



Design of Three Channel Boost Converter for Power Quality Improvement

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Abstract : The demand for electricity in the country is increasing due to a growing population. To meet peak load demands, renewable energy sources such as A.C. inputs can be used in conjunction with conventional sources. However, the widespread use of nonlinear electronic equipment has led to power quality issues in grid-connected systems. This is because power electronic converters inject harmonics into the system, causing various problems. In this study, the Boundary Conduction Mode (BCM) boost and Power Factor Correction (PFC) converter were used to improve power quality. BCM DC-DC converters are high-frequency converters that regulate unregulated D.C. power and reduce the voltage stress on MOSFETs additional DC/DC converter by lowering the DC bus voltage. Interleaved pulse-width modulation (PWM) is employed to manage the switches. Reducing the entry and delivery ripple currents and allowing for a decrease in output capacitance. The three basic configurations of DC-DC converters are buck, boost, and buck-boost converters. A buck-boost converter can either decrease or increase the input voltage, while a boost converter is commonly used in renewable energy systems due to their low and unregulated output voltage. The output evaluate through simulation and hardware implementation, resulting in significant improvements in power factor.

IndexTerms - Boundary Conduction Mode (BCM), Power Factor Correction (PFC), Pulse Width Modulation (PWM),

I. INTRODUCTION

The three-stage circuit topology was proposed in response to the difficulty of the control procedure and the number of changes in the DC/DC converter, first and second stages only employed for frequency commutation in the third stage, as indicated. As an outcome, a control strategy was developed to quickly alter the DC/DC converter's output current waveform. Provided the same configurations displayed, with the initial stage using two parallel shifts spaced away. However, the DC/DC converter switches constantly function with complex changes. The four-switch buck-boost converter, positive output voltage and low-voltage stress across the power relays.

Three-stage circuit arrangement: The first two stages were used to regulate voltage, while the third stage was employed for frequency transformation. This was done to reduce the number of switches that needed to be switched and to make the control approach less difficult for the DC/DC converter. The output current waveforms of the DC/DC converter could then be easily adjusted using a control system derived from topologies like those used in the first stage, which employed two staggered parallel shifts. However, the DC/DC converter always operates with hard shifting. As an outcome, analysts have presented a four-switch buck-boost conversion system, which operates with low voltage stress across the power shifts. It is important to note that if the switch is always on, the average output voltage will be equal to the input voltage. However, as the proportion of time the control is off increases, the average output voltage will decrease and will eventually reach zero when the switch is always off. This system can be classified as a buck converter, as it is able to regulate the output voltage from a maximum level equal to the voltage from the source to a minimum value of zero volts.

However, it is worth noting that while this system has the capability to adjust the average value of the output voltage, the instantaneous voltage changes between zero and the voltage of the source. Solar power plants (P.V.s) are an important solution for saving the environment and addressing the energy crisis. However, the distribution network's (D.N.) carrying capacity is limited due to voltage issues caused by the large concentration of home photovoltaics. In this outcome, an energy storage system (ESS) is employed to address this issue by boosting the high voltage of a PV construction and stepping down the voltage to meet load demand. A permissive control algorithm is applied to maintain the voltage within the specified range. Additionally, two suggested algorithms based on tiny communication networks are used: the first aims to distribute the power failure across ESSs, while the second adjusts the ESS output reference, which affects the state of charge (SOC) of ESSs.

II.LITERATURE SURVEY

The bidirectional D.C. converter has become an inquiry hotspot due to the constant expansion in the effectiveness of contemporary electric power generation apparatus. The performance of two-way non-isolated DC-DC converters with low current threshold, broad input and output voltages, and wide input and output voltages is studied using this approach. The problem of rising system loss due to weak phase shift control when the primary and secondary side voltages are not equal is addressed by proposing a three-mode switching control technique. By using the converter in bank, boost, and boost modes, you may improve its efficiency. [6].

The turning-on conditions of MOSFETs in this topology are fulfilled immediately under Zero Voltage Switching (ZVS) states. Furthermore, output diode turning-off conditions can be achieved in Zero Current Switching (ZCS) situations. The suggested converter's output voltage output is independent of the duty cycle frequency. The findings demonstrate that the changeover in the output voltage was adjusted Frequency Modulation (SFM) adhering to the reference voltage signal [7].

The voltage-type bidirectional converter is the dominant topology in DC-DC applications, but it is incompatible with renewable energy sources with an extensive voltage range. Although numerous current-type converters have been presented, most are for bidirectional or low-power systems. Large voltage conversion ratios, large input currents, and a wide input voltage range are the key challenges to accomplishing high-efficiency power conversions in a high-power energy storage technology [8]. Because of the low voltage level at the D.C. bus, establishing a photovoltaic (PV) system on an existing utility grid is typically a difficult task. A three-port switching inductor-based double boost DC-DC converter fed single-phase micro-inverter is presented to enhance voltage level and facilitate electrical power transfer. The recommended converter system elevates the D.C. voltage to the required level and improves coordination with the utility grid. Furthermore, the suggested topology reduces total costs while reducing switching losses. Design concerns for the proposed converter architecture and its many operating modes. Furthermore, the proposed dual DC-DC boost using three switched inductors [9].

During testing, a minor glitch in the control logic can harm the machine or drive. By replacing the original motor with a "Motor Emulator" (ME) test-bench system based on power electronic converters, such hazardous testing circumstances can be avoided. The consists of a two-stage, three-phase AC-DC-AC conversion through an emulation stage of AC-DC and a regenerative stage of DC-AC. This two-stage power transformation necessitates a separate control algorithm, which contributes to the load of control complexity and increases the need for power electronic switches [10]. The ZCT PWM DC-DC boost converter running in BCM is presented in full, including its operation modes and theoretical analysis. Comprehensive ZCT cell analysis and resonant component selection process are implemented to guarantee ZCT operation of the main switch. The suggested converter is created, put through testing, and field tests provide results. [11]. The quadratic boost converter is a popular choice for a variety of power applications due to its high-gain functioning. However, achieving low losses under light load levels can be difficult due to high switching losses, which cause a decline in efficiency. A brushless DC motor, also known as a BLDC motor, is electronically commutated. The controller sends brief current pulses to the motor windings to adjust the torque and speed of the synchronous motor. BLDC motors are effective at producing high torque across the entire speed range. In brushless motors, permanent magnets with a fixed armature are used to overcome the issue of connecting power to the armature [12].

III.MATERIALS AND METHOD

The demands for power quality resulting from user-connected solar power plants are analyses by grid-connected solar power generation from distribution system harmonic currents and reactive power/voltage. An inverter is needed for solar power generation to convert direct current to alternating current for power quality measurement. Inverters disrupt the stability of the electrical grid since they are switching devices that change the frequency of alternating current as needed. Harmonics are produced concurrently, which might disrupt the waveform and have an impact on the powered electrical devices. Next, the saw tooth signal and the amplified signal of the average current error are contrasted. Next, a Pulse Width Modulated Wave (PWM) is produced to estimate the induced current to the average induced current, find the duty cycle, and supply a driving signal to the power switching mode.

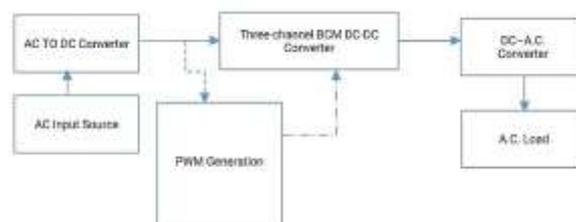


Figure 3. Block Diagram

Figure 3 shows the three-channel BCM boost converter that is being developed prevents voltage dips brought on by nonlinear loads. The boost converter's duty cycle tends to remain constant, assuming a perfect converter with no losses, and as a result, the output voltage approaches infinity. This is not feasible in reality, though, as expensive and precise drive circuits are needed to prevent even little changes in duty cycle from having a significant impact on the output voltage. In certainty, parasitic components like the filter choke's resistivity limit the static gain to a certain amount.

3.1 Power Supply

For economic reasons, energy is almost entirely generated, transferred, and distributed as alternating current; yet most electronic devices and circuits require a current source of power to operate. Dry cells and battery packs are suitable for this purpose. Conductivity and ripple-free operation are unquestionably advantageous, but the voltage is low and requires regular replacement, which is costly when compared to typical DC power supply.

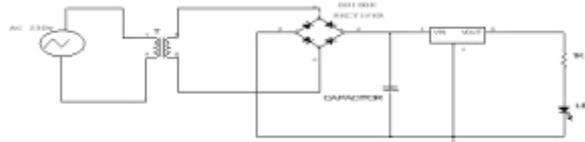


Figure 3.1. Power Supply Unit

Figure 3.1 shows the practically every electronic gadget contains a circuit that converts AC power to DC power. The portion of the gadget that converts AC power to DC power is known as a DC power supply. A transformer is normally located at the power supply's input end. A steady DC voltage is applied to the load via the DC power supply's output. Let's go over each DC power supply's operation in brief. Inverters are used to adjust the supply voltage needed by circuits and direct current devices that need power from a DC source. They are often used to step down the voltage. This keeps it away from electricity lines, which is crucial for safety. To stop electrical interference signals from the power line from getting into the power supply and interfering with the load, it could additionally include internal shielding.

3.2 DC-AC inverter

An AC electric motor's speed may be adjusted with an inverter, a motor control device. This is accomplished by altering the AC power of the machine's frequency. The voltage to the motor is also converted by the inverter. This procedure controls six different electronic devices using intricate electronic circuitry. To generate a three-phase AC voltage, it turns on and off.

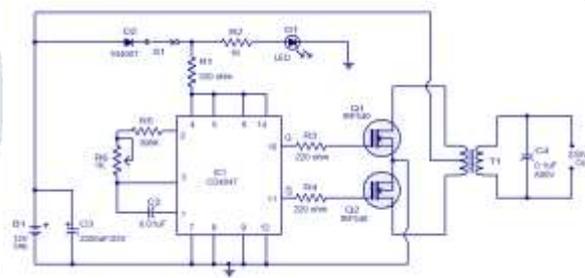


Figure 3.2 Inverter

The process of converting the DC bus voltage and current into an AC waveform supplied to the motor is commonly referred to as "inverting." This is where the term "inverter" originated. In this description, the variable speed drive will be referred to as an "inverter." Figure 3.2 circuit designed with a variable frequency and voltage capability and consists of three main components: the inverting team, the bus capacitor section, and the converter section. The incoming three-phase AC power, with a fixed voltage and frequency, is first converted into a DC voltage by the converter section using semiconductor devices. This DC voltage is then stored in the bus capacitor battery and transformed into a constant current source for the power components in the inverting region.

3.3 Three-channel Boundary Conduction Mode (BCM)

Because of the higher current, transient components in electronic power converters are subject to severe voltage stress. The diode's reverse recovery current is greater than that of the primary switch. Through local transit, electricity is transferred from the power source to a DC-DC converter. This thorough analysis of a 1-phase boost converter's input ripple current and output voltage calls for higher power, fewer components, and less switching loss. Power converters have spent the last several decades refining multi-phase parallel DC-DC converters to attain controlled output voltages from fuel cells, gas, and solar power, among other renewable input sources.

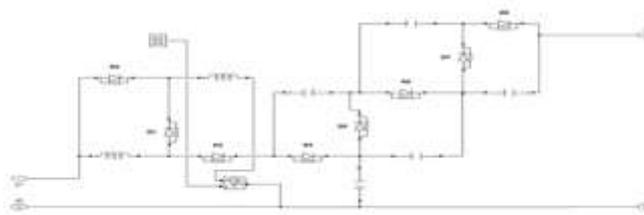


Figure 3.3 Boundary Conduction Mode in MATLAB Circuit.

Figure 3.3 depicts the BCM circuit, in which a power converter transforms an input voltage to an output voltage or current using boundary conduction mode (BCM) switching regulation. To operate in or near BCM, the BCM switching regulator identifies whether it is in continuous conduction mode (CCM) or discontinuous conduction mode (DCM) and changes the duty cycle or frequency appropriately. Among the many topologies, the stage interleaved boost converter offers numerous advantages, including a low component count, improved electrical performance, reduced weight, and small size for fuel cell systems. This gives output voltage in the absence of a supplemental transformer. The voltage converter uses an interleaved DC-DC boost converter to provide high reliability and enhance power processing capabilities. When compared to traditional single-stage and two-phase converters,

the suggested converter has fewer total components and a simpler construction. The interleaved boost converter characteristics low ripple withdrawal decreased ripple amplitude in the input and outputs.

To keep the DC bus voltage stable, high power PV systems with significant voltage gain require a boost converter and controller. To convert the P.V. and multiple voltages applying a three-level boost converter, the input filter size and current ripple termination must be reduced. The switching element voltage rating of a three-level boost converter is 50% of the output power. Because there are few distinct TPCs with various power flow pathways, the number of components is significantly greater. TPC isolation is one example of an isolation topology that uses high frequency switches to isolate ports.

In addition to greater voltage proposed converter has a path that allows the transfer of power from the input power source to the load and battery. Additionally, voltage lines are created for the battery to stimulate the load. The proposed converter uses two additional switches, two diodes, and a bidirectional channel. Higher efficiency is achieved by allowing current to flow from the input source and battery to the load in a single stage. The proposed converter contains three switches and two fixed duty cycles. Depending on the input power and battery condition, the duty cycle can be changed to manage the maximum input power and output voltage gains, increased power loss, and improved performance

4. Simulation

The grid-connected AC input system is shown in Figure 4, along with the proposed control approach for examining the power quality system. This approach involves providing control impulses to the inverter for each state of the Boundary Conduction Mode. Additionally, the Simulink model and control approach. The possibility of the suggested system is evaluated in terms of its ability to handle both balanced and unbalanced load changes on the grid side. Furthermore, alternative solution techniques are explored for their potential implementation in this system. The convergence parameters of the suggested gain factor optimization are also carefully analyzed.

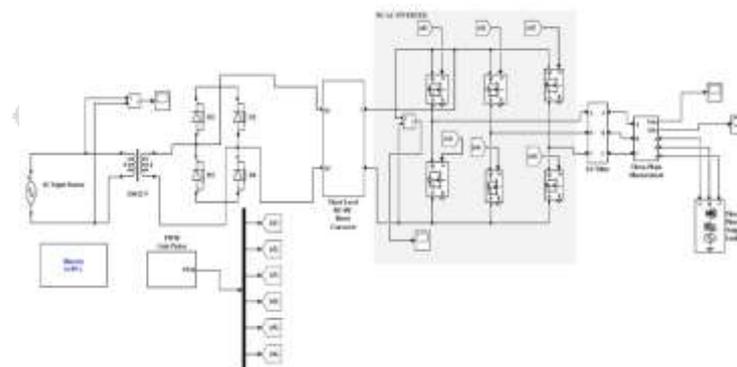


Figure 4. Mat lab simulation of grid connected system

4.1 Output waveform

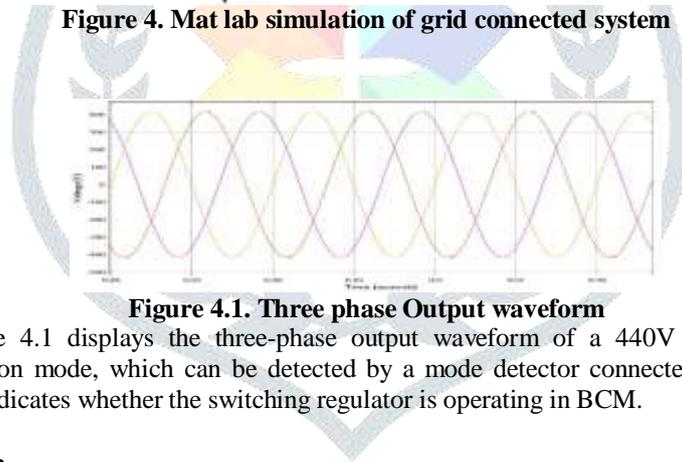


Figure 4.1. Three phase Output waveform

Figure 4.1 displays the three-phase output waveform of a 440V DC-AC inverter. The switching regulator operates in a conduction mode, which can be detected by a mode detector connected to the power stage. This mode detector produces a signal that indicates whether the switching regulator is operating in BCM.

4.2. Hardware Circuit Diagram

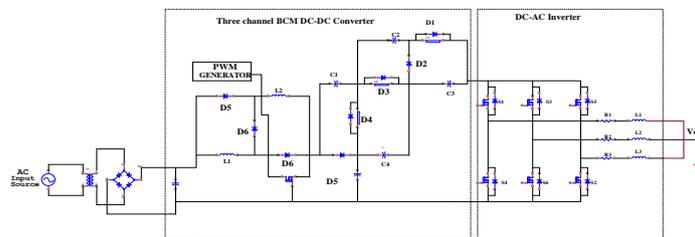


Figure 4.2 Hardware Circuit diagram

Figure 4.2 shows the overall circuit diagram power transistor, like a MOSFET, regulates the current passing through the inductor. The ON and OFF states of the switch determine the converter's operating modes and output voltage. In the switching cycle, the inductor current in CCM always drops to zero and remains positive. This function is commonly used in applications where minimal output voltage ripple is desired or significant power is required.

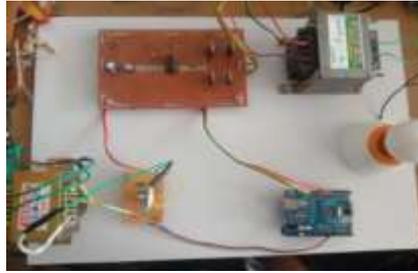


Figure 4.3. Hardware Components

Figure 4.3 shows the hardware output in continuous conduction mode, where there is always some current flowing through the switching regulator's inductor. In critical conduction mode, the inductor turns on when the current falls to zero, which only happens when a certain duty cycle is met. When the PWM signal pulses again, the inductor current decreases to zero in the discontinuous conduction condition.

Table 1. Hardware Specification

Hardware	Specification	Input Ranges	Output Ranges
Transformer	Step down	230v	110V
Rectifier	Input power	110V AC	230V DC
Three Channel BCM DC-DC Converter	DC-DC Converter	12V DC	12 V DC to 22 V DC
Microcontroller (For PWM generation)	PIC (16F877A)	5V DC	5V DC
Inverter	Output power	110V DC	110V AC
Transformer	step-up	110v AC	230v AC
Load (AC LOAD)	Load	230V	2A

5. Conclusion

Using BCM DC-DC converters in renewable energy applications has significantly reduced power quality problems and losses, while also increasing efficiency. In these applications, a boost converter is typically used due to the low and unregulated voltage obtained from wind turbines. However, it is important to note that the unidirectional AC-DC boost converter has inherent limitations, which can unintentionally distort the grid current when operating in RPC mode. This is because the THD (total harmonic distortion) of the capacitive current is worse than that of the inductive current, resulting in extended distortions. Therefore, it is necessary to restrict the amount of reactive power injected from each individual converter to the grid. However, by combining the operation of multiple converters, each specified in RPC, the reactive power demand can still be met while effectively compensating for generated harmonics. In future, the DC-DC converter will have improved performance and high-power use throughout a variety of operating conditions and a wide range of workloads.

6. References

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