Volume : 3 | Issue : 7 | July 2014 • ISSN No 2277 - 8179

Research Paper

Modelling and Analysis of Three Phase Four Switch Pwm Converter

Engineering

KEYWORDS : PWM, voltage source rectifier

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ABSTRACT

Controller design for six-switch pulse width modulated (PWM) voltage source rectifiers (vsrs) is often accomplished in the rotating d-q frame coordinates in order to achieve a high-performance control. In contrast, the development of a d-q Frame controller for a four-switch PWM VSR is rarely reported in the literature. . For this purpose, a mathematical model of the four-switch PWM VSR In rotating d-q frame is first derived. Its success is relied on performing a so-called "reduced Park Transformation" on switching functions. The derived model shares much structural property with that of a six-switch VSR. The modeling and design of four switch three phase PWM converter with controller performance are analyzed in this paper. The high performance control of two d-q frame current controller design based on propositional plus integral controller (LPI) is performed in this project. Their effectiveness is verified via computer simulation and hardware experiment. The performance of four switch PWM voltage source rectifier results will be compared with three phase six switch rectifier. With LPI D-Q current controller delivers nearly sinusoidal and balanced line currents and small dc bus voltage ripples. The proposed voltage source rectifier will be fabricated by using MOSFET. Then, two d-q frame current controller designs, input–output feedback linearization (IOFL) and linear

1. INTRODUCTION

Due to their low input current distortions, improved power factor, and regulated dc-ink voltage, pulse width modulated (PWM) voltage source rectifiers (VSRs) are favorable substitutes for line-commutated rectifiers in high performance industrial applications.

Recent investigations have mainly focused on the development of high-performance VSRs with six power switches, leading to a high maturity in the development of both circuit topology and control methodology for this type of VSRs.

"Performance Investigation of a Current-Controlled Voltage-Regulated PWM Rectifier in Rotating and Stationary Frames", by Navid R. Zargari and GCza Jobs, Senior Member, IEEE, IEEE Transactions on industrial Electronics, Vol. 42, No. 4, August 1995.

It explains about the active front-end rectifiers with reduced input current harmonics and high input power factor will be required in the near future for utility interfaced applications. In order to meet the new and more stringent regulations with force-commutated switches, the voltage source inverter approach is superior to the conventional current source approach, in terms of number of components and control options. PWM pattern generation is based on a carrier technique and the current controller is implemented in the: a) stationary (abc) frame, and b) rotating *(d-q) f*rame. The design and the performance of the two controller options are investigated and compared.

"A Reduced Hysteresis Controller for a Four-Switch Three-Phase Bidirectional Power Electronics Interface", by Yu-Kang Lo, Huang-Jen Chiu, and Wen-Tsair Li, IEEE transactions on industrial electronics, vol. 46, no. 4, august 1999.It tells about a reduced hysteresis controller for a four-switch three-phase bidirectional power electronics interface is proposed in this letter. Polarity detection of the input voltages to determine the switching states is not required. The circuit is simple. Experimental results show unity input power factor operation and bidirectional power transfer capability.

"Input–Output Linearization and Zero-Dynamics Control of Three-Phase AC/DC Voltage-Source Converters" by Tzann-Shin Lee, IEEE transactions on power electronics, vol. 18, no. 1, January 2003.

It explains the Non linear differential-geometric techniques that have been proposed for the design of feedback controller for three-phase voltage-source pulse width modulation (PWM) ac/dc boost converters

"An Analytical Modelling of Three-Phase Four-Switch PWM Rectifier Under Unbalanced Supply Conditions" by J. Klima, J. Skramlik, and V. Valouch, IEEE transactions on circuits and systems, vol. 54, no. 12, December 2007.

It explains a new description of the three-phase four-switch converter aimed at compensating reactive power in the general case of unbalanced source voltages is proposed.

A mixed - approach based on integral transformations (the Laplace and modified -transform) is suggested for obtaining solution in a closed form. The analytical procedure is verified by experimental results to confirm the effectiveness of the proposed control scheme.

"Overview of Modulation Techniques for the Four-Switch Converter Topology", by M. Monfared, H. Rastegar, H. M. Kojabadi, 2008.It explains a lot of advantages, there are extensive motivations to utilize four-switch converters in industrial applications. Many modulation techniques have been proposed to design a good four-switch converter that is less sensitive to DC link voltage fluctuations, and have low AC currents THD and at the Same time low distortion in the uncontrolled phase.

Among various techniques, design procedure and Advantages and disadvantages of three most used methods namely; hysteresis band current control, sinusoidal PWM, and space vector modulation are discussed. In order to have clear and effective comparison, simulation results have been provided and given in this paper.

2. THE PROPOSED CIRCUIT OF FOUR SWITCH THREE PHASE PWM CONVERTER

The scope of the project is to propose a four switches using computer. The power supply circuit is designed to operate the PIC where the two switches are driven by the 14-pin driver IC. Then the power circuit is operated with the help of MOSFETS where the 230VAC voltage is converted to 400 v at the load side.

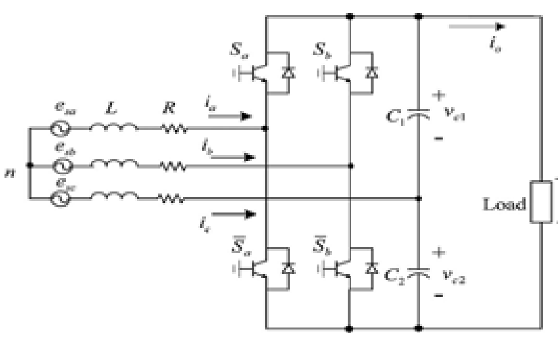

Fig. 1. Power circuit of the three-phase four-switch PWM voltage source rectifier

Volume : 3 | Issue : 7 | July 2014 • ISSN No 2277 - 8179

2. MODELING IN ROTATING D-Q FRAME

2.1. COORDINATE TRANSFORMATION

The Park Transformation converts the three-phase system from a stationary reference frame into synchronously rotating frame with direct, quadrature, and zero-sequence components. In this coordinates, as the *d*-axis is aligned with the source supply voltage, the unity-power-factor requirement can be achieved by simply regulating the *q*-axis source current to zero. Park Transformation has some variants. The reduced Park Transformation (3) converts d- and q-axis dc Components into two sinusoidal signals with 60◦ out of phase from each other.

2.2. MODELING IN ROTATING D-Q FRAME

The schematic diagram of a three-phase four-switch VSR under consideration is shown in Fig. 1. It is assumed that a resistive load RL is connected to the output terminal. Also, the two series-connected output capacitors are identical (i.e., C1 =C2 = C). As demonstrated in , assuming that esa + esb +esc = 0and ia+ ib+ ic= 0.

The *d-q* frame model derived in assuming that the VSR operates at steady state and $vc1 = vc2 = (1/2)\ vo$.*It* can be checked that in the derivation of the state-space model no such assumptions are made. Therefore, the derived state equations provide a mathematical model more suitable for controller design. As compared to the *d-q* frame model for a six-switchVSR the capacitor voltage difference terms *vcd* and *vcq* are unique to the four-switch VSR. Accordingly, when there is no difference between capacitor voltages *vc*1 and *vc*2,*vcd* and *vcq* vanish, and the *d-q* frame model is almost identical to that of a six-switch VSR. As using two identical capacitors in the capacitor bank, it is reasonable to assume that *vc*1 is equal to *vc*2 if the imperfection of the capacitors is ignored. Then, a wealth of analytical and control methods for the six-switch VSR may be directly applied to the four-switch VSR.

2.3. STEADY-STATE SOLUTION

The d-q frame model derived in Section II for four-switch VSRs is a two-input nonlinear system. With a resistive load RL connected at dc output, as dc-bus voltage v_o reaches a given desired setting Vo with a unity power factor, the steady-statesolution may be found as follows. Since the two series-connected output capacitors are identical, it is further assumed that

vc1 = vc2 =1\2V∗

When there is a failure of one bridge arm of a Six-switch VSR, a practical application of this topology is to recover the functionality of the six-switch VSR with split dc link capacitors.

In this situation, under the condition that the ac Supply and dc load remain unchanged, the delivered power of this simplified VSR will increase since the lower output voltage bound of the four-switch VSR is normally much higher than that of a six-switch VSR Typically, the lower output voltage bound of the four-switch VSR is increased by 173.2%. Thus, the simplified VSR will deliver power triple as much as that of the original six-switch PWM VSR.

3. SIMULATION MODEL

Simulations are done by using MATLAB/Simulink SimPowerSystems Toolbox to first validate the effectiveness of the proposed controllers designed with the *d-q* frame model. The following results are documented for the parameters:

Source voltage Em = 50 V,
Dc-bus output voltage Vo=180 V,
Line inductor L = 5 mH,
Inductor resistance R = 0.4Ω,
Dc-bus capacitors C1 = C2 = C =2200 μF,
Line frequency ω = 120π rad/s,
Load resistor RL = 100/50 Ω.

The gating signals for the four insulated gate bipolar transistor switches are generated via sinusoidal PWM strategy.

Carrier frequency fsw = 10 kHz

Amplitude of the PWM carrier kvt = 10V.

On the other hand, since a unity power factor is required, the *q*-axis current reference *i∗q* is set to zero. As thesoftware package does not provide a four-switch VSR block, arectifier bridge consisting of four power switches and two outputcapacitors is built. The VSR operates using a sinusoidal PWM strategy. Simulations are carried out for evaluating the dynamicperformance under step changes in load.

4. RESULT ANALYSIS

CASE (I)

In this case, comparing the output voltage using resistive load, inductive load and RLC load.

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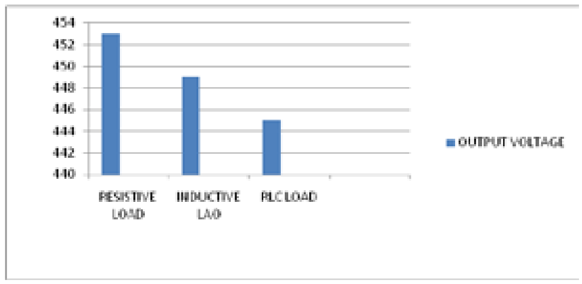

Fig.2: comparison of output voltage Using R, RL and RLC load

CASE (II)

In this case, comparing the output current using Resistive load, inductive load and RLC load. This Comparison shows in figure3

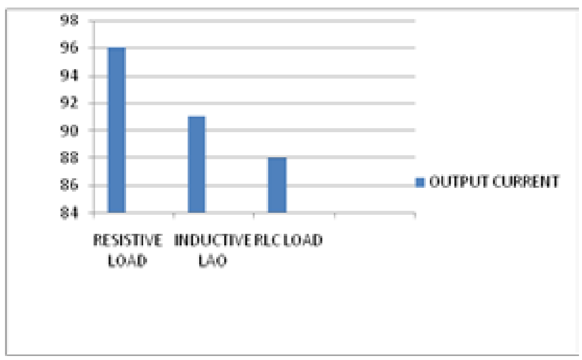

Fig.3: comparison of output voltage and output current Using R, RL and RLC load

WAVEFORM FOR RLC LOAD

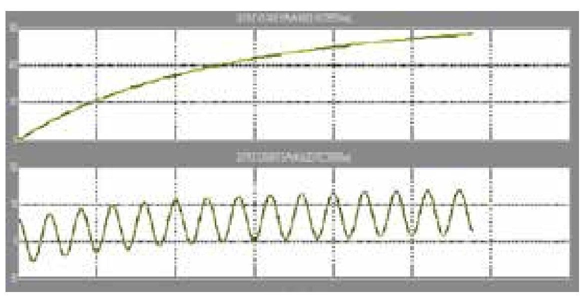

Fig.4: OUTPUT V & I FOR MOTOR LOAD

A laboratory prototype, with the same circuit parameters as in the case of simulation, was built for practical verification of the performance of the proposed controllers. This developing platform contains a DS1104 PPC controller board and real time interface that enables programming in MATLAB/Simulink environment. The controller board is equipped with a PowerPC 603e processor running at a clock speed of 250 MHz necessary in/out interfaces for implementingthecontrolscheme.

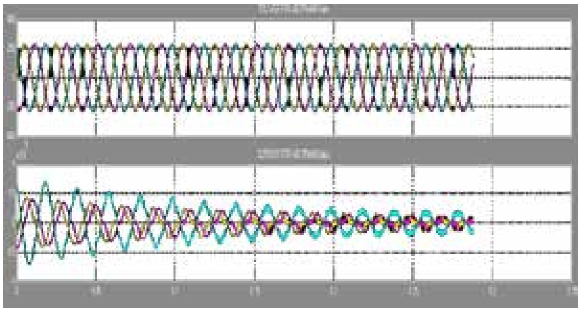

Fig.5: V&I FOR ABC FRAME

5. CONCLUSION

In this project, the simulation results of modeling and design of three phase four switch PWM converter using IGBT developed in MATLAB/SIMULINK have been presented. The pulse width modulation has been proposed as the switching schemes for converters. This simulation output is compared with six switches PWM converter that results shows the higher output voltage obtained in the four switch PWM converter when compared to six switch PWM converters. The simulation result proves that the four switches with the proposed switching schemes functions successfully as the real time controller. This paper presented the real time control of power electronics converter constraints which is widely used in industries.

Dr.s.baskar was completed the Ph.D at Annamalai university. presently working as associate professor at Saveetha university.

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