International Journal of Scientific Research & Engineering Trends
Volume 7, Issue 6, Nov-Dec-2021, ISSN (Online): 2395-566X

A Review on Power Quality Based on UPFC

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Abstract-Power electronic controllers for a flexible ac transmission system (FACTS) can offer a greater control of power flow, secure loading and damping of power system oscillations. A unified power flow controller (UPFC) is a one of FACTS elements that can provide VAR compensation, line impedance control and phase angle shifting. The UPFC consist of two fully controlled inverters, series inverter is connected in series with the transmission line by series transformer, whereas parallel inverter is connected in parallel with the transmission line by parallel transformer. The real and reactive power flow in the transmission line can be controlled by changing the magnitude and phase angle of the injected voltage produced by the series inverter. The basic function of the parallel inverter is to supply the real power demanded by series inverter through the common dc link. The parallel inverter can also generate or absorb controllable reactive power. This paper offers and discusses most papers that used a UPFC to improving the active and reactive power flow of the power systems the unified power flow controller (UPFC) is an advanced member of flexible AC transmission systems (FACTS) group. This paper is focused on three techniques for inclusion of the steady state models of the UPFC in power flow programs. This paper also presents a review of various benefits and applications of UPFC in power flow studies such as minimization of loss, enhancement of load ability, voltage stability etc. using various optimization techniques. A case study is also shown to analysis effect of UPFC using comprehensive NR method based power flow.

Index Terms- Microgrids (MGs), unified power flow controller (UPFC), Partical swarm optimization (PSO), proportional-integral-derivative (PID) Controller, Solar, Wind Turbine, Battery, Fuel Cell.

I. INTRODUCTION

Power flow calculations are performed in power systems for planning, operational planning, and operation/control. Power flow equations, commonly referred to as power flow are the backbone of power system analysis and design. The power flow problem consists of the calculation of power flows and voltages of a network for a specified terminal or bus conditions. Appropriate steady state model of power system is needed for writing the computer programs. The model includes non-linear algebraic equations, which must be solved iteratively. Power flow calculations are needed for both steady state analysis and initializations of different dynamic analysis.

1. Flexible AC Transmission systems (FACTS):

Is a concept based on power-electronic controllers, which enhance the value of transmission networks by increasing the use of their capacity? These controllers are used for enhancing dynamic performance of power systems in terms of voltage/angle stability while improving the power transfer capability and voltage profile in steady state.

The Unified Power Flow Controller (UPFC) is, arguably, the most comprehensive device to have emanated so far from the FACTS initiative. UPFC is capable of providing active and reactive power control, as well as adaptive voltage magnitude control. Power system Security and Transient Stability [1] presented a new UPFC operation algorithm to find the operating point of UPFCs for the system security level Enhancement. The proposed algorithm iteratively minimizes the security index which indicates the overload level of transmission lines. The sensitivity representing the change of the index for a given set of changes in the UPFC real power outputs is derived. In each iteration, with this sensitivity, the proposed algorithm finds a new UPFC operating point that reduces the index or increases the security margin. The algorithm is verified by IEEE 39 bus system with multiple UPFCs.

The proposed algorithm is tested with 3 UPFCs on the normal operating system and on the same system with a line fault. The study results show two things. The first is UPFCs operated by the algorithm can provide the normal operating system with the relief of the power flow congestion in the system and enhance the system security level. And the second is by applying the algorithm the UPFCs with a proper capacity can enlarge the security margin to prevent the overload problem of the system in an increased load or faulted condition [9] presented a comparison between three heuristic methods (Simulated Annealing, Tabu Search method, Genetic Algorithms) applied to the optimal location of UPFC in order to enhance the system security.

The optimizations are made on three parameters: the location of the UPFC, their types and their sizes. The three methods lead to similar results, but generally Tabu Search method and Genetic Algorithm converge faster than Simulated Annealing. IEEE 118 bus test system is applied for the comparative study. [20] Discussed the application of neuro – fuzzy controlled UPFC to improve transient stability of power system.

Neuro-fuzzy control method the membership function parameters of fuzzy controller can be computed with learning information about a data set. This Adaptive Network Fuzzy Inference System (ANFIS) can track the given input-output data the best. The process of training data generation is based on maximizing the energy function of UPFC. Proposed method is tested on a single machine infinitive bus system to confirm its performance through simulation.

The purpose of maximizing the transient stability margin has been achieved by maximizing the injected energy of UPFC by using its energy function. Consequently, the ANFIS controller operation is based on energy function optimization. By keeping the series (shunt) branch inactive, UPFC can operate as a STATCOM (SSSC) and the corresponding behavior is also evaluated and compared. The superiority of the proposed controlled UPFC over a STATCOM or a SSSC in improving transient stability of a single machine infinitive bus has been demonstrated. The functionality of FACTS devices varies, but the UPFC provides the most versatility.

To add variety, it can be used in conjunction with a phase angle regulator to perform some of the static synchronous compensator's functions. This contains the thyristor switched capacitor as well as the thyristor switched compensator (STATCOM). The UPFC's primary duties include injecting voltage and controlling active and reactive power flow.

The magnitude and phase angle of the voltage can be varied independently. The power system's transient and small signal stability can be improved by applying actual and reactive power flow regulation to load transmission lines closer to their thermal limits.

UPFC is divided into two sections, with UPFCFC being the third. An injector transformer and a voltage source converter are used to make the series branch. To connect to the AC power grid, the UPFC employs a shunt inverter connected in series to the UPFC's output inverter. Voltage and phase angle fluctuations can be injected into the UPFC series branch, and real power can be exchanged with the transmission. A power source is required at its DC terminals for UPFC power supply or absorption in a constant state (apart from the power consumed to compensate for losses).

2. Solar Photovoltaic:

Figure 1 depicts a solar power generation system to go along with this. A solar cell or panel is made up of a series or parallel arrangement of solar cells that are connected in series or parallel to supply the required currents and energy.

A solar cell or a solar panel Solar photovoltaic (PV) systems with integrated inverters are simple to grasp. To begin, solar panels collect sunlight and turn it into useful electrical energy. The DC signals are converted into AC electricity that may be used on the grid after being fed into an inverter (which is what you use in your home).
Various switch boxes are provided for added security, and everything is linked and conducted together.

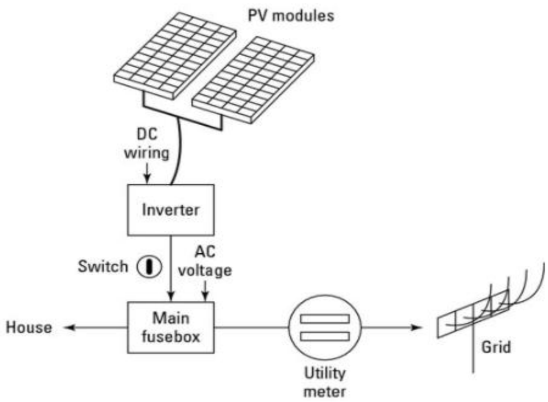

Fig 1. Basic Solar (Photovoltaic) System. [6]

Storage batteries can provide protective power during periods of free sunlight by storing more or part of the power from solar panels. Solar power generation systems are used for private power consumption, weather stations, and radio or television stations, entertainment venues, such as cinemas, hotels, restaurants, villages, and islands. The traditional p-n junction solar cell is the most advanced solar energy collection technology. The fundamental physics of energy input and carrier output functions the physical properties and the associated electrical properties (i.e., the band distance).

The electron needs to have energy greater than the band gap to excite electrons from the valence band to the conduction band. An ideal solar cell has a straight band gap of 1.4 eV to absorb as many photons from the sun's radiation as feasible. The lattice, with its seemingly endless structure, generates bands of permissible energy levels; silicon leaves a band gap (1.1 eV wide) in which no electrons may survive. In contrast, the radius of the sun is close to the temperature of the dark section of the spectrum (approximately 6000 K).

This suggests that the bulk of the sun's rays that reach Earth are powered by something other than the silicon group of the sun. Solar cells will use a lot of energy to neutralize these phonons. While this is true, the gap between the phonons and the silicon band will generate heat rather than usable energy (through an overflow called phonons). The highest efficiency for a single meeting cell will be roughly 20%.

Current research methodologies for doing multi-node photovoltaic design to overcome efficiency constraints do not appear to be a cost-effective solution to this problem. An integrated PV device, on the other hand, can be used only during the day and requires direct sunlight (a link to the inside) to function properly.

3. Island Mode:
In the event of a mains failure, disconnect the MG from the mains on the PCC by operating a switch that separates the MG from the mains. After disconnection from the mains, the MG will work solely according to a predefined control strategy and supply power to the load by gradually increasing the power provided by all micro-sources. In this way, the load can be turned on, even during a power failure.

If the load requirement exceeds the micro-source capacity in island mode, some non-emergency loads can be disconnected. Maintain mains voltage and frequency by operating at least one converter under V / f control. After troubleshooting, only when the voltage error is less than 3%, the frequency error -is less than 0.1 Hz, or the phase angle error is less than 100 can MG be reconnected to the mains [8-15].

4. Benefits of UPFC:
In past, researchers have used various techniques in power flow studies to incorporate UPFC to minimize losses, generation costs and maximize loadability, social welfare etc. To seek optimal allocation and parameter settings of UPFC in power system various evolutionary techniques have been applied recently.

Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) techniques have been used to find out optimal location and parameter setting of UPFC device to minimize active power losses in a power system. Various such benefits have been surveyed herewith.

II. LITERATURE SURVEY

The principles of FACTS controller functioning will be discussed in this chapter. This overview would include a cursory glance at the power flow analysis. Finally, we'd provide critiques of comparable works.
Jinjiao Lin; (2018) et.al FACTS devices, such as the Unified Power Flow Controller (UPFC), are capable of controlling system voltage and power flow in a timely, precise, and continuous manner, providing a viable means to circumvent present city-scale power grid expansion constraints. This paper examines the approach for UPFC system control because it is a direct link and a critical difficulty for the application.

In this research endeavor, a multi-mode coordination system control technique is also developed for optimizing power flow distribution under diverse power grid operating conditions. Furthermore, the strategy's actual control effect on the power grid is demonstrated by the completion of the Western Nanjing Power Grid's UPFC project. This provides hands-on experience for popularizing and deploying UPFC.

A. Hamache (2019) et.al This article synthesizes a UPFC (unified power flow controller) device controller using the Decentralized Discrete Time Quasi Sliding Mode Control (DDTQSMC) technique to track actual and reactive power references over an EHV link. The DDTQSMC control intends to improve on existing linear continuous controls in terms of durability and transient precision.

This application makes use of discrete state dynamics and a discrete sliding mode approach developed at UPFC. Before building the DDTQSMC controller, which employs plant dynamics and discrete time sliding mode theory, a discrete state space model of the UPFC's dynamic behavior is required. Numerical simulation reveals that the suggested controller is accurate, effective, and long-lasting when utilized to direct an EHV interconnection using the DDTQSMC approach.

G. Shahgholian (2017) et.al The unified power flow controller, often known as the FACTS, is a popular alternative for increasing transmission capacity and improving power system stability. This article examines the impact of UPFCs on power flow regulation in electrical power networks. The UPFC model is what we employ. This study's simulations were all performed in MATLAB/SIMULINK.

Lin Jinjiao (2018) et.al The ability of the UPFC project to manage and perform is dependent on how it is used. The UPFC project control system of the Southern Suzhou 500kV power grid is being examined and analyzed. To begin, we'll go over the UPFC project's position on several problems. The basic control performance index and function requirements are then discussed. Following that, a UPFC fundamental control system is proposed in accordance with the application criteria of the Southern Suzhou UPFC grid.

When a power grid has a substantial defect, the commissioning procedure examines the project control system's steady-state and dynamic control performance for each main electrical quantity, as well as the system's ability to ride through failures. It investigates the impact of the control system on the UPFC of the southern Suzhou 500kV power grid, gathering critical references and data for the development of follow-up engineering and standardization.

P. Rajivgandhi (2019) et.al Transmission networks are critical in regulating the amount of reactive power in a utility grid that supplies energy to a system. With the advancement of wind storage technology, wind-connected turbines will be required to generate reactive power during periods of high demand as well as under temporary conditions. Production of reactive power.

This study investigates the effect of UPFC modulation on wind power system strength. To ensure the UPFC's efficacy in regulating the wind resource utility grid system, component tuning of the UPFC compensators is critical in the regularization process. For the first time, the DFIG system is detailed in detail in this publication. Following that, UPFC-connected systems, as well as wind farms and electrical grids, are explored.

As a result, the compensation technique for the UPFC network's Levy fly Gray wolf optimizer is clarified. Finally, methods for regulating reactive and true power are discussed. Simulations are used to explain the results of implementing each control strategy. The performance of the proposed compensator is associated with the results of MATLAB/Simulink simulations.

Xiangping Kong (2018) et.al The transmission line power flow control technique is one of the various control strategies available in the control system that the UPFC must use to regulate power flow. One of the most important aspects of this research is the modular multilevel converter-based UPFC project in the power system of western Nanjing. Furthermore, the method of managing the power flow of the transmission line is thoroughly analyzed. The control approach described above can be used to alter active and reactive power on a transmission line quickly, separately, and safely. Finally, field test findings reveal that the previously proposed control mechanism is effective.

Wu-wei (2017) et.al According to the study's findings, UPFC in Suzhou's southern grid can be managed using a multi-target adaptive system control technique. If there is an N-1 failure or if conditions change during operation, the adaptive module should only be used if a transmission line is running at or near its target power level under typical circumstances. As demonstrated by the simulations, the proposed UPFC multi-target adaptive system control can provide the necessary control effect in both normal operating conditions and failure scenarios.

Smitkumar D (2018) et.al To handle today's increased load, more generation capacity is required. External and internal unbalance causes voltage instability, causing the bus voltage to change. FACTS devices, such as the UPFC, maintain transmission line voltage while increasing the amount of power flowing through it. This paper investigates and contrasts UPFCs with other FACTS devices for active and reactive power control. Other FACTS devices, such as STATCOM, which only controls voltage, and TCSC, which controls impedance, cannot compete with UPFC's capacity to handle phase angle, voltage magnitude, impedance, and a number of line parameters concurrently or selectively. It also describes the UPFC transmission line structure in great detail.

Jinjiao Lin;Peng Li (2017) et.al The UPFC structure and approach to rapid fault isolation are presented first, followed by a coordination technique between the UPFC control protection system and the power grid protection system to improve fault ride-through capabilities.

Following an in-depth analysis to identify which operating modes for the UPFC are most suited, the AC protection system is coordinated to carry it out. The strategy determines which operating modes are most appropriate, after which the AC protection system coordinates their implementation and the power grid state and switch position are thoroughly analyzed. The method goes into great depth about discrimination theory and application technique.

The technique was validated throughout the system commissioning and operation of the Western Nanjing 220kV UPFC project, as well as the control protection system's closing-loop test in the Southern Suzhou 500kV UPFC. A positive outcome indicates that this technology has the potential to further improve UPFC's fault-tolerance capabilities.

Hong Ji (2018) et.al UPFC (unified power flow controller) can be used to manage the voltage on the bus, the flow of power along the line, and the system's dynamic stability. The auxiliary damping controller may have an effect on the dynamic stability of the system. This paper incorporates UPFC into the linearized system model before performing DTA (damping torque analysis) to determine how responsive it is.

So, using the DTA-time-delay frequency domain model, a DTA model for adjusting UPFC supplemental controller settings can be created, which can then be used in conjunction with the phase compensation method. Finally, the proposed model's validity and viability are proven using two real-world scenarios. Simulation results suggest that reducing oscillations improves system stability.

Xiaomei Yang (2017) et.al Since December 14, 2015, the Nanjing unified power flow controller (UPFC) project has been operating in the Nanjing Western Power Grid. It is the world's first MMC-based UPFC (MMC-UPFC). This project, which is connected to a 220 kV ac grid, utilizes three 60 MVA converters. This document outlines the installation of the project, including the most efficient structure and organization.

Additionally, the approach for controlling the UPFC at the system level is described. Under normal operating conditions, the proposed system-level control technique will maintain the preset operating point of a crucial transmission segment of the Nanjing Western Power Grid. While in the event of a fault, the transmission section's power flows can be managed within the line loading constraints. Additionally, the results of the commissioning tests for the Nanjing UPFC project are reported, as is the approach for system-level control that is envisaged. The collected waveforms reveal that the project performs brilliantly under normal and fault conditions. The Nanjing UPFC project bolsters the Western Power Grid's security.

Samiksha Thakare (2019) et.al FACTS and other alternating current transmission systems are used to transport power from one area to another. FACTS technology is a method of making power systems more manageable and efficient in power transfer. A large number of FACTS devices are in use for a variety of applications.

UPFC is used in this investigation. UPFC is formed through the merger of STATCOM and SSSC. The UPFC regulates the voltage and current flow. This article discusses the many operating modes of a series and shunt converter. The Unified Power Flow Controller (UPFC) is an IGBT-based voltage source converter with step change (UPFC).

Salah Kamel (2019) et.al Unified power flow controllers are used in power systems to better manage and stabilize voltages. The Adaptive Neuro-Fuzzy Inference System can solve nonlinear functions and estimate the optimal solution (ANFIS). This study investigates ANFIS's capacity to detect the right UPFC control gain values during three-phase faults in order to improve the performance of a blended wind farm (BWF). BWF creates electricity by combining SCIG and variable-speed doubly-fed induction generators (DFIG). We employed UPFC controlled by artificial neural networks to compare the performance of BWF with ANFIS UPFC to BWF without UPFC. In terms of performance, RMS error compares one case to others of the same type. The ANFIS UPFC, according to researchers, has the potential to significantly improve BWF efficiency. The system was built using MATLAB-Simulink.

III. METHODOLOGY

FACTS can improve the controllability and stability of an alternating current system while increasing its power transfer capacity (Flexible Alternating Current Transmission System). FACTS devices produce their own plans and designs by combining basic power framework components (such as transformers, reactors, switches, and capacitors) with power electronics parts. Because thyristor ratings have increased in recent years, power electronics are now capable of handling loads of tens, hundreds, or even thousands of megawatts. Because FACTS devices are fast, they can help the transmission framework in a variety of ways, such is enhanced transmission ability, improved transient stability, regulation of power flow, reduction of power oscillations, and voltage constancy, for example.

FACTS components can enhance transmission capacity by 40–50 percent depending on the device type and rating, voltage level, and network circumstances in a particular location. Similarly to mechanically determined devices, FACTS controllers are less prone to wear and require less maintenance than mechanically determined devices.

Costs, complexity, and reliability concerns are now the major barriers to the integration of these promising developments from the perspective of the TSOs. Promote FACTS penetration will be contingent on innovators' ability to overcome these barriers as a result of increased institutionalization, interoperability, and economies of scale.

To increase the performance of the standard PSO formulation, The PSOs in real number space are explained in full, including their gbest and lbest topologies, associated mathematical equations, and an details of the PSO out comes. When some (or all) of the decision variables are integers, an better particle swarm optimizer is projected, along with a detailed description of its theory.

1. Control of UPFC:

The UPFC is the most extensively utilized and multipurpose member of FACTs devices, with the ability to govern power flow via power electronics. The UPFC includes a series controller (SSSC) and a shunt controller (STATCOM), which are coupled via a common DC bus (illustrated in Figure 1) [12].

The Voltage Sourced Converter (VSC) is used in both shunt and series converters, and it is connected to the secondary of the coupled transformer via the coupling transformer.When using VSC, a direct current voltage source is employed to drive the commutated power electronic elements (such as GTOs, IGBTs, and IGCTs) to generate voltage.
When the shared capacitor is connected to the VSC's direct current side, it acts as a direct current source (DC).

2. Shunt Converter Controls:

The shunt converter controls the voltage on transmitting end bus. The series converter provides reactive power at the dc terminals while also committing to active power generation and absorption.

In the event of a real power overflow or deficit, boosting or decreasing the dc voltage will be employed to balance it out between the shunt and series converters. By altering the angle and amplitude of the shunt converter-produced voltage, this converter controls both reactive and active power flow [13,14].

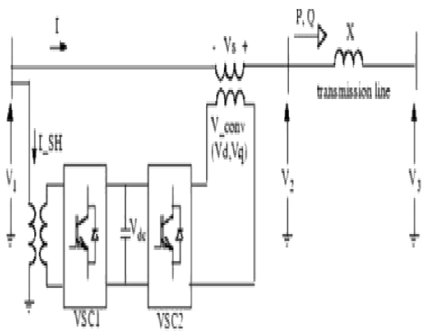

Fig 2. The basic scheme of UPFC.

IV. CONCLUSION

This paper gives the review of UPFC device, its benefits and various optimization techniques used for optimal allocation of UPFC converter for damping oscillations, power loss minimization, enhancement of system load ability, power transfer capability etc.

The three steady state models namely UPFC Decoupled model, UPFC injection model and UPFC comprehensive NR model are compared. A case study is also presented to show the effectiveness of UPFC device to regulate voltage magnitude and also controls the power flow between the two busses. It is expected that this review will be helpful to researchers working in the area of power flow and optimal allocation of UPFC.

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