Bharat Lal Yadav, 2024, 12:5
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

International Journal of Science, Engineering and Technology

An Open Access Journal

Microgrid Modelling and its Performance Identification Using Matlab Simulink

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Abstract- In this work, a Microgrid (MG) test model based on the 14-busbar IEEE distribution system is proposed. This model can constitute an important research tool for the analysis of electrical grids in its transition to Smart Grids (SG). The benchmark is used as a base case for power flow analysis and quality variables related with SG and holds distributed resources. The proposed MG consists of DC and AC buses with different types of loads and distributed generation at two voltage levels. A complete model of this MG has been simulated using the MATLAB/Simulink environmental simulation platform. The proposed electrical system will provide a base case for other studies such as: reactive power compensation, stability and inertia analysis, reliability, demand response studies, hierarchical control, fault tolerant control, optimization and energy storage strategies.

Keywords- Electrical engineering, System diagnostics, Power system operation, Power converter, Smart grid technology, Distributed resources, Microgrid benchmark, Hybrid energy systems, Power flow.

I. INTRODUCTION

The liberation of the energy market and the new conditions in the energy field are leading towards the finding of more efficient ways of energy production and management. The introduction of new ideas capable of evolving in the new conditions might lead to more suitable solutions compared to any possible malfunctions the new market model can create.

Renewable energy systems (RES) propose a new technology that is cleaner and capable of supplying the growing electricity demands of interconnected and isolated communities. In recent years, MGs have become a great attraction for the scientific community as well as a promising solution for future traditional energy systems. MGs are seen as a possible technology for the integration of variable renewable energy systems in the traditional grid. Currently, with the evolution of new digital technologies, such as micro-processed systems and advances in power electronics, many applications have been implemented in SG, specifically in the development of controllers and electronic energy converters. In recent decades, researchers have made significant contributions which have had a high impact in these areas, mainly aimed at data acquisition, automation, and control of MGs [1, 2, 3]. MGs not only integrate the distributed generation to the Main Grid in a reliable and clean fashion, but also provide high reliability in its capacity to operate in the face of natural phenomena and active Distribution Grids, which in turn results in less energy losses in transmission and distribution and less construction and investment time [3, 4, 5, 6]. Research developed in [7, 8, 9, 10, 11, 12, 13, 14, 15] show actual implemented MGs. Some of the examples can be seen in CERTS in the US, NEDO in Japan, and a vast majority of MGs in Europe.

The combination of utility restructuring, technology evolutions, recent environmental policies provide the basis for DG to progress as an important energy option in the near future. Utility restructuring opens energy markets, allowing the customer to choose the energy provider, method of delivery, and attendant services. The market forces favour small, modular power technologies that can be installed quickly in response to market signals.

This restructuring comes at a time when:

- Demand for electricity is escalating domestically and internationally;
- Impressive gains have been made in the cost and performance of small, modular distributed generation technologies
- Regional and global environmental concerns have placed a premium on efficiency and environmental performance; and
- Concerns have grown regarding the reliability and quality of electric power.

II. DISTRIBUTED GENERATION IN MICROGRID/SMARTGRID

Definition

Generally, the term Distributed or Distributed Generation refers to any electric power production technology that is integrated within distribution systems, close to the point of use. Distributed generators are connected to the medium or low voltage grid. They are not centrally planned and they are typically smaller than 30 MWe (DTI 2001).

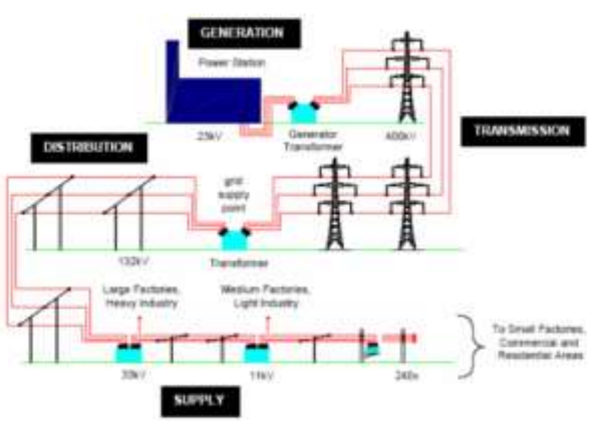

Fig 1: An electric power system

The concept of DG contrasts with the traditional centralised power generation concept, where the electricity is generated in large power stations and is transmitted to the end users through transmission and distributions lines (see figure.1). While central power systems remain critical to the global energy supply, their flexibility to adjust to changing energy needs is limited. Central power is composed of large capital-intensive plants and a transmission and distribution (T&D) grid to disperse electricity.

A distributed electricity system is one in which small and micro generators are connected directly to factories, offices, households and to lower voltage distribution networks. Electricity not demanded by the directly connected customers is fed into the active distribution network to meet demand elsewhere. Electricity storage systems may be utilised to store any excess generation. Large power stations and large-scale renewables, e.g. offshore wind, remain connected to the high voltage transmission network providing national back up and ensure quality of supply. Again, storage may be utilised to accommodate the variable output of some forms of generation. Such a distributed electricity system is represented in figure 1.2 below.

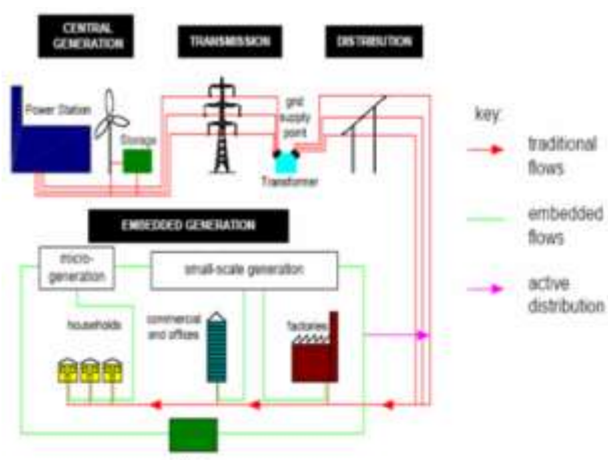

Fig 2: A Distributed Electricity System

The non-traditional operating model of DG has drawn strong interest because of its potential to cost effectively increase system capacity while meeting the industry restructuring objective of market driven, customer-oriented solutions. These distributed generation systems, capable of operating on a broad range of gas fuels, offer clean, efficient, reliable, and flexible on-site power alternatives. This emerging portfolio of distributed generation options being offered by energy service companies and independent power producers is changing the way customers view energy.

Both options require significant investments of time and money to increase capacity. Distributed generation complements central power by (1) providing in many cases a relatively low capital cost response to incremental increases in power demand, (2) avoiding T&D capacity upgrades by locating power where it is most needed, and (3) having the flexibility to put power back into the grid at user sites. Significant technological advances through decades of intensive research have yielded major improvements in the economic, operational, and environmental performance of small, modular gas-fuelled power generation options. Forecasts predict a total 520GW from newly installed DG around the globe by 2030.

III. PROPOSED METHODOLOGY

A micro- grid includes a small scale power supply such as wind turbine, photovoltaic array or diesel generator connected to serve the demand of small communities. Precisely, we can say it is a distributed generation (DG) network work as a group or individually to provide energy [2].

A micro-grid have green energy sources like wind turbine, PV array and all are connected to conventional utility through bidirectional convertor. This mode of operation is called grid-connected mode, unlike the autonomous island mode where the conventional utility is disconnected from the micro-grid. In fact, micro-grid can include AC sources, DC sources or both of them to form a Hybrid Micro-Grid [3].

Energy sustainability is biggest challenge and to enhance power supply reliability micro grids are future promising. Micro grid is an energy sector for better utilization of distributed energy generation using renewable energy sources like wind, tidal, biomass, solar etc.

According to US Department of Energy

"A Micro grid is a group of interconnected loads and distributed energy sources within clearly defined electrical boundaries that act as a single controllable entity with respect to the grid".

As electrical distribution technology steps into next century, there are many trends becoming noticeable that will change the requirements of energy delivery. And these modifications are being driven from both the demand side where higher energy availability and efficiency are desired and from the supply side where the integration of distributed generation and peak-saving technology must be accommodated. Power system currently undergo considerable change in operating conditions and requirements mainly as a result of deregulation and due to an increasing amount of distributed energy resources (DER).

The strategy is to maintain the per unit values of the voltage at dc side and the frequency on ac side. By this control strategy the demanded load in ac and dc micro grids can be shared among the whole micro grid sources.

Basic component in micro grids-

Local Generation

Conventional energy sources – diesel and renewable energy sources – wind, solar.

Consumption

Lighting, heating system of buildings, commercial centers etc.

Energy Storage

In micro grid, energy storage is able to perform multiple functions such as ensuring power quality, including frequency and voltage regulation, smoothing the output of renewable energy sources, providing backup power for the system and playing crucial role in cost optimization.

Point of Common Coupling (PCC)

It is the point in the electric circuit where a micro grid is connected to a main grid. Micro grid that do not have a PCC are called isolated micro grid.

The DC micro grids have already been proposed which are hosting dc technologies like energy resources and dc loads are adopted. But AC energy resources and AC loads would require AC/DC converters before they can be connected to DC micro grids. To reduce conversion requirement associated with both ac and dc micro grids, an AC/DC hybrid micro grid would be advantageous. Also today's advanced metering infrastructure (AMI) enables AC and DC micro grids to be connected, coordinated and also controlled efficiently.

IV. RESULT AND SIMULATION

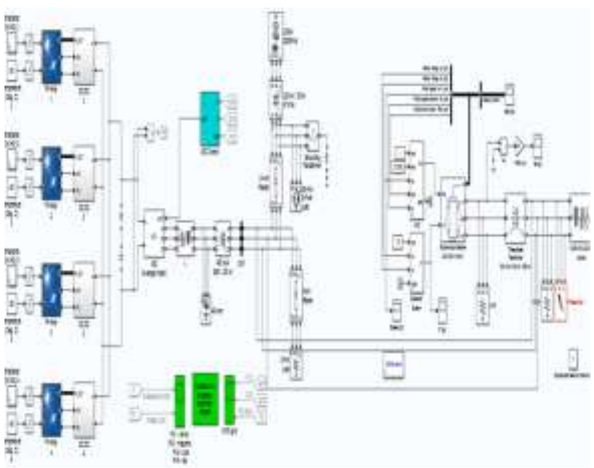

Fig 3: Simulink model

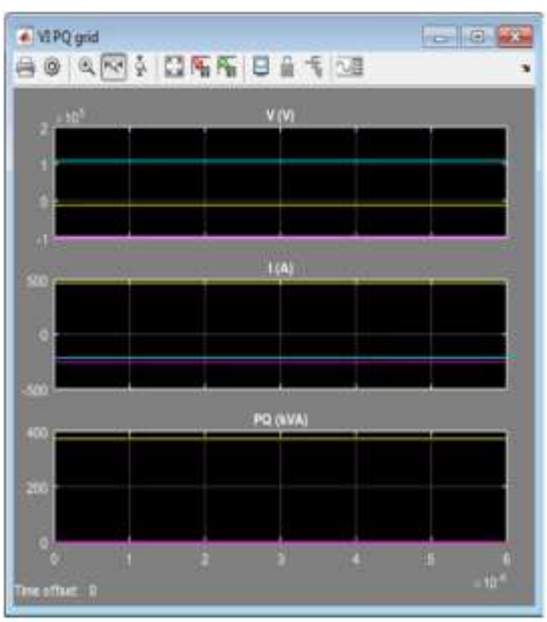

Fig 4: Solar across power variation

V. CONCLUSION

In this Review, AC/DC hybrid micro-grid using MATLAB/Simulink has implemented. Simulation results at each individual block of the designed systems have given. The simulation results show that the system is stable under various load and supply conditions. A hybrid AC/DC micro-grid concept is introduced in this paper to avoid multiple reverse conversions in an individual AC or DC grid and to facilitate the connection of various renewable AC and DC sources and loads. A typical hybrid grid and the operation issues are investigated. Different operating modes of the hybrid grid and control techniques are investigated. A control algorithm is proposed to eliminate the problem caused by unbalance and nonlinear load in AC link. The simulation results show that the algorithm is effective. A control technique is proposed to maintain voltage stability and smooth power transfer between AC and DC links under various supply and load conditions. The simulation results show that the power flow can be smoothly transferred based on the proposed control index

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