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Voltage Stability Analysis using Voltage Dependent Load Model

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ABSTRACT

Load models play an important role in power system planning. They let us decide the reactive power requirements of a power system. Hence they are considered a requirement in power system voltage stability studies. Voltage stability defines the ability of a power system network to maintain stable voltages at all the buses under normal and abnormal operating conditions. The research presented as part of this paper, deals with analysis of Voltage Dependent load models for voltage stability studies. The precision of the results are directly related to the load models used in this analysis. The method is analyzed using continuation power flow routine backed by fast decoupled iterative computational approach. Thyristor Controlled Switched Capacitor is used to address the voltage instability caused by the load variations using search procedure. The stability analysis is performed through quantitative simulation on standard IEEE 14 bus system.

KEYWORDS: *Continuation Power Flow, Search Procedure, Voltage Stability, Voltage Dependent Load*

I. Introduction

Load Stability or Voltage Stability is one of the concerns in power systems which are heavily loaded, faulted or having a shortage of reactive power [1]. Load imbalances are one of the many causes of reactive power shortages. During such system disturbances, system stability is imperilled. The probability of moving to the global instability increases [2]. This will usually result in a blackout unless some precautions are considered. The problem of voltage stability concerns the whole power system, although it usually has a large involvement in one critical area of the power system. Power System Load Modeling is a technique used to model the power system and essential for stability assessments. In this paper, we are trying to analyze Voltage Dependent load model for voltage stability studies. Different load models would greatly affect voltage stability aspect of an interconnected power system. We are using continuation power flow backed by BX based fast decoupled load flow to analyze the effects of the above load model and compare the results. Flexible AC Transmission Systems in short FACTS controllers are used to control the variables such as phase angle and voltage magnitude at a given bus and line impedance where a voltage collapse is observed [4]. Introducing FACTS controllers is the most effective way for utilities to improve the voltage profile and voltage stability margin of the system. As the size and the cost of the FACTS devices are high, an optimal location and size has to be identified before they are actually installed.

II. Problem Formulation

Load modeling is essential for stability studies in order to address instability issues for any power system operating in long run. Load modeling has been addressed in [8] using cat swarm optimization for different static load models with a solution of UPFC in identifying its optimal size and location. Accurate modeling of loads continues to be a difficult task due to several reasons. Lack of precise information on the composition of the load, changing of load composition with time like day and week, seasons, weather, through time and more influence the load models. Electric utility analysts and their management need evidence of the benefits in improved load representation to justify the effort and expense of collecting and processing load data. Also to modify computer program using load models. The interest in load modeling has increased in the last few years, and power system load modeling has become a new research area in power systems stability [5]. Several studies have reported the critical effect of load representation in voltage stability studies. This leads to identify accurate load models than the traditionally used ones. Though ours is not the first paper to test various static load models for determining the voltage stability limits of a power network, it happens to readdress stability issues related to Voltage Dependent load model for voltage stability. We present a simple binary search procedure to locate and size Thyristor Controlled Switched Capacitor to address load instability caused by Voltage Dependent load model.

III. MATERIAL

A. *IEEE 14 Bus Network*

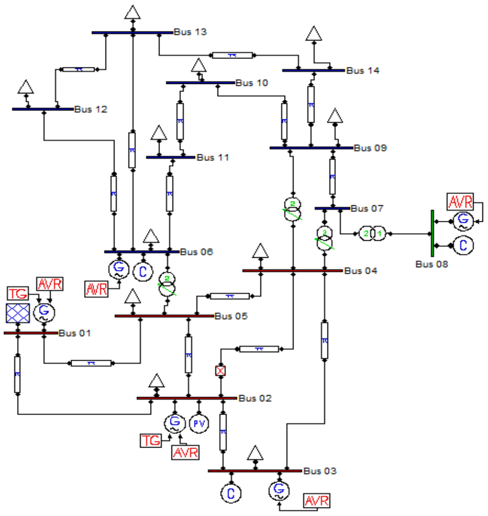

Figure 1: IEEE 14-bus Network

We are testing our load model on IEEE 14 bus power network as shown in Figure 1. The test system consists of twenty one branches, fourteen buses, eleven loads totalling 259 MW and 81.4 MVAR. The tolerance for bus voltages in P.U. was assumed to be 5%. Bus 1 is assumed slack. The anlysis is peformed in power system analysis toolbox [6]. We are applying continuation power routine with fast decoupled iterative approach [3]. The number of iteration limit in powerflow routine is set to twenty count.

B. *Voltage Dependent Load model*

A voltage dependent load is an electrical device whose power consumption changes with the voltage being supplied to it. Examples for these loads are the most common types of incandescent lamps, standard tungsten filament lamps, tungsten halogen and reflector lamps and motor load.

C. *Thyristor Controlled Switched Capacitor*

TCSC shown in figure 2 is series type compensator, used to reduce the possibility of voltage collapse. TCSC is used to improve power flow capability of the line as well as to enhance system stability. To reduce the series reactive impedance and to minimize receiving end voltage variation series capacitive compensation is used.

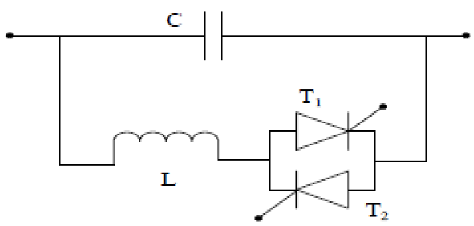

Figure 2: Structure of TCSC

D. Flow chart: Binary Search

The flow chart for binary search approach [7] is presented in figure 3.

IV. IMPLEMENTATION, RESULTS & DISCUSSION

The Voltage Dependent loads were installed at buses 9 to 14. Here we observe a decline in voltage magnitude as a result of reactive power deficit after installation of Voltage Dependent loads as compared to a case without these loads. As can be seen from table 1 and figure 4, we observe an improvement in bus voltage magnitude profile after the placement of TCSC using binary search approach. Also, observe similar kind of decline in maximum loading limit before and after placement of Voltage Dependent loads. The loading limit is enhanced using placement of TCSC in this case to improve the steady state stability limit at the heavily loaded power system buses. For pre-disturbance condition, the loading limit was 2.375 which were improved to 2.865. We observe an increase in steady state limit of the system.

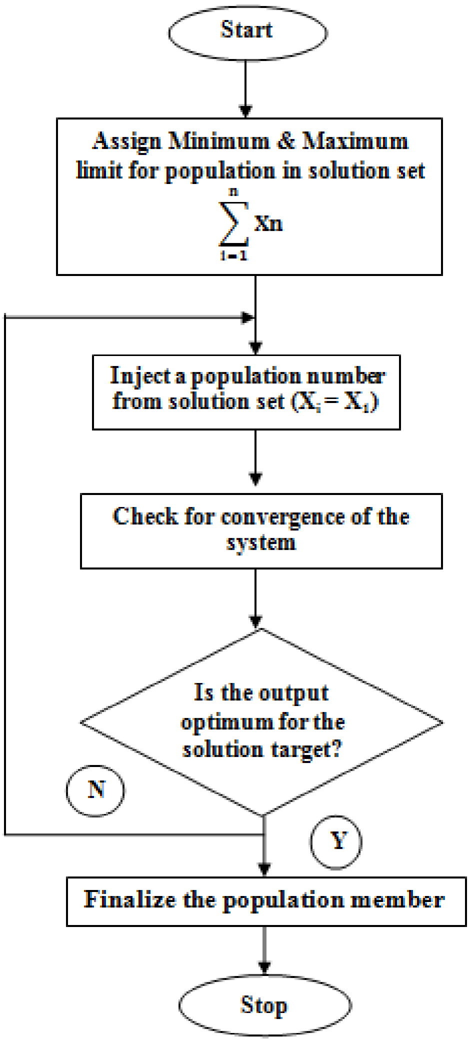

Figure 3: Binary Search Procedure

Table 1: Voltage Magnitude Profile

Bus No.	Voltage Profile	Voltage Profile with VD Loads	Voltage Profile with TCSC
1	1.0572	1.0572	1.0572
2	0.93175	0.88923	0.91217
3	0.85811	0.74095	0.76217
4	0.77903	0.74086	0.76347
5	0.79614	0.76757	0.76722
6	0.82196	0.83625	0.83433
7	0.79451	0.80221	0.81243
8	0.93818	0.94304	0.94882
9	0.72084	0.74587	0.75282
10	0.71213	0.74231	0.74699
11	0.75452	0.77959	0.78075
12	0.7663	0.79402	0.79131
13	0.7445	0.77805	0.77566
14	0.66135	0.71354	0.71458

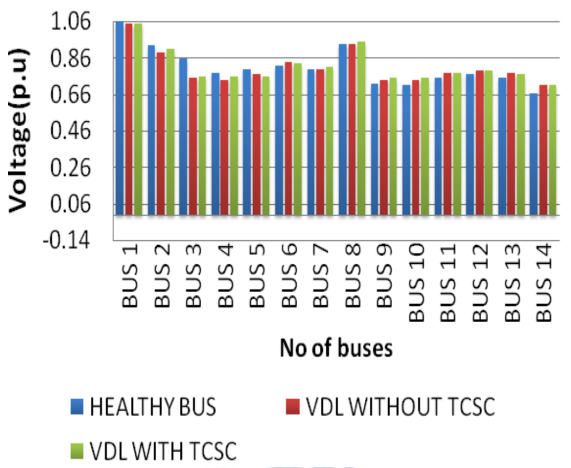

Figure 4: Voltage Magnitude Profile Comparison

V. Conclusion and Future Scope

The work presented here details a load model study for voltage stability using Search Procedure. The case study considered was modelled using Voltage Dependent static loads and analyzed for their performance in terms of voltage magnitude profile and maximum loading parameter. The inclusion of load models in the power system causes a decline in voltage profile as a result of reactive power deficit. A method is showcased for determination of the optimal location and size of TCSC to enhance the voltage stability. This method is based on Binary Search. This algorithm is simple in implementing compared to rigid Artificial Intelligence techniques. It is capable and flexible to make the final decision about the location of the FACTS controller. The future scope of this work deals with the testing of above techniques for higher order IEEE case studies and practical networks.

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