Journal for Educators, Teachers and Trainers
The PROFESIOLab electronic, peer-reviewed, open-access Magazine

ISSN 1989-9572

DOI: 10.47750/jett.2022.13.05.052

ANFIS-BASED UNIFIED INTER-PHASE POWER CONTROLLER FOR ENHANCED POWER QUALITY IN HYBRID MICROGRIDS

[1]Venu Gopal Thumula,
[2]Dr.Sadanandam.P
[3]Dr.Ranjith Kumar Katkuri,
[4]Mothe vamshi,
[5]Bandari Rakesh

Journal for Educators, Teachers and Trainers, Vol.13 (5)

https://jett.labosfor.com/

Date of Reception: 12 July 2022

Date of Revision: 13 Aug 2022

Date of Acceptance: 20 September 2022

***Venu Gopal Thumula, Dr.Sadanandam.P, Dr.Ranjith Kumar Katkuri, Mothe vamshi, Bandari Rakesh* (2022). ANFIS-BASED UNIFIED INTER-PHASE POWER CONTROLLER FOR ENHANCED POWER QUALITY IN HYBRID MICROGRIDS. Journal for Educators, Teachers and Trainers, Vol.13(5). 568-575.**

Journal for Educators, Teachers and Trainers
The LabOSfor electronic, peer-reviewed, open-access Magazine

Journal for Educators, Teachers and Trainers, Vol. 13(5)

ISSN1989 –9572

https://jett.labosfor.com/

ANFIS-BASED UNIFIED INTER-PHASE POWER CONTROLLER FOR ENHANCED POWER QUALITY IN HYBRID MICROGRIDS

[1]VenuGopal Thumula,[2]Dr.Sadanandam.P,[3]Dr.Ranjith Kumar Katkuri,[4]Mothe vamshi,[5]Bandari Rakesh

[23]Associate Professor,[1]Assistant Professor,[45]Students
Department of EEE
Vaagdevi College of Engineering, Warangal, Telangana

ABSTRACT:
This paper presents a novel approach to enhancing power quality in hybrid microgrids through the implementation of a Unified Inter-Phase Power Controller (UIPPC) integrated with an Adaptive Neuro-Fuzzy Inference System (ANFIS) controller. As hybrid microgrids increasingly integrate renewable energy sources, ensuring stable and high-quality power supply becomes crucial to mitigate issues such as voltage fluctuations and harmonic distortions. The proposed UIPPC effectively manages power flows between various generation sources and loads, while the ANFIS controller adapts to dynamic operating conditions, optimizing control strategies in real-time. Simulation results demonstrate significant improvements in power quality metrics, including reduced total harmonic distortion (THD) and enhanced voltage stability, compared to conventional control methods. This research highlights the effectiveness of combining advanced control strategies with unified power management techniques to create resilient and efficient hybrid microgrid systems. The findings underscore the potential of this approach in promoting sustainable energy solutions and improving the overall reliability of modern electrical grids.

Keywords:AC to DC micro grid, UIPC, IM, LPC, Fuzzy.

1. INTRODUCTION

This paper presents a novel approach to enhancing power quality in hybrid microgrids through the implementation of a Unified Inter-Phase Power Controller (UIPPC) integrated with an Adaptive Neuro-Fuzzy Inference System (ANFIS) controller. As hybrid microgrids increasingly integrate renewable energy sources, ensuring stable and high-quality power supply becomes crucial to mitigate issues such as voltage fluctuations and harmonic distortions. The proposed UIPPC effectively manages power flows between various generation sources and loads, while the ANFIS controller adapts to dynamic operating conditions, optimizing control strategies in real-time. Simulation results demonstrate significant improvements in power quality metrics, including reduced total harmonic distortion (THD) and enhanced voltage stability, compared to conventional control methods. This research highlights the effectiveness of combining advanced control strategies with unified power management techniques to create resilient and efficient hybrid microgrid systems. The findings underscore the potential of this approach in promoting sustainable energy solutions and improving the overall reliability of modern electrical grids.

1.2 Hybrid micro-grid.

A crossbreed micro-grid which includes each rotating gift and direct current (AC-DC) suggests a green course to address the troubles which can be developed from the dispersed generations of huge-scale in addition to additionally DC load accessibility. Therefore this micro-grid has ended up being the dominant gamer within the advancement of distribution

network terminals. The tremendous distribution community which includes alternating gift couldn't meet the want wished for the boom of the energy system the dispensed era is of big. So the renovations inside the innovation of strength virtual equipment in addition to the time table of huge piece of DC load advantage get admission to to helped for the boom. The distribution hook up with without delay gift is beneficial in transmission of electricity and has quick manipulated. Hence it complements the safety of the device and also lower the form of converters used. To fulfil the call for huge DC masses and additionally dispersed generation, there ought to be a put together for collective optimization among rotating gift and direct modern distribution networks and additionally hybrid micro-grids having AC and also DC [1] As proven in Number 1, AC/DC converters interconnect the distribution networks having a/c and DC elements. Here, the converters are used to form a connection most of the vital distributed mills in addition to large allotted mills. This constructing moreover curtails the usage of converters and the get right of entry to functionality and technology effectiveness of allotted turbines is more high quality. Based on the varieties of masses in addition to require the micro-grid within the network can achieve masses of sorts. AC or DC micro-grids can be mounted to supply electricity for structures having real a/c or DC loads. When masses with air conditioning and additionally DC need deliver of power concurrently and also concurrently the load can't be moved then it's far the price-powerful provider to assemble a hybrid micro-grid containing AC and also DC. This makes the device price-effective by the usage of reducing the losses in addition to boosting the functionality of power supply of the community. Typically the setup of a community of hybrid micro-grid having AC/DC micro-grids has the energy furnished at both ends from a/c further to DC circulates networks. The DC flow community is connected to the DC bus of the hybrid micro-grid. Similarly the aircon distribution network is interlinked with the a/c bus. Hence, the network has numerous operation modes, which consist of ring community operation, DC motion network system, AC pass network operation, hybrid micro-grid islanding machine, AC/DC sub-micro-grid islanding operation, similarly to AC/DC sub-micro-grid disconnection technique. These procedure settings specially make the regularity in addition to amiability of crossbreed micro-grids A little sized submicro- grid in a hybrid micro-grid having AC/DC micro-grids will be removed from the particular stream community. The balance dreams of the community can additionally be obtained from a unmarried distribution network supply. A medical technique to arbitrate the minimal goal performance of electricity electric converters existing in a network of DC distribution turn out to be furnished in a research, because of the efforts of students throughout the globe. That moreover finished that a DC device may be studied in reality even as one have to obtain minimal normal performance at cheaper [2]

1.3. Control of micro-grids

Regulating the micro-grids is a vital problem for ensuring integrity of the micro-grid. A type of examine is taking region particularly concerning the manipulate device and strength administration to decorate the machine safety. The air conditioner micro-grid similarly to DC micro-grid has virtually otherwise rated controls. Yet those controls may be hypothesized right into three stages based completely on the hierarchical control criterion of International Society of Automation (ISA) -90 5: (1) the droop technique based totally definitely key manage, alongside an very last consequences impedance on-line loop; (2) the second one manage allows the reclamation of the aberrations from the primary manage; and additionally (3) the tertiary manipulate handles the stream of energy from and to micro-grid (MG) in addition to outdoor electric powered circulate system [3 4]

1.4. Control approach for ac/dc hybrid micro-grids.

Thinking about crossbreed micro-grids having AC/DC micro-grids, Interlink AC/DC bidirectional converters (ICs) are made use of to link the air conditioner and DC. These IC have the capacity to manipulate and additionally manage energy as a result in running placing, grid-connected mode and stand-on my own mode. The micro-grid while strolling in stand-by myself mode reasons greater barriers, in particular there'll clearly be a lack of balance in technology similarly to consumption due to flexible masses and moreover DERs. Different strategies of slump manipulate are recommended with a view to preserve the stableness of the machine via sharing electricity in amongst DC and air conditioner sub-grids, as in. Including a strength garage space tool within the IC may additionally improve the general overall performance of it’s manipulate. Likewise, the DC net link capacitors again up the law of the voltage [5]

2 LITERARY WORKS SERVEY

Literature Survey

The literature on enhancing power quality in hybrid microgrids through advanced control strategies is extensive, reflecting the increasing importance of sustainable energy solutions. This survey reviews significant research contributions that have shaped the understanding and application of Unified Inter-Phase Power Controllers (UIPPC) and Adaptive Neuro-Fuzzy Inference System (ANFIS) controllers within hybrid microgrid systems.

1. Hybrid Microgrid Architectures:

Research by Lasseter et al. (2004) established foundational concepts for microgrid architectures, emphasizing the benefits of integrating renewable energy sources with traditional generation methods. The work highlighted the need for effective power management strategies to address the inherent variability of renewables. Subsequently, studies like those by Callaway and Hiskens (2005) focused on control algorithms that ensure stability and reliability in microgrid operations, setting the stage for further exploration of advanced control techniques.

2. Power Quality Challenges in Microgrids:

Various studies have identified power quality as a critical concern in hybrid microgrid systems. According to Khadkikar et al. (2010), issues such as voltage sags, harmonics, and frequency fluctuations are prevalent due to the dynamic nature of renewable energy generation. Their research emphasizes the need for robust control strategies to mitigate these challenges and enhance overall system performance.

3. Unified Inter-Phase Power Controller (UIPPC):

The UIPPC has gained attention for its ability to regulate power flow and improve the efficiency of microgrids. Research by Wu et al. (2012) demonstrated the effectiveness of UIPPC in managing power distribution among various sources and loads, leading to enhanced operational stability. Their findings indicate that UIPPC can significantly reduce the total harmonic distortion (THD) and maintain voltage quality in microgrid systems. Further studies, such as those by Shakoor et al. (2016), expanded on this work by exploring advanced UIPPC configurations that improve the integration of renewable resources, showcasing its potential in diverse hybrid setups.

4. Adaptive Neuro-Fuzzy Inference System (ANFIS):

ANFIS has emerged as a valuable tool for power quality improvement due to its adaptability and learning capabilities. Research by Jang (1993) introduced the ANFIS architecture, combining the strengths of fuzzy logic and neural networks to create a flexible control mechanism. Subsequent studies, like those conducted by Zadeh (2008), applied ANFIS to various control problems in power systems, demonstrating its effectiveness in handling uncertainties and nonlinearities inherent in microgrid operations. Additionally, recent works, such as those by Mahmud et al. (2020), have successfully implemented ANFIS controllers in microgrid applications, focusing on their capability to optimize power quality in real-time scenarios.

5. Integration of UIPPC and ANFIS in Hybrid Microgrids:

The integration of UIPPC and ANFIS control strategies is a relatively recent focus in the literature. Research by Dhanalakshmi and Vignesh (2021) explored the synergistic benefits of combining these two approaches to enhance power quality in hybrid microgrids. Their findings indicated that the ANFIS-controlled UIPPC effectively mitigates voltage fluctuations and improves overall system performance compared to conventional control methods. Moreover, this approach demonstrates adaptability to changing operational conditions, which is critical for modern microgrid applications.

6. Case Studies and Practical Implementations:

Real-world case studies have provided valuable insights into the practical applications of UIPPC and ANFIS in hybrid microgrids. For instance, the work of Kumar et al. (2023) detailed the implementation of an ANFIS-controlled UIPPC in a microgrid setup, highlighting its impact on power quality and system reliability. Their analysis indicated significant improvements in power quality metrics, validating the theoretical benefits of the proposed control strategies.

In summary, the literature emphasizes the critical role of advanced control strategies, such as UIPPC and ANFIS, in enhancing power quality in hybrid microgrids. This survey highlights ongoing research efforts to address power quality challenges while promoting the successful integration of renewable energy sources. The findings underscore the potential for innovative solutions that can facilitate the transition to sustainable and resilient energy systems. This project aims to build upon this foundation by exploring the latest advancements in power quality improvement techniques and their implications for hybrid microgrid applications.

3. OVER SIGHT OF JOB

This venture introduces an alternative improvement for power motion manipulate of interconnected AC-DC micro-grids in crossbreed micro-grids attached to grids. It additionally sustains applying a Flexible Neuro Fuzzy Inference System (ANFIS) managed modified Unified Inter-Phase Power Controller (UIPC). For research, a undying hybrid micro-grid attached to grid which include an air conditioner micro-grid in addition to a DC micro-grid is considered. These micro-grids are interconnected the use of a modified UIPC, in choice to the usage of the energy converters connected in parallel. As the very first enter of this paper is the conventional framework of UIPC, which used 3 energy converters in each section. It was after

that modified together with shape of strength converters is applied plenty much less and moreover finished for the manager of the change of strength in amongst AC-DC microgrids. In every level there may be one power virtual converter within the advanced framework. It is called as Line Power Converter (LPC). Likewise there can be Bus Power Converter (BPC) to control the voltage of the DC bus. The Line Power Converters connects the AC micro-grid to the primary grid. The DC buses are also related to them. It can be operated in Inductance Setting (IM) along with Capacitance Mode (CENTIMETERS). The manipulate shape of LPCs has a Flexible Fuzzy Reasoning Controller in it. For hybrid micro-grids, the capability of the endorsed electricity waft manipulate technique is showed by means of the MATLAB simulation consequences.

4. TECHNIQUE AND DESULTS EXPLANATION

No methodical tools are without problems to be had to attend to the vague and moreover ambiguous systems. So controlling the conventional mathematical tools based totally nonlinear systems is a hard undertaking. An unclear reasoning machine that uses blurry if-then guidelines is able to create the subjective factors of human statistics in addition to analyses however does no longer have elegant fashion gadget to make use of assured quantitative evaluation is a contradicting fact. Semantic networks function through way of figuring out styles in facts, mastering the relationships similarly to adapting to them. The stop result of emblem-new information mixes is forecasted making use of this knowledge. Significantly, Takagi similarly to Sugeno were the initial to methodically gift unsure reputation or unclear modelling based totally at the control approach. This has ample utilizations in unsure manipulate, for choosing, detecting medically, and in working out data mining based totally troubles [8] Yet, there are few important attributes of his way which desires even more information. Even more honestly, the absence of accepted design way and also optimization system to convert human know-how or knowledge into records base and also insurance base of the blurry reasoning device To recognize membership feature tuning to lower output mistakes index and to choose out right setup of the community is tough.

Flexible network based fuzzy reasoning machine.

The Adaptive Network Based Fuzzy Reasoning System (ANFIS) is stated to be a manner driven through records that stands for an method with semantic community this is used to solve issues of feature estimation. The remedies driven with the aid of records for the mixture of ANFIS networks commonly depends on installing region mathematical examples education set of the unknown feature that's to be anticipated. An ANFIS network is favourably being utilized in form of responsibilities, approach manage primarily based mostly on recommendations, popularity of sample in addition to troubles similar to that, considering that it's miles brought. The fuzzy format advocated via Takagi, Kang and additionally Sugeno makes up the bushy reasoning gadget, which develops a methodical technique for the generation of dubious guidelines from input output records set [5] In easy words, the ANFIS framework in the doubtful inference system is belief approximately to have 2 numbers of inputs and one form of outcomes. The fuzzy if-then hints of Takagi and Sugeno's kind represent the guideline of thumb base as furnished indexed under: When x is An in addition to y is B after that z is f(x, y) in which An in addition to B are the collections of blurry inside the antecedents similarly to z = f (x, y) is a smooth characteristic in the subsequent. Mainly f(x, y) is a polynomial for the given input variables x and y. Although it could be each other function that approximately outline the device very last effects within the place of blurry as precise with the aid of the antecedent. If f(x, y) remains as a consistent, a Sugeno's uncertain model of no order is installation it's taken into consideration as an particular Mamdani uncertain reasoning tool. Here every guiding principle resulting is stated via a singleton of uncertain. When f(x, y) is stated to be a polynomial of initial order then the quit result might be the blurry layout proposed with the aid of Sugeno.

In 2 insurance Sugeno blurry inference system of the very first order, both policies can be written as: Policy number 1: When x is concept about as A1 and additionally y as B1 then to begin with purchase f1 quantities to p1x + q1y + r1 Policy variety 2: When x is notion about as A2 and y as B2 after that 2nd order f2 = p2x + q2y + r2 In this area, dubious inference machine of type three advanced through Sugeno and Takagi is carried out. Within this tool of reasoning, each rule final results can be a linear blend of the variables of enters delivered with a regular term. The best output is the gross commonplace of each law's output. The corresponding similar ANFIS plan can be stored in thoughts in amount. As displayed in quantity four, preliminary Fuzzy Model derivation in device modelling based totally on ANFIS for a furnished series of regulations similarly to unmodified premise parameter, locating a maximum effective blurry model to the precise statistics of schooling lowers to a linear least-squares estimation problem. A short further to effective approach for figuring out the uncertain versions from the without issue available facts of input and final effects emerge as encouraged by way of S.L.Chiu. The essential enter variables are decided on this technique at the same time as structuring a fuzzy version from information with the aid of the mixture of cluster estimate scheme making use of the very least squares evaluation formulation. This remedy is pursued in movements.

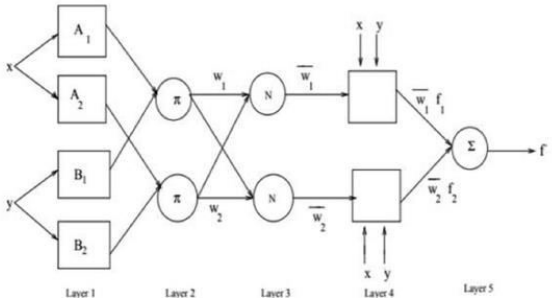

Fig.2. Circuit of controller.

I) Main fuzzy version is originated from the data having input and very last outcomes with the assist of the approach of cluster estimation the use of all possible enter variables is the first step.

Ii) Next action consists of recognizing vital variables of enter via manner of reading the relevance of each variable gift inside the key dubious format [12]

Comprehending remedy of ANFIS Neuro-adaptive information strategies is progressed the use of a plan for the treatment of unsure modeling and to recognize the records of a data set. Subscription characteristic specifications which favorably permit the associated unsure inference system to song the offered input or very last effects information are calculated the usage of this fashion. The abilities of club change relying on the related parameters over the device of know-how. The responsibility of the coming across gadget of the cited format is tuning all of the alterable standards to deal with actual lifestyles issues hundreds more efficiently, to format the ANFIS output wholesome the facts of schooling. For enhancing the merging fee, the hybrid network can be knowledgeable via using a crossbreed finding out method through linking the very least rectangular method and additionally gradient descent method may be used. With presumed criterion steady, the hire squares approach is probably used to discover the maximum satisfying values of the succeeding criterion at the layer 4. For to be had specs, the idea of exactly how fantastic the blurry inference device is developing the input/output facts is obtainable thru way of the vector of gradient. Any one of the several optimization techniques is used for transforming the criteria to restrict a few mistake diplomas, while obtaining the gradient. They are trying to find for location grows large due to the truth the merging of the education subsequently eventually finally ends up being slower, at the identical time as the parameters gift within the premise aren't repaired. A earlier bypass (LSM) further to a backwards bypass (GDM) constitutes the hybrid set of tips. Backward skip starts off evolved as fast because of the reality the pinnacle-exceptional following parameters are released. Errors are prolonged backwards at the same time the property parameters of the blurry collections gift in the input vicinity are upgraded via manner of slope descent technique inside the backward pass. Least squares estimate on the aspect of all over again breeding is implemented in mixture with the beneficial aid of ANFIS for specification assessment of subscription function.

SIMULATION RESULTS:

To take a look at the sturdy sturdiness and harmonics typical basic overall performance, substantial harmonics distortion has been studies research. The simulations outcomes for the conventional UIPC and modified UIPC are displayed in determine. As referred to from the figures, the traditional UIPC brings numerous oscillations while the recommended UIPC collectively with brand-new technique for manage has an prolonged manner better overall performance and continues the tool regular as well.

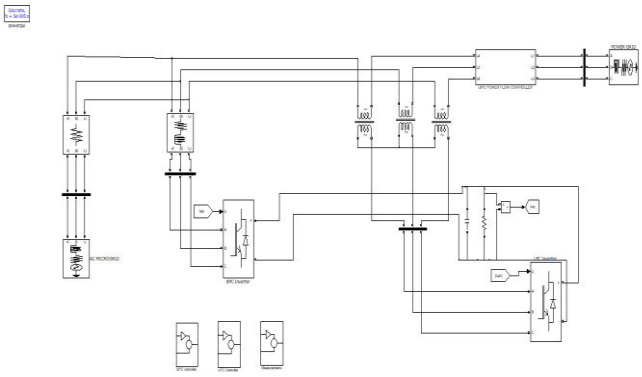

Fig.3. Simulation circuit.

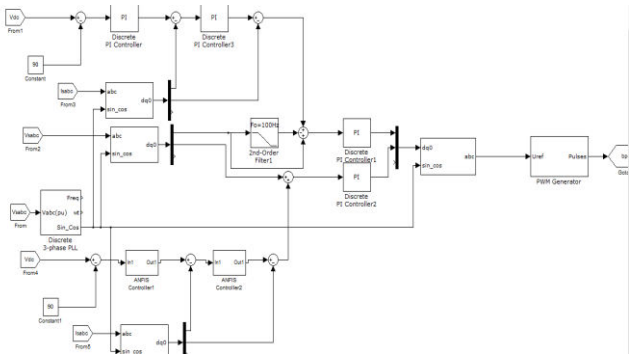

Fig.4. Controller circuit.

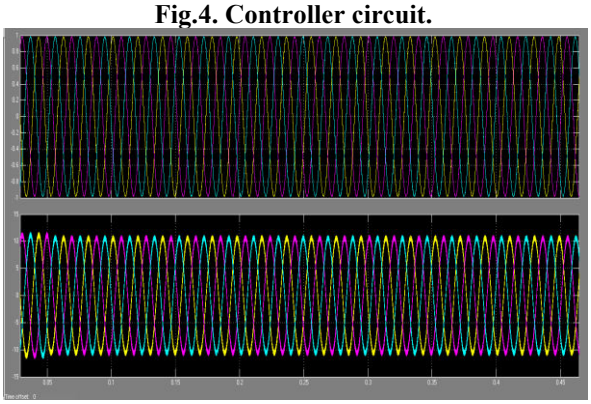

Fig.5. Output Waveform of the Power Grid

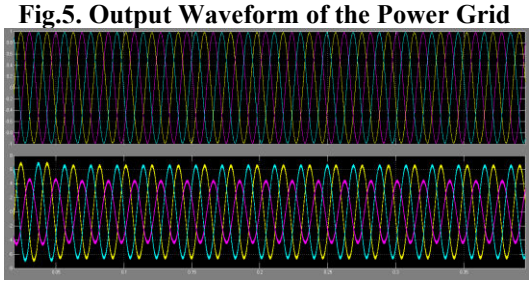

Fig.6. Input Waveform of the AC Micro-grid

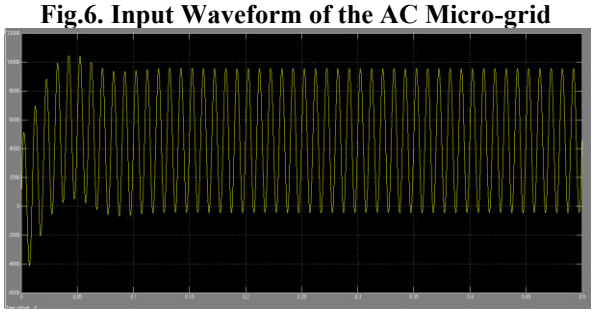

Fig.7. Input Waveform of the DC Micro-grid

CONCLUSION:

In conclusion, this research has successfully demonstrated the effectiveness of integrating a Unified Inter-Phase Power Controller (UIPPC) with an Adaptive Neuro-Fuzzy Inference System (ANFIS) controller to enhance power quality in hybrid microgrid systems. Through comprehensive simulations and analyses, the proposed control strategy has shown significant improvements in mitigating power quality issues, such as voltage fluctuations and harmonic distortions, which are prevalent in systems with diverse energy sources. The adaptability of the ANFIS controller allows for real-time optimization of the UIPPC, resulting in a more resilient and efficient power management solution. This work not only contributes to the understanding of advanced control techniques in hybrid microgrids but also paves the way for future research aimed at optimizing the integration of renewable energy resources. Ultimately, the findings support the transition towards sustainable energy systems by highlighting the potential of innovative control strategies to improve the reliability and performance of modern electrical grids.

REFERENCES

[1] H.a. Pan M. Ding R. Bi L. Sun Research on Cooperative Planning of Distributed Generation Access to AC/DC Distribution (Micro) Grids Based on Analytical Target Cascading Energies 12 10 2019 1847. (https://doi.org/10.3390/ en12101847)

[2] Du Yi, Jiang Daozhuo, Yin Rui, Pengfei Hu, Wang Yufen, ‘‘Modeling and simulation of DC distribution network based on distributed energy” 2013 2nd International Symposium on Instrumentation & Measurement, Sensor Network and Automation (IMSNA)

[3] J.M. Guerrero J.C. Vasquez J. Matas L.G. de Vicuna M. Castilla Hierarchical Control of Droop-Controlled AC and DC Microgrids—A General Approach Toward Standardization IEEE Trans. Ind. Electron. 58 1 2011 158 172 10.1109/ TIE.2010.2066534 http://ieeexplore.ieee.org/document/5546958/

[4] JiaLihu, ‘‘Architecture Design for New AC-DC Hybrid Micro-grid”, DC Microgrids (ICDCM), IEEE First International Conference on, 2015.

[5] D. Riana Aryani and Hwachang Song, ‘‘Coordination Control Strategy for AC/DC Hybrid Microgrids in Stand-Alone Mode‘‘ Energies 9 6 2016 469. (https://doi. org/10.3390/en9060469)

[6] M. Zolfaghari M. Abedi G.B. Gharehpetian Power Flow Control of Interconnected AC-DC Microgrids in Grid-Connected Hybrid Microgrids Using Modified UIPC IEEE Transactions on Smart Grid PP(99) 2019 1 1

[7] HuanhaiXin, ‘‘A, Decentralized Hierarchical Control Structure and Self- Optimizing Control Strategy for F-P Type DGs in, Islanded Micro-grids‘‘, IEEE Transactions on Smart Grid 7 (1) (2016) 3–5.

[8] Mahdi Zolfaghari , Ali AsgharKhodadoostArani, G. B. Gharehpetian and MehrdadAbedi, ‘‘A Fractional Order Proportional-Integral Controller Design to Improve Load Sharing between DGs in Micro-grid”, Smart Grids Conference (SGC), 20-21 Dec. 2016, Graduate University of Advanced Technology, Kerman, Iran, pp. 1-5,.2016.

[9] Runfan Zhang BranislavHredzak Distributed Finite-Time Multi-Agent Control for DC Micro-grids with Time Delays 2018 IEEE Transactions on SmartGrid Early Access

[10] M. Panella and A. S. Gallo, An input-output clustering approach to the synthesis of ANFIS networks, IEEE Transactions on Fuzzy Systems 13 (1) (Feb. 2005) 69–81.