iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 4 Issue: X Month of publication: October 2016

DOI:

Volume 4 Issue X, October 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Output Voltage Control of a 3-Phase Multilevel Inverter Considering Input Voltage Fluctuations using PI-Technique

Dr. S Narasimha[1], Dr. M. Sushama[2], J. Lingappa[3]
[1] Professor, Dept of E.E.E, St.Peter's Engineering College, Hyd,
[2] Professor, Dept Of E.E.E, JNTUH, Hyderabad, India.
[3] Asst. Professor, EEE-Dept, Siddhartha Institute of Tech &Science, Hyd,

***Abstract*— A new approach for the control of the superposition ratio of odd harmonic wave into output voltage feedback control and improvement on voltage utilization factor has been presented. The input DC source is considering from cogeneration system, In case of the power generation using natural energy and fuel cell comparatively large fluctuations are generated at the DC voltage. This paper presented detailed analysis of the improvement on the controllability and absorption of the DC voltage fluctuations has been absorbed using SVPWM with PI-control technique. The results have obtained using 3-level inverters with 6kW Resistance load. Results are validated with MATLAB/ simulink.**
***Keywords*— Multilevel inverter, closed loop control, Space vector pulse width modulation (SVPWM), Superposition ratio control, Proportional plus Integral (PI) control,**

I. INTRODUCTION

The last decade's growth in the production of electric energy from renewable energy sources has led to an increased focus on power electronics systems. Renewable energy sources like photovoltaic, wind and wave energy are relying on power converters in order to exchange power with the grid [1]. These inputs are not constant with time always in fluctuating nature and anyone who wants to produce power for the grid has to make sure that their facilities are complying with national grid codes. The grid codes have strict regulations when it comes to the voltage quality, including limits for rapid voltage variations, flicker and harmonic distortion. Rapid voltage variations and flicker are matters of control of the inverter system, but harmonic distortion is created by the pulse width modulated switching of the converter. Different filters topologies can be used in order to reduce the harmonics generated by the switching action in the converter. However [2][3], filters for high power converters can be of substantial size and weight and therefore also of great cost since they are made of several expensive metals. Therefore, a lot of effort is made in order to improve the converter system so that the filter can be reduced while the cried codes and system specifications are still met. There are mainly two ways of reducing the harmonic distortion. One way is to optimize the switching sequence, with harmonics as the most important constraint. Another way is to use several levels to build the fundamental voltage i.e. converters with three levels or more [4][5].

In an effort to improve voltage quality and efficiency, a simple control method for improving the voltage utilization factor of multilevel inverter [9][11]. In this paper a control method which introduced the control of superposition ratio of third harmonic wave into output voltage feedback control and improvement on voltage utilization factor is proposed.

It is applied to the multilevel inverter, and the operation principle and features are explained. Which including Solar and fuel cell system .The fluctuating input DC voltage has been converted to stable output voltage by using Multilevel inverter.

II. OUTPUT VOLTAGE TRACKING CONTROL

Two phase output line voltages V_{RY} and V_{BR} are taken into the Simulation the following can be obtained from the fundamental equations for a three-phase three-wire system, and from the relationship between the line voltages and phase voltages[8]:

$$V_{RY}+V_{YB}+V_{BR}=0$$
$$V_{RY}=V_{BN}-V_{YN}$$
$$V_{YB}=V_{YN}-V_{BN}$$

$$V_{BR}=V_{BN}-V_{RN} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Volume 4 Issue X, October 2016
ISSN: 2321-9653

Therefore,

$$V_{BN} = 1/3(V_{RY} - V_{BR})$$
$$V_{YN} = 1/3(V_{YB} - V_{RY})$$
$$V_{BN} = 1/3\,(V_{BR} - V_{YB}) \ldots\ldots\ldots\ldots\ldots (2)$$

Three phase voltages V_{RN},V_{YN} and V_{BN} are converted into two-phase AC voltages $V\alpha$ and $V\beta$ by using the following:

$$\begin{bmatrix} V\alpha \\ V\beta \end{bmatrix} = \frac{\sqrt{3}}{2} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} V_{RN} \\ V_{YN} \\ V_{BN} \end{bmatrix} \ldots\ldots\ldots\ldots\ldots (3)$$

Now the magnitude V_{out} of the resultant output vector is calculated as follows:

$$V_{out} = \sqrt{\left|\dot{V}_{\alpha}\right|^2 + \left|\dot{V}_{\beta}\right|^2} \ldots\ldots\ldots\ldots (4)$$

The magnitude Vout corresponds to the effective value of the output line voltage, which is a DC value in the case of a three-phase balanced voltage without fluctuation. Therefore, tracking control of the output voltage can be implemented by maintaining this value at a stable level[8].

The difference between the output voltage references V*out and the resultant vector magnitude Vout is given to the proportional integrator, and the DC voltage compensation on V_{pi} is calculated. A coefficient related to the superposition ratio α is applied to this value, and then a sinusoidal reference is obtained by multiplying by a three-phase sine Wave with amplitude of one[7][8].

The advantage of this system is obtaining the fixed control characteristic, when the AC voltage of any frequency is output, because the signal input to the proportional integrator is the instant DC voltage which does not depend on the frequency of the output Voltage. That is, the method can be applied to variable speed drive of electric motors and to other cases when a variable-frequency source is required.

A. *Control Method*

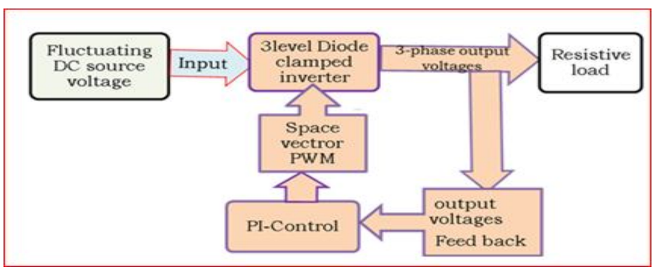


Fig1. Block diagram of closed loop Voltage Control technique

The Input fluctuating DC voltages are generally coming from Co-generation systems Like Wind, Solar and fuel cells etc., these generated voltages are directly connected to multilevel circuit as input. The multilevel inverter circuit outputs are connected to three phase loads. Due to DC voltage fluctuations at input side of inverter, the output voltage of inverter also get distorted but loads which are connected to this circuits requires constant voltage magnitude. To maintain the inverter output voltage magnitude constant irrespective of its DC voltage fluctuations, the output voltages are taken as feed back to control circuit, This output voltage signal is converted in to suitable form, than compare with fundamental rated values next generate the error correcting signal to PWM unit. This PWM circuits generates the switching pulses according to the error signal. In this closed loop control method the output voltages are always constant magnitudes and this control method is to realize improvement on the controllability and absorption of the fluctuation of the DC voltage by superimposing the moderate third harmonic wave. If the instantaneous voltage ripple was absorbed.

B. *PI-Model*

The PI-controller basic mathematical equation is

Volume 4 Issue X, October 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

$$U = Kpe_k + Ki\sum_{j=0}^{k} e_k + u_0$$

$$u_k = \begin{Bmatrix} Umax(U \geq Umax) \\ Umin(U \leq Umin) \end{Bmatrix}$$

Kp=proportional coefficient

Ki=integral coefficient

e_k =K-th sampling time

u_0=initial value ....(5)

III.SVPWM FOR 3-LEVEL CONVERTER

One of the features of two parallel connected inverters is the ability to obtain three levels of voltage (phase to neutral) P =V_{DC}, H = VDC and O = 0. Describing system in the meaning of three voltage levels provides similarity to Three-Level Neutral Point Clamped Inverter. This similarity allows to approach Space Vector Modulation in the same way like for Neutral Point Clamped Inverter.

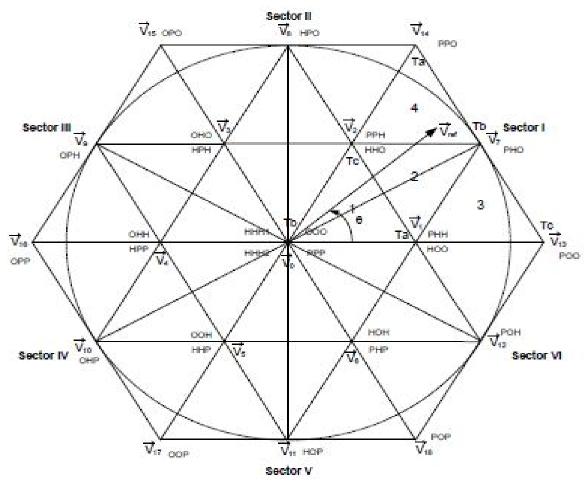


Fig.2-level space vector modulation sectors

Table.1. Switching pattern for sector

SECTOR 1				
Segments	1	2	3	4
1	[OOO]	[HOO]	[HOO]	[HHO]
2	[HOO]	[HHO]	[POO]	[PHO]
3	[HHO]	[PHO]	[PHO]	[PPO]
4	[HHH]	[PHH]	[PHH]	[PPH]
5	[HHO]	[PHO]	[PHO]	[PPO]
6	[HOO]	[HHO]	[POO]	[PHO]
7	[OOO]	[HOO]	[HOO]	[HHO]

Table.1 presents the switching sequence for Vref positioned in sector I. The transition of Vref successive sector is done excluding change in switching state. Also transition of regions is realized with minimum number of switches changes. Reference vector in region three can be synthesized by three nearest stationary vectors: V1, V7 and V13. It can be observed at Fig.3.5, that transition of state includes change only between O and H state, or H and P.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

IV. SIMULATION RESULTS

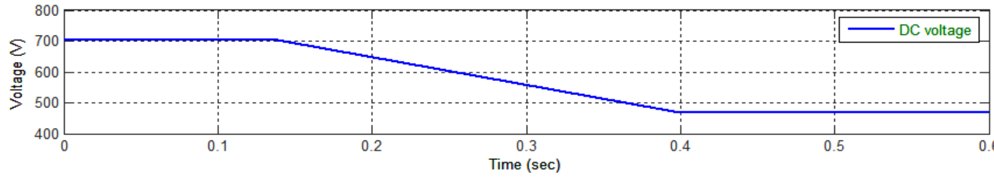


Fig .3 DC voltage fluctuations of about 20%.

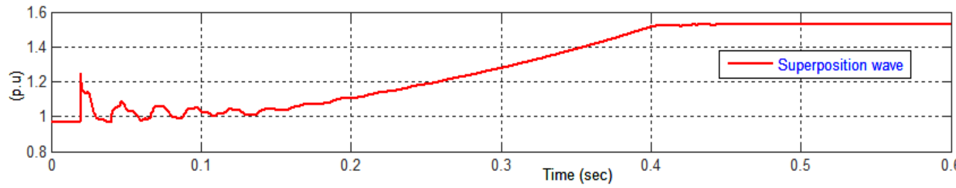


Fig. 4 SPR-wave

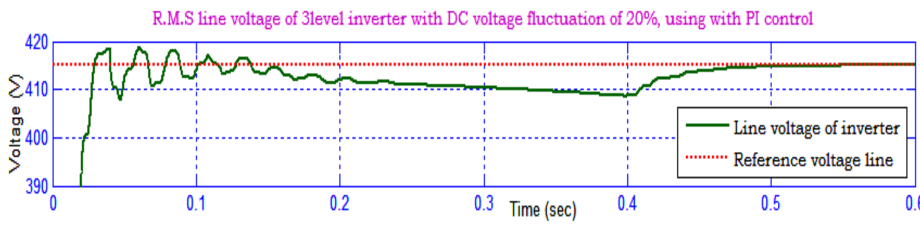


Fig .5. R.M.S line voltage

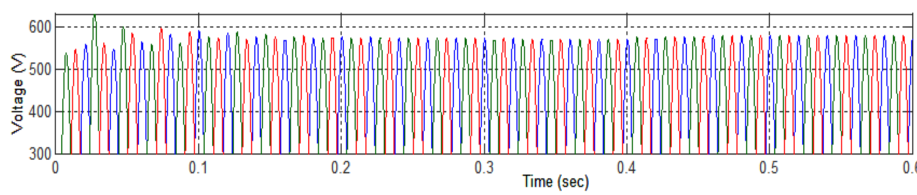


Fig. 6 the 3-phase output voltage

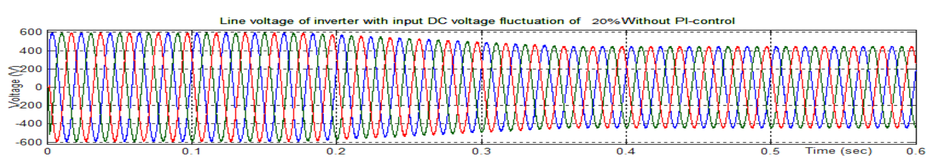


Fig.7, 3-phase output voltage without using proposed PI-technique

Fig.no 3,4,5 & 6: Simulation results of 3-phase MLI, using proposed PI-SVPWM with proposed PI control technique connected to 6kW-Resistive load has been presented connected to 5kW Resistance-load.

The superposition ratio has been increased to the maximum as to compensate for the voltage deficiency. The SP ratio begins to decrease and the output voltage attains to reference, the SP ratio drops to fixed (pu). And normal operation (without SPR-control) has been taken place is as shown in the Fig.4 The output voltage is attains to reference voltage is as shown in the Fig 5&6. Thus it has been confirmed that, appropriate adjustment of the SP ratio to fluctuations of the input DC voltage has been confirmed with using the proposed PI-SVPWM.

The superposition wave gradually increases in magnitude, and the output AC line voltage (V_{RMS}) has been remained unaffected by

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

the input DC voltage drop with improvement of superposition ratio by the SVPWM, with the proposed PI-technique is as shown in the Fig 4. As a result, the output voltage waveform attain to reference voltage is as shown in the Fig. 5.

It has been confirmed that, the 3-phase AC output line voltage(V_{peak}) waveforms has been remained unaffected even when the input DC source voltage fluctuation of 20% generated from the cogeneration systems is as shown in the Fig.6 with using the proposed PI-SVPWM.

Without using proposed technique, the 3-phase AC output line voltage waveform is as shown in Fig.7 and the THD output voltage of 3-phase multilevel inverter is as shown in fig.8.

Table.2, 3-phase MLI-output voltage characteristics.

S.No	Proposed PI-technique with load	DC voltage fluctuation of about	3-level Inverter Output Voltage (THD)
1	Resistance(5kW)	20%	1.35%

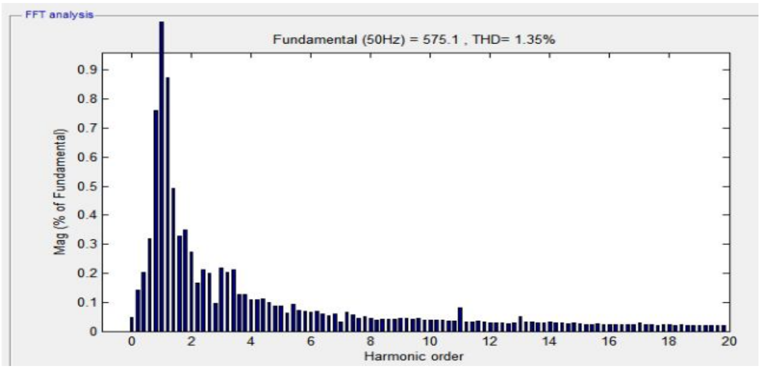


Fig.8. THD of MLI- Output voltage

V. CONCLUSIONS

It has been confirmed that, the 3-phase AC output line voltage remained unaffected even when the input DC source voltage fluctuation of about 20% generated from the cogeneration systems with using by the proposed PI-SVPWM technique. In future, it can be intended to focus on further reduction of output voltage distortion in the 3-phase MLI for unbalanced loads.

REFERENCES

[1] E. Najafi, Yatim, and A.H.M , “Design and Implementation of a New Multilevel Inverter Topology” IEEE Transactions on Industry Electronics, vol. 59, no.11, pp. 4148-4154, Nov 2012.
[2] Amei K, Maeda T, Ohji T, Sakui M. “Method for reducing of high frequency component in the single phase PWM inverter by the multilevel”. Joint Technical Meeting on Semiconductor Power Converter and Industry Electric Application IEE Japan, SPC-03, No. 95, p 41–46, 2003.
[3] M. Malinowski , k. Gopakumar , j. Rodriguez and m. A. Pérez "a survey on cascaded multilevel inverters", IEEE trans. Ind. Electron., vol. 57, no. 7, pp.2197 -2206, 2010.
[4] Imai K. Power electronics hand book. NTS Co. Ltd.; 2002. p 533–535.
[5] A.M. Almaktoof, A.K. Raji, and M.T.E. Kahn “Robust current control technique for variable DC-link Voltage Source Inverters for Renewable Energy Systems,” IEEE Industrial and commercial use of energy(ICUE)no. 2, pp. 1–8, August. 2014.
[6] Version 2 EE IIT, Kharagpur “ DC to AC converters” Module5
[7] Yaow-Ming Chen, Yuan-Ming Cheng “Modified PWM control for the DC-AC inverter with a non-constant voltage source,” IEEE Trans. Power Electronics and Drive system , vol. 2, pp.938–941, Jul 1999.
[8] Amei,K.;Tanizaki,Y.;Ohji,T.;Sakui,M.”A Control Method of Superposition Ratio in the Improvement of Voltage Utilization Factor in Three phase Multilevel Inverter considering the DC Voltage Fluctuation” Power Conversion Conference - Nagoya, 2007.7Publication Year: 2007 , Page(s):37 – 142
[9] Maruyama T, Asaeda T, Ikeda K. “Multilevel inverter”. 1992 Annual Meeting Record IEE Japan, No. S8-4.
[10] S. Narasimha, M. Sushama, “Control Method for Improving the Voltage Utilization Factor of Multilevel Inverters Considering Co-Generation System Voltage Fluctuation” Volume-3 Issue-6, August 2014 International Journal of Engineering and Advanced Technology (IJEAT), Pg No: 64-67, ISSN: 2249 – 8958.
[11] S. Narasimha, M.Sushama “Digital Control of Multi Level cascade Inverter with Variable DC Voltage Sources” Vol. 7 No.1 January 2015, International Journal of Engineering Science and Technology (IJEST) pg No:32-45, ISSN : 0975-5462.
[12] T.P.Mote, Dr.S.D.Lokhande, “Temperature Control System Using ANFIS” ISSN: 2231-2307,Volume-2, Issue-1, March 2012
[13] Ajay B Patil “Adaptive Neuro Fuzzy Controller for Process Control System”, 978-1-4244-2806-9/08/2008, IEEE.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

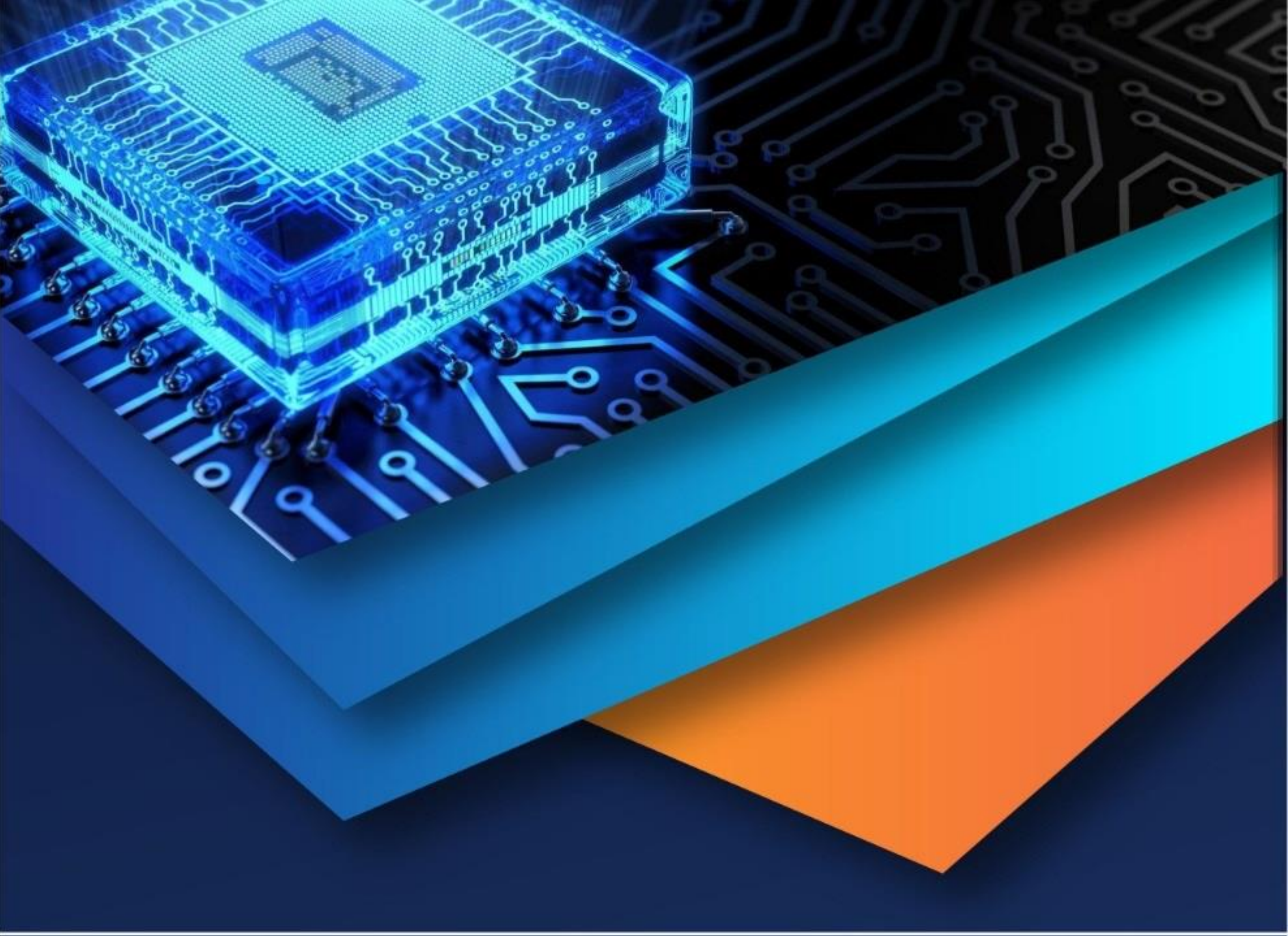
[14] Kaijun Xu, Xiaoping Qiu ,Xiaobing ,Li Yang Xu "A dynamic neuro-fuzzy controller for gas-Fired water heater", 3304-9/08 /2008 IEEE.
[15] Otman M. Ahtiwash and Mohd Zaki Abdulmuin,V.N. Alexandrov "An Adaptive Neuro-Fuzzy Approach for Modeling and Control of Nonlinear Systems", ICCS 2001, LNCS 2074, 198–207, 2001. Springer-Verlag Berlin Heidelberg.

ABOUT THE AUTHORS

[1]Dr.S.Narasimha born on 10th Aug 1979, obtained B. Tech degree in 2003 and M. Tech degree in 2009 from JNTUHCEH, INDIA. He obtained Ph.D. from JNTUH, India in 2016 in the area of "Power Electronics". Presently he is working as Professor in the Department of EEE, St.peter Engineering College, Hyderabad. His interests include Smart grid, Power Quality issue in co-generation systems.

[2]Dr. M.Sushama, born on 8th Feb 1973, .Obtained her B.Tech degree in 1993 and M.Tech degree in 2003 with a specialization in Electrical Power Systems from JNTU, INDIA. She obtained her Ph.D. from JNTU Hyderabad, India in 2009 in the area of "Power Quality" using Wavelet Transforms Presently she is working as Professor in the Department of EEE, JNTUH College of Engineering, Kukatpally, Hyderabad.

[3]J.Lingappa received his B.Tech degree in Electrical & Electronics Engineering from jntuh, Hyderabsd in 2010,M.Tech degree in Electrical Power Systems from JNTU Hyderabad in 2014. Presently he is working as Asst.Professor in Siddhartha Institute of Technology& Sciences,Ghatkesar,Hyderabad.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY