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Simulation of DC Motor Control Strategy for PWM Rectifier with Power Factor Correction

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ABSTRACT: Power electronics equipments become more widely used. Unfortunately, the standard diode/Thyristor bridge rectifiers at the input side cause several problems as: Low input power factor, high values of harmonic distortion of ac line currents, and harmonic pollution on the grid. In recent years, the research interest in the area of PWM rectifiers has grown rapidly. The PWM rectifier offers several advantages such as: control of DC bus voltage, bi-directional power flow, unity power factor, and sinusoidal line current. Many pulse-width modulation (PWM) techniques have been adopted for these rectification devices to improve the input power factor and shape the input current of the rectifier into sinusoidal waveform. The phase and amplitude control (PAC) seems to be the most simple structure and provides a good switching pattern, but the dc offset on input current of the rectifier during transient state deteriorates the control system stability. The current regulating fashion in synchronous frame has the advantages of fast dynamic current response, good accuracy, fixed switching frequency and less sensitive to parameter variations. This project analyzes the principle of PWM rectifier, and presents a unity power factor control method of PWM rectifier. Controller used double closed-loop PI control, which inner uses three-phase input current control method controlled by unity power factor and outer controls the output DC voltage of rectifier. The proposed concept can be implemented with DC motor using MATLAB/SIMULINK software.

Keywords- PWM, rectifier, unity power factor, filter

I INTRODUCTION

Since the rectifier consisted of diode or thyristor is easy to control and reliable, it is widely used in industry. However, the input current of this rectifier contains a large number of harmonics, which has become to the main source of grid. In addition, this rectifier also has the issue about low power factor. PWM rectifier does not produce harmonics on the gain, while the input power factor can be controlled and the output DC voltage can be adjustable, is a high performance fairing. In this paper, a PWM rectifier is studied, which focus on an unity power factor control method. The result of the simulation and experiment show the feasibility and effectiveness of the method[1].

II PWM RECTIFIER AND ITS UNITY POWER FACTOR CONTROL METHOD SELECTING A TEMPLATE

Figure 1 shows the structure of the PWM rectifier. $e_a(t), e_b(t), e_c(t)$ is the three phase voltages. L is the support filtering inductance of the AC side voltage. R is the equivalent resistance of the system. C is the support capacitance of the DC side voltage.R*L* is the resistive load. e*L*is the load force.

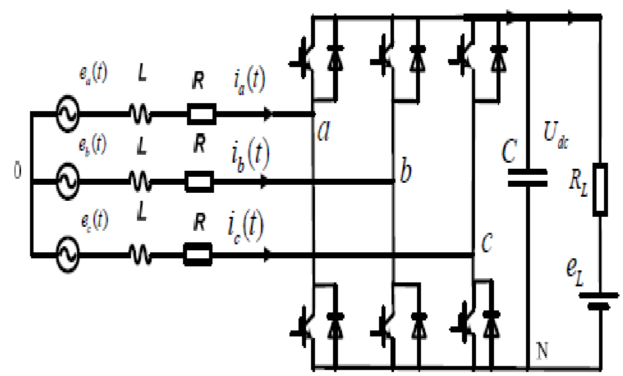

Fig.1 The structure of the PWM rectifier

When the load force *L e* is zero or less than the DC voltage across the capacitor, the DC side is a purely resistive load and the rectifier operates in the rectifier mode. When the load forces *eL*is greater than the DC voltage across the capacitor, the rectifier operates in active inverter mode. Figure2 shows the direct power control method block diagram of the PWM rectifier. Controller used double closed loop PI control, which inner uses three-phase input current control method controlled by unity power factor and outer controls

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the output DC voltage of rectifier, to control the power of the rectifier[2].

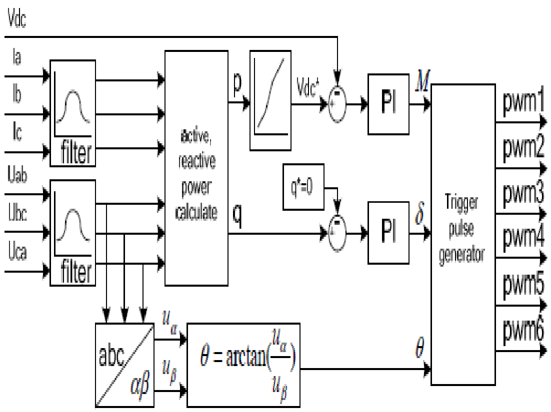

Fig.2 The direct power control method block diagram of the PWM rectifier

This control method of the control system is implemented as follows:

1) Detection the instantaneous fundamental component of the voltage and current. Using the second-order Butterworth digital filtering algorithm of equation 1, the amplitude, and phase and frequency characteristics of this filter is shown in figure 3.

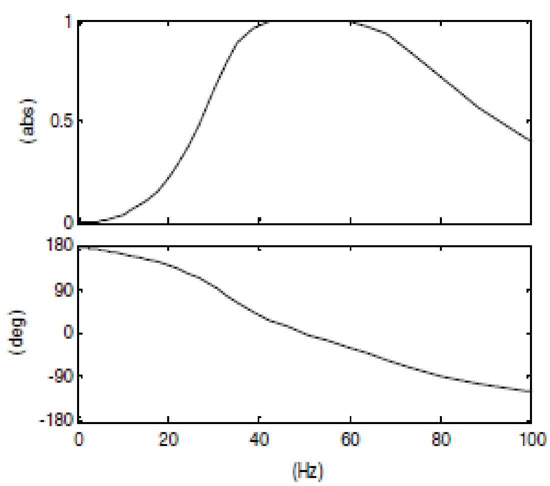

Fig.3 The amplitude, phase and frequency characteristics of Butterworth band-pass filter

From which we can see, amplitude of the fundamental component part of the signal does not decay, the phase does not shift, which on the basis of ensuring filters the DC component of the input signal and high harmonics.

$$G_1(z) = \frac{0.001915z^{-1} - 0.001971z^{-2} - 0.0018033948z^{-3} + 0.001859z^{-4}}{1 - 3.903z^{-1} + 5.722z^{-2} - 3.734z^{-3} + 0.915z^{-4}}$$

The sampling frequency of the discrete formula is 5000Hz, and filter quality factor of the design is 1 [3].

2) Calculate the instantaneous active power and reactive power. Obtain the input active power and reactive power via the the calculation of equation 2 and equation 3.

$$p = Ua * Ia + Ub * Ib + Uc * Ic$$

$$q = ((Ua - Ub) * Ia + (Ub - Uc) * Ib + (Uc - Ua) * Ic) / \sqrt{3}$$

3) Calculate the average active power, reactive power and DC voltage in each cycle. Using the average formula of equation 4 to obtain the input active power, reactive power and dc capacitor voltage of the rectifier.

$$X = \sum_{1}^{100} X_i \quad i = 1,2 \ldots 100 \qquad X = p, q, vdc$$

4) For reactive power q, the use of the inner PI control algorithm make the input reactive power of the rectifier is zero, which achieves the unity power factor input. The block diagram to achieve the inner PI control algorithm is shown in Figure 4.

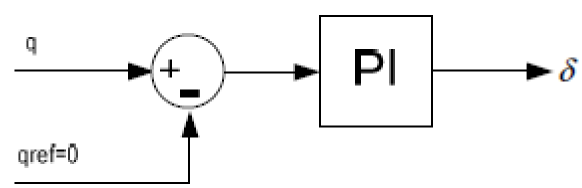

Fig.4 The inner loop PI controller of power factor

5) For the DC voltage across the capacitor, use of the outer PI control algorithm and adjust the output DC voltage across the capacitor of the rectifier, thus control the output power. The block diagram to achieve the outer PI control algorithm is shown in Figure 5 [4].

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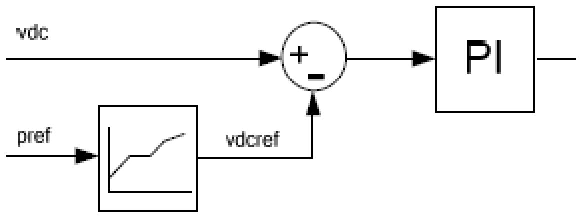

Fig.5 The outer loop PI controller of power

6) Obtain the real-time phase of the grid. The three-phase fundamental voltage obtained in Step1) can obtain the real time phase information of the grid by using formula 5, formula 6 and formula 7.

$$u_{\alpha} = u_{a} - 0.5 * u_{b} - 0.5 * u_{c}$$

$$u_{\beta} = -0.86 * u_{b} - 0.65 * u_{c}$$

$$\theta = \arctan(\frac{u_{\alpha}}{u_{\beta}})$$

7) Obtain the three-phase output current reference value. Use formula 8 to obtain the three-phase output current reference value.

$$ia = M * \sin(\theta + \delta)$$

$$ib = M * \sin(\theta + \delta - 120)$$

$$ic = M * \sin(\theta + \delta + 120)$$

The output of PWM signal. Switch the output current reference value of rectifier to the switching time of each switch device[5].

III DC MOTOR

DC motors are preferred where wide speed range control is required. Phase controlled converters provide an adjustable dc voltage from a fixed ac input voltage. DC choppers are also providing dc output voltage from a fixed dc input voltage. The use of phase controlled rectifiers and dc choppers for the speed control of dc motors modern industrial controlled applications. DC drives are classified into the following methods:

A.DC Motor Control System

Figure 4 shows the schematic arrangement of a two quadrant controller's dc drives system .The figure showing the 2 control loops. First one is outer speed control loop and the other one is inner current control loop. The feedback signal of speed is derived from a tacho generator. Although alternatively an approximation of the motor speed can be derived by feeding back a signal proportional to the motor voltage. The Position criticism can be incorporated for servo applications by utilizing a position encoder on the engine shaft. The pace input circle contrasts the taco yield voltage and a pace reference signal. The voltage signal blunder gives the present reference command. In that present summon sign is contrasted and the genuine engine current in the internal control circle. In this control circle incorporates the current cutoff setting which shields that engine and the device from over streams. On the off chance that the controller requests a substantial pace change then the present interest is kept up beneath the greatest level by this present farthest point setting. Motoring or recovering operation is distinguished in circuit straightforwardly from the extremity of the blunder voltage flag and used to figure out if it is the base or top MOSFET and which is controlling the current. The motoring recovering rationale circuit incorporates a few hysteresis to guarantee that control does not waver between the motoring and recovering modes at low engine currents. There are conceivable methods for controlling so as to control engine current the changing successions to the fundamental Power Metal oxide semiconductor (MOS) device. In resistance band control the engine current is contrasted and the reference sign and a permitted current swell resilience. Amid motoring operation the real current is more prominent than the permitted greatest estimation of the resistance band. At that point the yield comparator turns off the door drive to the force MOSFET in this manner the permitting engine current to fall. at the point when the comparator walks out on The present then free wheels until it achieves the lower furthest reaches of the resilience band, .by Using this present control procedure the powerful variable, depending up on the rate at which the armature current changes, however the top to crest current swell in the framework is steady. by utilizing Beat width regulation (PWM) system current control Alternately the device can be exchanged a steady recurrence . Here the present blunder contrasted and altered recurrence triangular wave and the comparator yield is then used to give the sign to the principle exchanging device. Whenever the blunder sign is not exactly the triangular transporter then the gadget is exchanged off. At the point when the blunder sign is more prominent than triangular wave then the power gadget is switched on.

IV MATLAB/SIMULINK RESULTS

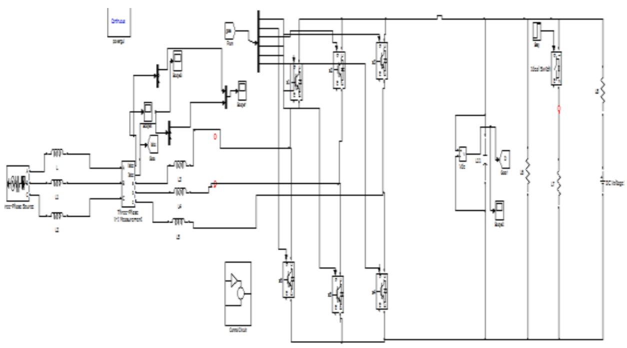

Fig 6 Matlab/simulation circuit of The structure of the PWM rectifier

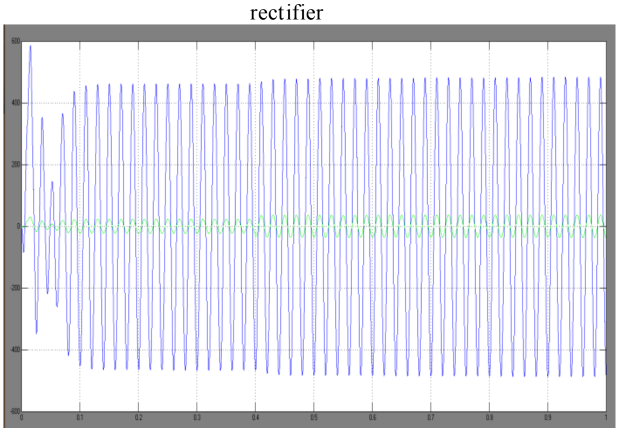

Fig 7 simulation wave form the input voltage, input current and output voltage waveform when the rectifier work in rectifying mode

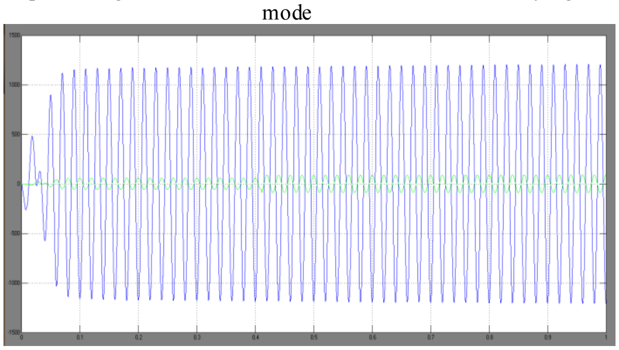

Fig 8 the input voltage and input current waveform when the rectifier work in the inverter mode

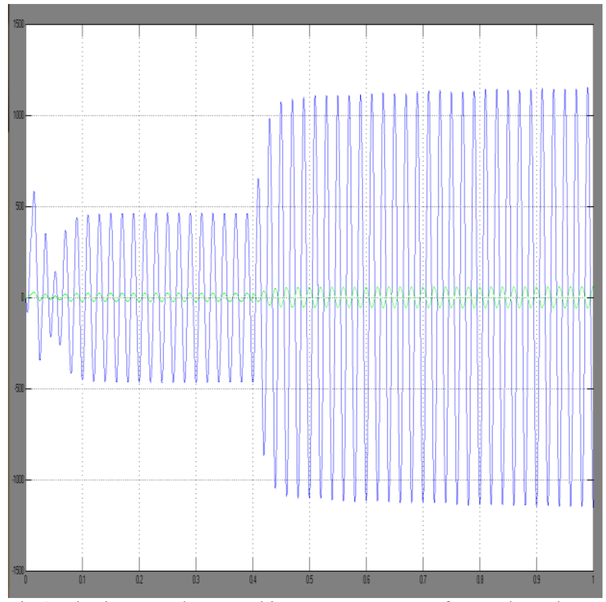

Fig 9 The input voltage and input current waveform when the rectifier work in the rectifier inverter mode

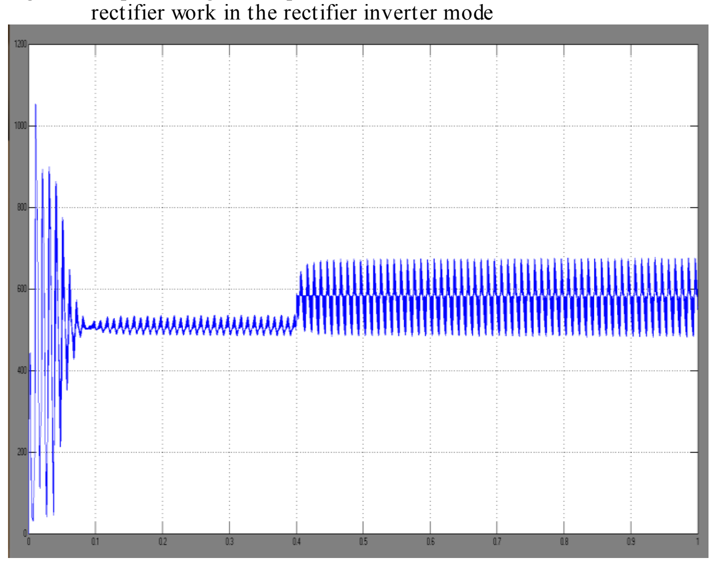

Fig 10 simulation wave form of capacitor voltage

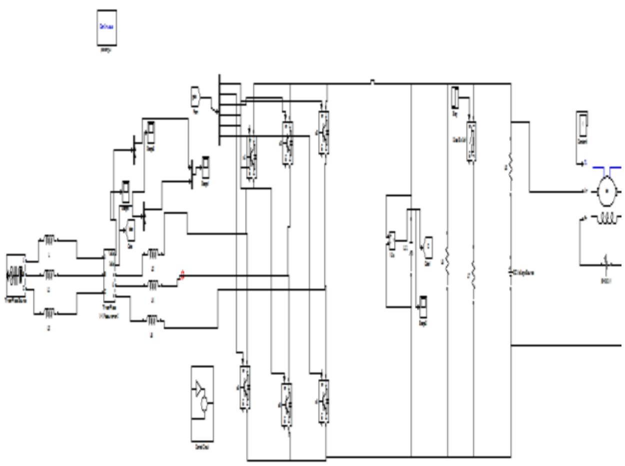

Fig 11 Matlab/simulation circuit of The structure of the PWM rectifier with DC Motor

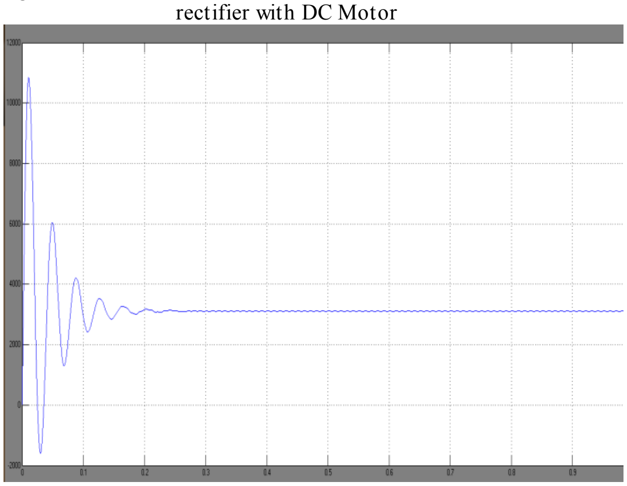

Fig 12 simulation wave form of the PWM rectifier with DC Motor speed

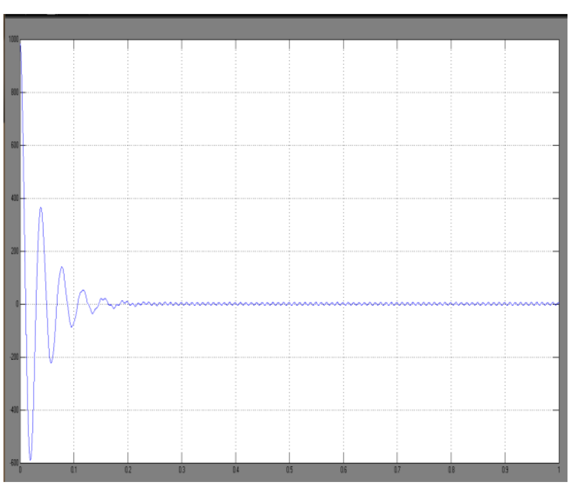

Fig 13 simulation wave form of the PWM rectifier with DC Motor stator current

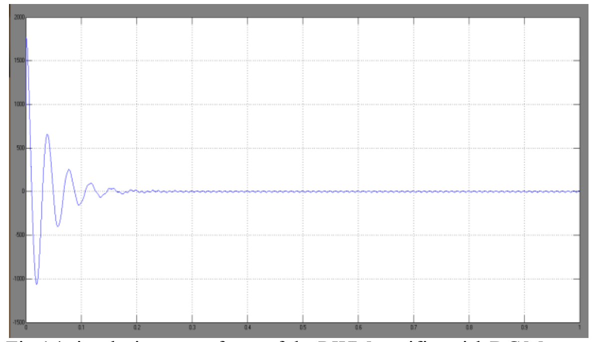

Fig 14 simulation wave form of the PWM rectifier with DC Motor torque

CONCLUSION

This paper analyzes the principle of PWM rectifier, and presents a input unity power factor control method of PWM rectifier. The result of the simulation and experiment verify the feasibility and effectiveness of the method. The proposed method DC Motor characteristics can be speed, current and torque be studied

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