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SVM Based Reduction of Input Current Harmonics in Three Phase Rectifier

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Abstract. Current Scenario of power system engineering field is facing problem of harmonics in voltage and current. In power converter harmonics are mainly disturb the stability of voltage and current in uncertainty of load and transient. This paper proposes space vector modulation based analysis of input current in 3 phase converter. Harmonics in input current in converter is a big challenge of power Electronics research. In power converters non-linear load are one of the reason for increasing the harmonics in electronic circuits. Modified space vector modulation is proposed for reducing the harmonics in 3 phase converter and also control the total harmonic distortion. Matlab simulink software is used to simulate and analyse the 3 phase converter and SVM is modelled for above converter. In this propose method THD of input current harmonics has reduced below 5 percentages and compared with IEEE standard.

Keywords:-- Harmonic current, Harmonic distortion, PWM, SVM.

1. Introduction

Increasing a stage of non linear load in our electrical field harmonics are placed in would it an current. Harmonics are defenders the multiple integral of fundamental frequency In linear load the voltage and current are linearly very good that means both are directly proportional to the each other. Example of linear load is a direct current serious and front motors. In non linear load the voltage and current are inversely proportional and not buried linearly. Induction motor and synchronous motor and special electrical machines are examples of non linear load. in non linearity electrical circuits having problems in frequency. A power Electronics converter operation depends on switching variations of power electronic devices. Due to transient of electronic circuits .harmonious may be developed changes or load variation of circuit as developing the harmonics.

In advance the life the world is started to run essay automatic smart and digital. Games and controllers are parts of automatic welding. Man linear load or necessarily for real time automatic condition power electronic converter for controlled need to control the non linear load especially for Electrical drives. Generally conventional electrical motors may be used in open loop system without automatic. Non-



conventional Motors power electronic commentator are converted with electrical Motors search with the exact speed control. Harmonics are developing the converter circuit due to the speed variation in power electronics circuits. As per IEEE standard total harmonic distortion of voltage should be less than 5 percentages and current less than 10 percentages but real time due to usage non linear loads and also based on induction principle motors, it produces maximum harmonics in voltage and current. Some of major harmonics producers from AC drives in induction motor, synchronous motor, Blde motor, switched reluctance motor and PMSM motor.

Figure 1 shows the proposed concept block diagram of three phase inverter with SVM technique. In this concept output current are taken as feedback from 3 phase converter and is compared with reference current. Error can be detected and it is converted into two current regulators, the duty of current regulator is producer architecture access current and direct Axis current. In this time direct answer is current or considered as zero. Proportional integral controllers are used as current regulator for developing the current I_{qs} based on the error from detector. In generally proportional controller may be used to get quick settling time of a signal and integral controller are prescribed for reducing peak overshoot of the signal. Voltage regulator develops the voltage of quadrature Axis and direct axis depend upon the harmonic calculation. Three phase voltages of ABC are converted into v_{ds} and v_{qs} by DQ transformation. Based the basic concept of SPM produces the gate pulses for three phase converter. In this type getting calls itself hormones can reduces to converter. Three phase rectifier can operating by giving firing pulse from space vector modulation. Finally three phase converter competitions the output voltage with fewer amounts of harmonics and total harmonic distortion of current can be read easily below 5 percentages with attribute standard.

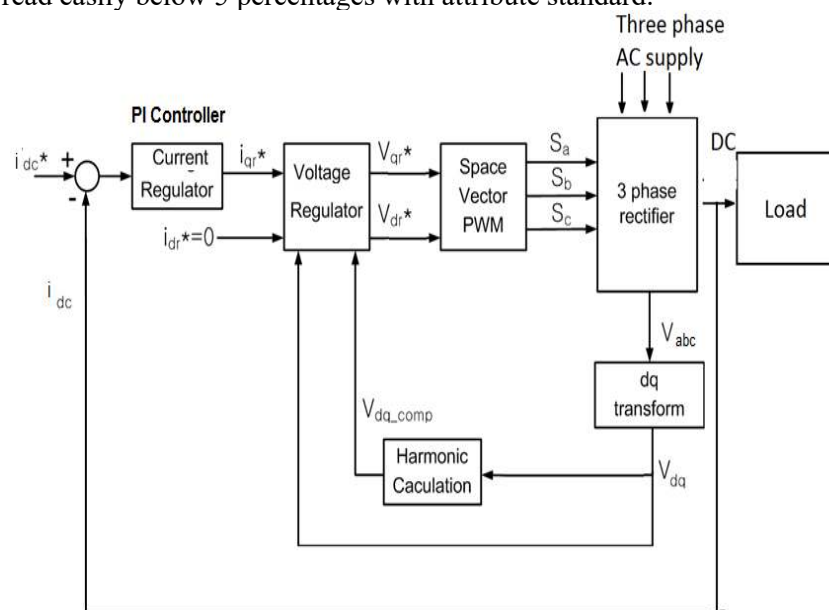


Figure 1. Block diagram of the Proposed PWM rectifier

2. Space Vector Pulse Width Modulation

Space Vector Modulation was developed in the year of 1980s. In conventional pulse width modulation techniques, reference signals compare with carrier signals modulation pwm signals can produced. Some of conventional methods are sinusoidal pulse width modulation multiple pwm, single pwm, trapezoidal pwm and harmonic pwm. In SVM consist of eight vector for states during the time period of TS and eighth factor are called as zero state or null vector because there is no power old flowing from source to load during the zero state operation so in which state all the switches or off condition. In other states in anyone switch will be turn on so the voltage are flowing from input to load the switching States from 2 to 7 are operating States. Figure 2 shows the switching state of proposal space

vector modulation. The total time period of modulation technique is 360 degree and each modulation consists of minimum 30degree. For power converter each States consists of vectors and switches are controlled by by svm get pulses. Output voltage can be improved in this method and harmonics are maximum reduced [13].

$$V_k = \frac{2}{3} V_{dc} * e^{j(k-1)\frac{\pi}{3}}, k=1,2,\dots,6. \quad (1)$$

$$T_1 = M * \frac{\sin(60^\circ - \alpha)}{\sin 60^\circ} * T_s \quad (2.1)$$

$$T_2 = M * \frac{\sin \alpha}{\sin 60^\circ} * T_s \quad (2.2)$$

$$T_Z = T_s - T_1 - T_2 \quad (2.3)$$

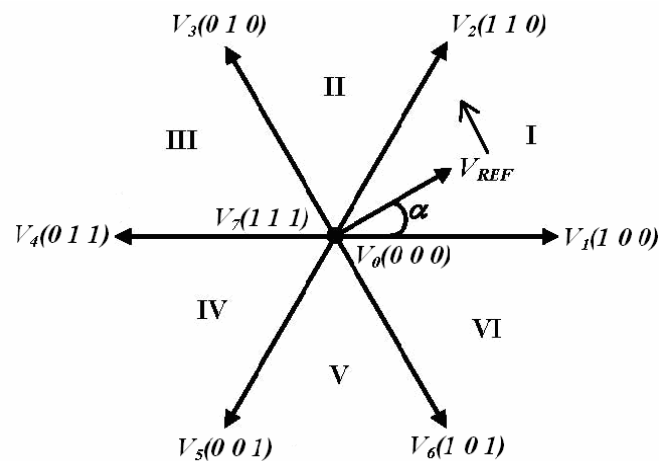


Figure 2. Switching states and corresponding voltage vectors of a three phase VSI. I, II, III, IV, V, VI are the sectors.

Thus, SVPWM uses $V_0, V_k, V_{k+1}, V_7, V_{k+1}, V_k, V_0$ sequence for odd sectors and $V_0, V_{k+1}, V_k, V_7, V_k, V_{k+1}, V_0$ sequence for even sectors respectively.

3. Harmonics Reduction Technique of Input Currents

Stationary frame of current can be converted into synchronous form is shown in equation 3.

$$\begin{bmatrix} i_d^{s*} \\ i_q^{s*} \end{bmatrix} = \begin{bmatrix} \cos \theta & -\sin \theta \\ \sin \theta & \cos \theta \end{bmatrix} \begin{bmatrix} i_d^{e*} \\ i_q^{e*} \end{bmatrix}. \quad (3)$$

$$\begin{aligned} \begin{bmatrix} i_d^{s*} \\ i_q^{s*} \end{bmatrix} &= \begin{bmatrix} \cos(\theta + \Delta\theta) & -\sin(\theta + \Delta\theta) \\ \sin(\theta + \Delta\theta) & \cos(\theta + \Delta\theta) \end{bmatrix} \begin{bmatrix} i_d^{e**} \\ i_q^{e**} \end{bmatrix} \\ &= \begin{bmatrix} \cos \theta & -\sin \theta \\ \sin \theta & \cos \theta \end{bmatrix} \begin{bmatrix} i_d^{e*} \\ i_q^{e*} \end{bmatrix}. \end{aligned} \quad (4)$$

By using the references i^{c**}_d , i^{c**}_q and the phase angle, the corrected current references i^{e**}_d , i^{e**}_q can be derived by (6).

$$\begin{aligned} \begin{bmatrix} i^{e**}_d \\ i^{e**}_q \end{bmatrix} &= \begin{bmatrix} \cos(\theta + \Delta\theta) & -\sin(\theta + \Delta\theta) \\ \sin(\theta + \Delta\theta) & \cos(\theta + \Delta\theta) \end{bmatrix}^{-1} \begin{bmatrix} i^{s**}_d \\ i^{s**}_q \end{bmatrix} \\ &= \begin{bmatrix} \cos(\theta + \Delta\theta) & \sin(\theta + \Delta\theta) \\ -\sin(\theta + \Delta\theta) & \cos(\theta + \Delta\theta) \end{bmatrix} \begin{bmatrix} i^{s**}_d \\ i^{s**}_q \end{bmatrix} \\ &= \begin{bmatrix} \cos(\theta + \Delta\theta) & \sin(\theta + \Delta\theta) \\ -\sin(\theta + \Delta\theta) & \cos(\theta + \Delta\theta) \end{bmatrix} \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} i^{e*}_d \\ i^{e*}_q \end{bmatrix} \\ &= \begin{bmatrix} \cos\Delta\theta & \sin\Delta\theta \\ -\sin\Delta\theta & \cos\Delta\theta \end{bmatrix} \begin{bmatrix} i^{e*}_d \\ i^{e*}_q \end{bmatrix}. \end{aligned} \tag{5}$$

$$\begin{aligned} [R(\theta)] \begin{bmatrix} \cos(\theta + \Delta\theta) \\ \sin(\theta + \Delta\theta) \end{bmatrix} &= \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} \cos(\theta + \Delta\theta) \\ \sin(\theta + \Delta\theta) \end{bmatrix} \\ &= \begin{bmatrix} \cos\theta \cos(\theta + \Delta\theta) + \sin\theta \sin(\theta + \Delta\theta) \\ -\sin\theta \cos(\theta + \Delta\theta) + \cos\theta \sin(\theta + \Delta\theta) \end{bmatrix} \\ &= \begin{bmatrix} \cos\Delta\theta \\ \sin\Delta\theta \end{bmatrix}. \end{aligned} \tag{6}$$

The distortion components $\sin\Delta\theta$ and $\cos\Delta\theta$ necessary for calculating (4) can be obtained by (5). To extract such distortion components, the phase angles θ and $\theta + \Delta\theta$ should be known

4. Simulations and Results

Figure.3 Shows MATLAB simulation of Three phase Rectifier under the distortion of Input Voltage. Here Source voltage is distorted by series connected reactance. MATLAB /Simulink diagram has been run up to 0.1 sec and fundamental frequency of supply is 50 Hz.

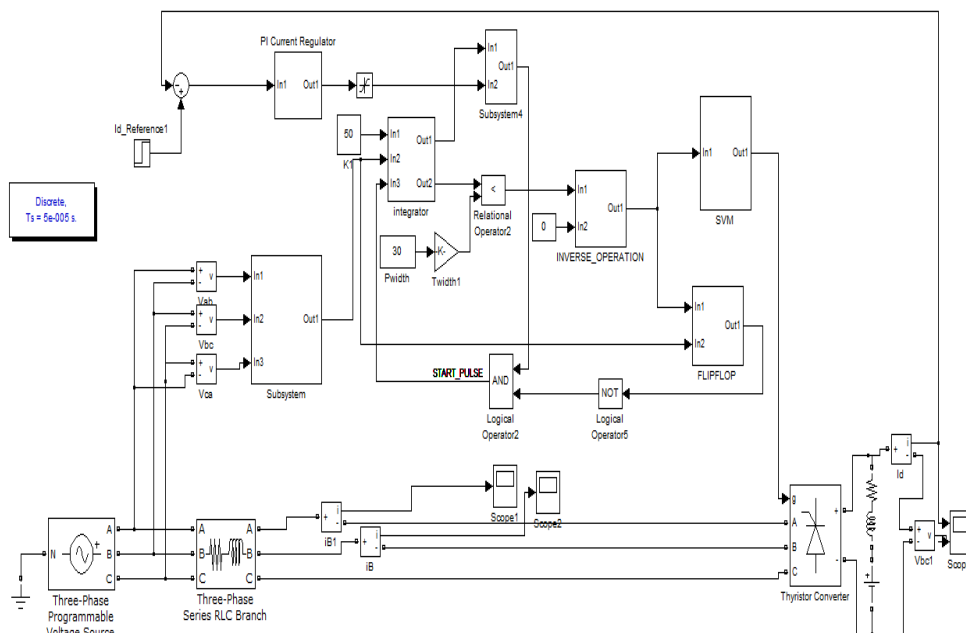


Figure 3. MATLAB Simulation of SVM based Three Phase Rectifier

Figure 4 shows Actual output current and reference current of three phase Rectifier. Reference current is settled 10A at t=0sec and current is changed to 25A at t=0.06sec as shown in Figure

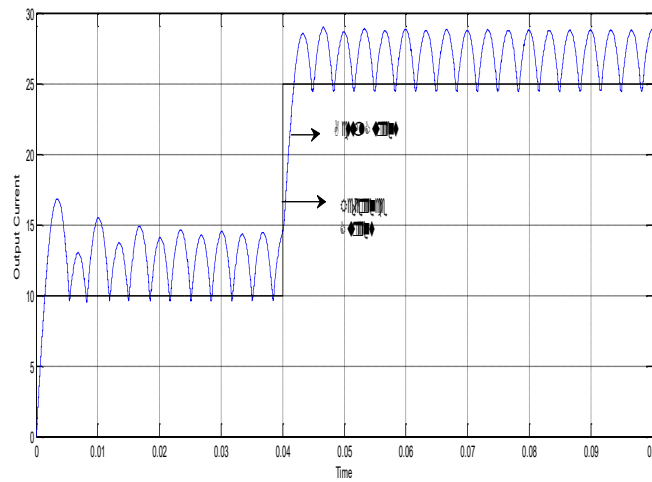


Figure 4.Actual Output current and reference current of three phase Rectifier.

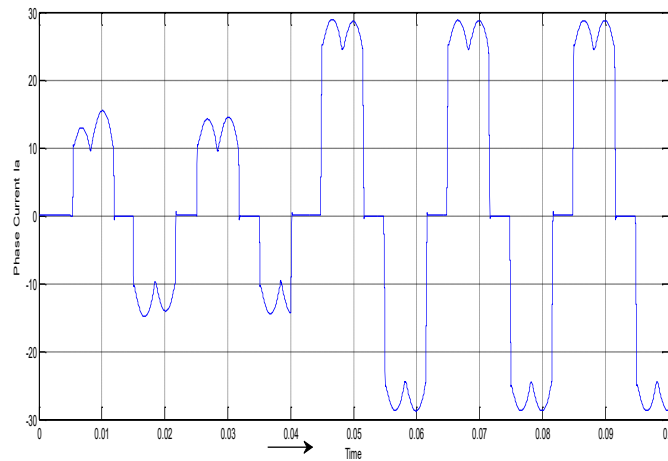


Figure 5.Input Phase Current Ia of Three phase Rectifier

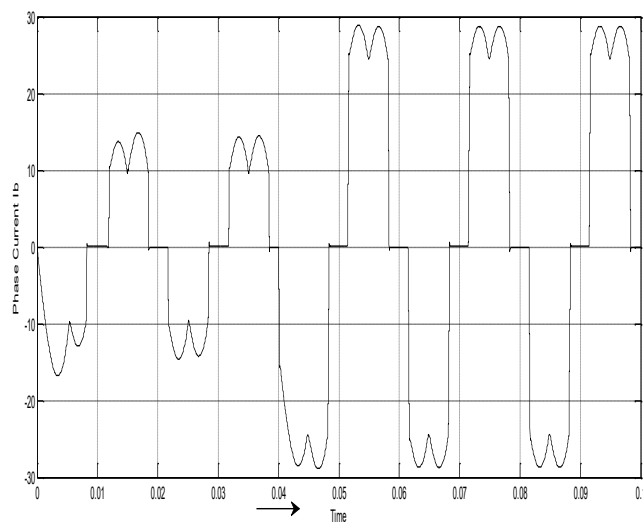


Figure 6.Input Phase Current Ib of Three phase Rectifier

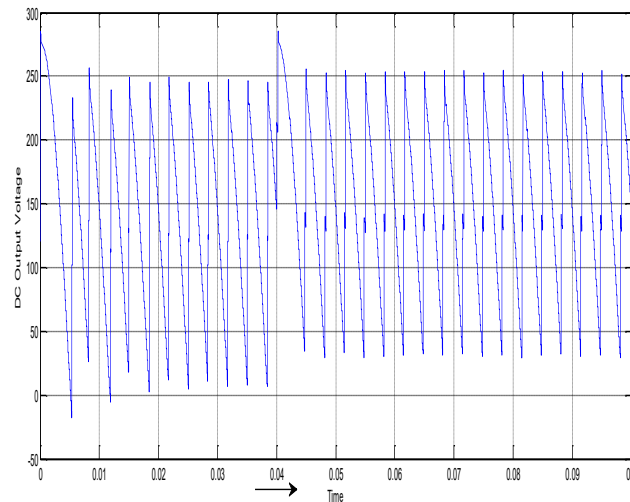


Figure 7. Output DC Voltage of Three phase Rectifier

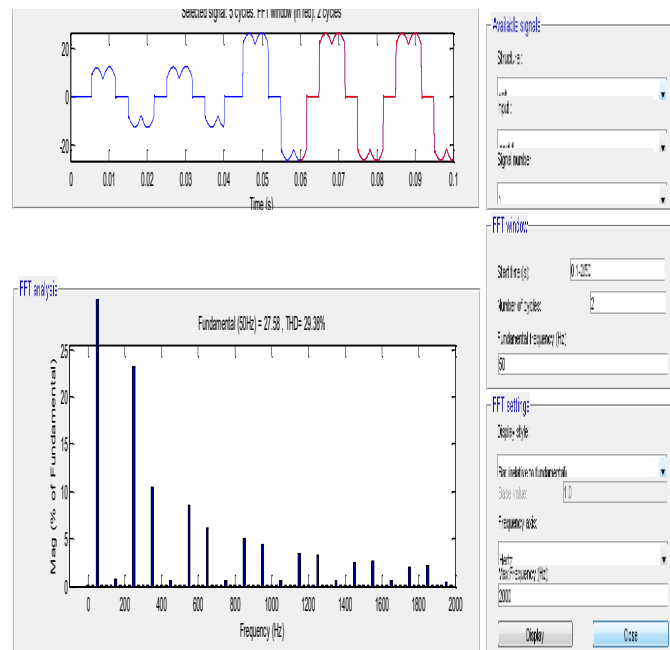


Figure 8. THD Analysis of Input Phase Current Ia of Three phase Rectifier

Figure 8 shows the THD Analysis of Input Phase Current Ia of Three phase Rectifier. By using proposed method, getting the THD 2.23% of Input phase current.

5. Conclusion

In this paper input phase current harmonics of three phase rectifier has been analysed by MATLAB simulation. THD of input current under source voltage distorted has been minimized without using any additional filter circuit. Output current of rectifier has been controlled by space vector Modulation should have a brief caption describing it and, if necessary, a key to interpret the various lines and symbols on the figure.

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