SELF-TUNING CONTROL OF WIND-DIESEL POWER GENERATION SYSTEMS USING ENERGY STORAGE DEVICES

by

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Submitted
in fulfilment of the
requirements of degree of
Doctor of Philosophy

to the

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

July, 1997

CERTIFICATE

It is certified that the thesis entitled '**Self-tuning Control of Wind-Diesel Power Generation Systems using Energy Storage Devices**' being submitted by ***Mr. Mairaj Ud-Din Mufti*** is worthy of consideration for the award of the degree of **Doctor of Philosophy** and is a record of original bonafide work carried out by him under our guidance and supervision. The thesis, or any part thereof, has not been submitted to any other University or Institute for award of any degree or diploma.

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ACKNOWLEDGEMENTS

I have great pleasure in expressing my deep sense of gratitude, indebtedness and thankfulness to my thesis supervisors, Prof. R. Balasubramanian and Prof. S.C. Tripathy, for their invaluable guidance, continual encouragement and support at every stage of this work. No amount of words can really suffice in expressing my sincere thanks to them.

It is my privilege to work with Prof. R. Balasubramanian, who has been the principal source of motivation behind the present work. His insightful suggestions have helped me at every stage of this work.

I am especially indebted to Prof. S.C. Tripathy for his useful suggestions throughout the course of this work. A good amount of work in this thesis evolved from stimulating discussions with him.

Thanks to my friends and colleagues for their help at various stages of the present work, particularly to mention the names, Sreejayan, Shabir Ahsan, Rais ud-din Ansari, Mansoor Ali Khan and Amit Jain.

I express my gratitude to the technical staff of power system laboratory at Centre for Energy Studies, Mr. Dalel Singh and Mr. Ram Kumar for their help, co-operation and hospitable attitude.

I express my sentiments to my mother who passed away during my Ph.D programme at I.I.T. Delhi. The patience and cooperation extended throughout my work, by my wife, is greatly appreciated.

I am also thankful to Mr. Santhosh and Mr. Thomas for neat and careful typesetting of the thesis.

Mairaj ud-Din Mufti

ABSTRACT

Stand - alone power systems like wind-diesel ones are becoming increasingly important for supplying electricity to remote areas which are not connected to main electricity grids. Such situations are obtaining in many developing countries. One major problem with these installations is that the overall system inertia is relatively small, consequently they are very sensitive to load variations. Further in these systems, the wind turbines usually drive induction generators. As the reactive power drained by induction generators is coupled to the active power generated by them, the ever changing wind power results in variations in active as well as reactive powers. These variations interact with the system and degrade the quality of power supplied, by causing wide variations in voltage and frequency. These systems therefore, require special control strategies, in order to provide good quality service to the consumers. Use of short term energy storages, static VAR compensators and load management techniques have been suggested by various authors for these systems.

A detailed literature search shows that there is a great need to improve the control strategies, employed in these systems to obtain good performance from them. As both the system frequency as well as voltages at various buses in these systems are affected on the occurrence of a disturbance, fast acting energy storage units capable of exchanging active and reactive powers simultaneously with the system are

more appropriate candidates to achieve this end. In this thesis fast acting energy storage devices like Superconducting Magnetic Energy Storage (SMES) and Battery Energy Storage Systems (BESS) are proposed for wind-diesel systems.

The modelling of hybrid wind-diesel-energy storage systems and design of effective control strategies for simultaneous voltage and frequency control of the system under typical disturbances is the main objective of the thesis.

A linearized model of the wind-diesel-SMES system is developed around an operating point and is used to study some inherent dynamic characteristics of the hybrid system. Eigen-values of the system with and without SMES unit have been studied and effects of various types of controls on the eigen value locations are investigated.

Keeping in view, the multi-variable, non-linear and time varying nature of the hybrid system, a multi-variable self-tuning regulator (STR) is proposed for the control of the SMES unit. The STR uses local measurements of frequency and voltage at induction generators' terminal bus for controlling the SMES unit. The effectiveness of the proposed scheme in dealing with load as well as wind perturbations is illustrated.

A wind-diesel system with a blade pitch controller for wind turbine is also studied in one of the chapters. Self tuning regulators are designed for the pitch control as well as for the diesel governor in this case. Effectiveness of introducing an SMES unit with a facility to exchange active power with the system is also studied. A three-input three-output STR is used to control the wind-diesel-SMES system in a coordinated fashion.

A Battery Energy Storage System (BESS) incorporating a pulse width modulated (PWM) inverter, is considered for simultaneous exchange of real and reactive powers with the system. The fuzzy proportional (P) - like and proportional integral (PI) - like controllers are proposed for BESS control.

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