RFID ANTI-THEFT SECURITY AND POWER REGENERATIVE SYSTEM FOR SHOPPING CART

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ABSTRACT

RFID Anti-Theft Security and Power Regenerative System for Shopping Cart offers a reliable and a low cost design to prevent shopping cart from missing. Many retail store companies face the problem of missing shopping cart because it regularly happen, and it cost them a big loss. In this case, shoppers seem to push the shopping cart away from the shopping compound and later the cart will be abandoned outside the shopping compound. Currently, a simple security system that use coins or token had been developed to prevent the cart being placed outside of the shopping compound, but the system is proven not quite effective to prevent the missing cart problem. Therefore, this system is proposed in order to achieve several objectives which are to reduce number of missing carts, to provide systematic management of carts via RFID, to prevent inconvenience cause at parking lot by abandoned carts and also to design a sustainable system which can recharge the battery by its own. Active RFID unidirectional wireless communication between both shopping cart (receiver) and shopping compound entrance or exit gate (transmitter) will initiate the locking mechanism which leads the carts' wheels get locked. This system also has power regenerative system that is to charge the main battery by using a dynamo. Highly secured, reliable and low cost anti-theft system is expected to be developed.

ABSTRAK

Sistem keselamatan anti-kecurian RFID dengan sistem penjanaan kuasa untuk troli membeli belah menawarkan reka bentuk yang murah dan dipercayai untuk menghalang troli membeli belah daripada hilang.Kebanyakan syarikat membeli belah menghadapi kerugian besar akibat kehilangan troli yang kerap. Dalam hal ini, pembeli belah selalunya menolak troli membeli-belah ke kawasan yang lebih jauh dari kawasan membeli-belah dan kemudian tinggalkan troli itu di luar kawasan membeli-belah. Pada masa kini, satu sistem yang mudah yang menggunakan menggunakan syiling atau token telah di cipta bagi mengelakkan troli itu berada di luar sekitar kawasan membeli-belah, tetapi sistem ini terbukti tidak cukup berkesan untuk mencegah masalah kehilangan troli. Oleh itu, sistem ini dicadangkan untuk mencapai beberapa objektif iaitu mengurangkan bilangan troli hilang, untuk menyediakan pengurusan yang sistematik troli melalui RFID , untuk mengelakkan berlaku kesulitan di tempat kereta kerana troli tersebut dan juga untuk mereka bentuk sistem yang mampan yang boleh mengecas bateri dengan sendiri. Active RFID unidirectional wireless communication between both shopping cart (receiver) and shopping compound entrance or exit gate (transmitter) will initiate the locking mechanism which leads the carts' wheels get locked. Sistem ini juga mempunyai kuasa regeneratif iaitu untuk mengecas bateri utama dengan menggunakan dinamo. Terjamin selamat, dipercayai dan sistem telah dibangunkan dengan kos yang rendah. Komunikasi tanpa wayar RFID aktif antara troli (penerima) dan pintu pusat membeli-belah (pemancar) akan mengaktifkan mekanisme pengunci yang boleh mengunci roda troli tersebut.

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CHAPTER 1

INTRODUCTION

This chapter explains about project background, problem statement, objectives, scope of the project and also thesis outline.

1.1 Project Background

Shopping cart is a cart supplied by retail store for customer use to carry their goods around the shopping floor until the payment counter. Most of the customers use the shopping cart to carry their purchased goods until the car parking area, and sometimes until outside of the shopping complex. Previously shoppers have to use token or coin to use the cart, and they can retrieve back the token or coin when put back the cart into its parking area. Unfortunately, nowadays those systems no longer being implemented as it is not efficient or proven in order to prevent the cart from being missing. A shopping cart cost ranging from MYR 800 to MYR 1500 depends on size and build quality.

This projects utilizes RFID wireless technology and a locking mechanism for the shopping cart's wheel. RFID is famous for its stability against interference and robust security level which prevents people to hack the communication. RFID comes in many types of packages such as passive RFID, semi-active RFID and active RFID. Passive RFID is the cheapest one whereas the active RFID is the most expensive.

Passive RFID normally use a tag (transmitter) which absorbs energy transmitted by a receiver while both tag and receiver in touch, and then transmit its identification code back to the receiver. After that the receiver will analyse and identify the identification code received from the tag, and then proceed to next process. In contrast, the active RFID transmitter uses own power supply unlike tag which depends on receiver's signal power. This means the receiver still can receive the identification code from the transmitter even if the transmitter in distant. The more distance an RFID coverage goes, the more it become expensive. In this project design, RFID transmitter will be placed at every entrance and exit gate of shopping complex compound, while the RFID receiver will be placed inside the shopping cart.

To control the whole system PIC16F84A [7] microcontroller will be used because it is cheap and easily available in market. This controller will receive signals from the RFID receiver circuit, then it will initiate the locking mechanism of the shopping cart. Solenoid has been chosen as the locking component since it can be activated easily by combining switching circuit with a microcontroller. Two units of dynamo will be used to convert mechanical motion from the cart's wheel to electric energy for system's battery charging purpose.

1.2 Problem Statement

Shopping cart missing phenomena regularly occurs around the world. According to survey done by N. Othman [1] around Melaka, Malaysia, almost 70 units of shopping cart reported missing yearly in Mydin MITC, and Jusco Melaka. Figure 1.1 and Figure 1.2 clearly shows the number of missing carts.

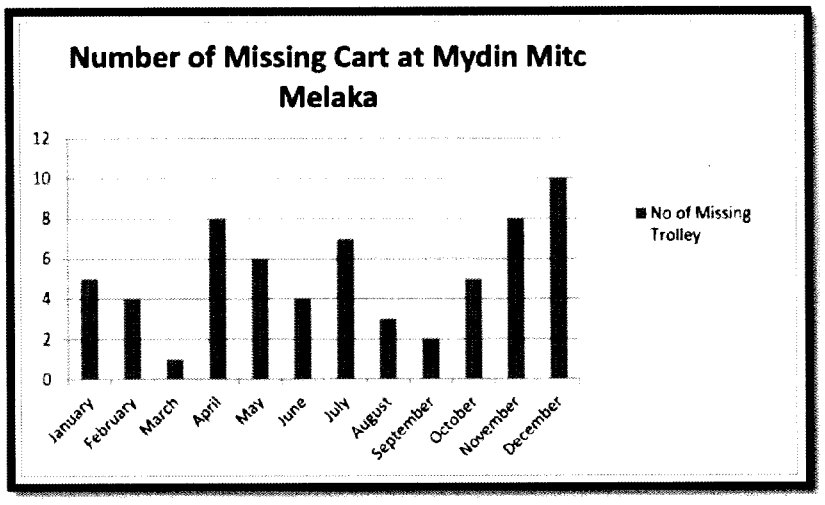

Figure 1.1: Missing cart statistics in Mydin MITC for year 2012 [1]

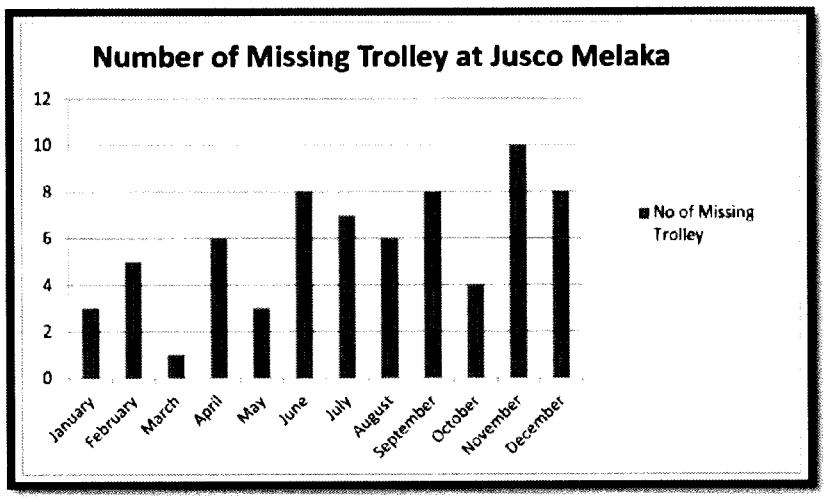

Figure 1.2: Missing cart statistics in Jusco Melaka for year 2012 [1]

Such phenomena much be avoided as it cost much for the retail store owners. Below Figure 1.3 shows a worker gathering back the cart which has been pushed away from the shopping complex by customer. This scenario happened nearby Kiara Square, Bahau. From these, we can simply tell that this problem getting serious and there is no proper solution until today.

Figure 1.3: A worker gather back missing cart at Kiara Square, Bahau

The summary of problem statements are:

(a) Shopping cart pushed far away from hypermarket or mall.
(b) Hire extra workforce to retrieve the carts. Extra, unwanted cost.
(c) If not retrievable, consider lost. Costly to replace, thus increase operational cost.
(d) Shopping carts left at parking lots causing inconvenience to shoppers to park their cars.
(e) Shortage of carts due to missing carts creates bad image to the retailer.
(f) Abandoned carts creates nuisance to surrounding community.

1.3 Objectives

There are many shopping cart security systems have been developed but those system is proven not so effective in preventing the missing cart problem. Hence this project has been designed to cover several important aspects such as reliability, robustness and efficiency. This project is known as "RFID Anti-Theft Security and Power Regenerative System for Shopping Cart" and the objectives are:

(a) To reduce number of missing carts at hypermarkets and shopping malls.
(b) To provide systematic management of carts via RFID: Each cart will have own, unique id.

(c) To prevent inconvenience caused at parking lots by abandoned carts.

(d) To design a sustainable system which can recharge the battery by its own.

1.4 Scope of Project

To achieve the objectives, the project is divided into 3 main parts which is shopping cart's wheel locking mechanism, RFID communication, and finally the controller circuit. The locking mechanism is consist of 2 units of 12V DC solenoid for each rear wheel, the wheel which its design is compatible with installed solenoid. Active RFID receiver and transmitter circuit which has been used to cover for 8 meters radius coverage because main exit or main entrance gate in any shopping mall is almost 8 meters length. The RFID receiver is interfaced with PIC16F877A and then this microcontroller will activate the DC solenoid if RFID receiver gives signal to it. The whole microcontroller circuit will be designed in a single PCB along with relay switching circuit and power circuits.

1.5 Thesis Outline

This report is covered by five chapters. The first chapter starts with project background, problem statement, objectives, scope of project and thesis outline. The literature review were discussed in chapter 2 and project methodology in chapter 3. The chapter 4 covers result and discussion, and finally conclusion and recommendation are respectively covered in chapter 5. For the project to be successfully implemented, there are several areas to look in to. The following are the main chapters:

(a) *Chapter I: Study the objectives and scope of work on the project.*

The aim of this project is to design and develop a shopping cart anti-theft security system by using a transmitter, receiver and special wheel to overcome the problem.

(b) Chapter II: Literature review about shopping cart anti-theft security system, important components and relevant hardware.

Research and read up relevant topics from sources such as reference book, internet and journal will enable to gain more understanding and information for project. Research on similar system in the market and knowing what are the features and capabilities of current products will also provide more information and understanding on the project.

(c) *Chapter III: Project methodology includes the planning, the development of the design and the management of the project.*

This chapter will explain more about the project methodology used in the project. This part will explain more about the project path from the beginning until it is completed. Every work flow that has been done in this project should be explained step by step

(d) *Chapter IV: Implementation, problems faced and the solution.*

The fourth chapter should focus on hardware and simulation of the design circuit. This chapter also shows about testing process. Testing will be performed on each individual module on both hardware and software of the system.

(e) *Chapter V: Conclusions and suggestions on the project.*

The last chapter will review on the project, whether the implemented solution meet the objective of the project. Discussion on problems encountered, conclusions and suggestions will be included for the future improvements on this project.

CHAPTER 2

LITERATURE REVIEW

This chapter discuss about other related projects, hardware, tool, and important component for this project. These related works have been studied prudently in order to enhance the quality and reliability of this project. By analysing the ideas of previous researchers, we get to know that these project lacks in certain area and same time it has their own quality too. By studying the preceding works, a proper design on how this project can be led and the features that have to be added in order to make this project become reliable and marketable. As well that, there are a little findings from internet and books that are extremely contributes to this project. Throughout the analysis at the beginning of the project, the special feature in this project is determined and the components used in this project are decided. In addition, the function and the concept are well understood.

2.1 Related Projects

Previously many security systems for shopping cart was developed but all of them has some lacking in terms of stability, performance, reliability and cost. However, all these projects are giving some useful recommendations and it is considerable for this project. Here in this segment, previous projects will be discussed particularly about its strength, weakness and recommendations.

2.1.1 Overview of Projects

One of the similar project is Shopping Cart Anti-Theft System by N. Othman [1]. The system utilize 433 MHz RF for communication and simple locking method by using solenoid. This project also involves some techniques in measuring distance of the signal transmitted between transmitter and receiver for triggering the circuit. Transmitter will send a signal to the receiver, and whenever the signal from transmitter did not received by receiver, it will trigger switching circuit which consists of relay, diode and transistor. Thus, solenoid will be pushed down to lock the wheel and prevent the cart from being pushed away from supermarket. Besides, the system's compartment also has been designed to ensure the components in the system not affected by environmental factor. However, the main drawback of the system is RF signals is easy to get interfere with other signal or sometimes the communication between RF transmitter and receiver may break due to environmental factor such as heavy rain. Besides, short distance signal transmission may occur in certain phenomena. Hence, the RFID was proposed by the designer to solve these problems. Figure 2.1 shows the locking mechanism of this project. Solenoid was used because of its low power consumption and yet it is cheap. The designer did not design the wheel of the cart to fully suitable with the solenoid, in other words the solenoid needs proper mechanical arrangement to lock the wheel firmly.

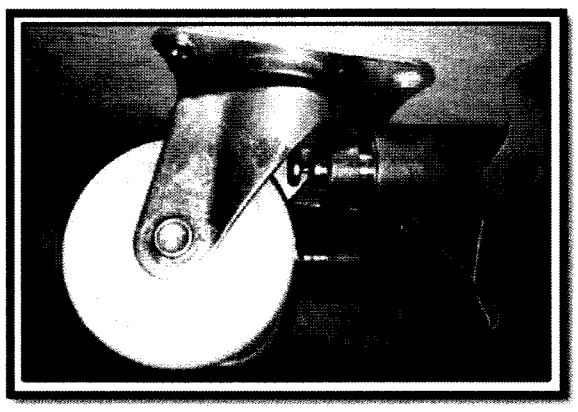

Figure 2.1: Simple locking mechanism proposed by N. Othman [1]

Another system is Shopping Cart Theft Prevention System by Anthony M.D. Paolo and John T. Hood [2]. This system designed particularly for security purpose

where it prevents the theft to steal the shopping carts from a parking lot. The parking lot has at least one entrance and exit driveway. The system includes a magnet mounted on the shopping cart and an actuator buried below the surface of the driveway for generating a signal in response to passage of the cart with the magnet over the driveway. The actuator extends transversely with respect to the magnetic pole inside the shopping cart. An alarm issues a warning in response to the signal generated by the actuator. This system also for monitoring the unauthorized entry into restricted area by having a door with magnet and an actuator which is controlled by the magnet to produce signals for opening the door. The sensor is connected to a power source whereby upon passage of a magnet proximate to the sensor at any point along the length of the sensor, one of the reed switches of the sensor is responsive to the passage of the magnet proximate to the reed switch for generating signal. Figure 2.2 below shows the design system proposed by Anthony M.D. Paolo and John T. Hood. The disadvantage of the design is it depends on magnet to be activated. The magnet will act as a switch; it will turn on or turn off the system. Thus, the magnet needs to be protected from missing. Other than that, the system is a passive system, which requires magnet to activate it.

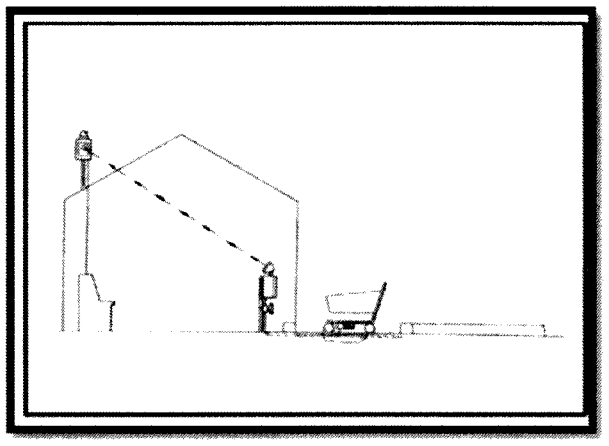

Figure 2.2: Proposed system by Anthony M.D. Paolo and John T. Hood [2]

Meanwhile, Larry W. Goldstein proposed a system named Shopping Cart Anti-Theft System, SCATS [3]. This project is focusing on anti-theft assembly for shopping carts including a housing adapted to fit adjacent a wheel of a cart, a receiver within the housing for sensing the passage of the cart beyond a preselected range and providing a signal indicative thereof, and an arrangement responsive to the signal for lowering an arm into the direct path of the adjacent wheel. The clamp-on assembly houses a

battery-powered receiver for sensing when cart leaves the area adjacent the business and has means for disabling the wheels of the shopping cart when the shopping cart is outside the area. A mechanical arrangement is provided within the clamp-on assembly which responds to signals from the receiver to disable the cart by causing at least one of its wheels to turn to an angle such that the cart must be driven in circle. The clamp-on arrangement required little power to operate and thus, it can function for a longer period of time at least for about five years before its batteries need to be replaced. Figure 2.3 and Figure 2.4 shows design system by Larry W. Goldstein.

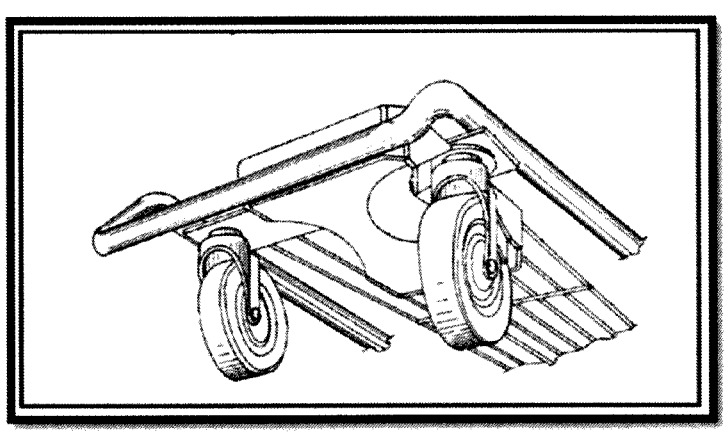

Figure 2.3: Bottom view of the design by Larry W. Goldstein [3]

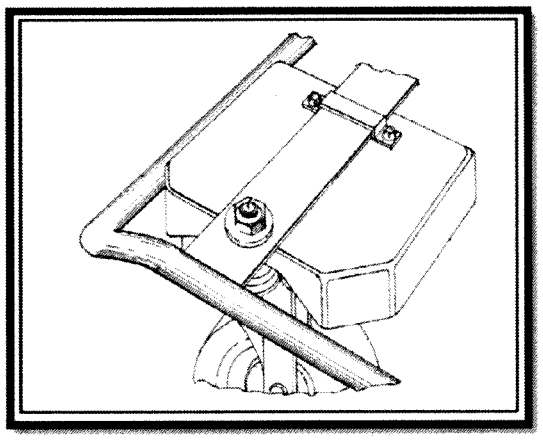

Figure 2.4: Top view of the design by Larry W. Goldstein [3]

On the other hand, Jeffrey J. Lace proposed a system called Anti-Theft Vehicle System. The system is designed for a vehicle wheel having a rotational axis includes at least one inhibitor disposed within the vehicle wheel to selectively engage the vehicle wheel. This is to prevent the vehicle from rotating about its rotational axis.