VOLTAGE BASED COORDINATING CONTROLLER MODELLING AND PERFORMANCE ANALYSIS FOR ISLANDED RENEWABLE ENERGY SYSTEM

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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ABSTRACT

A multilevel voltage-based coordinating controller is responsible to coordinate, switch, manage and effectively distribute generated energy from two renewable energy resources (Solar and Wind) where both generate energy simultaneously but performing different roles in this proposed system. The proposed controller uses the multilevel voltage sensing technique to sense and measure the output voltage from solar and wind energy resources. Then the controller uses the output voltage information from solar and wind to supply to the connected load or charge the battery energy storage system to store the excessive energy generated by either source which not connected to the load. Therefore, developing the coordinating controller using multilevel voltage sensing provide assistance to effectively switch, manage and distribute all the generated energy for efficient utilization. The controller also is responsible to smoothly coordinate and switch between renewable energy resources and properly manage the battery energy storage system charging during availability of excessive energy from either resource. The proposed project will be modelled and simulated using the SIMULINK/MATLAB and the simulation results of the system will be used to validate the developed methodology.

ABSTRAK

Alat kawalan penyelarasan menggunakan pengesanan voltan bertingkat bertanggungjawab untuk menyelaraskan, menukar, mengurus dan mengagihkan secara efektif tenaga yang dihasilkan dari dua sumber tenaga boleh diperbaharui (solar dan angin) di mana kedua-dua menghasilkan tenaga secara serentak tetapi melaksanakan peranan yang berbeza dalam sistem yang dicadangkan ini. Alat kawalan yang dicadangkan menggunakan teknik pengesanan voltan bertingkat untuk mengesan dan mengukur voltan keluaran dari sumber solar dan tenaga angin. Seterusya, alat kawalan ini menggunakan maklumat voltan keluaran dari solar dan angin untuk membekalkan kepada penggunaan beban yang disambungkan atau mengecaj sistem penyimpanan tenaga bateri untuk menyimpan tenaga yang berlebihan yang dijana oleh sumber yang tidak bersambung dengan penggunaan beban. Oleh itu, membangunkan pengawal selia penyelarasan menggunakan pengesana voltan bertingkat menyediakan bantuan untuk menukar, mengurus dan mengagihkan semua tenaga yang dihasilkan untuk penggunaan yang cekap. Alat kawalan juga bertanggungjawab untuk menyelaraskan dan menukar antara sumber tenaga boleh diperbaharui dengan lancar dan menguruskan sistem storan tenaga bateri dengan betul semasa kehadiran tenaga yang berlebihan dari salah satu sumber

tenaga. Projek yang dicadangkan akan dimodelkan dan disimulasikan menggunakan MATLAB/SIMULINK.

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LIST OF SYMBOLS AND ABBREVIATIONS

RER	:	Renewable Energy Resource
AC	:	Alternating Current
DC	:	Direct Current
EMS	:	Energy Management S
CEMS	:	Centralized Energy Management System
DEMS	:	Decentralized Energy Management System
DG	:	Distributed Generation
PV	:	Photovoltaic
m-CHP	:	micro Combined Heating and Power Generator
RFS	:	Radiant Floor heating/cooling System
AMF	:	Agent Management Framework
CCA	:	Central Coordinating Agent
RESA	:	Renewable Energy System Agent
BMA	:	Building Management Agent
BBA	:	Battery Bank Agent
SoC	:	State of Charge
MAS	:	Multi Agent System
PEM	:	Proton Exchange Membrane
ESS	:	Energy Storage System

MPBEMS	:	Multi Power-Based Building Energy Management System
PCS	:	Power Convert System
PDM	:	Power Distribution Method
TOU	:	Time Of Use
ESCC	:	Electronic Stateflow Chart Circuit
ELGC	:	Electronic Logic Gate Circuit
ECSC	:	Electronic Conditional Switching Circuit
CCC	:	Current Conversion Circuit

CHAPTER 1

INTRODUCTION

Before the 1801, people use wood as the main energy source supplier for cooking, heating and lighting. Beginning of 1801 till now, fossil fuels resources like coal, petroleum, natural gases such as methane and ethane, have been the major energy source supplier for daily usage. The fossil fuels resources are known as non-renewable energy resources, the limitation of consuming these resources contributes toward the carbon emissions and increase in the fuel production and utilization costing [1].

The limitations of consuming the fossil fueled have increased the concern on the carbon emissions produce by the fossil fueled based system. Due to the limitations and concerns, scholars around the globe have introduced smart renewable microgrid systems as the solutions. The introduction of smart renewable microgrid system comprises of different kinds of energy resources and able to minimize the negative impact toward the environment. Example of renewable energy resources (RER) that commonly integrated in the smart system are solar energy, wind energy, hydro, biomass and tidal wave[2][3] Moreover, country such as Malaysia have a bright future in optimizing the solar and wind energy resources. Malaysia is fortunate to be located in the second largest solar radiation region so we can utilize this opportunity by using solar resource. Next, Weibull density function has proven that Malaysia can also fully utilize the wind resource. For example, Kuala Terengganu has the highest solar radiation while Mersing has the highest reading in wind speed although not every state can have the chance to use these renewable energy resources. [4]

Scholar have derived that microgrid systems can be divided into AC-based system and DC-based system. The AC-based system is connected to the grid network transmission and the DC-based system is not connected to the grid network transmission, usually known as stand-alone DC-based system. DC-based microgrid systems are employed to provide electricity energy in rural communities where the grid network transmission is not available. The employability of DC based microgrid systems are for space heating and cooling as well as producing portable water for daily usage. Even though DC based microgrid systems have limited usability but in terms of technical, economic and environmental it has its own advantages.[5] Among the advantages of DC based microgrid systems are DC based microgrid systems have less energy conversion lost compared with the ac based microgrid systems. Therefore, it maximizes the utilization of the distributed energy produced by the system. Also, less investment is required compared with the conventional power plants and most importantly DC based microgrid systems eliminate the use of fossil fueled, hence produce zero emission. [6][7][8]

Irregularity energy production and generation by renewable energy resources (RER) makes it necessary for the microgrid system to integrate energy storage system to stabilize the overall performance of the DC based microgrid system. Reviewing the evolution of DC based microgrid systems and their complexity, scholars have introduced Energy Management Systems (EMS)[2], [9]–[13]. Looking at the EMS evolution, EMS technology for microgrid based systems can be divided into two categories: (i) Centralized EMS (CEMS) and (ii) Decentralized EMS (DEMS)[6]CEMS is also known as AC-based system, a microgrid connected to transmission grid while DEMS is a DC-based system where the microgrid is a standalone system.

Employing the EMS into the distributed generation (DG) resources such as solar photovoltaic(PV) panels, wind turbine system, hydropower system and etc. into DC based microgrid systems provides an ideal and reliable solution to supply electricity power to the rural communities where the national grid is not reachable [7]. Looking at the advantage of having EMS DC based microgrid systems for the rural communities, this thesis introduces to model a multi-level voltage-based coordinating controller for the proposed DC based microgrid system. The proposed multi-level voltage-based coordinating controller senses, measures, controls and manages the output voltages from the distributed generators.

1.1 Problem Statement

Based on the literature review study, many renewable energy-based systems, especially solar photovoltaic system performs energy sharing between the load and battery. The energy sharing may cause low energy supply, especially to the connected load. Moreover, most methods involved agents/controllers in each component (PV, wind turbine, battery and load).

According to schemes and techniques in [9], scholars have come out with a centralized management system with an individual agent in each distributed generators such as PV cell, wind turbine and battery load. The centralized system has too many tasking because it needs to work simultaneously with all the agents which involved complicated algorithm and structures. Moreover, each agent have its own algorithm and structure, different from each other. [10], [12]

Due to complexity, we proposed new multilevel voltage-based coordinating controllers which does sensing, managing and switching all the connected DG. Similar to [14] except that this coordinating controller uses stateflow technique. The controller also responsible for effectively distribute generated energy from two renewable energy resources (Solar and Wind) where both generate energy simultaneously but performing different roles in this proposed system.

1.2 Objectives

The objectives for this research is to develop a multilevel voltage-based coordinating controller mechanism to effectively coordinate, switch and manage the renewable energy resources. Next objective is to create and implement an effective switching of conditions between solar, wind and battery energy storage system. The multilevel voltage-based coordinating controller mechanism is responsible to sense, coordinate, switch and manage the RER and battery storage. It acts similarly like CEMS but without any additional agent and complicated algorithm. Lastly is to validate the developed multilevel voltage-based coordinating controller mechanism and the effective switching of conditions in term of functionality.

1.3 Scope of Work

The first task in this thesis is to develop a multi-level voltage sensing and measuring mechanism. The electronic mechanism is responsible for effective sensing and measuring the multiple output voltages from RERs. For this task, further study on state flow chart condition is required to choose the suitable voltage division method to use for measuring output voltages from RERs. After identifying a good voltage division method, the electronic circuit can be developed using MATLAB/Simulink simulation software. Condition chart or state flow chart is also coordinated in this stage to coordinate, switch and manage the produced output voltage by the RERs. The condition/state flow chart is like the operating point for the system as it will produce logic 1/0 for an easier decision making compared to previous studies.

The second task is more focused to create and implement effective switching conditions between solar, wind and battery energy storage system. This task is important as the switching conditions ensure seamless transition between the RERs and battery energy storage system without any complication. This stage is divided into two stages. Firstly, switching conditions for solar and wind is developed and implemented. Second stage is to develop and implement condition chart for charging and discharging of battery energy storage system. The switching between solar and wind has to be done first because battery storage has its own different system. Both tasks' algorithm/coding was simulated in Simulink.

Lastly, the developed conditions in first and second tasks is integrated in the proposed microgrid system. This step is carried out to validate the multi-level voltage sensing and measurement electronic mechanism and conditioning coordinating chart. The validation of the whole system is to achieve the successful switching between solar, wind and battery using the developed coordinating controller. The results obtained will validate the aim of the proposed coordinating controller.