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PERFORMANCE ASSESMENT OF GRID-INTERACTIVE SOLAR PHOTOVOLTAIC ROOF TOP SYSTEM

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ABSTRACT

In this paper, a study and analysis is done for the expenditure and payback period of approx. 28KW roof top based solar energy system based on a urban plot of size 35*90 feet located in omaxe colony Bathinda. A solar array of size 22 series and 5 parallel combinations is designed in AutoCAD consisting of total 110 panels. Different expenditures like panel cost, inverter cost, cables, Combiner box ,junction boxes, Maintenance cost and Installation cost are calculated for 28KW roof top system which comes out to be 1826000 Indian rupees. After providing the power to the major home appliances, payback period calculated is 5 years 11.5 months approx. Simulation of the proposed system is carried out using Matlab in which for MPPT improvement, perturb observe-method has been implemented for photovoltaic energy systems. Proposed method considers current and previous power comparisons to evaluate the coming duty cycle for IGBT pulses. It has been found that, the proposed system not only reduces the fluctuations in the system but also achieve initial power point tracing earlier than the traditional perturb observe method. It has been found that the presented MPPT technique attains optimum value after .3 seconds of the start of the system in ideal conditions an attains the maximum power limit forever if similar weather conditions are prevailed by the system. The experimental results of outcomes of the simulated system are shown in terms of power, current and voltage waveforms

Keywords: Roof top based PV framework, MPPT, perturb & observe, Buck booster etc.

I. INRTODUCTION

A rooftop photovoltaic system is a method of generating electricity by means of photovoltaic (PV) panels on the rooftops of both commercial and residential structures. Different segments incorporate the mounting framework embellishments and devices, links, inverter, switches, boards and other electrical parts [1]. The housetop PV framework generally is under One Hundred kW evaluated limit. Figure 1.8 underneath demonstrates a housetop PV framework in Australia.

Figure 1: Rooftop PV System in Australia [2]

Some factors affecting the efficiency of rooftop PV system are as follows [3]:

• Irradiance: Irradiance is the measure of sun based light episode straightforwardly on the surface of the earth. The irradiance levels play a main consideration influencing the proficiency of the housetop PV framework.

• Ambient Temperature: Ambient temperature is the temperature at the site of establishment. It altogether influences the productivity of the PV System.

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• Shading and Soiling: Shading is the impact caused by the shadow of close-by articles, for example, structures, trees or other such protests that square the episode light falling on the PV Panels. [4]
• Weather Conditions: Weather conditions are another factor influencing the PV System productivity. Brilliant and Sunny climate is ideal over shady and moist climate for PV power age.
• Time of year: Time of year is vital as the light in summer is episode for longer length when contrasted with in winter months. The point of episode light changes round the year in view of the seasons.
• Inverter effectiveness: Inverter productivity is the proficiency of changing over the direct current (DC) created into alternating current (AC) that is utilized in most electrical apparatuses.

The essential component in the photovoltaic module is the sun oriented cell (figure 1.2). Sun based cells comprise of different semiconducting materials, which are electrically conductive components when provided with light or warmth, however work as encasings at low temperatures. The essential semiconducting material utilized is silicon (Si), which isn't just a non-lethal component, but at the same time is the second richest component in earth's covering and consequently is accessible in adequate amounts. Through a procedure called 'doping' synthetic components are purposefully acquainted with the semiconductor, hence making two distinct layers, called p-sort and n-type layers. The p-leading semiconductor layer has an excess of positive charge transporters and the n-directing semiconductor layer an overflow of negative charge bearers from the semiconductor material. Between these two layers an alleged p-n-intersection is made.

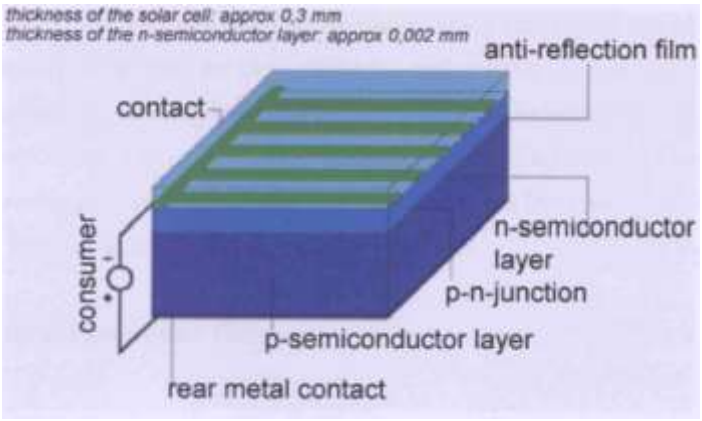

Figure 2: Model of a crystalline solar cell.
(Source: http://www.mesmer.us/pv/system_overview.htm)

At the point when a molecule of light, called photon, with the proper measure of vitality infiltrates the phone close to the intersection of the two kinds of gem and experiences a silicon particle it unsticks a portion of the electrons, which desert an opening of an equivalent and inverse (positive) charge. The two kinds of charge transporter - electrons and gaps - can cross through this intersection. The vitality required to advance the electron into the conduction band is known as the band hole. The electron in this manner advanced, has a tendency to relocate into the layer of the n-type silicon and the opening has a tendency to move into the p-type silicon. Since the electrons can without much of a stretch cross the limit, however can't return the other way (against the field inclination), a charge irregularity results between the two semiconductor districts. Electrons being cleared into the n-layer have a characteristic inclination to leave the layer with a specific end goal to revise this lopsidedness. In the event that either bearer meanders over the intersection, the field and the idea of the semiconductor material dishearten it from re-crossing. By giving an outside circuit electrons can come back to the next layer. The electron, in this manner, at that point goes to the present gatherer on the front surface of the cell, produces an electric current in the outer circuit (as immediate current DC) and afterward returns in the layer of p-type silicon, where it can recombine with holding up openings.

II. LITERATURE

Deepak Kumar et al. (2015) connected for the level of scope of the power request and the financial achievability of framework associated photovoltaic frameworks introduced on the tops of structures. The got results demonstrated the hard to estimate the PV frameworks in huge urban settings in a legitimate and powerful way

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and call attention to the appropriateness of the device for vitality arranging of the above frameworks. Considering vitality and financial parameters the cover factor diminishes.

Blanca Corona et al. (2017) propose that modules and sun based trackers share a comparative measure of effect on each classification. This high effect has been related with the utilization of aluminum and steel. Inverters share between 1.5 % (in fossil consumption classification) and 13.5 % (in human poisonous quality classification) of effect on each classification, owing their most astounding offer of effect to the gadgets materials.

Dikai Huang et al. (2017) introduced the vitality payback of rooftop mounted photovoltaic frameworks is far not as much as it's life cycle, in this manner hypothetically three photovoltaic frameworks are on the whole practical and earth neighborly sustainable power source frameworks from the point of view of vitality utilization. In any case, in some real building-coordinated photovoltaics ventures, the aftereffects of vitality sparing are not perfect because of ill-advised plan, establishment or task.

L.S. Wijesinghe et al. (2017) acquainted a strategy with enhance the sun based insolation utilizing settled reflector course of action and subsequently upgrading the power yield of a sun oriented board. An effective scientific model has been produced to discover the best places of reflectors to improve the yield of sunlight based boards. The affectivity of the model is demonstrated since no less than one of the reflectors is compelling whenever amid 8 long periods of the day.

M. Tripathy et al. (2017) exhibit sufficient help for demonstrating the ecological and financial practicality of the utilization of BIPV warm framework in India. The EPBT of frameworks is observed to lie between 7.5 years to 16 years which is considerably less than the life of silicon BIPV modules. The cost of generation of vitality for the frameworks is observed to run from 1.6 to 3.6 US$/kW h. The financial suitability can be expanded by utilizing the warm vitality yield also.

G.N. Tiwari et al. (2018) presented that the life cycle assessment of the 3.2 kW CdTe PV system has been done on the basis of energy metrics analysis for the same climatic condition. They also present the performance of the PV technologies depends on the type of the material and operating environment condition. The CdTe PV technology has a lower value of the embodied energy in comparison to the other c-Si PV technologies.
*Gobind Pillai et al. (2018)*introduced the execution of largescale lattice associated PV frameworks to lessen the cost of intensity age and expansion the electrical vitality source is prescribed in Bahrain. While approaches prompting interest sponsorships for renewables will be capable advance PV establishments in Bahrain, it is apparent from the LCOE, NPV and PBP esteems that it isn't significant for financial reasonability of brought together largescale PV establishments at current PV module and rest of framework costs.

H. Calleja et al. (2018) displayed a module temperature models affect appraisal concentrated on the vitality yield of a photovoltaic framework. The appraisal was performed considering meteorological information from nine locales situated in the Yucatan landmass, between the Gulf of Mexico and the Caribbean Sea. Meteorological information included one-year of estimation, every one relating to a ten-minute normal.

Hongxiang Fu et al. (2018) performed LCA on the environmental impact of Chinese multi-crystalline photovoltaic production. Their main findings includes: The mass and energy inputs and outputs were obtained using large-scale site investigation, questionnaires, and field monitoring. The production yield of the studied samples accounted for an average 66% of the national yield in 2013.

III. PROPOSED WORK

The main objective is to conserve energy and use renewable energy resulting in non-renewable resource saving with implementation of Roof based photovoltaic panels in order to drive the home appliances of the location and to fed extra energy into the Grid. For this a section of plots range from 175 to 194 in Omaxe City, Bathinda are chosen foe analysis as given in the figure below is chosen for Roof top installation. Each plot is 35 feet wide and 90 feet long and there are 38 total plots of same size.

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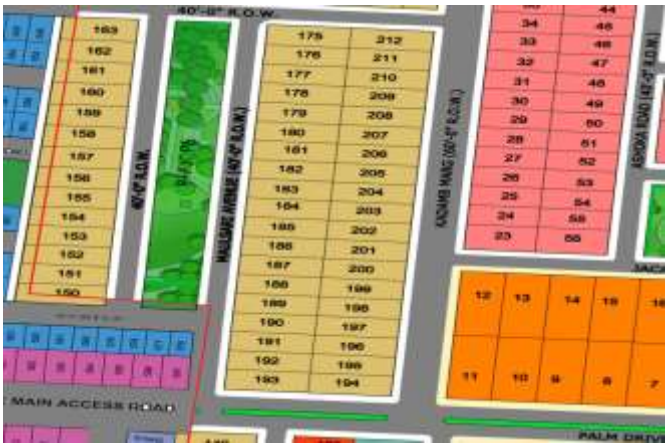

Figure 3: Number 175 to 194 plots are selected for analysis for Roof top solar systems

In high power applications, the cost of MPPT control is dwarfed by the cost of the photovoltaic (PV) array and power converters. However, in low power applications, the implementation cost of an MPPT algorithm must be given serious attention. A popular example of such applications is in commercial PV pumping systems which utilize low power dc pumps ranging from 200 to 2000 W. A common practice is to connect these pumps directly to the PV array. This eliminates the need for a pump controller but reduces the energy utilization efficiency of the system. A significant improvement in energy utilization can be achieved by using a simple dc–dc converter controlled by an MPPT algorithm, reducing the required size of the PV array for a given power output. In order to allow wide scale use of pump controllers with MPPT control, the cost savings due to the reduction in PV array size must be higher than the cost of the pump controller itself. This means only efficient low-cost MPPT control can be considered for these systems.

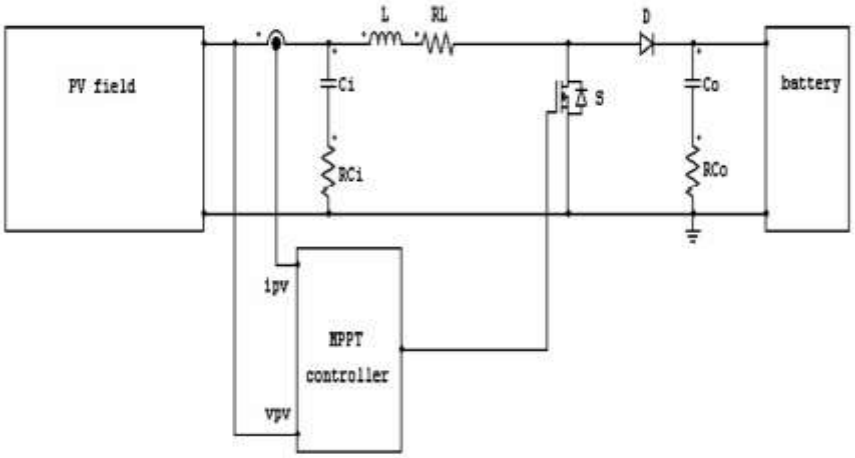

Figure 4: System design for the presented work

In simulation work first of all perturb-observe method has been implemented in order to analyze its working behavior. The blocks used in the implementation are shown in figure above which includes the PV field array, MPPT control block, boost dc converter and battery to store the electricity.

The parameters used in solar array design and buck and booster circuit are written in table below

Table 1: The parameters used in solar array design and buck and booster circuit [5]

Parameter	Value
Open circuit Voltage V_{oc}	37.6 volt
Short circuit current I_{sc}	8.82 Amp
Voltage at maximum power point V_{mp}	30.8 volt
current at maximum power point I_{mp}	8.29 Amp

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Cells per module	60
Capacitance C1	1000 uF
Capacitance C2	1600 uf
Inductance L1	3 mH

- *MPPT with Perturb and Observe method*

Numerous papers concerning the greatest power point following (MPPT) of sustainable power sources have showed up in most recent ten years. The greater part of them treat systems went for drawing the most extreme power from a photovoltaic (PV) field at the current natural conditions, as far as irradiance and temperature, paying little mind to the real PV field conditions, e.g. regarding maturing. The best piece of such techniques joins into two methodologies, that are outstanding as bother and watch (P&O) and incremental conductance (IC) strategies. The previous is regularly utilized for its straightforwardness, since it is basically in view of a slope climbing way to deal with the greatest power point (MPP) of the power-voltage normal for the PV field. Then again, its fundamental disadvantages are the misuse of vitality in stationary conditions, when the working point moves over the MPP, and the poor powerful exhibitions displayed when a lofty change in sunlight based irradiance happens.

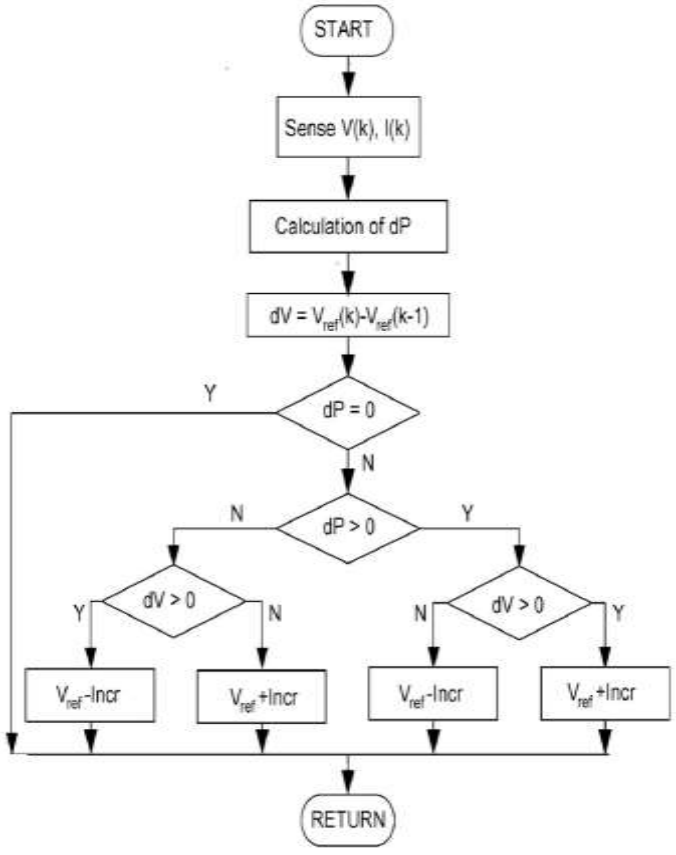

Figure 5: Algorithm steps in perturb-observe method

IV. RESULTS AND DISCUSSIONS

The simulink modal implemented for single phase power grid connected pv system with mppt working at different temperature conditions is shown below. In this model MPPT block has been presented by perturb and observe algorithm.

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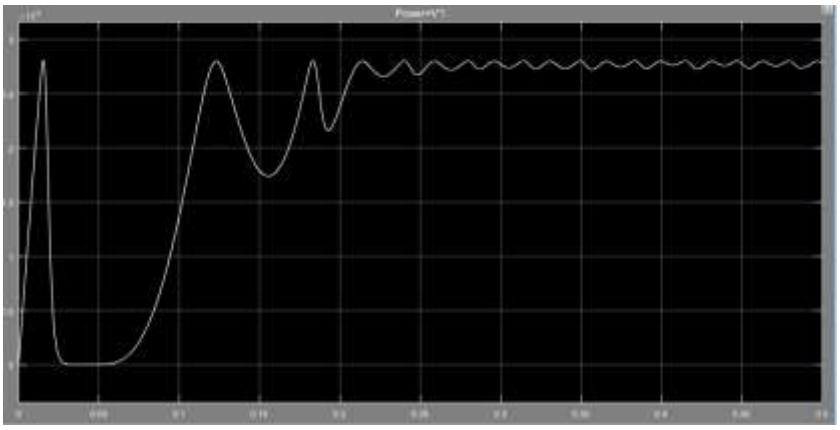

Figure 6: Power Waveforms using perturb and observe based MPPT control

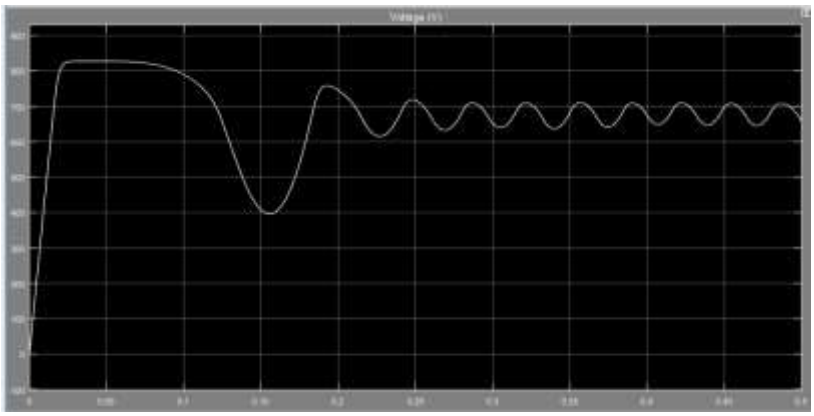

Figure 7: Voltage waveforms using perturb and observe based MPPT control

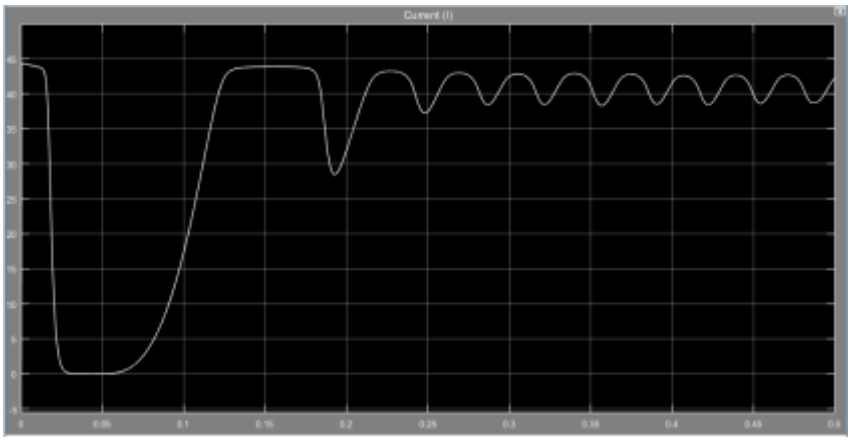

Figure 8: Current Waveforms using perturb and observe based MPPT control

By using the same parameters in all blocks such as temperature, irradiance value etc. proposed method performs well as compared to Perturb and observe method. Old method gets poor tracking in the start and stables the Maximum power point after long period of time than the hybrid method. The second improvement that has been achieved by proposed method is that the range of power produced fluctuates less than the P & O method.

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- *Expenditure and Payback for installation of equipment's of proposed solar array*

Table 2: Expenditure of solar system equipment's, installation cost and maintenance cost

Item name	Expenditure in Indian Rupees
Cost per watt	40
Total cost of panels	1120000
Cost of 30 KVA Inverter	500000
Cables	50,000
Combiner box	40000 (4*10000)
Main junction box	32000 (4*8000)
Maintenance cost	56000 (2/W for 1 year)
Installation cost	28000 (1/w)
Total cost of equipment's	1826000 approx.

Table 3: Home appliances that can use the solar energy

Home appliance	Number and rating	Daily usage	Yearly Unit consumption
Number of air-conditioner	9 (1.5 KW each)	16 hours (six months)	9*1.5*16*180=38880
Number of fans	12 (40 watt each)	16 hours	12*40*16*365/1000=2830
Number of Lights	12 (12 watt each)	8 hours	12*12*8*365/1000= 420.4800
Number of Geysers (25 liter)	3 (2 KW Watt each)	3 hours (six months)	3*2*3*180=3240
Total Units			45370

Table 4: Units consumed by Home appliances in a year

Units produced by proposed roof based Solar system (considering working optimal 5 hours a day)	28*5*365=51100 units
Units consumed by home appliances	45370 units
Units provided to Grid in a year	51100-45370= 5730 units
Revenue generated from 51100 units	51100*6=306600 rupees
Payback Perid	Expenditure/ Revenue generated per year=(1826000/306600) = 5 years 11.5 months approx..

V. CONCLUSION

Presently conventional fossil-fuel and hydroelectric generation are far more widely arrayed than PV. The question arises then, of how PV systems can penetrate the world's electric supply in antagonism with these alternatives, or, more scarcely, how a PV system can compete with other electricity sources for a specified application. PV is a rapidly developing technology with declining costs. The reason includes the economic benefits and the solar system's modularity, low maintenance, low noise level, long life and non-emission of greenhouse gases. To explore the home based photovoltaic systems, rooftop solar energy system has been designed and simulated in this work in which Omaxe City, Bathinda has been selected for analysis work in which a single plot of size 35*90 feet is selected and solar array of size 22 series and 5 parallel combination is designed in AutoCAD in such a way that a person can clearly move in between panels to clean the equipment's and roof. Total 110 panels are used in series and parallel which can provide approx. 28 KW of power in ideal conditions. Further for MPPT improvement, perturb observe-method has been implemented for photovoltaic energy systems. Proposed method considers current and previous power comparisons to evaluate the coming duty cycle for IGBT pulses. It has been found that, the proposed system not only reduces the fluctuations in the system but also achieve initial power point tracing earlier than the traditional perturb observe method. By using the proposed system, total expenditure of 1826000 Indian rupees has been found when 28 KW rooftop based installation and equipment's are considered. After providing the power to the major home appliances, payback period calculated is 5 years 11.5 months approx.

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