Comparative Analysis on Optimal Placement of TCSC under Single Line Contingency by Using PSO and GA

Su Myat Noe Oo[1], Swe Swe Myint[1], and Shouji Usuda[2]
[1] Mandalay Technological University /Electrical Power Engineering Department, Mnadalay, Myanmar
[2] Osaka Electro-Communication University, Japan
Email: sumyatnoeoo.59@gmail.com; sweswemyint1980@gmail.com; u-shouji@osakac.ac.jp

***Abstract*—In the network contingencies, the branch overloading and voltage violation are the most serious conditions and may lead to security problems. The application of Thyristor Controlled Series Capacitor (TCSC) can provide the required apparent reactance smoothly and rapidly and can reduce network contingency problems. This paper focuses an application of Particle Swarm Optimization (PSO) and Genetic Algorithm (GA) to find out the optimal locations of TCSC devices under single contingency to reduce the voltage drops at system buses and line flow improvement on transmission lines. The suitability of the proposed technique is examined on Myanmar Electric Power System. The optimized location provided by each method is applied to single line contingency condition and the responses are observed. According to the simulation results, PSO method can provide the better the stability performance under single line contingency.**

***Index Terms*—Contingency analysis, genetic algorithm, optimal placement, particle swarm optimization, thyristor controlled series capacitor**

I. Introduction

Power system security is capability of power system to survive through possible contingencies and to resist the transition conditions while maintaining at new steady state condition. As the power system becomes more complex, there are an increase in number of situations where power flow equations have either no real solution or solution with violating operating limits such as contingency analysis, planning applications and voltage limit. Contingency ranking is one of the components of on-line system security assessment. The purpose of contingency ranking and screening is to rapidly reduce contingencies from a large list of plausible contingencies and rank them according to their severity for further serious analysis. Performance Index (PI) based methods have been published for contingency ranking [1].

Flexible Alternating Current Transmission System (FACTS) devices enhance the control capability of various electrical parameters in transmission networks. These solid state devices, by controlling the power flows in the system, can reduce the flows in heavily loaded transmission lines, reduce system loss, resulting in an increased loadability, improved stability of the power system, and reduced cost of generation [2], [3] and [4]. Thyristor Controlled Series Capacitor (TCSC) operates smooth and flexible control for security enhancement with much faster than the traditional control devices [5].

Genetic Algorithm (GA) is one of the first metaheuristic techniques reported in [6], and [7]. Dynamic stability in power system is enhanced by modified salp swarm optimization algorithm (MSSA) and moth-flame optimization algorithm (MFO) with Unified Power Flow Controller (UPFC) [8]. Fuzzy-Based Improved Comprehensive-Learning Particle Swarm Optimization (FBICLPSO) algorithm is used to enhance power flow integrated with FACTS devices [9]. In [10], Cumulative Gravitational Search algorithm is used for STATCOM placement to reduce power losses in the system. DSTATCOM is selected for loss reduction and voltage profile improvement by Loss Sensitivity Factor [11]. A secured optimal power flow is obtained by Contingency Capacity Index (CCI) and Thermal Capacity Index (TCI) with location of TCSC [12]. Optimal allocation of TCSC and SVC is applied by Whale optimization algorithm (WOA) algorithms [13].

Whale Optimization Algorithm (WOA) can provide the optimal solution for battery energy storage system (BESS) location in the distribution network which reduce the total system Losses [14]. Optimal Unified Power Flow Controller (OUPFC) enhances energy system security under normal and contingency operations of entire transmission systems, from technical and economical view points. [15]. Power system security is enhanced by exploring the novel global harmony search (NGHS) method with optimal location and rating of capacitor bank and SVC [16]. Effectiveness, optimal allocation and utilization of phasor measurement unit (PMUs) for different types FACTS devices designed for the power flow control and increasing transfer capacity [17]. Differential Evolution and Genetic Algorithm are proposed to select the optimal allocation of TCSC which minimize the active power losses in the power network

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Corresponding author: Su Myat Noe Oo (email: sumyatnoeoo.59 @ gmail.com).

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[18]. Min cut algorithm is proposed to selected location of TCSC for optimal power flow under normal and contingencies condition [19]. Multiway decision tree (MDT) is promoted an approach to assess power system operating security assessment for multiple contingencies [20].

The work in this paper describes utilization of the TCSC during single contingencies. In order to allocate the suitability of a given branch for placing a TCSC, Particle Swarm Optimization and Genetic Algorithm are selected for each branch. These techniques are proposed to rank the branches that are mostly affected during all the possible single contingencies. After having the ranked list of branches, an optimization problem is formed to allocate the best locations among the ranked branches to install the TCSCs and to determine the optimal parameters of the installed TCSC based on single line contingencies. The objective of this research is to eliminate or reduce the transmission line overloads and maintain the security margin. This paper deals with the application of Particle Swarm Optimization (PSO) and Genetic Algorithm (GA) for the optimal location of the TCSC with the consideration reduction in the power system. The PSO method is simpler than other methods and is more suitable for developing countries with technical difficulties such as Myanmar.

The aim of this paper is to propose Myanmar national grid in Power System Analysis Toolbox for power system contingency analysis to increase power system security. The paper is organized in seven sections. Section II shows Problem Formulation and TCSC. Optimal Placement Algorithms have been discussed in Section III. Section IV presents Case Study for Optimal Placement of TCSC. Simulation Results and Analysis are presented and discussed in Section V followed by the conclusion in Section VI.

II. Problem Formulation and TCSC

A. Contingency Ranking

Contingency ranking operates to list the transmission lines which are more sensitive to the largest number of contingencies. TCSC is in series with the selected lines can provide the most efficient control of the network flows in the largest number of contingencies. This section describes calculation of the contingency severity index and the definitions of matrices and array.

A binary matrix is used in the participation matrix (U), whose entries are “0” or “1” depending upon whether or not the corresponding line is overloaded, where n is the total number of lines of interest, and m is the total number of considered contingencies. The ratio matrix (W) is an ($m \times n$) matrix of normalized excess branch flows. W_{ij} is the normalized excess power flow (with respect to the base case flow) through branch j during contingency i and is given by:

$$W_{ij} = \frac{P_{ij,\,\mathrm{cont}}}{P_{j,\,\mathrm{base}}} - 1 \tag{1}$$

where $P_{ij,\mathrm{cont}}$ is power flow through branch j during contingency i and $P_{j,\mathrm{base}}$ is base case power flow through branch j.

The probability array (P) is an ($m\times1$) array of branch outage probabilities. The probabilities of branches outage are calculated based on the historical data about the faults occurring along that particular transmission line in a specified duration of time. It may have the following form:

$$P = \begin{bmatrix} p_1 & p_2 & \cdots & p_k & \cdots & p_m \end{bmatrix}^T \tag{2}$$

where p_k is probability of occurrence for contingency i and is taken as 0.02 and m is the number of contingencies.

Thus for a certain branch j, Contingency Severity Index (CSI) can be expressed as the addition of the sensitivities of the selected branch j to all considered single line contingencies as follow:

$$\mathrm{CSI}_j = \sum_{i=1}^{m} p_i u_{ij} w_{ij} \tag{3}$$

Transmission lines are then ranked by Contingency Severity index values. In general, the larger the index value a line has, the more severity than the other lines.

B. Thyristor Control Series Compensator (TCSC)

For the rapid and continuous control of impedance of the transmission line, the commonly used FACTS device is Thyristor Controlled Series Capacitor. TCSC [21] and [22] controls the active power transmitted by varying the effective line reactance by connecting a variable reactance in series with line and is shown in Fig. 1.

One of the main functions of TCSC is the improvement of the active power flow on the transmission line. In the next section, a discussion about the PSO and GA algorithms and how it can be applied to study the Myanmar Electric Power system is discussed.

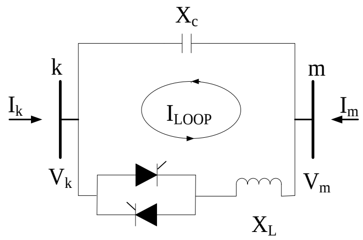

Fig. 1. Circuit diagram of TCSC

In Fig. 1, k and m are the bus numbers where TCSC is connected. V_k and V_m are voltages at bus k and m. I_k and I_m are the currents injected at bus k and m. X_C and X_L are the capacitive reactance and inductive reactance of TCSC.

III. Optimal Placement Algorithms

A. Particle Swarm Optimization (PSO)

PSO is a computational intelligence-based algorithm that is not largely affected by the size and non-linearity of the problem, and can achieve to the optimal solution in many problems where most analytical methods can diverge [23]. PSO is more efficient in maintaining the diversity of the swarm. In the real number space, each individual possible solution can be designed as a particle that moves through the problem hyperspace. The vector $x_i \in R^n$ determines the position of each particle, given as

$$X_i(t) = x_i(t-1) + v_i(t) \tag{4}$$

The best fitness value obtained at the best earlier location of the ith particle is denoted and is expressed as $P_i = [P_{i1}, P_{i2}, \cdots, P_{iD}]$. This value is also called as P_{best}. The data accessible for each individual depends on its self-experience (the decisions that it had made up until this point and the achievement of each decision) and the information on the performances of others in its neighborhood. Since the relative important of these two factors can change from one decision to another, it is reasonable to use random weights to each part, and thus the velocity is decided by

$$\begin{aligned} V_i(t) = v_i(t-1) + \psi_1 \text{rand}_1 \left(p_i - x_i(t-1) \right) + \\ \psi_2 \text{rand}_2 \left(p_g - x_i(t-1) \right) \end{aligned} \tag{5}$$

where ψ_1 and ψ_2 are two positive numbers. The values rand_1, rand_2 are two random numbers. They have the same distribution range between 0.0 and 1.0. The value P_i is P_{best} of the particle 'I' and P_g is best within the group.

The velocity update equation has three major components. The first component is sometimes referred to as "momentum", "inertia", or "habit". These component models the tendency of the equal direction it has been travelling. The second component is a linear attraction towards the best position ever found by the given particle: p_i (whose corresponding fitness value is called the particle's best: p_{best}), scaled by another random weight $\psi_1 \text{rand}_1$. This component is also known as "self-knowledge" or sometime it is referred as "memory remembrance", or "nostalgia".

The third element in (5) represents a linear attraction leading to the best position of a certain particle: p_g. It is scaled by the random weight $\psi_2 \text{rand}_2$. This component is commonly known as "social knowledge," or "cooperation". In some literature this component is expressed as "shared information", or "group knowledge". According to the above formulation, the following strategy can be used for executing the PSO algorithm.

Step 1: Initialize the swarm by assigning a random position in the problem hyperspace to each particle.

Step 2: Estimate the fitness function for each particle.

Step 3: For each individual particle, the fitness value of particle is compared to its p_{best}. If the value at current position is better than the previous p_{best} value, then this value is set as the new p_{best} and the current position, x_i, is noted as p_i.

Step 4: Select the particle with the best fitness value. This fitness value is assigned as p_{best} and its position is memorized as p_g.

Step 5: Find and update the velocities and positions of other remaining particles according to the step (4) and (5).

Step 6: Repeat Step (2) to Step (5) until a stopping criterion is match. It may be maximum number of iterations or ac acceptable fitness value.

B. Genetic Algorithm (GA)

The genetic algorithm works with the initial set organized by random solutions called population. The population of candidate solutions also known as individuals is maintained in a process. In GA, individuals competes each other for their survival. Evaluation is done through the fitness function calculation. After evaluation, the stronger individuals are able to contribute for the production of new individuals called 'offspring'. The weaker individuals may not contribute at all. This phenomenon is known as the selection procedure. Offspring are produced in the recombination processes. They inherit their specific features from the parents. The mutation process can confer some truly innovative features as well. In the next selection step i.e. next generation, the offspring are made to compete with each other, and possibly also with their parents. Through the process of the repeated selection of the best parents, the improvement of the population is obtained. The process again produces good offspring and low-performers are eliminated. After several generations, the algorithm converges to the best individual, which hopefully represents the optimal solution to the problem [24].

1) Penalty parameter less constraint handling scheme

In GA, penalty function approach is used for constraint handling. Penalty functions can be stationary or non-stationary. Stationary penalty functions add a fixed penalty when a violation occurs, as opposed to non-stationary penalty functions which add a penalty proportional to the amount with which the constraint is violated, and are also a function of the iteration number. The difficulty of using penalty parameter is the selection of an appropriate penalty value for the problem. In this study, the constant-handling method is utilized since no penalty parameters are needed. In penalty parameter-less constraint-handling scheme, all feasible solutions have zero constraint violation and all infeasible solutions are evaluated according to their constraint violations alone. Thus, it is not needed to combine the constant violation condition and the objective function value for any solution of the population. Again, no penalty factor is required in this approach. In penalty parameter less scheme, the fitness function is calculated using the following.

$$F(\bar{x}) = \begin{cases} f(\bar{x}) \\ f_{\max} + \sum_{j=1}^{m} g(\bar{x}) \end{cases} \tag{6}$$

where $F(\bar{x})$ is the fitness function, $f(\bar{x})$ is the objective function, $g(\bar{x})$ is the violation of normalized absolute constraint and $f_{\max}$ is the objective function value of worst feasible solution.

In processing of GA, pairwise comparison is used to make sure that

(a) In case of two feasible solutions, the solution with better objective function value must be selected.

(b) In case of one feasible and one infeasible solution, the feasible solution must be selected.

(c) In case of two infeasible solutions, the solution with smaller constraint violation must be selected.

In the above scenarios, the solutions are not compared in terms of constraint violation data or objective functions. Thus, penalty parameters are not needed in this method. The advantages of this scheme when compared with the usual penalty parameter based scheme are:

(a) The process of selecting an appropriate penalty parameter can be eliminated. The selection of incorrect penalty parameter degrades the performance of genetic algorithm.

(b) The values of objective function for individuals are not needed to evaluate. This can reduce the computation time.

2) Algorithm

The implementation of the proposed method to the device allocation problem is performed in the following steps.

Step 1: Set the input parameters such as bus and line data, FACTS device data, etc.

Step 2: Set the solution variable, here the setting and location of TCSC.

Step 3: Create initial population of individuals in normalized form. This must satisfy the constraints of the FACTS device.

Step 4: Evaluate the fitness function for each individual of the population in denormalized form. This must be done after simulating all likely single line contingencies with AC load flow. For handling of the constraints, new penalty parameter-less technique is used.

Step 5: By applying tournament selection, Simulated Binary Crossover (SBX) and Polynomial mutation, new offspring population is created for next generation.

Step 6: If maximum number of function evaluations is reached, then go to next step, else go to Step 4.

Step 7: Print the best locations and corresponding settings.

IV. Case Study for Optimal Placement of TCSC

To observe the single line contingency condition and optimal placement of TCSC, the detail study is carried out on Myanmar Electric Power System. The power-flow program is developed in Power System Analysis Toolbox (PSAT) environment using Newton-Raphson method to obtain the power flow solution [25] and [26]. This program computes the voltage magnitude, angle at each bus and power losses in a power system. In Myanmar Electric Power System, electrical power is generated by four main methods: hydro sources, gas turbine station, coal fired station and steam generating stations.

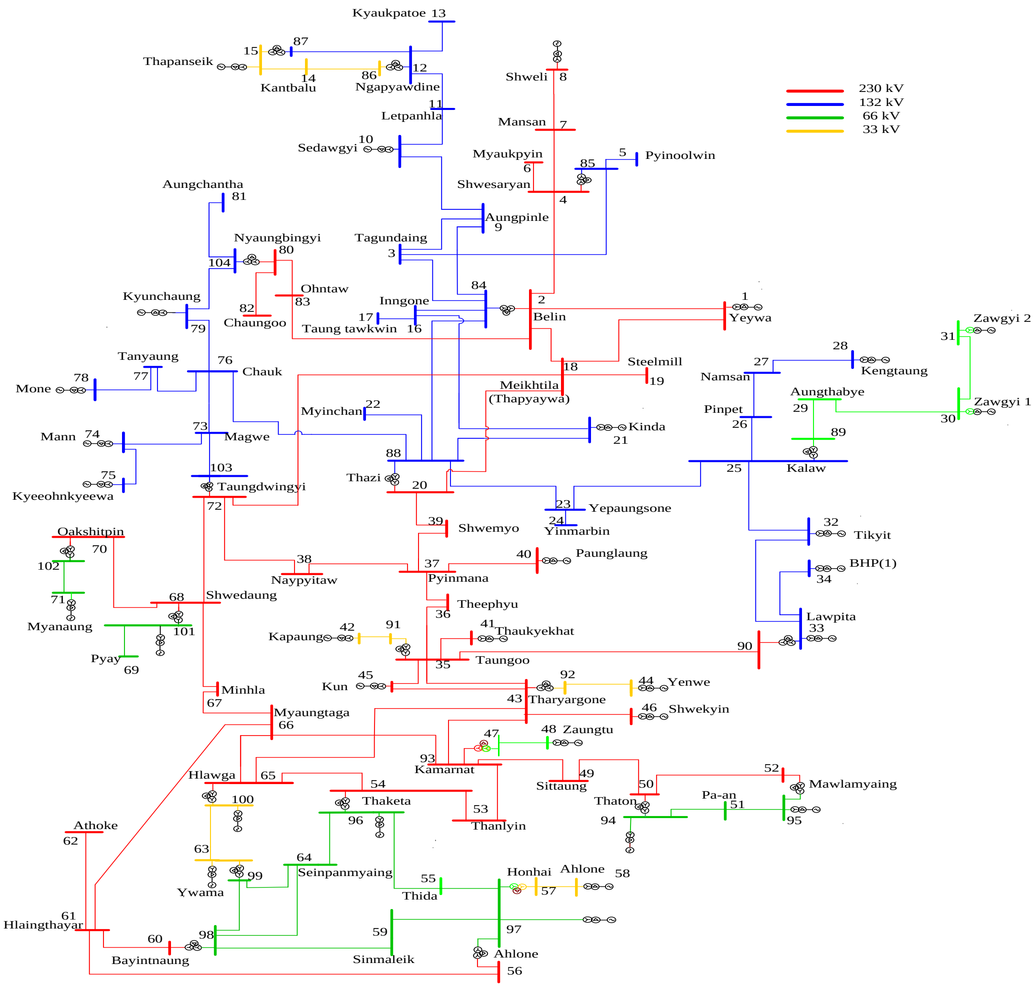

Fig. 2. Single line diagram of Myanmar electric power system.

Voltage levels of the test system were 230kV, 132 kV, 66kV and 33kV respectively. There will be included 104 bus, 123 lines, 22 transformers and 32 generators in the selected system. For the power flow study and analysis, Yeywa Hydro Power Station was assigned as bus 1 and is taken as the slack bus. Remaining generator buses were taken as voltage controlled bus. Line data containing the per unit series impedance, and one-half of the shunt capacitance were based on 100MVA, 50Hz. Bus data, slack generator, PV generator, PQ load, shunt for each bus and line data each transmission line were used as input data of selected network. In the load flow program, the voltage magnitude was set to 1.0 per unit and the specified voltage violation limit was taken as ±5 percent. The single line diagram for the selected case is shown in the following Fig. 2.

V. Simulation Results and Analysis

For optimal placement of TCSC under single line contingency, the simulations are carried out with Matlab2014A software. The simulation without TSCS is formerly executed. Then the optimal allocations of TCSC are found out by using Particle Swarm Optimization method and Genetic Algorithm. The optimal location is determined based on CSI index. According to the simulation results, the optima location of TCSC is obtained at Line 51 (Taungoo-Tharyargone 230kV Line) by PSO method and with GA method it is obtained at 79 (Tharketa-Hlawga 230kV Line). Then the single line contingency with TCSC are executed for each case. The measurements are carried out for voltage magnitude, voltage phase angle, base apparent power and maximum apparent power. The simulation results for various single line contingency conditions are show in Fig. 3 to Fig. 7.

Fig. 3 shows voltage magnitude comparison for single line contingency with three schemes. The voltage magnitude at most buses are exactly equal or nearly equal for three schemes. Thus, the buses with different voltage magnitudes for three schemes are shown in Fig. 3. Most of bus voltages are within 0.94pu and 1.0pu. The bus voltages of bus 11, 12, 13, 86 and 87 are above 1.04pu. The bus voltage magnitudes of with TCSC are more close to nominal value 1.0pu compared to without TCSC case. At bus 95, the bus voltage magnitude with TCSC of GA method is only about 0.96pu that lower than other schemes. Thus TCSC allocation with PSO method can provide the better voltage magnitude under single line contingency.

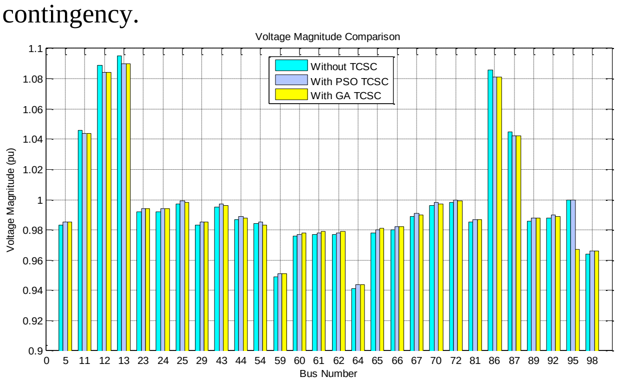

Fig. 3. Voltage magnitude comparison.

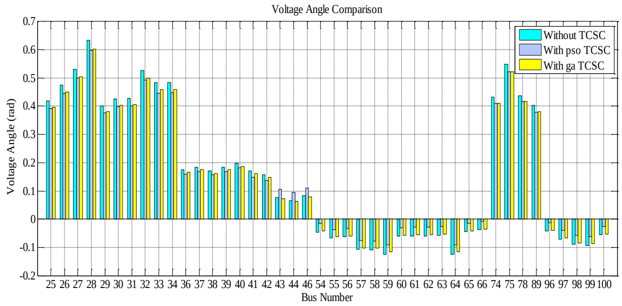

Fig. 4. Voltage angle comparison.

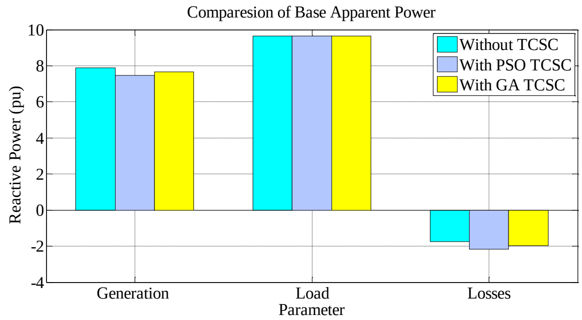

Fig. 5. Reactive power flow and losses comparison.

Fig. 4 shows voltage angle comparison for single line contingency with three schemes. The voltage phase angles which are differed with schemes are shown in this figure. As shown in figure, voltage phase angles of buses between bus 25 and bus 34 and between bus 74 and bus 89 are large compared to other voltage angles. The voltage phase angle of buses between bus 36 and bus 46 are small. The voltage angles with negative values are observed at buses between 54 and 66 as well as bus 96 and 100. All bus voltage angles are small and thus the system is stable under single line contingency.

The voltage angles with TCSC are nearly equal and smaller compared to without TCSC case. Thus TCSC can provide better stability under single line contingency. The voltage angles of buses 43 to bus 46 of with TCSC by PSO scheme are larger compared to GA scheme. In the remaining buses, the voltage angles with PSO scheme are smaller compared to GA scheme. Thus, PSO scheme is better for voltage angle stability under single line contingency.

The reactive power generations, loads and losses comparison are shown in Fig. 5. The reactive power generation is least with PSO scheme and largest for without TCSC case. The load reactive powers are the same for all three schemes. The reactive power losses are maximum with PSO method and minimum for without TCSC case.

Fig. 6 shows comparison for base apparent power for three schemes. Up to bus 46, the base apparent powers of three schemes are nearly the same. The base apparent powers of buses 49, 51, 63, 64, 68 and 69 are significantly large for PSO scheme. The values at buses 52, 56, 59, 61 and 103 are small with PSO scheme. At remaining buses, base apparent power with GA scheme is larger compared to PSO allocation scheme. In most case, the base apparent power with GA allocation scheme is nearly equal to that of without TCSC case.

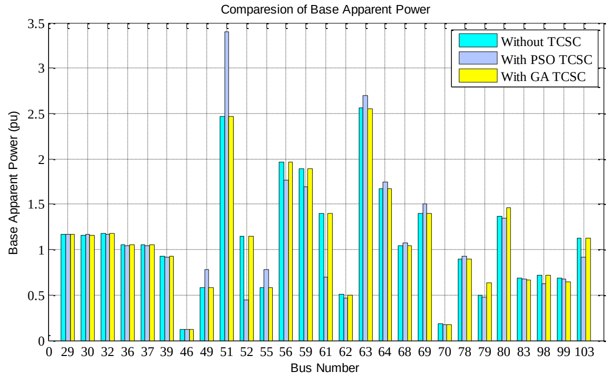

Fig. 6. Comparison of base apparent power.

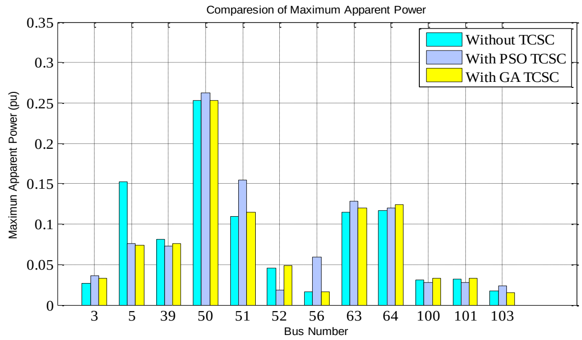

Fig. 7. Comparison of maximum apparent power.

Comparison of maximum apparent power for three schemes is depicted in Fig. 7. Only the buses where the maximum apparent powers are differed are shown in this figure. At remaining buses, the maximum apparent powers of three schemes are nearly equal. At bus 5, the maximum apparent power for without TCSC is significantly large compared to other scheme. At bus 51 and 56, the maximum apparent power with PSO scheme is significantly large compared to other scheme. At bus 52, this value is noticeably small compared to others. At remaining buss, the maximum apparent powers with GA scheme are slightly larger compared to PSO allocation scheme. In all aspects, the TCSC allocation with PSO scheme can provide better maximum apparent power under single line condition.

VI. Conclusion

The Myanmar Electric Power system has been used to demonstrate the proposed method over a wide range of power flow variations in the transmission system. Myanmar Electric Power system is unstable when voltage decreases beyond particular limit because of outage of equipment, heavily loaded such as industrial zone, decrease in controller's action or loss of generation. Voltage increase beyond particular limit because of limit voltage rise on open circuit or light load. Voltage collapse is basically the effect of reactive power imbalance between generation and load. Most of these problems are common in developing country such as Myanmar.

The purpose of this study is to explore this problem and derive simulation results. In this research, optimal placement of TCSC under single line contingency is carried out based on particle swarm optimization method and genetic algorithm method. TCSC increase power transfer capacity in transmission lines under normal and contingency. Moreover, TCSC can minimize the system from instability problem. The best TCSC allocation is executed by two methods differently. According to the simulation results, the optimal location of TCSC is obtained at Line 51 (Taungoo-Tharyargone 230 kV Line) by PSO method and with GA method it is obtained at 79 (Tharketa-Hlawga 230 kV Line). In further, the single line contingency with TCSC are executed for each case. By comparing the single line contingency results, PSO method can provide better condition for the system stability compared to GA method. With the location and rating of TCSC provided by PSO algorithm, the system has improved the security such as enhancement of voltage profile and voltage angle at every bus. For further study, other optimization methods should be considered and the results should be analyzed.

Appendix
Parametres of Myanmar National Grid

Table I: Bus Load and Injection Data of Myanmar National Grid

Bus	Type	P_d (p.u)	Q_d (p.u)	P_g (p.u)	Q_g (p.u)
1	1	0	0	4.87	0
2	0	0.109	0.0574	0	0
3	0	0.321	0.169	0	0
4	0	0.155	0.0817	0	0
5	0	0.215	0.113	0	0
6	0	1.030	0.543	0	0
7	0	0.257	0.135	0	0
8	2	0	0	2.50	0
9	0	0.198	0.104	0	0
10	2	0	0	0.13	0
11	0	0.116	0.0611	0	0
12	0	0.097	0.0511	0	0
13	0	0.280	0.095	0	0
14	0	0.031	0.0163	0	0
15	2	0	0	0.12	0
16	0	0.113	0.0593	0	0
17	0	0.102	0.0537	0	0
18	0	0.160	0.0841	0	0
19	0	0.280	0.148	0	0
20	0	0.062	0.0327	0	0
21	2	0	0	0.32	0
22	0	0.151	0.0794	0	0
23	0	0.0039	0.0021	0	0
24	0	0.0029	0.15	0	0
25	0	0.0763	0.0402	0	0
26	0	0.230	0.121	0	0
27	0	0.100	0.0527	0	0
28	2	0	0	0.352	0
29	0	0.215	0.113	0	0
30	2	0	0	0.053	0
31	2	0	0	0.094	0
32	2	0	0	0.238	0
33	2	0	0	1.473	0
34	2	0	0	0.260	0
35	0	0	0	0	0
36	0	0.132	0.0696	0	0
37	0	0.587	0.309	0	0
38	0	0.242	0.128	0	0
39	0	0.116	0.0613	0	0
40	2	0	0	1.280	0
41	2	0	0	0.791	0
42	2	0	0	0.124	0
43	0	0.137	0.0724	0	0

Bus	Type	P_d (p.u)	Q_d (p.u)	P_g (p.u)	Q_g (p.u)
44	2	0	0	0.193	0
45	2	0	0	0.577	0
46	2	0	0	0.306	0
47	0	0.500	0.300	0	0
48	2	0	0	0.065	0
49	0	0.1708	0.0973	0	0
50	0	0	0	0	0
51	0	0.0439	0.0231	0	0
52	0	0	0	0	0
53	0	0.504	0.266	0	0
54	0	0.560	0.295	0	0
55	0	0.400	0.211	0	0
56	0	0.290	0.180	0	0
57	0	0.550	0.290	0	0
58	2	0	0	0.882	0
59	0	0.340	0.290	0	0
60	0	0.291	0.1185	0	0
61	0	0.759	0.495	0	0
62	0	0.320	0.151	0	0
63	2	0	0	0.370	0
64	0	0.160	0.0843	0	0
65	0	0	0	0	0
66	0	0.759	0.680	0	0
67	0	0.390	0.159	0	0
68	0	0	0	0	0
69	0	0.284	0.15	0	0
70	0	0.095	0.05	0	0
71	2	0	0	0.135	0
72	0	0.150	0.079	0	0
73	0	0.114	0.0601	0	0
74	2	0	0	0	0
75	2	0	0	0.202	0
76	0	0.174	0.0915	0	0
77	0	0.0114	0.006	0	0
78	2	0	0	0.2243	0
79	2	0	0	0.12	0
80	0	0.090	0.0474	0	0
81	0	0.221	0.116	0	0
82	0	0.0043	0.0023	0	0
83	0	0.184	0.0969	0	0
84	0	0.040	0.021	0	0
85	0	0.101	0.053	0	0
86	0	0.020	0.0105	0	0
87	0	0	00	0	0
88	0	0.051	0.0269	0	0
89	0	0.020	0.0105	0	0
90	0	0	0	0	0
91	0	0.103	0.0543	0	0
92	0	0	0	0	0
93	0	0	0	0	0
94	2	0	0	0.400	0
95	2	0	0	0.034	0
96	2	0	0	0.548	0
97	2	0	0	0.3	0
98	0	0	0	0	0
99	0	0	0	0	0
100	2	0	0	0.908	0
101	2	0	0	0.130	0
102	0	0	0	0	0
103	0	0.120	0.0632	0	0
104	0	0.030	0.0158	0	0

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Su Myat Noe Oo conducted the research, analyzed the data and wrote the draft paper. Swe Swe Myint planned the research outline, followed the research process. Shouji USUDA joined the paper writing process and proofread the final draft; all authors had approved the final version.

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Su Myat Noe Oo received her B.E from Technological University Mandalay (TUM) in 2010, M.E from Mandalay Technological University (MTU) in 2014. She is currently Ph.D. candidate at the Department of Electrical Power Engineering, Mandalay Technological University (MTU). Her current research interests are power system security, especially reactive power compensation and voltage stability.

Swe Swe Myint received her B.E. from Mandalay Technological University (MTU) in 2002, M.E. from Yangon Technological University (YTU) in 2003 and Ph.D. from MTU in 2007. She is currently Professor at the Department of Electrical Power Engineering, Mandalay Technological University (MTU). Her current research interests are power system, especially reactive power and voltage stability. She is teaching the subject of Power System Engineering.

Shouji Usuda received Ph.D. in electrical engineering from Hokkaido University in 1975, and after working for Toshiba Co., Ltd., became a professor at Osaka Prefectural College of Technology and the director of the industry-academia exchange office at the same school in 1994. After that, he became Professor and Research fellow at Osaka Electro-Communication University in 2013, and continues to this day. During this time, he was awarded the title of Visiting Professor at Mandalay Institute of Technology of Myanmar and Ho Chi Minh City University of Vietnam. He have also obtained membership as senior member of IEEE. In August 2020, he was newly appointed as specially appointed professor and researcher at Hosei University of Tokyo/Japan. His research fields are lithium-ion batteries and their applied research, and power system cooperation.