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HYBRID ENERGY SOURCE FOR INDUSTRIAL APPLICATION USING FUZZY

D.Prabhu[1], K.Balamurugan[2]

PG Student [PED], Dept. of EEE, Sri Ramakrishna Engineering College, Coimbatore, Tamilnadu, India [1]

Assistant Professor, Dept. of EEE, Sri Ramakrishna Engineering College, Coimbatore, Tamilnadu, India [2]

ABSTRACT: This paper concentrates on the implementation and operation of a three-port hybrid, Grid/Photovoltaic stand alone system with fuzzy energy management. Hybrid energy system is an excellent solution for electrification for industrial and remote rural areas. Hybrid Grid/PV systems are highly efficient and require very low maintenance. An average model of a hybrid Grid-photovoltaic generating system has been presented. The main objective is to provide 24 hrs demand quality power in industrial area. The method of investigation concerns with the definition of the system topology, interconnection of the various sources with maximum energy transfer, fuzzy control and energy management. The proposed energy management strategy was simulated in MATLAB/Simulink. The various models with the output waveforms are represented and discussed. The proposed system has very high accuracy and efficient operation which leads to a reduced operating cost.

Keyword: MPPT - Fuzzy logic - Photovoltaic system - DC-DC converter-Industrial load (light and induction motor)

I. INTRODUCTION

In this new era, the recent technological invasions have propelled the development of the entire world to its new heights. These developments have transformed the world into its new dimensions through technological aspects & impact. This is the main reason for the increase in power demand. The rate of world development in geometric ratio catalyses the need of extracting power from renewable energy resources and another reason is that the availability of conventional energy resources is only up to 60-70 years.

Out of the renewable energy resources such as Wind, Geothermal, Solar, Ocean, Biomass and Chemical resources, the Solar resources have its advancement due to its reliability, simplicity etc. Due to the frequent variation in the availability of these resources, the hybrid concept for power generation gains importance. Solar is an inexhaustible renewable energy source and they are widely available which has the good application prospect in terms of development. The Solar hybrid power system can increase reliability of power supply and reduce the system cost according to load characteristics of residential use and local environment condition. The production of pollution free electrical energy can be done and the advantage may extend up to the benefits of economics and developments. Battery units integrated with solar sub systems can give a good reliability.

In stand-alone solar hybrid power system, the lead- acid batteries play an important role as an energy storage component. Whereas charge/discharge strategies of battery storage directly affects the power supply quality in solar hybrid power system since electrical energy from solar has fluctuation. This causes a higher demand to electric power management system.

In this paper the solar is used as a main source of power but solar energy is not sufficient for all the time. It can be combined with the grid power to meet the load demand. Here battery is replaced by the grid power so electric power management system demand is reduced. The battery is used only during emergency condition.

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II. PROPOSED SYSTEM OVERVIEW

Figure 1 shows the block diagram of the three port energy source for industrial application.

- PV cell with MPPT
- Battery
- Grid source

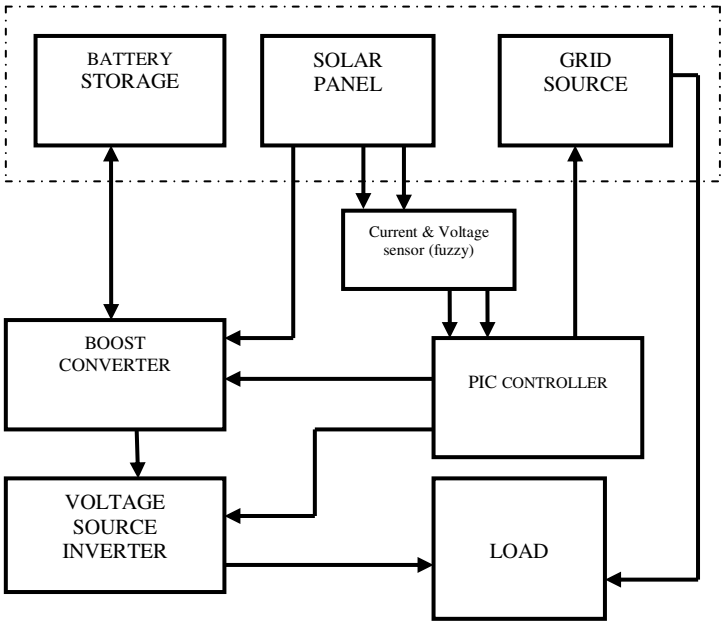

Fig.1 Block diagram of Hybrid Energy Source for Industrial Application.

A. Photovoltaic Cell Modelling

PV technology classified in to silicon crystalline technology and thin film technology. In this proposed method silicon crystalline is used. In this model 24v is obtained by connecting 40 cells each having 0.6v connected in series.

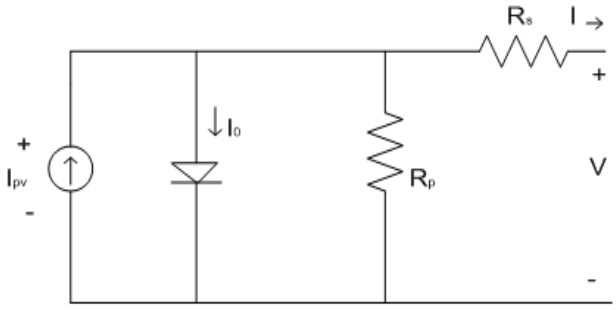

Fig.2 PV Equivalent Circuit

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The PV array is constructed by many series or parallel connections of solar cells. Each solar cell is formed by a PN junction semiconductor, which can produce currents by photovoltaic effects. The equivalent circuit of PV is shown in the figure (2).The current and voltage characteristics of solar cell are given by equations (1) and (2).

$$I = I_{ph} - I_D \quad \text{……..} \quad (1)$$

$$I = Isc - Io\{\exp[(q(V+RsI))/nkTk]-1\}((V+RsI)/Rsh) \quad \text{……..} \quad (2)$$

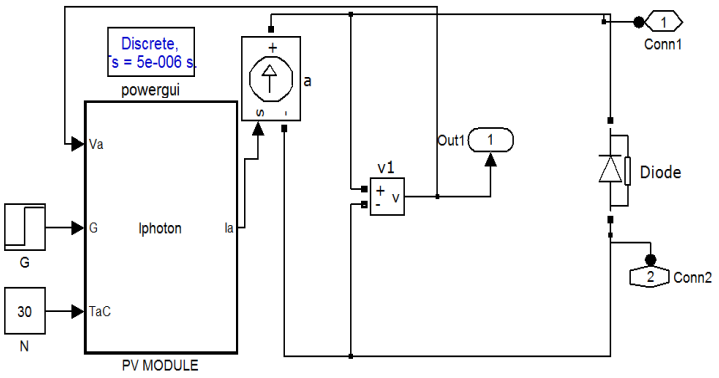

Fig. 3 Simulink model of a PV cell with boost converter

B. Battery Source

In renewable energy sources like solar, fuel cell etc are not stable output, it is not used directly so the battery storage has been preferred. But in this paper only battery is used in emergency condition so that it reduces the initial cost. In the charged state, each cell contains negative plates of elemental lead and positive plates of lead oxide. The charging process is driven by the forcible removal of electrons from the positive plate and the forcible introduction of them to the negative plate by the charging source. Discharged state both the positive and negative plates become lead sulfate and the electrolyte looses much of its dissolved sulfuric acid and becomes primarily water. The discharge process is impelled by the conduction of electrons from the negative plate back to the cell at the positive plate in the external circuit

C. Grid Source

An electrical grid is an interconnected network for delivering electricity from suppliers to consumers. It consist group of generating stations that produce electrical power, high-voltage transmission feeders that carry power from distant sources to demand centers and distribution lines that connect individual customers. In grid system power demand increased day by day. So the renewable source is used by the individual customer. If renewable energy is not sufficient the grid source is used.

D. Boost Converter

A boost converter (step-up converter) is a DC-to-DC power converter with an output voltage greater than its input voltage. It is a type of switched-mode power supply (SMPS) containing at least two semiconductor switches (a diode and a transistor) and at least one energy storage elements are capacitor, inductor and combination of both. Filters made of capacitors (sometimes in combination with inductors) are normally added to the output of the converter to reduce output voltage ripple. Here the output voltage of PV is increased by using boost converter.

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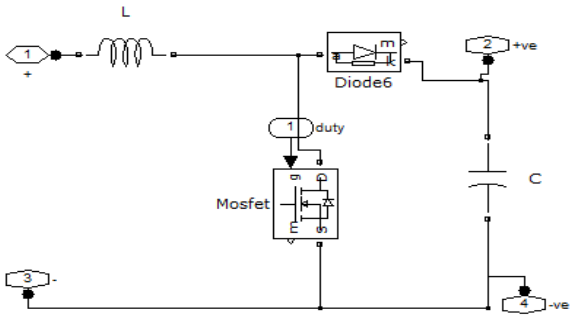

Fig.6 Simulation of DC/DC Boost converter

E. Fuzzy Logic Control

This paper proposes an intelligent control method for the maximum power point tracking (MPPT) for photovoltaic. This method uses a fuzzy logic controller applied to a boost converter control. This controller exhibits a better behaviour. The figure 4 show that the fuzzy logic controller for MPPT.

A fuzzy algorithm consists of situation and action pairs. Conditional rules expressed in AND and OR statements are generally used. In fuzzy if the output is lower than the requirement and the output is dropping moderately then the input to the system shall be increased greatly. The conversion of rule can make into more generally statement for application to fuzzy algorithms. Here fuzzy is used generate duty cycle for the operation of boost converter. The duty cycle is produced based on PV output voltage and current. In addition, it is necessary to quantize the qualitative statements and the following linguistic sets are assigned: 1. Positive minimum (Pim) 2.Positive maximum (Pm) 3. Negative minimum (Nmi) 4. Negative maximum (Nm).

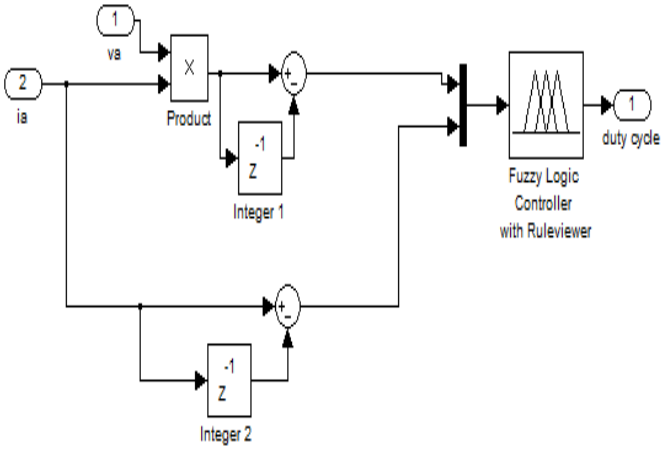

Fig.4 Block diagram of Fuzzy logic for MPPT

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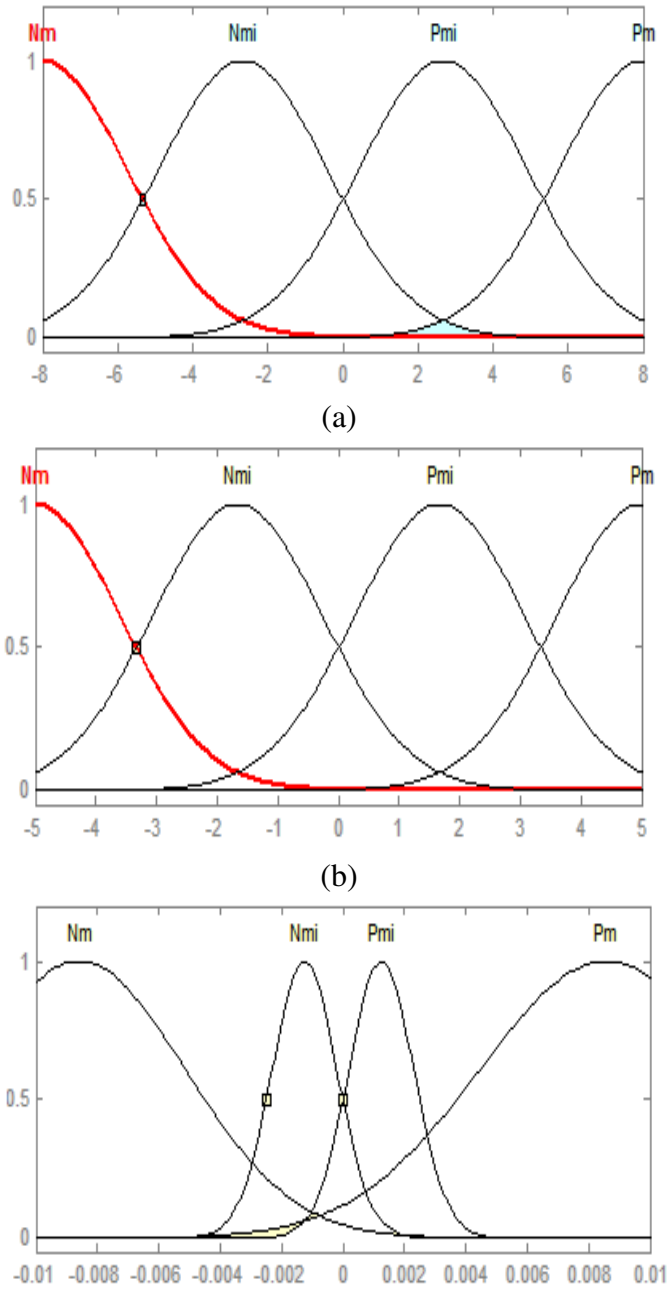

Fig. 5 Membership functions for (a) duty cycle (b) Change of voltage (c) Change of current

F. Load Parameter

In this paper light and motor loads used. An electric light is a device that produces light by the flow of electric current. In most of the industries above 10% of electrical energy is utilized for lighting, here the demand is compensated by solar energy.

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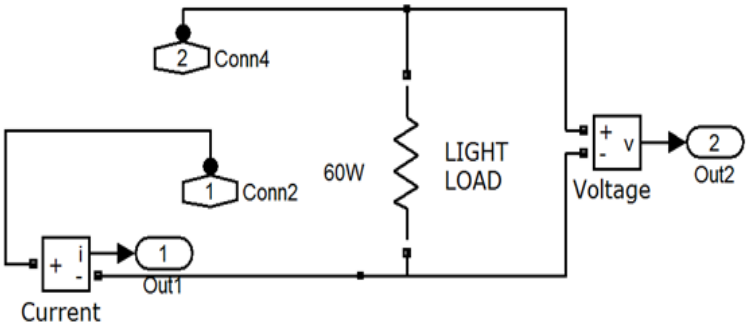

Fig .7 Simulation of Light Load.

In recent trends industry are used motor drives to meet their production. The efficiency of motor is 70-80% therefore motors are consumed more amount of electrical energy. This will increase the power demand. In this method solar energy is used to eliminate the power demand. Induction motor are widely used in industry because it does not require mechanical commutation,

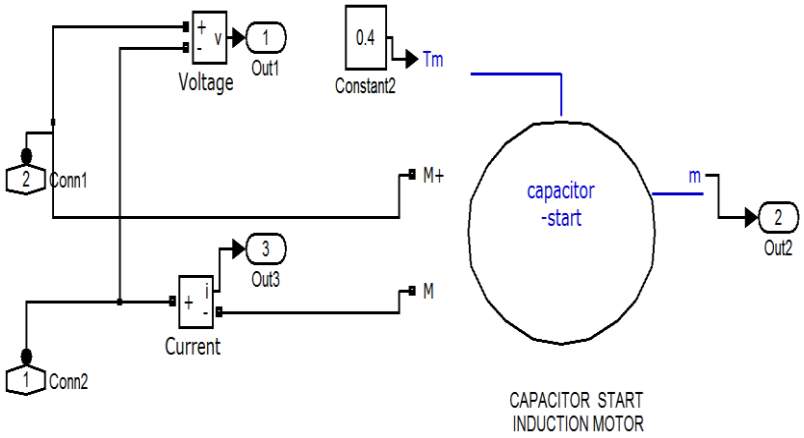

Fig .8 Simulation of Motor Load.

self-excitation for all or part of the energy transferred from stator to rotor, as in universal and large synchronous motors. The applications are diverse as industrial fans, blowers and pumps, machine tools and household appliances.

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III. SIMULATION CIRCUIT FOR ENTIRE SYSTEM

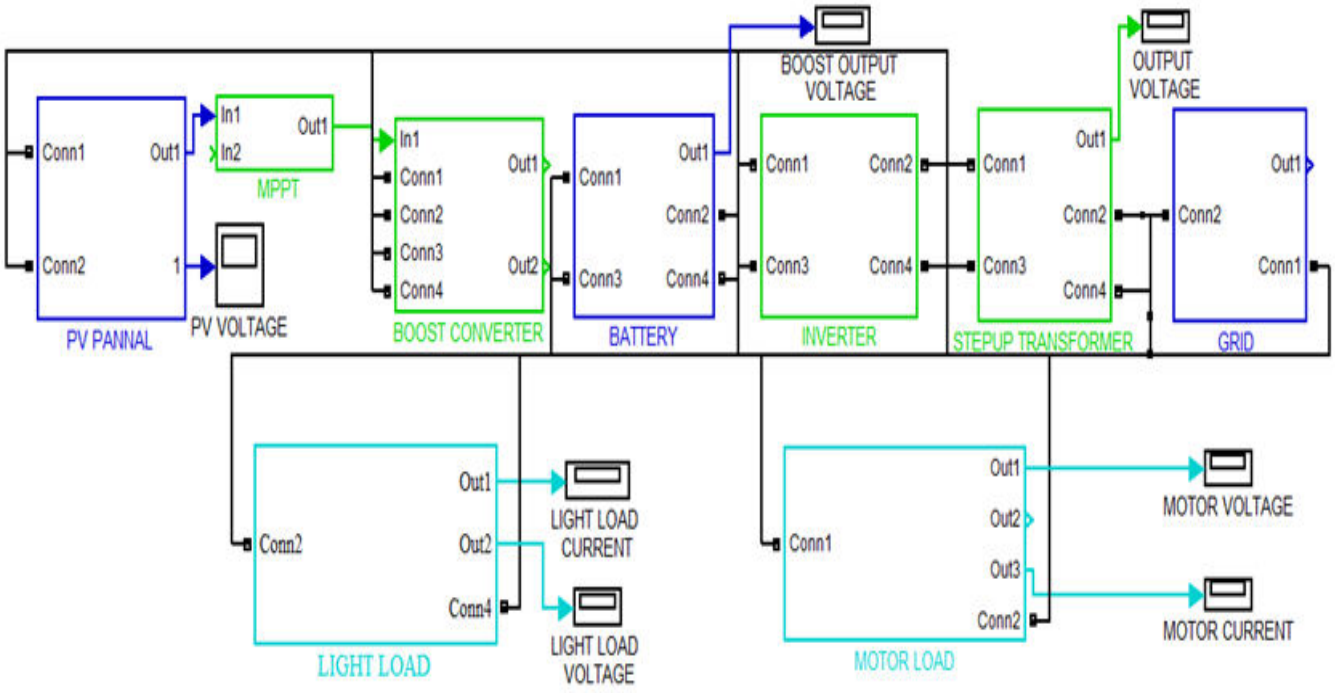

Fig .9 Simulink Model of the Entire System

IV. SIMULATION RESULT

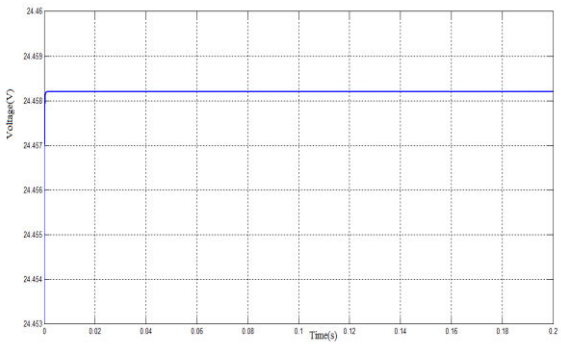

Fig.10 Output Voltage of a PV

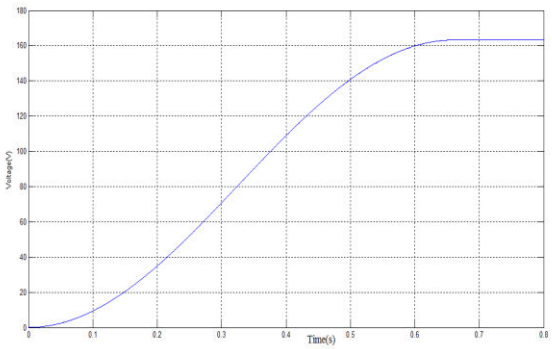

Fig.11 Output Voltage of a boost converter

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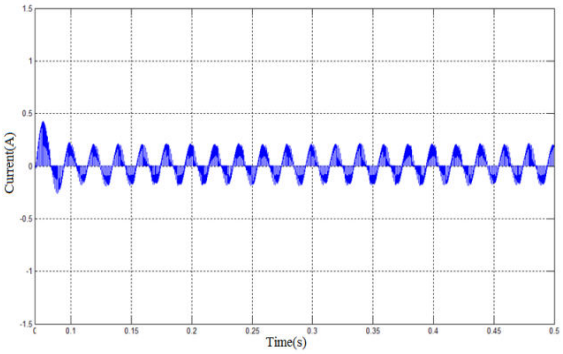

Fig .12 Light load current

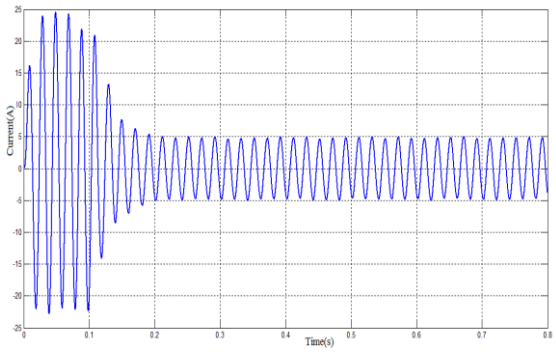

Fig.13 Motor load current

V. CONCLUSION

In this proposed method, photovoltaic for motor, lighting systems and minimum storage elements are used. In PV power generation is not sufficient it will be compensated by grid source .In addition, the designed converter fuzzy control system is highly stable for the all possible operation of MPPT. The simulation results show, the converter control system provides good transient and steady state responses for the converter with respect to the different step changes in the PV power generation and the load condition. The proposed converter has the merits of making use of low voltage batteries, working in constant margin operating points in addition to the advantages of bidirectional power flow at the storage port, simple construction and low-power components.

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