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Performance Evaluation of IRPT Controlled Dstatcom for Nonlinear Load

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Abstract - With the increased demand for energy, increasing the efficiency of the electricity is now a primary priority to be fulfilled at the distributors' end. Because of the emergence of more fragile variations in power electronic conductors, end-user devices have become considerably more susceptible to power quality. For the conservation of electrical quality, the word power quality is often used in the transmission, distribution, consumption, and generation of AC electric power. As a result of these power quality concerns degrading end users' equipment performance, there is a need to address issues connected to power quality in order to obtain improved efficiency of equipment and thus improve the overall performance of the system. DSTATCOM is one of the technologies employed in this academic study, and it appears to be an emerging tool for reactive control, load handling, and static current and resonance flow (if necessary). The reactive power is sent to the PCC on the line through a VSC 3 leg 6 pulse conversions. MATLAB Simulink is used to evaluate the suggested technique, and the test results are analysed.

***Key Words*:** THD (Total Harmonic Distortion), harmonics, DSTATCOM, IRPT (Instantaneous Reactive Power Theory).

1.INTRODUCTION

"Power quality is the notion of providing the desired output for device service by giving favorable power and grounding to complex equipment," according to the IEEE lexicon. The electrical power network must overcome a number of challenges in order to offer customers with consistent service. Condenser bank failure, over voltages, voltage loss, and higher current owing to harmonics are all problems caused by poor power quality.

Because solid state converters are prone to power quality difficulties and frequently create issues that reduce power quality, their usage in systems leads to a rise in power quality concerns.

The development of solid state devices in power electronics has increased the importance of power quality problems. There are numerous causes for energy efficiency that may be characterized as organic or man-made based on current, voltage change, and other factors. Faults, lightning, and climatic circumstances such as tornadoes, equipment failure, and so on are examples of natural causes.[1,2]

Power systems have benefited from advancements in power generating technology, such as renewable energy sources placed in the grid network and highly sophisticated end-user goods. In the industrial and commercial sectors, nonlinear loads have increased. Appliances and variable speed drives are examples of nonlinear loads. When operating on AC mains, non-saturating power condensers typically define non-linearity, produce a range of non-linear difficulties due to switching and resonance with magnetic system components, and are overwhelmed by the harmonic currents generated by the supply system's voltage harmonics.

DSTATCOM is a type of shunt-connected device. STATCOM is an important FACTS Controller that operates on either voltage or power. Voltage-sourced converters will be favored over current source converters from the standpoint of converter cost and inductor losses. In voltage-sourced converters, the dc voltage is always single polarized, and energy inversion is performed by reverse flow dc. DSTATCOM can be configured in such a way that it can operate as an active filter to reduce system harmonics.

As a result, the DSTATCOM configuration is determined throughout the exercise depending on the concerns. This section focuses on DSTATCOM's settings, layout, control algorithms, simulation, and graphical representations in order to mitigate existing energy performance difficulties, particularly in manufacturing structures. These issues are exacerbated in the presence of harmonics, either in the tension or currents. Economic shunting active power filters with particular adjustments to minimize harmonic emissions in nonlinear systems are also known as passive shunting compensators. The primary goal of shunting active power filters was to reduce harmonic streams generated by PCCs (common tuning points) with non-linear input.[3,4]

2. DSTATCOM

Transmission networks using DSTATCOM technology AC has matured into a technology that can provide reward for reactive power, load management, static current, and resonance flow (if needed). It has progressed in terms of varied settings, control techniques, and solid-state devices throughout the last quarter millennia. To enhance voltage balance, these compensating devices are also utilized in terminal voltage control, voltage flash suppression, and three phase systems. These goals can be met singly or in tandem, depending on the requests and control method, as well as the configuration that is properly chosen.

DSTATCOM is divided into three categories to fulfill the requirements of three types of client fees for producing appliances, namely one-phase two-wire, three-phase three-wire, and three-phase four-wire configurations. Single-phase systems such as residential lights and fireplaces, televisions, private energy appliances, air conditioners, laser printers, and Xerox machines all contribute to poor power quality[5,6].

To meet the demands of single-phase systems, a single-phase, two-wire DSTATCOM has been explored in diverse settings and control techniques. Since 1984, several configurations

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have been developed and marketed for a variety of applications. Single phase DSTATCOMs are created using current source converters (CsCs) with inductive power storage and power systems (VSCs) [13].

2.1 Principle of operation of DSTATCOM:-

The major purpose of DSTATCOMs is to reduce current-based power quality concerns in production systems. With its DC grid voltage management, a DSTATCOM mitigates most current performance difficulties such as elastic energy, imbalance, static flow, harmonics (if any), and changes existing in the customer supplies or elsewhere in the scheme, and provides sinusoidal regulated conditions in the supply.
A DSTATCOM, in particular, has a VSC connected to a DC cable, and its AC ends are commonly connected in shunt across customer charges or across the PCC, as illustrated in Figures 1. [7-9].

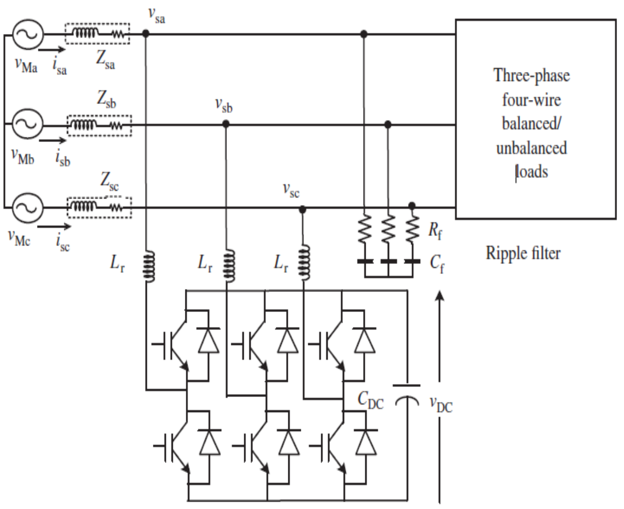

Fig -1: Block diagram of compensation by DSTATCOM

The order wherein overtones must be adjusted determines the active power filter rating. As an outcome, the APF will be shorter and less costly, with short channel effects being screened. The construction of this filter is based on this basic principle. The shunt-connected passive filter eliminates high-frequency portions, while the shunt-connected active power filter eliminates reduced frequency distortions. [10].

3. CONTROL STRATEGIES

The fundamental purpose of a DSTATCOM command algorithm is to analyse target flows using feedback inputs. These comparative currents, together with their corresponding sensed variables, are employed in PWM current sensors to acquire PWM gating data from the VSC used as a DSTATCOM for changing equipment (IGBTs). The proper reference flows for the DSTATCOM command must be collected, and they may be estimated using a variety of test techniques.[12]

This section provides a new command technique for three-phase wire STATCOM based on the principles of instantaneous reactive power hypothesis. The data were assessed using the instantaneous passive energy concept, which yielded current harmonics and passive energy gain. The technique and capacity of the proposed scheme were simulated using MATLAB / SIMULINK.

3.1 Instantaneous Reactive Power Theory

Figure 2 depicts the DSTATCOMs' IRPT-based control algorithm. The effective and reactive power are calculated in real time using three-phase storage flows and PCC voltages. Before being transformed to remove their ripple content, threephase PCC voltages are monitored and processed using BPFs (vsa; vsb; vsc). As a BPF, a first-order Butterworth filter is utilized [11].

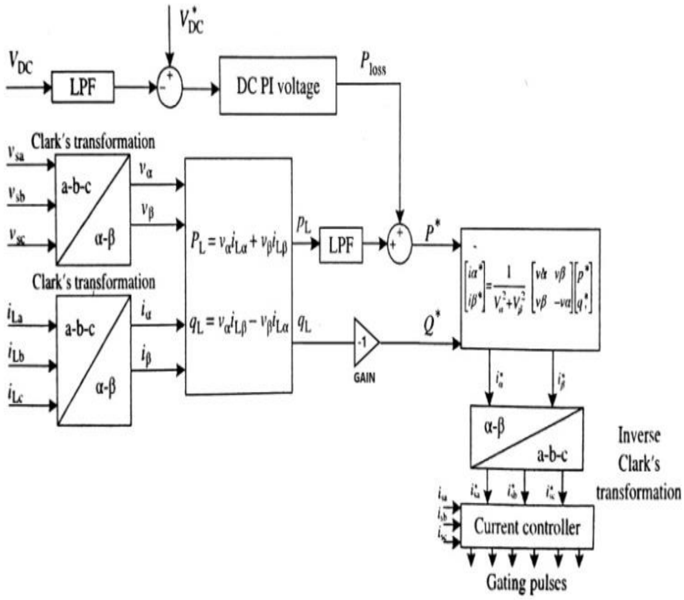

Fig -2: Instantaneous Reactive Power Theory

Clark's reduction is used to translate three phase output values into two phase - orthogonal observations, with orthogonal dimensions provided as(v_0, v_α, v_β).

$$\begin{pmatrix} v_\alpha \\ v_\beta \end{pmatrix} = \sqrt{\frac{2}{3}} \begin{pmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{pmatrix} \begin{pmatrix} v_{sa} \\ v_{sb} \\ v_{sc} \end{pmatrix} \qquad (1)$$

The conversion of 3 phase output current to two phase is given as follows:

$$\begin{pmatrix} i_{L\alpha} \\ i_{L\beta} \end{pmatrix} = \sqrt{\frac{2}{3}} \begin{pmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{pmatrix} \begin{pmatrix} i_{La} \\ i_{Lb} \\ i_{Lc} \end{pmatrix} \qquad (2)$$

Demand side instantaneous active power is :-

$$p_L = v_\alpha i_{L\alpha} + v_\beta i_{L\beta} \qquad (3)$$

The load side instantaneous reactive power can be given as:-

$$q_L = v_\alpha i_{L\alpha} - v_\beta i_{L\beta} \qquad (4)$$

Approximation of the 3 source current is as follows:-

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$$\begin{pmatrix} i_{sa}^{*} \\ i_{sb}^{*} \\ i_{sc}^{*} \end{pmatrix} = \sqrt{\frac{2}{3}} \begin{pmatrix} 1 & 0 \\ -\frac{1}{2} & -\frac{\sqrt{3}}{2} \\ -\frac{1}{2} & \frac{\sqrt{3}}{2} \end{pmatrix} \begin{pmatrix} v_{\alpha} & v_{\beta} \\ -v_{\beta} & v_{\alpha} \end{pmatrix}^{-1} \begin{pmatrix} p^{*} \\ q^{*} \end{pmatrix} \qquad (5)$$

Three-phase converted currents are reference source currents after conversion, and they are evaluated to detected supply currents as illustrated for DSTATCOM indirect control scheme.

4. SIMULATION RESULTS

The following are the parameters for simulation:-

Three phase supply voltage (L-L)= 415V
Supply frequency=50Hz
D-C capacitor=20Mf
Switching frequency=1.5kHz

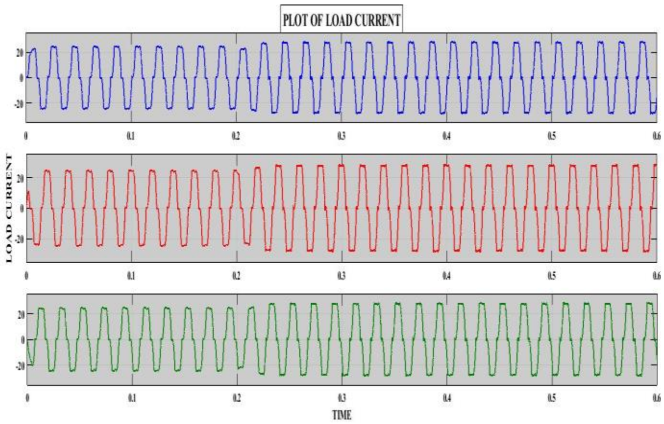

Fig -3: Tsree phase load current.

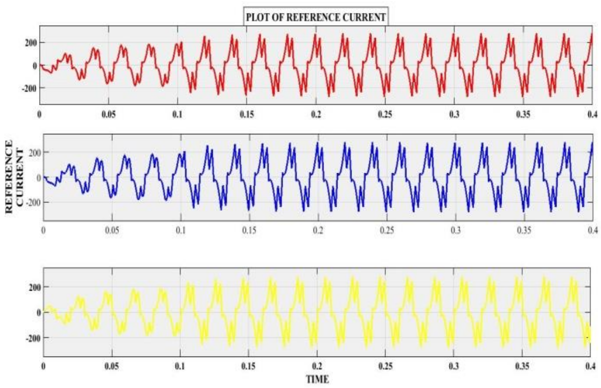

Fig -4: Simulation results of reference source current

The three phase load current and reference source current is shown in figure 3 and figure 4 respectively.

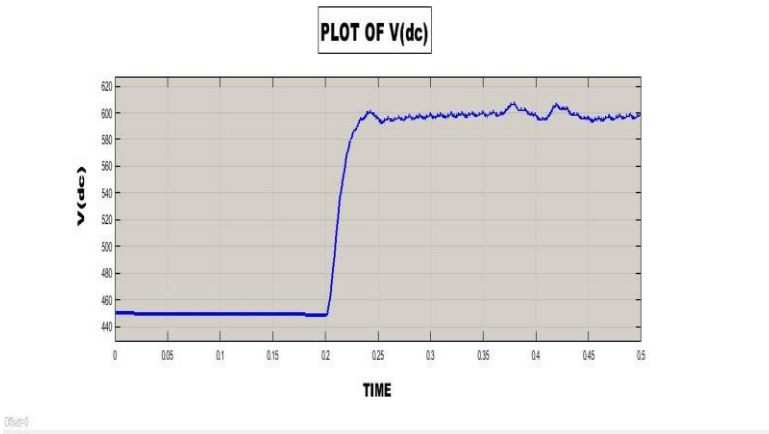

Fig -5: Simulation result of Vdc

The charging power of STATCOM is Vdc. It provides voltage to create current with strong overtones for reactive power correction.The plot of Vdc is shown in figure 5.

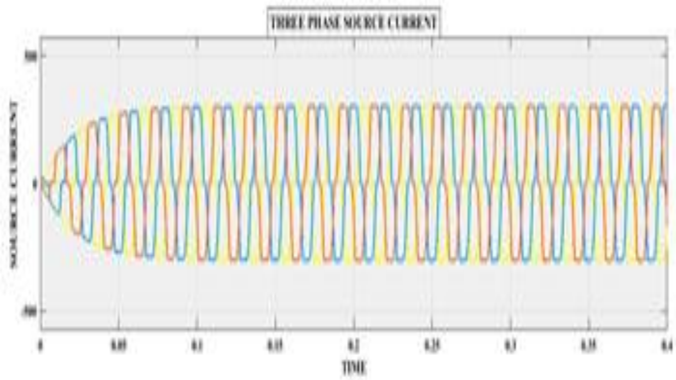

Fig -6: Three phase uncompensated source current

The three phase uncompensated current with THD of 16.65% is shown in figure 6.

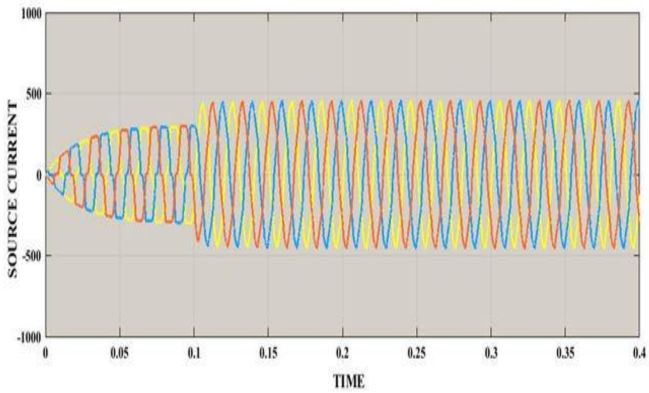

Fig -7: Simulation results of three phase compensated source current

The Simulation results of three phase compensated source current with THD of 3.35% is shown in figure 7.

5. CONCLUSIONS

The problem of distorted loads in electrical power architecture affecting power quality has become more important in crucial manufacturing activities. The power quality difficulties caused by load distortion in electrical systems are increasingly affecting essential manufacturing activities. To address this issue, static VAR compensators are necessary on the utility and charge parties. STATCOM systems offer good choices for reactive power adjustment concerns, such as faster responses, minimal harmonic material, and reduced device volume, with the advantages of quicker reaction, minimum harmonic, and smaller device dimensions. STATCOM solutions are an excellent choice.

D-STATCOMs have several advantages, including the ability to produce the same reactive power independent of demand voltage fluctuations, faster response, and smaller device volume. In this study, a VSC-based three-leg, six-pulse converter is employed to inject reactive power into the PCC at the line. Before adjustment, overall harmonic distortion was 16.65 percent, and after compensation, it was 3.35 percent, meeting the IEEE519-1992 standard .

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