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Coordination between SVC and OLTC for voltage control in Wind Energy Conversion System

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Abstract— *This paper proposes a coordinated control scheme between SVC and OLTC of transformer in the presence of distributed generation (DG). Here DG taken is WECS (wind energy conversion system) .The presence of DG would very disturb the power system operation and control mainly in distribution system. In the orthodox distribution system, the operation of equipment is based on the method that the voltage decreases along the feeder. This control is done by OLTC but due to the presence of DG power flow reversal occurs which leads to excessive operation of OLTC. The main aim of this work is to develop a method to coordinate SVC and OLTC so that they do not counteract each other operation and provide steady state voltage and reactive power control by reducing OLTC tap changing operations.*

Keywords— On Load Tap Changer (OLTC), Coordinated Control, emergency control, operating margin, SVC (Static VAR Compensator), DG (distributed generation), WECS (wind energy conversion system), induction generator (IG)

I. INTRODUCTION

In conventional distribution systems, power flows from generation to distribution end .But due to presence of DG, power flows from generation to distribution and distribution to generation. For the voltage and reactive power control in distribution system shunt capacitors, OLTC and SVC are engaged. Mostly three graded levels are made for voltage and reactive power control. The voltage control in distribution system is controlled by the volt/VAR control by time interval control [1]. The primary control is provided by automatic voltage regulators, this control is feasible in case of conventional distribution system and secondary control by locally operated OLTC and reactive power compensation. Meanwhile in tertiary control, a short time operation planning is developed to coordinate the action of primary and secondary control devices according to need. In power system reactive power compensation mainly static control is provided by Shunt Capacitor and Shunt Reactors whereas dynamic reactive power compensation is provided by SVC. WECS used IG [8].

In this paper, coordination of SVC and OLTC is shown in a proposed power system model. A DIGSILENT model is formed and the simulation is performed. The main aim is to reduce the OLTC tap positions and provide steady state voltage and reactive power control.

II. VOLTAGE CONTROLLING EQUIPMENTS

A. *SVC (Static VAR Compensator)*

The Static VAR Compensator (SVC), dynamically variable source of reactive power to stabilize the voltage, damp system instabilities. The SVC is used to regulate the system voltage; if the reactive power of the system is leading means capacitive then SVC consumes the reactive power. And in the case of lagging loads, it injects the reactive power in the system. Hence SVC provides the dynamic control in the system. The basic diagram is shown in fig.1. The main objective of these devices is to replace the existing slow acting machine-driven controls by rather fast acting power electronics control. The mechanical controls require power system operators and designers to provide generous margins to assure a stable and reliable operation of the system. Hence the system is unable to use its full capacity. However with the use of fast acting controls, power system limits can be reduced and power system capability could be more fully used. Machine-driven capacitors are the fixed source of reactive power replaced by the FACT device i.e. SVC [2].

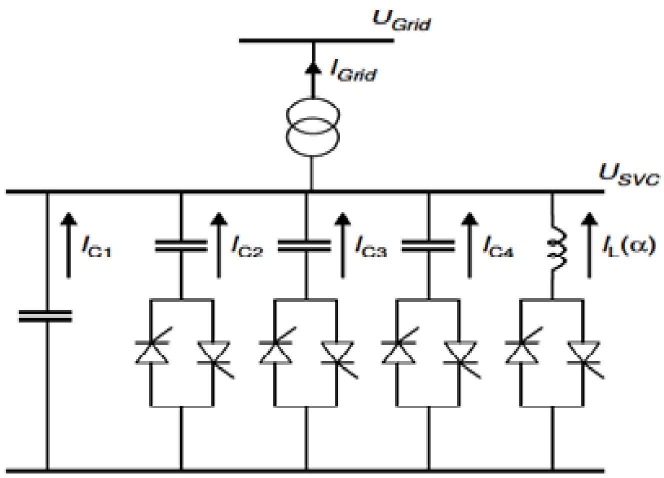


Fig.1 Basic diagram of SVC

B. *Tap Changing Transformers*

The simple but effective method to improve voltage stability is to prevent LTC transfer tap changing for low unregulated side voltage. A tap changer is a connection point selection mechanism along a power transfer winding that allows a variable no. of turns to be selected in discrete steps. A transformer with a flexible turn's ratio is formed, allowing stepped voltage regulation of the output. The tap selection may be prepared via an automatic or manual tap changer mechanism. Here automatic tap changer is used. The possible tap ratio change is -10% to +10%. 0.01% increase in voltage per step. The OLTC time dead band is decided to tackle the different disturbance conditions. OLTC transformers are used to damp power-angle oscillations [3].

III. PROPOSED COORDINATING METHODOLOGY

For the voltage control in WECS, the coordination of OLTC with the reactive power compensating FACT devices such as SVC is essential. The static control can be provided by the capacitors [6]. The dynamic control is provided by the Static VAR Compensator. The main method used in present paper is discussed below:

A. Coordination Of SVC and OLTC

This coordination is essential for the stability of the system. The installation of a SVC at a substation has to be coordinated with the available substation voltage and reactive power control equipment, e.g. OLTC and mechanically switched capacitors, especially for the steady state voltage and reactive power control, in order to get the maximum benefit from the SVC installation [5]. This is because a SVC provides continuous control with a rapid response. On the other hand, the OLTC and the capacitor control the bus voltage and the reactive power in a stepwise manner with much longer time delays. If the SVC is not coordinated with the OLTC and the capacitor, the OLTC and the capacitor will be unable to participate in controlling the voltage and the reactive power, except when the SVC has reached its limit. When the SVC reaches its limit, it will lose its capability to dynamically control the voltage or reactive power flow during an emergency. Different methods have been presented to coordinate the coordination. The SVC controls the load Centre voltage, according to the line drop compensation principle, while the OLTC controls the substation Secondary bus voltage. Similarly, the information from the SVC is sent to the OLTC. This information is then used by the OLTC to adaptively change its time delay operation. The OLTC dead band is set large than the SVC dead band. By using this coordination, neither the OLTC nor the SVC will operate for a voltage variation within the SVC dead band. If the voltage exceeds the OLTC dead band (but is still within the SVC dead band) for a time longer than the OLTC time delay, the OLTC will firstly operate to bring the voltage back within the OLTC dead band, and then the SVC will dynamically make an adjustment. If the voltage goes outside the SVC dead band, the SVC will dynamically operate to bring the voltage back to the OLTC dead band. The no. of OLTC operation decreases. In this dissertation mainly this method is used. The coordination of Static VAR Compensator and On Line Tap Changer is performed for the voltage controls in the case of wind generation i.e. WECS (Wind Energy Conversion System).

B.Proposed Single Line Diagram

A power system model is taken. It includes 70/10 KV transformer, substation capacitors, feeder capacitors and the wind generators at the load end as DG. A SVC having capacity -100 to 200 MVAR is installed at the substation bus. [4]-[7]. The single line diagram can be shown in the figure:

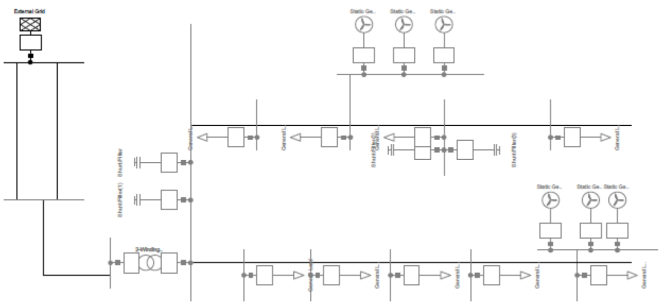


Fig.3 Single line diagram of proposed model

C. *DIGSILENT MODEL*

The DIGSILENT Power factory 14.1 is used for load flow calculation and simulation process.

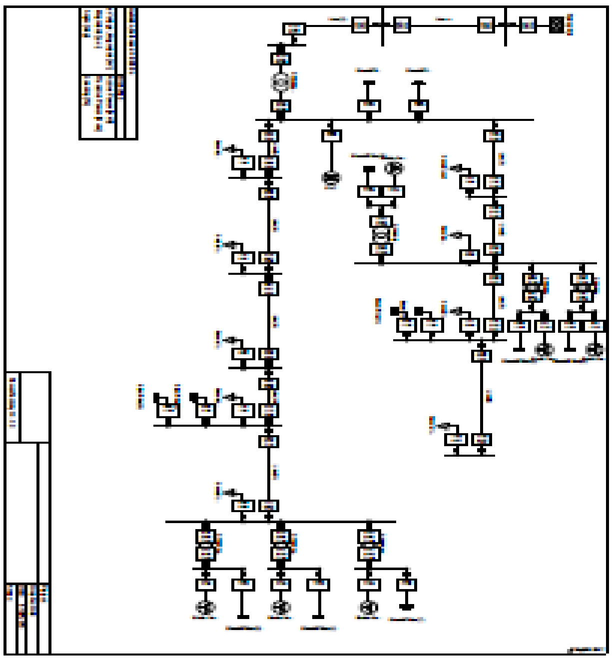


Fig.4 DIGSILENT MODEL

IV. SIMULATION RESULTS

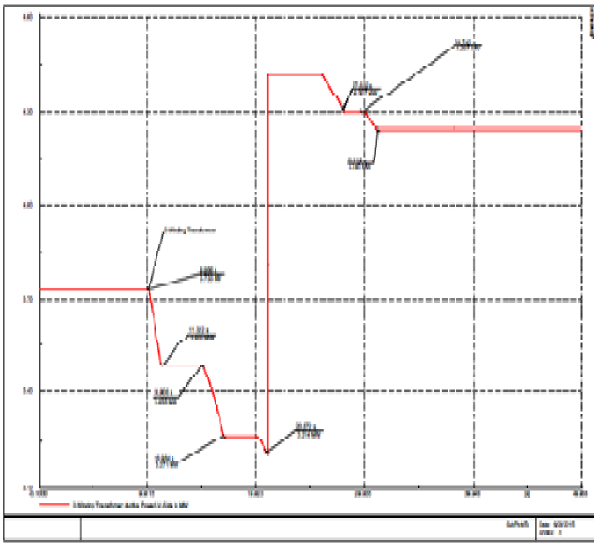
The DIGSILENT model is formed from the above single line diagram. The load flow analysis is performed for this model. The simulation is performed for the 50 sec and the simulation plots are observed for the system results. The tap position plot is selected for the desired result.

A. Simulation Plots

The simulation plots for the reactive power, active power, and tap positions is shown in fig. 5-10 given below:

1. *Active power*

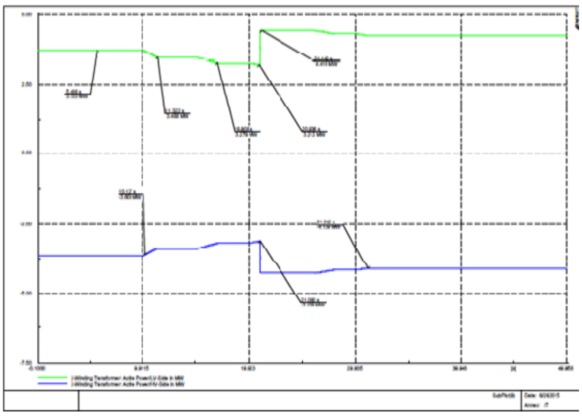
Active power



Time

Fig.5 Two winding transformer active power LV side

Active Power

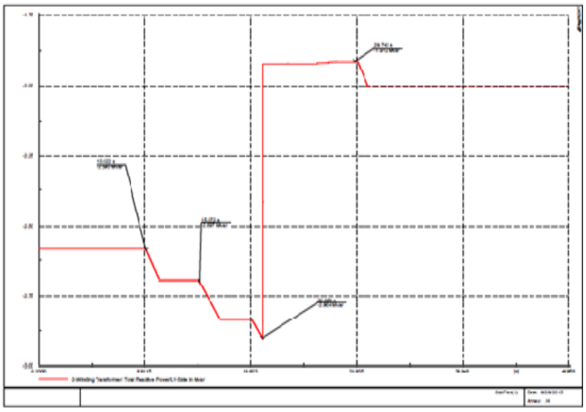


Time

Fig.6 Two winding T/F active power HV and LV side

2. Reactive power

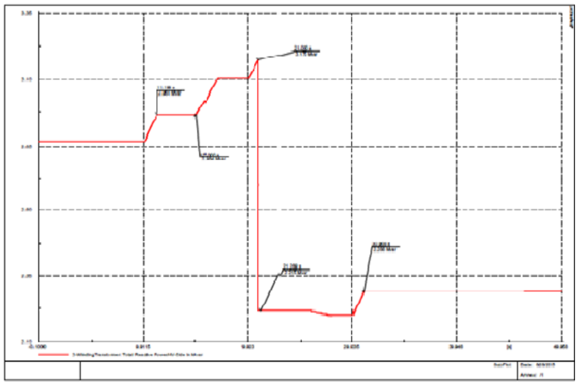
Reactive Power



Time

Fig. 7 Two winding T/F reactive power LV side

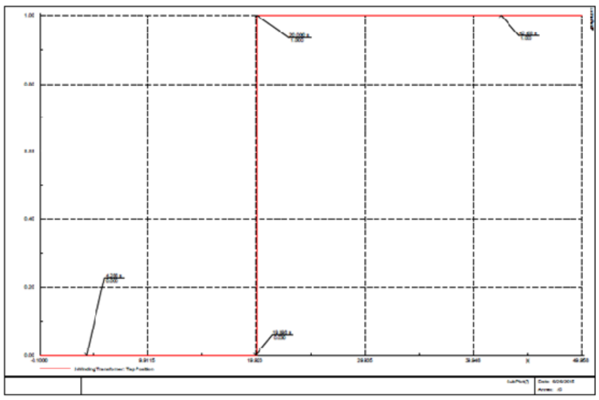
Reactive power



Time

Fig. 8 Two winding T/F reactive power HV side

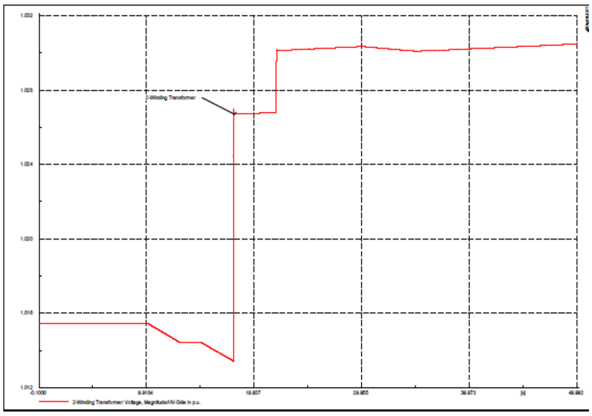
Tap position



Time

Fig.9 Tap position

Voltage



Time

Fig.10 Voltage HV side of two winding T/F

V. CONCLUSIONS

The paper presents the coordination of OLTC with SVC for voltage control. A proper coordination among OLTC and reactive power compensator has been presented. The dead band of the OLTC is adjusted more than the compensator i.e. SVC. In the wind system variable output is provided so the SVC handles the disturbances in the initial stages .if the system variations are not controlled the tap position of OLTC changes and controls the system. In the model taken for study the, the OLTC taps were changed for one time.

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