VSC based Bidirectional Converter for Microgrid Using Flyback Converter Topology

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Abstract- This Paper proposes a scheme of a single phase bidirectional voltage source converter (VSC) for Microgrid .The system consist of both AC and DC grid, the bidirectional flow of power depends on the availability of source. Whenever there is a need in AC grid the bidirectional VSC acts as an inverter as the DC source is available and if there is a requirement in DC grid it acts as a rectifier. These both modes of operation had performed with the help of flyback converter topology. The proposed topology is based on the integration of two Flyback converters, one for each half-cycle of the grid voltage, avoiding the usual diode bridge rectifier, thus providing a bidirectional power flow. Simulation studies and hardware setup are validated through experimental results presented to verify the operation of the converter.

Keywords: ***Bidirectional VSC, Flyback Converter, Diode bridge rectifier.***

I. INTRODUCTION

For Electric Grid, Distributed energy resources (DERs) are one changing the way of power generation and transmission. A microgrid is a small scale supply network with different generations and loads which formed with its Distributed power system. To the Grid DERs, the smaller power sources serve individually or combinely, have lead the way for a bidirectional flow of energy and permitted the alliance of new, hook up technologies for power generation. And For Efficient power transmission the integration of renewable energy sources with power electronics it's the more useful way. The rapid development in power-electronics technology, the larger adoption and improvement of renewable energy sources, and cost reduction of energy storage systems, have been proposed for large-scale power integration.

On the basis of previous published work the bidirectional flow of power had be done in various controlled strategies with algorithms. Due to the lengthy algorithms the system gets more complicated. Mostly, in previous bidirectional power flow configuration a heavy DC link capacitor in order to reduce second order ripple current. During filtration process it results into a low power density due to the low frequency ripple voltages also requires large space. The main objective during the bidirectional flow should match the power factor of both the grids, AC as well as DC. The DC Grid must have to achieve the power factor in accordance with AC and the transformation of power with minimum distortions. The design of converter will help to achieve those objectives. The efficient way to transfer the two way power is to make the operation of AC-DC/DC-AC converter flexible with a proper controlled scheme.

The objective of this paper is to match voltage and current level of both the grids when the different loads are integrated with the system. Flexible transmission of power in AC and DC grid with a proper battery backup protection so the converter will performed the inverter as well as rectifier operation properly. For this we design the voltage source converter (VSC) mechanism for microgrid.The operation of VSC is based on the flyback converter topology, which performed both the functions and controlled by microcontroller. So, there will be two operation modes: on one hand, During sun hours when the PV cell is on full generation mode and will generate excess of power, so the converter will act as an inverter, injecting in the AC grid, at the same time the PV panel charges the battery and also drive the DC loads. On the other hand, during the absence of sunlight, it will behave as a rectifier in order to supply the DC grid. The proposed topology is based on the integration of two Flyback converters, one for each half cycle of the grid voltage, avoiding the usual diode bridge rectifier, thus providing a bidirectional power flow.

So, these modes of operation is fully depends on signal given by the controller. There are many mechanisms to control the bidirectional flow of power such as PI controller, but the fact is the system gets more complicated with its controllers and comparators. In this, a mode of operation will performed by a single controller and the comparision is done by op-amp with relay mechanism. Detailed simulation studies are accomplish through PV as renewable energy source and Flyback converter topology is used for flexible two way power transmission. The proposed control scheme with bidirectional flow of power through VSC is validated through simulation studies and verified through hardware results.

I. FLYBACK CONVERTER

A. Working Principle

Flyback converters are largely used in renewable energy systems, as well as in low power lighting applications. This converter provides voltaic insulation having simpler structure, cheaper cost and high efficiency. Figure 1 shows the proposed topology of the bidirectional Flyback converter.

The proposed topology is originated by the combination of two Flyback converters that work uniformly, one in each half-cycle of the grid voltage. Hence, this allowing a bidirectional energy flow for the proper system operation avoids diode bridge rectifier. The both operating mode of the converter works in Discontinuous Conduction Mode (DCM).

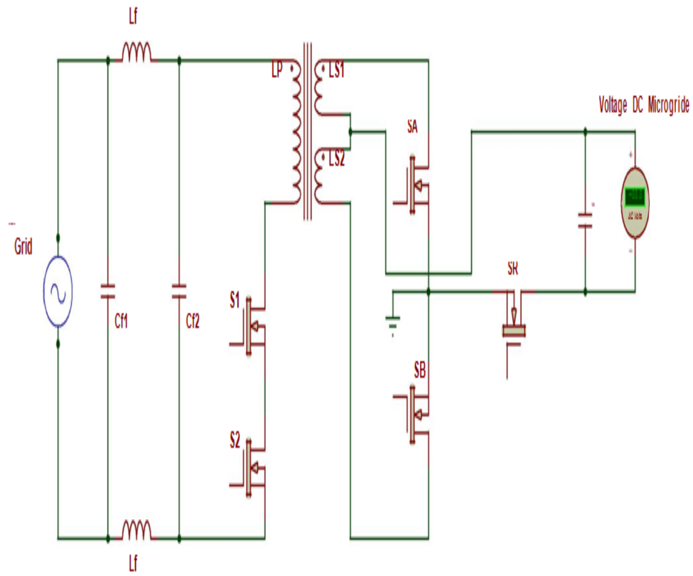

Figure 1. Circuit of Bidirectional flyback converter

B. Switching Mode of Flyback Converter

As the flyback converter consist of five switches on both the sides AC as well as DC which named as S1, S2 are connected at AC grid side and SA,SB are at DC grid side where SR is just for reference switch. Thus, the switch S1 and S2 gets turn on when the VSC will perform inverter operation and SA and SB will be during rectifier operation. The Figure 2 and Figure 3 show the main waveforms with the Switching driving signals of the bidirectional converter. During observation, for both, Inverter and Rectifier mode of operation the synchronization of both the grids is necessary. Thus it must be synchronize with the grid voltage, which is performed by a zero cross detector.

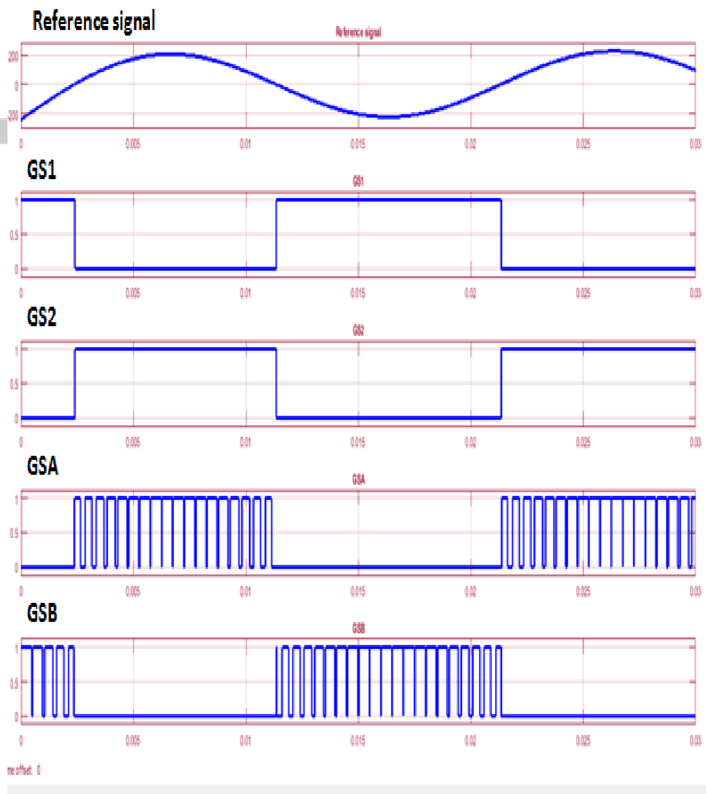

Figure 2. Rectifier switching mode

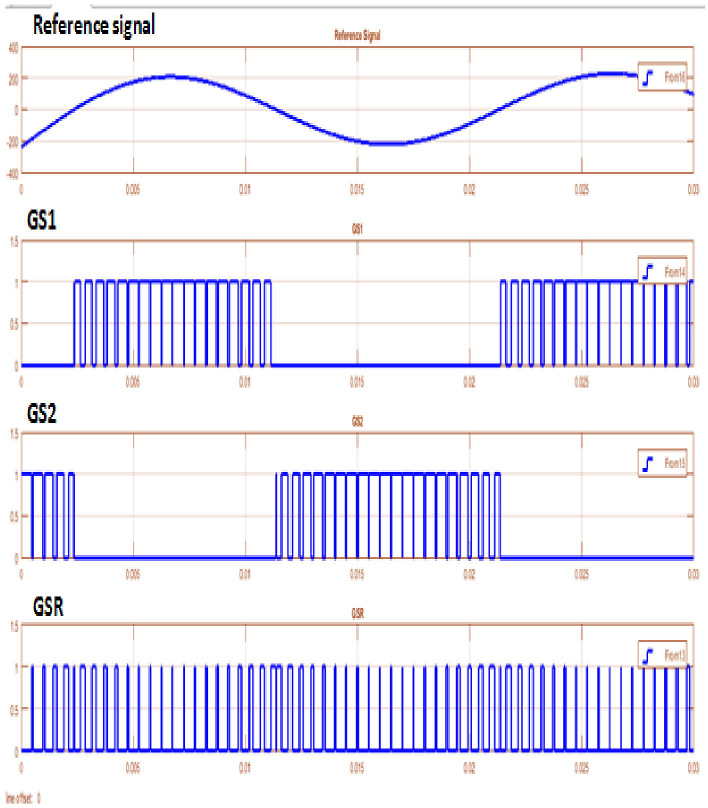

Figure 3. Inverter switching mode

III. CONTROL STRATEGY

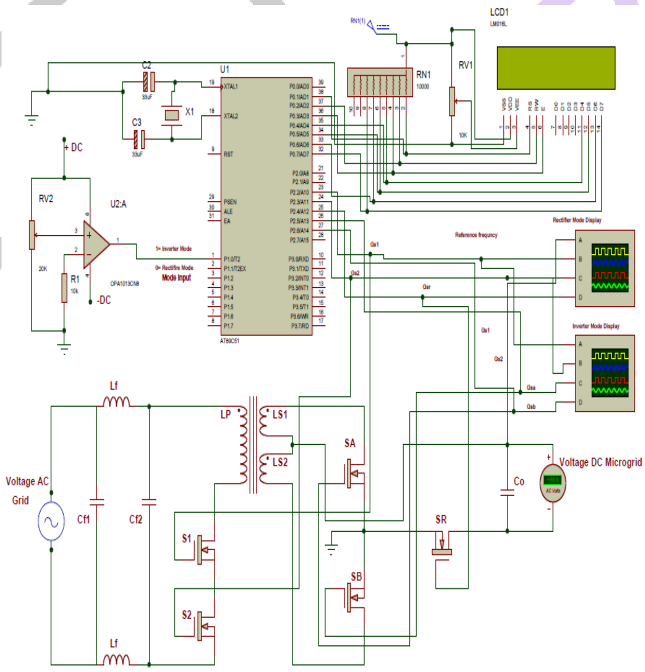

Figure 3. Mode Control and Gate Pulse system through Microcontroller 89C51

The Control Strategy for Bidirectional VSC is done through the Microcontroller 89C51 as shown in figure 3 .It also giving the gate pulses to the transistors according to the both inverter and rectifier mode of operation. At starting stage when the PV cell takes time and battery needs to charge hence the current rating at DC grid side is low as compared to AC then the comparator will compare and gives signal to the µC at port P1.0. Therefore the port goes to low i.e. P1.0=0 so the transistors switch for inverter mode and the switch SA and SB will b turn ON. Similarly, when DC gets fully charge and the PV generates excess of power then the current rating is greater than AC, thus its go with comparison and the port goes to high i.e. P1.0=1 and the transistors switch to Rectifier mode hence the S1 and S2 will gets turn ON.

The whole programming is done in embedded with the help of Keil CX51 C Compiler. The voltage and current output waveforms of bidirectional VSC are referred with the strategy as shown in figure 4.

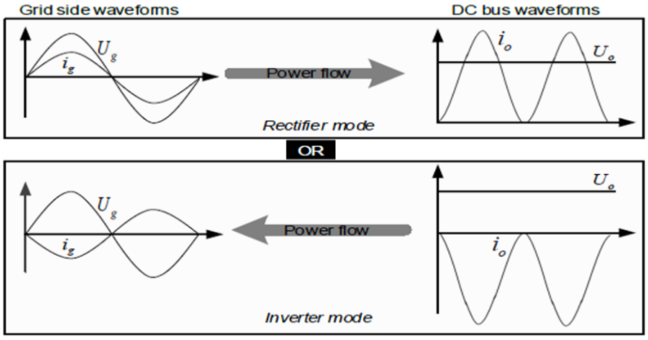

Figure 4. Bidirectional VSC Operation

IV. PROPOSED HARDWARE WORK

The Hardware implementation of Bidirectional VSC is as shown in figure 5.The Microgrid is working with the 48V.It consist of a four batteries each of 12V are connected in series which is for backup protection. At DC grid side PV cell is connected which charges the battery and also drive the DC load. Diode is connected between the solar panel and DC grid so that the power cannot flow in reverse direction.

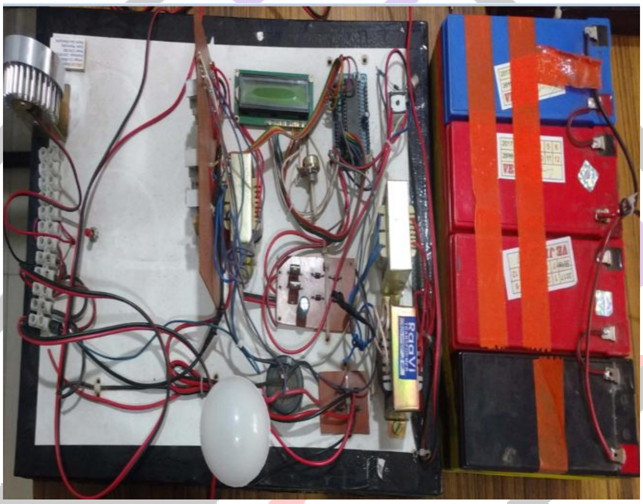
Figure 5. Hardware Model

A] Rectifier Circuit: It consists of two transformers, one is a step down transformer which is connected to the power supply and another is a control transformer. After step down transformer there is a rectifier circuit and a capacitor to filter.
Another rectifier circuit which consists of two regular ICs provides power circuit to the control circuit.

B] Control Circuit & Flyback Converter: The control circuit of bidirectional VSC consists of operational amplifier which is used as a comparator and a microcontroller 89C51.
The flyback converter consists of five FETs.The gate pulse to these five switches are given by µC and a diode is connected between them for isolation purpose of microcontroller. The control strategy of op-amp and µC is discussed in section III.

IV. HARDWARE RESULTS

The results of above Hardware model of Bidirectional VSC experimental results are shown below in waveforms.

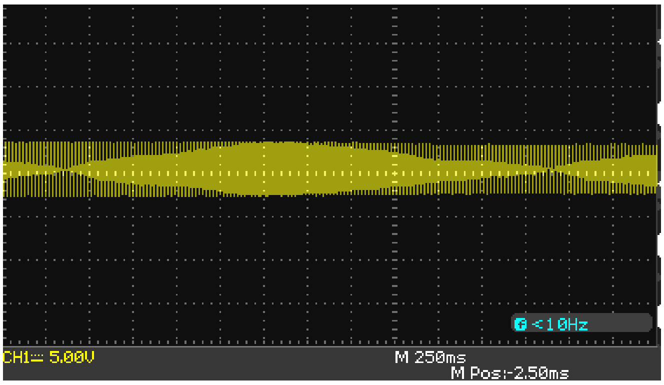

Figure 5a. Rectifier Operation across DC load

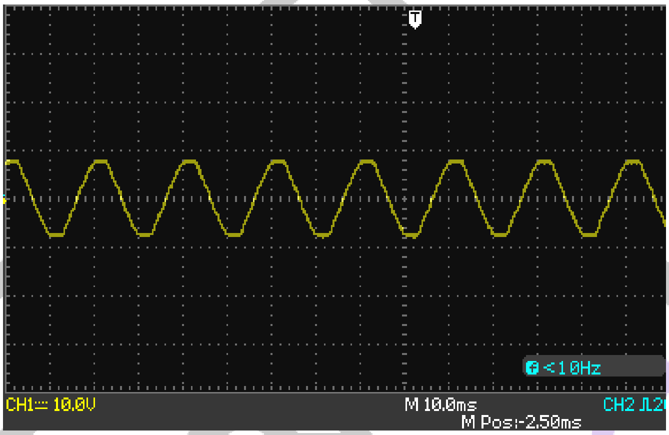

Figure 5b. Rectifier Operation across AC load

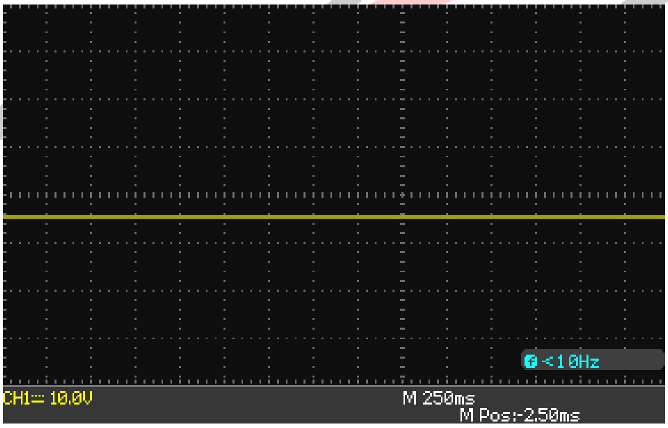

Figure 5c. Inverter Operation across DC load

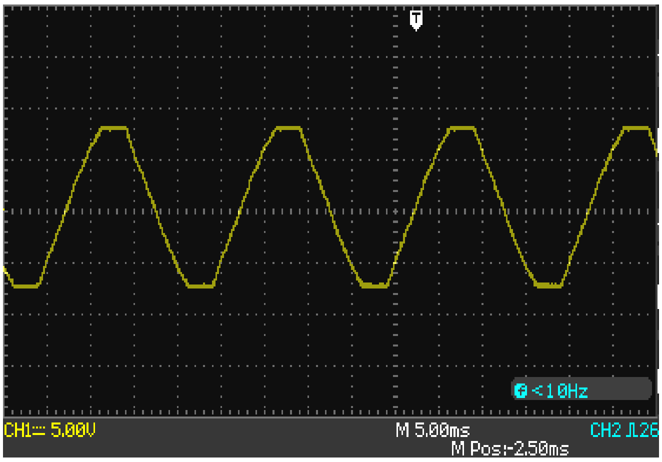

Figure 5d. Inverter Operation across AC load

From the experimental results of Bidirectional VSC, the two cases are investigated.
1) Case I: DC and AC load demand at microgrid when DC Power is less.
2) Case II: DC and AC load demand at microgrid when DC Power is greater.

V. CONCLUSION

In this Paper, a bidirectional VSC is designed for microgrid with the help of flyback converter topology through simple controlled strategy with the help of microcontroller. As the VSC is performed inverter and rectifier operation instantly whenever there is a change in the current rating at DC grid or AC grid. The operations of converters are more flexible with changeover at both sides. And the topology which is using is more efficient way to transfer two way power and compatible than the other lengthy algorithms.

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