iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 Issue: VII Month of publication: July 2023

DOI: https://doi.org/10.22214/ijraset.2023.54829

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VII Jul 2023- Available at www.ijraset.com

Modelling & Simulation of a Hybrid Microgrid System Using Renewable Energy Sources

Nilima Janbandhu[1], Ganesh Wakte[2]
[1]PG Scholar, Department of Electrical Engg, Tulshiramji Gaikwad Patil College of Engineering and Technology, Nagpur, India
[2]Assistant Professor, Department of Electrical Engg, Tulshiramji Gaikwad Patil College of Engineering and Technology, Nagpur, India

Abstract: The rapid growth of industries and load consumption increases the energy demand that needs to fulfilling this energy demand can be obtained from various alternative sources has much importance. The novel hybrid renewable energy system consists of different sources such as the Photovoltaic (PV) system, Wind Energy system (PMSG), Fuel Cell, and the AC source are implemented as energy sources.

The battery and Super Capacitor are used to store excess energy from all sources together which are connected to the DC microgrid. Therefore, the grid provides good quality of power to two different loads namely 48V DC output and 110V AC single-phase output. In this proposed system many individualized converters are used in the DC bus to deliver appropriate power in it. The DC microgrid simulated in the MATLAB Simulink, the observations and results authenticate that the power generation sources enhance the stability of power, reliability, and power efficiency in the microgrid.

Keywords: Organic solar cell, MPPT, DC micro-grid, Solar PV system, Distributed Generators (DG), Stability analysis.

I. INTRODUCTION

In recent years all know how rapidly industries aregrowing and load consumption is increasing because ofthat the energy demand was increases day by day. In the early 20th century AC power stations and transmission lines would be placed more throughout the countries to the generation of a large number of ACpower grids, with the quick adoption of AC powersupplies, DC power grids were left behind. However, the recent power grids failure across the country, communities, and government looking for a more reliable, efficient, and sustainable solution for power needs, DC microgrid has been a solution of unresisted power supply. A microgrid is a local energy grid with control capability consisting of interconnected loads and distributed generators, which means it can disconnect from the traditional power grid and operateautonomously.

Microgrid does not define with their size associated to the power consumption, but the U.S. Department of Energy defines them as systems consisting of less than 10MVA which is the standards of load. These DC Microgrids consist of hybrid renewable energy systemsconsists different sources such as Photovoltaic (PV) system, Wind Energy system (PMSG), Fuel Cell, and the AC source are implemented as energy sources. The battery and Super Capacitor are used to store excess energy from all sources together which are connected tothe microgrid [1]. To isolate the system from a larger utility microgrid having an interconnection switch that is used to operate upstream of the grid. The operating voltage of microgrid is depend upon their applications and it must have control capabilities, protection, and monitoring system of all units.

The renewable energy sources and storing units has able to carry a partial load or full load within acceptable and frequency variations. The microgrid consists of a DC sub-system that is used to cover smaller areas, such as a small industry or single building, which may operate at low 120V voltage levels.While the other side a system covering a larger area of several miles can operate at 12kV – 70kV voltage levels commonly seen in sub-transmission and distribution systems [2]. Renewable energy sources like wind turbines (PMSG), Photovoltaics (PV) are majorly used in the design of microgrids. If the larger grid fails, a microgrid can provide backup power with the help of adiesel generator to a single building, for a small-town generating power getting from the renewable energy sources and distribute throughout [3-4].

Combining renewable energy sources is an important feature because it is decreasing the capital cost required to changeover a system into a microgrid design. Usage microgrid and hybrid renewable energy sources can be utilized and the overall cost of consumers electric bills will be decreased. The hybrid renewable sources self-generated DC power supply with the help of individual convertors and fid to a grid for fulfilling energy demand, sometimes that system-generated excessive power then it will be storedin storing units like battery and super capacitor, etc., also it can supply to the main grid when total production exceeds consumption, the excess power generated is sold back to the main grid.

Using DC microgrids the power generation is localized and minimum energy losses from transmission lines by around 6% decreasing average emissions to produce energy. Additionally, the DC microgrids can Fargo some AC/DC or DC/AC conversions which cause around a 10% efficiency loss because the sources are natively DC producing [2]. Therefore, the system can be economical as well environmentally friendly.

II. CONFIGURATION OF DC MICROGRID

A DC microgrid system uses the different renewable sources that are generating the power required by the load. The system has comprised the following elements.

1) 110V DC bus which integrates renewable sources, converters, storage components with the local loads.
2) The wind energy system consists of 1kW PMSG, which has a gearless wind rotor and generator, because of that it does not require frequentmaintenance.
3) PV module which is made up of semiconductor device (i.e. silicon) with boost converter based on the requirement.
4) 200V Battery and Super Capacitor are integrated into the DC grid via a buck-boost converter.
5) 48V DC load and Varying Single-phase load integrated to the DC grid through Inverter.

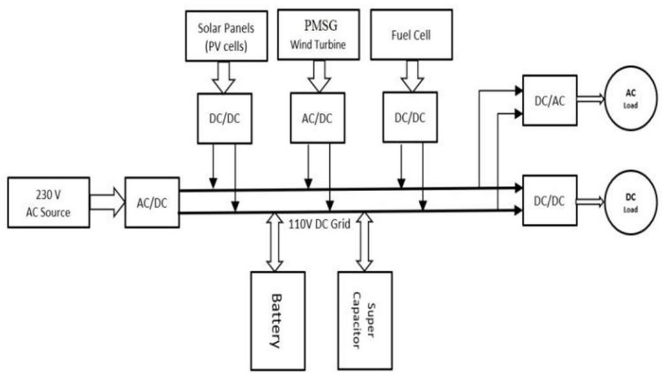


Fig. 1 Configuration of DC Microgrid

By using the DBR (Diode bridge rectifier) thesingle-phase 230V with 50Hz output voltage of the AC grid is converted to ripple DC. The rippled DC gets converted into the constant DC with the help of a buck inductor, which is fed to the DC grid from the ZETA converter where all the other modules are connected. We have two loads on the load side, one is a 48V DC load and another is a 110V 50Hz AC load integrated through the inverter. The inverter works on the simple sinusoidal PWM technique converting DC to 110V 50Hz AC output. The 48V DC load is connected to a DC-DC buck-boost converter with a switching frequency of 20 kHz and the 0.1 duty ratio [4-5].

III. MODELLING OF PROPOSED SYSTEM

The proposed system is shown in fig.1. It can be divided into three main parts as mentioned above; in this section, we explained the modeling of each source.

A. Wind Energy System (WES)

The WES comprises a wind turbine, a PMSG, a rectifier to convert AC-DC and DC-DC boost converter are connected in sequence with the grid. The generatingpower from wind turbine system is expressed as,

$$P_{WE} = \frac{1}{2} A V^3_{wind} \rho \, C_p(\theta, \lambda) \qquad (1)$$

Where, A is the swiping area of the rotor blades in m^2, V_{wind} is the wind velocity in m/s, ρ is the air density in kg/m^3 which is $1.225 kg/m^3$, C_p is the power coefficientand is a function of tip speed ratio (λ) and pitch angle (θ)*3+.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VII Jul 2023- Available at www.ijraset.com

In this system, the variable speed turbine is used. Fig.2 shows the characteristics of a wind turbine, C_p for different pitch angles at various wind speeds. A gearless permanent magnet synchronous generator (PMSG) is used for its low operation cost and low maintenance. The three-phase output power is rectifiedby using a diode bridge rectifier (DBR) and with the help of a DC-DC boost converter increases the voltage level as shown in fig. 3.

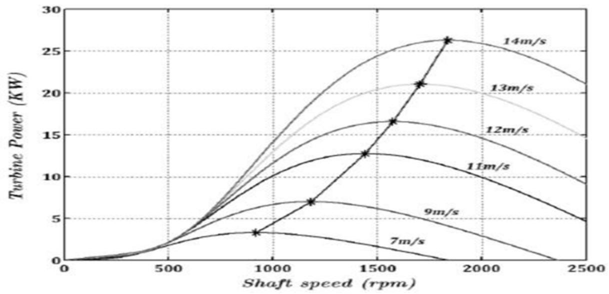


Fig. 2 Characteristics of a wind turbine at a differentspeed

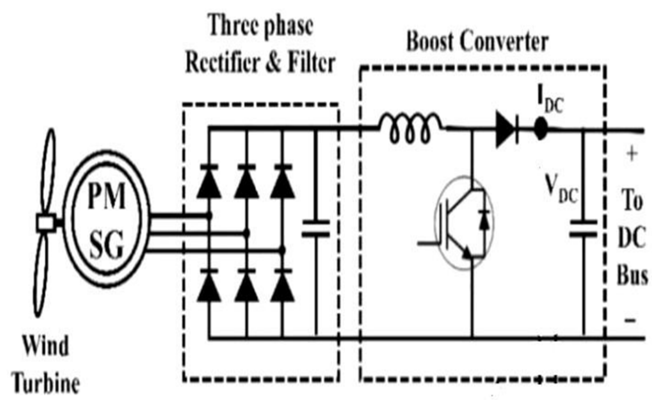


Fig. 3 Wind Energy System (WES)

B. Solar PV Panel

The first photovoltaic (PV) module was built in 1954,at Bell Laboratory. PV module is the collection of PV cells and it's made up of semiconductor devices (i.e. silicon) with a boost converter. This system uses one or more solar panels which are connected in series and parallel combinations based on the required power output. The integrated PV module has electrical connections for regulating and modifying the electrical output. When sunlight falls on it with a certain frequency, they produce free electrons due to the electromotive force.

To understand the performance of PV modules and arrays it is useful to consider the equivalent circuit, which is shown in fig.4,

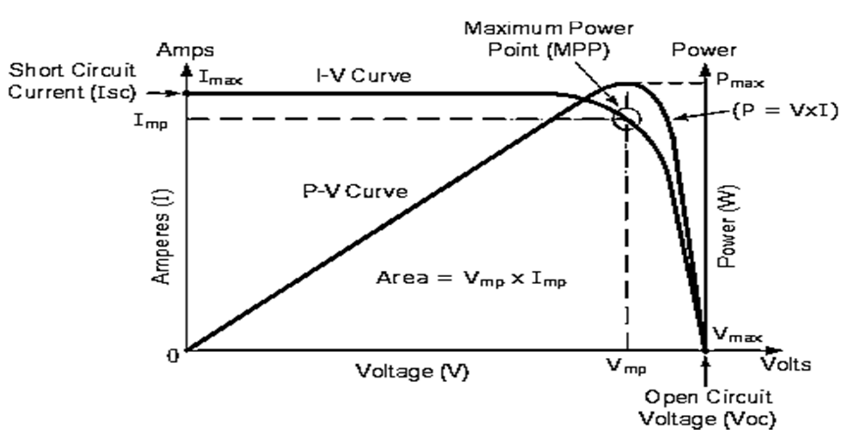


Fig. 4 Equivalent circuit of PV module

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VII Jul 2023- Available at www.ijraset.com

From the above circuit, we have the basicequations,

$$\begin{cases} I = I_{pv} - I_d - I_{sh} \text{ ....(Load Current)} \\ I_{sh} = \frac{U+IRs}{Rsh} \quad \& \quad I_d = I_0[e^{\frac{Ush}{nVT}} - 1] \end{cases}$$

$$I = I_{px} - I_0[e^{\frac{Ush}{nVT}} - 1] - \frac{U+IRs}{Rsh} \qquad (2)$$

Where I be the current through load in ampere, $I_{pv}$is the current generated by PV in ampere, I_d be the current through a diode in ampere, I_{sh} be the current through a shunt resistor, R_s be the series resistance in ohm, R_{sh} be the shunt resistance in ohm, U be the voltage applied to the load in volt, U_{sh} is the shunt voltage in volt, K be the Boltzmann's constant*7+.

Expression (2) is representing the characteristicequation of the PV cell (module).

The output voltage of the PV array is boosted by a boost converter. Generating energy from the Solar system (PV) is an auspicious and easy technology among renewable energy, and it can be used to find both output voltage and current. If the power increasesthen a voltage is increased further, if the power decreases then the voltage is reduced [6]. Equation (2) is used to draw the I-V characteristic of the PV cell and shows their I-V Characteristic Curve of PV module in fig. (5).

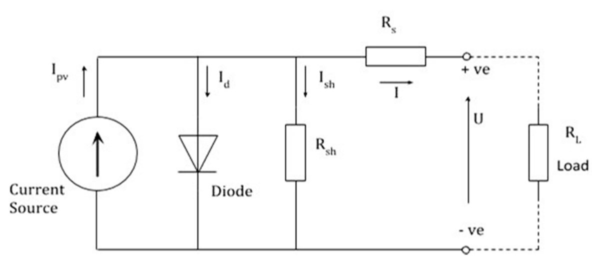


Fig. 5 I-V Characteristic Curve of PV module

C. Storage System

The Storage system consists of two units, one a rechargeable battery (Battery energy storage) and the other a super capacitor. Both are connected with a bidirectional DC-DC buck-boost converter for maintaining DC bus voltage.

1) Battery Energy Storage

Storing of generated excessive energy in batteries is themost common and useful method in the field of electrical energy storage. In a hybrid renewable energy system, the batteries are charged from chemical energy.Batteries are classified according to the materials that are made, for a long life purpose customer uses nickel-cadmium (Ni-Cd), for higher density they used sodium-sulfur (Na-S), lead-acid batteries easily available at the cheapest cost, lithium (Li-ion) batteries are the most widely used by the costumers [8]. The capacity of the battery can depend on the size and massof the electrolyte; each battery has a different energy rating based on the capacity.

Fig. (6) Shows the workingof rechargeable batteries.

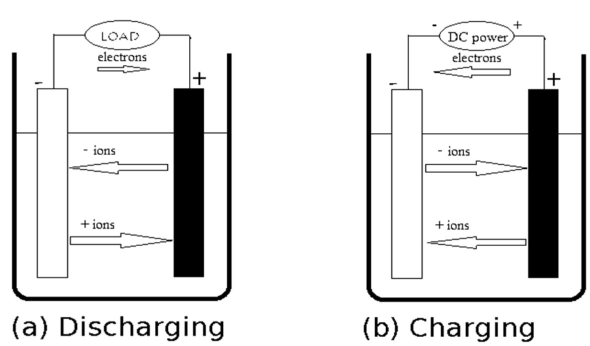


Fig. 6 Working of rechargeable batteries

2) Super Capacitors

A super capacitor is a work on the principle of storing electrical energy, it is the most modernized technology to serve electrical energy storage. A super capacitor is preferred in the place of batteries because they have a quick and simple charging method and can deliver quality power at a faster rate. They have a long life span, reliable and efficient, do not require much maintenance, and do get affected by wear and tear [9-10]. Super capacitors can deliver high load current without any inconvenience because they have a low value of resistance and hence it prohibits from overheating. Fig. (7) shows the structure of the super capacitor.

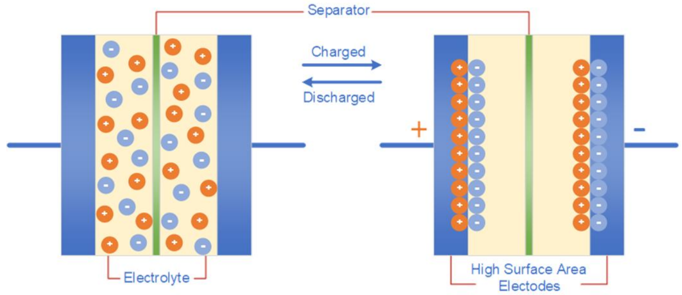


Fig.7 Structure of Super capacitor

Table 1. represent the ambient temperature of somematerials for values of relative permittivity.

Materials	εr
Bakelite	5.1
Nylon	2.2
Soft Glass	6-7
Teflon	2.6
High permeability oxides	(10-15) e^3
Distilled water	80

IV. SIMULATION RESULT

The working simulation diagram of the hybrid renewable system is shown in the fig. (8) this model consists of PVA, wind farm, loads, and AC source with buck and Zeta converter and storage units is designed in MATLAB Simulink environment. After total analysis of this hybrid system, it's clear that the voltage rating of DC bus has 110V from all the renewable sources and it remains constant at whole simulation time, fig. (9) shows the bus voltage.

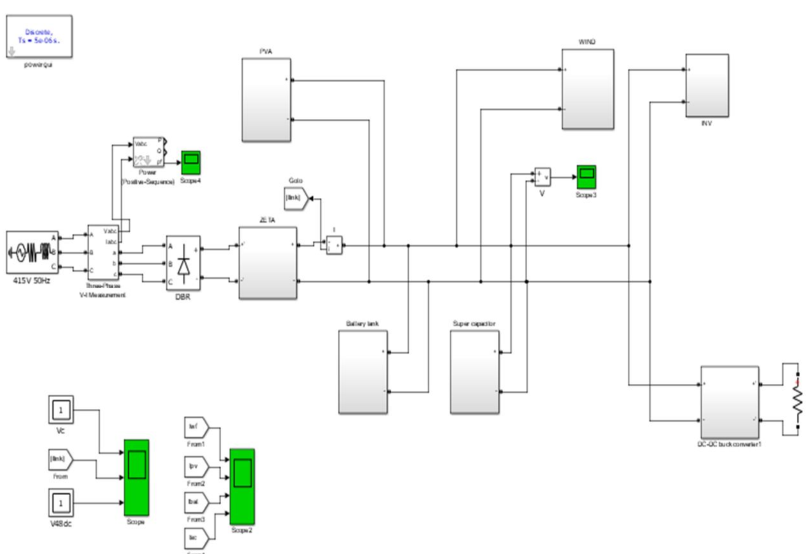


Fig.8 Simulation diagram of the proposed system

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VII Jul 2023- Available at www.ijraset.com

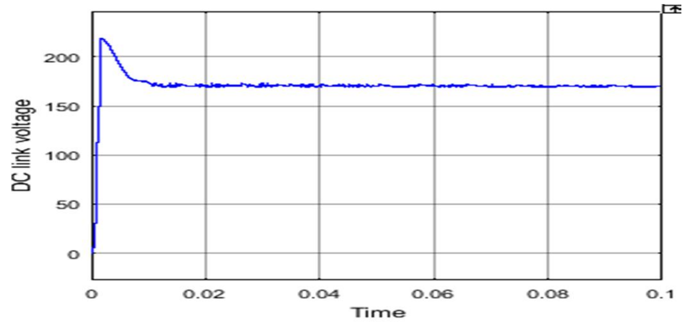


Fig. 9 DC bus voltage

From the graph, the DC bus has 110V and at the load side, we have variable single-phase AC voltage throughthe inverter circuit and 48V DC load which are shown in fig. (10) and Fig. (11).

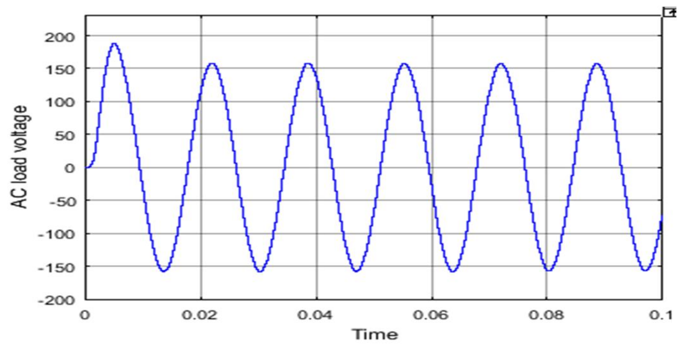


Fig. 10 Output voltage for AC load

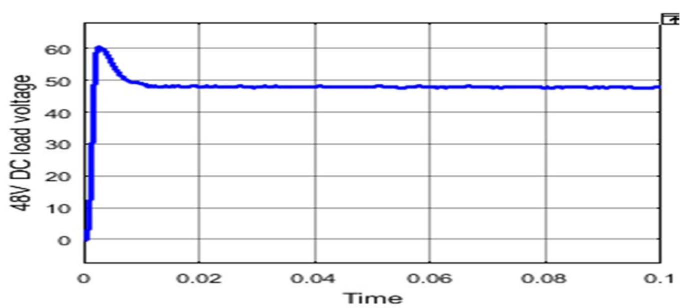


Fig. 11 48V DC load voltage

The above figures show the modeling of hybridmicrogrid with renewable energy sources are reliable, power-efficient, economic, and low maintenancesystems. Some results of the simulation are described asfollows.

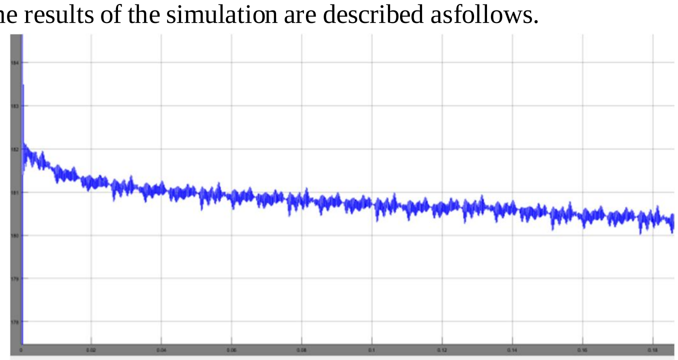


Fig. 12 DC link voltage at Buck converter

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VII Jul 2023- Available at www.ijraset.com

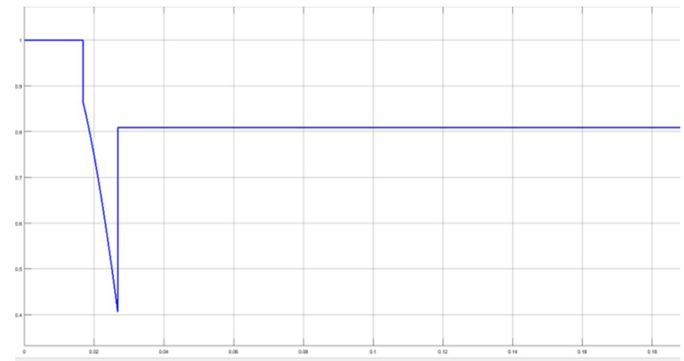


Fig. 13 Power factor of three-phase source with buck converter

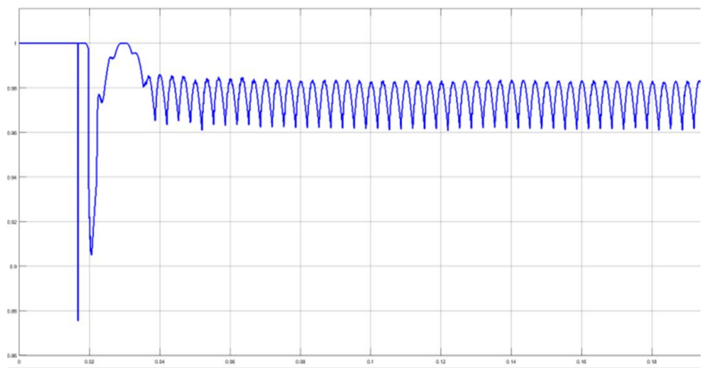


Fig. 14 Power factor of three-phase source with Zeta converter

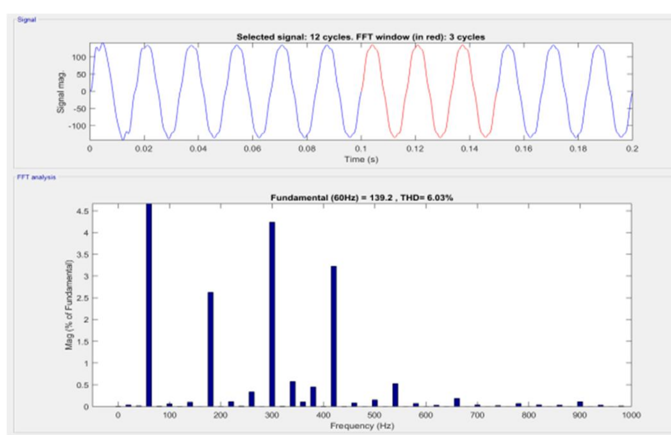


Fig. 15 Total Harmonic Distortion of AC load

V. CONCLUSION

In this paper, a hybrid renewable energy based microgrid system is developed, analysed, and investigated. In that, we study the behaviour of the gridconnected hybrid system with two different loads are connected to them. Using zeta converter ripples are lessin DC link, improved power factor 0.8 -0.96, and reducing harmonics in the voltage waveform. This system utilizes an alternating off-grid power transmission system with economic parameters. Various techniques and modeling of storage devices were presented. The simulation result shows that the system has desirable, can maintain better quality power, cost efficient to the customers and utilities easily in all domains.

A. Conflict of Interest Statement

Authors declare that they do not have any conflict ofinterest.

REFERENCES

[1] Gajraj Singh Rawat, Sathans, “Modelling and Performance Analysis of Renewable Sources under Islanded DC Microgrid” International Conference on Inventive Research in Computing Applications (ICIRCA 2018): CFP18N67-ART; ISBN:978-1-5386-2456-2

[2] P. Satish Kumar, R.P.S. Chandrasena, V. Ramu, G.N. Sreenivas and K. Victor Sam Moses Babu, “Energy Management System for Small Scale Hybrid Wind Solar Battery Based Microgrid” Digital Object Identifier 10.1109/ACCESS.2020.2964052

[3] Ahmed Samawi Alkafaji, Hafedh Trabelsi, “Hybrid Energy Storage Review for Renewable Energy System Technologies and Applications” 2021 18th International Multi-Conference on Systems, Signals & Devices, 978-0-7381-4392-7/21/$31.00

[4] Mojtaba Abbasi, Alexander G. Garganeev, “Hybrid Microgrid in Islanded Operation Based on Renewable Energy Sources” 19th International Conference on Micro / Nanotechnologies and Electron Devices Edm, 978-1-5386-5021-9/18/$31.00 ©2018

[5] Vallem V. V. S. N. Murty and Ashwani Kumar, “Optimal Energy Management and Techno-economic Analysis in Microgrid with Hybrid Renewable Energy Sources” JOURNAL OF MODERN POWER SYSTEMS AND CLEAN ENERGY, VOL. 8, NO. 5, September 2020

[6] Ashutosh Barua, Arvind Kumar Jain, Manish Gupta, “Control and Techno-Economic Analysis of PVDiesel-Battery based Hybrid Microgrid System” 2017 Conference on Information andCommunication Technology (CICT'17)978-1-5386-1866-0/17/$31.00 ©2017

[7] ianfang Xiao, Tianyang Zhao, Koh Leong Hai, “Smart energy hub-Modularized Hybrid AC/DC Microgrid system design and Deployment” International Journal of Precision Engineering andManufacturing-Green Technology Vol. 1, No. 2, Pp. 157-173 April 2014 / 157.

[8] ErsanKabalci, HilalIrgan, Yasin Kabalci, "Hybrid Microgrid System Design with Renewable Energy Sources" Institute of Electronics and Electrical Engineers,978-1-5386-4198-9/18/ 2018.

[9] Gabriel Veilleux, TanaiPotisat, Daniel Pezim, Christian Ribback,Jarmo Ling, Adam Krysztofinski, Afaq Ahmed, Jessica Papenheim, Astrid Mon Pineda, Siva Sembian, SasiniphaChucherd, "Techno-economic analysis of microgrid projects for rural electrification: A systematic approach to the redesign of Koh Jikoffgrid case study", International EnergyInitiative, pp. 0973-0826/september 2019.

[10] Binayak Bhandari1, Shiva Raj Poudel1, Kyung-Tae Lee1, and Sung-Hoon Ahn1,2, "Mathematical Modeling of Hybrid Renewable Energy System: A Review on Small Hydro-Solar-Wind Power Generation" International Journal of Precision Engineering and Manufacturing-Green Technology Vol. 1, No. 2, Pp. 157-173 April 2014 / 157.

[11] Salman Hajiaghasi, Ahmad Salemnia, Mohsen Hamzeh "Hybrid energy storage system for microgrids applications," IEE Proceedings- Journal of Energy Storage, Volume 21, February 2019, pp. 543-570.

[12] Swati Negi and Lini Mathew, "Hybrid Renewable Energy System," International Journal of Electronic and Electrical Engineering. ISSN 0974-2174, Volume 7, Number 5 (2018), pp. 535-542.

[13] I. Çolak, E. Kabalcı, G. Bal, "Parallel DC -AC conversion system based on separate solar farms with MPPT control", 4th International Conference on Power Engineering, Energy andElectrical Drives, pp. 1071 -1075, May 13 -17, 2013, Istanbul, Turkey.

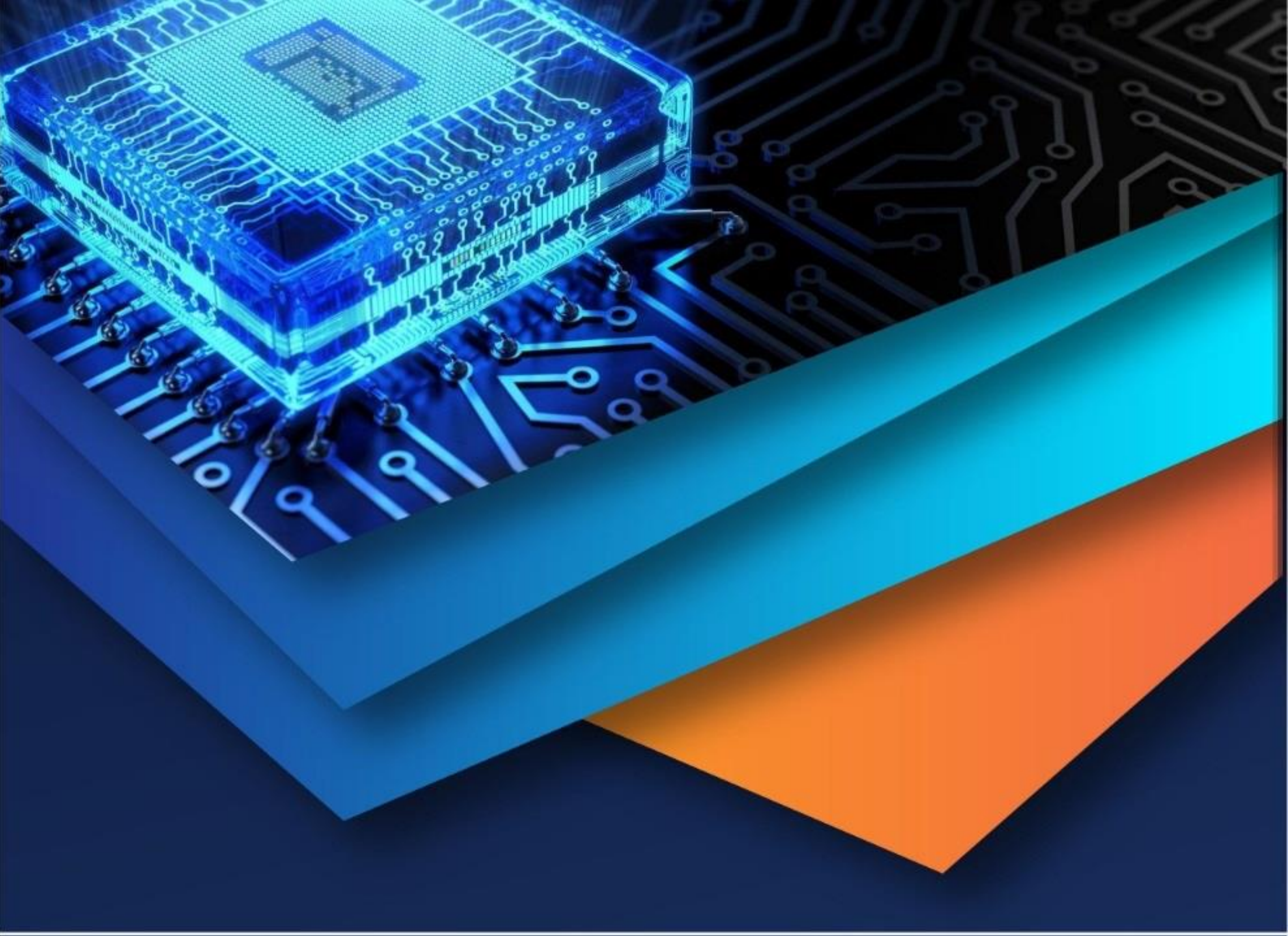
[14] E. Kabalcı, A. Görgün, Y. Kabalcı, "Design and Implementation of a Renewable Energy Monitoring System", IEEE 8th International Conference on Power Electronics, pp. 1469 - 1475, May 30 -June 3 2011, Jeju Korea.

[15] E. Kabalcı, F. Batta, O. Battal, "Modelling of a Hybrid RenewableEnergy Conversion System", 3rd International Conference on Nuclear and Renewable Energy Resources (NURER 2012), pp. 1-6, May 20 -23, 2012, Istanbul, Turkey.

[16] M.H. Nehrir, C. Wang, K. Strunz, H. Aki, R. Ramakumar, J. Bing, Z. Miao, Z. Salameh, "A review of hybrid renewable/alternative energy systems for electric power generation: configurations, control, and applications", IEEE Transactions on Sustainable Energy, vol.2, no.4, pp.392 -403, Oct. 2011.

[17] E. Kabalci, R. Bay indir, E. Hossain," Hybrid Microgrid Testbed Involving Wind/Solar/Fuel Cell Plants", 3rd International Conference on Renewable Energy Research and Applications, p.880 -885, 19 -22 Oct 2014, Milwakuee, USA.

[18] E. Kabalci, R. Bay indir, E. Hossain, "Microgrid test -bed design with renewable energy sources", Power Electronics and Motion Control Conference and Exposition (PEMC), 21 -24 Sept. 2014, Antalya, Turkey.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY