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Control Strategies in Dc Microgrid Environment

Chandana Manjunath[1] and Dr. B K Keshavan[2]
[1-2]PES University, Department of Electrical and Electronics Engineering, Bengaluru, India
Email: pes1202002578@pesu.pes.edu, keshavanbk@pes.edu

***Abstract*—Microgrids are changing the traditional approach of addressing energy demands in a variety of communities and businesses. They open up new paths to a carbon-free, dependable, and resilient electric system. DC Microgrids are becoming more prevalent as power electronic converter technology advances. Today and in the future, higher fuel prices, deregulation, and environmental constraints present more opportunities for the use of renewable energy sources (RES) in power systems. A micro grid idea is necessary to integrate renewable energy sources into the electrical system. As a result, this proposed system has a micro grid control mechanism involving solar (PV), battery energy storage systems (BESS)and wind. To begin, voltage control alternatives for an island micro grid are investigated using hierarchical control approaches. Furthermore, the cost and electricity generated by renewable sources are calculated. Finally, this study presents an energy management system for micro grid functioning. In grid-connected mode, MATLAB and Arduino programming are used to find the lowest cost of electricity generation and power availability. The simulation results indicate that the suggested solutions are close to being accurate and efficient. The corresponding hardware model has been implemented.**

***Index Terms*— first environmental constraints, energy management, cost effective.**

I. INTRODUCTION

Because of the growing concern about sustainability and energy consumption, governments, academics, and investors are becoming more interested in renewable generating, resulting in an increase in the number of renewable power systems integrated into present electrical grids. Renewable energy penetration, on the other hand, is hampered by its variability and intermittency, prompting the development of Microgrids powered by renewable power sources. These decentralised power systems, whether grid-connected or islanded, are thought to be the most viable approach for boosting clean energy penetration in the future, and have gained increasing relevance in recent years because to their widespread availability and low production costs. As the use of solar power expands, so does the need to improve the quality of the energy produced. Renewable energy technologies are becoming increasingly the most cost-effective way to build new capacity in an increasingly diverse world and areas, and they are typically the most cost-effective way to build when there is new grid-connected capacity and sufficient resources available. Costs have been driven down by the rapid adoption of renewable energy generation technology and strong learning rates. Renewables are predicted to become extremely competitive with fossil fuels in countries across the world as a result of this trend, and the most cost-effective option in a growing number of markets. Renewables contributed for 72 percent of new capacity additions globally in 2019 indicating their productivity and competitiveness. Renewable energy's cost competitiveness has hit new heights, with 56 percent of new utility-scale capacity costing less than the cheapest new coal option. Solar PV at utility

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scale, biomass for power, hydropower, geothermal energy, and onshore wind are all now feasible electricity sources. Cost reductions in solar and wind power are expected to develop in the future, as even more equipment and balance of plant efficiency improvements and performance improvements are anticipated, lowering the renewables weighted-average levelized cost of electricity (LCOE). As economies of scale, more challenging supply chains, and technological advancements continue, solar and wind power costs will continue to fall. The same factors will improve the availability of these vital renewable energy sources at night and under various weather conditions.

II. Literature survey

Due to the growing demand caused due to increase in load, the amount of energy generated is not adequate, hence other energy sources apart from the conventional energy sources has to be explored. In [1, 2, 5] Microgrids can help with the aforementioned issue. The main contribution focuses on the issues and objectives of various hierarchical control levels, as well as the mechanisms by which different control schemes achieve their specific goals at each level in order to operate a DC Microgrid with distributed generator units in an optimal and cost-effective manner. [3] Presents an extensive review of hierarchical control strategies that provide effective and robust control for a DC microgrid. [4] presents a current review of power converter control and AC Microgrid control techniques. [6] Microgrid System are used for powering remote areas where both DC-producing and AC-producing sources may require only one conversion, resulting in fewer converters needed, which in turn gives better efficiency. [7] The integration of a controller for DC/DC bidirectional converter for an MG system comprising of Photovoltaic panels, grid linked, and Li-ion Battery Storage systems is based on the management of battery charging and discharging.

III. Methodology

a. This proposed model allows us to use multiple sources and multiple loads to be controlled efficiently and effectively.
b. This model allows us to measure output of all sources.
c. Least cost of production of electrical energy is taken care of.
d. Software for choosing the best option among the sources depending on the availability of power and cost.
e. Since Renewable energy sources are being used which are unpredictable in nature, converters are used to maintain constant voltage at point of common coupling.
f. From the common point of coupling, power is supplied to loads with proper rated voltage using converters.

This model is divided into two units which are shown in the Fig. 1.

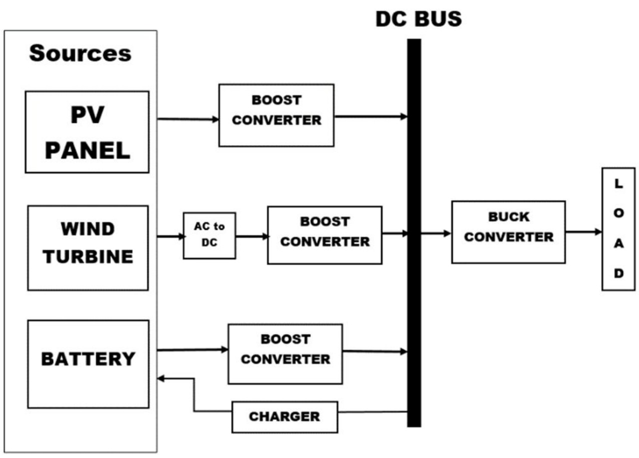


Figure 1. Block Diagram

The first unit consists of three sources out of which two are renewable and since they are unpredictable, a DC source (Battery) is used. Boost converters are used to keep the voltage on the DC bus constant. The second unit consists of buck converter and loads. Buck converter is used in order to step down voltage as per the load requirement. DC Bus maintains constant voltage from all the sources and the excess power can be used to charge the battery via a charger.

IV. Hardware Implementation

The hardware model consists of DC Motor, Arduino UNO, Current and Voltage Sensors, Boost and Buck Converters, Relay and Power supply systems. DC motor is the load that is used to run the model. Arduino UNO carries the cost optimization code for minimum cost of power generation. Current and Voltage sensors are used to sense and measure current and voltage of the load used. From the point of common coupling, power is distributed to loads with the required voltage level using buck converter. Boost converters are used in order to maintain constant voltage at the DC Bus. Relay is used in order to choose the source automatically via a microcontroller.

This model consists of three sources out of which two are renewable which are unpredictable and a DC source (Battery). All the three sources are connected to a Boost converter in order to maintain a common voltage at a point known as DC Bus, the extra voltage or charge is used to charge the battery from the DC Bus. The relay modules are used to identify the sources. The buck converter then automatically reduces the voltage in order to maintain rated voltage as per the load requirement. Current and Voltage sensors are used to read sense the rated current and voltage of the running motor respectively. The cost optimization program is loaded into the Arduino UNO in order to obtain least cost of operation.

The circuit below shows the hardware implementation.

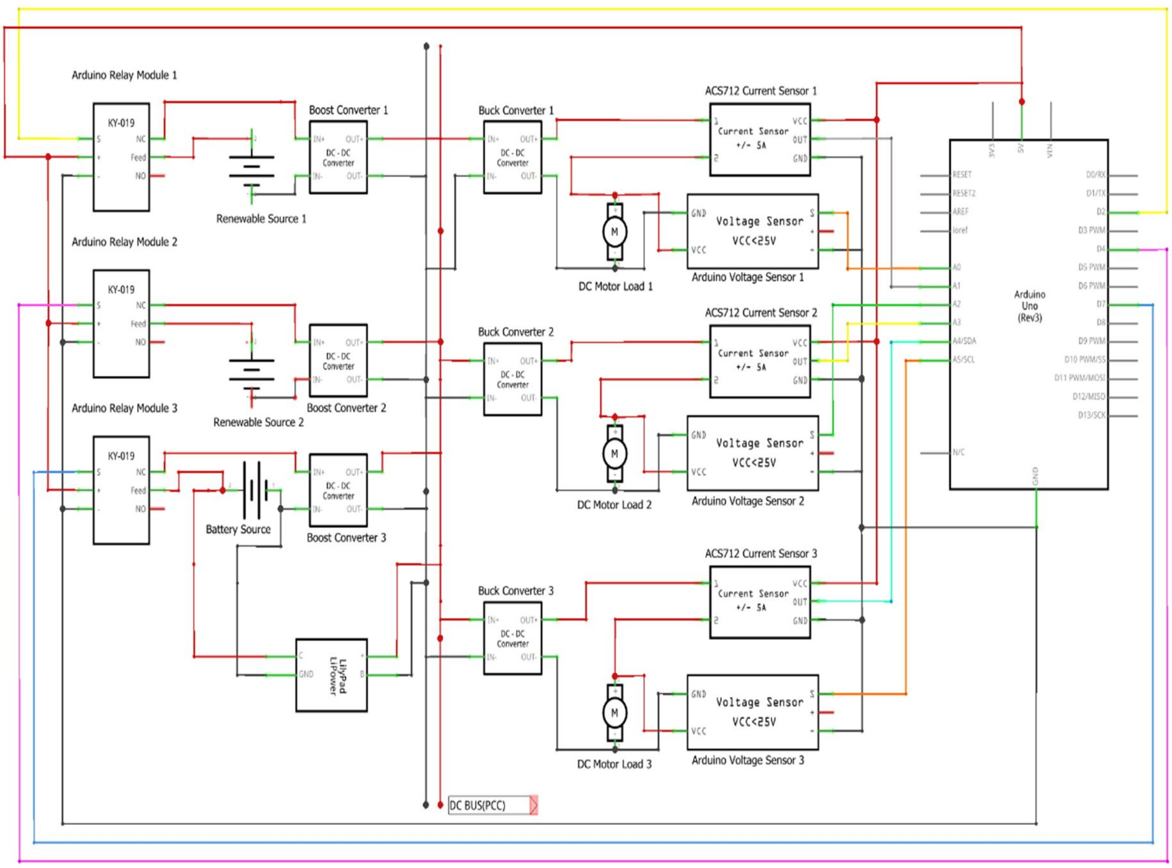


Figure 2. Circuit Diagram

A. Cost Optimization

Power generation from the source having least cost is chosen by running this cost optimization program and the program is designed such that it runs at maximum efficiency and efficiently. The flowchart is as shown in Fig. 3.

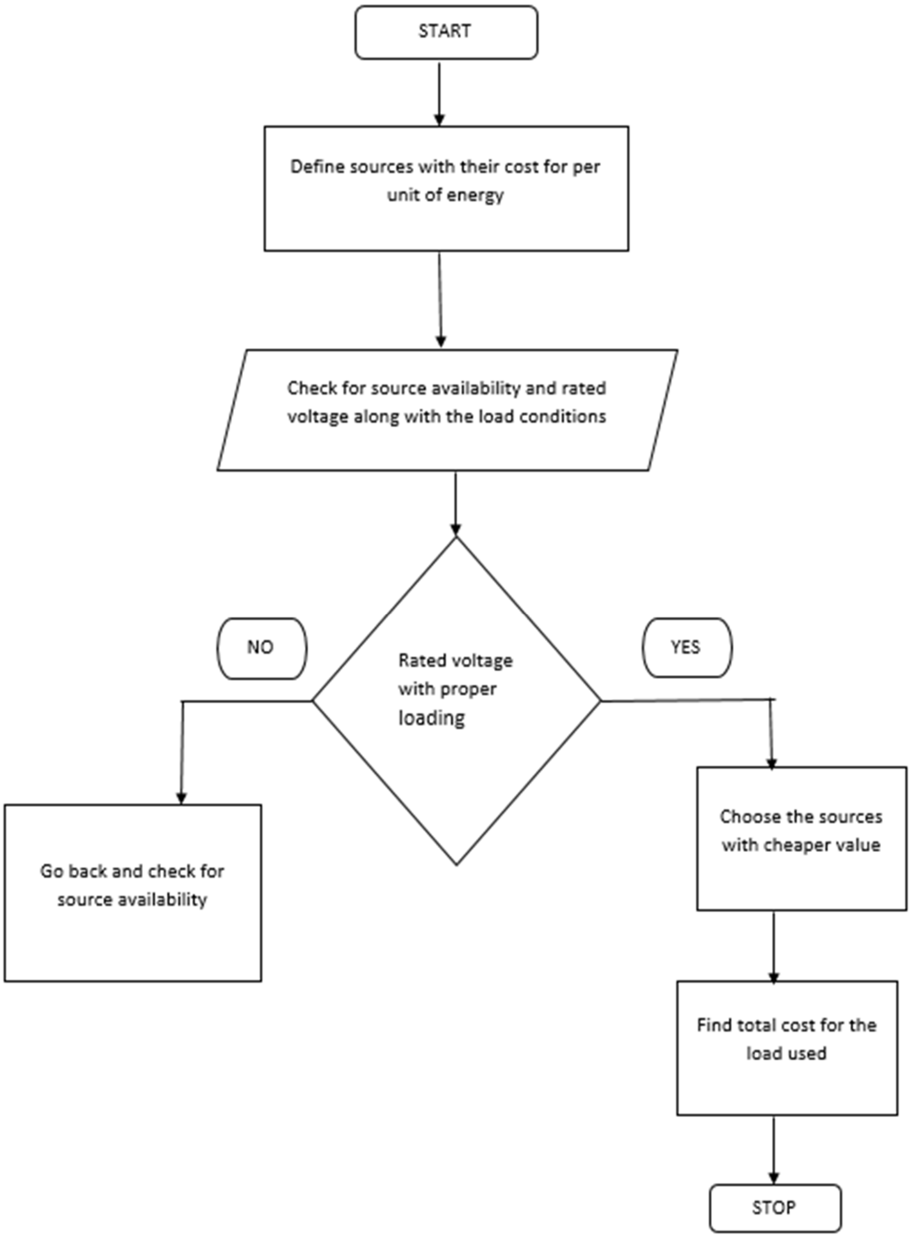


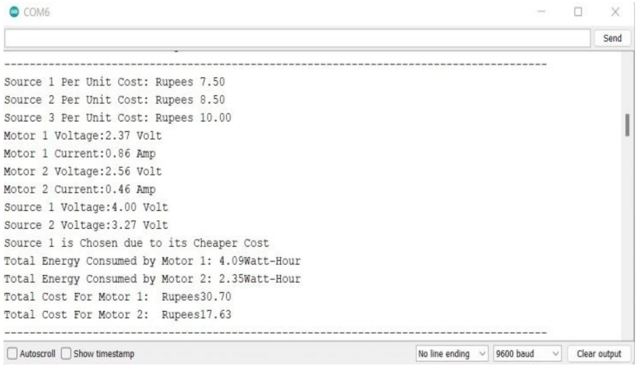
Figure 3. Cost Optimization Flow Chart

V. RESULTS AND DESCRIPTION

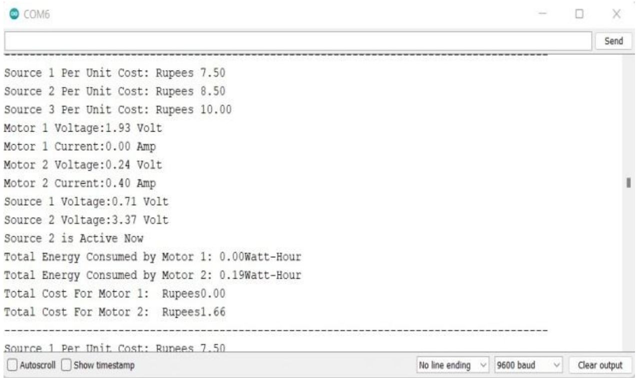
Following are the 4 modes of operation considered for the work.

(a) Both the sources and both the loads are connected.
(b) Both sources active and load 1 is disconnected.
(c) Source 1 is disconnected and both loads present.
(d) Source 2 is disconnected and both loads present

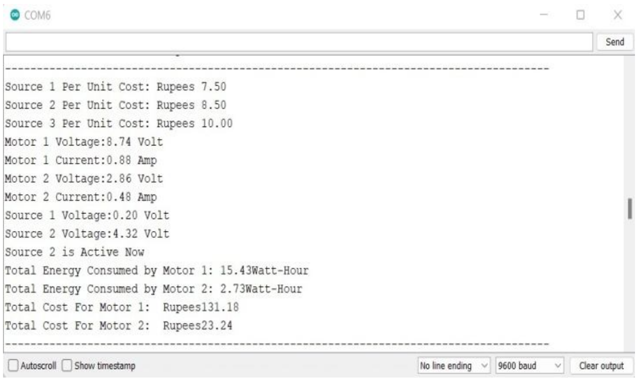
The load is run for a period of 2 hours.



Case (i): Both the sources and both the loads are connected



Case (ii): Both sources active and load 1 is disconnected



Case (iii): Source 1 is disconnected and both loads present

Case (iv): Source 2 is disconnected and both loads present

VI. CONCLUSIONS

This document describes the structure, components, usage, control, and advantages of the DC Microgrid over the AC Microgrid. The primary purpose of this research is to investigate the hierarchical control structure of a DC Microgrid as well as load sharing in one. In today's energy environment, and especially in light of future energy trends, DC Microgrids can distribute electricity efficiently and cost-effectively. Success can be attributed to reliable and resilient control systems like hierarchical control. When load is not operating, the power generated can be used to charge the battery and in case both the sources fail to generate power then power can be drawn from the battery. In a Microgrid, the hierarchical control technique shows promise for assuring stable, optimal, and secure power and energy management. This model contains a DC Microgrid with a PV array and battery, as well as energy management control using a hierarchical state machine based on low utilisation cost. This technique lowers the cost of an energy storage system while maintaining energy storage levels and load power availability.

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