

## Charging Lead-Acid Batteries

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### Abstract

This document examines the charging scenario of lead-acid batteries using various methods using converters. Batteries are charged by adjusting the working conditions and pulse currents of the converter. With the advancement of materials science and packaging technologies, newer batteries with higher energy density and reliability are being manufactured today. This method of charging the battery is inexpensive and produces fast charging, higher efficiency, higher power factor and high reliability. Acid batteries are used in a wide range, e.g. they are also used in Gird's energy storage systems, for example, in the power supply of mobile phone towers, hospitals, and autonomous power systems, the commissioning of motor vehicles, lighting and lighting.

**Keywords:** Lead-acid battery; Current charging; Pulse charging; High surge currents

### Introduction

Recently, battery power is widely used in our daily life. A dc source with a single cell batteries or a battery packed by a small number of cells are used for the requirements like portable electronic devices. Electronic systems that require high energy density as a backup at low cost typically use lead-acid batteries as batteries. In order to avoid premature elimination and thus environmental pollution, the chargers construct various charging methods like constant current charging and constant voltage charging methods have been investigated and which are arranged to be rechargeable while the life of the battery is not affected. On the other hand, a power bank with numerous cells connected in series or parallel connections has to be used for high-voltages and high power requirements such as electric vehicles and back-up power of uninterruptible power supplies, energy storage of micro-grids in power systems [1].

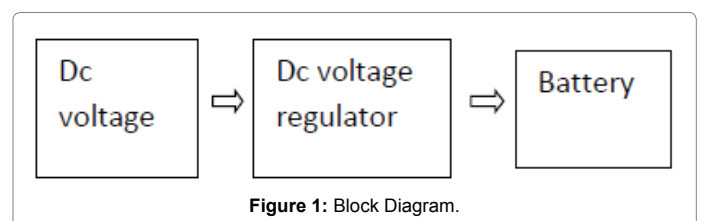
When connected in series, batteries may be overcharged or over discharged resulting in malfunctioning. To overcome this problem the power bank with battery power modules is used. In which each single packed battery is connected with a converter. With this configuration we can prevent the malfunction.

### Lead-Acid Batteries

Lead-acid batteries are one of the oldest rechargeable batteries but are currently used for various applications. It has a low energy and a low energy to volume ratio. During startup, this feature is used to start the starters of the vehicle. Lead-acid batteries are commonly found in Gell cells, and the types of absorbed glass mats are known as valve-regulated lead-acid batteries [2].

### Charging Process of Batteries

To charge a battery with alternating current, we need a reducing transformer, a rectifier, a filter circuit and a regulator to keep the voltage constant. Then we can give the battery the regulated voltage to charge. If you only have DC power and charge the lead-acid battery, you can do this by applying this DC voltage to a DC regulator and some additional circuits before using the lead acid. Car battery is also a lead acid battery (Figure 1), as you can see in the block diagram above, DC voltage is supplied to the DC voltage regulator. The regulated DC output voltage is given to the battery. There is also a slow charge circuit that helps reduce the current when the battery is fully charged [3-6].



Charging a lead-acid battery is a matter of replenishing the amount of energy that the battery has lost during the operation. This recharging operation can be performed with several different charger implementations: "Constant Voltage Charger", "Constant Current Charger" or "Multistage Constant Voltage/Current Charger". Each of these approaches has its pros and cons, which must be compared and weighed to find out which is the most practical and realistic to meet our needs.

### Constant voltage charging

Constant voltage charging is one of the most common charging methods for lead-acid batteries. The idea behind this approach is to maintain a constant voltage across the battery terminals at all times. Initially, a large current is removed from the voltage source. However, as the battery recharges and its internal voltage increases, the current will decrease and decrease exponentially. When the battery reaches a possible full charge, which is normally 13.8 V, the charging voltage drops to a lower level, which provides a slow charge that will hold the battery while it is plugged into the charger. The best feature of this method is that it provides a way to quickly return a large part of the charge to the battery. The disadvantage, of course, is that the completion of a full charge would take much longer because the current decreases exponentially when the battery is charged. A longer loading time should be considered as one of the problems of this design (Figure 2) [7-10].

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Received December 06, 2018; Accepted January 30, 2019; Published February 07, 2019

Citation: Rakshana N (2019) Charging Lead-Acid Batteries. J Electr Electron Syst 8: 294. doi: 10.4172/2332-0796.1000294

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### Constant current charging

Constant current charging is another simple but effective way to charge lead-acid batteries. A current source is used to conduct a uniform current in the opposite direction to the battery discharge. This can be analogous to pouring water into a bucket of constant water flow, no matter how full the bucket is. Constant current sources are not very difficult to implement; the final solution would therefore require a very simple design.

This approach has a great disadvantage. Since the battery is always pushed at a constant speed when it is almost fully charged, the charger forces additional power into the battery, resulting in overcharging. The ability to use this power is the key to a successful loader. By monitoring the voltage across the battery, the state of charge can be determined, and at some point, the power source must be folded back to maintain only a slow charge and avoid overcharging (Figure 3).

### Methodologies

#### Using bidirectional buck boost BPMS

The bidirectional buck-boost BPM uses two MOSFETs as power switches, as shown in Figure 1. The switch is connected on the battery side and the other on the charger side. These two power mosfets are used for power control and synchronous rectification. These buck-boost BPMS may be based on circuit parameters and operational performance. Basically, three levels of operation are performed while the battery is charging. In step 1, the switch on the charger side is turned on. Then, the capacitor voltage is supplied to the inductance side of the inductor. In stage 2, the inductance of the power supply to the battery side is supplied. Stage 3 occurs only when the energy stored in the inductor becomes zero due to high switching frequencies. When both switches are off, discontinuous operation occurs (Figure 4) [11-15].

The main advantage of this method is that we can charge the multiple batteries simultaneously with the series-connected Buck Boost BPM. In battery power bank with series configuration of n BPM's, each BPM is composed of single-packed battery equipped with a bi-directional buck-boost converter. For charging operation, the battery current can be controlled by adjusting the duty ratio of the buck-boost converter. All BPM's are operated at the same switching frequency with equal phase shift to reduce ripple of the charger's current. In addition, we can control the charge and discharge of each battery by adjusting the working ratio of the connected converter. We can also isolate fully charged batteries or damaged batteries without interrupting the charging process.

#### Using multilevel converter

The multi-level converter is also used to load applications. This multistage converter uses four switches with filters and operates in two modes: in boost mode S1, S2 acts as a main switch S3, S4 as a complementary switch. During this process, the inductor is charged. In S3-buck mode, S4 acts as a main switch and S1, S2 as complementary switches in which the inductor energy is discharged. The phase change method is used for the continuous charging process and also reduces the problem of equalizing the battery. The battery life can be extended by this charging method (Figure 5) [16].

#### Using PV cell with unidirectional converters

In this method, the unidirectional converter is used to charge the batteries. The circuit is as shown in Figure 5, where the system uses two unidirectional transducers with the transducer 1 connected between the PV cell and the DC bus. During operation of the converter 1, the battery

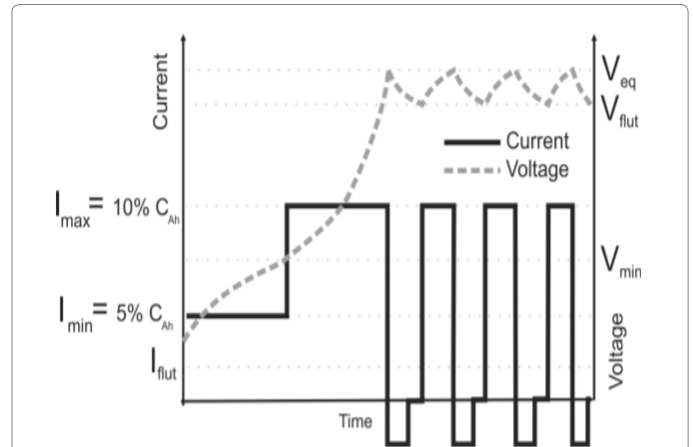


Figure 2: Voltage charging method.

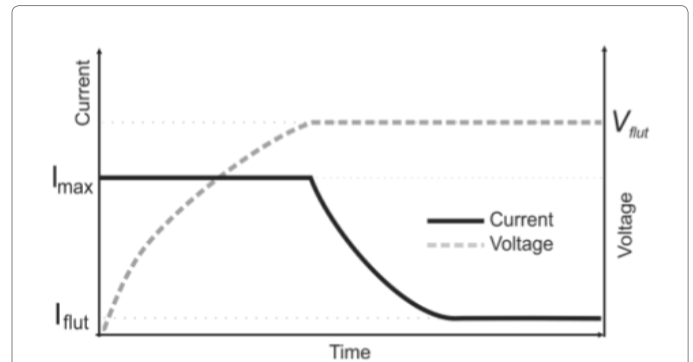


Figure 3: Current charging method.

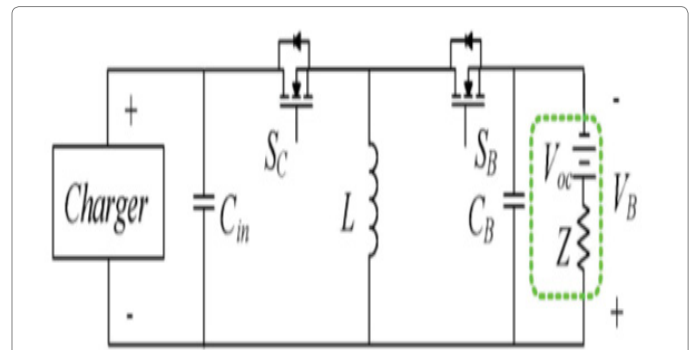


Figure 4: Buck boost BPM.

is charged. Converter 2 is the back converter that connects the battery and the bus voltage. The converter 1 is for charging the batteries and the converter 2 for voltage regulation. In the proposed photovoltaic battery system circuit the DC / DC converter 1 is an integrated boost converter in which the booster inductor L1 stores the battery and supplies power while the inverse transformer T1 sends power to the bus. The DC/DC converter 2 is a normal flyback converter that connects the battery and the bus voltage. The operating principle of the converters is described below: The DC/DC converter 1 mainly controls the energy flow from the photovoltaic panel to the bus and the battery and implements MPPT. Converter 2 used for the voltage regulation (Figures 6 and 7) [17-20].

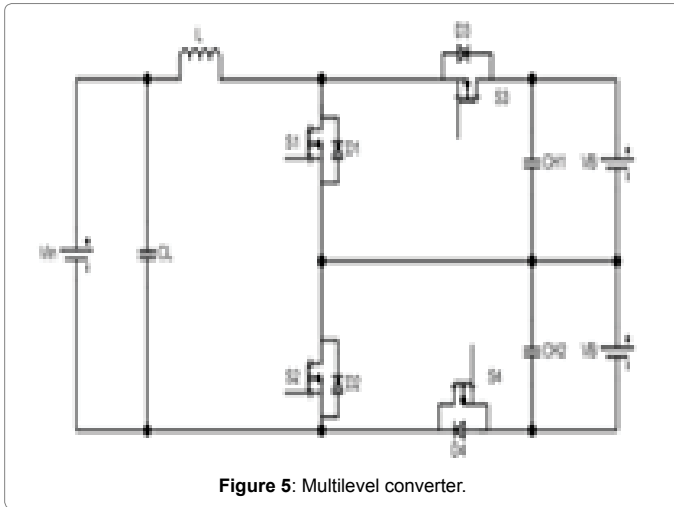


Figure 5: Multilevel converter.

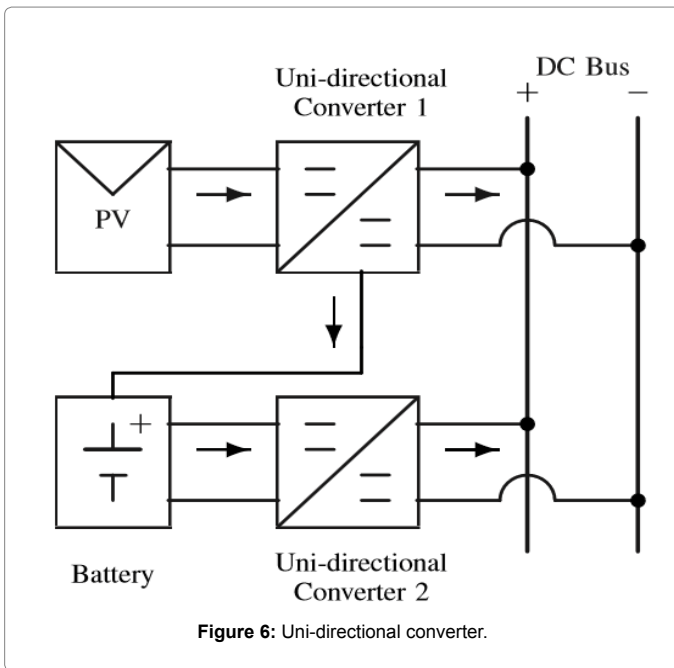


Figure 6: Uni-directional converter.

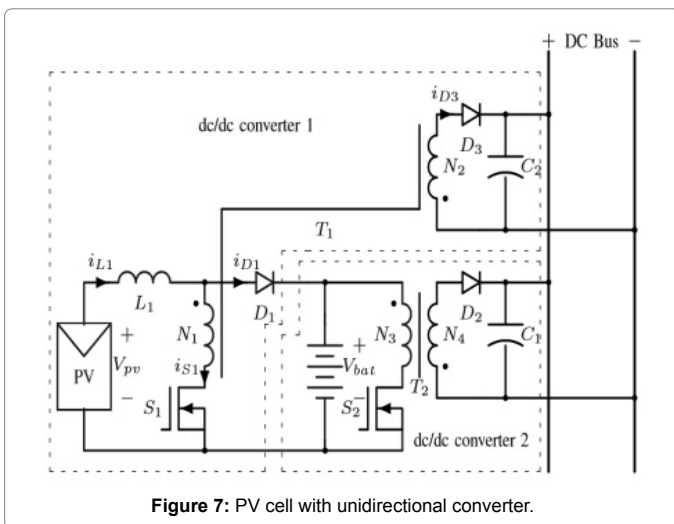


Figure 7: PV cell with unidirectional converter.

### Using full converters

There are many ways to charge the batteries; mostly buck converter is used for charging process. In order to achieve galvanic isolation Full Bridge converter is used where the operations are as same as the buck converter. Here the batteries are charged by pulse charging method where in current charging method the high current is applied. So it is not guarantee that batteries are fully charged. Due to high initial charging current, the batteries get damaged. To overcome it full bridge converter is used, since it requires the less charging time and also the life span of the batteries is prolonged.

### Conclusion

Therefore, this paper shows, the lead-acid batteries are charged by constant current, constant voltage charging methods and with converters. Since lead acid batteries are used in many applications, even high intensity currents are produced. Widely Buck Boost converters are used in charging batteries strongly.

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