IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 7, April 2023

Simulation of Two-Stage Solar Grid Connected PV System

Unnati N. Chacharkar[1], Samiksha H. Yadav[2], Amey V. Dongre[3], Nidhi P. Rokde[4]
Tanvi R. Gaikwad[5], Mayank Mishra[6], Prof. Prasad Joshi[7]
Students, Bachelor of Electrical Engineering[1,2,3,4,5,6]
Guide, Bachelor of Electrical Engineering[7]
Yeshwantrao Chavan College of Engineering, Nagpur, Maharashtra, India
An Autonomous Institution Affiliated to Rashtrasant Tukdoji Maharaj Nagpur University, Nagpur, Maharashtra, India

Abstract: *The project concerns with the study of generation of electricity along with low-cost waste water treatment from Dual Chamber Microbial Fuel Cell (MFC). This study attempts to evaluate the performance of a double chamber MFC by manipulating the waste water, electrode thickness, the distance etc in order to attain the maximum power output along with waste water treatment. Today we are witnessing a global energy crisis due to huge energy demands and limited resources. Non-renewable energy sources are depleting and renewable energy sources are not properly utilized. There is an immediate need for search of alternate routes for energy generation. Microbial fuel cell (MFC) technology, which uses microorganisms to transform chemical energy of organic compounds into electricity, is considered as a promising alternative for simultaneous treatment of wastewater along with energy production. Extensive studies have corroborated new insights into MFC, which show that a wide array of carbon sources including wastes can be employed using a variety of microbes. Consequently, microbial transformation of wastes using novel bioremediation strategies such as MFC for energy generation is considered as an efficient and environmentally benign Approach.*

Keywords: Microbial fuel cell (MFC), Electricity, Technology, Waste, Pollutant, Waste- to- energy

I. INTRODUCTION

Renewable energy sources have become increasingly popular due to their environmental benefits and cost-effectiveness. Solar energy, in particular, has gained widespread adoption in residential and commercial settings. A Two-Stage Solar Grid Connected PV System is a type of solar power system that combines both grid-tied and off-grid functionality, providing users with the stability of a grid connection while also having backup power in case of a grid outage.

The Two-Stage Solar Grid Connected PV System consists of a solar panel, a boost converter, a battery bank, an inverter, and the utility grid. The solar panel converts sunlight into electricity, which is then fed through a boost converter to increase the voltage and stored in a battery bank. The inverter then converts the DC power from the battery bank into AC power that can be used to power household appliances. The utility grid is used as backup power in case of low solar panel output or high household energy demand, and excess power generated by the solar panel can be fed back into the grid through a net metering arrangement.

Simulation models are often used to test and optimize the performance of Two-Stage Solar Grid Connected PV Systems. These models can be used to determine the system's capacity, energy output, and efficiency. Through simulations, users can gain valuable insights into the system's behavior under various conditions and make informed decisions on system design and operation.

II. LITERATURE REVIEW

This Chapter reviews the various literature survey done on Microbial Fuel Cells. This Chapter also discussed the work done by other researcher in the field of Microbial Fuel Cells.

The use of solar photovoltaic (PV) systems has gained popularity over the years due to their ability to generate clean and renewable energy. In recent times, the use of two-stage solar grid-connected PV systems has been proposed as a means of improving the efficiency and reliability of PV systems. In this literature review, we will explore the concept of two-stage solar grid-connected PV systems and highlight some of the relevant studies in this area.

Two-stage solar grid-connected PV systems consist of two DC-DC converters, which are used to maximize the power generated by the PV system and to improve the voltage stability of the system. The first stage converter is a Maximum Power Point Tracking (MPPT) converter, which is used to track the maximum power point of the PV array. The second stage converter is a DC-DC boost converter, which is used to boost the voltage of the DC power generated by the PV array to match the grid voltage.

In a study conducted by V. C. Pandian et al. (2015), a two-stage grid-connected PV system was developed and tested in a laboratory. The system consisted of a 1 kWp PV array, a MPPT converter, a DC-DC boost converter, and an inverter. The results of the study showed that the system was able to efficiently generate and supply power to the grid, with a maximum efficiency of 96.2%.

Another study by G. L. P. Melo et al. (2017) proposed a two-stage PV system with an additional AC-DC converter, which was used to improve the power quality of the system. The proposed system was tested under different operating conditions and the results showed that the system was able to improve the power factor and reduce the total harmonic distortion (THD) of the output current.

In a more recent study, M. Kumar et al. (2021) proposed a two-stage PV system with an adaptive fuzzy controller. The controller was used to improve the tracking efficiency of the MPPT converter and to regulate the output voltage of the DC-DC converter. The proposed system was tested under different operating conditions and the results showed that the system was able to efficiently generate and supply power to the grid, with a maximum efficiency of 99.7%.

In conclusion, two-stage solar grid-connected PV systems have been shown to improve the efficiency and reliability of PV systems. The use of MPPT converters and DC-DC boost converters can maximize the power generated by the PV array and improve the voltage stability of the system. The addition of AC-DC converters and adaptive fuzzy controllers can further improve the power quality and tracking efficiency of the system.

III. METHODOLOGY

The simulation of a two-stage solar grid-connected PV system involves the use of software tools such as MATLAB/Simulink, and PSCAD to model the system and evaluate its performance. The following is a general methodology that can be followed for this purpose:

- System Description: Define the specifications of the solar grid-connected PV system, including the ratings of the PV modules, inverter, transformer, and other components. Also, determine the location and solar irradiance data for the site.
- PV Module Modeling: Develop a mathematical model of the PV module using the single-diode model, which considers the effects of temperature and irradiance on the PV module output. Use the manufacturer's data sheet to obtain the necessary parameters for the model.
- Inverter Modeling: Develop a mathematical model of the inverter, which includes the DC-AC conversion, maximum power point tracking (MPPT), and control algorithms. Use the manufacturer's data sheet to obtain the necessary parameters for the model.
- System Integration: Integrate the PV module and inverter models into the system model. Define the control strategy for the system, including the MPPT algorithm and power quality control.
- Simulation: Simulate the system under different scenarios, including varying solar irradiance, temperature, and load conditions. Evaluate the system performance in terms of power output, efficiency, and voltage and current waveforms.
- Optimization: Optimize the system parameters, such as the sizing of the PV array, inverter rating, and transformer rating, to improve system performance and reduce the cost.
- Results Analysis: Analyze the simulation results to determine the system's overall performance, identify potential problems, and propose solutions.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 7, April 2023

- By following this methodology, you can simulate and evaluate the performance of a two-stage solar grid-connected PV system and optimize its design to achieve the desired performance and cost- effectiveness.
- A grid-connected photovoltaic system or grid-connected PV system is electricity generating solar PV power system that is connected to the utility grid. A grid-connected PV system consists of solar panels, one or several inverters, a power conditioning unit and grid connection equipment.
- As the solar panel often provides low level dc voltage in PV systems.
- The first stage is typically a dc-dc converter for amplifying voltage and extracting electrical energy from the PV array.
- The second stage is a dc-ac inverter for delivering electrical energy to the utility grid.

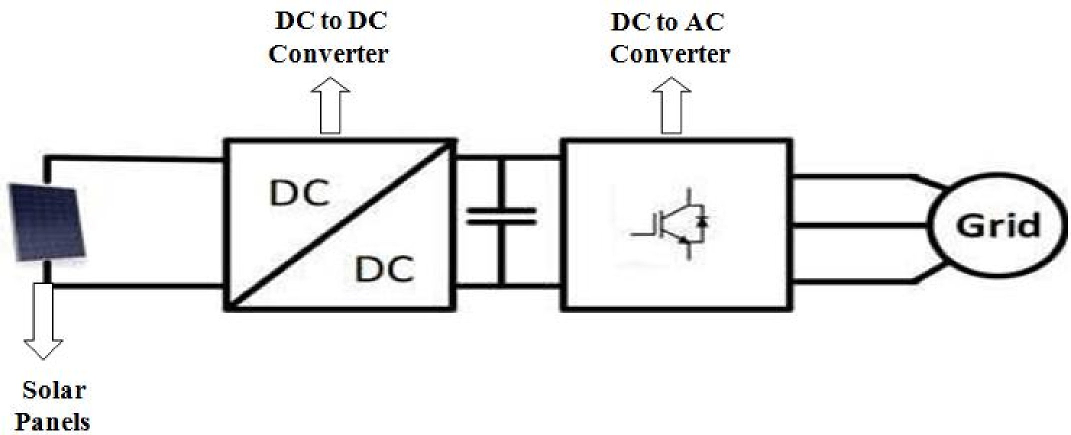


Fig.1: Two stage solar grid connected PV system

Maximum Power Point Tracking

- The efficiency of a solar cell is very low.
- In order to increase the efficiency, methods are to be undertaken to match the source and load properly.
- One such method is the Maximum Power Point Tracking (MPPT).
- This is a technique used to obtain the maximum possible power from a varying source
- In photovoltaic systems the I-V curve is non-linear, thereby making it difficult to be used to power a certain load. This is done by utilizing a boost converter whose duty cycle is varied by using a MPPT algorithm.
- Over the past decades many methods to find the MPP have been developed and published. These techniques differ in many aspects such as required sensors, complexity, cost, range of effectiveness, convergence speed, correct tracking when irradiation and/or temperature change, hardware needed for the implementation.
- There are many methods used for maximum power point tracking a few are listed below:

1. Perturb & Observe (P&O) method
2. Incremental Conductance method
3. Beta Method
4. Constant Voltage method
5. Constant Current method
6. Hill climbing

Work Done

The topic of a two-stage solar grid-connected PV system is a complex and interdisciplinary area of research that requires a wide range of skills and expertise. Overall, the work done in the area of a two-stage solar grid-connected PV system is extensive and involves a range of disciplines, including electrical engineering, control systems, optimization, and economics. This research is crucial for the development of efficient, cost-effective, and sustainable solar power systems that can contribute to the transition to renewable energy

DOI: 10.48175/568

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 7, April 2023

Perturb and Observe Method

- Perturb & Observe (P&O) method is the simplest method.
- It has only one sensor that is the voltage sensor, used to sense the PV array voltage.
- The cost of implementation of voltage sensor is less and hence easy to implement.
- The time complexity of this algorithm is very less but on reaching very close to the maximum power it doesn't stop at the MPP and keeps on perturbing on both the directions

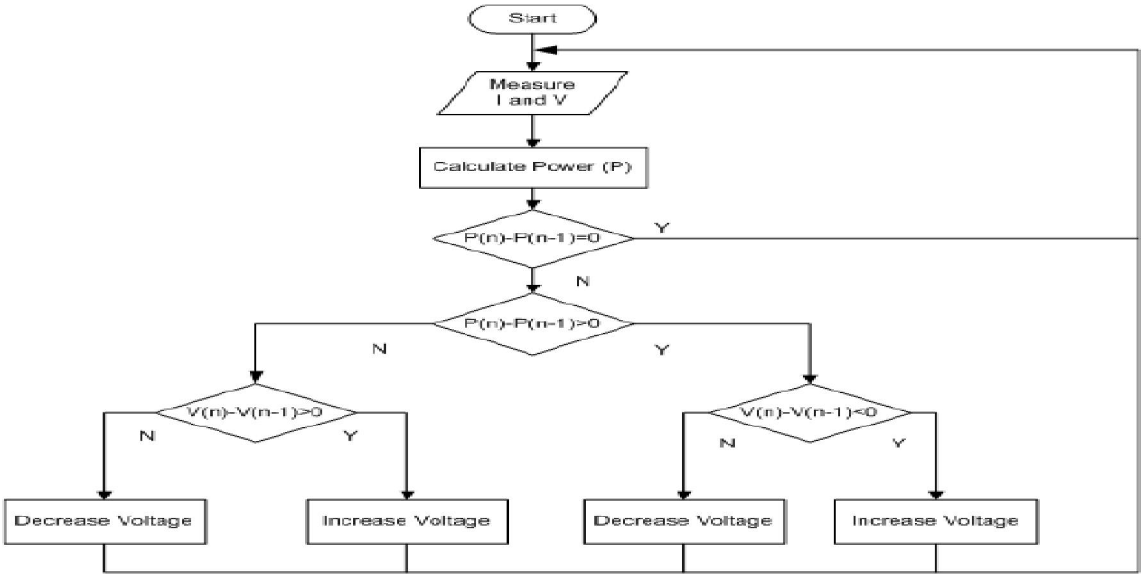
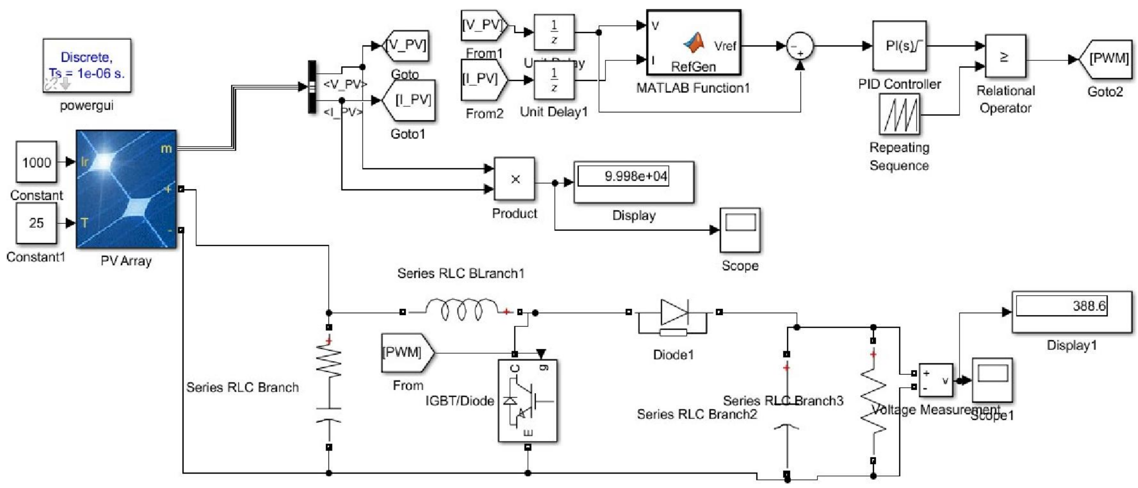
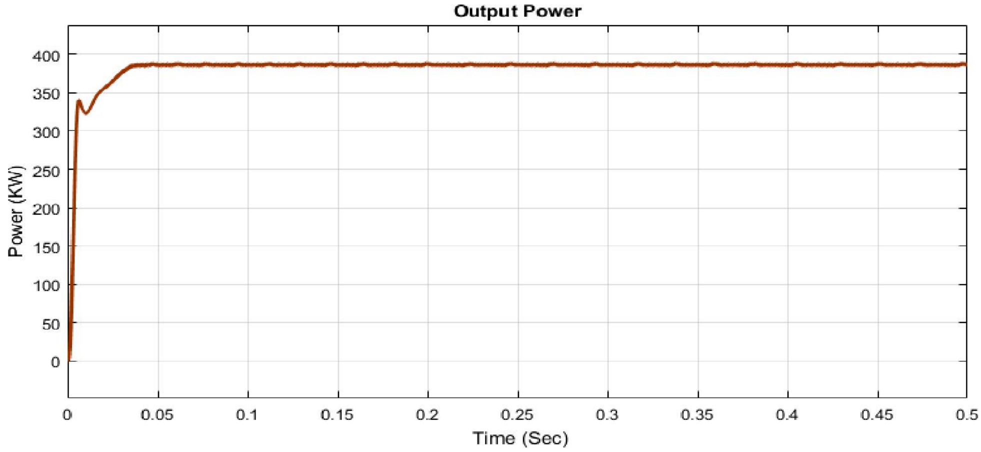


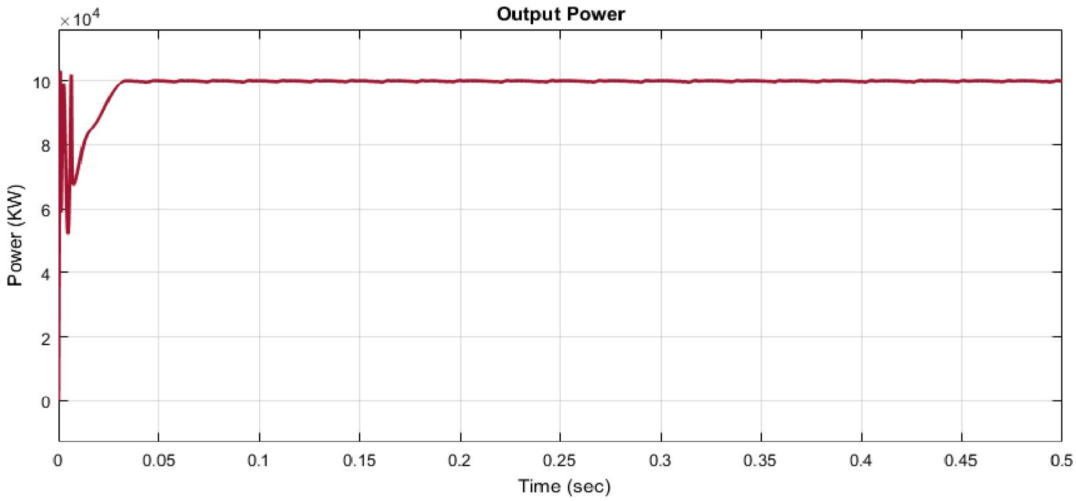
Fig.2:- Flowchart of P & O Algorithm



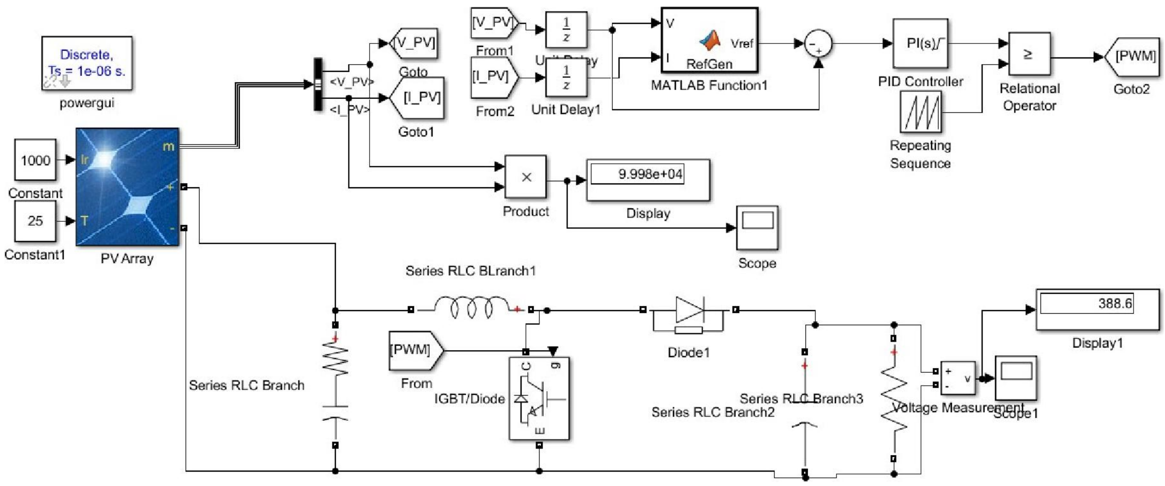
Simulation.1:- MATLAB Simulation Diagram @1000w/m2solar Irradiance

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 7, April 2023





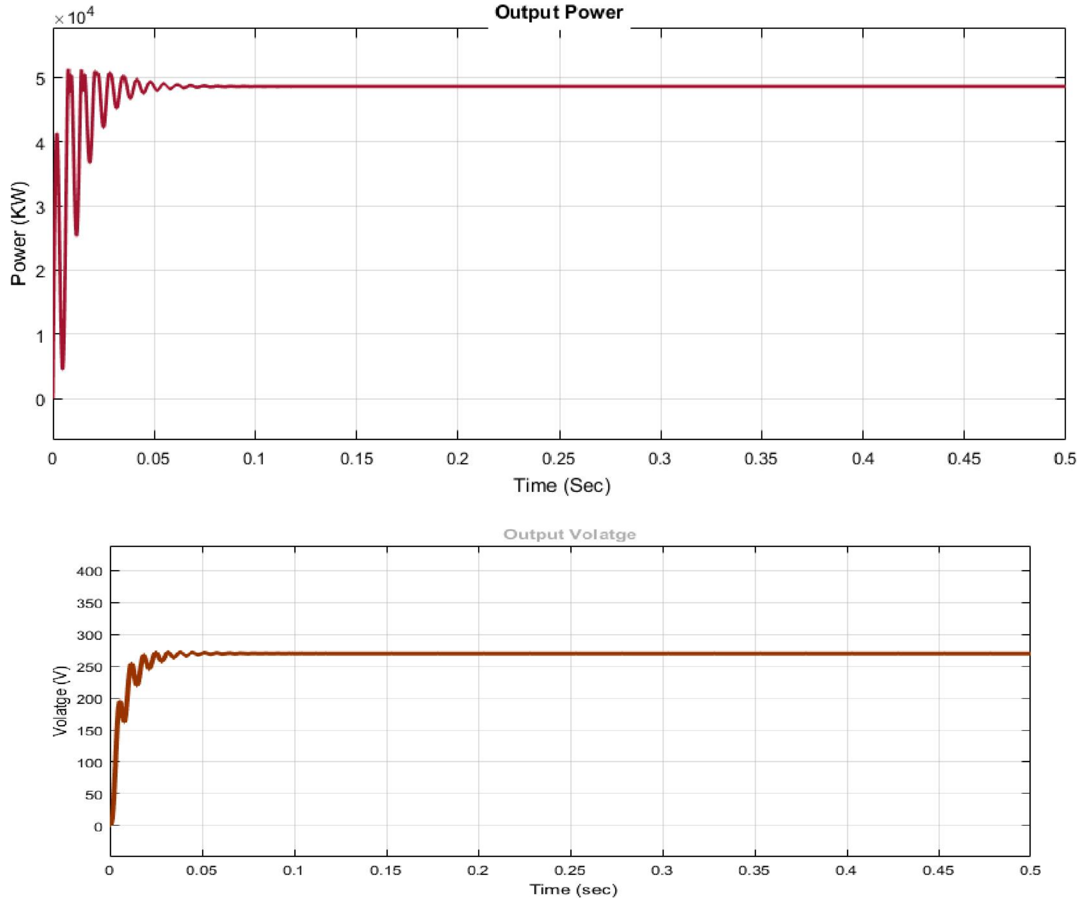
Graph.1:- Simulation Result @1000w/m2 Solar Irradiance



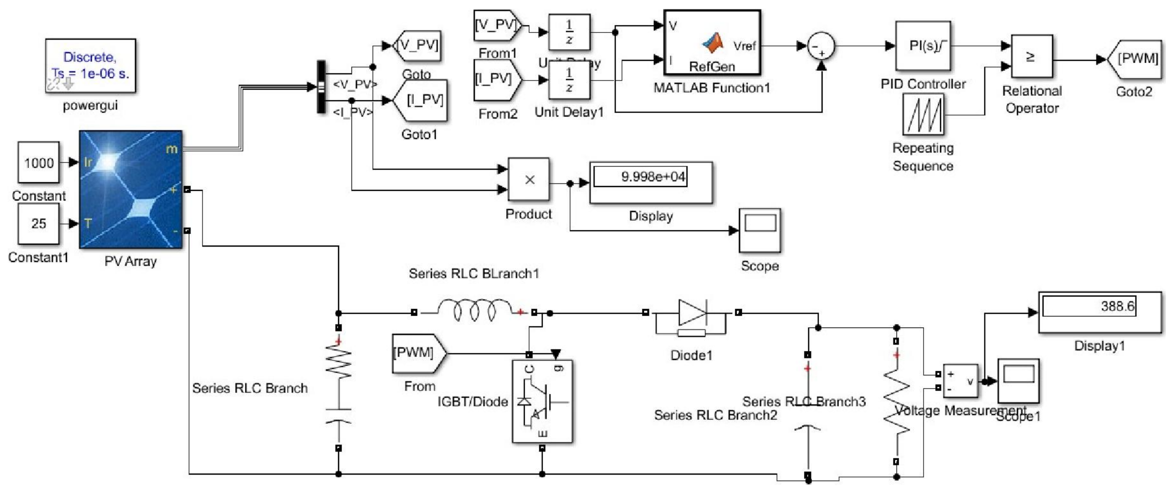
Simulation.2:- MATLAB Simulation Diagram @500w/m2solar Irradiance

DOI: 10.48175/568

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 7, April 2023

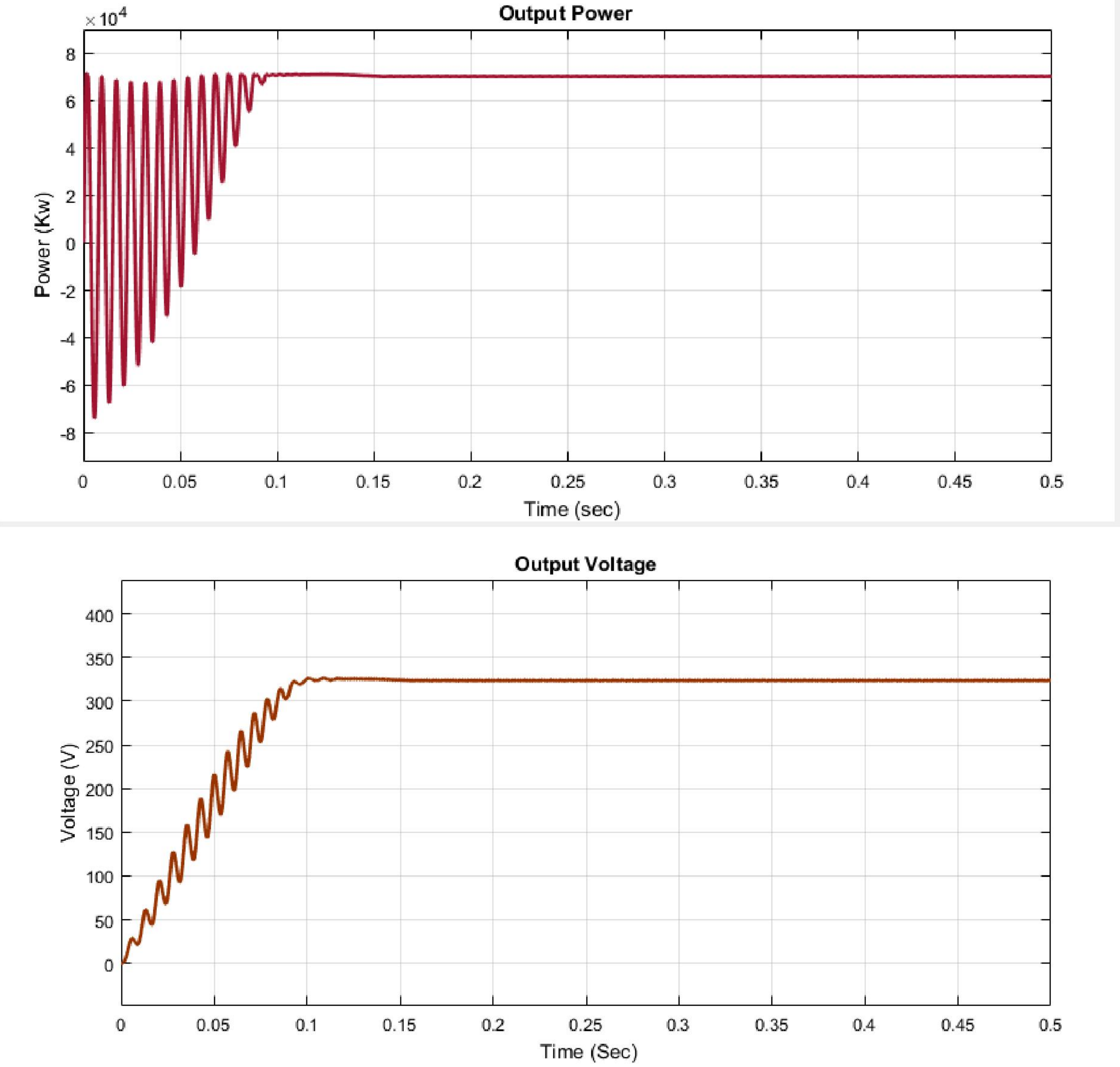


Graph.2:- Simulation Result @500w/m2 Solar Irradiance



Simulation.3:- MATLAB Simulation Diagram @700w/m2solar Irradiance

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 7, April 2023



Graph.3:- Simulation Result @700w/m2 Solar Irradiance

IV. CONCLUSION

In this study we have analyzed the performance of a double chamber MFC by varying the types of electrolytes, the electrode thickness and electrode distance. The output of these systems (electric current and electric power) is still some way less as compared to the large-scale applications. More technological advancements in terms of material, costs and substrates being used are necessary to bring these systems at a level where they can be commercially exploited.

MFC's are a promising technology for renewable energy production; they face several challenges such as low levels of power density, high cost of component materials, and large internal resistance. Microbial fuel cell can generate electricity no matter how small, shows that microbial fuel cell could help in reducing the damage to our environment and household appliances. The double chamber MFC tested also produced the highest electricity when it was run using fertilizer water in comparison to soil water and lake water. This showed that the rich content of fertilizer water is influential to the performance of the double chamber MFC. In recent years, many studies have been conducted to explore microbial fuel cells in many aspects, such as electron transfer mechanisms, enhancing power outputs, reactor developments and applications.

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.301

Volume 3, Issue 7, April 2023

Although MFC's are a promising technology for renewable energy production, they face several challenges such as low levels of power density, high cost of component materials, and large internal resistance. Microbial fuel cell could help in reducing the damage to our environment and household appliances.

With the help of this result we can proof that by changing duty ratio we get the power output for system. Since due to the variation in power of solar input, there are number of losses formed in output, so by stabilizing the output power we can reduce the number of losses.

Solar irradiance w/m^2	Power (Kw)	Voltage (V) Duty
1000 w/m^2	9.978	388.6
500 w/m^2	4.85	299.7
700 w/m^2	7.02	324.9

V. FUTURE SCOPE

1. Development of fuel cells that can use hydrogen, methanol or ethanol to power portable applications.
2. If the development of MFCs leads to a product that has a reasonable (read- usable) power output per unit of MFC volume, it will be a viable product. Customer will accept a larger battery and a larger feeding tank, provided the feeding is easy to perform and has a green and safe label. 3) In the future, the amount of low power devices implanted in the human body will significantly expand. These devices (Body Fluid batteries) need long term, stable power provision. To provide this power, a MFC can be used.
3. In future the other potential ways to use MFC are in areas like desalination, pollution remediation, remote sensing and hydrogen production. The process of removing salt i.e., desalination from sea and brackish water which needs a lot of external power to be supplied, an MFC can be used for desalination without the supply of external power.
4. The cost of materials employed for the construction of MFC is also a key factor for the successful application of the technology at large scales. Hence developing a cost- effective procedure which is environmentally sound and sustainable due to utilization of wastewater as substrate is the need of the moment.
5. The various substrates that have been used in MFCs for current production and waste treatment are numerous but there is also scope of production or utilization of newer substrates along with improved outputs both in terms of power generation as well as waste treatment. Substrates being used in both MFCs have grown in complexity and strength. Several new substrates can be used under the MFC set ups such as the wastewaters from molasses-based distilleries rich in organic matter and produced in large volumes, wastewater from large number of pharmaceutical industries with recalcitrant pollutants, waste plant biomass (agriculture residue) which is burnt at this moment, etc.
6. We still face many problems concerning the efficiency and installation costs. Mainly, these costs are related to the proton exchange membrane production, since it's highly used NAFION as a PEM. In some new researches, it was possible to see new membranes being developed with better properties and less cost per energy generated. But still, the efficiency isn't great yet and still it isn't viable to do large scale production.
7. MFC can be scaled-up to produce more power; it can also be categorized as a safe waste disposal technology where multiple problems are solved simultaneously. It can also be used as a biosensor (medical device) for detecting certain biological molecule.
8. While low current density and long-time of operation is its biggest drawbacks. Many scientists are working on suitable
9. MFC design to increase the current density. It's been believed that MFC will be one of the main sources of electricity generation and wastewater treatment technology in future.
10. Another development in the field of utilizing microbial fuel cells is that we can think of power our house with sewage or can charge our pacemaker with household sewage rather than using conventional source of energy as it is not only eco-friendly but also can increase GDP or gross domestic production of a nation. As the whole world is depended on conventional source of energy this field is emerging to be a reusable, nonconventional and renewable and bio friendly source of energy

11. While low current density and long-time of operation is its biggest drawbacks. Many scientists are working on suitable
12. MFC design to increase the current density. It's been believed that MFC will be one of the main sources of electricity generation and wastewater treatment technology in future.
13. Another development in the field of utilizing microbial fuel cells is that we can think of power our house with sewage or can charge our pacemaker with household sewage rather than using conventional source of energy as it is not only eco-friendly but also can increase GDP or gross domestic production of a nation. As the whole world is depended on conventional source of energy this field is emerging to be a reusable, nonconventional and renewable and bio friendly source of energy.

Societal Relevance

The simulation of a two-stage solar grid-connected PV system has significant societal relevance, as it can provide clean and renewable energy to households, businesses, and communities.

1. Firstly, such a system can help reduce dependence on traditional fossil fuels, which are major contributors to air pollution and climate change. By using solar energy, which is clean and renewable, the system can significantly reduce the carbon footprint of the community, leading to a cleaner and healthier environment.
2. Secondly, the two-stage solar grid-connected PV system can also help increase energy independence and security. With the ability to generate electricity locally, communities can reduce their reliance on centralized power grids, which are vulnerable to outages and disruptions. In the event of a natural disaster or other emergency, the system can continue to provide power to critical infrastructure, such as hospitals and emergency response centers.
3. Thirdly, the use of solar energy can also help create local jobs and stimulate economic growth. The installation and maintenance of the system require skilled labor, which can create employment opportunities for local communities. Moreover, the cost savings resulting from the use of solar energy can be reinvested into the local economy, leading to increased economic activity and development.

Overall, the simulation of a two-stage solar grid-connected PV system has significant societal relevance, as it can help reduce carbon emissions, increase energy independence and security, and stimulate economic growth. By promoting the adoption of clean and renewable energy sources, we can create a sustainable future for ourselves and future generation.

REFERENCES

[1]. Mostafa Rahimnejad, Arash Adhami, Soheil Darvari, Alireza Zirepour, Sang-Eun Oh.

[2]. "Microbial fuel cell as new technology for bioelectricity generation", Alexandria Engineering Journal 54 (3), 745-756, 2015.

[3]. He Z, Minteer SD, Angenent LT. "Electricity generation from artificial wastewater using an upflow microbial fuel cell." Environmental science & technology 39 (14), 5262-5267, 2005.

[4]. Amit Prem Khare, Dr. Hemlata Bundela, "Applicability of Single Chamber Microbial Fuel Cell for the Electricity Generation Using Waste Water obtained from Biscuit

[5]. Factory and Potato Processing Factory", International Journal of Engineering Sciences & Research Technology, 2014.

[6]. Deepak Pant, Gilbert Van Bogaert, Ludo Diels, Karolien Vanbroekhoven. "The substrates used in microbial fuel cells (MFCs) for sustainable energy production", Bioresource technology 101 (6), 1533-1543, 2010.

[7]. Raoo, J. R.; Richter, G. J.; Von Sturm, F.; Weidlich, E. "The performance of glucose electrodes and the characteristics of different biofuel cell constructions". International Symposium on Bioelectrochemistry. Jülich, 27–31 October 1975

[8]. Min, B.; Logan, B. E. "Continuous electricity generation from domestic wastewater and organic substrates in a flat plate microbial fuel cell." Environ. Sci. Technol, 2004.

[9]. S. Cheng and E. B. Logan. "Ammonia treatment of carbon cloth anodes to enhance power generation of microbial fuel cells", Electrochemistry Communications, Volume 9, Issue 3, March 2007.

[10]. Marzieh Aghababaie, Mehrdad Farhadian, Azam Jeihanipour &David Biria, "Effective factors on the performance of microbial fuel cells in wastewater treatment – a review", Environmental Technology Reviews Volume 4, 2015.

[11]. Surajit Das and Neelaam Mangani, “Recent developments in microbial fuel cells: a review”, Publisher NISCAIR-CSIR, appears in collections JSIR Volume 69(10) (Oct2010).

[12]. D.H. Park and J.G. Zeikus, "Electricity generation in microbial fuel cells using neutral red as an electronophore", Applied and Environmental Microbiology, vol. 66, pp. 12921297, (17 December, 2000).

[13]. Liu, H., Cheng, S.A., Logan, B.E “Production of electricity from acetate or butyrate using a single-chamber microbial fuel cell, Environmental Science Technology” (2005) 39,658–662, (December 3, 2004).

[14]. Z. Du, H. Li and T. Gu, "A state of the art review on microbial fuel cells: A promising technology for wastewater treatment and bioenergy", Biotechnol. Adv., vol. 25, pp. 464482, (May 23-2007).

[15]. Santoro C, Arbizzani C, Erable B, Ieropoulos I " Microbial fuel cells: from fundamentals to applications", ELSEVIER, Journal of Power Sources, (15 July, 2017), 356:225–244.

[16]. Gajda I, Greenman J, Melhuish C, Ieropoulos IA "Electricity and disinfectant production from wastewater: microbial fuel cell as a self-powered electrolyser", Scientific Reports, (12 May, 2016). 6:25571.

[17]. Scott K, Murano C, Rimbu G, "A tubular microbial fuel cell", Journal of Applied Electrochemistry (37),1063–1068,2007.

[18]. Logan BE, Regan JM "Electricity-producing bacterial communities in microbial fuel cells”, Trends Microbial 14(12):512–518, 2006.

[19]. Emmanuel P. Leana and Sandhya Babel, School of Biochemical Engineering and Technology, Sirindhorn International Institute of Technology, Thammasat University,

[20]. Pathum Thani, Thailand, “Electricity Generation from Anaerobic Sludge and Cassava Wastewater Subjected to Pre-treatment Methods Using Microbial Fuel Cell”, 20ll IEEE First Conference on Clean Energy and Technology CET,2011 IEEE Paper.

[21]. Arwa Fraiwan, Sayantika Mukherjee, Steven Sundermier, Hyung-Sool Lee and Seokhun Choi, "A paper-based Microbial Fuel Cell: Instant battery for disposable diagnostic devices", Biosensors and Bioelectronics, vol. 49, pp. 410-414, 2013.

[22]. Andrew Meehan, Hongwei Gao, Senior Member, IEEE, and Zbigniew Lewandowski,

[23]. “Energy Harvesting with Microbial Fuel Cell and Power Management System”, IEEE Transactions on Power Electronics, Volume 26, January 2011.

[24]. Helinando P. de Oliveira, Mateus M. da Costa Universidade Federal do Vale do Sao Francisco Univasf, Juazeiro, BA, Brazil, “Development of low-cost microbial fuel cell based on Escherichia coli.” IEEE Paper 2015 (Page no.: 940-942).

[25]. K Hossain and O. Badr, “Prospects of renewable energy utilisation for electricity generation in Bangladesh,” Renewable and Sustainable Energy Reviews, volume 11, no. 8, pp. 1617–1649, (2007).

[26]. B.E. Logan, B. Hamelers, R. Rozendal, U. Schro ¨ der, J. Keller, S. Freguia, P. Aelterman, W. Verstraete, K. Rabaey, “Microbial Fuel Cells: methodology and technology,” Environmemt Science Technology, Volume 40, pp. 5181–5192, (2006).

[27]. Park DH, Zeikus JG, "Electricity generation in microbial fuel cells using neutral red as an electronophore", Applied Environment Microbial (66),1292–1297(2000).

[28]. Ye, Y., Ngo, H.H., Guo, W., Liu, Y., Chang, S.W., Nguyen, D.D., Ren, J., Liu, Y., Zhang, X, “Feasibility study on a double chamber microbial fuel cell for nutrient recovery from municipal wastewater” Chemical Engineering Journal, 358, 2019.

[29]. Arwa Fraiwan and Seokheun Choi, "A Stackable Two-chambered Paper-based Microbial Fuel Cell", Biosensors and Bioelectronics, volume 83, pp. 27-32, 2016.

[30]. Mathuriya AS, VN Sharma, “Bioelectricity production from paper industry waste using a microbial fuel cell by Clostridium species”. J. Biochemical Technology 1(2):49-52, 2009.

[31]. G. C. Gil, I. S. Chang, “operational parameters affecting the performance of mediator less MFC”. Bio electron (18), 327-34, 2010.

[32]. S. Kumar, "A study on the electricity generation from the cow dung using MFC". JB. Chem.tech.3 (4); 442. 447 2012.

[33]. N. Sriram and D. Reethq, "Enhancing and optimization of electricity production of electricity production by dye degrading bacteria in MFC". International Journal of Advanced Research in Biological Sciences ISSN: 2348-8069, 2015.

[34]. H. P. Bennetto, "Microbial fuel cell" life chem. Rep. 2,363-4 1984.