A Brief Look at Batteries

At some point during 501/502 you will need to use one or more batteries in order to provide power to a system that needs to be deployed away from line power.

It's a good idea to understand a few fundamental points about using and charging batteries so you can estimate the required battery capacity. Let's begin by looking at the concepts of charge, power and energy

Charge

The unit of charge is the Coulomb. This is defined as the quantity of charge transferred in one second by a steady current of one ampere.

$$1 \text{ Coulomb} = 1 \text{ Amp-Second}$$

Power

The unit of power is the Watt. One Amp of steady current through a one Ohm resistor results in one Watt of dissipated power.

Energy

The unit of energy is the Joule. One Joule of electrical energy is equal to the work done when a current of one ampere is passed through a resistance of one ohm for one second. A better way of looking at this is:

$$1 \text{ Joule} = 1 \text{ Watt-Second}$$

Batteries are rated in Amp-hours, or milliamp-hours. Here's an example for alkaline batteries:

Battery Type	Capacity (mAh)	Typical Drain (mA)
D	12000	200
C	6000	100
AA	2000	50
AAA	1000	10
N	650	10
9 Volt	500	15
6 Volt Lantern	11000	300

Material originally prepared by Prof. Prescott

Calculating how long a battery will last at a given rate of discharge is not as simple as "amp-hours" - battery capacity *decreases* as the rate of discharge *increases*.

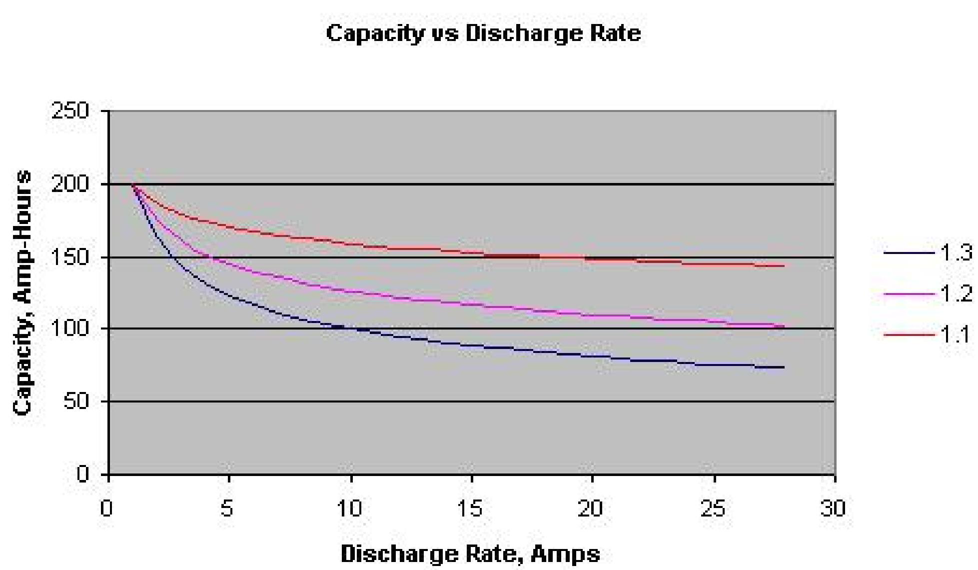
For this reason, battery manufacturers prefer to rate their batteries at very low rates of discharge, as they last longer and get higher ratings that way.

The formula for calculating how long a battery will really last has the charming name of "Peukert's Formula". It is...

$$T = \frac{C}{I^n}$$

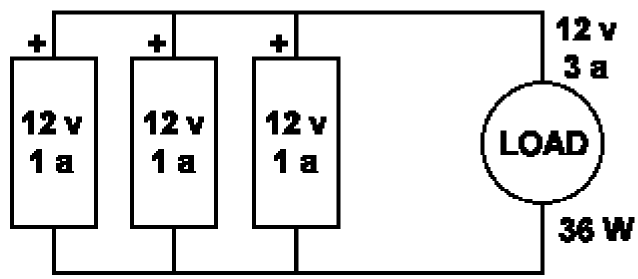
where **C** is *theoretical* capacity (in amp-hours, equal to actual capacity at one amp), **I** is current (in amps), **T** is time (in hours), and **n** is the Peukert number for the battery.

The Peukert number shows how well the battery holds up under high rates of discharge - most range from 1.1 to 1.3, and the closer to 1, the better. The Peukert number is determined empirically, by testing the battery at different rates.

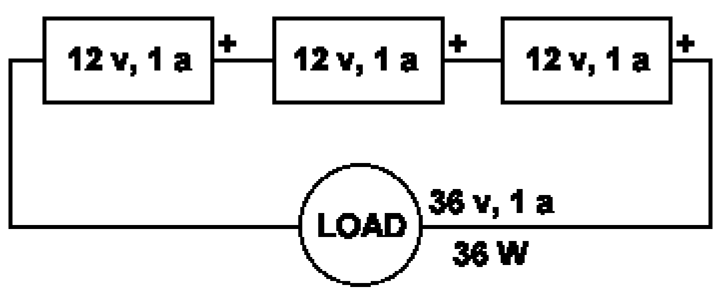


Much of this material taken from http://www.gizmology.net/batteries.htm

Hooking batteries in *parallel* will give you the same voltage as a single battery, but with a Ah and current carrying capacity equal to the sum of the capacities of all the batteries. For example, three 12v 20 Ah batteries in parallel will give you 12v 60 Ah. If each battery could put out 200 amps max, three in parallel could put out 600 amps max.



Hooking the batteries in *series* will give you a voltage equal to the total voltage of all the batteries, but the Ah and current carrying capacity of only one. For example, three 12v 20 Ah batteries in series will give you 36v 20 Ah. If each battery could put out 200 amps max, then three in series will put out only 200 amps max.



In other words, you can combine voltage, or capacity, but not both.

Current draw is divided up among the batteries the same way that capacity is combined.

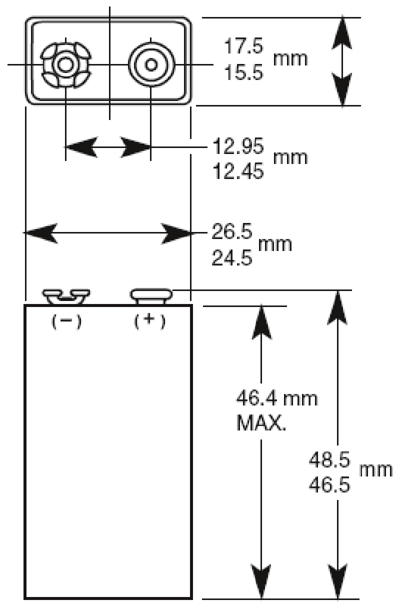
In parallel, each battery only need supply a fraction of the total current drawn by the load; in series, each battery must supply the full current. Thus, a circuit drawing 150 amps from three 12 volt batteries in parallel will draw 50 amps from each.

The kind of batteries we are most likely to use in JEDL applications are classified as "household" batteries, such as the 9 volt battery described below:

DURACELL® COPPERTOP™ MN1604

Alkaline-Manganese Dioxide Battery

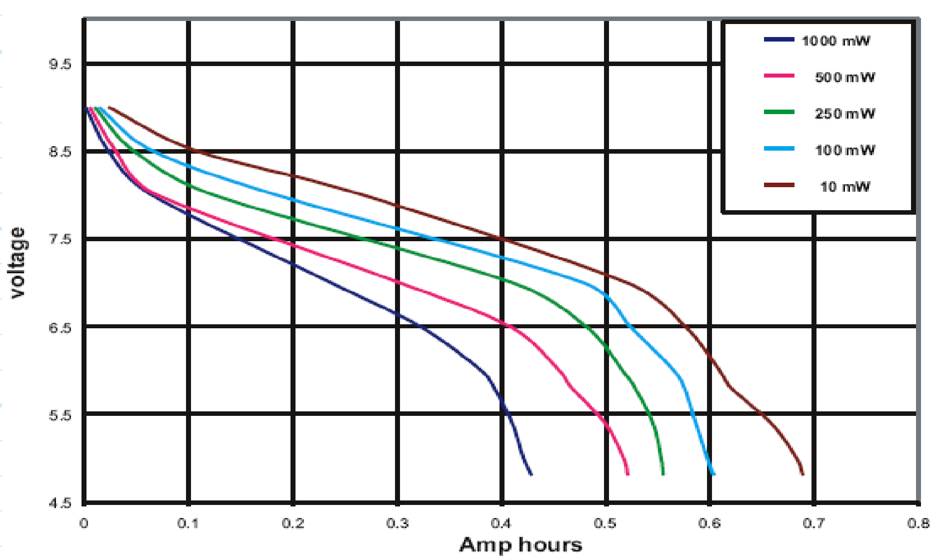
Size: 9V (6LR61)



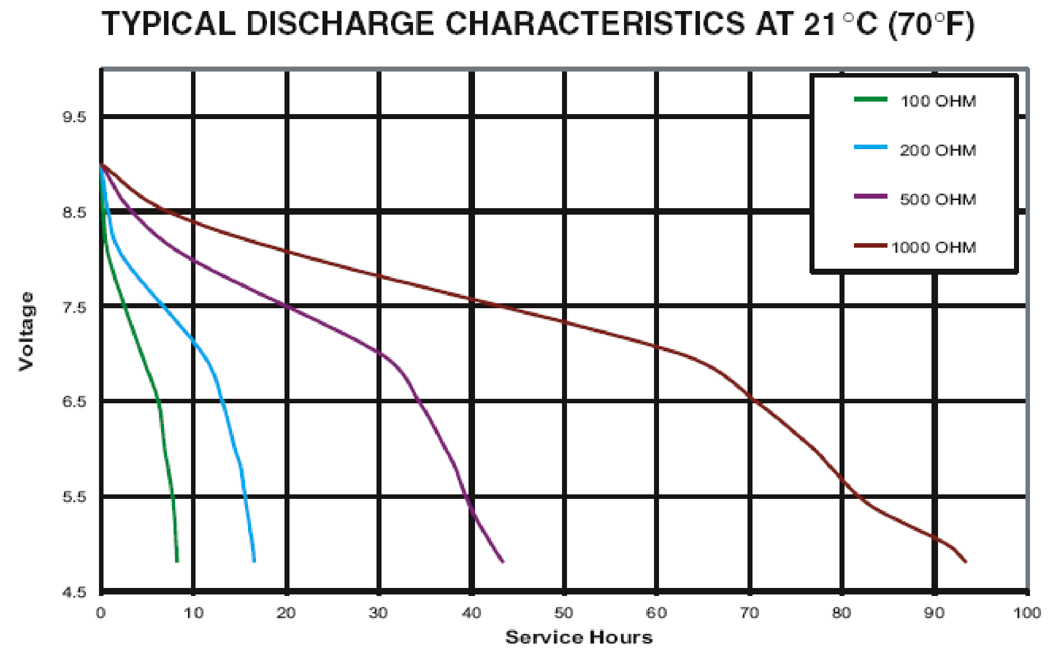
Dimensions shown are IEC/ANSI standards

Nominal Voltage:	9 V
Nominal Internal Impedance:	1,700 m-ohm @ 1kHz
Average Weight:	45 gm (1.6 oz.)
Volume:	22.8 cm^3 (1.39 $in.^3$)
Terminals:	Miniature Snap
Operating Temperature Range:	-20°C to 54°C (-4°F to 130°F)
NEDA/ANSI: IEC:	1604A 6LR61

TYPICAL DISCHARGE CHARACTERISTICS AT 21°C (70°F)



 Material originally prepared by Prof. Prescott



Common types of household batteries are:

- Zinc-Carbon Battery

Old technology. Case was one of the electrodes – uneven discharge resulted in leaks, etc.

- Zinc Manganese Dioxide Alkaline (Alkaline battery)

Have 5 to 6 times longer life than Zinc-Carbon batteries. Approx 30% of all household batteries sold today are of this type.

- Rechargeable Alkaline Battery

Longer shelf life than Ni-Cd batteries. No memory effects.

- Nickel-Cadmium (Ni-Cd) Battery

Most common rechargeable household battery

- Nickel-Metal Hydride (Ni-MH)

Lasts 40% longer than same size Ni-Cd and can have a life span of up to 600 charge/discharge cycles.

- Lithium and Lithium Ion

Very light weight.