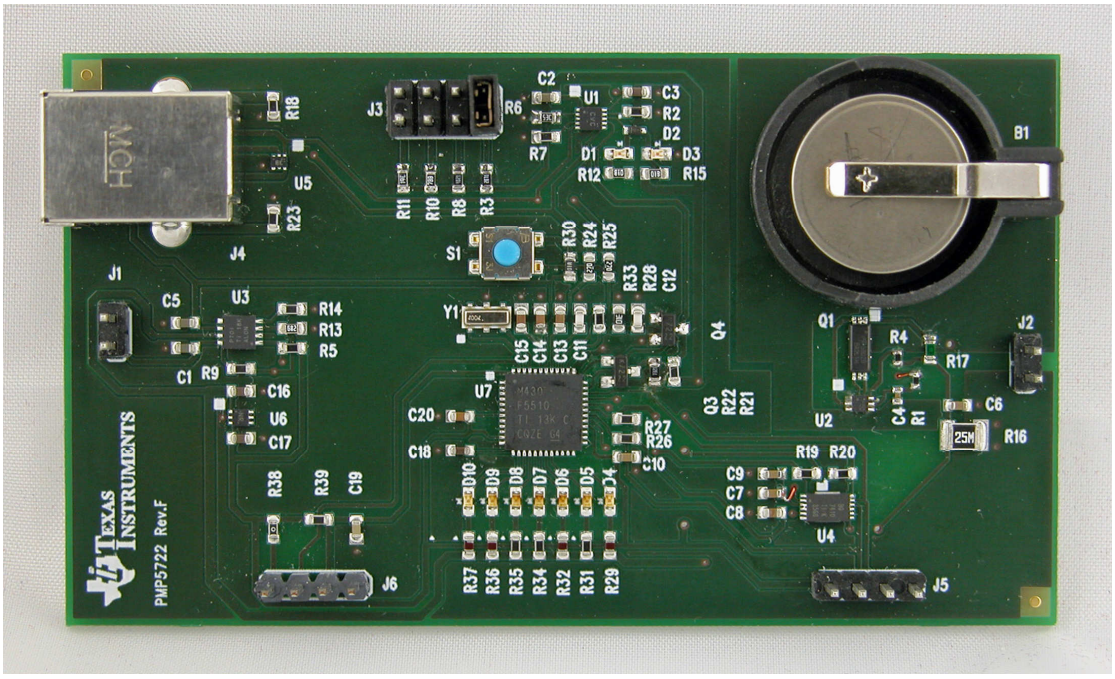
Single Cell Battery Power Solution

- Input 5V DC
- Output 2.80 .. 4.28V (dependent on charge state of battery)
  Current limited to 500mA max.
- Devices

TPS2113A	Autoswitching Power MUX
TPD4S012	4-Channel USB ESD Solution
bq24050	Single Cell Battery Charger with USB Detection
bq29707	Single Cell Battery Protection
bq27410	Fuel Gauge
TLV70033	Linear Regulator
MSP430F5510	Mixed Signal Microcontroller

- Battery Varta CP1654, Coin-Cell Battery, 100mAh



Description

This circuit shows the functionality and performance of a complete single-cell rechargeable battery power solution. It can be either powered by an external adapter or by an USB port.

The TPS2113A power multiplexer automatically uses the external adapter as power source, if available. If not, the USB port is used.

The bq24050 charges the battery (Varta CP1654). The maximum charging current can be limited by jumpers between 15mA and 200mA. It automatically detects if the power source is an USB port. In this case, the maximum charging current is automatically limited to 100mA. To override this setting, pin ISET2 needs to be toggled, which is explained later on.

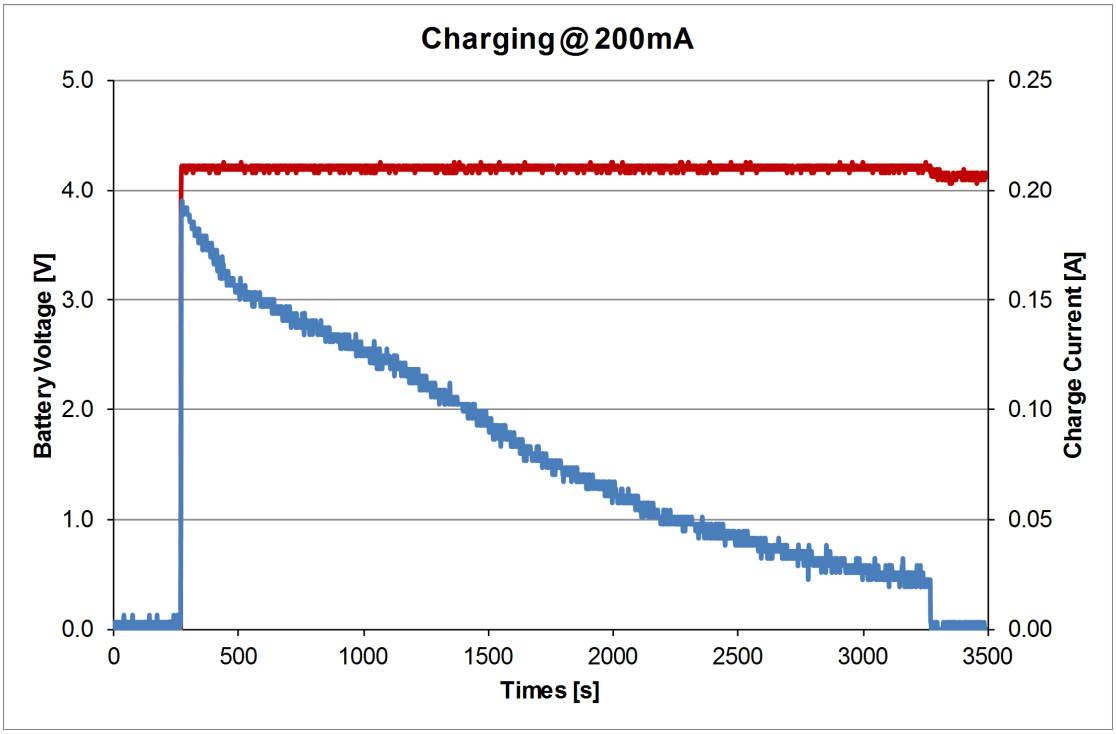
To protect the battery from over- or undercharge and too high charge or discharge currents, a bq29707 battery protection is utilized. If the safe operation is exceeded, it disconnects the battery from the charger and/or load.

A bq27410 fuel gauge determines the state-of-charge of the battery.

A microcontroller MSP430F5510 with an integrated USB port acts as system controller. It is seen as a serial port on a computer, when it is connected to the USB port. The information about the battery (state-of-charge for example) is gathered by an I2C connection between the fuel gauge and the microcontroller. This data is sent to the computer, where it is visualized by a graphical user interface. The microcontroller controls also several LEDs to visualize the actually used power source (external adapter or USB port) and input current limit.
If the board is only supplied by an USB port, the input current limit is automatically limited to 100mA by the bq24050 battery charger. To overrides this setting, the pin ISET2 needs to be toggled. If the microcontroller detects that the input power source is an USB port, it toggles this pin to give back the controller over the maximum input current to the jumpers connected to pin SET of the charger. As the charger works in a linear mode like a linear voltage regulator, the maximum input current is equal to the maximum charging current.

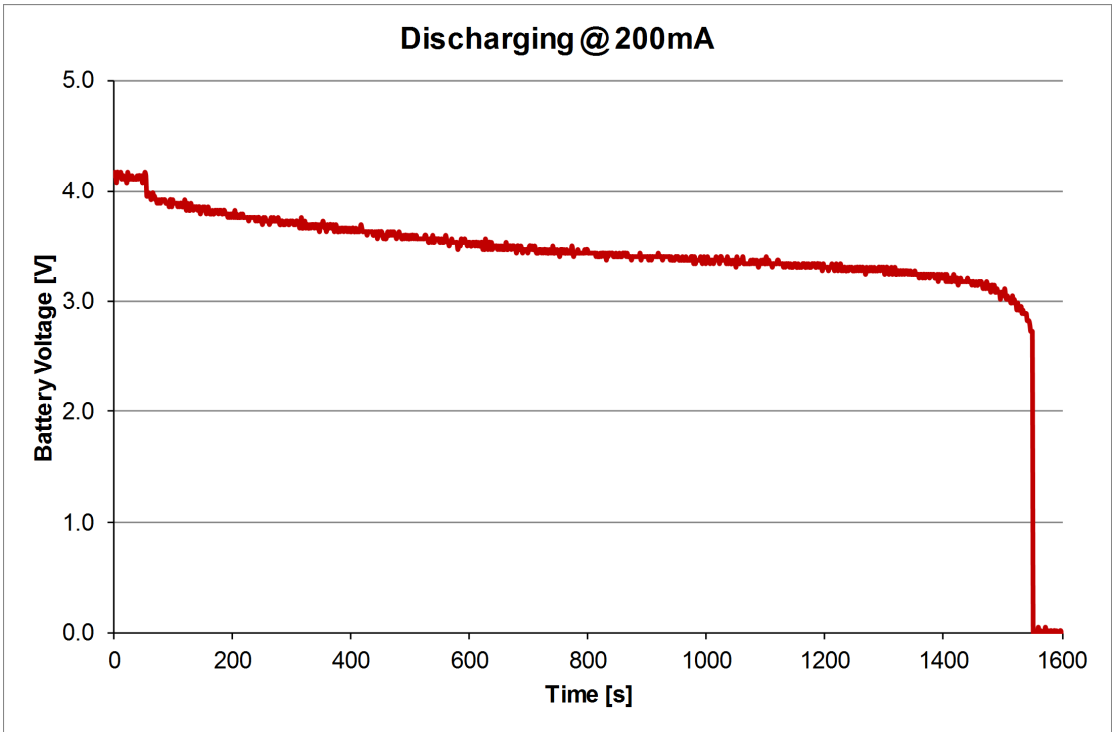
Charging Cycle

The picture below shows a charging cycle of a fully discharged battery. At the beginning, the voltage on the output connector is zero. This means, the battery protection has disconnected the battery from the load to prevent any over-discharge.
As soon as the input power (USB port) is connected, the battery voltage rises to 4.2V and the charge current to 200mA.
The total charging time is around 50 minutes for the 100mAh cell.
It's easy to see, that the current limits sets only a maximum limit, which is never exceeded. It doesn't mean that the battery is charged with this current until it is completely full.



Discharging Cycle

The picture below shows a discharging cycle of a fully charged battery. At the beginning without any load attached, the battery voltage is around 4.1V.
After a load which draws a constant current of 200mA is attached, the voltage drops around 150mA and then goes slowly down within 25 minutes. When the voltage hits 2.8V, the load is disconnected by the battery protection to prevent an over-discharge of the battery.



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