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Modelling and Simulation of Closed Loop Two-Phase Interleaved Boost Converter and Three Phase Inverter with Closed Loop Voltage Control for PV Grid-tied System using MATLAB/SIMULINK

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ABSTRACT: Power DC-DC converters are picking up ever-expanding significance because of its huge advantages. The interest on a good power DC-DC converter is progressing as of late, for the effective power transfer in various fields like renewable sources, high and medium power applications. Efficient power conversion is greatly needed to satisfy the framework need in numerous applications. Interleaved Boost converter is one sort of DC-DC converter which gives higher yield dc voltage from the low input voltage. The high output voltage can be fed to a three-stage voltage source inverter and can be tied to the grid framework for photovoltaic applications. The main objective of this paper is to simulate closed-loop interleaved boost converter and three-phase inverter with closed-loop voltage control for grid-tied photovoltaic systems using MATLAB/SIMULINK.

KEYWORDS: Interleaved boost converter, closed-loop control, three-phase inverter, PV Grid, Voltage control, Simulation

I.INTRODUCTION

As in the present day [1],the use of electrical energy is expanding and the pace of progression of the generation of electrical energy is less contrasted and the rate of addition of utilization. Thus, a distributed form of power from different sustainable sources is the need for this time. The age of power from sustainable sources should be possible by utilizing sources, for example, water, air, solar-based systems, and so on. These sources are accessible in the mass sum in nature and subsequently their appropriation in the power generation is expanding all through the world. The main issue with the inexhaustible sources is that they are fluctuating in nature. Consequently, it is critical to change their qualities before connecting it to the inverter. The equipment utilized to change the electrical parameters such as voltage and current fluctuates with the kind of generation. Out of all accessible renewable sources, sunlight and wind energy are generally accessible in India. Out of the above, a solar-based energy system is getting well-known decisions among installers because of its fixed structure. The control should be possible by utilizing different types of equipment, for example, charge controller, inverter, and so forth. In this, inverter control has a lot of significancebecause the produced energy is DC in nature, if there should be an occurrence of a close loop system. The point of the plan is to synchronize the out coming ACsignal with the power grid in voltage, frequency, and phase.

The enthusiasm on a perfect power DC-DC converter is expanding as of late for getting the desired power transformation in various fields like sustainable power source, medium and high power applications[2]. But, there are a few impediments, for example, it gives huge voltage and current waves, reverse recovery issues, the huge voltage stress on semiconductor switches and so forth. These diminish the stability and productivity of the system. To take care of these issues numerous strategies are concentrated in different fields of the research. Among them, interleaving or multi-staging techniques are a remarkable solution to take care of these issues. Parallel converters are associated with interleaving techniques. This technique is progressively reasonable as opposed to connecting converters in parallel or series configuration. To improve the performance of the converter, the interleaved boost converter has been investigated as of late for its potential acceptability. The multi-staging interleaved boost converter gives lower ripple in yield voltage, input and yield current, lower switching losses, quicker transient response, and smaller size of filter elements, increment of performance, and efficiency.

The PWM inverters have been normally utilized for interfacing the sustainable power source to the utility power grid. It ought to work in grid-connected operation mode and islanding mode. During the grid-connected operation mode, the network associated inverter in the distributed generation framework is typically worked to infuse present real and reactive power to the power grid, which is the control mode in synchronization with the power grid voltage. At the point when the power grid framework is detached by abnormal conditions, for example, voltage droops/swell, blackout (deliberate islanding mode), the inverter changes its controller to voltage control mode to supply an ideal voltage to the delicate load requirement[3].

II.LITERATURE SURVEY

According to the work proposed in [1] a simulation of a three-phase grid-tied inverter that synchronizes with the power grid framework according to grid requirements is carried out. The point of this simulation is the usage of the structured filter to adequately decrease the ripple part of voltage and current infused into the power grid framework to an acceptable value. The attention is on designing the inverter which will synchronize with voltage, frequency, and phase with the grid network. The structure and examination of the grid framework synchronization technique are has been dealtin detail. With the proper design of filter and inverter, the ripple content and harmonic content injection into the grid from the photovoltaic system and associated system such as boost converter can be reduced effectively.

As referenced in [2] the power DC-DC converter has been engaged as a significant part of various topologies in different applications. To overcome the significant drawbacks of DC/DC power converters, for example, high voltage and current waves, low performance, and efficiency, interleaving methodologies assume a critical job. The interleaved boost converter offers numerous focal points, for example, minimum voltage and current ripples, lower switching losses, higher performance, and efficiency as contrasted with a conventional boost converter. To upgrade the whole performance of the converter, 'n' quantities of parallel converters are associated with the interleaved boost converter. The interleaved boost converter (IBC) is utilized in better places for its multipurpose applications. It is regularly utilized to lessen the size of filter segments, voltage, and current ripple, increment the yield power, performance, and proficiency. In interleaved boost converter, 'n' quantities of parallel converters are connected and worked by 2/n radians or 360°/n phase shift techniques among the switches and a similar duty cycle**.**

As referenced in [3] a basic simple current control technique for the grid associated operations, and inverter voltage control strategy depends on the phase-locked loop (PLL) for the deliberate islanding activity of the three-phase grid-connected inverter framework is discussed. The PLL controller is based on the pq hypothesis with a basic P-controller is utilized to synchronize the phase of inverter yield voltage with a network voltage at the grid-connected framework operations or produce an ideal inverter yield voltage at the islanding activity. The yields of the current controller are associated together to those of the voltage controller, to forestall an unexpected change in the yields of the two controllers during the transfer moment. The effective control of the output voltage of the inverter is achieved with the use of the PLL circuit which is usually used to synchronize the frequency and phase of the output voltage of the inverter concerning the grid.

III.CIRCUIT MODELLING

A.Two-phase Interleaved Boost converter with one voltage multiplier circuit

Interleaved boost converters utilize a voltage multiplier circuit is as shown in fig. 1. The operation of converters at high power levels decreases the size of magnetic components, decreases the current ripple, and improved transient response are the prominent merits [4]. The two inductors can likewise be placed into the same core with the goal that the size of the converter is diminished. The methodology can be reached out to any number of voltage multiplier circuits, while the static gain can be increased further. The voltage stress concerning the semiconductor switches is limited for this technique of power setup using converters. Since the reverse recovery currents flow through the output diode and multiplier diodes are added, efficiency can be undermined, while the utilization of a non-dissipative snubber is essential for this configuration of the boost converter.

The circuit is modelled in Simulink and following are the parameters of the elements of the circuit

L_1=L_2=1e-6 H

C_0=100e-6 F

C_{c1}=C_{c2}=1e-6 F

R_0=500 ohms

V_{in}=55V

V_{out}=670V

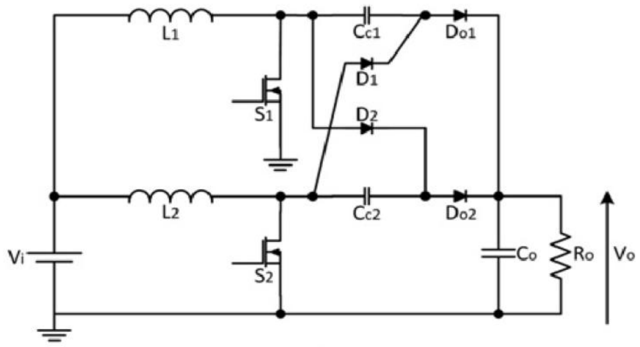

Figure 1. Two phase interleaved boost converter with one voltage multiplier circuit

B. Three Phase inverter with closed-loop voltage control

The MATLAB simulation of three-phase closed-loop voltage control is as shown in fig 3. The IGBTs of an inverter are activated with the assistance of PWM level 2 generators which gets the reference voltage from the PLL circuit. The signal given to the PWM generator is from dq0 change. The dq0 change over three-phase AC to DC and afterward is given to the PWM generator. The outer three-phase source is utilized for producing PWM pulses and this pulse is given to the PLL as a reference signal. These signals are contrasted with the carrier frequency waveform to create the pulse waveform of PWM and which are given to a universal bridge for activating of IGBTs for the conversion of DC to AC voltage and current waveforms. Fig .3 shows the Simulink model of the closed-loop voltage control scheme connected with the inverter. The control of the grid-connected inverter which supplies the utility grid framework with real and reactive power is actualized by utilizing the present control approach. In any case, the grid-connected framework must be linearized before the self-tuning device of the PI controller could be actualized, due to the non-linear characteristics of the VSI inverter blockwith the IGBT switches**.**

The circuit parameters of the modelled three-phase inverter are as follows
L=350e-3 H
C=330e-6 F
R=1.65 ohms
V_{in}=670V
V_{out}=230 V RMS

IV. SIMULATION

A. Two-phase Interleaved Boost converter with one voltage multiplier circuit

The interleaved boost converter is simulated in Simulink with closed-loop control for constant voltage output as shown in fig 2. The converter incorporates two actively controlled switches for dynamic switching and to reduce the voltage stress on the semiconductor switches. The closed-loop control is achieved with the help of a proportional-integral (PI) controller with the control parameters set as per the needs of the system configuration. The average output voltage obtained from the PV modular array is assumed to be 55V which is the input to the boost converter. Then the voltage is stepped up to 670Vwith the help of a high gain boost converter with one voltage multiplier circuit.

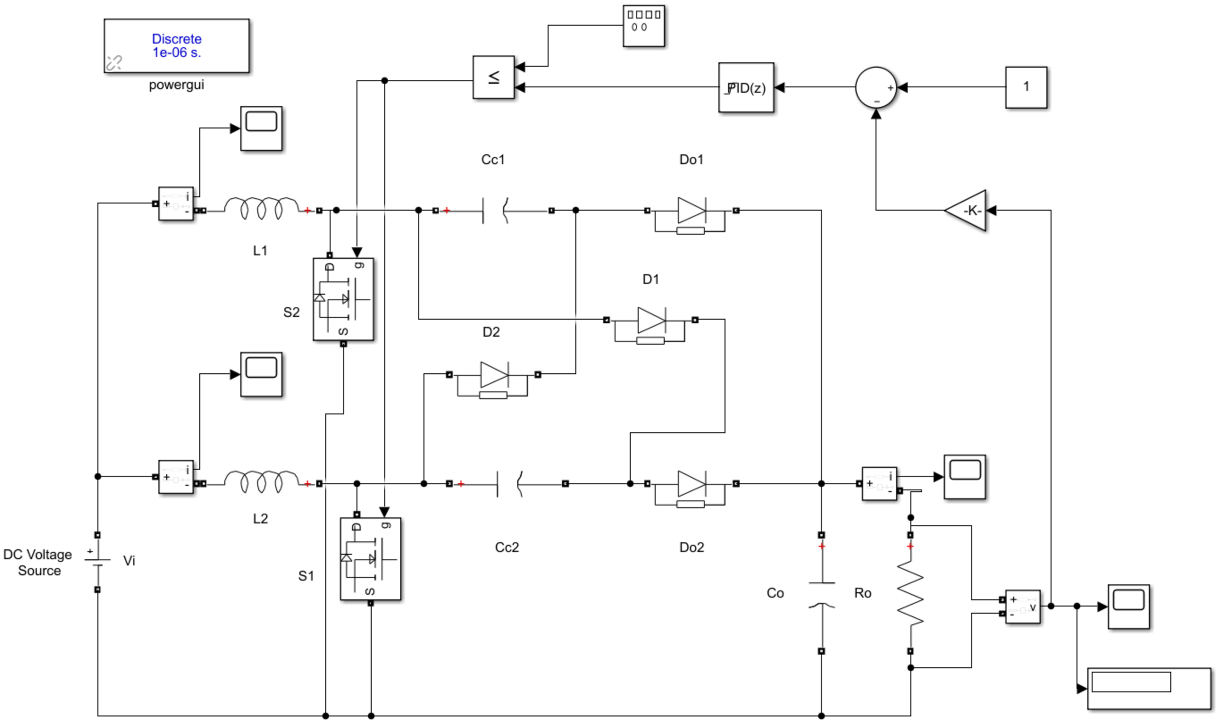

Figure2.Simulink model of two phase interleaved boost converter with voltage multiplier circuit

B. Three Phase inverter with closed-loop voltage control

The Simulink model of three-phase with closed-loop voltage control is as shown in fig.3. The voltage control is achieved with the help of the PLL circuit and PI controller, due to which the output voltage and current can be synchronized with the grid specifications [5]. A filter is connected to the output side of the inverter to reduce the voltage ripple and reduce the harmonic distortion. The dq0 conversion technique is used to realize the discrete PI controller. The input voltage for the inverter is obtained from the interleaved boost converter which is 670V, with triggering of the gate terminal of IGBT with PWM signal obtained from the PWM level 2 converter. The output voltage obtained is AC 230V RMS.

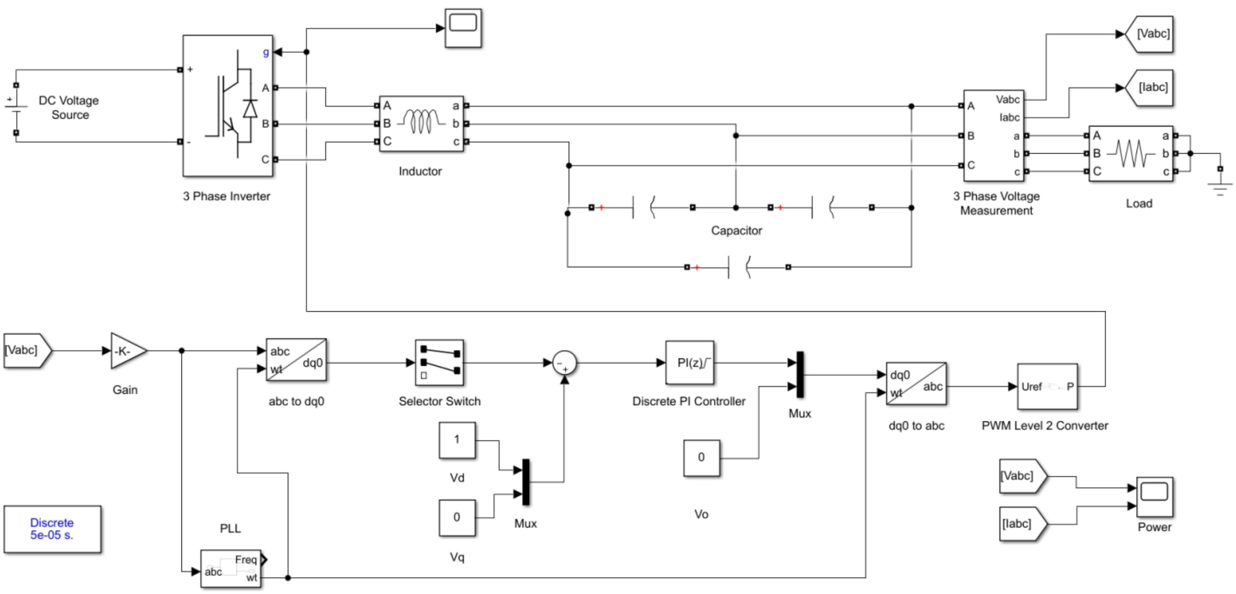

Figure 3.Simulink model of three phase inverter with closed loop voltage control

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V. SIMULATION RESULT AND DISCUSSION

The pulse width modulation signal obtained from the closed-loop control circuit is 1V in amplitude and switching frequency is 50kHz and the duty cycle is varied as per the feedback obtained from the PI controller as shown in fig 4.The output voltage obtained is 670V as shown in fig 5.

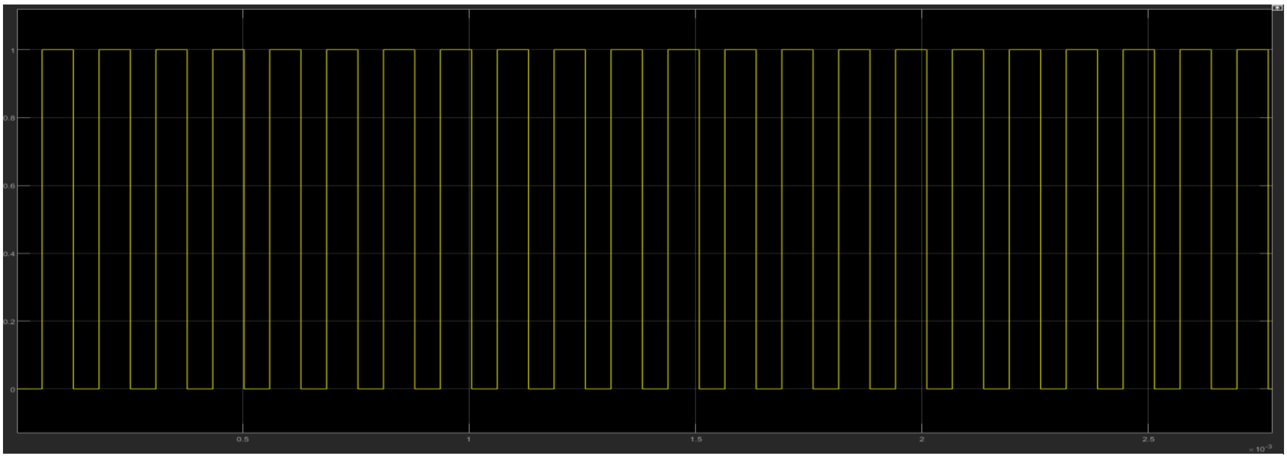

Figure 4.Pulse width modulated signal obtained from closed loop control circuit for interleaved boost converter

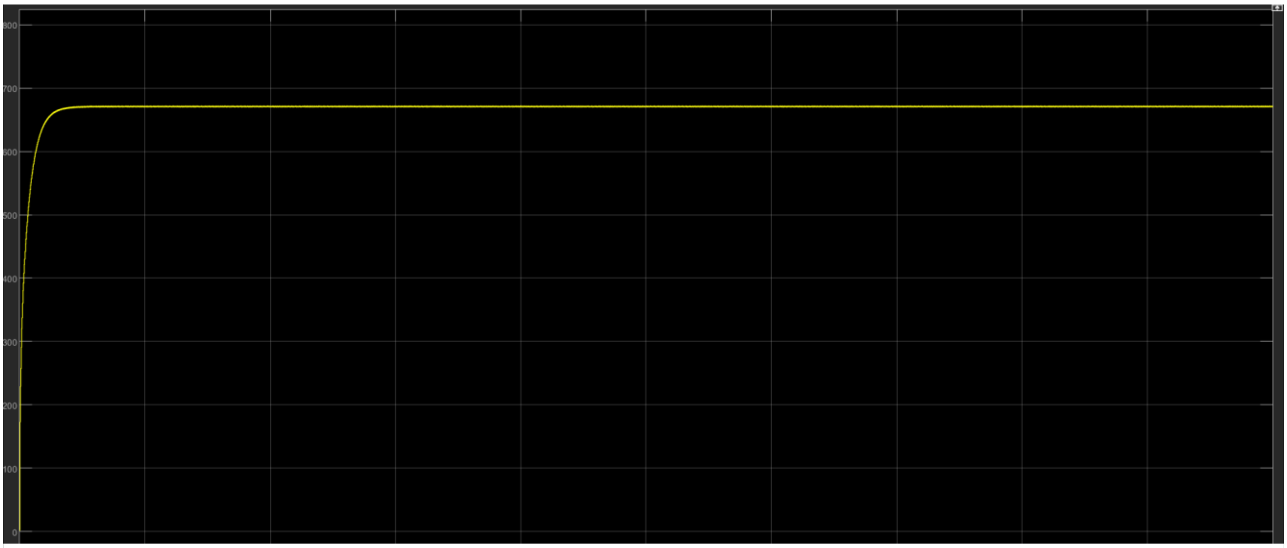

Figure 5.Output Voltage waveform of two phase interleaved boost converter

The three-phase inverter has input voltage to be 670V and with the help of the PLL circuit and PI controller the PWM signal is generated with required duty cycle with 4 kHz as switching frequency for closed-loop voltage control. As shown in fig .6 the gate pulses for the universal bridge are generated from the PWM level 2 converter. Fig .7 represents output voltage and current waveforms of the three-phase inverter. The harmonic content and voltage and current ripple are reduced significantly by connecting a filter to the output of the inverter.

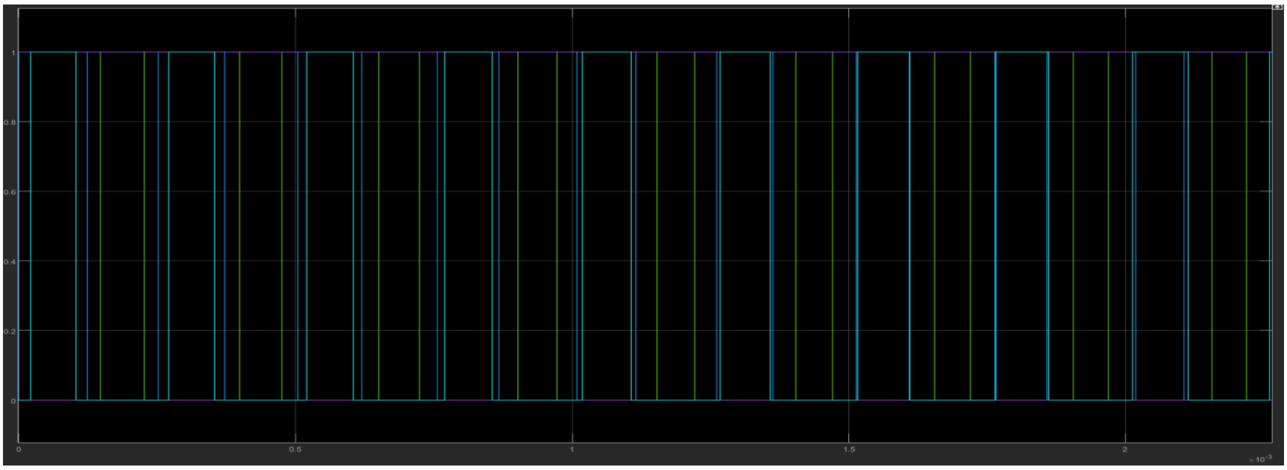

Figure 6. Pulse width modulated signal obtained from PWM level 2 Modulator for three phase inverter

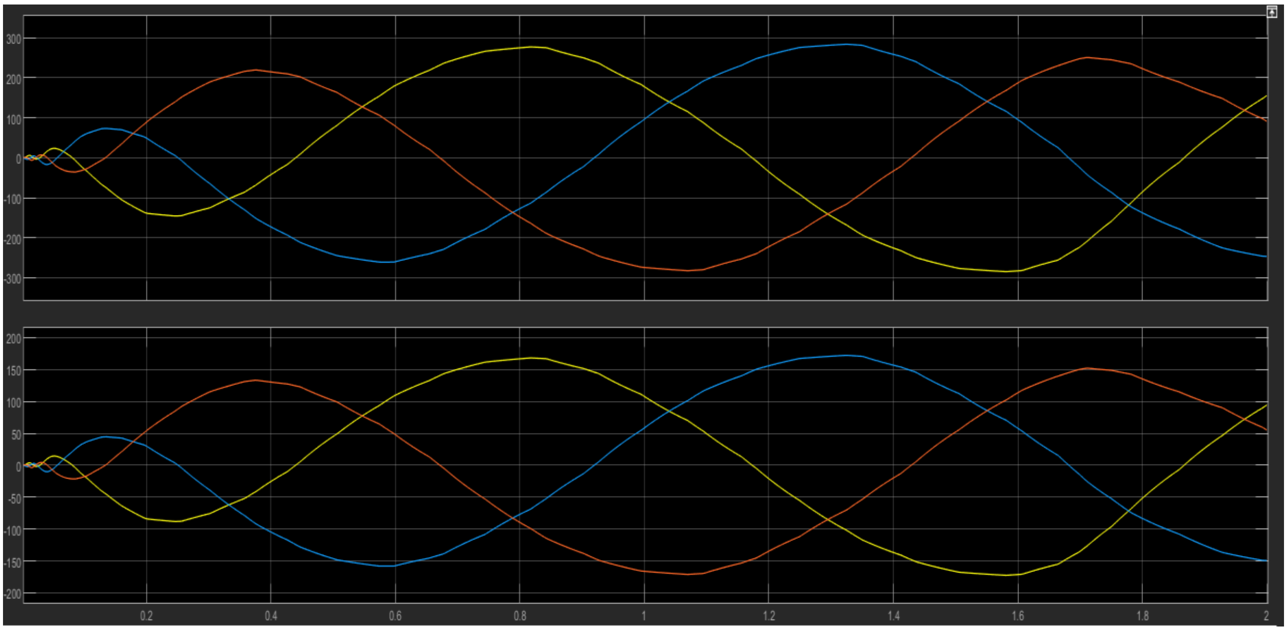

Figure 7.Output Voltage and current waveforms of the three phase inverter with closed loop voltage control

VI.CONCLUSION

The simulation of the two-phase interleaved boost converter and three-phase inverter with the closed-loop operation was carried using SIMULINK. For decreasing ripple in current and voltages and upgrading performance and efficiency, the interleaved boost converter has been ended up being a potential interface when contrasted with a conventional boost converter. The interleaved converters are capable of producing high DC voltages as output with the addition of closed-loop control; the output voltage can be maintained without any fluctuations. Subsequently, by utilizing interleaving methods with expanding the units of stages, we can decrease the current and voltage ripples, switching losses and develop better performance. The general reproduction of a three-phase inverter framework is recreated in MATLAB through PLL based PWM procedure by utilizing the DC source. The proposed framework is competent for synchronizing with a grid with little distortion according to grid network necessity. Thus, three-phase inverters can be coupled with interleaved boost converters for high power applications which include grid-tied photovoltaic system that has huge potential to provide bulk energy.

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