CONTROL AND OPERATION OF WIND-POWER AND WAVE-POWER GENERATION SYSTEMS USING A DC MICRO GRID USING FUZZY CONTROLLER

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ABSTRACT

This paper presents analysis of power flow management in wind power and wave power. This paper proposed an integrated wind and wave power generation system fed to an ac power grid or connected with an isolated load using a dc microgrid using FUZZY controller. The proposed dc microgrid connects with a wind power generator through a voltage -source converter (VSC), a wave power generator through a VSC, an energy storage battery through a bidirectional dc/dc converter, a resistive dc load through a load dc/dc converter, and an ac power grid through a bidirectional grid - tied inverter. The studied integrated wind and wave system joined with the dc microgrid is modeled and simulated using MATLAB/Simulink model design reveals that the proposed integrated control systemcan maintain stable operation to supply power under different operating conditions using the proposed dc microgrid by varying duty ratios of individual converter and pitch angle of wind system is shown.

Keyword: *- Wind power, Wave power, fuzzy control, Battery storage, Micro grid*

I. INTRODUCTION

In recent years, renewable energy and distributed generation systems (DGSs) have attracted increasing attention and have been extensively researched and developed. They gradually alter the concepts and operations of conventional power generation systems. The rise in several countries makes it possible that this kind of DGS can be practically applied to a grid-tied system or an isolated system with wind power, solar energy, hydropower, etc. The output of DGS usually includes two kinds: dc and variable ac. Moreover, the generating capacity of DGS comparing with conventional large synchronous generators is much smaller, and hence, the dc micro grid can be practically applied to convert the generated time-varying quantities of natural renewable energy and DGS into smooth dc electricity that can then be converted back into ac quantities delivered to other power systems. Because of the intermittence of renewable energy and DGS, bidirectional dc/dc converters are usually necessary to feed the connected loads with smooth power.

In order to simulate a hybrid ac/dc micro grid system, photovoltaic and wind power generator models, a doubly fed induction generator model, and an inverter model were established to simulate the dynamic responses of the studied system in. A practical low-voltage bipolar-type dc micro grid was constructed using a gas engine as the power source, while a bidirectional dc/dc converter shunting a super capacitor was utilized as an energy storage device to balance the power demand of the studied system in. Unexplored energy and resources in ocean such as marine energy, tidal energy, ocean thermal energy, ocean wave energy, salinity gradient energy, etc., are abundant. The simulated results of an Archimedes wave swing (AWS) power convertor coupling with a linear permanent magnet generator (LPMG) were compared with the experimental outcomes using the measured data obtained from a 2-MW AWS test system along the coastline.

A configuration of a marine power plant with two AWSs connecting to a power grid was proposed in, and the outputs of the two AWSs were converted to dc quantity by individual diode bridge rectifiers and then subsequently converted into ac quantity by an inverter to reduce the fluctuation of the combined rectified output power. A hybrid electric vehicular power system in utilized two motors connected to a dc bus through a voltage source converter (VSC), and a bidirectional converter was connected between a battery and the dc bus. The dynamic average model was used in for all power electronics models by neglecting the switching phenomena to reduce simulation computational intensity. A no isolated bidirectional zerovoltage switching dc/dc converter was proposed in, and the converter utilized a very simple auxiliary circuit consisting of an additional winding of a main inductor and an auxiliary inductor to reach zero voltage switching and reduce the reverse-recovery problem of power diodes. Modeling and testing the data centers of a dc micro grid using PSCAD/EMTDC were proposed in and since most data centers were sensitive to the variations of electronic loads.

2. DESIGN OF A WIND TURBINE GENERATING SYSTEMS

The realization of a wind turbine as a source of clean, non-polluting and renewable energy may depend on the optimum design of the system and the control strategies of the different possible parameters that can operate efficiently under extreme variations in wind conditions. The general goal of this paper is to optimize the electromechanical energy conversion of the wind turbines, developing suitable strategies of control. Both induction and synchronous generators can be used for wind turbine systems. Mainly, three types of induction generators are used in wind power conversion systems: cage rotor, wound rotor with slip control and doubly fed induction rotors. The last one is the most utilized in wind speed generation because it provides a wide range of speed variation. However, the variable-speed directly-driven multipole permanent magnet synchronous generator (PMSG) wind architecture is chosen for this purpose and it is going to be modeled: it offers better performance due to higher efficiency and less maintenance because it does not have rotor current. What is more, PMSG can be used without a gearbox, which implies a reduction of the weight of the nacelle and reduction of costs.

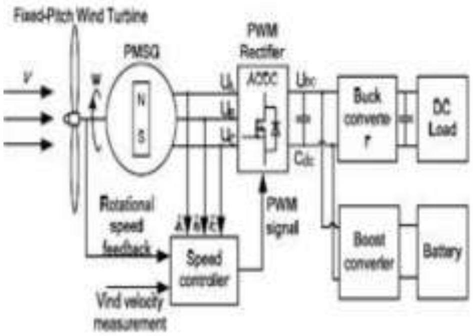

Fig-1: Topology of non grid connected wind energy conversion system

The wind systems that exist over the earth‟ s surface are a result of variations in air pressure. These are in turn due to the variations in solar heating. Warm air rises and cooler air rushes in to take its place. Wind is merely the movement of air from one place to another. There are global wind patterns related to large scale solar heating of different regions of the earth‟ s surface and seasonal variations in solar incidence. There are also localized wind patterns due the effects of temperature differences between land and seas, or mountains and valleys. Wind speed generally increases with height above ground. This is because the roughness of ground features such as vegetation and houses cause the wind to be slowed.

3. MODELLING OF THE PROPOSED SYSTEM

3.1 Overview of Sys tem Configuration

Fig. 2 shows the configuration of the studied integrated wind and wave power generation system connected to an ac grid through a dc microgrid. The wind power generation system simulated by a permanent-magnet synchronous generator (PMSG) driven by a wind turbine (WT) is connected to the dc microgrid through a VSC of VSC_PMSG.

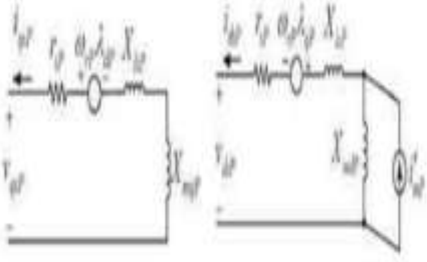

Fig-2: q-d axis equivalent circuit model of the studied wind PMSG

The wave power generation system simulated by an LPMG driven by a linear permanent magnet motor (LPMM) is also connected to the dc microgrid through a VSC of VSC_LPMG. A resistive dc load R-Load is connected to the dc microgrid through a load dc/dc converter. To achieve stable power flow (or power balance condition) and load demand control of the dc microgrid under different operating conditions, a battery is connected to the dc microgrid through a bidirectional dc/dc converter, while an ac grid is connected to the dc microgrid through a bidirectional grid-tied inverter and a transmission line.

When available wind power and/or wave power can be injected into the dc microgrid with a fully charged battery, the surplus power of the dc microgrid can be delivered to the ac grid through the bidirectional grid-tied inverter. When no wind power or no wave power is delivered to the dc microgrid with a low-energy battery, the insufficient power of the dc microgrid can be captured fromthe ac grid through the bidirectional grid-tied inverter. The power of the resistive dc load R-Load can be obtained from the dc microgrid through the load dc/dc converter only when the dc microgrid has enough power. The load dc/dc converter with the resistive dc load R-Load can also slightly adjust the power balance condition of the dc microgrid. The control functions of the bidirectional dc/dc converter, the bidirectional grid-tied inverter, and the load dc/dc converter must be adequately coordinated with each other to obtain stable operation of the dc microgrid. In this thesis, the mathematical models of the studied integrated system with the proposed dc microgrid are derived in detail, including the wind WT -PMSG set with its VSC, the wave LPMM-LPMG set with its VSC, the bidirectional dc/dc converter with the battery, the load dc/dc converter with the resistive load, and the bidirectional grid -tied inverter. Both frequency-domain analysis and time-domain simulations are performed using MATLAB/Simulink.

3.2 Equivalent Models of Wt and Pmsg

The WT model employed in this paper includes the following operation conditions: the cut -in wind speed of 4 m/s, the rated wind speed of 13 m/s, and the cut-out wind speed of 24 m/s. The detailed characteristics and expressions for the captured mechanical power Pw, the dimensionless power coefficient Cpw, the mechanical torque Tw, the tip speed ratio λw, and the blade pitch angle βw of the studied WT can be seen. Fig. 3 plots the q–d-axis equivalent circuit of the studied wind PMSG. The per-unit (p.u.) q- and d axis stator winding voltages of the studied PMSG can be expressed by equation as follows are the q- and d-axis stator-winding magnetic fluxes, respectively iqsP and idsP are the q- and d-axis stator-winding currents, respectively; XmqP and XmdP are the qand d-axis magnetizing reactance‟ s, respectively; XlsP is the leakage reactance; XmP is the magnetizing current; rsP is the stator winding equivalent resistance; and ωrP is the rotor speed of the studied PMSG, while p is the differential operator with respect to time t (i.e., p = d/dt), and ωb is the base angular speed in radians per second.

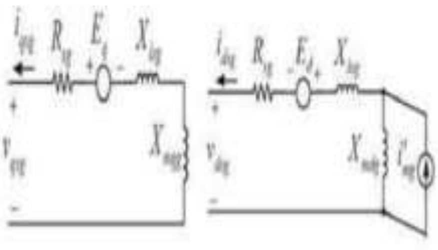

Fig-3: q–d-axis equivalent circuit model of the studied LPMG.

3.3 Equivalent Models Of Aws And Lpmg

The AWS utilizes the wave swing to drive the generator to produce electric power without transmission medium. The motion of the AWS in fluid is affected by the damping force and spring force. The equivalent mass -spring- damper model of the studied AWS is illustrated, whose motion equations can be described by where m is the sum of the masses of the floater and the LPMG translator; D and S are the damping coefficient and spring constant, respectively; and F wave, z, and u are the floater driving force, distance traveled by the floater, and speed of the floater of the AWS, respectively [18]–[21]. Fig. 4 draws the q–d-axis equivalent circuit model of an LPMG. The nonlinear p.u. differential equations of the LPMG can be written as where idsg and iqsg are the d- and q-axis equivalent magnetizing currents, respectively; Xmg is the magnetizing current; Xlsg is the equivalent leakage reactance; Rsg is the equivalent internal resistance; Xmqd and Xmdg are the q and d-axis magnetizing inductance, respectively; and Xd = Xlsg + Xmdg and Xq = Xlsg + Xmqg of the studied LPMG, while K = π/τp, τp is the electrode distance, and us is the forcer movement speed of the LPMG.

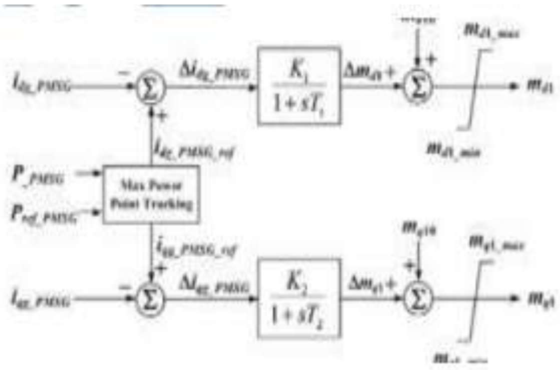

Fig-4: Control block diagram of the modulation indices of the VSC of the studied PMSG.

4.SIMULATION RESULTS

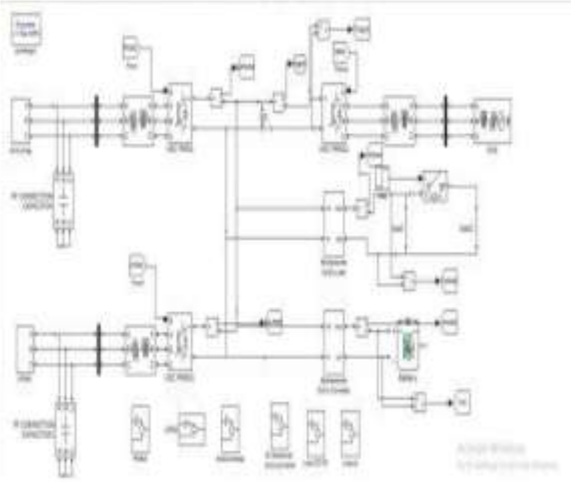

Fig 5. MATLAB/SIMULATION diagram of proposed wind and wave system

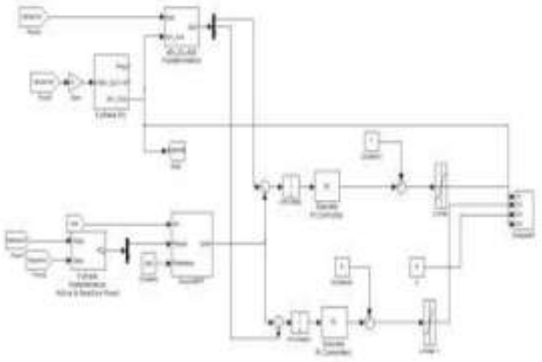

Fig 6. PMSG controller

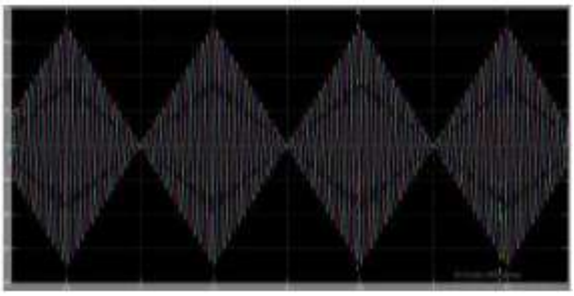

Fig 7. Out put voltage of the wind LPMG

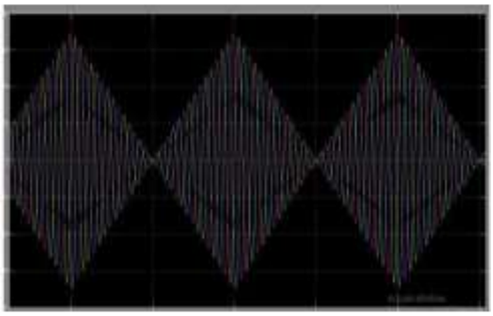

Fig 8. Out put current of wave LPMG

CONLUSION

An integration of both wind power and wave power generation systems joined with a dc microgrid has been proposed. A laboratory grade test system has been presented in this paper to examine the fundamental operating characteristics of the studied integrated system fed to isolated loads using a dc microgrid. For simulation parts, the results of the root-loci plot and the time-domain responses have revealed that the studied integrated system with the proposed dc microgrid can maintain stable operation under a sudden load -switching condition. Comparative simulated and measured results under a load switching have been performed, and it shows that the studied integrated system with the proposed dc microgrid can be operated stably under different disturbance conditions, while both measured and simulated results can match with each other. In extension we using fuzzy controller for better accuracy and observed by output results.

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