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Hybrid MPPT for Hybrid Energy Conversion System

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***Abstract*— This paper provide the solution to fast and high efficient MPP tracking to the renewable energy sources. The main theme of this paper is to propose a hybrid MPPT algorithm for the Hybrid system comprising of Wind and Solar Energy system. In the hybrid MPPT we combined the features of P & O and Hill climbing algorithm for the fast and better tracking efficiency. Here the hybrid MPPT technique is used to design the MPPT and to generate the control signals for the converters. The converter used is proposed to be of boost type that is used to step up the source voltage to the suitable value of the grid. The simulation can be implemented for this project using MATLAB. With the implementation of this project grid stability, efficiency and speed of the tracking system can be analyzed. The proposed control framework has been actualized in MATLAB programming and tried for different wind and load conditions.**

***Keywords*— Battery storage, Hybrid Excellence Controller (HEC), Energy Management And Power Regulation System, PV cell, load control, hybrid power system, wind energy conversion system.**

I. INTRODUCTION

Solar radiation is one of the brilliant energy emitted by the sun, especially electromagnetic energy. About a large portion of the radiation is in the visible short-wave path of the electromagnetic range. The other half is generally in the close infrared part, with some in the ultraviolet a piece of the range. In Solar PV framework it is important to know the measure of daylight accessible at a specific area at a given time. The two basic systems which describe sun based radiation are the solar radiance (or radiation) and solar insolation[16]. The solar radiance is an instantaneous power density in units of kw/m2. The combination of base waveform and higher harmonics produce a distorted wave shape that resembles a distorted sinusoidal wave. Converted DC output, derived from the solar power, is considered to be a numerous superimposition of odd and even numbers of harmonics. To obtain a relatively clean sinusoidal output, most inverters employ electronic circuitry to filter a large number of harmonics. Filter circuits consist of specially designed inductive and capacitor circuits to block certain unwanted harmonics. In general, DC-to-AC inverters are intricate electronic power conversion equipment designed to convert direct current to a single or three-phase current that replicates the regular electrical services provided by utilities[16].

The wind is a free, clean, and inexhaustible type of solar powered energy. Winds originate from the uneven heating in the atmosphere from the sun, the irregularities from the earth's surface, and rotation of the earth. Wind flow patterns are modified through the land terrain, environmental conditions and buildings. This wind flow, or motion energy, when harvested by modern wind turbines, enable to generate electricity. The terms wind energy or wind generation describes the task where the wind is utilized to come up with mechanical power or electricity. Wind turbines convert the kinetic energy inside wind turbine into mechanical power.

Renewable energy is the energy which comes from natural resources such as sunlight, wind, rain, tides and geothermal heat. These resources are renewable and can be naturally replenished. Therefore, for all practical purposes, these resources can be considered to be inexhaustible, unlike dwindling conventional fossil fuels [1]. The global energy crunch has provided a renewed impetus to the growth and development of Clean and Renewable Energy sources. Clean Development Mechanisms (CDMs) [2] are being adopted by organizations all across the globe. Hybrid power generation systems provide an environmentally friendly alternative to grid connected and standalone operations. However, there are several challenges to the hybrid power system. Appropriate control and coordination strategies among various elements of the hybrid system are required so it can deliver required power. Renewable-energy-based hybrid systems must also be also reliable and cost-effective. A renewable energy system converts the electric power found in sunlight, wind, falling water, tidal, heat energy or biomass into a form; we can use such as heat or electricity. This paper proposes about improve regulation and performance of hybrid stand-alone energy system.

II. PREVIOUS RESEARCH:

Numerous related research works have already existed in literature which based on Hybrid MPPT control, THD and Voltage compensation system. Some of them are reviewed here.

Luigi Galotto *et al* [7]. Presented the evaluations among the most usual maximum power point tracking (MPPT) techniques, doing meaningful comparisons with respect to the amount of energy extracted from the photovoltaic (PV) panel tracking factor in relation to the power, PV voltage ripple, dynamic response, and use of sensors. Using MatLab / Simulink and dSPACE platforms, a digitally controlled boost dc–dc converter was implemented and connected to an Solar Array simulator in order to verify the analytical procedures.

M. Imran Hamid *et al* [9].presented the modeling and simulation of wind energy and solar hybrid generation system for grid connected system. The proposed system consists of buck converter, pulse width modulation inverter, synchronizing system. The synchronizing system operation is to verify whether the output of the PWM inverter is same as the grid system. The synchronizing system consists of voltage, frequency and phase comparator. Modeling and simulation of the entire system is carried out using PSPICE.

Sweeka Meshram *et al*[10],presented simulation modeling of the grid connected DC linked PV/Hydro hybrid system has been done. The DC bus of the PV and hydro system has been common linked to reduce the cost and complexity of the hybrid system. The hybrid system acts as a dominant system and power grid will be acts as a standby to compensate the deficit in the hybrid system. In rainy days/night, the solar energy will be unavailable, hence the power requirement will fulfilled by hydro system and power grid. In summer, the hydro power will be less; in that case the power requirement will be fulfilled by the PV system and power grid. In other days, the power will be fed by the PV/Hydro hybrid system. Thus, the power requirement throughout the year can be satisfied by the proposed system. The proposed system is tested under the linear resistive, RL and Induction Motor (IM) as a dynamic load.

Yuan-Chih Chang *et al* [8]. This paper develops the operational control of two maximum power point trackers (MPPTs) for two-string photovoltaic (PV) panels in dc distribution systems. This dc distribution system is connected to ac grid via a bidirectional inverter. Two PV strings and two MPPTs are implemented in this system. The proposed MPPT topology consists of buck and boost converters to deal with wide output voltage range of PV panels. To accurately determine the input current of MPPTs, the PV-string configuration check is accomplished online. The perturbation and observation method are applied for maximum power point tracking. Moreover, the current balancing of two MPPT modules in parallel is achieved. In this paper, the system configuration and the operational principle of the proposed MPPT are first introduced.

E. M. Natsheh, *et al*[11], Implemented the model of smart grid-connected PV/Wind hybrid system was developed. It comprises photovoltaic array, wind turbine, asynchronous (induction) generator, controller and converters. The model was implemented using MATLAB/SIMULINK software package. Perturb and observe (P&O) algorithm was used for maximizing the generated power based on maximum power point tracker (MPPT) implementation.

Yipeng & Heng (2015) presented a modularized control strategy for wind energy conversion system. Two converters such as grid side and rotor side converters are considered and both the converters are operated to reach MPP.

All the above said methods have certain difficulties in obtaining the maximum power point. Hence three MPPT methods are proposed to receive maximum power from solar and wind energy conversion system.

III. PROPOSEDMETHODOLOGY:

The advanced hill climbing based algorithm consists of hybrid algorithm using a different algorithm technique along with the hill climbing method for faster and accurate tracking of MPP. The voltage and current controlled algorithms are more accurate and effective than most commonly used hill-climbing algorithms at low solar radiation. Therefore these algorithms are combined with P&O and INC algorithms to increase their effectiveness. The hill climbing based algorithms oscillate around the MPP in slow varying atmospheric conditions.

Therefore to decrease losses due to oscillations, the hill climbing based algorithms are suitable in only rapidly changing atmospheric conditions and the constant voltage method is fast and sufficient for constant conditions. The two mode control algorithm combines these two algorithms by using incremental conductance method for more than 30% normalized solar radiation and constant voltage method for less than 30% normalized radiation.

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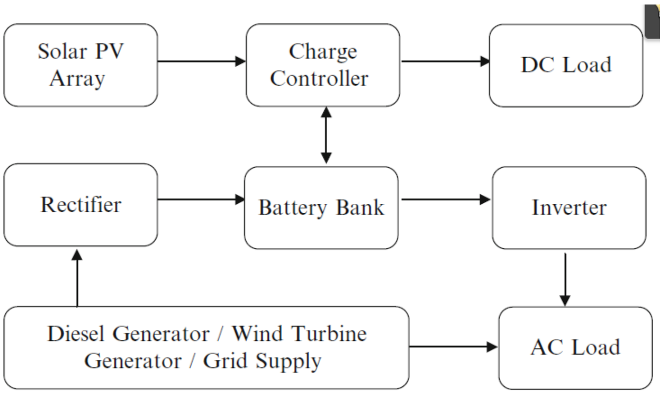

Fig. 1 Block diagram of Proposed HECS

A.Modelling of Photovoltaic Array

In PV framework daylight vitality is changed over into power in view of the idea of photovoltaic impact. The photo current relies on upon light and temperature. On the chance that irradiation is higher current discharged by the cell will be more. A perfect solar cell is spoken to by a Current source and a diode parallel with it. However no solar cell is perfect there by series resistance Rs which has little esteem and Rsh is the comparable shunt resistance whose esteem is high. The PV cell current Equation (1) as takes after

$$I = I_{PV,Cell} - \left(I_0\left(V+\frac{IR_S}{V_T}\right)-1\right)+\left(V+\frac{IR_S}{R_P}\right) \quad (1)$$

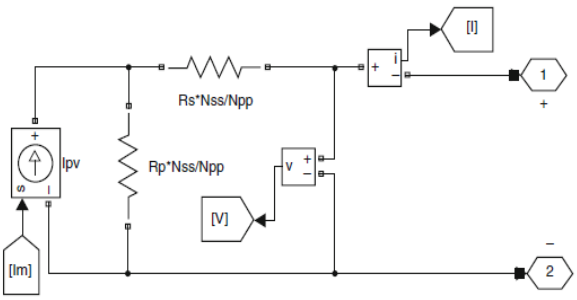

Fig. 2 Modelling of Photovoltaic Array

Where Ipv, cell is the current created by the incident light, rely on upon the solar powered radiation and cell temperature. Io is the reverse saturation or leakage current of the diode, VT is the thermal voltage.

This section describes the procedure used for simulating the I–V and P–V characteristics of a partially shaded PV array. It is important to understand how the shading pattern and the PV array structure are defined in MATLAB (Fig 4) using the proposed scheme. The PV array is configured as a combination of six series of PV modules connected in three parallel connections. Each set of PV modules operate under different solar radiations and different cell temperatures.

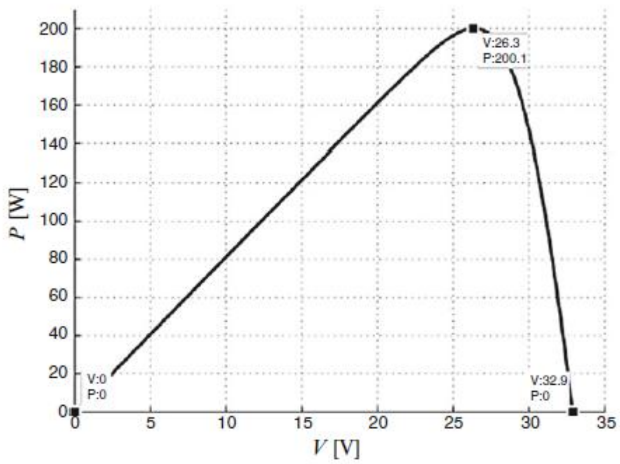

Fig. 3 PV Curve

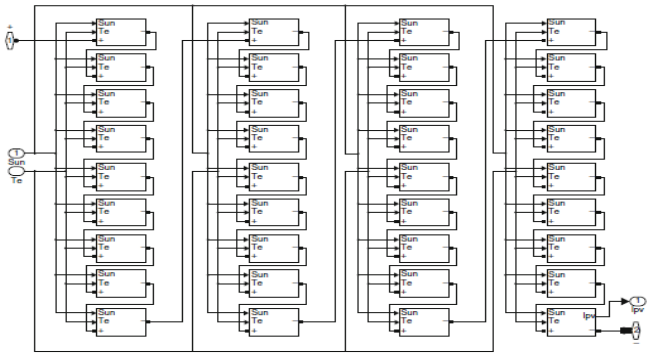

Fig. 4 PV Module SIMULINK Model

B.Charge Controller

A charge controller, charge regulator or battery regulator limits the rate at which electric current is added to or drawn from electric batteries. It prevents overcharging and may prevent against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk. To protect battery life, charge controller may prevent battery from deep discharging or it will perform controlled discharges, depending on the battery technology. The terms "charge controller" or "charge regulator" may refer to either a stand-alone device, or to control circuitry integrated within a battery pack, battery-powered device, or battery recharger. Solar Charge Controllers are the controllers which regulate the power output or the DC output voltage of the solar PV panels to the batteries. Charge controllers take the DC output voltage as the input voltage converts it into same DC voltage required for battery charging. These are mostly used in off grid scenario and uses Maximum Power Point Tracking scheme which maximizes the output efficiency of the Solar PV Panel. In battery charging system, the output voltage regulation is an important factor as batteries require specific charging method with various voltage and current levels for specific stage.

C.Wind Energy Conversion (WEC) system

Wind energy systems encompass essentially the choice on the turbine, configurations, their sizing, wind conditions and its control options. The maximum generation capability is limited by the Betz limit. Hence the choice of the type of generators and the control mode becomes a point of improvement in the whole of the wind energy conversion systems. In this chapter the types of the conventional wind energy systems, the review on the various types of generators used for the wind energy systems and the converter topologies are presented.

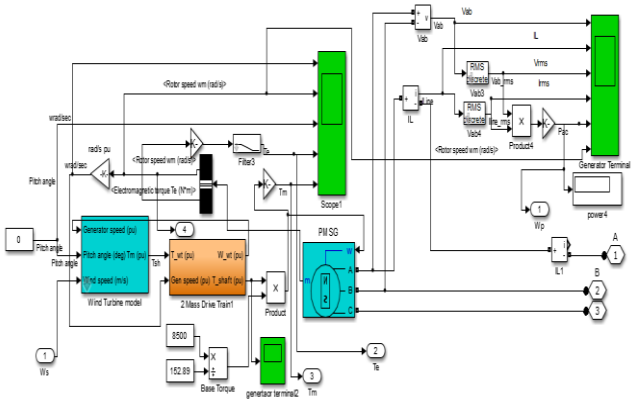

Fig. 5 Wind- Machine Simulation model

Building blocks of WECS are wind turbine, doubly fed induction generator (DFIG), and two masse drive train Pitch point controller and consecutive converters. Wind power is a standout amongst the most imperative sources of renewable energy. For a wind turbine, if the wind speed surpasses the cut-in esteem, the wind turbine generator begins producing energy.

IV. HYBRID MPPT METHODOLOGY:

Maximum Power Point Tracking, frequently referred to as MPPT, operates Solar PV modules in a manner that allows the modules to produce all the power they are capable of generating. MPPT is not a mechanical tracking system but it works on a particular tracking algorithm and it based on a control system. MPPT can be used in conjunction with a mechanical tracking system, but the two systems are completely different. MPPT algorithms are used to obtain the maximum power from the solar array based on the variation in the irradiation and temperature. The voltage at which PV module can produce maximum power is called 'maximum power point' (or peak power voltage). Maximum power varies with solar radiation, ambient temperature and solar cell temperature.

a. *MPPT Techniques*

Over the past decades many methods to find the MPP have been developed. These techniques differ in many aspects such as required sensors, complexity, cost, range of effectiveness, convergence speed, correct tracking when irradiation and/or temperature change, hardware needed for the implementation or popularity, among others. Some of the most popular MPPT techniques are:

1. Perturb and Observe (hill climbing method).
2. Incremental Conductance method.
3. Fractional short circuit current.
4. Fractional open circuit voltage.
5. Fuzzy logic.
6. Neural networks.
7. Ripple Correlation Control.
8. Current Sweep.
9. DC-link capacitor droop control.
10. Load current or load voltage maximization.
11. dP/dV or dP/dI Feedback control.

b. *Proposed MPPT technique*

In Hybrid framework number of electrical power generators and electrical power storage components are joined together to take care of the electrical power demand of remote and in addition provincial territory or even an entire group. It is additionally utilized as a standalone control framework, is a self-sufficient framework that provisions power to the client Load without being associated with the electrical power grid. In this model Solar PV and WECS is joined to get hybrid framework which is conveying energy to load combinable.

In this hybrid MPPT algorithm for solar power system, from the measurement of solar panel output voltage and current the solar power is calculated. The duty cycle is adjusted by a small amount ΔD to reach the maximum power point based on the change of solar power, voltage and current. This algorithm is very effective, since it considers all the three parameters of solar power system.

This algorithm Flowchart has four cases as given below.

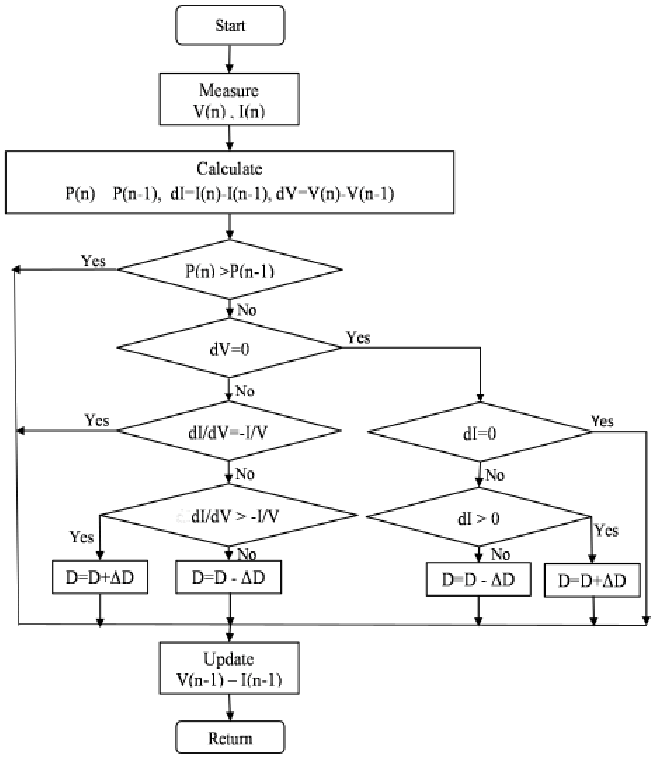

Fig. 6 Flowchart of proposed Hybrid MPPT controller

The Hybrid MPPT algorithm for Hybrid power system is implemented in MATLAB as a sub-system. Solar panel is simulated in MATLAB. Temperature and irradiance are taken as input to the solar panel. The solar panel develops voltage across its output terminals according to the temperature and irradiance. The solar panel is connected to the boost converter. The converter matches the impedance of the solar panel to the impedance of the load to enable to transfer the maximum power from solar PV system to the load. The boost converter feeds the load. When the load changes, the solar panel acts as a source supplying the power. MPPT for the solar panel is achieved by hybrid the incremental conductance and hill climbing methods.

V. SIMULATION MODEL:

The Hybrid MPPT algorithm for Hybrid power system is implemented in MATLAB as a sub-system. Solar panel is simulated in MATLAB. Temperature and irradiance are taken as input to the solar panel. The solar panel develops voltage across its output terminals according to the temperature and irradiance. The solar panel is connected to the boost converter. The converter matches the impedance of the solar panel to the impedance of the load to enable to transfer the maximum power from solar PV system to the load. The boost converter feeds the load. When the load changes, the solar panel acts as a source supplying the power. MPPT for the solar panel is achieved by hybrid the incremental conductance and hill climbing methods.

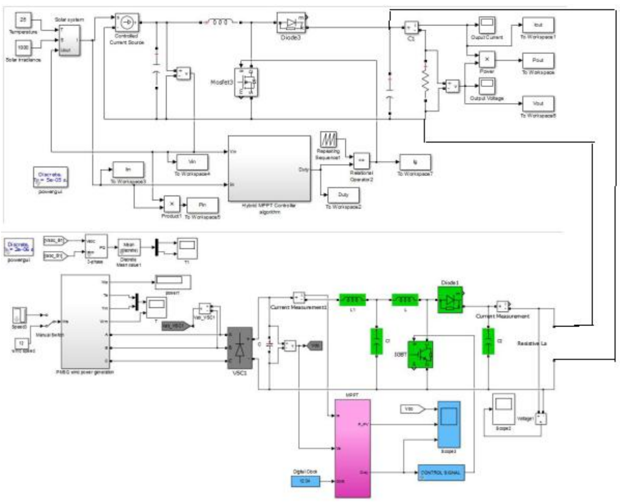

Fig. 7 Simulation design of Hybrid MPPT for HECS

VI. RESULTS AND DISCUSSION:

Simulation results shown in Fig. 9, Fig 10, Fig 11 illustrate performance of Hybrid system with Hybrid MPPT controller which tracks the maximum power delivery operating point. In order to verify that maximum power is extracted from the available wind, power coefficient Cp(λ) has to be observed. The parameters of the proposed controller are selected by a guided trial and error off-line simulation to ensure the minimum induction load and generator voltage excursion for any large wind and load variation.

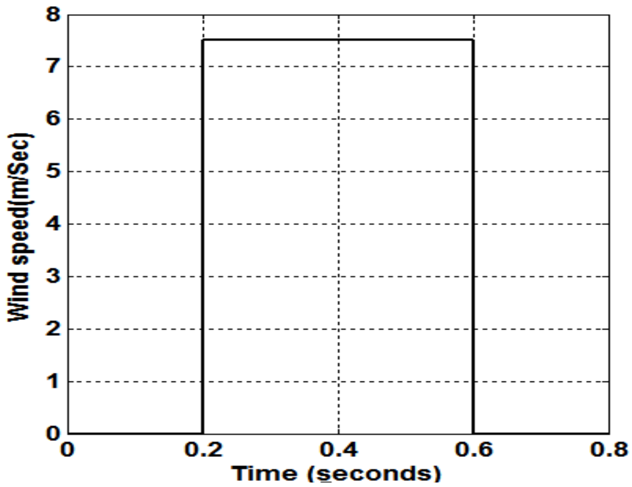

Fig. 8 Wind speed

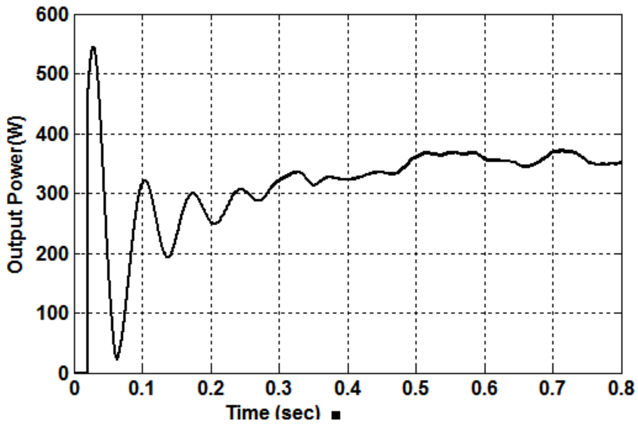

Fig. 9 Power output

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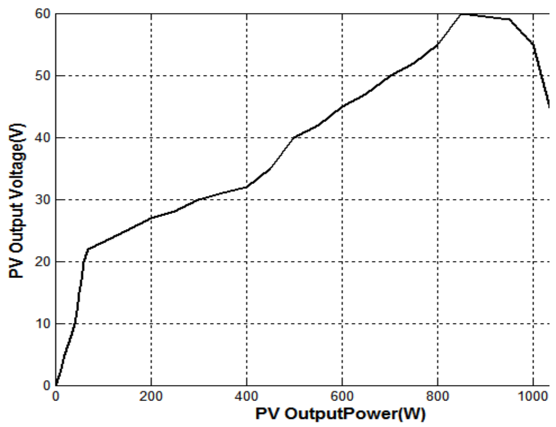


Fig. 10 Voltage versus Power for the solar irradiance (1000 w/m^2) in hybrid MPPT technique

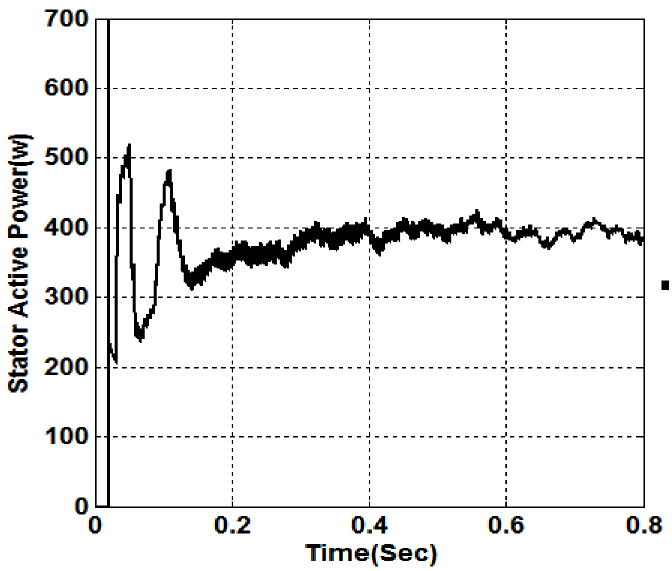


Fig. 11 Stator Power for the wind speed of 6.5 m/s

From this above figure have the simulated results of wind/ PV voltage and current with power. In that, Fig .9. Shows the power output of the hybrid system according to the irradiance values from the sun and wind velocity. Figure 10. Shows Voltage versus Power for the solar irradiance (1000 w/m^2) in hybrid MPPT technique.

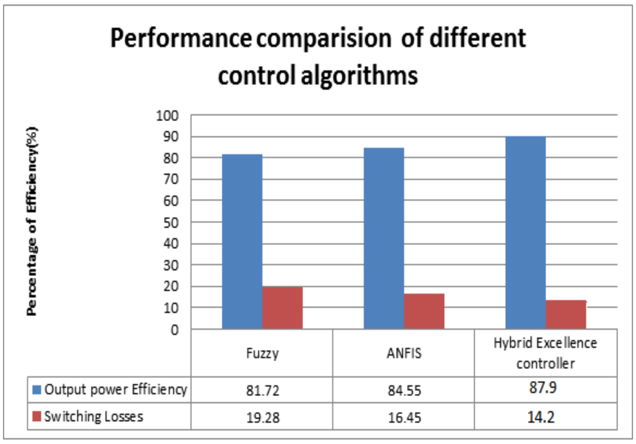
a. Performance Comparison

From the investigation of reproduction results in the different parameters, for example,switching losses, maximum Output power and efficiency estimations of converters are recorded in Table 1. Fuzzy, ANFIS and Proposed HEC converter has the Efficiency values of 81.72%, 84.55% and 89.92% respectively. The Comparison table clearly shows the effectiveness of the proposed under a different level of control index.

Table I **Comparison of the proposed Model**

Hybrid Sources	**Controller used**	**Out put power in per unit**	**Switching Losses (%)**	**Maximum output Power Efficiency(%)**
PV+Wind	P & O	0.76	25.1	74.9
PV+Wind	Incremental conductance	0.79	22.5	77.5
PV+Wind	Fuzzy	0.81	19.28	81.72
PV+Wind	ANFIS	0.84	16.45	84.55
PV+Wind	Hybrid MPPT	0.86	14.08	87.92

Maximum power tracking Efficiency comparison of different converters with proposed converter system are shown as graph below



Graph.1 Comparison chart of various controllers based HRES System.

VII. CONCLUSIONS

In This paper has displayed and assessed – Hybrid energy conversion based hybrid MPPT control framework. It comprises of renewable vitality sources Wind Turbine and PV board. The execution examination and control of a hybrid stand-alone renewable energy system. The execution of the proposed control procedure is assessed under various wind and load conditions. It is uncovered that the machine side converter can extricate the ideal power. It is likewise ready to work the PM synchronous generator with most extreme proficiency. It builds up the general coordination in energy management conspire. From the recreation comes about, the Hybrid MPPT controller oversees and gives the greatest power of the no/low wind condition. The favorable position is to keep away from/keep the framework shut out at the deficient vitality save.

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