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An Implementation Of Ultracapacitor Energy Storage For Pv Systems Using Mppt Controller

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Abstract- Due to the physical properties of the network components, energy and power losses occur when electrical energy is transported from generating facilities to customers via transmission and distribution networks. These losses are unavoidable in the transmission of electrical energy through physical channels. Existing networks and planned additions provide a great opportunity to increase energy efficiency. Improving efficiency entails putting in place measures beyond the activity's current best practices in terms of efficacy. To decrease network losses, various practical procedures and technologies may be employed. Salp Swarm Algorithm and Particle Swarm Optimization (PSO) (SSA) The performance study of hybrid energy storage systems (HESSs) reveals various benefits, including a low component count, ease of management and complete control of source energies. An energy management plan must properly estimate the power levels of sources in these systems (EMS). This work provides an energy management system (EMS) for a battery/ultra-capacitor (UC). By using an MPPT controller, the UC state-of-charge is not only smoothed but the battery power profile is also smoothed. As a result, it produces a HESS that is more durable and has longer battery life.

Keywords: - Energy efficiency, physical channels, EMS etc.

I. INTRODUCTION

Power Electronics is the application of solid-state electronics to control and convert electric power. It also refers to research in electronic and electrical engineering which deals with the design, control, computation and integration of nonlinear, time-varying energy-processing electronic systems with fast dynamics. The available devices determine the capabilities and economy of the power electronics system. Their characteristics and limitations are key elements in the design of power electronics systems.
Solar cell systems or solar cell systems are power systems designed to deliver functional solar power through solar cells. It consists of many apparatuses, counting photovoltaic systems that absorb sunlight or convert it into electrical power, photovoltaic systems that convert electricity from direct present to alternating current, or installation, wiring or other electrical accessories to build a functioning classification. It can also use solar cell tracking systems to recover largely performance of classification and include integrated battery solutions as the price of storage devices is predicted to fall. Strictly speaking, a photovoltaic system includes only a synergy of photovoltaic systems, that is, the visible part of the photovoltaic system, excluding all other hardware, and is usually summarized as the balance of the system. In addition, the photovoltaic organization directly convert light into electrical energy or should not be mystified with other technologies, such as concentrated solar energy or solar heating for heating and cooling.

Ultra-capacitors: Conventional capacitors store energy by physically separating unlike charges on two separate electrodes with a dielectric in between. This charge separation causes a potential between two electrodes. Ultra-capacitors, on the other hand, do not make use of the electrolyte in the same way. A significant charge separation is achieved by the use of electric double layer technology, resulting in extremely large capacitance. In Figure 1.8, you can see that they are made by two metal electrode foils that have been coated with activated carbon, which are immersed in an electrolyte and separated by a paper separator.

Electrons collect in the electrode that is connected to the negative terminal and attract positive ions from the electrolyte as a result of the electrostatic attraction. Positive charges attract negative electrolyte ions on the other electrode, and current flows via the external load on the other electrode. The separator prevents current from flowing directly between the two electrodes and creates the appearance of two charge layers, which is why ultracapacitors are also referred to as electric double-layer capacitors when they have two charge layers.

Since the electrodes are made of a porous material, the charge can be stored in the micro- pores at the electrode and the electrolyte interface. Moreover, the electrode surface is significantly larger than a normal capacitor reaching 2000 $m2/gr$ [16]. This combination of large surface and small separation between electrodes enables capacitances to reach thousands of farads. This structure has major implications on the properties such as cycle life, efficiency, energy and power density, and voltage as a function of SOC.

II. RELATED WORK

In the past decade, low and medium energy storage has been linked to new active systems, such as wind turbines, power generators, biomass, and geothermal manufacturers, photovoltaic systems, fuel cells, storage, and quality improvement tools of electricity. The main objective of this work is the definition of a general methodology for the analytical solution.

Zahra Amjadi et al. (2020) A control strategy for fuel cells (FC), batteries and Ultracapacitors (UC) modules in electric vehicles (EV) and hybrid electric vehicles (HEV) is being proposed and studied in 4Quadrant (4Q) switch capacitors became (SC) Luo DC/DC bidirectional converter. The FC strategy is also one of EVs' most popular and favorite energy storage systems (ESS) due to its high efficiency and ability to use hydrogen as fuel. FC and UC modules can be combined to produce a high-speed dynamic response and high output, making them ideal for automotive applications. FC also contains a high energy density, and its weight is 8-14 times that of a lithium-ion battery (Li-ion), and the FC stack can extend the battery life of EVs and HEVs. This white paper describes a novel topology and intelligent balancing strategy proposed for EV and HEV energy storage system (ESS) applications. [26]

M. Zeeshan Tariq et al. (2021) In response to the global contribution of renewable energy storage systems (RES), we have noticed an undeniable surge in marine electrical systems. On the other hand, to address the intermittent RES. A battery energy storage system is built into the system. However, the problem is that the energy density is low and the lifespan is short, which increases the space required and increases the cost. To solve this problem, it is recommended to equip an ultra-capacitor battery energy storage device. Therefore, the integrated system provides greater dynamic performance using relatively less space and higher energy.

In order to take advantage of these advantages in this integrated system, it is necessary to realize the optimal management of power generation and consumption. This requires the development of accurate and robust control algorithms. This paper proposes an effective control technique in which a PV-powered hybrid energy storage system (HESS) integrates with a conventional diesel generator to supply power to marine loads, primarily lighting and heating. In addition, various possible operating modes for realizing optimal performance given the inconsistency of PV generation are described and verified using simulation results. Meanwhile, some of the major contributions of the proposed control scheme are maximum power extraction from PV panels, power factor single operation of the utility grid and improved reliability of connected loads. [36]

III. PROPOSED SYSTEM

This proposed EMS regulates the state-of-charge of UC and smooths the battery power profile by using an MPPT Controller. Therefore, it results in a sustainable HESS with longer battery life. Through a simulation study and an experimental setup including a real EMS, the performance of the proposed system is evaluated comprehensively. Then, based on experimental results, battery cycle life improvement due to the battery/UC hybridization is explored as stated above. Utilizing both a battery and a UC as a hybrid storage solution has many benefits.

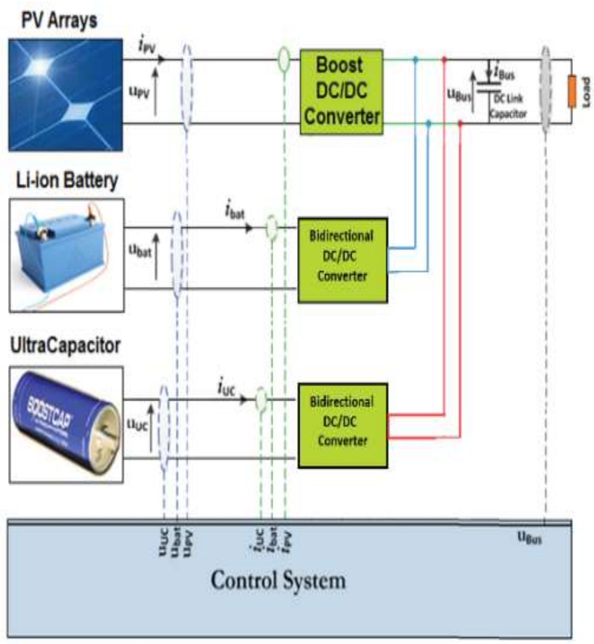

Figure 1 Proposed Block Diagram.

This Hybrid (Battery / UC) storage solution can be classified according to system configuration. Thus, the UC has a certain upper voltage limit since the battery voltage determines the capacitor array size. In addition, the power enhancement is limited due to the current sharing between the battery and UC, according to the internal resistances of each component.

The storage system terminal voltage follows the battery discharge curve, varying between fully charged and fully depleted. In UC-battery HESS, the two ESS devices can be coupled to either a common DC or AC bus. For standalone renewable Microgrid, a common DC bus is the preferred choice because most renewable energy sources operate in DC, and no synchronization is needed, which minimizes the system complexity. The system responses are studied using the MATLAB Simulink platform. Finally, PSO and SSA techniques are applied to tune the FOPID controller to control the system frequency and maintain the power balance in the proposed system. The results interpret the superior performances of SSA over PSO. The study reported system stability within accepted system frequency limits during both the source and load variations.

Simulink Model :

Each block from Figure 4.2 was modelled in MATLAB/Simulink. The schematic of the boost converter. The input to the boost converter is the PV output voltage, and the output is the DC link voltage. The control input is a PWM signal generated based on the P&O controller. Voltage and current sensors are utilized to measure the change in power, which is the control feedback term. Optimising an autonomous photovoltaic system with storage is crucial as the photovoltaic panels are the only generation source. The system optimisation is performed on an annual basis to minimise the system lifetime cost under several constraints. The constraints employed in the optimization include the battery SOC limit, restrictions on component dimensions, and an LPSP limit. The input data required for the optimisation include the annual solar radiation and the load profile.

The storage system is utilized as an energy buffer to supply power to the load at night time and during periods of low solar radiation. The extent of the storage elements required to supply the load throughout the year fluctuates depending on the number of photovoltaic panels installed in the system. The quantity of photovoltaic panels is varied from the best to the worst case. The storage system is optimized based on the power available to charge the storage elements and the load power required from the storage system. In the HESS, the ultracapacitors are employed to supply the peak power requirements of the load with the average power supplied by the battery bank.

The optimization of the reactive energy compensation is to be understood as the choice of the powers of the capacitor banks, their locations and even the time during which they will remain in line if it is an adaptive compensation. Of course, these choices must be made so that there is the least power loss in line and an improvement in the voltage profile while having a positive economic return. The choices of the objective function are dictated by the concern to take into account both the electrical and economic aspects of the problem. The objective

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function, over which all authors are involved in the issue of advancing responsive vitality remuneration, is the purported monetary bring capacity back (saving function). However, since the installation of capacitor banks reduces active losses and reactive power losses, unlike all the authors who dealt with a problem of concern, this article will introduce the objective function of reducing reactive power losses. Therefore, the goal is to determine the battery capacities and their location in order to minimize power losses, improve the voltage profile and thereby increase the throughput of these lines.

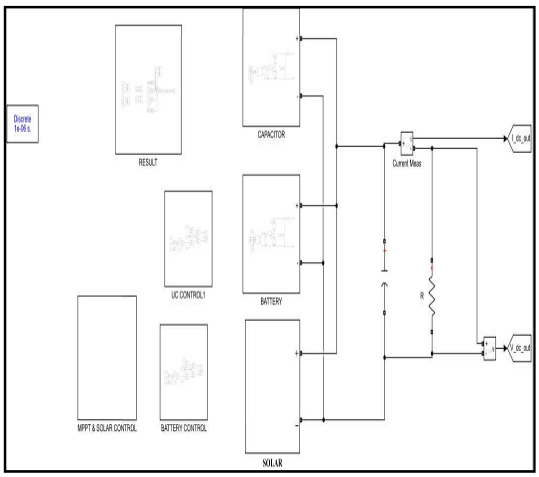

Figure 2: Simulink Model.

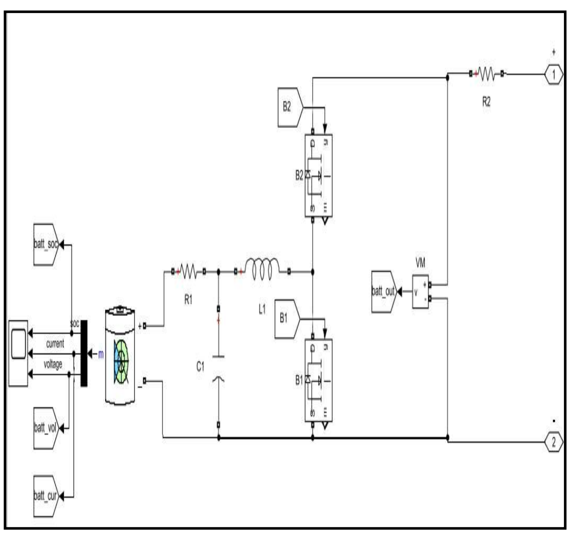

Figure.3: Battery Model.

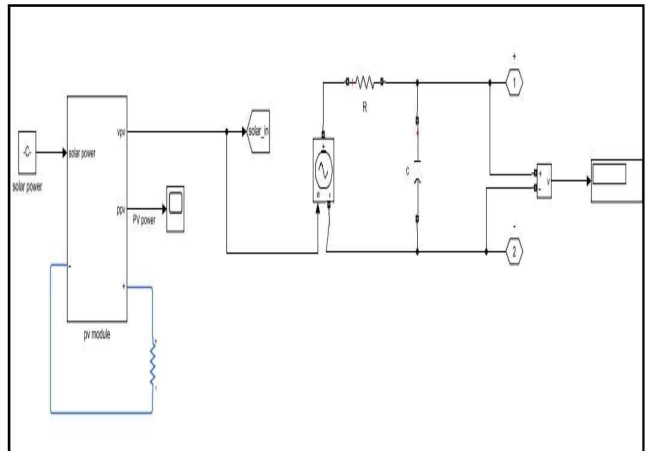

Figure 4 Solar Subsystem 1.

This block model a solar cell as a parallel combination of a current source, two exponential diodes and a parallel resistor, Rp, that are connected in series with a resistance Rs. The output current I is given by:

$$I = I_{ph} - I_s*(e^{((V+I*R_s)/(N*V_t))}-1) - I_{s2}*(e^{((V+I*R_s)/(N2*V_t))}-1) - (V+I*R_s)/R_p \quad ....4.1$$

Where Is and Is2 are the diode saturation currents, Vt is the thermal voltage, N and N2 are the quality factors (diode emission coefficients), and Iph is the solar-generated current. Models of reduced complexity can be specified in the mask. The quality factor varies for amorphous cells and typically has a value in the range of 1 to 2. The PS input Ir is the irradiance (light intensity) in W/m^2 falling on the cell. The solar-generated current Iph is given by Ir*(Iph0/Ir0), where Iph0 is the measured solar-generated current for irradiance Ir0.

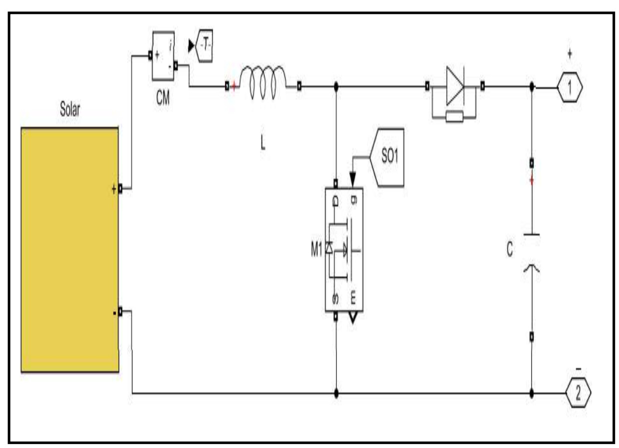

Figure.5: Solar Subsystem 2

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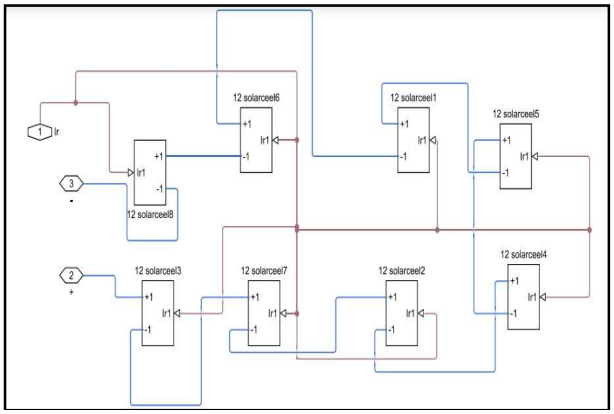

Figure 6: Solar Cell Structure

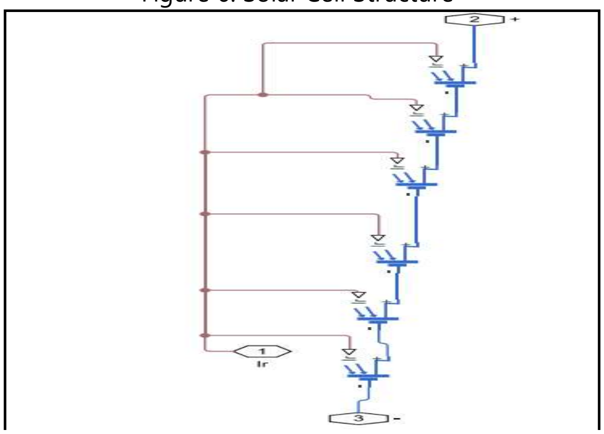
Figure 7: Solar Cel Internal Structure

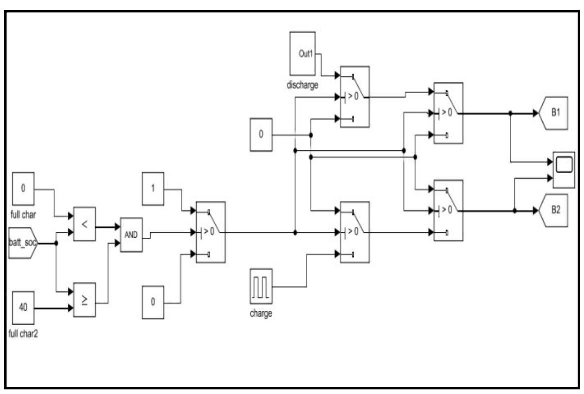

Figure 8: Battery Control

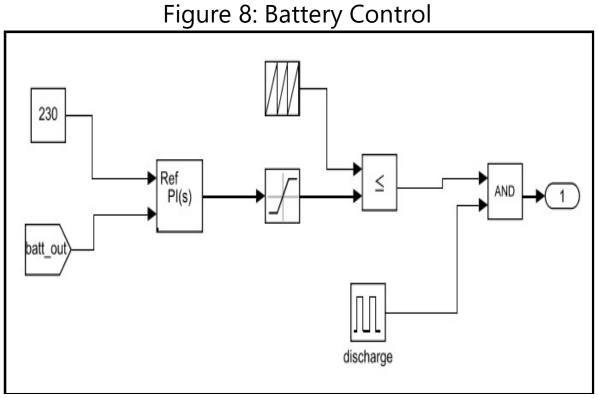

Figure9: Battery Charging and Discharging

Implements a generic supercapacitor model which allows the simulation of Electric Double Layer Capacitors (EDLCs)

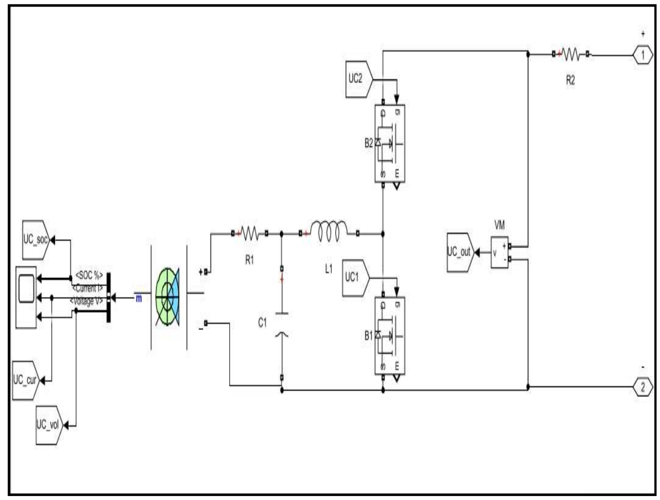

Figure 10: Ultra Capacitor Simulink

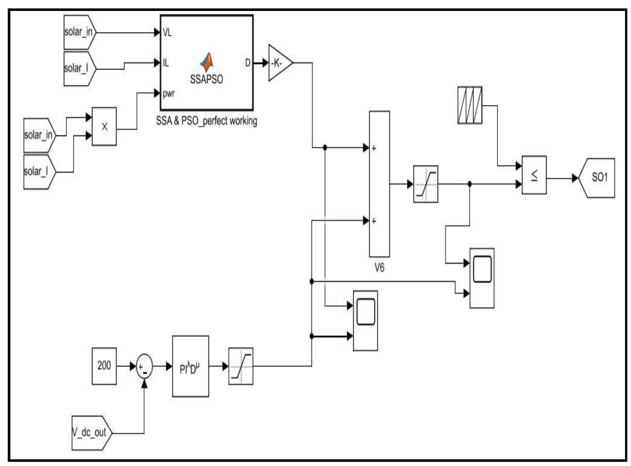

Figure11: PSO and SSA.

Salp swarm algorithm (SSA): SSA is one of the random population-based algorithms suggested SSA simulates the swarm-ing mechanism of salps when foraging in oceans. Salps usually shape a swarm known as the salp chain in heavy oceans. In the SSA algorithm, the leader is the salp at the front of the chain and whatever remains of the Salps are called followers. Like other swarm-based techniques, the position of salps is defined in an n-dimensional search space, where s is the number of variables of a given problem. Therefore, the position of all salps is stored in a two-dimensional matrix called z. It is also assumed that the swarm's target is a food source called P in the search space.

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IV. SIMULATION RESULTS

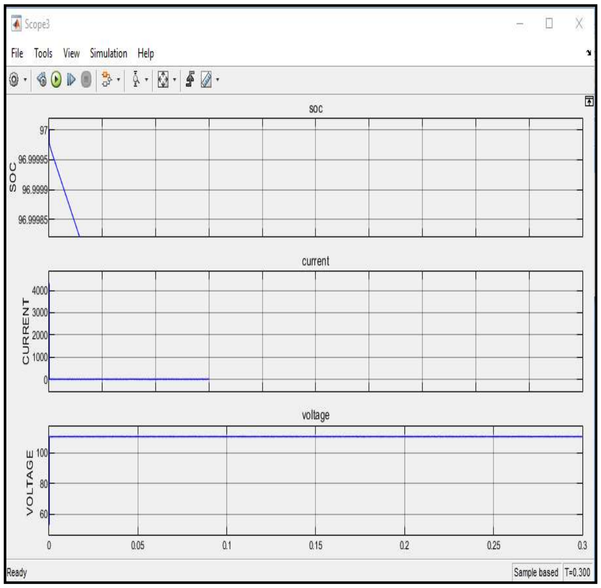

Figure 12: Battery Output

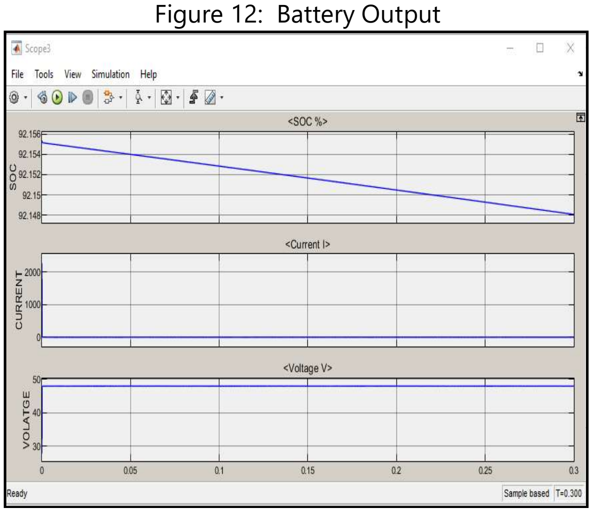

Figure 13: Capacitor Output

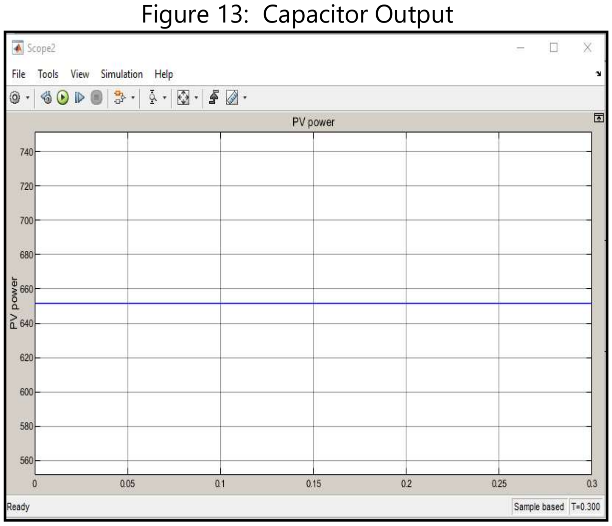

Figure 14: PV Power

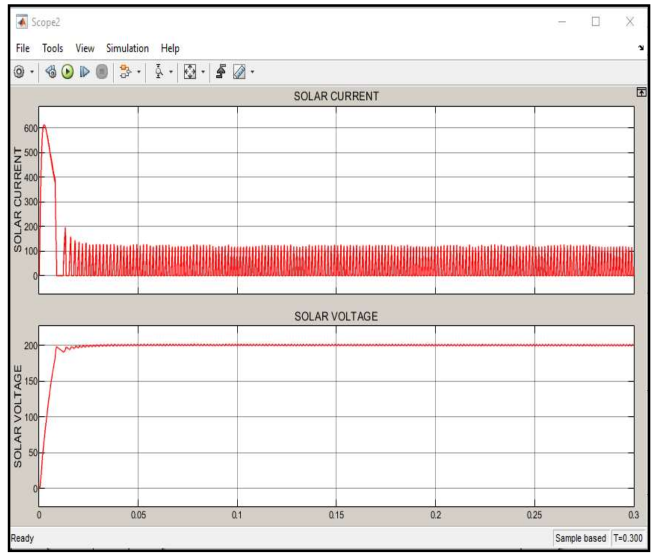

Figure 15: Solar Voltage and Solar Current.

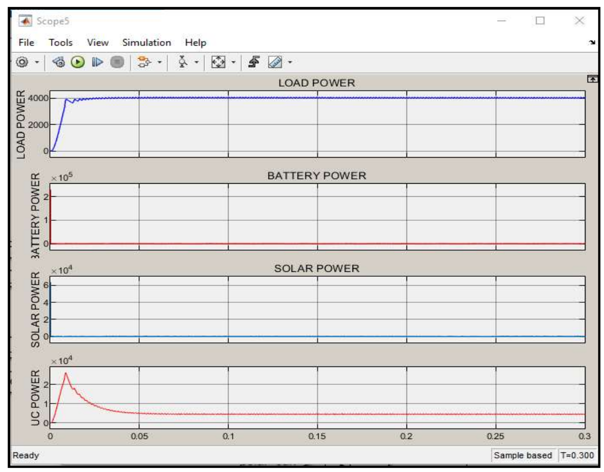

Figure 16: Load Power, Battery Power, Solar Power

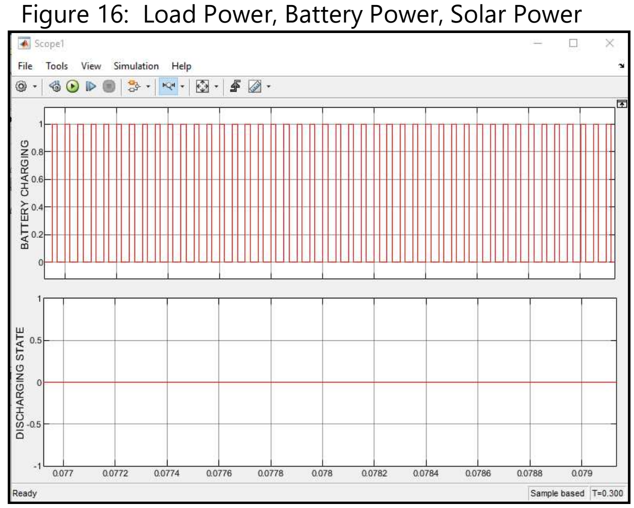

Figure 17: Battery Charging and Discharging

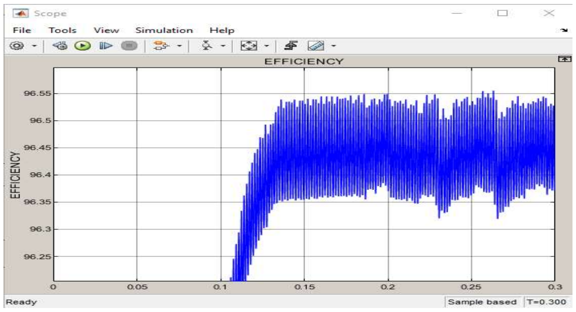

Figure 18: Efficiency of The System

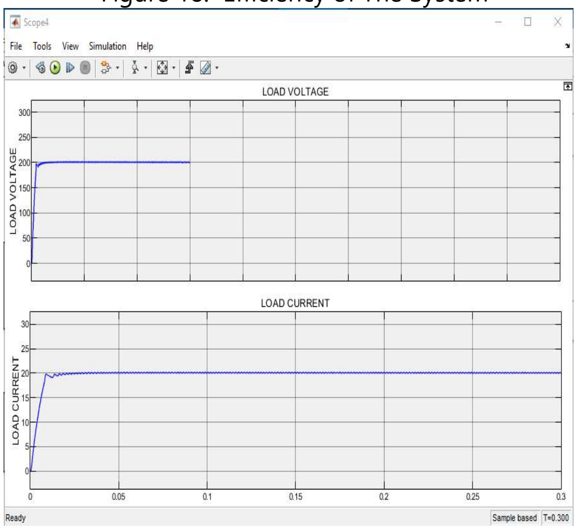

Figure 19: Load Voltage and Current.

V. CONCLUSION

This thesis is based on an energy management strategy (EMS) for a battery/ultra-capacitor hybrid energy storage system (HESS) that has been presented in this work. The HESS is composed of a bidirectional non-isolated multi-input dc-dc converter which can achieve power flow between each input source and output port. An EMS has been designed for controlling the SOC of UC while smoothing the battery power profile.

By applying this EMS, it aims to ensure the practicability of the hybrid system and decrease the battery power peaks, thus extending the battery cycle life. A sustainable energy system consisting of a photovoltaic array with a battery ultra capacitor HESS to supply a non-grid connected load was introduced. The impact of including the ultra-capacitor in the photovoltaic system was analyzed. The batteries and ultra-capacitors complement each other in their power and energy densities. Electrical loads that contain motors can have power spikes of between three and seven times their rated wattage at start-up, while loads requiring large capacitors to be charged at the start-up can result in a power surge up to three times their rated wattage. THIS THESIS ANALYSED a DC system, but the same principles apply to AC systems. In an AC system, the inverter must be sized to consider the starting power requirement of the load, with the battery bank being sized to handle the voltage drop due to the high current surge. Otherwise, the voltage drop could cause the inverter to shut down. Depending on the discharge rate. Peak power loads requiring high power reduce the battery capacity, resulting in a voltage drop.

This thesis may assist microgrid operators in making judgments, investing heavily in rural electrification, developing a competitive hybrid microgrid, and optimising energy dispatches. Furthermore, for microgrid system engineers, this study enables preliminary design and project cost projection.

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