ANALYSIS OF PV INVERTER USING MATLAB SIMULINK

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Abstract – *Smart grids have been a major research focus in power systems, aiming to create a more reliable and efficient infrastructure for the future. A key goal is to seamlessly integrate renewable energy sources, like solar PV, which has seen tremendous growth. This paper analyzes four scenarios for incorporating household solar PV systems into the grid, highlighting their characteristics, benefits, and drawbacks. By selecting the suitable scenario, an effective system layout can be designed to meet specific requirements.*

KEY WORDS :Index term- Distributed generation, DC Micro-grids, Energy management system, Smart Grids, Solar home system

1.INTRODUCTION

The world has seen a significant surge in energy demand due to population growth and rising living standards. However, conventional power generation resources are limited, depleting rapidly, and contributing to climate change. This has driven the development of renewable energy sources (RES), although they still face challenges in replacing traditional sources due to their unpredictability. One solution is to create multiple buffers to compensate for this uncertainty. Smart Grids, which enable intelligent and flexible grid operation, offer a promising approach. By integrating advanced monitoring and control systems, Smart Grids can optimize power flow and manage various components. This paper proposes a system that combines solar home systems with the power grid, utilizing effective controls and information transfer to meet future energy needs. Advanced technologies are explored to enhance system performance and create a more efficient power scheme.

2. SOLAR HOME SYSTEM

Solar photovoltaic systems are the preferred renewable energy source for many consumers, especially in sunny regions, due to their ease of installation and low maintenance. These systems enable local generation, reducing transmission losses and allowing households to manage their energy usage. A typical Solar Home System (SHS) includes solar panels, batteries for energy storage, and controllers/converters for efficient use. Energy storage enhances system reliability and control, while demand side management helps match energy usage with generation, reducing grid stress. Excess energy can be stored or fed back into the grid, although this poses challenges like low feed-in tariffs and power quality standards.

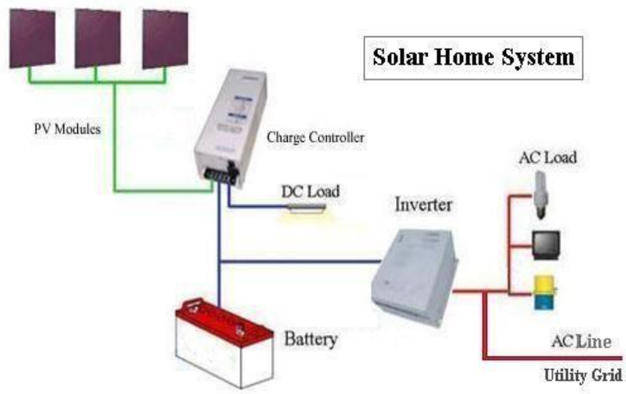

Fig1. Layout for conventional solar homesystem

Decentralized generation makes the system more robust and reliable, but integrating SHS into the existing grid infrastructure requires careful consideration to ensure user comfort and satisfaction.

3. SMART GRIDS

The power infrastructure needs a redesign to integrate new technologies in generation, storage, and efficient use of power. Smart Grids, a bi-directional electric and communication network, can improve reliability, security, and efficiency. It includes software and hardware applications for dynamic optimization, distributed generation, and consumer feedback. Information Communication Technology (ICT) plays a crucial role in monitoring and controlling the system. A smart grid infrastructure ensures reliability, efficient power exchange, and seamless integration of distributed generation and renewable energy sources. It empowers users to participate in the power grid with a deeper understanding of the system. The system features multiple sensors, relays, and communication technologies for efficient operation. It can operate in island mode during disturbances, isolating affected components and ensuring limited disruption. This paper focuses on designing a micro-grid with Solar Home Systems (SHS) as distributed generation, which can be combined to create a larger, more stable network.

4. HOME ENERGY MANAGEMENT SYSTEM

A Home Energy Management System (HEMS) is a crucial interface for controlling loads and grids, empowering users to manage power flows according to their needs. HEMS monitors and controls power usage, allowing users to prioritize demands, select preferred power sources, and customize energy consumption. By leveraging demand side management principles, HEMS optimizes power usage based on user instructions and environmental conditions. It can operate in various modes and be programmed for different scenarios, acting as an intelligent hub that responds to grid and load signals. By giving users control over their energy usage, HEMS plays a vital role in energy management.

5. INTELLIGENT LOADS

Intelligent loads are designed to integrate seamlessly into the evolving grid network, leveraging advanced technology to optimize performance and synchronize with network conditions. These loads can be controlled remotely through the Home Energy Management System (HEMS) or have individual controls, enabling automated operation under specific conditions. Some intelligent loads, like electric vehicles, can even store energy, acting as buffers to enhance grid stability.

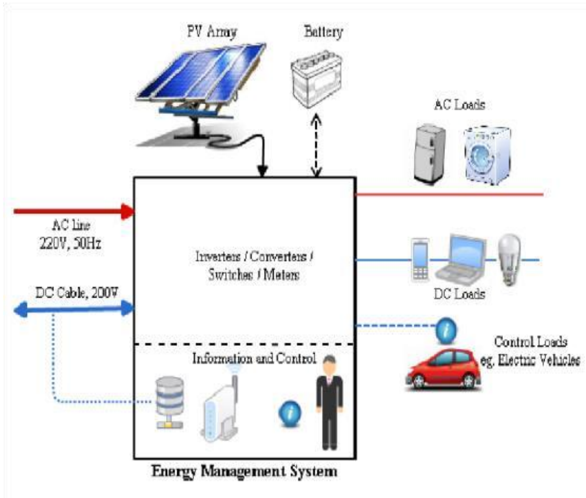

Fig 2. home energy management system articulture

6. PV inverter circuit and its analysis using MATLAB Simulink:

PV Inverter Circuit:

A PV inverter is a power electronic device that converts DC power from solar panels to AC power, suitable for grid integration or load supply. The circuit typically consists of:

1. Solar panel (DC source)
2. Inverter bridge (IGBTs or MOSFETs)
3. Filter (LCL or LC)
4. Grid connection or load

7. MATLAB SIMULINK MODEL

In Simulink, we can create a model of the PV inverter circuit using various blocks, such as:

1. Solar panel: Modeled using the PV Array block 2. Inverter bridge: Modeled using the Universal Bridge block (IGBT or MOSFET)
3. Filter: Modeled using inductor and capacitor blocks 4. Grid connection: Modeled using a voltage source or a grid model
5. Control system: Modeled using control blocks (e.g., PI controllers, PWM generators)

Analysis :

Using Simulink, we can perform various analyses on the PV inverter circuit, such as:

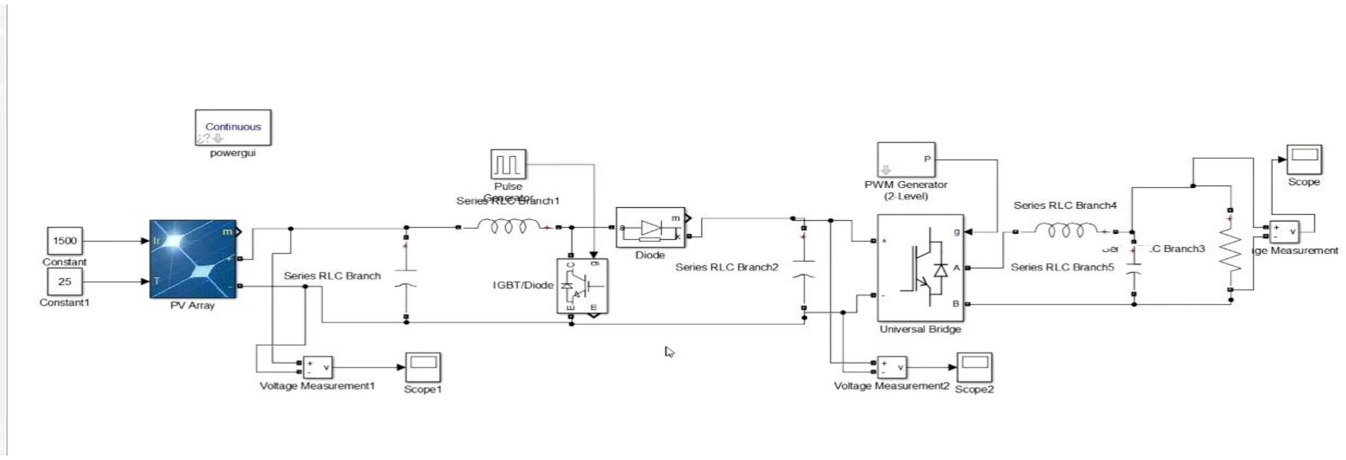

Fig.3 Block diagram of PV inverter using simulink

1. Power quality analysis: Evaluate the total harmonic distortion (THD) of the output current and voltage.
2. Efficiency analysis: Calculate the efficiency of the inverter under various operating conditions.
3. Stability analysis: Analyze the stability of the system under different grid conditions and control parameters.
4. Dynamic response analysis: Evaluate the response of the system to changes in solar irradiance, temperature, or load.

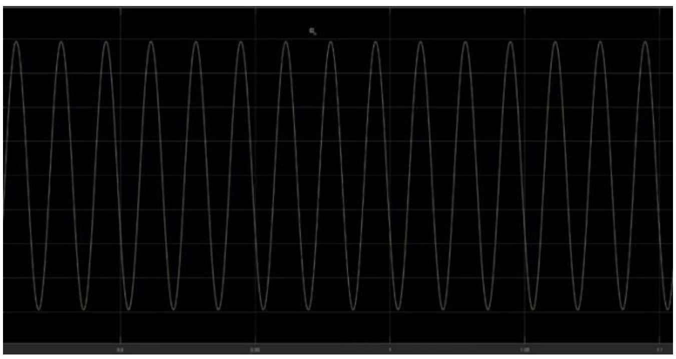

Fig.4 Output of PC inverter

8. SIMULATION RESULT

Simulation results may include:

1. Output current and voltage waveforms
2. Power quality metrics (THD, power factor)
3. Efficiency plots
4. Dynamic response plots (e.g., step response)

By analyzing the simulation results, we can optimize the design and control of the PV inverter for improved performance, efficiency, and reliability.

9. CONCLUSION

The conclusion of the project or research appears to be that the Solar Home Energy Management System can be effectively integrated into a Smart Grid design, providing users with flexibility, reliability, and efficiency. The system enables informed decisionmaking, optimizes energy use, and has the potential to create a more robust and versatile power infrastructure.

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