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Design Analysis of Portable 1 Channel Infusion Device Analyzer Using Sensor SKU 237545

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ABSTRACT An infusion pump is a tool used to inject a certain amount of fluid into the patient's body through the patient's veins continuously over a certain period of time. A syringe pump is a tool that functions to push the syringe rod so that it can produce a flow ranging from microliters to milliliters per minute periodically with high accuracy. Very often there are problems with blockages or occlusion when using infusion pumps and syringe pumps. The occlusion limit set is ≤20 PSI according to ECRI. The presence of occlusion in the infusion pump and syringe pump can be identified when there is an alarm buzzer which will sound when a blockage is detected. A 1 Channel Portable Infusion Device Analyzer has been designed using the SKU 237545 Sensor, namely by using a 1 channel flowrate and occlusion sensor and making it portable to be efficient. For this reason, it is necessary to analyze the performance of the tools that have been created. How accurate is it? From the results of performance testing, Oclusion was corrected at 0.242 psi and 0.3 Psi. For flow rate, the largest correction was 2.4 ml/hour and the uncertainty was 6,046 ml/hour. This shows that the accuracy of the design is still quite high and the resulting tool is still not stable, this can be seen from the uncertainty value. The uncertainty that occurs is likely due to the sensitivity of the droplet sensor related to the detection time of the droplet

INDEX TERMS Calibration, Flowrate, Arduino, Real Time

I. INTRODUCTION

Infusion Device Analyzer (IDA) is a tool to test the performance of an infusion pump and syringe pump. This tool measures the flow and volume of infusion fluids and also measures the occlusion-pressure[1]. Flow rate calibration activities for infusion pumps and syringe pumps later, it will be compared to national guidelines for measurement units, precision of results, and apparatus settings. Syringe pump is a tool that functions to push the rod of the syringe so that it can issue a flow range of microliters to milliliters per minute periodically with high accuracy so that there are no errors in dosing to patients[2].Infusion Device Analyzer has several channels, namely 1,2,3, and 4 channels. Infusion Device Analyzer brands include Fluke Biomedical, Rigel Multi-Flo, and others. Fluke 1 Channel and 5 Channel Infusion Device Analyzers[3]. The IDA-1S Infusion Device Analyzer, a portable, battery operated tester that makes it easy to track results for performing preventive maintenance at multiple locations, prefer manual testing, or need a single channel analyzer[4]. The IDA-5 Infusion Pump Tester is a multi-line tester, providing comprehensive results. Ability to test up to four infusion pumps simultaneously and has on-board and stand-alone Automation for fast testing[5].

In 2020 Nuritza Maulidia has conducted research on the Development of Infusion Device Analyzer with Infrared Photodiode Sensor for Drip GRAPH (FLOWRATE) "which has been able to display data by displaying graphics on a TFT LCD with SD Card storage. In 2022 Anisa Rahma has conducted research with the title Analysis of Pressure Sensor Accuracy for Flowrate Measurements on a 2 Channel Infusion Device Analyzer Displaying TFT[6]. In this study, as a comparison, the measurement results used the Rigel Multi-Flo Infusion Device Analyzer[7]. Rigel Multi-Flo is portable for accurately and quickly verifying the performance of all infusion devices[8]. With a choice of single or multichannel configurations, the Multi-Flo tests up to four infusion devices at once, ranging from 10µL to 1500mL per hour, with all data stored internally[9]. Multi-Flo offers instant, precise flow measurement, even at low rates, enabling users to test double the infusion devices within the same timeframe as other volumetric analyzer[10]. To meet the prerequisites of IEC 60601-2-24, Multi-Flo likewise gives accurate backpressure simulation, impediment caution observing and bolus estimation (PCA), and a variety chart display[11].

The drawback of Nuritza Maulidia's 2020 research is that it still uses a character LCD with a small size of 16x2, so this tool cannot display real-time graphs to see flowrate against time and still uses 1 channel[12]. The deficiencies in Nila Nurmala's 2021 research are that the module still uses channel 1 and uses a 4.3 inch TFT LCD[13]. So that the real-time graph displayed on the TFT LCD is less clear. Weaknesses in Anisa Rahma's research in 2022 are mechanical errors in the module which cause water in the hose to leak when testing the tool because the connection to the hose is not strong enough, so it can endanger components exposed to water[14]. This study was also not equipped with a drain as a suction for leftover water in the hose so that quite a lot of bubbles were found due to insufficient cleaning[15]. Based on these problems, the author wants to improve and intends to make Design of a 1 Channel Portable Infusion Device Analyzer Using SKU 237545 Sensor and Drip Sensor with TFT (Flowrate) Graphic Display by using flowrate and occlusion sensors which are made portable to make them more efficient. By using graphs in real time, users can see previous data that has been plotted. With the development of the addition of a drain motor so that at the time the process of draining the remaining water in the hose can also be wasted[16].

The results of tracking and identifying the problems above are the improvement of an Infusion Device Analyzer (IDA) apparatus outfitted with an infrared sensor and photodiode to determine the correct flow rate value that can perform measurements commonly or a limitless number of times. The data processing technique method that the author involves is to find the mistake and relative for the distinction between the mean and the overall blunder in percent. The average of measurements to calculate the uncertainty because of the littlest scale esteem, alignment mistakes and deviations[17]. The specific objective of this research is to enable Arduino as a controller for the overall device. Make a program on Arduino to measure flow rate values and graphs on infusion pumps and syringe pumps. Make a program for TFT LCD so that it can display measurement results as numbers and charts is real time. Create a program on Arduino to store data on the SD card.

This article is made out of Part II Materials and Techniques utilized in the examination, Section III Exploration results, Section IV conversation and Part V End[18].

II. MATERIALS AND METHOD

This study used the Terumo TE-331 brand Syringe Pump using the setting; 100, 50, and 10 mL/hour and using the TOP-3300 brand Infusion Pump using the setting; 100, 50 and 10 ml/hour. The various experiments were repeated 5 times. This study uses an infusion drop sensor as a stream input, then, at that point, the information stream will be handled utilizing the Arduino Mega 2560 microcontroller, and the stream results will be shown on the TFT LCD. This module uses the RIGEL brand Infusion Device Analyzer (IDA) comparator.

1) Materials and Tools

The designed infusion device will be compared with standard infusion devices (which are on the market). The measurements taken were occlusion and flow rate. From the results of this measurement, analysis will be carried out.

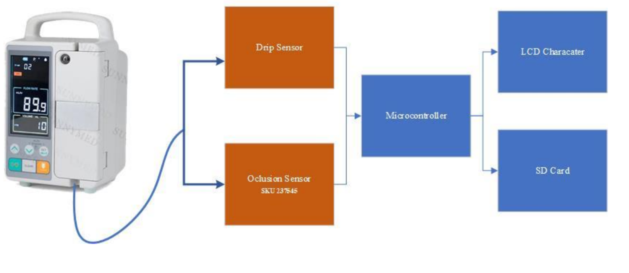

FIGURE 1. Design of Portable 1 Channel Infusion Device Analyzer Using Sensor SKU 237545

Figure 1 is a block diagram consisting of a portable 1 channel infusion device analyzer with TFT display, pressure sensor SKU 237545, microcontroller, 7 inch TFT LCD, SD card. The working principle is to first press the power button to activate the infusion device analyzer. So that the power supply circuit and the entire circuit gets voltage. After that, set the Infusion Pump/Syringe pump with a flow speed of 100ml/hour. Select the occlusion parameters on the LCD, then the fluid from the infusion pump and syringe pump will flow into the hose. The liquid will be held by the solenoid valve so that the liquid is trapped inside and produces water pressure which is detected by the SKU 237545 water pressure sensor. The measured pressure is processed by the microcontroller and displayed on the 7 inch TFT LCD in the form of graphs and numbers and stored on the SD card.

2) Experiment

Test the output of the Syringe Pump and Infusion Pump in the form of a flow rate with settings of 100, 50 and 10 mL/hour for. Each setting, the result of the Infusion Device Analyzer is calculated to approve the result of this review. Convert the drop count every 20 drops.

FIGURE 2. The measurements taken were occlusion and flow rate. From the results of this measurement, analysis will be carried out.

FIGURE 2 The designed infusion device will be compared with standard infusion devices (which are on the market). The measurements taken were occlusion and flow rate. From the results of this measurement, analysis will be carried out source to drain the water.

Estimation of every boundary was rehashed multiple times. The typical worth is gotten by ascertaining the mean Eq. (1) where n is the quantity of estimations and x_i is the worth of the it estimation. To work out the kind a standard vulnerability, utilize the accompanying equation.

$$\overline{x} = \frac{x1+x2\ldots+xn}{n} \qquad (1)$$

Where ¯x is the normal of n estimations, with x_1 as the principal estimation, x_2 as the subsequent estimation, and x_n as the nth estimation. The standard deviation is a proportion of the variety in the information or the standard deviation from the mean. The standard deviation formula (SD) can be show in Eq. (2):

$$\text{SD} = \sqrt{\frac{\sum(xi-\overline{x})^2}{(n-1)}} \qquad (2)$$

Where xi means the ideal worth, x signifies the typical measurement result, n indicates the quantity of measurements. The release formula (UA) can be seen in Eq. (3). The value calculation results are because of the littlest scale esteem, calibration blunder, changes in estimation boundary values and the environment, causing estimation measurement so that the actual value is difficult to obtain.

$$UA = \frac{SD}{\sqrt{n}} \qquad (3)$$

Eq. (4) presents a formula for measuring the total vulnerability worth of UA, SD is the standard deviation, n is a measure magnitude, % mistake demonstrates framework blunder. The least blunder is the distinction in the average of the data, indicating a design deviation. The formula calculates the relative error in proportions, expressing the deviation of the measured value from the true value. Small error percentage indicates high accuracy and precision

$$\%\text{ERROR} = \frac{(x_n - \text{x})}{x_n} \times 100\% \qquad (4)$$

Xn is the worth acquired from the examination device, while X shows the measured worth from the module or measuring instrument

III. RESULT

The measurement test on the syringe pump was carried out with a Terumo TE-331 brand syringe pump whose output was connected to the inlet module. In this measurement test, the volume used on the syringe pump is 50 mL and the highest flow rate value is 100 ml/hour on the infusion pump.

Table 1
TE-331 Syringe Pump Performance Results

Device	Test (Psi)				
	1	2	3	4	5
Design	8.57	9.42	9	10.7	10.49
Comparison	8.04	9.08	9.1	10.62	10.65
Corection	0.53	0.34	0.1	0.08	0.16

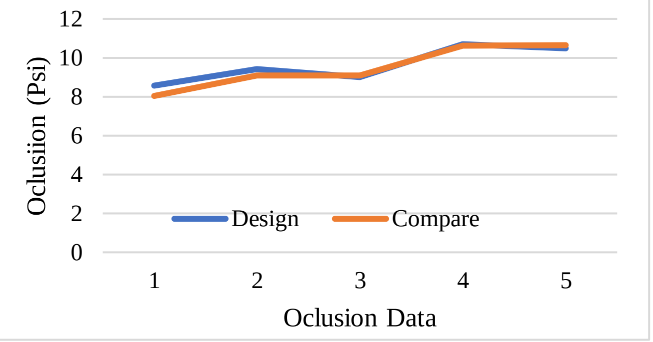

Figure 3. Graphic Trend Oclusion with **TE-331 Syringe Pump**

The measurement test on the syringe pump was carried out with a TOP-3300 brand infusion pump whose output was connected to the inlet module. In the volume measurement test used in the infusion pump with 500ml infusion fluid.

TABLE 2
TOP-3300 Infusion Pump Performance Results

Device	Test (Psi)				
	1	2	3	4	5
Design	7.09	6.24	7.09	7.72	6.03
Comparison	7.06	6.05	7.95	7.23	6
Corection	0.03	0.19	0.86	0.49	0.03

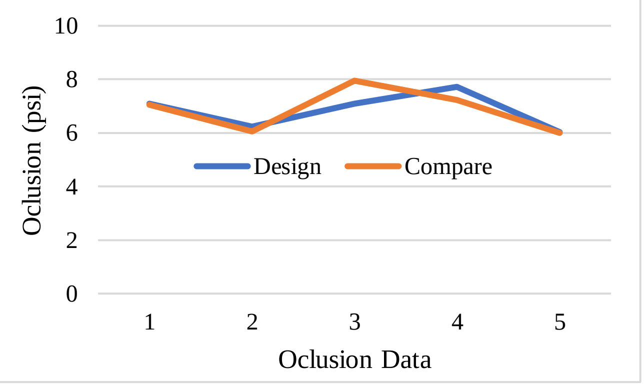

Figure 4. Graphic Trend Oclusion with **TOP 3300 Infusion Pump**

The SKU 237545 sensor is pressured by liquid, there is a change in the sensor output in the form of voltage on the sensor before being pressured by the liquid and after being pressured by the liquid. The voltage output increases linearly when the liquid presses the SKU 237545 sensor. The output from the SKU 237545 pressure sensor will be connected to the Arduino Mega ADC pin which will convert the analog results of the pressure reading into an occlusion value in Psi units. From the measurement results table, it can be seen that the SKU 237545 sensor works well by looking at the correction values.

Flow Rate Testing With Terumo TE-331 Brand Syringe Pump.The measurement test on the syringe pump was carried out with a Terumo TE-331 brand syringe pump whose output was connected to the inlet module. In this measurement test, the volume used on the syringe pump is 50 mL and the highest flow rate value is 100 ml/hour on the infusion pump. as shown in TABLE 1 and TABLE 2 or FIGURE 3 and FIGURE 4.

TABLE 3
TE-331 Syringe Pump Flow Rate Test Results

Setting 100 ml/H					
Device	Data ml/h				
	1	**2**	**3**	**4**	**5**
Design	110	93	94	98	99
Comparison	101.64	100.12	101.21	101.01	101.5
Setting 50 ml/h					
Device	Data ml/h				
	1	**2**	**3**	**4**	**5**
Design	52	54	49	51	53
Comparison	50.42	51.61	50.03	51.97	50.89
Setting 10 ml/h					
Device	Data ml/h				
	1	**2**	**3**	**4**	**5**
Design	10.5	10.5	9.5	10.5	10.5
Comparison	10.11	10.42	9.89	10.31	9.68

Flow Rate Testing With TOP-3300 Brand Infusion Pump.The measurement test on the syringe pump was carried out with a TOP-3300 brand infusion pump whose output was connected to the inlet module. In this measurement test, the volume used in the infusion pump with infusion fluid is 500ml

TABLE 4
TOP-3300 Infusion Pump Performance Results

Setting 100					
Device	Data ml/h				
	1	**2**	**3**	**4**	**5**
Design	101	109	103	96	103
Comparison	99.56	98.37	98.41	99.93	98.69
Setting 50					
Device	Data Ke ml/h				
	1	**2**	**3**	**4**	**5**
Design	52	53	44	53	49
Comparison	49.24	49.08	49.98	49.65	49.38
Setting 10					
Device	Data Ke ml/h				
	1	**2**	**3**	**4**	**5**
Design	10.5	9.5	9.5	9.5	8
Comparison	9.34	9.23	9.56	9.01	9.12

If the sensor is not blocked by water, the resistance received by the photodiode is smaller, so the voltage and current will also be smaller. After the photodiode sensor is blocked by water, the sensor output in the form of voltage will enter the comparator circuit to be compared to the ADC pin of the Arduino Mega 2560. The Arduino Mega 2560 will calculate and convert the time from one drop to another into a flow rate value in milliliters per hour. From the measurement results for higher flowrates, the sensor does not work well, this can be seen from the corrections obtained as shown in TABLE 3 and TABLE 4.

IV. DISCUSSION

Terumo TE-331 Syringe Pump Occlusion Test, The average correction value in the occlusion test is 0.242 Psi. The correction is very small which shows that the SKU 237545 sensor is accurate. TOP 3300 Infusion Pump Oclusion Test. The average correction value in the occlusion test is 0.32 Psi. The correction is very small which shows that the SKU 237545 sensor is accurate.

TABLE 5
Comparison of Uncertainty in Flow Rate testing with the TE 331 Syringe Pump

Setting	U95 Design	U95 Comparison
100	6.0465	0.535
50	1.72	0.7213
10	0.4	0.271

Terumo TE331 Syringe Pump Flow Rate Testing. In the flow rate test it was seen that the highest correction was 1.8 ml/h at the 50 ml/h setting but the uncertainty was still high, namely at the 100ml/h setting it was 6.0465 ml/h.

TABLE 6
Testing Flow Rate Infusion Pump TOP 3300

Setting	U95 Rancangan	U95 Pembanding
100	4.176	0.635
50	3.429	0.318
10	0.8	0.189

Testing the Flow Rate Infusion Pump TOP 3300. In the flow rate testing, it can be seen that the highest correction is 2.4 ml/h at the 50 ml/h setting but the uncertainty is still high, namely at the 100ml/h setting it is 4,176 ml/h. As Show in TABLE 5 and TABLE 6 From the correction and uncertainty data (u95), it can be seen that the correction is relatively very small but the uncertainty value is high at the flow rate settings of 100 ml/h and 50 ml/h. This shows that the design results are less stable. The uncertainty that occurs is likely due to the sensitivity of the droplet sensor related to the detection time of the droplet

V. CONCLUSION

From the correction and uncertainty data (u95), it can be seen that the correction is relatively very small but the uncertainty value is high at the flow rate settings of 100 ml/h and 50 ml/h. This shows that the design results are less stable. The uncertainty that occurs is likely due to the sensitivity of the droplet sensor related to the detection time of the The accuracy of the occlusion and flow rate is quite good, this can be seen from the correction values obtained by corrections of 0.242 psi and 0.3 Psi. For flow rate, the largest correction was obtained at 2.4 ml/hour.The precision of the flow rate still needs to be improved, this can be seen from the uncertainty value of 6,046 ml/hour.The sensor system needs to be improved again so that the stability of the design is better.

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