Comprehensive Survey on Recent Trends in Optimization Methods and Different Facts Controllers-Based Power Quality Improvement System

A. V. Sunil Kumar, Prakash, Shivakumara R. S. Aradhya, and G. Swetha

Abstract Power consumption has risen dramatically in the last two decades, yet power generation and transmission have been severely hampered due to limited resources and environmental restrictions. Some transmission lines are essentially charged, and system stability becomes a limiting issue in energy transmission. A range of steady-state control problems has been addressed by flexible AC transmission system (FACTS) controllers. A FACTS is a system made up of static equipment used to transmit electrical energy via AC lines. Since the 1970s, FACTS devices have been utilized to create and improve the dynamic performance of modern power systems. This paper examines different techniques and tactics for coordinating control across FACTS controllers in multi-machine power systems in depth. The authors are certain that academics will find this survey study to identify important references in FACTS controller coordination.

Keywords Flexible alternating current transmission system · Power transfer limiting · Unified power flow controller · Optimization methods

1 Introduction

Electric utility planners have a significant problem in fulfilling rising load demand while maintaining good dependability and investing little in new transmission systems. The cost of laying more parallel lines and procuring the appropriate right of ways and boosting system operating voltages may be prohibitive due to economic and other factors.

The need for electrical energy is continuously increasing. Given the restricted availability of transmission corridors, optimal transmission line usage has become a

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severe necessity for energy systems. With the growing need for bulk power transmission to expanding load centers through constrained right of ways, the necessity to use transmission infrastructure as efficiently as possible is becoming more apparent. The development of modern transmission lines, in particular, is required to keep up with the rising power plant capacity and energy demand.

Finding the adequate right of ways is especially difficult in developed nations, and obtaining the requisite clearance takes time, especially owing to environmental concerns. Due to these restrictions, making better use of existing electricity cables has become a major task. This problem may be seen from two perspectives. First and foremost, long-distance high-voltage transmission lines must enhance their transient and steady-state stability. Long transmission lines have a restricted power transfer capability, both in terms of steady-state and transient stability.

Another consideration is the flexibility that an energy deregulation market needs. Innovative characteristics are required for power systems operating to ensure that energy supply contracts can be honored in a deregulated market.

1.1 Flexible A.C Transmission Systems

Basic transmission issues that have resulted in ineffective transmission and other assets have prompted power system experts to reconsider traditional compensating approaches in favor of power electronics-based technologies. The flexible AC transmission system (FACTS) technology was created to address issues in power networks caused by rising demand and supply of electricity and restrictions on transmission line development owing to required right of ways. The main objectives of FACTS technology are

i. To improve transmission systems' power transfer capacity.
ii. Maintaining power flow over defined pathways.

According to the first aim, power flow in a particular line should be raised to the thermal limit by pushing the required current through the series line impedance. FACTS technology allows transmission lines to be operated at their thermal limitations, resulting in greater electricity. This motivation does not imply that the lines are typically loaded to their thermal limits (the transmission losses would be intolerable). Even yet, if serious system contingencies were to arise, this alternative would be accessible. However, the standard power transfer through transmission lines is projected to rise dramatically by employing FACTS controllers instead of huge steady-state margins to provide the requisite rotational and voltage stability. This article provides a detailed overview of how FACTs controllers may enhance power quality.

2 Literature Survey

Voltage stability, FACTS devices, and intelligent methods have all received much attention in the literature. The first study on voltage stability concepts and techniques and FACTS devices clarifies the fundamentals of FACTS device operations. Following that, modeling, analysis, and control are examined, culminating in the most recent application testing.

2.1 Survey on Optimal Location

Vijayapriya et al. [1] presented optimal placement for a FACTS device to increase system stability, optimize system load capacity, and decrease network losses. Power system analysis toolbox (PSAT) was used to perform small signal stability and time-domain analysis. UPFC was built to reduce losses, increase load capacity, and preserve stability in a line connected to the most critical buses.

Minguez et al. [2] looked at where SVCs should be placed in a transmission network to maximize its loading margin. For determining the actual SVC placement, this issue began as a nonlinear programming problem with binary decisions as variables. Contingencies were examined in a multi-scenario framework. To determine the best number, position, and settings for a range of UPFC devices, Shaheen et al.[3] employed evolutionary optimization methods, such as particle swarm optimization (PSO) and genetic algorithm (GA).

Saravanan et al. [4] presented the PSO technique for determining the optimal location of TCSC, SVC, and UPFC devices. By using this method, system load ability is increased and also cost is decreased. The buses' temperature and voltage limit have been used as constraints for the optimum location.

Samimi et al. [5] presented a particularly sensitive strategy for the transmission system to improve the power load capacities of TCSC and UPFC. The efficacy of the suggested technique was evaluated and shown on the IEEE 5 bus and IEEE 14 bus systems. Santiago-Luna and Cedeno-Maldonado [6] developed a strategy based on the evolutionary algorithm and evolution strategies to place the FACTS controllers in a power system to maximize load capacity. All key optimization factors were the sorts of FACTS devices utilized where they were positioned and set. The results suggest that using a variety of FACTS devices simultaneously is the most effective way to increase system load capacity using the IEEE 30 bus system.

In three-phase imbalanced distribution networks, Sarker et al. [7] have introduced cuckoo optimization algorithm (COA). UPQC's efficiency is tested by minimizing load disturbance in test systems during the fault, reducing the percentage of overall harmonic distortion and the individual harmonics, reducing true power losses, and reducing voltage imbalance and cost savings under ordinary operating circumstances.

Singh et al. [8] provided simulated experiments to conduct by correct positioning of FACTS devices ideally verified by traditional technique, with the results being compared to the evolutionary method. A comparison is conducted between traditional and evolutionary computation techniques to authenticate performance, and the findings demonstrate that the projected approach is more beneficial.

Piatek et al. [9] evaluated existing techniques for the optimal positioning of metering stations in distribution networks. For a comprehensive analysis and comparison testing, three approaches were used. It has been discovered that the approaches can be used, although their effectiveness varies greatly depending on the topology of the test grid. Because the approaches rely on state estimates, their effectiveness is solely dependent on observability analysis.

The swarm moth-flame optimization (SMFO) was utilized to solve a Tan et al. [10] objective function that included integrated power losses, voltage profile, and pollution emission. The performance of SMFO was validated using simulation with IEEE 33 bus configuration.

Karunarathne et al. [11] suggest an area where distributed generators (DGs) may be optimally integrated into an active network distribution (AND) that contains multiple soft opening points (SOPs) which depends on the DG size and the DG integration node's impedance.

2.2 *Survey on Nonlinear Programming*

Nonlinear programming (NLP) is a problem-solving approach that uses nonlinear objectives and constraints to solve issues. Equation and inequality formulations may be used as restrictions, and the inequality can be defined as being both above and below bounded. The solutions applied to the OPF issues were the sequential uncompromising minimization method (SUMT), a big multiplier based on the modular idea enhanced for core nonlinear optimization systems. This class was solved utilizing quadratic programming and network flow programming approach together. Each area's tie-line security and transfer restrictions are taken into account. In addition, a multi-area examination of a purchasing and selling contract is offered. Four linked electricity networks were used to test this approach, and it is both possible and efficient.

Daryani et al. [12] proposed to overcome the optimal power flow issues using adaptive group search optimization (AGSO). Many elements of the OPF problem are studied in this work to create an acceptable multi-target model. The system's overall operation cost, emission, and safety index are the first, second, and third targets. Transmission losses and other equality and inequality restrictions are also addressed to build an exact scenario model such as the actual operating ranges of generator units and power flow equations. Furthermore, this research proposes an adaptable form of traditional group search optimization (GSO) to pinpoint GSO's convergence feature. To verify the efficiency and correctness of the suggested technique for managing nonlinear and non-convex problems, simulation testing on sample benchmarks and 30 bus and 57 bus IEEE standards is utilized. Extensive simulation studies have proved the accuracy of this technique.

Jordehi [13] used thyristor-controlled phase-shifting transformers (TCPSTs) and thyristor-controlled series compensators-based FACTS device to reduce the power losses. The most popular ways to coping with FACTS part problems are metaheuristics. The imperialistic competitive algorithm (ICA) is a well-known optimization approach used to tackle complicated optimization issues in various sectors. The results of using ICA for the FACTS portion issue show that it reduces voltage deviations better than other methods.

Dalman et al. [14] dealt multi-objective nonlinear programming problems using interactive fuzzy goal programming (FGP) with interval type 2 fuzzy numbers (IT2-FNs) method. This IT2-FNs method gives a good result against all power quality issues.

In the presence of renewable energy sources (RES) and fluctuating loads, Chamanbaz et al. [15] examined some approaches to handle the optimal power flow (OPF) issue. The inclusion of renewable energy sources and fluctuating demands is inherent in today's power networks. Their existence creates considerable uncertainty in the grid that must be considered when sending regulated (conventional) generators. Alternatively, network restrictions are virtually definitely breached resulting in line tripping or even cascading failures.

Multi-Population Modified Jaya (MPMJ) nonlinear optimization technique based on optimal power flow solution is considered by Padma et al. [16]. This algorithm, developed from the Jaya algorithm, includes multi-population-based population diversity control for early convergence and optimal values. Use the OPF solution of the UPFC's instrument to calculate the total generator fuel cost, active power reduction, voltage deviation purpose function, and voltage stability indicator increase using the standard IEEE 57 bus test system.

2.3 Survey on Quadratic Programming

The objective function is a quadratic programming (QP) which is quadratic, and the constraints are linearized. To deal with OPF (loss, voltage economic dispatch) issues, several QP methods (about 15%) have been used. In real-world online OPF issues, quasi-Newton and sensitivity-based techniques have been used.

Suresh et al. [17] offered reactive power optimization, which took a wide range of practical restrictions into account. A sequential quadratic programming method was used to formulate and solve the reactive power optimization problem. A simulation test on a 3 bus and 6 bus system was conducted to assess the method's usefulness.

Fortenbacher et al. [18] introduced new approaches to convert nonlinear optimal AC issues into tractable LP/QP-based OPF planning and operational power system problems. Four OPF techniques are shown in this article, each of which loosens the absolute power loss functions as linear constraints.

The technique for hybrid sequential quadratic programming (SQP) has been presented by Angalaeswari et al. [19]. In the form of an active method set, this approach minimizes actual power loss while meeting power equations and voltage levels inside radial distribution systems (RDS) to establish optimal distribution generation (DG) location and ratings. To obtain the optimum answer, SQP employs an active set approach for sequence-level quadratic programming.

Arteaga et al. [20] developed the approach of hurricane optimization to specify the optimum delivery in the master phase of the DG system. The power balancing limitations of non-convexities issues are rectified using a sequential power control approach. This paper's main contribution was an unadulterated algorithmic OPF for DC networks.

Dao et al. [21] suggested a home energy management system (HEMS) to fulfill home energy demands while increasing profits. Intensive quadratic programming optimizations for each HEMS are also used to smooth the sales and procurement profiles while keeping the utility proportion of the decline in the home profit. It helps to flatten the trading power curve, resulting in a drop in fair profit for families. According to a calculation, peak power demand at the transformer at the substation would be reduced by 44%, and each residence would only get 10% of the maximum possible home prof.

2.4 Survey on Linear Programming

Linear programming (LP) is used to solve constraint and objective function problems with non-negative variables. About a quarter of the publications evaluated employed LP-based techniques to address OPF issues. The improved simplex approach is the most widely utilized methodology. The simplex method is well known for its success in addressing LP problems. The objective functions are linearized to allow an LP solution, such as voltage, loss, and economic dispatch.

Harini et al. [22] have linearized the difficult nonlinear security-constrained optimal power flow problem (SCOPF). The goal functions are partially linearized, and linear sensitivity factors are used to build the constraints. The addition of power router control in the post-contingency period formalizes the typical SCOPF. To assess the actual flow in lines, DC flow studies are done. As a result, power router control is utilized in this study to save even more money, and it is compared to the standard SCOPF approach.

Lom et al. [23] introduced the sequential linear programming (SLP) formulation approach to handling reactive power optimization problems. The fundamental goal is to reduce transmission losses as much as possible. A secondary feasibility improvement target is utilized when the initial base case contains overvoltages, yielding a more feasible solution than the loss minimization objective.

The wind-driven optimization (WDO) method was established by Senthilkumar et al. [24] to overcome the OPF issue in power systems. The best optimization approach based on atmospherical motion is the WDO algorithm, a global optimization method inspired by nature. An IEEE 30 bus system WDO has been effectively and successfully implemented by minimizing generation fuel cost as an objective function.

Naderi et al. [25] gave an in-depth look at the most recent applications of heuristic-based optimization methods to tackle various variations of the OPF issue. In addition, a thorough examination of the different methodologies from diverse perspectives is provided. The examination of about 50 publications is the most noteworthy element of this study that adds substantial value to its thoroughness.

Karimulla et al. [26] suggested strategies for solving multi-target power flow functions, including production costs, losses, power plant emissions, and voltage stabilization. The IEEE Standard 30 bus system was evaluated using four different multi-objective functions. The enhanced sine cosine algorithm (ESCA) obtained a good convergence rate compared with GA and PSO strategies.

2.5 *Survey on Optimizing Flexible AC Transmission System Controllers*

Sahu et al. [27] examined the issue of static voltage stability and voltage collapse. The main inspiration of the work is the incidence of a multi-voltage crash in the last few decades throughout the world. A new voltage stability index has been developed to estimate load bus loading of the distance between operational and collapse points. Other tensile stability indices are compared to the suggested index for static tensile instability assessment.

The symbiotic organisms search (SOS) system for FACT devices was presented in Prasad and Muharjee [28]. SOS is the most up-to-date, parameter-independent evolutionary algorithm. This addresses the issue of optimal power flow in fact-based power systems. A thyristor-controlled array capacitor and a thyristor-controlled phase shift are used to evaluate the effectiveness of the emergency algorithm at fixed positions.

Niknam et al. [29] developed the multi-target optimal power flow (OPF) issue improved particulate swarm optimization (IPSO) approach. The multi-target OPF presented covers costs, losses, voltage stability, and emission effects. The optimal compromise choice in the Pareto set provided by this algorithm is utilized with a furious decision-based technique. This research also contains an IPSO that employs messy queues and self-adaptive principles to change the PSO's parameters to enhance solution quality, particularly to avoid the system becoming caught in optimal local circumstances. A new mutation is also used to improve the suggested algorithm's search capabilities.

In addition to total fuel cost and total emissions, the updated teaching–learning optimization techniques employed by Shabanpour-Haghighi et al. [30] have solved the multiple objective optimum flow problems. These techniques enable the algorithm to scan for optimum solutions while maintaining a rapid rate of convergence. Furthermore, a smooth clustering technique and intelligent population selection for the following iteration are given to avoid an overly huge repository. The performance of this technique is evaluated using IEEE 30 bus and 57 bus systems, with results that are comparable to those published. It was demonstrated that the suggested method outperforms alternative options.

Including just tap-change transformers does not considerably enhance voltage stability, according to Patel et al. [31]. Voltage levels and critical voltages but not the maximum voltages associated with these critical voltages are impacted. As such, a tap-changing transformer at the load terminals can perhaps help to maintain tensile stability. If a static VAR compensator with variable control gains is provided, the maximum load power can be increased several times higher than its original quantity. Controller increases and reference voltages interact with the off-nominal tap transformer ratio to maintain constant load node voltage in all load situations.

To design a fast and accurate heuristic optimization technique for the sized shunt condensers in radial distribution systems, Sirjani and Bade [32] utilized the global harmony search algorithm (GHS), incorporating mutual coupling and load imbalance and harmonic effects. The reverse/further power stream and harmonic radial power flow techniques were developed to evaluate power loss.

Dwivedi et al. [33] suggested an optimization-based method to filter design that decreases power consumption during filter execution while minimizing passband and stopband ripples. The trade-off is between passband ripple, stopband ripple, and power consumption avoid using traditional single-objective optimization methods. Consequently, the filter design task has been reframed by employing the modified version of the multi-target artificial bee colony technique.

The optimal reactive power dispatch is defined by Mukherjee and Mukherjee [34] as a method of reducing active power transmission losses and introducing voltage fluctuations by regulating various control variables that fulfill specified balances and disparity criteria. The suggested Chaotic Krill Herd (CKHA) algorithm was designed and tested satisfactorily inside the IEEE 30 bus test control framework. For the power framework patterns under investigation, there are two types of FACTS controllers. In the end, the novel CKHA approach is replicated in various important control models, including IEEE 57 buses and IEEE 118 bus test control frameworks.

Sai Ram and Kota [35] projected a novel approach for updating FACTS devices in power transmission networks to preserve voltage constancy. The suggested algorithm is a feasible method for locating and sizing FACTS controllers in the best possible position. In the suggested improvement, the PSO method maximizes gravitational consistency and improves the GSA’s searching performance.

According to Mahdad and Srairi [36], developing a flexible and dependable power framework arranging approach under basic conditions is critical for experts and industry to reduce the likelihood of power outages. The primary goal of this proposed arranging approach is to maintain an acceptable power framework by preventing power outages caused by a hazy view of defects in generating units or critical transmission links. The fundamental phase of this functional technique is shown in this paper, which employs gray wolf optimizer in conjunction with a pattern search algorithm to address the security smart grid power system management problem in basic settings. The suggested method’s reachability and efficacy are determined using the IEEE 30 bus test framework. The findings are encouraging, demonstrating that the proposed procedure may assure system security in everyday settings.

The voltage profile on a power framework's load buses, according to Subramanian et al. [37], is a crucial element in maintaining the framework's security and keeping a safe distance from voltage collapse. Therefore, the voltage profile (VP) should be monitored and regulated on load transporters. Another method has been added to this article to better distribute FACTS devices in appropriate locations and enhance their parameters. The method was compared to PSO and GA algorithms using IEEE standard 14, 30, and 57 bus frameworks. The results are appropriate, indicating the method's applicability and components.

Gupta and Sharma [38] introduced a non-traditional optimization technique with genetic algorithm-based FACTS devices to control the function of line flow, maintain desired bus voltage, and reduce the power loss. The main goals are to enhance static safety margins and stability in voltage while reducing losses. FACTS controllers are also strategically managed by putting them in areas where line failures occur. For simulation, MATLAB code was created. SVC and TCSC-based two FACTS devices are built in a steady state to test the IEEE 30 bus system under various loading circumstances. The findings demonstrate that the propounding algorithm is effective in determining the best location for power system stability.

Rashtchi and Pirooz [39] utilized the imperialist competitive algorithm (ICA) to figure out where the static compensator (STATCOM) should be in power systems and how big it should be. The technique gives the optimal number and STATCOM size of the bus, a two-dimensional array, to decrease all deviations of bus voltage from their nominal value. IEEE 5, 14 and 30 bus testing systems are used for simulations. In several instances, ICA has been contrasted with the famous PSO algorithm. The findings show that this electric network is one of the most sensitive methods for determining the proper stabilizer position.

Arul and Chellaswamy [40] presented cuckoo search algorithm (CSA) to increase the IPFC in multiline transmission. It significantly decreases the congestion of the transmission line. Subtracting a line use factor (SLUF) and CSA-based optimum tuning will enhance IPFC placement. CSA improves the multifunctional function and finds the best position for reduced congestion in the transmission line. The performance of the CSA was comparable under different loading situations with two other optimization techniques: PSO and differential development algorithm (DEA). The results show that CSA exceeds the two other methods.

Vijay Kumar and Srikanth [41] introduced a hybrid algorithm (the firefly algorithm (FA) and cuckoo search (CS)) to improve the power system stability. These algorithms enhanced searchability, decreased impressibility, and made the procedure easier. The FA technique is used to optimize the highest power loss line as the ideal placement for the UPFC. Using the CS method, the damaged location parameters and dynamic stability restrictions are restored.

Zeinhom [42] considered the UPFC for a genuine 380 kV 400 km double circuit line linking Saudi Arabia's central and western networks. The GA method is used to establish the UPFC's optimum size and assignment in the real system. In addition, UPFC assesses the impact of the existing protection system and offers different options. To frame the problem and identify the best UPFC settings and locations, MATLAB/Simulink is utilized. The simulation's findings are shown and analyzed, and recommendations are made to enhance the interconnection system's voltage and stability margin.

Amirtham and Uma [43] recommend discovering the unified power flow controller in light of the real power execution record (severity list) in the power system network. The two-voltage source (power infusion) model is used to improve the UPFC's performance in regulating active power, reactive power, and voltage profile. The particle swarm optimization (PSO) method was employed in this study to minimize fuel consumption with and without a unified power controller. The IEEE 30 bus system has been used to approve and correlate the logic for the recommended techniques and simulations. The proper placement of the unified power flow controller might enhance the power framework's exhibitions substantially.

Sekhar et al. [44] projected that by constructing the power injection representation of UPFC as indicated by the regular algorithm, they would improve the voltage profile and reduce losses in electrical systems. The study also discusses the best placement and size for a UPFC and the optimization techniques GA-PSO and DA-PSO, which were suggested to determine the device's best setup and dimensions. The stated optimization was the optimum method for selecting the ideal UPFC device configuration, improving the voltage profile, and lowering transmission line power system losses. On IEEE 57 test frameworks, this hybrid GA-PSO and DA-PSO has a lot of experience.

Pilla et al. [45] introduced teaching–learning-based optimization (TLBO) tuned, PID) two-area hydro-thermic generator controller for automatic generation control (AGC). This approach considers physical constraints such as transit delay (TD), generation rate constraint (GRC), and governor dead band (GDB) nonlinearities.

A fractional evolving method using FACTS devices was presented by Muhammade et al. [46] to achieve reactive power planning objectives. In the conventional bus test system of IEEE 30, IEEE 57, and IEEE 118, fractional-order Darwinian particle swarm optimization (FODPSO). Static VAR compensator (SVC) offers shunt compensation, whereas thyristor-driven series compensator (TCSC) provides series compensation.

2.6 Control Stability of FACTS

The control stability of the FACTS model is shown in Fig. 1. The optimization control method is seen as the most efficient way to solve single-transform optimum power flow problems. Static VAR compensator (SVC), thyristor-controlled series compensator (TCSC), and thyristor-controlled phase-shifting transformer (TCPST) are the best shunt-connected devices in FACTS family. Bus voltage can be controlled by injecting reactive power into the system. FACTS need equipment that can take on an essential job for side management and, in this way, control the transmission line congestion.

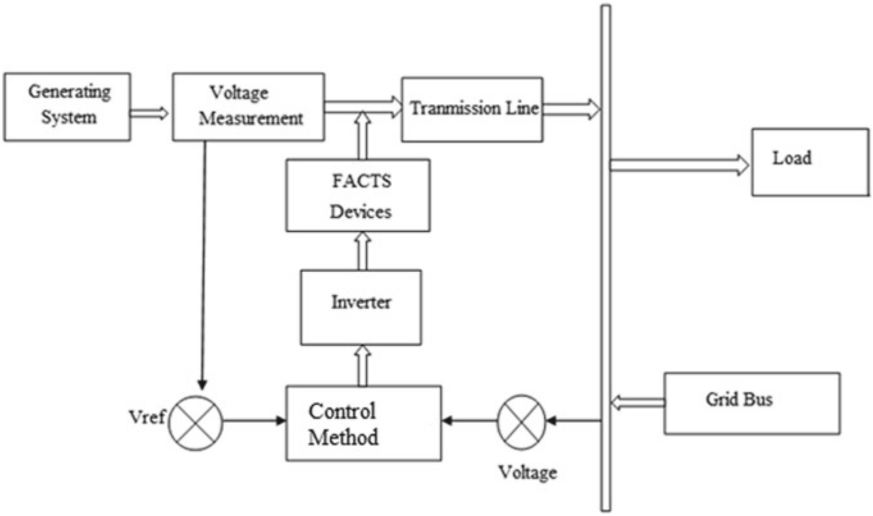

Fig. 1 Control stability analysis of FACTS

2.7 Performance Evaluation

Based on this literature survey, GA, PSO, and selective PSO methods give good results. The performance analysis of this methods is discussed for this section.

Table 1 discusses the line loss analysis of different optimization methods with different FACTS control devices.

Table 2 discusses the settling time analysis of different optimization methods with different FACTS control devices.

Table 1 Line losses analysis

Control technique	Line losses PSO (%)	Line losses SPSO (%)	Line loss GA (%)
SVC	5.3	6.1	6.5
TCSC	4.5	5.7	5.1
TCPST	2.5	3.3	2.9

Table 2 Settling time analysis

Control technique	Settling time PSO (s)	Settling time SPSO (s)	Settling time GA (s)
SVC	11.5	9.56	8.36
TCSC	9.6	8.64	7.62
TCPST	8.2	7.9	6.98

3 Conclusion

In the literature, several approaches have been examined. Considering one objective as a target and the others as a constraint is one approach for reducing a multi-objective issue to a single-objective problem. Another option is to combine all objective functions into a single one. The following techniques have several flaws, such as restricting the number of options accessible and requiring previous selection of weights for each objective function. Apart from the flaws mentioned above, the most serious flaw in these techniques is their inability to identify a single solution to a multi-objective issue.

The real power, voltage magnitude, and angle, which are maintained by altering the above parameters, are the fundamental determinants of the framework's voltage stability. Furthermore, the FACTS controller's location and size may be seen as a multi-objective issue with several destinations and needs. The control variables, y and v, do not affect the minimum objective function, equal to zero. The inequality restriction R is based on the control variables y and v which are less than or equal to zero. Under identical conditions, the actual power generated in bus no is the same as the real power generated by the nth generator and the real power generated by the *n*th load bus.

The injecting reactive power into the n bus is the *n*th generator reactive power and nth load bus reactivation power. The lowest real power flow is below or equal to the *n*th bus's maximum real power flow limitation in terms of inequality. The lowest reactive power flow must be equal or less than the *n*th bus's maximum reactive power flow restrictions. The minimum voltage magnitude must be less than or equal to the nth bus's maximum voltage magnitude restrictions. The following findings are drawn from the examination of existing mechanisms:

i. In FACTS devices, the essential criticalness is optimizing and keeping up the voltage stability in the power transmission frameworks.
ii. Power flow controllers are generally changing from mechanical to electrical cases. In the past, reactors were associated with power lines by mechanical switches, and nowadays, they are changed to power electronic-based switching devices.
iii. Even though shunt and series capacitors and reactors can change the voltage profile and power flow pattern, they are one moment as FACTS components.
iv. The power flow research resolves bus voltages, active power, reactive power, and power loss.
v. The equality and inequality restrictions are used to determine where and how big the FACTS devices should be. These various characteristics determine different outcomes on the target work.
vi. Finding the best position and size for FACTS devices is challenging when using several systems.

To overcome these issues, effective techniques must be developed.

In the future, some of them are considered and overcome by proposing effective techniques. Hence, the objectives can be formulated as follows:

i. To design optimal localization and sizing of FACTS devices with the aid of predictive cross-difference progression optimization (PCDPO)
ii. To develop optimal localization and sizing of FACTS devices with the substantial transformative optimization (STO) method.

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