Improving voltage for 13 bus radial distribution system using SVC-FUZZYs

U Ramesh Babu¹, V Vijay Kumar Reddy¹, S Tara Kalyani ²

¹ NBKRIET, Dept of Electrical and Electronics Engineering, Nellore, India-525413
² JNTUH, Dept of Electrical and Electronics Engineering, Hyderabad, India-500085

Abstract. Most of the Radial distribution systems (RDS) are incurring huge Power losses due to the connected loads are wide spread, reactive power providers are inadequate and the reactive power compensation facilities do not have a proper control system. In general typical static VAR compensator (svc) consists of fixed capacitor group with sequential steps, operated in connected with a power electronic thyristor switch controlled reactor of the finest step size. This SVC provides fine operating control of apparent power almost equal to load reactive requirements. The SVCs require an appropriately controlled reactor which is called thyristor controlled reactor (TCR). This Paper deals with a reactor suitable for IEEE 13 bus RDS provided with FC-TCR Simulation using Fuzzy Logic Controller (FLC) using MATLAB SIMULINK.

Keywords: Radial distribution system, Voltage Improvement, SVC, FC-TCR, Fuzzy

1 Introduction

Voltage is the one of the most important parameter of the control of electric Radial Distribution System. Flexible AC Transmission Systems (FACTS) controllers are provided to maintain the voltage which is supply to consumers within tolerable limits. In general, fixed capacitors can be provided at almost any voltage level in the distribution system. Separate capacitor units can be supposed to add in parallel to achieve the required KVAR capacity and can be added in series to achieve kilovolt voltage. They were employed at or nearer to rated voltage for economic reasons [1].

The summative data collected for the entire utility industry indicates that approximately 60% of the capacitors are provided to the feeders, 30% to the distribution substation buses, and remaining 10% to the transmission system [2]. The implementation of capacitors to the secondary systems is very rare due to less marginal economic advantages. Zimmerman [3] has developed a nomograph to identify the economic justification, if any, of the secondary capacitors banks by accounting in the system only the savings in distribution transformer cost. FACTS in the modern generation are familiar equipment for higher controllability in power systems with the help of power electronic switches. A number of advanced types of FACTS devices are in the stage of being introduced in practice [4].

The employment of SVC was motivated for the compensation of dynamic varying loads such as steel mills and arc furnaces. The application for Power system reactive power correction equipments was commenced in the late seventies. SVC-FC-TCR has very less inertia when compared to synchronous condensers and can have an super fast response (2-3 cycles). This activates the control of reactive power in the control range [5].

Artificial neural networks and fuzzy Intelligence based methods include particle swarm optimization [6, 7], genetic algorithm [8], and differential evolution [9]. Since 1989, artificial neural networks (ANN) methodology has captured the interest of a large number of applications in electrical power engineering. An adaptive Neuro-Fuzzy Inference System (ANFIS) combines the fuzzy qualitative approach with the adaptive capabilities of neural networks to achieve an improved performance [10-12].

2 Static VAR Compensators

The SVC provides a right choice of rapidly controllable reactive power shunt compensation for dynamic voltage level control through its rapid thyristor switching reactive devices.
SVC works on the principle of controlling the Shunt Susceptance (B). This can be achieved by changing the firing angle of the thyristor, Fig. 1 illustrates an SVC, including operational concept along with the Physical connection. The control objective of the (FCTCR) SVC is to maintain a desired voltage at the voltage bus. In the steady-state, the SVC will assist some steady-state control of the voltage to maintain the Voltage bus at a Tolerance level. If there is a sudden increase in the load, the voltage bus begins to fall below its set point in such a condition the SVC will inject reactive power (Qnet) into system, thereby increasing the bus voltage back to its net desired voltage level. If load falls suddenly, then bus voltage increases, the SVC (thyristor controlled reactor) will absorb reactive power, resulting in achieving the desired bus voltage. From Fig. 1, +Qcap is a fixed capacitive reactance value, therefore the net magnitude of reactive power injected into the system, Qnet, is controlled by the magnitude of (−Qind) inductive reactive power absorbed by the TCR.

3 Fuzzy Logic Controller

Mamdani based fuzzy interfacing rule is adopted for control of voltage level. Complex power is taken from simulink power measuring block, in which power factor angle is taken as input of fuzzy controller. According to power factor angle, control output (firing angle) is provided by fuzzy controller. Input (the Power factor angle) has 8 membership functions i.e very very small, very small, small, medium , large, very large, huge, very huge and the Output (the firing angle) has 8 membership functions. And rules are
1. If Power factor (PF) angle is VVS Then Firing angle (FA) is VVS
2. If PF angle is VS Then FA is VS
3. If PF angle is S Then FA is S
4. If PF angle is M Then FA angle is M
5. If PF angle is L Then FA angle is L
6. If PF angle is VL Then FA angle is VL
7. If PF angle is H Then FA is H
8. If PF angle is VH Then FA angle is VH

When power factor angle is very very large, firing angle is very very large. Controlled output is supplied to variable delay circuit and the thyristor. According to the output of variable time delay circuit, firing angle of thyristor is changed. Figure 4, 5 shows the input output membership functions of fuzzy logic controller.
4 Case Study and simulation

In this section the proposed svc-fuzzy controller is applied to the IEEE 13bus radial distribution system and the voltage improvement of the system is observed for with and without the presence of controller. The following table 1 and table 2 show the IEEE 13bus radial distribution data for constructing Simulink model. 13-bus system is fed from 115KV supply and the distribution system operated at 4.16KV and 0.48KV [13]. Step time maintained is 0.1 sec to get the results with and without controller. System tested with conventional PI controller and Fuzzy controller figure 6 and 7 shows voltage response of bus 634 and it is observed that transient response and voltage profile is good in fuzzy svc when compared to conventional PI controller. Figure 8 shows the bus voltages for all 13 buses, it is observed that without controller bus voltage is 3.945KV (0.948 P.U) and with controller improved the voltage is 4.356KV (1.047 P.U) for better understanding bus voltages 650, 646, 634, 652 shown in figure 9 to 12.

Table 1 Distribution Transformer Details

<table>
<thead>
<tr>
<th>Substation</th>
<th>KVA</th>
<th>KV-hv</th>
<th>KV-lv</th>
<th>R-%</th>
<th>X - %</th>
</tr>
</thead>
<tbody>
<tr>
<td>XFM-1</td>
<td>500</td>
<td>4.16</td>
<td>0.48</td>
<td>1.1</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 2 IEEE 13 bus RDS line Data (13)

<table>
<thead>
<tr>
<th>Se. node</th>
<th>Re. node</th>
<th>Length (ft)</th>
<th>Impedance</th>
</tr>
</thead>
<tbody>
<tr>
<td>632</td>
<td>645</td>
<td>500</td>
<td>0.2066-j0.4591</td>
</tr>
<tr>
<td>633</td>
<td>634</td>
<td>0</td>
<td>XFM-1</td>
</tr>
<tr>
<td>645</td>
<td>646</td>
<td>300</td>
<td>0.2066-j0.4591</td>
</tr>
<tr>
<td>650</td>
<td>632</td>
<td>2000</td>
<td>0.3465+j1.0179</td>
</tr>
<tr>
<td>684</td>
<td>652</td>
<td>800</td>
<td>1.3425-j0.5124</td>
</tr>
<tr>
<td>632</td>
<td>671</td>
<td>2000</td>
<td>0.3465+j1.0179</td>
</tr>
<tr>
<td>671</td>
<td>684</td>
<td>300</td>
<td>1.3238+j1.3569</td>
</tr>
<tr>
<td>671</td>
<td>680</td>
<td>1000</td>
<td>0.3465+j1.0179</td>
</tr>
<tr>
<td>671</td>
<td>692</td>
<td>0</td>
<td>Switch</td>
</tr>
<tr>
<td>684</td>
<td>611</td>
<td>300</td>
<td>1.3292+j1.3475</td>
</tr>
<tr>
<td>692</td>
<td>675</td>
<td>500</td>
<td>0.7982-j0.4463</td>
</tr>
</tbody>
</table>
Figure 6: Bus voltages for SVC-PI controller

Figure 7: Bus voltage for SVC-Fuzzy controller

Figure 8: Bus voltages in 13bus Radial Distribution System
Conclusion From the results and discussion the SVC facilitates smooth control of apparent power nearly equal to load requirements and improves the voltage stability and transient response for IEEE 13 bus radial distribution system

References