Control of Series Active Power Filter for Improvement of Power Quality

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Abstract— **Reduction of the Harmonics is one of the major needs for Power System & it is demanded that source should provide a balanced & pure sinusoidal three-phase voltage of constant amplitude to the loads. But, due to excessive use of Power Electronics, a complex power quality problem evolved characterized by the voltage and current harmonics. Active power filters have been developed to solve these problems to improve power quality. A novel control scheme compensating for source voltage unbalance and current harmonics in series-type active power filter is proposed. Here, one of the most effective custom power device, Series active power filter is studied and also the control strategy to control these is presented. The proposed control strategy is simulated in MATLAB SIMULINK & the results are presented.**

Keywords— **Active Power Filter, Harmonics, Power Quality, Series active filter, Voltage unbalances**

I. INTRODUCTION

Due to Power Electronics nonlinear characteristics and fast switching, it creates most of the power issues. On the other hand, the new Power Electronics based corrective devices have ability to attenuate the issues created by PE. Both electric utility and end users of electric power are becoming increasingly concerned about the quality of electric power [1].

IEEE defines Power Quality as the ability of a system or equipment to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment. Power quality is a set of electrical boundaries that allows a piece of equipment to function in its intended manner without significant loss of performance or life expectancy.

IEEE 1100 defines Power quality as "The concept of grounding and powering sensitive electronic equipment in a manner suitable for the equipment" [2]. Active power filters have proved to be an important and flexible alternative to compensate for current and voltage disturbances in power distribution systems.

II. SERIES ACTIVE POWER FILTER

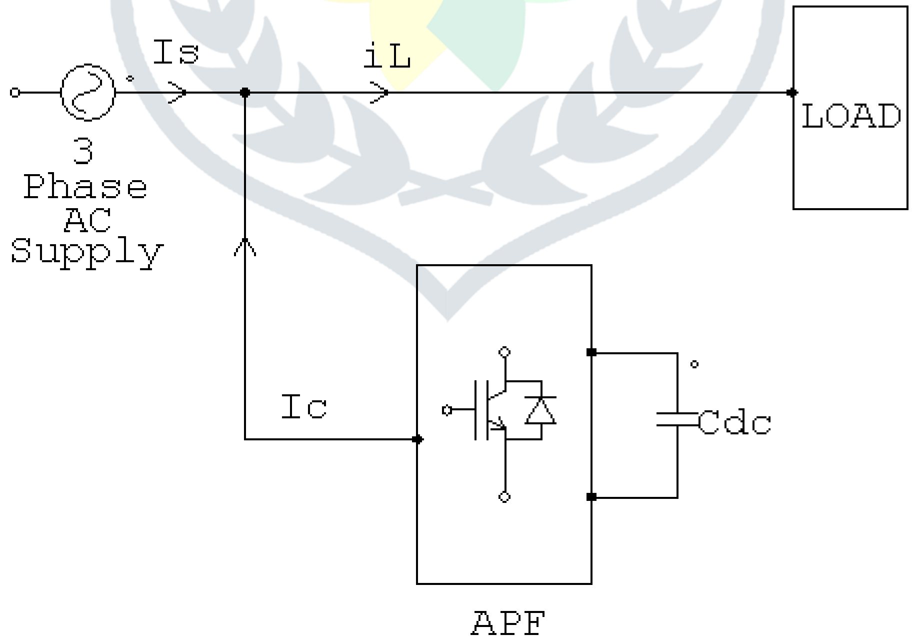

Figure 1. Basic Configuration of Series APF

It is a voltage-source inverter connected in series with AC line through a series transformer and acts as a voltage source to mitigate voltage distortions. It eliminates supply voltage flickers and imbalances from the load terminal voltage. Control of the series inverter output is performed by using pulse width modulation (PWM). Among the various PWM technique, the hysteresis band PWM is frequently used because of its ease of implementation. Also, besides fast response, the method does not need any knowledge of system parameters.

III. CONTROL SCHEME OF SERIES APF

The function of the series APF is to compensate the voltage disturbance in the source side, which is due to the fault in the distribution line at the PCC. The series APF control algorithm calculates the reference value to be injected by the series APF transformers, comparing the positive-sequence component with the load side line voltages [4].

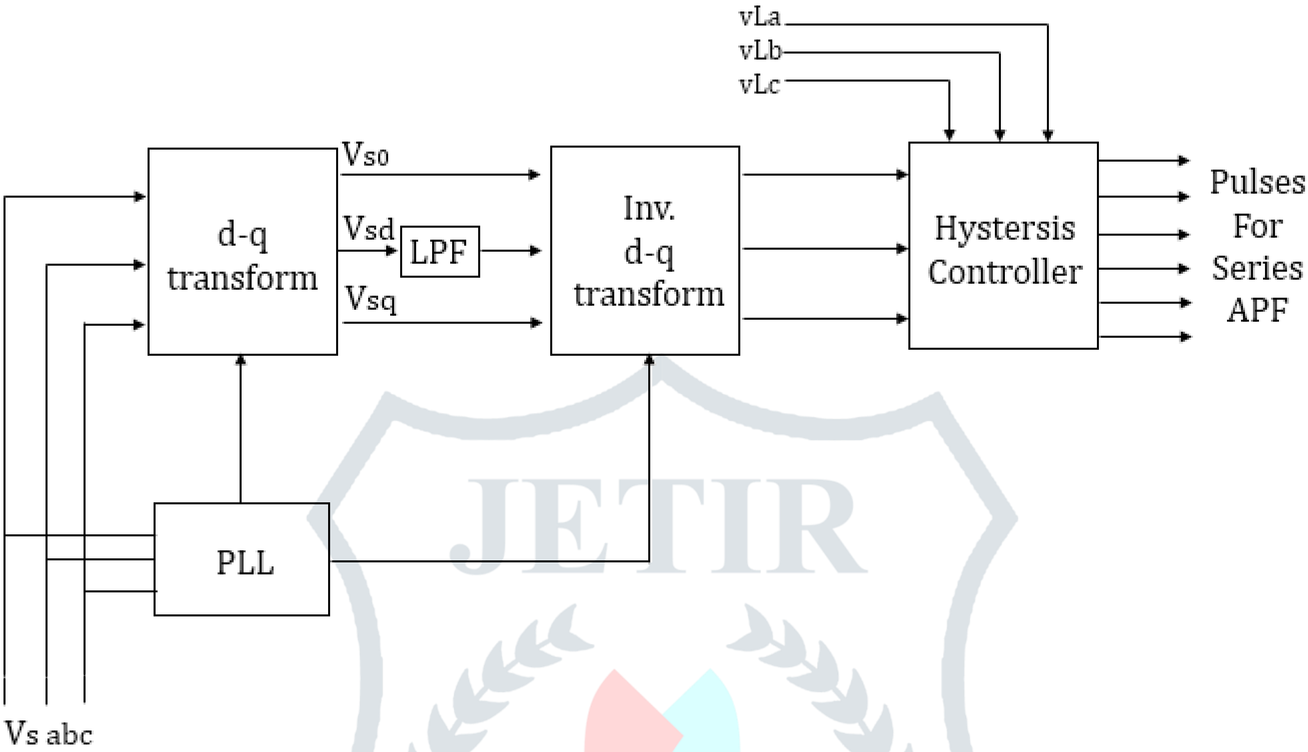

Figure 2. Control Block Diagram of Series APF

The proposed series APF reference voltage signal generation algorithm is shown in Fig. 3. In equation (1), supply voltages V abc are transformed to d-q co-ordinates.

$$\begin{bmatrix} V_{so} \\ V_{sd} \\ V_{sq} \end{bmatrix} = \frac{2}{3}\begin{bmatrix} \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \\ \sin(\omega t) & \sin(\omega t-\frac{2\pi}{3}) & \sin(\omega t+\frac{2\pi}{3}) \\ \cos(\omega t) & \cos(\omega t-\frac{2\pi}{3}) & \cos(\omega t+\frac{2\pi}{3}) \end{bmatrix}\begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} \tag{1}$$

The voltage in d axes (V_{sd}) given in (2) consists of average and oscillating components of source voltages. The average voltage V_{sd} is calculated by using second order LPF (low pass filter).

$$V_{sd} = \overline{V}_{sd} + \widetilde{V}_{sd} \tag{2}$$

$$\begin{bmatrix} V_{la}^* \\ V_{lb}^* \\ V_{lc}^* \end{bmatrix} = \frac{2}{3}\begin{bmatrix} \sin(\omega t) & \cos(\omega t) & 1 \\ \sin(\omega t-\frac{2\pi}{3}) & \cos(\omega t-\frac{2\pi}{3}) & 1 \\ \sin(\omega t+\frac{2\pi}{3}) & \cos(\omega t+\frac{2\pi}{3}) & 1 \end{bmatrix}\begin{bmatrix} \overline{V}_{sd} \\ 0 \\ 0 \end{bmatrix} \tag{3}$$

The load side reference voltages V_{Labc}* are calculated as given in equation (3).These produced three-phase load reference voltages are compared with load line voltages and errors are then processed by sinusoidal PWM controller to generate the required switching signals for series APF IGBT switches.

IV. SIMULATION & RESULTS

Simulations with MATLAB software were performed for the purpose of analysing the operation of proposed Series active power filter. The power circuit is modelled as a 3-phase system with a load that is composed of 3-phase RL load in the DC side.

The controller was modelled using the built-in control block in MATLAB software. The Simulation circuit in the SIMULINK are shown as follows:

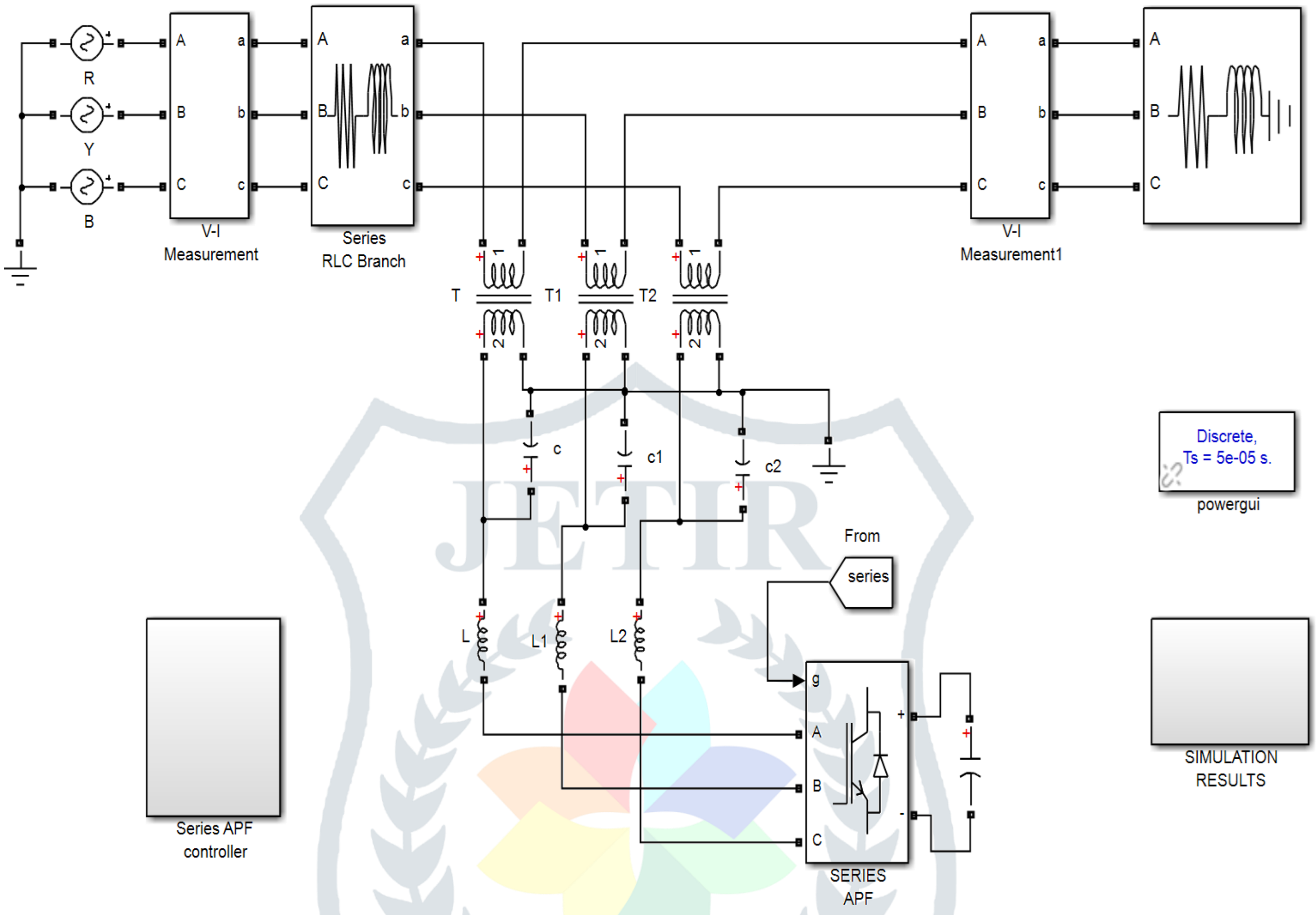

Figure 3. Simulation circuit of Series APF in MATLAB

Here, three phase three wire system of series active power filter is simulated in MATLAB Simulink. The three phase RMS source voltage given is 338 V. Here, IGBT inverter is use as series active power filter.

The voltage across the DC capacitor provides the self-supporting DC voltage for proper operation of the inverter. With proper control, the DC link voltage acts as a source of active as well as reactive power and thus eliminates the need of external DC source like battery.

The necessary voltage generated by the series inverter to maintain a pure sinusoidal load voltage and at the desired value is injected in to the line through these series transformers.

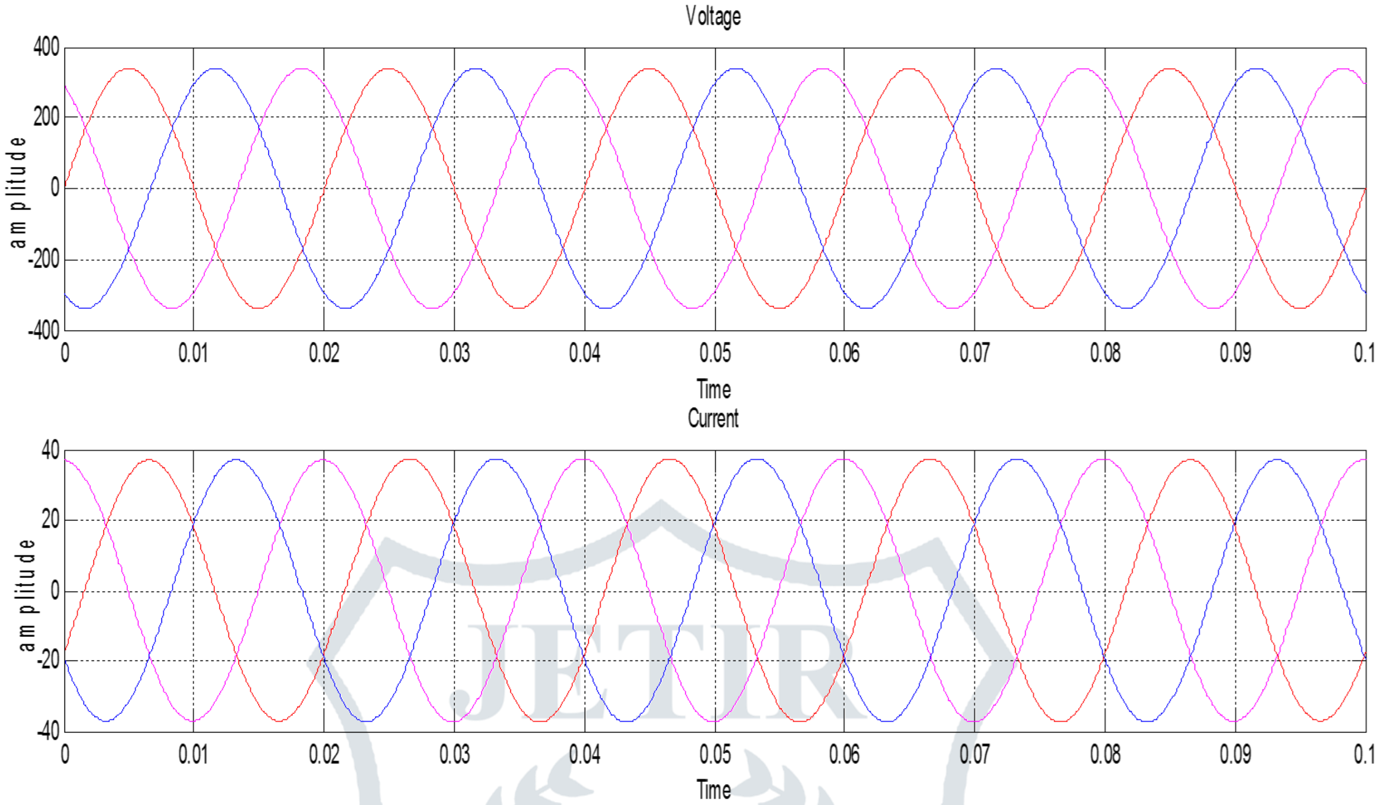

Figure 4. Waveform of Current & Voltage

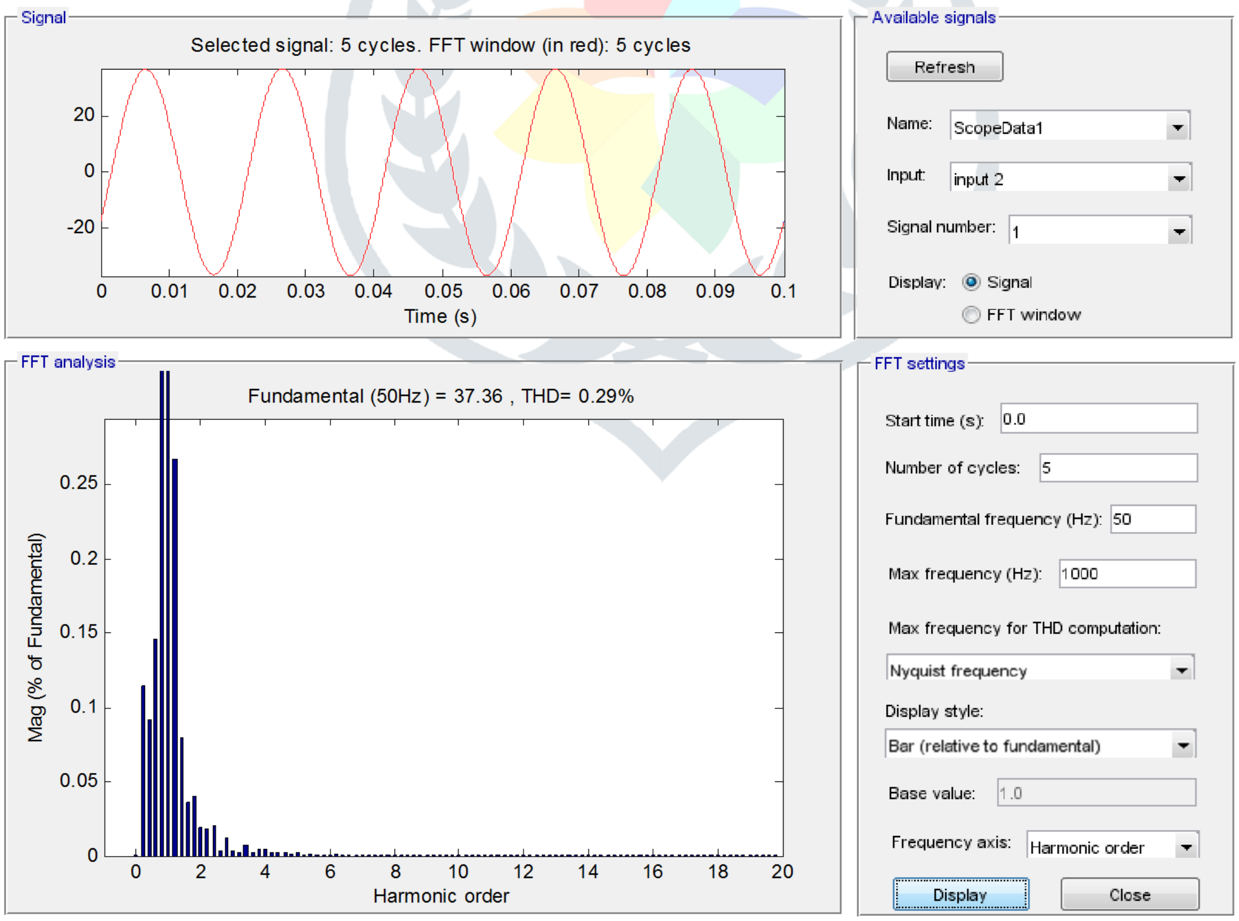

Figure 5. THD analysis

After performing Simulation, analyzing the Total Harmonic Distortion (THD) value shows that the compensation of voltage & current related problems is done & the THD value is within the Limits. Hence, the over-all power quality is improve by using the Series Active Power Filter.

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References

[1] Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, H.Wayne Beaty, “Electrical Power System Quality”, the McGraw-Hill, Second Edition, 2004.
[2] C. Sankaran, “Power Quality”, CRC Press LLC, 2002.
[3] Joao L. Afonso, H. J. da Silva, J. s. Martins, “Active filters for power quality improvement”, IEEE Porto Power Tech, September 2001.
[4] G. Myoung Lee, Dong-Choon Lee, “Control of Series Active Power Filters Compensating for Source Voltage Unbalance and Current Harmonics”, IEEE Transactions on Industrial Electronics, Vol. 51, No. 1, February 2004.
[5] Fang zheng Peng, Hirofumi Akagi, “Compensation characteristics of the combined system of shunt passive & series Active Filter”, IEEE Transactions on Industrial Electronics, Vol. 29, January/February 1994.
[6] Gabrio s. Furga, Grazia T, “Discussion on Instantaneous p-q Strategies for Control of Active Filters”, IEEE Transactions on Power Electronics, Vol. 23, No. 4, July 2008.