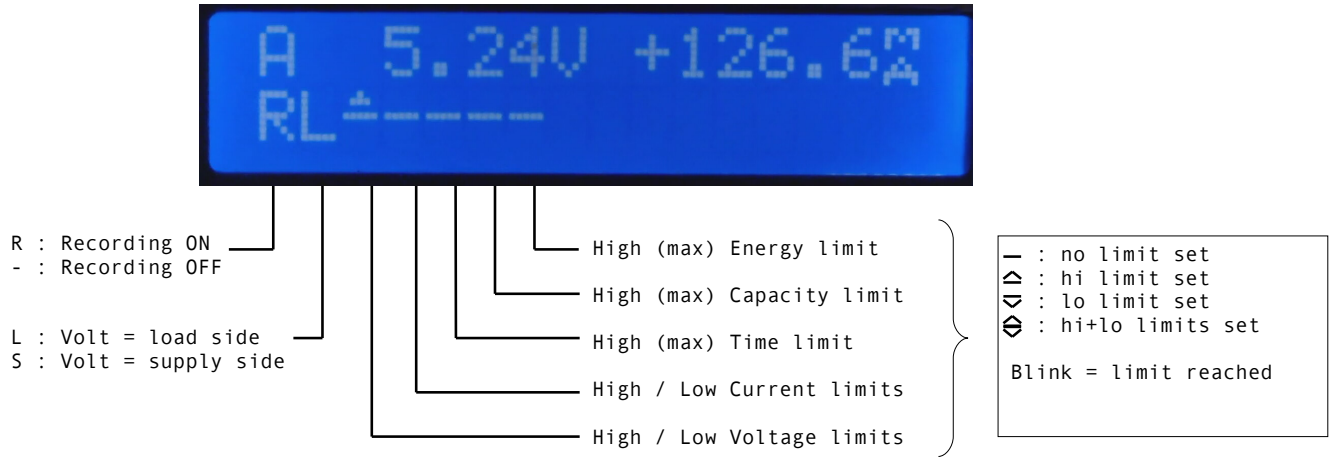

Figure 5: Run Menu display with status

2.2.3 SNAPSHOT:

When pressed, Powermon takes a snapshot of most of the parameters that are currently measured or calculated and adds them as a new line to the SNAPSHOT.TXT file. If the file does not exist, it is automatically created. Each line in the SNAPSHOT file starts with a unique date+time stamp. The file format is CSV, so it is possible to import the file into a spreadsheet.

2.2.4 CLEAR:

When pressed, CLEAR resets all calculated statistics values back to zero and restarts the run time counter.

2.2.5 START:

When pressed, START does three functions in one go:

(1) perform a CLEAR

(2) start Recording (if automatic recording is enabled)

(3) activate the relay

START is ideal to conduct measurements that perform recording such as discharge or charge of batteries

2.3 Other Menus

There are just two menu levels, the main menu and everything else. The normal way of operating is to select a sub menu from the main menu and when finished, a short press of the BACK button returns to the main menu. There is no way to go from one sub menu directly to another, so to go from LIMITS to

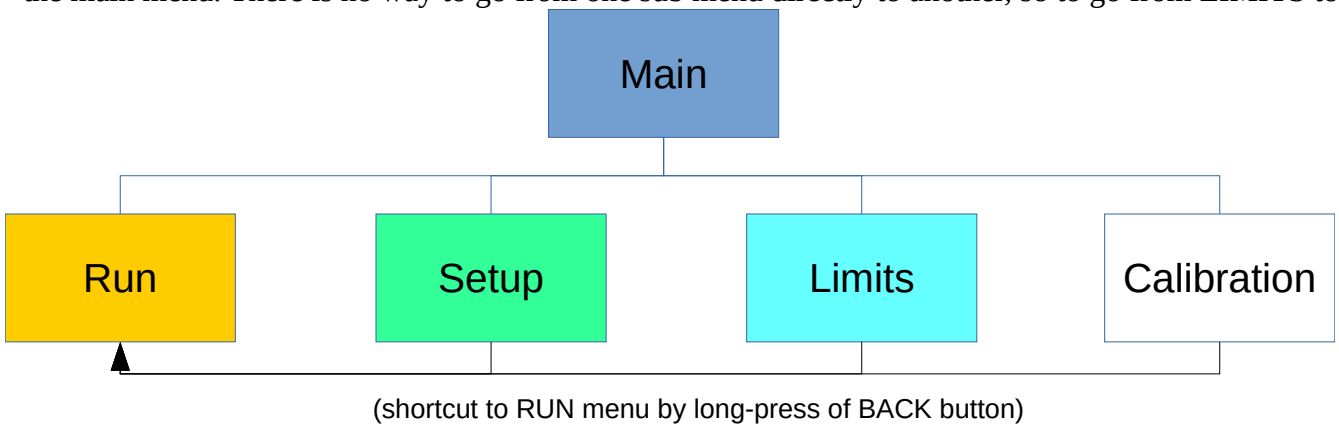

Figure 6: Menu levels

SETUP you must first return to MAIN. The one exception to that rule is that a long press of the BACK button in each sub menu goes directly to the RUN menu.

Figure 7 shows a detailed map of all sub menus and their options.

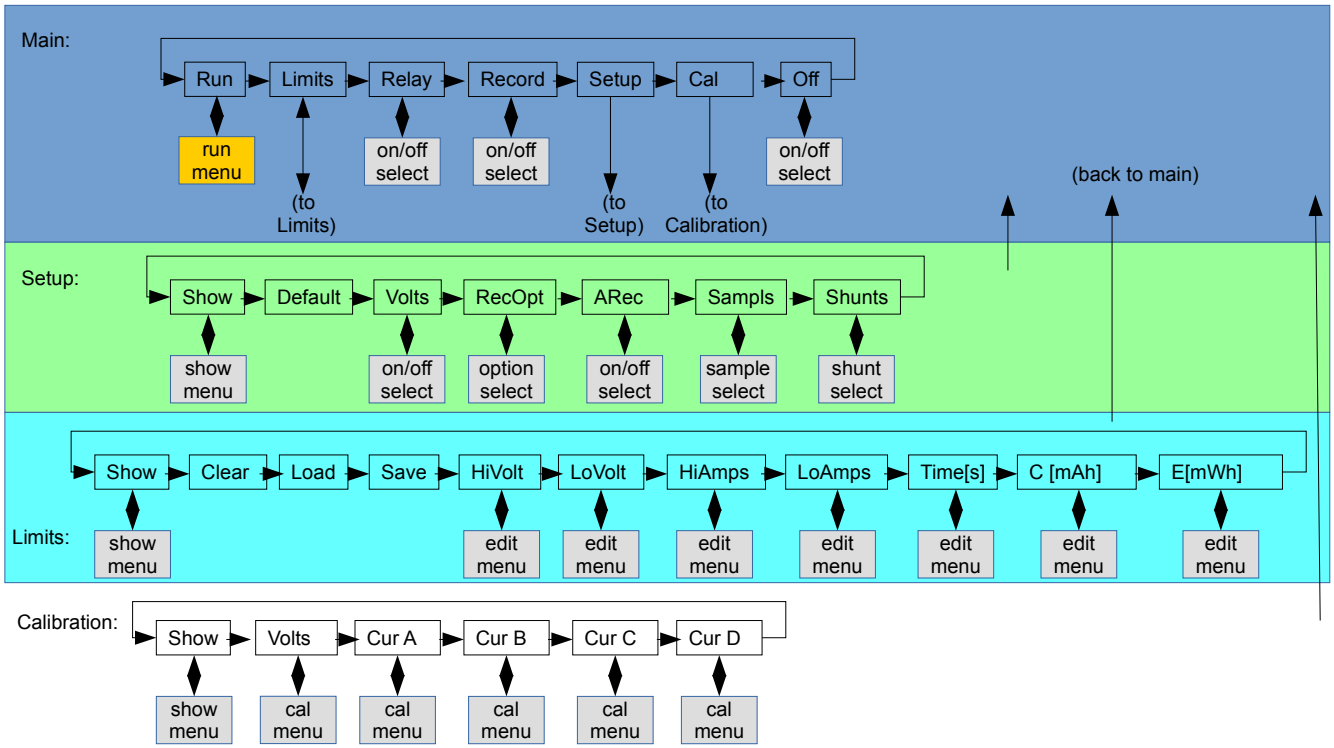

Figure 7: Menu structure

2.3.1 Setup:

All changes in setup are automatically saved in SETUP.TXT and restored when the program starts

Show: shows the current setup values without allowing any changes to be made.

Default: resets the setup to default values

Volts: selects which voltage is displayed (and recorded), the supply side (red terminals) or the load side (yellow or white terminals). The two voltages differ by the voltage drop across the shunt resistor.

- RecOpt: Allows a choice of recording options. They are
- RecChg: records only changes of more than 10mV in voltage or 1mA in currently
- RecFast: records every measurement and thus produces very large files very quickly.
- Rec 1s ...Rec5min: records at regular time intervals from one every second to on every 5 minutes.

Arec: Automatic recording (on / off). When selected on the START button in the RUN menu will also start recording

Sampls: Selects the number of samples taken and averaged by the INA219 chip. Higher sample rates, reduce noise but also slow down the measurements

Shunt: selects a different shunt resistor (and its calibration data)

2.3.2 Limits:

Limits can be saved and loaded from LIMITS.TXT but this is not done automatically. By default there are no limits set.

Show: shows the current limit values without allowing any changes to be made.

Clear: deletes all limits in memory (not in LIMITS.TXT)

Load: loads all limits from LIMITS.TXT

Save: saves the current limits to LIMITS.TXT, overwriting any previously saved values.

HiVolts: allows setting of a high voltage limit. A long press of SEL activates or deactivates the checking for this limit. If HiVolts is set and active, the relay is deactivated if the voltage exceeds the limit. Note: HiVolts must be greater than LoVolts

LoVolts: allows setting of a low voltage limit. A long press of SEL activates or deactivates the checking for this limit. If LoVolts is set and active, the relay is deactivated if the voltage falls below the limit. Note: HiVolts must be greater than LoVolts

HiAmps: allows setting of a high current limit. A long press of SEL activates or deactivates the checking for this limit. If HiAmps is set and active, the relay is deactivated if the current exceeds the limit. Note: HiAmps must be greater than LoAmps

LoAmps allows setting of a low current limit. A long press of SEL activates or deactivates the checking for this limit. If LoAmps is set and active, the relay is deactivated if the current falls below the limit. Note: HiAmps must be greater than LoAmps

Time: allows setting of a time limit. A long press of SEL activates or deactivates the checking for this limit. If Time is set and active, the relay is deactivated if the run time exceeds the limit.

C[mAh]: allows setting of a capacity limit. A long press of SEL activates or deactivates the checking for this limit. If C[mAh] is set and active, the relay is deactivated if the capacity exceeds the limit.

E[mWh]: allows setting of an energy limit. A long press of SEL activates or deactivates the checking for this limit. If E[mWh] is set and active, the relay is deactivated if the energy exceeds the limit.

2.3.3 Calibration:

Calibration values are saved in the CALDATA.TXT file. Voltage calibration is independent of the shunt resistor but current calibration works only on the selected shunt (SETUP-SHUNT)

Show: shows the current calibration values without allowing any changes to be made. These values sometimes but not always very small. To be able to show anything meaningful in the limited space, the program uses a notation that employs m (milli), u micro), and n(nano) notation if necessary.

Volts: allows the calibration of the voltage range. Calibration uses 2 steps, a low target and a high target. For each step a reference instrument must be used to ensure that the applied voltage matches the target value. Once that is confirmed using the SEL button, Powermon calculates the required calibration values, applies them and stores them in CALDATA.TXT.

CurA .. CurD: allows the calibration of the 4 current ranges. It uses the same 2 step process as described above except that now target currents are use.

3 Source and data files

Table 4: Source and data files

Name	Content	Expected location
Buttons.py	Handling of buttons (keypad)	~/INA
Cal.py	Calibration dialog	~/INA
CALDATA.TXT	Stores shunts and calibration data	~/INA
CommonDefs.py	Common definitions across all Powermon modules	~/INA
Display.py	Run menu and display conversions	~/INA
Edit.py	Dialog allowing editing of numbers	~/INA
INA219.py	Handles the INA219 chip	~/INA
LCDpanel.py	Handles the LCD panel	~/INA
LIMITS.TXT	Saved limits	~/INA

Name	Content	Expected location
Measure.py	Calculates statistics and loads and saves files (SETUP.TXT, CALDATA.TXT)	~/INA
Menu.py	Dialog for selecting options from a list	~/INA
Powermon.py	Main program and all menus except run menu	~/INA
Recording.py	Handles recording in CSV format	~/INA
Relay.py	Handles the relay output	~/INA
SETUP.TXT	Stores the setup data	~/INA
Show.py	Dialog to show values but not to edit them.	~/INA
SNAPSHOT.TXT	Snapshot data (automatically created)	~/INA/Rec
REC_yyyymmddhhmmss.csv	Recording file (automatically created). “yyyymmdd” is year, month,day, “hhmmss” is hour, minute, sec	~/INA/Rec
powermon.service	Service description to automatically start powermon at boot	/lib/systemd/system/

4 Installation

On Raspberry Pi, as user Pi,

- create directory INA, i.e. `/home/pi/INA` and
- subdirectory Rec i.e. `/home/pi/INA/Rec`

In Raspberry Pi configuration menu:

- enable SSH and I2C (and VNC if you want to use it)
- setup networking (Wifi) to be able to remote login and get your recording files.

Install Adafruit GPIO library

Install Adarfruit-Blinka

Install Adafruit-CircuitPython-CharLCD

Copy all python files and text files to `/home/pi/INA`

copy file `powermon.service` to `/lib/systemd/system/`

change permissions:

```
sudo chmod 644 /lib/systemd/system/powermon.service
```

configure systemd:

```
sudo systemctl daemon-reload
sudo systemctl enable powermon.service
sudo reboot
```