Chapter 1

1. Introduction

1.1 Background

This study is related to coordinating shunt reactance switching (BSC Bank or Reactor) in power transmission and/or supply systems, and in one embodiment, for coordinating shunt compensation switching with on load tap change transformers.

A system and method for coordinating shunt reactance switching in a power system with transformer having primary and secondary voltage for supplying low voltage power to a load. Voltage (V), Current (I), Power (W) and Reactive power (Q) are measured at both side of the transformer flowing to the load. A Programmable Logic Controller (PLC) or Intelligent Electronic Device (IED) receives as one set of input measurements of primary voltage and reactive power flowing to the load and as another set of inputs, predetermine ranges establishing high and low limits for the voltage and reactive power. Base on these inputs, PLC connects or disconnects at least one shunt reactance to maintain the load voltage substantially constant.

Voltage fluctuation and drop on High Voltage AC system can be reduced by installing static reactive power generators (Some time known as VAR generators) on the grid substation or on the transmission/distribution lines [5]. Voltage regulation is based on the fact that essentially inductive transmission lines, transformers, voltage increases if capacitive current is injected in to the system by for example, connection of a shunt capacitor across the line/load. Alternatively voltage can be decrease by connecting and inductor across the line/load (or by removing a previously connected capacitor). Static VAR generators may be switched across the line using electromagnetic relay devices controlled by a predetermined timer or using a thyristor.

A problem facing many utilities is controlling shunt compensation on voltage buses especially where voltage is already regulated by an On Load Tap Change (OLTC) transformer. In an OLTC transformer, the low side line voltage delivered to the load is monitored and regulated by a conventional, fine tuning OLTC controller. Such a controller measures actual low side voltage, compares it with desired value, and then adjusts the position where the OLTC makes contact with high side OLTC transformer coil, e.g., via a control signal to a motorized tap changer. Typical OLTC transformers may have 16 to 32 tap positions, with each position being representative of some fractional portion of the rated voltage. Thus, for example, a one position tap change on a 32 tap OLTC transformer would cause a relatively small bus voltage change as compared with the rated or desired output voltage.

In operation, an OLTC transformer compares the secondary side voltage with both a minimum and a maximum voltage threshold. If either threshold is exceeded, a timer is started [10]. If the timer exceeds a predetermined delay period, the OLTC controller moves the tap to increase or decrease the secondary voltage as necessary.

OLTC transformers function well to effect small changes in voltage. However large voltage fluctuations required switching of shunt reactance to ensure that sufficient reactive power is provided to the system, end-users and customers such that secondary voltage can be held essentially constant. Since the OLTC controller is already monitoring and regulating the secondary distribution voltage, a shunt reactance control unit cannot also directly control that secondary distribution voltage. As a result, most utilities typically follow a fairly rigid load cycle to estimate roughly when a reactance element, such as a capacitor bank, should be switched in shunt across the load to offset a decrease in the secondary distribution voltage from an increased load.

After capacitor bank switching, The OLTC controller gradually adjusts the tap to return the low side voltage to the desired value. This rigid scheduling is far from optimal because it fails to accurately respond to actual system need (as opposed to scheduled estimates) and to detect abnormal system condition. On the other hand the power factor controlling of the shunt BSC bank too have similar effect because it did not take in to account of the low side bus voltage variation. Some time when these two controllers are responding there may be instances that some hunting of the two control system is experienced and this too not good for the system and the component itself.

1.2 Objectives

The present method seeks to overcome these problems by flexibly coordinating the OLTC fine tune controller and shunt reactance switching (BSC or Reactor). More specifically this method provides voltage and reactive power regulation using a programmable controller (PLC) or intelligent electronic device (IED) for controlling shunt capacitor switching in order to attain following exemplary objectives.

- Coordinate of the two controllers for making optimal use of the BSC bank VAR and transformer OLTC operations
- Maintain the distribution and transmission voltages at required set value;
- Track the station loading;
- Complements the action of the OLTC transformer;
- Provide sufficient dead-band and time delays to avoid hunting;
- Detect and compensate abnormal system conditions;

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1.3 Scope of work

This study seeks the following problems faced by the GSS. It is also noted that frequent tap operations of the transformer deteriorate the diverter switch of the OLTC which is much expensive unit to be replaced. On the other hand the VAR – Voltage Optimisation did not take in to account when operating these two controllers because they are responded by independently.

- Studying the existing Transformer AVR and BSC bank control system used in CEB Tx. Network;

- ➢ Check whether parameterizations have been properly done;
- ➢ Studying the available above controllers in the present market;
- ➢ Simulate the Q-V variation/requirement in grid by using PSCAD;
- ➢ Simulate the present Q-V hunting problem at 33kV bus bar with using actual loads;
- ➢ Check whether this could be overcome by changing all possible parameters in AVR and capacitor controller;
- ➢ Prove that communication is needed between AVR and controller to overcome the problem;
- ➢ Seek possibilities of designing a control module between two units;
- ➢ If it is not workable, then design a integrated control module to cater both *functions in a single module;*

1.4 Present problems in AVR and PF control in Transmission Grids Substations

Most of the utility systems that delivers power to customer, prime statutory obligation is to keep the voltage as much as possible at constant at delivery point of the substation. Voltage control mainly done by transformer AVR control which changes the turn ratio of the transformer primary winding. Some time there are GSS which installed a breaker switch capacitor to control VAR flow of the substation [2]. When these two systems responses to the different parameters they are finally adjust the voltage and VAR in the substation. Following operational constraints have to be taken in to account when studying the system as a unit [3].

- AVR system connected to transformers is controlled by system voltage;
- PF controller connected to capacitors is operated as per Q requirements;
- No coordination between AVR and PF controllers though they control system Q and V;
- Experience the hunting phenomena in both AVR and PF controllers;