ABSTRACT

The world has been concerned with its stable operation of non-conventional PV power system without any adverse effect on the environment. Tracing the true Maximum Power Point (MPP) is critical for the implementation of an effective PV system. Consequently, a Maximum Power Point Tracking (MPPT) controller is required for the collection of maximum energy from the solar panel. Many PV panels can be connected in series or in parallel to obtain the necessary voltage and current. Due to the shade of woodlands, houses and moving clouds, partial shading conditions (PSC) occur in these systems and photovoltaic modules will be insolated differently. The PSC complicates the current versus voltage curve with multiple peaks. One of them is the real MPP known as Global MPP (GMPP), while all other MPPs are called Local MPPs (LMPPs).

The current research work aims to investigate how MPPT techniques for solar photovoltaic systems work for a stand-alone PV system under uniform and shaded irradiance conditions, and to include the best among the proposed MPPT approaches for grid connected system. The research initially explored the significance of an MPPT algorithm in a photovoltaic system for working with maximum efficiency using conventional P&O technique. The analysis showed that the MPPT algorithm improves system performance by significantly increasing PV power and thus improving PV systems effectiveness.

In this research work, for stand-alone photovoltaic system, four different MPPT approaches are suggested, named DFP&O, DFVSSP&O, ABCPO and PCC. In MATLAB / Simulink, a two-panel PV power system is modelled under uniform and PSC using traditional MPPT algorithms such as Perturb & Observe (P&O) and Incremental Conductance (INC), biologically inspired Artificial Bee Colony (ABC) algorithms, conventional and biological model hybrid (ABC-PO) and Predictive Current Control (PCC) methods.

The first work analyzes the conventional P&O and variable step size P&O (VSSPO) for tracking MPP of solar PV systems. The change in the operating point is referred to as drift, and the drift problem causes energy loss as insolation increases dramatically, resulting in lower efficiency. The drift phenomenon and the changes to eradicate the drift problem were studied. In the event of a rapid increase in sunlight, traditional P&O and VSSPO have drift in power output because there is no perception of increased sunlight. In order to overcome the drift problem, Drift Free P&O (DFP&O) and Drift Free VSSPO (DFVSSPO) under rapidly increasing insolation is proposed. An additional loop to evaluate the change in current would help to resolve the drift problem instead of only taking the change in power and voltage into account, as was the case with the general P&O algorithm. The simulated findings show that the MPPT drift free approach decreases power loss and time of tracking compared to conventional P&O and VSSPO. This enhances the competence of the proposed system by gaining a large power during the entire PV panel life cycle. Taking into account the general life expectancy of a photovoltaic system, the proposed drift free technology can make a considerable energy gain.

Partial illumination of solar cell results in unnecessary power loss. The shaded PV modules are typically shortened by bypass diodes which stop it from operating at negative voltage and dissipating energy. In fact, the resulting PV characteristic becomes more complex with multiple peaks. The traditional MPPT algorithms like P&O and INC may not be able to track the GMPP and may slip into any of the LMPP. This will cause power loss and result in low PV system performance. Therefore, through updating the algorithm for shading phases to track GMPP, the output of the system would certainly be improved. This can be accomplished by including an effective algorithm in the first stage prior to the application of the P&O. Therefore certain modifications were proposed to the P&O algorithm to improve its PSC performance. The bioinspired ABC algorithm is incorporated into the proposed method with the generic P&O algorithm to effectively monitor the GMPP within a PSC. The global search capability of ABC is first exploited in the search capacity of local

P&O to obtain a fast and efficient ABC-PO MPPT algorithm. This reduces the probability of convergence at LMPPs during PSC and prevents steady state swings. Three different shading patterns were used for simulations. The proposed ABC-PO algorithm exceeds existing P&O, INC and ABC algorithms under all conditions in all circumstances. It is found that in ABC-PO, a 30% decrease in maximum overshoot than the existing ABC algorithm. The findings of this simulation clearly demonstrate very detailed ABC-PO algorithm tracking properties with high efficiency, low return time and fast tracking speed.

In order to achieve the highest performance from the photovoltaic system, a different MPPT approach called predictive current control (PCC) is proposed. While moving on to PCC, the primary function of predictive control is to use the system's computational model to predict the controlled variables ' future behaviour with the current known values. This requires traditional P&O in the first stage and predictive mean value (PMV) technique in the second stage. The optimum duty cycle for the second phase is calculated by using the first stage reference current. The entire system is examined with (i) uniform irradiance conditions with a ramp input signal, (ii) partial shading conditions with three shading patterns and (iii) varying temperature conditions. The findings were analyzed in the performance aspects such as power, efficiency, tracking speed, maximum overshoot and payback time. The analysis shows that PCC work best and equally effective with the ABC technology than traditional P&O and INC techniques.

Finally, the P&O integrated Artificial Bee Colony algorithm is found to best of with all four MPPT technologies proposed and is used as an MPPT technique for a 1kW single-phase grid-connected network. ABC-PO is suggested to monitor GMPP under PSC for grid connected applications. In MATLAB / Simulink the effectiveness of the ABC – PO algorithm under PSC in grid-connected applications is validated using three different shading conditions. The converter and the inverter output are also achieved with the specified values under all three conditions. The voltage of 230V is also achieved on the grid side for all PSCs. In addition, the synchronization of grid current with grid voltage was carried out successfully under various irradiance and load conditions.