

APPLICATION NOTE:

# Converting a Boat, RV or Caravan from a Lead-Acid to a Lithium Battery System

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Lithium batteries offer faster charging, longer runtime, longer life, and weigh less than the equivalent size lead-acid battery. However, it's essential to understand that lithium batteries also feature significant differences compared to lead-acid batteries.

Therefore, specific onboard electrical equipment changes are required when converting your boat, recreational vehicle, or caravan from a lead-acid to a lithium battery system.

Hiring a professional to install a lithium system is highly recommended to ensure system compliance, longevity, and safety, including other onboard equipment.

## THE MAIN DIFFERENCES BETWEEN LEAD-ACID AND LITHIUM BATTERIES:

### Most lithium batteries aren't capable of starting engines.

Most lithium batteries are designed to support deep-cycle house loads. Using lithium to start an engine can cause damage to the internal battery management system (BMS) and internal relay.

- Use a lithium battery explicitly designed for starting or a separate starting battery system with a lead-acid battery.

### The voltage of lithium and lead-acid batteries is different.

A lithium battery requires a slightly lower charging voltage than does a lead-acid battery. A lithium battery with a smart BMS will protect the lithium battery from the higher lead-acid charge voltage by 'switching off' and disconnecting from the electrical system.

- Not all brands of lithium batteries charge at precisely the identical voltage either. A charger that can be custom programmed with a charging profile matched to the lithium battery brand is required.

### Lead-acid batteries don't switch off.

A lead-acid battery never disconnects from an electrical system. However, lithium batteries with a smart BMS will disconnect when high-voltage, over-temperature and over-current thresholds are exceeded, which will cause load dumps and voltage spikes.

- A high-quality lithium battery precisely regulates its cut-off at high-voltage, low voltage, over and under temperature and over-current with a BMS. A charger with a lithium profile prevents unexpected disconnection of a lithium battery.
- Alternators must also be protected from load dumps caused by the sudden disconnection of the lithium battery by using a DC-DC Converter.



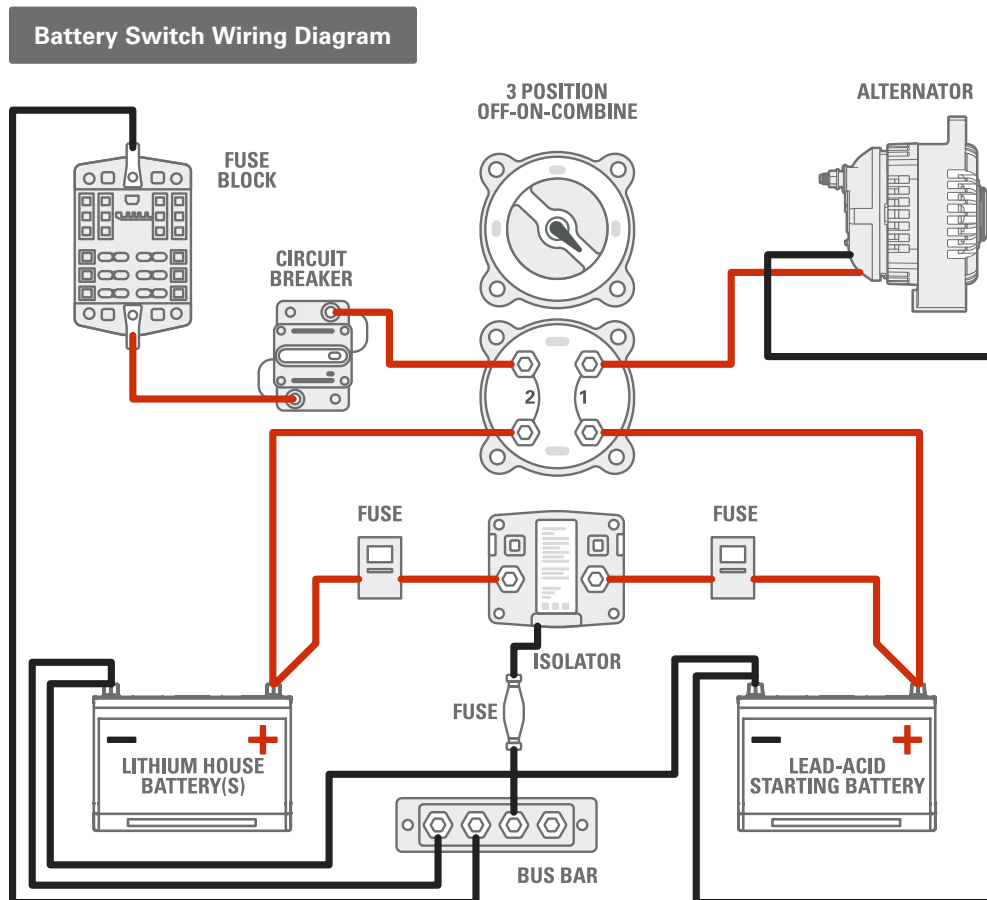
## HOW DOES MY LEAD-ACID BATTERY SYSTEM WORK TODAY?

The engine's alternator connects to a lead-acid 12V starter battery and charges it.

In a dual battery system, the 12V starter battery connects through a battery isolator and allows current to pass through to charge the 'house' bank of 12V deep-cycle lead-acid batteries.

The battery isolator enables the starter battery to charge before charging the house batteries. It also prevents the house battery loads from discharging the starter battery.

An onboard charger that plugs into shore power, or park power, is usually available to charge the house batteries. A combiner switch may temporarily combine the starter battery with the 'house' bank to provide for emergency engine starting when the starting battery has failed.



## WHAT NEEDS TO BE CHANGED TO ACCOMMODATE A LITHIUM BATTERY SYSTEM?

Safely charging the new lithium battery system requires all charging devices to use a new charge profile that explicitly matches the lithium battery. Additionally, the electrical system must be protected from load dumps and voltage spikes. Some additional pieces of equipment will be required:

- A **battery charger** with programmable charge settings matching the lithium battery.
- If you have solar panels or a wind turbine, they require a **charge controller** with programmable charge settings matching the lithium battery.
- A **DC-DC converter** with programmable charge settings matching the lithium battery to regulate voltage and control the flow of current between the alternator and lithium batteries.

The alternator is the primary method of charging the battery system for powerboats and caravans when away from shore power and underway. Significant changes are needed to upgrade the alternators' charging capabilities and protect the alternator and batteries from damage caused by a sudden load dump.

## THE MAIN CONCERNS ARE:

### Alternator load dumps are bad.

When a lithium battery's BMS protects itself, it suddenly disconnects the lithium battery from the electrical system, interrupting the alternator's connection.

- The energy that was being produced by the alternator needs to quickly go somewhere, resulting in a voltage spike (or load dump) that will likely damage the alternator along with anything connected to the electrical system.

### Alternators need to be kept cool.

As an alternator spins, it produces the current demanded by the load (battery). Fan blades on the alternator need to run at high speed to keep alternator temperature at an acceptable level. Otherwise, it will overheat.

- Lithium batteries can demand a much higher current during charging than lead-acid batteries and for a longer time. At low alternator speeds, such as when the engine is idle, the alternators' cooling airflow will be insufficient and overheat.



## Alternator voltage may be too high or low.

A common problem with alternators is poor voltage regulation. Lithium batteries protect themselves because of precise voltage set points.

- Voltage too high will force the lithium battery to disconnect, causing a load dump or voltage spike.
- A low charging voltage will fail to charge a lithium battery fully.

Both situations will destabilize the system, and the lithium battery will receive an inadequate charge, limiting run time and possibly shortening battery life.

## WHAT IS A DC-DC CONVERTER, AND WHY IS IT REQUIRED?

Alternators can either burn up if the current they are producing isn't controlled correctly or fail during an alternator load dump event. They aren't usually able to be configured to the precise charge settings lithium batteries require.

A DC-DC converter performs two roles,

1. Acting as an isolator between the alternator charging circuit and the lithium batteries, preventing the sudden disconnection of the lithium battery and the associated alternator load dump.
2. Regulates voltage and controls the current flowing between the alternator and lithium batteries, which prevents the alternator from overheating.

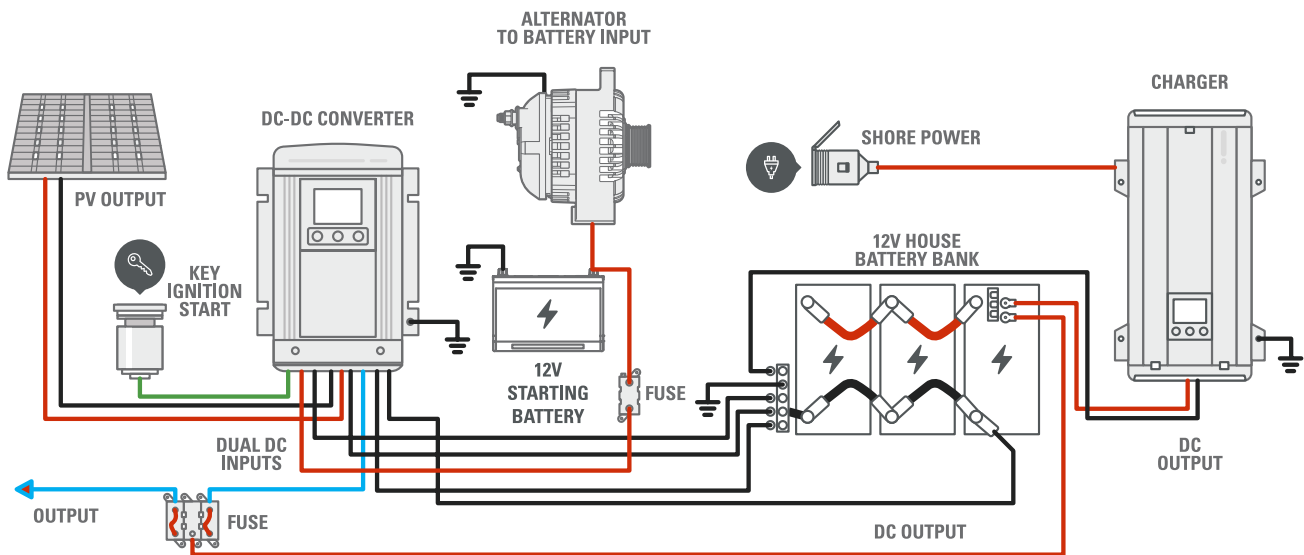
Selecting a DC-DC converter with programmable settings will allow for a precise match with the chosen lithium battery brand. The DC-DC converter's maximum charging amps should be no greater than the combined sum of the max charge rate specified for the lithium batteries. It need not be more than the alternator's maximum charging amp capacity.



## WHERE DOES THE DC-DC CONVERTER INSTALL IN THE SYSTEM?

The battery isolator between the 12V house batteries and the starting battery is removed and replaced by the DC-DC converter. Set up the DC-DC converter with the precise charge settings specified by your lithium battery.

Connect the output of the solar panels or wind turbine to the DC-DC converter if it's equipped with a separate input for a built-in charger controller. Leave the onboard battery charger connected directly to the 12V house battery bank.



*The above schematic should be used only as a guide. Ensure the installation of your system meets local code requirements and seek the help of a certified professional.*

## I HAVE A BATTERY COMBINER SWITCH. DO I HAVE TO TAKE IT OUT?

It can be left installed but only be used in an emergency to charge up your starting battery. In this situation, a fully charged lithium battery will have a higher voltage than the lead-acid battery, so combining the lithium with a lead-acid battery will cause a charging current to flow to the lead-acid starting battery.

The batteries should be left connected for five-to-10 minutes to allow the starting battery to accept a charge sufficient for starting the engine. To protect the lithium battery from being damaged, disconnect the lithium battery from the lead-acid starter battery before starting the engine. Leave the engine running long enough to allow the alternator to charge the starting battery.

## IN SUMMARY - THE KEY TAKEAWAYS:

When converting your boat or caravan to a lithium battery system, it's critical to understand the differences between lithium and lead-acid batteries.

How they work have many implications for the life of your batteries and overall system:

- **Most lithium batteries aren't capable of starting engines:** Using lithium to start an engine can cause damage to the internal battery management system (BMS) and internal relay.
- **Lithium batteries use a different charge profile:** A lead-acid charger will result in the overcharging of a lithium battery and shorten its life.
- **Lithium batteries can switch off:** A lead-acid battery never disconnects from an electrical system. However, lithium batteries will disconnect at high-voltage, low voltage, over-temperature and over-current, which can cause load dumps and damaging voltage spikes.

## THE MAIN CONCERNS OF USING AN ALTERNATOR TO CHARGE A LITHIUM SYSTEM ARE:

- **Lithium batteries protect themselves by disconnecting from the system:** this may damage the alternator along with anything connected to it.
- **Alternators need to be kept cool:** fan blades on the alternator need to run at high speed to keep alternator temperature at an acceptable level. Otherwise, it will overheat.
- **Alternator voltage may be too high or low:** the lithium battery will receive an inadequate charge, limiting run time and shortening battery life.

## EQUIPMENT CHANGES REQUIRED TO ACCOMMODATE A LITHIUM BATTERY SYSTEM:

- A **battery charger** with programmable charge settings matching the lithium battery.
- If there are solar panels or a wind turbine, a **charge controller** with programmable charge settings matching the lithium battery is required.
- A **DC-DC converter** with programmable charge profile settings matching the lithium battery to regulate voltage and control the flow of current between the alternator and lithium batteries.

Hiring a professional to install a lithium system is highly recommended to ensure system compliance, longevity, and safety, including other onboard equipment.

