Manuscript received November 10, 2025; revised March 3, 2026; accepted April 21, 20216 date of publication June 17, 2026
Digital Object Identifier (DOI): 10.1109/ELECTROMEDIC.v1.i1.1

Design and Development of an Arduino Mega-Based Sphygmomanometer Calibrator for Simultaneous Pressure and Time Measurement

Nining Nur Indah Sari[1], Ipin Prasojo[1], and Mahardira Dewantara[1]
[3]Electrioeical Engineering Department, Universitas Muhammadiyah PKU Surakarta, Surakarta, Indonesia

Corresponding author: Ipin Prasojo (e-mail: ipinprasojo@umpku.ac.id).

ABSTRACT A sphygmomanometer is used to measure a person's blood pressure. The accuracy of the sphygmomanometer is very important in the world of health because it affects the diagnosis and treatment of patients. To find out the accuracy level of the sphygmomanometer**,** calibration can be carried out which is currently still being carried out using several calibrators such as digital pressure meters and digital stopwatches. Objective: to design an Arduino Mega-based sphygmomanometer calibrator that can measure pressure and time parameters simultaneously with a single calibrator. Research Method: designed a sphygmomanometer calibrator using the MPX -5050GP Pressure Sensor as a pressure measurement reader and Arduino Mega 2560 as a microcontroller. Results: the time accuracy value had an error percentage of 0.10% with a maximum accuracy of 99.92%. Meanwhile, the pressure accuracy value was obtained with an error percentage of 0.0284% with a maximum accuracy of 100%. Conclusion: the measurement results obtained have high accuracy and a low error percentage so that Arduino Mega-based sphygmomanometer calibrator can be used effectively and accurately.

INDEX TERMS Arduino Mega, Calibrator, Sensor MPX-5050GP, Sphygmomanometer.

I. INTRODUCTION

Sphygmomanometer or measuring device, blood pressure is a very important medical device in the world of health, used to measure a person's blood pressure. The continuous use of sphygmomanometers results in a decrease in the accuracy and precision of measurement results. The accuracy and precision of the sphygmomanometer greatly affect the diagnosis and treatment of patients. Therefore, this device needs to be checked regularly, and the function of the tool continues to provide accurate and reliable results. To check the accuracy of the tool, an activity is needed, namely calibration. According to Permenkes No.54/2015[1], calibration is an application activity to determine the correctness of the value of the appointment of measuring instruments and/or measuring materials.

Based on the Decree of the Director General of Health Services Number HK.02.02/D/43649/2024 dated July 22 concerning the Working Method of Testing and Calibration of Non-Automatic Sphygmomanometer Number (KMKMK-090.0 Working Method of Sphygmomanometer)[2], it is stated that the equipment that needs to be used in the calibration of sphygmomanometer includes digital pressure meters, digital timers/ stopwatches and digital thermohygrometers. Currently, the implementation of sphygmomanometer calibration is still mostly carried out using different calibrators that have limited measurement parameters. This makes it less efficient for job mobility and calibrator purchase expenses. Calibrators sold on the market often have a high price because they include medical devices of a certain standard. Additionally, the purchased tool may not have features that can be customized as per the user's specific needs. Therefore, it is important to consider the manufacture of a calibrator tool yourself as a more flexible and economical solution.

Self-built calibrators allow for flexibility and customization such as combining pressure and time measurement parameters in a single tool to make them more compact. In addition, the creation of the tool itself can also be added with a more user-friendly display feature. Another advantage of building your own tool is the cost and flexibility benefits, and users can better understand how the tool works, including the working principle of pressure sensors, calibration methods, and data processing. This understanding is very useful in the event of damage or repair needs to be carried out so that it does not depend on the services of technicians from the appliance manufacturer.

Previous research [3], has developed a sphygmomanometer calibrator using MPX5050GP as the pressure sensor and Atmega 328 as the microcontroller with an average accuracy rate of 98.16%., further research [4], has developed a digital pressure meter (DPM) design based on the internet of things using MPX5050GP and Arduino Wemos D1 with the greatest accuracy value of 94.6% at the measurement point of 50 mmHg. Therefore, it is necessary to develop research using MPX5050GP sensors as pressure sensors and Arduino Mega 2560 as microcontrollers to increase the accuracy value of the calibrator design. Nextion LCD is also added as a display because it can display a lot of data and a very good interface [5].

1. Blood Pressure

Blood pressure is a very important factor in the circulatory system. Blood pressure is the pressure felt by the walls of the arteries when blood is pumped by the heart throughout the body. In blood pressure measurement, there are two important values used, namely systolic and diastolic. Systolic blood pressure occurs when the ventricles contract and bleed into the arteries. Diastolic blood pressure occurs when the ventricles relax and fill with blood from the atrium[6]

2. Sphygmomanometer

A sphygmomanometer is a physical instrument used to measure blood pressure. Measured blood pressure is the relative pressure between the pressures inside the blood vessels compared to the pressure of the outside air or atmosphere. The unit used in blood pressure measurement is mmHg [7]. A sphygmomanometer is a sphygmomanometer that uses the rotation of a skeleton or needle, this sphygmomanometer also requires a stethoscope in its use.

3. Calibration

According to the Indonesia's Minister of Health Regulation [1], calibration is an application activity to determine the correctness of the value of the designation of measuring instruments and/or measuring materials. To ensure the availability of medical devices in accordance with service standards, quality requirements, safety, benefits, safety and suitability, it is necessary to carry out testing and/or calibration. Calibration activities aim to:

a. Providing reference for the government, local governments, and the community in the implementation of Medical Device Testing and/or Calibration;
b. Ensuring the availability of Medical Devices that are in accordance with service standards, quality requirements, safety, benefits, safety, and suitability for use in Health Service Facilities and other Health Facilities; and
c. Improving the accountability and quality of services of Health Facility Testing Centers and Health Testing Institutions in Testing and/or Calibration of Medical Devices.

4. Digital Pressure Meter

A Digital Pressure Meter (DPM) is a standard tool used to measure the accuracy of positive pressure and negative pressure[3], [8]. The results of the accuracy measurement will be compared with the Under Test Unit (UUT). The Digital Pressure Meter (DPM) can be used to measure the accuracy of the sphygmomanometer for tools with positive pressure samples and suction pumps for tools with negative pressure samples.

5. MPX-5050GP Pressure Sensor

MPX5050GP sensor is an air pressure sensor that is used to convert pressure into an analog signal [9] as seen in fig. 1. The sensor is equipped with signal conditioning and a built-in operational amplifier (op-amp), so the output can be directly connected to an analog-to-digital converter (ADC). The sensor has a fairly good level of accuracy of up to 50 kPa, with specifications including a supply voltage of +5V DC, a pressure measurement ranges from 0 to 50 kPa (equivalent to 375 mmHg), and a sensitivity of around 90 mV/kPa or 12 mV/mmHg[10].

Figure 1. MPX-5050GP Pressure Sensor[11]

6. Arduino Mega 2560

Arduino is a microcontroller-based board or electronic circuit board in which there is a main component, namely a microcontroller chip The microcontroller itself is a chip or IC (integrated circuit) that can be programmed using a computer[12] as seen in fig. 2. The purpose of embedding a program on a microcontroller is so that the electronic circuit can read the inputs, process those inputs and then produce the output as desired. So, the microcontroller serves as the brain that controls the input and output processes of an electronic circuit[13].

Figure 2. Arduino Mega 2560 [13]

7. LCD Nextion

Nextion's LCD is a graphical user interface (Human Machine Interface / HMI) module designed to provide ease of displaying information and controlling microcontroller-based systems, such as Arduino, ESP32, and the like. This module is equipped with a touch screen that can be either resistive or capacitive type, depending on the type of module used.[5]. The physical appearance as seen in fig. 3 below

Figure 3. Nextion LCD[5]

8. LM2596 Module

The regulator module LM2596 is a regulator that functions to lower the voltage (stepdown). This regulator can output a maximum current of 1.5A, with an input power of 3.5V to 40V, and an output power of 1.2V to 37V. In this circuit, the power supply uses the regulator module LM2596, the regulator is used to lower the voltage to 5 Volts which can be used as an input for Arduino Mega, LCD, sensors, and the whole circuit.[14]. The physical appearance as seen in fig. 4 below

Figure 4. LM2596 Module[14]

9. Adaptor PSU 12V

The 12V 2A PSU (Power Supply Unit) adapter is an external power supply device used to provide DC (unidirectional) voltage and current in a stable manner in electronic devices as seen in fig. 5. In microcontroller-based systems or laboratory equipment, these adapters play an important role in maintaining system performance and stability.

Figure 5. 12V PSU Adapter

II. METHOD

Research and Development (R&D) is a research method used to produce certain products and test the effectiveness of those products [15]. This research focuses on innovations in monitoring the work of sphygmomanometer calibrators. Flowchart of research stages as shown in fig. 6 below

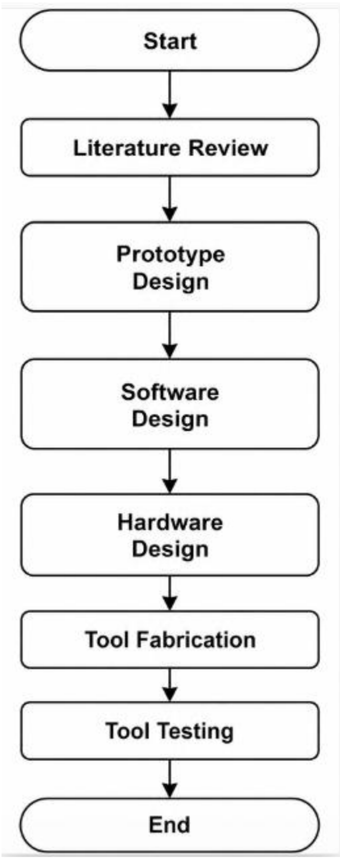


Figure 6. Research Flow Diagram.

There are three modes presented in the program design which will then be processed based on the selected mode as seen in fig. 7. The modes presented in the program are as follows.

1. Mode 1 (Leak Test)
   The leak test measurement aims to ensure that the sphygmomanometer tool including hoses, manometers, connectors and pumps does not experience air leakage.
2. Mode 2 (Fast Dump Rate)
   Rapid discharge rates are performed to test whether the system can discharge pressure quickly and safely.
3. Mode 3 (Pressure Accuracy)
   Pressure accuracy measurement is used to measure the accuracy of each setting point of the sphygmomanometer.

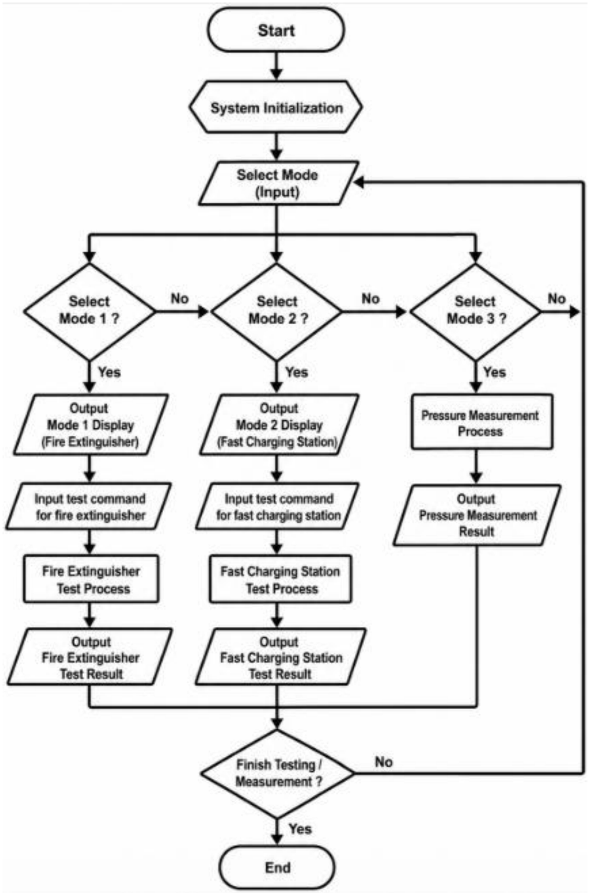
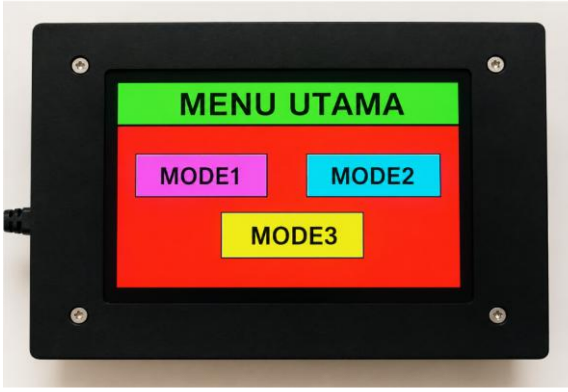


Figure 7. Software Program Design Flowchart

III. RESULTS

A prototype of the tool consisting of the MPX-5050GP sensor as a pressure sensor, the Arduino Mega 2560 as a microcontroller has advantages compared to previous research, and Nextion's LCD as a touch layer display that displays the timer and pressure accuracy. With this touch layer display, the operation of the prototype becomes easier, and the appearance is more attractive.



Gambar 8. Prototype Calibrator Sphygmo-manometer

From the prototype that have been developed as seen in fig. 8, then test to see the performance of the tools that have been developed, the test is aimed at two parameters, namely, time parameters and pressure parameters. Testing of the prototype for time parameters is carried out by comparing the measurement results on the prototype and the stopwatch. In summary, the results of the prototype tests for the time parameters can be seen in Table 1 and fig. 9 as follows.

Table 1. Prototype Test Results for Time Parameters

No	Setting Point	Standard Deviation *Prototype*	Standard Deviation *Stopwatch*	*Error*	Accuracy
	seconds			%	
1	10	0	0,079	0,0074	99,25
2	20	0	0,117	0,0029	99,71
3	30	0	0,098	0,0016	99,84
4	40	0	0,246	0,0001	99,99
5	50	0	0,122	0,0004	99,96
6	60	0	0,178	0,0002	99,98

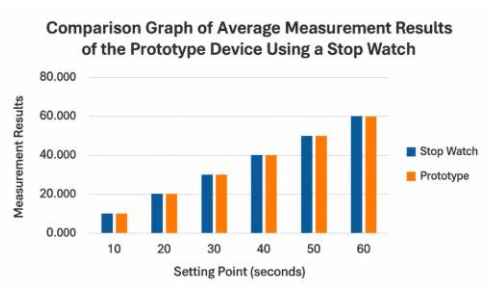


Figure 9. Time Measurement Average Comparison Chart

The tool test for pressure parameters is carried out by comparing the measurement results on the prototype and *the Digital Pressure Meter*. In summary, the results of the tool tests for pressure parameters can be seen in Table 2 and fig. 10 as follows.

Table 2. Prototype Test Results for Pressure Parameters

No	Setting Point	Standard Deviation *Prototype*	DPM Standard Deviation	*Error*	Accuracy
	seconds			%	
1	0	0,00	0,00	0	100,00
2	50	0,25	0,20	0,00024	99,98
3	100	0,25	0,16	0,00147	99,85
4	150	0,30	0,32	0,00065	99,94
5	200	0,33	0,16	0,00015	99,99
6	250	0,29	0,31	0,00056	99,94

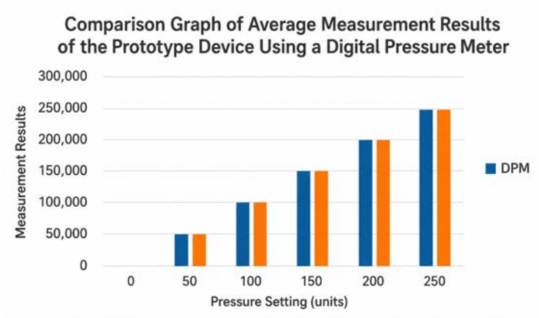


Figure 10. Comparison Chart of Average Measurement of Prototype Tool with DPM

IV. DISCUSSION

In the time accuracy test as seen in table 1, for each point measurements are made 5 times, from this measurement the standard values of deviation, error and accuracy are obtained. The results of the test obtained a deviation value of 0.246 seconds from the measurement results as the largest deviation value at the 40-second setting point of the *stopwatch* test. As for the percentage of errors (% *error*) from the results of testing the prototype tool on *the stopwatch*, the smallest and largest values were obtained of 0.0001% at the 10-second setting point and 0.0074% at the 40-second setting point. The range of accuracy values obtained from time measurement testing is 99.25% - 99.99%.

In the pressure accuracy test as seen in table 2, for each point measurements are made 5 times, from this measurement the standard values of deviation, error and accuracy are obtained. The results of the test obtained the largest deviation value of the reading of the measurement results, which was 0.33 at the 200-mmHg setting point for the prototype test results and 0.32 seconds at the 150-mmHg setting point for the DPM test. Meanwhile, the percentage of errors (% *error*) from the results of testing the prototype tool on DPM was obtained with the smallest and largest values of 0.00015% at the 200-mmHg setting point and 0.00147% at the 100-mmHg setting point. The range of accuracy values obtained from pressure measurement testing is 99.85% - 100%.

IV. CONCLUSION.

The design of the sphygmomanometer calibrator using the MPX-5050GP Pressure sensor and the Arduino Mega has a working principle that the positive pressure input is received by the MPX-5050GP pressure sensor which is then converted into an analog signal through data processing by the Arduino Mega as a microcontroller and displayed on the Nextion LCD.

In this study, the prototype of the tool was validated by calculating the error value of the prototype measurement results against the standard measuring tool. The largest error percentage obtained in the time parameter was 0.0074% with a deviation value of the maximum measurement reading of 0.246 seconds and a maximum accuracy of 99.99%. As for the largest error percentage obtained in the pressure parameter which is 0.0147% with a deviation value of the maximum measurement reading of 0.33 mmHg in the prototype and the maximum accuracy reaches 100%.

REFERENCES

[1] Permenkes No. 54 Tahun 2015. 2015.
[2] Keputusan Direktur Jenderal Pelayanan Kesehatan HK.02.02/D/43649/2024. 2024.
[3] R. Crismonika, “Kalibrator Sphygmomanometer,” Universitas Widya Husada Semarang, 2020.
[4] H. M. Sari, M. A. Hariyono, and M. M. Akbar, “Rancang Bangun Digital Pressure Meter (DPM) Berbasis Internet of Things,” J. Elektron. Mhs. Polanka JEMPOL, vol. 2, no. 1, 2024, doi: https://doi.org/10.52674/jmpl.v2i1.175.
[5] I. Tri Harsoyo, M. Ulin Nuha Aba, B. Wahyudi, and D. Aji Firmansyach, “Hotplate Magnetic Stirrer Dilengkapi Pengatur Waktu, Suhu dan Kecepatan Melalui LCD Nextion,” J. Teori Dan Apl. Fis., vol. 12, no. 01, Jan. 2024, doi: 10.23960/jtaf.v12i1.14197.
[6] Muhamad Afif Nurochman, Wahyu Tri Sudaryanto, and Seliana Sinta Debi, “Penyuluhan Hipertensi Kepada Pengunjung Posyandu RW 14 Kelurahan Sumber,” Cakrawala J. Pengabdi. Masy. Glob., vol. 3, no. 1, pp. 126–132, Jan. 2024, doi: 10.30640/cakrawala.v3i1.2122.
[7] M. Zuhdi, J. Ardhuha, and M. Taufik, “Keunggulan Pengukuran Tekanan Darah Menggunakan Tensimeter Digital Dibandingkan dengan Tensimeter Pegas,” JPPFI, vol. 2, no. 2, 2020.
[8] K. D. Kusumadewi, S. Syaifudin, and T. B. Indrato, “DPM Dua Mode Dilengkapi Thermohygrometer dan Pemilihan Tekanan (Positive Pressure),” J. Teknokes, vol. 13, no. 2, pp. 91–97, Dec. 2020, doi: 10.35882/teknokes.v13i2.5.
[9] A. Sujiwa, “Design an Internet of Things-Based Blood Pressure Detector and Monitor,” BEST J. Appl. Electr. Sci. Technol., vol. 5, no. 1, pp. 25–32, Sep. 2023, doi: 10.36456/best.vol5.no1.7188.
[10] W. F. Bastari, A. Sujiwa, and R. Setyobudi, “Penerapan Internet of Things Pada Aplikasi Alat Deteksi Dan Monitoring Tekanan Darah,” Pros. Semin. Nas. Has. Ris. Dan Pengabdi., 2023.
[11] P. C. Ning Tyas and R. Nur Hidayati, “Development of a Portable Digital System for Vital Sign Measurement Using Multi-Sensor Integration,” Electromed. J. Med. Electron., vol. 2, no. 2, pp. 86–95, Dec. 2025, doi: 10.66508/electromedic.v2i2.76.
[12] W. Wahyudi, W. Purnamasari S, A. Hidayat, and M. M. Fakhri, “Penerapan Machine Learning Pada Mikrokontroler Arduino Mega PRO MINI ATmega2560-16AU,” J. Embed. Syst. Secur. Intell. Syst., vol. 3, no. 1, p. 30, Jun. 2022, doi: 10.26858/jessi.v3i1.33370.
[13] J. W. Simatupang, B. Prasetyo, M. Galina, and A. Suhartomo, “Prototipe Mesin Penjual Air Mineral Otomatis berbasis Arduino Mega 2560 dan RFID-RC522,” ELKOMIKA J. Tek. Energi Elektr. Tek. Telekomun. Tek. Elektron., vol. 10, no. 2, p. 484, Apr. 2022, doi: 10.26760/elkomika.v10i2.484.
[14] B. Artono, D. N. Prakoso, and H. N. K. Ningrum, “ATS AMF Monitoring System on DSE 4520 MKII Module Based on IOT (Internet Of Things),” Int. Res. J. Adv. Eng. Sci., vol. 7, no. 4, 2022.
[15] J. Ali, A. Annisa, A. Wasid, K. Rahmadani, A. Fricticarani, and P. Dayurni, “Pengembangan Media Pembelajaran Berbasis Android Menggunakan Aplikasi Smart App Creator 3 Pada Mata Pelajaran Teknologi Informasi Dan Komunikasi,” J. Inov. Pendidik. Dan Teknol. Inf. JIPTI, vol. 5, no. 1, pp. 144–150, Apr. 2024, doi: 10.52060/jipti.v5i1.1843.