DEPARTMENT OF ELECTRICAL ENGINEERING
UNIVERSITY OF LAMPUNG

PROCEEDINGS ICCTEIE 2021

2021 International Conference on Converging Technology in Electrical and Informatic Engineering

Bandar Lampung, October 27-28, 2021

Converging Technology for Sustainable Society

ISBN 978-1-6654-0081-7

2021 International Conference on Converging Technology in Electrical and Information Engineering (ICCTEIE) | 978-1-6654-0081-7/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICCTEIE54047.2021.9650652

Copyright

2021 International Conference on Converging Technology in Electrical and Information Engineering (ICCTEIE)

took place October 27-28, 2021 virtually.

IEEE Conference Number:	54047

Copyright and Reprint Permission:

IEEE catalog number: CFP21BE0-ART

ISBN 978-1-6654-0081-7

2021 International Conference on Converging Technology in Electrical and Information Engineering (ICCTEIE) | 978-1-6654-0081-7/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICCTEIE54047.2021.9650624

Foreword from Rector of University of Lampung

Assalamu'alaikum warrahmatullahi wabarakatuh

All praise be to Allah SWT who has given us all salvation and blessing in Life. The Lord who created this word.

I'll never forget to sholawat and salam to our beloved Prophet Muhammad SAW who really loved by ALLAH SWT and saved the human life from destruction in the safety, that's the right path of ALLAH SWT.

I would like to say welcome to the First International Conference on Converging Technology in Electrical and Information Engineering (1st ICCTEIE 2021) with the theme: "Converging Technology for a Sustainable Society ".

The University of Lampung is very committed to advancing research and international collaboration as an effort to advance world civilization. ICCTEIE is an international conference co-sponsored by The IEEE Indonesian Section and organized by the Department of Electrical Engineering and Informatics – University of Lampung. The conference is held on October 27-28, 2021, in Bandar Lampung, Indonesia, on a virtual meeting base. This event provides a good platform for researchers, scientists, and the entire engineering community to meet virtually and exchange their ideas on electrical engineering, control engineering, electronics, telecommunications, computer science and engineering, cyber-physical system, informatics, sustainable energy and environment-related fields and their applications.

I do expect this conference will give imperative contributions to the development on the aspects of researches, academics, and industries nationally and globally. I hope that all participants have fruitful and technical discussions and please enjoy the meeting.

See you on next 2nd ICCTEIE 2023.

Thank you for your excellent attention.

Prof. Karomani – Rector of University of Lampung

2021 International Conference on Converging Technology in Electrical and Information Engineering (ICCTEIE) | 978-1-6654-0081-7/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICCTEIE54047.2021.9650642

Welcome message from General Chair of 1st ICCTEIE 2021

Assalamu'alaikum Warrahmatullahi Wabarakatuh

Peace be upon you and God's mercy and blessings

On behalf of the committee, I am very pleased to welcome you to the 1st ICCTEIE 2021, The International Conference on Converging Technology in Electrical and Information Engineering, 2021.

We are very grateful for all the support from the Rector of the University of Lampung, all vice-rectors, director of the research institute and dean of faculty of engineering. I would also like to extend my sincere gratitude to IEEE Indonesia Section, Advisory Committee, Technical Program Committee, Steering Committee, and Organizing Committee for their support and efforts so that this event can be successfully conducted.

I welcome all the eminent speakers and guests from all over the countries from different walks of life you had come here virtually to share the knowledge and experience among the scientific community.

The conference will highlight recent and significant advances, the state-of-the-art, current status and future challenges on all aspects related to the research and development in the field of Electrical and Information Engineering including:

- Communication, Networking & Broadcasting,
- Components, Circuits, Devices & Systems,
- Computing & Processing (Hardware/Software),
- Engineered Materials, Dielectrics & Plasmas,
- Power, Energy, & Industry Applications,
- Robotics & Control Systems,
- Signal Processing & Analysis,
- Information Technology,
- Internet of Things, and
- Artificial Intelligence

The call for the paper was issued on the 25th of May, 2021 and closed on the 15th of October 2021. There are 46 submissions papers during that time. 31 papers are presented today. After this conference, the reviewing process will continue to ensure each article is ready for submission in the IEEXplore or otherwise it will be excluded.

As The University of Lampung is progressively expanding its research network and contributions to the world of science and technology, it is expected that the conference will significantly provide means to both UNILA's researchers and other researchers to engage in a fruitful discussion during and after the conference.

The 1st ICCTEIE is starting this year as the 1st year and it is projected to continue every 2 years. Hopefully, the Covid-19 pandemic soon subsides so the next conferences would be able to commence in the real meeting. This year our theme is Converging Technology for a Sustainable Society, and we are very happy the experts from the field of electrical and information as well as computer technology are with us today. We cordially welcome our keynote speakers:

1. Dr Laksana Tri Handoko, M.Sc., as the Head of National Research and Innovation Agency Republic of Indonesia,
2. Ir. Bob Saril, M.Eng.Sc., Director of Commerce and Consumer Management Indonesian National Grid Company,
3. Prof. Yasunori Mitani, The President of Kyushu Institute of Technology, Japan,
4. Prof. Prashant Pillai, University of Wolverhampton, England,
5. Prof. Jing-Ming Guo, National Taiwan University of Science and Technology, Taiwan, and
6. Dr Daniel Eghbal, Manager Future Network Strategy at Energy Queensland Australia and Australia Council Chair Institute of Electrical and Electronics Engineers (IEEE)

Also, let me inform you that all of our local committees are now registered as IEEE members as well as 15 of our electrical and informatics students are now also registered. Next month we plan to launch the IEEE Student Branch of Lampung, we hope through this endeavour will be able to broaden their horizons to the international society.

Before coming to a close with these remarks, I would also like to remind you and especially our moderators to strictly stick to our schedule and not to let any session overrun. I sincerely hope you will enjoy today of discussion, debate and networking.

I am sure you will have fruitful and rewarding exchanges on this conference day. I wish you all the best and success.

Thank you.

Dr. Khairudin – General Chair 1st ICCTEIE 2021

2021 International Conference on Converging Technology in Electrical and Information Engineering (ICCTEIE) | 978-1-6654-0081-7/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICCTEIE54047.2021.9650650

Committee

ADVISORY BOARD

Dr. Laksana Tri Handoko, M.Sc. - National Research and Innovation Agency Republic of Indonesia

Prof. Dr. Karomani, M.Si. - Rector of University of Lampung

Prof. Mitra Djamal - Rector of Sumatera Institute of Technology

Prof. Yasunori Mitani - President of Kyushu Institute of Technology

Ir. Bob Saril, M.Eng.Sc. - Director of Commerce and Customer Management PLN Persero

Dr.Ing. Wahyudi Hasbi - IEEE Indonesia Section Chair

Prof. Dr. Heryandi, S.H., M.S. - Vice Rector for Academic Affairs

Prof. Dr. dr. Asep Sukohar, S.Ked., M.Kes. - Vice Rector for General Affairs and Finance

Prof. Dr. Yulianto, M.Si. - Vice Rector for Student Affairs and Alumni

Prof. Ir. Suharso, Ph.D. - Vice Rector for Planning, Cooperation and Information Communication Technology

Prof. Zainuddin Nawawi - Vice Rector for Academic Affairs of University of Sriwijaya

Prof. Yim Fun Hu - University of Bradford

Prof. Jin-Ming Guo - National Taiwan University

Prof. Prashant Pillai – University of Wolverhampton

Assoc. Prof. Paul Timotiwu - Head of LTSIT University of Lampung

Dr. Daniel Eghbal - IEEE Australia Council Chair

STEERING COMMITTEE

Prof. Suharno

Dr. Lusmeilia Afriani

Prof. Wan Abbas Zakaria

Prof. Hassan Bevrani

Prof. Josaphat Tetuko

Prof. Dr. Ahmad Saudi Samosir

Alkali Muhammad, Ph.D

Thongchart Kerdphol, Ph.D

Dr. Fathin Saifur Rahman

Ing. Helmi Ahmad El Hajjeh

GENERAL CHAIR

Dr. Khairudin

TECHNICAL PROGRAM

TPC Chair: Dr. Eng. Lukmanul Hakim

TPC Member:

Assoc. Prof. Dr. Mohd Ashraf Ahmad - Univesiti Malaysia Pahang

Dr. Eng. Helmy Fitriawan

Dr. Eng. Ageng Sadnowo Repelianto

Mona Arif Muda Batubara, M.T.

M. Komarudin, M.T.

Wahyu Eko Sulistiono, M.Sc.

Syaiful Alam, M.T.

Ir. Gigih Forda Nama, M.T.I., IPM.

Ing. Heri Dian Septama

Emir Nashrullah, M.T.

Mahendra, M.Eng.

Afri Yudamson, M.Eng

Zulmiftah Huda, M.Eng.

PUBLICATION

Dr. Misfa Susanto

Dr. Sri Ratna

Dr. Herman Halomoan Sinaga

Dr. Eng. Diah Permata

Dr. Eng. Mardiana

Dr. Eng. Charles Harahap

Dr. Eng. Sri Purwiyanti

Umi Murdika, M.T.

Yessi Mulyani, M.T.

Noer Soedjarwanto, M.T.

Fadhil Hamdani, M.T.

TREASURER

Herri Gusmedi, M.T.

Dr. Eng. FX Arinto

Herlinawati, M.T.

Dr. Eng. Endah Komalasari

Osea Zebua, M.T.

SECRETARY

Dr. Eng. Nining Poerwasih

Yetti Yuniati, M.T.

Resti Annisa, M.Kom.

Rio Ariestia Pradipta, M.T.

SPONSORSHIP

Dr. Eng. Dikpride Despa

Meizano Ardhi Muhammad, M.T.

Trisya Septiana, M.T.

Annisa Ulya Darajat, M.T.

Puput Budiwantoro, M.T.

2021 International Conference on Converging Technology in Electrical and Information Engineering (ICCTEIE) | 978-1-6654-0081-7/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICCTEIE54047.2021.9650645

Author Index

2021 International Conference on Converging Technology in Electrical and Information Engineering (ICCTEIE) | 978-1-6654-0081-7/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICCTEIE54047.2021.9650627

Table of Contents

Measurement Instrument of Blood Glucose and Oxygen Saturation Non-Invasive by Using Oximeter Sensor

Sri Purwiyanti
Departemen of Electrical engineering
University of lampung
Bandar Lampung, Indonesia
sri.purwiyanti@eng.unila.ac.id

FX. Arinto Setyawan
Departemen of Electrical engineering
University of lampung
Bandar Lampung,Indonesia
fx.arinto@eng.unila.ac.id

Helmy Fitriawan
Departemen of Electrical engineering
University of lampung
Bandar Lampung,Indonesia
helmy.fitriawan@eng.unila.ac.id

Anggie Novianto
Departemen of Electrical engineering
University of lampung
Bandar Lampung,Indonesia
anggie.novianto03@gmail.com

Sri Ratna Sulistiyanti
Departemen of Electrical engineering
University of lampung
Bandar Lampung,Indonesia
sr_sulistyanti@eng.unila.ac.id

***Abstract*—This research aims to design and realize non-invasive instrument to measure both blood glucose level and saturated oxygen level by using optical methods, i.e oximeter sensor. This method has the advantage of being painless, more hygienic, and allows continuous measurement. Both of these parameters will be measured through the fingertips continuously and can be monitored remotely using Android technology in real-time. The instrument is also equipped with a monitoring system in the form of a buzzer, which will activate when blood glucose and oxygen levels are detected abnormally. From measurement results it found that averages error obtained are 4.9% for Glucose level and 1.02% for oxygen saturation level. The measurement results will be displayed on LCD screen and on the Android with a delay of 10 seconds. This research may contribute to build a smart healthy instrument.**

Keywords—Blood glucose, saturated oxygen, non-invasive, measurement, oximeter

I. Introduction

Measurement of blood glucose levels so far has been carried out by chemical testing using blood samples taken from the body using needles. This method is called invasive method [1]. The problem with this method is that the process is painful and allows infection if the equipment used is not hygienic. The measurement method used to overcome these problems is a non-invasive method, a method that does not injure skin tissue. This method has the advantage of being painless, more hygienic, and allows continuous measurement.

Several researches have been published in efforts to design the non-invasive sugar detectors, for example optically [2] and ultrasonic [3]. Media used include skin, tears [4-6], and saliva [7]. Other methods are still being developed along with research conducted to further study the property of sugar in the blood. One of the studies conducted is to study the electronic property of sugar in the blood through the skin of the fingers [8]. In this study it is known that changes in blood glucose levels will change the value of admittance that can be measured from outside the skin tissue. Research that has been done to measure electronic properties, namely the value of admittance, is using the inter-digital electrode [9], but the results obtained cannot accommodate different individual traits and the resulting sensor design cannot be used in measuring sugar at the tip finger.

Non-invasive methods allow continuous measurement, and continuous measurements can be developed to be activated and monitored remotely based on the concept of the Internet of Thing (IoT). Thus, health workers can obtain patient condition data from distant locations, and it will be easy to monitor the condition of several patients at once accurately and in real time.

For this reason, this research aims to design and realize noninvasive blood glucose measurement equipment using optical methods. In the design made, this instrument can also be used to measure oxygen saturation in the blood using the same sensor. Both of these parameters will be measured through the fingertips continuously and can be monitored remotely using Android technology in real-time. The instrument is also equipped with a monitoring system in the form of a buzzer, which will activate when blood glucose and oxygen levels are detected abnormally.

II. Design and Method

The measurement method used is one of the non-invasive optical measurement techniques. Diagram block of the instrument is shown in Fig. 1. The detector used is an oximeter sensor. Oximeter Ds 100A SPO2 sensor consists of red LED, infrared and photodiode. Red LEDs and infrared LEDs emit light with wavelengths of 660 and 940 nm [Fig. 2]. Both of these waves will penetrate the fingertips and be received by the photodiode.

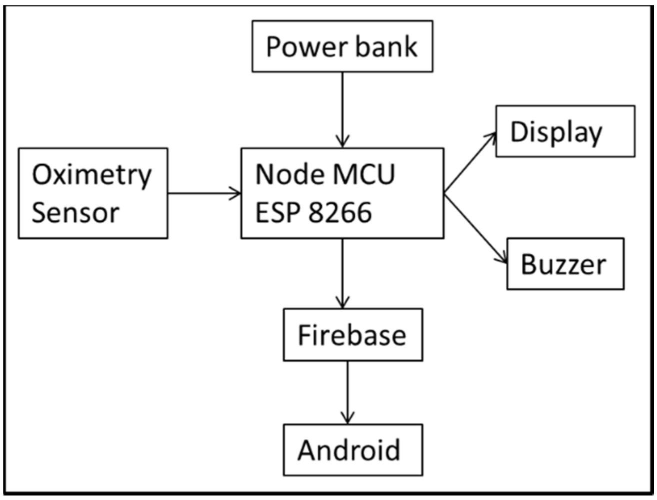


Fig. 1. Diagram Block of the instrument

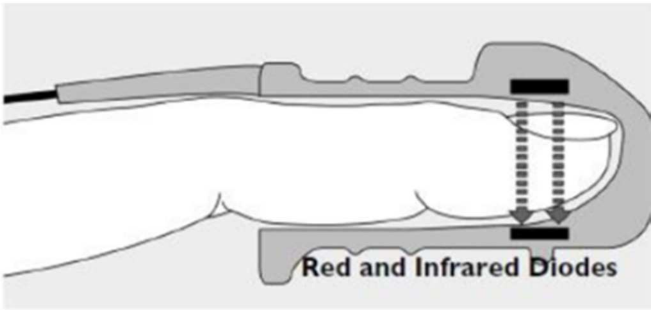


Fig. 2. Oximeter sensor [10]

The sensor output is the voltage generated by the photodiode. The resulting voltage will be proportional to the glucose level and oxygen saturation measured.

In this system, the red LED and infrared LED on the sensor are made ON and OFF alternately by setting the PWM and the specified time delay. Hemoglobin that does not contain O2 (deoxyhemoglobin) has the characteristic of high absorption of red LED light and Hemoglobin that contains O2 (oxyhemoglobin) has the characteristic of high absorption of LED infrared light. To get the glucose levels, the output value is taken only from the red LED light, this is because the blood component that carries glucose, i.e blood plasma, only absorbs the emission of the red LED, while oxygen saturation is obtained by calculating the ratio between the two lights.

The value of oxygen content can be calculated by the formula contained in the following equation by Hariyanto in [11].

$$SpO2 = [Hb02]/ [Hb] + [Hb0_2] \quad (1)$$

where SpO2 is oxygen saturation, HbO_2 is Oxygenated hemoglobin, and Hb is non-Oxygenated hemoglobin.

Figure 3, shows the length of time the ON and OFF conditions of each LED. Infrared LED and red LED turn on alternately to find the ratio of light absorption affected by blood components. When the red LED lights up, the photodiode will detect the amount of light intensity that radiates through the finger, and the same treatment is carried out when the Infrared LED is on. The two LEDs are turned on alternately for 4 seconds to get the minimum and maximum conditions of each LED. The minimum and maximum values can be said to be the AC (Alternating Component) value. Based on Eq. (2), finding the AC value for each LED is to determine the difference between the minimum and maximum values of absorption by the photodiode. The DC (Direct Component) value can be found by looking for the average photodiode light absorption of each LED. After the data has been acquired, calculations are performed on the program using Eq. (3).

Infrared LED and red LED turn on alternately to find the ratio of light, *R,*

$$R = (ac660/dc660) / (ac940/dc940) \quad (2)$$

where AC660 is Alternating Component of red LED (660 nm), DC660 is Direct Component of red LED (660 nm), AC940 is Alternating Component of infrared LED (940 nm), and DC940 is Direct Component of infrared LED (940 nm)

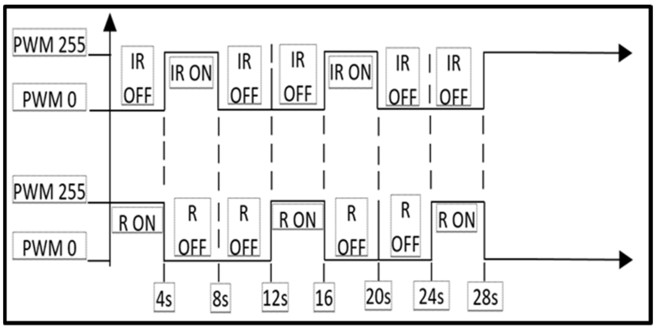


Fig. 3. ON and OFF time of LED infrared and red

The value of SpO2 can be calculated by entering the value of R in the linear equation [11].

$$SpO2 = 110 - 25 * R \quad (3)$$

For glucose measurement, only the detection results on the red LED are used. When the red LED lights up, the photodiode will detect the amount of light intensity it can receive.

The output of oximeter sensor will be processed by the MCU Node. Data communication from the Oximeter sensor is USART communication so to connect it to NodeMCU requires RS 232 as the connector. NodeMCU functions as a microcontroller and also activates the Wi-Fi module. The data received from the Oximeter sensor is still in the form of analog data so that the data will be converted to digital in the Analog to Digital Converter (ADC) first before processing the data. The data processing is the conversion of voltage to blood glucose and saturated oxygen levels by NodeMCU. The realization of the instrument is shown in Figure 4. Furthermore, the measurement results are displayed on the LCD and sent to the Android system. Firebase is used as a database before measurement values can appear on Android. Buzzer on this tool serves as an indicator if the measurement results are not normal.

The measurement results are displayed on the LCD. The final display on the LCD can be seen in Fig. 5. Measurement results are displayed also on android using Firebase technology. Firebase is used as a database before measurement values can appear on Android. Firebase is a service provider in the form of a real time database and backend that can be used for various platforms. The backend itself is a part of the application code that is directly connected to the database. Firebase on this system is used as a database before data is sent to Android. Before used, the Firebase connection must be tested with the Mcu Esp 8266 Microcontroller by setting the program on the Arduino IDE. The tests include testing the connection between the Node Mcu ESP 8266 to the wifi network and the Mcu ESP 8266 Microcontroller connection with Firebase.

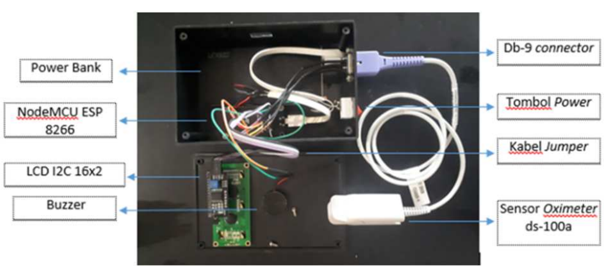


Fig. 4. Realization of the instrument

Fig. 5. Display of the measurement results

III. RESULTS

After the entire system of these devices has been confirmed to be functioning properly, a calibration is then performed to obtain accurate measurement data. Calibration is a process of checking and adjusting the accuracy of a device built by comparing it to a reference tool. In this research, the reference device used is Gluco Dr on glucose measurement and LV-80 oximeter on measuring oxygen saturation.

In the measurement of glucose, 25 respondents were measured using both the instrument produced and the reference instrument. Then the two measurement results were compared. From the comparison of these measurement data, the correlation is obtained in the form of a polynomial regression with the equation: $Y=-0{,}0407x^2 + 6{,}3817x - 140.54$

Then, the equation is used in the program to adjust the measurements results. With, Y is final measurement result and x is the result of sensor data processing. The measurement data of the designed instrument is shown in Table. 1. Data from the reference instrument also shown as a comparison. The reference instrument that has been used is Gluco Dr. The average error obtained is 4.9.

The glucose content in the human body normally ranges from less than 100 mg / dl when fasting for 8 hours, 70 - 130 mg / dl before meals, less than 180 mg / dl when measured 1 to 2 hours after eating and 100-140 mg / dl when measured at bedtime. This design instrument can measure blood glucose levels from 80 mg / dl to 140 mg / dl.

A similar process is carried out in the calibration and the measurement of oxygen saturation levels in the blood. The measurement data of the designed instrument and the reference instrument is shown in Table. 2. The data has been taken for 11 respondents.

TABLE 1. MEASUREMENT RESULTS OF BLOOD GLUCOSE

No	Respondents	Glucose level (Instrument)	Glucose level (Reference)	Error (%)	Accuracy (%)
1	Patient 1	110	125	13,64	86,36
2	Patient 2	109	123	12,84	87,16
3	Patient 3	107	115	7,48	92,52
4	Patient 4	107	115	7,48	92,52
5	Patient 5	108	114	5,56	94,44
6	Patient 6	105	113	7,62	92,38
7	Patient 7	106	110	3,77	96,23
8	Patient 8	108	110	1,85	98,15
9	Patient 9	108	109	0,93	99,07
10	Patient 10	108	109	0,93	99,07
11	Patient 11	106	108	1,89	98,11
12	Patient 12	106	108	1,89	98,11
13	Patient 13	109	107	1,83	98,17
14	Patient 14	110	107	2,73	97,27
15	Patient 15	107	106	0,93	99,07
16	Patient 16	109	106	2,75	97,25
17	Patient 17	107	105	1,87	98,13
18	Patient 18	109	105	3,67	96,33
19	Patient 19	109	105	3,67	96,33
20	Patient 20	107	104	2,80	97,20
21	Patient 21	108	101	6,48	93,52
22	Patient 22	109	100	8,26	91,74
23	Patient 23	107	99	7,48	92,52
24	Patient 24	108	99	8,33	91,67
25	Patient 25	104	98	5,77	94,23
Average				4,90	95,10

TABLE 2. MEASUREMENT RESULTS OF OXYGEN SATURATION

No	Respondents	SpO2 (Reference)	SpO_2 (Instrument)	Error (%)	Accuracy (%)
1	Patient 1	98	99	1.1	98.9
2	Patient 2	99	96	3.2	96.8
3	Patient 3	99	100	1	99.00
4	Patient 4	98	98	0	100
5	Patient 5	96	97	1.04	98.96
6	Patient 6	99	99	0	100
7	Patient 7	99	97	2.07	97.93
8	Patient 8	98	97	1.04	98.96
9	Patient 9	97	97	0	100
10	Patient 10	99	98	1.03	98.97
11	Patient 11	92	89	3.37	96.63
Average				1.02	98.8

The saturated oxygen values that have been measured by a design measuring instrument then calibrated by Polynomial regression were compared with an invasive measuring instrument.

From the measurement results it can be seen that the designed instrument has an average deviation of 1.18, an average error value of 1.02%, and an accuracy value of 98.8%. It can be seen that even after the calibration process, errors are still encountered in the measurement results. This error is caused by several factors, such as finger thickness, finger shape that is too small, and the intensity of ambient light. The instrument is also equipped with a monitoring system in the form of a buzzer, which will activate when blood glucose or oxygen levels are detected abnormally. Experiments have been done by using the instrument to measure some respondent and buzzer is observed. The experiment results are shown in Table. 3. From the measurement results it can be seen that the buzzer will ON if abnormality detected, i.e., saturated oxygen is under 90.

TABLE 3. ABNORMALITY DETECTION

No	Respondents	SpO_2 (Instrument)	Buzzer
1	Patient 1	99	Off
2	Patient 2	96	Off
3	Patient 3	100	Off
4	Patient 4	98	Off
5	Patient 5	97	Off
6	Patient 6	99	Off
7	Patient 7	97	Off
8	Patient 8	97	Off
9	Patient 9	97	Off
10	Patient 10	98	Off
11	Patient 11	89	On

The measurement results are displayed on the LCD screen and on the Android application. The measurement results will be displayed immediately after the calculation process is completed with a delay of 10 seconds. Fig. 6 shows the display of the measurement results on both LCD and Android.

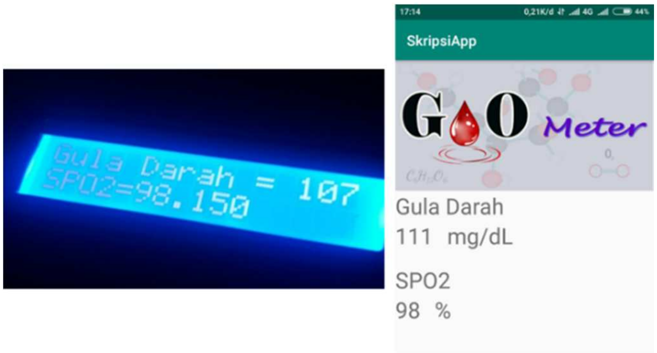
Android application testing is carried out to determine whether the application installed on Android can display measurement data correctly or not. This test is done by running the application on Android and running the tool. The application can be said to be running if it can display the results of measuring blood glucose levels. The display of the android application can be seen in Figure 5(b). The display of this android application has two parameters displayed, namely *gula darah* for blood glucose in mg / dl and SPO2 or oxygen levels in% (percent) units.

IV. CONSCLUSIONS

Based on the experiment, conclusions of this research are a non-invasive instrument has been realized for measuring blood glucose levels and oxygen saturation using NodeMCU and Oximeter sensor. This instrument can display measurement data through LCD (Liquid Crystal Display) and Android applications. Averages error obtained are 4.9% for Glucose level and 1.02% for oxygen saturation level. This research may contribute to build a smart healthy instrument.

ACKNOWLEDGEMENT

Authors thanks to LPPM Lampung University for funding support through Innovation Research Program and Electronic Laboratory of the Department of Electrical Engineering Lampung University for facilitating this research.



(a) (b)

Fig. 6. Display of the measurement results on (a) LCD and (b) Android

REFERENCES

[1] A. Mazady, Non-invasive Glucose Meter, USA: University of Connecticut, 2013.

[2] N. Jahangiri, A. Bahrampour, and M. Taraz, "Non-invasive Optical Techniques for determination of blood Glucose levels: A Review Article," Iranian Journal of Medical Physics, vol. 11 no. 2, pp. 224-232, 2014.

[3] E.J. Park, M.S.J Werner, V.M.D.J. Beebe, S. Chan and N.B. Smith, "Noninvasive Ultrasonic Glucose Sensing with Large Pigs (~200 Pounds) Using a Lightweight Cymbal Transducer Array and Biosensors," Journal of Diabetes Science and Technology, vol 3, no. 3, 2009.

[4] S.R. Corrie, J. W Coffey, J. Islam, K.A Markey, and M.A.F Kendall, "Blood, sweat, and tears: developing clinically relevant protein biosensors for integrated body fluid analysis," The Royal Societies of Chemistry. USA:University of California., 2015.

[5] S. Purwiyanti, R. Nuryadi, and D. Hartanto, "The Modelling of Glucose Detector Using Single Electron Transistor," Procc. QIR 2010, 2010.

[6] S. Purwiyanti, R.Nuryadi, and D.Hartanto, "The Mathematical Model of Glucose Detector Using Single Electron Transistor," Procc. IceMATH 2011, 2011.

[7] S. Gupta, S.V Sandhu, H.Bansal, and D. Sharma, "Comparison of Salivary and Serum Glucose Levels in Diabetic Patients," J Diabetes Sci Technol, vol. 2, no. 3, 2014.

[8] Y. Calvinus, Electronic Properties Modeling of Finger Skin for Non-invasive Blood Glucose Sensor Design, Thesis, Jakarta: Universitas Indonesia, 2009.

[9] V. Pockevisius, V. Markevicius, M. Cepenas, D. Andriukaitis, and D. Navikas, "Blood Glucose Level Estimation Using Interdigital Electrodes," Elektronika Ir Elektrotechnika vol. 19, no. 6, 2013.

[10] V. Gomathy, Development of oxygen saturasion monitoring system by embedded electronics, Washington : University of Arkansas, Fayetteville, 2017.

[11] Hariyanto, G. Rancang Bangung Oksimeter Digital Berbasis Mikrokontroller Atmega 16. Thesis, Surabaya: Universitas Airlangga, 2012.