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Review of Maximum Power Point Tracking Based PV Array to Produce Electric Energy

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Abstract - *The isolated DC microgrid is independent from the power grid. It consists of distributed energy sources (DER) in the form of solar photovoltaic (PV) panels, as well as batteries and connected loads. The goal of this concept is to meet the growing demand for energy. Until now, countries like India have used conventional energy sources, which are in limited supply. To balance the growing demand for energy, the best way is to switch to renewable sources for energy production. Also in dark areas where it is almost impossible to transport electricity, this concept of an isolated DC microgrid can be implemented to electrify remote areas. Another advantage is that; earn carbon credits. The whole system includes a photovoltaic generator, an MPPT (Maximum Power Point Tracking) algorithm and a battery to maintain the voltage level because the nature of solar energy is intermittent as the glare from the sun fluctuates each time. This is achieved using the MPPT charge controller. The electronically operated DC-DC converter is MPPT, which stands for Maximum Power Point Tracking. MPPT controller improves solar and battery power. It also protects the battery from overcharging, thus protecting the battery. The voltage obtained from MPPT is DC voltage and is used for the operation of the AC charging inverter circuit. This article presents an MPPT design using the observation and disturbance method.*

Key Words: *PV solar array, Battery, Load, MPPT charge controller, Arduino*.

1. INTRODUCTION

A MicroGrid (MG) is a small power grid designed for the reliable and massive integration of distributed generation (DG) at the low-voltage level, especially renewable energy (photovoltaic (PV) and wind (WT) systems), low-tech carbon (fuel cell (FC) [1]. However, the integration of energy storage systems (ESS) in MG is necessary since they are the main responsible for compensation of energy balances [2]. An MG is a flexible network and can connect to the main network or operate as an island [1], [3]. An example of MG AC is shown in FIG. 1. Includes micro sources (MS) (photovoltaic system (PVS), wind turbine and fuel cell), ESS, loads (controllable and uncontrollable) and electric vehicle (EV). The connection to the main network is controlled by the intelligent switch (IS). In case of malfunction or unforeseen events in the core network, the IS transparently disconnects the MG from the core network [4]

The first technical literature for microgrid was first proposed in and as a solution to integration problem of renewable energy resources (RESs) in a Microgrid (MG)[4]. A number of definitions based on different control aspects and type of sources connected to MGs are available; here, an MG can be defined as a local or a small scale energy grid at distribution side having control capabilities within. An MG can work while connected with the main grid (grid-connected mode) or without a grid connected to it (Islanded mode).Rural and remote areas already suffer from load shading issues due to lack of electricity or small-scale independent power systems, such as diesel generator-based power systems, typically without renewable energy sources to provide the required power.

The integrated renewable energy system is used to provide dark areas with a more sustainable form of energy [5].Therefore, a small unit of such a power system, known as a microgrid or mini-grid, could be seen as a viable solution to maintain the progress of power supply in remote areas for critical loads, while reducing greenhouse gas emissions. , increasing the carbon credits obtained through efficiency. use of available renewable resources. The microgrid is a low-voltage transmission network that can be connected to the grid or an isolated off-grid system.

Photovoltaic panels are connected in series and parallel to provide the necessary voltage and power. The efficiency of the solar photovoltaic generator is low because the sun is intermittent in nature. Therefore, it is necessary to increase the efficiency and maintain a constant voltage. The nature of solar energy is continuous in nature. It can be set to different power levels to adjust the output between the panel and the battery using the MPPT (Maximum Power Point Tracking) charge controller to maximize the efficiency of the solar panel and also protect the battery from overheating. Therefore, this article aims to increase the efficiency of photovoltaic solar panels using MPPT charge controller.

MPPT techniques are used to get maximum power from the PV array, while many DC-DC converter topologies are used to transfer maximum power from PV modules to batteries. Different modes of MPPT have been proposed,for instance. open-circuit voltage methods, short-circuit current methods, fuzzy logic technique, disturbance and observation (P&O), incremental conductance (IC) technique. Among the

different MPPT modes, the Perturbation and Observation (P&O) technique produces excellent results and is relatively easy to implement and use [6]. This work consists of the design of the MPPT charge controller using a DC-DC step-down converter. The converter is controlled by arduino.

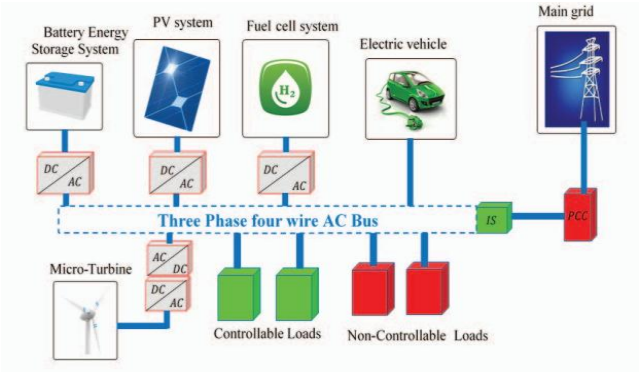

Figure 1: Example of an AC microgrid

2. BACKGROUND

All tropical countries are endowed with good natural resources. Solar power, wind power, tidal power, hydropower are some examples.

As for India, it has 34 solar parks in 24 states whose energy can be used in many fields, such as agriculture, for industrial purposes, or for some household appliances separately in rural or urban areas. It also holds the record for the world's largest rooftop solar installation of 12.5 MW in Punjab [7]. The other sources such as wind power, tidal power and hydroelectric power are widely used in some parts of the country.

Considering India, it has 34 solar parks in 24 states, the energy of which can be used everywhere in many fields like in agriculture, for industrial use or for some home appliances separately in rural or urban areas [8]. It also held record of world's largest solar roof top installation of 12.5MW in Punjab [9]. The other resources like wind energy, tidal energy, hydro power energy are widely used in some of the country.

3. STRUCTURAL OVERVIEW

3.1 PV ARRAY

The solar model consists of many photovoltaic cells in parallel and series connection and this entire representation constitutes the PV array [10]. The PN junction is formed by these cells made up of silicon crystals, thereby forming the semiconductor wherein the electrons move freely to combine with the holes to form electron-hole pairs. This process of electron-hole pair generation leads to the formation of depletion region (also known as space charge region) which is deprived of any charge carriers .

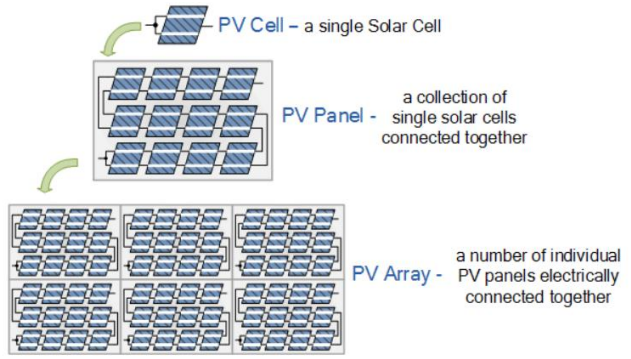

Figure 2 : Photovoltaic Solar Array

Photovoltaic cells and panels convert the solar energy into direct-current (DC) electricity. The connection of the solar panels in a single photovoltaic array is same as that of the PV cells in a single panel.

The panels in an array can be electrically connected together in either a series, a parallel, or a mixture of the two, but generally a series connection is chosen to give an increased output voltage[11]. For example, when two solar panels are wired together in series, their voltage is doubled while the current remains the same.

The size of a photovoltaic array can consist of a few individual PV modules or panels connected together in an urban environment and mounted on a rooftop, or may consist of many hundreds of PV panels interconnected together in a field to supply power for a whole town or neighborhood [12]. The flexibility of the modular photovoltaic array (PV system) allows designers to create solar power systems that can meet a wide variety of electrical needs, no matter how large or small.

It is important to note that photovoltaic panels or modules from different manufacturers should not be mixed together in a single array, even if their power, voltage or current outputs are nominally similar [13]. This is because differences in the solar cell I-V characteristic curves as well as their spectral response are likely to cause additional mismatch losses within the array, thereby reducing its overall efficiency.

3.2 MAXIMUM POWER POINT TRACKING

An MPPT, or maximum power point tracker is an electronic DC to DC converter that optimizes the match between the solar array (PV panels), and the battery bank or utility grid. To put it simply, they convert a higher voltage DC output from solar panels (and a few wind generators) down to the lower voltage needed to charge batteries

Maximum Power Point Tracking is electronic tracking - usually digital. The charge controller looks at the output of the panels and compares it to the battery voltage. It then figures out what is the best power that the panel can put out

to charge the battery. It takes this and converts it to best voltage to get maximum AMPS into the battery. (Remember, it is Amps into the battery that counts). Most modern MPPT's are around 93-97% efficient in the conversion. You typically get a 20 to 45% power gain in winter and 10-15% in summer. Actual gain can vary widely depending weather, temperature, battery state of charge, and other factors.

MPPT serves the purpose of tracking the solar energy to achieve maximum power from the PV system. The various types of MPPT are listed below [5]:

1) Perturb and Observe
2) Incremental conductance
3) Fractional short circuit current
4) Fractional open circuit voltage
5) Fuzzy Logic
6) Neutral Network

A specific algorithm to be used depends upon the nature of complexity and time taken to track the maximum power. In this representation, perturb and observe method is used using MATLAB/ Simulink [14].

Perturb and Observe

In this technique, as the name suggests, perturbation and observation is done to get the MPP. A perturbation is done to vary the output power of the PV module by periodically measuring it and comparing with the previous power. If the output decreases, then the perturbation is reversed or else the same process is repeated. If the power is increased due to increase in voltage, the operating point is on the left of Maximum Power Point and thus, the PV module will perform further perturbations on the right to reach the MPP. Contrarily, if the power is decreased due to increase in voltage, the operating point is on the right of the Maximum Power Point and thus, perturbations will be performed on the left to reach the MPP [15, 16]. The process flow chart adopted is shown in the figure below. The MPPT charge controller linked between the PV module and the battery plays an important role of measuring the array and battery voltages. It also detects when the battery is completely charged and protects it from over charging [17, 18].

Similarly, when the battery is not charged completely, it activates the converter circuit to charge the battery. The new power, P(new) is measured by the microcontroller and compares it with the previous power P(old). If P(new) is greater than P(old), then the maximum power is extracted from the PV panel by increasing the PWM duty cycle. Conversely, when the P(new) is less than P(old), then the system is moved back to the previous maximum limit by decreasing the duty cycle. Hence, this method is simple to effectuate with very little complexities and with low cost [19, 20].

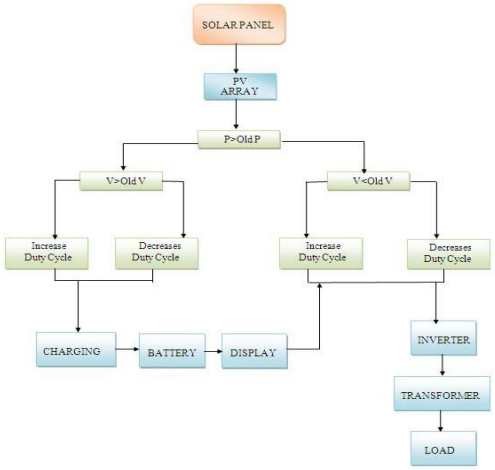

Figure 3: MPPT Algorithm.

The load and PV array will interface with each other if there is tunable matching network present beetween them then mppt operate accurately. As we can see in fig .3 below are the main portions of PV cell are power stage and controller. For switching on power stage DC to DC converter are used. In this case we are using Buck converter which is connected to PV array for employing PWM control .

For maximum exactraction of power from PV array the control parameter is duty ratio which is δ, utilized for tunning of the network.

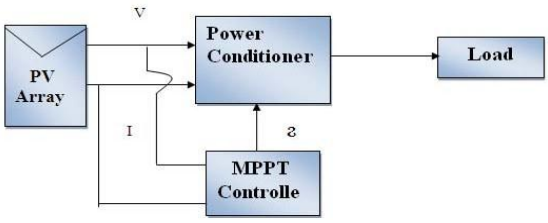

Fig.3. MPPT with PV system.

The characteristic graphs of MPPT and PV array are shown in below fig.4. Which give us the maximum operating point in both the cases, like in P-Vcurve and I-V curve.

There are varies method of MPPT techniques listed below. The necessity of MPPT used here is dealing with volatge parameter, absence of periodic tunning, easy in implementation and should have instant changing convergence speed . These all conditions are fulfiiled by Perturb and Observe method from all MPPT techniques.

TABLE 1: Characteristic Comparison Of Different MPPT Techniques

MPPT Techniques	Convergence speed	Implementation complexity	Periodic tunning	Sensed Para-meters
Perturb and Observe	Varies	Low	No	Voltage
Incremental conductance	Varies	Medium	No	Voltage, current
Fractional Voc	Medium	Low	Yes	Voltage
Fractional Ioc	Medium	Medium	Yes	Current
Fuzzy Logic	Fast	High	Yes	Varies
Neutral Network	Fast	High	Yes	Varies

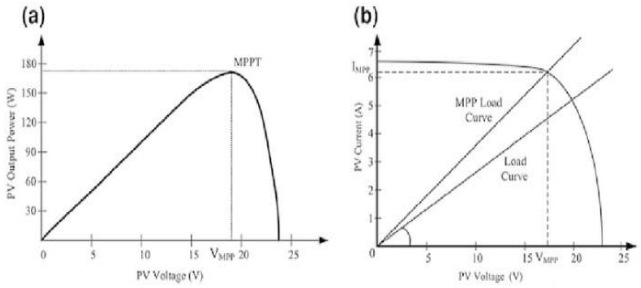

Figure 4: Interfacing graph of PV and MPPT.

3.3 BOOST CONVERTER

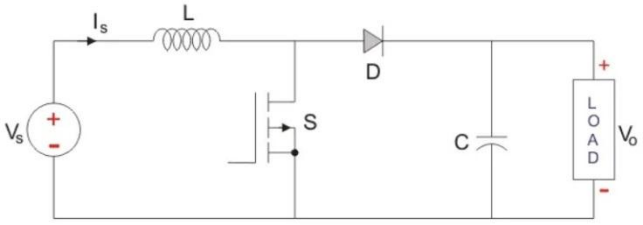

Figure 5 : Boost Converter Circuit Diagram

DC-DC converters are also known as Choppers. Here we will have a look at the Step Up Chopper or Boost converter which increases the input DC voltage to a specified DC output voltage. A typical Boost converter is shown below.

The buck device could be a terribly straightforward style of DC to DC converter that produces an output voltage that's but its input . The buck device, because the name suggests "bucks" or acts against the input voltage. The output voltage of a perfect buck device is adequate to the merchandise of the change duty cycle and therefore the provide voltage [22]. The dc to dc device is employed to step down the 18 volts obtained from the PV array to 12 volts which fits to the resistances circuit [24, 25].

3.4 INVERTER

Inverter is a basically a device that converter the electricity derived from a DC source to AC source [28]. The converter is totally based on the application. In a solar energy system, as an example, the ability hold on by batteries charged by star panels is born-again to straightforward AC power by the electrical converter, that provides the ability to plug-in shops and alternative normal 120 volts [24].

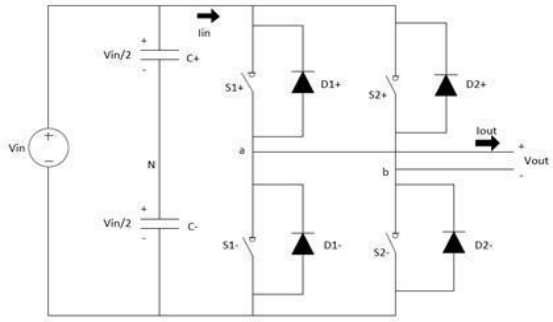

Figure 6: Inverter Circuit Diagram

3.5 WORKING

In the isolated dc micro grid the working is totally based on the block which we have studied above. When sun rays of the sun hits on the solar panel then the MPPT gets activated and collect the good amount of energy coming from sun. The MPPT will send this charge to the voltage divider for stepping down the voltage, as arduino require voltage only up to 5V and the output voltage getting from the solar is 18V. These all rating are displayed on the LDC display. The output from the arduino is given to the inverter and then to the transformer and finally to load. This process takes place at the day time. At night, the voltage remains after dividing the voltage is get stored in the battery which is connected to MMPT device. So at the day time battery get charged form the sun and stored energy, and the night when no sun available the charged battery can be used from the consumer [3]. This is method to generate a separate and independent source of electricity to the remote parts.

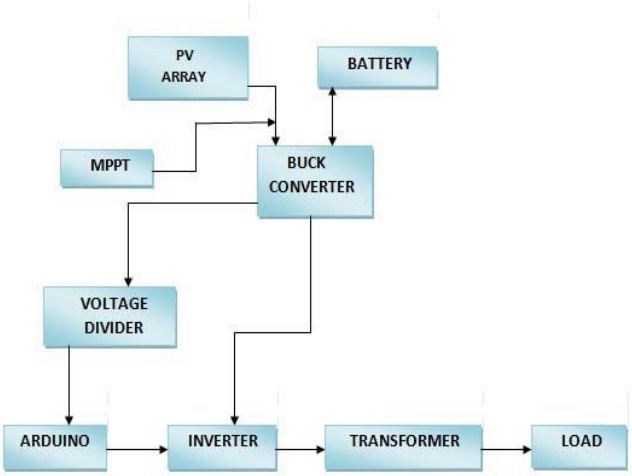

Figure 7: Basic Block Diagram of MPPT PV Array

As the concept is completely based on renewable source of energy i.e. solar energy, this idea can be extended at a great level in future. Taking as an example, India receives all over 5000 trillion kWh of pure solar energy each year which is excessively more than the electricity consumption of the country. The geographical location of India will help to implement more such projects based on the renewable source of energy. It will help diminish the problems of frequent power outages and discontinuity of supply. It is also reliable and has cost benefits. The cost will mainly be dependent on the development and installation, storage of energy as well as on the automation of grid. The barriers to overcome are monitoring and control, storage and alternative generation source, cost collection, site identification, changing weather, etc.

4. LIMITATION

- In rainy season the irradiation of solar would fluctuated, which may affect the efficiency of MPPT output.
- Even after achieving the MPP, the system will still perform perturbations to achieve another maximum point.
- In a circumstance where the irradiance changes rapidly, the MPP likewise proceed onward the correct hand side of the bend [4].

5. CONCLUSIONS

Since, major parts of India have not been electrified yet, this project will provide with an alternate solution to use electricity without any interruptions. The implementation is simple and hence, ease of use is collateral.

The coordination of various components used enables high efficiency and a sense of getting electricity independently and using it judiciously.

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