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Analysis of Conventional Bicycle Assembly Transformed into an Electric Bicycle Using a BLDC Electric Motor

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Abstract: Along with the increasing problem of oil price volatility, vehicles with alternative fuels are the right vehicles to use at this time. Electric bicycles are one of the vehicles that use alternative fuels. Electric bicycles use battery power as a power source. Electric bicycles consist of two main parts, namely bicycles and electrical components. Bicycles are made through a sequence of planning processes and then assembling bicycle components. Electrical components consisting of batteries, controllers, gas grips, and electric motors are assembled and connected to one bicycle.

Keywords: Components, Electric Bikes, Electric Motor

1. Introduction

The development and implementation of vehicles with environmentally friendly alternative fuels needs serious attention from the government. There is a need for alternative fuels that are easily available, environmentally friendly, and can help the overall economy of the community. Along with the increasing problem of petroleum price instability, alternative fuel vehicles are vehicles that can operate using fuels other than fossil fuels. The example of those vehicles is electric vehicles [1].

Electric bicycles are one of the alternative fuel vehicles. Electric bicycles utilize electricity as a source of power. Electrical energy is used to convert into motion energy. To convert electrical energy into motion energy, an electric motor is needed or often called an electric dynamo. This electric dynamo becomes a core engine or main drive in an electric bicycle.[26]

The working mechanism of an electric bicycle is very simple. Electric bicycles utilize a power source in the form of a battery that is used to drive a motor that aims to run the bicycle. Therefore, an electric bicycle is equipped with several components. The most basic components needed to make an electric bicycle or e-bike are the motor, controller, battery and gas handle [16].

Here is a picture of the parts of an electric bicycle sorted as follows:

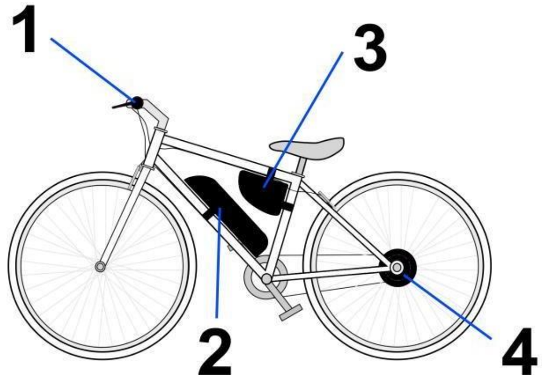

Figure 1. Electric Bicycle Parts

1. **Grip Gas**, Grip gas is used to regulate speed and maintain one's stability when riding an electric bicycle and walking stably.
2. **Battery,** Battery is a source of electrical energy used in electric bicycles. The function of the battery in an electric bicycle is as a source of electricity that can drive the dynamo.
3. ***Controller***, *Controller* is used to regulate how fast or slow the electric bicycle is when traveling, in short, regulating the motion of the electric bicycle when used.
4. **Electric Motor,** commonly called a dynamo, is a component that generates power on an electric bicycle and makes it move with electrical energy which is converted into motion energy.

BLDC motors are a great choice for applications that require high reliability, high efficiency and high power-to-volume ratio. In general, BLDC motors are considered to be high-performance motors capable of generating large torque over a large speed range [21,22,23,24].

BLDC motors are derivatives of the most commonly used DC motors, which are DC motors with brushes, and they have the same torque and speed characteristic curves. The main difference between BLDC and DC motors is the use of brushes. BLDC motors do not have brushes and must be electronically commutated. Commutation is the change in phase of the motor current at the right time to produce rotational torque [24].

BLDC motors are very reliable because they have no brushes to replace. When operated under optimal conditions, the motor lifetime can be more than 10,000 hours. For long-term applications, this can be a great advantage. Whenever a motor breaks down or needs to be replaced, the plant or part of the plant must be shut down. This costs time and money, depending on how long it takes to replace worn and damaged components to get the plant running again [19].

BLDC (Brushless DC) motor is an electric motor with a simple structure, high reliability and easy maintenance with the advantages of DC motors such as high efficiency, no excitation loss and compared to other electric motors, BLDC motors have shown better performance as actuators [19,20].

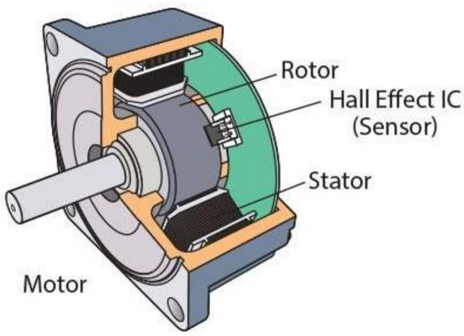

Figure 2. BLDC Motor

Basically, BLDC motors work using the principle of the attractive force between two magnets that are on magnets with different poles or the repulsive force between two magnets with the same pole. The rotor in the BLDC motor is composed of permanent magnets so that the poles are fixed while the stator is made of windings so that the magnetic poles can change depending on the polarity of the stator winding current given [19].

The way the BLDC motor works is quite simple, namely the magnet on the motor shaft will be attracted and pushed by the electromagnetic force regulated by the driver on the BLDC motor. This distinguishes BLDC motors from DC motors which use mechanical brushes located on the commutator to set the time and provide a magnetic field on the winding [20].

BLDCs can provide significantly higher power to load ratios and provide better efficiency than traditional brushless motors. The basic principle of a magnetic field is the same poles will repel each other while if it is different poles it will attract. If you have two magnets and mark one side of the north magnet and south magnet, then the north side will try to attract south, otherwise if the north side of the first magnet will reject the second north side and so on if both sides of the magnet have the same pole [21].

The principle of magnetic poles can be applied in the working principle of BLDC motors. In general, BLDC motors have a permanent magnetic field on the rotor and magnets that come from electromagnetic forces (magnets generated from providing input electric current) in the stator coil. In BLDC motors, the driver functions to regulate the input current that must be flowed into the stator coil to be able to cause the appropriate electromagnetic field to rotate the rotor. This is the difference with conventional DC motors and replaces the mechanical commutation work [19].

2. Research Methods

The block diagram for the conventional bicycle to electric bicycle using BLDC motor is as follows:

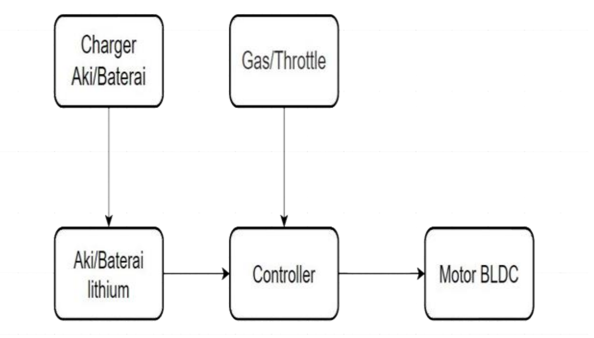

Figure 3. 1 Block Diagram of Electric Bicycle

The overall circuit diagram of the electric bicycle is as follows:

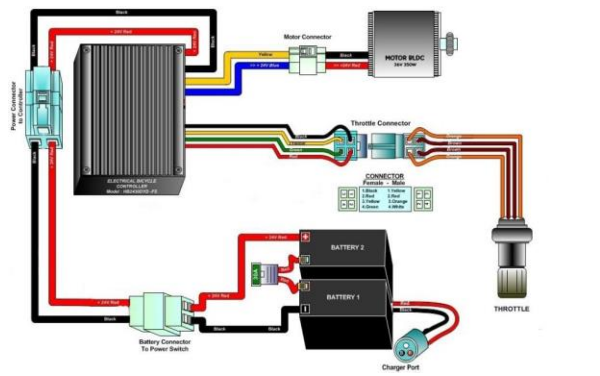

Figure 3. 3 Electric Bicycle Circuit Diagram

A *flowchart* is a chart that explains how a device works in a sequential manner to make it easier to understand the design and manufacture of tools.

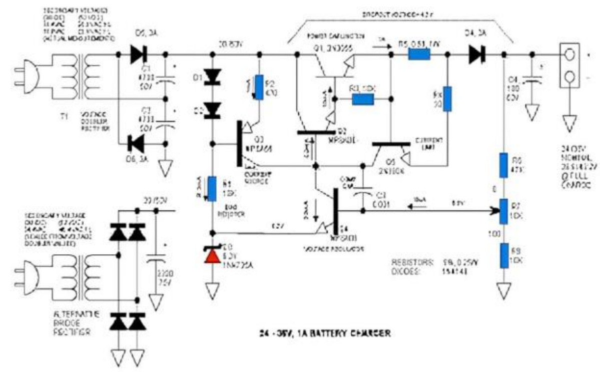

Figure 3. 4 Adoptor circuit

To understand the design and workings of an electric bicycle using a BLDC motor, it can be done by understanding the *flowchart* image below:

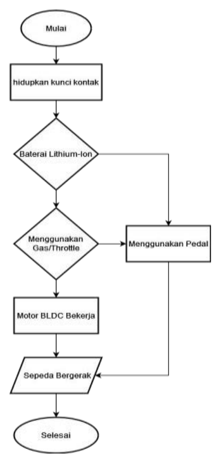

Figure 3. 2 Electric Bicycle *Flowchart*

The *charger* circuit is a circuit that functions to convert AC current into DC current. The type of *charger* must be adjusted to the specifications of the battery used or being used. The selection of an improper *charger* will make the battery short-lived. So, the *charger* must be right according to the battery.

As with how batteries work in general, *lithium-ion* batteries also have advantages in terms of recharging. Then in general, the *lithium-ion* battery component is made of one or more power-producing compartments with the term cell.

Each negative cell basically has three components of positive electrode (which is connected to the positive battery terminal or +), negative electrode (which is connected to the negative terminal or -), and the chemicals with the term electrolyte.

Then the positive electrode is usually made of the chemical compound *lithium-cobalt-oxide* (LiCoO2), or the newer battery models, made of *lithium-iron-phosphate* (LiFePO4). While the negative electrode is made of carbon (*graphite*) and this electrolyte varies from one type of battery to another. But our focus is to understand the basic concepts of how *lithium-ion* batteries work to produce electricity. Regarding the explanation of the components, I'll leave it at this paragraph.

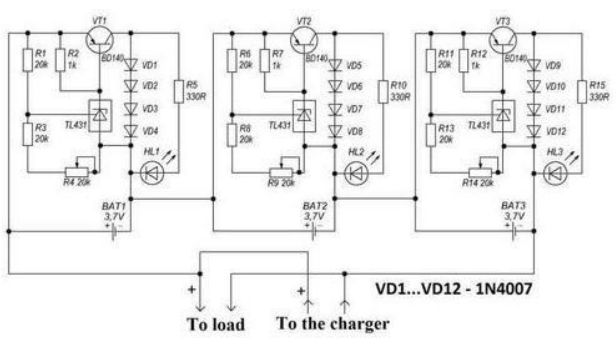

Figure 3. 5 BMS Circuit for *Lithium-Ion* Batteries

The battery that I use on this electric bicycle is a *lithium-ion* battery. This battery is generally *removable*, so this battery can be removed when you want to recharge the battery and also can be replaced with a new battery if one day the battery drops quickly.

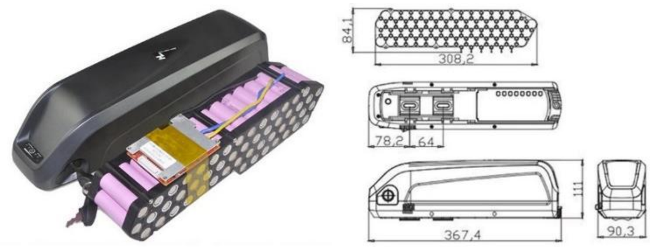

Figure 3. 10 Physical Shape of The Battery

For the specifications of the battery used can be seen in table 3.4. below:

Table 3.4. *Lithium-Ion* Battery Specifications

Type	Li-Ion
Voltage	36 V
Capacity	10 AH
Weight	2,8 kg
Diameter	90 x 110 x 370 mm

In general, *lithium-ion* cells are cylinder-shaped. These cells have a better safety and reliability record than generic cells. In addition to the cells, *lithium-ion* batteries also require a *Battery Management System* (BMS), which monitors the voltage of each cell and activates a circuit breaker so that the battery will not be charged or overcharged.

Controller is a small device that consists of a main chip called a microcontroller and peripheral components that include resistors, various types of sensors, and MOSFET (metal oxide semiconductor field effect transistor). The chip contains several circuits to perform the functions of the *e-bike*, including *Pulse Width Modulation* (PWM) circuits and power circuits.

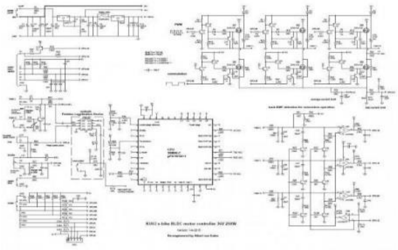

Figure 3. 6 Controller circuit

E-bike controller is connected to every electrical component such as battery, motor, sensors, display screen (if any), *throttle*. It regulates how the various electrical components work for a safe and smooth ride.

When you press the *throttle*, the controller pulls energy from the battery through the motor, regulating the speed of the bike. It is a type of mini-computer that receives inputs from various parts of the *e-bike* like the *throttle*, battery, motor, speed sensor and it responds with an output or response. The examples of that response include some statistics or control options on the screen or an increase or decrease in speed

3. Results and Discussion

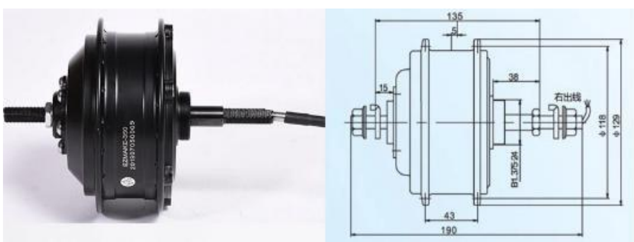

Figure 3. 7 Physical Shape of a BLDC Motor

For the electric bicycle, a 350-Watt BLDC motor is used so that the designed motor can achieve high *speed* and high efficiency. In general, BLDC motors are considered as high-performance motors that can produce large torque at a large speed *range*. The other specifications of this BLDC motor can be seen in table 3.1. below:

Table 3. 1. BLDC Motors Specifications

Type	Brushless Gear Hub Motor
Voltage	36 V
Power	350 W
Weight	3 kg
Diameter	200 x 135 x 135 mm
Wheel Size	14 inch – 28 inch

The *controller* used in this tool is a universal 36V DC 350W brushless *controller* for electric bicycles. The main advantage of this *controller* is to make the engine soundless or smooth (<55db), larger rotation and better efficiency. For other specifications can be seen in table 3.2. below:

Table 3.2. *Controller* Specifications

Type	Brushless Gear Hub Motor
Voltage	Universal 36 V DC
Power	350 W
Weight	300 Gram
Diameter	126x 66 x 38 mm

Figure 3. 8 Physical Form of *Controller*

3.1.1 Gas/*Throttle*

Gas / *Throttle* which is used in this tool is a gas that is equipped with a ignition key to turn on and off the electrical system and a battery indicator *led display*. The function of this component is to regulate the rotation of the motor by providing the data signal to the *controller*.

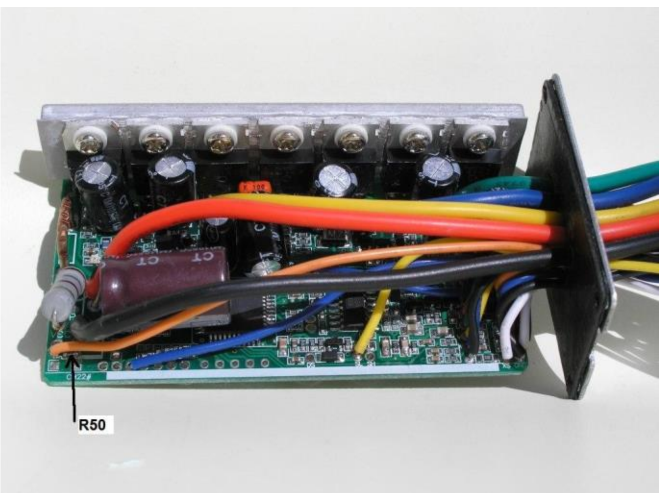

Figure 3. 11 Physical Shape of Gas/*Throttle*

For complete specifications can be seen in table 3.5. below:

Table 3.5. Gas/*Throttle* Specifications

Voltage	36 V DC
Weight	400 grams
Cable	6 Without Socket
Dimensions	170 x 80 x 100 mm
Provided	Ignition key and battery indicator display

The electrical path in the tool design is as shown below:

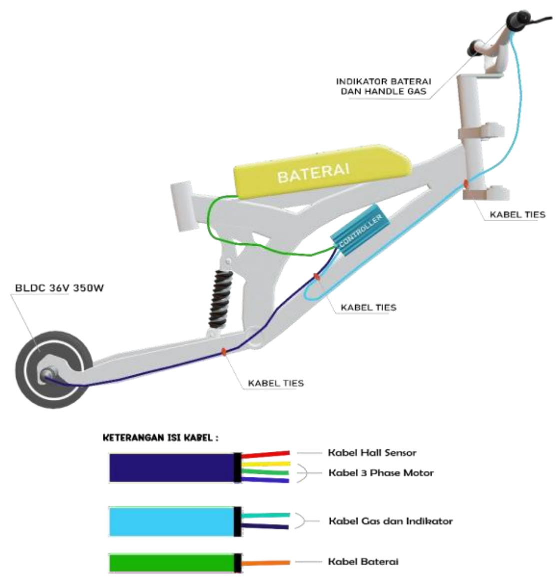

Figure 3. 12 Cable Electrical Path

In the part of the cable that is placed on the outside of the frame, the ties cable is given to make it tidier so that it facilitates the user in cycling and does not cause prone to being pinched, causing it to break.

Figure 4. 1 Electric Bike

The specifications of the bicycle that will be used for the road test are as follows:

1. Bicycle:
   - Bicycle length = 148 cm
   - Bicycle width = 60 cm
   - Bicycle height = 85 cm
   - Bicycle tire diameter = 41 cm
   - Bicycle weight = ±20 Kg
2. Electric Motor:
   - Electric motor length = 13 cm
   - Electric motor width = 10 cm
   - Electric motor height = 10 cm
   - Shaft diameter (gear) = 6 cm
   - Electric motor weight = 3 Kg
   - DC motor voltage = 36 Volt
   - DC motor electrical power = 350 W
3. Battery:
   - Battery length = 36 cm
   - Battery width = 9 cm
   - Battery height = 11 cm
   - Battery weight= 3 kg
   - Battery voltage = 36 Volt

In testing for battery durability, there are two conditions of electric bicycles where the first condition of the electric bicycle is tested without a rider by setting the maximum speed but the back wheel is lifted so that it does not touch the track, and then measuring the current used when the electric bicycle is tested.

For the second condition, the electric bicycle is tested by a rider with a different rider weight in the trial, the electric bicycle is run at maximum speed and then measures the current used when the electric bicycle is run.

Table 4. 1 Measurement Results of Current Used

Experiment	Rider weight	Measured current	Battery Time Out
1	No Load	0,8 A	12 Hours 30 Minutes
2	50 kg	6,33 A	1 Hour 34 Minutes
3	55 kg	6,97 A	1 Hour 25 Minutes
4	60 kg	7,40 A	1 Hour 21 Minutes
5	65 kg	7,85 A	1 Hour 16 Minutes

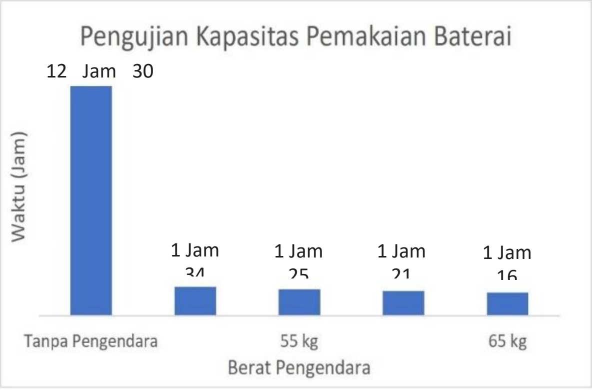

Figure 4. 4 Testing Battery Usage Capacity

In this test, an electric bicycle road test is carried out within a distance of 100 meters with different rider weights, the following data can be obtained:

1. In testing the speed of electric bicycles carried out along the Alghazali mosque road in Bukit Besar. road tests are carried out with riders who had a weight of 50 kg. The experiment was carried out at a distance of 100 m and calculated using a stop watch and obtained a travel time of 15.60 seconds and a final speed of 30 km / hour.
2. The electric bicycle speed test was carried out along the Alghazali mosque road in Bukit Besar. the road test was carried out with a rider who had a weight 55 kg. The experiment was carried out at a distance of 100 m and calculated using a stop watch and obtained a travel time of 16.21 seconds and a final speed of 30 km / hour.
3. The speed test of the electric bicycle was carried out along the Alghazali mosque road in Bukit Besar. The road test was carried out with a rider who had a weight 60 kg. The experiment was carried out at a distance of 100 m and calculated using a stop watch and obtained a travel time of 17.96 seconds and a final speed of 30 km / hour.
4. The speed test of the electric bicycle was carried out along the Alghazali mosque road in Bukit Besar. the road test was carried out with who had a weight 65 kg. The experiment was carried out at a distance of 100 m and calculated using a stop watch and obtained a travel time of 18.54 seconds and a final speed of 30 km / hour.

Experiment	Distance	Rider Weight	Final Speed	Gained Time
1	100	50	30	15.60
2		55	30	16,21
3		60	30	17.96
4		65	30	18.54

Table 4. 2. Table of Electric Bike Travel Time Test Results

Based on the tests that have been done, the results of comparison data with different weights are as shown in the graph below:

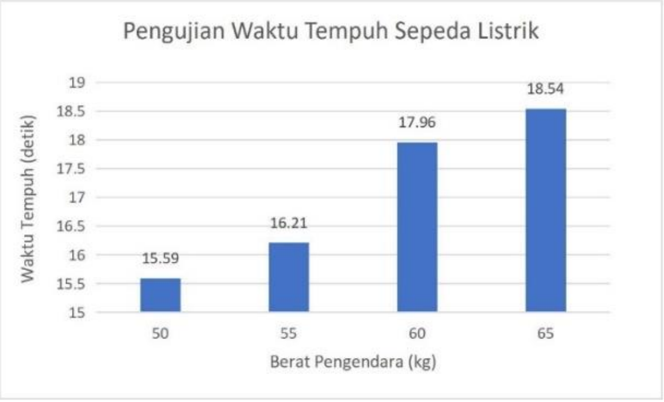

Figure 4. 5 Travel time testing

4. Conclusion

The following are the conclusions from the results of designing an electric bicycle:

1. The road test of the electric bicycle was done along the Palembang city road. From the road test that has been done, the electric bicycle covers a distance of 44.9 km and can reach a speed of 30 km / hour with a 50 kg rider weight.

2. From the results of the experiments that have been done, it is found that the greater the weight of the rider will affect the speed of the electric bicycle and the duration of the travel

References

[1] Andyk Probo Prasetya dkk. 2012. “Analisi Perbandingan Sistem Pengasutan Motor Induksi 3 Fasa Sebagai Penggerak Pompa Pada Perusahaan Daerah Air Minum (PDAM) Wendit Malang” Institute Teknologi Malang.

[2] Anonim. 2013. HC-05 Bluetooth to Serial Module + Level Converter

[3] Arduino, 2015. Overview of Arduino Uno, www.Arduino.cc /en/main/arduino boarduno.

[4] Aripriharta, 2014. Smart Relay and Application, Yogyakarta: Graha Ilmu.

[5] Baretho, Septiadho. 2015. Pengaruh Perubahan Faktor Daya Terhadap Torsi Dan Efisiensi Motor Induksi Tiga Fasa (Rotor Lilit).

[6] Budiharto, W. 2011. Aneka Proyek Mikrokontroler. Yogyakarta :

[7] Daryanto. 2014. “Konsep Dasar Teknik Elektronika Kelistrikan.” Edisi pertama Penerbit Alfabet. Bandung

[8] Faizal, A. 2012. Belajar Menggunakan Arduino. Yogyakarta

[9] G. Bhor, P. Bhandari, R.l Ghodekar,and S. Deshmukh, 2016, MINI RADAR,‖ International Journal of Technical Research and Applications, vol. 39, pp. 68- 71

[10] Islamiati, Y., Dewi, T. ., & Rusdianasari. (2022). IoT Monitoring for Solar Powered Pump Applied in Hydroponic House. International Journal of Research in Vocational Studies (IJRVOCAS), 2(2), 22–30. https://doi.org/10.53893/ijrvocas.v2i2.102

[11] Kaswan K. S, Singh S. P., Sagar S., 2020, Role Of Arduino In Real World Applications, INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH, Vol 9, Issue 01, ISSN 2277-8616

[12] L. Buechley, M. Eisenberg, J. Catchen, and A. Crockett, 2008, The Lily Pad Arduino: Using computational textiles to investigate engagement, aesthetics, and diversity in computer science education,‖ Proceedings of the 2008 Conference on Human Factors in Computing Systems, CHI 2008, pp.423-432

[13] M. M. Abdulkareem, Q. A. Mohammed and M. M. Shakir, 2016, A Short Range Radar System : Rangefinder,‖ Technical Report TR-EEE351, Electrical and Electronics Department, University of Turkish Aeronautical Association Electric and Electronic Engineering Department

[14] P.S. Teja,, V. M. Krishna, and D.C. . Raja, 2017, Industry Supervising System By Using Arduino & IOT, International Journal of Advanced Research in 0,24 0,25 0,25 0,89 0,9 0,9 0 0,1 0,2 0,3 0,4 0,5 0,6 0,7 0,8 0,9 1 L1 L2 L3 (A) STAR DELTA 60 Nofiansah et al.: Operation 3 Phase Induction Motor 1 Kw Star Delta System Using Smart Phone Electronics and Communication Engineering , vol. 6, no. 3, pp. 93-95.

[15] Revy, S., Taqwa, A. . ., & Arifin, F. . . (2022). Utilization of Solar Energy in the Substation Energy in Provider Connected to PT. PLN (Persero) Based on IoT. International Journal of Research in Vocational Studies (IJRVOCAS), 2(2), 41–47. https://doi.org/10.53893/ijrvocas.v2i2.108

[16] Santosa, N. Safaat. 2015 Android; Pemograman Aplikasi Mobile Smartphone Dan Tablet PC Berbasis Android. Bandung:

[17] Zuhal, T and Amran S (2009), Fundamentals of Electricity, Theory and Applications, Issue 4, Publisher ITB, Bandung

[18] Maya Gian Sister, Noor, A. . ., & Anwar Hafizd , K. . (2021). OHS Information System (Occupational Health and Safety) In PT. United Tractors Tbk, SiteSatui Mobile Web Based. International Journal of Research in Vocational Studies (IJRVOCAS), 1(1), 01–10. https://doi.org/10.53893/ijrvocas.v1i1.

[19] Builder future construction, 2021. "Motor BLDC Cara Kerja Dinamo BLDC dan Konstruksinya", https://www.builder.id/motor-bldc//, diakses pada 7 April 2022 08.12.

[20] Faj`ri, Muhammad Hafidz . 2018. Desain Sepeda Listrik Dengan Style Motor Boardtrack Sebagai Sarana Mobilitas Di Perkotaan Yang Cepat Dan Efisien. Tugas akhir. Institut Teknologi Sepuluh Nopember

[21] Arduino, 2015. Overview of Arduino Uno, www.Arduino.cc /en/main/arduino boarduno.

[22] Setiyawan, Beny. 2012. *Rancang Bangun Sepeda Listrik*. Proyek Akhir. Universitas Sebelah Maret Surakarta.

[23] Sulistyanto, Dwi. 2008. “Rancang bangun sepeda listrik menngunakan system portable”, Tugas akhir. Universitas Mercu Buana : Jakarta.

[24] Susanti, I., Rumiasih., RS, Carlos., & Firmansyah, Anton., 2019. Analisa Penentuan Kapasitas Baterai Dan Pengisiannya Pada Mobil Listrik. Vol. 4(2). ISSN: 2503-0221. Halaman 29 – 37

[25] Perdana, Fengky Adie., 2020. Baterai Lithium. Vol. 9(2). ISSN: 2615-7489. Halaman 103 -109

[26] YaleTools. *Bagian-Bagian Sepeda Listrik dan Fungsinya*. https://yaletools.com /id/bagian- bagian-sepeda-listrik/. Diakses pada 28/4/2022.