Simulation Analysis on Non-conventional Energy & Three – Level Inverter Grid Connected System

Sonu Kumar , Prof. Anurag Shrivastava
M.Tech Student, Professor
Electrical & Electronics Department of Engineering
Trinity Institute of Technology & Research, Bhopal, India

Abstract : The rising energy demand need coupled with the possibility of minimization in provider of non-non-conventional fuels, proven by fossil oil crisis, together with increasing issues concerning ecological conservation, has driven study and enlargement of other energy sources that area unit cleaner, area unit non-conventional and with growing awareness over environmental condition changes and pollution, the demand for non-conventional energy resources primarily based power generation systems has augmented drastically. The combination of those systems with the utility grid has evolved into active analysis space among the sector of power systems. The scope of this analysis was to research varied best management ways and propose economical a good and efficient strategy for energy conversion system with attention on wind energy that may feed the grid. At first the thesis presents, varied mathematical aspects over the mixture of the turbine and corresponding static magnet Synchronous Generator (PMSG) via optimized management algorithms for the whole power network would be illustrated well. During this treatise a unique management strategy that analyzes the static magnet synchronous machine (PMSM) and turbine via complicated machine models. Associate degree optimized management approach was designed that addresses varied grid connected and energy conversion problems with relevancy best power generation. The projected approach is predicated on the 3-Level electrical {converter} management exploitation DC transformer circuit for dominant the machine and grid aspect converter of the turbine. A detail simulation analysis was performed on MATLAB primarily based simulation setting to analyze the practicableness of the system over period setting.

Index Terms *- PMSG, 3-Level Inverter, PMSM, non-conventional energy & simulation.*

I. INTRODUCTION

"Power System engineering" has been around for several decades and is considered as the vital engineering discipline within the field of the electrical engineering. The scope of the engineering that incorporates robust, efficient, effective power system network. Most of the world is depend and utilize various power based systems starting from a mobile phone to advance navigation system. This fact signifies the predominance of power engineering activities. In general, power system network can be viewed as a combination of three independent activities that are interconnected with each other i.e. namely,

1. Power Generation Activities
2. Power Transmission Activities
3. Power Distribution Activities

These set of activities consists of various tasks like need elicitation, feasibility exercise, estimation, modeling, designing, construction, control algorithms, transmission network, maintenance and etc. Due to the sequence of the activities, most of the current issues that demands are the minimization of losses and efficient power flow that is really troubling the present power generation industry. There are over power, economics regarding depleting non-conventional energy sources and environment (As per environment pact signed by INDIA in Paris G20-summit).

1.1 Non-conventional Source of Energy

In the recent G-20 environment pact, several countries have entered into environment-pact which ensures a large investment and awareness activities to highlight the use of non-conventional energy sources. As India is a fastest developing nation it power need is quite high accompanied with vision 2020 wherein every household would be connected to grid also makes our power system network highly complex. Until now, our energy needs often satisfied by the non-non-conventional energy sources such as coal, petro-chemical products and etc that has significant impact on the environment conditions. For example, smog that covered Delhi city is the best and live result of extensive pollution. Furthermore, due to our nation huge power need we are using fossils fuels at rate that our reserves would last for next few years. These are issues compounded created the need to study and incorporate non-conventional energy sources in our daily to a greater extent. Unfortunately, some of the commonly used energy sources tend to operate at certain intervals and other periods their performance would not be up-to the needed level. Due to this constant switching (generation of power) could induce harmonics into the system if connected without addressing

1.2 Non-conventional Wind Energy

Unlike the commonly used solar and hydro energy sources, wind energy is available almost throughout the year but the intensity changes with is considered as the major limitation for incorporation wind energy as primary energy source for power generation. The power generation is directly proportional to the speed of the wind at any given instance as the speed varies the corresponding power generated varies and minimal wind speed is needed for generation of power even wind flow is available but it is less that the threshold the generation of power is not possible. Several works have been proposed in improving the designing of the wind turbine and corresponding control strategies so as to address the above issues pertaining to minimal and changing wind speed operation. In addition, we also focus on exploiting the benefits link with permanent magnet synchronous generator (PMSG) so enhance the operation control over wind energy conversion systems.

1.3 Problem formulation

This paper aims for enhanced wind energy conversion system with better performance, as it is a new emerging domain with huge business potential and the needs is different from conventional vector control strategies. The objective is to provide real time integration of WECS to the power grid that plays a vital role for power system based utilization. There is a huge need for algorithms with better controllability, efficiency, and increased power ratings with sophisticated parameters. There are various algorithms which have been used in WECS to provide better harmonics minimizations, enhance power quality, and reduced losses.

The main problems link with the grid connected wind energy system often induces harmonics. These harmonics often occur due to the frequent changes in voltage levels of the inputs. The topology influences the working and efficiency of the utilized within the network wherein traditional inverters use PWM modulation to minimize the distortion in voltage and current. Today in much utilization photovoltaic (PV) sources are used as they have the benefit of pollution free and having effective maintenance.

II. MODIFIED MULTI-LEVEL INVERTER

The execution of the multi-level inverter had been developed and enhanced by utilizing pulse-width-modulation control plan. The utilization of a two-level inverter diminishes the symphonious parts of the yield voltage contrasted and the customary three stage inverter at the same exchanging recurrence. It needs no extra reactors or transformers to diminish the symphonious parts. At that point, it is suitable for medium voltage and medium power frameworks. The outlined and executed two-level inverter understood the necessities and bolstered R-C load by the needed estimations of voltage and recurrence [8]. Although some of the existing methods are very popular than others, but due to various factors and working constraints of the each technique that needs to be considered. It is evident that each technique has several benefits and corresponding drawback, so to obtain a precise design for inverter that needs to be employed that will make the entire process complex and very costly.

2.1 Multilevel Inverters Application & Types

Since multilevel inverters could produce the output voltages by increasing levels they overcome traditional 2 and 3 level inverters with reference to harmonic distortion. These multilevel converters are divided broadly into three categories based on their design and the switches configurations. Traditional two-level inverters can produce two outputs "V_{pv}/ 2" or "$-V_{pv}$ /2"for a given input voltage that are often switched with PWM. In typical sense a three-level inverter presents every phase-leg can create the three voltages V_{dc} /2, 0, $-V_{dc}$ /2 as illustrated in the Figure 3.1 and 3.2. [4-7].

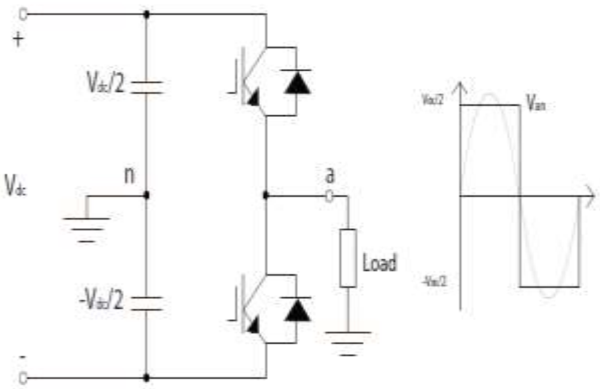

Figure 2.1-level Inverter and Corresponding Waveform

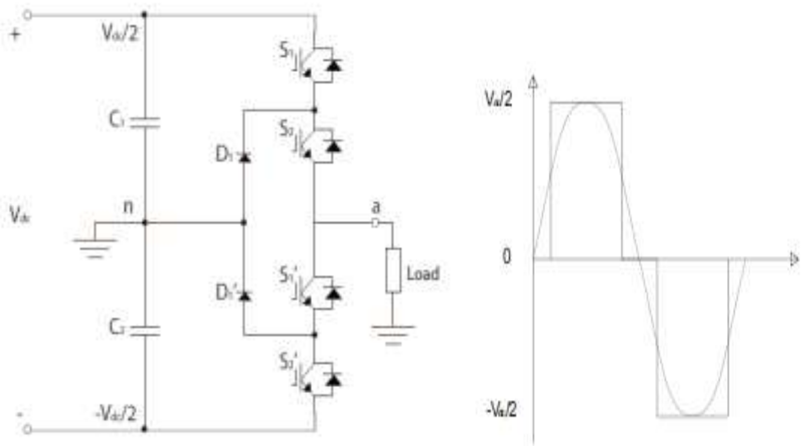

Figure 2. 2-Level Inverter and Corresponding Waveform

2.1.1 H-Bridges Cascaded Inverter

In cascade H-bridge there are several different configurations as well. A general limitation of this cascade H-Bridge topology is that it requires a significant amount of independent voltage sources to power supply each cell unit separately [3]. In this study focus is on the increasing different levels in converters starting from basic three levels to the nine levels with their simulated results giving a similarity on using two different topologies neutral point (NCP) and cascade H-Bridge (CHB) type. **Ease of Use**

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2.2 Techniques for Modulation

In this section, modulation technique which is the one of the prominent threshold algorithm is based on characteristics and features link with the modules (i.e. voltages and current waveforms). A similarity definition is incorporated for the best modulation process that is usually considers the complication of priority metrics within the proximity measure of at least. Now-a-days, we often operate in various "switching modes" that needs to be transformed in to states that operate normal transition for controlling the flow of voltage and current. These techniques are considered as modulation process of which the most commonly used approach is the Pulse Width Modulation (PWM) [8].

2.2.1 PWM Multi Carrier Module

In this section, first fundamentals of 2-level PWM and its characteristics will be explained. Based on these characteristics, this method will be extended for its application in multilevel inverters. For all of inverters (2-level or multilevel) minimum and maximum values of the carrier and reference signals and the corresponding output voltages will be normalized to -1 and +1 with respect to the input dc voltage.

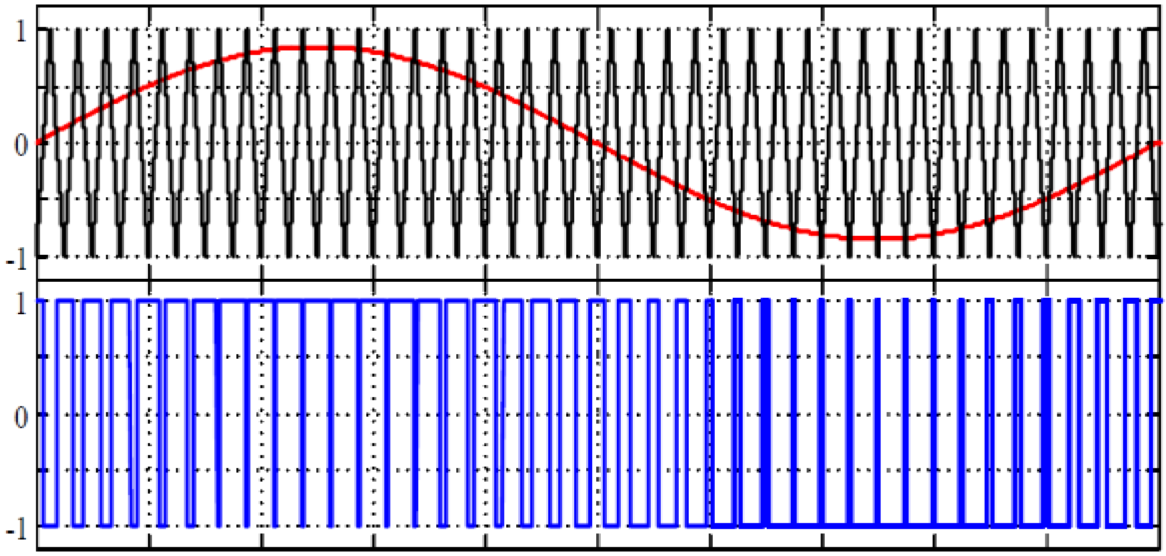

Figure II-1: Carrier and Reference Waveform of 2-Level PWM

III. CONVERTER CONTROL ANALYSIS

In this paper, we employed the control algorithms with different characteristics and functionalities as per prior WECS analysis. These analyses are processed by the proposed algorithm to determine the convergence of each algorithm and corresponding formations results would be displayed. The determined control technique would have various metrics that are calculated according to various inbuilt factors such as the losses, THD, power rating, and etc.

3.1 Converter Control Based on VOC

The basic functional elements in this library blocks such as, step signals, comparators, gain blocks, integrators, switches, FWDs, loads, multiplexers, sinks, scopes, etc. which are available in the Simulink library are which is used in the development of the Simulink model. The developed Simulink model is run by simulation method to obtained the various responses with and without the harmonic elimination unit are observed.

A 3-Φ inverter simulated circuit developed which is power supplying a inductive load in which, the inverter changes the DC input voltage to a 3-Φ variable frequency- variable output voltage. The input DC voltage can be from a DC source or from a rectified AC voltage from the mains or from an AC generator and which is constructed by combining three single phase half bridge inverters, consisting of thyristor switches with 6 link FWDs shown in the Simulink model. In the Simulink model shown, the 6 are the outputs of the thyristor switch bridges. In the output sections, we can see the R-L load is connected. The switches are opened and closed periodically in the proper sequence to produce the desired output waveform (proper switching scheme employed). In Phase Opposition Disposition, the carrier signal over zero axes is in phase with each other having same frequency and same amplitude:

Where the currents link with grid, and , are the voltages link with the grid.

Selective Harmonic Elimination Control (SHEC) is used to remove the harmonic contents from a given v/i signal. Here, there is no need to calculate the firing angles by placing the switches due to which the harmonics of lower order will be reduced by the dominant harmonics of same order generated in opposite phase by sine wave PWM inverter and is obtained by changing the phase angle of the carrier wave of the PWM inverter.

Then first calculate the THD for 1stand3rdorder harmonics, after that calculate the amplitude of the harmonic signal. The anti-signal generation takes place which is given through the switches to the system due to this elimination of the harmonics signals and generating smoothened signals. The resultant sine wave is compared with the triangular waveforms and pulses are generated by PWM which will be given combined to the switches, which in turn interacts with the original waveform of the system which are infected with harmonics (occurred due to switching) they will produces a smoothen voltage or current wave form. By applying before and after signal to the system, it will incorporate with the compensating unit, due to which THD is reduced drastically in the existing system.

The 3-ϕ VSI using harmonic elimination method is carried out in the MATLAB-Simulink environment. The model is developed in the said environment with the necessary parameters set inside the relevant boxes and devices. Blocks from simulink library such as the Thyristors Bridge, mux, scopes, comparators, loads, etc. are used in the development of the model. Once, the connection is done, then the model is run for a certain simulation period of so many seconds (changing). The voltage and current waveforms are observed before the incorporation of the harmonic elimination method and after the incorporation of the proposed elimination scheme. The Voltage Oriented Control (VOC) is commonly employed technique that addresses issues link with grid-side the details of the phasor diagram are illustrated in the Figure 3.1.

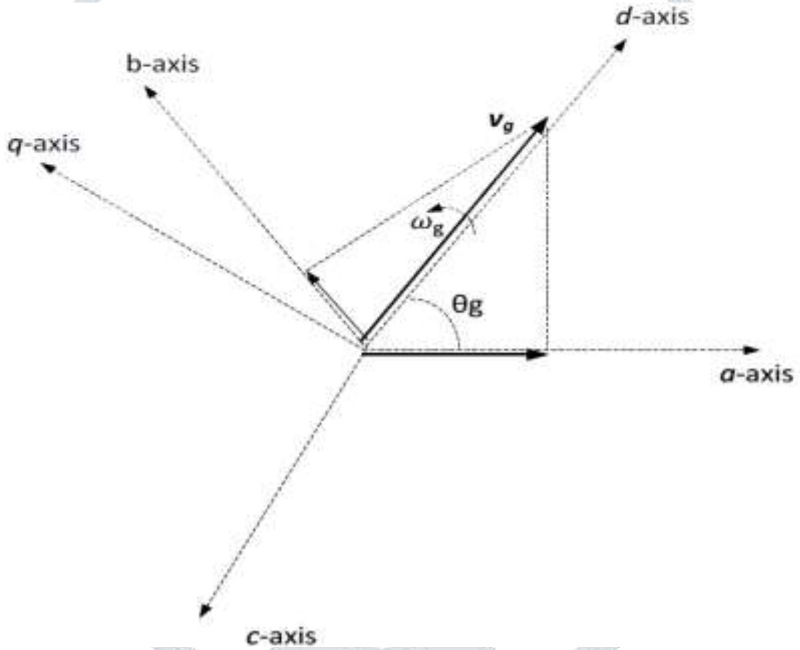

Figure 3-1 : Voltage Oriented Control Based Phasor Diagram

The active and reactive power equations link with the proposed algorithm are expressed mathematically by the expressions below:

$$P_g = \frac{3}{2} v_{dg} i_{dg} = v_{dc} i_{dc}$$

$$Q_g = -\frac{3}{2} v_{dg} i_{qg}$$

Where, v_{dc}andi_{dc} , are the voltages and current of the DC bus, respectively.

3.1 Mathematical Modeling

The mathematical equation of the three- phase PWM rectifier are shown as follows

$$L\frac{di_a}{dt} + Ri_a = e_a - (v_{dc}s_a + v_{NO})$$

$$L\frac{di_b}{dt} + Ri_b = e_b - (v_{dc}s_b + v_{NO})$$

$$L\frac{di_c}{dt} + Ri_c = e_c - (v_{dc}s_c + v_{NO})$$

$$C\frac{dv_{dc}}{dt} = i_a s_a + i_b s_b + i_c s_c - \frac{v_{dc} - e_L}{R_L}$$

The above equation is the mathematical model of the three-phase PWM rectifier in three-phase static frame.

$$L\frac{di_q}{dt} + \omega L i_d + Ri_q = e_q - v_{dc}s_q$$

$L\frac{di_d}{dt} + \omega L i_q + R i_d = e_d - v_{dc} s_d 0$

$$C\frac{dv_{dc}}{dt} = \frac{3}{2}\left(i_q s_q + i_d s_d\right) - i_L$$

Above equation is a non-linear model system and it is needed to be linearized. There are three new variables u, u_d, u_q are defined and the enhance model of three-phase PWM rectifier is shown above

$$u = v_{dc}^2$$
$$u_d = e_d - v_{dc} s_d = e_d - v_d$$
$$u_q = e_q - v_{dc} s_q = e_d - v_d$$

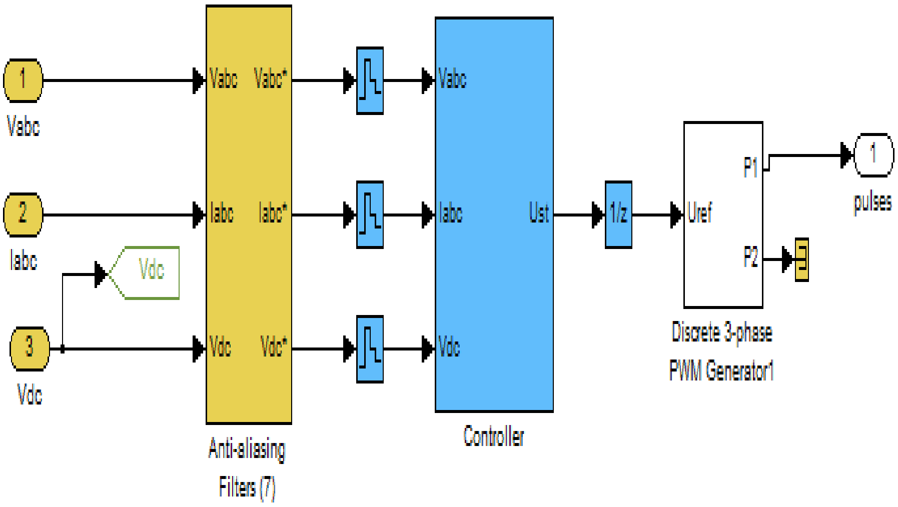

Figure 3-2: Simulink Model For Firing Control

In the Figure a Simulink model for firing control is shown which is used to provide gate signal to the inverter. The block consists of various Proportional and Integral control to ensure the proper functioning of the block as shown in the Figure 3.2. The firing control requires the input as V_{abc}, I_{abc} and V_{dc} which is further applied to the gate for providing gating signals.

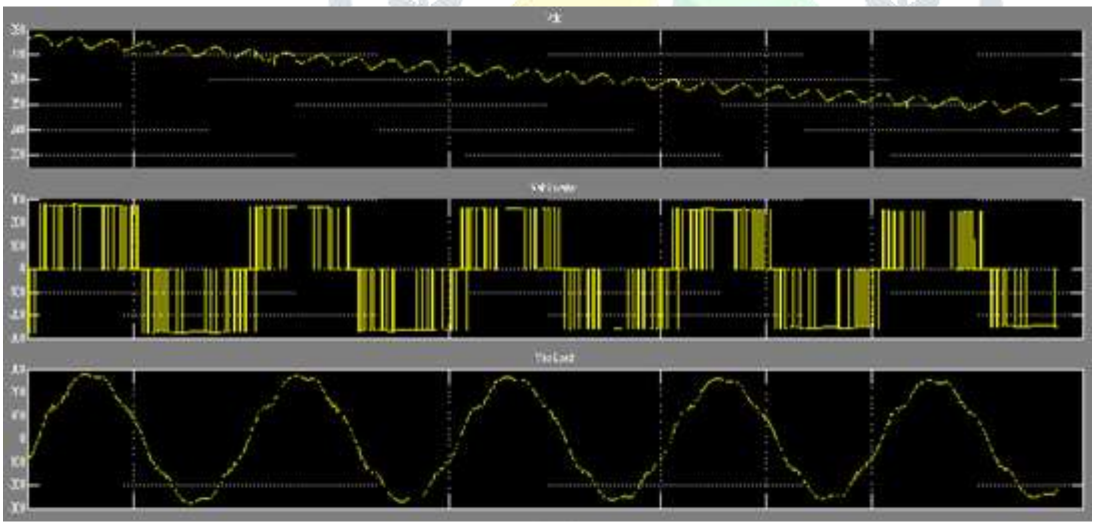

Figure 3-3: Controller Block

The above mentioned Figure focuses on the DC Voltage Regulator block. The block is a modified form for conventional pulse width modulation approach which generates the appropriate gate drive waveform for each PWM cycle. The Figure 3.4 shown fully describes the waveform for the existing system. The foresaid generated signal is then feed to the gate terminal of the inverter. The set of 6 switching signal will further trigger the device to generate a controlled output voltage.

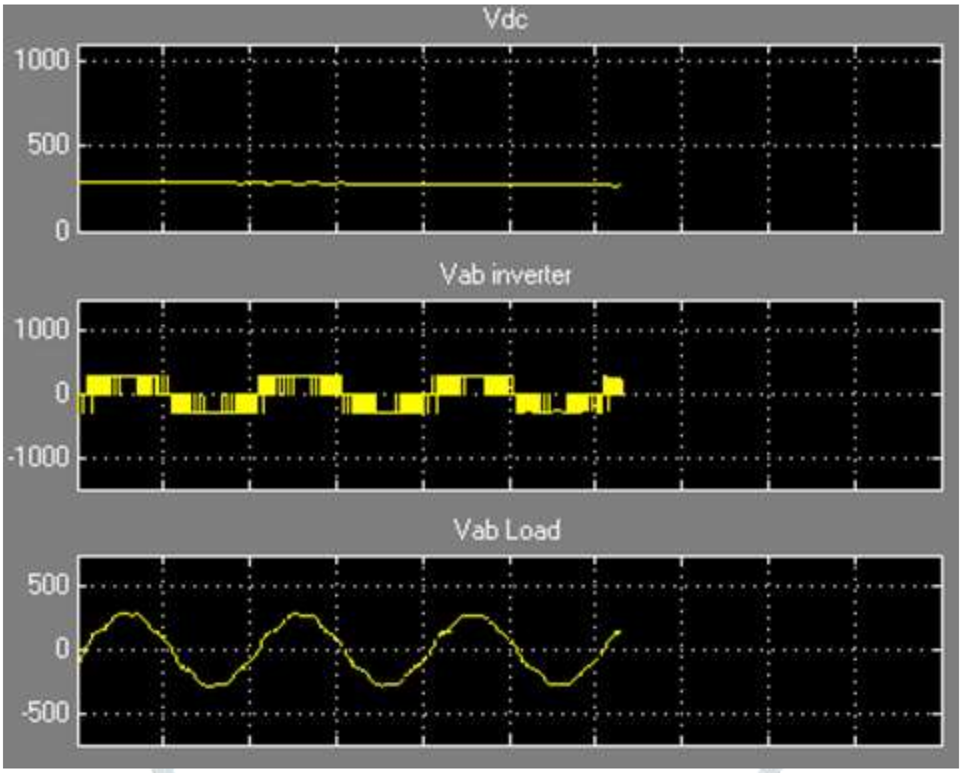

Figure 3-4: Output Waveform for Firing Circuit

IV. RESULTS AND DISCUSSION

3- level inverter control technique for wind turbine was studies. In order to further validate this technique, the method is applied to a wind energy conversion system and the simulation results show enhance performance.

In addition, the high dynamic performances of the DC voltage regulator control method for 3-level inverter. This work acts as basis for analyzing optimal control strategies for an effective strategy for the operation of wind energy conversion system feeding grid. The results show that the optimized control approach addressed various grid connected and energy conversion issues with reference to optimal power generation. The proposed approach is based on the 3 Level Inverter Control using DC voltage regulator circuit for controlling the machine when wind turbine based converter is connected to grid side of the system. A detail simulation analysis that was performed on MATLAB based simulation environment show that the active and reactive power components of the grid current are balanced.

Future Scope:

In this dissertation, a simulation study was carried out to validate the purposed control algorithms for a 2 MW wind energy conversion system. In order to further test the performance of 3 level inverter, a real time experimental test needs to be done in the future research work. Hybrid system also can be used as an input to the system.

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