Simulation of Solar PV and DG based Hybrid Micro Grid

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Abstract - *Electrical energy has consistently been a conspicuous need for the day by day human life. This paper focuses on access the electricity to the rural areas. Renewable energy sources are the enhanced alternative to congregate those difficulties. The renewable energy based islanded hybrid micro grid systems offer aggressive solution especially for the energy incapacitated communities. At the present time, according to green energy fabrication policy, solar systems are associated to actual diesel grids used in several small isolated areas for power supply. As for classical power systems, the stability analysis, forecast, recognition, systematize and investigative of hybrid solar-diesel micro grids need precise modeling of its key components. In this paper, simulation of hybrid micro-grid with solar PV and diesel is presented. A solar PV is modeled depends up on temperature and diesel generator is assumed to consist of a diesel motor connected to a synchronous generator. Solar and diesel generator models are designed with boost convertors in turn to get the most favorable voltage. The hybrid micro- grid had an inverter controller technique to control the output voltage, current and power. Design and simulation hybrid micro grid is modeled with the help of MATLAB /SIMULINK.*

*Key Words***: Hybrid micro grids, off-grid, Boost converter, Diesel generators, Solar PV system, Inverter.**

1. INTRODUCTION

Electrical energy has invaded our lives and become vital in all aspects to our society. The lack of reliability of electricity often discourages households and agriculture in rural areas [1]. The grid extension is not possible in isolated areas because these areas are normally located far from the national grid, therefore high cost is required for transmission lines [3]. To improve their quality of life micro-grids are introduce. Micro-grids are small or intermediate voltage grids placed near the consumer sites and these also bid a best way out for utilize localized renewable energy resources [2]. Numerous locations offer excellent natural conditions for the use of solar photovoltaic (PV), wind, or small hydro power. Other than it is impossible to get the continuity of supply with only renewable energy sources since the non-conventional energy sources are mostly depends up on the environment conditions [4]. In order to get the stability of power flow non-renewable energy sources also proffered like diesel, fossil fuels etc. Integration of different technologies with different energy sources provides competitive advantages compared with using a single technology. Hybrid micro-grid combines at least two special technologies for generation of power [5]. Solar photovoltaic are locally available, no fuel cost, pollution free, no transportation cost, PV system can be constructed to any size according our demand but the main drawback is these are non-dispatch able that means energy production is mostly depends upon sun. Diesel generators are dispatch able, and can distribute energy when scheduled [6]. By combining these two sources, a multiplicity of variable load profiles can be covered. So the hybrid micro grids are least cost and longer term solutions for the rural areas.

In this paper hybrid micro-grid is consisting of solar PV and a DG, generally supplied with diesel, used as a back-up [7]. Solar PV is designed to produced 1.5 KW of power and diesel generator also planned to create 1.5 KW of power. DC-DC boost converters are increases the voltage rating to required level. The system is designed to generate 3000watts or 3KW of power for stand-alone systems. In this paper the design of hybrid micro-grid comprises of solar photovoltaic and diesel generator are performed by using MATLAB/SIMULINK.

2. SYSTEM MODELLING

The hybrid micro-grid composed of solar PV, DG, rectifier, boost converter, inverter, DC bus, AC bus, load and dump load. Each source is attached with DC-DC boost converter to rise the voltage level. From diesel generator AC supply is produced that will be converted to DC with the help of bridge rectifier. DC supply from solar PV and DG tied to DC bus. Inverter changed the DC supply to AC. And through the AC bus ac supply will be connected to the load. The block diagram of hybrid micro grid consisting of solar and diesel generator is shown below.
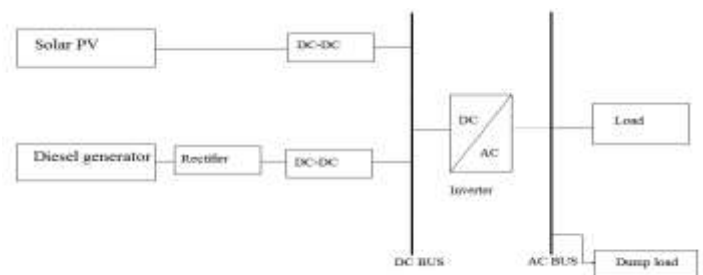

Figure-1: Block diagram of solar and DG based hybrid micro-grid

Dump load is a diversion load, when two sources are produces power if the demand is fullfilled still making power, then it will be sent to dump load. There is one three phase filter used for Even though micro grids are connected to both the utility grid and stand alone systems but In this paper Solar and DG based hybrid micro-grid is used only for stand alone system.

2.1 Solar photovoltaic cell

Solar energy is mostly prefferable when compared to other renewable energy sources due to its long life and less maintainance. Solar PV system designed to supply electricity from solar energy. In solar power system the main components are solar cells, PV array, modules and battery bank system. PV array is combination of Several cells. Number of arrays are connected together to form PV module. Solar panels are abosrbs the sun energy and converted that in to eectrical energy [8]. In day times maximum amount of power will be generated because solar power is directly propotional to the radiations. Extra created power will be stored in the battery bank systems which is uses to supply electricity in the night times and rainy seasons. Solar power system also maintains voltage ratings. In stand-alone PV systems, the PV array is directly connected to a battery; which stores PV generated electricity and acts as the main power supply. An inverter can be connected to a battery to convert the PV generated DC power into AC power. It enables the usage of house hold appliances without mains power. The specific components required may include major components such as battery controller, auxiliary energy sources and sometimes the particular electrical load. In addition, a collection of balance of system (BOS) hardware, including wiring, over current, surge protection and disconnect devices, and other power processing equipment. PV cells are connected series and parallel in order to get the desired current and voltage. Output current of the solar PV system is expressed as

$$I_{PV} = N_P * I_{Ph} - N_P * I_{rs}\left(\exp\left[\frac{Q\,V_o}{T K A N_s}\right] - 1\right)$$

Where I_{pv} is the load current of solar PV cell, N_P is the number of cells connected in parallel, N_s is the number of cells connected in series, I_{ph} is the photo current due to excitation of PV junction, Q is the charge of electrons, V_o is the open circuit voltage, A is the ideality factor, K is the Boltzmann's constant, T is operating temperature [11].

2.2 Simulation of solar PV system

The operations of solar PV system explained here with two stages. Solar energy is generated and it will be converted to electricity in the first stage. In the second stage boost converter is used for boost up the voltage. A boost converter

is a DC-to-DC power converter. This converter steps up the voltage while the current is stepped down.
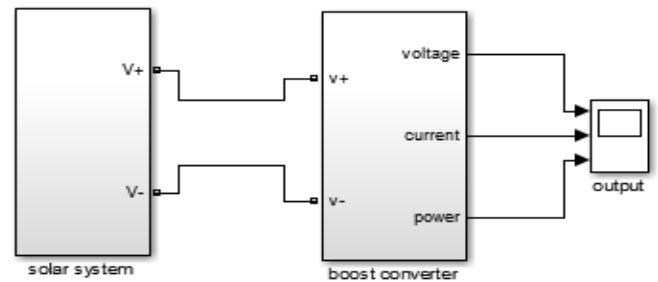

Figure-3: Simulation diagram of solar PV system

The converter uses two semiconductors an IGBT and a diode, an energy storage element inductor, in order to reduce voltage ripple a capacitor is added at load side. In this system the output voltage of solar PV is 250volts and current is 6A. Boost converter is used to raise the voltage to 1000volts and current is 1.5A. Total power from the solar power system is 1500watts.

3. Modeling of Diesel generator

Diesel generator is one of the non renewable energy sources if emergency power supply is required than DG's are used. A diesel generator set can be divided into three main components the prime mover which includes an engine with a speed governor, the synchronous generator (SG), and the automatic voltage regulator (AVR) [9]. A governor can be defined as a mechanical device for controlling the speed of an engine automatically by relating the intake of fuel. The "Engine" block comprises the combustion system of the diesel engine. The injected fuel is ignited by the compressed hot air in the combustion chamber, causing the movement of the piston during the power strokes. The main function of an excitation system is to supply and automatically adjust the field current of the synchronous generator considering control and protective functions essential to the satisfactory performance of the system. The Automatic voltage regulator (AVR) controls the exciter field to provide a constant terminal voltage the speed controller is designed to keep constant the internal combustion engine speed by changing the quantity of fuel consumed by the motor [12]. The self-excited DC exciter is represented as

$$V_R = K_E E_{FD} + S_E(E_{FD})E_{FD} + T_E \frac{dE_{FD}}{dt}$$

 Where

K_E = Gain of the exciter system

T_E = Time constant of exciter

E_{FD} = Excited field voltage

Modern diesel engines have overcome disadvantages of earlier models of higher noise and maintenance costs. They are now quiet and require less maintenance as compared with gas engines of similar size. Diesel engines are commonly used as mechanical engines, power generators and in mobile drives. They find wide spread use in locomotives, construction equipment, automobiles, and countless industrial applications.

3.1 Simulation of diesel generator

Diesel generator is used as back up protection. Simulation of diesel generator consists of two stages of operation. Diesel as fuel, synchronous generator converters mechanical energy to electrical energy with the use of prime mover these processes happen in first stage. AC supply is obtained from the diesel generator and bridge rectifier is preferred here to convert AC to DC In the second stage boost converter is used to get the optimal voltage level. Here in the boost converter one inductor, IGBT, pulse generator, resistor and one capacitor is placed in order to filter the output voltage. The simulation diagram of diesel generator is shown below.
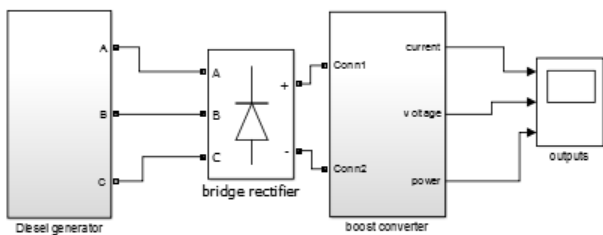

Figure-4: Simulation diagram of diesel generator

The output of diesel generator output voltage is 625volts and this is the input to the boost converter. Boost converter raises the voltage to 1000volts from 625volts. The input current is 5A it will be decreases to 1.5A. So the total output power of the diesel generator is 1500watts.

3.2 Simulation of hybrid micro grid

The hybrid micro grid system model is designed using two different power generation sources, i.e., diesel generators, solar photovoltaic's. The energy storage device is batteries in solar photovoltaics. The solar PV generate electricity based on temperature, the diesel generators use diesel as a fuel and can generate electricity anytime without any constraints of weather or storage [10]. Excess power is stored in the battery bank in the solar system.
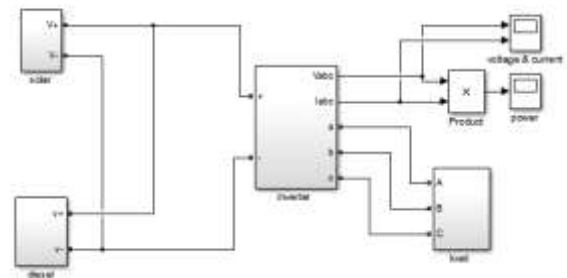

Figure-5: Simulation of hybrid micro grid comprises of solar PV and DG

The simulation diagram composed solar, diesel, inverter circuit and load. From the solar PV produces dc supply that will be converter to AC by using inverter. Diesel generator output voltage is AC supply; bridge rectifier changes the voltage to DC. Each source individually have boost converter. The voltage level solar and DG are increases to the desired voltage. Finally inverter converts the DC supply from boost converter to AC and it will be given to the load. At the load side if there is any disturbances that will be eliminated by using filter.

4. Results and discussion

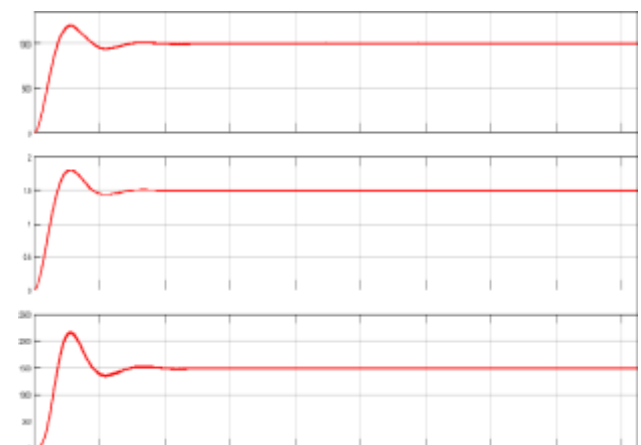## 4.1 Simulation outputs of solar energy system

Figure -6: output voltage, current and power for the solar PV

The simulation outputs i.e. voltage, current and power of the solar power system is show below. On X-axis time in seconds and on Y-axis voltage in volts in the first output. The voltage is 1000v here appear as output. In the second output, current is on Y-axis and time is on X-axis. The output current is 1.5A. Third output is having power on X-axis and time on Y-axis and power output is 1.5KW. Solar power system the output voltage of solar PV is 230volts and current is 6A. Boost converter is used to raise the voltage to 1000volts and current is 1.5A. So the input voltage and current of boost

converter is230V and 6A respectively. The output voltage and current of the boost converter is 1000V and 1.5A and output power of the solar power system is 1500watts.

4.2 Simulation output of diesel generator

The simulation outputs i.e. voltage, current and power of the diesel generator show below. On X-axis time in seconds and on Y-axis current in amps in the first output. The voltage is 1.5A here appear as output. In the second output, voltage is on Y-axis and time is on X-axis. The output voltage is 1000v. Third output is having power on X-axis and time on Y-axis and power output is 1.5KW.
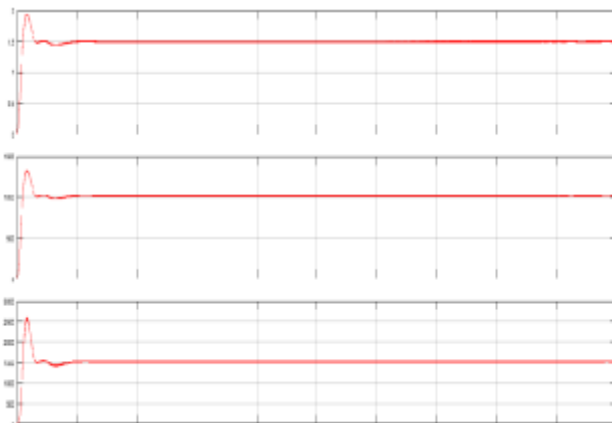

Figure-6: Output voltage, current and power for the solar PV

Diesel generator output voltage is 625volts and this is the input to the boost converter. Boost converter raises the voltage to 1000volts from 625volts. The input current is 5A it will be decreases to 1.5A. So the input voltage and current of the boost converter is respectively 625V and 1.5A and the output voltage and currents of boost converter is 1000V and 1.5A and total output power of the diesel generator is 1500watts.

4.3 Simulation outputs of hybrid micro-grid

Modeling of hybrid micro-grid employs solar PV and diesel generator performed in the SIMULINK platform. In this grid solar PV have output voltage and current 1000V and 1.5A. Diesel generator also had same voltage and current levels. Here the two different resources are integrated and changes their functions with the help of rectifier, dc-dc converter, inverter. So the final hybrid micro-grid output voltage and current obtained. The output voltage of the hybrid micro grid is 440V and output current is 6.818A.
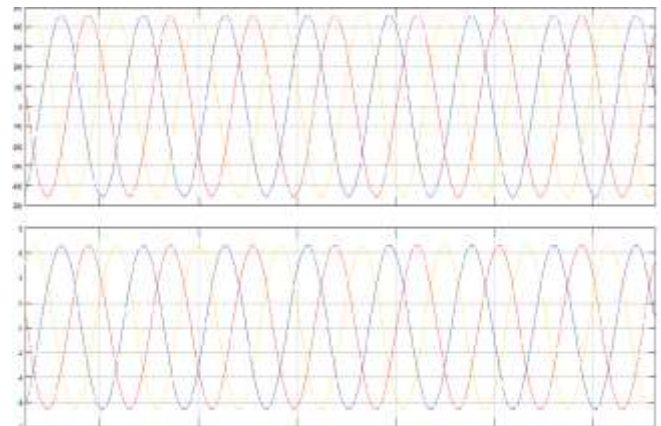

Figure-7: Current and voltage outputs of the hybrid micro-grid

The simulation outputs i.e. voltage, current of the hybrid micro-grid show below. On X-axis time in seconds and on Y-axis current in amps in the first output. The voltage is 6.8A here appear as output. In the second output, voltage is on Y-axis and time is on X-axis. The output voltage is 440v.

The solar PV system output power is 1500W and diesel generator output power also 1500W. Integration of these sources i.e. hybrid micro-grid output power is 3000W.
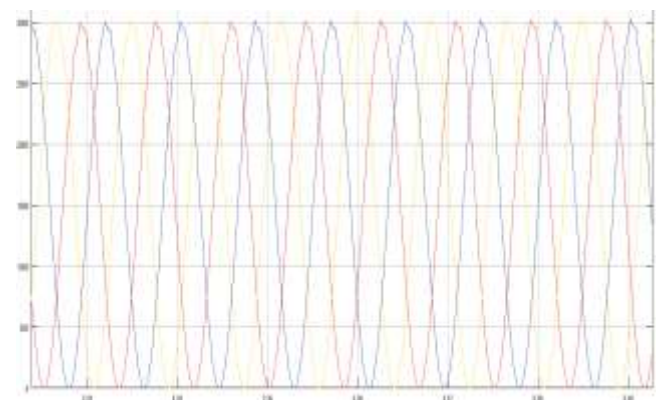

Figure-8: Output power of the hybrid micro-grid

The simulation output of hybrid micro grid is having power on X-axis and time on Y-axis and power output is 3KW or 3000watt.

5.CONCLUSION

In this paper design of the hybrid micro grid is modeled with the help of MATLAB /SIMULATION. In this paper a hybrid micro-grid is designed, modeled and optimized using two different generation technologies. An efficient model of a diesel-generator set organized in a standard form is proposed in this paper. The content of the present paper can be seen as a fundamental and step towards modeling of a hybrid solar-diesel energy conversion system. The solar PV is better option as compared to the diesel generator because it is friendly but the solar PV have a high capital cost. Solar

system and DG system both are modeled by using MATLAB. The hybrid micro-grid produces 3KW of power to the stand-alone systems. Hybrid systems have been recognized as a feasible opportunity for energy supply rural areas and it is also cost effective to the remote areas.

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