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Dehydration Urine Color Detection as Human Dehydration Level Based on Light Emitting Diode and Light Dependent Resistors

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***Abstract*- Dehydration is a condition where the body are lack of fluids. It is because the amount of fluid that enter in the body is less of fluid than the discharge. Dehydration is something that cannot be ignored. The high incidence of dehydration is due to the difficulty of seeing the signs and symptoms of dehydration for ordinary people. This tool is designed to handle the level of human dehydration by seeing whether the urine is normal or abnormal, whether is it mild dehydration, or severe dehydration. It can handled based on the color of the urine using a tool named Light Emitting Diode Sensor (LED) and a light dependent resistor (LDR). Tool innovation is the use of rechargeable batteries and a charger module to make it easier for users to recharge exhausted batteries. On the LCD also displays the proportion of the battery to make it easier for users to see the remaining battery weaponry. This tool is expected to be able to check the dehydration among the public in order to achieve the public health status. After the process of designing, testing, collecting and analyzing data on 15 samples and reading 20 times for each sample, the result is that the tool can work well, can measure the level of dehydration according to the human urine with an average value of 62.10. The reading results that appear on the LCD are the same or according to the level of dehydration shown on the urine color chart.**

Keywords - dehydration, urine, detection, human

I. INTRODUCTION

Water is the main component and one of the nutritional elements in the human body. The body consists of 70% water content. Therefore, water intake is very important so that the organs of the body can work optimally. Every day, body needs water to be consumed, approximately 1 to 2.5 litters or as same as 6-8 glasses each day. According to the consuming mineral water can help the digestive process, regulate metabolism, regulate substances and body balance [1][2]. If water intake is not fulfilled, the body's functions do not run smoothly and become dehydrated. Dehydration is a condition in which the body is lack of fluids because the amount of fluid that enters is less than the fluid that comes out [3] The process of losing fluids in the body depends on the amount of activity [4]. Meanwhile, hydration is the balance of fluids in the body. Hydration status is associated with health and body performance [5]. Basically, dehydration is quite dangerous. If not addressed, it can be fatal and even death.

Dehydration is classified into three, such as mild dehydration, moderate dehydration, and severe dehydration. Usually, to distinguish the degree of dehydration, it can be done by matching the colour of the urine with a paper colour classification dehydration rules. This is certainly less efficient, so that many people do not pay attention to their hydration status [6]. Based on the results of the Indonesian Regional Dehydration Study (THIRST) which involved 1,200 people, it was shown that 46.1% of the Indonesian population had mild dehydration, this number was higher in adolescents, and around 49.5% compared to adults 42.5% [7][8]. Based on these data, dehydration is something that cannot be ignored. The high incidence of dehydration is due to the difficulty in knowing the signs and symptoms of dehydration for ordinary people [9].

Several studies have been conducted regarding to the dehydration detection. Rokim (2015) designed a dehydration detection device in a rectangular shape with a place to insert a bottle containing a sample so that it could be detected. The method used by these authors is to use LED and photodiode [10]. Then, Latif (2016) developed a program from Rokim's research so that not only dehydration is detected or not but also detected the level of dehydration (mild dehydration and severe dehydration) [11]. In addition, Hasani (2017) created a system that aimed to determine the condition of human body fluids using photodiode and LED to analyse the colour of body fluids [12]. However, this study had the disadvantage of being able to read urine colour correctly, because it only reads the value of the output voltage from the photodiode. Amani (2017) developed a dehydration detection system based on colour and ammonia levels in urine with TC3200 and MQ135 sensors using the naive bayes method [13]. However, from this study there is a lack data which is not directly tested on urine but uses training data[14].

From some of these studies, the detection system used still uses LEDs and photodiodes, and still uses disposable batteries. Therefore, the authors took the initiative to use a different sensor, namely the light dependent resistor (LDR). The author also uses a rechargeable battery and a charger module to make it easier for users to recharge when the battery runs out. The LCD also displays the battery percentage to make it easier for users to see what percentage of the battery is left.

The purpose of this study is to make it easier to check dehydration in the human body which can be used among the public and in *Puskemas* (PUSTU) to monitor the health status

of the public. Besides, Light Dependent resistor (LDR) "which detects the level of dehydration in the body by distinguishing 3 levels of dehydration, namely normal urine, mild dehydration and severe dehydration.

II. LITERATURE REVIEW

A. Theoretical Framework

a) Urine

Urine or urine is the waste product of metabolism excreted by the kidneys, and then excreted from the body. This is necessary to remove the remaining molecules in the blood which are filtered by the kidneys to maintain body fluid homeostasis [15].

b) Urine color

Urine color is a sign of the level of concentration of waste dissolved in urine [16]. There are many reasons for the unusual color of urine. The changes in urine color can be affected by fluid intake and medication consumption. The amount of fluid that enters in the body affects the dark or light color of the urine. The more fluids that enter, the lighter color of the urine. Other causes that may be more serious to make urine color unusual is the presence of certain medical conditions or diseases [17], [18].The following things might happen when the urine changes color:

1. Pale yellow to gold.
   Pale yellow urine to gold is a natural thing because the color comes from the body pigments and indicates that everything is normal and healthy.
2. No color/clear.
   Urine that has no color or clear occurs because of enough water consumption.
3. Deep dark yellow or brown.
   Urine, which has a very dark yellow or brown color, is a sign that the body is dehydrated and must immediately get more fluid [19].

A person who is dehydrated can be seen through the color of the urine and the clarity of the urine that is excreted. This is what can be determine by someone is acutely dehydrated or not. If the color of the urine is clear, this indicates a person has a good hydration status. Conversely, if the color of urine becomes dark yellow, then the person is dehydrated [16]. The color of urine can turn dark yellow (thick) because the high concentration of compounds in the urine that can make the color darker. In Figure 1, there is a urine color chart to see whether there is dehydration or not in the body[20] .

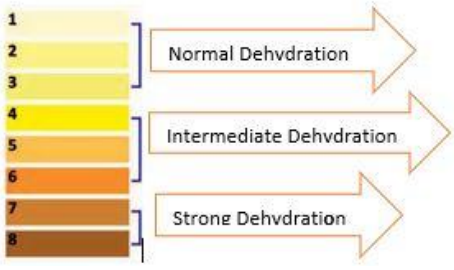

Fig. 1. Urine *Color Chart* [14].

If the urine color is 1-3, then the urine is normal or well-hydrated, if the urine is 4-6 the urine is mildly dehydrated or poorly hydrated, and if the urine is at number 7-8 is urine with a high degree of dehydration or lack of fluids[22]

c) Dehydration

The condition when the body does not get enough water or loses water about 5% Dehydration is a condition of losing excess body fluids that can be caused by several conditions such as diarrhea, sweating, or urine elimination. Dehydration greatly affects the kidneys because the kidneys has a function to filter blood in the body, maintain fluid balance in the body, and maintain electrolyte levels in the body [19].

According to the Asian Food Information Center, dehydration is divided into three groups, they are mild dehydration, moderate dehydration, and severe dehydration. Dehydration can disrupt the balance and regulation of body temperature and at a very severe level it can lead to decreased consciousness and coma. Dehydration can be a risk factor for obesity in children and adolescents. This is caused by an electrolyte imbalance in the body which spurs an increase in appetite and intake of foods rich in fat so that fluid intake in the body decreases . Adequate hydration is essential for maintaining physical and mental function[23].

Dehydration or lack of fluids in the body triggers health problems. Starting from minor disorders such as drowsiness to serious illnesses such as decreased kidney function. In severe dehydration, there is fluid loss equal to or more than 10% of body weight [24]

d) Light Emitting Diode(LED)

Light Emitting Diodes or often abbreviated as LEDs are electronic components that can emit monochromatic light when applied forward bias. LED belongs to a family of diodes made from semiconductor materials. such as gallium arsenide phosphide (GaAsP), gallium phosphide (GaP), and gallium aluminum arsenide (GaAlAs) [25]. The colors of light emitted by LEDs depend on the type of semiconductor material it uses [26][27]. The shape of the LED can be seen in Figure 2. This LED is similar to a small bulb (light bulb) and can be easily inserted into various electronic devices. In contrast to incandescent lamps, LEDs do not require the filament burning, so that they do not cause heat to produce light

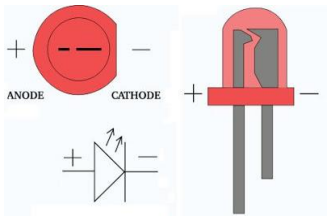

Fig. 2. LED

e) LDR Sensor

Light Dependent Resistor (LDR) is a type of resistor whose resistance if there is a change in light reception [28]. LDR is often referred as a device or sensor in the form of resistor that is sensitive to light [29]. The amount of resistance value depends on the size of the light received by the LDR itself. LDR is usually made of Cadmium Sulfide

(CdS) and Cadmium Selenide (CdSe*)*, which is a semiconductor material in which the resistance changes depending on the amount of light (rays) encounter. As seen in Figure 3 is a physical form of the LDR sensor.

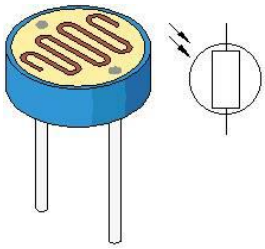

Fig. 3. The LDR sensor *symbol* and physical form

f) ATmega AVR Microcontroller 8

AVR is a type of microcontroller in which there are various functions, with RISC (Reduced Instruction Set Computing) technology [30]. The advantage of the AVR is that it has a power-on reset, no need to reset a button from the outside, it is just turn off the automatic supply so the AVR will reset it [31]. For some types of AVR there are several special functions such as ADC, EEPROM which around 128 bytes to 512 bytes [32]. AT mega 8 pins configuration can be seen in Figure 4.

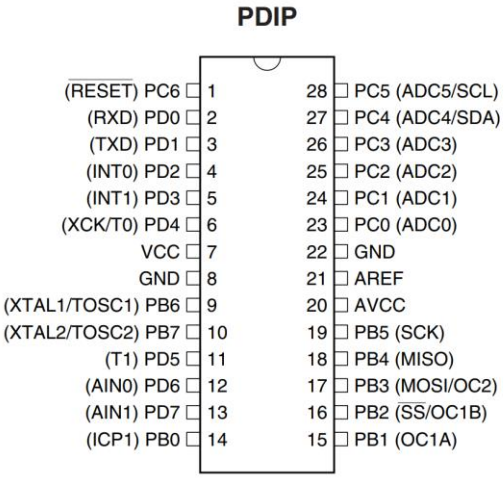

Fig. 4. Atmega 8 pin configuration

ATmega8 has 28 pins, each of pins has a different function, and they can be both as a pin and other functions [33][34].

III. RESEARCH METHODS

The method used in this study consisted of several stages, namely: *hardware* design, *software* design, instrument testing, and data collection.

A. Hardware and Software Design

Several circuits, including the minimum ATmega8 system circuit series and the sensor circuit, were used in this study as *hardware* design. While the software used was the CVAVR programming *software* as a data processing tool. The sensors used in the instrument were LED and LDR sensors.

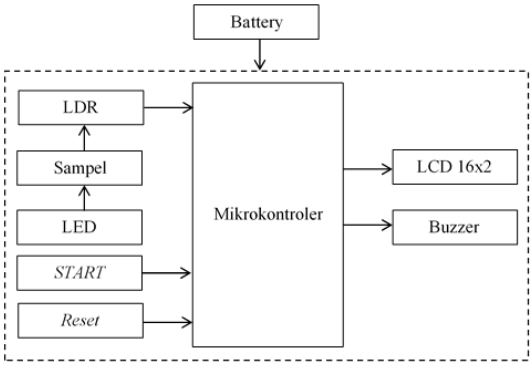

Fig. 5. System Block Diagram

In Figure 5 is a block diagram of a dehydration level detection system. When the device is turned on, the battery will supply voltage to the entire circuit. Press the *start* button to get the instrument started. The LED will emit light, which will then penetrate the sample. The amount of light received by the LDR will be processed in the ATmega8 microcontroller. LCD functions as a viewer reading results. *Buzzer* functions as a marker when the tool detects the level of mild dehydration and severe dehydration and the *reset* functions to restore the initial condition. The software in the device for processing the signal obtained from the driver using a CVAVR microcontroller as a data processor. The design of the tool module can be seen in Figure 6

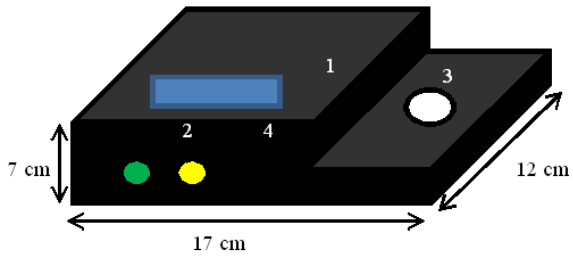

Fig. 6. Dehydration Detector Module Design.

Information:
1. LCD
2. START
3. Sample container
4. Reset

B. Testing Tools and Data Retrieval

In Figure 7 is a process flow chart for reading the level of dehydration. When it starts, the LCD initialization will occur then when there is a sample, the sample will be detected then analyzed, the analysis results will be displayed on the LCD. When finished, the tool is turned off and stored in its original place

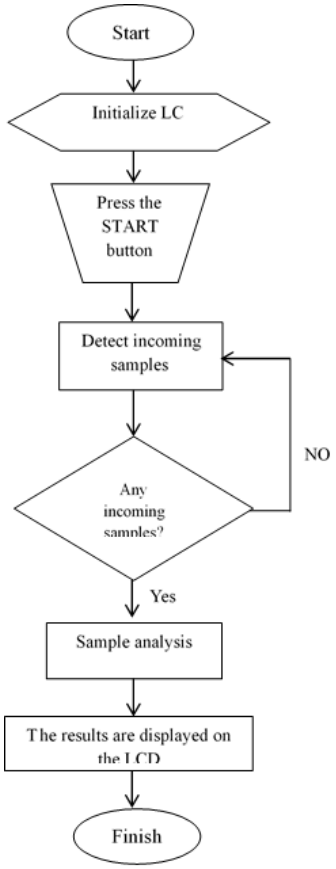

Fig. 7. Flow Chart Block

IV. RESULTS AND DISCUSSION

In Table 1 shows the reading data using a sample that has been made by the researcher. It shows the color is the same as 8 colors on the urine color chart, shown in Figure 1. Referring to Figure 1, colors 1-3 are normal urine conditions / safe zone and maintain fluid consumption, Color 4-6 is a condition of mild dehydrated urine, immediately consume fluids, and color 7-8 is a condition where severe dehydration of urine, it requires immediate consumption of fluids.

TABLE I. COLOR SAMPLES READING RESULTS

The colors made based on Urine Color Chart	***Prototype***	**ADC Reading**					***Buzzer***
		1	2	3	4	5	
1	Safe Zone	62	62	62	63	63	*Off*
2	Safe Zone	64	64	64	64	65	*Off*
3	Safe Zone	69	69	70	71	71	*Off*
4	Mild Dehydration	75	75	76	76	77	*On*
5	Dehydration Mild	79	79	79	79	79	*On*
6	Mild Dehydration	85	86	86	86	87	*On*
7	Severe Dehydration	111	111	111	112	113	*On*
8	Severe Dehydration	121	121	122	120	121	*On*

Table 2 is the reading data for self-made samples according to the eight colors in the urine color chart. Tests on this sample were carried out five times with a gap of 10 seconds in each reader. Of the eight self-made color samples, the samples seen using the urine color chart were the same as those read by the research prototype. At a normal level / safe zone reading and mild dehydration, the *buzzer* would not sound, the *buzzer* would sound when the sample detected was a sample with mild dehydration and severe dehydration.

TABLE II. RESULTS OF URINE READING FROM 20 TRIALS

Urine Sample	**Urine color chart In (figure 2.1)**	**prototype**	**ADC 20 attempts Mean**	**Buzzer**
Patient 1	1	Safe Zone Maintain Fluid Consumption	55.95	*Off*
Patient 2	2	Safe Zone Maintain Fluid Consumption	61.05	*Off*
Patient 3	3	Safe Zone Maintain Fluid Consumption	72.15	*Off*
Patient 4	4	Mild Dehydration Consume Fluid Shortly	76.80	*Off*

V. CONCLUSION

Based on the results obtained after the process of designing, testing, collecting and analyzing the data, it can be concluded that LDR sensor is able to detect the intensity of the light provided by the LED so that it can detect the level of dehydration based on the color of human urine. It was tested by 15 samples and reading as many as 20 times on each sample. It can obtain an average of 62.10 with the reading results displayed on the LCD or as same as the level of dehydration that shown on the urine color graph.

REFERENCES

[1] I. P. T. P. Sari, "Tingkat Pengetahuan Tentang Pentingnya Mengkonsumsi Air Mineral Pada Siswa Kelas IV Di Sd Negeri Keputran a Yogyakarta," *J. Pendidik. Jasm. Indones.*, vol. 10, no. November, pp. 55–61, 2014.

[2] J. Senecal, A. Nordin, P. Simha, and B. Vinnerås, "Hygiene aspect of treating human urine by alkaline dehydration," *Water Res.*, vol. 144, pp. 474–481, 2018.

[3] B. A. Yates, L. A. Ellis, C. X. Muñoz, and L. E. Armstrong, "Diagnostic accuracy of urinary indices to detect mild dehydration in young men following acute riboflavin, Vitamin C or beetroot supplementation," *Clin. Nutr. ESPEN*, vol. 37, pp. 129–133, 2020.

[4] J. Beurskens-Meijerink *et al.*, "Validation of sodium concentration in urine using point-of-care testing; feasibility to detect dehydration in patients with an ileostomy or short bowel," *Clin. Nutr.*, vol. 37, no. 2018, p. S100, 2018.

[5] M. Ring, S. Member, C. Lohmueller, M. Rauh, J. Mester, and B. M. Eskofier, "Estimation During Physical Exercise," vol. 21, no. 5, pp. 1306–1314, 2017.

[6] D. R. Cornish, Y. C. H. Lee, M. Von Poser, K. J. Nixon, and I. R. Jandrell, "Investigation of the dehydration effects of lightning impulses," *2014 Int. Conf. Light. Prot. ICLP 2014*, pp. 1467–1471, 2014.

[7] R. Halim, M. Hana, and M. Mardhiyah, "Gambaran Asupan Cairan Dan Status Gizi Pada Mahasiswa Kedokteran Universitas Jambi," *JAMBI Med. J. "Jurnal Kedokt. dan Kesehatan,"* vol. 6, no. 1, pp. 68–75, 2018.

[8] D. Benton, "Dehydration influences mood and Cognition: A Plausible Hypothesis?," *Nutrients*, vol. 3, no. 5, pp. 555–573, 2011.

[9] N. Pross, "Effects of Dehydration on Brain Functioning: A Life-Span Perspective," *Ann. Nutr. Metab.*, vol. 70, no. Suppl1, pp. 30–36, 2017.

[10] P. S. Fisika, F. Sains, D. A. N. Teknologi, U. Islam, and N. Sunan, "Menggunakan Led Dan Fotodioda Melalui Warna Urine," 2015.

[11] N. Latif, "Pengembangan alat deteksi tingkat dehidrasi berdasarkan warna urine menggunakan led dan fotodioda," *Prodi Stud. Fis. Fak. Sains dan Teknol. UIN Sunan Kalijaga*, pp. 1–42, 2016.

[12] M. C. Hasani, "Elektroanaliser pada Pengukuran Cairan Tubuh," *Semin. Nas. Teknol. dan Rekayasa*, no. eISSN 2527-6050, pp. 1–3, 2017.

[13] R. Z. Amani, R. Maulana, and D. Syauqy, "Sistem Pendeteksi Dehidrasi Berdasarkan Warna dan Kadar Amonia pada Urin Berbasis Sensor TCS3200 Dan MQ135 dengan Metode Naive Bayes," *Pengemb. Teknol. Inf. dan Ilmu Komput.*, vol. 1, no. 5, pp. 436–444, 2017.

[14] Z. Huang, C. Huang, and X. Luo, "Influence of the thermal contact resistance on the thermoelectric property of PANI/Ag nanocomposites," *Solid State Commun.*, vol. 276, no. March, pp. 37–41, 2018.

[15] P. Simha, J. Senecal, A. Nordin, C. Lalander, and B. Vinnerås, "Alkaline dehydration of anion–exchanged human urine: Volume reduction, nutrient recovery and process optimisation," *Water Res.*, vol. 142, pp. 325–336, 2018.

[16] C. Asogwa, S. Collins, P. Mclaughlin, and D. Lai, "A Galvanic Coupling Method for Assessing Hydration Rates," *Electronics*, vol. 5, no. 4, p. 39, 2016.

[17] J. Riungu, M. Ronteltap, and J. B. van Lier, "Build-up and impact of volatile fatty acids on E. coli and A. lumbricoides during co-digestion of urine diverting dehydrating toilet (UDDT-F) faeces," *J. Environ. Manage.*, vol. 215, pp. 22–31, 2018.

[18] R. J. Maughan *et al.*, "A randomized trial to assess the potential of different beverages to affect hydration status: Development of a beverage hydration index," *Am. J. Clin. Nutr.*, vol. 103, no. 3, pp. 717–723, 2016.

[19] C. Roncal-Jimenez, M. A. Lanaspa, T. Jensen, L. G. Sanchez-Lozada, and R. J. Johnson, "Mechanisms by which dehydration may lead to chronic kidney disease," *Ann. Nutr. Metab.*, vol. 66, no. suppl 3, pp. 10–13, 2015.

[20] P. J. McIntire, I. Kilic, E. M. Wojcik, G. A. Barkan, and S. E. Pambuccian, "The color of urine: then and now—a comprehensive review of the literature with emphasis on intracytoplasmic pigments encountered in urinary cytology," *J. Am. Soc. Cytopathol.*, vol. 9, no. 1, pp. 9–19, 2020.

[21] Y. D. Yulianti, "Indikasi Warna Urine dan pencegahan Dehidrasi saat puasa," *puffydevil.blogspot*, 2014. .

[22] S. Sajjad *et al.*, "Differential proteomic analyses of green microalga Ettlia sp. at various dehydration levels," *Plant Physiol. Biochem.*, vol. 146, no. July 2019, pp. 198–210, 2020.

[23] E. Dupouy and M. Gurinovic, "Sustainable food systems for healthy diets in Europe and Central Asia: Introduction to the special issue," *Food Policy*, no. June, p. 101952, 2020.

[24] K. B. Jayasekara *et al.*, "Relevance of heat stress and dehydration to chronic kidney disease (CKDu) in Sri Lanka," *Prev. Med. Reports*, vol. 15, no. April, p. 100928, 2019.

[25] X. Zhang, Z. Bian, X. Yuan, X. Chen, and C. Lu, "A review on the effects of light-emitting diode (LED) light on the nutrients of sprouts and microgreens," *Trends Food Sci. Technol.*, vol. 99, no. January 2019, pp. 203–216, 2020.

[26] N. Aburai, R. Kunishima, F. Iijima, and K. Fujii, "Effects of light-emitting diodes (LEDs) on lipid production of the aerial microalga Coccomyxa sp. KGU-D001 under liquid- and aerial-phase conditions," *J. Biotechnol.*, vol. 323, no. April, pp. 274–282, 2020.

[27] A. I. Mardianto, E. M. Setiawatie, W. P. Lestari, A. Rasheed, and S. D. Astuti, "Photodynamic Inactivation of Streptococcus mutan Bacteri with Photosensitizer Moringa oleifera Activated by Light Emitting Diode (LED)," *J. Phys. Conf. Ser.*, vol. 1505, no. 1, 2020.

[28] I. Rawal, N. Dwivedi, R. K. Tripathi, O. S. Panwar, and H. K. Malik, "Organic-inorganic hybrid nanomaterials for advanced light dependent resistors," *Mater. Chem. Phys.*, vol. 202, pp. 169–176, 2017.

[29] C. M. Ojeda and J. C. Dela Cruz, "Analysis on the Optical Response of Ldr and Phototransistor in Photoplethysmography," *Sens. Bio-Sensing Res.*, vol. 28, no. March, p. 100334, 2020.

[30] M. Gulan, G. Takács, N. Anh Nguyen, S. Olaru, P. Rodriguez-Ayerbe, and B. Rohaľ-Ilkiv, "Embedded linear model predictive control for 8-bit microcontrollers via convex lifting," *IFAC-PapersOnLine*, vol. 50, no. 1, pp. 10697–10704, 2017.

[31] M. Miftakul Amin, M. Azel Aji Nugratama, A. Maseleno, M. Huda, and K. A. Jasmi, "Design of cigarette disposal blower and automatic freshner using MQ-5 sensor based on atmega 8535 microcontroller," *Int. J. Eng. Technol.*, vol. 7, no. 3, pp. 1108–1113, 2018.

[32] J. Spale, "Home automation with a low-cost AVR-based board," *IFAC-PapersOnLine*, vol. 28, no. 4, pp. 398–403, 2015.

[33] D. G. Zhang, D. C. Dong, and H. T. Peng, "Research on development of embedded uninterruptable power supply system for IOT-based mobile service," *Comput. Electr. Eng.*, vol. 38, no. 6, pp. 1377–1387, 2012.

[34] C. Mde, "Spesifikasi ATmega 8," 2008.