Hybrid Energy System and its Modelling in Smart Grid

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Abstract— **The renewable energy power resource ensures uninterruptable, quality power delivered. Solar, wind energy Etc. Among solar system plays a major role the MPPT techniques used. A small change in the tracking techniques will improves a closer following of the sun, yields more power. This paper describes the improved method of solar energy conversion model with PMSG wind energy system based Hybrid MATLAB model and simulation studies.**

Keywords—**Renewable energy source (RES), distributed generation (DG), power quality (PQ), distribution system, grid interconnection.**

I. INTRODUCTION

The energy consumption is always unpredictable because of the load demand, power capacity of a system. The Renewable energy resource will ensure quality of power with load variation. Most of the power about 75% is getting through fossil fuels, the increase of pollution and global warming are the constraints will made us to move toward Green resources.   For the past decades Renewable energy conversion system (RECS) reached the considerable level of worldwide power production systems.

Number of RECS integrated to form a Distributed Generation DG is the threats on power quality like Voltage regulation and the stability leads to use of these DG's in a high level. Therefore DG systems are requires strict and technical, regulatory frameworks for ensure reliable, safe and efficient operation of network. The advancement in power electronics, digital control technology, DG is actively controlled for enhance of the system operation which improves Power quality.

II. GRID INTERFACE WITH RECS

A grid interconnected network used for delivering electricity from suppliers to consumers. It has three main components:

1) Generating plants used for produce electricity from combustible fuels (biomass, coal, natural gas etc.) or non-combustible fuels (solar, hydro power, wind, nuclear).

2) Transmission system lines carry power from power plants to demand centers through feeders.

3) Transformers step down the voltage to required level and delivered to distribution lines. The Basic power quality requirement has to be met for voltage profile, harmonics, frequency etc. for Grid interconnection.

Renewable energy system plays a major contribution to met large scale demand in time. Large-scale PV System. Large-scale wind farms systems used though it has to meet a spectrum of challenges technically arising from expanding application with power rated power electronic devices.

Tamil Nadu 2MW4;132.72 MW	Andhra Pradesh 10MW; 122.45MW
Maharashtra 11.2MW;1837.85 MW	Madhya Pradesh 2MW ;187.69 MW
Karnataka 10MW ;1184.45 MW	Kerala 10MW; 23.00 MW
Rajasthan 105MW; 670.97 MW	West Bengal 2MW;1.10MW
Gujarat 654.81MW;1432.71MW	Other States 35MW;3.20 MW

Table.1 Solar and wind energy systems in India

In INDIA the renewable energy sector is developing with a slower pace .India's total grid connected renewable energy capacity (excluding large hydro) is around 26.96 GW out of which 68.9% comes from wind source while 4.59% comes from solar PV cells.

III. THE SOLAR PV MODEL

In Earlier day they use circuit simulator PSPICE to verify impact of the different topologies and control techniques. This model deal's with Single diode-model for PV system. Three remarkable point's Short circuit current, Maximum power point, open circuit voltage(SC,MPP,OC)

Internal characteristics Series and parallel resistances (Rs and Rp) External characteristics (irradiation and temperature) We use MATLAB for our simulation purpose Fig shows the equivalent circuit of the ideal photovoltaic cell. The basic equation from the theory of semiconductors that mathematically describes the I-Characteristics of the ideal photovoltaic cell is

$$I = I_{\mathrm{pv,cell}} - \underbrace{I_{0,\mathrm{cell}}\left[\exp\left(\frac{qV}{akT}\right) - 1\right]}_{I_d}$$

Where,

Ipv,cell is the current generated by the incident light
(it is directly proportional to the Sun irradiation),
Id is the Shockley diode equation,
Io is the reverse saturation or leakage current of the diode [A],
q is the electron charge [1.6021764.10−19C],32
k is the Boltzmann constant [1.3806503.10−23J/K],
T [K] is the temperature of the p-n junction, and
a is the diode ideality constant.

Figure.1 below shows without series and parallel module circuit here I use single diode PV model, yet there are many other models like single diode, double diode and multi diode models, because of simplicity in modeling and reducing complexity. The models for finding the reverse saturation current, cell current, module current (Io , Ipv , Im) are based on mathematical equations shown below. In general they use multi-diode modeling there is a complexity on tracking the Maximum power point (MPPT) because it is based on appropriate calculation based on series module resistance and parallel module resistance (Rss and Rpp), and also the Ipv ≈ Isc. But these conditions not really suits to practical situation. So I use an iterative method of finding the Rss and Rpp by setting the Rss at minimum value the corresponding Rpp values is found through iterative procedure based on MPPT. Here I obtain value which suits to practical situation that Ipv Isc.Figure.1 below shows simulation model of without series and parallel module.
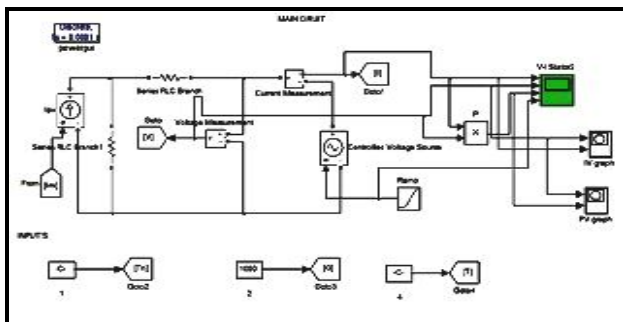

Figure.1 without Series and Parallel Module

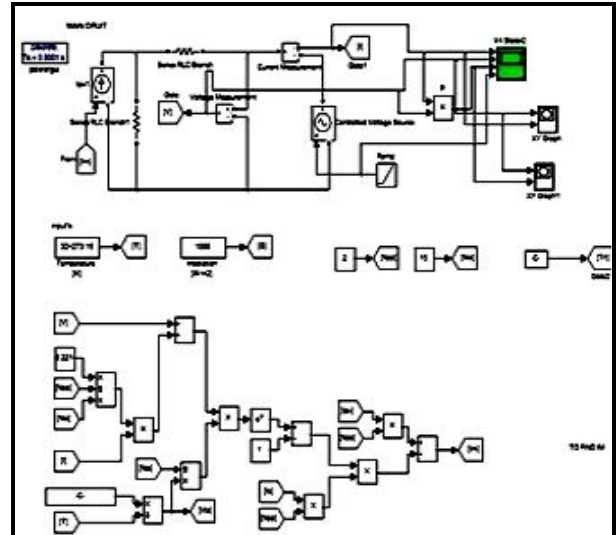Figure.2 below shows the simuation model of with series and parallel module.

Figure.2 with Series and Parallel Module

The Io, Ipv, Im are individually modeled as mathematical block and it's used for calculating in real time through iterative method. Here the Ipv, Isc that suits to practical situation, it's calculated by keeping the Rss constant, Rpp was increased by iterative method by Maximum Power Point Tracking (MPPT).

Parameter's used in these circuits:
Short circuit current (Iscn) = 8.21A
Open circuit voltage (Vocn) = 32.9V
Maximum point current (Imp) = 7.61A
Maximum point voltage (Vmp) = 26.3V
Maximum point Power (Pmax) = Vmp * Imp;
Voltage constant (Kv) = -0.123
Current constant (Ki) = 3.18e-3
No. of Series plates (Ns) = 54
No. Of Series module (Nss) = 15
No. of parallel module plates (Npp) = 2;
Diode constant K = 1.3806503e-23;
Charge (q) = 1.60217646e-19;
Diode constant (a) = 1.3;
Irradiation (Gn) = 1000;
Irradiation temperature (Tn) = 25+273.15;
Series initial resistance (Rs) = 0.

Figure.3 shows the individual series and parallel cells are added in form of array called modules. Number series and parallel plates will have the effect on increasing the capactiy of plant.Increase in series plates in an array causes the voltage to vary by keeping current constant. Increasing the parallel plates causes the current to vary by keeping the voltage constant. Here the changing the value of Nss causes the voltage to vary, changing the value of Npp causes the current to vary.

IV. MODELING OF WIND ENERGY PMSG SYSTEM

The Permanent magnet synchronous generator (PMSG) based wind energy conversion system used more in developing new designs because of higher efficiency, high power density, availability of high-energy permanent magnet material at reasonable price, and possibility of smaller turbine diameter in direct drive applications. Here we use three phase four leg interfacing inverter improves the power from grid as well as the three phase loads, four leg of the inverter compensates the neutral current provides balance. Renewable energy resource availability was taken within the range of 0.8 - 3kWh/m2 for solar resource, a variable wind speed from 2 to 20 m/s.

array composed of N_{ss} x N_{pp} modules.
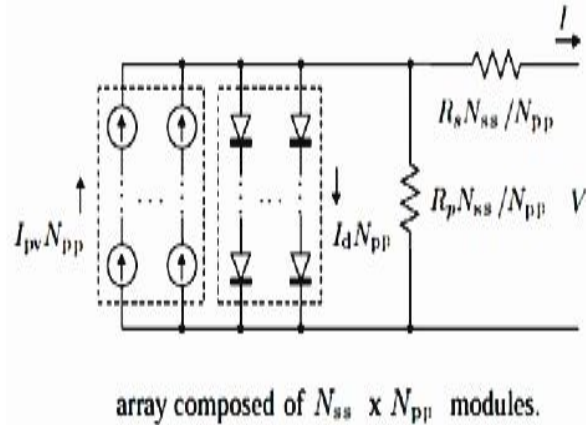
$$ I = I_{pv}N_{pp} - I_0N_{pp}\left[\exp\left(\frac{V + R_s\left(\frac{N_{ss}}{N_{pp}}\right)I}{V_t a N_{ss}}\right) - 1\right] $$

THE MAIN EQUATION'S FOR R_s AND R_p:

$$ R_s max = \frac{(V_{oc} - V_{mp})}{I_{mp}} \qquad R_p min = \frac{V_{mp}}{(I_{scn} - I_{mp}) - R_s max} $$

$$ R_p = \frac{V_{mp} * (V_{mp} + I_{mp} * R_s)}{(V_{mp} * I_{pv}) - (V_{mp} * I_o) exp\left[\frac{(V_{mp} + I_{mp} * R_s)}{N_s a}\frac{q}{kT}\right] + V_{mp} * I_o - p_{max,e}} $$

Figure.3 PV Array

The modified model of the Wind turbine (WT) is implemented as shown in this model, whereas the inputs are the wind speed and generator speed, the output is the torque applied to the generator shaft. The torque of the generator is based on the generator power and speed. The wind turbine induction generator (WTIG) model is designed using the built-in Sim Power System library. The rotor shaft is driven by the WT which produces the

mechanical torque according to the generator and wind speed values. The electrical power output of the generator (stator winding) is connected to the smart grid.

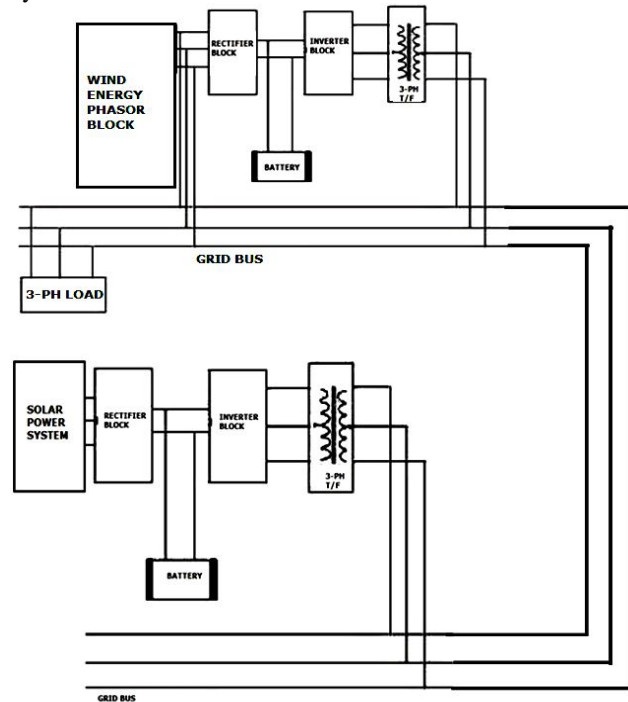Figure.4 below shows the Topology model of this hybrid system.

Figure.4 Topology model of Hybrid system

The Phase Locked Loop (PLL):

A phase locked loop (PLL) ensures the synchronization of the reference frame with the source phase voltages by maintaining their d component at zero (Ed=0) through a PI controller; the grid frequency is delivered by knowing the line-line grid voltages (EBA, EBC),

   (a) line-line to three phases
   (b) (A, B, C)-(alfa, beta)

The transformation of the coordinates

   (a) Calculus of the required PLL's input trigonometric functions
   (b) PLL MATLAB/Simulink-Based Grid Power

Inverter for Renewable Energy Sources Integration

   (a) The PI regulator of the PLL
   (b) The integrator for angle calculation
   (c) dq grid voltage components: ED, EQ

The Current Controllers:

By using a decoupling of the nonlinear terms, the cross coupling (due to boost input inductance) between the d and q axes was compensated. To decouple current loops, the proper

utility voltage components have been added. Voltage decoupling control shows the Simulink. The implementation of the reverse transformation from synchronous reference frame (d,q) to fixed reference frame (A,B,C) through the (alfa,beta) transformations. (a) DQ-ABC (b) DQ-(alfa, beta) (c) (alfa,beta)-(A,B,C)

V.   HYBRID SYSTEM

Figure.5 below shows the Hybrid system in smart grid Modelling which it gives a flexible control of grid by using grid controlled converters and inverters based on power electronics based controllers.
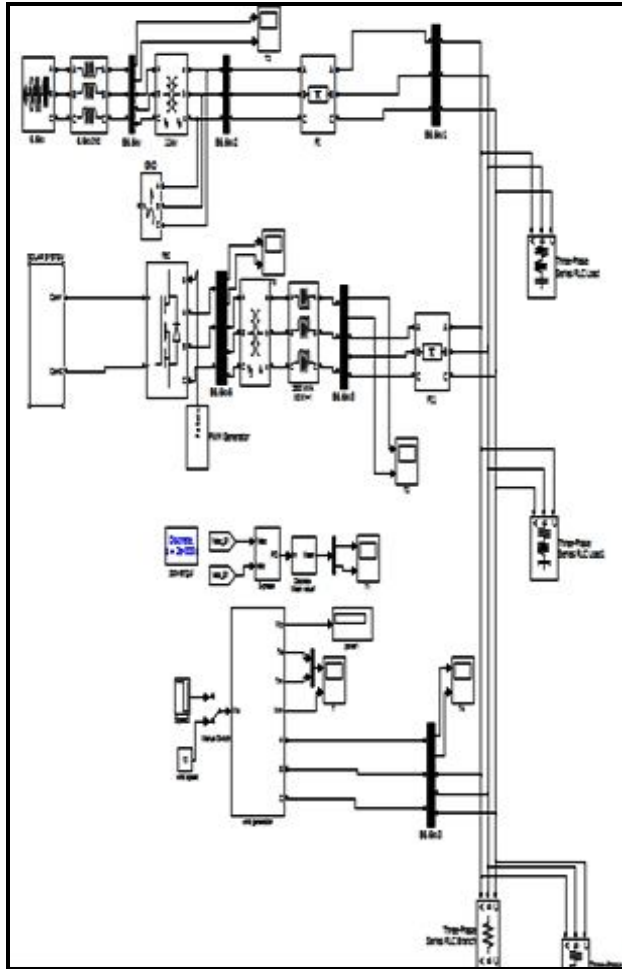

Figure.5 Hybrid Simulation Model circuit

Parameter's used in these circuits:
 Voltage is 560V.
 Wind speed 10ms.
 Torque 15.4N-M.
 Power is 3927W
Figure.6, 7, 8, 9 below shows the simulation output of the hybrid system and the output of individual REC's. The PLC and current controllers have a great control on the parameters to maintain the voltage and power level between the grid and the individual REC's output.
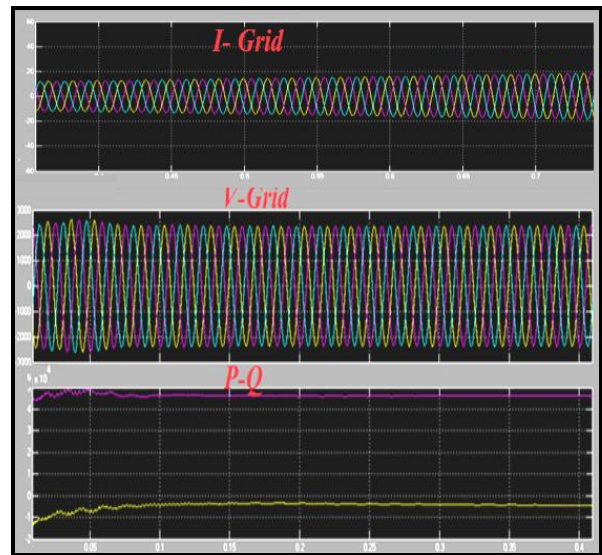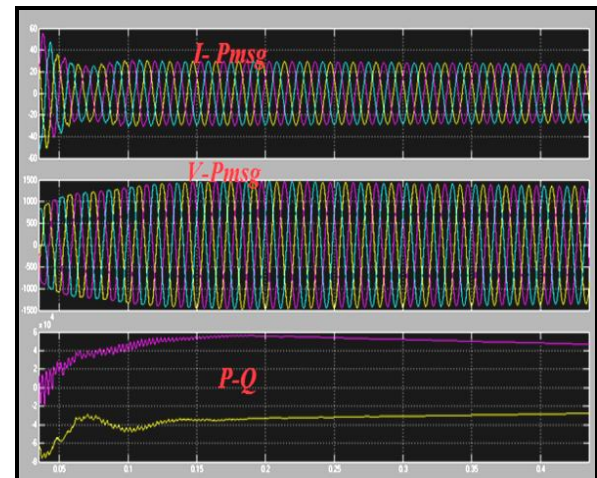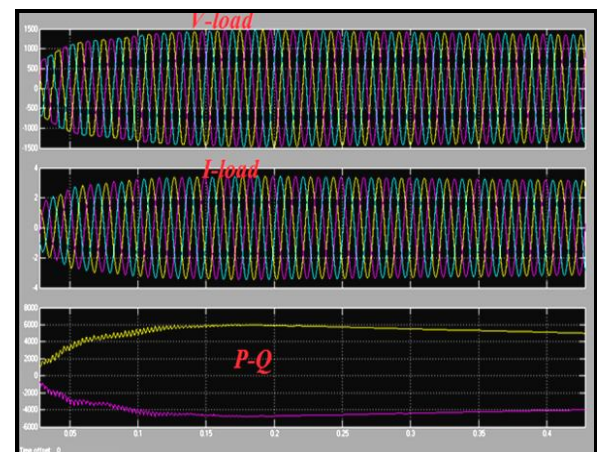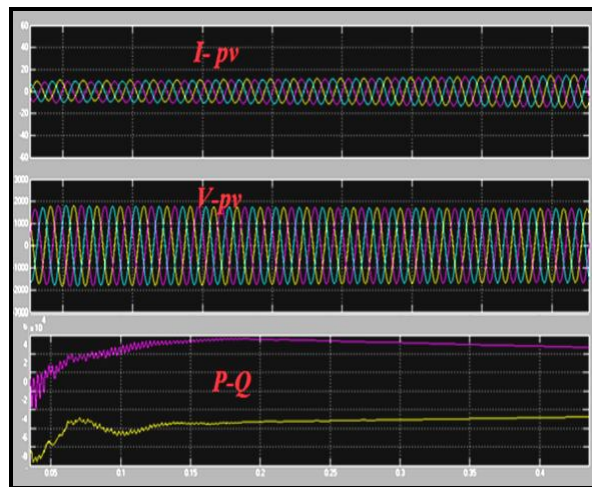

Figure.6 Grid output

Figure.7 PMSG output

Figure.8 Load

Figure.9 PV output

VI. CONCLUSION

Solar PV system has modeled in a simple way using single diode PV model. Here assumption based (Ipv≈Isc) modeling is avoided and it was replaced .The Ipv and Isc based on series and parallel resistances found through an iterative method, here found Ipv and Isc values are not same as in real time solutions. The PMSG based wind energy conversion system used more in developing new designs because of higher efficiency, high power density, availability of high-energy permanent magnet material at reasonable price, and possibility of smaller turbine diameter in direct drive applications. Here we use three phase four leg interfacing inverter improves the power from grid as well as the three phase loads, four leg of the inverter compensates the neutral current provides balance. Renewable energy resource availability was taken within the range of 0.8 - 3kWh/m2 for solar resource, a variable wind speed from 2 to 20 m/s . By using PLL control, Current loop control, the output of the gird is maintained by tuning the associated RE Re-sources.

VII.REFERENCE

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