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Negative Pressure Gauge on a Suction Pump Equipped with MIT APP Inventor-Based Measurement Data Input and Storage

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ABSTRACT Research conducted by Muhaji, Bedjo Santoso, Putrono on the comparison of the effectiveness of two levels of suction pressure on oxygen saturation in endotracheal tube patients. The findings show that there is a significant effect of negative pressure on oxygen saturation. So that the use of the pressure value must be ensured that it is appropriate so as not to injure the patient. The accuracy and accuracy of the pressure value can be ensured by calibrating the suction pump with a calibrator, namely Digital Pressure Meter. From this case, a digital pressure meter module was created with an application. This tool serves to read the pressure value on the suction pump in real time. This tool was created with the aim of measuring negative pressure on a suction pump which is equipped with an application for inputting and storing measurement data based on the MIT App Inventor to make it easier for users to input tool identity and calibration results. To get results that are in accordance with the purpose of writing, using the study method to the library, the preparation stage, the design stage includes making software and hardware, then testing and measuring. Negative pressure measurement testing uses a Suction Pump as a measurement sample and uses 2 comparison tools, namely DPM4 and Manometer. Negative pressure testing was carried out 10 times at each measurement point, namely -10.6, -20, -30 kPa and -80, -150, -225 mmHg. After the measurements were taken, it was concluded that the module test compared to DPM4 obtained an accuracy of 99.09%, while the module test compared to the Manometer obtained an accuracy of 98.85%. Pressure measurement compared to DPM4 has 0.24% higher accuracy than pressure measurement developed with Manometer. This module is designed to be used for power calibration specifically for Suction Pump equipment. To make it easier to use the TFT nexion LCD.

INDEX TERMS Suction Pump, Negative Pressure, MPXV4115VC6U, HC-05, and Internet of Things.

I. INTRODUCTION

In modern times, now there are many medical devices that have good quality and performance so that various kinds of diseases can now be easily detected and cured by medical devices. However, no matter how modern or sophisticated medical devices are, they will still experience a decrease in performance and quality. A decrease in the performance or quality of medical devices can be seen from the measurement results that are starting to be inaccurate, this can be known with the help of standard tools or calibrators. Therefore, every medical device must be calibrated by the Health Facility Testing Center or Health Facility Testing Institution periodically at least 1 (one) time in 1 (one) year which is stipulated in Permenkes No. 54 of 2015. Calibration of medical devices is important because calibrating medical devices can minimize misdiagnosis, ensure accuracy, and accuracy, as well as maintain the safety of both doctors as users and patients who receive treatment from the medical devices themselves.

According to Permenkes No.363/MENKES/PER/IV/ of 1998, regarding Testing and Calibration of Medical Devices, Medical Suction Pumps are one of the medical devices that must be tested or calibrated and the regulations for calibration of medical devices are also described in the Law Article 16 of Law Number 44 concerning Hospitals requires that all medical equipment must be tested and calibrated periodically by the health facility testing center or authorized health testing institution. If not, (Public health center and hospitals) can be closed and this will have an impact on the community.

The surgical suction pump is one of the 13 items of equipment essential for surgical treatment[1][2] Suction is an essential component of any surgery, which serves to aspirate (removal) blood, gases, tissues, mucus, saliva, pus and irrigation fluids from the patient's body while the surgical procedure is being performed by applying negative pressure to create aspiration movements[3]. If the suction power on the Suction Pump is not in accordance with the user's settings, whether the suction power is too low or too high, the user will have difficulty sucking the liquid and fear that it will injure the patient, so that its use is not optimal. It would be very unfortunate if the patient uses a medical device with the aim of obtaining health or healing instead, he actually gets into an accident due to the device not functioning properly. To avoid this, the Suction Pump must be tested or calibrated using a calibrator (DPM 4) to measure its suction power. Based on other sources, the Suction Pump is a medical device that functions to suck up fluids that are not needed by the body during the operation process, such as blood, stomach contents, and immediately. Then the sucked liquid is accommodated in a container. The working principle of the Suction Pump is that the motor will rotate together with the suction fan so that it can suck fluid into the patient's body through the suction hose connected through the tube and filter[4][5][6].

Suction can prevent severe complications and can save lives in an emergency. But like all medical procedures, it carries some risks, namely Negative pressure pulmonary edema, Atelectasis, Hypoxemia, Pulmonary hemorrhage, and Local trauma[7]. One analysis found a complication rate of 38.6 percent in routine endotracheal suctioning, although a less invasive procedure reduced complications to 28.6 percent. Other analyzes suggest that small changes in technique, such as proper initial oxygen administration to the patient prior to suctioning, can reduce the risk of complications. The most common side effects of suctioning can be prevented[8]. Research conducted by Muhaji, Bedjo Santoso, Putrono on the comparison of the effectiveness of two levels of suction pressure on oxygen saturation in endotracheal tube patients. The findings showed that there was a statistically significant effect of suction pressure of 130 and 140 mmHg on oxygen saturation in patients with endotracheal tubes with $p < 0.05$. There was a significant difference in the mean oxygen saturation between the 130 mmHg suction pressure group and the 140 mmHg suction pressure group with a p value of 0.004 (<0.05). The mean difference in oxygen saturation between the two groups was 13.157. from the case above shows that the pressure on the suction will affect the oxygen saturation. So to guarantee the accuracy and precision of the pressure value used, the suction pump must be calibrated at least once a year[9]. Abdi Wibowo, Triana Rahmawati, Priyambada Cahya Nugraha, I Dewa Gede Hari Wisana, Mansour Asghari, and Honey Honey in 2022 conducted research on the accuracy of positive and negative pressure calibrators to investigate the response of sensors. This study succeeded in measuring positive and negative pressure using autonics sensors, where the results obtained were accurate and in accordance with the results of standard tools. Therefore, the results of this tool can be used for multiple pressure calibrators using autonic sensors. The results of standard positive pressure measurements show that the sensor readings for pressure work according to their characteristics, which produces the largest error value of 0.87%, while the results of positive pressure measurements with standards obtain 11.25% results. The drawback of this module is that it cannot be used mobile, it must be connected to electricity [10]. In 2021, Fita Florensa Rooswita, Triana Rahmawati and Syaifudin made a Digital Pressure Meter Module with two modes namely kPa and mmHg equipped with an automatic leak test for measurements on a sphygmomanometer. The measurement results obtained an average error of 7.3 mm Hg for sphymomanometer measurements, and for suction pumps less than 1.5 Kpa. From these results it was concluded that this module can be used for measuring instruments that use positive pressure and negative pressure. In making this module the author has used a battery but with a small capacity so that its life span runs out quickly [11]. In 2020, research conducted by Abdul Cholid Ridwan, Her Gumiwang Ariswati, and Syaifudin created a DPM with two modes equipped with temperature and humidity. The measurement results of this tool have an error value of 0 to 0.58% and have an increment value or correction value of 0 - 3[12].

Based on the statement above, the authors want to design a special calibration tool for suction pumps to measure negative pressure and use applications that aim to make it easier for users to perform calibrations, users can input the identity of the data to be calibrated, distort data that has been taken on Google Sheets, and view data that has been calibrated. already stored in one application so there is no need to enter data manually or handwritten. The purpose of this study was to determine the most accurate level of the two comparison tools used, namely DPM4 and Manometer.

II. METHODHOLOGY

This research is experimental. The author aims to make a Negative Pressure Gauge equipped with an Application. The materials and method will be explained in the following section.

A. THEORETICAL BACKGROUND

According to ISO/IEC Guide 17025:2005 and Vocabulary of International Metrology (VIM) calibration is a series of activities that produce values indicated by a measuring instrument or measurement system, or values represented by measuring materials, using values that are known to be associated with a quantity that is measured under certain conditions[13]. According to ISO/IEC Guide 99:2007, measurement uncertainty is a non-negative parameter that defines the range of values within which the value of the quantity being measured is estimated to lie. And uncertainty is an estimate of the calibration results which characterizes a range of values in which there is a correct value[14].

In this study there are several things that must be looked for to determine if the measurement using a module compared to a standard tool has a maximum error of 10%[15]. First, the average value which is the sum of all values is then divided by the amount of data or the number of measurements. The formula of Average to calculate the group of numbers: $average = \frac{Sum\ of\ Numbers}{Numbers\ of\ Unit}$ [16]. Second, basically calibration error is included in a separate type of error, namely systematic error [17]. Systematic error is a measurement bias that leads to the mean of many separate measurements differing considerably from the true value of the instrument being measured. All measurements are prone to systematic error. Sources of systematic error can be due to improper calibration of measuring instruments, environmental changes that hinder the measurement process, and imperfect observation methods [18]. As a result, the measured value will always be smaller or greater than the actual value. This calibration error can still be overcome by resetting the device accordingly so that it can be used normally, and obtaining measurement accuracy [17]. Third, Accuracy is the proximity of the UUC result to the STD (true) value. This 'closeness' is usually represented as a percentage value (%) and can be expressed in the same units by converting it to an error value (% error). The closer the percentage value to ZERO (0%), the more accurate [19]. Accuracy is a qualitative concept and should not be used in place of uncertainty[20]. Fourth, The standard deviation is the basis for defining standard uncertainty – the uncertainty at the standard deviation level, denoted by a small u. Calculation of the standard deviation will be an easy calculation, especially if it is done in a spreadsheet program such as Excel [21].

B. DATA COLLECTION

Data collection was carried out at Dr. Hospital. SUYOTO. Data retrieval using one of the tools from the Surgical and Anesthesia Equipment group, namely a Suction Pump and a comparison tool using two calibrators, namely Digital Pressure Meter (DPM4) and Manometer. In this data the author will measure the negative pressure of the suction pump and compare it.

The test was carried out 10 times at each measurement point. In each measurement, 2 units are used, namely kPa and mmHg[22]. Conversion 1 kPa = 7.5006 mmHg and 1 mmHg = 0.13332 kPa[23].

This module uses two units of measurement, namely mmHg and kPa, and each unit of measurement has three measurement points. For mmHg units, the measuring points are -80[24], -150[24], -225 and for Kpa units, the measuring points are -10.6, -20[4], -30.

Testing and data collection were taken by measuring the negative pressure on the suction pump using DPM 4 and Manometer. Measurements were carried out 10 times at measurement points -80, -150, -225 mmHg and -10.6, -20, -30 kPa. The working method for testing the Suction Pump as a whole is described in the "Metode Kerja Naik Cetak", which contains the measuring instruments used for testing and/or calibration procedures, physical examination and function of the tools being tested/calibrated, electrical safety testing, and performance testing.
The research flow starts from a literature study which aims to find information about the title that will be used and information that will be used by the author in making scientific papers. The second stage is the preparation stage.

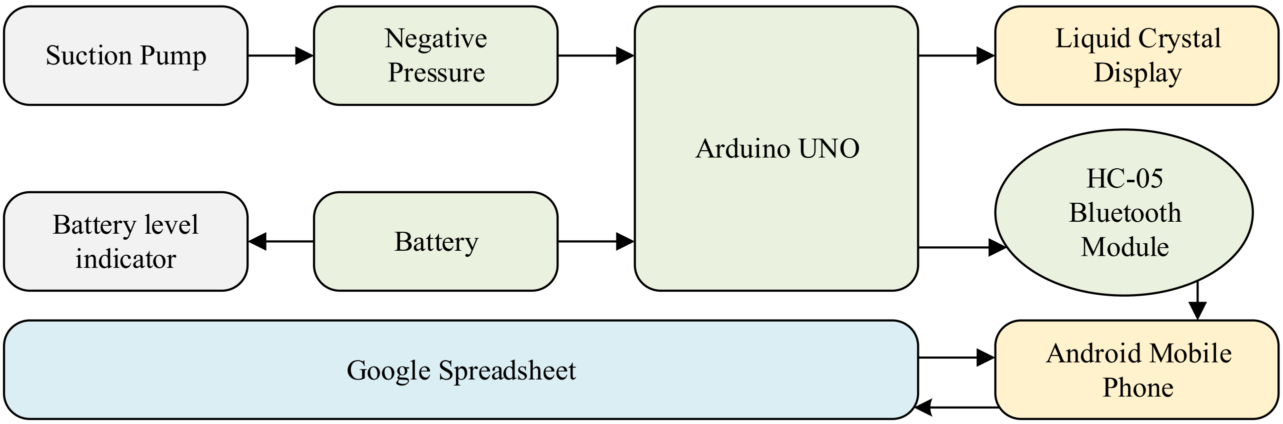

FIGURE 1. Block diagram of the negative pressure gauge module

At this stage, it is carried out to prepare the cost of making tools, making proposals, planning, and others. The third stage is the planning stage. This stage contains hardware and software design which includes designing the MXPV4115VC6U sensor circuit, designing the TFT LCD system, designing the indicator battery circuit, designing the HC-05 Bluetooth circuit, designing the MIT APP INVENTOR system, and storing data on Google Spreadsheet. This hardware and software will later be synchronized into a tool that will later be tested. The fourth stage is the tool making process. After completion, the next stage is tool testing. This stage aims to find out that the tools made can work properly. Tools that have passed the testing stage can be used to collect measurement data parameters.

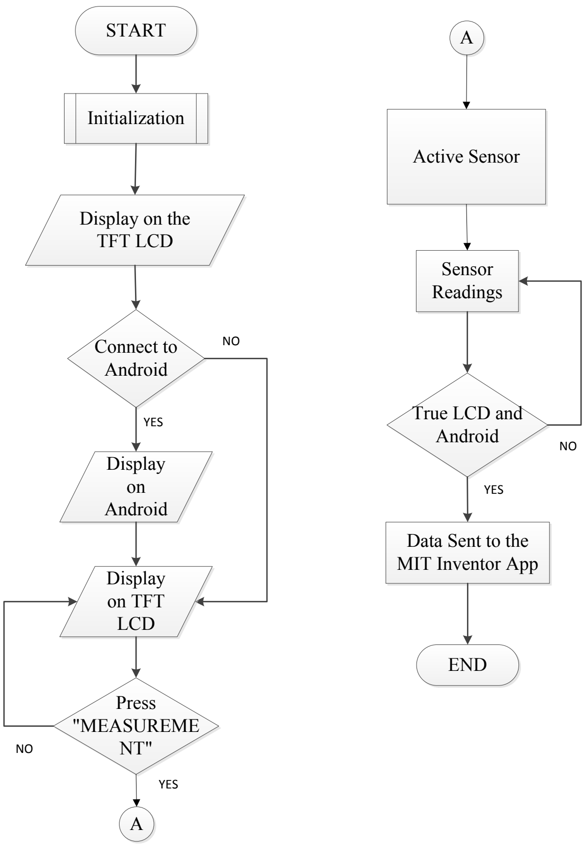

FIGURE 2. The flowchart of the negative pressure gauge module

The data that has been collected will be analyzed to determine the accuracy of the measurement of the tool and it can be said that the tool is feasible or not. The tool will get supply from a 9V battery and lower the voltage to 5V using the Step Down module. When the On/Off button on the tool is pressed, the Arduino Uno and other circuit blocks will get a voltage. Arduino Uno will give a command to do the initialization, then the TFT LCD will display information about the title of the tool and the name of the author. Then proceed with displaying the names of the two supervisors. Furthermore, to start the measurement process the user can press the "MEASUREMENT" button on the display. Then the display will change to the Measurement page, which consists of a measurement column containing the negative pressure value read on the sensor. When the suction pump is turned on, the sensor will read the given negative pressure, so the sensor will process the data into voltage. After the data is converted into voltage, the data will be inputted into the microcontroller to be processed into digital data and will be displayed on the TFT LCD. The data displayed is a negative pressure value from the suction pump and its units of measurement, namely mmHg and kPa. In the Mit App Inventor application, officers can input device identities such as: Tool Name, Type/Brand, Serial Number, Location, Officer Name and Calibrator. Then the data on the MIT APP Inventor is stored in Google Sheets as shown in FIGURE 1.

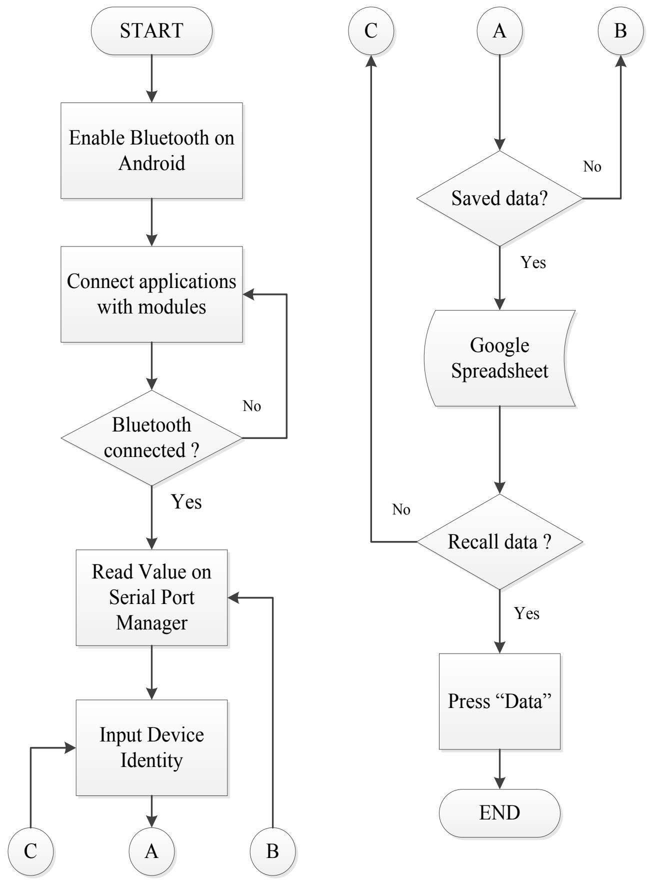

FIGURE 3. The flowchart of the application "MIT APP Inventor"

When the device is activated, by pressing the On/Off button, Arduino will initialize the program and configure all the commands used. The TFT LCD display displays information about the title of the instrument and the author's name. Then followed by the names of the two supervisors. Then switch to the next screen, namely the Home page where there is a "MEASUREMENT" button to go to the measurement page. On the measurement page there is a column that contains the pressure value that is read on the sensor. When the "MEASUREMENT" button is pressed, the measurement can be started. The author connects the module with android (application) using Bluetooth mode. In this application, you can input the identity of the device. After the input and measurement process is complete, the data that has been taken will be stored in Google Sheets and the stored data can be viewed again in the android application. After the measurement process is complete if the user is no longer using the tool, press the On/Off button as shown in FIGURE 2. After the device is activated, turn on the Bluetooth mode on the android, then connect the Bluetooth with the HC-05 module that is connected to the Arduino. If Bluetooth is not connected then the data on the Arduino Serial port cannot be read on the application. If Bluetooth is connected, the Bluetooth module will send data in the form of values on the serial port to the MIT APP Inventor application. After the data is visible in the application, the user can input the identity of the tool such as the name of the tool, Type/Brand, serial number, location, name of the officer and calibrator. After the process of measuring and inputting tool data is complete, the data that has been taken is stored in Google Sheets and the data that has been stored can be viewed again in the android application by pressing the "Data" button as shown in FIGURE 3.

C. DATA ANALYSIS

In the data collection technique, the writer will describe the measurement results at each measurement point. As well as determining how many error findings support the theory with the results of practice using the formula.

Average value

The average value is the sum of the overall values then divided by the number of data or the number of measurements. The average value can be calculated using the formula below:

$$\bar{x} = \frac{1}{n}\sum_{i}^{n} Xi \quad (1)$$

where x̄ indicates average value, xi indicates measurement value, for example x1, x2, x3, and n indicates amount of data retrieved

Error Value

This value is the difference between the value on the device (Unit Under Test) and the value on the standard measuring instrument. The error value can be calculated by:

$$|Error| = \bar{x} - Default\ Tool\ Value \quad (2)$$

Percentage Error Value

This value is the difference between the value on the tool (Unit Under Test) and the value on the standard measuring instrument then multiplied by 100%. The error value can be calculated by:

$$|Error| = (\bar{x} - DefaultTool\ Value) \times 100\% \quad (3)$$

Accuracy Value

Accuracy can be calculated by the formula:

$$\%\ accuracy = 100\% - \%\ Error \quad (4)$$

III. RESULT

In modern times, now there are many medical devices that have good quality and performance so that various kinds of diseases can now be easily detected by medical devices. However, no matter how modern or sophisticated medical devices are, they will still experience a decrease in performance and quality. A decrease in the performance or quality of medical devices can be seen from the measurement results that are starting to be inaccurate, this can be known with the help of standard tools or calibrators. Therefore, every medical device must be calibrated by the Health Facility Testing Center or Health Facility Testing Institution periodically at least 1 (one) time in 1 (one) year which is stipulated in Permenkes No. 54 of 2015. Calibration of medical devices is important because calibrating medical devices can minimize misdiagnosis, ensure accuracy, and accuracy, as well as maintain the safety of both doctors as users and patients who receive treatment from the medical devices themselves. The general purpose of the module is to create a negative pressure gauge on a suction pump that is equipped with input and storage of measurement data based on the MIT App Inventor. Meanwhile, the specific objectives of this final project are to compare the results of negative pressure measurement data with DPM 4 and Manometer to determine the level of accuracy of the modules made by the author, display the measurement data results on Google Sheets, use the MIT APP Inventor as a measurement data storage medium and be able to input Tool Name, Type/Brand, Serial Number, Location, Name of Officer and Calibrator.

TABLE 1
Function Test Tool

No.	Tested Part	Result
1.	Batteray	Working
2.	LCD TFT	Working
3.	Sensor MPXV4115VC6U	Working
4.	Modul HC-05	Working
5.	MIT APP Inventor	Working

Based on TABLE 1, the first part of the equipment tested, namely the battery was tested using the Avometer, the test was carried out with 4 conditions, namely at 100%, 80%, 50%, and 30% conditions. As for the TFT LCD test, it is done by looking at the results of the writing that appears on the display, for the MPXV4115VC6U sensor, measurements are made by looking at the sensor output results in the form of numbers listed on the display and compared with a comparison tool, for Module HC-05 the test is carried out by pairing HC -05 with android and see the data sent to the application, then the last one is the MIT APP Inventor, the application made by the author is tested on the button, tool identification column, and storage in the application.

TABLE 2
Measurement of negative pressure on the suction pump with units of kPa using DPM4.

Pressure Measurement (kPa)	Sample	Setting Pressure (kPa)		
		-10.6	-20	-30
DPM 4	1	-10.5	-20	-30
	2	-10.5	-20	-30
	3	-10.5	-20	-30
	4	-10.5	-20	-30
	5	-10.5	-20	-30
	6	-10.5	-20	-30
	7	-10.5	-20	-30
	8	-10.5	-20	-30
	9	-10.5	-20	-30
	10	-10.5	-20	-30
Module	1	-10.88	-20.33	-30.42
	2	-10.62	-19.95	-30.42
	3	-10.50	-19.82	-30.17
	4	-10.62	-20.72	-30.81
	5	-10.11	-20.84	-30.30
	6	-11.13	-19.69	-30.17
	7	-11.26	-20.46	-29.91
	8	-10.75	-19.95	-29.79
	9	-11.13	-19.18	-30.68
	10	-10.50	-20.33	-30.17
Average		-10.75	-20.13	-30.28
Error		0.15	0.13	0.28
Error (%)		1.40	0.64	0.93
Accuracy (%)		98.6	99.36	99.07
Standard Deviation		0.3549 96	0.5053 06	0.315 108

In TABLE 2, negative pressure measurements at the suction pump are set to -10.6, -20, and -30 kPa using DPM4 and the module. Measurements are made by connecting the suction pump with DPM4 and the module using a treeway. Measurements were carried out 10 times each with a time per 5 seconds for each setting.

TABLE 3
Measurement of negative pressure on the suction pump with units of mmHg using DPM4.

Pressure Measurement (mmHg)	Sample	Setting Pressure (mmHg)		
		-80	-150	-225
DPM 4	1	-80	-150	-225
	2	-80	-150	-225
	3	-80	-150	-225
	4	-80	-150	-225
	5	-80	-150	-225
	6	-80	-150	-225
	7	-80	-150	-225
	8	-80	-150	-225
	9	-80	-150	-225
	10	-80	-150	-225
Module	1	-81.59	-152.49	-228.18
	2	-79.68	-149.62	-230.10
	3	-78.72	-148.66	-226.27
	4	-79.68	-155.37	-231.06
	5	-75.84	-156.33	-227.23
	6	-83.51	-147.70	-226.27
	7	-84.47	-153.45	-224.35
	8	-80.63	-149.62	-223.39
	9	-83.51	-143.87	-230.10
	10	-78.72	-152.49	-226.27
Average		-10.75	-80.63	-150.96
Error		0.15	0.63	0.96
Error (%)		1.40	0.8	0.64
Accuracy (%)		98.6	99.2	99.36
Standard Deviation		0.3549 96	2.6729 31	3.7851 14

Based on TABLE 3, the suction pump setting the pressure to be measured is -80, -150, -225 mmHg which is the result of conversion from the setting value -10.6, -20, -30 kPa to mmHg. Measurements are made by connecting the suction pump to the Manometer and Module using a treeway. Measurements were carried out 10 times each with a time per 5 seconds for each setting.

TABLE 4
Measurement of negative pressure on the suction pump with units of kPa using a manometer.

Pressure Measurement (kPa)	Sample	Setting Pressure (kPa)		
		-10.6	-20	-30
Manometer	1	-10.5	-20	-30
	2	-10.5	-20	-30
	3	-10.5	-20	-30
	4	-10.5	-20	-30
	5	-10.5	-20	-30
	6	-10.5	-20	-30
	7	-10.5	-20	-30
	8	-10.5	-20	-30
	9	-10.5	-20	-30
	10	-10.5	-20	-30
Module	1	-11.01	-20.59	-30.42
	2	-10.50	-19.57	-29.79
	3	-10.24	-20.20	-30.17
	4	-10.11	-19.82	-29.40
	5	-10.75	-20.97	-29.53
	6	-11.65	-19.95	-29.79
	7	-11.26	-19.57	-30.04
	8	-10.75	-20.97	-29.66
	9	-11.01	-19.82	-30.30
	10	-10.75	-21.48	-29.66
Average		-10.75	10.80	20.29
Error		0.15	0.2	0.29
Error (%)		1.40	1.9	1.45
Accuracy (%)		98.6	98.1	98.55
Standard Deviation		0.3549 96	0.4606 05	0.669 414

Based on TABLE 4, the negative pressure measurement on the suction pump is set from -10.6, -20, and -30 kPa using a manometer and module. Measurements are made by connecting the suction pump to the Manometer and Module using a treeway. Measurements were carried out 10 times each with a time per 5 seconds for each setting.

TABLE 5
Measurement of negative pressure on the suction pump with units of mmHg using a manometer.

Pressure Measurement (mmHg)	Sample	Setting Pressure (mmHg)		
		-80	-150	-225
DPM 4	1	-80	-150	-225
	2	-80	-150	-225
	3	-80	-150	-225
	4	-80	-150	-225
	5	-80	-150	-225
	6	-80	-150	-225
	7	-80	-150	-225
	8	-80	-150	-225
	9	-80	-150	-225
	10	-80	-150	-225
Module	1	-82.55	-154.41	-228.18
	2	-78.72	-146.74	-223.39
	3	-76.80	-151.53	-226.27
	4	-75.84	-148.66	-220.52
	5	-80.63	-157.28	-221.48
	6	-87.34	-149.62	-223.39
	7	-84.47	-146.74	-225.31
	8	-80.63	-157.28	-222.43
	9	-82.55	-148.66	-227.23
	10	-80.63	-161.12	-222.43
Average		-10.75	81.02	152.20
Error		0.15	1.02	2.2
Error (%)		1.40	1.27	1.46
Accuracy (%)		98.6	98.73	98.54
Standard Deviation		0.3549 96	3.4466 35	5.0316 2

Based on TABLE 5, the suction pump setting the pressure to be measured is -80, -150, -225 mmHg which is the result of conversion from the setting value -10.6, -20, -30 kPa to mmHg. Measurements are made by connecting the suction pump to the Manometer and Module using a treeway. Measurements were carried out 10 times each with a time per 5 seconds for each setting.

TABLE 6
Comparison of Module Pressure Readings with DPM4.

Setting Pressure	**Average of 10 times Measurement**		**Error**
	Module	**DPM4**	
-10.6	-10.75	-10.5	0.025
-20	-20.13	-20	0.065
-30	-30.28	-30	0.14
-80	-80.63	-80	0.31
-150	-150.96	-150	0.48
-225	-227.32	-225	1.16

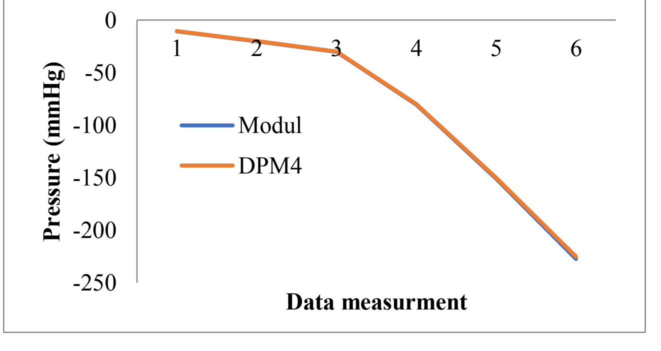

FIGURE 4. **Comparison Graph of Module Pressure Readings with DPM4.**

From the graphical results in FIGURE 4, the average reading of the Suction pump pressure between the module and DPM 4 which has been calculated is shown in table 6. It can be seen from the graph that the readings on the module do not deviate much from the pressure at DPM 4 and comparison of module pressure readings with dpm4 shown in TABLE 6.

TABLE 7
Comparison of Module Pressure Readings with Manometer.

Setting Pressure	Average of 10 times Measurement		Error
	Module	Manometer	
-10.6	-10.6	-10.8	0.1
-20	-20	-20.29	0.145
-30	-30	-29.88	-0.06
-80	-80	-81.02	0.51
-150	-150	-152.2	1.1
-225	-225	-224.06	-0.47

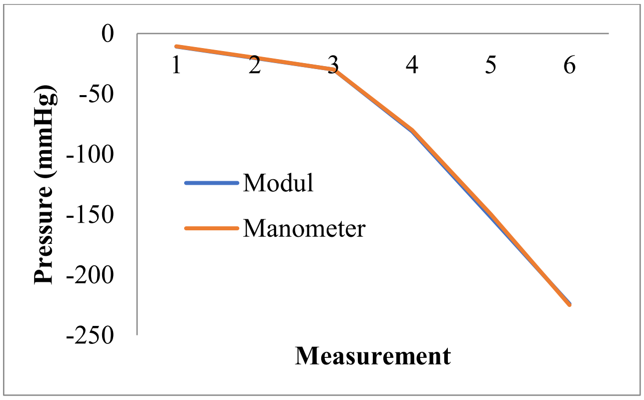

FIGURE 5. Comparison Graph of Module Pressure Readings with Manometer.

From the results of the graph in FIGURE 5, the average reading of the Suction pump pressure between the module and the Manometer has been calculated as shown in TABLE 7. It can be seen from the graph that the readings on the module do not deviate much from the pressure on the Manometer. The first initialization displays the title of the Scientific Paper, namely "Design of a Negative Pressure Measuring Device on a Suction Pump Equipped with Data Processing" and the name of the author. In the second initialization, it displays the names of supervisor 1 and supervisor 2 along with NIP. The Third Initialization is in the form of a menu display with the words “Suction pump Negative Pressure Calibration” and a button with the words “MEASUREMENT” to go to the pressure measurement page. On the pressure measurement page will display the value read by the sensor in 2 units (kPa and mmHg) and the HOME button which functions to return to the MENU page and LCD function test shown in TABLE 8.

TABLE 8
LCD screen function test

LCD	LCD TFT Display	Condition	
		works	not
Tool Initialization	Final Project Title, Author's Name along with NIM, Names of both supervisors and NIP.	√	-
Menu	The red button says "Measurements". Serves to display the negative pressure measurement page.	√	-
“*Home*” Button	The green button says "Home". Function to return to the home page.	√	-
Sensor Value Reading	Negative pressure values with 2 units: kPa and mmHg.	√	-

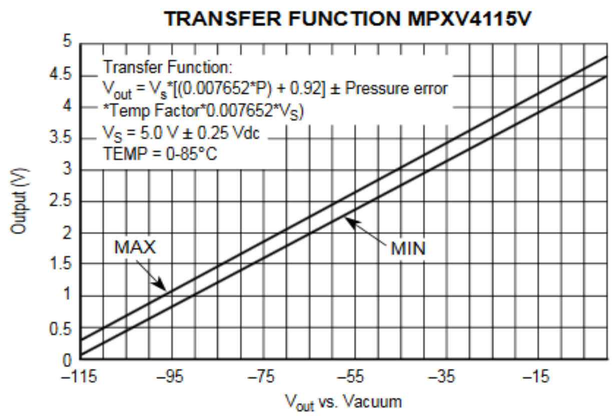

FIGURE 6. V_{out} vs. Vacuum[25]

FIGURE 6 shows the relationship between the input voltage and the negative pressure value read on the MPXV4115VC6U negative pressure sensor. In this study, no further research was conducted on this relationship, but the authors realized that when measuring negative pressure, the smaller the input voltage, the more negative the pressure value read in the image above.

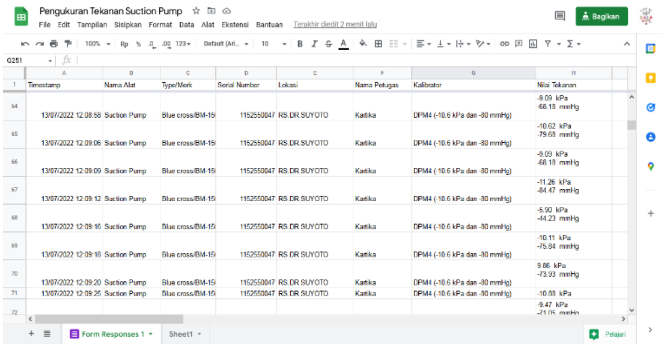

FIGURE 7. Comparison Graph of Module Pressure Readings with Manometer.

In FIGURE 7, displaying the results of storage on a Google Spreadsheet containing the date, tool name, type/brand, serial number, location, officer name, calibrator, and pressure value.

TABLE 9
Mit App Inventor testing.

Device	Function	Condition	
		Working	Not Working
MIT APP Inventor	Device identity input	√	-
	Pressure reading	√	-
	Storage on Google Sheets	√	-

In TABLE 9 is the result of the function test on the Mit App Inventor application. Starting from the column function for filling in the device identity, negative pressure values that are read, and the results of data that have been stored in Google spreadsheets can be retrieved in the application.

Battery percentage to battery level indicator:

- At 100%:
  8.50 VDC
- At 80%:
  8.50 ×80% = 6.8 VDC
- At 50%:
  8.50 ×50%=4.25 VDC
- At 30%:
  8.50 ×30%=2.25 VDC

In TABLE 10 is a function test on the battery level indicator in 4 conditions, where the module uses a battery with a capacity of 9 Volts. Measurement using the avometer. The 100% condition is read on the 8.50 Volt avometer with information that LEDs 1,2,3 and 4 are on. The 80% condition is read on the 6.77 Volt avometer with information that LEDs 2, 3 and 4 are on while LED 1 is off. The 50% condition reads 4.66 Volts with the condition that LEDs 3 and 4 are on while LEDs 1 and 2 are off. The 30% condition reads 2,225 Volts with the description that LED 4 is on while LEDs 1, 2 and 3 are off.

TABLE 10
Battery Voltage Measurement Results and Battery Level Indicator

Device	Value	Condition		Description
		Working	Not Working	
Battery 9V	8.50	√	-	LEDs 1,2,3 and 4 light up
	6.77	√	-	LEDs 2, 3, and 4 are on, while led 1 is off
	4.66	√	-	LEDs 3 and 4 are on while LEDs 1 and 2 are off.
	2.225	√	-	LED 4 is on. LEDs 1, 2, and 3 are off.

IV. DISCUSSION

Calibration of medical devices is important because calibrating medical devices can minimize misdiagnosis, guarantee accuracy and precision, and maintain the safety of doctors as users and patients who receive treatment from the medical devices themselves. According to Permenkes No.363/MENKES/PER/IV/1998 concerning Testing and Calibration of Medical Devices, Medical Suction Pumps are one of the medical devices that must be tested or calibrated and the provisions for calibrating medical devices are also explained in Law Number 44 concerning Hospital, article 16 which requires all medical devices to be tested and calibrated regularly by testing centers or testing institutions that must have facilities. If not (Public health center and Hospital) can be closed and this will have an impact on the community.

Compared to previous research, the advantage of this research is the use of applications or the internet of things which make it easier for users, especially calibration officers, because users can easily input device identities into applications on smartphones so that officers do not need to record manually and are more environmentally friendly because they reduce paper use. . From this study it was also found that the theory in FIGURE 6 [25] is true, the smaller the input voltage, the more negative the pressure value will be. The voltage value against the negative pressure value greatly affects accuracy, so that in the future you can use a stable input voltage.

IV. CONCLUSION

This study aims to optimize the Digital Pressure Meter equipped with the Internet of Things. From the research conducted, it can be concluded that the negative pressure measuring device module on the suction pump has been successfully developed and can be used properly. The results of the MPXV4115VC6U negative pressure sensor test compared to the DPM4 calibrator, after calculating two units (kPa & mmHg) the accuracy is 99.09%, while the MPXV4115VC6U negative pressure sensor test is compared to the Manometer calibrator, after calculating two units (kPa & mmHg) an accuracy of 98.85%. Pressure measurement compared to DPM4 has 0.24% higher accuracy than pressure measurement developed with Manometer. For future work, you can use a battery with a larger capacity and make the best use of the features on the ILI9486 TFT LCD.

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