INVESTIGATION AND CONTROL OF HYBRID WIND-PV SYSTEM WITH ISOLATED MODE

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Abstract- This paper present hybrid wind-PV-battery system dynamic model developed in MATLAB/Simulink software, the control strategy for energy management proposed by the fuzzy logic rule viewer. A PV panel, wind panel and dynamic models of lithium-ion storage connected together with the DC link and all these sources are working on the basis of fuzzy rule based control. The DC link is connected through the power electronic interfacing circuit (converters) and converters connected to a source for a diverse electricity generation. All sources work on the basis of the MPPT control algorithm, which will work if and only if the panel operates at the peak point of power generation. The hybrid generation systems that can maintain continuous load power demand and provide satisfied operation on the main constraints. The developed control strategy can control various devices and different power interface circuitry. The main objective of this thesis is that to ensure a continuous power by coordinating appropriate control strategy with all sources. The simulation studies have been carried out to determine system performance with different scenarios of the sources such as typical solar radiation, temperature, air and battery charge or discharge conditions. Simulation test results show variable power generation and verify the performance of the integrated system with control strategy is overall effective for real-time installation. The developed system is essential in an isolated region where an existing grid is unable to supply secure power generation and system is beneficial with smartly feed ultimate power generation sources.

IndexTerms- Hybrid system wind -PV , Maximum Power Point Tracking (MPPT), Fuzzy logic controller (FLC), Photo voltaic array(PVarray).

1. INTRODUCTION

All the equipments surrounding us operate on the electricity, without electricity all equipment is dreams only. For sustainable energy growth in any nation or state, it must fulfill all requirement of the electricity supply. The world is moving towards extensive utilization of renewable energy in recent days as a solution for the energy crisis. Growing electricity demand, increasing fuel prices, and greenhouse gas emissions have led us to turn to renewable energy resources, such as wind and solar power, for their higher potential to solve these issues. However, renewable energy faces two major dispatch ability issues: technical and financial. Battery energy storage systems (BESS) are known in the hybrid system for improving the grid performance and reliability. Further, hybrid system, BESS combined with the renewable sources with a single unit, solves many RES issues. Renewable energy is an energy sources that can replace rapidly conventional sources by a natural process such as solar, wind, hydro, geothermal etc. and provides sustainable energy.

The solar thermal energy source is a finite energy resource to meet-up long-term global energy crisis due to oil environmental hazards are drawing enormous attention to use solar energy utilization. The National Action Plan on Climate Change (NAPCC) also points out: "India is a tropical country, where sunshine is available for longer hours per day with great intensity. Solar energy, therefore, has great potential today as well as near future energy source. It also has the benefits of permitting the decentralized distribution of energy, thereby empowering people at the grassroots level, figure 1.1 shows working of solar panel.

Fig. 1.1: Solar Power Generation Diagram

2. PROPOSED HYBRID WIND-PV SYSTEM

Controlling of the hybrid system is used for the management of power flow in the hybrid system. The controlled system receives all time data collected from various measurement devices from the hybrid system, which must be generated. The power fluxes must be precisely controlled from different sources in order to carry out the power reference imposed by centrally placed micro network controller (which is load profile) as shown in fig. 2.1.

This must be ensured to achieve the objective of pilotage:

- Power delivered by each source must be a fast and accurate measurement of power,
- Charging and discharging conditions is always checked, respecting the limits of their state of charge and maximum charging/discharging currents.

Fig. 2.1: A Block Diagram of a Proposed Control Strategy for the Hybrid System

Fig. 2.2: Controlling of Power Electronics Equipment

For their clarity in design and organization, we use a hierarchical command which is now recalled whenever required. According to measured data and power demand, a control system gives command instruction to the electronic converter of three sources (choppers) and load side inverter.

This controlling is done through four level of control:

- Control of operating modes (mode control),
- The remote control (power control),
- Close control of each inverter (Automatic control),
- Switching control,

As from fig. 2.2 shows that automatic control strategy gives instruction to each converter to control current in storage elements, the voltage at PV panel terminals (followed by maximum or limited power point according to the operating mode), control DC bus voltage, and load consumed current. At last switching control block gives the semiconductor switching signals to perform the desired command.

3. MATHEMATICAL MODELING OF HYBRID WIND-PV SYSTEM

3.1 PV array modelling

Parallel structure of PV arrays has higher efficiency than series structure due to their performance. The output current can achieve much higher amounts with parallel PV arrays, on the other hand, the voltage produced by a parallel structure is low, and so the structure cannot be used alone. Making solar cells series and parallel, we can achieve reasonably current and voltage

Fig. 3.1: The Equivalent Circuit of a Solar Cell

According to this model, current-voltage characteristic of a solar module is obtained using the following relationship:

$$I = I_{ph} - I_{RP} - I_D \quad (3.1)$$

$$I_{RP} = \frac{V_m + R_s I_m}{R_p} \quad (3.2)$$

$$I_D = I_s \left(\exp \left(\frac{V_m + R_s I_m}{m \eta V_T} \right) - 1 \right) \quad (3.3)$$

3.2 Control of the Boost Converter with MPPT Controller

From the characteristic I-V and P-V curves of photovoltaic modules, it is shown that there was a unique point for the maximum power (PMPP). This point is defined as the maximum power point (MPP) with the optimal voltage V_{mpp} and the optimal current I_{mpp} . At this point, the entire PV system should operate with the maximum efficiency and produce its maximum output power.

perturb and observe are used: reduced perturbation step size, variable step size, three points weights comparison methods and optimized sampling rate.

Fig.3.2 described the flow chart of perturb and observe method. At the input, there are the photovoltaic voltage and photovoltaic current. The power is then calculated from those two parameters. The sign of the power determines the duty cycle output of the MPP controller. In simulation, the duty ratio of the boost converter is the control variable. Perturbing the duty ratio of the converter perturbs the PV array current I_{pv} and consequently perturbs the PV array voltage. The initial value of the duty cycle and PV power are given. The voltage and current of the PV array are measured first and then the power P is calculated. The power is then compared with the previous value. If the difference is positive, the duty cycle is incremented. The switch used is ideal and the boost output voltage is supposed to be constant. The range of the duty cycle is limited between zero and one to ensure that the boost will step up the input voltage within limit.

Fig. 3.2 Flow Chart for P&O

4. RESULTS AND DISCUSSION

This system consists of two renewable energy sources which generate continuous power with battery back-up. These sources can generate different type of a power structure like DC or AC by using converter technology. This converted or DC/AC link power feed through a bus which is AC or DC bus. This feeding power should be at the same bus (AC or DC) then use however our load requirement but in this system, DC link will have used. The solar panel generates DC power but it is variable in nature due to irradiations are sometimes high and sometimes very low depends on the different seasonal weather condition. The maximum power production hour is 9AM-5PM in winter and 8AM-6PM in summer and in rainy season power may be productive and may not be produced it is depending on the weather characteristics. The power will be passed through a boost converter which can provide constant power for DC link and which make power at a constant value. Wind panel generates AC power through rotating wind turbine and the wind is also variable in nature, however, panel power pass-through AC to DC converter due to DC bus use for interfacing power from the generator to load. The battery is used for storing DC power, so it requires DC to DC bidirectional boost converter for constant power store.

4.1 Power Generated Output at 1000W/m^2 Solar Irradiance and 13m/s Wind Speed

In this case, solar irradiation at 1000W/m^2 fall on solar panel and wind blow at 13 m/s . In this case, solar output power by falling solar irradiation and temperature on solar panel shows in the waveform of figure 4.1 (a) shows solar generated power. In this case, generated power is sufficient to supply load demand with 240V constant voltage. In figure 4.1 (b) shows the load power demand in watt. Figure 4.1 (c) shows that wind panel generated power in watt. Figure (d) shows that power generated from single wind and single solar is not sufficient for providing load demand so the combination of wind and PV source can generate sufficient power for supply the load demand, total power generated from both sources show in figure 4.2 (d), 4.1 (e) shows battery initial condition, (f) shows DC link voltage.

(a) Solar Panel Generated Power (W)

(b) Wind Panel Generated Power (W)

(c) Total Power Generated from both Sources (W)

(d) Total Load Demand Power (W)

(e) DC link Terminal Voltage (Volt)

(f) Battery Initial Condition

Fig. 4.1 Waveforms of the output power, load demand, battery initial condition and DC link voltage at 1000W/m² solar irradiation and wind speed at 13m/s.

4.2 When Solar Irradiation at Zero W/m² and Wind Speed at 12m/s

In this case, night time solar generated power is zero, wind speed at 12m/s. In this case, only the wind power system is used with the battery bank. The load power is in variable nature so the battery will be charged or discharge depends on the generated power and load profile. Generated power from wind panel is varied between 0-4100W which is capable of supplying load demand and battery is initially charged in this case and extra generated power stored in the battery bank. The load power demand varies between 0-3500W.

(a) Generated Power from Wind in Watt

(b) Total Generated Power from both Sources in Watt

(c) Load Power in Watt

(d) DC Link Voltage in Volt

(e) Battery Initial Status

Fig. 4.2: Waveform of generated power, load power, DC link voltage and battery internal status at zero W/m^2 solar irradiation and 12 m/s wind speed.

The wind generated power is capable of supplying load power demand, but at the starting of simulation load power is high and wind generated power is less as compare to load than the battery bank act as a source, after sometime later wind generated power capable to supply load and battery bank act as a consumer. The high load period occurs maybe for one hour or maybe for several hours, figure 4.2 (a) shows that the generated power from wind source (b) shows that total generated power from both sources, (c) shows load power demand. In this case when sun or PV energy fails to operate especially at night and in a rainy season then one of the sources is used to provide power (wind source) otherwise battery provides whole load demand. Fig. 4.2 (d), (e) shows DC link voltage and battery internal status.

CONCLUSION

The present work is carried out for wind panel, PV panel and backup power as a battery. Those all sources combined and build hybrid renewable energy source and act as an uninterruptable power source (UPS). Individual PV and Wind resource unable to provide power for 24 hours because these are natural resources, solar power source is limitless but due to the limitations of PV panel can't operate in night time and wind power depends on that time of environmental condition, when the system fails, battery back-up builds a bond with power management to provide continuous power at that time of unavailable power period. The hybrid wind-PV-battery system model was developed in MATLAB/Simulink software and control strategy for energy management of the developed hybrid Wind/PV/Battery system is also presented.

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