Classification and Detection of Faults in a Photovoltaic System

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Abstract— PV systems have grown in relevance as the solar industry has grown rapidly in recent years. One of the primary goals of research in the development of integrated PV systems is to improve the system's efficiency, availability, and dependability. Despite the fact that much work has already been done on technological design to improve the system's efficiency, there is still work to be done in the area of defect identification in PV systems. If defects in a PV system are not recognised in a timely manner, it may not only result in a reduction in power output, but it may also raise questions about the system's availability, dependability, and, ultimately, "security".

Keywords: PV, N-Type, P-Type, PV Array

I. INTRODUCTION

The recent generation of power from renewable resources is aimed at closing the rising gap between supply and demand for electricity. The sun is the most important renewable energy source available today.

Solar energy, in compared to other traditional power-generation technologies, not only benefits individuals, but it also benefits communities on a local, national, and even global scale.

One of the main reasons for solar energy's utilisation is that it has a limitless supply. Solar energy is derived from sunlight. The sun is a constant source of energy that can be accessed from everywhere on the planet. It has delivered solar energy to the Earth for the past 4 billion years.

Another compelling argument to utilise solar energy is that it is a renewable and long-term source of energy with minimal environmental impact. Many traditional means of power generation contribute to harmful gas emissions by releasing carbon dioxide, nitrous oxide, sulphur dioxide, or mercury into the atmosphere; however, solar energy emits none of these deadly gases and has no effect on global warming, acid rain, or smog.

Solar power helps in providing advantage in financial fields too. Due to the decrease in resources and increase in demand, the cost of energy based on fossil fuels, such as coal and oil, have increased quickly in recent years and can be expected to increase at an even more rapid rates in the future; while the price of solar energy, once installed, is not affected by supply and demand. In case of photovoltaic systems (PV), the energy obtained from the sun is absolutely free only with the exception of the initial investment and maintenance cost. The duration of the payback period in case of this investment will depend on amount of electricity used.

Moreover, large consumer conversion to solar power would be profitable on a political level as well. In order to reduce the dependency of a nation on foreign sources of energy as well as the cost of their import, the government will provide financial incentives to reduce consumers installation costs. According to research, global solar energy consumption has increased at a rate of around 25% per year over the last 15 years, while solar energy prices have decreased at a rate of about 4% per year.

A. How PV Works?

PV system use cells to convert solar radiation directly into electricity without creating any pollution.

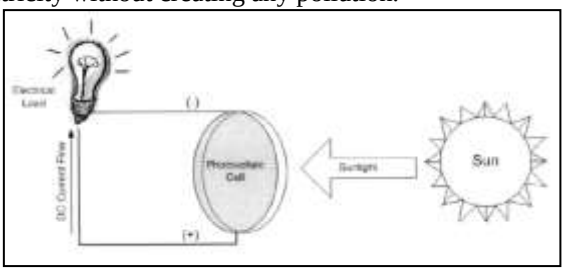

Fig. 1.1: How PV Cell Works

A typical silicon PV cell is made up of at least two layers of semi-conducting material. The layers are given positive and negative charges. A positive charge exists in an ultra-thin layer of phosphorus-doped (N-type) silicon, whereas a negative charge exists in a thicker layer of boron-doped (P-type) silicon. When P-type and N-type semiconductors are in close proximity, the P-N junction is the boundary interface.

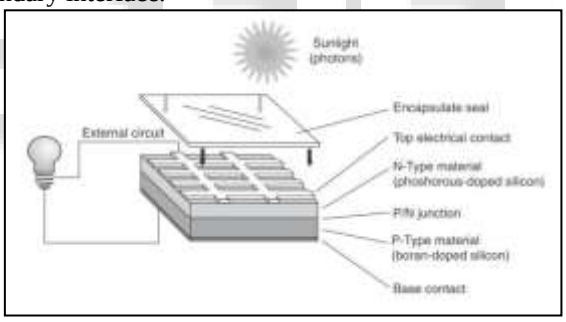

Fig. 1.2: Basic Solar Cell Construction

When sunlight strikes the solar cell, some photons are absorbed by semiconductors, causing light-stimulated electrons from the P-type negative layer of the solar cell to flow through an external circuit and back into the N-type positive layer. When the cell is linked to an electrical load, a current flow is created.

B. Photovoltaic (PV) Systems

The word "photovoltaic" is made up of two words: "photo," which means "light," and "voltaic," which means "voltage." As a result, a photovoltaic system is made up of photovoltaic cells that can directly convert sunlight into electricity. As a result, a photovoltaic system is a power system that can be configured to provide solar electricity by photovoltaic techniques.

II. METHODOLOGY

The importance of photovoltaic systems has grown in recent years due to the rapid growth of the solar sector. One of the primary goals of photovoltaic system development is to

increase the system's efficiency, availability, and reliability. Although much work has been done on technology design to improve the efficiency of PV Modules, very little has been done on fault identification for Photovoltaic Systems to date.

If faults in a photovoltaic system are not identified in a timely manner, they will reduce not only power generation but also availability, reliabilty, and, most critically, the "security" of the entire system.

The step-by-step procedure begins with the creation of a MATLAB-based circuit-based simulation baseline model of a photovoltaic system with maximum power point tracking (MPPT).

In our day-to-day context, MATLAB is one of the most popular tools for merging computing, visualisation, and programming.

Second, data is collected in a PV system at various surface temperatures under normal working conditions. The created Simulink model of a PV system is then calibrated and refined by comparing modelled IV and PV characteristic curves to measured IV and PV characteristic curves to guarantee that the values produced from simulation are close to those acquired from measurements.

Introduction To MATLAB and Simulink:- MATLAB is a high-performance programming language for technical computing. It has a user-friendly interface that integrates calculation, visualisation, and programming with problems and solutions represented in standard mathematical notation. The following are examples of typical applications:

- Math and computation
- Math and computation
- Algorithm creation
- Modeling, simulation, and prototyping
- Data analysis, exploration, and visualisation
- Scientific and engineering graphics

MATLAB is a computer programme that uses an array as its primary data element and does not require dimensioning. This enables you to solve a wide range of technical computing problems in a fraction of the time it takes to write a programme in a scalar noninteractive language like C or Fortran, particularly those using matrix and vector formulations.

III. OBJECTIVE

1) Fault analysis is required in the case of solar PV arrays so that if any unwanted scenario arises during the operation of PV arrays owing to the existence of various types of faults, it may be resolved as quickly as feasible.
2) If the fault detection method fails, uncleared faults in PV arrays can create not just fires, but also safety concerns for people and even power outages.
3) Because several types of faults can occur in a PV system, it's critical to understand what types of faults can occur before beginning system monitoring and fault diagnosis.
4) The diagnosis and monitoring of PV systems play a critical role in minimising energy losses in deployed PV systems. Irradiance and the surface temperature of PV cells determine the output power of a photovoltaic system.
5) The main motive of my thesis work is developing technology which can help in detecting PV system faults.

IV. PV MODEL DEVELOPMENT

A. Performance

- High-efficiency polycrystalline solar cells with high transmission and textured glass give a module series efficiency of up to 14.4%, lowering installation costs and increasing kWh production per unit area of your system.
- PV system mismatch losses are minimised using a power tolerance of +/-3 percent.

B. Quality and Reliability

- Robust, corrosion-resistant aluminium frame that has been independently certified to withstand wind loads of 2.4KPa and snow loads of 5.4KPa, guaranteeing that your modules have a long mechanical life.
- The modules come with a 25-year limited power warranty and a 5-year limited product warranty, and they are independently tested to ensure that they meet certification and regulatory criteria.
- ISO 9001 Quality Management System certification for manufacturing facilities.
- In the Table 3.1, the main components of MATLAB/Simulink PV model are mentioned in detail

Power Output	P (W)	280
Open Circuit Voltage	Voc (V)	45
Short Circuit Current	Isc (A)	8.35
Voltage at Pmpp	Vm (V)	35.5
Current at Pmpp	Im (A)	7.89
Temperature Coefficient of Isc	ki	+0.0006
Temperature Coefficient of Voc	kv	-0.0037
Temperature Coefficient of Pmpp	kp	-0.0045

Table 4.1: The key specifications of the YL280 P-35b PV panel

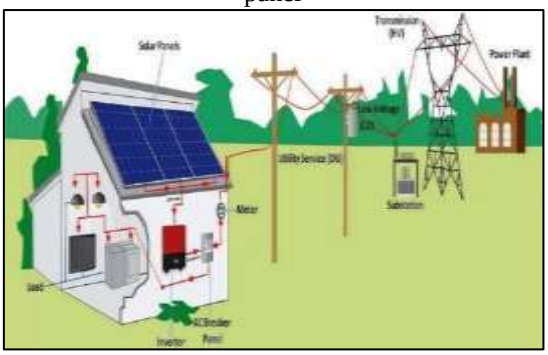

Fig. 4.1: Layout of a Photovoltaic System in Grid

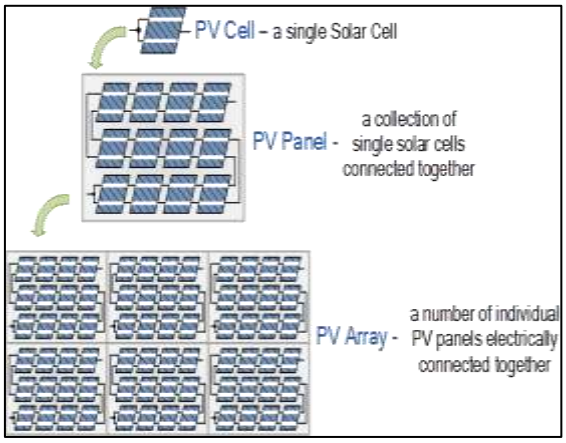

Fig. 4.2: Diagram showing a PV Cell, PV Panel and a PV Array

V. SOILING

Soiling losses are power losses that occur as a result of snow, dust, dirt, or other particles covering the PV Module's surface. The solar array's surface is covered with a thin coating of dust. Dust particles are smaller than 10um in diameter and vary in size depending on location and environment. Wind pollution, pedestrian volcanic eruptions, and human vehicle movement all contribute to the formation of dust. The effect of soiling is worsened by the accumulation of dust over time. The amount of dust that accumulates on the surface of a PV module has an impact on the overall energy delivered from the PV module on a daily, monthly, seasonal, and annual basis.

Soiling events have a negative impact on performance of PV system, especially in regions where rainfall is limited. Therefore, detecting soiling faults in the PV system is significant in reducing energy losses.

Assume that the soiling effect results in a 5% reduction of solar radiation over time. To investigate the performance of a soiled PV array, MATLAB/Simulink models of PV systems with soiling effects were built.

VI. FUTURE WORK

Under partial shading, snow cover, or soiling conditions, the P-V curves show several peaks. Special MPPT schemes to track the GP in these circumstances would be beneficial.

Although the methods utilised in this study can distinguish a variety of flaws, they are unable to detect the location of the fault inside the PV array. It would be advantageous to develop more ways for determining these places.

Finally, further study might consider the situation when two or more faults occur at the same time.

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