Battery Technologies a learn.sparkfun.com tutorial

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Battery Options

There are a multitude of different battery technologies available. There are some really great resources available for the nitty gritty details behind battery chemistries. Wikipedia is especially good and all encompassing. This tutorial focuses on the most often used batteries for embedded systems and DIY electronics.

There are some concepts and bits of knowledge you may want to know before reading this tutorial:

- Voltage, Current, Resistance, and Ohm's Law
- Connectors
- How electricity flows through a circuit

Terminology

Here are some terms often used when talking about batteries.

Capacity - Batteries have different ratings for the amount of power a given battery can store. When a battery is fully charged, the capacity is the amount of power it contains. Batteries of the same type will often be rated by the amount of current they can output over time. For example, there are 1000mAh (milli-Amp Hour) and 2000mAh batteries.

Shape - Batteries come in many sizes and shapes. The term 'AA' references a specific shape and style of a cell. There are a large variety.

Energy Density - Combining capacity with shape and size of a battery, the energy density of a battery can be calculated. Different technologies allow different densities. For example, lithium batteries typically pack more juice into a given volume than alkaline or coin cell batteries.

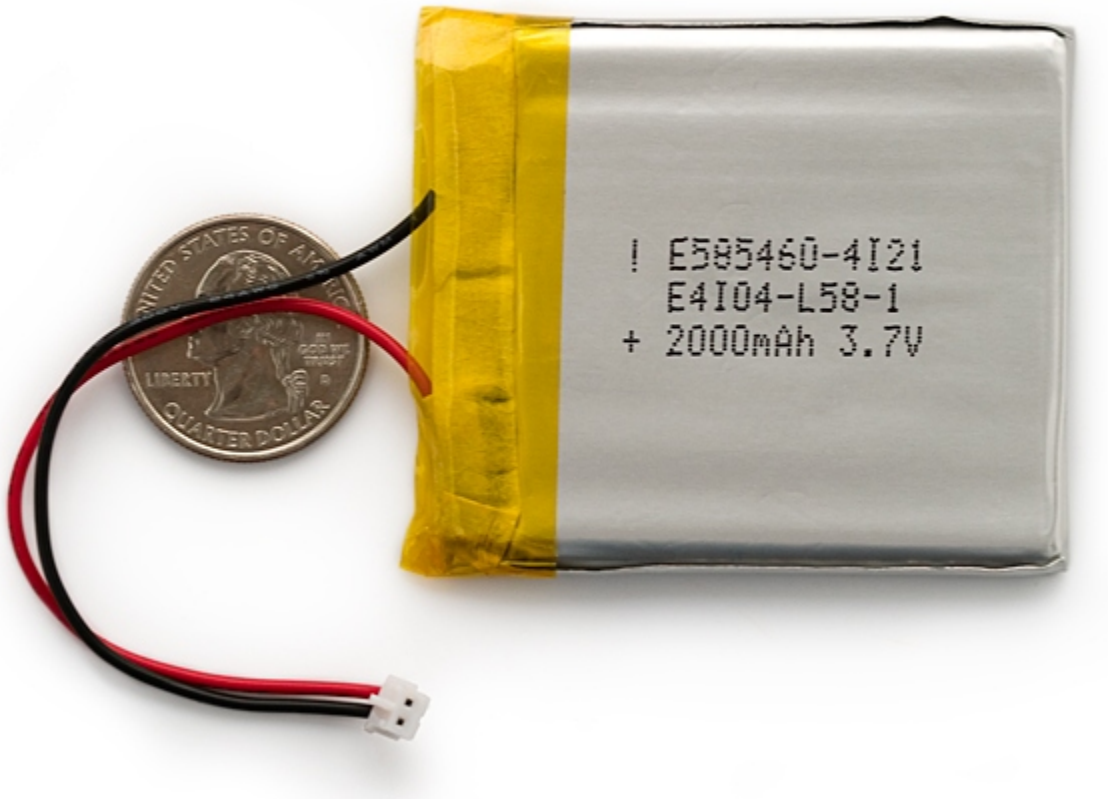
Nominal Cell Voltage - The average voltage a cell outputs when charged. A car battery will output 12V. A coin cell battery will output 3V. The voltage on a battery will change as it discharges.

Internal Discharge Rate - Have you ever tried to start a car that has been sitting for 6 months? Batteries discharge when sitting on the shelf or when unused. The rate at which the battery discharges itself over time is called internal discharge rate.

Safety - Because batteries store power, they are basically very tiny explosives. To prevent harm, batteries are designed to be as safe as possible. Most batteries technologies are designed to discharge safely in the event of misuse. If you hook up an alkaline battery incorrectly, it may get hot to the touch but should not catch fire. Most Lithium Polymer batteries have safety circuits built-in to prevent damage to battery and prevent it from unsafe usage.

For a full list of terms and technical overview Wikipedia is an excellent resource.

Lithium Polymer



Lithium Polymer (often abbreviated LiPo) batteries are very useful for embedded electronics. They offer the highest density readily available on the market. Because cell phones predominantly use this battery type, they are easy to find for reasonable prices. They **do** require special charging, so be sure to use the right charger for the job.

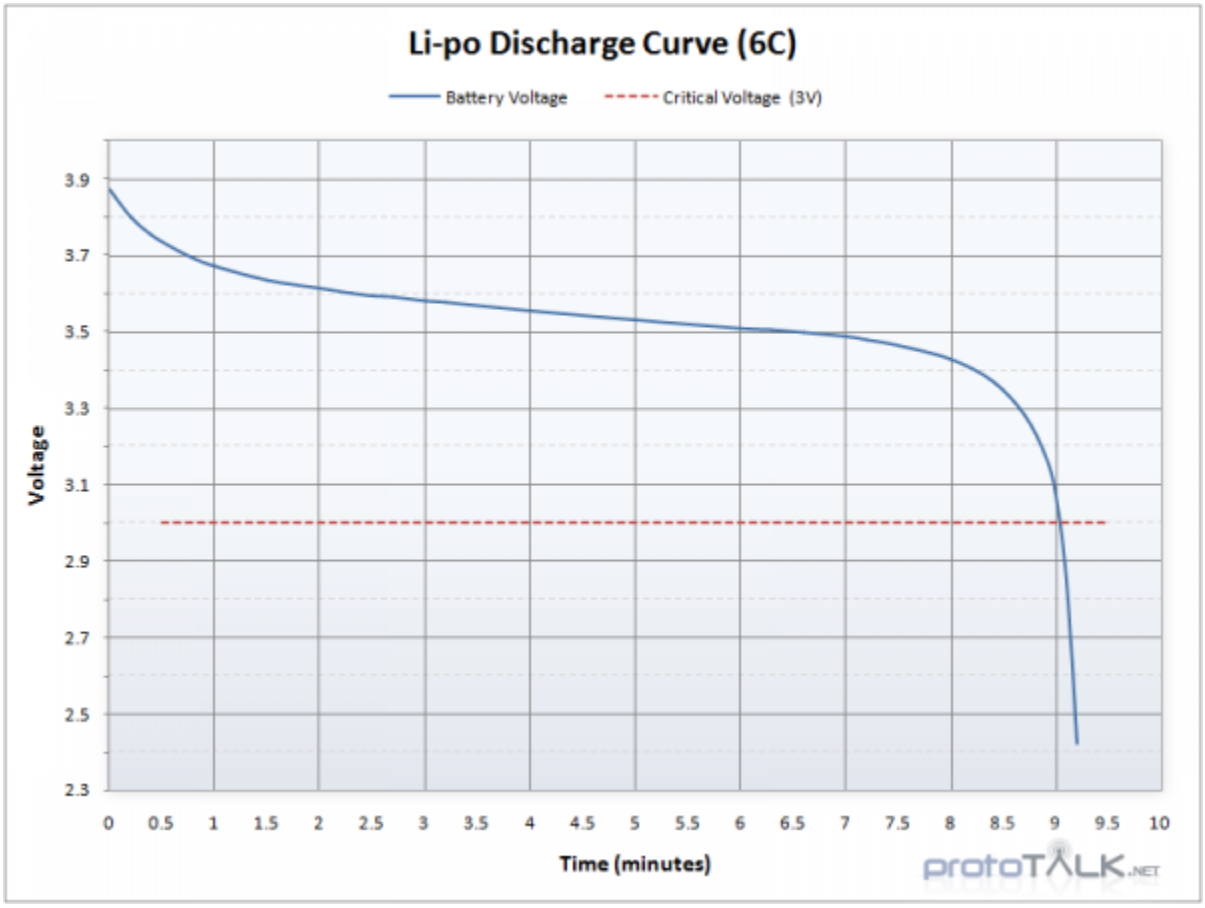
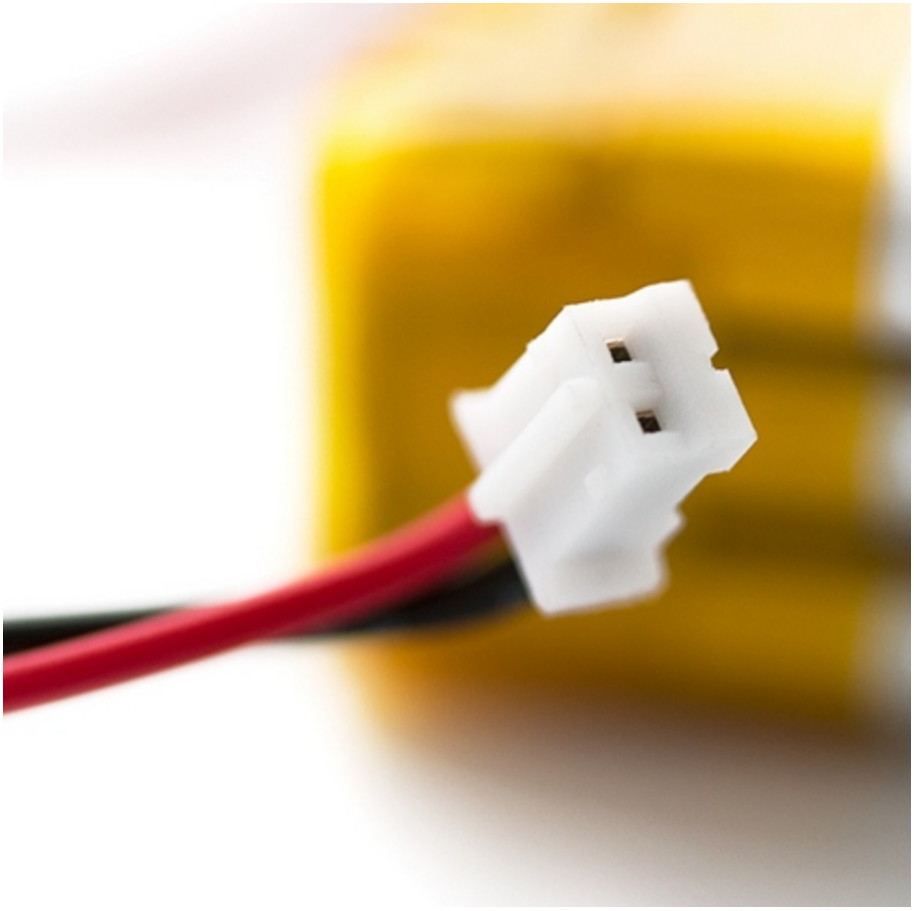


Image from [ProTalk.net]

An individual LiPo cell is 3.7V. When fully charged you will see nearly 4.3V on the cell but it will quickly drop to 3.7V under normal use. When depleted, the cell will be around 3V. This means your project will need to handle various voltages if you are running directly from a cell. If you need 5V you will need to combine two LiPos in series to create a 7.4V pack and regulate down to 5V. Here is a great thread on LiPo batteries when [used in packs].



In the small electronics world, most LiPo batteries come terminated with various 2-pin connectors. At SparkFun, we use the JST connector. This prevents the battery from being plugged in wrong. The connector is a friction fit so it's common to use pliers to gently remove the battery.

There are many low-cost chargers created to charge LiPo batteries. They commonly use USB to charge the battery. **Do not** attempt to charge a LiPos without a charger. A LiPo battery can be harmed by overcharging, so use a specifically designed LiPo charger.

LiPo batteries can also be harmed by being discharged too far. To protect against this, almost all LiPo batteries have a small safety circuit built into the top of the cell that will shut off the battery if the voltage drops below a certain threshold (usually 3V).

LiPo batteries have a very low internal discharge rate. This makes them a good candidate for projects that have low power requirements and need to run for many days or months.

We recommend LiPo for nearly every portable application. They are fairly robust and easy to use.

Nickel Metal Hydride

Nickel Metal Hydride (often abbreviated NiMH) batteries are a very proven rechargeable technology. The batteries are often lower cost than other technologies but suffer from lower densities than LiPo. NiMH batteries require less stringent charging curves, which lower the cost of the chargers. NiMH are often found in lower cost electronic devices such as toothbrushes and cordless shavers where output voltage is less of a concern (you'll notice your toothbrush running more slowly but continues to work).

Each cell outputs nominally 1.2V. This is very similar to alkaline batteries of the same size that output 1.5V. Combining four AA NiMH will get you a 4.8V pack which should run most 5V systems but will drop in voltage as the pack discharges.

Because of their similarity to regular consumer batteries, charging NiMH batteries is often done with chargers that plug into the wall.

We recommend NiMH for applications where a device has already been designed to use AA type batteries.

Coin Cell

Coin cell batteries are great for very small, low power projects. These batteries are cheap! Buy them in bulk if you need a

lot. They are great for testing LEDs. You'll find these type of batteries hidden inside remote controls, electronic tealight candles and lots of smaller disposable devices.

These batteries **are not** rechargeable. There are a few, more complex chargeable versions, but the vast majority of coin cells are meant to be thrown away once used.

Coin cell batteries come in a few different sizes, but the vast majority are the CR2032 sized battery. The CR2032 outputs 3 volts and is great for powering a ATtiny or other small microcontroller and LED.

Alkaline

We've all grown up with this type of disposable battery. These batteries have been around for many decades, so you'll find them everywhere! There's also a multitude of battery holders and accessories for AA and 9V batteries.

These batteries are cheap, safe to use, and available everywhere, but sadly, they **are not** rechargeable. The alkaline chemistry makes these batteries particularly idiot proof (safe).

AAs and AAAs are the most common alkaline batteries and output 1.2V nominally (but are around 1.5V when first used). Because AAs output 1.2V, you will need to combine them in packs of 3 or 4 to run your 3.3V or 5V system. 9V batteries are obviously 9V nominally.

A 9V battery with a connector cable is a great, quick way to make a project portable, but don't expect the battery to last very long! While it outputs 9 volts, the capacity of a 9V battery is pretty low.

We regularly use this type of batteries with beginners. They are often comfortable with this type of battery and can easily find them. If they attach the battery backwards it may heat up, but little damage is done. Once a student is past the basics we generally transition users to LiPos because they last longer and can be recharged.

Further Reading

Now that you know a little more about battery technologies you should check out these additional tutorials and projects:

- Connector Basics
- How do I power my project?
- Binary
