A DATA PROCESSING PROGRAM FOR WEB BASED RAIN GAUGE CALIBRATORS
PROGRAM PENGOLAH DATA UNTUK KALIBRATOR PENGUKUR CURAH HUJAN BERBASIS WEB

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ABSTRACT
The purpose of this study was to produce an application program for the data processing unit of a web base rain gauge calibrator. The application program was developed using Studio XE2 of C ++ RAD (Rapid Application Development) software. Testing result shows that what you get was what you command or there was no different between the result and the command.

Keywords: rain gauge, calibrator, standard, data processing, web, protocol, testing

ABSTRAK
Tujuan dari studi ini adalah untuk menghasilkan program aplikasi untuk unit pemrosesan data kalibrator pengukur curah hujan berbasis web. Perangkat lunak aplikasi dikembangkan menggunakan Studio XE2 dari perangkat lunak C ++ RAD. Hasil pengujian menunjukkan bahwa yang anda dapatkan adalah yang anda perintahkan atau tidak ada perbedaan antara hasil dengan perintah.

Kata kunci: pengukur curah hujan, kalibrator, standar, pengolah data, web, protokol, pengujian

I. INTRODUCTION
Manual calibrators (Allweatherinc, 2008) are still widely used to calibrate rain gauges in situ. Meanwhile, automated calibrators (Livaditis, 2000) are utilized for ex situ calibration such as a rain gauge calibration laboratory at BMKG headquarter (Wijonarko et al., 2016). To improve the available manual and automated calibrators especially from calibration process speed, rain intensity control, and human error aspects, Wijonarko et al. (2017) made a web-based rainfall gauge calibrator.
Concerning to the web based rain gauge is quite holistic, but it is still on the system level. For subsystem level, a further explanation is still needed. One of which is concerning the data processing unit (DPU).

The purpose of this study was to develop an application program for the data processing unit of a web base rain gauge calibrator. The discussion was concentrated to judge how good was the application program.

II. BASIC THEORY
To conduct a calibration, at least two systems are needed namely a calibrator and an instrument under test. In this case, the IUT is a rain gauge especially a tipping bucket sensor. The sensor will not be discussed anymore, but can be obtained for example from Wijonarko & Maftukhah (2014, 2016), Maftukhah et al. (2016, 2019), Prakosa et al. (2016, 2018), Wijonarko (2017, 2018), Qiyaman et al. (2018a, 2018b).

According to Wijonarko et al., 2017, the web-based rain gauge calibrator developed by them consists of three units, namely standard unit (SU), data processing unit (DPU), and calibration web data unit (CWDU). Each unit in the web-based rain gauge calibrator configuration are physically separated (Figure 1).

![Figure 1. The configuration of web based rain gauge calibrator](image)
In this paper, discussion will be focused on the DPU. Basically DPU is a portable data processing equipment such as a note book or a tablet. In the content of DPU is filled with a data processing application program dedicated to calibrate a rain gauge.

### III. METHODOLOGY

At least there are four methods to calibrate rain gauges. These are static method, dynamic method (Calder & Kidd, 1978), and automated method (Humphrey & Istok, 1997), attention will be paid on the web based method.

In this section, four things will be presented. The first is the protocol or rule (Simoneau, 2006) for communication between SU and DPU. The second is the kind of software that is used to develop the application program. The third is the application program flow chart. The fourth is the application program testing.

Standard Unit measures humidity, temperature, time duration and number of tipping (clicking) during the calibration process. The measurement data are sent to the data processing unit following the protocol made by Maftukhah et al. (2014) for sensor network communications in a water balance system (Table 1). Data received by data processing unit are processed, displayed, and stored in database files. By uploading the data in the database files, the calibration result in the form of a certificate can be seen on the web. This certificate is then printed, rechecked, and signed.

| No | Command (SK -> PDK) | Response (PDK -> SK) | description |
|----|---------------------|----------------------|-------------|
| 1  | inten=xxx<cr><lf>  | inten=xxx<cr><lf>  | Set the rain intensity |
| 2  | subp=xxx<cr><lf>   | subp=xxx<cr><lf>   | Set the PWM, so that the pump motor can move to the selected rain intensity. PWM 0 -> motor is off; PWM 255 -> motor is maximum. |
| 3  | ukurawal<cr><lf>   | Humidity=xx.xx&Temp=xx.xx&TempW=xx.xx<cr><lf> | Measure the air humidity, air temperature and water temperature. |
| 4  | start<cr><lf>      | start<cr><lf>      | The calibration process is started by running the pump to fill water into the tube of standard unit. |
| 5  | flush<cr><lf>      |                      | Water discharging from the tube. |
| 6  | stop<cr><lf>       | stop<cr><lf>       | The calibration process is complete. |
| 7  | t=xx.xx&RG=xxxx    |                      | As soon as the calibration process is complete, SU sends data (time and number of tip). |
Figure 2. The flow chart of DPU application program
DPU application software was made using Studio XE2 program of C ++ RAD (Rapid Application Development). The C ++ program (Soulie, 2007) was first developed by Bjarne Stroustrup and team at Bell USA Laboratories (Kirch-Prinz, Ulla & Peter, 2002). The C ++ program is used to develop simulation projects on an Object Oriented Program (OOP). Embarcadero RAD Studio is an OOP, that is a visual program for RAD. Embarcadero RAD Studio can build more efficient visual applications than manual C ++ (Embarcadero, 2010).

The flow chart of DPU application software consists of port checking, data input, water filling, calibration, additional water checking, data receiving, data processing, data presentation, data storage (Figure 2). Data input is sensor specification, resolution, and rain intensity.

Calibration results on the DPU are presented after the calibration process is completed. Following the definition of rainfall from WMO no 8 (2008, 2012) and KNMI (2000) for automated calibrators (Maftukhah, Wijonarko, & Rustandi, 2016), formulas for the calibration results are as follows.

\[ R_{STD} = \frac{V_{STD}}{A_{IUT}} \] \hspace{1cm} [1]

where:

\[ R_{STD} = \text{standard rainfall (mm)} \]

\[ V_{STD} = \text{standard tube [ml]} \]

\[ A_{IUT} = \text{IUT funnel area [cm}^2\text{]} \]

\[ E_r = \left( \frac{R_{IUT} - R_{STD}}{R_{STD}} \right) \times 100 \% \] \hspace{1cm} [2]

where:

\[ E_r = \text{Error [%]} \]

\[ R_{IUT} = \text{IUT (measurement) rainfall [mm]} \]

\[ R_{IUT} = R_g \times R_s \] \hspace{1cm} [3]

where:

\[ R_s = \text{calibration coefficient (Hodgkinson, Pepper, & Wilson, 2004) or resolution [mm]} \]

\[ R_g = \text{number of tipping (tilting, clicking)} \]

[dimensionless]

Program testing is conducted by giving a simulation value for the command protocol. This simulation will give a response. The result between the command and response is then compared. The application program works well if there is no discrepancy between them.

There are some kinds of data processing techniques, namely scientific, commercial, automatic or manual, batch, real time, online, multiprocessing, and time sharing techniques (Prakash, 2018).
The batch processing technique was used for this DPU.

IV. RESULT AND DISCUSSION
Testing was carried out by connecting the standard unit to the data processing unit with its application software in it, namely calibrator.exe. The display of data processing unit program (Figure 3) was filled with rain gauge specifications such as the rain gauge diameter, which in this case was 20 cm. The volume of water in the tube was set at 320 ml.

There were four kinds of testing, namely data capture (data collection, data gathering), data processing, data presentation and data storage. The testing was conducted for each data processing function.

![Figure 3. Data processing unit display](image-url)
a. Data Capture

When connected to the data processing unit, the standard unit sends the data protocol as follows: Humidity = xx.xx & Temp = xx.xx & TempW = xx.xx <cr> <lf>;

In the testing: Humidity = 90.00 & Temp = 25.00 & TempW = 20.00 <cr> <lf>;

The data were translated as follows: the value of humidity was 90.00 %, the temperature of data logger was 25.00°C, and the temperature of water in the tube was 20.00°C.

After the calibration process is complete, the standard unit sends data T = xxx & RG = xx. In the testing: T = 330 & RG = 50; Coincidentally, the IUT was clicking when the calibrator stopped to work. So, there was no additional water. From these data it can be seen that the number of clicking was 50 during the duration of 330 seconds.

b. Data calculation

The Calculation button on the Figure 3 works to execute the application program. The application program will calculate the input data to the data processing unit. In this testing, the standard rainfall value was 10.19 mm (Equation 4), while the IUT rainfall was 10.00 mm (Equation 6). The error between both rainfall data was -1.88 % (Equation [5]). These values were in line with the calculation results from a calculator.

\[ R_{STD} = \frac{V_{STD}}{A_{IUT}} = \frac{320}{\pi 10^2} \text{mm} = 10.19 \text{mm} \]

………………. [4]

where:

\[ R_{STD} = \text{standard rainfall} \]
\[ V_{STD} = \text{standard tube} \]
\[ A_{IUT} = \text{IUT funnel area.} \]

\[ E_r = \left(\frac{R_{IUT} - R_{STD}}{R_{STD}}\right) \times 100 \% = \left(\frac{10 - 10.19}{10.19}\right) = -1.88 \% \quad \ldots... \quad [5] \]

where:

\[ E_r = \text{Error (\%)} \]
\[ R_{IUT} = \text{IUT(measurement) rainfall.} \]

\[ R_{IUT} = R_G \times R_S = 50 \times 0.2 \text{mm} = 10.00 \text{mm} \quad \ldots\ldots \quad [6] \]

where:

\[ R_S = \text{resolution, it was 0.2 for this case} \]


c. Data presentation

![Figure 4. Testing data presentation](image)

The aforementioned data capture and data calculation were Humidity = 90.00 %,
Temperature = 25.00 celsius, Water Temperature = 20.00 celsius, t (Duration) = 3
30 sek, RG (Counter) = 50 tip, sensor funnel area = 314.00 cm², Standard rainfall = 10.19 mm, IUT rainfall (measurement rainfall) = 10.00 mm, and error = -1.88 % (Figure 4). This error is still acceptable for tipping bucket rain gauges. The stability testing result for tipping bucket rain gauges was around 5 % (Prakosa, Wijonarko, Rustandi, 2018). Minus sign on the error means that the IUT always shows underestimate rainfalls.

d. Data Storage
Apart from being displayed on the data processing unit display, the data is also stored in the database file, with the file name according to the name of the Month and Year when performing the calibration (mmyyyy.csv). The database file name for the calibration in August 2019, for example, is 082019.csv (Table 2).
### Table 2. Testing Data

| Date & Time       | No  | Brand            | Serial number       | Station | Operator      | Humidity | Water temp | Air temp | Resolution | Intensity | Duration | Tip | Area   | R_{STD} | R_{OUT} | E_r  |
|-------------------|-----|------------------|---------------------|---------|---------------|----------|------------|----------|------------|-----------|----------|-----|--------|--------|--------|-----|
| 01-08-2019 14:48:47; | 002; | Tipping Bucket; | RG13N2 / 2520166;  | Serpong; | LIPI team;    | 90.00;   | 25.00;     | 20.00;  | 0.2;       | 100;      | 330;    | 51; | 314.00;| 10.19; | 10.20; | 0.09;|
| 01-08-2019 14:50:40; | 002; | Tipping Bucket; | RG13N2 / 2520166;  | Serpong; | LIPI team;    | 90.00;   | 25.00;     | 20.00;  | 0.2;       | 100;      | 330;    | 50; | 314.00;| 10.19; | 10.00; | -1.88;|
| 01-08-2019 15:20:01; | 002; | Tipping Bucket; | RG13N2 / 2520166;  | Serpong; | Fulan;        | 89.54;   | 30.90;     | 29.19;  | 0.2;       | 100;      | 330;    | 51; | 314.00;| 10.22; | 10.20; | -0.19;|
| 01-08-2019 15:00:33; | 002; | Tipping Bucket; | RG13N2 / 2520166;  | Serpong; | LIPI team;    | 90.00;   | 25.00;     | 20.00;  | 0.2;       | 100;      | 335;    | 51; | 314.00;| 10.20; | 10.20; | 0.02;|
| 01-08-2019 15:03:29; | 002; | Tipping Bucket; | RG13N2 / 2520166;  | Serpong; | LIPI team;    | 90.00;   | 25.00;     | 20.00;  | 0.2;       | 100;      | 333;    | 51; | 314.00;| 10.20; | 10.20; | -0.04;|
| 01-08-2019 15:09:05; | 002; | Tipping Bucket; | RG13N2 / 2520166;  | Serpong; | LIPI team;    | 90.00;   | 25.00;     | 20.00;  | 0.2;       | 100;      | 333;    | 51; | 314.00;| 10.19; | 10.20; | 0.06;|
| 01-08-2019 15:09:44; | 002; | Tipping Bucket; | RG13N2 / 2520166;  | Serpong; | LIPI team;    | 90.00;   | 25.00;     | 20.00;  | 0.2;       | 100;      | 333;    | 50; | 314.00;| 10.19; | 10.00; | -1.88;|
V. CONCLUSION
A data processing application has been successfully made for a web-based rain gauge calibrator. The data processing application works as data capture, data processing, and data presentation, and data store. A testing was carried out by connecting the standard unit into the data processing unit. The test results show that the transmitting data was exactly the same with the receiving data. Data resulted from data processing, data at the display, and data stored in the database were in line with the formula in the protocol.

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