A REVIEW ON STATCOM CONTROLLER FOR POWER QUALITY ENHANCEMENT IN DISTRIBUTED SYSTEM

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Abstract: New technologies, using power Electronics-based concepts, have been Developed to provide protection for Commercial and industrial customers from Power quality problems on the electrical Distribution system known as Custom Power Products. Custom power devices are classified into three categories by their structures such as dynamic voltage regulator (DVR), distribution static compensator (STATCOM) and unified power quality compensator (UPQC). The Distribution Static Compensator (D-STATCOM), one of the custom power product, is a shunt-connected Power electronics-based device, is used for compensation of reactive power i.e. unbalance in line thus protecting the electrical system from a polluting (flicker producing) Load. The STATCOM can be used in place of a traditional static VAR Compensator and offers many advantages. This consists of three phase voltage source inverter, injection transformer, DC LINK. The performance of the STATCOM 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 STATCOM block depending on various theories and strategies like phase shift control, instantaneous PQ theory, synchronous frame theory, Adaline based theory.

Keywords: Power quality, PCC, SVC, UPQC, STATCOM, Harmonics, Wind energy. Custom power devices

I. Introduction

In the early days of power transmission in the late 19th century problems like voltage deviation during load changes and power transfer limitation were observed due to reactive power unbalances. Today these Problems have even higher impact on reliable and secure power supply in the world of Globalization and Privatization of electrical systems and energy transfer. The development in fast and reliable semiconductors devices (GTO and IGBT) allowed new power electronic Configurations to be introduced to the tasks of power Transmission and load flow control. The FACTS devices offer a fast and reliable control over the transmission parameters, i.e. Voltage, line impedance, and phase angle between the sending end voltage and receiving end voltage. On the other hand the custom power is for low voltage distribution, and improving the poor quality and reliability of supply affecting sensitive loads. Custom power devices are very similar to the FACTS. Most widely known custom power devices are STATCOM, UPQC, DVR among them STATCOM is very well known and can provide cost effective solution for the compensation of reactive power and unbalance loading in distribution system [3]. The performance of the STATCOM depends on the control algorithm i.e. the extraction of the current components. For this purpose there are many control schemes which are reported in the literature and some of these are instantaneous reactive power (IRP) theory, instantaneous compensation, instantaneous symmetrical components, synchronous reference frame (SRF) theory, computation based on per phase basis, and scheme based on neural network [4- 11]. Among these control schemes instantaneous reactive power theory and synchronous rotating reference frame are most widely used. This paper focuses on the compensating the voltage sag, swells and momentary interruptions. The dynamic performance is analyzed and verified through simulation.

Voltage sags is caused by a fault in the utility system, a fault within the customer's facility or a large increase of the load current, like starting a motor or transformer energizing .Voltage sags are one of the most occurring power quality problems. For an industry voltage sags occur more often and cause severe problems and economical losses. Utilities often focus on disturbances from end-user equipment as the main power quality problems.

Harmonic currents in distribution system can cause harmonic distortion, low power factor and additional losses as well as heating in the electrical equipment. It also can cause vibration and noise in machines and malfunction of the sensitive equipment. The development of power electronics devices such as Flexible AC Transmission System(FACTS) and customs power devices have introduced and emerging branch of technology providing the power system with versatile new control capabilities.

There are different ways to enhance power quality problems in transmission and distribution systems. Among these, the D-STATCOM is one of the most effective devices. A new PWM-based control scheme has been implemented to control the electronic valves in the DSTATCOM. The D-STATCOM has additional capability to sustain reactive current at low voltage, and can be developed as a voltage and frequency support by replacing capacitors with batteries as energy storage.

The rest of research paper is design as follows. The overall previous work is described in Section II. Section III describes problem formulation. performance parameter describe in section IV. Finally, Section V describes the conclusion of paper.

II. Literature Review

Numerous research works are already existed in literature which based on PQ problem compensating utilizing D-STATCOM. Some of them reviewed here.

Rakesh S. Kumbhare et.al (2015) presented the STATCOM-based control scheme for power quality improvement in grid connected wind generating system with non-linear loads. The operation of the STATCOM is simulated using two controllers: Hysteresis current controller and PI controller .STATCOM injects current to the grid and it cancel out the reactive and harmonic parts of the induction generator current and load current[1].

A. Yanushkevic et.al (2014) described an advanced approach to power quality enhancement, mainly to flicker mitigation. There is described the standard STATCOM device added by an energy storage in its DC circuit. Its function is then discussed and modeled for active power compensation in addition to the classical reactive power compensation [2].

Ilango K et.al (2014) presented a novel idea where a STATCOM is used innovatively as i) a load reactive power compensator ii) an interface unit between the grid and renewable energy source, and iii) as an effective method for real power exchange between the dynamic load system, grid and renewable energy source [3].

Aarathi A. R et.al (2014) discussed about Static synchronous compensators (STATCOMs) have been widely used for voltage support over the past decade, to improve power quality and voltage stability. However, STATCOMs are limited in their ability to improve the system stability margin due to their restricted capability for delivering real power. Super capacitors are devices which can store significant amounts of energy, and are able to quickly release it [3].

Mohit Bajaj et.al (2016) discussed techniques of D-STATCOM in case of disturbed supply voltage has been done to improve the quality of power in the supply system. The results obtained after Simulation proves that compensation approaches based on synchronous detection method, and a new approach in the a-b-c reference frame based on symmetrical components are most in effect [4]

Mohammed Abdul et.al (2016) designed and implemented of a Distribution type, Voltage Source Converter (VSC) based static synchronous compensator (DSTATCOM) has been carried out. It presents the enhancement of power quality problems, such as voltage sag and swell using Distribution Static Compensator (D-STATCOM) in distribution system [5].

D. Prakash et.al (2016) presented. a distribution static compensator (D-STATCOM) is one of the FACTS gadgets makes it productive answers for enhancing the PQ in distribution system. So as to diminish the PQ issues, the D-STATCOM exhibitions are enhanced. [6]

Masoud Farhoodnea et.al (2016) presented a novel method to optimally place the Distribution Static Synchronous Compensator (DSTATCOM) in a distribution system using the firefly algorithm (FA) for enhancing power quality [7].

Noramin Ismail et.al (2010) presented the enhancement of voltage sags, harmonic distortion and low power factor using Distribution Static Compensator (D-STATCOM) with LCL Passive Filter in distribution system. The model is based on the Voltage Source Converter (VSC) principle. Thus, it can be concluded that by adding D-STATCOM with LCL filter the power quality is improved [8].

T.Bharath Kumar et.al (2014) defined the wind power generation, utilization and its integration with electrical grid are increasing worldwide. The generated wind power is always changing due to its time varying nature and producing stability problem [9].

Soumya Mishra et al. have anticipated a low ranking photovoltaic fed enhanced hybrid distributed static compensator (D-STATCOM) for the recompense of harmonics and reactive power. The system convince the load active power requirement with minimized power rating of the photovoltaic source for same load rating as contrasted with the standard L or LCL filters [10]

M.R.Qader has depicted an innovated systematic scheme on the basis of optimal control and tracking with a PI (proportional integral) controller, to control complete flow of load and voltage sags/flickers; while neglecting harmonics concurrently, the preferred steady state behavior, and a linear quadratic tracker.

S.M.Abd-Elazimet al. have projected a met heuristic technique, the Cuckoo Search (CS) algorithm, depends on the life of a bird family for optimal design of STATCOM in a multi-machine surroundingsThe performance of the CS depend STATCOM was contrasted with Genetic Algorithm (GA) based STATCOM and open loop STATCOM under different operating conditions and turbulence [11]

Abdul Balikci et al. have explained a 3-phase, delta-connected, 5-level Static Synchronous Compensator with AC to DC converter for load balancing in three-phase systems. The control algorithm based on series decomposition of load current and reimbursement of its negative sequence element in addition compensation of imaginary component of positive sequence [12].

Bhim Singh et al. have depicted the modeling and execution of a three-phase DSTATCOM utilizing STF (Self Tuning Filter) based IRPT (Instantaneous Reactive Power Theory) control algorithm for power quality enhancement. An adaptive fuzzy logic controller was employed to control the dc bus voltage of VSC based D-STATCOM to enhance the response and to minimize the overshoot and undershoot of traditional PI (Proportional-Integral) controller under unbalanced loading conditions and supply voltage fluctuations [13].

III. Problem Formulation & Challenges

The purpose of determining optimal D-STATCOM placement is to improve power quality of a system by minimizing the total installation cost. Therefore, a multi objective optimization problem is formed where its objective function includes three sub functions and three constraints to the control variables as described in following subsections.

- Transients
- Interruptions
- Sag / Under voltage
- Swell / Over voltage
- Harmonic distortion
- Voltage Spike
- Noise

IV. POWER QUALITY ISSUES

A. Power quality standards

a. IEC standard

Common guidelines for measurement and rules for power quality of wind turbines are specified in IEC standard 61400.Both manufacturer and buyer utilized this standard for better power quality requirement [4].

The standard norms are specified.

1. IEC 61400-21: Wind turbine generating system, Part-21.Measurement and Assessment of power quality characteristics of grid connected wind turbine.
2. IEC 61400-13: Wind turbine – measuring procedure in determining the power behavior.
3. IEC 61400-3-7: Assessment of emission limit for fluctuating load.
4. IEC 61400-12: Wind turbine performance. The data sheet with electrical characteristics of wind turbine provides the base for the utility assessment regarding a grid connection [4].

B. Power Quality issues

a. Voltage Fluctuation

Better torque and wind velocity are the source of voltage discrepancy. The voltage variation occurs by variation in wind speed and its disparity directly linked with real and reactive power deviation. The voltage variation classified as voltage dip, voltage swell, short interruption and long duration voltage variation. The amplitude of voltage fluctuation depend and power factor of wind turbine [4].The dynamic variation in network caused by wind turbine is described by voltage flicker. IEC standard 61400-4-15 specifies flicker meter which is used to determine flicker directly.

b. Harmonics

Harmonics are referred as sinusoidal voltage, and current having frequency that are multiples of frequency at which the system intend to work .Power electronic devices are major source of harmonics. The harmonics voltage and current should be limited at a point of common coupling. To ensure the harmonic voltage at desire limit, each source of harmonic current permit only partial contribution as per IEC standard 61400-36.The harmonic current is generated at low distortion point in wind turbine. Two indices for measuring harmonic content are total harmonic distortion and total demand distortion.

c. Self excitation of WTGS

The wind turbine generating system is equipped with compensating capacitor. The capacitor which is connected with asynchronous generator gives reactive power compensation.

d. Consequence of issues

The voltage variation, voltage flickering effect and inducement of harmonics create much effect in wind turbine which is connected with grid .These power quality issues will affect the sensitive equipment and also it will affect the sensitivity of the grid. Voltage fluctuation, flicker, harmonics and frequency causes the malfunction of equipment such as microprocessor based control system, programmable logic controller, adjustable speed drive and flicker of light and screen.

V. Conclusion

Power quality has turned into dominant situation of late. This paper has examined the performance of various FACTS devices during various power quality conditions. From this study we can suggest that the Static Compensator can carry out better performance than other custom devices. Various Control techniques are adopted for enhancing the performance of the entire network while using custom power device. Unified power quality conditioner can do well according to power quality maintained at PCC. But only defect is cost effective. Static VAR compensator can support only for stabilization of voltage. But it fails to give reactive power support.

References

[1]Rakesh S. Kumbhare et.al "STATCOM- Control Scheme For Power Quality Improvement to Grid Connected Wind Energy Generating System" International Journal of Electrical, Electronics and Data Communication, pp 9-15 , June 2015.

[2]Aarathi A. R. , Dr. M. V. Jayan "Grid Connected Photovoltaic System with Super Capacitor Energy Storage and STATCOM for Power System Stability Enhancement" International Conference on Advances in Green Energy , pp 26-32 , Dec 2014.

[3]Yanushkevich, Z. Müller, J. Švec, J. Tlustý and V. Valouch "Power Quality Enhancement using STATCOM with Energy Storage" pp 349- 354 , International Conference on Renewable Energies and Power Quality , April 2014.

[4]Ilango K, Bhargav.A, Trivikram.A, Kavya.P.S, Mounika.G, and Manjula G. Nair "Power Quality Improvement using STATCOM with Renewable Energy Sources " IEEE Transaction Power Electronics, Vol.19, No.5, Dec 2012.

[5]Aarathi A. R , Dr. M. V. Jayan "Grid Connected Photovoltaic System with Super Capacitor Energy Storage and STATCOM for Power System Stability Enhancement " International Conference on Advances in Green Energy , pp 25-32 , Dec 2014.

[6]Mohit Bajaj, Chetan Bhardwaj and Mukesh Pushkarna "A Comparative Study of Control Techniques of Distribution-STATCOM under Abnormal Source Voltage " International Conference on Advances in Electrical, Electronics, Information, Communication and Bio-Informatics , pp. 660-669, July 2015.

[7]Mohammed Abdul et.al "Enhancement of Power Quality in Distribution System using D-Statcom" International conference on Signal Processing, Communication, Power and Embedded System pp 2093 – 2098 , 2016.

[8]D. Prakash, R. Mahalakshmi, and M.Karpagam "Power Quality Enhancement in STATCOM connected Distribution Systems based on Gravitational Search Algorithm" International Journal on Electrical Engineering and Informatics - Volume 8, Number 4, pp 907-924 , December 2016.

[9]Masoud Farhoodnea; Azah Mohamed "Optimum D-STATCOM Placement Using Firefly Algorithm for Power Quality Enhancement" 7th International Power Engineering and optimization Conference , pp 98-102 , 2016

[10]Noramin Ismail, Wan Norainin Wan Abdullah "Enhancement of Power Quality in Distribution System Using D-STATCOM" 4th International Power Engineering and Optimization Conference , pp 418-424 , June 2010

[11]T.Bharath Kumar and Dr.M.Venu Gopala Rao "Mitigation of Harmonics and Power Quality Enhancement for SEIG based Wind Farm using ANFIS based STATCOM" IEEE Trans. Ind. Appl., vol. 39, no. 4, pp. 936–944, Jul. 2014.

[12]Soumya Mishra and Pravat Kumar Ray, "Nonlinear modeling and control of a photovoltaic fed improved hybrid D-STATCOM for power quality improvement", International Journal of Electrical Power and Energy Systems, Vol.75, pp.245–254, 2016

[13]M.R.Qader, "Design and simulation of a different innovation controller-based UPFC (unified power flow controller) for the enhancement of power quality", International Journal of Energy, Vol.89, pp.576–592, 2015

[14]S.M.Abd-Elazim and E.S.Ali, "Optimal location of STATCOM in multi-machine power system for increasing loadability by Cuckoo Search algorithm", International Journal of Electrical Power and Energy Systems, Vol.80, pp.240–251, 2016

[15]Abdul Balikci and EyupAkpinar, "A multilevel converter with reduced number of switches in STATCOM for load balancing", International Journal of Electric Power Systems Research, Vol.123, pp.164–173, 2015

[16] Bhim Singh, Sunil Kumar Dube and Sabha Raj Arya, "An improved control algorithm of DSTATCOM for power quality improvement", International Journal of Electrical Power and Energy Systems, Vol.64, pp.493–504, 2015

[17]J. H. Choi and J. C. Kim, "Advanced voltage regulation method at the power distribution systems interconnected with dispersed storage and generation systems," IEEE Trans. Power Del, vol. 15, no. 2, pp. 691– 696, Apr. 2000.

[18]D. Seyoum, C. Grantham, and M. F. Rahman, "The dynamic characteristics of isolated self-excited induction generator driven by a wind turbine," IEEE Trans. Ind. Appl., vol. 39, no. 4, pp. 936–944, Jul.2003.

[19]M. S. El-Moursi and A. M. Sharaf, "Novel controllers for the 48-pulse VSC STATCOM and SSSC for voltage regulation and reactive power compensation," IEEE Trans. Power Syst., vol. 20, no. 4, pp. 1985–1997, Nov. 2005.

[20] C. W. Taylor, "The future in on-line security assessment and wide area stability control," in Proc. IEEE Power Eng. Soc. Winter Meeting, 2001, pp. 78–83.

[21]C. W. Taylor, M. V. Venkata subramanian, and Y. Chen, "Wide-area stability and voltage control," in Proc. Symp. Elect Oper Expansion Planning, 2000, vol. 1, pp. 1–9.