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Overview of Facts Devices for Power System Stability and Power Quality Concepts

Dr. M Mohanraj
Associate Professor ,Department of EEE.,Kumaraguru College of Technology, Coimbatore.
mohanraj.m.eee@kct.ac.in

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Abstract

This review paper tells various FACTS devices like STATCOM, UPFC for the improvement of power system stability and power quality. The increase in power demand increases the interconnection of the power system of various sources comprising the renewable energy source, so when demand increases the control over power system also becomes more complex, it may cause more reactive power will flow through system affects the system stability and power quality The economical solution to overcome this issue is to use FACTS (Flexible AC Transmission systems) devices.. In this paper, two FACTS devices are considered namely STATCOM and UPFC, a 13 bus sample system is considered in which four buses are connected with wind energy system and other buses are considered as load buses, due to fluctuating nature of the wind the power quality issues generated are rectified using FACTS diplomacies and it is simulated using MATLAB. The obtained simulation results are tabulated with STATCOM and UPFC with different performance indices.

Keywords; *Power system stability, Power quality, FACTS, STATCOM, UPFC*

I. INTRODUCTION

Power System has many buses and generators that are interconnected together and it becomes too complex when power demand increases [1]. Hence the existing transmission lines are over loaded which may impact the stability of the system. Study of Power system stability plays a vital role in both planning and setup of power networks [2-4]. The modern power system has high dimensionality and complexity and hence power system stability studies have a vital role in it [5-7]. Two types of problems are associated with the notion of power system stability. Usually, the first problem arises during the power system undergoes severe disturbance like transmission line fault and the second problem occurs when the system's fundamental oscillating frequency is not damped [8]. Nowadays, customers prefer sophisticated electronic devices which employ microprocessor based controllers and power electronic devices that require good quality power supply since these devices have non-linear characteristics hence they introduce distortions in the power supply [9,10]. Hence the importance of Power Quality is increasing nowadays because the power quality problems not only affects the customer side but also the electrical utilities. The effect of poor power quality on equipment depends on nature, magnitude, duration, the frequency of the power quality event [11,12].

Hence for the PSS and PQ problems, FACTS devices are used. FACTS devices are available in various configuration and topologies [13]. In this paper, two of FACTS devices, STATCOM and UPFC have been cover and their corrective measures to mitigate above-said problems are discussed theoretically [14,15]. These devices dynamically enhance the system performance.

Now a days, renewables play an important role in

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power production especially wind energy source. Generally, the wind power is fluctuating in nature due to variable wind speed. Hence while synchronising with the grid, there arise power quality issues such as reactive power demand, frequency mismatch [16,17]. This paper analyse the performance of STATCOM and UPFC which is connected to a 13 bus system, in which 4 buses are connected with wind energy conversion system which supplies other load buses using MATLAB. But during faulty conditions, sometimes wind energy system may not able to provide the desired reactive power, so it can be compensated with the help of FACTS devices [18-20]. The fault is created at wind energy generator output for a short duration, FACTS devices are incorporated to compensate the voltage profile and Total Harmonics Distortions (THD) of the system. The performance analysis of FACTS devices have been done with and without the controller.

II. POWER SYSTEM STABILITY

The PSS is elucidated as the capacity of an electric control framework, for a given introductory working condition, to recapture a state working balance after being subjected to a physical unsettling influence, with most framework factors bounded so that essentially the whole framework remains in stable by IEEE/CIGRE. The analysis of stability is associated with three terms namely rotor angle, voltage, frequency.

A. Terms and Definition

a.Rotor angle stability

In an interconnected power system, Rotor angle stability states that the ability to maintain the synchronism in synchronous machines, even after being exposed to some disturbances. In other words, it is the capability to equilibrium between the electromagnetic versus mechanical torque of synchronous machine in the power system. Due to lack of synchronizing torques, it can be oscillatory or non-oscillatory.

b.Voltage Stability

Voltage stability circumstances are the ability of the system to withstand disorders and keep voltage stability throughout the operation. It rest on on the ability to keep equilibrium between power demand and supply.

c.Frequency stability

Frequency stability statuses that the capacity to keep steady frequency, later unembellished sudden load change which may lead to large difference between the generation and load side.

III. POWER QUALITY

Power Quality is the theory of powering and grounding superficial apparatus in a way that is apt to the action of the equipment. It is demanded by customers to safeguard their equipment's from malfunctioning. Since it is caused by disturbances from generation and transmission side. On the other side, both industrial and domestic customers have sensitive and ununiform loads which could disturb the quality of power.

In recent day's equipment are sensitive to voltage disturbances. Even modern electronic equipment affected due to voltage variations and it may affect nearby devices. The customers are expecting consistent and quality power at distribution side and also utility demands the customers to maintain Power Quality. The loads interconnected with utility grid will work properly only when the quality of the power is good enough to ensure its efficiency.

Carbon credits and also running costs can be maintained in standard manner. The loads connected to a network may fail or lifetime may get decreased or the efficacy of the electrical fitting will reduce if the power quality of the system is ambitious. Installation running costs and carbon footprint will be high and operation is not conceivable. The key to improving the power quality is of very significant when the making processes get more difficult and need a greater responsibility level, which covers like

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to give energy lack of interruption, without harmonic distortion.

The requirement of FACTS controllers in power systems is to control the network condition of any situations in a precise rapid way, henceforth FACTS can be used to improve the voltage stability and steady state, transient stability of any system.

Interconnected systems frequently upward in size and ranging over huge geographical regions, it is very challenging to keep synchronisms among several portions of a power system and that leads to instability of a system. Instability performance systems a severe risk to the present system security and makes identical deadly working conditions. This feature avoids construction of new transmission lines and thus providing the existing network having its use factor closer to its thermal loading capacity.

FACTS controllers be located in the system to improve power transmission ability, to increase voltage profile laterally the line, to increase steady-state and transient stability limit. FACTS is defined as "a power electronic established system and other stationary apparatus that make available controller of one or many AC transmission system limitations to improve controllability and raise power transmission proficiency." A number of new types of devices are introduced into practice. In this paper, a review has been proposed for STATCOM and UPFC.

IV. POWER QUALITY INDICES

A.Voltage sag

Voltage sag can be directed as sudden drop in voltage level in the range 10 % to 90 % of the minimal (RMS) voltage for the period less than 1 minute but more than 0.5 rotations. When compared to further power quality harms, voltage sag happens frequently.

B.Voltage swell

Voltage swells is nothing but voltage surge are voltage dissimilarities, which beat 110 % of the minimal voltage and it takes for lower than 1 minute for short duration. Usually, in power system, single line to ground fault origins voltage swell and it leads to insulation failure of equipment. Voltage regulation devices can be incorporated to overcome this problem.

C.Long-duration overvoltages

Long-duration overvoltage's remain similar to voltage swell nevertheless they past lengthier than one minute. It may be of sustained interruptions occurs during under voltage or over voltage conditions. The reason for overvoltages is due to capacitor switching.

D.Undervoltages

Undervoltages can be referred as voltage drops under 90 % of the minimal value for further than one minute.

E.Interruptions

Interruptions can be termed as short term voltage loss by one or other phases.

F.Transients

Subcycle disorder in the AC waveform evinced by a high-pitched or short-term break of the waveform. It can be of any division either seasoning or subtractive from the regular waveform. Transients happen because of rapid variation in the voltage or the current that occurs in system. Transients are small-duration measures, it can be characterized by the R, L and C of the system setup at the point of concern.

G.Voltage unbalance

Voltage unbalances is the deviancy of every phase from the normal voltage of every phases.

H.Harmonics

Harmonics are characterized by sinusoidal element of a episodic wave taking a frequency of integral multiple of the central frequency. Non linear devices

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such as adjustable speed drive, SMPS, stationary UPS systems, power electronics based heating control, electronic stabilizers for fluorescent lamps electronic equipment in medical field and testing are the source of harmonics.

I.Electric noise

Supply voltage comprises the modules, which are not episodic are called as noise. The arrangement of several dissimilar non-linear loads may be the source of noise.

V. FACTS DEVICES

A.Statcom

Static Synchronous Compensator is mentioned by IEEE as A Static synchronous generator operated as a shunt-connected static VAR compensator whose capacitive or inductive output current can be controlled independent of the AC system voltage". STATCOM can work with voltage source or current source converter.

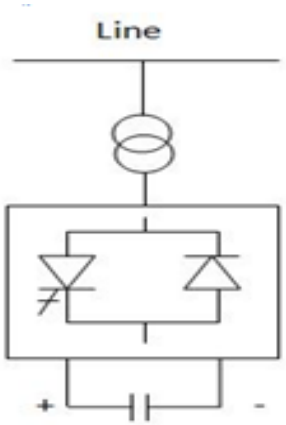

Fig. 1. STATCOM Layout

B.UPFC

Unified Power Flow Controller is characterized by IEEE as "An arrangement of static synchronous compensator (STATCOM) and a static series compensator (SSSC) joined via a public DC link, to permit two-way flow of real power among the series output edge of the SSSC and the shunt output edge of the STATCOM, and are well-ordered to provide parallel real and reactive series line compensation without an outside electric energy basis". The UPFC is planned to control, the transmission line voltage, impedance and phase angle, real and reactive power movement in the line by providing series voltage injection. It also provides compensation in the static and dynamic process of the system.

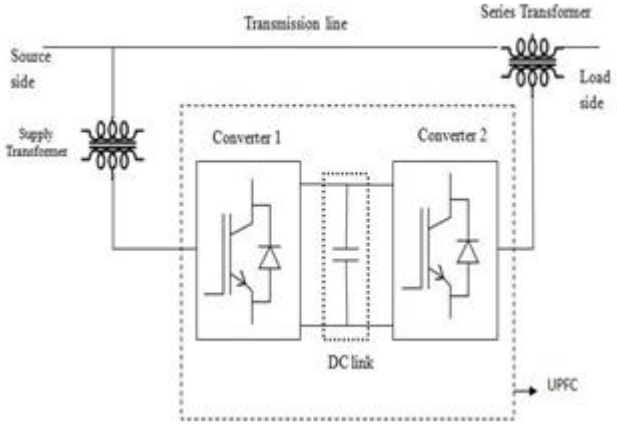

Fig. 2. UPFC Layout

Table 1Theoretical Comparison of Facts Devices

S.NO	CONTROL ATTRIBUTES	FACTS CONTROLLERS	
		STATCOM	UPFC
1	Power flow control	NO	YES
2	Voltage source converter	YES	YES
3	Transient and dynamic converter	NO	YES
4	Voltage profile improvement	YES	YES
5	Current source converter	YES	NO
6	Forced commutated	YES	YES
7	Damping oscillation	YES	YES
8	Fault current limiting	NO	YES
9	Voltage stability	YES	YES

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10	static voltage stability	YES	YES
11	Rotor angle stability	YES	YES
12	Dynamic stability	YES	YES

Table 2.Problems and their Corrective Measures

S.NO	PROBLEM	FACTS DEVICES	CORRECTIVE MEASURE
1	HV on small loads	STATCOM	Absorbs the reactive power
2	Power flow in direction	UPFC	Adjusted the Phase angle
3	HV after outage	STATCOM	Rivet reactive power and avoid overloading
4	LV at heavy loads	STATCOM	Fund reactive power
5	Post-fault power distribution	UPFC	Network restructured
6	Similar line load distribution	UPFC	Adjust the Series reactance
7	LV behind outage	STATCOM	Fund reactive power and avoid overburdening
8	Tripping of Similar lines	UPFC	Limit the line loading
9	Transmission circuit overload	UPFC	Reduce overload

VI. SIMULATION AND RESULTS

A 13-bus system is considered for testing. Out of 13 buses, 4 buses have wind turbine generators and other buses are considered as load buses. The loads considered in this system are dynamic in nature and the reactive power is supplied when it is heavily loaded. During that condition, wind generator is fluctuating in environment so that it cannot provide reactive power to the weak or heavily loaded buses. So FACTS controllers like STATCOM and UPFC are used in this system in order to supply the real and reactive power. Also it has been simulated by introducing faults for small interval of time and the test results also been obtained. The THD in voltage and current waveform in load bus of the system have been observed and tabulated in Table. 3.

Table 3.Result Table

S.No	FACTS Devices	Voltage THD	Current THD
1	STATCOM without controller	8.82	8.82
2	STATCOM with Controller	1.49	2.49
3	UPFC without controller	8.49	8.49
4	UPFC with controller	0.02	0.87

VII. CONCLUSION

This paper gives a brief review about power system stability, power quality, their terms and indices have been discussed. The need of FACTS plans for the mitigation of various power system stability issues and power quality problems have been presented. For analysis purpose, Simulation using MATLAB have been carried out and after the results obtained it is saw that UPFC performs better than STATCOM which is validated by comparing the THD values obtained.

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