DEVELOP AN INTEGRATED MICRO-GRID CONTROL PLATFORM FOR RESILIENT AND SUSTAINABLE ENERGY MANAGEMENT IN DISTRIBUTION NETWORKS

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Master of Science (Major Component of Research)

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1. DECLARATION

I declare that this is my own work and this thesis/dissertation does not incorporate without acknowledgement 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 acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

31/08/2024

Signature: Date:

The above candidate has carried out research for the PhD/MPhil/Masters thesis/dissertation under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of Supervisor:

Signature of the Supervisor: Date:

2. DEDICATION

I dedicate this detailed thesis for the future research endeavors in electrical engineering as a motivation. And I also dedicate this for the people who were with me and supported me in every second to go to the top.

3. ACKNOWLEDGEMENT

Completing this research was not easy as well as single-handed task. First, I need to thank Prof. K.T.M.U. Hemapala, Dean, Faculty of Engineering, who recruited me as a researcher for Smart Grid Research Group. His advice always drove me through this research journey and motivated me to work in the research and development field. Simultaneously, I want to thank Prof. Lidula N. Widanagama Arachchige and Dr. W.D. Prasad, who evaluated my research. Their advice, suggestions and comments were always valuable for me to shine up my research quality.

It is my duty to acknowledge my parents and sister, who believed in me that I can successfully complete this research and supported me every day. And also, I need to remember my batchmates and friends, who supported and guided me, especially the two research motivated academics from civil engineering department, Mr. Nipun De Zoysa and Mr. Uditha Dinith Weerasinghe.

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Thank you

M.A.S. Wasitha

4. ABSTRACT

Microgrids are emerging throughout the world electrical engineering community as a feasible and more practical technical solution for renewable energy integration and small-scale harvesting. Microgrids are local area power networks that can be either connected or isolated from the grid. Microgrid controlling is a necessity in operation of microgrid due to the requirements of the grid stability, energy management as well as improving local controllability. The principle of this research is to develop microgrid controller, which follows resilient and sustainable energy management principles for a research level microgrid setup inside the UOM-LECO Smart Grid Research Lab. After a thorough literature review, a control platform with an energy management system was proposed which maximizes PV harvest and directs it to the customers. And the research contains simulated microgrid development with controls to implement its control strategies, using real-time digital simulator (RTDS) as a novel technological tool introduced to Sri Lanka. A new addition of hardware development is proposed to the lab to setup microgrid platform inside the lab environment to do further research in microgrid controlling. Simulation results were taken accordingly to claim the functioning of the control platform as well as the results are validated under the functioning of hardware platform.

Keywords: Microgrids, renewable energy, real-time digital simulators, sustainable energy management, resiliency

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8. LIST OF ABBREVIATIONS

Abbreviation	**Description**
DER	Distributed Energy Resources
PV	Photo Voltaic
DSO	Distribution System Operator
MPPT	Maximum Power Point Tracker
DC	Direct Current
AC	Alternating Current
PMSG	Permanent Magent Synchronous Generator
BESS	Batttery Energy Storage System
BMS	Battery Management System
MG	Microgrids
UOM	University of Moratuwa
LECO	Lanka Electricity Company
SGRL	Smart Grid Research Lab
RTDS	Real Time Digital Simulator
PCC	Point of Common Coupling
AI	Artificial Intelligence
GFI	Grid Forming Inverter
PLL	Phase Locked Loop
EMS	Energy Management System
ESS	Energy Storage System
FIS	Fuzzy Inference Systems
MILP	Mixed Integer Linear Programming
MPC	Model Predictive Control
DR	Demand Response
SDN	Software Defined Networks
RTS	Real Time Simulations
AVM	Average Value Model
AH	Ampere Hours
IGBT	Insulated Gate Bipolar Transistors
MW	Mega Watts
SOC	State Of Charge
TCP/IP	Transmission Control Protocol/ Internet Protocol
SCADA	System Control And Data Acquisition

9. LIST OF APPENDICES

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