Volume 2, No. 9 September 2023 - (904-916)
p-ISSN 2980-4868 | e-ISSN 2980-4841
https://ajesh.ph/index.php/gp

DESIGN OF SPIROMETRY FOR MEASURE AND MONITOR ELECTRIC SMOKERS LUNG VOLUME BASED ON INTERNET OF THINGS

[1*]Nizhom Rofid Robbani, [2]Ahmad Taqwa, [3]Suroso
[1,2,3] Department of Electrical Engineering, D4 Telecommunication Engineering Study Program, Politeknik Negeri Sriwijaya
Email : osorus11@gmail.com, taqwa@polsri.ac.id, 061940351952@student.polsri.ac.id

ABSTRACT:
Health is the primary necessity in human life. Without health, human cannot carry out their daily activities. Some people have unhealthy lifestyles, such as smoking habits, both conventional cigarettes and e-cigarettes. Smoking can cause dyspnea resulting in shortness of breath and decreased lung function. As the main organ in breathing, a spirometry test can be done to test whether lung function is normal or abnormal. Spirometry tools can measure forced vital capacity (FVC) and First Expiratory Volume (FEV1). In general, spirometry tools used are analog and have not integrated with the Internet of Things and can only be done in certain hospitals. This spirometry tool is designed with a flowmeter sensor YF-S201 that can measure a volume or fluid flow and the microcontroller NodeMCU ESP8266 to carry out microcontroller functions and connect devices to the internet network. The volume value will be calculated and sent to the smartphone through Blynk Application for monitoring and assessing the percentage of lung volume ratio. Percentage above 80% is normal, 80% - 60% is mild damage, 60% - 40% is moderate damage, and below 40% is severe damage. With this research, it is hoped that it can be a solution to help a doctor diagnose and monitor patient health.

Keywords: Spirometry**,** e-cigarettes **,**YF-S201**,** NodeMCU ESP8266**,** Blynk, IoT

INTRODUCTION

Health is an essential need in human life; without health, humans cannot carry out daily activities optimally. One of the organs that play an essential role in the health of the human body is the lungs (Woods et al., 2020). The lungs are organs in the human body that play a role in the respiratory process (Ionescu & Ionescu, 2013). If the lungs are disturbed, it will cause various dangerous diseases. The World Health Organization (WHO) states that by 2030 noncommunicable diseases such as cancer, heart disease, diabetes mellitus (DM), and Chronic Obstructive Pulmonary Disease (COPD) will experience a significant increase. Noncommunicable diseases result from unhealthy living habits and are common in people's lives. One of these bad habits is smoking (Boutayeb & Boutayeb, 2005).

A cigarette is a cylinder of paper measuring between 70 to 120 mm long with a diameter of about 10 mm containing chopped tobacco leaves. Along with the times, cigarettes have developed from tobacco to electronic cigarettes consumed with special liquids and special devices (Vanapalli et al., 2023). Smoking can cause dyspnea which causes shortness of breath to run lung function because cigarettes contain various harmful chemicals (Cheraghi & Salvi, 2009). Smoking is one of the highest causes of death from noncommunicable diseases. 7.2 million people die each year, making cigarettes the world's most preventable cause of death (Lopez & Mathers, 2006).

As the main organ in the respiratory process, a test to measure lung volume is a spirometry test. A spirometry test is a lung function test used to measure the volume of air that can be inhaled and exhaled for some time so that the condition of a person's lung function can be known, whether normal or abnormal (Sim et al., 2017). Forced Vital Capacity (FVC) and First Second Forced Expiratory Volume (FEV1) are indicators to see the lungs' condition. FVC indicates the amount of air a person can expire quickly and forcefully after full inspiration (Pierce, 2005). FEV1 indicates the amount of air a person can express in the first second of the FVC test. The ratio between FVC and FEV1 indicates the size of a person's lung volume. Sometimes, the *spirometry test* medical examination can only do in certain hospitals (Gayathri & Satapathy, 2020).

As in a study entitled, Design and Build a Lung Fitness Detection Device for TNI Personnel (Spirometer) Based on Arduino Uno, which uses Python programs to measure results (Saabith et al., 2019). Then there is also a study entitled Design and Build a Lung Force Vital Capacity Measuring Instrument with Arduino-Based Pressure Sensor and Labview, which uses the Webview application to read measurement results. In the research of Lung Volume Measurement Based on Arduino Microcontroller by Utilizing MPX5700DP Sensor which uses Arduino and Bluetooth module to read measurement results with a smartphone (Þórhallsson, 2015). The research entitled Arduino Atmega328

Portable Spirometer Using Gas Pressure Sensor for FVC And FEV1 Measurement. In research, lung Volume Measuring And Monitoring Systems Using Pressure Sensors And The Internet Of Things, Use The Blynk Application To Display Measurement Data (Nugraha & Lutfiah, 2019). Existing studies there have been no studies on measuring spirometry with a flowrate sensor YF-S201 and measuring in the lungs of electric smokers. Therefore, spirometry measuring instruments are needed to help doctors diagnose diseases (Nugraha & Lutfiah, 2019)v. Especially integrated with the Internet of Things.

RESEARCH METHODS

In this study, the spirometry measurement is designed using the YF-S201 flowmeter sensor that can measure force vital capacity (FVC) and Forced Expiratory Volume (FEV1). The measurement results then be calculated by the NodeMCU ESP8266 microcontroller, which is, integrated with the Blynk application as an Internet of Things service provider that smartphones can access. This research will use study literature methods, software and hardware design, experimental observation, and data collection.

Figure 1. Methods

System Design

Based on Fig. 2. Block diagrams. The system design divides into hardware and Software. The hardware comprises a YF-S201 Flow meter sensor, Power Supply, DC-to-DC converter, I2C LCD, and NodeMCU 8266 Microcontroller. The Software is for processing microcontrollers to collect data, and the Blnyk App displays notifications of the data on smartphone devices.

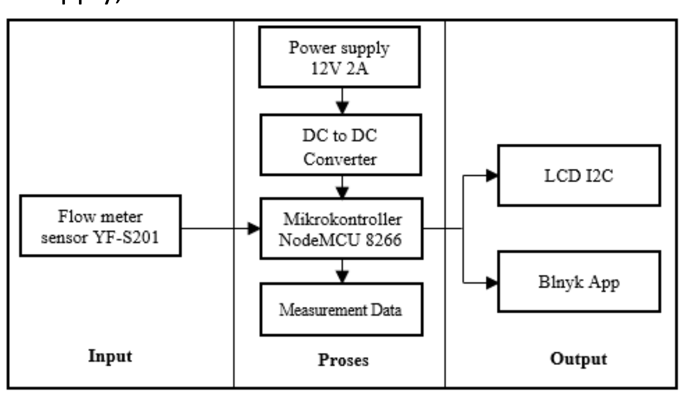

Figure 2. Block diagram

In this study, The Measurements will be carried out twice. Two Forced Vital Capacity (FVC), and two Forced Expiratory Volume (FEV1) samples will be obtained in one measurement, so four samples will obtain from one subject. Then the sample results get calculated to be the average value to determine the tolerance differentiation value and the classification ratio, equation (1) to determine the Tolerance difference value and equation (2) to determine the classification Ratio.

$$\text{Difference Tolerance} = \frac{(\mathrm{FVC}_1 - \mathrm{FVC}_2)}{((\mathrm{FVC}_1 + \mathrm{FVC}_2)/2)} \times 100 \qquad (1)$$

$$\text{Classification Ratio} = \frac{((\mathrm{FEV1}_1 + \mathrm{FEV1}_2)/2)}{((\mathrm{FVC}_1 + \mathrm{FVC}_2)/2)} \times 100 \qquad (2)$$

After the microcontroller processes the measurement data, the spirometry device will divide the measurement results into five categories according to the vital capacity of the subject that has been measured, but if the measurement results exceed the differential tolerance limit, the measurement value will be considered invalid. The device will return to standby mode then the subject will be asked to repeat the measurement.

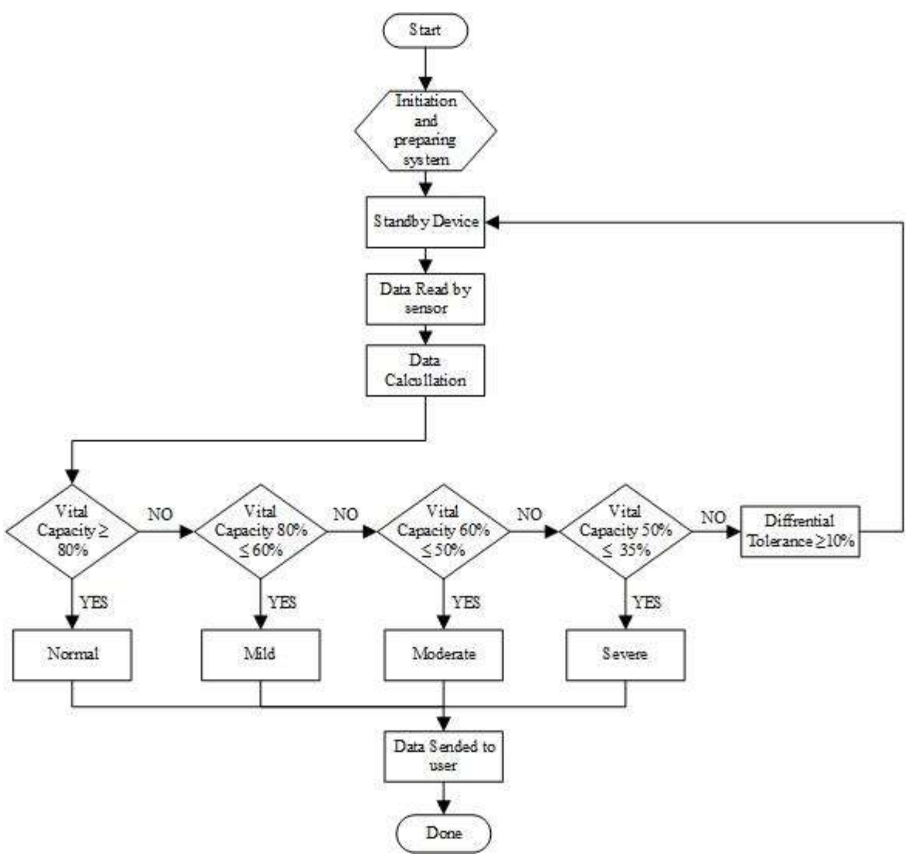

Figure 3. System Design flowchart

The air volume of the lungs FEV1/FVC is normal if the value is ≥80% with vital capacity (Sahebjami & Gartside, 1996). ≤80% will then be declared abnormal and classified according to the value sent by the device. Obstructive pulmonary sufferers will experience an apparent reduction in lung function due to the closure of the airway regulator. The pulmonary function status is examined by comparing the %FEV1 with the FVC value, whether it is in normal, obstructive, mixed obstructive, or restrictive conditions (Huang et al., 2020). Table 1 shows the classification category of lung volume ratio values.

Table 1
Volume Lung Classification

Class	Classification	Restrictive		Obstructive	
		VC%	FEV1/FVC	VC%	FEV1/FVC
0	Normal	>80	>75	>80	>75
I	Mild	60-80	>75	>80	60-75
II	Moderate	50-60	>75	>80	40-60
III	Severe	35-50	>75	>80	<40

Hardware Prototype

Based on fig.4. There are several main components of hardware, including NodeMCU ESP8266 Microcontroller as the central control of incoming data processing and outgoing commands, YF-S201 Sensor that functions to assess the volume of fluid in the vacuum valve chamber; when the fluid passes through the rotor, the magnetic rotor will rotate. The rotor's rotation depends on the fluid flow rate; then, the hall sensor readings will be read by the microcontroller and the Liquid Cristal Display component that functions as a display in the form of text and measurement numbers. In addition to hardware, there are other supporting devices, including pipes that function as air ducts to drain the measured air volume, an air filter that filters the incoming air, and a disposable mouthpiece placed in the mouth to blow air.

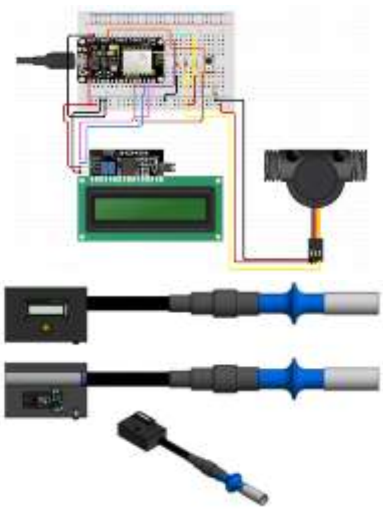

Figure 4. Prototype Design

Software Development

Software is developed and embedded in microcontrollers to process and transmit data. Measurement with the YF-S201 flow meter sensor will produce the flow rate in units of l / h (liters per hour) and convert it into l / S (liters per second). Based on the amount of this flow rate, if multiplied by time, it will produce a volume value. This volume value will be the basis for the volume

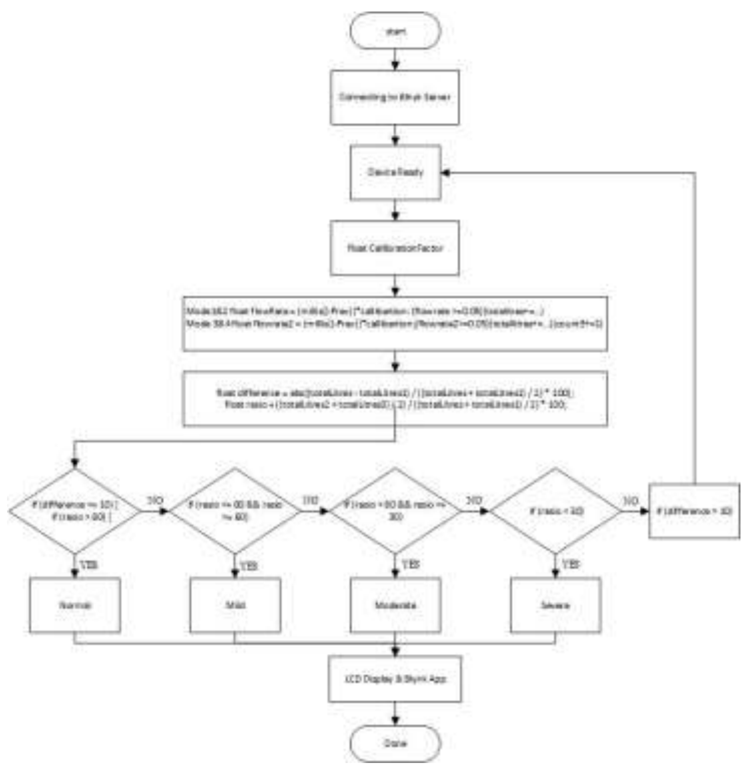

Figure 5. Computation code

After the YF-S201 sensor successfully measures the volume value, the microcontroller will process the data into different tolerance and classification ratio values. The different tolerance values will calculate the tolerance value from the measurement read by the sensor. The tolerance value is needed because the flow rate value read by the sensor will sometimes be different. This flow rate value depends on the maneuver of the subject blowing the mouthpiece, and if the subject blows with the wrong maneuver, then the reading value will be very much different. The tolerance value should not be ≥10%; if it exceeds ≥10%, the program will ask the subject to re-measure. So that the subject must blow with constant maneuvers so that the value successfully measured by the sensor can be accurate. This classification ratio value will calculate the ratio between the average total flow volume of the previous four measurement modes and multiplied by 100 to get the value in percentage form. Furthermore, both different and ratio values displayed on the LCD screen and the microcontroller will send notifications to user-friendly applications to support the Internet of Things. The application used is Blnyk Apps which can be accessed via Android and IOS Smartphones by logging in with an account registered on the microcontroller.

RESULTS AND DISCUSSION

As a measuring instrument, spirometry needs to be calibrated periodically to ensure accurate and consistent results. The spirometry tool designed has already been calibrated using the Hans Rudolph 5530 Syringe Calibrator tool. The syringe for calibration is executed manually by sucking in and pushing out the airflow.

Figure 6. Calibrating Proses

Spirometry performance measurement is carried out by the 3-liter method, with a volume range of 1-3 liters. Standard input 1.0 liters get 1.0 liters, standard input 1.5 get 1.6 liters, standard input 2.0 get 2.1 liters, standard input 2.5 get 2.5 liters, and standard input 3.0 get 3.2 liters. From the results, the value of spirometry correction has been deemed fit for use based on the allowable deviation value of ≤15%. Table 2 shows the values of spirometry calibration results.

Table 2
Calibration Result

Permissible deviations	Standard Settings	Correction
15%	1.0 liters	1.0 liters
	1.5 liters	1.6 liters
	2.0 liters	2.1 liters

	2.5 liters	2.5 liters
	3.0 liters	3.2 liters

For the measurement data collection process, the spirometry tool will measure twice with the aim of obtaining good results, with subject five electric smoker subjects aged 21-31 years, with a height of 150-177 cm, a body weight of 45-90 kg, and with room temperature ± 25ºc. Measurement will use a disposable mouthpiece placed in the mouth to blow air so that the sensor will read the value of the flowing volume. Subjects are required to be smoke-free for 2 hours and wear a nose clip. In the measurement, the subject should be in a standing position and will be asked to breathe as much air as possible and then as soon as possible exhale as much air as possible through the mouthpiece. Table 3 shows the results of the first measurement and Table 4 Shows the result of the first measurement.

Table 3
First Measurement

First Measurement										
ID	**Gender**	**Age**	**Height**	**Weight**	**Mode 1 FVC**	**Mode 2 FVC**	**Mode 3 FEV1**	**Mode 4 FEV1**	**Diff Ratio**	**Class**
1	M	22	165	60	2.57	2.66	3.63	3.60	0.65% 72.19%	Mild
2	M	24	168	90	4.22	4.43	3.77	3.82	4.68% 87.74%	Normal
3	M	31	177	75	3.40	3.40	2.98	3.33	0.16% 92.82%	Normal
4	F	21	150	50	4.75	4.92	3.00	3.87	3.55% 71.08%	Mild
5	F	25	160	55	3.15	3.34	2.57	2.56	5.83% 79.00%	Mild

Table 4
Second Measurement

Second Measurement										
ID	**Gender**	**Age**	**Height**	**Weight**	**Mode 1 FVC**	**Mode 2 FVC**	**Mode 3 FEV1**	**Mode 4 FEV1**	**Diff Ratio**	**Class**
1	M	22	165	60	3.04	3.09	4.59	4.71	2.49% 65.94%	Mild
2	M	24	168	90	3.80	3.84	3.77	3.63	1.04% 96.85%	Normal
3	M	31	177	75	3.60	3.41	3.34	3.57	5.40% 98.59%	Normal
4	F	21	150	50	4.82	4.72	3.77	3.84	2.01% 79.72%	Mild
5	F	25	160	55	3.11	3.09	1.95	2.51	0.47% 71.98%	Mild

Based on FVC and FEV1 measurements, there is a difference in measurement values in comparing the first and second measurement values. This difference in values, caused by several factors, such as the subject's breath, cannot be controlled to be generalized in conducting the test. The maneuver of the subject is assumed to change in making measurements, the breath exhaled by the subject does not run out, which causes inconstancy of values, and the mouthpiece used by the subject did not use properly, so leakage occurs.

Obstructive and restrictive classification gives the results of 5 subjects measured, stating that three subjects are classified as mild, and two subjects are declared normal. This obstructive and restrictive classification is affected by cigarette consumption during their life history. During this study, it was found that five subjects consumed ±60 ml of e-cigarette liquid over 1-2 weeks. Smokers who consumed 60ml of liquid for one week had a lower ratio than those who consumed 60ml for two weeks.

Figure 8. Blynk Notification

Figure 8 shows the results of the Internet of Things service. The Blynk service displays notifications of test results, notifications sent in the form of obstructive class classification, test date, and time. If a test failure is caused by a ratio difference value exceeding 10%, the microcontroller will not send data into the Blynk application.

CONCLUSION

In conclusion, the Design of Spirometry for Measure and Monitor Electric Smokers Lung Volume Based on the Internet of Things has worked well. This spirometry device can also be used on any subject other than electric smokers. E-cigarettes can cause a decrease in lung function, but the lung function caused by e-cigarettes is not as severe as tobacco cigarettes.

The system device successfully measures FVC / FEV1 with different tolerance values of <10%. The microcontroller sends Classification data to the Blynk application with a time delay of ± 30-60 seconds. This delay depends on the internet speed received by the microcontroller.

In the future, it is necessary to redevelop, such as selecting sensors with better accuracy to reduce reading errors, it is necessary to add a data storage system to store the personal data of subjects so that they can store the measurement results obtained, and it is necessary to add Peak Expiratory Flow (PEF) measurements.

BLIBLIOGRAPHY

Boutayeb, A., & Boutayeb, S. (2005). The burden of non communicable diseases in developing countries. *International Journal for Equity in Health*, *4*, 1–8.

Cheraghi, M., & Salvi, S. (2009). Environmental tobacco smoke (ETS) and respiratory health in children. *European Journal of Pediatrics*, *168*, 897–905.

Gayathri, G. V, & Satapathy, S. C. (2020). A survey on techniques for prediction of asthma. *Smart Intelligent Computing and Applications: Proceedings of the Third International Conference on Smart Computing and Informatics, Volume 1*, 751–758.

Huang, Y., Tan, C., Wu, J., Chen, M., Wang, Z., Luo, L., Zhou, X., Liu, X., Huang, X., & Yuan, S. (2020). Impact of coronavirus disease 2019 on pulmonary function in early convalescence phase. *Respiratory Research*, *21*, 1–10.

Ionescu, C. M., & Ionescu, C. M. (2013). The human respiratory system. *The Human Respiratory System: An Analysis of the Interplay between Anatomy, Structure, Breathing and Fractal Dynamics*, 13–22.

Lopez, A. D., & Mathers, C. D. (2006). Measuring the global burden of disease and epidemiological transitions: 2002–2030. *Annals of Tropical Medicine & Parasitology*, *100*(5–6), 481–499.

Nugraha, P. C., & Lutfiah, S. (2019). Portable Spirometer for Measuring Lung Function Health (FVC and FEV1). *Journal of Electronics, Electromedical Engineering, and Medical Informatics*, *1*(1), 16–20.

Pierce, R. (2005). Spirometry: an essential clinical measurement. *Australian Family Physician*, *34*(7).

Saabith, A. S., Fareez, M. M. M., & Vinothraj, T. (2019). Python current trend applications-an overview. *International Journal of Advance Engineering and Research Development*, *6*(10).

Sahebjami, H., & Gartside, P. S. (1996). Pulmonary function in obese subjects with a normal FEV1/FVC ratio. *Chest*, *110*(6), 1425–1429.

Sim, Y. S., Lee, J.-H., Lee, W.-Y., Suh, D. I., Oh, Y.-M., Yoon, J., Lee, J. H., Cho, J. H., Kwon, C. S., & Chang, J. H. (2017). Spirometry and bronchodilator test. *Tuberculosis and Respiratory Diseases*, *80*(2), 105–112.

Vanapalli, K. R., Sharma, H. B., Anand, S., Ranjan, V. P., Singh, H., Dubey, B. K., & Mohanty, B. (2023). Cigarettes butt littering: The story of the world's most littered item from the perspective of pollution, remedial actions, and policy measures. *Journal of Hazardous Materials*, *453*, 131387.

Woods, J. A., Hutchinson, N. T., Powers, S. K., Roberts, W. O., Gomez-Cabrera, M. C., Radak, Z., Berkes, I., Boros, A., Boldogh, I., & Leeuwenburgh, C. (2020). The COVID-19 pandemic and physical activity. *Sports Medicine and Health Science*, *2*(2), 55–64.

Þórhallsson, B. R. (2015). *Automatic control and user interface for central tire inflation system*. Citeseer.

Bakhtiar, A., Irviana, R., & Tantri, E. (2017). *Faal Paru Dinamis*.

Bandoro, Putu Gede Adiatmika, I., Tirtayasa, K., & Purnawati, S. (2021). Perbedaan Volume Ekspirasi Paksa Detik Pertama Per Kapasitas Vital Paksa (%Vep1/Kvp) Antara Laki-Laki Perokok. *Agustus*, *10*(8), 1–6. Https://Doi.Org/10.24843.Mu.2020.V10.I8.P18

By Alldatasheetcom, P. (N.D.). *Motorola Sensor Device Data 10 Kpa On-Chip Temperature Compensated & Calibrated Silicon Pressure Sensors*. Www.Freescale.Com

By Alldatasheetcom, P. (2021). *Sensors & Sensor Modules: Yf-S201 Water Flow Sensor*. Www.Tcpdf.Org

Ilman, S., & Wahyuningsih, E. (2020, December 23). *Portable Spirometer Using Air Pressure Sensor Mpx5500dp Based On Microcontroller Arduino Uno S*. Https://Doi.Org/10.4108/Eai.26-9-2020.2302783

Lia Andriani, Priyambada Cahya Nugraha, & Sari Lutfiah. (2019). Portable Spirometer For Measuring Lung Function Health (Fvc And Fev1). *Journal Of Electronics, Electromedical Engineering, And Medical Informatics*, *1*(1), 16–20. Https://Doi.Org/10.35882/Jeeemi.V1i1.4

Maharani, A., & Muid, A. (2019). Rancang Bangun Alat Pengukur Volume Paru-Paru Berbasis Sensor Tekanan Gas Mpx5700dp Dan Arduino Uno. *Prisma Fisika*, *7*(3), 231–237.

Meiliyani, Aisya Nur. (2017). *Pengaruh Merokok Terhadap Penurunan Arus Puncak Ekspirasi Pada Perokok Aktif & Pasif Di Kelurahan Barabai Barat*.

Muthohar, Agus. (2017). *Hubungan Kebiasaan Olahraga Dengan Kapasitas Vital Paru Pada Polisi Lalulintas Polres Pemalang*.

Purwanto, M. S., Hernawan, Y., & Nahroni, L. (N.D.). *Rancang Bangun Alat Pendeteksi Kebugaran Paru-Paru Pada Personil Tni (Spirometer) Berbasis Arduino Uno*.

Ramesh Iyengar, R. (2016). The Water Flow Monitoring Module. *International Journal Of Engineering Research And General Science*, *4*(3). Www.Ijergs.Org

Rifa, A., Supeni Edi, S., Jurusan Fisika, S., & Matematika Dan Ilmu Pengetahuan Alam, F. (2013). *Aplikasi Sensor Tekanan Gas Mpx5100 Dalam Alat Ukur Kapasitas Vital Paru-Paru*. Http://Journal.Unnes.Ac.Id/Sju/Index.Php/Upj

Riyanti, Ika. (2018). *Rancang Bangun Alat Ukur Kapasitas Vital Paksa Paru Dengan Sensor Tekanan Berbasis Arduino Dan Labview*.

Suryanto, Y., Supardi, & Chandra, F. (N.D.). *Perancangan Spirometer Portable Untuk Diagnosis Fev1 Dan Fvc Pada Paru*.

Systems, Espressif. (2015). *Esp8266ex Datasheet*. Http://Bbs.Espressif.Com/

Wasid, Asep, & Ridwan Nur Misbachus Soleh. (2021). *Pengukuran Volume Paru-Paru Berbasis Mikrokontroler Arduino Dengan Memanfaatkan Sensor Mpx5700dp*. *15*, 1–9.

Yastriska Ismartiandari, H. (2021). *Sistem Pengukur Dan Pemonitor Volume Paru-Paru Menggunakan Sensor Tekanan Dan Internet Of Things*.

Zainudin, A., & Rahmawati, E. (2015a). Pengukuran Volume Paru-Paru Dengan Memanfaatkan Sensor Tekanan. In *Jurnal Inovasi Fisika Indonesia* (Vol. 04).

Zainudin, A., & Rahmawati, E. (2015b). Pengukuran Volume Paru-Paru Dengan

Memanfaatkan Sensor Tekanan. In *Jurnal Inovasi Fisika Indonesia* (Vol. 04).

Zulkifli. (2020). *Identifikasi Faktor-Faktor Yang Mempengaruhi Pengguna Rokok Elektrik Pada Komunitas Di Malang*.