TO ENHANCE THE INSTANTANEOUS POWER PRODUCTION OF THE PV ARRAY

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ABSTRACT

This research will work on a project to improve the PV array's instantaneous power production when operating in partially shadowed situations. The thesis' key goals are as follows: To investigate the effect of partial shade on PV arrays using a literature review of textbooks and articles published in reputable international and national publications. To simulate a PV array under partial shade conditions, use an appropriate PV module model and modelling approaches. The purpose of this study is to see how partial shade affects the fundamental connecting schemes of a PV array. The purpose of this Paper was to see how important shading patterns are in PV array connecting systems. Develop a set structural approach for PV array module configuration. To evaluate the performance of PV array configurations.

Keywords: PV array's, solar cell.

I. INTRODUCTION

Because of new enthusiasm proclivities that improve the preservation of environment while meeting ever-increasing energy demand, renewable power production systems have become an essential study subject. Global energy consumption grew at a pace of 2.3 percent in 2018, the highest rate in the decade[1]. Because of their negative environmental impact and escalating expense, it is necessary to minimise the use of petroleum derivative-based sources. The year 2017 marked a watershed moment for renewable energy generation. Renewable installation additions of 178 gigawatts (GW) came out of nowhere, accounting for more than 66 percent of global net power capacity expansion. Solar photovoltaic (PV) installations grew the highest, reaching 97 GW, with China accounting for over half of this growth [2], [3]. Renewable energy output is predicted to expand by over 1 TW, or 46 percent, between 2018 and 2023, according to the International Energy Agency (IEA). Photovoltaic (PV) electricity accounts for about half of this increase, which is fuelled by government and market policies that encourage it[4]. Figure 1.1 depicts the increase in renewable energy generation, whereas Figure 1.2 depicts the increase in PV power generation.

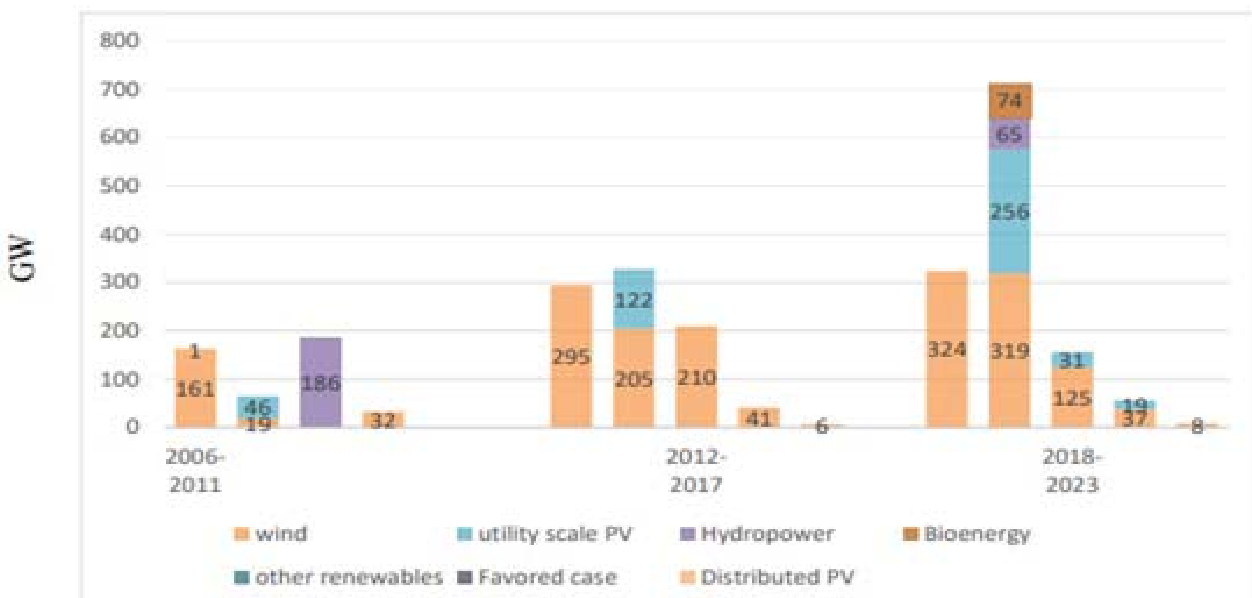

Fig. 1.1. Growth in renewable power generation.

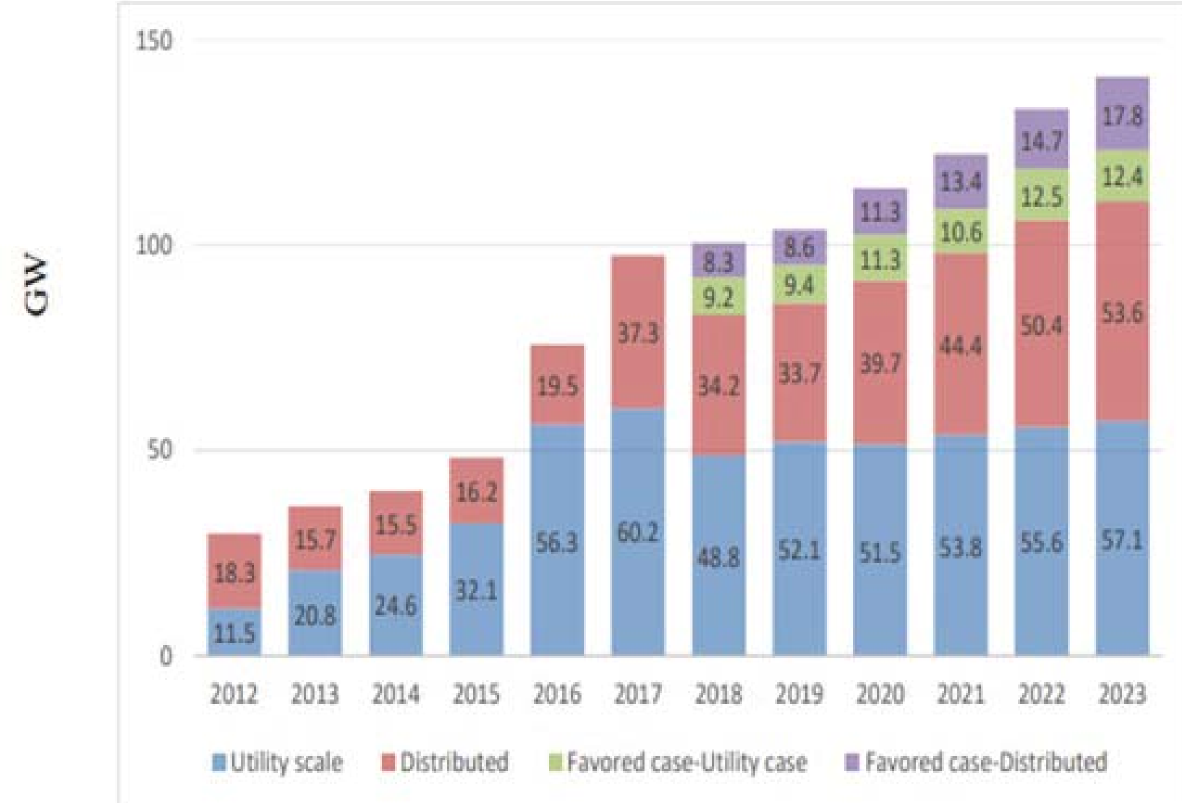

Fig. 1.2. Growth in PV power generation.

Wind is the second-largest source of renewable capability development, behind only by hydropower and biofuels, according to this forecast. Wind capacity is expected to increase by 60% (to roughly 324 GW), with offshore wind serving as a utility size solution. Distributed Favorite case: Utility Favored case-Distributed 10% of the development. Hydropower and bioenergy development prospects are both somewhat more optimistic than a year ago, owing to progress in China, for the most part. The IEA has looked into a different type of prediction known as the preferred case. In this preferred scenario of prediction, we'll look at how various market and strategy changes could affect renewable energy installations. Renewable energy installations might grow at a rate of 25% faster than in the prior scenario, reaching 1.3 TW by 2023.

II. SOLAR PHOTOVOLTAIC (PV)

Photovoltaic (PV) technology has grown at a nearly exponential rate during the previous two decades. Photovoltaic (PV) technology will dominate renewable energy development over the next six years, with 575 GW of new installations expected to be operational. Utility-scale projects are responsible for 55% of this growth, as well as the rapid expansion of distributed generating installations[5]. In the favourite scenario projection, photovoltaics alone account for half of the additional development. Annual augmentations are required to reach 140 GW by 2023, driven by faster cost reductions that make innovation more concentrated all around. Off-grid, residential, and commercial PVapplications account for the

great bulk of new growth, indicating untapped potential in these markets, notably in China, India, Europe, and the United States[4]. After China and the United States, India has been the third country to see tremendous growth in the solar power sector[4], [6]. In 2010, India announced the National Solar Mission, which aims to create 20 GW of solar energy by 2022. This goal was met in January 2018 after a four-year delay. India's government has set a new goal for renewable energy output by 2022. This revised aim includes 100 GW of solar-powered power generation and a total of 175 GW of renewable power generation[7].

III. GRID CONNECTED PV SYSTEM

The PV system is a collection of components that allows us to capture the sun's energy for a variety of applications. PV systems are typically made up of two primary components: PV modules and inverters. Battery storage is also necessary, depending on the system's architecture.

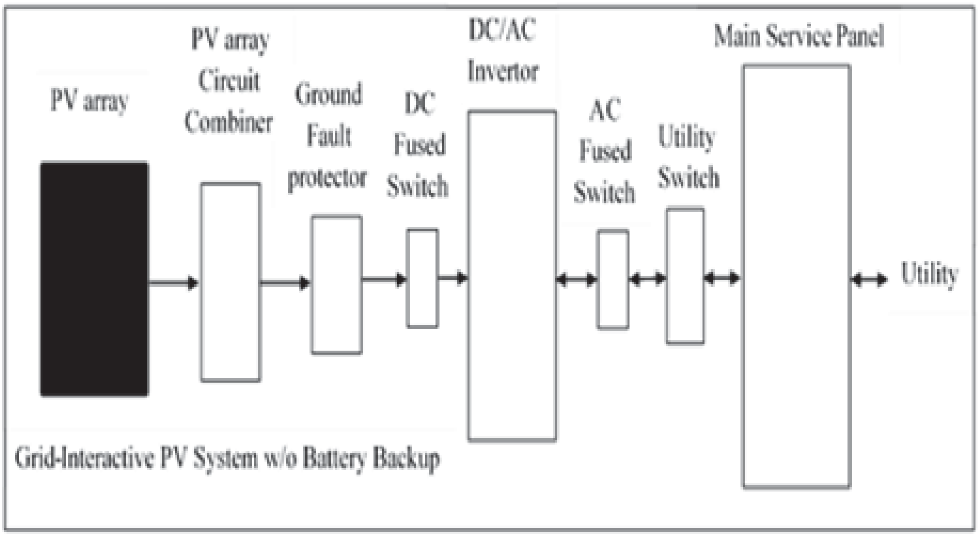

Fig. 1.3. Grid connected PV system

Grid-connected topologies are highly common in countries with solar-supporting policies, as surplus power generated by consumers may be fed into the power grid. The PV module and the inverter are the two main components of a grid-connected system. PV modules are in charge of power generation; the generated electricity must be able to fulfil load needs as well as feed excess power to the grid when supply exceeds demand. In this part, we'll look at PV modules in more detail, followed by inverters and battery storage.

A. PV Module

The modules are made up of a number of solar cells. These cells are wired together to make a PV module, which is then wired together to make a PV array. The properties of modules are influenced by the numerous ways in which cells and modules can be grouped (series and parallel). The open circuit voltage of each cell adds up in series connections, yet current through the series of the cell remains constant under steady state conditions. The voltage across all parallel cells is constant in parallel connections. The current generated by each cell is now added together.

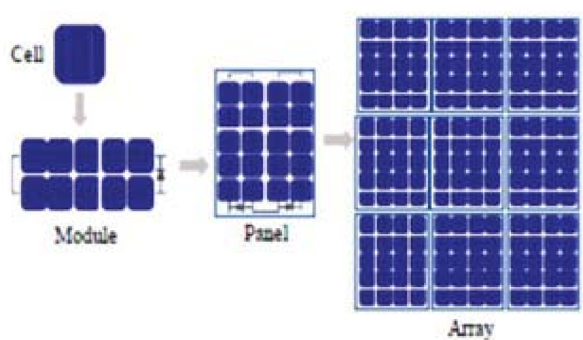

Fig. 1.4. Components of the PV array.

Take a deeper look at how a PV module functions in a system. They react differently based on the weather and where they are placed.

When the PV modules are exposed to direct sunshine, they operate optimally. Let's have a look at what module tilt and orientation mean, and how to get the most out of your PV modules. Tilt is the degree of freedom that determines the solar module's elevation or pitch in relation to the horizontal. The degree of freedom that specifies the azimuth of the surface of the modules in terms of position is called orientation. Azimuth is defined in a variety of ways by different places and individuals. The geographical north and south are the most prevalent points of reference.

B. Solar Inverter

The solar inverter is a critical power electronic equipment that allows current PV systems to be widely used. It transforms the DC power from the modules into AC electricity that may be used by all of the appliances. To comprehend an inverter, we must first comprehend its particular role in a PV system. Almost the whole national electric system is based on alternating current (AC). The majority of the homes have air conditioning. As a result, solar-generated DC power must be converted to AC power before it can be used in the current energy grid. The inverters are categorised depending on their mode of operation, size, and topology of implementation. Let's look at the categorization by mode of operation. A typical grid-connected system is seen in Figure 1.3. Grid-tied inverters link the DC of the PV modules to the AC electrical grid. Depending on available irradiance, the load can be provided by PV or grid. The inverter that supplies AC power to the grid works as a current source since it runs at the grid's voltage and frequency.

Only when an energy grid is accessible can the grid-connected topology be used. Because there is no grid accessible in certain regions, we must use standalone topology. A typical off-grid or independent PV system is seen in Fig. 1.5. As a result, the inverter is self-contained. In this case, the PV system is not connected to the grid, that means load can only depend on PV system for the power.

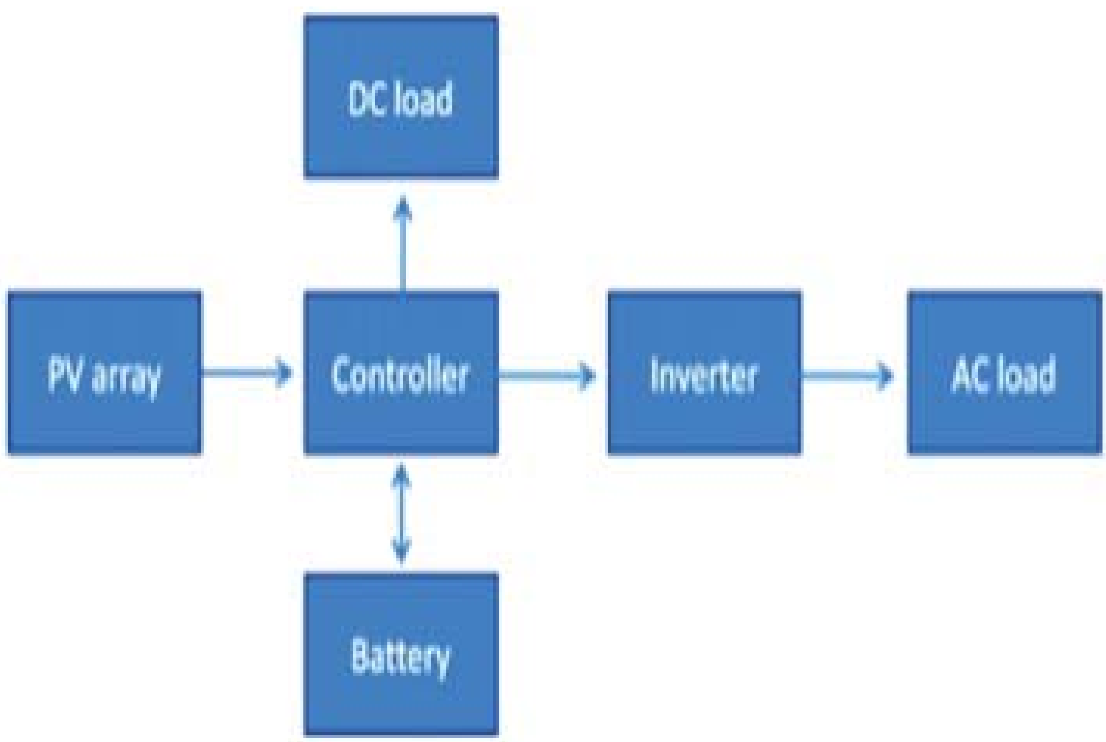

Fig. 1.5. Off-grid or standalone PV system.

The inverter that supplies AC power to the load must function as a voltage source with a constant voltage and frequency, operating at 230 V or 110 V AC. Excess energy must be stored in an off-grid system so that it may run even when there is no power generation at night. MPPT is an extra function provided by the inverter. This guarantees that the PV modules or arrays are operating at their full potential. Inverters are characterised not only by their modes of operation, but also by their implementation topologies. This categorization is divided into four subcategories.

1. Central inverter (Several kW to hundred MW)
2. Module inverter (50 W to 500 W)
3. String inverter (500 W to a few kW)
4. Multi string inverter (1 kW to 10 kW)

C. PV ARRAY-MODELING AND SIMULATION

In a Photovoltaic (PV) system, the elemental entity responsible for the conversion of energy from the sun into electrical energy is referred to as a PV cell. A PV module is made up of a collection of these PV cells that are frequently linked in series. The desired voltage is obtained by joining these modules in series, and the desired current is obtained by connecting these modules in parallel or by increasing the surface area of each cell. A PV array can be a single module or a group of modules connected in series or parallel.

There are two ways to use output of PV array;

1) Using DC output of array without any processing.

2) Using Power converters for further processing of output power.

In the first way, solar photovoltaic (PV)array is used to convert solar power, which is vacated at the common DC bus[17] The second way aids in the optimal operation of PV arrays by modifying parameters on the load side and managing the flow of electricity in a grid-connected system. A model that accurately represents PV cells, modules, and arrays is necessary to assess the performance of the PV system.

IV. RESULTS AND DISCUSSION

On the MATLAB Simulink platform, a simulation model for a (44) TCT arranged solar array with ODDEVEN structure is created. Simulation results for various system performance characteristics are obtained using various shading patterns as indicated in Case Studies I-IV. The PV array's modules are divided into three groups. The first set receives 1000 W/m2 of irradiance, whereas the second and third sets receive 600 W/m2 and 300 W/m2,

respectively. Table 1 depicts the shading conditions for all case studies conducted in this study. In the next part, the attained results are examined Case Study by Case Study (s

Shading Pattern	TCT configured PV array				ODD-EVEN structure of PV array				Shade diffusion with ODD-EVEN structure.			
Case study I	M_{11}	M_{12}	M_{13}	M_{14}	M_{11}	M_{13}	M_{31}	M_{33}	M_{11}	M_{12}	M_{13}	M_{14}
	M_{21}	M_{22}	M_{23}	M_{24}	M_{42}	M_{22}	M_{44}	M_{24}	M_{21}	M_{22}	M_{23}	M_{24}
	M_{31}	M_{32}	M_{33}	M_{34}	M_{12}	M_{32}	M_{14}	M_{34}	M_{31}	M_{32}	M_{33}	M_{34}
	M_{41}	M_{42}	M_{43}	M_{44}	M_{41}	M_{21}	M_{43}	M_{23}	M_{41}	M_{42}	M_{43}	M_{44}
Case study II	M_{11}	M_{12}	M_{13}	M_{14}	M_{11}	M_{13}	M_{31}	M_{33}	M_{11}	M_{12}	M_{13}	M_{14}
	M_{21}	M_{22}	M_{23}	M_{24}	M_{42}	M_{22}	M_{44}	M_{24}	M_{21}	M_{22}	M_{23}	M_{24}
	M_{31}	M_{32}	M_{33}	M_{34}	M_{12}	M_{32}	M_{14}	M_{34}	M_{31}	M_{32}	M_{33}	M_{34}
	M_{41}	M_{42}	M_{43}	M_{44}	M_{41}	M_{21}	M_{43}	M_{23}	M_{41}	M_{42}	M_{43}	M_{44}
Case study III	M_{11}	M_{12}	M_{13}	M_{14}	M_{11}	M_{13}	M_{31}	M_{33}	M_{11}	M_{12}	M_{13}	M_{14}
	M_{21}	M_{22}	M_{23}	M_{24}	M_{42}	M_{22}	M_{44}	M_{24}	M_{21}	M_{22}	M_{23}	M_{24}
	M_{31}	M_{32}	M_{33}	M_{34}	M_{12}	M_{32}	M_{14}	M_{34}	M_{31}	M_{32}	M_{33}	M_{34}
	M_{41}	M_{42}	M_{43}	M_{44}	M_{41}	M_{21}	M_{43}	M_{23}	M_{41}	M_{42}	M_{43}	M_{44}
Case study IV	M_{11}	M_{12}	M_{13}	M_{14}	M_{11}	M_{13}	M_{31}	M_{33}	M_{11}	M_{12}	M_{13}	M_{14}
	M_{21}	M_{22}	M_{23}	M_{24}	M_{42}	M_{22}	M_{44}	M_{24}	M_{21}	M_{22}	M_{23}	M_{24}
	M_{31}	M_{32}	M_{33}	M_{34}	M_{12}	M_{32}	M_{14}	M_{34}	M_{31}	M_{32}	M_{33}	M_{34}
	M_{41}	M_{42}	M_{43}	M_{44}	M_{41}	M_{21}	M_{43}	M_{23}	M_{41}	M_{42}	M_{43}	M_{44}

TABLE- 1 TCT configured PV array and ODD-EVEN Arranged PV array for different shading pattern

Case study I: Dwarf Broad Shading Pattern

According to the sequence in which modules are bypassed, it delivers module current and voltage. The power-voltage characteristics of a TCT constructed array are shown in Figure 1.6. As may be observed from the The PV array's highest produced power output is 1616W, with global maxima at 113V.

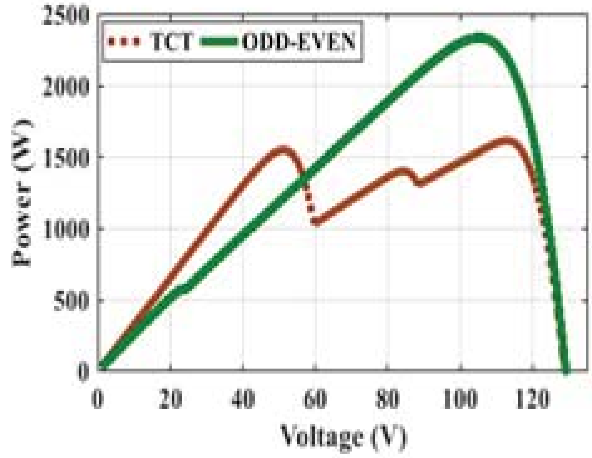

Fig. 1.6 (a). Power-Voltage characteristics for case study I.

The position of global maxima (GM) changes towards standard voltage of PV array following reconfiguration of modules as per ODD-EVEN structure. Furthermore, the power output by the PV array has grown by 30.88 percent from 1616 W to 2338 W when compared to the TCT arrangement.

Case study II:Tall Broad Shading Pattern

Alternatively, in a TCT design, maximum power extraction from PV array row 4 is skipped. The maximum power in an ODD-EVEN configuration occurs at standard voltage. The power-voltage characteristics of the array are shown in Fig.1.7 (a). The greatest power production by a PV array in the proposed structure is 2166 W, with global maxima at 109 V, whereas the maximum power output by a PV array in the 112 TCT design was 1856 W, resulting in a 14.31 percent increase in produced power.

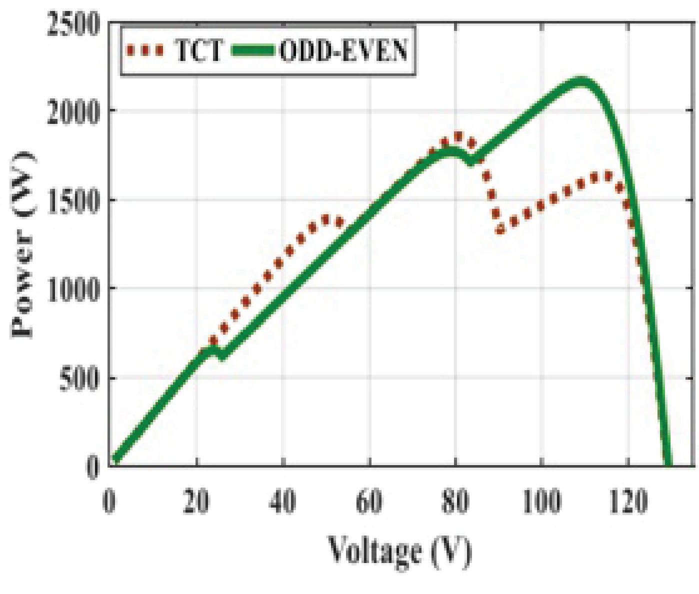

Fig. 1.7 (a). Power-Voltage characteristics for case study II.

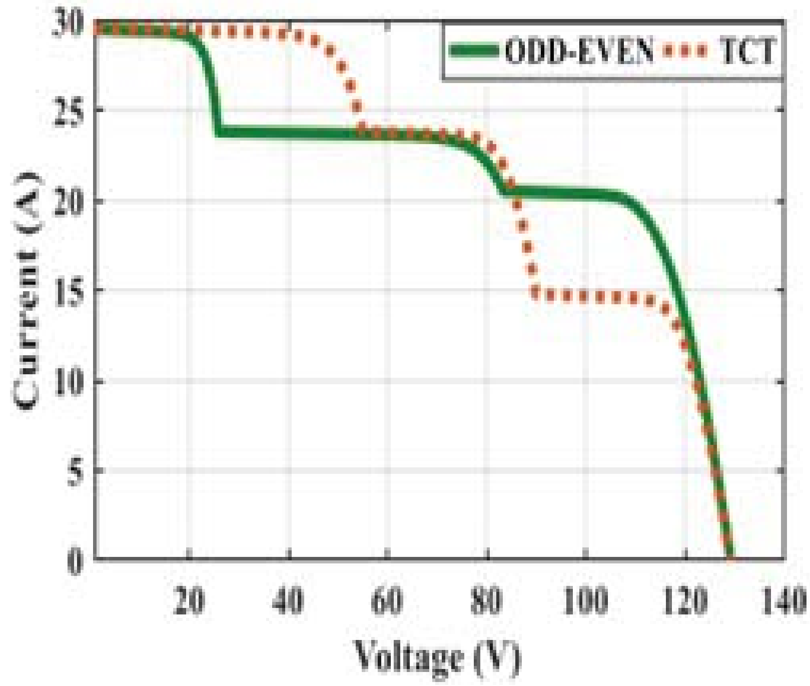

Fig.1.7 (b). Current-Voltage characteristics for case study II.

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