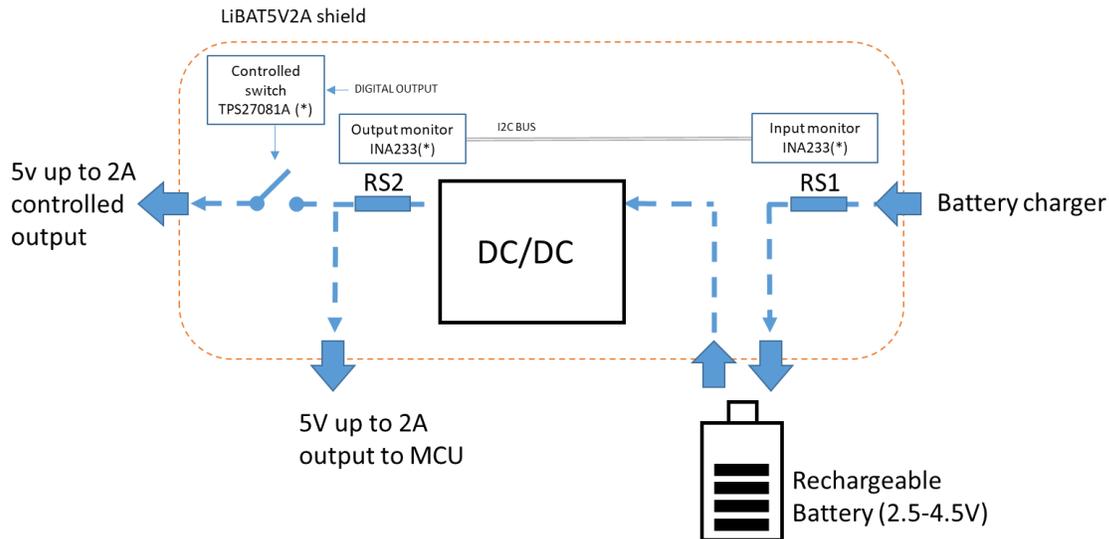


The following diagram represents the functionality of the infinityPV LiBAT5V2A. The big box labelled as DC/DC depicts the TPS61320 step-up converter which takes the energy from the rechargeable battery and converts it to a stable 5V output for supplying the 5V input pin of your programming platform. As stated before the battery connector is internally connected to JST connector for battery charging. This is the basic functionality, but we have added some components to offer an advanced functionality, that we call "MONITORING".



The board has the footprint for two energy monitor ICs through the bus I2C. We have chosen the analog to I2C converter INA233 from Texas Instruments, which monitors and reports values for current, voltage and power. It contains an integrated power accumulator that can be used for energy or average power calculations. These features make the INA233 the perfect IC to measure real consumption of your stand-alone application.

The first INA233 measures over the shunt resistor RS₁ the energy from the battery charger to the battery, the second one measures over RS₂ the energy from the converter output to your application. With this option you can control in your application how much power is your application consuming from battery, how efficient is your charging system or how much power is stored into and retrieved from the battery at any moment.

We have added a controlled switch (TPS27081A from Texas Instruments), which gives an extra 5V/2A output from the shield. The switch can be controlled simply from any digital output from your prototyping platform¹. The extra output can be a JST or a USB connector, according to the requirements of your external load. Through the USB connector you can supply any USB load (up to 2A), so yes!! You can smartly charge your phone or tablet (Check the section **Building a smart solar phone charger**).

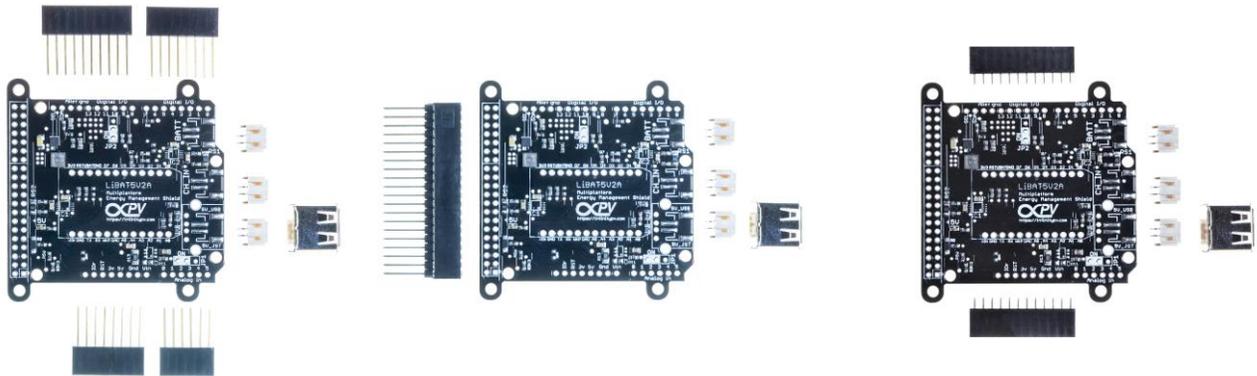
This is because we like to call the LiBAT5V2A and "Energy Management Shield", since you can measure how much energy your application is consuming, how much is left and decided in which moment you can supply or not the external load. It is perfect to experiment with smart programming about energy management.

¹ By default, the control is connected to the pin D7 (Arduino), D2 (Photon) and GPIO04 (Raspberry), but it can be attached to a different pin by removing R6, R7 or R8 and wiring it to the desired pin.

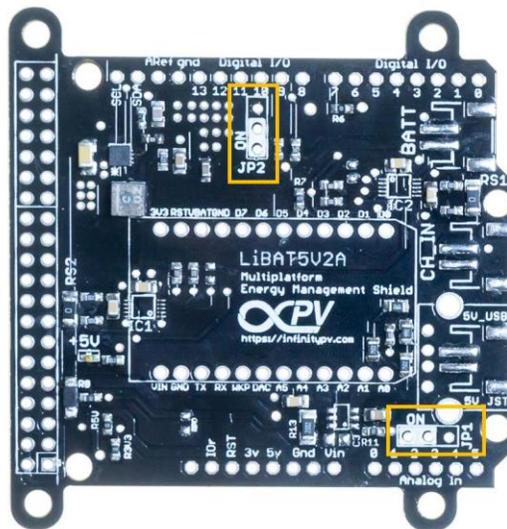
So, lets summarize the two options when you buy the infinityPV LiBAT5V2A:

BASIC option

- The BASIC option is recommended for DIY designers with some knowledge in soldering. The board is including the boost converter with the connectors (not soldered) for your selected prototyping platform: Raspberry, Arduino or Photon).



Apart from the prototyping platform connectors, you will receive three JST connectors and a USB connector. Also we provide components for jumpers JP1 and JP2, i.e. 3 pins (2.54mm) connectors and jumpers. JP2 jumper acts directly over the shutdown pin of the step-up converter and it must be in ON position for enabling the converter. JP1 jumper allows to control manually the extra 5V/2A output (bypassing the controlled switch).



© If you are quite good soldering you can upgrade your BASIC LiBAT5V2A to the MONITORING LiBAT5V2A almost for free, since you can order free samples to Texas Instruments for the INA233 and TPS27081A and solder them to the board. All the ancillary components (bypass capacitors, pull-up resistors... etc.) are there. Read "Changing the shunt resistors" section.

MONITORING option

- MONITORING option is like BASIC but including all the monitoring components and the soldered connectors.



You will receive the board ready to be use, just follow this procedure:

1. Attach the LIBAT5V2A shield to your programming platform (Raspberry, Arduino or Photon). It is always safer to do this step without supply, so nothing get damage making a wrong connection.
2. Double check the right matching of the shields and polarity of your battery.
3. Connect your battery to the battery connector.
4. Place the EN jumper from OFF to ON position.

The green LED 5V Indicator turns ON and also the ON LEDs in your prototyping platform



PLEASE, be EXTREMELY careful with polarity when connecting the battery to the battery connector (BAT_EXT). A wrong polarity can damage the board, especially the monitoring components.

Changing the shunt resistors for INA233

In the MONITORING option the shunt resistors (RS₁, RS₂) are not $\infty\Omega$, but smaller values that are used by the INA233 ICs to measure voltage, current and power at that point. The value of the shunt resistor determines the maximum current that the INA233 will be able to measure.

The INA233 has an internal preamplifier (PGA²), which can be set to different gains. This means that the scale of the measured voltage over RS can be considered $\pm 40\text{mV}$, $\pm 80\text{mV}$, $\pm 160\text{mV}$ or $\pm 320\text{mV}$. According to the RS and the maximum current you expect to measure the PGA must be configured to fit the best scale.

For example, if $RS=0.05\Omega$ and your expected $I_{\text{max}}=2\text{A}$, the maximum voltage over RS will be $V_{\text{BUS}}=0.05*2\text{A}=100\text{mV}$, so the GAIN should be configured to $\text{PGA}=1/4$, i.e. the $\pm 160\text{mV}$ range. PGA value is changed by programming the configuration register at INA233 by the I2c. By default, the range is set to the maximum $\pm 320\text{mV}$, but if you want to optimize the measurement to the maximum accuracy in this case $\pm 160\text{mV}$ would be better.

² Check INA233 datasheet for more details about PGA.

We are preparing an open-source Arduino library³, including simple functions that configure automatically the INA233 pre-gain amplifier optimizing it for the shunt resistor value and the maximum expected current in each application.

In the MONITORING option the LiBAT5V2A is provided with the $RS_1=RS_2= 0.05 \Omega$. We recommend using these values if the maximum current expected in your application is between 0.8A and 2A.

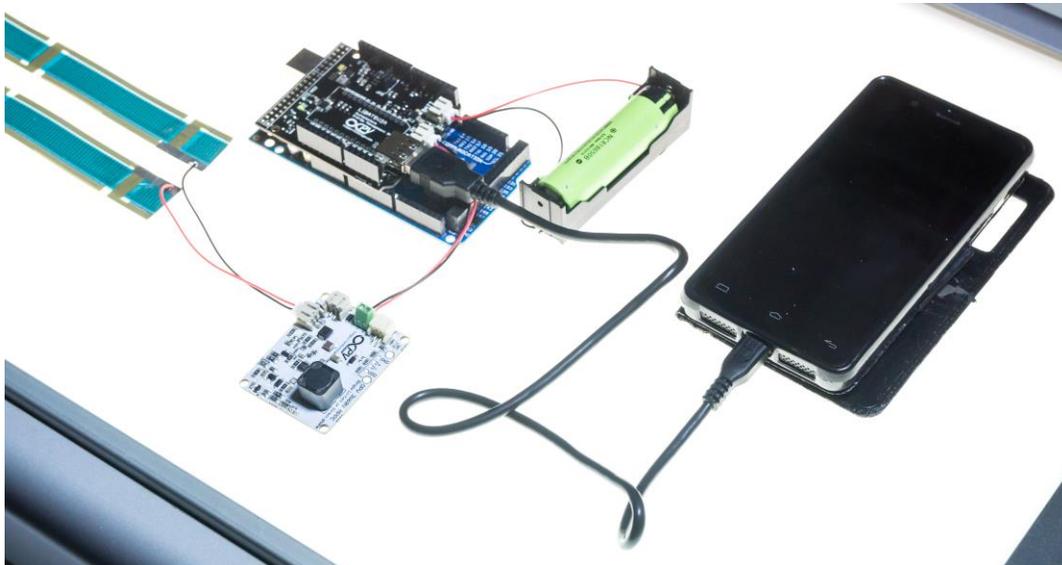
INA233 uses a calibration register which has some limitations, it means that not all the RS and I_{MAX} are possible. If you want to change the RS values, you can check the INA233 datasheet⁴ or write to us, and we will help you to choose the right value for your application.

Building a smart Solar phone charger

The LiBAT5V2A Energy Management Shield can be used for building a smart solar charger for your phone or other USB device. Smart, since the charging process can be supervised and controlled from your Arduino, Raspberry or photon.

The shield provides an extra 5V/2A output through an USB connector. The output can be safely switched on or off from a GPIO pin, configured as digital output.

The following picture shows an example of smart Solar phone charger using the LiBAT5V2A, where the prototyping platform is an Arduino Mega and the battery charger is our OPV3W60V charging from a bidirectional OPV foil.



³ https://github.com/infinityPV/infinityPV_INA233_Arduino-library (in debugging process)

⁴ <http://www.ti.com/lit/ds/symlink/ina233.pdf>



FAQ

Which kind of battery can I use with the LiBAT5V2A?

We recommend single-cell Li batteries (18650), but you can use any rechargeable battery with a voltage range between 2.5-4.5V.

When you choose your battery, it is quite important to keep in mind that batteries must not be charged/discharged at higher current than their capacity rating.

Example: A battery has a capacity of 450mAh. The recommended maximum discharge rate is 2C, so not more than $2 \times 450\text{mA} = 900\text{mA}$. Let's be conservative, so we will consider an efficiency of 90% between battery and your application, so the maximum current at your application can $900\text{mA} \times 90\% = 810\text{mA}$. If your application is going to consume more than 810mA you will need a battery with higher maximum discharge rate or higher capacity.

Where I can get 18650 battery holders for the LiBAT5V2A?

There are many suppliers, for example at Sparkfun we like these ones : <https://www.sparkfun.com/products/12899>.

Can you provide batteries for the LiBAT5V2A?

Rechargeable batteries are not included. We recommend buying them from your local (or nearest) supplier since transporting batteries has a lot of restrictions. You can also order from big suppliers such as

<https://www.sparkfun.com>

<http://www.hobbyking.com>

<http://seedstudio.com>

Can the LiBAT5V2A output be ON and the USB input for programming connected at the same time?

Yes, you can. The 5V output from the LiBAT5V2A is protected and it would not damage the boards or affect the programming.

What kind of battery charger can I use with the LiBAT5V2A?

We recommend the infinityPV OPV3W60V solar battery charger if you are going to charge your battery from infinityPV solar cells. But you can use any battery charger you prefer, just keep in mind the voltage range and the maximum charging current of your battery.

If you want to charge your battery from a USB source, we suggest this one for example: <https://www.adafruit.com/product/259>.

Can the LiBAT5V2A extra USB output charge an apple device (e.g. i-phone)?

Yes, we have included in the USB output the needed resistors at D+ and D- for charging apple devices, and we have tested the charge with different apple models. Anyway, we have not tested all the models in the market, so if you are experiencing problems with your device, let us know.