# Prototype a power bank charger without hardware headaches

Is it possible to prototype a power bank charger application without building dedicated hardware?

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**The short answer to this question is yes.** This article will review the process involved in developing an application using existing evaluation boards, discuss the challenges encountered and outline some recommendations for further revisions and improvements.

Ideally, any power supply design should start with some basic proof of concept tests, which often involve testing an existing demo board. This demo simply takes this pre-existing step (of testing single rails on the demo hardware) and expands on it to produce a working system using demo hardware. As this demo was needed within a relatively short time frame, the typical development process of design, layout, build, assemble, and test (plus any design iteration) was not possible, so the system was prototyped in its entirety using nothing but readily available hardware.

## Application

It was necessary to choose a high level application as a starting point to prove it is possible to prototype a power bank charger application without building dedicated hardware. This led to the power bank charging application being selected as a proof of concept. As power management is a prerequisite for every electronic project, any other application could have been selected.

A power bank charger is a common application, which most consumers have encountered and used. For example, many travellers carry one to ensure their phone remains charged over a long journey. A power bank is essentially a battery pack (capacity varies depending on the price and range required), with one or more USB-A ports as well as a USB-C input port to charge it. It is possible of course to layer additional complexity on top of this basic functionality. For example, the addition of a wireless charging pad or an input to allow solar charging of the bank for outdoor enthusiasts.

For this application, the option to charge the battery via solar or to charge via a DC input from a standard 12V AC/DC wall wart was included. The outputs included some basic USB-A charging ports (two in total), producing 5V for use with mobile phones and a range of USB-powered electronics.

## Hardware selection

In this example, the design will support two input power sources (a solar panel and an AC/DC wall wart, which is just a simple AC/DC power supply). For this reason, a clever device called a power path prioritiser is required not only to intelligently switch between the available sources depending on which was available but also to manage the situation where they both were available by assigning priority to one source or the other. A simple version of this implementation can be achieved by using some simple diodes, commonly connecting the two cathodes of the diodes and connecting the anodes to their respective sources. Unfortunately, this particular configuration is lossy due to the diode drop inherent in a typical diode (approximately 0.6V), but it also doesn't allow for any clever selection criteria to be

| | E2 | Operation Mode | IG(OFF)1 | IG(OFF)2 |
|---|---|---|---|---|
| 1 | 0 | Load sharing | Enabled | Enabled |
| 1 | Sense | V1 is less than V2 | Enabled | |
| Sense | 0 | V1 is greater than V2 | | Enabled |
| 0 | X | Channel 1 disabled Do not use | Disabled | |
| X | 1 | Channel 2 disabled Do not use | | Disabled |
| 0 | 1 | Both channels disabled | Disabled | Disabled |

**Table 1: Modes of Operation from the LTC4416 datasheet**

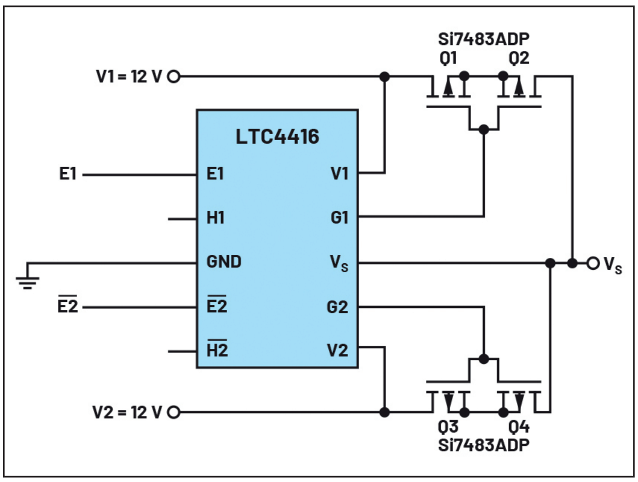


**Figure 1: An LTC4416 typical application circuit.**

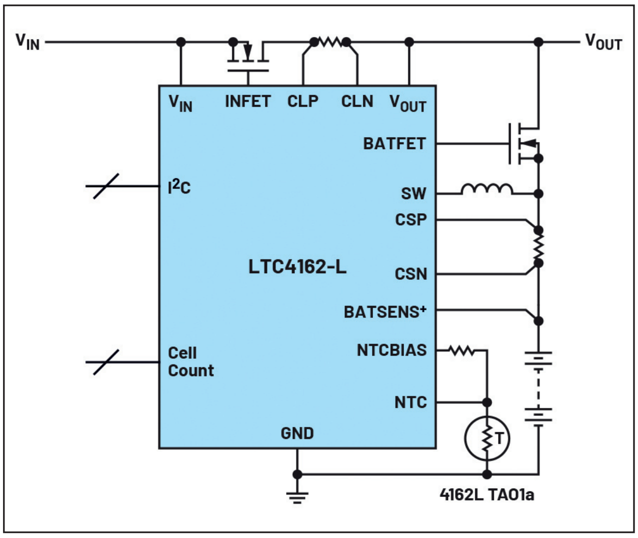


**Figure 2: An LTC4162-L typical application circuit.**

implemented, for example, priority selection. It simply allows the higher potential input to pass through.

The LTC4416 not only replaces the lossy diodes with PFETs, which are far more efficient, but also allows for priority to be assigned. In this particular application, priority will always be assigned to the wall wart. This allows the design to take advantage of the available power (and higher current) when it is available. This device is exceptionally flexible, with many operational modes possible depending on the design requirements. Table 1 (sourced from the LTC4416 data sheet) displays the modes of operation.

## Battery charger

For the battery charger, the LTC4162-L was selected due to its wide input voltage range (up to 35V) and 3.2A charging capability, as well as the integrated FET design, which results in a small solution size. This is a commonly used charger IC which has great application flexibility as it comes in many battery chemistry variants such as LiFePO4, Li-Ion, lead acid as well as an I²C interface to allow the user to extract telemetry information. It was selected for this particular application not only because of flexibility on the input and battery voltage but also because of the integrated nature, which helps to keep the solution size to a minimum. Another useful feature is maximum power point tracking (MPPT). If solar is one of the possible input sources for a design, MPPT is a must to ensure the design extracts as much available power as possible. The LTC4162 also has a built-in power path control that is useful in this application when the input source is removed, allowing the provision of the battery voltage to the output terminals for use downstream.

The board selected to provide the USB charging voltage for the connected device is from Analog Devices' Circuits from the Lab collection of reference designs and solutions. Typically, a single device is shown on an evaluation board to evaluate a specific device. Circuits from the Lab's boards make use of several Analog Devices' products from different product portfolios to solve a particular system requirement.

The CN0509 was designed to be a wide input range, dual USB power charger. It was developed for use in emergencies such as natural disasters or extended power outages. An example power source that many would have available to them is a car battery. This board can be powered by a car battery to provide two 5V ports, which are isolated from the primary voltage for safety. There is a range of alternative power sources that you may have available from stacks of loose batteries to motors to act as a simple generator.

The CN0509 has a wide input voltage range so it will be able to run from any supply in the range of 5V to 100V to pair up with the existing boards to provide the USB charging outputs required for the power bank charger.

## Protection features

Reverse polarity protection is included to protect the circuit from an incorrectly connected supply and an isolated flyback converter is utilised to isolate the charger outputs from the input source. This is particularly useful if a -48V communication back up supply is used as a power source. This can result in a phone being charged to -48V and creating a hazardous situation. Isolated conversion prevents this from occurring. Another note here is that the CN0509 board is quite small, largely due to the highly efficient ICs selected and the no-opto flyback LT8302. A key differentiation is that the flyback converter LT8302 does not need an isolated optical feedback path.

There are two USB ports on this particular board: one is a standard USB port (without D+/D- connected) and the other port has a DCP controller to monitor the USB data line voltages so that it can enable fast charging and provide 5V at 2A max. Achieving this higher level of charge current is dependent on the input voltage utilised, 12V is optimal based on the

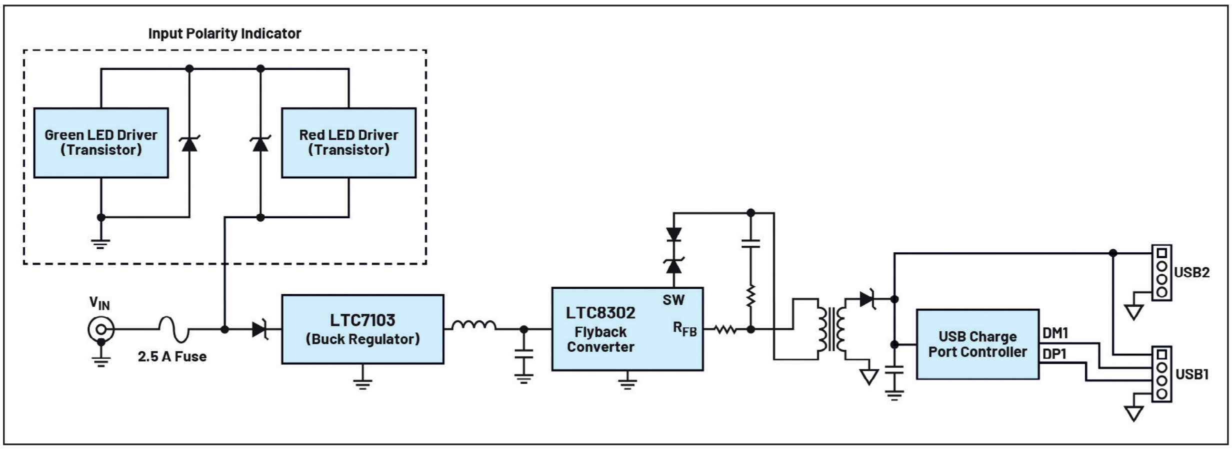


**Figure 3: A CN0509 application circuit.**

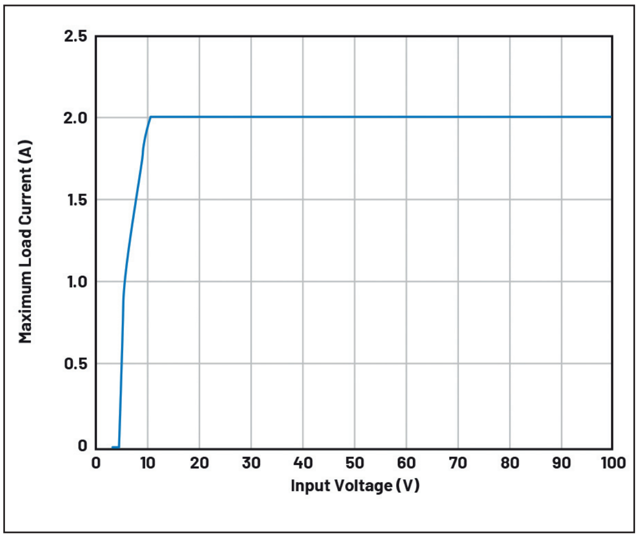


**Figure 4: A CN0509 max charge current vs VIN.**

performance graph shown in Figure 4.

## Power sources

The primary power source selected was a 60W AC/DC 12V adapter. This served as one input to the LTC4416 demo board, and a relatively small solar panel was purchased to provide an alternative input source. It should be noted that this project was to be used at an indoor event without sufficient lighting available to provide a reasonable level of available power to run from solar energy, therefore this feature was included simply to demonstrate the capability and functionality of the power path prioritiser.

This design was developed to be a power bank and as such it would require a battery pack to act as the storage element. Shipping restrictions in relation to batteries are prohibitive. The demo was developed specifically so that a generic battery pack could be bought and inserted to run the demo on its arrival. Based on this limitation, a rechargeable two-series cell Li-Ion battery pack generating a nominal 7.4V with a 2600mAh capacity was selected to run the demo for the event. It is worth noting that a larger capacity battery could easily be installed here if required.

## Build details

From a build perspective, the hardware was standard, so no electrical modifications were required beyond some adjustments of the LTC4416 thresholds to ensure the correct priority for the input power sources. In order to make it more visually appealing for the event, the boards were mounted on a simple black perspex sheet using some standard metal standoffs.

The charge current that was being provided for the evening was monitored by a simple USB meter. This device visually represented how much current was available to charge the attendee's phones (Figure 7).

The demo performed its core function effectively. It comfortably charged the battery pack from two alternate sources, the handover between sources was managed well by the power path prioritiser and the CN0509 provided charge to the connected USB devices.

This particular power bank has another useful feature that many power bank chargers do not have and that is the ability to simultaneously charge the battery pack and charge the connected USB device. Even a high end power bank may not charge a phone and the bank at the same time, which is a frustrating limitation.

The charge current to the USB port is limited by the capability of the LTC4162 with its internal FET design providing a max of 3.2A, the bulk of the current is sent to the battery during charging. The remaining current can be used through the USB charger ports.

Any time the input power source is removed, the power path FET on the LTC4162 demo board ensures that the battery power is redirected to the output port and hence maintains power to the CN0509 and USB ports. The available charge current in this mode drops as per the graph in Figure 4 since the input source to the CN0509 is now the battery voltage, which is a nominal 7.4V.

## Prototyping

Once the application has been proven to work using some simple, readily available demo boards, the next reasonable step is to develop a product prototype that takes learnings from the initial prototype work and integrates this into the end solution. Part of this would be to modify the existing schematics from the boards used to remove the superfluous items (e.g., test points or connectors).

Next is PCB development. While the demo board generally looks to be quite large in size, this is simply to aid the testability and usability of the device. Closer inspection of the board layout reveals that the IC for which the board was developed and the enabling circuitry (e.g., resistors, capacitors, inductor) are all designed into as small a space as possible to allow developers to bring this into their own layout. This will then provide confidence with a tested design, which can be verified on the bench before building their own version.

For the end application, a larger capacity battery with a higher voltage would help to optimise the amount of charge current



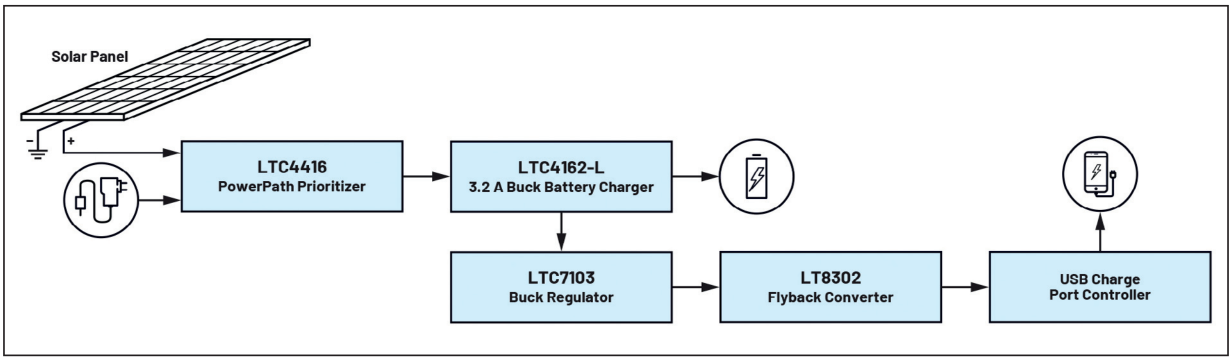


**Figure 5: The power bank charger application tree.**

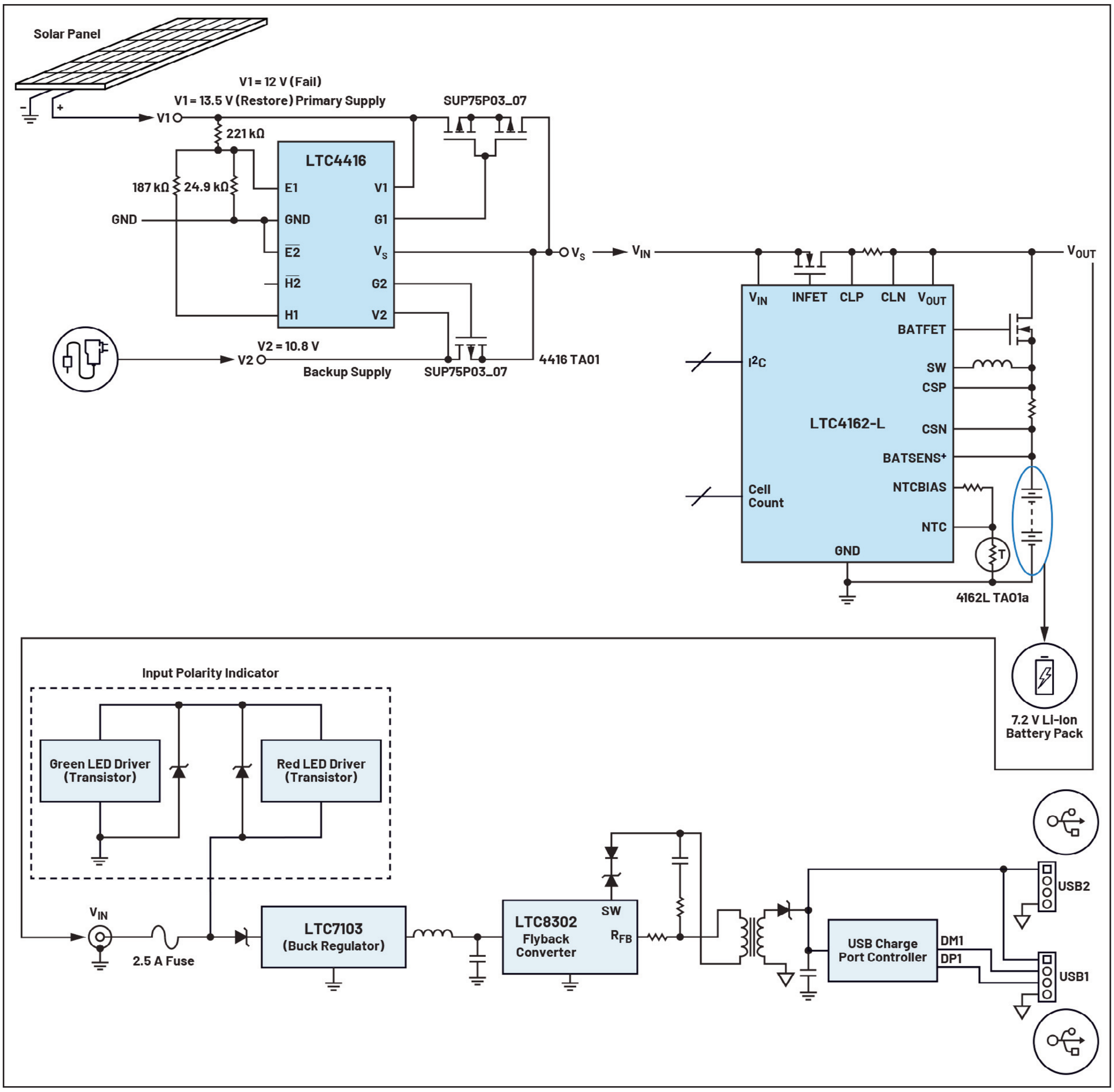


Figure 6: **A system diagram of the prototype.**

provided to the USB ports.

A more slimline version of the CN0509 could be used to reduce the overall battery bank cost. For example, the LTC7103 and input polarity protection circuitry would not be necessary for this design and the isolated flyback could be powered directly from the output of the LTC4162 (either 12V from the AC/DC wall wart or the battery voltage once mains power has been removed).

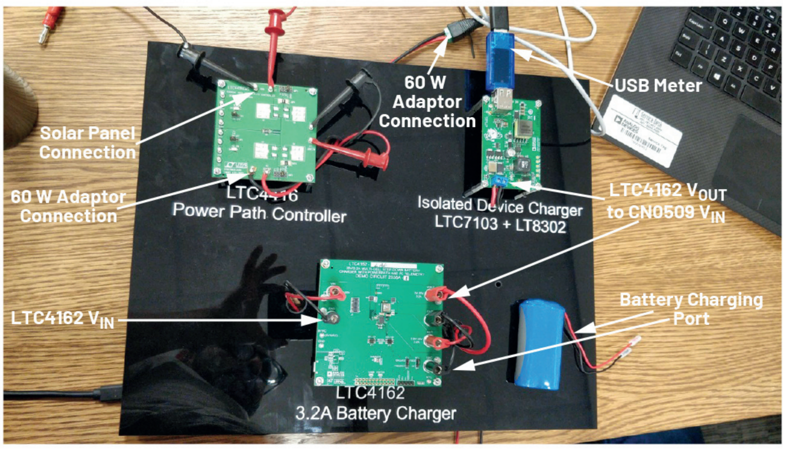


Figure 7: **A functional demo system.**

## Conclusion

It is possible to prototype a power bank charger, or any other power supply design, using some readily available hardware and simple power sources. This highlights that using available demo board hardware can quickly provide a proof of concept for potential projects without spending much on development. Furthermore, this relatively small step will provide the user with confidence before committing to a more integrated design. Another point worth reiterating is that power supply design and, more specifically, the layout of a power design can be challenging so it is worth utilising the resources available to reduce the overall development time.