DESIGN AND DEVELOPMENT OF A SOLAR PV SYSTEM FOR AGRICULTURE FARM WITH MULTIPLE APPLICATIONS

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ABSTRACT – The integration of solar photovoltaic (PV) systems in agricultural settings has garnered increasing interest due to its potential to address energy needs while promoting sustainable farming practices. This project focuses on the design and development of a solar PV system tailored for agriculture farms, encompassing multiple applications to enhance operational efficiency, productivityand it adopts a multidisciplinary approach, incorporating aspects of engineering, agronomy, and renewable energy systems to design an optimized solution. Key considerations include the sizing and placement of solar panels, integration with existing infrastructure, and the implementation of diverse applications such as irrigation, crop drying, and electrification of farm equipment. Through rigorous modelling and simulation the performance and feasibility of the proposed system are evaluated under varying environmental conditions and agricultural requirements. Results demonstrate the potential for significant energy savings, cost reduction, and environmental benefits compared to conventional power sources. Moreover, the versatility of the system enables farmers to diversify income streams and improve resilience to energy fluctuations. This study contributes valuable insights into the design and implementation of solar PV systems in agricultural contexts, facilitating the adoption of sustainable energy solutions to support modern farming practices.

Keywords – Power Supply, Telecommunications, Efficiency.

I. INTRODUCTION

Agriculture is the main source of food for human beings. However, agricultural farm needs a constant energy supply for operation of machineries, vehicles, irrigation pumps etc. which is conventionally, generated by fossil fuel. There is an increasing alarm that these fossil fuels will be exhausted soon due to increasing continuous demand for consumption. As a result, scientists, researchers and academicians are currently investigating the need to find an alternative renewable energy for sustainable agricultural farming, which can maximize crop productivity for maintaining economic stability while minimizing the environmental impacts. There are many possible sources of renewable energy but solar energy is the best form as it is possible to put up in almost all parts of the earth's land surface, pollution free and cost efficient. This has been accompanied with the works of many scientists and academicians, who are trying to bring public awareness about environmental problems due to global warming and climate change. Climate change is heightened by using machineries operated by fossil fuel energy in agricultural farms as it emits lots of greenhouse gases. The use of solar energy does not emit greenhouse gases unlike fossil fuel. As a result, now adays many developing countries are switching to renewable energy such as solar energy, which can be used for various purposes, including agriculture farm cultivation, greenhouse cultivation, water pump for irrigation, drying products, space heating, ventilation and so on in order to reduce the environmental problems.

There are two methods of converting solar energy into electrical energy: solar panel (Photovoltaic, PV) system and solar capture heating systems . In the PV system, the sun rays are converted directly to electricity by semiconductors, but needs more investments. Recently, due to advances in the field of solar energy technology, thermal methods are also being used for power supply. However, the current article will focus on the application of solar panel (Photovoltaic, PV) technology since this energy system technology has the main objective to satisfy the demand for electric power effectively, efficiently and reliably within technical, environmental and economic considerations, as it is the best renewable energy option for rural areas that have unstable electric power supply (. Since almost half of the world's population do not have access to modern energy supplies and many people still rely entirely on fossil fuels for energy, adopting this system is efficient, affordable and reliable, because it is not hazardous to health as well as the environment. Due to this, in the recent decades, the number of users of Solar Panel Energy Technology in the distant rural farm is gradually increasing (GNESD, 2004).

II. LITERATURE SURVEY

Integrated photovoltaic maximum power point tracking converter

A low-power low-cost highly efficient maximum power point tracker (MPPT) to be integrated into a photovoltaic (PV) panel is proposed. This can result in a 25% energy enhancement compared to a standard photovoltaic panel, while performing functions like battery voltage regulation and matching of the PV array with the load. Instead of using an externally connected MPPT, it is proposed to use an integrated MPPT converter as part of the PV panel. It is proposed that this integrated MPPT uses a simple controller in order to be cost effective. Furthermore, the power converter has to be very efficient, in order to transfer more energy to the load than a directly-coupled system. This is achieved by using a simple soft-switched topology. A much higher conversion efficiency at lower cost will then result, making the MPPT an affordable solution for small PV energy systems.

Development of a microcontroller-based, photovoltaic maximum power point tracking control system

Maximum power point tracking (MPPT) is used in photovoltaic (PV) systems to maximize the photovoltaic array output power, irrespective of the temperature and irradiation conditions and of the load electrical characteristics. A new MPPT system has been developed, consisting of a buck-type DC/DC converter, which is controlled by a microcontroller-based unit. The main difference between the method used in the proposed MPPT system and other techniques used in the past is that the PV array output power is used to directly control the DC/DC converter, thus reducing the complexity of the system. The resulting system has high-efficiency, lower-cost and can be easily modified to handle more energy sources (e.g., wind-generators).

III. ALTERNATIVE POWER SUPPLIES IN TELECOM

a) MPPT Controller

This document describes the modeling of the RTDS PV array model.

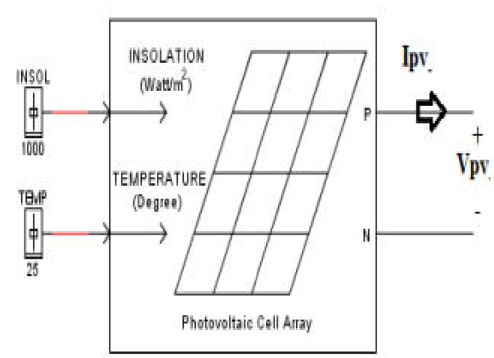

Fig. 1: RTDS PV Array model

The fundamental component of a PV array is the solar cell. Solar cells are manufactured using several types of semiconductor materials eg silicon and germanium; these semiconductor materials produce an electric charge when exposed to direct sunlight. Solar cells can be connected in series and/or parallel to form PV modules. A typical module will have 36/72 cells connected in series. The PV modules are then combined in series and parallel to form PV arrays. The combination of individual solar cells into PV arrays enables large values of voltages and currents to be obtained at the terminals of a PV array.

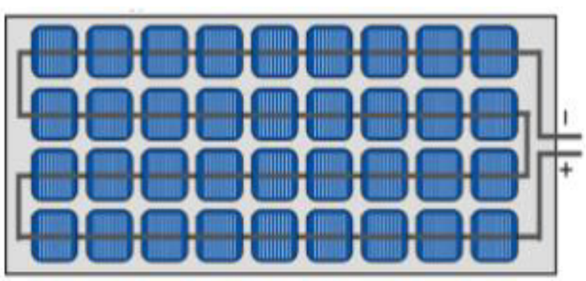

Fig. 2: Series connected cells in a module

The parameters that specify how the cells are connected to form arrays are the number of series connected cells in a module Nc, the number of parallel connected cells in a module Ncp, the number of series connected modules Ns and the number of parallel connected modules Np.

The solar cell is the basic unit of a PV system. An individual solar cell produces direct current and power typically between 1 and 2 W. in case of crystalline silicon solar cells with a typical area of 10 × 10 cm an output power is typically around 1.5 Wp, with Voc ≈ 0.6 V and Isc ≈ 3.5 A. For actual usage, the solar cells are interconnected in series/parallel combinations to form a PV module. In the outdoor environment the magnitude of the current output from a PV module directly depends on the solar irradiance and can be increased by connecting solar cells in parallel. The voltage of a solar cell does not depend strongly on the solar irradiance but depends primarily on the cell temperature. PV modules can be designed to operate at different voltages by connecting solar cells in series. The modules are manufactured in various sizes and are able to deliver power ranging from 5 to 240 W. For large-scale generation of solar electricity the solar modules are connected together into a solar array.

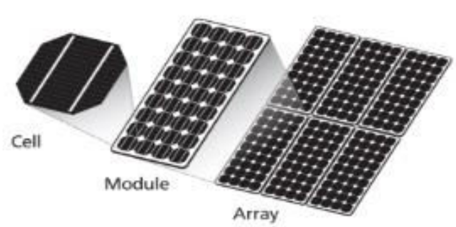

Fig. 3: Cell-Module-Array

The modeling of RTDS PV arrays holds paramount importance in the realm of renewable energy systems, facilitating the simulation and optimization of photovoltaic installations. At the heart of these arrays lies the solar cell, a foundational unit that converts sunlight into electricity. Through strategic interconnection of solar cells in series and parallel configurations, PV modules are constructed, each comprising numerous cells. These modules are then combined to form PV arrays, capable of producing significant electrical output. Beyond theoretical considerations, the practical applications of PV arrays are vast and diverse. They power everything from small-scale residential installations to large industrial complexes, providing clean and sustainable energy solutions worldwide. As society continues to prioritize sustainability and environmental stewardship, the modeling and optimization of PV arrays become increasingly crucial for advancing the transition towards renewable energy sources.

Photovoltaic cells are connected electrically in series and/or parallel circuits to produce higher voltages, currents and power levels. Photovoltaic modules consist of PV cell circuits sealed in an environmentally protective laminate, and are the fundamental building blocks of PV systems. Photovoltaic panels include one or more PV modules assembled as a pre-wired, field-installable unit. A photovoltaic array is the complete power-generating unit, consisting of any number of PV modules and panels.

b) Boost Converter

DC-DC boost power converters play an important role in solar power systems; they step up the input voltage of a solar array for a given set of conditions. This paper presents an overview of the variance boost converter topologies. Each boost converter is evaluated on its capability to operate efficient, size, and cost of implementation. Conventional boost converter and interleaved boost converter are widely used topologies in photovoltaic systems reported; however, they have negative sides of varied efficiency level under changed weather conditions.

The boost converter is used to "step-up" an input voltage to some higher level, required by a load. Thisunique capability is achieved by storing energy in an inductor and releasing it to the load at a higher voltage. This brief note highlights some of the more common pitfalls when using boost regulators. These include maximum achievable output current and voltage, short circuit behavior and basic layout issues.

The references at the end of this document provide excellent overviews of the operation of a boost regulator; and should be consulted if the reader is not familiar with the basic operation of this type of converter.

Therefore, interleaved boost converter with novel switch adaptive control, to maximise efficiency of standalone photovoltaic system under change of solar power levels.

c) Bi-Directional Converter

A bidirectional DC-to-DC converter stands as a cornerstone in contemporary power electronics, boasting the remarkable capability to fluidly transform DC power between distinct voltage levels in either direction. Operating in both buck and boost modes, these converters wield unparalleled versatility, accommodating the conversion from higher to lower voltages and vice versa with equal efficiency. Beyond their technical prowess, bidirectional DC to DC converters serve as linchpins in a myriad of critical applications, including energy storage systems, electric vehicles, and renewable energy infrastructures.

By facilitating bidirectional power flow, they enable seamless integration between various energy storage devices and the larger electrical grid, thereby fostering enhanced efficiency, reliability, and sustainability in our evolving energy landscape. A bi-directional DC to DC converter is an electronic device capable of converting DC power from one voltage level to another bidirectionally. Unlike traditional converters that operate unidirectionally (either stepping up or stepping down voltage), bi-directional converters can facilitate power flow in both directions. This bidirectional capability is particularly useful in applications where energy needs to be efficiently transferred between two DC sources or loads bi-directionally.

d) Singe Phase Full Bridge Inverter

Inverters are circuits that convert Direct Current (DC) to Alternating Current (AC). Since the main objective of the inverter is to use a DC voltage source to supply a load requiring AC, it is useful to describe the quality of AC output . The input of the inverter is taken from various DC source like a battery, photovoltaic, fuel cell, alternator, etc. There are two types of circuit used in single-phase inverter circuit which are half-bridge and full bridge configurations. Inverters have been widely used for applications, from small switched power supplies for a computer to large electric utility applications to transport bulk power.

The Sinusoidal Pulse Width Modulation (SPWM) technique is the most common one and it is based on the principle of comparing a triangular carrier signal with a sinusoidal reference waveform according to . The advantages of unipolar SPWM is this technique only need small filter to produce sine wave and reduce Total Harmonic Distortion (THD). Thus, the purpose of this project is to compare and analyze the results of THD between the bipolar SPWM and unipolar SPWM switching technique. Furthermore, the hardware prototype of the inverter using unipolar SPWM was developed to confirm the simulation results are verified. Arduino Uno is used as a microcontroller.

e) Battery Management System

Increase in human population has elevated the power demand. In order to satisfy the power demand, fossil based energy source alone was utilized but, this has lead to pollution. Hence, the increase power demand can be met out using renewable energy sources. Solar electrical phenomenon cells are promising and gaining an excellent deal of attention, however, wattage generation from these sources is intermittent, looking on the climatic conditions. Thus, in tiny autonomous renewable energy systems, energy storage is needed therefore on extend the response rate and power capability of the power offer. The major challenge for implementing this technology is due to the unreliable power grid structure . There are various methods to increase the effectiveness of the electrical power grid using renewable sources

The inconsistency in radiation received from the sun demands for a tracking system to harvest the optimum power from the PV system for ensuring reliable operation. Hence, a charge control system becomes so vital to harvest the most available power for a given irradiation. This is important for regulating the battery as well as the load. This work includes monitoring the ac and dc loads in the PV based autonomous system. This kind of system needs a secondary source like battery to supply energy to loads during off sunshine periods. Hence, to regulate the battery power, a kind buck boost converters is very essential. Inverters also become part of the autonomous system for delivering power to AC loads in the system. Therefore, reliable power to the entire load in the system has been ensured by proper coordination among converters and inverters.

With an increasing share of fluctuating renewable energies, the need for storage technologies is growing and the demand for reliable and safe energy storage systems is ever more increasing. In parallel, driven by the set global climate goals, the transformation of the mobility sector away from combustion engines to battery electric solutions such as the Battery-Electric-Vehicle is the key driver for the rapidly rising battery demand. The field of application for batteries is wide-ranging and the demands on them are constantly increasing. In order to meet the necessary requirements and to ensure a safe operation, battery management systems are an indispensable part of the application. The primary task of the battery management system (BMS) is to protect the individual cells of a battery and to increase the lifespan as well as the number of cycles. This is especially important for lithium-ion technology, where the batteries must be protected against overcharging and over-temperature to prevent the destruction of the cell. Necessary performance characteristics of new accumulators can only be achieved by intelligent battery management systems.

The basic task of a Battery Management System (BMS) is to ensure that optimum use is made of the energy inside the battery powering the portable product and that the risk of damage inflicted upon the battery is minimized. This is achieved by monitoring and controlling the battery's charging and discharging process.

Battery management system (BMS) is technology dedicated to the oversight of a battery pack, which is an assembly of battery cells, electrically organized in a row x column matrix configuration to enable delivery of targeted range of voltage and current for a duration of time against expected load scenarios

IV. RESULTS

Simulation Model of a Design And Development Of A Solar PV System For Agriculture Farm With Multiple Applications.

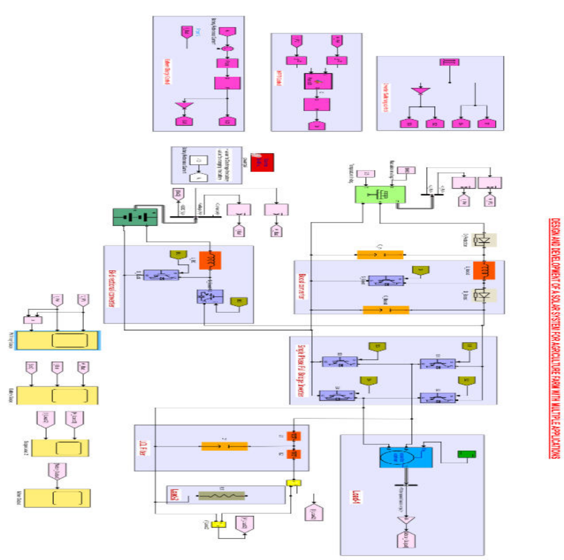

Fig. 4: PV Solar System for Agriculture Farm with Multiple Applications

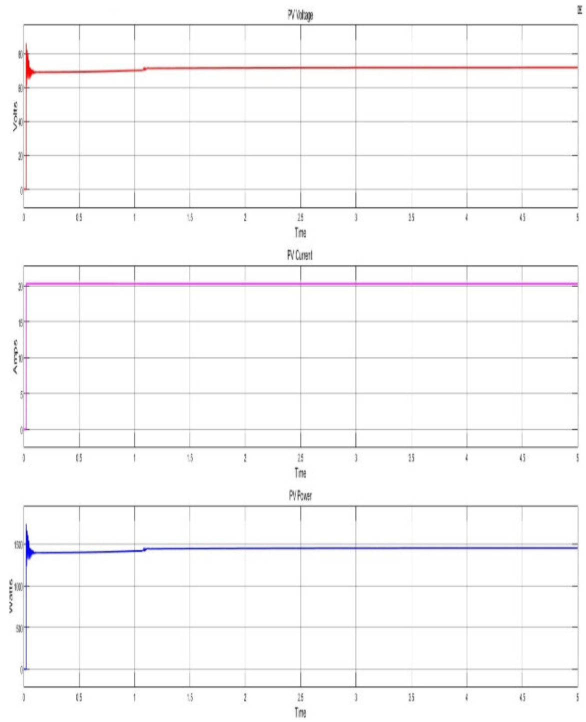

Fig. 5: PV Array output waveform

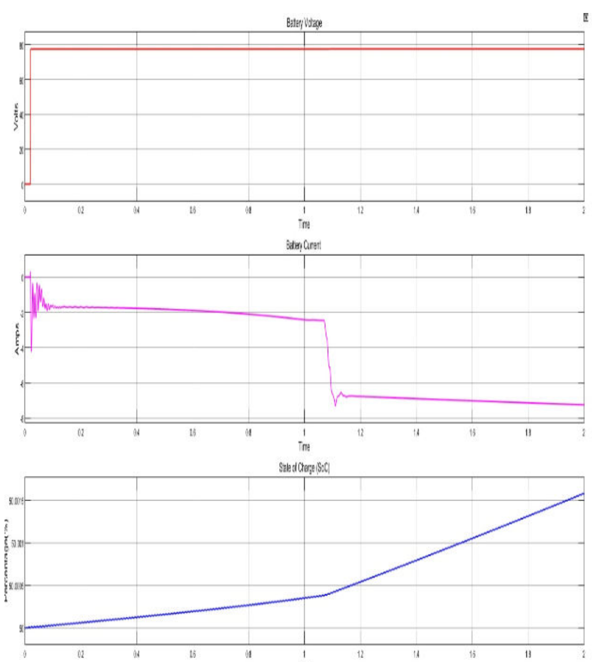

Fig. 6: The Bidirectional coverter charge the battery from the Source

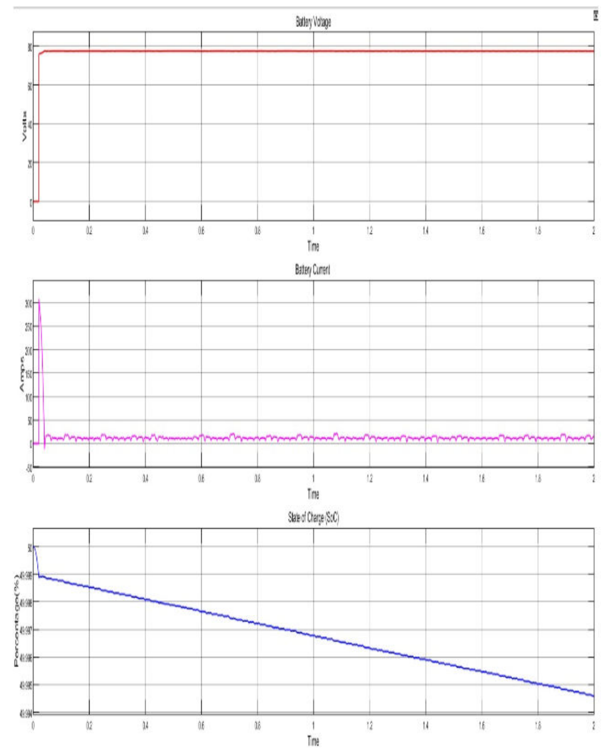

Fig. 7: The Bidirectional coverter Discharge the battery to disconnecting from the source or connected to a load

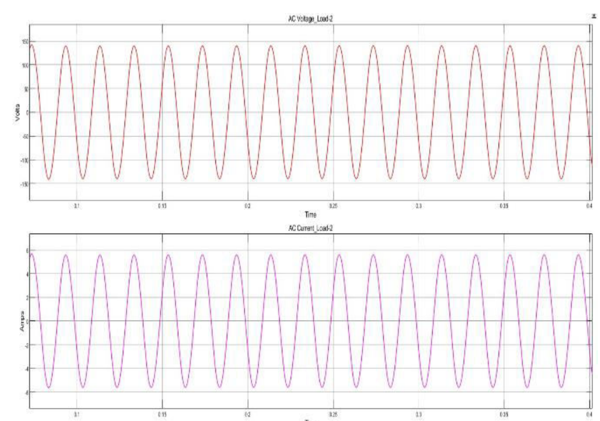

Fig. 8: Output AC voltage Across the Load

V. CONCLUSION

This project suggests that solar energy may offer a long-term solution to many of the world's current issues, including climate change, energy shortages, atmospheric conservation, and drought. Farmers in the United States, the European Union, and Asian countries are at the forefront of adopting solar energy, as evidenced by the literature. However, despite the fact that this technology has numerous advantages, as demonstrated in this article, most farmers on the African continent are less accepting of solar systems for agriculture. The African continent also benefits from increasing solar radiation and has 60% of the world's productive land. Solar power is suitable for agricultural applications such as electrical shielding, threshing, aerating, grinding, drainage, purification, and so on. Solar energy is now widely used by Indian farmers in the water sector, especially in irrigation systems, for their agricultural.

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