Euthenic Energy Solutions

WHITE PAPER

ON

PowerPlus: Battery Life Enhancer

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Technical Details on Lead Acid Batteries:

The Chemistry of Sulfation, and Why Pulsing Helps:

Here is a basic look at the chemistry of conventional lead-acid batteries under charge and discharge.

The basic electrochemical reaction equation in a lead-acid battery can be written as follows:

$Pb + 2H_2SO_4 + PbO_2$	<---- Charging Discharging---->	$+ PbSO_4 + 2H_2O + PbSO_4$

Or, in words:

Porous lead active material negative plate	+	sulfuric acid electrolyte	+	porous lead dioxide active material positive plate

Becomes: ↑ Charging ↑ / --------------- / ↓ Discharging ↓

Lead sulfate active material negative plate	+	water electrolyte	+	lead sulfate active material positive plate

Discharge:

During the discharge portion of the reaction, lead dioxide (positive plate) and lead (negative plate) react with sulfuric acid to create lead sulfate, water and energy.

Charge:

During the recharge phase of the reaction, the cycle is reversed: the lead sulfate and water are electro-chemically converted to lead, lead oxide and sulfuric acid by an external electrical charging source.

This is how things work when the battery is new and clean. There are several effects that come in as the battery is used. One is the process called Sulfation, which is of central concern to this effort.

The biggest problem in lead-acid cells is Sulfation due to chronic undercharging. Here the sulfate ions have entered into deep bonds with the lead on the cell's plates. The sulfate ions can bond with the lead at three successively deeper energy levels.

Level One is the bond we use when we normally charge and discharge the cell. After a month or so at Level One, some of the bonds form;

Level Two bonds which require more electric power to break. After several months of being at Level Two bond, the sulfate ions really cozy up to the lead and form;

Level Three bonds which are not accessible electrically. No amount of recharging will break Level Three bonds. The longer the lead sulfate bond stays at a level the more likely it is to form a closer acquaintance and enter the next deeper level. This is why it is so important to fully, regularly, and completely, recharge lead-acid cells.

Equalization Charges:

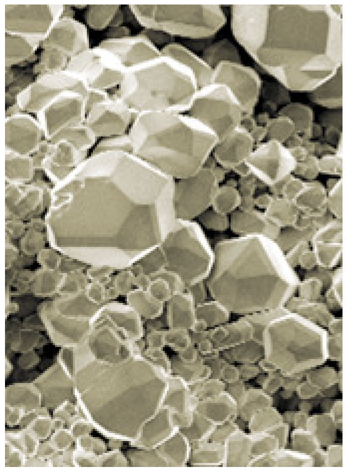
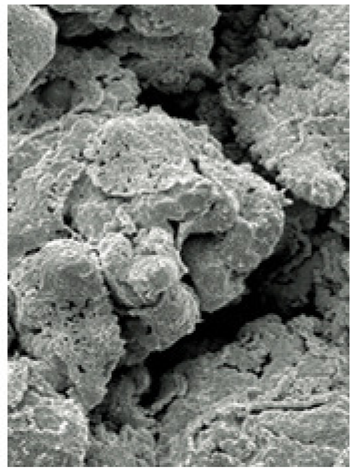
If the loss in capacity is due to Level Two bonding, then a repeated series of equalizing charges will break the Level Two bonds. Under equalization the Level Two bonds will first be transformed into Level One bonds, and then the sulfate ion can be kicked loose of the lead entirely and reenter the electrolyte solution. If your lead-acid cells have lost capacity, then a regime of equalizing charges is the first procedure to try. An equalization charge is a controlled overcharge of an already fully recharged cell. First recharge the cell and then continue to charge the cell at a C/20 rate for five to seven hours. During equalization charges, the cell voltage will become very high, about 2.7 VDC per cell. This overcharge contains the necessary power to break the Level Two bonds and force them to Level One. Once they reach Level One, the bond is easily broken and the sulfate ions reenter into solution in the electrolyte.

How Pulsing helps:

In the above, the Level One, Two, or Three bonds refer to progressively larger and insoluble crystals of lead sulfate. Like most crystal formation, it is a slow process. So the question is, how could pulse charging affect this situation?

The active material in the positive electrode....is lead dioxide. This molecule is a relative of rust, it is a corrosion product. When you charge a lead acid battery, one of the things you attempt to accomplish is the repair or reformation of the corrosion layer of the positive plate. If you don't properly charge the battery, the corrosion layer begins to break down in the acid environment and the voltage characteristic of the battery changes for the worse.

Pulse charging does not influence or improve the corrosion layer of the positive electrode and therefore, does not permanently or properly improve the performance of the battery. It is only through the electrochemical process of corroding the positive electrode that you optimize the battery's performance. To properly corrode the positive electrode the battery voltage has to reach and then exceed the gassing potential of the battery. In a deep cycle battery, not gassing the cells will result in stratified electrolyte, ineffective corrosion of the positive plate, reduced performance and shortened life.

Photos:

(Left) Microphotograph of a battery plate covered in heavy Sulfation buildup (lead sulfate crystals).

(Right) PowerPlus removes these sulfate crystals and expose the active material of the battery plates. More active material means stronger batteries.

How we generate Pulses:

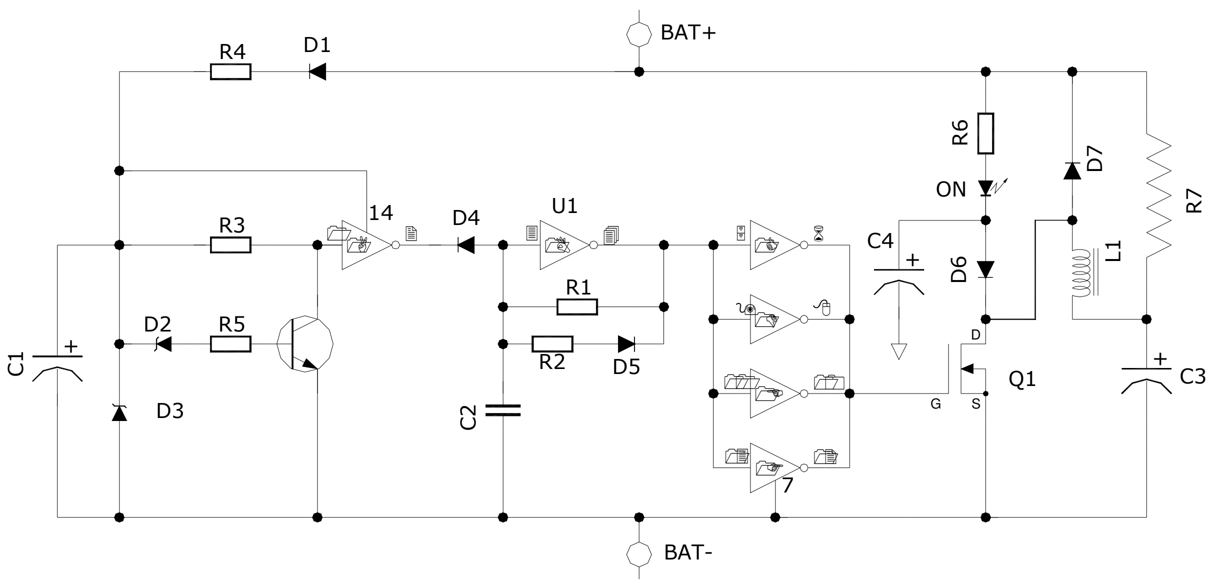


Figure-1 Power Plus Circuit Diagram

Circuit Description:

The circuit is in essence a very widely used form of switching DC to DC converter, which can take a DC voltage and step it up to a higher level.

Figure shows circuit diagram of Power Plus. The basic pulse rate and width are set by the oscillator (U1), which switches the MOSFET Q1 at desired frequency.

When Q1 is in the non-conducting state, current is drawn from the battery via resistor R7 so that capacitor C3 can be charged slowly. Then Q1 is turned on for a very short time, causing the charge stored in C3 to start flowing through L1.

When Q1 is turned off again, the stored inductive energy in L1 has to continue to flow some where, so it pulses back into the battery via D7. The use of an inductor to supply this pulse is what makes it possible to restore sulfated batteries with high internal resistance. The peak voltage drop across the battery can as high as 50V for badly sulfated battery. With continued treatment, this peak voltage will decrease as the battery's internal resistance gradually declines.

Mentioned circuit is common for both 12V & 24V, except some components & inductor values are being changed that decides the pulse strength. Normally pulse strength is depending on size (AH) of the battery.

Our opinion on the matter, subject to further learning is:

- ***That, pulsing does' affect the Level Two bonds by constantly applying an over potential above the gassing point, at a kilohertz rate. Thus, even if the battery is not fully charged, it keeps the Level One bonds from turning into Level Two bonds. Since the process is slow and continuous, it does not liberate significant amounts of gasses, as they are able to dissolve into the electrolyte.***

- ***That, pulsing can also affect the Level Three bonds by virtue of the high rise time of the pulses. Since the Level Three bond crystals are insoluble and electrically inactive to DC current, they act as a dielectric. This forms a capacitive connection between the deeper layer of the plate and the electrolyte that will pass transients of current with low impedance. This then allows for enough energy to be transferred to the material to allow for the slow breaking apart of the crystals.***

- ***The main factors are: fast rise time, high peak amperage, and moderate repetition rate.***

Thanks.

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