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Harmonic Elimination and Load Balancing using Distribution Static Compensator for Enhancement of Power Quality

Laxman Prasad Patel[1], Arvind Jain[2]

Abstract: **The optimization of planning becomes critical in order to accomplish the targets, aiming at the correct level of reliability, operating the system at a low overall cost while maintaining reasonable power quality. There are several issues that obstruct the effective and efficient efficiency of the delivery networks in order to preserve the quality of power. Greater power losses, weak voltage profile near the end users, harmonics in load currents, sags and swells in the voltage of the source etc. are all these concerns. Because of the existence of nonlinear loads, volatile loads, pulse loads, sensor as well as other energy loads, propulsion loads and DG connections, etc., all these problems which occur. Therefore, certain power quality mitigation equipment, such as delivery static synchronous compensator (DSTATCOM), dynamic voltage restore (DVR), and unified power quality conditioner (UPQC) etc., need to be set up to boost the power quality of power distribution networks. The purpose of this project work is to schedule the optimum allocation of DSTATCOM in distribution networks using optimization methods in order to provide compensation for reactive power and increase the efficiency of power. Using a D-STATCOM, the basic principle of voltage sag reduction is to dynamically insert into the grid line a current of the desired amplitude, frequency and phase. In order to compensate for voltage errors, the suggested approach uses the instantaneous reactive power principle to produce reference values of the current that must be inserted into the D-STATCOM link point. Structural consistency and less computation complexity are given by the proposed process. The results of the simulation show that this approach is efficient and D-STATCOM has reasonable success in controlling the load and minimizing harmonic current components.**

Keywords: **Power Quality, DSTATCOM, DVR, UPQC, Distribution Systems,**

I. INTRODUCTION

The growing variety of equipment focused on power electronics has dangerously impacted the exceptional supply of electric power. Harmonics are generated with each linear load in the device, which decreases the quality of electricity. This suggests that the harmonic in the power supply system provides serious power quality problems that result in larger power losses in the distribution system and are responsible for electrical equipment operational disasters.

Via the effect of power electronic systems, FACTS, filters and various forms of control methods, attempts to compensate for power quality issues are undertaken in order to implement a complex and adaptable outcome of such power quality disruptions. DSTATCOM's output depends on the range of ac inductor, DC bus capacitor, and IGBT interfaces. Various studies provide a full assessment of the compensating device for the enhancement of the system's power output. Synchronous condensers, passive filters, compensating devices such as shunt compensating system (DSTATCOM) series compensating device (DVR) and shunt hybrid and series compensating device (UPQC) are used by active control filters [1, 2]. Proper resolution for everything that is solved in the proposed device victimization Allocation Static Reward (DSTATCOM) for capturing this advantage on top of the above problems [3]. DSTATCOM's efficiency relies on the control algorithm used to get the comparison current. An instantaneous principle of reactive power is used in this paper as a control algorithm to achieve the reference current.

II. QUALITY PROBLEMS OF GNENRATED POWER

2.1 Quality of Power

At all levels of consumption, energy users face problems with power quality. Power output actually determines the power supply properties delivered to consumers in standard test conditions. New electrical systems and devices are more vulnerable to issues with energy efficiency. For both power sources and clients, decreased PQ has become a big concern. Bad PQ suggests that there is ample inconsistency in the power supply to impact devices which may lead to their malfunction or failure. Disturbances in the delivery chain cannot be fully regulated, but utilities make attempts and investments to eliminate interruptions.

Standard operations like loads and condensers or failures to turn and circuit breakers to open up failures contribute mostly to disruptions. Cases such as burning, the birds which fly near power lines and are electrocuted or accidental actions such as trees or appliances which touch power lines are usually blamed for failures.

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IEEA 1100 standard is described as "the definition of electrical equipment for powering and grounding in an appliance-friendly manner" by the Institute of Electrical and Electronic Engineers (IEEE)".

2.2 Power Quality Problems

It can be said from the above topic that the issue of power quality implies power supply that causes inconvenience or reduced productivity; variation in voltage, current, frequency that results in market equipment failure or mal-operation; unsatisfactory customer care.

2.2.1 Transients

Transients are quick distributions of reference voltage as a few microseconds to a few milliseconds [1] over a period of time. Such differences, even at low voltages, can exceed thousands of volts. Transients are of two kinds, given below:

2.2.1.1 Impulsive Transients

A pulse transient indicates that the voltage, current or both are changed unidirectional on a power line. Impulse transients are often triggered by lightning, load resistance switchover and heavy load disconnection [4]. The impulsive transitor influences electrical components, separation fabrics, and results in electromagnetic fields and data processing defects.

2.2.1.2 Oscillatory Transients

An oscillatory gradient is a tiny two-way voltage, current or both changes on a power line. The reasons behind such transient conditions are power factor correction condensers, inductive loads switching and ferro-resonance transformers. The consequences of oscillatory transient conditions are isolation material defects, overheating and electromagnetic contamination of all cables.

2.2.1.3 Voltage Sag

Voltage sag[1] is characterized as a decrease in the standard voltage level at the higher frequencies from 0.5 cycle to 1 minute for 10% of the nominal rms voltage. When the engine pulls a current up to ten times the maximum load current and during start, the start of large induced engines will result into a voltage drop. The effects of voltage deceleration in electric spinning engines are disconnection and lack of performance, electro-magnetic relays are tripped and information technologies, including the microprocessor-facing communications systems, are malfunctioning.

2.2.2 Voltage Swell

The voltage swell is characterized as an immediate volume rise at the power frequency with a period of more than one cycle and usually within a few seconds beyond the standard tolerances. The amplitude of the voltage increase due to the swell of voltage[28].

2.2.4.2 Long Interruptions

Long stoppage is a lack of electricity of more than two minutes as a result of significant local or regional incidents[2]. This means a loss of power. This is triggered by a power grid network breakdown, floods and artifacts that hit wires or poles, electric grid failure and malfunction causes lengthy breakage. Long disruptions lead to all machinery being halted.

2.2.4 Interruption

An interruption is considered a very brief but full supply failure. An interruption happens if the voltage of the supply reduces below 10% from the actual cost to one minute. The number of supply disruption often raises the voltage drop that needs to be mitigated properly [27].

2.2.4.1 Very Short Interruption

Very brief interruption [2] is described as full electric power supply interruption for a span of a few milliseconds to 1-2 seconds. This is triggered by isolation loss, flashes, device failings, faults in machinery and flickering of the insulator. Keeps information out of use and breakdown of data processing systems, tricking protective devices and closing down critical equipments are the effects of very short disturbances.

2.3 Solutions to PQ problems

The power quality solution can be accessed on the consumer or the utility side. The following ways to maximize the efficiency of power are:

- *The load conditioning:* make sure the machinery is less prone to power perturbations, which enables operation even with high voltage distortions.
- *Line conditioning:* they remove or remedy disturbances to the power grid.

Passive filters attached to critical load terminals are used to boost power efficiency. The objection is to prescribe the responsive load output voltages in order to preserve the same magnitude and to reduce any harmonic components to an acceptable degree.

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III. Distribution STATCOM

The voltage converter regulates the power system interchange between both the DC voltage backup system as well as the AC system through the transformer's leaks reaction. In order to have the appropriate amount of lead or reactive current lag mitigation to minimize voltage fluctuation the DSTATCOM verifies constantly the line waveform in relation to reference ac signal. A DSTATCOM is like STATCOM and differs from the way that STATCOM is used to control basic reactive power and provide voltage assistance at the recommended intervals while the DSTATCOM is being used to control voltage and correct the power factor at the distribution levels. The Absolute Harmonical Disturbances, voltage sags and swells, can also be utilized to remove DSTATCOM [9]. In order to minimize unbalance and distortion in the source current or supplier voltage, a DSTATCOM may also serve as shunting active filter.

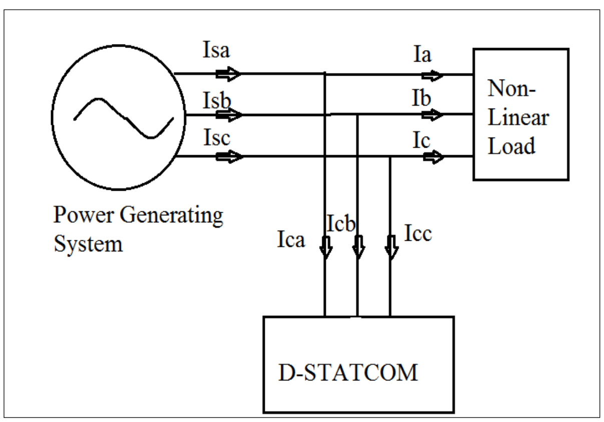

Fig. 3.1 Basic Structure of the DSTATCOM

IV. Proposed Method

Harmonics - It is commonly used to repeat impulses, including sinusoidal waves. A wave harmonic with a frequency is a positive integer several times the frequency of the original wave, known as the fundamental frequency.

Harmonic Number – Harmonic number (h) indicates the discrete waveform frequency components

Odd and even the order harmonics – Odd harmonics have weird numbers (for example,3,5,,7,9,11) (e.g.,2,4,6,8,10)

Single-phase load compensation — the in the diagram shows a single phase load compensator that generates non-linear load from a voltage sources. The connection point between load and source is the typical connection point (pcc).

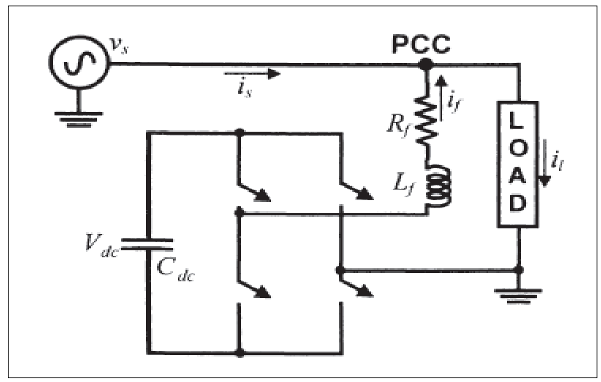

Fig. 4.1 Schematic diagram of single phase compensator

The load is a non-linear load, as seen in figure. The following new components have the instant load impedance

Here it=Ilp+Ilq+Ilh Ilp and Ilq , are the actual and the reactive component of the load stream and Ilh is the harmonic part of the load stream.

The active and reactive power load current portion is compensated by using DSTATCOM. There must then be an IF* = Ilq+Ilh current inserted into DSTATCOM.

The relation present of the DSTATCOM is defined as IF*. If the inverter can be used to reliably monitor the system response, harmonics are excluded from the source current IS and the positive sequence factor will be equal to unity.

When the load is unstable in a three-phase configuration, which needs a separate reactive power in one of the three phases as well as the actual power demand of all three buses, the inconsistent reactive power in the source waveforms is also removed.

Three-Phase Configuration of Shunt Compensator: Ifa, the point of general communication (PCC), the Shunt Compensator consists of three appropriate power sources. The new sources are related to the four-wire grid in Y-with their neutral links. The shunt compensator has the objective to inject current so that perhaps the source currents (isa,isb,isc) are harmonic free balanced sinusoids and the required source voltages phase angle (vsa,vsb and vsc). The shunt compensator often injects current.

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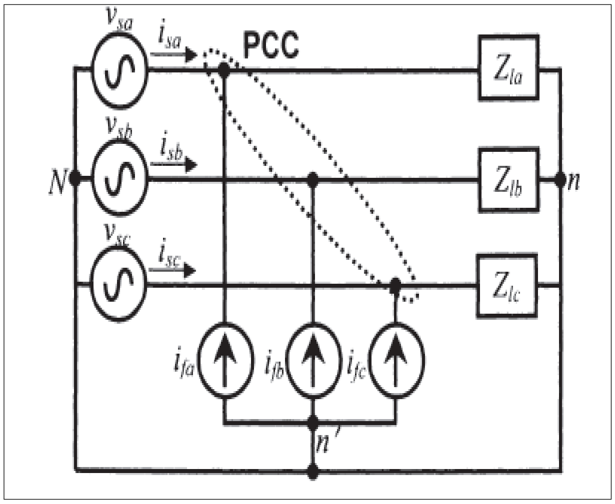

Fig 4.2 Schematic diagram of a shunt compensator for 3p-4w distribution system that is supplying a ϒ−connected load

Generating Reference Currents using Instantaneous P-Q Theory Somewhat since different meanings of this approach have been provided, this methodology has an immediate method of production referenced currents for shunt compensator. Find the following equilibrium currents and voltages of three phases.

va=vmsinωt,_ia=imsin(ωt−ϕ)_
vb=vmsin(ωt−120), ib=imsin(ωt−120−ϕ)_
vc=vmsin(ωt+120), ic=imsin(ωt+120−ϕ)_
It_can_then_write
va−vb=√3vmsin(ωt+30)_
vb−vc=√3vmsin(□□−90)_
vc−va=√3vmsin(ωt+150)
Using_the_above_relation_we_get_
(v_b−v_c)=−√3{cosωtsin(ωt−ϕ)}
=√3/2{sin(2ωt−ϕ)−sinϕ}
Adding_the_above_three_terms_together_we_get_
(vb−vc)+(vc−va)+ic(va−vb)=3√32$vmim$sinϕ=√3Q=−√3q
Where_Q_is_the_reactive_power_required_by_the_circuit_

Therefore, we can see that the sum q given reactive power consumed by a circuit if pressures and currents only include the transfer function which is called instant imaginary electricity.

$P3\phi = vaia+vbib+vcic$
q = $v\alpha i\beta - v\beta i\alpha$

$$\begin{bmatrix} p \\ q \end{bmatrix} = \begin{bmatrix} v_\alpha & v_\beta \\ -v_\beta & v_\alpha \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix}$$

This is equivalent to writing

$$\begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} = \frac{1}{v_\alpha^2 + v_\beta^2} \begin{bmatrix} v_\alpha & -v_\beta \\ v_\beta & v_\alpha \end{bmatrix} \begin{bmatrix} p \\ q \end{bmatrix}$$

$$\frac{1}{v_\alpha^2+v_\beta^2} \begin{bmatrix} v_\alpha & -v_\beta \\ v_\beta & v_\alpha \end{bmatrix} \left\{ \begin{bmatrix} p \\ 0 \end{bmatrix} + \begin{bmatrix} 0 \\ q \end{bmatrix} \right\}$$

$$= \begin{bmatrix} i_{\alpha p} \\ i_{\beta p} \end{bmatrix} + \begin{bmatrix} i_{\alpha q} \\ i_{\beta q} \end{bmatrix}$$

The following components of current can then be defined from the above equations are:

α-axis instantaneous active power:=$v\alpha i\alpha p$
α -axis instantaneous reactive power: $p\alpha q$=$v\alpha i\alpha q$
β-axis instantaneous active power: $p\beta p$=$v\beta i\beta p$
β-axis instantaneous reactive power: $p\beta q$=$v\beta i\beta q$

4.1 Implementation

The implementation of PWM converter parallel power conditioner, known as DSTATCOM, is because traditional devices are not able of solving the problems of the power quality such as voltage settings, voltage swells and flicker, harmonic distortion and disruption of power supply. DSTATCOM contains an inverter circuit with PWM voltage source and a one-end DC condenser. Due to its smaller switching losses and compact scale, the integrated bipolar transistor (IGBT), which is used in the voltage stage of the delivery? The switching approach is used to reduce the output voltage with the Puls width modulation (PWM). The energy storage facility is added to the electricity conditioner to flexibly function which also allows quick scheduling for service and business. In this study, DSTATCOM based on Dqo Transformation is modeled and built using tools from MATLAB/SIMULINK. This test device is analyzed under normal conditions and load disruption. The DSTATCOM is attached to the regular feeder which supplies the different charges. A dqo conversion is used to monitor the difference among load current and the reference current. The reference voltage (modulator reference signal) is thus generated for the inverter.

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In this function simulation is conducted to verify the performance of DSTATCOM in order to compare the constant voltage harmonics of the delivery network under different process parameters.

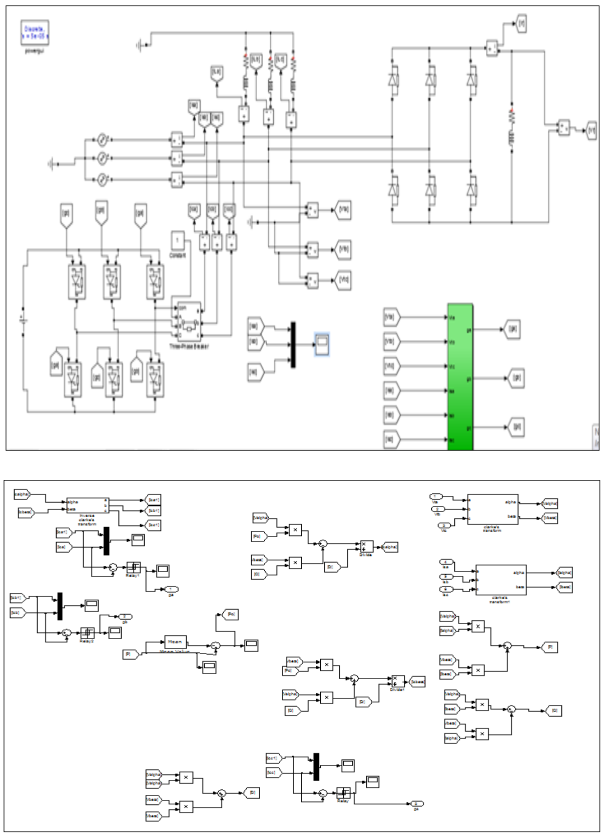

Fig. 4.1 Control Circuit Unit

V. Results And Discussion

The energy efficiency issues of customized control electronic devices D-STATCOM, including voltage dips, swells and interruptions, effects and strategies of alleviation. D-STATCOM is planned and implemented for voltage sags, interruptions, swells, and detailed effects. The calculations suggest that the DSTATCOM gives a relative increase in the voltage power The ability to compensate for power and monitor DSTATCOM depending on the rating of the dc storage unit. It was also shown. It is evident from the modelling framework described in the section that the proposed control strategy greatly decreases load unbalancing and also reduces the waveform obtained by and without compensator considerable to the THD that constitutes absolute harmonic distortion.

The simulation results show that the method is efficient and DSTATCOM is efficient both to balance the load and to reduce the current harmonics. It provides the unbalance & non-linear three-part supply. 6-IGBT linked to the DSTATCOM operation. It is used for misbalancing & non-linear charges into equilibrium & linear charges. In model of model emulation, the supply voltage is 230volt. The nominal frequency is 50 hz. Snubber is 500 ohm resistance, snubber is 250*10^(-9) F capacitance. This component is similar to the Earth by three voltage sources (230v rms). Isa, Isb, Isc, each with the frequency 50 hz, is produced three source present.

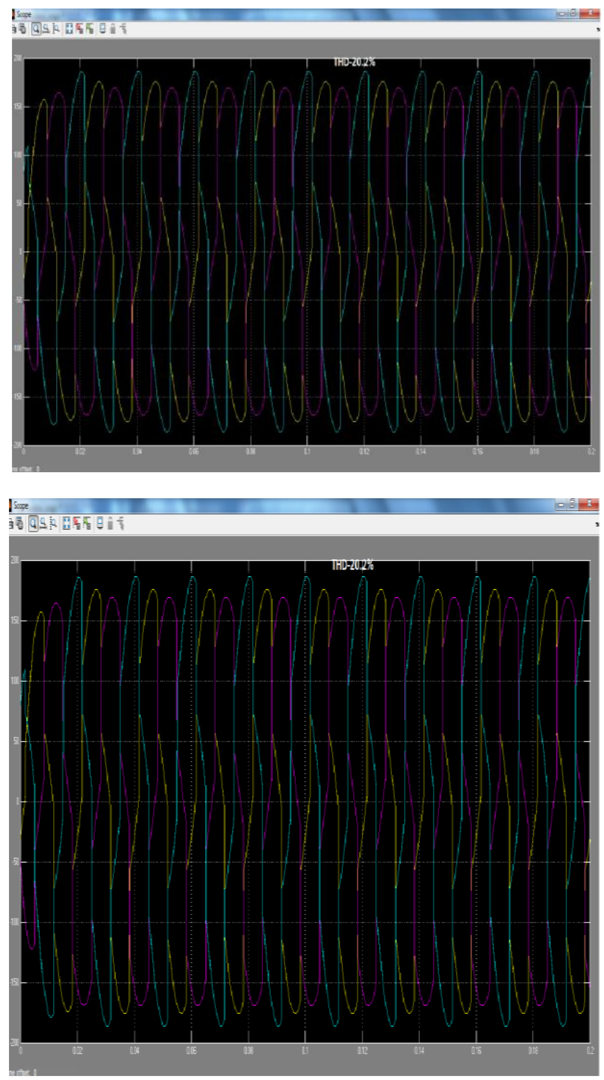

Figure 5.1 Three Phase Source Current without Compensator

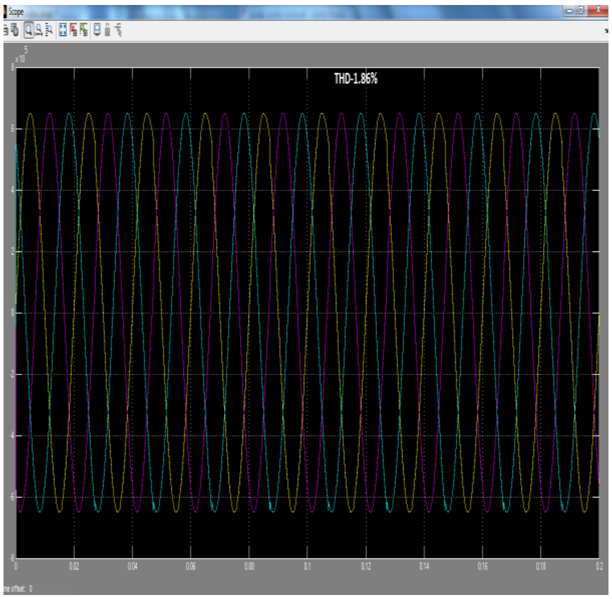

Figure 5.2 Three Phase Load Current with Compensator

VI. CONCLUSION

The design and applications of D-STATCOM for voltage sags, interruptions and swells, and comprehensive results are presented. The simulations carried out showed that the DSTATCOM provides relatively better voltage regulation capabilities. It was also observed that the capacity for power compensation and voltage regulation of DSTATCOM depends on the rating of the dc storage device. From Simulation model presented in the chapter it is clear shown that with a proposed control method the load unbalancing is been reduced considerably and also the THD that is the total harmonics distortion has been reduced considerably the waveform obtained with and without compensator. The simulation results show that the method is efficient and DSTATCOM is efficient both to balance the load and to reduce the current harmonics. It provides the unbalance & non-linear three-part supply. 6-IGBT linked to the DSTATCOM operation. It is used for imbalancing & non-linear charges into equilibrium & linear charges. In model of model emulation, the supply voltage is 230volt. The nominal frequency is 50 hz. Snubber is 500 ohm resistance, snubber is 250*10^(-9) F capacitance. This component is similar to the Earth by three voltage sources (230v rms). Isa, Isb, Isc, each with the frequency 50 hz, is produced three source present.

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