Abstract- The renewable energy sources one type of photovoltaic system is an attractive option because of enormous amounts of power available in sunlight. In this paper hybrid system of photovoltaic module (PV) and fuel cell is connected to AC micro grid with Proportional Resonant (PR) controller. It consists of a PV, a proton exchange membrane fuel cell (PEMFC), PR controller and, voltage source inverter (VSI). The role of this hybrid system is to produce DC electrical energy is given to the input of VSI. The hybrid system depends on input parameter of renewable energies. The hybrid system of AC micro grid is designed using MATLAB/SIMULINK software. Simulation results such as micro grid output of voltage with and without PR controller and including less THD measurement output of micro grid voltage and current. Above mentioned simulation output is presented in MATLAB/SIMULINK.

Keywords – AC micro grid, Fuel cell, Hybrid system, PV Module, PR controller, Voltage Source Inverter.

I. INTRODUCTION
HYBRID power system (HPS) combine two or more sources of renewable energy into one or more conventional energy sources the purpose of a hybrid power system is to produce as much energy from renewable energy sources to ensure the load demand. A micro grid is conceptually considered as a small-scale grid, formed by DG systems, EES devices, and loads that are electrically interconnected and hierarchically controlled, with the capability to operate either as a grid connected or as an intentionally islanded system [1]. The development of new energy sources is continuously enhanced because of the critical situation of the chemical industrial fuels such as oil, gas and others. Thus, the renewable energy sources have become a more important contributor to the total energy consumed in the world. [2]. Paper focuses on the improved PR current control strategy and its verification to minimize the current ripples of a three-phase inverter with LC filter [3]. The PR controller acts Low frequency isolation transformer can be eliminated at the AC side [8]. Current controller can have a significant effect on the quality of the current supplied to the grid by the PV inverter, and therefore it is important that the controller provides a high quality sinusoidal output with minimal distortion to avoid creating harmonics [9]. Filter is an essential component that suppresses the harmonics introduced through the Pulse-Width Modulation (PWM) technique used to grid-connected inverter [10]. Inverter uses PWM using its switches, there are various methods for doing the pulse-width modulation in an inverter beneficial to frame the output ac voltages nearly to sine wave [11]. Solar power is becoming more cost because it is maintenance free, an inexhaustible source and low environment emission [12]. Micro grid is commonly called as an integrated power system consisting of distributed generators (DGs), distributed energy storages (DSS), and interconnected load, which can operate in grid-connected mode or in intentional islanded mode [13]. The main attributes of Micro grid are generation sources, loads and energy storages. [14]. Micro-grid is inevitable in future due to its obvious advantages in reduced central generation capacity increased utilization of transmission & distribution capacity, enhanced system security and reduced CO2 emission [15].

In this paper a hybrid system of PV module and proton exchange membrane fuel cell is connected to AC micro grid with PR controller. This paper is organized as follows. Section II describes the system description. Section III describes the proposed controller in micro grid. Section IV presents the simulation model and results. Section V conclusion discussed.

II. SYSTEM DESCRIPTION

The block diagram of hybrid system is shown in Fig.1. It consists of PV module, fuel cell, DC-DC boost converter, DC-
AC voltage source inverter, PWM generator and PR controller.

A. Hybrid System

Hybrid system one model of PV system occurs of many cells connected in series and parallel to provide needed output voltage and current. The parameters used in the mathematical modeling of the PV system are as follows:
- a - ideality or completion factor
- Ipv - PV cell output current (A)
- Isc - short circuit cell current (A)
- K - Boltzmann’ constant (J/0K)
- Np - the number of parallel strings
- Ns - the number of series cells per string
- q - electron charge (C)
- Rs – the series resistance of PV cell (U)
- T - PV cell temperature (K)
- Vpv - terminal voltage for PV cell (V)

The equation of output current of the PV system can be expressed as (1).

\[
I = I_{pv} - I_{sc} \left[ \frac{e^{(V + R_s I) / NKT}}{1} - 1 \right] - \frac{(V + R_s I)}{R_{sh}}
\] (1)

Another model is proton exchange membrane (PEM) fuel cell. Hydrogen, which is most popular of the renewable fuels, has been obtained from various environmentally friendly sources. The advantages of fuel cell is higher efficiency, especially when the waste heat is used for co-generation, quiet operation suitable for residential applications, and almost zero levels of produced pollutant gases.

B. PR Controller

A proportional–resonant (PR) controller introduces an infinite gain at a selected resonant frequency to eliminate steady-state error or current harmonic at that frequency. However, the harmonic compensators of the PR controller are limited to several low-order harmonics due to system instability when the compensated frequency is out of the bandwidth of the system. Passive damping is often used to maintain system stability, but it is limited by cost, losses, and degradation of the filter performance. The use of active damping by means of control may seem attractive, but it is often limited by a complex tuning procedure of the controllers. This controller gives an advantage in performance at the fundamental frequency and ignores other frequency. The transfer function of PR controller equation is expressed as (2).

\[
G_{ac}(S) = K_p + \frac{K_i S}{S^2 + \omega_0^2}
\] (2)

Where \( \omega_0 \) is the fundamental frequency and \( K_p \) and \( K_i \) represent proportional and resonant gains respectively. PR control for the ac quantity in the stationary frame is equal to the PI control for the dc quantity in the synchronous frame. Designed controller was divided into three main parts which is input, controller contains of proportional gain (Kp), integration gain (Ki), transfer function (\( \omega = 2\pi f \) where \( f = 50Hz \)) andLastly output.

IV. SIMULATION MODEL AND RESULTS

A. Simulink Model of Hybrid System

Fig.2. Simulink Model of Hybrid System
Hybrid system of PV module consists of multiple individual solar cells connected, nearly always in parallel, to increasing a power and voltage above that from a single solar cell. The current from the PV module depends primarily on the size of the solar cells and also their efficiency. It consists of 48 PV cell connected in parallel so increased PV module output current.

Another model of proton exchange membrane (PEMFC) fuel cell operated at low temperature (below 100 degrees Celsius) and electrical output to meet the dynamic power requirements. Acidic polymer membrane is act as an electrolyte. PEM fuel cell connected to 100Vdc DC-DC converter. This converter loaded by an RL element of 6KW range.

i. Output of Hybrid System

SIMULINK model of PR controller output is generated to square wave and this wave is given to the input of inverter gate pulses. Generally PR controller is used to reduce the steady state error, but this paper controller purpose is minimize the value of total harmonic distortion (THD)

\[ \omega_0 = 98696 \]  

C. AC Micro Grid

AC micro grid consists of Hybrid system of photovoltaic module and fuel cell system, PR controller, LC filter, voltage source inverter. Simulink model of AC micro grid is presented in Fig.6.

i. Output of AC Micro Grid with PR Controller

Simulink output of AC micro grid with PR controller output is presented. Three phase AC output voltage value is 360V and Simulink running time is 1secs.

\[ \omega_0 = 98696 \]  

\[ \omega_0 = (2 \pi \times 50)^2 \]  \hspace{1cm} (3) 
\[ \omega_0 = (314.16)^2 \]  \hspace{1cm} (4)
ii. **THD Measurement of with PR Controller**

THD (Total Harmonic Distortion) measurement in AC micro grid with PR controller outputs using SIMULINK tool box of FFT analysis. Set the starting time is 0.02999 seconds and total simulation model run time is 1 seconds. Fundamental frequency is 50 Hertz.

![Fig. 7. Simulink Output of Three Phase AC Micro Grid System](image)

V. **COMPARISION OF THD VALUE WITH AND WITHOUT PR CONTROLLER**

<table>
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<tr>
<th>Contents</th>
<th>THD value</th>
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<tbody>
<tr>
<td>With PR controller</td>
<td>4.44%</td>
</tr>
<tr>
<td>Without PR controller</td>
<td>13.37%</td>
</tr>
</tbody>
</table>

VI. **CONCLUSION**

This paper designed the MATLAB/SIMULINK model of hybrid system such as photovoltaic module, fuel cell. SIMULINK system of PV module and micro grid running time within 0.05sec and 1 sec respectively. Without ripples outputs is got in SIMULINK model of micro grid, which is used to LC filter, this consist of inductance and capacitance.

**VI. REFERENCES**


[14] Srihari Mandava , Ramesh Varadarajan “Microgrid Design and Control Using a Discrete Proportional Resonant Controller” INTERNATIONAL