Traffic Light Design with Infrared Sensors

1st Meiyanto Eko Sulistyo
Department of Electrical Engineering
Universitas Sebelas Maret
Surakarta, Indonesia
mekosulistyo@staff.uns.ac.id

2nd Feri Adriyanto
Department of Electrical Engineering
Universitas Sebelas Maret
Surakarta, Indonesia
feri.adriyanto@staff.uns.ac.id

3rd Royani Aulia Ihsanti
Department of Electrical Engineering
Universitas Sebelas Maret
Surakarta, Indonesia
royaniaulia.i@gmail.com

***Abstract*— The development of Traffic Light Design with Infrared Sensors is done to accommodate about how many vehicles may pass through each lane in inersections. The traffic light is using infrared sensors at each lane to measure the density of vehicles. Infrared sensor then sends those data to micro-SD card module to be stored. Arduino Mega will receive data from infrared and real-time clock module about how many vehicles and what time they were counted to then display it on liquid crystal display. A detailed description of each component, the architecture and system design of prototype has been provided. The system prototype has been simulated in Fritzing simulation software.**

Keywords*— *traffic light, vehicle, infrared, Arduino Mega, real-time clock

I. Introduction

Traffic light or traffic signalling device is an electronic device that uses light signals which can be equipped with sound signals to regulate traffic of perople and/or vehicles at intersections or on the road [4]. The function itself as referred to its definition is to control flows of traffic at intersections, pedestrian crossings, or other location on the road. The main components of traffic light consist of luminaires, support poles, construction foundation, control device, and installation.

In relation to its function, traffic lights can also be installed with vehicle detection devices, camera, Display Information Systems (DIS), and information technology equipment for traffic purposes. Ini this design, the system will add an infrared sensor to help calculate the vehicle.

If an emergency vehicle such as an ambulance on the road stops due to a red light, the system will automatically change the traffic light to green, allowing the emergency vehicle to arrive at the clinic on time [10]. In addition, vehicle-to-infrastructure cooperation beyond visual range and non-blind area methods, based on heterogeneous sensors [11]. Another study on the proposed adaptive method determines priorities based on the degree of traffic congestion, assessed by processing images captured by remote digital cameras, based on the computation of Fog, installed at intersections [12]. In other conditions, surface snow melting due to heat transfer energy from the vehicle chassis can result in wrinkles that appear on the upstream side of traffic flow, where vehicles frequently stop at red lights [13]. Besides that, the masking algorithm is used to process images and calculate the number of vehicles on the highway [14]. Other studies have shown that flashing messages can increase VMS effectiveness depending on environmental and traffic conditions [15]. Furthermore, another study demonstrated the design of a smart street lighting system supported by a combination of NB-IoT and LoRa communication technologies [16].

II. Components and Their Descriptions

A. Arduino Mega

Arduino is electronic kit or open-source electronic board with the main component is a mocrocontroller chip with the AVR type from ATMEL company. Arduino Mega is a microcontroller board based on the Atmega 2560 [9]. Arduino Mega has 54 digital input/output pins with specifications: 15 pins can be used as PWM outputs, 16 analog inputs, 4 UARTs (hardware serial ports), 16 MHz crystal oscillator, USB connection, ICP header, reset button, and power jack.

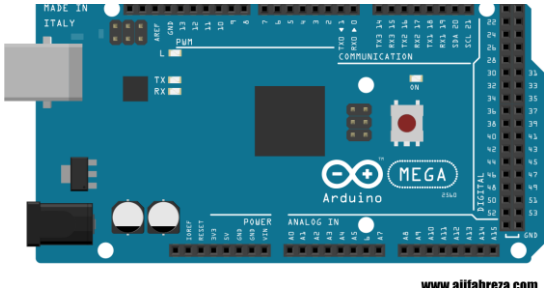

Fig. 1. Arduino Mega 2560

B. Infrared Sensor

An infrared sensor is an electronic device that measures and detects infrared radiation in the surrounding environment [1]. Infrared sensor has two main parts, namely IR transmitter and IR receiver. The function of IR transmitter is to emit infrared radiation to an object or obstacle, while IR receiver is to detect the radiation reflected by the object based on the IR transmitter. IR transmitter in general has appearance of an LED but the radiation emitted can't be seen by human eyes.

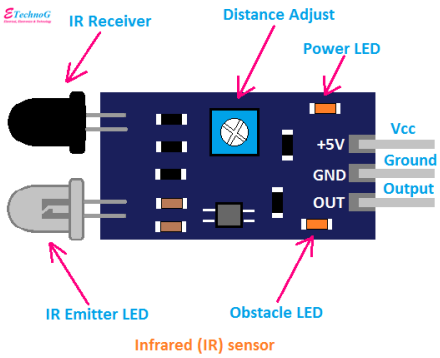

Fig. 2. Sensor Infrared

C. *Traffic Light Module*

The traffic light module is a prototype of a traffic light that works like a real traffic light [8].

Fig. 3. Traffic Light Module

D. *LCD Display 16x2*

LCD (Liquid Crystal Display) is data display module that uses liquid cystal as a material for diplaying data in the form of writing and images [5]. Consists of 16 columns and 2 rows, it can be viewed in 4-bit and 8-bit modes and stored 192 characters.

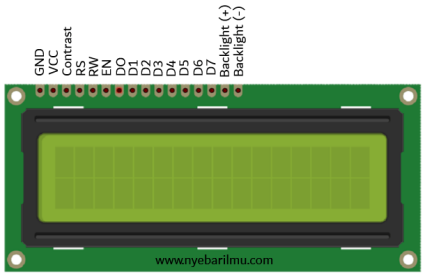

Fig. 4. LCD Display 16x2

E. *Real-Time Clock Module (DS3231)*

Time clock module is a module that measures the time, dependently or independently of their Arduino card through the cell [7]. The Arduino card measures the elapsed time since the module was turned on (in ms).

Fig. 5. Real-Time Clock Module

F. *SD Card Reader Module*

The micro-SD module is a module to access micro-SD for reading and writing data using SPI (Serial Parallel Interface) interface system [6]. This module is suitable for various applications that require data storage media.

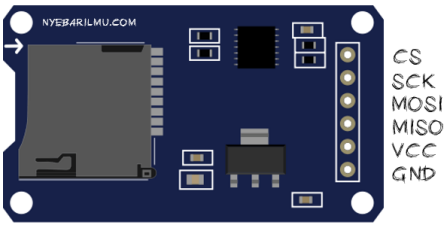

Fig. 6. SD Card Reader Module

III. Design Traffic Light Architecture and System

In this section, there's two part of prototype that need to be designed first. Architectural of prototype and their system.

Architecture prototype was designed first to get an idea of the prototype to be made so it can predict the steps needed in manufacturing process.

The design and manufacture of the system consists of 2 processes that carried out side by side, which is making a circuit simulation on the Fritzing aplication and the prototype assembly. This is intended so when trial-and-error occurs, the parts that need improvement can be immediately seen before being placed permanently on prototype.

A. *Prototype Architecture*

The architecture of the four-way road intersection with IR sensor is shown below. Every lane is marked by A, B, C, D represent the roads and there's an aroow to represent the movement of traffic through that road. IR sensor named IR1 and IR2 are facing towards road A. similarly IR3 and IR4 are facing towards road B, IR5 and IR6 are facing towards road C, and lastly IR7 and IR8 are facing towards road D.

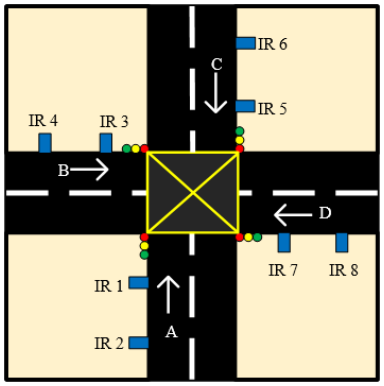

Fig. 7. Architecture Prototype Design

When traffic reaches in front of IR sensor, IR sensor will consider that as an input to how many vehicles are in the lane. The more number vehichels are detected, the denser of traffic in that lane. IR sensor works as a counter for every vehicle in that road and later display those in LCD display.

B. Prototype System

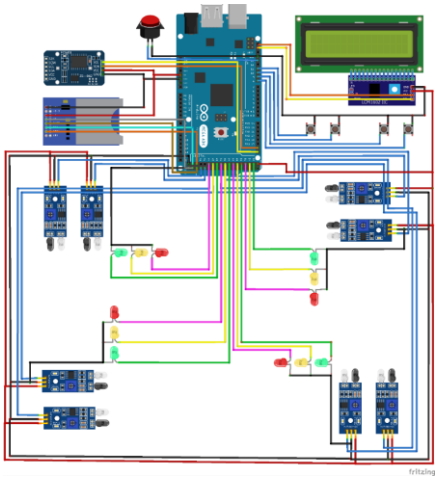

Fig. 8. System Circuit Design Prototype on Fritzing

Below traffic light architecture, there will be electrical circuits that will power up and running the system. RTC (real-time clock) module were added to get a valid data of time and day in real time. Every object that was detected by IR will be counted and stored in SD card module.

IV. Hardware Implementation

In this section is how architecture and system will be merged.

A. Prototype Architecture

The protype architecture consists of several components, including 4 traffic light modules, 8 IR sensor modules, 5 push buttons, and a 16x2 LCD display. Components are designed by following the architectural design form and using acrylic media as a framework to unite all components.

The prototype is a square shape measuring 30cm x 30cm and featuring 4 crossing lanes. Each lane has a width of 6 cm, with the placement of two IR sensors and one traffic light module. The IR sensor function to detect objects. The 16x2 LCD display functions as a data display such as the number of vehicles per day on an hourly basis by using a push button to adjust it.

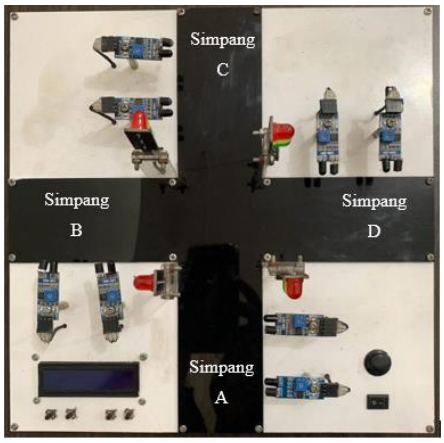

Fig. 9. Architecture Prototype Top View

B. Prototype System

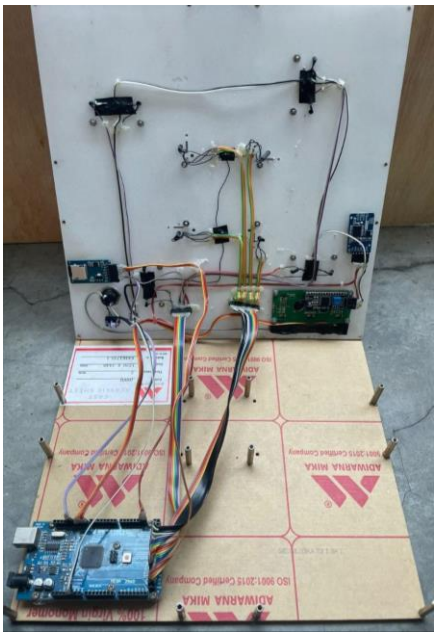

Fig. 10. System Prototype Below View

The prototype system uses several components such as RTC module, SD card module, and Arduino Mega 2650.

RTC (Real-Time Clock) serves function to provide real-time data, both days and hours, so data retrieval can be obtained validly. The IR sensor that functions to detect object by simulating the detected object is a vehicle.

The detected object will be counted simultaneously at each lanto detect the number of passing vehicles, and then data will be stored in SD card module.

Arduino Mega works as a microcontroller that functions as the main brain to give orders to traffic light module to turn on, receive data from IR and RTC sensors, which then give command to 16x2 LCD to display the data that has been obtained.

Next is programming the system. The application used is Arduino IDE which functions as a code editor, namely creating and validating code. Program that needed to be embedded in the microcontroller include getting input data, processing data, and provising output.

For input data, we need to define Arduino pins and turn on traffic light module so then IR sensors could work to detect objects.

For processing data, every detection result by IR will be stored in SD card module whhile also stored day and time when those data collected in real-time using RTC module

For output data, 16x2 LCD will display how many vehicles has been detected along with their timing in accordance with command from push button.

Program and system testing must be carried out to ensure the prototype can run properly.

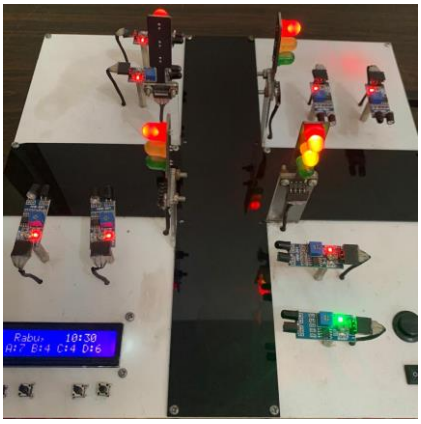

Fig. 11. Traffic Light Design with Infrared Sensor

V. Conclusion

Traffic light system with infrared sensor has been successfully implemented. The infrared sensor then sends those data to the micro-SD card module to be stored. Arduino Mega will receive data from the infrared and real-time clock module about how many vehicles and what time they were counted to then display it on the liquid crystal display.

References

[1] D. Jost (2019), *What is an IR sensor?*, accessed 3 January 2022, https://www.fierceelectronics.com/sensors/what-ir-sensor

[2] D. Patel, Y. Rohilla, "Infrared Sensor based Self-Adaptive Traffic Signal System using Arduino Board", 12th International Conference on Computational Intelligence and Communication Networks (CICN), 2020, pp. 175-181

[3] Fachrizal, "Rancang Bangun Sistem Respon Lampu Lalu Lintas Berdasarkan Kondisi Darurat Menggunakan Teknologi RFID", Universitas Islam Negeri Alauddin Makassar, 2016

[4] Menteri Perhubungan Republik Indonesia, "Peraturan Menteri Perhubungan Republik Indonesia Nomor PM 49 Tahun 2014 tenatng Alat Pemebri Isyarat Lalu Lintas", Kementerian Perhubungan

[5] Nyebar Ilmu (2017), *Cara Mengakses Modul Display LCD 16x2*, accessed 6 October 2022, https://www.nyebarilmu.com/cara-mengakses-modul-display-lcd-16x2/

[6] Nyebar Ilmu (2018), *Cara Mengakses Module Micro SD Menggunakan Arduino*, accessed 7 October 2022, https://www.nyebarilmu.com/cara-mengakses-module-micro-sd-menggunakan-arduino

[7] Project Hub (2022) , *How to Use a Real-Time Clock Module (DS3231)*, accessed 7 October 2022, https://create.arduino.cc/projecthub/MisterBotBreak/how-to-use-a-real-time-clock-module-ds3231-bc90fe

[8] Proto Supplies (2022), *Traffic Light LED Module*, accessed 6 October 2022, https://protosupplies.com/product/traffic-light-led-module/

[9] The Engineering Prohect (2018). *Introduction to Arduino Mega 2560*, accessed 3 January 2022, https://www.theengineeringprojects.com/2018/06/introduction-to-arduino-mega-2560.html

[10] P. Kumar, S. Vinodh Kumar, and L. Priya, "Smart and Safety Traffic System for the Vehicles on the Road", IOT with Smart Systems Proceedings of ICTIS 2022, Volume 2, pp 509–522, DOI: 10.1007/978-981-19-3575-6_51

[11] T. Luo, L. Chen, T. Luan, Y. Li, and Y. Li, "A Vehicle-to-Infrastructure beyond Visual Range Cooperative Perception Method Based on Heterogeneous Sensors", Energies 2022, 15(21), 7956; DOI: 10.3390/en15217956

[12] A. Alharbi, G. Halikias, A. A. A. Sen, and M. Yamin, "A framework for dynamic smart traffic light management system," International Journal of Information Technology, 2021, volume 13, page 1769–1776.

[13] S. Kanie and H. Zheng "Environmental Conditions Leading to Spontaneous Corrugation on Snowy-Icy Roads Due to Repeated Loading by Moving Vehicles", 18th International Conference on Cold Regions Engineering, ICCRE 2019 and 8th Canadian Permafrost Conference, CPC 2019, page 146-152, DOI: 10.1061/9780784482599.017

[14] R. Vani, N. Thendral, J. C. Kavitha, and N. P. G. Bhavani, "Intelligent Traffic Control System with Priority to Emergency Vehicles", IOP Conference Series: Materials Science and Engineering, Volume 455, 2nd International Conference on Advancements in Aeromechanical Materials for Manufacturing 13–14 July 2018, DOI: 10.1088/1757-899X/455/1/012023

[15] F. Basso, P. Maldonado, R. Pezoa, N. Szoloch, and M. Varas, "The Impact of Flashing on the Efficacy of Variable Message Signs: A Vehicle-by-Vehicle Approach", Sustainability, 2022, 14(15), 9705; DOI: 10.3390/su14159705

[16] J. Zhang, W. Zeng, S. Hou, Y. Chen, L. Guo, and Y. Li, "A low-power and low cost smart streetlight system based on Internet of Things technology", Telecommunication Systems volume 79, page 83-93, 2022.