Engineering Universe for Scientific Research and Management
ISSN (Online): 2319-3069
Vol. XVI Issue I
January 2024

Performance Analysis of Advanced Microgrid Using IOT

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Abstract

Energy is one of the world's most important economic, environmental, and sustainability concerns. To improve living standards and reduce poverty, developing countries, in particular, need reliable, accessible, safe, and effective energy services. In recent years, many solar photovoltaic(PV)based DC microgrids have been developed to provide electric power to rural areas in developing countries. This research paper has proposed an IoT-based smart microgrid system for rural areas with an advanced control system for the optimal microgrid operation using the internet. The solution is provided by thinking a group of people living in a remote area. This prototype would detect the branch's failure and it could be managed from anywhere at any time with the help of internet. The power ratings would be displayed to the authority via a power monitoring system. In case of an emergency, a generator would be used to provide power to the rural region. The simulation of the projects was successfully done with satisfied results.

Keywords: ***IoT, Advanced Microgrid, Power Monitoring System, Renewable Energy***

1. Introduction

Decentralized electricity generation has recently improved its performance in the energy market. Emergency backup systems in hospitals, rural telecom tower stations, military applications, and powering off-grid islands are only a few of the applications for autonomous energy supply systems. The need for renewable energy systems is growing as fossil fuel prices continue to rise and energy demand in rural areas rises at the same time. As a result, there is a movement toward hybrid energy supply options that include renewable sources in order to minimize operating costs [1]. Renewable energy has become continued support and encouragement and is widely used in recent decades as countries have sought a cleaner and greener source of energy. Renewable energy sources have their own drawbacks, such as intermittent power supply due to changing weather patterns. This problem, however, can be solved by combining various renewable energy sources (RES) and energy storage systems (ESS) to create a microgrid climate. A microgrid is a low-voltage local distributed energy infrastructure with multiple kilowatts of distributed energy sources on a small scale. Microgrids are divided into two categories: grid-connected microgrids and islanded microgrids. By linking the microgrid to the main grid, operational performance and economics can be improved. In islanded mode, however, the supply can be more stable and reliable in places like mountains, islands, and remote areas where grid connectivity is difficult. Microgrids may also be categorized based on their composition, such as A Cor DC microgrids. Grid synchronization and the need for reactive control are two of the many difficulties of an AC microgrid [2]. DC microgrid, on the other hand, has no such drawbacks [3]. Sub transmission systems are typically used to transfer small quantities of power from transmission systems to distribution levels. However, in recent years, this situation has shifted. A paradigm change occurred as a result of the introduction of renewable energy sources in to delivery systems. The generation is now present in these networks, allowing transmission systems to be decoupled via the formation of microgrids. Distribution networks in urban areas are already developed and linked to the grid [4], so their operation and planning, such as grid expansion to the outskirt soft own and transformer maintenance, are part of the electric sector companies' operating structure. Rural delivery systems, on the other hand, do not experience this. Three options are available for these devices, thanks to modern generating technologies. The first involves extending the grid from urban to rural areas. The second step is to build a microgrid in a rural area after conducting an analysis of the area's parameters, such as population and weather, in order to scale the generators and storage systems that will be used. The third and final choice is to combine grid expansion and microgrid deployment. In the event that the microgrid does not produce enough power to meet the load, the grid will step in to fill the gap. If the microgrid's generation exceeds its load, the energy may be exported to the main grid. Batteries and source disconnection (for generation surplus) or load shedding (for generation deficit) are used to stabilize the system if it is isolated. This thesis investigates those circumstances. The main goal of this research paper is to build an idea for an IoT-based smart microgrid for rural areas that will provide continuous power. This research paper has7sections. Section II discusses about literature review whereas section III discusses about engineering problem statement. Section IV represents the comparison, and section V shows the methodology and modeling. Also, section VI & VII represent results analysis and conclusion.

2. Engineering Problem Statement

Traditional microgrid systems are being used to generate electricity at the moment. Traditional power infrastructure makes it difficult to control energy. When energy leaves a power plant or substation, companies have no control of how it is delivered. Because of their age and weaknesses, traditional microgrid technology is prone to failure. When equipment fails, the end customer's system loses control, resulting in downtime. Due to shortcomings in traditional infrastructure, energy distribution must be manually controlled. All systems can be managed digitally if a smart microgrid can be built. As renewable energy sources, solar and wind energy can be used to fuel microgrids. To provide electricity for stabilization, a generator may be used. Authorities can see the power ratings digitally by adding a power monitoring device to the microgrid. It would be a one- of-a-kind feature if this monitoring device could detect the branch's electrical fault. Traditional electric generation requires a large amount of ground, while solar panels can be installed on the roof so buildings and are both cost-effective and economical.

3. Comparison With Traditional Method

All The traditional microgrid is a one-way system in which power is produced at one end from a source and then distributed to those who need it. It is transmitted to each customer through a distribution transformer, which lowers the voltage at the user stage, after the long transmission. Furthermore, there is no digital device that can regulate the branch's electricity flow. Almost every conventional system lacks a power monitoring system and an automated generator. The figure of traditional method is given below in figure1.

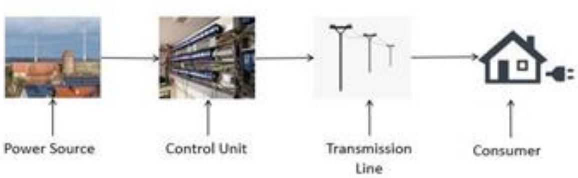

Fig. 1 Generator side distributed ESS.

The whole system becomes useless if there is a mistake in producing or delivering electricity. And a man is always needed to keep the machine running. In addition, the conventional microgrid method necessitates a significant amount of ground. In this smart microgrid system, on the other hand, the system would be operated digitally via IoT. To install the Solar PV, no workers are required, no land is required, and a generator will be used for high electric power. output. And the generator would start using IoT, and a power monitoring device would be installed to see the branch's power rating and fault. The proposed model is given below in figure 2.

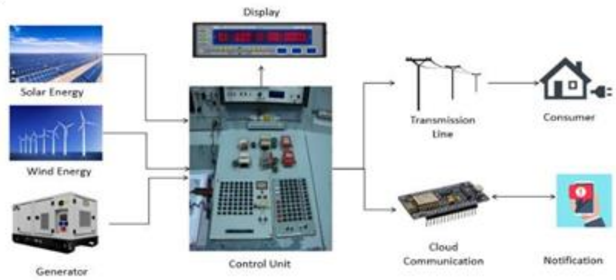

Fig. 2 Proposed System

4. Methodology & Modeling

All In this section the methodology and modeling of the project will be discussed with block diagrams and simulations which will highlight the project's function elegantly.

3.1 Block Diagram of the Project

A microgrid powered by renewable energy sources are proposed in this research paper that will assist to mitigate some of the environmental problems associated with fossil fuel combustion. Solar and Wind power are used here to produce electricity in this project. Diesel generator is also used as a power source in this project as a backup source. Solar, wind, and diesel engine will produce electricity separately and the grid system would add them. There are three phase circuit breakers to save the microgrid. To get the expected results, this project was developed by the integration of bus connection systems, relay ,transformer, etc. The whole method of this project is given below in fig. 3.

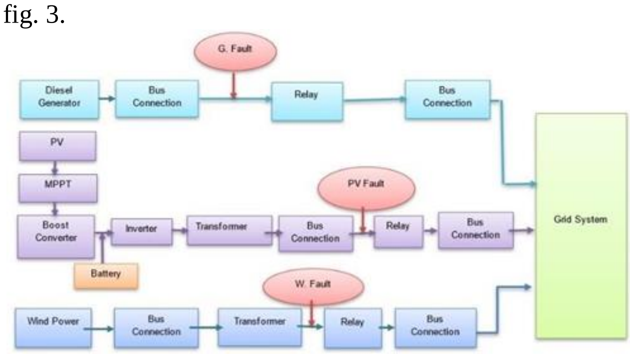

Fig. 3 Block Diagram for Power Production System

On the other hand, power monitoring system is connected to this microgrid system. In this system, the usage power ratings are measured and updated continuously to the display also the cloud server. This monitoring interfaced

Engineering Universe for Scientific Research and Management
ISSN (Online): 2319-3069
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is plays the current power status, Fault Status, Branch Status, etc. Three scopes are connected to Simulink file to see the power status individually. The controller unit measures the power ratings and displays them. Not only inner microgrid interface but also it updates the data to ThingSpeak cloud server periodically. The authority can see the status of the microgrid system from anywhere at any time. The block diagram is given in fig. 4.

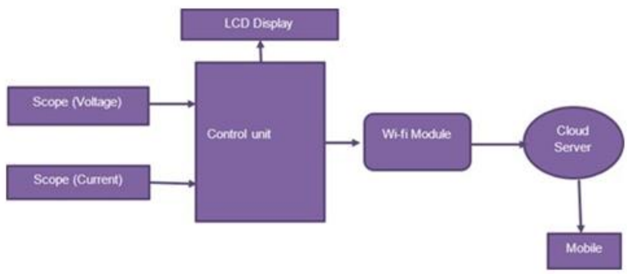

Fig. 4 Block Diagram for Cloud Communication System

3.2 Simulation Of The Project

In fig.5, the simulated circuit has been shown where all the parts are integrated with each other. Also, an application interface has been developed to control the microgrid system that is shown in the picture. Everything is developed according to block diagram that has been discussed before

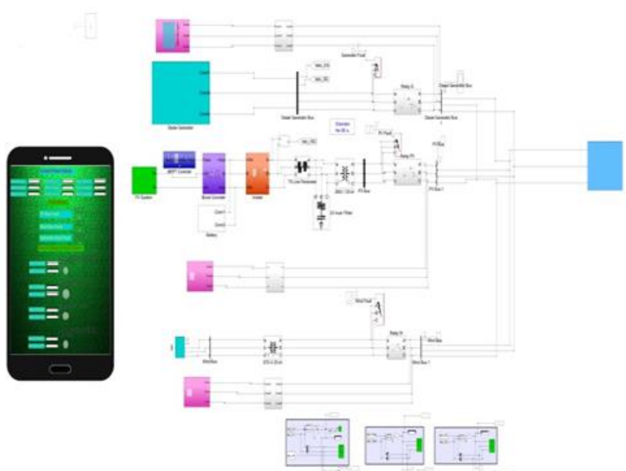

Fig.5.OverallSimulatedCircuit

The simulation of the grid system is mentioned in fig.6. Diesel generator, PV system and Wind Energy are used in this Simulink. Diesel generator produces electric power by using fuel and delivers the power to the diesel generator bus. Then the power goes to the relay where the electric fault. can be detected. On the other hand, solar power produces electric power by using sunlight and passes the power to the grid system. For better results, MPPT controller and Boost Converter are used. In this line, a 250V/25KV transformer is used and a relay is used to detect the fault automatically.

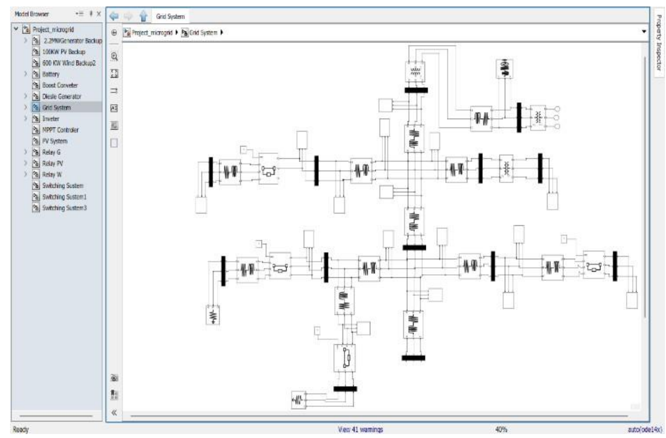

Fig.6.SimulationoftheGridSystem

4. Results & Output Analysis

In this section, the individual results of solar power, wind power, and diesel generator will be discussed. In Part A, the results of MATLAB platform have been discussed whereas the part B will discuss about ThingSpeak Server results. Part C and D will discuss about the out put and results of controller unit and android mobile application.

MATLAB Results Analysis:

1) Diesel Generator Bus Output

From the generator bus analysis, we get almost 16000kW, where the voltage is almost 2000V,and the current is 4000A. The diagram is given below in fig. 7. Here, the first graph represents the power ratings, the second graph represents the voltage ratings, and the final graph represents the current ratings.

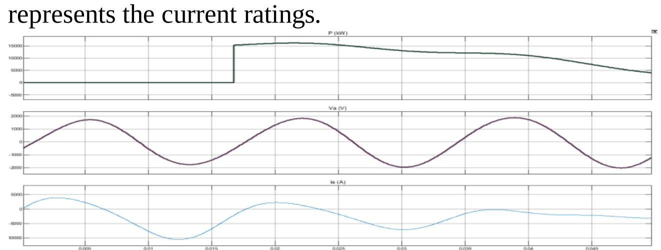

Fig.7.DieselGeneratorBus Output

2) PV Bus Voltage and Current With & Without Filter

The graph of voltage and current of PV Bus with filter and without a filter has been shown in fig.8.Thefirstgraph indicates the voltage graph, and the second graph indicates the current signal with filtration. On the other hand, the third graph indicates the signal without a filter.

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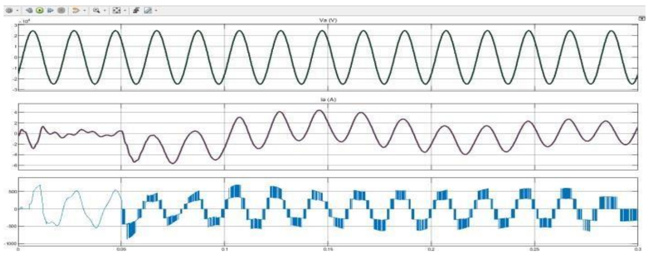

Fig.8.PV Bus Voltage and Current with & without filter

3) PV Bus Output Power & Voltage

This figure 9 shows the output of the PV bus and its DC voltage. We get 100kW from PV bus. Here, the first graph represents the power ratings and the second one is voltage ratings.

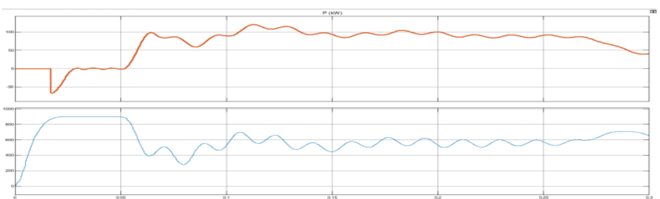

Fig.9 PV Bus Output Power & Voltage

4) Wind Bus Output Voltage, Current & Power

From the Wind Bus, we get almost 5000kW. The output graph is given below in fig. 10. Here, the first graph shows the output of power, the second graph shows the voltage and the third one represents the current of the wind bus.

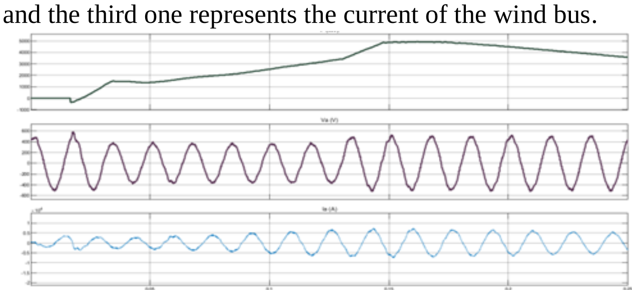

Fig.10 Wind Bus Output Power & Voltage

Results Analysis of Thingspeak Server:

As the suggested microgrid system is IoT-Based, so the authority can see the real-time data in cloud server. The authority can access this server from anywhere at anytime with the help of a username and password. The results of the individual's section are given below sequentially. The ThingSpeak cloud server has been taken as a prototype server.

1) PV Results

Two field sections were created in the cloud server to analyze the PV module. One is PV voltage, whereas another is PV power analysis. We get 278.58kV in the ThingSpeak server from our designed PV system and get100.36kWpowerfrom that. The results has been shown in fig. 11.

Fig.11. PV Results in Thingspeak Server

2) Wind Result

Wind voltage and wind power are given in this analysis. We get 30.60kV and136.14kW as power from this wind module. The output result is given below in fig. 12.

Fig.12.WindResultsinThingspeakServer

3) Generator Results

In this Generator analysis section, two fields were created for measuring the voltage and power. After running the Simulink file, we get 279.52kV as voltage and 2222.76kW as owner. The output is given below in fig. 13.

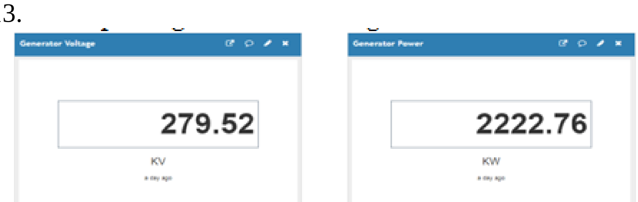

Fig.13.Generator Results in Thingspeak Server

4) Fault Analysis

Three notifications lights were added in this section to indicate the electrical fault of the branch. When the solar energy occurs fault, it indicates a fault on the solar energy bus. Similarly, the wind and the diesel generator do the same process in the ThingSpeak Server. This field is given below in fig. 14

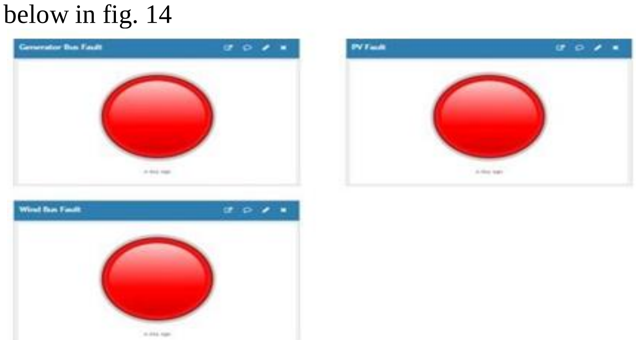

Fig.14. Fault Analysis in Thingspeak Server

6. Conclusion

The key purpose is to show how the research can solve a real-world problem. For the greater good of humanity, researchers are solving real-world issues. For people living in rural areas, this research proposed an IoT-based Smart Microgrid. To increase the grid system's functionality, many researchers have worked on a number of microgrid initiatives. This research, on the other hand, proposes a smart microgrid system that can be monitored from afar at any moment. In addition, using renewable energy sources can help reduce environmental effect. Multiple renewable energy source scan provide a constant supply of electricity, and any excess current can be retained for when there is an outage.

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