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## Online air velocity control, temperature and humidity monitoring system for clean room using Raspberry Pi

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# Online air velocity control, temperature and humidity monitoring system for clean room using Raspberry Pi

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**Abstract.** The requirement of a clean room in the pharmaceutical industry is to maintain the airflow between 0.36-0.54 m/sec and record the temperature and humidity parameters. The laminar airflow machine is used to maintain the air velocity. The air velocity settings in laminar airflow machine are usually done manually by adjusting the speed control knob. In this study, we have designed a prototype of automatic air velocity control, temperature, and humidity monitoring system using Arduino nano and Raspberry Pi. The airflow control is done by the PID method. From the test results, the prototype has worked as expected. The accuracy of the measurement is  $\pm 5\%$  for air velocity,  $\pm 2\text{ }^\circ\text{C}$  for temperature and  $\pm 5\%$  for moisture. The system can control the air velocity between 0.36 m/s to 0.54 m/s. The measured parameters then send to the server and utilized for online monitoring the air velocity, temperature, and humidity in the clean room.

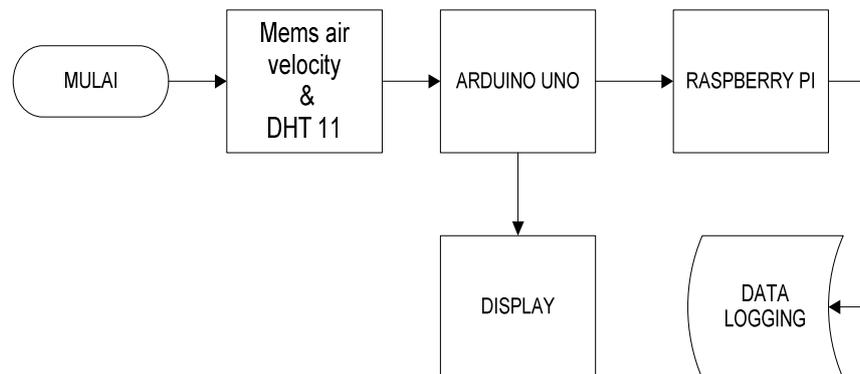
## 1. Introduction

The requirement for a clean room on a laminar air flow machine in the pharmaceutical industry which is regulated in the operational manual applies the guidelines for how to make a good drug [1], which maintains air velocity between 0.36-0.54 m/s and records temperature and humidity [2]. The laminar air flow machine is a machine that produces a laminar air flow direction because it consists of a blower motor that blows air regulated by speed control through several filters [3]. In the process of setting the speed set manually by rotating the potentiometer on speed control, this is done when the engine installation is first and every six months an operational check is carried out on the amount of airspace to ensure the airspeed is in accordance with the conditions. In these conditions, records are also carried out to monitor the results of airspeed, temperature and humidity manually into the operational qualification form as one of the controlled written reports to the drug and food regulatory agency [4]. Airspeed, temperature and humidity are not monitored so one to find out these results is to use an airspeed, temperature and humidity monitoring system through a web server so that it can be monitored online [5]. Still the manual controls on the laminar air flow engine in the airspeed setting that is required to encourage recording of airspeed data online.

## 2. Research methods

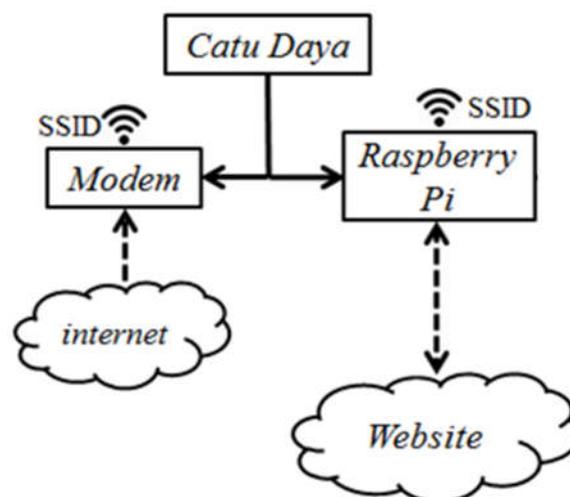
The process flow diagram is intended to describe the operational processes of the system that will later be made, and so that if later there are problems it can help to solve the problem. figure 1. Process flowcharts can be seen.





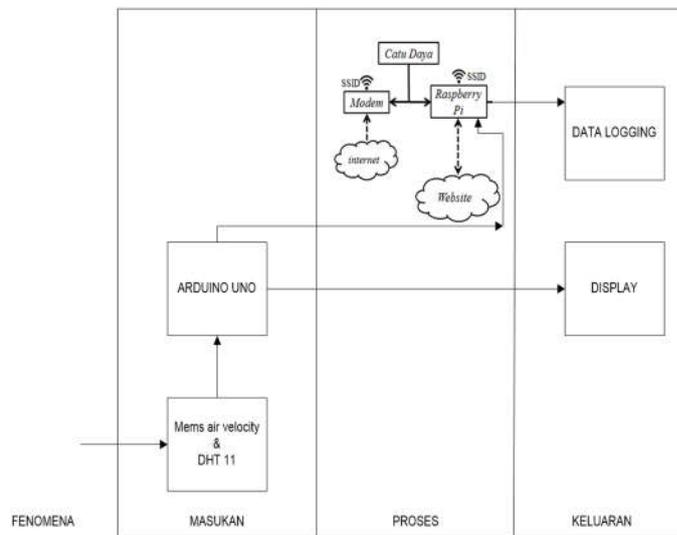
**Figure 1.** Process flow chart.

Data sender block diagram to website contains the power supply, raspberry pi, and modem. The working principle is all data from Arduino is sent from Raspberry Pi which contains the results of airspeed, temperature and humidity to be sent to the website that is connected to the modem WiFi SSID as shown in figure 2.



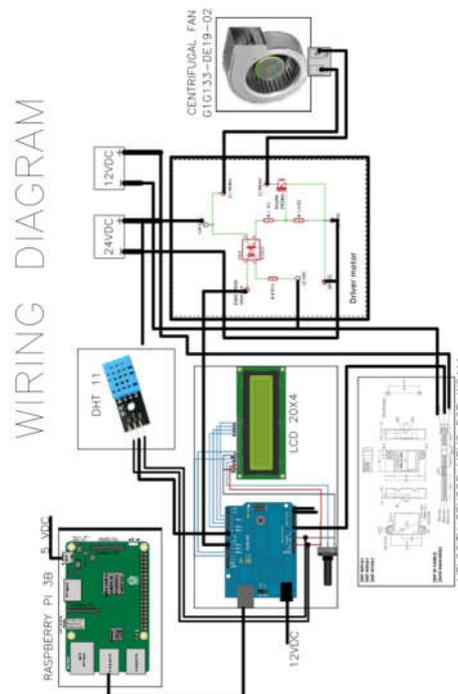
**Figure 2.** Block diagram receiving response from website.

The overall diagram contains block phenomena, input blocks, process blocks and output blocks. Block phenomenon contains the phenomenon of temperature, humidity, and air velocity which will later be captured or felt by the sensor. The input block contains the airspeed mems air sensor, DHT11, Arduino Uno, the principle works is airspeed as an input phenomenon, which will be captured by the sensor mems air velocity into an analog signal and converted into digital data by Arduino to be sent via serial USB connection. The process block contains the website and raspberry pi, the principle works is when data is sent to the website, then the website will manage the data to become information. The output block contains a blower motor which is controlled by a motor drive that uses a PWM system, and a display, the working principle is as an output. For logging data on temperature, humidity and velocity regulated by raspberries. Blower motor serves as an airspeed control system if the air is less or more than 0.36 - 0.54 m / sec which is regulated by Arduino. While the display serves to display information on temperature, humidity, and airspeed or from the website. Figure 3 system block diagram can be seen below.



**Figure 3.** Block diagram of the overall system.

Hardware designing is to combine hardware design for sensor data senders to websites and hardware design for recipients of responses from websites, for the overall design of this system can be seen in figure 4 below.



**Figure 4.** Hard system design.

Website design is intended to receive data from the DHT1 sensor and mems the air velocity through Arduino sent to Raspberry Pi via USB serial communication and displayed on the website.

The design of the Arduino Uno Program is intended to receive data from the DHT 11 sensor, mems air velocity, and the PID control system via Arduino Uno using the Arduino IDE program.

The design of the Raspberry Pi program is intended after getting a trigger from the website to enable the Raspberry Pi GPIO pin to be used. In this case what is connected to the Raspberry Pi GPIO pin is the servo motor on the GPIO 7 pin and the buzzer on the GPIO 0 pin. Raspberry Pi GPIO pins are by default programmed using Python language, where the Python language runs on an operating system (OS) installed on raspberry pi, for this final project I use Debian Linux OS. Before programming on raspberry pi, it is necessary to update and upgrade the system, and install the Python library for GPIO pins first through the raspberry pi command terminal on the Debian Linux OS, so that when the program starts it does not experience problems.

Database design is intended to receive data from the DHT sensor 11 and mems air velocity through Arduino that is sent to Raspberry Pi via USB serial communication and stored in the database via XAMPP. The overall design of this system is made in the form of a prototype as a system modeling, the shape of the current prototype seen in figure 5.



**Figure 5.** Tool prototype.

### 3. Results and discussion

Testing and analysis of the tool aim to test and determine the extent of the performance of the design results discussed in Chapter III and determine the level of success of each specification that has been submitted. Tests carried out include part testing and the whole system.

#### 3.1. Airspeed detection verification Results with a calibrated tool.

This test is conducted to find the value of the air velocity captured by mems air velocity based on the datasheet (14) that will be compared against the velocity of the calibrated instrument:

a) Airspeed verification in PWM settings 0.

This test is carried out 10 times the result of the mean air velocity of the tool 0.21 m / sec, while the average value of the instrument air velocity is 0.114 m / sec, so the average accuracy is 0.84%.

b) Airspeed verification in PWM settings 11.

This test is carried out 10x the result of the mean air velocity of the instrument is 0.413 m / sec, while the average value of the instrument air velocity calibrated is 0.463 m / sec, so the average accuracy is -0.108%.

c) Airspeed verification on PWM settings 64.

This test is carried out 10 times the result of the tool air velocity average value of 0.46 m / sec, while the average value of the calibrated instrument air velocity is 0.544 m / sec, so the average accuracy is -0.15%.

## d) Airspeed verification at PWM settings 127.

This test is carried out 10 times the result of the mean air velocity of the tool 0.483 m / sec, while the average value of the calibrated instrument air velocity is 0.635 m / sec, so the average accuracy is -0.24%.

## e) Airspeed verification at PWM settings 191.

This test is carried out 10 times the result of the mean air velocity of the tool is 0.513 m / sec, while the average value of the instrument air velocity is calibrated 0.681 m / sec, so the average accuracy is -0.25%.

## f) Airspeed verification on PWM settings 255.

This test is carried out 10x the result of the mean air velocity of the tool is 0.622 m / sec, while the average value of the instrument air velocity is calibrated 0.737 m / sec, so the average accuracy is -0.25%.

## 3.2. Motor RPM results use a calibrated tool

## a) PWM motor RPM results 64 settings.

This test is carried out 10x standard 500 meter RPM, while the average value of Rpm meter instrument is calibrated 556.8, so the average accuracy is = 0.1%.

## b) PWM Motor RPM Results Settings 127.

This test is carried out 10x standard 1000 meter RPM, while the average value of Rpm meter instrument is calibrated 1258.2, so the average accuracy is = 0.205%.

## c) PWM Motor RPM Results Settings 191

This test is carried out 10x standard 1500 meter RPM, while the average value of Rpm meter instrument is calibrated at 1480.5, so the average accuracy is = -0.013%.

## d) PWM Motor RPM Results Settings 255

This test is carried out 10x standard 2000 meter RPM, while the average value of Rpm meter instrument is calibrated 2140.7, so the average accuracy = -0.066%.

Airflow testing was carried out 10 times to test the airflow of a prototype laminar air flow machine. Table 1. shows the results of testing airflow. The procedures in this test are as follows:

1. Turn on the Engine Prototype.
2. Prepare a smoke test.
3. Place the smoke test inside the engine chamber
4. See the results whether laminar air flow or turbulence

**Table 1.** Airflow test results.

No	Result
1	Laminar
2	Laminar
3	Laminar
4	Laminar
5	Laminar
6	Laminar
7	Laminar
8	Laminar
9	Laminar
10	Laminar

Test results for the temperature of the DHT 11 Sensor with a Calibrated Tool. Tests that have been done on the results of the average value of DHT 11 temperature are 29 ° C, while the average value of the instrument is calibrated 29.6 ° C, so the average accuracy = -0.020%.

Test Results for DHT 11 Sensor rH with a Calibrated Tool. Tests that have been done result in the average value of DHT 11 rH is 47%, while the average value of the instrument is calibrated 44.7%, so the average accuracy = 0.051%.

#### 4. Conclusion

Based on the design, implementation and testing, conclusions can be drawn as follows: This tool works to provide information on temperature, RH, and airspeed that can be displayed via the web. This tool produces Laminar Airflow. Average airspeed accuracy = 0.84% in PWM setting 0 Average airspeed accuracy = -0.108%, average airspeed accuracy = -0.15% in PWM setting 25. Average air speed accuracy = -0.24% in PWM setting 50. Average accuracy of DHT temperature 11 = -0.020% and Average accuracy - rH = 0.051%.

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