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Reactive Power Compensation using Distribution Static Synchronous Compensator (DSTATCOM): A Review

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Abstract:

The inductive loads and power electronic converters absorbs the reactive power. If reactive power is increase beyond the limit, the power quality of voltage and current at the source side is deteriorated. The DSTATCOM is a shunt compensator which compensates the reactive power of a system. Hence power quality is improved and power factor of the system is also improved. The problem will be simulated using MATLAB and all the results are validated using sim power system tool box.

***Keywords* — Distribution static compensator, Reactive power compensation, power quality**

1. INTRODUCTION

Power systems voltage and current waveforms are deteriorates by highly use of power converters and nonlinear loads. Harmonics are generated because of high frequency of switching of power electronics converters. The presence of harmonics in voltage and current waveforms increases the power loss.[1]

The unbalanced load current with large reactive components leads results in voltage fluctuations and unbalance due to the source (system) impedances. Because of unbalanced current the harmonic components increases and reduction in power factor of distribution network. A shunt compensator also helps to reduce voltage fluctuation sat the point of common coupling (PCC). If the source voltages are unbalanced and varying, it is also possible for a shunt compensator to achieve this. [1]

In distribution system the power quality can be improved by custom power devices which can able to exchange of extra demanded reactive power which are also called FACTS devices. The commonly FACTS controller devices used for improving the power quality are as follows:

1. Static VAR Compensators (SVC)
2. Thyristor Controlled Series Capacitors (TCSC)
3. Static Compensators (STATCOM)
4. Static Series Synchronous Compensators (SSSC)
5. Unified Power Flow Controllers (UPFC)

Among of the various distribution FACTS controllers, Distribution Static Compensator (DSTATCOM) is an important shunt compensator which has the capability to solve power quality problems faced by distribution systems. DSTATCOM has effectively replaced a Static VAR Compensator (SVC), as it takes large response time in addition it is connected with the passive filter banks and capable only steady state reactive power compensation. A DSTATCOM is a Voltage Source Inverter (VSI) based FACTS controller sharing similar concepts with a STATCOM used at transmission level. Moreover SVCs which have been largely used in arc welding plants for voltage flicker mitigation have been replaced by DSTATCOMs because SVCs exhibit limited reduction of instantaneous flicker level. [2]

A DSTATCOM is basically a Voltage Source Converter (VSC) based FACTS controller sharing many similar concepts with that of a STATCOM used at transmission level. A STATCOM at the transmission level handles only fundamental reactive power and provides voltage support while as a DSTATCOM is employed at the distribution level or at the load end for power factor improvement and voltage regulation. DSTATCOM have similar functionality as compared to shunt active filter, it can work as a shunt active filter to eliminate unbalance and distortion in source current and supply voltage. [1]

The performance of the DSTATCOM depends on the control algorithm i.e. the extraction of the current components. So, for this, there are various control algorithms for the control of DSTATCOM block depending on various theories and strategies like phase shift control, instantaneous PQ theory, and synchronous frame theory [2]. Each of the algorithms specified have their own merits and demerits. In this dissertation there are five control strategies have been implemented to compensate the required reactive power at the load side. Phase control method has used for enhancement of power transmission system performance. The other control strategies are Synchronous frame theory, instantaneous PQ theory and fryze method used for compensation of the unbalanced linear load and nonlinear power electronic load. The hysteresis current control strategy has implemented to compensate reactive power requirement of single-phase load. [1]

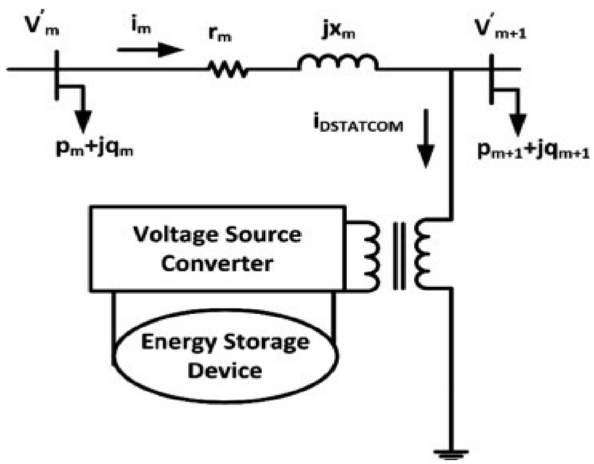

Fig. 1 Operating Principle of DSTATCOM

Fig.1 shows the single-line diagram of the shunt connected DSTATCOM based distribution system. The DC capacitor connected at DC bus of converter act as energy storage element and DC voltage provide to system. DSTATCOM absorbs or produce the reactive current (i_c).

The DSTATCOM have four control schemes:
(1) Phase shift control
(2) Decoupled current control
(3) Regulation of ac bus and DC link voltage
Synchronous reference frame theory

2 OPERATING PRINCIPLE OF DSTATCOM

The operation of DSTATCOM is similar to synchronous machine. DSTATCOM can generate and absorbs reactive power similar to that the synchronous machine and it can also exchange real power if provided with an external device DC source. [3]

Exchange of reactive power:
If the output voltage of the VSC is greater than the system voltage then the DSATCOM work as capacitor and provide reactive power (that is generate lagging current to the system). [3]

Exchange of real power:

The exchange of real power is required to maintain the voltage level of the capacitor constant in the case of direct voltage control. If the capacitor is connected with the external DC source, DSTATCOM can exchange the active power with ac system. [3]

STATCOM monitors only fundamental reactive power at the transmission level and give voltage support. DSTATCOM is engaged at the distribution level for voltage regulation and power factor improvement. Because of same functionality DSTATCOM can be also used as active shunt filter to eliminate the harmonics .DSTATCOM is capable to generate the compensating current with any of control algorithm, which make the DSTATCOM flexible. [3]

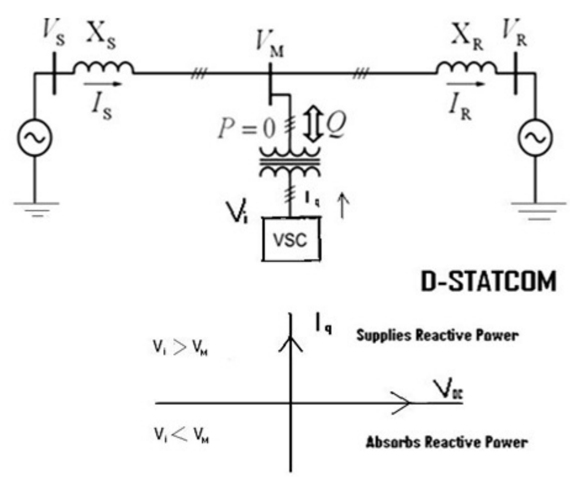

Fig. 2 The single line diagram of DSTATCOM

Block Diagram of DSTATCOM:

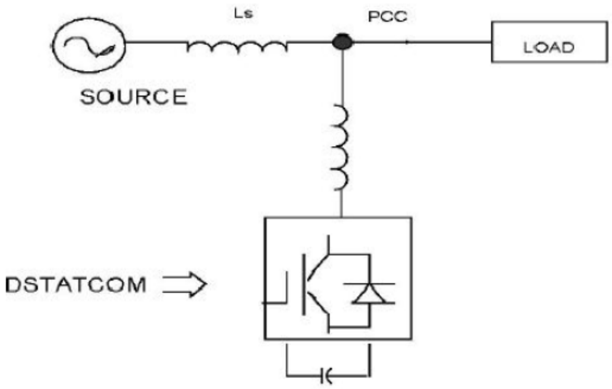

Fig. 3 Block Diagram of DSTATCOM

STATCOM monitors only fundamental reactive power at the transmission level and give voltage support. DSTATCOM is engaged at the distribution level for voltage regulation and power factor improvement. Because of same functionality DSTATCOM can be also used as active shunt filter to eliminate the harmonics. DSTATCOM is capable to generate the compensating current with any of control algorithm, which makes the DSTATCOM flexible. [4]

The main function of control scheme is to generate the proper PWM triggering pulses. Because of similar concepts to the STATCOM some controlling schemes are directly employed to a DSTATCOM [3]. The main controlling schemes for reactive power compensation are [4]:

1. Phase Control Method (PCM)
2. Decoupled Current Control (p-q) Theory
3. Regulation of ac bus and dc link Voltage
4. Synchronous Reference Frame Theory (SRFT) Method

3 OPERATING CHARACTERISTIC

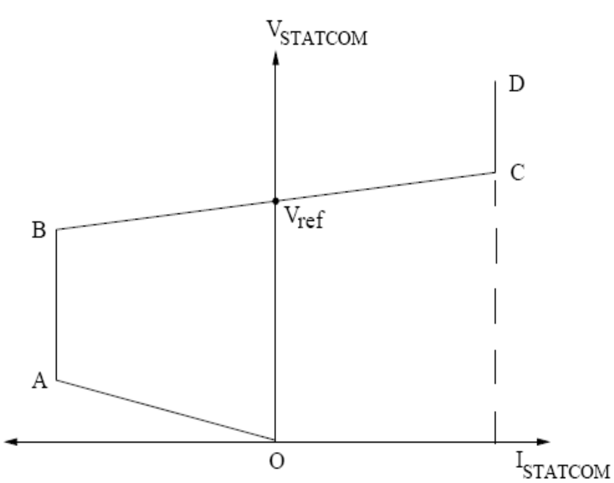

FIG. 4 Operating Characteristic of DSTATCOM

At the starting the capacitor will be charged OA capacitive part. At reach peak point the current would be stable due to threshold value and only voltage will be increased. At $V_{ref}=V_{statcom.}$ We can get unity power factor with the help of DSTATCOM. For the inductive load, the voltage should be stable at peak value and only current will increase. [4]

Controlling Schemes of DSTATCOM

I. Fryze Power Theory (FPT) Method

The block diagram of this control algorithm is as shown in Fig. 5. In this controlling algorithm the load current and the source voltages are sensed and the active fryze conductance Ge is calculated by,

$$G_e = \frac{V_s I_{La} + V_s I_{Lb} + V_s I_{Lc}}{V_{sa}^2 + V_{sb}^2 + V_{sc}^2}$$

Where,
$i_{La};i_{Lb};i_{Lc}$ = Load current of phase a, phase b and phase c respectively
$V_{sa};V_{sb};V_{sc}$ = Source voltage of phase a, phase b and phase c respectively

Then this signal G_e is fed to the LPF which is denoted by Ge. The active instantaneous currents are calculated as shown below:

$$I_{wa} = I_{sa} = G_e V_{sa}$$
$$I_{wb} = I_{sb} = G_e V_{sb}$$
$$I_{wc} = I_{sc} = G_e V_{sc}$$

Where,
i_{wa}, i_{wb}, i_{wc} = Active instantaneous current of phase a, phase b and phase c respectively
i_{sa}, i_{sb}, i_{sc} = Source current of phase a, phase b and phase c respectively Then the reference current are calculated by,

$$i^*_{Ca} = i_{La} - i_{wa}$$
$$i^*_{Cb} = i_{Lb} - i_{wb}$$
$$i^*_{Cc} = i_{Lc} - i_{wc}$$

Here,
i_{Ca}, i_{Cb}, i_{Cc} = Measured compensating current of phase a, b and c respectively
i_{Ca}, i_{Cb}, i_{Cc} = Calculated compensating current of phase a, b and c respectively This calculated compensated current is compared by measured compensated current and the generated error signal is given to the voltage source inverter which is generated triggering pulses and is fed to the gate of the inverter [4].

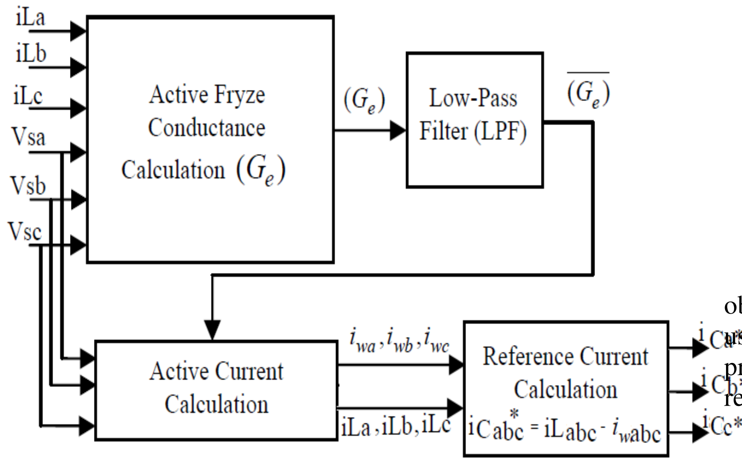

Fig. 5 Block diagram of FPT method

II. Synchronous Reference Frame Theory (SRFT)

The synchronous reference frame theory is based on the transformation of the current in synchronously rotating d-q frame Fig.. 6 explain the basic building blocks of the theory if Ø is the transformation angle, then the currents transformation from α-β to d-q frame is defined as: [5]

$$\begin{bmatrix} i_d \\ i_q \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix}$$

SRFT isolator extracts the dc component by low pass filters (LPF) for each id and iq realized by moving average at 100Hz. The extracted DC components i_d dc and i_q dc are transformed back into α-β frame as shown below: [5]

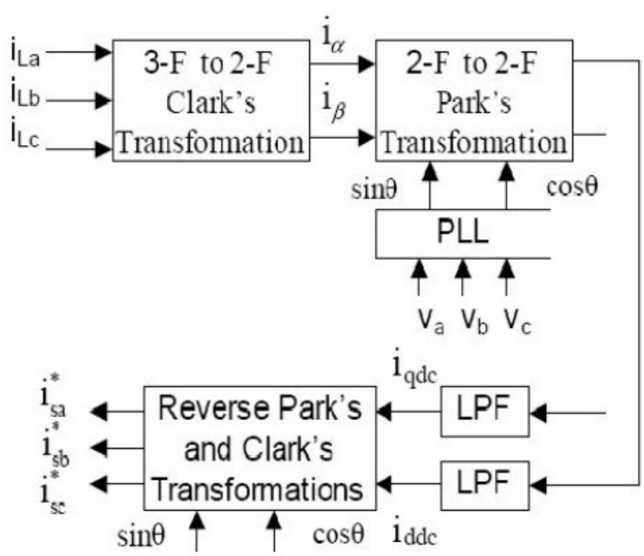

Fig. 6 Block Diagram of SRFT

$$\begin{bmatrix} i_{\alpha dc} \\ i_{\beta dc} \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} i_{ddc} \\ i_{qdc} \end{bmatrix}$$

From here the transformation can be made to obtain three phase reference currents in a-b-c coordinates using. The reactive power compensation can also be provided by keeping i_q component zero for calculating reference currents [5].

$$\begin{bmatrix} i_{\alpha dc} \\ i_{\beta dc} \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} i_{ddc} \\ i_{qdc} \end{bmatrix}$$

CONCLUSION

The main aim of this paper is to review all the controlling methods of DSTATCOM and suitable methods Fryze Power Theory and Synchronous Reference Frame Theory (SRFT) are discussed in this paper. The excessive reactive power of power system is compensated by above two discussed methods.

Reactive power can be compensated by absorbing or supplying the required power using DSTATCOM. Power factor and power quality are compensated by DSTATCOM.

REFERENCES

[1] K.R. Padiyar, ``FACTS CONTROLLERS IN POWER TRANSMISSION AND DISTRIBUTION”, *New Age International Limited, Publishers.*

[2] P. Bapaiah, “Power Quality Improvement by using DSTATCOM”, *International Journal of Emerging Trends in Electrical and Electronics (IJETEE) Vol. 2, Issue. 4, April-2013.*

[3] Ankur Gheewala, ‘‘A Review on Different Control Algorithms of DSTATCOM’’, *International Journal of Engineering Science and Computing, Volume 7 Issue No. 2, February 2017.*

[4] Jaruppanan P, Kanta Mahapatra, Jeyaraman.K and Jeraldine Viji, “Fryze Power Theory with AdaptiveHCC based Active Power Line Conditioners", *International Conference on Power and Energy Systems (ICPS), Dec 22-24, 2011, IIT-Madras.*

[5] Bhim Singh and Jitendra Solanki, “A Comparison of Control Algorithm for DSTATCOM”, *IEEE Transactions On Industrial Electronics, Vol. 56, No. 7, July 2009.*