MODELING AND SIMULATION OF A MICROGRID

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1. Abstract

Power supply is becoming more complex as a result of increasing population, expansion and improper planning of government and individuals. To address this trend, there is need to develop a model capable of efficiently managing the power supply system. In this study a microgrid was modeled and simulated for the Federal University of Agriculture Abeokuta (FUNAAB), Ogun State to manage the power supply challenge. Electrical loads and facilities audits were carried within the University campus. Matlab/simulink was used to model a microgrid for FUNAAB. The modeled microgrid of the proposed power houses was simulated and the waveforms obtained were compared with that of Power Holding Company of Nigeria (PHCN). Facilities audit revealed that FUNAAB had a total power generator rating of 6130kVA. From the load audit the generator capacity could be aggregated into three power houses of 2 x 2000kVA and 1 x 1950kVA. The remaining 3 x 60kVA generators were left unaggregated to serve as auxiliary/back up. The total power from PHCN was 2100kVA and 2 x 2000kVA for the proposed power houses 1 and 2 when synchronized. Comparison of

PHCN power waveform and that of proposed power houses 1 and 2 showed that these proposed power houses could adequately supply the whole power network of FUNAAB. However, there would be need to upgrade the power transformer of rating 2000kVA (11/0.415kV) to 2 x 2500kVA (11/ 0.415kV) for this purpose and for future expansion. The proposed power house 3 could then serve as a backup. The modeled microgrid could be used in the development of supply infrastructure for estates, communities, organizations and establishments.

Keywords: Modeling, Simulation, Microgrid, Development and Unaggregated

2. Introduction

The rate of development and the use of some equipment which normally result to gross darkness or collapsed of power system called for modeling and simulation of microgrid. Microgrid is an aggregation of loads and micro sources operating in as a single system providing both power and heat. The majority of the micro sources must be power electronics based to provide the required flexibility to insure operation as single aggregated system. This control flexibility allows the microgrid to present itself as a single controlled unit which meets local needs for reliability and security. In addition microgrids have the capability to isolate themselves from the utility power grid in case of faults in the grid, in order to protect the micro sources and loads within the microgrid. This operation is called the islanded mode, in which the microgrid operates independently until stability is restored in the utility grid. Microgrid contains an energy manager within them which is responsible for maintaining balance between energy demand and supply within the microgrid by the use of energy management strategy, while making sure certain criteria such as minimizing operating cost, fuel consumptions, emissions etc are met. A microgrid is a collection of distributed power generators and loads acting together, Lasseter *et al* (2002)

Micro grids encourage the use of renewable energy sources. Although renewable energy resources, such as wind and solar, enhance the generation capability of a micro grid and address the environmental concerns Da Sila (2010).

3. Justification for microgrid

Microgrid model offers a number of advantages as stated below:

- It is easy to maintain
- It requires lesser operators.
- The emission of carbon monoxide will be reduced and easy to control
- Back up will be available, in case there is fault in one power house, auxiliary/back up power house will be switched on
- Reliable and save to run
- The facilities could be well managed and controlled
- The cost of operation and running is very cheap

4. LOAD AUDIT CALCULATION

The power demand for electrical components is given by equation below 1

$$S = IV \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

$$S = P + JQ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

$$Where\ P = S\ Cos\ \emptyset = IV cos\ \emptyset \ldots\ldots\ldots\ldots\ldots 3$$

$$Q = Sin\emptyset = IV\ Sin\emptyset \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

$$Where\ P = Real\ power\ (watts),\ Q = Reactive\ power,$$

$S = Complex\ power\ or\ apparent\ power$, $I = Measured\ Current\ (Amperes)$

$V = Voltage\ supplied\ (volts)$ The

conversion of power in horse power (hp) to watt is given below: 1hp =746 watts.

5. METHODOLOGY

5.1 MATERIALS

The study was non-experimental, the data of this study was from electrical network of this Federal University of Agriculture, Abeokuta, Ogun State, and data were collected from logbooks and was analyzed with ***matlab***. The materials used were: Utility grid, Monthly electric loads consumption, transformers ratings and generators ratings in the university.

5.2 METHOD

The objectives were achieved by simulations. Firstly, a micro grid model was developed, which comprise of a utility grid, generators, transformers, loads, and the simulation was performed by (R2012a) matlab/simulink. Facilities audit revealed that FUNAAB had a total power rating of 6130kVA generators From the load audit the generator capacity could be aggregated into three power houses of 2 x 2000kVA and 1 x 1950kVA. The remaining 3 x 60kVA generators were left unaggregated to serve as auxiliary/back up.

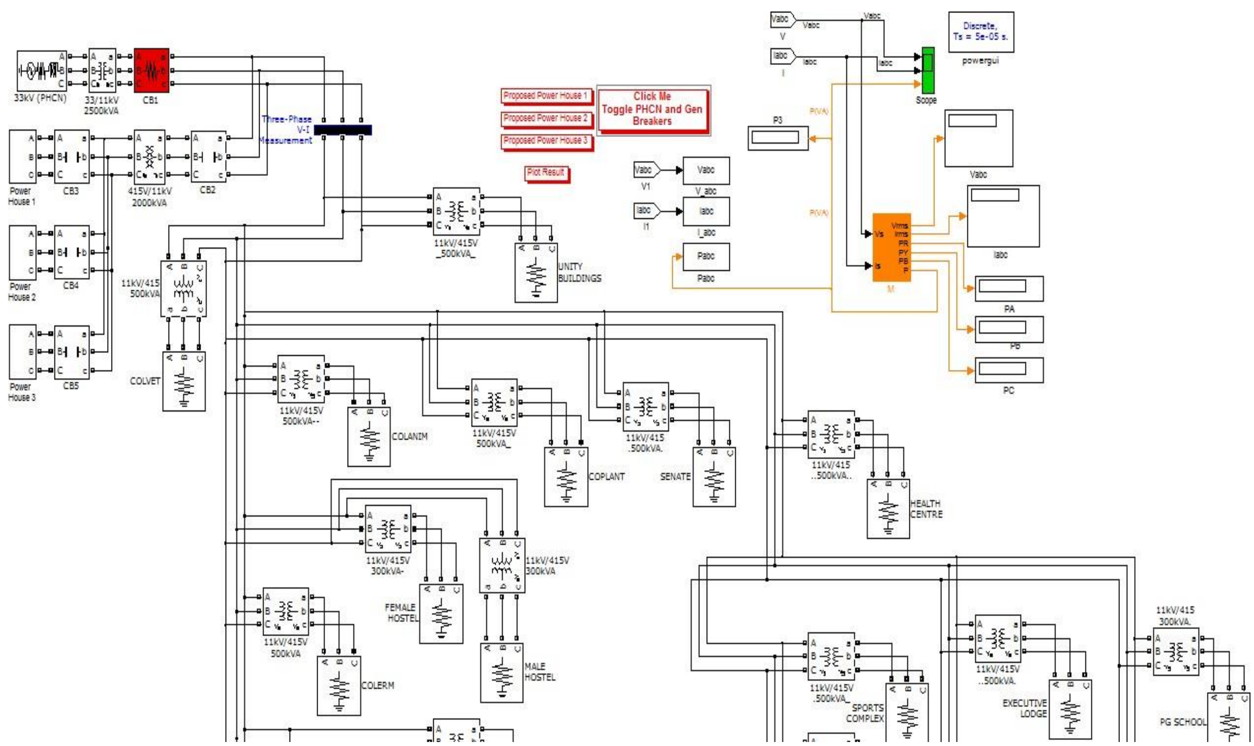

Figure 1: Crossectional view of microgrid developed for Federal University of Agriculture,Abeokuta.

6.0 Modeling of Microgrid For Federal University of Agriculture, Abeokuta using MATLAB/Simulink

Simulink is an environment for multi-domain simulation and Model-Based Design for dynamic and embedded systems. It provides an interactive graphical environment and a customizable set of block libraries that let you design, simulate, implement, and test a variety of time-varying systems, including communications, controls, signal processing, video processing, and image processing. In this project, the sympowersystems block set was utilized for modeling the power system. SimPowerSystems provides component libraries for modeling and simulating electrical power system.

The simulation was done with the following parameters setting for the Simulink environment:

- ode14x fixed step solver (solver for the ordinary differential equation solution of the model)
- Simulation step size of 50µs
- Simulation time of 0.3s

The solution was model based on the fact that the model was represented internally in this form:

$V(t) = R_{eq} \; y(t) + L_{eq} \frac{d(t)}{dt}$...................................5

Rewritten as

$v = R_{eq}y + L_{eq}y'$ 6

This integration is done using the ode14x fixed step solver over the simulation time range, where y(t) represents the equivalent load current in the system, V represents the supply voltage, R_{eq} and L_{eq} represent the equivalent resistance and inductance of the network respectively.

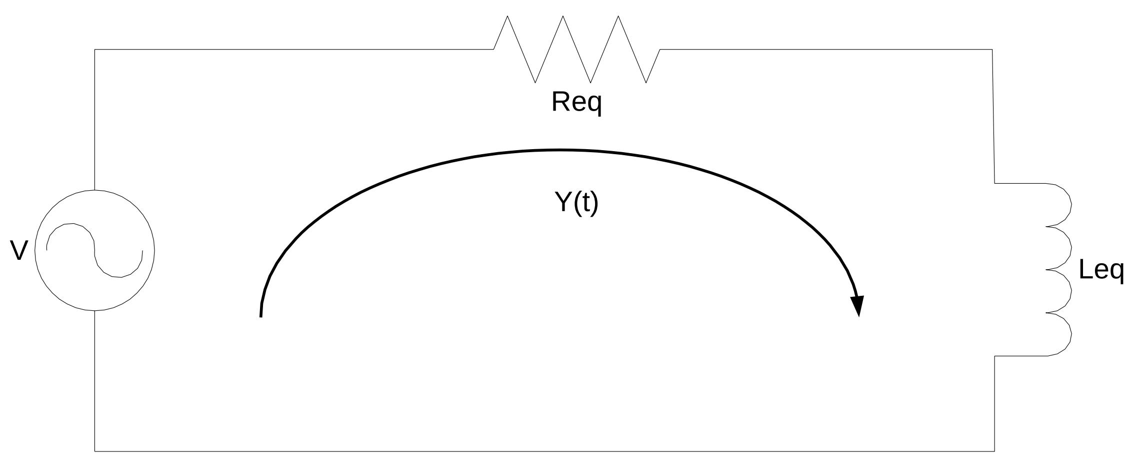

Figure 2: Equivalent circuit diagram of the model

This ode14x solver is an implicit, extrapolating fixed-step solver whose extrapolation order and number of Newton's method iterations can be specified via Simulink configuration parameters. The ode14x solver is faster than Simulink explicit fixed-step solvers for certain types of stiff systems that require a very small step size to avoid unstable solutions.

7. Simulations results

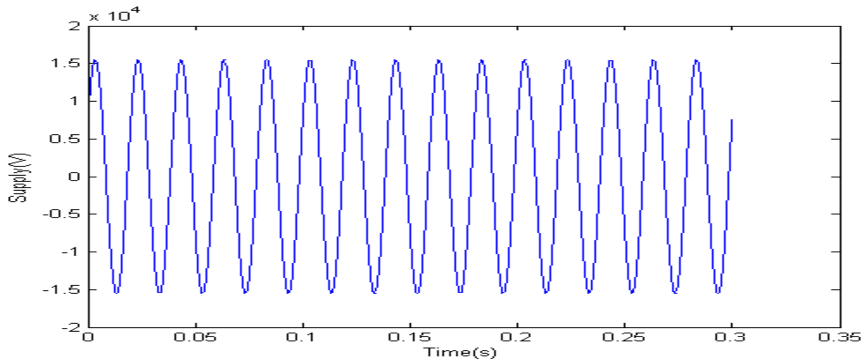

Figure 12: Waveform of supplied voltage to the network

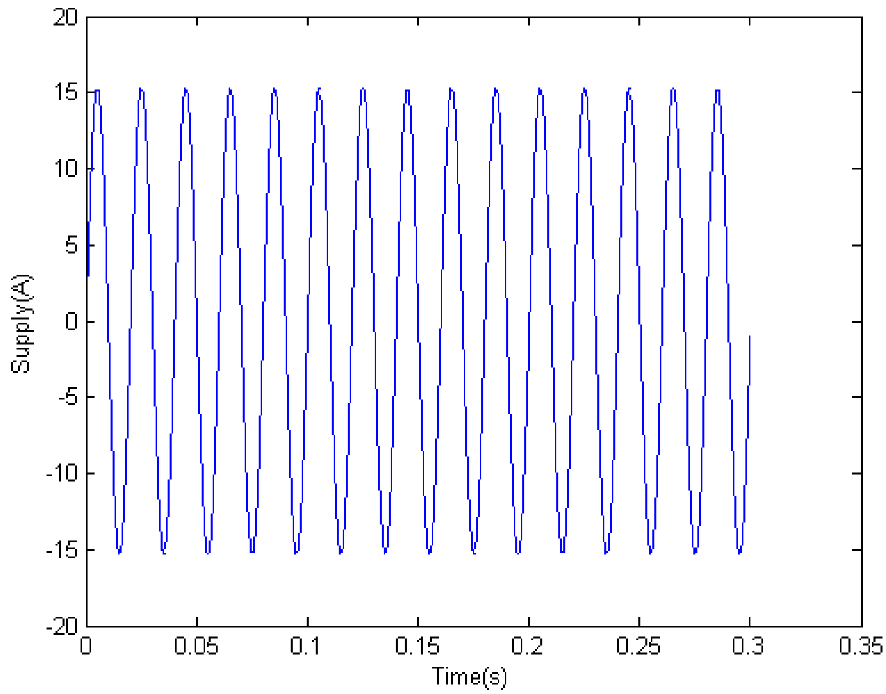

Figure 13: Waveform of supplied current to the networks

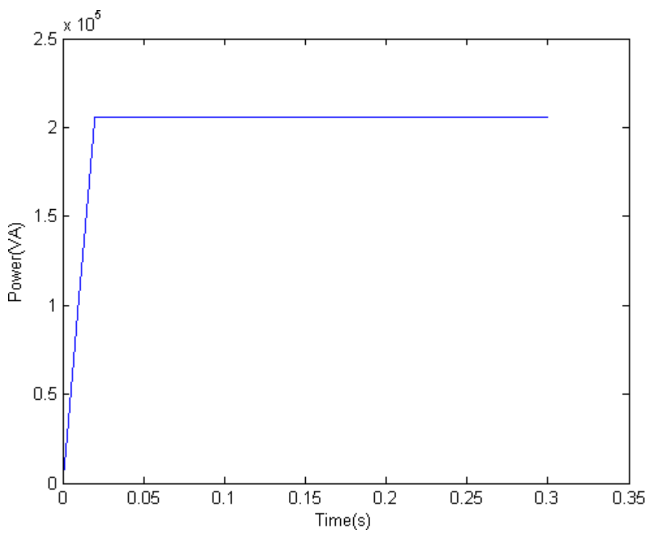

Figure 14: Waveform of supplied power from PHCN to the network

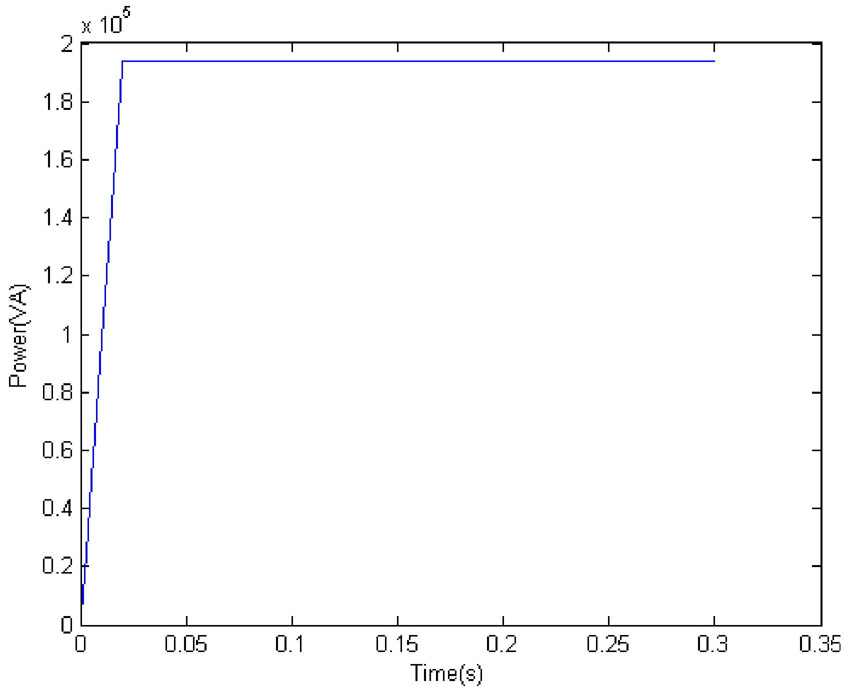

Figure 15: power supplied to the network by power house 1

8. Results discussion

The power supply from PHCN is 2500 KVA (2000kw) and this always caters for the whole power network. The power waveform value obtained when PHCN supplied to the microgrid was simulated and modeled with equation 4.4 is around $2.1X10^4$VA with PHCN currently catered for the whole power network of Federal University of Agriculture, Abeokuta in Ogun State and the incomer from PHCN is 2500 kVA.

Similarly, from the power waveform obtained from the simulation of proposed power house 1 (2000 KVA) which is around $1.9x10^5$VA, which is lower to that of PHCN that is currently cater for the whole network, proposed power house 1 can only cater for 80% of the network. To improve the supply power to the network, two of the three proposed power houses can be synchronized together; this will effectively cater for the whole power network. When proposed power houses 1 and 2 were synchronized, we have $2.0x10^5$VA, which is closer to that of PHCN; this shows that when 2 of these proposed power houses are synchronized can adequately cater for the whole power network and the one that is not synchronized (proposed power house 3) can serve as auxiliary/back up.

9. Conclusion

From the load audit the generator capacity were aggregated into three power houses of 2 x 2000kVA and 1 x 1950kVA. The remaining 3 x 60kVA generators were left unaggregated to serve as auxiliary/back up for effective maintenance and the various environmental impacts of running generators across the campus will be controlled. Energy efficiency, reliability, availability, conservation and optimization can be guaranteed by aggregating the generators into three proposed power houses.

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