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

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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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September 2012
DECLARATION

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

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(Prof. J.R. Lucas)

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(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 ± 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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I would like to take this opportunity to extend my sincere thanks to Deputy General Manager (System Control Branch), Chief Engineer (System Operation) and Chief Engineer (Operation Planning) for giving me their cooperation to conduct my research successfully. I deeply indebted to my colleagues in the system control branch, Ceylon Electricity Board giving me an excellent support to carry out the experiment in the power system to figure out the power system parameters.

In particular, I am thankful to officers in transmission planning branch, Ceylon Electricity Board for giving the required data for the power system modeling.

Also I am grateful to the Sustainable Energy Authority for giving me wind speed data with low sampling intervals to make the research more effective.

I wish to express my appreciation to Electrical Manager in, Seguwanthive wind power (pvt) ltd for giving me guidance on wind power modeling.

This dissertation would not have been possible unless the understanding, encouragement and patience and support provided my wife. Therefore I owe my deepest gratitude to my wife.

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