A Novel Method to Reduce Power Quality Issues in Smart Grids

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***Abstract*:**
The integration of power distribution to needed customers and establishing communication between the power grid and customers is called Smart grid. Smart grid provides secure transfer of power supply, reliable and efficient power source. Smart grid is very essential in present days of power transfer as to ensure the customer is more interested in digital control in almost every field as in case of power supply too. Hence, all the customers have interest to know how a smart grid is built and its functions and operations. In this paper, smart grid importance, its architecture, the power quality related problems in smart grids and a method to reduce the power quality issues are discussed. The design of smart grid model is simulated in MATLAB/Simulink environment. The simulation model has its power supply inputs from grid as well as from renewable energy sources. Any customer expects input power to be reliable and efficient. Power Quality plays a major role in anykind of power system. To reduce the basic power quality issues, a controlling scheme is discussed in this paper. The controlling scheme discussed in this paper is SPWM technique and LC filters to enhance power quality issues in smart grid.

***Keywords*: Smart grid, Distributed energy sources, Simulink, harmonic distribution, Voltage Source Inverter (VSI), Power Quality(PQ), LC Filters.**

INTRODUCTION:

Electrical power includes generation, transmission and distribution of electrical energy. Electrical power is generated in accordance to the demand of electric supply. The electrical power generated is distributed to customers through Power Grid. Power Grid is basically an interconnection between the generating station and the customers. It is a network of power lines and equipment to transfer power. Depending on the population, the demand for power supply has increased drastically. Hence, to support that drastic increase of power, non-conventional energy sources came into existence apart from conventional energy sources. Renewable energy sources supported the power demand to a very large extent.

The idea to make grid digitalize has made power grid to Smart Grid. Smart Grid establishes two way communication between the customer and utilities. The visualisation to sense the power along the power lines is what makes the grid smarter. It is possible by introducing communication networks into the grid. It gives the information of how much amount of power is being utilised by customers time to time, so that customer can have a record, done by Smart meters. Smart grid has the potential to help the customer to save money by managing the electricity usage. Renewable energy interconnection with Smart Grid can even save more by generating own power. It makes the grid intelligent, efficient and environment friendly. Smart Grid even helps in quicker restoration of electricity after power disturbances. Energy and communication together conceptualise the Smart Grid operation. *European Technology Platform for Smart Grids* defined smart grids as 'Smart Grid is an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies. A Smart Grid employs innovative products and services together with intelligent monitoring, control, communication and self healing technologies to it.' *Department of Energy (DOE)* defined Smart Grid as, 'Grid 2030 envisions a fully automated power delivery network that monitors and controls every customer and node, ensuring two – way flow of information and electricity between the power plant and the appliance, and all points in between.' *International Electrotechnical Commission (IEC)* defined Smart Grid as 'The Smart Grid is a developing network of transmission lines, equipment, control and new technologies working together to respond immediately to our 21st century demand for electricity.' This paper explains with the importance of Smart Grid and its architecture, a design of Smart Grid is explained using MATLAB/Simulink. In present days, as we have interconnected renewable energy sources and non-linear loads to Smart Grid, these loads introduce many power quality problems into the grid which has now become a major issue. The power quality issues such as flickers,

interruptions, voltage spikes etc., arises harmonics in the power system which are necessarily to be reduced. In this paper, a novel controlling scheme using SPWM inverter and LC filters at the point of common coupling is introduced.

Smart Grid:

The smart grid is the integration of power technologies with the modern information and communication technologies. Indeed, the integration of renewable energy resources (e.g. solar and wind plants) will supply green energy and reduce greenhouse gas emissions. A robust, secured, and reliable communication network makes the grid smarter because it enables real-time data exchange, real-time control, and effective interaction among components in the smart grid For example, using real-time energy demand data, the operation control can accurately schedule power supply and forecast peaks hours. Users could use the price information received from the utility to monitor, adjust, and schedule their power usage accordingly. The smart grid architectural model is a domain model, which consists of domains: markets, operations, service providers, bulk generation, transmission, distribution, and customers The architectural model defines communications, energy flows, and relationships between domains and how they interact. The basic Smart Grid is given in Fig. 1 below. The architecture of Smart Grid is shown in Fig. 2 below.

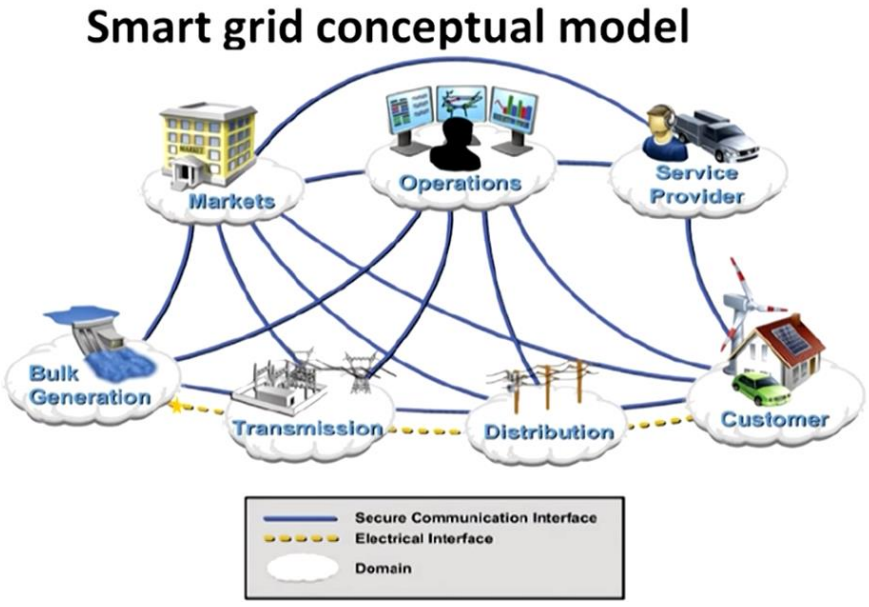

Fig. 1 Smart Grid Conceptual Model

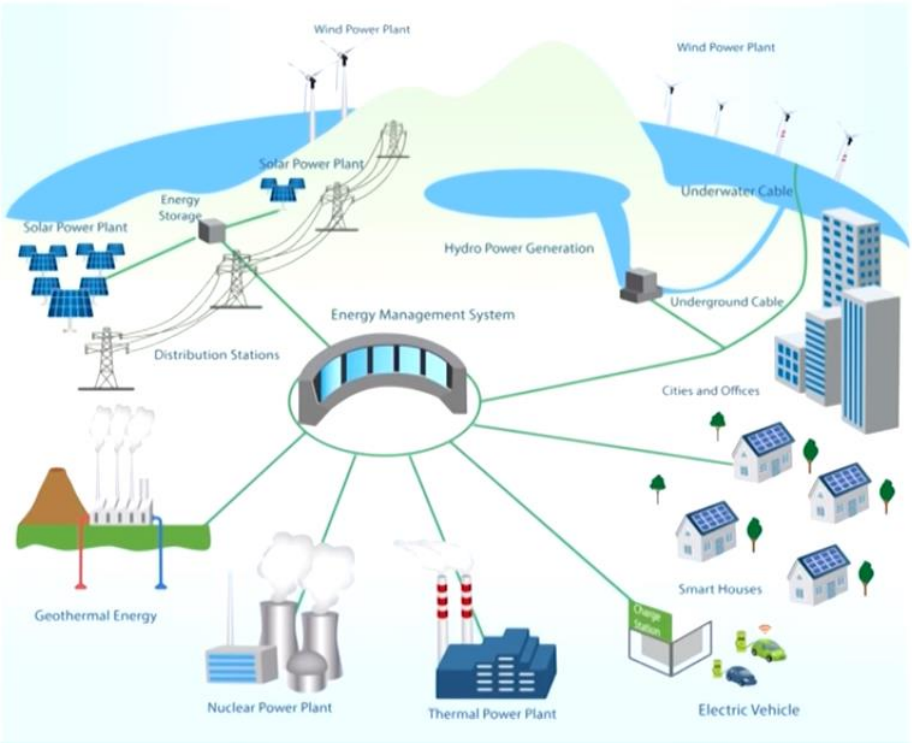

Fig. 2. Smart Grid Architecture.

In the Smart Grid Architecture, we can understand that the power supply to smart homes and cities is from distributed energy system, renewable energy and non-renewable energy systems which is integrated through smart energy management system. The smart infrastructure system is divided into two parts. namely, Smart energy system and smart information system. Smart energy systems include, power generation, transmission and distribution. Smart Information System includes Smart metering, Sensors and information management systems. The simulink model developed to explain Smart Grid is as shown in Fig. 3 below.

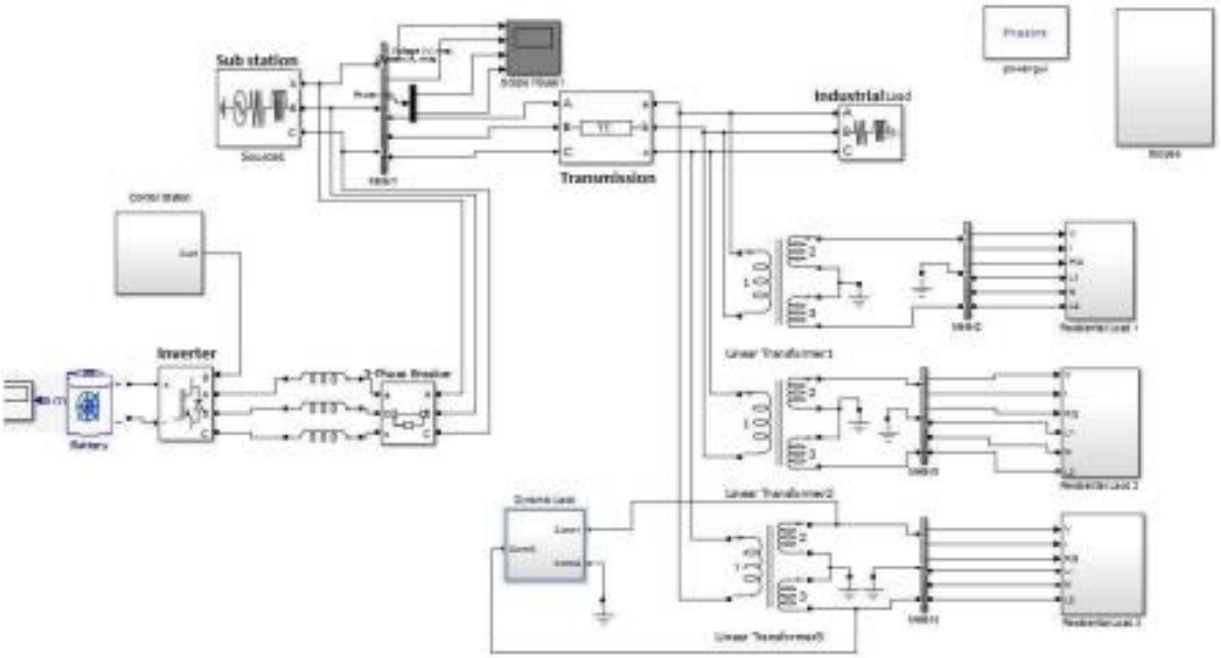

Fig. 3 Smart Grid Simulink Model

METHOD FOR POWER QUALITY IMPROVEMENT:

Power Quality issues generally include Harmonics. For harmonics reduction, current controlled methods are used commonly. Here, a novel control strategy based on voltage control method has been adopted in the system. Compared to traditional current control method, voltage control method is more flexible. Sometimes during the period of no harmonic compensation, harmonic currents will be pushed to the grid side in the case of current control method, hence voltage at the common coupling will get polluted. But in contrast to this method, in voltage controlled method it can sustain even in uncontrolled mode for some period of time. Here a voltage control strategy has been adopted by synchronising SPWM inverter and LC filter.

Fig. 4 gives the block diagram for reduction of harmonic content in smart grid. It consists of a renewable energy source namely wind power system and solar system, three phase source, Pulse width Modulated Inverter, LC Filter and non linear loads. Introduction of non linear loads and sudden switching of loads, harmonics are initiated into system and create PQ problems. For improving PQ, the method employed in this paper is VSI functioning using SPWM. The demerit of VSI is it can control harmonics only upto certain level. So, to control harmonics of higher levels, LC filters are employed at the PCC. It even helps in reduction of unwanted switching frequencies produced by non linear loads.

Fig. 5 gives the block diagram for SPWM technique which is used to trigger the VSI switches. VSI is inverter which converts input DC voltage AC voltage using SPWM gate pulses. With the change in sine wave (voltage and frequency) of SPWM technique, the inverter output can be controlled. In particular, changing amplitude and duty cycle of pulses, effects the gate pulses to the inverter, which in turn changes the output of inverter and reduces harmonics to some extent and residue harmonics are controlled by employed LC filters at the PCC. SPWM technique is achieved by selecting three phase sine wave, having 120^0 phase angle as reference wave and a high frequency triangular carrier wave. The reference wave is compared with the high frequency carrier wave at the comparator and if the reference sine signal is greater than the high frequency carrier wave, an output pulse is generated. The generated output pulses at the comparator are given as triggering gate pulses to VSI.

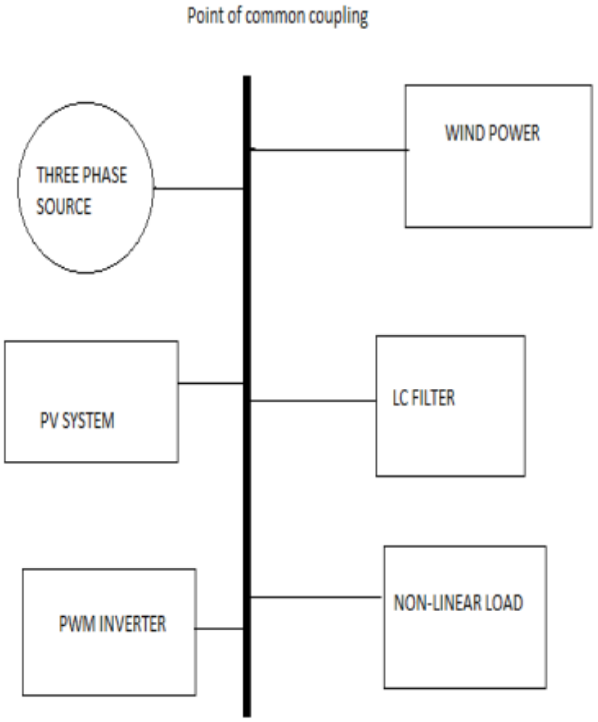

Fig. 4 : Block diagram showing harmonic reduction in smart grid.

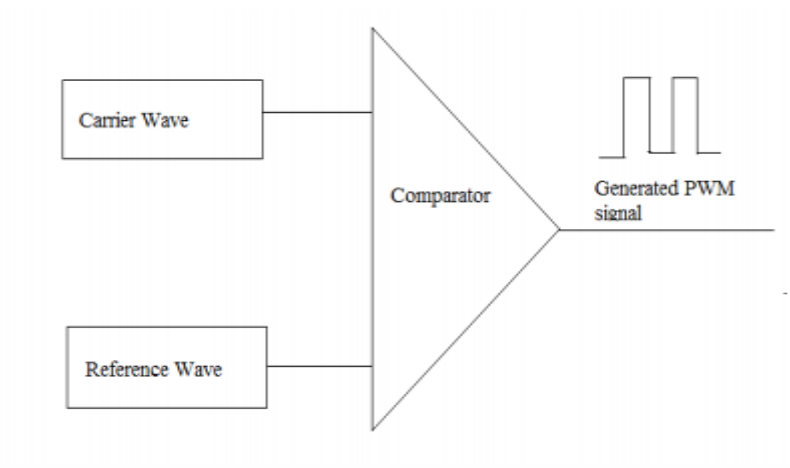

Fig. 5 : Block diagram showing SPWM technique to reduce harmonics in smart grid.

Fig. 6 shows the simulink model to reduce harmonics in smart grid. This model integrates the wind, solar power plants to the smart grid connected to a non-linear load. Non-linear loads create distortions in current and voltage waves which are supposed to be reduced. SPWM inverter employed LC filters reduces the power quality issues that arise in the smart grid.

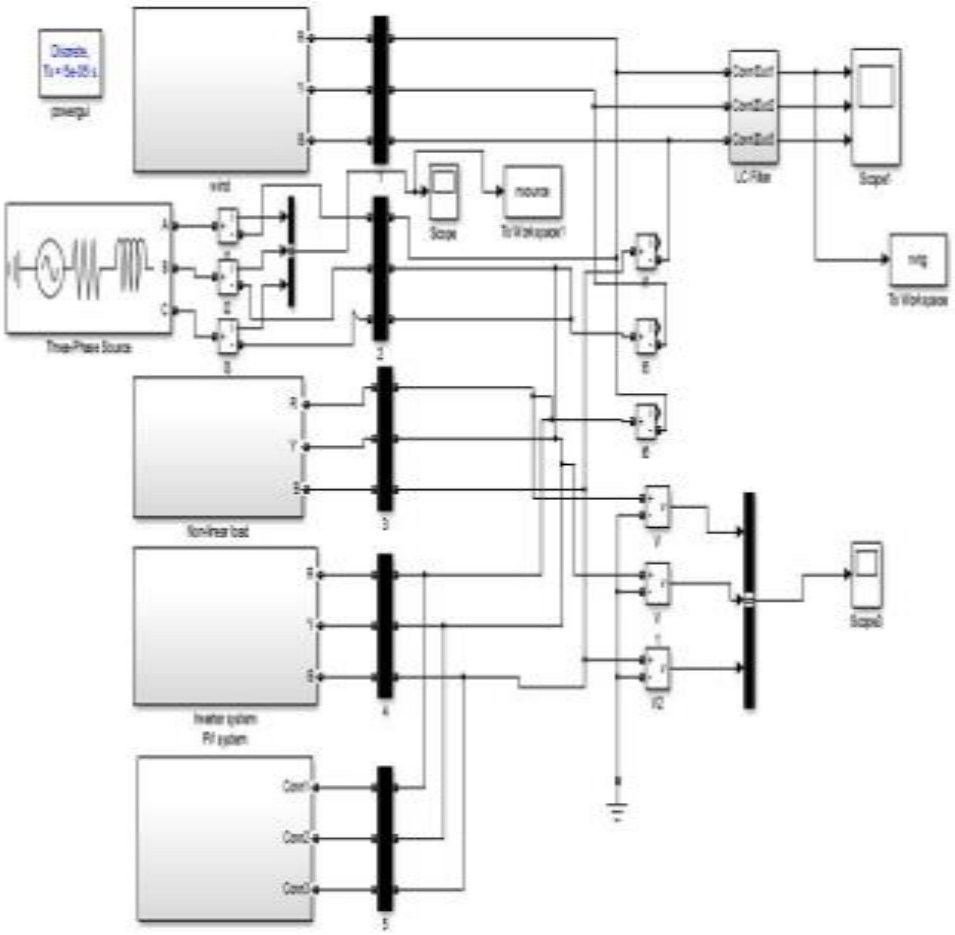

Fig. 6: Simulink model to reduce PQ issues in smart grid.

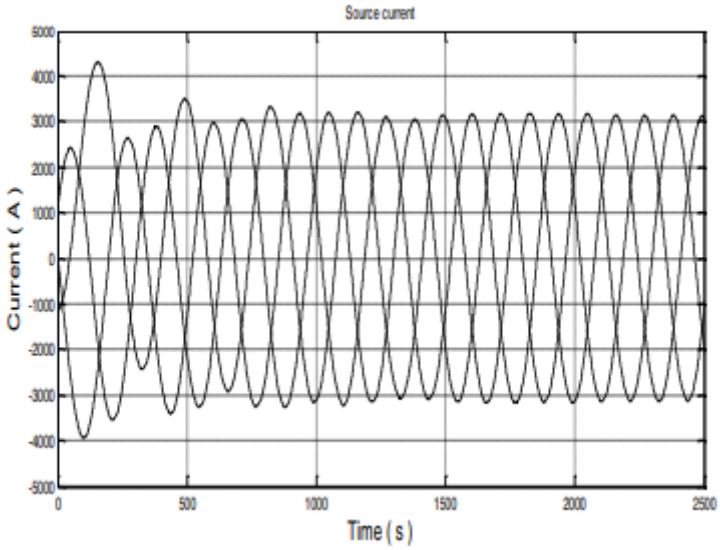

Fig. 7: Source Current

Fig. 7 shows the source current waveform, where small disturbances can be observed initially. But, after applying control technique, a pure sinusoidal waveform can be observed.

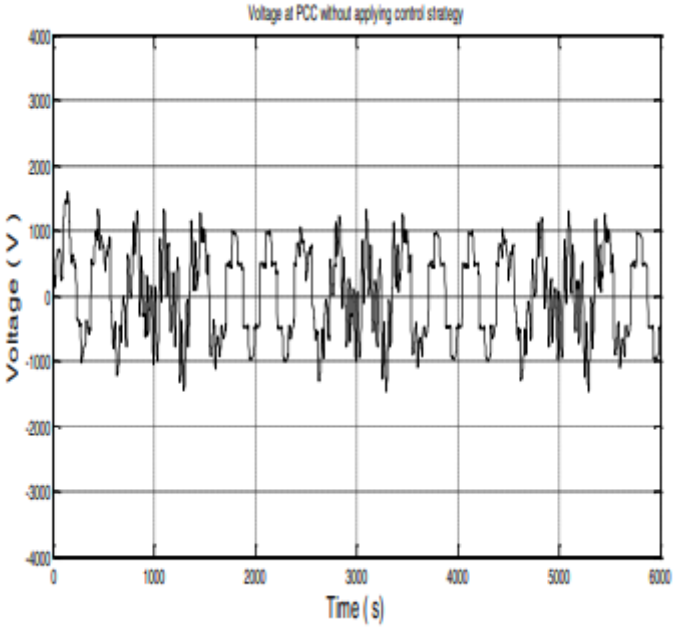

Fig. 8 : Voltage at PCC without control technique

Fig. 8 shows the voltage at PCC without applying control strategy of SPWM inverter and LC filter. Hence, due to non- linear load, voltage distortions can be observed.

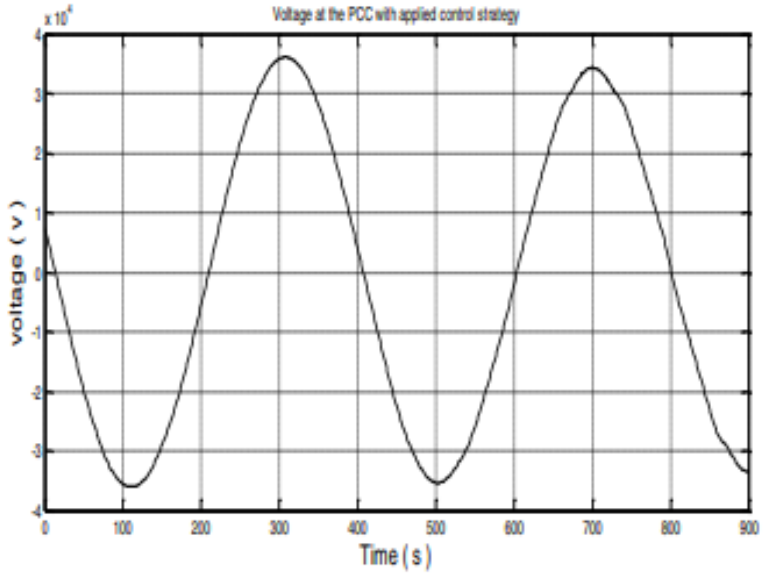

Fig. 9 : Voltage at PCC with control technique

Fig. 9 shows the voltage at PCC after applying control strategy of SPWM inverter and LC filter. So, a sinusoidal output can be observed here.

CONCLUSION:

This paper introduces smart grid and simple simulink model to construct a smart grid. It even discusses about how and why the power quality issues generally arise in smart grids and a novel control strategy to reduce the power quality issues by integrating a SPWM inverter with a LC filters.

REFERENCES:

[1] Roger N. Anderson, Reza Ghafurian, Hamid Gharavi, "Smart Grid: The Future of the Electric Energy System", June 2018.

[2] Ilhami Colak, "Introduction to Smart Grid", 3rd International Smart Grid Workshop and Certificate Program (ISGWCP)", March 2016.

[3] Oana CEAKI, George SERITAN, Ramona VATU, Monica MANCASI, "Analysis of Power Quality Improvement in Smart Grids", THE 10th INTERNATIONAL SYMPOSIUM ON ADVANCED TOPICS IN ELECTRICAL ENGINEERING, March 2017.

[4] Kella Ramakrishna, K. V. Govardhan Rao, Dr. P. Surendra, " Simulation of Shunt Active Filter in 3-Phase, 4-Wire System for Power Quality Improvement", International Journal of Scientific Engineering and Technology Research(IJSETR), VOL.05, NOV.2016, PP:8228-8234, ISSN:2319-8885.

[5] Siriyala Trilochana, Thalanki Venkata Sai Kalyani, Sangeetha. Cn, Cheera Srinivas, "A Review on Adaptive tuning and Auto tuning of PI &PID Controllers for Effective speed control of DC Motor", International Journal of Engineering Research and Application, Pg. 37-43.

[6] Jingyue Zhang, "Reserch on Power Quality Problems on Smart Grids and New Energy Generation", 4th International Conference on Energy Science and Applied Technology, 2018.

[7] K. V. Govardhan Rao & P. Babu Rao, " A Novel Hybrid PV/FC Energy Management Scheme For Grid Connection And Islanded Operation Capabilities", International Journal Of Electrical & Electronics Engineering Research (IJEEER), VOL.04, ISSUE.05, OCT-2014, PP:13-26, ISSN:2250-155X.

[8] K. V. Govardhan Rao & P. Babu Rao, "Reactive Power Compensation using DSTATCOM", International Journal of Knowledge Learning and Research (IJKLR), VOL.01, ISSUE.01, JAN-2014, PP: 23-28, ISSN: 2348-1463

[9] K. V. Govardhan Rao, " An Innovative Proposal to Solve the Power Systems Power Flow Equations", International Journal of Knowledge Learning and Research (IJKLR), VOL.01, ISSUE.02, AUG-2014, PP: 19-24, ISSN: 2348-1463.

[11] K. V. Govardhan Rao, "Fuzzy – Genetic Algorithm Approach for Fact Placement in Electrical Power System", International Journal of Inventions in Electronics & Electrical Engineering (IJIEEE), VOL.01, JAN-DEC-2015, PP: 17-29, ISSN: 2454-8081.

[12] K. V. Govardhan Rao, " Interfacing Of Hybrid Pv/Battery System to The Grid Using Flc Technique For PQ Improvement", International Journal of Scientific Progress and Research(IJSPR), VOL.27, NOV-2016, PP:119-124, ISSN:2349-4689.

[13] K. V. Govardhan Rao, " Diminution of Power Quality Disturbances by using an Novel Interline DVR Device with Photo Voltaic System", SSRG-International Journal of Electrical & Electronics Engineering (SSRG-IJEEE), VOL.04, Issue:07, Jul-2017, PP:27-36, ISSN:2348-8379.

[14] T. V. Sai Kalyani, "A Simplified SVPWM Control Method for Dual Inverter Fed Induction Motor Drive", IJSETR, Vol. 4, Issue 39, Sept. 15, Pg. 8450-8455

[15] Murat H. SAZLI, İlhan KOŞALAY Galbadrakh ERDENESAIKHAN, "A Brief Review of Power Quality Issues in Smart Grid and a Simple User Friendly Software", 26th International Istanbul Smart Grids and Cities Congress and Fair (ICSG), 2018.