Wind and Solar Energy Conversion Using Power Electronics System

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Abstract- **A multilevel dc–dc power conversion system with multiple PV array based dc sources and A multilevel cascaded voltage source converter is developed to synthesize a high sinusoidal output voltage is proposed in this Research. To reduce switching frequency deviation of DC-DC converter is in the events of line and load variations, an adaptive feed forward control scheme that varies the hysteresis band according to the change of line input voltage and an adaptive feedback control scheme that varies the control parameter (i.e., sliding coefficient) according to the change of the output load are proposed. The multilevel dc–dc power conversion system of solar power generation is combined with the Multilevel cascaded voltage source inverter (11-level) configuration of wind power generation to get the high efficient operation is proposed.**

Keywords: **Adaptive feedback control, adaptive feed forward control, buck converter, hysteresis modulation, pulse-width-modulation (PWM), sliding mode (SM) control.**

1. INTRODUCTION

DOUBLY-FED induction machines (DFIMs) have recently become popular as generators for variable-speed wind turbines. Half of the world's leading wind turbine manufacturers use the DFIM as generator. In addition, the cost of the converter becomes lower.

2. THE DOUBLY-FED INDUCTION MACHINE

The principle of the DFIG is that rotor windings are connected to the grid via slip rings and back-to-back voltage source converter that controls both the rotor and the grid currents.

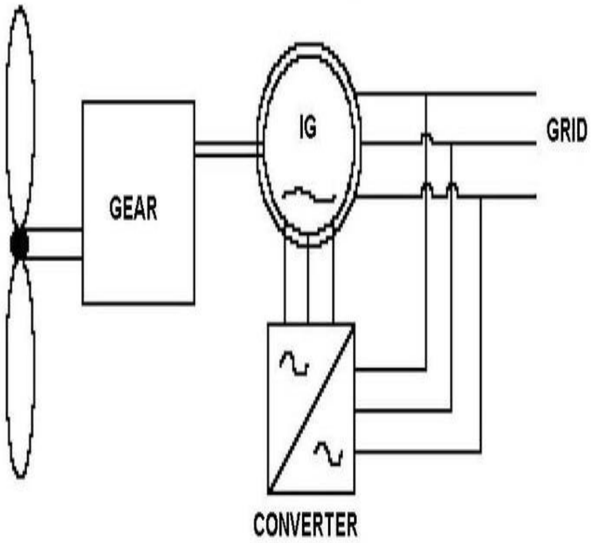

Fig.1.Principle of DFIG connected to the wind turbine

TRADITIONAL dc–dc converters require at least one inductive component, which is bulky, heavy, and costly. With the technology advancement of the silicon carbide (SiC) devices and ceramic capacitors, very high temperature components (above 250 C) will be available except magnetic cores. Thus, very high temperature operation of magnetic-less converter becomes possible and very attractive because natural air cooling can be adopted, which will reduce the size, weight, and the cost of the converter significantly. The multilevel dc–dc converter becomes a good candidate for this application, because there are no magnetic components necessary, and also because of its bidirectional nature. Traditional multilevel dc–dc converters usually output a fixed voltage for a given input voltage, this may become a drawback of these converters because for some applications, such as hybrid power systems, a variable dc bus voltage is preferable so that the inverter can always be operated at its most efficient dc voltage. In this Research, a bidirectional multilevel dc–dc conversion system that can output variable voltage with multiple dc sources will be proposed.

3. COMPARISON BETWEEN PROPOSED AND EXISTING CONVERTER

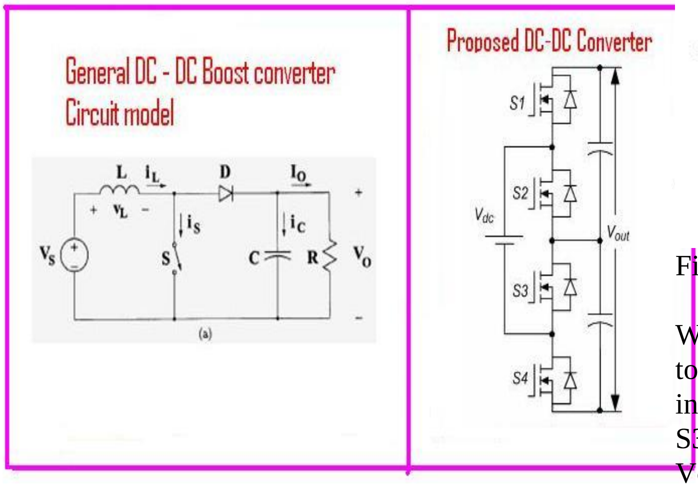

Fig.2.Comparison of proposed and general DC-DC Boost converter

4. DESCRIPTION OF THE DC–DC CONVERSION SYSTEM

The proposed dc–dc conversion system is shown in Fig. 3(a), where there are isolated dc sources, Vdc1~Vdcn , and n identical dc–dc converters cells with the output connected in series. One possible application of this topology is hybrid electric power plants, instead of connecting all batteries in series as one power source and a bidirectional boost converter to interface the battery and the dc bus, one can use separate batteries to power separate converter modules and connect the output of the modules in series as a dc bus supplying the inverter. The dc–dc converter cell is shown in Fig. 3(b), which is a two level converter. For each dc–dc converter cell as shown in Fig. 3(b), there are three switching states as illustrated in Fig. 4.

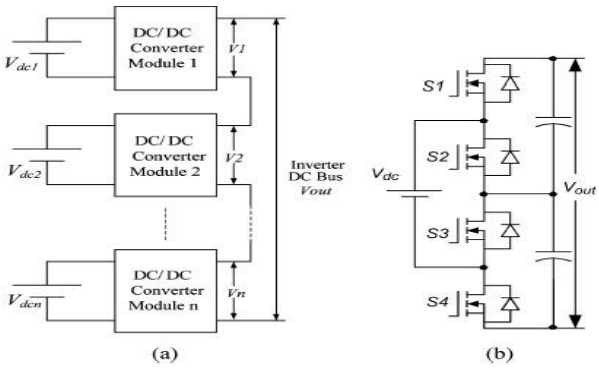

Fig . 3. DC-DC Power conversion configuration and converter cell topology: (a) DC-DC power converter configuration and (b) topology of the DC-DC converter module

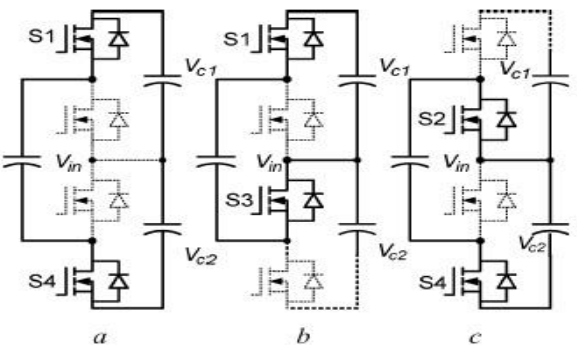

Fig. 4. Converter switching states

With these three switching states, the converter is able to output two different voltages. When the converter is in switching state, (switches S1 and S4 are on, S2 and S3 are off), the following equation will be met Vout=Vin.

Obviously, when the switches (MOSFETs or IGBTs with freewheeling diodes) are turned on, the current can flow in either direction, so the converter is a bidirectional converter. In the second mode, the converter alternates its switching states between and complementarily with 50% duty ratio for each switching state at a high frequency, the following equations will be metVc1=Vin, Vc2=Vin. Thus, the output voltage is Vout=2Vin . Also, the converter is bidirectional in this mode.

Therefore, each single module is able to output two different voltages: Vin or 2Vin. For a system that consists of cells, the system is able to output n+1different voltages from nVin to 2nVin with step of Vin. When the number of n increases, the output voltage can be considered as almost continuous, and the inverter fed by the dc–dc converter can always operate close to the optimum voltage point.

5. PROPOSED SYSTEM

In this proposed system the Wind and Solar Energy Conversion Using the multilevel dc–dc power conversion system is combined with the multilevel cascaded voltage source inverter (11-level) configuration.

5. Proposed system

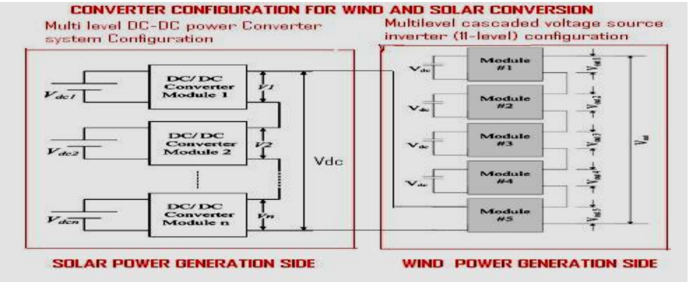

Fig. 6. Converter configuration

6. PROPOSED CONTROL

A major disadvantage of applying sliding mode control to dc/dc converters is that the steady-state switching frequency is affected by line and load variations To reduce switching frequency deviation in the events of line and load variations, an adaptive feed forward control scheme that varies the hysteresis band according to the change of line input voltage and an adaptive feedback control scheme that varies the control parameter (i.e., sliding coefficient) according to the change of the output load are proposed.

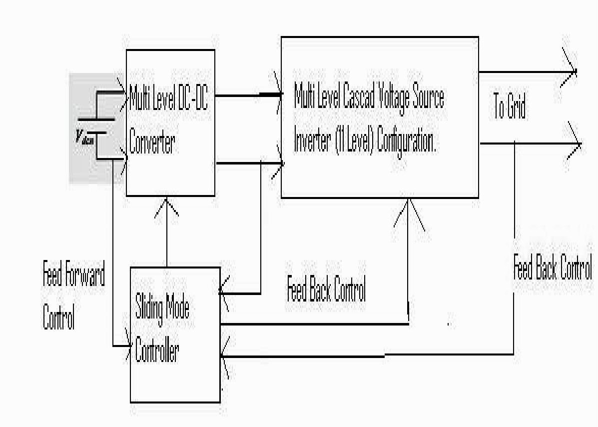

Fig. 7. Proposed control

7. ADAPTIVE FEEDFORWARD CONTROL SCHEME

Several methods of varying the hysteresis band of the hysteresis modulator are possible. In the case of employing the Schmitt trigger as the hysteresis modulator, the hysteresis band can be adjusted by changing the resistor gain ratio R_{st2}/R_{st1}, or by adjusting the power supply V^{+}_{cc}/V^{-}_{CC}.

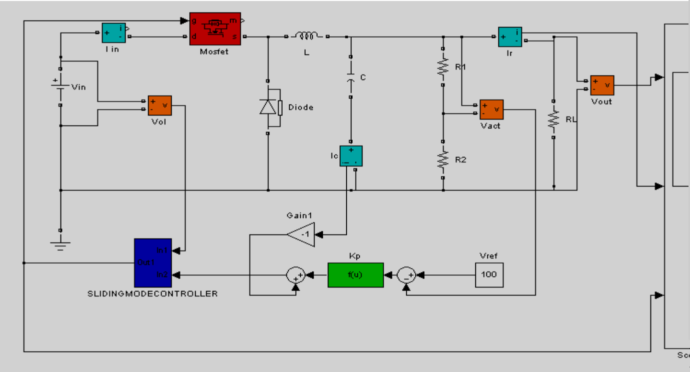

Fig. 8. Adaptive feed forward control scheme

In this work, the latter option is chosen. Fig. 8 shows the schematic of the non inverting Schmitt Trigger used in our implementation. The hysteresis bandwidth Of this circuit is

$$2k=R_{st1}/R_{st2}\ (V^{+}_{cc}-V^{-}_{CC})$$

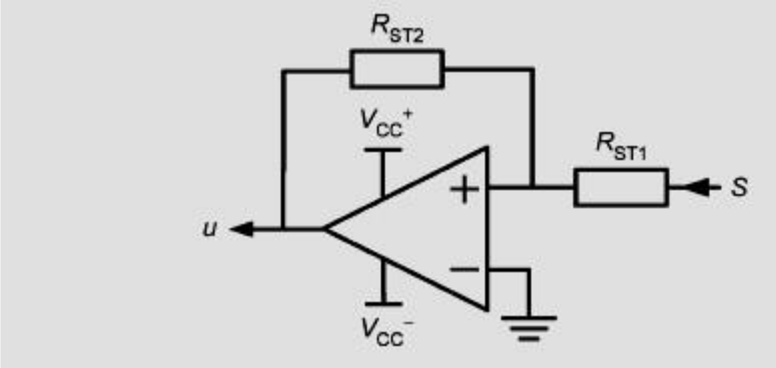

Fig. 9.schematic of the non-inverting schmitt triggers circuit

$$(V^{+}_{cc}-V^{-}_{CC}) = (R_{st2}/R_{st1})\ (V_{od}/f_{sd}L)\ [1-\ V_{od}/V_{i}]$$

$$V^{+}_{cc}= ½\ G_{s}\ [1-\ V_{od}/V_{i}]$$

$$V^{-}_{CC} = -\ ½\ G_{s}\ [1-\ V_{od}/V_{i}]$$

8. ADAPTIVE FEEDBACK CONTROL SCHEME

By making the sliding coefficient adaptive, i.e., $\alpha= 1/R_{L}C_{1}$,
SM control equation becomes
$S=1/\beta R_{L}(V_{ref}-\beta V_{o})-i_{c}$

Clearly, the computation of the control signal S requires the measurement of all involving variables in the equation. However, since it is not possible to measure resistance directly, the relationship
$R_{L}=V_{o}/i_{R}$

is exploited to obtain the instantaneous loading resistance.

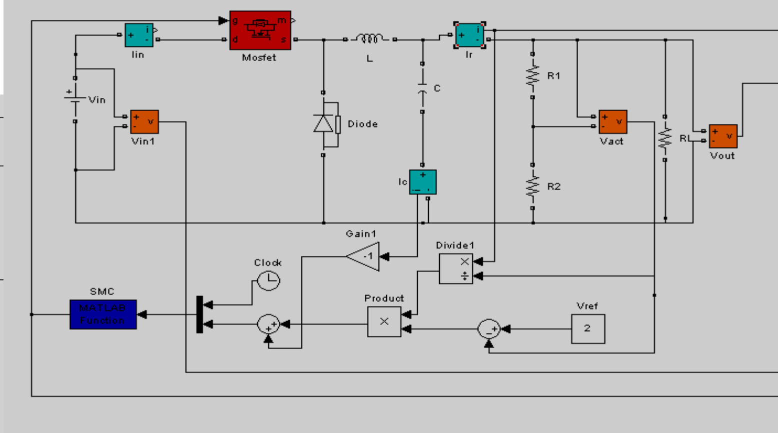

Fig. 10. Basic structure of an adaptive feedback SMVC Buck converter

9.EXPECTED RESULTS AND DISCUSSIONS

9.1 Line variation

The experimental waveform(1)of the converter system at minimum and maximum input voltages, for the SM controller with and without using the adaptive feedforward control scheme. It can be easily observed that for both the cases Vi=18 V and Vi= 30 V, with the same input voltage, the system with the adaptive feedforward control has switching period much closer to the desired switching period t=5u s. A plot of the measured average switching frequency versus different input voltages is shown in Fig. 12.

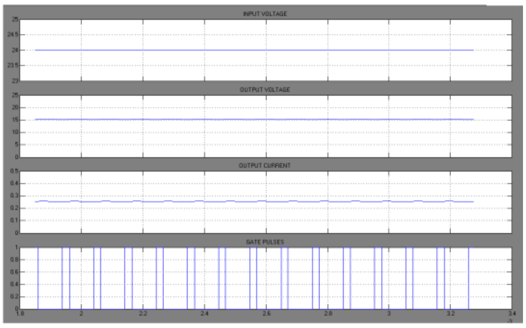

Fig . 11. Simulated output V and I for line variation

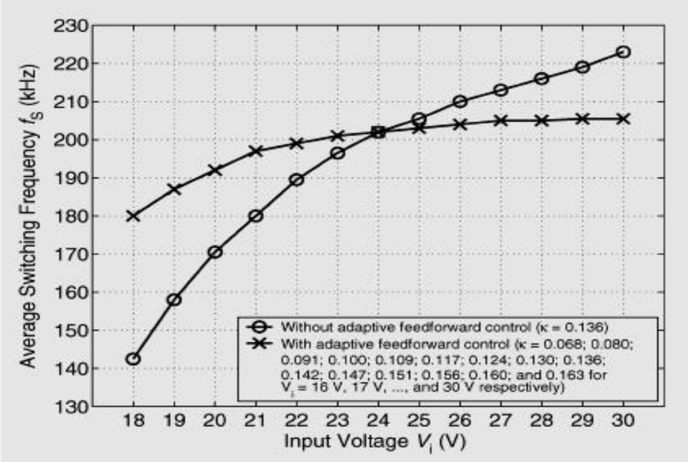

Fig . 12. Average switching frequency fs for line variation

9.2 load variation

Figs. 13 and 14 show the experimental data of the converter system at different load resistances for the SM controller with and without the adaptive feedback control scheme. From Fig. 16, it can be seen that with the adaptive feedback control, the variation of switching frequency with respect to load resistance improves from an average of 3.0 kHz (without adaptive feedback control) to an average of 2.1 kHz (with adaptive feedback control). Thus, for the load resistance range 3Ω≤R_L≤12 Ω, the frequency variation has been reduced from ±8.5% to within ± 6.0% F_{sd}.

±

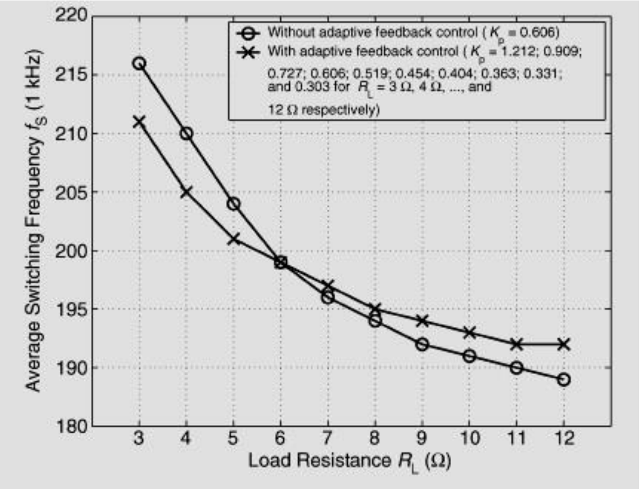

Fig . 13. Average switching frequency fs for load variation

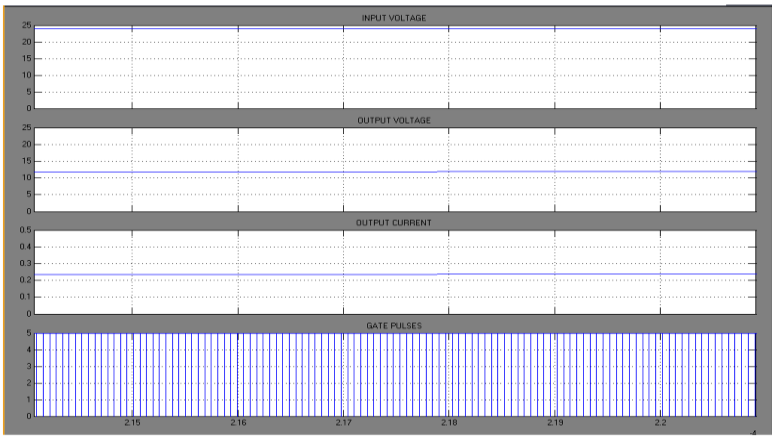

Fig . 14. Simulated output V and I for load variation

10. CONCLUSION

In this paper, a multilevel dc–dc conversion system with multiple dc sources and A multilevel cascaded voltage source converter is developed to synthesize a high sinusoidal output voltage is proposed. The Circuit analysis and Adaptive Feedforward and Feedback Control Schemes for Sliding Mode Controller will process. After the Analysis Will show that a small amount of parasitic inductance reduces the power loss in the converter dramatically and reduces the capacitance requirement significantly. It will show that the requirement of semiconductor of the proposed multilevel converter is no greater than the traditional boost converter and switched capacitor converters and that the proposed converter requires less capacitance. The features and application of the multilevel cascaded voltage source inverter will analyze in this Research. We will investigate to some depth the problem of switching frequency variation in the SM controlled dc/dc converter.

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