Optimal Placement of Fact Device Using Optimization Techniques: Literature Review

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Abstract: **The FACTS technology is not a single high-power Controller, but rather an assortment of Controllers. As power system interconnections are continuously increasing, new technologies and controls for system instability are used. Voltage stability, frequency stability and inter-area oscillations have become greater concern than in the past. Different type of fact devices are used to control the voltage profile of power system by placing them on appropriate location by help of optimization techniques. In this paper, review of different type of fact device and optimization techniques are studied for improve the voltage profile of power system.**

IndexTerms **– Statcom, Fact, Optimization Techniques,SVC,Power System,Genetic Algorithm.**

I. INTRODUCTION

FACTS devices are an effective technique for enhancing system voltage stability and increase load capacity margin, but it is cost effective controllers so the placing of such device in ideal location to improve both static and dynamic voltage stability. So studies of finding perfect location of STATCOM are important to prevent additional costs. The work on 'Genetic Algorithm' assisted optimal placement of FACTS controller in voltage stability has been carried out to find optimal location of STATCOM and to reduces the losses and improving voltage profile of the system

II. LITERATURE SURVEY

Many researchers are work for improving the voltage stability of power system by using fact devices on optimal location with ai to utilized maximum capacity of power system. Some authors view are discussed under this section.

Pranesh Rao et al (2000), Describe the Static Compensator (STATCOM) is a device that gives reactive support to a bus. It made up of voltage sourced converters which are connected to an energy storage device on one side and on the other side it connected to the power system network. The conventional method of PI control is compared and contrasted with various feedback control strategies are discussed in this paper. It is shown that a linear optimal control based on LQR control is superior in provisos of response profile and control attempt required. **Ying Xiao et al.[2002]** focused on developing an approach to steady-state power flow control of power system having FACTS devices. They developed a power-injection model of FACTS devices and an optional power flow model, which is capable of implementing power flow control incorporating any FACTS device flexibly. Different from existing FACTS device control, the active and/or reactive power injections are taken as independent control variables. They discussed 1500-bus practical system with various FACTS devices, covering shunt controllers, series controllers and unified controller. **Nadarajah Mithulananthan et al.[2003]**, in this paper different control techniques for damping undesirable inter area oscillation in power system by means of power system stabilizers (PSS), static var compensators (SVC), and static synchronous compensators (STATCOM) are compared. The difficulty is evaluated from the point of view of Hoaf bifurcations, an extended Eigen analysis to learn various controllers, their locations, and the use of a variety of control signals for effective damping of these oscillations. **M. H. Haque [2004]** in this paper they proposed control strategy improves the stability limit first by maximizing the decelerating area and then fully utilizing it in counterbalancing the accelerating area. This requires continuing the operation of shunt FACTS devices at full capacitive rating until the machine speed reaches a reasonable negative value during the first return journey. In both the systems, it is found that the proposed control can provide significantly higher stability limit than that of the BBC. **Sidhartha Panda et al [2006]** they proposed the off-centre location of shunt FACTS devices to improve power system transient stability in this paper. In a long transmission line, legality of the midpoint position of shunt FACTS devices is verified, with static synchronous compensator (STATCOM) and static VAR compensator by the real line model. It supervised, when FACTS devices located imprecisely off-centre towards sending-end, provide improved performance in enhancing transient stability and the position depends on the amount of local laod. **B. Sookananta et al [2006],** this paper will present the background of FACTS, ATC and the optimisation method to be considered as part of the research work into FACTS placement on the network. A combination of lack of investment and environmental issues results in lack of building of new transmission infrastructure. **M.P. Donsion et al [2007],** they discuss that the FACTS controllers recommend a vast chance to regulate the transmission of alternating current (AC), rising or retreating the power flow in specific lines and responding just about instantaneously to the stability troublesA FACT allows the flexible as well as dynamic control of power systems. This paper is focused on advantages of using FACTS devices for enhancing the performance of power system. **A. Parastar et al [2007],** In this paper modified particle swarm optimization (MPSO) is applied to optimize the variety of process parameters. The different parameters are taking into deliberation such as device's location, their type, and device's rated value. The simulations were performed on a IEEE 30-bus in power system with SVC and TCSC, modeled for steady state studies. The optimization consequences point toward that preface of FACTS in a correct position increases the system's load ability and algorithm can be efficiently apply for this kind of optimization. FACTS controllers' device SVC is introduced by **M.M. El Metwally et al [2008]** in this paper. genetic algorithms (GAs) is used to Provide optimal locations for placing the fact device at transmission line, FACTS devices is used to attain the best possible power flow (OPF) devoid of any restraint violation and raise the utilization of

the lowest cost generation in power system **H.R. Baghaee et.al, [2008]** work to find optimal location by using presents a Genetic Algorithm (GA) to placing the fact device at power system. A modern power system is flush to prevalent failures. As the raise in demand of power in any system, operation of system and planning of large interconnected network in power system are flattering more complex and difficult, consequently power system is not as much of secure for power transmission. To sustain safety of such systems, it is enviable to plan appropriate actions to get better power system security and boost the margin of voltage stability. FACTS devices are adjust the reactive power and active power control over and above adaptive to voltage-magnitude control at the same time because of their flexibility and rapid control characteristics. **E. Nasr Azadani et al [2008],** discussed the placement of STATCOM device in power system using particle swarm optimization (PSO) and continuation power flow (CPF) to enhance the voltage profile, minimize losses, and for exploiting system loadability with respect to the size of STATCOM. **Mahdi Karami et al [2009]** they showsthe importance of FACTS elements allocation to describe the effect of FACTS devices and placement of these devices in the electric power system. **Heinz. K. Tyll et al [2009],** The paper discusses devices for FACTS (Flexible AC transmission systems) like SVCs, TCSCs and VSC-based systems providing fast reactive power compensation and fast controlled active power transfer as key technologies for enforcing power systems and making them able to meet the requirements of today and tomorrow. Increased transmission voltages have been one important measure making systems capable of meeting growing demands. While in the early days power systems had high reserve capacities economical and environmental constraints gradually increased loading of existing systems closer to their power transfer limits. **V. A. Preethi et al[2011],** This paper presents an effective method which is used to find the best optimal location of FACTS controllers by using metaheuristic algorithm called Genetic Algorithm. Placing FACTS devices like SVC, TCSC, etc., in a suitable location will help to maintain bus voltages at a desired level and also to improve the Voltage Stability margins. In this paper, the load flow analysis is performed by using conventional Newton Raphson technique. Different loading conditions are considered and MATLAB coding is developed for simulation. **G Naveen Kumar et al [2011]**, in this paper, authors deals with the implementation of Imperialist Competitive Algorithm (ICA) in determining the optimal location and optimal control parameters of TCSC and STATCOM devices for enhancing the power system performance. Improving the systems reactive power handling capacity via FACTS devices during large disturbance voltage instability is the idea behind this paper. **K. Radha Rani et.al, [2011],** also proposed a method using Genetic Algorithm to find out the best location of placing FACTS devices to maximizing the existing transfer ability of power transactions in the deregulated power system. Thyristor Controlled Series Compensator (TCSC) and Unified Power Flow Controller (UPFC) are studied for enhancing the accessible transfer ability of the interconnected power system network. **M. Karthikeyan et al [2011]**, they discussed shunt connected compensation (STATCOM) in this paper. FACTS device is used to control the voltage and also power flow in transmission line. The STATCOM are used in various place in transmission line like as sending end, middle point and receiving end of line. MATLAB Simulink environment is used as simulation tool. **E. Kazemi Abharianet al [2011]**, also describe static synchronous compensator (STATCOM) a controller based on neural networks (NNs) have been designed; i.e. multilayer perception (MLP). **Surekha Manoja et al [2011],** this paper discusses various FACTS controllers which can be employed in power systems and their implications in developing countries. And **S.Sakthivel et.al [2011],** proposed a method to find the best location for placing fact device and the method is Particle Swarm Optimization (PSO) which is used to place svc to best possible place to improve voltage stability of power system under the grave line outage contingency in a power system network.**M. Kowsalya et al.[2011],** talks about shunt connected compensation (STATCOM) based FACTS device in this paper. Reactive Power Compensation plays a significant role in the transmission of Power. They discussed the reactive power is injected into the transmission system with and without STATCOM under different loading condition. For Simulation MATLAB software is used and results shows that STATCOM device place on optimal position in system gives better performance as compare to system without STATCOM devices. **Therese Uzochukwuamaka Okeke [2013**]; in this paper, author discuss basically the importance of FACTS in our networks, its components, the earliest technology used - Static VAR Compensator (SVC), and the most recent technology used - Unified Power Flow Controller (UPFC) and **Zhang Fei et al [2013]** propose a design to suitable structure controllers of TCSC and SVC. They also examines the characteristics of many type of voltage stability troubles and control laws of not only medium but long-term voltage stability issues also and transient voltage stability. **Haniyeh Marefatjou et al [2013] is** discussed the significant power system phenomenon for voltage stability. They use continuation power flow method and steady-state modeling of Thyristor Controlled Series Capacitor and Static Synchronous Compensator (STATCOM). In this paper they carried a Case studies on 9 bus network. Simulation is done with PSAT in MATLAB. **Esmaeil Ghahremani et al [2013],** presents a graphical user interface (GUI) based on a genetic algorithm (GA) which is shown able to find the optimal locations and sizing parameters of multi-type FACTS devices in large power systems. Study shows that FACTS placement toolbox is effective and flexible enough for analyzing a large number of scenarios with mixed types of FACTS to be optimally sited at multiple locations simultaneously. **Anwar S. Siddiqui et al [2014],** explores the effect of SVC and STATCOM on static voltage stability. IEEE- 14 bus system has been used to demonstrate the ability of SVC and STATCOM in improving the voltage stability margin. **Abdollah Shokri, et al [2014],** Author studied configuration of STATCOM, their working, fundamentals of controlling by the STATCOM and important function of each fact device in power devices. Flexible Ac Transmission Systems controller device accomplish rapid control response time also giving superior control power than conventional control method. **Ghaeth Fandi et al [2014],** this paper deals with the implementation of shunt and series FACTS devices into electrical transmission systems and their influence on active power losses. And explained basic principles and the results are presented on the IEEE/CIGRE transmission system model. **Qiang Tong [2015],** summarized power flow calculation of power system with FACTS devices also makes discussions on further study in choice of state variables, selection of initial value and exceeding constraint of control variables, and analyses the direction of research on power flow calculation with

FACTS. **Mitali Chakravorty et al [2015],** describe that Power flow analysis is one of the necessary tools used worldwide to study the voltage profile of a transmission network. This paper aims to study the various power flow methods used to obtain the line flows and enhancement of voltage profile using FACTS devices. And **Prashant Kumar [2015]** describes an application of fact devises such as STATCOM and SVC for efficiently regulating system voltage in this paper and effect of such devices on the voltage stability of any power system network. The STATCOM device is used to normalize voltage in power system network. MATLAB/Simulink is used as tool for modeling and simulation of fact device such as STATCOM and SVC for dynamic voltage control. **Youjie Ma et al (2015)** introduces the background, application status, challenges and development trend of STATCOM, pointing out that with the development of new technology and new power electronic devices and STATCOM in distribution network and Comparing with the traditional synchronous condenser. Static var compensator SVC, STATCOM which has a small size, a faster speed, a wide operation range has a great advantage in performance and can effectively compensate the reactive power, suppress harmonic current and provide voltage support for transmission system. **Mitali Chakravorty et al [2016]** aims to study the improvement of voltage profile of power systems using FACTS devices.Eigen values are used to determine the system voltage stability and participation factors are used to determine the weakest bus which has the maximum contribution to voltage collapse of the system. FACTS controllers (SVC and STATCOM) are then applied to the weakest buses for voltage improvement. **Gagari Deb et al [2016],** described that Voltage stability is one of the important issues of power system. Voltage stability should be maintained for secure operation of power system. Load flow analysis of Newton Raphson method is coded in MATLAB programming for finding different parameters of the system and utilised for the stability analysis. The result from the proposed index is also verified by another standard indicator named `reactive power sensitivity index'. Test results show the effectiveness of the proposed technique. **R. Kalaivani et al [2016],** discussed, the optimal location of like Static VAR Compensator, Thyristor Controlled Series Capacitor and Unified Power Flow Controller devices are searching by Genetic Algorithm optimization technique. **Mithilesh Singh et al [2016]** told abot technological development with modeling of FACTS devices shown to increase line loadability and reduce the transmission congestion by voltage profile improvement. IntThis paper shows the solutions of load flow equations for power systems with UPFC flexible ac transmissions devices for the standard IEEE 14 bus to validate and effectiveness of the proposed method. **S. Selvakumaran ; S.M. Kalidasan [2016],** shows performance of different types of devices have been used to solve the drawbacks by injecting the voltage and to control the power flow and other parameters. **Mohammad Rafee Shaik et al [2016],** proposed a systematic method for searching best possible position of SVC to get better voltage profile in power system under normal conditions and under contingency conditions with Artificial Bee Colony (ABC) Algorithm. **Sankalp Asawa et al [2016],** The purpose of this paper is to analyse the impact of three different Flexible Alternating Current Transmission System (FACTS) devices on a power system and to analyse their capabilities with respect to various disturbances. FACTS devices discussed in this paper are UPFC, TCSC and SVC, The impact on power-flow and Power Oscillation Damping due to these devices is analysed in detail. Simulations based on different choices of Power Oscillation Damping (POD) signal are simulated for small and large disturbance incurred on the system. **Esrom Mahlatsi Malatji et al [i2017]** presents an optimal placement of multi-type FACTS devices within the grid for maximizing the system loadability and there is a budget threshold above which no increase in system loadability is observed. **Shaswat Chirantan et al [2017],** represents the modeling and simulation of various FACTS devices like static var compensator/static synchronous compensator/thyristor controlled series capacitor/ static synchronous series compensator and unified power flow controller. Results of this papers shows that the use of FACTS devices in transmission line /power system network enhancement the power profile of the system. **R.M. Monteiro Pereira et al [2017]** told about FACTS performance in the dynamic voltage stability of an electric power system. Fact device provide a better understanding of the dynamic voltage stability using FACTS devices during a disturbance are pointed out. **Unnati P. Prajapati at al [2017]** discuss optimal location of FACTs device for base case of 5-bus system using sensitivity approach has been found. And **Naseeb Khatoon et al [2017]** , present review on different types of FACTS controller has been discussed and also a new device of FACTS family named as amalgam power flow controller (APFC) is introduced and also gives idea regarding various applications of FACTS controllers **Qi Wang et al (2018),** shows study the reactive power regulation of STATCOM in microgrid, the relationship between reactive power flow and voltage in microgrid is analyzed theoretically. The simulation results show that the voltage at PCC point will be unstable under the two conditions. STATCOM can effectively maintain the voltage balance of PCC point in the microgrid access to the grid and meet the requirements of flexible regulation and stable operation of microgrid. **Samiya Zafar et al (2018),** discussed about the outcome of a thorough research and extensive simulation development project, focused on designing a MATLAB simulation for STATCOM (Static Synchronous Compensator) with attention concentrating on its trigger circuit. STATCOM is a FACTS device that enables real time VAR compensation. **Deepro Sen et al [2018]** author discuss upfc fact device. The UPFC losses such as switching losses of converters, losses due to coupling transformers and power transmission losses in UPFC are taken into account for power flow calculation. **Kadir Abac [2018]**, In this paper, a new and easy to implement heuristic method related to the Artificial Bee Colony(ABC) algorithm is discussed by them and also comparing the results obtained by using ABC algorithm and Differential Evolution (DE) method, it can be stated that proposed algorithm can converge to better results by using minimum device number. **Waseem Aslam et al [2018],** author works with the primarily aim to increase the load capability of the system to maintain system stability after a fault transient. Performance result of considered series FACTS controller shows an unstable steady state without a power system stabilizer. This paper presents modeling and simulation of SSSC and TCSC in MATLAB/Simulink to maintain transient stability. **Zhen Hu [2019},** In this paper, ZX and SD stations will invest in STATCOM with rated capacity of 120 Mvar as an example. STATCOM is a typical reactive power regulating equipment and analysis results shows the influence of STATCOM on the voltage security and stability of provincial power grid in practical application. **Kishan Jivandas Bhayani et al**

[2019], This paper reviews on four different FACTS devices in the power system such as series, shunt, combine series and shunt, combine shunt and series devices, which is selected to place in suitable locations to heighten the voltage level and reduce the losses in the power. **Aditya Chorghade et al (2020),** gives brief information about advanced generation of FACTS devices such as Static Synchronous Series Compensator (SSSC)/, Static Synchronous Compensator (STATCOM)/, Interline Power Flow Controller (IPFC) and Unified Power Flow Controller (UPFC) and the role of the same for reactive power compensation as well as the power flow control. in this research work **Adnan Ali Shaukat et al (2020)** focus on analyzing the changes in the behavior of a transmission system upon the addition of compensating devices. Effect of series and shunt devices has been examined in MATLAB/Simulink software via computer simulation. The aim of given work is to show via simulation how various Flexible Alternating Current Transmission System controllers are exercised for effective power transport and voltage constancy.

III. CONCLUSION

A detailed literature survey has been made in the areas of FACTS devices, General control schemes, intelligent control schemes and Energy storage systems. It is clear from the literature survey, that statcom is having wide applications in the areas of power flow control, transient stability enhancement, voltage stability, power oscillation damping and subsynchronous oscillation damping. Today's era power systems are not capable to rampant failure. With the rapidly raise in power demand, procedure and creation of enormous interconnected power system network are becoming more complex, that's why power system will turn out to be less secure. In this paper Different technologies are used to compensate these disturbances and to provide quality power. One of the technologies is the implementation of Flexible AC Transmission System (FACTS) devices. The use of the existing power system can be improved by the use of improved power electronics technologies such as FACT. Devices, such as a STATCOM, SVC, SSSC, and UPFC, can be connected in series/shunt (or a grouping of the two) to accomplish a lot of control functions, including power flow control, voltage regulation and system damping. Many works in the general and intelligent control schemes have been discussed for power system. Study shows that Genetic algorithm is widely used to find the optimal location to placing statcom to improve the voltage stability.

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