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Research Study on Solar PV based Scalable DC Microgrid Design and simulation for Rural Electrification

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Abstract: In this paper We present the analysis and design of the e dc micro grid system for electrification. The micro grid configuration has been driven by field information gathered from India. The important parameter of such system depends on the Micro grid capacity of the transmission network which overflows the value of the voltage and the current from the main grid, which power the cost matrix analysis of the overall system which has to be equal. In this paper, we compute that the excessive cost of power (COE) for the proposed dc micro grid framework will be under minimal charges as put forth by the electrification governing agency according to the per kW-hr. We additionally present test results from a privately introduced dc micro grid model that exhibit the consistent state conduct, the bother reaction, and the general efficiency of the framework. The results show the reasonableness of the introduced dc micro grid design has totally inflicts with the main grid feasibly and found out to be very easy to implement without any extra cost to the system as far as the rising districts and the number of population in such districts are concerns.

1.INTRODUCTION

Power machine harmonic distortion has existed for the reason By 2035, the population of the world is supposed to increase by almost 1.5 billion which will make the population reach 8.8 billion people. This increase in the population will cause two things. The first one is an increase of the demand on energies. The demand on energies will cause the decrease of fossil fuels resources and the increase of CO2 emissions to reach approximately 39 billion tones by 2035. The second one is creating issues related to power grids which can be resumed to;

- Congestion : The components of the power grids are old and cannot satisfy the demand for a growingpopulation
- Security, protection, transmission losses and losses due to the gap between production andconsumption.
- Problems emerge when the power grids are far from where the power isneeded.

naturally replenished on a human timescale, such as sunlight,wind,rain,tides,waves,and other mal heat.

2. IMPLEMENTATION

More than half of the world is still in need of electrification. Most of these areas are far away from the grid and are in a location where it is impossible for the grid to penetrate. Due to this the growth ofthese areas is substantially affected. This problem can be solved by employing DC (Direct Current) off grid systems according to the needs of these places. The main advantage of employing a DC off grid system is that it can be powered by renewable energy sources directly. This is a good opportunity to initiate the use of renewable energy technologies in areas where the grid cannot penetrate. As most of the basic appliances like lights, cell phone chargers etc., consume DC it will be easy to incorporate renewable energy technologies like solar PV, wind turbines and fuel cells. The storage batteries used in these kinds of systems also require DC for charging. So the off grid DC micro grid will be suitable for rural areas where grid connection is hard to reach. The DC micro grid and mini grid systems are gaining more and more importance in recent days. Research is being done in this area by developed countries to bring about a change in the electrification of buildings. The DC mini grid is seen as a viable alternative for the existing AC electrification network due to its advantages.DC electrification is not only considered for rural areas but also for urban buildings as well. DC electrification is not a new idea as it was in usage before the arrival of AC as the electrical load was DC back in the old days. The arrival of complex appliances like air conditioning, AC (Alternative Current) motors and long-range power transmission influenced the use of AC electrification. There is a steady increase in the appliances that work on DC and more and more are being invented. Most electronic appliances that we use today such as laptops, computers, TV etc. require DC for their working. These appliances draw AC and convert it to low voltage DC through the adaptors provided for these appliances. This conversion can be avoided if the electrification is DC. Most of the appliances in our daily life consume DC, for example, light bulbs which are in use for a long time.Due to the technological advancements, we now have LED lights, which work by converting AC to DC with a sufficient working voltage. One of the major issues in converting AC to DC is the power loss associated with it. Due to these disadvantages the DC electricity network and mini grid are seen as a viable option to replace AC grid and electrification in developing regions.A micro grid (MG) can be defined as a group of renewable energy sources and energy storage devices controlled by a monitoring

system to provide power to the loads for which it is designed The energy source may or may not include the local utility grid. A microgrid can be seen as a smaller version of the traditional power grids. The consortium of Electric Reliability Technology Solutions (CERT) describes the concept of a microgrid as an — aggregation of loads and micro sources operating as a single system providing both power and heat. A microgrid consists of power generators, distribution and control systems for voltage regulation just like a conventional grid. However, the main difference between the conventional grid and the microgrid is the close proximity between the power generation and the end users. In recent years microgrids have gained a lot of attention due to the advancements in renewable energy technologies. 2.. The diesel generators can be used as a backup power supply or as a regular power source running parallel to the renewable energy sources (RES). The control system denoted is used as a means to regulate the power from various sources to theload.

A solar PV module can be described as an arrangement of solar cells in series and parallel enclosed in protective casing. The solar cells are stacked in series and parallel to generate a notable amount of power. A solar cell is a device, which converts sunlight into electrical energy.It can be described as a silicon (or other material) PN junction diode. A single solar cell generates a voltage of 0.5 to 0.8V depending on the technology with which it is made of. Matlab/Simulink is a platform where any component can be modeled using its respective mathematical expressions. The first method is by modeling the component using mathematical equations of the chosen component. In this case the mathematical expression of a solarcell.

3.MODEL DETAIL

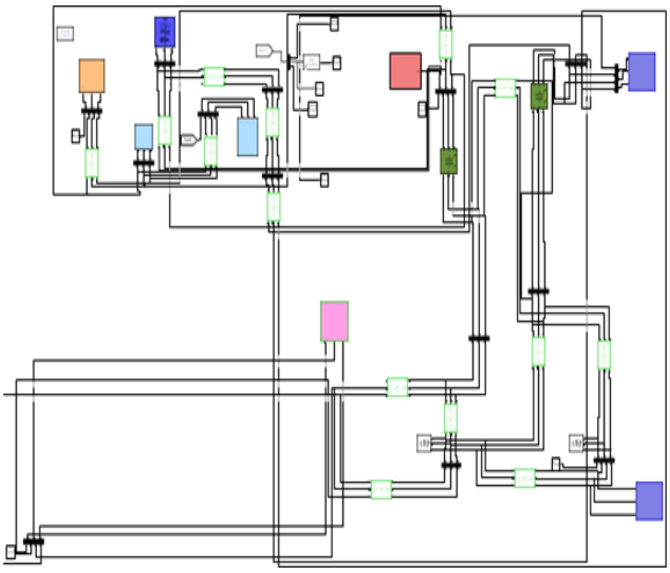

Figure 1: Simulation Model of System

4.RESULT ANALYSIS

As in standalone system solar energy is the only source of energy, battery system is used to mitigate the load demand. Some times when solar energy production is low the battery system can provide the excess energy demanded by the load. When load varies there will be a power mismatch between solar generation and local load, and that power gap can be fulfilled by the use the lead-acid battery system**.** When load increases the battery have to supply the extra power and when load decreases the battery have to consume this extra power. Here a resistive load is taken for simulation and it is varied like the following 7.5 W → 6 W → 5 W, and the simulation results are captured for output voltage, load current, battery's SOC and powers at generation and demand.In other words active power load is varied in the following sequence, 1.6 kW → 2 kW → 2.4 kW. For this load variation the steady state output voltage is shown Figure 4.7, which indicates that under load variation the output voltage is remains unchanged and stable. This proves the effectiveness of inverter current control technique which is responsible for maintaining 110 V of constant voltage across the load.

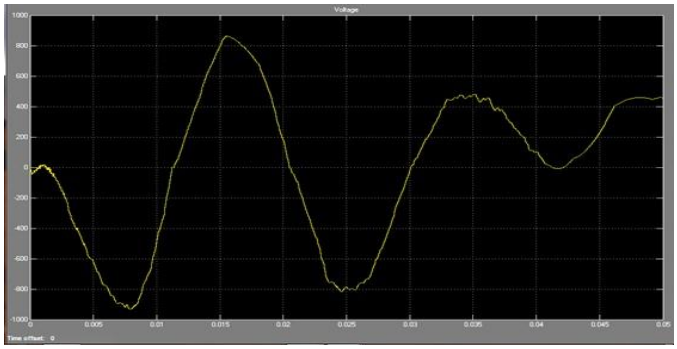

Figure 2: Result of PV Scope in MATLAB

WITH SOLAR IRRADIANCE VARIATION

As we know solar power is intermittent in nature, it can not provide a steady power to the load connected. That means sometimes load power demand is constant, but due to the variation in solar power generation, we need the help of BSS to compensate that extra power. So when PV generation power is not sufficient tomitigate the load demand, BSS needs to provide the extra power through the discharging process and this condition is called underproduction. When PV generation power is more than the load power demand, the BSS needs to store the excess power through the charging process and this condition is called over production.

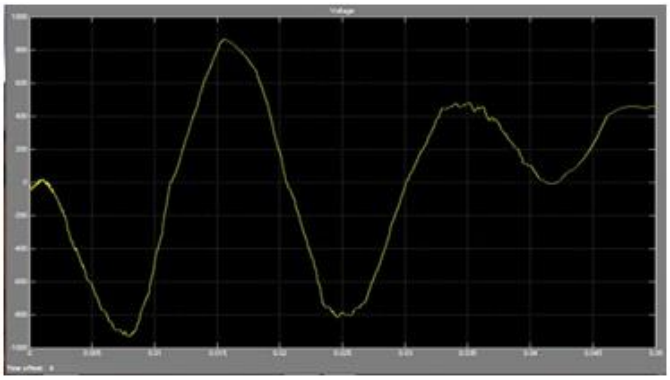

Figure 3.Result of Voltage Scope in MATLAB

In a standalone PV system, battery is used as backup source to provide stable voltage and current to the load. Stable voltage and current at the load can be achieved when the PV generated power should be balanced with the load demand power. That means when PV generation is less than the load demand, battery needs toprovide the extra power and when PV generation is more than the load demand, battery needs to store the extra power. Battery is a bidirectional device as it can store and give energy by its charging and discharging process respectively. So in this research work, the standalone PV system is simulated and the simulation results show the effectiveness of all the three control loops used. And simulation results also show the purpose of using BSS in the standalone PV system.

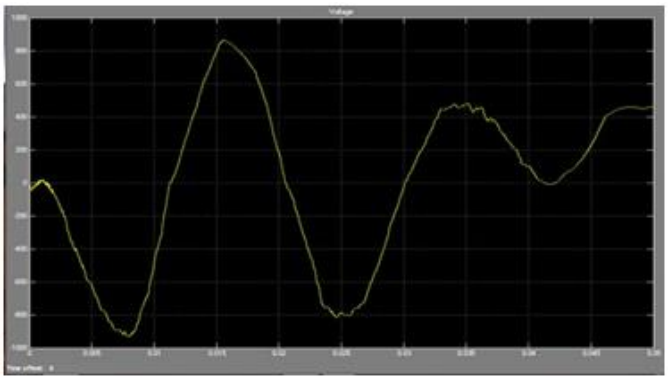

Figure 4. Output of System

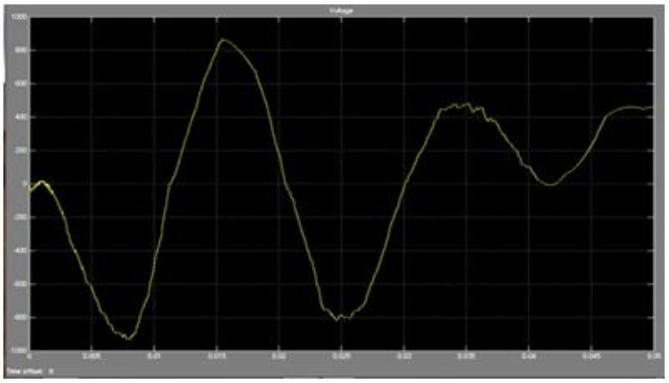

Figure5. Result of PV Array in MATLAB

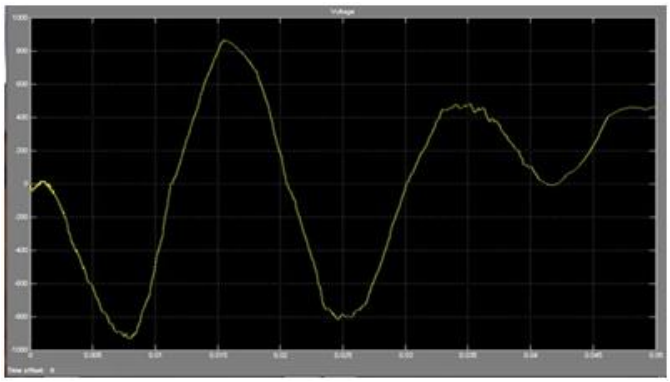

Figure 6: Result of Output Power in MATLAB

5. CONCLUSION

DC Microgrid is preferred if more components are directly DC compatible. For that particular system, it is possible to reduce the dump load size and also improved efficiency by removing all types of converters. Examples of DC compatible components are LED lights, TV, laptop, mobile charger etc. DC micro grids are cheaper in cost. AC Microgrid is preferred when Microgrid directly connected to the grid here no dump load is required. Microgrids are expensive due to inverters. The main advantage with AC Microgrids is expandable and efficient.

This master thesis helps to encourage further study of individuals in the renewable energy system. The worldwide prospect is to reduce fossil energy supply. It is one of the important issues in present days. By using renewable energy sources; if the energy produced locally it would result in a build of the Microgrid in the region as well as reduced transmission losses i.e. energy produced and used locally. Local pollution can also be lowered and in a wider perspective, since the electric power-grid is connected throughout many countries with a common trade system, it can also help to reduce the pollution globally .It is also the prospect for

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