UNIVERSITI TEKNIKAL MALAYSIA MELAKA

RAILWAY CRACK DETECTION SYSTEM USING ULTRASONIC SENSORS AND ARDUINO UNO

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Electronics Engineering Technology (Industrial Electronics) with Honours

by

WONG WEI QING

B071310560

931215145457

FACULTY OF ENGINEERING TECHNOLOGY

2016

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **RAILWAY CRACK DETECTION SYSTEM USING ULTRASONIC SENSORS AND ARDUINO UNO**

SESI PENGAJIAN: **2016/17 Semester 1**

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I hereby, declared this report entitled “Railway Crack Detection System Using Ultrasonic Sensors and Arduino UNO” is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours. The member of the supervisor committee is as follow:

……

(IR MOHAMMAD ‘AFIF BIN KASNO)

ABSTRAK

Report ini menerangkan pembangunan of sistem pengesanan rekahan landasan kereta api yang kos efektif. Sistem ini menggunakan ultrasonik sensor dan Arduino UNO. Rekahan landasan kereta api berlaku pada masa kini kerana ada tekanan antara roda dan permukaan landasan kereta api. Hal ini sedemikian, rekahan akan membawa kerugian yang banyak kepada nyawa manusia dan harta benda. Pembangunan Sistem ini akan mengurangkan rekahan landasan kereta api. Pendekatan sistem ini menggunakan dua ultrasonik sensor untuk mengesan rekahan yang berlaku di landasan kereta api, iaitu di landasan KTM. Ultrasonik sensor berkomunikasi dengan Arduino dan memaparkan mesej kepada pasukan penyelenggaran supaya landasan kereta api dapat membaiki dengan masa yang cepat. Selain itu, pasukan penyelenggaran boleh berinteraksi dengan sistem ini melalui satu sistem Graphical User Interface (GUI) bahawa sistem ini bergerak dalam mod keselamatan atau mod biasa. Arduino UNO ialah satu cip kawalan utama, pembalakan data dapat dicapai dengan penggunaan monitor siri dan LCD berfungsi sebagai paparan mesej kepada pasukan penyelenggaran. Hasil ujian ini menunjukkan pembangunan sistem mempunyai perwatakan yang kos efektif dan akan digunakan secara meluas. Interaksi dengan penguna dapat dicapai melalui sistem GUI untuk sistem pengesan rekahan landasan kereta api. GUI ini mempunyai mod keselamatan dan mod biasa bahawa sistem ini akan bergerak dengan kelajuan yang ditetapkan dalam program.

ABSTRACT

This report present the development of Design a Cost Effective Railway Crack Detection System Using Ultrasonic Sensors and Arduino UNO. Railway crack continues to occur in modern architecture due to contact stresses between the wheel of the train and the surface of the railway. Thus, it will bought huge losses to the people's lives and property. In order to reduce railway crack in railway track, a railway crack detector device installed into an essential. The approach of railway crack detection system is by using two ultrasonic sensors to detect crack for that occurs in railway track such as in KTM komunter train area. The ultrasonic sensors then integrated with Arduino itself and display message to the maintenance team so that the maintenance could done faster. Besides, the maintenance team can interact with the crack detector system and the system will continue to scan for any defect at the railway tracks by Graphical User Interface (GUI) program whether is in safety run mode or normal run mode. Arduino UNO is adopted as main control chip, data logging are achieved by using Serial Monitor and LCD functions as display message. The result of test shows this design has characters of cost effective, and will be widely used. Communication with the users is fulfilled through the GUI in this crack detection system. Its consists of safety run mode and normal run mode, which the device will run at its speed according to the mode.

DEDICATION

This thesis is dedicated to:

My beloved family,

My Parents,

My Supervisors,

My lectures,

And all my friends,

Thank you for their encouragement and support.

ACKNOWLEDGEMENT

I convey my gratefulness to my supervisor, IR Mohammad ‘Afif Bin Kasno as my supervisor for giving me the precious chance to have my final year project under their supervision. Besides that, I appreciate all the guidance, motivation and invaluable throughout the project. Despite he is being extraordinarily busy with their jobs and duties, he still managed to guide me along, apart from suggesting me the best solutions to almost every challenge. I would also like to thank all my friends that support me during working on this project.

Besides, we would like to thank to Universiti Teknikal Malaysia Melaka (UTeM) especially to the Department of Electronics & Computer Engineering Technology (JTKEK), Faculty of Engineering Technology (FTK) for providing us with good environment and facilities to complete this project. Thanks also to the Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) librarian and related staff for providing us valuable information throughout the project.

Most important, I wish to dedicate my special appreciation to my family for the support and attention in my entire study. Their endless support has extended to me throughout these four years’ study and my life in general.

Without helps of the particular that mentioned above, I would face many difficulties while doing this project. Through this final year project, I gained valuable knowledge and I hope I able to apply it in the future.

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LIST OF SYMBOLS AND ABBREVIATIONS

KTM – Kereta Tanah Melayu
LCD – Liquid Crystal Display
FRA – Federal Rail Administration
SMS – Short Message Service
B & E – Ex-Bristol and Exeter
GSM – Global System for Mobile Communications
IR – Infrared
PIC – Peripheral Interface Controller
LED – Light Emitting Diode
PWM— Pulse Width Modulation
USB— Universal Serial Bus
ICSP— In-Circuit Serial Programming
AC— Alternating Current
DC— Direct Current
MCU— Memory Controller Unit
TX— Transmit
RX— Receive
EN— Enable
IDE— Integrated Development Environment
LDR – Light Dependent Resistor
P— Power
f— Frequency
t— Time
GUI – Graphical User Interface
RF – Radio Frequency
IoT— Internet of Things
cm— centimeter
mm— millimeter
LiPo— lithium battery

CHAPTER 1
INTRODUCTION

1.1 Background

Transport plays a vital role because it enables the action of buying and selling good and service between persons, which is essential for the development of civilizations. Thus, transportation has throughout history been a spur to expansion as better transport leads to more trade. The stage in an economic cycle has always been dependent on increasing the capacity and rationality of transport. But the infrastructure and operation of transport has a great effect on the land and is the largest drainer of energy, making transport sustainability and safety a major issue. In Malaysia, the rail transport occupies a prominent position in providing the necessary transport infrastructure to sustain and quench the ever burgeoning needs of a rapidly growing economy. Today, Malaysia possesses the fifth largest railway network in the world and development to make the trains as the main transportation become true.

In era for development train as a main transportation, one horrific accident which 22 passengers were injured in train accident at the Batu Anam station, near Segamat. According to the witness, incident at about 11:45 am Monday, the train was going quite fast as when the it travels from Gemas onwards. In the incident, a Singaporean Mohd Noor Rahmat, 78, and his wife, Madam Mahawi Sulaiman, 70, a permanent resident, who were also badly injured. Mr. Mohd Noor suffered a swollen left eye and had to wear a neck brace and need further check-ups to see if he had broken any bones or injured his neck seriously. During the incident, a train with eight carriages carry 243 passengers travelling from Kuala Lumpur to Tampin.

Figure 1.:1 Horrific Accident at Batu Anam station, near Segamat.

On this tragedy, a group of Indian students on a youth exchange programme with Rotary International were not so lucky. Their coach was one those that fell on its side. The group of eight, including their team leader, Mr Sudhindra Mohan Sharma,43, and four boys and three girls from ages of 16 to 19. The group later sought treatment from Raffles Hospital in Singapore.

Another case was record by AsiaOne which incident occurred at the Bukit Timah road near King Albert Park at about 8:15am on Tuesday morning when the KTM train from Singapore to Malaysia in the journey carrying 60 passengers aboard the 3 carriages. The first three carriages that which contains of 20 passenger boarded at the back of the front carriages disconnected from the connection, causing it to derail and luckily there no casualties have been reported.

Figure 1.2: Train Derailment at Bukit Timah road near King Albert Park

The matter of interest for both this resource is the accident arise from railroad problem which the train out form the railroad. According to the resource, two major problems that always have been occurred are crack and loosening bolt on railroad. These current situation of railway always occur because the temperature on railroad always changes from hot and cold temperature. From that, the structure of railroad also changed to breakable and easy to crack and loosening bolt.

1.2. Problem Statement

The existing systems are incompetent in monitoring the surface and near surface cracks precisely and it is inappropriate in tunnels. Nowadays, the monitoring is by manually and waste more human energy. The time delay in informing the maintenance team about the crack is large. It has high cost and is less accurate.

Table 1.1: Condition of railroad that can cause accidents

Figure 1.3: Loosening Bolt

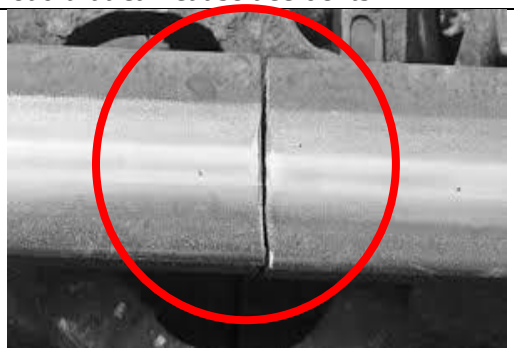

Figure 1.4: Crack On Railroad

Figure 1.5 : Non- junction on track

Figure 1.6 : Serious Crack on Railroad

1.2.1 Factor of Crack in Rails

Cracks in rails have been recognized to be the main factor of derailments in the past, yet there have been no cheap self-acting solutions available for testing purposes. Hence, owing to the crucial repercussions of this problem, design on implementing a better performance and cost effective solution suitable for large scale application. Since the railway was created, rail maintenance had always been a problem crack or damage rail could lead the train derail from track.

The problem has been the lack of cheap and efficient technology to detect defects in the rail tracks and of course, the insufficiency of maintenance of rails which have resulted in the formation of cracks in the rails and other similar problems caused by anti-social elements which threaten the security of operation 5 of rail transport. In the past, this problem has influence to a number of derailments resulting in a heavy loss of life and property. High safety standards need in the management of railroad lines demand the inspection of railway wheels directly after production in order to detect the presence of surface cracks and bolt loosening that could seriously affect the condition of the railway, and therefore passenger's safety.

1.3. Objective

This project is:

I. to study about the solution and the problem of railway cracks
II. to develop a railway crack detection system that able to solve the railway crack problem.
III. to analysis the best performance of the system for the railway crack.

1.4. Scope

For the project, the scope is depending the system of railway crack detection that will be develop. For example,

I. Choosing the suitable electronic items for build up the system. This is because the electronics component has their own characteristics and limitations for designing circuit process to avoid this component is burn out during attach on the circuit. For example, Arduino microcontroller, Motor driver, LCD, Ultrasonic sensor, DC motor.
II. Understanding all railway crack detection system, apply at which application and limitation and also to define their classifications The system has their own limitation than other sophisticated system that develops by other country. For example, the ultrasonic sensor able to detect the distance in centimetre, but not in millimetre. The system detect crack and do data logging and give a message and display out at the monitor so that the maintenance team could quickly done the repairing of the railway crack.
III. Designing the suitable design for build up the railway crack detection system. The design of system should be taken in terms of dimension and position of components, it because the sensors, motor driver and motor will be place on lower base platform. For the upper base platform, the components will be placed are Arduino, LCD, and the circuit of connection for all the components in breadboard.

1.5. Structure/Summary of this report

From this report have four chapters. Firstly, in chapter one (i) is discuss about the objective and scope of the project. Secondly, chapter two (ii) is discusses about the theory example the literature review related to the project. From this chapter discusses about history of railway crack detection system. Chapter three (iii) discusses methodology by flowchart of the programming and the work flow of the system. The result and discussion covered in Chapter 4. Lastly, Chapter 5 was concluded the overall of this project.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

From this chapter, I have been research about theory related to the project. From this chapter, I started to define the equipment and related law example railway crack detection system. This chapter covers LCD, motor driver, ultrasonic sensors and Arduino. This chapter easy to design and constructing the circuit of railway crack detection system. Reinach and Gertler (2002) state that the train accident and incident rate in railway yards far exceeds the rates across the entire railroad industry. Train accidents include collisions and derailments that involve the operation of on-track equipment and that satisfy the certain reporting thresholds set by the Federal Railroad Administration, (FRA, 2003).

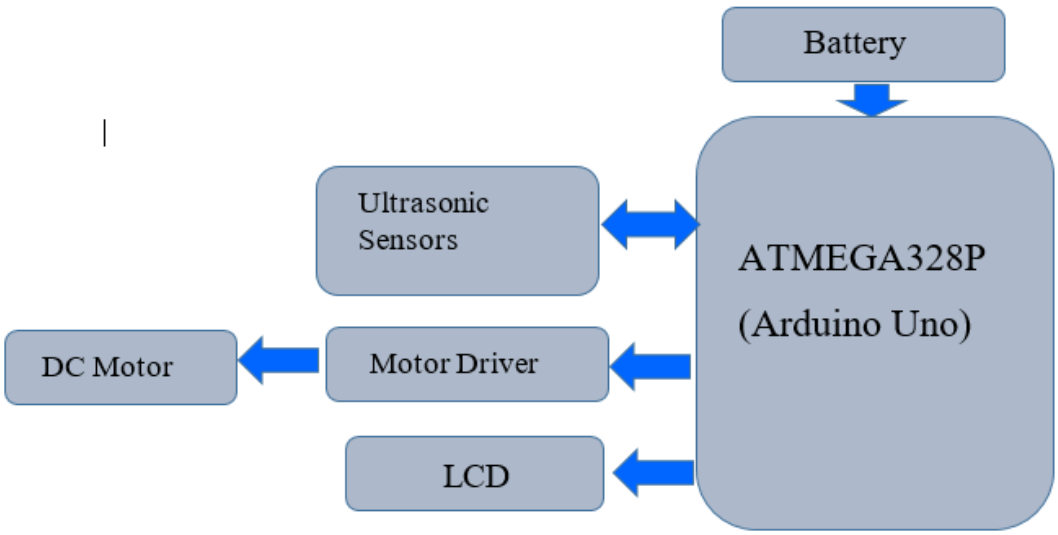

Figure 2.1: Block Schematic of Rail Crack Detection Scheme

2.2 History about railway crack detection system

Nowadays, each year has many train accidents reported in worldwide due to railway defect. Thus, there will be losses of human lives and injury. For example, the need for better rail inspections came after a derailment at Manchester, New York, in 1911. The particular accident resulted in the death of 29 people and injuries to 60 others. A railway crack detection system is using the sensors to detect defect and do data logging for the crack is detected. Then, the system will inform the maintenance team via GSM or SMS so that the repairing job could done faster. The Railroad Hand-Pump Section Car is a simple track maintenance vehicle made up of a platform built on 4 flanged railroad wheels and propelled by hand power. Rods, gears and cranks are utilized to enable the car to travel along the rails. These unique vehicles were created in the late 1850's and early 1860's.

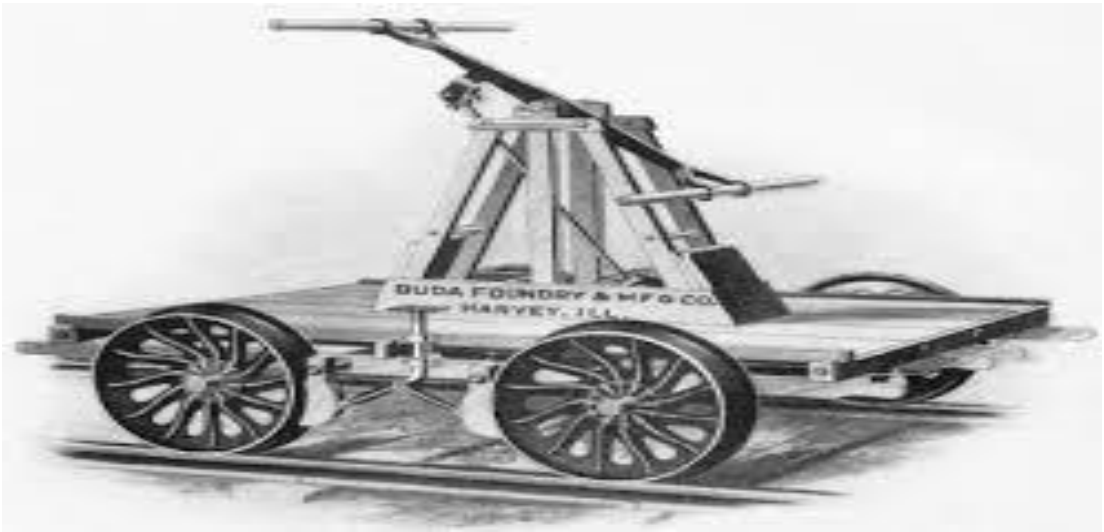

Figure 2.2: Railroad Hand-Pump Section Car

The 3-wheeled Velocipede Hand Car became popular and applied on American railroads during the 1880's. It was specially refashioned for the use of Road Masters, Bridge Inspectors, Telegraph Line Repairers, and Crosstie Inspectors. However, the Velocipede was convenient for all types of rail work where one or two men wished to go over the line at will. Velocipedes were mainly used by railway officials to personally check the portions of the line that came under their direct authority. The Velocipede permitted the official to stop wherever men were at work, giving them direction and paying attention to crack in form of defects he had noted during his journey. In this way, his section of railroad would be assured of being maintain in the best possible condition. The Velocipede is propelled by one person and has a seating capacity for two, allowing the driver or inspector to bring along an extra

section hand or another official. The vehicle is adjusting into motion by a rowing motion and auxiliary, foot pedal-power. The frame, wheels and outrigger are made of white ash, the frame are being firmly held together by bolts. The outrigger is stiffened by an iron brace. The tires are cast iron, the axles and crank shaft are iron, and the crank and pedals are made of malleable iron.

Figure 2.3: The 3-wheeled Velocipede Hand Car

Ex-Bristol and Exeter (B&E) Railway coach changed to a Divisional Engineer's Inspection Saloon by the Great Western Railway in circa 1900 and witnessed at Warwick on 25th January 1954 in its 1920s livery. This saloon carried British Railway's number W14643 and is probably the Wolverhampton Divisional Engineer's Inspection Saloon, which is understood to be the last of this type of coach to remain in service The coach lighting was also gas supplied from the cylinder tanks below the frame. When built in 1875, the coaches had four compartments plus a central luggage area. They also had six wheels, but the centre set of wheels had already been removed in the late 1880s prior to conversion.