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Dynamic Analysis of Micro-Grid with Photovoltaic, Diesel Generators and SOFC based Energy System

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Abstract : The microgrid concept assumes a group of loads and micro sources that act as a single controllable system that supplies both electricity and heat to its local area. Micrograds can be connected to the main power grid or run autonomously, similar to power systems on physical islands. This paper presents model steady state microgrid subsystems and also to study their transient responses to changing inputs. At present, models of a solar cell module, a fuel cell, a diesel generator and finally a power conditioning unit have been developed.

Index Terms **– PV, DC-DC, Boost Converter, SOFC, Energy, Microgrid, Sustainable.**

I. Introduction

Every distribution utility has an obligation to supply its customer's electricity at a voltage within a specified limit. This requirement often determines the design and expense of the distribution circuit so that over the years techniques have been developed to make the maximum use of distribution circuits to supply customers within the required voltage [1]. Some distribution utilities use more sophisticated control of the on load tap changers of the distribution transformer by using regulators on the feeder and also including the use of the current signal compounded with the voltage measurement at the switched capacitor on feeders [2]. Feeding power from a Distribution Generator (DG) unit can cause negative impacts on the network voltage in case a DG unit is placed just downstream to a load tap- changer transformer [3].

Two aspects of power quality are usually considered to be important. One is transient voltage variations and other is the harmonic distortion of the network voltage [4]. The Microgrid can cause transient voltage variations on the network if relatively large current changes during connection and disconnection of the generator are allowed. Therefore, it is necessary to limit voltage variations to restrict the light variation. Generally, load fluctuation can cause voltage variation as well as source fluctuation [5]. Microgrid units have the potential to cause unwanted transient voltage variations at the local power grid. Step changes in the outputs of the Microgrid units with frequent fluctuations and the interaction between the Microgrid and voltage controlling devices in the feeder can result in significant voltage variations [6]. The standalone operation of Microgrid units gives more potential for voltage variations due to load disturbances, which cause sudden current changes to the DG inverter. If the output impedance of the inverter is high enough, the changes in the current will cause significant changes in the voltage drop, and thus, the AC output voltage will fluctuate. Conversely, weak ties in the grid integration mode give a chance for transient voltage variations to take place but lower degrees than in the standalone mode [7].

An energy system refers to the collection of technologies, processes, and infrastructure that convert and deliver energy to end-users. The energy system can be divided into several components, including primary energy sources, conversion technologies, transmission and distribution networks, and end-use technologies. Primary energy sources are the raw materials that are converted into energy, such as fossil fuels (coal, oil, and natural gas), nuclear energy, renewable energy (solar, wind, hydro, geothermal, and biomass), and others.

Conversion technologies are the means by which primary energy sources are transformed into usable energy, such as electricity, heat, or mechanical power. Examples of conversion technologies include power plants, engines, turbines, and fuel cells. Transmission and distribution networks are the systems that transport energy from the point of production to the point of use. These networks can include pipelines, power grids, and other infrastructure.

End-use technologies are the devices and equipment that consume energy, such as appliances, vehicles, and industrial machinery.

The design and operation of an energy system can have significant impacts on the environment and the economy. Therefore, there is ongoing research and development in the energy sector to increase efficiency, reduce emissions, and promote sustainability.

II. SOLAR PV MODULE

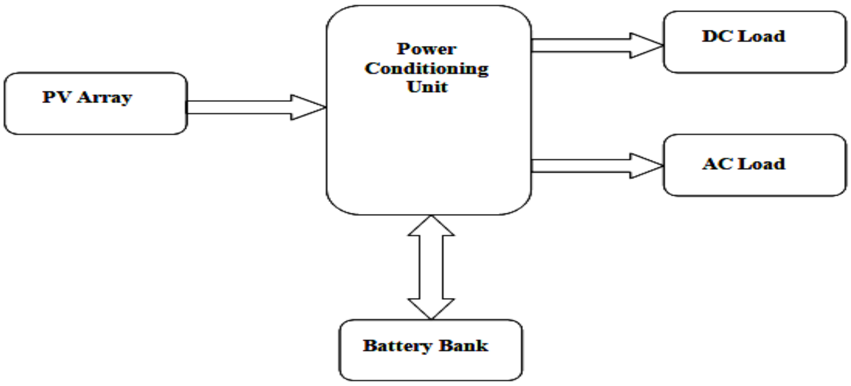

Figure 1: Solar model

Figure 1 shows the schematic diagram standalone PV system with battery backup. This system will provides the supply to the power conditioning unit. In the power conditioning unit the DC voltage coming from the solar PV array is boost up and give supply to the DC load and the power conditioning unit consists of charge controller which controls the charging of the battery the DC supply is converted to AC supply with an inverter and fed to the AC loads.

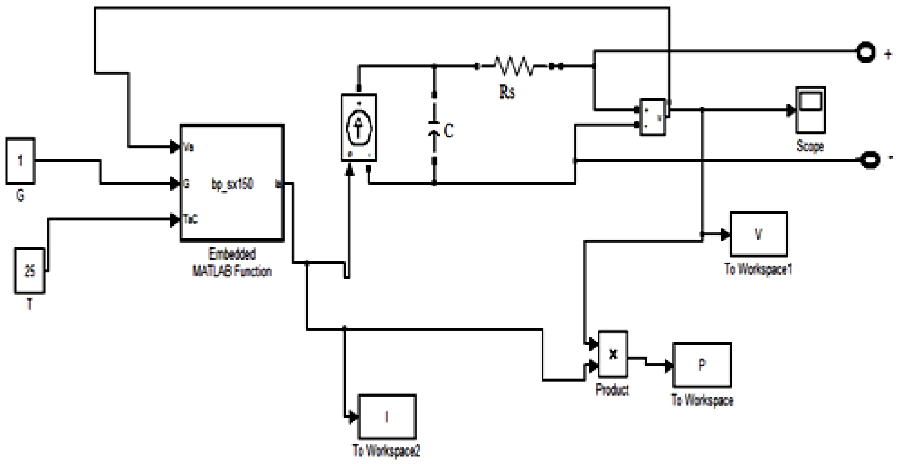

Figure 2: Matlab/Simulink model of BPSX 150 solar panel

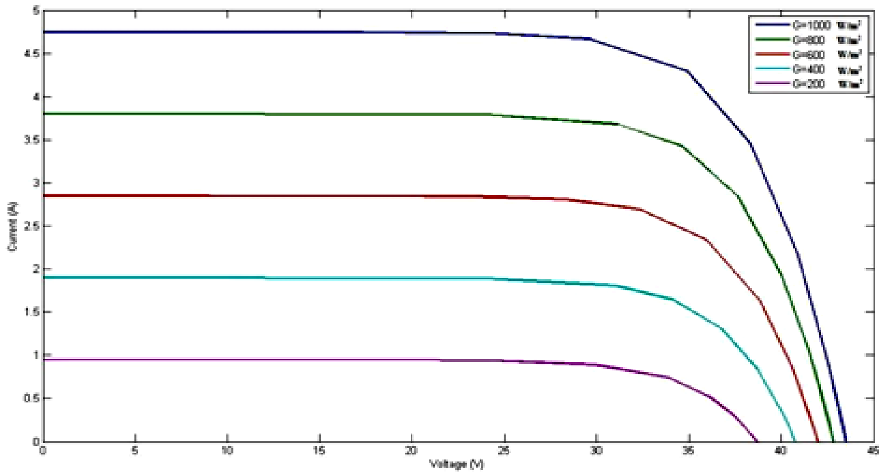

Figure 3: I-V characteristic for a PV cell at a constant temperature of 250C

III. MODELING OF FUEL CELL

Fuel cells generate power through the electrochemical reaction between hydrogen and oxygen. The conversion is highly efficient and leaves only water and heat as by-products, which is the main motivation for the increasing interest in the technology.

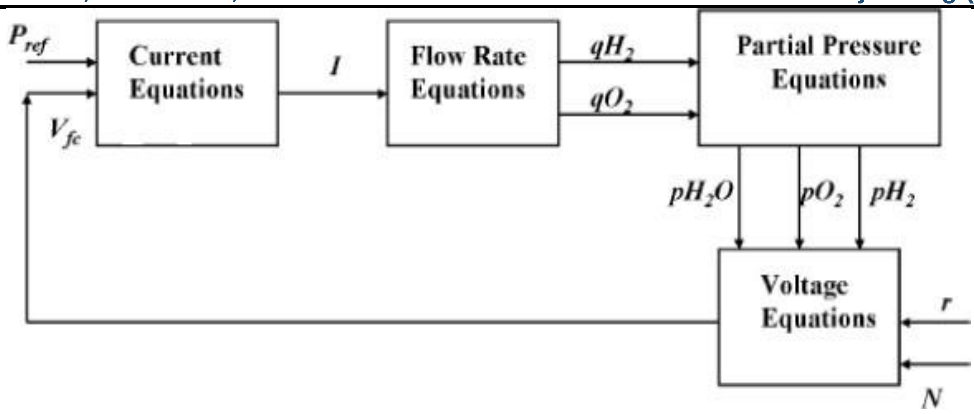

Figure 4: Block diagram for dynamic model of SOFC

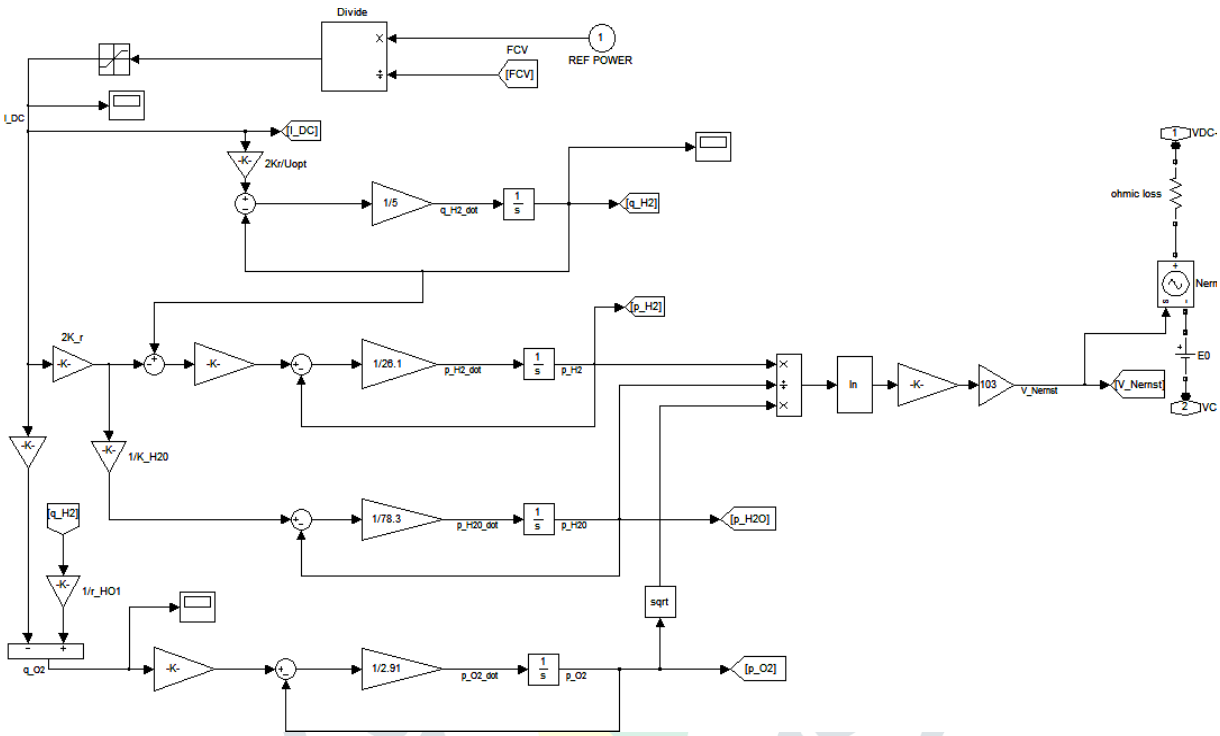

Figure 5: Simulation circuit of SOFC

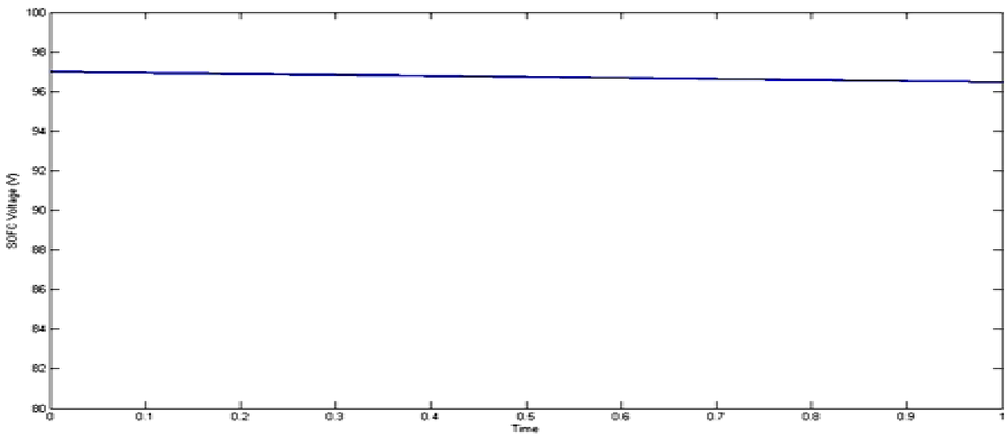

Figure 6: Voltage waveform of SOFC

IV. MODELING OF DIESEL GENERATOR

A diesel generator is the combination of a diesel engine with an electrical generator (often called an alternator) to generate electric energy. Diesel generating sets are used in places without connection to the power grid or as emergency power-supply if the grid fails.

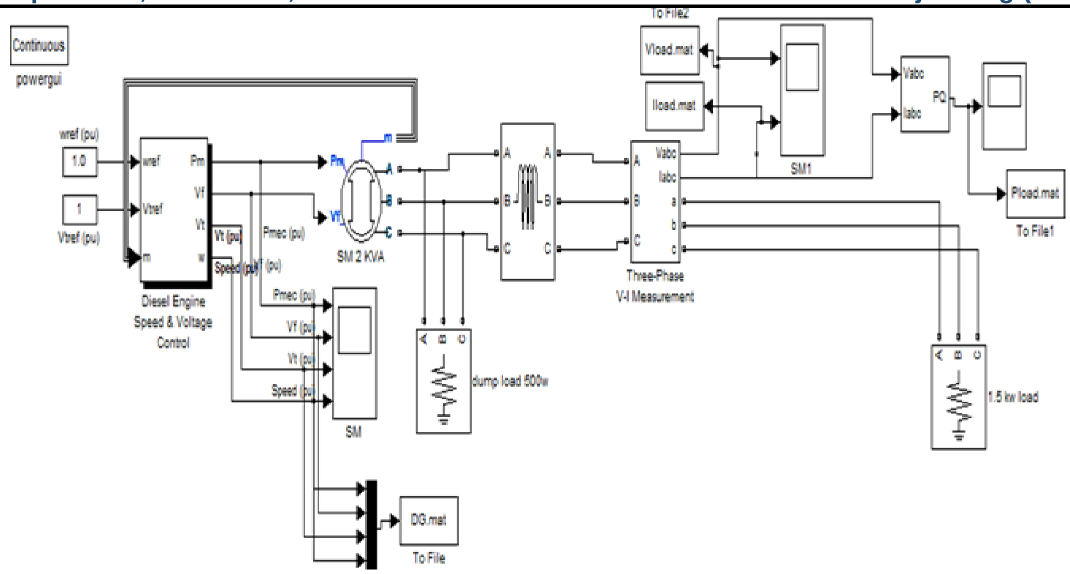

Figure 7: Simulink model of Diesel Generator system

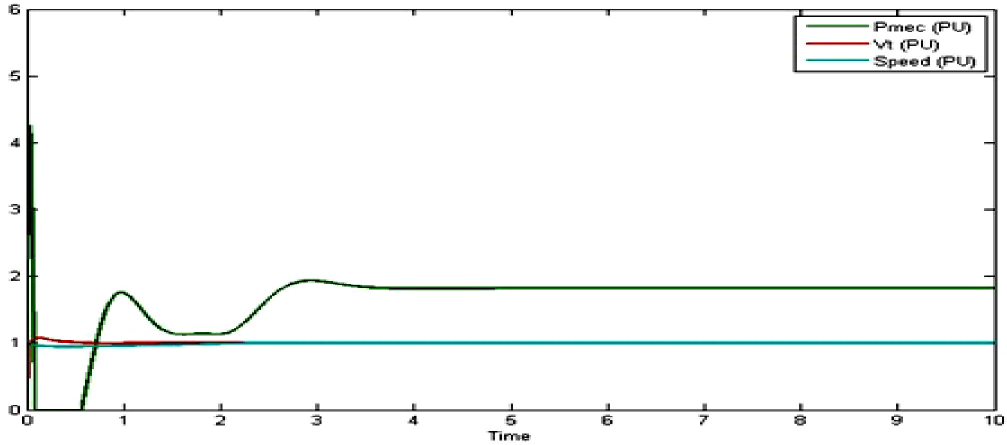

Figure 8: Generator power output (p.u.), Excitation Voltage (p.u.) and Engine speed / frequency (p.u.)

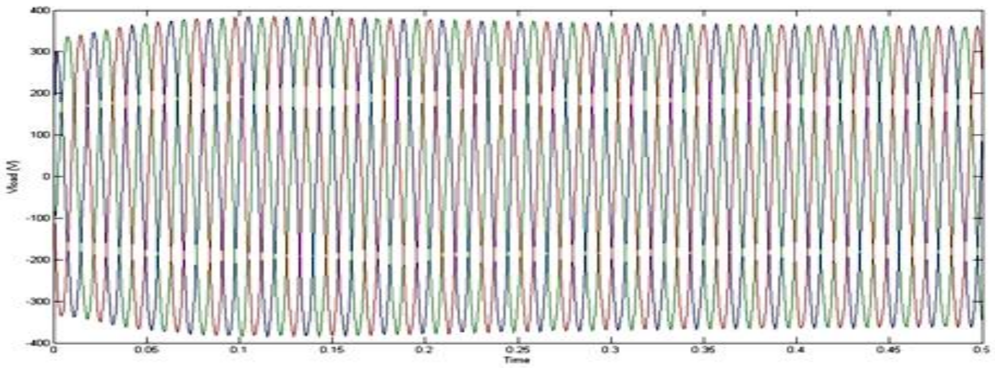

Figure 9: Voltage across the load

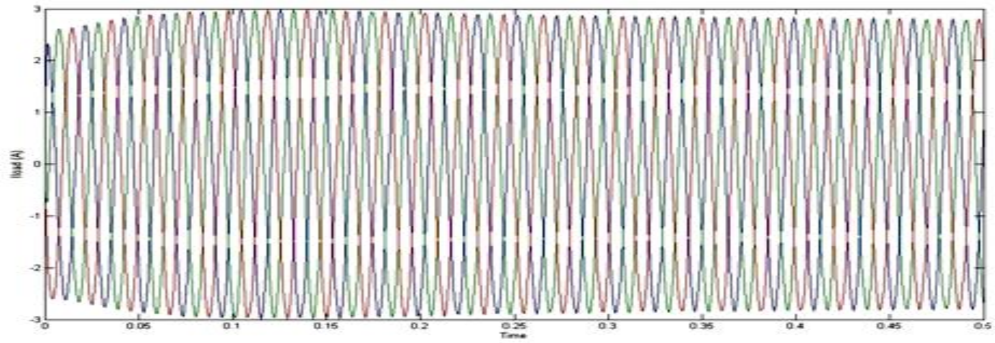

Figure 10: Current wave forms across the load

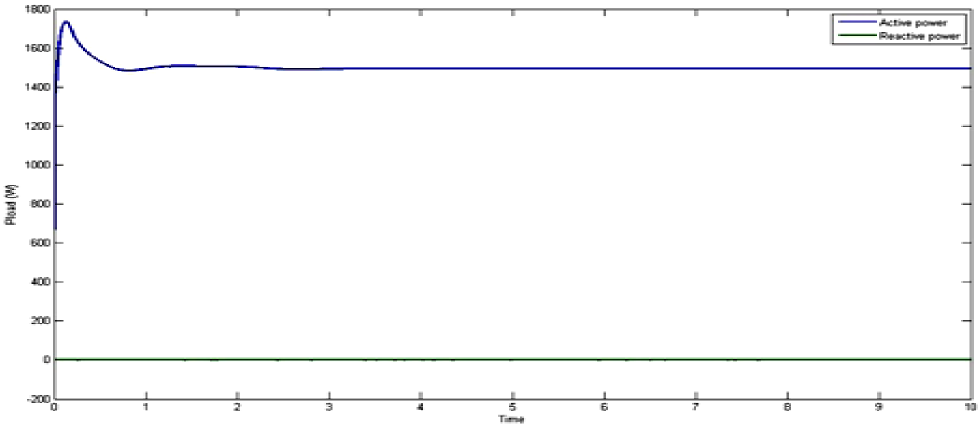

Figure 11: Load power wave form

V. CONCLUSION

Microgrid behavior on the whole is not well understood. For this reason the thesis aims to develop models suitable for overall analysis and design. The aim of the work was to model both the transient and the steady-state behavior of the MG's individual power sources. The final goal was to lay a groundwork which would allow analysis for the further development of a more complete model. More specifically, models of a solar photovoltaic cell,fuel cell, diesel generator, DC to DC boost converter and Grid connected DC to AC inverter have been developed. This work has been successful in accomplishing the objective. All models developed will allow for investigation that will provide an understanding of MGs to facilitate the evolution of a more sophisticated model.

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