Performance Analysis of a Grid Connected PV-Wind with Super Capacitor Hybrid Energy Generation & Storage System

S. Viswalingam, G. Emayavaramban, M. Siva Ramkumar, A. Amudha, K. Balachander, S. Divyapriya, IR.V. Mohamed Mansoor

Abstract--- ***The usage of renewable energy like solar photovoltaic (PV), wind [1] and super capacitor is garnering muchpopularity due to the environmental awareness and progress in technology combined with reduced manufacturing overhead. Power electronic converters are generallyutilizedfor converting the power from the renewable sources to match with the load demand and grid needs to enhance the dynamic and steady-state characteristics of these green generation systems, to yield the maximum power point tracking (MPPT) control, and the energy storage system to resolve this problem. With the aim of improving the efficacy and the power density of the overall circuit, the usage of a three-port DC-DC converter [3] that comprises of a DC input port for the renewable source, a bidirectional DC input port for the energy storage system, and a DC output port for driving the load, is a desirable solution to the conventionaltechniqueemploying two DC-DC converters: one for the renewable sources and another for the energy storage system. Recently, several DC-DC three-port converters have been introduced and studied in the literature. In this research, a comparison made on the characteristics of various topologies of three-port DC/DC converters, which have been introduced by various research groups is reviewed in brief. The research work also explains the probable research expansion of the topologies from three-port DC-DC converters with three switches and single inductor [9] and minimizes the switching losses and supplies the power to grid. The simulation of the proposed system is donewith MATLAB/SIMULINK environment.***

Keywords---*PV,* ***MPPT,Three Point DC-DCConverter, Super Capacitor, PI Controller, Matlab/Simulink.***

I. INTRODUCTION

The power generated from renewable power sources is differentialby nature, and may havenon-permissiblevariations that can be mitigated with the help of energy storage systems. But, the expensein cured in batteries and their short lifetime are criticaldrawbacks. In order to resolve these issues, an improvement comprising of the co-operative relationship of batteries and super capacitors has been evaluated. However, these studies don't deal with the case of residential and large-scale photovoltaic systems in detail. In this project work, a chosen combined topology and a novel control approach isintroduced to regulate the power sharing between batteries and super capacitors. In addition, a technique for the sizing of the energy storage system [4] along with the hybrid distribution depending on the photovoltaic power curves is presented. This inventive contribution not justminimizes the stress levels on the battery [5], and thereforemaximizes its life time, but also renders a consistent power delivery to the grid during a pre-defined time interval. The newly introduced approach is then validated by elaborate simulation and experimental tests.

In this research work, discussion on the system of wind generator and PV panel [11] connected to the grid is carried out. The unit wind generator and indicative solar data converted to relative values were utilized. The ratio between energy amount entering the grid and the generated energy was evaluated for various energy needs in case of fluctuating wind power levels and solar irradiation intensities. If the generated and consumed in site yearly energy is equivalent, then the amount of energy delivered to grid and consumed is approximately equivalent to 50% of the energy generated. With the rise in the wind energy part, this ratio reduces. Wind – PV panels' solution is the most efficient in case of energy sold to the grid during the period of less demand.

II. LITERATURE SURVEY

2.1. DFIG Voltage Control Based on Dynamically Adjusted Control Gains

ZhiqiangJinet al., Therisingapplication of wind power introduces several technical problems to power system operations. Onepre-dominant challenge is the demand of voltage control to keep up the constant terminal voltage of a wind plant to render it a PV bus similar to traditional generators with excitation control. In the earlier work for regulating the wind plant, particularly the Doubly Fed Induction Generator (DFIG) system, the proportional-integral (PI) controllers are used generously.

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These techniquesgenerallyhave to tune the PI controllers [8] to get control gains in the form of a balance or compromise among different operating situations.

In this research work, a novel voltage control scheme depending on another principle issuggested. In the newly introduced mechanism, the dynamic adjustment of the PI control gains for the DFIG systems are done depending on the dynamic, continuous sensitivity thatnecessarilyrepresents the dynamic association between the variation in control gains and the necessary output voltage. Therefore, this control mechanism does not need any good estimation of stable control gains since it exhibits the self-learning mechanism through the dynamic sensitivity. This also provides the plug-and-play feature of DFIG controllers to render it useful in utility practices. The results ofsimulation show that the performance of the newly introducedscheme meets the expectations under different operating conditions.

2.2. Stability Analysis for a PI Controller of a DFIG Wind Power System When the Parameter are Uncertainties

AbdelkarimChemidi et al.,Generally, the parameters of the electrical machines are ambiguousowing to the diverse condition like temperature. For computing the regulators of the inverter control, it is necessary to consider these uncertainties. In this research work, a reliable PI controller with stability analysis dependent on Kharitonv theorem is introduced for a double fed induction generator where the parameters have uncertainties. With the aim of verifying the reliability of the PI controller, the Nyquist diagram is useful in analyzing the system's stability. Key-Words— Wind power system, Double fed induction generator (DFIG), parametric uncertainty, PI controller, Kharitonov theorem.

2.3. Power Control of Wind Energy Conversion System based doubly Fed Induction Generator

KamelDjamelEddineKerroucheet al., Theobjective of this research work is to introduce varioustechniques of control for a Doubly-Fed Induction Generator (DFIG) utilized in wind energy conversion systems. This workintroduces a comparative analysis on the performance of three control approaches for DFIG wind turbine. The comparison highlights on the control of the active and reactive power exchanged between the generator and the grid by the generator inverter employing the control algorithm depending on vector control concept (stator flux orientation), with conventional PI controllers: proportional–integral. The various techniques of control for the generator are simulated in MATLAB / SIMULINK and explained. Hence, a conclusion is made on which method is a desirable control of DFIG in Wind Energy Conversion System.

2.4. PI Controller for Control of Active and Reactive Power in DFIG Operating In a Grid-Connected Variable Speed Wind Energy Conversion System

Azzouz Tamaarat et al, Owing to various factors, wind energy has emerged to be an important kind of electricity generation. The contribution of this kind of energy in the network is increasing exponentially. The aim of this project work is to introduce the modelling and control mechanism of a grid connected wind power generation approach employing a doubly fed induction generator (DFIG) powered by the rotor.

This research work presents the overallmodeling and simulation of a wind turbine driven DFIG in the second mode of operation (the wind turbine pitch control is deactivated here).

It will present the vector control that renders it feasible to independently control the active and reactive power that is exchanged between the stator of the generator and the grid, depending on vector control concept (with stator flux or voltage orientation) with conventional PI controllers. Different simulation tests are carried out to monitor the system behavior and assess the performance of the control for some optimization criteria (energy efficiency and the reliability of the control). It is also exciting to work on the quality of electric power by regulating the reactive power that is exchanged with the grid that, in turn, will help in carrying out a local correction of power factor.

2.5. A Study of Wind Speed Characteristic in PI Controller based DFIG Wind Turbine

T. Unchim et al., The Wind Turbine Modeling in Wind Energy Conversion System (WECS)[7] using Doubly-Fed Induction Generator (DFIG) PI Controller based design is introduced to analyze about the differential wind speed. The PI controller operates in response to the dynamic performance. The aim is to evaluate the characteristic of wind turbine and getting the optimum wind speed appropriate for wind turbine performance. This system will permit for the specification setting (2.5MW). The output active power that also corresponds to the same input is provided. Then the reactive power generated by the wind turbine is controlled at 0 Mvar. Differential wind speed is optimum for drive train performance at 12.5 m/s (at maximum power coefficient point) from the simulation of DFIG by Simulink is explained.

III. PROPOSED MODULE

3.1 Proposed Topology and Operational Principle

Three-port DC/DC converter offers the benefits of less component count, less conversion stages, economic and greater reliability. IMPTC[13-31] contains two groups: Non-isolated and isolated topologies.

Non-isolated is found to perform better than isolated one as in Non-isolated converter isolation is not necessary and non-isolated converter has the benefits of sleek design and greater power density. Various kinds of non-isolated DC/DC converters [10] are as below:

- Buck (Step down) converter.
- Boost (Step up) converter.

3.1.1. Buck (Step Down) Converter

Buck converter is also referred to as step down converter since the output voltage is lesser than the input voltage. If the switch is in open state, current passing through inductor is zero. If switch is in closed state, the current through inductor increases linearly and the inductor will generate an opposing voltage across its terminals responding to the varying current.

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This voltage drop balances the voltage of the source and hence decreases the net voltage across the load.

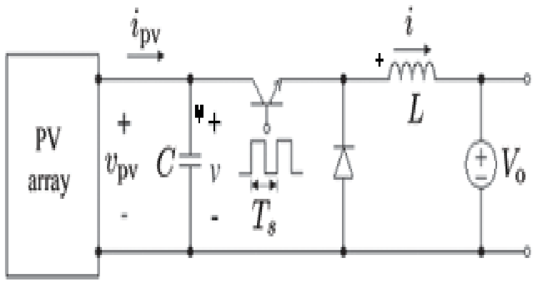

Figure 3.1: Buck Converter

3.1.2. Boost (Step Up) Converter

Boost converter is also called as step up converter as the output voltage is higher compared to that of input voltage.

- If the switch is closed, then the current flowing through the inductor increases in clockwise direction and the inductor stores some amount of energy through the generation of a magnetic field. The polarity of the left side of the inductor is positive.
- If the switch is opened, then the inductor current will be decreased since the impedance is greater. The magnetic field earlier produced will be disrupted, so as to maintain the current flowing towards the load.
- This way, the polarity will get reversed (indicating that left side of inductor will become negative now). Consequently, the two sources will be in series resulting in a higher voltage for charging the capacitor through the diode D.

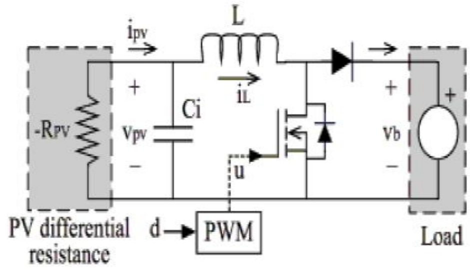

Figure 3.2: Boost Converter

3.1.3. PLL

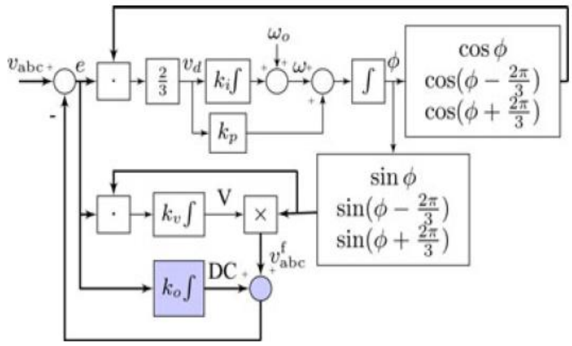

Figure 3.3: Phase Lock Loop (PLL)

New three-phase phase-locked loop (PLL) system, which does the primary estimation of the phase angles, frequency, and magnitudes of the three-phase input signal and also yields a filtered variant of the input is illustrated in figure 3.1.

Then it isimproved for the estimation of the sequence components, their magnitudes, and phase angles.

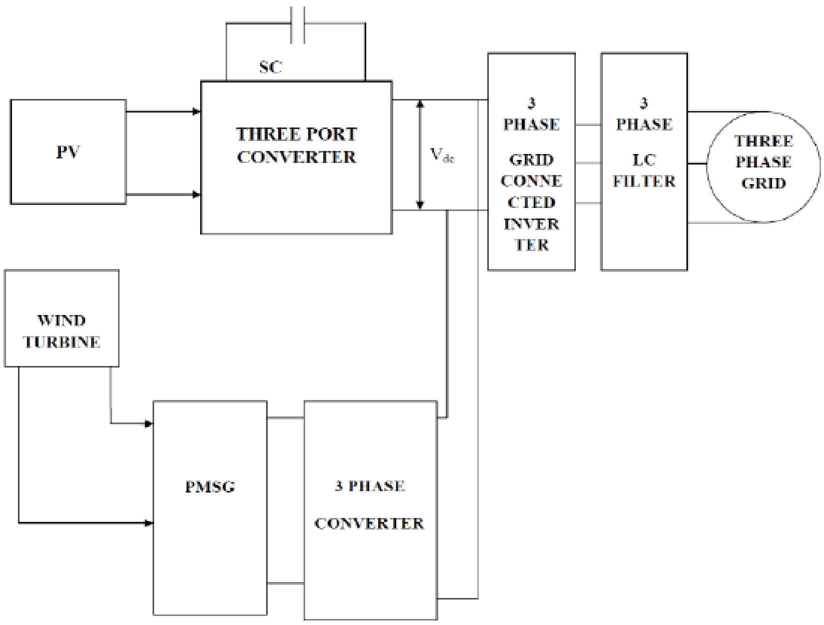

Figure 3.4: Proposed Block Diagram

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In comparison with the classical three-phase PLL [4], this technique is not affected by errors, which result from the signal imbalance non linear load.

It also yields the estimate for various other variables that are not included in the classical three-phase PLL. In comparison with the technique of making use of three independent single-phase enhanced PLLs, the newly introducedapproachprovides a simpler structure. In addition, the estimated frequency offers more accuracy and also smoothness since it makes use of the information from all the three phases for estimating one single value for frequency.

The research also introduces a change, which rendersthe PLL parameters not dependent on the input signal amplitude. The same change applies to the availabletechniques likeclassical three-phase PLL. The results of simulation are studied in order to ensurethe commendable performance of the newly introducedtechnique.

3.2 Working Principle of the Proposed Converter

By merging any two of the three elementary converters (buck, boost, and buck-boost converter)[12], a family of new one inductor three-port DC-DC converters is introduced in this research. These converters make use of just one switch to deal with the power distribution amongst the three ports that decreases the size and expense of the converter considerably. This converter is designed through the integration of two conventional buck converters together.

By integrating a two-inductor boost converter & buck converter together and making use of one inductor to implement the voltage-second balance of all of the inductors, a three-port converter with three switches in addition to one inductor is studied in this concept. It will decrease the cost involved in the system and also decreases the switching losses and increases the system stability, when simultaneously improving the system performance. Owing to reactive power compensation, excessive power afterthe drawing of load, power gets injected into the grid better.

In this technique, voltage control loop is used for activation of charging, discharging the supercapacitor [6]and control of MPPT for tracking the maximum power from PV and for wind energy, speed of the machine is used with the aid of wind turbine and pitch angle control.S1 switch is employed for MPPT control.S2 switch is helpful in discharging the supercapacitor and S3switch is useful in charging thsupercapacitor.

3.4. PI Controller

3.4.1. Introduction

PI controller will suppress the forced oscillations and steady state error leading to the operation of on-off controller and P controller correspondingly. But the introduction of integral mode has an adverse effect on the speed of the response and the total stability of the system.

This way, the PI controller will not improve the speed of response. It can be anticipated, as the PI controller does not have any way to guess what will occur with the error in the future.

This issue can be resolved by the introduction of derivative mode that has the capability of predicting what will occur with the error in the future and thereby reduce the controller's reaction time. PI controllers are very frequently employed in industry, particularly if the speed of the response is not a problem.

A control without D mode is employed if:

a) Quick response of the system is not necessary

b) Massivedistortions and noise exists duringtheoperation of the process

c) There is just one energy storage in process (capacitive or inductive)

d) There are huge transport delays in the system.

In control engineering, a PI Controller (proportional-integral controller) acts as a feedback controller that powers the plant to be regulated by a weighted sum of the error (difference between the output and necessary set-point) and the integral of that value. It is a special scenario of the PID controller in which the derivative (D) part of the error is not brought into use.

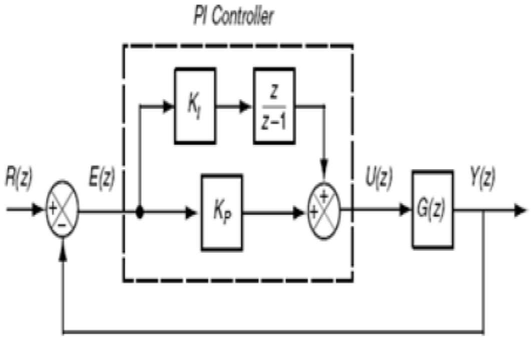

Figure 3.5: PI Controller

Integral control action merged to the proportional controller transforms the actual system into high order. Therefore, the control system may be rendered unstable for a huge value of K_p.As the roots of the characteristic eqn. may have positive real part. In this kind of control, proportional control action tries stabilizing the system, whereas the integral control action tries to suppress or decrease the steady-state error in response to different inputs. When the value of T_p is improved, in the primitive history of automatic process control the PID controller was realized in the form of a mechanical device. These mechanical controllers were utilized in the form of a lever, spring and a mass and were frequently powered by compressed air. These pneumatic controllers remained the industry standard once. Electronic analog controllers can be derived from a solid-state or tube amplifier, a capacitor and a resistance.

IV. SIMULATION RESULTS

4.1. MATLAB R2011a

The simulation of this project output is done in MATLAB R2011b tool that is user friendly software.

MATLAB is a high-level language and interactive environment used for numerical computation, visualization, and programming. Making use of MATLAB, data can be analyzed, algorithms can be developed, and models and applications can be created.

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The language, tools, and built-in math functions facilitate in exploring several schemes and attain a solution quicker compared to spreadsheets or conventional programming languages, like C/C++ or Java™.

MATLABcan be used for a range of applications, inclusive of signal processing and communications, image and video processing, control systems, test and measurement, computational finance, and computational biology. Several million engineers and scientists in industry and academia make use of MATLAB, which is the language of technical computing, Simulink is a data flow graphical programming language tool used for modeling, simulation and analysis of multi domain dynamic systems.

Its foremost interface is basically a graphical block diagramming tool and a customizable group of block libraries. It provides a strong integration with the remaining of the MATLAB environment and can either help in driving MATLAB or be scripted from it. Simulink is extensively utilized in control theory and digital signal processing for multi domain simulation and Model-Based Design.

4.2. Simulation Diagram of Proposed Method

Renewable sources like solar photovoltaic (PV) and wind and then SC are finding extensive application due to the environmental concerns and progress made in the technology and fast reducing manufacturing cost.

But, the intermittent characteristic of the renewable sources and the uncertainty of the demand for loadhas created a problem for the extensiveencouragementto these clean energy sources. Hence, power electronic converters with energy storage systems are generallyutilizedfor converting the output power from the PV panels, so as to match with the load demand, to enhance the dynamic and steady-state features of the green generation systems, to yield MPPT control, and to merge the energy storage system to tackle with the problem of the inconsistent nature of the renewable energy and the uncertainty of the load demand.

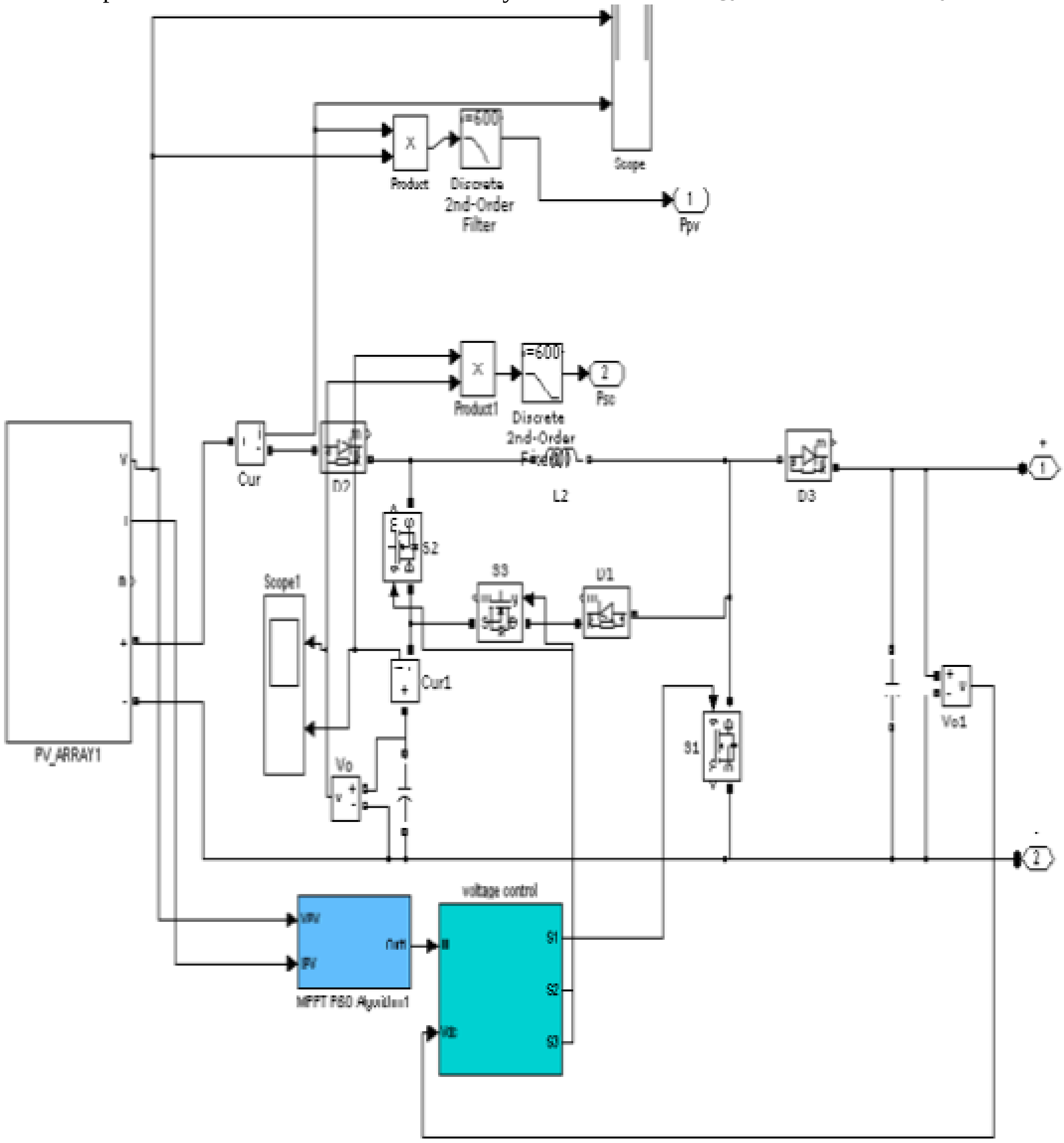

Figure 4.1: Simulation Diagram of TPC-PV-SC-Wind Energy System for Grid Connected System

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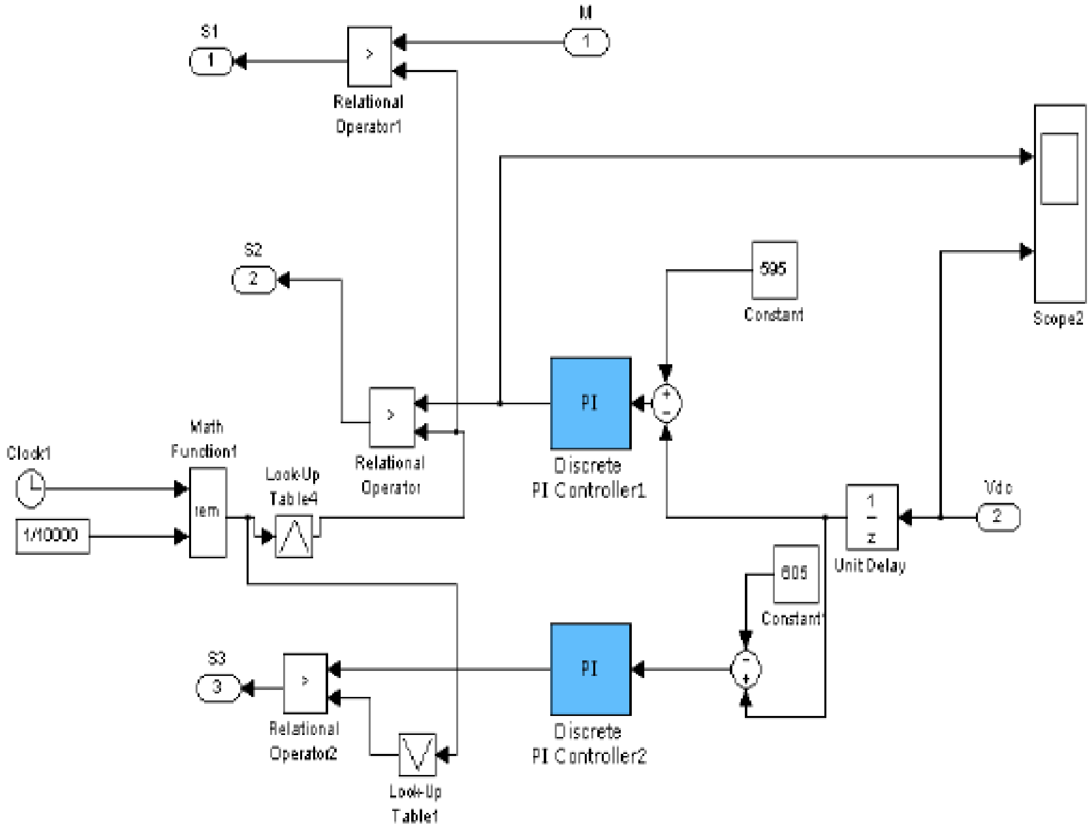

Figure 4.2: Simulation Diagram of PV-MPPT with Voltage Control System

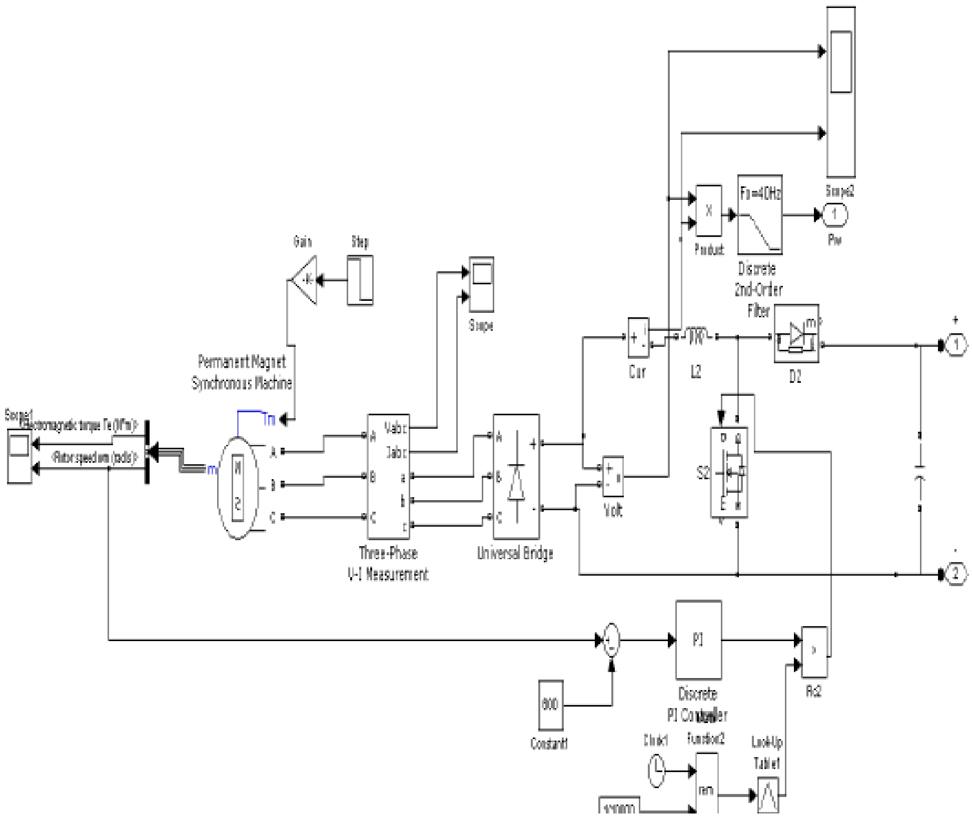

Figure 4.3: Simulation Diagram of Voltage Control Loop

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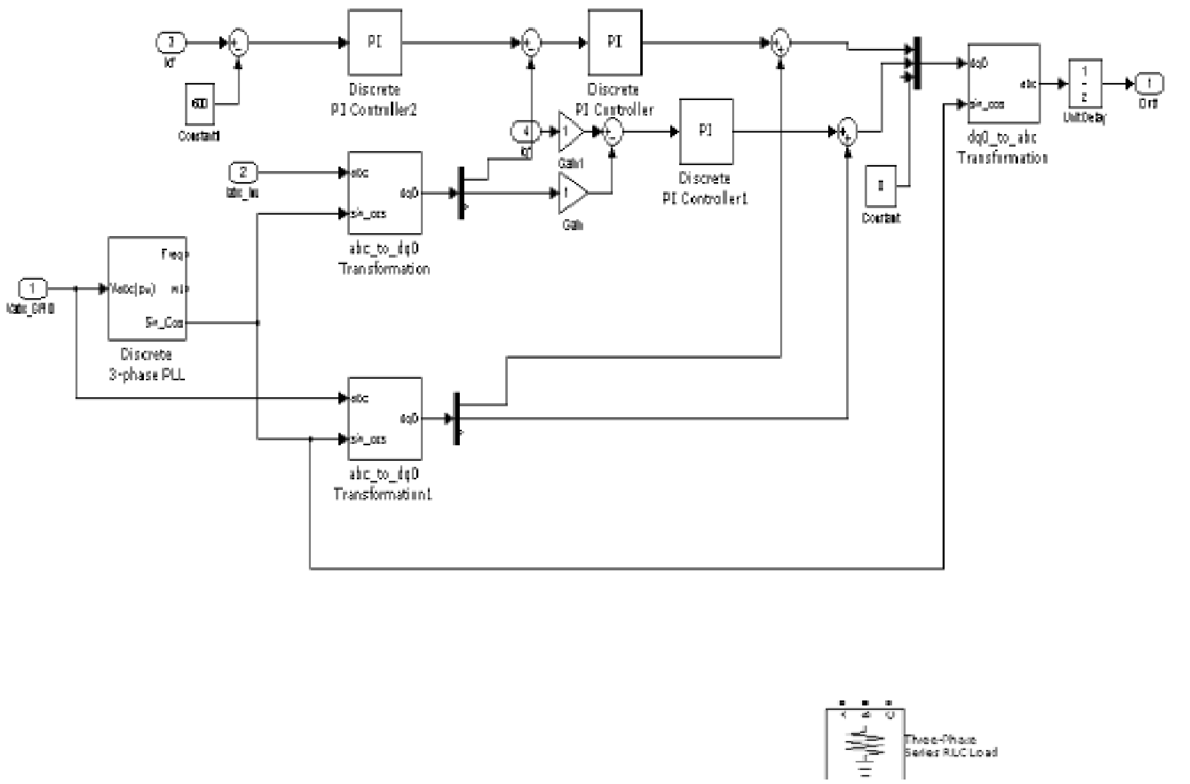

Figure 4.4: Simulation Diagram of Wind Energy System (PMSG)

Even though the terms of power quality hold true for transmission and distribution systems, their mechanism towards power quality has various aspects.

An engineer working on a transmission system tackles with controlling the active and reactive power flow so as to increase both the loading capability and stability constraints of the transmission system.

A three-port DC-DC converter with high voltage conversion ratio is introduced, which is based on a unidirectional three-state switching cell.

Owing to the generic characteristics of this converter's structure, all of the switches can work under the soft switching condition over an extensive operational range and with minimized voltage stresses that can lead to higher overall efficiency and system stability. The features like high-gain, superior efficiency and soft switching of the converter has been accomplished. It is confirmed by the results shown below.

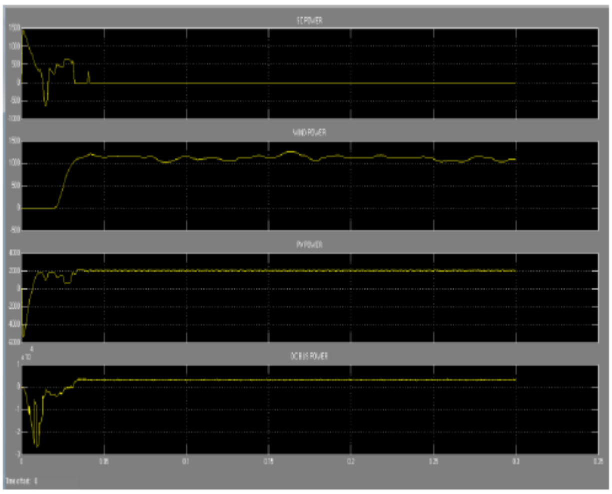

Figure 4.5: Simulation Diagram of PI Controller unit

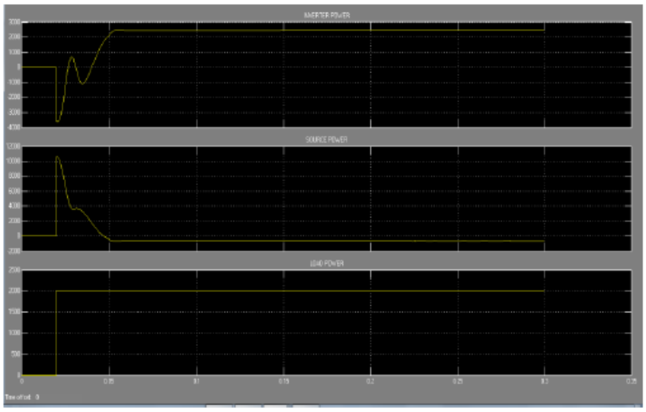

Figure 4.6: Simulation Output of SC/WIND/PV/DC Bus Power

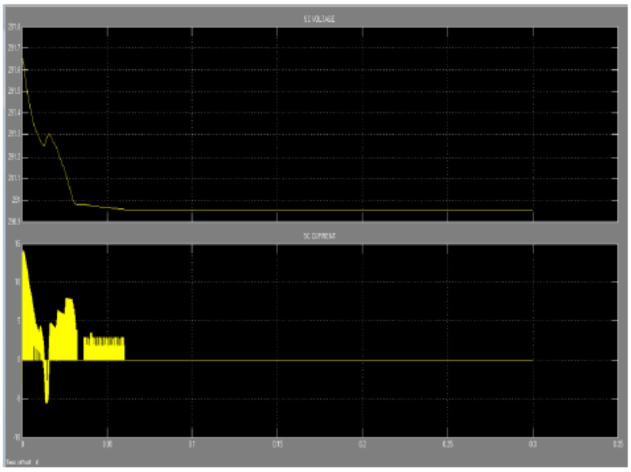

Figure 4.7: Simulation Output of Inverter/Source/Load Power

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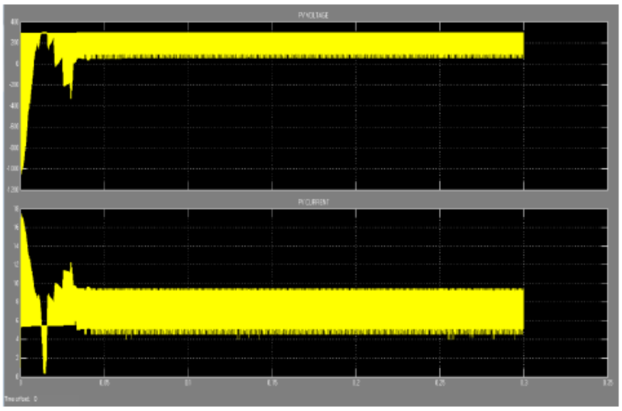

Figure 4.8: Simulation Output of Supercapacitor Voltage/Current

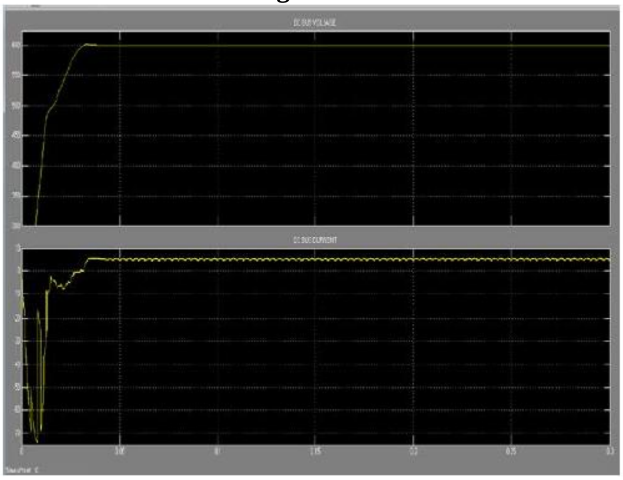

Figure 4.9: Simulation Output of PV Voltage/Current

V. CONCULSION

This project has studied the literature review on the topologies employed for the three-port DC-DC converters. The review highlights that the research of three-port DC-DC converters has made considerableimproved and has also garneredfor mixable interest from researchers focusing in the area of combining renewable energy and energy storage systems to get over the inconsistent nature of renewable energy resources. The common operation principles and various topologies of the three-port DC-DC converters are studied.

The three-port DC-DC converter mechanisms usually outperform the classical two-stage architecture of renewable energy and energy storage system in terms of system stability, efficiency, power density, size, and cost of the converter. With the aim of encouraging the extensive application of three-port DC-DC converters in the integration of renewable resources and energy storage systems, future research has to be performed in order to improve the voltage gain of the converter and to develop new three-port DC-AC inverters.

REFERENCES

1. Sinha S., Chandel S. S. Review of recent trends in optimization techniques for solar photovoltaic-wind based hybrid energy systems. Renewable Sustainable Energy Rev 2015; 50: 755–769.
2. Rehman Z., AI-Bahadly I., Mukhopadhyay S. Multiinput DC-DC converters in renewable energy applicatons-An overview. Renewable Sustainable Energy Rev 2015; 41: 521-539.
3. Sun K., Zhang L., Xing Y., Guerrero J. M. A distributed control strategy based on dc bus signaling for modular photovoltaic generation system with battery energy storage. IEEE Transaction on Power Electronics 2011; 26 (10):3032 - 3045.
4. Víctor Manuel Miñambres-Marcos, “A Grid Connected Photovoltaic Inverter with Battery-Supercapacitor Hybrid Energy Storage,” Sensors, August 2017.
5. Choi, M.; Kim, S.; Seo, S. Energy Management Optimization in a Battery/Supercapacitor Hybrid Energy Storage System. IEEE Trans. Smart Grid 2012, 3, 463–472.
6. Mendis, N.; Muttaqi, K.; Perera, S. Management of Battery-Supercapacitor Hybrid Energy Storage and Synchronous Condenser for Isolated Operation of PMSG Based Variable-Speed Wind Turbine Generating Systems. IEEE Trans. Smart Grid 2014, 5, 944–953.
7. Etxeberria, A.; Vechiu, I.; Camblong, H.; Vinassa, J. Comparison of Sliding Mode and PI Control of a Hybrid Energy Storage System in a Microgrid Application. Energy Procedia 2011, 12, 966–974.
8. Chen Y., Wen G., Peng L., Kang Y., J. Chen. A family of cost-efficient non-isolated single-inductor three-port converters for low power stand-alone renewable power applications. In: APEC; 2013: 1083 - 1088.
9. Chen Y. M., Yu X., Huang A. Q. A new non-isolated three-port DC/DC converter with high step-up/down ratio. In:ECCE; 2012: 1520 - 1526.
10. Zhu H., Zhang D., Zhang B., Zhou Z. A non-isolated three-port DC-DC converter and three-domain control method for PV-battery power systems. IEEE Transactions on Industrial Electronics 2015; 62(8): 4937–4947.
11. Alves D. B. S., Praca P. P., Oliveira Jr. D. S., Barreto L. H. S. C., de Freitas L. C. G. A single-stage three-port boost converter with high voltage gain based on the bidirectional version of the three-state switching cell. In: APEC;
12. Zhang P., Chen Y., Zhou Z., Kang Y. The cost-efficient, common-ground, non-isolated three-port converter deduced from the single-inductor dual-output topology. In: APEC; 2015: 2020 - 2025.
13. Qian Z., Rahman O. A., Al-Atrash H., Batarseh I. Modelling and control of three-port DC/DC converter interface for satellite applications. IEEE Transactions on Power Electronics 2010; 25(3): 637–649.
14. Qian Z., Rahman O. A., Reese J., Atrash H. A., Batarseh I. Dynamic analysis of three-port DC/DC converter for space applications. In: APEC; 2009: 28 - 34.
15. Dr.A.Amudha,M.SivaRamkumar, M.,SivaramKrishnan “Perturb and Observe Based Photovoltaic Power Generation System For Off-Grid Using Sepic Converter” International Journal of Pure and Applied Mathematics, 114(7), pp. 619-628,2017.
16. M.SivaRamkumar, M.Sivaram Krishnan, Dr.A. Amudha “Resonant Power Converter Using GA For PV Applications” International Journal Of Electronics, Electrical And Computational System, 6 (9) pp239-245, 2017.
17. M.SivaRamkumar, M.Sivaram Krishnan, Dr.A.Amudha “Impedance Source Inverter and Permanent Magnet Synchronous Generator For Variable Speed Wind Turbine ” International Journal of Computer & Mathematical Sciences (IJCMS) 6 (9) pp 98-105, 2017.

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18. M.SivaRamkumar "Unmanned Automated Railway Level Crossing System Using Zigbee" in International Journal of Electronics Engineering Research (IJEER) 9 (9) pp1361-1371, 2017.
19. M. Sivaram Krishnan M. Siva Ramkumar and A. Amudha "Frequency Deviation Control In Hybrid Renewable Energy System Using Fc-Uc" in International Journal of Control Theory and Applications (IJCTA) 10 (2) pp 333-344, 2017.
20. M Siva RamKumar, Dr.A. Amudha, R. Rajeev "Optimization For A Novel Single Switch Resonant Power Converter Using Ga To Improve Mppt Efficiency Of Pv Applications" in International Journal of Applied Engineering Research (IJAER) 11(9) pp 6485-6488, 2016. .
21. M.SivaramKrishnan, M.SivaRamkumar andM.Sownthara "Power Management Of Hybrid Renewable Energy System By Frequency Deviation Control" in 'International Journal of Innovative Research in Science, Engineering and Technology' on 3 (3) pp 763-769, 2016.
22. R.Sudhakar and M.SivaRamkumar "Boosting With SEPIC" in 'International Journal of Engineering and Science' 3 (4) pp 14-19,2014.
23. M.Sownthara and M.SivaRamkumar "Wireless Communication Module To Replace Resolver Cable In Welding Robot" in International Journal of Advanced Information Science and Technology on 23(23) pp 230-235,2014.
24. M.SivaRamkumar and M.Sivaram Krishnan "Hybrid Solar-Wind Energy System" in 'International Journal of Advance Research in Computer Science and Management Studies' 2(2), 2014.
25. M.SivaramKrishnan andM.SivaRamkumar "Power Management Of A Hybrid Solar-Wind Energy System" in 'International Journal of Engineering Research &Technology' 2 (1) pp1988-1992, 2014.
26. M.Sivaram Krishnan and M.SivaRamkumar "Power Quality Analysis In Hybrid Energy Generation System" in 'International Journal of Advance Research in Computer Science and Management Studies 2 (1) pp 188-193,2014
27. S. Ananthanarayanan, Dr.A. Amudha, Dr.K. Balachander, M. Siva Ramkumar and D. Kavitha, "Design and Analysis of Power Quality Improvement in Distribution Side Using PCC Technique with Fuzzy Logic Control" Journal of Advanced Research in Dynamical and Control Systems, (12), pp 844-852
28. T. Kalimuthu, M. Siva Ramkumar, Dr.A. Amudha, Dr.K. Balachander and M. Sivaram Krishnan "A High Gain Input-Parallel Output-Series DC/DC Converter with Dual Coupled-Inductors" Journal of Advanced Research in Dynamical and Control Systems, (12), pp 818-824
29. C. Chinnusamy, Dr.G. Emayavaramban, Dr.A. Amudha, Dr.K. Balacahnder and M. Siva Ramkumar,"Transient Stability Improvement in Power System with SMES and Battery Energy Storage System" Journal of Advanced Research in Dynamical and Control Systems, (12), pp 900-914
30. K. Kaleeswari, Dr.K. Balachander, Dr.A. Amudha, M. Siva Ramkumar and D. Kavitha, "Analysis and Parallel Operation of Novel Bidirectional DC-DC Converter for DC Micro Grid" Journal of Advanced Research in Dynamical and Control Systems, (12), pp 928-940
31. M. Jayaprakash, D. Kavitha, M. Siva Ramkumar, Dr.K. Balacahnder and M. Sivaram Krishnan, "Achieving Efficient and Secure Data Acquisition for Cloud-Supported Internet of Things in Grid Connected Solar, Wind and Battery Systems" Journal of Advanced Research in Dynamical and Control Systems, (12), pp 966-981
32. LiJunwei, S.Ramkumar, G. Emayavaramban, D.Frankl n vinod, M. Thilagaraj, V. Muneeswaran, M. PallikondaRajasekaran, V. Venkataraman, Ahmed Faeq Hussein, IEEE Access, "Brain Computer Interface for Neurodegenerative Person Using Electroencephalogram", pp.2439 - 2452 Vol.(7), 2019.
33. GuJialu,S.Ramkumar, G. Emayavaramban, M. Thilagaraj, V.Muneeswaran, M. PallikondaRajasekaran, Ahmed Faeq Hussein "Offline Analysis for Designing Electrooculogram Based Human Computer Interface Control for Paralyzed Patients" IEEE Access, 2018 , Vol.(6), pp: 79151 – 79161.
34. G.Emayavaramban, S.Ramkumar, A.Amudha, "Classification of Hand Gestures Using FFNN and TDNN Networks", International Journal of Pure and Applied Mathematics, Vol.118 (8), 27-32.
35. G Emayavaramban, A Amudha, "Identifying Hand Gestures Using SEMG for Human Machine Interaction", ARPN Journal of Engineering and Applied Sciences, Vol.11 (21), pp.12777-12785.
36. G Emayavaramban, A Amudha, "Recognition of sEMG for Prosthetic Control Using Static and Dynamic Neural Networks", International Journal of Control Theory and Applications, Vol. 9 (24), pp.205-215.
37. D.Kavitha, Dr.C.Vivekanandan, "AnAdjustable Speed PFC Buck- boost Converter Fed Sensor less BLDC Motor" in International Journal of Applied Engineering Research, ISSN 0973-4562 Vol. 10 No.20 (2015), pg. 17749-17754.
38. D. Kavitha, N. Sivakumar, M. Siva Ramkumar, V. Bhavithira, and S. Kalaiarasi, "A Single Stage High Gain Converter for Grid Interconnected Renewable Application using Perturb and Observe" in International Journal of Control Theory and Applications, ISSN: 0974-5572 Vol. 10 No.38 (2017), pg. 161-175.
39. D.Kavitha, Dr.A.Amudha and S.Divyapriya, "Design of Controller for Regenerative Braking using BLDC Motor Applicable for Electric Vehicle" in International Journal of Electronics, Electrical and Computational System-IJEECS, ISSN 2348-117X, Volume 6, Issue 9, September 2017, pg.245-252
40. K. Govindaraju, V. Bhavithira, D. Kavitha, S. Kuppusamy, and K. Balachander, "Improvement of Voltage Profile and Loss Minimization in IEEE 14 Bus System using FACTS Devices" in International Journal of Control Theory and Applications, ISSN: 0974-5572 Vol. 10 No.38 (2017), pg. 213-224.
41. Xin Wan , Kezhong Zhang1, S. Ramkumar J. Deny, G. Emayavaramban , M. Siva RamkumarAnd Ahmed Faeq Hussein ," A Review on Electroencephalogram Based BrainComputer Interface for Elderly Disabled" in IEEE Access, 2019 , Vol.(7), pp: 36380 – 36387.
42. Dr.A.Amudha, M.SivaRamkumar, M.Sivaram Krishnan "DESIGN AND SIMULATION OF ZETA CONVERTER WITH ZVZCS SWITCHING TECHNIQUE" Journal of Engineering and Applied Sciences ,14(9) pp 2764-2774 (DOI: 10.3923/jeasci.2019.2764.2774
43. M. Sivaram Krishnan, S. Sri Ragavi, M. Siva RamKumar, D. Kavitha "Smart Asthma Prediction System using Internet of Things" Indian Journal of Public Health Research & Development, 10 (2) , pp 1103-1107 DOI:10.5958/0976-5506.2019.00445.5