Fluids level monitoring using Zigbee

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Abstract. Measurement is a critical element in the instrumentation and control systems in the industry, especially in the process industry. The analysis can be made in various ways and methods, one who is designing a monitoring system. The design of this monitoring system can be realized as a simulation through similar visualization with industrial monitoring systems. This paper has developed and applied fluids level monitoring systems based on Zigbee to transmit and receive data wirelessly. The system design is divided into two parts. The first one is plant design and Human Machine Interface (HMI), the system that is applied in designing measurement systems fluid level. The design and application of HMI systems use Visual Basic as the user interface with the plant. In this plant, ATmega16 is being used for the system controller and MPX2010DP sensor, which was chosen to measuring the level of fluids. This sensor is selected because this sensor uses the principle of differential pressure making it easier to use. Sending and receiving data from the PC to the plant runs very well using Local Area Network (LAN). The maximum range is 30m for indoors and 90m for outdoors.

1. Introduction

The system of monitoring is widely used to sense an enormous sort of application in residential, medical, and industrial automation, especially in the process industry. Measurement is an important element in the instrumentation and control system in the industry that can be done in various ways and methods, one of which is designing a monitoring system [1-3]. This research will be a focus on prototyping for industrial automation and intend to remotely sense liquid inside industrial tanks. Using the monitoring system will make the accuracy of level reading better throughout the storage tank management process. In a manual mode, a person needs to check the water level inside the tanks, and the process could quickly fail. When automatically system is used, the monitoring system for several tanks could be simultaneously done, and the solutions for possible could be quickly and remotely taken [4-6].

One of the so many devices that can be used for protocol on Wireless Personal Area Network (WPAN) is Zigbee [7,8]. Zigbee is expected to transmit for a long distance, depend on the type of device that chosen, the RF environment, and output power [9,10]. Zigbee has the advantage that this device is easy to operate; the dimension is small and requires low power consumption [11,12].

The wireless technology is widely used in many areas such as agriculture, health, building automation, environmental observations, and other fields. The results of this research can show how reliable wireless technology in prototyping fluids level for industrial area, data transmission used Local Area Network to transfer data from the system to another device using the same IP address [1,12,13].
2. Method

The application of a monitoring system to measure the water level is designed as a simulation system for monitoring water levels where the measurement results of the data will be processed in DAQ (Data Acquisition) [14,15]. Broadly speaking, this system is designed only to display the results of measurement data based on the water level. In monitoring, this water level has no set point given, which serves as a height limit on the water level. So overall, this system is designed only to provide information about the height of the coupled tank in real-time to the operators who run it [15,16].

2.1. Design

The entire system made consists of three blocks. There is a sensor block as a signal processor, the ATmega16 block, and the HMI block as output. Besides that, by using these three buttons, the height can be adjusted manually by the operator. By using DAQ (Data Acquisition), the operator can review the results of measurement or monitoring data. The data will be saved (Data logging). The diagram block of the system design is shown in Figure 1.

![Diagram block of system design.](image)

The sensor that will be used for measurements on physical quantities is first calibrated to recognize the work area and obtain the characteristics of these sensors. The method used in the sensor calibration process is to compare the measurement results of the sensor with the parameters that are accurate so that the difference between the sensor and the settings will be manipulated close to the actual value in the sensor realization.

Software design using primary language, BASCOM AVR. The description of the program designed on ATmega16 looks like a flowchart shown in Figures 2 and 3.
Software design is initiated by initializing each desired quantity or data type for each variable or word used. After that, the data set in ATmega16 is fixed and does not change, and when there is input data entering the microcontroller automatically will equalize the data sent by HMI, if correct, then the next process will be carried out but if no, the program will automatically loop to get data that matches the microcontroller instructions. The awaiting program will be inserted, which functions to find the comma value because it is the requirements for entering the next application that will always loop if it does not find a comma. After the data received, the program will then enter the results of the calculation data on the amount of water level. If every data sent is in the form of an "R" the microcontroller will always carry the measurement level fluids data. And after that, go back into the program waiting to look for the comma value, and after it is fulfilled, the data after the comma is either "1" or "0", when "1" it will activate the actuator.
Initialize all data type and sub program
Serial port is open = True
Timer 1 = Off
Timer 2 = Off
Timer 1 = Start
Timer 2 = Start
End

**Figure 4.** Flowchart for HMI design.

Figure 4 shown an outline of a program flowchart designed using VB.net, described the Serial port used is connected, it will activate the Timer 1 and Timer 2 programs.

In sub-program timer 1 functions to process the data obtained from ATmega16. At sub timer 1 will send the command "$ AA, R" to command the microcontroller to provide measurement data on the level. And after the data is finished parsed, the data can be displayed graphically.

In the design of the sub timer program 2 four buttons function to give commands to activate the actuator on the plant. The form of data sent is in the format "$ AA, 0,0,0,0" where $ AA functions as a header to recognize commands from HMI, and the number format after "$ AA" is to represent "valve1, valve2, pump". Figure 5 shown hardware design to applied the system.

**Figure 5.** Plant system design.
Plant design, which is carried out like Figure 5, will be applied as shown. The ratio between the actual plant and what will be applied is 100:1. Regarding this is a prototype system for industrial use.

2.2. Implementation
Realization is an advanced stage of the design stage. The results of the design that has been made will be realized into an integrated system where the specifications are in accordance with what is desired to translate the results of design into a tool or system in accordance with the desired specifications. Implementation of the system consists of two tanks and one water reservoir to supply fluid to each tank. This circuit serves to provide all circuits to run according to their respective functions.

The implementation of software is making code program accordance that has been designed in the flow chart that is shown in Figure 3. The program is created using the basic programming language, namely Bascom AVR. Visual Studio.net is used to design the HMI (Human Machine Interface), which will be used as an application to display the results of measurement levels and temperature data and process and store measurement data sent using the wireless connection.

3. Result and discussion
Tests carried out to get data from the system so that it can be used as a basis for analyzing determining errors if one day, there is damage to the system. Before the test is carried out, the calibration process of the MPX2010DP sensor is first performed by using INA 118 reinforcement. The following is the conversion result shown in Table 1.

This sensor module produces an average output of 0.4 volts per 1 cm. However, in converting to ADC 10 bits, the results are not linear, so that it causes the inaccurate level measurement to get the most precise results when measuring fluid levels from 17 cm to 30 cm and errors from water level measurements around on average 6.27%.

This data is used to view the condition of the water tank. There is a button on the HMI that is used to adjust the height of the monitored water level, which is used to adjust the water level in the tank as needed.

| Height (cm) | Output (V) | ADC | Data Shown (cm) | Error (%) |
|------------|------------|-----|----------------|-----------|
| 0          | 0.000      | 0   | 0              | 0         |
| 1          | 0.030      | 0–3 | 1.52           | 52        |
| 2          | 0.047      | 6–9 | 2.02           | 1         |
| 3          | 0.088      | 14–16 | 3.33       | 11        |
| 4          | 0.123      | 24–26 | 4.67       | 16        |
| 5          | 0.204      | 30–33 | 5.71       | 14        |
| 6          | 0.240      | 37–39 | 6.88       | 14        |
| 7          | 0.281      | 46–49 | 7.50       | 7         |
| 8          | 0.316      | 55–57 | 8.82       | 10        |

Tests carried out on the x-bee module intending to determine the distance of the ability data transfer between x-bee on the PC that carried out indoors and outdoors. The results are shown in Table 2.
Table 2. X-Bee testing indoors.

| No. | Range (m) | Transferred |
|-----|-----------|-------------|
| 1   | 1         | Yes         |
| 2   | 3         | Yes         |
| 3   | 5         | Yes         |
| 4   | 7         | Yes         |
| 5   | 10        | Yes         |
| 6   | 15        | Yes         |
| 7   | 20        | Yes         |
| 8   | 25        | Yes         |
| 9   | 30        | Yes         |
| 10  | 31        | No          |

Table 3. X-Bee testing outdoors.

| No. | Range (m) | Transferred |
|-----|-----------|-------------|
| 1   | 10        | Yes         |
| 2   | 20        | Yes         |
| 3   | 30        | Yes         |
| 4   | 40        | Yes         |
| 5   | 50        | Yes         |
| 6   | 60        | Yes         |
| 7   | 70        | Yes         |
| 8   | 80        | Yes         |
| 9   | 90        | Yes         |
| 10  | 100       | No          |

The testing of shipments on x-bee indoors is a maximum distance of 30 meters and a maximum distance of 90 meters outside the room. The results of this test are slightly different from the x-bee specifications contained in the datasheet with a maximum data transmission within 100 meters.

4. Conclusions

Using MPX2010DP sensor is sufficient for measuring water level, on results are shown that error results in measuring the level of water are quite small, but in transmitting data results of detection water level using Zigbee there are still limitations where the condition of a building if there are many barrier walls, will affect the process of sending data, it would be better if this system placed in the buildings that have not have many obstacles so that data can be sent with a longer distance. For further development, use a PID or Fuzzy Logic control system and use a database system so that all measurement results on the system can be accessed by all users everywhere and every time.

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