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A REVIEW ON EFFICIENT FAULT DIAGNOSIS SCHEME FOR PV SYSTEM USING MACHINE LEARNING TECHNIQUES IN THE DC SIDE

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Abstract- A PV system converts the solar energy into electrical energy, and this energy is either stored in a battery bank in a standalone system or transmitted to the grid through grid interfacing power electronic converters. PV fault protection/detection and isolation devices of multiple kinds are installed in a PV station to isolate the PV converters/grid from the PV array during any fault in the PV system. Although, the rest of the power processing or storage units are isolated from the faulty PV array, the solar cells remain active and may produce significant current flow within the modules that may result in damages even catastrophic fire. The conducted work within the scope of this dissertation describes various faults in a PV plant, and explains the limitations of existing detection and suppression techniques. Different fault detection techniques proposed in literatures have been discussed and it was concluded that there is no universal fault detection technique that can detect and classify all faults in a PV system. Moreover, this digest proposes a transmission line model for PV panels that can be useful for interpreting faults in PV using different refelectomery methods.

Keywords: Photovoltaic system, fault detection, artitifcial intelligence, Probabilistic neural network.

I INTRODUCTION

With the increasing environmental concerns, solar energy has been widely used because of its inexhaustible and environmentally friendly advantages [1]. Under complex and changeable climate conditions, operational faults in a photovoltaic (PV) system have always been one of the important factors affecting its power-generation efficiency [2,3]. However, faults in the direct current (DC) side of a PV system, such as open-circuit, short-circuit, degradation and shading faults, are often difficult to avoid and can result in system energy loss, PV module lifespan reduction, or even serious safety concerns. Hence, the development of a fault detection method for the PV array faults is particularly significant for improving the energy conversion efficiency of the PV system, increasing the service life of the PV modules, and reducing maintenance cost [4, 5].

Existing fault-detection methods include those based on thermal infrared detection, time domain reflectometry, artificial intelligence algorithm, mathematical model analysis methods, and so on. The thermal infrared detection method detects and identifies faults by an infrared scanner to measure the surface temperature of the PV modules for abnormal heat caused by faults.

The principles of the semiconductor's electroluminescence to design image acquisition devices that can obtain infrared image of PV modules. The devices can detect the faults including black pieces, fragmentation, broken grid and crack for the PV modules.

The method can accurately identify the normal, shading and degradation status of the PV modules. However, the thermal infrared detection method mainly focuses on the detection of hot spot faults inside a PV array. The time domain reflectometry method needs to inject a pulse signal into the series PV modules circuits of a PV array, and then identifies the fault status of the PV array by comparing the input pulse signal with the feedback output signal. The time domain reflectometry method to detect degradation faults and locate fault positions of the PV module in a PV array by the change of response waveform. However, when utilizing the time domain reflectometry method to detect faults, the PV system must be turned off, which will critically affect the system's productivity.

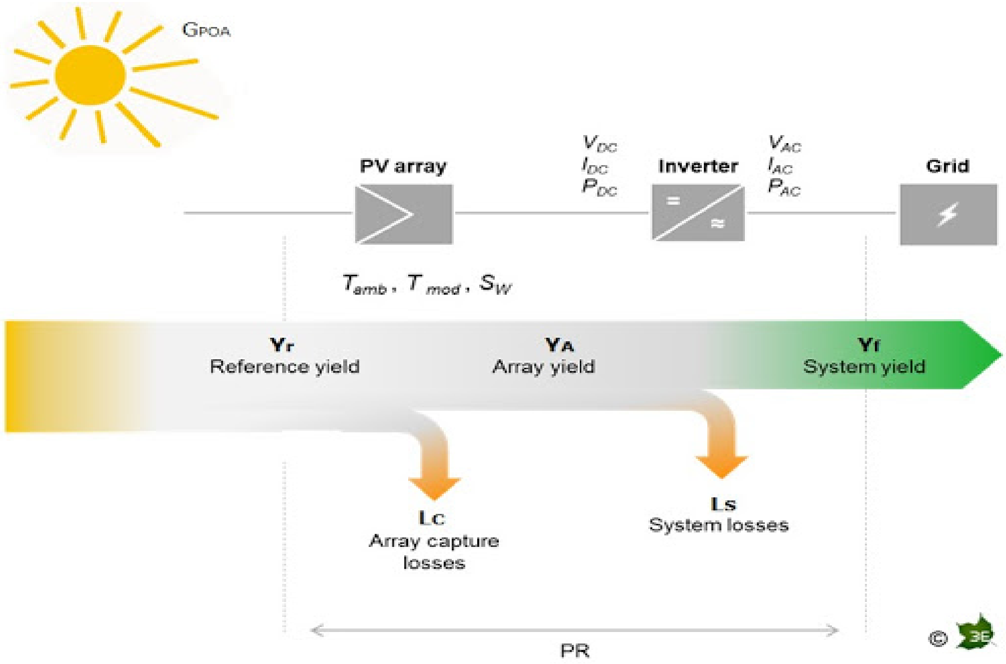

Figure1: Fault detection in Photo Voltaic system.

Power generation based on photovoltaic sources has gradually become an increasingly larger source of power generation during the last few decades. This trend has been matched with research into more efficient solar panels. Efficiency is measured as the ratio of incoming sun energy to the maximum attainable output power, with the current record being an efficiency of 44.7% [1-30].

II LITERATURE REVIEW

In this section an overview of the previously proposed papers is given this will ultimately help to examine the disadvantages, advantages as well as the proposed work.Statistical methods have been adapted as the prominent solution for classification and detection of PV system faults (Table 1).

In this paper [1] author proposes a control strategy aiming at operating cascaded DC-DC converter architectures of photovoltaic (PV) modules at maximum power independent of the irradiance conditions, in the mean time meeting imperatives of voltage-confinement type. The worldwide ideal of fell associations of PV modules is commonly identical with working all the modules at most extreme force point following (MPPT). The most significant unsettling influence happens when the irradiance levels of modules are reasonably unique on account of different reasons – for this situation, voltage-restriction necessities might be broken. The proposed regulating system at that point endeavors to build up the best imperfect force system.

The k-nearest neighbours rule has been used in the classification and regression for string connected fault identification and diagnosis of PV systems [15]. This strategy is completely ready to recognize and characterize various sorts of issues continuously, for example, open circuit, line to line issues, halfway concealing with/without sidestep diode faults and incomplete concealing with rearranged sidestep diode deficiencies. Also, the proposed technique precisely follows the exhibition of PV frameworks at various insolation and temperature levels. In contrast with this technique, concealing issues and deficiency location on the DC side of a framework associated PV framework are explored with exponentially weighted moving normal (EWMA) control diagram. The EWMA strategy had the option to distinguish the boundary changes between the shortcoming and ordinary conditions [2].

The instrument is to perceive the ordinary yield boundaries of PV framework, for example, most extreme force, current and voltage under various irradiance and cell temperature. The lingering, the contrast between the deliberate and anticipated yield from the single diode model, is taken as the fault pointer of PV frameworks. At that point, an EWMA outline is used to screen the non-corresponded residuals to recognize the sort of deficiency. For checking execution of PV frameworks, the factual methodology based univariate and multivariate exponentially weighted moving normal (EWMA) graphs approach is again used to recognize and analyze the deficiencies on DC side of PV framework [16]. A deviation number of electrical boundaries of PV frameworks under issue and typical conditions is resolved as the fault marker. Truth be told, the proposed multivariate EWMA can't recognize the deficiency types, except if the univariate EWMA plot is

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sent later to distinguish the short out, open-circuit and concealing issues.

The observing capacity of shortcomings in PV frameworks is improved through the upgraded techniques for factual disappointment distinguishing proof [17]. The objective of the proposed technique is to diminish the bogus alert and missed recognizable proof rates by sending the multiscale-weighted summed up probability proportion test (MS-WGLRT) strategy. The explanation behind this methodology is the multiscale nature may give better power to clamor and checking quality contrasted with the freely summed up probability proportion test strategy. Programmed recognition and determination of potential issues in network associated PV frameworks dependent on factual strategies thinking about atmosphere information and electrical boundaries are introduced as another option [18].

The calculation of fault identification based factual t-test is to look at the deliberate and perfect yield power, while the area of issue is resolved from the deliberate and perfect estimations of DC capacity to voltage proportion. This technique is successfully used to recognize various blames in PV board, PV string and MPPT controller. In the mean time, comparative factual techniques for t-tests and f-tests are utilized to examine the impact of splits on PV board electroluminescence estimations [19]. Estimation results demonstrate that not a wide range of breaks have noteworthy decrease of yield power creation of PV boards.

In this paper [26] author proposed an online calculation to analyze flaws of PV module dependent on multi-class bolster vector machine (SVM). The reproduction models of the photovoltaic module have been executed and the yield power age qualities of PV modules under two commonplace shortcoming conditions (line-to-line deficiency and strange corruption flaw) have been examined.

In this paper [27] author proposed a techniquefor ongoing observing and deficiency conclusion in photovoltaic frameworks. The proposed technique has been founded on an examination between the exhibitions of a flawed photovoltaic module, with its precise model by measuring the particular differential buildup that will be related with it.

In this paper [28] author introduced another calculation for identifying flaws in matrix associated photovoltaic (GCPV) plant. There are hardly any occasions of factual apparatuses being conveyed in the investigation of photovoltaic (PV) estimated information. The primary focal point of this exploration is to plot a PV flaw discovery calculation that can analyze issues on the DC side of the inspected GCPV framework dependent on the ttest factual investigation strategy.

In this paper [29] author proposed a novel plan for the issue recognition in a DCconverter associated with a sun oriented PV module with the assistance of a proposed state machine based model. This plan can be for all intents and purposes utilized by applying Peak Current Mode (PCM) control procedure with an inordinate slope signal.

In this paper [30] author investigated and decide the decrease of proficiency for issues related with Solar PV cell and modules. Likewise, extraordinary flaw discovery plot are talked about that are embraced around the world. The principle center is moved in different issues that upset the force age of PV modules. The deficiencies of PV cell and modules have been examined. The point of this paper is to measure the loss of creation and effectiveness just as to accept the issue level around by scientific demonstrating if an issue begins to create. The diverse standard PV module testing methodology have been talked about.

Table 2.1: Comparative analysis of Methods.

Authors	Methods	Purposes	Tasks
ElyesGaroudja [2]	Exponentially weighted moving average (EWMA)	Early detection	Shading of PV modules and faults on the direct current (DC) side
Siva Ramakrishna Madeti [15]	k-nearest neighbors rule	Real-time classification & detection	Open circuit, line to line faults, partial shading with/without bypass diode faults and partial shading with inverted bypass diode faults
FouziHarrou [16]	Univariate and multivariate EWMA	Detection & diagnosis	Monitor the direct current (DC) side
MajdiMansouri [17]	Multi scale weighted generalized likelihood	Monitoring & detection	Reduced the false alarm and missed

	ratio test (MSWGLRT)		identification rates

In the above table 1 the comparative analysis over previously used algorithms is given.

III DETECTION AND DIAGNOSIS USING MACHINE LEARNING TECHNIQUES

- Support Vector Machines (SVM)

SVMs are managed learning models that dissect information utilized for non-probabilistic order or relapse investigation. One traditional work on the utilization of SVM towards distinguishing bearing issues can be found in, where grouping results acquired by the SVM are ideal in the entirety of the cases, with a general improvement over the exhibition of ANN. Other comparable SVM based papers additionally showed the viability and productivity of utilizing SVM to fill in as the fault classifier.

- Principle Component Analysis (PCA)

PCA is a calculation that uncovers the interior structure of the information such that best clarifies the change in the information. In the event that a multivariate dataset is envisioned as a lot of directions in a high-dimensional information space (one hub for every factor), PCA can gracefully the client with a lower-dimensional projection of this item saw from its most useful perspective. Since the affectability of different highlights that are qualities of an orientation imperfection may change significantly at various working conditions, PCA has substantiated itself as a compelling and precise element choice plan that gives direction on physically picking the most agent highlights for order purposes.

IV PROBLEM DEFINITION

There are a lot of studies analyzing different issues present in PV systems, demonstrating an interest in detecting faults to the greatest extent as early as possible.

1. Delamination, Yellowing and browning
2. Bubbles in the solar module
3. Cracks in cells
4. Defects in anti-reflective coating
5. Hot spots caused by the panel acting as a load

V CONCLUSION

Installation of PV power plants has been sped up for a huge scope for the most recent decade, and the majority of the nations with huge economy are presently building huge scope (>30 MW) PV plants so as to satisfy the developing energy need and to diminish carbon emanation in the earth. Be that as it may, PV industry is as yet taking a shot at the protected activity of these PV plants and creating items to forestall or smother different PV deficiencies. There have been a few mishaps incorporating fire perils detailed lately, and the greater part of these occurrences happened because of the absence of information on various sorts of shortcomings in PV framework. This part has talked about various sort of PV faults including ground shortcomings, line-to-line issues, circular segment deficiencies, sidestep diode disappointment, hotspot, and other minor blames that may be available in a PV plant, and impediments of existing recognition gadgets has been portrayed too.

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