Indian J.Sci.Res. 17(2): 191-195, 2017 ISSN: 0976-2876 (Print)
ISSN: 2250-0138(Online)

STUDY FOR ENHANCING POWER QUALITY FOR SMART GRIDS AND MICROGRIDS USING FACTS DEVICES

[1]Mohd Mustafa, [2]Syed Abdul Razzaq, [3] K Mahesh
[1,3] Department of EEE Aurora's Scientific Technological and Research Acdemy, Hyderabad
[2] Vel-Tech Rangarajan and Dr.sagunthala R&D Institute of Science and Technology, Chennai

Abstract —Almost from the last two decades, renewable energy sources in electrical has been emerging and come up with new challanges for quality of power delivering. Power electronics devices are extensively utilised like flexible ac transmission systems (FACTS), voltage sources converters (VSI) and current source converters (CSI) and filters to improve power quality.FACTS play a vital role for improving power quality ensuring efficient energy utilization for smart grids .

Keywords - FACTS, D-FACTS, VSI, CSI, Power Quality, Power electronics Devices.

I. Introduction

Utilization of FACTS devices has been proven as most efficient energy system for improving power quality, reducing harmonics, better voltage stabilization, power factor correction. The role of power electronics has been increased with the use of renewable and distributed generation of micro grids. Power quality issues and mitigation merged as serious task to be take into consideration.

FACTS devices and various control stratergies helps to mitigate and enhance power quality. Research has focused on voltage source converter (vsc) architectures and new techniques. The results of FACTS devices when implemented in smart grids are impressive

This paper focuses on application of FACTS devices in smart grids

Role of FACTS devices and control strategies in electrical power system power quality and voltage regulation. Impact of distributed-FACTS (D-FACTS) systems and emerging vol-tage source inverter (VSI) on modern electrical systems stabiliza-tion. Power quality harmonic reduction in AC-DC- AC interfaced renewable energy and battery storage devices.

FACT devices also i\,proves the voltage regulation and fluctuations in the Transmission lines

II. Facts Devices

FACTS devices and power electronics converters using in emerging smart grids and they are based on concepts of

1. Injecting ac components in series and parallel at node section to create current flows or superimposed voltage.
2. To maintain reactive power, supplying localized reactive or capacitive current at the bus.
3. Modulating apparent admittance(Y) and impedance (Z) at the point of common coupling.

Controlling stratergies are based on power. Voltage, angle and reactive power flow which basically uses proportional integral controllers (PID).

Converter topologies can be classified into:

a) Active power filter topologies

a) Switched/modulated inductors or capacitors

b) Voltage source-converter fed

c) Dc-current source injection interface

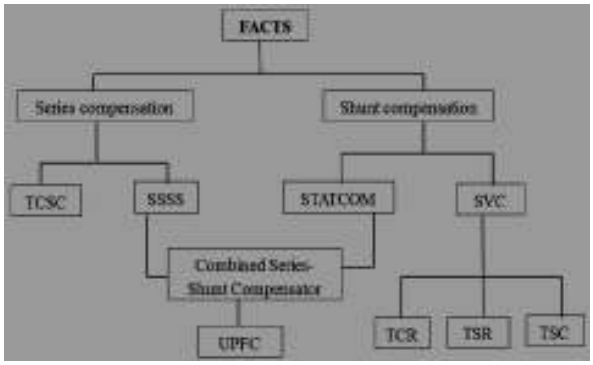

Fig.1. Classification of FACTS devices

The main objectives of FACTS devices are to increase the useable transmission capacity of lines and to control the power flow over designated transmission routes. Then there are Controllers that are based on conventional thyristors (without turn off capability) and those that are based on turn-off Thyristor (GTO, SGTO, IGCT) and transistor (IGBT).

In case of SVC, the current is a function of the line voltage and hence its reactive power is function of square of the line voltage. Thus when the dynamic voltage is say 80%, the injected reactive power is reduced to 64%, just when more is needed. The converter based STATCOM on the other hand injects the required current of either polarity and hence injects appropriate reactive power as needed. For similar performance

[1]Corresponding Author

STATCOM size would be much smaller and should be the more cost effective of the two in many applications. Numerous SVCs and many STATCOMs have been installed throughout the world. strictly speaking, not a FACTS device, are also considered as the potential solution for harmonic mitigation, as they have been, and are still most widely used for this purpose by utilities and industrial installations due to their cost- effectiveness. STATCOMs do not require large inductive and capacitive components to provide inductive or capacitive reactive power to high voltage transmission systems as required in SVCs.

The FACTS and custom power devices have been developed for mitigating specific power quality problems. For example, UPFC works well for power flow control, DVR which acts as a series compensator is used for voltage sag compensation and STATCOM which is a shunt compensator is used for reactive power and voltage sag compensation. The STATCOM, VR, UPS and active power conditioner are only useful for compensating a particular type of power quality problems and therefore, it has become necessary to develop a new kind of Unified Series-Shunt Compensator (USSC) which can mitigate a wider range of power quality problems. The main power quality parameters include voltage and frequency along with harmonic distortion, which has been improved by adopting Static VAR Compensator (SVC) and Shunt Active Power Filter (SAPF) in [4]. Frequency and voltage control modes are used in microgrid. Droop control technique is more then efficient to intensify power quality with controlling active power and reactive, which has been implemented in [5].

III. Facts Devices in Power Quality Improvement

The importance of D-STATCOM for enhances power quality through positive sequence and negative sequence for micro grids. To surpass the voltage of negative sequence D-STATCOM of an acceptable value is used. To withhold the harmonic current and to track the fundamental current, a regulation of resonant current is employed [8] in this work. Author Lee et al extended his paper to mitigate voltage variation from which he came to conclusion. Placing DSTATCOM at the end of the line Voltage regulation performance is appreciated. In comparison to the right side of the installation point, the left side gives better performance.

The simulation results by coordinating the D- STATCOM with other devices such as SVC and OLTC

(1) Reactive power compensation is controlled in stepwise the same can be done with DSTATCOM.

(2) the DSTATCOM injects required reactive power with quick response time compared to OLTC. Therefore, the integration of DSTATCOM with OLTC is highly preferable.

(3) Similar to the operation of DSTATCOM with other devices, multiple DSTATCOMs are implemented together to restore the voltage.

IV Distributed FACTS (D-FACTS)

With a high demand of RESs as DG in the electrical distribution network, the policy of investment in the energy area and control of power system has changed [9,10]. In [11], a new concept of D-FACTS was suggested as an alternative solution to solve the main problem of the last generation of FACTS devices, which is the cost effective power flow control. Currently, D-FACTS are designed to address power control types of problems. D-FACTS can be used to dynamically control the effective line impedance. Also, from a power system perspective, D-FACTS devices offer many potential benefits since they are less expensive and smaller than usual FACTS devices, which may make them better candidates for wide scale deployment The most important D-FACTS that have been used in the smart/micro grids are shown in Table I.

Recently-Introduced Distributed FACTS Devices – Capacitive or inductive– Distributed Static Series Compensator (DSSC) Distributed Series Reactor (DSR) (inductive only) – Synchronous Voltage Source – Attach directly to lines – Small and modular Exploit the fact that not all locations have equal impact Determine the best locations for the applications of interest Then, determine D-FACTS settings to achieve the desired purpose • Potential applications for D-FACTS include – reducing flow through overloaded lines – minimizing losses – minimizing cost

TABLE I. D-FACTS devices in modern electrical networks

D-FACTS	Features
Distributed Switched Filter Compensator (D-SFC) [60,61]	• Voltage stabilization • Power factor improvement • Mitigating THD at buses
Distributed Green Plug SFC (D-GPSFC) [62]	• Stabilization of the dc bus voltage • Low power losses
Distributed Static Compensator (D-STATCOM) [63,64]	• Voltage regulation • Compensation of current harmonics • Control of reactive power • Uninterrupted supply in the case of using an energy storage device
Distributed Static Series Compensator (DSSC) [65]	• Allowing control of active power flow of the line • Smaller and less expensive than traditional FACTS devices • Minimizing real power losses
Distributed TCSC (D-TCSC) [66]	• System stability and development of corresponding cyber-secure control method • Controlling system voltages

D-FACTS devices, can provide a higher performance and lower cost method for enhancing smart/micro grids controllability and reliability, enhancing asset utilization and end-user power quality, while environmental impact and minimizing system cost [14,15].

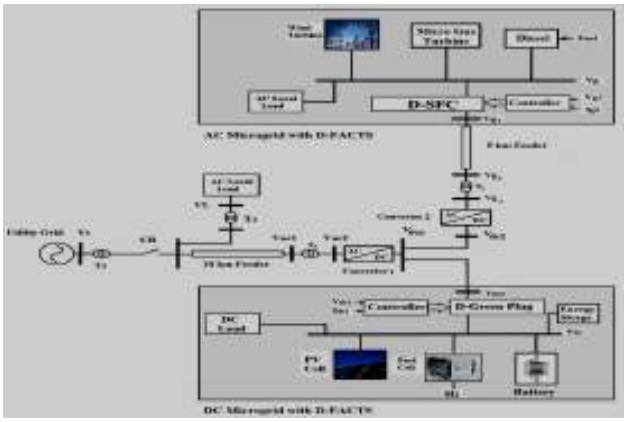

Fig. 2. Modern electrical system with D-FACTS devices.

Moreover, to solve different problems in smart/micro grids such as voltage sags, voltage swells, voltage fluctuations, interruptions and harmonics, various power conversion and control devices have been introduced to regulate and control the generation, transmission and distribution of electrical energy. The main solution to most of the power quality problems is represented by D-FACTS devices. Fig. 2 shows a micro grid with different types of D-FACTS devices.

V. Benefits, Applications And Utilizing Facts Devices

The advantages of using FACTS devices in electricaltransmission systems are described below: More utilization of existing transmission system Reliability of Transmission system increases. More Increased transient and dynamic stability of the system. Increased more quality of supply for large industries Beneficial for Environment. A. More utilization of existing transmission system In all the countries, the power demand is increasing day by day to transfer the electrical power and controlling the load flow of the transmission system is very necessary .this can be achieved by more load centers which can change frequently. Addition of new transmission line is very costly to take the increased load on the system; in that case FACTS devices are much economical to meet the increased load on the same transmission lines. B. More Increased transient and dynamic stability ofthe system The Long transmission lines are inter-connected with grids to absorb the changing the loading of the transmission line and it is also seen that there should be no line fault creates in the line / transmission system. By doing this the power flow is reduced and transmission line can be trip. By the use of FACTS devices high power transfer capacity is increased at the same time line tripling faults are also reduces. C. Increased more quality of supply for large industries New industries wants good quality of electric supply, constant voltage with less fluctuation and desired frequency as mentioned by electricity department . Reduce voltage, variation in frequency or loss of electric power can reduce the manufacturing of the industry and cause to high economical loss .FACTS devices can helps to provide the required quality of supply. D. Beneficial for Environment FACTS devices are becoming environmentally friendly. FACTS devices does not produce any type of waste hazard material so they are pollution free. These devices help us to deliver the electrical power more economically with better use of existing transmission lines while reducing the cost of new transmission line and generating more power. E. Increased transmission system reliability andavailability Transmission system reliability and availability is affected bymany different factors. Although FACTS devices had abilityto reduce such factors and improves the system reliability andavailability.

The basic applications of FACTS-devices are:

1. power flow control,
2. increase of transmission capability,
3. voltage control,
4. reactive power compensation,
5. stability improvement,
6. power quality improvement,
7. power conditioning,
8. flicker mitigation,
9. Interconnection of renewable and distributed generation and storages.

1.More Utilization Of Existing Transmission System

In all the countries, the power demand is increasing day by day to transfer the electrical power and controlling the load flow of the transmission system is very necessary this can be achieved by more load centers which can change frequently.Addition of new transmission line is very costly to take the increased load on the system; in that case FACTS devices are much economical to meet the increased load on the same transmission lines.

2. More Increased Transient And Dynamic Stability Of The System

The Long transmission lines are inter-connected with grids to absorb the changing the loading of the transmission line and it is also seen that there should be no line fault creates in the line / transmission system. By doing this the power flow is reduced and transmission line can be trip. By the use of FACTS devices high power transfer capacity is increased at the same time line tripling faults are also reduces.

3. Increased More Quality Of Supply For Large Industries

New industries wants good quality of electric supply, constant voltage with less fluctuation and desired frequency as mentioned by electricity department . Reduce voltage, variation in frequency or loss of electric power can reduce the manufacturing of the industry and cause to high economical loss. FACTS devices can helps to provide the required quality of supply.

4. Beneficial For Environment

FACTS devices are becoming environmentally friendly. FACTS devices does not produce any type of waste hazard material so they are pollution free. These devices help us to deliver the electrical power more economically with better use of existing transmission lines while reducing the cost of new transmission line and generating more power.

5. Increased Transmission System Reliability And Availability

Transmission system reliability and availability is affected by many different factors. Although FACTS devices had ability to reduce such factors and improves the system reliability and availability.

VI Conclusion

This paper has presented a comprehensive overview of use of FACTS, D-FACTS technology and its application in emerging electric utilities using RESs with power electronic converters. The existing FACTS devices are undergoing tremendous changes in configurations based on soft computing control strategies using smart grid-based fast control strategies and the multi-functional use of voltage control, stabilization, reactive power compensation and unified power flow control. The paper has presented FACTS based solutions and a list of control strategies to deal with the extensive use of nonlinear/sensitive loads, renewable energy sources, battery storage and EV-charging. Suitability and adequacy of the FACTS devices such as SVC, D-STATCOM, SSSC and APFs as well as LC switched compensators have been presented. The emphasis of the presented analysis is on energy efficient utilization, loss reduction, voltage stabilization, power factor, power quality and harmonic reduction at the point of common coupling with nonlinear loads. Also, other issues, including interfacing wind/PV farms with weak ac electric utility systems were considered. Future applications of FACTS devices include renewable energy resources, residential and commercial smart building, residential use of hybrid DC-AC grid, increased use of vehicles-to-grid and vehicles-tohouse, battery charging system, and street, buildings and airports light emitting diode (LED) lighting technology.

References

[1] Velamuri S, Sreejith S. Power flow analysis incorporating renewable energy sources and FACTS devices. Int J Renew Energy Res 2017;7(1):452–8.

[2] Crow ML. Power quality enhancement using custom power devices. IEEE Power Energy Mag 2004;2:50.

[3] Rajpoot PS, Rajpoot SC, Singh DK. Power system stability improvement using FACTS devices. Int J Sci Eng Technol Res 2014;3:2374–9.

[4] G. Xiaozhi, L. Linchuan, and C. Wengan, "Power quality improvement for microgrid in islanded mode," *Procedia Engineering*,vol.23,pp.174–179,2011.

[5] I.-Y. Cheng, W. Liu, D. A. Cartes, E. G. Collins Jr., and S.-I. Moon, "Control methods of inverter-interfaced distributed generators in a microgrid system," *IEEE Transactions on IndustryApplications*, vol. 46, no. 3, pp. 1078–1088, 2010.

[6] T.-L. Lee, S.-H. Hu, and Y.-H. Chan, "Design of D-STATCOM for voltage regulation in microgrids," in *Proceedings of the 2ndIEEE Energy Conversion Congress and Exposition (ECCE '10)*, pp.3456–3463,Atlanta,Ga,USA,September2010.

[7] T.Lee, S. Hu, and Y. Chan, "D-STATCOM with positivesequence admittance and negative-sequence conductance to mitigate voltage fluctuations in high-level penetration of distributed generation systems," *IEEE Transactions on Industrial Electronics*, vol.60,no.4,pp.1417–1428,2013.

[8] M. Castilla, J. Miret, J. Matas, L. G. de Vicuna, and J. M.Guerrero, "Linear current control scheme with series resonant harmonic compensator for single-phase grid-connected photovoltaic inverters," *IEEE Transactions on Industrial Electronics*,vol. 55, no. 7,pp.2724–2733,2008.

[9] Hamidi A, Golshannavaz S, Nazarpour D. D-FACTS cooperation in renewable integrated microgrids: a linear multi-objective approach. IEEE Trans Sustain Energy 2017;PP(99). [1-1].

[10] Gabbar HA, Othman AM. Performance optimisation for novel green plug-energy economizer in micro-grids based on recent heuristic algorithm. IET Gener Transm Distrib 2016;10(3):678–87.

[11] Muttaqi KM, Aghaei J, Ganapathy V, Nezhad AE. Technical challenges for electric power industries with implementation of distribution system automation in smart grids. Renew Sustain Energy Rev 2015;46:129–42.

[12] Georgilakis PS, Hatziargyriou ND. A review of power distribution planning in the modern power systems era: models, methods and future research. Electr Power Syst Res 2015;121:89–100.

[13] Chakraborty C, Iu HHC, Lu DDC. Power converters, control, and energy management for distributed generation. IEEE Trans Ind Electron 2015;62(7):4466–70.

[14] Kakkar V, Agarwa NK. Recent trends on FACTS and D-FACTS, in Proc. of the International Symposium of Modern Electric Power Systems (MEPS), Wroclaw; 20–22 Sep. 2010. p. 1–8.

[15] Divan DM, Brumsickle WE, Schneider RS, Kranz B, Gascoigne RW, Bradshaw DT, Ingram MR, Grant IS. A distributed static series compensator system for realizing active power flow control on existing power lines. IEEE Trans Power Deliv 2007;1(22):642–9.

[16] Alabduljabbar AA, Milanovi JV. Assessment of techno-economic contribution of FACTS devices to power system operation. Electr Power Syst Res 2010;80:1247–55.

[17] Review of FACTS technologies and applications for power quality in smart grids with renewable energy systemsRenewable and Sustainable Energy Reviews 82 (2018) 502–514