Analysis of Microgrid System with Photovoltaic Array

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Abstract. As the modern power system is advancing, new challenges are coming into picture. The micro-grid concept along with renewable energy PV systems is emerging as a key factor for the long-term doable solution for future energy sector requirements. Micro-grid can have distributed energy resources like PV panels, wind turbines, Geothermal Tidal energy & power generators that produce power. Controlling and protection are the main problems that need to be handled in microgrid operation. Microgrids need to provide multiple end user needs simultaneously. For example, electricity generation, heating and cooling. This paper accords with the analysis of a Microgrid system connected with a Photovoltaic array.

1. Introduction

Now a days electrical power is the prominent source for many of the electrical equipment. For the generation of electrical power renewable energy source and Non-Renewable Sources are the main resources. Among these two Non-renewable energy sources are widely used for the generation of electricity till date. But as the resources for Non-renewable sources are diminishing and their impact on environment conditions are more, now days the focus on the Renewable energy sources usage for the generation of electrical energy is increasing. These inexhaustible energy sources are Solar, wind, tidal, hydro and geothermal etc., These resources are intermittent and not continuous. Out of these solar energy plays a major role for the power generation. Solar energy production is going to have more focus because of no fuel cost. The power generated with the photovoltaic cells is called solar power generation. With usage of solar insolation the DC power can be generated. By arranging the PV cells in a proper order a PV module will be developed. Set of PV modules is called an array. With the help of these PV Arrays we can increase the capacity of the power generation.

2. Photovoltaic connected microgrid- Line Diagram

Photovoltaic connected microgrid- Line Diagram is shown in figure-1
The sources consist of four 100KW PV Arrays and are connected to the inverter which is controlled by a Voltage Source Controller (VSC). The inverter output is connected to a Step Up transformer and is given to conventional grid or to the load. The PV Arrays deliver power to the grid through a converter which can be step up or step down by transformer as per the requirement. Hot Summer months PV Systems generate more than the adequate power, that power is stored in batteries or diverted to the local distribution Stations.

3. **Microgrid Structure**

   a. **PV cell** is a composition of Semiconductor diode which will produce diode action as well as photon Current, this diode exhibits the inverse V-I Characteristics when it is exposed to the solar irradiance.

   b. **Inverter** is a Power electronic device that converts DC Quantity into AC Quantity. the switching device used is a MOSFET because it is the most efficient and effective when compared to other switching devices.
c. **Voltage Source Controller** controls the output of an inverter to maintain the sinusoidal wave for the grid.

d. **Transformer** is a passive device which is used to control voltage with no change in the frequency.

4. **Results**

The simulink model developed for the analysis is as shown in Fig.4. It's going to consist of 4 PV arrays each rated with a maximum generating capacity of 100kW. Each array is made of strings of PV modules connected in equivalent. Each string consists of modules connected in series. The outputs of the arrays are connected to a common DC busbar through Boost converters. From the DC common bus bar the DC output is converted to unity power factor AC through a Voltage converter. The output voltage of the Voltage converter is stepped up using a step up transformer and then fed to the grid. Here the grid is modeled by the combination of distribution and transmission systems.

Fig.4. SIMULINK Model of 400KW PV Array Micro Grid

The microgrid system is analysed in two different cases. (1) With irradiance as constant at 1000W/m² and variable temperature (2) With constant Temperature and variable irradiance.
Case (1) The sun irradiance of the PV arrays are kept constant at 1000W/m². Where as the operating temperature had varied at three different values of 25°C, 35°C and 45°C. For each temperature values the mean power generated and PQ waveforms at the grid were shown in Fig.(5) to Fig.(10).

Fig.5. Output waveforms 4 PV arrays at 25°C

Fig.6. Waveforms of Voltage, Current and PQ at grid with 25°C

Fig.7 Output waveforms 4 PV arrays at 35°C
By observing the figures from Fig.2 to Fig.7., we can come to note that the mean power generated by the four PV arrays was decreasing with the increase in operating temperatures of the PV array. At
25°C the mean power generated by each array was 100kW at 35°C the mean power is 97.8kW whereas at 45°C it has been reduced to 94.7kW. At the same time, at 25°C the grid power is 400kW, 35°C the grid power is 385kW whereas at 45°C it has been reduced to 372 kW.

Case (2): The irradiance is varied with three different values of 1000W/m², 750W/m² and 500W/m² with a constant temperature of 25°C.
By observing the figures from Fig.11 to Fig.16, we can come to note that the active power delivered to grid is decreasing as the sun irradiance is decreasing. At 25°C, with sun irradiance of 1000W/m², the active power delivered to grid is 400kW and it has decreased to 300kW with sun irradiance reduced to 750W/m² and to 197.65kW with sun irradiance of 500W/m².
5. **Conclusion**

Hence, from above Analysis it has been observed that the mean power delivered by the PV arrays and active power delivered to the load is maximum at a temperature of 25°C and sun irradiance of 1000W/m².

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