Journal of Intelligent System and Telecommunications

Journal homepage: https://journal.unesa.ac.id/index.php/jistel/index

Design of Fuzzy-PI Control System for Voltage Regulation of Boost Converter

Rifqi Firmansyah[1], Nanda Eka Saputra[2], Habib Brilian Wicaksono[3], Wahyu Cahya Putra[4], Muhammad Saud Khan[5]*

[1,2,3,4] Department of Electrical Engineering, Universitas Negeri Surabaya, Indonesia
[5]Department of Electrical and Computer Engineering, King Abdulaziz University, Saudi Arabia
*Correspondence: E-mail: rifqifirmansyah@unesa.ac.id

ARTICLE INFO

Article History:
Submitted/Received 15 December 2025
First Revised 24 April 2026
Accepted 28 April 2026
First Available Online 29 October 2026
Publication Date 29 October 2026

Keyword:
Boost converter, Voltage regulation, Fuzzy-PI control

ABSTRACT

One of important component in a voltage regulation system of electric vehicle is a boost converter. In its application, the boost converter often faces several challenges in maintaining performance especially under the influence of varying load conditions. In order to make the boost converter function under various conditions, an efficient and adaptive control with optimal performance needs to be realized. This paper proposes the Fuzzy-PI method for voltage regulation in the boost converter. The application of this method is expected to improve the performance of the boost converter. Based on the test results, Fuzzy-PI control can provide the best superior performance when contrasted with other conventional methods with the characteristics of quick rise time, low overshoot, and minimum steady state error. The system also possesses high disturbance robustness and rapid adaptation to change, hence a good and effective solution for voltage regulation in various applications.

© 2026 Tim Pengembang Jurnal UNESA

1. INTRODUCTION

In electric vehicles, boost converters are crucial for preserving voltage stability [1]. Issues like performance degradation and voltage fluctuations are still frequent [2,3]. To tackle the issues, proportional-integral (PI) controller is used. PI control provides a highly effective but several issues are faced such as the response of the control system in dealing with voltage changes[4,5]. While fuzzy logic control is more adaptable to non-linear systems but has drawbacks like overshoot [6,7]. By combining fuzzy and PI, a Mamdani-based fuzzy-PI system can handle uncertainty, enhance dynamic response, and maintain output voltage based on load conditions.

Research conducted by Kunjittipong N et al. in 2020 is only one of the findings of a literature review. The researchers contrasted fuzzy and PI controlled control systems for single high voltage switch boost converters was proposed. According to the simulated results of this paper, under the same simulation settings, the fuzzy control system performs better than the PI control system in terms of output voltage [8]. Performances of PID and fuzzy control systems for DC-DC boost converter voltage regulation were also conducted by other researchers. Comparative performance of fuzzy logic and PID controllers on DC-DC boost converters was research conducted in 2023 by Daraz A. Findings confirmed that the fuzzy-based method performs superior to PID-based control in transient response [9].

Besides that, Murillo-Yarce D et al. also conducted a study in 2020 on fuzzy-PI control of boost converters which discussed the fuzzy-PI control system used to regulate the output of the boost converter. Though it displays more ripples on inductor, the fuzzy-PI control system has minimum steady-state error value and better response towards multiple conditions compared to deadbeat controller [10]. In 2022, Sierra J et al. presented more research on fuzzy-PI controller for the boost converter which introduced the analysis to assess the advantages and disadvantages of the fuzzy-PI control system. The fuzzy-PI system of the present research is a hybrid method that reduces errors to the lowest possible level [11]. The next research that focuses on the Fuzzy-PI control system was conducted by Chen Z et al. in 2024. This study addresses the shortcomings of traditional control systems by presenting a Fuzzy-PI control system with a variable domain PI that can be adjusted in real-time by fuzzy based on input errors to increase control effectiveness. The four-phase interleaved parallel converter with fuzzy-PI control design for the voltage outer loop in a double closed-loop structure. The conclusion demonstrates that the boost converter stability has greatly increased, it is also shown by lower overshoot values and better output control [12].

On the other hand, A study conducted by Demirtas et al. in 2023 the research compared the ability of PI, fuzzy-PI, and fractional order PI (FOPI) to modify the boost converter active input current to increase the power factor of boost converter. This circuit simulated on MATLAB/Simulink as part of the research, and the results showed that the combination of FOPI and PI control is better than the combination of fuzzy-PI in power factor regulation [13]. The study about Fuzzy Logic-based PI Controller with PWM for Buck-Boost converter was carried out by Al-Dabbagh Z et al. in 2024. This research focuses on improving system performance, particularly in renewable energy sources like solar energy. To improve system performance, a control system must be added to converter capabilities, which are often inconsistent. According to simulation results, the fuzzy-PI control system performs better than conventional control systems like fuzzy logic and PI in terms of response time, rise time, and upper and lower bypass levels [14].

A research study by Sharma P. et al. in 2018 utilized fuzzy logic in employing the application of a boost converter to a photovoltaic system. In solar photovoltaic-based system applications, control system methodology must be employed to deliver a constant voltage under

DOI: https://doi.org/10.26740/jistel.v2n2.p89-103
e- ISSN 3090-613X

varied conditions and supply voltage. To provide stability, reliability, and system stability to respond to various load conditions, researchers decided to model the system as a boost converter. Fuzzy logic plays an important role in controlling the non-linearity of the system and achieves the controlled output voltage. The conclusion confirms that the fuzzy logic control boost converter system better [15].

2. METHODS

2.1. Boost Converter

A traditional topology to increasing low input voltage to higher output is the DC-DC boost converter, or step-up converter. Because open and closed switch switching conditions are regulated by control methods based on pulse width modulation (PWM) signals to determine the switch duty cycle for each switching cycle, the converter is non-linear [1]. In high efficiency applications, the boost converter circuit typically consists of switches, diodes, and energy storage elements like inductors and capacitors that are operating for minimizing output current ripple and providing stability to voltage [10,16]. The boost converter is configured as shown in **Figure 1.**

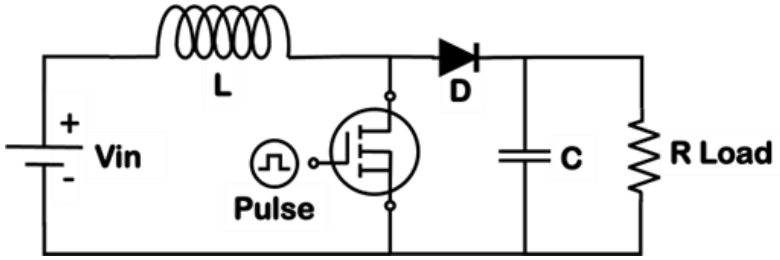


Figure 1. Boost Converter

In **Figure 1**, the energy flow from the source to the load is controlled by periodic switching. Current passes through the inductor during the charging phase when the switch is active, storing energy in its magnetic field. In the release phase, the switch is disabled so that the inductor releases energy to the load through the diode. The diode is responsible for filtering the current direction so that it only flows towards the capacitor and load, and prevents the current from returning to the voltage source. Capacitors play an important role in maintaining the stability of the output voltage by dampening the voltage fluctuations that occur during the switching process, so that the end result is a more stable voltage output that meets the needs of the system [11,17].

2.1.1. Switch ON

In the switch on condition, current flows from the DC voltage source to the inductor and switch. In this condition, the diode is in a reversed bias state and blocks the current from going to the load. The current stored in the inductor will increase until the switch changes to the off condition, contained in the mathematical model (1).

$$\frac{V_{in}}{L} = \frac{di_L}{dt} \tag{1}$$

Where V_{in} is the voltage value on the inductor, L is the inductor value, and $\frac{di_L}{dt}$ is the change in inductor current over time.

DOI: https://doi.org/10.26740/jistel.v2n2.p89-103
e- ISSN 3090-613X

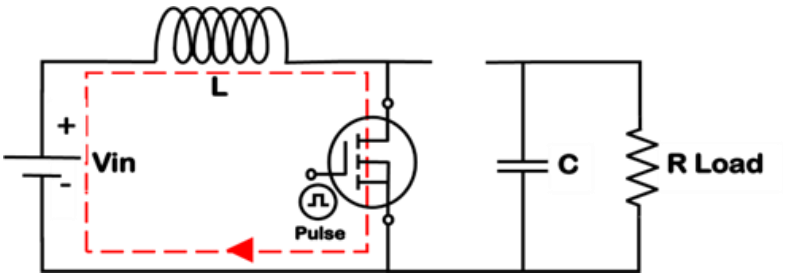


Figure 2. Boost converter when switch is on

2.1.2. Switch OFF

In the second mode when the switch condition is off, current will flow from the dc voltage source to the inductor, diode, capacitor, and load resistance. The inductor current will drop until the switch condition returns to on in the next period. The mathematical calculation formula of the condition when the switch is off is contained in the mathematical model (2) [18].

$$\frac{V_{in}-V_o}{L} = \frac{di_L}{dt} \tag{2}$$

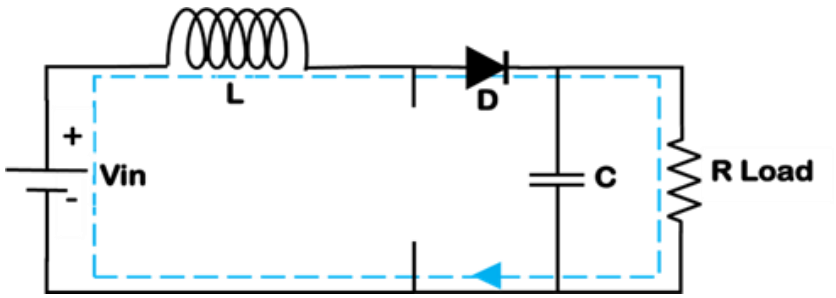


Figure 3. Boost converter when switch is off

The value of V_o in the boost converter is obtained from equation (3) [19].

$$V_o = \frac{V_{in}}{(1-D)} \tag{3}$$

Where V_o is the voltage output and D is the duty cycle.

Here are the boost converter parameters obtained from experiments.

Table 1. Boost Converter Component Parameter

NO	Components	Value
1.	DC source Voltage	$12\ V$
2.	Resistor (R)	$100\ \Omega$
3.	Inductor (L)	$4.7\ mH$
4.	Capacitor (C)	$47\ \mu F$
5.	Switching Frequency (f)	$20\ kHz$
6.	Duty cycle	50%

DOI: https://doi.org/10.26740/jistel.v2n2.p89-103
e- ISSN 3090-613X

2.2. Fuzzy Logic Controller

Fuzzy logic control is a technique based on one's knowledge and understanding of a system, where control performance is greatly influenced by the quality of that understanding. System designers set control constraints through a collection of IF-THEN rules that form the rule base and determine system actions based on input conditions. The process begins with the formation of a membership function, which assigns a value a membership level in a fuzzy set numerically between 0 and 1 [10]. The crisp input values are then converted into fuzzy form through the fuzzification process. After that, the fuzzy values are processed through an inference stage based on fuzzy rules to produce fuzzy outputs, which are finally converted back to definite values through defuzzification to produce control responses that can be applied to the system in real time [20].

In the fuzzification stage, the crisp input is converted into fuzzy form using a membership function, which can be triangular, shoulder, trapezoidal, Gaussian, bell-shaped, or sigmoid. This research uses a triangular function because it is simple, computationally efficient, and easy to use to divide linguistic regions, and a shoulder function for extreme categories such as large negative and positive values to reflect stability at maximum or minimum values [21].

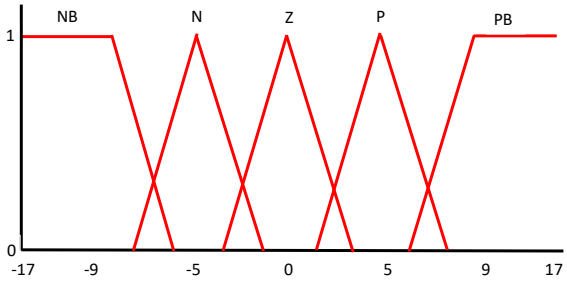


Figure 4. Membership function input error

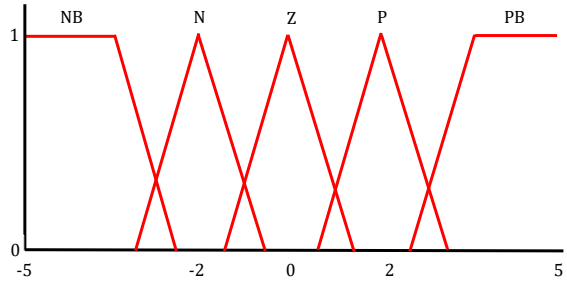


Figure 5. Membership function input delta error

In the fuzzy inference stage, the rule base is applied to fuzzy values resulting from fuzzification to produce fuzzy outputs. There are two inference methods, namely Mamdani and Sugeno, with Mamdani chosen in this study because it is able to handle nonlinear systems flexibly without requiring complex mathematical models. The inference process uses a MIN-MAX approach, where the MIN operator determines the contribution of each rule, and the MAX operator combines the results into one fuzzy output set which is then ready for the defuzzification stage [21].

DOI: https://doi.org/10.26740/jistel.v2n2.p89-103
e- ISSN 3090-613X

Table 2. Rule base for K_P

ΔE / E	NB	N	Z	P	PB
NB	NB	N	Z	Z	NB
N	N	N	Z	Z	Z
Z	Z	Z	Z	Z	Z
P	P	P	Z	P	P
PB	PB	P	Z	P	PB

Table 3. Rule base for K_i

ΔE / E	NB	N	Z	P	PB
NB	NB	N	Z	Z	Z
N	N	N	Z	Z	Z
Z	Z	Z	Z	Z	Z
P	Z	Z	Z	P	P
PB	Z	Z	Z	P	PB

The defuzzification process converts the inferred fuzzy values into crisp values that can be applied to the system. This research uses the centroid method, which calculates the average of the output fuzzy set to obtain the final result. This method is known to be precise and flexible, making it suitable for nonlinear systems such as boost converters, both in discrete and continuous domains [22].

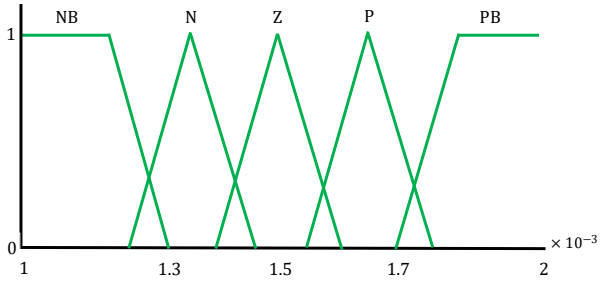


Figure 6. Membership function output K_p

DOI: https://doi.org/10.26740/jistel.v2n2.p89-103
e- ISSN 3090-613X

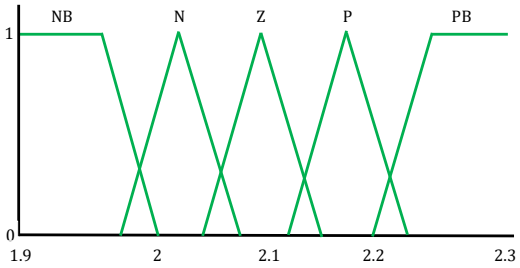


Figure 7. Membership function output $\boldsymbol{K_i}$

2.3. PI Controller

PI control system aims to regulate the process variable to match the set point by minimizing the error. While the I component removes long-term errors, the P component responds quickly to changes. When the two are combined, the system remains accurate and responsive even when there are disruptions or changes in the parameters [23,24]. By undergoing a tuning process, the optimal K_P and K_I values are established, and also for PI control to regulate the boost converter's output voltage with accuracy. This technique is suitable for linear systems as it is easy, simple to implement, and efficient [25]. It is although capable of responding quickly to changes, its performance in non-linear systems is very poor.

A PI control system can be modeled with Equation (4) [26].

$$m(t) = K_P e(t) + K_I \int_0^1 e(t)dt \tag{4}$$

2.4. Fuzzy-PI Controller

Fuzzy-PI controller combines the ability of fuzzy logic and a conventional PI system to make control more accurate in systems with non-linear properties and variable parameters. This combination enhanced the capacity for PI parameter adjustment using fuzzy rules that react to error value changes and error change, creating a more accurate and adaptive control system [27].

In generating error and error change, the fuzzy-PI control system reads the value of the output using feedback. the system compares it to the set point by a subtraction block. In compensating the voltage error, the value is applied in the fuzzy-PI system in generating an output signal which is converted into a pulse that would control the MOSFET in the converter using the PWM block. To keep the output voltage near the reference value under another type of error conditions, fuzzy logic is applied to adaptive modify the K_P and K_I value [28].

This method is easy to implement and cheaper computationally because it utilizes the PI benefits control and the flexibility of the fuzzy to adapt parameter adjustments without the requirement for sophisticated mathematical calculations to optimize the nonlinear system to make it more effective. PI control is good within a given design range, and more flexible and finer control when combined with fuzzy [29,30]. **Figure 8** illustrates the suggested approach diagram block.

DOI: https://doi.org/10.26740/jistel.v2n2.p89-103
e- ISSN 3090-613X

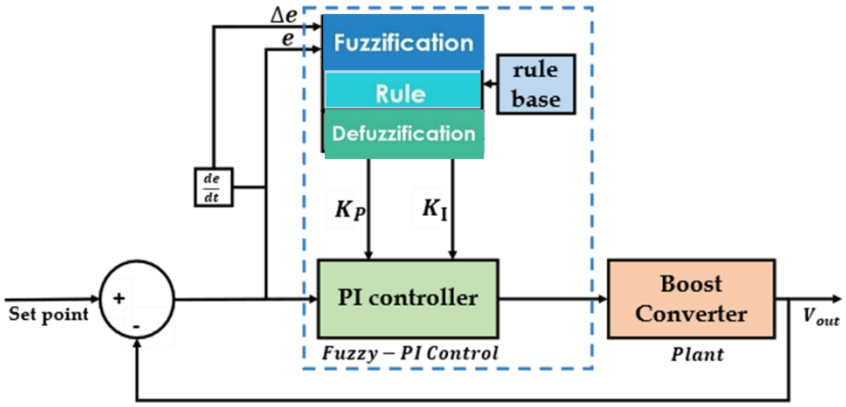


Figure 8. Suggested Method Diagram Block

3. RESULTS AND DISCUSSION

3.1. Fixed Set Point

Testing the Boost Converter when the set point is fixed aims to evaluate the stability of the system in maintaining the output according to the set point, with constant input and set point. Parameters observed include rise time (time to reach the set point), minimum-maximum oscillation (output fluctuation), and maximum overshoot (spike before stabilization), to assess the initial response and stability of the system

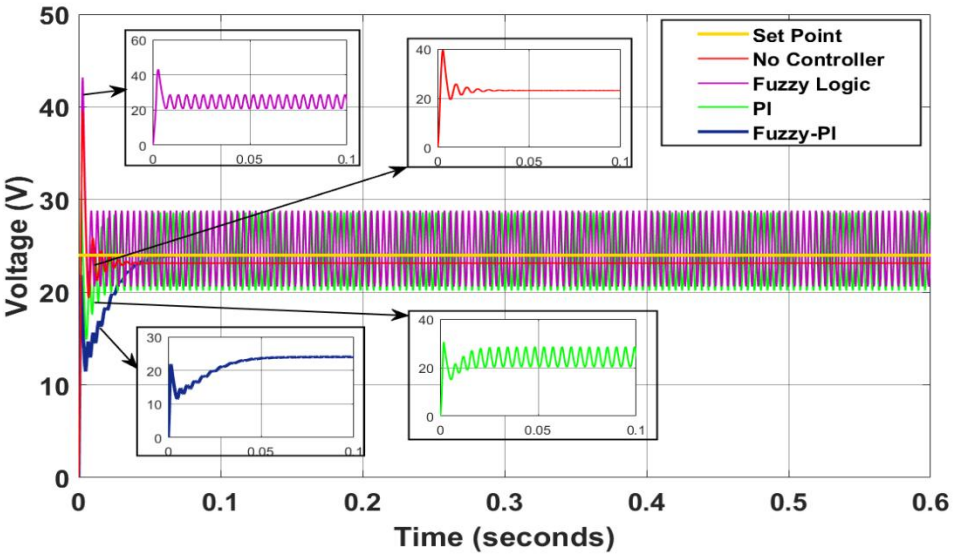


Figure 9. Fixed Set Point Performance Test

Table 4. Fixed Set point Performance

Controller	Rise Time (s)	Oscillation (V)		Maximum Overshoot (V)
		Min	Max	
Fuzzy-PI	1.01m	23.93	24.07	24.07
PI	935.85µ	20.18	28.63	30.56
Fuzzy Logic	1.31m	20.59	28.59	42.99

DOI: https://doi.org/10.26740/jistel.v2n2.p89-103
e- ISSN 3090-613X

No Controller	1.08m	23.08	23.21	39.58

Based on **Figure 9** and **Table 4**, performance comparisons can be made between several types of controllers, namely Fuzzy-PI, PI, fuzzy logic, and no controller. The evaluation parameters used include rise time, voltage oscillation, and maximum overshoot. The Fuzzy-PI controller shows the most balanced performance, with a rise time of 1.01 ms, very small oscillations in the range of 23.93-24.07 V, and a maximum overshoot of only 24.07 V, which is almost close to the set point of 24 V. This indicates that Fuzzy-PI is able to provide a fast response while maintaining system stability, so it can be said to be the controller with the best overall performance. In contrast, the PI controller shows the fastest rise time of 935.85 µs, but this performance is accompanied by considerable oscillations, in the range of 20.18-28.63 V, as well as a high maximum overshoot of 30.56 V. This indicates that although the initial response is very fast, the maximum overshoot is very low. This shows that although the initial response is very fast, the system can become unstable.

Furthermore, the fuzzy logic controller has the slowest rise time of 1.31 ms and shows large oscillations, which are between 20.59-28.59 V, as well as the highest overshoot of 42.99 V, indicating an unstable system. Meanwhile, the system without control has a rise time of 1.08 ms, small oscillations, but the overshoot remains high at 39.58 V, indicating the system's shortcomings in effectively regulating the response to the set point. Overall, it can be concluded that the Fuzzy-PI controller provides the most optimal results, with a fairly fast response time and good system stability, compared to other controllers.

3.2. Set Point Change

The set point change test on the Boost Converter aims to evaluate the system's ability to maintain the output voltage when the set point value is changed, with the input voltage remaining constant. The main parameters observed are voltage deviation and recovery time. The deviation reflects the difference between the actual output and the new set point, while the recovery time indicates the speed at which the system stabilizes again. Tests were conducted on four scenarios: no control, PI control, fuzzy control, and Fuzzy-PI control to assess the transient response and stability of the system.

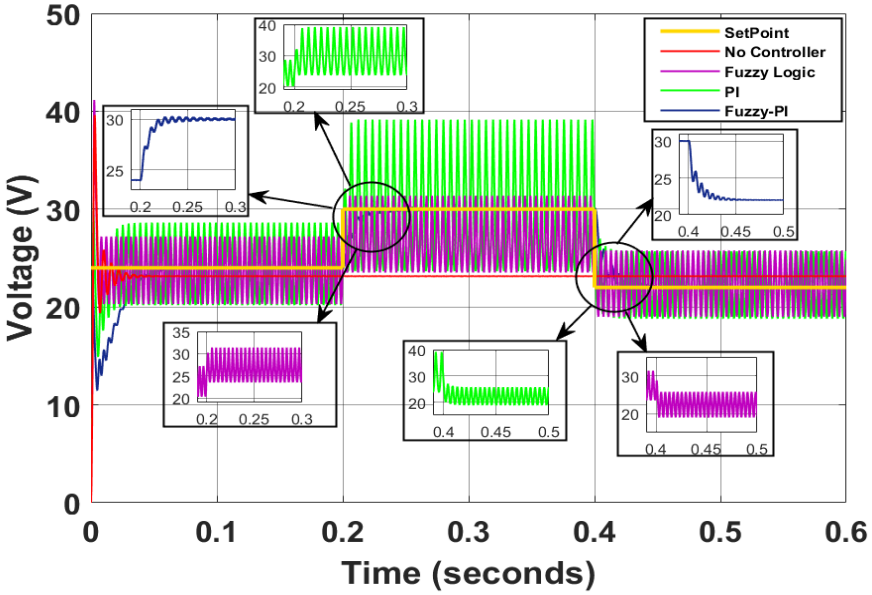


Figure 10. Set Point Voltage Change Performance Test

DOI: https://doi.org/10.26740/jistel.v2n2.p89-103
e- ISSN 3090-613X

Table 5. Set Point Voltage Change Performance

Time (s)	Vin (V)	R (Ω)	*Set Point* (V)	*Fuzzy-PI*		PI		*Fuzzy Logic*		No Controller	
				t_{rec} (s)	ΔV (V)	t_{rec} (s)	ΔV (V)	t_{rec} (s)	ΔV (V)	t_{rec} (s)	ΔV (V)
0	12	100	24	0	0	0	0	0	0	0	0
0.2			30	0.07	0.27	0.02	9.18	0.01	7.33	-	-
0.4			22	0.05	0.006	0.03	2.92	0.01	1.79	-	-

Based on **Figure 10** and **Table 5**, the controller performance is analyzed when there is a change in the set point value from 24 V to 30 V and then down to 22 V, with the input voltage condition of 12 V and 100 Ω load resistance. The parameters observed include rise time and voltage deviation (ΔV) against the set point value. In the initial condition (set point 24 V), all controllers show a rise time and voltage deviation value of zero, which indicates that the system is in a steady state without any changes.

When the set point rises to 30 V, the fuzzy-PI controller shows the most stable response with a recovery time of 0.07 seconds and a deviation of 0.35 V. In contrast, the PI controller has the fastest recovery (0.02 seconds) but large overshoot (9.18 V) and high oscillation range (23.66-39.15 V). The fuzzy logic controller recorded the fastest recovery (0.01 seconds) but also significant overshoot (7.33 V). The system without control failed to respond, showing an inability to keep up with set point changes.

When the set point drops to 22 V, the fuzzy-PI controller shows the most stable performance with a recovery time of 0.05 seconds and very small deviation (0.006 V). The PI controller provides fast response (0.03 seconds) but experiences significant undershoot (2.92 V) and oscillation (18.08-24.3 V). The fuzzy logic controller recorded the fastest recovery (0.01 s) but still experienced undershoot (1.79 V) and oscillations (19.21-24.73 V). The system without control did not respond to changes in set point.

Overall, the Fuzzy-PI controller showed the best performance in responding to set point changes, with a balance between recovery speed and output stability. Although not the fastest, the deviation is very small and without significant overshoot/undershoot. In contrast, PI and fuzzy logic controllers are faster but produce large deviations and risk causing instability. The system without control failed to keep up with the change in set point.

3.3. Input Voltage Change

Testing the condition of the boost converter when the input changes, aims to evaluate the ability of the system to maintain the output voltage according to a fixed set point, even though the input value changes. The parameters observed include voltage deviation and recovery time. The test is also conducted in four scenarios: no control, PI control, fuzzy control, and fuzzy-PI control.

DOI: https://doi.org/10.26740/jistel.v2n2.p89-103
e- ISSN 3090-613X

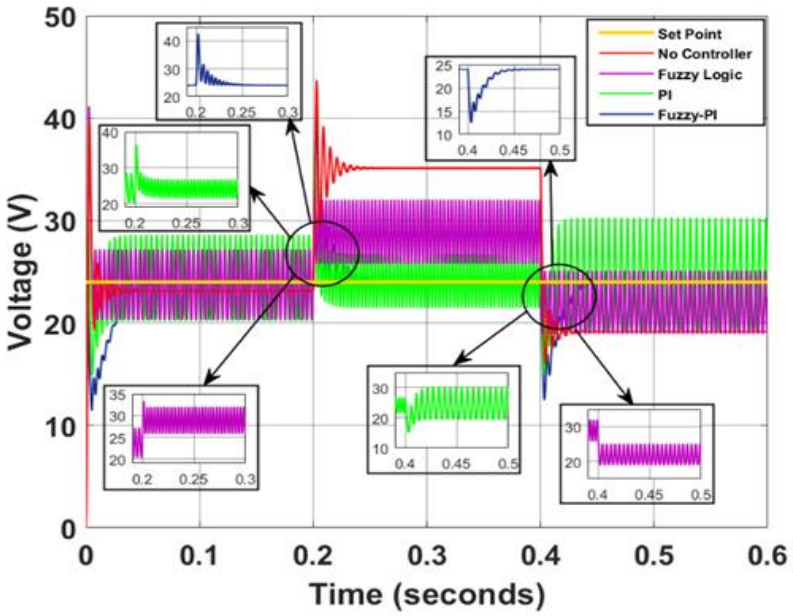


Figure 11. Set Point Voltage Change Performance Test

Table 6. Input Voltage Change Performance

Time(s)	Vin (V)	R (Ω)	*Set Point* (V)	***Fuzzy-PI***		**PI**		***Fuzzy Logic***		**No Controller**	
				t_{rec} (s)	ΔV (V)	t_{rec} (s)	ΔV (V)	t_{rec} (s)	ΔV (V)	t_{rec} (s)	ΔV (V)
0	12	100	24	0	0	0	0	0	0	0	0
0.2	18			0.06	17.43	0.03	12.41	-	14.05	-	19.7
0.4	10			0.05	10.99	0.03	8.96	0.005	4.54	-	7.97

Based on **Figure 11** and **Table 6**, when Vin changes from 12 V to 18 V then down to 10 and the set point remains at 24 V the entire system initially stabilizes without deviation or recovery time. When Vin rises to 18 V, overshoot occurs in all controllers, the largest in the system without control (19.7 V), followed by Fuzzy-PI (17.43 V), fuzzy logic (14.05 V), and PI (12.41 V). PI had the fastest recovery time (0.03 s) compared to Fuzzy-PI (0.06 s), but experienced oscillations (21.45-26.74 V). Fuzzy logic and uncontrolled systems failed to adjust the voltage to the set point.

When Vin drops to 10 V, the entire control system undershoots. The largest deviation is recorded for Fuzzy-PI (10.99 V), followed by PI (8.96 V), no control (7.97 V), and Fuzzy Logic (4.54 V). Fuzzy Logic has the fastest recovery time (0.005 s), followed by PI (0.03 s) and Fuzzy-PI (0.05 s). PI and Fuzzy Logic showed significant oscillations, while the system without control did not respond. Although Fuzzy-PI experienced considerable initial deviation, the simulation graphs showed its output was more stable and quickly reached the set point value than the other controllers.

3.4. Disturbance

Testing the condition of the boost converter when there is a disturbance is done to evaluate the ability of the system to respond to changes if there is a disturbance at the output. In this test, the input voltage and set point given are constant to see how the system adapts when there

DOI: https://doi.org/10.26740/jistel.v2n2.p89-103
e- ISSN 3090-613X

is a disturbance. The main parameters observed in this test include voltage deviation and recovery time. Four scenarios will be tested, namely no controller, PI control, fuzzy logic control, and Fuzzy-PI control.

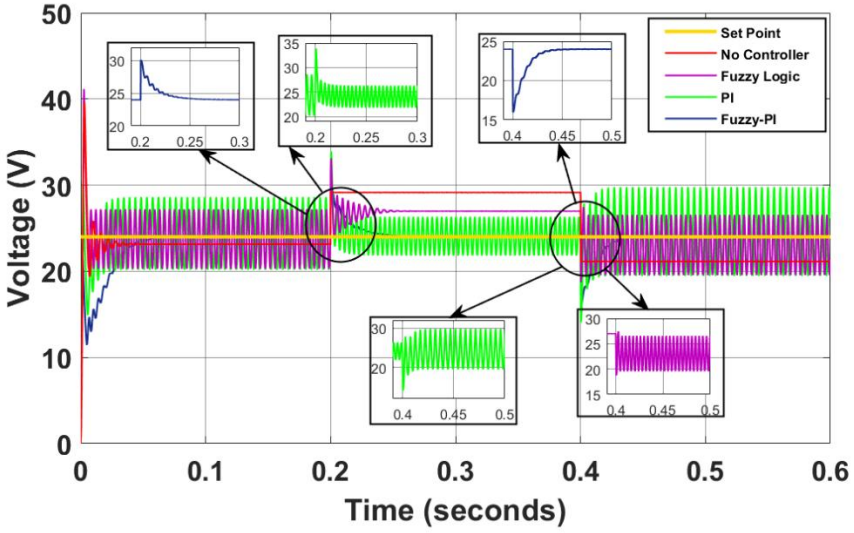


Figure 12. Disturbance at Output Performance Test

Table 7. Disturbance at Output Performance

Time (s)	Disturbance (V)	*Fuzzy-PI*		PI		*Fuzzy Logic*		No Controller	
		t_{rec} (s)	ΔV (V)	t_{rec} (s)	ΔV (V)	t_{rec} (s)	ΔV (V)	t_{rec} (s)	ΔV (V)
0.2	+ 6	0.05	6.08	0.04	9.92	0.01	7.44	-	5.21
0.4	- 9	0.04	8.05	0.03	9.89	0.01	5.65	-	2.89

Based on **Figure 12** and **Table 7**, each method shows a different response to a +6 V and -9V disturbance. At 6 V increments, Fuzzy-PI produced a deviation of 6.08 V and recovery time of 0.05 s, indicating moderate stability. PI recorded the highest deviation (9.92 V), recovery time 0.04 s, and oscillation (21.82-26.33 V). Fuzzy Logic had the fastest recovery (0.01 s) but high deviation (7.44 V) and oscillation (23.98-28.35 V). The system without control failed to adjust the voltage, with a deviation of 5.21 V.

Meanwhile, when there was a disturbance in the form of a voltage drop of 9V, Fuzzy-PI again showed good performance with a recovery time of 0.04 s and a deviation of 8.05 V. Under the same conditions, PI produces the largest deviation of 9.89 V, recovery time of 0.03 s, and there are still oscillations with a range of 19.47 V to 29.78 V, while Fuzzy Logic records a deviation of 5.65 V, recovery time of 0.01 s but also experiences oscillations with a range of 19.87 V to 28.87 V. The system without controller still could not adjust the voltage to the set point after showing a voltage deviation of 2.89 V.

Based on the simulation graphs, the Fuzzy-PI controller shows the best stability with smooth transitions, minimal oscillation, and output close to the set point. Although slightly slower than Fuzzy Logic, Fuzzy-PI is more stable in the long run without extreme deviations. Overall, Fuzzy-PI provides an optimal balance between recovery speed and stability, making it the most superior method in dealing with voltage disturbances.

DOI: https://doi.org/10.26740/jistel.v2n2.p89-103
e- ISSN 3090-613X

4. CONCLUSION

Fuzzy-PI control system is successfully designed by integrating fuzzy logic and PI control, through membership function selection, rule base for K_P and K_I, and defuzzification. Simulation shows that this system can adjust the duty cycle effectively based on error and delta error. Compared to other methods (PI, Fuzzy Logic, no control), Fuzzy-PI provides the best performance with low overshoot and minimal steady state error in various scenarios, thus improving the stability and reliability of the boost converter. This research is still limited to MATLAB simulation, so it needs to be developed through physical implementation using microcontrollers or DSPs to test the effectiveness of Fuzzy-PI control in real conditions. In addition, the system performance can be improved with optimization methods such as PSO or GA to refine the selection of K_P and K_I parameters to make the system more precise and adaptive to changing conditions.

5. AUTHOR'S NOTE

The authors declare that there is no conflict of interest regarding the publication of this paper.

6. AUTHOR'S CONTRIBUTION/ROLE

Rifqi Firmansyah: Conceptualization, methodology development, system design, simulation, and writing of the original draft. Nanda Eka Saputra: Data analysis, simulation validation, and result interpretation. Habib Brilian Wicaksono: Development of the fuzzy logic controller and performance evaluation. Wahyu Cahya Putra: Implementation of the PI controller, comparative analysis, and visualization of results. Muhammad Saud Khan: Supervision, review and editing of the manuscript, and technical guidance throughout the research. All authors have read and approved the final version of the manuscript.

7. DECLARATION OF THE USE GENERATIVE AI IN THE MANUSCRIPT PREPARATION PROCESS

Declaration of the use Generative AI in manuscript preparation is used to describe the specific roles and contributions of Generative AI in the manuscript preparation process upon submission of the paper.

REFERENCES

[1] Muktiadji RF, Ramli MAM, Bouchekara HREH, Milyani AH, Rawa M, Seedahmed MMA, et al. Control of Boost Converter Using Observer-Based Backstepping Sliding Mode Control for DC Microgrid. Front Energy Res 2022;10. https://doi.org/10.3389/fenrg.2022.828978.

[2] Atacak I, Bay OF. A type-2 fuzzy logic controller design for buck and boost DC-DC converters. J Intell Manuf 2012;23:1023–34. https://doi.org/10.1007/s10845-010-0388-1.

[3] Firmansyah R, Seedahmed MMA, Mahmoud A, Nugroho YS, Saputra PPS. IoT-Based Flow Control System Using Node MCU with PI Controller CHR Tuning Method. Proceedings of the International Joint Conference on Science and Engineering 2022

DOI: https://doi.org/10.26740/jistel.v2n2.p89-103
e- ISSN 3090-613X

(IJCSE 2022), Atlantis Press International BV; 2022, p. 186–95. https://doi.org/10.2991/978-94-6463-100-5_19.

[4] Dwiono W. Fuzzy PI Controllers Performance on Boost Converter. International Journal of Electrical and Computer Engineering (IJECE) 2013;3:215–20.

[5] Kalarathi M, Jayanthi K. Dual state DC-DC converter with PI and fuzzy PI controller for LED drivers. International Journal of Engineering Trends and Technology 2021;69:180–4. https://doi.org/10.14445/22315381/IJETT-V69I3P227.

[6] Panda B, Sarkar A, Panda B, Hota PK. A comparative study of PI and fuzzy controllers for solar powered DC-DC boost converter. Proceedings - 1st International Conference on Computational Intelligence and Networks, CINE 2015, Institute of Electrical and Electronics Engineers Inc.; 2015, p. 47–51. https://doi.org/10.1109/CINE.2015.19.

[7] Mohamed HA, Khattab HA, Mobarka A, Morsy GA. HYBRID PI FUZZY LOGIC CONTROLLER FOR BOOST CONVERTER OPERATING IN PV ENERGY SYSTEM. vol. 40. 2017.

[8] Kunjittipong N, Kongkanjana K, Khwan-On S. Comparison of Fuzzy Controller and PI Controller for a High Step-Up SingleSwitch Boost Converter. 2020 3rd International Conference on Power and Energy Applications, ICPEA 2020, Institute of Electrical and Electronics Engineers Inc.; 2020, p. 94–8. https://doi.org/10.1109/ICPEA49807.2020.9280118.

[9] Daraz A, Basit A, Zhang G. Performance analysis of PID controller and fuzzy logic controller for DC-DC boostconverter. PLoS One 2023;18. https://doi.org/10.1371/journal.pone.0281122.

[10] Murillo-Yarce D, Munoz J, Restrepo C. Mamdani type PI-fuzzy controller in a boost converter 2020.

[11] Sierra JE, Guerrero Hernández AS, López Prado JL. Classic And Fuzzy PI Controller For A DC-DC Boost Converter. vol. 19. 2022.

[12] Chen Z, Hu X, Wang W, Liu W, Liao M, Fu Z. Power Source Converter Based on a Variable-Domain Fuzzy PI Control. Electronics (Switzerland) 2024;13. https://doi.org/10.3390/electronics13040674.

[13] Demirtas M, Ahmad F. Fractional fuzzy PI controller using particle swarm optimization to improve power factor by boost converter. International Journal of Optimization and Control: Theories and Applications 2023;13:205–13. https://doi.org/10.11121/ijocta.2023.1260.

[14] Al-Dabbagh ZA, Waley Shneen S, Hanfesh AO. Fuzzy Logic-based PI Controller with PWM for Buck-Boost Converter. Journal of Fuzzy Systems and Control 2024;2:2024. https://doi.org/10.59247/jfsc.v2i3.239.

[15] Sharma P, Kumar P, Pal N. Design and Implementation of Closed Loop Controlled Boost Converter for Solar Power Installation System using Fuzzy Logic Controller. IEEE; 2018.

DOI: https://doi.org/10.26740/jistel.v2n2.p89-103
e- ISSN 3090-613X

[16] K V, Nema R, Ojha A. BOOST CONVERTER WITH FUZZY LOGIC, PI CONTROLLER AND SLIDING MODE CONTROL FOR A VARIABLE SOURCE INPUT 2020.

[17] Muktiadji RF, Ramli MAM, Milyani AH. Twin-Delayed Deep Deterministic Policy Gradient Algorithm to Control a Boost Converter in a DC Microgrid. Electronics (Switzerland) 2024;13. https://doi.org/10.3390/electronics13020433.

[18] Rashid MH. Power electronics handbook. Academic Press; 2001.

[19] Hart W. Power electronics by Daniel W. Hart 2011.

[20] Lwin MM. HIGH-PERFORMANCE DOUBLE BOOST DC-DC CONVERTER BASED ON FUZZY LOGIC CONTROLLER. An International Journal (MECHATROJ) 2021;2.

[21] Kusumadewi S, Purnomo H. Aplikasi Logika Fuzzy untuk pendukung keputusan. Yogyakarta: Graha Ilmu 2010;2.

[22] Setiawan A, Yanto B, Yasdomi K. LOGIKA FUZZY Dengan MATLAB (Contoh Kasus Penelitian Penyakit Bayi dengan Fuzzy Tsukamoto). n.d.

[23] Laoprom I, Tunyasrirut S. Design of PI Controller for Voltage Controller of Four-Phase Interleaved Boost Converter Using Particle Swarm Optimization. Journal of Control Science and Engineering 2020;2020. https://doi.org/10.1155/2020/9515160.

[24] Firmansyah R, Irmawanto R. Comparison study of PI controller tuning method to regulate the DC motor speed. 2021 3rd International Conference on Research and Academic Community Services (ICRACOS), 2021, p. 93–7.

[25] Seborg DE. Process Dynamics and Control. Wiley 2002.

[26] Yudaningtyas E. Belajar sistem kontrol: Soal dan pembahasan. Universitas Brawijaya Press; 2017.

[27] Gnanavadivel J, Senthil Kumar N, Yogalakshmi P. Comparative study of PI, fuzzy and fuzzy tuned PI controllers for single-phase AC-DC three-level converter. Journal of Electrical Engineering and Technology 2017;12:78–90. https://doi.org/10.5370/JEET.2017.12.1.078.

[28] Ihsan A-F, Aripriharta, Handayani A, Rosmin N, Omar S. Fuzzy-PI Control for Buck Converter Output Voltage Stabilizer 2022;14:2580.

[29] Doubabi H, Salhi I, Chennani M. Voltage control of DC-DC Three level Boost converter using TS Fuzzy PI controller. IEEE; 2019.

[30] Muktiadji RF, Ramli MAM, Seedahmed MMA, Uswarman R, Endryansyah. Power Sharing Control and Voltage Restoration in DC Microgrid Using PI Fuzzy. 2022 Fifth International Conference on Vocational Education and Electrical Engineering (ICVEE), 2022, p. 130–5. https://doi.org/10.1109/ICVEE57061.2022.9930441.

DOI: https://doi.org/10.26740/jistel.v2n2.p89-103
e- ISSN 3090-613X