Chapter 7
Performance Analysis of Unified Power Quality Controller for a Two Bus System with Different types of Loads

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ABSTRACT
In this chapter, a Unified Power Quality Conditioning (UPQC) system has been presented for a two bus system. This is capable of compensating voltage and current disturbances simultaneously in a two bus system. In this topology one shunt voltage source converter (VSC) and two series VSC are present. All the converters are connected back to back on the dc side with a common dc link capacitor. Power transfer from one feeder to other feeder is made through this dc link during sag/swell and interruption. The performance of the UPQC and the proposed control algorithm has been validated in MATLAB/SIMULINK environment on a two bus system.

1. INTRODUCTION
The purpose of a power transmission line is to group generating stations and Load centres. It is generally constrained by line impedance, operating variables voltages and currents. Therefore generating stations may not be able to supply power demand. In addition now a days deformation of Power Quality which is effected by non linear loads and electronically switched devices is also a constraint. This affects the cost and reliability of the supply of the electricity. This may lead to large power flows with inadequate control, excessive reactive power in various parts of the power system, large dynamic swings between different parts of the system, thus the full potential of transmission line can not be utilized.

This need emerged new technology Flexible AC Transmission systems (FACTS). FACTS technology uses switching power electronics to
Performance Analysis of Unified Power Quality Controller for a Two Bus System

control power flow. The FACTS technology is a collection of controllers, which can be applied individually with others to control one or more of the interrelated system parameters (Padiyar, 2007). FACTS controllers can enable a transmission line to carry power closer to its thermal rating. The idea of FACTS is to use power electronics for controlling power flow in a transmission line and allowing it to fully load up to its capability (Hingorani & Gyugyi, 2011).

The overview of the FACTS devices is shown in Table 1. The thyristor based FACTS devices are Static VAR compensator (SVC), Thyristor Controlled Series Compensator (TCSC) and Dynamic Flow Controller (DFC). These devices have low losses due to their low switching frequency.

The other type of FACT devices are voltage source converters based uses mainly Insulated Gate Bipolar Transistors (IGBT) or Insulated Gate Commutated Thyristor (IGCT) as devices. The FACT devices are namely Static Synchronous Compensator (SSC or STATCOM), Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC). These types of FACTS controllers are more advanced Technology. The use of IGBT with Pulse Width Modulation (PWM) allows high modulation frequencies to get low harmonics in the output voltage in magnitude and phase. With the increase in switching frequency, the switching losses also increase.

The shunt compensating FACT devices SVC and STATCOM are primarily for reactive power compensation, a current is injected in to the system at the point of common coupling and it’s a good way to control the voltage. The SVC provides smoother and precise control in comparison with mechanically switched shunt compensation and improves stability. The STATCOM in comparison with SVC provides power quality in against even dips and flickers. Shunt compensator can not provide control of the power flow in the lines.

The series compensating FACT devices TCSC and SSSC are also for reactive power compensation. These devices drive the voltage in to the line and impact the current and power flow directly. A conclusion can be made that if the current, power flow or damp oscillations are to be controlled then series compensator is used.

Power flow devices shift power flows from overloaded parts of the power system to areas with free transmission capability. Phase Shifting Transformer (PST) are the most common devices in this area but they have limitations like low control speed together with a high wearing and maintenance. Unified Power Flow controller (UPFC) provides power flow control together with independent voltage control. The Dynamic Power Flow Controller (DFC) is introduced to fill the gap between UPFC and PST. Thyristor switched capacitor with a PST will provide dynamic controllability over parts of the control range.

The application of FACTS in distribution systems has resulted new type of compensating devices. A unified power-quality conditioner (UPQC) is the extension of the unified power-flow controller (UPFC) concept at the distribution level. It consists of combined series and shunt converters for simultaneous compensation of voltage and current imperfections in a supply feeder.

Table 1. FACTS devices

<table>
<thead>
<tr>
<th>Shunt Device</th>
<th>Thyristor Based</th>
<th>VSC Based</th>
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</thead>
<tbody>
<tr>
<td>Shunt Device</td>
<td>Static VAR compensator (SVC)</td>
<td>Static Synchronous Compensator (SSC or STATCOM)</td>
</tr>
<tr>
<td>Series Device</td>
<td>Thyristor Controlled Series Compensator (TCSC)</td>
<td>Synchronous Series Compensator (SSSC)</td>
</tr>
<tr>
<td>Shunt and Series Device</td>
<td>Dynamic Flow Controller (DFC)</td>
<td>Unified Power Flow Controller (UPFC)</td>
</tr>
</tbody>
</table>
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