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How long does it take to charge a battery?

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This is one of the most often asked questions – usually after the battery pack has degraded to the extent that the capacity has reduced to an unusable level.

The aim of this document is not to go through all the technicalities and calculations or lengthy explanations of battery chemistry, charging profiles etc. It is simply to help gain an understanding of what it takes to recharge your batteries properly to maximise their life.

There are half a dozen or so different types of battery but the most popular are:

- **Open Lead Acid** – like the car batteries of old, these need topping up with distilled water such as the Trojan 6V. These are robust batteries that will do a lot of cycles (discharge/charge) but do need careful attention.
- **Sealed Lead Acid (SLA)** – probably the most popular 'leisure' type of battery commonly used on boats and in camper vans. They are 'maintenance free' which means they tend not to be looked after very well!
- **Absorbent Glass Matt (AGM)** – also popular on boats and camper vans. AGM batteries will do more cycles than SLA and are pretty good at handling heavy loads so are good with power inverters.
- **GEL** – popular on yachts and in telecoms systems. Spill free, GEL batteries have reliable power delivery but are not as good as AGM in handling high loads so AGM would be a better choice for high inverter loads.
- **LiFePO4** – "Lithium" batteries now gaining popularity due to their superb energy density, performance, cycle life and quick charge time. Initially expensive compared to the other types but much cheaper cost of ownership due to huge cycle ability and hence much longer life.

Each type of battery will require a different charging regime. Whilst the lead-acid batteries are pretty similar in charging requirements, LiFePO4 are a different ball-game all together and require specific charging and battery management.

By their very nature, Service/Domestic batteries are cycled (discharged/charged) frequently. It is therefore important to take the expected number of cycles that the battery is designed to achieve into account when deciding on a solution. Sealed Lead Acid (SLA) batteries tend to cycle significantly less than other batteries such as open Lead-Acid, AGM, GEL or LiFePO4 (lithium). Some SLA batteries only achieve c.70-80 cycles whereas some LiFePO4 batteries achieve in excess of 10,000 cycles!

When comparing batteries, be sure to compare the capacity, C rate and the number of cycles it is designed for. If that information isn't available, walk away!

In addition to the number of cycles, it is important to note the C rating when comparing batteries. Most manufacturers quote the capacity in Ah @ C/20 (sometimes as 'C20' or '20hour' rate) – this is the theoretical energy a battery can deliver continuously for 20 hours at 30°C (80°F) without falling below 10.5 volts (on a 12V battery). Care should be taken that when comparing batteries; you are also comparing them at the same discharge ('C') rate. Batteries are sometimes advertised with a different C rate which suggests a larger capacity than a comparable unit. For example, a battery quoted as 144Ah at the C100 rate is, in fact a 130Ah battery at the C20 rate:-

Capacity (C5)	105 Ah	Capacity (C10)	120 Ah
Capacity (C20)	130 Ah	Capacity (C100)	144 Ah

Back to the question…

What comes out, must go back in. However, it is not a simple calculation because other things such as the battery chemistry, charging efficiency, temperature etc. all affect the recharge of the batteries. There may also be a load on the batteries when you're recharging.

Firstly, we need to look at depth of Discharge (DoD). For SLA batteries, a good rule of thumb is you should not discharge deeper than 50% DoD. A lighter DoD will increase the life of the battery at the cost of available, usable capacity, a heavier DoD will increase usable capacity but will shorten the battery life. For AGM and GEL batteries, 50%-60% DoD is a reasonable compromise – the exception being Victron SuperCycle AGM which will happily go to 65% regularly and have been tested to over 300cycles at 100% DoD! LiFePO4 "Lithium" are happy to 80%+ DoD.

Lead-acid batteries have an internal résistance which affects the efficiency of charging and there are inefficiencies in the charging system itself. LiFePO4 batteries have very little internal resistance. All of these things can be calculated. For simplicity, we'll assume a battery with a capacity of 100Ah at C20, discharged to 50% DoD – so the equivalent of 50Ah has been used. These are basic calculations and there are other factors including temperature etc that should be taken into account but the following serves to illustrate the point.

Ah Capacity @C20	DoD %	Efficiency factor	CAh	Charge rate A	Load Ah	Net charge A	SLA	AGM	GEL	LiFePO4
100	50%	1.25	62.5	10	1	9	10.94hrs			
100	50%	1.15	57.5	10	1	9		10.39hrs		
100	50%	1.12	56	10	1	9			10.22hrs	
100	50%	1	50	10	1	9				5.56hrs

In the above example we're using a 10A charge. As you can see, it would actually take nearly 11 hours to charge a standard SLA 'Leisure' battery! The AGM and GEL batteries are a little faster and the LiFePO4 takes almost half the time.

With a higher charge rate, the time comes down as can be seen below but, the inefficiencies of charging a lead-acid battery mean that you can't just 'up the amps' to shorten the time. There is a limit to the charge acceptance a lead-acid battery can take. This is usually around 15-20% of the battery overall capacity. So in our example 100Ah @ C20 battery, that would be 15A-20A.

"Upping the voltage and amps will charge a battery faster."

Batteries have a charge acceptance limit. It doesn't matter how much you throw at them, they will only take the most they can. AGM and GEL batteries charge a little faster but in most tests, you save just 20mins or so on a 7hour charge. LiFePO4 are different and charge much faster but that's down to negligible internal resistance, different chemistry etc but they too have their limits.

Ah Capacity @C20	DoD %	Efficiency factor	CAh	Charge rate A	Load Ah	Net charge Ah	SLA	AGM	GEL	LiFePO4
100	50%	1.25	62.5	20	1	19	7.29hrs			
100	50%	1.15	57.5	20	1	19		7.03hrs		
100	50%	1.12	56	20	1	19			6.95hrs	
100	50%	1	50	20	1	19				2.63hrs

In the above example we're using a 20A charge. As you can see, the charge time has reduced but it would still take over 7 hours to charge a standard SLA 'Leisure' battery! The AGM and GEL batteries are a little faster and the LiFePO4 takes under 3 hours.

Killing your batteries over time…

Under-estimating the time needed to recharge batteries leads to chronic under-charging and as a result, an ever-decreasing capacity to power your appliances and devices. As this continues, the battery's ability to recover its original capacity decreases until you find that although the rested 'charged' voltage may be achieved (for example 12.7V on a 12V battery), you'll find that the voltage drops quickly and you no longer have the capacity to run appliances/devices for anything like the amount of time when the batteries were new.

In the real world, most of us don't have the luxury of disconnecting all loads and letting the charger run a full charge when we want to. So we need to be realistic and accept that we won't be able to fully charge the batteries every time. There may also be additional charging throughout a day, weekend or week with solar, running the engine etc. All of this will help and in a well-specified solution will keep the batteries topped up.

It is also possible to over-charge your batteries and this too can considerably shorten their life. It is important that you follow the battery manufacturers directions when it comes to setting up your charger. Quality manufacturers will provide the data you need to set up your charging properly. This will include the recommended charge voltage and float voltage with temperature compensated levels.

The battery life compromise…

For those of us who live full time on our boat or in our van, we should aim to get a full charge into the batteries once a week even if that means charging all day. There are other things we can do to help off-set running the engine/generator. If you have access to a shore power/mains hook-up, then a decent multi-stage charger can be used to charge and maintain the batteries. For those of us who live off-grid, then a solar system is a must. Even a modest system with a decent MPPT controller/charger will make a huge difference to the overall charging requirement.

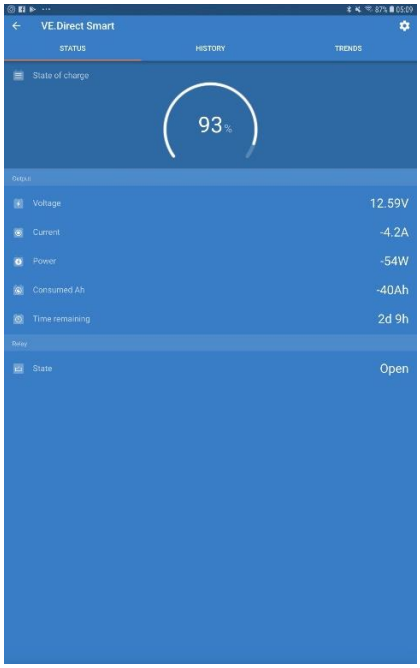
Knowing what your batteries are up to…

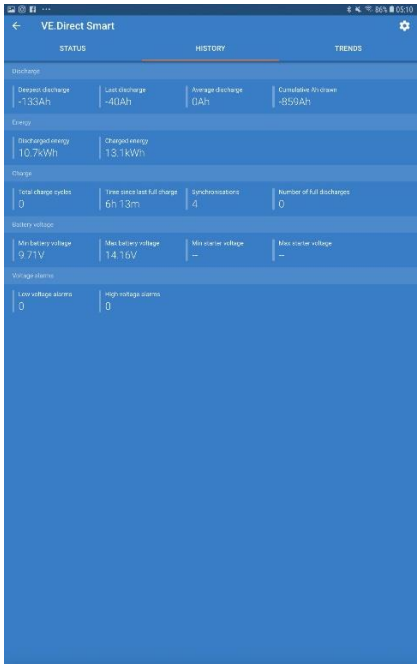
Knowledge is power and in the case of batteries, that is particularly true. Simply looking at the voltage your batteries are at, gives little indication of their true state of health. There are lots of charts on the internet that suggest for example, on a 12V battery, a voltage reading of 12.1V = 50% DoD. This is really inaccurate and could lead to charging when it's not needed (more cycles = shorter life) or under-estimating the true depth of discharge and therefore the remaining capacity.

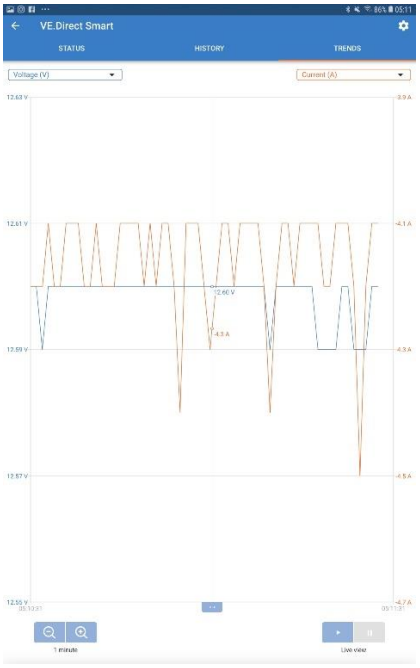
The complexities of calculating accurately the state of charge and therefore capacity of your batteries mean that most of us have neither the time or inclination to work it out properly or frequently and ideally want a simple device that we can use to monitor the batteries and indicate when we should be charging. Sadly, no such 'simple' device exists but there are some pretty sophisticated devices that are reasonably easy to use and if set up properly, will be a major help in looking after and getting the best life out of your batteries. However, battery state is a moving target and as they age, capacity reduces so battery monitors are only as accurate as the information you feed them and the frequency you synchronise them.

We use the Victron BMV-700 and Victron BMV-712 battery monitors. The BMV-700 we use has a Victron Bluetooth dongle attached and the BMV-712 comes with Bluetooth already integrated. The Bluetooth function enables us to set up, synchronise and monitor our batteries using the free Victron Connect App on a Smartphone and/or Tablet.

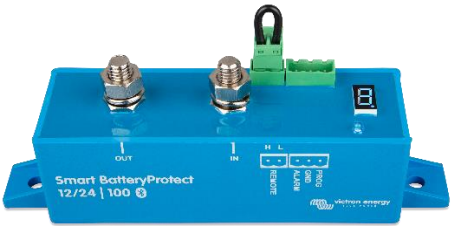
Here are some screen-shots from the Victron Connect App. We can see the overall state of charge, battery voltage etc. Using the Trace function, we can also look in real time at the voltage, current being drawn or supplied when under charge (Ah), power (Watts) and state of charge (%).







Another device seriously worth considering is the Victron BatteryProtect. These devices protects the battery against excessive discharge and can be used as a system on/off switch. The BatteryProtect disconnects the battery from non-essential loads before it is completely discharged (which would damage the battery). One of nine predefined engage/disengage levels can be set with the programming pin or with the Smart version using Bluetooth, the Victron Connect App can be used to program the required engage/disengage levels.



As a Victron Energy Distributor, obviously we recommend Victron products and there is a substantial range of batteries, battery monitors, battery chargers, solar controller/chargers etc that offer quality solutions to your energy storage and power delivery requirements. All Victron products come with a 5-year warranty and Victron batteries come with a 2-year warranty. If you'd like to discuss the options or have any questions regarding your batteries and charging, please get in touch.

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