

## High Efficiency Bi-Directional Converter Used For Renewable System

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### Abstract

This paper presents an Isolated bi-directional converter for renewable system. Voltage stress and current stress was decreases in switches. Power flows in both side. The proposed converter three phase ac voltage to dc voltage, dc voltage to three phase a.c voltage and synchronous the two voltage source. Silicon carbide diodes and bi-directional switches Mosfet's are used for decreases the switching loss. LC Series resonant converter connected to the high efficiency. This converter power conversion control by the output voltage information.

**Keywords**-component; Isolation Transformer, lc series resonant convertr, DC-Link Capacitor, Bi-directional dc-ac converter

### I. INTRODUCTION

An isolated bi-directional converter used synchronous alternatind current has been take wind mills and direct curent take solar power plant with the help of renewable source. The Bi-directional DC-AC converter connected between A.C Distribution and DC Distribution system . LC Resonant converter topology has been extensively used in various dc-ac and ac-dc applications. Now a day's power demand is very high. Some time wind energy is high that time alternating current is high but can not store the alternating current. We can store the direct current. So need bi-directional dc-ac converter. Normal antiparallel diode causes turn on switching noise and high reverse recovery current some isolated bi-directional DC-DC and AC-DC converter topologies have been presented in recent year. A boost full bridge ZVS PWM (Zero Voltage Switching Pulse with modulation) dc-dc converter was create for bi-directional high power application. How ever , It need extra snubber circuits to decreases the voltage stress of the switches . The proposed bi-directional dc-ac converter work at without any snubber circuit. This converter switches ON and OFF Control as output voltage variation. In This proposed bi-directional converter with several improvement techineques used. This paper involves simulation of bi-directional dc-ac converter circuits and the analysis of objective of improving the high efficiency in bi-directional dc-ac converter. Generally, electric power generated by renewable energy sources is unstable in nature, thus producing a bad effect on the utility grid. This fact spurs research

on energy storage systems to smooth out active-power flow on the utility grid.

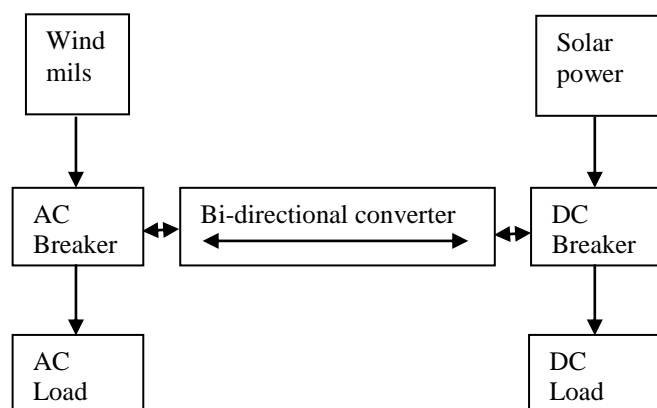


Fig.1. Schematic Bi-directional converter.

### II. PROPOSED BI-DIRECTIONAL DC-AC CONVERTER BASIC PRINCIPLE OF OPERATION

Fig. 2 shows the circuit configuration of the proposed isolated bidirectional dc-ac converter. It consists of the three phase bidirectional rectifier for grid interface and the isolated bidirectional full-bridge LC resonant converter for galvanic isolation. To control the proposed converter, a single controller was used. The power flow directions in the converter are defined as follows rectification mode (forward direction of power flow) and generation mode (backward direction of power flow). The switching method of the proposed three-phase bidirectional

rectifier is unipolar SPWM. In order to reduce the switching losses caused by the reverse recovery current in the rectification mode, the high-side switches of the proposed rectifier are composed of  $S_{14}$ ) for reducing conduction loss and for using ZVS operation in the generation mode. The detailed circuit operation of the proposed bidirectional rectifier and advanced method will be discussed. The proposed bidirectional full-bridge LC resonant converter has the full-bridge symmetric

twoMosfets without antiparallel diodes ( $S_{11}$  and  $S_{13}$ ) and two SiC diodes ( $DS_1$  and  $DS_3$ ). The lowside switches are composed of two MOSFETs ( $S_{12}$  and

structure of the primary inverting stage and secondary rectifying stage with a symmetric transformer. Using the high-frequency transformer, the converter can achieve galvanic isolation between the primary side.

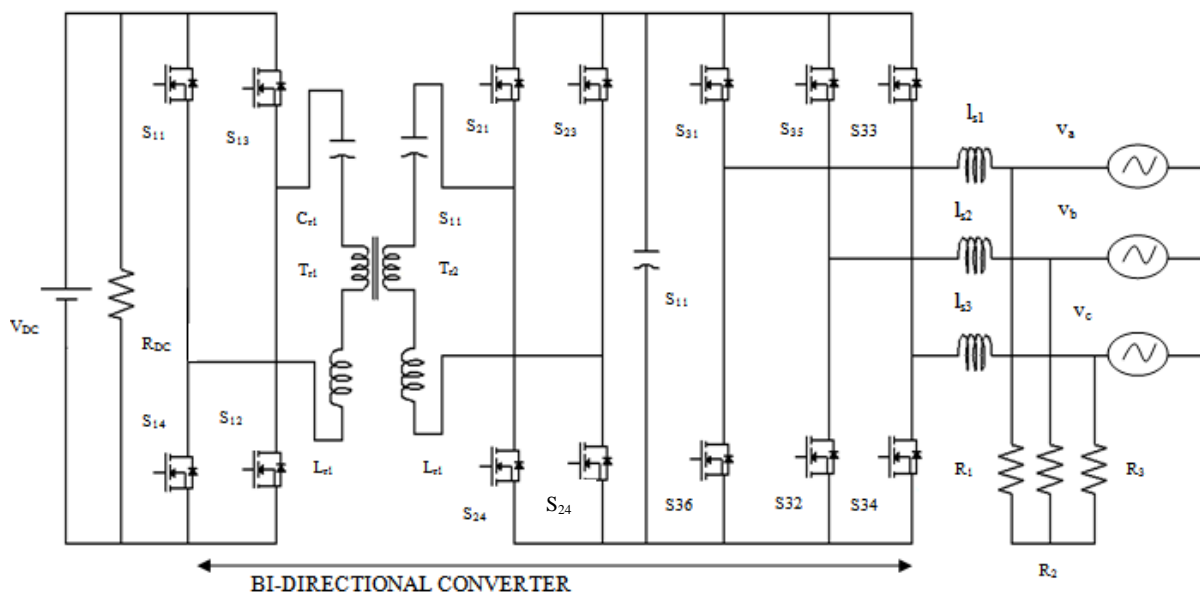


Fig. 2 Proposed Bi-directional converter

### III. NONISOLATED AC-DC BIDIRECTIONAL RECTIFIER

High-power rectifiers do not have a wide choice of switching devices because there are not many kinds of the switching devices for high-power capacity. Generally, the full-bridge rectifier in high-power applications consists of the same four devices: IGBT modules or intelligent power modules are chiefly used. This modular devices have antiparallel diodes, which have fast recovery characteristics. A fast recovery diode (FRD) has a small reverse recovery time  $t_{rr}$ . When the fullbridge rectifier operates, the time  $t_{rr}$  causes a reverse recovery current which increases power loss and EMC problems. Therefore, soft-switching techniques using additional passive or active snubber circuits have been proposed. Even though these methods require a relatively large number of passive or active components, which decrease the reliability of the rectifier system and increase system cost, the soft-switching techniques in the high-power rectifier are a unique solution for reducing the reverse recovery problems. On the other hand, a medium-power rectifier system around 5 kWfor a residential house or Industry has a wide selection of switching devices

such as discrete-type MOSFETs. Especially, commercial without the antiparallel diode can be selected to replace antiparallel FRDs to SiC diodes. In theory, the SiC diode does not have  $t_{rr}$ . Therefore,

the combination of IGBTs without the antiparallel diode and the SiC diodes is an other viable solution to reduce the reverse recovery problems. In the bidirectional rectifier using the unipolar switching method, the turn-on period of low-side switches increases one and half times more than the turn-on period of the high-side switches. Therefore, the low-side switches should be chosen to consider low conduction losses for increasing the power conversion efficiency. The latest generation of MOSFETs employing superjunction technology can achieve extremely low on-resistance  $R_{DS(on)}$ .

and the secondary side. The transformer  $Tr$  is modeled with the magnetizing inductance  $L_m$  and the transformer's turn ratio of 1:1. The leakage inductance of the transformer's primary and secondary windings is merged to the resonant inductor  $L_{r1}$  and  $L_{r2}$ , respectively. The resonant capacitors  $C_{r1}$  and  $C_{r2}$  make automatic flux balancing and high resonant frequency with  $L_{r1}$

and  $Lr2$ . The detailed analysis and design guides of the proposed converter will be discussed in following Section.

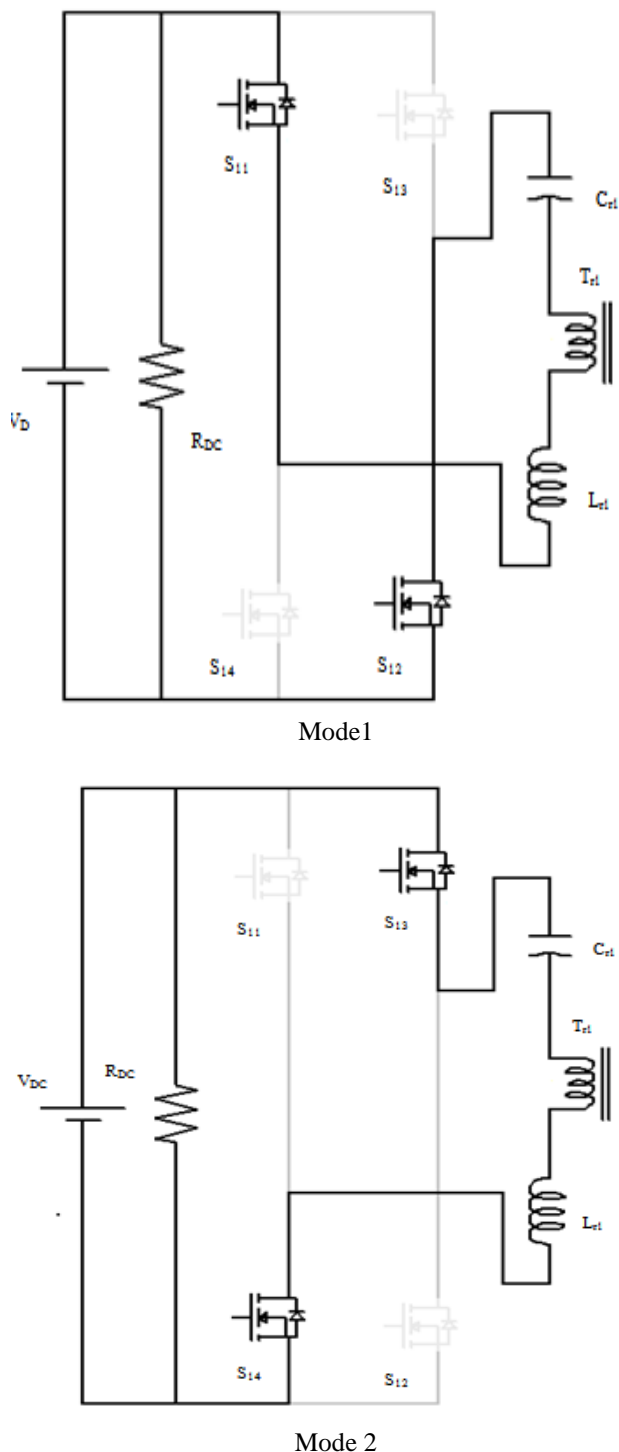


Fig.3. Operating modes of the proposed bidirectional DC-AC converter in the rectification mode: *Mode 1*, *Mode 2*.

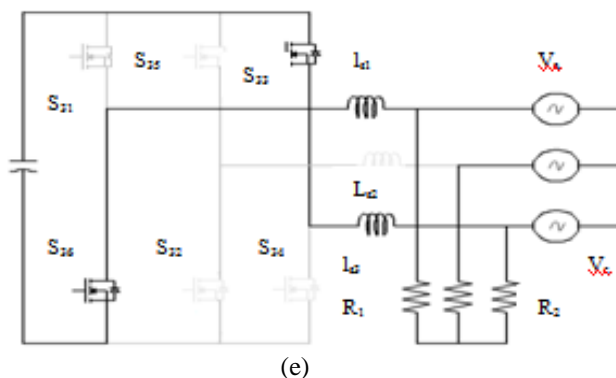
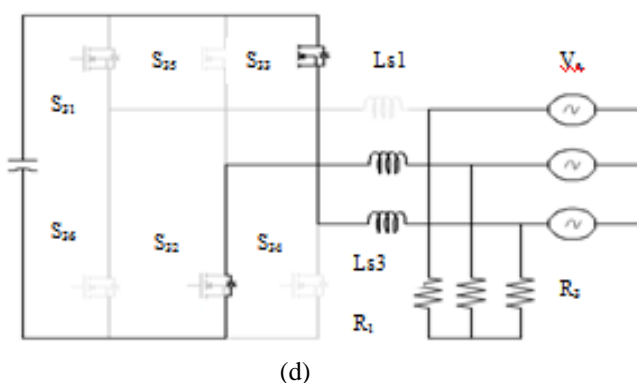
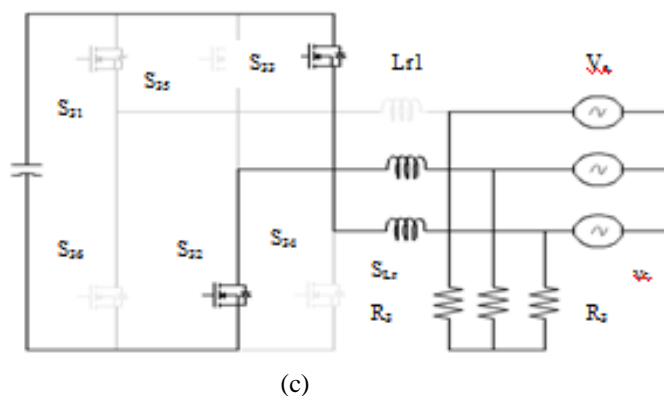
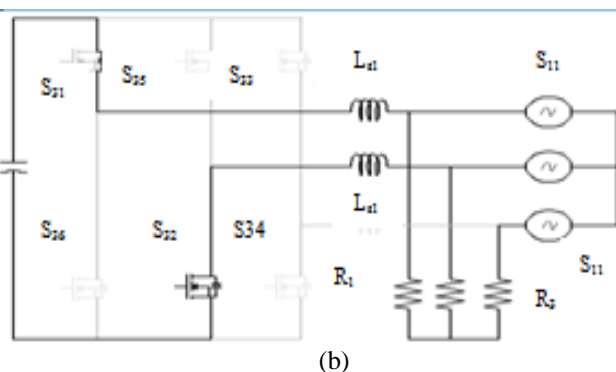
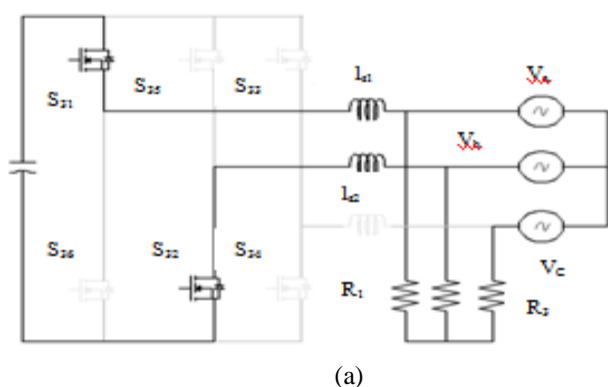
In the generation mode using the same switching pattern as the rectification mode, the proposed bidirectional rectifier has five operating modes in a single switching cycle. The circuit operations in the positive half period of the input voltage are shown in Fig. 3 After the discharge operation of dc-link's energy, the antiparallel diode including the low-side switch  $S_2$  will be conducted by freewheeling operation using inductor's energy as shown in *Mode 2*. During this period, the energy stored in the output capacitance of  $S_2$  can be fully discharged. In *Mode 2*,  $S_{12}$  turns ON under the ZVS condition. Through these operation modes, the turn-on losses in the low-side switches can be reduced. When the high-side switch  $S_{11}$  turns ON in *Mode 2*, the antiparallel diode of  $S_2$  cannot immediately turn OFF because of poor reverse recovery performance of the MOSFET's antiparallel diode. It causes an additional switching loss on  $S_{11}$  through the reverse recovery current. Therefore, the generation mode using the same switching pattern of the rectification mode has advantages of soft switching and disadvantages of reverse recovery loss. The MOSFET's losses in the generation mode depend on the MOSFET's  $R_{DS(on)}$  and the reverse recovery characteristics of the antiparallel diode. The selection of the MOSFET can determine the significant loss factor between switching and conduction losses. However, if IGBTs are used for the low-side switches, the ZVS operation is not significant to reduce their switching loss. There are also reverse recovery losses through the reverse recovery characteristics of the antiparallel diode. They can increase the turn-off switching losses through the MOSFET's tailing current.

If the reverse recovery loss through the MOSFETs is significant, it can be overcome employing the inverted switching pattern in the generation mode. The operation mode of the inverted switching pattern is shown in Fig. 2. In this operation, the switching pattern is perfectly inverted and the turn-on period of the high-side switches is one and half times longer than the turn-on period of the low-side switches. In *Mode 2*, the low-side switch  $S_{14}$  turns ON. At the same time, the reverse recovery current should be limited by the SiC diode  $D_{S3}$ . Using this switching pattern in the generation mode, there are no benefits of the ZVS operation. However, the reverse recovery losses can be significantly reduced as compared with the same switching pattern of the rectification mode. The modified switching pattern does not affect the power conversion and control performances of the ac-dc rectifier.

#### IV. Consideration for Switching Losses in a rectification Mode

#### V LC-Filter

The LC-filter in Figure is a second order filter giving  $-40$  dB/decade attenuation. Since the previous L-filter achieves low attenuation of the inverter switching components, a series element might be needed to further attenuate the switching frequency components. This series component must be selected to produce low reactance at the switching frequency. Within the control frequency range, this element must present high magnitude impedance. A capacitor is used as the series element. At and above the switching frequency, this LC-filter is suited to configurations where the load impedance across C is relatively high. The cost and the reactive power consumption of the LC-filter are larger compared to the L-filter because of the addition of the shunt element. For the application of the grid-interactive power converters, the phase estimation of the supply voltage is required to control the entire power system; especially, the phase information of the supply voltage is mandatory to generate the current reference[7]. The phase estimation method requires robustness to noise and disturbance from grid, accuracy to the fundamental frequency variation and harmonic distortion, and easy implementation using analog or digital platforms. The SRF-PLL is one of the popular methods. It has a weak point of a frequency tracking performance. In the constant angular frequency of the fundamental component  $\omega s$  is used as a feedforward term for compensating the phase angle tracking[6]. It can cause a tracking error in the PLL operation when the fundamental frequency changes to the different value of the constant  $\omega s$ .



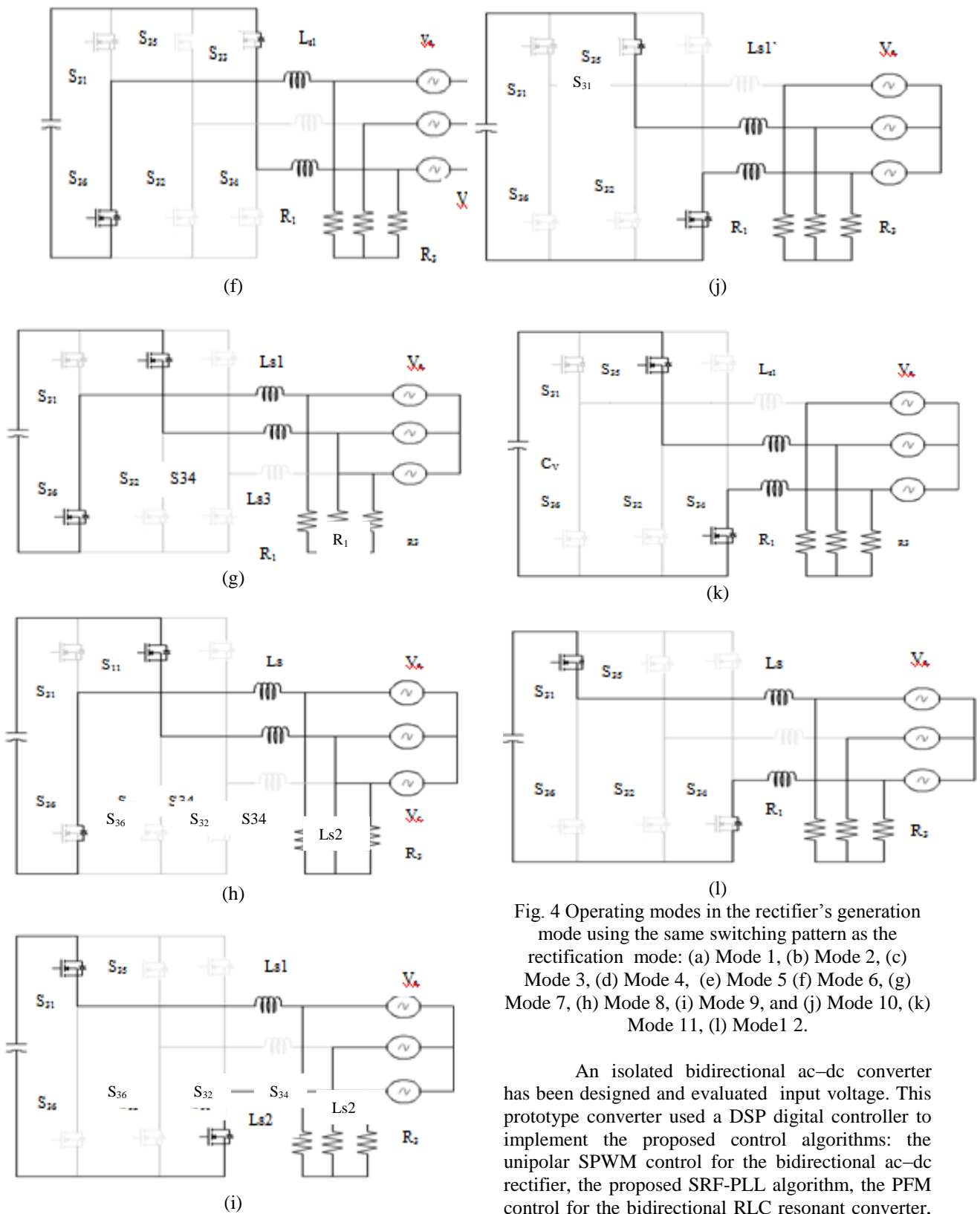


Fig. 4 Operating modes in the rectifier's generation mode using the same switching pattern as the rectification mode: (a) Mode 1, (b) Mode 2, (c) Mode 3, (d) Mode 4, (e) Mode 5 (f) Mode 6, (g) Mode 7, (h) Mode 8, (i) Mode 9, and (j) Mode 10, (k) Mode 11, (l) Mode 12.

An isolated bidirectional ac–dc converter has been designed and evaluated input voltage. This prototype converter used a DSP digital controller to implement the proposed control algorithms: the unipolar SPWM control for the bidirectional ac–dc rectifier, the proposed SRF-PLL algorithm, the PFM control for the bidirectional RLC resonant converter, and the dead-band and switch transition controls for the bidirectional power conversion. The switching frequency of the ac–dc rectifier and the dc–dc converter operates within the range. The magnetizing

inductance is selected as the prototype dc–dc converter which is the overload condition containing margin from the rated load . Shows the configuration of the prototype converter. As shown in the line voltage and current waveforms of the bidirectional ac–dc rectifier under the full-load condition are almost in phase.

Voltage (v) vs Time (msec) is shown in the fig. 6 Output from the scope are the same value of voltage. In the graph during the starting period the voltage and current gets linearly increase up to 0.4 msec after that which get constant. Finally the value of the voltage is 325 volts.

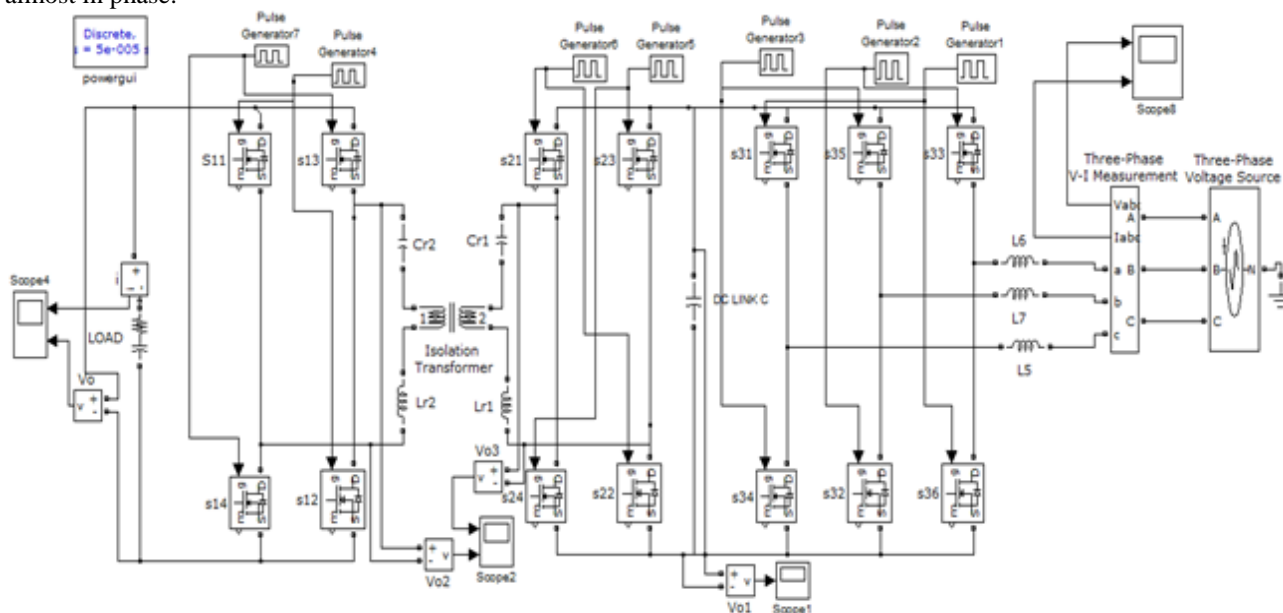


Fig. 5 Simulation Circuit for Proposed bi-directional converter

### V. Simulation and results

This paper involves simulation of basic power electronic circuits and the analysis of the current and voltage wave forms. It starts with complexity by

inclusion of new components and their subsequent effect on the current and voltage waveforms. We focus on the objective of improving the input current waveform . All the simulation work is done in Matlab simulink.

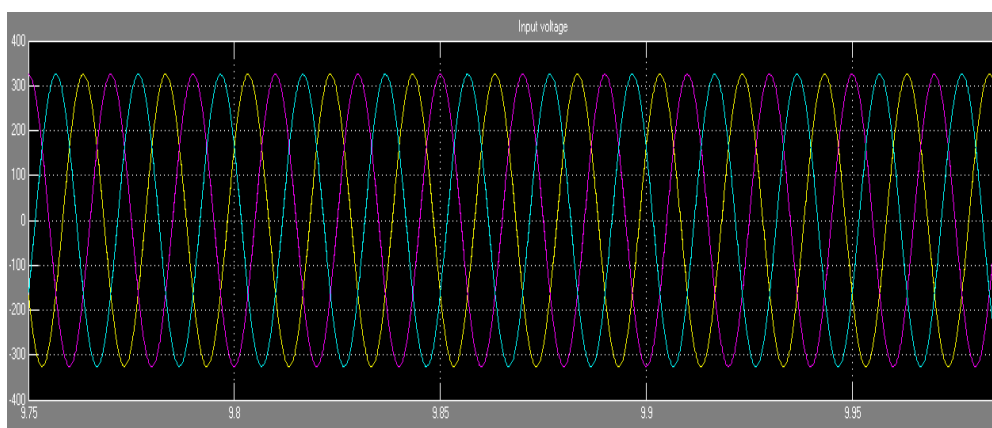


Fig. 6 Simulation for Three phase input Voltage to reverse Direction

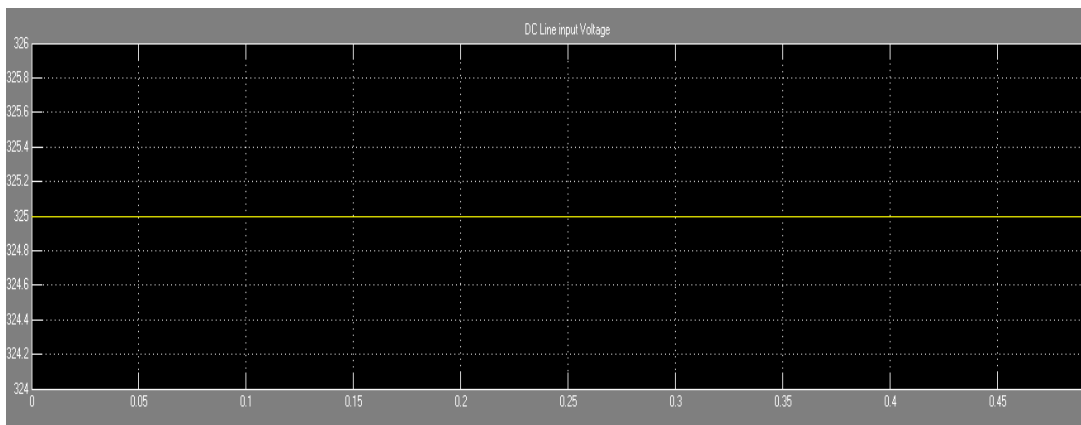


Fig. 7 Simulation for Dc Input Voltage for forward direction

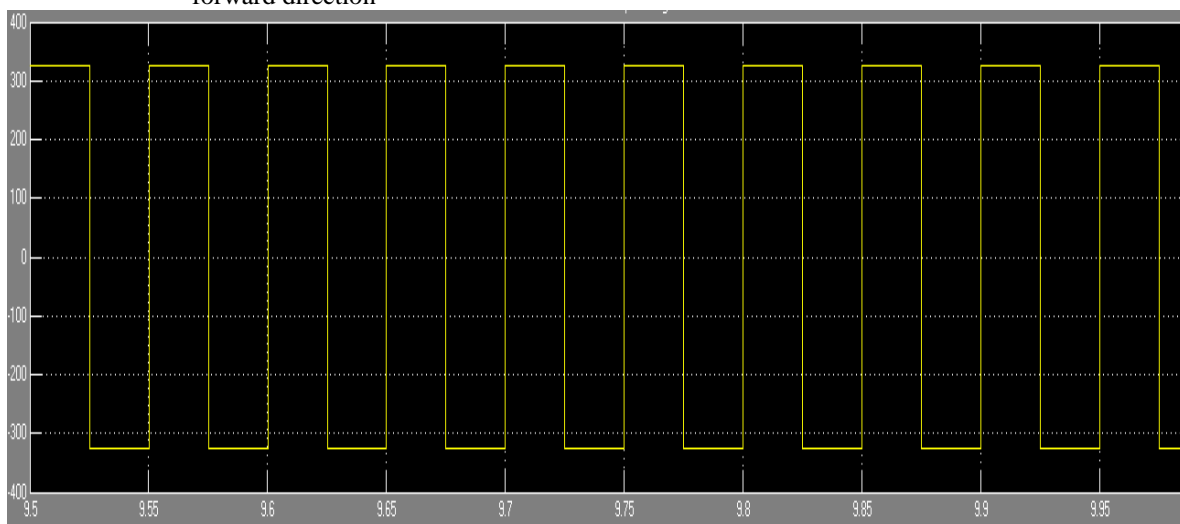


Fig. 8 Isolation transformer output voltage

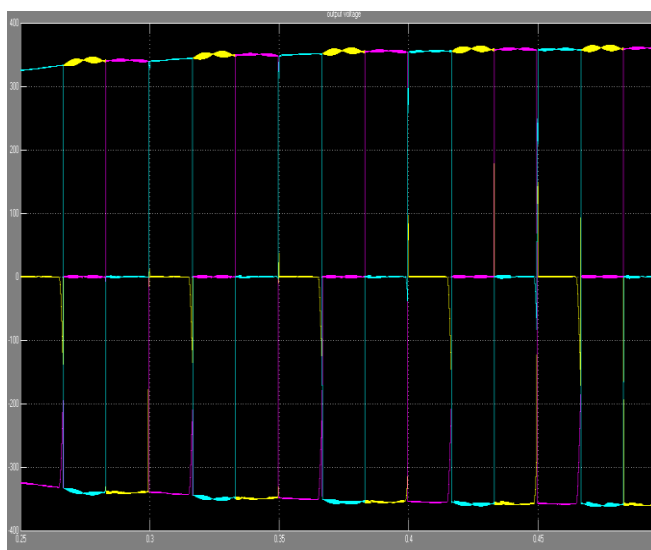


Fig. 9 Forward directional dc-ac converter three phase output voltage

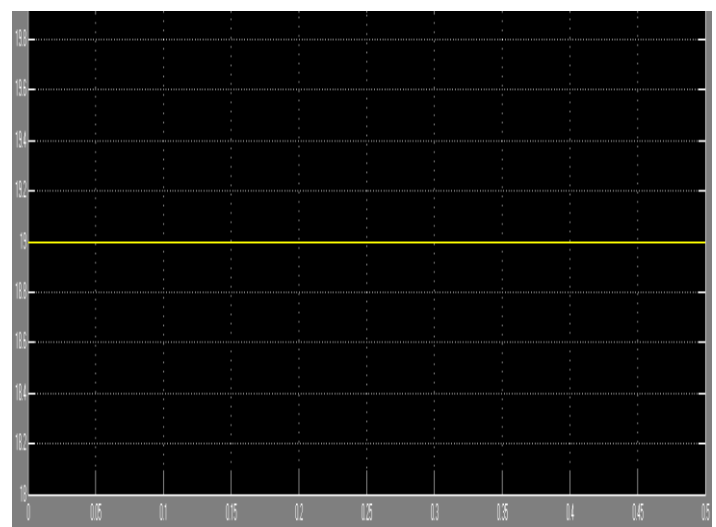


Fig.10 Reverse directional DC current waveform



Fig. 11 Reverse Directional DC voltage wave form

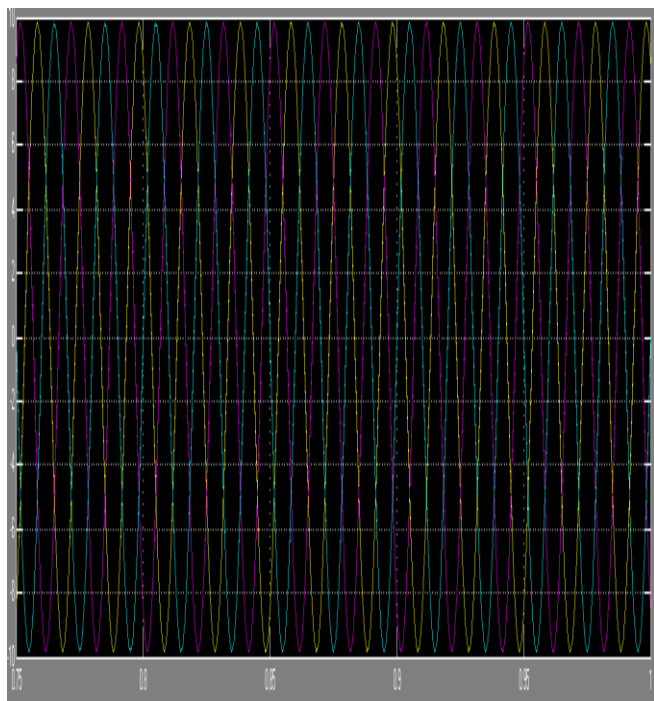


Fig. 12 Forward directional AC current waveform Result

The bidirectional converter simulation output above. Reverse direction Ac voltage input 325V Output voltage 325DC and Current 10A. Forward direction 325DC voltage output 9A Current and 325V output voltage get. We get power 3250W

## VI. Conclution

The proposed bidirectional converter get the high efficiency. LC Resonant converter used. . The bidirectional ac–dc converter is proposed for the dc power distribution system to control the bidirectional power flow and to improve its power conversion efficiency. In order to improve the reverse recovery problem, the high-side switches of the ac–dc rectifier employ MOSFET without antiparallel diodes and SiC diodes. In addition, the low-side switches are composed of two MOSFETs to reduce the conduction loss in the rectification mode. For comparison with the conventional MOSFETs switches, the total conduction losses of the rectifier's switches are calculated in the rectification mode. The simple and intuitive frequency detection method for the single-phase SRF-PLL is also proposed using the filter compensator, and FIR filter to improve the robustness and accuracy of the PLL performance under fundamental frequency variations. The proposed PLL system shows lower detection fluctuation and faster transient response than the conventional techniques. Finally, the proposed RLC resonant converter can operate under the ZVS for the primary switches and the soft commutation for the output rectifiers. The soft-switching condition of the converter is derived to obtain the design methodology of the resonant network. Gain properties are also analyzed to avoid gain reduction and nonmonotonic gain curve under high-load conditions.

## REFERENCE

- [1] Mishra, Olive Ray, Ravindranath Adda, Santana K. Member, IEEE, 'Synchronous-Reference-Frame-Based Control of Switched Boost Inverter for Standalone DC Nano grid Applications'. IEEE Transactinon on industry application, Power Electronics, vol. 28, no. 3, pp. 229–236. (2013)
- [2] Ching-ming Lai, Yi-Hung Liao, Member, IEEE, 'Newly-Constructed simplified single-phase multistring multilevel inverter topology for distributed energy resources'. IEEE Transactinon on industry application, Power Electronics, vol.2653, no. 9, pp.500–510, (2011).
- [3] Andrew J.R.T, Forsyth, Naayagi, and R.Shuttleworth, Member; IEEE, 'High power bidirectional Dc-Dc converter for Aerospace Applications' IEEE Transactinon on industry application, Power Electronics, vol. 27, no. 11 (2012)..
- [4] Jiann-Fuh chen, Lung-sheng Yang, Shih-Ming Chen, Tssornng-Juu Liang, Member, IEEE. 'A Safety enhanced, high step up dc dc converter for ac photovoltaic module



- Application'. IEEE Transactinon on industry application, Power Electronics , vol. 27 (2012).
- [5] Hsieh Y.-C, Hsueh T.-C, and Yen H.-C. 'An interleaved boost converter with zero-voltage transition'. IEEE Transactinon on industry application, Power Electronics, vol. 24, no.pp. 973–978 (2009).
- [6] Bingsen Wang, Bush Craig R. Senior Member, ' A Single-Phase Current Source Solar Inverter with Reduced-Size DC Link'. (2009).
- [7] Friedli.T, Minibock.J, Kolar.J and Stupar.A, 'Towards a 99% efficient three-phase buck-type PFC rectifier for 400-V dc distribution systems' IEEE Transactinon on industry application, Power Electronics, vol. 27, no. 4, pp. 1732–1744 (2012).
- [8] Chang C.H, Kuo C.-L., Sun K.-H., Wu T.-F. , 'Predictive current controlled 5-kW single-phase bidirectional inverter with wide nductance variation for dc-microgrid applications' IEEE Transactinon on industry application, Power Electronics, vol. 25, no. 12, pp. 3076–3084 (2010).
- [9] Boroyevich .D, Burgos .R, Thacker .T, Wang .F, 'Phase-locked loop noise reduction via phase detector implementation for single-phase systems'. IEEE Transactinon on industry application, Power Electronics, vol. 58, no. 6, pp. 2482–2490 (2011)..
- [10] Chang Y.R, Lin C.Y, Wai R.J, 'High step-up bidirectional isolated converter with two input power sources'. vol. 56, no. 7, pp. 2629–2643 (2009)..
- [11] Caisheng Wang, and Hashem Nehrir .M, Senior Member, 'Power Management of a Stand-Alone Wind/Photovoltaic/Fuel Cell Energy System' IEEE Transactions on energy conversion, vol. 23, no. 3 (2008).
- [12] Alfio Consoli, Mario Cacciato, Vittorio Fellow IEEE, 'A New Resonant Active Clamping Technique for Bi-directional Converters in HEVs'. IEEE Transactions on energy conversion, vol. 47, no.7 (2007).