www.ijecs.in
International Journal Of Engineering And Computer Science ISSN:2319-7242
Volume 4 Issue 1 January 2015, Page No. 9841-9848

To Improve the Power Quality by Varying the Block Parameter ($K_{P,}$ K_i, K_d)

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ABSTRACT : In this paper to investigate the effect of Electrolytic Capacitor and Ultra Capacitor The electrolytic capacitor produces distortion in output while ultra capacitor produces distortion less output. By way of habit DSTATCOM & Tuning the block Parameter of Controller by using matlab Simulation. The foremost detached of the research paper is to appearance that using DISTRIBUTION STATCOM (DSTATCOM) it is possible to reduce the voltage fluctuations like drop and fabulous conditions in distribution systems. In this paper diverse topologies of DSTATCOM (distribution static compensator) are discussed. The distribution static compensator (DSTATCOM) is a shunt connected device capable of compensating power quality problems in the load current. A shunt active filter intended for installation on a power distribution system. The active filter has an addition a capability to regulate the distribution line voltage by means of adjusting reactive power. Theoretical analysis investigates the dynamic performance of combined harmonic damping and voltage regulation. As a result, harmonic damping makes it possible to improve the stability of the control loop for voltage regulation, and the combined harmonic curbing. The system with control scheme is implemented in Matlab / Simulink. The simulation results are shown in figures. The main detached of the research paper is to show that using (DSTATCOM) it is possible to reduce the voltage fluctuations like fall and marvelous conditions in distribution systems.
Keywords: - Dstatcom, Dynamic Voltage Restorer, Electrolytic capacitor, Facts, Power quality, Pulse Width Modulation, Ultra capacitor.

INTRODUCTION

Power quality is certainly a major concern in the contemporary time. It becomes particularly important with the outline of erudite devices, whose performance is very delicate to the quality of power supply. Modern industrial processes are based on a large amount of microelectronic devices such as programmable logic controllers and amendable speed drives. As marketable and manufacturing customers become more and more contingent on high quality and high-reliability electric power, utilities have considered approaches that would provide different options or levels of premium power for those customers who require something more than what the bulk power system can provide. Insufficient power quality can be caused by firstly failures and switching operations in the network, which mainly result in voltage dips, disruptions, and transients and secondly network turbulences from loads that mainly result in spark (fast voltage variations), harmonics, and phase imbalance.

TECHNIQUES OF TUNING CONTROLLER

The output from DSTATCOM can be controlled by different types of controllers using various types of control system.

1. Genomic Arrangement (GAs)

The GAs is well-known there exist a hundred of works employing the GAs technique to design the controller in various forms. The GAs is a stochastic search technique that leads a set of population in solution space evolved using the principles of genetic evolution and natural selection, called genetic operators e.g. crossover, mutation, etc [4].

2. Artificial Immune System (AIS)

Most of the control techniques are offline and require prior knowledge of the system behavior. But AIS, which is inspired by theoretical immunology and observed immune functions, principles and models, has the potential for online adaptive system identification and control. Abnormal changes in the system response are identified and acted upon without having any prior knowledge. AIS controller parameters are first tuned by particle swarm optimization (PSO), so that it can provide innate immunity to common system disturbances. The fast acting power electronic switching devices are also simulated in such a way that it can be interfaced with a practical hardware system any time. The tuning of the controller parameters using PSO is carried out on a digital signal processor (DSP) interfaced to the RTDS. The AIS based control strategy is also implemented on a DSP [24].

3. Particle Swarm Optimization (PSO)

Particle swarm optimization is a population based search algorithm modeled after the motion of flock of birds and school of fish. A swarm is considered to be a collection of particles, where each particle represents a potential solution to a given problem. The particle changes its position within the swarm based on the experience and knowledge of its neighbors. Basically it 'flies' over the search space to find out the optimal solution .Initially a population of random solutions is considered.

4. Immediate Reactive Power (IRP) Theory

The major power consumption has been in reactive loads, such as fans, pumps etc. These loads draw lagging power-factor currents and therefore give rise to reactive power burden in the distribution system. Moreover, situation worsens in the presence of unbalanced loads. Excessive reactive power demand increases feeder losses and reduces active power flow capability of the distribution system, whereas unbalancing affects the operation of transformers and generators. A Distribution static compensator (DSTATCOM) can be used for compensation of reactive power and unbalance loading in the distribution system. The performance of DSTATCOM depends on the control algorithm used for extraction of reference current components. For this purpose, many control schemes are reported in literature, and some of these are instantaneous reactive power (IRP) theory, instantaneous symmetrical components, synchronous reference frame (SRF) theory and current compensation using dc bus regulation, computation based on per phase basis, and scheme based on neural network technique. Among these control schemes, SRF theories are most widely used [13].

METHODOLOGY AND EQUATIONS

The purposed research work can be explained in the form of diagram as shown in Fig.1. In this diagram to tuning the parameter of kp, K_d and K_i as shown in function block parameter Controller. To discuss simulation comparison with electrolytic capacitor and ultra capacitor. Under Dstatcom controller different value of block parameters are substitute and dissimilar result as shown below.

A DSTATCOM connected with ultra capacitor of voltage 2.8V, capacitance 640f and ESR =0.80mΩ [29].The variable load produces the voltage dip from 0.2 to 0.3 sec. The voltage and current measurement (on BSTATCOM) measure the voltage and current on 0.2 sec. When the voltage dip is sensed by voltage controller, it sends the signal to PWM signal generator. The PWM signal generator operates the IGBTs. The energy of capacitor bank supplies to the load via IGBTs. The voltage is controlled by injecting the current in line by DSTATCOM. By equation number (8) the direct axis and quadrature axis voltage is changed into three phase voltage and three phase voltage is change into direct axis and quadrature axis voltage using Park's transformation. Current also follows the same Park's transformation.

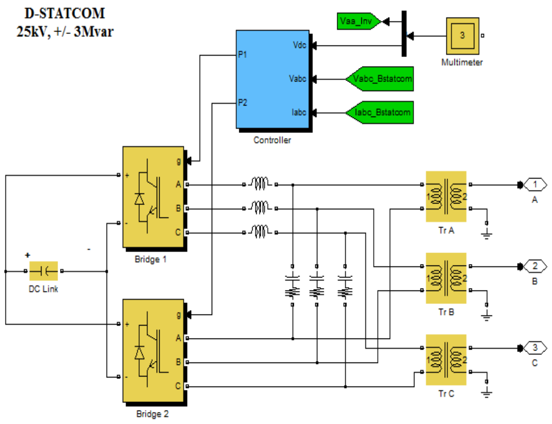

Fig.1 Dstatcom Controller

Fig.1 Power

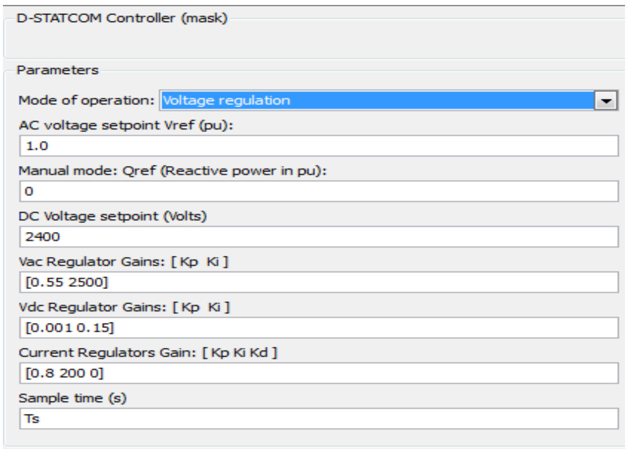

Fig.2 Function Block Parameter Controller

Formulation Equation of DSTATCOM, in steady state operation, the angle triggering angle α is very close to zero. Now, if VPCC < VC, reactive power flows from the DSTATCOM to the bus. So, by controlling the inverter voltage magnitude VC, the reactive power flow from the DSTATCOM can be regulated. This can be done in several ways. In this paper, a GTO based square wave Voltage Source Converter (VSC) is used to generate the alternating voltage from the DC bus. In this type of inverters, the fundamental component of the inverter output voltage is proportional to the DC bus voltage. So, the control objective is to regulate VDC as per requirement. Also, the phase angle should be maintained so that the AC generated voltage is in phase with the bus voltage.

Here, the PLL (phase lock loop) synchronizes the GTO pulses to the system voltage and generates a reference angle. This reference angle is used to calculate positive sequence component of the DSTATCOM current using a-b-c to d-q-0 transformation. The voltage regulator block calculates the difference between reference voltage and measured bus voltage and the output is passed through a PID controller to generate the reactive current reference. This reactive current reference is then passed through a current regulator block to generate the angle α. This current regulator block also consists of a PID controller to keep the angle α close to zero. The Firing Pulse Generator block generates square pulses for the inverter from the output of the PLL and the current regulator block. If due to the application of a pulsed load the bus voltage reduces to some extent, the voltage regulator changes the reactive current reference and as a result the current regulator increases the angle α so that more active power flows from bus to the DSTATCOM and energizes the capacitor.

This work proposes the use of an enhanced electric model of an UC based on that reflects accurately the effects of frequency, voltage and temperature in the dynamic behavior.

$$E_{UCB} = \frac{1}{2} C_{UCB} \left(V^2_{UCBi} - V^2_{UCBf} \right)$$

(1)

So the DC voltage increases and consequently the AC output of the inverter also increases and the necessary reactive power flows from DSTATCOM to the bus [20].

Active power of DSTATCOM is given as:-

(2)

$$Q_{DSTATCOM} = \frac{|V_O| \cdot |V_S|}{X_T} \cdot Cos(\delta) - \frac{|V_S|^2}{X_T}$$

(3)

Here PDSTATCOM is the active power supply by DSTATCOM, QDSTATCOM is the reactive supply by the DSTATCOM is the output voltage of DSTACOM, V_S is the source voltage, X_T is the transformer reactance and δ is load angle. The reactive power of DSTATCOM is

When δ=0

$$(4)\quad P_{DSTATCOM} = \frac{|V_O|\cdot|V_S|}{X_T}.Sin(0) = 0$$

$$P_{DSTATCOM} = 0(W) \quad (5)$$

$$Q_{DSTATCOM} = \frac{|V_O|\cdot|V_S|}{X_T}.Cos(0) - \frac{|V_S|^2}{X_T} = \frac{|V_O|\cdot|V_S|}{X_T} - \frac{|V_S|^2}{X_T} \quad (6)$$

$$Q_{DSTATCOM} = \frac{|V_S - V_O|V_S}{X_T} \quad [VAR] \quad (7)$$

The DSTATCOM does not supply any reactive power to the load (as shown in eq. 4) and recharge capacitor bank (as shown in eq. 6) when $\delta =$ 0.When $\delta >$ 0, DSTATCOM supplies the reactive power to the load. To control the reactive power flows from the DSTACOM to the load, converter's voltage magnitude V_{CON} is to be controlled. Direct axis converter voltage V_{dCON} and quadrature axis converter voltage V_{qCON} is calculates as:-

$$\overline{V_{CON}} = L\frac{d\overline{i_{CON}}}{dt} + R\overline{i_{CON}} + \overline{V_S} \quad (8)$$

Where,

$\overline{V_{CON}}$ is converter voltage vector = $\begin{bmatrix} V_{aCON} \\ V_{bCON} \\ V_{cCON} \end{bmatrix}$ are converter line voltages

$\overline{i_{CON}}$ is converter current vector = $\begin{bmatrix} i_{aCON} \\ i_{bCON} \\ i_{cCON} \end{bmatrix}$ are converter line currents

$\overline{V_S}$ is the source voltage vector = $\begin{bmatrix} V_{aS} \\ V_{bS} \\ V_{cS} \end{bmatrix}$ are line voltages

Let abc V and 0dq V be voltage vectors referred to the abc and 0dq reference frames, respectively. Any voltage vector in the abc reference can be transformed to the 0dq reference, and vice versa. [4]

Neglecting zero sequence components in Park's transformation matrix given by

$$\begin{bmatrix} V_d \\ V_q \end{bmatrix} = \begin{bmatrix} \cos(\omega t) & \cos\left(\omega t - \frac{2\pi}{3}\right) & \cos\left(\omega t - \frac{4\pi}{3}\right) \\ \sin(\omega t) & \sin\left(\omega t - \frac{2\pi}{3}\right) & \sin\left(\omega t - \frac{4\pi}{3}\right) \end{bmatrix} \begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix}$$

(9) Using Park's transformation the eq. (7) is:

$$T\overline{V_{CON}} = LT\frac{d\overline{i_{CON}}}{dt} + RT\overline{i_{CON}} + T\overline{V_S} \quad (10)$$

Now the dynamic equation governing the instantaneous values of the three-phase output voltage in the ac side of the DSTATCOM and the current exchanged with the distribution grid is given as:

$$T\begin{bmatrix} V_{aCON} \\ V_{bCON} \\ V_{cCON} \end{bmatrix} = LT\frac{d}{dt}\begin{bmatrix} i_{aCON} \\ i_{bCON} \\ i_{cCON} \end{bmatrix} + RT\begin{bmatrix} i_{aCON} \\ i_{bCON} \\ i_{cCON} \end{bmatrix} + T\begin{bmatrix} V_{aS} \\ V_{bS} \\ V_{cS} \end{bmatrix} \quad (11)$$

At any time the value of current supplied by DSTATCOM is:

$$\frac{d}{dt}(T\overline{i_{CON}}) = T\frac{d}{dt}(\overline{i_{CON}}) + \frac{d}{dt}(T)\overline{i_{CON}} \quad (12)$$

And,

$$P_{DSTATCOM} = \frac{|V_O|\cdot|V_S|}{X_T}.Sin(\delta)$$

$$T\frac{d}{dt}(\overline{i_{CON}}) = \frac{d}{dt}(T\overline{i_{CON}}) - \frac{d}{dt}(T)\overline{i_{CON}} \quad (13)$$

The derivative of 'T' with respect to time't' is:

$$\frac{d}{dt}(T) = \frac{2}{3}\begin{bmatrix} -\omega\sin(\omega t) & -\omega\sin\left(\omega t-\frac{2\pi}{3}\right) & -\omega\sin\left(\omega t+\frac{4\pi}{3}\right) \\ -\omega\cos(\omega t) & -\omega\cos\left(\omega t-\frac{2\pi}{3}\right) & -\omega\cos\left(\omega t-\frac{2\pi}{3}\right)\end{bmatrix}$$

(14) In polar co-ordinate

$$\frac{d}{dt}(T)\overline{i_{CON}} = \omega\begin{bmatrix} i_{qCON} \\ -i_{dCON}\end{bmatrix}$$

(15)

$$T\frac{d}{dt}\left(\overline{i_{CON}}\right) = \frac{d}{dt}\begin{bmatrix} i_{dCON} \\ i_{qCON}\end{bmatrix} - \omega\begin{bmatrix} i_{qCON} \\ -i_{dCON}\end{bmatrix}$$

(16)

So eq. (1) in d-q form is:

$$\begin{bmatrix} V_{dCON} \\ V_{qCON}\end{bmatrix} = L\frac{d}{dt}\begin{bmatrix} i_{dCON} \\ i_{qCON}\end{bmatrix} + R\begin{bmatrix} i_{dCON} \\ i_{qCON}\end{bmatrix} + \begin{bmatrix} V_{dS} \\ V_{qS}\end{bmatrix} - \omega L\begin{bmatrix} i_{qCON} \\ -i_{dCON}\end{bmatrix}$$

(17)

From eq. (10) the direct axis and quadrature axis voltage is define as:

$$V_{dCON} = L\frac{d}{dt}(i_{dCON}) + Ri_{dCON} + V_{dS} - \omega Li_{qCON}$$

(18)

$$V_{qCON} = L\frac{d}{dt}(i_{qCON}) + Ri_{qCON} + V_{qS} + \omega Li_{dCON}$$

(19)

By taking $V_{dS} = V_S$ and $V_{qS} = 0$, direct axis and quadrature axis voltage is:

$$V_{dCON} = L\frac{d}{dt}(i_{dCON}) + Ri_{dCON} + v_S - \omega Li_{qCON}$$

(20)

$$V_{qCON} = L\frac{d}{dt}(i_{qCON}) + Ri_{qCON} + 0 + \omega Li_{dCON}$$

(21)

ωLi_{qCON} And ωLi_{dCON} have very small value, so can be neglected. Solving with help of Laplace transformation of eq. (13) and (14)

$$V_{dCON} = sLI_{dCON} + RI_{dCON}$$

(22)

$$V_{qCON} = sLI_{qCON} + RI_{qCON}$$

(23)

RESULT AND DISCUSSION

DSTATCOM is consists the PWM voltage source inverter circuit and a DC capacitor connected at one end. At the distribution voltage level (11kv), the integrated gate bipolar transistors (IGBT) are uses for inverter circuit due to its lower switching losses and compact size. Moreover, the power rating of custom power devices is relatively low. Consequently, the output voltage control may be executed through the pulse width modulation (PWM) switching method. IGBT based PWM inverter is implemented using Universal bridge block from Power Electronics subset of Sims Power Systems. A 25kV/1.25kV coupling transformer which ensures coupling between the PWM inverter and the network. A voltage-sourced PWM inverter consisting of two IGBT bridges. This twin inverter configuration produces fewer harmonic than a single bridge, resulting in smaller filters and improved dynamic response. In this case, the inverter modulation frequency is 28*60=1.68 kHz so that the first harmonics will be around 3.36 kHz. LC damped filters connected at the inverter output. Resistances connected in series with capacitors provide a quality factor of 40 at 60 Hz. A 10000-microfarad capacitor acting as a DC voltage source for the inverter voltage regulator that controls voltage at bus B3 A PWM pulse generator using a modulation frequency of 1.68 kHz.

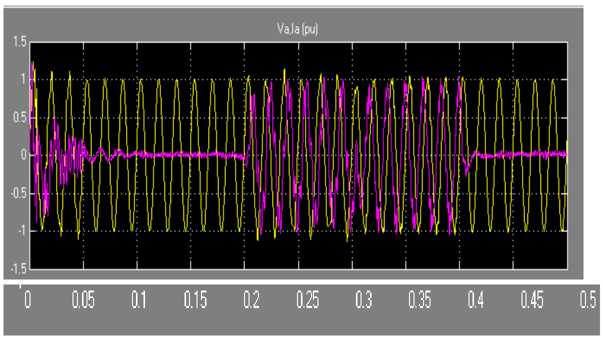

Fig. 4.1 The current and voltage in per unit with electrolytic capacitor

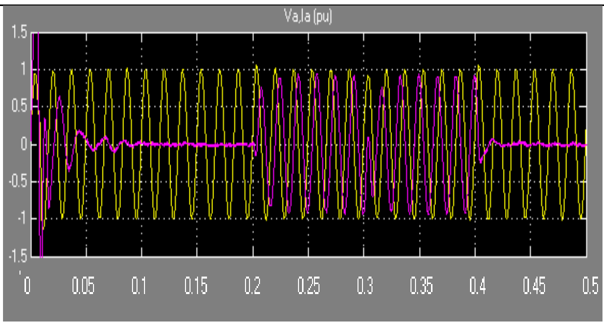

Fig. 4.2 The current and voltage in per unit with ultra capacitor

In these figs. time in seconds along the x axis and voltage of bus 3 along y axis. The current injection by DSTATCOM is also shown in both the fig. 4.1 and 4.2. The current is injects from 0.2 sec to 0.4 sec. The DSTATCOM injects current with help of capacitor. The electrolytic capacitor produces distortion in output while ultra capacitor produces distortion less output.

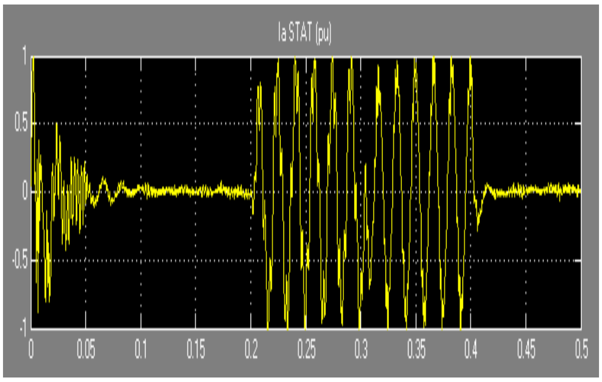

Fig. 4.13 The converter current in per unit with electrolytic capacitor.

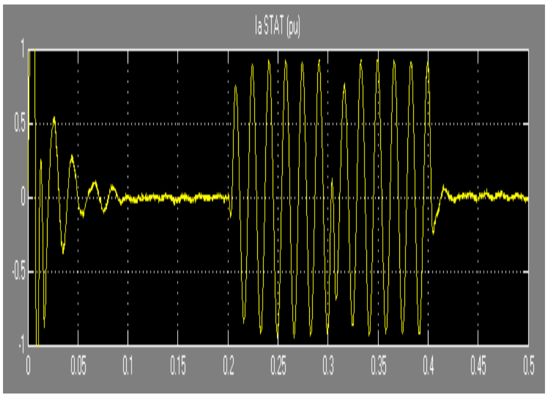

Fig. 4.14 The converter current in per unit with ultra capacitor.

In these figs. time in seconds along the x axis and converter current in per unit along y axis. During load 0.2 sec to 0.4 sec the electrolytic capacitor as in fig. 4.13 injects distorted current but in fig. 4.14 with ultra capacitor current injects is less distorted.

CONCLUSION

Energy drop and undulations have emerged as a major concern in the area of power quality. The voltage slump and tremendous problems in a distribution system can be investigated. The consumption of active or reactive power by the DSTATCOM is represented by positive values and the generation by negative values. Penetrating equipment and non-linear loads are common place in both the industrial and the domestic environment; because of this a discriminating awareness of power quality is developing. The type of controller used in DSTATCOM is PID controller. The modulation technique which is used to trigger IGBT's is PWM. The DSTATCOM with capacitor bank energy source is used in simulation. It is because the capacitor bank is cheaper, requires less maintenance and less time of charging and discharging. The loads which are connecting to the DSTATCOM is distribution network load. For simulations and results of DSTATCOM using ultra capacitor and electrolytic capacitor, the matlab/simulink software is uses. Ultra capacitor produces less distortion than the electrolytic capacitor. Modulation index is improves in case of ultra capacitor. Ultra capacitor produces good voltage stability in DSTATCOM when we observe voltage of converter. But when we compare the harmonics produces by DSTATCOM with electrolytic and ultra capacitor bank, the result are much better with ultra-capacitor. DSTATCOM provides utilities with a means for enhancing their electric service. In an industry undergoing transition into a competitive marketplace, this type of value-added service can open up additional business opportunities; enhance business relations with customers, and position utilities and their customers for the competitive markets foreseen for the 21st century.

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