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# DESIGN AND IMPLEMENTATION OF SMART NANOGRID

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**Abstract**

Centralized electricity systems are being integrated by a multitude of small distributed generation clusters, called nanogrids, capable of ensuring full utilization of renewable energy sources, high flexibility, efficiency and improved reliability of the power grid due to redundancy. In this context, nanogrid is used and energy for nanogrid is obtained from renewable resources such as solar photovoltaic cells, wind, energy storage device and utility grid. The purpose of this project is to deal with a DC nanogrid suitable for small energetic clusters such as residential or office buildings then control and monitoring the grid. The design & simulation has been carried out using MATLAB and hardware implementation of DC nanogrid is done.

***Key Words*:**PV array, Wind turbine, Boost converter, Inverter

## 1 INTRODUCTION

Electricity is a convenient form of energy for lighting, heating ,cooling and also produces motive power for number of applications .Hence ,the annual consumption of electricity has been increasing rapidly throughout the world .Until recently the planets energy requirements could be managed with the help of non renewable energy sources like coal, oil, etc..., but due to the exponentially growing demand for energy , it has become difficult to manage the demand only by these exhaustible sources, so there is an obligation to turn towards the renewable energy sources like solar, wind, etc..,

The nanogrid is a small scale power system that consists of renewable and non renewable power resources that supply power to nearby loads. The performance of the nanogrid is not totally satisfactory as large overshoot may occur in the output voltage and current disturbances may occur at load side. Also power electronic system can become unstable when the source interface converters are connected to load interface converters rather than separate loads.

A nanogrid is a standalone system that uses renewable and non renewable power resources that supply power to local loads. A nanogrid is similar to the microgrid concept, but smaller in size than a microgrid. It has a capacity in the order of 2-20kw. A small scale grid which has been implemented at community level to cater the local needs of energy production, distribution and consumption is called the nanogrid. Matching electricity demand to supply is a growing challenge. On a large scale this challenge is central to the emerging smart grid where demand will need to be managed to match intermittent renewable energy sources. This proposed smart nanogrid offers the reporting and control mechanisms to enable matching such variable supply to demand at the large scale of grids.

## 2 SYSTEM DESCRIPTION

***Solar Cell***

A solar cell module is the basic element of each photovoltaic system. It consists of many jointly connected solar cells. A number of solar cell models have been developed, but the one diode electrical equivalent circuit shown in Fig. 1(a) is commonly used for cell based or module based analysis. It consists of a diode, a current source, a series resistance and a parallel resistance. The current source generates the photo-current that is a function of the incident solar cell radiation and temperature [6]-[8]. The diode represents the p-n junction of a solar cell. The temperature dependence of the diode saturation current and constant diode ideality factor are included in the modeling. At real solar cells, a voltage loss on the way to the external contacts is observed. This voltage loss is expressed by a series resistance (Rs). Furthermore leakage currents are described by a parallel resistance (Rsh). However, the series resistance is very small and the parallel resistance is very large [8]. So we can ignore Rs and Rsh. The solar cell simplified circuit is then shown in Fig.1(b).

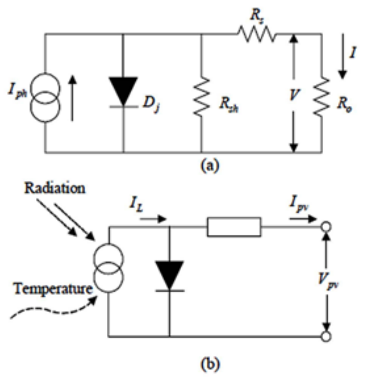


Fig. 1. Solar cell (a) equivalent circuit (b) simplified circuit.

The solar cell current equation is

$$I_{pv}(t) = I_{sc}\left\{1 - C_1\left[\exp\left(\frac{V_{mp}}{C_2 V_{oc}}\right) - 1\right]\right\} + \left(\frac{E_{tt}(t)}{E_{st}}\right)\left[\alpha\left(T_a(t) + 0.002E_{tt}(t) + 1\right)\right] - I_{mp} \quad (1)$$

The solar cell voltage equation is

$$V_{pv}(t) = V_{mp}\left[1 + 0.0539\log\left(\frac{E_{tt}(t)}{E_{st}}\right)\right] + \beta\left(T_a(t) + 0.02E_{tt}(t)\right) \quad (2)$$

$$C_1 = (1 - \frac{I_{mp}}{I_{sc}})\exp\left[\frac{-V_{mp}}{C_2 V_{oc}}\right] \quad (3)$$

$$C_2 = \frac{\frac{V_{mp}}{V_{oc}} - 1}{\ln(1 - \frac{I_{mp}}{I_{sc}})} \quad (4)$$

We used the solar cell current and voltage equation to build a solar cell model by MATLAB/Simulink. The solar cell subsystem model is shown in Fig. 2.

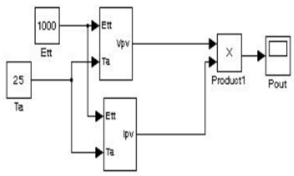


Fig. 2. Solar cell subsystem model.

***Wind turbine***

A wind turbine is a device that converts the winds kinetic energy into electrical energy. Wind turbines are manufactured in a wide range of vertical and horizontal axis types. The smallest turbines are used for applications such as battery charging for auxiliary power for boats or caravans or to power traffic warning signs. Slightly larger turbines can be used for making contributions to a domestic power supply while selling unused power back to the utility supplier via the electrical grid. Array of large turbines, known as wind farms, are becoming an increasingly importance source of intermittent renewable energy and are used by many countries as part of a strategy to reduce their reliance on fossil fuels.

## 2.12. RADIO FREQUENCY TRANSMITTER AND RECEIVER

An RF module (radio frequency module) is a (usually) small electronic device used to transmit and/or receive radio signals between two devices. In an embedded system it is often desirable to communicate with another device wirelessly. This wireless communication may be accomplished through optical communication or through radio frequency (RF) communication.

RF modules typically communicate with an embedded system, such as a microcontroller or a microprocessor. The communication protocols include UART, used in Digi International's X-Bee modules, Serial Peripheral Interface Bus used in Anaren's AIR modules and Universal Serial Bus used in Roving Networks' modules. Although the module may use a standardized protocol for wireless communication, the commands sent over the microcontroller interface are typically not standardized as each vendor has its own proprietary communications format. The speed of the microcontroller interface depends on the speed of the underlying RF protocol used: higher speed RF protocols such as Wi-Fi require a high-speed serial interface such as USB whereas protocols with a slower data rate such as Bluetooth Low Energy may use a UART interface.

**2.12. MULTI UTILITY CONTROLLER (MUC)**

Multi utility controller is an adaptable controller system for a smart nanogrid environment. It is portable in size, battery operated and has a LCD display to monitor the status of the grid and a user interface for grid control. Multiple type of communication protocol are available to communicate with different types of utility meters.

# 3 SIMULATION RESULTS.

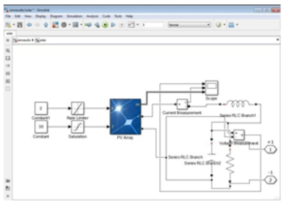

Fig.3 Solar energy conversion system

Solar array works mainly based on irradiation and temperature. Depending upon the energy obtained from the solar radiation, PV panel delivers the output energy. The above mentioned PV array consists of 20 parallel and 10 series PV cells.

The output voltage and current are in the range of 30V and 7.36A respectively. To prevent from harmonics and oscillations LC filter is used. The delivered energy from the solar array is fed to the Boost Converter.

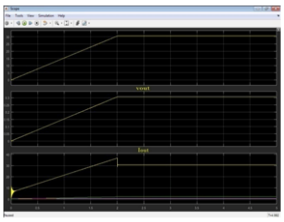

Fig.4 output waveform of solar energy conversion system.

**Simulation of the wind power**

The below diagram depicts the wind energy conversion system. Depending upon the generator speed1, wind speed2 and wind angle3 the direction of rotation of the turbine blades are tilted. Based on the comparison of these three parameters equivalent torque (TL) can be generated. Separate excitation to the can be fed to the DC generator. The output from the dc generator are directed to the boost converter.

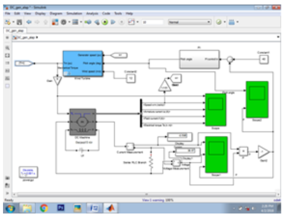

Fig.5 wind turbine

In order to maintain the constant output voltage and to provide varying pitch angle according to the wind speed PI controller is used.

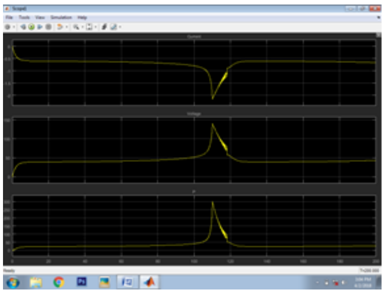

Fig.6 wind turbine output

**Boost converter**

Boost converter is provided with Inductor, MOSFET, Diode and Capacitor. Depending upon triggering pulse provided by pulse generator, the inductor charges if the MOSFET switch is off and discharges if the MOSFET switch is on.

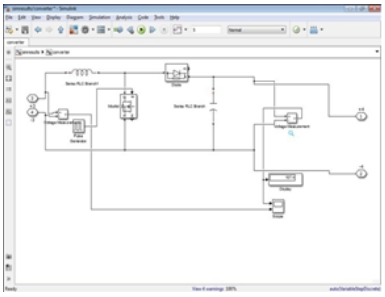

Fig.7 boost converter

Capacitive filter are use to reduce harmonics and output is fed to the inverter.

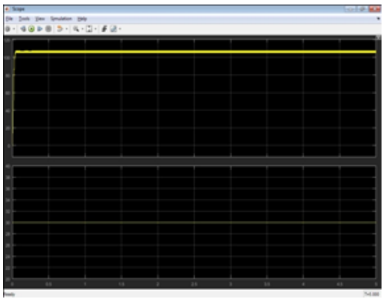

Fig.8 output of boost converters

Inverter

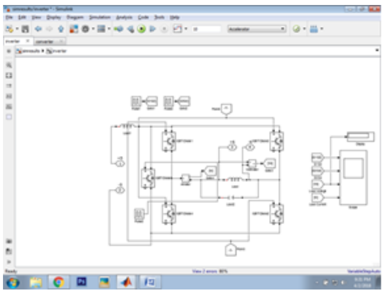

Fig.9 Inverter circuit

To pair of IGBT are used. To convert DC supply into single phase AC supply. Depending upon pulse generator frequency output voltage is developed.

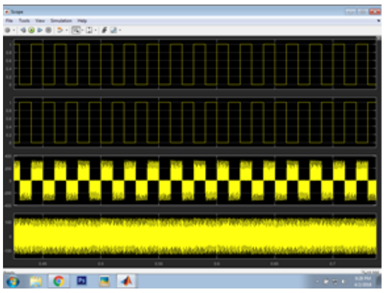

Fig.10 Inverter output

# 4 CONCLUSION

The source of energy is obtained from various sources such as solar, wind, battery and external grid. The derived energy is converted to DC in order to provide the sufficient energy boost converters are used. The converter output is fed to the DC grid. AC supply is used for the residential purposes, hence the output from the DC grid is fed to the inverter to provide AC. Converters, DC grid and Inverter are controlled and monitored using Multi Utility Controller (MUC). RF receiver and transmitter acts communication protocol between controller and various parts of the operating sector. Depending on the information obtained from the controller, case (1) excess energy is stored in the battery; if the battery is full the energy is transmitted to the external grid. Case (2) if the energy is not sufficient it obtains energy form the grid.

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