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Optimum Hybrid Energy System Using Microcontroller

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ABSTRACT: In the coming years, ships will rely on hybrid power management systems that combine fuel cells (FCs) and batteries as their driving power sources. These systems are composed of an FC, a converter, an inverter, and a battery. The FC is responsible for providing a consistent supply of energy, while the battery plays a crucial role in supplying dynamic energy during the ship's start-up phase, ensuring smooth operations. Additionally, the battery is capable of absorbing or providing peak or dynamic power when the load fluctuates and the FC cannot respond instantaneously. Due to the wide voltage range of the FC, it cannot be directly connected to the inverter. To address this, our paper proposes a power management strategy and design process that incorporates a unidirectional converter, a bidirectional converter, and an inverter. This approach takes into account the ship's operating conditions as well as the power requirements of the FC and the battery. The experimental results presented in this study have been validated through simulation.

KEYWORDS: Fuel cell, battery, Microcontroller, AC-DC converters, Inverters.

I. INTRODUCTION

This paper presents a novel power management scheme designed for a hybrid power system that utilizes both a fuel cell (FC) and a battery. The hybrid power system is specifically designed for small ships and comprises an FC, converters, an inverter, and a battery to drive the propulsion system. While FCs have certain limitations in terms of energy storage, response capability, cold start, and voltage fluctuation under peak load conditions, these challenges can be overcome by integrating auxiliary energy systems such as batteries or ultra-capacitors. However, battery systems lack the ability to control their charging and discharging current. To address this issue, the installation of a converter between a DC bus and the battery is necessary to regulate the charging/discharging current. The hybrid power system being proposed consists of two power sources: a fuel cell (FC) and a battery system serving as an auxiliary source. The battery system is directly connected in parallel to the DC bus, with its primary purpose being to boost the peak power capacity and provide power to the load during a cold start. Both the FC and the battery system are linked to the same DC bus using an appropriate unidirectional converter (UDC) and bidirectional converter (BDC), respectively.

II. LITERATURE REVIEW

Microgrids are electricity distribution systems that consist of distributed energy resources (DERs), storage devices, and loads. These systems can operate either connected to the main grid or independently. Integrating microgrids with the distribution network requires a hierarchical control structure to ensure stable operation and control. However, this integration poses challenges, especially when dealing with the large-scale integration of inverter-based resources (IBR). This paper aims to address these challenges by identifying them and providing a comprehensive review of the state-of-the-art hierarchical control structure. Additionally, the paper discusses the emergence of advanced control trends, such as cooperative distributed control methodologies and the unification of the traditional three layers of hierarchical control into fewer layers (two or one) based on specific applications and operation requirements [1]. The majority of existing methods tend to focus on a subset of these models, resulting in a lack of comprehensive modeling and simplified system representations. To address this issue, this research paper proposes a three-step approach that facilitates the seamless integration of generation and storage system models into the control algorithm of a voltage source converter (VSC). This approach proves particularly valuable for microgrid studies. The DERs taken into account in this study include battery energy storage systems (BESS), wind generation, and photovoltaic (PV) generation systems [2].

The integration of intermittent distributed energy resources (DERs) into AC microgrids is a growing trend that presents operational challenges in terms of stability and protection. In islanded microgrids with power electronic interfaces, protection becomes a major challenge due to the reduced level of short circuit currents caused by inverter output capabilities. However, traditional protection schemes used in distribution systems are no longer suitable for protecting the microgrid when different levels of fault currents are present.This research paper proposes an integrated control and protection framework that utilizes state observer and fault current limiter (FCL) devices. The state observer is designed to detect and identify faults occurring within multiple protection zones. Additionally, controlled switches, which consist of FCLs, are used to limit fault currents and enable rapid switching during faults, thereby enhancing system reliability [3]. In this study, we propose a multi-objective power scheduling approach for a residential microgrid that includes photovoltaic (PV) panels, a wind generator (WG), EVs, and a battery energy storage system (BESS). Additionally, we compare two energy management techniques: renewable base control (RBC) and load base control (LBC) for managing the charging and discharging of plug-in-electric vehicles. The uniqueness of this research lies in the comparison of four different scenarios for sizing the residential load, which aims to assess the economic feasibility and environmental sustainability of integrating EVs into microgrids. Furthermore, we introduce a control technique for managing the charging and discharging of the BESS, taking into account Time-of-Use (ToU) prices and EVs' power requirements. We also compare two optimization algorithms to validate the effectiveness of the control techniques [4].

Power management and energy management are dependent on the regulation of various components within the DC microgrid. This research paper introduces an Islanded DCMG, where the PV system and wind system are linked to the DC bus via interfacing devices (specifically, DC/DC boost and buck converters). The duty cycle of these devices is controlled by the P&O MPPT algorithm. The generated power is distributed to both AC and DC loads. The DC load undergoes incremental changes, while the AC loads consist of single-phase linear, non-linear, and three-phase inductive loads [5].

The approach presented in this method offers a distinct control architecture that caters to both islanding and grid-connected modes. Notably, the method eliminates the need for an operating mode signal to identify whether the system is operating in islanding or grid-connected mode. As a result, it simplifies the transition between operation modes by avoiding the need to switch between different sets of controllers. To achieve this, a synergetic-based nonlinear control architecture is employed for the local control of the power converters [6].

The proposed model integrates the electrical, heating, cooling, and water components to improve the adaptability and dependability of the microgrid system. A multi-layer energy scheduling framework has been implemented to optimize operating cost, carbon emissions, underground water extraction, and the self-sufficiency of the multi-energy system. The initial layer of the suggested model focuses on the efficient and cost-effective operation management of the multi-energy microgrid system. The second layer addresses environmental concerns and introduces a multi-objective framework to minimize both underground water extraction and emission pollution concurrently [7].

A novel approach is introduced in the lower AC/DC hybrid microgrid cluster, presenting a virtual synchronous generator-error tracking controller (VSG-ETC) strategy for AC/DC bidirectional converters. This strategy effectively ensures power equilibrium on both AC and DC sides while mitigating frequency and voltage fluctuations without the need for normalization processing. Additionally, a Q-V control method, utilizing a virtual phase angle, is proposed for the DC microgrid. This method achieves proportional current sharing and bus voltage regulation, enhancing the overall performance of the microgrid system [8]. This paper presents a comprehensive analysis of different technologies used in fuel cells, focusing on their basic design, working principle, applications, advantages, and disadvantages. Furthermore, it compares the techno-economic aspects of hydrogen fuel cell vehicles (FCV) and internal combustion engine vehicles (ICEV). The findings demonstrate that fuel cell systems offer a straightforward design, exceptional reliability, silent operation, remarkable efficiency, and minimal environmental footprint. The primary objective of this research is to provide a valuable resource for reviewing power generation through fuel cells [9]. This document introduces the control strategies and performance evaluation of the doubly fed induction generator (DFIG) in a grid-connected wind energy conversion system (WECS). The utilization of wind power enables the production of environmentally friendly electricity and aids in meeting the national energy demand, especially as non-renewable resources diminish. The advancement of WECS is closely tied to the progress in power electronics technology. Currently, the two primary types of generators employed in WECS are the DFIG and the permanent magnet synchronous generator (PMSG). Both generators utilize variable operational speeds in wind turbines. Due to their exceptional performance, reliability, controllability, and high-power and voltage capabilities, multilevel converters have gained popularity as a viable option for multi-megawatt WECSs. This paper specifically concentrates on the implementation of back-to-back modular multilevel converters in DFIG and PMSG-based WECSs[10].

III. PROPOSED METHODOLOGY

This paper introduces a novel hybrid power system design specifically tailored for small ships, such as leisure ships and fishing boats. Fuel cells (FCs) have emerged as a highly promising technology for generating electric power in ships due to their exceptional efficiency and minimal carbon emissions. Typically, the ship's primary power system operates as an independent entity, with a significant portion of the power dedicated to propulsion. Figure 1 illustrates the power system employed in small ships for electric propulsion. It comprises various components, including the generator, storage unit, converter, filter, and the propulsion mechanism. The FC has a broad output voltage range that is influenced by the load, making it unsuitable for direct connection to the inverter. The selection of the FC's output voltage is based on the rated power. In peak power scenarios, a battery is employed in modules that consist of multiple submodules connected in series and parallel to achieve the desired voltage and power levels. The number of battery submodules required for a module is determined by the battery terminal voltage, Vb.

IV. METHODOLOGY

A. Fuel cell

A fuel cell is a method of generating electrical energy that is environmentally friendly. It undergoes a chemical process to convert fuel into electrical energy, similar to a battery. The cell contains cathode and anode electrodes to facilitate chemical reactions. Additionally, a catalyst is used to accelerate the chemical reaction and increase energy production efficiency. Hydrogen gas is used as the input fuel, which reacts with oxygen to produce electrical energy. As a result of this process, water is produced as a byproduct.

B. Microcontroller

The microcontroller has a wide range of applications in the current era of advanced technology. It is commonly utilized in automated machines and plays a crucial role in the field of robotics. Essentially, a microcontroller can be considered as a miniature computer. Upon examining its internal structure, it consists of a storage memory, a central processing unit (CPU), and various input and output components. Its functionality is determined by the programming that has been embedded within it. The input and output peripherals of microcontrollers, also known as GPIO, are configured by the interconnected software based on the specific requirements and preferences. Utilizing this input, the microcontroller transmits commands to the output pins, enabling control over motor speed, the brightness of decorative lights, and the linear motion of robotics. In the realm of electrical power generation (EPG) and distribution to residential areas, the microcontroller plays a critical role in ensuring the production, protection, and provision of electricity to the general public.

C. Battery System

In a unit battery, there are two distinct points known as the anode and cathode. At the anode point, oxidation takes place, leading to the accumulation of electrons. Conversely, reduction occurs at the cathode point, causing electrons to travel towards the anode. This flow of electron current establishes a circuit within the battery. Although physically separated, the cathode and anode sites are electrically connected and collectively referred to as cathodes.

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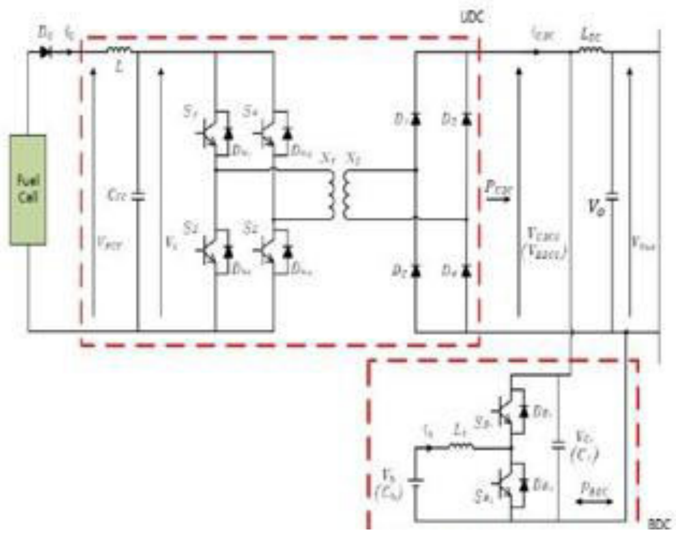
D. DC-DC Convertor

The hybrid power system comprises of a UDC (Universal DC) and a BDC (Battery DC). The UDC plays a crucial role in maintaining a constant output voltage, which serves as the input voltage for the inverter. It ensures that the input and output currents, as well as the voltage ripple, remain minimal, thereby guaranteeing the safe operation of the FC (Fuel Cell) module. The UDC is responsible for controlling and conditioning the FC's output power, and its electrical characteristics must align with the specifications provided by the FC and required by the load. To achieve these objectives, the UDC is constructed using a full-bridge converter, a widely employed component in FC power systems. It can function effectively under both constant voltage and limited current conditions. For a visual representation, refer to Figure 2, which illustrates the primary circuit of the power management system.



DC-DC Convertor operator

At time t = t0, all switches in the UDC are closed. The VFCT magnetizes the inductor L, and its maximum current iLm can be calculated using the given formula. The difference between the current flowing through the inductor iL and the current flowing through the switches (S1 – S4) charges the capacitor CFC. This continues until both currents reach the same value iT at t1s. The operation of the UDC shown in Figure 2 is simplified, assuming all devices and components are ideal. Figure 3 illustrates the operation mode diagrams of the UDC, which can be divided into four modes during one operating cycle.

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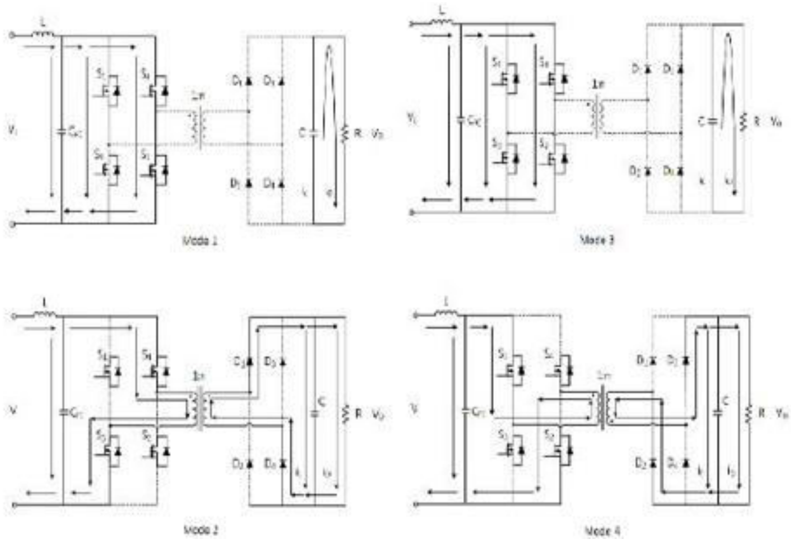

Simulated Output

The UDC serves as the connection between the FC and the DC bus, while the battery is connected to the DC bus through the BDC. Both the UDC and the BDC need to be controlled appropriately based on the conditions of the FC and the battery. To ensure proper control, we need The UDC serves as the connection between the FC and the DC bus, while the battery is connected to the DC bus through the BDC. Both the UDC and the BDC need to be controlled appropriately based on the conditions of the FC and the battery. To ensure proper control, we need to select the VFCLP, which is the limit-power point voltage of the FC. This voltage has two control points, namely the slip-in point VSLIP and the slip-out point VSLOP. Additionally, Vbus is monitored for the control process of the hybrid power system. During overload conditions, the battery needs to be integrated into the system, and the BDC should operate in boost constant-voltage mode. Under these circumstances, VSLIP can be determined, which should be lower than VBCDO-Boost but close to VBDCO-Boost. On the other hand, VSLOP is determined based on the slip-out time of the battery and the self-start finish time of the FC. Once the FC completes its self-start and powers up the load, the UDC operates under a constant-voltage condition with Vbus equal to VUDCO. In this study, we determine that VBDDO-Boost < VSLOP < VUDCO for VSLOP. The FC has a response time of tens of seconds during the cold-start state and hundreds of milliseconds in the standby (warm up) condition. On the other hand, the UDC has a response time of tens of microseconds. Therefore, the response performance of the UDC is not a significant concern in the hybrid system. VFCLP, which is the limit-power point voltage of the FC. This voltage has two control points, namely the slip-in point VSLIP and the slip-out point VSLOP. Additionally, Vbus is monitored for the control process of the hybrid power system. During overload conditions, the battery needs to be integrated into the system, and the BDC should operate in boost constant-voltage mode. Under these circumstances, VSLIP can be determined, which should be lower than VBCDO-Boost but close to VBDCO-Boost. On the other hand, VSLOP is determined based on the slip-out time of the battery and the self-start finish time of the FC. Once the FC completes its self-start and powers up the load, the UDC operates under a constant-voltage condition with Vbus equal to VUDCO. In this study, we determine that VBDDO-Boost < VSLOP < VUDCO for VSLOP. The FC has a response time of tens of seconds during the cold-start state and hundreds of milliseconds in the standby (warm up) condition. On the other hand, the UDC has a response time of tens of microseconds. Therefore, the response performance of the UDC is not a significant concern in the hybrid system.

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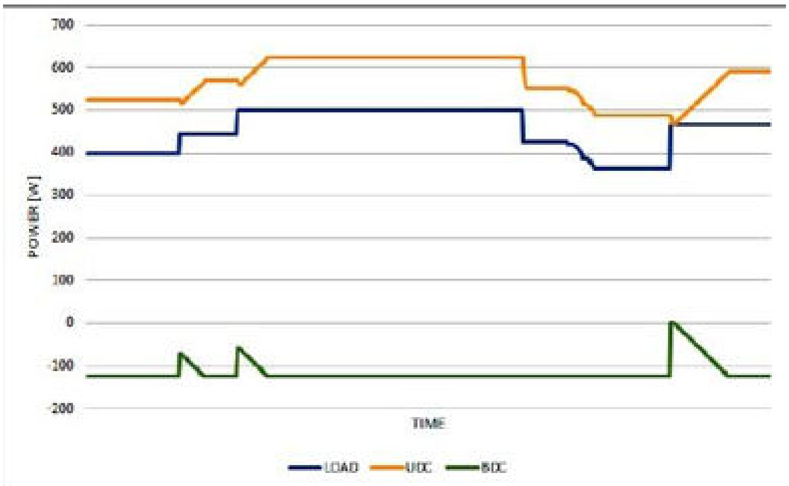

V. CONCLUSION

Fuel cell stacks and batteries are two types of energy sources that are not only environmentally friendly but also renewable. Consequently, the hybrid energy system becomes highly sustainable. In this study, a combination of fuel cells and batteries is utilized to create a hybrid energy system. These systems, known as HES, have the capability to operate in four different modes, which are determined by factors such as the state of the battery and the load requirement. To facilitate this intelligent operation, an AVR microcontroller is employed.

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REFERENCES

1. Majid Ali, Mohsin Ali Koondhar, Jyotsna Ogale,Ahmed Ali, Baseem Khan“Grid integration impacts and control strategies for renewable based microgrid” September 2023.
2. Saad Alzahrani, Khalil Sinjari, Joydeep Mitra, “An advanced control and protection integration scheme for microgrids” Dec 2022.
3. C.Garcia-Ceballos, S. Perez-Londono, J. Mora-Florez “Integration of distributed energy resource models in the VSC control for microgrid applications” July 2021.
4. Jaynendra Kumar, Anshul Agarwal, Nitin Singh “Design, operation and control of a vast DC microgrid for integration of renewable energy sources” Sept 2020.
5. Eghtedarpour “A synergetic control architecture for the integration of photovoltaic generation and battery energy storage in DC microgrids” Dec 2019.
6. Yuchong Huo, Francois Bouffard, Geza Joos “Integrating learning and explicit model predictive control for unit commitment in microgrids”15 January 2022.
7. Zhilin Lyu, Jiaqi Yi, Jian Song, Bin Liu “Coordinated optimal control and dispatching operation of grid-connected AC/DC hybrid microgrid group” august 2023.
8. Hamid Karimi, Shahram Jadid, Saeed Hasanzadeh " Optimal- sustainable multi-energy management of microgrid systems considering integration of renewable energy resources: A multi-layer four-objective optimization" march 2023.
9. S. Mekhilef, R. Saidur, A. Safari "Comparative study of different fuel cell technologies" Jan 2020.
10. Hla Tun, Krishna Reddi, Amgad Elgowainy, Sajag Poudel "Thermodynamic parametric analysis of refueling heavy-duty hydrogen fuel-cell electric vehicles" Aug 2023.

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