Adaptive Charging: how it works

The text below closely follows the explanation given in the Phoenix battery charger info sheet, but with additional detail.

For general knowledge about batteries and battery charging, please refer to the text Electricity on Board, available on the website of Victron Energy.

1. The right amount of charge: variable absorption time

To fully charge a battery, a period of charging at a relatively high voltage is needed. This period of the charging process is called absorption charge. A battery that has been deeply discharged needs an absorption time of several hours, whereas a battery that is only slightly discharged requires a much shorter absorptoin period.

Classic 3-step chargers nevertheless have a fixed absorption time, for example 4 hours. Charging a battery with a fixed absorption time works well as long the battery has been, on average, substantially discharged before a recharge cycle is started.

In several applications however a fixed absorption time can lead to overcharging, which will reduce service life. In case of flooded batteries frequent topping off of the electrolyte will also be needed, due to increased gassing.

Consider for example a typical boat, or a coach, connected to a shore-side supply with limited output. Household equipment like a microwave, coffee maker, washing machine or an electric stove might trip the shore supply circuit breaker. The solution is to run this equipment from the battery with help of an inverter. A charger is connected to shore power to charge the battery. The battery in this case is used as a peak shaver, with short discharges every time there is a high current draw due to household equipment being used. Chances are that, in case of a fixed absorption time, the battery will be subjected almost continually to absorption charge. The result is overcharging, which will substantially shorten battery life and might even result in thermal runaway of the batteries.
An adaptive charger will also execute a recharge cycle after each shallow discharge, but the absorption time will be much shorter, thereby increasing battery life.

The absorption time of a Phoenix Charger or Phoenix Multi will adapt itself as follows:
after each period of bulk charge (= the charger has reached its maximum current) an absorption period of 5 times the the bulk charge period will follow, with a maximum set at, for example, 4 hours.
- A bulk charge of 5 minutes (battery was nearly fully charged) will result in an absorption charge of 5 x 5 = 25 minutes.
- A bulk charge of 30 minutes will result in an absorption charge of 30 x 5 = 150 minutes, or 2,5 hours.
- A bulk charge of 2 hours will result in the maximum absorption charge time of 4 hours.
- When connected to a fully charged battery and switched on, no absorption charge will occur because the charge current will almost immediately drop off

to a low level.

2. Preventing damage due to excessive gassing: the BatterySafe mode

Often the absorption charge voltage of a battery does not exceed the gassing voltage limit (approximately 14,4 V for a fully charged 12 V battery). Some batteries however need a higher absorption voltage to fully charge them (tubular or thick plate deep cycle batteries for ex.), and open, flooded, batteries in general can be charged faster by not only increasing the bulk charge rate, but also the absorption voltage.

A high charge rate will heat the battery (temperature compensation needed!) and will also increase gassing, in extreme cases up to the point that the gas bubbles will push the active mass out of the plates, destroying the battery. The BatterySafe mode limits the rate of voltage rise of the charger output after the gassing voltage has been reached. The effect is a sharp drop in charge current which prevents excessive gassing (see fig. 2 on the Phoenix battery charger info sheet).

3. Less maintenance and aging when the battery is not in use: the Storage mode

After completion of the absorption period, a battery charger in general switches to the float charge mode. In case of a 3-stage charger the float voltage should be sufficiently high to compensate for self discharge of the battery, but should at the same time be as low as possible in order to limit corrosion of the positive plates and gassing. In practice the balance isn't perfect: flooded batteries will gas substantially more than when left open circuited and will need regular topping up.

We have therefore introduced a fourth stage: the Storage mode. The Storage mode kicks in whenever the battery has not been subjected to discharge during 24 hours. In the Storage mode float voltage is reduced to 2,2 V/cell (13,2 V for a 12 V battery), which is close to the open circuit voltage of a fully charged battery.
Corrosion and gassing are reduced to absolute minimum, but self-discharge is not compensated. To compensate for self discharge, and to stir up the electrolyte, the voltage is raised back to absorption level once every week.

Note: although sealed (VLRA AGM or gel) batteries can be float charged at 13,5 V to 13,8 V during long periods of time (no topping up needed!), some studies have shown that the Storage mode will increase service life of sealed batteries (see for ex. 'Batterie Technik' by Heinz Wenzl, Expert Verlag, 1999).

Adding a forth charge stage, the Storage mode, also provides the option to increase the voltage during the third, 'float' stage to 2,33 V/cell (14 V for a 12 V battery). This is the charge voltage generally used for starter batteries in vehicles, and is ideal to 'supercharge' an already charged battery.