CHAPTER 4

SIMULTANEOUS CAPACITOR PLACEMENT AND RECONFIGURATION OF RADIAL DISTRIBUTION SYSTEM USING HYBRID FUZZY-TEACHING LEARNING ALGORITHM

4.1 INTRODUCTION

Distribution system reconfiguration and optimal capacitor placement are the two most popular techniques adopted for the control of power loss. The techniques not only concentrate on power loss control but also control volt/var of the distribution system, and at the same time improve the system reliability and security. The present chapter proposed a method to handle reconfiguration and capacitor placement simultaneously for the effective optimization. Furthermore, it utilizes TLA for efficient searching for the optimal solution. In order to consider the constraints along with the objective, heuristic fuzzy has been integrated with TLA. The objective functions are given through the equations from (3.1) to (3.5).

The backward-forward sweep Harmonic Load Flow (HLF) is used to evaluate the harmonics present in the distribution system, which has been integrated with hybrid FTLA. The proposed hybrid FTLA method has been validated with IEEE-33 bus distribution system and 83-bus Taiwan power company distribution system.
4.2 SELECTION OF COURSES FOR SIMULTANEOUS OPTIMIZATION

4.2.1 Selection of Courses for Reconfiguration

In distribution system optimization, the switch is usually selected as the decision variable. It can be assigned either a value 0 (zero) or 1, which means open switch or closed switch respectively. Owing to the complexity involved with selecting number of switches as decision courses for optimization it is better to employ individual loops as decision courses. In a distribution system, the number of independent loops is the same as the number of tie switches. This process of selection of courses greatly reduces the search space.

The basic procedure for designing the new decision variable is:

i) Open and closed switches are used to construct the RDS.

ii) The open switch of the $n^{th}$ loop is closed to form $n^{th}$ independent loop.

iii) It is assumed that the decision variable of loop $n$ as $L_n$, and the switches are numbered in loop $n$ using consecutive integers, the numbers of all the switches in loop $n$ constitute the possible solution set of $L_n$.

In order to avoid unfeasible solutions in the iterative process, the dimension of the courses is greatly decreased by classifying the switches into four states. They are,

i) Open state: A switch is open in a feasible solution.

ii) Closed state: A switch is closed in a feasible solution.
iii) Permanent closed state: A switch is closed in all the feasible solutions.

iv) Temporary closed state: Switches common to more than one loop.

After the depiction of the states of all the switches, the permanently closed switches can be eliminated from the possible solution sets of the decision courses. Similarly, temporarily closed switches can be monetarily deleted.

### 4.2.2 Selection of Courses for Capacitor Placement

Optimal capacitor placement process has two major tasks:

i) The capacitors location identification.

ii) The search for optimal sizing of capacitors.

For finding the optimal location and optimal sizing of the capacitor, TLA has been carried out. In this case, the total number of optimal locations is considered as courses for optimal capacitor sizing. The number of locations has been decided based on the previous experience.

The selection of the number of courses has been decided based on the three different cases,

Case i. For the network reconfiguration alone, the individual loops are selected as courses and TLA is used to identify the open switches in each loop order to minimize the power loss. For instance, if the system has ‘x’ identified loops, TLA should then have ‘x’ courses.

Case ii. For the optimal capacitor placement alone, the number of optimal locations is the number of courses considered for searching. For
instance, if the system has ‘y’ identified locations, TLA should then have ‘y’ courses.

Case iii. For simultaneous reconfiguration and optimal capacitor placement, the sum of the number of loops and number of locations are the total number of courses considered for searching. For instance, the system with ‘x’ loops and ‘y’ locations have ‘x+2y’ courses (i.e., ‘2y’ refers to sum of courses for the location identification and sizing of the capacitors).

4.3 COMPUTATIONAL FLOWCHART FOR SIMULTANEOUS OPTIMISATION THROUGH HYBRID FTLA

The simultaneous optimization scheme begins with finding the solution sets of the RDS. The total number of switches present in each set/loop is then calculated and applied as state courses for hybrid FTLA. In addition, the number of locations for capacitor placement has been included with state courses for hybrid FTLA. Therefore, for the simultaneous optimization, the search space includes the courses for reconfiguration and courses for optimal capacitor locations and capacitor sizing.

With the use of hybrid FTLA, the optimal solution for the reconfiguration and capacitor sizing has been simultaneously carried out with the fitness function shown in equation (3.7) as an objective. During this process, reconfiguration and capacitor placement has been attempted only if the present configuration is better than the previous configuration. The final configuration has been arrived after the fixed number of iterations. The reconfiguration procedure based on hybrid FTLA is illustrated in the flowchart shown in Figure 4.1.
Start

Read Line data and Bus data of RDS

Run Radial Load Flow (RLF) get $P_{loss}$, total iteration($N$), $i=0$, $j=0$, $k=0$, $P_{nloss}=0$, $NP$

Assume courses ($V$) for hybrid FTLA as per case iii.

Initialize the population $f(NP,V)$

Find the best individual population

Evaluate the teaching factor

Produce the improved learners and produce the teachers

Find the best population with $\mu_D$ and prepare the set of learners

Interaction phase of the learners

Is iter $< N$

Yes

No

iter=iter+1

End

Figure 4.1 Flowchart for Simultaneous Reconfiguration and Capacitor Placement using hybrid FTLA
4.4 SIMULATION RESULTS

The effectiveness of the algorithm has been validated through two test distribution systems; Test System 1 and Test System 2 as described in Figure 2.4 and Figure 2.5. The characteristic data of the system are given in Table 2.1 and Table 2.2. It is assumed that both the systems are in balanced working condition and all the branches are being loaded without violating its limits and voltage at the buses is within limit.

4.4.1 Optimization under Normal Condition

In this section, optimization has been carried out by considering both the systems working under normal condition.

4.4.1.1 Test System 1

The proposed scheme has been tested on 33 bus RDS, which has 5 normally opened switches, 32 normally closed switches with 33 buses and it is assumed as balanced three-phase with 12.66kV. The corresponding power loss is 202.7kW. For the distorted voltage, harmonic-producing loads namely fluorescent lighting, Adjustable Speed Drives (ASD), and non-specific sources such as PCs, TVs, and etc, were considered. A complete description of the system harmonics is shown through the Table 2.3. All loads were treated as constant PQ spot loads for harmonic studies for the 33 bus RDS. Load composition in terms of harmonic sources is given in Table 2.4. The initial configuration harmonic voltages with %THD has been shown in Table 2.5, after the successful execution of radial load flow and harmonic load flow. From the Table 2.5, it is observed that for the buses 15, 16, 17, 27, 28, 29, 30, 31 and 32, %THD exceeds the set THD_{max} (3%).
The decision courses are designed for the Test System 1. As per the proposed approach all the switches of the loops are considered as closed. Test System 1 with decision courses is shown in the Figure 2.4.

The description of the switch states are identified as,

i) The open switches are \( S_{33}, S_{34}, S_{35}, S_{36} \) and \( S_{37} \).

ii) The closed switches are \( S_1 \) to \( S_{32} \).

The possible solution sets for Test System 1 are given by,

\[
L_1 = \{S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_{33}, S_{34}, S_{35}, S_{36}, S_{37}, S_{38}, S_{39}, S_{18}\}
\]

\[
L_2 = \{S_1, S_5, S_{10}, S_{11}, S_{12}, S_{21}, S_{33}\}
\]

\[
L_3 = \{S_9, S_{10}, S_{11}, S_{12}, S_{13}, S_{14}, S_{15}\}
\]

\[
L_4 = \{S_3, S_4, S_{22}, S_{23}, S_{24}, S_{25}, S_{26}, S_{27}, S_{28}, S_{29}, S_{30}, S_{31}, S_{32}\}
\]

\[
L_5 = \{S_6, S_7, S_{16}, S_{17}, S_{18}, S_{19}, S_{20}, S_{21}, S_{22}, S_{23}, S_{24}, S_{25}, S_{26}, S_{27}, S_{28}, S_{29}, S_{30}, S_{31}, S_{32}\}
\]

\[ (4.1) \]

iii) Identification of permanently closed switches.

In order to maintain the radial structure, switches close to the source should be permanently closed. The switches \( S_2, S_3 \) and \( S_{18} \) of \( L_1 \) are considered as permanently closed. Hence, they can be eliminated from the solution set. Similarly the permanently closed switches from the other solution sets are eliminated.

\[
L_1 = \{S_4, S_5, S_6, S_7, S_{33}, S_{34}, S_{19}\}
\]

\[
L_4 = \{S_4, S_5, S_{22}, S_{23}, S_{26}, S_{27}, S_{28}, S_{37}, S_{24}\}
\]

\[ (4.2) \]

iv) Identification of temporary closed state switches

Some switches, which belong to two or three independent loops, are interrelated. In a feasible solution, only one of the interrelated switches
may be in open state; otherwise, isolated islands will appear in the corresponding system. In Test System 1, switches $S_9$, $S_{10}$ and $S_{11}$ belong to both then loops 2 and 3, and so they are interrelated. If the solution of $L_2$ is switch $S_9$, then the solution of $L_3$ cannot be the switch $S_{10}$ or $S_{11}$. In other words, the switches $S_{10}$ and $S_{11}$ must be temporarily closed while switch $S_9$ is in open state. Inclusion of the concept of temporary closed state avoids finding the unfeasible solution due to the interrelation of some switches.

As a result, the solution sets are,

$$
L_1 = \{ S_4, S_5, S_6, S_7, S_{20}, S_{19}, S_{33} \} \\
L_2 = \{ S_8, S_9, S_{10}, S_{11}, S_{21}, S_{35} \} \\
L_3 = \{ S_{12}, S_{13}, S_{14}, S_{34} \} \\
L_4 = \{ S_{25}, S_{26}, S_{27}, S_{28}, S_{23}, S_{24}, S_{37} \} \\
L_5 = \{ S_{15}, S_{16}, S_{17}, S_{32}, S_{31}, S_{30}, S_{29}, S_{36} \} 
$$

(4.3)

From the above equation, it is clear that the Test System 1 has five courses ($L_1$, $L_2$, $L_3$, $L_4$ and $L_5$) for reconfiguration and these courses have 7,6,4,7 and 8 number of switches respectively. For optimal capacitor locations, as per the TLA, the number of locations are considered as the total number of courses for optimal capacitor sizing. For this Test System, with the previous experience, it is assumed that three capacitor locations are cost effective. Therefore, total courses considered for TLA are,

i) Reconfiguration courses $Z_i$  
   (i=1 to 5, each variable ranges from 1 to 7,6,4,7 and 8 respectively)

ii) Capacitor optimal location courses $Z_i$  
   (i=6 to 8, each variable ranges from 1 to 33)
iii) Capacitor optimal sizing courses $Z_i$

$(i= 9$ to $11$, each variable ranges from $150$ to $4050$)

Therefore, a total of 11 courses have been considered for the simultaneous optimization process (5 courses for reconfiguration, 3 courses for capacitor location and 3 courses for capacitor sizing). The initial population and their respective losses were calculated and stored. The generation size ($P$) and maximum iteration number (MAXIT) are assumed as 20 and 50 respectively. The best solutions with the fitness function (3.7) as multi-objective and its respective configuration have been stored at the end of iteration. The same process has been repeated for MAXIT.

The proposed method reduces the power loss from 202.67kW to 101.42kW, and maintains the bus voltages well above the minimum value. The kVAR at the buses 16, 27 and 30 are 776, 1227 and 550 respectively. With the effective influence of capacitors at the optimal locations the total operating cost of the system has been reduced from $34,049.75$ /year to $18,198.96$ /year. Thus the proposed algorithm has achieved 46.55% of cost saving with optimal capacitor placement. The convergence characteristic of the hybrid FTLA is shown in Figure 4.2. The bus voltages, branch currents and %THD for the three cases are shown in Figure 4.3, Figure 4.4 and Figure 4.5 respectively after implementing the proposed method. From these figures, it is noted that the loss is minimized, branch currents are kept under limit, and the bus voltages are maintained under limit and the % THD has been reduced from its initial configuration. Also, the results of the three cases such as capacitor only, reconfiguration only and simultaneous optimization are compared in Table 4.1. From the Table, it is understood that the annual operating cost and power loss has been greatly reduced with the proposed simultaneous optimization procedure and reduces the % THD without compromising the objective function of the problem.
Figure 4.2 Convergence characteristic through simultaneous optimization as per hybrid FTLA for Test System 1 under normal condition

Figure 4.3 Final configuration bus voltages of Test System 1 under normal condition as per hybrid FTLA
Figure 4.4 Final configuration branch currents of Test System 1 under normal condition as per hybrid FTLA

Figure 4.5 Final configuration %THD of Test System 1 under normal condition as per hybrid FTLA
Table 4.1 Results of 33-bus RDS with simultaneous optimization

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Loss (kW)</td>
<td>202.67</td>
<td>152.34</td>
<td>139.54</td>
<td>101.64</td>
</tr>
<tr>
<td>Min. bus Voltage (pu)</td>
<td>0.913</td>
<td>0.9226</td>
<td>0.9378</td>
<td>0.9475</td>
</tr>
<tr>
<td>THD_{max} (%)</td>
<td>4.77</td>
<td>21.23</td>
<td>3.25</td>
<td>2.46</td>
</tr>
<tr>
<td>Open Switches</td>
<td>S_{33}, S_{34}, S_{35}, S_{36}, S_{37}</td>
<td>-</td>
<td>S_{7}, S_{9}, S_{14}, S_{32}, S_{37}</td>
<td>S_{7}, S_{9}, S_{14}, S_{32}, S_{37}</td>
</tr>
<tr>
<td>Total Capacitor size (kVAR)</td>
<td>-</td>
<td>1731</td>
<td>-</td>
<td>2553</td>
</tr>
<tr>
<td>Power Loss Cost ($/yr)</td>
<td>-</td>
<td>25,593.12</td>
<td>23,442.72</td>
<td>17039.03</td>
</tr>
<tr>
<td>Capacitor Cost ($/yr)</td>
<td>-</td>
<td>1562.24</td>
<td>-</td>
<td>1780.41</td>
</tr>
<tr>
<td>Total Annual Cost ($/yr)</td>
<td>34049.75</td>
<td>28,155.36</td>
<td>23,442.72</td>
<td>19819.44</td>
</tr>
<tr>
<td>%saving</td>
<td>-</td>
<td>17.31</td>
<td>31.15</td>
<td>41.79</td>
</tr>
<tr>
<td>NFE</td>
<td>-</td>
<td>532</td>
<td>415</td>
<td>434</td>
</tr>
</tbody>
</table>

4.4.1.2 Test System 2

The Test System 2 is a balanced three-phase system with a base of 11.4kV. It consists of 11 feeders, 83 normally closed switches and 13 normally open switches. For this test system, total of 3 locations is assumed for the capacitor placement. Load composition in terms of harmonic sources, by referring Table 2.3, is assumed for all the load buses of the test system.
The decision courses are designed for the Test System 2. As per the proposed approach all the switches of the loops are considered as closed. Test System 2 with decision courses is shown in the Figure 2.5. It is observed from the figure that this Test System has 13 loops. Therefore, 13 courses have been constructed for reconfiguration; each variable gets the range according to the number of switches present. For the capacitor placement, with the previous experience, it is assumed that three capacitor locations are cost effective. In total, this system has been constructed with 19 courses (13 courses for reconfiguration and 3 courses for capacitor location and 3 courses for capacitor sizing). After applying the proposed methodology, the system loss is reduced from 542.55 kW to 411.20kW. The identified optimal locations for the capacitor placement are 27, 53 and 70. The optimal sizing (kVAR) at the locations are 1259, 542 and 779 respectively. The identified switches to be opened at the final configuration are S7, S13, S34, S39, S42, S55, S62, S72, S83, S86, S89, S90, and S92. The feeder currents are maintained under limit which is compared with the initial configuration feeder currents and it is shown in the Figure 4.6. The bus voltages, branch currents and %THD for the three cases are shown in Figure 4.7, Figure 4.8 and Figure 4.9 respectively after implementing the proposed method. From these figures, it is noted that the loss is minimized, branch currents are kept under limit, and the bus voltages are maintained under limit and the % THD has been reduced from its initial configuration.
Figure 4.6  Feeder Currents of Test System 2 with and without Optimization under Base Load Condition as per hybrid FTLA

Figure 4.7  Final configuration bus voltages of Test System 2 after CP under normal condition as per hybrid FTLA
Figure 4.8  Final configuration branch currents of Test System 2 after CP under normal condition as per hybrid FTLA

Figure 4.9  Final configuration %THD of Test System 2 after CP under normal condition as per hybrid FTLA
The results of the three cases such as capacitor only, reconfiguration only and simultaneous optimization are compared in Table 4.2. From the Table, it is understood that the annual operating cost and power loss has been greatly reduced with the proposed simultaneous optimization procedure and reduces the % THD without compromising the objective function of the problem.

**Table 4.2** Comparison of results with other methods in literature for Test System 2

<table>
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<tr>
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<tbody>
<tr>
<td>Capacitor Locations</td>
<td>-</td>
<td>16and20/DSTATCOM</td>
<td>3-16-20</td>
<td>7-70-53</td>
</tr>
<tr>
<td>Loss (kW)</td>
<td>542.55</td>
<td>447.8</td>
<td>442.3</td>
<td>411.20</td>
</tr>
<tr>
<td>Min. bus Voltage (pu)</td>
<td>0.95573</td>
<td>0.9481</td>
<td>0.9556</td>
<td>0.9561</td>
</tr>
<tr>
<td>% THD</td>
<td>8.81</td>
<td>19.23</td>
<td>22.45</td>
<td>2.75</td>
</tr>
<tr>
<td>Total Capacitor size (kVAR)</td>
<td>-</td>
<td>4887.3</td>
<td>4682</td>
<td>2580</td>
</tr>
<tr>
<td>Power Loss Cost ($/yr)</td>
<td>91148.40</td>
<td>75230.4</td>
<td>74306.4</td>
<td>69081.60</td>
</tr>
<tr>
<td>Capacitor Cost ($/yr)</td>
<td>-</td>
<td>-</td>
<td>1136.35</td>
<td>942.67</td>
</tr>
<tr>
<td>Total Annual Cost ($/yr)</td>
<td>91148.40</td>
<td>Not Considered</td>
<td>76442.75</td>
<td>70024.27</td>
</tr>
<tr>
<td>% saving</td>
<td>-</td>
<td>-</td>
<td>16.13</td>
<td>23.17</td>
</tr>
</tbody>
</table>
4.4.2 Optimization under Critical Load Condition

The robustness of the proposed algorithm was tested by keeping the test systems under critical load condition. As an initial step, the critical buses are identified based on their voltage profile. These buses were kept under critical condition by further inclusion of loads on the buses. Then the system with the present state has been fed into the hybrid FTLA.

4.4.2.1 Test System 1

In this case, Test System 1 is overloaded by 2.5%, 5% and 10% from its initial condition. With the effect of 2.5%, 5% and 10% overloading, the system loss increases from 202.66kW of base load condition to 213.76kW, 225.21kW and 249.15kW respectively at critical load condition. The system with the present state has been fed to the proposed optimal capacitor placement algorithm with the intention of bringing the system into normal condition from critical without compromising on operational constraints. With the effective introduction of the algorithm the system has been optimized. In the resultant system, the power loss has been reduced from 213kW to 122.61kW, 225.21kW to 143.42kW and 249.15kW to 159.71kW for different critical load conditions which are shown in Figure 4.10. The branch currents and bus voltages are maintained under limit. The branch currents, bus voltages and %THD under different critical condition are shown in Figure 4.11, Figure 4.12 and Figure 4.13 respectively. From the figures, it is proven that none of the bus voltages, branch currents and %THD was beyond the threshold value.
Figure 4.10  Convergence characteristics of power loss under critical load condition of Test System 1 as per hybrid FTLA

Figure 4.11  Final configuration branch currents of Test System1 under critical condition as per hybrid FTLA
Figure 4.12  Final configuration bus voltages of Test System1 under critical condition as per hybrid FTLA

Figure 4.13  Final configuration %THD of Test System1 under critical condition as per hybrid FTLA
4.4.2.2 Test System 2

In this case, Test System 2 is overloaded to 10%, 20% and 30% from its initial condition. With the effect of 10%, 20% and 30% overloading, the system loss increases from 531.99kW of base load condition to 662.77kW, 796.48kW and 944.20kW respectively at critical load condition. The system with the present state has been fed to the proposed capacitor placement algorithm with the intention of bringing the system into normal condition from critical. With the effective inclusion of the proposed algorithm, the system has been optimized. In the resultant system, the power loss has been reduced from 662.77kW to 571.58kW, 796.48kW to 692.47kW and 944.20kW to 813.28kW for different critical load conditions which are shown in Figure 4.14.

![Figure 4.14 Convergence characteristics of power loss under critical load condition of Test System 2 as per hybrid FTLA](image)

The branch currents and bus voltages are maintained under limits. The branch currents and bus voltages under different critical load condition are shown in figures from Figure 4.15 to Figure 4.20. Figure 4.21 shows the %THD after
implementing the proposed algorithm under different critical load conditions and ensures that the %THD of none of the buses are beyond threshold value.

Figure 4.15 Final configuration branch currents of Test System 2 under critical condition (10% overloaded) as per hybrid FTLA

Figure 4.16 Final configuration branch currents of Test System 2 under critical condition (20% overloaded) as per hybrid FTLA
Figure 4.17 Final configuration branch currents of Test System 2 under critical condition (30% overloaded) as per hybrid FTLA

Figure 4.18 Final configuration bus voltages of Test System 2 under critical condition (10% overloaded) as per hybrid FTLA
Figure 4.19  Final configuration bus voltages of Test System 2 under critical condition (20% overloaded) as per hybrid FTLA

Figure 4.20  Final configuration bus voltages of Test System 2 under critical condition (30% overloaded) as per hybrid FTLA
In this chapter, hybrid FTLA has been proposed to solve distribution system optimization through simultaneous capacitor placement and reconfiguration handling in the presence of harmonics in distribution system. It has been validated with two different kinds of distribution systems. For both the systems, the proposed algorithm minimizes the total annual operating cost considering the power flow, operational, capacitor and power quality constraints.

Table 4.3 summarizes the percentage of loss reduction from the initial configuration to the final configuration of the Test System 1 and Test System 2, under normal and critical load conditions. For Test System 1, 49.82%, 42.64%, 36.31% and 35.89% reduction of loss has been achieved under normal, and 2.5%, 5.0% and 10.0% overloaded conditions respectively.
from its initial configuration. Similarly, for Test System 2, 22.70%, 13.75%, 13.05% and 13.86% reduction of loss has been achieved under normal and 10%, 20% and 30% overloaded conditions respectively from its initial configuration. For the resultant configurations, the other objectives such as bus voltages, branch currents and % THD are maintained within the limit as shown in Figure 4.10 to Figure 4.13 for Test System 1 and Figure 4.14 to Figure 4.21 for Test System 2.

### Table 4.3 Summary of Results using hybrid FTLA

<table>
<thead>
<tr>
<th>Cases Considered</th>
<th>Test System 1</th>
<th></th>
<th>Test System 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial Loss</td>
<td>Loss after applying hybrid FTLA</td>
<td>Initial Loss</td>
<td>Loss after applying hybrid FTLA</td>
</tr>
<tr>
<td></td>
<td>(kW)</td>
<td>(kW)</td>
<td>(kW)</td>
<td>(kW)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>% reduction</td>
<td></td>
<td>% reduction</td>
</tr>
<tr>
<td>Normal Condition</td>
<td>202.66</td>
<td>101.64</td>
<td>531.99</td>
<td>411.20</td>
</tr>
<tr>
<td>Critical Load Condition -I</td>
<td>213.76</td>
<td>122.61</td>
<td>662.77</td>
<td>571.58</td>
</tr>
<tr>
<td>Critical Load Condition -II</td>
<td>225.21</td>
<td>143.42</td>
<td>796.48</td>
<td>692.47</td>
</tr>
<tr>
<td>Critical Load Condition -III</td>
<td>249.15</td>
<td>159.71</td>
<td>944.20</td>
<td>813.28</td>
</tr>
</tbody>
</table>

Thus, it is clear from the results that the proper installation of capacitors and efficient reconfiguration brings the violated bus voltages back within the limits. The main advantage of the proposed algorithm is that it not only provides solution for the optimal installation of shunt capacitors with harmonics consideration, but also it mitigates harmonic distortions in the system and maintains harmonic distortion levels within the limit. The proposed algorithm has features such as simultaneous handling of reconfiguration and capacitor placement, evade from algorithm specific control parameters, location identification through hybrid FTLA (replacement for sensitivity analysis), quick convergence and suitable for different kind of
distribution systems with single and/or multiple feeders. The outcome of this work is that the optimal capacitor placement was carried out with the presence of harmonics and the conventional sensitivity analysis used for determining the optimal capacitor location was replaced with optimization algorithm by increasing the number of learners in the algorithm. Though the proposed algorithm effectively handles simultaneous reconfiguration and capacitor placement for case studies, it addresses test cases only under normal and critical load conditions. Still a suitable technique is required to restore the system to normal operating condition from abnormal conditions (under faulted conditions).