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Railway Gate Control: An Efficient Design

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Abstract: Railway transportation is one of the most important land vehicles in the country. A train station scenario consists of a gate which is located two kilometers. The gatekeeper controls the gate based on information from railway station master regarding the presence of train. However, there are cases involving accidents at the railway gate especially due to the negligence of the railway gatekeeper which is controlled manually. The main objective of this work is to develop an automatic railway gate control using Arduino Atmega microcontroller. The developed prototype of automatic railway gate control are used Arduino Mega Atmega 2560 to control the overall gate control system, and Arduino Uno Atmega 328 to control the movement of the train. The develop system is achieved using wireless system. One unit of Xbee wireless acted as a transmitter to send a signal for the train arrival, and two units of Xbee are used as receivers of the signal from the transmitter. This wireless system is able to detect the presence of addressed objects within a frequency of 2.4GHz. The whole control system status using microcontroller is displayed on the LCD screen. The programming of the developed prototype is written using Arduino Alpha software. The prototype was test run using a model train and the system was able to function without manually controlling the gate.

Keywords: Railway System; Microcontroller; Gate Control;

1. Introduction, Background and Previous Work

Automatic railway gate control is one of the new technology that using microcontroller to prevent accidents at level crossing [1]. The automatic railway gate control can replace the manual gate that is operated by gatekeeper. This work is to reduce time for which the gate is being kept closed, and indirectly can provide safety to the road users from accidents that always occur due to carelessness of road user and time errors that is conducted manually by the gatekeeper. In Malaysia, most of the railway gates are still control manually by gatekeeper. The train arrival at the next railway station is determined using rail signaling [2]. For example, Kluang Railway Station, Johor, is one of the railway stations using an interlocked block rail signaling [3]. The interlocked block rail signaling is produced by SIEMENS from Germany and the signal is produced by ALSTOM. The rail signal is connected through cable which is integrated with the interlocked block rail signaling [4]. The system is used to control railway traffic essentially to prevent trains from colliding. The monitoring board is observed by the Railway Station Master through the indicator light provided on this board. Thus, Station master will be able to make a phone call to railway gatekeeper regarding the train status in order to operate the railway gate [5]. Other countries such as China and Thailand also control the railway gate manually by gatekeeper. In Ireland, the railway gate is controlled manually by road users. They are unsafe to use without possessing the knowledge of the train timetable and may be instructed to telephone the railway signaler. However, in United States, reflector is added to the side of each train to help prevent accidents at level crossings. In the United Kingdom, railway gate are still control manually with gatekeeper, but many gate crossings have been replaced by lifting barriers. Video cameras are used at level crossings to allow human operator to be some distance from the crossing. The railways of Taiwan using San Lien Technology Corporation proposed a system of horizontal EL beam sensors to span the excavation area on either side of the tracks [6-8]. A Campbell Scientific CR10X data logger was used to read the sensor which is powered by a 12V power supply that charged by a solar panel [9-10]. There is previous conference paper present the architecture of SENSORAIL based on Wireless Sensor Network (WSNs) for railway infrastructure monitoring [11-13]. Smart sensors are installed along railway line which controlled from control room.

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There are also journal about multi sensory system for obstacle detection at level crossing using IR sensor and Ultrasonic sensor [14]. In Korea, there is research about intelligent safety equipment using magnetic sensor to recognize movement direction of automobile to pass railway crossing. For this work, Xbee wireless sensors are used as a train sensor and rail sensor [15]. This sensor can be used for detect the train arrival and the signal will send to microcontroller to turn operation of motor and the gate will be close. Meanwhile, the rail sensor for departure of the train will send the signal to microcontroller to turn operation of motor and the gate will be open. IR sensor is used for the vehicle presence sensor [16]. Thus, the system is more efficient compared to manually operate due to highly economical microcontroller based arrangement, and designed with provide reduction of time error.

2. Methodology of Work

The work is imitated by first identifying the problems that exist in the current system of railway gate control. A literature review was done on related knowledge to assist in any ways that it may. Detail research in hardware is needed for the mechanical development while at the same time a lot of time has been spent to search and compare compatible sensor and microcontroller in terms of availability, performance and technical supports. The system requirement was then determined to do this work. The flowchart in developing this work is shown in Fig. 1.

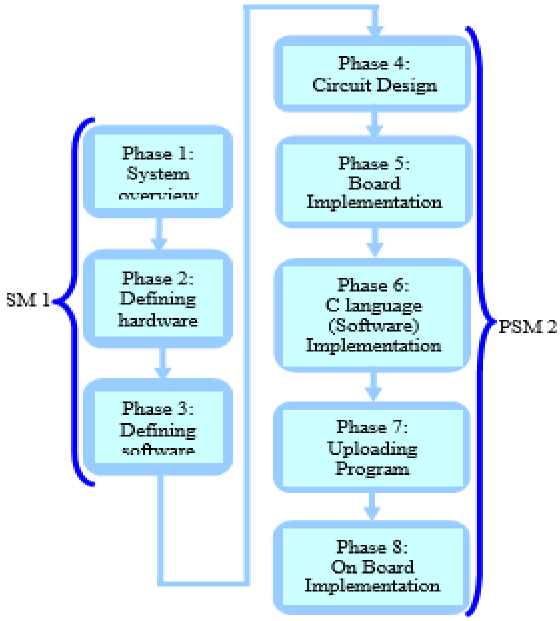

Fig. 1 – Research Methodology

2.1 Architecture System

Fig. 2shows the main hardware that is used in this work. Meanwhile, the software involved is Arduino Alpha, and Proteus 7.5 Professional.

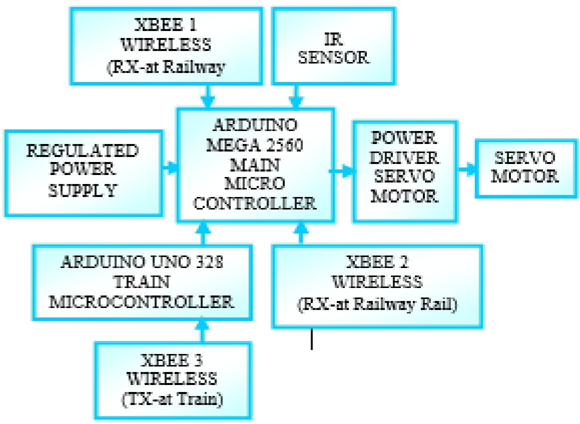

Fig. 2 – Architecture of Railway Gate Control

2.2 Working Operation

This prototype work was designed, which are scale of distance and the actual position of the hardware components are reduced to give a real imagination of this work work as shown in Fig. 3. This work is designed for only one direction of train travel. There are two main reasons, where this work is designed for one direction only, to reduce the cost of equipment and to facilitate this work demonstration. The work is designed based on two conditions that occurred when no vehicles on level crossings and the second situation is when a vehicle presence at the level crossing.

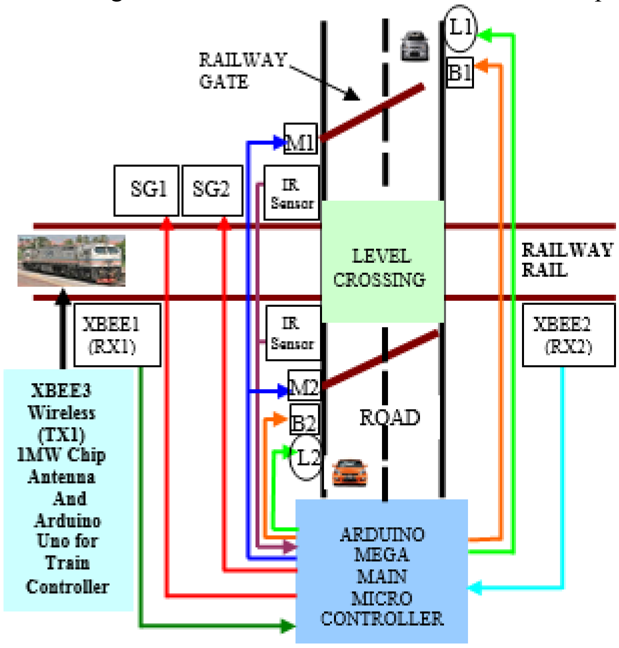

Fig. 3 – Working operation of Railway Gate Control

Based on Fig. 3, the summary descriptions of implementation the process of automatic railway gate control using microcontroller describe in Table 1

Table 1 – Schematic outlay automatic railway gate control using microcontroller

No.	Hardware	Description
1.	**Train Sensor (TX1) -XBee 3**	Sensor in the train. -This sensor can transmit the data to rail sensor RX1 when the train moves to level crossing, or -This sensor can transmit the data to rail sensor RX2 when the train crossing the level crossing.
2.	**Rail Sensor (RX1) -XBee 1**	Sensor for detecting arrival of train. -Location: beside the rail
3.	**Rail Sensor (RX 2) - XBee 2**	Sensor for detecting departure of train -Location: beside the rail
4.	**Rail Signal (SG1) -LED**	SG1 is the first signal placed at the side of the rail. -SG1 is still given a YELLOW light to inform the train driver
5.	**Rail Signal (SG2) -LED**	SG2 is the second signal placed at the side of the track to inform the train driver when the gate is closing or opening. - if any vehicle or obstacle: signal SG2 is RED light
6.	**Buzzer (B)**	To warn the road user that the train is approaching.
7.	**DC Servo Motor(M)**	Motor for gate operation
8.	**Motor Controller (M)**	Servo motor controller is interfaced with servo motor
9.	**Traffic light (L) -LED**	Traffic light is the signal to warn the road user about the train presence.
10.	**IR sensor**	Sensor for detection of vehicle presence on level crossing.
11.	**Regulated power supply**	To control the output voltage or current to a specific value
12.	**Arduino Mega 2560**	Main Microcontroller of the system
13.	**Arduino Uno 328**	Microcontroller for the train

2.2 Hardware

The schematic design of the electrical circuits was designed using ISIS from Proteus Professional v7.5. The schematic diagram, schematic outlay for real case, and schematic outlay for prototype with two cases. Fig. 4 show the development of hardware for this proposed work.

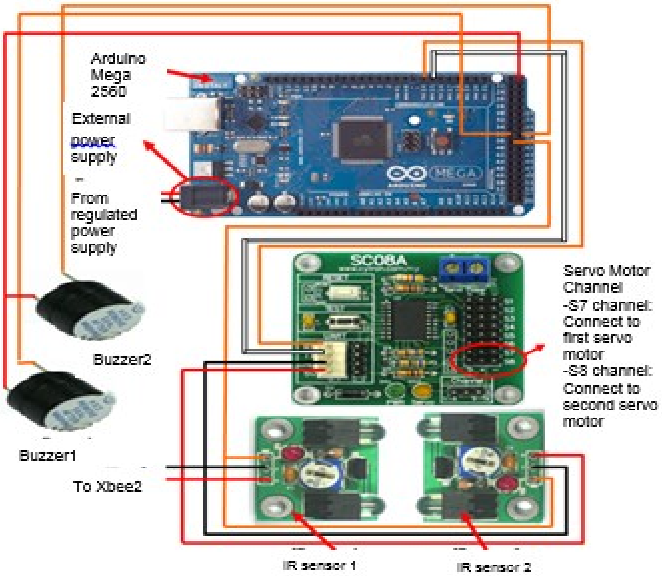

Fig. 4 – Schematic layout of Arduino Mega 2560 to Buzzer, IR sensor and Servo motor

2.3 Software

The work is the final state in completing this work. Software written using Arduino is called sketches. The sketch is written in the text editor. Code writing was using C language in Arduino Alpha software. All programs written will be burnt into Arduino Uno 328 and Arduino Mega 2560 microcontroller board. The ATmega328 and ATmega2560 are running at 16 MHz with auto-reset. The main steps for development of the programs are;

Writing the program in Arduino Alpha.
Compiling of the program.
Simulating of the program.
Uploading the program to Arduino Uno 328 and Mega 2560 Microcontroller boards.

2.4 Compiling process

The Fig. 5 and Fig. 6 shows the successful compilation of this work code for Arduino Uno328 and Mega2560 respectively.

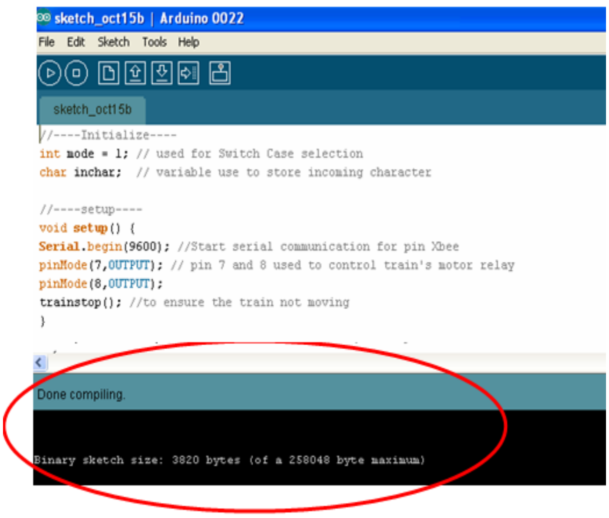

Fig. 5 – The 'done compiling' status for Arduino Uno 328

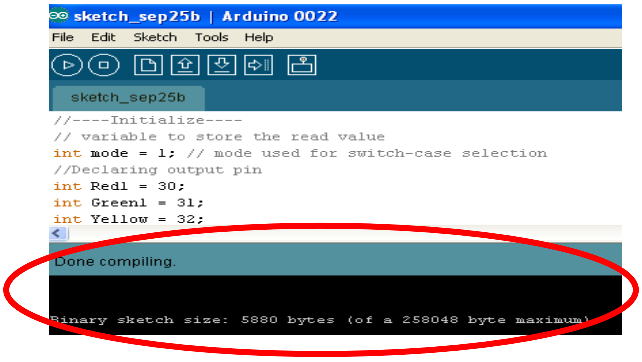

Fig. 6 – The 'done compiling' status for Arduino Mega 2560

3. Experimental Result and Analysis

The result can be divided into two parts which are software and hardware assembly, Software assembly and Proteus V5 Simulation. Fig. 7 shows the status of transmission data by character 'A'. Meanwhile Fig. 8 shows the result of digital waveform of data transmission from Xbee3 with microcontroller of Arduino Uno 328. Both Fig. 7 and Fig. 8 have proved that there is wireless communication on Xbee module.

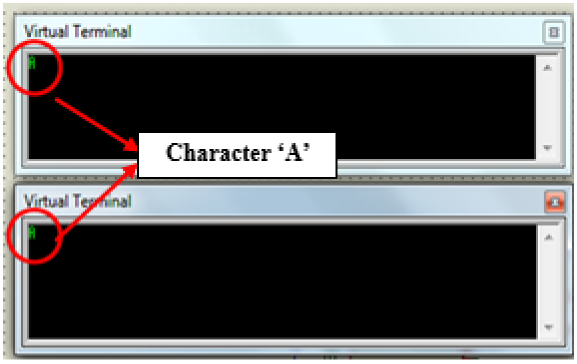

Fig. 7 – Uart/Serial Data representative (TX) in Proteus Professional v7.5 (simulation).

Data transmission from Xbee3 (TX1) to Xbee1 (RX1) or Xbee2 (RX2) occurred through wireless communication by using the Xbee 1mW chip antenna. The advantages of Xbee module are such that there is no setting (programming) required for Xbee and no have master and sleeve. Other than that, to communicate the Xbee to microcontroller, it just uses a cable. Xbee module is a wireless communication which is what ever input given to first Xbee, the input (data) will be receiving only the next Xbee. Therefore, when the Xbee3 was transmitted to Xbee1, the character 'A' was represented in Uart/Serial Data for 'Arriving', which is it shows the train move to level crossing (the process of Arduino Uno328 to Arduino Mega 2560). It can be proved by Arduino Uno 328 writing code as Fig. 9.

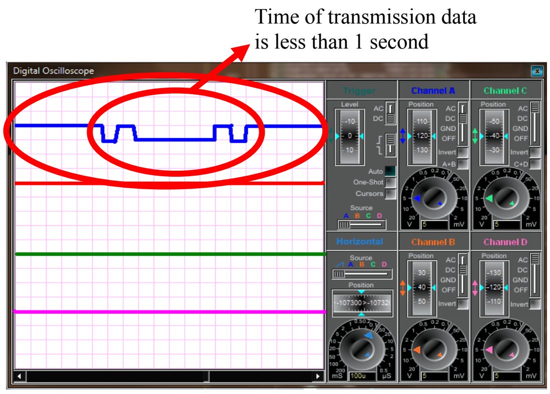

Fig. 8 – Oscilloscope reading for Digital waveform of data transmission from Xbee3 with Arduino Uno 328

Referring to Fig. 8, the waveform is represented in digital waveform in order to shows the transmission data of train arrival using wireless communication. Therefore, the resulting waveform is bit 1 and 0. Each bit 0 and 1 are produced, shows that there is the transmission. The process of data transmission from Xbee3 (TX1) to Xbee1 (RX1) was less than 1 second to ensure the Xbee1 receives the signal without any disturbance and is related with the speed of the train. At the start of the signal, it produces a bit 1. This occurs because the coding for 'train move' in Arduino Uno was set to '2 seconds delay' before the train moving. In this regard, no data transmission is made for the first '2 seconds' of time. Among the reasons why it is so even though the switch train set has been activated is because to show that the railway has not entered or is preparing to enter the zone of automatic railway gate control system because it is designed as a prototype for demonstration only. Data transmission from Xbee3 to Xbee1 or Xbee2 stops after 1 second doing data transmission. Therefore, the waveform always produces a bit after the data transmission waveform as Fig. 8.

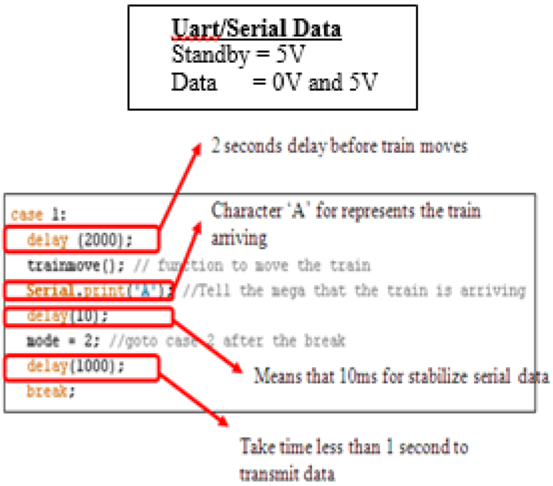

Fig. 9 – Arduino Uno 328 (for train) code for case 1(Train arriving to level crossing)

3.1 Hardware assembly

There are two tests in order to prove that this work is using wireless communication for transmission data from train arrival and departure (XBee3) to rail track sensors (XBee1 as RX1 and Xbee2 as RX2). Therefore another test has been made to successful the work. Transmission data from Xbee3 to Xbee1

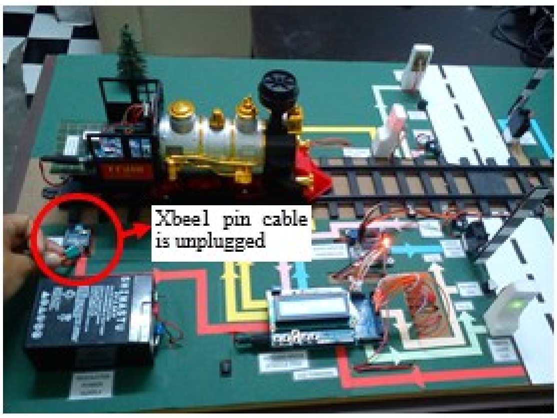

Fig. 10 – Xbee1 pins cable is unplugged

The first test is to prove that Xbee3 can transmit a data to Xbee1. Xbee1 pins cable is unplugged from Xbee1 module, and the train is activated. This condition is shown in Fig. 10. Observations made during the data transmission process until the train stopped. The result shows that the train was stopped at the rail track signal. For this condition, the train was stopped after three seconds it is on. This is because the data transmitted from Xbee3 cannot be received by Xbee1, due to pin cable of Xbee1 was unplugged. Thus, the situation of this system is similar to its initial condition. It is because Xbee is using wireless communication which is what ever input given to first Xbee, the input (data) will be receiving only the next Xbee. Therefore, Xbee2 cannot receive a signal that is sent as long as Xbee1 not function properly or not receive the signal. The system failure could determine by detection of the status of the system which is displayed on LCD display with 'TRAIN STANDBY' status, and gate still opened as Fig. 11.

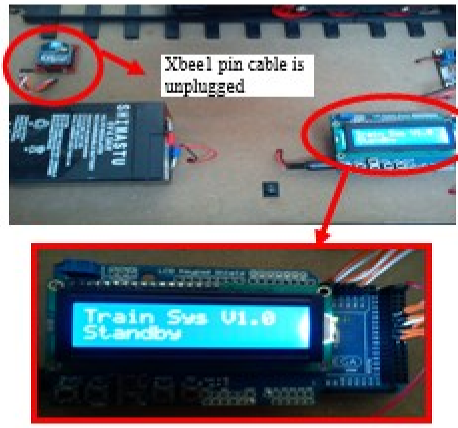

Fig. 11 – LCD display during Xbee1 pins cable is unplugged

3.2 System condition when there is vehicle at level crossing

Since there is no vehicle, signals SG1 given a YELLOW signal to signal that the train is in the control zone automatic gates. If the road user sensor indicates the presence of vehicle, the signal for train, SG2 should be made RED in order to slow down the train to avoid collision. Then the obstacle should be warned to clear the path. Fig. 12 shows the condition for any vehicle at level crossing. Meanwhile Table 6 shows the summary of description of this condition.

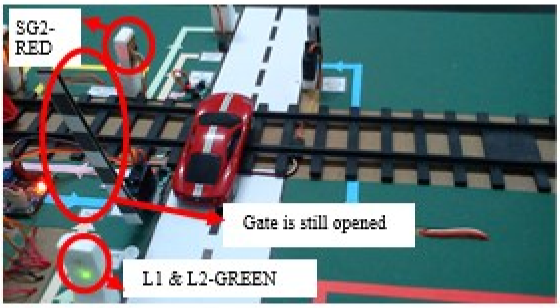

Fig. 12 – System condition for any vehicle at level crossing

3.3 Discussion

The train movement is delay for two seconds before it start moving because of some following reasons;

i.. This work presents a prototype. In reality, each train has a driver which can control in terms of train speed, and the train began to move and stop. Therefore, to demonstrate a prototype system, it should be set to for two seconds to make an initial condition.

ii. Small space in the prototype. For real case, the Xbee can transmit and receive data through the range of 100meter. Therefore, this Xbee and microcontroller are ready to process the data transmission of the presence of trains on the system.

This system is very efficient and conducted with LCD to display the system status. When the switch at the rail track work board is activated, the LED terminal displayed the status of 'Train System Standby'. While the status of 'Train System Running' displayed when the train start moving on the rail track until it stop moving at Xbee2. The system is very efficient because of some features as follows;

i. Automatic control system using Arduino microcontrollers

a)Reduce the time error of operation of railway gate control

b)Overcome the problem of workforce

Give priority to the safety of train and road user

a) Safety of train

- Provide SG1 with YELLOW signal as a warning to train that it was in the automatic railway gate control zone using microcontroller in order to slow the train.

-Provide SG2 after SG1, as a signal to the train on the presence of vehicle on a level crossing.

b) Safety of road user

-L1 and L2 indicated the road users with RED signals immediately upon receiving the information about the presence of the train.

-IR sensor works separately with L1 and L2.

iii.Data transmission system is very efficient using Xbee wireless communication (peer to peer).

4. Conclusion

The basic function of the system has been successfully verified via interface functionality between the Xbee Sensor, motor control, IR sensors, and Arduino microcontroller. Based on the simulations and test results, the objectives have been successfully accomplished since the motor can be control and interfacing with the IR sensors works perfect. The program was written for one direction according to the prototype system construction. However, the program is efficient to use in a real system.

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