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PROTOTYPE OF WATER LEVEL DETECTION SYSTEM WITH WIRELESS

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ABSTRACT

Water level detection system is designed to facilitate human in collecting water levels data that can be performed in real-time. Ping sensor is used as a distance sensor for detecting water level by measuring distance between sensor and water surfaces. The system consists of two modules, transmitter and receiver. Transmitter module performs water level detection and transmits it to the receiver module as a data collector. Receiver module then displays the data on the screen. This system can be used as a part of the system that need the water level detection which can be collect remotely, such as, flood control system.

Keywords: *Ping Sensor, Interface, Detector, Wireless, Water Level Detection*

1. INTRODUCTION

Almost all aspects of human life have undergone rapid development. This development is supported by the advance of electronics and information technology. The job can be performed on schedule precisely and efficiently by adopting this advance technology.

An achievement in computer technology is used not only in business and industry but has also covers almost all fields, including control system where a computer system can be used to control the hardware in a flexible way. Therefore, computer-based control system is become more common in recent development of control system.

Computer-based control system also can be implemented for optimizing river flow management to minimize flood caused by water overflow. Management can be performed based on elevation of water level on the river as an input data and control the sluices along the river stream based on that data.

The aim of this research is to develop prototype of water level detection that can be viewed as a part of control system of river flow management system. The system consist of two parts, transmitter and receiver modules. Transmitter module detect water level automatically, then transmit the data to receiver. Ultrasonic sensor (ping sensor) is used to detect the distance between sensor and the water surface. Water level detection is performed without physical contact between the sensor and water surface. Ping sensors utilize the principle of sound reflection to measure the level of the water. Elapsed time required to transmit and receive the reflected ultrasonic wave is multiplied by the rapid propagation of sound in water in order to obtain the distance value. The calculation is performed by C language program that reside in microcontroller ATMega8535. The distance value then is transmitted using wireless network.

In receiver module, distance value received is passed the computer to display the water level every 5 cm differences by using micro-controller AT89S51. The water level then is displayed. If water level is changed rapidly and considerably dangerous, the buzzer will be activated. Water level information is also displayed in LCD.

2. BACKGROUND KNOWLEDGE

2.1. IC AT89S51

Microcontroller literally means that micro-sized controller [1]. At first glance similar to the microprocessor. However, many components are integrated in microcontroller, such as timers/ counters. AT89S51 microcontroller is an 8-bit CMOS low-powered and equipped with high-

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performance flash memory that can be programmed at 8 Kbytes. Pin structure of AT89S51 is shown in figure 1.

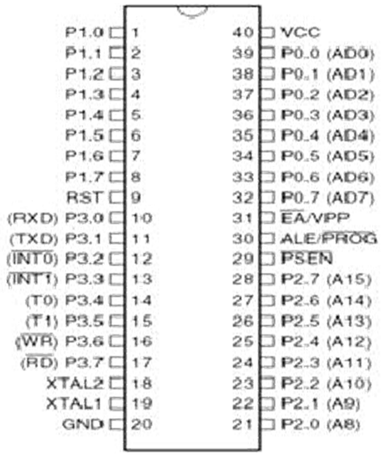

Figure 1. Pin structure of AT89S51 [2]

On chip oscillator is controlled by XTAL and connected to pin 18 and pin 19. 10 pF capacitor is required as a stabilizer. It uses XTAL as Frequency Generator, while XTAL2 is the output of the inverting oscillator amplifier.

2.2. IC ATMega8535

ATMega8535 is a representation of a microcontroller which is one of the AVR families produced by ATMEL [2]. 8-Bit RISC architecture, low-power and other superior features, ATMega8535 is highly efficient and effective to use as the main controller in this control system.

Another sibling of ATMega8535 is ATMega8535L. Both of them share the same specification and the differences only on operating voltage and the speed grades. I/O port of microcontroller ATMega8535 can act as input or output with high or low output. This input and output function are established via DDR and PORT settings. Pin structure of ATMega8535 is shown in figure 2.

2.3. Ultrasonics Sensor and Transducer

An ultrasonic transducer is a device that converts energy into ultrasound, or sound waves above the normal range of human hearing. Ultrasonic sensor generates high frequency sound waves and evaluates the echo which is received back by the sensor. The physical shape of ultrasonic sensor is shown in figure 3.

Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object. Sometime ultrasonic detector (transceiver) use separate transmitter and receiver components while others combine both in a single piezoelectric transceiver. This detector, usually, is used in submarine for detecting surrounding objects [3].

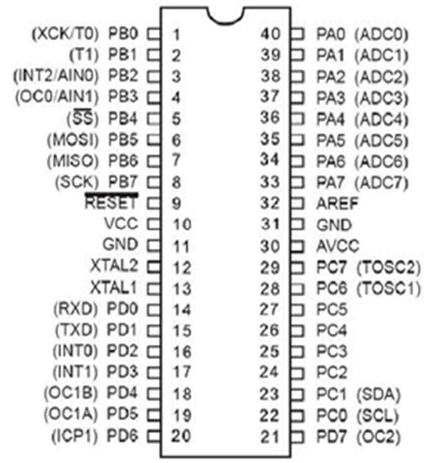

Figure 2. Pin structure of ATMega8535 [4]

Figure 3. Physical shape of ping sensor [5]

2.4. LED (Light Emitting Diode)

LED is an extension of the Light Emitting Diode (light-emitting diodes) of a type of diode that can emit light energy when the energy out as heat. LEDs are widely used as indicator lights and displays (display). The LEDs emit a variety of different colors like red, yellow and infrared (invisible) by using elements such as gallium, arsenic and phosphorus.

2.5. LCD (Liquid Crystal Display)

LCD (Liquid Crystal Display) is a viewer module which is widely used because it simple looks. The most widely LCD module used today is M1632 LCD because the price is quite cheap. M1632 LCD display is an LCD module with 2x16 (2 rows x 16 columns) with low power consumption. The module is equipped with a microcontroller specifically designed to control the LCD, HD44780 [6]. The LCD module used is shown in figure 4.

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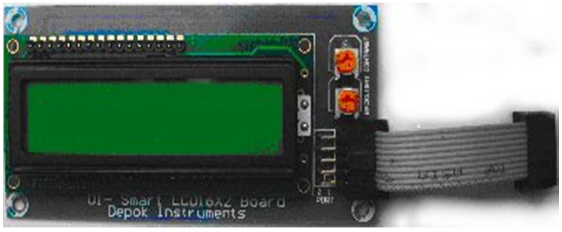

Figure 4. LCD Module [6]

2.6. Wireless

Wireless telecommunications is the transfer of information between two or more points that are not physically connected. Distances can be short, such as a few meters, or as far as thousands or even millions of kilometers for deep-space radio communications. Wireless communication can be via, radio frequency, microwave communication, and infra red. Common 27MHz wireless remote control module is used for the system with the range about 5 meters.

3. RESULTS AND DISCUSSION

3.1. Hardware Design

Basically, prototype of Water Level Detection System consist of two modules, receiver and transmitter module. Transmitter module responsible to transmit and display data received from the ping sensor. Receiver module accepts the data transmitted from transmitter module and transfer it to the computer for further process. Two modules system is designed to accommodate a flexibility development of the system. The ideal system consists of three modules: sensor, actuator and main controller modules. This prototype system consist only sensor and main controller part, actuator part is not included in this research.

Transmitter module consists of ultrasonic sensor input which converts the level of water to digital data and passes it to the microcontroller block ATMega8535. This block then process the input and give the desire output based on the input to LED, 16X2 LCD and send transmit it to receiver via wireless communications. In the other side, receiver module consists of microcontroller block to process the data received from wireless communication. The microcontroller AT89S51 then route the data to computer via RS232. The water level information then is displayed on a monitor in a real-time. Diagram block of the water level system is shown in figure 5.

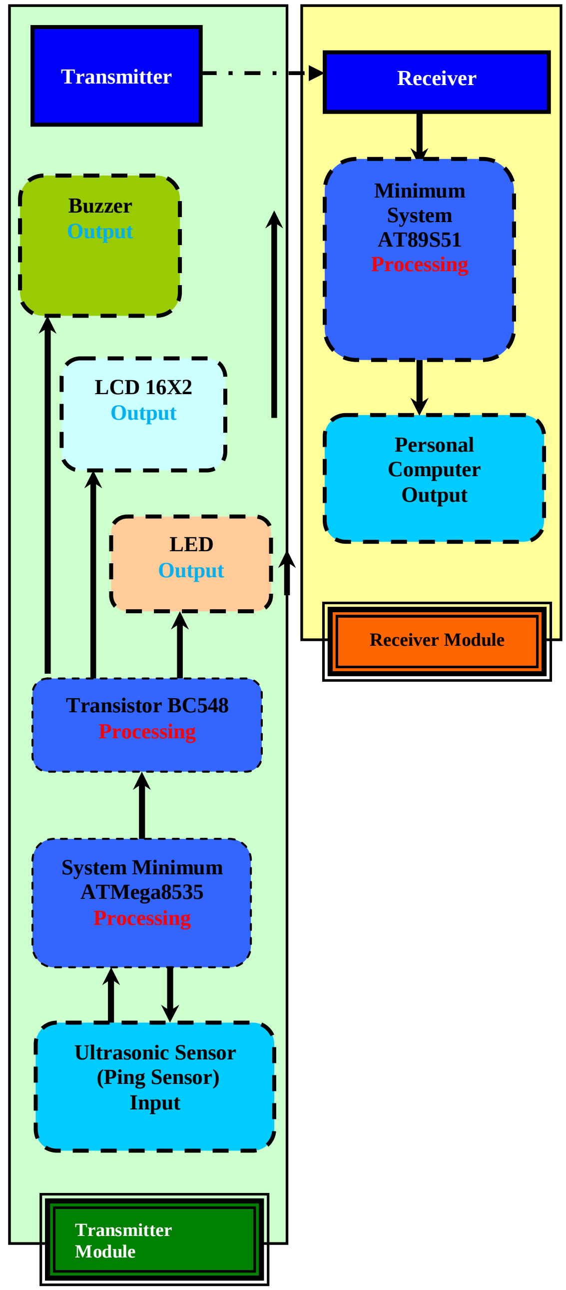

Figure 5. Prototype block diagram

3.2. Software Design

Flow chart of the system is shown in figure 6. Initialization process is performed by checking and setting the component including ping sensor, LCD and microcontroller. Ultrasonic wave is generated and reflection of ultrasonic wave then is received. The water level then is calculated based on travel time of ultrasonic wave. The water level data then is displayed using LCD and LED. This data is also sending to the transmitter. This process is

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performed periodically. The water level data then is received at receiver and display it based on the value of water level. At receiver module, the water level data is also displayed in computer display using Delphi programming [7, 8]

Figure 6. System Flow Chart

3.3. Detail Analysis

Transmitter module consists of ping sensor, ATMega8535 microcontroller, LCD and transmitter, as shown in figure 7. Ping sensor is a proximity sensor that can be used to measure the distance of objects as far as 3 cm to 300 cm when the sensor is obstructed by an object.

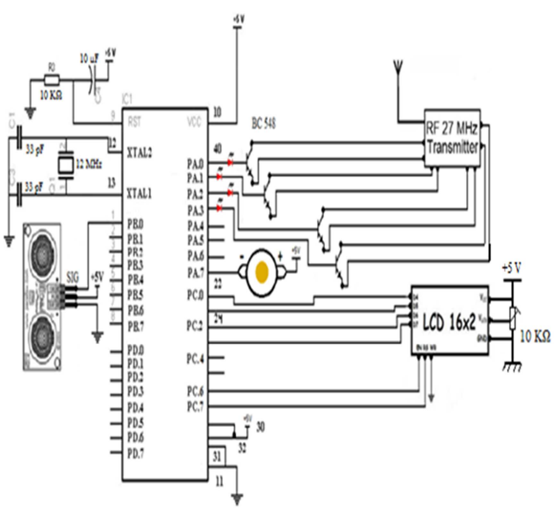

Figure 7. Transmitter module

The position of the object must be measured perpendicular to the line of sight sensor. Otherwise there will be an imperfect reflection of ultrasonic waves and cause measurement errors. In addition, water surface must also be calm in order to detect the level of water correctly or at least with the minimum measurement error. Measurements were obtain by sending ultrasonic waves with a frequency of 40 KHz and speed of 344 m/s then ping will receive reflected wave, then generate the logic pulse, shown in figure 8.

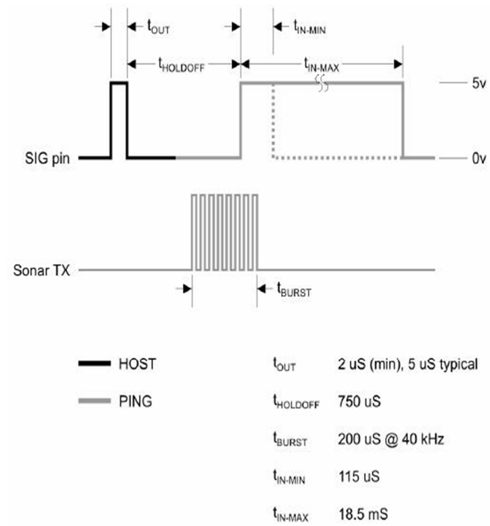

Figure 8. Sensor timing diagram [3]

Basically, ping sensor consists of a 40 KHz signal generator chip, an ultrasonic speaker and an ultrasonic microphone. Ultrasonic speaker converts the signals into 40 KHz ultrasonic sounds while the microphone is used to detect the reflected sound. In the ping sensor, there are 3 connector pins which are power supply (+5 V), ground and signal. Signal pin can be connected directly to the microcontroller input pin without any additional circuit. Ping sensor detects objects by sending ultrasonic sound and then "listens" to the echoes. Ping will only transmit ultrasonic sound when there is a trigger pulse from the microcontroller (high pulse for 3 µs). Ultrasonic sound with a frequency of 40 KHz is emitted in 200µs time. This sound will propagate in the air at speeds of 344,424 m/s (or 1 cm per 29.034µs), detect the object and then reflected back to the ping sensor. While waiting for the reflection, the ping sensor will generate a pulse. These pulses will stop (low) when the reflected sound is detected by the ping sensor. Therefore, the distance between ping sensor and object is represented by pulse width *pw*. The microcontroller then simply measures the width of these pulses, converts them into a distance *d*, based on the calculation as follows:

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$$d = 0.5\left(\frac{pw}{29.034}\right)\ cm$$

or

$$d = (pw * 0.034442)cm$$

since

$$0.5\left(\frac{1}{29.034}\right) = 0.034442$$

As an example, if the pulse width generated by the ping sensor is 1745 µs then the distance between sensor and the object is:

$$d = 0.5\left(\frac{1745}{29.034}\right)\ cm$$
$$= 30.050645\ cm$$

Then the data is processed by the ATMega8535 microcontroller. ATMega8535 is the brain of transmitter module that controls the work of the ping sensor and calculates the distance based on the pulse width. Actual distance calculation for this microcontroller is:

$$d = 50 - \left((c * 0.034442)/2.5\right)$$

Where, *c* is number of counter and 2.5 value is a divisor value depend on microcontroller clock applied. The port switching time need to be considered carefully, since the same port is used as an output to trigger the ping sensor and as an input to receive high logic indicating arrival of reflecting wave on ping sensor afterward. Traveling time of ultrasonic wave must be greater then port switching time. Based on this limitation, therefore the simple time validation is performed by comparing the time calculated and the actual distance, as shown in a table 1.

Table 1. Comparison of ping sensor distance and travel time

Distance (in cm)	Travel Time (in µs)
10	5,813,953
20	11,627,906
30	17,441,860
40	2325.5813
50	29,069,767
60	34,883,720

Water level detected from ping sensor is also displayed on 2X16 LCD display. There are two types of interfaces that can be used in controlling the LCD which is 4 bits and 8 bits. In a 4-bit interface, the LCD only requires four data pins, DB4 (pin 11) - DB7 (pin14), which is connected with the controller. Number of pins required for controlling the LCD can be adjusted by setting it in initialization process. Basically the transmitted data is 8 bits, if 4-bits control is used, the process of sending data is done twice through 4 pin, DB4-DB7. 10 KΩ trimpot is used as a regulator to adjust the brightness of the LCD.

Instead displaying the actual water level, the system is also displaying the water level status. These statuses are presented for making the water level information more readable and useful for flood mitigation. The status is generated by comparing the water level data with the status reference (look up table), for example, warning status is generated if the water level is greater then 40 cm and less than 50 cm.

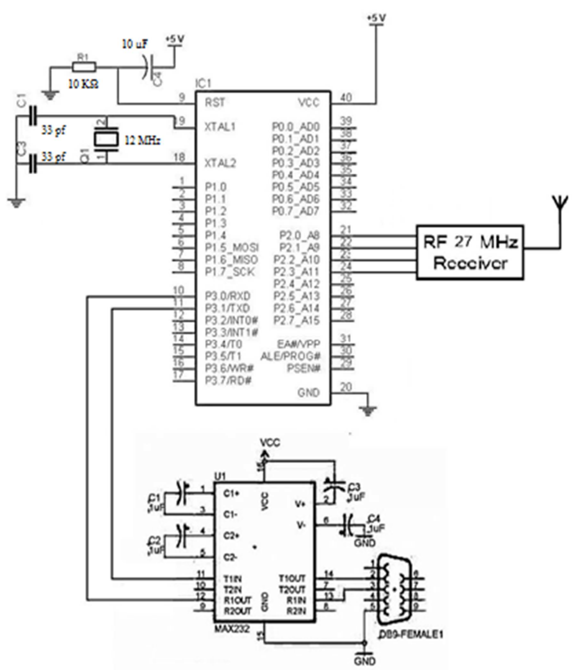

Figure 8. Receiver module

This prototype is also equipped with the buzzer for warning status. The buzzer will be on when the warning status active. The buzzer is activated by sending hexadecimal value 71 (0111 0001b) in via PORTA. Buzzer is connected to PA.7 so if given the logic of 71 then the bit A.7 gets a 0 logic which makes the buzzer activated. Bits 0, 1, 2 and 3 are connected to each LED and transistor. Only bit 0 that has a 1 logic and the others are 0. Since, the LED will turn on when the voltage on the anode is greater than the cathode, so only red LED is on as an indicator for danger status. This signal is then

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routed to related transistor. Based on the principle of a transistor, the NPN transistor will saturated when the voltage at its base is greater than the voltage at its collector so that current flows from collector to emitter. Its emitter wirelessly connected to the circuit, causing the logic circuit F1 is transmitted to wireless and make the circuit active.

In the receiver module, as shown in figure 8, microcontroller program initially will set all value of port 2 to 1 by sending the hexadecimal value F (1111 binary). This value will be changed depend on detected water level. The ASCII code received by the computer via serial communication is equal to the value on port A. For example, the hexadecimal value for the status of hazard is 0100 1110b (4Eh) the same as the ASCII code N [9].

3.4. Test Results

Figure 9 shows the water level (Tinggi Air) is 2 cm and the water level status is safe (AMAN). The lowest level of water, in this prototype is 0 cm, or the distance water level from the ping sensor is 50 cm. Therefore, the actual distance is 48 cm, and based on the calculation the water level is 50 cm - 48 cm = 2 cm, as displayed on the LCD.

Figure 9. Water level status display on the LCD

Besides information about the status of water level, water level and timing of the rise in water level will also be displayed in PC applications as shown in figure 10.

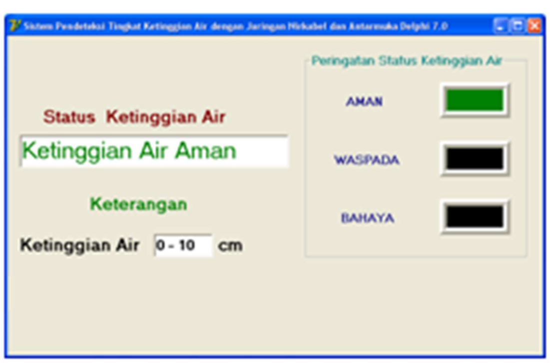

Figure 10. Information is being displayed on PC when the water level at 0 - 10 cm

If the water reaches the dangerous level, for example, then the system will display the alert status (BAHAYA) on LCD display, as shown in figure 11.

Figure 11. Display the status of the water on the LCD

The computer (receiver module) will also display the same information with the transmitter module, as shown in figure 12. The alert status (BAHAYA) and the measured water level 41 cm are displayed.

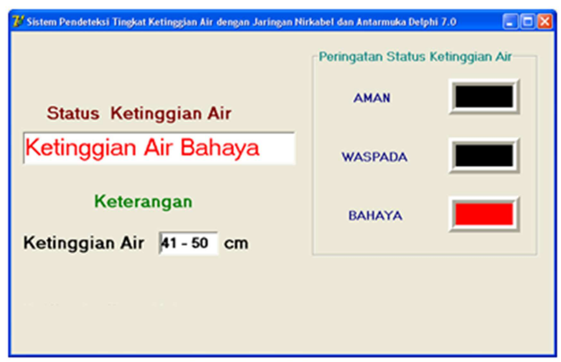

Figure 12. Information is being displayed on PC when the water level at 41 - 50 cm

4. CONCLUSION

Prototype of Water Level Detection System has been tested and reasonably good performance is shown based on the test result. The main contribution of this performance is the ping sensor calibration by adjusting calculation of distance based on an actual data. Testing need to be carried out for the real fluctuated water surface condition to get the system performance in the real condition.

The water level data is successfully displayed locally or remotely, therefore this prototype can be used as a part of the bigger system, such as, river flow management system which controls the stream to minimize the flood. The receiver acts as a water level data feeder that can be transmit the data remotely to the server.

Since computer is used as a part of receiver module, therefore more sophisticated system can be

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developed to display and analysis time series water level data, instead of only displaying the current water level data.

4.1. Suggestions

- The better radio frequency module can be used, in order to reach longer distances.
- This tool can be developed to measure water depth using the other type of ultrasonic sensors such as srf02, srf04 or srf08
- The better display applications can be developed for example by displaying time series data in graphic form
- The better receiver module can be developed to receive the water level data from multiple transmitter modules.
- The repeater can be employed to reach a longer distance, especially for remote area.

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