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# MODELING AND ANALYSIS OF HYBRID AC MICRO-GRID

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**Abstract -** *This project will take attention towards the renewable sources. The hybridized production consist of two sources combined that is Solar and Wind Energy. The motto for making the hybrid connection is for total absorption of both the sources and improve the reliability of the network. The work is developed here using the MATLAB software. Here the focus is on developing a small micro-grid for a particular region which gets supplied with energy generated using renewable sources only. By integrating this entire small micro grid with state utility grid reliable and sustainable energy is obtained. During disturbances, the generation and corresponding loads can be sequestered from the utility to protect the micro-grids load from the disruption and not harming the transmission grids integrity. This ability of energy generation and feeding independently to a certain small regional load has the capacity of providing a greater local reliability than that by the total power system.*

***Key Words***: Solar panel, wind generation, boost converter, SPWM based inverter, Battery backup, Grid.

## 1. INTRODUCTION

Nowadays use of hybrid systems has boosted immensely in cities as well as in village areas. Government is focusing more towards renewable resources due to alarming drop in conventional resources like coal, oil and natural gas. Also, by using a single renewable energy source isn't reliable due to its intermittent nature and electricity supply can't be ensured.

Therefore, a hybrid ac micro-grid and its coordinate control deals with the new growing concept of smart grids and its synchronization. Smart grids is the best panacea available for these non-conventional way of electricity production. The demands are growing every year, hence to obtain better efficiency has led to this concept. At one end, peak sharing techniques are employed and on the other side distributed generation is conducted. Usually renewable sources are utilized due to its easy availability, reducing pollution as well as fuel costs too. Hybrid generation can be used from various sources like solar, wind, biogas, geothermal power, tidal power, hydroelectricity, biomass etc. But, the best combination for rural and urban micro-grid is solar and wind along with battery backup. Biogas plant can be combined to increase the efficiency of the system. At night wind energy is used to supply the load and during day time solar satisfies the requirement. Battery can store the energy in form of dc and supplies when both the sources are unable to process. This is use to counterpart the fact that energy from the wind is fluctuating and thus its frequency is not maintained constant. Control coordination algorithms allows controlling the flow of energy from both the sources to the load.

## 2. PHOTOVOLTAIC SYSTEM

The photoelectric effect was first proposed by French physicist Edmund Becquerel in 1839. He proposed that "certain materials possess the property of producing very small amounts of electricity when exposed to sunlight". In 1905, Albert Einstein studied the photoelectric effect which has become the basic principle for photovoltaic technology. In 1954, the first photovoltaic module was built in Bell Laboratory.[2]

A photovoltaic system uses one or more solar panel. It consists of various components which include the photovoltaic modules, mountings, mechanical and electrical connections, and means of regulating and modifying the electrical output.

### 2.1 PV ARRAY

A PV array is simply an interconnection of numerous modules which is made up of multiple cells in series and parallel. The power generated by only one module isn't sufficient to satisfy commercial requirements, so interconnection of modules for an array formation is used to supply the load.[2] The module connection in an array is similar to that of cells in a module. To obtain desired output voltage the modules are connected in series and in parallel for current.

The efficiency of a cell is more than a module due to the fact that some radiations are reflected back because the glass cover and also due to frame shadowing. Also, the major part of sunrays is infrared rays (not visible to human eye) which passes through the cell without converting into energy. New technologies have been developed to prepare silicon that can absorb Infrared Rays (IR) and improve the efficiency of PV cell by 30%.

### 2.2 MODELING OF PV PANEL

The photovoltaic system generates dc power without harming the environment when it's brought into sunlight. The building block of PV arrays is the solar cell, which is connected in series and parallel according to the required power output. The output characteristic depends on factors like the solar irradiation, output voltage of the module and cell temperature. The figure shows the equivalent circuit of a PV array with a load.[1]

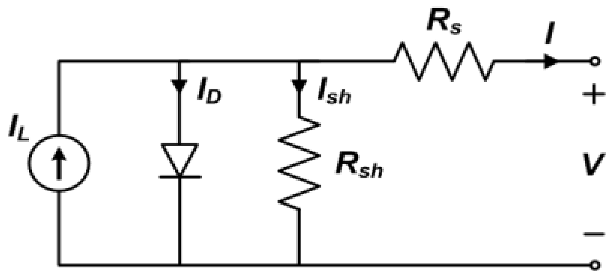


**Fig -1:** Equivalent Circuit of Solar Cell

Normally the equivalent circuit generally consists of a diode, a parallel resistor which limits leakage current, a series resistor ($R_s$) describing internal resistance to the current flow and a photocurrent.

The voltage current characteristic of a solar cell is given as:

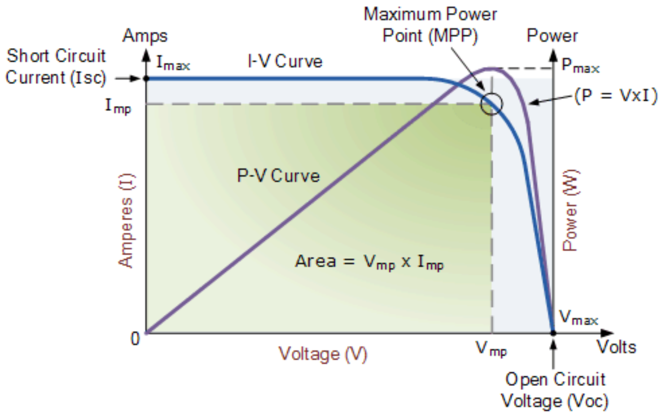


**Fig -2:** Solar Cell I-V Characteristic Curve

The characteristic equation for a PV cell is given by:[3]

$I_o = (N_p * I_{ph}) - (N_p * I_{rs}) * (\exp((q/(k*T*A))*(V_o/N_s)) - 1)$

Where,
$I_{ph} = (I_{scr} + ki*(T-Tr))*(s/100)$
$I_{rs} = I_{rr} * ((T/Tr)^3) * \exp(q*Eg/(k*A) * ((1/Tr)-(1/T))$
$T = (T_{r1}-32)+273$

## 3. WIND ENERGY SYSTEM

Generating energy from wind is the best and promising technology among the renewable energy. Also their economic aspects justifies its usage for standalone applications as well as grid connected operations. But the wind speed varies as per the area and climate, the energy available from it also varies continuously.

### 3.1 VARIABLE-SPEED AND CONSTANT-SPEED WIND TURBINES

The performance coefficient, Cp, of a wind turbine is plotted against the tip speed ratio, λ.[3]

The tip speed ratio, λ, is defined as "the ratio between the tip speed of the blades and the wind speed". Where, ω is the blades angular velocity (in rad/s), R is the rotor radius (in m) and v the wind speed (in m/s).

The coefficient of performance, Cp, is defined as "the fraction of energy absorbed be the wind turbine of the total energy that would have flowed through the area swept by the rotor if the turbine wasn't there".

Power output from a WTG is determined by[13]:

$$Pm = 0.5\rho ACp(\gamma, \beta)V\omega^3$$

The coefficient of performance Cp has a theoretical optimum of 0.59. The turbines can only convert some quantity of the total wind into useful energy. The power available for the turbine is equal to the change in kinetic energy of the air as it passes through the rotor. It is conventional to plot the variation of performance coefficient, Cp, against the tip speed ratio, λ, rather than against the wind velocity, as this creates a dimensionless graph.

### 3.2 POWER CONTROL

The kinetic energy is the flow of air through a unit area perpendicular to the wind direction is ½ v2 per mass flow rate.

For an air stream flowing through an area A,

Mass flow rate is ρ · A· v.[2]

Therefore the power in the wind is equal to:

$P = (\rho \cdot A \cdot v).\ ½ v^2 = ½ \cdot \rho \cdot A \cdot v^3$

Where, ρ is the air density (in $kg/m^3$), A the area (in $m^2$) and v the wind speed (in m/s), and P the power of the wind (in watts or J/s).

## 4. BATTERY

Nowadays, the battery industries are sectioned under the large-scale sector and produce millions of batteries every month. Improving the energy capacity is one development issue along with customer's safety.

With the electric vehicles growing into the market, there is technological development in the field of batteries which leads in dropping of fuel usage and gas emissions. Battery improvement is a crucial task for both industry and academic research.[14]

## 5. RESULTS AND SIMULATION

### 5.1 MODELING OF PV MODULE

A module is constructed by interconnection of various cells in series and parallel. Thus in MATLAB, equations need to be written describing all the parameters and thus its model can also be formed by connecting basic math blocks like summer, comparator, integrator etc.

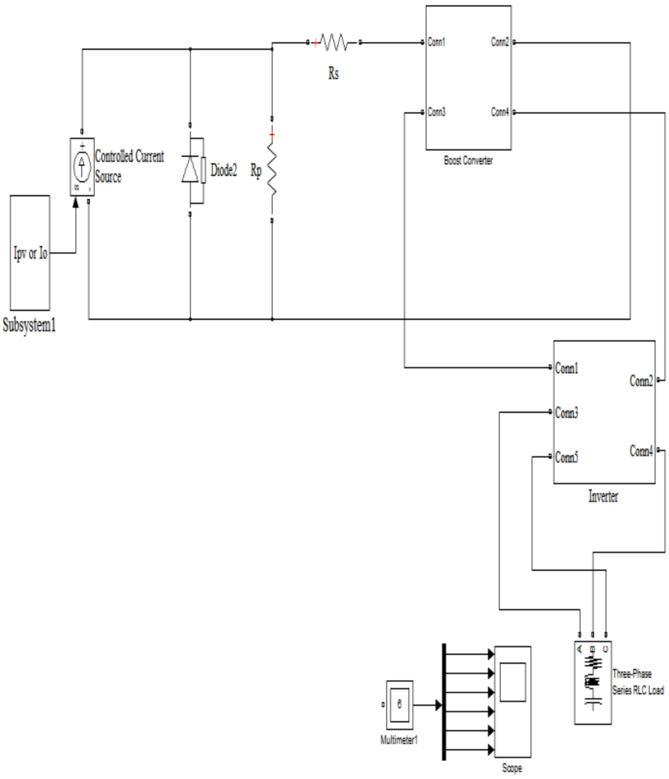


**Fig -3:** Modeling of PV Module

### 5.2 SIMULATION OF BOOST CONVERTER

A transformer cannot step-up dc voltage. This task is done by boost converter. Usually the output voltage available from the solar panel is not sufficient enough to feed to the load after its ac conversion. So it is first levelled up and then fed to the inverter where the harmonics are reduced and it is converted to ac and then fed to the utility grid.
The waveforms of simulation of converter are:

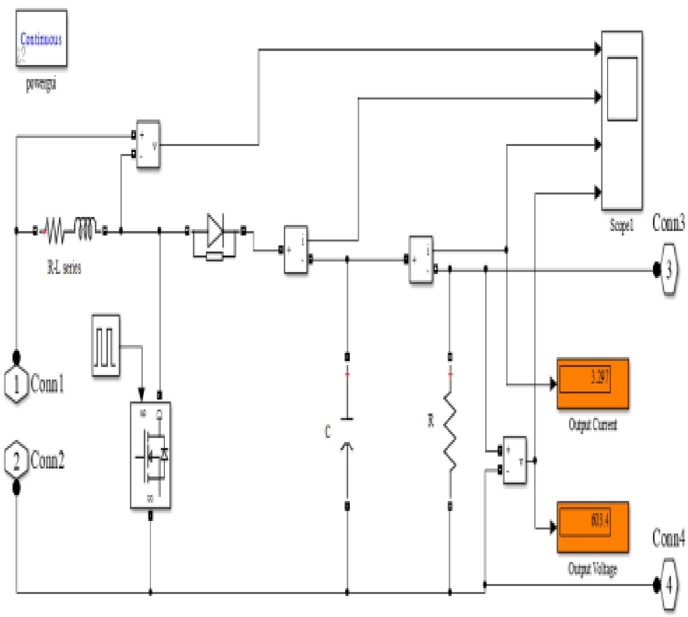


**Fig -4:** Boost Converter

#### 5.2.1 Output Voltage of Boost Converter

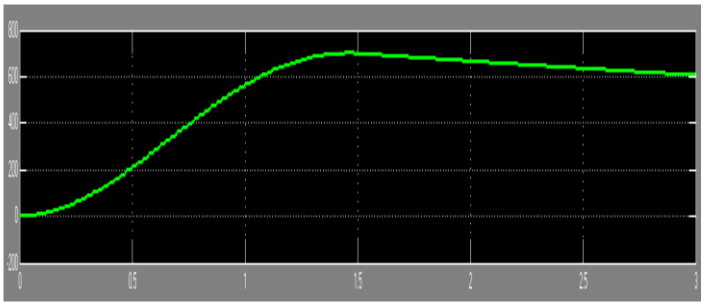

**Fig -5**

#### 5.2.2 Output Current of Boost Converter

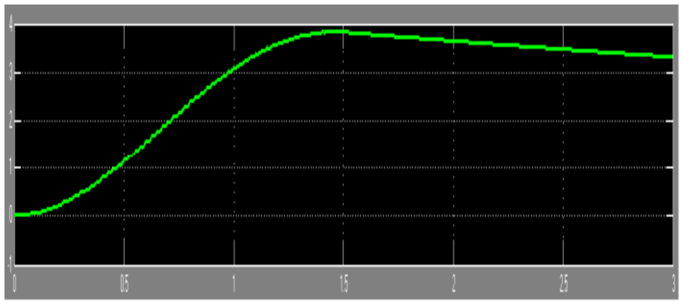

**Fig -6**

### 5.3 SIMULATION OF SPWM INVERTER

Inverter helps to convert dc to ac and thus plays a significant role in transmission as long line can be conducted only in case of ac to avoid long line transmission costs. Here SPWM inverter is used as it helps to reduce harmonics and ripples better as compared to other techniques of inverter.

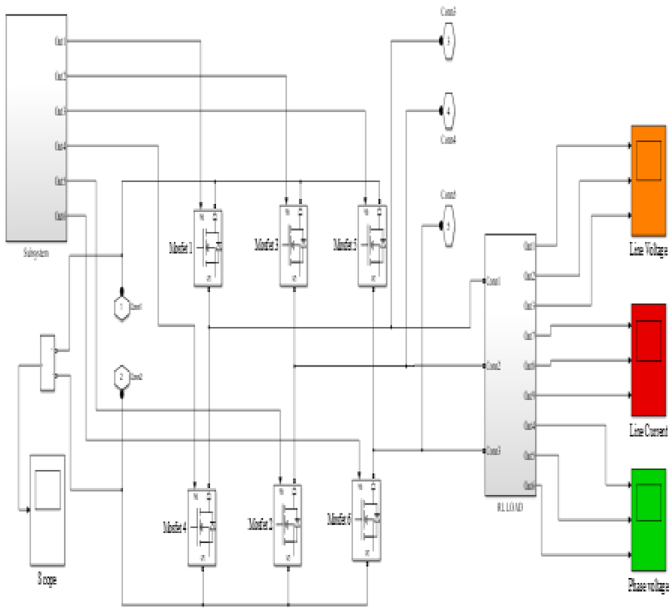


**Fig -7:** SPWM Inverter

### 5.3.1 INVERTER LINE CURRENT

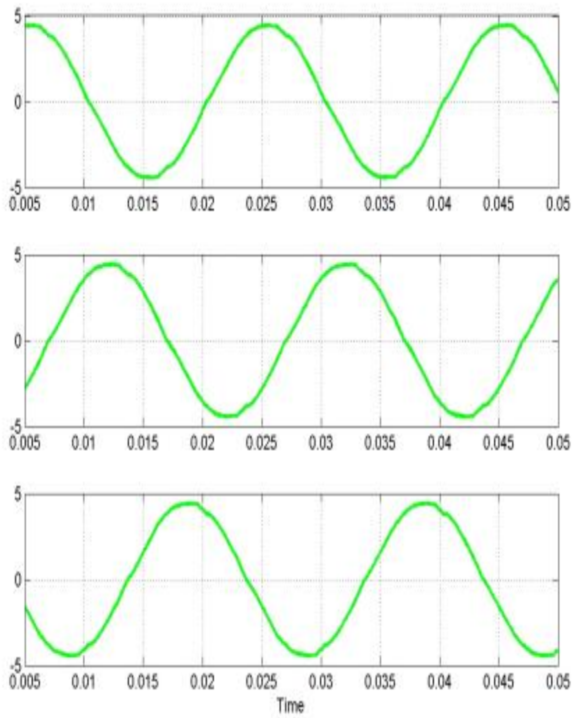


**Fig -8**

### 5.3.2 INVERTER LINE VOLTAGE

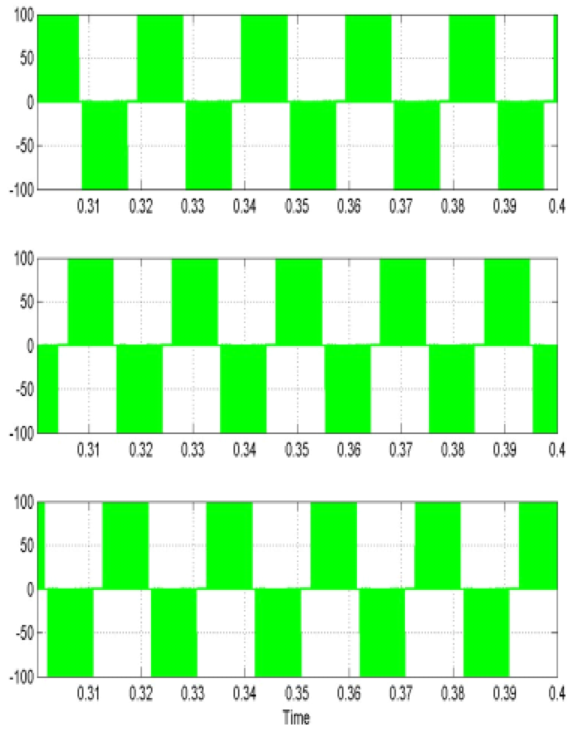


**Fig -9**

### 5.3.3 INVERTER PHASE VOLTAGE

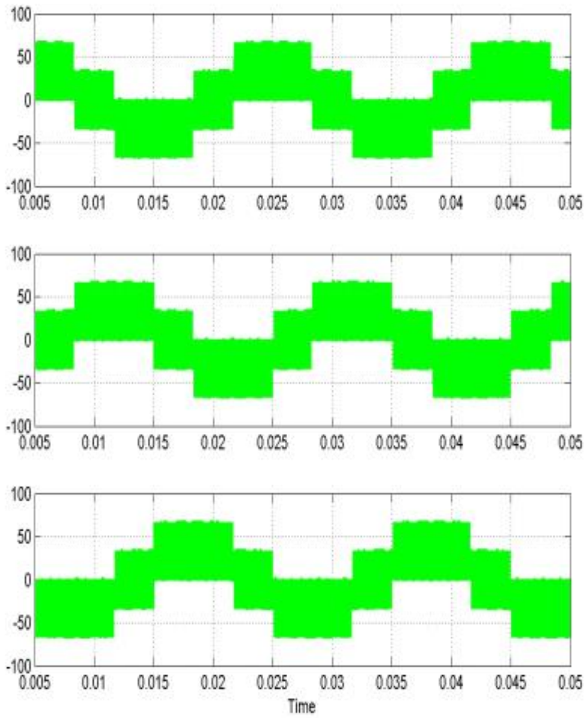


**Fig -10**

### 5.4 BATTERY BACKUP

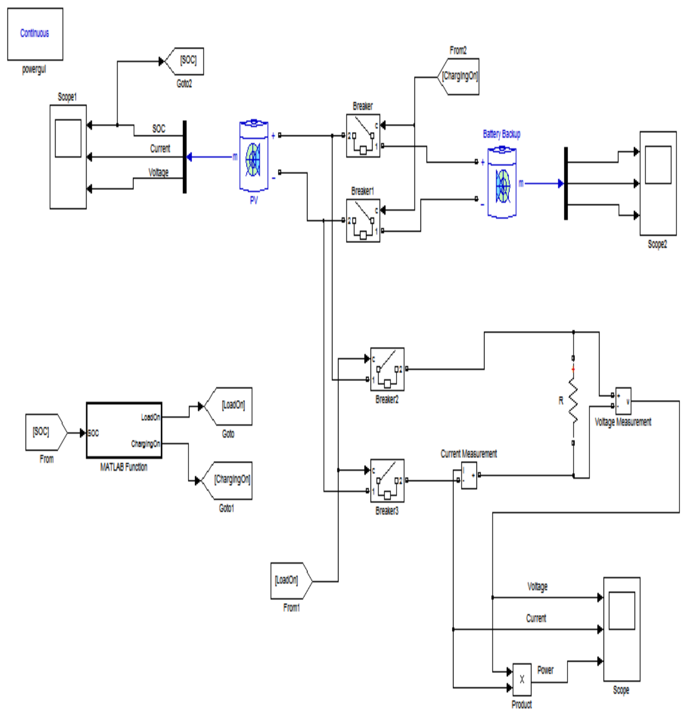


**Fig -11:** Battery Backup

### 5.4.1 BATTERY OUTPUT

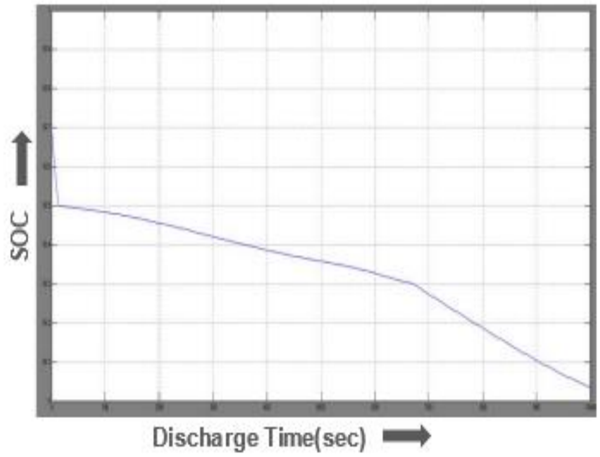


**Fig -12**

### 5.4.2 BATTERY CHARGING CHARACTERISTICS

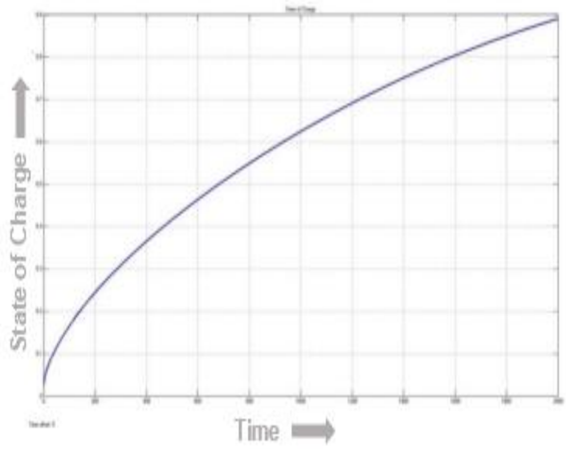


**Fig -13**

### 5.4.3 BATTERY CHARACTERISTICS

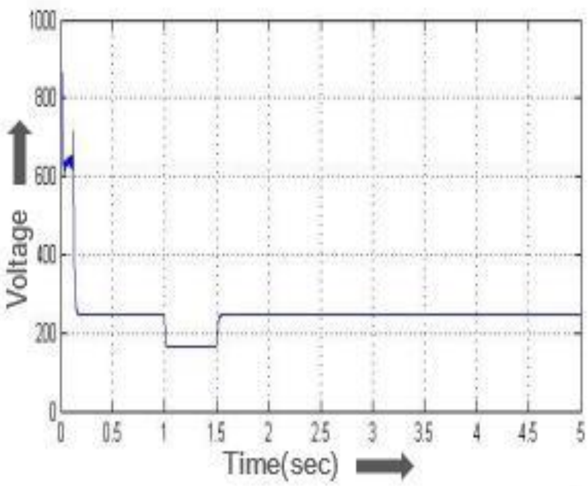


**Fig -14**

## 5.5 WIND GENERATOR

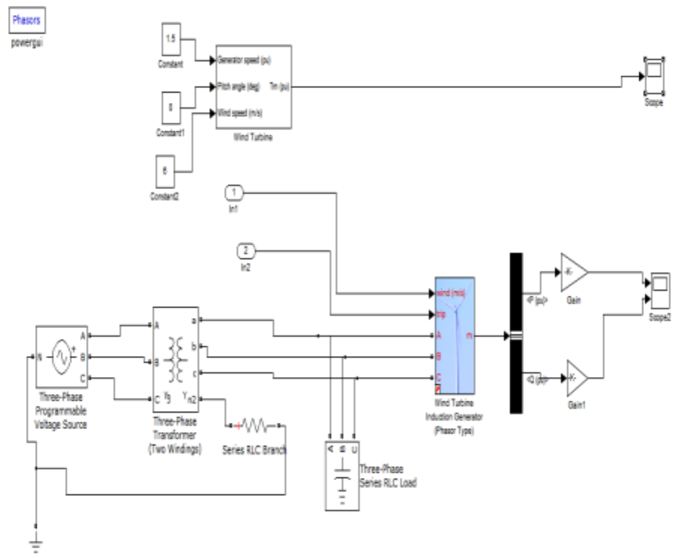

**Fig -15:** Wind Generator

### 5.5.1 WAVEFORM OF WIND

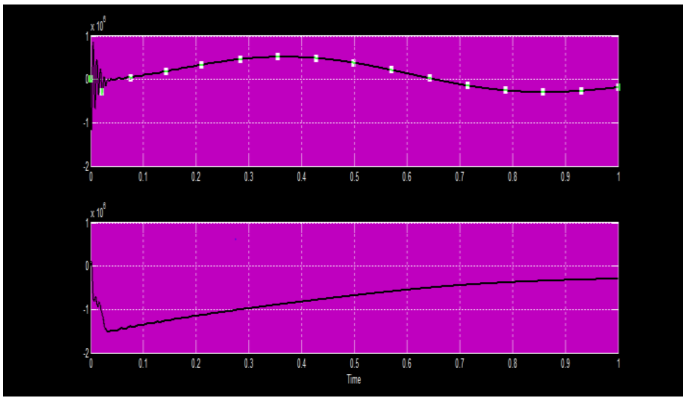

**Fig -16**

## 5.6 HARDWARE

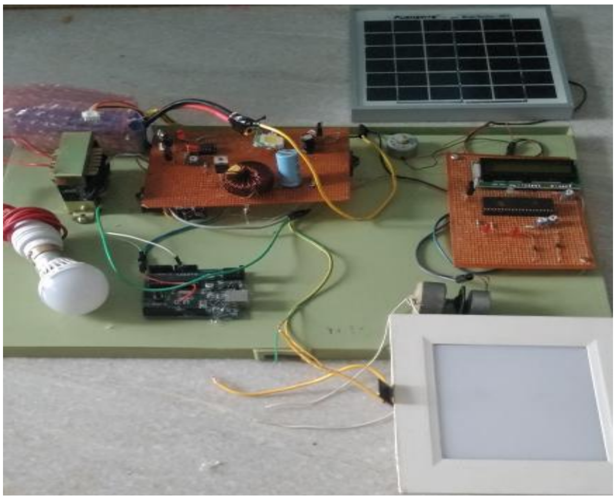

**Fig -17:** Prototype

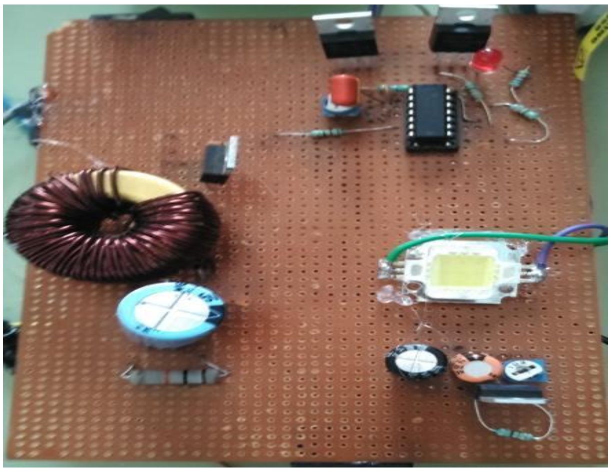

**Fig -18:** Buck-Boost Converter, Inverter and Voltage regulator

## 6. CONCLUSIONS

Thus, we finally conclude that wind and solar can compensate their internal flaws and can act as sources of generation of green and clean energy system. Modeling and Operation of micro-grid with the combination of solar and wind energy is scrutinized in this paper. Continuously varying irradiance and wind energy fluctuations are considered in this paper. The micro-grid is equipped with an Energy Storing System. Wind Turbine (IG), Photo Voltaic cell, Battery Backup are considered in this paper. Moreover, the concept of micro-grid helps to sort the problems once associated with the functioning and effectiveness of the micro-grid.

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