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A Novel Approach for Modelling of Micro Grid with Solar and Wind Energy Systems by Using Fuzzy Control

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ABSTRACT:
This paper presents the analysis and operation strategies for a microgrid by using the hybrid systems. A hybrid system includes the combination of different systems such as wind-diesel, solar-diesel, solar-wind etc., but in this paper a solar-wind system was used for the analysis of a microgrid. A current source interface cuk converter is used to integrate the renewable energy sources to the main DC bus. In this paper, a direct driven PMSG is used with a variable speed control method whose strategy is to capture the maximum wind energy below the rated wind speed. Incremental conductance method has been implemented to track the maximum power in case of solar panels. In this paper, Fuzzy logic controller has been used in Inverter control.

KEYWORDS:
PV system, Wind system, CUK converter, Fuzzy logic controller

I.INTRODUCTION:
Looking at sustainable energy solutions to preserve the earth for the future generations , Other than hydro power, wind and photovoltaic energy holds the most potential to meet our energy demands. Alone, wind energy is capable of supplying large amounts of power but its presence is highly unpredictable as it can be here one moment and gone in another [1]. Similarly, solar energy is present throughout the day but the solar irradiation levels vary due to sun intensity and unpredictable shadows cast by clouds, birds, trees, etc.

The common inherent drawback of wind and photovoltaic systems are their intermittent natures that make them unreliable. However, by combining these two intermittent sources and by incorporating maximum power point tracking (MPPT) algorithms, the system's power transfer efficiency and reliability can be improved significantly. The proposed microgrid is also equipped with energy storage devices such as batteries. The hybrid system, unlike conventional systems, considers the stability and dispatch-ability of its power injection into the grid. The hybrid system can operate in three different modes, which include normal operation without use of battery, dispatch operation, and averaging operation [2].

A wind turbine system model was developed and compared with a real system. Using MPPT we can obtain maximum power from wind source. Maximum Power Point Trackers utilize some type of control circuit or logic to search for this point and thus to allow the converter circuit to extract the maximum power available circuit. Due to the similarities of the shape of the wind and PV array power curves, a similar maximum power point tracking scheme known as Incremental conductance method strategy is often applied to these energy sources to extract maximum power [3].

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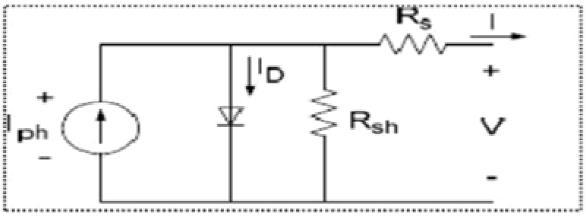
II.SOLAR AND WIND ENERGIES:

Solar energy has been the greatest potential of all the sources of all the sources of renewable energy and if only small amount of this form of energy can be used. Solar energy can be a major source of power. Its potential is 178 billion MW which is about 20,000 times the world's demand. Solar energy could not be developed on a large scale. Sun's energy can be utilized as thermal and PV's. The former is currently being used for steam and hot water production. Electricity can be produced from the solar energy by photovoltaic solar cells, which convert solar energy directly to electricity [4]. The heat from the solar energy can be used for buildings, using the absorption cooling principle operative in gas-fired refrigerators. Energy of wind can be economically used for the generation of electrical energy. In wind energy we get kinetic energy and wind energy converts the mechanical energy to electrical energy. Winds are caused from two main reasons:

- Heating and cooling of the atmosphere which generates convection currents. Heating is caused by the absorption of solar energy on the earth's surface and in the atmosphere.

- The rotation of the earth with respect to atmosphere, and its motion around the sun.

III.EQUIVALENT CIRCUIT OF PV CELL

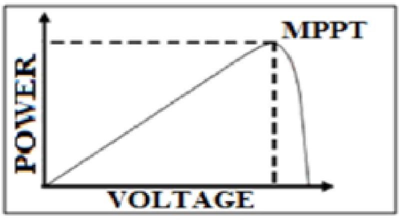


The open-circuit voltage Voc of the cell is obtained when the load current is zero, i.e., when I = 0, and is given by Voc=V+IRsh The shunt resistance (Rsh) is very large and the series resistance (Rs) is very small. Therefore, it is common to neglect these resistances in order to simplify the solar cell model [6].

The resultant ideal voltage-current characteristic of a photovoltaic cell is given by the relation below.

$$I = I_{ph} - I_0 \left[\exp\left(\frac{q(V+R_s I)}{Ak_BT}\right)-1\right] - \frac{V+R_s I}{R_{sh}}$$

The power-voltage (P-V) characteristic of a photovoltaic module operating at a standard Irradiance of 1000 W/m2 and temperature of 25 deg C is shown below.



It can be seen from the characteristics, that there is a unique point on the characteristics at which the photovoltaic power is maximum. This point is termed as the maximum Power Point (MPP). The power corresponding to this point is termed as power at maximum Power point (Pmpp) and the voltage as voltage at maximum power point (Vmpp) [5]. Due to high Cost of solar cells, it must be ensured that the photovoltaic array operates at all time to Provide maximum power output. Hence a maximum power point tracker must be used to track the maximum power of the system. This is commonly known as maximum power point tracking (MPPT).

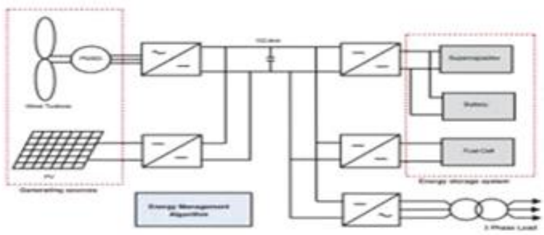


Fig: Bolock diagram

IV.INCREMENTAL CONDUCTANCE METHOD:

This method consists in using the slope of the derivative of the current with respect to the voltage in order to reach the maximum power point.

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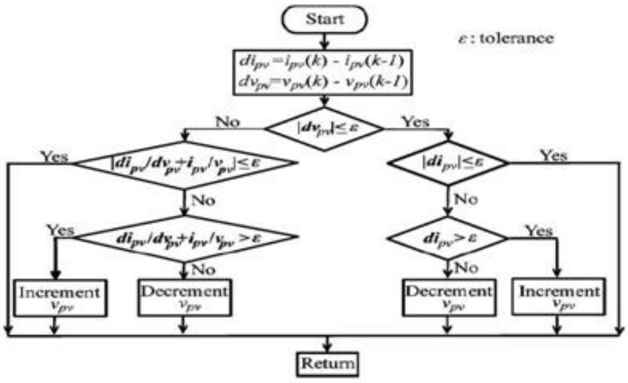
What advantage does MPPT give in the real world that depends on the array, their climate, and their seasonal load pattern It gives us an effective current boost only when the Vpp is more than about 1V higher than the battery voltage [7]. In hot weather, this may not be the case unless the batteries are low in charge. In cold weather however, the Vpp can rise to energy use is greatest in the winter (typical in most homes) and they have cold winter weather, then the can gain a substantial boost in energy when the need it the most.



Wind Turbine Model:

The model is based on the steady-state power characteristics of the turbine. The stiffness of the drive train is infinite and the friction factor and the inertia of the turbine must be combined with those of the generator coupled to the turbine. The output power of the turbine is given by the following equation.

$$P_m = c_p(\lambda, \beta)\frac{\rho A}{2} V^3 wind$$

Permanent Magnet Synchronous Generator is a type of Synchronous Generator which its excitation field is a permanent magnet instead of a coil. Synchronous Generators are the primary source of all electrical energy and commonly used to convert the mechanical power output of steam turbines, gas turbines, reciprocating engines, hydro turbines and wind turbines into electrical power for the grid. They are known as synchronous generators because they operate at synchronous speed [9]. The speed of the rotor always matches supply frequency. The maximum wind energy below the variable rated wind speeds will be captured by using this control strategy.

The below figure shows the mechanical power captured by the wind turbine blades at each rotor speed of the wind turbine and the various wind speeds. The optimal power line which was shown will be obtained by connecting MPPs at each wind speed. Hence the operation of the wind turbine at the optimal rotor speed on the optimal power curve ensures that the wind turbine captures the maximum wind energy below the rated wind speeds [8].

V.ĆUK CONVERTER:

In a CUK converter, there is an inductor at the input side and it will acts as a filter for the input dc supply and reduces the harmonic content. In a buck-boost converter, the energy transfer is associated with the Inductor but in CUK converter, energy transfer is associated with the capacitor. The input current is continuous in this converter and requires additional capacitors and inductors. The Capacitor used in this converter is very large. Thus both the input current and the current feeding the output stage are largely ripple free. It is an inverting converter, so the output voltage is negative with respect to the input voltage. The advantage is the continuous input and output currents for the cuk converter. The CUK converter is similar to the buck-boost converter provides a negative polarity regulated output voltage with respect to a common terminal [10].

VI.STORAGE SYSTEM MODEL:

The ESS in this micro grid is controlled to regulate the main dc bus voltage both when there is not sufficient power production from the wind generator and PV modules and when there is excess local power production to charge the batteries.

Fuzzy Logic controller:

In this context, FL is a problem-solving control system methodology that lends itself to implementation in systems ranging from simple, small, embedded micro-controllers to large, networked, multi-channel PC or workstation-based data acquisition and control systems.

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It can be implemented in hardware, software, or a combination of both. FL provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information. FL's approach to control problems mimics how a person would make decisions, only much faster.

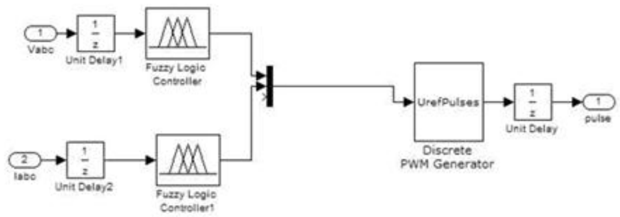


Fig: Fuzzy logic controller simulation diagram

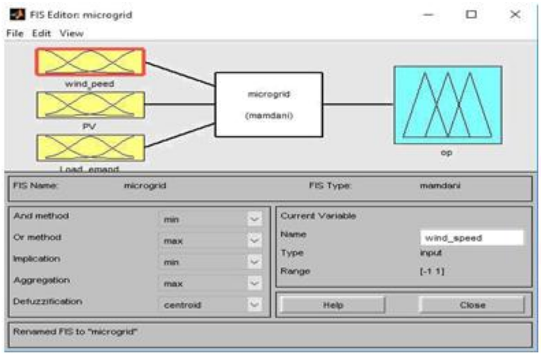
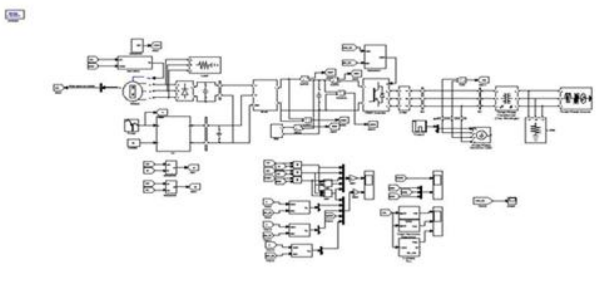


Fig: Fuzzy logic controller workspace

Simulation Diagram



SIMULATION WAVEFORMS

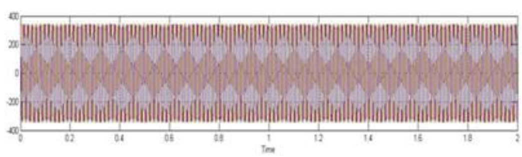


Fig: Load voltage

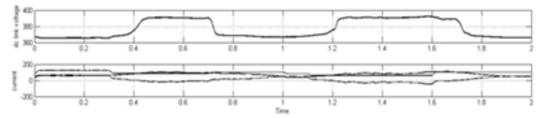


Fig: Dc link voltage, I_{MIC},I_{ESS},I_{INV}

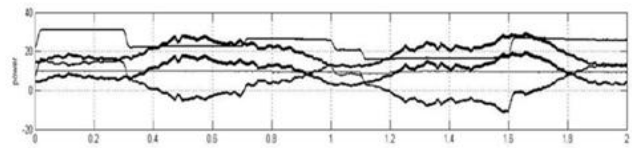


Fig: Power output

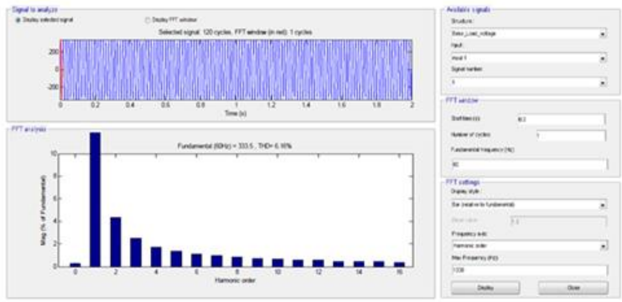


Fig: FFT analysi using PI controllers

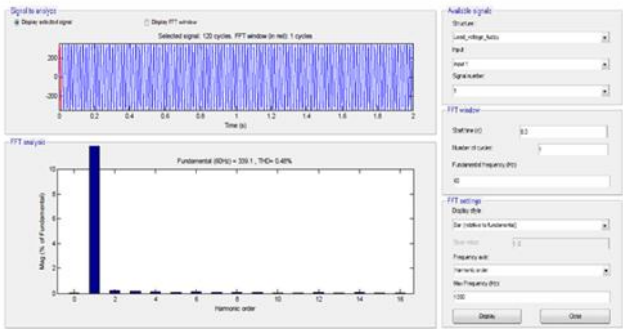


Fig: FFT analysis using Fuzzy controller

VII.CONCLUSION:

This paper presented the analysis of dynamic modeling of a Microgrid by using solar and wind energy systems. These systems were integrated to the grid with the help of different converting topologies. Cuk converter had been used here to convert dc components into ac components. In addition to this, the system was equipped with an energy storage system.

For the wind generator, this paper used variable speed control method whose strategy is to capture the maximum wind energy below the rated wind speed. The Fuzzy controller has been taken at the inverter side control and THD was analysed and it was observed that THD factor has been reduced to some extent by using Fuzzy logic controller than a PI controller.

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