THE DESIGN FOR WIND SPEED MEASUREMENT USING LabVIEW

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Abstract. In general, wind is every movement of air on the surface of the earth. Technically, wind is every horizontal or near horizontal movement of the air. The wind has the direction and the velocity that is defined by the air pressure difference on the surface of the earth. This device was designed to measure the velocity of the wind using the combination of Arduino Uno and the Labview Software. It worked where the movement of the wind turn the propeller that was connected to the disk. The disk had a hole that was sensed by photoelectric sensor connected to a port at Arduino Microcontroller in order to provide a pulse. This pulse was calculated by Labview program and converted into speed measurement (meter/second). The result of the measurement using this device were compared with the result of Android based application and a calibrated Anemometer to compare the accuracy of the designed device. The result showed that the accuracy of the designed device is 70-80%.

1. Introduction
Wind energy potential in a place can be known based on the speed of the wind. The instrument used to measure wind speed is known as an anemometer (Matondang, 2011). Most wind measurements use an analog instrument, therefore to record the measurement value depends on the person reading meter manually. The permanent one usually used on BMKG consists of a three-bowl system that is symmetrically mounted on the vertical axis. At the bottom of the vertical axis a generator is rotated by the three-bowl system. Voltage of the generator is proportional to the rotational speed of the propeller formed from a three-bowl system The rotation of the bowl system is used to drive the generator, therefore the rotary motion of the bowl becomes relatively obstructed, because of the rotor’s weight. This results in a greater moment of inertia of the tool system, so that the sensitivity of the tool becomes lower. To overcome the errors in reading wind gauges, a wind speed based on arduino Uno R3 with Labview was designed. The sensor that is applied to the wind speed meter is the EE-SPX406 type photomicrosensor product from OMRON, with the ATMega 328 Arduino Uno R3 microcontroller as the data processing center whose results will be displayed in Lab VIEW

2. Theory
2.1 Arduino
Arduino Uno is a microcontroller board based on the ATmega328P controller. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform
2.2. Arduino IDE
Arduino IDE is an Arduino-shaped window programming environment used to write programs. The window has six toolbars with each function on each toolbar.

![Figure 2.1. IDE Window](image1)

2.3. LABVIEW
LabVIEW (Virtual Instrumentation Engineering Workbench) is a graphical computer programming language that uses icons instead of text in creating applications. The LabVIEW program is called Virtual Instrument (VI) because several views and operations in the LabVIEW program resemble an instrument such as an oscilloscope and multimeter. Each VI uses functions that manipulate input from the User Interface or other sources and display the information or move the information to another file / computer

2.4. Speed Sensor
Rotary or speed sensor can be made with an "U" type optocoupler and a chopped wheel. This rotary or speed sensor can be used for read the rotation of an object that rotates like a vehicle wheel, the rotation of an electric motor and others. This rotation or speed sensor is made with an "U" type optocoupler which is placed in the middle of a chopping wheel. Optocoupler is an optoisolator component that has the characteristics of the receiver (photo transistor). It will experience a logic change if there is a change in the intensity of the light emitted by the transmitter (infrared LED) for the receiver. The brightness of the LED is directly proportional to the current of the diode. Because the collector current is proportional to the brightness level of the LED, it can be said that the diode current controls the collector current like a transistor in general. Usually the current which allowed to flow in the infrared is in the range of 15 to 25 milliamperes. Photo transistors are a type of transistor that is sensitive to infrared light.

![Figure 2.2. Speed sensor](image2)
3. Methodology
3.1 Design And Development
To make the design process easier, a conceptual model is needed, while the concept is made based on a block diagram. The hardware design system scenario is shown on Figure 3.1.

![Figure 3.1. Tool System Scenario](image)

3.2 Wind Speed Meter
The wind speed meter consists of a bowl propeller coupled with a sensor dish, EE-SPX406 photomicrosensor speed sensor and Arduino Uno microcontroller.

1. Wind Speed Measuring Mechanism
   a. Propeler bowl

   ![Figure 3.2. Propeler bowl](image)

   The material used for 3 bowl anemometer propellers is acrylic material with 2 mm of thickness. It aims to be lightweight and easy to move. The bowl is made of plastic material with 60 mm of bowl diameter.

   The formula for calculating the circumference of a circle is: \( K = \pi d \), with \( \pi = 3.14 \). This propeller has a diameter of 210 mm, then the circumference of the propeller trajectory is: \( K = 3.14 \times 210 = 659 \text{ mm} \).

   b. Sensor Disc
The sensor disc is made from acrylic with a thickness of 2mm to be lightweight and easy to move. This disc has a diameter of 80mm, and there is one slot on the side with a width of 5mm which is used to cut the infrared signal emitted by the sensor as a pulse input for Arduino.

![Figure 3.3. Sensor disc](image)

The frame of 3 bowls anemometer system is used to support sensor disc, sensor and propeler. This frame is made from acrylic with a thickness of 10mm to be sturdy and not easily deformed. The design of the 3-bowl anemometer frame can be seen in Figure 3.4.

![Figure 3.4. 3-bowl anemometer frame](image)

2. Software Design
This system uses LabVIEW 2013 for wind speed measurement. The following is a flow chart of the system.
When the system starts, the Arduino Uno microcontroller and the EE-SPX406 sensor are active. If there is a windflow, the propeller will rotate along with the rotation of the disc which has a slot to be read by the photoelectric sensor. When the photoelectric sensor is blocked by the disc, the sensor will be worth 1 (high) and when the photoelectric sensor is not blocked the disc, it will be 0 (low). Changes from 1 to 0 will be calculated by the counter program at LabVIEW. The number of pulses calculated on the program counter for one minute (60 seconds) will be converted to the amount of wind speed in units of meters/seconds (m/s) based on the previous formula. The display on the monitor screen will display a transition signal which is the result of sensor readings and the amount of wind speed through this wind speed instrument.

4. Results And Analysis
4.1 Arduino uno Test Results
The microcontroller is the main brain of the system. The program is inserted into the programmed chip which will later be processed into the input and output needed for the device system to run. Therefore measurement of the ports of the microcontroller is needed whether it works properly or not in generating high (5 volt) or low (0 volt) signals as the input signal and the output to be supplied.

Figure 3.2. Flowchart System

Figure 4.1. Measurement of Arduino Uno port with multimeter

The measurement results of the Arduino Uno port are included in table 4.1.
Table 4.1. Arduino Uno port measurement results

| Port | Voltage (volt) | H ( volt ) | L ( Volt ) |
|------|----------------|------------|------------|
| 0    | 4,76           | 0,0042     |
| 1    | 4,65           | 0,003      |
| 2    | 4,96           | 0,0033     |
| 3    | 5,01           | 0,0044     |
| 4    | 4,85           | 0,0046     |
| 5    | 5,02           | 0,0033     |
| 6    | 4,79           | 0,0045     |
| 7    | 5,01           | 0,003      |
| 8    | 4,65           | 0,0046     |
| 9    | 4,59           | 0,003      |
| 10   | 5,01           | 0,0046     |
| 11   | 4,92           | 0,003      |
| 12   | 4,99           | 0,0032     |
| 13   | 4,95           | 0,0046     |

From table 4.1, the results of measurements of Arduino Uno ports, concluded that the high signal produced is at an average voltage of 5V and that is in accordance with the existing theory. Similarly, the low signal is at a voltage of 0 V.

4.2 Sensor EE-SPX406 Test Results

Testing of the EE-SPX406 sensor is performed by giving a voltage between 5-24Vdc, according to the characteristics of the sensor which only requires input voltage between 5-24Vdc. Figure 4.1. shows sensor testing using a multimeter.

![Sensor EE-SPX406 Testing](image)

Figure 4.2. Sensor EE-SPX406 Testing

Then, table 4.2. shows sensor EE-SP406 Testing Results.

Table 4.2. EE-SP406 Test Results

| NO | INPUT Voltage (Volt) | OUTPUT Voltage (Volt) |
|----|----------------------|-----------------------|
| 1  | 5                    | 4.96                  |
From the test results of the EE-SPX 406 sensor in table 4.2 it can be concluded that the sensor output voltage corresponds to the sensor input voltage.

4.3 How The System Works
Once the system runs, the Arduino Uno and the EE-SPX406 are active. If there is a wind flow, the propeller will rotate along with the disc which has a slot. The rotation read by the photoelectric sensor. When the photoelectric sensor is blocked by the disc, it will be 1 (high) and when the photoelectric sensor is not blocked, it will be 0 (low). The transition from 1 to 0 will be calculated by the counter program at Labview. The number of pulses calculated on the program counter for one minute (60 seconds) will be converted to the amount of wind speed in units of m/s. the monitor screen will display the transition signal from the sensor reading and the amount of wind speed through this wind speed instrument.

Testing of wind speed gauges is performed in two ways. First, by indoor test using the wind from a fan, and the second is out door test.

This aims to obtain valid data for analysis. Simple calculation of wind speed as measured by a three cups anemometer. This three-bowl system rotates to form a circular path.

The length of the circumference of the arrangement of the bowls is 3 m, and the arrangement at a time of spin produces 20 rotation in 10 seconds, then the wind speed can be calculated.

\[ \text{Wind Speed} = \frac{\text{Rotation amount} \times \text{circumference}}{\text{Time Interval}} \]  

(1)

the wind speed can be calculated with eq (1). if the three bowls system rotates the circumference is 659 mm or 0.659 m.

From the equation, the wind speed is shown in table 4.2.

| Number of rotation/pulse | Length of circumference (m) | Time (s) | Speed (m/s) |
|--------------------------|-----------------------------|----------|-------------|
| 1                        | 0.659                       | 60       | 0.010933    |
| 2                        | 0.659                       | 60       | 0.02167     |
| 3                        | 0.659                       | 60       | 0.0325      |
| 5                        | 0.659                       | 60       | 0.054667    |
| 6                        | 0.659                       | 60       | 0.0659      |
| 7                        | 0.659                       | 60       | 0.076333    |
| 8                        | 0.659                       | 60       | 0.087667    |
The flow chart of the 3-bowl system in LabVIEW can be seen in Figure 4.3.

![Figure 4.3. The 3 bowls measurement flow chart on LabVIEW](image)

The output graph of the 3-bowl system measurement in LabVIEW can be seen in the Figure 4.4.

![Figure 4.4. The output of the measurement on LabVIEW](image)

The graph above shows when the sensor is blocked by the disc then it is in high (5V) condition, otherwise, the disc it is in low (0V) condition.

### 4.4 Testing with a Wind Source from a Fan

Testing wind speed measuring devices using a multi-speed fan source. Speed 1 is the lowest speed, speed 3 is the highest speed. This test is carried out to determine the function of the tool before testing in an open space. The following are the test results using the fan.
Figure 4.4 Measurement Results in the LabVIEW Front Panel

The picture above shows the number of rotations = 118 rotations in 60 seconds. From the results of the test, the wind speed can be calculated as follows:

\[
\text{Wind Speed} = \frac{\text{Rotation amount} \times \text{circumference}}{\text{Time Interval}}
\]

\[
\text{Wind speed} = \frac{(166 \times 0.659)}{60} = 1.82 \text{ m/s}
\]

Description:
Number of rotation = 166
Circumference of 3 bowl system = 0.659 mm
Time = 60 (seconds)

The form a waveform chart in the LabVIEW Front Panel can be seen in Figure 4.5.

Figure 4.5. Waveform with wind source from a fan

4.5 Test with Direct Wind Sources at Open Air

The test was conducted in Pasir Cikupa, Tangerang.

The measurement results obtained the number of rotation 206 in 60 seconds. Then the wind speed is:

\[
\text{Wind speed} = \frac{(206 \times 0.659)}{60} = 2.26 \text{ m/s}
\]

Description:
Number of rotation = 206
Circumference of the system = 0.659 m
Time = 60 seconds
Figure 4.6 Two Fan Measurement Results in the LabVIEW Front Panel

Figure 4.7 The waveform chart on LabVIEW use two fan

4.6 Benchmarking The System With Dwyer 471B-1

The objective of the test is to determine the percentage of equipment errors with the DWYER 471B-1 anemometer as a reference. DWYER 471B-1 Anemometer is a wind speed instrument that has been calibrated to the standards and the calibrator, PT Delta Instrumentation, has been proven by International Standards with certificate No: S 15001516.

Table 4.3. Calculation of error percentage of the tool compare to Dwyer 471B

| No | The system’s result (m/s) | Anemometer DWYER 471B-1’s result (m/s) | Error percentage (%) | Accuracy percentage (%) |
|----|--------------------------|---------------------------------------|----------------------|------------------------|
| 1  | 1.49                     | 1.96                                  | 31.54                | 68.46                  |
| 2  | 1.34                     | 1.7                                   | 26.86                | 73.14                  |
| 3  | 1.52                     | 2                                     | 31.57                | 68.43                  |
| 4  | 1.27                     | 1.69                                  | 33.07                | 66.93                  |
| 5  | 1.1                      | 1.4                                   | 27.27                | 72.73                  |
| 6  | 1.7                      | 2.16                                  | 27.05                | 72.95                  |
| 7  | 2                        | 2.53                                  | 26.5                 | 73.5                   |
| 8  | 2.36                     | 3                                     | 27.11                | 72.89                  |
| 9  | 1.63                     | 2.1                                   | 28.83                | 71.17                  |
| 10 | 1.74                     | 2.31                                  | 32.75                | 67.25                  |

Total \( \bar{e} = 29.2 \)  
\( A = 70.75 \)
The process of testing wind speed instruments with direct wind sources from open air has been performed at the same place. Sampling of the measurement was acquired for 10 times. The result can be seen on Table 4.3. The table shows the mean error percentage ($e$) and the average percentage accuracy ($A$). The result showed that the mean error percentage $e = 29.25\%$ and the average of accuracy $A = 70.75\%$. The accuracy value means that the wind speed measuring instrument has a high accuracy. This is because the device is not affected by the source of the wind. Wherever the source of the wind direction moves the wind speed meter can still work properly.

5. Conclusion

Based on the data obtained and the analysis, it can be concluded that
1. The wind speed measuring instrument can detect wind speed with an accuracy of 70.25% when compared with the results of wind speed data from the DWYER 471B-1 anemometer.
2. Propellers formed from plastic material with a diameter of 60mm. The sensor disc is used from acrylic material with a thickness of 2mm and an 80mm disc diameter. The speed sensor of the U type optocoupler (EE-SPX406).
3. The measurement of the wind speed was performed in an open space where the source of the wind direction can be from anywhere

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