TELKOMNIKA, Vol.16, No.2, April 2018, pp. 635~640
ISSN: 1693-6930, accredited A by DIKTI, Decree No: 58/DIKTI/Kep/2013
DOI:10.12928/TELKOMNIKA.v16i2.7067

Accumulator Charging Control with Piezoelectric Based on Fuzzy Algorithm Scheduling

Iswanto*[1], Wahyu Sari Agustiningsih[2], Faaris Mujaahid[3], Rohmansyah Rohmansyah[4], Aris Budiman[5]
[1,2,3,4]Department of Electrical Engineering, Universitas Muhammadiyah Yogyakarta, Yogyakarta, Indonesia
[5]Department of Electrical Engineering, Universitas Muhammadiyah Surakarta, Surakarta, Indonesia
[1]Laboratory Center for Automation Instrumentation Control Aerospace and Robotics (CAICAR), Universitas Muhammadiyah Yogyakarta, Indonesia
*Corresponding author, e-mail: iswanto_te@umy.ac.id

Abstract

Battery accumulator charging with pizoelectric takes considerable long time so that an energy harvester is needed by using in this study LTC 3588 circuit. However, by using the energy harvester, the pizoelectric cannot be used to charge 12 volt battery, thus a boost converter is needed. The output voltage is too small to increase by using the boost converter so that the output from the energy converter is used to charge four AA batteries. After the voltage of the four AA batteries as much as 4.7 volt is increased by using the boost converter, the batteries can be used to charge accumulator battery 12 volt. To charge the battery to accumulator, scheduling algorithm planted in microcontroller arduino is needed. By using the scheduling algorithm with fuzzy logic in the arduino microcontroller, the microcontroller is able to control schedule of accumulatro battery charging.

Keywords: *battery accumulator, arduino, fuzzy logic, microcontroller*

1. Introduction

Piezoelectric is a material having an ability to generate electric potential as a respond of mechanical pressure given to the material [1]. The material used is known as pizoelectric composed as crystal molecule. Pizoelectric material is the material composed of silicon or germanium which are able to generate electtricity when experience direc pizoelectric, on the other hand it experiences inverse pizoelectric when it is given a voltage. Pizoelectric is able to generate electrical energy if it is given pressure and stretch. This ability then later will be used to generate electrical energy used the pressure from the vibration of the materials [2].

Pizoelectric has been studied by several researhers as Vasic et al conducting a research by using pizoelectric tranduser used to harvest energy when cycling [3]. The tranduser was pled on the bike's body so that whem the bike pass on the uneven road, the vibration resulted generates energy. The pizoelectric tranduse was used by Viola et al to harvest rain energy [4]. The pizoelectric was mounted to cartiviler and placed outside the house. When it is rainy, the rain moves the carteviler so that the pizoelectric generates energy.

Pizoelectric tranduser was used by Greve to detect pipe damage [5]. It was placed on the pipe and then waves were transmitted from the tranduser directed to the pipe and the pipe would retransmit the waves and captured by the pizoelectric if the pipe was not damage. The control of drug distribution was used by using pizoelectric was studied by Ahmadi et al [6] served as a transmitter and receiver antenna used to transfer drug data.

Sound energy changed into electrical energy has been studied by Jamal et al by using pizoelectric tranduser [7]. Twenty circuits of pizoelectric were connected to voltage summer amplifier with op-amp LM324 to generate high output voltage by using pizoelectric. Rotation energy was changed into electrical energy by Khameneifar et al. using pizoelectric circuits [8]. The circuits were arranged as a fan and rotated to generate electrical energy.

Renewable energy by using pizoelectric tranduser has beem studied by Chow and Alan [9]. The tranduser was arranged serial to generate big waves to turn on LED. Inverter design with pizoelectric has been studied by Huanh et al by using hybrid loop control [10]. The inverter design was used to increase the voltage generated by pizoelectric.

Received August 22, 2017; Revised January 15, 2018; Accepted February 3, 2018

From the previous researches conducted, electrical energy generated was considerably small so that a method to charge accumulator battery is needed. The method used is by charging four AA batteries and then flow the electrical energy from the AA batteries to charge accumulator battery. The process of accumulator charging using pizoelectric is carried out by scheduling algorithm.

Several algorithm schedulings have been studied by previous researhers such as fuzzy algorithm used by Wang et al to make store keeper schedule [11]. There were some problems in the store keeper scheduling that could be overcome by using A Hybrid Discrete Imperialist Competition. The genetic algorithm used for the scheduling algorithm is investigated by Zuo et al. [12]. This algorithm is used for scheduling bus transportation system. The taboo search algorithm coupled with the swarm particles algorithm were investigated by Gao et al [13]. The algorithm is to overcome the problem on the work shop scheduling.The paper describes scheduling algorithm by using fuzzy algorithm applied in Arduino for accumulator charging scheduling by using pizoelectric.

2. Research Method

Need analysis system is needed in making accumulator battery charging controller by scheduling algorithm based on fuzzy logic, one of them is voltage sensor to read the voltage on two AA batteries arranged serially. The arduino mocrocontroller is as the main control [14], LCD 16x2 is used to read the sensor and driver transistor as the path to accumulator battery charging. The concept of the design is shown in Figure 1 describing the process on how it works.

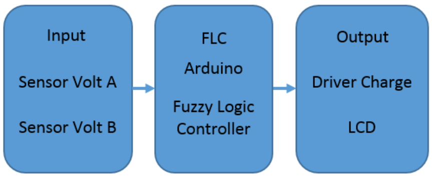

Figure 1. Block diagram of the design

Figure shows that there are two voltage sensors used as inputs to read the voltage on two serial circuits of two AA batteries. And then the result will be proceeded in arduino microcontroller by using programming algorithm of fuzzy logic with Mamdani inference method, so that it will generate produce output voltage that manages transistor to flow electrical current of accumulator charging and the result of reading shown in LCD 16x2.

In the process of designing and creating accumulator charging controller using pizoelectric based on fuzzy logic, there are two design parts namely hardwareand software. The hardware includes arduino microcontroller, voltage sensor, LCD 16x2 circuits and accumulator charging driver. Flowchart program as shown in Figure 2 is made to ease the program creation.

In the flowchart of the program shown in Figure 2, it can be seen that when the program starts, arduino initiates the analog digital converter (ADC) and then the two voltage data are taken by using two ADCs on the arduino. The two-voltage data are used to enter the scheduling control algorithm for accumulator charging.

In this paper a scheduling algorithm is used by using fuzzy logic algorithm. The fuzzy logic algorithm is an artificial intelligence algorithm invented by Zadeh and used by Iswanto et al. for quadrotor path planning [15]-[16] and control [17]-[18]. By using this algorithm, the quadrotor can move to destination position and avoid obstacles. The fuzzy algorithm used for robot trash was studied by Tunggal et al. [19]. By using the algorithm, the robots can pursue garbage thrown away. The fuzzy algorithm was used for search algorithm by Mubarok et al [20]. By using the algorithm, the position of the borrowed motorbike can be identified.

Fuzzy algorithm was also used for scheduling method by Chang et al. [21] for offshore workers schedule system. Pattern recognition with fuzzy logic algorithm combined with the neural network algorithm was studied by Xue & Dong [22]. The algorithm is used for traffic lights scheduling. The fuzzy algorithm applied to store workers schedule was investigated by Gonzalez-Rodriguez et al. [23]. There was a problem in the algorithm so that it is solved by using semantic schedule.

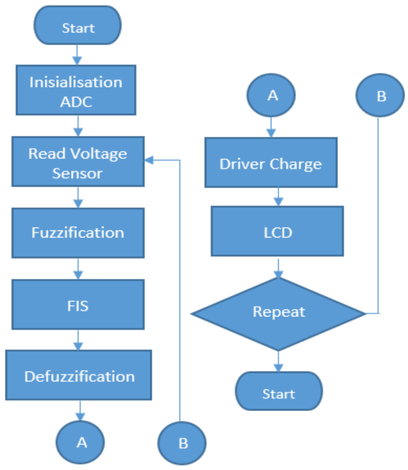

Figure 2. The flowchart of the program

The scheduling method with fuzzy algorithm was also used in the field of control performed by Benitez et al [24]. The algorithm is used for gain scheduling at industrial temperature controls. The Fuzzy scheduling method was studied by Rodriguez-martinez et al for start-up control of gas turbine power plant [25]. The method was used for gain scheduling combined with PI control.

The scheduling method with fuzzy used in this paper is to schedule accumulator charging. The fuzzy logic algorithm has three stages namely fuzzification, FIS (Fuzzy Inference System) or rule base, and defuzzification. There are two parts in fuzzification that is the input and output. Voltage sensor A and voltage sensor B have the same form of membership function as shown in Figure 3. The picture shows that the sensor input will be divided into 4 variables that are small, normal, medium, and large with a range of 0-5 volt measurement.

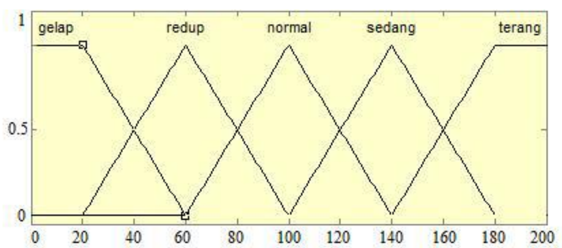

Figure 3. Input membership function

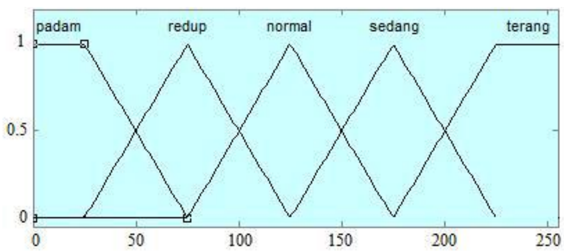

Figure 4. Output membership function

While the output is divided into 3 variables that are small, normal, and large with the output range of 0-255 as in Figure 4. After performing the fuzzification stage, the result of the fuzzification will be set by using the rule base previously created. The rule base in Table 1 is created to generate output to control the accumulator charging driver.

The last process in fuzzy logic is defuzzification. Defuzzification is the process of changing the biased values into true values. In this case the defuzzification process is using centroid of area method.

Table 1. Basis of Rules

Idrb \ Indra	Gelap	Redup	Normal	Sedang	Terang
Gelap	Terang	Terang	Sedang	Normal	Normal
Redup	Terang	Sedang	Normal	Normal	Redup
Normal	Sedang	Normal	Normal	Redup	Redup
Sedang	Normal	Normal	Redup	Redup	Padam
Terang	Normal	Redup	Redup	Redup	Padam

3. Results and Analysis

In the first test, a voltage sensor test was placed on both AA batteries that are not connected with a fuzzy scheduling method to determine whether the sensor is working properly or not. The voltage sensor test was performed by measuring the voltage on the AA and ADC batteries displayed on the LCD when the piezoelectric's staircase is pressed and electrical energy is stored on the piezoelectric as shown in Table 2 and Figure 5.

Table 2. Result of Voltage Sensor Test on AA batteries

No	Pressure	AA 1 battery voltage		AA 2 battery voltage	
		Voltmeter	LCD	Voltmeter	LCD
1	1	0,5 Volt	0,3 Volt	0,4 Volt	0,5 Volt
2	2	1,3 Volt	1,4 Volt	1,2 Volt	1,3 Volt
3	3	1,7 Volt	1,5 Volt	1,8 Volt	1,9 Volt
4	4	2,0 Volt	2,1 Volt	2,1 Volt	2,0 Volt
5	5	2,9 Volt	2,8 Volt	2,8 Volt	2,9 Volt
6	6	3,0 Volt	3,0 Volt	3,0 Volt	3,0 Volt
7	7	3,0 Volt	3,0 Volt	3,0 Volt	3,0 Volt

Based on the test results shown in Table 3, it appears that both AA batteries can be charged with piezoelectric for about 5 times the pressure. Both voltage sensors used to measure AA battery voltage work well and both can be said to have almost the same sensitivity.

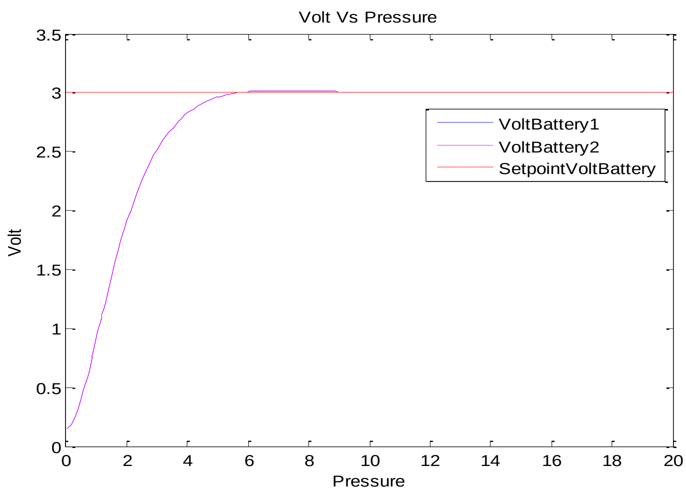

Figure 5. Test on AA batteries charging with piezoelectric

There are 3 graphics shown in figure 5 that is AA 1 battery charging, AA 2 battery charging, and battery charging point. The scheduling control algorithm stabilizes the voltage quickly and takes 4.968 seconds of the steady state, 2.166 seconds of settling time. In addition, the time for charging AA batteries is fast and takes 1,607 seconds of the raise time. There are no oscillation and overshoot in charging AA batteries.

4. Conclusion

A scheduling method with fuzzy algorithm to control the accumulator charging process using piezoelectric has been implemented in this paper. This method is not a scheduling method of industrial control, it was made to control the charging current to the accumulator of AA batteries by using the fuzzy algorithm. It showed that fuzzy logic algorithm with mamdani method might be applied to the control of accumulator charging scheduling. The input of the FLC control that is AA battery voltage obtained from the voltage sensor. By controlling the accumulator charging scheduling with 5x5 rule base, the accumulator voltage has 6.089 second of the steady state and 1.539 secoonds of the raise time.

References

[1] S Ma, Q Sun, Y Su, R Chen, L Wang. Experimental Investigation of Piezoelectricity of Near Field Electrospun PVDF Nanofibers. *TELKOMNIKA (Telecommunication, Computing, Electronics and Control)*. 2016; 14(2A): 145.

[2] S Pang, W Li, J Kan. Simulation Analysis of Interface Circuits for Piezoelectric Energy Harvesting with Damped Sinusoidal Signals and Random Signals. *TELKOMNIKA (Telecommunication, Computing, Electronics and Control)*. 2015; 13(3): 767–775.

[3] D Vasic, YY Chen, F Costa. *Self-powered piezoelectric energy harvester for bicycle*. In IECON 2013-39th Annual Conference of the IEEE Industrial Electronics Society. 2013: 1856–1861.

[4] F Viola, P Romano, R Miceli, G Acciari. *On the harvest of rainfall energy by means of piezoelectric transducer*. In 2013 International Conference on Renewable Energy Research and Applications (ICRERA). 2013: 1133–1138.

[5] DW Greve, P Gong, IJ Oppenheim. *A novel split inductively coupled piezoelectric transducer for flaw detection in pipes*. In 2015 IEEE International Ultrasonics Symposium (IUS). 2015: 1–4.

[6] SA Ahmadi, T Fanaei Sheikholeslami, M Mehrjoo, SM Barakati. *Controlling a drug delivery micropump using surface acoustic wave correlator*. In 2013 20th Iranian Conference on Biomedical Engineering (ICBME). 2013; Icbme: 87–92.

[7] GRA Jamal, H Hassan, A Das, J Ferdous, SA Lisa. *Generation of usable electric power from available random sound energy*. In 2013 International Conference on Informatics, Electronics and Vision (ICIEV). 2013: 1–4.

[8] F Khameneifar, S Arzanpour, M Moallem. A Piezoelectric Energy Harvester for Rotary Motion Applications: Design and Experiments. *IEEE/ASME Trans. Mechatronics*. 2013; 18(5): 1527–1534.

[9] LS Chow, M Alan. Generating renewable electrical energy using piezoelectric. In 2013 *IEEE Student Conference on Research and Development*. 2013: 13–14.

[10] SJ Huang, TS Lee, RY Chen, YH Yeh. Application of hybrid-loop control approach to inverter design with piezoelectric transducers. In 2015 *IEEE International Conference on Industrial Technology (ICIT).* 2015; 2015: 935–940.

[11] S Wang, Aorigele, G Liu, S Gao. A Hybrid Discrete Imperialist Competition Algorithm for Fuzzy Job-Shop Scheduling Problems. *IEEE Access*. 2016; 4(c): 9320–9331.

[12] X Zuo, C Chen, W Tan, M Zhou. Vehicle Scheduling of an Urban Bus Line via an Improved Multiobjective Genetic Algorithm. *IEEE Trans. Intell. Transp. Syst*. 2014; 16(2): 1–12.

[13] H Gao, S Kwong, B Fan, R Wang. A Hybrid Particle-Swarm Tabu Search Algorithm for Solving Job Shop Scheduling Problems. *IEEE Trans. Ind. Informatics*. 2014; 10(4): 2044–2054.

[14] H Ferdinando, H Khoswanto, D Purwanto. Performance Evaluation of MMA7260QT and ADXL345 on Self Balancing Robot. 2013; 11(1).

[15] I Iswanto, O Wahyunggoro, AI Cahyadi. Formation Pattern Based on Modified Cell Decomposition Algorithm. *Int. J. Adv. Sci. Eng. Inf. Technol*. 2017; 7(3): 829–835.

[16] I Iswanto, O Wahyunggoro, AI Cahyadi. Quadrotor Path Planning Based On Modified Fuzzy Cell Decomposition Algorithm. *TELKOMNIKA (Telecommunication, Computing, Electronics and Control)*. 2016; 14(2): 655–664.

[17] I Iswanto, A Ataka, R Inovan, O Wahyunggoro, A Imam Cahyadi. Disturbance Rejection for Quadrotor Attitude Control Based on PD and Fuzzy Logic Algorithm. *Int. Rev. Autom. Control*. 2016; 9(6): 405.

[18] Iswanto, O Wahyunggoro, AI Cahyadi. Hover position of quadrotor based on PD-like fuzzy linear programming. *(IJECE) International Journal of Electrical and Computer Engineering* 2016; 6(5): 2251–2261.

[19] TP Tunggal, A Supriyanto, NMZRI Faishal, I Pambudi, Iswanto. Pursuit Algorithm for Robot Trash Can Based on Fuzzy-Cell Decomposition. *(IJECE) International Journal of Electrical and Computer Engineering* 2016; 6(6): 2863–2869.

[20] R Mubarok, DV Firmansyah, D Haryanto, NP Apriyanto, U Mahmudah, I Iswanto. Motorcycle-Security using Position Searching Algorithm Based on Hybrid Fuzzy-Dijkstra. *(IJEECS) Indonesian Journal of Electrical Engineering and Computer Science*. 2016; 3(2): 468–474.

[21] CS Chang, Z Wang, F Yang, and WW Tan. Hierarchical Fuzzy Logic System for Implementing Maintenance Schedules of Offshore Power Systems. *IEEE Trans. Smart Grid*. 2012; 3(1): 3–11.
[22] D Xue, Z Dong. An intelligent contraflow control method for real-time optimal traffic scheduling using artificial neural network, fuzzy pattern recognition, and optimization. *IEEE Trans. Control Syst. Technol*. 2000; 8(1): 183–191.
[23] I Gonzalez-Rodriguez, J Puente, CR Vela, R Varela. Semantics of Schedules for the Fuzzy Job-Shop Problem. *IEEE Trans. Syst. Man, Cybern.-Part A Syst. Humans*. 2008; 38(3): 655–666.
[24] IO Benitez Gonzalez, R Rivas Perez, V FeliuBatlle, LP Sanchez Fernandez, LA Sanchez Perez. Fuzzy Gain Scheduled Smith Predictor for Temperature Control in an Industrial Steel Slab Reheating Furnace. *IEEE Lat. Am. Trans*. 2016; 14(11): 4439–4447.
[25] A Rodriguez-Martinez, R Garduno-Ramirez. *PI Fuzzy Gain-Scheduling Speed Control of a Gas Turbine Power Plant*. In Proceedings of the 13th International Conference on, Intelligent Systems Application to Power Systems. 4493; 26(1): 302–307.