Efficiency Improvement of Renewable Integrated Power System Using Advance Power Tracking Algorithm

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Abstract— The need for energy-efficient electric power sources in remote locations is a driving force for research in hybrid energy systems. Power utilities in many countries around the world are diverting their attention towards more energy efficient and renewable electric power sources. Reasons for this interest include the possibilities of "taxes" or other penalties for emissions of greenhouse gases as well as other pollutants plus the finite supply of fossil fuels. The use of renewable energy sources in remote locations could help reduce the operating cost through the reduction in fuel consumption, increased system efficiency and reduced noise and emissions. A PV system which can be tied to the grid converts sunlight to electrical energy that can be fed into AC distribution board along with main supply. The generated power by PV module will reduce the consumption from the main grid. A roof-top PV system means that the PV arrays are mounted on the roof of buildings. A PV system along with its components are specifically designed for power requirement and can be used within the specified power limits. By this project we aim to to tackle the existing load and energy demands of the population and try to cure the existing grid system to be more efficient, cost efficient, reliable and can provide uninterrupted power supply to consumer. Power quality is same as that of grid power and can be used for any applications along with the grid supply.

Keywords: Energy Resources, Renewable Energy, Energy Use Efficiency, Generation Technology

I. INTRODUCTION

Through the human history, energy is an indispensable subject that is almost surrounding life. Although conventional energy resources like coal, oil or gas are been using commonly to provide energy, oil reserves run short in 50 years, gas reserves are only enough for 70 years and coal reserves are consumed away completely in 200 years [1]. Therefore, conventional world is in a search for new energy sources. In order to begin the new eco-friendly energy usage, some countries establish new awareness about renewable energy. The main objective in the energy policy is to gain the energy by reliable, continuous, clean and inexpensive ways, besides expand the sources.

For these energy policies to be implemented in future, at first sight the energy related education should be considered. The objective of this paper is to analyze the perspective of students towards renewable energy and within this framework, to contribute the existing curricula related to energy subject. The efficient speed controller is found to be an important requirement to run the motor for the brushless direct current (BLDC) motor. This requirement is considered as superior, as it may increase the operating speed and system efficiency. In the existing methods, proportional plus integral (PI) controller has been included because of its simple architecture. But the PI controller produces load disturbance, control complexity and some parametric (Proportional plus integral) variations[2].

The Solar Photovoltaic module works on Photo-Voltaic principle generating Direct Current (DC) electricity when sunlight is incident on its surface. The PV module uses silicon cells connected in series to generate the rated voltage and current. The module has an outer anodized aluminum frame which holds the front toughened glass, silicon cells inside and a back sheet for protection. The electrical termination from the module is through cables with connectors or through a junction. The frame also has bolts as a provision to position the module above the roof with the help of module mounting structure[3].

The joining of inexhaustible sources into petroleum product based power system (hybrid framework system) has expanded over the previous decades particularly after the noteworthy development of non-renewable energy source cost. Specifically, the combination of inexhaustible asset and diesel gen-set makes it the most fitting producing approach for detached networks [4]. The fundamental preferences of a hybrid smaller than expected matrix system are decreasing the fuel utilization and certification a solid power supply.

In separated networks with low populace densities, providing power by broadening the transmission line from national power matrix is exorbitant and a few areas are outlandish in view of topographical obstacles. In this way, those networks use their own age and dissemination system to supply power, this plan is called small scale matrix system.

Likewise, because of this substitute activity, the general system has delayed life demonstrated by the release dimension of the battery is being kept ideal. The hybrid system receives an ecological well-disposed innovation whereby the diesel generator is utilized irregularly and the entire activity itself is a lot calmer [5]. This is represented by a smaller scale processor-based controller unit. The principal establishment may take up a staggering expense, however the upkeep cost a while later is low, on account of the system's self-conservation instrument. Furthermore, we can spare fuel utilization of the genset on the grounds that the sunlight based photovoltaic (PV) modules bolsters the base power load while the genset gives extra vitality ought to there be a sudden crest in the vitality request.

II. RELATED WORKS

A. Some of the recent workings related to the research paper is described below,

The point of solar energy use has been viewed by numerous researchers all around the world. It has been realized that solar cell works at exceptionally low efficiency and in this manner, a superior control system is required to build the efficiency of the solar cell. In this field, researchers have created what is currently called the Maximum Power Point Tracking (MPPT) algorithm [6]. Fathabadi H. has given the

idea about the novel PV based battery charger including novel high-efficiency step-up DC/DC converter, A PV panel together with a combination of the circuit that provides an appropriate voltage/current for charging rechargeable batteries is called PV battery charger [7]. In combination with the inverter connected to the battery which will result in providing the supply when there is a need or the main supply is switched off automatically.

Deng Y et al. discuss the lack of change in the pattern for energy usage and consistently expanding of the oil value. Also examining the sustainable and efficient power vitality sources, particularly the sun-based power and the energy components which turn out to be the increasingly crucial source. The most effective method to accomplish high-efficiency DC/DC converters is the real thought in the sustainable framework associated with controlling several applications because of the low voltage of PV modules which is needed to be converted into a high voltage for the cause [8].

Gu B et al. outline a non-isolated, high-efficiency DC-DC converter with some applications for a low-voltage sustainable power source, i.e. PV module. The proposed converter uses a transformer to exchange the inductive and capacitive voltage while accomplishing a high efficiency with a little measured attractive part. Because of consolidating the full activity mode into the customary high efficiency, the loss of the specified switch is decreased, expanding the efficiency of a DC/DC converter under all conditions [9].

Da Silva ES et al. presents an enhanced regenerative delicate turn-on and turn-off snubber connected to a lift PWM converter. The soft-single-switched type boost converter has a switch of the single type which is used to operate for soft switching in PWM without any high voltage and current stresses. This is accomplished by utilising an assistant inductor, which is attractively combined with the principle inductor of the converter [10].

Li Q & Wolfs P talks about the yearly photovoltaic (PV) module creation is developing at a high increase rate and has achieved an approximate 8 of 1727 MW in 2005. Building coordinated PV (BIPV) ventures have developed the most grounded piece for the PV market, and intuitive network inverters serve as a critical part for deciding an aggregate framework revenue. Module incorporated converter (MIC) innovation had been turned into a worldwide pattern in lattice intuitive for PV applications and might help in driving down the equalisation for framework expenses in anchoring of enhanced aggregate framework cost [11].

III. Modelling of Photovoltaic Cell

A solar cell is the building block of a solar panel. A photovoltaic module is formed by connecting many solar cells in series and parallel. Considering only a single solar cell; it can be modeled by utilizing a current source, a diode and two resistors. This model is known as a single diode model of solar cell. Two diode models are also available but only single diode model is considered here]12]and]13[.

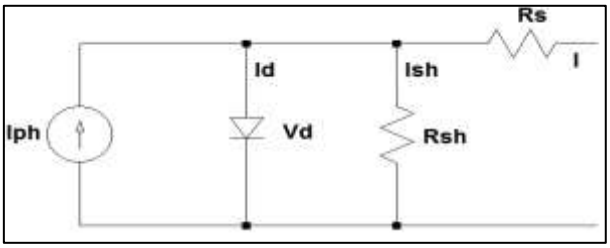


Fig. 1: Single diode model of a solar cell

The characteristic equation for a photovoltaic cell is given by]10[,

IV. Boost Converter

Basically, dc-dc boost converter is mostly used in nowadays for many industrial applications, which a variable dc supply needed. In solar application dc-dc boost converter use for boosting the output voltage of solar panel for varying in the input side resistance of solar panel compare with the load side resistance by changing the duty cycle a boost converter [14]. A boost converter is use for this work, it misses out the maximum tracking point, our system either for trying to other application such as water pumping system which operate on 230 V, so we use a boost converter [15].

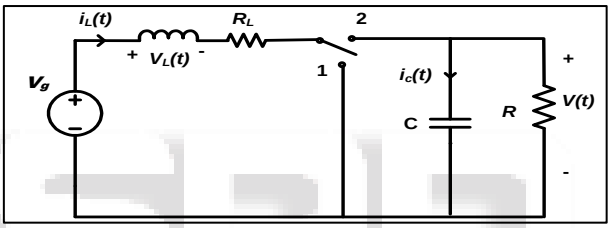


Fig. 2: Power Circuit of Boost Converter

Mode 1-The operating condition of the boost converter is depending on the duty cycle of the switching frequency, if the switch is closed (ON), battery provides the charging current to the inductor and inductor is fully charged. There is no current flowing through the diode cause of capacitor polarity and so that load current remains constant which is being supplied due to the discharging of the capacitor [16]. Mode 2- In the operation of second mode the switch is disconnecting (off), the diode is becomes forward bias. The capacitor will charged through the energy released by inductor. The load current remains constant in the operation of boost converter [17].

V. Battery Modeling

Battery model usually divide in experimental model, electrochemical model, equivalent model. For dynamic simulation equivalent model is always prefer over other models. In this thesis generic model for dynamic simulation is used which based on shepherd battery model[18]. In this model resistance of battery are assume constant during both charged and discharged cycle of battery. This generic model consist state of charge as the only state variable.

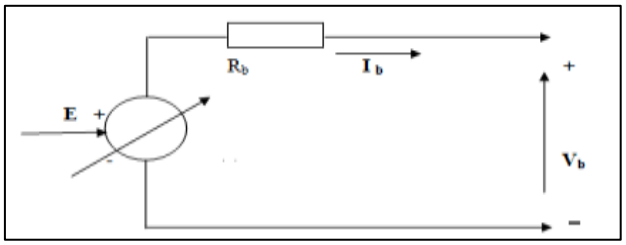


Fig. 3: Generic model of battery

The expression of the controlled voltage source is

$$E = E_0 - K\frac{Q}{Q - \int i_b dt} + A\exp\left(-B \cdot \int i_b dt\right)$$

E_o = is battery constant voltage, K is polarization voltage, Q is battery (Ah), A is exponent zonal amplitude; B is exponent zonal inverse time constant (A/h).

A. Battery Charged and Discharged Logic

In this thesis battery is connected with grid through bi directional Converter. This system helps the battery to charge if the grid have extra power and discharge if grid has power shortage[19]. In this simulation model utility grid is act as a back-up power and battery served as short duration power source during contingency. Battery storage system consists of battery-bank and charged and discharged circuit. In this model objective of battery converter is maintain the common dc voltage constant. It consist of two thyristor switch S_1 and S_2. In charged mode, Switch S_1 is activated and converter work as boost circuit, and in discharged mode, Switch S_2 is activated and converter work as buck converter. The control system including two loop which is external voltage control, internal current control[20]. When the voltage at dc link is lower than the reference voltage then switch S_2 is activated.

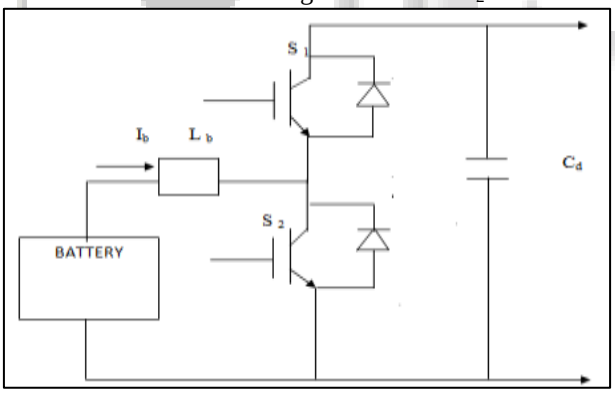


Fig. 4. The bi-directional DC/DC converter

when the voltage at dc link is higher than the reference voltage the S_1 is activate[21].

VI. PROBLEM FORMULATION

As we know Solar energy has the potential to reduce energy dependency on non-renewable sources, we have tried to implement a procedure in which Photovoltaics will be used and their efficiency to maintain maximum impedance will be executed through Maximum Power Point Tracking and P&O algorithm in which voltage is perturbed to ensure maximum power[22]. MPPT charging controller is also included which ensures charging and discharging faster and this battery can be used during contrasting weather conditions like night and rainy conditions. This battery will act as backup which will be charged during Insolation and will maintain energy demands during nights[23].

Rapid operational readiness and maximum reliability and availability are essential for energy-intensive operations in mining, raw material processing, agriculture, water desalination and other areas[24]. In order to be prepared for power outages and power supply interruptions from the grid, the diesel generators often run constantly. This results high operating costs and leads to high volume of CO_2 emissions. But a backup supply using diesel generation always force the system frequency to retain into permissible limits. Load frequency control is an alternative scheme that reduces the mismatch between generation and load[25]. If there is an increase or decrease in load demand it will be taken care by diesel generating unit working in parallel and therefore it must be equipped with supplementary controller for raising or lowering the generation level. So on grid integration of PV and diesel not only increasing the generation level as well as improves the load frequency control problem[26].

VII. PROPOSED METHODOLOGY

A. Proposed Methodology

Following processes are involved in the conversion of solar power to AC at transmission standards:

A bug boost is DC to DC converter which converts the value of voltage to the other level voltage values[27]. It is one type of power converters in power Electronics.. The inverter is used to convert the current from DC to AC. The output of solar array is DC. This DC current is converted into AC. This AC value can now met the energy needs of AC load. Hence PV supplies ac load[28].

Fig. 5: Power flow from PV channel to load

B. Flow Chart

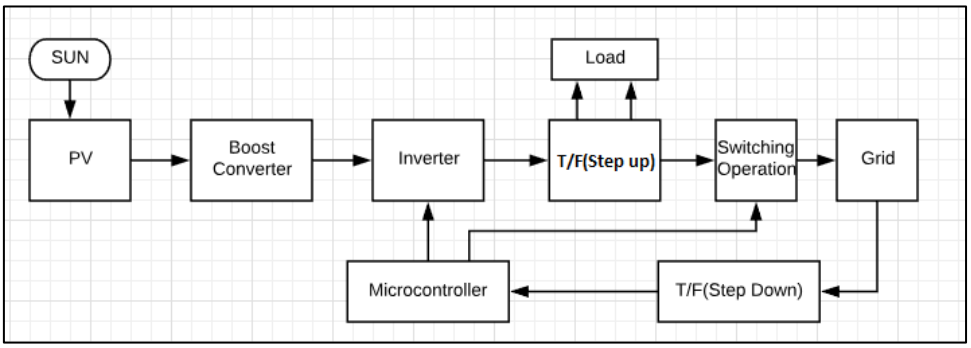


Fig. 6: Schematic diagram of PV fed hybrid power system

VIII. SIMULATION & RESULTS

The hybrid PV and diesel is connected with utility grid and three loads L 1, L 2 and L 3 in system load block. The load supply is maintained by both utility grid and the micro grid (PV and DG). Firstly load took power from micro grid and if the power exceeded the capacity of micro grid then extra power is maintained by the utility grid. If load is less than capacity of micro grid the used power is supply towards utility grid side. The proposed model through MATLAB SIMULATION combination of PV array and utility grid are shown in figure 5.5.

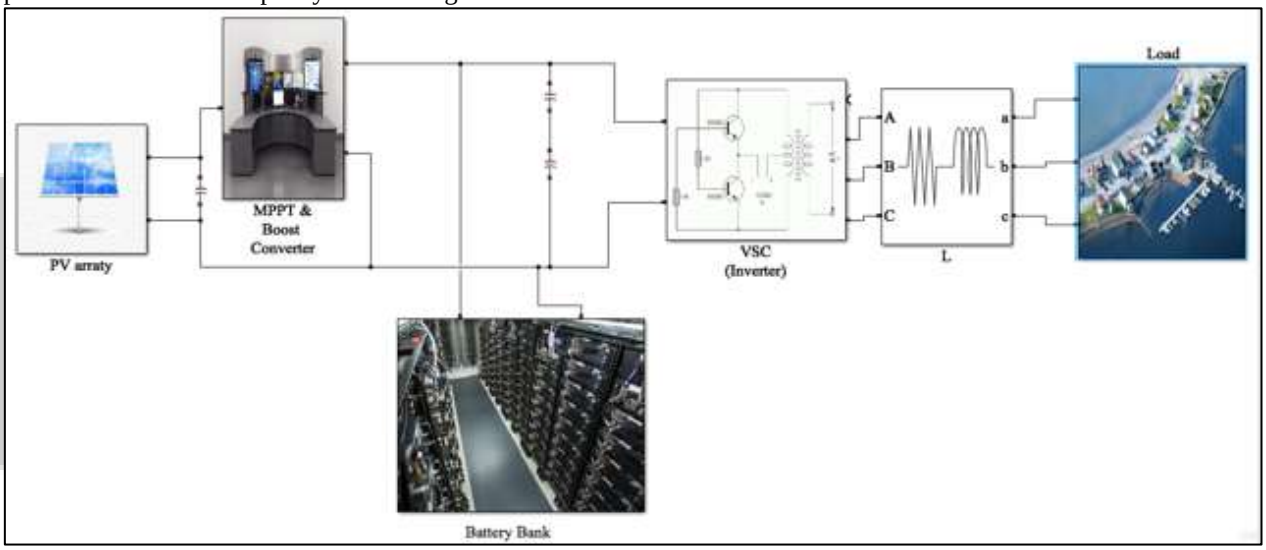


Fig. 7: Existing simulink model of off grid hybrid power system

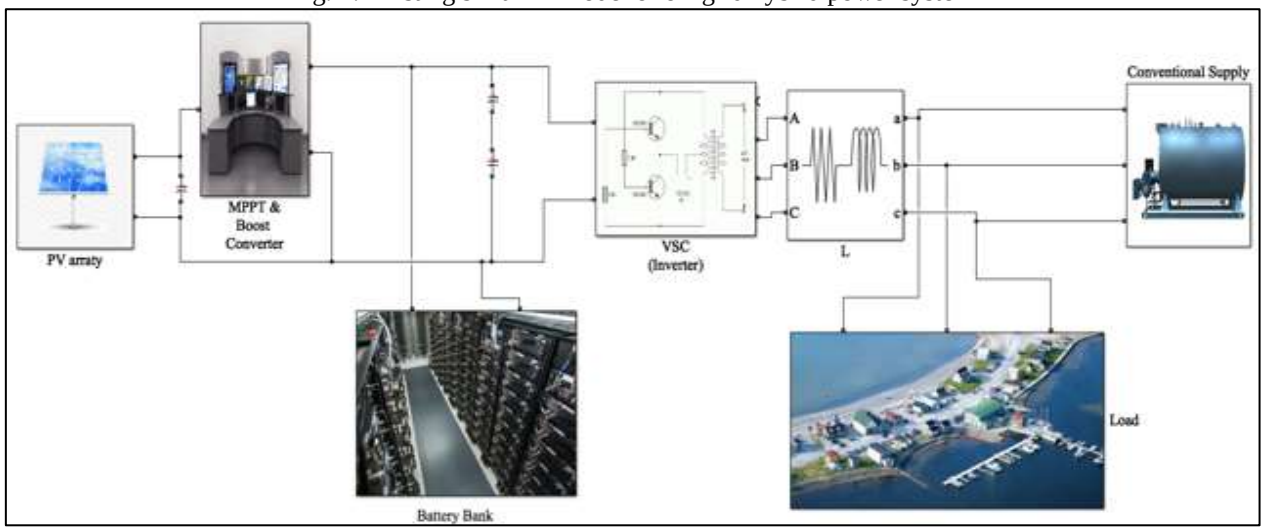


Fig. 8: Hybrid power grid interconnected with solar generation

To make the system fully oriented with 24 hour supply a diesel generation plant is also implemented in the system as a backup supply source. Solar plant can supply the electricity to the overall system only in daytime. For obtaining the supply in night timing it is necessary to have a storage unit by virtue of which system can get supply from that storage device by means of converters. The simulink model of DG is shown in figure 5.3

MAT-LAB SIMULATION model of 100 KW PV array are shown in fig.5.7. In this model PV array deliver a maximum of 100 KW at 1000 W/m ^{2} sun irradiance at 25 degree Celsius. PV array is connected with load and utility grid by using voltage source converter and the line filter (line filter use to filter the harmonics produced by voltage source inverter). This photo voltaic array contain sixty six string of five series connected module connected in parallel. The maximum voltage of 260 Volt is delivering at maximum power to the voltage source converter. The open circuit voltage V_{oc} is 64.2 Volt, short circuit current is 5.96 A and value of voltage and current at maximum power are 54.7 Volt and 5.58 A. MPP tracking scheme is used here to deliver maximum power towards load and grid.

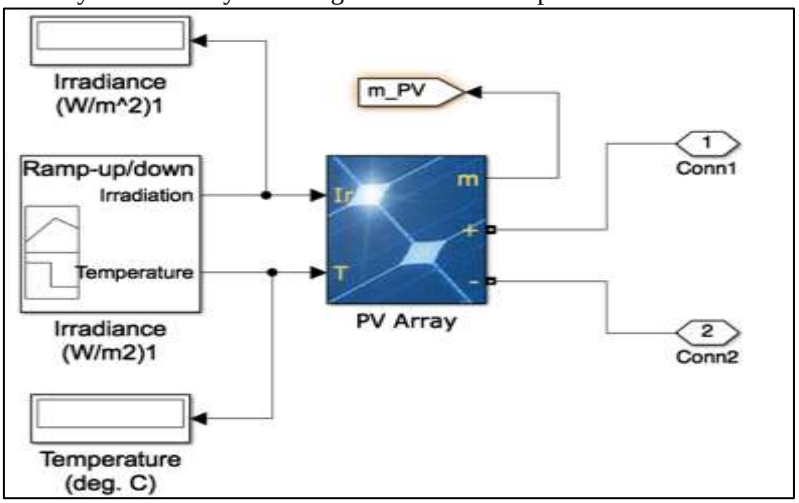


Fig. 9: Simulink model of PV Array

The dc to ac converters more commonly known as inverter, depend on the type of the power source and the related topology of the power circuit are divided in two types one is VSI and CSI. Single phase VSI covered low-range electrical energy application and the three phase VSI covered medium to high electrical energy application. The main reason of using this topology is providing three phase voltage, amplitude, phase, and the frequency of the voltage can be controlled.

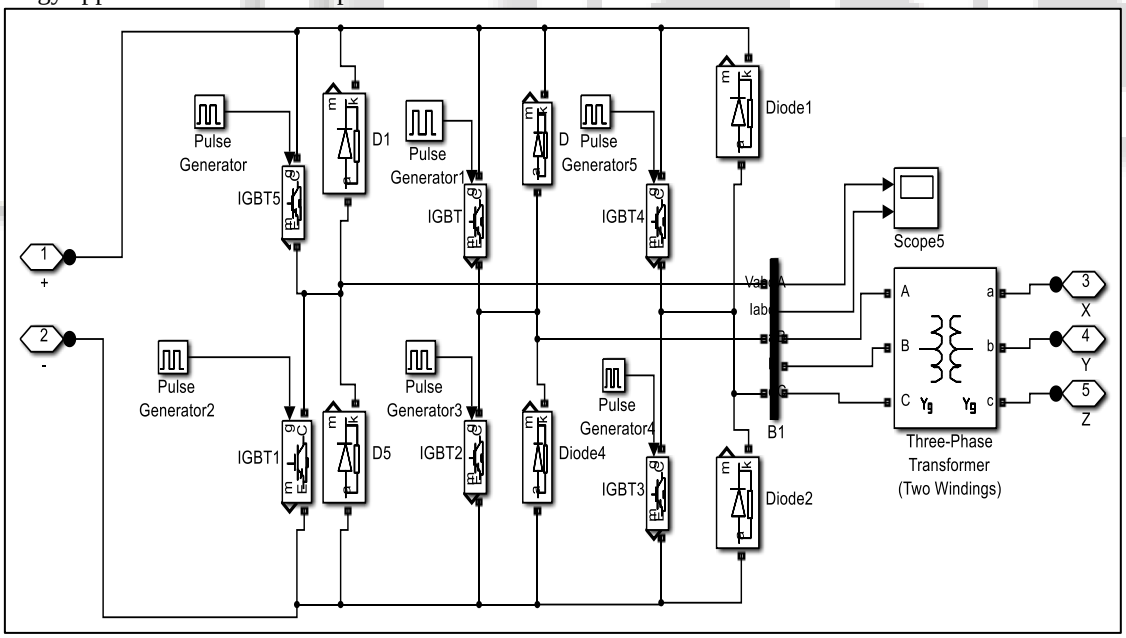
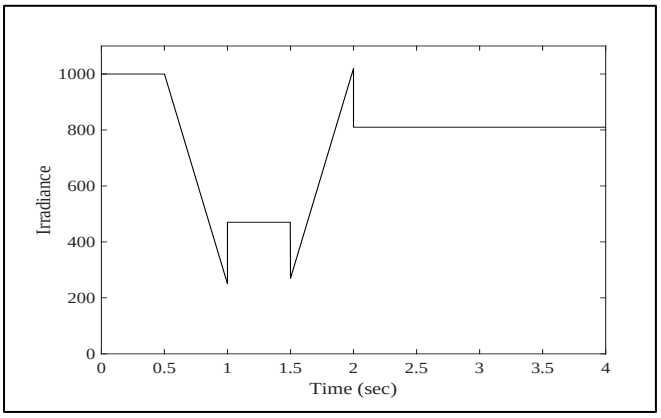


Fig. 10: Converter section of grid

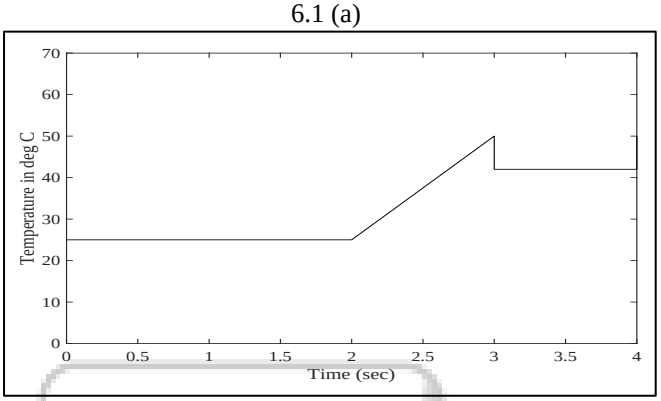
The three-phase dc/ac voltage source converters are extensively being used in motor drive, active filter and power flow controller. In power system and uninterrupted power supplies to generate control frequency and ac voltage using various pulse width modulation strategies. The three-phase converter has six switches the switching of which depends on the modulation scheme. The direct current is obtained from single phase or three phase electric power supply through a bridge type rectifier and LC or C filter. Simulation model of PWM based voltage source converter are shown in figure 5.8.

A. Simulation Results

The study of solar PV-diesel hybrid mini grid based on the time of system loading fluctuation is developed in MATLAB simulation tool has been analyzed. After the optimization analysis for the minimum level cost of electricity, the most optimum configuration from each case study is taken for comparison. The component sizes and key parameters of the best system from each system are given.



6.1 (a)



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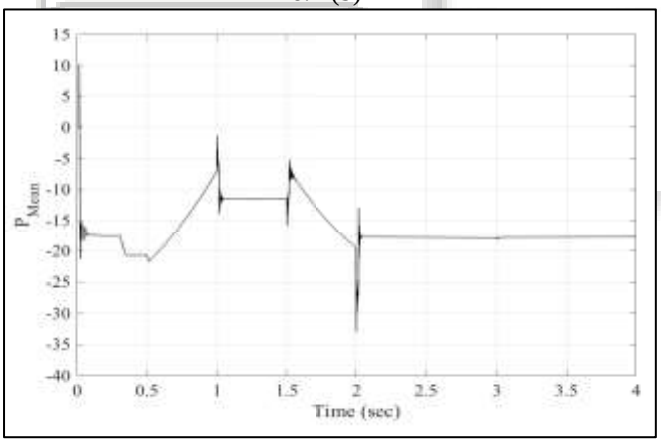

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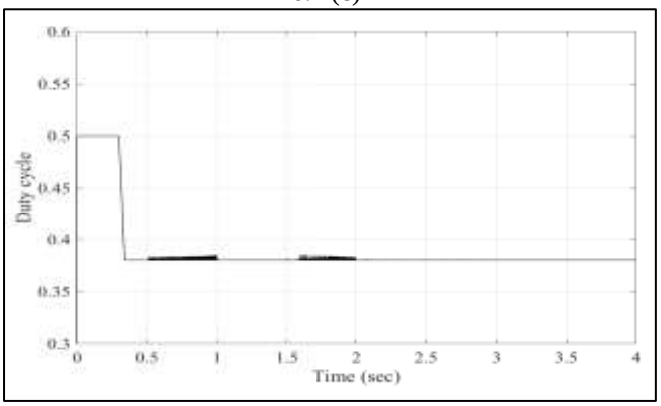

6.1(d)

Fig. 6.1: Showing the wave form of Power, irradiance and temperature getting from solar

When moving to the side of diesel generation speed of governor and terminal voltage of generator varies according to their phenomenon value as represented in figure 4. The value of different parameter of diesel is represented in per unit. Their effective value represents the system behavior.

Energy storage devices can buffer the variable PV system output to provide smoother diesel loading. These storage devices help to align energy production and consumption, when short-term energy imbalance occurs, and when integrated with variable energy sources, the combined system becomes dispatchable for short periods.

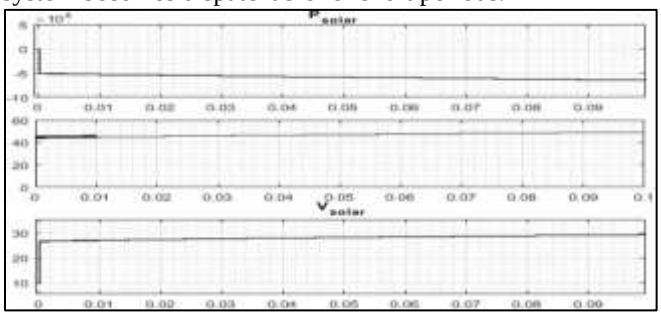

Fig. 6.2: simulation result of solar unit

Output response of solar unit and DG unit decided the dependency of off grid supply to house or industries. As we observed the peak of solar power and DG power, so a offgrid channel is maintained if the average demand is less than the peak magnitude of power generated.

B. Comparision of Results with Existing System

Results are analyzed above are only describe the function of on grid hybrid power system. But to show the superiority of proposed work with existing work their area some comparisons which different each other.

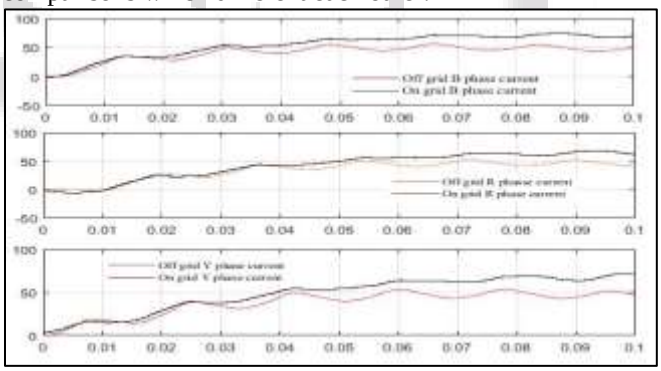

Fig. 6.3: Load current of each phase

In each phase loading current coming from the model of on grid hybrid power system has large magnitude. It is because extra current is supplied through utility grid that's why red colored waveform in each has least value of loading current.

Similarly, in case of voltage there is an improvement of voltage level but not such as in case of current because the voltage considered is same for both the cases as shown below for each phase.

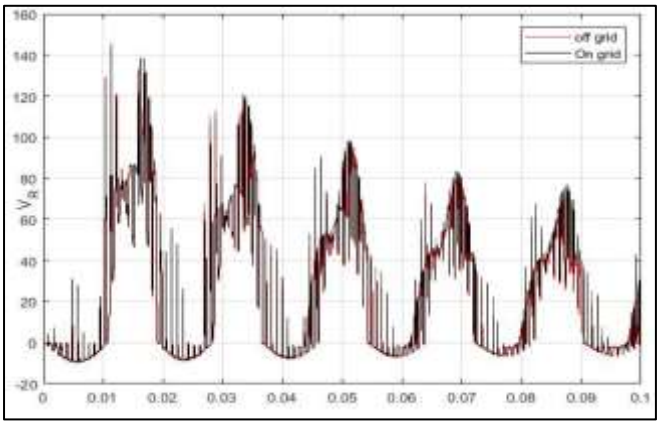

Fig. 6.4: R phase voltage profile comparison for both cases

As mentioned above an improved waveform is generated but level of voltage remain same.

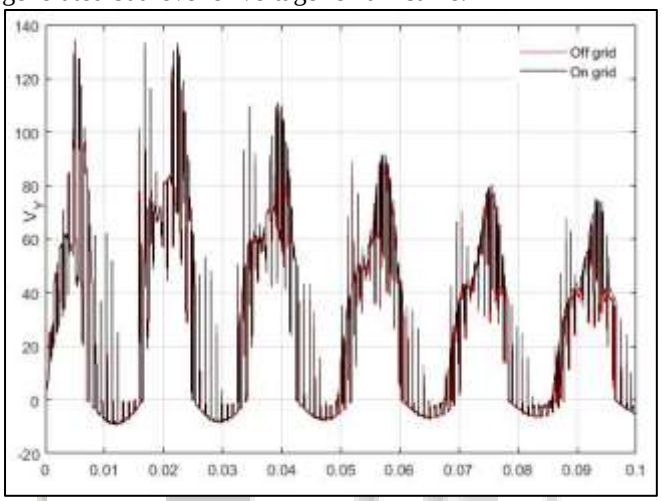

Fig. 6.5: Y phase profile for both cases

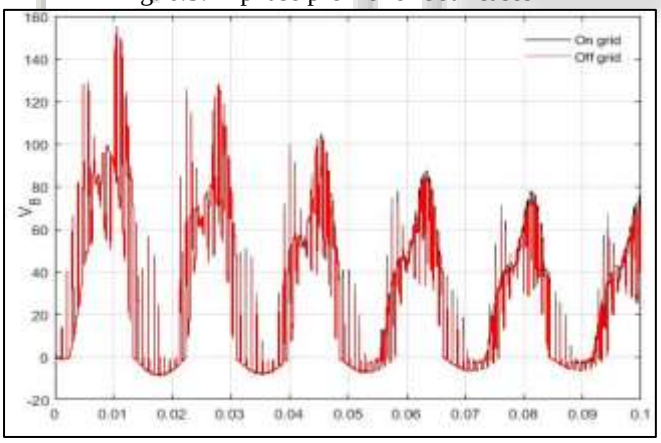

Fig. 6.6: B phase profile for both cases

Another comparison is going in contrast with the system expenditure value for same loading. On grid system has least consumption of diesel because diesel generation is only used when system demand and generation level mismatches.

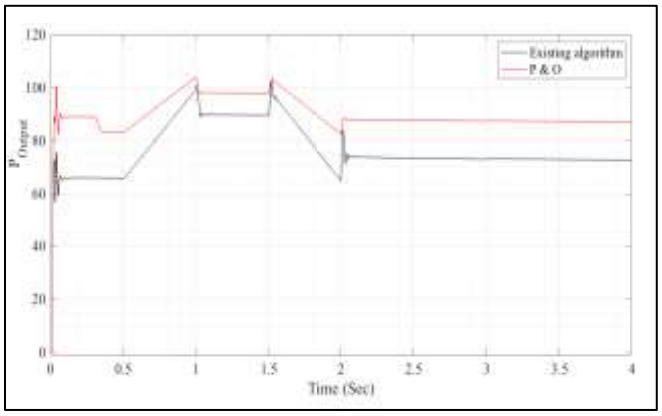

Fig. 6.7: Comparison of output power under different MPPT algorithm

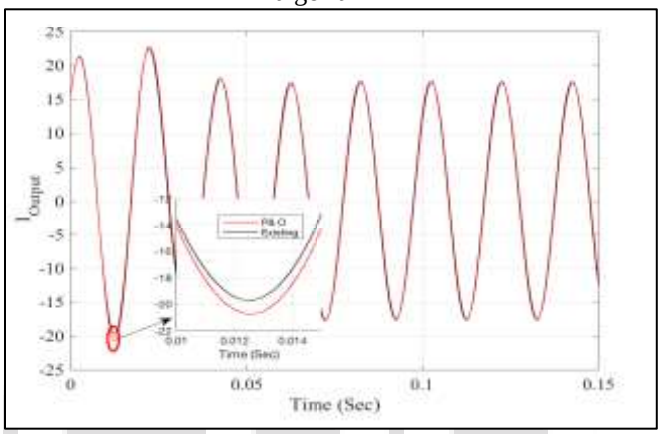

Fig. 6.8: Comparison of output current under different MPPT algorithm

IX. CONCLUSION

The examination has endeavored to investigate the conceivable outcomes of incorporating sun-oriented PV exhibit into systems to decrease the non-renewable energy source utilization and to advance condition well-disposed sun powered PV assets for power issue. It has been shown that incorporating a decent measure of centralized PV array capacity into conventional fuel arrange is techno-financially achievable. The plan of a vitality stockpiling system should be lined up with the sun-oriented unit and the abundance measure of power which can be put away. Disseminated PV systems could be an incredible decision, when purchasers can hold up under the higher PV-battery forthright expense[29]. By incorporating the battery bank an independency happens in the system conduct. The joining of battery bank and PV unit with utility framework give extensive measure of vitality as well as give a backup source in type of battery bank which supply vitality immediately if there should arise an occurrence of unbalancing among free market activity.

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