IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

GRID INTEGRATED DFIG BASED WIND ENERGY CONVERSION USING SPWM AND SVPWM CONTROLLED THREE PHASE TWO LEVEL BACK TO BACK CONVERTER

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***Abstract*: A wind turbine, a doubly fed induction generator, and advanced AC/DC/AC power converters connected to the grid make up a modern type-3 wind energy conversion system. A dynamic model is required to investigate the dynamic difficulties of the wind energy conversion system. The various power converter topologies were used to do the grid stability analysis with the use of back to back converters. It's important to understand how grid integration works. This paper delves into the fundamentals of sinusoidal pulse width modulation and space vector modulation techniques, as well as their basic functioning, circuit design, topologies, and an overview of the back-to-back converter's control structure for wind power conversion systems.**

Index Terms - Wind Turbine, Doubly Fed Induction Generator AC/DC/AC power converters, sinusoidal PWM, space vector modulation

I. INTRODUCTION

Because of the expanding interest for power and worry for the climate, individuals are endeavoring to create power from environmentally friendly power sources. The fundamental benefit of utilizing sustainable power is that unsafe outflows are bountiful and non-existent. Wind energy is one of the most well-known environmentally friendly power sources in nature. Wind energy can be created by wind energy converters and #40; WECS and # 41; It comprises of wind turbines, generators, power electronic converters and comparing regulators.

Wind energy as a type of money environmentally friendly power has expanded lately. Because of rising oil costs, wellbeing measures and ecological contemplations, worldwide energy interest in 2020 will be met by just a little piece of wind energy [1]. Wind energy is an indirect energy source from the sun. Hilbert said in 1971: "The limited quantity of sun oriented radiation got by the earth is changed over into motor energy. The primary explanations behind the age of wind are the approaching net radiation, active radiation, temperature angles, earth revolution and geology at low and high scopes. The contrast between highlights. Wind energy is created by changing over the dynamic energy of moving air into usable energy. Subsequently, the monetary parts of using wind power age are extremely tricky to local breeze conditions, and wind turbines are utilized to get the greatest energy from regular breeze speeds [2].

Wind energy is as yet a significant piece of the worldwide force supply. Seaward wind energy is a perceived force age innovation. Seaward wind energy is a weight for scientists in this field. Because of the flightiness of twist, huge and medium-sized investigation fields associated with electrical cables have many irritating issues [3], [4].

FFT examination is performed on the critical electrical and mechanical boundaries, (for example, rotor speed, stator flow and electromagnetic force) that decide the exhibition of doubly-took care of engines. Lift converters and inverters are utilized as AC/DC converters in factor speed wind turbines. Regardless of how the breeze speed and generator power change, the variable recurrence got by DFIG is changed over to a decent yield recurrence. Space vector balance altogether diminishes the degree of music in the inverter circuit. In this way, reproduction ought to demonstrate the adequacy of the framework. By choosing a proper control procedure from SVPWM, the stator motion and rotor speed can be expanded to acquire the best exhibition. Use MATLAB/Simulink/Sim Power Systems to perform variable speed recreation on the total model to concentrate on the general presentation attributes of DFIG.

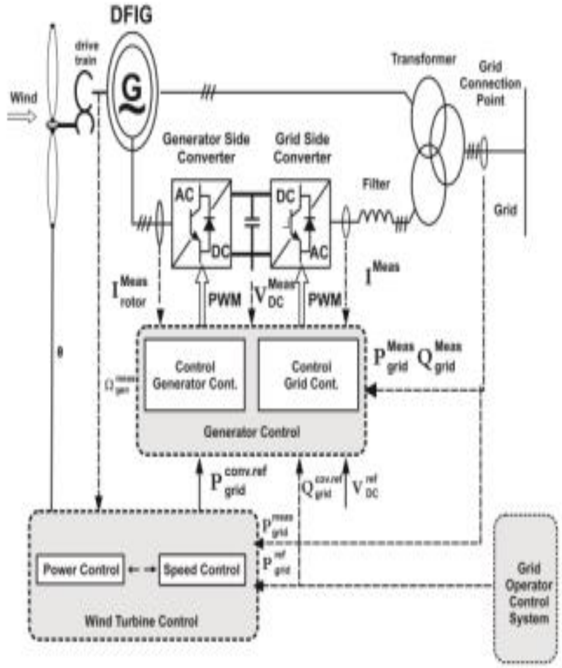


Figure 1 BT Type3 with closed-loop power converter interface

Details of annual energy are shown in Table 1. Electricity worldwide is 56.7 EJ. As a result, wind energy can be efficiently used to generate electricity.

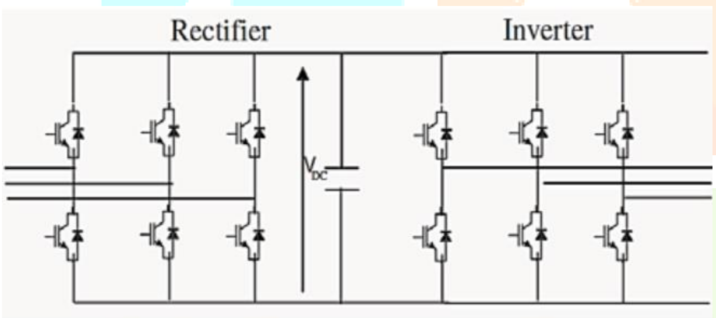
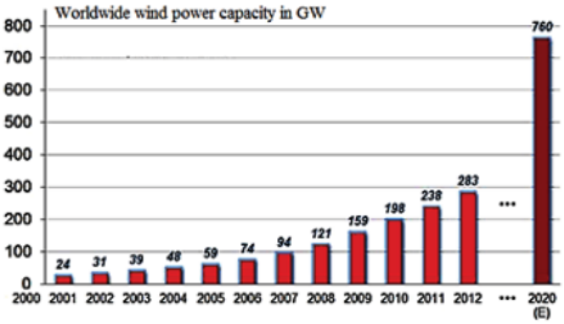


Fig. 2 Diagram of a reverse converter

Energy from sun	3,850,000 EJ
Wind energy	2,250 EJ
Biomass energy	3,000 EJ
Primary energy use	487 EJ
Electrical energy	56.7 EJ

Table 1: Annual solar flux and energy consumption

Figure 3 shows the development of wind energy production in 2001-2020, which shows that by 2020 wind energy production, is to reach 760 GW. Consequently; wind energy is a significant present day energy supply framework. Advances in power hardware and control innovation have prompted the improvement of productive Grid Connected Wind Energy Conversion Systems (WECS) [79].



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$$T = \frac{3}{2} pL_m \left(I_{rd} I_{sq} - I_{rq} I_{sd} \right)$$

Lm - common inductance

Ird - direct rotor pivotal current

Isq - quadrature stator pivotal current

Irq - square rotor pivotal current

Isd - steady stator hub current take into account, and also the rotor voltage on the d-q axis in synchronous mode. The mathematical equation for steady state electromagnetic torque can be obtained as:

$$T_g = T_s + T_r + T_{sr\cos} + T_{sr\sin}$$

Where

Ts is the asynchronous torque component from the stator supply, and Tr is the torque component from the rotor supply: Tsrcos + Tsrsin– Synchronous torque caused by the excitation of the voltage vectors of the rotor elements. The sum of the asynchronous moments Ts and Tr is approximately equal to the amplitudes of the synchronous pairs, but opposite in sign. Therefore, the magnitude and sign of the generator's total torque is mainly determined by the synchronous torque component.

II. DFIG PERFORMANCE CHARACTERISTICS

The The DFIG is a set of multistage wound rotors and a brushed multistage slip ring that provides access to the rotor windings. The stator windings are directly linked to the three-stage organization and the rotor windings are powered from the organization via a reverse voltage converter. The term "dual-force" refers to the way in which the stator voltage is supplied by the mains and the rotor voltage is generated by the force converter. This frame allows for variable speed operation over a wide range. Dual feeders are commonly used in applications where the speed of the shaft moves within a limited range around the coordinate speed. One amazing element of the DFIG compared to conventional generators is the working power that comes from the stator and rotor windings. Different things. DFIG . rotor windings work with extra energy trade between the DFIG and the framework. It can likewise enter from the electrical framework and produce receptive force through an electronic converter.

This prompts the solidness of the force supply framework and permits the machine to keep up with the organization under certain voltage unsettling influences, for example, a long voltage stroke. DFIG control is acknowledged with various voltage and force acquire controls by converters on the stator and rotor side to accomplish stable activity of the breeze turbine.

In case of a shortcoming, the current can be restricted by various calculations, dynamic and series voltage recuperation successions have been proposed for the default disappointment, a FRT crowbar running in the rotor circuit. The important factor of DFIG being used as a wind turbine is that it can operate in speed factor mode while maintaining a sufficient and repeatable output voltage level. The rationalization of the created power as indicated by the breeze speed can be handily accomplished, and the virtual sudden variety of the rotor force and the produced yield force can be acquired to accomplish the unit recurrence power factor. . Mechanical and electrical by applying a variable recurrence flow to the rotor. The activity and conduct of the DFIG is in this manner administered by the force converter and its regulator.

III. Control Strategies in dfig

Typically, inverters require high power, variable voltage and variable cycle capacity for their business. Pulse width adjustment techniques are used to achieve variable voltage and variable repeatability in the ACDC and DCAC tests. This process has also been used in applications, for example, SFC stationary circle transformers; uninterruptible power supplies UPS, DFIG, etc. Part of the main PWM measurement in a DC/AC inverter is the sine wave PWM (SPWM), which checks the triangle wave. SVM or SVPWM throttling, Irregular PWM, and Current Controlled PWM (CCPWM). The main rationale for measuring cavity width variation in inverters is output voltage control. Variable span widths for the focus and side bands are used to further promote the drive presentation with a less melodic age. The most commonly used PWM planes for DFIG are carrier-based sine wave PWM and spatial vector PWM.

A. The SPWM

sinusoidal pulse width modulation technique is the most widely recognized technique for controlling motors and inverters. The SPWM technique uses three Ur sine waves and a highly reproducible delta transporter Uc to generate a PWM signal in a three-stage inverter. The three-stage sine wave is called the reference signal and is phased by 120°.

The recurrence of the sine wave is equivalent to the inverter yield recurrence (50/60 Hz). The three-sided wave of a high recurrence transporter is contrasted with a sine wave. The comparator produces a yield beat when Ur> Uc and moves the flip switch as needs be. To stay away from obscure exchanging conditions and obscure AC yield voltage in the VSI, never turn on two switches all the while on a similar branch. The proportion among Uc and Ur should be a whole number N. The abundancy regulation coefficient is given by the equation:

$$m_a = \frac{A_r}{A_c}$$

The frequency modulation ratio is given by:

$$m_f = \frac{F_r}{F_c}$$

The total harmonic distortion is given by:

$$THD = \frac{\sqrt{V^2_{out} - V_1^2}}{V_1^2}$$

Where V1 = main components. To improvise both regulation and control strategies, more and more control methods are implemented, including Sliding Power Control, Carrier Based Sinusoidal PWM and SVPWM. Thanks to the slip control in the generated torque, there are no vibrations that can lead to an increase in mechanical stress due to strong fluctuations in torque. Some disadvantages of the SPWM method are that the total greater harmonic distortion, smaller modulation index, the generated current is less, and therefore the above disadvantages are overcome by the SVPWM method.

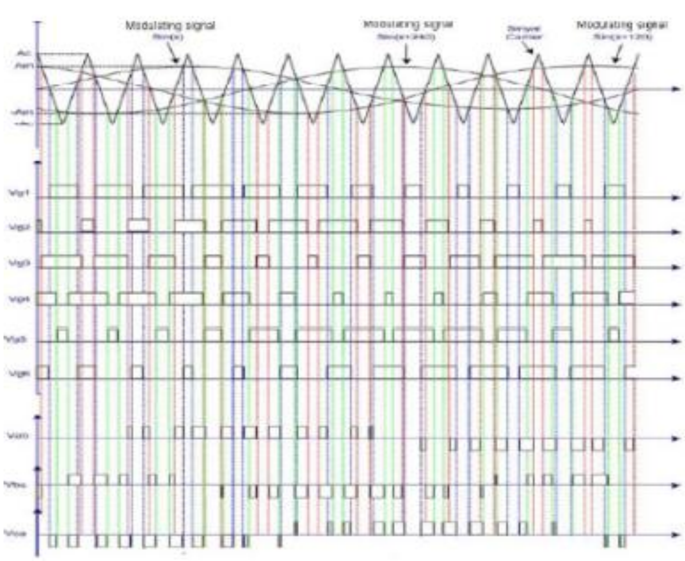


Figure 4 SPWM generation techniques for three-stage voltage source inverter

IV. SIMULATION OF SVPWM SWITCHING TECHNIQUES

Spatial Vector beat width regulation is usually evolved as a vector intends to deal with heartbeat width tweak for three-stage inverters. SVPWM has an exceptional component that can deal with all the important problems identified with SPWM procedures such as computational complexity, timing, and full consonant transform, DC carrier voltage regulation and normal mode voltage. In this way, the proposed The SVPWM system is suitable for heavy duty applications because it clears the lower part tones after time, further developing THD through different waveform equalizations. Staying away from sound can prevent overheating and damage in sensitive settings. PWM spatial vectors have been gradually used in recent times. This matching did not use three separate modulators for each of the three stages, violating the entire voltage reference vector.

The overall location of the three-stage The voltage source inverter is displayed in Figure 5. The Insulated Gate Bipolar Transistors (IGBTs) in the VSI analog branch should not turn on, but this will cut the DC power. So swap operation is done reciprocally in an analog pin. In the SVPWM strategy, eight exchange states are stored for the inverter, out of which eight, two are the zero or empty vector exchange states V0 and V7, and the other six states are non-zero exchange or dynamic states from V1 to V6. The exchange vectors besides the current-current comparison voltage are given in Table 3. To implement the SVPWM exchange procedure, a rotational reference voltage vector (Vref) is introduced as the substitution voltage reference. position. like a three-stage equilibrium wave. By plotting eight stress vectors on a puzzling plane, six unique vectors (V1 to V6) construct the hexagonal square structure as shown in Figure 6, giving the load limit. The remaining two empty vectors (V0 and V7) are in their only positions and provide no power. A reference vector is taken between two adjacent single commercial vectors and one or one of the zero vectors. This voltage vector (Vref) is used to direct the limit of the inverter. Vref is represented in the fundamental space of two tightly distributed voltage vectors, namely V1 and V3.

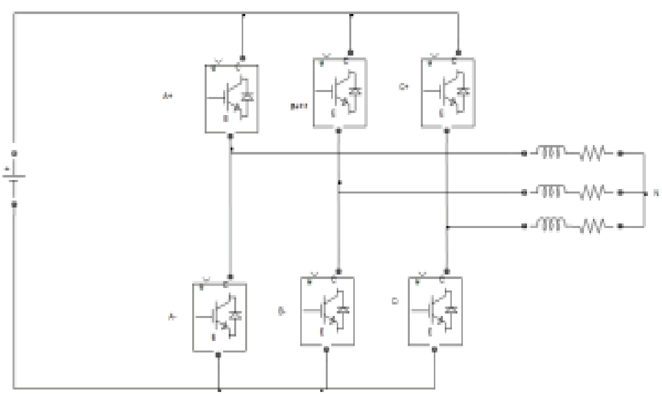


Figure 5 Inverter with a three-phase voltage source.

Range of actuator voltage vector controlled by joint:

$$T_s V_{ref} = T_0V_0 + T_1V_1 + T_2V_2$$

$$T_S = T_0 + T_1 + T_2 \quad (5)$$

TS = sampling time

Vref is in the triangular region of vectors V0, V1 and V2 and its duration is denoted as T0, T1, and T2, respectively. Figure 7 shows a spatial vector diagram. It has 6 sectors of the same size (A to F). To implement SVPWM, consider the following steps:

Identify the region,

Calculate switch times, and

Set switching states

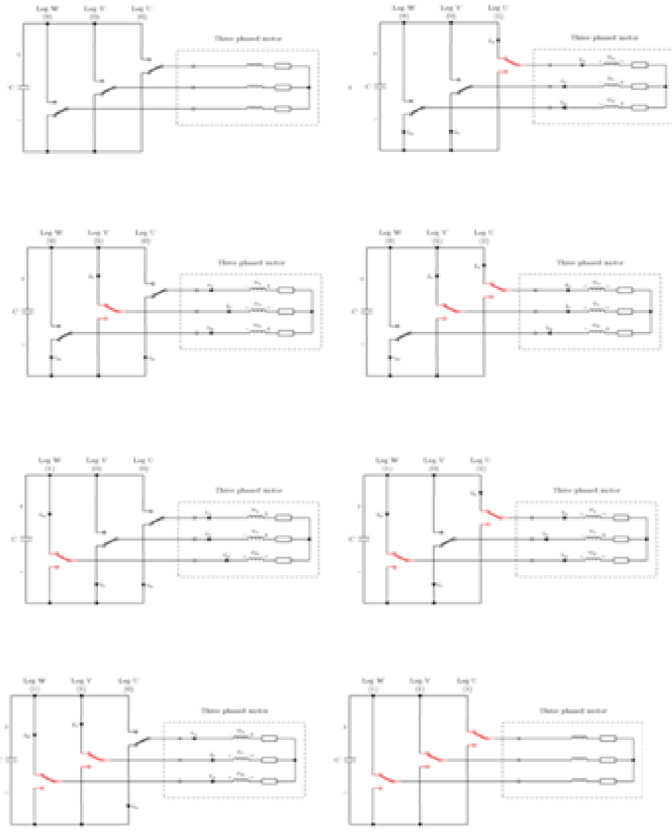


Figure 6 Switching states of the double level converter

When the switches S1-S6 are additionally switched, the switching vectors form six states with non-zero voltage and the two states have zero voltage at the yield. Table 2 shows the definition of industry. Acceptable voltages and vectors are given in Table 3.

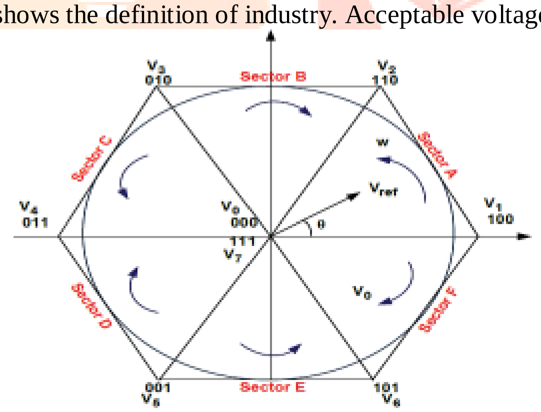


Figure 7 Spatial vector diagrams of a two-level transformer

Table 2 Definition of sectors

Angle (⁰)	Sector where Vref is placed	Angle (⁰)	Sector where Vref is placed
0	A	180	D
60	B	240	E
120	C	300	F

Table 3 Switching states and mains voltage

Voltage vector	Switching vector	A+	B+	C+	A–	B–	C–	Line to Line voltage		
								Vab	Vbc	Vca
V0	000	OFF	OFF	OFF	ON	ON	ON	0	0	0
V1	100	ON	OFF	OFF	OFF	ON	ON	+Vdc	0	–Vdc
V2	110	ON	ON	OFF	OFF	OFF	ON	0	+Vdc	–Vdc
V3	010	OFF	ON	OFF	ON	OFF	ON	–Vdc	+Vdc	0
V4	011	OFF	ON	ON	ON	OFF	OFF	–Vdc	0	+Vdc
V5	001	OFF	OFF	ON	ON	ON	OFF	0	–Vdc	+Vdc
V6	101	ON	OFF	ON	OFF	ON	OFF	+Vdc	–Vdc	0
V7	111	ON	ON	ON	OFF	OFF	OFF	0	0	0

The vector in the root region can be controlled by exchanging time dilation examples, i.e. t0, t1, t2 and t7 separately. The four intervals change continuously as the Vref moves between different arcs for a particular configuration file, such as a file. The entire cycle ends with six comparable regions named 1, 2, and so on. Come 6. While Vref is moving towards region 2, the inverter keeps switching state vectors V2 at period t1 and at V3 at instantaneous time t2. For region 3, V3 for t1 and V4 for t2, and so on. SVPWM square plot as shown in figure 8, settings for three stage diode rectifier, gear, three stage inverter motor, speed regulator and SVM block.

Cruise control is used to control the engine skidding. Rotor speed aberration is corrected for genuine engine speed and reference speed to guarantee the necessary inverter voltage and reproducibility. The last cycle is likewise used to create the inverter voltage expected to keep the engine U/f proportion stable. The essential reproduction was acted in a three-stage PWM space vector VSI engine drive as displayed in Figure 8.Entertainment using different Simulink/Sim source frame squares can be seen in the attached Figure 9. The different squares used for the regeneration can be clarified as follows: a 3-stage, 460V, 50Hz voltage source was used, and its output voltage was further rectified and maintained and transmitted. to the voltage source inverter at the end are three stages linked to the face stator of the DFIG. The inverter input heart rate is given after the speed estimate

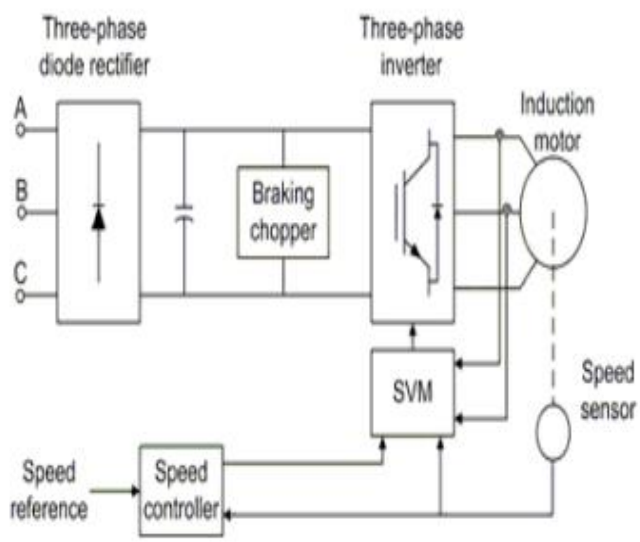


Figure 8 Block diagram of svpwm

V SIMULATION RESULTS

Results of the simulation of the sinusoidal PWM technique and modulation of the spatial vector used in the WECS BTB converter are shown in Figure 1013 below, and the parameters used for the simulation are shown in Table 4.

Table 4 Simulation parameters

Parameters used during simulation	Parameter Value
DC Supply Voltage	400V
Fundamental Frequency	50Hz
Carrier Frequency	400Hz
Sine Wave Amplitude	1
Carrier wave amplitude	1
Cut Off frequency	5Khz
Modulation index	0.5-1
Output line Voltage	282.84V
Output Phase Voltage	212.12 V
Phase Current	90A

The results below are a comparison of PWM and PWM methods, with both SVPWM methods giving better results. And THD also fell in SVPWM.

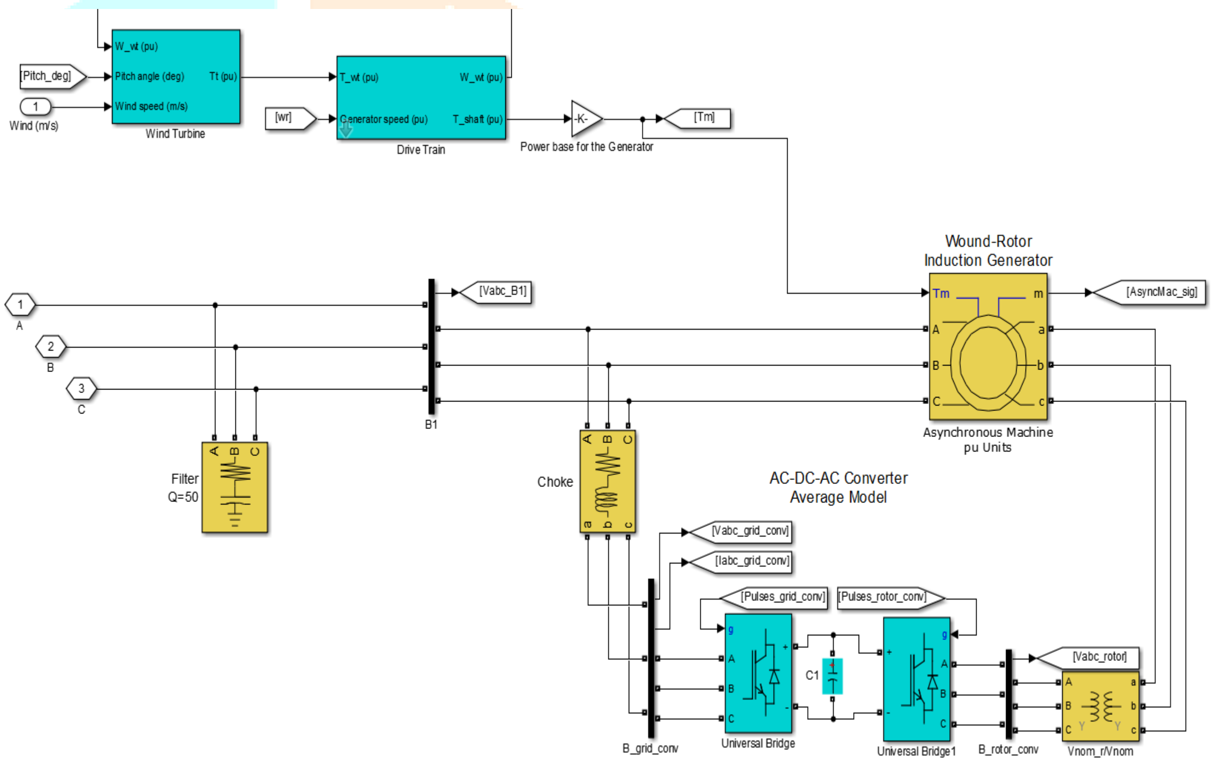
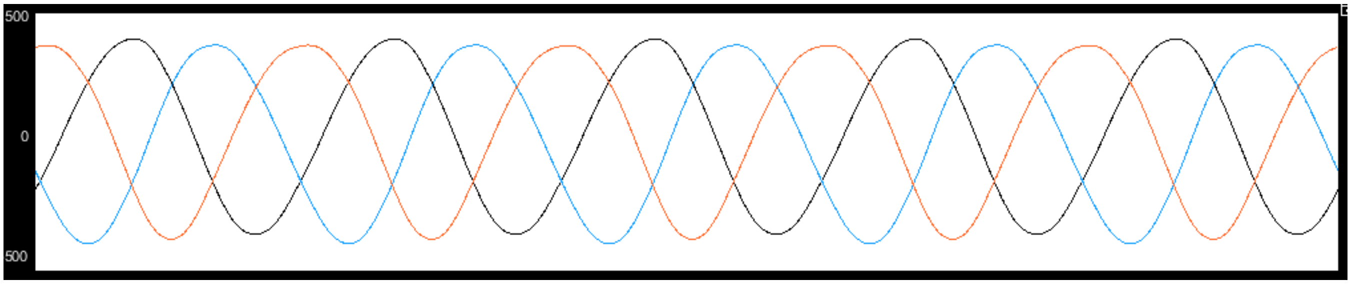
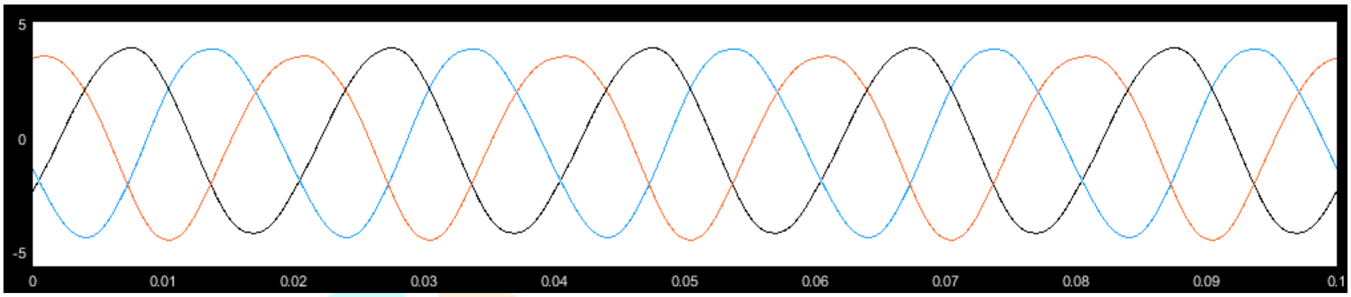


Figure 9 Simulation model

SPWM Method



(a)



(b)

Fig. 10 (a) Phase voltage, (b) Phase current

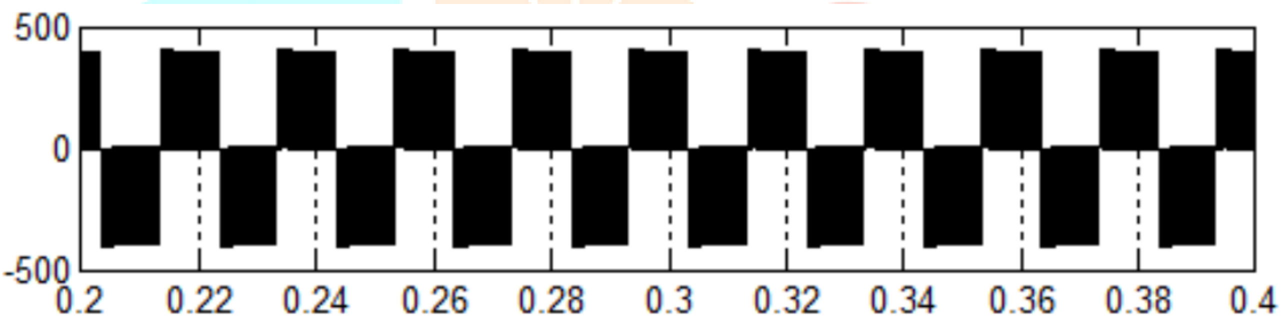
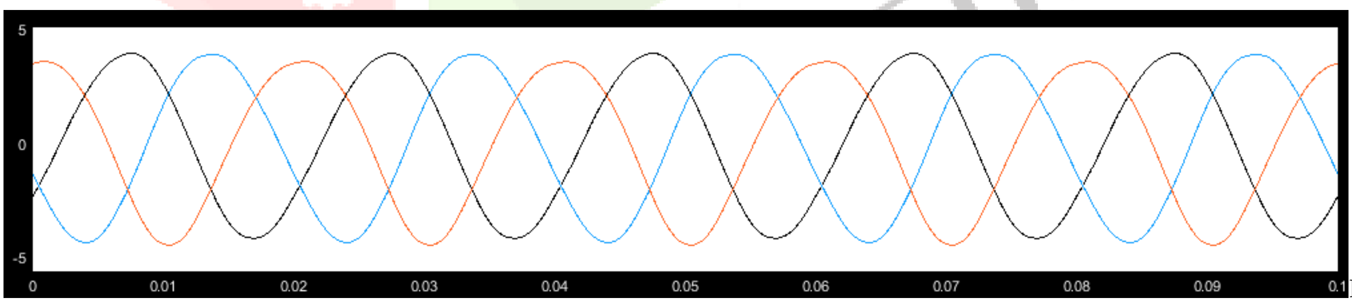


Fig.11 Line voltage

Space vector modulation



Figure

Fig.12 Phase current

Figure

Fig.13 Line voltage

VI. CONCLUSION

The PWM technique required for WECS converters has been thoroughly investigated and simulation results have been obtained. The results show that these modulation techniques are it is best suited for grid-connected wind power to solve dynamic problems such as average wind speed and gusts, while maximizing energy transformation effectiveness. Further investigation of the The reliability of the BTB power converter to wind speed variation and the unique WECS reconstruction can be made in future work.

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