

A Review on Fuzzy based Fuel Cell

Niraj Singh Suman¹, Dr. Achala Jain²

^{1,2}Dept. of Power Electronics & Power System, Shri Shankaracharya Technical Campus, Bilai, C.G., India

Abstract: The energy unit is a significant innovation for new versatile applications and force matrix dispersion frameworks. For power appropriation, energy component framework requires a matrix interconnection converter to supply capacity to the force lattice. A network interconnection converter utilizing a detachment transformer is ideal for power matrix circulation frameworks as far as flood security and clamor decrease. Furthermore, size decrease and high productivity are fundamental necessities. One of the issues in the energy component framework is that the lifetime is diminished by the wave current. Accordingly, to broaden the lifetime, the power device swell current should be decreased in the matrix interconnection converter. Nonetheless, when a solitary stage beat width-regulated (PWM) inverter is utilized for matrix association framework, the force swell is double the recurrence of the force lattice. Subsequently, in customary matrix association inverters, huge electrolytic capacitors are associated in corresponding to the power module to decrease the current wave. Notwithstanding, the utilization of huge estimated electrolytic capacitors increments both the gadget volume and cost.

Keywords: Review, fuel cell, power, fuzzy

Literature Review:

Sudip K. Mazumder et al. (2007) proposed an energy-efficient, energy component power-molding framework (laptops) for fixed application, which decreases the varieties in the current drawn from the power device stack and might conceivably meet the \$40/kW cost target. The computers comprises of a zero-swell lift converter (ZRBC) trailed by a delicate exchanged and multi level high-frequency (HF) inverter and a single-phase cyclo converter. The ZRBC includes again zero-swell filter (ZRF), which significantly decreases the info low-and high-recurrence current waves, there by possibly upgrading the strength of the stack. Another stage moved sine wave tweak of the staggered HF inverter is proposed, which brings about the zero-voltage exchanging (ZVS) of each of the four switches without the utilization of any assistant circuit parts. For such a sine wave tweak procedure, 90% ZVS range is acquired per line cycle for about 70% of the evaluated load. Further, the line-recurrence exchanging of the cycloconverter (at near solidarity power factor) results in incredibly low exchanging misfortunes. The halfway dc transport works with the consideration of force frameworks dependent on different types of option energy procedures (e.g., photovoltaic/high-voltage stack). A 5 kW model of the proposed laptops is constructed, which right now accomplishes a pinnacle efficiency of 92.4%. We present an itemized depiction of the activity of the computers alongside its critical components and benefits. At last, trial results showing the palatable exhibition and the activity of the computers are illustrated.

Markus Grotzsch et al. (2009) proposed the association between PEM energy units and normal DC-DC converters is

analyzed. The examination is model-based and accomplished for lift, buck and buck-support converters. In a first step, the impact of the converter swells upon the PEM energy unit is shown. They present motions in the energy unit. Their appearance is clarified, talked about and opportunities for their concealment are given. From that point onward, the general practices of the coupled energy component converter frameworks are broke down. It is shown, that neither fixed multiplicities nor motions can be presented by the couplings and in this manner separate control approaches for both the PEMFC and the DC-DC converters are appropriate.

Tiwari and Sunil Kumar Gupta (2010)proposed voltage hang pay is introduced in this paper and this is constrained by unique voltage restorer took care of energy unit framework. Remuneration and persistent RMS voltage are drawn by DC-interface voltage of DVR so this can be noticed and conveyed DC power from the energy unit framework. SOFC sort of energy component is presented across a DC connection of DVR. PI regulator is carried out to control the force stream of DVR. Different profundities of hang pay are examinations of changing the quantities of cells in power device and better pay are accomplished with MATLAB/Simulink results.

Sampath Naveen Kumar et al. (2013)described combination of power module stack with an inverter is mind boggling in nature. Various variables must be considered in planning the inverter just as during the mix. One of these components is swell current which could influence the existence of the power device stack in case there is fuel or potentially oxidant starvation. In this paper an inverter geography is

explored which essentially lessens or even invalidates the wave content in the power module framework. The examinations have been done utilizing natively evolved 1 KW PEMFC stack and a 4 kW PEMFC stack with single and multi stage inverter. The outcomes are introduced here.

M. Sindhubala et al. (2013) introduced the impacts of sounds in a force framework and to limit the impacts of the force framework music. This twisting will bring about low force quality and further developed unsettling influences in power framework. So this symphonious strategy is utilized to further develop the force quality. This improvement incorporates the recreation moreover. Inverter is utilized to change a DC into AC, during this change; the sounds will lessen the force quality a ton. The expansion in power quality utilizing a method is clarified exhaustively here.

B. Haritha et al. (2014) proposed the lift inverter geography is utilized as a structure block for a solitary stage matrix associated energy unit (FC) framework offering minimal expense and smallness. Also, the proposed framework fuses battery-based energy stockpiling and a dc-dc bidirectional converter to help the lethargic elements of the FC. The single-stage help inverter is voltage-mode controlled and the dc-dc bidirectional converter is current-mode controlled. The low recurrence current wave is provided by the battery which limits the impacts of such wave being drawn straightforwardly from the FC itself. Additionally, this framework can work either in a matrix associated or independent mode. In the network associated mode, the lift inverter can handle the dynamic (P) and responsive (Q) powers utilizing a calculation dependent on a second-request summed up integrator which gives a quick sign molding to single-stage frameworks. Plan rules, reenactment, and trial results taken from a lab model are introduced to affirm the presentation.

Jayaprakash et al. (2014) presented focuses on restricting rating of dynamic voltage restorer for issue pay plans. Distinctive power levels are being attempted and finding sensible control method to restrict the rating of DVR, the synchronous reference layout controller is familiar from turning composed edge with the decent packaging using unit vector load evaluation. The given SRF controller is successfully restricted on the rating of Voltage source converter of DVR and showed up at a prevalent compensation in hang, swell and music while we differentiated and existing composing which is presented on paper.

Sachin N. Phad et al. (2014) proposed work is completed to lessen swell current which is stream to the energy component/Battery through power gadgets during dc-ac

activity. FCs enjoy benefits like high productivity, zero or low outflow (of contamination gases), and adaptable secluded design With clean working climate and high energy change effectiveness, energy component is standing out enough to be noticed, particularly for the fixed force application. Such an application, either conveying power with utility intertie or straightforwardly providing to local location as an independent force source, can be utilized for future dispersed age frameworks.

M. Revathi et al. (2015) dealt with the writing audit of demonstrating and reenactment of Energy component framework utilizing Double Dynamic scaffold DC-DC Converter and the adequacy of consonant current ingestion by the energy stockpiling branch in energy unit power molding framework is basically assessed. The shut circle yield impedances of the converter under single-voltage-circle and double circle controls are determined and analyzed. The DC source from the power module is given to DC-DC converter then it is separated and it is given to inverter then, at that point provided to stack. The open circle control framework is a non criticism framework wherein there is no criticism to decide whether the framework is accomplishing the ideal yield dependent on the reference input. A shut circle control framework in any case named as criticism control framework in which a few or the entirety of its yield is utilized as its feedback.

Majid Valizadeh et al. (2015) introduced a thorough powerful model of a proton trade layer energy component (FC) in view of the electrical experimental model. The introduced model is valuable for online control just as having appropriate exactness. FC stacks produce a DC voltage with a proportion of 2:1 in yield from no-heap to full-stack. In vehicles that are outfitted with FCs, the yield voltage of the FC is radically changed in light of the fact that the force and force of the vehicle change with the driving cycle. To work on the presentation of the immediate force control of enlistment engines, the secluded design of a FC is proposed. This proposed structure ensures the greatest force point following and force swell decrease. The legitimacy of the proposed structure is satisfied by recreation results utilizing MATLAB/Simulink programming.

Shyamal Kumar Roy et al. (2015) depicted various sorts of DC-DC converters that are utilized for controlling the yield voltage of energy unit modules. A conversation of the activity of the power modules and the kinds of energy components is introduced. The paper likewise depicts guideline of the yield voltage of the power module utilizing DC-DC converters.

H. Jagadeesh et al. (2016) introduced a wave current decrease technique is recommended that doesn't need extra exchanging gadgets. A current wave that has double the stock recurrence of the force supply is produced in the dc part when a solitary stage beat width adjusted inverter is utilized for a framework association. The current wave causes shortening of the lifetime of electrolytic capacitors, batteries, and energy units. The proposed circuit understands a dc dynamic channel work without expanding the quantity of exchanging gadgets, on the grounds that the energy cradle capacitor is associated with the middle tap of the separation transformer. What's more, the cushion capacitor voltage is constrained by the normal mode voltage of the inverter. The elements of the proposed circuit are portrayed and Recreation results are introduced. A recreation result demonstrates the wave decrease, to roughly 20% that of the customary circuit.

Satbir Singh et al. (2015) managed the displaying, examination and control plan of framework associated energy component framework with single stage DC-AC interface. The yield of the Power module framework is associated with the DC side of the Voltage Source Inverter (VSI) for interfacing to the utility Matrix. Energy component framework supply dynamic force just as receptive force pay to utility matrix having neighborhood load. The conduct of an energy unit by shifting DC interface voltage which makes change in the yield of the dynamic force has been researched. Examination for THD because of variety in DC interface force of lattice associated power device framework has been done. Conduct of latent channel to kill the consonant created by power device is likewise concentrated in this work. Detached channel might prompt force misfortunes, which will be overwhelmed by utilizing ideal worth of R, L, and C. Variable dynamic/receptive force stream can be made according to necessity of the neighborhood load. The whole framework is demonstrated in MATLAB/Simulink climate and different reproduction results are introduced for the proposed lattice associated power module framework.

Radhakrishna Das et al. (2016) proposed demonstrating and reenactment of single stage inverter as a recurrence transformer adjusted by Heartbeat Width Balance (PWM). An inverter is a circuit that changes over DC sources to AC sources. Heartbeat Width Regulations a method that utilization as an approach to diminish absolute consonant contortion in inverter circuit. The model is executed utilizing MATLAB/Simulink programming with the SimPower Framework Square Set dependent on virtual experience. Programmatic experience assumes a significant part in the plan, examination, and assessment of force electronic converter and their regulator. MATLAB is a

compelling apparatus to investigate a PWM inverter. Benefits of utilizing MATLAB are the accompanying: Quicker reaction, accessibility of different reenactment apparatuses and useful squares and the shortfall of assembly issues. Safe-recompense procedure need be executed is to address exchanging Homeless people. Along these lines, Protected Entryway Bipolar Semiconductor (IGBT) is use as exchanging gadgets. IGBT is ideal since it is not difficult to control and low misfortunes. The outcome from Simulink was confirmed utilizing matlab reproduction before Exploratory confirmations.

Ahmed Medhat M. Youssef et al. (2016) proposed petroleum product contaminations being siphoned from inward burning motor vehicles have a significant danger to our environment and our wellbeing. Electric vehicles have been proposed as options in contrast to traditional vehicles and are considered as one of the mainstay of eco-accommodating answers for conquer the issue of worldwide contamination and radiations because of ozone depleting substances. By and large power devices are low-voltage high-flow sources and their yield voltages are touchy to changes in the heaps, consequently incorporating them with the high voltage of the DC-connection of electric vehicles' footing drives addresses a significant test for vehicle originators. Lift DC/DC converters are normally used to interface the components in the electric force train, consequently the target of this paper is to plan a fitting lift DC/DC converter construction to deal with the energy move from the power module stack to the DC-transport dependent on high efficiency range. A multi-stage interleaved help DC/DC converter structure is proposed, which offers decrease of: input current waves, voltage weights on switches, yield voltage waves, and detached part estimates. Working on transient reaction and unwavering quality are among the many benefits of utilizing such converters.

Muhamad Norfais Faisala et al. (2017) proposed mass commercialization of energy units (FC) and its use in transportation necessitates that the FC innovation to be cutthroat with respect to execution and cost, while meeting effectiveness and outflows targets. Subsequently, energy unit yield current wave that might abbreviate FC life expectancy, deteriorate FC productivity and decrease the FC yield limit should be tended to. In this paper, an improved multi-gadget interleaved support converter (MDIBC) with novel multiplex regulator geography is intended to additionally lessen the info current and yield voltage swells, without expanding the quantity of MDIBC exchanging gadgets. The Matlab/Simulink conduct model of the further developed MDIBC with novel multiplex regulator and regular MDIBC circuit are created in the recreation

examines. The proposed further developed MDIBC configuration is then contrasted and the traditional MDIBC and its presentation is confirmed.

Nanjun Lu et al. (2017) proposed a well-known issue of fuel-cell-powered single-phase uninterruptible power supplies (UPS) is that the input current from the dc source is coupled with the second-order current ripple due to the ac-side instantaneous power pulsating at twice the line frequency. The low-frequency ripple component has been confirmed to have detrimental impacts on fuel cell's reliability and lifespan. To solve this issue, a boost inverter that can work in both differential mode (DM) and common mode (CM) operations is adopted by this paper. The DM operation achieves active power conversion and a well-regulated ac output voltage. Meanwhile, the CM operation ensures effective dc current ripple reduction. In addition to operating with linear loads, the proposed control method extends its working scope to nonlinear loads, where meticulously designed repetitive controllers are employed to handle the multiple low-harmonic situations. Moreover, the proposed control method also introduces an interleaved pulse-width modulation to further reduce the switching frequency ripple in the dc current. The stability of the proposed control system is stringently examined. Finally, presented experimental results validate the theoretical analysis as well as the effectiveness of the proposed method in current ripple reduction.

Soumya Sinha et al. (2017) proposed fuel cells serve as clean, renewable and an efficient source of electrical energy. The power conditioning system associated with their applications consists of a DC-DC Converter stage and a DC-AC inverter stage. In a single-phase fuel cell system, the single-phase inverter introduces a second harmonic component in the current drawn from the fuel cell source. This low-frequency current ripple has been found to be detrimental to the performance, lifespan, and efficiency of the fuel cell, if not adequately controlled. The paper presents a single loop current control method for the DC-DC converter stage that reduces the input current ripple drawn from the source in the single-phase fuel cell system. Simulations are carried out using MATLAB; the results compared with the conventional method. To validate the proposed approach, experimental results from a laboratory prototype are presented. The proposed method uses a Digital Signal Processor for control system monitoring and control.

Prabhuraj Shanmugham et al. (2018) proposed fuel cell system is a promising alternate way of power generation from clean, green fuel such as Hydrogen with almost zero emissions. It can be a primary power or an aiding power to

the grid during instability. Grid connected fuel cell systems experience double line frequency ripples from the inverters which affect the life of fuel cells. The current ripples are to be limited within 15% for safe operation of the fuel cells. This paper presents design of a dual active bridge DC-DC converter to step up the low voltage DC output from fuel cell to a high voltage DC with galvanic isolation and a PLL based grid synchronized single phase PWM inverter with dq reference frame grid current control suitable for fuel cell systems. Extended Symmetrical Optimum method is used for optimal tuning of the PI controllers. An LCL filter is designed for effective ripple attenuation in the grid current with active damping of the resonance in the region of stability. MATLAB/Simulink® is used for the design and is verified with a 1kW Horizon PEM fuel cell system. The power is exported to the grid with measured THD of 1.7% in the grid current with reactive power injection by simple phase shift modulation control. The maximum overall system efficiency is measured to be 85.

Conclusion:

An energy component is one of the as of late recognized electrical energy assets which goes through certain synthetic responses to deliver electrical force utilizing hydrogen as fuel and oxygen as an oxidizing specialist. The heap voltage music, load current sounds and uneven burden which happen because of nonlinearity and unequal burden are available in the appropriation framework. These impacts of burden voltage and burden current sounds influence the general exhibition of the dissemination framework. It additionally influences the voltage across the purpose in like manner coupling. Because of this, other straight loads associated with the reason behind normal coupling additionally get debased. The lift converters give the upside of decreased wave in the source current subsequently giving expanded life to the sources like battery. By taking on the current mode control plot in converters, better unique execution of the framework is accomplished. The diminished wave in the source current gives the upside of decreased electromagnetic obstruction. The component of the converters give a benefit of having lesser channel capacitor. Converters give the choice of taking on higher exchanging recurrence and in this manner by decreasing the size and cost of the framework.

References:

1. Ahmed Medhat M. Youssef, "Multi phase interleaved boost DC/DC converter for fuel cell/battery powered electric vehicles", World Journal of Modelling and Simulation Vol. 13 (2017) No. 3, pp. 200-211.

2. B.HARITHA, P.DHANAMAJAYA, "A Grid Connected Fuel Cell Based on Boost Inverter System", INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING, Vol. 2, Issue 8, August 2014.
3. Jun-ichi Itoh, Fumihiro Hayashi, "Ripple Current Reduction of a Fuel Cell for a Single-Phase Isolated Converter using a DC Active Filter with a Center Tap",
4. Majid VALIZADEH*, Mohammad Reza FEYZI, Ebrahim BABAEI, Mehran SABAHI, "Dynamic modeling of modular fuel cell for maximum power point tracking and torque ripple reduction in direct torque control of induction motor", Turkish Journal of Electrical Engineering & Computer Sciences,
5. M. Revathi, PG Scholar, B.G. Manikandan Sathyagan, "Literature Survey on Modeling and Simulation of FUEL CELL system using Dual Active Bridge (DAB) DC-DC Converter", International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 02 Issue: 09 | Dec-2015.
6. Markus Grotsch , Michael Mangold and Achim Kienle, "Analysis of the Coupling Behavior of PEM Fuel Cells and DC-DC Converters", Energies 2009.
7. Mr H. Jagadeesh, Mr V. Raghavendra, Mr K Manohar, Mr K Harsha Vardhan Reddy, Mr S. Dileep Kumar, Mr K. Jagadeesh, "APPLICATION OF DC ACTIVE FILTER IN A FUEL CELL FOR RIPPLE CURRENT REDUCTION", IJAICT Volume 2, Issue 11, March 2016.
8. Mrs. M. Sindhubala, Ms. Allan Mary George, "Harmonic Reduction in Power System", Int. Journal of Engineering Research and Applications www.ijera.com ISSN : 2248-9622, Vol. 3, Issue 6, Nov-Dec 2013, pp.712-714.
9. Mr. Sachin N.Phad, A.M.Jain, "Control for Reliable Fuel Cell Power System with Input Ripple Current Compensation", International Journal of Engineering Trends and Technology (IJETT) - Volume 12 Number 1 - Jun 2014.
10. Muhamad Norfais Faisala, Azah Mohameda, M. A. Hannana, Wan Ramli Wan Dauda, Edy Herianto Majlana, "AN IMPROVED MULTIDEVICE INTERLEAVED BOOST CONVERTER WITH NOVEL MULTIPLEX CONTROLLER FOR FUEL CELL", 79:1 (2017) 143-151.
11. Nanjun Lu, Shunfeng Yang and Yi Tang, "Ripple Current Reduction for Fuel-Cell-Powered Single-Phase Uninterruptible Power Supplies", IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 64, NO. 8, AUGUST 2017.
12. Prabhuraj Shanmugham, Ahmad Ali, Sakda Somkun, "A Galvanic-Isolated Grid-Connected fuel cell single phase AC power generation system with LCL filter", INTERNATIONAL JOURNAL of RENEWABLE ENERGY RESEARCH Prabhuraj Shanmugham et al., Vol.8, No.4, December, 2018.
13. Radhakrishna Das, Jayant Kumar Sahoo, Sarada Prasanna Sahoo, "Harmonic Analysis of Single Phase Inverter", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 5, Issue 2, February 2016.
14. Sampath Naveen Kumar, Natarajan Rajalakshmi, Kaveripatnam Samban Dhathathreyan, "Efficient Power Conditioner for a Fuel Cell Stack-Ripple Current Reduction Using Multiphase Converter", Smart Grid and Renewable Energy, 2013, 4, 53-56.
15. Satbir Singh, Neha Sharma, Kuldeep Singh Bedi, "Harmonic Analysis of Fuel Cell System Connected to Grid and Harmonic Elimination by using Passive Filter", International Research Journal of Engineering and Technology (IRJET) Volume: 03 Issue: 09 | Sep-2016.
16. Sudip K. Mazumder, Rajni K. Burra and Kaustuva Acharyaer, "A Ripple-Mitigating and Energy-Efficient Fuel Cell Power-Conditioning System", IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 22, NO. 4, JULY 2007.
17. Shyamal Kumar Roy, "DC-DC Converters for Fuel Cells", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 4, Issue 5, May 2015.
18. Soumya Sinha , Wajiha Shireen, and Sumit Pramanick, "Mitigation of Input Ripple Current in Single Phase Fuel Cell Power Systems", International Journal of Power and Energy Research, Vol. 1, No. 3, October 2017.

19. W. Rui, G. Wei and W. Zhi, "Economic and optimal operation of a combined heat and power with renewable energy resources", *Automation of Electric Power Systems*, vol. 35, pp. 22-27, 2011.
20. Priyadharshini.R and S.P. Devendran." Implementation of fuel cell distributed generation system with conventional and fuzzy based PI controllers," in *International Journal of Engineering Research and Applications (IJERA)* Vol. 2, Issue 3, May-Jun 2012, pp. 450-464.
21. Babu Y. Raju * and P. Linga Reddy . "A Three-Phase GridConnected Fuel Cell System based on a Boost-Inverter," *Indian Journal of Science and Technology*, Vol 8(23), September 2015, pp. 1-4.
22. Mehta Gitanjali , S. P. Singh, "Grid-interfacing Fuel Cell System with active and Reactive Power Flow Control ," in *Chennai and Dr.MGR University Second International Conference on Sustainable Energy and Intelligent System*, Dr. M.G.R. University, Maduravoyal, Chennai, Tamil Nadu, India, July, 2011 , pp. 554-559.
23. Hajizadeh Amin and Masoud Aliakbar Golkar. "Power Flow Control of Grid-Connected Fuel Cell Distributed Generation Systems , " in *Journal of Electrical Engineering & Technology*, Vol. 3, No. 2, 2008 , pp. 143151.
24. Kumar Deepak, Kuldeep Singh Bedi and Ankit Goel. "Transformer less Grid Connected Fuel Cell System to Control the Flow of Active and Reactive Power." in *Journal of Engineering Research and Applications*, Vol. No 3, Issue No 6, Nov-Dec, 2013, pp. 1740-1743.
25. Mehta Viral, Joycee Smith Cooper "Review and analysis of PMC FUEL CELL design and manufacturing" in *Journal of Power Sources* 114 (2003) pp. 32-53.
26. Gupta Akhil, Saurabh Chanana & Tilak Thakur. "Power quality improvement of solar photovoltaic transformer- less grid-connected system with maximum power point tracking control ," in *International Journal of Sustainable Energy* (2014), Vol. 33, No. 4, pp. 921-936.
27. B. Harithai and P. Dhanamajaya. "A Grid Connected Fuel Cell Based on Boost Inverter System" in *International journal of innovative research in Electrical, Electronics, Instrumentation and Control System* Vol. 2, Issue 8, August (2014), pp.1529-1534.
28. Vijayakumar Ananthu , Vidya M Nair, "Control of Fuel Cell Based Distribution Generation System", Vol. 2, Special Issue 1,December (2013), pp. 242 - 251.
29. PP.Aseeb Nayana and Deepa Sankar . "Grid Connected Photo Voltaic- Hydrogen Fuel Cell Hybrid System." *International Research Journal of Engineering and Technology (IRJET)* e-ISSN: 2395 - 0056 Volume: 02 Issue: 04 July-2015 pp. 843-847.
30. Bedi Kuldeep Singh. " PV and Fuel Cell Hybrid System Connected to grid with Data Based MPPT Technique," in *International Journal of Advanced Research in Computer Science and Software Engineering* , Volume 3, Issue 11, November 2013 pp. 901-909.
31. G.R.Rajeshkanna and S. Thiagarajan, "A Single-Phase Grid-Connected PV Cell System Based on a Boost-Inverter." in *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering* Vol. 4, Issue 10, October 2015, pp 8360 - 8367.
32. Mewar University Simulation, "Study of Grid Connected Fuel Cell," *International Journal of Science and Research (IJSR)* ISSN (Online): Index Copernicus Value (2013) pp .1015 - 1018.