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Implementation of Solar Based MPPT Charge Controller for R.O Filter Application

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ABSTRACT:The challenge of a photovoltaic (PV) controller for maximum power point tracking (MPPT) under changi ng insolation and shading conditions is tackled with this method.The goal of a generalpurpose adaptive maximum powe r controller is to keep the PV system operating at its peak output while continuously avoiding local maxima caused by s hifting environmental conditions.Few standard MPPT algorithms have been able to provide genuine maximum power d uring sudden changes in solar shading, despite the fact that many of them have been developed under perfect operating conditions.Most MPPT algorithms are locked at local maxima and are unable to quickly discover the global maximum power point under these dynamic fluctuations, which results in inconsistent power generation and low system efficienc y. Our application in this paper is Perturb and observe (P&O) technique. Simulation results confirmed by practical experimental tests showed the improvements of the suggested method over the most advanced approaches. This technique maximizes the solar system's overall output power while reducing tracking time and steady state fluctuations.

KEYWORDS: MPPT controller , Reverse Osmosis(RO), Solar Energy , Perturb & Observe(P&O).

I. INTRODUCTION

The utilization of solar energy has surfaced as a viable and enduring substitute for traditional fossil fuels in order to fulfill the global demand for energy. Most places have plenty of sunshine, thus using solar energy has major advantages for the environment and the economy, such as lower carbon emissions and energy independence. The development of cutting-edge technology to maximize solar energy capture and use and transform sunshine into useable electricity is essential to the optimal use of solar energy. An overview of solar power generation is given in this introduction, along with a discussion of the idea of solar-based Maximum Power Point Tracking (MPPT) charge controllers and their significance in raising the effectiveness and efficiency of solar photovoltaic (PV) systems. Solar Power Generation: Photovoltaic (PV) cells, often known as solar panels, are used in solar power generation to convert sunlight into electrical energy. These panels are made of semiconductor materials, such silicon, which, through the photovoltaic effect, produce electricity when exposed to sunlight. Usually produced as direct current (DC), the electricity can be transformed into alternating current (AC) via inverters for usage in commercial, industrial, or domestic settings.

A number of variables, such as temperature, shade, angle of incidence, and sunshine intensity, affect how much pow er solar panels can produce.To ensure that solar panels operate at their maximum power point (MPP) under a variety of climatic situations, optimal power output from them necessitates precise control over their working conditions.
MPPT Charge Controllers Powered by the Sun:In order to maximize the power production of solar panels, Maximum P ower Point Tracking (MPPT) charge controllers are crucial parts of solar PV systems. They do this by continuously alte ring the operating voltage and current to track the MPP.To guarantee optimal power transfer and efficiency, these contr ollers use complex algorithms to dynamically adjust the impedance of the solar panels to the load.The following are some of the ways that solar-based MPPT charge controllers improve the efficiency and dependability of solar PV systems: Optimizing Energy Harvesting: MPPT charge controllers increase the system's overall energy generation, particularly in situations with fluctuating environmental circumstances, by tracking the MPP of solar panels. Increasing System Efficiency: By guaranteeing that the panels function at their peak performance point even in

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situations with partial shade or low light, MPPT charge controllers reduce power losses and raise the overall efficiency of solar PV systems. Increasing Battery Life: MPPT charge controllers manage how much energy is taken up by the batteries in off-grid or hybrid solar PV systems that have battery storage. This keeps the batteries from being over- or undercharged.

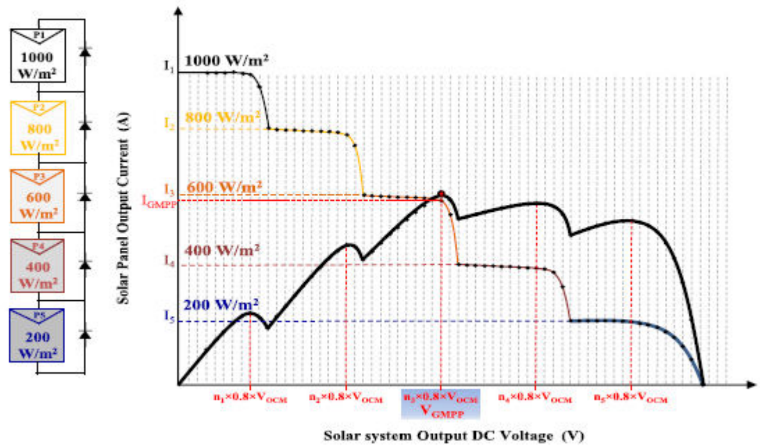

Fig.1 Typical I_V and P_V characteristic curves of a partially shaded PV array consisting of 5 modules connected in series each with different insolation levels

There are other peaks, but the one with the red circle is the global maximum power point (GMPP), which is significant and should be precisely located by the mppt.

Mathematical model of PV cell :
Ideal Equivalent cell

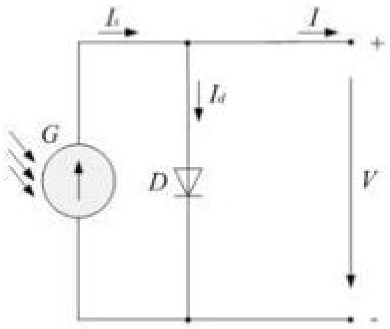

Fig .2 PV cell equivalent cell

Id=Io*[exp(Vd/VT)-1] (1)

VT=KT/q x nI x Ncell (2)

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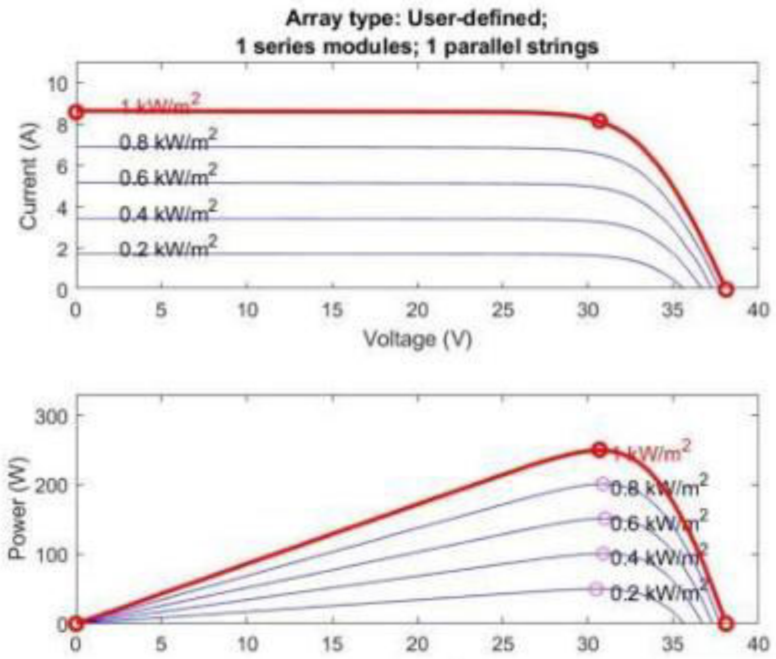
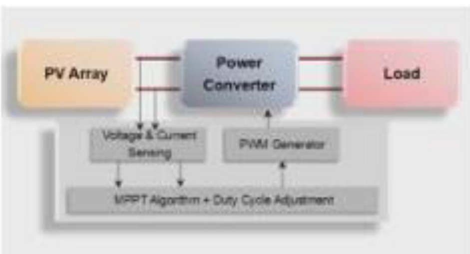


Fig .3. PV characteristics under function of irradiance

Section I discusses introduction,section II Methodology,Section III working principle ,Section IV experimental results ,section V conclusion.

II. METHODOLOGY

The methodology entails building and choosing parts for a solar-powered MPPT charge controller specifically designed for RO filtration systems, creating and integrating a dynamic MPPT algorithm, putting hardware and software solutions into place, testing the system's performance and functionality in a variety of scenarios, iteratively optimizing its operation, and recording the procedure and results for distribution through Why is MPPT technology used? In this case, a non-MPPT solar charge controller can help shield batteries from unfavorable charging circumstances, but it cannot boost system efficiency. PV panels are typically designed to operate at 12 volts and are utilized to provide output between 16 and 18 volts. However, depending on the level of charge, the true value of the 12V batteries ranges from 10.5 to 12.7V. Assume a 130 watt solar panel with a current rating of 7.39 amps at 17.6 volts at a specific voltage andcurrent. Comparison between MPPT vs Conventional Technology



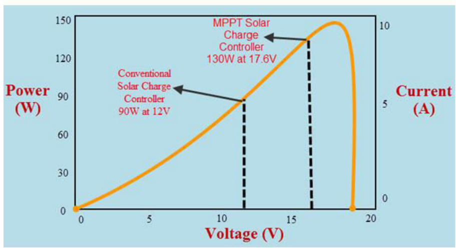


Fig.4. General block diagram of MPPT controller . Fig.5. Comparsion between Conventional and MPPT Technology

This 130 watt solar panel may produce power equal to the product of its current when connected to a battery via a non-MPPT solar charge controller. 7.4 amps and a battery voltage of 12 volts, or roughly 88.8 watts. As a result, we lose 41 watts (about 130-88.8=41.2). This is because the solar panel and batteries are not well matched. Therefore, we may boost the power gain by 20 to 45% if we use an MPPT solar charge controller. However, in order to do so, we must first understand MPPT technology, which is employed in solar panel charge controllers.

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III. WORKING PRINCIPLE

The algorithm and electronic circuitry are used by the maximum power tracking system. The process is predicated on the idea that maximum power transfer requires impedance matching between the PV module and the load. Generally speaking, MPPT is a DC to DC switching voltage regulator adaption. The DC to DC converter is used to match the impedance. By adjusting the duty cycle of the switch, the impedance is matched through the use of a DC to DC converter. It can be necessary to provide a greater voltage or higher current while coupling to the load in order to maximize power transfer. With voltage and current sensors connected to a feedback loop and a controller to change the switching times, a buck boost method is frequently employed. Additionally, buck converters can also be used .The block diagram is shown below .

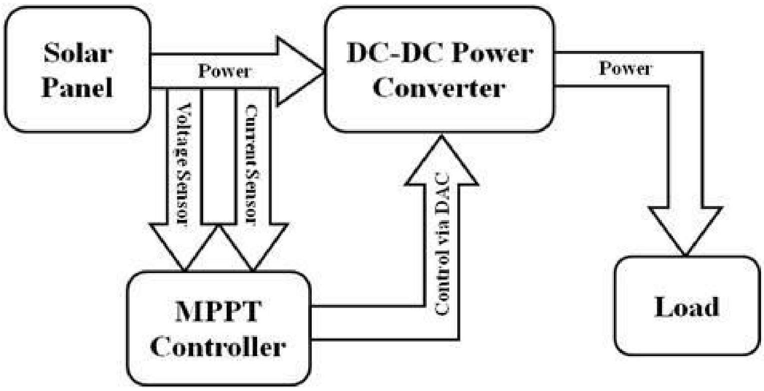

Fig 6 – Block diagram of overall system

By measuring the voltage and current, the power from the solar module may be computed. This power is used as an input by the algorithm to modify the duty cycle of the switch, which in turn modifies the reflected load impedance in accordance with the PV module's power output. For example, the relationship of a buck type DC to DC converter's input voltage (Vi), output voltage (Vo), and load impedance (RL) reflected at the input side (Ri) can be expressed as follows:

$Vo = Vi \times d$

$Ri = RL / d2$

Where d is the duty cycle. By adjusting the duty cycle, Ri can be varied which should be same as the impedance of solar PV module (RPV) in a given operating condition for maximum power transfer.

The power output of a PV system is given by,

$P = V \times I$

With incremental change in current and voltage, the modified power is given by,

$P + \delta P = (I + \delta I) \times (V + \delta V)$

This after ignoring small terms simplifies to,

$\delta P = (\delta V \times I) + (\delta I \times V)$

δP must be zero at break point. Therefore at peak point the above expression in the limit becomes,

$dV / dI = -V / I$

It may be noted here that dV / dI is the dynamic impedance of the source, which is required to be equal to negative of static impedance, V / I

Application:

R.O. FILTER: A semipermeable membrane is used in reverse osmosis (R.O.) filtration systems to separate water mo lecules from pollutants and dissolved solids.The membrane is pushed and compressed with water, allowing only molec ules of water to flow through while obstructing larger molecules and ions.This procedure efficiently purges the water of pollutants such salts, minerals, germs, viruses, and organic substances, leaving behind clean, drinkable water.Prefilters are used to remove sediment and chlorine from water, a highpressure pump is used to raise water pressure, the RO. me mbrane module is used to improve flavor, and postfilters are used to remove any leftover contaminants.The pore size of the membrane is important; it usually ranges from 0.0001 to 0.001 micrometers, guaranteeing effective filtering and re ducing water waste.RO filtration is widely used in many different applications, including home drinking water

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purification, industrial water treatment, wastewater recycling, and desalination of seawater, providing a reliable and efficient method for producing high-quality water

IV. EXPERIMENTAL RESULTS

Main Components of Hardware :

Zener Diode One kind of semiconductor diode made to function in the reverse-biased orientation is the Zener diode. Zener diodes are specially designed to have a controlled breakdown voltage, known as the Zener voltage, in contrast to ordinary diodes, which conduct energy in the forward direction and block it in the reverse direction.

EL817 An infrared LED (the input side) and a phototransistor (the output side) are usually housed in a single package like the EL817 optocoupler. The phototransistor conducts current when it detects infrared light emitted by the LED when current passes through it. This gives the EL817 isolation and defense against noise and voltage spikes by enabling the transfer of signals or control of currents between two circuits without a direct electrical connection.

555 Timer It is possible to set up the 555 timer IC to run in bistable mode, commonly referred to as latch or flip-flop mode. The 555 timer functions as a basic memory element with two stable states in this setup.

BC 547:

An NPN bipolar junction transistor (BJT) that is frequently used in electronics is the BC547. Because of its affordability, availability, and versatility, BC547 is a well-liked option for both professionals and enthusiasts. It can also be utilized in low-power applications as a switch.

IRF640M

Power MOSFETs (Metal Oxide Semiconductor Field-Effect Transistors) like the IRF640M are made for high-power switching uses. With a maximum continuous drain current (ID) of approximately 18 amps and a maximum drain-source voltage (VDS) of approximately 200 volts, the IRF640M is intended for high-power applications.

Separation Diode

An isolation diode, blocking diode, or separation diode is a kind of diode that stops reverse current flow between two coupled circuits or parts. By only letting current to flow in one way and obstructing it in the other, it helps to isolate one circuit from another.

GDS:

The three terminals of a Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET), a kind of semiconductor device commonly used in electronics for switching and amplification, are referred to as the "gate-drain-source" (GDS) nomenclature.

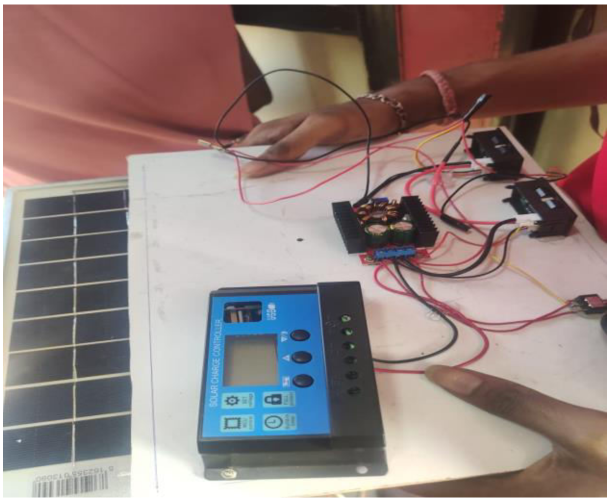

FIG 8– PHOTOGRAPH OF PROTOTYPE IMPLENTATION OF SOLAR BASED MPPT CHARGE CONTROLLER FOR RO FILTER APPLICATION

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Table 1:Hardware results

1	Solar Panel	12 V
2	MPPT	12 V
3	Battery	24V

Table .2. Boost converter results

1	Input 3V	Output 12V	0.4A	4.8W
2	Input 12V	Output 18V	1.6A	28.8W
3	Input 12V	Output 24V	1 A	24W

V. CONCLUSION

In conclusion, the combination of solar-powered Reverse Osmosis (R.O.) filtration systems with Maximum Power Point Tracking (MPPT) charge controllers provides an effective and sustainable way to supply clean drinking water, especially in isolated or off-grid areas. Reliance on traditional energy sources is decreased by using solar energy to run the RO system, which has positive effects for the environment and economy. The MPPT charge controller increases the operating autonomy of the RO system and maximizes the power output of the solar panels to provide maximum energy harvesting in a variety of environmental situations. This improves the system's efficiency and dependability, making it appropriate for use in environmental conservation, rural electrification, and humanitarian assistance. In general, the solar-powered MPPT charge controller is a noteworthy development in the field of renewable energy technology, offering the provision of safe drinking water and addressing water scarcity challenges worldwide.

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