ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 10, October 2015

Grid Power Compensation by Micro Grid System with Bidirectional AC/DC Converter and DC/DC Converter PWM Strategy

J.Dani Abraham[1], P.Kani Rajan[2]

PG Student [PED] , Dept. of EEE, Raja College of Engineering & Technology, Madurai, Tamilnadu, India[1]

Associate Professor, Dept. of EEE, Raja College of Engineering & Technology, Madurai, Tamilnadu, India[2]

ABSTRACT: This paper introduces a new topology that is used to maintain continuous power supply to the grid with distributed generation system. To have un- interrupted supply and to maintain power quality bidirectional AC/DC converter is used along with buck and boost converter with battery storage devices. The simulation results show an improvement over the existing technique especially in grid side voltage. The same techniques were also adopted using PV cell.

KEYWORDS: Bidirectional AC/DC converter, simplified PWM strategy, total harmonic distortion.

I.INTRODUCTION

The single phase ac/dc PWM converter is widely used in many applications such as adjustable-speed drives, switch-mode power supplies and uninterrupted power supplies. The single-phase ac/dc PWM converters [1] [2] are usually employed as the utility interface in a grid-tied renewable resource system, to utilize the distributed energy resources (DERs) efficiently and retain power system stability the bidirectional AC/DC converter plays an important role in the renewable energy system [3]. When DERs have enough power the energy from the DC Bus can be easily transferred into the AC grid through the bidirectional AC/DC converter. In contrast, when the DER power does not have enough energy to provide electricity to the load in the DC Bus, the bidirectional AC/DC converters can simultaneously and quickly change the power flow direction from AC grid to DC grid and give enough power to the DC load and energy storage system [4]. There are many requirements for ac/dc PWM converters as utility interface in a grid-tied system; for instance, providing power factor correction functions, low distortion line currents high quality dc output voltage and bi-directional power flow capability Moreover, PWM converters are also suitable for modular system design and system reconfiguration. In this paper, a novel PWM control strategy with feed-forward control scheme of a bidirectional single phase ac/dc converter is presented.

II.GRID POWER COMPENSATION SYSTEM

A single-phase bidirectional AC-DC converter and bidirectional DC-DC converter is proposed to transfer electrical power from the grid to DC bus and from a DC bus to the grid while keeping improved power factor of the grid. In first stage, a 230 V 50 Hz AC supply is converted in to 380V DC using a single-phase bidirectional AC-DC converter and in the second stage, a bidirectional DC-DC converter (Buck and Boost) is used to charge and discharge the battery. In discharging mode, it delivers energy back to the grid at 230V, 50 Hz. The DC-DC converter charges the batter in buck mode and when battery discharges, it works in boost mode.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 10, October 2015

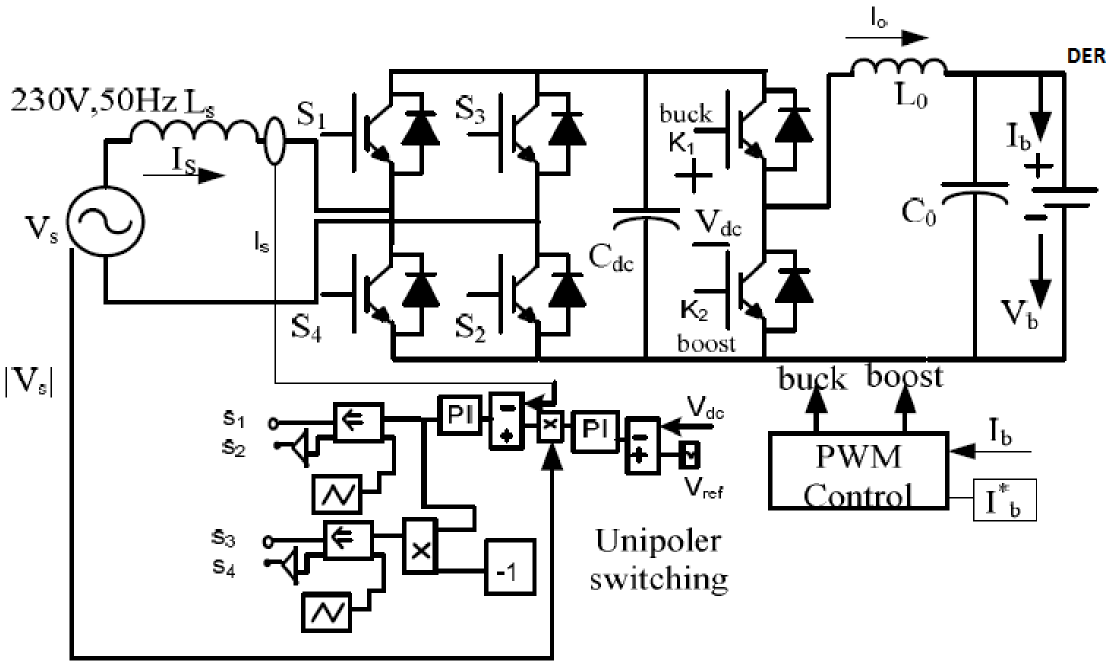

Fig. 1. Switches S1 through S4 is the Bidirectional AC/DC Converter, following a capacitor filter, Buck and a Boost converter. A DER (Distributed Energy Resource) is connected to a battery for storing the produced DC power.

III.OPERATION PRINCIPLE

A single-phase bidirectional AC-DC converter and bidirectional DC-DC converter is proposed to transfer electrical power from the grid to DC bus and from and DC bus to the grid while keeping improved power factor of the grid. In first stage, a 230 V 50 Hz AC supply is converted in to 120V DC using a single-phase bidirectional AC-DC converter and in the second stage, a bidirectional DC-DC converter (Buck and Boost) is used to charge and discharge the battery. In discharging mode, it delivers energy back to the grid at 230V, 50 Hz. The DC-DC converter charges the batter in buck mode and when battery discharges, it works in boost mode.A Buck converter is the one which gives an output power lesser than the input. The basic operation of the buck converter has the current in an inductor controlled by two switches (usually a transistor and a diode). In the idealized converter, all the components are considered to be perfect. There are two modes of operation (i) Continuous and (ii) Discontinuous mode.

In Continuous mode, When the switch is closed (on state), the diode is reverse biased the current through the inductor rises linearly. When the switch is opened (off state) the diode is forward biased. The current through inductor decreases.In Discontinuous conduction mode, this case the current through the inductor falls to zero during part of the period. The only difference in the principle described above is that the inductor is completely discharged at the end of the commutation cycle.

The Boost converter is the one which gives an output power higher than the input. This has two modes of operation as (i) Continuous and (ii) Discontinuous mode. In Continuous conduction mode the switch S is closed, resulting in an increase in the inductor current. The switch S is open, so the inductor current flows through the load. In Discontinuous conduction mode, the output voltage gain not only depends on the duty cycle, but also on the inductor value, the input voltage, the switching frequency, and the output current. A Bi-Directional AC/DC Converter is the one which converts AC power in to DC power and vice versa. The AC power from the grid is converted in to DC power for the purpose of supplying the DC loads and Battery charging. The DC power output from the Battery and any DC generator is converted in to AC power and supplied back to the grid.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 10, October 2015

FEED-FORWARD CONTROL SCHEME

The operating mechanism of the proposed simplified PWM is clearly explained in Section II. However, the conventional dual loop control scheme applied to the proposed simplified PWM cannot produce good performance in a single-phase bidirectional AC/DC converter. In this section, based on the proposed simplified PWM strategy, a feed-forward control scheme is also developed to provide better line current shaping and better output voltage regulation compared with the conventional dual loop control scheme. In the conventional dual loop control scheme applied to the single-phase bidirectional AC/DC converter, the inner current loop and outer voltage loop are utilized as shown in figure. Where Vdc* is the DC voltage command, Vdcis the actual DC voltage; iL* is the AC current command, iLis the actual AC current. The voltage controller calculates the voltage error and generates the current amplitude command iLmultiplied by the unit sinusoidal waveform, obtained from the phase lock loop to generate the current command iL*. In general, a proportional-integral (PI) controller is adopted as the voltage controller and current controller to achieve power factor correction at the AC side and voltage regulation at the DC side

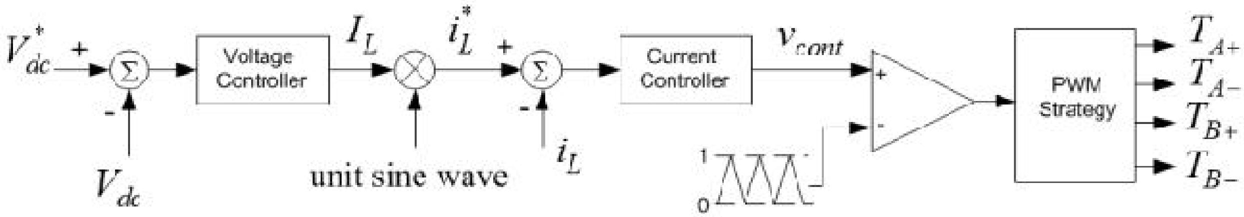

Fig 2 conventional dual loop control scheme for a single-phase bidirectional AC/DC converter

Based on the proposed simplified PWM a novel feed-forward control scheme is presented in this section. For a convenient explanation the converter operated in the rectifier mode is discussed first. The rectifier mode switching combination is listed in Table 1. One can choose operation Status A and Status E during the condition Vs > 0, Status C and Status E during the condition Vs < 0. It should be noted that the selection of Status A or B for increasing inductor current, and status C or D for decreasing inductor current are all allowable in the proposed simplified PWM strategy. To derive the state-space averaged equation for the proposed simplified PWM strategy the duty ratio Don is defined as Don = ton / T, where ton is the time duration when the switch is turned ON, ie. Son=1, and T is the time period of triangular waveform. The duty ratio Doff is defined as Doff =1- Don, which is the duty ratio when the switch is turned off. While the ac grid voltage source is operating in the positive half-cycle Vs > 0, the switching duty ratio of status A is defined as Don and that of status E is defined as Doff. The corresponding circuit equations of status A and status E were obtained in equations (1) and (2), respectively. By introducing the state-space averaged technique and volt-second balance theory the state-space averaged equation is derived as follows:

Vs-(1-D)Vdc=0.

When the converter is operated in the steady state, the DC voltage is equal to the desired command Vdc =Vdc*, equation (12) also can be expressed in the following form.

$D_{on} = [1 – Vs / V_{dc}]$

Consider that the converter is operated in the inverter mode with the switching combination listed in Table 2. One can choose Status F and Status H for increasing and decreasing the inductor current, respectively, during condition Vs > 0, and Status I and Status K for decreasing and increasing the inductor current, respectively, during the condition Vs < 0. Note that selecting Status F or Status G for increasing the inductor current and Status I or Status J for decreasing the inductor current is all allowable in the proposed simplified PWM strategy. While the converter is operated in the inverter mode, the control signal v'contcan be obtained using a similar manner in the rectifier mode. After calculation the control signal v'contoperated in the inverter mode is the same as that in the rectifier mode. Because the control signal vcontis proportional to Don, one can regard the calculated signal v'contin equation (17) as the duty ratio feed-forward control signal vffto add into the dual loop feedback control signal vfb. The feed-forward control signal vff can enhance the control ability to provide fast output voltage response as well as improve current shaping. The switching signals T_A+, T_A-, T_{B+}, T_B– are generated. The feed forward system is applicable for all BPWM and UPMW scemes.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 10, October 2015

IV.MODELING AND SIMULATION USING MATLAB

The modelling of the proposed system is done using MATLAB, and the simulation result is given for both boost mode and buck mode

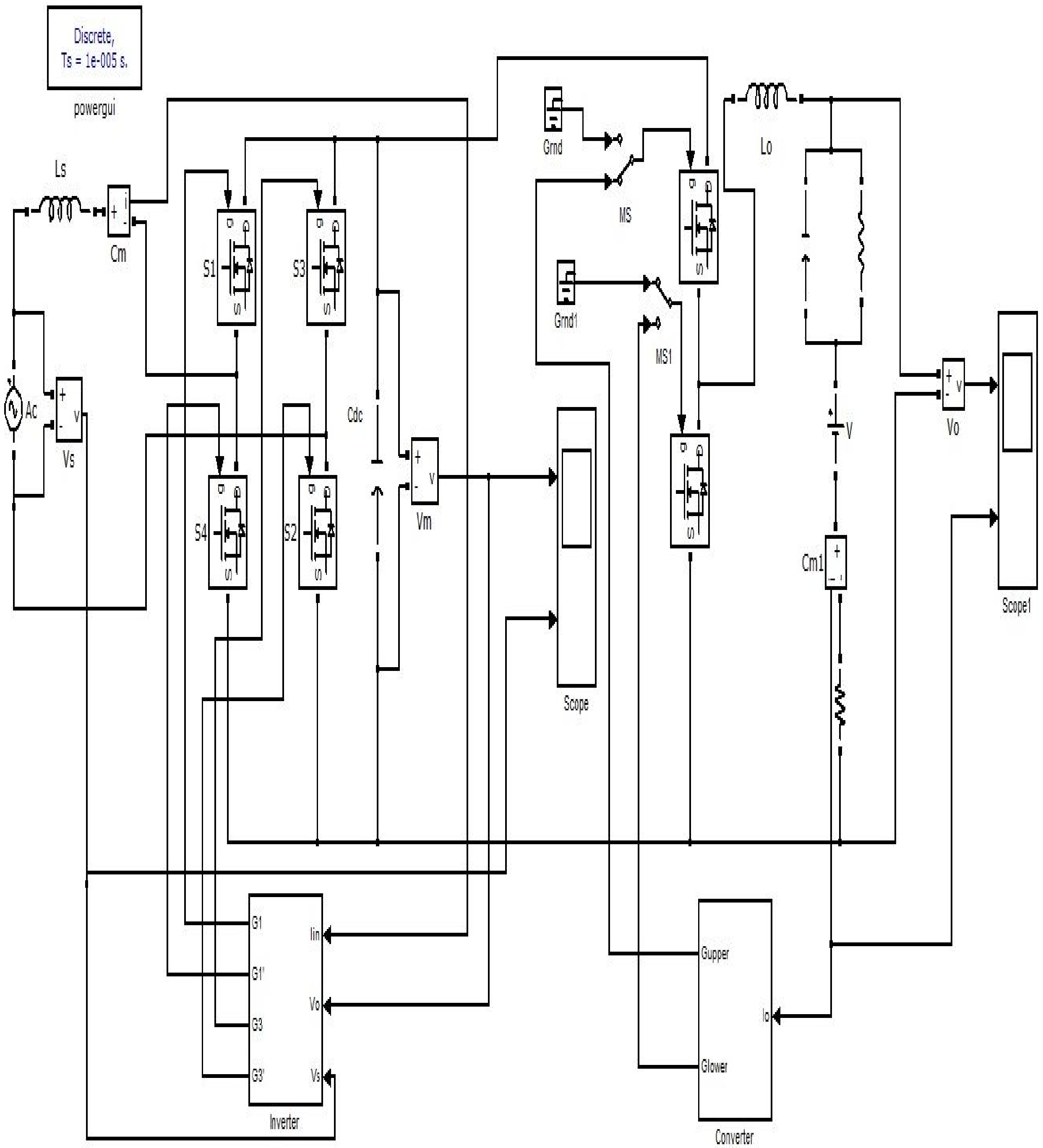

Fig. 3. Simulation Circuit of Proposed System

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 10, October 2015

V. RESULT AND DISCUSSION

The simulation done using the mat lab gives the following results. Fig .4 shows the grid side AC voltage 230 V is being converted to DC voltage by the AC/DC Converter. Fig. 6 shows the bucked DC voltage 120 V and current of 5A to charge the battery. This operation is done by the buck converter under the system's buck mode of operation. Fig.5 shows the boosted up voltage from the battery units, i.e. from 120 V to 300 V by the boost converter. The boosted voltage is then converted to the rated grid side voltage of 230 V.
The voltage and current waveforms shows some minute ripples. These can be eliminating by using appropriate selection of the circuit components.

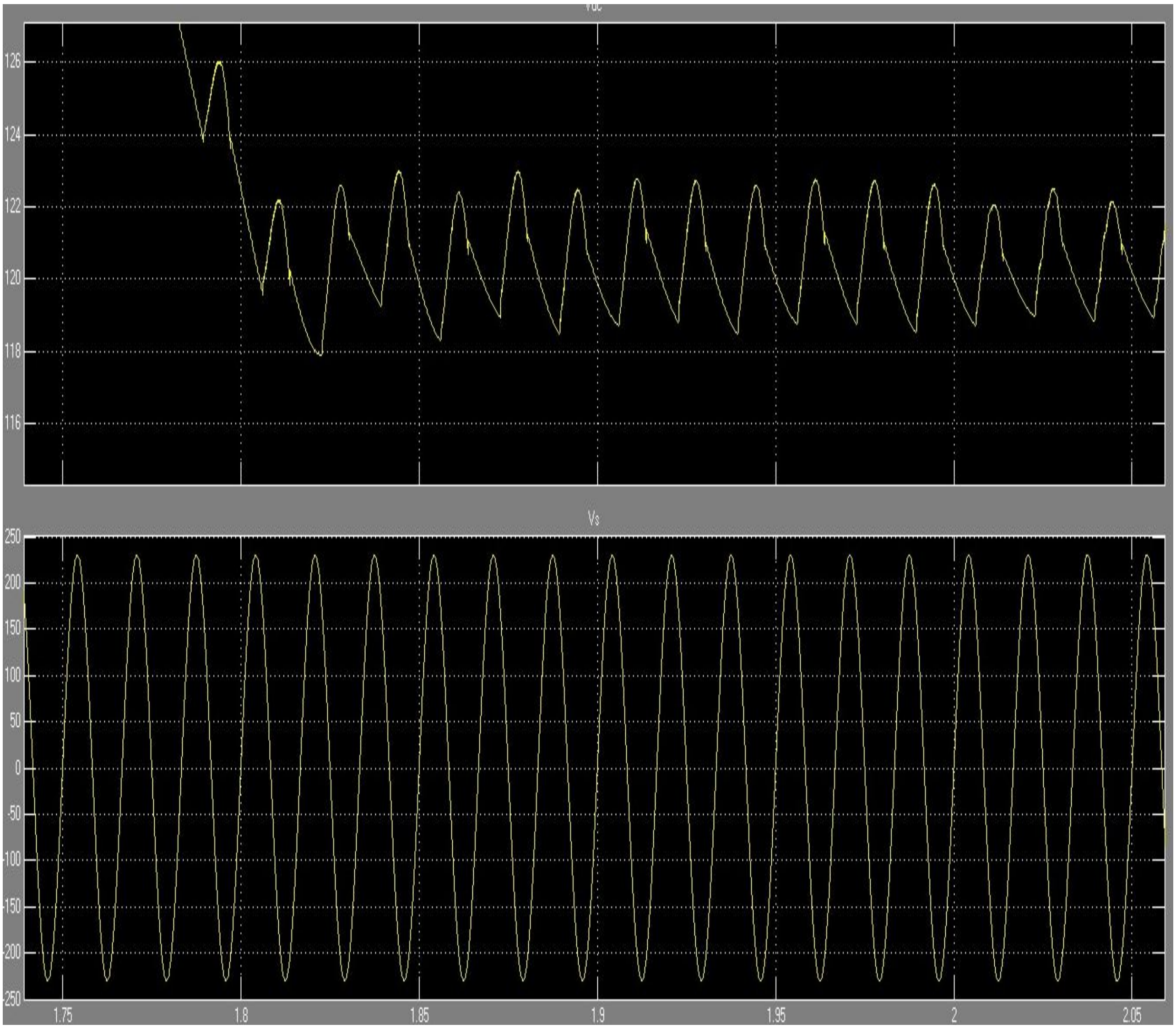

Fig 4. Voltage $_{(Vdc)}$ and the Grid side Voltage $_{(Vs)}$ respectively.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 10, October 2015

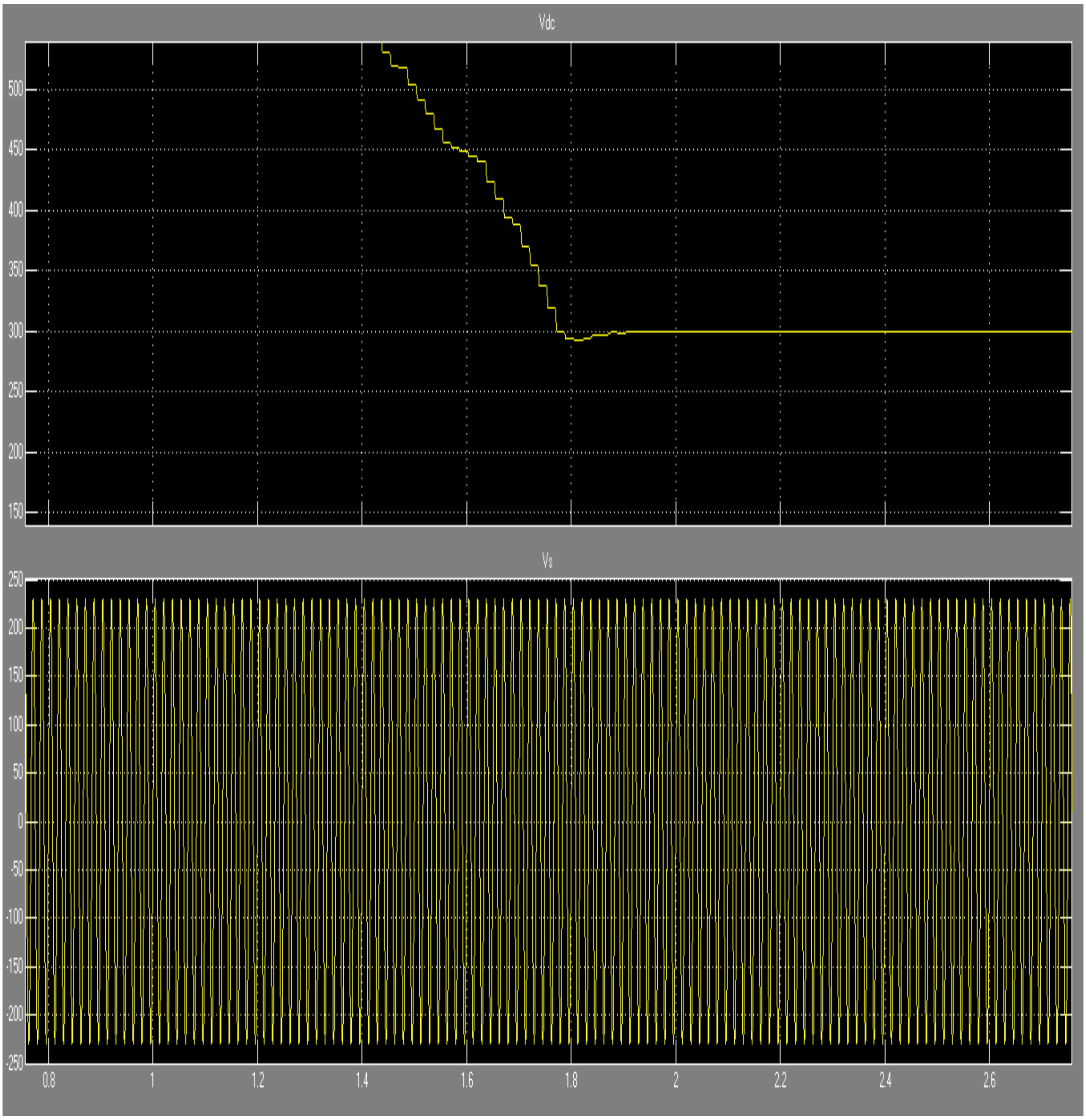

Fig 5. Boosted Voltage $_{Vdc}$ and Grid Voltage $_{Vs}$

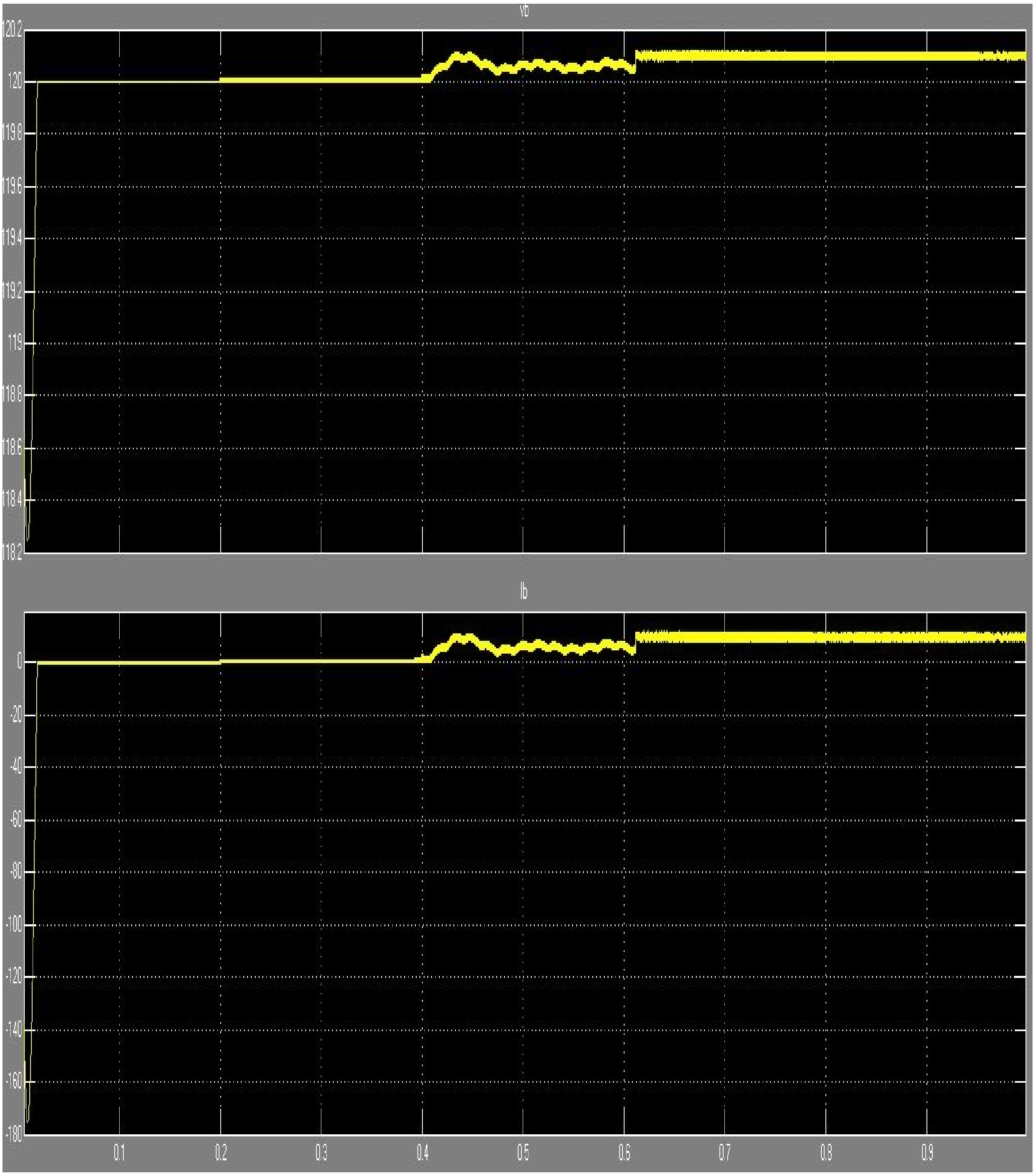

Fig 6. Bucked DC Voltage $_{(Vb)}$ and Current Output $_{(Ib)}$ Waveforms.

V.CONCLUSION

The project used the PWM strategy using a feed-forward control scheme in the bidirectional single phase AC/DC converter. The proposed simplified PWM strategy only requires changing one active switch status in the

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 10, October 2015

switching period instead of changing four active switch statuses as required in the unipolar and bipolar PWM strategy. The efficiency of an AC/DC converter operated in the proposed simplified PWM strategy is higher than that in the unipolar and bipolar PWM strategy. Based on the proposed feed-forward control scheme both AC current shaping and DC voltage regulation are achieved in both the rectifier and inverterA single-phase bidirectional AC-DC converter and bidirectional DC-DC converter is proposed to transfer electrical power from the grid to DC bus and from an DC bus to the grid while keeping improved power factor of the grid. In first stage, the available AC supply is converted DC using a single-phase bidirectional AC-DC converter and in the second stage, a bidirectional DC-DC converter uses Buck mode to charge the battery and Boost mode while discharging from the battery. In discharging mode, it delivers energy back to the grid at the rated grid power and frequency. Thus providing improved power quality at the grid,High power factor, LowTHD,and well regulated voltage.

REFERENCES

[1]Yi-Hung Liao, Member, IEEE , A Novel Reduced Switching Loss Bidirectional AC/DC Converter PWM Strategy with Feed-Forward Control for Grid-Tied Micro Grid Systems, IEEE Transactions, November 2013

[2]H. S. Kim, M.H.Ryu, J.W.Baek, J. H. Jung, "High-Efficiency Isolated Bidirectional AC–DC Converter for a DC Distribution System," IEEE Trans. Power Electron. , vol.28, no.4, pp.1642-1654, April 2013

[3]S. Golestan, M. Monfared, F. D. Freijedo, J. M. Guerrero, "Design and Tuning of a Modified Power-Based PLL for Single-Phase Grid-Connected Power Conditioning Systems," Power Electronics, IEEE Transactions on , vol.27, no.8, pp.3639-3650, Aug. 2012

[4]S. Dasgupta, S. K. Sahoo, S. K. Panda, G. A. J. Amaratunga, "Single-Phase Inverter-Control Techniques for Interfacing Renewable Energy Sources With Microgrid—Part II: Series-Connected Inverter Topology to Mitigate Voltage-Related Problems Along With Active Power Flow Control," Power Electronics, IEEE Transactions on , vol.26, no.3, pp.732-746, March 2011.

[5]D. Dong, F. Luo, D. Boroyevich, P. Mattavelli, "Leakage Current Reduction in a Single-Phase Bidirectional AC–DC Full-Bridge Inverter," Power Electronics, IEEE Transactions on, vol.27, no.10, pp.4281-4291, Oct. 2012.

BIOGRAPHY

J.Dani Abrahamwas born in Tamil Nadu, India in 1982. He received the B.E degree in Electrical and Electronics Engineering discipline from SACS M.A.V.M.M Engineering College in 2003.He worked as Sr. Service Engineer in T.V.S.and Sons LTD, Madurai since 2006.He received the M.E degree in Power Electronics and Drives discipline at Raja College of Engineering Technology in 2015. His research interest includes Embedded System Control, Grid Connected System.

P.KaniRajan graduated in Electrical & Electronics Engineering from Bharathiar University, Coimbatore, India in 1999, with a post-graduate qualification in Power Systems from Thiagarajar College of Engineering, Madurai India in 2003.He is currently working toward his Ph.D. in power quality at Anna University, Tamilnadu, India. He is currently working as an Associate Professor in the department of Electrical and Electronics Engineering at the Raja College of Engineering and Technology, Madurai, Tamilnadu, India. His fields of interest include power quality and artificial intelligence.