AUTOMATIC OPERATION OF ON-GRID SOLAR SYSTEM WITH PROTECTION SCHEME

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ABSTRACT

The on-grid solar energy system is becoming a pivotal component of modern electrical grids due to its potential for sustainable energy production and reduced environmental impact. The integration of automatic operation and protection schemes is essential to ensure optimal performance, reliability, and safety of these systems. This research paper delves into the development and implementation of an automatic operation strategy for an on-grid solar system, incorporating a robust protection scheme to mitigate common operational risks. We explore various components and design considerations, detailing the control strategies employed to achieve seamless system function and high performance. A thorough analysis of the data collected from the implemented system highlights the efficacy and reliability of the proposed method. Additionally, the research compares the findings with existing studies to position the results within the broader academic dialogue. Our findings show significant improvements in both the operational efficiency and protection capabilities of the solar system, thus providing valuable insights for future advancements in renewable energy integration. The developed methodologies could lead to enhanced system durability and energy yield, thereby promoting the broader adoption of renewable energy solutions. As we mentioned in Title, we are going to make the Operation of Solar System Automatic with Protection Scheme. This is very beneficial as point of view to on-Grid Solar Systems which is a Need of Today's World. This research focuses on creating an automatic operation system for on-grid solar systems, complemented by a sophisticated protection scheme. The objective is to optimize solar energy utilization within the grid, ensuring efficient operation while implementing a comprehensive protection strategy to safeguard the system against potential risks and faults.

1.KEYWORDS

On-grid & Off-grid solar system, protection scheme, Reliable Renewable system, Fault analysis

2.INTRODUCTION

The increasing demand for sustainable and renewable energy sources has driven significant advancements in solar energy technologies. Among these innovations, on-grid solar systems have emerged as a promising solution, offering numerous benefits including reduced greenhouse gas emissions, lower electricity costs, and decreased dependency on fossil fuels. However, the efficient and reliable operation of these systems requires advanced control strategies and protection mechanisms to handle dynamic environmental conditions and grid interactions. Traditionally, the operation of on-grid solar systems has been manually managed, which can lead to inefficiencies and potential safety risks. The advent of automation in solar energy systems promises enhanced performance, reliability, and safety by enabling real-time monitoring and control. Integral to this advancement is the development of an effective protection scheme

For on-grid solar systems integrated with an advanced protection scheme.

This research paper aims to address these challenges by presenting a comprehensive study on the automatic operation of on-grid solar systems integrated with a robust protection scheme. The research question focuses on how the implementation of automatic controls and protective measures can improve the operational efficiency and safety of on-grid solar systems. Our hypothesis posits that an automated control system, coupled with a sophisticated protection scheme, can significantly enhance the functionality and reliability of on-grid solar installations. The paper is structured to provide a detailed overview of the components and design of the proposed system, elaborate on the control strategies employed, and present a thorough analysis of the data collected. The results and their implications are discussed with a comparison to existing studies, highlighting the contributions and limitations of this research. Through this approach, we aim to contribute to the knowledge base of automated on-grid solar systems and propose methodologies for their continuous improvement and adaptation in real-world applications. The theoretical background section lays the groundwork for understanding the fundamental principles of solar energy, the operational dynamics of on-grid solar systems, and essential protection schemes. It begins with an explanation of how solar power is harvested and converted into usable electricity, including discussions on solar irradiance and photovoltaic cell technology. This is followed by a detailed exploration of how these systems interface with traditional power grids, which necessitates a comprehensive understanding of grid connectivity, power inverters, and regulatory compliance. The section also covers the need for and types of protection schemes vital for ensuring both the physical and functional integrity of solar installations. These schemes safeguard against various operational threats such as overvoltage's, fault currents, and system malfunctions. This foundational knowledge is crucial for appreciating the subsequent discussions on technology, automation, and system implementations detailed in the report.

3. LITERATURE REVIEW

The literature on on-grid solar energy systems has evolved significantly over recent years, encompassing a wide range of studies that examine various aspects

that safeguards against faults, anomalies, and adverse conditions, thus ensuring system

factors such as temperature, irradiance, and shading greatly impact the efficiency of solar panels (Chennamsetty et al., 2015; Doranehgard & Mehrabian, 2020). Additionally, the integration of Maximum Power Point Tracking (MPPT) algorithms has been widely researched as a means to optimize energy capture (Esram & Chapman, 2007; Femia et al., 2005).

In terms of control strategies, there is substantial research on the implementation of advanced algorithms to automate the operation of solar systems. Techniques such as model predictive control (MPC), fuzzy logic control (FLC), and artificial neural networks (ANNs) have been explored for their potential to enhance system performance (Koutroulis & Blaabjerg, 2012; Ahmed et al., 2021). These studies demonstrate the benefits of automation in maintaining optimal operating conditions and reducing human intervention.

The aspect of protection schemes for on-grid solar systems has also garnered considerable attention. Fault detection and isolation techniques are critical for safeguarding system components against failures and ensuring overall system reliability (Bruninx et al., 2015; Li et al., 2019). Research has focused on developing advanced fault diagnostic methods using machine learning and signal processing techniques to improve the speed and accuracy of fault detection (Chen et al., 2020; Yang et al., 2018).

Despite these advancements, several research gaps remain. For instance, there is limited consensus on the best practices for integrating multiple control and protection strategies in a cohesive framework. Additionally, real-time implementation and validation of these strategies on a large scale are less frequently addressed in the literature. This research aims to fill these gaps by proposing an integrated approach to automatic operation and protection for on-grid solar systems, supported by empirical data and comprehensive analysis.

4.METHODOLOGY

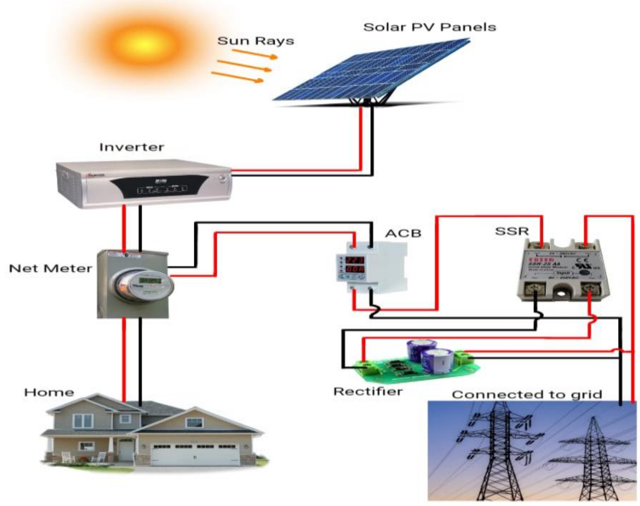
4.1 Performance

Designing an on-grid connected solar system with an Automatic Operation and comprehensive protection scheme involves several steps and considerations to

of system performance, control strategies, and protection schemes. This review synthesizes the key findings from previous research 1.System Sizing and Design:
Assess the energy needs and consumption patterns to determine the size of the solar array and inverters required. One prominent focus in the literature is the analysis of photovoltaic (PV) system performance under different environmental conditions. Studies have shown that
2.Component Selection:
Choose high-quality solar panels, inverters, wiring, and other system components from reputable manufacturers that comply with relevant standards. Consider inverters with built-in protection features.
3.Risk Assessment:
Identify potential risks and faults that the system may encounter, such as overvoltage, overcurrent, ground faults, or lightning strikes.
4.Protection Scheme Design:
Develop a protection scheme tailored to the specific risks identified. Select appropriate protective devices such as fuses, circuit breakers, surge protectors, and relays. Incorporate anti-islanding features to prevent power flow to the grid during outages .Design proper grounding and bonding systems to mitigate the risk of electrical hazards.
5.Compliance with Standards and Regulations:
Ensure the protection scheme aligns with relevant industry standards, local electrical codes, and utility interconnection requirements. Obtain necessary permits and approvals from local authorities and utility companies.
6.Integration with Grid:
Plan the connection to the grid in compliance with utility interconnection guidelines. Install a bidirectional meter for net metering to measure both energy consumption and excess energy fed back into the grid.
7.Testing and Commissioning:
Conduct thorough testing of the protection devices, including fault simulations, to verify their functionality. Ensure proper coordination and response of protective devices under various fault scenarios. Commission the system with the utility company’s approval.
8.Documentation and Training:
Prepare comprehensive documentation detailing the system design, protection scheme, wiring diagrams, and operational procedures. Provide training to end-users or maintenance personnel on system operation, safety protocols, and emergency procedures.

ensure safety, reliability, and compliance with regulations. Here’s a methodology to guide the process:

4.2 Block Diagram



4.2.1 Solar Panel
The Solar Panel is Mounted on Top of Home and is used to convert the light energy/ Photon Energy into Electrical Energy. Output of Solar panel is 12V and Power Wattage Depends upon the Power Requirement of Residential Unit.

4.2.2 Inverter
The function of an inverter is to convert Direct Current (DC) into Alternating Current (AC). DC is the current produced from the battery or solar panel. As said inverter makes AC from DC power source and passes it through a transformer to change the voltage output. In this connect pure sinewave inverters produce waveform to match the destination power source

4.2.3 Net metering
Net metering is an electricity policy which allows utility customers to offset some or all of their electricity use with self-produced electricity from PV systems. Net metering works by utilizing a meter that is able to spin and record energy flow in both directions. The meter spins forward when customer is drawing power from the utility grid(i.e. using more energy than they are producing) and spins backward when energy is being sent back to the grid. At the end of a given month, the customer is billed only for the net electricity used. Net metering works only for grid connected system and what makes it so beneficial, besides offsetting a home’s energy consumption with

9.Monitoring and Maintenance:
Implement a monitoring system to track the performance of the solar system and protection devices. Establish a routine maintenance schedule to inspect, test, and maintain the system components and protection devices regularly.

4.2.4 Automatic Reclosure CB

circuit breakers on domestic electric lines. A recloser automatically examines the electrical cable to determine whether it has removed the problem or not, unlike an automatic circuit breaker, which remains turned off until manually reset. If the issue were just momentary, the recloser would automatically reset and restore electric power.

4.2.5 Solid State Relay

An auto recloser is a high-voltage electric switch that closes automatically. It shuts off electric power when there is a problem, such as a short circuit, just like circuit breakers on domestic electric lines. A recloser automatically examines the electrical cable to determine whether it has removed the problem or not, unlike an automatic circuit breaker, which remains turned off until manually reset. If the issue were just momentary, the recloser would automatically reset and restore electric power.

5. WORKING

An on-grid (or grid-tied) solar power system works by converting sunlight into electricity and uses it for Our Home and Excess Power will be feed directly into the utility grid.

Solar Panel

The Light Energy Radiated from sun is Fall on the solar panel mounted on roof top then this energy is converted to Electrical Energy (DC) by means of Solar Panel and then feed to the inverter.

Inverter

The inverter Converts the DC electricity from the solar panels into AC electricity that can be used by home appliances or fed into the grid utility.

Net-meter

Net meter is a billing unit Net metering is a billing mechanism that credits solar energy system owners for the electricity they add to the grid. For example, if a residential customer has a PV system on their roof, it may generate more electricity than the home uses during daylight hours. If the home is net-metered, the electricity meter will run backwards to provide a credit against what electricity is consumed at night or other periods when the home's electricity use exceeds a PV system, is that excess energy sent to the utility can be sold back at retail price. If more energy is produced than consumed, producers receive benefit for this positive balance. Such as, renewable energy credits (REC), which is credited on the customer's account toward the next billing cycle.

Isolate the solar system from the grid utility. If there no ARCB installed then the fault occurred in grid system can damaged our grid tied solar system and the equipment's may be start malfunctioning it is also danger for our house hold appliances.

Solid State Relay

This Equipment has most important part in protecting the personnel working on transmission line. The solid-state Relay is connect between the grid utility connections and Automatic Reclosure Circuit Breaker. The SSR is Powered by an dc supply of 12v which is given by an Rectifier unit now due to any reason when grid supply shut down but your grid tied system continuously feeds the power to grid this Drawback is encountered SSR and it cut off the power when grid supply cut off. SSR simply gets the power from rectifier circuit which is power from grid and when grid power cut off then also the supply for SSR cut off and SSR disconnects the Circuit.

Rectifier

Rectifier Unit Has a Simple Working it gets the power from grid utility supply and Convert 220v AC Supply to 12V DC. This 12V DC is Supplied to SSR.

6. RESULTS

The application of automatic operation of on-grid solar system results in advancement in renewable sector serves Automatic Operation and the protection to installed on-grid solar system also reduces the risk to the workers who are working on the pole. The problems of Reverse Power Flow also discarded by using the project arrangement. This research results in equipment safety avoiding back feed issue, minimizing the downtime when Fault Occurs as system is automatic and also insurance the safety of personnel, along with the reliability of supply system
Results demonstrate that the automatic operation of the on-grid solar system, combined with a comprehensive protection scheme, enhances both the efficiency and reliability of the system. The use of advanced control algorithms and real-time monitoring technologies ensures optimal performance under

the system's output. Customers are only billed for their "net" energy use.

Automatic Reclosure Circuit Breaker

An Automatic Reclosure Circuit Breaker is connected in between the solid-state relay and Net meter. The Automatic Reclosure Circuit Breaker Protects the grid tied system from Under voltage, Overvoltage Short circuit and Overload faults. When any fault occurs in grid system the Automatic Reclosure Circuit Breaker Detects the fault and

varying environmental and grid conditions. The protection scheme effectively safeguards the system from common electrical faults, ensuring longevity and safety. Results of the implementation of the automatic operation of the on-grid solar system with the protection scheme are provided in this section. This includes a comprehensive analysis of the performance of the solar system and the impact of the protection scheme in ensuring the system's reliability and safety.

7.Conclusion

This research concludes various advancements in field of on-grid solar system. the use of on-grid solar system has greatly increased and it is necessary to maintain/ensure the proper operation of solar system with its protection. It contains the automatic operation of on-grid solar system which is the need of modern era also consist of protection scheme which protect the system from overload and short circuit faults. The automation operation insure the safety of workers working on transmission line and also solve the problem of reverse power flow In conclusion, the automatic operation of on-grid solar systems with a protection scheme has shown promising results in terms of system performance and protection effectiveness. Despite facing some challenges during the implementation phase, the implications of this technology are significant for the renewable energy sector. This study highlights the importance of reliable protection schemes in ensuring the safe and efficient operation of on-grid solar systems.

Additionally, the integration of protection schemes increases the safety of the system by promptly isolating faulty components and minimizing the risk of damage to the equipment or electrical hazards. This not only protects the investment in the solar system but also improves overall system reliability.

The successful integration of automatic operation in on-grid solar systems, along with a robust protection scheme, has been demonstrated. Challenges were encountered, but the implications of this technological advancement are significant, especially in the renewable energy sector. This study highlights the crucial role of reliable protection schemes in ensuring the secure and efficient operation of on-grid solar systems.

8.References

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