Performance Analysis of a System with Optimal SVC Device Location Using a Meta-Heuristic Algorithm

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Abstract: *The static and dynamic performance of power systems can be significantly enhanced using FACTS devices. However, a key factor in determining how effectively the goal of enhancing the System performance is accomplished on a budget is the kind, position, and rating of the FACTS devices. In order to maximise the advantages of their installation, an objective function made up of cost, line loadings, and load voltage variations is provided in this study, and the weights given to them define their respective relevance. For the purpose of strengthening security under situations of increased system loading, the effects of installing TCSC, SVC, TCSC-SVC, and UPFC on reducing the defined aim have been examined.*

Keywords: FACTS devices; PSO , Enhance system security; Optimal placement

1. INTRODUCTION

One component of an integrated power system delivery solution is optimal power flow (OPF). The primary purpose of OPF is to maximise the chosen objective feature, which may include fuel cost, voltage stability indices, active and reactive power loss, and the best possible control parameters for the power system. But it still needs to adhere to reactive power restrictions on equality and inequality limitations [1]. One of the power system issues that has received the greatest research attention is the OPF issue. The gradient approach [7], interior point methods [3, 4], Newton's method [5,] linear programming methods [6,] non-linear programming, and other classical (deterministic) optimization algorithms have all been effectively utilised in the past to address optimal power flow issues. Additionally, the traditional

The above-mentioned issues have caused the study to already turn toward the meta-heuristic algorithm. Particle swarm optimizations (PSO) [8], an unique hybrid bat algorithm [9], the artificial bee colony algorithm (ABC) [10], and fruit fly optimization are just a few examples of the many different types of meta-heuristic algorithms that may resolve optimal power flow issues. The analytical hierarchy technique can assist in identifying and precisely defining problems and successfully helps decision-making about complicated sustainability challenges. It is frequently employed to break down decision problems into their fundamental components, which are then organised hierarchically. As a result, AHP provides a rating of choices to make choosing a strategy easier [12]. This study applies the STATCOM FACTS device allocation to the

2. system developing

The most common setup for this kind of shunt-connected device is a parallel combination of a fixed capacitor C and a responding SVC with an auxiliary controller [21] that is controlled by a thyristor, as illustrated in Fig. 1b. The SVC controller's voltage input, DVscc, is determined from the SVC bus. The auxiliary controller receives its control input from the machine speed, Dm (=Dx/xs). The amount of susceptance incorporated in the network depends on the firing angle (a) of the thyristors. Bsvsc at the fundamental frequency, the SVC equivalent susceptance, is provided by [22]

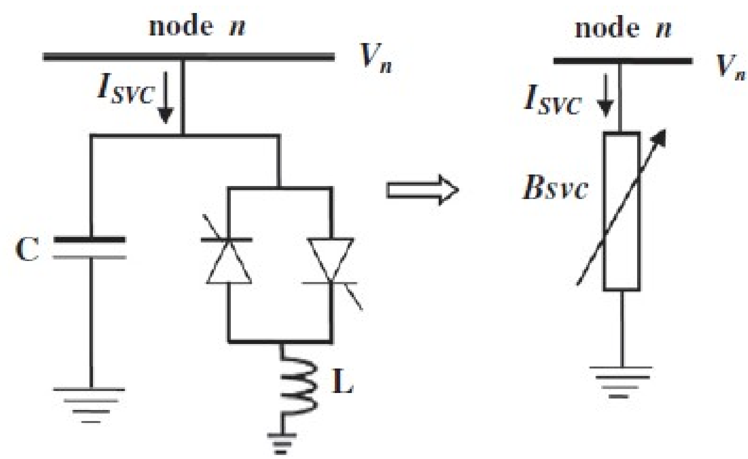

Figure-1 SVC controller

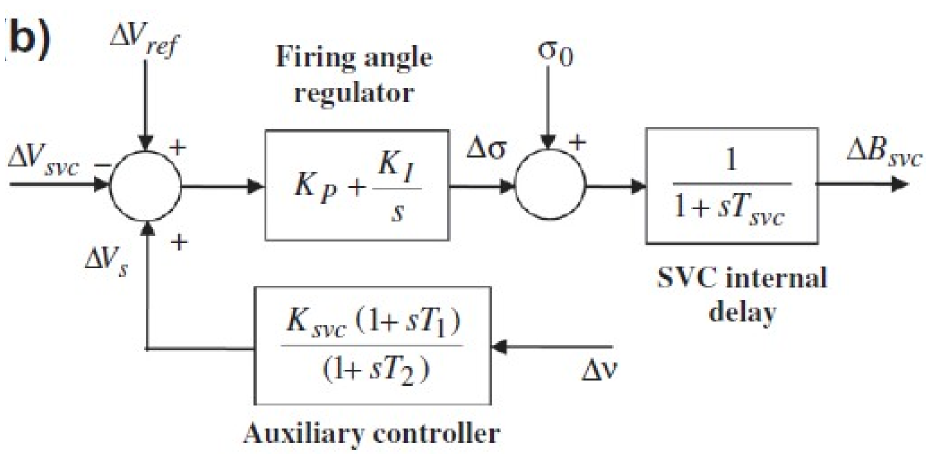

Figure-2 Block Diagram

.3. OVERVIEW OF OPTIMIZATION ALGORITHMS

SVC modeling

SVC is used to inject or absorb reactive power to control a transmission line system's end voltage. The reactive power restrictions of the generator play a major role in determining its stability. For this reason, the reactive power range is shown as follows:

The voltage level is kept between 0.95 and 1.05 PU and is maintained at -100 MVAR QSVC 100 MVAR. When the voltage decreases to 0.95 PU, the assessed 100 MVAR will thus supply 90 MVAR, but 110 MVAR when the voltage increases to 1.05 PU. These data are helpful after inductors are employed to calculate voltage deviation. The reactive power capacity level, which corresponds to the system's maximum loading limit, is 1.795 when the generator's reactive power capabilities are approximated by the constant.

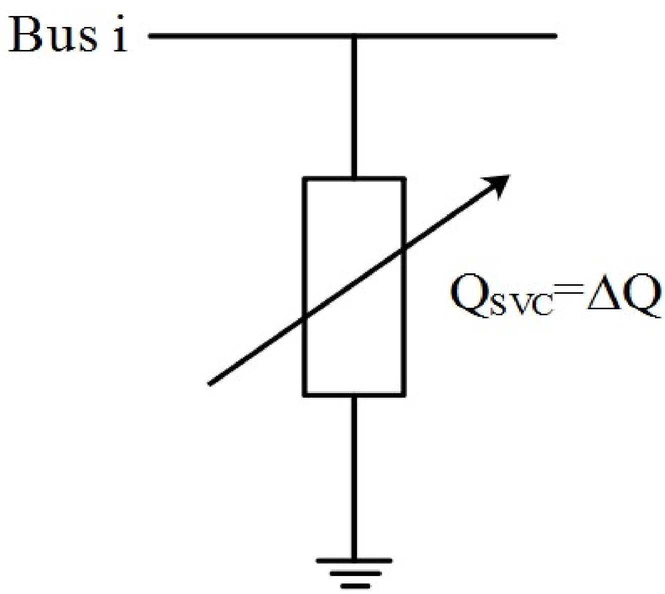

Figure 3 Model of SVC

The location of the SVC in a node is expressed in the following equation (1).

$$\Delta Q = Q_{SVC} \quad (1)$$

where the size of SVC is represented as ΔQ. The Reactive Power Dispatch (RPD) issue with SVC placementis given as follows:

The cost function of SVC:

The SVC cost function is specified in equation (2).

$$Cost - svc = 0.0003 \times s^2 - 0.305 \times s + 127.38 \quad (2)$$

where the functional limit of the FACTS device is represented as s.

The advantages of the extra power system control must be established once the limitations of the power system have been identified and workable solutions have been discovered through system research. Here is a list of some of these benefits:

- More effective use of transmission halls and increased loading
- Flow Control for Additional Power
- Improvements in Power System Stability
- Additional System Security
- Boosted System Reliability
- More Options for Placing New Generation
- Removing or postponing the requirement for a different transmission line

The SVR device is a shunt-connected device that is installed in parallel with a bus, and it has the capability to produce power at the point of association. The SVC is a joint term for a Thyristor Controlled Reactor (TCR) and a Thyristor Switched Capacitor (TSC). It performs in two diverse modes: inductive mode and capacitive mode. reactive power absorbs in inductive mode and reactive power injects in capacitive mode, which is shown as an ideal reactive power injection at the bus. The reactive power is restricted as follows: -100 MVAR [18].

Particle Swarm Optimization Algorithm

PSO is a global search technique that uses a collection of particles with random positions and velocities. The velocity of each particle in PSO, which reflects its movement in the search space, is dynamically adjusted depending on the behavior of the particle in question. Particles seek the explanation space by changing their position and velocity because they tend to travel towards better points inside the search space (Trelea 2003). There are several SI algorithms in use, but PSO has been demonstrated to perform better and be more sophisticated in large-scale situations. Associated to other SI algorithms, such as genetic algorithms, it takes less time to compute. Additionally, it employs actual numerical values rather than binary encoding GA does. Thus, in the current research, a PSO algorithm will be used in optimization.

In terms of computational time, the PSO method offers effective performance in a distributed setting like cloud computing, where it is quicker than meta-heuristic algorithms like GA and ACO. In terms of processing and implementation, PSO was discovered to be quicker and easier than GA, and it offers a few parameters to tweak and advance the convergence speed, according to

Pongchairerks (2009). The task scheduling problem will be optimized in this study using PSO.

For example, PSO is constrained by local optima and a slow convergence rate in large spaces. PSO has two options for resolving these issues. The PSO algorithm can first be modified by altering certain of its formulas and parameters. Additionally, it iss used in conjunction with other meta-heuristic techniques. According to the goals and the nature of the problem, the two methodologies will be applied in this thesis. For task scheduling and negotiation, the modified PSO will be utilized; for VM allocation, the conventional PSO will be used. It will be paired with another algorithm to enhance PSO's performance in data clustering with the K-means technique.

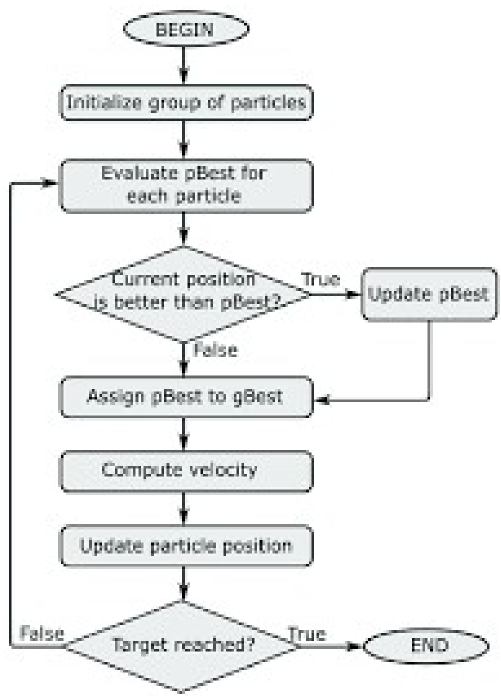

Figure 4 PSO Algorithm

.4. RESULT AND DISCUSSION

Particular	
	14 BUS
Transmission lines	20
Transformers	3 locations (6-11, 6-12, 6-9)
Shunt compensators	2 locations (10, 12)
Generators	5 buses (1,2,5,8,11)

TABLE-1 SYSTEM DETAILS

Control Variables	Initial Values	Optimal Values
V1	1.0500	1.0299
V2	1.0400	1.0390
V5	1.0100	1.0331
V8	**1.0100**	**1.0087**
V11	**1.0500**	**1.0292**
V13	**1.0500**	**0.9909**
T11	**1.0780**	**0.9982**
T12	**1.0690**	**0.9928**
T15	**1.0320**	**0.9537**
T36	**1.0680**	**0.9801**
Qc10	**0.0000**	**2.1377**
Qc12	**0.0000**	**1.5403**
Qc13	**0.0000**	**2.2657**
Qc17	**0.0000**	**3.5854**
Qc20	**0.0000**	**3.0387**
Qc21	**0.0000**	**2.4162**

Qc23	**0.0000**	**3.1345**
Qc24	**0.0000**	**2.6004**
Qc29	**0.0000**	**2.4739**
SVC location	**15.0000**	**15.0000**
SVC size	**0.0000**	**0.2557**
SVC cost ($/MVAR)	**-**	**127.365**
TVD (p.u)	**1.47**	**0.1274**
Ploss (MW)	**5.74**	**4.5435**
LL	**6.42**	**3.9129**

Table 2 IEEE TEST SYSTEM RESULT

Table 2 provides the scenario 1 performance analysis. For 14 buses with SVC alone, the findings are shown in Table 2. For scenario 1, the corresponding TVD, Ploss, and LL values are 0.1274 p.u., 4.5435 MW, and 3.9129. The SVC's size and location are 15 and 0.2557, respectively. The SVC employed in this scenario 2 costs 127.365 $/MVAR in addition.

CONCLUSION

The SVC controller has been introduced in this research to reduce the TVD issue in a multimachine system. The PSO algorithm has been used to identify the ideal SVC location and select the best possible parameters. By minimizing an objective function, it has proven possible to improve tiny signal stability. Additionally, taking into account all network bus characteristics, the performance of the PSO-based SVC has been compared to the application in a typical multimachine power system. The present PSO-based optimization strategy seems to be accurate, has a quicker rate of convergence, and is not computationally demanding.

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