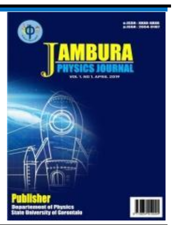
Jambura Physics Journal (2022) Vol.4 (2): 77-86
DOI: 10.34312/jpj.v4i2.15840

Jambura Physics Journal

p-ISSN: 2654-9107 e-ISSN: 2721-5687
Journal homepage: http://ejurnal.ung.ac.id/index.php/JPJ



PROTOTYPE DESIGN OF 4 PROBES METHOD BASED ON MICROCONTROLLER WITH MEMORY CARD STORAGE MODULE

Imam Sya'roni[1], Nugrahani Primari Putri[1*], Lydia Rohmawati[1]

[1] Physics department, Faculty Mathematics and Natural Science State University of Surabaya. Jalan Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213

*Email: nugrahaniprimary@unesa.ac.id

Received: 12 August 2022. Accepted: 23 September 2022. Published: 8 October 2022

ARTICLE INFO

Keywords:

Four Point probes, Conductivity, Microcontroller

How to cite:

Sya'roni, I., et al. (2022). Pani Resistivity Measurement Using 4 Probe Method Based on Microcontroller with Memory Card Storage Module. *Jambura Physics Journal*. Vol 4 (2), 77-86

DOI:
https://doi.org/10.34312/jpj.v4i2.15840

ABSTRACT

The goal of this study is to create a prototype that uses a microcontroller to determine the physical phenomenon worth of a fabric victimisation, method by four-point probe. The amendment in resistance of a material once an electrical current flow through it's wont to quantify electrical conductivity. The example took measurements and saved them as data.txt. Using IC 741 100X gain amplifier circuit, prototype amplifies the output voltage and current for convenient monitoring. The source flag value is used in prototype calibration; the tolerance value for the measurement uncertainty uncertainty of voltage is 2.1 percent and tolerance value of uncertainty of current is 2.1 percent, respectively, based on comparisons with the calibration output. For voltage readings, prototype's measurement accuracy is 97.89 percent, and for current assignments, it's 97.64 percent. The output values will be saved and analyzed before being graphed to determine the material's conductivity value. Pani, a substance with a composition of 0.25 M anilin + 0.5 M HCL, was used to test the electrical conductivity of prototype Four Point Probe. The experiments were carried out by varying the voltage from 1 to 5 until the value of material conductivity Pani was between 0.9 and 1,25 x 107 (m)-1. Range 73.47 percent linearity value.

1. Introduction

The measurement of the material resistivity value is done manually using a multimeter measurement which can affect the accuracy of the results. Only material that are classified as thin layers are not easy to measure using a multimeter (Hong et al., 2022; Lian et al., 2023; L. Wang et al., 2023). materials into a thin layer are more difficult when measured manually except using four-point probe (Akhbarifar et al., 2021; Han et al., 2019; Novita et al., 2017a). The thin layer has electrical properties, namely conductivity and resistivity (Turkay et al., 2021; X. Wang et al., 2019; Zhu & Ren, 2020). Technological developments in the 4.0 era have made a lot of research collaborating technology and measurement. The collaborations that are often used are microcontrollers and sensors. The microcontroller was compared to a prototype brain. If a command (code) is given to the microcontroller the results obtained will correspond to the initial command. The brain needs senses called sensors. A sensor works to convert a measured quantity into a signal according to the input of the microcontroller. A prototype was built to support the measurement of these materials in the electrical resistivity study of these materials. The sensors used are current sensor and voltage sensor and are controlled by Atmega328p microcontroller with 16x2 LCD output (Nikmah et al., 2022; Sya'roni et al., 2023) and storage via SD card module. In this study, researchers want to design a four-point probe measuring instrument with automatic storage and see the accuracy of the resulting tool by measuring the test material.

2. Methode

This type of research is research and development with quantitative data collection. The tool developed uses a microcontroller with a test material. The first research stage is to prepare tool and design prototype, the second stage is to

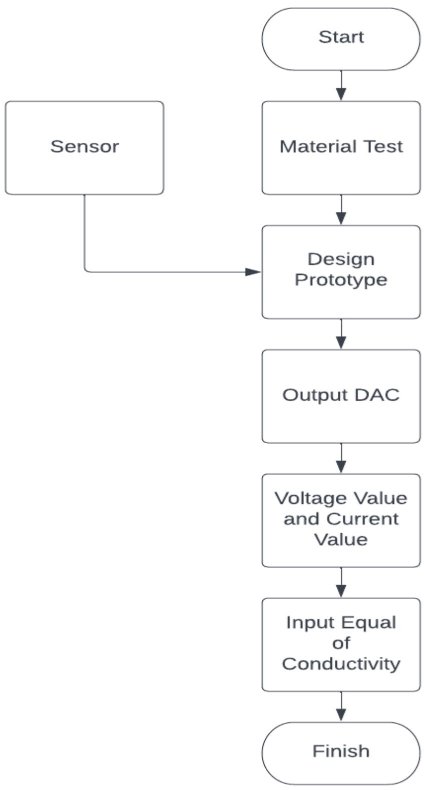


Figure 1 Flow of prototype research

calibrate prototype and the third stage is to test prototype. The parameters measured in the design of this tool are voltage and current which will be analyzed into the value of the electrical conductivity of the material. Research procedure flow chart show in Figure 1.

The data collection scheme is:

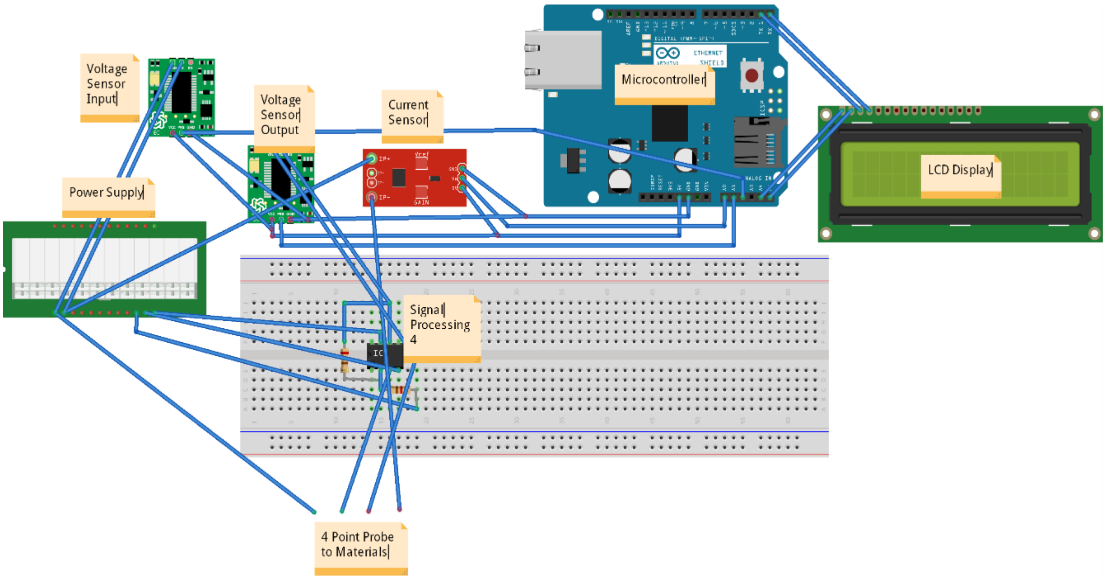


Figure 2. 4-point pin probe resistance measuring system block diagram

Resistance knowledge collected from measurements is used in conductivity measurements. The microcontroller is configured to scan and convert current and stress values in values of physical phenomena. Figure 3 shows the software flowchart for the impedance measurement paradigm.

Because the V and I flowing through the material are small, electrical equipment and signal conditioners are required to achieve the minimum values detected and

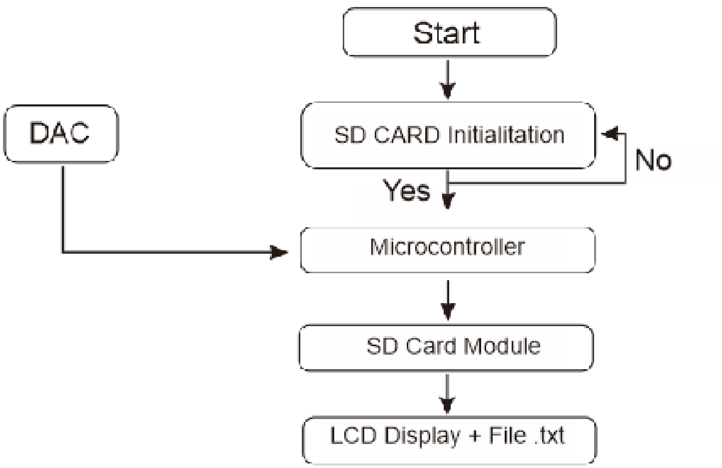


Figure 3. Flow of Parameter I and V Processing

present by the voltage sensing devices IC0741 could be a type of gain IC commonly used to amplify any low-level signal so it can produce the required output. In this figure, the gain is set to 100x magnification, after which the signal is received by the voltage sensor and work by the microcontroller (Sya'roni et al., 2023).

Prototype will try to measure one of materials sample after prototype have a calibration value. The material result will compare with theory. PaNi materials composition value 0.25 M anilin + 0.5 M HCL.

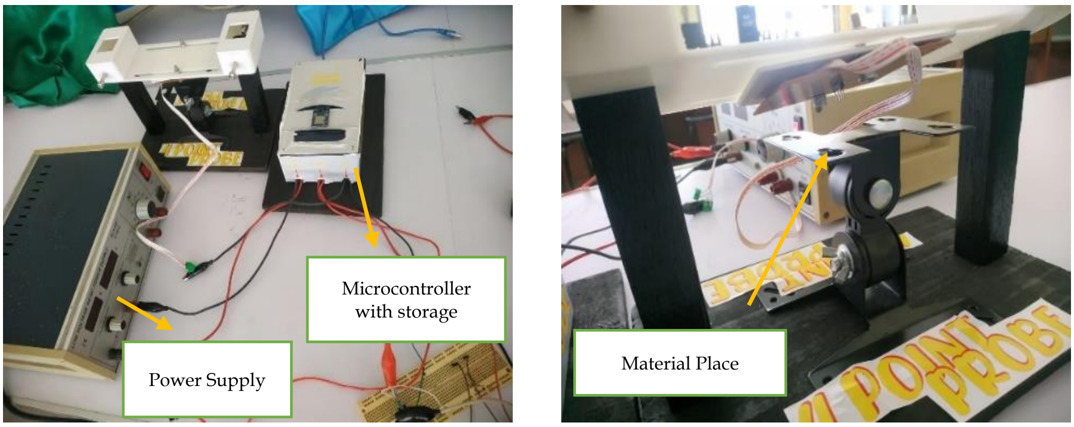
3. Results and Discussion

The results of the manufacture of measuring devices using the automatic 4 probe method divided into three, namely the results of design, the calibration of tool and the results of testing tools.

The results of design

Measurements using a prototype 4-point probe based on a microcontroller (Beltrán-Pitarch et al., 2023; Dong et al., 2023) with a memory card storage module were pre-calibrated to determine the level of accuracy and tolerance limits of prototype. Calibration prototype power supply indicator. The following is the appearance and appearance of the prototype from Figure 4.

Prototype is designed to make it easier for thin layers of material to be placed in the center of prototype. Distance of probe constant with 2 mm and height of prototype can change depend on the object. The series of tools is divided into three parts, namely the voltage source, microcontroller with storage, and material place. Microcontroller inside a box that processing all input sensor to display it and save it to .txt as figure 5 that spill with; symbol to easy convert to be a column in excel.



(a) (b)

Figure 4. (a) Four Probe Point Wiring with I and V Source, (b) Probes on Four Probe Point prototype's support

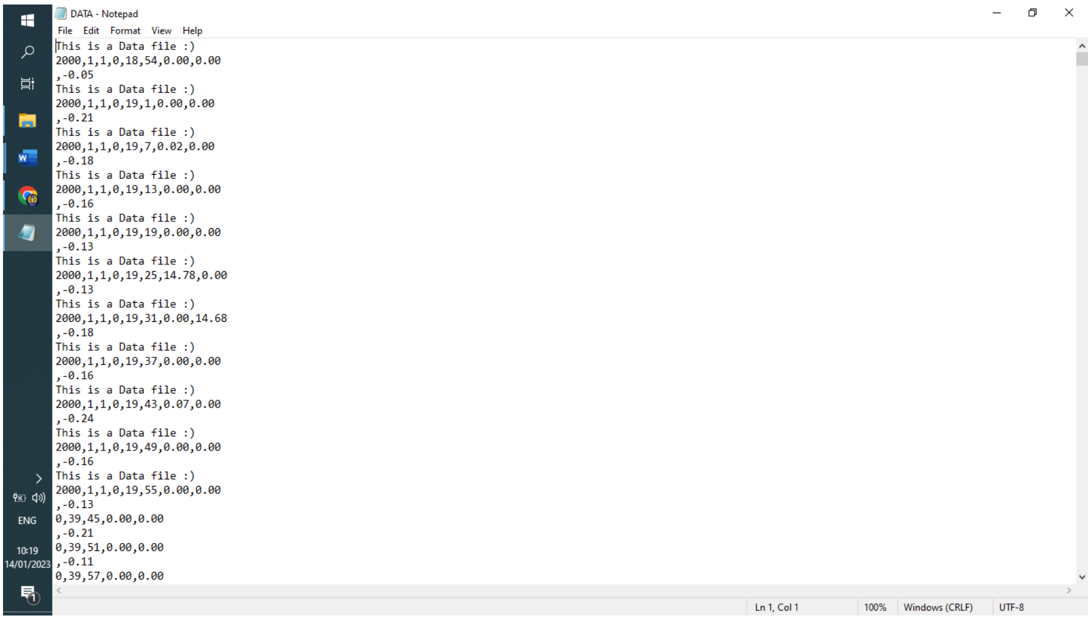


Figure 5. Data inside .txt

The calibration of tool

The calibration results of prototype are shown in table 1.

Table 1. Testing Value for Voltage

No.	Prototype Output Voltage (V)	Input Voltage (V)	Uncertainty in Relative Terms (%)	Accuracy (%)
1	0.97	1.00	3.00	97
2	2.00	2.00	0.00	100
3	3.05	3.00	1.67	98.33
4	4.13	4.00	3.25	96.75
5	5.13	5.00	2.64	97.41
Average Measurement			2.10	97.89

This process is carried out by comparison, namely the display of prototype readings and power supply indicators. The percentage of tool error is calculated using the formula:

$$XY = \frac{Y-X}{Y} \text{ x } 100\% \quad (3)$$

With:

X = Value on comparator

Y = Value on measuring instrument (Nikmah et al., 2022)

Model calibration and indicator voltage value acquired from 5 trials are the initial standardization. The difference in readings is 0.3 - 13 volts for prototype voltage reading. The paradigm uncertainty level is calculated to be 2.103 p.c from table 1, with Associate in Nursing accuracy of 97.89667 percent. This accuracy

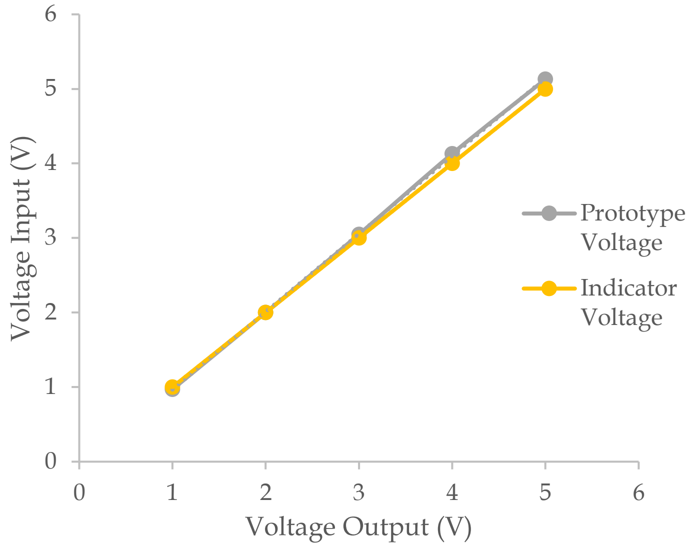


Figure 6. Prototype and Indicator Value of V Readings Linearity

scores satisfactory and demonstrates the effect of this prototype is very clever and well used. An indefinite patience level is set 36.57 percent (Sun et al., 2022)

The graph higher than depicts the linearity value Meters that simulate voltage measurements and display voltage changes. Adds simplicity to the index 1 or 100% from figure 6, however the figure has a linearity of ninety nine percent, indicating a touch variation within the association between the reading values and every different.

Table 2. Valueer of Calibration in Use

No	Prototype	Indicator	Relative Uncertainty (%)	Accuracy (%)
1	1.11	1.1	0,90	100
2	1.47	1.4	5	99,09
3	2.30	2.3	0	95
4	2.63	2.6	1,15	100
Average Measurement			2,35	97,64

The second activity involves decisive this reading of the paradigm likewise because the indications that show from table 2. Four experiments were carried out to vary the voltage 0,2 V to 0,8 V accumulate the average measurement error under the 97,64 percent accuracy conditions shown in Table 2. The accuracy of these current measurements was basically satisfactory. The performance of this prototype is very intuitive so get used to measuring current. Tolerance for uncertainty is over 36,57. (Sun et al., 2022)

Figure 8.

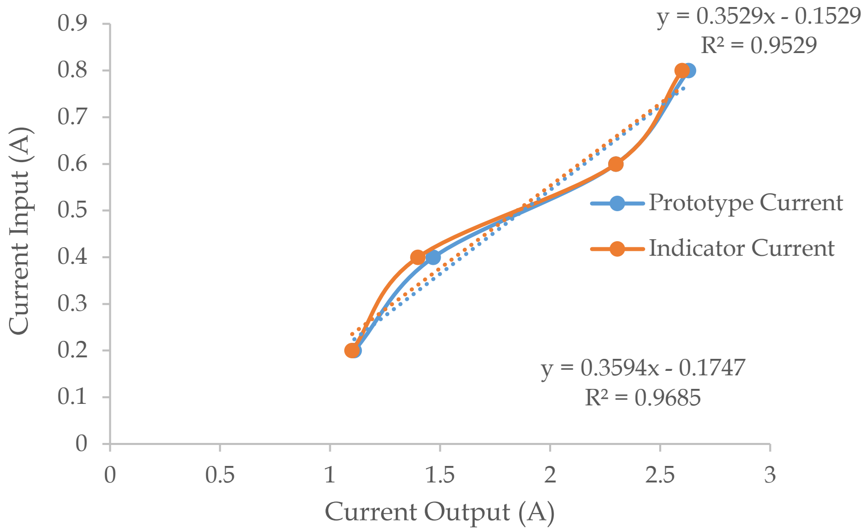


Figure 7. Prototype and Flow Value Indicator of Reading Linearity

The graph on figure 7 of shows the linearity of the current reading and value indicator that appears to vary the voltage. The notation includes the linearity of 1 or 96,85% the letters, but the figure includes letters with a slightly different ratio of 95,29% readability for each key.

The results of testing tools

The objects around us are made up of various materials. One of them is polyaniline (PANi). Polyaniline is a material that has good electrical conductivity (Bruchez et al., 2020). The nature of the conductivity in PANi arises because of the movement of electrons in their orbits, this movement of electrons triggers the electrical effect of PANi. The movement of electrons in the orbit affects the value of the electrical conductivity of the material. The conductivity of PANi can be calculated using the resistivity approach of the material. Resistivity is influenced by the voltage and current flowing in the material (Novita et al., 2017b)

The equation of Conductivity (σ) from 1/resistivity. Resistivity (ρ) can calculate from output prototype, Voltage and Current value can insert to equation so.

$$\rho = \frac{VA}{IL} \quad (1)$$

$$\sigma = \frac{1}{\rho} \quad (2)$$

From material test PANi, A = 9,42 cm and L = 0,7 cm.

Table 3. Result of measurement Prototype and Calculate Material Conductivity

Voltage Output (V)	Current Output (A)	Resistivity (Ω. Cm)	Conductivity (Ω. Cm^{-1})
17,2	0,29	7981477,833	1,2529E-07
16,34	0,24	9162071,429	1,09146E-07
15,15	0,24	8494821,429	1,17719E-07
14,83	0,21	9503306,122	1,05227E-07
13,41	0,18	10025571,43	9,97449E-08

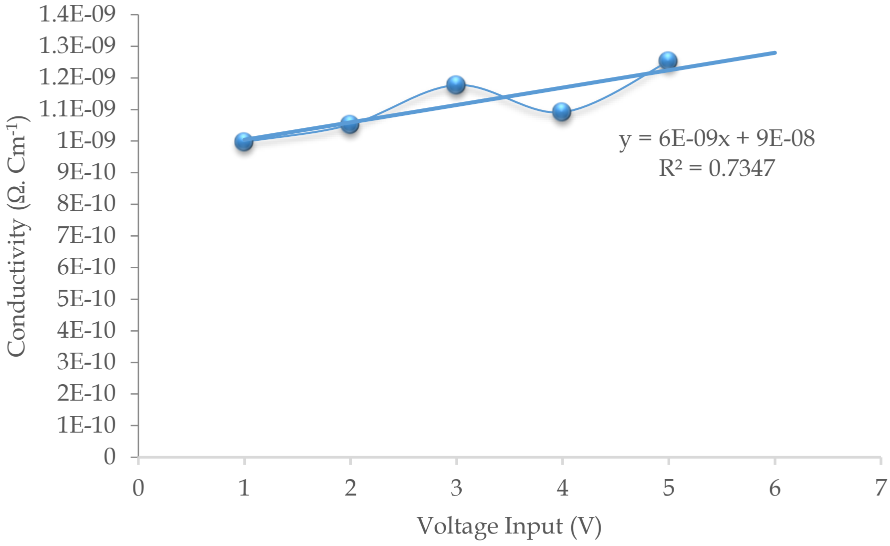


Figure 8. Conductivity Measurement of PaNi Materials Composition Value 0.25 M anilin + 0.5 M HCL

The conductivity method is a material used to measure water which consists of four concrete films 0.25 M anilin + 0.5 M HCL from figure 8. The meter is operated by adjusting the voltage from one to five volts so that the value of the electrical conductivity of the pot material is 0.9 x 107 - 1.25 x 107 (Ωm)-1 and linierity value of 73,47%.

4. Conclusion

In the manufacture of the measurement prototype 4 poin-probes have been successfully made and the results of the calibration of the tool have a good level of precision value is 97,64 % and accuracy are 96,85%. The application of measurement tools on PANi materials obtains linear conductivity results in accordance with the theory that is used as a reference with linierity value of 73,47%.

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