VOL. 13, NO. 17, SEPTEMBER 2018 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

BLUETOOTH ELECTROMECHANICAL LOCK DESIGN FOR SMART HOME USE

Edwar Jacinto G., Fernando Martínez S. and Holman Montiel A.
Universidad Distrital Francisco José de Caldas, Bogotá, Colombia
E-Mail: hmontiela@udistrital.edu.co

ABSTRACT

The main objective of this paper is to show the design of an electromechanical lock controlled by a Bluetooth communications module, the description of the two main structural blocks is made, which are: Mechanical structure based on an endless screw and the electronic control unit based on an embedded 32-bit microcontroller system. The proposed design also establishes the use of a Bluetooth Low Energy (BLE) communication module associated with the operation of an application for smart phones that allows activating or deactivating the electromechanical mechanism designed. Likewise, emphasis is placed on the description of the communication frame used, describing its operational structure byte by byte.

Keywords: bluetooth, electromechanical systems, microcontrollers, communication frame, smart home.

1. INTRODUCTION

The development of technological elements oriented to its use in Smart home is growing day by day, the integration of multiple devices that allow generating an environment of security and comfort in the home is in full swing; the control of lights and appliances [1-2], the monitoring of multiple sensors associated with security [6-9] (primary domestic services, humidity, temperature, motion detection, among many others), are technologies developed mainly to work hand in hand with the internet of things and generally, seeking to be controlled from the inseparable element for today's society, a Smart phone. [10]

One of the fundamental factors associated with the operation of this type of gadgets are the M2M (Machine to Machine) protocols, since they facilitate communication between electronic devices because the communication protocols they use are aimed at optimizing the transfer of information [3]. Another important factor associated with these technological products is reflected in the communications infrastructure used [5], for this case the type of wireless technology used to define the network of devices; this type of applications is mostly supported over Wi-Fi architectures, ZIGBEE or Bluetooth Low Energy. [4]

Taking into account the above, this paper presents a novel and practical proposal for the design of a prototype of security system for enclosures (Electromechanical lock for doors); In the development of the document, both the electromechanical design and the design of the electronic control unit will be appreciated, with emphasis on the communications protocol used by the Bluetooth communications module. Its electromechanical design will be controlled by an application based on BLE 4.0 technology that will allow the prototype to be locked and unlocked from any Smartphone.

2. METHODOLOGY

The proposed design consists of two functional blocks: an electromechanical locking system energized by means of a rechargeable lithium battery and an electronic control system based on the transfer of information via BLE. The proposed prototype seeks to eliminate the use of physical mechanical keys, see Figure-1, both for the opening or closing of the lock, optimizing, personalizing and making safer the device designed compared to other locks found in the market.

Figure-1. Conventional locking system by physical key.

Mechanical structure

The proposed mechanical design consists of an endless screw steering system coupled by an end to the shaft of a motor and geared to a toothed rack. This system is characterized by the simplicity of its mechanism and its assembly, see Figure-2. The prototype itself will be located on the inside of the door, in this way, as an "invisible" lock will be more difficult to violate the security of the enclosure.

In the system, the screw constantly meshes with a toothed rack, for this reason, every time the worm takes a complete turn by means of the micromotor, the rack advances a number of teeth giving rise to a linear displacement, which allows locking or unlocking the lock. Thanks to the angle of the propeller, among other factors, it allows the mechanism to be safe and practically irreversible, meaning that, only by means of the control of rotation of the actuator can the opening and closing of the lock be activated.

ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

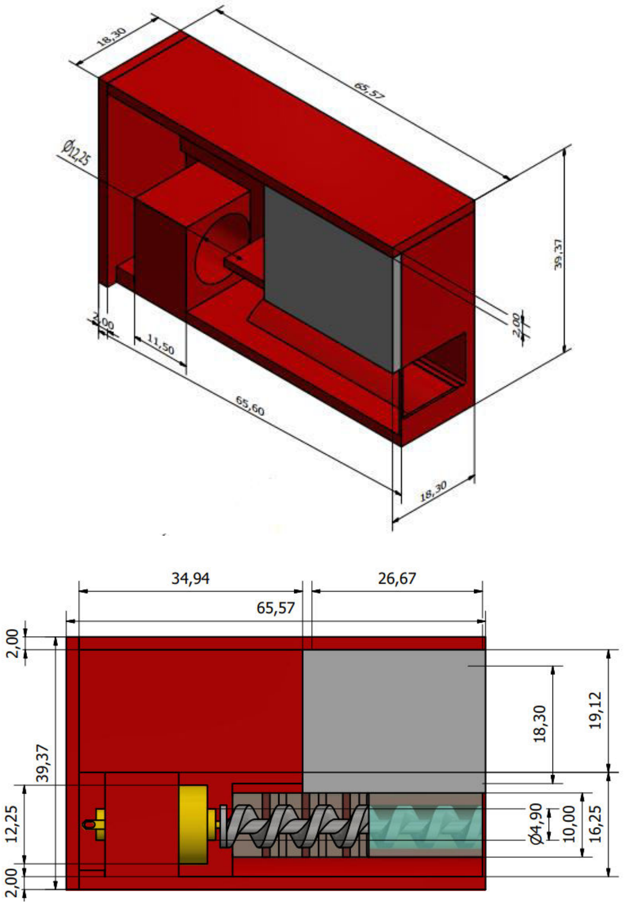
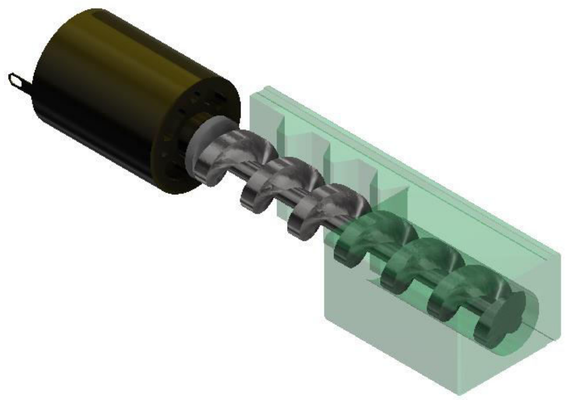
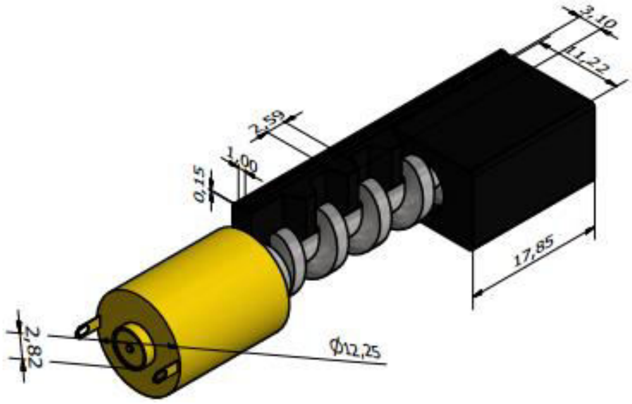


Figure-2. Structural view of the locking system designed.

The operational and electronic design of the prototype will be enabled at all times. The lithium battery inside is in a selected compartment which has a removable lid. By means of a red LED and an audible alarm the battery will indicate if it is below 30% of its load, and likewise with the change from red to green it will indicate a full charge. However, if the battery becomes completely discharged, a 3-cell battery will enter to back up and always keep the system energized. The mechanism of the electric micromotor in conjunction with the rack system is shown in Figure-3.



a)



b)

Figure-3. a) Mechanical structure Endless screw lock b) Zipper mechanism with pin.

Electronic design

The electronic block is based on the transfer and comparison of the opening and closing key sent through an APP supported on Bluetooth communication, the flow diagram used in the communication can be fully appreciated in Figure-4.

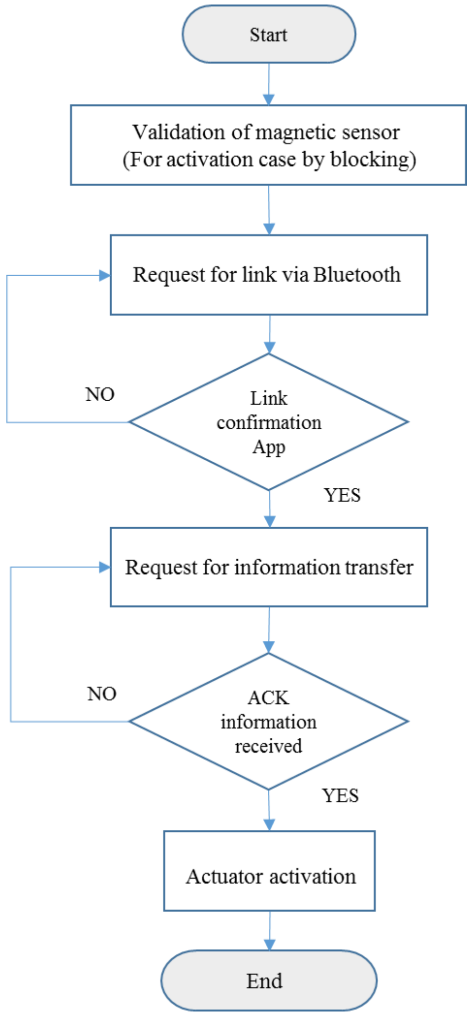


Figure-4. Operational flow diagram for the microcontroller.

ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

The formulated architecture is based on the implementation of a central microcontroller in charge of executing all the operative activities of the lock; see Figure-5, among which the following should be highlighted:

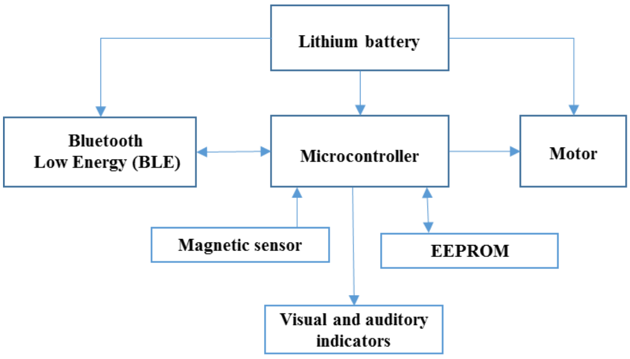


Figure-5. Proposed architecture for the electronic control unit.

Communication process: The microcontroller is responsible for receiving and transmitting information through the UART at a transfer rate of 115200, 8, N, 1; referring to the Bluetooth module.

Sensorial module for blocking process: The electronic card has a magnetic sensor that guarantees total control over the closing process or locking (authorization or permission based on sensors), this guarantees that the motor will only activate when the door it is completely closed and the lock is fully aligned in its locking casing. This process is essential since otherwise irreversible damage to the mechanical infrastructure of the device may occur.

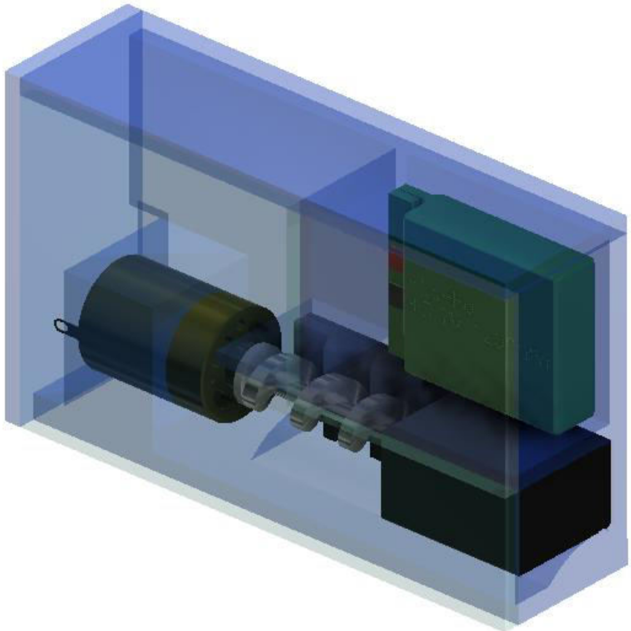
Micromotor control: The electronic control unit uses a power driver (H Bridge) to perform the rotation control of the respective activation and blocking motor.

Battery level indicator: The constant monitoring of the level of the main battery will be displayed by the use of LEDs, a red LED to indicate that the level is below 30% of the load and a green one to indicate a load greater than 30%. In addition to these visual signals, a buzzer will be used as an audible alarm when the battery level is less than or equal to 25%, indicating to the user that it is time to recharge it.

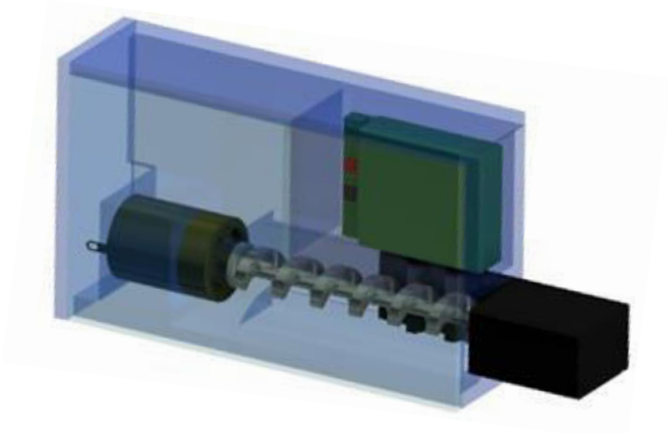
3. RESULTS

The proposed design for this electromechanical device integrates a wide variety of simple elements that together give life to an innovative solution in terms of electronic security devices. Regarding its mechanical component, the times associated with the linear displacement of the pin on the worm, both for opening and closing, are approximately 1.2 seconds, see Figure-6.

The validation process is oriented to the comparison of a 32-bit register, taking advantage of the architecture of the microcontroller used, in this way the password validation only takes 50 microseconds to be performed. Table-1 shows the plot used in the communication process between the microcontroller and the elaborated APP.



a)



b)

Figure-6. a) Complete assembly of the locking mechanism and housing. b) Linear displacement of the blocking bar.

ARPN Journal of Engineering and Applied Sciences

Table-1. Proposed frame scheme.

Frame fields		**Offset**	**Exam.**	**Description**
Start delimiter	**INI TX**	**0**	@	**Frame beginning**
Frame Specific Data	ID	1 2 3	C 1 5	Product ID
	Info	4 5 6 7	W O L F	Password
	Function	8	W	Read / Write
End Delimiter	END TX	9	#	

In the other hand, respect to the password validation for opening or closing sent from the APP, a module is used to compare characters stored electronically in the card of the device, for this purpose a communication frame designed is used. This plot allows identifying the hardware elaborated by means of an identification code and at the same time it allows to rapidly validate the password for the device.

4. CONCLUSIONS

The proposed design provides a practical and effective solution for the construction of a smart security device that can be implemented on any door in the home, its control system through Bluetooth applications ensures that it can be operated from any Smart phone, tablet or PC, guaranteeing the continued functionality of the designed device.

The mechanical structure offers a robust design based on an endless helical screw system (zipper), thus ensuring that the device is completely irreversible once its insurance is blocked, therefore it is very safe and impenetrable. Both the communication frame and the algorithmic validation structure were designed in order to take advantage of the 32-bit architecture of the microcontroller used as main structure for the electronic control unit, demonstrating that optimizing the algorithmic structures reduces the elaborated device execution times.

ACKNOWLEDGEMENT

This work was supported by the Universidad Distrital Francisco José de Caldas, in part through CIDC, and partly by the Technological Faculty. The views expressed in this paper are not necessarily endorsed by the University. The authors thank the research group ARMOS for the evaluation carried out on prototypes of ideas and strategies.

REFERENCES

[1] Alvarez R., Araque J. and Sierra J. 2017. A Novel Smart Home Energy Management System: Architecture and Optimization Model. Indian Journal of Science and Technology. 10(26): 1-8.

[2] Arunkumar K. and Sugadev M. 2015. Real-time home automation and monitoring system with task scheduling and internet connectivity. ARPN Journal of Engineering and Applied Sciences. 10(11): 4954-4958.

[3] Devi P. and Venkata D. 2017. Privacy Preserving M2M-Iot Environment. Indian Journal of Science and Technology. 10(42): 1-7.

[4] Grover M., Pardeshi S. and Singh N. 2015. A Guide to Bluetooth Low Energy Technology. Journal of Engineering and Applied Sciences. 10(8): 3528-3531.

[5] Joshi A., Singh G. and Singh G. 2016. Internet of Things: A Beginners' Précis and Future Scope. Indian Journal of Science and Technology. 9(47): 1-9.

[6] Kalaivanan S. and Manoharan S. 2016. Monitoring and controlling of smart homes using iot and low power wireless technology. Indian Journal of Science and Technology. 9(31): 1-9.

[7] Kaur T., Kakkar S. and Rani S. 2017. Smart Homes: Sensible Living Using Internet of Things. Indian Journal of Science and Technology. 10(31): 1-8.

[8] Kim J. 2016. HEMS (Home Energy Management System) Base on the IoT Smart Home. Contemporary Engineering Sciences. 9(1): 21-28.

[9] Mohamed S., Ahmad A., Abdulwadoud A. and Mohamed O. 2017. Design and implementation of a real-time smart home automation system based on arduino microcontroller kit and labview platform. International Journal of Applied Engineering Research. 12(18): 7259-7264.

[10] Piyare R. 2013. Internet of Things: Ubiquitous home control and monitoring system using Android based smart phone. International Journal of Internet of Things. 2(1): 5-11.