AN ANALYSIS OF SOLAR MAXIMUM POWER POINT TRACKING (MPPT)

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ABSTRACT: Modern society is facing serious challenges due to the ever-increasing need for energy caused by technological advancements. Energy resources, both renewable and nonrenewable, are in short supply and will run out in the next decades if not managed properly, driving up demand for them. The energy demand is rising, and technological solutions are increasingly relying on renewable energy sources. More and more businesses are moving away from fossil fuels and toward renewable energy sources like solar electricity and coal, which are both becoming more accessible and affordable globally, but still have efficiency issues. Solar power may be more widely used in rural regions if a maximum power point tracker could be designed that was inexpensive, easily replaceable, and repairable. These handheld devices, once created and disseminated, might greatly augment the production of renewable energy. Researchers found that MPPT trackers contributed to a more stable supply chain and provided load power. Potentially leading to better power consumption in underdeveloped nations, the tracker increased solar panel output during efficiency and voltage testing.

KEYWORDS: Solar power, Mppt, Renewable energy resources, Power Electronics.

1. INTRODUCTION

Solar energy: Solar is a key source of renewable energy. Heat and light from the sun are captured. Solar thermal energy can be used to heat spaces. Solar energy can also be used to generate electricity, which has a wide range of applications. Although more expensive to install, it provides long-term benefits.

Wind energy: Wind turbines generate power from wind flow. Wind kinetic energy can be turned into mechanical and electrical energy. Wind turbines capture wind energy. The power of an air turbine is proportional to wind speed cubed.

Hydro energy: Hydropower is a renewable energy source that converts flowing water into electricity. Hydropower is used for irrigation. Water engines use hydroelectric power converted into electricity. Hydropower stations with capacities of up to 10MW are renewable.

Geothermal energy: Renewable geothermal energy exists in Earth's layers. Temperature variations cause heat to move from the core of the planet to the surface. The heat generates extremely hot steam, which drives steam turbines.

Biomass: Biomass is a renewable energy source derived from plants and plant-based compounds. Biomass functions similarly to a battery, storing and releasing solar energy. The most common biomass energy source is wood. Biomass generates electricity.

Renewable Energy's Latest Trends: Renewable energy sources are being introduced steadily. Renewable energy accounted for 19% of worldwide energy consumption in 2012, and it has increased since then. Solar PV has grown at a 55 percent yearly rate over the last 4-5 years. Despite their enormous potential, renewable resources are mostly untapped.

2. LITERATURE REVIEW

R. Faranda et al. used Simulinkreg to compare and assess ten popular MPPT algorithms in 2018. This study contrasts the approaches' effects under different sun radiation. Solar electricity will be crucial in the future. By using solar arrays Over 45% of the world's energy will be generated. Thus, we must reduce application costs and improve performance. This second statement is based on the fact that photovoltaic array output is nonlinear and changes with sun irradiation and cell temperature. Use maximum power point tracking (MPPT) to maximize solar array power.

MPPT algorithms and a DC-DC boost converter provide equal impedance measurements between PV components and loads. The most common commercial products method is perturb and observe (P&O), but several others have been proposed in the literature. P&O can be implemented into cheap digital devices and still be resilient and MPPT-effective. In 2014, A. Gaga et al. built a photovoltaic system employing the modified P&O algorithm to improve solar system efficiency, stability, and precision. We test the proposed solar control system using the PowerSim tool simulator and test results from our updated system, which uses two MPPT algorithms—the old P&O and the new advanced P&O.

Solar energy is abundant and free. It can replace fossil fuels and petroleum products in power generation as an NRES. Solar cells absorb sunlight to meet energy needs instead of NRES. Solar cells have changed over time. Solar cell efficiency and cost hinder progress. To identify the optimum cells for a site, operators must grasp the fundamental workings and topologies of different solar photovoltaic (PV) systems utilizing MPPT methodologies. O. Singh et al. (2018) examined solar PV cell research over the previous decade and predicted its future trends and behaviors. This article also highlights solar energy experiments and innovations.

Photovoltaic (PV) systems need maximum point tracking (MPPT) to harvest maximum power despite temperature and light irradiation variations. The research examines a sensor-less curve (SC) MPPT method employing modal predictive control (MPC). The study by M. Metro et al. (P&O) is particularly notable for using model-based predictive control principles to eliminate the necessity for the current sensor in perturb and observe MPPT approaches. The suggested technology becomes a stylish integrated controller that outperforms the conventional P&O approach in steady-state responsiveness and power ripple reduction in rapidly fluctuating atmospheric conditions by making time-dependent PV system statistics predictions. Sun irradiation changes can now be detected without expensive sensor and communications equipment and networks.

Our SC-MPC-MPPT's improved load sensitivity was tested using the commercial European Efficiency Test (EN 50530), which analyzes PV system efficiency in dynamic situations. Experimentally deploying the recommended control method on the space DS1007 platform validates simulated results. In 2011, A. Durgadevi and colleagues explored the Maximum Point Tracking (MPPT) approach to plan, simulate, and test a simple but efficient photovoltaic system. Both theoretical and experimental research has focused on 36-cell photovoltaic arrays that yield maximum load power. However, photovoltaic generators have nonlinear I-V characteristics and vary their maximum point with solar insulation. For optimal photovoltaic cell array functioning, an intermediary converter matches the solar system to the load and maximizes capacity. We use the Perturb and Observe method to create and evaluate a Maximum Point tracking algorithm for a water pumping system in a simulated environment. V pv and I pv denote the array voltage and current, respectively. Models and experiments determine I-V and P-V properties as a function of temperature and insulation. outcomes reveal no difference between experimental and simulation outcomes. MPPT results with ck converter simulation are also shown.

A. S. Ahmed et al.'s 2016 Maximum Point Tracking approach is crucial to photovoltaic (PV) system efficiency. Tracking the utmost point (MPP) with techniques like Incremental Conductance Tracking (ICT) and Perturb and Observe (P&O) maximizes power. These algorithms are most popular because they are easy to implement. The article shows that MPPT improves PV systems. It also demonstrates INC and P&O algorithms. Matlab/Simulink simulated and tested the algorithms under varying temperature and sun irradiation conditions. The results indicated that each method had advantages: The INC algorithm reaches the MPP with fewer perturbations, resulting in a lower switching rate, more efficiency, and longer battery life. P&O is the fastest to reach the MPP and charge the battery, but it cannot sustain it.

A Generalized MPPT control-based DC-DC boost converter by C. V. Ramachandra Rao et al. (2019) provides continuous power while maintaining dynamic system integrity. An algebraic loop represents the PV array for several iterations to get an accurate result. This model uses longer time steps for faster simulation. PV systems optimize continuous power and duty cycle with the Generalized P and O technique and MPPT controller. A strategy to create consistent power regardless of temperature and irradiance includes the recommended converter and MPPT controller. MATLAB SIMULINK is used to investigate a 100kW PV array connected to a 25kV utility grid and compare it to other models in the literature. The produced model is advantageous. For performance, design, and economic studies, solar panels and collector systems in varied climates, tilt angles, and locations need radiation distribution calculations. Integrating angle and ambient temperature into a thorough study optimized PV array power generation. Comparing anisotropic and isotropic models shows that the anisotropic model gains 5% more energy.

3. RELATED WORK

Solar power efficiency problem

In recent years, leading renewable energy countries have focused increasingly on solar energy, one of the most important and freely available renewable energy sources (RES). Solar energy dominates several nations. One day of solar energy powers the earth for a year. Solar energy does not harm the environment. Solar energy to electricity conversion has several uses. Sun thermal and photovoltaic conversion generate power. sun thermal is similar to steam turbine AC energy generation, except it uses concentrated sun rays to create steam and store it in thermally insulated tanks for day and night consumption. Silicon or other semiconductor photovoltaic cells convert sunlight into DC power. Due to intermittency, electricity must be stored in buttery at night. Recently, low-cost flat-film solar panel research increased. Thin-film devices, focusing systems, and other breakthroughs increased. Tiny solar-power modular modules and plants will soon be inexpensive for large-scale solar energy generation and use. MPPTs are the best way to increase solar panel efficiency. It outputs maximum power at the maximum power point (MPP). To reduce system charge, MPPTs optimize array efficiency.

Need for renewable energy and its harnessing through MPPT

Solar power is independent of oil, coal, and other resources. Solar has low conversion efficiency, insufficient regulation, and expensive installation prices. This is being researched to increase control and efficiency. Thus, PV charging system installation prices fall. The initiative is motivated by difficult field research. Abundant, free, and open solar energy can be captured and used. Solar energy can be grid-connected or freestanding, depending on grid availability. Power can be generated in rural areas without grids. Sunlight-to-electricity solar energy is the best without a climate change crisis. Solar plants convert this energy. Solar chargers must charge batteries quickly to store energy. Maximum power point tracking improves solar panel efficiency. Most common include hill-climbing, fractional open circuit voltage control, perturb and observe (P&O), incremental conductance (INC), neural network control, fuzzy control, and others. The simplicity, efficacy, merging speed, sensor required, and cost of algorithms vary. The most used current and voltage methods are incremental conductance (INC) and perturb and observe (P&O) due to their simplicity, efficacy, and merging speed.

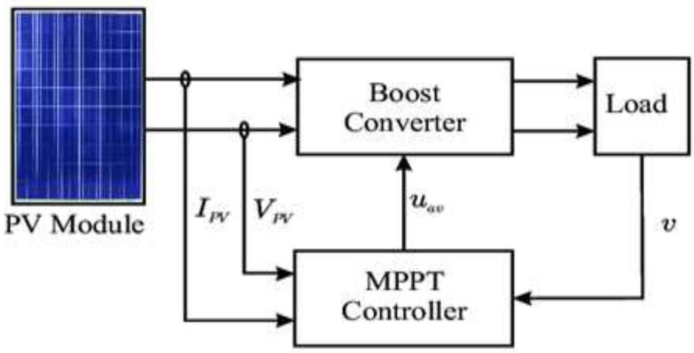

Fig.1. MPPT model

P&O miscalculates MPP when MPPT changes drastically with solar irradiation ratio and misinterprets it as disturbance-induced maximum power point variation. To estimate MPP, incremental conductance approach algorithm track needs two voltage and current trials, avoiding this issue. The incremental conductance method is more accurate than P&O due to its efficiency and complexity. This MPPT algorithm uses a battery charging loop to charge lead-acid batteries with constant current, voltage, and float. The optimal lead-acid battery charging pattern is constant current, constant voltage, and float.

Solar panel photovoltaic cell

As an element of a bigger photovoltaic system, a solar sheet containing photovoltaic cells can produce and distribute power for industrial, household, and outdoor lighting needs. The photovoltaic effect is used by solar panels to convert sunlight into electricity. Composed of non-magnetic conductive transition metals like as silicon or telluride, the majority of modules employ wafer-based or thin-film cells. You can get the voltage you want out of a series connection, and the current you want out of a parallel one. A current-taking wire might be made of silver, copper, or another transition metal with good magnetic conductivity. There must be an electrical connection between the cells and the system. In typical conditions, the DC output power from solar panels ranges from 1001 to 320 watts. Not all solar ranges, including ultraviolet and low or dispersed light, may be used to create power by photovoltaic panels. Solar panels waste a lot of the sunlight that hits them, although they work better with monochromatic light.

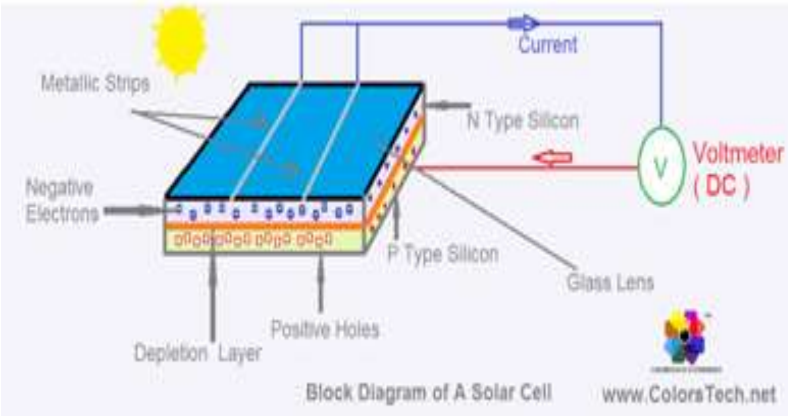

Fig.2. circuit diagram

Advantages of solar panels

- This is the solar technology that is most widely available.
- Their lifespan can be indefinite.
- They needed very little upkeep because of this.
- When there is little to no barrier to the sun's rays, the optimal conditions for operation are bright days.

Solar cells:

A semiconductor device called a photovoltaic cell transforms light energy to electricity using the photovoltaics effect. When light photon energy exceeds the band gap, electrons are released and form electric current. However, photovoltaic cells differ from photodiodes. In a photodiode, light hits the semiconductor junction's n-channel and generates a current or voltage signal, whereas a photovoltaic cell is always forward biased.

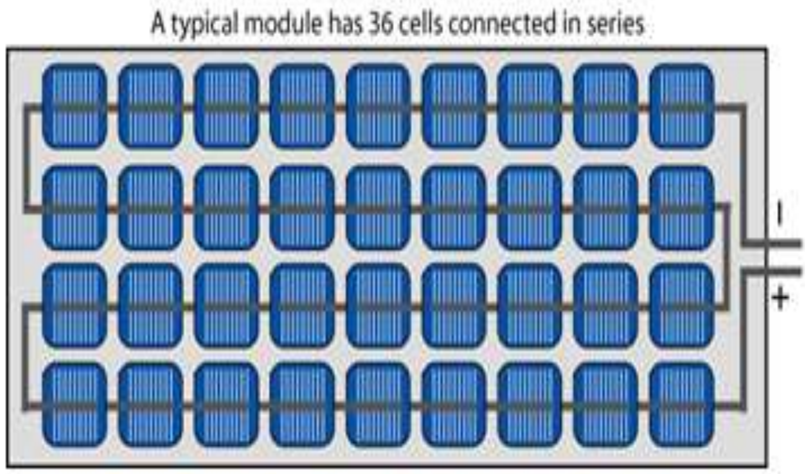

Fig.3. solar cell layout

Solar I-V and P-V characteristics:

The ideal I-V characteristics of a PV module are illustrated in fig.4, which plots various current (I) for varied voltage (V) on the X&Y axis.

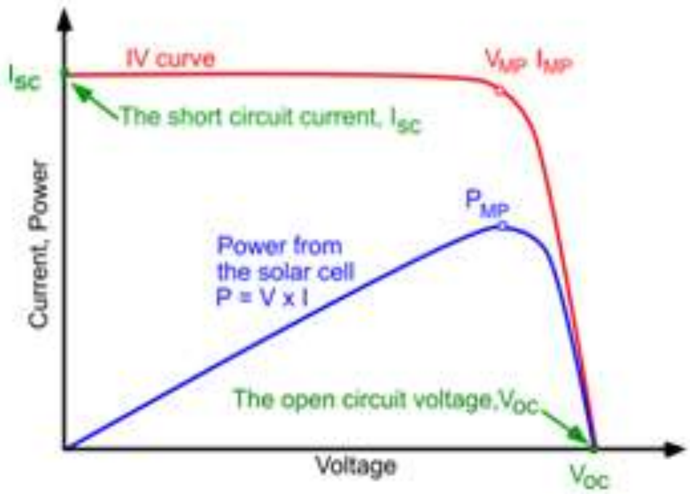

Fig 4 I-V and PV curve

4. MAXIMUM POWER POINT TRACKING (MPPT)

Solar cells have one operating point where optimal current and voltage values maximize system power output under all expected working conditions. These values produce a low-ohm load resistance R=V/I. Basic circuit theory states that system performance is affected by the branch of the I-V curve and voltage curve opposite the I/V ratio. The “knee point” of the power output curve is the maximum power point (MPP) of an operational system under typical operating conditions. The load through Resistance R=V/I is near to the reciprocal of this set point value and maximizes device power. The spectrum of sunlight absorbed by any panel, as well as environmental factors like temperature, shade, moisture, and photovoltaic cell life, affect this dynamic intensity and capacity over days. If the system's internal resistance is lower or higher than the cell's power drown rate, Varity and multiple controller routes or rationalities discover the maximum power point and let the converter get the most power from the cell.

Methods of MPPT algorithm:

MPPT maximizes system power. These uses may use more electricity than the PV system can provide. Simple voltage connections to complex multiple sample-based analysis can enhance PV system power. MPPT methods differ, helping users choose the optimal one for their needs. This includes implementation, sensor, convergence speed, multiple local maximum, cost, application, and array parameter dependency. Simple analog or digital circuitry implements hardware. Number of sensors affect MPPT choice. MPPT accuracy requires more sensors (National Instruments 2009). Voltage is simpler to measure than current. Costly irradiance and temperature sensors.

High-performance MPPT systems must have junction speed below the operational voltage or current to reach the maximum power point (MPP). Quick and intermittent MPP tweaking maximized efficiency and minimized power losses. Recognizing several local maxima under different irradiation levels is another important requirement. Under regulated shadow, a local maximum can replace the genuine MPP and lose 70% power. Users also consider performance cost. Digital systems cost more than analog. System cost increases with sensor amount and kind, which need power or electrical components.

Different MPPTs serve different purposes. Different PV system factors may be needed for different applications. In expensive space satellite and orbital station applications, MPP tracker performance and dependability are more critical than cost and complexity. The tracker should track the real MPP quickly and without adjustment. MPPT may use array settings directly or indirectly. PV voltage/current is directly used. Direct techniques independently configure and factor PV arrays. Temperature, dilapidation, and irradiance do not impact the operating point. The best MPPT algorithm characteristics used to match different techniques are reviewed using indirect methods that use a record of factors that contain data of typical P–V curves of PV systems for different irradiances and temperatures or mathematical functions from experimental data.

MPPT methods and algorithm

The most common tracking method changes input voltage or DC/DC converter duty cycle to watch output power. The interruption of the previous cycle is reversed unless the solar panel's power P(k) is greater than P(k-1).

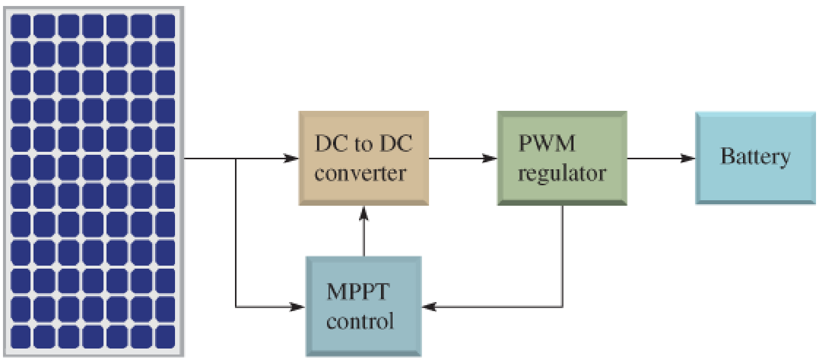

Fig.6 MPPT circuit diagram

The most common method is perturb and observe. This approach maximizes PV power by adjusting voltage or current. This procedure matches input and output impedances to maximize power. Power change is given by the equation below.

Perturb and observe mothers

This tracking method is based on the perturbation of the system, which can be performed by either increasing or reducing the input voltage or by acting directly on the duty cycle of the DC/DC converter. Furthermore, the name of this tracking method suggests that it is based on the perturbation of the system. The influence on the power output of the system is then observed when this step has been completed. An algorithm like this is the tracking method that is utilized the most frequently. If the power P(k) of the solar panel is greater than the previous value of P(k-1), then the disturbance that occurred previously is occurring in the same direction. If it is not the case, then the disturbance that occurred before is occurring in the opposite direction, in the opposite direction.

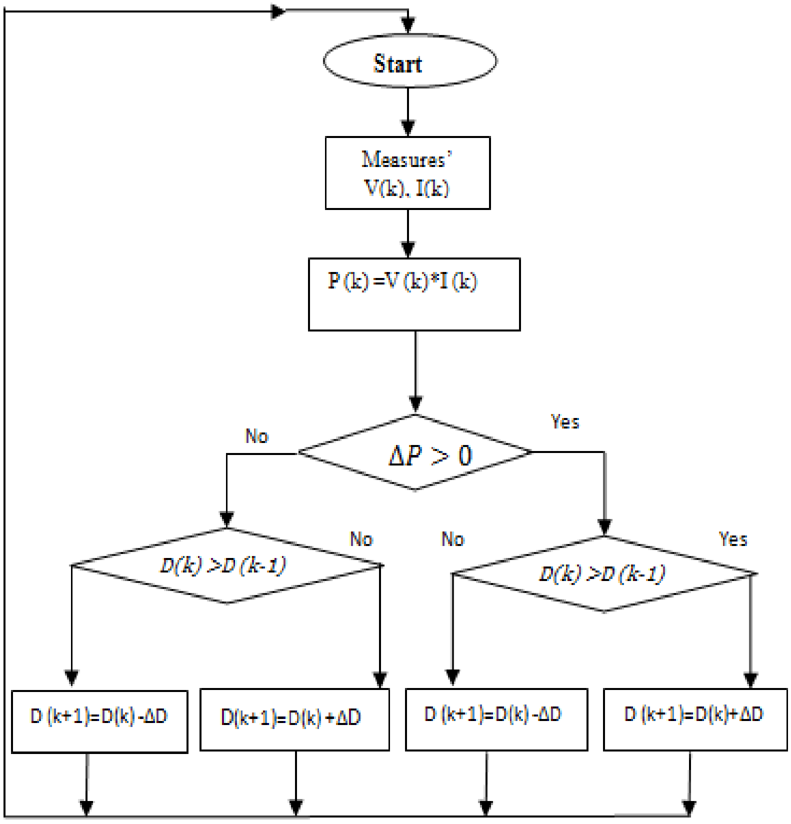

Fig.7.MPPT circuit diagram

The most popular method is "perturb and observe." Changing the voltage or current operates the PV at its maximum power point. This maximizes solar panel power. Impedance matching matches input and output impedances to maximize power. Additionally, the following equation describes power shift.

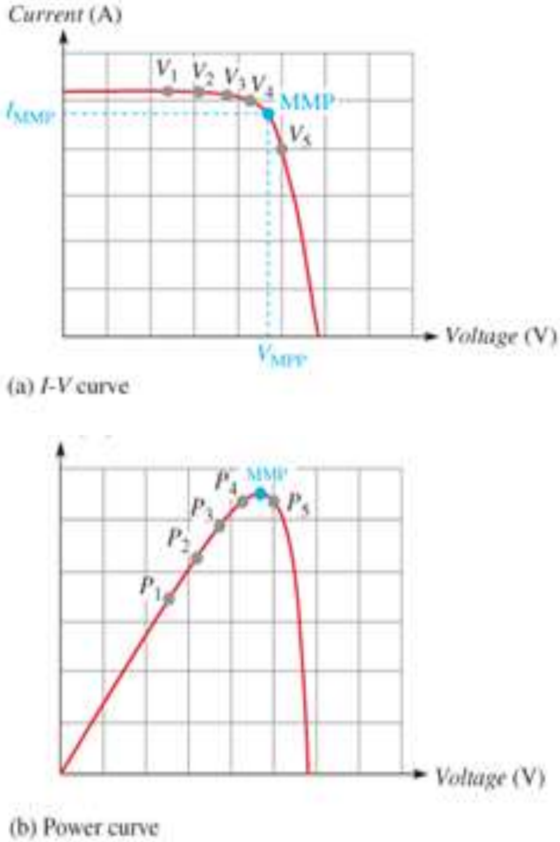

Fig.8. maximum power on the IV curve

Incremental conductance method:

The MPP happens when incremental conductance matches solar PV range. Current and voltage are monitored concurrently. The must ignore irradiance variable performance mistake to optimize output. System installations are harder due to labor costs. Large generation systems may cost more to develop and maintain. Most methods involve perturb-and-observe and incremental conductance. Currant can watch but needs more calculations to identify power change. P&O receiving abrupt irradiance level changes as maximum power point changes due to external disturbance farther than range isolation often computes MPP incorrectly. Incremental conductance improves output and fixes these concerns. Dual voltage and current samples boost solar module power. Observation and perturbation are less effective than incremental conductance. Gradual over perturb and observe can cause P&O and power output oscillation. Improve system setup, management, maintenance, and performance The controller maintains voltage until sunlight insolation changes by detecting incremental solar array conductance.

Fractional short circuit:

In certain weather conditions, fractional short circuit algorithms fail. The maximum power point IMMP is closely related to the PV array's short circuit currant (ISC): IMMP=K2Isc, where K2 is the proportionality constant. PV arrays determine K2, like Voc. K2 is usually 0.78–0.92, making short circuit currant Isc difficult to measure during operation. The power converter normally has a switch to shoot the PV array for current sensor measurement.

Fuzzy logic

The use of fuzzy logic control for maximum power point tracking (MPPT) has become feasible because to the development of microcontrollers over the course of a decade. On the other hand, fuzzy logic controllers have the advantage of being able to deal with nonlinearity and working with inputs that are not accurate. Additionally, in order for them to function, they do not require a mathematical model that is accurate.

5. CONCLUSION

Both industrial and household renewable energy systems are possible. Adjusted for hardware, the perturb and observe strategy, the most popular among trackers, may compete with the other method for maximum power tracking efficiency. Studies of the four MMP controller approaches suggest that P&O (perturb and observe) is the most popular, efficient, and easy to design. In all ways, good algorithms increase power and output. Also beneficial for robotics, electric vehicles, and other applications that improve low-range electric vehicle efficiency, driving range, and panel cost. This solar energy system can be built without changing a home or business's electrical infrastructure. Network marketing sells excess energy from these systems to the grid. The PV simulation system with MPPT capability uses only the PV module model for DC/DC converter and MPPT control system models. Under varying weather voltage, simulate MPPT algorithms' voltage and execution efficiency. Thus, perturb and observe MPPT approaches boost photovoltaic system efficiency over former output power. It reduces air pollution, deforestation, and promotes human and animal health. It will reduce fossil fuel power generation costs.

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