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Grid Interface Of Wind Power Using Multilevel Inverter

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Abstract

The aim of the project is to interface the wind power to the grids. The wind energy conversion based on a cascaded H-bridge multilevel topology has been proposed to be used for the grid interface of wind power. The generation of reference currents for the voltage source inverter depends on the available wind power. A method is presented showing that a cascade multilevel inverter can be implemented using only a single DC power source and capacitors. A standard cascade multilevel inverter requires n DC sources for 2n + 1 levels. Without requiring transformers, the scheme proposed here allows the use of a single DC power source with the remaining n−1 DC sources being capacitors. The equal distribution of switching stress and the power losses provides efficient output in the inverter. The modeling of cascaded H-bridge multilevel inverter and grid was performed using MATLAB. The output voltage of multilevel inverter is synchronized with grid voltage.

1. Introduction

Wind energy has proved to be the most promising renewable energy source because of its environmental friendliness. Wind Energy is generated by harnessing the kinetic energy of atmospheric air. Wind Energy has had been in use for centuries for several other purposes such as sailing, irrigation and for grinding grain. Wind power systems transform kinetic energy of the wind into useful sources of power. During ancient times, wind power systems were used for both milling and irrigation. It was during the early years of the 20th century that wind power was started to be harnessed for generation of electricity. Windmills have also been used in several countries to pump water.

The current trend in wind turbines is to increase the size of the turbine in order to harvest more energy and thus reduce cost per megawatt of capacity. Power ratings of 3–5 MW per machine are becoming common in areas with large wind potentials, especially offshore wind installations .The major problem in interfacing such machines to the grid is the limitation imposed by the ratings of currently available switching devices in the converter. The ratings of the semiconductor devices used in the conventional two-level or three-level VSI topologies do not support the higher power ratings necessary for the grid interface of such large machines.

Power-electronic inverters are becoming popular for various industrial drives applications. In recent years also high-power and medium-voltage drive applications have been installed. To overcome the limited semiconductor voltage and current ratings, some kind of series and/or parallel connection will be necessary. Due to their ability to synthesize waveforms with a better harmonic spectrum and attain higher voltages, multi-level inverters are receiving increasing attention in the past few years. The multilevel inverter was introduced as a solution to increase the converter operating voltage above the voltage limits of classical semiconductors. One of the significant advantages of multilevel configuration is the harmonic reduction in the output waveform without increasing switching frequency or decreasing the inverter power output. As the number of levels reach infinity, the output THD (Total Harmonic Distortion) approaches zero. Multilevel inverters synthesizing a large number of levels have a lot of merits such as improved output waveform, a smaller filter size, a lower EMI (Electro Magnetic Interference), and other advantages. The principle advantage of using multilevel inverters is the low harmonic distortion obtained due to the multiple voltage levels at the output and reduced stresses on the switching devices used.

2 Wind Energy System

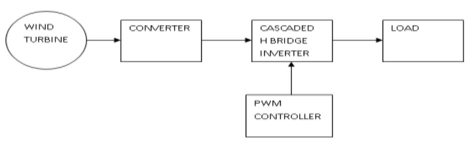

Fig 1: Block diagram of wind energy system

2.1 Wind Turbines

Wind turbines work by transforming the Wind Energy into mechanical power that can be used for conversion to electricity or for other mechanical purposes like grinding. Wind turbines are used either as stand-alone units or in groups known as Wind Farms. Small-sized wind turbines, known as aero generators are used for charging large-sized batteries.

2.2 Converters

Converter includes both inverters and rectifiers. In wind energy system output from the generator is AC so we are using rectifiers. Universal bridge rectifier is used to produce the rectified DC output which is to be given to the MLI.

2.3 Pulse Width Modulation

The advent of the transformer less multilevel inverter topology has brought forth various pulse width modulation (PWM) schemes as a means to control the switching of the active devices in each of the multiple voltage levels in the inverter. The most efficient method of controlling the output voltage is to incorporate pulse width modulation control (PWM control) within the inverters. In this method , a fixed dc.input voltage is supplied to the inverter and a controlled ac. output voltage is obtained by adjusting the on and–off periods of the inverter devices.

Multilevel Inverters

A cascade multilevel inverter is a power electronic device built to synthesize a desired AC voltage from several levels of DC voltages. To operate a cascade multilevel inverter using a single DC source, it is proposed to use capacitors as the DC sources for all but the first and second sources. The modeling of 15level cascaded H- bridge Multilevel inverter is performed.

The circuit of 15level Multilevel Inverter is shown in Fig 2. The diagram shows the inverter with single DC source.

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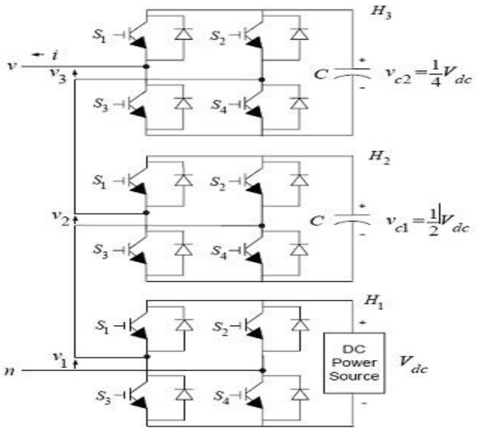

Fig 2: Circuit Of Multilevel Inverter

3.1 Output Voltage Of 15level Multilevel Inverter

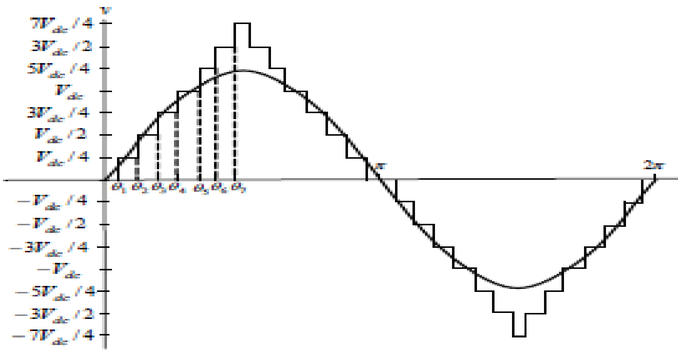

Fig 3: Output levels of Multilevel Inverter

3.2 Calculation Of Voltage Levels

Mulilevel Inverter

No Of Level V(t)= V1(t)+V2(t)+V3(t)

Let

Vdc= 100 V : V1

Vdc/2= 50 V : V2

Vdc /4= 25 V: V3

No of switches = 12 (s1-s12)

For V1 , V2 and V3 Total Angle =180 For Positive Cycle.

3.3 Switching Pattern Of Multilevel Inverter

θ	v_1	v_2	v_3	$v_1+v_2+v_3$
$0\le\theta\le\theta_1$	0	0	0	0
$\theta_1\le\theta\le\theta_2$	0		$V_{dc}/4$	$V_{dc}/4$
$\theta_1\le\theta\le\theta_2$	0	$V_{dc}/2$	$-V_{dc}/4$	$V_{dc}/4$
$\theta_1\le\theta\le\theta_2$	V_{dc}	$-V_{dc}/2$	$-V_{dc}/4$	$V_{dc}/4$
$\theta_2\le\theta\le\theta_3$	0	$V_{dc}/2$	0	$V_{dc}/2$
$\theta_2\le\theta\le\theta_3$	V_{dc}	$-V_{dc}/2$	0	$V_{dc}/2$
$\theta_3\le\theta\le\theta_4$	0	$V_{dc}/2$	$V_{dc}/4$	$3V_{dc}/4$
$\theta_3\le\theta\le\theta_4$	V_{dc}	0	$-V_{dc}/4$	$3V_{dc}/4$
$\theta_3\le\theta\le\theta_4$	V_{dc}	$-V_{dc}/2$	$V_{dc}/4$	$3V_{dc}/4$
$\theta_4\le\theta\le\theta_5$	V_{dc}	0	0	V_{dc}
$\theta_5\le\theta\le\theta_6$	V_{dc}	0	$V_{dc}/4$	$5V_{dc}/4$
$\theta_5\le\theta\le\theta_6$	V_{dc}	$V_{dc}/2$	$-V_{dc}/4$	$5V_{dc}/4$
$\theta_6\le\theta\le\theta_7$	V_{dc}	$V_{dc}/2$	0	$6V_{dc}/4$
$\theta_7\le\theta\le\pi/2$	V_{dc}	$V_{dc}/2$	$V_{dc}/4$	$7V_{dc}/4$

Table 1: Switching pattern for 15levels

Simulation And Results

A three-phase wye-connected cascaded multilevel inverter using 100 V, 70 A MOSFETs as the switching devices was used to carry out the experiments. The simulation of the grid interface of wind system was done in MATLAB- SIMULINK version 2011. The simulink model was given below.

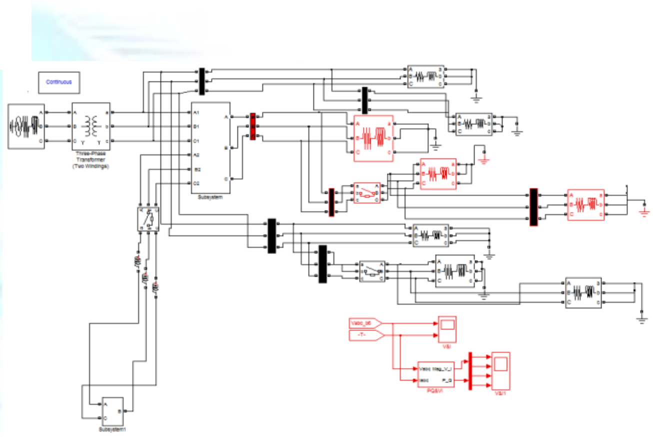

Fig 4. Simulink model Wind Energy To Grid

4.1 Output Voltage of Multilevel Inverter

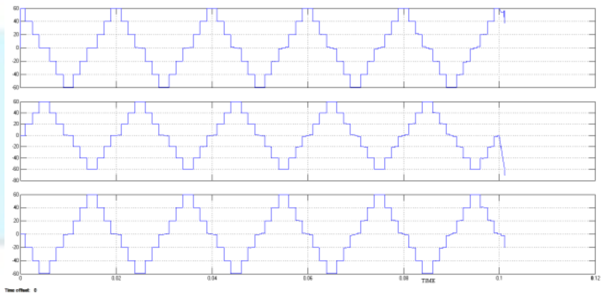

Fig 5: Three Phase Output Of Multilevel Inverter

4.2 Grid Voltage

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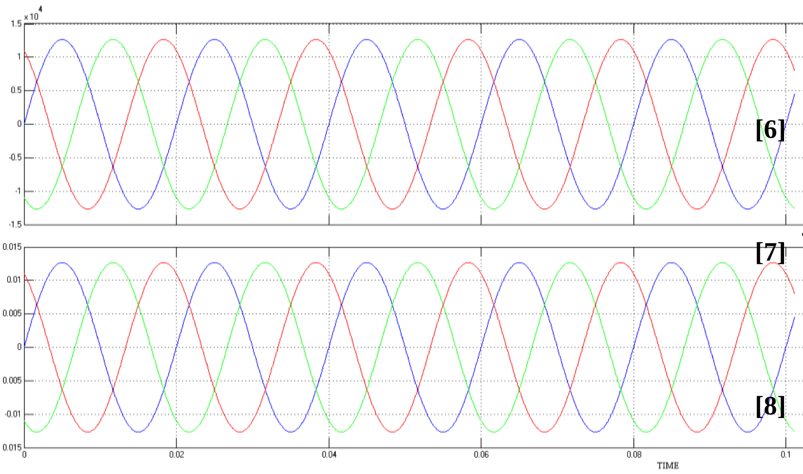

Fig 6: Three Phase Grid Voltage

Conclusion

As the non-conventional energy sources are getting depleted and the per capita consumption is getting increased broadly it is necessary for us to generate more energy for our needs. So, I have gone for renewable wind energy sources. The wind energy was generated from the wind turbine and it is given to the multilevel inverter. 15 level multilevel inverter is designed and simulated, its output voltage is interfaced with grid voltage. Pi modeling of the transmission line was designed. All the simulations and designs are done in MATLAB.

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