Simple Dual Battery System

by M Lauterbach

There are numerous dual battery management systems. Most of these connect the auxiliary battery in parallel with the starting battery after a predetermined time, so that the main battery starter drain can be recharged before recharging the auxiliary battery. Ideally, each battery needs to be charged on its own, so that the alternator can "read" the exact state of charge in that battery. Some expensive systems do this. Then there are also other systems which utilise boost charging at higher voltages (and currents), to reduce charging time.

The auxiliary battery should be a deep cycle battery, which can be discharged more often than a normal starting battery. A starting battery can be expected to fail after 30 completed discharges. A deep cycle battery will last much longer, even if often discharged to 80%. A deep cycle battery can be expected to last 4 to 8 times longer.

The basic differences between the two batteries is that the starting battery has numerous thin plates for maximum surface area, to facilitate large starting currents. Some describe the setup as a "lead sponge", which gets easily damaged by deep cycling.

The deep cycle batteries are not designed for huge current draws, but rather for high discharges. As a result they comprise of thick lead plates, which can buckle and short out when exposed to huge current draws, such as when running winches off them.

There are many more battery designs, such as the sealed gel batteries. Their characteristics with respect to charging/discharging voltages/currents, capacities and longevity, are all different.

The following figures represent a rough guide to a battery state of charge at 20 degrees C:

100%	**12.6V**
90%	**12.5V**
80%	**12.4V**
70%	**12.3V**
60%	**12.2V**
50%	**12.1V**
40%	**11.95V**
30%	**11.78V**
20%	**11.58V**
10%	**11.2V**
0%	**10.5V**

Ideally, one should try not to discharge the battery below 40%. Additionally, charging rates should not exceed a tenth of the amp hour (AH) rating of a battery for too long a period, ie 10.5A for a 105AH battery.

When a battery is discharged, its internal resistance is low, hence the initial charge current is high. As it gets charged, the internal resistance increases with a resultant drop in charge current, unless the voltage is increased.

In an alternator, the output is regulated by the regulator, by managing the current to the field coils (energising the field coils). Normally, the alternator will have an initial output of between 13.6V to 14.1V, which will then tapers off to typically 12.8V to 13.4V as the internal resistance of the battery increases to normal ie it tapers off while restoring the charge drained during starting.

Deep cycle batteries take a lot longer to charge than starting batteries. Contrary to popular belief, a fully drained battery can take longer than 8 hours to recharge at 13.8V! Hence some companies are marketing special boosters, which raise the alternator voltage, so that the batteries can be charged at a higher rate. This however reduces battery life, but allows the batteries to become fully charged during a day's drive.

Some of the best charging systems are three stage boost charges. Various manufactures have different voltages for these different stages, which they believe are best. The first stage, often referred to as the *bulk charge*, the voltage is regulated (changed) to keep a maximum safe current rate, until the battery reaches 80 to 90% of full charge. Voltage ranges are between 10.5V and 15.4V.

During next stage (*absorption charge*), the voltage is kept constant, while the current gradually tapers off as the internal battery resistance gradually increases. Typical voltages here are 14.1V to 15.4V

During the last *float charge* stage, the voltage is reduced to a level, where the battery is just trickle charged at typically between 12.8V to 13.2V.

If you alternator charges correctly at between 13.8V and 14.1V when the batteries are not fully charged, then the simple non-boosted battery systems work just fine, provided you have enough time to charge the batteries. A timer is added, to leave the auxiliary battery disconnected for about 9 minutes, to allow the starting battery to be fully charged first.

When doing the installation, there are a few vital items to observe:

- All connections should be sound, and, ideally soldered. When using lugs, use proper crimping tools. Using a vice, or a hammer and punch for "crimping", is not good enough, as these connections will have a volt drop at higher currents. A minor volt drop of eg 0.3V will drop the charge voltage from 13.8V to 13.5V, preventing the battery from becoming fully charged.
- The charging cable between the alternator and the battery often only consist of two $4mm^2$ wires in parallel, which have an allowable current carrying capacity of about 77 amps. At 77 amps, the volt drop will be between 0.3V to 0.4V per meter, which is too much. Solder in an additional 10 to $16mm^2$ welding cable to prevent any volt drop
- Only use quality brass battery terminals and lugs. Check each joint, eg on the Cole Hersee relay. If not tightened properly, you can easily experience a 0.2V drop per joint.
- Check your earth cable between the batteries and the chassis. Often the earth cable is routed from the battery to the chassis, and then from there to the engine or gearbox. This contains one extra connection, which is exposed to the environment. It is best if you connect another welding cable ($25mm^2$) directly from an earth on, or near, the alternator, directly to the negative terminal on the starting battery.
- Connect both the earth and positive terminals of the deep cycle battery to the starting battery (positive via Cole Hersee relay) with at least $16mm^2$ welding cables.

Ask 10 different fundis around a camp fire on what the best battery charging system or dual battery system is, and you might get ten different answers, as there is no consensus as to the best charging voltages and currents. And there cannot be and exact answer, as there are too many different battery types, which have different charge conditions. The chances are good that you will never get the ideal battery life while achieving more than 95% charge on average.

As the top-of-the-range charging systems cost a great deal more than a quality deep cycle 105AH battery, it can be argued that a simple system, such as in the diagram above, could be used to charge an additional 105AH battery (ie doubling your battery capacity), giving you a lot more amp hours, even if you only manage to charge your batteries to 85 or 90%.

Good luck in your decision, as to which system to buy, or build, for your application.