Dijlah Journal of Sciences and Technology (DJST) Vol. 1, No. 2, August, 2024, pp. 32-39
ISSN: Printed: 3007-8644, Online: 3007-8652, paper ID: 010

Study and Analysis of Universal Bridge AC/DC Converter Techniques

Ola Hussein Abd Ali[1], Hadeel Alaa[2]
[1,2] Electrical Engineering Technical College, Middle Technical University, Baghdad, Iraq

Article Info

Article history:

Received June 21, 2024
Revised July 20, 2024
Accepted August 15, 2024

Keywords:

Universal bridge
AC/DC Converter
PWM
IGBT
SIMULINK

ABSTRACT (10 PT)

In this paper, the study and analysis of universal bridge converter Based Insulated Gate Bipolar Transistors (IGBT) and pulse width modulation (PWM) Techniques in SIMULIK Environments is presents. To realize a PWM as controller with three phase AC/DC converter, the basic of space vector modulation is investigated and developed. The progression of this type of conversion in many active conditions effectively is depending on the applied methods. The power of proposed procedure approach is located in the current distortion and switching frequency which is inspected in this work. The off line calculation in the pulse width first cycle section is depending and save these data in specific tables. For all cycle life, the residual pulses are created base on the value of initial quarter cycle since there are situations of quarter and half wave reliability. The results of simulation design show a significant economy in microcontroller time and memory increasing which will support all converter duty.

Corresponding Author: **Ola Hussein Abd Ali[1]**
Electrical Engineering Technical College ,Middle Technical University ,Baghdad, Iraq

Alhader street, Baghdad, Iraq
Email: ola_hussein@mtu.edu.iq

1. INTRODUCTION

The PWM techniques are used to control the electronic switching power conversions since the user demand increasing nowadays. Firstly, the signals of PWM controller is generated in terms of electronic hardware which have life form participated a main responsibility in the plan and manage the signal generator of power inverter in the circuits [1]. In the traditional design systems, the microcomputer was use to produce an orientation signals while the actual PWM and timing signals are generated using hardware electronic circuits [2]. Subsequently, when the microcomputer systems were developed, the computer switching is used to PWM design without harmonic to recover the recomputed design from lookup table techniques properly. In the case of controlling the system velocity with specific generated frequency range, the microprocessor has used to produce PWM signal to keep a stable voltage frequency per ratio [3].

Since the limitation of computer speed was found in many applications, a researcher was concluding that the online computation of switching design is not realistic. Hence, nowadays advances in microelectronics produce modern microcomputers with faster speeds to compute on line the switching design [4]. The alternating current (AC) to direct current (DC) converter is an integrated section of any power supply unit which is used in the electronic devices. The interfacing between usefulness and power electronic devices could be implements by using the power converters. The line frequency diode bridge rectifiers are usually used to change the line frequency AC to DC. Sometimes, large filter capacitor is used to decrease the ripple phenomena in the DC output voltage line [5]. The

AC/DC converter provides rectifications in the voltage paths in industrial, agriculture and any application which need this property. This type of device is used as standalone units which feed signals to multiple DC motors as input stage to AC drivers due to their practically infinite power and controllability properties [6]. The converter reaction is almost handling electromechanically transient happen in many drivers through the work. The line of AC/DC converters is the majority choice for applications where a single or three phase supply is available in the circuit due to the simplicity of circuit which require less number of active component as well as passive device. The thyristors are a line commutated power switched device which is mean move the current from one conducting part to another. To lunch on the thyristor, an injection of current pulse to its gate is required for running this device [7]. The electronic power converter always considers a source of harmonic distortion in the network distribution systems. The distortion in the current and voltage waveforms could produce problems for other equipments which are connected in the same networks. The advance approach to decrease this effect is by using accurate converter design. To prevent the distortion in the waveforms, an efficient design of controller with converter could add which will minimize the effect on other part of networks. To design appropriate controller and a specific data about the performance of converter under many situation will needed. The switching model of DC converter is used as regulator to convert a non-regulated DC voltage to regulated voltage which will achieved by using PWM techniques, wherever, the switching frequency is 50 KHz as highest frequency [8]. The most popular device switch is the transistor type BJT and IGBT with minimum ripple by use LC filter design. The PWM frequency is concentrated by two factors one is the transistor switching time and the second is the inductors core loss which is increase with frequency rising. Figure 1 and Figure 2 illustrates the converter circuit which is known as buck converter [9]. The switch is placed in the DC input voltage as shown below.

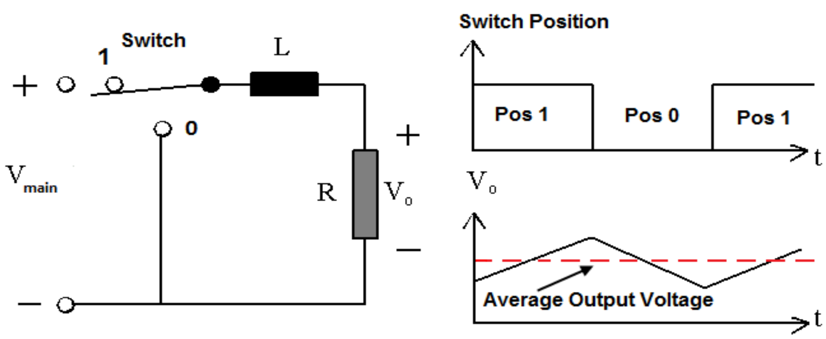

Figure 1: buck converter circuit [9]

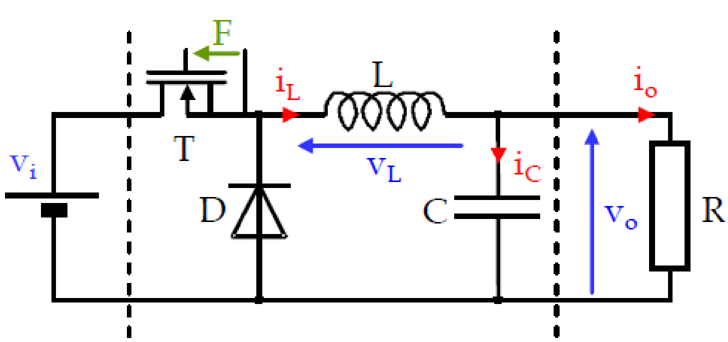

Figure 2: Buck RC Converter

The improvement and developments of power microelectronic equipments is still in progress for both realization and designing of speed driver adjustable. Many researchers has been proposed an advanced amplification of control method for voltage source inverters in last decades motivated by AC/DC line side converter named PWM rectifiers systems [10]. The importance of these front end rectifiers is because their specifications which are analytically transferred the diode bridges becoming imperative element of the frequency converter for control applications intelligent motions [11]. To provide sinusoidal current line and bidirectional power flow, the 3-phase two level AC/DC converters should be used at the unity power factor achievements. For these reasons, the PWM rectifiers have been used to compensate the electrical power excellence [12]. The control systems duty in current control converter is to force the current in 3-phase AC load to follow the original signal. The command and measured values of the phase current generate switching state for the converter power device to reduce the error in current through the circuit. Hence, the implementation of current control is to improve the error [13]. The ability of generating sinusoidal current could be achieved by using the sophisticated methods named pulse width modulation. The PWM technique produce a sequence of width modulated pulses to control the power switch in the circuit. According to the requirements of circuits and optimization criteria, the PWM techniques has developed and improved. The selection of exacting PWM techniques happened from the preferred presentation of the synchronous rectifier circuit [14]. In addition, the PWM technique for frequency converter could be classified into:

1. Sinusoidal PWM
2. Hysteresis PWM
3. Space Vector PWM
4. Selected Harmonic Elimination PWM
5. Minimum current ripple PWM
6. Sinusoidal PWM with instantaneous current control and random PWM

The 3-phase AC/DC converter is an important part to much power electronic circuit such as motor driver and battery chargers. Conventionally diode rectifiers are used for AC/DC conversion but it can convert a constant DC voltage as a function of circuit voltage. Although, the thyristor rectifier could be used to produce variable DC voltage but both these rictifiers perform as a non-linear loads and the output current include harmonic components. Additionally, the voltage drop through inductance line will distort the original voltage due to the current harmonic. Thus, the other load which connected in the same circuit is also feed with distorted voltage caused many problems. The common bridge block in MATLAB permits to simulate a converter using commutated power electronic device and forced commutated device IGBT. The number of device is different if the power electronic device are naturally commutated or forced commutated. In this paper, a fundamental statement and applications of selected frequency used modulation techniques applied to PWM rectifiers is investigated and designing.

2. MATERIAL AND METHODS

The universal bridge is an inverter with pulse width modulated (PWM) to generate 3-phase 50 Hz sinusoidal voltage in its output. The structure of universal bridge shown in Figure 3 contains many components with inverter chopping frequency of 2000Hz. The power bridge highlights the use of two universal bridges in the AC/DC converter with rectifier feeding an IGBT inverter Via DC link in this design.

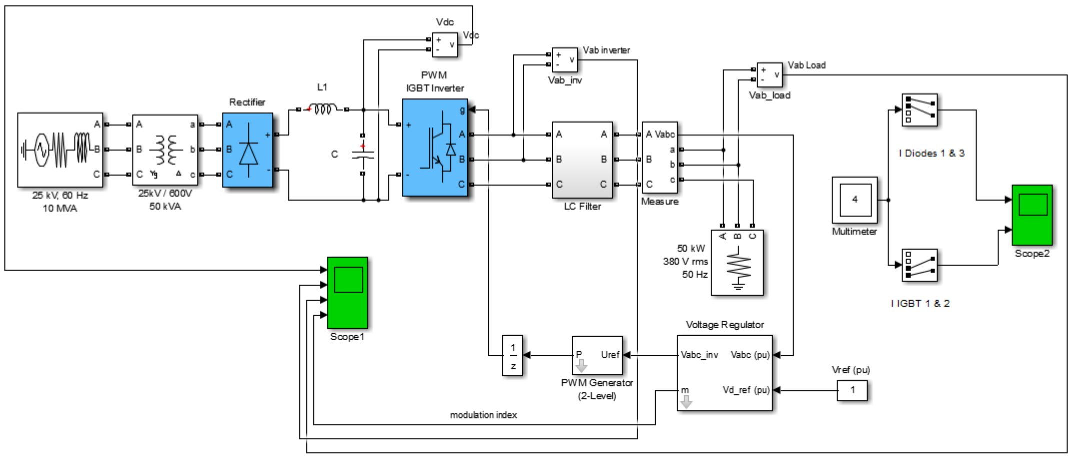

Figure 3: Universal Bridge Converter Model

To overcome the numerical oscillations, one could specify Rs and Cs values for diode and thyristors bridges. For forced commutated device IGBT, the bridge operate acceptable with merely resistive as long as firing pulses are sent to switching device. The anti-parallel diodes are operating when the firing pulses are blocked and the bridge operate as diode rectifier in this case. Therefore, appropriate values of Rs and Cs should be used. The following formula should be used to compute the approximate values of Rs and Cs when the systems are discredited.

$R_s > 2\,T_s/C_s$ ……………………………………………………………………..(1)

$C_s < P_n/(1000(2\pi f)\,V_n^2)$ ………………………………………………...…………(2)

Where

P_n : represent a nominal power of single or three phase converter (VA)
V_n : represent the nominal line-to-line AC voltage (Vrms)
f : is the fundamental frequency (Hz)

T_s : is the sample time (s)

These values of Rs and Cs could be derived by the leakage current at fundamental frequency should be less than 0.1% of normal current in case of power electronic device are not conducting. Consequently, the RC time constant is higher than two times the sample time Ts. The Insulated Gate Bipolar Transistors (IGBT) inverter is controlled with PI regulator to keep a one pu voltage with 380 Vrms/50Hz at the output. To view the communication of current between diodes, a multimeter block is used through D1 and D3 as well as between IGBT 1 and 2. After starting simulation, the transient period of 40 ms, the system will achieve a steady state conditions. About 2kHz of harmonic will generated by the inverter which should be filtered by LC filter. The expected peak value of the load voltage is about 380 rms. The mean value of modulation index is about 0.8 in steady state conditions and the mean value of DC voltage about 770 volts. Hence, the chopper inverter voltage could be calculated as:

$V_{ab} = 770 \times 0.6 \times 0.8 \cong 380$ rms……………………………………………………………..(3)

The LC filter circuit shown in Figure 4 is connected after IGBT Bridge which represent the harmonic removal filter from the current.

Dijlah Journal of Sciences and Technology (DJST) Vol. 1, No. 2, August, 2024, pp. 32-39
ISSN: Printed: 3007-8644, Online: 3007-8652, paper ID: 010

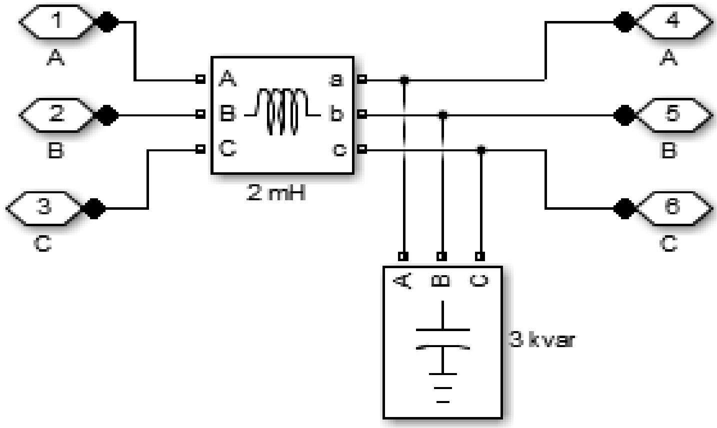

Figure 4: LC Filter structure

1. RESULTS AND DISCUSSION

Figure 5 shows the diode current, time scope 2 is used as in trace 1 from diode 1 to diode 3 in the model. Trace 2 illustrates the current in switch 1 and 2 of the IGBT diode bridge. These currents represent a complementary current. The current flow in the IGBT is showing a positive current while a negative current shows the current flow through anti parallel diode bridge. Figure 6 illustrate the currents after zoom out. Figure 7 and Figure 8 illustrate the input and output waveforms of PWM IGBT bridge converter.

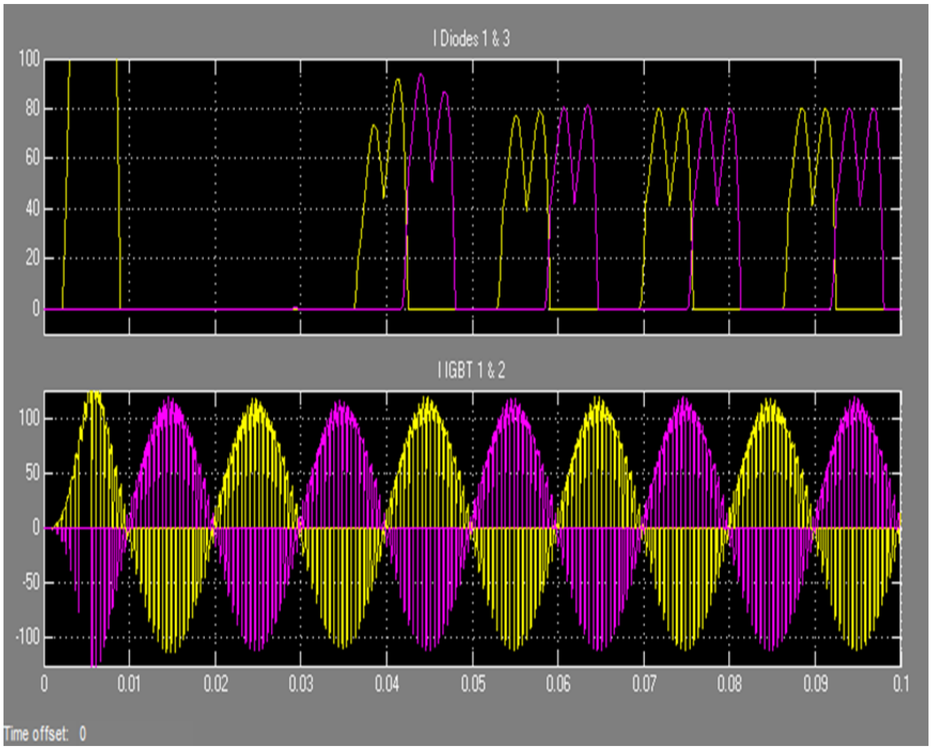

Figure 5: Scope 2 Output

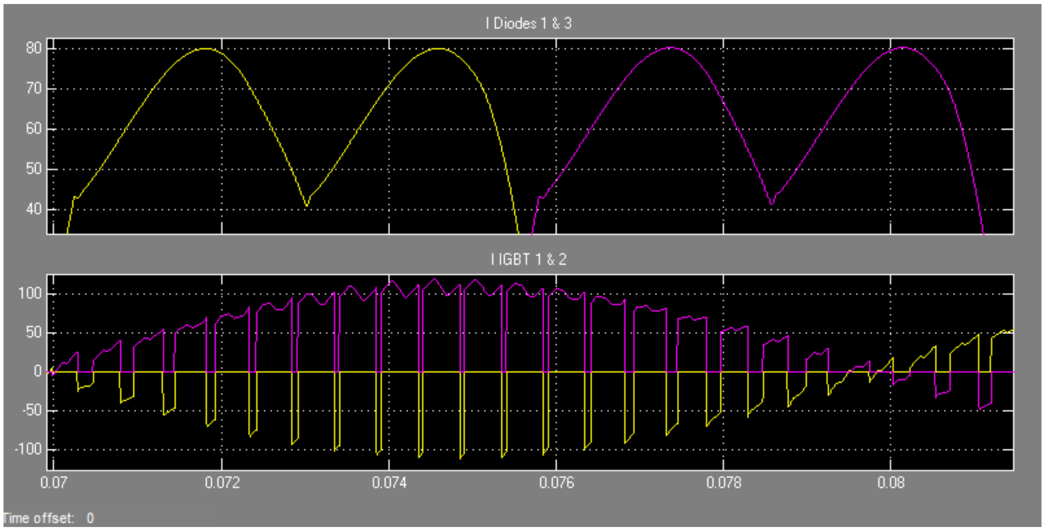

Figure 6 : Zoom Out Scope 2

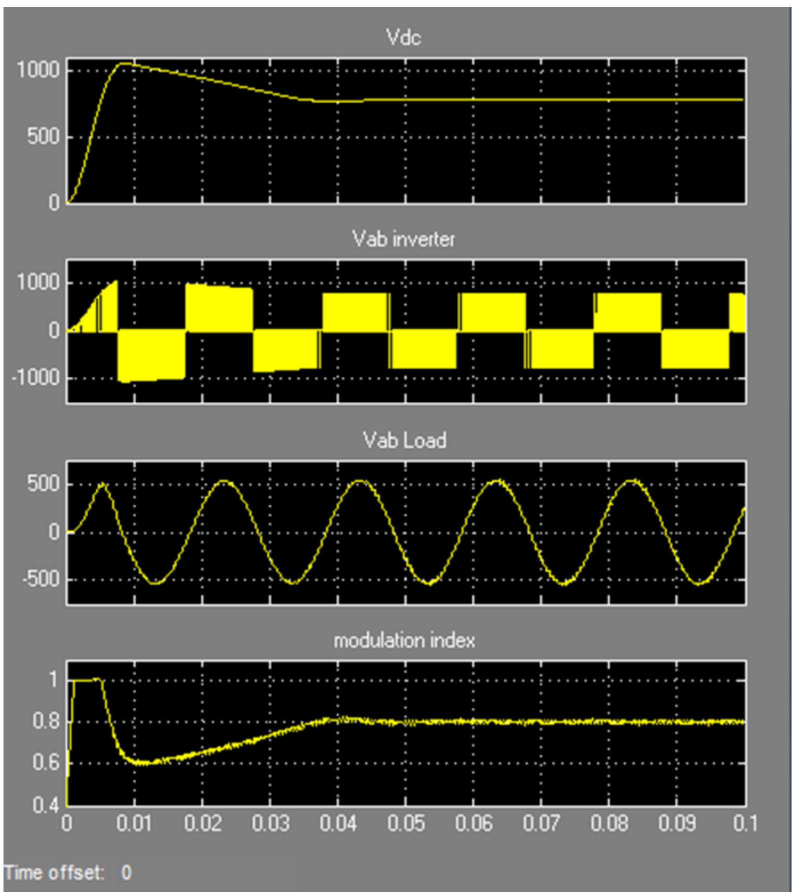

Figure 7: Scope 1 waveforms

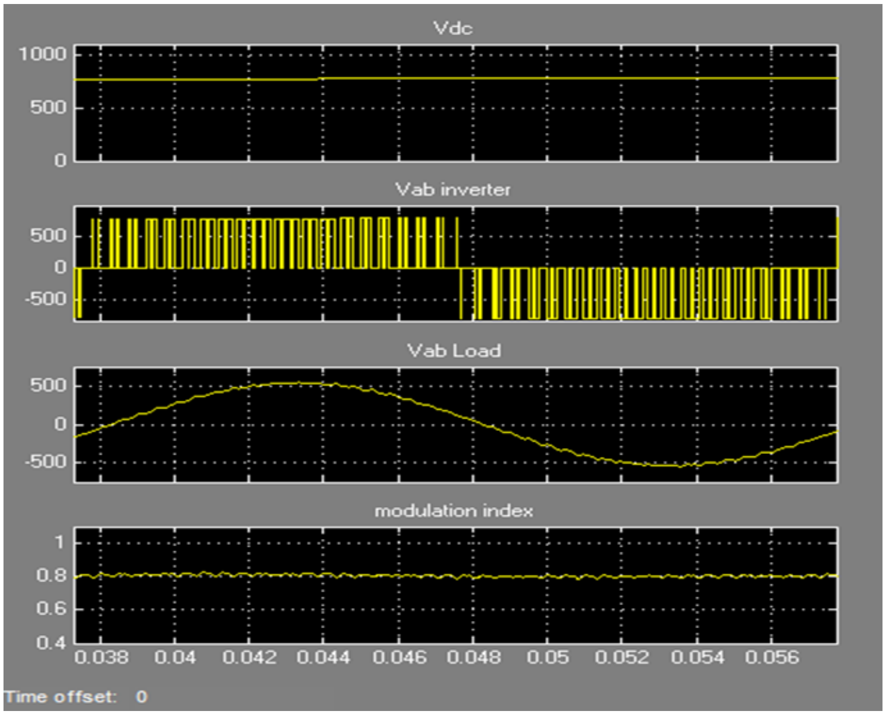

Figure 8 : Zoom out scope 1 waveforms

2. CONCLUSION

This paper presents the possible simulation of many electrical power converters by using SIMULINK in MATLAB which keep away from a buy of expensive and complex devoted software programs. The simulation techniques are based on the variable topology advance where switching condition realization was produced. Definitely, the low thermal resistance and high current density could be satisfied by using RC and IGBT as bridge. The high capacity single phase PWM converter offer high reliability and power density. The de-saturation control of the integrated RC-IGBT structure for switching device to full bridge circuit has been realized and investigated in the proposed work. Additionally, the compensating current control of the PWM converter is considered. To avoid the de-saturation pulses in the zero crossing, and setting of the loss decrement threshold limited is established. The performance of the PWM operation in low switching frequency is developed. The simulation results show a conformation the effectiveness of over saturation control in this research. A very small power platform has been verified the effectiveness of the control approach. In addition, the results of simulation design show a significant economy in microcontroller time and memory increasing which will support all converter duty.

REFERENCES

[1] Xianjin Huang, et al., " Research on Single-Phase PWM Converter with Reverse Conducting IGBT Based on Loss Threshold Desaturation Control", Energies , 10, 1845; doi:10.3390/en1011184, 2017

[2] [2] MAREK JASINSKI, et al., "Direct Power and Torque Control of AC/DC/AC Converter with Induction Generator for Renewable Energy System – Wave Dragon MW", Proceedings of the 6th WSEAS/IASME Int. Conf. on Electric Power Systems, High Voltages, Electric Machines, Tenerife, Spain, December 16-18, 2006

[3] [3] Vinay Kumar Prajapati, "Three-Phase High Frequency Isolated DC–DC Converter with PWM Generator", International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value , 2016

[4] [4] C.S.Sharma and Tali Nagwani, "Simulation and Analysis of PWM Inverter Fed Induction Motor Drive", International Journal of Science, Engineering and Technology Research (IJSETR) Volume 2, Issue 2, February 2013

[5] [5] Pradeep. H. Yakkundi. Et al.," Design and Simulation of Space Vector PWM for Three-Phase Induction Motor",IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 9, Issue 3 Ver. III , PP 01-08, 2014

[6] [5[Djafar Hadiouche, et al. "Space-Vector PWM Techniques for Dual Three-Phase AC Machine: Analysis, Performance Evaluation, and DSP Implementation", IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 42, NO. 4, JULY/AUGUST 2006

[7] [6] J S SIVA PRASAD, et al., "Vector control of three-phase AC/DC front-end converter", S¯adhan¯a Vol. 33, Part 5, pp. 591–613, 2008

[8] [7] MANOJ KUMAR MODI, et al.," Space vector-based analysis of overmodulation in triangle-comparison based PWM for voltage source inverter", Sa¯dhana¯ Vol. 38, Part 3, , pp. 331–358, June 2013

[9] [8] K.Vinoth Kumar, et al., " Soft Computing Module of High Step-Up DC–DC Converter for PV Module using Simulink Environment", International Journal of Power Electronics and Drive Systems (IJPEDS),Vol. 3, No. 1, pp. 53~61,2013

[10] [9]Marvin Barivure Sigalo and Lewis T. Osikibo, " Design and Simulation of Dc-Dc Voltage Converters Using Matlab/Simulink", American Journal of Engineering Research (AJER), Volume-5, Issue-2, pp-229-236, 2016

[11] S. E. M. de Oliveira and J. O. R. P. Guimaraes, "Effects of Voltage Supply Unbalance on AC Harmonic Current Components Produced by AC/DC Converters", IEEE Trans. on Power Delivery, vol. 22, no. 4, pp. 2498-2507, Oct. 2007.

[12] Wen, J.P. Research on the Control Strategies of Single-Phase Three-Level Pwm Rectifier; Beijing Jiaotong University: Beijing, pp. 1–96, China, 2012

[13] Song, K.J. Research and Implementation of Three Phase Current Source Rectifier; Nanjing University of Aeronautics and Astronautics: Nanjing, pp. 1–99, China, 2014

[14] Liu, B. Constant-Frequency-Hysteresis Control Strategy for Single Phase PWM Rectifiers; Southwest Jiaotong University: Chengdu, pp. 1–75, China, 2016

[15] Zhang, Y.C.; Peng, Y.B.; Qu, C.Q. Predictive current control of PWM rectifier under unbalanced grid voltage condition. Trans. 31, 88–94, China Electrotech. Soc. 2016

[16] Song,W.S.; Deng, Z.X. Model predictive power control scheme for single-phase PWM rectifiers with constant switching frequency. Electr. Mach. 20, 93–100, Control 2016

[17] Yin, K.; Ma, M.Y.; Cao, M.H.; He, Y.M.; Deng, Y.; Hen, X.N. Research on three-phase hybrid-clamped five-level PWM rectifier, 32, 59–66, Proc. CSEE 2012

[18] Huang, H. The Research of Single-Phase PWM Rectifier and Control Strategy; Huazhong University of Science & Technology: pp. 1–66, Wuhan, China, 2012, Yang, L.Y.; Yang, S.; Zhang,W.P.; Chen, Z.G.; Long, X.U. An improved deadbeat predictive current control method for single-phase PWM rectifiers. 35, 5842–5850, Proc. CSEE 2015