

# Application of SVC for Multiobjective Optimization Powerflow Problem Using PSO

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## Abstract

PSO algorithm with SVC is used for multi objective optimization power flow that is minimize generation cost, minimizing the voltage deviation, minimize voltage deviation stability index of voltage, minimize the total transmission line power loss & minimize the installation of SVC device cost by including some of constraints including voltage deviation and SVC constraints. Simulations for optimal power flow considered by taking IEEE 30-bus reference bus data without and with SVC. The MATLAB results is obtained by running NR-Load flow with SVC using PSO.

Keywords: Newton Rap son's Load flow Method, Static Var compensator (SVC), PSO, Multi Objective

Optimization Optimal Power Flow problem,  
Minimization of Objective Functions.

## 1 INTRODUCTION

FACTS controllers [1] is mainly control voltage magnetude, active power & reactive power. The application using Facts controller will enhance the voltage. The transmission line Power flow [2] is increased by decreasing the line reactance or increasing the excitation voltage with the control of any one parameter the power flow will changed. The authors [3-13] describe different optimization techniques. Here the application of SVC for multi objective optimization i.e. minimizing the cost of generation, minimizing of voltage deviation, minimizing of voltage stability L-Index, minimizing of total power loss and minimizing of total installation cost of SVC device is reduced using PSO. Multi objective optimization with SVC [14] has more advantage compared to single objective optimization. In [15-17], different programming control strategies are mentioned.

## 2 SVC Model

SVC typically consists of thyristor switching Capacitor, thyristor Controlling Reactor & thyristor Switching Reactor.

$$i = jB.V_k \quad (1)$$

$$Q_k = -V_k^2 B \quad (2)$$

SVC Susceptance type method [4]

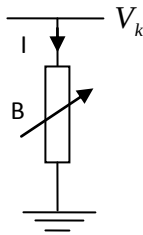


Figure 1 shunt susceptance model

$$\begin{bmatrix} \Delta P_n \\ \Delta Q_n \end{bmatrix}^m = \begin{bmatrix} 0 & 0 \\ 0 & Q_n \end{bmatrix}^m \begin{bmatrix} \Delta \theta_n \\ \Delta B_{SVC}/B_{SVC} \end{bmatrix} \quad (3)$$

$$B_{SVC}^{m+1} = B_{SVC}^m + \left( \frac{\Delta B_{SVC}}{B_{SVC}} \right)^m \cdot B_{SVC}^m \quad (4)$$

### 3 OPTIMAL POWER FLOW PROBLEM ATTRIBUTES [6]

#### Objective Functions

A. Single objective optimization OPF problem.

B. Multi Objective PSO Optimization Optimal Power Flow Problem

A. Single objective optimization OPF problem

$$\text{Minimize } F = \sum_{i=1}^{ng} (a_i P_{gi}^2 + b_i P_{gi} + c_i) \quad (5)$$

B. Multi Objective PSO Optimization [7-8] Optimal Power Flow Problem

The minimizing function with PSO is written as eq. (6)

$$F(x) = x_1 * F_1 + x_2 * F_2 + x_3 * F_3 + x_4 * F_4 + x_5 * F_5 \quad (6)$$

$$\text{fitness value} = f_{\max} = 1/F(x) \quad (7)$$

Where

$F_1$  = Fuel cost minimization

$F_2$  = Minimizing the Voltage Stability Index (L-index)

$F_3$  = minimize the transmission line loss

$F_4$  = minimize the deviation of voltage in transmission line.

$F_5$  = Minimizing the cost of SVC FACTS Device.

The different objectives of optimal power flow problem is given below

- Fuel cost minimization.
- Minimizing the Voltage Stability Index (L-index) Computation.
- Minimizing the total power loss.
- Voltage deviation minimization.
- Minimizing the cost of SVC

(a) Fuel cost minimization The fuel cost objective function is represented

as shown in below Eq. (8)

$$F_i = p_i P_{gi}^2 + q_i P_{gi} + r_i \quad (8)$$

$P_{gi}$  will be the Generating power in MW

$p_i, q_i, r_i$  will be the coefficients of cost of generation

$$F_1 = \sum_{i=1}^{ng} (p_i P_{gi}^2 + q_i P_{gi} + r_i) \quad (9)$$

ng = number of generators including slack bus.

(b) Minimizing the Voltage deviation Stability Index (L-index) [13] It is a stability measure its value will be changed from no load to full load during voltage collapse its value will be one (10) ,

$$L_j = \left| 1 - \sum_{i=1}^g F_{ji} \frac{V_i}{V_j} \right| \quad (10)$$

$$j = g+1, \dots, n$$

$$L_{\max} = \max(L_j)$$

$$\text{Minimize} \quad F_2 = \min(L_{\max}) \quad (11)$$

(c) Minimize the total transmission line loss Mathematically to minimize total transmission line loss is given in equation (12)

$$F_3 = \min(P_{\text{loss}}) = \min \sum_{i=1}^{NL} G_{i,j} (V_i^2 + V_j^2 - 2V_i V_j \cos(\delta_i - \delta_j)) \quad (12)$$

Where NL = transmission lines

$G_{i,j}$  = transmission line conductance between i&j

$V_i$  = voltage at bus i

$V_j$  = The voltage at bus j

(d) Minimizing deviation of voltage Voltage Deviation (VD) can be minimized by using the following equation (13)

$$F_4 = \min(VD) = \min \left( \sum_{i=1}^{n_{PQ}} (|V_i - 1|)^2 \right) \quad (13)$$

$V_i$  = the magnitude of voltage at buses i

(e) Minimizing the cost of SVC [9] For minimizing the cost of SVC the

following equation is used i.e Eq. (14)

$$F_5 = \min(C_{SVC}) = \min(0.0003S^2 - 0.4S + 128) \quad (14)$$

$C_{SVC}$  = the installation of SVC cost in \$/Mvar

$S$  = range of operation of SVC

$$S = |q_2 - q_1|$$

$q_1$  = reactive power flowing in a transmission line without SVC.

$q_2$  = reactive power flowing in a transmission line with SVC.

Using all the above objective functions from (8) to (14) the fitness function can be expressed as Eq.(15):

$$\text{Fitness function} = \frac{1}{(x_1 * F_1 + x_2 * F_2 + x_3 * F_3 + x_4 * F_4 + x_5 * F_5)} \quad (15)$$

Where,  $x_1, x_2, x_3, x_4, x_5$  is weighting factors Eq.(16):

$$x_1 + x_2 + x_3 + x_4 + x_5 = 1 \quad (16)$$

Values of  $x_1, x_2, x_3, x_4$  &  $x_5$  is adjusted to 0.2 for all weighting factors.

## 4 Application of PSO in NR- Load flow Model [10]

The updated Velocity at each particle is given by:

$$V_i^{t+1} = wV_i^t + C_1 * r_1(pbest_i - X_i^t) + C_2 * r_2(gbest_g - X_i^t) \quad (17)$$

$w$  is the inertia weight;

Next updated position can be given by the following:

$$X_i^{t+1} = X_i^t + V_i^{t+1} \quad (18)$$

## 5 Computational algorithm [11]

Implementation procedure of multi objective with SVC using PSO [12] is given by

Step 1: Loading input data that is 30 bus data in MATLAB

Step 2: Run NR-load flow without SVC and choose optimal placement of SVC.

Step 3: For the first generation identify the simulation constants of PSO and assign “n” individuals and save them.

Step 4: For each and every “n” individual run load flow and determine load voltages, power losses, voltage stability L-index.

Step 5: find objective function and fitness of each individual

Step 6: Calculate the localized best value and globalized best value and save the values.

Step 7: Gradually increase generation to next value

Step 8: Apply new constants for PSO for the generation of new “n” individuals.

Step 9: With the next “n” individual run NR load flow with SVC determine updated new voltages, voltage stability L-Index, power flows..

Step 10: Calculated the new objective function values of each k value and find fitness of each

Step 12: Update the new generated localized best and globalized best value

Step 14: Finally Print results

## 6 Simulation results

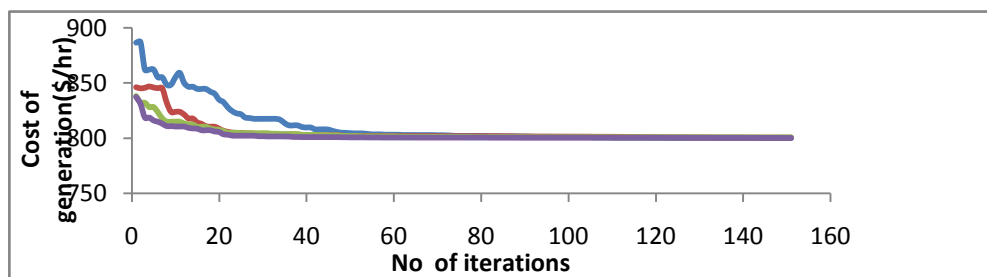


Figure 2 the characteristics for minimizing the cost of generation

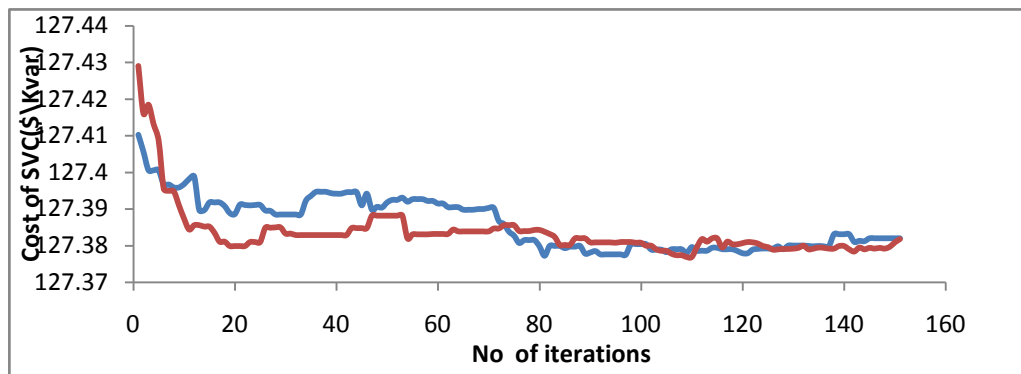


Figure 3 characteristics for minimizing the installation cost SVC

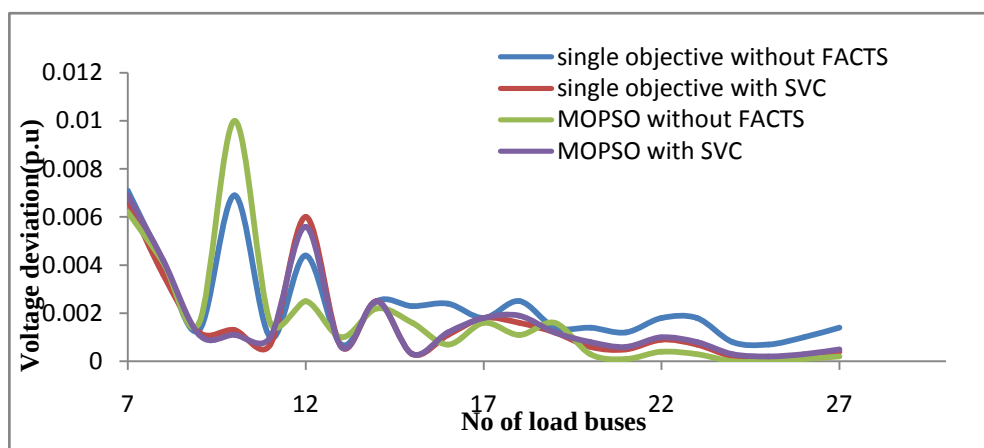


Figure 4 deviations in voltage without and with SVC

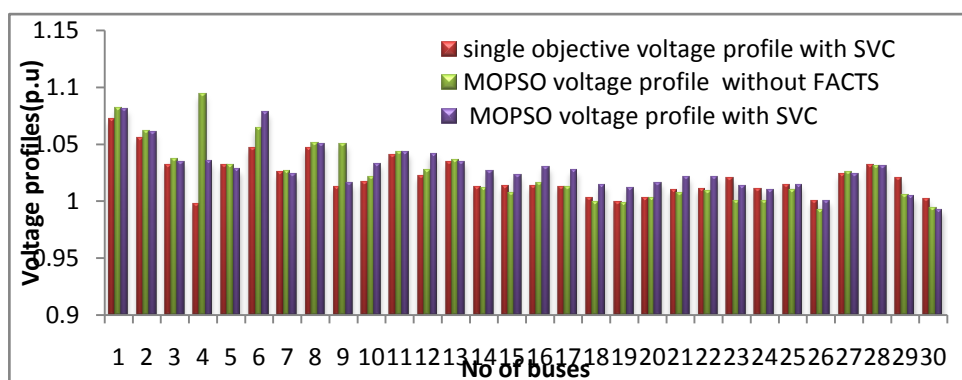


Fig 5 Voltages of single and multi objective without and with SVC

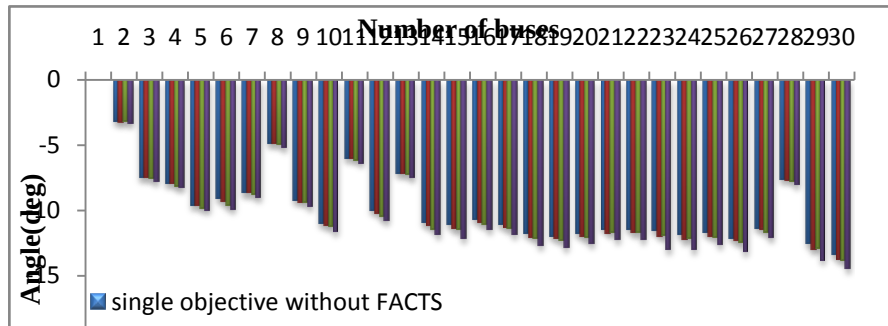


Fig 6 load angles of single and multi objective without and with SVC

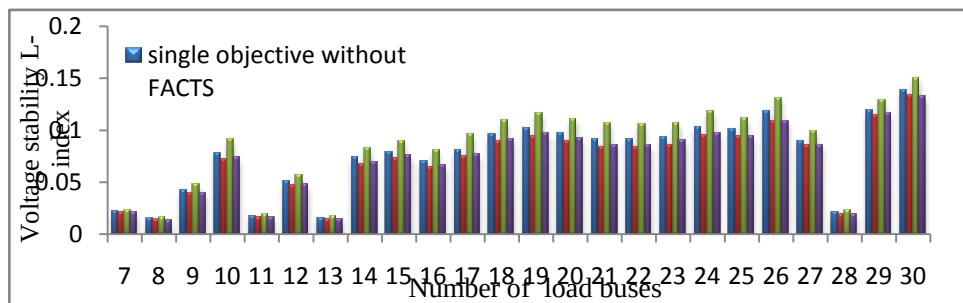


Fig 7 Voltage deviation index of single and multi objective without and with SVC

## 7 Compare the cost of generation of single and multi objective optimization

Table 1

| Type of Algorithm                                                    | Cost of fuel<br>in (\$/hr) |
|----------------------------------------------------------------------|----------------------------|
| Eveluatory [15]                                                      | 802.836                    |
| Tabusearch Algorithm                                                 | 802.502                    |
| Integrated Evelutionary proگرامing [16]                              | 802.465                    |
| Using PSO with single objective without SVC                          | 800.8705                   |
| PSO(proposed)(single objective with SVC<br>FACTS device)             | 800.6439                   |
| PSO(proposed)(multi objective optimization<br>without FACTS device)  | 800.4794                   |
| PSO(proposed)(multi objective optimization<br>with SVC FACTS device) | 800.1432                   |

## 8 Conclusions

The application SVC is used for multi objective power flow that is minimize generation cost, minimizing the voltage deviation, minimizing of voltage deviation stability L-Index, minimizing of total power loss and minimizing the installation cost of SVC device by including some of constraints. Overall the multi objective optimization will used for future load flow analysis and effective planning in power system.

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