DESIGN OF HIGH PERFORMANCE AND LOW COST AUTOMATIC TOLL PAYMENT SYSTEM

AMYRUL AZUAN BIN MOHD BAHAR

This report is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Wireless Communication) with Honours

Faculty of Electronics and Computer Engineering
Universiti Teknikal Malaysia Melaka

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Dedicated to the most supporting parents Mohd Bahar Bin Mohd Yusoff and Suminah Binti Ahmad Jalil, my siblings and to all my beloved persons.

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ABSTRACT

The proposed Automatic Toll Payment System is design for efficient and convenience use of public. The system is upgraded by using passive Radio Frequency Identification (RFID) technology instead of infrared that currently used nowadays to improved and make it low cost and have high performance toll payment system. Malaysian toll payment system such as Touch n' Go and SmartTag have the constrains that can lead to traffic congestion especially during festival period. The RFID system uses tags that are mounted on the windshield of vehicles, through which information embedded on the tags are read by long read range RFID reader. The passive RFID technology is come up with more advantages for public comfort. It is also less expensive since the passive RFID doesn't use internal power supply to operate and it provides high speed detection. As vehicles don't have to stop in a queue for make a payment, it assures time saving, fuel conservation, contributing in saving money, and at the same time reduced pollutions. Visual basic software is needed for implementation of the system for running the database of entire system. The interface that has been designed is used for output power and reading distance analysis before installation. The frequency analysis is carried out based on reading range from 1 meter to 5 meter for efficient speed detection. Every single frequency between 902.4 MHz to 927.8 MHz has been analysing to gain efficiency of tagging against times. There are frequency band that cannot detect the transponder and vice versa. So frequency configuration is important during installation for public convenience.

ABSTRAK

Tujuan Sistem Membayar Automatik Rangkaian Tol direka adalah untuk kecekapan dan memudahkan orang ramai. Sistem ini ditambah baik dari sistem yang sedia ada iaitu sistem inframerah dengan mengunakan Identifikasi Frekuensi Radio, (RFID) pasif teknologi untuk ditambah baik dari segi kos dan prestasi mengimbas kad identifikasi pengguna. Sistem Membayar Automatik di Malaysia seperti *Touch n' Go* dan *SmartTag* mempunyai beberapa masalah yang boleh mengakibatkan kesesakan trafik terutamanya pada musim perayaan. Sistem RFID ini menggunakan tag yang ditampal di cermin hadapan kenderaan, dimana segala data dan maklumat telah dimasukkan ke dalam kad pasif tersebut dan akan dibaca oleh alat pembaca RFID dari jarak yang jauh. RFID pasif memberi kelebihan kepada penguna untuk keselesaan bersama. Ia juga lebih murah dari segi kos memandangkan RFID pasif tag tidak menggunakan bateri dan ia mempunyai pengesan yang berkelajuan tinggi. Kenderaan pengguna tidak perlu beratur panjang sekaligus menjimatkan masa, minyak, wang ringgit dan dapat mengurangkan pencemaran udara. *Visual Basic* perisian perlu digunakan dalam pelaksanaan keseluruhan sistem ini untuk pangkalan data. Perisian yang telah direkabentuk digunakan untuk analisis kuasa keluaran dan jarak membaca sebelum pemasangan. Analisis frekuensi yang telah dijalankan berdasarkan jarak membaca dari satu meter sehingga lima meter untuk kecekapan pengesanan kelajuan. Setiap frekuensi antara 902.4 MHz sehingga 927.8 MHz telah dianalisis untuk mendapatkan kecekapan terhadap masa. Ada sesetengah frekuensi yang tidak dapat mengesan kad identifikasi dan sebaliknya. Jadi, konfigurasi alat pembaca amat penting ketika pemasangan sistem bagi kemudahan orang ramai.

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LIST OF ABBREVIATION

MHA	- Malaysian Highway Authority
MOW	- Ministry of Works
RFID	- Radio Frequency Identification
PIC	- Programmable Interface Controller
ID	- Identification
SLEX	- South Luzon Expressway
ETC	- Electronic Toll Collection
ETR	- Express Toll Route
OCR	- Optical Character Recognition
NATCS	- National Automatic Toll Collection System
NATCC	- National Automatic Toll Collection Center
OBU	- On-board units
GPS	- Global Positioning System
DSRC	- Digital short range communication
MLFF	- Multi Lane Free Flow
WORM	- Write once read-many
EIRP	- Equivalent Isotropic Radiated Power
IR	- Infrared

DTE	- Data Terminal Equipment
DCE	- Data Circuit-Terminating Equipment
LCD	- Liquid-Crystal Display
LED	- Light-Emitting Diode
BJT	- Bipolar Junction Transistor
MOSFET	- metal–oxide–semiconductor field-effect transistor
A/D	- Analogue to Digital
USART	- Universal Asynchronous Receiver Transmitter
IC	- Integrated Circuit
USD	- United Stated Dollar

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CHAPTER 1

INTRODUCTION

1.1 Project Introduction

Nowadays, our country has developed tremendously. However, these developments caused many effect on environment and civilization life itself. Every year new technology will be invent to save the cost, reduced pollution and decreased time consuming to make a better life for health, safety and welfare of the public. Malaysian Expressway Network can be considered as one of the best expressway network in Southeast Asia. The development of expressway is monitor by government agency, Malaysian Highway Authority (MHA) under Malaysian Ministry of Works (MOW). Cost and time consuming comes to be a priority factors for designing the whole automatic toll payment system.

Currently, SmartTag and Touch n' Go being used as an automatic toll payment system in Malaysia, but this project attempts as a new system that has

improvement on performance and less expensive in cost. As we can see, most of the toll booths still operated manually. Only several booths operated automatically with SmartTag system and it will slowing down traffic significantly.

Basically, for this project the system is replace by Radio Frequency Identification, (RFID) instead of infrared for transmit the information. It is compulsory for all the vehicle owners to have a registered RFID tag attached to their vehicles windshield. The tag owners should submit their details information to be saved on database and specified unique code will be embedded on the tag such as ID number, username, address, phone number, car registration number and date travelling.

RFID reader would be installed at the entrance and the end point of the expressway. These readers are connected directly to the Personal Computer (PC) unit via RS232 interface. PC will be used as monitoring system in this project. It works as the core project for controlling and monitoring the data base and signal received to process the information signal from the registered tag.

First of all, when the vehicles come to the entrance booth, RFID reader will transmit the signal to the tag on the user windshield. The tag will received the signal and charged enough energy to transmit back the information that embedded on the tag in the form of electromagnetic waves (identifying response). Then, the reader will send the information data received to the personal computer unit (PC) via RS232 wired interface. PC will process the signal by separating the ID and saved on the database.

Moreover, when the vehicles reach the end booth, the reader again will read the tag and PC system will compare the ID to indicate a right vehicle which is the same vehicle that passed at the first booth to let it pass exit gate.

1.2 Problem Statement

Every year the total number of vehicle production in Malaysia increasing significantly by depending on population civilization. The consequence is the number of expressway user increased dramatically and caused jammed along the routes and congested especially during festive seasons when traffic tends to be heavier than normal, at the same time wasting time, fuel, money and increased pollutions [1].

Most of the highway users nowadays make a toll payment manually on the booth and this will take a longer time and caused traffic jammed along the cash lane. Considering the current toll collection system by using Touch n' Go is more convenient but still need to stop for transaction and consume time.

The number on vehicles was increased over the years and at the same time increase the amount of fuels usage that contributed air pollutions to an environment especially during traffic congestion which time is taken for running engine will be longer and consume more fuels and money. If there are 100 vehicles every hour for each toll booth with more than 20 toll plaza all over Malaysia expressway, how much congestion can lead to problems? [2].

SmartTag can be described as the best and fastest current toll collection payment in Malaysia expressway. SmartTag is a device that works with combination of Touch 'n Go card to allow user to pay toll with drive through convenience. Currently, it transmits the information via infrared. However, the constrains of infrared are low speed detection and easy to interfere. The device is also expensive [1].

In order to avoid all these problems and inconvenience, this project will develop a high performance that dealing with speed detection and secure transaction method with a low cost manufacturing devices.

1.3 Project Objective

The idea is focusing on Automatic Toll Payment System that can operate conveniently and give advantages to the users and toll operator. The objective of this project:

i. To develop high performance and low cost Automatic Toll Payment System by using RFID technology.
ii. To analyse the effect of output power and distance of the detection with the frequency speed detection in RFID system.

1.4 Scope of Project

In this project, the main part that been covered is developing high performance and low cost Automatic Toll Payment System by using RFID. In order to achieve the objective of the project, there is several scope of work that needs to be considered:

i. The project focusing on designing low cost toll payment method with high performance which is high speed detection and secure transaction payment.
ii. This system is using passive RFID instead of active RFID that can be functioning without battery which is less expensive.
iii. Microsoft Visual Basic Express is used for the framework that is used to structure, plan, and control the information received.
iv. Several parameters analysis will be done such as reading range, output power and times per tagging.
v. Running the system at frequency of 902.4 MHz – 927.8 MHz

1.5 Thesis Outline

This thesis contains of five chapters. The first chapter concisely discusses the overview about the project such as Project Introduction, Project Objectives, Problem Statement, Scope of Work and Project Methodology.

Chapter II describes about the research and information which is the literature review of the project. Every facts and information, which are found through by any references has been selected. This literature review covers the whole things about the toll payment including other countries toll payment system technology. Further research that is related to the toll payment such as Smart Tag and also Touch n go has been done through this literature review.

Chapter III will discuss about the methodology that have been used in this project. Methodology is one of the most important things in planning of a project. The project must be understood first and then followed by further research about the previous projects that are related to this project.

Chapter IV describes about the result and discussion. In this chapter, the results of the project, all the problems encountered and discussion on the works will be presented. The results that presented here involving the hardware and software part.

Finally, Chapter V covers the conclusion and recommendation of the project. The conclusion describes about the task that have been completed for the entire two semesters. On the other hand, the recommendation part is added in order to give an opinion and also for further improvement on future works.

CHAPTER 2

LITERATURE REVIEW

2.1 Previous Study and Research

The electronic toll collection system is currently being used throughout the world. The countries that have applied the electronic toll collection system are Singapore, United States, Philippines, Japan, Canada, Poland and Malaysia itself among many others. Some research has been done to get the information about the main idea of the project.

2.1.1 Philippines Electronic Toll Collection

The Electronic Toll Collection, (ETC) system used in the Philippines has been implemented at the South Luzon Expressway (SLEX) since August 2000. The ETC is referred to as the E-PASS system, which uses Transcode technology. Here,

electronic transponders are placed in front of a vehicle's review mirror. Each time a vehicle enters the toll booth, the tag is read by the receiver, automatically identifying the account and debiting the toll fee amount from the corresponding account. Once the amount has been debited, the control gate will lift and the vehicle is allowed to pass through [2]. The advantage of the system is that the amounts of toll fees will be deduct straight away right after second scanning at exit point of the toll plaza.

2.1.2 Canada Express Toll Route

The electronic collection system used in Canada is known as the 407 Express Toll Route (ETR), which is one of the most sophisticated toll expressways in the world. The Canada 407 ETR is a closed-access toll road, which means that there are gantries placed at the entrance and exit points of each toll. In this system, cameras are equipped with Optical Character Recognition (OCR). The OCR cameras are used to photograph license plate numbers of vehicles that do not have transponders (tag). The toll bill will then be sent directly to the registered address of the vehicle owners. Monthly bill statement will be mailed to users. Other than that, two laser beam scanners are placed above the roadway to detect the types of vehicles passing through the gantries. Nevertheless, this toll road bears a very high infrastructure cost, and the users are the ones who help recover the cost through increments in their toll bills [3].

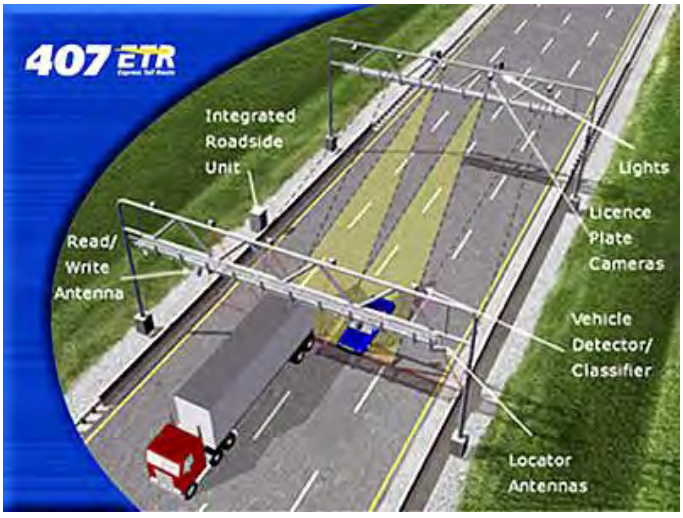

Figure 2.1: Canada's 407 ETR for ETC [6]

2.1.3 United States Toll Collection System

In 2007, Tang et al, filed a US patent on their proposed ETC system. Their proposed system provides two lanes: one on the side and the other where overhead-based antennas are installed per lane. Both antennas are used for conducting toll transactions. Of the two, the side antenna will act as a backup in case the overhead antenna fails to capture the signal emitted from the vehicles. In the case of a failure, the overhead antenna will be deactivated, and the side antenna will be activated. If the side antenna also fails, then an error signal will be issued [4].

2.1.4 Poland National Automatic Toll System

The ETC system used in Poland has been proposed by the Motor Transport Institute along with the University of Technology in Warsaw and Dublin. This system is called the National Automatic Toll Collection System (NATCS), and consists of the National Automatic Toll Collection Center (NATCC), control gates, and On-Board Units (OBU). The NATCS uses a combination of mobile telecommunication technology (GSM) with satellite-based Global Positioning System (GPS). Using GPS technology, the OBUs determine the kilometres that have been driven, calculate the toll fees and rates, and then transmit the information to the NATCS computer center. Each vehicle will be charged from the highway entrance up until the end of the highway. In order to identify the plate numbers of trucks, the system has control gates equipped with digital short range communication (DSRC) detection equipment and high resolution cameras [5]. Due to the technical specifications, this system incurs a high cost for motorists.

2.1.5 Malaysia SmartTag System

Currently, Malaysia toll payment system is divided by 3 systems. Firstly, manual toll lane (cash lane) by using ticket to indicate the entrance booth. Secondly, Touch n' Go system which is the smartcard that have information embedded on it