POWER SYSTEM MODEL TO ANALYZE THE FREQUENCY STABILITY OF THE SRI LANKAN POWER SYSTEM DUE TO WIND POWER PENETRATION LEVEL

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Degree of Master of Science

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Dissertation submitted in partial fulfillment of the requirements for the Degree Master of Science in Electrical Installations

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DECLARATION

"I declare that this is my own work and this dissertation does not incorporate without acknowledgment any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgment is made in text.

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The above candidate has carried out research for the Masters Dissertation under my supervision.

Signature of the supervisor: Date:

(Prof. J.R. Lucas)

Signature of the supervisor: Date:

(Mr. M.L. Weerasinghe)

ABSTRACT

Power System Model to Analyze the Frequency Stability of the Sri Lankan Power System due to Wind Power Penetration Level

The National Energy Policy published by the ministry of power and energy stipulated that by year 2016, energy contribution from non conventional renewable energy dispatch to be at least 10% of total generation. Hence relevant government organizations have introduced various incentives to the private sector to do develop the renewable energy sources in the country. This has led to various research activities by entities to study the economic and technical aspects.

The incentive provided for the wind power development is the form of tariff by GOSL i.e. the cost at which utility to purchases from the wind developer is the highest among other NCRE's. Hence there is lots of interest to develop wind power. Wind power output varies depending on the wind speed and also due to uncontrollable nature of its prime mover. It is necessary to study to impact of wind power in the whole system as it will affect the system frequency.

This dissertation concentrates on two aspects namely development of power system model to analyze effect on system frequency due to supply- demand unbalance and determination of wind penetration level to the Sri Lankan power system which does not cause significant frequency variations. The Total power system is modeled as a single machine connected to a load. For a more accurate model the generator is split into hydro and thermal separately. The frequency controller of the power system is model explicitly to the power system model. By feeding wind power output variation to the model externally as electrical power change in the system, steady state frequency deviation could be obtained. If we have accurate wind turbine characteristic and the wind speed variation approximately in 1 min interval where wind turbines are located, maximum wind penetration level, which does not cause frequency variations beyond 50 Hz $\pm$ 1% can be found from this model. This will be the amount of wind power that system could absorb without having frequency instability but will not be the maximum wind penetration level of the Sri Lankan power system. Normal practice is to operate system with 5% spinning reserve and keep all the generation except frequency controlling machine at free governor operation with 5% speed droop. Droop setting of frequency controlling station is maintained at 2%. These values are included into model to study the impact of frequency deviation. Analysis of the most economical wind penetration limit for the Sri Lankan power system with the required network modification is beyond the scope of this research.

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LIST OF ABBREVIATIONS

Abbreviation	Description
NCRE	Non Conventional Renewable Energy
DFIG	Doubly Fed Induction Generator
IPP	Independent Power Producers
HRSG	Heat Recovery System Generator
AGC	Automatic Generation Control
DFR	Digital Fault Recorder
SCADA	Supervisory Control And Data Acquisition
WTG	Wind Turbine Generator
LFC	Load Frequency Control
GSS	Grid Sub Station

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