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Flood Detection Design based on the Internet of Things

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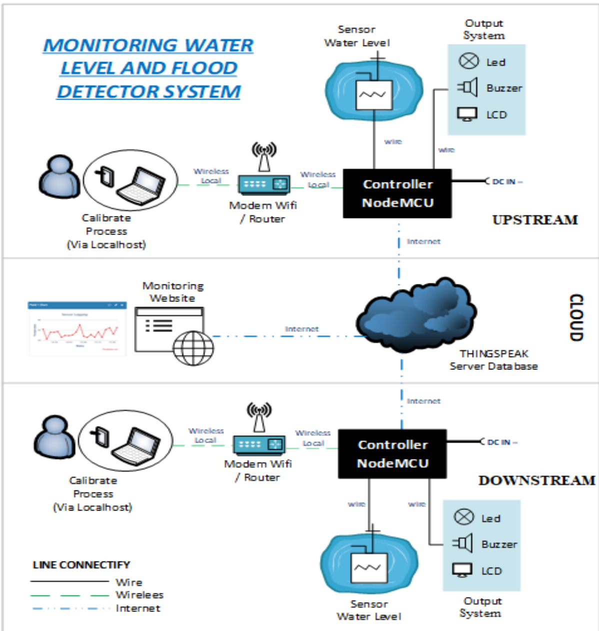
ABSTRACT



Flood detection devices and water levels from several previous research studies were not optimal because they were still running and manual information, such as through loudspeakers, in some research, electronic devices have been used, but no information has been obtained, and it is not optimal if there is a danger sign. So this research is a study on the development of an automatic flood detection system and water level based on the IoT (Internet of Things). The system uses a NodeMCU Esp8266 controller with a combination of potentiometer sensors mounted on a water-level mechanic and connected to the Thingspeak IoT platform. Based on the results of the analysis and testing that have been done, the system is designed to combine the previous research algorithms so that it works more optimally and is better. The flood detection system and water level are made in two parts: one is placed upstream and the other is placed downstream, where the devices are connected. The device will turn on a danger alert when the altitude percentage is more than 85% of the maximum height. The lag time in the upload and download process is included in the Fast category (≤10 seconds). The resulting information can be monitored through the media portal website.

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1. INTRODUCTION

The frequent occurrence of floods in various regions is one of the factors related to this research. The causes of flooding include high rainfall and environmental conditions that have begun to deteriorate, especially in river areas [1]–[5], because the function of riverbanks as water catchment areas and green areas has begun to disappear. If there is high-intensity rain accompanied by large amounts of water from upstream to downstream, it can make the water space narrow and clogged so that water can overflow into residential areas [6]–[8]. The lack of information obtained by the community around the river at the time of a flood has made people unable to prepare themselves [9]–[10]. Therefore, it is necessary to make a tool for the early detection of floods [11]–[13].

In previous research, many have discussed the real-time IoT-based water level monitoring system from the riverbank using the NodeMCU Esp8266 controller [14]–[18], but the interface method of reading results and components used, in my opinion, is still inefficient [19]–[20]. Therefore, research uses a water level sensor with design mechanics that can provide notifications in the form of a water level graphic on the media website and can provide information to the public to anticipate flood disasters. So the research focuses on developing a flood detector and a water level detector based on the IoT (Internet of Things) [21]–[22].

The steps taken start with calibrating the water level sensor to determine the value of the sensor reading so that it is following the actual situation, then creating a website display that is used to display the water level sensor readings on the IoT Thingspeak platform [23]–[27]. One of the functions of this design is to provide warnings for areas that are frequently flooded. Flood warning in the form of an alarm and level height monitoring on the website The tools used are expected to work effectively with environmental conditions that require the sensor to have a long-term lifetime, and the accuracy of sensor readings can also be better than previous research, given that the components used are mechanically based and the signal obtained by analog data is converted into digital data by the controller..

2. METHODS

In the design and development of a flood detection device and water level based on IoT (Internet of Things), several steps must be done to make a device that has been designed, the stages are:

2.1. Architecture Tool Development

The system created is a control system that can be used to monitor water levels via the internet using the Thingspeak server. Using the Thingspeak server, devices can be connected. If the equipment upstream reads the water level rising and crossing the safe limit, then the alarm will go off, and the downstream equipment will also fire an alarm warning because there could be a potential for flooding in the area. The data that is on the Thingspeak server can also be displayed on the website so that users can see details of the water level in a certain area can be seen in Figure 1.

After the architectural development research was done, it was continued to make block circuit diagrams, which are one of the most important parts of designing a tool because from this block diagram, it can be seen how the entire circuit works. So that the entire block circuit diagram illustrates how the tools are made. Before looking at the block diagram, you must know the work flow of the block diagram for the system being designed shown in the Figure 2.

DC power supply as the input voltage for controller power consumption. Voltage Regulator: a voltage decrease from ± 9V to ± 5V as input to the VIN NodeMCU. The NodeMCU controller, the main component of the tool, functions to regulate the overall system performance and get a ± 5V supply. A water level is an object that is controlled and monitored in this system. The Water Level Sensor, a component used to determine the value of the object being measured, uses a mechanical pulley method that rotates the potentiometer. A laptop or smartphone device is a device used for the tool calibration process. It has to be connected to the same network as NodeMCU via the same router or modem. How to access the calibration menu using the IP (Internet Protocol) address, which can be found on the modem or router interface settings menu The WiFi modem is used so that the system can connect to the internet. Thingspeak is an IoT (Internet of Things) platform that functions as a server from NodeMCU for a database feature that stores sensor data. The website functions to display water level information on the database server.

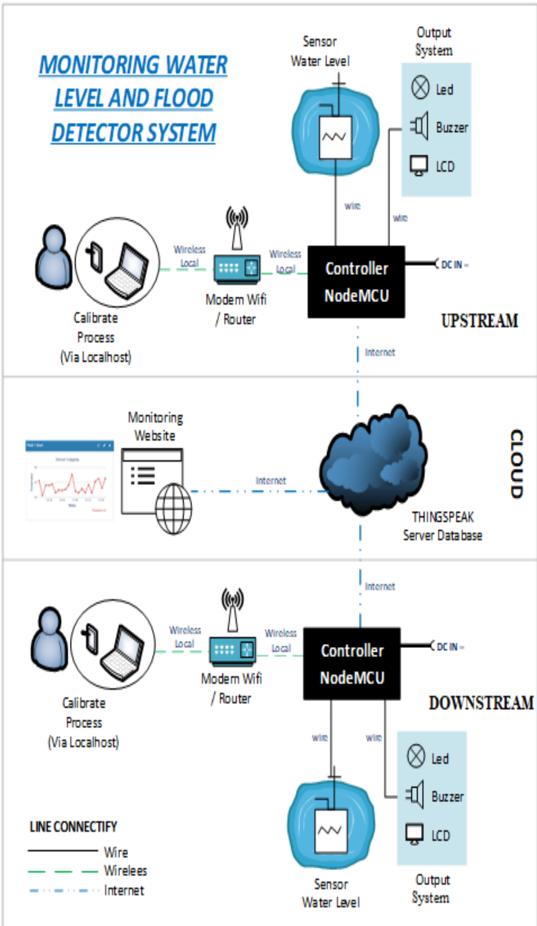


Figure 1. Design and development architecture

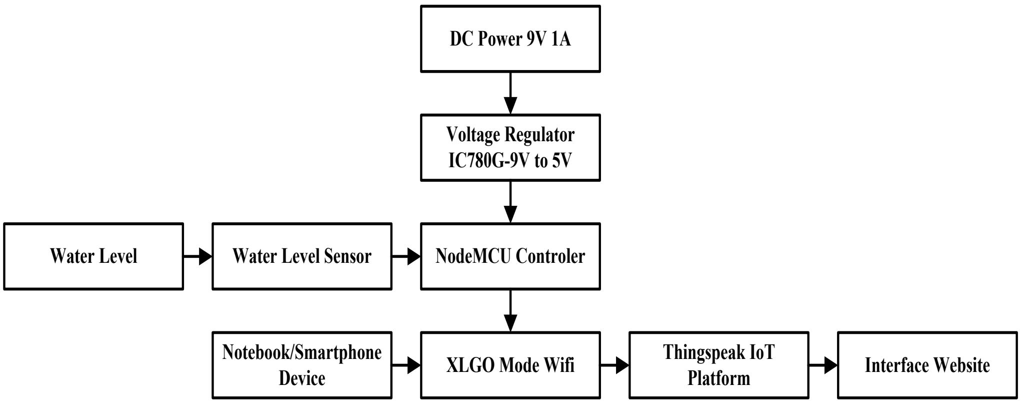


Figure 2. Development block diagram

2.2. Water Level Sensor Design

In general, most people use ultrasonic sensors to measure the water level, but in this research and development study, a river water level sensor uses the float method, which is mechanically arranged. The water level sensor is placed in the water so that the float can float and go up and down to adjust the water level. The sensor mechanic that is made can be applied to the water level monitoring system; the sensor design can be used for measurements at river locations because the material used is iron; the tool can be used in the long term, given the erratic river water conditions; so in designing the sensor, one must pay attention to the life condition of the sensor that is made so that it can last a long time with the conditions in which this sensor will be placed. The sensor design used uses the pulley method, which will pulley between the float and the ballast.

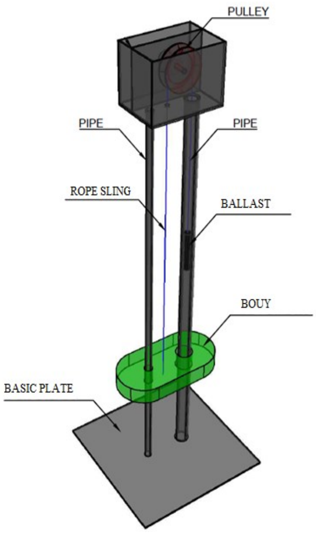


Figure 3. Buoy sensor design

2.3. Sensor Weight Calculations

The sensor for measuring the water level uses the pulley method, which involves a ballast on the side of the float and a weight in the pipe. The working principle of this sensor is that the ballast on the buoy must be heavier than the ballast in the pipe. This functions so that when the float is lifted by rising water, the ballast pulls the rope that surrounds the pulley, thus making the potentiometer sensor rotate too, and when the water condition decreases, the buoy also drops and pulls back the ballast in the lifted pipe. Taking into account the ballast used, the following data.

$$Weight\ on\ the\ \frac{buoy}{weight}\ load\ (Fb) = 400\ gr$$

$$Weight\ in\ the\ pipe\ \frac{support}{magnitude}\ of\ power\ (Fk) = 400\ gr$$

So the data is obtained that $Fb = Fk$, so the amount of power (weight in the pipe) to pull the load is equal to the weight of the load (Fb), while the mechanical advantage of the pulley can still be calculated, as can be seen in the equation (1).

$$KM = \frac{Fb}{Fk} = \frac{400}{400} = 1 \tag{1}$$

If the mechanical advantage that is obtained is 1, then the force required to lift the buoy load is the same as the weight of the ballast load in the pipe itself. The weight on the pipe, which functions as the force (Fk), is lifted if the buoyancy load (Fb) decreases or the water condition decreases, and when the water rises, the load (Fb) is also lifted by the pulling force from Fk because it gets help from the buoyancy force water.

2.4. Sensor Data Calculations

Sensor data calculations are used for data processing in programming, data that must be known, among others, pulley data used. **Pulley Data**, Pulley diameter (D) 68 mm, Radius (R) is 34 mm, Maximum Circumference of Pulley (1x round) (K_{1x}) is 214 mm. After the pulley data is obtained, it is combined with the potentiometer data as follows, **Pulley X Potentiometer data**, Potentiometer Resistance Value (Resistance) is 10000 Ω, Potentiometer Rotation Maximum (N) is 10 × round, Digital sensor data (10 x round) ($DataDigital_{10x}$) is 1024, Ratio $K_{pulley} \div K_{timing\ potentio}$ is 1.25, Maximum Circumference of Pulley (10 x round) or the maximum height that can be measured ($K_{1x} \times n$) is 1710 Mm, Digital sensor data (1x round) ($DataDigital_{1x}$) is 102.40, and Maximum Circumference of Pulley (1x round) (K_{10x} / n) is 170.97 Mm.

After the pulley and potentiometer data are combined, it is then combined with the mechanical data from the float sensor. **Pulley Data x Potentiometer x Buoy Sensor**, Maximum height measured (H) is 1000 mm, Digital sensor data is 599, Condition of Actual Altitude is 200 Mm, Current sensor data is 255, $Data_{lower\ limit}$ is 241.4, and $Data_{upper\ limit}$ is 734.1.

Several values are in yellow, which indicates that the value can be changed according to the actual condition of the float sensor. After the pulley calculation process, potentiometer, and float sensor are combined, the required range data is obtained from the minimum to the maximum height of 479, and that value is processed in programming.

2.5. Website Interface Design

The website interface developed is to use a blog site, namely Blogger, because bloggers already support HTML programming for templates and uploaded content. The HTML code for widgets can be obtained directly from the Thingspeak channel that was previously created. The website interface in this study can be accessed at the following address: HTTP://waterlevel.iot.blogspot.com/2020/06/monitoring.html, Here is the appearance of the website page:

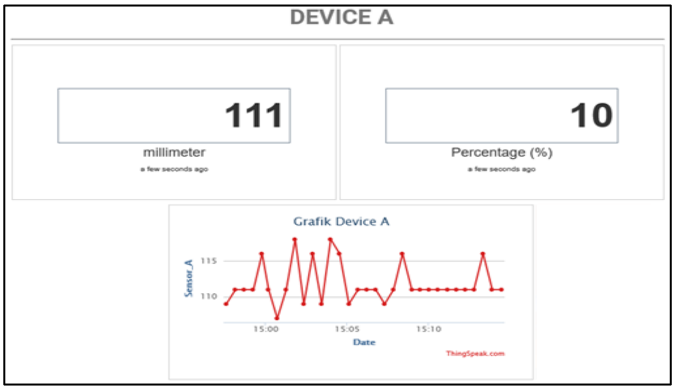


Figure 4. Website interface display

3. RESULT AND DISCUSSION

At this stage, it is a process of willingness to develop and analyze all the data that has been taken. Three points are discussed in the analysis of this research, according to the tests that have been carried out, and all are related to the performance of the tools made.

3.1. Sensor Trial Analysis

The sensor analysis stage is the process of determining whether the sensor can be used and applied to the system being created. The number of data samples taken in the Device A test is based on the total number of maximum potentiometer turns. The potentiometer used on Device A has a maximum of 10 rounds, so for the data taken, 11 data points, starting from 0x turns to 10x rounds. On Device B, because the type of potentiometer used is different, the number of data samples taken is also different. The potentiometer used has a resistance value of 1k. The data taken in the analysis of the sensor test results are the number of potentiometer turns (for device A) and the degree of potential rotation (for device B), the amount of resistance R1 and R2 on the potentiometer, analog data output in the form of voltage accompanied by a percentage, and digital data output. in the form of 10-bit digital data along with the percentage. Based on the data in Tables 1 and Table 2, namely the test table for sensor test devices A and B, the sensor test results are obtained for the analysis process of whether the sensor can be used in the system.

Table 1. Test results for sensor device A

No	Potentiometer			Output			
	Round	R1 (Ω)	R2 (Ω)	Analog Sensor Data		Digital Sensor Data	
				Voltage (V)	Percentage (%)	Data 10-bit	Percentage (%)
1	0x	0	9980	0	0.00%	0	0.00
2	1x	979	9006	0.38	9.97%	110	10.74
3	2x	1995	7998	0.75	19.69%	222	21.68
4	3x	2980	6990	1.13	29.66%	334	32.62
5	4x	4010	5975	1.52	39.90%	448	43.75
6	5x	4950	4930	1.88	49.34%	553	54.00
7	6x	5890	4050	2.27	59.58%	660	64.45
8	7x	7010	2850	2.65	69.55%	777	75.88
9	8x	7920	1910	3.03	79.53%	895	87.40
10	9x	8890	1050	3.41	89.50%	1000	97.66
11	10x	9950	20	3.81	100.00%	1024	100.00

Table 2. Test results for sensor device B

No	Potentiometer			Output			
	Round	R1 (Ω)	R2 (Ω)	Analog Sensor Data		Digital Sensor Data	
				Voltage (V)	Percentage (%)	Data 10-bit	Percentage (%)
1	0°	2	989	0	0.00%	2	0.20%
2	75°	201	7699	0.9	23.68%	250	24.41%
3	150°	498	467	1.9	50.00%	500	48.83%
4	225°	771	213	2.7	71.05%	800	78.13%
5	300°	990	4	3.8	100.00%	1024	100.00%

Table 1 and Table 2 are tables to show the output percentage value in both analog and digital data. The percentage is obtained from the comparison of the output value with the maximum value of the output data. The analog data output range value is 0 V to 3.78 V, which is obtained from the internal NodeMCU analog pin process. While the maximum value for digital data is 0–1023, the data is the result of analog data conversion. The results of the percentage data can be seen in Figure 5 and Figure 6.

Figure 5 and Figure 6 show the output data for devices A and B. The graph shows that with each rotation of the potentiometer, the resistance values r1 and r2 change and affect the analog and digital outputs that enter NodeMCU, so the percentage graph tends to go up, which means the sensor is in the state of being ready to use.

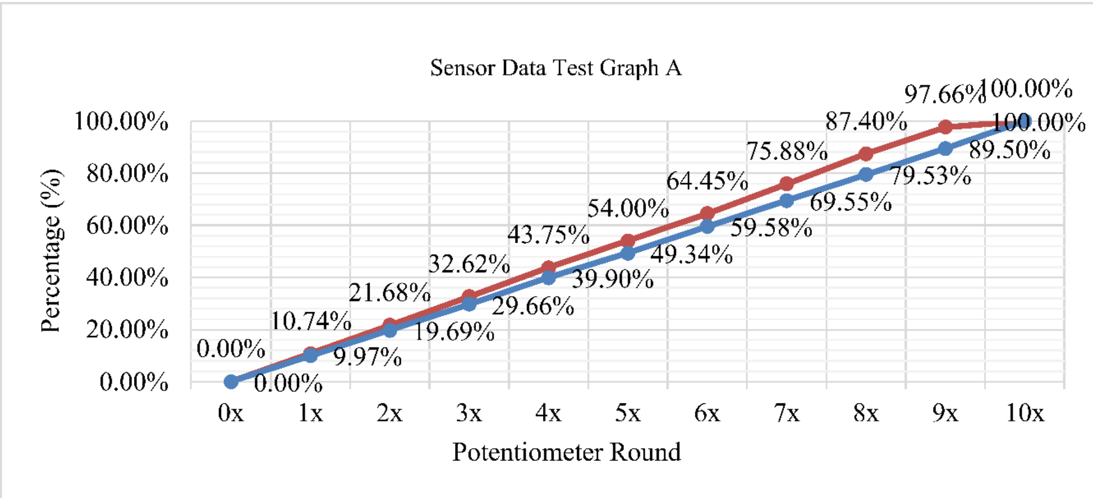


Figure 5. The percentage result of Device A sensor output

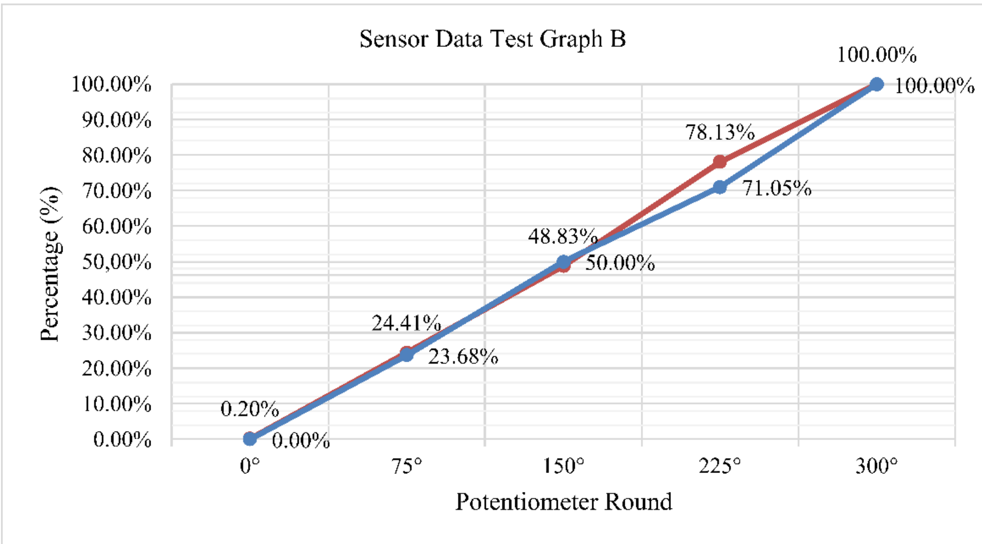


Figure 6. The result of the percentage output the device sensor B

3.2. Calibration Analysis Tool

The sensor calibration stage is the process of adjusting the sensor data to the actual altitude data. This calibration process is done via the localhost web, which can be accessed via the IP address (internet protocol) of each device.

After the calibration web opens, the data that must be filled in is the maximum height of the sensor and the percentage limit. Press the Min button when the position of the mechanical sensor is minimal, and press the Max button for the maximum sensor height position. After the data is entered, the calibration process is complete. However, the controller cannot be connected to the Thingspeak platform before pressing the Thingspeak button. The following is a table of results from the calibration test for devices A and B can be seen in Table 3.

Table 3. Device calibration test results

Device	Maximum Height of Sensor (mm)	Range Data			Limit		
		Min	Max	Distance	Limit Percentage	Data Sensor	Height (mm)
A	1100	303	962	659	85%	863	935
B	1100	130	734	604	85%	643	935

In device A, the maximum height is set to 1100 mm, with a minimum range of 303, and a maximum range of 962, so the difference between the max and min ranges is 659 and the percentage limit is 85%. The results of the calibration data can be calculated by equation (2).

$$Device\ A$$

$$Limit\ Data\ Sensor = Data\ Min + \big((Data\ Max - Data\ Min) \times Limit\ Percentage\big)$$

$$= 303 + \big((962 - 303) \times 85\%\big) = 863 \tag{2}$$

$$Limit\ Data\ Height = Maximum\ Height\ of\ Sensor \times Limit\ Percentage$$

$$= 1100 \times 85\% = 935\ mm$$

Sensor data limit is the process of knowing the data sensor value when the limit condition is reached, meaning that this data value becomes the limit for the tool's danger sign. The data limit value is obtained when the percentage of 85% is 863; if the sensor value exceeds the value of the sensor data limit, the DANGER sign lights up. Limit altitude data is a process to find out what the actual height of the water is when it crosses the limit. 85% of the actual height of the sensor is 935 mm, which means that if it exceeds that height, the DANGER sign will light up.

In device A, the maximum height is set to 1100 mm, with a minimum range of 303 and a maximum range of 962, so the difference between the max and min ranges is 659, and the percentage limit is 85%. The results of the calibration data can be calculated by equation (3).

$$Device\ B$$

$$Limit\ Data\ Sensor = Data\ Min + \big((Data\ Max - Data\ Min) \times Limit\ Percentage\big)$$

$$= 130 + \big((734 - 604) \times 85\%\big) = 643 \tag{3}$$

$$Limit\ Data\ Height = Maximum\ Height\ of\ Sensor \times Limit\ Percentage$$

$$= 1100 \times 85\% = 935\ mm$$

3.3. Inter-Device Testing Analysis

In the analysis phase, testing between devices is the stage where the device work process is in normal conditions, namely the conditions in Thingspeak that make the device connect with others. In this connection, the parameters taken are the height and the percentage of sensor readings, so that each device can display the parameter values of the readings on other devices. The parameter used for the safe and dangerous limit markers is the reading percentage; that is, when the percentage value shows <85%, then the condition is in the SAFE category, but if ≤ 85%, it is in the DANGER category. In testing between devices, the programming tools have been changed using 4 Thingspeak channels, namely for the following parameters, The height of device A, Percentage of device A, The height of device B, and Percentage of device B.

This was done because, seeing the response of the tool regarding the time lag during internal device testing, there were still many time lags that were included in the slow and very slow criteria. The internal channel update is still set to 15 seconds, as it was during the internal device test, because this value is the minimum update interval setting of Thingspeak. The data collection process starts from the lowest reading to the highest, after which a random reading is carried out. The results of testing devices A and B that have been done can be seen in Table 4 and Table 5. The results of testing between devices on the device (B) can be seen in Table 5.

In Table 4 and Table 5, there is data on the length of time and time lag criteria during the upload and download process. The criteria for the upload delay time are: fast (1–10 seconds), normal (11–20 seconds), slow (21–30 seconds), and very slow (<31 seconds). So that you can get a fast grouping graph, see Figure 7 and Figure 8.

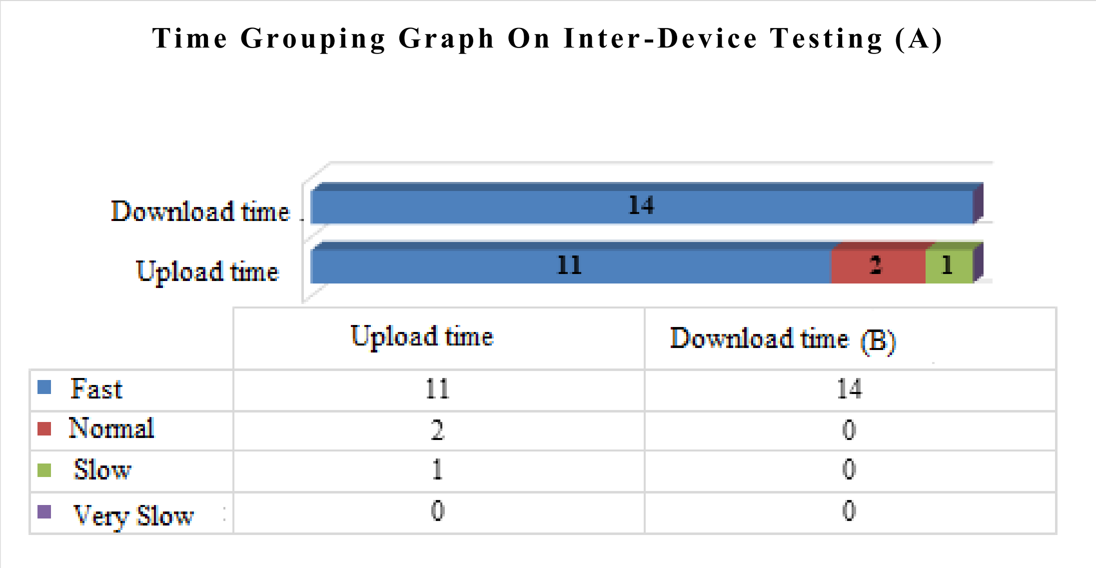
Table 4. Test results between devices part (A)

No	Date & Time	Height (mm)	Percent (%)	Info	Data Pause Time (Second)		Time-off criteria	
					Upload	Download	Upload	Download
1	2020-07-06 02:18:08 WIB	110	10	Secure	2.5	1.5	Fast	Fast
2	2020-07-06 02:19:35 WIB	196	17	Secure	2.5	3.5	Fast	Fast
3	2020-07-06 02:21:01 WIB	297	27	Secure	1.5	4.5	Fast	Fast
4	2020-07-06 02:23:24 WIB	394	35	Secure	1.5	2.5	Fast	Fast
5	2020-07-06 02:25:13 WIB	503	45	Secure	2.5	1.5	Fast	Fast
6	2020-07-06 02:27:15 WIB	609	55	Secure	1.5	3.5	Fast	Fast
7	2020-07-06 02:29:18 WIB	707	64	Standby 3	2.5	2.5	Fast	Fast
8	2020-07-06 02:29:53 WIB	815	74	Standby 2	2.5	2	Fast	Fast
9	2020-07-06 02:32:18 WIB	912	82	Standby 1	6	4	Normal	Fast
10	2020-07-06 02:32:54 WIB	1001	91	Danger	2.5	1.5	Fast	Fast
11	2020-07-06 02:33:29 WIB	1096	99	Danger	6.5	4	Normal	Fast
12	2020-07-06 02:34:20 WIB	970	88	Danger	2.5	3.5	Fast	Fast
13	2020-07-06 02:34:56 WIB	921	83	Standby 1	2.5	3.5	Fast	Fast
14	2020-07-06 02:37:47 WIB	765	69	Standby 3	13.5	1.5	Slow	Fast

Table 5. Test results between devices part (B)

No	Date & Time	Height (mm)	Percent (%)	Info	Data Pause Time (Second)		Time-off criteria	
					Upload	Download	Upload	Download
1	2020-07-06 02:17:43 WIB	107	9	Secure	4	1.5	Fast	Fast
2	2020-07-06 02:19:07 WIB	204	18	Secure	4	1.5	Fast	Fast
3	2020-07-06 02:20:48 WIB	306	27	Secure	3	2.5	Fast	Fast
4	2020-07-06 02:22:30 WIB	306	27	Secure	2.5	1	Fast	Fast
5	2020-07-06 02:24:27 WIB	499	45	Secure	2.5	1	Fast	Fast
6	2020-07-06 02:26:24 WIB	600	54	Secure	2.5	3.5	Fast	Fast
7	2020-07-06 02:28:23 WIB	704	64	Standby 3	4.5	2.5	Fast	Fast
8	2020-07-06 02:29:31 WIB	802	72	Standby 2	8.5	1	Normal	Fast
9	2020-07-06 02:30:56 WIB	904	82	Standby 1	4	5	Fast	Fast
10	2020-07-06 02:32:54 WIB	1001	91	Danger	2.5	2.5	Fast	Fast
11	2020-07-06 02:33:10 WIB	1089	99	Danger	2	3	Fast	Fast
12	2020-07-06 02:34:01 WIB	771	70	Standby 3	14	1.5	Slow	Fast
13	2020-07-06 02:35:42 WIB	769	69	Standby 3	1.5	1.5	Fast	Fast
14	2020-07-06 02:37:55 WIB	1107	100	Danger	2.5	3.5	Fast	Fast

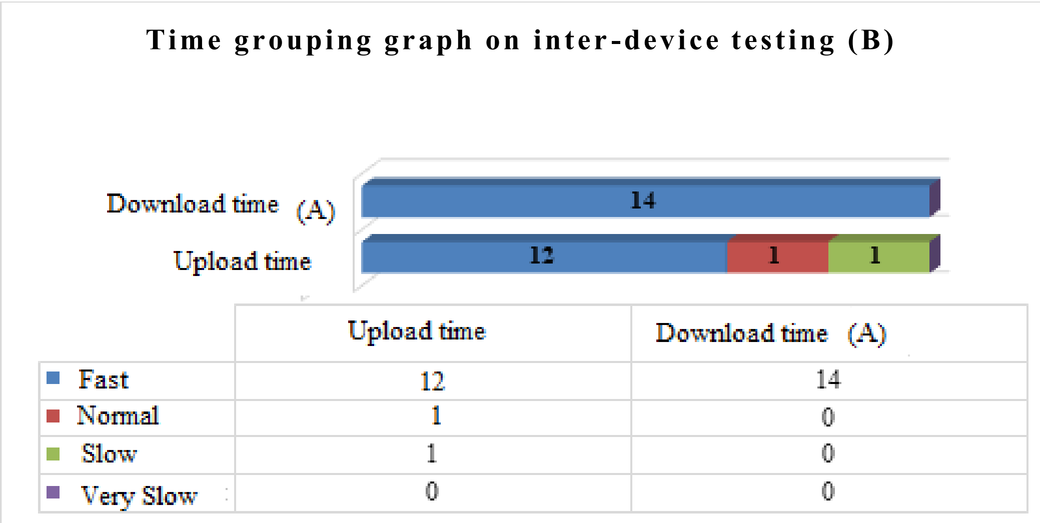
Figure 7 shows the upload time in testing between devices A, which is classified as fast, while the download time shows the results of the fast time lag criteria (≤ 5 seconds). When compared with the internal test data for device A in Figure 7, the test results between devices (A) in Figure 7 show better results; this can be seen in the results of the time criteria graph for each test. Testing between devices (A) can be better because, in the testing process, each parameter uses one channel, meaning that the update interval is 15 seconds, always updating data on only one parameter that is taken (such as height).



	Upload time	Download time (B)
Fast	11	14
Normal	2	0
Slow	1	0
Very Slow	0	0

Figure 7. Graph of test results between devices (A)

Figure 8 shows the upload time in testing between devices B is classified as fast, while the upload time shows good results. The criterion for lag time is fast (≤ 5 seconds). When compared with the internal test data for device B in Figure 8, the test results between devices (B) in Figure 8 show better results; this can be seen in the results of the time criteria graph for each test. Testing between devices (B) can be better because, in the testing process, each parameter uses one channel, meaning that the update interval is 15 seconds, always updating data on only one parameter that is taken (such as height).



	Upload time	Download time (A)
Fast	12	14
Normal	1	0
Slow	1	0
Very Slow	0	0

Figure 8. Graph of test results between devices (B)

4. CONCLUSIONS

The design and development of a flood detection-based internet of things can run according to the designed concept. The tool can measure the water level. When the actual condition of the water level is, for example, 1058 mm, the sensor reading also shows the number 1058 mm. If the sensor reads the water level ≤ 60% (≤ 660mm), then the altitude condition is in the secure category. If the sensor reads a water level of 61–70% (671–770 mm), then the altitude condition is in the category Standard 3. If the sensor reads a water level of 71–80% (781–880 mm), then the altitude condition is in the standby 2 category. If the sensor reads 81–85% (891–935 mm) water level, then the altitude condition is in the standby 1 category. If the sensor reads water level = ≥ 85% (≥ 935mm), then the altitude condition is in the DANGER category, so the alarm is active.

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