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MECHANICAL DESIGN FOR FLOODING DETECTION SYSTEM USING MOTOR DIRECT CURRENT CONTROL BASED ON ARDUINO

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Abstract

Floods are known as natural disasters that occur throughout the world. In Indonesia, flooding is the most serious disaster, as flash floods that occurred in Manado on January 15, 2014 caused tens of thousands of people to become victims, and caused tens of thousands of homes and infrastructure facilities to be damaged. The residents who were victims were none other than those who lived near the riverbank. In this study, detecting water level is important. Many researchers use microcontroller-based ultrasonic sensors to calculate the flow of water, but when the water exceeds the position of the sensor height, the flood detector cannot function anymore. Therefore the most recent contribution of this research is to design flood detectors equipped with dynamic mechanical systems. The tool does not only measure the height of the water but also can adjust to the conditions of development from the height of the flood itself. Information about water level will be announced for residents, and if a flood occurs at night then an alarm siren for residents living on the river side will be activated.

Keywords – Flooding, Ultrasonic Sensor, Microcontroller, Dynamic Mechanical System.

1. Introduction

A number of natural disasters, such as earthquake, storm surge, Tsunami wave, and the flood, etc. occur annually in various parts of the world. This earth has already observed the destructive mode of nature which has taken millions of lives. Flooding is known as one of the natural disasters that occur all around the world. It could lead damage of houses and buildings, and carry soil away from valuable farming land. Floods generally develop over a period of days, when there is too much rainwater to fit in the rivers and water spreads over the land next to it.

However, it can happen very quickly when lots of heavy rain falls over a short period of time. These flash floods occur with little or no warning and cause the biggest loss of human life than any other type of flooding. At 2013, the northeastern section of Buenos Aires Province, Argentina, experienced several flash floods that claimed the lives of 101 people. The 2012 Nigeria floods began in early July 2012, and killed 363 people and displaced over 2.1 million people as of 5 November 2012.

According to the National Emergency Management Agency (NEMA), 30 of Nigeria's 36 states were affected by the floods. The floods were termed as the worst in 40 years and affected an estimated total of seven million people. The estimated damages and losses caused by the floods were worth 2.6 trillion. A large number of studies have been conducted by researchers from various disciplines all around the world on floods. All of these studies are focusing on the understanding of the real cause of floods and the effects of floods in the future. The shortcomings of previous studies, they did not discuss alarm system when flooding will occur. We know together one example of hazardous events such as fires, many researchers doing research in this area to save people by using a guiding alarm system.

The disaster management consists of four fundamental steps such as mitigation, preparedness, response, and recovery. The numerical evacuation analysis is also becoming popular to estimate the extent of the damage of human being. In the evacuation analysis, it is very important to evaluate the evacuation behavior of the human being in the time during the disaster accurately [1]. Mardiatno and his colleagues have conducted research based on the shape of river channels, so that they can identify locations prone to flooding. From a geomorphological point of view, they found floods would inundate several areas near the river. If the drainage system in this city is not managed properly, flooding will expand to the city. Based on these conditions, the researchers explained the initial results of the determination of flood hazard, as a basis for conducting a more comprehensive synthesis such as flood risk and flood hazard mitigation [2].

An important factor of flood occurrence near settlements is erroneous land use in these areas. It is clearer in developing and under-developed countries. Increasing population rates cause uncontrolled and disordered settlements. It is also important that artificial human effects on hydrographic structures cause a flood. Irfan and his colleagues have been trying to explain the effects of land use features on flood occurrence have been determined by using Geographic

Information System (GIS) and remote sensing. Pixel-based classification method has been used for analyzing land use features. In this study, geometric data composes the basis of the model. These data are rivers, river coasts, stream ways, cross sections and land use. To determine the flow of the simulation model and the possibility of flooding in an area, the researchers used the same method to get the results they are looking for. The objective of their research is to explore the integration of GIS and hydraulic simulation model, Hydrologic Engineering Centers River Analysis System (HEC-RAS) [3].

Additional flooding problems are also discussed by a group of researchers, they are focusing on a flooding into an underground space where the evacuation situation is facing more challenges due to its enclosure and complex structure in the layout of emergency exits and the evacuation routes. In addition, people may feel panic during a flood hazard due to uninformative of outside conditions. Early evacuation is highly recommended for the hazard of underground inundation but difficulties still exist within minorities who either take a late response or get injured or even totally unaware of the coming hazard. Therefore, they are already in the survivability critical situation when they take coping actions. [4].

Detecting water level can be done using a microcontroller-based ultrasonic sensor. In a previous study, an ultrasonic-based flood detection system with the Gate Way SMS communication media had flood warning results in the form of an SMS containing the speed of the water level [5]. The shortcomings found in the study, when the water level exceeds the height of the sensor, the flood detector does not function anymore, because the design of the flood detector is not equipped with a dynamic mechanical system. In addition, the tool can only detect on 1 observation area.

In developing large areas in Manado, it would be very useful to identify all areas at risk of flooding. Thus, developing the Microcontroller-based Early Warning System Design with the Up and Down mechanical system using a motor DC (direct current) is very important for the city of Manado.

2. Literature Study

We do a literature review to learn more about the needs of the system. As for the library review it is divided into 3 parts:

2.1 Flooding Prediction

Mokh Sholihul Hadi and friends have already conducted research in this field. In their research, they designed a water level monitoring system by implementing Arduino nano-based ultrasonic sensors and esp 8266 modules for data logging so that they could find water levels at certain levels [6]. The disadvantages of this research are in how to convey information about the status of the water level to the citizens, because the information is distributed through twitter social media. Another with Amelia and friends, in providing the design of remote flood detectors using a communication system, they designed a water level measurement system with a parallax ultrasonic ping sensor which is controlled by an ATMega 8535 microcontroller where the processed data is then sent wirelessly using the Xbee transmitter -PRO. In the process, the data that has been sent is then received by the reciver and then sent back serially to the computer [7]. This research still has shortcomings where information is only received by one reciver and also does not discuss the dissemination of flood information to all residents.

2.2 IoT Implementation In Human Life

The presence of the internet in recent decades has revolutionized the way the world works so quickly. The era of the Internet of Things is at the doorstep, many researchers have discussed the development of IoT itself. M. Andang Novianta is one of the researchers who discussed the advanced communication technology by taking the internet concept in it. In its research, it has the aim to overcome the problems that arise by designing a monitoring system for changes in water level based on cellular communication networks (GSM) as the communication backbone of data packages from monitoring stations [8]. Muhammad also carried out an IoT-based research development. He discussed the concept of developing smart door locks that are supported by cloud computing technology as data storage. In its method, it combines technologies such as ESP8266 for communication, Firebase for cloud computing based services, and android applications to control or monitor the ESP8266 module through Firebase which functions as a mobile backend as a Service by implementing IoT rules [9]. From the discussion of the two studies above, it can be seen that the application of IoT has become one of the rules that greatly helps human needs and performance so that the results obtained are very satisfying.

Therefore, even in this study, we wish to develop a system for designing flood detectors by combining IoT into it.

2.3 Smart Actuator System

In perfecting this research, we not only designed an early flood detection system but we also thought how to make the system to be built equipped with mechanical equipment that could interact with environmental changes. DC (Direct Current) motor is an electric machine that has the working principle of converting electrical energy to mechanical energy, so that the energy produced is the energy of rotating motion on the motor shaft. The application of DC motors is very broad, starting from the main movers of several functions of industrial machinery, the main drivers of transportation systems even to meet the driving needs of household appliances.

In the merry research and Jeffry discussed about the realization of an elevator miniature plant that can represent a real plant elevator using PLC and SCADA controllers to monitor the speed, capacity, and carrying capacity of the elevator. Based on the results of the analysis, the ideal load that can be transported by the elevator miniature plant is a maximum of 5kg and by prioritizing search calls, the power and time used by the elevator miniature plant are more effective and efficient [10].

3. System Model and Problem Definition

A natural disaster is one of the disasters arising from a human that were careless and have destructive actions. Any natural disaster will inevitably lead to losses, both materially and psychologically. The disasters caused many people lost their homes, livelihoods, family members, and natural disasters also caused trauma for victims. Therefore, any natural disasters should be prevented in order to achieve a secure and peaceful life. And one of the typical natural disasters is flooding. Before prensenting more detail of our work, in this section we will discuss about the model system and scenarion applications that we designed. After that the problem definition is provided to clarify the objective and constraints of our system.

3.1 System Model

Before presenting the details of our IoT flooding system, this section formally defines the considered system model and application scenario of this paper.

a. Application Scenario

Data from 8 rainfall monitoring stations and from the sensors along the river were collected, then sent to the base station. The results of flooding alarm and navigation are then forwarded to mobile phones which are in hazardous areas. The proposed system is summarized in figure 1.

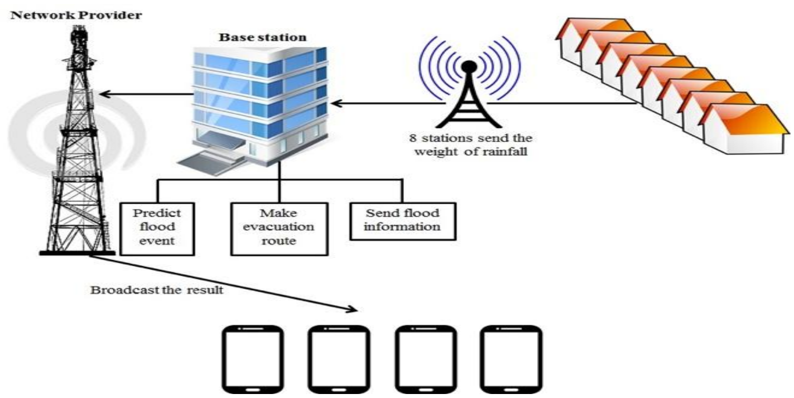

Figure 1. Application Scenario

b. System Stack

Here we design our system stack:

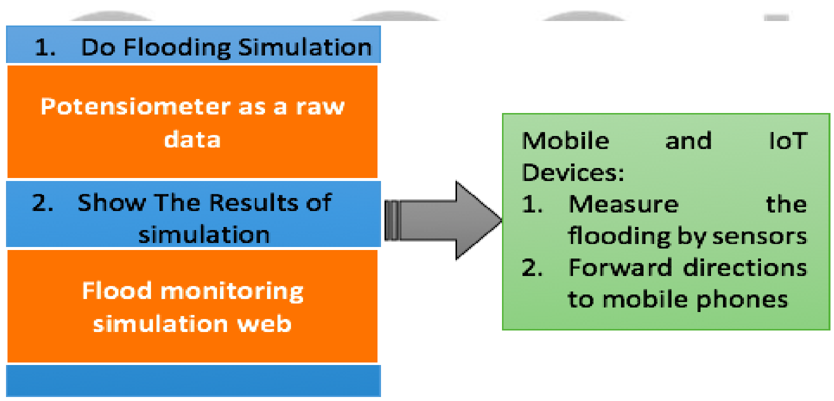

Figure 2. System stack

To provide the flooding detection system, there are several phases to complete the whole system as shown in figure 2. The system stack shows that the rainfall data should be processed first, after that the results should be forwarded to users. Here the complete explenations of the system stack.

1. Entering the data of rainfall into the potensiometer.
2. The resulth of the simulation will be displayed in flooding monitoring simulation web.
3. IoT device will measure the flooding event by the sensors, after that the results will forward direction to mobile phone of users.

c. Framework of IoT System

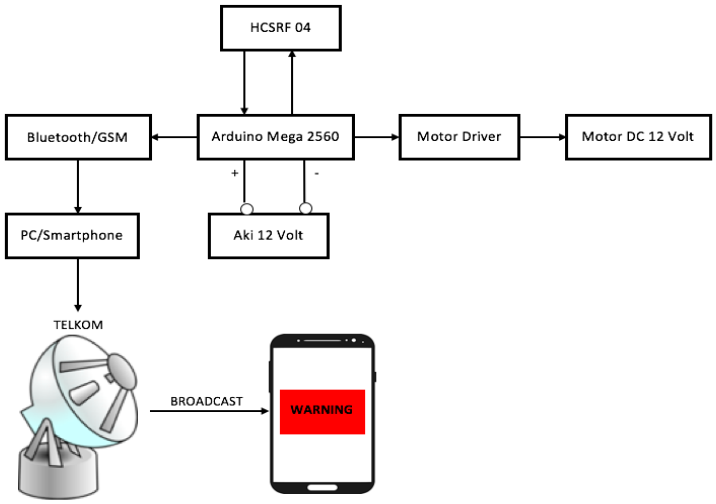

Figure 3. Framework of IoT System

The below is an explanation of the IoT system framework:

1. HCSRF04 is used to detect water level.
2. Arduino is used to manage the data.
3. Motor Driver is used as a driver of motor DC.
4. Motor DC is used a driver of flood detection devices.
5. Bluetooth is used to sending the information to PC or smartphone.

HCSRF04 sensor will detect the water level and send the data to Arduino for processing. When the water level exceeds the specified limit, Arduino will send a signal to the motor driver to drive the DC motor (up / down) according to changes that occur at the water level. After that, the data obtained will be sent to the PC / smartphone past the Bluetooth sensor and then forwarded to residents.

3.2 Problem Definition

Flood arise from the forest and trees that can no longer hold the excess water. When rains happen the water will absorb by plants and trees, and the water that is not absorbed will flow into the river. When the river can no longer continue or drain the water, it will overflow to the mainland. Flooding usually occurs when heavy rain fell continuously and flood with high speed causing soil erosion as well as destruction problem of sediment to the estuary, also damaging spawning grounds and jungle life, the animals residence are also often destroyed, many residents who lost their homes, crop failures, interruption of economic activities, roads flooded, then distribution vehicles stalled because could not go through it.

Flash floods that hit Manado city on January 15, 2014 crashed thousands of homes, displaced 40,000 people, isolated 7 villages, and killed 15 people. However, there is still no early warning system for flooding detection in Indonesia. Regarding the shortage of flooding emergency system and the historical lessons, this paper wants to develop an alarm for detect flooding events that can announce to people and reduce the damage in flooding events. On the figure 4 shows an example that several people are in a to-be-flooded area.

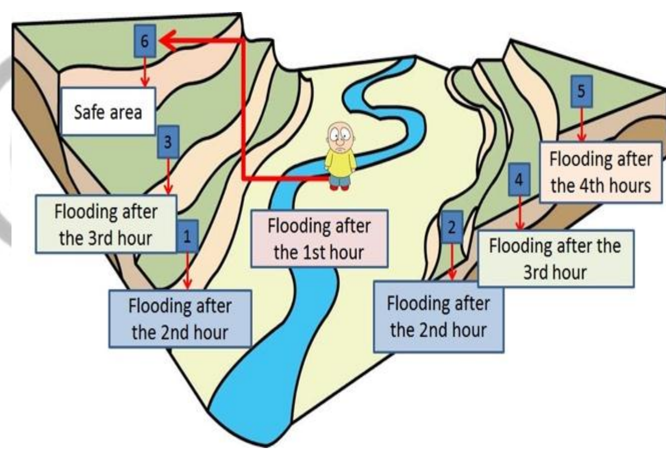

Figure 4. Problem Issue

In the example, the river is going to overflow to the nearby areas, and people there could be panic and try to find a way out to save their lives. Assume that there isn't have a flooding estimation system which can tell the timing information about flooding. If the people choose a wrong way and do not cross the river by some bridge, they will go area 2, area 4, and area 5 and be trapped at area 5. After the 4-th hour of flooding, people at area 5 will die. However, if the alarm system can give them announce to go area 1, area 3, and area 6, finally, they will be safe. Therefore, it is very important to develop the early warning system for saving people's lives in Manado City.

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4. Mechanical Design Flooding-Aware

In perfecting this research, we not only designed an early flood detection system but we also thought how to make the system to be built equipped with mechanical equipment that could interact with environmental changes.

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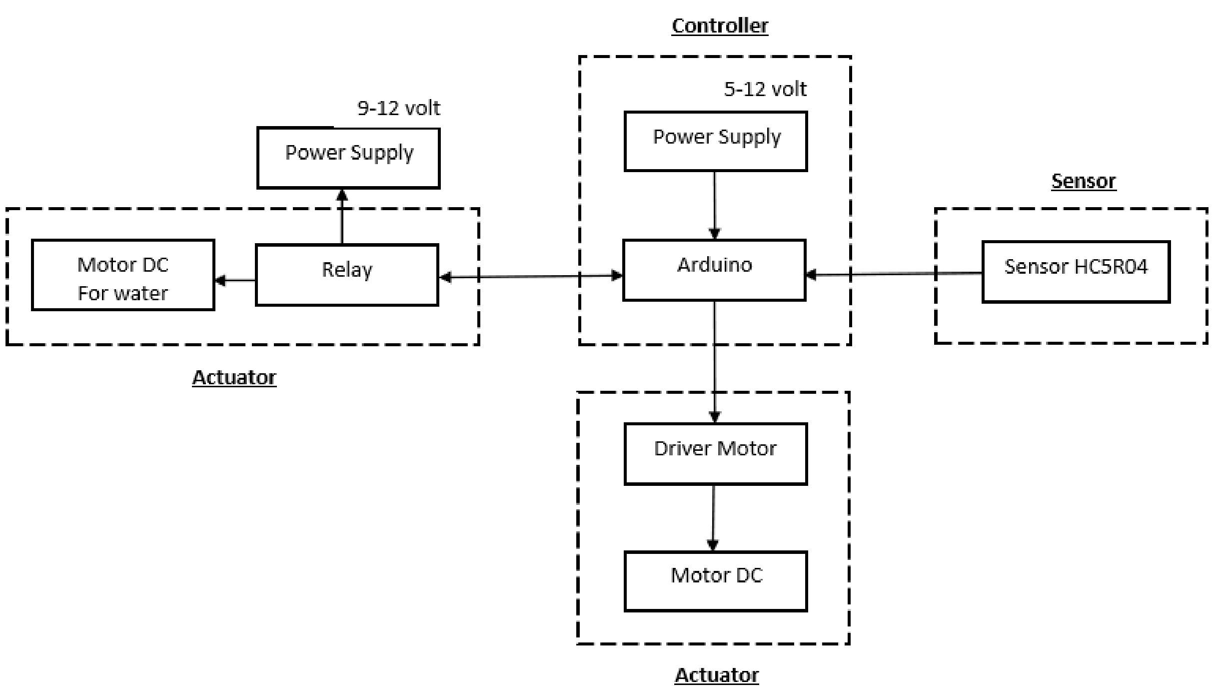

Figure 4. Design Architecture

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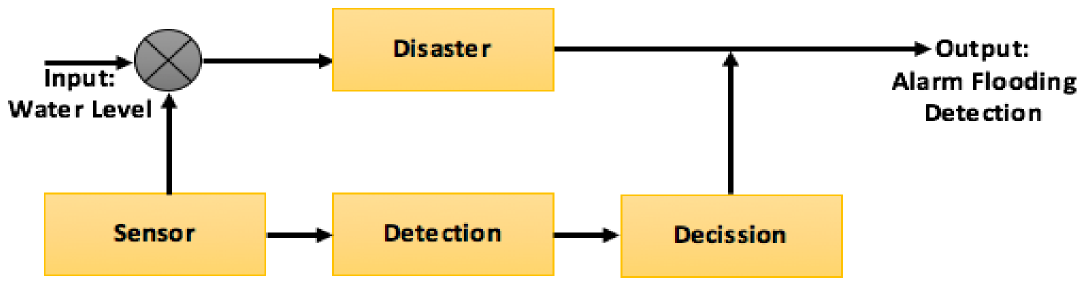

Figure 5. General Description

Figure 4 shown the architecture of the sensors on the system has built. Figure 5 is a general description of the system to be built. Seems like; water level as input. Water level will be measured using a sensor. When the water level changes, the sensor will record the changes as reference data in decision making. In the event of a disaster the system will issue an alarm flooding detection as output to people.

Below is a flow chart of the mechanical system that we used:

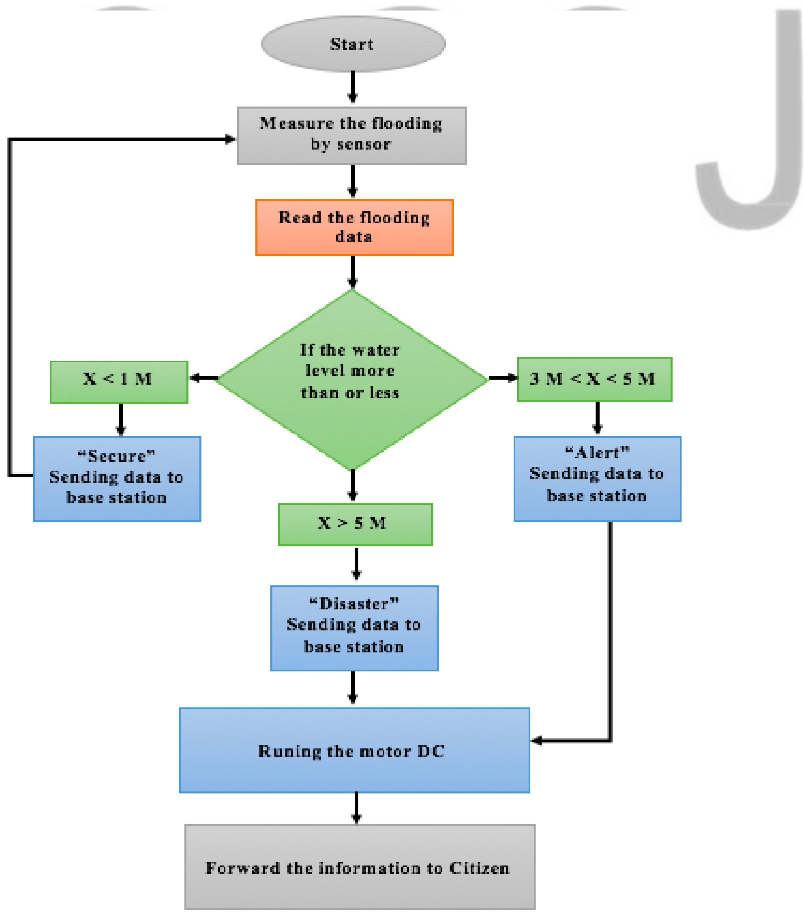

Figure 6. Flow Chart

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Here our table description:

Table 1. Water Level Condition

Input by Water Sensor	Output				Motor DC
Water Level (X)	**LCD**	**Buzzer**	**Bluetooth**	**PC**	
X<1 m	Secure				
3 m<X<5 m	Alert	✓	✓	✓	✓
X >5 m	Disaster	✓	✓	✓	✓

There are three conditions that we explain in this system:

1. Secure

If the conditions of water level is less than 1 m, which means that the state is normal and not seen any flood attack. Buzzer on this condition will not be switched off so well by the Bluetooth device. No information will sending to PC and the DC motor will not move.

2. Alert

In these conditions the water level in the river indicate the position of less than 5 m but greater than 3 m, which means that the water level has increased so the conditions are classified as flood alert. The LCD will provide information about the distance of the water with the tools that we put near a river. At this stage buzzer will also provide information to warn people who's living in the area nearby river. While the data generated by the microcontroller will be sent via Bluetooth to PC. The DC motor will change position according to changes in water level.

3. Disaster

The condition where the water level is bigger than 5 m away from the mounted device position near the river. LCD, buzzer and a Bluetooth device will work as the Alert condition.

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5. Result and Conclusion

Based on the following pictures, the system is working properly. Direct Current (DC) using as a motors mover or actuators for the mechanics of flooding detector that run dynamically. This prototype system is more profitable than the system because of the sensor will be more flexible to support the height of the air. HCSR04 sensor is an ultrasonic sensor that is used to measure the height of the air and the results obtained from the sensor are proper in accordance with the specifications of approximately 3 meters, and used threshold approximately 1 meter above the air surface. Water released over 1 meter will drive the mechanics system and will request an early transfer.

Microcontroller used Arduino ATmega 2650 because the number of pins and sensors is more than one. The amount of memory is also chosen in the selection of the microcontroller. The specifications of the Arduino ATmega are 256 KB for flash memory, 8 KB for SRAM and 4 KB for EEPROM, the amount of memory from this specification is very possible to collecting the data from the system created. The results of the system shown by the picture have been taken.

Figure 7.a. The system back side

Figure 7.b. The system front side

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