Work-Ready Electronics

Synchronizing Curriculum to the Rapidly Changing Workplace

Module: Portable Power Technology
Batteries, Battery Charging, and Applications

WORKREADY ELECTRONICS

Portable Power Technology

Portable power is the electrical energy source for hand held, portable, and mobile electronic products. Over the years, there has been an enormous increase in the number of portable devices including cell phones, laptop computers, PDAs, MP3 players, digital cameras, portable TV sets, radios, and GPS receivers. Portable devices rely mainly on batteries.

During the past decade, battery sales have more than doubled. The battery industry currently sells over $50 billion worth of batteries each year. Sales are also increasing by double digits each year.

With more equipment relying upon batteries and the wide variety of battery types, it is essential that technicians understand battery basics and applications.

While everyone is familiar with the basic battery types, there are many of new kinds of batteries. This makes selection, replacement, and charging an increasingly challenging endeavor. This module is an update on modern battery technology.

Module Prerequisites

This module is designed primarily to be used with a DC Circuits course. It can also serve as a supplement to any other course where the prerequisites given below are met.

To successfully complete this module, the student should have knowledge and skills in the following areas:

- Basic DC circuit operation
- Introduction to batteries
- Ohm's law
- Series and parallel circuits
- Kirchhoff's laws

What Technicians Need to Know

- Modern battery types, voltage, capacity and energy capacity
- Battery specifications
- Common battery applications and relevant battery types
- Battery selection and replacement
- Battery testing
- Battery charging requirements and methods
- Battery safety and disposal techniques

Review of Battery Basics

Battery Background

Batteries were invented by Italian Alessandro Volta in the late 1790s and early 1800s. They are our oldest continuous electrical power source.

They have been continuously improved upon and adopted over the years. The past few decades have brought us increasingly more dense integrated circuits with their small size and low power consumption making sophisticated portable electronic devices practical.

The result is that battery usage has soared in the past decade. New types have been developed thereby making even more applications possible.

Changing Requirements

While all electronic technology education programs cover batteries, that coverage is shallow and often dated. New types of batteries and technical charging requirements are ignored.

Dealing with batteries and other power sources is a key responsibility for technicians. This module will provide an update on battery technology to supplement the traditionally weak courses that are lacking in technology.

Battery Applications

Before reviewing battery basics, consider how widely used batteries are.

They are a part of all of our every day lives, so much so that we forget how important they are.

Just to make the point, before going to the next slides in this module, take a few minutes to write down all of the products that you own that use batteries.

After you do that, write down as many other products you can think of that use batteries but that you may not own.

A list of where batteries are use is provided in the Learning Resources section of this module.

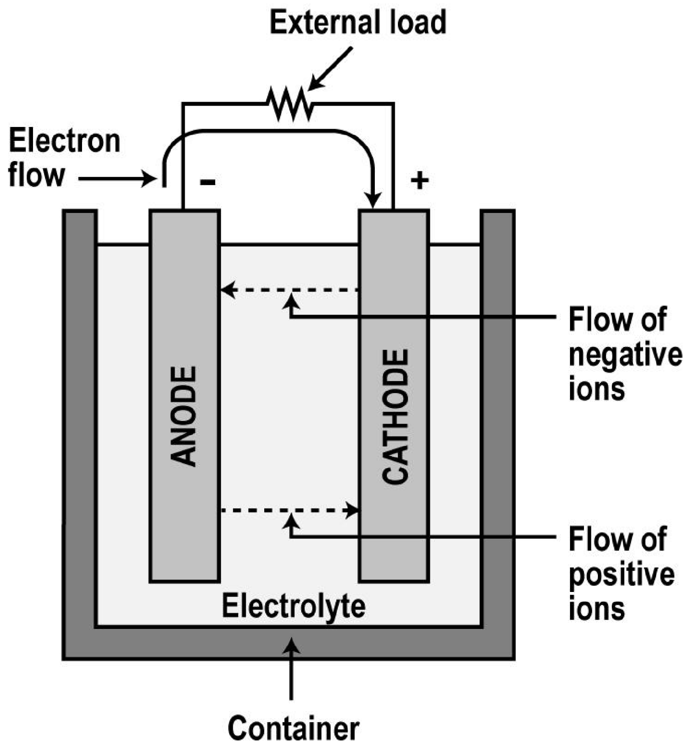
Battery Operation

Batteries are a chemical source of electrical energy

Batteries are made up of multiple basic cells that consist of a cathode, an anode, and an electrolyte.

The anode and cathode are made of different materials.

When exposed to a wet or dry electrolyte, they produce a chemical reaction that releases electrons that collect on the negative terminal of the battery.



Battery Operation

The anode is the negative terminal. It supplies the electrons to the load and becomes oxidized by the chemical reaction taking place.

The cathode is the positive terminal of the cell that receives the electrons from the load. This element is chemically reduced during the internal chemical reaction.

The electrolyte chemically reacts with the anode and cathode and provides a conductive path between anode and cathode by way of both positive and negative ions.

The battery action is referred to as electrochemical oxidation and reduction. The chemistry of cells is beyond the scope of this module and not necessary to the selection, usage, and servicing of batteries.

Battery Terminology

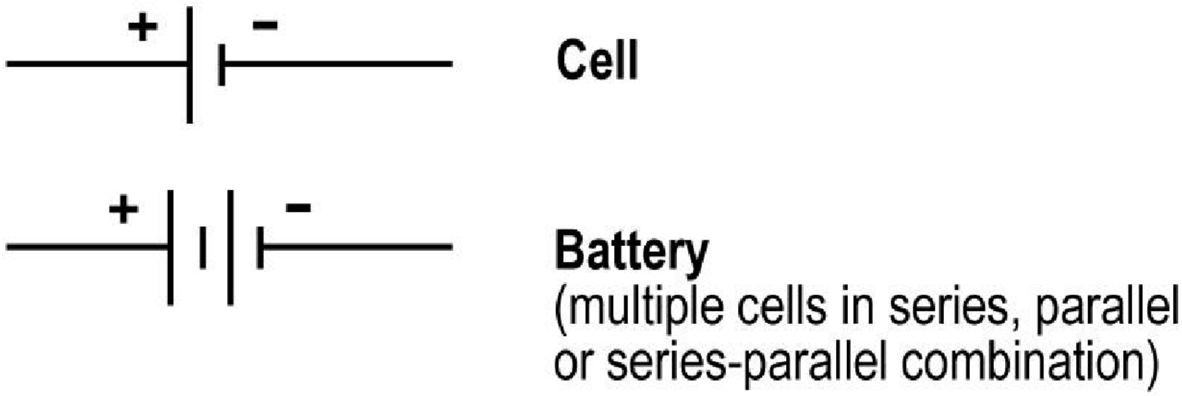
The types of materials used in making the cell determine the voltage produced by the cell.

The size (volume) of the cell and its material determine the current capability and overall power/energy capacity of the battery.

Multiple cells are connected in series or in series-parallel combinations to produce higher voltages or current capacity.

There are two types of cells: primary and secondary. Primary cells are those whose chemicals are used up in supplying electricity and must be replaced when exhausted. Secondary cells are those that can be recharged and reused many times.

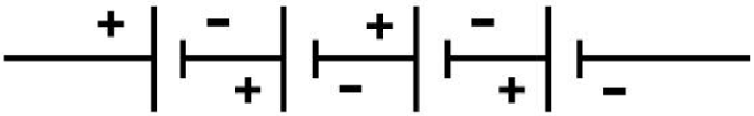
Battery Connections



As stated earlier, cells consist of a cathode, an anode, and an electrolyte. The figure above shows the schematic symbols of a cell and battery.

Batteries are made up of multiple cells in series, parallel, or in series-parallel combinations.

Series Connection

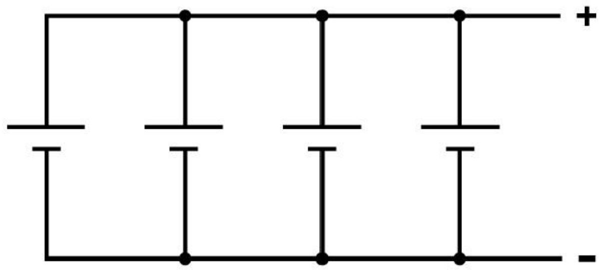


Series connection increases battery voltage

In a series connection, the cells are connected to produce a higher voltage than that available from a single cell.

Two common examples are the 9 volt battery made from six 1.5 volt alkaline cells and a 12 volt car battery made of six 2.1 volt lead-acid cells. The total battery voltage is the sum of the individual cell voltages. The cells are connected positive (+) to negative (–) so that the voltages add.

Parallel Connection



Parallel connection increases cell current capacity

The parallel connection is used to increase the current capacity of a battery.

Each battery has a maximum current output. Batteries of the same voltage are connected in parallel to give increased current output.

Other series-parallel combinations are used to form battery packs that give just the desired voltage and current.

Battery Specifications

In addition to the voltage requirements of the battery, other specifications include:

- Capacity: the maximum available current supplied over time
- C-rate: the charge or discharge current
- Energy capacity: the power per unit of time
- Energy density: the amount of Wh capacity compared to the size of the battery
- Internal resistance: the resistance of the battery elements and electrolyte that appears in series with the voltage produced
- Shelf life: the time over which the cell or battery retains a useful charge while not in use
- Cycle life: the number of time a secondary battery can be discharged and recharged

These specifications will be addressed in the following slides.

Battery Specifications: Output Voltage

The output voltage specification can be expressed in several different ways.

The theoretical voltage is the value determined by materials used.

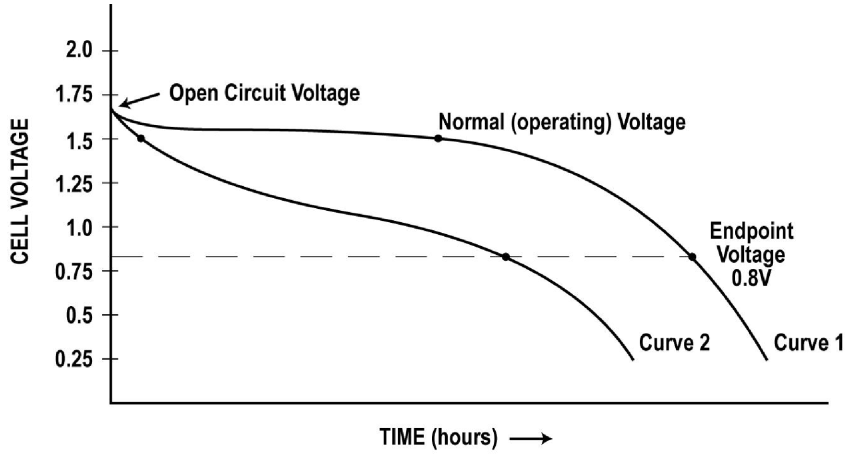
Open circuit voltage is the output voltage with no load. It is close to the theoretical voltage.

The working voltage is the operating voltage with a typical load.

Nominal voltage is the common voltage accepted as normal for this battery type. It is usually the same as working voltage.

The cut-off or end voltage is the voltage at the end of a discharge cycle. Any voltage below the end voltage indicates a discharged cell that is no longer useful.

Battery Specifications: Discharge Curves

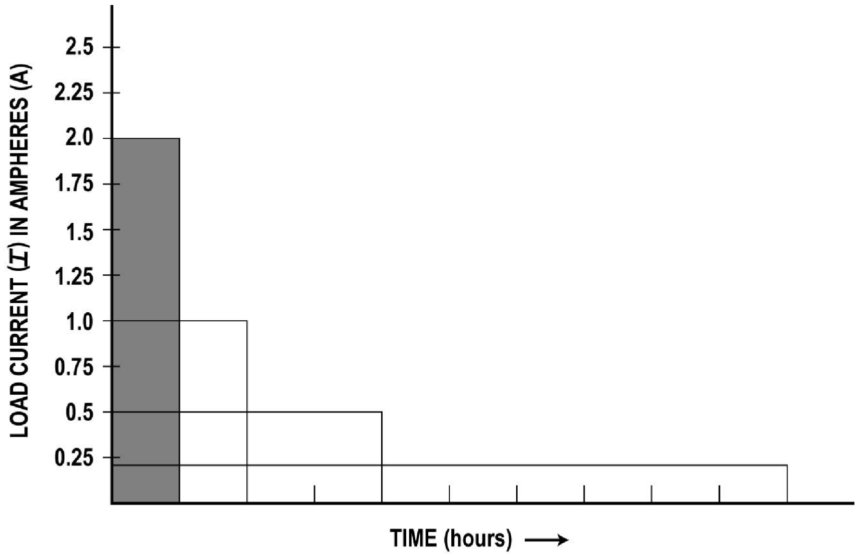


Curve 1 = low current load
Curve 2 high current load

The amount the battery discharges for different current loads can be plotted showing the cell voltage and the time in hours.

As you can see from the figure above, the open circuit voltage is the just over 1.5 volts. The end point voltage is reached quicker when the current load is higher (Curve 2).

Battery Specifications: Capacity

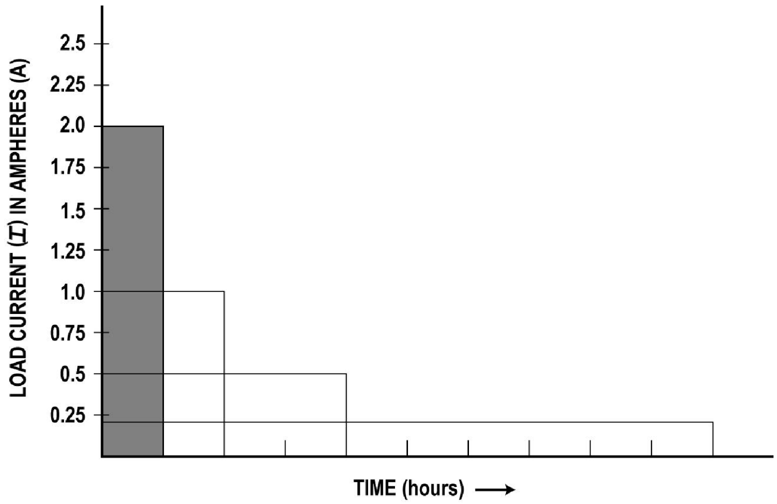


BATTERY RATING = 2Ah

Ampere-hour rating (or capacity) is used to indicate the capacity of a cell. It is the maximum available current supplied over time.

The ampere-hour rating of a battery is the amperes (A) drawn over some time usually hours (h). Ampere-hours = Ah.

Battery Specifications: Capacity Example



BATTERY RATING = 2Ah

Batteries have an Ah rating such as 200 Ah. This means that the battery can supply 200 A for one hour until it is discharged.

This battery may also supply 1 A for 200 hours or 50 A for four hours as designated by the formula: Ah = A x hours.

The Ah rating of a battery is a function of the size of the battery and the quantities of the chemical materials used.

Battery Specifications: C-Rate and Energy Capacity

The charge or discharge current expressed in multiples or fractions of the rated capacity is called the C-rate (charge rate).

For example, a charge rate of C/10 for a battery with an Ah rating of 4 Ah is 4/10 = 0.4 A or 400 mA.

The energy capacity is the power per unit of time. It is rated in watthours (Wh) = (battery voltage) x (Ah)

Battery Specifications: Energy Density

Energy density is the amount of Wh capacity compared to the size of the battery.

It is determined by the types and quantity of material used.

Energy density is expressed in terms of watthours per unit of volume or weight such as watthours per liter (Wh/L) or watthours per kilogram (Wh/kg).

The energy density determines the overall merit of the battery. High energy density is desirable because the battery supplies more Wh for a given size or weight.

For example, a lithium-ion battery has a much greater energy density than a lead-acid battery because it has longer operating time and is smaller in size and weight for its given Ah rating.

Battery Specifications: Internal Resistance

Internal resistance is the resistance of the battery elements and electrolyte that appears in series with the voltage produced.

It ranges from a fraction of an ohm in large batteries to tens of ohms in smaller batteries.

Internal resistance lowers output voltage under load and dissipates heat like any other resistance.

Battery Specifications: Shelf Life and Cycle Life

Cells and batteries tend to discharge themselves (self-discharge) due to internal chemical actions over a period of time. Self-discharge rates vary from a few days to many years depending upon battery type.

The time over which the cell or battery retains a useful charge while not in use is referred to as the shelf life.

The number of times a secondary battery can be discharged and recharged is referred to as the charge/discharge cycles. It is also called the cycle life. Batteries can be charged and discharged several hundred to several thousand cycles for most batteries.

Test your knowledge

Portable Power Technology
Knowledge Probe 1
Review of Battery Basics

Click on Course Materials at the top of the page.

Then choose **Knowledge Probe 1**.