SAFE AND EFFECTIVE RENEWABLE ENERGY MANAGEMENT FOR UNIVERSAL MICROGRID DC USING RASPBERRY PI PICO W AND OLED

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Abstract

A power system that integrates various renewable energy generation methods, or a combination of renewable and conventional sources, is referred to as a hybrid system. This project explores a hybrid power system utilizing both wind and solar energy. The widespread reliance on depleting fossil fuels presents significant challenges. The continued consumption of resources like petroleum and diesel is leading to their scarcity, and consequently, a surge in their market prices. Therefore, this project aims to investigate and implement sustainable, environmentally conscious, and economically viable energy alternatives for residential and industrial applications. Furthermore, the incorporation of embedded technology seeks to enhance the system's efficiency and compactness.

Key words: Complier, Hybrid microgrid, OLED, solar panel, Wind mill, etc.

Introduction

Renewable based DC microgrid is at the upfront for achieving rural electrification, especially in developing nations such as India. DC microgrid is a self-sufficient and independent power system which includes one or more generating sources, energy storage system, energy management and loads. Such a system may or may not be connected to the grid. The need for renewable based DC microgrid arises to fulfill energy requirement of rural, isolated regions. Grid connected systems are mainly established in cities and have sparsely reached villages or isolated regions. The regions where grid connected supply is available pay for poor quality of supply, the supply is time-limited and this hampers the social and economic growth of that region. Even in cities where the grid is stronger comparatively, load shedding and poor quality of supply make the grid unreliable. Limitations of AC grid create a need for localized power systems or microgrids, which are not limited to a certain region, which are cost-efficient and reliable, and contribute towards sustainability rather than degradation of the

environment. Renewable based DC microgrid harness inexhaustible energy resources which are available in plenty and are free of cost. DC microgrid can utilize DC-DC power converters having efficiency more than 95%, and reduce the need of AC/DC converters. Centralized AC power grids face severe transmission and distribution losses. Earlier, majority of the loads were AC, such as induction machine and incandescent lamps. Nowadays, many DC loads are used such as LED lights, Heating Ventilation and Air Conditioning (HVAC) equipment and variable speed motor drive [1].

According to many renewable energy experts, a small "hybrid" electric system that combines home wind electric and home solar electric (photovoltaic or PV) technologies offers several advantages over either single system. In much of the United States, wind speeds are low in the summer when the sun shines brightest and longest. The wind is strong in the winter when less sunlight is available. Because the peak operating times for wind and solar systems occur at different times of the day and year, hybrid systems are more likely to produce power when you need it. Many hybrid systems are stand-alone systems, which operate "off-grid" - that is, not connected to an electricity distribution system. For the times when neither the wind nor the solar system are producing, most hybrid systems provide power through batteries and/or an engine generator powered by conventional fuels, such as diesel. If the batteries run low, the engine generator can provide power and recharge the batteries.

Advantages of DC Microgrid

- A DC microgrid can easily integrate with the RES with reduced stages of power converters.
- A DC system has no skin effect. The current will flow through the entire cable. This will reduce losses to transmit power with fewer conductors.
- Grid synchronization, harmonics compensation, and reactive power control are not required for DC-based systems. Therefore, the operational complexity of the system is reduced.

Need For Energy Management

Energy management algorithm and power converters together provide the necessary control to the system [2]. WTG and photovoltaic panel can be controlled to extract maximum power from the available natural sources. Energy storage system requires management for deciding which storage should be used in case of a hybrid energy storage system, and for deciding the charge-discharge cycles of chosen storage. The DC-link voltage must be maintained constant for balanced flow of energy among the multiple sources and loads, in a DC microgrid. Also, a variation of DC-link voltage would disrupt normal operation of the system and could cause the whole system to collapse [3]. Eq. 1 and Eq. 2 gives the generalized stability criteria for microgrid:

$$\frac{Pm - Pe}{\omega} = J(d\omega/dt) \qquad (1)$$

$$Pload(t) \leq Pg(t) \bullet \} Ps(t) \quad (2)$$

Where,
Pm = wind turbine mechanical power (W)
Pe = wind turbine electrical power (W)
J = inertia ($kg.m2$)
ω = WTG speed (rad/sec)
$Pload(t)$ = instantaneous load power (W)
$Pg(t)$ = total instantaneous power of generating sources (W)
$Ps(t)$ = total instantaneous power delivered by ESS (W)

Energy management algorithm (EMA) provides intelligence to the system and controls the functioning of each block of the system. Energy management algorithm has several significant roles:

- Reliability: providing uninterrupted supply to the load.
- Quality: maintaining quality of supply.
- Stability: maintaining DC-link voltage constant.
- Maximum utilization of generating sources using
- MPPT algorithm.
- Efficient management of storages.

Simulation of DC Microgrid

An isolated DC microgrid has been designed and validated using MATLAB/SIMULINK. It consists of four main parts:generating sources, energy storage system, loads and energy management system. Energy management algorithm monitors DC link voltage and state-of-charge of battery and supercapacitor. Energy management system consists of field oriented control for WTG, MPPT algorithms for WTG and PV, charge discharge algorithm fuel cell control and critical load shedding control [4].

Materials required

- **Hardware required:** Power supply, microcontroller, wind mill, high power, solar panel, switching driver, LED,LCD, sensor, transistor, utility source (transformer), etc.
- **Software required:** embedded C, Keilcompiler, etc.

Component List

S. No.	Components	Quantity
1	Transformer (12-0-12 V,3 amp)	1
2	Diode (IN4007)	4
3	Capacitor (1000 uF, 25 V)	1
4	Voltage regulator IC 7805	1
5	Capacitor (1 uF)	1

6	LED	3
7	Resistors	15
8	Disc capacitors	5
9	IC Base	5
10	PCB	1
11	Wires (green, blue, red and black)	4
12	Solder wire	1
13	Cabinet	1
14	Mains cord	1
15	Resistors (2 Watt)	5
16	Power BJT	2
17	TB	1
18	Heat sink	2
19	Microcontroller – Raspberry Pi P W	1
20	OLED	1
21	DHT 11	1

Construction of the System

- In this system, a solar panel of 1200 volt and a wind mill of 500 mili amp were used as renewable source of electricity. A microcontroller, a sensor, one transformer of 250 volt were used as an utility source with primary binding of 5 amp and secondary binding of 12 volt or 1002 amp and used for the conversion of DC volt. Other than that, an unit was setup with a rectifier, a filter and a regulator, LED, and switch on/off panel for knowing the power supply availability.
- A circuit was designed with 12 volt as a logical unit due to the 12volt supply of renewable source. In this circuit design, 2 wire which is green and blue in colour were added and connected with the raspberry pi pico W that will help to know that which renewable source is available for electricity will be detected from it.
- Other than this, a 12 volt sugar coop relay were required to connect directly to transformer and one LED, transistor BC547, resistor were also connected. The transistor plays an important role as traverse and it will triverse the relay unit. This transistor will get input from pin no. 23 of raspberry pi and pin no. 18 and 19 were used for renewable energy source connection for solar panel and wind mill, when solar panel and wind mill are available, it will processed the data from memory decode and execute due to which will know that, which renewable source is available, wind or solar.
- An OLED was connected as surface mounting component, an advanced system of project that will help to display of the system and its working and it is 0.96 inch in size.

Working of the System

- The blue wire of the circuit design is connected to the red wire of the renewable energy source and green wire is connected to the black wire. Now, when power supply was given , the LED will on and microcontroller will evaluate that how much energy/ power supply is present. Now, OLED will display that solar and wind energy is not available, safety alarm is off, current temperature and charging of the system.

- Now, when we start the wind mill, we will observe that, LED available on the circuit design will get on, and electricity will generate and main bulb will glow. On OLED display screen the message will be display as follows-
  Temperature: 28.70 ℃
  Temperature: Normal
  Wind energy is available
  Charging: On
  Alarm: Off

- Similarly, when light source is focused on solar panel, the LED on circuit design andrelay unit will get on and electricity will generate and main bulb start to glow. On OLED display screen the message will be display as follows-
  Temperature: 29.75 ℃
  Temperature: Normal
  Solar energy is available
  Charging: On
  Alarm: Off

- Similarly, when both renewable sources are connected, the LED on circuit design and relay unit will get on and electricity will generate and main bulb start to glow. On OLED display screen, the message will be display as follows-
  Temperature: 32.75 ℃
  Temperature: Normal
  Solar and Wind energy is available
  Charging: On
  Alarm: Off

- But, when the temperature get out of the range, that is more than 37 ℃, the sensor will detect it and after that wind or solar energy source is on, but electricity will not generate and main bulb will not glow due to automatic disconnection of electricity and safety.It will restore or connectedagain when temperatute is lower than 33℃**.** On OLED display screen, the message will be display as follows-
  Temperature: 37.69 ℃
  Temperature: Over

Charging: Off
Alarm: On

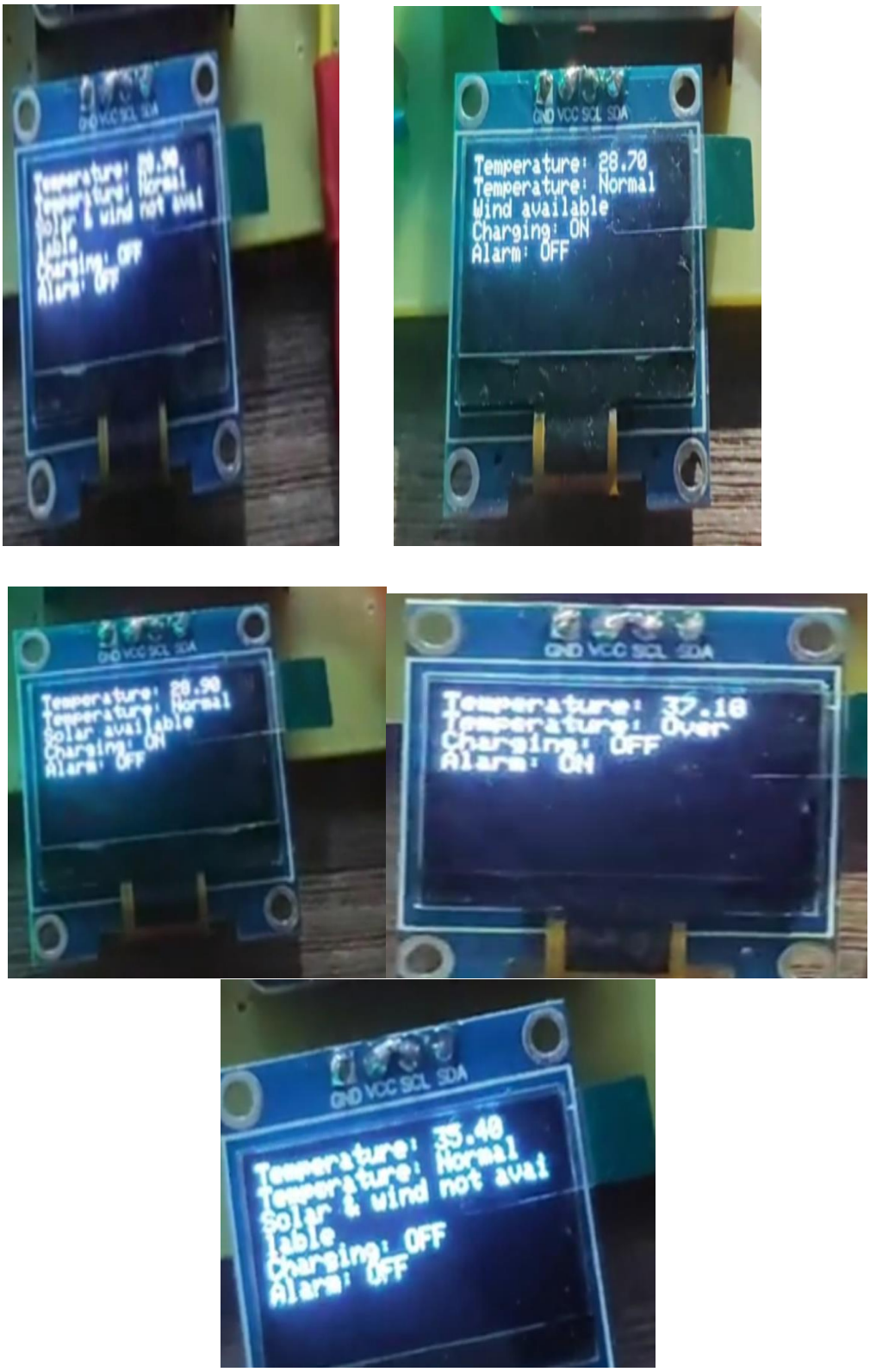

Figure: OLED Display screen with different messages of management and safety of electricity

Conclusion

In this research paper, we can see that, a hybrid power system of microgrid DC, that is combined multiple sources such as wind mill and solar panel are very beneficial to deliver the non- intermittent electrical power with safe and impactful management of electricity by using raspberry pi pico W and OLED by using MATLAB simulation.

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