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Research paper

Voltage Oriented Control(VOC) Of The PWM Rectifier Using Active Filtering Function

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Abstract

Pulse width modulation rectifier has gathered its demand during the recent years for modification needs of the ac-dc conversion systems need for industries, customer and power grid sectors. This bidirectional converter can act as ac to dc boost rectifier with near unity power factor at the grid side along with the regulated and ripple free output voltage at the dc side. This paper deals with the evaluation of control strategy called voltage oriented control with active filtering function, Total harmonic distortion (THD),dynamic performance and parameter sensitivity is studied theoretical concept is provided and results of computer simulations are given by using mat lab.

Keywords: *PWM Rectifier, Harmonic Reduction, voltage oriented control, active filtering function, dynamic performance*

1. Introduction

PWM rectifier as compared to other conventional type of rectifiers has nice characteristics compared to conventional diode based or thyristors based rectifiers. The power quality at the grid side can be controlled with required control scheme and there by high power factor can be assured with less harmonic content in the input current and also the capacity of the bi-directional flow makes it most useful for industrial applications[1] .The function of a controller in a PWM rectifier is in such a way that it is to generate proper switching logic so as to generate required grid current which is sinusoidal and in phase along with the grid voltage. Many control techniques have been developed and implemented [7-8]

Voltage Oriented Control (VOC) of a PWM rectifier is a well known scheme among the various control methods prevailing among the PWM rectifiers .Here the reference voltage is calculated from the currents in synchronously rotating in the d-q reference frame .The direct axis component of current is controlled in similar lines to the active power demand and the quadrature axis current to control the reactive power .Thus the performance of a rectifier rely upon its controlling capability.

2. Introduction to PWM Rectifier with Active

Filtering Function

Shunt Active Power Filters (SAF) and PWM rectifiers are two kind of the examples from a few solutions, which are utilized for harmonic disposal[5]. The two have fundamentally a similar power circuit setup and can work in light of a similar control guideline. SAF can compensate current harmonics, as well as a imaginary power and load unbalance. PWM Rectifiers as non-contaminating devices with sinusoidal input currents will be more famous in light of a few advantages like: Bi-directional power stream, Closed loop based stabilizing of o/p dc voltage, Low harmonic distortion of line currents and flows, Regulations of i/p p.f to unity. Present paper investigates another undertaking of PWM rectifier - active filtering functionality**.** which includes points of benefits of SAF and PWM Rec-tifiers. Along these lines, the PWM rectifier supplies its load and in the meantime adjust or compensate the AC grid current[2].The SAPf can be parceled into two gatherings a parallel alongside arrangement and series kind of Active power filter. The intial gathering relavant to current along with the next one to voltage compensating.

Shunt Active Filters (SAF) are more than likely utilized for compensating current disturbance delivered by nonlinear burdens, as diode and alternatively thyristor rectifier fed adjustable speed drives

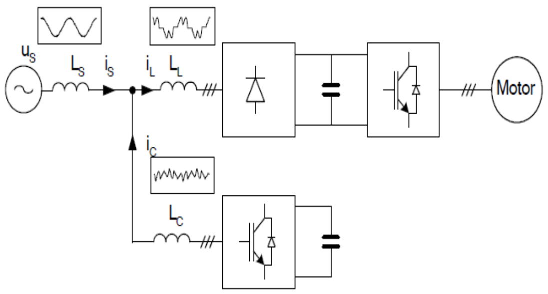


Fig1. Basic Configuration Of Shunt Active Filter

The SAf current infusion affects the grids current & just a little on the not linear loads current . The grids potential could be changed by SAf, especially if it was tremendously disturbed and subsequently, it adjusts load currents. The SAf impact on the load current is very less, however may prompt un-stable task now and again if the simulating has not been considered its elements. In the event that this little impact is disregarded and the loads are considered as a Curren-tsource, there is no connection between's the AF and the load

3. Control of Shunt Active Filter

3.1 Open Loop Control of SAF:

This system relies upon loads current estimation and afterward the harmonic substance is possesed from the load current . On the comparative lines, the SAF infuses the compensatory current into the grids, without data relating the network current . All mistakes inside the framework, similar to parameter vulnerabilities, measurement blunders or control mistakes, will appear in the grid present as unfiltered harmonic. The superiorly helpful favorable position of open looped technique is system strength, how ever it is relied upon expanded control calculation and more on decision on no of current sensors.

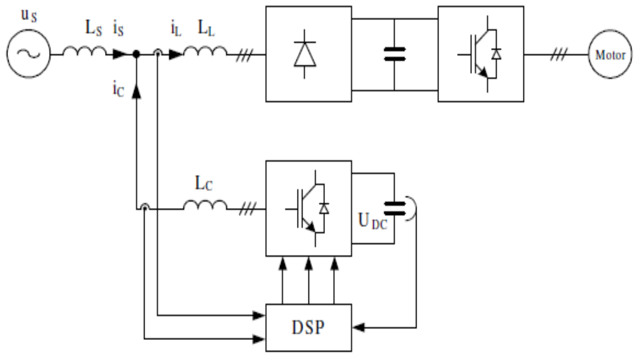


Fig2. Open Loop Shunt Active Filter

3.2 Closed Loop Control of SAF

Another approach to deliver the reference current is that one may quantify the grids current. Along these lines, notwithstanding the internal load current control loops, there's an external grids current loop in the control. This strategy does not affirm harmonics correction without phase balance and reactive power compensations. The control calculation is moreeasy in contrast with open loop strategy and calls for negligible numbers of current sensors

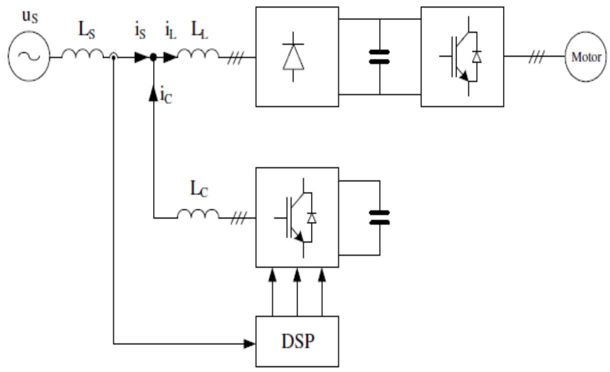


Fig 3. Closed Loop Control of SAF

4. Different Control Strategies:

4.1 Voltage Oriented Control

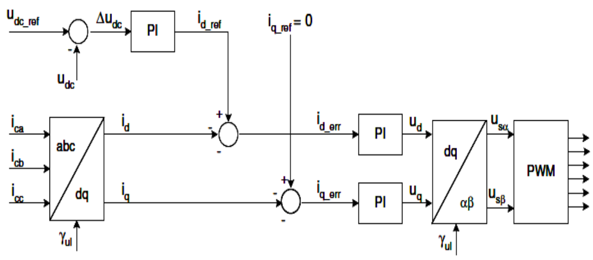


Fig 4. Block diagram of VOC

Voltage Oriented Control (VOC) depends on arrange transformations amidst stationary α–β and synchronous turning d-q reference framework. It guarantees snappy transient reaction and high performance in relentless state. Because of VOC utilizes an inside current control loops last execution of the framework unequivocally relys on used current control strategies.

The run of the mill VOC framework (Fig. 4) utilizes synchronous current control in pivoting reference arranges, as showed in (Fig. 5). An important development for this kind of current controller is signals processed in two arrange frameworks. The first is stationary α–β and the second one is synchronously turning d-q coordinates framework. Three phases estimation value are swung in to equal 2-Ø framework α–β and after that are changed to turning coordinate framework in a block α–β□/d-q.

$$\begin{bmatrix} k_d \\ k_q \end{bmatrix} = \begin{bmatrix} \cos\gamma_{US} & \sin\gamma_{US} \\ -\sin\gamma_{US} & \cos\gamma_{US} \end{bmatrix} \begin{bmatrix} k_\alpha \\ k_\beta \end{bmatrix} \quad \text{------------1}$$

Because of the above data the control values are DC signals. A inverse trnsforming, d-q/α-β□is used on the yield of control framework and it gives an outcome on rectifier reference motions in stationary cordinate:

$$\begin{bmatrix} k_\alpha \\ k_\beta \end{bmatrix} = \begin{bmatrix} \cos\gamma_{US} & -\sin\gamma_{US} \\ \sin\gamma_{US} & \cos\gamma_{US} \end{bmatrix} \begin{bmatrix} k_d \\ k_q \end{bmatrix} \quad \text{..............2}$$

The angles of our voltage vector u_s characterised as:

$$\sin\gamma_{US} = u_{S\beta} / \sqrt{(u_{S\alpha})^2 + (u_{S\beta})^2}$$

$$\cos\gamma_{US} = u_{S\alpha} / \sqrt{(u_{S\alpha})^2 + (u_{S\beta})^2}$$

In voltage arranged d-q co-ordinate, the AC line current vector i_C is partitioned into two rectangular segments i_C= [i_{Cd}, i_{Cq}] as in (Fig. 5). The part i_{Cd} sets up real power(P), where icq settles on choice about reactive power stream. Hence the real and the reactive power can be controlled autonomously by methods for real&reactive parts of line current vector i_C. The UPF condition is met when the line current vector, i_C, is co-ordinated with the line voltage vector, u_S. By setting the d-axes of the rotating co-ordinates on line voltage vector u_S a disentangled powerful example can be gotten[3-4].

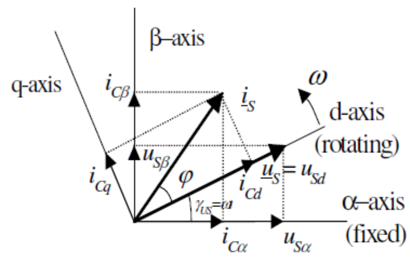


Fig 5.Vector graph of VOC.and its Coordinates for transformation from stationary to rotating cordinates

4.2. VOC with active filtering function:

As an active filter, PWM rectifiers can compensate higher harmonics in a grid current taken by the entire load[6]. Keeping in mind the end goal for compensation of higher harmonics additional control block(AFF) must be joined with standard VOC methodology . The disturbed currents i_{la}, i_{lb}, i_{lc} are conveyed to the abc/dq change, where a fundamental (50 Hz)harmonic turns into a DC quantity and other harmonics are non-DC values. Next all together, those signals are conveyed to the High-Pass Filter (HPF), which delivers the higher harmonic signals derivations. At that point higher harmonic compensated signals id _fr, iq_fr are joined with a contrary sign to the standard VOC reference signals $i_{Cd}$and i_{Cq} gives the last signals id_err, iq_err conveyed to PI current controllers. A similar plan is taken after for every portrayed harmonics.

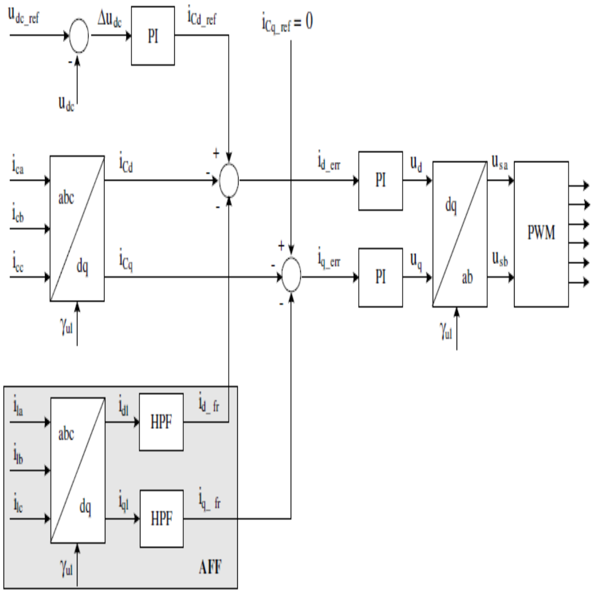


Fig 6. Block diagram of VOC system with active filtering- function

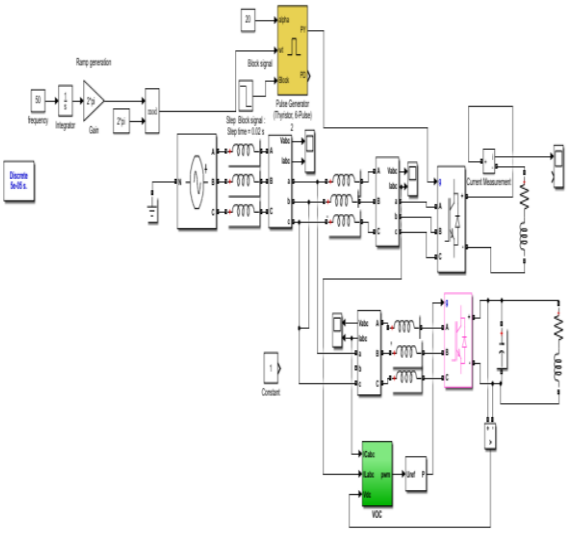


Fig7. Simulink diagram of VOC with active filtering- function

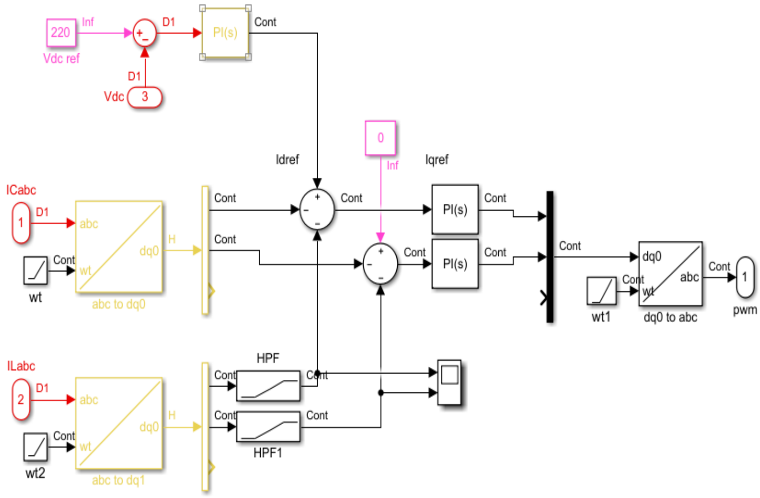


Fig8 Simulink block of active filtering function

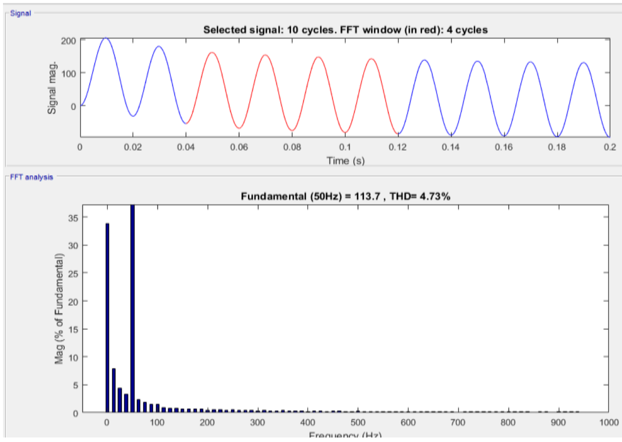
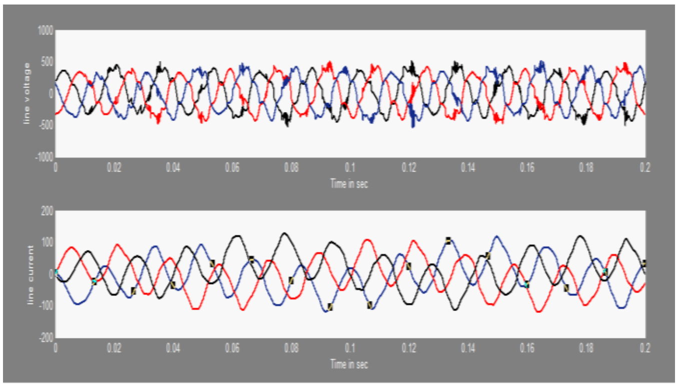


Fig 9. Total Harmonic Distortion



. **Fig10.** Wave forms of line voltage(top) line current(bottom) for VOC

Table1:parameters of circuit and its values

Parameters	Value
Resitance	100Ω
Inductance of reactor L	10mH
Dc link capacitor	450μF
Sampling frequency	10 KHz
Phase voltage v	230R.M.S
Dc link voltage	600 V
Pwm rectifier load resistance R	150Ω

5. Simulation Results and Analysis:

In order to evaluate performance of the PWM rectifier it has been simulated using the Matlab/Simulink with the sytem parameters as given in the table Simulation studies have been carried out to show the active filtering function usefulness with PWM rectifier in reducing the total harmonic distortion and also to analyse the capability of system to provide regulated and ripple free dc output voltage for varying loads .It is observed that the total THD is 4.73 which is acceptable in IEEE standards

6. Conclusion:

Voltage oriented control with active filtering function for the three phase boost type PWM rectifier is presented and VOC-AFF constitutes to be a perfect alternative for the control strategies where the extra equipment is required to reduce the harmonic and maintain the system healthy.

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