IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-7, Special Issue-18, May 2019 E-ISSN: 2347-2693

Transient and Sub-transient Electrical Parameters based Classification of Micro Grids

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Available online at: www.ijcseonline.org

***Abstract*—** This work deals with transient and sub-transient nature of electrical parameters based classification of micro grid. Various type of models used in micro grid system using IGBT/Diodes, MOSFET / Diodes, GTO/Diodes, Ideal Switches, Switching – function based VSC, Thyristor, Diodes, Average-Model Based VSC have been studied. Different useful electrical parameters like voltage, current, active power, reactive power, etc have been monitored and their sub transient and transient behavior have been analyzed at normal load condition. Based on the observation, attempt has been taken to classify different types of present day micro grid systems with respect to sub-transient and transient nature of those useful electrical parameters. The study may be useful for modeling, synchronization, protection and performance analysis of various micro grid systems.

***Keywords*—** Classification, micro-grid, sub-transient, transient.

I. INTRODUCTION

With the increase of use of renewable and nonconventional energy resources, application of micro-grid system is increasing day by day. To meet the ever increasing, variable and complex power demand, design and operation of micro-grid system are gradually updating. It has become essential to study quality issues and performance of such system in the perspective of modern power system application.

Micro grid refers to a localized grouping of electricity sources and loads that normally operates in connection and synchronism with the traditional centralized electrical grid (macro grid), but can disconnect and function autonomously as physical and/or economic conditions dictate [1]. By this way, it paves a way to effectively integrate various sources of distributed generation (DG), especially Renewable Energy Sources (RES). It also provides a good solution for supplying power in case of an emergency by having the ability to change between islanded mode and grid.

A micro grid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode.
According to an EU research project [4]-[5], microgrids comprise Low-Voltage (LV) distribution systems with distributed energy resources (DERs) (micro turbines, fuel cells, Photo Voltaic (PV), etc.), storage devices (flywheels, batteries) energy storage system and flexible loads. The proper use of sources in this system can provide many benefits to the overall system performance provided they are properly managed and coordinated.

Many conventional types of classification of micro grid have been introduced. For example, microgrids can be classified [6] as (a) Campus Environment/Institutional Micro grids, (b) Remote “Off-grid” Micro grids, (c) Military based Microgrids and (d) Commercial and Industrial (C&I) Microgrids. It may be noted that such micro-grids should consider the quality issues [7] to improve their performance. Further the micro grid can be classified on the basis of connectivity with the grid into following categories: (a) Tied grid (interconnected to the grid) (b) Island or Stand alone (disconnected from the main grid). Again micro grids can be classified according to the behaviour of operations as follows: (a) Non-autonomous and (b) Autonomous. Ambarnath Banerji et al (2013) reviewed microgrids [8] that evolving for the way electrical power is being generated in traditional concept of centralized large generators to small generators connected to the distribution system powered by renewable sources, were primarily for back up and not synchronized to the grid. Later trend has been observed in the shift of the role of these distributed generations from back up to primary source in the form of micro grid.

Saeed Anwar et al (2013) performed detail analysis of harmonics elimination and distribution based on the compromise between voltage regulation at point of common coupling (PCC) and harmonics sharing [9] where the decentralized control of a new harmonics distribution method for micro grid technique has been introduced and effect of small error in coupling impedance estimation is ensured and the remedies to resolve the problem is presented. Snehamoy Dhar et al (2015) performed detail analysis of photovoltaic based voltage source converter based micro grid operation [10] where a new fast negative sequence power injection oriented Islanding detection technique has been introduced. In this attempt efficient detection of islanding with a fast run on time is ensured by the result analysis, where no significant effect in power quality during normal operating condition has been maintained. Harmonic analysis of grid connected power electronic systems has been carried out by Dinesh Kumar & Firuz Zare (2015) in low voltage distribution networks where the harmonic performance of a small grid system has been analyzed with respect to different grid and power electronic parameters [11]. In this attempt, to verify and analyze the harmonics performance, the passive harmonic mitigation technique has been introduced with a comprehensive modeling and simulation in SABER and MATLAB/Simulink. Blessy Sabu and Anns George (2016) studied harmonic mitigation analysis in Minigrid integrated distributed power system [12] where the effects of harmonics in the minigrid side and steps to reduce have been explained. In this attempt the harmonic distortion is one of the major issues related with power quality and creates several disturbances to the distributed system discussed; PWM based technique has been introduced to reduce the THD ratio. Analysis and optimization of droop controller for micro grid system have been done by Kai Yu et al (2016) based on small-signal dynamic model [13] where, a precise small-signal state-space model of the whole micro grid including droop controller has been introduced to improve the dynamic characteristics of an inverter-based micro grid. Shailendra Singh et al (2016) performed detail analysis of frequency stability of hybrid power system based on solar PV with SMEs unit with the HPS [14] where to solve the frequency fluctuating problem in renewable power generation, genetic algorithm based optimizing controller has been applied. Rashad et al (2016) reviewed on new inverter control for balancing standalone micro-grid phase voltages and power quality improvement [15] where in detail a comprehensive survey about the available techniques and controllers for power quality improvement, recent trends and schemes for the standalone power quality improvement have been reported. Pritha Roy et al (2016) studied synchronization aspects of single phase SPWM inverters for microgrid mode of operation [16]. A GPS- based control framework for accurate current sharing and power quality improvement in Microgrids [17] has been introduced by Mohammad Golsorkhi et al (2016) to improve the current sharing accuracy at high loading conditions. Presently, most of the micro-grids have become integrated along with the provision of digital protection and control units [18]-[19]. T.K Das et al (2017) introduced the different fault analysis techniques for solar microgrid system [20]-[22].

However very few of the work are found to classify different types of Microgrids having different inverters based on sub-transient and transient nature of different electrical parameters like voltage, current, powers etc. Therefore, in this work, attempt will be taken to classify present day micro grids with respect to sub-transient and transient nature of some useful electrical parameters.

II. MODELING OF MICRO-GRID

In this work solid oxide fuel cell (SOFC) based microgrid system (MATLAB, version-14) has been used for classification. Output of SOFC is fed to inverter system through a fixed capacitor as shown in Figure-1 Output of the inverter is stepped up by three phase transformer connected with load. In modeling and simulation following eight categories of inverter system has been considered: IGBT/Diodes, MOSFET/Diodes, GTO/Diodes, Ideal switches, Switching -function based VSC, Thyristor, Diodes and Average -model based VSC.

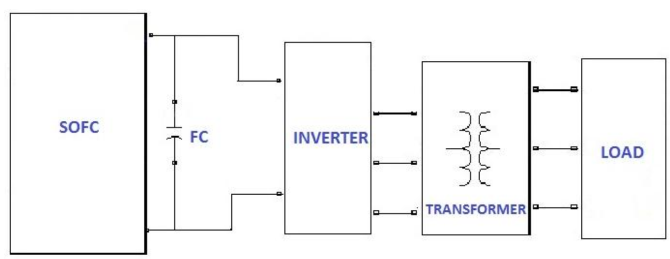

Figure-1 Solid oxide fuel cell based microgrid model.

However, in all case the same battery units is used. In the battery unit 450 numbers of cells are connected in series each having potential of 1.18 volt, ohomic loss per cell is $3.2813x10^{-4}$ ohms. Ratio of hydrogen and oxygen is 1.145. Inverter is fed to 3-phase two windings Y/Y transformer (1MVA, phase to phase primary RMS voltage, phase to phase secondary RMS voltage is 440volts).

III. SUB-TRANSIENT AND TRANSIENT VOLTAGE AND CURRENT BASED CLASSIFICATION

Sub-transient and transient of voltage and current of different microgrid system of different inverter configuration have been analyzed. Nature of voltage and current signals for different inverter configurations have been observed as shown in figure 2-a, 2-b, 2-c, and 2-d. Voltage signals and current signals for inverter configuration IGBT/Diodes, MOSFET / Diodes, GTO/Diodes, Ideal switches and

Switching -function based VSC inverters are found of same category as shown in Figure 2-a and 2-c respectively. Nature of voltage and current signals for inverter configurations with Thyristor, Diodes and Average -model based VSC inverters are found of same category as shown in Figure 2-b and 2-d respectively.

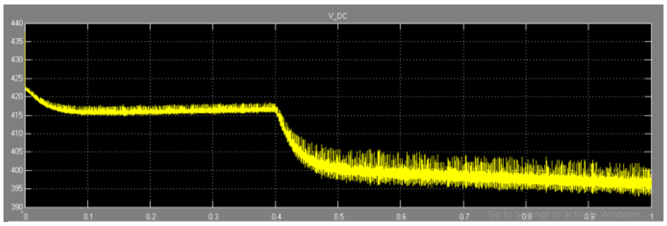

Figure 2-a Voltage signal of IGBT/Diodes, MOSFET / Diodes, GTO/Diodes, Ideal switches, Switching -function based VSC inverter at normal load

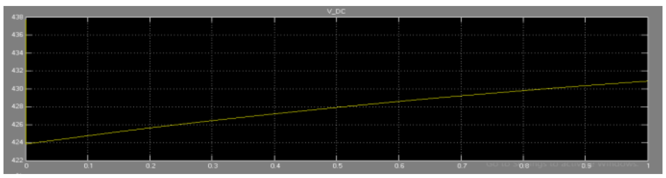

Figure 2-b Voltage signal of Thyristor, Diodes, Average -model Based VSC inverter at normal load

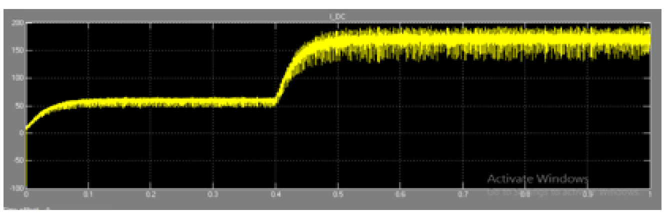

Figure 2-c Current signal of IGBT/Diodes, MOSFET / Diodes, GTO/Diodes, Ideal switches, Switching -function based VSC inverter at normal load

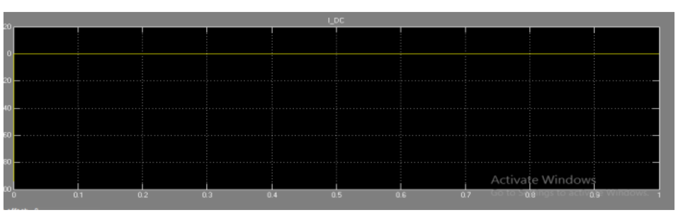

Figure 2-d Current signal of Thyristor, Diodes, Average -model based VSC inverter at normal load

Based on the observation of sub-transient and transient nature of voltage and current signals microgrid systems of different inverter configurations may be grouped into two categories as presented in Table 1. For group-A, voltage is exponentially decreasing during sub- transient & transient period and current is showing exponentially decreasing at sub transient & transient period and for group-B, voltage is ramp in nature and current is step in nature.

Table 1
Classification based on sub-transient and transient of Voltage and Current (V_{DC} and I_{DC})

CATEGORY	NAME	NATURE
Group –A	IGBT/Diodes, MOSFET / Diodes, GTO/Diodes, Ideal switches, Switching -function based VSC	Voltage is exponentially decreasing during sub-transient & transient period and current is showing exponentially decreasing at sub transient & transient period
Group –B	Thyristor, Diodes, Average-model based VSC	Voltage is ramp in nature and current is step in nature

IV. SUB-TRANSIENT AND TRANSIENT ACTIVE AND REACTIVE POWER BASED CLASSIFICATION AND DISCUSSION

Sub-transient and transient nature of active power and reactive power of different micro grid system of different inverter configurations has been analyzed. Active and reactive power of IGBT/Diodes, MOSFET / Diodes, GTO/Diodes, Ideal switches, Switching -function based VSC inverters are found of same nature as shown in Figure 3-a and that of thyristor and diode inverters are found of same nature as shown in Figure 3-b. however, the nature of active and reactive power of average - model based VSC inverter is different from them as shown in Figure 3-c.

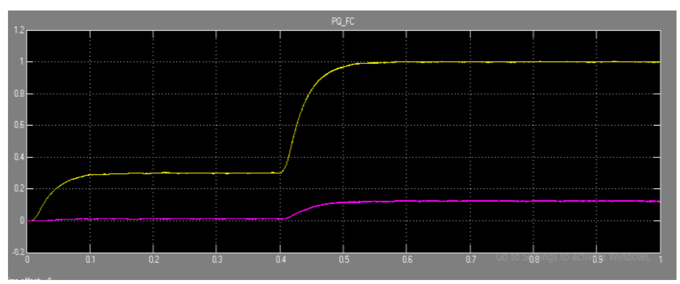

Figure 3-a Active power and reactive power across fixed capacitor signal of IGBT/Diodes, MOSFET / Diodes, GTO/Diodes, Ideal switches, Switching -function based VSC inverter at normal load

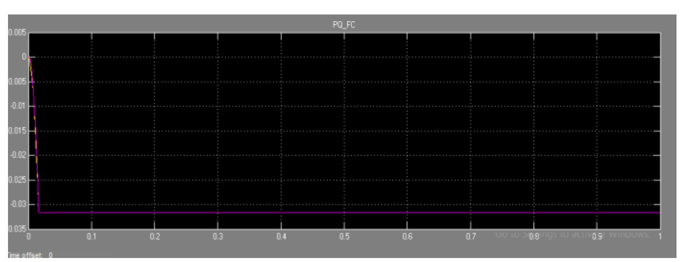

Figure 3-b Active power and reactive power across fixed capacitor signal of thyristor and diode inverter at normal load

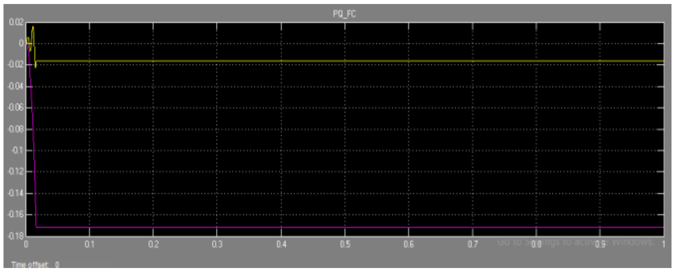

Figure 3-c Active power and reactive power across fixed capacitor signal of average -model based VSC inverter at normal load

Based on the nature of active and reactive power observed across the fixed capacitor for different inverters, microgrid systems are grouped into three categories as presented in Table 2. For group-A, Active power in both cases is exponentially increasing during sub-transient & transient period and then step in nature during steady state. For group-B, All powers are step in nature and for group-C, Active powers are showing oscillatory during sub-transient period before getting constant magnitude.

Table 2
Classification based on sub-transient and transient of active power and reactive power ($PQ_{\_FC}$)

CATEGORY	NAME	NATURE
Group –A	IGBT/Diodes, MOSFET / Diodes, GTO/Diodes, Ideal switches, Switching -function based VSC	Active power in both cases is exponentially increasing during sub-transient & transient period and then step in nature during steady state.
Group –B	Thyristor , Diode	All powers are step in nature
Group –C	Average -model based VSC	Active powers are showing oscillatory during sub-transient period before getting constant magnitude.

V. SUB-TRANSIENT AND TRANSIENT OF VOLTAGE ACROSS FIXED CAPACITOR BASED CLASSIFICATION

Sub-transient and transient of voltage across fixed capacitor of different micro grid systems of different inverter configuration have been analyzed. The voltage of IGBT/Diodes, MOSFET / Diodes, GTO/Diodes, Ideal switches, Switching -function based VSC inverters are found of same nature as shown in Figure 4-a. The nature of voltage for thyristor and diode inverters is different as shown in Figure 4-b. The voltage profile of average -model based VSC inverter is different from previous two as shown in Figure 4-c.

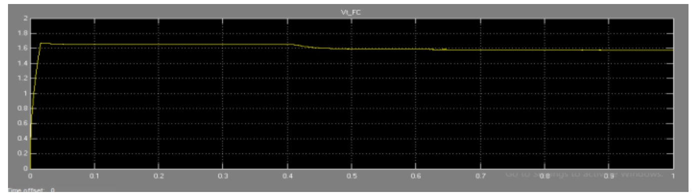

Figure 4-a Voltage signal across fixed capacitor of IGBT/Diodes, MOSFET / Diodes, GTO/Diodes, Ideal switches, Switching -function based VSC inverter at normal load

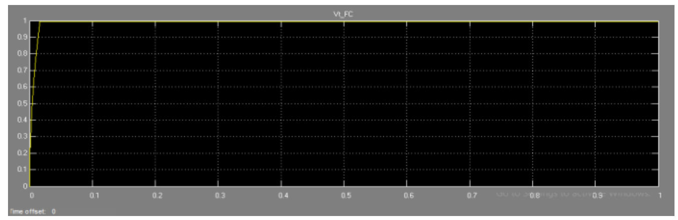

Figure 4-bVoltage signal across fixed capacitor of thyristor and diode inverter at normal load

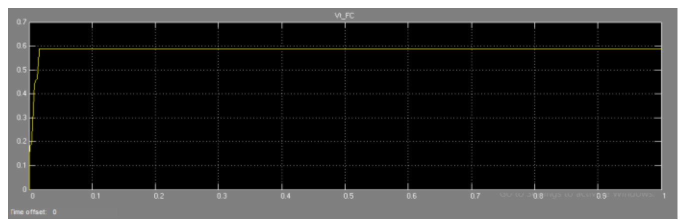

Figure 4-c Voltage signal across fixed capacitor of average -model based VSC inverter at normal load

Based on the observation made on voltage profile across fixed capacitor, micro-grids may be grouped into three categories as presented in Table 3. For group-A, voltage magnitude across fixed capacitor is almost step in nature. For group-B, voltage magnitude across fixed capacitor is perfect step in nature. For group-C, voltage magnitude across fixed capacitor is perfect step in nature having different initial rise.

Table 3
Classification based on sub-transient and transient of V_t across fixed capacitor (FC)

CATEGORY	NAME	NATURE
Group –A	IGBT/Diodes, MOSFET/Diodes, GTO/Diodes, Ideal switches, Switching-function based VSC	The voltage magnitude across fixed capacitor is almost step in nature
Group –B	Thyristor and Diode	The voltage magnitude across fixed capacitor is perfect step in nature
Group –C	Average -model based VSC	The voltage magnitude across fixed capacitor is perfect step in nature having different initial rise

VI. SUB-TRANSIENT AND TRANSIENT CURRENT BASED CLASSIFICATION

Sub-transient and transient of current after inversion different micro-grid system of different inverter configuration have been analyzed. The current of IGBT/Diodes, MOSFET/Diodes, GTO/Diodes, Ideal switches, Switching-function based VSC inverters are found of same nature as shown in Figure 5-a. The current of thyristor, diode and average-model based VSC inverters are found of different nature as shown in Figure 5-b.

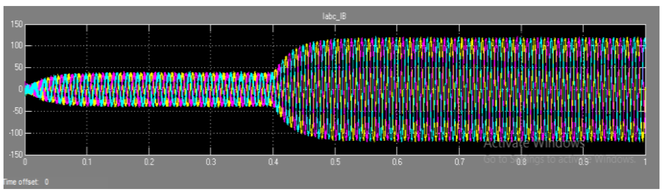

Figure 5-a Current signal after inverter of IGBT/Diodes, MOSFET/Diodes, GTO/Diodes, Ideal switches and Switching -function based VSC inverter at normal load

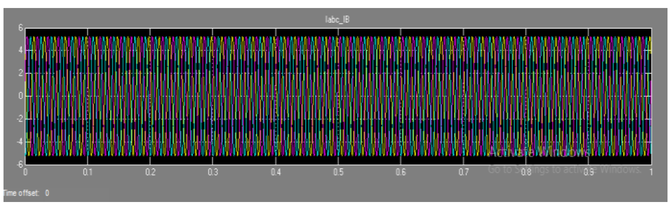

Figure5-b Current signal after inverter of thyristor, diode and average-model based VSC inverter at normal load

Based on the observation made on nature of current in fixed capacitor, micro-grids may be classified into two categories as presented in Table 4.

Table 4
Classification based on sub-transient and transient of current in fixed capacitor (FC)

CATEGORY	NAME	NATURE
Group –A	IGBT/Diodes, MOSFET/Diodes, GTO/Diodes, Ideal switches and Switching function based VSC	Current magnitude is increasing exponentially during sub-transient & transient period before getting constant magnitude
Group –B	Thyristor , Diode and Average model based VSC	Current is constant in magnitude from starting

VII. COMPARATIVE STUDY

Sub-transient and transient natures of various electrical parameters have been compared as presented in Table 5 which shows significant changes in those behaviours at normal load condition.

Table 5 Comparative chart based on sub-transient and transient behaviour of various electrical parameters

Type of Power Electronics Devices	**V_DC vs. Time & I_ DC vs. Time**	**PQ_FC vs. Time**	**V_t _ FC vs. Time**	**I_{abc} vs. Time**
IGBT/ Diodes	Voltage is exponentially decreasing during sub-transient & transient period And current is showing exponentially decreasing at sub transient & transient period	Active powers in both cases are exponentially increasing during sub transient & transient period & then step in nature during steady state	The voltage magnitude across fixed capacitor is almost step in nature	Current magnitude is increasing exponentially during sub transient & transient period before getting constant magnitude
Thyristor	Different and voltage is ramp in nature and current is step in nature	Different and all powers are step in nature	Different and the voltage magnitude across fixed capacitor is perfect step in nature	Different and current is constant in magnitude from starting
MOSFET / Diodes	Same as IGBT / Diodes	Same as IGBT/ Diodes	Same as IGBT / Diodes	Same as IGBT / Diodes
GTO / Diodes	Same as IGBT / Diodes	Same as IGBT/ Diodes	Same as IGBT / Diodes	Same as IGBT / Diodes
Diodes	Same as IGBT / Diodes	Same as IGBT/ Diodes	Same as IGBT / Diodes	Same as IGBT / Diodes
Switching Function based VSC	Same as IGBT / Diodes	Same as IGBT/ Diodes	Same as IGBT / Diodes	Same as IGBT / Diodes
Diodes	Same as Thyristor	Same as Thyristor and all powers are step in nature	Same as Thyristor and the voltage magnitude across fixed capacitor is perfect step in nature	Different and current is constant in magnitude from starting

VIII. SPECIFIC OUTCOME

Sub-transient and transient based classification of micro grid has been done in previous sections by studying various type of models used in micro grid system using IGBT/Diodes, MOSFET/Diodes, GTO/Diodes, Ideal switches, Switching -function based VSC, Thyristor, Diodes, Average -model based VSC units. Sub-transient and transient behaviour of different useful electrical parameters like voltage, current, active power, reactive power, etc have been observed at normal load condition. Based on the observation, sub-transient and transient based classification of different types of present day micro grid systems has been done with respect those useful electrical parameters as follows:

- Sub-transient and transient voltage and current based classification: two groups are found
- Sub-transient and transient current based classification: two groups are found
- Sub-transient and transient active and reactive power based classification: three groups are found
- Sub-transient and transient of voltage across fixed capacitor based classification: three groups are found

IX. CONCLUTION

In this work, transient and sub-transient based classification of micro grid has been done. This has been done by studying various type of models used in micro grid system using IGBT/Diodes, MOSFET/Diodes, GTO/Diodes, Ideal switches, Switching-function based VSC, Thyristor, Diodes and Average-model based VSC units. Different useful electrical parameters like voltage, current, active power, reactive power, etc have been observed. Sub transient and transient behaviour of those parameters have been observed at normal load condition. Based on the observation, sub-transient and transient based classification of different types of present day micro grid systems has been done with respect those useful electrical parameters, which may be useful for modelling, synchronization, and protection and performance analysis of various micro grid systems.

REFERENCES

[1] https://building-microgrid.lbl.gov/about-microgrids, Microgrid at Berkeley Lab, U.S. Department of Energy.

[2] RamakrishnanVenkatraman & Siddhartha Kumar Khaitan, *"A Survey of Techniques for Designing and Managing Microgrids*", IEEE PES GM 2015, 2015 IEEE Power & Energy Society General Meeting, , Pages: **1 - 5**, DOI**: 10.1109**/PESGM.**2015.7286590,** Year : **2015**.

[3] San Diego, California S.K. Sharma, "*Performance Analysis of Reactive and Proactive Routing Protocols for Mobile Ad-hoc – Networks"*, International Journal of Scientific Research in Network Security and Communication, Vol.**1,** No.**5**, pp.**1-4**, **2013**.

[4] IEC- 61850-7-420.IEEE-1547 (Standard for Interconnecting Distributed Resources with Electric Power Systems) IEEE-1547.4(Standard for Defining installation, design practice equipment parameter of Micro grid)

[5] Hatziargyriou, Nikos, "Microgrids *Architectures and Control*" John Wiley and Sons Ltd. p. 4. ISBN 978-1-118-72068-4, 2014.

[6] S Chattopadhyay, M Mitra, S Sengupta, *" Electric Power quality"* , Springer, First Edition, **2011 .**

[7] Ambarnath Banerji, Debasmita Sen, Ayan K. Bera, Debtanu Ray, Debjyoti Paul, Anurag Bhakat, Sujit K. Biswas, *"Microgrid: A review -2013",* IEEE Global Humanitarian Technology Conference**: South Asia Satellite**, Pages:**27-35**, DOI:**10.1109**/ GHTC-SAS.**2013.6629883**, **2013**.

[8] Saeed Anwar, AliElrayyah and Yilmaz Sozer, "*Harmonics elimination and distribution using decentralized control for microgrid applications",* - Energytech, 2013, IEEE Xplore: Electronic ISBN: **978-1-4673-4444-9**, INSPEC Accession Number: **13867164, 2013**.

[9] Snehamoy Dhar & Pradipta Kishore Dash,"*Performance analysis of a new fast negative sequence power injection oriented islanding detection technique for photovoltaic based voltage source converter based micro grid operation*"-IET Generation, Transmission & Distribution (Volume**: 9**, Issue: **15, 11 19 2015**, Page(s): **2079 – 2090, 2015.**

[10] Dinesh Kumar & Firuz Zare, "*Harmonic Analysis of Grid Connected Power Electronic Systems in Low Voltage Distribution Networks",* IEEE Journal of Emerging and Selected Topics in Power Electronics Volume**: 4**, Issue: **1**, Page(s): **70 - 79**, INSPEC Accession Number: **15754626, 2016.**

[11] Blessy Sabu & Anns George, "*Harmonic mitigation in minigrid integrated distributed power system"*, Circuit, Power and Computing Technologies (ICCPCT), 2016 International Conference on, Date of Conference: **18-19**, Added to IEEE Xplore: 04, INSPEC Accession Number: **16195204, 2016.**

[12] Kai Yu, Qian Ai, Shiyi Wang, Jianmo Ni, Tianguang Lv "*Analysis and Optimization of Droop Controller for Microgrid System Based on Small-Signal Dynamic Model",*-IEEE Transactions on Smart Grid (Volume: **7**, Issue: **2**, Page(s)**: 695 - 705**, INSPEC Accession Number: **15786882,** Date of Publication: **24 November 2015.**

[13] Shailendra Singh, Rohit Kumar Verma, Ashish Kumar Shakya, Satyendra Pratap Singh, *" Frequency stability analysis of hybrid power system based on solar PV with SMEs unit, Emerging Trends in Electrical Electronics & Sustainable Energy Systems (ICETEESES)",* International Conference , Venue: Kamla Nehru Institute Of Technology, Sultanpur, **India, 2016.**

[14] Rashad M. Kamel *"New inverter control for balancing standalone micro-grid phase voltages: A review on MG power quality improvement",*Renewable and Sustainable Energy Reviews-Elsevier, September **2016**

[15] Pritha Roy, J. N. Bera, S. Chowdhuri & G. *Sarkar " Synchronization aspects of single phase SPWM inverters for microgrid mode of operation"*, Control, Instrumentation, Energy & Communication (CIEC), 2nd International Conference, IEEE Xplore: **18 July 2016**, INSPEC Accession Number: **16156428,** Date of Conference**: 28-30** Jan. **2016**.

[16] Mohammad Golsorkhi, Mehdi Savaghebi, Dylan Lu, Josep Guerrero, Juan Vasquez *"A GPS- Based Control Framework for Accurate Current Sharing and Power Quality Improvement in Microgrids",* IEEE Transactions on Power Electronics (Volume: PP, Issue: **99**) Page(s): **1 - 1** Date of Publication: 07 September **2016.**

[17] Alireza Kahrobaeian and Yasser Abdel-Rady I. Mohamed, *"Interactive Distributed Generation Interface for Flexible Micro-Grid Operation in Smart Distribution Systems"*, IEEE Transactions on Sustainable Energy (Volume: **3**, Issue: **2,** Page(s): **295 - 305**, Date of Publication: 19 March **2012**.

[18] Weiqiang Chen, Ali M. Bazzi, James Hare, Shalabh *Gupta "Real-time integrated model of a micro-grid with distributed clean energy generators and their power electronics"*, Applied Power Electronics Conference and Exposition (APEC), **2016** IEEE (**USA**), INSPEC Accession Number: **15987282,** Date of Conference:**20-24 March 2016.**

[19] Haidar Samet *"Evaluation of digital metering methods used in protection and reactive power compensation of micro-grids"*, Renewable and Sustainable Energy Reviews, Volume **62**, Pages **260–279**, Publisher: Elsevier, Date: September **2016**.

[20] T. K. Das, A. Banik, S. Chattopadhyay, A. Das*, "Sub-harmonics based String Fault Assessment in Solar PV Arrays"*, Modelling and Simulation in Science, Technology and Engineering Mathematics – Proceedings of International conference on Modeling and Simulation(MS-17), ISBN-**9783319748078**, computer science, ISSN-**21945357**, paper ID-**132**, Kolkata, **India**, 4th -5th November, **2017.**

[21] T. K. Das, S. Chattopadhyay, A. Das, *"Load Bus Symmetrical Fault Analysis in Microgrid System"*, Lectures on Modelling and Simulation (AMSE), ISSN-**1961-5086**, pp **151-162**, **France,** November, **2017.**

[22] T. K. Das, S. Chattopadhyay, A. Das, *"Line to Line Short Circuit Fault Diagonisis in Photo-Voltaic Array based Microgrid System"* , Modelling Measurement and Control, Series A. General Physics and Electrical Application (AMSE) , ISSN-**1259-5985**, pp **341-352** , **France,** November**, 2017.**

AUTHOR'S PROFILE

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