Decubitus pump health device implementation with pressure sensor based on Atmega 328

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Abstract. The decubitus, also known as pressure ulcer, is a wound that occurs due to pressure mainly on the protruding bones due to the patient is lying in bed on long time. This research purpose is to help prevent decubitus sores for immobility patients who are more bedridden during treatment at the hospital. This research module is a special mattress with an automatic pump which is equipped with an air pressure monitoring system on the mattress. The MPX5700 sensor measures mattress pressure. On the module testing, it can be observing that the largest error value on the low setting value measurement that is 2.25 % while the smallest error value on high setting measurement that is 1.84 %. Based on the results of tests and supported by the research, it can be concluded that the decubitus pump module can run well because it is still at the error tolerance threshold at ± 5 %.

1. Introduction

In Indonesia, the incidence of pressure sores patient treated in the ICU (Intensive Care Unit) reaches 33 %. This is very high when it is compared to the incidence of pressure sores in Southeast Asia which ranges from 2.1 % - 31.3 % [1]. In Moewardi Solo Hospital, 38.18 % of patients suffer decubitus and Abdul Wahab Sjahranie Hospital in Samarinda obtained 26.44 % had pressure sores patient in the period June to December 2014, and RSI Sultan Agung Hospital patients who had pressure sores were 40.3 % in July 2016 to October 2017. The ICU (Intensive Care Unit) room is used to treat patients with critical conditions or have severe disease rates. Of course, patients treated in this room take a long time to treat until the patient's body condition increase [1][2]. Patients treated in this room are immobility patients who have limited energy to do any activities as with the healthy patient [3][4]. So that more patients lying in bed causing a portion of his body suffered a wound known in the medical term named decubitus [3]. Pressure ulcers also known as decubitus are sores that appear due to pressure mainly on the protruding bones due to lying in bed for a long time [5][2].

Patients who has limited activity can be known to have symptoms or early signs of decubitus sores in more than 6 hours [6][7]. The main cause of decubitus sores is pressure which can cause soft tissue ischemia. Pressure sores indicate necrosis or death of local tissue due to few blood flow, this often occurs in prominent parts of the body, namely the elbows, heels, hips, ankles, shoulders, back and back of the head [8][9]. The decubitus injuries certainly need special attention because it is a serious problem because it has a significant impact on physical health and quality of life can even cause death. The decubitus prevention procedure cites from the American Health of Care Plan Resources (AHCPR)
clinical practice guide to prevent the decubitus; the first step is to minimalize pressure with a mattress or a special bed mattress. Prevention of pressure sores should focus more on efforts to prevent excessive and continuous pressure [10][11][8][2][12]. Preventing the decubitus sores including giving a special mattress. In previous studies the prevention of decubitus wounds was carried out by using a soft coating device which was formed in a circle like a donut made of silicone (gel), and mounted on the patient's heel with skeletal traction attached so that the heel did not get pressure due to the process immobilization [13][1].

This research was only able to prevent decubitus sores on the heel area, whereas other prominent parts of the body such as the elbows, hips, ankles, shoulders, back and head of the back will have a risk of pressure sores, then further research on the prevention of decubitus wounds were carried out by using special mattress equipped with air pumps. The making of this module uses additional components that is solenoid valve 3/2 which has three valves, namely the inlet, outlet and exhaust valves. This solenoid functions as an automatic valve for the input and output of the wind that connects the compressor and the mattress. The mattress that are used for all the bearings are connected to each other, therefore in this module the process of filling and discharging wind occurs alternately [14][15][16].

The research module cannot display the air pressure that inside on the mattress and the use of a solenoid as a regulator of the air valve causes the overheated solenoid which causes the solenoid to stop working when used for a long period of time, so the use of solenoid on this module becomes unfavorable. From the problems above, a decubitus pump was designed for the prevention of decubitus wounds in the form of a special mattress with an automatic air pump system and equipped with a pressure sensor MPX5700 for monitoring air pressure in a special mattress based on Arduino. The mattress in this research was designed as well as possible with the aim of providing prevention of decubitus wounds to the patients during treatment in the hospital. In this tool uses an LCD display (Liquid Crystal Display) with a good interface that serves to display the value of the existing air pressure on the mattress. This module innovation was made as a prevention to the occurrence of decubitus sores, which is caused by lying down for a long time during treatment in hospital.

2. Methodology
The method used in this research consists of several stages that is hardware design, software design, module testing, and data retrieval. The hardware design of the research module uses a number of circuits including the ATMega328 minimum system circuit. While the software used is Arduino programming software as a data processor. In Figure 2 is a minimum system circuit. Then The Figure 2 is a block diagram decubitus pump module.

![Figure 1. The Minimum System Circuit](image)
Figure 2. Block Diagram System

The working principle of this module is when the power supply gets an input voltage of 220 VAC from PLN, the power supply will supply a voltage of +12 VDC at the minimum system circuit and at the same time will supply a +5 VDC voltage for the pressure sensor circuit and synchronous motor driver. Then press the settings button as needed then the pump will drain air to the mattress. The ATMega 328P as a microcontroller that rule the work of the module. The software for processing signals using Arduino as data processing.

Figure 3. Flowchart
This power supply unit circuit on Figure 4 is used to reduce the voltage from a 220 V to a voltage of 12 V required as a step-down transformer. Meanwhile, to change the waveform from an AC to DC signal several steps are required. These stages include the rectification stage (rectifier), filtering (filter) and the regulation stage (regulator). After the electrical voltage signal comes out of the transformer, the voltage is still in the form of an AC signal. So to synchronize it requires a bridge diode circuit. This bridge diode circuit is also known as a full wave rectifier. But the output of this circuit is still in the form of half sinusoidal waves. Because the voltage is not constant, the voltage must be filtered to make the voltage more stable. The filter circuit in the power supply circuit uses capacitor components. Capacitors is used to filter the electrical signals that have low frequencies, so that most AC electrical signals will be eliminated. The output of this filter circuit looks more stable than before. Even though it has been through the filtering process, the shape of the filter output signal is still not good enough because it is still bumpy even though a little.

3. Result and Discussion
The testing of this module by comparing the pressure read by the MPX5700 sensor on the module and using a comparator device. The data is collected 20 times using namely Fluke DPM4 tools.

| No. | Decubitus Pump | Sensor 1 | Fluke DPM4 |
|-----|----------------|----------|------------|
| 1   | 2.0            | 1.8      |
| 2   | 2.0            | 1.9      |
| 3   | 2.0            | 2.1      |
| 4   | 2.5            | 3.0      |
| 5   | 2.0            | 2.1      |
| 6   | 2.0            | 2.2      |
| 7   | 2.5            | 2.4      |
| 8   | 2.0            | 2.1      |
| 9   | 2.0            | 2.2      |
| 10  | 2.3            | 2.1      |
| 11  | 2.0            | 3.0      |
| 12  | 2.3            | 2.1      |
| 13  | 2.0            | 2.1      |
| 14  | 2.0            | 2.0      |
| 15  | 2.0            | 2.4      |
| 16  | 2.8            | 3.0      |
| 17  | 2.2            | 2.1      |
| 18  | 2.7            | 2.4      |
| 19  | 2.0            | 2.1      |
| 20  | 2.1            | 2.0      |
| Mean| 2.17           | 2.22     |
| Standard Deviation| 0.05 |
| % Error | 2.25 |

Based on the test results shown at Table 1 of the suitability of the decubitus pump using the Fluke DPM4 comparator on the low pressure setting the reference value and data collection were performed 20 times, the average sensor 1 obtained on the module was 2.17 kPa while the average value obtained
by the comparator device was 2.22 kPa with a sensor deviation value of 1, 0.05 and an error of 2.25 %, which means the error value obtained is still within the tolerance threshold of ± 5 %.

Figure 4. The Power Supply Unit Circuit

4. Conclusion
After making the research with this stage that is the module and the literature review, planning, testing module and data collection, it can be concluded as follows.
1. Obtaining the largest error value on the pressure measurement value with a low setting of 2.25% and the smallest error value on the pressure measurement with a high setting is 1.84 %.
2. The decubitus pump module can run well, because it is still within the tolerance threshold of ± 5 %

References

[1] E. Loniza, H. Habiburrahman, and S. Ariwibowo, “Prototype Injeksi Insulin Pump Dengan Control Panel Arduino Uno,” Med. Tek. J. Tek. Elektromedik Indones., vol. 1, no. 2, pp. 1–5, 2020.
[2] N. H. Wijaya, B. Untara, and I. Khoirunnisa, “Monitoring Tekanan Gas Medis Pada Instalasi Gas Medis Rumah Sakit,” Med. Tek. J. Tek. Elektromedik Indones., vol. 1, no. 1, pp. 2–7, 2019.
[3] Yuhefizar, A. Nasution, R. Putra, E. Asri, and D. Satria, “IoT: Heart Rate Monitoring Tool Using Android with Alert Messanger Telegram System,” IOP Conf. Ser. Mater. Sci. Eng., vol. 846, no. 1, 2020.
[4] N. H. Wijaya, Budimansyah, and D. Sukwono, “Wireless X-ray Machine Control Based on Arduino with Kv Parameters,” J. Phys. Conf. Ser., vol. 1430, p. 012040, Jan. 2020.
[5] M. Safitri, W. D. Iswara, and T. Harjono, “Blood Bag Shaker Dilengkapi Pemilihan Kecepatan Motor,” Med. Tek. J. Tek. Elektromedik Indones., vol. 1, no. 2, 2020.
[6] E. Loniza, D. C. Dhamayanti, M. Safitri, and U. M. Yogyakarta, “Dehydration Urine Color Detection as Human Dehydration Level Based on Light Emitting Diode and Light Dependent Resistors,” J. Robot. Control, vol. 2, no. 3, pp. 140–144, 2021.
[7] G. Santoso, S. Hani, S. Kristiyana, and Y. A. Saputra, “Design Non-Invasive of Blood Sugar Detector Prototypes Using Cellular Technology GPS-Based,” J. Phys. Conf. Ser., vol. 1381, no. 1, 2019.
[8] Subekti, A. Budi Setiawan, and A. Hammid, “Simulation of Robot Arm for Diabetes Mellitus Patients,” J. Phys. Conf. Ser., vol. 1424, p. 012041, Dec. 2019.
[9] N. Yasmin Khairani Zakaria, H. Zaini, S. Siraj, M. Md Yunus, and H. Hashim, “Learning of Medicinal Herbs Using QR Codes,” J. Phys. Conf. Ser., vol. 1424, p. 012049, Dec. 2019.
[10] T. P. Tunngal, S. A. Juliani, H. A. Widodo, R. A. Atmoko, and P. T. Nguyen, “The Design of Digital Heart Rate Meter Using Microcontroller,” J. Robot. Control, vol. 1, no. 5, pp. 141–144, 2020.
[11] D. S. Putra, M. A. Ihsan, A. D. Kuraesin, Mustakim, G. S. Achmad Daengs, and I. B. A. I. Iswara, “Electromyography (EMG) signal classification for wrist movement using naïve bayes classifier,” J. Phys. Conf. Ser., vol. 1424, p. 012013, Dec. 2019.
[12] H. R. Fajrin, U. Zakiyyah, and K. Supriyadi, “Alat Pengukur Ph Berbasis Arduino,” Med. Tek.
[13] Y. Mukhlis, E. Triawati, and V. Ernita, “Design System on Chip PreAmp Embedded on Electrocardiograph Based 0.35 CMOS Technology,” *J. Phys. Conf. Ser.*, vol. 1175, no. 1, pp. 0–9, 2019.

[14] H. R. Fajrin, R. N. Adnan, M. Irfan, and I. P. Sari, “Electronic Snellen Chart with Bluetooth Connection and Smartphone App,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 851, p. 012018, 2020.

[15] H. R. Fajrin, M. R. Ilahi, B. S. Handoko, and I. P. Sari, “Body temperature monitoring based on telemedicine,” *J. Phys. Conf. Ser.*, vol. 1381, no. 1, 2019.

[16] I. P. Sari and H. R. Fajrin, “Mobile augmented reality using cloud database for interactive museum guiding system,” *J. Phys. Conf. Ser.*, vol. 1193, no. 1, 2019.