Secure Access Solutions using Passive Radio Frequency Identification Technology

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Abstract- RFID based security and tracking applications are one of the growing trends, integrating in all the sectors of modern day industries. High-end applications are proved to be more secure via the RFID system, than the traditional mechanical lock and key system because of the difficulties in duplication of the key in case of RFID systems. The focus of this paper will be on Passive RFID technology for two-wheeler vehicles in the automotive sector. Hardware implementation of a security module using RFID for motorcycles is shown.

Keywords – Passive RFID, active RFID, identification, secure access, keyless entry, two-wheeler vehicles.

I. INTRODUCTION

Evolving technology with RFID based devices for security is one of the growing areas in all sectors. RFID is a recent wireless technology used for identification purposes. RFID uses electromagnetic fields to automatically identify and track tags attached to objects. Each tag contains a unique serial number which helps in the identification. The different types of RFID tags include passive tags, active tags and battery assisted passive tags. Passive tags do not have a primary power source, so they use the interrogating radio waves of a nearby RFID reader to power themselves and transmit stored data. Active tags have a primary power source and emit stored data continuously, regardless of whether it is in the field range of the reader. Battery assisted passive tags wait for a signal from an RFID reader before they respond. Once they get a signal, the internal power source turns on and powers the tag to return a signal to the RFID reader.

Many researchers have utilized RFID technology in developing access control systems and passive RFID modules. Various applications of RFID technology is discussed in [1-2]. Alírio J. Soares Boaventura [3] discusses a TV remote consisting of N passive RFID chips and N switches. The RFID chips are connected to a single antenna with the help of a multi-port micro strip network. Each key of the remote control is associated to an RFID chip with a unique identifier, which allows the device to be controlled to identify the key pressed by the user. Passive RFIDs are also being rapidly adopted in secure access to buildings and automobiles. Shital Y. Gaikwad [4] discusses a security system that was developed for cars using RFID, biometrics, steering lock, GSM and GPS technologies. To unlock the car, the person is asked for a valid RFID identification. Accelerometer sensors are used to detect breaking of windows or movement of the car. A camera is also placed in the car that captures an image of the person in the car. G. Ostojic [5] designed a passive RFID system to automate the entry, exit and payment at parking lots. The system uses a reader that reads data from the ticket given to the parking place user, displays information like the amount of time spent in the parking place and the amount payable, on a monitor for the user to see, and lifts the barrier to allow the user to exit the parking once the amount has been successfully deducted from the card. Secured access to hostel rooms or work place to track people based on RFID is reported in [6-7]. An RFID based digital door lock is discussed in [8]. Automation of bike renting process using RFID is reported in [9]. Even in the area of ticket management in public transport system RFID technology is used [10].

This paper focuses on the designing and development of a security module for motorcycles using Passive RFID technology. The paper is organized as follows: background theory of RFID technology is given in section II.

Methodology is discussed in section III. Section IV discusses hardware implementation. Conclusions are drawn in section V.

II. METHODOLOGY

2.1 System design

This portion of the paper explains the working and sequence of operation for the fundamental units of an RFID system which includes a Passive RFID tag and a base module for the integrated security measures for a typical two-wheeler automotive in India.

2.2 Electronic Design

This section of the paper concentrates on the implementation and fabrication of the RFID system. As explained above, the hardware unit will consist of a Passive RFID tag, easily available in the market, and a base module consisting of an RFID reader, MCU unit, alarm system and motors for actuating the authorized access to the plant, in two-wheel drive in our experiment.

2.2.1 Passive RFID Tag

Passive RFID tags and readers come in different frequency ranges, but the most commonly used tags are those having frequencies of 125 kHz and 13.56 MHz. We used 125kHz frequency tags; they are read-only tags, because of which they are very hard to duplicate and hence are economically feasible and can be used as an integrated security measure as a solution for the spiking rate of two-wheeler thefts in India because of the traditional mechanical lock system. The 13.56MHz frequency tags are more complex. They have advance functions like reading/writing data and communication using encrypted protocols. They are more suitable for ticketing. A passive tag is an RFID tag that does not have a power source of its own; the power is supplied by the interrogating waves of the RFID reader. An RFID tag consists of an antenna and an integrated circuit. The antenna is used to receive and transmit signals to the nearby RFID reader as shown in Fig.1. Fig. 2 shows a typical key ring type passive RFID tag.

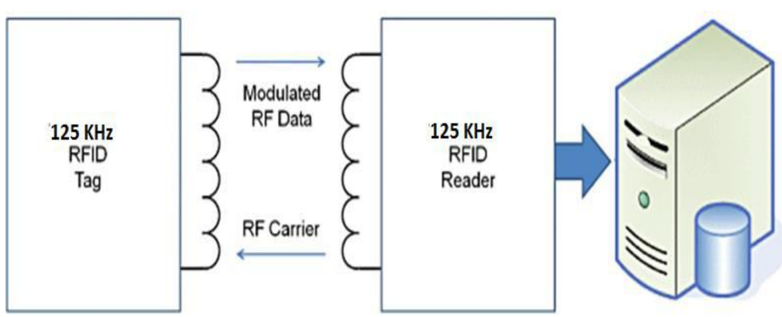

Fig. 1 Data exchange between RFID tag and reader. (source: www.sensormag.com)

Fig. 2 Key ring type passive RFID tag (source: www.aliexpress.com)

2.2.2 Base Module

Fig. 3 shows the base module which consists of an Atmel Atmega88 microcontroller that is responsible for controlling different functions for the desired operation of the system including secure access to the ignition system, steering lock and an alarm system in case of unauthorized access.

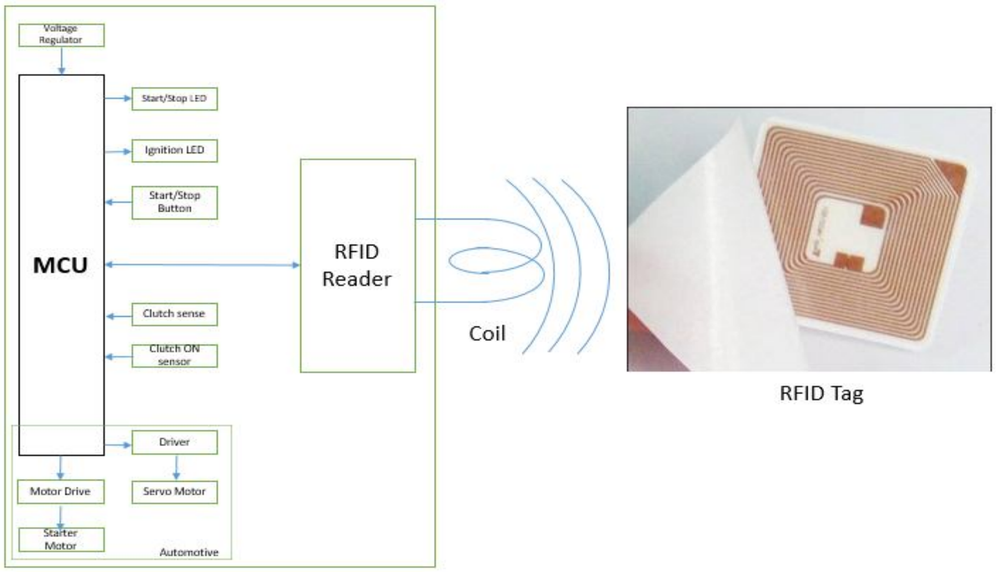

Fig. 3 Base Module block diagram

The servo motor and DC motor, used for steering lock mechanism and ignition mechanism respectively, are being driven with the help of MOSFETs. The buzzer for the alarm system is being driven with the help of a transistor. There are 3 LEDs in this module as acknowledgement interface, including the status LED, ignition status LED and handle lock LED. There are 4 switches connected to the microcontroller. These are for ignition, clutch sense, handle lock and reset.

A EM-18 RFID receiver is connected to the MCU through the serial data pin (Rx). The receiver requires 5V to function, and hence is being powered by a Texas Instruments REG-104 voltage regulator. The servo motor is interfaced with the microcontroller through a MOSFET which acts as a solid state driver.

A servo motor is interfaced with the microcontroller through a MOSFET which acts as a solid state driver. The servo motor is being used to denote the locking and unlocking mechanism of the bike handle. The servo motor is capable of rotating 180˚. The motor is required to rotate 90˚ and hence a servo motor was used.

A 100rpm, 5V DC motor is being used to denote the engine running mechanism of a motorcycle. A 5V buzzer is also interfaced to make different sounds upon using a valid or invalid tag. It also acts as an alarm system.

2.3 Software Implementation

Controller programming for the verification of the received tag signals and the interfacing of other peripheral devices to be accessed through the system is discussed briefly in this section in the form of an algorithm which is shown in Fig..4. Modular programming approach has been taken, so that modifications and scaling can be done easily. In modular programming technique, each functionality of the program is divided into independent interchangeable modules making it easier to edit certain parts of the program without affecting the whole code.

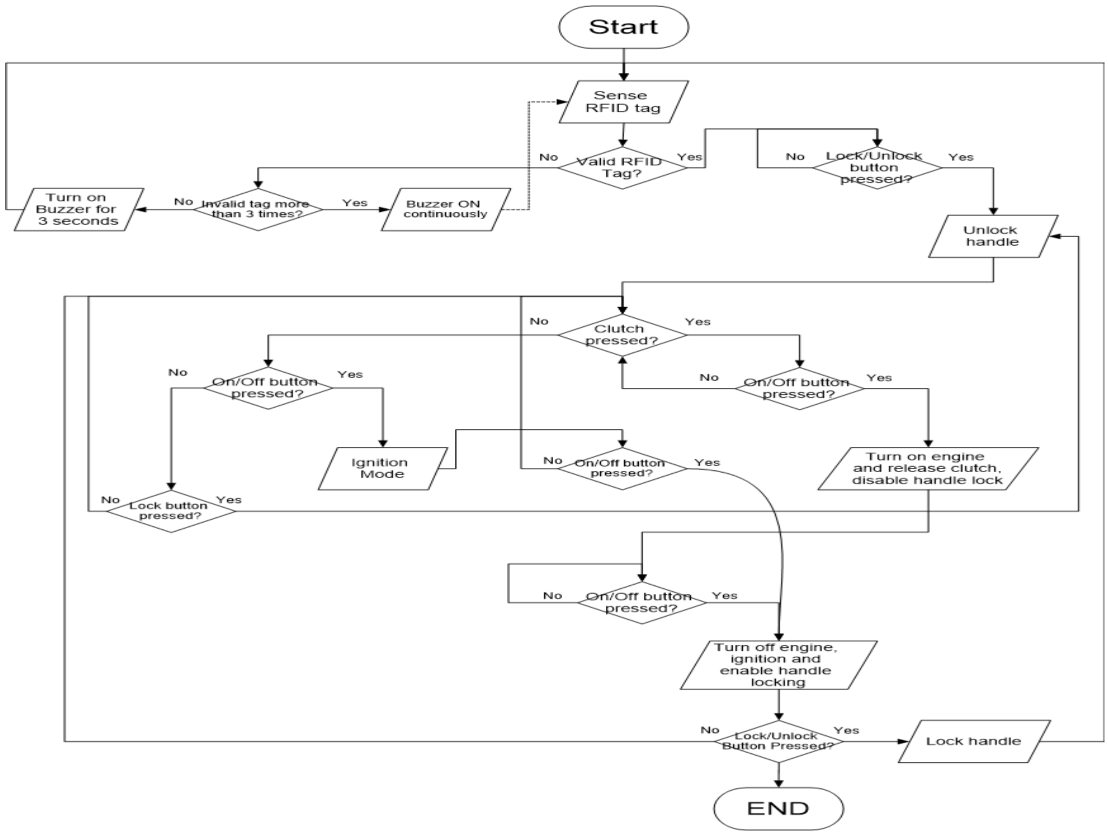

Fig. 4 Flow chart

The RFID receiver starts sensing tags when the circuit is powered up. When it senses a tag, it extracts the digital data that is stored on the tag by communicating with it in the form of modulated signals. If the data extracted from the tag does not match the data on the MCU, the buzzer sounds a long beep. If an invalid tag is sensed more than 3 times, the buzzer beeps indefinitely until a valid tag is sensed. This can also alert passers-by of a potential theft.

If the data on the tag matches the data on the microcontroller, the user gets access to the bike. The user is then able to unlock the bike handle and turn on the ignition. The lock handle button is disabled as soon as the ignition is turned on. This is done to prevent accidental locking of the bike handle. The user can turn on the engine by pressing the clutch and ignition button together. When in ignition mode or engine on mode, pressing the ignition button again turns off the bike and enables the lock switch. The user can then lock the bike again.

There are LEDs to notify the user of the current status of the system. There is a handle lock LED which turns off when the handle is unlocked and turns back on when the handle is locked. There is also an LED for the ignition status which turns on when the ignition button is pressed and the bike enters accessory mode or the engine is turned on. These notification LEDs eliminate the need for an LCD to notify the user about the same. The LEDs along with the buzzer are sufficient to notify about the status.

III. HARDWARE IMPLEMENTATION

The hardware was successfully designed and developed. Upon assembly of the circuit and its final testing with the complete program, we got the expected outcome. The security features worked as planned. The invalid tag was not accepted with a long buzzing from the buzzer. The buzzer stayed on when the invalid tag was used more than 3 times and turned off only when a valid tag was used. The user was only given access whenever a valid tag was used and the motors worked as desired for denoting the locking and unlocking mechanism of the handle and the engine running mechanism of the bike engine.

Initially, the data of each tag was read and stored in the EEPROM. This helped in keeping a record of the data and writing the code in such a way that only 2 of the 3 tags were accepted. Due to switch bouncing, i.e., the switch acting as if it has been pressed multiple times upon being pressed once, debouncing capacitors were used. Once all the components were confirmed to function properly as desired, the different parts of the code were combined and tested to be working properly. Fig.5 shows the developed security module for motorcycles.

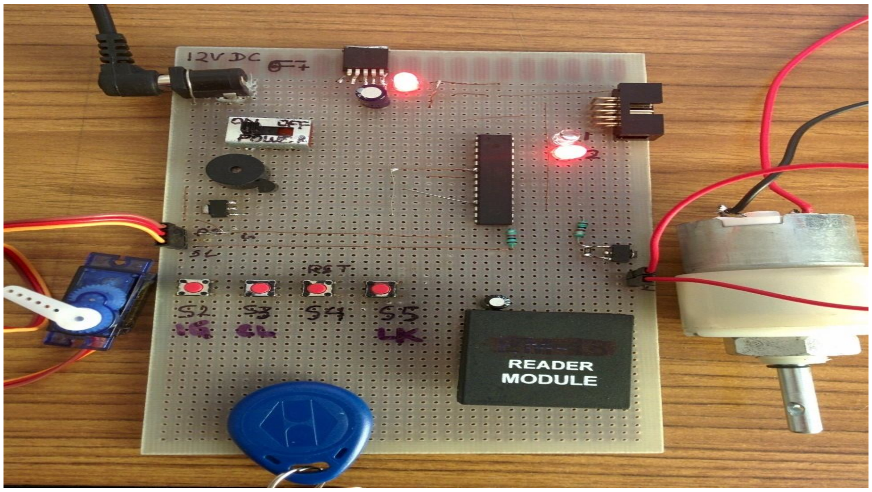

Fig. 5 Developed RFID system prototype

IV. CONCLUSION

The aim of the paper was to design and develop a security solution for motorcycles that was both economically feasible and easy to use. Such a solution was developed successfully. The system is easy to use and the production cost is also low. The final outcome proved that in addition to making the process of turning on the ignition a lot easier and faster compared to the mechanical system, this security system is comparatively more secure than the typical mechanical lock and key method currently being used in motorcycles since it cannot be re-programmed, nor can the reader be tampered with. Since a passive key is being used, the data isn't being constantly transmitted. The data is transmitted only when it gets powered by the receiver. This eliminates the possibility of someone being able to access the data from a distance and develop a duplicate tag with that data.

In case the key is stolen or lost and is being used by someone else, the other person would also be able to get access to the controls of the bike just like the original user. This drawback is also present in cars as well. Anyone having the key can access the controls and ignition of the vehicle.

Further work on this solution in the future may lead to better security options, like the addition of the GSM module. The system can be reinforced with biometric scan for the secondary access to the vehicle including steering lock and ignition control while RFID is only limited for the primary access of the vehicle doors. The system may become even more compact in size making it easier to add more features for the root application.

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