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ENERGY MANAGEMENT SYSTEM OF MICROGRID WITH RENEWABLE ENERGY SOURCES

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ABSTRACT -The most recent development in the electrical system is the microgrid. Many scattered, networked energy storage, loads, and generation units make up a typical microgrid system. An energy system made up entirely of renewable resources is called a microgrid (MG), an energy storage device, and loads that can operate in grid-connected or islanded mode. The demand for the load and the power flow within MG should be managed by scheduling renewable resources. This paper presents a hybrid microgrid energy management system (MEMS) that combines grid-connected solar (PV), wind power from microturbines, and battery energy storage systems (BESS). Due to their increased energy efficiency, microgrid units are becoming more and more well-liked every day. Energy management for microgrids is required since renewable energy sources provide an imbalance in the Power System due to their stochastic behavior. Controlling the DC/DC bidirectional converter (DBC), which links the Ni-H battery to the DC bus of the grid-connected microgrid, is the primary goal of this study. The start-up of a wind/photovoltaic power generation system to the load is covered in this study. MATLAB/SIMULINK was used to model a microgrid system that is connected to the grid.

Key Words: Microgrid, Photovoltaic (PV)

1. INTRODUCTION

Dispersed generators, energy storage apparatuses, and loads operating in islanded and grid-connected modes make up a microgrid (MG). Because grid-connected MGs provide consistent designs for dynamic or fluctuating loads that must be fed continuously, they are frequently used. However, when many energy sources are available to feed the load and meet demand requirements, these resources provide significant issues for the system's power management, control, and economic functioning. Lower-level and upper-level controls are the systematization of power management and control techniques. Primary control, sometimes called lower-level control, oversees maintaining voltage and frequency stability. The energy management system (EMS), a type of upper-level control, schedules available energy production and load demand within an MG.

2. STRUCTURE OF MICROGRID

Microgrids are tiny power systems designed to offer a selected group of users a more reliable and efficient energy source. As shown in Fig.2, it integrates a variety of energy sources, including PV panels, microturbines, as well as storage systems for backup power and AC/DC loads for energy consumption. In a microgrid, every component is connected by a DC bus. Power converters are used in an AC microgrid to connect the sources and load to an AC bus. We will employ a hybrid microgrid—a combination of DC and AC bus—in this project. Compared to both AC and DC systems, the system has a few advantages. By eliminating the requirement for a separate converter interface, AC or DC loads can be delivered, enhancing the system's dependability and efficiency.

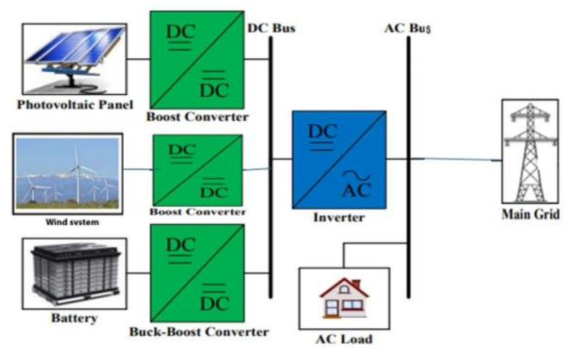


Figure 1 Schematic diagram for PV-based AC microgrid

3. MICROGRID SYSTEM

3.1. Photovoltaic System

The dynamic PV model, which was developed and evaluated using Simulink subsystems, is the main emphasis of the PV cell model.

The PV cell's current is shown as follows:

$$I_{pv} = I_{ph} - I_0\left[\exp\left(\frac{qV_d}{K_b F T_c}\right) - 1\right] - \frac{V_d}{R_p}$$

In this work, we used an implemented PV model at MATLAB (Sun Power SPR-305-WHT) as a reference module. The choice of a 250 W module is useful to facilitate the calculation. This PV model's properties are displayed in Table 2.

Table 1 Description of the parameters used in Eq. (1)

Parameters	Description
I_{ph}	Light current
I_0	Cell saturation current
Q	Charge of electron (1.6×10^{-19} C)
K_b	Boltzmann's constant
F	Ideality factor
T_c	Cell's absolute temperature
V_d	Voltage of diode
R_p	Parallel resistance

Table 2 Characteristics of (Sun Power SPR-305-WHT) PV model

Parameters	Values
Cellule numbers	72
Temperature coefficient of open-circuit voltage	−0.29103%/°C
Temperature coefficient of current court circuit	0.013306%/°C
Shunt resistance	448.6949 Ω
Series resistance	0.37759

3.2. MICRO TURBINE(WIND)

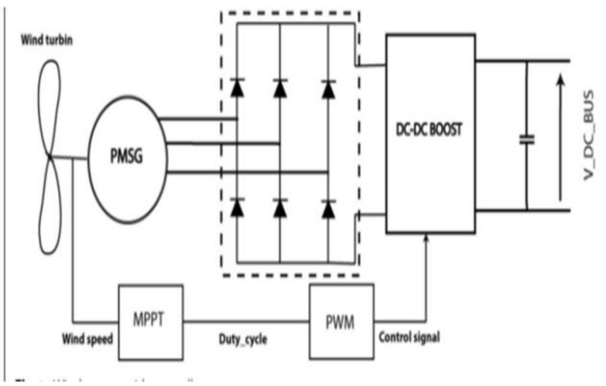


Figure 2 Wind turbine with controller

The wind energy system (WES) is the most accessible and promising electrical energy source after solar energy. Using rotating turbines, the kinetic energy of the wind generates mechanical energy. The wind speed and the amount of wind energy produced are related linearly. The wind turbine will provide nominal electricity when the wind speed is at that level. The model of the wind turbine is defined as:

$$P_{\text{wind}}(v) = \begin{cases} \frac{P_{\text{nom}}(v - v_{\text{ci}})}{(v_{\text{r}} - v_{\text{ci}})} & (V_{\text{ic}} \le v \le v_{\text{r}}) \\ P_{\text{nom}} & (V_{\text{r}} \le v \le v_{\text{co}}) \\ 0 & (v \le v_{\text{ci}} \text{ or } V_{\text{co}} \le v) \end{cases},$$

Losses account for Pout≤Pwind (ϑ) in the final output. It is always possible to balance a wind turbine's output power to match load demand. Wind turbines, a boost converter, a diode rectifier, a permanent magnet synchronous generator (PMSG), and other components make up the WES.

3.3 Ni-MH BATTERY (ENERGY STORAGE SYSTEM)

Batteries made of nickel metal hydride (Ni-MH) are frequently used to store energy in microgrids. These batteries function by first turning chemical energy, which is electrical energy, back into electrical energy as needed. Ni-MH batteries can assist regulate the power supply in a microgrid by storing extra energy generated throughout times releasing it when it's scarce and in periods of peak demand. This aids in maintaining equilibrium between the microgrid's power demand and supply.

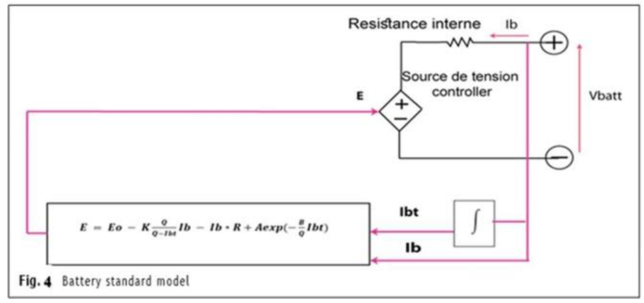


Figure 3 Battery standard model

Table 5 Description of the parameters used in Eq. (4)

Parameters	Description
E	Battery open-circuit voltage
E_0	A constant voltage of the battery
K	Polarization constant or polarization resistanc
Q	The capacity of the battery
$q = it$	Actual charge of the battery
A	Exponential zone amplitude
B	Exponential zone time constant inverse
R	Internal resistance

The open-circuit voltage E can be found using two alternative formulas. E = VDish in discharge mode, as shown in Eq. (3) (Table 5).

$$V_{\text{Dish}} = E_0 - \frac{KQ}{Q-q} * i - \frac{KQ}{Q-q} * q + A\exp(-Bq). \quad (3)$$

In the charge mode, $E = V_{\text{Ch}}$, as calculated in Eq. (4).

$$V_{\text{ch}} = E_0 - \frac{KQ}{0.1Q-q} * i - \frac{KQ}{Q-q} * q + A\exp(-Bq). \quad (4)$$

4. PROPOSED MODEL:

The structure is made up of two sustainable energy sources that power a DC bus to supply loads that are attached to it: a photovoltaic solar system and a wind turbine. Additionally, a Ni-MH battery for energy storage and a DC/AC converter to link the AC charger to the DC bus make up the backup system. Coordinating and managing all converters, the energy management system is the main controller in grid-connected systems. The complete energy management system is contained in the DC bus, which gathers energy from all sources. Most Ni-MH battery explosion incidents were caused by overcharging or discharging. Controlling the battery SoC is therefore crucial for safe battery operation. Therefore, in this study, we employed the SoC value in energy management.

The primary goal of the control strategy employed here is to maintain a 400 V DC bus voltage. The main component of energy management is the bidirectional DC-DC converter. By charging or discharging the battery, the bidirectional converter maintains the microgrid system's energy balance. It also functions as a boost converter when the DC bus voltage is less than 400 V and energy is flowing from the battery to the bus. On the other hand, when the bus voltage exceeds 400 V, the converter functions as a buck and charges the battery to store the excess energy, thereby controlling the bus voltage.

5. RESULT AND DISCUSSION:

Since sustainable energy resources fluctuate, the electricity generated from them is not stable over time. Consequently, it leads to two distinct processing modes: excess power at the DC bus or none. MATLAB is accustomed to simulating the proposed single-phase hybrid energy system. There are separate DC sources in the hybrid system. To extract the most power possible from each energy source in this simulation, a boost converter is attached to each one

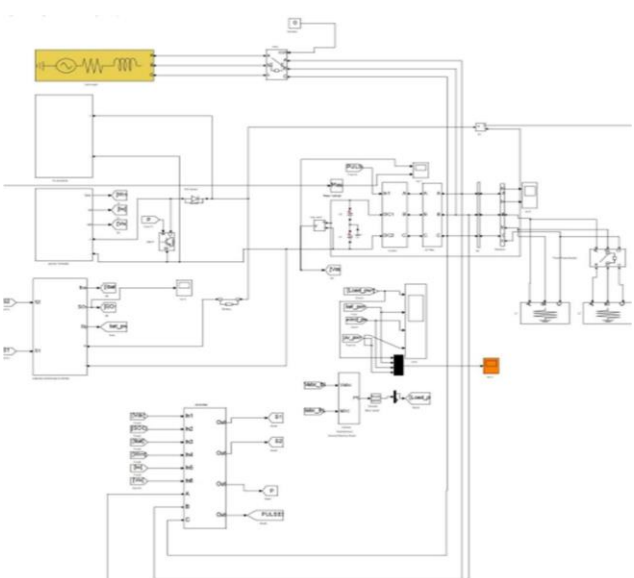
The simulation runs for 2s with a sampling time of 2e-5 to display the voltage at the DC bus for various solar radiation and wind speed values.

Table 6 describes the technological details of the hybrid wind-solar battery under study.

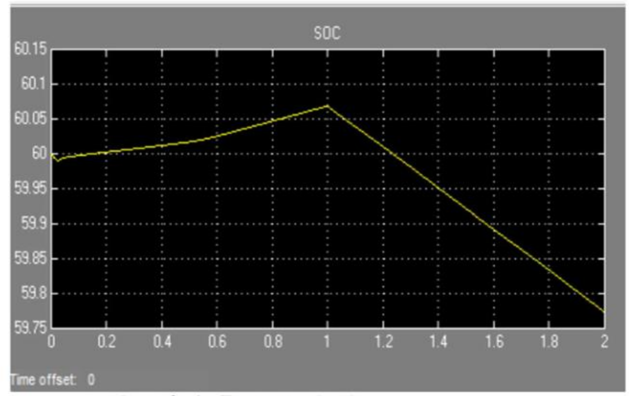
Table 6 Hybrid wind–solar battery technical details

Symbol	Specification
DC_BUS	V=400 V
Battery	Type: Ni-MH V=300 V; Q batt=7Ah
PV PANEL	TYPE: Sunpower SPR-305 WHT P W=10KW
Wind turbine	P_W=10 KW
Load	P_LOAD=20 KW

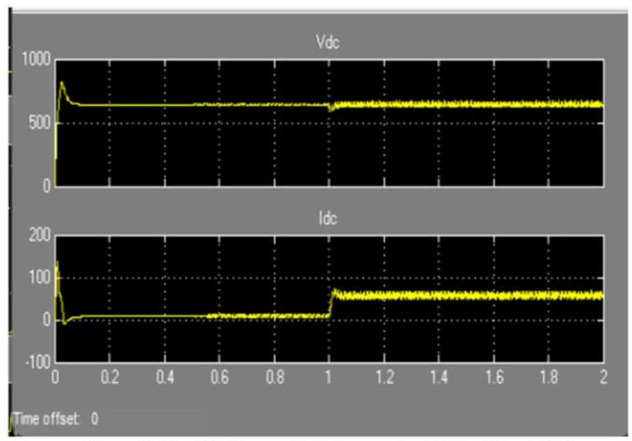
6. SIMULATION:



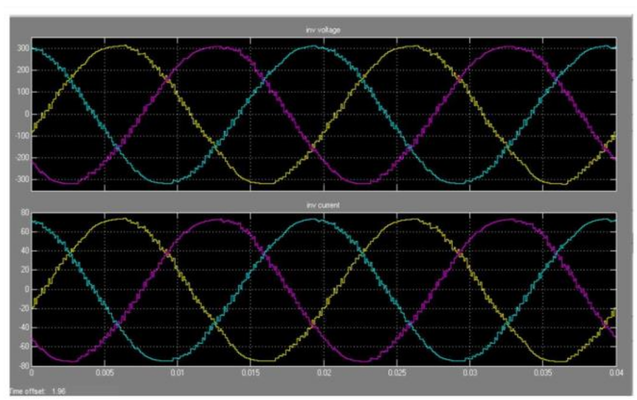
7. OUTPUT WAVEFORMS



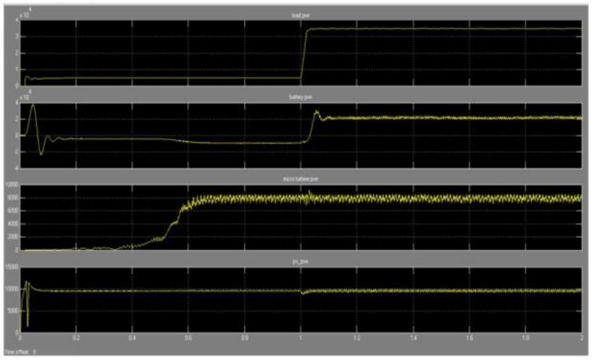
Graph 1: Battery SoC



Graph 2: Voltage & Current at the Bus DC



Graph 3: Voltage & Current at the Bus AC



Graph 4: Power of Load, Battery, Microturbine &PV

8. CONCLUSION

The knowledge of the challenges and opportunities related to combining wind and solar energy sources for energy generation has been reviewed in this research. The main barrier to the grid-connected framework is the sporadic availability of solar PV and wind sources. The influence due in part to the erratic nature of solar and wind resources alleviated and the entire system becomes increasingly dependable and cost-effective to operate through combining the two resources into an ideal microgrid, the AC bus or DC bus with an energy storage system as a fallback setup. The system of a hybrid microgrid, which combines several sustainable energy sources, is described in this paper. These sustainable energy sources consist of a 10-kW solar panel, a 10-kW wind microturbine, as well as a 20-kW load requirement. The output voltage of each system has been linked to the DC bus such that 400 V is available where theDC bus is. Powering the inverter is the intensity across the DCbus bar. From Alternating current (AC) to Direct current (DC) conversion is accomplished by the full-bridge inverter, which functions as an open loop. The values of PV panel irradiance and wind velocity have been varied during system testing. The outcomes demonstrate how well the suggested system synchronizes the load AC's amplitude, frequency, and AC output voltage. The intended outcomes have been generated by the system. The research revealed that the voltages at the outputs of the converter rapidly reached 400v as a reference voltage and stayed constant for this amount despite varied fluctuations (sun radiation as well as wind velocity).

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9. REFERENCES

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