3.12 Maximum power point tracking:

3.12.1 MAXIMUM POWER POINT TRACKING:

- MPPT or Maximum Power Point Tracking is algorithm that included in charge controllers used for extracting maximum available power from PV module under certain conditions. The voltage at which PV module can produce maximum power is called „maximum power point" (or peak power voltage). Maximum power varies with solar radiation, ambient temperature and solar cell temperature.
- A 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.
- Several algorithms were proposed to accomplish MPPT controller. Published MPPT methods include:
  (1) Perturb and Observe (PAO) ,
  (2) Incremental Conductance Technique (ICT), and
  (3) Constant Reference Voltage/Current.

Perturb and Observe (PAO):

- Perturb-and-observe (P&O) method, also known as perturbation method is a type of MPPT algorithm. The concept behind the "perturb and observe" method is to modify the operating voltage or current of the photovoltaic panel until you obtain maximum power from it. It is often referred to as hill climbing method, because they depend on the fact that on the left side of the MPP, the curve is rising ($dP/dV > 0$) while on the right side of the MPP the curve is falling ($dP/dV < 0$). Perturb and observe is the most commonly used MPPT method due to its ease of implementation. Perturb and observe method may result in top-level efficiency, provided that a proper predictive and adaptive hill climbing strategy is adopted.

Algorithm:

- The voltage to a cell is increased initially. If the output power increases, the voltage is continually increased till the output power starts decreasing. Once the output power starts decreasing, the voltage to the cell is decreased till maximum power is reached. This

process is continued till the MPP is attained. This results in an oscillation of the output power around the MPP.

Drawback:

- One of the major drawbacks of the perturb and observe method is that under steady state operation, the output power oscillates around the maximum power point.
- This algorithm can track wrongly under rapidly varying irradiation conditions.

Incremental Conductance Technique (ICT):

- Incremental conductance (INC) method is a type of MPPT algorithm. This method utilizes the incremental conductance (dI/dV) of the photovoltaic array to compute the sign of the change in power with respect to voltage (dP/dV). INC method provides rapid MPP tracking even in rapidly changing irradiation conditions with higher accuracy than the Perturb and observes method.

Algorithm:

- The power-voltage curve's slope is null at the MPP, negative to the right of the MPP and positive to the left of the MPP. INC computes the maximum power point by comparison of the incremental conductance ($\Delta I/\Delta V$) to the instantaneous conductance (I/V). When the incremental conductance is zero, the output voltage is ascertained to be the MPP voltage and fixed at this voltage until the MPP encounters a change due to the change in irradiation conditions. Then the process above is repeated until a new maximum power point is reached.

Advantage:

- This technique has an advantage over the perturb and observe method because it can stop and determine when the Maximum Power Point is reached without having to oscillate around this value.
- It can perform Maximum Power Point Tracking under rapidly varying irradiation conditions with higher accuracy than the perturb and observe method.

Drawback:

- It can produce oscillations and can perform erratically under rapidly changing atmospheric conditions.

- The computational time is increased due to slowing down of the sampling frequency resulting from the higher complexity of the algorithm compared to the P&O method.

CONSTANT REFERENCE VOLTAGE/CURRENT:

- ✓ Constant voltage method is a type of MPPT algorithm. This method makes use of the fact that the ratio of maximum power point voltage and the open circuit voltage is 0.76. It is the simplest MPPT control method.

Algorithm:

- ✓ The operating point of the PV array is kept near the MPP by regulating the array voltage and matching it to a fixed reference voltage Vref. The Vref value is set equal to the maximum power point voltage of the characteristic PV module or to another calculated best fixed voltage.
- ✓ One of the approximations of this method is that, variations encountered by individual panels need not be considered as the constant reference voltage can be considered as the maximum power point voltage.
- ✓ The data for this method varies with geographical location and has to be processed differently for different geographical locations. The CV method does not require any input. It is important to observe that when the PV panel is in low insolation conditions, the CV technique is more effective than either the P&O method or the IC method (analyzed below) .

Drawback:

- ✓ The current from the photovoltaic array must be set to zero momentarily to measure the open circuit voltage and then afterwards set to 76% of the measured voltage.
- ✓ Energy is wasted during the time time the current is set to zero.
- ✓ The approximation setting the voltage to 76% of the measured voltage is not accurate.