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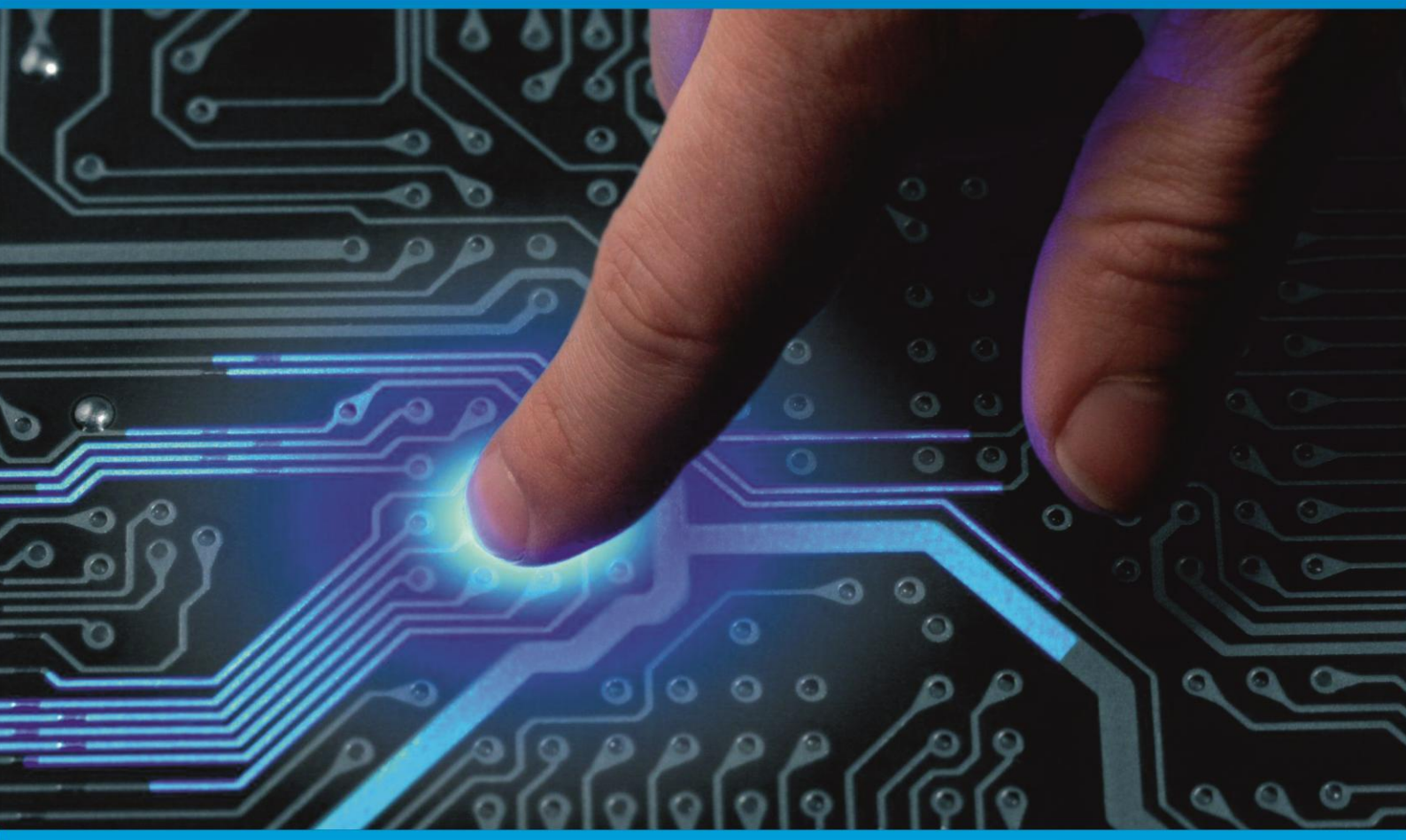

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Survey of Various PV Cable Fault Analysis Models and Challenges

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ABSTRACT: The environmentally clean nature of solar photovoltaic (PV) technology causes PV power generation to be embraced by all countries across the globe. Consequently, installation and utilization of PV power systems have seen much growth in recent years. Although PV arrays of such systems are robust, they are not immune to faults. The exponential growth in global photovoltaic (PV) power capacity, protection of PV systems has gained prodigious importance in last few decades. Even with the use of standard protection devices in a PV system, faults occurring in a PV array may remain undetected. Inspired by the ever increasing demand for a reliable fault detection technique, several advanced techniques have been proposed in literature; especially in the last few years. Hence, this paper carries out an in depth analysis of various fault occurrences, protection challenges and ramifications due to undetected faults in PV systems. Furthermore, with a widespread literature, the paper reviews numerous fault detection algorithms/techniques available for PV systems of previous research.

KEYWORDS: Solar, Pulse, Renewable, Fault, Panel, Microgrid, Line, Ground, Cable, Photovoltaic Cable.

I. INTRODUCTION

Cable faults are damage to cables which affect a resistance in the cable. If allowed to persist, this can lead to a voltage breakdown. There are different types of cable faults, which must first be classified before they can be located. The insulation of the cable plays a significant role in this. At the point when electrical energy is created in the generations' stations, it is distributed to the various burdens, for example urban communities, towns and towns for utilization at that point. The procedure includes venturing up the voltage to limit the loss of energy as warmth. The ventured up voltage is distributed to network stations where it is ventured down for dispersion to the nearby transformers where it is at long last ventured down and distributed to the customers.

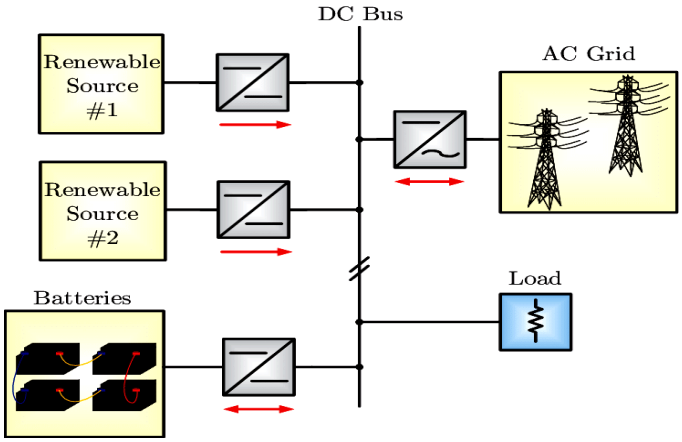

Figure 1: DC Microgrid

An autonomous controls method for a DC microgrid system having distribution power generators. This system consists of following five generation and control units; a solar-cell generation unit, a wind-turbine generation unit, a

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battery energy-storage unit, a flywheel power-leveling unit, and an AC grid-connected power control unit. The control method intended for suppression of circulating current detects only the DC grid voltage. Each unit could be controlled autonomously without communicating each other. This method brings high reliability, high-flexibility and maintenance-free operation to the system. Experimental results from a 10 kW-prototype system verify the validity and effectiveness of the proposed control method.

A DC microgrid maintains a DC bus, which feeds DC loads connected to it. Normally, DC loads are low-power rating electronic devices such as laptops, cell phone, wireless phones, DVD players, battery-powered vacuum cleaner, and Internet routers. In DC microgrid structure, sources with DC output are connected to DC bus directly, whereas sources with AC output are interfaced to DC bus through AC/DC converter [8]. As the number of DC-generating renewable energy sources is higher as compared to AC-generating sources, lesser converter units are required. This increases the overall efficiency of DC micro grid. In addition, the problem of harmonics due to power electronic converter is not present due to DC nature of output power.

II. RELATED WORK

E. Mohanty,et al., [1] This work proposes the location of islanding and shortcoming in a PV entered power framework. A far reaching numerical model of photovoltaic (PV) exhibit associated with network comprising of electrical switch and three stage shortcoming including most extreme power point tracker, IGBT bridge and controller is introduced dependent on MATLAB simulink instrument. PV model is developed by taking essential circuit condition of photovoltaic solar cells remembering impacts of solar illumination and change for temperature. Islanding is where a little piece of framework is separated from head lattice which is done when there is a deficiency or upkeep is required.

G. Kou, et al., [2] Inverter-based distributed energy resources (DERs) are portrayed with low shortcoming present and immaterial measure of negative and zero grouping flows. Understanding DER's issue attributes is basic for deficiency examination and defensive transfer setting. In spite of the bottomless work on DER demonstrating, hardly any exploration contemplates have been done to break down DER's issue practices during genuine issue occasions. This work investigates recorded issue occasions gathered by Dominion Energy. Flaw size, edge, and succession parts are examined to show that genuine DER shortcoming reaction may vary from past understandings.

M. Akmal, et al., [3] In this manner, it is basic to keep away from restricted power outages due to mal-activity of defensive transfers under high infiltration of DGs in circulation organize. The focal point of this examination is to contemplate the significance and ramifications of defensive transfers and over-current insurance within the sight of distributed generation; where the effect of distributed generation on appropriation arrange is recognized. Hand-off coordination is seen to decide their activity attributes to maintain a strategic distance from mal-activity with the nearness of DGs (for example solar-PV).

P. Jain, et al., [4] The PVECU establishes a PV source and a source-level power converter. The issue determination is performed by creating and assessing a mistake lingering vector, which is the distinction between the evaluated and estimated yields. A PV panellevel power converter model is worked to show how the detecting, preparing, and incitation abilities of the converter can empower viable shortcoming determination progressively.

G. Suriya Priya et al., [5] This work advances an insurance plan to refine the stumbling conduct of hand-off and to guarantee the security coordination between regular power framework and wind power distributed generation framework. The interconnected power framework is considered with typical and shortcoming condition (Line to Line Fault) and the blamed zone is distinguished dependent on the impedance count technique.

D. Millare et al., [6] Evaluating the viability of lattice tied solar inverters requires explicit tests to be led. With the capacity to give a reenacted lattice condition, different voltage and recurrence conditions can be applied to a device under test (DUT) to evaluate its presentation. A trademark, for example, ride-through ability requires the device to be presented to determined voltage occasions to approve its adjustment to industry gauges. Be that as it may, interconnections between the network test system condition, inverters, and matrix tie transformers give difficulties in deciding the voltages to yield in the framework test system that are seen by the inverter.

J. Crepaldi et al., [7] The energy generation by inexhaustible sources doesn't partake in the control of the voltage and recurrence of the electrical framework, and in the event of aggravations that surpass the pre-set up standard points of confinement and that influence the framework's PQ, separating it until the PQ is reestablished, so it will be reconnected after the arrival of the typical activity. To institutionalize and measure the electromagnetic aggravations of the electrical energy quality (QEE), as to guarantee the quality of the item and administrations, guidelines and

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techniques were intended to teach from generators to energy purchasers, in Brazil the most utilized standard is the electric power appropriation method in the national electric framework (PRODIST)- module 8.

A. Mishra,et al., [8] During this appraisal, the current norms for interconnection of IBDG on dispersion arrange are contrasted along and assessment of business inverters for consistence to existing models. The deficiency attributes and LVRT are dictated by direct perception, instead of reproduction. The exploratory set up to evaluate flaw current commitment of single stage matrix associated inverters is clarified and the LVRT attributes of a few inverters tended to. The conduct of the inverters during voltage and recurrence based lattice abnormalities is displayed alongside potential models found through state estimation.

S. P. George et al., [9] The DG sources like breeze energy, solar energy and so forth are dynamic in nature which brings about the variety of source impedance. Within the sight of distributed generation the fault current qualities are likewise evolving. The current hand-off parameters are not ready to recognize these changes, which brings about glitch of transfers. The arrangement system embraced for the breakdown of transfers is versatile handing-off. Versatile transferring implies the hand-off needs to adjust to the changing condition and the decision making ability is to be included with existing transfers.

T. Yamamoto et al., [10] Two sorts of battery associations have been proposed: in particular, AC side association through an inverter and DC side direct associations with the PV system. Right now, creators propose a mixture type battery association which comprises of both AC and DC side batteries to remunerate a control deferral of the AC side battery.

Y. Liu, P. Lan et al., [11] Photovoltaic inverter, that is responsible for electric power transformation, is a basic part utilized in solar photovoltaic power systems. Numerous worries are centered around the activity of photovoltaic inverter because of the more terrible structuring may cause the horrendous effects on security, execution and network interconnection qualities of solar photovoltaic power systems. IEEE SCC21 gives a uniform standard, known as IEEE 1547 standard, for interconnection contemplations of distributed resources with electric power systems.

III. TYPES OF SOLAR CABLE DC ARC FAULTS

SERIES: A series arc occurs when a connection is broken while the PV is producing current. Any intermittent connection in the DC circuit has the potential for producing a DC arc fault. These connections may include soldered joints within the module, compression type wire connections, connectors used on the wire leads attached to PV modules, connections in DC isolators, connections in the inverter, any DC circuitry in the inverter or any of the DC cabling in the string circuit.

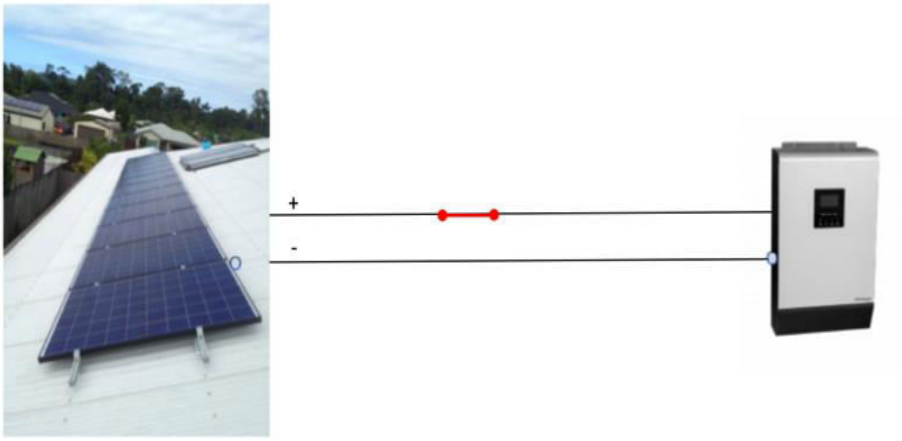

Figure 2: Series Fault

PARALLEL: Parallel arcs occur when there is a breakdown in the insulation system and current flows between positive and negative. Two conductors of opposite polarity in the same DC circuit are often run in close proximity to each other. The insulation between the two wires can become ineffective due to animals chewing on them, UV breakdown, embrittlement, cracking, moisture ingress and mechanical damage. Parallel arc faults can continue along the conductors towards the array burning materials along the way.

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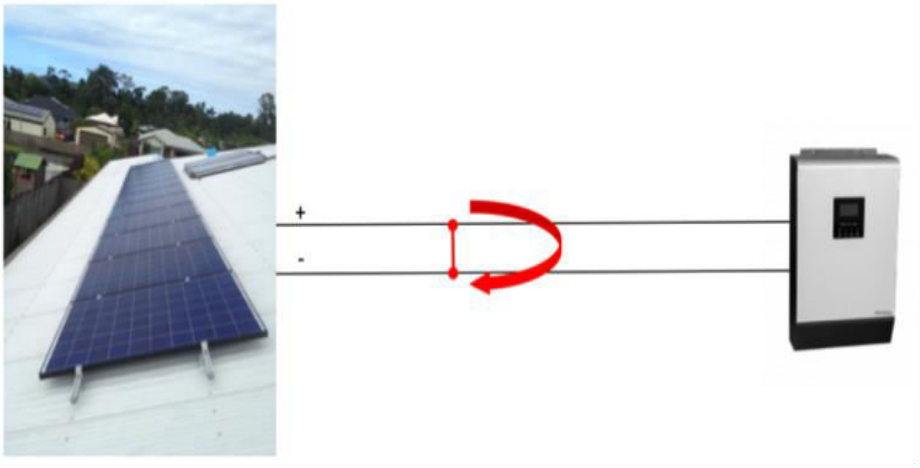

Figure 3: Parallel fault

TO GROUND: This fault only requires the failure of one insulation system to ground. This can be the solar module frame, the solar array racking, the roof or any other grounded surfaces.

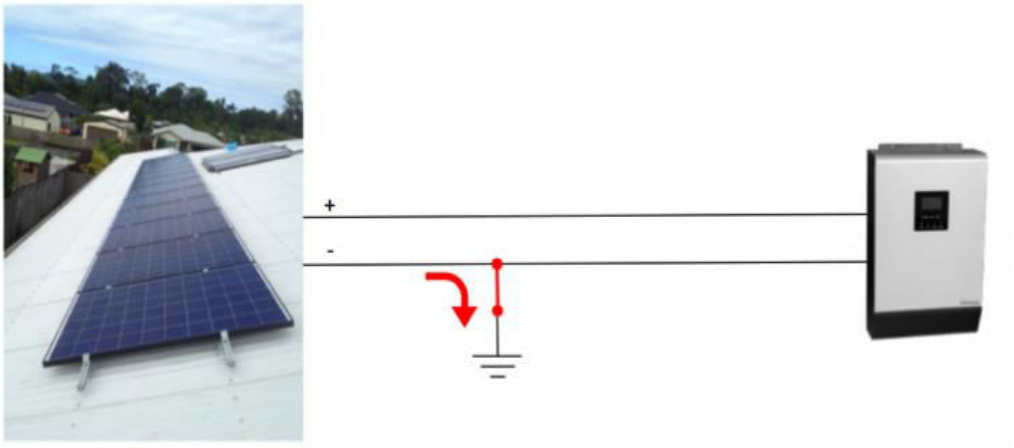

Figure 4: Ground fault

Often a fault can start out as one type of fault (e.g. series fault) but develop into a different type of fault (e.g. parallel fault).

IV. PV ARRAY FAULT MANAGEMENT

From the assortment of studies looked into right now, exhibit fault the executive's future patterns and proposals exude as follows.

(i) Climate change concerns and diminishing fossil assets will keep on driving the demand for solar PV vitality. Therefore, establishment of numerous enormous stand-alone and lattice associated PV power plants will be seen all inclusive. For huge PV power plants, a significant necessity in its fault the executives is fault limitation. Fault restriction assists with separating just the faulty segment of the PV plant, which guarantees the unwavering quality of power supply and quick fixes or substitution of influenced parts.

(ii) With regards to fault separation, an astute and quick insurance plot is significant for solar PV power frameworks. The structure of quick activity and low-misfortune switches can improve the presentation of fault disconnection plans. A DC confinement (interference) in view of strong state gadgets is exceptionally encouraging. Some examination

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endeavors have been devoted to the acknowledgment of such gadgets with regards to DC microgrids, however very little is seen for PV cluster fault disengagement. Consequently, explore is required right now.

(iii) In the audits, it was seen that ML-based fault detection and diagnosis-based systems have pulled in a huge research consideration, and it is required to proceed in the coming years. When all is said in done, the presentation of a ML calculation generally relies upon the nature of the preparation information it trains with.

(iv)In genuine applications, observing of PV power framework establishments for control, fault detection, and diagnosis is commonly executed from remote areas because of the brutal natural conditions where they are introduced. Such remote observing requires a dependable correspondence medium among plant and checking station. Throughout the years, link wiring has been utilized to trade data between power plants and observing stations. For long separations, weakening and postponement in signal proliferation can forestall continuous checking.

(v) It was seen in the audit that no single fault detection and diagnosis has the capacity to recognize and analyze all the four fault cases considered right now. Towards an objective of building up an across the board fault detection and diagnosis models, future research is relied upon to concentrate on cross breed strategies, where at least two systems will be consolidated to build up a progressively complete fault detection and diagnosis (FDD) method.

V. CONCLUSION

In recent years, there has been an exponential growth in photovoltaics across the world. This brings many problems associated with the quality of the systems due to several factors. The most crucial component in PV systems is the photovoltaic module whose diagnostics can be sometimes relatively difficult. Fault diagnosis and condition monitoring are important to increase the efficiency and reliability of photovoltaic modules. A thorough analysis of various faults responsible for failure of solar modules has been discussed. This paper has presented a review on major PV array fault types along with their detection and diagnosis techniques.

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