AN INNOVATE ON HYBRID POWER GENERATION ON DC–DC BUCK CONVERTER WITH MPPT SYSTEMS

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Abstract – There are two types of DC-DC buck-boost converters used in solar Maximum Power Point Tracking (MPPT) PV systems: stand-alone and grid-connected. Stand-alone PV systems are employed in places where there is no access to the utility grid. The performance of a PV system in these systems is determined by the operating conditions. Three variables have a significant impact on the maximum power collected from a PV source: irradiation, load profile, and temperature. Grid-connected PV systems are employed in places where the utility grid is readily available. The solar module provides the maximum power at the point on the I-V curve where the product of voltage and current is greatest. The Maximum Power Point is the name given to this point (MPP). The voltage level at each bus, as well as transmission line losses, have been simulated and tabulated. The consequences of integrating wind turbine generators with the defined grid have been studied. This thesis proposes a DC-DC Buck-Boost converter with a solar MPPT algorithm for the analysis of solar PV installations. When compared to the other converters stated in this study, the proposed technique outperforms them.

Keyword- HPG systems, DC–DC Buck Converter, Maximum Power Point Tracking

Introduction –

MPPT (Maximum Power Point Tracking) ensures that the PV module operates at its maximum electricity point (MPP), extracting the most power possible. The solar system may generate maximum electricity successfully if the irradiance situation is good and the system is using an effective MPPT algorithm. MPPT techniques such as the Differential approach, Perturb and Observe (P & O), Incremental Conductance (Inc. Con.), Curve fitting, Open- Circuit Voltage PV generator, Short circuit PV generator method, and others have been created by researchers from all over the world. Three elements determine the efficiency of a PV plant: the PV module's efficiency, the inverter's efficiency, and the MPPT algorithm's effectiveness. MPPT algorithms are necessary to extract the most power from a solar array because the MPP of a solar panel fluctuates with irradiance and temperature (Lu et al 2009). The P & O and Incremental Conductance algorithms are the most widely used of all the algorithms since they are simple to implement. The P-V curve has only one maximum point in most conditions, hence it is insignificant. If the PV array is partially shaded, however, these curves have a lot of maxima. shows a PV system that includes a PV panel, DC-DC converter, and MPPT controller.

1. A favourable performance-to-cost ratio is necessary to encourage the commercialisation of innovative PV technology.
2. An optimal control that can gather the highest output power from PV arrays under any operational and weather circumstances.

Designing a PV system that can achieve these technological requirements is a technically demanding aspect since the PV array has a highly nonlinear feature and its performance changes with operational variables such as insulation and ambient temperature. The DC-DC converter in a PV system has a significant impact on the system's efficiency. Various DC-DC converters used in PV systems have been the subject of many previous research. Converters are classified into a variety of groups based on their use, switching kinds, current modes, and other variables. In order to get the most power out of the PV panel, the performance of a solar power system with a buck converter was investigated. Each converter, according to a prior study, has its own set of benefits and drawbacks. As a result, it's critical to design a PV system that's high in efficiency, low in stress, and low in ripple. The maximum power delivered by a PV system is determined by irradiation and the operational point of the system. The impedance of a PV panel determines its operating point. MPPT controllers shift a PV panel's operating point from input impedance (Ri) to optimal resistance (Ro) (RMPP). Various MPPTs have been studied by various researchers in the past. For a variety of PV-based applications, early researchers explored the performance of a number of MPPT algorithms. Complex algorithms are clearly necessary to attain maximum MPPT efficiency, as evidenced by the aforementioned assessments. As a result, an MPPT controller that is both simple and effective is required for a PV system. As a result, this study proposes a unique DC-DC Buck-Boost converter with an MPPT controller for maximum power extraction from the PV system.

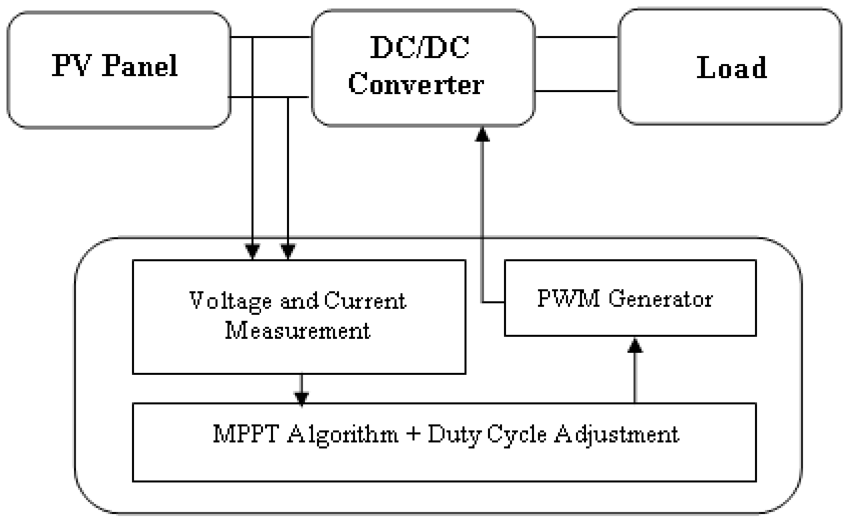

Figure 1 Block Diagram of PV Panel with Converter and MPPT

Methodology

A step-down converter is another name for a DC-DC buck converter (Bilsalam et al 2011). In typically, the voltage gain of this converter is less than one. As a result, this design allows high module voltages to be coupled to low load or battery voltages. It's an SMPS with at least two semiconductor switches (a diode and a transistor) and at least two energy storage devices (a capacitor and an inductor).

$$D = \frac{Vo}{Vi} (1)$$

where,

V_o is the output voltage of the converter

V_i is the input voltage of the converter.

<u>DC-DC Boost Converter</u>

A DC-DC boost or step-up converter's output voltage magnitude is always bigger than the input voltage magnitude (Nejabatkhah et al 2012). As a result, large load/battery voltages can be connected to low module voltages using this architecture. It's an SMPS that has at least two semiconductor switches (a diode and a transistor) and at least one energy storage device, such as a capacitor, inductor, or a combination of both. DCDC boost converter applications in PV systems have resulted from a number of research efforts. The duty cycle of the boost converter is

$$D = 1 - \frac{Vi}{Vo} (2)$$

DC–DC Cuk converter

The Cuk converter (Vaigundamoorthi & Ramesh 2012) is a DC-DC converter that functions similarly to a buck–boost converter, allowing it to step up or down the input voltage with reverse polarity via the common terminal. This configuration can be used to connect module voltages to batteries or loads that are virtually identical. It's an SMPS with at least one semiconductor switch (diode or transistor) and at least four energy storage devices (two capacitors and two inductors). The difference between a cuk converter and a buck-boost system is the addition of a capacitor and an inductor. The inductor Li, which filters the large harmonics in the DC input, is the energy transfer device. The duty cycle of the cuk converter is,

$$\frac{D}{1-D} = \frac{Vo}{Vi} \qquad (3)$$

The continuous current at the converter input and output is a significant benefit of this topology. Many academics have concentrated on it in order to harvest the optimum amount of electricity from PV panels using various methods. The cuk converter's only flaw is the enormous electrical stress placed on the switch, diode, and capacitor C1. It demands a reduction in component stress in order to increase efficiency.The duty cycle of the cuk converter is:

DC-DC Buck- Boost Converter

The circuit diagram for a DC-DC buck-boost converter (Sahin&Okumus 2012). When switch S1 is turned on, it operates in buck mode, while switch S2 is always turned off. Supply voltage appears across the load when S1 is closed, and the inductor stores energy. When S1 is opened, the inductor's stored energy freewheels through the load and diodes D1, D2. Switch S1 is remained in the ON position while S2 is turned on to function in boost mode.

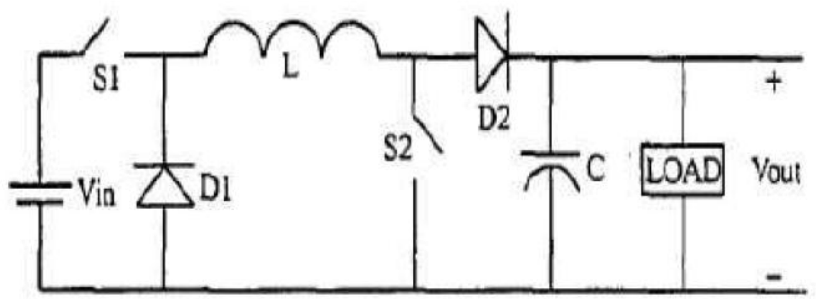

Figure 1 Circuit Diagram for DC-DC Buck-Boost Converter

Inductor L stores energy when S2 is closed, and when S2 is opened, the supply voltage appears across the load, and the energy in the inductor appears as additive energy to the load, resulting in boost operation.

Because both buck and boost operation are dependent on the energy of the inductor, which is further dependent on its predicted value, the design of L and C is critical for both software and hardware implementation. The formulas below can be used to calculate L and C.

$L=V_{in}* \delta /(f*dI)$ (4)

$C=I_{out} * \delta /(f*dV)$ (5)

$dI=0.8+I$ (6)

$\delta = (V_{out} + V_d)/(V_{out} + V_{in} +V_d)$ (7)

Where, Vout = output voltage

Vd = diode forward drop

Vin = minimum input voltage

I = average inductor current = Iout/(1- δ)

Iout = average output current

f=switching frequency

dV=output ripple voltage

dI = ripple current

δ = duty cycle

The performance characteristics of a DC-DC Buck boost converter with MPPT controller are examined and shown in this research study using the MATLAB/ SIMULINK software platform. Figure shows the simulation schematic for the proposed DC-DC Buck Boost Converter with solar MPPT controller, while Figure 2 shows the converter's control circuit.

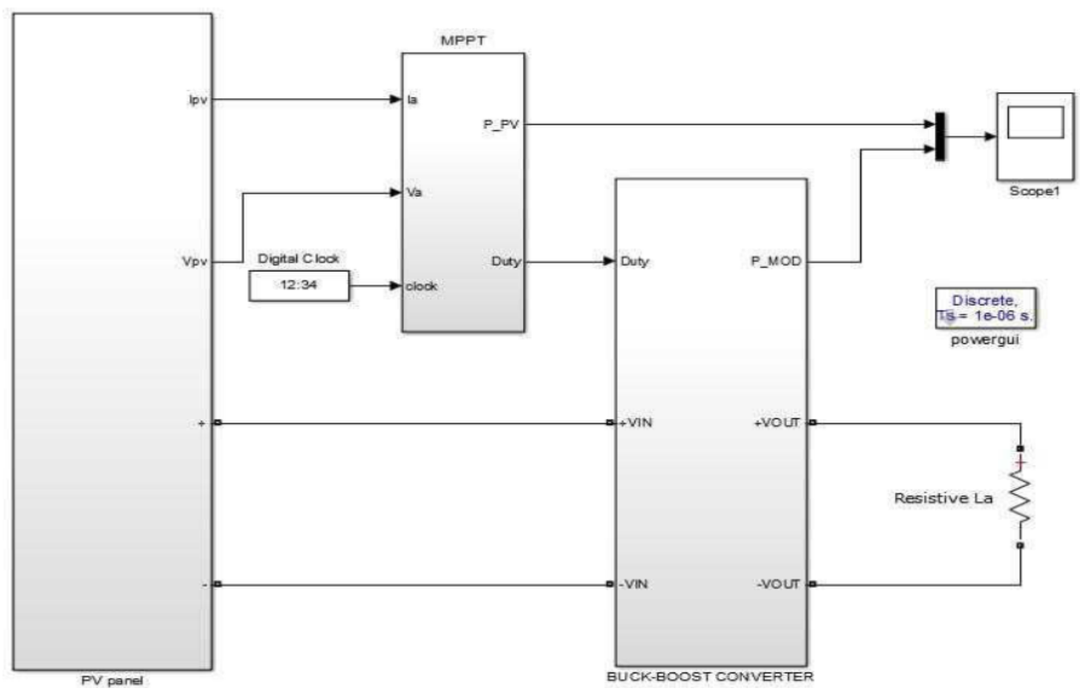

Figure 2 Simulation Diagram for DC-DC Buck Boost Converter with Solar MPPT Controller (MATLAB/SIMULINK Model)

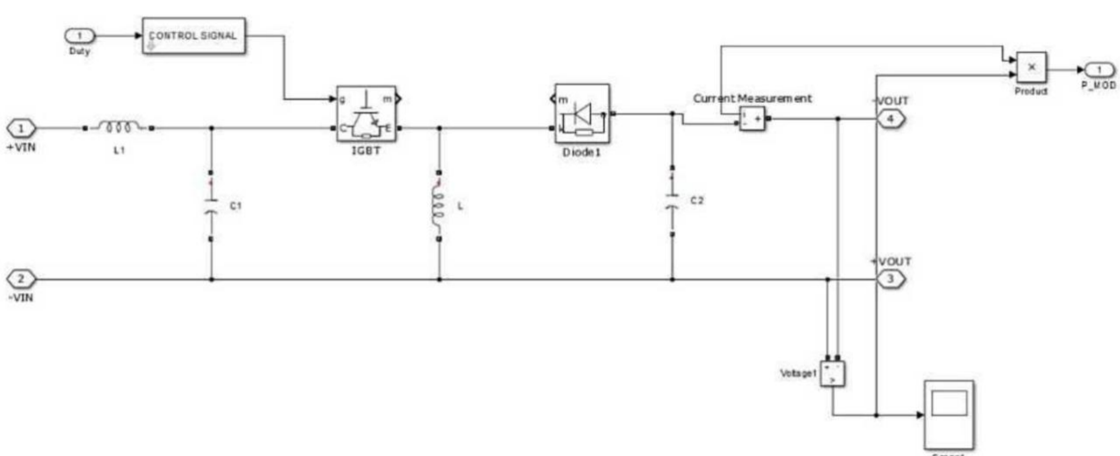

Figure 3 Simulation Diagram for DC-DC Buck Boost Converter Control Circuit

The performance characteristics for power output from the solar panel and the MPPT are illustrated in Figure 3.

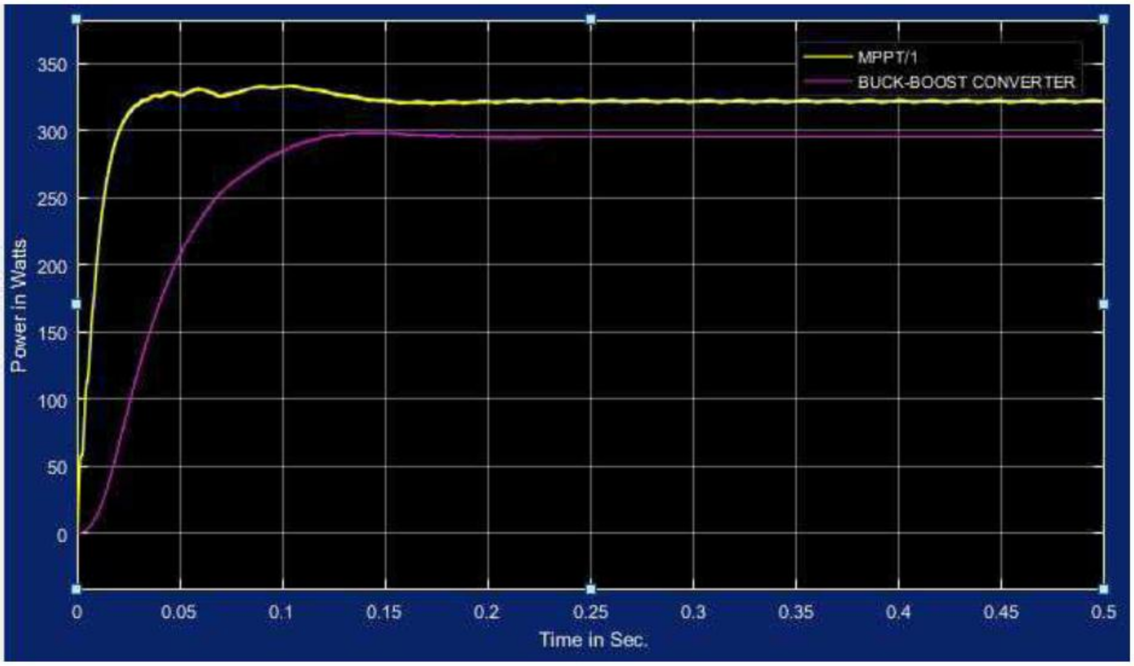

Figure 4 Performance Characteristics of Solar Panel and MPPT Controller

The output voltage from the converter is given in Figure 5

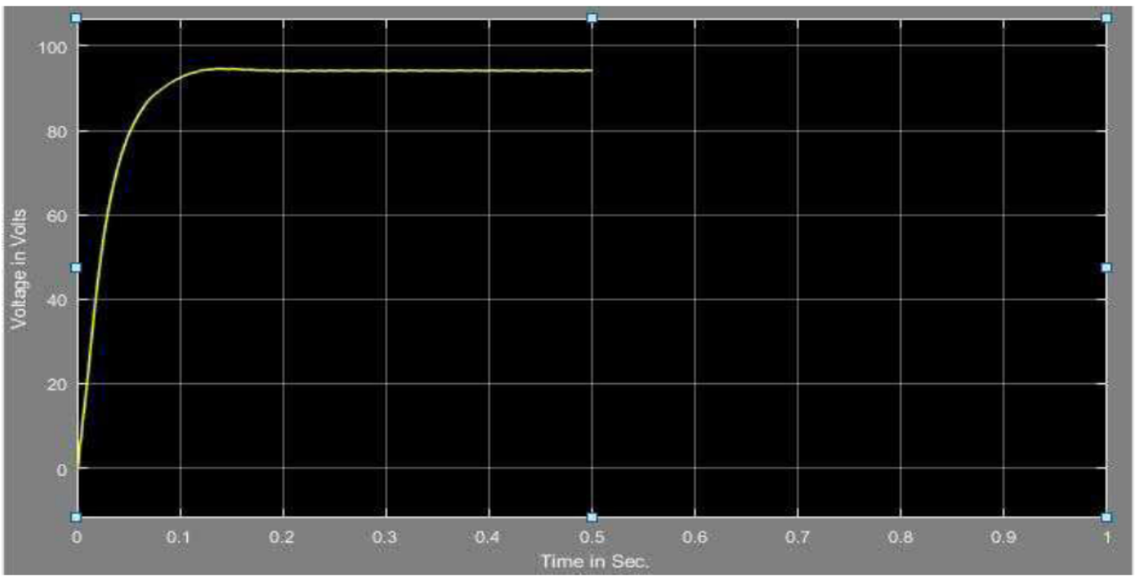

Figure 5 Output Voltage from DC-DC Buck-Boost Converter

MPPT Algorithms for PV System

It is difficult to improve the efficiency of the PV panel and inverter because it is dependent on the technology available. It may necessitate higher-quality components, raising the installation cost significantly. As a result, using new control algorithms to improve the tracking of the Maximum Power Point (MPP) is easier and less expensive. A simple and effective MPPT controller is required for an efficient PV system. Traditional MPPT approaches like Perturb & Observe (P&O) and incremental conductance are compared in this study.

Perturb & Observe (P&O) MPPT

As the name suggests, the Perturb and Observe (P&O) approach is based on inspecting the array output power and perturbing (adding or removing) the power in response to changes in array voltage or current. With regard to the preceding power sample, this approach constantly adds or subtracts the reference current or voltage. Figure 5 depicts the working of the P&O MPPT. The computation of the current state k and the prior state k-1 of the parameters V and I is taken into account. The current and prior states of the power P and voltage V parameters are compared. Increase or decrease of perturbed voltage V will be applied to the PV module operating voltage according to the criteria shown in Figure 4.58. Figure 4.58 depicts the power-voltage characteristic feature of the PV model, which explains the MPP tracking mechanism. There are four probable scenarios which will affect the direction of the tracking in P&O MPPT.

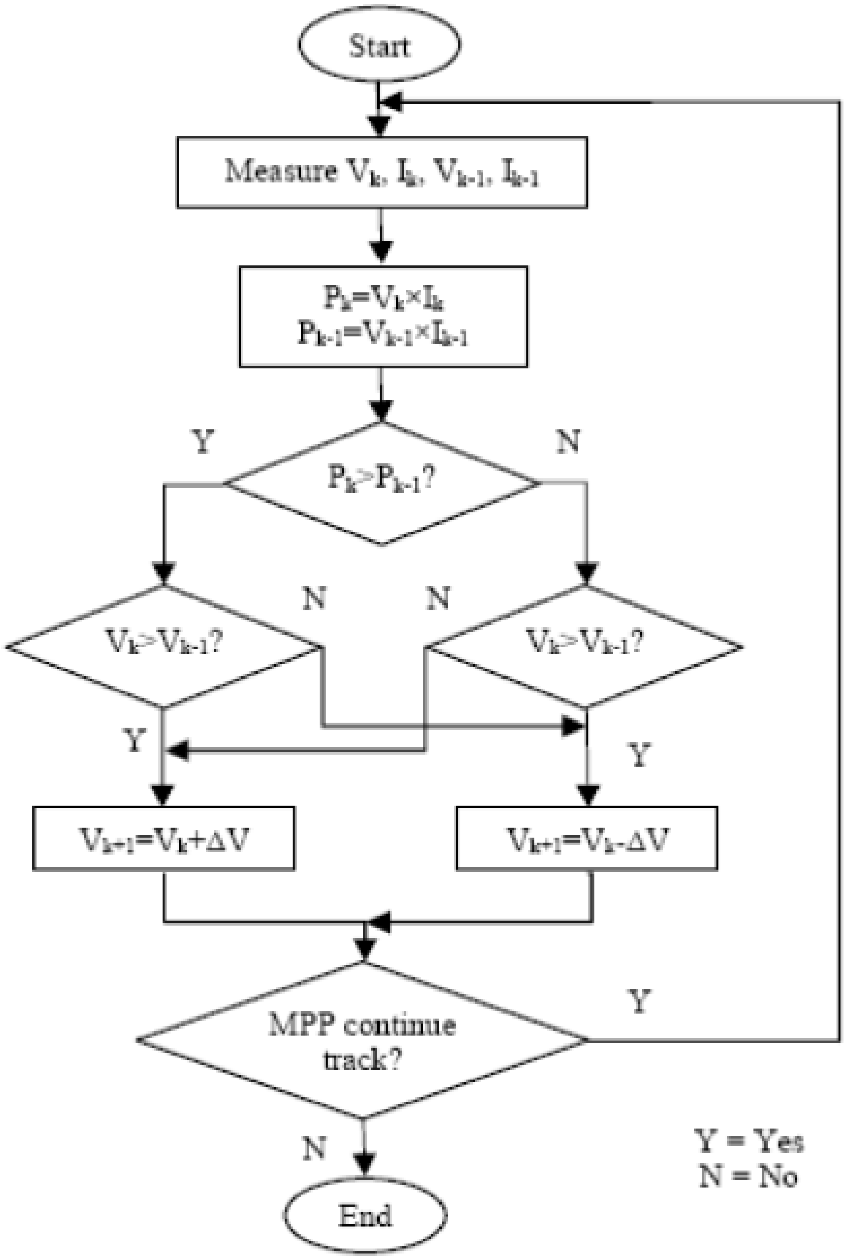

Figure 6 Flowchart of P&O Algorithm

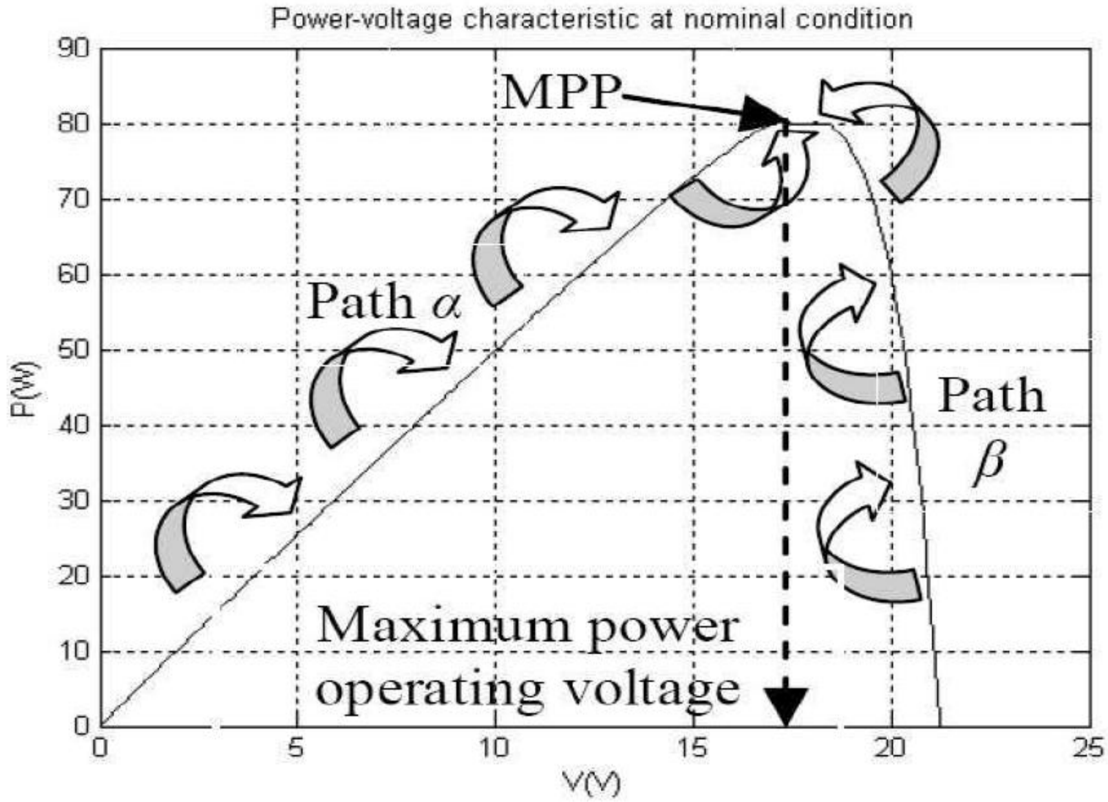

Figure 7 Principle of MPP Tracking

Case I The situation can be illustrated as path in Figure 6 for Pk> Pk-1 and Vk> Vk-1. When the operational voltage is raised, the PV power rises along with it. As a result, a modest voltage change of V must be applied to the current PV operating voltage, followed by PV power monitoring. This procedure is repeated until the MPP is found.

Case (ii) The Pk> Pk-1 and Vk Vk-1 are referred to in Figure 4.58 as the way. When the working voltage is reduced, the PV power increases, as can be seen. To identify the MPP operating point, the current PV operating voltage should be reduced by V, and the parameters Pk and Pk-1 should be compared. If the criteria Pk> Pk-1 is met, V will continue to decrease until the MPP is effectively spotted.

Case (iii) In Figure 7, the Pk Pk-1 and Vk> Vk-1 can be shown as a path. In this case, when the PV operating voltage rises, the PV power decreases. As a result, the current PV operating voltage should be reduced by V.

Case (iv) In Figure 4.58, the Pk Pk-1 and Vk Vk-1 are shown as path. The PV power decreases as the PV operating voltage decreases. As a result, the PV operating voltage should be increased by a factor of V to match the PV maximum power point.

The PV module operational voltage is disturbed in every cycle, which is the fundamental disadvantage of the P&O MPPT technique. This algorithm will always increase or decrease the PV operating voltage by a factor of V. Even after the MPP has been successfully monitored, the maximum power tracking process will continue. This is due to the fact that the PV module's output power for the next perturbed cycle is unpredictable.

4.5.6 Incremental Conductance MPPT

The array terminal voltage is always modified according to the MPP voltage in the incremental conductance approach. It is based on the PV module's incremental and instantaneous conductance. The PV array power curve has a slope of zero at MPP, increasing on the left side of MPP and decreasing on the right side of MPP.

The basic equations of this method are as follows:

$$\frac{dI}{dV} = -\frac{I}{V} \quad at\ MPP \qquad (8)$$

$$\frac{dI}{dV} > -\frac{I}{V}\text{left at MPP} \qquad (9)$$

$$\frac{dI}{dV} < -\frac{I}{V}\text{Right of MPP} \qquad (10)$$

PV array output current and voltage are represented by I and V in the equations above. The incremental conductance of a PV module is shown on the left side of the equations, while the instantaneous conductance is represented on the right. The solar array will function at the MPP when the ratio of change in output conductance equals the negative output conductance. In other words, the MPPT will track the maximum power of the PV module by measuring the conductance at each sampling interval. The incremental conductance algorithm's operating flow chart is shown in Figure 8. It all starts with determining the PV module's current voltage and current values. The incremental changes (dI and dV) are then calculated using the current and historical voltage and current values. The major check is conducted out utilizing the Equation 8-

10 relationships. If the condition does not satisfy Equation 10, the operating point is presumed to be on the left side of the MPP, and the module voltage must be increased to move into the right.

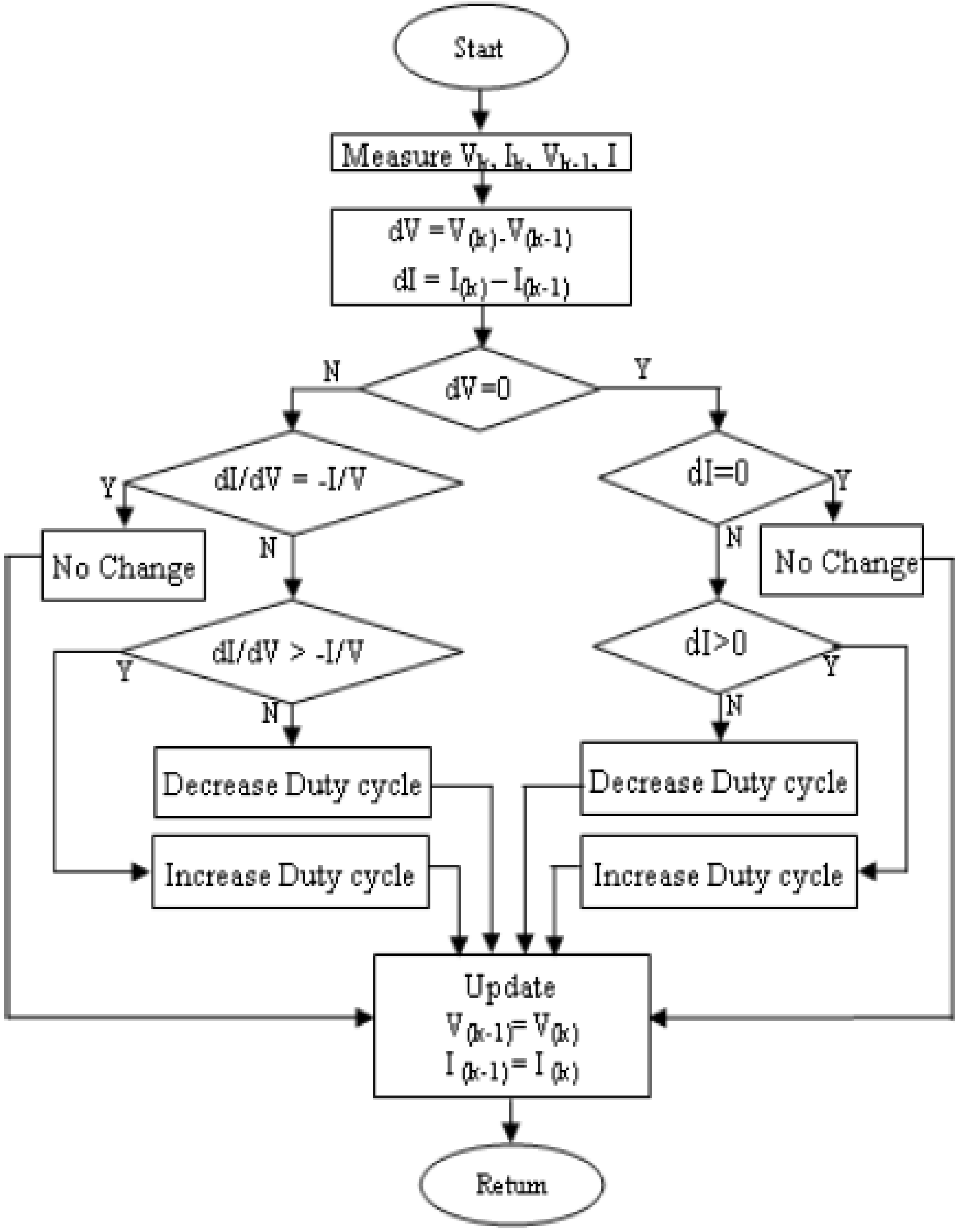

Figure 8 Flowchart of Incremental Conductance

Similarly, if the condition fulfils the inequality Equation 10, the operating point is expected to be on the right side of the MPP and must be shifted to the left by lowering the module voltage. When the operating point approaches the MPP, the condition fulfils Equation 8, and the voltage adjustment is skipped by the algorithm. Finally, at the end of the cycle, it saves the voltage and current data that will be utilised as prior values in the following cycle, updating the history. The disadvantage is that noise in the components causes reliability concerns.

The numerical performance of the aforesaid converters with the P&O and Incremental Conductance methods is shown in Table 1. Table 1 shows that the suggested Buck-Boost Converter outperforms other converters in terms of efficiency.

Table 1 Comparison of Efficiency for Converters with MPPT

MPPT	**P&O**			**INC. CON**		
Converter	**P_{in} (watts)**	**P_{out} (watts)**	**Efficiency (%)**	**P_{in} (watts)**	**P_{out} (watts)**	**Efficiency (%)**
BUCK	400	322.4	80.6	400	331.3	82.83
BOOST	400	321.7	80.43	400	330.5	82.63
CUK	400	323.9	80.98	400	332.6	83.15
BUCKBOOST	400	325.2	81.3	400	336.4	84.1

Conclusion

We looked at PV systems with various converters like as buck, boost, cuk, and Buck-Boost converters. P&O and incremental conductance MPPT techniques are used to examine each converter. The MATLAB/SIMULINK software platform is used to model the entire system. The suggested Buck-Boost converter with incremental conductance method provides a significant boost in solar PV system efficiency, according to simulation data.

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