# A COUPLED INDUCTOR BASED SOFT SWITCHING BIDIRECTIONAL DC-DC CONVERTER USING HYBRID ENERGY STORAGE SYSTEM

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## ABSTRACT

*A Soft switching bidirectional DC-DC Converter based on the coupled inductor for battery supercapacitor hybrid energy storage system applied in electric vehicle and hybrid electric vehicles. The bidirectional DC-DC converter (BDC) is the key component to control the energy flow between the battery and the super-capacitor. To reduce the internal energy loss of the BSHESS, the efficient BDC with soft-switching characteristics is the best choice. The renewable energy sources as solar panel can be used as the input sources. This BDC has a simple structure without any auxiliary switch and can provide soft-switching conditions for both switches without additional control signals. In order to prove the feasibility of the proposed BDC, experimental results, which are obtained from an experimental prototype, are presented. Experimental results show that soft-switching conditions of both switches of the proposed BDC are achieved.*

**Keywords** –*Soft Switching, DC/DC Converter, ZVS, Coupled inductor, Solar panel*

## 1. INTRODUCTION

In the hybrid electric vehicles, the battery super-capacitor hybrid energy storage system (BSHESS) is widely used to improve charge and discharge characteristics of the battery, increase the instantaneous output power, and extend the battery life. For the battery super-capacitor hybrid energy storage system (BSHESS) applied to the electric vehicle (EV) or the hybrid electric vehicle (HEV), the bidirectional DC-DC converter (BDC) is the key component to control the energy flow between the battery and the super-capacitor. As the soft-switching auxiliary component, the coupled inductor is more and more widely used in the soft-switching technology of the non-isolated DC/DC converter to obtain better soft-switching characteristics. A novel zero voltage transition (ZVT) auxiliary circuit applied to a bidirectional converter for interface circuit between super capacitors or batteries with DC bus in electric vehicle (EV). The proposed converter acts as a ZVT Buck to charge super capacitor or battery. On the other hand, it acts as a ZVT Boost to discharge super capacitor or battery.

## 2. WORKING PRINCIPLE

A new soft-switching Bidirectional DC to DC Converter for the BSHESS applied to the HEV and EV. The BDC provides soft-switching conditions for both switches with a simple structure, which is composed of only two diodes, one coupled inductor and one resonant inductor. The bidirectional DC-DC converter (BDC) is the key component to control the energy flow between the battery and the super-capacitor. To reduce the internal energy loss of the BSHESS and the efficient.

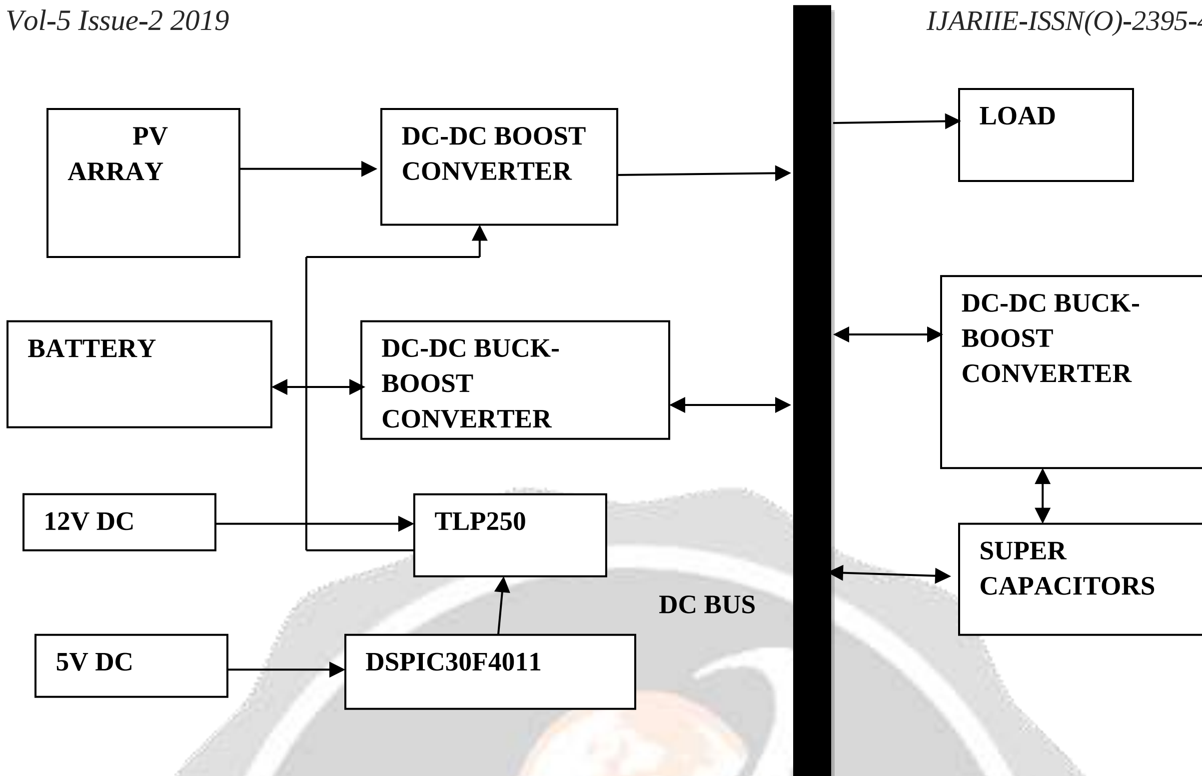


**Fig-1** Block diagram Bidirectional converter using renewable energy sources.

BDC with soft-switching characteristics is the best choice. In Figure 1,shows the block diagram of renewable energy by using the PV sources, the battery and the super-capacitor are charged initially. The dc load run through the charge of the battery. Then the battery charges goes down, the dc load utilize the energy through the solar PV. The super-capacitor is used when both the battery and the PV is not available. At the time we can charge the battery by discharging the supercapacitor. The battery banks provide the base load backup power while the SC bank provides only the transient power backup. The PV panel should provide maximum power output at any given isolation. This is ensured by the MPPT controller which provides gate pulses to a unidirectional boost converter. Bidirectional DC-DC converters are designed to control the charging and discharging modes of the storage devices. In the coupled inductor is coupled with the main inductor, which will have a continuous current, and then generates and keeps a recycle current for the active switch to provide ZVS conditions. In a simple structure composing of one resonant inductor and two auxiliary switches is used to provide soft-switching conditions for the bidirectional DC/DC converter. The soft-switching condition is obtained by the additional current generated by the coupled inductor.

## 3. ZERO VOLTAGE SWITCHING

Zero Voltage Switching means that the power to the load (heater or cooler or other device) is witched on or off only when the output voltage is zero volts. Zero Voltage Switching can extend the life of a controller and of the load being controlled. With AC current the voltage is zero 50 to 60 times a second. For example, with 120VAC at 60 Hz the voltage swings from 0 volts to - 120 volts to 0 volts to +120 volts and back to 0 volts 60 times a second. The controller only turns the power to the load on or off when the voltage is zero. (Since the cycle described above repeats itself, there are, at 60 Hz, 120 times every second that the AC voltage is at zero volts and power switching can occur.) With DC power, as used with thermoelectric controllers, the DC voltage is first converted by the controller to DC PWM. The lowest voltage of these DC pulses is zero, and so this power source for a load can also be switched on or off when the voltage is zero. The frequency of these pulses is high enough that a peltierdevice considers the DC PWM power to be simple DC power, and so pulsing the voltage in this way does not harm a peltier device.

## 4. BIDIRECTIONAL CONVERTER

In soft-switching topologies the coupled inductor is coupled with the main inductor to provide ZVS conditions for the active switch in the synchronous rectifier converter. The soft-switching sync buck converter and the soft-switching sync boost converter reported. These two converters only have unidirectional soft-switching capability. Based on these two soft-switching converters, a soft-switching bidirectional DC/DC converter is proposed. This bidirectional DC/DC converter combines the soft-switching sync buck converter and the soft-switching sync boost converter by introducing two auxiliary switches as switch1 and switch2.When switch2 is on, and switch1 is off, this bidirectional converter is same to the soft-switching sync buck converter When switch1 is on, and switch2 is off, this bidirectional converter is same to the soft-switching sync boost converter. Comparing to converters this bidirectional soft-switching converter adds not only one diode but also two extra auxiliary switches and their drive circuits, which will increase costs. And to obtain soft-switching conditions in both operation (buck mode and boost mode), the mode-switching control of the auxiliary circuit is needed when the power flow direction changes. The switching process will reduce the reliability and convenience of the bidirectional converter in the BSHESS application. To solve this problem, a new soft-switching bidirectional DC/DC converter is proposed based on the converter. The proposed bidirectional DC/DC converter only adds one diode comparing to converters .

Bidirectional DC-DC converters are used in applications where bidirectional power flow may be required. In hybrid electric vehicles (HEVs) and electric vehicles (EVs), these bidirectional converters charge a low voltage (12 V) battery during normal operation (buck mode) and charge or assist the high-voltage (400 V/600 V) battery or bus in emergency situations like when a high-voltage battery has discharged to a very low energy or capacity level (boost mode). A typical system consists of a full-bridge power stage on the high-voltage (HV) side, which is isolated from a full-bridge or a current-fed push-pull stage on the low voltage (LV) side.

## 5. HARDWARE CIRCUIT DIAGRAM

In Figure 2, shows that the hardware circuit diagram of the proposed system. The input will be 230/12V step down transformer. The transformer used for the controller, the PWM as the input. In bridge rectifier used for converting the AC to DC supply. Where the bridge rectifier convert into pulsating DC but we want pure DC so capacitor used for converting into pure dc. From the transformer we get 12V but the controller capability is 5V so IC 7805 voltage regulator is used because we have to get 5V for the controller. The whole controller can be called as the power supply unit. The driver used for converting the 5V controller to 12V in driver circuit. For 12V MOSFET we have trigger by the driver amplifying the signals of each transistors. Here there is no purpose to connect the voltage regulator. The diode act as the biasing diodes for the battery, super capacitors and solar panel. The converter circuit is used in battery, super capacitor and PV panel. Here the supercapacitors need more place so the parallel plate capacitors is connected. The output will be obtained by boost up voltage across the solar panel to run the DC load.

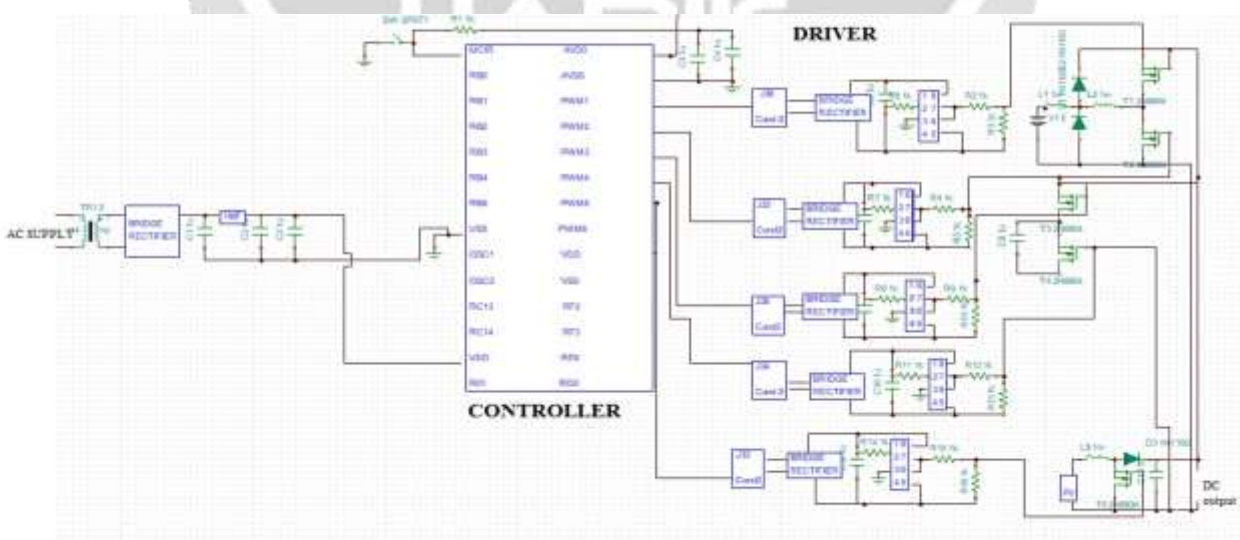


**Fig-2** Hardware circuit diagram

## 6. HARDWARE REQUIREMENTS

- MOSFET-IR840N
- CONTROLLER-DSPIC30F2010
- DRIVER-TLP250
- CAPACITORS-420mf/25v,65mf/10v,1000mf/10v.
- INDUCTOR-2.5mH,1.8mH.

## 7. SOFTWARE REQUIREMENTS

MATLAB software.

## 8. HARDWARE KIT

**Fig-3** Hardware circuit

## 9.CONCLUSION

Thus an Soft switching bidirectional converter for the battery super capacitor hybrid energy storage system. This method can be implemented in the hybrid electric vehicle and electric vehicle. It provides soft-switching conditions for both switches with a simple structure, which is composed of only two diodes, one coupled inductor and one resonant inductor. Through experimental results obtained by 40V-100V in experimental prototype a soft-switching conditions and efficiency improvements are verified.

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