IoT-based Sensor System for Stop Line Traffic Area Using ATmega2560 Microcontroller

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***Abstract*—Internet of Things (IoT) based sensor systems has provided sophisticated services by connecting objects based on information exchange technology. This paper proposes the development of an IoT-based sensor system for monitoring stop line traffic area using the Atmega2560 microcontroller. The focus on traffic monitoring was chosen because currently traffic enforcement is one of the efforts to reduce the number of accidents and increase progress in the traffic system. The sensor used is an ultrasonic sensor connected to the SIM800L module. The ultrasonic sensor will work when the driver or motorist crosses the line by sending text message to the device, while the camera in the sensor system will monitor and capture images of violation in the traffic area. The sensor will not work if the reading distance above 110mm, since the distance indicates that the traffic line is heading in the opposite direction.**

***Keywords*—ATmega2560 microcontroller; Internet of Thing (IoT); traffic area; ultrasonic sensor.**

I. Introduction

With the rapid development of urban growth and human movement, as well as the scope of life, indicated by the increase in population and vehicles, the demand for public transportation also increases. The level of efficiency in the field of road traffic and transportation is required to create smooth, safe and orderly traffic. Hence, it is necessary to have proper transportation facilities and infrastructure [1]. Transportation activities utilizing road facilities are the most dominant type of transportation compared to other types. Therefore, the transportation problems faced by road users are almost the same, namely congestion and traffic accidents [2].

A traffic accident is an incident where a motorized vehicle collides with another object and causes damage. Sometimes These accidents sometimes can cause in human or animal injury or death [3]. Traffic accidents are one of the health problems classified as non-communicable diseases. The negative impact of traffic accidents such as material loss, illness, and death can affect the degree of public health. In Indonesia, traffic accidents in the last three years have became the third-largest killer after coronary heart disease and tuberculosis [4]. The number of traffic accidents continues to increase every year, in which it is in line with the increasing number of motorized vehicles. The increase in the number of motorized vehicles has the highest rate among other types.

Based on Haddon Matrix [5], accidents have three main causes, i.e. human, vehicle, and environmental factors, and are divided into three stages, namely pre, during, and post-accident. Factors in the pre-accident stage are to prevent accidents from occurring, while in the stage during the accident are for injury prevention, and in the post-accident stage are to survive. In Haddon matrix, knowledge, lane use, and driving speed are also components of behavioral factors which are classified as pre-accident human factors. The use of traffic lanes is included in the pre-accident stage for both human and environmental factors when viewed by the theory of Haddon matrix. Human factors are related to knowledge and attitudes in implementing traffic regulations that can lead to traffic accidents [6].

Accidents that occur on the highway are generally caused by violations committed by motorists. Therefore, enforcement of regulations is an effort to reduce the number of accidents. Such as not obeying traffic rules has the potential to cause accidents. This situation caused in serious injuries and death. Violation of stopping stops at traffic lights is one of the violations that can result in the fatality of the traffic accident. For this reason, it is necessary to design a sensor system based Internet of Things (IoT) used in the vehicle stop line area useful to provide a sense of security for users who pass through the zebra cross and reduce traffic violations [7]–[9].

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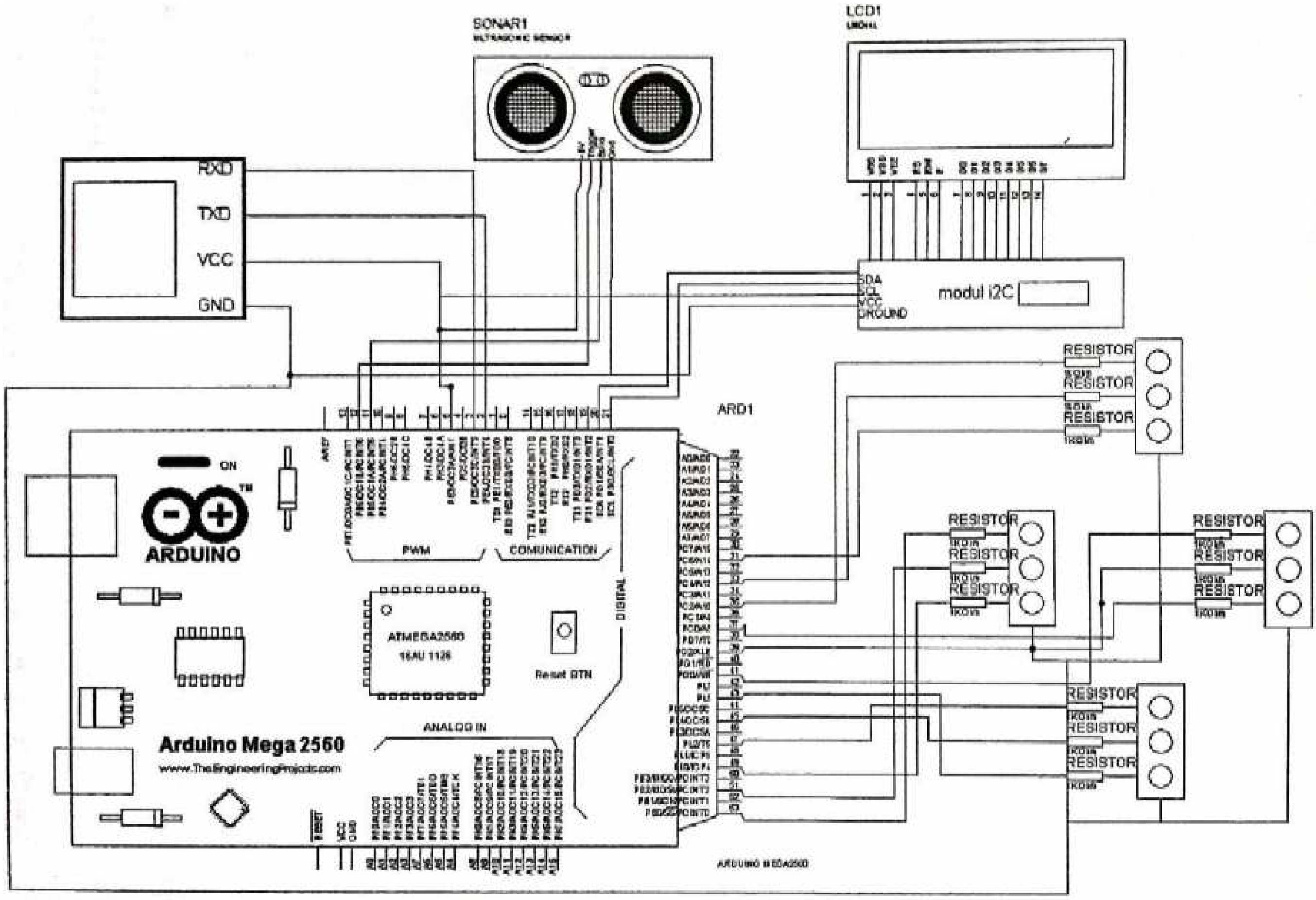

Fig. 1. Overall schematic circuit of IoT based sensor system for stop line traffic area.

II. Overview of IoT-based Sensor System Design

Basically, the proposed IoT-based sensor system for stop line traffic area using ATmega2560 microcontroller is divided into 2 main portions, i.e. hardware and software. As shown in Fig. 1, an overall schematic circuit of IoT-based sensor system consists of microcontroller, ultrasonic sensor, SIM800L module, and Liquid Crystal Display (LCD). The ATmega2560 microcontroller has many I/O, analog input, PWM signal, and UART port [10]. The sensor circuit is designed using ultrasonic sensor which serves to provide notification to motorists if crossing the stop line. Fig. 2 shows the schematic circuit of ultrasonic sensors.

Furthermore, to make communication between the main monitor and the mobile device, i.e. handphone, the ATmega2560 microcontroller circuit is connected to the SIM800L module. By using the ATCommand, a model of Global System for Mobile Communication (GSM) or Code Division Multiple Access (CDMA) network can send and receive a text message, i.e. Short Message Service (SMS). Here, the SIM800L module is set to receive an SMS message after the ultrasonic sensor is active. The SIM800L module has several pins including V_{CC}, GND, Tx, and Rx. The V_{CC} and GND pins are connected to a 5V voltage and a negative sources, respectively. The D0 RXD port is connected to the Tx pin as the SIM800L module input, while the DI TXD port pin is connected to the Rx pin as the SIM800L module output. Fig. 3 depicts the schematic circuit of SIM800L module.

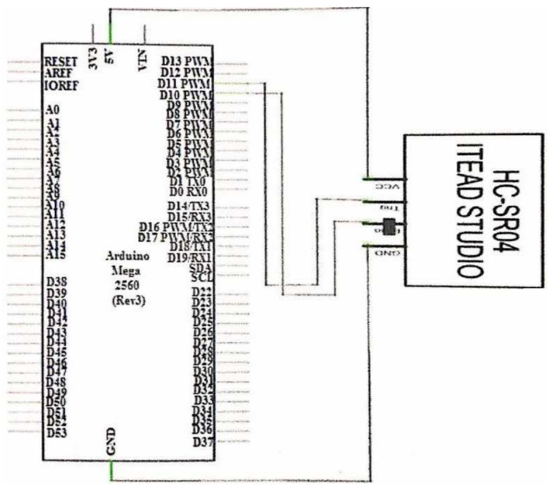

Fig. 2. Schematic circuit of ultrasonic sensor.

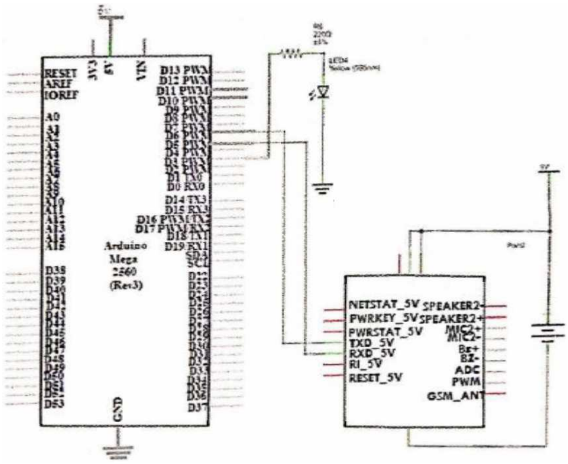

Fig. 3. Schematic circuit of SIM800L module.

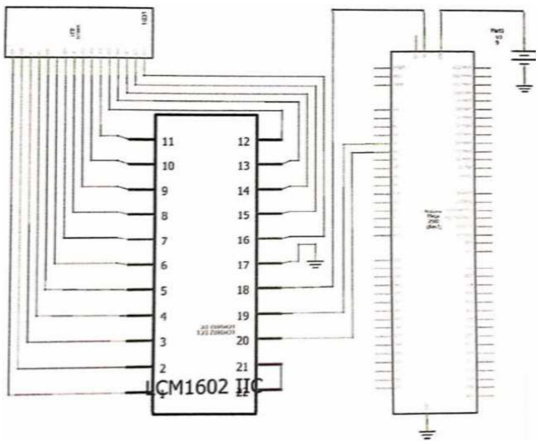

Fig. 4. Schematic circuit of LCD monitor.

Fig. 4 shows the schematic circuit of LCD monitor to display the voltage and current used in the sensor system. The used LCD monitor has a size of 20 columns × 4 rows. In designing the LCD monitor, an i^2C Display Control module is applied to reduce the use of ports on the ATMega2560 microcontroller board. Therefore the ports used on the board are V_{CC}, GND, A4, and A5 for SDA and SCL, respectively. The contrast setting for the displayed characters can be adjusted on the i^2C Display Control module.

III. System Implementation and Characterization

To ensure every schematic circuit proposed can run properly, part-by-part characterization is conducted prior characterizing the performance of overall system. The SIM800L module characterization aims to determine the performance of the module in sending SMS to mobile devices. The SMS sent by the module is used for one type of notification. Here, the characterization carried out by sending an SMS is to ensure that the motorist correctly crosses the red light at the stop line. Table I summarized the characterization result of SIM800L module when the ultrasonic sensor is active. It is seen that the time interval for sending SMS via mobile device has an average of 6.82 seconds. This is possibly evoked by the quality of signal around the mobile device.

TABLE I
Characterization result of SIM800L module.

Testing (second)					Average (second)
1	*2*	*3*	*4*	*5*	
7.9	7.1	5.2	7.1	6.9	6.82

Furthermore, the characterization results of sensitivity testing on the ultrasonic sensor are tabulated in Table II. It shows that the ultrasonic sensor will work to send messages via SMS when it reads a maximum distance of 110mm, otherwise it will not be detected. Fig. 5 shows the mechanism of sensitivity testing for the ultrasonic sensor. It can be seen that the distance of 110mm is the separation between the traffic light pole for installing ultrasonic sensor to the centerline of road. Hence, the ultrasonic sensor will not work if the reading distance is exceeded indicating the traffic line is heading in the opposite direction. This proves that the ultrasonic sensor has worked properly according to the requirement.

The testing for the warning system is to notify if something happens by crossing the congestion line at a red light. Here, the warning system is manifested by using Light Emitting Diode

TABLE II
Characterization result of sensitivity testing.

Testing	Distance (mm)	SIM800L module	Sensor response (s)
1	30	Active	7.1
2	50	Active	7.8
3	70	Active	6.9
4	80	Active	7.3
5	110	Active	7.1
6	140	Active, Inactive	–
7	150	Active, Inactive	–
8	160	Active, Inactive	–
9	170	Active, Inactive	–
10	230	Active, Inactive	–

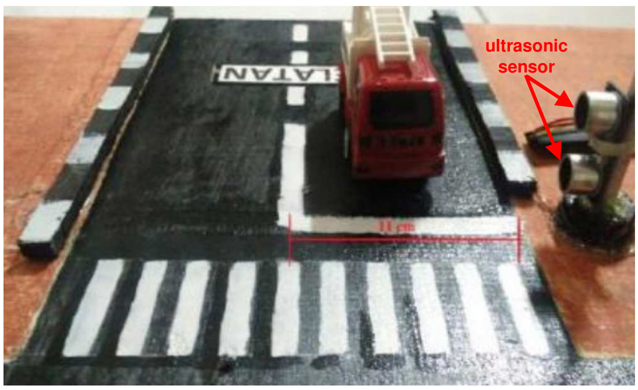

Fig. 5. Sensitivity testing for ultrasonic sensor.

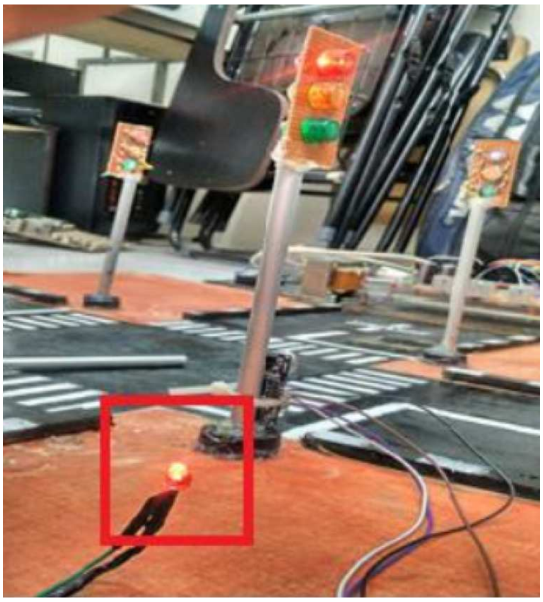

Fig. 6. Testing mechanism for warning system using LED indicator.

(LED) indicator instead of alarms to be easy observed visually. Fig. 6 illustrates the testing mechanism for the warning system. If the driver or motorist crosses the stop line at the traffic light, the LED indicator will then light up. However, turning on the LED indicator is part of the form of conveying information to the driver. It is expected that the community will better in obeying the traffic light signs.

IV. Conclusion

The development of IoT-based sensor system for monitoring stop line traffic area using ATmega2560 microcontroller has been presented. The sensor system which is mainly driven by the microcontroller has demonstrated the capability to monitor the traffic area by sending SMS message when the driver or motorist crosses the line and by capturing images of violation. From part-by-part characterization, it was shown that the time interval when the ultrasonic sensor was active ranged from 5.2 seconds to 7.8 seconds. Meanwhile, the ultrasonic sensor will not work when the reading distance exceeds 110mm. In addition, a further investigation to improve the performance of IoT-based sensor system is in progress where the results will be presented later.

Acknowledgment

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