Modelling and simulation of a hybrid green source engineering essay

Engineering

DEEPIKA. SPost Graduate Scholar, Department of EEE, Anna University, Regional Centre-Maduraideepikasankar06@gmail. comSATHISHKUMAR. RFaculty, Department of EEE, Anna University, Regional Centre-Madurairskgct@gmail. com

Abstract__ The depleting fossil fuel reserves and increasing concern towards global warming have created the need to surge for the alternative power generation Resource. Renewable energy resources like Wind, Solar-PV, Biomass and fuel cells are gaining eminence nowadays, as they are reduce pollution, more energy efficient and also they serve as a promising solution to the toughest energy crisis faced during the recent years. This paper proposes an hybrid wind/photovoltaic (PV)/fuel cell (FC) alternative energy system for stand-alone applications. Wind and PV are the primary power resources of the system, and an FC is used as a backup. The intermittent nature of solar and wind energy sources make them uncertain. Hence Maximum Power Point Tracking (MPPT) is used to extract maximum power from the available wind and sun . The standard perturbs and observes method of MPPT is used for both PV and wind generation system. An overall power management strategy is designed for the proposed system to manage power flows among the different energy sources and the storage unit in the system. A simulation model has been developed using MATLAB/Simulink for the proposed hybrid energy system.

Keywords__ Hybrid Energy system, Renewable Sources, MPPT, P&O method, Power Management.

I. INTRODUCTIONThe ever increasing energy consumption, the flying cost and the exhaustible nature of the fossil fuel, and the worsening global environment have combines two or more energy sources, usually solar and wind created increased interest in green power generation systems. A Hybrid renewable energy system power. The main advantage of hybrid system is the enhancement of reliability of the hybrid generation system used. Also, the battery size can be reduced as the Solar and Wind energy sources are complementary in nature. The growth of wind and photovoltaic (PV) power generation systems has exceeded the most optimistic estimation. The surge for suitable alternative energy sources is growing more intense than ever in order to reduce the heavy dependence on fossil fuels [2],[3]. FC's also show great potential to be green power sources of the future because of many merits they have and the rapid progress in FC technologies . i. e. Fuel cells have high efficiency, high reliability, low carbon emissions due to the limited number of moving parts and longer life than batteries. In this paper, a standalone hybrid alternative energy system consisting of wind, PV, and FC is proposed [1],[5]. Wind and PV are the primary power sources of the system to take full advantage of renewable energy, and the FC-Power Deficit Controller combination is used as a backup. The maximum point power tracking of the wind generator and PV array is performed by using MPPT algorithms. MPPT algorithm is used for extracting maximum available power from PV module and wind energy system under varying operating conditions [4],[6]. In solar photovoltaic system, MPPT is achieved with the DC to DC converter which operates PV module at its maximum power point by using the standard Perturb and Observe (P&O) Algorithm. In Wind energy system, the tracking of windmill power around the maximum power operating point is achieved by the proposed standard P&O algorithm. II. SYSTEM

CONFIGURATIONA. Simplified Block DiagramThe Fig. 1 shows a simplified diagram of a stand-alone DG system comprising PV, WT and FC. The power available from PV and WT feeds the load, and when there is power deficit, the FC-power deficit controller combination turns the hydrogen into electric power and serves the load demand. Fig. 1: Simplified Block diagram RepresentationB. Photovoltaic Conversion SystemPhotovoltaic (PV) or solar cells are semiconductor devices that convert sunlight in to direct current (DC) electricity. When sunlight strikes the surface of the PV cell, this electric field provide momentum and direction to light stimulated electrons, results flow of current when the cell is connected to an electric load. The building block of PV array is the solar cell, which is basically an p-n junction semiconductor junction that directly converts light energy into electricity. The physical structure and equivalent circuit are shown below. Fig. 2: Physical Structure of Solar CellThe equivalent circuit of a Photovoltaic cell consists of a current source parallel with a diode as shown in Fig. Fig. 3: Equivalent circuit of Solar CellThe output power of PV panels using a set of separate vertical and horizontal components of the solar irradiation data is calculated based on the following conventional model :(1) where, is perpendicular radiation at array’s surface (W/), is rated power of each PV array at G= 1000 W/, and is the efficiency of the Maximum Power Point Tracker (MPPT), connected to it. C. Wind Conversion SystemWind is simply air in motion. Wind turbines are used to convert the wind power into electric power. Electric generator inside the turbine converts the mechanical power into the electric power. The energy production by wind turbines depends on the wind velocity acting on the turbine. This variable speed wind turbine is self-regulating with a permanent magnet alternator. Wind energy systems harness the kinetic energy of wind and convert it into electrical energy. Like the other renewable energy resources, wind energy is clean and safe. Power Extraction: The power from the wind is given asP = 1/2AV3 (2)Where, P= power output in watts.= air density in kg/m3A= swept area of blade in m2V= Wind speed in m/secSince and A are constants for wind mills, the power output varies proportional to the cube of speed. D. Fuel cell – Power Deficit Controller1) Fuel cell: Fuel cells are electrochemical devices that convert the chemical energy of a reaction directly into electrical energy. Exchange membrane fuel-cell (PEMFC) has reliable performance under intermittent supply and is commercially available at large industrial scale capacities. This kind of fuel cell is suitable for large-scale stationary generation and has fast dynamic response with a power release response time of only 1 - 3 s. Here, PEMFC stacks were applied to enhance the performance of the hybrid system. The Figure shown below is the electrical equivalent of fuel cell. E is thermodynamic potential, Ra is the activation resistance and Rint is the fuel cell internal resistant. The dynamics of the fuel cell voltage can be modeled by the addition of a capacitor C to the steady state model. Fig. 4: Equivalent Circuit of Fuel cellA simplified model to compute the output power of the fuel cell is to multiply the efficiency of the device by the power of the input hydrogen:(3)The same story as for fuel cell stands true for inverter namely the calculation of power by efficiency:(4)Where ηinv is the inverter's efficiency. The efficiency is roughly supposed to be constant for whole the inverter's working range. 2) Power Deficit controller: The Controller arbitrarily analyze the solar irradiation level and wind speed level, when there is decrement in any of these parameters it leads to power deficit. Hence the controller analyzes the range of power deficit and decides the fuel flow rate for the PEM-FC stack and supplies fuel to the FC stack to generate electricity to meet the Load demand. III. MAXIMUM POWER POINT TRACKING (MPPT)The maximum power point tracker (MPPT) is necessary to draw the maximum amount of power from PV module/Wind. The perturb and observe(P &O) algorithm is used, is also known as " Hill climbing" method which is popular because of its simplicity and ease of implementation. The current and voltage are extracting from the output of PV-array module/Wind generator to find out power. Change in power is calculated by comparing the extracted power with transport delay block. If the change in power is positive then enters into the loop to check the voltage condition, if the output is positive after comparison of present voltage and previous voltage then voltage gets Incremented and generate pulse. Else the loop continuous until the voltage is positive. MPPT for SolarTo improve efficiency, PV system must operate on maximum power point (MPP) so necessary to determine it. Determination of MPP (MPPT) is a method to arrange PV system operate at peak power point so that maximum power can be delivered to load although ambient temperature and solar irradiation change is happened. MPPT aims to determine MPP of PV system because it’s always changing depending solar junction cell and solar irradiation. Changes in temperature and solar irradiation will cause the operating point away from the MPP of PV changed so that the efficiency of systems will decline. Perturb and observe methodology is most commonly used. This algorithm arbitrarily measures the voltage and current inputs and increments or decrements of the array voltage. This method has advantage that direct array voltage measurement so that require a lower cost than the method which uses measurements of solar irradiation and other environmental factors. Dc-dc converters connected PV system with the load. The main purpose of the MPPT control is to regulate the duty cycle of MOSFET transistors in dc-dc converters so that voltage of the PV array remain on operating point(MPP). Fig. 5: Block Representation of MPPT-SolarB. MPPT for windThe wind generator consists of a wind turbine coupled with a permanent magnet synchronous generator (PMSG). The three phase diode rectifier is used for converting AC voltage to DC voltage and then fed to the MOSFET in that the voltage input-output ratio is controlled by a PWM (Pulse width modulation) signal from the MPPT controller. The MPPT controller reads the voltage and current values of the wind generator output to determine the PWM signal. The P&O algorithm operates by varying the duty cycle of the MOSFET, thus varying the output voltage of the wind generator and observes the resulting power to increase or decrease the duty cycle in the next cycle. If the increase of duty cycle results in power increase, then the direction of the perturbation signal (duty cycle) is the same as the previous cycle. In Contradiction, if the change in duty cycle produces a decrease of the power, then the direction of perturbation signal is reversed. Fig. 6: Block Representation of MPPT-WindIV. SIMULATION RESULTSA simulation system test bed for the proposed Hybrid wind/PV/FC–Power Deficit Controller energy system has been developed using MATLAB/Simulink. In order to validate the system performance, simulation studies have been carried with ambient solar Irradiation and wind Velocity. Fig. 7: Solar Energy with and without MPPTFig. 8: Wind Generator-

PMSG Output PowerFig. 9: Wind Energy with and without MPPTFig. 10: DC Output Power Waveforms of Hybrid Energy System with different energy Resource combinationFig. 11: Inverter Output and AC Output power Waveforms of Hybrid Energy SystemFig. 12: Three Phase Current and Voltage WaveformV. OVER-ALL POWER MANAGEMENT STRATEGYPower Flow Management Strategy of the system operation is according to the following rules: If load demand exceeds the power generated due to unavailability of sufficient wind and solar source, Power Deficit occurs, the fuel cell will come into action. Therefore, the power balance equation can be written as:(5)If the wind and solar generations equal the load demand, then whole power generated by renewable sources is injected to the load. Therefore, the power balance equation can be written as:(6)VI. CONCLUSIONRenewable energy sources like Wind, Solar, Biomass and fuel cells are gaining eminence nowadays, as they are reduce pollution, more energy efficient and also they serve as a promising solution to the toughest energy crisis faced during the recent years. A complete model simulating the proposed hybrid generation system including the wind, solar and fuel cell system is done using Matlab/Simulink. The MPPT controller has been developed for both the wind and solar energy resources. The simulation results showed satisfactory performance of the hybrid system.