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Partial Shading Detection using String Arrangement Technique on Photo-Voltaic System

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***Abstract*—The maximum power point tracking (MPPT) controller is a crucial concept under solar modules. Various MPPT processes are used to attain maximum power point (MPP) from photovoltaic (PV) system under various environmental circumstances. This study provides a basic understanding of solar energy consumption and PV systems. In addition, numerous MPPT approaches are examined in various studies. The Perturb and Observe methodology and the Incremental conductance methodology are used to review and debate a string arrangement strategy that has been developed to obtain increased power output. Simulation data are used to validate the suggested methodology's performance.**

***Index Terms*— Maximum power point tracking (MPPT) controller, Photovoltaic, Maximum power point (MPP), Perturb and Observe, Incremental conductance, Simulation.**

I. INTRODUCTION

In recent years, innovation has exploded, making the burgeoning renewable energy industry more cost-effective and ensuring the future supply of "clean" energy. This indicates that the rising energy sector is gradually replacing "soiled" fossil fuels in the energy sector, resulting in lower levels of pollution such as carbon. The unsoiled energy is the energy that originates from nature or through natural form processes that are always replenishing. This energy is typically portrayed as a cutting-edge technology that harnesses the power of nature. Because of the advancements in technology and the use of less expensive methods to conserve solar energy, it has become a more important source of energy.

The use of solar energy has been going on for thousands of years. Such capacity scaling happens on a scale as large and as small as the roofing sheets on homes that sell electricity back to the grid. Solar farms have implemented the use of mirrors to focus sunlight through the farm and generate electricity for thousands of buildings. As the renewable resource industries have grown over the years, there are more than 10 million job openings globally, with solar photovoltaic as the leading business in the industry. Solar photovoltaic has become the new economic power source in most countries. Since the renewable resource sectors have evolved throughout time, there are now more than 10 million job openings worldwide, with Solar PV being the largest company in this sector. In most nations, photovoltaic solar has emerged as the most cost-effective new-build energy source.

Cells containing silicon-like materials are used to convert sunlight into electricity. Photovoltaic (PV) or solar cells are the names given to these cells. Pots, or power packets, fall on the solar panel, generating electricity

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with the effect of photovoltaic. Solar panels produce Direct current (DC). DC power is used in electrical appliances such as computers and cell phones, which are designed to operate on a variable current grid (AC). As a result, an inverter is used to convert solar electricity from DC to AC power, which may then be used to charge electrical devices or delivered to the grid for consumption.

The operation of the PV structure is dependent on the operating conditions. The major factors that change the maximum energy obtained from the photovoltaic source are the load profile, temperature, and irradiance. The maximum power point (MMP) of a solar unit's I-V characteristics is the point at which the product of current and voltage is the highest, giving the highest current. A maximum power point tracker (MPPT) is used to ensure the proper operation of the PV structure and to obtain the highest current at MPP. The PV module's efficacy changes depending on the MPPT algorithm's efficacy, the PV module's efficacy, and the inverter's efficacy.

A major premise of MPPT is to get the most power out of the PV modules by operating them at their most efficient voltage. The MPPT verifies the output from the PV module and compares it to the battery voltage. After a comparison, MPPT determines the best power that a PV system can provide and converts it to the best voltage to achieve the maximum current to charge the battery. This energy can also be delivered to a DC load connected to the battery directly. The MPPT module's basic operation is depicted in Fig 1.

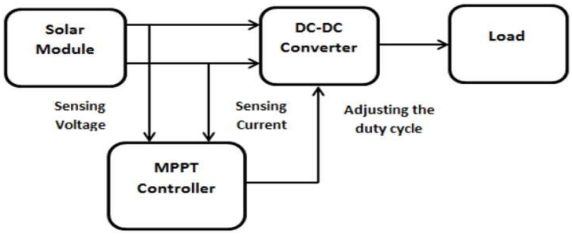

Figure 1. Basic work flow of MPPT

The change of sun powered photovoltaic energy into electrical energy is completed by photovoltaic cells. The series/equal relationship of these photovoltaic cells establishes a photovoltaic generator. The energy delivered by these PV generators isn't consistent for the duration of the day, it relies upon a few variables including light and temperature, which are two exceptionally fluctuating boundaries starting with one season then onto the next or even starting with one second then onto the next. For each given illumination and temperature, the power-voltage normal for the PV generator goes through a greatest called MPP (Maximum Power Point). It's critical to follow up on this most extreme gradually in order to separate the most power from the PV module. Various types of MPP search calculations known as computerised reasoning-based calculations have been experienced in the writing, such as those based on hereditary calculations, neural organisation, and fluffy rationale whose PPM research is extremely quick, but their detriment is their complicated equipment execution. The traditional approaches, in contrast to intelligent methods, are easier to implement; they rely on slope climbing methods, in which the MPPT regulator strives to develop the functioning mark of the GPV alongside the trademark P (V) till reaching the PPM. Further section 2 throws light on some of the different techniques carried out to obtain the MPP in partial shading condition.

II. Literature Analysis

In [1,5,8] MPPT technique is performed in two phases with open loop manoeuvre. The first phase determines the amount of Partial Shading Condition. In the next phase array's global maximum power point is attained through a methodology grounded on uninterrupted sampling of P-V characteristic and ramp variation of duty cycle followed by re-activation of P&O technique to trail minor variations of novel MPP. [2] focuses on detections of Global maximum power point by carrying out simulation testing, fast functioning of power-tracking time and high efficacy of PV arrays in shading state. Proposed algorithm undergoes searching, tracking, detecting and avoiding of partially shaded PV graphs dead spots [3]. Performance of Cuk converter in [4] is obtainable by directing altered Incremental conductance algorithm generating switching pulses for withdrawal of maximum power from partially shaded panels. [6] highlights improved mutable phase volume perturb & observe (MVSS-P&O) MPPT with two stage interleaved boost converter for solar photovoltaic structure. Flower pollination algorithm for MPPT in shaded condition is carried out in [7] with different shading

patterns. [9] presents distributed MPPT technique by compensation of current. PV modules are kept in special arrangement and resonates in shunt connected flyback dc-dc converter and operates in two modes tracking MPP.

III. IMPLEMENTATION

Fig 2 depicts the proposed method to counter the partial shading problem faced during solar energy harvesting. Each block represents a part of the system which helps the system to run smoothly. The Solar energy generation unit is connected either in series/parallel for energy generation. Voltage sensor is placed in each panel which helps in the detection of partial shading.

The response from the sensors is given to the microcontroller to check which of the panels have gone under shading and thus triggering the string arrangement block for efficient division of shaded and unshaded panels which can be fed to different mppts. This completes the initial steps in the system. These divided panels are then connected to their respective shaded and unshaded mppts. These mppt blocks contain a mppt module are connected to boost converter. It is step up voltage DC to DC power device from its supply to its load. It is used in the mppt block because as the source of energy is PV panels, they tend to vary over time, thus changing the voltage output. As we need a constant voltage of 12 V for the charging of the battery, we cannot take the chance of the voltage dropping below 12 V. Hence, at first, the PV panel output voltage is boosted in the mppt block and then supplied to the Buck converter block to maintain the same voltage throughout the later part of the system. It is a step-down voltage DC to DC power device from supply to load. The generated power stays stored in the battery for further use. This power can be converted to whichever form is required to satisfy the load demands thus making it flexible to use.

A. String Arrangement Technique

String arrangement for Series connected panels is proposed in fig 3. Here we have assumed 5 panels connected in series. There are total of 5 relays are connected to 5 panels. All the relays that are used is Single pole double throw (SPDT) relay. A SPDT switch has one input and associates to two outputs. The sensors in the sensor section are collecting data from the panel and compiling the program in the microcontroller to check for shading of panels. When the sensor sensing the shading on the panel, the microcontroller sends signal to the respective relays so that with the help of relays.

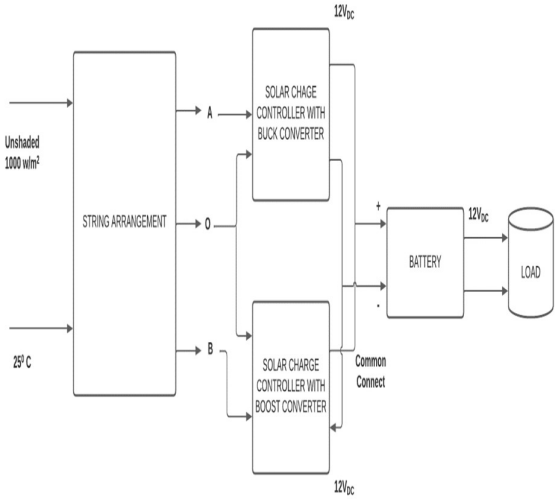

Figure 2. General block diagram to counter partial shading problem

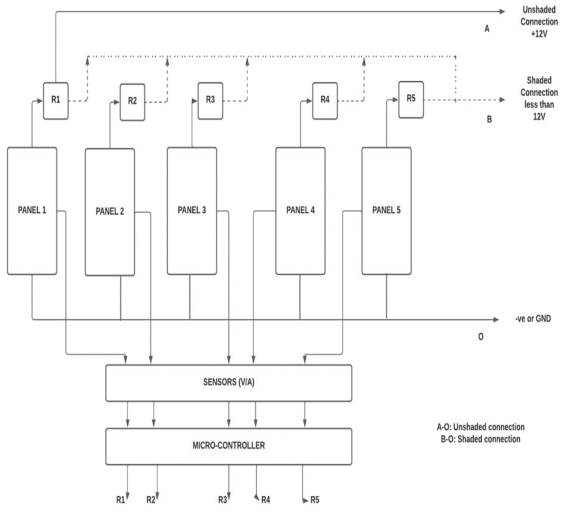

Figure 3. String arrangement block diagram

The shaded solar panel can be removed from the unshaded arrangement and can be added to the shaded arrangement. Assuming Solar Panel 2 and 4 is shaded. The sensor section senses the shading on these two panels and alerts the microcontroller. The microcontroller sends the signal to relays 2 for Solar panel 2 and relays 4 for solar panel 4. Thus, separating them from unshaded arrangement. Now the unshaded arrangement runs like Solar Panel 1 to Relay 1 to directly Relay 3 to Solar 3 to Relay 5 to Solar 5 to Output A. The shaded arrangement runs like Solar 2 to Relay 2 to Solar 4 to Relay 4 to Output B.

B. Perturb and Observe (P&O) Practice

P&O procedure is solely appreciated, reasonable strategy to reap the most possible power obtainable from PV framework. Calculation depends on power estimation, voltage and current detection. This is depicted bothering PV framework in addition to discovery of the result force of photovoltaic board. This occurs by carrying out the shifting obligation proportion of the device to acquire MPPT naturally. On the off chance that the novel current is not exactly the old-fashioned current put away in a retention, MPPT procedure diminishes the source voltage. Yet, on the off chance that the modern current P(k+1) is more prominent than the out-dated current P(k), the source voltage will be expanded till ideal greatest result of current has been accomplished. A slight perturbation is presented in this calculation. The perturbation makes the force of the sunlight-based module change persistently. Assuming the power increases due to perturbation then, at that instance the perturbation is carried out in like manner. The power produced in subsequent instance lessens later the pinnacle power is reached, and later that the perturbation switches. The calculation wavers around the pinnacle moment that the consistent state is reached. The perturbation size is maintained tiny in control to keep the power variety little. Calculation is handily perceived in accompanying flow illustration in fig 4.

C. Incremental Conductance (IC) Practice

Incremental Conductance (IC) strategy conquers drawback of P&O technique with following the pinnacle current beneath quick shifting environmental circumstance as shown in Fig 5. This strategy is be able to decide if MPPT gained the maximum power point and furthermore quits bothering the working instant. On the forth attempt when condition isn't met, the course in of MPPT working at that instance should be perturbed can be determined utilizing the connection amid dl/dV and – I/V.

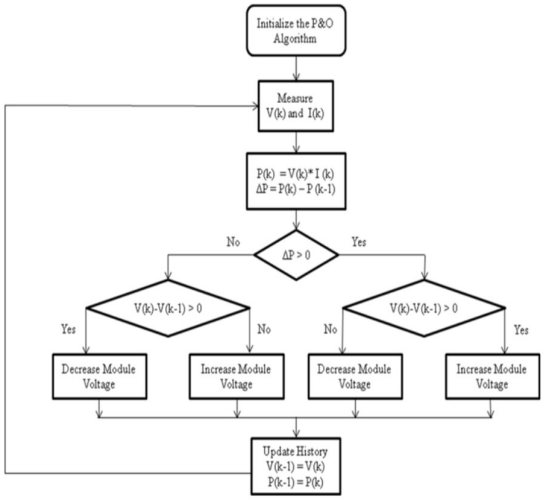

Figure 4. Perturb and Observe (P&O) flowchart

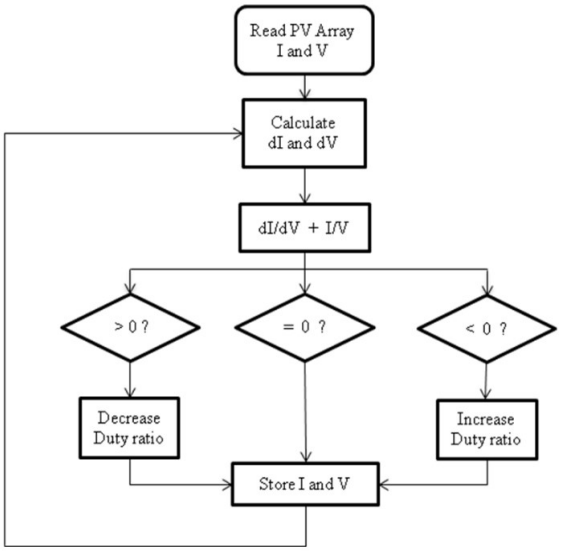

Figure 5. Incremental conductance (IC) flowchart

This connection is gotten its way that dP/dV is minus while MPPT is towards right of MPP and plus while towards left. This calculation decides at what time the MPPT arrived at MPP, while P&O wavers about the MPP. Hence it plainly a benefit in comparison to P&O. Additionally, IC can follow quickly expanding in addition to diminishing irradiance circumstances with advanced exactness compared to perturb and observe technique. Thus, disservice of the calculation when contrasted with P&O is beyond perplexing. Thus, calculation is effortlessly perceived from accompanying course diagram. PV system's derivative power is zero at MPP. This is the point when incremental conductance technique functions i.e., dP/dV=0. By comparing the instantaneous conductance (I/V) to Incremental conductance (ΔI/ΔV) we can trace the MPP of a PV system. The PV module's reference voltage is $Vref$. When the maximum power point is reached, $Vref$ should equal Vmpp. The output voltage is kept at MPP until there is a change in the atmospheric state. The IC adjusts the $Vref$ value to achieve a new maximum power point, either increasing or decreasing it. In compared to P&O practise, the ability to track the MPP in less fluctuating behaviour and extreme weather situations is an added value. The hardware's execution is complex, which is a disadvantage.

IV. PROJECT SIMULATION AND RESULTS

The project was implemented using two MPPT methods considered above. Simulations were done considering different scenarios and expected results were observed. Fig 6 & 7 shows the simulation and resulting graph of the project using P&O methodology. Fig 8 & 9 represent the simulation of the project through IC technique. On the whole the project was simulated and a resultant graph was obtained representing the voltage values achieved through fig 10 & 11.

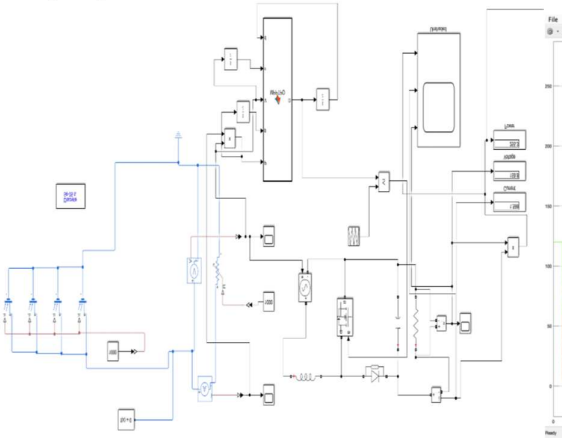

Figure 6. P&O method scenario simulation

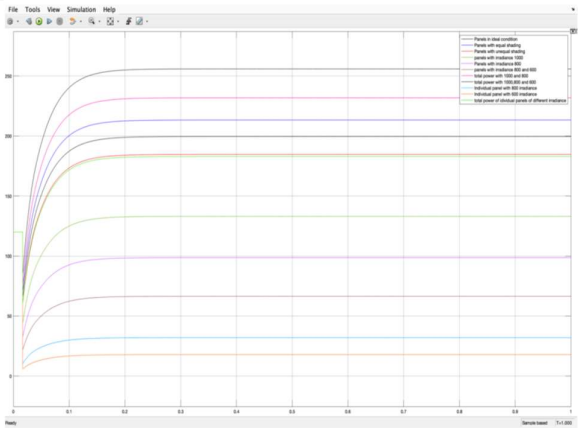

Figure 7. P&O method scenario simulation graph

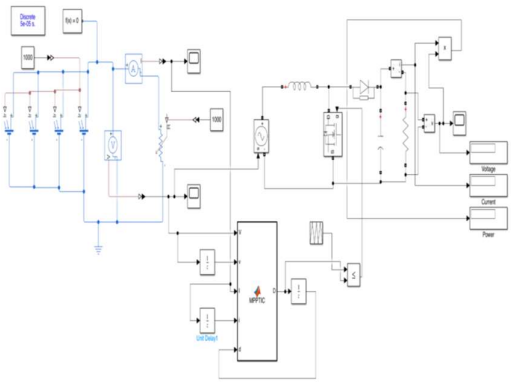

Figure 8. IC method scenario simulation

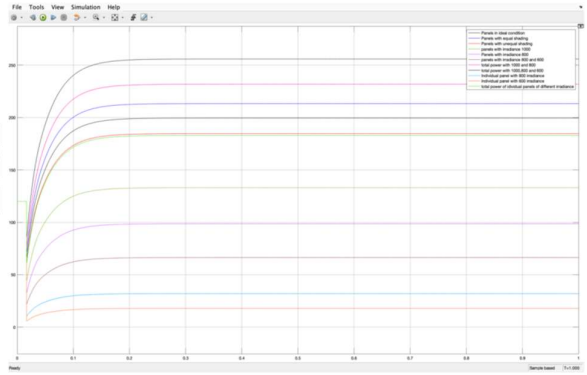

Figure 9. IC method scenario simulation graph

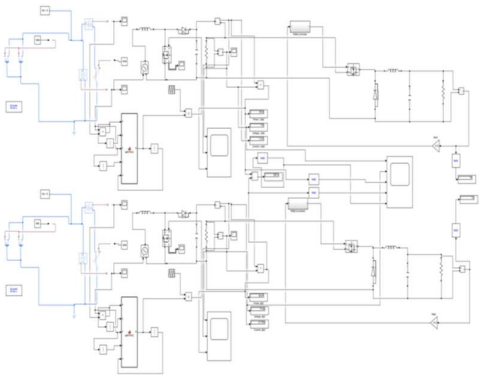

Figure 10. Project simulation

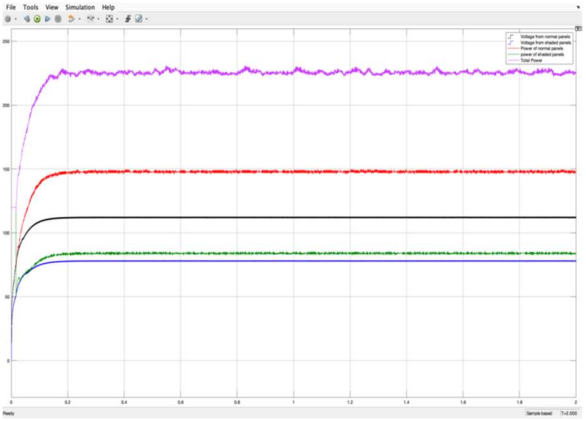

Figure 11. Project simulation graph

The entire model as depicted in fig 12 is divided into two sections: Relay section, Charge controller section. The Relay section consists of relay arrangement of 12 relays and their indications, an Arduino uno board, voltage divider circuit, blocking diode and input plugs for panels and their indicators. The charge controller section consists of two MPPT module, a boost convertor and a buck convertor, a charge controller module and a battery. Voltage from panels is read by voltage divider, the required signals are sent to the board. The uno board decides based on the voltage whether the panels are shaded or not. Based on this decision the panels are divided, the output from these divided panels is sent to the respective MPPTs. The MPPTs are in turn connected to the respective convertors (buck or boost) this in turn is connected to charge controller and to the battery completing the power flow.

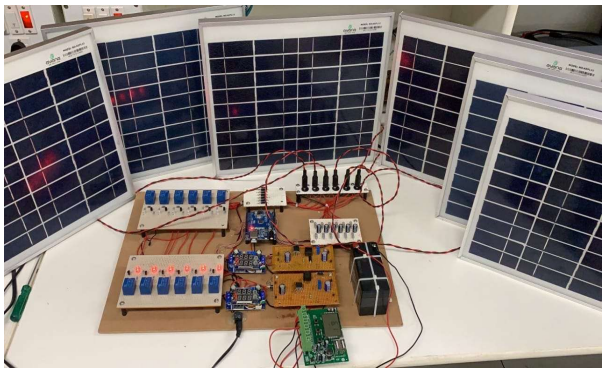

Figure 12. Project Setup

V. CONCLUSION

The paper gave us detailed information on the importance of the solar energy. Further an analysis of different papers was made to get an idea about several other MPPT techniques conducted in partial shaded condition of PV arrays. Lastly the proposed methodology to counter the Partial shading losses in the Solar/ PV panels is proving to be promising. The simulation results are indicating that the methodology of splitting the panels as Shaded or Unshaded panels which are fed to separate mppts, thus increasing the overall output

of the proposed system. It is indicated that the overall power can be increased by 15 to 20 percent in the ideal case without losses considered in the relay part. With the completion of the Hardware, the exact amount of increase in power can be determined. Using the above simulations, we can understand that the prescribed method can be used. Thus, trying to find a new way to counter the partial shading problem.

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