Modelling and Simulation of Power Sharing in Micro Grid

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Abstract— A small community of micro grid simulation platform is introduced in this paper. This simulation platform is capable of simulating the large grid models with high switching frequency. A small community of micro grid model which includes the PV, fuel cell, wind turbine LES, power electronic circuits, and circuit breakers. By using this model we can use the renewable energy more effectively in the little group like homes, parks and in offices. On this platform a case study is demonstrated and also the simulation result shows the importance of the micro grid.

Key words: Micro Grid, Model Description, Simulation by using MATLAB

I. INTRODUCTION

With developing necessity of electrical power, nature of service and coherence of supply has been the most vital for all significant power segments over the world; this can be accomplished from the smart grid.

Smart grid implies usage of renewable energy, energy storage systems by utilizing the controllers, power electronics and communication system keeping in mind the end goal to accomplish more dependable, financial and earth-friendly electric power system. A renewable energy resources, for example, photovoltaic (PV), wind turbine, battery and so on are utilized as a part of smart grid furthermore controls electronic circuits is utilized. The trial investigations of large scale smart grid are not economical, so we will go for smaller scale grid; in this likewise energy sources are limited. In micro grid two renewable energy sources and two inverters in [1] can keep running with 1 kHz switching frequency in real time. Along these lines different methods are expected to accelerate real time simulation of smart grid.

Then again, the communication network is fundamental to effectively use the a large number of the elements of the smart grid, for example, distributed automated system, presentation of network state and execution, energy resource protection, controlling and islanding. Along these lines, incorporation of various types of communication network and to stimulate the electric power system at real time is the challenge to the smart grid [2]-[3].

This paper presents the study of the micro grid and its simulation. In section II study of micro grid. Section III is about a case study. Section IV is simulation results and lastly, in Section V, conclusion and future work are explained.

II. ABOUT MICRO GRIDS

Micro grid is a power supply which gives energy to a little group in which a gathering of renewable resource for example: homes, parks, and office structures. The micro grid has got more enthusiasm by this its changing the dependency on centralized power system. Centralized power system is used to transmit the power from a big source to so many utilities by transmission line and a main centralized control and hence can create losses in the line so the efficiency of the power supply will reduce. In Oregon City during 1996, twelve million customers lost power in eight states because of the transmission line were damaged. This incident can be avoided by implementing the power grid or micro grid.

When trouble occurs in the main distribution system, the micro grid can be separated from the main distribution system to separate the loads from the trouble and by this the continuity and reliability of the power supply is maintained without affecting the main transmission grid. The Louisiana State University (LSU) includes micro grid network along with the main power supplied by Entergy. Micro grid generates 20MW power by using a gas turbine and supplies the power to the different campus buildings. The remaining power required to the campus is supplied by the main grid of Entergy. During Hurricane Gustav in 2008, when the rest of Baton Rouge was out of power, the buildings in LSU still had power because LSU has its own generation.

Modern micro grids are referred to small power systems that help us to generate the electric energy, from both renewable energy sources and conventional synchronous generators, and two customer loads with respect to produced electric energy. This can be connected to the main electric grids or it can be operated as islanding mode. In micro grids, alternative energy sources such as renewable can be integrated with local consumptions and are more efficient and as less environmental issues.

This enables the increase in performance and increases the supply reliability. Since micro grid are to be on or close to the site which they are to supply control, the misfortunes which happens during the transmitting the power can be minimized, which makes micro grid considerably more prominent. Finally, micro grids can be adjusted by requirements of the site where it is using. For example, it can be used only for lighting purpose or for working on big machinery.

As we know that, micro grid helps us to use of the renewable resources, such as wind and solar, increases the generation capability of a micro grid and address the environmental concerns, due to the unpredictable nature the economic operation and stability are the challenges to the micro grid system. Power fluctuations caused by unpredictable nature of the renewable should be maintained to serve the load demand more appropriately. The lack of same relationship between the mentioned renewable energy sources and the consumption, challenges the economic operation of the power grid. Usually the wind energy is mostly available during nights when the consumption is at its lowest level and also in the middle of the day the maximum energy is produced in the solar cells, at this instant the consumption is not more and no solar energy is available on cloudy days this all are the complication. Hence, by using the stored energy (battery) we can avoid the complication in case of wind energy and solar energy.

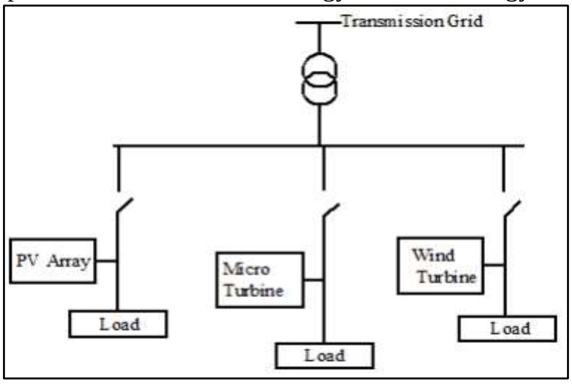

Fig. 1: Basic module of micro grid

III. CASE STUDY

A. *Model Description*

The Fig. 2 Shows the small community of smart grid called micro grid is modeled with simulation in MATLAB.

Micro grid includes PV generation, wind energy, fuel cell stack, Local energy storage (LES), non critical load and critical loads.

Here each unit in micro grid is built with detailed characteristics. The PV is built with converter and inverter circuit with MPPT to give the maximum ac output [4]. The wind turbine is built with back to back inverter as doubly fed induction generator (DFIG) [5]. The recycled battery is modeled as LES. The output voltage of LES is determined by the state of charge [6]-[9]. The non critical load and critical load is built as resistive load. All circuit breakers built as solid state circuit breakers. The switches are operated at 10 kHz switching frequency. Fig 13 and 13.1 shows the prototype micro grid model.

B. *Control Circuit*

The aim of the control circuit is to maintain the voltage and current spikes of the system when it is switching from grid connected mode to when grid is absent.

1) Grid-Connected Mode:

A multi loop controller is used in grid connected mode for grid tied inverters. To keep the DC link voltage constant is the main function of the inverter control circuit. The external loop of the controller comprises of a voltage circle with dc-link voltage as input. The inward loop is a grid current control loop, with the active current reference created by the external voltage loop and receptive current reference set to 0, as appeared in Fig. 3.

With considering the circuit in Fig. 2.1, the rearranged transfer function of current open-loop in dq-rotating reference is

$$\frac{Id}{V^{*}dl} = \frac{1}{Lfs + Rf}$$

Compared to the external voltage loop the reaction of the inward current loop should be much faster, for the decent system execution the proportional–integral (PI) controller is utilized. The design of the voltage control loop depends on the assumption that the inward current loop is ideal. The open-loop transfer function is

$$\frac{Vdc}{I^{*}d} = \frac{1}{Cs}$$

Again, a PI controller is connected to get the required system response attributes. The LES with converter will be operated in current control mode.

2) Islanding Mode:

In islanding mode, the same control circuit as shown in Fig. 3 is used for LES inverter but the ac bus voltage as the feedback in the external voltage as shown in the Fig. 4. The inward loop is same as the in Fig. 3.

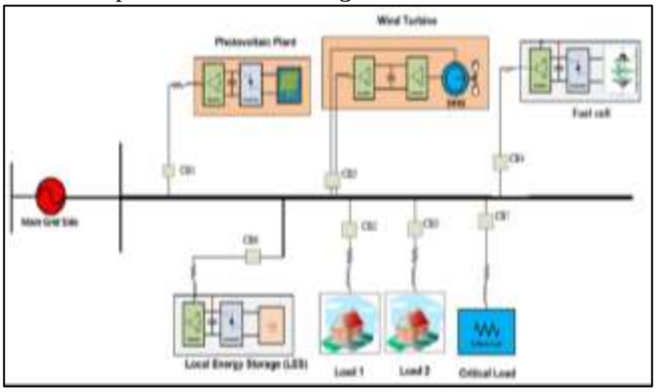

Fig. 2: Small module of micro grid

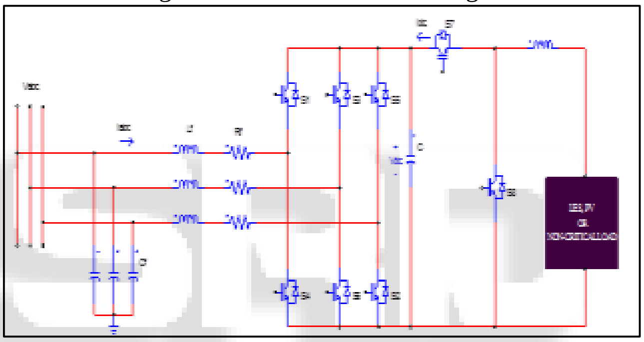

Fig. 2.1: Circuit topology

The current open loop transfer function of the islanding mode is given by

$$\frac{Id}{V^{*}dl} = \frac{Cfs}{LfCfs^{2} + RfCfs + 1}$$

A current control is executed by the PI controller. At the same time, the external voltage loop transfer function is given by

$$\frac{Vd}{I^{*}d} = \frac{KcpS + Kci}{(LfCfs^{3} + (RfCf + KcpCf)s^{2} + (KciCf + 1)s)}$$

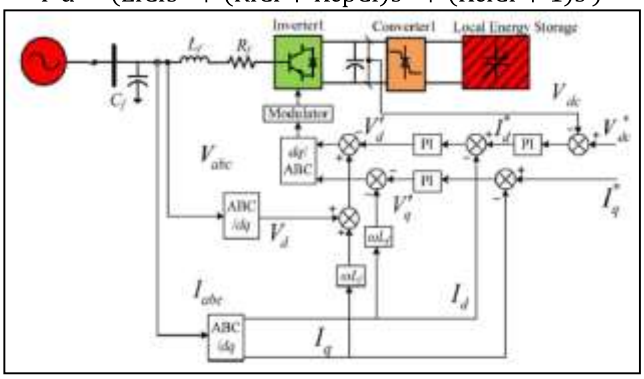

Fig. 3: Control circuit for LES (Grid connected mode)

Here the Kcp and Kci are the proportional gain and integral gain of current PI controller. Here for voltage control requirement PI controller is used.

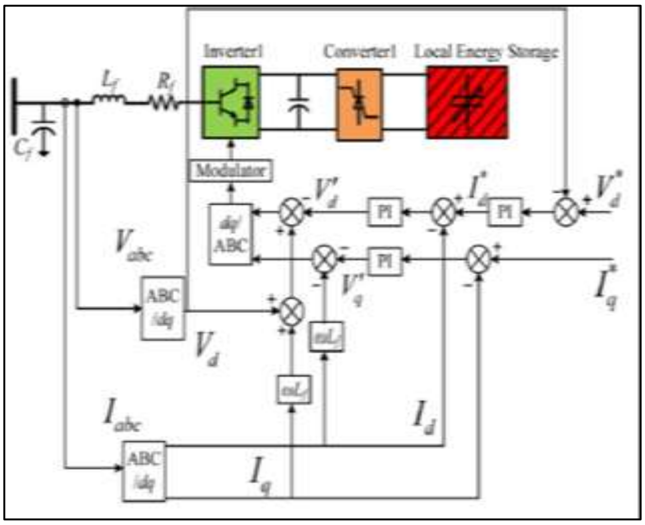

Fig. 4: Control circuit for LES (Islanding mode)

The main observable contrast between control techniques in grid associated and islanding mode is that the change from dc bus voltage to ac bus voltage in the voltage reference of LES-associated.

IV. SIMULATION RESULTS

Here the simulation is performed in both grid connected mode and also the islanding mode and MATLAB simulation circuit is as shown in Fig. 5. The simulation result shows the ac current and ac voltage of the micro grid which contains PV,wind turbine,fuel cell,LES,critical load and non critical load as shown in the Fig. 6 and in Fig. 6.1. The simulation parameters are as shown in the Table1.

The output of grid connected mode and in islanding is shown in Fig. 6 and Fig. 6.1 by comparing this two we can illustrate that dc bus voltage and ac bus voltage and load currents remains constant.

In Fig. 5.Initially the circuit breakers (CB) are open and it will be closed at their respective transistion time, the transistion time of PV is connected from 0 to 0.1 at this time CB is closed and the PV output is connected to the grid and similarly the transistion time of non critical load1 and load2, fuel cell, wind turbine, LES and critical load is 0.2-0.3, 0.4-0.5, 0.5-0.6, 0.6-0.7, 0.7-0.9 ,0.9-1 respectively.

It is assumed that during islanding mode we wont get the required power from the PV,LES and wind to the loads, therfore to maintain the system stable the load shedding is necessary. In islanding mode, the LES can give a most extreme power of 8.3 kW, the PV 5.3 kW, and the wind turbine 10 kW. On the load side, the power utilization of each noncritical load and critical load is 15 kW and 10 kW, separately. The dc bus voltage limit is 730 V.

The Fig.7, Fig.8, Fig.9, Fig.10, Fig.11, Fig.12 shows the ac voltage and ac current output of PV, non critical load, fuel cell, wind turbine, LES and critical load respectively.

System Frequency f	60 Hz
Switching Frequency fsw	10KHz
Dc Bus Voltage Vdc	800v
Capacitor C	4.4 mF
Ac Bus Voltage Vbus	240V L-g
Inductor Lf	0.76 mH
Resistor Rf	1m ohm
Capacitor Cf	8.3 uF
PV Power Ppv	5.3 kW
Wind Turbine Power Pwind	10 kW
Critical Load Power Consumption Pcritical	10 kW
Noncritical Load Power Consumption Pnoncritical	15kW

Table 1: Simulation Values

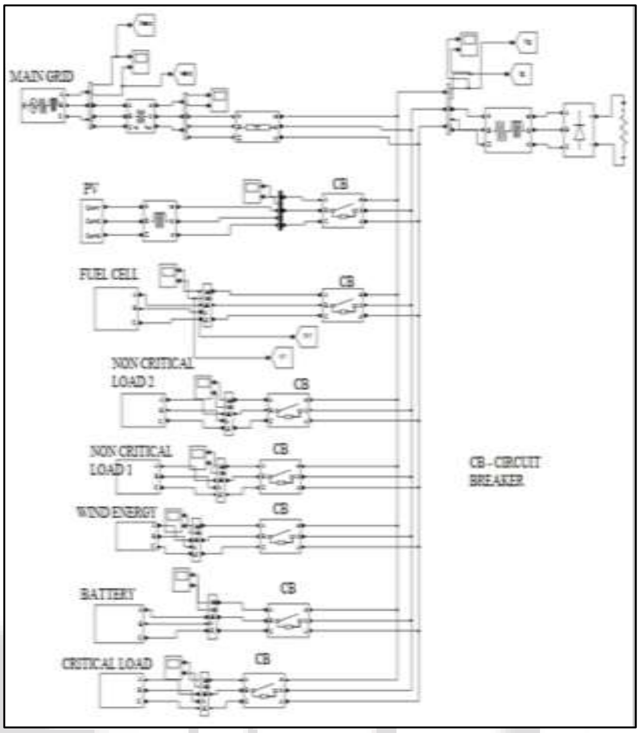

Fig. 5: Simulation circuit of Micro Grid

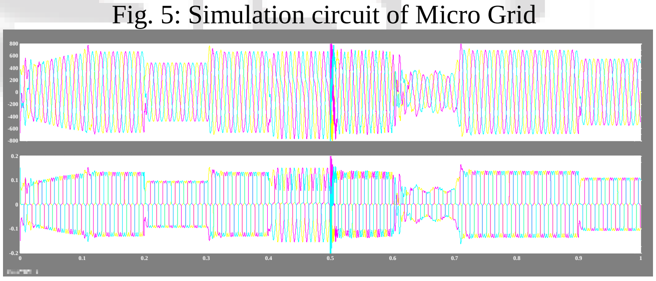

Fig. 6: Simulation result of micro grid (Grid connected)

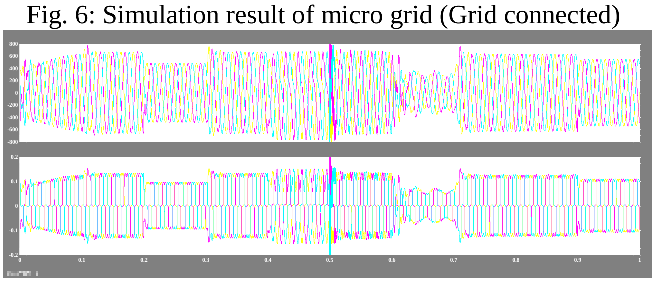

Fig. 6.1: Simulation result of micro grid (Islanding mode)

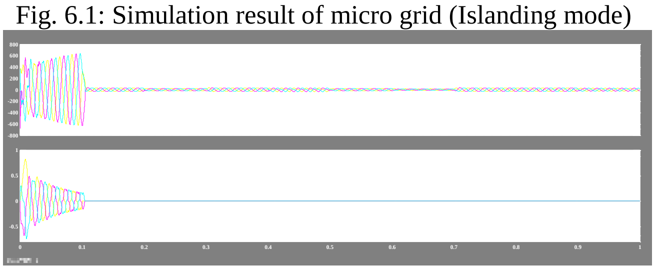

Fig. 7: PV generation ac output

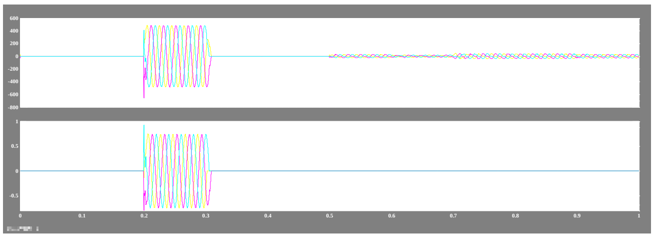

Fig. 8: Non critical load output

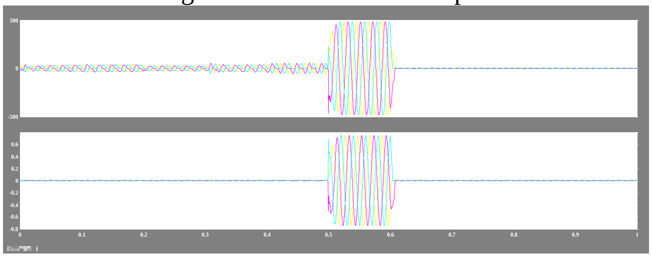

Fig. 9: Fuel cell ac output

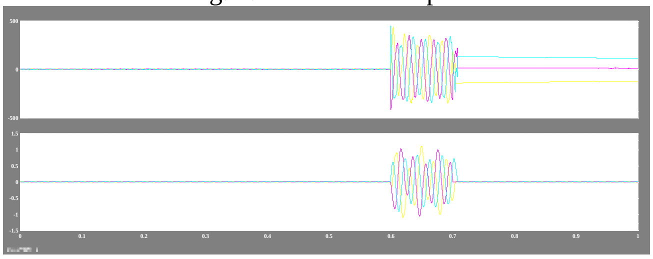

Fig. 10: Wind energy output

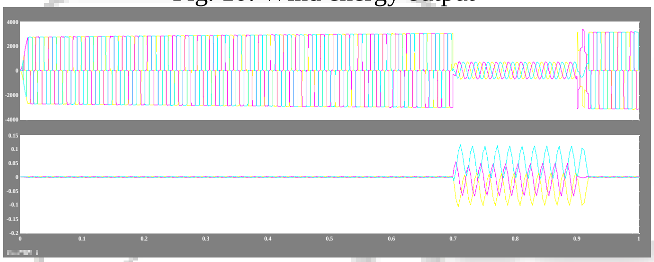

Fig. 11: LES output

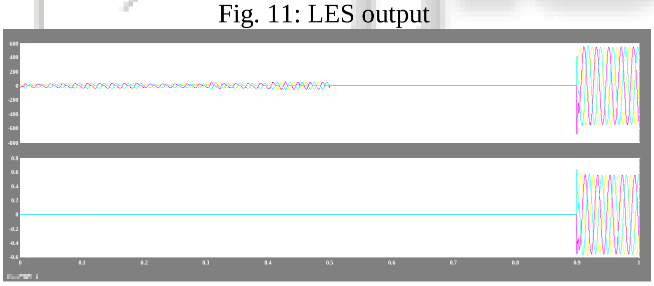

Fig. 12: Critical load output

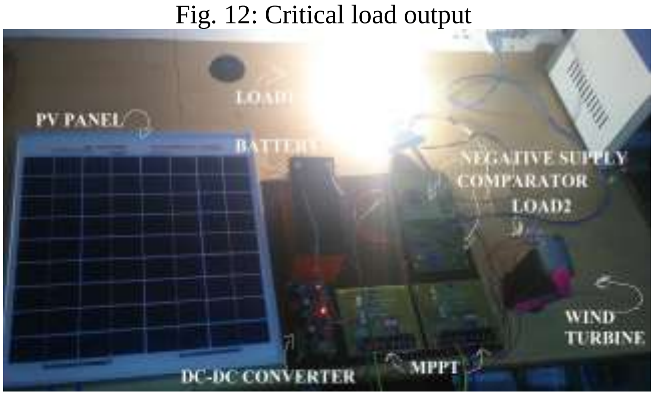

Fig. 13: Prototype hardware model(Grid connected)

Fig. 13.1: Prototype hardware model(Islanding mode)

V. Conclusion and Future Work

This paper presents a micro grid model of a small community which includes the PV, fuel cell, wind turbine LES, power electronic circuits, circuit breakers. This model is stimulated with 10 kHz switching frequency and it is verified. By using this model we can use the renewable energy more effectively in the little group like homes, parks and in offices. The future scope is by using PV with MPPT, solar inverter, LES and NET meters we can use renewable energy and also we sell the excess power to the electrical boards.

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