A NOVEL POWER CONDITIONING UNIT FOR GRID CONNECTED WIND POWER SYSTEMS

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Abstract— Utilization of wind power as renewable resources of energy has been growing rapidly around the world in the last decades. Wind power generation is fluctuating due to the variation of the wind speed. Therefore, the assessment of the output power of this type of generators is always associated with some amount of uncertainties. The output voltage and frequency from the ac generator varies with wind speed. The main disadvantage of the variable speed wind turbines is the presence of bulky gear box systems and step-up transformers. To overcome this disadvantage a phase shifted semi-bridgeless boost converter with a Dual carrier multi-level inverter is used. The proposed one is analyzed in detail using Simulink model in MATLAB. The entire control section of the circuit is realized using PIC microcontroller. The system proposed is reliable, economical and convenient to use and has been validated using simulation results and experimental work.

Index Terms— Phase shifted semi-bridgeless boost converter, Dual carrier multi level inverter, Renewable energy.

I. INTRODUCTION

Due to deterioration of fossil fuel and policies on greenhouse gas mitigation, wind energy systems (WESs) has gained traction as one of the most promising renewable energy systems for electric power generation during the past years [1-2]. Extracting maximum power from wind and feeding the grid with high quality electricity are two main objectives for wind energy conversion systems (WECSs) [3]. Power electronics provides the feasibility of these objectives for

WESs [4] since they can perform active and reactive power control, injecting the high quality power into grid, as well as make the variable speed operation of wind turbine possible.

In the variable-speed generation system, the wind turbine can be operated at the maximum power operating point (MPP) for various wind velocities by adjusting the generator speed optimally [5], [6]. Variable-speed wind energy conversion systems (VSWECSs) can be implemented with doubly fed induction generators (DFIGs), squirrel cage induction generators (SCIGs) , or PMSGs [2]. In the variable speed generation system, the wind turbine can be operated at the maximum power operating point (MPP) for various wind velocities by adjusting the generator speed optimally [5], [6]. Variable-speed wind energy conversion systems (VSWECSs) can be implemented with doubly fed induction generators (DFIGs), squirrel cage induction generators (SCIGs) , or PMSGs [2].

Among electrical generators, PMSGs are favored in WECSs due to their advantages such as higher efficiency, high power density, reasonable price, and possibility of smaller turbine diameter in direct drive applications [7]. To analyze and improve the performance the converter feature, high efficiency at light loads and low lines for wind power systems. Variable speed operation of ac machines has become increasingly frequent in motor applications during the last decade. The reasons for this are several, e.g.reduction of energy consumption, new power electronics technology and application in new industrial processes. Generator applications of ac machines, have until some years ago, been restricted to essentially constant speed operation. However,with the increased interest in small-scale energy resources, variable speed operation of generators becoming very important. This can be done mainly using Gear box systems and step-up transformers. Main disadvantages of this system is speed is controllable up to a limited range, Installation cost is high,maintanace cost is also high and the presence of gearbox system and step-up transformer makes the system bulky , costly.

II. CONFIGURATION OF PROPOSED NINE LEVEL INVERTER

Here the proposed topology consists of wind turbine, ac generator, phase shifted semi-bridgeless boost converter, and a multilevel inverter. The output voltage and frequency from the ac generator varies with wind speed.

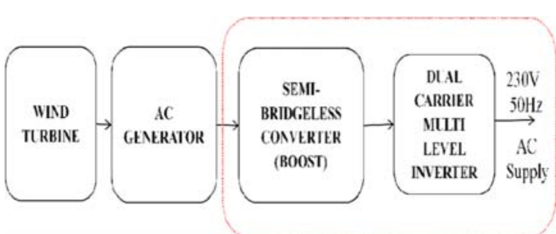

Fig.1. Proposed Power Conditioning Unit

Here the phase-shifted semi-bridgeless boost converter converts it into 230V dc voltage. By means of using a multi level inverter it converts into a 230V ac voltage.

This topology features high efficiency at light loads and low lines, which is critical to minimize the converter size, charging time and the amount and cost of electricity drawn from the utility; the component count, which reduces the cost; and reduced EMI. The proposed topology introduces two more slow diodes D_a and D_b to the bridgeless configuration to link the ground to the input line. However, the current does not always return through these diodes, so their associated conduction losses are low. This occurs since the inductors exhibit low impedance at the line frequency, a large portion of the current flows through the FET intrinsic body diodes. Also the gating signals for FETs are 180^0 out of phase.

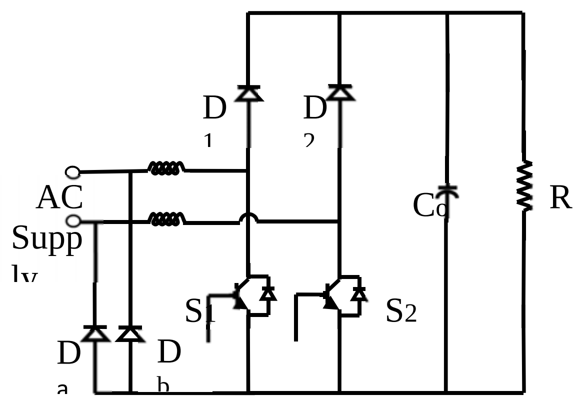

Fig.2.Phase Shifted Semi-bridgeless Boost Converter[2]

During the positive half-cycle, when the AC input voltage is positive, S1 turns on and current flows through L1 and S1 and continues through S2 and then L2, returning to the line while storing energy in L1 and L2. When S1 turns off, energy stored in L1 and L2 is released as current flows through D1, through the load and returns through the body diode of S2/partially through Db back to the input. During the negative half-cycle, when the AC input voltage is negative, S2 turns on and current flows through L2 and S2 and continues through S1 and then L1, returning to the line while storing energy in L2 and L1. When S2 turns off, energy stored in L2 and L1 is released as current flows through D2, through the load and returns split between the body diode of S1 and Da back to the input.

II. DUAL CARRIER MULTI-LEVEL INVERTER

The basic operational principle of five level cascaded multilevel inverter is to generate a five level output voltage i.e zero, +0.5Vs,+Vs,-0.5Vs and –Vs, where Vs is the supply voltage. The auxiliary circuit which consists of four diodes and switch Q1 is used between the DC-bus capacitor and the full bridge inverter. By proper switching of the auxiliary circuit can generate half level of the supply voltage i.e. zero, +0.5Vs, Vs,-0.5Vs and –Vs.

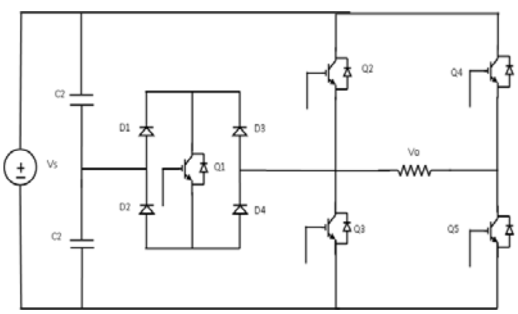

Fig.3. Dual Carrier Multi-level Inveretr[4]

The circuit operation is explained as follows: The switches Q1 ,Q2 and Q3 will be switching at the rate of the carrier signal frequency while Q4 and Q5 will operate at a frequency equivalent to the fundamental frequency.

Table.1.Switching Sequence of Dual Carrier Multi-level Inverter[4]

Q1	Q2	Q3	Q4	Q5	VO
ON	OFF	OFF	OFF	ON	+Vs/2
OFF	ON	OFF	OFF	ON	+Vs
OFF	OFF	OFF	ON	ON	0
ON	OFF	OFF	ON	OFF	-Vs/2
OFF	OFF	ON	ON	OFF	-Vs

The circuit operation is divided into four modes:

Mode 1: Q2 is in ON state, connects the load positive terminal to Vs, and Q5 is in ON state, connects the load negative terminal to ground. The other switches are OFF thus the applied voltage to the load terminals is Vs.

Mode 2: The auxiliary switch, Q1 and Q5 is ON and the other controlled switches are OFF; the voltage applied to the load terminals is +.5Vs.

Mode 3: The two main switches Q3 and Q5 are ON, short-circuiting the load. All other controlled switches are OFF; the voltage applied to the load terminals is zero.

Mode 4: The auxiliary switch, Q1 is ON and Q4 is ON and the other controlled switches are OFF; the voltage applied to the load terminals is -.5Vs

Mode 5:Q4 is ON and Q3 is ON and the other controlled switches are OFF; the voltage applied to the load terminals is - Vs

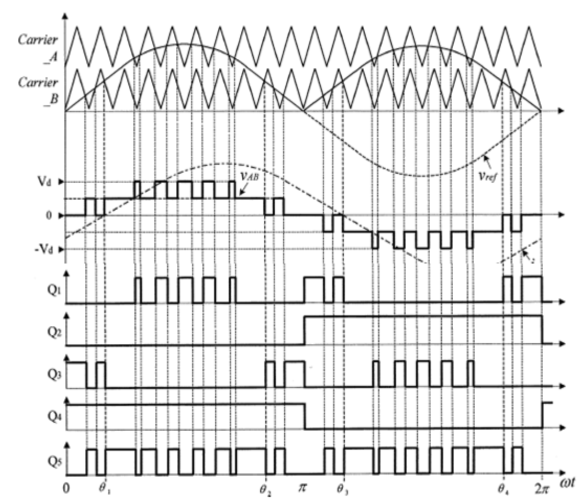

Fig.4.Multi Carrier PWM using Phase Disposition[4]

III. EXPERIMENTAL RESULTS

The Simulink model for the proposed power conditioning unit is given in the figure below.The simulation is carried out in MATLAB/SIMULINK. The control strategy is also given. The figure 5 shows the simulink diagram of phase shifted semi-bridgeless boost converter.

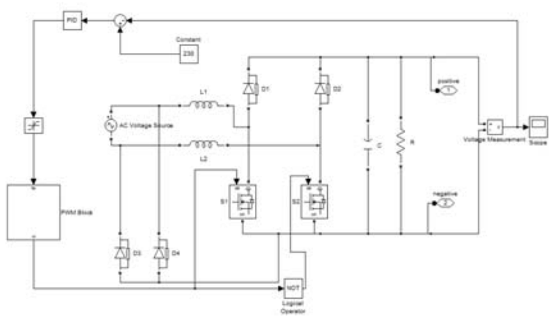

Fig.6. Simulink Model of Phse Shifted Smei-bridgeless Boost Converter

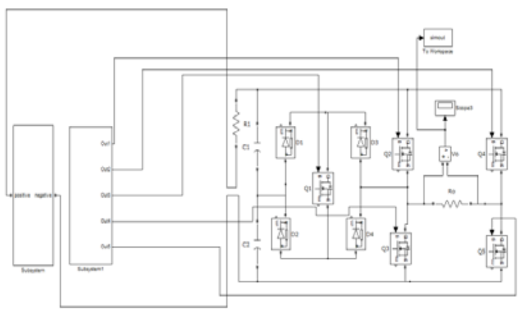

Fig.5. Simulink Model Multi-level Inverter

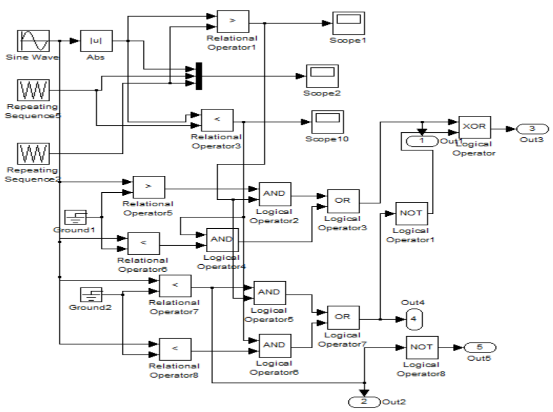

Fig.6.Dual Carrier Multi-level Inverter Control Strategy

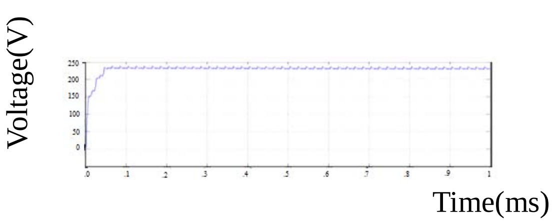

Fig.7. Output DC Voltage of Phase Shifted Bridgeless Boost Converter

The dual carrier multicarrier phase shifting pulse width modulation scheme is shown in Fig.6. The advantage of this scheme is that it offers the charge balance control in the input DC sources and voltage across the capacitor are also balanced .

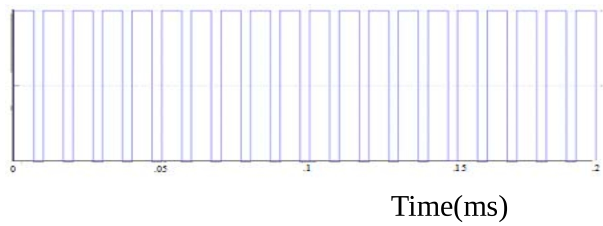

Fig.8. Switching Pulses for Phase Shifted Semi- Bridgeless Boost

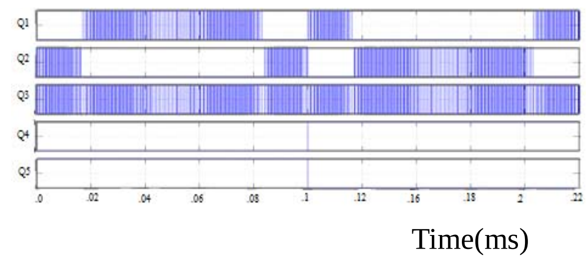

Fig.9. Switching Pulses for Five-level Inverter

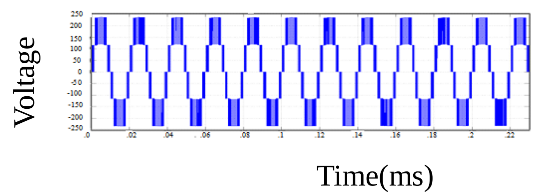

Fig.10.Output voltage of Dual carrier Multi-level Inverter

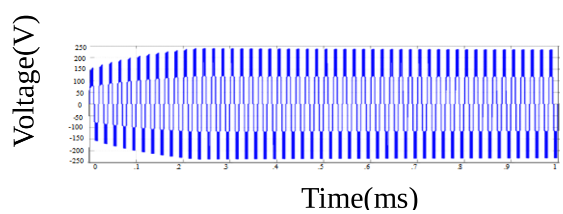

Fig.11. Regulated Output Voltage of the Proposed Topology

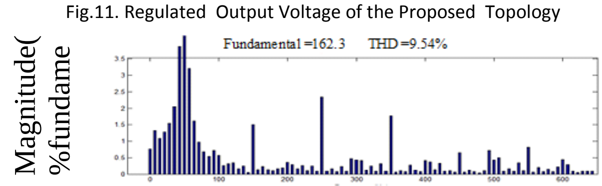

Fig.12. FFT Analysis of Regulated Output Voltage of the Proposed Topology

The THD obtained is about 9.54%.This improves the efficiency of the proposed inverter.

The hardware is implemented using MOSFET IRFZ44 and TLP250.The gating pulses are generated using PIC16F877A. The hardware setup is shown in Fig.13. The protype uses single 6V ac source as input and the five level output of 13 V is obtained as in Fig.15.

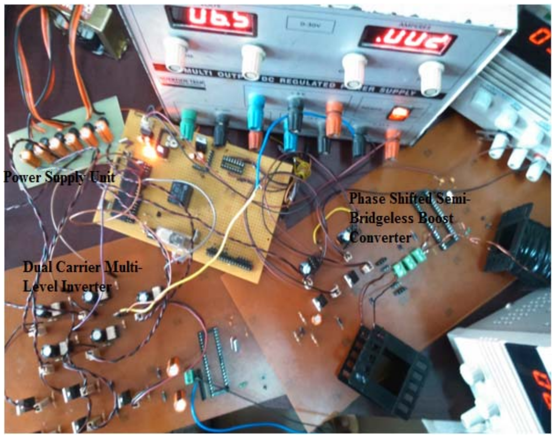

Fig.13. Hardware Set up

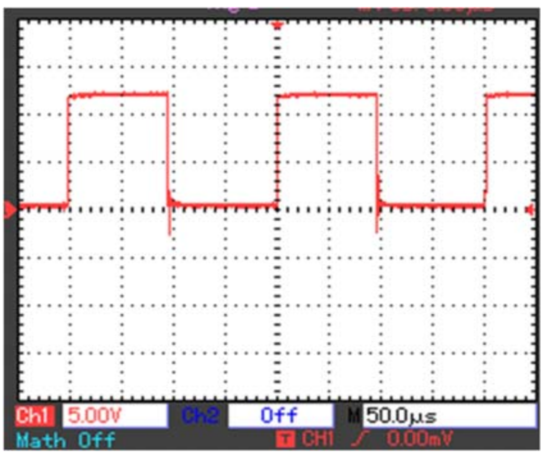

Fig.14. Observed Output Voltage Waveform boost converter

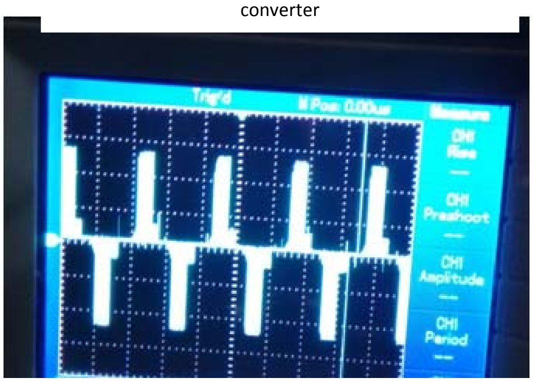

Fig.15. Observed Output Voltage Waveform of PCU

The desired nine level output voltage is obtained as above.

V.CONCLUSION

A new high performance phase shifted semi-bridgeless AC-DC Boost converter topology has been presented. The proposed converter features high efficiency at light loads and low lines, which is critical to minimize the converter size, the amount and cost of electricity drawn from the utility; the component count, which reduces the converter cost; and reduced EMI.They are,

- Single stage power conversion
- Low switching losses
- Compact size
- Light weight
- Can step up or down the voltage

Future scope is that zero voltage and zero current switching can be done to the high frequency switches to reduce the switching losses in the circuit.

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