A simple strategy of development water resistance for water comparison using AVR microcontroller

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Abstract. Quality of water can be determined by measuring water resistance values. The resistance parameter is used as a reference to determine water quality based on physical properties where the minimum value for the clean water category is 333.33 Ω. Therefore we need a measuring device to check the value of water resistance. A voltage divider is a simple circuit that can be used to read water resistance values. In this research, a water resistance measuring instrument has been made with a simple method involving a voltage divider circuit with 1 sensor and 2 resistors installed in series, each resistor has a value of 10 kΩ. The sensor output voltage is in the form of an analog signal converted by a 10-bit ADC by an ATMega16 microcontroller. The DC output voltage of the ADC is entered into the voltage divider formula to obtain the water-resistance value from the sensor probe. With the comparative method of reading the tools between the tools made and the standard tools, a calibration using a simple linear regression method is used with the equation model 2984.783216 + (-0.00187724X). An error of 0.79% was obtained after the device was calibrated. The results of clean water testing for comparison in Perum PKT 2939 35764 Ω and Perum HOP 2940.8132 Ω.

1. Introduction
Water was required by humans to support their life. It is important to know the parameters of water to determine whether the quality of water. Water feasibility can be analyzed by checking the chemical content with a special tool and expensive cost, therefore approach and prediction of chemical content in water based on water physical properties was carried out [1].

Water quality using sensor arrays such as pH, dissolved oxygen, ammonium nitrogen used in fishery [2] and water resistance in water filter [3]. Water filters using silica sand filters [4] and fly ash [3] enable water testing after filtering. The physical properties of water can be reviewed in terms of conductivity, amount of dissolved solids in water (Total Dissolved Solid) [1] and resistivity that water ability to inhibit electricity. Resistivity is the opposite of conductivity.

The stainless steel probe of the sensor with 2 conductors allows physical quantities (resistivity) to be converted into electrical quantities (voltage) [5] therefore water resistance can be measured. The output voltage of the sensor is the output of the voltage divider circuit that has been modified and integrated with the sensor. Using Analog to Digital Converter (ADC) on the ATmega16 microcontroller to change the number of analog signals from sensors to digital signals. The
measurement results can be easily displayed on an LCD display [6]. A calibration process is required to maintain the reading accuracy of the water-resistance value. With a microcontroller as a controller, it is easy to calibration and programming [7].

2. Research Method
D_WR (Development of Water Resistance) is a tool for water resistivity measurement, therefore, the quality of clean water can be determined by approach the physical parameters from the value of water resistivity. The design of this tool is a collaboration between software and hardware. The hardware there is a voltage power supply with an output 5 Vdc to supply sensor and microcontroller, voltage divider circuit integrated with probe sensor, ATmega16, step down dc to dc with IC 7805, and Liquid Crystal Display (LCD). The block diagram of the D_WR to water resistance measuring is shown in figure 1. The software design consists of C language programming for ATmega16 with CodeVision AVR and calibration tool using simple linear regression with a comparison using the Thermo Scientific type ORION which type of resistivity meter.

![Figure 1. Diagram Blok of Development Water Resistance Using AVR Microcontroller ATMega16](image)

2.1 Power Supply.
The value of source 9 Vdc from battery is reduced to 5 Vdc using the dc to dc step down with IC 7805.

2.2 Voltage Divider Integrated with Sensor.
The value of water resistance received by the probe of the sensor then converted to a voltage by a voltage divider circuit with the basic formula of voltage divider. Resistors mounted in series on a circuit that drive an equal current, therefore, the voltage would be drop at each resistor [8]. The voltage divider circuit with a sensor is shown in figure 2.

2.3 Microcontroller ATMega16.
A microcontroller in this system is used to process data from the sensor and displayed on the LCD through converting process analog to digital signals with 10-bit ADC that integrated on ATMega16. The output sensor become the ADC input on port A0 (ADC port 0) with an output form of the resistance displayed by LCD through ports D0-D6 is shown in figure 3. The input voltage of the
analog signal is converted to bits (decimal), and then converted to the voltage by multiplying with voltage per step of the 10-bit ADC that is 4.88 mV.

Figure 2. Voltage Divider Circuit with Sensor

Figure 3. Microcontroller ATMega16 Circuit

2.4 Pemrograman Mikrokontroler.
In the duties, ATMega16 requires commands and logic in order to manage input data and displaying it on an LCD. C programming for ATMega16 using the CodeVision AVR application. By doing some initial settings during configuration to support the work of the system such as LCD settings, chips, ADC.
3. Results and Analysis

3.1 The voltage of Power Supply

Power supply output is very influential on the accuracy of reading the value of water resistance due to as a reference voltage that enters the programming equation that is 5 Vdc and the value is fixed. But in fact, the source output voltage would not be reached. According to the data sheet which is 5 Vdc due to it has a tolerance of ± 0.2 Vdc [8]. The results of the measuring voltage of the source are shown on average 4.94 Vdc.

3.2 Tool Comparison for Calibration

Comparison of tool that is designed with the Thermo Scientific ORION that type tool to calibrate therefore the results of the reading would be accurate and standardized. Calibration is done by taking data from the test of 2 devices with the same sample, the physical results of the test are shown in figure 4.

![Figure 4. Water Measuring Result for Comparison](image)

The data obtained are used for calibration with simple linear regression. Simple linear regression can be calculated using the MS Excel application on the Regression Analysis Data menu and will display a summary output in the form of a and b. Then the values of a and b are entered into a simple linear regression equation.

From the calculations, the simple linear regression equation then entered into the C programming of ATMega16 shown in value, with the following equation 1:

\[ Y = a + bX \]  

where:
X = independent variable (resistance value of voltage divider output)
Y = dependent value (water-resistance value)
Figure 5. Linier Regression Summary Output MS Excel

Sample testing with ORION and D_WR is done after calibration to ensure the reading accuracy of water-resistance on the designed tool that is D_WR shown in figure 6. From the test results, it can be seen the value of a reading error DW_R against ORION 0.79% as graphic below being.

Figure 6. Water-Resistance Value After Calibration
3.3 Water Comparison
The goal of this study is to test 2 samples from different places, namely Perum PKT and Perum HOP to determine the quality of clean water that they used is appropriate or not based on the value of water-resistance. The measurement results of the two samples are shown in figure 7.

![Figure 7. Chart of Clean Water Resistance Measurement Results](chart)

4. Conclusion
D_WR is made to measure water-resistance, therefore, can determine the quality of water include the category of clean water or not, where the minimum value of water resistance is 333.33Ω. Calibration is done to get the reading accuracy. A simple linear regression method is applied to the D_WR tool, therefore, a reading error of 0.79% is obtained. From the test results which the value of water-resistance at Perum HOP 2940.8132Ω and at Perum PKT 2939.35764Ω. Higher resistance value at Perum HOP then Perum PKT means clean water quality at Perum HOP is better in terms of resistivity. However, both of them are still included in the category of clean water.

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