

## Design of Real Time Anemometer Based on Wind Speed-Direction and Temperature

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### ABSTRACT

Data acquisition of wind speed, wind direction and environmental temperature are needed to get the data potential of wind power. The aim of this research is to generate a device of wind speed, wind direction and temperature with the real time condition. With this device, we will obtain an analysis about the potential of wind power electrical generation around the Puger beach, Jember, Indonesia. In this study, parameters investigated were made into three types of measurement variables that measure of wind speed, wind direction, temperature and a data to show real time data. The device which is used to measure wind speed using hall effect sensor as a transducer. With using of the active magnet that spins will be created pwm that will be read by sensor to get the wind speed. As for the shows wind direction, we use a compass sensor CMPS 03 is a digital sensor that outputs in the form of digital bits so that be able to show wind direction from 0° to 360°. The magnitude of angle will be used in analyzing the direction of the wind, the real time clock (RTC) will be used to directly to determine the time and date of recording data. Then the temperature DS1621 sensor to show environmental temperature.

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## 1. INTRODUCTION

Development of green energy is the best key for solving environmental problems. The applications of wind force are the most skillful technologies today, which have been as important direction of green energy in highly developed country. Until now the technical development of wind force already achieves the skillful technique of application, and China becomes another leader in this field [1].

Pakistan country is blessed with enormous renewable energy potential but has not been harnessed so far. Wind energy is one of the most suitable and attractive option at present due to sustainability, having low environmental damage and reasonable costs. The data recorded at Hawksbay site shows that the yearly average wind speed is nearly 6m/s at 80m and 60m heights. The estimated energy generated by Nordex N82/1500 wind turbine is 5.41GWh with at 80m height and 4.92GWh at 60m height [2].

In new energy development, wind power has boomed. It is due to the proliferation of wind parks and their operation in supplying the national electric grid with low cost and clean resources. Hence, there is an increased need to establish a proactive maintenance for wind turbine machines based on remote control and monitoring. That is necessary with a real-time wireless connection in offshore or inaccessible locations while the wired method has many flaws [3].

In the development of the technology to search of sources of wind energy, it would require a data obtained from an anemometer. Anemometer is a device used to measure the wind speed that is widely used in

the fields of metrology and Geophysics or station weather forecasts. The wind speed was measured by the cup anemometer has three wind catcher cup and rotates in the direction of the wind catcher. The effect of the rotor's geometry on the cup anemometer transfer function has been investigated experimentally and analytically. The analysis of the anemometer's output signal as a way of monitoring the anemometer status is revealed as a promising procedure for detecting anomalies [4]. The anemometer very helpful in thorough research about the movement of wind. Therefore, the development of anemometer is very important in knowing wind potential which is exist in certain areas.

A system focused on three weather variables measurement, are temperature, wind speed, and wind direction. The instrument is a type of data acquisition system which is deal with the design and implementation of data acquisition system based on personal computer (Pentium) using Industry Standard Architecture (ISA) bus [5]. Wind power electric generation is the renewable electric energy utilizing wind as a driving force. Therefore we need to conduct a research on the wind potential and wind direction in order to know the exact wind farm to build wind power.

Therefore, the researchers want to know more focus of the existing wind potential in the coastal areas. In the reference [6] the device created just based on wind speed and direction. And furthermore we equip with a device of time to indicate the time and date when the data recording experiments. So with the help of a Hall Effect sensor, a compass sensor and a RTC device, we can measure the wind speed, wind direction and time eventually expected will be helpful in the research process [7].

Furthermore in this paper we add a temperature sensor which is required in determining air density so that the device can be more complete made in analyzing the wind power potential. The sensor used is a sensor that does not require an encoder with many holes, but only uses active magnet which has side of north and south. With the changes in the magnetic motion through hall effect sensor, then the sensor will send a pulse that will be converted into speed. While the compass sensor is used to determine wind direction and the RTC is used to determine the real time of the actual data recording. In addition we add a temperature sensor to determine the temperature conditions directly in accordance with conditions of weather when wind speed data obtained.

All the data of wind speed, wind direction, temperature, real time and date will be stored in a micro SD memory combined with data storage module. The data stored aims to find out all the speed and wind direction when the tool is not used in a long period of time, then will store the data again when the next addition. By using arduino uno control system so that more compact design can be created for these tools. Moreover, we use LCD that can display data of wind speed and direction while at the sites.

## 2. RESEARCH METHOD

### 2.1. Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328 with 14 pins which have digital inputs/outputs. Among them is 6 PWM output pins, 6 analog inputs, a crystal oscillator of 16 MHz. Arduino UNO contains all needed to support the microcontroller, easy to connect it to a computer with a USB cable or supply it by an AC to DC adapter. ATmega328 has 32 KB to 0.5 KB used for the bootloader. ATmega328 also has 2 KB of SRAM and 1 KB EEPROM. Figure 1 shows an Arduino UNO [8]:



Figure 1. Arduino UNO

With the help of this arduino all the data will be processed and controlled to obtain data of wind speed, wind direction and real time in accordance with a state of the research that has been determined. Pins

are used to obtain performance sensors are pin A4 and A5 are used for compass sensor. Pin 2 is used for hall effect sensor.

## 2.2. Hall Effect Sensor

Hall effect sensors are used to detect magnetic fields and position and displacement of objects. The effect is based on the interaction between moving electric carriers and an external magnetic field. In metals, these carriers are electrons. When an electron moves through a magnetic field, a sideways force acts upon it [9]. This sensor is designed to detect magnetic objects with position changes. The change over in the magnetic field that continuously causes the pulse frequency can be determined. This type of sensor is used to measure speed. Hall effect sensor can also be used to detect the proximity, the presence of magnetic objects using a critical distance. Figure 2 shows hall effect sensor which is placed near a magnetic field.



Figure 2. Position of Hall Effect Sensor

Hall effect sensors will be used to provide pulse is converted to be frequency in order to detect the speed corresponding to the real state of the rotating object. By giving count pulse then there will be a change to the speed frequency.

## 2.3. Kompas CMPS03 Sensor

CMPS03 compass sensor is a sensor that can determine the angle position. This sensor is designed specifically for the field of robotics with the aim as a navigator that is used for the movement of the robot [10]. This sensor is produced by Devantech uses two magnetic field sensors artificial KMZ51 Philips which sensitive enough to detect the Earth's magnetic field, where the installation of two sensor intersecting. In the compass module has been installed a series of state of the signal and the microcontroller, so that the data can be accessed easily. CMPS03 requires a working voltage of 5 volts with a current consumption of 15 mA. There are two ways to access generated data of these sensors by using a PWM signal or using the I2C protocol. The following Figure 3 is a compass CMPS03 uses I2C communication and Figure 4 is CMPS03 sensor mounted on the tail flipper of anemometer.

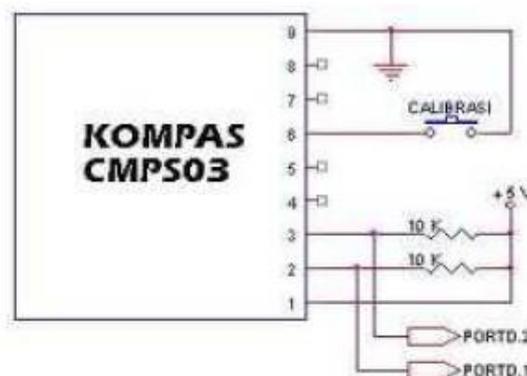


Figure 3. CMPS03 Sensor



Figure 4. CMPS03 sensor mounted on the tail flipper of anemometer

PWM signal by 16-bit timer of the processor on the compass module that produces a resolution of 1  $\mu$ s. So it is recommended by the manufacturer for detecting the PWM signal with the timer which the resolution is lower than that produced by the compass. To pin I2C, SDA and SCL connected to the supply 5 VDC through pull up resistor, because the SDA and SCL does not have the pull up. I2C communication protocol is the same as that used in Serial EEPROM production of Atmel 24CXX and Serial of RTC (Real Time Clock) production of Dallas Semiconductor RTC1307, so the SDA and SCL lines can be used simultaneously. The reading of this compass sensor connected with arduino microcontroller.

#### 2.4. Temperature DS1621 Sensor

The DS1621 Digital Thermometer and Thermostat provides 9-bit temperature readings, which indicate the temperature of the device. The thermal alarm output, TOUT is active when the temperature of the device exceeds a user-defined temperature TH. The output remains active until the temperature drops below user defined temperature TL, allowing for any hysteresis necessary. User-defined temperature settings are stored in nonvolatile memory so parts may be programmed prior to insertion in a system. Temperature settings and temperature readings are all communicated from the DS1621 over a simple 2-wire serial interface. Figure 5 shows the DS1621 thermometer sensor.

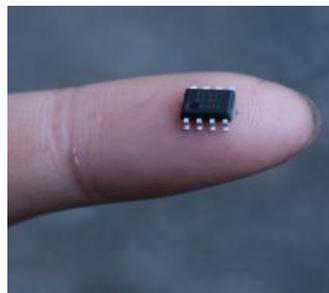


Figure 5. DS1621 Temperature Sensor

#### 2.5. Liquid Crystal Display

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD. Click to learn more about internal structure of a LCD. Figure 6 shows the LCD.



Figure 6. LCD

## 2.6. Real Time Clock And Data Logger

RTC is used to indicate the data based on the time and date actually and follow when the data is retrieved. The data obtained are wind speed and direction will be recorded on a data logger and stored on the memory card. From experiments in a full day of data collection obtained large data storage capacity is used about 250 kB. Figure 7 shows a Figure of series RTC and RTC components are mounted on the anemometer. While Figure 8 is komponen data logger that serves as a data recording.

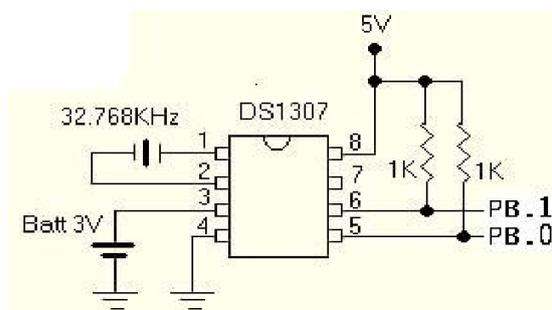


Figure 7. Figure of RTC series

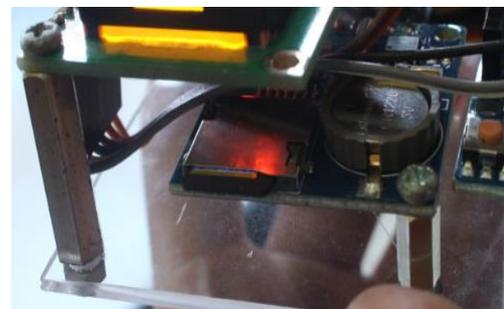


Figure 8. Data Logger

The research was conducted by making listing program on arduino software using the C ++ language. The program that created is started by the wind speed program, compass program CMPS03 and RTC program. The program that was created is loaded in the ATmega328 microcontroller. Sensors mounted on the mechanical design of the anemometer. Speed sensors placed on the propeller system of the cup anemometer that can read the magnetic field pulse that has been attached to the propeller. With different mounting point between the speed sensor and its compass, sensor will allow for stability without any wind disturbance caused by crash with wind catcher cup. Anemometer design that is designed as in Figure 9 and trial anemometer with real time data retrieval is done as in Figure 10. Tables and Figures are presented center, as shown below and cited in the manuscript.

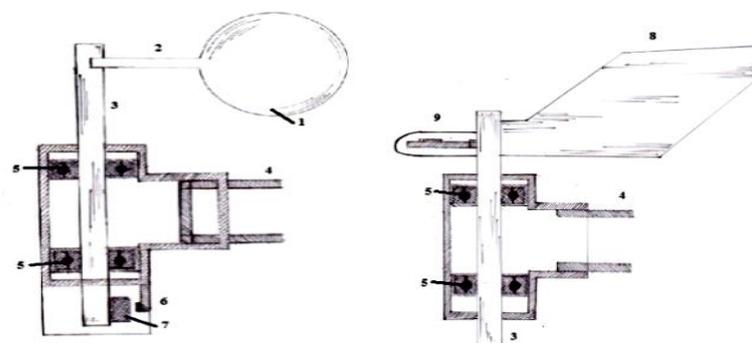


Figure 9. Design of Anemometer



Figure 10. Anemometer Experiment

From Figure 10 can be explained that the wind catcher cup design with 10 x 7 cm for height and width. As for the wind direction flipper with a size of 10 x 15 cm for height and width. While the sensor is placed in the number position of 6 and 4. Number 6 is mounted hall effect sensor to measure wind speed. While number 4 for compass sensor CMPS03.

### 3. RESULTS AND ANALYSIS

The data shown in Table 1 is the data calibration is done on the beach Puger Jember district with the highest per cent error in wind speed 1.26 m/s at 3.08%. Error lowest percent at 0.23% speed 8.78 m/s. The data does not have that much different from the distance measuring instrument as a comparison to conventional measurement tools worth using.

Table 1. Calibration of anemometer

Anemometer with Arduino Uno	The Conventional Anemometer	Error %
1.26	1.3	3.08
2.51	2.5	0.40
3.77	3.8	0.79
5.02	5	0.40
6.28	6.3	0.32
7.54	7.5	0.53
8.78	8.8	0.23
10.05	10	0.50

The experiments were carried out on the beach Puger in one day started at 21:24:17 to 21:24:31. Data obtained from the test results as shown in Table 2:

Table 2. Experiment of anemometer based on real time of wind speed and directions

Time	Date	Speed (m/s)	Direction (degree)
21:24:17	27/06/2015	1.26	320
21:24:19	27/06/2015	1.26	329
21:24:21	27/06/2015	1.26	326
21:24:23	27/06/2015	1.26	326
21:24:25	27/06/2015	1.26	326
21:24:31	27/06/2015	1.26	325

Equation of calculation results from the rotation speed of the rotor magnet into units of m/s are:

$$v = (\pi \times 2 \times r_{rotor} \times rpm) / 3600$$

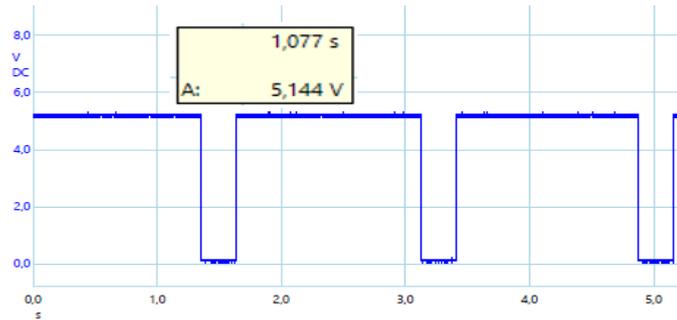


Figure 10. Voltage of Sensor Hall Output

Speeds Equation above is used to determine the results of the data speed actually. From the experimental results obtained in Table 2 wind speeds found in column 3 of 1.26 m/s. At this speed indicated on sensor Hall voltage value of 5.14 V as in Figure 10. Device of anemometer made this already follows the real-time data with the data condition wind speed, wind direction, temperature, time and date data retrieval. For data obtained from the trial on September 16, 2015 is shown by the following Table 3.

The first coloumn in Table 3 shows us the data of the real time, the second coloumn shows us the real date-time; meanwhile, the third coloumn refers to the speed of the wind and the fourth coloumn shows us the direction of the wind.  $0^\circ$  indicates the North,  $90^\circ$  indicates the East,  $180^\circ$  the South and  $270^\circ$  the West. For example: on September 16th at 13 (1 pm), the speed of the wind is 6.28 m/s, it headed SouthEast and the temperature is  $25^\circ\text{C}$ .

Table 3. Trial Data of Wind Speed and Direction At September 16 th, 2015

Time	Date	Speed (m/s)	Direction (degree)	Temperature ( $^\circ\text{C}$ )
0:00	16/09/2015	1.26	94	30
1:00	16/09/2015	0.00	84	21
2:00	16/09/2015	0.00	90	20
3:00	16/09/2015	0.00	92	19
4:00	16/09/2015	0.00	89	19
5:00	16/09/2015	0.00	89	19
6:00	16/09/2015	0.00	80	19
7:00	16/09/2015	0.00	76	25
8:00	16/09/2015	0.00	110	24
9:00	16/09/2015	2.51	130	24
10:00	16/09/2015	3.77	122	23
11:00	16/09/2015	5.02	139	24
12:00	16/09/2015	5.02	139	25
13:00	16/09/2015	6.28	140	25
14:00	16/09/2015	6.28	138	26
15:00	16/09/2015	6.28	138	27
16:00	16/09/2015	6.28	141	25
17:00	16/09/2015	5.02	144	24
18:00	16/09/2015	3.77	143	24
19:00	16/09/2015	0.00	122	23
20:00	16/09/2015	0.00	104	22
21:00	16/09/2015	0.00	106	22
22:00	16/09/2015	0.00	100	22
23:00	16/09/2015	0.00	100	22

#### 4. CONCLUSION

From the results of tests performed it was concluded that the speed sensor in the form of an electronic circuit that consists of a hall effect sensor generates a frequency that is proportional to the speed of the wind catcher cup mechanical and wind speed measurements an average of 5.023 m/s at 09:00 to 18:00 and the average angle of  $112.92^\circ$  with the average environmental temperature of  $23.1^\circ\text{C}$  were carried out around the Puger beach, Jember, Indonesia.

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