## Original Article

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# Eco-Pedal Bicycle Prototype Design as An Alternative Multi-Information Display Energy Generator

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**Abstract:** As technology grows, so does the consumption of energy, especially electricity. Today, electricity has become the most used energy worldwide, and the demand keeps on increasing every year. According to PLN annual report, the highest electricity consumption came from the domestic sector, which peaked at 97.832,28 GWh in 2018. However Indonesia's current power supplies are not enough to fulfill those demands. It was the main reason to develop another form of cheaper, more efficient, and environmentally friendly power supply, especially for stand-alone devices application. This research aims to build a simple system which able to generate electricity for bicycles and to determine the voltage and the current it generates at a certain speed, which can be stored in portable batteries. This design uses propulsion from the bicycle and using a 16.8 volt 6600 mAh Lithium-ion battery as its energy storage. The tests show that Multi Information Display (MID) LCD may update and notify the changes of voltage, temperature, speed in every second. The average power released is 13 Watt with maximum output can reach 34 Watt. The test shows that the average voltage error is 0.79% while average temperature error is 1.28% and average speed error is 2.77%.

**Keywords:** *Alternative Energy, Generator, RPM, MID*

## Introduction

Electricity has become the most used energy worldwide today. With so many electronic devices around us, it can be ascertained that the demand of electrical power will be endless, and also will be always increasing [1]. Naturally, to answer this demand, more power plants will be needed and must been built. But instead of build massive power plant which using fossil fuels to generate a large amount of electrical power, people these days prefer using micro power generators powered by endless alternative of renewable energy sources as an environmentally friendly and continuous solution [2]. One of the highly potential renewable energy, which is become the core of this research, is by using bicycle pedal rotation generated by human power. This might be a simple and cheap way to generate electricity for domestic electronic devices consumption and can also provide a fun, cheap, and environmentally friendly alternative transportation modes [3].

This modified bike can be used to drive the DC generator by simply pedaling the bike. The electrical energy generated from this system can be stored in batteries for future usage. It can be used to power low power consumption devices

## Method

Authors identified that the electrical energy power consumption around them were too high for what their local power plant can support [1]. It caused frequent shortage and cause damages to some devices. While short distance transportation modes become crucial lately, the authors came up with some ideas for an eco-friendly alternative mode to replace heavily carbon waste vehicles while supplying electricity for average daily use. The authors then designed a device that can generate electricity without using any fossil fuels, as well as fulfil the demand of average daily energy consumption using bicycle generator [4]. The power generated from this device can be stored in a portable battery for later use.

This bicycle-powered charging station [5] also equipped with devices to monitor the voltage, speed and temperature it generates, since these parameters have their own limits. Authors using MID LCD for ancillary device while building this charging station [6]. Based on these objectives, authors determine the specification of the tools used in this research. In the design stage, authors determine the form of the tools and their components [7].

Before the testing begin, this designed system needed to be calibrated and adjusted, especially to normalized the software. After that, authors may test the accuracy from how it detects voltage, temperature and speed.

To sum up, the methods used in this research is shown in the **Figure 1**.

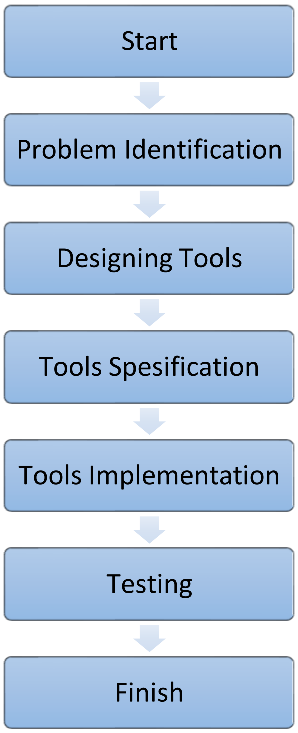


**Figure 1.** Eco-Pedal Bicycle prototype design build method

## Designing and Implementation

### Designing

This portable electrical generator hardware design can be divided into two major part which are the generator and monitoring section. For this research, authors were designing both monitoring and generator hardware. The design itself can be detailed as follows.

### Monitoring Hardware

This monitoring hardware was design to read and display the voltage, temperature, and speed value. The workflow of this designed system is shown in the **Figure 2**.

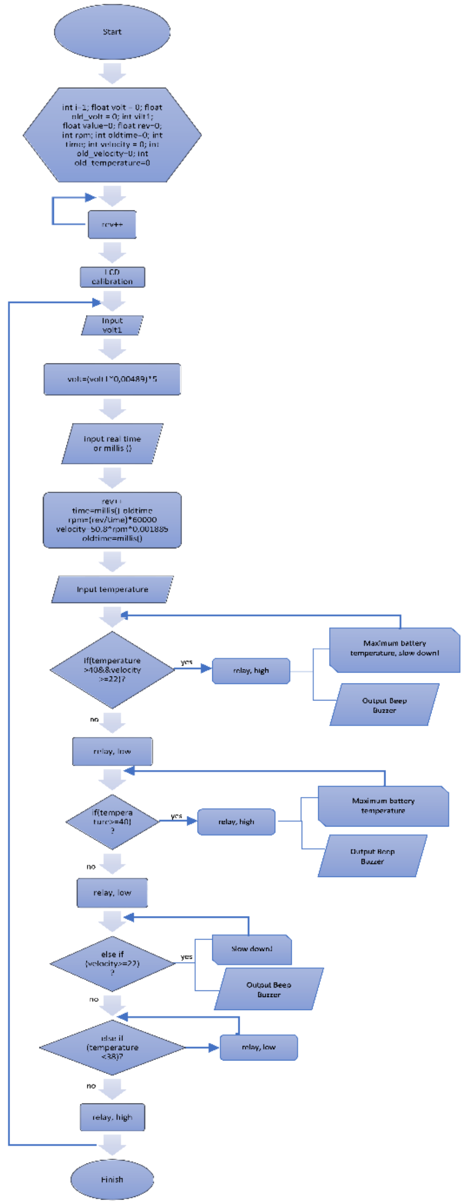


**Figure 2.** MID system flowchart

The components used in this monitoring hardware are:

1. Arduino Mega 2560 microcontroller, is an open source electronic platform based on easy to use hardware and software. It's ability to read inputs and turn it into an output used in this research as the controller for this instrument
2. 0-25V DC Voltage sensor, as an electronic device working as a sensor to calculate and monitor the amount of voltage in the instrument
3. DHT11 temperature sensor, as an electronic device working as a sensor that measures the temperature of its environment and converts the input data into electronic

data to monitor the temperature changes in this instrument

4. Obstacle Sensor (IR Proximity), as an electronic device working as a sensor to detect objects and obstacles in front of the sensor by continuously transmitting infrared light so it can detect obstacle by monitoring the reflected light from the object in front of it.
5. Passive buzzer module, as a replacement of a small speaker

### Generator Hardware System

The hardware for generator system were expected to function as a power generator, as a 24V to 12V step down transformer, and also as the circuit breaker when the temperature exceeds 40o C. In this research, authors were using Tokushu Denso TD3150G-24F-9K24F with 24 VDC maximum voltage, 7,5 A current, and 180 W power. When the sensor reads close to its maximum temperature, the relay will automatically set itself into the cutoff position, to prevent overheat. Authors installed a buck-boost converter, a type of DC-to-DC converter with customable voltage magnitude, into the device so it can be used as a charging station. The detailed design of this electrical generating hardware system explained in the **Figure 3**.

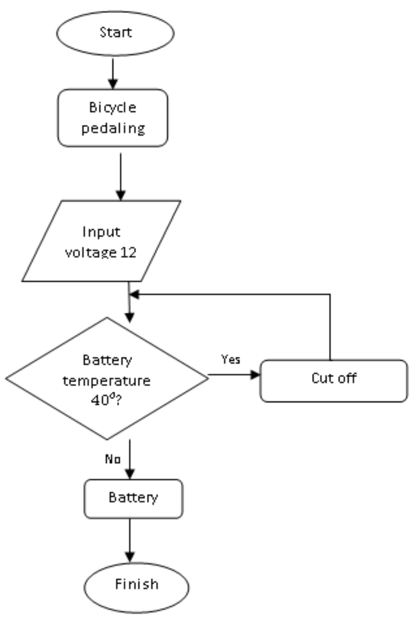


**Figure 3.** Generator flowchart

### Implementation

Authors are using a standard Li-ion battery pack RRC2024 as an energy saving device. Battery specifications are shown in the **Table 1**.

**Table 1.** Battery specification

| | |
|---|---|
| **General** | |
| Basic cell type | 18650 |
| Delivery status battery capacity | 30% |
| Operating temperature | 0°C to 45°C (charge)<br>-20°C to 60°C (discharge) |
| Storage temperature | -20°C to 60°C max.<br>-20°C to 20°C recommended |
| Compliance information | CE / UL2054 / FCC / PSE / KC / Gost / EAC / CQC / RCM / IEC 62133 / UN 38.3 / RoHS / REACH / BIS |
| **Electrical Parameters** | |
| Nominal voltage | 14.4V |
| Nominal capacity | 6600mAh |
| Initial impedance | <150mΩ @ 1kHz at 20°C |
| Max. charge current | 4620mA |
| Max. charge voltage | 16.8V |
| Cont. discharge | 10000mA |
| Peak discharge | 14000mA |
| Life expectancy @25°C 3.3A Charge/3.3A Discharge | >300 cycles with min 80% of initial capacity |
| **Battery Dimensions** | |
| Length | 167.2mm±0.5 |
| Width | 107.5mm+0.4/-0.3 |
| Thickness | 21.5mm+0.3/-0.5 |
| Weight | 590g |
| Contacts | +, C, D, T, - |
| **Safety Parameters PCM** | |
| Overcharge detection voltage | 4300mV/cell |
| Overcharge release voltage | 4100mV/cell |
| Overdischarge detection voltage | 2750mV/cell |
| Overdischarge release voltage | 3000mV/cell |
| Overcharge detection current | 5300mA |
| Overdischarge detection current | 11000mA |

The generator and MID LCD was combined into one module and secured with acrylic box (**Figure 4**), to protect the electronic component such as Arduino mega, LCD TFT, battery capacity module and buzzer module inside it.


**Figure 4.** MID Implementation


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It is shown in **Figure 5** and **Figure 6** are the module implementation on a bike. This device made protected in 2 mm acrylic box which supported with frame made by stainless steel. This electrical generator system equipped with 24V to 12V DC converter as the step-down transformer to supply power to its battery as well as the cutoff system to protect battery when its temperature reaches 40° C.

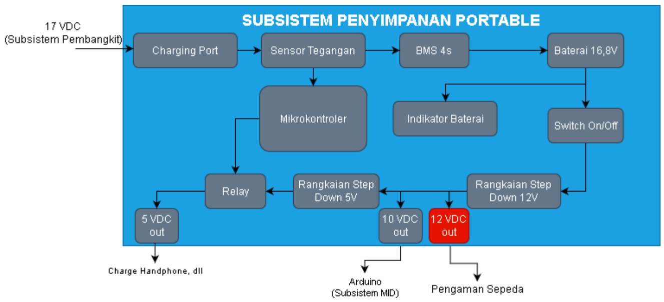


**Figure 2**. Portable saving device diagram block

**Figure 3**. Electrical generator system implementation

## Results And Discussion

Series of test would be needed on this module to observe its impulse response, durability and efficiency. At the early testing series, this monitoring system was tested using 4 main parameters which are voltage, temperature, speed, and some notifications under certain condition. The accuracy of each parameter verified by using multimeter, tachometer, and thermal infrared.

The voltage parameters were tested using a DC power supply so authors can adjust the input in a range of 0-25V. The algorithm used to run the voltage sensor read the ADC value from the installed output pin, then decrease it by 5 times the value read before converted it again using the equation below

$$V_{out} = \left(V_{read}\ x\ \frac{5}{1023}\right) x\ 5 \ldots \ldots \ldots (1)$$

Here is the syntax used to define the voltage parameter

```
Volt1=analogRead(15);
Volt=((Volt1*0.00489)*5);
```

**Table 1**. Voltage sensor reading

| Attempt | Multimeter | Voltage Sensor | Error | %error |
|---|---|---|---|---|
| 1 | 0.99 | 1.02 | 0.03 | 3.03 |
| 2 | 1.99 | 2.03 | 0.04 | 2.01 |
| 3 | 2.98 | 2.96 | 0.02 | 0.67 |
| 4 | 3.98 | 3.99 | 0.01 | 0.25 |
| 5 | 4.98 | 5.04 | 0.06 | 1.20 |
| 6 | 5.97 | 5.93 | 0.04 | 0.67 |
| 7 | 6.97 | 7.01 | 0.04 | 0.57 |
| 8 | 7.96 | 7.9 | 0.06 | 0.75 |
| 9 | 8.96 | 8.99 | 0.03 | 0.33 |
| 10 | 9.96 | 9.89 | 0.07 | 0.7 |
| 11 | 10.95 | 10.93 | 0.02 | 0.18 |
| 12 | 11.95 | 11.99 | 0.04 | 0.33 |
| 13 | 12.94 | 13.03 | 0.09 | 0.7 |
| 14 | 13.94 | 13.98 | 0.04 | 0.29 |
| 15 | 14.93 | 14.97 | 0.04 | 0.27 |
| 16 | 15.93 | 16.02 | 0.09 | 0.56 |
| 17 | 16.93 | 16.89 | 0.04 | 0.24 |
| 18 | 17.92 | 17.87 | 0.05 | 0.28 |
| 19 | 18.92 | 18.99 | 0.07 | 0.37 |
| 20 | 19.91 | 20.02 | 0.11 | 0.55 |
| 21 | 20.91 | 20.97 | 0.06 | 0.29 |
| 22 | 21.9 | 21.79 | 0.11 | 0.5 |
| 23 | 22.9 | 22.87 | 0.03 | 0.13 |
| 24 | 23.89 | 24.98 | 1.09 | 4.56 |
| 25 | 24.89 | 24.96 | 0.07 | 0.28 |
| **Average** | **12.94** | **12.5** | **0.09** | **0.79** |

From these data, the authors translate it into a **Figure 8.**

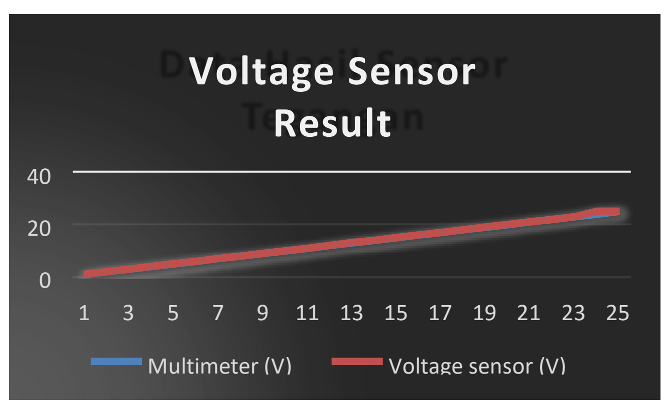


**Figure 4.** Voltage sensor reading

The voltage sensor reading as shown in Figure 7 above shows that the sensor output is linier and close to the reference value. From the 0-14 VDC voltage reads, it was found that sensor the average error value is 0.79%.

Temperature testing was carried out by increasing the temperature using solder as the external heat source for the system. The temperature range was 26-47C. When the temperature reaches the maximum limit, the relay will automatically cut off the supply power because the temperature system was getting too hot. From the measurement data, temperature sensor detection result is shown in the **Figure 9**.

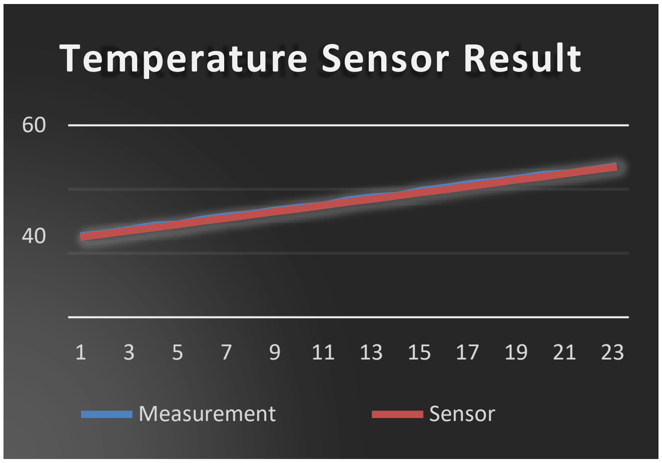


**Figure 5**. Temperature Sensor Reading

The sensor gave a linear value and apparently close to its reference value. This was shown by the temperature measurement graph that measured using the thermal infrared sensors.

In the speed parameter test, 10 speed samples were taken during the test to compare the read values with the velocity values obtained using a tachometer. The result was shown in figure below, after converted it to km/h using following equation.

$$velocity\ \frac{km}{h} = 50.8\ x\ RPM\ x\ 0.001855 \ldots\ldots\ldots (2)$$

To define the velocity parameter below syntax was used:

```
detachInterrupt(2);
time=millis()-oldtime;
rpm=(rev/time)*60000;
velocity = (50.8*rpm*0.001885)
```

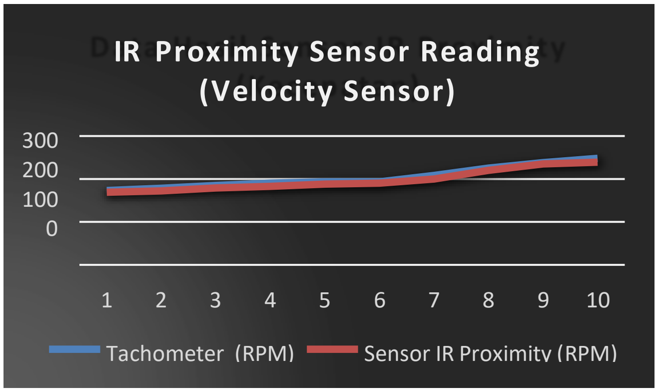


**Figure 6**. IR Proximity sensor reading

The result of the speed reading on the IR proximity sensor shows a good reading. The value generated by the sensor looks close to the reference value. This is indicated by a graph of the readings on the sensor along with the reading on the tachometer. The average error of the reading value on the IR proximity sensor is 2.77%.

In testing the generator power reading, voltage and current data are taken gradually from low speed to maximum speed. It can be seen in Figure 10 that the power generated will be greater the higher the bicycle speed.

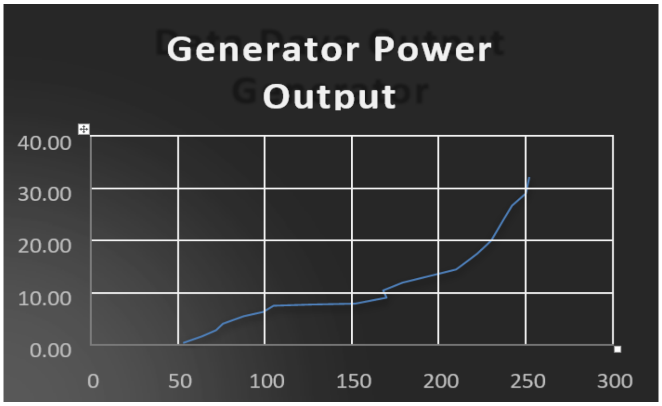


**Figure 11**. Power output from generator

## Conclusion

1. The kinetic energy that used to move the bicycle can be convert to electrical energy, and can be stored using a li-ion battery that embedded into the device.
2. From the trials, authors found that detection of the voltage sensor using the DC voltage sensor has an average error of 0.79%.
3. Detection of temperature sensors using DHT11 has an average error of 1.28%


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4. Speed detection using the IR proximity sensor has an average error of 2.77%
5. This eco pedal bicycle prototype generator produces 13 Watt average power, and can produce power up to 35 Watt. This electrical power enough to support small portable devices like cellphones and portable power bank.

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