Design and implementation of water pump control system for rice field irrigation

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Abstract. We have built an electronic instrument of water pump control system for rice field irrigation. This instrument is developed from our previous prototype with some additional features. This instrument is equipped with the keypad, GSM modem, water flow sensor, and relay as the input sources. An Arduino Mega 2560 is used as the main controller of the system. The working time of the water pump can be set using the keypad or short message service, which is received by GSM modem in the instrument. If there is no water flowing through the water pump as detected by the water flow sensor, the instrument will automatically shut down the water pump, and send the notification message to the user’s handphone. When the abnormal condition is detected on the water pump, the relay will disconnect the electricity to avoid the severe damage of the water pump. This instrument has been installed and used by the farmer in Desa Ngunut, Babadan District, Ponorogo Regency, with support from DRPM Kemenristekdikti through Program Kemitraan Masyarakat.

1. Introduction

Agriculture and food are necessary fields in human life. Research in this field continues to be intensively carried out, especially in agrarian countries. Scientists in this field are trying to improve the quantity and quality of agricultural products by providing superior seeds \cite{1,2}, improving cultivation \cite{3,4} and pest prevention systems \cite{5,6}, and developing mechanization and automation of agricultural equipment \cite{7-10}.

Although many efforts have been made by researchers to improve the quantity and quality of agriculture, but most farmers in developing countries have not been able to use existing technology because of the high enough price and complicated ways of use. That is why we strive to make inexpensive and user-friendly tools to help farmers with irrigation in the field using an electric water
pump. With this tool we hope that farmers can prevent losses due to damage to the water pump, and they can do other activities during the irrigation process to get extra income.

2. Method
In this section, we explain the method of creating a control system consisting of tool design and microcontroller programming.

2.1. Hardware design
The design of this remote rice field irrigation control system consists of 3 blocks, viz. input block, control block and output block, as shown in Figure 1.

![Figure 1. Hardware configuration scheme](image)

We can see in Figure 1 that the hardware made includes the input, control, and output sections. The mobile phone acts as the sender of the input signal in the form of an SMS sent to a number that already exists in a GSM modem (SIM800L) and is programmed in the microcontroller to generate the output signal. GSM modem (SIM800L) functions as a receiver of SMS signals from mobile phones that then provide input to the microcontroller to turn the water pump on and off. The keyboard is used as a button input to manually set how long the irrigation process takes. The keypad can also be used to set the time, date, and other controls related to the controller. Water flow sensor acts as a sensor of a series of microcontroller systems that work when there is a flow of water that subsequently flows and becomes a digital voltage that then supplies input to the microcontroller to output the program according to the program. Thermal overload relay (TOR) functions as a detection sensor in the event of a power surge caused by the heat from an electric water pump. If extreme heat occurs, the TOR supplies input to the relay contactor to turn off the electric water pump.

In control block, Arduino Mega 2560 microcontroller is used as the main controller of the entire system or can be called the brain of the system. Figure 2 also shows that the output block consists of LCD, relay, buzzer, contactor, and pilot lamp. LCD functions as a notification viewer of program activities on the microcontroller system. The relay functions as a switch to provide the contactor voltage to turn the water pump on or off. Buzzer is used as an indicator if the device receives the input command or sends the output. Switch is used to switch the electric water pump ON/OFF according to the microcontroller instruction. And the indicator light functions as an ON/OFF indicator for the water pump and the indicator when the TOR detects abnormal electrical current.
2.2. Microcontroller programming
The instruction of this control system device can be written in Arduino IDE package using the C++ language program that can be seen in figure 2.

![C++ code written in Arduino IDE](image)

Figure 2. C++ code written in Arduino IDE

After all instruction is completely written in C++, it is then converted into hexadecimal code that is uploaded into the microcontroller.

3. Results and Discussion
In this part, the assembly processes of the device are presented and the picture of the device are also shown.

3.1. Creating the device model and its assembly
Figure 3 shows the model of the device that is created using drawing software. We are then built our device based on this model using the electronic components which have been explained in section 3.

![Model of the control system device](image)

Figure 3. Model of the control system device
3.2. Device working process

Figure 4 shows the program flow diagram on the Arduino Mega 2560. First the microcontroller reads or analyzes the installed components correctly. If all components are installed correctly, the microcontroller checks the LCD, GSM modem and I/O. The user then determines the use of SMS / keyboard to switch on the water pump. If the user chooses to send an SMS, the GSM modem analyzes the SMS if it is in the programmed format. If it does not match, there is no input response. Farmers receive an SMS that the SMS format is incorrect. If the SMS format matches the programmed one, the command is forwarded to the microcontroller.

The first SMS format is "ON 1-9". This step is used to switch on the water pump according to the desired time. The time indicated in this SMS menu is from 1 hour to 9 hours. In addition, the tool sends text messages to farmers about the status at what time and date, as well as the time in accordance with the program. After 1 minute after the water pump is switched on, the water flow sensor detects whether there is water or not. If that is the case, it will complete the rice field irrigation process. But if there is no running water pending damage to the water pump, the sensor provides input to the microcontroller to turn off the water pump. As a secondary protection, a thermal overload relay has been installed that functions if an electric current does not comply with the provisions, so that the water pump is switched

Figure 4. Flowchart of device working process
off so that it does not burn. The second format is "OFF" which indicates that the water pump is switched off and the user receives a text message that the water pump is switched off.

The second menu is to use the keyboard as input. Users only have to press buttons 1-9 to switch on the water pump if necessary. If you want to switch the water pump off manually, simply press the 0 button to switch off the pump. On the keyboard there are also some that can be set by the farmer, among other things to determine how long it takes for the sensor to start the water reading process, set a minimum limit for running water, the state of the GSM modem checks, sets the current time and date and finds out whether the contactor can switch on the water pump or not.

Figure 5. The control system device

Figure 5 shows the rice field irrigation control system that is packaged in a box. After conducting field tests, we get the result that all components have worked according to their respective functions. Power supply can operate in accordance with the specified voltage. Input from SMS, keypad and sensors can be well received to be sent and processed by a microcontroller. The microcontroller sends the instruction to the output components according to the program implanted in the system. The performance of the device is evaluated by taking some data when it is operated. First, the power supply test is performed by analyzing the output of the 24-volt adapter and the output of the LM 2596 reducer in the microcontroller circuit. The expected output voltage of the LM 2596 regulator is 12 volts so that the microcontroller is able to work optimally. The measurement is carried out using a voltmeter, MASDA KS268L series, where the voltage calibration needle is placed in a multiplication of 12 volts. The measurement results of the input voltage are 11.8 Volt, as shown in table 1. The output voltage that must be obtained from a voltage drop using LM 2596 is 12 volts DC. The difference of this value is only 1.6% of the ideal value, and the device can still work properly.

| Measurement No. | V_{in} (Volt) - AC | V_{out} (Volt) - DC |
|-----------------|-------------------|-------------------|
| 1               | 24.0              | 11.8              |
| 2               | 24.0              | 11.8              |
| 3               | 24.0              | 11.8              |
| Average         | 24.0              | 11.8              |

Further, the performance of the water flow sensor was also evaluated. The results are shown in the table 2. When the sensor detects the flow of water, the measured voltage value is 5 Volt, and the voltage is 0 Volt, otherwise.

| Water flow detection | V_{sensor} (Volt) |
|----------------------|-------------------|
| true                 | 5.0               |
| false                | 0.0               |

Table 1. Measurement data of the input voltage $V_{in}$ and output voltage $V_{out}$ of the power supply

Table 2. Measurement data of the voltage from water flow sensor $V_{sensor}$
Based on the examination results of the device, it is known that the safety system of the water pump with the help of a water flow sensor and TOR is already working properly in accordance with its function. Ten devices have been installed and used by the farmer in Desa Ngunut, Babadan District, Ponorogo Regency, with support from DRPM Kemenristekdikti through Program Kemitraan Masyarakat [11].

4. Conclusion
We have developed the electronic instrument of water pump control system for rice field irrigation. This instrument has the ability to receive the input working hours either from keypad or from short message service sent by the user. We have installed water flow sensor in this instrument to detect the potential water loss that causes the damage of the water pump. If the sensor detects that there are no water flows, the water pump will be shut down by the instrument. The relay has also been installed in this instrument as the additional safety feature.

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