Jurnal Teknokes
Multidisciplinary : Rapid Review : Open Access Journal **Vol. 15, No. 1, March 2022, pp. 21-27** **ISSN: 2407-896**

RESEARCH ARTICLE **OPEN ACCESS**

Manuscript received February 10, 2022; revised February 17, 2021; accepted March 1, 2022; date of publication March 20, 2022
Digital Object Identifier (DOI): https://doi.org/10.35882/teknokes.v15i1.4

How to cite Anita Miftahul Maghfiroh, Nina Havilda, and D. Silas Stephen, "Development of Infusion Device Analyzer Equipped with Occlusion Detection and a Real-Time Parameters Monitoring on Computer System ", Jurnal Teknokes, vol. 15, no. 1, pp. 21–27, March. 2022.

Development of Infusion Device Analyzer Equipped with Occlusion Detection and a Real-Time Parameters Monitoring on Computer System

Anita Miftahul Maghfiroh[1,#], Nina Havilda[1], and D. Silas Stephen[2]
[1] Departement of Electromedical Engineering Poltekkes Kemenkes, Surabaya, INDONESIA
[2] Panimalar Engineering College, Chennai, INDIA

Email: (anitamiftah@poltekkesdepkes-sby.ac.id, silasstephen@gmail.com)

[#]Corresponding author: Anita Miftahul Maghfiroh (e-mail: anitamiftah@poltekkesdepkes-sby.ac.id).

ABSTRACT Medical infusion device provides drugs or fluids directly through a blood vessel. However, the occurrence of occlusion in the infusion device causes the incoming drug fluid does not to flow constantly, and pressure is formed on the infusion tube. When an infusion device has been used for a long time, there will be a change in the precision of the flow and pressure values. Furthermore, a calibration process must be carried out at least once a year. This research aims to design an infusion device analyzer which able to show parameters in a graphic equipped with occlusion parameters and Bluetooth communication in real-time to the computer unit. This study uses a solenoid valve for pressure simulation. The allowable occlusion limit is <20 Psi. The SKU 237545 sensor detects the water pressure that is blocked by the solenoid valve. Then the data will be displayed on the Parallax data acquisitions using Bluetooth communication. The Parallax data acquisitions will display real-time occlusion data, data averages, instant values, and graphs. The results of the IDA design, when tested using the Syringe Pump TOP 5300, obtained an average of 0.68 Psi. Meanwhile, when the IDA design was tested using the Infusion Pump 3300, it brought 0.73 Psi. Furthermore, it showed that the occlusion parameter was compared with the Fluke IDA 4, a mean error was 0.7 Psi. Therefore, it can be concluded that this IDA design can be used for calibration to see the feasibility of an infusion pump or syringe pump.

INDEX TERMS Bluetooth, Calibration, Occlusion, Parallax Data Acquisitions.

I. INTRODUCTION

Infusion is the introduction of a fluid or drug into the body through the intravenous route at a constant rate over a certain period of time [1]. In modern medical practice, up to 80% of hospitalized patients receive intravenous therapy. Drugs, fluids, nutrients, and blood products [2]. Medical infusion devices are widely used because they are very important in primary health care, namely for administering drugs, nutrition, and hydration to patients [3][4]. Problems that often arise are occlusion caused by mechanical resistance, bent intravenous catheter, hypertension blood pressure [5]. If left unchecked, swelling will occur. In order to ensure that this does not happen, calibration is required at least once a year [6][7]. It is also necessary to pay attention to how to determine the accuracy of the data in carrying out calibration readings. The time lag that occurs when the operator sees the indicator and then records it manually or an error in reading by the operator's eye is most likely to cause the large measurement uncertainty [8]. This is where the function of using graphs is to see if there is empty data or writing errors, and compare data in graph form [9]. It is also important to carry out the infusion pump calibration function to ensure that the tool is suitable for use

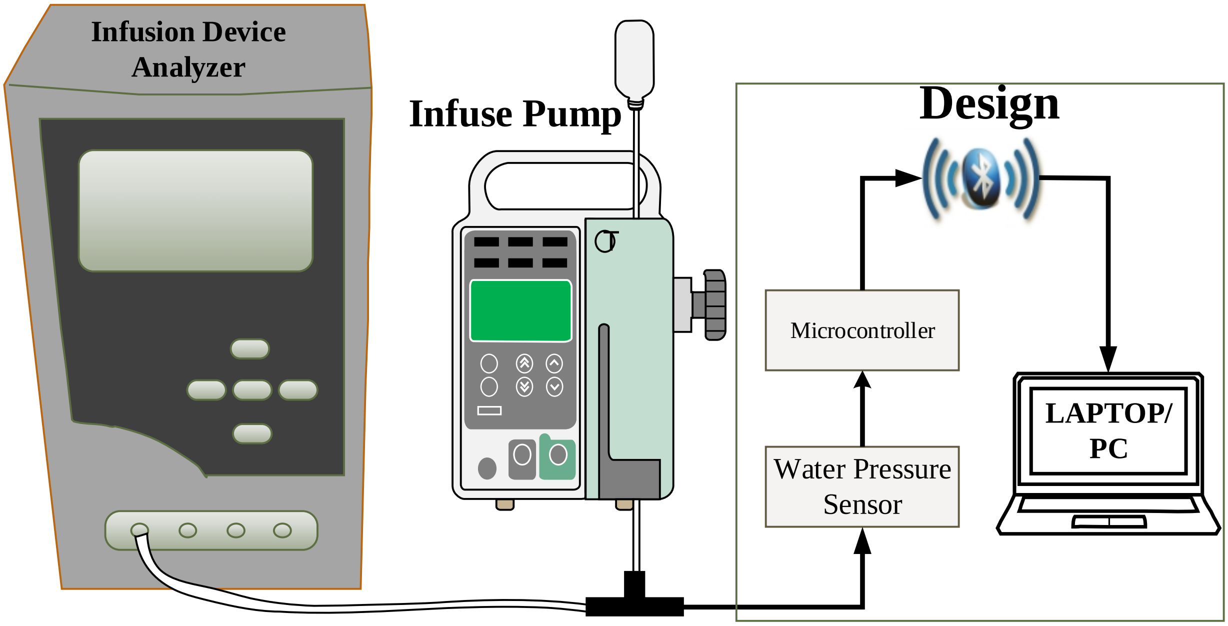

FIGURE 1. Block diagram infusion design analyzer consists of a system water pressure sensor then controlled by a microcontroller then the output is sent via bluetooth for monitoring via a computer unit

[3]. The infusion pump calibration tool is the Infusion Device Analyzer (IDA) [10].

The design of the infusion device analyzer (IDA) was carried out by several researchers [11][12][13]. Meanwhile, research has also been carried out for data transmission technology and application usage [14]. Andjar pudji at al., IDA design has also been investigated by utilizing a photodiode sensor for sensor sensitivity for flowrate detection [11][15]. In this system, the photodiode is used for the flowrate sensor and the data is stored in the SD-Card. However, the speed of the Syringe pump or infusion pump is not stable. Nuntachai Thongpance et al. made an infusion pump calibrator with the principles of physics, electronics, and a microcontroller [13] consisting of a load and pressure sensor, then N Thongpance et al., IDA has been developed has been made equipped with a construction analysis. A load cell sensor is used to measure the flow rate value. However, the cost of making the tool is too expensive [12].

Safira Pintasari, in 2019 developed a tool that is able to detect the flow rate and volume of fluid in infusions. In data processing, this tool uses an Atmega 328 microcontroller with an LCD and is equipped with a buzzer indicator, where the buzzer will sound when the infrared photodiode sensor has determined the results of the flow rate and water level of a chamber. Peng Zhang et al. determines the chamber size using the tube area formula; the calibration results are obtained from the water flow rate formula. However, this tool can only perform one measurement and there is no occlusion parameter [16]. Sumet Umchid et al., in this study, a load cell was used to measure the weight of the solution. The electrical signal from the load cell will be amplified and converted from an analog signal to a digital signal before being transferred to the microcontroller to determine the value of the solution volume and the solution flow rate [17]. Flowrate and grafting are important parts for the infusion pump to run properly or be fit for use. As has been done by Nur Hasanah Ahniar et al., comparing the types of vertical and horizontal infusion pumps [18].

From previous investigations, researchers have not found a system of occlusion in IDA. Therefore, this study aims to test the feasibility of the infusion pump, especially in the occlusion system, so that the manufacturer of IDA in this study is equipped with real-time graphs to monitor occlusion in the infusion pump. This proposed design is more effective because it has advantages in terms of data storage in excel, monitoring the stability of data occlusion, and connecting to any computer system using Bluetooth communication. Therefore, this research aims to design an infusion device analyzer that can show parameters in a graphic equipped with occlusion parameters and Bluetooth transmission in real-time to the computer unit. This article consists of five parts. Section II contains the methods and developments, Section III is the results obtained in this study, Section IV is a discussion of the findings, and Section V is a conclusion.

II. MATERIALS AND METHODS

A. EXPERIMENTAL SETUP

This measurement uses a Syringe Pump TOP 5300 and an Infusion Pump TOP 3300 using a setting of 100ml/hour. Collecting data in the form of occlusion 6 times. Data is displayed in Microsoft Excel in the form of occlusion data, averages, and graphs in real time. This tool uses bluetooth communication. This research uses the TOP 5300 Syringe

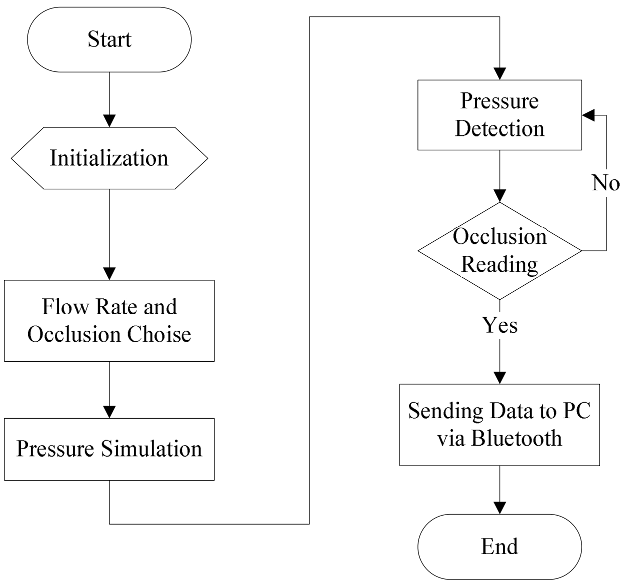

FIGURE 2. Flowcarth system The first is the process of initializing the program starting from the LCD, activating the button and the process of starting the next system

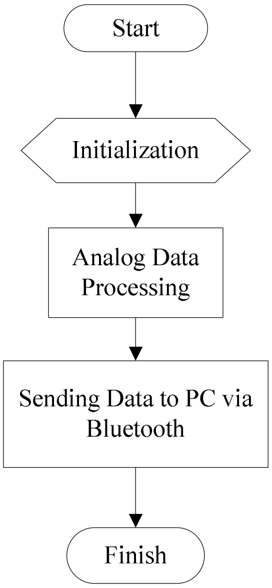

FIGURE 3. Arduino Flowchart Program

Pump [19], TOP 3300 Infusion Pump [20], Infusion Decice Analyzer 4 Merk Fluke [21] and water pressure sensor SKU 237545 [22]. The components used are solenoid valve [23], BD139 and diode for solenoid driver, arduino nano [24], HC-05 [25], USB TL [26]. In this study, researchers used a syringe pump TOP 5300 and an infusion pump TOP 3300. The liquid that will enter the Infusion Device Analyzer Design will pass through the solenoid so that water flows into the water pressure sensor SKU 237545 and is blocked by another solenoid. The sensor output will go to the arduino nano. Output from arduino nano displayed on Parallax Data Acqusitions using Bluetooth communication.

The calibration process uses a tool that has been made by installing an infusion pump infusion hose and connecting it to inlet 1 on the IDA. Determine the flow rate setting at 5 ~ 500 ml/hour (repeat for 5 flow rate options, from minimum to maximum). Start measuring from the largest to the smallest point or vice versa. Wait a few moments until the flow rate chart position is stable. Record the designation of each measured flow rate value on the Infusion Device analyzer digital display on the calibration worksheet at least 6 data at each measurement data point or use a printout. Do priming using a 20 ml spit so that the liquid will fill at the inlet until the liquid comes out at the outlet.

B. THE DIAGRAM BLOCK

In FIGURE 1, it is explained that when the adapter is connected to the circuit to supply voltage. In the occlusion parameter, the liquid that comes out of the infusion pump or syringe pump that has been set at 100mL/hour will enter the device into the chamber. The liquid will be blocked by the solenoid valve. In this study, the setting used was 100 mL/hour. The water pressure sensor will read the resulting water pressure. Arduino will read the output voltage from the sensor to measure the resulting water pressure and convert it according to the specified unit. The microcontroller will process the data and then send the processed data via Bluetooth HC-05 to the personal computer. On the personal computer it will display the occlusion value data along with the delivery time in excel so that the data in excel can be plotted on a graph of the occlusion value against time to display occlusion conditions. In addition, numerical data in the form of mean data and real time data are also displayed to facilitate the retrieval of calibration data.

C. THE FLOWCHART

The process flow chart as shown in FIGURE 2, the first is the process of initializing the program starting from the LCD, activating the button and the process of starting the next system that the selection of occlusion will cause the solenoid valve connected to the water pressure sensor to open and the solenoid valve connected to the infrared photodiode sensor to be closed, simulated working pressure and the solenoid valve connected to the photodiode and infrared sensor is closed. The water pressure sensor will detect the resulting water pressure. The reading will repeat itself if there is no water pressure detection by the water pressure sensor. Then the occlusion data is processed and sent to the personal computer via Bluetooth and displayed in graphical and numerical form on the personal computer.

In the arduino flowchart program FIGURE 3 explains that when the tool is turned on, the pressure simulation on the tool will work, the water will be clogged and the pressure will be read by the sensor, then the detected data will be processed

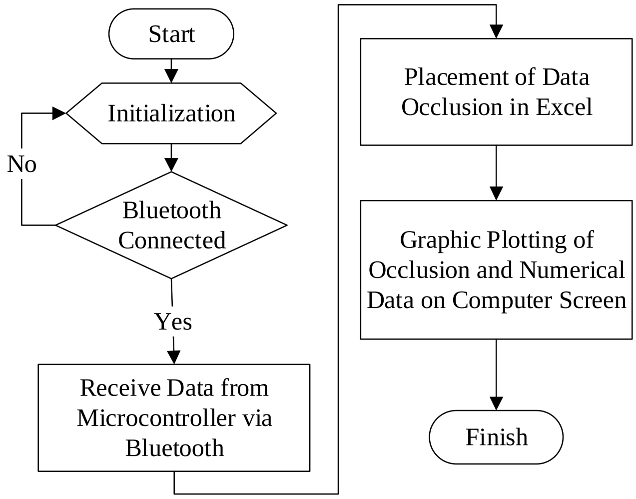

FIGURE 4. Delphi programming flowchart for data acquisition

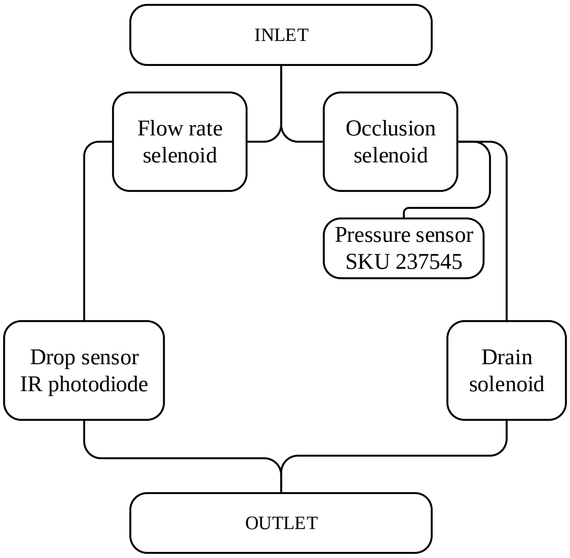

FIGURE 5. Selenoid Valve Placement

by the ADC microcontroller after that it will be sent to the serial port using Bluetooth. Then from Bluetooth the data will be sent and processed on a personal computer to display data values in the form of numerical data presentations from occlusion results and stability graphs. The flow diagram of FIGURE 4 begins with a bluetooth connection, where bluetooth here functions as a receiver from the microcontroller. The data received by bluetooth on the personal computer will be processed and will provide a numeric occlusion value to facilitate data collection and plotting the occlusion value graph in excel to determine the stability of the device.

D. ANALOG CIRCUIT

This solenoid valve driver circuit is used for selection of flow rate or occlusion mode and for drain. Where is the solenoid to block the water from flowing. Each driver is connected to a solenoid valve. The workings of this driver circuit uses the workings of the transistor as a switch. The solenoid valve is arranged as shown in FIGURE 5**.** The specifications of the required Solenoid Valve driver are Supply voltage DC +12V and ground, NPN BD139 transistor. as an ON OFF switch [20], Diode as a safety and Resistor as a safety transistor base.

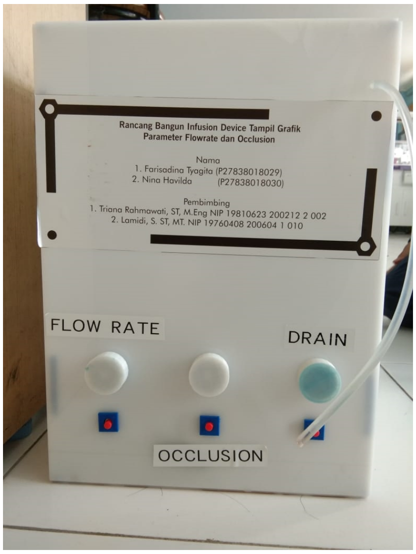

FIGURE 6. Design Module

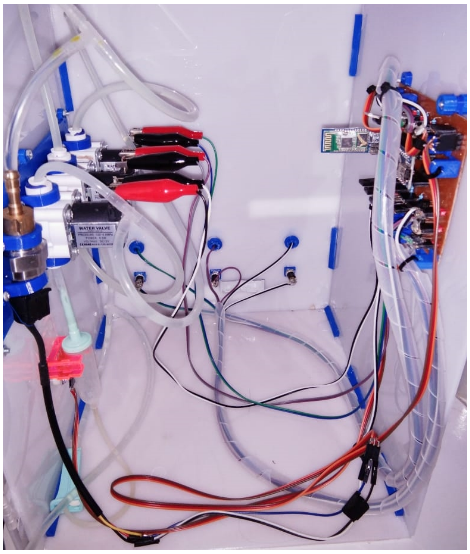

FIGURE 7. Water Pressure Sensor

III. RESULT

FIGURE 6 shows the front-view image of the final task tool titled "Development of Infusion Device Analyzer with Occlusion Parameters Graphic Display Real Time". The design of the Infusion Device Analyzer module is shown in FIGURE 6. The analog part consists of the solenoid driver circuit and the SKU 237545 sensor. The digital part consists of the Arduino Nano which controls the entire system. There is an HC-05 module for sending data to a personal computer. Meanwhile, to receive data, there is an HC-05 and USB TTL connected to a computer. Testing and measuring the water pressure sensor in FIGURE 7 measured at the sensor output, the red probe of the multimeter is connected to the output leg of the water pressure sensor and the black probe of the multimeter is connected to ground. The data occlusion display used the Parallax data acqusitions application. The box shown A is a table of data sent via bluetooth, which contains the time the data was retrieved, the data occlusion, and the data flow rate. Box B is the real time data mean which always changes according to the data taken. The formula used for the mean data is "=AVERAGE(B:B)". Box C is the setting for entering data into the Parallax Data Acqusitions application. Which contains the port and baud rate that can be changed according to the device manager and arduino program. Clear column and reset timer for clear data and reset time. Box D is a real time occlusion graph that can be scrolled index and zoomed in, the data is taken from tables A and B in box A. Then there is box E which contains data right away, to facilitate data retrieval when the graph is stable and there is no need scroll to get data. "=LOOKUP (2;1/(B:B<>"");B:B)" is the formula entered to get the data in real time. Finally, the F box is a place to scroll index and scroll zoom on the chart, there is also a button to display the Parallax Data Acqusitions setting box again when it is closed. FIGURE 8 is a graph of the results of the comparison of the occlusion syringe pump measurement on the Design IDA with the IDA 4 Fluke Plus. It can be seen in the graph that the results from Design IDA, the smallest result from Design IDA is 11.5 Psi and the highest is 12 Psi. While the smallest result of IDA 4 fluke is 12.2 Psi and the highest is 12.7 Psi. TABLE 1 is the result of calculations from data that was carried out 6 times, adjusted to the working method of testing the syringe pump. From the results of these measurements obtained an error of 0.68 Psi with a percentage of 5.4%. In Figure 12 is a graph of the results of the comparison of the occlusion infusion pump measurement on the Design IDA with the IDA 4 Fluke Plus. It can be seen in the graph that the results from Design IDA, the smallest result from Design IDA is 7.28 Psi and the highest is 7.79 Psi. While the smallest result from IDA 4 fluke is 8.2 Psi and the highest is 8.43 Psi.

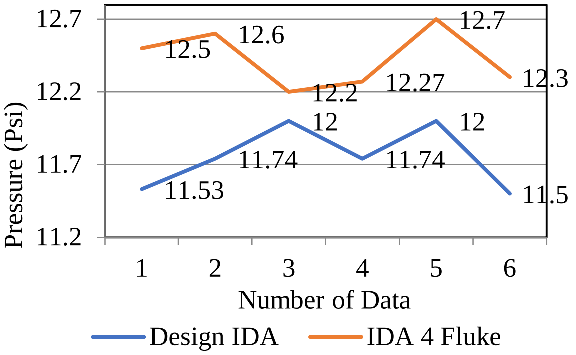

FIGURE 8. Comparison of pressure measurement between IDA and IDA 4 Fluke for Syringe Pump device.

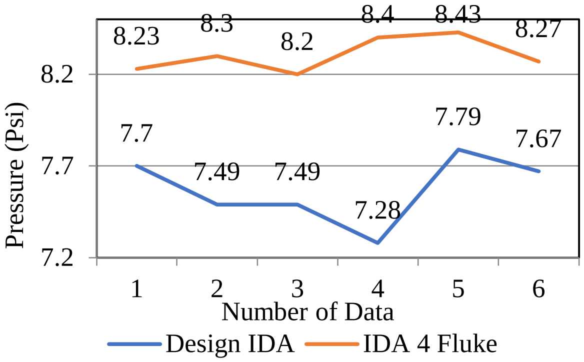

FIGURE 9. Comparison of pressure measurement between IDA and IDA 4 Fluke for Infusion Pump device.

From TABLE 2 it is known that the measurement was carried out 6 times because it was adjusted to the work method of testing the infusion pump. From the measurement results, an error of 0.73 Psi was obtained with a percentage of 8.9%. The results of the microcontroller are displayed in Microsoft excel with the help of Parallax Data Acqusitions sent via bluetooth. This IDA design has a drawback, it cannot be used for more than 30 minutes. The solenoid on the IDA Design will heat up and not respond to commands.

TABLE 1
Syringe Pump TOP 5300 Calculation Results on IDA Design and IDA 4 Fluke

Parameters	IDA (Proposed Design) (Psi)	IDA 4 Fluke Plus (Psi)
Average	11.75	12.43
Error	0.68	
Relative Error%	5.44	
STDEV	0.22	
UA	0.09	
UB 1	0.14	
UB 2	0.04	
UC	0.17	
U	0.18	

TABLE 2

Top 3300 Infusion Pump Calculation Results On Fluke Ida And Ida 4 Designs

Parameters	IDA Proposed design (Psi)	IDA 4 Fluke Plus (Psi)
Average	7.57	8.31
Error	0.73	
Relative error%	8.85	
STDEV	0.19	
UA	0.08	
UB 1	0.15	
UB 2	0.04	
UC	0.17	
U	0.15	

Therefore a cooler is needed for the solenoid. In addition, this IDA design requires a stable AC voltage to produce the appropriate value. The benefit of this study is that it can detect occlusion with a time span of about 3-5 minutes. Can be used by any personal computer provided that it has the Parallax Data Acquisitions application and CH340 installer. Can display graphs and instantaneous values in real time without a time range. Has an error of less than 10% which can be used to calibrate the infusion pump and syringe pump.

IV. DISCUSSION

The Infusion Device Analyzer Design Module tested the Infusion Pump TOP 3300 and Syringe Pump TOP 5300 against the IDA Fluke 4 Plus (FIGURE 9). The results of the Syringe Pump TOP 5300 measurements compared with the IDA Fluke 4 Plus obtained an error of 0.68 Psi with a percentage of 5.44%. Meanwhile, the TOP 3300 Infusion pump measurement compared to the IDA Fluke 4 Plus obtained an error of 0.73 Psi with a percentage of 8.85% (TABLE 2). This IDA design utilizes a solenoid valve to be a pressure simulation, where the water pressure will be measured. But after 30 minutes the solenoid will be hot and not responding to commands. Sending data from Design IDA to Microsoft Excel using 2 Bluetooth with sending data reading of 900 milliseconds. The results of tool errors are influenced by fluid velocity, water leaks in hoses, hose connections, solenoid valve connections, and voltage instability that affect calibration results. The weakness of this research is that the response of the sensor used is less responsive, it is hoped that this research can be used for calibration of infusion pumps and syringe pumps as well as the ease of operators to monitor the calibration value graph using the Bluetooth system displayed on the PERCONAL COMPUTER screen.

V. CONCLUSION

This research has succeeded in making Design IDA to detect occlusion in the syringe pump and infusion pump, using 2 Bluetooth for data transmission every 0.9 seconds, using the Parallax data acquisitions application to display graphs in real time. With the average error of the syringe pump test of 5.4% and 8.8% of the test on the infusion pump. Error results are influenced by fluid velocity, water leaks in hoses, hose connections, solenoid valve connections, and voltage instability that affect calibration results. Developments that can be done from this research are adding channels so that you can calibrate more than one device, reduce errors from the comparison tool, add coolant to the solenoid valve, so that the solenoid does not heat up, create a circuit to stabilize the voltage that enters the circuit. For further research, it is hoped that it can improve the sensor response and additional channels on the IDA so that it can be used to calibrate several infusion pumps simultaneously so that it can speed up the calibration process.

REFERENCES

[1] A. Blandford *et al.*, "Intravenous Infusion Administration: A Comparative Study of Practices and Errors Between the United States and England and Their Implications for Patient Safety," *Drug Saf.*, vol. 42, no. 10, pp. 1157–1165, 2019, doi: 10.1007/s40264-019-00841-2.

[2] T. H. E. Britisw, "INTRAVENOUS TERAPY .: A : kaL I30 ," *Br. Med. J.*, pp. 792–794, 1927.

[3] E. Batista, J. Alves E Sousa, A. Ribeiro, L. Martins, M. Pereira, and H. Navas, "Calibration of Infusion Pumps Analyser," *J. Phys. Conf. Ser.*, vol. 1065, no. 9, 2018, doi: 10.1088/1742-6596/1065/9/092003.

[4] W. Q. Feng, Z. Y. Liu, H. Y. Tam, and J. H. Yin, "The pore water pressure sensor based on Sagnac interferometer with polarization-maintaining photonic crystal fiber for the geotechnical engineering," *Meas. J. Int. Meas. Confed.*, vol. 90, pp. 208–214, 2016, doi: 10.1016/j.measurement.2016.04.067.

[5] G. P. Alessandra Frattola, "Frattola1993.Pdf," *J. Hypertens.*, vol. 11 No.10, pp. 11:1133-1137, 1993, doi: 10.1097/00004872-199310000-00019.

[6] D. E. Whitney, C. A. Lozinski, and J. M. Rourke, "Industrial robot forward calibration method and results," *J. Dyn. Syst. Meas. Control. Trans. ASME*, vol. 108, no. 1, pp. 1–8, 1986, doi: 10.1115/1.3143737.

[7] P. A. Lonnqvist, "How continuous are continuous drug infusions?," *Intensive Care Med.*, vol. 26, no. 6, pp. 660–661, 2000, doi: 10.1007/s001340051229.

[8] E. Koutroulis and K. Kalaitzakis, "Development of an integrated data-acquisition system for renewable energy sources systems monitoring," *Fuel Energy Abstr.*, vol. 44, no. 3, p. 163, 2003, doi: 10.1016/s0140-6701(03)81847-7.

[9] ECRI, "Inspection and Preventive Maintenance System," in *3rd ed., ECRI, Plymouth Meeting, PA*, Procedure/., vol. 1, no. 610, USA: ECRI, 1995, p. 200.

[10] H. K. Tavokali Golpaygani A, Movahedi MM, Reza M, "A study on performance and savety test of infusion pump device," *Biomed. Reserch*, vol. 28, no. 12, 2017.

[11] A. P. Pudji, A. M. Maghfiroh, and N. Thongpance, "Design an Infusion Device Analyzer with Flow Rate Parameters using Photodiode Sensor," *Indones. J. Electron. Electromed. Eng. Med. informatics*, vol. 3, no. 2, pp. 39–44, 2021, doi: 10.35882/ijeeemi.v3i2.1.

[12] N. Thongpance and K. Roongprasert, "Design and construction of infusion device analyzer," *BMEiCON 2014 - 7th Biomed. Eng. Int. Conf.*, 2014, doi: 10.1109/BMEiCON.2014.7017377.

[13] G. Fico, J. Montalva, A. Medrano, N. Liappas, G. Cea, and M. T. Arredondo, “EMBEC & NBC 2017,” *IFMBE Proc.*, vol. 65, no. June, pp. 1089–1090, 2018, doi: 10.1007/978-981-10-5122-7.

[14] L. Fidelit *et al.*, "Li-Fi Technology : Data Transmission through," vol. 2015, no. june, 2015.

[15] P. Ajmera, "A Review Paper on Infrared sensor," *Int. J. Eng. Res. Technol.*, vol. 5, no. 23, pp. 1–3, 2017.

[16] P. Zhang, S.-Y. Wang, C.-Y. Yu, and M.-Y. Zhang, "Design of occlusion pressure testing system for infusion pump," *J. Biomed. Sci. Eng.*, vol. 02, no. 06, pp. 431–434, 2009, doi: 10.4236/jbise.2009.26062.

[17] S. Umchid and P. Saoruk, "Development of a Touch Screen Based Infusion Pump Analyzer," vol. 14, no. 1, pp. 44–53, 2021.

[18] N. H. Ahniar, Hendra Marwazi, and Rismarini Yufita, "Comparison of Flowrate and Occlusion in a Vertical Infusion Pump and Horizontal Infusion Pump," *J. Electron. Electromed. Eng. Med. Informatics*, vol. 2, no. 1, pp. 1–6, 2020, doi: 10.35882/jeeemi.v2i1.1.

[19] Top corporation, *Manual Book Syringe Pump TOP 5300.pdf*. Tokyo-Japan: TOP Corporation, 2015.

[20] I. À. Informática and L. Gitleman, "Technical Reference Manual TOP infusion Pump -3300," in *Paper Knowledge . Toward a Media History of Documents*, 2014, p. 200.

[21] U. S. B. Firewire and P. C. I. Card, "Operators Manual IDA4," in *Operators manual*, USA, 2005, pp. 1–37.

[22] R. Pérez, V. Puig, J. Pascual, A. Peralta, E. Landeros, and L. Jordanas, “Pressure sensor distribution for leak detection in Barcelona water distribution network,” *Water Sci. Technol. Water Supply*, vol. 9, no. 6, pp. 715–721, 2009, doi: 10.2166/ws.2009.372.

[23] W. Flowing, "Keeping the World Flowing Solenoid Valves," in *Rotork Instrumenst*, 07/17., China, 2011, pp. 1–196.

[24] A. N. Front and A. N. Rear, "Arduino Nano Specifications :," *Datasheet Arduino Nano*, vol. 0. pp. 1–10.

[25] ITead Studio, "Hc-05 Bluetooth Module," *Datasheet*, p. 1, 2010.

[26] N. Kang, "PL-2303 Edition USB to Serial Bridge Controller Product Datasheet," no. 48, pp. 1–18, 2005.