



Dynamic Power channel for force using so as to mold Space Vector Modulation controller

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Abstract:

In this undertaking, introduces a control system for cross breed dynamic force channel utilizing Space Vector Pulse Width Modulation (SVPWM). In the proposed control system, the Active Power Filter (APF) reference voltage vector is created rather than the reference current, and the sought APF yield voltage is produced by SVPWM. Legitimate controller is created to keep up force quality with APF. Uninvolved channels have a few downsides, which may bring about consonant connection with the utility issues with the utility framework, in the vicinity of solid utility sharp tuning of the LC channel is required and may not meet the predetermined symphonious current breaking points. Presently we have awesome test is to examination of a dynamic channel topology, which is for all intents and purposes practical, financially savvy and can meet the prescribed standard for high power nonlinear burdens. Along these lines, in this venture, another controller is proposed to keep up great force quality. The proposed framework is a control approach for the APF utilizing SVPWM. This system requires couple of sensors, straightforward in calculation and ready to remunerate sounds and lopsided burdens. In the proposed system producing APF reference voltage vector rather than reference current, and creating fancied APF yield voltage by Space Vector Pulse Width Modulation (SVPWM) taking into account created reference voltage. In this manner, the proposed strategy is straightforward and simple to complete. Voltage current wave structures are contorted on account of a heap which differs with time and loads which are nonlinear. Abundance power misfortunes, warming in turning machine, sounds reverberation, and obstruction with correspondence circuit, discernable clamor and off base operation of touchy burdens is because of symphonious contortion. Symphonious current which are produced nonlinear Loads, are consumed by LC tuned channel. Dynamic channel is exceptionally solid and has likewise low thrown yet inactive channel may have symphonious connection with utility framework additionally sharp tuning are

required and current utmost are not got. Their fundamental favorable position is high unwavering quality and minimal effort. On the other hand, latent channels have a few disadvantages, which may bring about consonant association with the utility. This prompts creation of Active channel which give standard to nonlinear burdens. In light of high evaluating, high exchanging recurrence in PWM inverter dynamic channel is not practical.

Key Words: Discrete PWM Technique, Hybrid Active Power Filter, Reference Voltage Vector, Active power filters, Non-linear loads, Space Vector Modulation.

I. Introduction

Power quality is the fundamental issue that the business is confronting today. The nature of force has been disintegrating with the vicinity of different current and voltage music, low power element, voltage droops and swells, glimmer and numerous different unsettling influences. Among the different unsettling influences, Harmonic mutilation [1] is a standout amongst the most genuine force quality issues. Especially, in the dissemination frameworks, sounds are the major concerned issue. The developing utilization of electronic gear's is one of the significant reasons to ascribe the sounds, which prompted bending of voltage and current waveforms and expanded responsive force request in air conditioning mains as they go through the framework impedance. On the other hand, in the current circumstance different force quality change arrangements are accessible; Isolate symphonious burdens on particular circuits (with or without consonant channels), Harmonic moderating transformers, Phase moving (crisscross) transformers, Filter capacitor banks, Line Reactors, K-Rated/Drive Isolation Transformers, Harmonic Mitigating/Phase Shifting Transformers, Passive parallel/arrangement tuned Filters and Active Filters[2-4]. Inactive sifting is the least difficult ordinary answer for diminish the music. In any case, they have numerous negative marks, for example, a) the quantity of detached channels introduced would rely on upon the quantity of symphonious segment to be adjusted, this requests

for the data of consonant substance to be know ahead of time. b) These can't work under the immersed conditions, c) At a few frequencies, these channels may prompt reverberation. All the above faults of the channels are overcome by the utilization of dynamic channels. In any case, for high power applications, the Active channels are not financially savvy because of their expansive rating and high exchanging recurrence prerequisite of the beat width tweak inverter. For consonant current following controls, there are two plans .One is the direct current control and the other is nonlinear current control. Hysteresis nonlinear control strategy is straightforward yet prompts a generally differing exchanging recurrence [5]. This impediment has been enhanced with variable hysteresis band exchanging methodologies however it requires a perplexing controller to accomplish attractive execution. Prescient current control offers the best potential for exact current control, yet the execution of a down to earth framework can be troublesome and complex. As of late, fluffy rationale controllers (FLC) [6-8] have gotten a lot of consideration for their application in dynamic force channels (APFs). The upsides of FLC over routine controllers are that they don't require a precise scientific model, can work with uncertain inputs, can deal with non-linearity and are more hearty than the ordinary controllers. The Mamdani sort of FLC is utilized for the control of an APF and it gives better results, yet it has the downside of a bigger number of fluffy standards. In this paper, Fuzzy based SVPWM controller was proposed. The proposed controller channel indicates shorter reaction time and higher control accuracy. The reenactment comes about additionally demonstrate that the new control system is anything but difficult to be ascertained and actualized, as well as exceptionally compelling in diminishing music.

II. Principal of operation

In each switching cycle the controller samples the supply current i_a, i_b & i_c are calculated as $-i_a=i_b+i_c$ (1) As the summation of three supply currents is zero. These three phase supply currents are measured & transformed into direct & quadrature axis components of two dimensional planes. The fundamental component of supply currents are transformed into d-q axis & supply current amplitude I_s is generated. That I_s is controlled by the fuzzy controller with V_{dc} & V_{ref} (Reference value of DC bus voltage). The output of fuzzy controller is equivalent to reference voltage vector. By using Fourier magnitude block, voltage magnitude & angle is calculated. From the obtained signal, these values are fed to developed code & compare to the relative sequence. The generated switching actions are applied to & balancing of the filter takes place.

II. PROPOSED CONTROL METHODS

1. Using Discrete PWM Technique Based Hybrid Filter

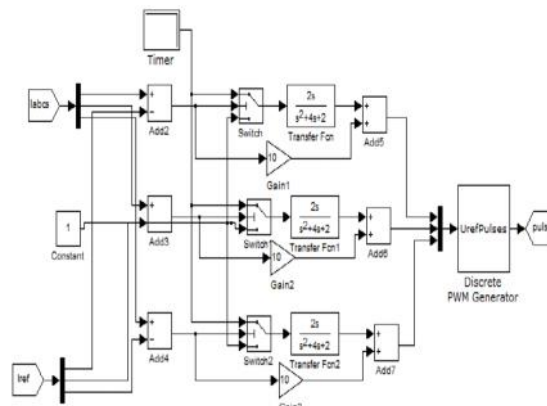


Figure 2.1. Simulation circuit of integral controller with Discrete PWM Generator

The Figure 2.1 is the integral controller used to generate the PWM pulses, which are generated based on the error produced by comparing the reference current and the source current. The differences calculated along with the gains are sent to discrete PWM generator and the resultant PWM pulses are given to the IGBT bridge for controlling.

2. d-q Transformation

The abc_to_dq0 Transformation block computes the direct axis, quadratic axis, and zero sequence quantities in a two-axis rotating reference frame for a three-phase sinusoidal signal. The following transformation is used

$$\begin{aligned} - &= \sin \theta + \sin (\theta - 23) + \sin (\theta + 23) \\ & \quad (2.1) \end{aligned}$$

$$\begin{aligned} - &= \cos \theta + \cos (\theta - 23) + \cos (\theta + 23) \\ & \quad (2.2) \end{aligned}$$

$$\begin{aligned} = &+ \\ & \quad (2.3) \end{aligned}$$

Where ω = rotation speed (rad/s) of the rotating frame.

The transformation is the same for the case of a three-phase current; which can be obtained by replacing the $V_a, V_b, V_c, V_d, V_q,$ and V_0 variables with the $I_a, I_b, I_c, I_d, I_q,$ and I_0 variables. This block can be used in a control system to measure the positive-sequence component V_1 of a set of three-phase voltages or currents. The V_d and V_q (or I_d and I_q) then represent the rectangular coordinates of the positive-sequence component.

IV. PASSIVE FILTERS

To reduce the harmonics, conventionally passive L-C filters were used and also capacitors were employed to improve the power factor of the ac loads. But the passive filters have several drawbacks like fixed compensation, large size and resonance problem. To mitigate the harmonics problem, many research work

development are developed on the Active Power Filters (APF) or Active Power Line Conditioners (APLC).

V. ACTIVE POWER FILTER

In recent years both power engineers and consumers have been giving focus on the “Electrical Power Quality” i.e. degradation of voltage and current due to harmonics, low power factor etc. Nearly two decades ago majority loads used by the consumers are passive and linear in nature, with a few non-linear loads thus having less impact on the power system. However, due to technical advancement in semiconductor devices and easy controllability of electrical power, non-linear loads such as SMPS, rectifier, chopper etc. are more used. The power handling capacity of modern power electronics devices such as power diode, Silicon Controlled Rectifier (SCR), Insulated Gate Bipolar Transistor (IGBT), Metal Oxide Semiconductor Field Effect Transistor (MOSFET) are very large, so the application of such semiconductor devices is very popular in industry as well as in domestic purpose. Whilst these advantages are certainly good but there lies of such excessive use of power electronic devices a great problem, i.e. generation of current harmonics and reactive power in the power system network. As a result, the voltage at different buses of power system network is getting distorted and the utilities connected to these buses are not operated as designed. The harmonic current pollute the power system causing problems such as transformer overheating, voltage quality degradation, rotary machine vibration, destruction of electric power components and malfunctioning of medical facilities etc. To provide clean power at the consumer-end Active Power Filter (APF) is used. Digital domain like microcontroller, Digital Signal Processing (DSP) and Field Programmable Gate Array (FPGA) implemented to the APF giving a number of advantages compared to analog controllers.

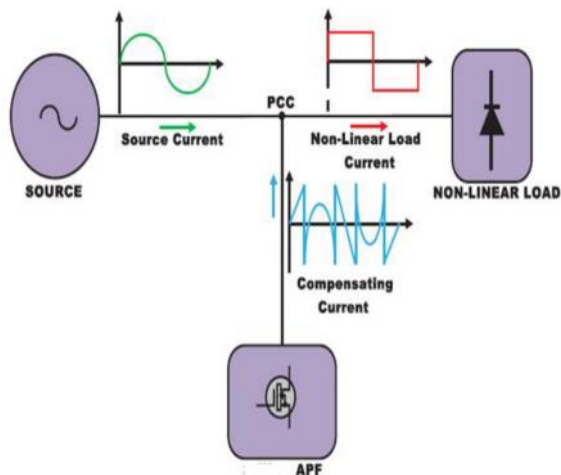


Fig.1.1 shows an active power filter connected to the power system at the Point of Common Coupling (PCC).

Due to use of non-linear loads, the load current is highly nonlinear in nature. The compensating current which is output of the APF is injected at PCC, so the harmonic cancellation takes place and the current between sources to PCC is sinusoidal in nature. The Active Power Filter (APF) is a popular approach for cancelling the harmonics in power system. The main component in the APF is the control unit. The control unit is mainly divided into two parts as follows.

VI. Control strategies of hybrid active power filter

The Fig.4 shows the block diagram of active filter controller implemented for reducing the harmonics with hybrid active filter system. In each switching cycle, the controller samples the supply currents i_a , i_b and the supply current i_c is calculated with the equation of $-(i_a+i_b)$, as the summation of three supply current is equal to zero. These three-phase supply currents are measured and transformed into synchronous reference frame (d-q axis). The fundamental component of the supply current is transformed into dc quantities in the (d-q) axis and the supply current amplitude I_s is generated by the fuzzy logic controller with V_{dc} and V_{ref} , the reference value of the dc bus voltage. The obtained d-q axis components generate voltage command signal [4]. By using Fourier magnitude block, voltage magnitude and angle is calculated from the obtained signal. These values are fed to the developed code and compared with the repeating sequence. Then the time durations T_1 , T_2 and T_0 , the on-time of V_1 , V_2 and V_0 are calculated [5]. The generated switching actions are applied to the APF and power balancing of the filter takes place.

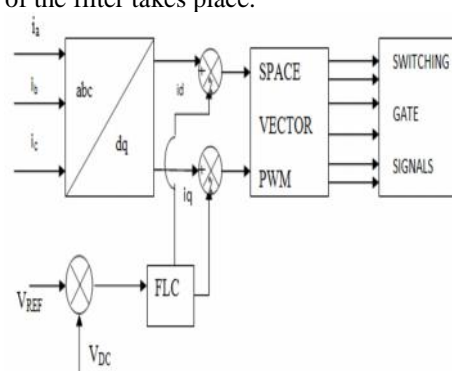


Fig.4 Control block diagram of Fuzzy based SVPWM

VII. HARMONIC EXTRACTION

Harmonic extraction is the process in which, reference current is generated by using the distorted waveform. Many theories have been developed such as p-q theory (instantaneous reactive power theory), d-q theory, frieze controller, PLL with fuzzy logic

controller, neural network etc. Out of these theories, more than 60% research works consider using p-q theory and d-q theory due to their accuracy, robustness and easy calculation.

Current Modulator (Gate Control Signal)

Current modulator is mainly used to provide the gate pulse to the active power filter (Inverter). There are many techniques used for giving the gating signals to PWM VSI such as sinusoidal PWM, triangular PWM, hysteresis current controller, adaptive hysteresis current controller, space vector modulation and space vector with hysteresis current controller etc. The above described two control techniques (harmonics extraction technique and current modulator technique) are main research foci of many researchers in the recent years. It may be noted that either harmonics extraction technique or the current modulator can be used individually or both at a time. Apart from these two techniques, most of the research works are directed also in dealing with multi-level inverter control problems.

Various Topology of Active Power Filter

APLC's are basically categorized into two types, namely, single phase (two-wire connection), three-phase (three wire and four-wire connection) configurations to meet the requirements of the nonlinear loads in the distribution systems. Single-phase loads, such as domestic lights, TVs, air conditioners, and laser printers behave as non-linear loads and cause harmonics in the power system. Many configurations, such as the active series filter, active shunt filter, and combination of shunt and series filter has been developed. The above mentioned APFC's either based on a Current Source Inverter (CSI) with inductive energy storage or Voltage Source Inverter (VSI) with capacitive energy storage devices.

VIII. RESULTS AND DISCUSSIONS

Discrete PWM Technique Based Hybrid Shunt Active Power Filter

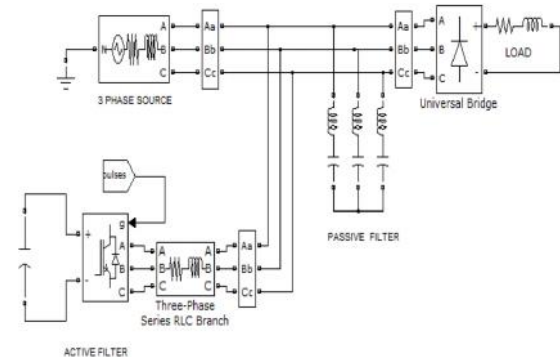


Figure. Simulation circuit of hybrid shunt active power filter

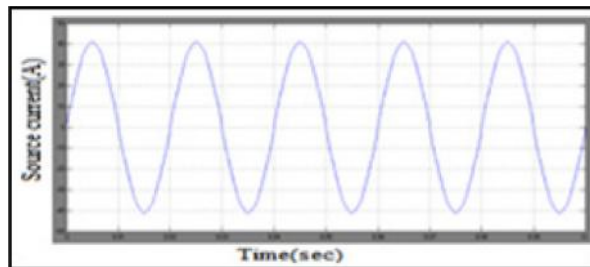


Figure. Source current waveform with hybrid filter

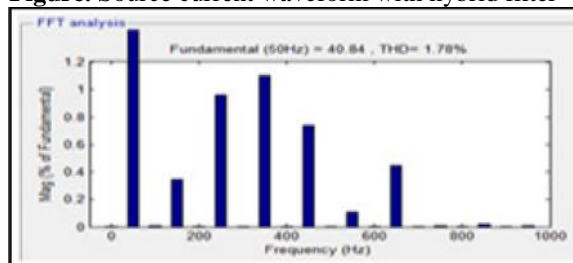


Figure. FFT analysis of source current with hybrid filter

The circuit shown in Figure consists of both active and passive filters, the main purpose of this hybrid filter is that it reduces the harmonic content to a larger extent compared with the above methods. The lower and higher order harmonics are reduced by the passive filter and the other order harmonics are reduced by the active filter. In the case of hybrid filters, the wave form appears in a sinusoidal shape and the distortions are less as shown in the Figure compared with the previous techniques. So, the hybrid filter is preferred due to its better performance characteristics. From the FFT analysis of source current with hybrid filter, It is observed that the %THD is 1.78.

SVPWM Technique Based Hybrid Shunt Active Power Filter

The developed control method for three-phase shunt APF is simulated in MATLAB/ Simulink. Firstly, the three-phase supply currents are sensed and transformed into synchronous reference frame (d-q) axis. The fundamental component of the supply current is transformed into DC quantities in the (d-q) axis and the supply current amplitude I_s generated by the PI controller. The obtained d-q axis components generate voltage command signal. By using Fourier magnitude block, voltage magnitude and angle is calculated from the obtained signal. These values are fed to the developed code and generated switching actions are applied to the APF. Thus, power balancing of the filter takes place. Further, the performance with different type of loads is presented. The complete simulation model of APF with different type of loads is shown in Figure 3.5

and Figure 3.8. For an input supply voltage of 230V (rms) and switching frequency of 5kHz, the simulation results before and after power balancing are shown.

For Balanced Linear Load

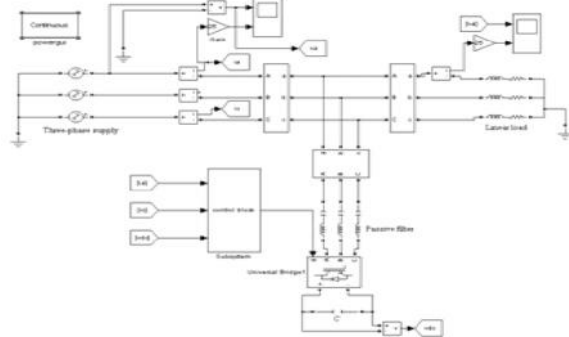


Figure. Simulation model of APF with linear load
The Figure shows the simulation results of the APF when load is three-phase balanced RL load. Figure (a) is the waveforms of the phase-A supply voltage and the load current before compensation. Figure (b) is the waveforms of the phase-A supply voltage and the supply current after compensation.

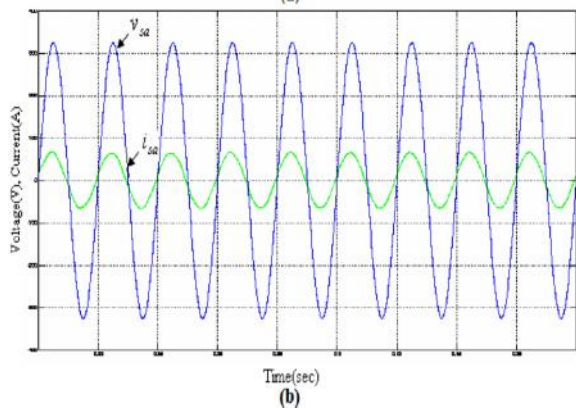
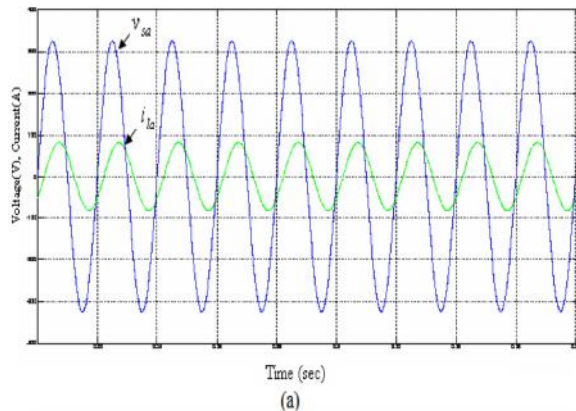
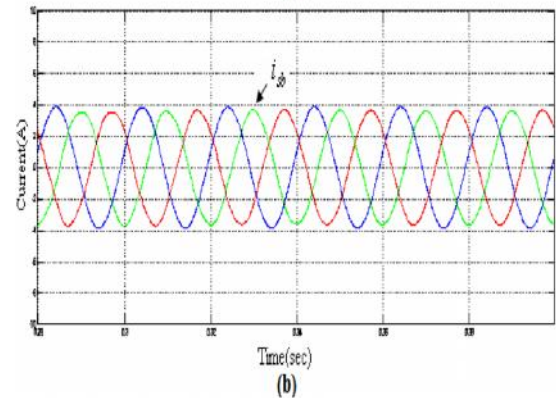
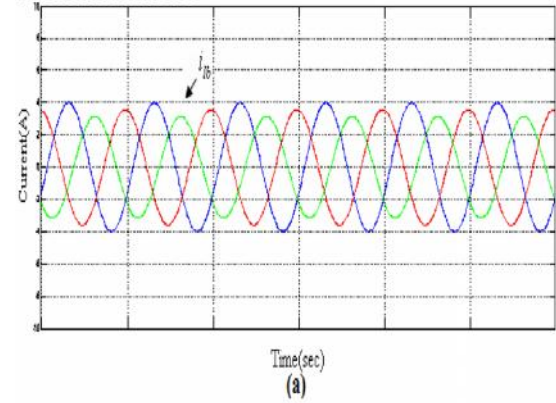


Figure Simulation results of balanced
(a)The phase-A supply voltage and load current waveforms
(b)The phase-A supply voltage and supply current waveforms

For Unbalanced



FigureSimulation results of unbalanced
(a)Three-phase load current waveforms
(b)Three-phase supply current waveforms

The Figure shows the simulation results of APF when three-phase unbalanced RL load is considered. Figure (a) is the waveforms of the three-phase load current before compensation. Figure (b) is the waveforms of the three-phase mains current after compensation. From the Ree-phase mains current after compensation.

CONCLUSION

In this paper, a control methodology for the APF using Discrete PWM and SVPWM is proposed. These methods require a few sensors, simple in algorithm and are able to compensate harmonics and unbalanced loads. The performance of APF with these methods is done in MATLAB/Simulink. The algorithm will be able to reduce the complexity of the control circuitry. The harmonic spectrum under non-linear load conditions shows that reduction of harmonics is better. Under unbalanced linear load, the magnitude of three-phase source currents are

made equal and also with balanced linear load the voltage and current are made in phase with each other. The simulation study of two level inverter is carried out using SVPWM because of its better utilization of DC bus voltage more efficiently and generates less harmonic distortion in three-phase voltage source inverter. This SVPWM control methodology can be used with series APF to compensate power quality distortions. From the simulated results of the filtering techniques, it is observed that Total Harmonic Distortion is reduced to an extent by the SVPWM Hybrid filter when compared to the Discrete PWM filtering technique i.e. from 1.78% to 1.61%.

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