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Design Of Asthma Detection Devices Through Heart Rate and Oxygen Saturation Selvi Indriani¹, Endang Dian Setyoningsih¹, Dyah Titisari¹, Arif Joko Wuryanto² ¹Department [of Medical Electronics Engineering Technology of Politeknik Kesehatan Kementerian Kesehatan Surabaya Jl. Pucang Jajar Timur No. 10, Surabaya \(60282\), Indonesia](#) ²Rumah Sakit Jiwa Sambang Lihum, Kalimantan Selatan Indisindris08 [@gmail.com](#), [diancholik@gmail.com](#), [ti2_sari@yahoo.com](#) Article Info Article History: Received May 15, 2020 Revised Nov 14, 2020 Accepted Nov 25, 2020 **Keywords:** Asthma, Heart Rate, Oxygen Saturation. Abstract Respiratory problems can cause asthma, acute asthma attacks are very difficult to predict because they often occur suddenly and asthma can also cause death in sufferers because the breath can suddenly stop. The [purpose of this research is to design an asthma detection device](#) through indicators of [heart rate and oxygen saturation](#). The contribution [of](#) this study [is](#) to categorize the patient's condition by looking at the value of the heartbeat and oxygen saturation so that when asthma occurs the message of a location will be sent. To measure heart rate and oxygen saturation, a Nellcor finger sensor is placed on the patient's index finger. The finger sensor enters the signal conditioning circuit, then sent to the microcontroller to be processed to produce a heart rate value and the percentage of oxygen saturation. The [testing of this tool is done by comparing the module with a standard](#) measuring instrument [that produces](#) the highest [value of](#) oxygen saturation error which is 1.715% and the largest value of heart rate error is 3.548%. The results showed that the device was appropriate to use, because in the Medical Devices Testing and Calibration Guidelines of the Ministry of Health of the Republic of Indonesia in 2001, [the maximum limit in oxygen saturation error tolerance was 2%, and heart rate was 5%. The results of this study can be implemented](#) in patients who have been diagnosed with asthma so that it can facilitate the family in monitoring the patient's condition. **Corresponding Author:** [Endang Dian Setyoningsih](#) Department [of Medical Electronics Engineering Technology Politeknik Kesehatan Kementerian Kesehatan Surabaya Jl. Pucang Jajar Timur No. 10, Surabaya \(60282\), Indonesia](#) E-mail: [diancholik@gmail.com](#) [This work is an open-access article and licensed under a Creative Commons Attribution-ShareAlike 4.0 International License \(CC BY-SA 4.0\).](#) **I. INTRODUCTION** Patient monitoring is an important part of the health care system both at the hospital and at home [1]. Patient monitoring can be done using pulse oximetry because it can detect the absorption of light varies based on the amount of oxygen in the blood [2]. Pulse oximetry is used to measure the per minute heart rate (BPM) and the percentage [of oxygen saturation in the blood \(SPO2\)](#) [3]. Changes in [heart rate](#) and oxygen saturation can affect the respiratory system if they show abnormal values. Respiratory disorders can cause asthma which is characterized by airway inflammation, airway obstruction, and the hyperresponsive airway can cause inflammation and swelling of the airways in the lungs [4]. In the past, asthma was commonly suffered by adults but now, asthma can also be suffered by children [5]. The direct cause of asthma is still unknown. However, various studies have shown that several factors can influence

the increase in the number of asthma sufferers around the world, including genetic and environmental factors [6]. The number of asthmatics has increased significantly since the 1970s. In 2011, patients diagnosed with asthma were 235 million while 250,000 died due to asthma attacks. In 2014, the number of asthmatics increased to 334 million worldwide [7]. Asthma attacks are very difficult to predict because they often occur suddenly [8]. Most asthma deaths can be avoided by timely intervention or prevention [9]. In the management guidelines for asthma exacerbations (GINA), assume that heart rates from [100-120 bpm and SpO2 from 90-95%](#) as [mild or moderate asthma](#) while [heart rates are greater than 120 bpm and SpO2 less than 90% as severe asthma](#) [10]. Therefore it is needed a tool to detect asthma attacks making it easier for patient monitoring. In a previous study, in 2013 Nur Ilham Imarah made a study regarding the design of a monitoring tool to assess the severity of asthma in patients [11]. However, in that study, the device must be connected to a PC because the monitoring system uses the MATLAB application. Furthermore, in 2015 Kaushal et al Indonesian Journal of Electronics, Electromedical Engineering and Medical Informatics (IJEEEMI) 143 made an asthma detection system using a pellet sensor by analyzing exhaled breath [12]. However, this tool has not been able to classify mild, moderate, and severe asthma conditions. Then, in 2015 Uwaoma et al made a tool to detect asthma symptoms using a smartphone in real-time [13]. However, in that study, there was no notification when an asthma attack occurred. Then, in 2016 Shaharum et al classified the severity of asthma using wheezing sound analysis in patients [14]. However, in this study, there were also no indicators when an asthma attack occurred. Furthermore, in 2016 Abinayaa et al made a portable monitoring tool for asthma patients [15]. However, these devices require Wi-Fi signals so that doctors can examine and diagnose the patient's condition from a distance. In the same year, Anumeha et al made detection and monitoring of asthma triggers using Zigbee [16]. However, in the detection device, there is no notification for a warning system of asthma triggers. Then, in 2017 Gouma et al made a tool for asthma monitoring by measuring the levels of nitric oxide in a patient's breath [17]. However, this study requires a PC for recording and processing data. Then, in 2018 Alexander et al made the design of a broadband microwave applicator to diagnose bronchial asthma [18]. However, this research requires high frequency through the chest and requires at least two different frequencies to diagnose. Furthermore, in 2018 Hong et al made the development of an electronic kit to detect asthma in human respiration [19]. However, this study requires a PC to see the graphical differences between normal people and people with asthma. In 2018 Siddiqui et al made a classification and analysis of the severity [of chronic obstructive pulmonary disease and asthma](#) using [heart rate](#) sensors [and SpO2](#) [10][20]. However, in that study there were no indicators and notifications about asthma classification. Based on the identification of the problem above, the writer wants to make the Design of Asthma Detection Devices Through BPM and SpO2 Indicators. The making of this module is expected to make it easier for patients' families to find out the patient's location through SMS notifications if asthma patients who are outside the home experience an asthma attack suddenly so that it can be treated immediately. Because it is very difficult to predict acute asthma attacks because it often occurs suddenly and asthma can also cause death in patients due to breathing that can suddenly stop. For that reason, the writer wants to make a medium and severe asthma attack detection device that can be seen from the BPM and SpO2 values. [This Article is composed of: Chapter 1 introduction, Chapter 2 Material and Methods, Chapter 3 Result, Chapter 4 Discussion, Chapter 5 Conclusion, and Chapter 6 Reference. II. MATERIALS AND METHODS A. Experimental Setup This study used](#) on normal [subject](#) aged 22 years old and weighing 66 kg. Subjects were taken randomly by

conducting 3 trials and each trial was taken 6 data. [B. Materials and Device This study uses the](#) finger [sensor](#) (Nellcor, DS-100A, Mexico) to measure [oxygen saturation in the blood \(SpO₂\) and heart rate \(BPM\)](#). A microcontroller (Arduino Nano, R3, Italy) was used to process the data. LCD (Oled, 0,96", China) [as a display for displaying the value SpO₂ and BPM. Using the 3 batteries as a power supply](#) (Toshiba, Li-ion, China). Pulse Oximetry (Elitech, Fox-1, Indonesia) was used as a means of comparison. GSM module (SIM800L, China) was used to send message notifications. GPS module (Ublox, Neo M8N, China) was used to determine patient location. [C. Experiment In this study, researchers measured the value of](#) oxygen saturation (SpO₂) and heart rate (BPM) [from](#) the respondent [who](#) was [randomly selected and the results were compared with standard](#). INPUT DRIVER LAMP DEMULTI PLEXER (CD4051) SENSOR FINGER (NELLCOR 9 PIN) GPS (GY-Ublox NEO M8N) BPF (2,34 Hz) BUFFER & LPF (0,7 Hz) BPF (2,34 Hz) BUFFER & LPF (0,7 Hz) NILAI AC RED LED NILAI DC RED LED NILAI AC INFRARED NILAI DC INFRARED PROCESS ARDUINO NANO PROGRAM OUTPUT DISPLAY GSM (SIM800L) HANDPHONE BUZZER ARDUINO [Fig. 1. The Diagram Block Design of Asthma Detection Devices Through Heart Rate and Oxygen Saturation Indicators](#) [D. The Diagram Block In \(Fig. 1.\)](#), the finger [sensor](#) gets the voltage supply from the lamp driver. Inside the lamp driver there is a range of astable, transistor drivers and IC logic circuit NOT 7404, transistor drivers connected to red led and infrared will be set on using an astable circuit which is a frequency generator of 1,000 Hz, while IC logic NOT functions to condition different logic between red led and infrared so as not to light simultaneously. Then the finger sensor will produce an output in the form of photodiode output from the transmitter red led and infrared. From the finger sensor and lamp, the driver will enter the demultiplexer circuit, where when the demultiplexer gets logic 1 from IC logic NOT 7404 will enter the BPF circuit to produce AC Red led values and to the buffer & LPF circuit to produce DC Red led values. When the demultiplexer gets logic 0 from IC the logic NOT 7404 will enter the BPF circuit to produce AC Infrared values and to the buffer & LPF circuit to produce DC Infrared values. The four outputs of the SpO₂ circuit will enter the microcontroller via Arduino Nano so that the SpO₂ and BPM values will be displayed on the display. When the SPO₂ and BPM values are not normal (moderate asthma or severe asthma value categories), the buzzer will sound and the device will send a notification in the form of an SMS containing a link to the location of an asthmatic patient to his family. [E. The Flowchart In \(Fig. 2.\)](#), when the device is turned [on](#) or start, the microcontroller will initialize the ADC input in the form of AC Red led, AC Infrared, DC Red led, and DC Infrared data. Of the 4 ADC inputs, the SpO₂ signal will be detected, from the SpO₂ signal the BPM value will be obtained. The SpO₂ and BPM values will be used to detect conditions by monitoring the SPO₂ and BPM values through the index finger in patients who have been diagnosed with asthma. When the SPO₂ and BPM values are still in the normal category, the SPO₂ and BPM values will only be monitored on the display. However, when the SPO₂ and BPM values are not normal (in the category of moderate asthma values that is, in the presence of features such as [heart rate](#) from [100- 120 bpm and SpO₂](#) from [90 - 95%](#) and severe [asthma](#) value categories ie, in the presence of features such as a [heart rate greater than 120 bpm and](#) an SPO₂ of less than 90%), the buzzer will sound and the device will send a notification in the form of an SMS containing a link to the location of an asthmatic patient to his family. Start F. Circuit 1) Astable In (Fig. 3.), the astable circuit is a frequency generator of 1.000 Hz which is used to adjust the red led and infrared flares of the transistor driver. +5v R19 U7 8 4 NE555 1k 7 DIS VCC R Q 3 R20 [6.8K 6 2 THR TR CV GND 5 1 C13 0.1uf C12 0.1uf](#) J15 PWM 1 2 Fig. 3. Astable Circuit Uses NE555 for 1000 Hz Frequency Generator 2) Driver Transistor In (Fig. 4.) driver transistors are used to condition the different logic (1/0) between the red led and infrared so

they do not light up simultaneously. Initialization NO Signal Detection Fig. 4. Circuit of Driver Transistor Uses C9013 to Condition The Different Logic (1/0) NO Asthma 3) Amplifier and Filter In (Fig. 5.) amplifiers and filters are used to give a better Condition emphasis on the noise signal after the first filter is done. YES GPS Data Buzzer Notification Handphone End Fig. 2. The Flowchart Design of Asthma Detection Devices Through Heart Rate and Oxygen Saturation Indicators Fig. 5. Circuit of Amplifier and Filter Uses LF353 to Emphasis Noise Signals 4) Low Pass Filter 0,7 Hz In (Fig. 6), [low pass filter](#) circuit [with a cut off frequency of 0. 7 Hz to discard the AC signal and pass the DC signal.](#) Where the amplitude will be suppressed when the input frequency exceeds the cut-off frequency. Fig. 6. Circuit of Low Pass Filter 0,7 Hz Uses Capacitor and Resistor to Suppress The Amplitude When The Input Frequency Exceeds 0,7 Hz 5) High Pass Filter 2,34 Hz In (Fig. 7), a high-pass filter circuit is used to pass the amplitude when the input frequency exceeds the cut-off frequency. Fig. 7. Circuit of High Pass Filter 2,34 Hz Uses Capacitor and Resistor to Pass The Amplitude When The Input Frequency Exceeds 2.34 Hz III. RESULTS A. Results of Respondent In (Fig. 8), [researchers measured the value of oxygen saturation \(SpO2\) and heart rate \(BPM\) from the respondent who was randomly selected and the results were compared with standard.](#) Fig. 8. [Results of Respondent to Be Compared With Standard \(Pulse Oximetry Elitech\).](#) B. [Listing program](#) for SpO2 In the initial process of compiling the program, the program will initialize the input data from the SpO2 circuit consisting of ACred, ACir, DCred, and DCir. These four data will be entered into the ADC module when switching to digital data. Then from the 4 ADC inputs, the SpO2 signal will be detected, from this SpO2 signal the percentage value of SpO2 will be used to support the patient's requirements. ACredlamp = analogRead(A2); float ACredlamp1 = (ACredlamp / 1023) * 5 ; float ACinfrared = analogRead(A3); float ACinfrared1 = (ACinfrared / 1023) * 5 ; [if \(counteran == 5\) {if \(DCredlamp == 0\) {bagi1 = 0;} else {bagi1 = \(float\) maksimumACredlamp / DCredlamp;} if \(DCinfrared == 0\) { bagi2 = 0; if \(maksimumACinfrared < ACinfrared\) {maksimumACinfrared = ACinfrared;} else {maksimumACinfrared = maksimumACinfrared; holdACinfrared = \(maksimumACinfrared * 0.4\); k=1;} if \(ACinfrared > holdACinfrared\) { if \(logika == 0\) {counteran++; nodetak = 0;} logika = 1;} else {logika = 0;} if \(counteran == 5\) {if \(DCredlamp == 0\) {bagi1 = 0;} Else {bagi1 = \(float\) maksimumACredlamp / DCredlamp;} if \(DCinfrared == 0\) { bagi2 = 0; else {bagi2 = \(float\) maksimumACinfrared / DCinfrared;} if \(bagi2 == 1\) {spo2 = spo2;} Else { ratoratio =\(float\) bagi1/bagi2; ratio = \(float\) bagi1 / bagi2; spo2 = 110 - \(25 * ratio\);} if\(k==1\) { rasiopuncak=ratio; k=0;} counteran = 0; maksimumACredlamp = 0; maksimumACinfrared = 0; } tampilkan++; cekdetak++; if \(cekdetak == 10 && nodetak == 0\) {spo2 = spo2; nodetak = 0; cekdetak = 0;} { tampilkan = 0; int spo2, temp; } if \(DCinfrared <= 1\) {spo2 = 0; } waktures=millis\(\)-cal; if\(waktures>=1000\)}](#) C. Listing Program for BPM The BPM value is taken from the peak to peak signal graph on SpO2 where the BPM program will calculate the number of peak to peak values on the SpO2 graph in minutes. So that the heart rate associated with activity in the heart can be measured by the number of contractions as beats per minute (bpm). The graph on the SpO2 is very influential on the BPM value because if the oxygen saturation value (SpO2) is low then it can cause the heart to pump faster so that the heart rate per minute (BPM) becomes high. void bpm(){ sensor = ACredlamp; if (ref<=sensor){ref=sensor;} else{ref=ref;hold=(ref*0.6);} waktuu=millis()-waktureset; if (sensor>hold) {beat=1; } waktumonostabil=waktumonostabil+100; if(beat==1){ if (sensor<(hold*0.85)) { detak++; beat=0; waktumonostabil=0;}} if(detak==3) { bpmoled=180000/waktuu; detak=0; timer1=0; waktureset=millis();} D. Listing Program for Message SIM800L GSM Module is a GSM module that can function as an SMS gateway when connected to a microcontroller. So that the GSM module can be used

optimally, it must be filled with a sim card that has a good signal so that it can send or receive SMS quickly. This module is used to send SMS to families to find out when a sudden asthma attack occurs in asthmatics who are outside the home. The SMS is in the form of an asthma sufferer's location link that will be directly connected to Maps.

```
void kirim() {
while(kirimmas==0) { SIM800L.println("AT+CMGF=1"); delay(1000);
SIM800L.println("AT+CMGS=\"+62823456789\"\\r"); delay(1000);
SIM800L.println(link); delay(1000); SIM800L.println((char)26);
delay(1000);kirimmas++;}}
```

E. Listing Program for Location The Ublox NEO M8N GPS module is very easy to use and is connected to a microcontroller or can be accessed directly with a PC. This GPS module supports knowing the position (coordinates) with the help of GPS satellites. This module is used to determine the location of the victim as a compass that occurs with the help of satellites and latitude with the help of GPS satellites

```
void GPS(){ if(Serial.available()){
gps.encode(Serial.read());} if(gps.location.isUpdated()){ latitude =
gps.location.lat(); longitude = gps.location.lng(); Serial.println (link); lo
=longitude; la =latitude; link = "www.google.com/maps/place/" + String(
la, 6) + "," + String( lo, 6); } }
```

F. BPM Measurement Result for Respondent In (TABLE I.), the result of a comparison between the module and the comparison tool by conducting three trials and each experiment is taken 6 measurement data, then the average results and standard deviation of the BPM will be obtained. The largest value of the average BPM is 88.33 and the smallest value is 84.67. The largest value of the standard deviation of BPM is 3.141 and the smallest value is 0.754. The largest BPM error value is 3.548% and the smallest is 2.472%. Fig. 9. Display Notification Message from the Device in the form of a Link

Measurement	Mean	SD (%)	Error
1	85.50	2.757	2.495
2	88.33	1.967	3.548
3	84.67	3.141	2.472

G. SpO2 Measurement Result for Respondent In (TABLE II.), the results of the comparison between the module and the comparison tool by conducting three trials and each experiment is taken 6 measurement data, then the average results and standard deviation of the SpO2 value will be

Measurement	Mean	SD (%)	Error
1	98.00	0.000	0.168
2	99.00	0.000	1.715
3	98.33	0.517	0.34

Fig. 10. Display When a Link is Opened Using Maps obtained. The largest value of the average SpO2 is 99 and the smallest value is 97.33, while the largest value of the standard deviation of SpO2 is 0.517 and the smallest value is 0.168. In (TABLE I. & TABLE. II), shows the measurement of highest SpO2 error value obtained is 1.715% and the smallest the BPM and SpO2 values of respondents where these values value is 0.168%. can be used to classify the patient's condition as normal, mild asthma, and severe asthma. It has also been investigated by

Measurement	Mean	SD (%)	Error
1	98.00	0.000	0.168
2	99.00	0.000	1.715
3	98.33	0.517	0.34

Siddiqui et al in 2018 to make [Severity Classification of Chronic Obstructive Pulmonary Disease and Asthma with Measurement Mean SD \(%\) Error Heart Rate and SpO2 Sensors \[10\]](#). However, in that study, there were no indicators and notifications about asthma

But the difference between this study and that research is that in addition to detecting asthma, the device also comes with a notification message in the form of a patient's location that will be sent to his family in the event of an asthma attack so that it can be treated immediately. This can be seen in (Fig. 9. & Fig. 10.).

V. CONCLUSION H. Display of Message and Location The purpose of this study is to make an asthma detection When the device identifies an abnormality in a patient's tool through BPM and SpO2 indicators for patients who have condition (asthma) using the SpO2 and BPM indications, the been diagnosed with asthma equipped with notifications, device will send an SMS notification containing a link that making it easier for families to know when a sudden asthma when opened will be directly connected to maps because it attack occurs in asthmatics who are outside the home. The contains longitude and latitude points with the help of GPS

testing of this tool is done by comparing the module with a

satellites. This can be seen in (Fig. 9. & Fig. 10.). standard measuring instrument that produces the highest value of oxygen saturation error which is 1.715% and the largest value of heart rate error is 3.548%. The results showed that the device was appropriate to use, because in the Medical Devices Test and Calibration Guidelines of the Ministry of Health of the Republic of Indonesia in 2001, the maximum limit in oxygen saturation error tolerance was 2%, and heart rate was 5%. The results of this study can be implemented in patients who have been diagnosed with asthma so that it can facilitate the family in monitoring the patient's condition. Further development in this study can be done by improving the astable and filter circuit so that the error value is smaller so that the error rate in heart rate and oxygen saturation in the device, when compared with the comparison, is also smaller.

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