International Journal of Control Theory and Applications

ISSN : 0974-5572

Volume 10 • Number 36 • 2017

Harmonic Analysis in Three Phase Three Level Inverter in Solar PV Array using MPPT Controller and DC-DC Converter

S.K. Saranya[a] and G.N. Sachin Amreiss[b]

[a,b]Department of Electrical and Electronics engineering, M. Kumarasamy College of Engineering, Karur, India. Email: sarankasieee@gmail.com, sachinamreish@gmail.com

Abstract: Battery energy storage system is proposed in this paper. It is used for mitigate the real power and voltage deviation in micro grid. This can supply for the peculiar requirements of quality of the micro grid, such as the frequent voltage fluctuation, over current phenomenon, and bidirectional power flow BESS is also used for the frequency regulation application of BESS including the high power penetration also. Load shedding is considered as one of the frequency control method then the frequency control performance will improve the BESS combination. The system control strategy is also analyzed in detail by using MATLAB simulation. A set of BESS with load has been constructed. The experimental results are provided to validate the analyses.

Keywords: BESS, Micro grid, Over current, Power flow, Power quality, Real power.

1. INTRODUCTION

The invention of combustion engine initiated to use the petroleum based products to fulfil our power demands. The use of energy plays a important role in one's life. Since the usage of energy had become more important in our life, its source and supply will be safe and sustainable. It should be economically, natural eco friendly & generally acceptable one. The recent trends in power consuming methods are not suitable and not sustainable. The increasing usage of fuel products from fossils and respective prices, it tends to increase in ozone layer depletion, lurks our energy demands. Therefore for the clean environment, safety, sustainable, renewable energy sources should be the main objective of our century. To get the maximum power the tracking is important in a PV array and it is vital part of a PV system. Now many Maximum power point techniques had been implemented and executed. The techniques had been vary in design, availability of sensors, cost, high speed, popularity, the length of effectiveness, hardware implementation on real time application and in other expects. The range of the panel should be the most resourceful. The number of methods had been implemented in that more methods are become tough to apply for getting maximum power, the proposed system will be is more suitable for the PV module [1]. The paper based on solar Photo Voltaic cell with MPPT has grown significantly of the last decades and remains strong.

The SEPIC converter is used to produce output voltage either increase or decrease in input voltage without inverting the polarity [2] [3]. The VSI which is used to convert the direct current to alternating current will produce either two or three level based on the modes of operation. The output of voltage source inverter has high harmonics distortion. Increasing the voltage levels will decrease the harmonics.

2. PROPOSED SYSTEM CONFIGURATION

2.1. Maximum Power Point Tracking

When a solar PV module is used in a system, its operating point is decided by the load to which it is connected. Since, the solar radiation falling on a PV module varies throughout the day, the operating point of module also changes throughout the day. In order to ensure the operation of PV modules for maximum power transfer, a special method called maximum power point tracking (MPPT) is employed in PV systems[4], [5]. The electronic circuitry is used in MPPT to transfer maximum power.

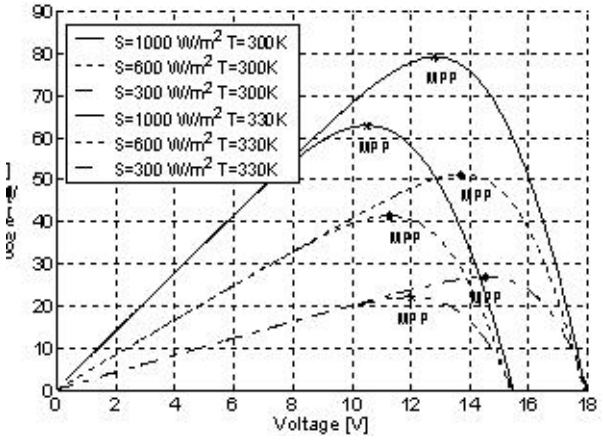

Figure 1: PV Array Characteristics

The function of a MPPT is similar to the movement of a car. When the movement is in the wrong gear, the wheels do not receive maximum power. This is because, the engine is running either slower or faster than its approximate speed range. The purpose of movement is to couple the wheels to the engine, in a way that let the engine run in an appropriate speed, despite varying acceleration [6]. Let's relate a PV module to a car engine. Its voltage is similar to engine speed. Its epitome voltage is that at which it can put out maximum power. This is called its maximum power point. It is also called as peak power voltage (V_{PP}). V_{PP} varies with intensity of sunlight and with temperature of the solar PV cell [7].

2.2. Perturb and Observe Algorithm

The maximum power will be get by the MPPT technique in that the hill climbing method is more useful and easy compare to the fuzzy logic and neural network. In that the more methods are used in the hill climbing method such as the constant current method, the perturb and observe method and the incremental conductance. The Perturb is nothing but the disturbance and observe is nothing but the observation by varying the voltage the changes have done in the PV panel that should be observed and make calculation and these algorithm involves a disturbance in the voltage and the duty ratio of the power will be recorded and calculated based upon the present value and previous value, so that we are getting the power. If we getting the power value we can make the PV curve and the IV curve and we can check the slope for the representing curve or the conducting region will be carried out and if the changes happen in D (duty ratio) it will affect the direction, so that the conducting region (maximum power point) will get clear PV characteristics.

If the system oscillates the maximum power point also will get oscillate [8][9]. These oscillation can be reduced by controlling the step size of disturbance (i.e perturbation). Thus the small disturbance will shows the process of Maximum power point tracking technique, by using modified Perturb and the Observe algorithm will reduce the drift size compared to the normal Perturb and the Observe algorithm because it will sense the power, voltage, current on every duty cycle [10].

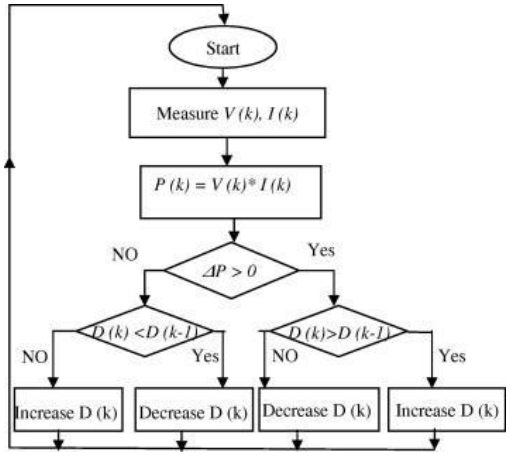

Figure 2: Flowchart For P&O Algorithm

Table 1
Working of P&O Algorithm

Perturbation	*Change in Power*	*Next Perturbation*
Positive	Positive	Positive
Positive	Negative	Negative
Negative	Positive	Negative
Negative	Negative	Positive

2.3. Sepic DC-DC Converter

The buck converter and boost converter are the basic DC-DC Converter in which the single-ended primary-inductance converter (SEPIC) is one of the DC-DC converter the special function in these converter is in normal converter either we can reduce or increase the input but in single ended primary inductance converter we can do both functions[11]. The pulse is given to the power semiconductor switch in order to control the output of the SEPIC converter [12][13]. The SEPIC converter is basically derived from the boost type converter in which inductance is placed in the input side and it shows similar to the olden days BUCK- BOOST converter, the another advantage of using the SEPIC converter is having same polarity at the output side so the output will be get from the positive side. And if the power semiconductor switch is turned off the voltage will be drop to Zero volt.

The circuit diagram for the circuit diagram shown in Figure 3.

Mode 1: The Metal Oxide Semiconductor field Effect Transistor switch S1 is turned on, the current will get absorb by the inductance L1 and the L2 will be more negative. The inductance L1 will get more power because of in input side. The switch S1 is a partially closed, the polarity must be same because of same voltage that is input voltage as same as Vin in L1, then the voltage from the inductance in L2 will be opposite polarity –VL2 [14]. Then the capacitor C2 will store the energy and if supplies if the switch is turn off to increase the magnitude of the current of inductance L2.

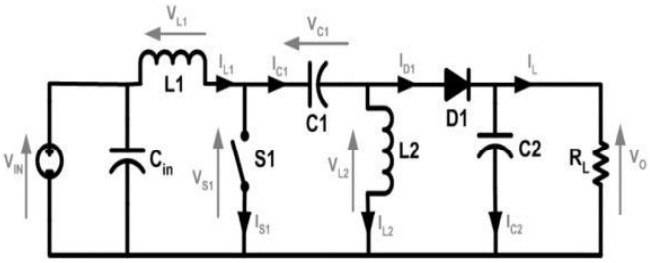

Figure 3: Circuit Diagram for SEPIC Converter

Mode 2: Then the MOSFET switch will turn off the current of C1 will be same as the input. And also the inductance will not allow the changes of current regularly. The reverse current will flow so that it moves in reverse direction because of the conducting flow by the diagram we can see the flow of current. By the Kirchoff's current law we can prove that *I*D1 = *I*C1 – *I*L2. Thus we can conclude that switch S1 is turned off [15] [16], the power will be go to load by the discharge of inductance L1 and L2. After obtaining the values of voltage across inductors in ON and OFF modes, relationship between the source and load voltages can obtained in similar as for the boost and buck-boost converters. Since d is the duty cycle and it can be varied between 0 and 1, depending on the output of the solar PV cell. One possible drawback of this converter is that the switch cannot have terminal at ground, this complicates the driving circuitry.

2.4. Three Phase Three Level Voltage Source Inverter

Solar PV array generates current electricity from solar installation. However, there are several loads which will work with AC electricity. Also the grid connected applications requires that the DC is converted AC before the power the power can be fed into the grid. A DC-AC converter is also called as Inverter converts a DC quantity into an AC quantity. In the voltage source inverter by controlling the frequency of duty cycle, we can control the frequency of the output voltages and the output voltage could be fixed or variable frequency. The inverter gain is defined as the ratio of the ac output voltage to the dc input voltage.

The output voltages from an ideal inverter will be sinusoidal. However, the waveforms of practical inverter are non-sinusoidal and contain harmonics. For low and medium-power applications, square or quasi-square wave voltages may be acceptable and for high power applications low distorted sinusoidal wave forms are required [17].

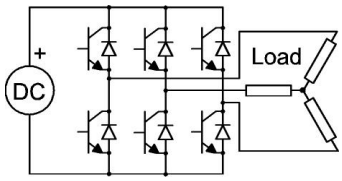

Figure 4: Three Phase-Three Level Voltage Source Inverter

With the availability of high speed power semiconductor devices, the harmonic in output voltage can be minimized or reduced significantly by switching techniques [18]. However, for our domestic and industrial AC appliances as well as for feeding the PV power to the grid, it is desirable to get an AC voltage of 50HZ. The gating signal of three phase inverters can be either 120° or 180° mode.

The line to neutral voltages of three phase inverter can be expressed in Fourier series.

The line *a* to *b* voltage is $V_{ab} = \sqrt{3}\, V_{an}$ phase advance of 30°. Therefore the instantaneous line to line voltage will be expressed.

2.5. Total Harmonic Distortion

The output of AC voltage is of square shape but not sinusoidal shape. The squared AC waveform can be considered as a distorted version of the perfect sinusoidal waveform. In principle, a square waveform can be represented by the sum of several sinusoidal waveforms of different frequency and amplitude. The distortion in the waveform is represented in the form of Total Hamonic Distortion (THD).

The THD is defined as the ratio of sum of the power of total harmonic components to the power of the fundamental component. In terms of voltages, the THD is defined as the ratio of square root of the sum of the squares (RMS voltages) of all harmonic component to the fundamental component as given in eqn.

The THD represents the losses in the inverter when used in the circuit. Therefore it's value should be as low as possible.

3. SIMULATION DIAGRAM

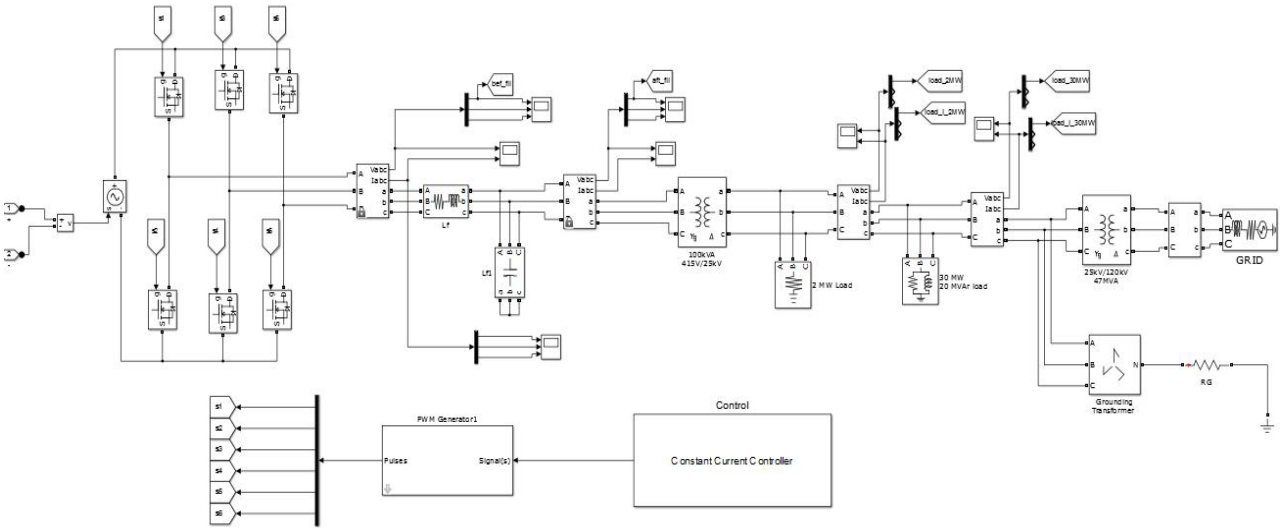

Figure 5: Grid Connected Inverter

4. SIMULATION RESULT

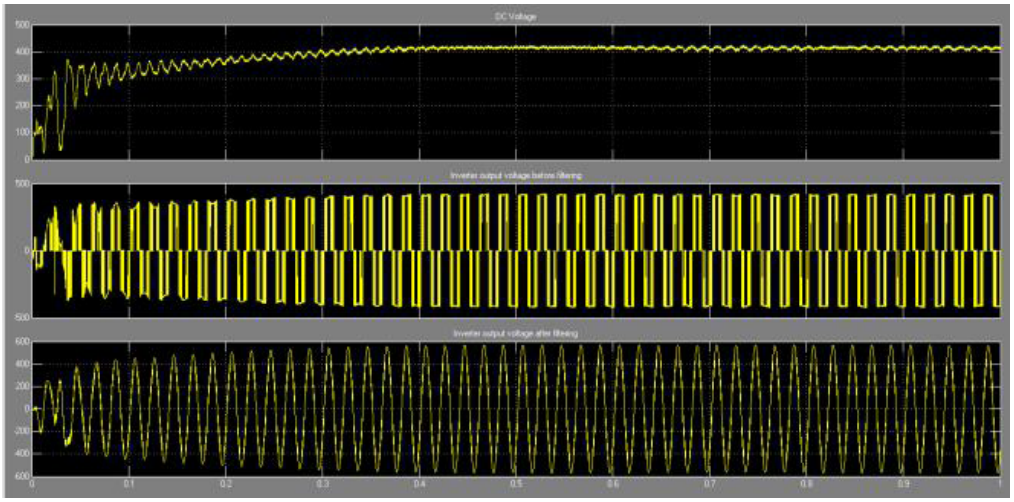

Figure 6: Output of SEPIC Converter, VSI

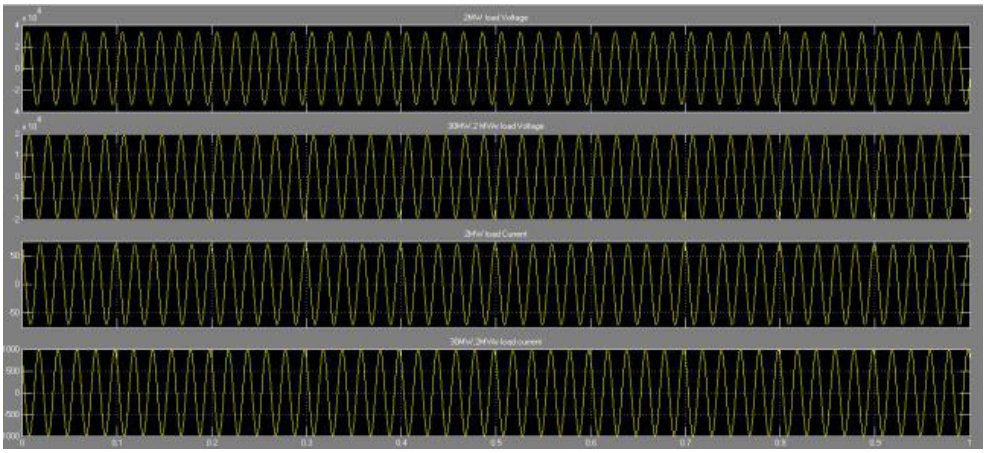

Figure 7: Output of VSI After Filtering With Load

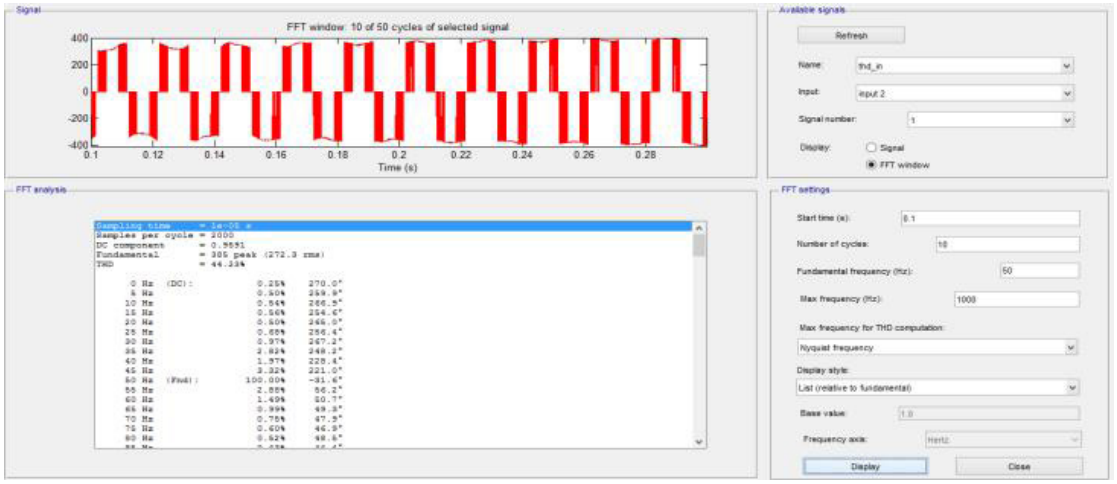

Figure 8: Output of Inverter before Filter

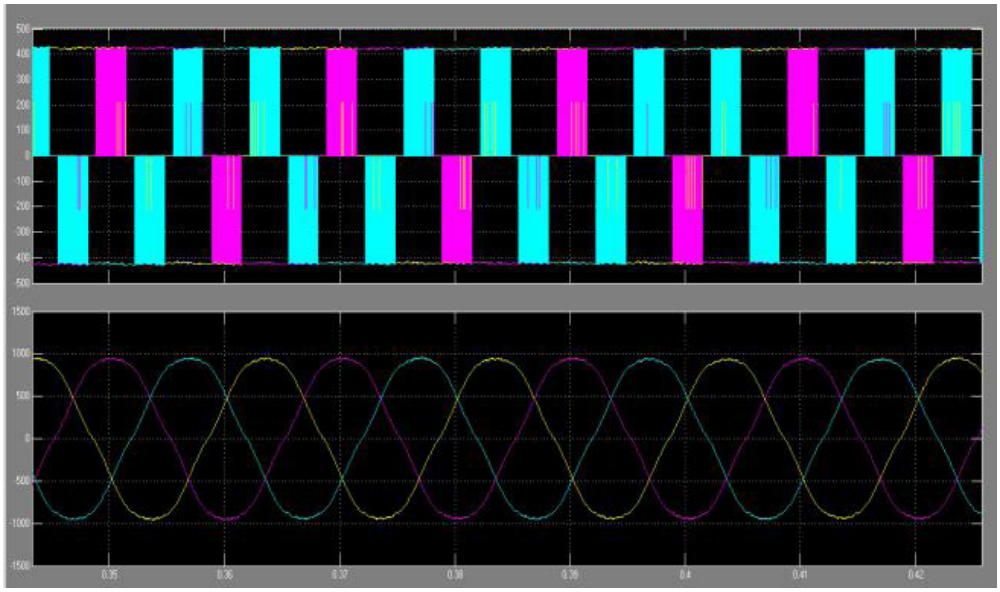

Figure 9: Total Harmonic Distortion from Inverter

5. CONCLUSION

By using MPPT tracker, the output of solar PV cell is 650 watts. With the help of SEPIC converter and PI controller the voltage is regulated to 415V and given as input to the VSI. As the output of VSI is three level, the THD of inverter is very high. This THD can be reduced by using Multi-level inverter (MLI) or by calculating the optimal switching angles for the MOSFET switch.

REFERENCES

[1] K. Irisawa, T. Saito, I. Takano, and Y. Sawada, "Maximum power point tracking control of photovoltaic generation system under non-uniform insolation by means of monitoring cells," in *Proc. 28th IEEE Photovoltaic Specialists Conf.*, pp. 1707–1710, September 2000.

[2] K. H. Hussein, I. Muta, T. Hshino, and M. Osakada, "Maximum photovoltaic power tracking: an algorithm for rapidly changing atmospheric conditions," *Proc. Inst. Elect. Eng.*, Vol. 142, No. 1, pp. 59–64, Jan. 1995.

[3] O. Wasynczuk, "Dynamic behavior of a class of photovoltaic power systems," *IEEE Trans. Power App. Syst.*, Vol. 102, No. 9, pp. 3031–3037,Sep. 1983.

[4] M. A. Slonim and L. M. Rahovich, "Maximum power point regulator for 4 kWsolar cell array connected through inverter to the AC grid," in *Proc. 31st Intersociety Energy Conver. Eng. Conf.*, pp. 1669–1672, October 1996.

[5] L.V. Suresh Kumar, G.V. Nagesh Kumar," A Logic sort Algorithm based Voltage Balancing of Modular Multilevel Converter in Back HVDC system", International Journal of Control theory and application, Vol. No. 9, Issue No. 32, pp. 11-22, December 2016. (indexed in scopus) (ISSN No. 0974-5572)..

[6] X. Yuan, W. Merk, H. Stemmler, and J. Allmeling, "Stationary-frame generalized integrators for current control of active power filters with zero steady-state error for current harmonics of concern under unbalanced and distorted operating conditions," *IEEE Trans. Ind. Appl.*, Vol. 38, No. 2, pp. 523–532, Mar./Apr. 2002.

[7] L.V. Suresh Kumar, G.V. Nagesh Kumar," Multi winding Transformer through Multi level Inverter with Super Capacitor Based standalone Integrated wind Energy system", International Journal of Control theory and application, Vol. No. 9, Issue No. 32, pp. 1-9, December 2016.(indexed in scopus) (ISSN No. 0974-5572).

[8] M. Liserre, R. Teodorescu, and F. Blaabjerg, "Multiple harmonics control for three-phase grid converter systems with the use of PI-RES current controller in a rotating frame," *IEEE Trans. Power Electron.*, Vol. 21, No. 3, pp. 836–841, May 2006.

[9] T. Tafticht and K. Agbossou, "Development of a MPPT method for photovoltaic systems," in *Canadian Conf. Elect. Comput. Eng.*, pp. 1123– 1126, june 2004.

[10] T. Tafticht and K. Agbossou, "Development of a MPPT method for photovoltaic systems," in *Canadian Conf. Elect. Comput. Eng.*, pp. 1123– 1126 june 2004.

[11] N. Femia, G. Petrone, G. Spagnuolo, and M. Vitelli, "Optimization of perturb and observe maximum power point tracking method," *IEEE Trans. Power Electron.*, Vol. 20, No. 4, pp. 963–973, Jul. 2005.

[12] S. Fukuda and T. Yoda, "A novel current-tracking method for active filters based on a sinusoidal internal model," *IEEE Trans. Ind. Appl.*, Vol. 37, No. 3, pp. 888– 895, May/Jun. 2001.

[13] S.K. Saranya and Dr. R. Karthikeyan "Security for Smart distribution grid by using wireless communication", International Journal of Innovative Research in computer and communication Engineering, Vol. 2, No. 1, pp.791-799, march 2014.

[14] Dr. R. Udhaya Shankar, Dr. Rani Thottungal, T. Gowtham Raj, "comparative analysis of cuk and luo converter fed bldc motor" International journl of applied engineering research, Vol. 10, No. 88, pp.68-72.

[15] K. Sundararaju and Nirmal Kumar, "Control analysis of STATCOM with enhanced methods for compensation of load variation", A. European Journal of Scientific Research, Vol. 53, No. 4 (2011), pp. 590-597.

[16] R. Karthikeyan and S. Chendur Pandian, "An efficient multilevel inverter system for reducing THD with Space Vector Modulation", International Journal of Computer Applications 23 (2), 0975-8887.

[17] R. Karthikeyan and S. Chenthur Pandian, "Generalized space vector PWM algorithm for minimizing THD in hybrid multilevel inverters" International Review of Electrical Engineering, Vol. 6, N. 5 2011, pp 2094-2099.

[18] J. Gouthaman, R Bharathwajanprabhu, A Srikanth, "Automated urban drinking water supply control and Water theft identification system", Students' Technology Symposium (TechSym), 2011 IEEE, 87-91.