TELKOMNIKA, Vol.16, No.3, June 2018, pp. 1061~1070
ISSN: 1693-6930, accredited **A** by DIKTI, Decree No: 58/DIKTI/Kep/2013
DOI:10.12928/TELKOMNIKA.v16i3.5194

AC-AC Voltage Controller of Power Supply for Heater on Drying System

Renny Rakhmawati*[1], Farid Dwi Murdianto[2]
Politeknik Elektronika Negeri Surabaya
PENS Campus on street ITS Surabaya, telp.031-5947280, Indonesia
*Corresponding author, e-mail: renny@pens.ac.id,farid@pens.ac.id

Abstract

The coconut fruits is very useful to be processed into cooking oil and it can meet the needs of cooking for Indonesia people, But before the coconuts processed into oil, The coconuts should be dried first. Usually the drying process is manually, that is dried in the sun. Unfortunately this way is not hygienic and can't be done continuously, causing the coconut fungus overgrow. This paper proposes methode to solve the problem above.This research makes the dryer coconut fruitssystem by using the heater.Dryer system used for dry some coconut fruits that must be reduced the water content up to 5%, this dry coconutis called copra. System requires heater which will be regulated the temperature. Heater temperature setting is done by adjusting the heater supply voltage, and this is the task of ac to ac voltage controller. Ac to ac voltage controller is a circuit converter is capable converting ac voltage with value 220 Vrms at 50 Hz frequency and have waveform pure sinusoidal becom e ac voltage frequency at 50 Hz with an output voltage suitable with our need but the voltage waveform not impure sinusoidal or defective as a result firing angle effects. The output voltage which we set determines the value of the heater temperature. The output voltage is set from the firing angle of the triac component using the addition and decreasing angle values. Based on the results of experiments that have been done, if the drying chamber which has volume 135.2 liters and the temperature regulated at 70^0 C then the heater with a power requirement of 400 W should receive supply 216 V from ac to ac voltage controller. So the triac of ac to ac voltage controller fired on 0.55 radians so that the to ac voltage controller that gets 220 V input voltage can produce 216 V output voltage.

Keywords: *dryer system, AC to AC voltage controller, firing angle, triac, temperature control*

1. Introduction

In our daily life sometimes there is a need to drying some foodstuffs or medicinal. This is done to enhance the material to be processed further. For examples drying process coconuts to be copra, dried crackers so that can be fried, or drying medicinal then grinded and then to be packed into herbal medicine that ready to drink. To make it real, must be created dryer system because this process will save more time than when dried under the sun. Beside that, drying process can be completed without interruption, this gives hygienic result.

Indonesia is a tropical country and produces coconuts in large quantities. Coconuts fruit is very useful to be made many processed, such as young coconut can be drunk directly water and meat. The old coconut meat can be taken coconut milk for various processed dishes. Coconut meat can also be processed into cooking oil, but must go through the dry process first until the water content in the remaining coconut is less than 5%. The process of drying coconut fruit that has been done by the population of Indonesia so far by drying in the sun. This conventional method takes 7 days if the weather is sunny. The process is not continuous because after the afternoon, the drying process stalled and can only be continued tomorrow. Impact on the fruit of coconut drying less hygienic and moldy. Especially if the rainy season, then this process is certainly failed miserably.

This paper offers drying method that do not depend on sunlight andthe process can be continuous so as to obtain maximum results andhygienic. In this paper made design ac to ac voltage controller responsible for managing the heat generated by the heater in order for stabilizes the temperature of dryer chamber at setting pointnya. Ac to ac voltage controller is built on the triac which will turn on after the angle of ignition [3]. Ac to ac voltage controller, heater and all devices are integrated to build dryer system.

Received November 15, 2016; Revised April 4, 2018; Accepted May 10, 2018

Demand could be fulfilled by utilizing abundant number of agriculture and plantation by-products which processed through feed technology. Palm oil's plantation and mill are potential feed source which produces various and huge amount of by-product. Palm frond, palm leave and palm cover crop are an alternative fresh forage. Empty fruit bunch, palm pressed fiber and palm oil sludge are energy source for production, while palm kernel cake and solid decanter are potential protein. Many of palm oil's by-product is feedstuffs resource with digest-ease concentrate. This utilization is regarded as an effort to make an efficiency in term of production cost but it also requires new technology innovation to manage and improve the nutritional value.

Triac is a device that is essentially an integrated pair of phase-controlled thyristors connected in inverse-parallel on the same chip. When a voltage pulse is present on the gate terminal, the device turns on. Once the device is turned on, the device cannot be turned off. This device is considered bi-polar and reverse voltage blocking [6]. The explanation looks at Figure 1 above.

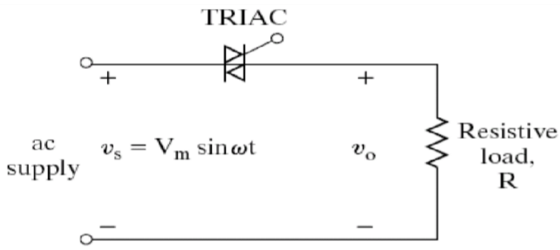

Figure 1. Single phase full wave ac voltage controller (Bi-directional Controller) using TRIAC

2. Research Method

The following block diagram of research looks at Figure 2. In this chapter described the process of design ac to ac voltage controller to regulate output heater [7], where in the heater is resistive load.

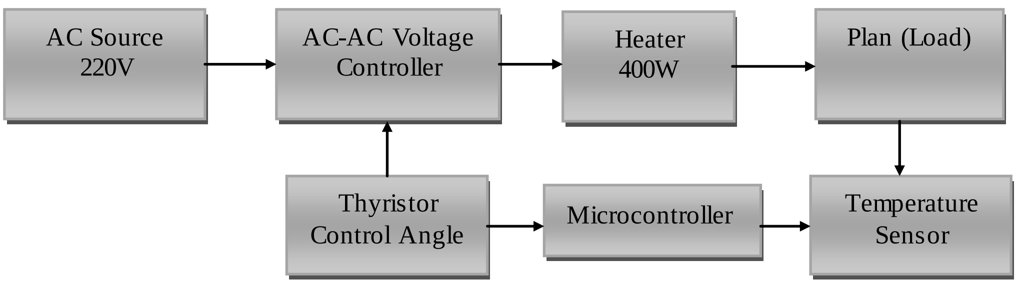

Figure 2. Block diagram of research

Design and calculation of AC to AC Voltage Controller at equation (1).

$$Vo = Vs \text{ x } \sqrt{1 - \frac{\propto}{\pi} + \frac{(\sin 2\propto)}{2\pi}} \quad (1)$$

To dry the object to be dried and burned while conditioning system volume 135.2 liters, the heater is set at room temperature of 70^0 C. Thus, heater voltage must have value 216 V for generate the temperature. Then AC to AC voltage controller is designed for 220 Vrms input and output 216 Vrms. Then put into the formula equation (2) and is obtained:

$$216 = 220 \text{ x } \sqrt{1 - \frac{\propto}{\pi} + \frac{(\sin 2\propto)}{2\pi}} \quad (2)$$

Thus obtained α=0.55 radian=31.530, then the triac is fired at 0.55 radians. While the heater is used requires a power of 400 W, with a voltage of 216 V, the obtained calculation of the resistance heater is as shown in equation (3)-(7).

$$R\ heater=(216)^2/400=116{,}64\ \Omega. \quad (3)$$

$$I_{orms}=V_{o\ rms}/R=216/116{,}64=1{,}855\ A. \quad (4)$$

$$Pf=V_{o\ rms}/V_{s\ rms}=216/220=0{,}98 \quad (5)$$

Or we can find pf using formula

$$pf=\sqrt{1-\frac{0{,}55}{\pi}+\frac{(\sin 2x\,0{,}55)}{2\pi}}=0{,}98 \quad (6)$$

$$P_{out}=V_{out}.\,I_{out}.\,Pf=216\ .\ 1{,}855\ .\ 0{,}98=400\ Watt. \quad (7)$$

So the next step make the circuit into PSIM software and simulated it like Figure 3.

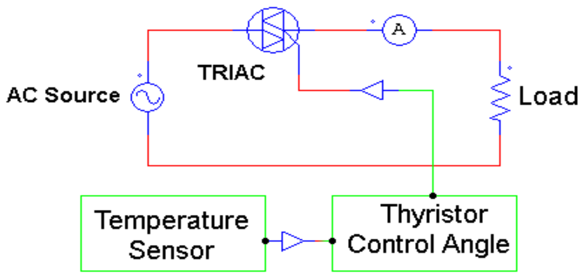

Figure 3. AC to AC voltage controller circuit in PSIM

The circuit is built on:
Sources with Vmax=311.127 V
Switching components using a TRIAC
firing angle (α)=0.55 radians or 31.530 degree and repeated every π radian.
frequency of 50 Hz
Rload=116.64 Ω and the pwm signals and output voltage of ac to ac like as Figure 4a and 4b. And the value of current looks at Figure 5.

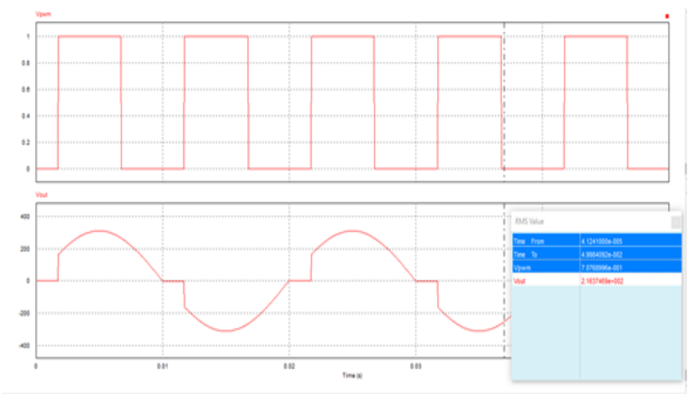

Figure 4a. PWM Signal and 4b. Output voltage waveform

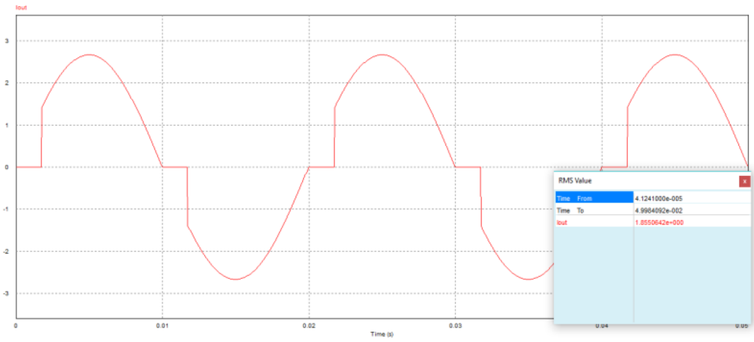

Figure 5. Output Current waveform

The results of design and counting is suitable with simulation results for current and voltage parameter. From simulation results, we find Voutput=216 using duty cycle 0,7 and output current value 1,855 A. Value of heater current is suitable with counting results.

2.1. TCA 785

TCA785 IC components, also known as phase control is installed on the system will be used as a firing angle controller on TRIAC so that AC voltage supply heater until the heater can control the temperature in the drying chamber. The Figure 6 following image a schematic drawing of TCA785.

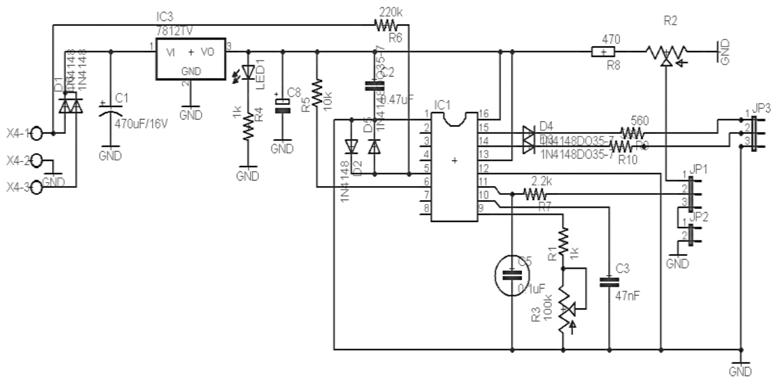

Figure 6. Skematik TCA785

IC 785 also known as TCA is supplied by Source 12 Vac from the transformer CT. The 12 Vac output will be through a diode to review rectified so that the output wave characteristics such as fullwave rectifier. Regulator IC 7812 is used as a voltage stabilizer that will go into IC TCA 785.Even ac to ac voltage controller circuit and heater is implemented in a dryer system with a volume of 135.2 liters. Conditioning system can be seen as the Figure 7. The drying chamber have dimension looks like on Figure 7. The camber have eight side, so sectional area of the side is as shown equation 8 and 9.

$$\text{extensive} = 2S^2\left(\sqrt{2}+1\right) \tag{8}$$

$$extensive = 2.(0,2)^2\left(\sqrt{2}+1\right)$$

$$extensive = 2.(0,04)\left(\sqrt{2}+1\right) = 0,193\ m^3$$

$$Volume\ chamber = extensivex\ length =$$
$$2.(0,04)\left(\sqrt{2}+1\right)x0,7 = 0,1352\ m^3 = 135,2liters \tag{9}$$

The heater islocated on the lowest position in the chamber. At left side there is blower that taking task to spread hot air. When humidity high so exhuast will turn on to discardwater vapor until on specified value then exhaust will turn off.

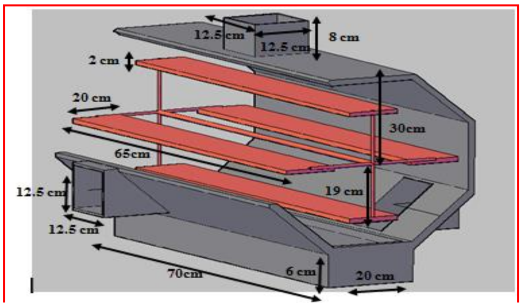

Figure 7. Dimension of the drying chamber

3. Results and Analysis

3.1. The test of IC TCA 785 circuit

Driver IC TCA circuit have function as a pulse generator circuit with value 12 volts and is used for triggering the triac component contained in the AC-AC Voltage Controller circuit. So in this case it can be seen the response and waveform at each pin-pin IC TCA 785.

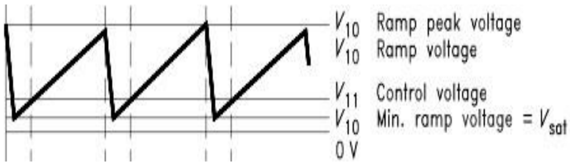

Figure 8. Output waveform IC TCA 785 Pin 10

Figure 8 show the test circuit IC TCA 785. On 14 and 15 pin IC TCA will display the output signal to be used to adjust the angle of firing the TRIAC components. The output waveform on pin 14 and 15 make form pulses/box corresponding datasheet shown in the following Figure 9.

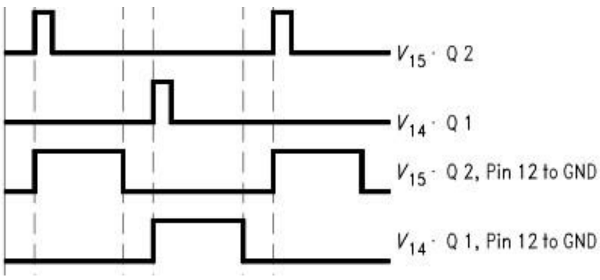

Figure 9. Output waveformIC TCA 785 Pin 14 and 15.

Figure 9 show intersection between the resulting output pin 14 and the pin 15. In the IC TCA 785 circuit pins 14 and 15 will be combined into a single output. The output waveform in pins 14 and 15 monitored use the oscilloscope with Volt/div=5V and Time/div=5ms on IC TCA showed in Figure 10.

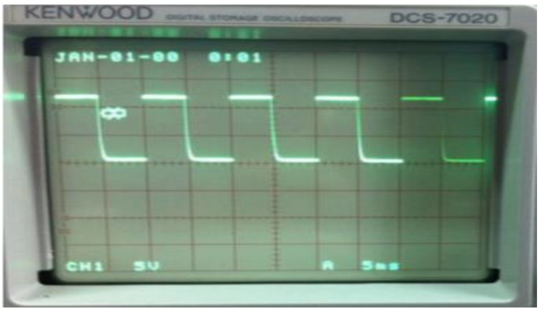

Figure 10. Output waveform IC TCA 785 Pin 14 and 15 using oscilloscope

3.2. The Test Circuit AC to AC Voltage Controller

Setting the temperature in the drying chamber by regulating voltage into the heater. The AC to AC Voltage Controller circuit can be used to adjust the amount of voltage to the load, ie as the input voltage load. For the test circuit AC to AC Voltage Controller requires TCA 785 circuit as setting the firing angle. The AC to AC Voltage Controller circuit using MOC3021 components as optoisolator. The output voltage waveform is displayed using Oscilloscope from AC to AC Voltage Controller. At Figure 11 as shown output voltage when the firing angle 40^{o}, Volt/div=50V, time/div=5ms.

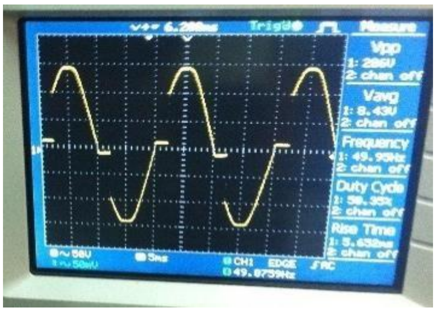

Figure 11. Output waveform on 40^{0} firing angle

While if the firing angle 80^{o}, Volt/div=50V, time/div=5ms. So the output voltage looks like Figure 12.

Figure 12. Output waveform on 80^{0} firing angle

Table 1 below give result testing firing on AC-AC Voltage Controller at variation angle and compare the output voltage betwen practice, theory and PSIM simulation. Calculating value ofoutput voltage Ac to Ac Voltage Controller using formula equation (10).

$$Vo=Vs \times \sqrt{1-\frac{\propto}{\pi}+\frac{(\sin 2\propto)}{2\pi}} \quad (10)$$

Reference to equation 11, so output voltage Ac to Ac Voltage Controller calculate below as shown in equation (11)-(13).
If $\alpha=40^0$

$$Vo=Vs \times \sqrt{1-\frac{\propto}{\pi}+\frac{(\sin 2\propto)}{2\pi}} \quad (11)$$

$$Vo=220 \text{ Volt} \times \sqrt{1-\frac{40}{\pi}+\frac{(\sin 2\times 40^0)}{2\pi}} = 212{,}6 \text{ Volt.} \quad (12)$$

Error percentage of output voltage AC to AC Voltage Controller at $\alpha=20^0$ can seen below.

$$\%\ Error = \frac{|Vt-Vp|}{Vt} \times 100\% = \frac{|212{,}6-201|}{212{,}6} \times 100\% = 5{,}45\ \% \quad (13)$$

From the result test to the AC-AC Voltage Controller, data contained in Table 1, when firing angle is given the greater the percentage of error between computation theory and practice results will be even greater.

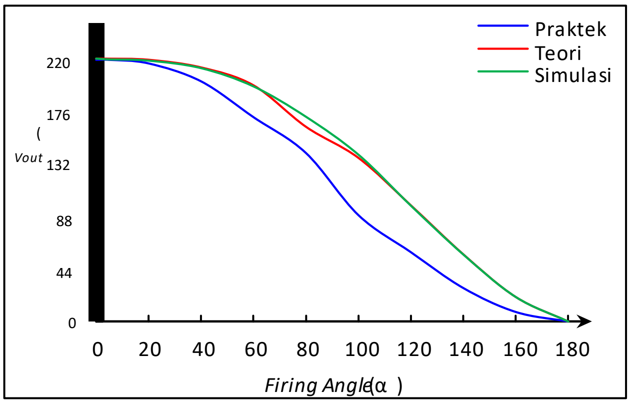

Figure 13. Graph of the relationship among the firing angle vs output voltage of practice, theory and simulation.

Figure 13 above is a graph of the relationship among the firing angle vs output voltage of practice, theory and simulation. From the graph it can be seen that the output voltage have high value if the firing angle small, but if firing angle increase so the output voltage will be lower. Graph of output voltage theory and simulation coinciding, but compare with result of practice, there is little error.

3.3. The Test Heater Function

From data on Table 2, so we can make graph as respon of heater when we operate open loop (without control), and the graph looks at Figure 14. The implementation result for drying system with AC to AC voltage controller produce coconut are shown in Figure 17. The implementation result without AC to AC voltage controller are shown in Figure 16. We compare the results of Figure 16 and Figure 17, with the AC-AC volgate controller better than without AC to AC voltage controller.

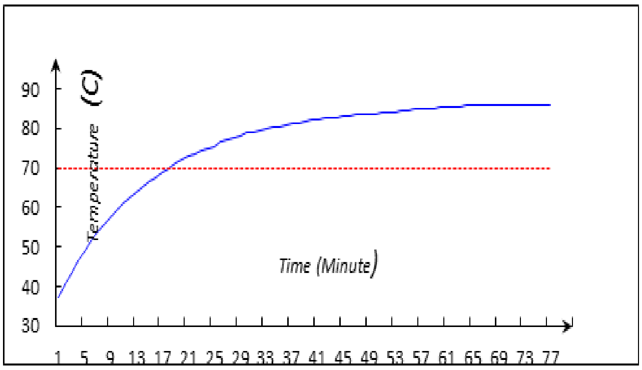

Figure 14. Respon of heater when we operate open loop

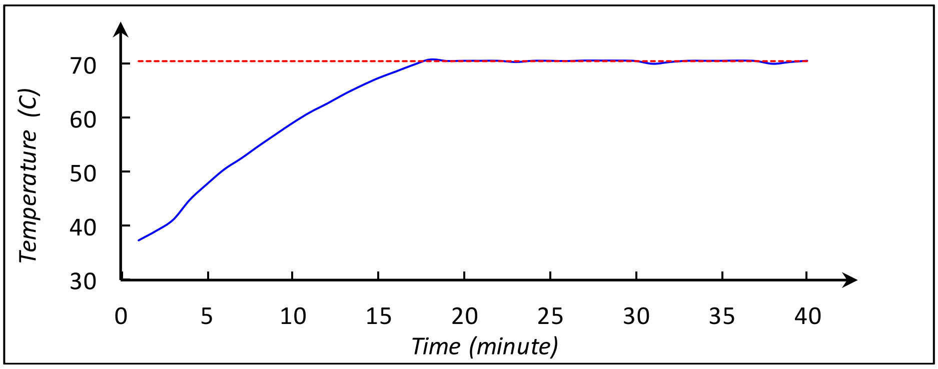

Figure 15. Graph respon of heater when we operate close loop (on/off control temperature)

Figure 16. The result of drying the coconut in the sun

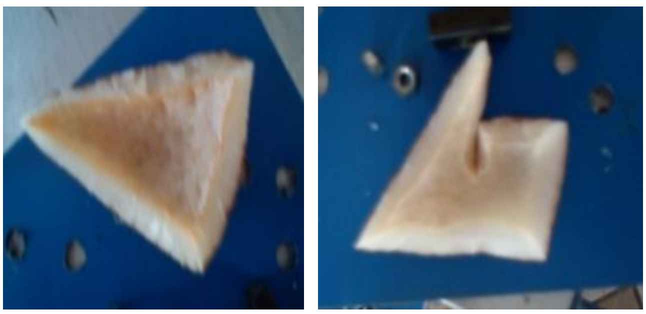

Figure 17. The result of drying the coconut using drying system

4. Conclusion

The Implementation results show that using the addition and subtraction control alpha angle (Tyristor control Angle) is obtained stable result and got temperature according to target (Accurate) resulting in high quality coconut drying. The Experiment result showed that if the drying chamber which has volume 135.2 liters and the temperature regulated at 70^0 C then the heater with a power requirement of 400 W and the output voltage is 216 V from ac to ac voltage controller. After this research will be developed again towards products that can be used by villagers or city.

References

[1] Akbar AN Bahar, MK Baowaly, A Chakraborty. An intelligent approach of regulating electricfan adapting to temperature and relative humidity. *International Journal Intelligent Systems and Applications*. 2012; 4(7): 61-69.

[2] Andrzej Kandyba, Marian Hyla. *Control of Transistors in AC Voltage PWM Controller with Elimination of Commutation Overvoltages*. 16th International Conference on Computational Problems of Electrical Engineering (CPEE). Lviv, Ukraine. 2015: 62–67.

[3] Daniel W Hart. Introduction to power electronics. 1996: 162-171. (ISBN) 9780071289306

[4] D Soto, R Peña, P Wheeler, TC Green. *Regulation of the Capacitor Voltages in a Directlike Cascade AC-AC Converter for FACTS Controllers.* Power Electronics Specialists Conference. PESC IEEE. 2008.

[5] ES Oluwasogo, IK Okakwu. Performance analysis of a single-phase ac voltage controller under induction motor load. *International Journal of Research in Engineering and Technology*. 2014; 3(6): 184-191.

[6] Gennady Zinoviev, Maksim Ganin, Evgeny Levin, Aleksey Obuhov, Vladimir Popov. New Class Of Buck -Boost Ac-Ac Frequency Converters And Voltage Controllers. 0-7803-6486-4/00/$10.00~ 2000 *IEEE*. 2000: 303–308.

[7] HA Ashou, RA Ibrahim. *Comparison analysis of ac voltage controllers based on experimental and simulated application studies*. The 2006 International Conference Computer Engineering and Systems. 2006; 79–84.

[8] Hanuman Prasad, Tanmoy Maity. *Design of a Stable and Efficient Z-Source AC-AC Converter using Small Signal Analysis*. IEEE Power, Communication and Information Technology Conference (PCITC) Siksha 'O' Anusandhan University, Bhubaneswar, India. 2015. 978-1-4799-7455-9/15/$31.00 © 2015 IEEE.

[9] Mahmoud AM Albreem, Hassan TA Naser, Mustafa EA Abofares. *Design of Indirect AC–AC Converter Based on Linear Controller for Power System*. International Conference on Advances in Electrical, Electronic and System Engineering. Putrajaya, Malaysia. 978-1-5090-2889-4/16/$31.00 © 2016 IEEE. 2016: 500–505.

[10] Mahmoud A Sayed, Kazuma Suzuki, Takaharu Takeshita, Wataru Kitagawa. Modeling and Control of Bidirectional Isolated Battery Charging and Discharging Converter Based High-Frequency Link Transformer. *IEEE* .2016. 978-1-4673-8617-3/16/$31.00 © 2016.

[11] Md Imtiaz Khan, Abdul Ahad, Kamrul Islam. Design of a single phase ac-ac converter. Bachelor Thesis. Dhaka: BRAC University. 2012.

[12] M Narayanan, RM Karthika, K Karthika, VK Aravind, S Vignesh. Comparative Study of Control Strategies of AC Voltage Controller. *IPASJ International Journal of Electrical Engineering*. 2015; 3(11): 11-21.

[13] Mohammad Rubaiyat Tanvir Hossain, Mohammad Ali Choudhury. *New Three Phase Bidirectional Switch Based AC Voltage Controller Topologies*. International Conference on Electrical, Computer and Communication Engineering (ECCE), Cox's Bazar, Bangladesh. 2017: 757–762.

[14] N Radhakrishnan, M Ramaswamy. Fuzzy-based field-programmable gate array implementation of a power quality enhancement strategy for ac–ac converters. *Journal of Electrical Engineering & Technology*. 2011; 6(2): 233-238.

[15] Pankaj Kumar Bhowmik, Somasundaram Essakiappan, Madhav Manjrekar. State Space Analysis and Duty Cycle Control of a Switched Reactance based Center-Point-Clamped Reactive Power Compensator. 978-1-4673-9550-2/16/$31.00 ©2016 *IEEE*. 2016: 2706–2713.

[16] Pankaj Kumar Bhowmik, Sushma Yellapragada, Madhav Manjrekar. Dynamic Analysis and Controller Design for a Center-Point-Clamped AC-AC Converter. 978-1-4799-6735-3/15/$31.00 ©2015 *IEEE*. 2015: 535 – 542.

[17] Peng Li , Grain Philip Adam, Derrick Holliday, Stephen Jon Finney, Barry Wayne Williams. Simulation study of FACTS devices based on AC–AC modular multilevel hexagonal chopper. *IET Power Electron*. 2017; 10(8): 919-930.

[18] R Geetha, C Sumithra, M Ramaswamy. *Harmonic Reduction Strategy For An AC Voltage Controller Without DC Link*. International Conference On Computation Of Power, Energy, Information And Communlcation. 978-1-4673-6524-6/15/$ 31.00 © 2015 IEEE. 2015: 0140–0143.
[19] Soedibyo, Farid Dwi Murdianto, Suyanto, Mochamad Ashari, Ontoseno Penangsang. "Modeling and simulation of mppt SEPIC combined bidirectional control invers KY converter using ANFIS in microgrid system". *Indonesian Journal of Electrical Engineering and Computer Science (IJEECS)*. 2016; 1: 264-272.
[20] Efendi MZ, Murdianto FD, Setiawan RE. *Modeling and simulation of MPPT sepie converter using modified PSO to overcome partial shading impact on DC microgrid system*. International Electronics Symposium on Engineering Technology and Applications (IES-ETA). 2017.
[21] Murdianto FD, Nansur AR, Hermawan ASL. *Modeling and simulation of MPPT coupled inductor sepie converter using Flower Pollination Algorithm (FPA) Method in DC mierogrid system*. International Electronics Symposium on Engineering Technology and Applications (IES-ETA). 2017.
[22] Farid Dwi Murdianto, Ontoseno Penangsang, Ardyono Priyadi. *Modeling and simulation of mppt-bidirectional using adaptive neuro fuzzy inference system (ANFIS) in distributed energy generation system*. IEEE International Seminar on Intelligent Technology and Its Applications (ISITIA). 2015.
[23] Oladimeji ibrahim, Nor Zaihar Yahaya, Nordin Saad. State-space Modelling and Digital Controller Design for DC-DC Converter. *TELKOMNIKA (Telecommunication, Computing, Electronics and Control)*. 2016; 14(2): 497-506.
[24] Yahui Wang, Yijia Cao, Yong Li, Chang Li. An Improved Repetitive Control for Circulating Current Restraining in MMC-MTDC. 2017; 15(3): 1048-1060.