A DUAL BATTERY SYSTEM WITH A DC-DC BOOST CONVERTER

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ABSTRACT: This paper is an implementation of a secondary battery inside the cars so that the charged battery can be used to power the appliances when needed. The entire energy in the secondary battery without the tension of not cranking the engine when needed. A battery system is designed to crank the engine either from the primary battery or the secondary battery. In this battery system design the alternator and the battery are directly connected in parallel configuration meaning the alternator charges the battery and powers the components or just charges the battery depending on the consumption, this means that the alternator has to run right from the start of the engine to minute the car stops so why don't we charge another battery by a system which can be toggled on or off by a switch depending on the need, the system in the below paper does exactly what mentioned above. Several batteries can be chosen from, however, depending on the cost and usage Lead-acid and Li batteries can be best suited as the secondary battery. The differences and the similarities are shown below along with the different battery types.

IndexTerms **- Boost converter, DC-DC converter, Dual battery system, Lead-acid, Lithium battery**

I. INTRODUCTION

The consumption of energy is increasing day by day so does fossil fuel consumption, if we try to harvest the energy, we are at least saving the environment. New technology is revolutionizing the auto industry every day, among those technologies, energy storage is the most integral part of the industry. Energy cannot be stored without using a battery, there are a lot of battery technologies that can do the same thing as store electricity. Depending on the arrangement in either series or parallel we can achieve more voltage and less current or more current and less voltage. Some battery technology includes.

Types of Battery

Lead-acid

Lead-acid comes under electrochemical batteries which produce voltage difference by the exchange of ions from the metallic oxide (PbO2) to the acid and vice versa. Because of the price compared to other battery types, these are used vastly, this is the main advantage of Lead Acid batteries. However, this battery technology has one main drawback as well which is its low specific energy. This battery type has 30Wh/kg The more advanced lead-acid battery types allow higher energy density. The chemical reaction of the battery can be reversed as well this allows the battery to be rechargeable [1].

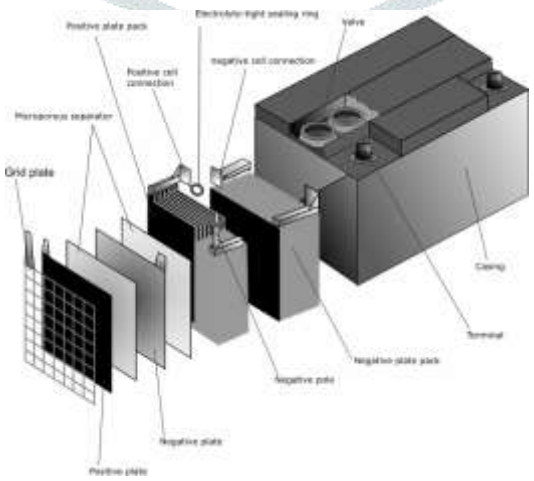

Fig. 1. Construction of Lead-Acid Battery [2]

Alkaline batteries

This battery technology is alkaline based and there are few types of them. These batteries include Nickel in them, few types of Alkaline batteries are included.

1. Nickel Cadmium
2. Nickel-metal Hydride
3. Nickel Zinc

Lithium batteries

This battery type is vastly used because of its compact size and high specific energy. Lithium-based batteries can output up to 2000 WH/kg, due to this reason these are used widely varying from simple tools to even cars. These are compact and have a high weight to power ratio. These batteries can be stacked to obtain high voltage and current depending on the arrangement.

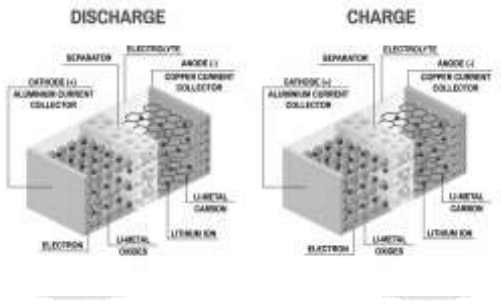

Fig. 2. Charge and Discharge of Lithium-ion battery [3]

These batteries have considerably higher battery life cycles than other battery technology and have low self-discharge capability.

High-temperature batteries

After discussing the battery types to pick one battery technology that works for the project is hard, so to make it easy there is a way to compare the battery technology that is by using Rag one Plot. This is a plot that compares the battery types based on their size and voltage which is being outputted by the battery types. Fig.3 is the Rag one plot of the above-mentioned battery types. X-axis tells the specific energy density in WH/kg and the weight further moved toward the right. Y-axis tells the volumetric energy density WH/l and also the size when moved upward.

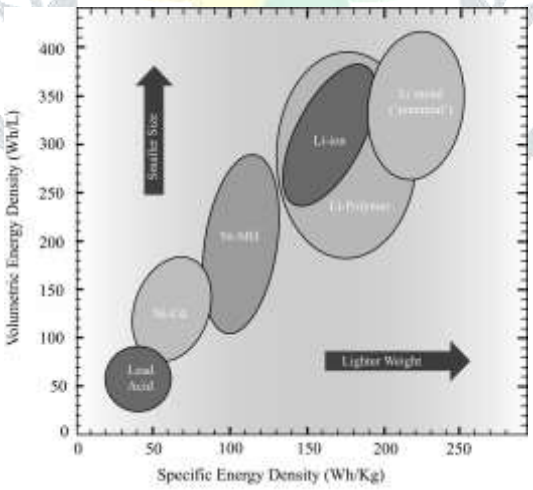

Fig. 3. Ragone Plot of various battery types [4]

II. LEAD-ACID VS LITHIUM-ION

From the above-discussed battery types, the readily available battery options are Lead Acid and Li-Ion batteries, so to choose which suits perfectly for the battery system. The two battery technologies are being compared in almost every battery aspect be it in compactness, cost, energy density, etc.

Lead-acid batteries are designed especially for deep discharging meaning these batteries can be discharged completely with little or no effect on discharge cycles whereas the Li-ion batteries are not designed for deep discharge cycles, deep discharge affects the Li-

ion batteries. The ideal discharge and charge cycles for Li-ion batteries are 20-80 means stop discharging below 20 and charging above 80.

III. DUAL BATTERY SYSTEM

The Dual battery system is a simplified circuit that contains a Boost converter and a switch to toggle between the charging of two batteries. This battery system shown in Fig.6 increases the efficiency of the engine and reduces the charging time and outputs high voltage compared to the input voltage. A DC-DC boost converter is a circuit that increases the output voltage. This is a simple circuit with a transistor dc source and an inductor all connected in series with each other, and a capacitor is connected in parallel with the transistor. Now the inductor is an energy-storing component that does not allow sudden polarity change. The inductor stores energy when the circuit is closed by the transistor which is gate controlled to act as a fast operating switch when the transistor is disconnected the charged inductor discharges via the capacitor and the load. The capacitor now stores energy and discharges via the load when the transistor is turned on, all this happens in under a second. A sample boost converter is shown in Fig 6. There is also a diode connected in series with the capacitor to prevent the reverse flow of charge. The output voltage depends on the time the switch is on. The capacitor charges with one polarity and discharges with another. Fig 5 shows a sample boost converter.

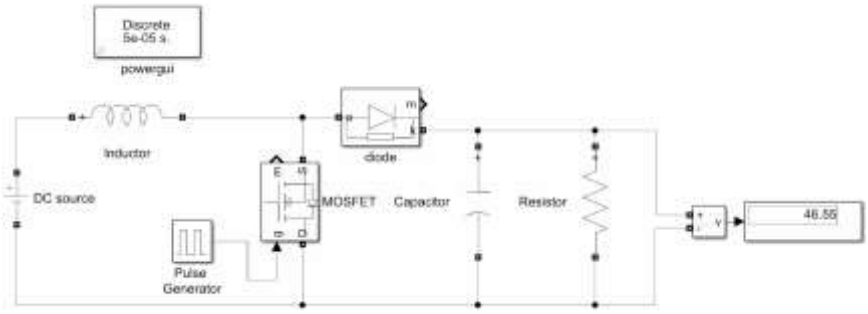

Fig. 5. DC-DC Boost converter.

It has been observed that the output voltage is stepped up to 46.55V from 30V. The dc voltage is separated between two boost converters. The DC-DC boost converter is being used because of the following reasons:

- Increases the output voltage.
- Reduces the charging time as the output energy is higher than the input energy.
- The battery pack can be charged quickly when needed.
- The rating of the alternator can be reduced, this does not only reduce the stress on the engine but also increases the efficiency. This means that an existing alternator can charge both the batteries at a time or charge a single battery.

The battery system is combined from two circuits which can output different type of voltages, the voltages can be toggled via the toggle switch

- Which charges both the primary and secondary batteries at a time.
- Turn off the Secondary battery charging and turn on the primary battery charging.

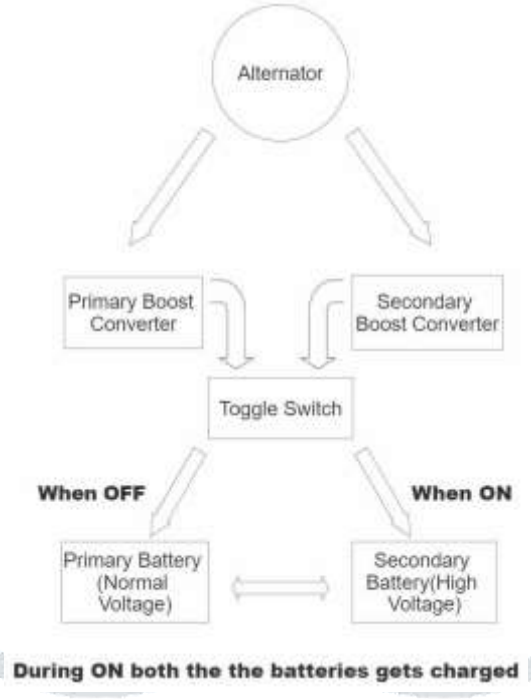

Fig. 6. Flow chart of alternator circuit

IV. CIRCUITS

There are two circuits mentioned below one is for charging only the primary battery and the other is for charging both the batteries at a time. The software that is being used in designing the circuits is MATLAB vR2019b, the software is good at designing complicated circuits at ease. After opening the software click SIMULINK which can be found in the Home tab, a new tab opens and there the circuit can be designed. Browse the components in the library browser.

In this first circuit, the primary battery is the only battery that gets charged as in this case the primary battery is always connected to the alternator in the first place. First, the charge from the alternator goes to the first boost converter which is associated with the primary battery. This scenario takes place normally in every Automobile. But in this battery system, the small alternator can charge the big battery because the voltage is getting increased. This means the low-rating alternator can charge both the batteries simultaneously or a single battery at once. As it is visible that though we are providing 50V as supply voltage from the alternator the output is leveling around 70V which is more than the 50V, that is the main reason why the DC-DC boost converters are used in the battery system in the first place. The circuit has two identical circuits with different parameters, the top circuit is referred to as a Primary boost converter because the primary battery is connected to it and the other circuit is referred to as a secondary boost converter because the secondary battery is connected to it. The secondary boost converter produces a higher voltage than the primary boost converter because the battery secondary battery has a higher rating than the primary battery.

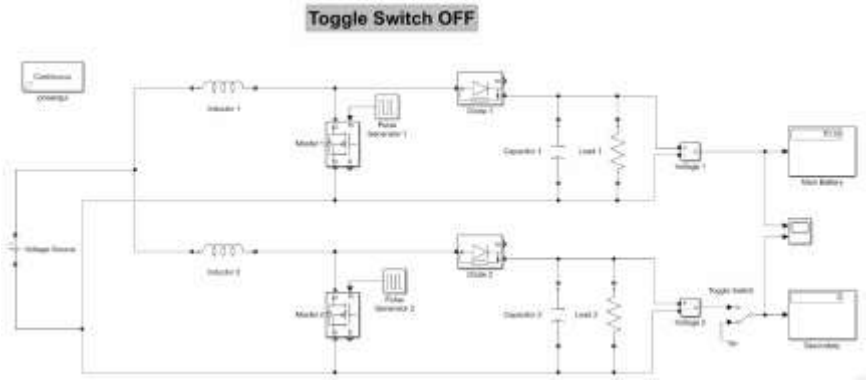

Fig. 7. Battery system when the toggle switch is OFF

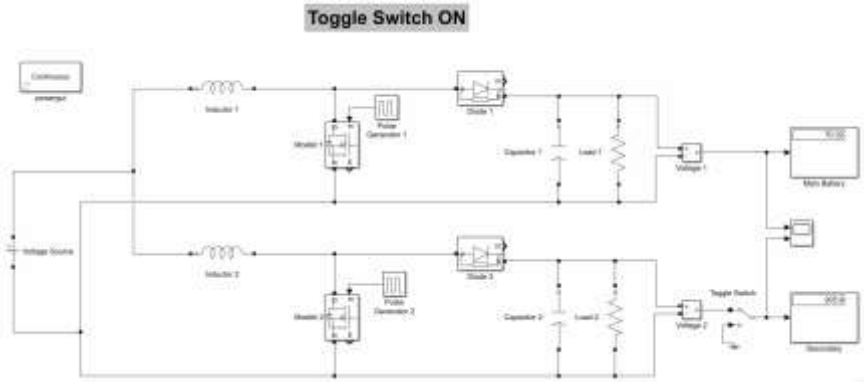

Fig. 8. Battery system when the toggle switch is ON

The observation from the above Fig.8 is that though the input voltage is constant at 50V the output of the converters is more than the input voltage. The DC-DC converters play an important role in the battery system, not only the converters increase the output voltage these are responsible for the load on the alternators as the alternator used in the battery system is rated quite lower than the normal alternator in automobiles. Another observation is that the secondary battery is charging twice as fast as the primary battery because of the DC-DC Boost converter, this situation is so helpful when we need a source when there is no energy source nearby. After a couple of miles, the battery gets fully charged.

V. CONCLUSION

This paper modifies the charging system in Automobiles by using a secondary battery which comes in handy without the tension of using all the charge in the battery, the battery system does this by using circuits like DC-DC Boost converter and other battery technologies. Doing this increases the battery's capacity and charges the battery faster than the usual speed because of the converters used in the system. The whole setup does not take much space, so the unit can be placed inside the dashboard, and then the battery unit can be placed under the seat.

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