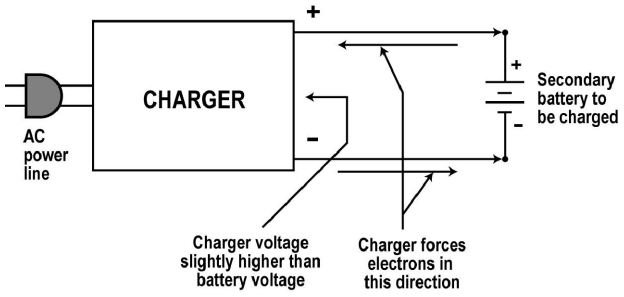
Battery Charging

Principles for Secondary Batteries

Battery Charging Principles



Battery charging is the process of applying a voltage or current to a discharged secondary battery to reverse the current flow in the battery. This causes the chemical process to reverse thereby restoring the condition of the battery.

In the simplest process of charging, a DC voltage source, usually from an AC operated power supply or battery charger, applies a voltage a bit higher than the nominal voltage of the battery. This higher voltage is recommended by the battery manufacturer.

For example, for a 12 volt lead-acid battery, the usual charging voltage is 13.8 to 14 volts.

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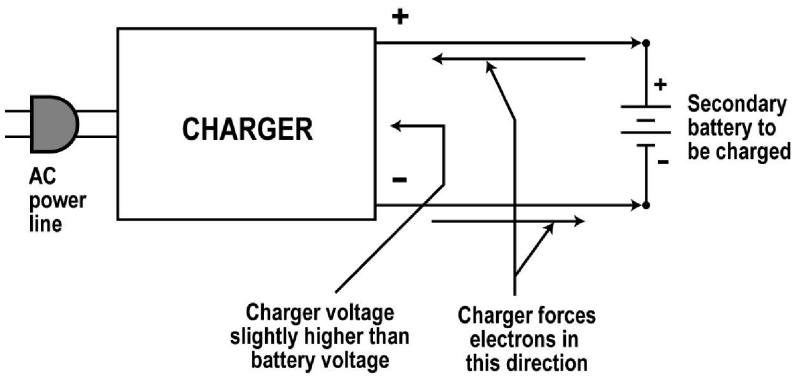
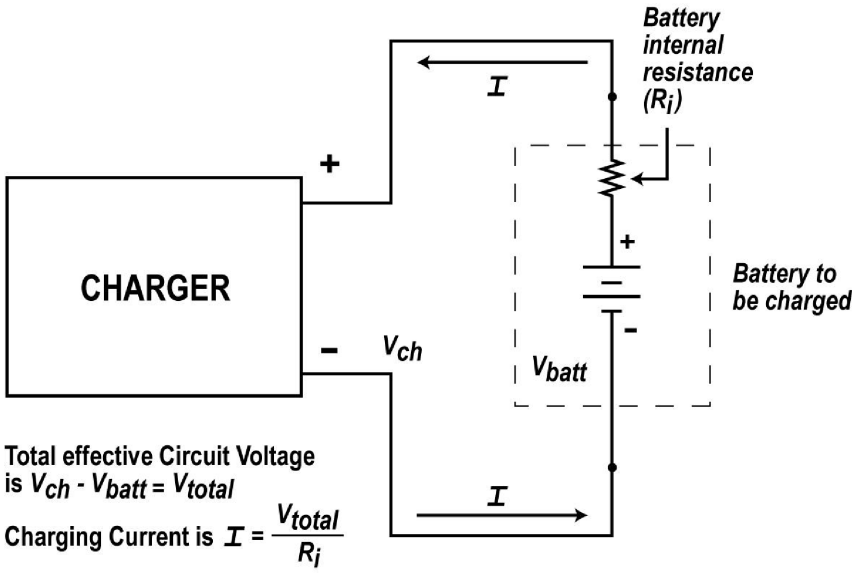


If the charging voltage is not high enough, no recharging will take place. The battery will then actually try to force current back through the charger further discharging the battery and possibly damaging the charger.

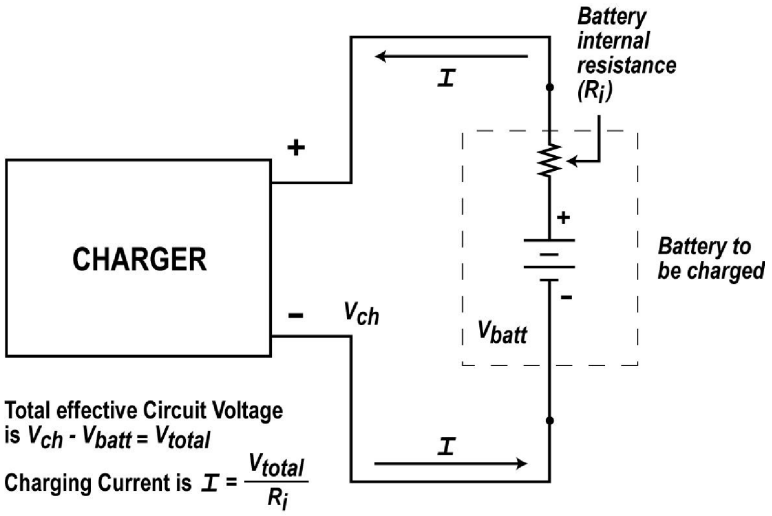
If the charger voltage is too high, the charging current and temperature will damage the battery.

Battery Voltage and DC Charging Voltage



The battery voltage (V_{batt}) and the DC charging voltage (V_{ch}) are connected in a series circuit where their voltages are in opposition to one another.

Total Effective Circuit Voltage



The total effective circuit voltage (V_{total}) is the difference between the actual battery voltage and the charging voltage that will set the charging current. $V_{total} = V_{ch} – V_{batt}$

The only current limiting part of the circuit is the internal resistance (R_i) of the battery itself.

Charging Current

If the battery voltage is very low, the initial charging current will be very high. But as the battery recharges, its voltage will rise. As a result, it will increasingly oppose the charging voltage. The effective voltage in the circuit will decrease as will the charging current.

When the battery voltage increases to near the charging voltage, the charging current will gradually decrease to a very low value. At this point the battery is fully charged.

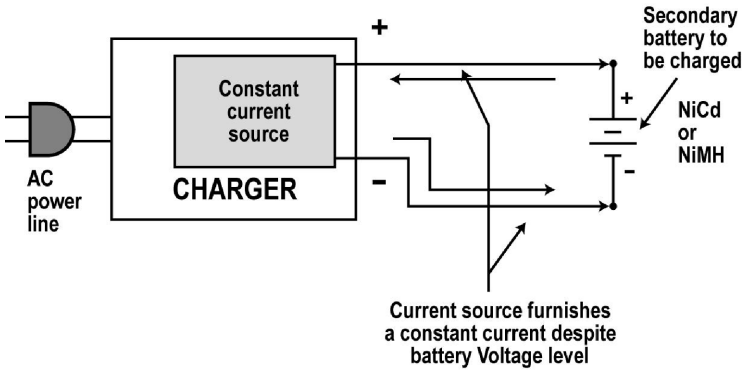
Limiting Charging Current

In some cases, a series resistor is connected in series with the charging voltage to further limit the charging current. Too much current will damage the battery internally.

The constant voltage battery charging method like this is used with lead-acid batteries and lithium cells.

The most important factor in battery charging is to use a charger specifically designed for the battery type. Excessive charging voltage or current will destroy a battery or shorten its life. In the worst case scenario, excessive charging voltage or current can overheat the battery. In the case of lithium batteries, this can cause a fire or explosion.

Constant Charging Current



Some types of batteries, such as nickel-cadmium and nickel metal hydride batteries, require a constant charging current rather than a voltage.

The charger of NiCd and NiMH batteries is designed to supply a constant current as dictated by the battery manufacturer. This current applied over time produces an Ah rating that is some fraction of the maximum Ah rating of the battery.

A typical charging circuit is an AC operated DC voltage source that operates a constant current source. This circuit is designed to supply a constant current to the battery.

Choosing the Right Charger

As a precaution, only use chargers that are specifically designed for the battery type. A lead-acid or Li-Ion charger cannot be used with NiCd or NiMH batteries or vise versa.

Some chargers contain a trickle charge mode that produces just enough voltage or current charge to offset the self-discharge associated with most batteries.

Connecting the wrong charger may produce no recharging or overheat and destroy the battery. A fire or explosion could also result. Batteries are small bombs if not treated properly.

Battery Charging Integrated Circuits

Most products using secondary batteries are supplied with a charger designed for the battery type used. This is true of almost all portable products such as cell phones, laptop computers, MP3 music players, PDAs, and power tools.

Each charger, or in some cases the product itself, contains a sophisticated integrated circuit (IC) that applies precisely the correct amount of voltage or current to the battery during recharge. It monitors and measures the voltage, current, and even the temperature. It automatically cuts off when the battery is fully charged. If the temperature exceeds a specific dangerous level, the circuit automatically cuts off.

Power Management Circuits

The battery charger ICs are usually part of what is referred to as power management circuits. These power management circuits not only charge the battery, they also monitor battery status to predict the remaining time of the charge.

These are referred to in the industry as “gas gauge” chips because they act like the gas gauge in a car that tells how much “gas” is remaining.

Most cell phones, for example, have some indicator on the display that shows battery charge and capacity status.

Laptop computers monitor battery status and are designed to alert the user when the battery is about to be fully discharged so work can be saved.

Power Management Chips

Most battery powered devices also include some form of battery management circuitry. This may be included with the charger IC or may be a separate IC or collection of circuits.

Power management chips are used to monitor battery voltage and compute remaining energy available.

Power management chips also turn off major sections of the device after a short period if they are not being used.

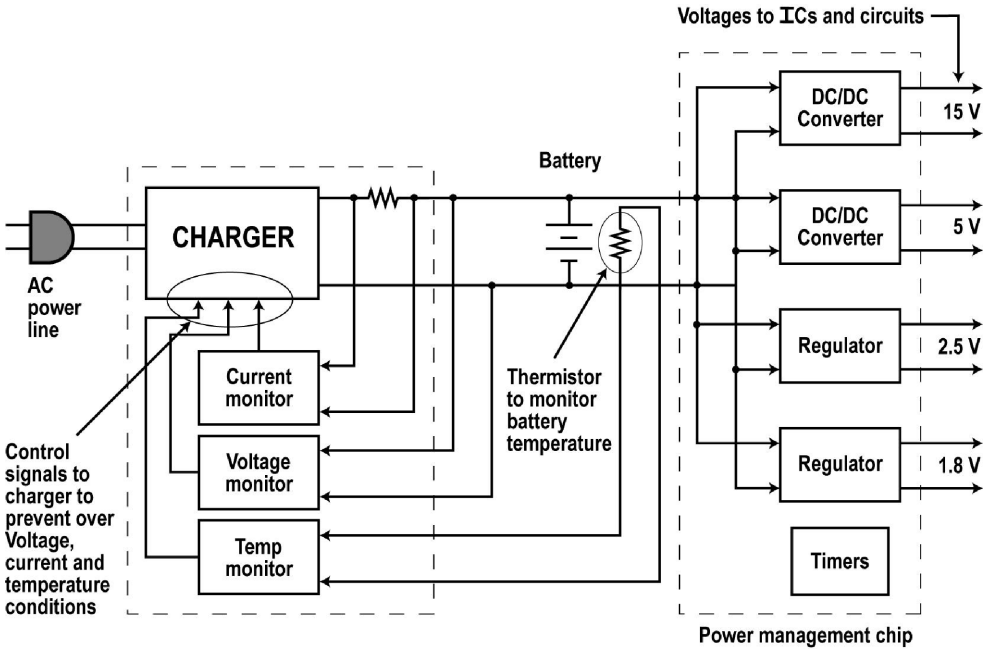
For example, in cell phones, the display or other lighting is turned off after a few seconds since it requires a significant amount of power. Laptop computer power management devices also turn off the LCD display when not in use to conserve power.

Other Functions

Power management chips also provide DC voltage conversion. Most ICs and other circuits operate at voltages other than that available from the battery. DC-DC converter circuits change the battery voltage to higher or lower voltages as needed.

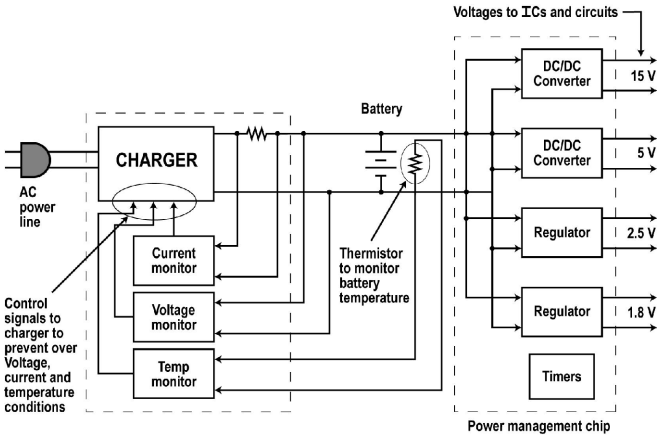
They also provide voltage regulation. Voltage regulators maintain a precise voltage value despite battery or load conditions.

Power Management IC Circuit



A discussion of this graphic is presented in the pages that follow. You can print this graphic for study purposes before going on.

Power Management IC Circuit



In the typical battery/power management IC, as used in most cell phones and laptop computers, a thermistor is used to monitor the temperature of the battery as it is charging.

The more sophisticated power management systems actually incorporate a small 8-bit embedded microcontroller. It works in conjunction with the voltage, current and temperature sensors, timers and other circuits to more accurately calculate and control the power circuits. These are referred to as smart power circuits.

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Battery Charging

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