IJCTA, 10(5) 2017, pp. 577-587

Wind Energy Source Interfacing to Grid by Using Five-Level Inverter

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Abstract: A novel topology for Five-Level inverters which is sensible for wind energy source interfacing to grid is proposed in this paper. The proposed topology altogether lessens the utilization of number of DC voltage sources, switches, and control diodes as the quantity of voltage levels increment. The world electrical energy utilization is rising and there is a relentless increment of the request on the power limit, proficient creation, dissemination and use of electrical energy. The customary power frameworks are changing, number of wind energy sources, for example, wind turbines, photovoltaic generators, energy units, little hydro, wave generators, are being incorporated into power frameworks at appropriation level. The Five-Level converters have key influence in the coordination of the wind energy sources. This paper surveys the utilization of five level converters in the incorporation of wind energy sources. Execution assessment of the Five-Level inverter is done on MATLAB stage. The suitability of the proposed plan is affirmed by performing reenactment and results approval. This undertaking presents another procedure for getting a blended five level yield further more utilizes PWM control systems, in this strategy, the quantity of DC voltage sources, switches, and control diodes utilized for the DC to AC change is diminished. So this DC to air conditioning transformation altogether decreases the underlying expense. The methods of operation are laid out for Five-Level inverter, as comparable modes will be acknowledged for more elevated amounts. MATLAB Simulink environment is utilized to recreate the outcomes.

Keywords: Wind energy, Five-Level inverter, Converter, Grid, Diode clamped, Wind generator.

1. INTRODUCTION

The expansion of the world energy request has involved the speculation of enormous measures of assets, human, to grow new advancements fit to create, transmit and change over all required electric force. What's more, the reliance (depends) on fossil energizes and the dynamic increment of its cost lead to appearance of new less expensive and cleaner energy assets not identified with fossil fills. In extreme decades, wind energy assets have been the center for specialists, and distinctive groups of force converters have been intended to coordinate these sorts of supplies into the conveyance grid. Alongside the era, electric force transmission needs high power electronic systems to guarantee transformation and the energy quality. Various industry applications, such as material and paper industry, steel factories, electric and cross breed electric vehicles, ship impetus, railroad footing, and so on, require use of variable rate electric drives. [1] To extent the variable velocity operation of electric drives is concerned, these days perpetually accomplished by supplying the machine, paying little mind to the sort, from a force electronic converter. Subsequently, control electronic converters have the obligation to do these undertakings with high effectiveness. At each of these stages quick advancement of the force electronic lead to execution of new power converter topologies and semiconductor innovations. A consistent race to create higher-voltage and higher current force semiconductors to drive high-control systems still goes on. Along these lines, the last-era gadgets are appropriate to high voltages and streams (around 6.5 kV and 2.5 kA). In any case, right now there is intense rivalry between the utilization of exemplary force converter topologies utilizing

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high-voltage semiconductors and new converter topologies utilizing medium-voltage gadgets. The five level converters fabricated utilizing adult medium-power semiconductors are rivaling exemplary force converters utilizing high-control semiconductors that are under nonstop improvement and not develop. To be sure, five level converters utilizing additionally exchanging segments can be both less expensive and more dependable than standard Two-Level arrangements with uncommon and more costly parts. What's more, five level arrangement requires littler channel to fulfill power quality prerequisites, which can be critical thing in high-control range. [2] These days, five level converters are a decent answer for force applications since they can accomplish high power utilizing full grown medium-power semiconductor innovation covering power range from 1 MW to 30 MW. The most extreme force point of confinement of standard three-stage converters is identified with the cutoff points of the greatest voltage and current of an exchanging segment. Moreover, higher is the force of a switch lower is the exchanging recurrence. An underlying answer for conquer these constraints was association of a few switches in arrangement or in parallel.

The arrangement association of two or more semiconductor gadgets confronts issues because of the trouble to synchronize flawlessly their substitutions. Indeed, in the event that one part switches off speedier than the others it will explode in light of the fact that it will be liable to the whole voltage drop intended for the arrangement. [3]

2. SYSTEM DESCRIPTION

Wind Energy Conversion System

The wind generator system using Permanent Magnet Synchronous Generator is shown in Figure 1. The kinetic energy produced by the wind turbine is the most desirable type of energy which is converted into electrical power which can be stored in batteries or linked to a utility power grid [5].

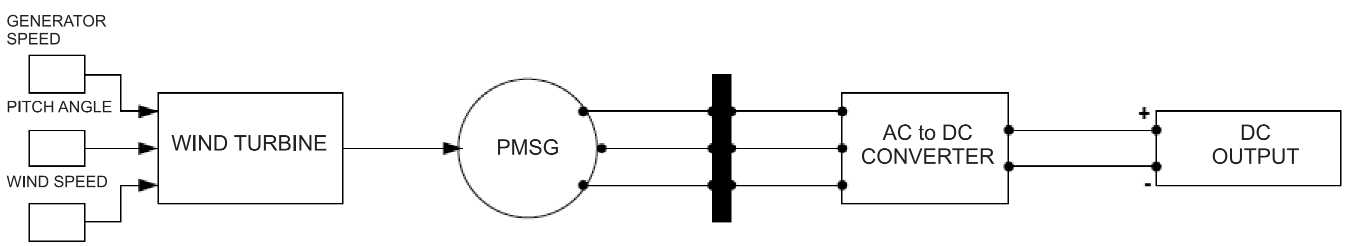

Figure 1: Proposed power converter using wind structure

An important parameter of wind rotor is the tip speed ratio λ which is the ratio of the circumferential velocity of the blade tips and the wind speed.

The power from the wind is maximized when the power coefficient is at its maximum. This occurs at a defined value of the tip speed ratio. Hence for each wind speed there is an optimum rotor speed where maximum power is extracted from the wind.

Thus by controlling the rotor speed, the power output of turbine is controlled.

Wind Generator

Recently, the commercial trend of wind power generation is in using variable speed wind turbine driving a Permanent Magnet Synchronous Generator (PMSG). PMSG is considered in many research articles, a good option to be used in WECS due to its self-excitation property, which allows operation at high power factor and efficiency. The salient pole of PMSG operates at low speed and thus the gearbox can be removed. This is a big advantage of PMSG based WECS as the gearbox is a sensitive device in wind power systems. The mathematical model of a PMSG is similar to that of a wound rotor synchronous machine and is expressed in the rotor reference frame (dq frame) [3].

Wind energy, even though abundant, varies continually as wind speed varies throughout the day. Amount of power output from WECS depends upon the accuracy with which the peak power points are tracked by the MPPT controller. The MPPT control used in this paper is based on directly adjusting the DC-DC converter duty cycle 'D' based on the result of the comparison of wind generator output power [6]-[7]. The wind turbine characteristics of a typical turbine is shown in Figure 2, from which we understand that the maximum power point is obtained when, The maximum power is tracked by searching the rectified DC power rather than environmental conditions. In order to search for maximum power at any wind speed, four conditions must be met. The maximum power searching process is initiated by setting an arbitrary DC side voltage reference V_{ref}. The controller then measures both the DC side current and voltage. [4] [9]

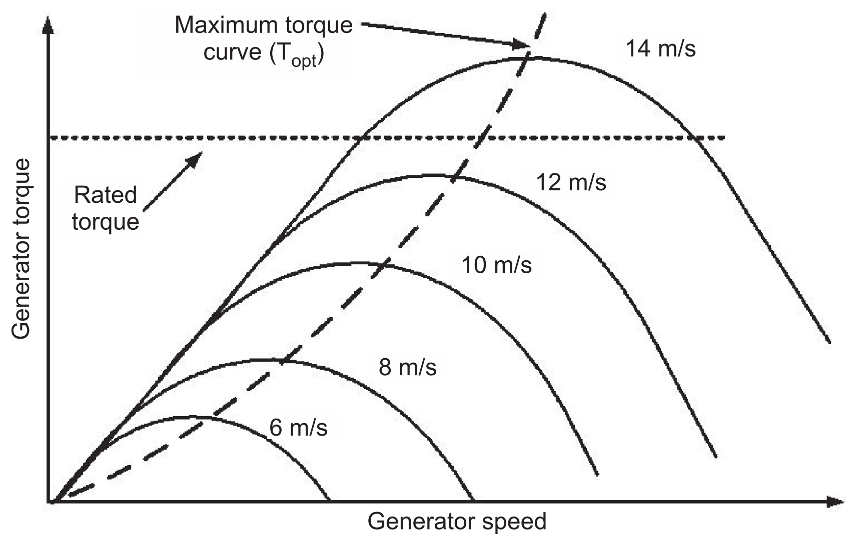

Figure 2: Wind Turbine Characteristics

3. FIVE LEVEL INVERTER TOPOLOGY

Diode Clamped Five-Level Inverter

The first invention in five level converters was the neutral point clamped inverter. It has been shown that the principle of diode clamping can extended to any level. A diode clamped leg circuit is shown in Figure 3 the main advantages and disadvantages of this topology are:

Advantages:

- High efficiency for the fundamental switching frequency.
- The capacitors can be pre-charged together at the desired voltage level.
- The capacitance requirement of the inverter is minimized due to all phases sharing a common DC link.

Disadvantages:

- Packaging for inverters with a high number of levels could be a problem due to the qudratically relation between the number of diodes and the numbers of levels.

- Intermediate DC levels tend to be uneven without the appropriate control making the real power transmission a problem.
- Uneven rating in the diodes needed for the converter.

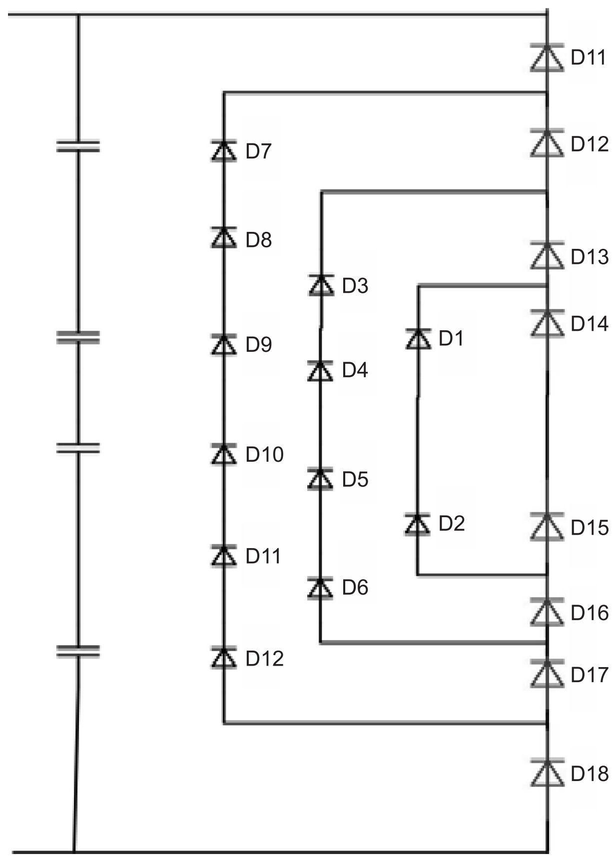

Figure 3: Diode clamped

Two diodes are used to conduct the current loop, and four power electronic switches are used to control the voltage levels. The output voltage of the basic diode clamped five level inverter has five levels. The control for balancing these two DC capacitors is very important. [5]

4. FIVE-LEVEL INVERTER TOPOLOGY AND SPWM TECHNIQUE

The proposed five level inverter topology consists of the level module units. A level module unit is constructed by a DC voltage source and a bidirectional switch capable of conducting current and blocking voltage in both directions. Advantage of this switch structure is that each level module unit requires only one .It is shown that this structure consists of two basic parts. The first is the side of level module units producing DC voltage levels. The second is diode clamped topology, which generates both of the positive and the negative output voltages. There are different switching states to obtain a full period of the output voltage in 5-level five level inverter. [6] [9]

Figure 6 shows the circuit configuration of the five-level inverter applied to a wind power generation system. As can be seen, it is configured by a wind turbine, a DC–DC converter, a Five-Level inverter, two switches, and a SPWM based controller.

As shown in the Figure 4 the SPWM technique is designed for Five-Level inverter. And from the Figure 5 we can observe the switching states of FLV combined with SPWM Technique.

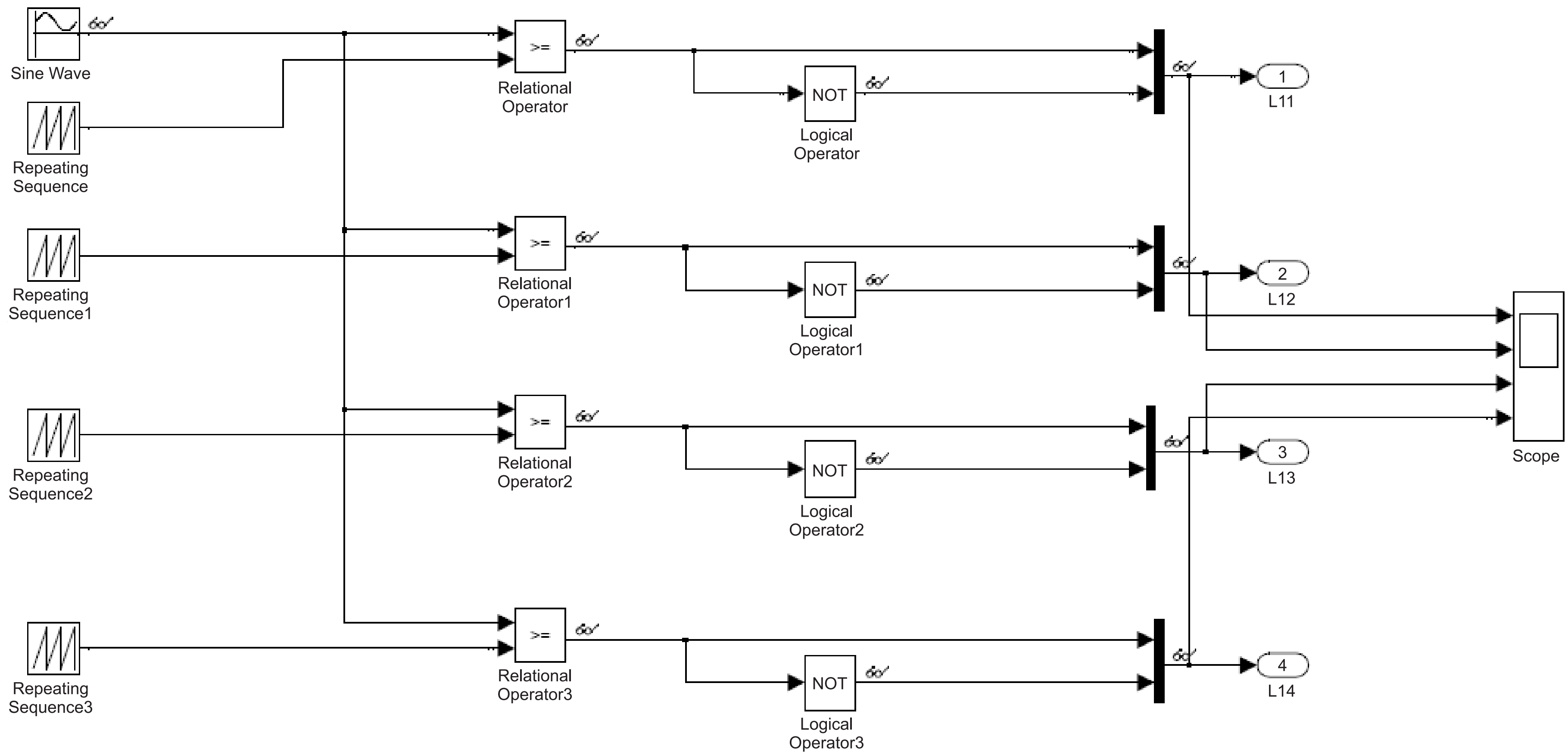

Figure 4: SPWM Technique

Table 1
Switching states of Five-Level inverter

Voltage \ *Switches*	*A11*	*A12*	*A13*	*A14*	*A21*	*A22*	*A23*	*A24*
V5 = Vdc	1	1	1	1	0	0	0	0
V4 = 3Vdc/4	0	1	1	1	1	0	0	0
V3 = Vdc/2	0	0	1	1	1	1	0	0
V2 = Vdc/4	0	0	0	1	1	1	1	0
V1 = 0	0	0	0	0	1	1	1	1

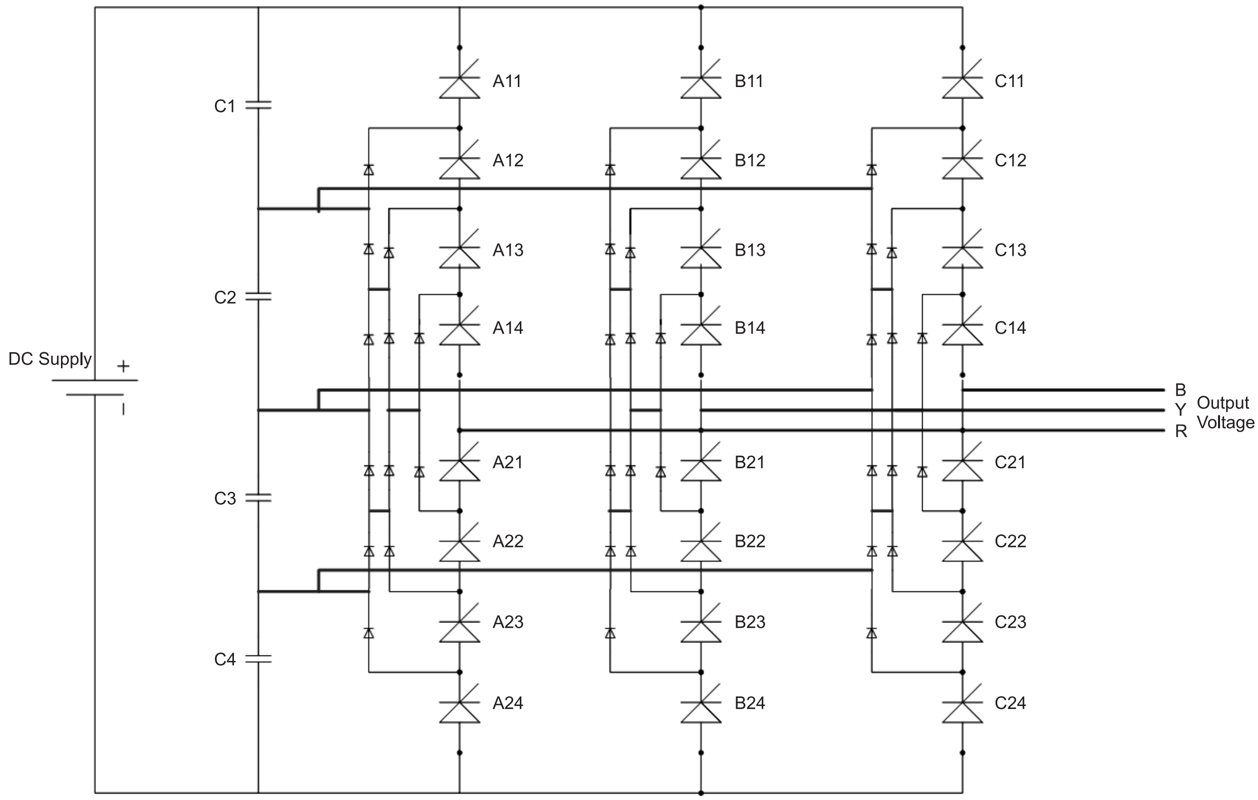

Figure 5: Five-Level Inverter with Wind grid connected

5. PROPOSED POWER CONVERTER STRUCTURE

The base configuration of the proposed grid connected Wind system is presented in Figure 6. This system consists of wind turbine, AC-DC power converters, and five level DC-AC power converter. Wind turbine is connected to an AC-DC converter. The output of these converters is the DC power supply of the five level DC/AC power converter. The proposed Five-Level inverter uses a four-wire voltage source inverter. [10]

As shown in the below Figure 6 the MATLAB construction of wind energy source interfacing to grid using Five-Level inverter is designed.

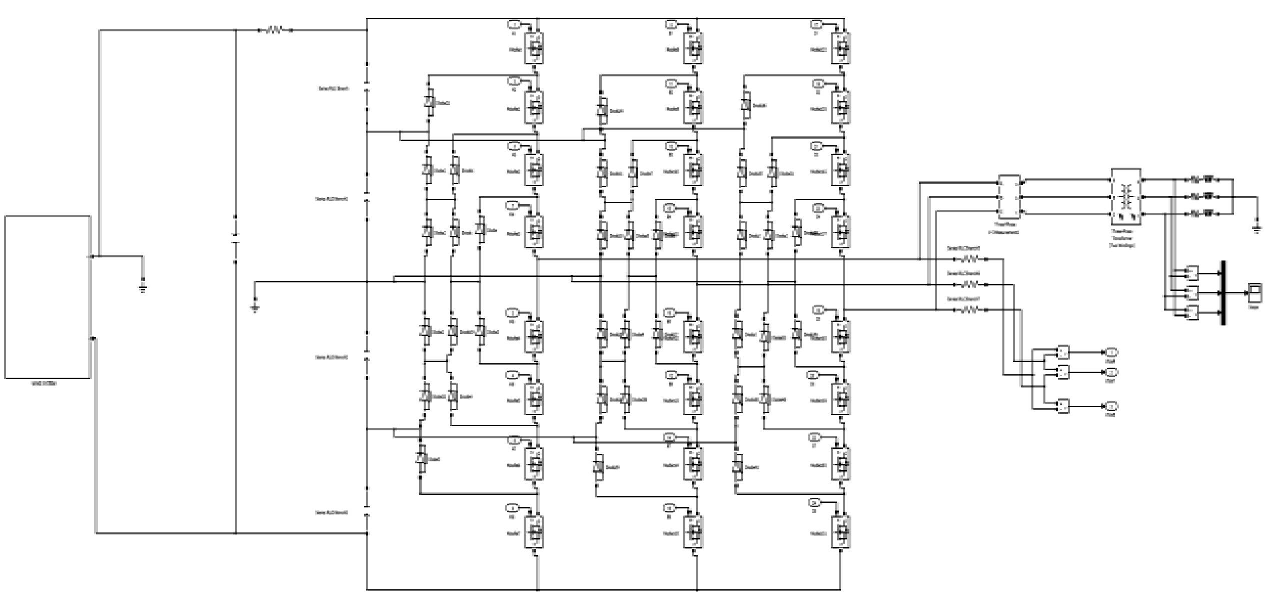

Figure 6: MATLAB structure of Wind energy interfacing to grid using Five-Level inverter

6. SIMULATION RESULTS

The performance of the proposed structure is assessed by a computer simulation that uses MATLAB Software. The parameters of the proposed system are given in the tables below. The performance of the system with proposed control scheme is discussed, which includes the following case studies.

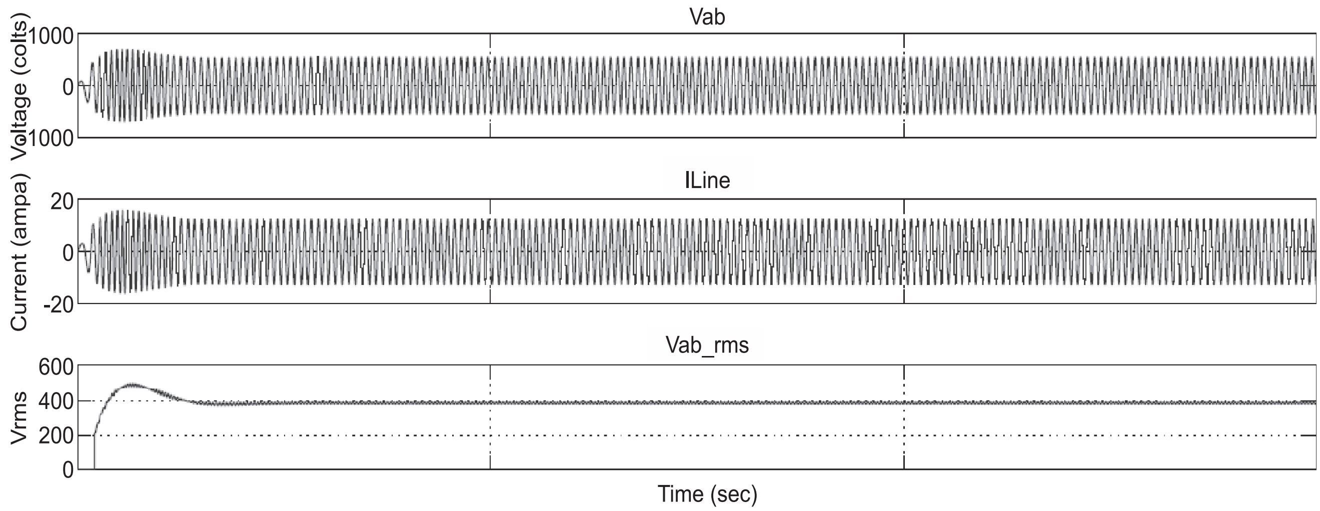

Figure 7: Output Voltage, Current and RMS voltage of wind energy system

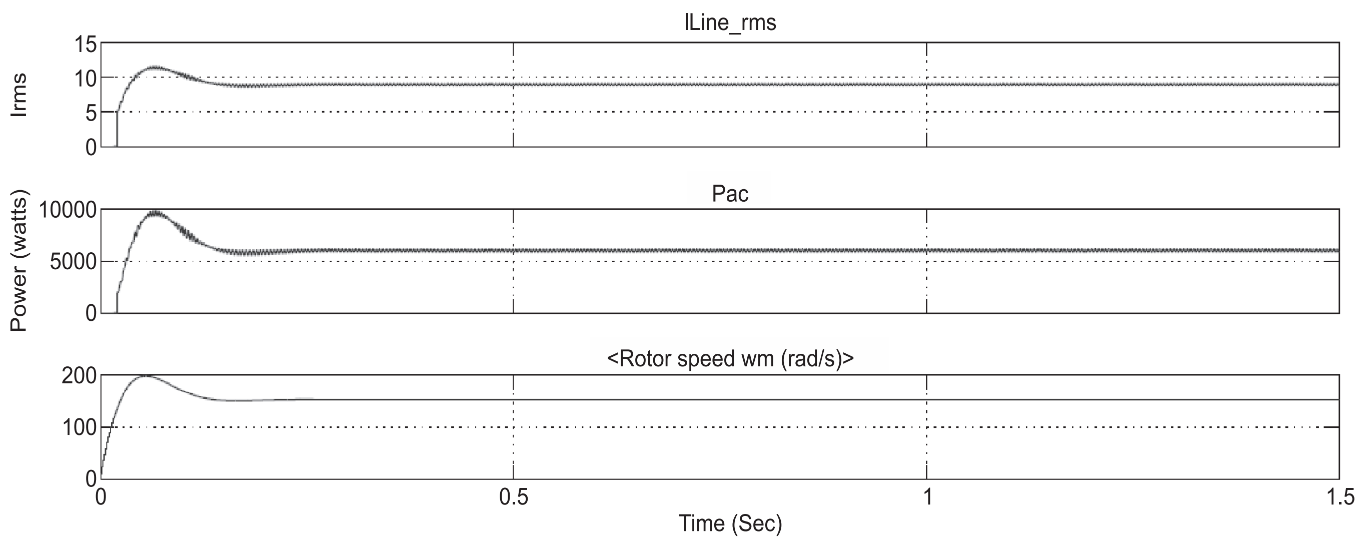

Figure 8: Output of RMS current, Power and Rotor speed of wind energy system

7. CONCLUSION

A diode clamped five level inverter is well suited for the grid interface of a higher power rated wind energy conversion system. The proposed fixed switching frequency control leads to an equal and uniform distribution of the switching stress among the various switches. In this paper, improvised Diode clamped Five-level inverter used for wind grid integration application has been presented. The performance Evaluation of the five-level inverter is done on MATLAB platform. Control strategy based on SPWM topology is very simple technique for grid integration. This is follows under the Voltage level and phase angle between voltage and current. The THD level is much improvised in this system and the final output THD is 2.91% for this improvised Five-Level inverter.

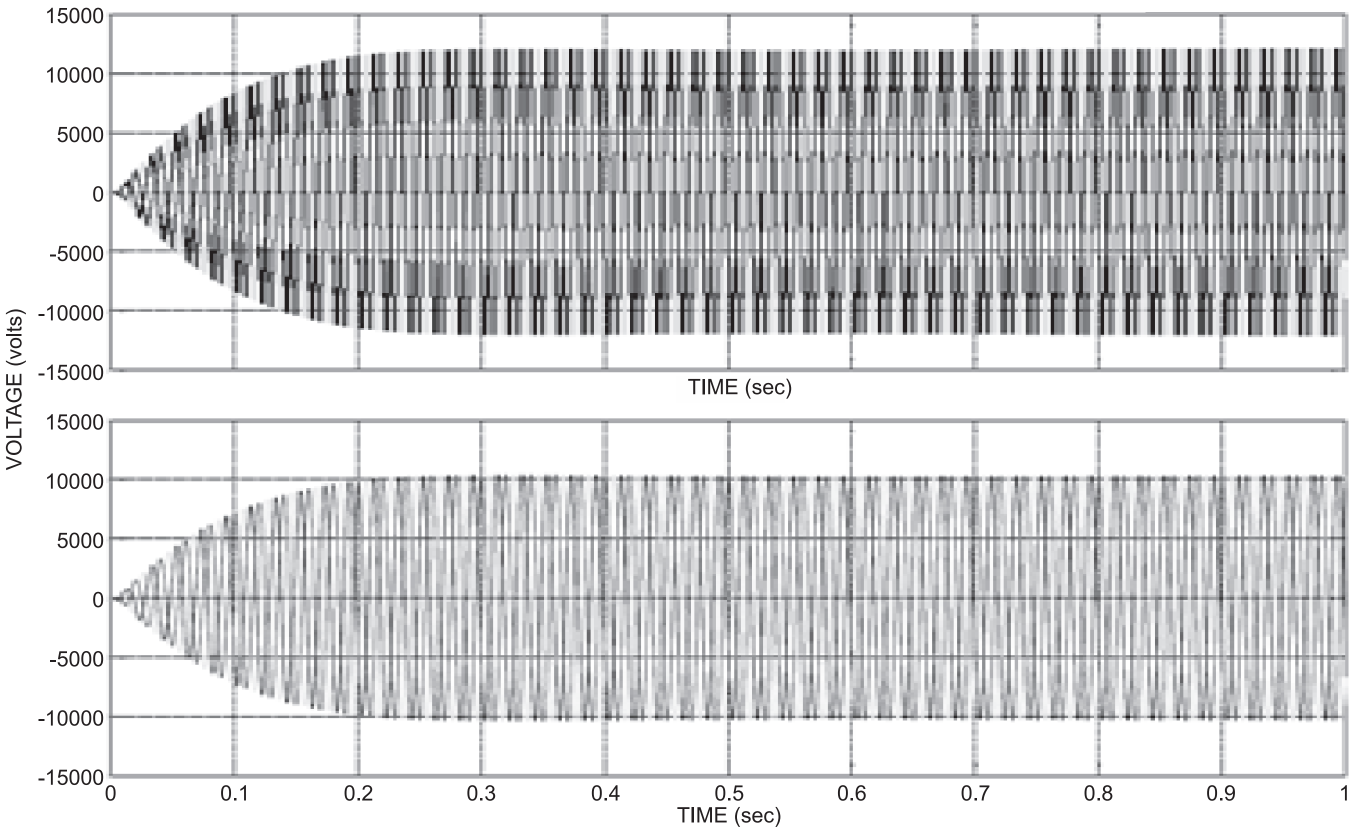

Figure 9: Output of Five-Level inverter

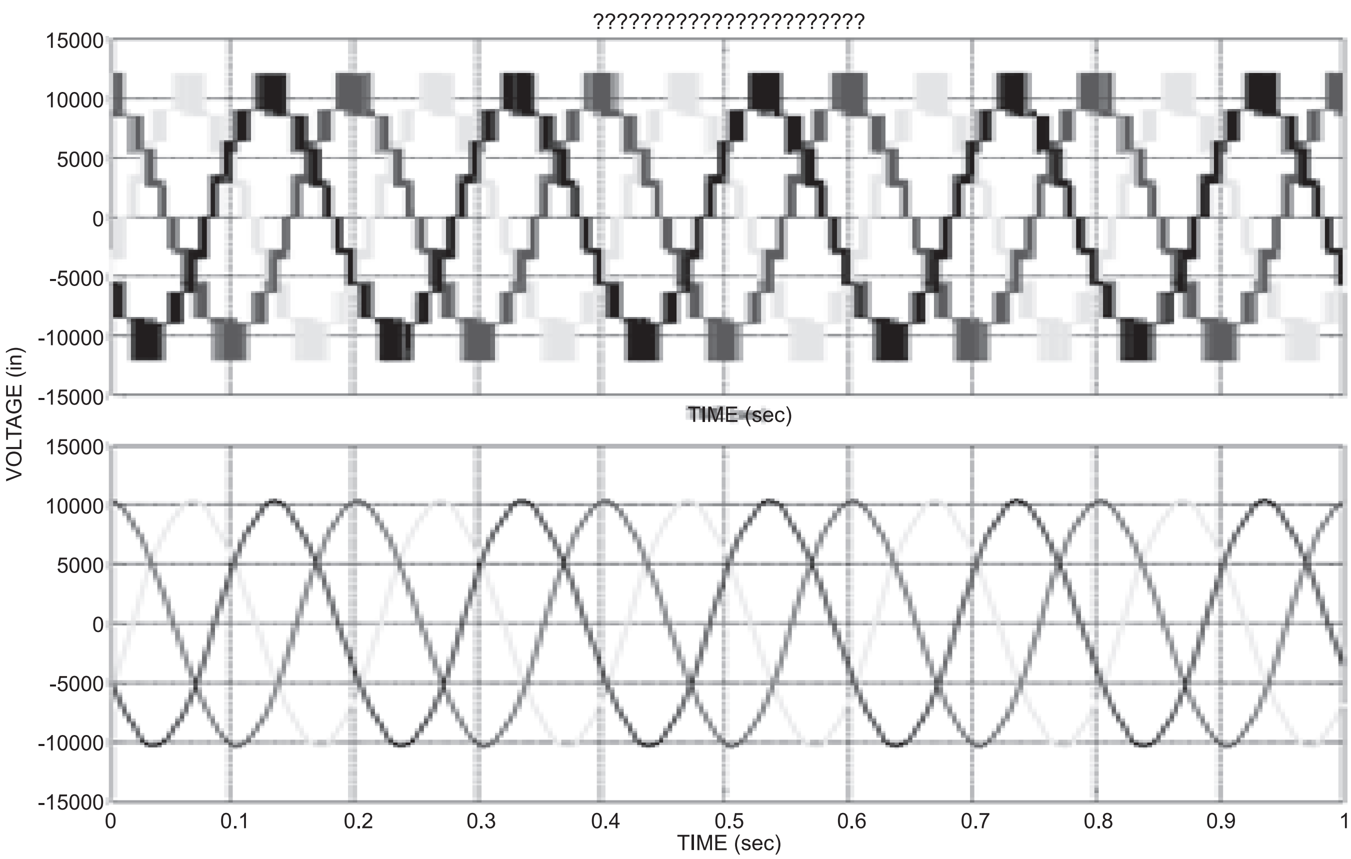

Figure 10: Output of Five-Level inverter after connecting with the wind energy source

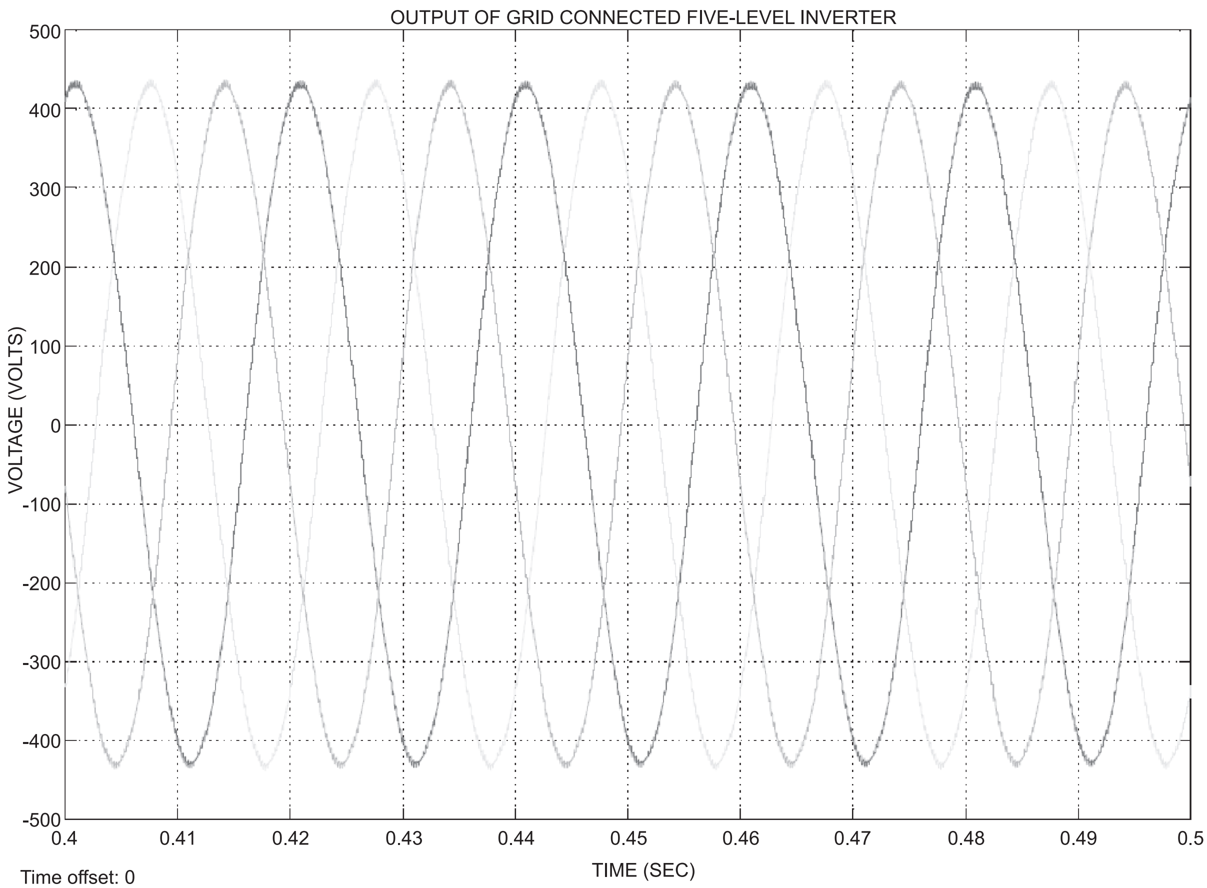

Figure 11: Output of grid voltage

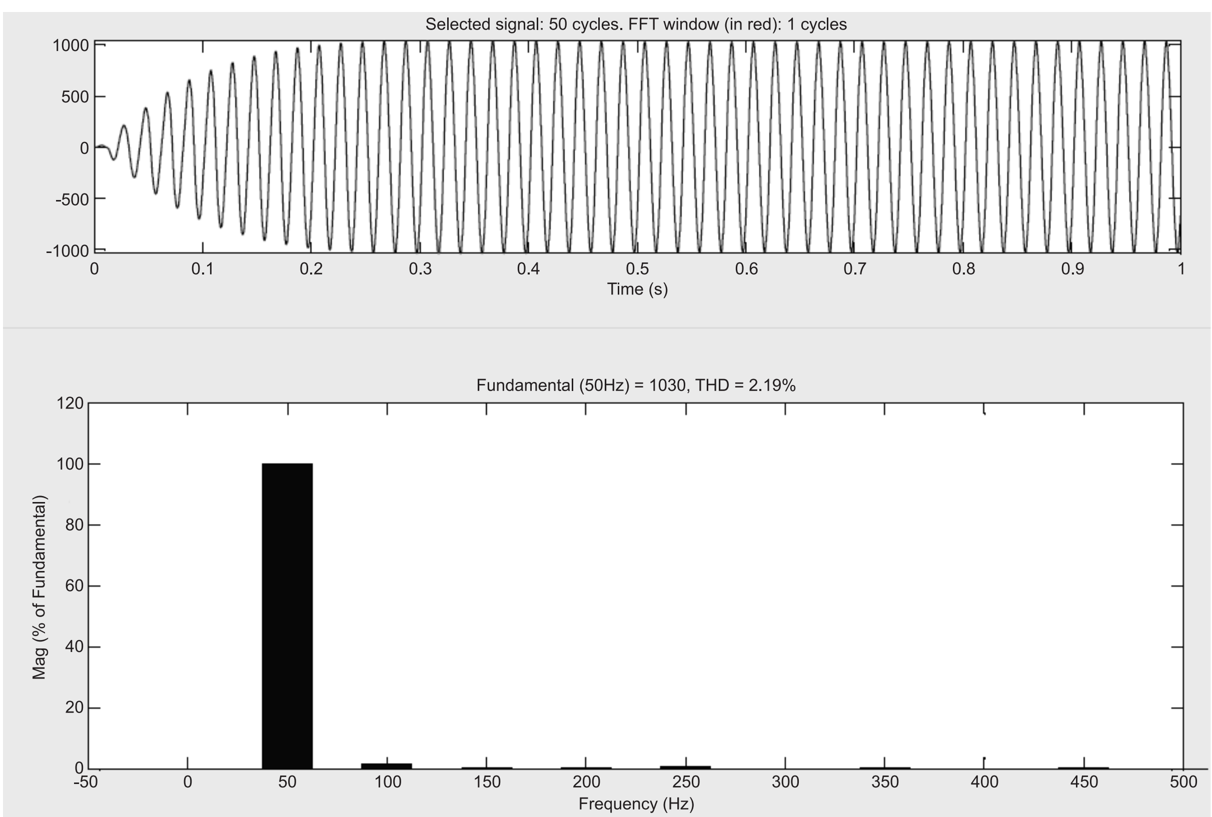

Figure 12: THD = 2.91% for sinusoidal output of FLV

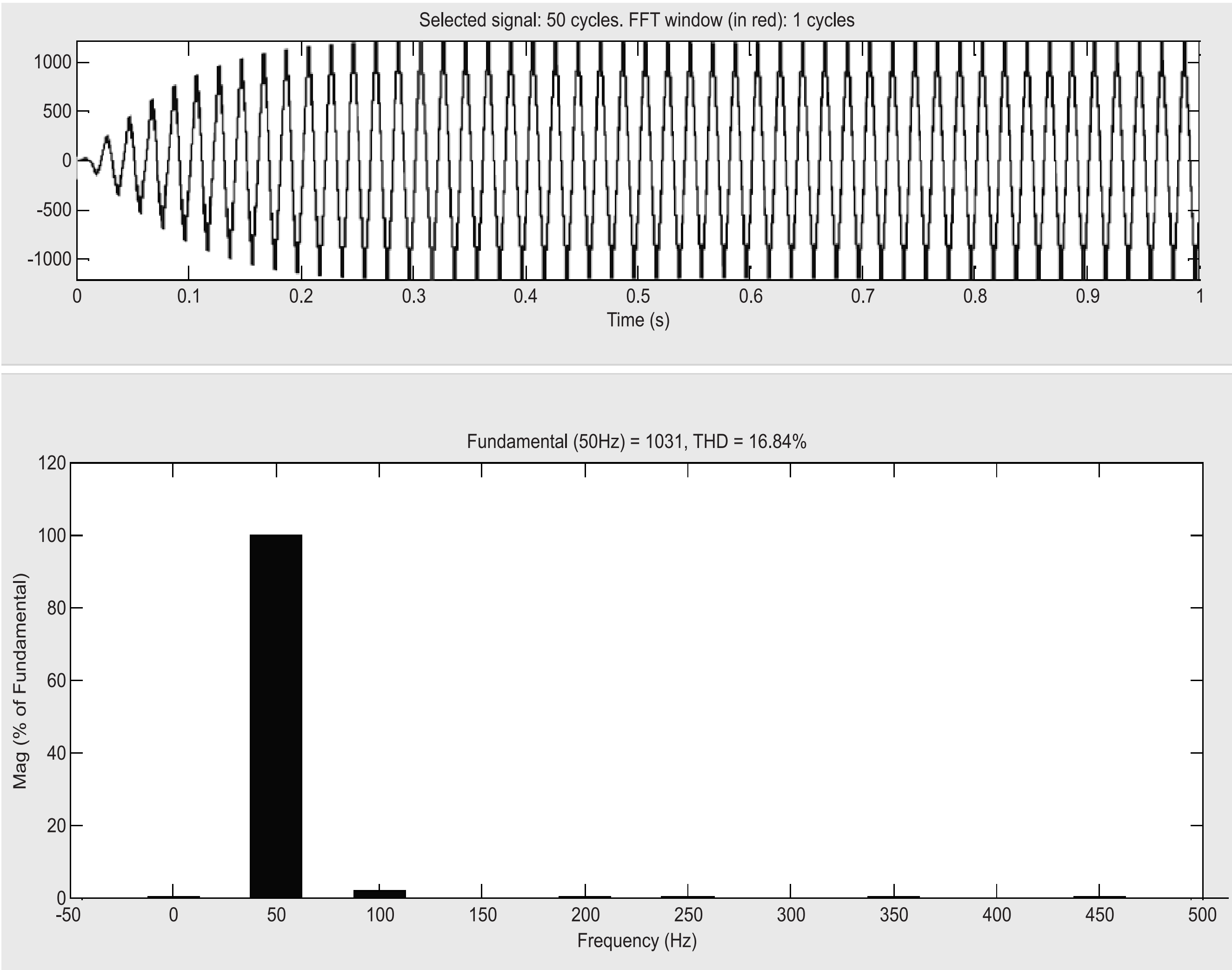

Figure 13: THD = 16.84% for Five-Level voltage output

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