Simulation of Automatic Train Doorstop Using Hall Effect A3144 Sensor based on Arduino Uno

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Abstract— As a security for land traffic in the area of railroad crossing in general, a crossing is required. Increasingly busy traffic, the number of railroad crossings today, to prevent accidents either due to human error or the lack of compliance by motorists with traffic regulations, a controller that can regulate the flow of traffic at the railroad crossing is needed.

The research objective was to design an automatic railroad crossing controlled by Arduino with the C language programming command.

This research will make a prototype of the Automatic Crossing Gate using the halls effect A3144 sensor as an on and off switch by detecting the presence of a magnetic field (Lorentz force) on a passing train. The stages of the research method are:

1. Provide the necessary components, namely Arduino, bread board circuit board, buzzer, A3144 sensor, LED, servo motor as a latch dynamo.
2. Make programming tests on the Arduino for each buzzer, LED, A3144 sensor, servo motor as a latch dynamo.
3. Assembling the overall components on the bread board as a model.
4. Make overall programming on the Arduino from the circuit, and test the circuit on the bread model board.
5. Assemble the prototype clearly with a mini train accompanied by a rail with a loop in the form of a track.
6. Test the maximum distance, the effective distance between the A3144 half effect sensor and the train

Keywords— Arduino, halls effect, magnetic field

I. INTRODUCTION

Train is an example of land transportation that is found around us, because trains have advantages in overcoming congestion. The more trains that operate, the more railroads will pass through residential areas and roads. Nowadays there are many accidents in the world of transportation. One of them is in the railroad industry. The cause of accidents is the number of crosses between the railroad and the highway.

Of the many crosses that are only partially guarded by railway officials. Some were not monitored. Especially in small cities and rural areas. This unattended intersection often causes casualties due to the lack of vigilance and carelessness of passing road users. Likewise, the officers' error factors, who often make mistakes, either intentionally or accidentally. The gate crossing guard officers generally only rely on notification signals from officers on guard beforehand. If there is no signal, they usually rely on the regular schedule of trains and rely on their hearing. In addition, the unavailability of latches in the crossing area is also a factor in accidents.

Therefore, to reduce the incidence of casualties, especially on routes that are not guarded by officers from the railway service, an automatic railroad crossing is made. Where the doorstop can detect the presence or absence of a passing train. If there is a train that is about to cross, the device installed will detect and signal the latch to close immediately.

a. Railway Crossings

In Indonesia, there are many people interested in rail transportation. Apart from being effective and efficient, inter-city rail transportation costs are also cheap. Therefore, the Indonesian government issued Law of the Republic of Indonesia Number 23 of 2007 concerning Railways which in chapter I article 1 reads "Railways are a unitary system consisting of infrastructure, facilities and human resources, as well as norms, criteria, requirements, and procedures for operation. rail transport ". From the enactment of this law, it is clear that the importance of the safety of railroad crossings.

In general, the railroad crossing is still manual, which is controlled by humans as follows: when the officer receives a signal that a train will pass, the officer will immediately lower the crossbar for motorized vehicles and pedestrians and let the train pass crossing beforehand.

b. Prototype

According to Raymond McLeod (Sidik: 2013), Prototype is defined as a tool that provides ideas for both the maker and potential user about how the system functions in its complete form, and the process for producing a prototype is called prototyping.

Prototyping is the process of creating a simple software model that allows users to have a basic overview of the program and perform initial testing. Prototyping provides facilities for developers and users to interact with each other during the manufacturing process, so that developers can easily model the software to be created. Prototyping is one of the widely used software development methods.

c. Arduino Uno

According to Abdul Kadir (2013: 16), Arduino Uno is a product labeled Arduino which is actually an electronic board containing an ATMega 328 microcontroller (a chip that functionally acts like a computer). This device can be utilized to realize electronic circuits from simple to complex.

LED control to robot control can be implemented using this relatively small board. Even with the addition of certain components, this tool can be used for monitoring the condition of patients in hospitals and controlling equipment at home or office. (Source: B. Gustomo, 2015)

d. Arduino software

The Arduino software used is the Arduino IDE (Integrated Development Environment), a processing software written using a combination of C and Java languages to make it easier to design program sketches for the Arduino Uno board. Arduino IDE consists of:

1. Program Editor.

A window that allows the user to write and edit programs in a processing language. The Arduino program linsting is called Sketch.

2. Compiler.

A module that functions as a sketch compilation without uploading it to the Arduino board which is used to check syntax errors in the sketch.

3. Uploader.

Serves to upload the sketch compilation results to the intended Arduino board. An error message will appear if the board is not installed or the COM port address is not configured correctly.

The command structure on Arduino generally consists of two parts, namely void setup and void loop. Void setup contains commands that will be executed only once since arduino is turned on, while void loop contains commands that will be executed repeatedly as long as arduino is turned on (Sulaiman, 2012).
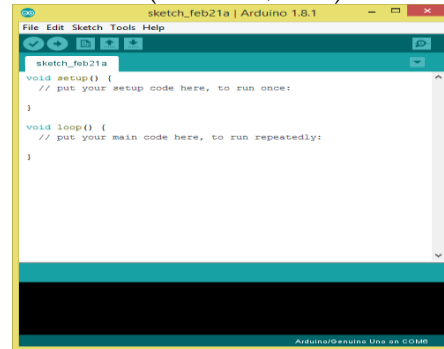

Figure 1 : Arduino IDE

e. Hall Sensor

Hall effect sensors are sensors that can detect the presence of magnetic fields around them. There are two types of hall effect sensors, namely those that have analog signal output and sensors that have digital signal output. The signal will provide logic 1 if it detects a magnetic field around it. This sensor has 3 legs, namely Vcc, Output and Ground.

Figure 2. Sensor hall effect A3144

f. Buzzer

Buzzer is an electronic component that functions to convert electrical vibrations into sound vibrations. Basically, the working principle of the buzzer is almost the same as the load speaker, the buzzer also consists of a coil attached to the diaphragm and then the coil is energized so that it becomes an eletromagnet, the coil will be attracted in or out, depending on the direction of the current and the magnetic polarity, because the coil is installed. on the diaphragm, each movement of the coil will move the diaphragm back and forth so as to make the air vibrate which will produce sound.

Figure 3. Buzzer

g. LED

LED (Light Emitting Diode) is a diode that can emit light when it gets forward bias current. LED (Light Emitting Diode) can emit light because it uses dopping of gallium, arsenic and phosphorus. LED is a type of diode, so it will only flow electric current in one direction only. The LED will emit light when given a voltage with a forward bias configuration. The LED consists of a semiconductor chip doped to create P and N junctions.

Figure 4. Diode

h. Servo Motor

The servo motor is a DC motor equipped with a control circuit with a closed feedback system integrated into the motor and capable of working in both directions (Clockwise and Counter Clockwise). In a servo motor, the position of the rotation of the axis (axis) of the motor will inform back the control circuit in the servo motor. This servo motor is composed of a gearbox, DC motor, variable resistor and control system.

The potentiometer determines the maximum limit of the rotation of the servo motor axis while the rotation direction and angle of the servo motor axis can be adjusted based on the PWM (Pulse Width Modulation) signal duty cycle setting on the servo motor control pin.

Figure 4. Servo Motor

II. Research Implementation Process

The flow of research that has been carried out includes the following activities:
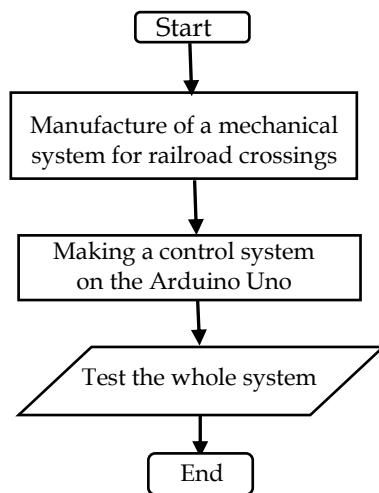

Figure 5: Flow of research implementation

Write briefly the results of the research implementation that have been achieved in accordance with the year of research. Presentation includes data, analysis results, and outcomes (mandatory and or additional). All reported results or achievements must be related to the stages of research implementation as planned in the proposal. Data presentation can be in the form of images, tables, graphics, and the like, and analysis is supported by relevant and current primary literature sources.

1. Mechanical manufacturing of railroad bars
   At this stage it will produce a mechanical design of the automatic railroad bar that is ready to be programmed or run. At this stage all components are installed and ready to operate.

2. Making a carriage control program
   At this stage, what we need is to create a program on the Arduino IDE then upload it to the Arduino Uno board so that it can operate automatic train bars.

3. Testing Tools
   In this test, each stage is tested so that you know the location of the error or the problem in mechanical manufacturing, the testing stages include:

a. Testing program
   In this test the program must be created first then the program is uploaded to the Arduino Uno board. If at this testing stage it fails then something is wrong with the program and if it is true then continue to the next stage.

b. Overall testing
   At this testing stage, all the mechanical circuits must have been installed and at this stage it is testing the whole if there is something wrong then the wrong location is in the circuit, as well as the maximum distance for Hall Effect A3144 sensor testing. According to the data books the Hall effect A3144 sensor specification is well used at a distance of 5 mm.

4. Tools and Materials
   In the manufacture of automatic railroad cross bar mechanics, tools and materials are needed, including:
   1) Arduino uno board: 1 piece
   2) Arduino uno adapter: 1 piece
   3) Hall effect A3144 sensors: 4 pieces
   4) Buzzer: 1 piece
   5) LED: 4 pieces
   6) Servo motor: 2 pieces
   7) Toy train: 1 piece
   8) Toy train tracks: to taste
   9) PCB matrix: to taste
   10) Jumper cables: to taste
   11) Resistors: to taste
   12) Magnets: to taste
   13) Tin: to taste

5. Block Circuit Diagram
   This tool consists of five series, the first of which is the hall effect sensor A3144 which functions to detect magnetic fields and send data to open and close railroad crossings automatically. The second circuit is the

Arduino Uno which functions to store programs to control the entire circuit. The third circuit is a servo motor which functions as a driving force for the railroad crossings and is also the output of the microcontroller. The fourth series is an LED which functions as a sign of the status of the bar opening or closing in the form of a lamp. The fifth circuit is a buzzer which functions as a sign of the status of the bar opening or closing in the form of a sound. The block circuit diagram is shown in Figure 6.
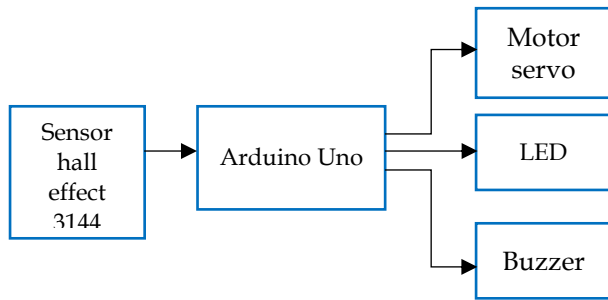
Figure 6: Block Circuit Diagram

6. Circuit Schematic

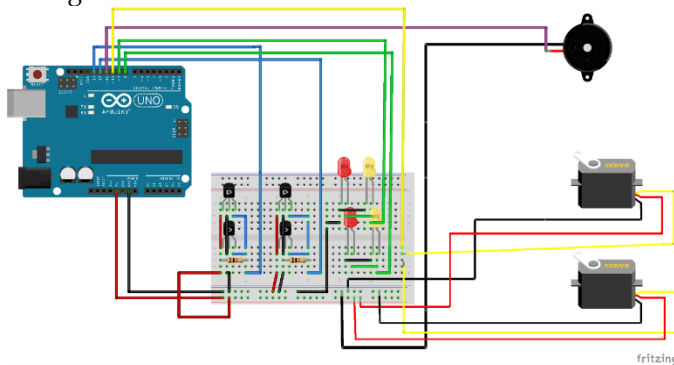At this stage, it is assembling the automation components of the railroad crossings shown in Figure 7.

Figure 7: Circuit Schematic

7. Arduino Uno programming

At this stage, programming will be made on the Arduino Uno so that it can move the railroad crossings automatically with the help of the Arduino IDE software. Arduino programming will make a flowchart so that control of the railroad bars is as desired, as shown in Figure 8.
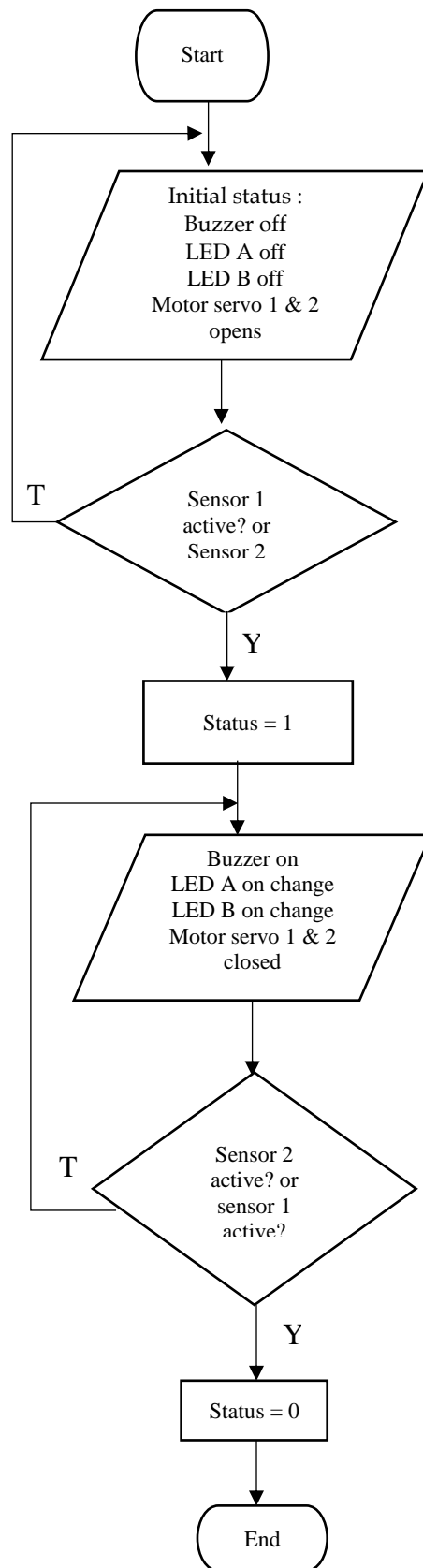

Figure 8. Railway Cross Control Flowchart

The steps for implementing programming in C ++ are as follows:

1) Creating a program in the Arduino IDE with the command #define, which means defining the pins to be used.
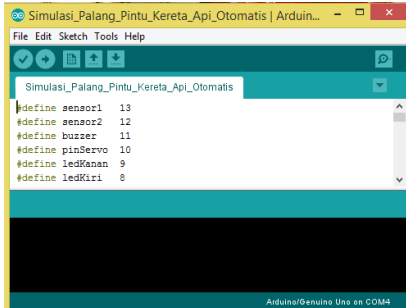

Figure 9. Programming Defining Arduino Pins

Shown in Figure 9, there is the command "#define sensor1 13" which is pin 13 Arduino is used for sensor 1 and "define sensor2 12" is pin 12 Arduino is used for sensor 2 and so on. In the command # include <Servo.h> which serves to include the servo motor library that will be used in the program. In the command "Servo cross;" that is, make a name on the servo with the name "cross".

2) Creating program code that is used to store a value in a name. For example, there are commands "int", "bool" and "void".
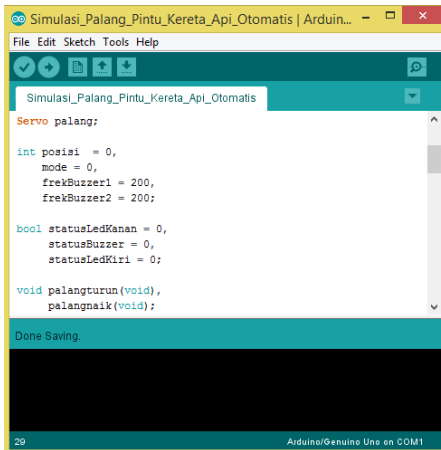

Figure 10: Arduino Programming Saves a Value

Shown in Figure 10, the command "int" is a command that is often used and can store 2 bytes (16 bits) of data. The command "bool" or it can be called "boolean" is a command to store true or false values (values 1 and 0) with only 1 bit. In the command "void palangturun (void)" or "void crossbars (void)" is a statement to carry out a certain task if the return value or parameter does not exist then write "void" only.

3) Create program commands that Arduino only reads once. With the command "void setup" all code covered in "void
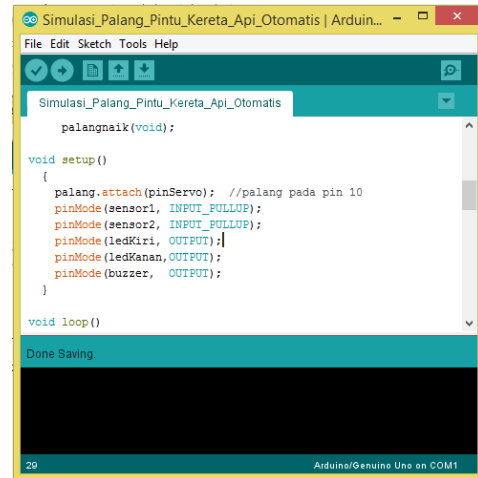

Figure 11: Arduino Void Setup program

Shown in Figure 11, there is a command "cross.attach (pinServo)" is a command to move the bar that has been programmed on pin 10 of the Arduino. Meanwhile, "pinMode" is a command to configure a pin that is used as input or output such as "pinMode (ledKiri, OUTPUT)" only. There is a command for the sensor, namely "input_pullup" which means to reverse the behavior, where high means the sensor is inactive and the low sensor is active.

4) Create a loop program command using "void loop" and create a subprogram cross. The command "void loop" means that all the code in the "void loop" will be repeated by Arduino.

Figure 12: Arduino Void Loop Program

Shown in Figure 12, the command "if (! DigitalRead (sensor1) ||! DigitalRead (sensor2) means that if sensor 1 or sensor 2 is low then it enters ++ mode." The command "mode ++" means when the position sensor is low, the status the value will increase by 1, from 0

to 1. The command "if (mode> 1) {mode = 0;}" means to determine the status of the bar to be activated if the mode is greater than 1 then the mode will be forced to 0, shown in the figure 13.
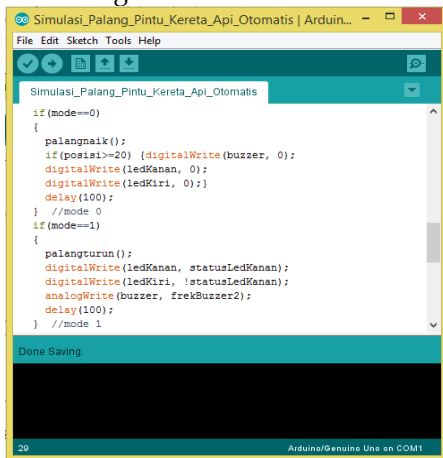

Figure 13: Cross Mode Subprogram Command

Shown in Figure 13, is an internal continuation of the "void loop" command which is used to activate the cross mode repeatedly. In the command "if (mode == 0)" means that if you enter mode 0 then continue. The bar rises with the command "if (position> = 20) {digitalWrite (buzzer, 0)" means that if the bar is more or equal to 20 degrees the LED output and the buzzer will turn off. On the other hand, when you are finished determining the activation of the bar mode, the bar will make a detailed expenditure in the form of a submenu when the bar is active as shown in Figure 14.
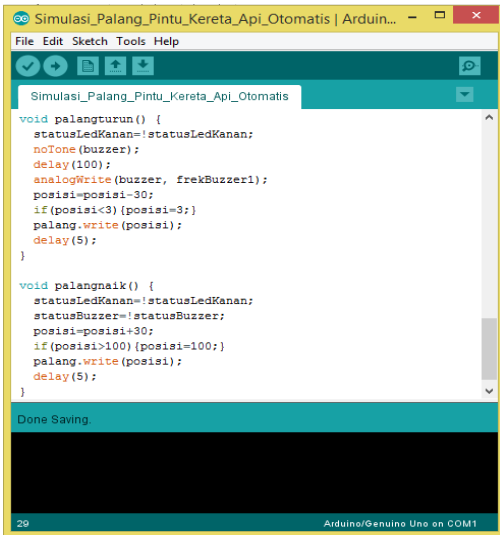

Figure 14: Cross Submenu Command

Figure 14, above in the submenu program code "void lower bar" in the command "position = position-30", the position of the bar will move down 30 degrees every second if the position value is 3 degrees smaller accompanied by a buzzer sound and the LED lights up. Whereas in the submenu code "void crossbar" in the command "position = position + 30", the position of the bar will move up 30 degrees every second if the position value is greater than 95 degrees with the stop of the buzzer sound and the LED off. The whole program can be seen on the appendix page.

III. Research result

1. Program Testing

After the program is created, it is "compiled" or can be called "verify" to determine the problematic program or not. If correct, the word "Done compiling" will appear as shown in Figure 15.
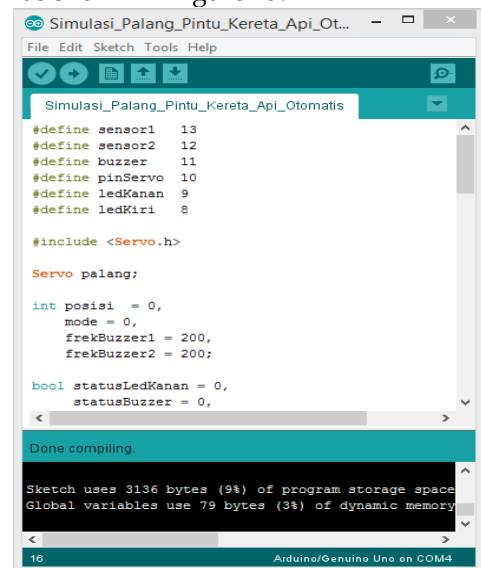

Figure 15: The Program Display Is Correct

2. Overall Testing

At this stage it is a test that combines the mechanical design with the Arduino program control. If the mechanic does not move as desired, the fault lies in the mechanical circuit. The results of the overall test are as follows:

a) The first condition can be seen in Figure 16, that when a train passes, sensor 1 will be detected, the crossing bar will close and the LED lights up accompanied by a buzzer sound.

Figure 16. Sensor Testing 1

b) The second condition can be seen in Figure 17, that when the train has passed the crossing crossbar, sensor 2 will be detected, the crossing bar will open along with the LED and the buzzer turns off .

Figure 16. Sensor Testing 2

c) Measurement of the distance between the hall effect A3144 sensor and the magnet attached to the train to find out how far the sensor is detected. Shown in Figure 17, produces a detected sensor distance of 1 - 2 cm (depending on the strength of the magnetic field when detected by the sensor and the speed of the train).
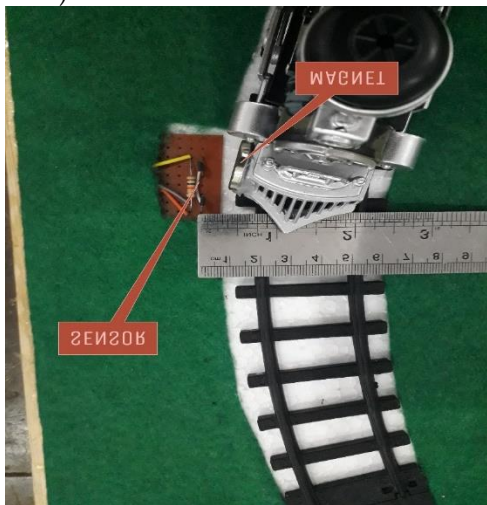

Figure 17. Effective distance sensor

IV. Conclusions and suggestions

4.1. Conclusion

From the results of the design and testing of the Arduino Uno-based railroad automation system, it can be concluded that:

1) The railroad crossing can move automatically with the detection of a magnetic field when it passes through the hall effect sensor A3144 which is controlled via Arduino Uno.
2) There are 2 sensors, if sensor 1 is detected then the bar will close along with the LED lights up and the buzzer sound, then if sensor 2 is detected then the bar will open along with the LED and the buzzer turns off.
3) The crossbar will close if the head of the train is detected on sensor 1 and the door will open when the last carriage of the train is detected on sensor 2.
4) The train flow is only one direction, from sensor 1 to sensor 2.
5) The hall effect A3144 sensor has an effective distance of about 1 - 2 cm in detecting a magnet which depends on the strength of the magnetic field and the speed of the train.

4.2 Suggestions

For further development, the authors provide very useful suggestions in making reports for the future as follows:

1) For notification, it should be completed with writing in detecting trains that will cross the crossbar by adding a 16x2 LCD.
2) In order for the train to pass the two-way line, it needs to be developed by adding sensors.
3) The use of the hall effect A3144 sensor needs to be tested for other types of sensors to make it more accurate in detecting the sensor's distance from the train.

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