

Forecasting Joule Thief Efficiency Using Fuzzy Logic Method

Jamaaluddin Jamaaluddin^{1*}, Ilham Yusuf Akbar¹, Dwi Hadidjaja¹, M Ahfas¹

University of Muhammadiyah Sidoarjo, Gelam No.250 Street, Sidoarjo, 61271, Indonesia¹

*Corresponding Author Email: jamaaluddin@umsida.ac.id

Abstract -- The electrical device is initially require energy to operate now gradually began to change with a device that could save electricity and more environmentally friendly, Eifisien is the ratio between the input (input) and output (between benefit with the resources used. Joule Thief has the potential to become an innovation because it is able to generate electrical energy through the development of electrical components that generate electromagnetic fields in coils or coils. Where in this analysis using using fuzzy logic to analyze the efficiency of Joule Thief. Of testing and research that has been downLighted lamps old forecasting for the Joule Thief circuit on the primary winding 10 and secondary winding 17 obtained the value of the average percentage error 0.2994, Then on the primary winding and the secondary winding 5 7 Average values obtained percentage error 0.434 as well as on the primary winding 5 and the secondary winding 20 obtained average value percentage error 0.8711, Based on these data also concluded that the Joule Thief with the primary winding 10 and secondary winding 17 is the most efficient because it has an average percentage of a small error is 0.2994.

Keywords:

Fuzzy logic, Joule Thief, Efficiency, Percentage Error

Article History:

Received: 21 April 2025

Revised: 20 May 2025

Accepted: 30 May 2025

Published: 31 May 2025

Copyright © 2025 FORTEI-JEERI. All right reserved.

DOI: 10.46962/forteijeeri.v6i1.29

IV. INTRODUCTION

With the development of technology, electrical devices that initially require large amounts of energy to operate are now gradually starting to replace with devices that are able to save electricity and are more environmentally friendly [1][2][3]. Efforts in saving electricity are likely to continue to grow because the supply of available electrical energy reserves is limited compared to the extraordinary needs and demands of electricity supply [16][17][18][4][5]. From the above problems, the idea to save electrical energy by using it efficiently continues to be developed. Efficient is the ratio between input and output, as well as the optimal result achieved by using limited resources [18][6].

Joule Thief has the potential to be an innovation because it is able to generate electrical energy through the development of electrical components that produce electromagnetic fields in the form of coils or coils [7]. The basic working principle of this circuit is to apply electromotive force (EMF) in an optimal way based on the concept of magnetic induction [8][9][10]. One form of application of the above concept is by designing a circuit dubbed as Joule Thief. This circuit is also known as a simple blocking transistor useful for generating electrical energy through a very small energy source because one of the characteristics of this circuit is able to steal energy [11][12] [16].

Through Fuzzy logic, it is able to transfer intelligence designed by humans into robots, computers, washing machines, and other electronic devices so that they are able to think like human minds thanks to the application of Fuzzy Logic [13][14][15]. In this study using Fuzzy Logic to analyse the forecasting of Joule Thief efficiency which focuses on the output of the length of time the Joule Thief lamp is on [16] [17].

V. METHOD

This analysis is carried out using the fuzzy logic method as a determinant of forecasting the length of light on produced by a joule thief circuit.

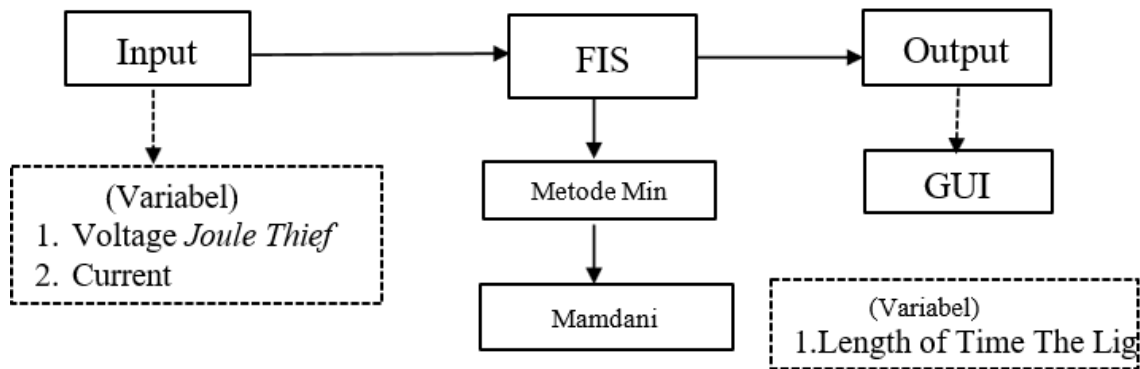


Figure 1. Block Diagram

A. Determination of the Fuzzy Set

In creating a Fuzzy Inference System based on the search for Joule Thief Efficiency that needs to be done is to create a set for each of the variables to be used. Namely by determining the value of each linguistic variable such as battery voltage, primary winding, secondary winding, load, length of time on and electric current into numeric form or numbers in Table 1. following:

TABLE I. FUZZY SETS

No	Function	Variable	Fuzzy Sets	Domain	Description
1.	Input	Voltage <i>Joule Thief</i>	Low	[0 0.9 1.7]	Voltage Electricity in units of Volts
			Medium	[0.98 1.98 2.98]	
			High	[2.8 3.6 4.5]	
2.	Input	Current	Small	[0 0.7 1.3]	Electric Current in units of Amperes
			Medium	[0.84 1.5 2.09]	
			Many	[1.66 2.4 3]	
3.	Output	Length of Time The Light is On	Small	[0 35 60]	Length of Time The Light is On in units of hours / hours

Table 1. above explains that there are 6 variables from each linguistic formed based on the Joule Thief efficiency design that has represented the nature and characteristics of Joule Thief. In addition, there is also a set group or Membership Function that functions as a limit to determine the degree of membership represented by many or few values according to the numerical domain that has been made:

The modelling of linguistic variables is formed using a triangular graph as follows:

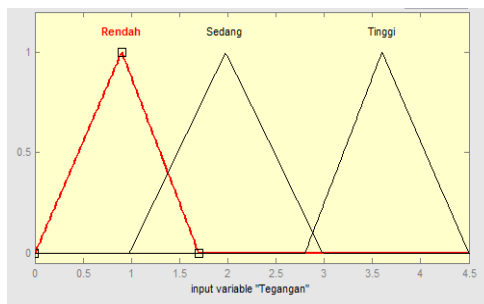


Figure 2. Membership function graph of Joule Thief Voltage with Low, Medium and High Fuzzy sets

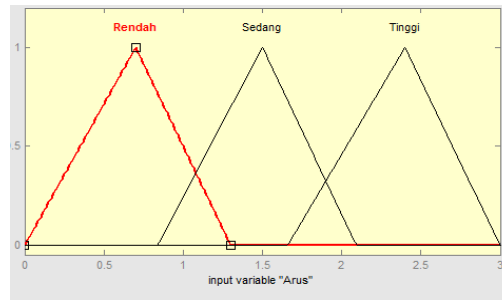


Figure 3. Membership function graph of Joule Thief Flow with Fuzzy sets Few, Medium and Many

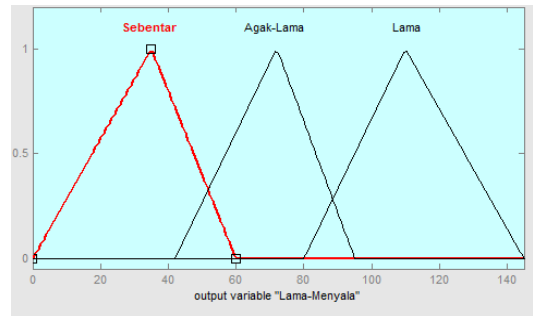


Figure 4. Membership function graph of Duration of Switching on with the Fuzzy sets Briefly, Somewhat Longer and Longer

B. Fuzzy Logic Rules

In applying the Mamdani method, implications that play a role in forming rules through the min function using the AND operator. The rule design is as follows:

1. If (Voltage is Low) and (Current is Low) then (Long On is Brief) (1)
2. If (Voltage is Low) and (Current is High) then (Long On is Long) (1)
3. If (Voltage is Low) then (Long On is Brief) (1)
4. If (Voltage is High) and (Current is Low) then (Long On is Somewhat Long) (1)
5. If (Voltage is High) and (Current is High) then (Long-Turn-on is Long) (1)
6. If (Voltage is High) then (Long-Turn-on is Somewhat Long) (1)
7. If (Current is Low) then (Long-Turn-on is Brief) (1)
8. If (Current is High) then (Long-Turn-on is Long) (1)
9. If (Voltage is Low) and (Current is Medium) then (Long-Flow is Somewhat Long) (1)
10. If (Voltage is Medium) and (Current is Low) then (Long-Flow is Somewhat Long) (1)
11. If (Voltage is Medium) and (Current is Medium) then (Long-Flow is Somewhat Long) (1)
12. If (Voltage is Medium) and (Current is High) then (Long-Time On is Long) (1)
13. If (Voltage is Medium) then (Long-Time On is Somewhat Long) (1)
14. If (Voltage is High) then (Long-Time On is Long) (1)
15. If (Voltage is Medium) then (Long-Time On is Somewhat Long) (1)



Figure 5. Research Flowchart

III. RESULTS AND ANALYSIS

The results of tests carried out from several data collections based on three different Joule Thief circuits and looking for data forecasting the length of time the lights are on through using the fuzzy logic method.

A. Tool Testing Based on Measuring Instruments

Tool testing is carried out using measuring instruments with the aim of knowing the value of voltage and current produced by Joule Thief. There are 2 measuring instruments used in this test, namely using an AVO meter and an Oscilloscope.

1) Measurement With AVO Meter

In the test carried out using an AVO Meter measuring instrument to determine the amount of current and voltage produced by each different joule thief circuit.

TABLE II VOLTAGE AND CURRENT MEASUREMENT RESULTS OF JOULE THIEF WITH AVO METER

No	Winding		Voltage		Current
	Primer	Sekunder	DC	AC	
1.	10	17	0.7v	1.2v	0.73mA
2.	10	17	1.44v	2.6v	2.04mA
3.	10	17	1.3v	3.1v	0.74mA
4.	10	17	1.31v	2.9v	1.20mA
5.	5	7	1.25v	2.1v	0.10mA
6.	5	7	0.94v	1.6v	1.03mA
7.	5	7	1.53v	2.8v	2.94mA
8.	5	7	1.45v	2.4v	1.38mA
9.	5	7	1.50	3.3v	1.86mA
10.	5	20	1.42v	2.7v	1.6mA
11.	5	20	1.24v	2.2v	1.82mA
12.	5	20	0.84v	1.9v	0.16mA
13.	5	20	0.93v	2.0v	0.16mA

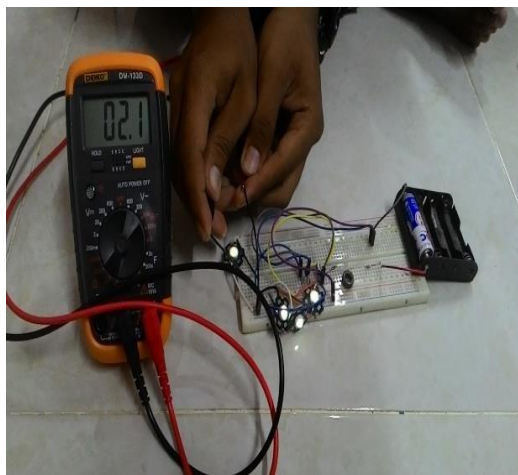


Figure 6. Measurement of Joule Thief Voltage and Current Output with Avo Meter

Based on Table 2. the measurement test above obtained different data from the voltage and current output of Joule Thief through a different number of toroid winding coils. With this data it is useful for data collection based on voltage measurements that have been made using an Avo Meter.

2) Measurement With Oscilloscope

In this test carried out using an Oscilloscope, an Oscilloscope as an electronic measuring tool that can display the shape of an electrical voltage signal both in the form of peak to peak voltage (maximum voltage) and RMS voltage (root mean square).

TABLE III VOLTAGE MEASUREMENT RESULTS OF JOULE THIEF WITH OSCILLOSCOPE

No	Winding		Voltage	
	Primer	Sekunder	Vrms	Vpp
1.	10	17	2.21v	10.0v
2.	10	17	3.10v	10.4v
3.	10	17	3.87v	16.8v
4.	10	17	3.40v	12.8v
5.	5	7	2.41v	9.36v
6.	5	7	2.37v	10.0v
7.	5	7	3.00v	8.88v
8.	5	7	4.19v	16.4v
9.	5	7	3.65v	12.8v
10.	5	20	2.80v	10.2v
11.	5	20	2.86v	9.52
12.	5	20	3.02v	18.6v
13.	5	20	3.04v	19.0v

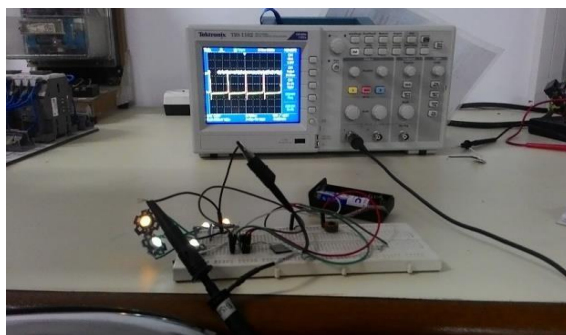


Figure 7. Joule Thief Voltage Measurement with Oscilloscope



Figure 8. Display Result of Joule Thief Output Voltage Signal on Oscilloscope

Based on Table 3. the measurement test above obtained different data from the voltage output of Joule Thief through a different number of toroid winding coils. With this data is useful for proving the voltage measurements that have been made using an Oscilloscope to determine the shape of the signal and the voltage generated by Joule Thief.

So from here, a provision is taken in making expertise in measuring electric current taken through an Avo Meter while for electric voltage taking data from Oscilloscope readings.

TABLE IV COMPREHENSIVE DATA COLLECTION

No	Voltage <i>Joule Thief</i>	Current	Winding		Length of Time The Light is On
			Primer	Sekunder	
1	2.21v	0.73mA	10	17	50 hours
2	3.10v	2.04mA	10	17	144 hours
3	3.87v	0.74mA	10	17	120 hours
4	3.40v	1.20mA	10	17	144 hours
5	2.41v	0.10mA	5	7	13 hours
6	2.37v	1.03mA	5	7	10 hours
7	3.00v	2.94mA	5	7	75 hours
8	4.19v	1.38mA	5	7	48 hours
9	3.65v	1.86mA	5	7	72 hours
10	2.80v	1.6mA	5	20	120 hours
11	2.86v	1.82mA	5	20	120 hours
12	3.02v	0.16mA	5	20	6 hours
13	3.04v	0.16mA	5	20	6.30 hours

Based on Table 4. above data collection is still universal or general not yet grouped because in testing this data involves 3 pieces of Joule Thief tools that have a different number of turns on the toroid coil.

B. Grouping of Data Collection Based on the Number of Winding.

This testing phase includes 3 stages of testing voltage, current and duration of lights on with different numbers of turns, including:

1. Primary winding 10 times round and Secondary winding 17 times round.
2. Primary winding 5 times round and Secondary winding 7 times round.
3. Primary winding 5 turns and Secondary winding 20 turns.

1) Data Collection Primary Winding 10 and Secondary Winding 17

Data collection on Joule Thief with primary winding 10 and secondary winding 17 is done to find out the length of time the lamp is on which is produced as a reference in the actual data.

TABLE V DATA COLLECTION OF PRIMARY WINDING 10 AND SECONDARY WINDING 17

No	Input		Output
	Voltage	Current	Length of Time The Light is On
1	2.21v	0.73mA	50 hours
2	3.10v	2.04mA	144 hours
3	3.87v	0.74mA	120 hours
4	3.40v	1.20mA	144 hours
Average			114.5 hours

Based on Table 5. above through 4 tests with varying voltages and currents resulting in differences from the length of the lamp produced as the output of Joule Thief with an average of 114.5 hours.

2) Data Retrieval Primary Winding 5 and Secondary Winding 7

Data retrieval on Joule Thief with primary winding 5 and secondary winding 7 is carried out to determine the length of time the lamp is on which is produced as a reference in the actual data.

TABLE VI DATA COLLECTION OF PRIMARY WINDING 5 AND SECONDARY WINDING 7

No	Input		Output
	Voltage	Current	Length of Time The Light is On
1	2.41v	0.10mA	13 hours
2	2.37v	1.03mA	10 hours
3	3.00v	2.94mA	75 hours
4	4.19v	1.38mA	48 hours
5	3.65v	1.86mA	72 hours
Average			43.6 Hours

Based on Table 6. above through 5 times testing with varying voltage and current produces a difference from the length of the lamp produced as the output of Joule Thief with an average of 43.6 hours.

3) Data Retrieval Primary Winding 5 and Secondary Winding 20

Data retrieval on Joule Thief with primary winding 5 and secondary winding 20 is done to find out the length of time the lamp is lit as a reference in actual data.

TABLE VII DATA COLLECTION OF PRIMARY WINDING 5 AND SECONDARY WINDING 20

No	Input		Output
	Voltage	Current	Length of Time The Light is On
1	2.80v	1.6mA	120 hours
2	2.86v	1.82mA	120 hours
3	3.02v	0.16mA	6 hours
4	3.04v	0.16mA	6.30 hours
Average			63.075 hours

Based on Table 7. above through 4 tests with varying voltage and current produces a difference from the length of the lamp produced as a Joule Thief output with an average of 63.075 hours.

C. Data Retrieval Through Matlab GUI

Data Retrieval Through Matlab GUI is intended to find the Forecasting value produced by the design of the Fuzzy Logic system with the help of the Matlab GUI interface programme makes it easier to find these values. Similar to the previous data collection on the tool (Joule Thief) which is used to be a reference for actual (Real) or actual data because in testing this data involves 3 Joule Thief tools that have a different number of turns on the toroid coil and produce different data.

1) Grouping of Data Collection Based on the Number of Toroid Winding in the Matlab GUI Program

This testing phase includes 3 stages of testing voltage, current and duration of lights on with different numbers of turns, including:

1. Primary winding 10 times round and Secondary winding 17 times round.
2. Primary winding 5 times round and Secondary winding 7 times round.
3. Primary winding 5 turns and Secondary winding 20 turns.

a) Data Retrieval of Primary Winding 10 Turns and Secondary Winding 17 Turns Through Matlab GUI

Data retrieval through the Matlab GUI based on actual data of primary winding 10 and secondary winding 17 is carried out to determine the length of time the lamp is lit as a reference in finding forecasting data.



Figure 9. Forecasting Data Collection on Three Different Joule Thief Circuits via Matlab GUI

TABLE VIII DATA RETRIEVAL OF PRIMARY WINDING 10 TURNS AND SECONDARY WINDING 17 TURNS THROUGH MATLAB GUI

No	Input		Output
	Voltage	Current	Length of Time The Light is On
1	2.21v	0.73mA	48.8 hours
2	3.10v	2.04mA	95.4 hours
3	3.87v	0.74mA	71.2 hours
4	3.40v	1.20mA	85 hours
Average			75.1 hours

Based on Table 8. above through 4 times testing with varying voltages and currents produces differences from the length of the lamp produced as a Defuzzification output through the Matlab GUI with an average of 75.1 hours.

b) Data Retrieval of Primary Winding 5 Turns and Secondary Winding 7 Turns Through Matlab GUI

Data retrieval through the Matlab GUI based on actual data of primary winding 10 and secondary winding 17 is carried out to determine the length of time the lamp is lit as a reference in finding forecasting data.

TABLE IX DATA RETRIEVAL OF PRIMARY WINDING 5 TURNS AND SECONDARY WINDING 7 TURNS THROUGH MATLAB GUI

No	Input		Output
	Voltage	Current	Length of Time The Light is On
1	2.41v	0.10mA	59.4 hours
2	2.37v	1.03mA	50.8 hours
3	3.00v	2.94mA	93.2 hours

4	4.19v	1.38mA	93.1 hours
5	3.65v	1.86mA	92.9 hours
Average			77.8 hours

Based on Table 9. above through 5 times testing with varying voltage and current produces a difference from the length of the lamp produced as a Defuzzification output through the Matlab GUI with an average of 77.8 hours.

c) Data Retrieval of Primary Winding 5 Turns and Secondary Winding 20 Turns Through Matlab GUI

Data retrieval through Matlab GUI based on actual data of primary winding 5 and secondary winding 20 is carried out to determine the length of time the lamp burns as a reference in finding forecasting data.

TABLE X DATA CAPTURE OF PRIMARY WINDING 5 TURNS AND SECONDARY WINDING 20 TURNS THROUGH MATLAB GUI

No	Input		Output
	Voltage	Current	Length of Time The Light is On
1	2.80v	1.6mA	68.8 hours
2	2.86v	1.82mA	99 hours
3	3.02v	0.16mA	74.8 hours
4	3.04v	0.16mA	75.8 hours
Average			79.6 hours

Based on Table 10. above through 4 tests with varying voltage and current produces a difference in the length of the lamp produced as a Defuzzification output through the Matlab GUI with an average of 79.6 hours.

D. Research Results

After obtaining the actual value and forecasting value, the next step is to find the percentage error value in order to determine the error rate between the forecasting and actual values. The following presents some data in the form of tables and graphs containing the percentage error based on each Joule Thief test that has been carried out.

1) Actual Data and Estimated Length of Light on Joule Thief and Percentage Error With Primary Winding 10 and Secondary Winding 17

The actual test data and estimated length of light on Joule Thief as well as the percentage error have been presented as Table 11 as follows:

TABLE XI DATA RETRIEVAL OF PRIMARY WINDING 10 TURNS AND SECONDARY WINDING 17 TURNS THROUGH MATLAB GUI

No	Input		Output
	Voltage	Current	Length of Time The Light is On
1	2.21v	0.73mA	48.8 hours
2	3.10v	2.04mA	95.4 hours
3	3.87v	0.74mA	71.2 hours
4	3.40v	1.20mA	85 hours
Average			75.1 hours

The calculation of the percent error value in testing the primary winding 10 and the secondary winding 17 is obtained:

Which :

$$Error = \frac{(Forecasting - Actual)}{Forecasting}$$

Description :

Forecasting : Forecasting Value of Fuzzy Logic
Actual : Real Value based on actual data

First data:

$$\begin{aligned} \text{Error} &= \frac{(\text{Forecasting} - \text{Actual})}{\text{Forecasting}} \\ &= \frac{62.22 - 50}{62.22} = 0.196399871 \end{aligned}$$

Third data:

$$\begin{aligned} \text{Error} &= \frac{(\text{Forecasting} - \text{Actual})}{\text{Forecasting}} \\ &= \frac{97.0129 - 120}{97.0129} = 0.236948901 \end{aligned}$$

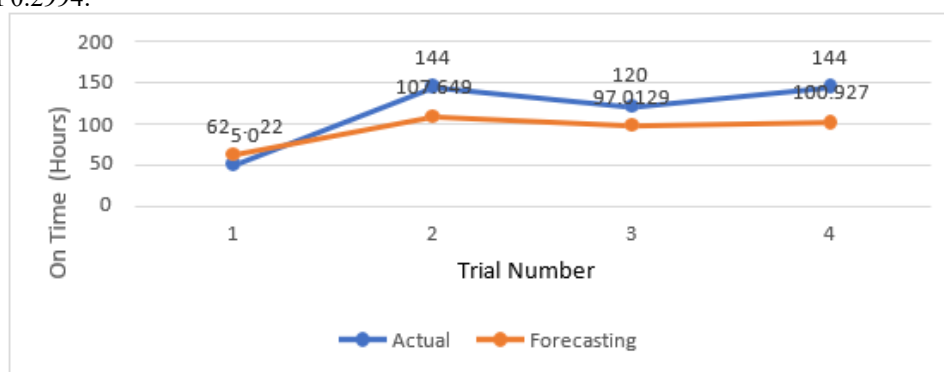
Second data:

$$\begin{aligned} \text{Error} &= \frac{(\text{Forecasting} - \text{Actual})}{\text{Forecasting}} \\ &= \frac{107.649 - 144}{107.649} = 0.337680796 \end{aligned}$$

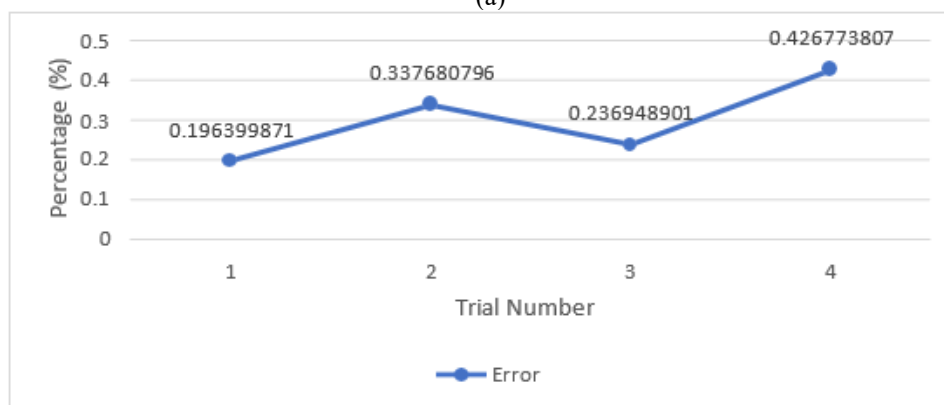
Fourth data:

$$\begin{aligned} \text{Error} &= \frac{(\text{Forecasting} - \text{Actual})}{\text{Forecasting}} \\ &= \frac{100.927 - 144}{100.927} = 0.426773807 \end{aligned}$$

Based on table 11. above, the lowest error value is obtained in the first data with an actual value of 50, forecasting 62.22 and an error value of 0.1963 percent. While the highest error value is in the fourth data with an actual value of 144, forecasting 100.92 and an error value of 0.426 per cent and an average error value of 0.2994.



(a)



(b)

Figure 10. Graph of Actual and Estimated Length of Lights On at Joule Thief With Primary Winding 10 and Secondary Winding 17 (a) On Time (b) Error Percentage

Based on Figure 10.A and Figure 10.B above, the percentage error value is below one percent and the closest error value is at a value of 0.1963 percent for actual data 50 and forecasting data 62.22 while the graph between the actual and forecasting axes is almost linear.

2) *Actual and Forecast Data of Lamp Light Time on Joule Thief and Percentage Error With Primary Winding 5 and Secondary Winding 7*

The actual test data and the estimated lamp light time on Joule Thief and the percentage error have been presented as Table 12 below:

TABLE XII PERCENTAGE ERROR ALONG WITH ACTUAL AND FORECASTING DATA ON PRIMARY WINDING 5 AND SECONDARY WINDING 7

No	Actual	Forecasting	Error
1	13	21.06	0.382716049
2	10	35.9229	0.721626038
3	75	50.5991	0.482239803
4	48	50.981	0.058472764
5	72	47.1551	0.526876202
Average			0.434386171

The calculation of the percent error value in testing primary winding 5 and secondary winding 7 is as follows:

First data:

$$\begin{aligned} \text{Error} &= \frac{(\text{Forecasting} - \text{Actual})}{\text{Forecasting}} \\ &= \frac{21.06 - 13}{21.06} = 0.382716049 \end{aligned}$$

Second data:

$$\begin{aligned} \text{Error} &= \frac{(\text{Forecasting} - \text{Actual})}{\text{Forecasting}} \\ &= \frac{35.9229 - 10}{35.9229} = 0.721626038 \end{aligned}$$

Third data:

$$\begin{aligned} \text{Error} &= \frac{(\text{Forecasting} - \text{Actual})}{\text{Forecasting}} \\ &= \frac{50.5991 - 75}{50.5991} = -0.482239803 \end{aligned}$$

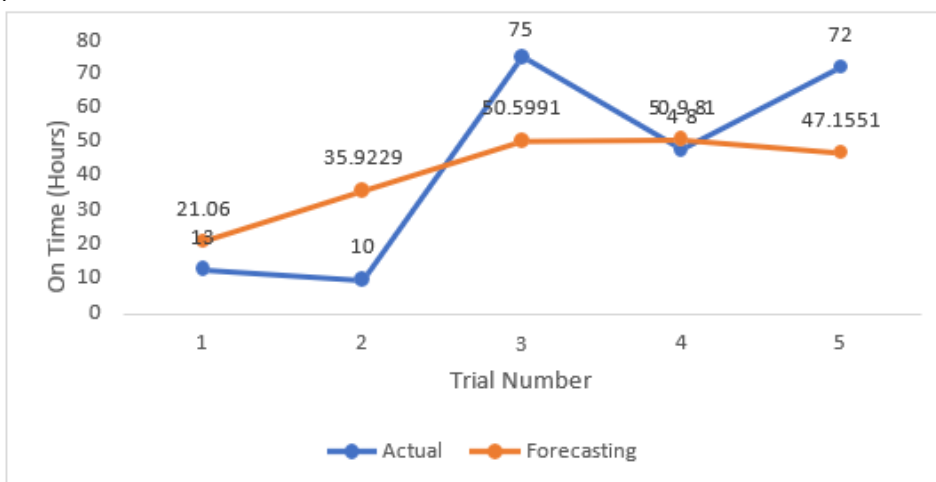
Fourth data:

$$\begin{aligned} \text{Error} &= \frac{(\text{Forecasting} - \text{Actual})}{\text{Forecasting}} \\ &= \frac{50.981 - 48}{50.981} = 0.058472764 \end{aligned}$$

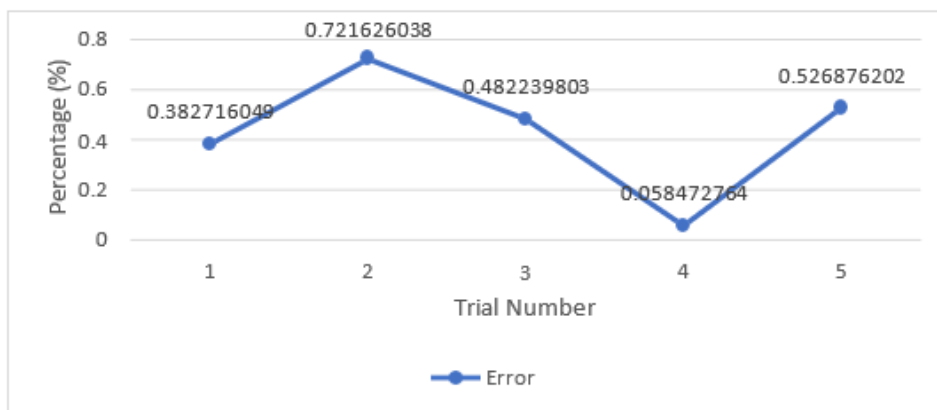
Fifth data:

$$\begin{aligned} \text{Error} &= \frac{(\text{Forecasting} - \text{Actual})}{\text{Forecasting}} \\ &= \frac{47.1551 - 72}{47.1551} = 0.526876202 \end{aligned}$$

Based on Table 12 above, the lowest error value is obtained on the fourth data with an actual value of 48, forecasting 50.9 and an error value of 0.058 percent While the highest error value is on the second data with an actual value of 10, forecasting 35.9 and an error value of 0.721 percent and an average error value of 0.434.



(a)



(b)

Figure 11. Graph of Actual and Estimated Length of Lights On at Joule Thief With Primary Winding 5 and Secondary Winding 7 (a) On Time (b) Error Percentage

Based on Figure 11.A. and Figure 11.B. above, the percentage error value is below one percent and the closest error value is at a value of 0.0584 percent for actual data 48 and forecasting data 50,981 while the graph between the actual and forecasting axis is not linear.

3) *Actual and Forecast Data for the Length of Time the Lamp Stays On at Joule Thief and Percentage Error With Primary Winding 5 and Secondary Winding 20*

The actual test data and the estimated lamp light time on Joule Thief and the percentage error have been presented as Table 13 below:

TABLE XIII PERCENTAGE ERROR ALONG WITH ACTUAL AND FORECASTING DATA ON PRIMARY WINDING 5 AND SECONDARY WINDING 20

No	Actual	Forecasting	Error
1	120	59.9483	1.00172482
2	120	71.4571	0.679329276
3	6	62.2118	0.903555274
4	6.3	63	0.9
Average			0.871152343

The calculation of the percent error value in testing primary winding 5 and secondary winding 20 is as follows:

First data:

$$Error = \frac{(Forecasting - Actual)}{Forecasting} = \frac{59.9 - 120}{59.9} = 1.001$$

Second data:

$$Error = \frac{(Forecasting - Actual)}{Forecasting} = \frac{71.4571 - 120}{71.4571} = 0.679329276$$

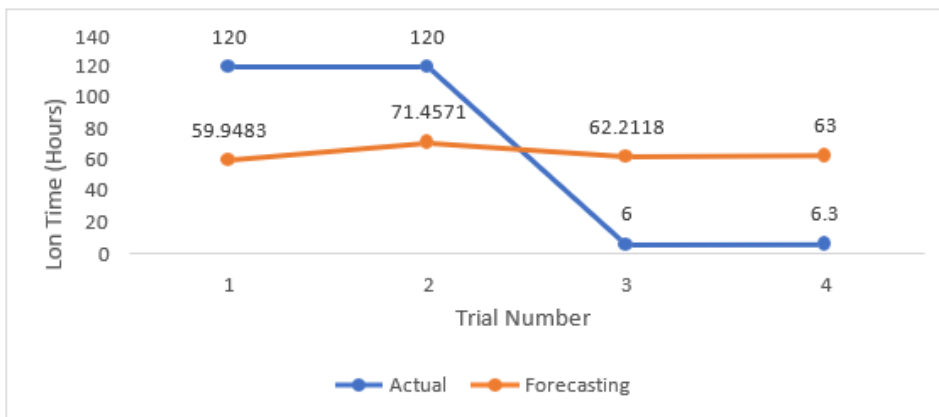
Third data:

$$Error = \frac{(Forecasting - Actual)}{Forecasting} = \frac{62.2118 - 6}{62.2118} = 0.903555274$$

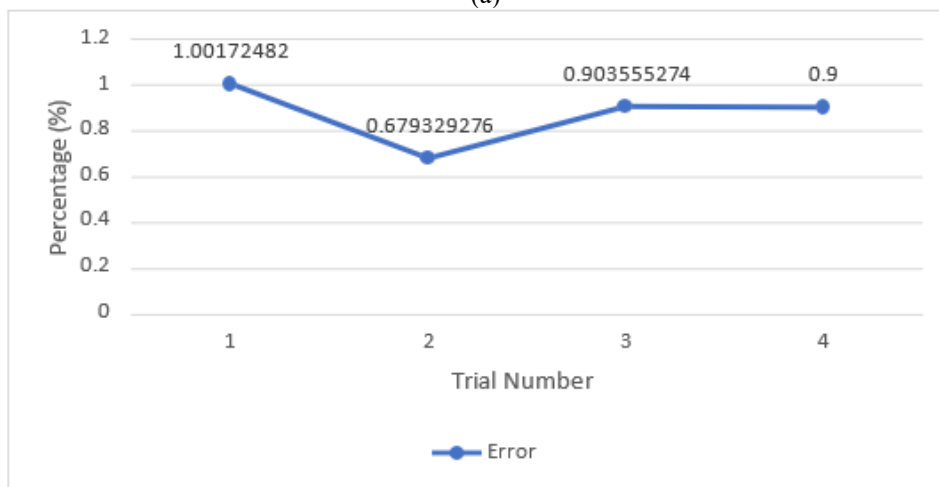
Fourth data:

$$Error = \frac{(Forecasting - Actual)}{Forecasting} = \frac{63 - 6.3}{63} = 0.9$$

Based on Table 13. above, the lowest error value is obtained in the second data with an actual value of 120, forecasting 71.45 and an error value of 0.679 percent while the highest error value is in the first data with an actual value of 120, forecasting 59.9 and an error value of 1.001 percent and an average error value of 0.8711.



(a)



(b)

Figure 12. Graph of Actual and Estimated Length of Lights On at Joule Thief With Primary Winding 5 and Secondary Winding 20 (a) On Time (b) Error Percentage

Based on Figure 12.A and Figure 12.B above, the percentage error value is below one per cent and the closest error value is 0.679 per cent for actual data 120 and forecasting data 71.45 while the actual and forecasting axis graphs are not linear.

IV. CONCLUSION

Based on the results of the analysis, it can be concluded that forecasting the length of the lamp on for the Joule Thief circuit in Primary winding 10 and secondary winding 17 obtained an average percentage error value of 0.2994, then in primary winding 5 and secondary winding 7 obtained an average percentage error value of 0.434 and in primary winding 5 and secondary winding 20 obtained an average percentage error value of 0.8711. Based on this data, it is also concluded that Joule Thief with primary winding 10 and secondary winding 17 is the most efficient because it has a small average percentage error of 0.2994.

Thus, Fuzzy Logic can be proposed as one of the methods used to forecast the length of time the lamp is on from the Joule Thief circuit. The membership function can be expanded to increase the accuracy of membership function level models to produce more accurate forecasting results.

Based on the results of the analysis, it can be concluded that forecasting the length of the lamp on for the Joule Thief circuit in Primary winding 10 and secondary winding 17 obtained an average percentage error value of 0.2994, then in primary winding 5 and secondary winding 7 obtained an average percentage error value of 0.434 and in primary winding 5 and secondary winding 20 obtained an average percentage error value of 0.8711. Based on this data, it is also concluded that Joule Thief with primary winding 10 and secondary winding 17 is the most efficient because it has a small average percentage error of 0.2994.

V. ACKNOWLEDGEMENTS

In this preparation, it is inseparable from the support of various parties. The researcher would like to express his deepest gratitude to all parties, especially his parents, siblings and family as well as the supervising lecturers who have helped. Researchers received a lot of guidance, instructions and assistance and encouragement from various parties both morally and materially.

VI. REFERENCES

- [1] R. Amshari, "Rancang Bangun Sistem Real Time Watermeter Berbasis Internet of Things (Iot)," *Bandung*, vol. 1, no. 1, pp. 1–46, 2020, [Online]. Available: <http://journals.sagepub.com/doi/10.1177/1120700020921110%0Ahttps://doi.org/10.1016/j.reuma.2018.06.001%0Ahttps://doi.org/10.1016/j.arth.2018.03.044%0Ahttps://reader.elsevier.com/reader/sd/pii/S1063458420300078?token=C039B8B13922A2079230DC9AF11A333E295FCD8>
- [2] Y. M. Djaksana, "Perancangan Sistem Monitoring Dan Kontroling," vol. 2, no. 3, pp. 13–24, 2020.
- [3] S. LaMonaca and L. Ryan, "The state of play in electric vehicle charging services – A review of infrastructure provision, players, and policies," *Renew. Sustain. Energy Rev.*, vol. 154, no. September 2021, p. 111733, 2022, doi: 10.1016/j.rser.2021.111733.
- [4] Y. F. Nassar and A. A. A. Hafez, "Solar Energy Charging Systems/Techniques of Electric Vehicle: A Comprehensive Review," no. July, 2024.
- [5] J. Jamaaluddin *et al.*, "Heat Transfer Management of Solar Power Plant for Dryer," *Int. J. Eng. Appl.*, vol. 12, no. 3, pp. 195–203, 2024, doi: 10.15866/irea.v12i3.23959.
- [6] H. R. Iskandar, C. B. Elysees, and R. Ridwanulloh, "Analisis Performa Baterai Jenis Valve Regulated Lead Acid pada PLTS Off-grid 1 kWp," *J. Teknol. Univ. Muhammadiyah Jakarta*, vol. 13, no. 2, pp. 129–140, 2021, [Online]. Available: <https://jurnal.umj.ac.id/index.php/jurtek/article/view/7624>
- [7] S. Saodah, I. M. W. Kastawan, E. Yusuf, B. P. Manunggal, and M. Maryanti, "Simulation of Effects of Using Capacitor for Reactive Power (VAR) Compensation on Electrical Power Supply Quality," *Proc. 5th FIRST T1 T2 2021 Int. Conf. (FIRST-T1-T2 2021)*, vol. 9, pp. 168–174, 2022, doi: 10.2991/ahc.k.220205.029.
- [8] S. Hardi, M. Rahmat, and E. P. Sinulingga, "Improved Quality of using Voltage Static Var Compensator and Capacitor Bank on the Transmission Line," *J. Phys. Conf. Ser.*, 2021, doi: 10.1088/1742-6596/1811/1/012066.
- [9] A. J. Watkins, "Power factor improvement," *Electrical Installation Calculations: Advanced*. pp. 70–75, 2020. doi: 10.4324/9780080953946-12.
- [10] N. M. Karmiathi and I. K. A. Putra, "Technical analysis of power factor improvement using ETAP 12.6 at Regent Resort & Holiday Inn Canggü," *Matrix J. Manaj. Teknol. dan Inform.*, vol. 12, no. 1, pp. 38–50, 2022, doi: 10.31940/matrix.v12i1.38-50.
- [11] M. Y. Rofandy and A. Hasibuan, "Analysis of the Effect of Bank Capacitor Placement As," vol. 02, no. 01, 2022.
- [12] Lisiani, A. Razikin, and Syaifurrahman, "Identifikasi dan Analisis Jenis Beban Listrik Rumah Tangga Terhadap Faktor Daya (Cos Phi)," *J. Untan*, vol. 1, no. 3, pp. 1–9, 2020.
- [13] Jamaaluddin, I. Robandi, and I. Anshory, "A very short-term load forecasting in time of peak loads using interval type-2 fuzzy inference system: A case study on java bali electrical system," *J. Eng. Sci. Technol.*, vol. 14, no. 1, pp. 464–478, 2019, [Online]. Available: http://jestec.taylors.edu.my/Vol14issue1February2019/14_1_31.pdf
- [14] J. Jamaaluddin, I. Anshory, A. Akbar, Khoiri, Mardiyono, and A. Fudholi, "Analysis of the Use of Digital Ultrasonic Based on Fuzzy Inference System to Get More Precise Water Discharge Measurement Results," *Int. Rev. Model. Simulations*, vol. 16, no. 6, pp. 396–404, 2023, doi: 10.15866/iremos.v16i6.24023.
- [15] S. Hernada, O.E., Sumarno, Jamaaluddin, J., "Enhancing design and print services: A web-based ordering system for indesign digital printing storeNo Title," *AIP Conf. Proc.*, vol. 1, no. 1, 2024, doi: 10.1063/5.0219709.
- [16] Jamaaluddin Jamaaluddin, Putra, Boy Isma and S. Agus Hayatal, "TRAINER SMART PLTS UNTUK PEMBELAJARAN SISTEM PLTS PADA SISWA SMK MUHAMMADIYAH 3 NGORO," *MARTABE J. Pengabd. Masy.*, vol. 7, pp. 3552–3559, 2024, doi: 10.31604/jpm.v7i9.3552-3559.

- [17] Jamaaluddin, I. Robandi, I. Anshory, Mahfudz, and R. Rahim, "Application of interval type-2 fuzzy inference system and big bang big crunch algorithm in short term load forecasting new year holiday," *J. Adv. Res. Dyn. Control Syst.*, 2020, doi: 10.5373/JARDCS/V12I2/S202010024.