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# Measurement of Non-Invasive Blood Glucose Level Based Sensor Color TCS3200 and Arduino

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**Abstract.** Design and measurement of Arduino-based urinary (non-invasive) urine glucose using RGB tcs3200 sensor. This research was conducted by making use of the urine in diabetes patients detected by sensor colours then measured levels of colour based on the RGB colour of the urine of diabetics. The detection is done on 4 urine samples with each consisting of 3 diabetics and 1 non-diabetics. Equipment used in this research, among others, Arduino Uno, colour sensor tcs3200, LCD 16x4. The results showed that the detection of RGB values in diabetics 230 with blue and not diabetics 200 with red.

## 1. Introduction

Diabetes Mellitus (DM) is one of the largest number of sufferers of the disease around the world. According to the WHO, approximately 415 million people are affected by the disease of DM [1]. Whereas in Indonesia by the year 2015 was ranked seventh with number of sufferers ±10 million [2]. The disease is closely related to the rise in blood glucose levels or Hyperglycaemia [2]. Resulting in abnormalities in the metabolism of the body because the body cannot use the insulin it perfectly or does not produce any insulin at all. In the process of digestion, the food eaten to make blood glucose rise and stimulate the pancreas to producing insulin. Insulin moves sugar into the cells make to converted into energy. If too much glucose in the blood then the pancreas difficult making insulin work well [3]. Normal range blood sugar levels around ≤ 120 mg/dl [4].

Checking blood sugar levels in the diagnosis distinguished into two categories, namely minimally invasive and non-invasive techniques. Minimally invasive technique is to measure levels of glucose by way of hurting the patient's blood inside the body are taken using a needle. The weakness of this method is the use of a needle that results in pain in people with DM. Non-invasive use of biofluids techniques namely saliva, sweat, tears, and urine, is used to measure glucose levels so that this technique was felt more comfortable by diabetics [5], [6]. Research the use of urine as a basis for measuring glucose levels include: using spectroscopic method using infrared light (NIR) and photodiode using the Arduino and microcontroller, which are brought on the finger of a patient DM [7], [8], [9], [10], [11].

Each colour can be composed from the basic colours. On the basis of the colour of light has its compilation is the colour red, green and blue, or better known as the RGB (Red, Green, Blue). The colour spectrum is contained within a perfect light (white). The RGB colour model is a model based on the concept of adding strong colour radiance primer i.e. Red, Green and Blue. In a space that is absolutely no light, then the room is dark. There is no signal light waves are absorbed by the eye or RGB (0, 0, 0). When adding the red light in the room, then the room will change colour to red for

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instance RGB (255, 0, 0), all objects in the room only can be seen in red [12]. TCS3200 is a programmable IC which is the way it works to convert light into colour frequency with output signal box-shaped. The main constituent of this colour is the sensor and photodiode current to frequency converter. Sensor colour TCS3200 colour sensor light is equipped with a filter and a light base colour RGB [13].

This research created tool to measure sugar levels without having to hurt patients (non-invasive) and can be a good alternative for monitoring blood sugar levels without any pain with the use of TCS3200 sensors to detect the color of urine at sufferers of DM and not a sufferers of DM connected to the Arduino and microcontroller, as displayed on the LCD.

## 2. Theoretical Review

### *2.1. Urine*

Urine or urine is liquid waste excreted by the kidneys that would then be removed from the body through the process of the Urineasi. The excretion of urine is needed to dispose of the rest of the molecule is a molecule in the blood is filtered by kidneys and to maintain the homeostasis of bodily fluids. The urine is filtered by the kidney, brought through the ureter toward the bladder, finally being dumped out of body through the urethra (s. Nojoatmojo, 2000). In macroscopic tests include urine colour and clarity (a normal urine is yellow and crystal clear clarity or slightly turbid), smell (the smell of urine is normally a characteristic caused by volatile organic acid), the volume of urine (people normal adult urine production of approximately 1500 ml/24 hours, is useful for determining the presence of impaired kidney abnormalities Faal balance of body fluids), gravity or BJ (gives an impression about the sensitivity of urine, urine concentrations with BJ >1,030 indicates the possibility of glucose in the urine. The limit of the normal range from 1,003 – 1,030 BJ).

### *2.2. Colour Sensor of TCS3200*

TCS3200 colour sensor is the way it works to change the colour into the frequency. Made from a mixture of silicone and current to frequency converter on one circuit integration. This gave rise to a wave of censorship output box with 50% duty cycle with a proportional frequency. Pin configuration TCS3200 can be seen in Figure 1

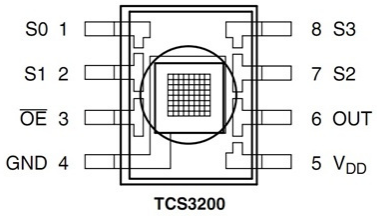


**Figure 1.** Pin TCS3200

A full-scale frequency can be set with one of the three initial values through two control input pin. On TCS3200, the sensor light to frequency converter read 8 x 8 array of photodiodes, 16 blue filter photodiodes, 16 green photodiode filters, and the last is red filter photodiode. Example of the colour sensor can be seen in Figure 2

**Figure 2.** Sensor TCS3200

PIN S2 and S3 is used to select the photodiode that want enabled. The combination of inputs for each colour can be seen in table 1.

**Table 1.** Sensor TCS3200

| S2 | S3 | Color |
|---|---|---|
| **L** | L | Red |
| **L** | H | Blue |
| **H** | L | Clear |
| **H** | H | Green |

Terminal function TCS3200 can be seen the table 2

**Table 2.** Sensor TCS3200

| Name | No | *I/O* | Description |
|---|---|---|---|
| GND | 4 | | *Ground* |
| OE | 3 | I | Active Low |
| OUT | 6 | O | Output Frequency |
| S0, S1 | 1,2 | I | Output Frequency at scale |
| S2, S3 | 7,8 | I | Type photodiode |
| VDD | 5 | | *Power Supply* |

*2.3. Arduino UNO*

Arduino UNO is a microcontroller board based on ATmega328. Arduino has a 14 pin input/output, 6 pin which can be used as PWM outputs, 6 analogue input, a 16 MHz crystal oscillator, a USB connection, power jack, head of the ICSP, and the reset button. Arduino UNO is able to download support microcontroller; can be connected to the computer using the USB cable and can be supplied with an AC adapter to the DC or battery to get started. Figure 2.3 the Board Arduino UNO.

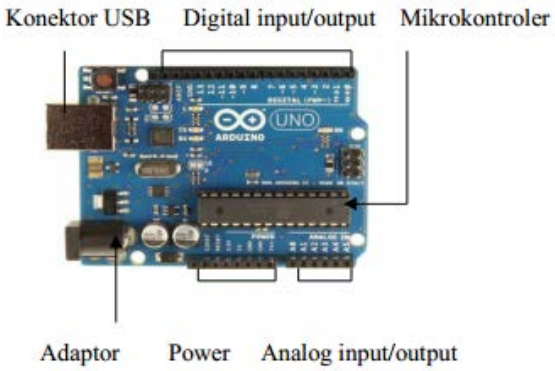


**Figure 3.** Board Arduino Uno

Board Arduino UNO has the following features:

a. Pin out 1.0: SDA and SCL pins plus closer to AREF pin and two new pin the other is placed close to pin RESET, IOREF which allows shield-shield to adjust the voltage supplied from the board. For the future, the shield will be made compatible/match the board which uses an AVR

that operates with a voltage of 5V Arduino Due and with operating voltages 3 .3V. The second is a pin is not connected, which provided for the purpose in the future.

b. Reset Circuit.
c. Atmega16U2 replaces Atmega8U2.

As for the Arduino UNO specification summary is as follows:

a. Microcontroller: ATMEGA328b.
b. Operating voltage: 5V
c. Input voltage (recommended): 7 - 12 V
d. Input voltage (limit): 6-20 V
e. Digital pin I/O: 14 (six of them is PWM pin)
f. Analog input pin: 6
g. DC current I/O pin: 40 mA
h. DC current for pin 3.3 V: 150 mA
i. Flash Memory: 32 KB with 0.5 KB to use for the bootloader
j. EEPROM: 1 KB
k. SRAM: 2 KB
l. The timing speed: 16 Mhz

## 3. Research Methodology

On the design of measuring glucose levels in urine, there are 2 main stages, namely designing hardware and designing software. The stages of design as follows:

### *3.1. Design of Hardware*

Tool test levels of glucose in the urine as described in Figure 4 blocks

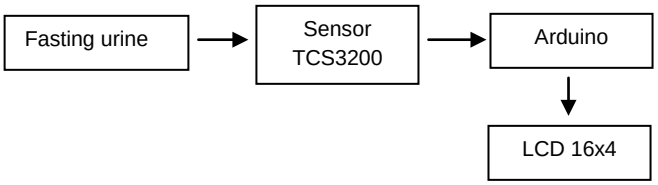


**Figure 4.** Block Diagram Tools Urine Glucose Levels

a. Fasting Urine
   Testing tool to measure levels of glucose in urine is done twice experiment using 4 samples of urine that is fasting urine 4. Fasting urine used consists of 3 DM urine and 1 is not a DM urine. Fasting Urine taken after first wake up in the morning before eating or drinking anything.
b. Sensor TCS3200
   The function to change the colour into an electric current, electric current is then converted into the form of a frequency signal box shape. Direct sensor bias output data is read by the series of Arduino UNO.
c. Arduino UNO
   A microcontroller is used the Arduino Uno. That serves as a data processing unit later in the show to the output.
d. LCD 16x4
   To display the output in the form of letters or numbers used LCD display 16 x 4, where the LCD is composed in 16 columns and 4 rows.

### *3.2. Design of Software*

Software test tools glucose levels in urine include reading frequency of the colour sensor and then displays the RGB value of the colour sensor output TCS3200 by setting a filter on the sensor mode through pin S2 and S3.

## 4. Result And Discussion

Realization of measuring glucose levels in urine as a whole looks in Figure 5

**Figure 5.** Fasting Urine Levels of measurement

Measuring blood sugar levels in urine is composed of several sections, among others; the power supply as a voltage source to switch on the measuring instrument, the calibration button is green is used as the initial calibration by using the normal urine (not a DM) before making measurement, the urine is used as shelter samples of urine, TCS3200 sensor serves to detect urine color based on RGB values, and 16 x 4 LCD is used to display data for measuring results.

Initial display on the gauge levels of glucose in urine is visible in Figure 6

**Figure 6.** Fasting urine Measurement Result

Overall tool testing done by pouring a pot of urine into the box urine and close the box made of urine in a meeting. TCS3200 sensors to detect the colour based on RGB visible in Figure 7

**Figure 7.** Fasting urine Measurement Result

The following data result measurement levels of glucose in the urine compared to lab test result are shown in Table 3

**Table 3.** Fasting Urine Measurement Result

| Kode | Color Value | | | | | | Result Value RGB | Lab Results | Result Value Lab |
|---|---|---|---|---|---|---|---|---|---|
| | R | | G | | B | | | | |
| | I | II | I | II | I | II | | | |
| **A** | 214 | 214 | 224 | 224 | 236 | 236 | Blue | ++ | |
| **B** | 211 | 209 | 217 | 214 | 230 | 230 | Blue | +++ | |
| **I** | 218 | 215 | 221 | 221 | 234 | 232 | Blue | ++++ | |
| **J** | 205 | 203 | 193 | 192 | 188 | 188 | Red | - | |

From Table 3 Result of reading levels of glucose in urine is obtained as a result of reading the sensor colour TCS3200 colour of urine that was diagnosed with DM is blue while not diagnosed DM are red. Specific value of each sample is as follows:

a. RGB values for sample code A on the first test and both have the same value i.e. R = 214, G = 224, B = 236 with the results a foregone conclusion is blue while the lab results showed the two positive (++) which means it is among 51 mg/dl up to 100 mg/dl and diagnosed DM.
b. Sample code B on the first test value of R = 211, G = 217, B = 230, in the second test of the value of R = 209, G = 230, B = 214 with the conclusion is blue with the results of the lab shows the positive three (+++) which means the value of DM medically among 101 mg/dl to with 300 mg/dl. The value of R and G on RGB to sample B has different values between the first and second experiments with difference of 3 numbers.
c. For the code samples I in the first test of the value of R = 218, G = 221, B = 234, while in the second test of the acquired value of R = 215, G = 221, B = 232 with the result of the reading is blue and shows a positive lab four hail (++++) with the range of value of DM 301 mg/dl to with 1000 mg/dl. There is a difference between the value of R and B in RGB at first and second experiments with difference value for $R_I$ and $R_{II}$3 numbers as well as $B_I$ and $B_{II}$ 2 numbers.
d. On the samples I RGB values in each experiment the first value R = 205, G = 193, B = 188. For second experiment the value R = 203, G = 192, B = 188 with a conclusion that is red

which means not diagnosed DM. Lab Results also showed a negative value (-). The experiment result between the first and second experiments had a slight difference in the value of $R_I$ and $R_{II}$ 2 numbers as well as $G_I$ and $G_{II}$ 1 numbers.

## 5. Conclusion

Based on the results of the research conducted, it can be drawn the conclusion that the gauge levels of glucose in the urine has been successfully created and analyzed. The result of two times the measurement reading RGB colour obtained results that are diagnosed DM in each urine sample produced a reading of the blue colour of the urine sample while in the not diagnosed DM are red.

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## References

[1] WHO. 2016. *Diabetes Fakta dan Angka.* Artikel:http://www.searo.who.int/indonesia/topics/8-whd2016-diabetes-fact-and numbers indonesian.pdf?=1.

[2] Kemenkes RI. 2014. *Tahun 2030 Prevalensi Diabetes Melitus di Indonesia Mencapai 21,3 Juta Orang.* Artikel. www.depkes.go.id.

[3] Akhbar, Zheni. 2014. *Rancangan Prototype Instrumen Ukur Kadar Gula Darah dengan Metode Pengenalan Warna dan Tingkat Kekeruhan Urine dalam Uji Benedict Berbasis Visual Basic.Net.* Skripsi Jurusan Teknik Elektro Fakultas Teknik Universitas Jember.

[4] Aulia Haque, Aditta Putri dkk. 2013. *Analisis Profil Potensial Listrik Pada Titik Akupuntur Untuk Diagnosis Diabetes Mellitus.* Jurnal Fisika dan Terapannya Fisika Unair. Vol. 1. No. 4. Hal. 1. Desember 2013.

[5] C.P. John et al. 2005. *In vivo Glucose Monitoring: The Clinical Reality and The Promise, Biosens*. Bioelectron. 20 (2005) 1897-1902.

[6] H.D. Park et al. 2005. *Design of portable Urine Glucose Monitoring System for Healthcare, Comput.* Biol. Med. 35 (2005) 275-286.

[7] Anas et al. 2012. *Non-Invasive Blood Glucose Measurement.* IEEE Conference on Sustainable Utilization and Development in Engineering and Technology (Student) Universiti Tunku Abdul Rahman, Kuala Lumpur Malaysia. 978-1-4673-1705-4/12/$31.00.

[8] Buda, R.A. and Mohd.Addi, M. 2014. *A Portable Non-Invasive Blood Glucose Monitoring Device.* IEEE Conference on Biomedical Engineering an Sciences Sarawak Malaysia. 978-1-4799-4084-4/14.

[9] Lawand, Komal et al. 2015. *Design And Development of Infrared LED Based Non Invasive Blood Glucometer*. IEEE Indicon. 1570186243.

[10] Tamridho, Reza. 2010. *Rancang Bangun Alat Pengukur Kadar Gula Darah.* Skripsi Fakultas Teknik Program Studi Teknik Elektro UI Depok.

[11] Vivekanandan, S. dan Devanand, S. 2015. *Remote Monitoring for Diabetes Disorder: Pilot Study Using InDiaTel Prototype.* European Research in Telemedicine 2015 4, 63 - 69. http://dx.doi.org/10.1016/j.eurtel.2015.04.002. 2212-764X/c 2015 Elsevier Masson SAS.

[12] Sutisna, Dedi., Ihsanto, Eko. 2014. *Perancangan dan Pembuatan Alat Pendeteksi Warna Menggunakan Sensor TCS3200 Pada Proses Produksi Kaleng Berbasis Arduino.* Skripsi Teknik Elektro Universitas Mercu Buana.

[13] Sutisna, Dede., and Ihasanto, Eko. 2015. *Perancangan dan Pembuatan Alat Pendeteksi Warna Menggunakan Sensor TCS3200 Pada Proses Produksi Kaleng Berbasis Arduino.* Tugas Akhir: Program Studi Teknik Elektro Universitas Mercu Buana Jakarta.

[14] Notoatmojo, S. 2000. *Metodelogi Penelitian Kesehatan.* Jakarta: Rineka Cipta.