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Speed Control and Monitoring System for Electric vehicle Based on Fuzzy Logic and Internet of Things

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ABSTRACT: Electric vehicle is one of the solutions to solving problems faced by the automotive sector around the world for environmental and energy sustainability. In this study, the dynamics of an electric vehicle when on an uphill and downhill trajectory affect energy consumption. This is because, when an electric vehicleuphill, the higher the grade of resistance (Rg) against the vehicle's speed is greater and vice versa when the electric vehicledownhill it benefits from the grade resistance (Rg) which helps the vehicle speed. Therefore, the system is fuzzy logic controller used for the BLDC motor control performance management when on uphill and downhill with the Mamdani type. The variable inputs the ADCpotentiometer value and the angle from the MPU 6050 sensor, while the variable output is PWM from the Arduino DUE microcontroller. The speed of an electric vehicle is automatically controlled by adding or decreasing the PWM when going uphill and downhill. The use of technology Internet ofThings (IoT)in the system monitoring TITEN EV-3 electric vehicle can be done via Blynk anywhere online and in real-time. The Blynk application is used for monitoring voltage, current, power, energy, angle, gas pedal, PWM, speed, mileage of electric vehicles. This test is carried out dynamically with the conditions of the road uphill, downhill, turning, and straight as far as 1105.47 meters with a maximum time of 5 minutes. The energy consumption of the control system testing driver mode was 38.464 km / kwh, while the FLC control system was 44.39 km / kwh. So that the energy consumption of the FLC control system is more efficient with a longer distance.

KEYWORDS: Blynk, Fuzzy Logic, Electric Vehicle, Uphill, Downhill.

I.INTRODUCTION

Electric vehicle are one of the solutions in solving problems faced by the automotive sector around the world for environmental and energy sustainability[1]. In the last decade, electric vehicle have been used as alternative transportation for an internal combustion engine (ICE) vehicles [2]. Industrial development is a challenge for engineers to be directly involved in designing devices that can be implemented in the industrial sector. The industrial revolution 4.0 is a solution to these challenges, that the Internet of Things (IoT) and artificial intelligence (AI) are a priority [3]. Internet of Things (IoT) is a system that can interact with one another, users with computers, and machines with machines via the internet [4].

The motion of the vehicle while driving is generated by the thrust of the front wheels (Ff) and the thrust of the rear wheels (Fr). The vehicle that is driving has 3 drag forces, namely Aerodynamic Resistance (Ra), Rolling Resistance (Rr), and Grade Resistance (Rg). When the vehicle is driving on an uphill, it will increase engine torque so that the vehicle speed decreases due to the grade resistance against the direction of the vehicle which is declared a positive slope, while on the descent trajectory it benefits from the assistance of grade resistance which is declared a negative slope. Grade resistance also affects rolling resistance, when the hill is going up the rolling resistance will be bigger and vice versa if the drop is rolling resistance getting smaller [5]. The fuel consumption of a vehicle increases when on an uphill, while it decreases when on a downhill. The results of the study with a simulation of vehicle consumption when on an uphill were 878.4 mg, while on the downhill it was 834.2 mg [6].

This study used a speed control of electric vehicle currently on the uphill and downhill with FuzzyLogic Controller and system monitoring with communication media wireless fidelity (Wi-Fi), namely modules NodeMCU ESP8266 which can be monitored via the Blynk app in real-time.

II. SYSTEM DESIGN

2.1 Wiring Diagram System

Figure 1 show thewiring diagram systemof TITEN EV-3 is an electric vehicle in the category Urban Concept. Battery Lithium-Ion 36V 10Ahis the main source of electric vehicle with 250W BLDC motor as a prime mover. The BLDC motor speed controller uses a factory-made sunrace 500W. The speed of an electric vehicle can be controlled via the gas pedal from the potentiometer. The voltage sensor is installed on a 36V Li-Ion battery with a voltage input maximum of 42V. The current sensor is installed in series between the Li-Ion battery. The speed sensor and mileage sensor are installed on the edge of the rear wheel to detect wheel-mounted magnets. Theangle sensor is installed parallel to the front frame of the electric vehicle. The relay is used to connect the Arduino DUE PWM microcontroller to the driver the BLDC control MOSFET based on the driver or FLC mode.

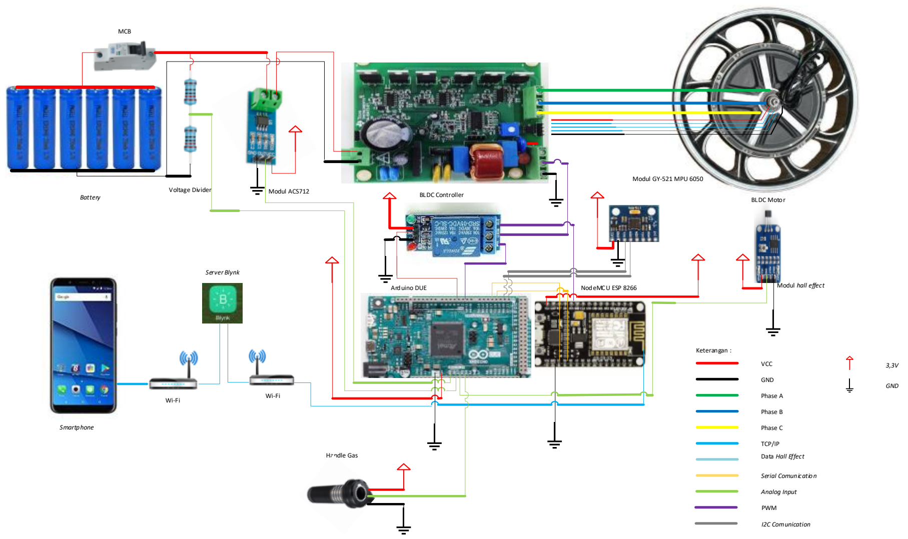

Fig. 1Wiring diagram system

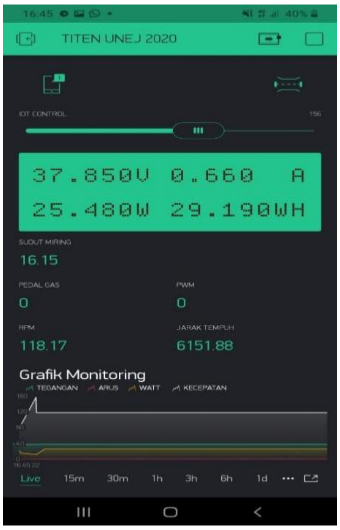

Fig. 2Blynk GUI design

The voltage sensor uses two resistors with a voltage dividing principle, namely R1 of 10K and R2 of 1K so that the voltage that goes to the Arduino DUE microcontroller is less than 5V. The current sensor uses the ACS712 module which can read the maximum current flowing of 20A. Speed and distance traveled using sensors hall effect 319 by detecting the presence of a magnet which is then converted into revolutions per minute (RPM) and the number of wheel rotations used as the distance sensor. Theangle sensor uses the MPU 6050 sensor to detect the Y-axis angle.

The Arduino DUE microcontroller and the NodeMCU ESP8266 microcontroller are connected via Rx and Tx pins, namely by serial communication. The Arduino DUE microcontroller is used to convert analog sensor data into digital data. The sensor data is stored on the SD card and then sent to the ESP8266 NodeMCU microcontroller. The ESP8266 NodeMCU microcontroller is used to transmit sensor data to the Blynk GUI via the internet network.

2.2 Blynk GUI design

Figure 2 show the monitoring design of electric vehicle using the Blynk application. Application is used to monitoring voltage, current, power, energy,angle, gas pedal, PWM, speed, mileage of electric vehicle. LDC widget displays voltage, current, power, and energy data. The value display widget displays accelerator, speed, PWM,angle, and distance traveled. The supercart widget displays graphs of voltage, current, power, and speed.

Blynk is connected to the NodeMCU ESP8266 microcontroller by initializing the token code, SSID, and hotspot password. The token code is obtained when you first create a project in Blynk which is sent via email. The SSID and hotspot password of the smartphone are used so that NodeMCU ESP8266 is connected to the internet network.

2.3 Flowchart System

Figure 3 show the speed control system consists of driver and FLC mode. Driver mode is the driver controlling the speed of the electric vehicle directly by adding or subtracting gas to control the speed according to the set-point. When the road conditions are uphillor downhill, the gas pedal is stable according to the set-point. FLC mode that an electric vehicle speed is controlled automatically by adding or decreasing PWM go to control BLDCusingalgorithms fuzzy logiccontroller by rule-base. When the electric vehicle is uphill or downhill, the system will increase or decrease the PWM automatically. PWM addition or subtraction is controlled by the FLC system based on variables input POT andangle.

Input variables in the form of potentiometer ADC value and angle sensor then go through a process of fuzzification, fuzzy inference, and defuzzification. The defuzzification output data is a PWM value that is used to adjust the percentage of the high pulse width to the period in the MOSFET driver circuit. If the speed matches the set-point, then the data from Arduino DUE is saved to the data logger and sent to the Blynk GUI. Data loggers are used to storing data on voltage, current, power, energy, angle, gas pedal, PWM, speed, and mileage of electric cars in real-time. In the next process, data from Arduino DUE is sent to the Blynk GUI via NodeMCU ESP8266. If the data has been received by Blynk GUI, the process has been successfully carried out. If the Blynk GUI has not received data, the process will return to the initial process.

III.METHOD

3.1 Calculation of Vehicle Grade Resistance

Figure 4 showwhen the vehicle is driving, there is a drag force, one of which is influenced by the slope of the road or grade resistance. Grade resistance can be calculated using the following mathematical formula [5]:

$$R_g = \pm m \times g \times \sin \vartheta$$

R_g = Grade resistance (N)

m = Mass of Vehicle (Kg)

g = Acceleration of Gravity (m / s^2)

ϑ = Angle of Inclination (°)

$$R_g = \pm(130 + 70) \times 9{,}8 \times 18{,}61°$$

$$= \pm 200 \times 9{,}8 \times 0{,}319$$

$$= \pm 625{,}16 \text{ N}$$

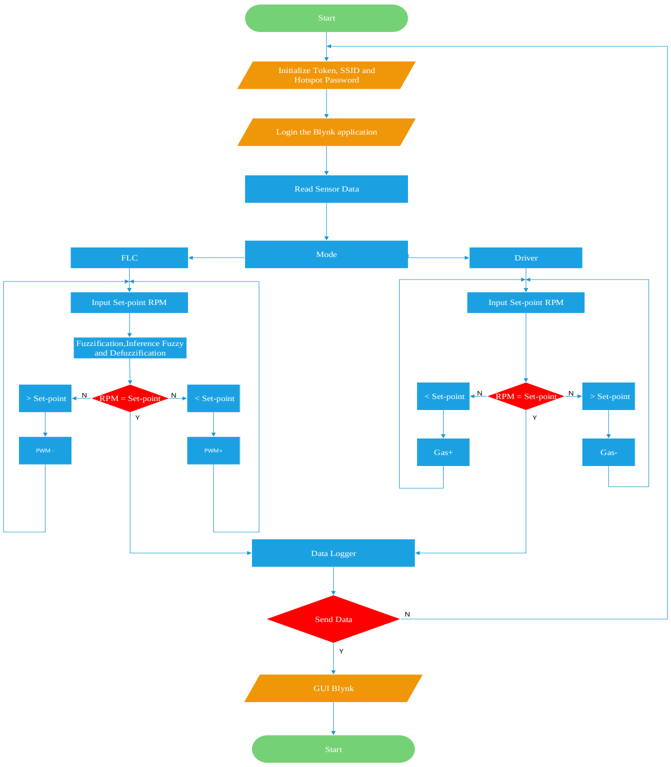

Fig. 3 Flowchart system

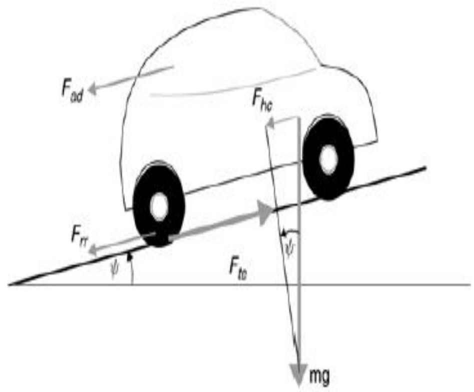

Fig. 4 Vehicle dynamics on a slope of 18.61 °

The load is distributed to the 4 wheels so that each wheel gets 156.29 Newton or 15.629 kg. When the vehicle is driving on an uphill, it will increase the torque of the BLDC motor so that the vehicle speed decreases due to the grade resistance that is against the direction of the vehicle's speed. When the vehicle is driving on a downhill, it benefits from the assistance of grade resistance. Grade resistance when decreasing will help to move a vehicle that is declared a negative slope.

3.2 Fuzzy Logic Controller

Fuzzy which means cryptic, fuzzy, or unclear which was first developed by LotfiZadeh in 1965. The basis of logic fuzzy is set fuzzy which means the degree of membership with unclear or vague boundaries as a determinant of elements in a set that have interval values between 0 and 1 [7]. FLC in its work is based on the linguistic rules that connect input and output. The biggest motivation for using control systems fuzzy is to describe complex real-world problems into a model but in a rule-dependent linguistic form (statement IF-THEN), all of which means that this control technique has a tremendous advantage that it will be easy to solve. understand and implement such categorizing speed as low, medium, and fast [8].

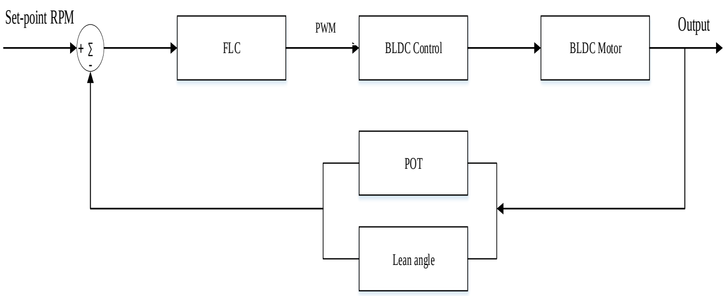

Fig. 5 Block diagram of Fuzzy logic controller

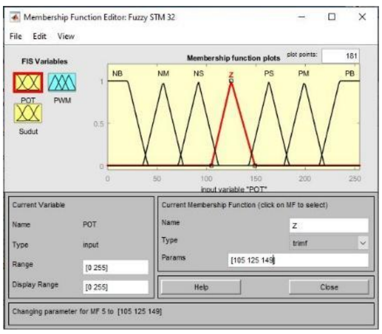

Fig. 6Membership function POT

The system is Fuzzy used for BLDC motor control performance management when on uphill and downhill with Mamdani type, input variables used are POT andangle, and the output variable is PWM. The fuzzy set that will be used

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is Negative Big (Nb), Negative Medium (Nm), Negative Small (Ns), Zero (Z), Positive Small (Ps), Positive Medium (Pm), and Positive Big (Pb).

POT =ADC potentiometer value with a range of 0 to 255
Angle = Sensor readableangle with a range of -60 ° to 60 °
PWM = Output Microcontroller digital with a range of 0 to 255

Based on the membership function, then the process of mapping the membership degree value of each variable, input namely POT and the angle to the table which contains the IF-THEN rule-base in the form of linguistic variables.

Table 1 show the rule-base used in the study.So that a decision can be made on the value input based on the rule-based rules that have been made. The design is a rule editor used as an input with the 49 rule-based design.

Table 1. Rule-base FLC

POT / Lean angle	Nb	Nm	Ns	Z	Ps	Pm	Pb
Nb	Nb	Nb	Nb	Nb	Nm	Ns	Z
Nm	Nb	Nb	Nm	Nm	Ns	Z	Ps
Ns	Nb	Nm	Ns	Ns	Z	Ps	Pm
Z	Nb	Nm	Ns	Z	Ps	Pm	Pb
Ps	Nm	Ns	Z	Ps	Ps	Pm	Pb
Pm	Ns	Z	Ps	Pm	Pm	Pb	Pb
Pb	Z	Ps	Pm	Pb	Pb	Pb	Pb

Furthermore, the defuzzification process is carried out, namely changing the linguistic value of the inference results fuzzy to the numerical value that is sent to the output. The variable output of each given rule is linear with variable input. So that at this stage it will produce an output in the form of addition or subtraction of PWM every second.

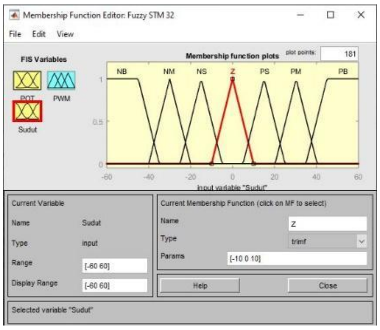

Fig. 7Membership function angle

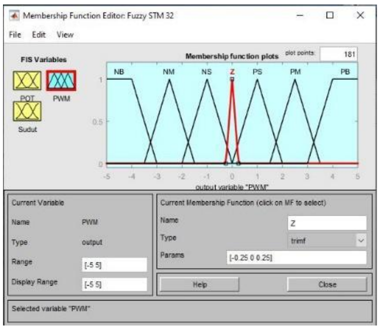

Fig. 8Membership function PWM

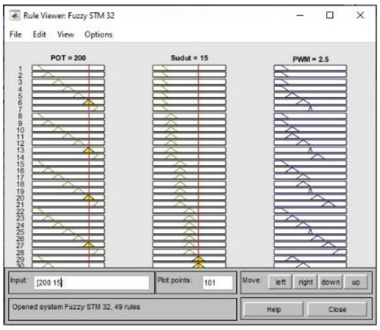

Fig. 9 The rule viewer in Matlab

Figure 9 show thevariable input in the form of POT and theangle and thevariable outputin the form of PWM. From the rule-base that has been made, it is known, if POT = 200 andangle = 15 ° then the output = 2.5. So that the output will be used as input driver BLDC control MOSFET. Based on the results to determine the output in FLC by simulating the rule-viewerin Matlab, it will be compared with the defuzzification calculation using themethod Center of Area (COA)[8].

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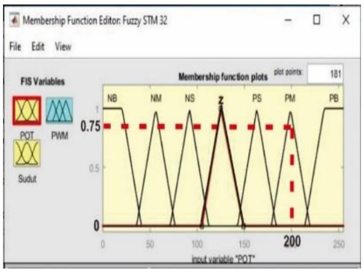

Fig. 10 POT 200 variable membership function

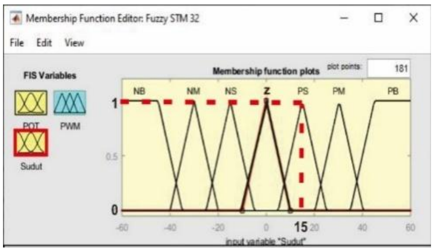

Fig. 11Angle variable 15 ° membership function

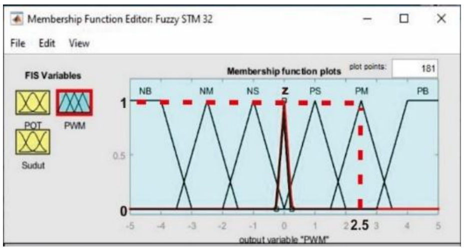

Fig. 12 PWM 2.5variable membership function

$$\mu(x)PM = \frac{c - x}{c - b} = \frac{215 - 200}{215 - 195} = \frac{15}{20} = 0{,}75$$

$$\mu(y)PS = \frac{x - a}{b - a} = \frac{15 - 5}{15 - 5} = \frac{10}{10} = 1$$

$$\mu(z)\,PM = \frac{x - a}{b - a} = \frac{2{,}5 - 1{,}5}{2{,}5 - 1{,}5} = \frac{1}{1} = 1$$

Next, create a fuzzy rule-base by comparing the fuzzification value for each input with the OR operator. The OR operator deals with union operations on sets. α-predicate as the result of operation with the OR operator is obtained by taking the largest membership value between elements in the relevant sets.

If POT is PM and Angle is PS then PWM is PM

$$\alpha - \text{predicate} = \mu PM(x) \cup \mu PS(y) = \text{MAX}\,(0{,}75\,;1) = 1$$

$$\frac{z1 - a}{b - a} = \alpha$$

$$\frac{z1 - 1{,}5}{2{,}5 - 1{,}5} = 1$$

$$z1 - 1{,}5 = 1\,x\,1$$

$$z1 = 1 + 1{,}5$$

$$z1 = 2{,}5$$

The final process is the defuzzification calculation using the method Center of Area (COA)as follows[9]:

$$\text{Defuzzifikasi (COA)} = \frac{\sum_{i=1}^{1} \alpha\ \text{x}\ z1}{\sum_{i=1}^{1} \alpha} = \frac{1\ \text{x}\ 2{,}5}{1} = 2{,}5$$

Based on the comparison of the defuzzification results in the Matlab simulation with defuzzification calculations, the results are the same. In the Matlab simulation, the output is PWM2.5, while the defuzzification calculation results are 2.5.

IV.RESULT AND DISCUSSION

4.1 Analysis of Control System Energy ConsumptionTesting The control
Systemenergy consumption test aims to determine the difference in energy consumptiond by a control system driver mode with an FLC control system. The calculation of energy consumption is by the regulations for the Kontes Mobil Hemat Energi (KMHE) in units of km / kwh. This test is carried out dynamically with the conditions of the uphill, downhill, turning and straight road as far as 1105.47 meters with a maximum time of 5 minutes to obtain changes in speed, power and energy.

1) Testing Energy Consumption Driver Mode Control System
Testing the energy consumption of the control system without using a fuzzy logic controller so that the set-point is directly from the potentiometer ADC. Set-point by adjusting the gas pedal from the potentiometer ADC. The potentiometer ADC value is used to adjust the PWM in the MOSFET driver circuit.

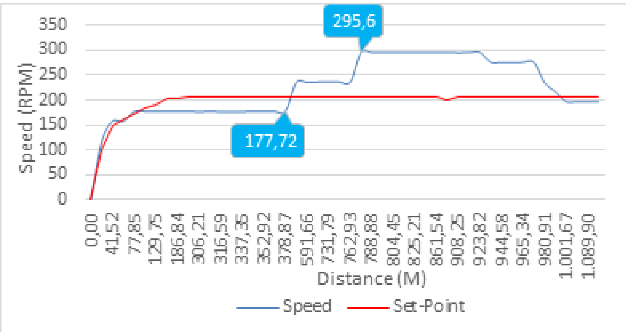

Fig. 13Graph of the speed responsein testing the energy consumption driver mode of control system

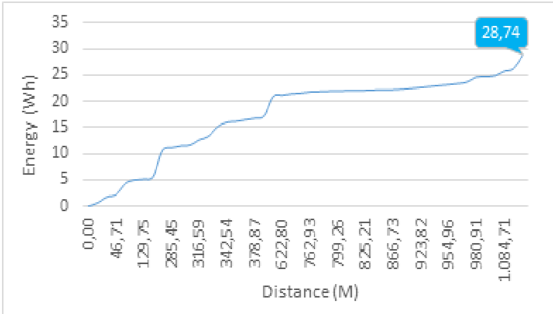

Fig. 14 Graph of energy consumption in the driver mode control system

Figure 13 show the smallest speed of 177.72 RPM while the largest speed is 295.6 RPM. The smallest speed is the speed when the electric vehicle is uphill. The decrease in speed is caused when the electric vehicleuphill higher, the grade resistance (Rg) which inhibits the vehicle's speed becomes greater while without any PWM feedback it causes the speed to slow down. The greatest speed is the speed at which the electric vehicledownhill. The increase in speed is caused when the electric vehicledownhill, benefiting from the grade resistance (Rg) which helps the vehicle speed while without any feedback the PWM control system causes the speed to increase.

Figure 14 show the energy of an electric vehicle during testing of 28.74 wh. Energy consumption is influenced by power so that the greater the power, the greater the energy consumption. The mathematical equation of energy consumption for electric vehicle mileage is:

$$\text{Energy Consumption} = \frac{\text{Distance (KM)}}{\text{Energy (KWh)}} = \frac{1{,}10547}{0{,}02874} = 38{,}464 \text{ km/kwh}$$

Energy usage is obtained of 38,464 km / kwh, so that an electric vehicle can run 38,464 km, requiring 1 kwh of energy.

2) Testing Energy Consumptionof theFLC Mode Control System
Testing of energy consumption of the FLC control system hasfeedbackfrom the ADC potentiometer and angle so that when the electric vehicleuphill or down the PWM is affected by the rule-base. When the electric vehicle is in normal condition or zero condition, then the PWM corresponds to the ADC potentiometer, while when the electric vehicle conditions go uphill or descent, the PWM corresponds to the addPWM value. The addPWM value is used to set the PWM in thecircuit driver MOSFETaccording to the rule-base.

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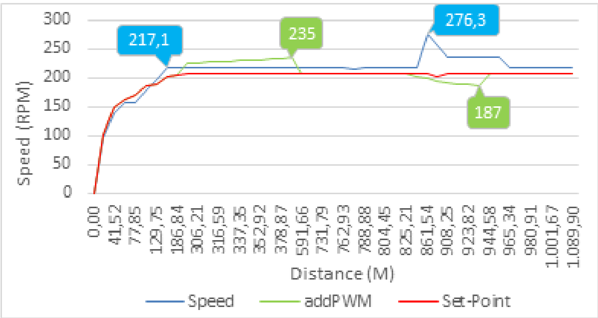


Fig. 15 Graph of the speed response in testing the energy consumption of the FLC control system

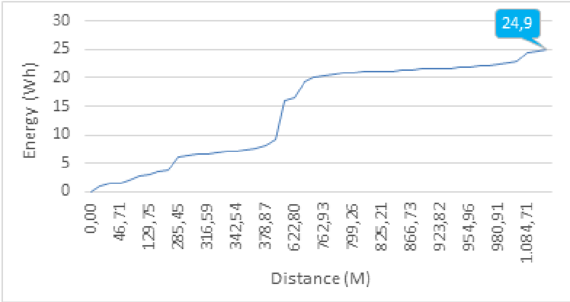


Fig. 16 Graph of energy consumption in the FLC control system

Figure 15 show the smallest speed of 217.14 RPM while the largest speed is 276.32 RPM. The smallest speed is the speed when the electric vehicle is uphill. This is because, when an electric vehicleuphill, the higher the grade of resistance (Rg) which inhibits the vehicle's speed becomes greater. However, the PWM of the control system has a feedback of the FLC system with the addition of PWM automatically according to the rule-base. The addition of PWM increases the percentage ofpulse width with high respect to the period in thecircuit driver MOSFETso that the voltage that enters the BLDC motor increases which results in the speed of the BLDC motor faster. The greatest speed is the speed at which the electric vehicledownhill. The increase in speed is caused when the electric vehicledownhilland benefits from the grade resistance (Rg) which helps the vehicle speed. However, the FLC control system when the electric vehicle is down there is a feedback from the FLC system with automatic reduction of PWM according to the rule-base. The reduction in PWM results in a decrease in the percentage ofpulse width with high respect to the period in thecircuit driver MOSFETso that the voltage that enters the BLDC motor decreases which results in the speed of the BLDC motor being slower.

Figure 16 show the energy of an electric vehicle during the test of 24.9 wh. Energy consumption is influenced by power so that the greater the power, the greater the energy consumption. The mathematical equation of energy consumption for electric vehicle mileage is:

$$\text{Energy consumption} = \frac{\text{Distance (KM)}}{\text{Energy (KWh)}} = \frac{1{,}10547}{0{,}0249} = 44{,}39 \text{ km/kwh}$$

The energy consumption is 44.39 km / kwh, so that an electric vehicle can travel 44.39 km requiring 1 kwh of energy.

VI. CONCLUSSION

Based on the results of testing and data analysis that has been carried out in a study entitled "Speed Control and Monitoring System for Electric vehicle Based onFuzzy Logic and Internet Of Things" it can be concluded as follows:

1. Speed control system design and monitoring can work well. The speed control system when uphill and downhill with FLC, while thesystem monitoring uses IoT which is sent to the Blynk GUI.
2. The use oftechnology Internet of Things (IoT)in thesystem monitoring TITEN EV-3 electric vehicle can be done via Blynk anywhere online and in real time.
3. The energy consumption of the control system testing driver mode was 38.464 km / kwh, while the FLC control system was 44.39 km / kwh. So that the energy consumption of the FLC control system is more efficient with a longer distance.

REFERENCES

[1] Q. Zhang and G. Li, “Experimental study on a semi-active battery-supercapacitor hybrid energy storage system for electric vehicle application,” *IEEE Trans. Power Electron.*, vol. 35, no. 1, pp. 1014–1021, 2020.

[2] H. Vdovic, G. S. Member, and J. Babic, “Automotive Software in Connected and Autonomous Electric Vehicles : A Review,” *IEEE Access*, vol. 7, pp. 166365–166379, 2019.

[3] Y. Giay and T. Adiono, “Design and Implementation IoT SmartPlug for Electricity Usage,” *2019 Int. Symp. Electron. Smart Devices*, pp. 1–5, 2019.

[4] M. Kushwah and R. Rani, "Home Automation and Security System Using Internet of Things," *2019 Int. Conf. Vis. Towar. Emerg. Trends Commun. Netw.*, pp. 235–258, 2019.

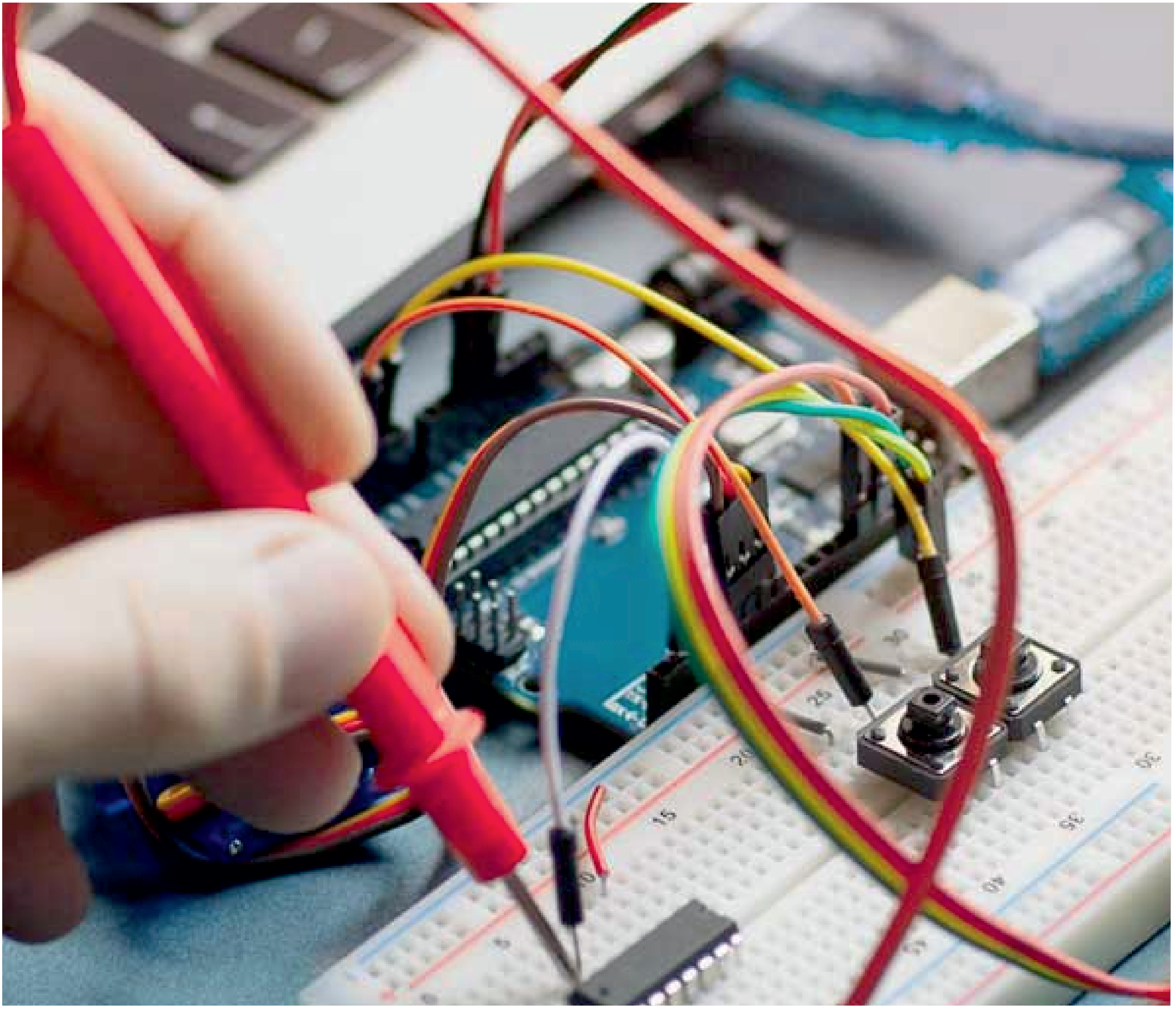
[5] Y. User and N. Tabanli, "Development of induction motor torque control algorithm for electric vehicles on inclined roads," *2017 11th Int. Conf. Electromechanical Power Syst. SIELMEN 2017 - Proc.*, vol. 2017-Janua, pp. 472–477, 2017.

[6] D. K. Bhoi, P. Sahoo, and D. S. Patel, "Predictive algorithm to detect uphill or downhill road ahead of vehicle and simulation analysis of impact on fuel economy and drivability," vol. 4, no. 1, pp. 1–10, 2013.

[7] A. Alazzam and I. Ahmed, "A Speed Control System Using Fuzzy Logic," *ITT 2018 - Inf. Technol. Trends Emerg. Technol. Artif. Intell.*, vol. 7, pp. 12–17, 2019.

[8] B. Wisely Ziliwu and dan Suhartati Agoes, "Analisis Sistem Estimasi Produksi Menggunakan Metode Fuzzy Berbasis Web," vol. 19, no. 1, pp. 12–22, 2017.

[9] A. O. Olajide, A. T. Busayo, and E. T. Olawale, "Analyzing the Effects of the Different Defuzzification Methods in the Evaluation of Javacomponents' Customizability for Reusability," *Int. J. Adv. Eng. Manag. Sci.*, vol. 3, no. 9, pp. 962–971, 2017.



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