Design of monitoring application for cathodic protection using data acquisition data module

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Abstract. The impressed current cathodic protection is one of the effort to prevent a metal from corrosion by supplying electricity to metal objects. However, the protection system that supplies electricity must always be monitored so that the electricity intake to the metal object is sufficient to protect it from the corrosion. The way how to monitor the electricity intake to the metal is to read the current in taking on the metal. To read the electric current more easily is to use an application software. This research talks about the application design to display the electric current in taking on the metal through the computer screen. In order to read the electric current directly, the Advantect Data Acquisition Modul (ADAM) devices are used. The results show that the application is able to display the value of protection current for iron plate steel with size 30x10 cm are between 0.15 A to 0.18 A while for iron plate with a size of 30x13 cm are between 0.20 to 0.24 A. These values also avoid the over protection.

1. Introduction
To prevent corrosion, one way is by force current cathodic protection, the way the forced current works is by supplying electricity to metal objects. This electricity supply will prevent corrosion so that equipment made of metal will be protected from corrosion and equipment made of metal can last longer which ultimately costs for the replacement of equipment made of metal can be minimized. The reason for using forced current cathodic because of the excess forced current system can be designed with a high degree of flexibility and has a wide range of output capacity. This means that the current requirements can be regulated both manually and automatically by changing the output voltage according to the needs, another advantage of this wide range of forced current protection systems, even if only installed in one place. When compared to the sacrificial anode system, the forced current range is wider [1].

However, the protection system that supplies electricity or commonly called the cathodic protection system must always be monitored so that the electrical intake to the metal object is sufficient to protect it from corrosion. One the way solution in order to be able to monitor is by computer application program. An application can clearly see the voltage entering the protected metal and how much current and voltages are needed without having to do it manually. Therefore this study is conducted to design
and implement a Cathodic Protection Control System Application Using Module Acquisition Data". It is expected that this application can help make the voltage fixed and in accordance with the level of metal flow requirements [2,3].

2. Methods
This research method includes various stages, the following are the research stages.

- Problem definition
- Analysis and design system
- Implementation
- Testing

2.1. Problem definition
The problem definition of the research is how to design the application that can read and display the current and voltage in taking to the metal.

2.2. Analysis and design system
The analysis stages talks about standard current calculation, requirement analysis, and system design. The detail of each is as follow.

The standard flow calculation is useful to be a reference or benchmark when testing is carried out. The following is the formula for finding a standard current [1].

$$ t = \left( \frac{SA \times CD \times CB}{1000} \right) \times (1 + SF1) $$

Where:
- $t$ = Total current needed to protect iron (A).
- $SA$ = Protected Surface Area ($m^2$).
- $CD$ = Density of current at work temperature (mA / $m^2$), current density (bore steel) at 300 is 20 mA / m2.
- $CB$ = damage rate per 2 years 10% (0.1)
- $SF1$ = Allowable safety factor for protective currents 25% (0.25).

The cathodic protection monitoring application using acquisition data module system is an application that should be able to read and view or display the current and voltage in taking to the metal. To design the system, there are some requirement should be fulfilled for the application, hardware, and software. The requirement of the application should be able to read and to display the current and voltage in taking to the metal. The requirements of hardware consist of a transformer, relays, Data Acquisition Module, Cables, a Personal Computer, and metals. The requirement of the software are an Operating system, a programming language, a driver [4,5].

The system design in this paper presents a block of diagram system, application interface design and architecture system. The block diagram of the system designed is shown in figure 1 as follow.

![Block Diagram](image)

**Figure 1.** The block diagram of the system designed.
In figure 3 above we can see that there are six boxes in which connected. A box labelled; PC, ADAM device function as I/O, ADAM device function as Processor, Relay, Transformer, and Metal. A transformer connects to the box labelled Relay and the Relay connects to a box ADAM function as I/O and a Load. The box labelled ADAM Devices function as Processor is stick on the line among the box of Relay, the box of ADAM device function as I/I and the box of load.

The application interface of the application designed is shown in figure 2 as follow.

![Application Interface](image1.png)

**Figure 2.** The application interface of system designed.

The application interface of system designed as shown in figure 4 above consist of six rectangular box, four circle, and one button labelled Exit. The two of the six rectangular box coloured grey function as output. These outputs are the result of reading from the ADAM device. One is to display voltage and the other is to display current. The four rectangular box with no colour are for data input; standard current data, sacrificial metal size data, protected metal size data, and data of distance between metals. The four circle are used as the relay indicators.

The architecture of the system is shown in figure 3 as follow.

![Architecture](image2.png)

**Figure 3.** The cathodic protection monitoring application using acquisition data module system.

In figure 3 above it can be seen that from the beginning of the right upper section is a transformer. The transformer produces current and voltage that are caught by the relays. The relays are a sequence of resistor and LED. From the relays, the current and voltage are continued to the first ADAM device that function as input and output device and then it is continued to the second of ADAM device that do adjustment process the current in order to fit with the needed. The output current from the second ADAM device then is sent to the sacrificed metal and to the first ADAM device back to read by the application.

In order to communicate between the application installed on the PC and Data Acquisition Module Device, a serial communication is established. Because data is defined individually, so the data sent by a synchronous communication using RS-485 cable.
2.3. The implementation
The implementation or the realization of the system is shown in figure 4 as follow.

![Figure 4](image_url)

Figure 4. The implementation of the system designed.

As shown in figure 4 above, the system design result are implemented as follow.

- A transformer with an input voltage of 240v and variable output.
- Relays, a circuit made of resistors and LED.
- Two ADAM 4000 series, they are ADAM 4017 and ADAM 4060. Adam 4017 8-ch Analog Input Module functions to read the voltage or current of the transformer so that it can be read by the computer. Adam 4060 4-ch Relay Output Modules function as a relay that will determine which relays will be used so that the metal can be protected so there is no over protection.
- A Personal Computer (PC) that has been installed the application.
- A metal

The Adam 4017 and Adam 4060 devices are given voltage using a power supply that comes from a laptop charger that uses 12V voltage, and then Adam 4060 is used as a relay supported by a connection of 4 led lights and each led light represents the relay used and the led circuit. This LED is from a power supply that comes from a mobile charger that has a voltage of 5V and for the connection between ADAM and the LED circuit to the computer using RS-232 that has been converted to the RS-485 to be readable by the computer.

3. Result and discussion
At the result and discussion section here are going to explain about the result of the connectivity testing. The connectivity testing consist of the ADAM devices connectivity testing with Personal Computer, Voltage Reading testing by The ADAM Devices, and the connectivity between the ADAM devices and LED Circuits testing.

3.1. The result of The ADAM devices connectivity testing with personal computer
To see the connectivity between Adam device and the Personal Computer by looking at the Device Manager. At the device manager window appears the Prolific USB-to-Serial Comm Port (COM2), it means that the computer with Adam has been connected and installed on COM2. On testing the application connectivity with ADAM devices worked well, the ADAM devices positioned on the computer / laptop on COM2 and on Port 04 for ADAM 4060 and Port 05 for ADAM 4017.

3.2. The result of the voltage reading testing by The ADAM devices
The ADAM devices driver is run to see whether the ADAM devices can read the voltage or can't. The testing result of voltage reading by The ADAM Devices driver shows that the ADAM device can read on channel 1.
3.3. The result of the testing between the ADAM devices connectivity and LED circuits
In the process of testing the ADAM connectivity with a series of LEDs, the results obtained with 100% validation were carried out repeatedly over a 1 week trial, and the result shown in table 1 as follow.

Table 1. The result of the testing between the ADAM devices connectivity and LED circuits.

| Day | Relay 1 (LED1) | Relay 2 (LED2) | Relay 3 (LED3) | Relay 4 (LED4) |
|-----|---------------|---------------|---------------|---------------|
| 1   | On            | On            | On            | On            |
| 2   | On            | On            | On            | On            |
| 3   | On            | On            | On            | On            |
| 4   | On            | On            | On            | On            |
| 5   | On            | On            | On            | On            |
| 6   | On            | On            | On            | On            |
| 7   | On            | On            | On            | On            |

3.4. The result of manual standard current calculation
Before the system is used, the manual calculation is carried on to find out what voltage is needed by the metal so that the protected metal gets a standard current value that must be achieved. In this testing stage, the protected metal size used is 30 x 10 cm and the sacrificed metal size used is 30 x 5 cm. The results obtained from the manual calculation are as shown in table 2 as follow:

Table 2. Manual standard current calculation.

| No  | Protected Metal Size (cm) | Sacrificed Metal Size (cm) | Distance (cm) | Voltage (volt) | Standard Current (Amp) |
|-----|----------------------------|-----------------------------|---------------|----------------|------------------------|
| 1   | 30 x 10                    | 30 x 5                      | 10            | 7.63           | 0.15                   |
| 2   | 30 x 10                    | 30 x 5                      | 20            | 8.53           | 0.15                   |
| 3   | 30 x 10                    | 30 x 5                      | 30            | 14.53          | 0.15                   |
| 4   | 30 x 13                    | 30 x 5                      | 10            | 13.42          | 0.2                    |
| 5   | 30 x 13                    | 30 x 5                      | 15            | 22.05          | 0.2                    |
| 6   | 30 x 13                    | 30 x 5                      | 20            | 23.2           | 0.2                    |
| 7   | 30 x 13                    | 30 x 5                      | 25            | 25.87          | 0.2                    |
| 8   | 30 x 13                    | 30 x 5                      | 30            | 36.81          | 0.2                    |

3.5. The result of step voltage calculation
After the standard current and the required voltage calculated, the process of determining the step voltage is carried out. Where the voltage is not too far from the test voltage, then the next step is to find the current generated based on the step voltage. The following step voltage result is shown in table 3 as follow:

Table 3. Step voltage calculation.

| No  | Protected Metal | Distance (cm) | Voltage (volt) | Step Voltage (volt) | Step | Reach Current (Amp) | Standard Current (Amp) |
|-----|-----------------|---------------|----------------|--------------------|------|---------------------|------------------------|
| 1   | 30 x 10         | 10            | 7.63           | 9                  | 1    | 0.17                | 0.15                   |
| 2   | 30 x 10         | 20            | 8.53           | 9                  | 1    | 0.15                | 0.15                   |
| 3   | 30 x 10         | 30            | 14.53          | 15                 | 2    | 0.15                | 0.15                   |
| 4   | 30 x 13         | 15            | 13.42          | 15                 | 2    | 0.22                | 0.20                   |
| 5   | 30 x 13         | 15            | 22.05          | 26                 | 3    | 0.23                | 0.20                   |
| 6   | 30 x 13         | 20            | 23.20          | 26                 | 3    | 0.22                | 0.20                   |
| 7   | 30 x 13         | 25            | 25.87          | 26                 | 3    | 0.20                | 0.20                   |
| 8   | 30 x 13         | 30            | 36.81          | 37                 | 4    | 0.20                | 0.20                   |
3.6. The result of the application testing result
After the step voltages are known, then the system testing is carried on. In the Set Point Flow box at the application interface appears a current value must be reached and then proceed with the relay reading process from relay to 1 to relay 4. Step 1 has 9V voltage in the application is in relay 1, step 2 has a voltage of 15V in the application is in relay 2, step 3 has a voltage of 26V in the application is in relay 3, and step 4 has a voltage of 37V on the application is in relay 4. The relay reading stops at relay 4 which is the largest relay. And the validation in the testing process is 100% successful in getting results that are in accordance with the relay used.

4. Conclusion
The conclusions that can be obtained from this study are as follows:

- The hardware work well
- The application can communicate with the data acquisition module through asynchronous communication so that the application can read and display the current and voltage reading by the data acquisition module.
- The step voltage generated in this research is 4 steps and then the step voltage will be used as the relay voltage value so the voltage in each relay is relay 1 = 9V, relay 2 = 15V, relay 3 = 26V and relay 4 = 37V.

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