ISSN No.: 2454- 2024 (online)

International Journal of Technical Research & Science

COMPARATIVE AND ANALYTIC DESIGN OF MATLAB MODELLING FOR SOLAR DC MICRO GRID IN RURAL ELECTRIFICATION

Ravi Kiran K C[1], Ramesh C H V[2]
E-Mail Id: kiranravi9535@gmail.com, venkataramesh.ch@nmit.ac.in
[1]M. Tech Student, Renewable Energy, NMIT, Bengaluru, India
[2]Assistant Professor Dept. of Electrical & Electronics Engineering NMIT Bengaluru, India

Abstract-This paper describes the detailed design, analysis of energy dip in solar PV based centralized DC micro grid in rural electrification. Based on the technical and environmental benefits of the renewable energy related solar PV systems are discussed in this paper comparison between the three types of microgrid systems is presented. In this work the consumption of load is about 4.5kWh including the Home load and water pumping system. The estimated required Components such as solar PV Panel, charge controller, battery, distribution system is considered for DC micro grid. further, the voltage dip and Energy drop calculations are presented. The analyzed three architectures are simulated in MATLAB/SIMULINK for power loss and results are presented.

Keywords- DC Micro grid, voltage dip, Power loss, Rural Electrification**.**

1. INTRODUCTION

Energy plays a crucial role in economic development and standard of living. The growth of a country is directly proportional to the per capita consumption of Electricity of the country so the power sector is involving in building a standardized life of living. Providing adequate and affordable power is essential for economic development, socio-economic for the better standard of living. The demand in power in a country like India is an extensive and is growing. Development of various sectors of economy is not possible without the power sector. In fact, it has become a major ingredient for improving the quality of life and its lacking leads to poverty and poor quality of life.

Solar energy plays an important role in the coming days, especially in this period most of the developing countries in the world focus in this area. So, the generation of electric power by using solar PV module is an effective technique nowadays [1]. Rural electrification is electrifying rural and remote areas. Usuage of electricity is crucial for lighting and household purposes, and also allows for mechanization of many farming operations, such as well-pumping, and milking. More than 204 million Indians were without electricity in 2016[2]. The decrement in cost of solar photovoltaic panels provides a viable renewable distributed alternative to grid generated electricity. Based on the usage data from recent studies to establish solar photovoltaics (PV)-powered microgrids [3], [4], there is a highly evidence to suggest that a solar based PV powered system with centralized generation and centralized storage systems are feasible to rural remote areas in which the houses are not built strong such that the foundation of the solar PV panels should withstand and should be long lasting. Further, the use of integrated microgrids containing local generation, local distribution and consumption has its benefits compared to standalone systems [5].

Conversion losses will be mitigated by using DC microgrids with DC generation and DC loads. DC micro grids are 20% more efficient than the AC micro grids [6]. This work is based on DC micro grid of low voltage direct current it will mitigates the costly up-conversion (to kV range) and down conversions since the distribution distances are shorter in village level and it is important to design a feasible architecture design.

In this paper, Solar based DC microgrid is explicitly modeled to compare its operational efficiency and power losses architectures namely C-type architecture I, C-type architecture II, and O-type architecture. In this work a rural remote village in which 16 houses and a water pump of 5HP,600V is considered. Generation of 5kW is required to feed the loads (Both home load and water pump). The comparative analysis of the architectures is shown in this work.

2. DIFFERENT TYPES OF ARCHITECTURE IN RURAL ELECTRIFICATION

Based upon the geography of the village and contiguous distribution of houses, three variety of power distribution architectures are proposed. These include C-type architecture I, C-type architecture II, and O-type Architecture [7] for a solar based DC microgrid built around a village having ‘16’ houses.

2.1 C-Type Architecture

For a village of 16 houses, the optical representation for linearly distributed C-architecture is shown in Fig. 2.1. It shows PV generation, spatial arrangement of houses and power distribution architecture along with the placement storage units. Distribution conductors are laid along the street(linearly), while generation and power processing and storage units (PPSU) are placed at one end i.e. left side of the layout, thus it looks like a C-like structure and is termed as linearly distributed C-architecture-I DC microgrid. Fig. 2.1 shows C-type Architecture I with solar PV generation, arrangement of houses & submersible water pump.

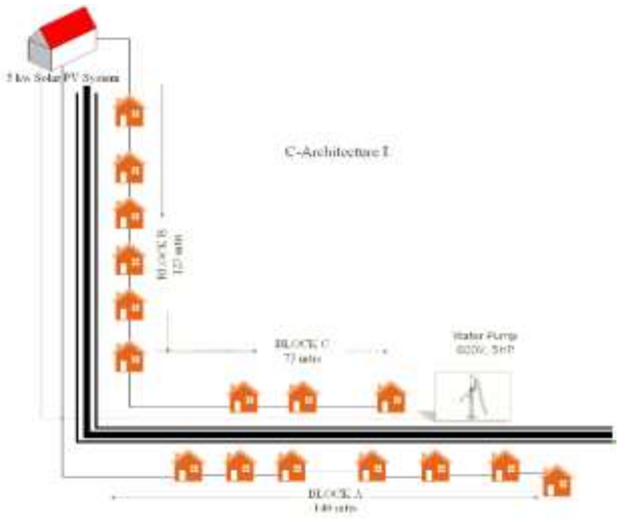

Fig. 2.1C-Type Architecture-I

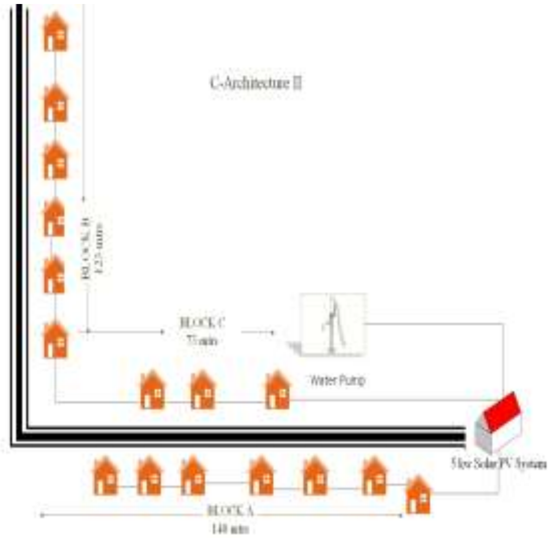

Fig. 2.2 C-Type Architecture-II

Fig. 2.3 O-Type Architecture

2.2 C-Type Architecture-II

For a village of 16 houses, the systematic representation for linearly distributed C-architecture is shown in Fig. 2.2. It shows solar based PV generation, spatial arrangement of houses and power distribution architecture along with the placement storage units. Distribution conductors are laid along the street of the site while the generation and power processing and storage units (PPSU) are placed at one end i.e. Right side of the layout, thus it forms a C-like structure and is termed as linearly distributed C-type Architecture-II DC microgrid.

2.3 O-Type Architecture

In this type of structure, the PV generation unit and PPSU may be located at both ends of the layout as shown in fig. 2.3. Thus, such a structure in which conductors are laid in a linear manner, interconnecting generation and storage hubs at both ends and it forms a linearly distributed O-architecture DC microgrid. Fig. 2.3 shows Schematic Diagram of O-type Architecture with solar based PV generation, spatial arrangement of houses & submersible water pump.

3. DC MICROGRID MODEL

The models presented in this paper dependent of the renewable energy source used. As solar energy is readily available in almost all the regions of the Globe, the presented models allows generation and utilization through solar

PV panels during the daytime, and back up battery bank is used during night. In this Analysis the rural remote village, each house manages to consume the power generated by the centralized generation [8].

The spatial arrangement of houses is Analyzed randomly and are divided into 3blocks namely A, B and C Block for the analysis as shown in fig 1. The total distance from the source to the end home load in Block A is 140m in which 7 houses are distributed linearly distributed, Block B consists of 6 houses and the distance from the source to the end home load in Block B is 123m and the Block C had 3 houses with the total distance of 76m. The distribution efficiency in these arrangements are a function of the arrangement of houses in each Block. Therefore, detailed power flow analysis techniques must be used to find the feasible distribution architecture including number of houses in each block to achieve the highest possible efficiency and lesser possible voltage drop from the far away generation unit. In such architectures, it is possible to further enhance the distribution efficiency and lower the voltage drops at the rear ends at the cost of an extra conductor using ring main scheme method of interconnection to connect the rear end house to the first house of each cluster. This Method is not detailed in the current extent of the work [9].

4. MATLAB MODELLING FOR VARIOUS ARCHITECTURES

The various types of Architectures discussed in section II are simulated in MATLAB/SIMULINK.

4.1 Solar PV Model

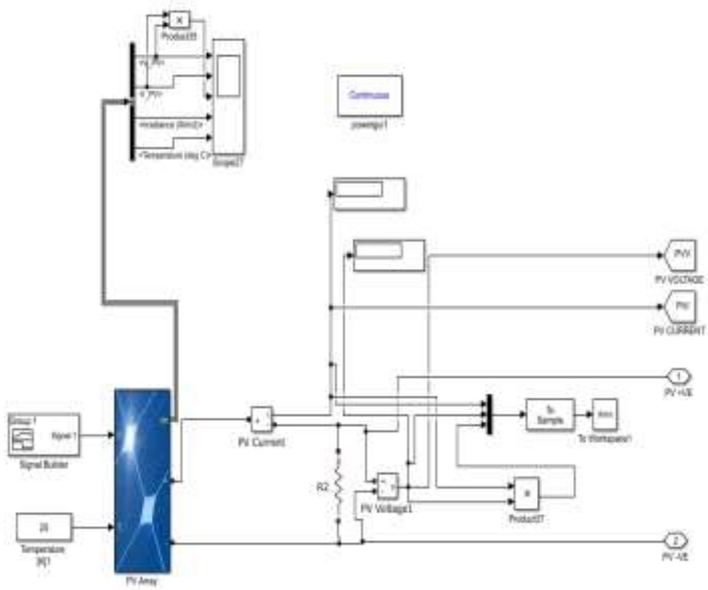

Fig. 4.1 PV Array with Variable Irradiance

The system is simulated for different irradiation profile started from 200 to 1000W/m^2 in this scenario 4 panels are connected in series to build an array of 145V, and 4 arrays are connected in parallel to build, 35A at 200W/m^2 the generation will be of 800W and at max irradiation, the generated power is 5kW. Manual changeover is incorporated to make all the panel in series to attain 600V to feed the pump.

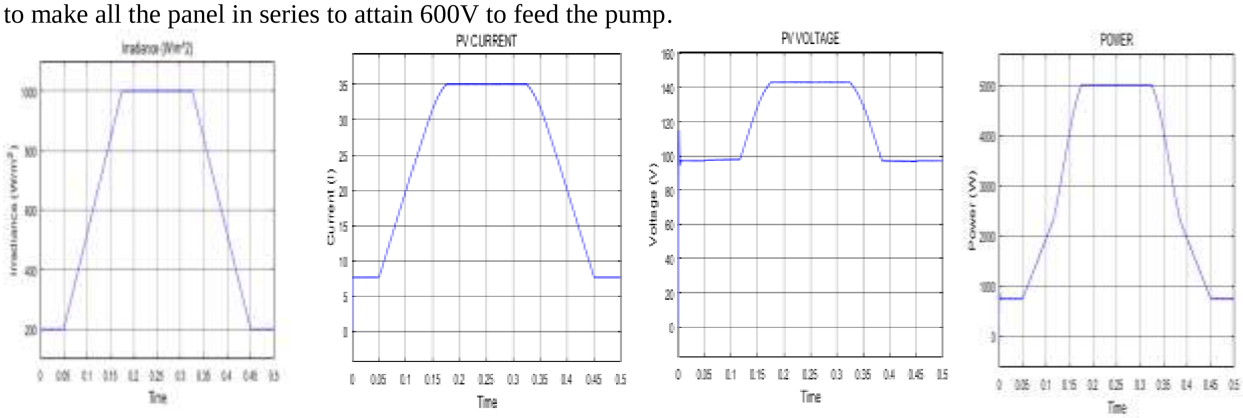

Fig. 4.2 Representation of Generated PV Voltage, Current and Power at Variable Irradiation

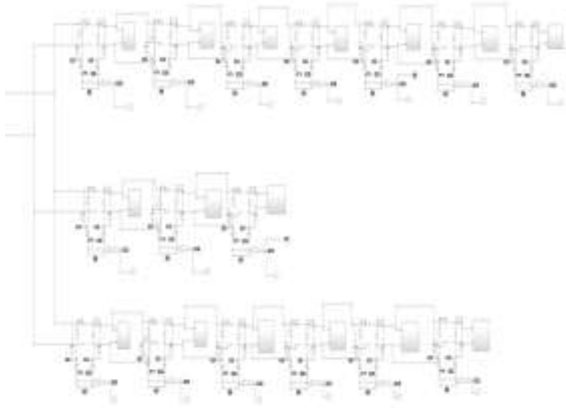

Fig. 4.3 Representation of Home Loads

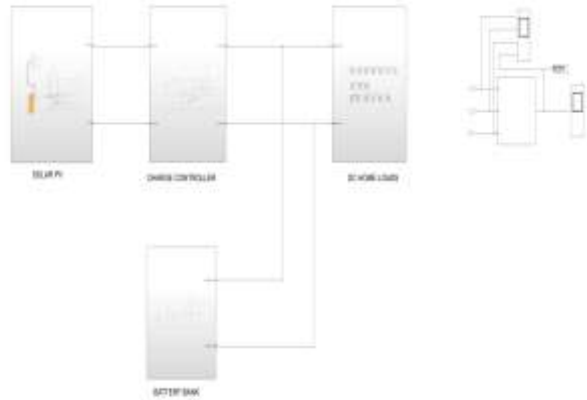

Fig. 4.4 MATLAB/SIMULINK Model

Usually the placement of houses is un-uniform in terms of distance, the generation and storage unit are placed at end of the layout, which is simulated in MATLAB/SIMULINK and power loss analysis is done for three types of Architectures. Fig 8 shows the simulation model of home loads with the variable distance from home to home.

5. RESULTS & DISCUSSION

A typical layout of 16 homes of 40W each is considered for analytic design for all three types of spatial distributions of a village. Distance from home to home is different. Based upon the analysis presented in section II distribution Power losses, efficiency and voltage dip of the distribution system are calculated for each of the analytic configuration. For the orientation of village, Randomly Distributed Architecture is considered with three Blocks.

The voltage drop and Energy loss can be calculated by following formulae:

$$Eb=a*\left(\frac{b*p*R*L}{S}\right)*I^2$$

Where;

Eb=Energy loss
a=1for DC Conductor
b=2(no. of Conductor)
R=Resistance of the Cable
I=Current in the Conductor
S=Cross Sectional Area of the Cable

$$V_D= \frac{b*p*I*L}{S}$$

Where;

V_D= voltage Drop
p=resistivity of the conductor
L=Length of the Conductor

Table-5.1 Comparison of Different Architectures

	Energy Drop		**Voltage drop**
ARCHITECTURES	**THEORITICAL RESULTS(w/h)**	**SIMULATION RESULTS(w/h)**	**THEORITICAL(V)**
C- architecture I (Left)	13.08	13.3	2.84
C- architecture II (Right)	14.58	10.73	2.65
O- architecture	4.90	4.615	1.78

ISSN No.: 2454- 2024 (online)

International Journal of Technical Research & Science

5.1 MATLAB Results for Different Architectures

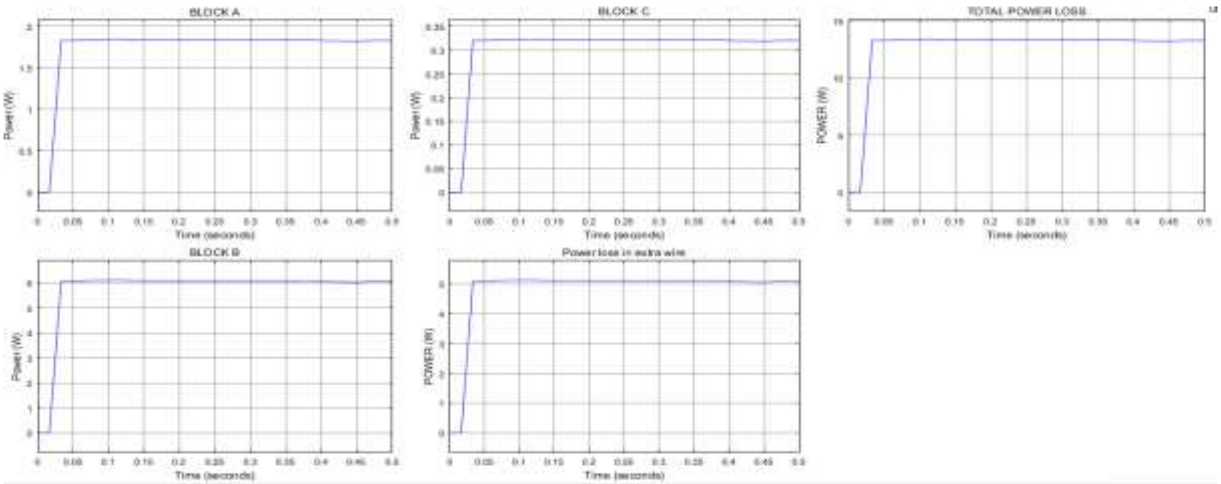

Fig. 5.1 Power Loss in C-Architecture-I

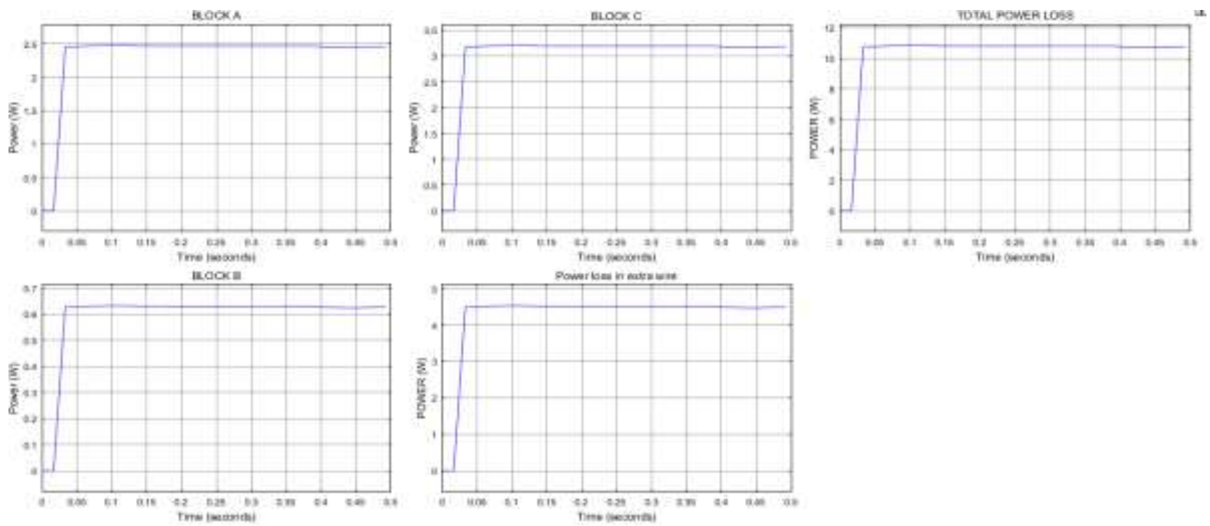

Fig. 5.2 Power Loss in C-Architecture-II

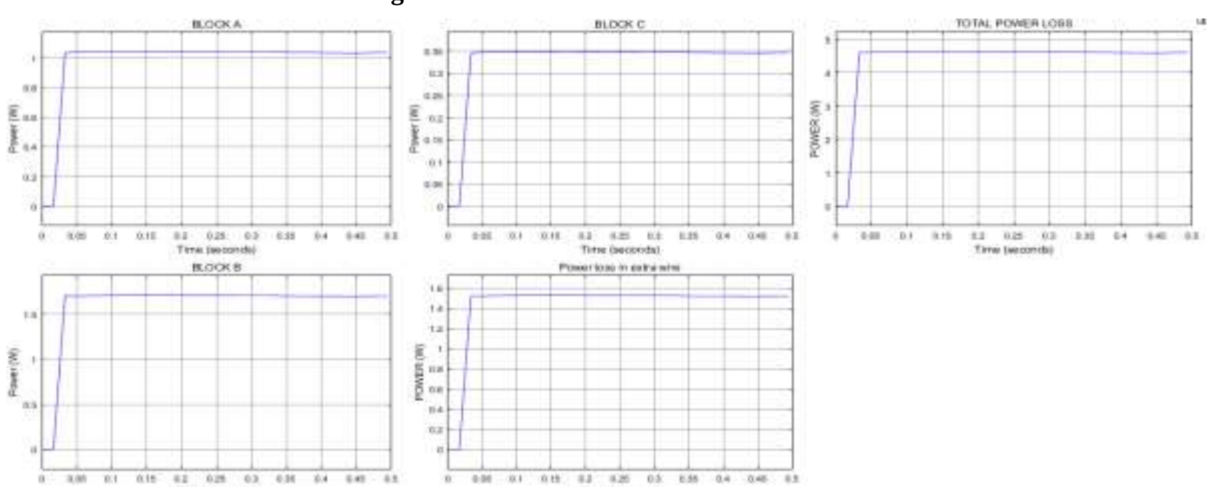

Fig. 5.3 Power Loss in O-Architecture

Above graphs shows the MATLAB/SIMULINK results of all Three architectures, the power loss in each block is simulated and the results are presented in Table 1, by this analysis it can be noted that the power loss in O-Type Architecture is less 4.615w/h and the C-Architecture I is 13.3w/hr. and the C-Architecture II is 10.7w/hr.

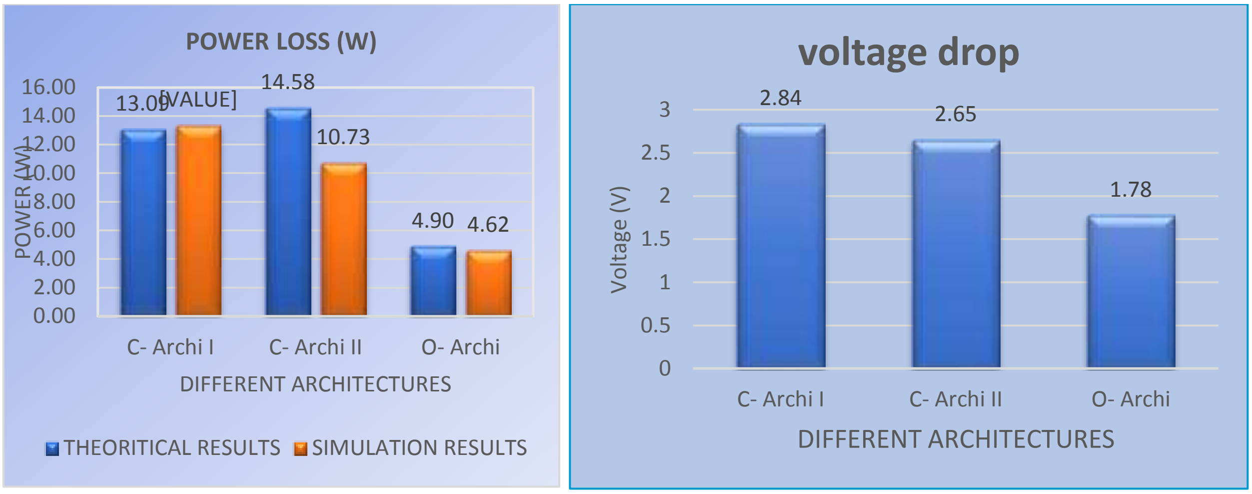

Fig. 5.4 Theoretical and Simulation Results

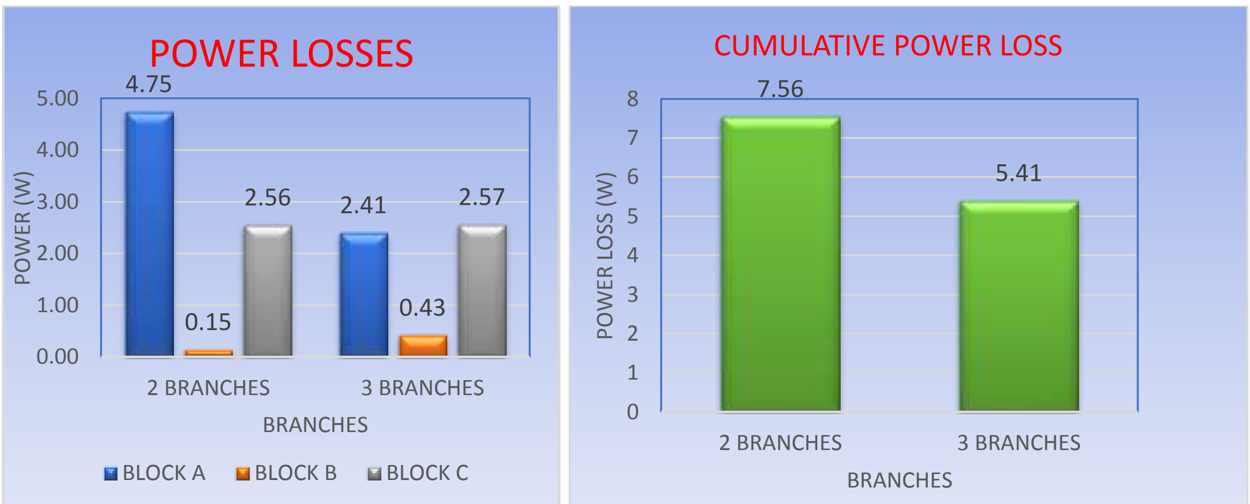

Fig. 5.5 Simulation Results

Earlier only two branches are considered and simulated it is observed that the losses were more. so, they are divided into three branches and the losses were reduced.

CONCLUSION

Solar based DC microgrids are attractive alternatives to traditional AC grids for rural electrification. Analysis of C-type architecture I, C-type architecture II, and O-type Architecture is simulated in MATLAB/SIMULINK and theoretical formulas are used to calculate the voltage dip and Energy loss. Based on Power loss analysis done in this Work the O-Architecture is efficient than the C-architectures. In the O-Architecture single source is divided into two sources and is connected in two ends of the layout. so, the distance from the source and the load will be less. Moreover, the energy balance methodology formulated in this work allows efficient system planning in accordance with village configurations. In the simulation results it is clearly showing that the difference between the C-Architecture and O-type architecture is comparatively more.so, finally it can be concluded that the O-type Architecture is Superior.

ACKNOWLEDGEMENT

The authors thank the authorities of Nitte Meenakshi Institute of Technology, Yelahanka, and MGIRED, Jakkuru, Bengaluru, Karnataka, India for permitting to publish this work. The facilities provided and the motivation by the Head of Department, Dr. V. Ranganathan is gratefully acknowledged.

REFERENCES

[1] Tuballa, Maria Lorena, and Michael Lochinvar Abundo. "A review of the development of Smart Grid technologies." Renewable and Sustainable Energy Reviews 59 (2016): 710-725.

[2] https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=IN

[3] D. Soto et al., “A prepaid architecture for solar electricity delivery in rural areas,” in Proc. 5th Int. Conf. Inf. Commun. Technol. Develop. (ICTD), New York, NY, USA, Mar. 2012, pp. 130–138. [Online]. Available: http://dl.acm.org/citation.cfm?id=2160673.2160691

[4] K. Ubilla et al., “Smart microgrids as a solution for rural electrification: Ensuring long-term sustainability through cadastre and business models,” IEEE Trans. Sustainable Energy, vol. 5, no. 4, pp. 1310–1318, Oct. 2014.

[5] Rajasekar, N., Nishant Bilakanti, and Masafumi Miyatake. "Energy management technique for home micro grid system." TENCON 2017-2017 IEEE Region 10 Conference. IEEE, 2017.

[6] Hamza, Muhammad, et al. "Design and analysis of solar PV based low-power low-voltage DC microgrid architectures for rural electrification." 2017 IEEE Power & Energy Society General Meeting. IEEE, 2017.

[7] Nasir, Mashood, Saqib Iqbal, and Hassan Abbas Khan. "Optimal planning and design of low-voltage low-power solar dc microgrids." IEEE Transactions on Power Systems 33.3 (2018): 2919-2928

[8] Nasir, Mashood, et al. "Solar PV-based scalable DC microgrid for rural electrification in developing regions." IEEE Transactions on sustainable energy 9.1 (2018): 390-399.

[9] Nasir, Mashood, Nauman Ahmad Zaffar, and Hassan Abbas Khan. "Analysis on central and distributed architectures of solar powered DC microgrids." 2016 Clemson University Power Systems Conference (PSC). IEEE, 2016.