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Simulation And Analysis Of A Grid Connected Microgrid

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Abstract — *A microgrid consists of distributed resources (DR) like wind, PV, small Hydro, DG set etc. A microgrid can work in grid connected mode as well as in islanded mode. Microgrid simulated in this paper consisted of a Photovoltaic, Wind Turbine and Battery system. After analyzing the microgrid in islanded mode, the microgrid was connected to grid and synchronized. Grid considered here is a nine bus system. Complete simulation was done using PSCAD.*

Keywords- *Microgrid; Renewables; Nine bus system; PV; Wind Turbine; PSCAD.*

I. INTRODUCTION

Electricity demand and consumption both have increased rapidly, in India and abroad. Advancing technologies can be considered as a major reason. As the demand increases supply need to be raised accordingly. Though the conventional power plants are already installed (307.28 GW in India), now it is time to move towards unconventional and decentralized power system. Decentralization is more beneficial in case of rural electrification. Also, it incorporates more renewables. [1]

Decentralization means instead of having the centralized large power generation, small power plants can be installed at the consumers' end. These small power plants would be able to fulfill the local power demand. Also, if surplus power is generated, it can be stored for emergency purpose or can be supplied to nearby other loads. Decentralization makes use of Distributed Generation (DG). DG is basically small scale generation of electricity. DG can be defined as electric power generation within distribution networks or on the customer side of the network. [2] The IEEE defines distributed generation as the generation of electricity by facilities that are sufficiently smaller than central generating plants so as to allow interconnection at nearly any point in a power system.[3] Generation of these is still not defined specifically but varies from less than One kW to Tens of MW. The distributed energy resources or distributed resources can be used either individually or can be clustered together to form a microgrid.

According to USA department of energy, microgrid is defined as A group of interconnected loads and distributed energy resources (DER) with clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid [and can] connect and disconnect from the grid to enable it to operate in both grid connected or island mode. DRs can include any of these, viz. Combined heat power (CHP), Fuel cells, Hybrid power systems (solar hybrid and wind hybrid systems), Microturbine, Photovoltaic systems etc.

II. MICROGRID

Microgrid can be defined as a cluster of microsources or distributed resources and loads working as a single system that is responsible for providing both power and heat to the local area [4]. These microresources can be either renewable sources, microturbine or diesel engine. Along with these distributed sources storage devices play a very vital role in maintaining continuous supply.

A microgrid comprises of small sources which have power electronic interfacing. These power electronic devices are responsible for controlling and they also ensure that the microgrid fulfils the demand of customer and utility. For accurate operation of a microgrid, three parts are mandatory:

- Local microsource controller.
- System optimizer.
- Distributed protection.

The existing Electrical Power System has centralized power generation. When DGs and microgrid are installed at consumer end these are responsible for fulfilling the load. But in case of any sort of interruption in supply, some other source must be present. For such a case microgrid formation is beneficial. So that in absence of one source other source is available. Microgrid is similar to a normal grid, just smaller in size. It can thus be operated in a similar way. In case of occurrence of any fault in microgrid or any source or any line of microgrid, it is of utmost important to prevent the flow of fault current through the system. To prevent it, the faulty part need to be removed or disconnected from the main grid. A similar disconnection can be made if such a fault occurs at main grid side. In such a case the microgrid need to be disconnected from main grid completely, known as Islanding of the grid. Based on the fault occurrence there are four modes of operations of a microgrid.

These modes can be enlisted as:

- Area EPS-connected mode (normal parallel operation).
- Transition to island mode (island condition recognized).
- Island mode (disconnected from main grid).
- Reconnection mode (Re-synchronization).

All such factors need to be considered while simulation of a grid connected microgrid. The paper discusses one example of a microgrid that comprises of PV and Wind turbine as generators and battery as storage. Formation of the microgrid requires formation of Photovoltaic module and wind turbine module along with power electronic converters.
The results obtained after simulation of the microgrid given in figure 1 are as shown in following figures.

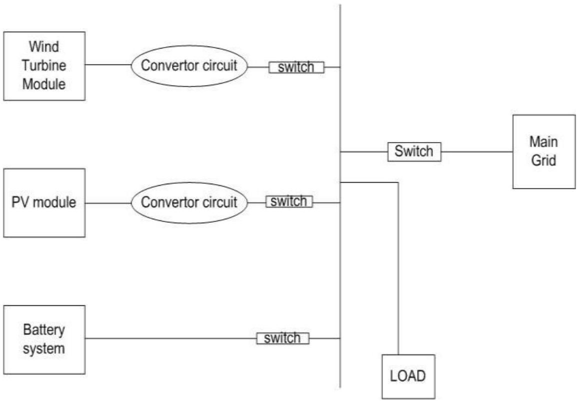

Fig. 1. Microgrid connected to main grid.

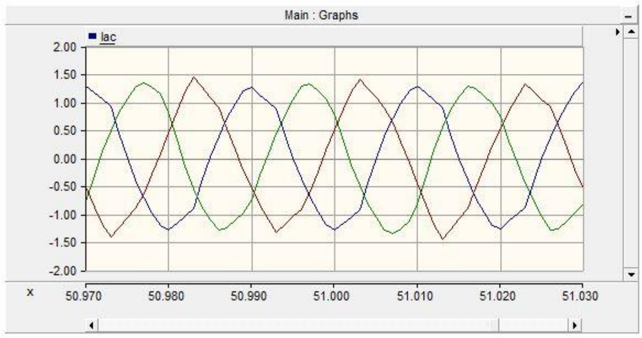

Fig. 2. Current output at inverter end of PV system.

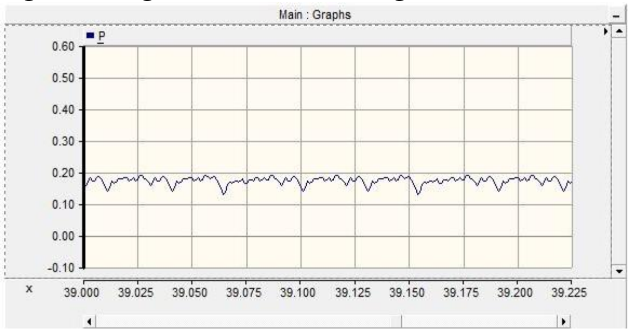

Fig. 3. Power output at inverter end of PV system.

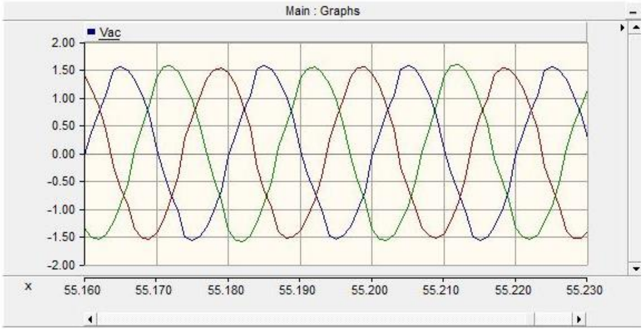

Fig. 4. Voltage output at inverter end of PV system.

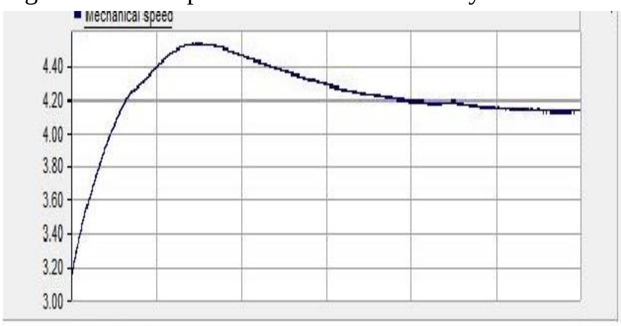

Fig. 5. Mechanical Speed.

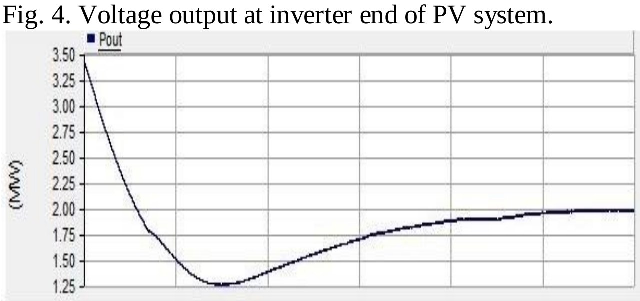

Fig. 6. Power at the converter end of Wind Turbine.

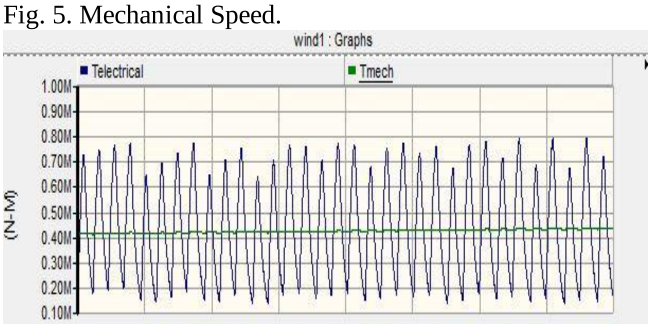

Fig. 7. Electrical and Mechanical Torque of Wind Turbine.

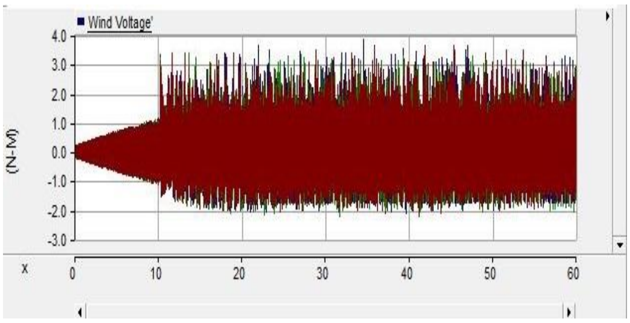

Fig. 8. Voltage obtained at the output end of Wind Turbine.

III. Main Grid

Centralized grid or main grid already exists in the current scenario. The microgrid formed after connecting different distributed resources is to be connected to the main existing grid and synchronized.

The WSCC 9-bus system refers to a system in Western System Coordinating Council (WSCC) that is equivalent to an electrical system that comprises of three generators and nine buses. The base KV levels are 13.8 kV, 16.5 kV, 18 kV, and 230 kV. Using the WSCC nine bus system case a similar system was designed and simulated in PSCAD. The simulated model in PSCAD is as shown in the figure 9.

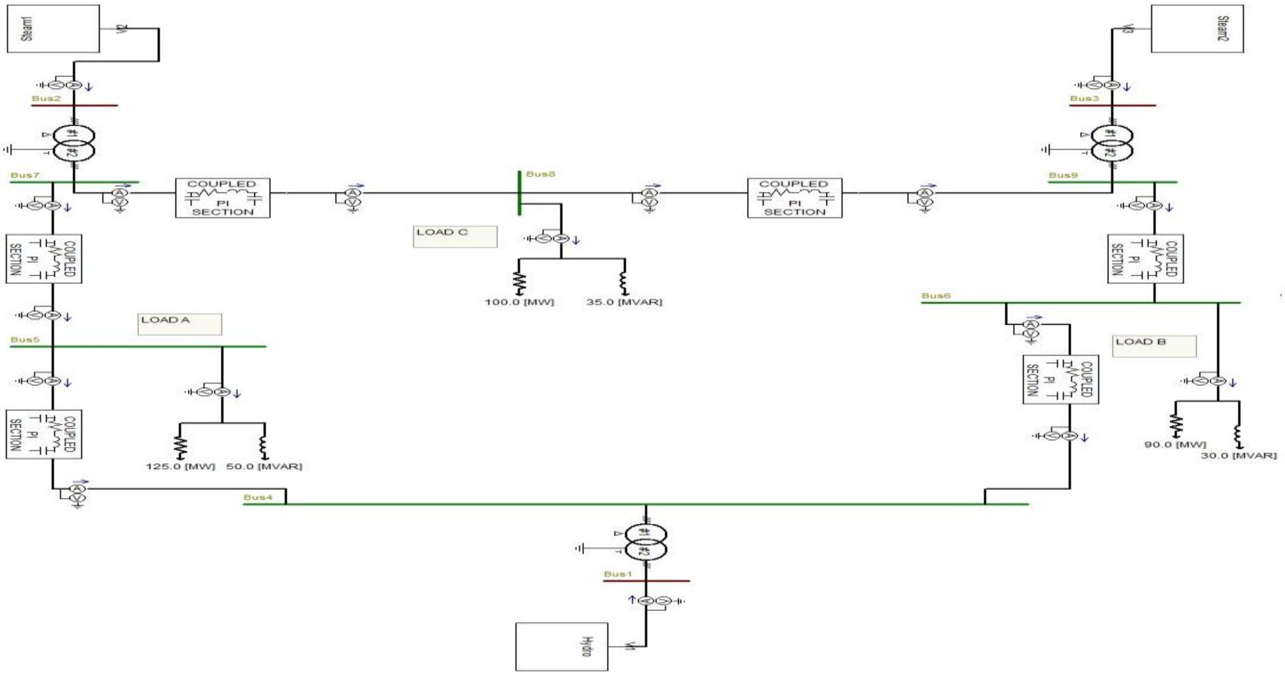

Fig. 9. Nine bus system.

Output received at all the generators in the nine bus system after simulation are given in the figures below

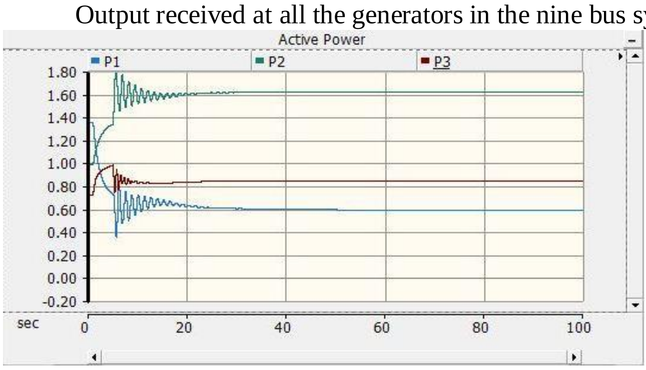

Fig. 10. Active Power at the generators.

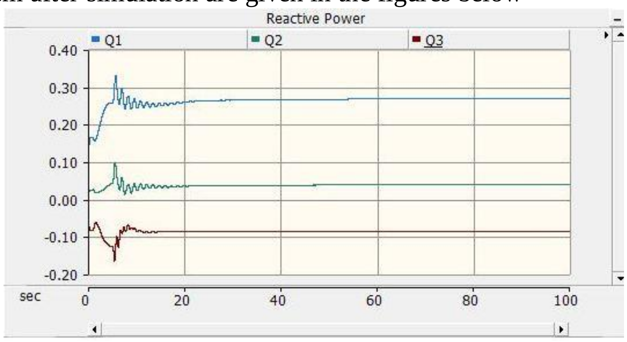

Fig. 11. Reactive Power at the generators.

In WSCC nine bus system out of three generators two are steam turbine generators and one is hydro generator. The Base or reference bus is the one connected to this hydro generator. The transmission lines and load are also designed as per the given data.

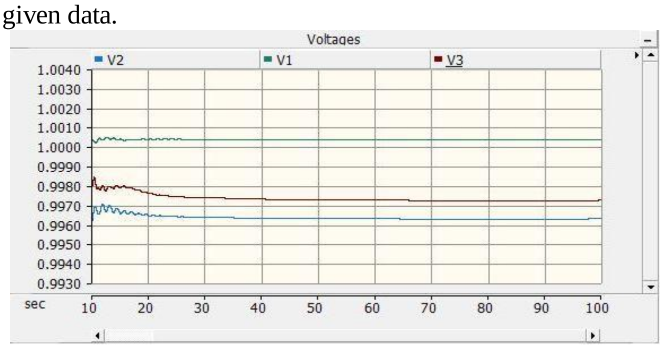

Fig. 12. Voltages obtained at generators.

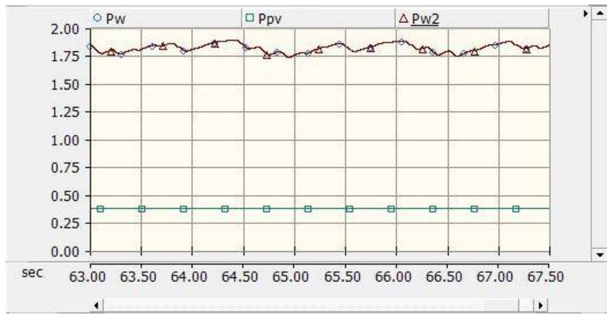

Fig. 13. Active Power at Distributed Resources.

IV. GRID CONNECTED MICROGRID

From [19] ,there are numerous sorts of insulating material however for the particular reason a few prerequisites ought to be satisfied. Insulating material need to keep their shape, tough and safe against mold and turbides. The dampness equalization of the build must be sure i.e. the water collecting inside the development amid the defrosting period must be evacuated to the outside amid the dissipation period. The position of twist tight layer at the external surface and water/air proof on the internal surface keep the protection material from being perfused with sticky and warm room air from within or chilly surrounding air from outside. Contingent upon the field of utilization, the protection material need to suffice the wellbeing necessity for the flame assurance.

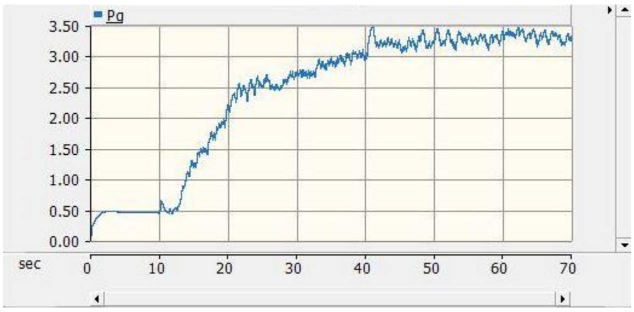

Fig. 14. Active power of main grid at PCC.

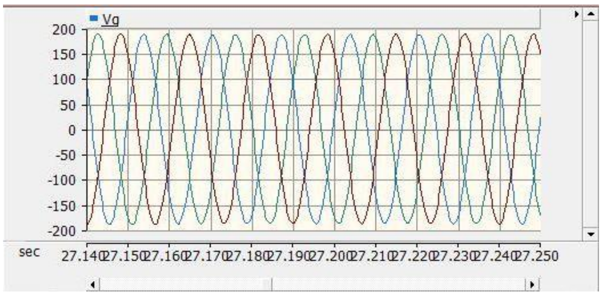

Fig. 15. Voltage at PCC

V. CONCLUSION

Microgrid is considered to be a possible solution for present energy crisis scenario. Microgrid finds its application in the decentralized electrical power system where several distributed resources are interconnected to form a small grid. There are basically two modes of operation of microgrid viz. Grid connected mode and Islanded mode. The transition from one mode to other should be smooth. In case of any fault in main grid the microgrid should be disconnected in order to protect itself. Several protection schemes also need to be implemented.

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