Design of an Identification System and Automated Access Control using RFID technology for the University canteen of the UNSA

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Abstract– An automated identification and control system has been developed to optimize the entry of students to the University dining room at the National University of San Agustin. The system of attendance and authentication is scalable, reliable and secure. The prototype consists of a master microcontroller with 2 slaves of RFID readers for a 13.56MHz frequency and works with two photoelectric proximity sensors, four actuators of pulse width modulation controlled servo motors (PWM) with a period of 20ms and a tape RGB smart led signaling. The purpose is to automate the entry of students so that long queues do not form while reporting on the attendance of students. Then, the proposal is to use a PWM control algorithm, which will run on the Atmega2560 master microcontroller, which is linked to a server. The database on the server verifies the identity and status of the student through a Java Netbeans graphical interface. The system is optimized to receive a rapid response and to function without line of sight of the tags.

Keywords-- RFID, control PWM,tag,Java Netbeans,sensor.

I. Introduction

Radio frequency identification (RFID) technology has been developing over the past few years, with the participation of several researchers who are spending their time developing low-cost and longer-lasting RFID systems using artificial intelligence, tools for decision making and the use of a variety of sensors that are used in different sectors [1], [2]. RFID technology is a key technology in daily life because, i.e. issuing tickets, payments, passports, car keys and a variety of access control systems.[3], [4]. Currently there are identification systems, applied to access control, based on biometric systems, bar codes and RFID cards.

Therefore, the incorporation of RFID on Internet of Things (IoT) alouds to obtain an automatic large-scale label monitoring system using a well designed algorithm. [5], [6]. Security is an important part in radiofrequency identification technology to ensure that user data is not stolen. Systems that have authentication data stored in the cloud need to process data from IoT devices in a secure way, approving or denying access without compromising data security. [7], [8].

The National Superintendence of Higher University Education (SUNEDU) is a government body responsible for the licensing of Universities in Peru to offer higher education service. The institution is responsible for verifyingcompliance with quality improvement and supervising public investment with the aim of improving the quality of higher education [9]. There are currently 51 public universities and students can apply to have access to the University canteen and this access is enabled on their student cards.

This work develops an automatic RFID system to increase control efficiency and optimization of data retrieval time, with Electromagnetic wireless technology. Our technology identifies a code incorporated in the university card and carry out an efficient look up of the person's identity. This work performs better, has a lower weight, a lower setup cost and has a lower maintenance cost than other systems such as biometric or barcode based systems. [10]

This article is developed as follows: Section II describes the reference frame used for the RFID antenna, Section III gives a brief explanation about the PWM control, in section IV it presents implementation of the control system, in Section V describes the prototype of the system and the interface platform and section VI shows the results obtained in the tests performed.

II. AERIAL REFERENCE FRAMEWORK 13.56MHZ

A. *Framework*

The RFID-MFRC522 reader module [11] is one of the main components within our 13.56MHz high frequency system that complies with the basic Faraday electromagnetic induction law, as shown in the Fig. 1.

The loop antenna produced by the magnetic field is given by the following equation: the magnetic field(Bz) produced loop antenna is given by:

$$B_z = \frac{\mu_0 I N r^2}{2\left(r^2+d^2\right)^{\frac{3}{2}}} \tag{1}$$

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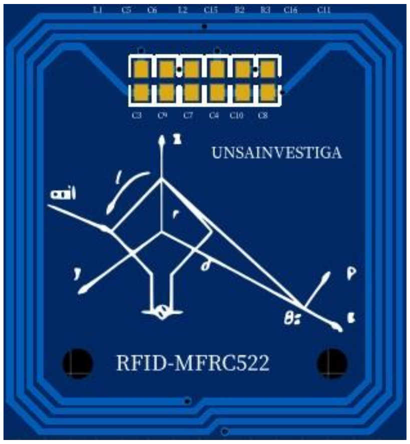

Fig. 1. Antenna MFRC522 normal direction of magnetic induction intensity

$$B_z = \frac{\mu_0 I N r^2}{2d^3} \quad d^2 >> r^2 \tag{2}$$

Where

I = current, N = the number of turns of antenna coil, r= radius of loop, d = distance from the center of wire and $\mu_0 = 4pix10^{-7}\frac{Henry}{meter}$ is permeability of free space .

Equation (1) shows that magnetic field is proportional to the number of turns of antenna coil and current. So, an increase of the number of turns of antenna and improving reader's power can effectively improve the reader range. When d2 >> r2, equation (2) shows that increasing the radius of antenna coil can improve the reader range.

The MFRC522 Antenna acts as a slave, has an integrated read / write circuit with a highly integrated operating distance of up to 50mm for contactless communication at a low power 13.56MHz frequency and is designed to communicate with ISO / IEC cards and transponders 14443A and cell phones with Near Field Communication (NFC) technology. The receiver module providing an implementation in the bit frame with error detection (parity and CRC) with robustness and efficiency to demodulate and decode signals with an Serial Peripheral Interface (SPI) communication protocol up to a 10Mbits / s transfer rate.

B. Faraday law of electromagnetic induction

The operating mode of the 13.56MHz RFID system is coupled inductance, when the tag antenna is close to the reader antenna, the magnetic field produced by the MFRC522 reader, the antenna will pass through the closed tag antenna.

According to Faraday's law of electromagnetic induction, the tag antenna will produce induced voltage (V). When V reaches the minimum working voltage of the label, the tag will start working. Then, the label sends a corresponding signal to the reader according to the label protocol used, the reader begins to identify the label.

Figure 2 shows a working design of the antenna in a RFID system of 13.56MHz following Equation (3). When the magnetic flux density generated by the reader's antenna coil is B, the area of the the coil is S, the magnetic flux through the antenna plane the coil is:

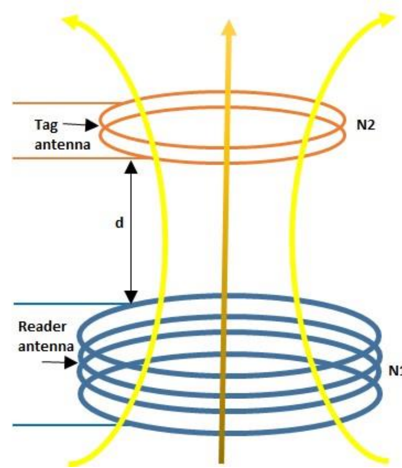

Fig. 2. The working design of 13.56MHz RFID systems antenna

$$\Psi = \int B.dS \tag{3}$$

Then the induced voltage (V) of the tag antenna is

$$V = -N\frac{\mathrm{d}\psi}{\mathrm{d}t} \tag{4}$$

Using equations (1) and (3), equation (4) can be written as:

$$V = -\left[\frac{\mu_0 N_1 N_2 r_1^2(\pi r_2^2)}{2(r_1^2+d^2)^{\frac{3}{2}}}\right]\frac{di_1}{dt} \tag{5}$$

where the part of equation (5) , $\frac{\mu_0 N_1 N_2 r_1^2(\pi r_2^2)}{2(r_1^2+d^2)^{\frac{3}{2}}}$, represents mutual inductance (M), r_1, r_2, respectively reader/write antenna radio and tag antenna radio, N_1, N_2, respectively the number of turns of the reader antenna and Tag antenna. Equation (5) shows that the structure of antenna, material and antenna size may affect the induced voltage, and V decays with $1/r^3$. Therefore, when the tag is gradually close to the reader, V will also grow larger and have a better read / write.

C. Analog signals

The analog circuit is highly integrated to demodulate and decode responses using the Serial Peripheral Interface.

To read the encoded information this must be placed near the reader (it is not necessary that it be within the direct line of sight of the reader). A reader generates an electromagnetic field that causes electrons to move

through the antenna of the tag and then feed the chip. The chip inside the tag responds by sending the stored information to the reader in the form of another radio signal, this is called backscatter. The reader detects and interprets backscatter, or change in the electromagnetic / RF wave, which then sends the data to a computer or microcontroller.

III. PWM CONTROL

The microcontroller used in this projecct includes Pulse Width Modulation, which converts analog system results into digital outputs. Pulse width modulation (PWM) can be controlled by high speed and position depending on the operating range [12]. The technique to obtain analog outputs with digital media is used by creating square waves, with signals switched between on and off. This square wave is defined in time by PW (pulse width) which is the pulse width in time and by the cycle (length / period) that is the total time the signal lasts.

The frequency is defined in Equation (6) as the number of pulses (on / off state) per second and its mathematical wexpression is the inverse of the period.

$$f = \frac{1}{T} \tag{6}$$

The *period* is measured in seconds, thus the unit to measure the frequency is the inverse of the unit of time [Hertz].

A. Control

An adequate and effective control of the servomotors that work at 50Hz is done by PWM, so the PWM signal will have a period of 20ms. The components of the internal circuit of the servomotor, receives specific signals for the position angle; therefore, to rotate 180 degrees 2400us is required, to rotate 90 degrees we need 1500us, to rotate at 45 degrees we need 900us and finally to achieve a rotation at 0 degrees 544us is required.

The effective value is especially used to study periodic waveforms, despite being applicable to all waveforms, constant or not [13]. Therefore, it is necessary to analyze the RMS voltage in the pulse train of PWM.

$$V_{rms} = \sqrt{\frac{1}{T}\oint_{t0}^{t0+T} v^2(t)\delta t} \tag{7}$$

The useful cycle or duty cycle of the signal expressed in equation 8 is determined by the ton time of the square signal, with respect to the period T of the signal, which is controlling the amount of power supplied to the load.

$$D = \frac{ton}{T} * 100 \tag{8}$$

Figure 3 shows the modulation signal of the system for closed fins with an inclination angle of the servo motors at 5º, 140º, 180º, 180º.

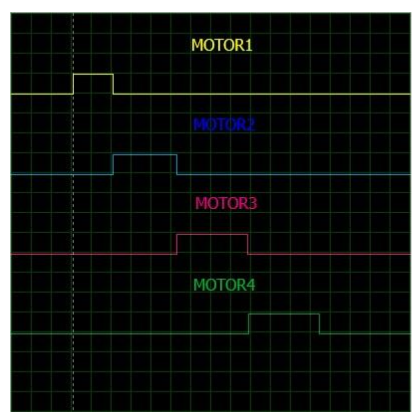

Fig. 3. PWM oscilloscope signal closed doors

Figure 4 shows the modulation signal of the system for open fins with an inclination angle of the servo motors at 45º, 100º, 120º, 120º.

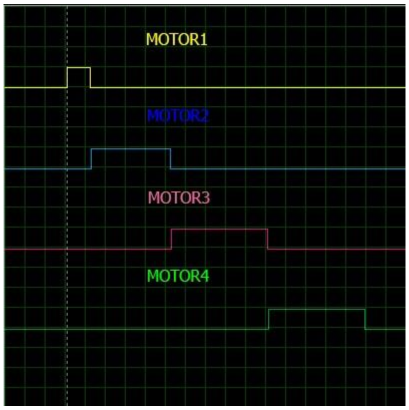

Fig. 4. Open door PWM oscilloscope signal

The PWM control mechanism gives us precision in the angle, reduces wear and energy consumption in the servomotors being ideal for areas with high flow of people. This system can have autonomy if a powerbank is installed when there is a power outage.

IV. IMPLEMENTATION OF CONTROL SYSTEM

The automatic door control system is implemented with reading sensors (card reader) and with a controller (Atmega2560) that interacts with the actuators for closing the loop with the infrared sensors according to the enabled door, as shown in the Fig. 5.

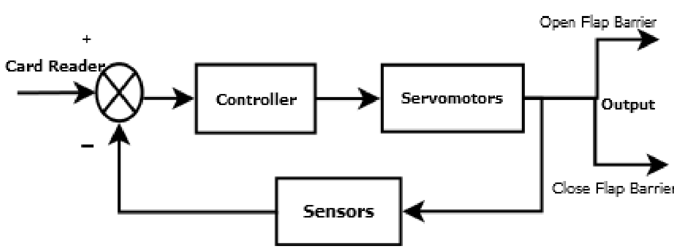

Fig. 5. System Control Diagram

In Fig. 6, the fin opening is schematized, since there is a binary code signal reading in the antenna, this is interpreted by the controller and sent in hexadecimal code to be compared in the database and an opening signal is sent to the actuators (servomotors) that were calibrated to open the fins at a specific elevation angle, with photo display and specific data on the screen.

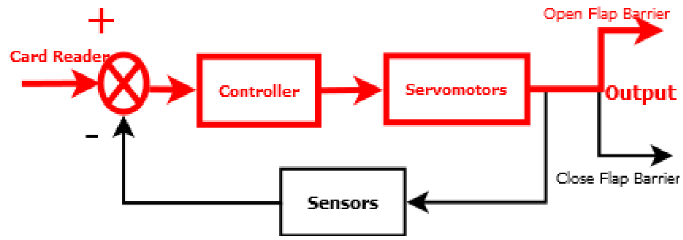

Fig. 6. Open Door Control Diagram

In Fig. 7, the closing of the fins is schematized, when the infrared sensor detects the output of a person sends a signal to the controller and it sends a PWM signal to the actuators to close the fins, activating a red signal to indicate its closing.

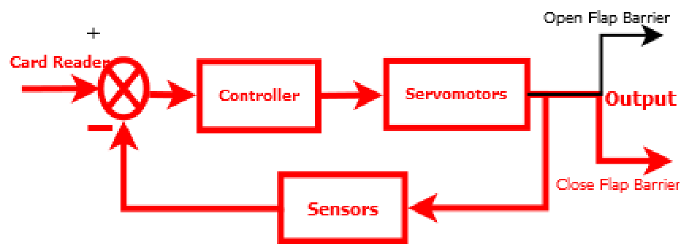

Fig. 7. Closed doors control diagram

V. IMPLEMENTATION OF THE SYSTEM PROTOTYPE AND THE INTERFACE PLATFORM

In Fig. 8, the components of the built prototype are shown, where the Servomotors (MG995), infrared sensor (E18-D80NK), the Microcontroller (ATmega2560) whose programming was developed in arduino IDE language, the Reader Module (RC552), the RGB LED Tape (WS2812B) and the powerbank.

The interface developed to perform the administration is shown in Fig 9. The program was developed in Java Netbeans using the application work environment and linked to a MySQL database, which in turn the software is free and cross-platform to perform an appropriate user interface. In the interface, three hierarchy users were established, establishing the user Administration all handling permissions, the user Cash collection was granted the permissions to enable the service and the expiration date, and the user Supervision, to control access and student income reports.

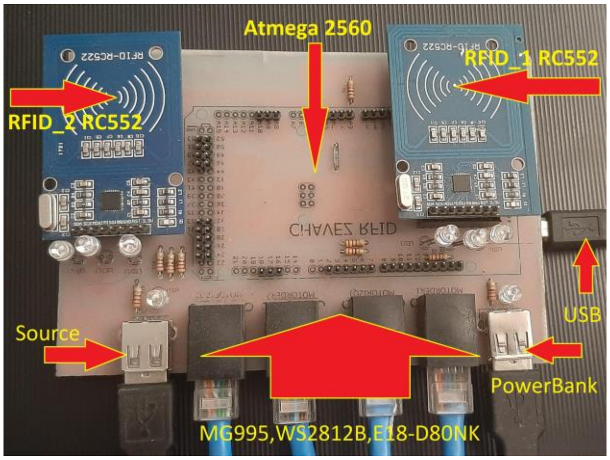

Fig. 8. Reader prototype

Fig. 9. Administration Interface

VI. EXPERIMENTS AND RESULTS

The prototype is a barrier with double fin (one on each side) which is activated by a master device and two slaves to indicate the entrances. It has visual intelligent signaling to indicate authorized access (green), denied (red) and with alert sound. Fig. 10 shows the graphical interface designed for the monitoring user, developed in Java Netbeans, being enabled for the two work functions performed by the supervisor such as identification control and statistical reporting.

The identification control is shown in Fig. 11, which enables the entry on the screen to allows access through the fins and the case of access denied, when it was not paid in cash or the date is expired. There is a report that allows you to present the report of attendees and to have the corresponding follow-up.

The report generated in Excel for filtering and counting the number of assistance and service is detailed in table I. The Record of date, time of the people entering is observed. With this system there are no access delays because it is suitable for this type of service giving a flow of 50 to 60 accesses / minute

Fig. 10. Supervision interface

Fig. 11. Fins enabling and closed state

TABLE I
EXCEL REPORT

Servicio del Comedor			
FECHA	HORA	CUI	SERVICIO
2019-10-24	13:19:42	20190000	A
2019-10-24	13:19:44	20080457	A
2019-10-24	13:19:48	20106452	A
2019-10-24	13:19:50	20180857	A
2019-10-24	13:19:53	332332	A
2019-10-24	13:19:55	20097788	A
2019-10-24	13:20:11	20190013	A
2019-10-24	13:20:12	20190014	A
2019-10-24	13:20:13	2019015	A
2019-10-24	13:20:18	20190016	A
2019-10-24	13:20:19	20190017	A
2019-10-24	13:20:20	20190018	A
2019-10-24	13:20:29	20104285	A
2019-10-24	13:20:30	20110857	A
2019-10-24	13:20:31	20190001	A
2019-10-24	13:20:33	20190002	A
2019-10-24	13:20:34	20190004	A
2019-10-24	13:20:35	20190005	A
2019-10-24	13:20:37	20190007	A
2019-10-24	13:20:38	20190008	A
2019-10-24	13:20:45	20190038	A
2019-10-24	13:20:46	20190037	A
2019-10-24	13:20:48	20190036	A
2019-10-24	13:20:5	20190009	A
2019-10-24	13:20:50	20190034	A

VII. CONCLUSION

With the development of the design of an automated identification and access control system using RFID technology, it has been established that using a PWM (Pulse Width Modulation) control for the door fin angles, the response time is less than

1.0 second per user, when there is no load on the fins of the servomotors. In case of loading the response is less than 1.5 seconds, fulfilling the purpose of optimizing the time.

The system is designed to have adequate reliability in its use, where the sensors and actuators do not have noise and power problems, for which there is an adequate filter and a starting capacitor that ensures the peak amperage necessary for the movement of torque, avoiding any problem of losses due to distance.

This work has achieved the automation with RFID technology of the access control in the dining room of the National University of San Agustin de Arequipa with efficiency and effectiveness, which can be replicated in access controls of public and private entities.

The best functioning of the system can be achieved by increasing the torque moment characteristics of the servomotors, achieving greater reliability and increasing their lifetime.

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