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Control of the reactive power supplied by a WECS based on an induction generator fed by a matrix converter

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This paper introduces an integrated energy storage and reactive power compensation in a large wind power plant, and it deals to regulate the reactive power supplied by a variable-speed Wind Energy Conversion System (WECS), based on an induction generator fed by a Matrix Converter (MC). The control strategy used in this paper is input current observer, implemented using an estimation of the modulation index, and a nonlinear control loop that regulates the displacement angle at the matrix converter input. This paper is described the implemention of the matrix converter to control the reactive power by using the Space Vector Pulse Width Modulation (SVPWM) technique in large wind farms and combining them into one system to maintain stability control of the wind power plant. Control of reactive power increases the regulating capacity, which can provide voltage stability in the wind farm. In this work, Matlab/Simulink™ model and simulation of the three phase matrix converter have been performed using the space vector control algorithm. The algorithm uses a simpler method than the other control algorithms to control the input power factor. To verify the performance of the proposed Matrix Converter, modulation strategy, and control design methodology, various simulation results are presented.

Keywords: *Wind Energy Conversion System (WECS), reactive power, Matrix Converter (MC), modulation index, induction generator, input current observer, SVPWM.*

1.0 INTRODUCTION

Wind power is very consistent from year to year, but has significant variation over shorter time scales. In the past, the power generated from the generator was transmitted directly to the grid without any kind of energy storage. Regardless of power demands during the peak and off-peak hours. Therefore, Wind power is extracted from air flow using wind turbines or sails to produce mechanical or electrical power. Windmills are used for their mechanical power, wind pumps for water pumping, and sails to propel ships. Wind energy as an alternative to fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during than those from other power sources. Large wind farms can consist of hundreds of individual wind turbines, which are connected to the electric power Transmission network. The Gansu Wind Farm, the largest wind farm in the world, has several thousands of turbines. Onshore wind is an inexpensive source of electricity, competitive with or in many places cheaper than coal, gas or fossil fuel plants. Offshore wind is steadier and stronger than on land, and offshore farms have less visual impact, but construction and maintenance costs are considerably higher. Small onshore wind farms can feed some energy into the grid or provide electricity to isolated off-grid

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locations. It is therefore used in conjunction with other sources to give a reliable supply. As the proportion of wind power in a region increases, a need to upgrade the grid, and a lowered ability to supplant conventional production can occur. Power management techniques such as having excess capacity, geographically distributed turbines, dispatchable backing sources, sufficient hydroelectric power, exporting and importing power to neighboring areas, using Vehicle-to-grid strategies or reducing demand when wind production is low, can in many cases overcome these problems. In addition, weather forecasting permits the electricity network to be readied for the predictable variations in production that occur. Wind is a free and unlimited source of energy that has attracted many people for its energy security and environmental benefit. With increasing construction of large wind power plant around the globe, maintaining control, stability becomes an important aspect of the wind power plant.

This paper will discuss the technical problems, many wind power plants need to solve in order to operate in a stable state. One of the major technical challenges for wind power plant is power fluctuation in the output. The power fluctuation is caused by the variations of the wind speed inducing the generator to produce different power levels at varying times. A large wind power plant, power fluctuation can lead to voltage variation at the interconnection point of the grid. The use of energy storage devices can smooth the power fluctuation; subsequently, it will improve power distribution of the wind power plant and will control stability of the wind power plant when subjected to any voltage fluctuations. Another major technical concern is the reactive power regulation in large wind farms. The amount of the reactive power produced or absorbed by the wind farm and the grid changes because of the power changes at different wind speed. So, the size and number of wind farms contribute the energy production are growing, the reactive power produced in large scale wind farms cannot be ignored. As the wind power scale continues to expand, all the influence of wind power on energy quality shouldered by power grid is not economic and even unaffordable. Therefore, it is totally necessary to make appropriate reactive power compensation within wind farm to be constructed. This paper introduces an integrated energy storage and reactive power compensation in a large wind power plant. The energy storage serves as auxiliary sources of energy for the wind farm during dynamic changes result in power fluctuations. Reactive power compensation can increase the reactive power regulating capacity, which can provide voltage stability in the wind farm. A control strategy is developed in this paper to manage system stability in wind power plants.

2.0 WIND TURBINES

Wind turbines operate on a simple principle. The energy in the wind turns two or three propeller-like blades around a rotor. The rotor is connected to the main shaft, which spins a generator to create electricity [1-3]. A wind turbine works the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.

Wind turbine produces electricity by using the power of the wind to drive an electrical generator[4]. Wind passes over the blades to exerting turning forces to turns the shaft inside the wind turbine, which goes into a gearbox. The gearbox increases the rotational speed to induce a magnetic field in the generators, and then converted into electrical energy.

Wind is a form of solar energy and is a result of the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and the rotation of the earth. Wind flow patterns and speeds vary greatly and are modified by bodies of water, vegetation, and differences in terrain. Humans use this wind flow, or motion energy, for many purposes: sailing, flying a kite, and even generating electricity. The terms wind energy or wind. Power describes the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity. Modern wind turbines fall into two basic groups: the horizontal-axis variety and the vertical-axis design, Horizontal-axis wind turbines typically either have two or three blades [5-8].

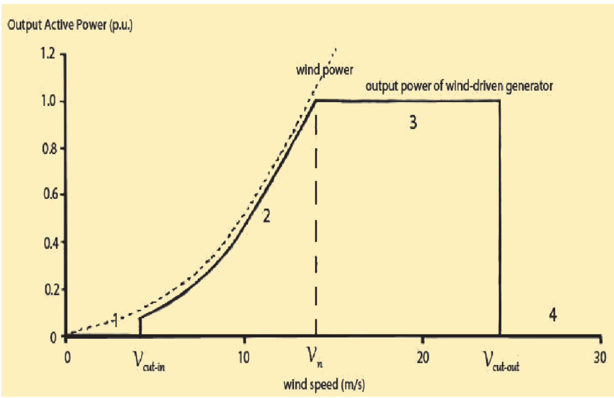

FIG. 1 THE POWER OF AIR FLOW TO THE WIND TURBINE

The generated power of air flow to the wind turbine characteristics are shown in Figure 1. This characteristics describes the out put power of the wind turbine varies with wind speed and it will given by the following equations.

$$P_{air} = \frac{1}{2} pAv^3 \quad ....(1)$$

Where,

p = air density, 1.255 kg/m^3

A = swept area rotor, m^3

v = wind speed,

The equation above gives the power available in the wind the power transferred to the wind turbine rotor is reduced by the power coefficient,

$$C = \frac{P_{wind\ turbine}}{P_{air}} \quad ....(2)$$

Where

$$P_{wind\ turbine} = \frac{1}{2} CpAv^3 \quad ....(3)$$

2.1 Mechanical Gearbox

The mechanical connection between an electrical generator and the turbine rotor may be direct or through a gearbox. In fact, the gearbox allows the matching of the generator speed to that of the turbine. The use of gearbox is dependent on the kind of electrical generator used in WECS. However, with a gearbox the system efficiency and, in some cases, the system reliability reduces. Control Method with the evolution of WECS during the last decade, many different control methods have been developed. The control methods developed for WECS are usually divided into the following two major categories:

- Constant-speed
- Variable-speed

Current fluctuations caused by the blades passing the tower and various current amplitudes caused by variable wind speeds. The fluctuations related to the electrical parts, such as voltage harmonics, is caused by the electrical converter. The electrical harmonics can be conquered by choosing the proper electrical filter. However, because of the large time constant of the fluctuations in mechanical components, they cannot be cancelled by electrical components. One solution that can largely reduce the disturbance related to mechanical parts is using a variable-speed wind turbine. The power output disturbance of a typical wind turbine with the constant-speed and variable-speed methods, as shown in Figure 2.

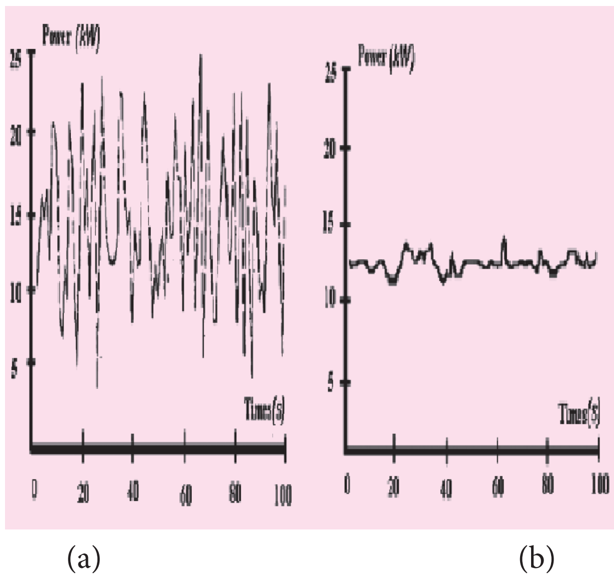

FIG. 2 POWER OUTPUT DISTURBANCE OF A TYPICAL WIND TURBINE WITH (A) CONSTANT-SPEED, (B) VARIABLE-SPEED

From Figure 2 says the power variations are more in the usage of constant speed wind turbine rather than the usage of variable speed wind turbines. So that in more applications variable speed generators are used for the power generation like Doubly Fed Induction Generator.

3.0 ANALYSIS OF CONVERTERS FOR WECS

Converters are the family of power electronic devices, it plays an important role in modern WECS. With variable speed control method. The constant speed systems hardly include a converter except for compensation of reactive power. The important challenges for the Power Electronic converter and its control strategy in a variable speed WECS are attain maximum power transfer from the wind, as the wind speed varies, by controlling the turbine rotor speed, and Change the resulting variable-frequency and variable-magnitude AC output from the electrical generator into a constant-frequency and constant-magnitude supply which can be fed into an electrical grid. The most common converter configuration in variable-speed wind turbine system is the rectifier-inverter pair. Which is shown in Figure 3.

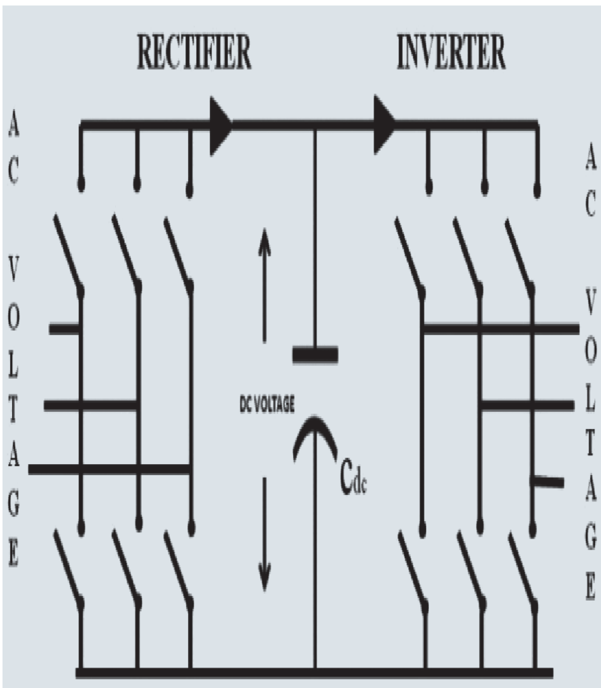

FIG. 3 RECTIFIER-INVERTER PAIR STRUCTURE

A matrix converter, as a direct AC/AC converter, has potential for replacing the rectifier-inverter pair structure and among three phase AC to AC converters. It is the most commonly used device. The dc-link energy-storage element provides decoupling between the rectifier and inverter. From the Converter analysis the converters are classified as.

1. Matrix converter
2. Single Phase Matrix Converter
3. Three Phase Matrix Converter

Which are described in the subsequent sections of this paper

3.1 Matrix Converter

Matrix converter is a device which converts variable AC input supply to the required constant AC supply as output without any intermediate conversion process, whereas in case of Rectifier - Inverter configuration which converts AC - DC - AC which takes more extra components as diode rectifiers, filters, charge-up circuit but not needed those in case of matrix converters. It is worth noting that due to its inherent bi-directionality and symmetry a dual connection might be also feasible for the matrix converter: a current- fed system at the input and a voltage- fed system at the output. The main advantage of matrix converter is elimination of the DC link filter, Zero switching loss devices can transfer input power to output power without any power loss. The switching frequency of the device decides the Total Harmonic Distortion (THD) of the converter. Maximum power transfer to the load is decided by the nature of the control algorithm. Matrix converter has a maximum input, output voltage transfer ratio limited to 87% for sinusoidal input and output waveforms, which can be improved. Further, matrix converter requires more semiconductor devices than a conventional AC-AC indirect power frequency converter. Since monolithic bi-directional switches are available, they are used for switching purposes. Matrix converter is particularly sensitive to the disturbances of the input voltage to the system.

This can be attenuated by intelligent control technique and the fuzzy controller has at least effect due to input side disturbance. In this paper simulation of the single phase matrix converter and three phase matrix converter are obtained from a simplified simulation model and more over single phase matrix converter, types of switching patterns, and simulation model of the matrix converter are described in the further following sections.

3.2 Single Phase Matrix Converter

The AC/AC converter is commonly classified as an indirect converter which utilizes a DC link between the two AC systems and converter that provides direct conversion. This converter consists of two converter stages and energy storage element, which convert input AC to DC and then reconverting DC back to output AC with variable amplitude and frequency. The operation of this converter stage is decoupled on an instantaneous basis of the energy storage elements and controlled independently, as long as the average energy flow is equal. A single phase matrix converter switching arrangement as shown in Figure 4.

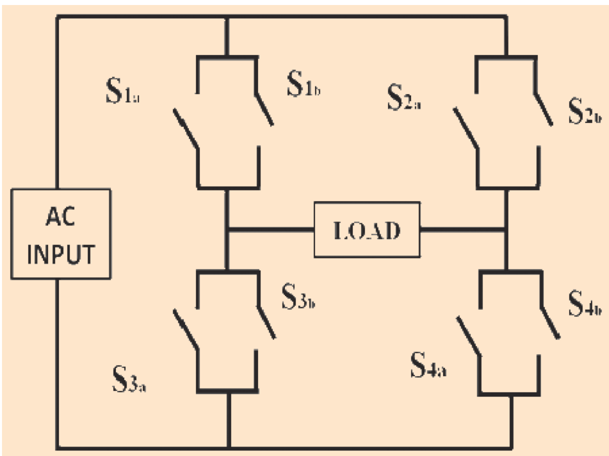

FIG. 4 SINGLE PHASE MATRIX CIRCUIT CONVERTER

The equivalent circuits of single phase matrix converter as shown in Figure 5 to Figure 8. In Figure 9 1_A, 1_B, 2_A and 2_B are gate drive pulses to the single phase matrix converter. The working of three phase matrix converter will be described in the next section of this paper.

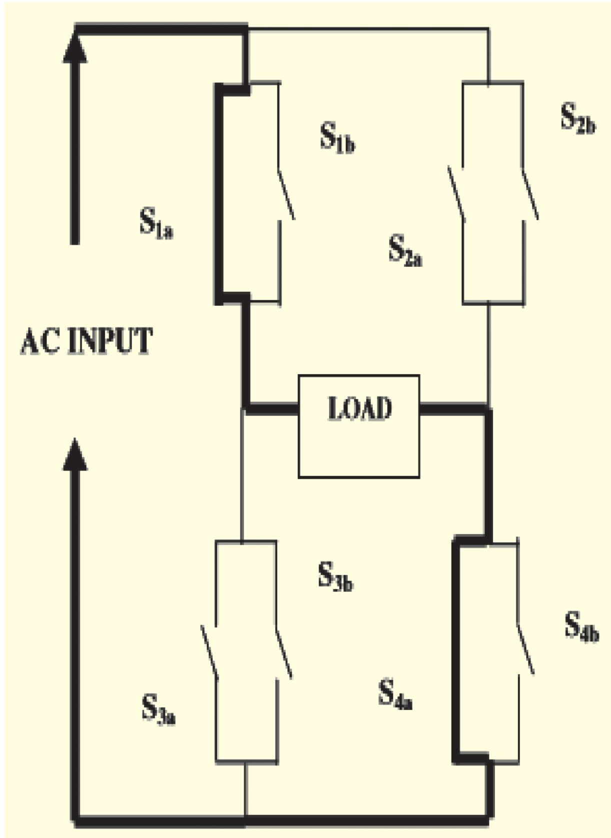

FIG. 5 $S1_A$ AND $S4_A$ SWITCHED ON DURING POSITIVE HALF CYCLE

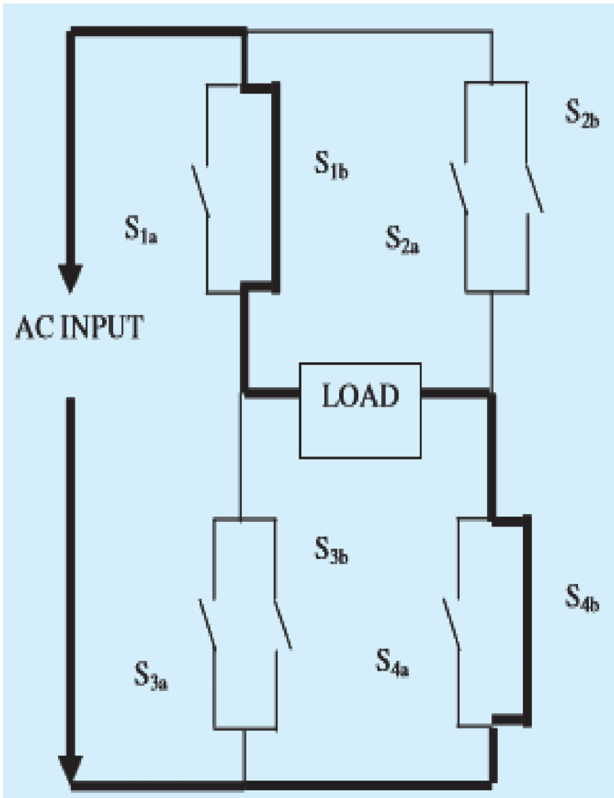

FIG. 6 $S1_B$ AND $S4_B$ SWITCHED ON DURING NEGATIVE HALF CYCLE

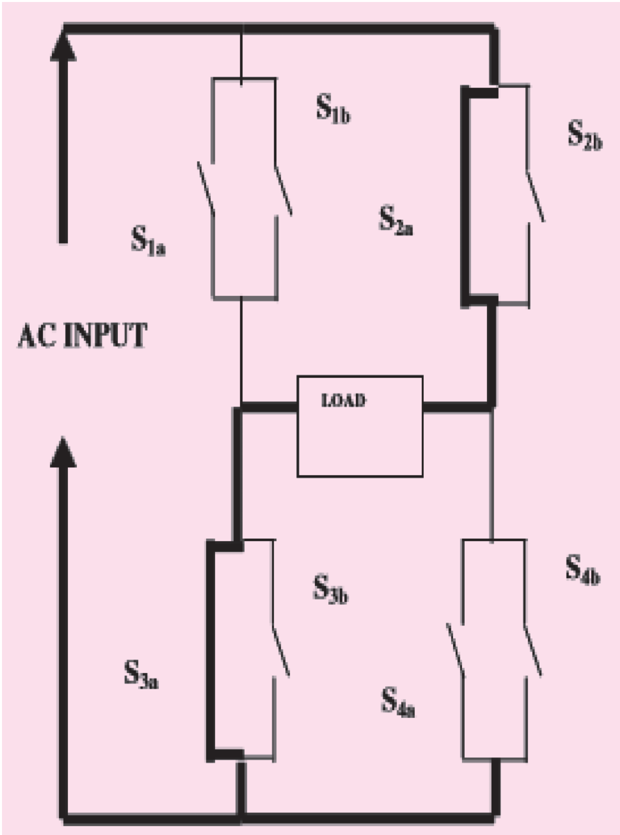

FIG. 7 S_{2A} AND S_{3A} SWITCHED ON DURING POSITIVE HALF CYCLE

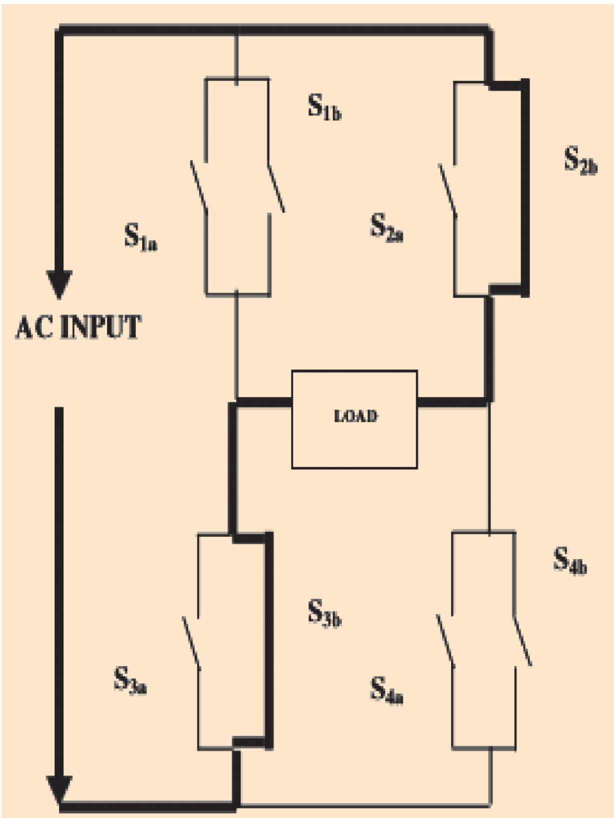

FIG. 8 S_{2B} AND S_{3B} SWITCHED ON DURING NEGATIVE HALF CYCLE

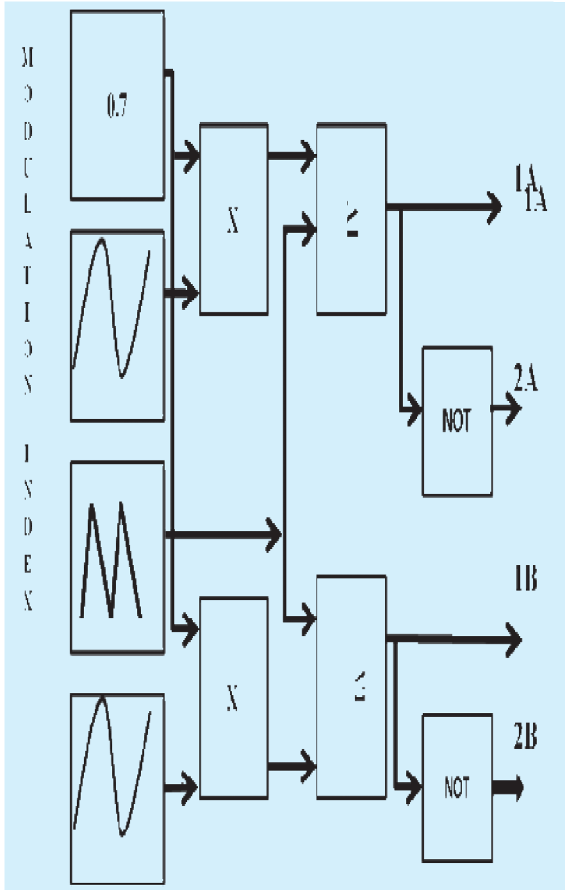

FIG. 9 GENERATION OF SINUSOIDAL PULSE WIDTH MODULATION GATE PULSE

3.3 Three Phase Matrix Converter

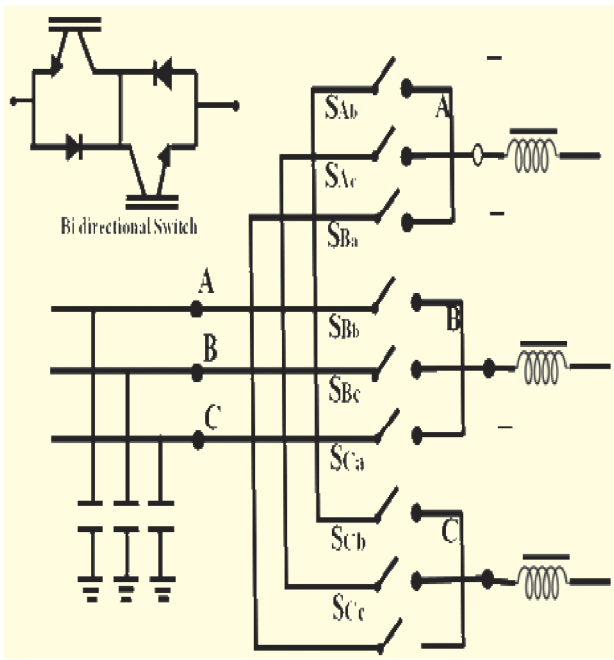

FIG. 10 CIRCUIT SCHEME OF A THREE PHASE MATRIX CIRCUIT CONVERTER

Three phase matrix converter consists of nine bidirectional switches shown in Figure 10. It has been arranged into three groups of three switches. Each group is connected to each phase of the output. These arrangements of switches can connect any input phase. With nine bi-directional switches the matrix converter can theoretically assume 512 (2^9) different switching state combinations. But not all of them can be usefully employed. Among them only 27 switching states are used to operate this converter, for safe operation and it should follow the given rules.

- Do not connect two different input lines to the same output line (input short circuited)
- Do not disconnect the output line circuits (output open circuited)

The Matrix Converter requires bidirectional switches with the capability to block the voltage and to conduct the current in both directions. There are two main topologies for bi-directional switches, namely the common emitter anti-parallel IGBT configuration and the common collector anti-parallel IGBT configuration. The common emitter arrangement is represented in Figure 11 (a). There are two IGBTs are connected with two diodes in an anti-parallel configuration. The diodes provide the reverse blocking capability. The complete connection scheme of the common emitter arrangement in matrix converter configuration is as shown in Figure 16. The main advantage of this connection is that the two IGBTs can be driven with respect to the same point, i.e. the same common emitter that can be considered as a local ground for the bidirectional switch. On the other hand, each bidirectional switch requires an insulated power supply, in order to ensure a correct operation and, hence, a total of nine insulated power supplies is needed. The power supplies must be insulated because, as a bidirectional switch is turned on, the common emitter assumes the potential of an input phase. Therefore, it is not possible for all the bidirectional switches to be driven with respect to the same common point.

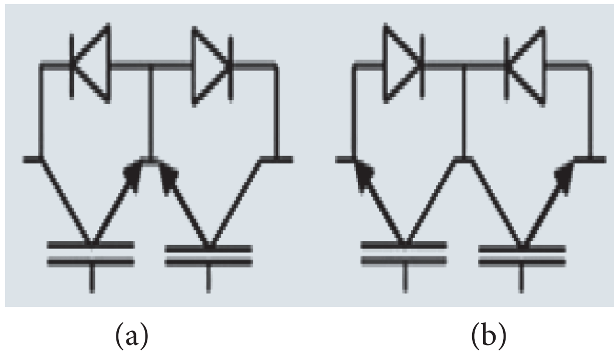

FIG. 11 BIDIRECTIONAL SWITCHES A) COMMON EMITTER CONFIGURATION B) COMMON COLLECTOR CONFIGURATION.

Figure 12 to 15 are showing different operating states of matrix converter. Here A, B and C are input phase voltages connected to the output phase. Figure 13 shows synchronous operating state vectors of three phase matrix converter. It shows that the converter switches are switched on rotational basis. In this case no two switches in a leg are switched on simultaneously. These states will not generate gate pulse when one phase of the supply is switched off.

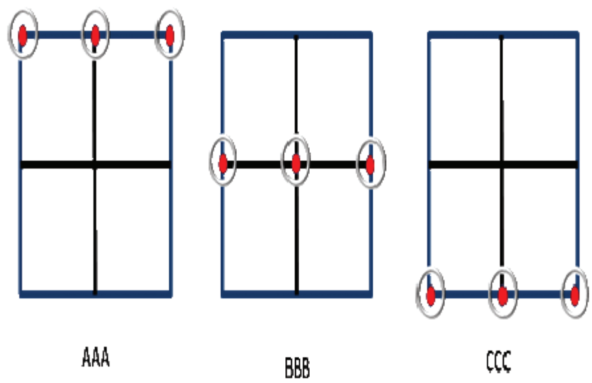

FIG. 12 MATRIX CONVERTER ZERO VECTORS

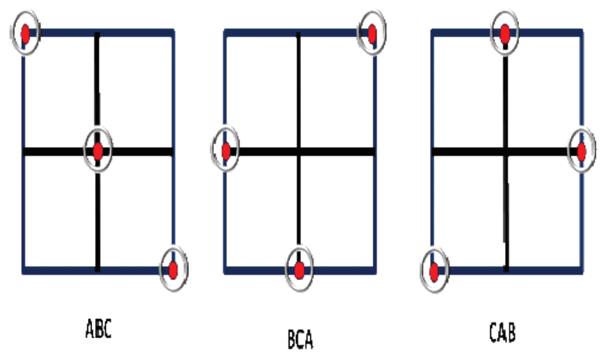

FIG. 13 MATRIX CONVERTER ROTATING VECTORS (SYNCHRONOUS VECTORS)

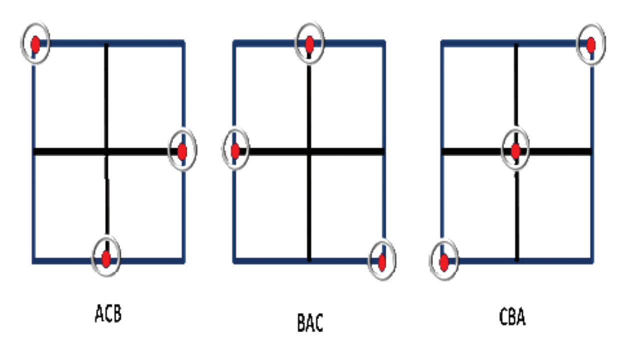

FIG. 14 MATRIX CONVERTER ROTATING VECTORS (INVERSE))OPERATION

Figure 14 shows inverse operating state vectors of three phase matrix converter. In this way one phase is rotated in such a way that it connects all the output phase in a cycle of operation. This operation may be selected during reverse operation of induction motor

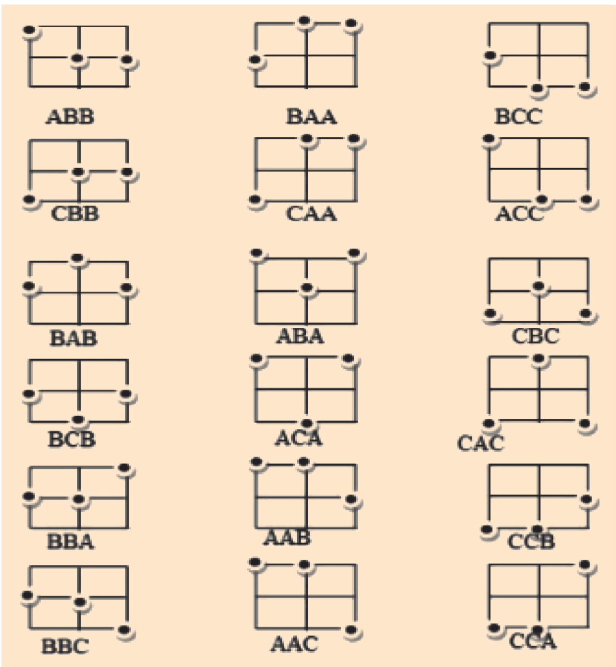

FIG. 15 MATRIX CONVERTER ACTIVE VECTORS (PULSATING)

Fig. 12 shows zero vectors of the matrix converter. Here all the output phases are connected in a single input line. It leads to damage to the device. Because three phase loads are directly connected to the single phase line. Figure 15 shows active vectors of the matrix converter which are the operating states in direct conversion. There are 18 operating states are available. We can select any combination for the operation of matrix converter. These vectors are generated by the space vector pulse width modulation strategy and to obtain the favours of the market, Matrix converter should overcome the performance of the other competitors in terms of cost, size and reliability. The most important alternative to Matrix converter is the back-to-back converter, whose scheme is shown in Figure 17.

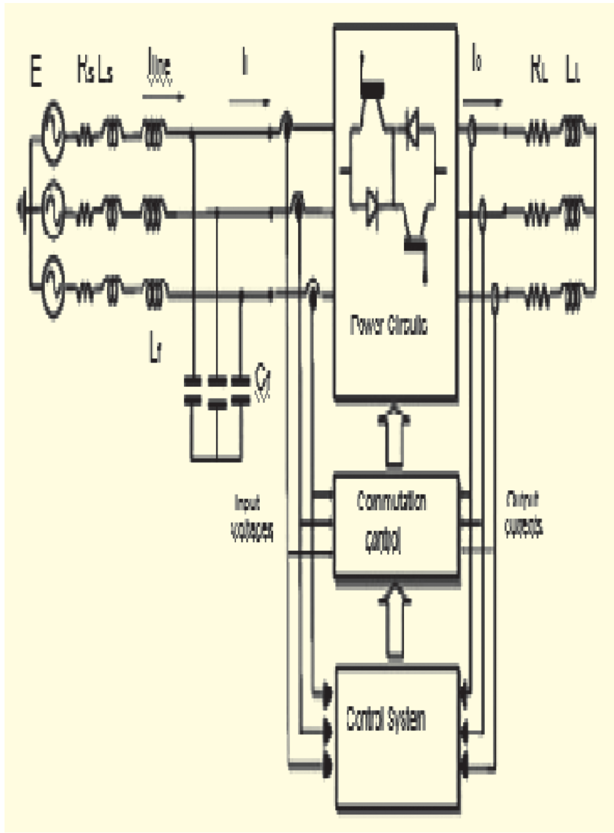

FIG. 16 COMPLETE SCHEME OF A MC SYSTEM

The Matrix converter has been compared with the back to back converter, then the comparison is extremely difficult due to the high number of system parameters such as input filter and load parameters, switching frequency, output frequency, modulation strategies, etc, and also to the inherent differences between the two converter topologies, such as the maximum voltage transfer ratio. For instance, the Matrix Converter is able to generate balanced and sinusoidal output voltages, whose amplitude can be regulated from zero to approximately 87% of the input voltage amplitude than back to back converter . The output voltage of the back-to-back converter is related to the DC-link voltage, and it can be equal or even greater than the input voltage.

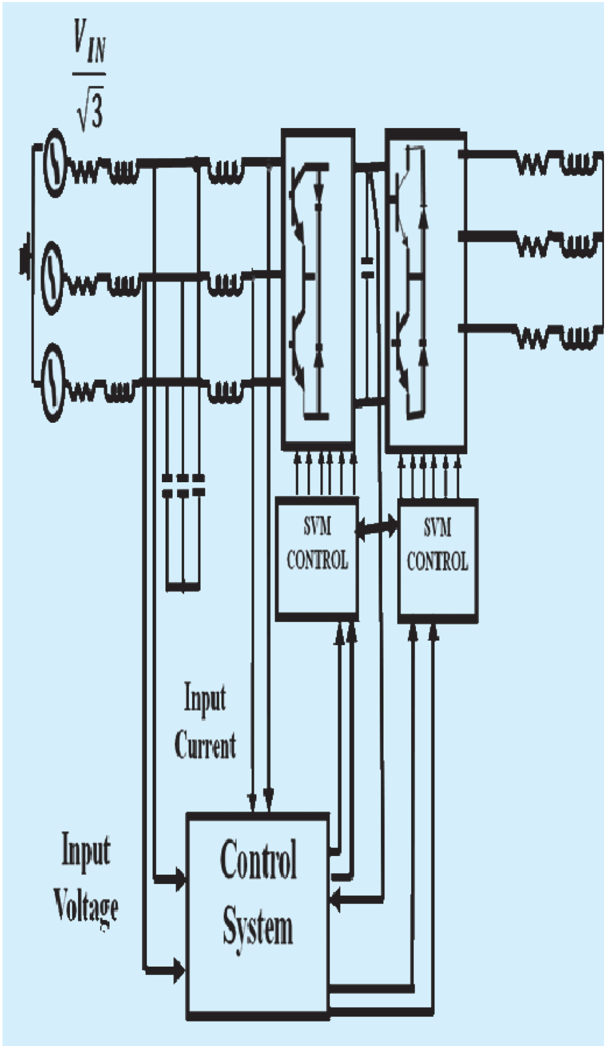

FIG. 17 SCHEMATIC DIAGRAM OF BACK TO BACK CONVERTER.

The switching frequencies of the two converters are related to the adopted modulation strategies and should be chosen with care in order to make a fair comparison. Furthermore, both converters need an input filter to reduce the input current harmonics, and the filter parameters are strictly related to the switching frequency converter.

3.4 Matrix Converter Control Strategies

The existing Matrix Converter control strategies like space vector modulation, current control modulation index and the 4-Leg Matrix Converter has been used for power supply applications. In this paper used control strategies are current control loop and modulation index. The main requirements for such a controller include capability for: (i) output voltage regulation subject to load changes; and (ii) output voltage regulation under unbalanced load conditions. The controllers used for aerospace applications cannot deploy cascade voltage and current feedback processes due to bandwidth limitations.

The proposed control strategies for power supply applications of Matrix Converter include: (i) tracking controller based on dq-frame, (ii) tracking controller based on a bc-frame or resonant-controller, and (iii) repetitive controller. The repetitive controller requires voltage regulation in case of unaccounted disturbances in the system. The tracking controller based on dq-frame can be implemented as a cascaded voltage-current feedback control or a multiple-input multiple-output (MIMO) controller. Since the cascaded knowledge of the disturbances in the system and is not guaranteed to provide a robust voltage and current feedback control has limited bandwidth and the MIMO controllers are designed in the context of balanced load, therefore, this paper considers the resonant controller strategy for the Matrix Converter. The resonant controllers are empirically designed, and cannot guarantee fast respond; therefore, this proposes a Least-Quadratic-Regulator (LQR) design approach to the design of resonant controllers. The LQR design approach provides a resonant controller that enables a fast response under any balance/ unbalance load conditions.

4.0 MATHEMATICAL MODELLING OF WECS

The mathematical modelling of Wind Energy Conversion Systems using filters such as L-C Filter, R-L-C filter and resonant filters mathematical modelling designing is explained in the subsequent sections as follows.

4.1 Mathematical Model Using L-C Filter

The whole system, which is composed by a second order L-C filter and a matrix converter operating at constant power, is represented as shown in Figure 18. The input current modulation strategy generally maintains a constant displacement angle between the input line-to-neutral voltage space vector and the input current space vector. In this case the input current modulation strategy can be expressed as

$$\overline{\Psi}_{ref} = \bar{\upsilon}_i e^{-j\varphi} \quad ....(4)$$

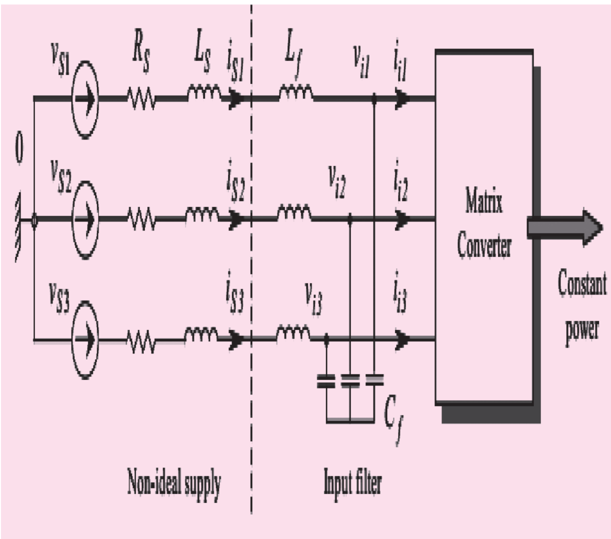

FIG. 18 BASIC SCHEME OF THE SYSTEM ANALYZED

In the following analysis, the analytical developments are carried out neglecting the effects of the switching harmonics, considering for the output voltages and input currents their average values over a switching interval.

The system equations, written using the space vector notation, are

$$\bar{v}_s = R_s \bar{\imath}_s + L_r \frac{d\bar{l}_s}{dt} \quad ....(5)$$

$$\bar{l}_f = C_f \frac{d\bar{v}_i}{dt} \quad ....(6)$$

$$\bar{l}_s = \bar{l}f + \bar{l}_i \quad ....(7)$$

$$\bar{l}_i = \frac{2}{3}\frac{P_0\bar{\Psi}_{ref}}{\bar{v}_{i.}\bar{\Psi}_{ref}} \quad ....(8)$$

Where $L_T = L_s + L_f$ and Po is the constant output power. Equation (8) is valid supposing that the converter is ideal, without power losses. In this case the output power is equal to the input power and the input current is perfectly modulated. From equations (5) to (8) it is possible to derive the nonlinear state space equations in a synchronous reference frame, which can be expressed as

$$\frac{d\bar{l}_s}{dt} = -\left(\frac{R_s}{L_T} + j\omega_j\right)\bar{l}_s - \frac{1}{L_T}\bar{v}_i \frac{1}{L_T}\bar{v}_s \quad ....(9)$$

$$\frac{d\bar{v}_i}{dt} = \frac{1}{c_f}\bar{l}_s - {}_j\omega_i\bar{v}_i - \frac{1}{c_f}\bar{l}_i \quad ....(10)$$

being ω_i the supply angular frequency.

It should be noted that the system behaviour depends on the adopted input current modulation strategy. This is emphasized by the presence in equation (8) of the space vector $\overline{\Psi}_{ref}$. Assuming for the expression given in equation (4) and using equation (8) leads for equation (10) the following new form is obtained.

$$\frac{d\bar{v}_i}{dt} = \frac{1}{C_f}\bar{\imath}_s - {}_j\omega\bar{v}_i \frac{\frac{2}{3}P_o e^{-j\omega}}{\bar{v}^*_i \cos\varphi} \quad ....(11)$$

This equation can be further simplified assuming that, which represents a unity input power factor.

4.2 Mathematical Model Using R-L-C Filter

The relationship emphasizes the positive effect of the resistance line on the system stability. Obviously, it is not possible to add a damping resistance in series with the L-C input filter, because this solution would seriously degrade the efficiency. A better solution is to add a resistance in parallel with L_f, so that, in practice, only the high frequency current harmonics flow through the damping resistance. The structure of the R-L-C type filter is shown in Figure 19. In order to show the effectiveness of this filter, the stability analysis has been carried out, but considering the third order R-L-C filter. The nonlinear state space equations of the whole system, in a synchronous reference frame, can be written as :

$$\frac{d\bar{v}_s}{dt} = -\left(\frac{1}{T_s}+j\omega\right)\bar{l}_s - \frac{1}{L_s}\bar{v}_i + \frac{R_f}{L_s}\bar{v}_{LF} + \frac{1}{L_s}\bar{v}_s \quad ...(12)$$

$$\frac{d\bar{v}_i}{dt} = \frac{1}{C_f}\bar{i}_s - j\omega\bar{v}_i - \frac{1}{C_f}\frac{\frac{2}{3}\bar{\Psi}_{ref}}{\bar{v}_i\bar{\Psi}_{ref}} \quad ....(13)$$

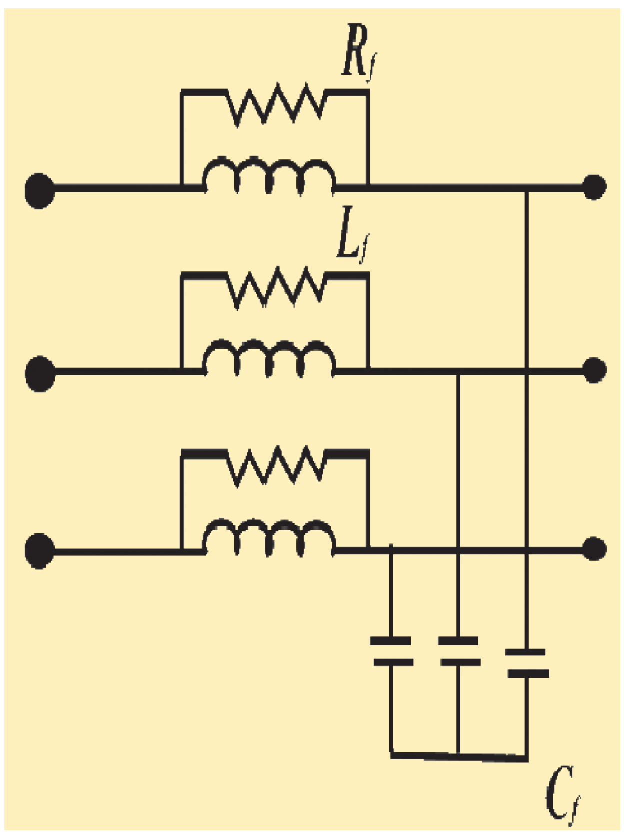

FIG. 19 TOPOLOGY OF THE R-L-C TYPE

$$\frac{d\bar{i}_{LF}}{dt} = \frac{R_f}{L_s}\bar{i}_s - \left(\frac{R_f}{L_f} + j\omega\right)\bar{i}_{LF} \quad ....(14)$$

$$\text{Being } \bar{i}_s = \frac{L_s}{R_s+R_f} \quad ....(15)$$

The above discussion explains the mathematical modeling of the Matrix Converter with filters and space vector pulse width modulation analysis.

5.0 SIMULATION RESULTS

Figure 20 : Simulink block diagram of WECS

Figure 20 shows the schematic simulink block diagram of the Wind Energy Conversion Systems consist of a Matrix Converter with pulse generation system along with the current control and space vector pulse wide the modulation system included.

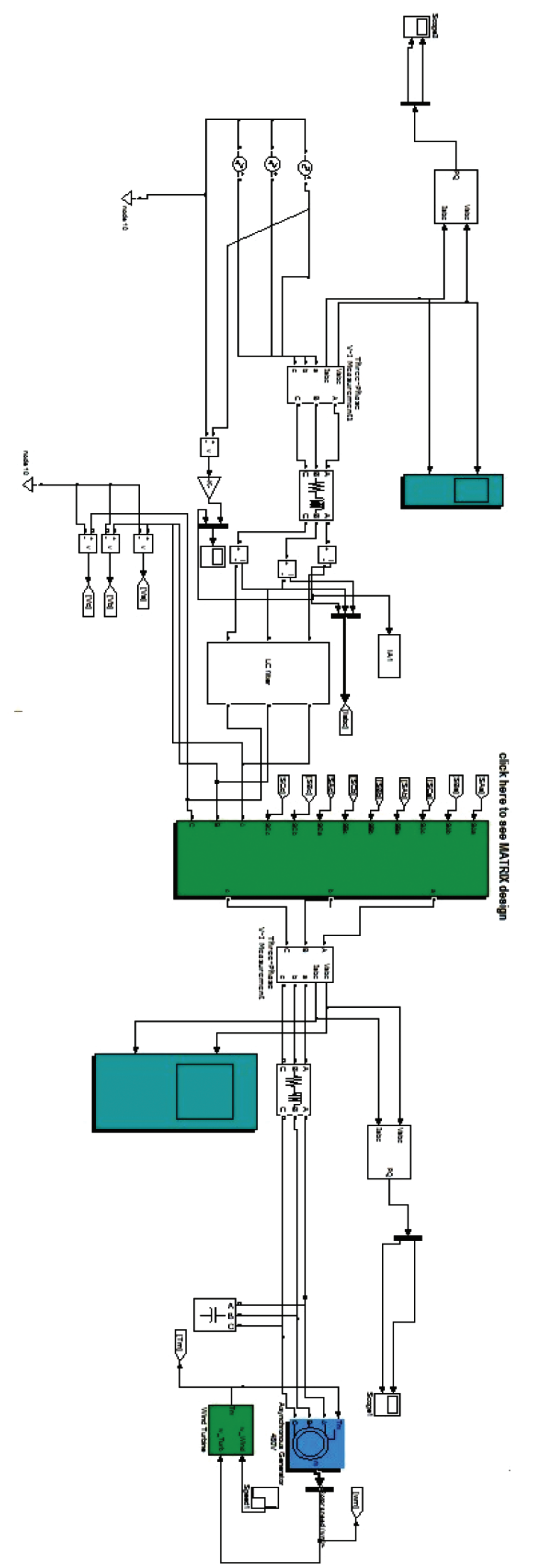

FIG. 20 SIMULINK BLOCK DIAGRAM OF WECS

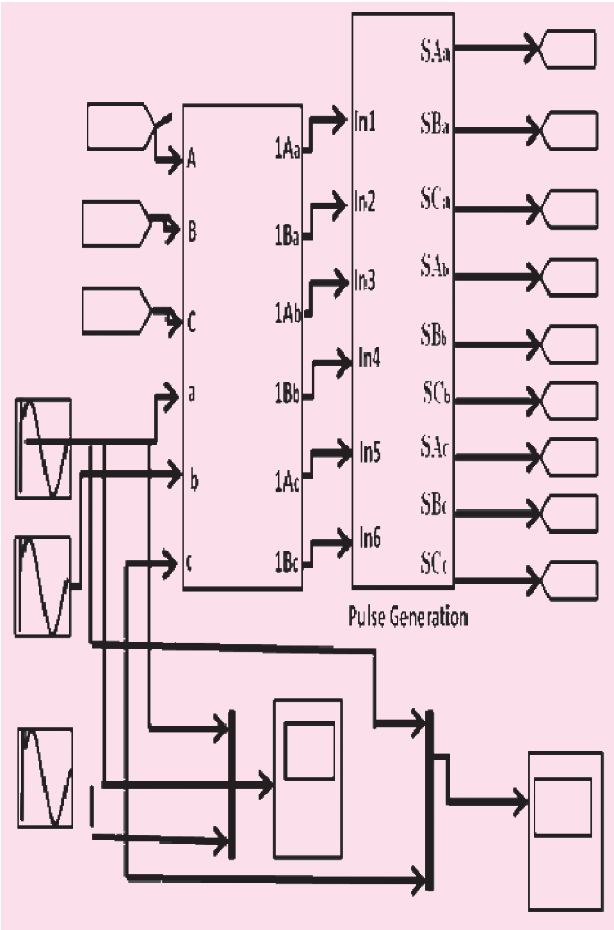

FIG. 21 PULSE GENERATION TO CONTROL MATRIX CONVERTER SWITCHES

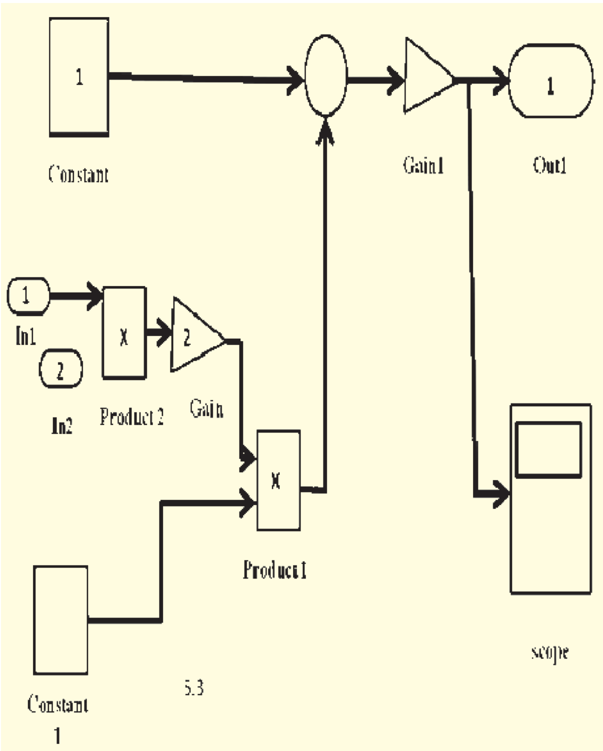

FIG. 22 REFERENECE WAVE GENERATION

Figure 21 represents the pulse generation in a Matrix converter to control the converter switching operations according to the voltage generated by the wind energy system and is compared with the reference wave generated by the system as shown in below Figure 22.

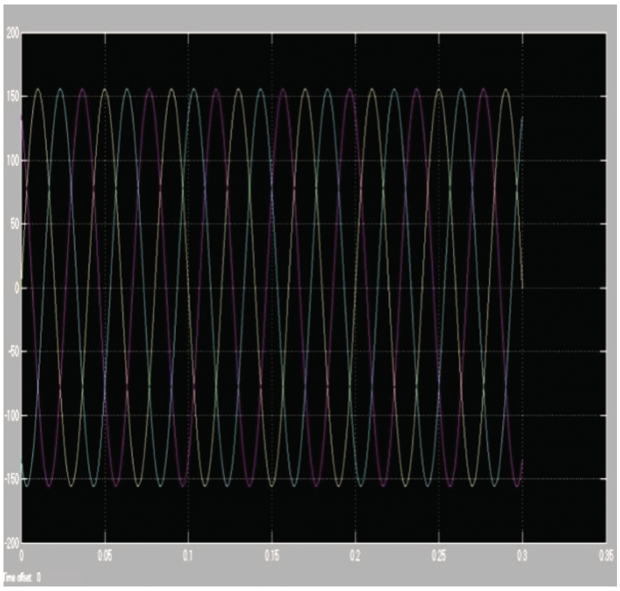

FIG. 23 REFERENCE WAVE OUTPUT

Figure 23 it represents the reference wave output which consists of time on X- axis and voltage on Y axis , here the generated voltage peak to peak is 300 volts and each wave is displaced by an angle of 120 degrees .This reference wave is used to generate the pulses corresponding to the variable voltages generated by wind generator.

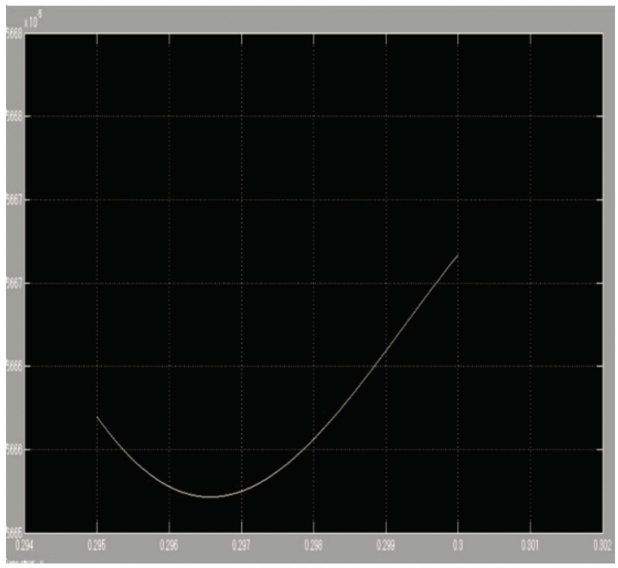

FIG. 24 GENERATED WAVE

Figure 24 shows the voltage wave of the wind energy and its corresponding equivalent reference wave pulses generated by the space vector pulse width modulation techniq used in matrix converter and its schematic diagrams are as shown in Figure 25 and Figure 26 repectively.

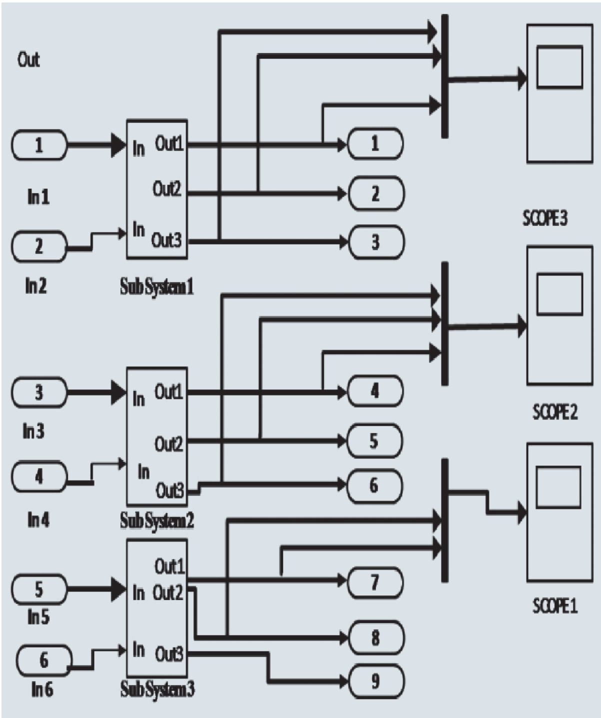

FIG. 25 PULSE GENERATOR

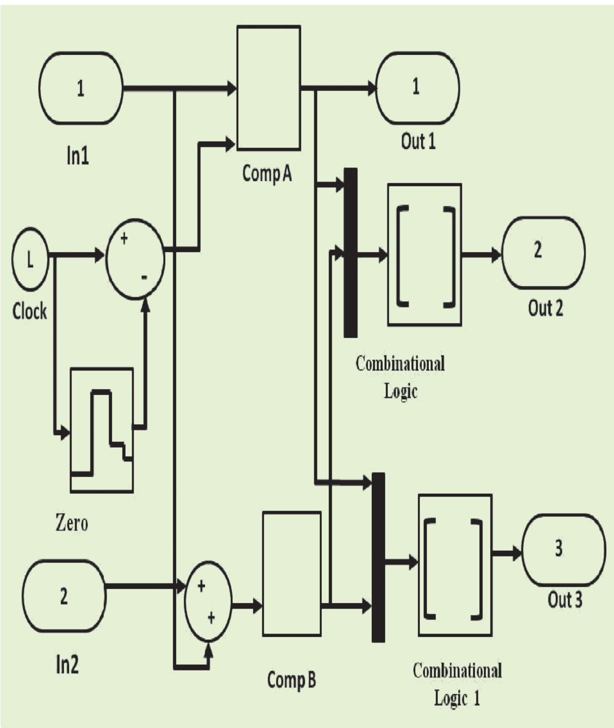

FIG. 26 SUB SYSTEM

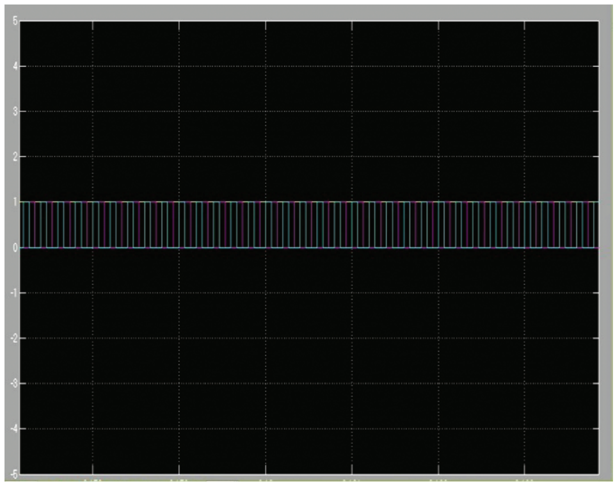

FIG. 27(A) GENERATED PULSE

Figure 27(a) and 27(b) represents the generated pulse in the matrix converter and group of pulses in the generated pulse.

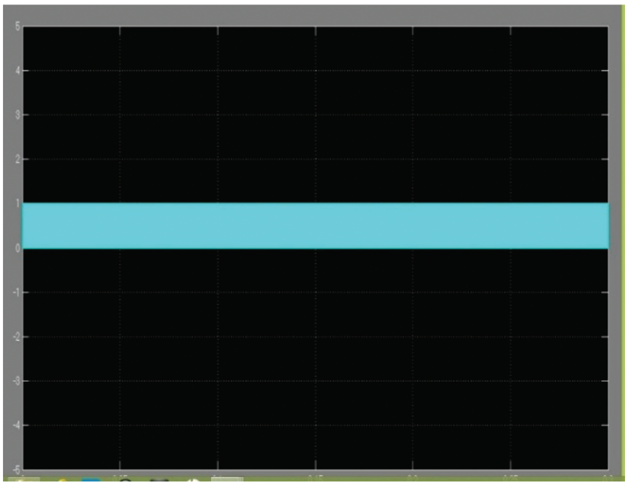

FIG. 27(B) GROUP OF PULSES IN A GENERATED PULSES

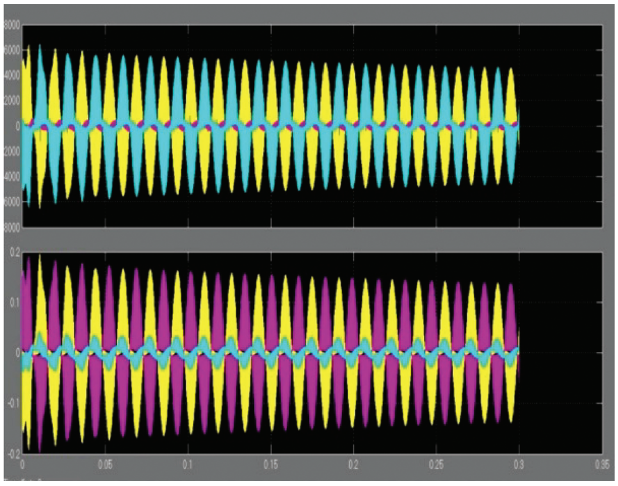

FIG. 28 THREE PHASE WAVEFORM AT THE SENDING END

Figure 28 shows that at the sending end side of the WECS the generated wave form having variable magnitude and variable dispalcement because of the variable speed in wind and correspondingly variable power generation.

Figure 29 shows that the variable power generated wave which is at sending end is converted into the constant magnitude and phase angle form at the receiving end by using the matrix converter and it is placed between the sending end and receiving end of the WECS.

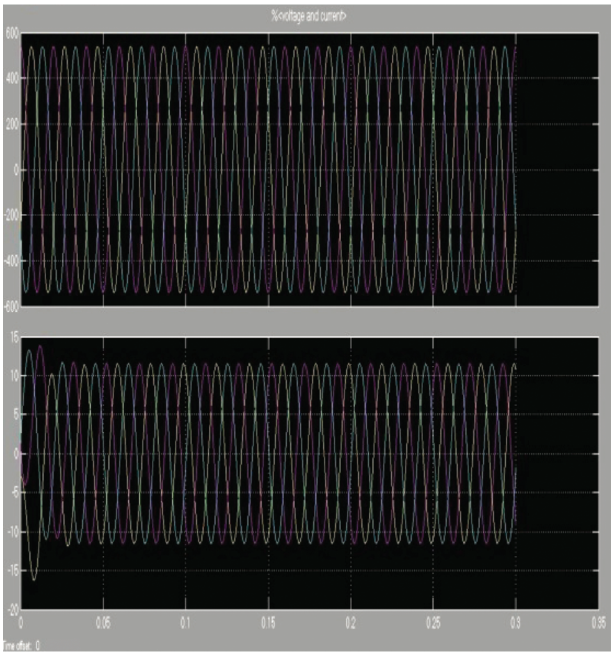

FIG. 29 OUTPUT SIDE GENERATED WAVES

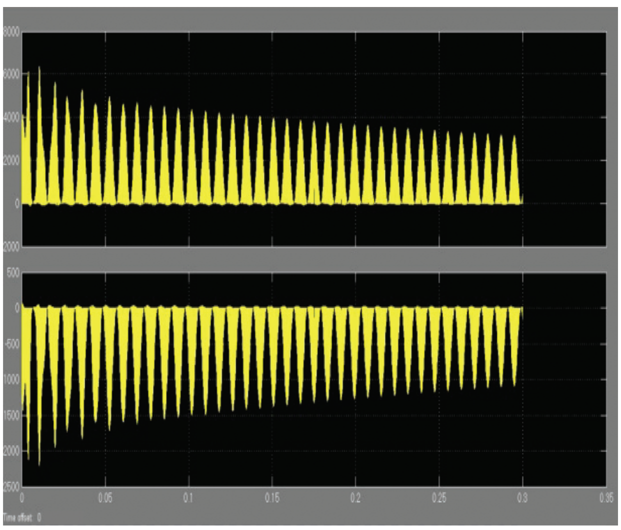

FIG. 30 ACTIVE AND REACTIVE POWER AT THE SENDING END

Figure 30 shows that the generation of the Active and Reactive powers at sending end. The Active and Reactive powers are varied due to the change in available wind speed.

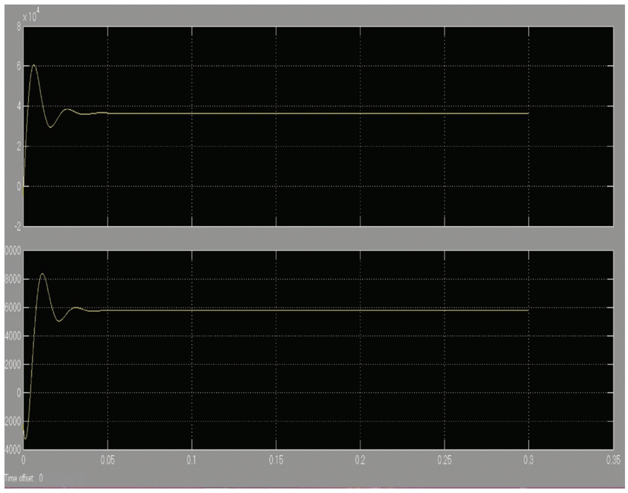

FIG. 31 ACTIVE AND REACTIVE POWER AT THE RECEIVING END

Figure 31 shows that the available active and reactive powers at the receiving end and are having constant in magnitude which are connected to the grid, even though the sending end side the power is varied. So with the help of matrix converter we supply the constant Active and Reactive powers to the grid even in the sending end side the power is fluctuates.

6.0 CONCLUSION

In this paper wind energy conversion system, including a Matrix Converter is proposed. Matrix Converter interfaces the squirrel-cage induction generator SCIG with the grid and transfers the entire power generated by the wind turbine to the grid.

A dynamic model that represents the proposed system and a closed-loop controller to track the desired active and reactive powers delivered to the grid are developed. The desired power is used as the reference for the closed-loop control of the power injected into the grid. The controller uses an algorithm to derive the maximum power that can be achieved at a given wind velocity. Matrix Converter adjusts the reactive power transfer at the grid interface to achieve voltage regulation or power factor correction.

Future work

A multilevel Matrix Converter is scalable to higher power and voltage levels. The purpose of using multilevel Matrix Converter is to improve the energy capture of the wind turbine. Studying the configuration and switching strategy of multilevel Matrix Converter, and developing a dynamic model of a wind turbine system including a multilevel Matrix Converter are suggested. To identify the wind turbine model parameters, the wind speed statistics should be collected at each operating point during long intervals. The developed model is subject to parameter uncertainty. In order to cope with the model uncertainties and design a controller accordingly, the techniques of linear robust control theory should be used.

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