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# An interleaved Buck Cascaded Buck-Boost converter with SMPS

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**Abstract:**
Power plays a great role wherever man lives and works. The living standard and prosperity of a nation vary directly with the increase in the use of power. The electricity requirement of the world is increasing at an alarming rate due to industrial growth, increased and extensive use of electrical gadgets. According to world energy report, we get around 80% of our energy from conventional fossil fuels like oil (36%), natural gas (21%) and coal (23%). It is well known that the time is not so far when all these sources will be completely exhausted. So, alternative sources should be used to avoid energy crisis in the nearby future. The best alternative source is Solar Energy. It has a two-stage power conversion, so power dissipation is more and due to this efficiency of the system decreases.so that we are using two-switch buck-boost (TSBB) inverter has been proposed by connecting a buck-cascaded buck-boost (BuCBB) converter in series with a line-frequency unfolding circuit, which simplify the circuit configuration and increase system efficiency. The proposed inverters have both step-up and step-down functions so that they are suitable for the applications with wide voltage-variation range. Depending on the conditions of dc input-voltage and ac output-voltage, the proposed circuits can work functionally as either buck-typed or boost-typed inverter. Due to operating with buck or boost principle, partial energy can be directly delivered to output to improve efficiency. The voltage from the Buck-Boost converter is fed to H-Bridge inverter which gives 12V AC signal that is fed as input to step up transformer to generate 230V AC which is used to turn ON the AC Induction motor.

**Keywords:**
SMPS, PIC Microcontroller, Buck-Boost Converter, H-Bridge Inverter circuit, Step up transformer, Induction motor, MOSFET

## 1. INTRODUCTION:

**Switched Mode Power Supply** uses a switching regulator to convert electric power efficiently. SMPS transfers electric power from a source ( AC mains) to the load by converting the characteristics of current and voltage. SMPS always provide a well regulated power to the load irrespective of the input variations. SMPS incorporates a Pass transistor that switches very fast typically at 50Hz and 1 MHz between the on and off states to minimize the energy waste. SMPS regulates the output power by varying the on to off time using minimum voltage so that efficiency is very high compared to the linear power supply.

**The SMPS essentially has**

1) Input rectifier
2) Inverter
3) Voltage converter
4) Output regulator

**Input rectifier**

The AC input from mains is first rectified in the SMPS using a rectifier to convert it into DC. The rectifiers consist of a full wave diode bridge or module that produces an unregulated DC voltage to the Smoothing capacitor.

**Inverter**

This stage converts the rectified DC into AC using a power oscillator. The power oscillator has a small output transformer with a few windings at the frequency 20-100 kHz. Switching is controlled by a MOSFET amplifier. The output AC voltage is usually isolated optically from the input AC by using an Optocoupler IC for safety reasons.

**Voltage converter**

This stage has a high frequency transformer and the inverted AC drives its primary windings. This creates the up and down voltage at the output. If DC is required, the output AC is converted to DC using a rectifier circuit using Silicon diodes or Schottky diodes (fast recovery and minimum loss of current and low forward voltage drop) . The rectified output DC is then filtered using the filter section consisting of inductors and capacitors. Some non isolated SMPS contains an inductor instead of the transformer and the circuit act as boost converter or buck converter. In high voltage SMPS,Capacitor-Diode multiplier is used instead of inductors or transformer.

## 2. LITERATURE SURVEY:

In order to gather reasonable information about renewable energy resource potentials of the country, hybrid energy systems, rural electrification techniques applying combined resources a detailed study of this all was needed. Different research efforts for the application of renewable energy options have been conducted for the access of renewable energy resource potentials and stand-alone hybrid systems. The following different authors were conducted for a range of hybrid systems at different times, sites and different countries.

According to **Chien-Hsuan Chang; Chun-An Cheng; Hung-Liang Cheng**, they simplified circuit configuration and increase system efficiency, a two-switch buck-boost (TSBB) inverter has been proposed by connecting a buck-cascaded buck-boost (BuCBB) converter in series with a line-frequency unfolding circuit. In accordance with the level of input voltage and sinusoidal output voltage, this inverter can work with buck or boost operation principle.

According to **J.P. Benner; L. Kazmerski**, Photovoltaics technology is well established as a reliable and economical source of electricity in small, scattered applications, far from urban centers. Now it is looming larger in size and public awareness. The author discusses the role of photovoltaic systems in the USA, their operating principles and developments for the future.

According to **Jan T. Bialasiewicz,** A substantial increase of photovoltaic (PV) power generators installations has taken place in recent years, due to the increasing efficiency of solar cells as well as the improvements of manufacturing technology of solar panels. These generators are both grid-connected and stand-alone applications. We present an overview of the essential research results. The paper concentrates on the operation and modeling of stand-alone power systems with PV power generators. Systems with PV array-inverter assemblies, operating in the slave-and-master modes, are discussed, and the simulation results obtained using a renewable energy power system modular simulator are presented.

## 3. Implementation:

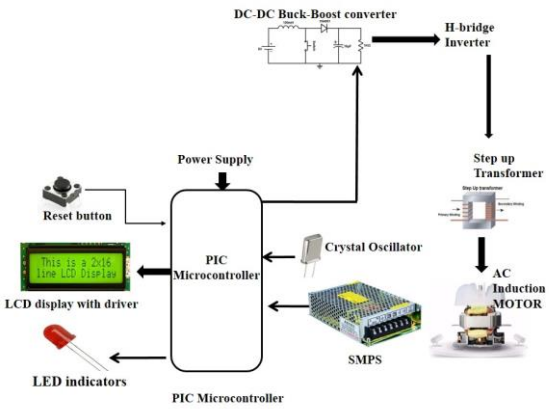



**Fig : Flow Diagram**

In this project, we are giving the DC input by using SMPS instead of PV panel because here

we are delivering the partial energy to the load irrespective of the variations in input DC voltage, so that if we use the PV panel it provides different DC voltages with respect to the sunlight but it takes long time i.e., sunlight is more during the afternoon and less during the evening. So that we are taking SMPS which provides different DC voltages as output. And this SMPS provides Minimum of 8V DC to Maximum of 16V DC.

Then this DC voltage is given to the BuBBC which is used to Step-up or Step-down the DC Voltage. This converter operates as Step-up mode (i.e., Boost mode) when we provide input voltage from 8V to 12V and it operates as Step-down mode (i.e., Buck mode) when we provide the input voltage above 12V. By doing this we are delivering the partial energy to the load which increases the efficiency.

In BuBBC the change of mode from Buck to Boost is controlled by the Microcontroller. And BuBBC always provides the 12V output. Then this 12V output is given as input to the 100W efficient inverter which converters the 12V DC to 230V AC. This Inverter output is given to the single-phase motor

IC CD 4047 is mainly used in Inverter circuits. It's very compact and has a very high life in inverter circuits. CD4047B consists of a gatable astable multi vibrator with logic techniques incorporated to permit positive or negative edge-triggered mono stable multi vibrator action with retriggering and external counting options. CD 4047 is the low power Mono stable / Astable Multi vibrator that require only an external capacitor and a resistor to give the output pulses.

## 4. Related Work:

The brief introduction of different modules used in this project is discussed below:

### 4.1. SMPS:

Switch mode power supplies (SMPSs) are used in a range of applications as an efficient and effective source of power. This is in major part of their efficiency. For anybody still working on a desktop, look for the fan output in the central processing units (CPU). That's where the SMPS is.

SMPS offers advantages in terms of size, weight, cost, efficiency and overall performance. These have become an accepted part of electronics gadgets. Basically, it is a device in which energy conversion and regulation is provided by power semiconductors that are continuously switching "on" and "off" with high frequency.

- DC to DC Converter
- Forward Converter
- Flyback Converter
- Self-OscillatingFlyback Converter

**DC-DC converter**

The primary power received from AC main is rectified and filtered as high voltage DC. It is then switched at a huge rate of speed and fed to the primary side of the step-down transformer. The step-down transformer is only a fraction of the size of a comparable 50 Hz unit thus relieving the size and weight problems.

We have the filtered and rectified output at the secondary side of the transformer. It is now sent to the output of the power supply. A sample of this output is sent back to the switch to control the output voltage.

**Forward converter**

In a forward converter, the choke carries the current when the transistor is conducting as well as when it's not. The diode carries the current during the OFF period of the transistor. Therefore, energy flows into the load during both the periods.

The choke stores energy during the ON period and also passes some energy into the output load.

**Flyback converter**

In a flyback converter, the magnetic field of the inductor stores energy during the ON period of the switch. The energy is emptied into the output voltage circuit when the switch is in the open state. The duty cycle determines the output voltage.

**Self-Oscillating Flyback Converter**

This is the most simple and basic converter based on the flyback principle. During the conduction time of the switching transistor, the current through the transformer primary starts ramping up linearly with the slope equal to Vin/Lp.

The voltage induced in the secondary winding and the feedback winding make the fast recovery rectifier reverse biased and hold the conducting transistor ON.

**Basic working concept of an SMPS**

A switching regulator does the regulation in the SMPS. A series switching element turns the current supply to a smoothing capacitor on and off. The voltage on the capacitor controls the time the series element is turned. The continuous switching of the capacitor maintains the voltage at the required level.

**4.2. IC4047:**

**IC CD4047**

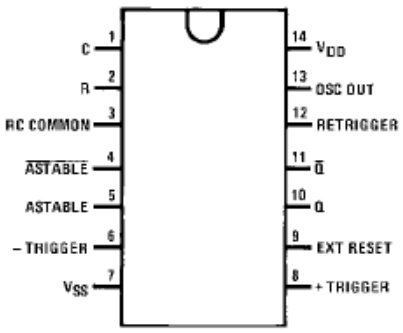



Fig : IC4047 Pin diagram

IC CD 4047 is mainly used in Inverter circuits. It's very compact and has a very high life in inverter circuits. CD4047B consists of a gatableastable multi vibrator with logic techniques incorporated to permit positive or negative edge-triggered mono stable multi vibrator action with retriggering and external counting options. CD 4047 is the low power Mono stable / Astable Multi vibrator that require only an external capacitor and a resistor to give the output pulses. The values of these components determine the output pulse width in the Monostable mode and output frequency in the Astable mode.Multivibrator creates an electrical signal that changes state on a regular basis (astable) or on demand (monostable). One of the benefits of the 4047 is being able to do so as well, but with fewer external components.

**Monostable mode** Monostable mode can be obtained by triggering the + input of the IC using a low to high pulse or by a high to low pulse at the – input. The IC can be retriggered by applying simultaneous low to high pulse in both the + and – inputs.

**Astable mode** This can be obtained by keeping a high / low level at the Astable input. Output frequency depends on the timing components.

**4.3. Induction Motor:**

An **induction** or **asynchronous motor** is a type of AC motor where power is supplied to the rotor by means of electromagnetic induction, rather than a commutator or slip rings as in other types of motor. Their speed is determined by the frequency of the supply current, so they are most widely used in constant-speed applications, although variable speed versions, using variable frequency drives are becoming more common. The most common type is the squirrel cage motor, and this term is sometimes used for induction motors generally.

- Single-phase induction motors are not self-starting without an auxiliary stator winding driven by an out of phase current of near 90o. Once started the auxiliary winding is optional.

- The auxiliary winding of a permanent-split capacitor motor has a capacitor in series with it during starting and running.
- A capacitor-start induction motor only has a capacitor in series with the auxiliary winding during starting.
- A capacitor-run motor typically has a large non-polarized electrolytic capacitor in series with the auxiliary winding for starting, then a smaller non-electrolytic capacitor during running.
- The auxiliary winding of a resistance split-phase motor develops a phase difference versus the main winding during starting by virtue of the difference in resistance.

**4.4 PIC Microcontroller:**

The control unit in our design is a PIC programmable interface controller. A microcontroller is like a computer that is on a chip and possesses elementary microprocessor components together with some functions that are specialized, like comparator and Analog/Digital converter. Applied in the authors work microcontroller belongs to the PIC32 advanced family of microcontroller devices. The program memory of this microcontroller has 256 KB and its data memory (RAM) has 64 KB. We use PIC 16F72 Microcontroller.

**4.5 Buck-Boost Converter:**

The buck–boost converter is a type of DC-to-DC converter (also knownas a chopper) that has an output voltage magnitude that is either greater than or less than the input voltage magnitude. It is used to "step up" the DC voltage, similar to a transformer for AC circuits.
It is equivalent to a flyback converter using a single inductor instead of a transformer. Two different topologies are called buck–boost converter.

A typical Buck-Boost converter is shown below.

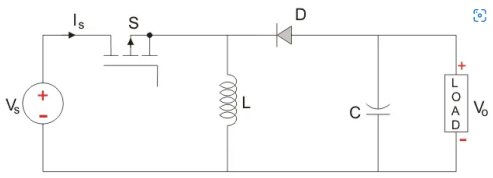
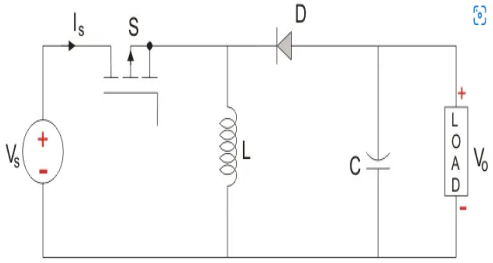



Fig : Buck Boost Converter

The input voltage source is connected to a solid state device. The second switch used is a diode. The diode is connected, in reverse to the direction of power flow from source, to a capacitor and the load and the two are connected in parallel as shown in the figure above.
The controlled switch is turned on and off by using Pulse Width Modulation(PWM). PWM can be time based or frequency based.

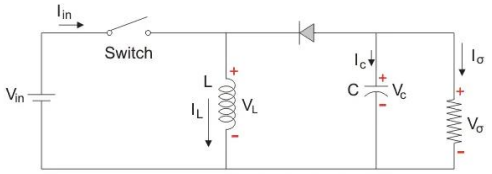
The **Buck Boost converter** has two modes of operation. The first mode is when the switch is on and conducting.

Mode I : Switch is ON, Diode is OFF




The Switch is ON and therefore represents a short circuit ideally offering zero resistance to the flow of current so when the switch is ON all the current will flow through the switch and the inductor and back to the DC input source.

Mode II : Switch is OFF, Diode is ON



In this mode the polarity of the inductor is reversed and the energy stored in the inductor is released and is ultimately dissipated in the load resistance and this helps to maintain the flow of current in the same direction through the load and also step-up the output voltage as the inductor is now also acting as a source in conjunction with the input source.

### 4.6 LCD:

One of the most common devices attached to a micro controller is an LCD display. Some of the most common LCD's connected to the many microcontrollers are 16x2 and 20x2 displays. This means 16 characters per line by 2 lines and 20 characters per line by 2 lines, respectively.

**Basic 16x 2 Characters LCD**

**Figure 1: LCD Pin diagram**

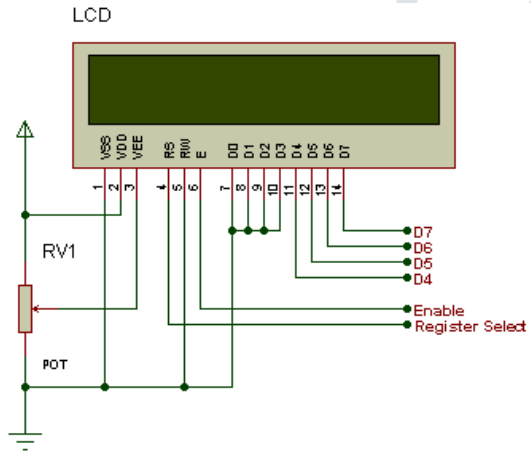



Fig:LCD display

## 5. CONCLUSION:

This research paper has discussed the performance of An Interleaved Buck Cascaded Buck Boost Converter with SMPS. Integrating features of all the hardware components used have been developed in it. Presence of every module has been reasoned out and placed carefully, thus contributing to the best working of the unit. Secondly, using highly advanced IC's with the help of growing technology, the project has been successfully implemented. This modern Buck-Boost Converter with SMPS was designed and developed. During the conducted experiments, the SMPS acted as a main source of energy. Moreover, the safety factor was calculated to be within the limits of two that shows the proposed system can meet the industrial safety limits.

## 6. ACKNOWLEDGEMENT

We would like to thank all the authors of different research papers referred during writing this paper. It was very knowledge gaining and helpful for the further research to be done in future.

## 7. FUTURE SCOPE:

To improve the efficiency of photovoltaic (PV) grid-tied systems and simplify the circuit structure, many pseudo DC-link inverters have been proposed by combining a sinusoidal pulse-width modulation (SPWM) controlled buck-boost converter and a low-frequency polarity unfolder. However, due to the non-ideal characteristics of power diodes, the voltage-gain of a buck-boost converter is limited. To meet the needs of grid-connected systems with low input voltage and 220 Vrms utility, we uses two two-switch buck-boost converters with coupled inductors to develop a transformer-less buck-boost grid-tied inverter with low leakage-current and high voltage-gain. The proposed inverter is charging on the primary side of the coupled inductor and discharging in series on the primary side and the secondary side so that the voltage-gain can be greatly increased. Furthermore, the utility line can be connected to the negative end of the PV array to suppress leakage current, and the unfolding circuit can be simplified to reduce the conduction losses. High-frequency switching is only performed in one metal-oxide-semiconductor field-effect transistor (MOSFET) in each mode, which can effectively improve conversion efficiency.

## 8. RESULTS:

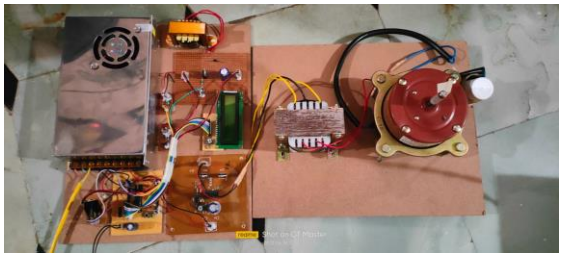


Fig : Image of An Interleaved Buck Cascaded Buck Boost Converter with SMPS

The paper represents an innovative idea on “An Interleaved Buck Cascaded Buck Boost Converter with SMPS” which is mainly intended to design a system which makes the induction motor running through SMPS. We are going to develop the Buck-boost converter that is driven by the PIC Microcontroller based on the input signal from SMPS. The voltage from the Buck-Boost converter is fed to H-Bridge inverter which gives 12V AC signal that is fed as input to step up transformer to generate 230V AC which is used to turn ON the AC Induction motor.

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