PROTOTYPE OF IOT BASED DC MICROGRID AUTOMATION

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Abstract - *A microgrid is a self-sufficient energy system that serves a discrete geographic footmark, such as a college campus, hospital and business center. With the development of computer network and automation technology, precise monitoring of microgrid parameters has become an essential part. Different methods are used to monitor the performance of a microgrid. An IoT based automated DC Microgrid system is represented in this paper. The main motive of the developed system is to monitor the performance of a DC microgrid and automatically isolate the load on detection of over voltage and under voltage condition. It mainly focuses on generating power using renewable energy resource such as solar energy and wind energy, monitoring the power supply and load voltages using Blynk Application.*

Key Words: **DC Microgrid, Automation, Internet of Things (IoT), Blynk Application.**

1. INTRODUCTION

The increase in demand for energy is evident with the fact that during the fiscal year (FY) 2019-20, the gross electricity generated by utilities in India was 1,383.5 TWh and the gross electricity consumption in FY2019 was 1,208 kWh per capita. Such numbers signify the requirement for renewable energy resources besides traditional ones. The proper usage of renewable energy sources is a task in the current scenario. A microgrid is a modern distributed power system using local sustainable power resources designed through various smart-grid initiatives. Microgrid combines distributed power, load, energy storage devices and management devices, forming a single and manageable power supply system. As a localized power grid, microgrid has its own generation sources, and definable load systems. It additionally works with renewable energy sources for power generation that tends to the usage of storage resources according to the requirement. They tend to provide various benefits such as improving energy efficiency, minimizing overall energy consumption and improves the quality and reliability of power supply.

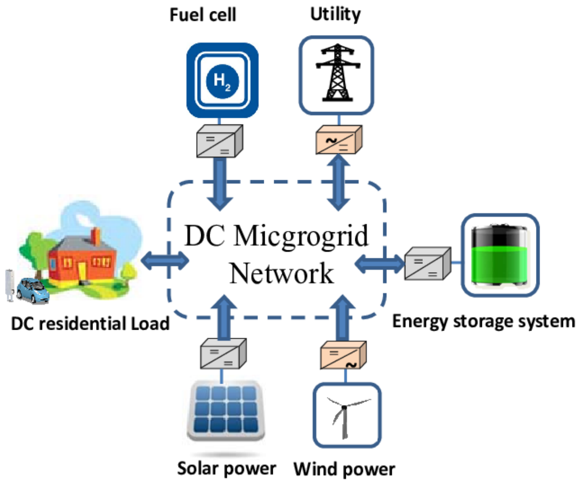

Fig-1 : Schematic diagram of DC microgrid

A great challenge lies in the protection of the grid as it should respond to the fault of a utility grid and renewable sources. The early identification of faults and removal of faults is also an enormous task in Microgrids. With growing rapid development and dependency on renewable energy resources in microgrid, its protection and command are resolved with the help of Internet of Things (IoT). The IoT grants the system an advantage to remotely observe and supervise the network. Hence a system is developed using IoT that monitors the power flow in DC Microgrid and protects the grid from undervoltage and overvoltage conditions.

2. RELATED STUDY

Microgrids, operating in either grid-connected mode or islanded mode, enable local integration of energy generation, distribution and storage at the consumer level for better power system efficiency and control of demand. DC microgrids are highly efficient, reliable and economic as power quality issues such as reactive power and skin effect are not present. Many methods and techniques are employed to automate the DC Microgrid.

To overcome the challenges associated with monitoring of Microgrid, researchers developed a system that uses B/S architecture to implement real-time monitoring and adjusting the value of the environment factor data [1]. The study provided a method for grid energy optimization for DC microgrids including distributed energy resources and residential building, using a Supervisory Control and Data Acquisition (SCADA) system. The inclusion of SCADA provides the common communication for all components of the microgrid to interconnect with the control room via wireless smart sensors to update the power setting [2]. The IoT based Battery Monitoring System which is developed in the study consists of a communication channel from and to the Intelligent Electronic Device [IED], data acquisition, cloud system and Human Machine Interface (HMI). All battery parameters have been created into an embedded system that functions as an IoT to enable communication from and to the IED, as well as data acquisition and an internet gateway, allowing for the storage, processing and access to all parameters through cloud system [3]. The paper presents a novel event-triggered distributed secondary control strategy for single-bus DC microgrid. Through the event-triggering mechanism, each converter can decide and choose locally when to transmit signals to its neighbors. In this way, there is significantly reduction in the communication burden among converters [4]. The paper presented a system that allows the source code portability of device drivers between different system. PIC microcontrollers is interfaced with UART, interfaced with LCD to control the operation of PIC controller using MP Lab IDE. The IoT module detects the location, number of loads operating, amount of energy consumed from supply, microgrid and sensor values [5].

The drawback of the observed systems is that for the data display, LCD are used and in case of faults, an alert message is not displayed. The suggested work solves the previously mentioned issues. The main objective of the developed system is to implement a system for the real time monitoring of DC microgrid using IoT technology and to analyse the performance of the system and rectify over voltage and under voltage conditions.

3. REQUIREMENTS

3.1 Solar Panel

Solar panels are used for the harnessing of solar energy. Solar panels are made up of numerous solar cells that are linked in a series of parallel lines. P-type and n-type silicon are the two types of semiconductors used in solar cells. Electrons in the silicon are ejected when sunlight strikes a solar cell. If this happens in the electric field, then the electrons will travel from the n-type layer to the p-type layer through the external wire creating a flow of electricity. The solar power then generated can be stored for future use. 12W, 21V rated solar panel is used in our prototype to supply power to a 12V DC load.

Fig-2 : ZS1210 Solar Panel

3.2 DC Geared Motor

These motors are simple DC Motors featuring Metal gears on the shaft for obtaining the best performance characteristics. They are known as Centre Shaft DC Geared Motors as their shaft extends through the centre of their gearbox assembly. This DC Motor – 150RPM – 12Volts finds its application in all-terrain robots and a variety of robotic applications. These motors have a 3 mm threaded drill hole in the middle of the shaft thus making it simple to attach it to the wheels or other mechanical assemblies.

Fig-3 : DC Geared Motor

3.3 Arduino UNO

Arduino Uno is a microcontroller board based on 8-bit ATmega328P microcontroller. Along with ATmega328P, it consists other components such as crystal oscillator, serial communication, voltage regulator, etc. to support the microcontroller. Arduino Uno has 14 digital input/output pins (out of which 6 can be used as PWM outputs), 6 analog input pins, a USB connection, A Power barrel jack, an ICSP header and a reset button.

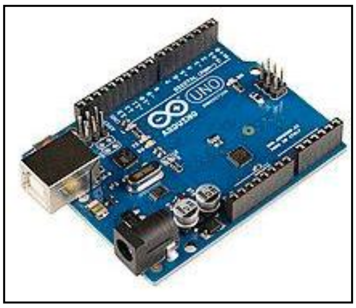

Fig-4 : Arduino UNO

3.4 ESP8266 Wi-Fi Module (NodeMCU)

The NodeMCU ESP8266 development board comes with the ESP-12E module containing the ESP8266 chip having Tensilica Xtensa 32-bit LX106 RISC microprocessor. This microprocessor supports RTOS and operates at 80MHz to 160 MHz adjustable clock frequency. NodeMCU has 128 KiloByte RAM and 4MB of Flash memory to store data and programs. Its high processing power with in-built Wi-Fi / Bluetooth and Deep Sleep Operating features make it ideal for IoT projects. NodeMCU is powered using a Micro USB jack and VIN pin (External Supply Pin). It supports UART, SPI, and I2C interface.

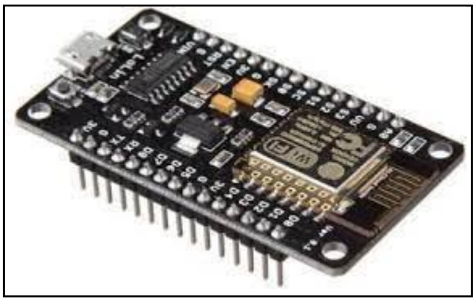

Fig-5 : Wi-fi Module

3.5 ACS712 Current Sensor

The 5A range Current Sensor Module ACS712 consists of an explicit, low-offset, linear Hall circuit with a copper conduction path placed near the surface of the die This ACS721 current module is based on the ACS712 sensor, that can accurately detect AC or DC current. The maximum AC or DC which can be detected can reach 5A, and the present current signal can be read via analog I/O port of Arduino.

Fig-6 : ACS712 Current Sensor

3.6 Voltage Sensor

A voltage sensor is a sensor used to calculate and monitor the amount of voltage in an object. Voltage sensors can determine the AC voltage or DC voltage level. The input of this sensor is the voltage, whereas the output is the switches, analog voltage signal, a current signal or an audible signal. The input voltage range is 0V-25V whereas the voltage detection range is 0.02445V to 25V.

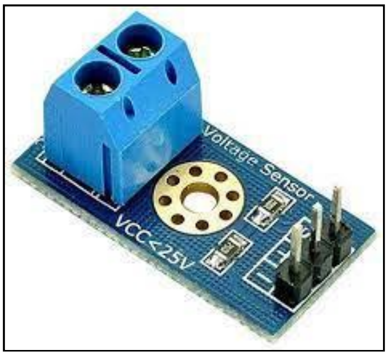

Fig-7 : Voltage Sensor

3.7 4 Channel 5V Relay

Each channel on a 5V 4-channel relay interface board requires 15-20mA driver current. It can be used to control a variety of high current appliances and devices. It has high-current relays that work under AC250V 10A or DC30V 10A. It features a standard interface that can be controlled directly by microcontroller.

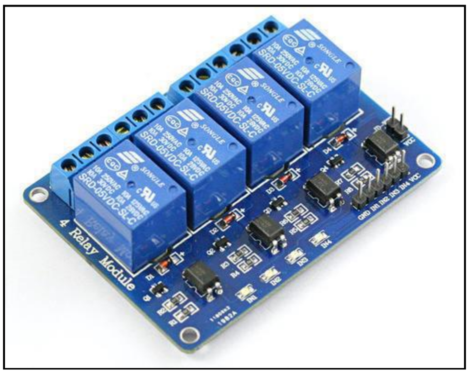

Fig-8 : Four channel 5V relay

3.8 Blynk Application

Blynk is a Platform that enables Internet based control of devices like Arduino, Raspberry Pi and other using IOS and android apps. By simply dragging and dropping widgets, you may create a graphic interface for your project on a digital dashboard. With Blynk anyone can connect their hardware to the cloud and create a no-code iOS, Android, and web applications to analyze real-time and historical data coming from devices, remotely control them from anywhere in the world, receive important notifications, and much more.

Fig-9 : Blynk App

4. SYSTEM DESIGN

4.1 Design of Power Circuit

A hybrid power generation system consists of two renewable energy sources such as solar and wind (DC geared Motor). This increases the efficiency and power reliability of the system. Solar panel of rating 21V is used to capture solar energy and Hand driven 150RPM Dynamo is used to represent wind power. The battery backup is used to meet the load demand when power from solar and DC geared motor (representing wind) is not sufficient. Each source is provided with voltage sensor for purpose of collecting values of voltage at source end. The data is fed to Arduino UNO microcontroller. Current sensor is added at load end to measure current entering the load. Microcontroller is connected to Blynk server through Node MCU that acts as bidirectional serial communicator. The circuit diagram of developed system is shown in figure 10.

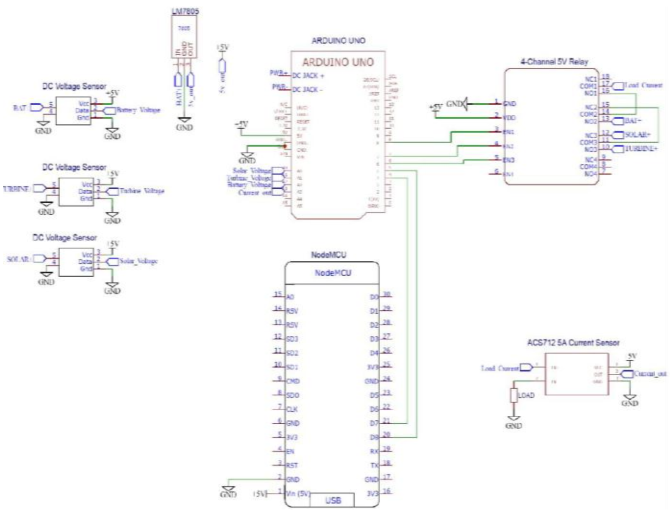

Fig-10 : Circuit diagram of developed system

4.2 Flowchart

Figure 11 represents the flowchart of the DC Microgrid automation system. Three power sources are considered. The voltage sensor after sensing the source voltage value, feeds the value to the Arduino. Based on the values received, the relay unit is set to select the value that has optimum voltage and hence source selection takes place. The selected source power flowing through buck converter is fed to current sensor that senses the current value and this measured current value is sent to wi-fi module via Arduino. The received voltage and current values are displayed on Blynk app.

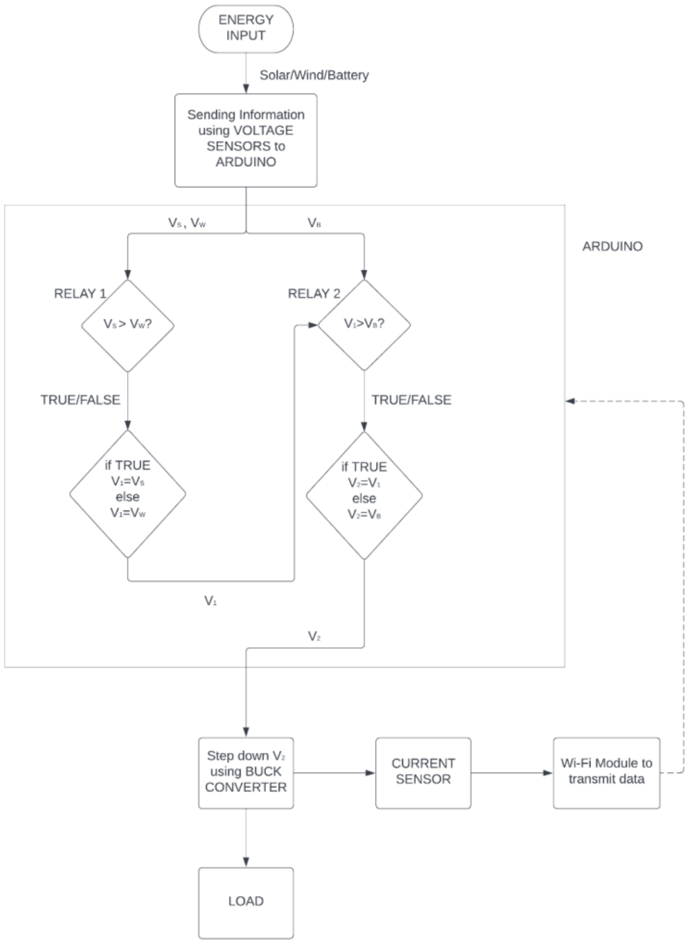

Fig-11 : Flowchart of the system

4.3 Working

Figure 12 shows the block diagram of the system.

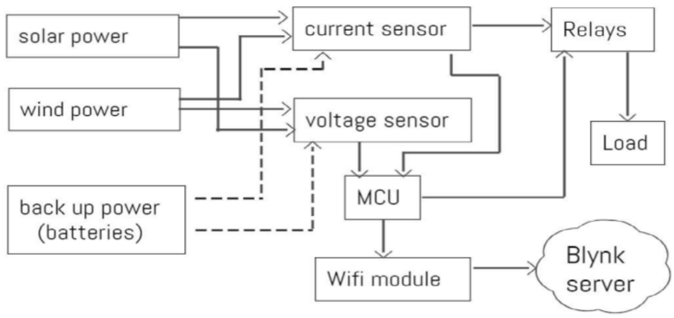

Fig-12 : Block diagram of the system

The proposed system consists of two parts i.e hardware and software. The hardware consists of solar panel, DC Geared motor, voltage sensor, current sensor, Arduino UNO, ESP8266 wi-fi module and relay. The software consists of Arduino IDE and Blynk App.

The proposed system incorporates a microgrid automation system which consists of various power sources, sensor unit, control unit, relaying unit and Internet of Things (IoT) based mobile application with a user interface. The power is drawn from solar and wind energy sources. The system also consists of a battery unit which can be utilized in case of power outage. The sensor unit consists of voltage and current sensors. The control unit is composed of microcontroller, Wi-Fi module and a set of relays suitable for the application.

The voltage and current sensors measure the respective voltages using the voltage divider method across all the sources. These values are fed to the microcontroller which makes decisions according to the program written to it. The current sensor measures the current consumed by the load using the Hall effect method which gives an idea about the demand and sends the same to the microcontroller. The relays are triggered by the microcontroller which switches the load to different sources or isolates the load in case of anomaly. All these operations can be viewed by the user with the help of a mobile application which gives the live data on the dashboard. This is done with the help of a Wi-Fi module which is connected to the microcontroller that feeds all the data to the IoT mobile application. The application also allows the user to set various thresholds and limits.

The user can set high voltage, low voltage limits in the Blynk app. Along with that, the maximum load that a source can withstand is also specified by the user. When the voltage of a source is below the low voltage threshold or above the high voltage threshold for the particular source, the microcontroller selects a different source by switching the load through relays. In case, neither solar nor turbine has sufficient voltage, the load is switched to the battery backup. The load is also switched to a different source when the power demand is higher than the particular source which it can handle. In case of total power outage or very large power demand which none of the sources can handle, the load is completely isolated by all the sources thus ensuring safety.

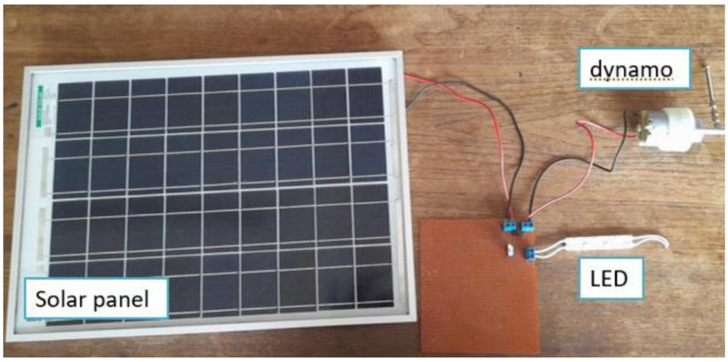

Fig-13 : Circuit connection of hybrid power generation setup

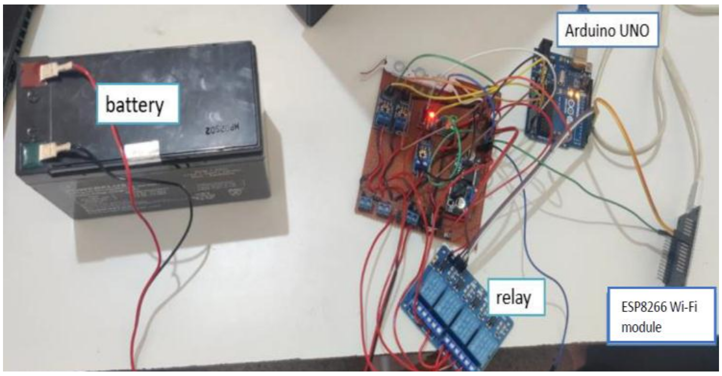

Fig-14 : Battery run DC microgrid automation circuit

5. RESULTS

When, the battery power is consumed by the load, Blynk application displays the mode from which power is supplied. The voltage value of source and current supplied to load is also illustrated as shown in figure 15.

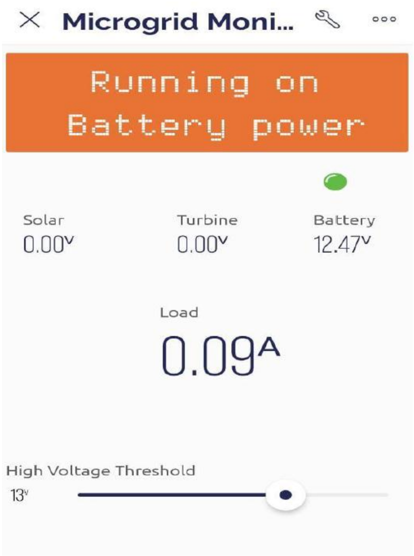

Fig-15 : Blynk output during battery mode

The Blynk application allows the user to set values for high voltage threshold. In one case, high voltage threshold was set to 12V. When battery supplied a voltage of 12.50V thereby exceeding the set limit, the load was isolated and an alert message of "Anomaly detected, load isolated" was notified to user in Blynk as shown in figure 16.

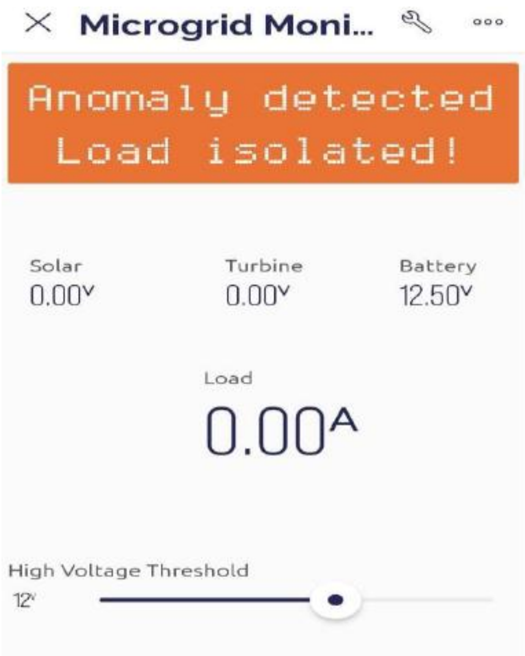

Fig-16 : Display in Blynk server during overvoltage condition

Figure 17 shows the limit setup of various data stream such as low voltage threshold, solar/turbine load limit, battery load limit values limit. The low voltage threshold limit is set to 10V. When all power sources are turned off depicting the situation of all power sources failing to supply the demanded power, the load is isolated from system. An alert message of "anomaly detected, load isolated!" is notified to user.

Fig-17 : An alert message for undervoltage condition

Similarly, with the use of Blynk application the voltage and current values fed to load over a time of 1hour, 6 hour and 3 months so on, are recorded and visualized in graph form. As shown in figure , the variation graph for values measured during wind power generation are obtained.

Fig-18 : Graphical Display of load current variation.

6. CONCLUSION AND FUTURE SCOPE

The system developed enhances the performance of the existing DC microgrid. The hybrid power generation adopted in the model showcased the application of solar and wind power in producing electricity thereby giving more importance to renewable energy usage.

The Blynk application used in the work allows the user to view real time data collected from the grid built. It also helps the user in setting up threshold limits to various data stream and in isolating the load during over voltage and over current condition. An alert message is generated in Blynk app to notify the user about the condition of microgrid. These features automate the Microgrid system thereby removing the need for manual isolation of load during faulty condition. As the load is isolated with very less delay after fault detection, it increases system reliability and performance. In this way, the internet of things can be used in various way to explore the problems occurring in DC and AC microgrids and to provide solution for the same.

With the modifications, model presented in this work can be extended for automation of AC Microgrids. The various other faults in DC microgrid such as arc faults, short circuit faults can be rectified by adopting some changes in built system.

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