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GRID CONNECTED MI CRO INVERTER FOR LOW VOLTAGE INTERFACE WITH ENERGY BUFFER

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Abstract

Solar photovoltaic (PV) panels having low-voltage is buffered in micro-inverter to connect with single-phase grid. It twice-line-frequency variations between the energy sourced by the PV panel and that required for the grid. A multilevel energy buffer and voltage modulator (MEB) that significantly reduces the range of voltage conversion ratios that the dc–ac converter portion of the microinverter must operate over by stepping its effective input voltage in pace with the line voltage. A prototype microinverter incorporating an MEB, designed for 12 to 138 V dc input voltage, 230-V rms ac output voltage, and rated for a line cycle average power of 20 W, has been built and tested in a grid-connected mode. It is shown that the MEB can successfully enhance the performance of a single-phase grid-interfaced microinverter by increasing its efficiency and reducing the total size of the twice-line-frequency energy buffering capacitance.

INTRODUCTION

increased consumption and abundancy of the conventional energy source , There is a increase in the usage of non conventional energy. Lot of researches are made by the researchers for efficient utilization of this conventional energy. Photovoltaic(PV) modules are one of that inventions that effectively uses the solar energy in which sun power is changed to direct current power using semiconductor materials. PV panels are used to operate the microinverters connected into single phase grid. In electric grid interconnection huge solar photovoltaic installations and multiple PV panels are connected through high power single inverter. Inverter have extreme importance in any solar oriented system in which they converts the DC electricity produced by the solar panel into AC electricity applicable to our requirement. PV microinverter are more effective and attractive way of installation in smaller residential and commercial application. The use of microinverter also allow us to monitor the production of power in each and individual panel. Microinverter converts DC electricity to AC electricity without use of separate central inverter .It has become more popular in residential solar system even though it is more expensive inverter option but nowadays it is used widely so it is expected that their cost will come down. The use of microinveter in grid interconnection reduces the power losses and increases the efficiency since the main grid is connected each panel directly. This makes easier expansion of earlier system since the microinverter modules can be added to existing system and without any special arrangement. Microinverter have some challenges like twice line frequency energy has to be buffered, Its wide operating voltage and power ranges. Cascaded power stages are used sometimes to decrease the operating ranges of the high frequency part of the system .Many techniques have been used to maintain the twice line frequency energy like employing the energy buffer in the inverter system but all this techniques is not suitable for single module microinverter system. Fig. 1 Architecture of a microinverter incorporating a twice-line-frequency energy buffer capacitance One of the microinverter architecture is shown in the Fig 1 which consists of a high frequency resonant inverter, a high frequency transformer and a cycloconverter. The resonant inverter operates such that it gives a high frequency resonant current with its amplitude modulated at the line frequency. The high frequency transformer is used to step up the voltage and it is converted to sinusoidal current by the cycloconverter.

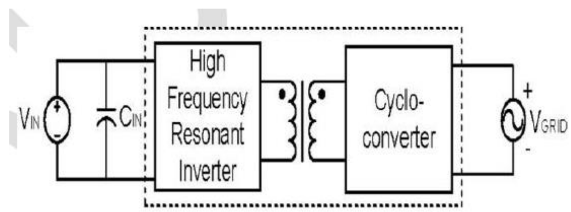

Fig. 1 Architecture of a microinverter incorporating a twice-line-frequency energy buffer capacitance

This paper introduce a new architecture which shares the advantages of both cascade converter structure topology and switched capacitor energy buffer .This architecture include Multilevel energy buffer(MEB) and voltage modulator.MEB include switched capacitor energy buffer(SCEB) and optional charge control circuit (CCC) which is connected between input capacitor and dc-ac converter block.

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PROPOSED MEB MICROINVERTER

The architecture of proposed system is shown in the Fig.2 Fig 2

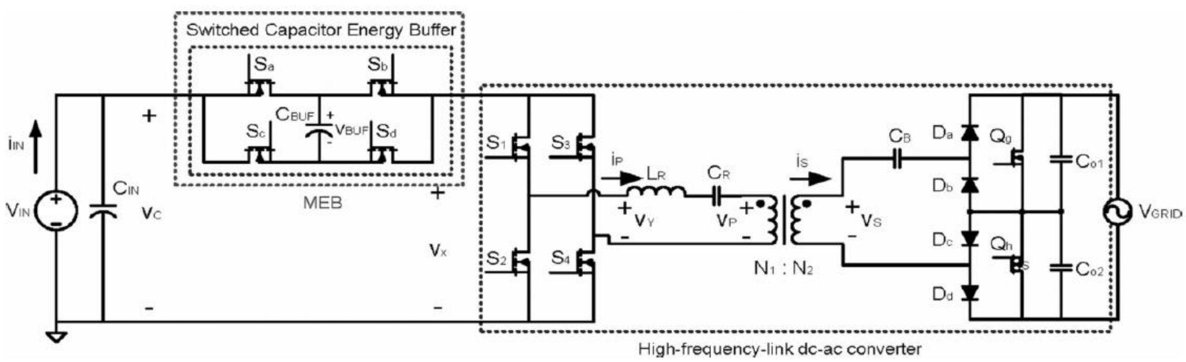


Fig. 1.1(a) Schematic of a simplified MEB microinverter without the CCC.

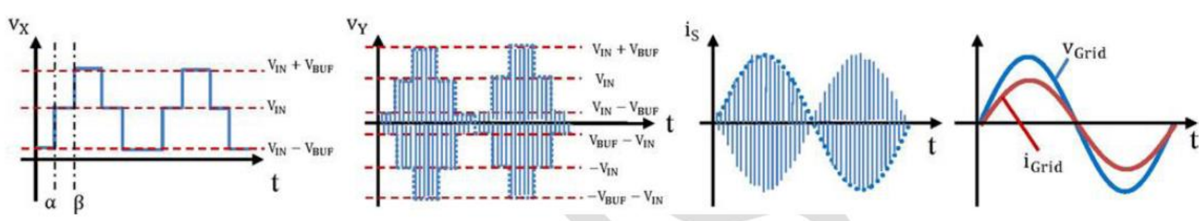


Fig. 1.1(a) Schematic of a simplified MEB microinverter without the CCC.

Fig.1.1(b) Conceptual operating waveform of multilevel voltage of MEB stage ,high frequency voltage created by H-bridge and line voltage and current

Architecture of proposed MEB system. The Multilevel energy buffer is connected in between the input capacitor and a dc-ac converter block. The MEB consists of two subunits which is switched capacitor energy buffer(SCEB) and an optional charge control circuit(CCC). The SCEB provides modulation to the input voltage Vx which in turn gives the variations in the voltage conversion ratio of the high frequency dc-ac converter block. It also separates the

energy buffer from the input voltage and hence reduces the energy storage requirement which function as active energy buffer. Switches in the SCEB operates at the low multiples of the line frequency which increase the efficiency of MEB and SCEB also boost the primary voltage of the transformer and hence reduces the primary current which in turn increase the efficiency by decrease the losses. In order to balance the charge entering and leaving the SCEB charge control circuit is introduced and it is a optional method of control. CCC provide the greater flexibility to SCEB and it operate only over a part of line cycle so it does not provide the any significant effect to overall power system efficiency.

III. OPERATING PRINCIPLE of PROPOSED MEB MICROINVETER. The proposed system is more broadly applicable to converter interfaced between low voltage dc and single phase ac grid. Schematic of MEB microinverter without CCC control is shown the Fig.3 The power path of this architecture is followed by two stages: a. MEB stage b. dc -ac converter stage.

A. MEB stage.

MEB stage consists of two subsystem SCEB and CCC to avoid circuit complexity we are not considering CCC. The SCEB consists of four switches which is connected as a full bridge and a buffer capacitor CBUF. Input voltage of dc-ac converter Vx is generated by switching actions of SCEB circuit at line angles α, β, (1800 − β), and (180*0* − α) They are three modes of MEB operation 1. step down mode 2. Bypass mode 3. Step up.

1) *Step down mode*: when the magnitude of line voltage is low i.e when the line angle in the range of 0 to α and (180*0* – α) to 1800. The SCEB operates in the step down with Sa and Sb in the on condition and Sb and Sc is in off condition and the output of MEB will be Vin-VBUF *Bypass mode*: When the magnitude of line voltage is high i.e when the line angle in range from α to β and (1800 – β) to (1800 – α). The SCEB operates in the stepdown mode with Sa and Sd in the on condition and Sc and Sd in the off condition and the output of MEB will be Vin. The current flow this mode is shown in the Fig.

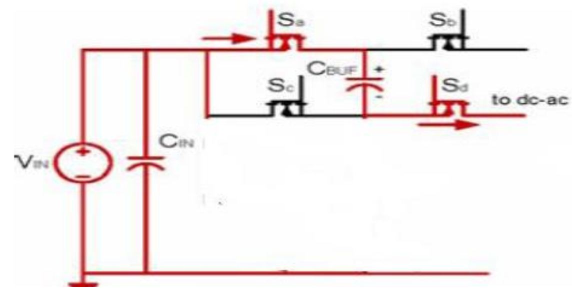


Fig. 5 Current flow directions in the MEB during Step-down mode of operation.

Step up mode: Sb and Sc will on and Sa and Sd will be off and the output voltage of MEB will be Vin+VBUF .The current flow of is mode is shown in the Fig. 7 In this manner SCEB will operating and modulate Vx in pace with the line voltage which significantly reduces the voltage conversion ratio for high frequency converter. Each switch changes its state twice on every haft cycle which lead to decrease of switching losses of SCEB.

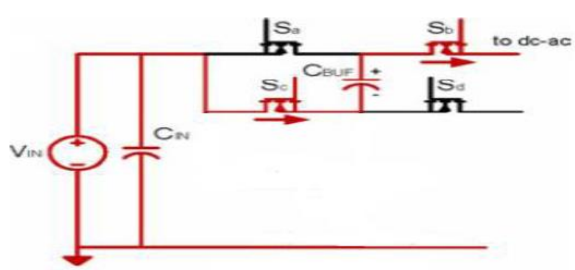
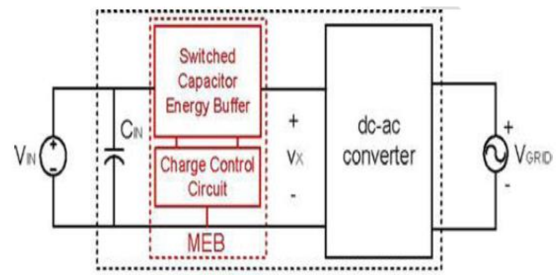


Fig. 7 Current flow directions in the MEB during step-up mode of operation.

Fig 2 Architecture of proposed MEB system.

In each half cycle all the three modes of



operation repeats periodically. It can be observed in Fig. 4 at zero crossing of the line voltage is not specified. To achieve perfect power factor the current needs to approach zero in continuous manner but it not possible practically in the continuous modulation of converter so a dead angle δ of some angle is introduced before and after the zero crossing of the line in which microinverter is shut off during this stage and no current is injected into grid. In this paper δ is selected as 60 and the optimal value of VBUF is 0.6 Vin, α is 12.80, β *is* 40.90 is selected to minimize the operating range of a line synchronized sinusoidal voltage is obtained by this control parameter. During the steady state buffer capacitor CBUF is charged when the line voltage is low and is discharged when the line voltage is high and VBUF is precharged to 0.6 Vin before the system enters to periodic steady state. Higher dc-ac converter efficiency is achieved by line synchronized multilevel voltage Vx which significantly reduces the required voltage conversion range. The MEB needs to be more efficient to achieve the overall system efficiency so switches in MEB is switched at the multiples of line frequency. Low on resistance semiconductor devices are used to reduce the conduction losses. In many microinverter topologies capacitor is placed across the PV panel to buffer the twice line frequency energy which makes large size of energy buffering capacitor which turn to maximum voltage ripple across the PV panel. In this MEB method CBUF absorbs energy when SCEB is in step down and bypass mode i.e when the grid is supplied by the high power. In this manner CBUF acts as a storage element of an active energy buffer and replaces the bulk input capacitor. The charge balance of CBUF is achieved by controlling the switching angle α, β, δ and

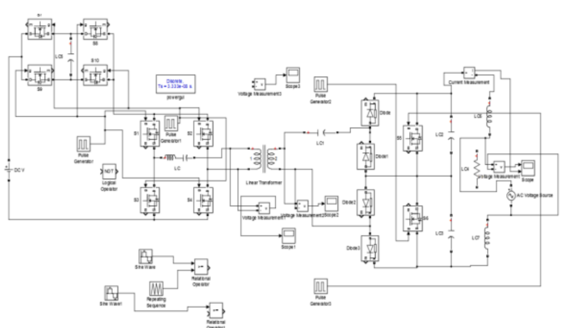


Fig.10 Simulation circuit of proposed system

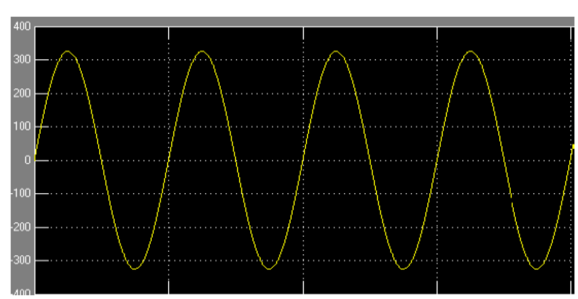
average current of CBUF is maintained zero over the line cycle. Assuming the dc-ac converter draws the sinusoidal input current

Design of the dc-ac converter stage.

High frequency series resonant link dc-ac converter is selected for this architecture. Because of the use of MEB technique transformer turns ratio and operating range is reduced and also it increases the input voltage of the dc-ac converter over a portion of line cycle which led decreases in the peak voltage stress of the switches than without MEB installation

IV. SIMULATION RESULT

The operation of different modes is learned by above its equivalent circuit model. We have get simulation results by Simulink model and microinverter parameters are give in below table 1. We have get simulation results by



Simulink model. Gird voltage and grid current are shown in the Fig.8 and Fig. 9 respectively.

V. CONCLUSION

This paper introduce a MEB stage for grid interfaced microinverter. This technique is used to achieve higher efficiency by significantly reducing the voltage conversion ratio. The converter stage of this architecture is operating by stepping its input voltage in pace with line voltage. MEB also functions as active energy buffer and reduces the volume of the twice line frequency energy buffering capacitor and hence reduces the overall size of the system. The designed architecture will be operating with 38V dc input voltage and gives the 230Vrms ac output. This architecture can widely used in converter interfaced between low voltage dc and single phase ac grid.

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