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Multi Winding Transformer through Multi Level Inverter with Super Capacitor base Stand Alone Integrated Wind Energy System

L.V. Suresh Kumar* and G.V. Nagesh Kumar**

ABSTRACT

This present Paper proposes, the harmonics of grid connected integrated wind energy conversion system is reduced to give quality power to consumers and industries. This system gives qualitative power through multilevel converter and its switching operation with changing conditional wind speeds. The technology in wind turbine source is developed with induction generators, and then connected to the load through standard multilevel inverters (MLI) and through super capacitor storage with PWM techniques. In this paper, a new six phase to three phase conversion transformer through multilevel converter base stand alone wind energy system have been developed. The developed scheme will have reduced harmonics with Phase Disposition (PD), Phase opposition disposition (POD), Alternate phase opposition disposition (APOD). In these techniques reference wave generated from PI control, the controller gains are tuned by pattern search algorithm Harmonic analysis of the Voltage, current and power is carried out by applying phase disposition scheme to five level multilevel converters at different wind conditions in the integrated wind energy system. Similarly by using super capacitor energy storage system was developed to reduce the dc link voltage fluctuations with PWM techniques.

Keywords: Multi winding Transformer, Diode Clamped Multilevel Inverter, Modulation Strategies, Energy storage system

1. INTRODUCTION

In recent year's renewable energy systems supplies more power to the micro grid, there is an increasing in clean and green power technology. The wind source is connected to wind turbines through induction generators (IGs) [1]. Mechanical energy from IG is converted in to electricity, that is sent through the generators, transformers and converters are connected to load [2]-[4]. the distinctive advantages, mainly due to their excellent harmonic performance at higher voltages and medium voltage range (2-13 kV),power and power quality conditioning applications. In the proposed scheme, variable speed wind turbines are used to generate high and low voltages with less cost. Here multi wind energy generation units are connected to the transformer, which converts multi phase voltages [5]-[8].by using MLC/MMC controllers variable frequency voltages are converted fixed frequency voltages Here MLI [9]-[13] is introduced with different level carrier (LC) PWM techniques [14]-[18] to decrease the reduce dc link oscillations and total harmonic distortion (THD) with super capacitor system [19]-[20]. paper deals with the wind energy system with the multi winding transformers and Multi level inverters (MLI), its modulation techniques are discussed and developed in matlab. The super capacitor with dc link is introduced and its DC response of the modal is observed. Different PWM strategies are applied to MLI for identification of best strategy. Those techniques are disposition (PD), alternate phase opposition disposition (APOD) and phase opposition disposition (POD). Fig. 1 shows five level DCMLI base stand alone wind energy system with super capacitor through MWT (25KVA).

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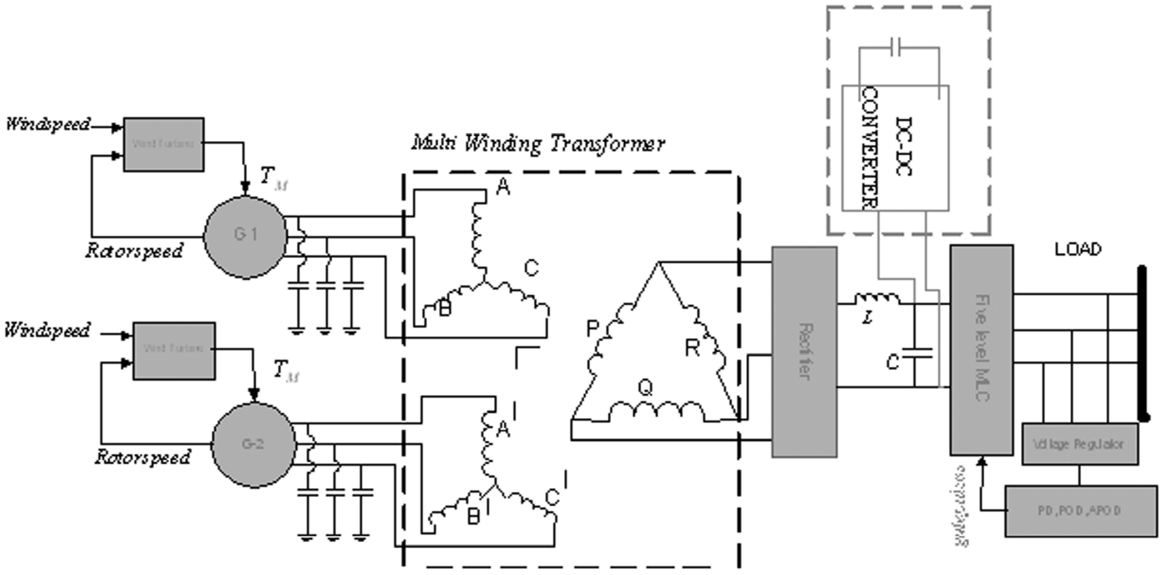


Figure 1: stand-alone wind energy system with super capacitor, POD, APOD, PD

2. MULTI WINDING TRANSFORMERS

Multi winding transformers are place major role in used in different renewable power conversion applications; it is used for number of transformers space is reduce, simple construction and easy installation so that more saving. In this paper MWT consists of one form of phase level voltages to different phase level voltages, which are connected in the primary side is star and the secondary side is delta , hence by this connection the output voltage is three phase [5]. Wind energy in to power energy conversion is more popular in this Fig.1 shows multiple wind energy sources integrated to multilevel converter through MWT. The location wind speeds applied to the wind turbine then it converts kinetic energy in to mechanical torque. This mechanical torque generates the electrical energy through the induction generator. A, B, C are the primary side connections of MWT with first generator and A^1, B^1, C^1 are primary side connection of MWT with second single wind generator similarly P, Q, R are secondary side connections of MWT connected with rectifier. [5]-[8].

2.1. Diode clamped multilevel inviters

In the power industries power electronic devices place vital role for looking for system stability, optimum accuracy, improving efficiency. In power electronic converters total harmonic distortion (THD) problems more so that MLC, MMC are developed for decreasing THD in the system. All PE converters exhibits complex waveforms, the complex wave produce different odd or even harmonics so that frequency effect is more on the load so depends on can be exterminated by designing their respective harmonic filters. In the high power applications and high voltage applications, the power device switching frequency must be below 1kHz.due to this gets more switching losses in the converter. In high power applications, suppression of the harmonics caused by raising switching frequency of two-level inverters became a big difficult task. In addition to that the DC/DC converter employed to the inverters so in this series connection rise voltage problems, it will effects to the switching devices. In this connection has been reduced more increasing switching frequency, generated harmonics reduction becomes big issue. Harmonic reduction and DC connecting voltage level concern, multilevel concepts commence to be best approach. The levels of harmonic in MLI are reduced greatly that of an normal bridge inverter for a equal switching frequency. Also the DC link voltage oscillations are blocking the switching device of the multilevel inverter within the less time. The MLI topology is usually employed for accomplishing the best performance in HVAC drive systems, FACTS, HVDC systems etc. According to load requirement, component specification and improved output response, the multilevel inverters (MLI) employed [9]-[11]. In Fig. 2 the basic schematic of Five Level

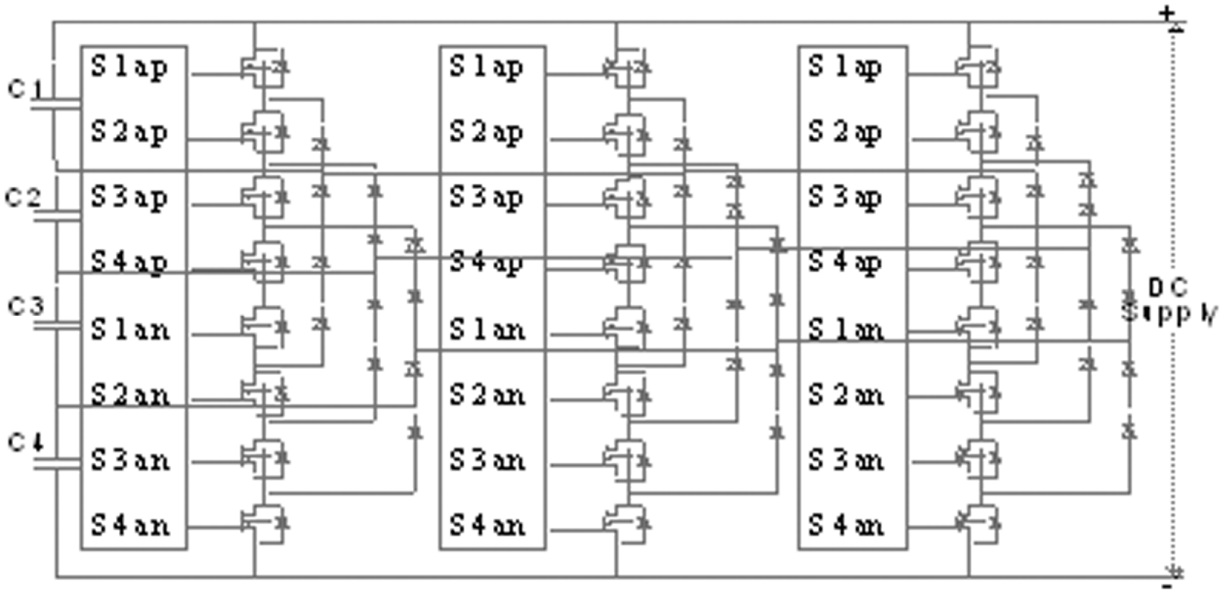


Figure 2: Schematic of three phase Five Level DCMLI

DCMLI. A three phase three legs Multi Level Inverter, it consist two arms upper and lower. Each arm consists of N number of switches connected in series.

2.2. Modulation strategies

There are several modulation strategies to control the multi level converters. The most general Strategies are used in the multi level carrier PWMs. An advantage of multi carrier PWM strategies is that it can be easily implemented to low voltage modules. The inverter switching time created by comparing 50Hz sine wave reference signal and high frequency multi carrier signals. The carrier based PWM is achieved by comparing the reference sinusoidal signal with high frequency triangular carrier signal. The entire strategies

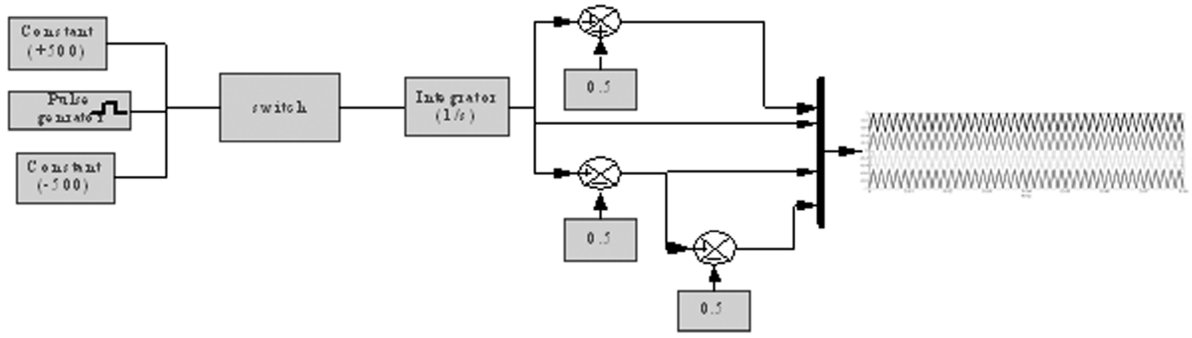


Figure 3: (a) Five level phase disposition PWM technique

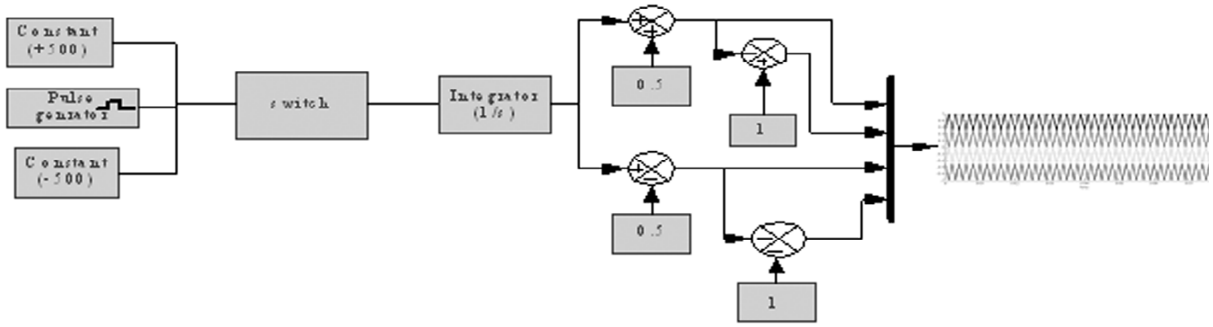


Figure 3: (b) Five level Anti-phase opposition deposition PWM technique

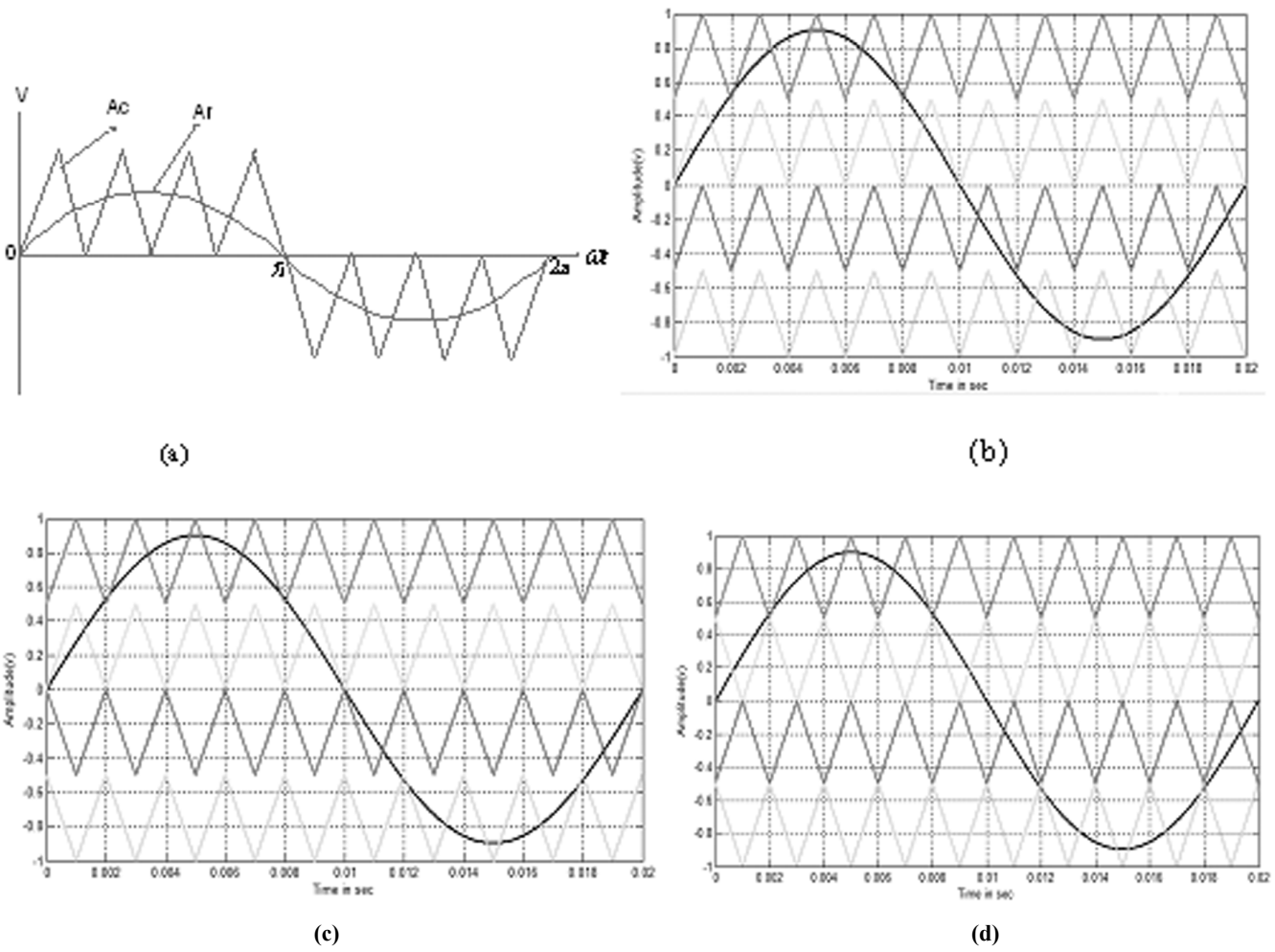


Figure 4: Modulation Techniques (a) SPWM (b) PD (c) POD (d) APOD

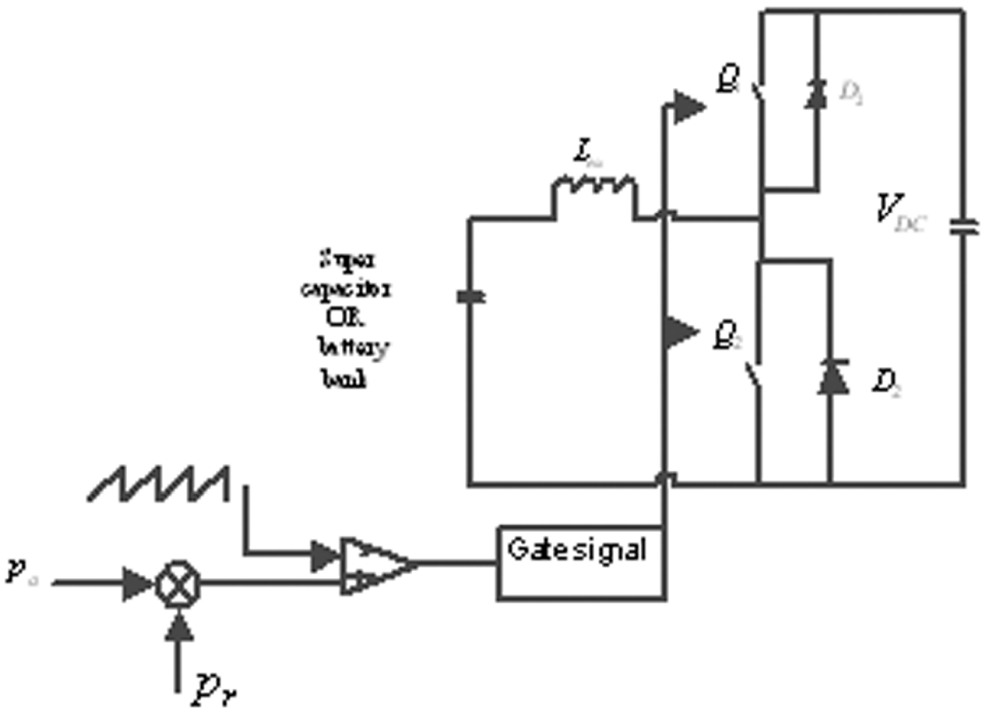


Figure 5: Scheme of the ESS.

carrier signal has the same frequency and amplitude. All the carriers' have 180 degrees phase shift Simulation development block of phase disposition pulse width modulation techniques mat lab implementation diagram shown in Fig. 3. the above said pulse generator gets triangular wave so it gives single module, but in five level MLC had five level switching operation so that the mathematical sum point techniques are applied and developed five level carrier wave forms. PD, POD, APOD are developed by changing small summing point values it shown in Fig. 3(a) & 3(b) as discussed in Fig. 3(a), Fig. 3(b) for generation carrier wave, it should be compare with reference wave of sinusoidal at different modulation index values by using MATLAB tool of relational operator for pulse generation for reverse pulse generation similarly used logical operator.

Fig. 5. shows ESS schematic control. The DC/DC converter proposed in this system uses two IGBT switches S1 and S2 for the operation. The input from the inverter is interconnected to energy storage system, it encompasses with a super capacitor bank. Regulation of GSC exchanges with load is done by employed S1 and S2, whose operation is get activated by duty ratio and this control operation is done with Pa active power. In Fig.6 shows the two different modes, these modes switches between buck or boost mode operation, based on the state of IGBT switches. It can be gives as if the switch S1 is open it gives the features of boost converter and if the switch S2 is opens the mode switches to buck converter mode operating from boost. The duty ratios are denoted as D1 and D2, these duty ratios and operating modes of converter are operated on basing the changes in reactive powers P_r of the rotor side power converter with change in then active power P_a of the GSC. If $P_r > P_a$ activation of buck mode condition is done and the duty ratio under this region is termed as D1, in this case absorption of active power is done by super capacitor bank

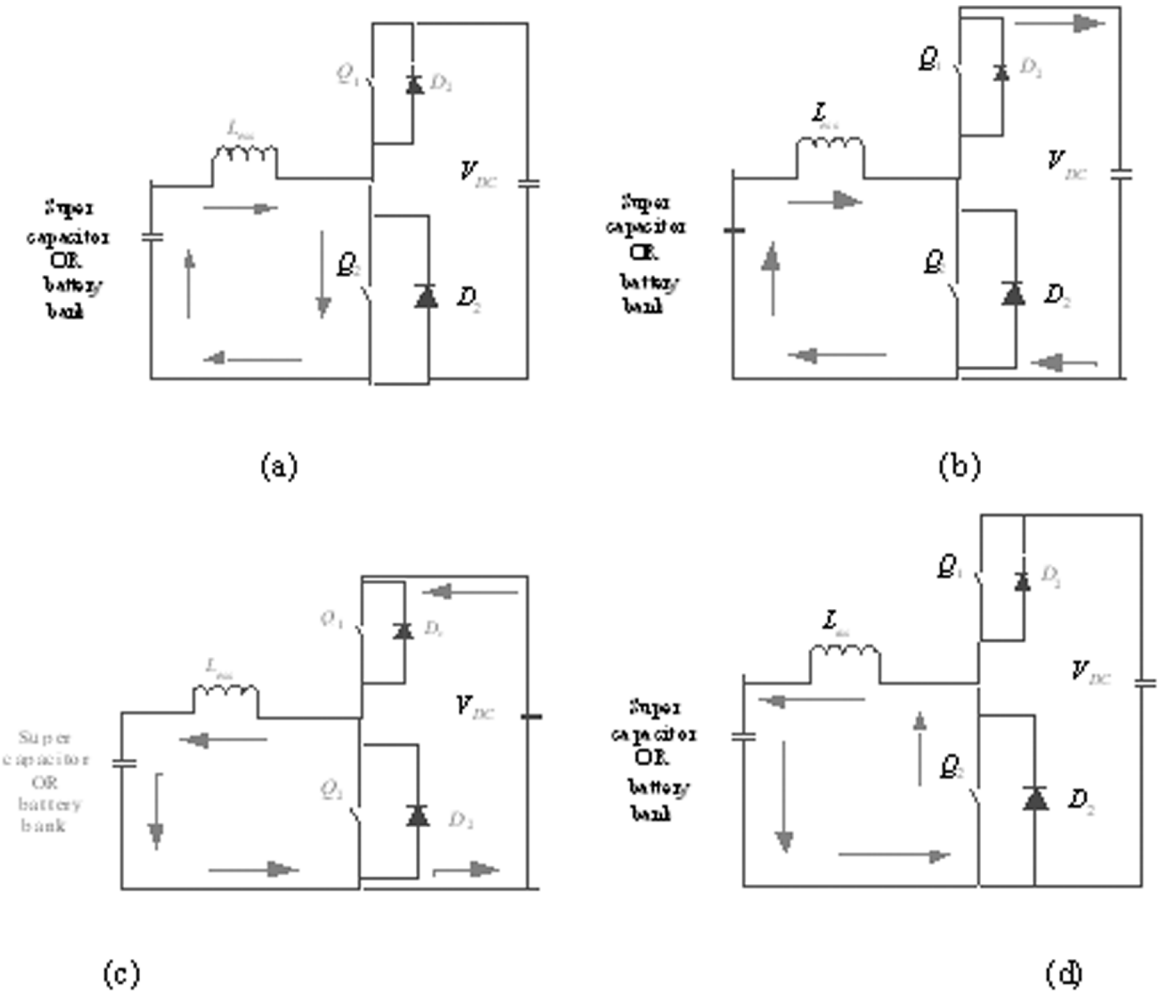


Figure 6: Modes of operation of ESS (a) Interval1 (b) Interval2 (c) Interval3 (d) Interval4

which intern causes voltage V_{SC} to increase. The opposite mode is activated when $P_a < P_r$, which is termed as boost mode and this mode is controlled under D2 duty ratio i.e.; in this case super capacitor bank acts as a source for supplying the active power which intern effects the voltage V_{SC} to get decrease. Therefore, the operation clearly gives an idea that by controlling the operating modes and duty ratios of the DC/DC converter, controlling of the generated active power of the source is done by employing the ESS (Energy storage system) as either a source or a sink of active power. [19]-[20].

Simulation Results

Filters are mainly used to reduce the multiple frequency components in the system. Otherwise these harmonics will produce unwanted disturbances in the entire system. Here low pass second order filter is designed to

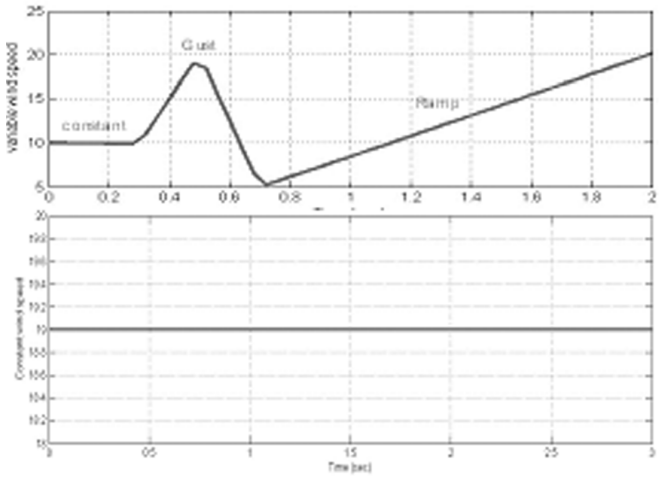


Figure 7: (a) Expected location wind speeds

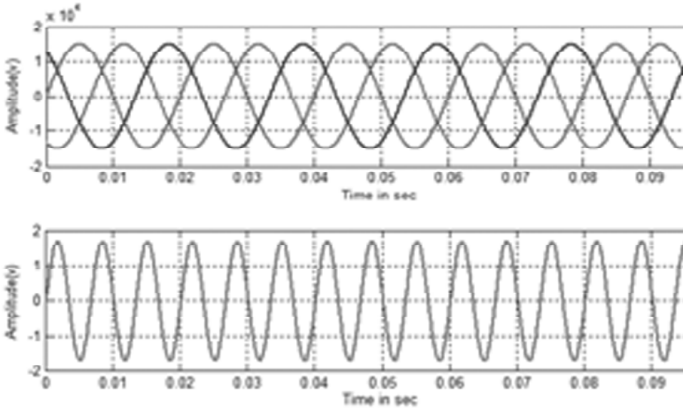


Figure 7: (b) MWT Voltage and currents

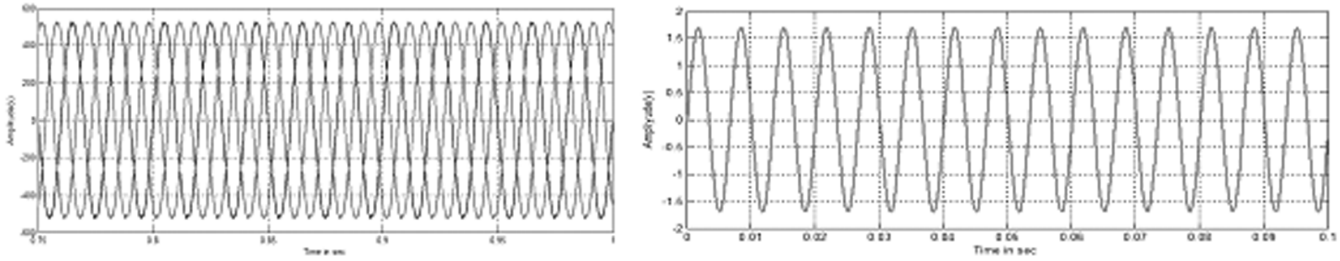
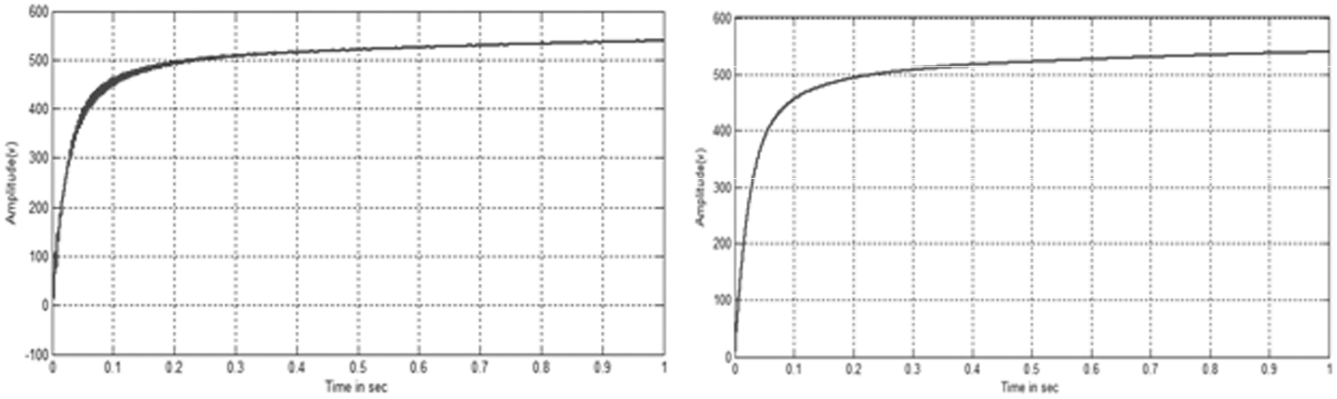


Figure 8: 25kv/440 MWT output voltage and currents



(a) **(b)**

Figure 9: DC-link capacitor voltage with PD (a) ES system without PD (b) ES system with PD

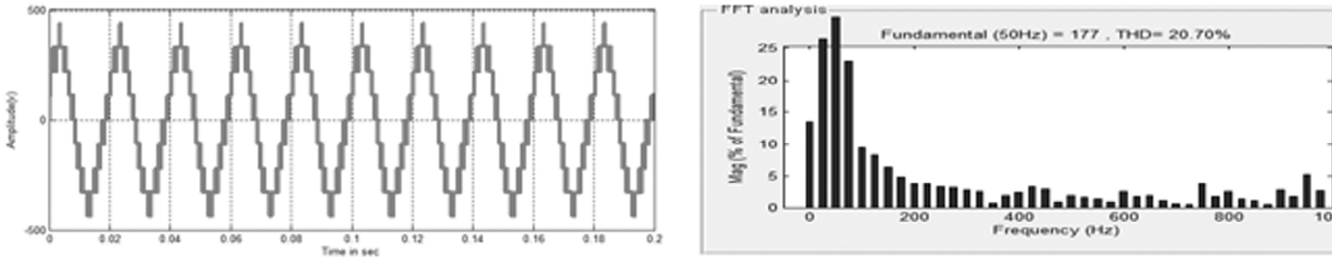


Figure 10: MLI output line voltages and FFT analysis of an open loop system with a phase disposition technique

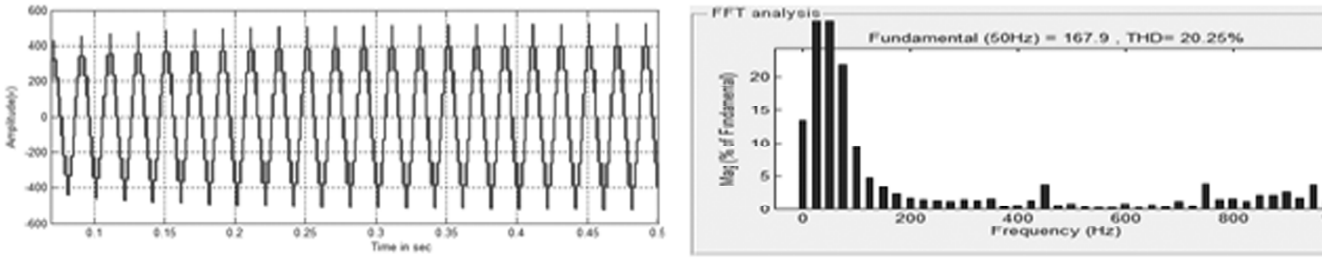


Figure 11: MLI output line voltages and FFT analysis of an open loop system with Filter

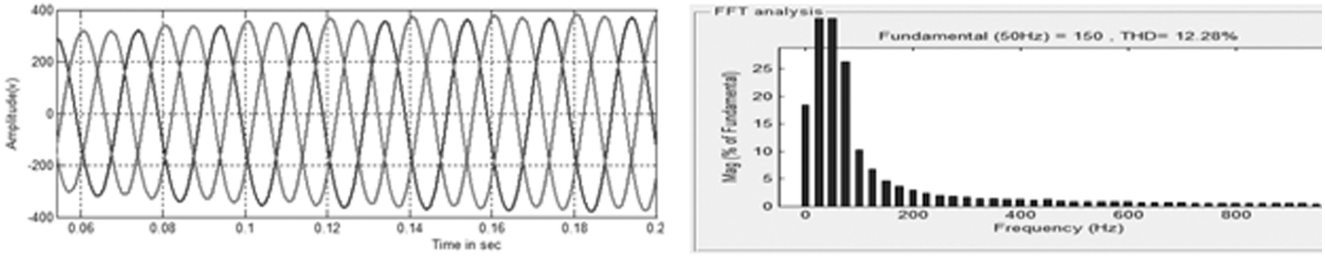


Figure 12: MLI output line voltages and FFT analysis of a closed loop system with a phase disposition technique

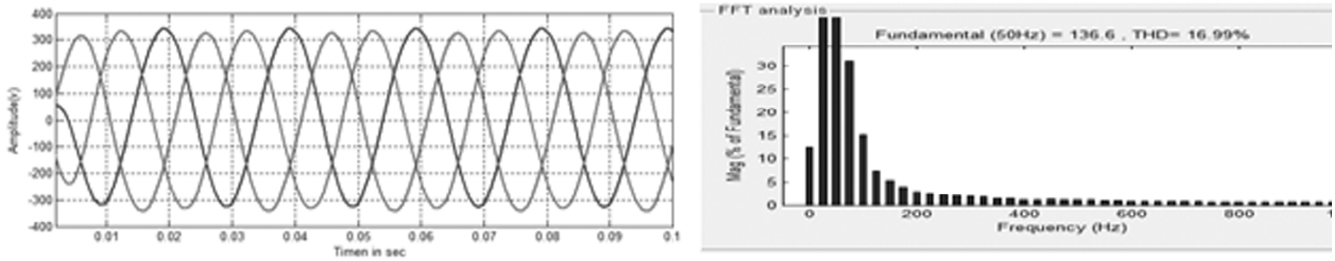


Figure 13: MLI output line voltages and FFT analysis of a closed loop system with Filter

keep the THD within limits. The designed values for filter is cut-off frequency = 100Hz and damping factor = 0.707. The cut-Off frequency is calculated from the FFT analysis. In the closed loop system the voltage will be sensed from the load side and this is summed with the generation side voltage to get the two phase transformation voltage and the voltage will be controlled by PI, PID controllers and this will generate sin wave signal with required modulation index. This sin wave will give as reference signal to pulse width modulation techniques and this will generate pulse pattern for multi level inverter. The PI controller is tuned by using pattern search algorithm to get the K_p and K_i values. The tuned values are K_p = 0.9 and K_i=0.8. Comparison of THD values for different modulation techniques with and without filter shown in table 1.

Table 1**.** Comparison of THD values With and Without Filter

Table 1
Parameters of the Simulation circuit

Technique	*With Filter Output voltage*	*Without Filter Output voltage*
PDPWM	16.99%	20.70%
PODPWM	18.92%	22.40%
APODPWM	23.27%	27.92%
SPWM	31.71%	19.42%

3. CONCLUSION

In this Paper, large number of renewable energy is connected to the system to meet the power generation. These energy units are connected to the load through multi winding transformer to achieve three phase voltage from the nine phase voltage. MLI in the system to convert variable voltage and frequency coming from the wind energy units to fixed voltage and frequency. The diode clamped multi level inverter is simulated with different modulation techniques to maintain harmonic distortion within limits. The simulation is preformed for open loop and closed loop of multi winding transformer through multi level inverter base Standalone integrated wind energy systems with energy storage system. Hence from analysis closed loop system will give better performance compared to open loop system and also by using ESS reduce fluctuation in DC link.

REFERENCES

[1] SEUL-KI KIM AND EUNG –SANG KIM :PSCAD/EMTDC-Based Modeling and analysis of Gearless Variable Speed Wind Turbine: IEEE transaction on energy conversion: vol.22:2007 .

[2] LUCIAN MIHET-POPA ,FREDE -BLAABJERG ,ION -BOLDEA:Wind Turbine Generator Modeling And Simulation Where Rotational Speed is the controlled Variable:IEEE transacton on industry applications:vol.40::2004.

[3] R.C. -BANSAL ,SENIOR -MEMBER, IEEE:Three-Phase Self-Excited Induction Generators: An Overview:IEEE transactions on energy conversion:vol.20: 2005.

[4] ZHE -CHEN, JOSEP M. -GUERRERO, FREDE -BLAABJERG :A Review of the State of the Art of Power Electronics for Wind Turbine: IEEE Transactions on Power Electronics, vol. 24: 2009.

[5] MISHRA, S., PALU, I., MADICHETTY, S., & SURESH KUMAR, L. V. Modelling of wind energy based microgrid system implementing MMC. International Journal of Energy Research.:Vol74,2016.

[6] D ANUSHA ,L V SURESH KUMAR:Nine phase transformer through MLI base stand alone integrated wind energy system.international journal of advanced research in electrical , electronics and instruentation engineering .Vol.4:2015.

[7] MR. -MERUGU MYSAIAH, MR. V.L.N- SASTRY, MR. ASWANI KUMAR -EEDARA, MR. V.-RAMAKRISHNA :Design of A Novel Three Phase to six Phase Transformation Using a Special Transformer Connection: International Journal of Engineering Research and Development.vol.4:2012.

[8] SHAIKH -MOINODDIN,ATIF -IQBAL,HAITHAM -ABU-RUB, SENIOR,M. -RIZWAN KHAN, AND SK. -MOIN AHMED:Three-Phase to Seven-Phase Power Converting Transformer:IEEE transactions on energy conversion, vol. 27, 2012.

[9] MOHAN M. -RENGE, HIRALAL M. -SURYAWANSHI:Five-Level Diode Clamped Inverter to Eliminate Common Mode Voltage and Reduce dv/dt in Medium Voltage Rating Induction Motor Drives:IEEE transactions on power electronics:vol. 23: no. 4:2008.

[10] J. -RODRIGUEZ, J.S. -LAI, F.Z. -PENG:Multilevel inverters: A survey of topologies, controls, and applications," IEEE Trans. Ind. Electron.:vol. 49: pp. 724–738:2002.

[11] Z. -PAN, F.Z. -PENG, K.A. -CORZINE, V.R. -STEFANOVIC, J.M. -LEUTHEN,S. -GATARIC:Voltage balancing control of diode-clamped multilevel rectifier/inverter systems IEEE Trans. Ind. Appli:vol. 41: pp. 1698–1706:2005.

[12] POH CHIANG -LOH,DONALD -GRAHAME HOLMES,YUSUKE -FUKUTA, THOMAS A. -LIPO :Reduced Common-Mode Modulation Strategies forCascaded MultilevelInverters:IEEE transactions on industry applications:vol.39:2003.

[13] ROSMADI -ABDULLAH, NASRUDIN ABD. -RAHIM, SITI ROHANI SHEIKH -RAIHAN,ABU -ZAHARIN AHMAD:Five-Level Diode-Clamped Inverter With Three-Level Boost Converter:IEEE transactions on industrial electronics:vol. 61:no. 10:2014.

[14] G.-KONSTANTINOU ,V.-AGELIDIS:Performance evaluation of half-bridge cascaded multilevel converters operated with multicarrier sinusoidal PWM techniques:*IEEE* conf. ind. electron. Appl:pp. 3399–3404:2009.

[15] LV SURESH KUMAR, GV NAGESH KUMAR, AND D. ANUSHA. "PSO Based Tuning of a Integral and Proportional Integral Controller for a Closed Loop Stand Alone Multi wind Energy Systems". Computational Intelligence in Data Mining—Volume 1. Springer India, 2016. 399-409.

[16] D.G.-HOLMES ,B. P. -MCGRATH:Opportunities for Harmonic Cancellation with Carrier-Based PWM for Two-Level and Multilevel Cascaded Inverters:IEEE trans. ind. appl.:vol. 37:no. 2: pp. 574-582: 2001.

[17] J. -MEI, K. -SHEN, B. -XIAO, L. M. -TOLBERT AND J. -ZHENG:A new selective loop bias mapping phase disposition pwm with dynamic voltage balance capability for modular multilevel converter: IEEE trans. on ind. Electron:vol. 61: pp. 798-807: 2014.

[18] D. Deepak Chowdary and G.V.Nagesh Kumar, "Restoration of Single Phase Distribution System Voltage under Fault Conditions with DVR using Sliding Mode Control", Indian Journal of Science and Technology, October 2008, Volume 1, No: 5, Page(s): 1-5, Gandhi nagar, Adyar, Chennai, India.

[19] CHAD- ABBEY,Géza -JOOS: Super capacitor Energy Storage for Wind Energy Applications" IEEE transactions on industry applications:vol. 43: no. 3:2007.

[20] LV Suresh kumar, GV Nagesh Kumar, and Sreedhar Madichetty, " Pattern Search Algorithm Based Automatic Online Estimation for AGC with Effects of Wind Power -International Journal of Electrical Power & Energy Systems, Volume 84, Elsevier 2016.