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LOAD MODELING EFFECT ON VOLTAGE STABILITY OF LARGE SCALE POWER SYSTEMS USING ENERGY FUNCTION TECHNIQUE

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by

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APPROVAL SHEET

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تأثير نمذجة الأحمال على استقرار الجهد لأنظمة القوى الكهربيةكبيرة السعة باستخدام أسلوب دالة الطاقة

تجتـذب مشـاكل اسـتقرار الجهـد اهتمامـا كبـيرا هـذه الأيـام نظـرا لأهميتهـا فى الاستخدامات الكهربية وأيضا بسبب العوامل المترتبة عن عدم استقرار الجهد أو ما يعرف باسم " تقـوض الجهـد".تم استخدام أسلوب دالـة الطاقـة فى بحـوث سـابقة لاستنتاج مقياس لاستقرار الجهد لنظم قوى كهربية متعددة الماكينات لأحمال ذات قـدرة ثابتـة.تقـدم هـذه الرسـالة دراسـة لتـأثير النمـوذج المختـار لتمثيل الأحمال ذات المعاوقـة الثابتـة و ذات التيـار الثابـت و ذات القـدرة الثابتـة علـي اسـتقرار الجهـد. تم تطبيـق المعـادلات المقترحـة علـى نظـام قـوى اختبـارى ثم علـى نظـام قـوى فعلـى يمثـل الشبكة المشتركة بين الولايات المتحدة و كندا

فى حالة الأحمال ذات القدرة الثابتة فإن الزيادة المتدرجة في الحمل يتبعها نقصان في استقرار جهد النظام حتى الوصول إلي نقطة الانهيار.أما بالنسبة للأحمال ذات النسبة الأكبر من المعاوقة الثابتة و التيار الثابت فإن الزيادة المتدرجة في الحمل يتبعها نقصان في استقرار الجهد حتى الوصول أولا إلى نقطة حمل حرج (أقصى حمل) و التي تحدث عند مستوى جهد أقل نسبيا من الجهد المقنن للنظام فى الأداء الطبيعي.فى حالة زيادة الحمل بعد هذه النقطة ، يبدأ الحمل الفعلي للشبكة في النقصان نتيجة اعتماد هذه النوعيـة مـن الأحمـال علـي مسـتوى الجهـد و يسـتمر هـذا الانخفـاض فى الحمـل حـتى الوصول إلى نقطة الانهيار.

تم تطبيق طريقة الشبكات العصبية الاصطناعية لدراسة استقرار الجهـد و قـد تم أولا اختيار مناسب للشبكة العصبية الاصطناعية المناسبة لهذا الغرض و من ثم تم تدريبها للقيام بهذه المهمة و أظهرت النتائج تطابقا كبيرا مع النتائج أسفرت عنها دوال الطاقة التى سبق استخدامها

LOAD MODELING EFFECT ON VOLTAGE STABILITY OF LARGE SCALE POWER SYSTEMS USING ENERGY FUNCTION TECHNIQUE

Voltage stability problems are now taking much more consideration due to its importance to the electric utility industry and due to the major consequences related to the voltage instability. The energy function technique has been previously applied to investigate the voltage stability of power systems for constant power load model only.

This research deals with the effect of load modeling(constant impedance, constant current and constant power load models) on voltage stability studies. The proposed formulation has been applied to both a test system and Ontario-Hydro real power system.

For the constant power load model, the gradual load increase is followed by a decrease in the system voltage stability until finally reaching the collapse point.

For higher constant impedance and constant current load percentages, and especially constant impedance, the gradual load increase is followed by a decrease in system stability until reaching first a critical power level (maximum power).This maximum power occurs at a voltage level not much lower than the system nominal value.

Any further increase of load fails to raise the system power beyond that critical power level (max. power). On the contrary, the system total power starts to decrease due to the dependency of such loads on the voltage levels, which continues dropping until reaching the collapse point at a power level very much lower than the maximum power.

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Chapter 1

INTRODUCTION

1.1 Power System Stability Problem

An electrical power system consists of many individual elements connected together to form a large complex system capable of generating, transmitting and distributing electrical energy over a large geographical area.

Power system stability is defined as the ability of the system to respond to any disturbance from normal operating condition and return back to the same or another normal operating condition. For three phase power systems, these disturbances can be divided into balanced and unbalanced disturbances[1].

- Unbalanced disturbances are usually caused by short circuit faults affecting only one or two of the phases (faults to ground are the most common).
- Balanced disturbances result from transmission outages and from load changes as well as symmetrical short circuit faults.

The study of power system stability defines the system behavior during these disturbances, these studies can be classified into two major areas [2]:

(a) Rotor angle stability.
(b) Voltage stability.

1.1.1 **Rotor angle Stability**

Transient and dynamic synchronous stability of power system generators are related to the motion of rotating masses and their capability to operate without loss of synchronism after large or small disturbances respectively.

(a) Transient stability analysis.

Transient stability analysis refers to the stability of the power system subject to a sudden and severe disturbance. For such cases, the system must be described by differential equations that may be nonlinear. Typical examples resulting in transient stability analysis are transmission system faults, Loss of generating units or line switching

(b) Dynamic stability analysis.

Dynamic stability studies are less extensive in scope and involve one or just a few machines undergoing small and sudden changes in operating conditions. Also, in dynamic studies the system equations may be linearized around the operating point.

1.1.2 **Voltage Stability**

It is the ability of the system to provide adequate reactive power support, under all operating conditions, in order to maintain load voltage magnitudes within specified limits in steady state(5%) and in transient conditions(10%).

All traditional power system stability studies were concerned with synchronous stability and were simply denoted by power system stability studies. Voltage stability problems are now taking much more consideration due to its importance to the electric utility industry.

1.2 Voltage Stability Study

Voltage stability is a subset of the overall power system stability. A power system is said to be voltage stable if (at a given operating state) is subjected to a given disturbance, the voltage near the loads approaches a post-disturbance equilibrium point.

On the other hand, a power system originally operating at a steady state operating condition and subjected to a given disturbance is said to have a voltage collapse, if the equilibrium voltage after the disturbance is found to be below acceptable limits. Several factors contribute to this voltage collapse[2].

- Stressed power systems.
- Inadequate reactive power resources due to excitation system limits.
- Load characteristics at low voltage are crucial and differ from those at normal values.
- Transformers tap changers false response to demand side voltage magnitude

- Unwanted relay operation during decreased voltage conditions.

The load type mainly affects voltage instability, constant active power loads are the loads which lead to voltage instability, constant impedance loads do not usually lead to voltage instability, while constant current loads may lead to voltage collapse to certain low values. (i.e.: Stiff loads are the source of voltage instability while soft loads are usually not).

System dynamics influencing voltage stability are usually slow. Therefore, it can be analyzed using static methods which examine the presence of the equilibrium point represented by a specified operating condition of the power system. Static analysis can also be used to determine stability margins that show how close the current operating point to the voltage collapse point.

Dynamic analysis, on the other hand, are useful for detailed study of specific voltage collapse solutions, co-ordination of protection and controls and can also examine whether and how the steady state equilibrium point will be reached.

In recent years, Transient and voltage instability has been responsible for several major network collapses such as [3]:

Transient Instability

- USA Northeast blackout of November 9, 1965.
- Con Edison (New York) blackout of July 17, 1977.

Voltage Instability

- Swedish system disturbance of December 27, 1983.