Common Battery Types

Overview of the Most Popular Batteries Used in Electronic Applications

Common Battery Types

There are literally dozens of types of both primary and secondary batteries. Many are special types for specific applications. The most common types are the alkaline, lead-acid, nickel-cadmium, nickel metal hydride, lithium manganese dioxide, lithium ion, and lithium polymer batteries.

The following pages describe these common batteries. The description includes their type (primary, secondary), chemistry, nominal voltage, end point voltage, standard packaging, ampere-hour capacity, energy density, and common applications.

A battery comparison chart is available in the Learning Resources section of this module.

Alkaline Batteries

By far, the most widely used battery type outside of the standard automotive battery is the alkaline battery. It is the successor to the original carbon-zinc cells. They are primary non-rechargeable batteries. The cathode is manganese dioxide and the cathode is powdered zinc metal with an aqueous alkaline electrolyte.

The nominal voltage is 1.5 volts and their end point voltage is 0.8 volts. Standard packages include AAA, AA, C, D cells, button cells, 9 volt (6 cell) battery, and the lantern battery.

The ampere-hour capacity varies with the size of package (30 mAh to 45 Ah). Energy density ranges from 125 – 225 Wh/kg

They are used in flashlights and most consumer electronic products and toys except cell phones and laptop computers.

Note: Some say that these batteries can be recharged. This is false; they cannot.

Lead-Acid Battery

The lead-acid battery is found in virtually all cars, trucks, and other vehicles for starting, lights, all electrical accessories, and electronics. It is a secondary battery and is rechargeable.

The anode is lead (Pb), the cathode is lead oxide (PbO_2), and the electrolyte is sulfuric acid (H_2SO_4).

The nominal voltage is 2.1 cell voltage. Most batteries have 6 cells giving 12.6 volts. The end point voltage is 1.75 volts per cell.

The ampere-hour capacity varies with the size of the battery from 1 to 10,000 Ah. Most car batteries have a 100 to 300 Ah rating.

The energy density ranges from 10 – 40 Wh/kg. There are different size standard packages depending upon Ah rating. There are smaller sizes for non-automotive applications.

Lead-acid batteries are used in all cars and trucks as well as portable vehicles like golf carts and scooters. They are also used in boats and planes. Non-vehicle versions are found in uninterruptible power supplies (UPS) and as storage for solar power systems.

Nickel-Cadmium (NiCd) Batteries

Nickel-cadmium batteries are a low cost, small size battery for many portable equipment uses such as cordless phones, power tools, appliances, and cameras. They are secondary batteries and rechargeable.

Cadmium (Cd) is used for the anode, nickel oxyhydroxide (NiO_2H) is used for the cathode, and the electrolyte is potassium hydroxide (KOH).

The nominal voltage is 1.2 volts. They are usually connected in series to create batteries of a desired voltage. The end point voltage is 1.0 volt. The energy density ranges from 20 – 40 Wh/kg and the ampere-hour capacity varies with the size of the battery. It ranges from 0.5 to 10 Ah.

Different sizes are available depending upon Ah rating. This includes the standard AAA, AA, C, and D cells as well as special packages.

NiCd batteries have the disadvantage of a “memory” effect that reduces their energy capacity when they are repeatedly discharged only a small amount and then recharged. It can be corrected by completely discharging the battery and then recharging.

Nickel Metal Hydride (NiMH) Batteries

Nickel metal hydride batteries are a high energy density cell that gives more power per given size. They are secondary and rechargeable.

Metal hydride (MH) is used for the anode, nickel oxyhydroxide (NiO_2H) for the cathode, and the electrolyte is potassium hydroxide (KOH). The nominal voltage is 1.2 volts and they are usually connected in series to create batteries of a desired voltage. The end point voltage is 1.0 volt. The ampere-hour capacity varies with the size of the battery. It ranges from 4 to 100 Ah. The energy density is typically 75 Wh/kg.

They are available in different sizes depending upon Ah rating including the standard AAA, AA, C, and D cells as well as special packages.

Nickel metal hydride batteries are used in cell phones and laptop computers. They are also the battery of choice for the newer hybrid-electric cars.

Lithium Manganese Dioxide ($LiMnO_2$) Batteries

Lithium manganese dioxide batteries are the highest energy density primary batteries available. They are expensive but very effective for some portable applications. They are non-rechargeable.

The anode is lithium, the cathode is manganese dioxide, and the electrolyte is some organic solvent or salt.

Nominal cell voltage is 3 volts and the end point voltage is 2 volts.

The ampere-hour capacity varies with size of battery ranging from 25 mAh – 2.9 Ah. The energy density: 30 to 260 Wh/kg

They are available in standard N type miniature tubular packages and there are some special button or rectangular packages.

They are used in cameras, watches, security equipment, and some medical applications.

They are highly dangerous in handling and disposal but they have the best shelf life of any primary battery.

Lithium Ion (Li+) and Lithium Polymer Batteries

Lithium ion and lithium polymer batteries are the most popular of several types of lithium based secondary batteries. They are expensive but very effective rechargeable batteries for portable applications.

They use lithium metal oxide for the cathode, lithiated carbon for the anode, and an electrolyte of some organic solvent. Lithium polymer batteries use a gelled electrolyte.

The nominal cell voltage of 4 volts is the highest of any available cell. The end point voltage is 3 volts. The ampere-hour capacity varies with size of battery up to 100 Ah. The typical energy density of 150 Wh/kg is the highest energy density of any secondary battery.

They are available in standard sizes depending upon Ah rating. Lithium polymer batteries are made in many special shapes and sizes to fit the application. They are used in cell phones and laptop computers.

Recharging and disposal are highly dangerous. They have the best shelf life of any secondary battery.

Other Common Batteries

Two primary cells that are often found in consumer and industrial applications are the silver oxide ($ZnAg_2O$) and zinc-air (ZnO_2) batteries.

The silver oxide cell has a working voltage of 1.5 volts and an Ah rating of 5 mAh to 200 mAh. The energy density is 530 Wh/kg typical.

The zinc-air cell has a working voltage of 1.4 volts and an Ah rating in the 30 mAh to 1.1 Ah range. The energy density is 1300 Wh/kg.

Both of these cells are commonly available in button size packages and are widely used in watches, clocks, hearing aids, some photographic equipment, and medical monitoring equipment.

Battery and Cell Packages

The most common primary cell packages are cylindrical packages from the smallest AAA to the larger AA, C, and D cells.

A small cylindrical N type package is used for lithium primary cells.

Special primary battery packages are the 9 volt battery and the 6 volt lantern battery.

Secondary batteries such as NiCd, NiMH, and Li+ are generally available in the same packages as the primary batteries listed above.

There are many special packages for secondary batteries.

The larger lead-acid batteries have several standard sizes like those used in cars. Special sealed gel batteries, smaller than car batteries, are available for non-automotive use.

Battery packages are standardized by American National Standards Institute.

Car and Truck Batteries

We are about to see a new size and type of battery for cars and trucks: the 42-volt battery. It will gradually replace the current 12 volt battery that has been in cars for many decades.

The last battery conversion in cars was 1955 when batteries went from 6 volts to 12 volts.

The conversion from 12 to 42 volt batteries began in 2004 and will continue until a complete conversion takes place. It is estimated to be in the 2010 - 2020 period.

The 42 Volt Battery

The reason for the change is that, over the past years, the electrical needs of cars has increased by over 50%. Modern cars use more electrical power equipment and electronic equipment than ever before.

Most systems are embedded controller based, use more motors and control systems, and more electronic units (antilock brakes, stability control, navigation, video, etc.) That trend continues. The current 12 volt battery based system is simply inadequate.

Most automotive systems with a 12 volt battery and alternator/charger produce up to 2.5 kW to 3 kW maximum. Newer cars demand more power with even greater expectations. The only way to provide this higher power is with a larger battery.

Why 42 Volts?

A value of 42 volts was a compromise size that provides the necessary power increase but also is not overly dangerous. Electrical shocks to humans begin to occur at about 50 volts so 42 volts is still a safe level.

42 volts is also a multiple of the current 12 volt battery standard. 12 volt car batteries are charged by the vehicle's alternator and a charger/regulator circuit producing about 14 volts.

While the car is running, all of the electrical and electronic circuits operate from 14 volts. A single 42 volt battery would simply be three 12 volt batteries repackaged in series giving 36 volts and charged by 42 volts.

42-volt systems are expected to provide up to 8 kW or 9 kW of total power.

42 Volt Conversion

Initial systems will be hybrid 12 volt/42 volt sources so that all equipment will not have to be converted at the same time (lights, motors, etc.)

The final battery technology is still to be determined but, it may be conventional lead-acid, NiMH, or lithium ion. The lead-acid battery is proven but it would be larger and heavier because of its lower energy density than current batteries or ones made with NiMH and Li-Ion.

Hybrid electric vehicles already use NiMH batteries and they are proven in vehicular use. Li-Ion batteries have a higher energy density and would be no larger than current 12 volt batteries. However, their safety and reliability would have to be proven in the harsh vehicular environment.

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