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Design of Mechanical Structure and Communications Frame Prototype for an Automobile Locking System via Bluetooth

Holman Montiel Ariza[1] , Jose Reyes Mozo and Henry Montaña Quintero

Assistant Professors Technological Faculty, District University Francisco José de Caldas
Calle 68 D Bis A Sur No. 49F – 70, Bogotá D.C., Colombia.
[1]ORCID ID: 0000-0002-6077-3510

Abstract

The integration of mobile communication devices with electromechanical solutions advances day by day, not only for the fact of modernizing processes but also in order to improve existing solutions in the competitive commercial and productive sector. This paper focuses on the design of a prototype of electromechanical structure as the central axis for a blocking pedal (brake or clutch) system in a car, seeking to completely eliminate the use of physical keys associated with the control of this type of elements. The proposed design establishes the implementation of a 32-bit embedded system that controls a Bluetooth Low Energy (BLE) communication module associated with an operation app (Opening/Blocking). The complete design of the electromechanical structure and the communications frame used between the APP and the electronic control unit is presented.

Keywords: Bluetooth, Electromechanical Systems, Microcontrollers, communication frames.

INTRODUCTION

The security systems associated with mobile devices are in full fury, anyone can find in the commercial environment a large number of products directly related to the daily activities of people, such as: smart locks, systems vehicle monitoring and blocking [1-4], Smart Home systems [5-8], Bluetooth padlocks for motorcycles, among many others; all these elements are directly associated with the rapid growth of the use of mobile phones and the development of low-consumption electronic technologies [9-12].

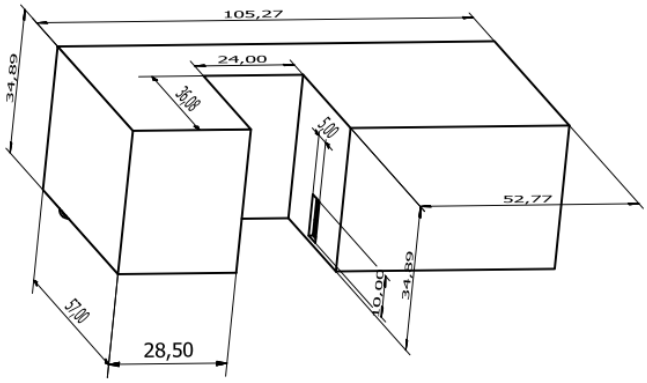
This specific boom associated with the large number of products available in the market handles a series of common factors: they are low cost elements, there is scalability for the integration of new devices and above all they are easy to use. Keeping in mind these factors and linking them directly to the strong dependence of people on their mobile device, the use of Bluetooth Low Energy (BLE) technology opens up a wide possibility of creating new products [11], thanks to its low power consumption since it does not require a direct line of sight with the device that is interconnected.

Taking into account the above, this paper establishes a proposal for the design of a prototype portable locking system for automobiles, based on the design of an electromechanical structure that allows to block the operation of the vehicle's pedals; This device will be controlled by an application based on BLE technology that will allow to open and close the padlock from any Smartphone. In the development of the document, it is possible to appreciate the two basic blocks by which the prototype, the mechanical structure and the electronic components are made, emphasizing mainly the design of the electromechanical block and the design of the communication frame used by the electronic control unit and the command application.

METHODOLOGY

The proposed design consists of two functional blocks: a rechargeable electromechanical locking system 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 Fig. 1, both for opening and closing the lock, optimizing and customizing the designed device in this way.

Figure 1: Conventional locking system by physical key



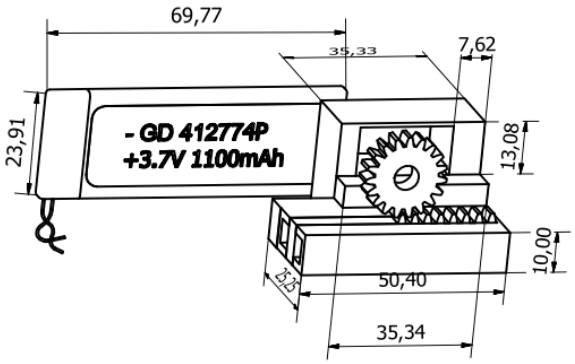


Figure 3: Zipper-type closing mechanism.

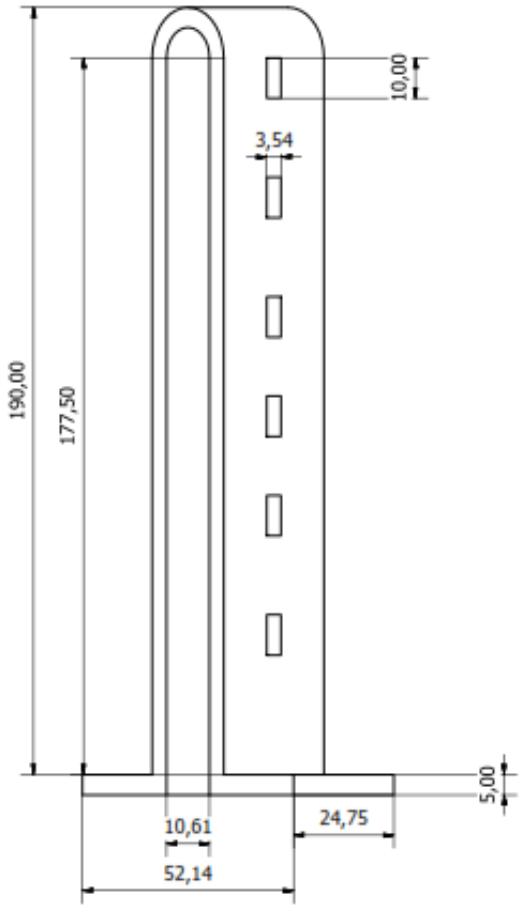


Figure 2: Structural view of the locking system designed.

Mechanical structure

The proposed design is made up of a system based on a flat pole and an electromechanical fastening and locking system, this system will be located in such a way that it does not allow the normal operation of the brake or clutch pedals of the car. The front pole has a series of perforations that allows the graduation and location of the locking system or electromechanical pin, thus allowing it to be adjusted to multiple vehicle manufacturers.

Basically, the main structure of this system focuses on the design of a padlock-type case, which incorporates a locking pin zipper-type that is activated by a micro electric motor; this actuator controls the actions of both opening and closing through the information processed by the electronic control unit (32 bit microcontroller) that is inside the case. The designed structure allows the incorporation of a rechargeable lithium battery that is responsible for supplying power to the entire system, including actuators, microcontroller and BLE communication module.

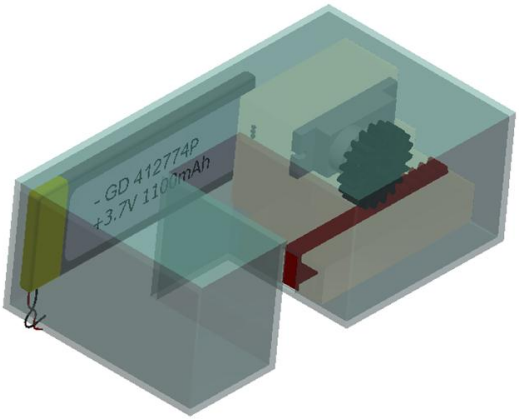


Figure 4: Complete assemble of the locking mechanism and the case.

The zipper system used for this prototype guarantees clean pin slides, avoiding the generation of high current consumption and a possible clogging in the used motor. The total displacement of the pin can be achieved with just half a turn of the used rotor. The operational design of this structure (case or padlock) is oriented so the battery is stored inside it with the electronic system, and the battery is enabled by means of a start operation button. This activation element will cause the whole system to leave its "Stand by" status to operate according to the stored state and the respective commands sent by the mobile device; in addition to this activation button, the case has a charge plug and a multicolor LED that will indicate the different states of the respective device.

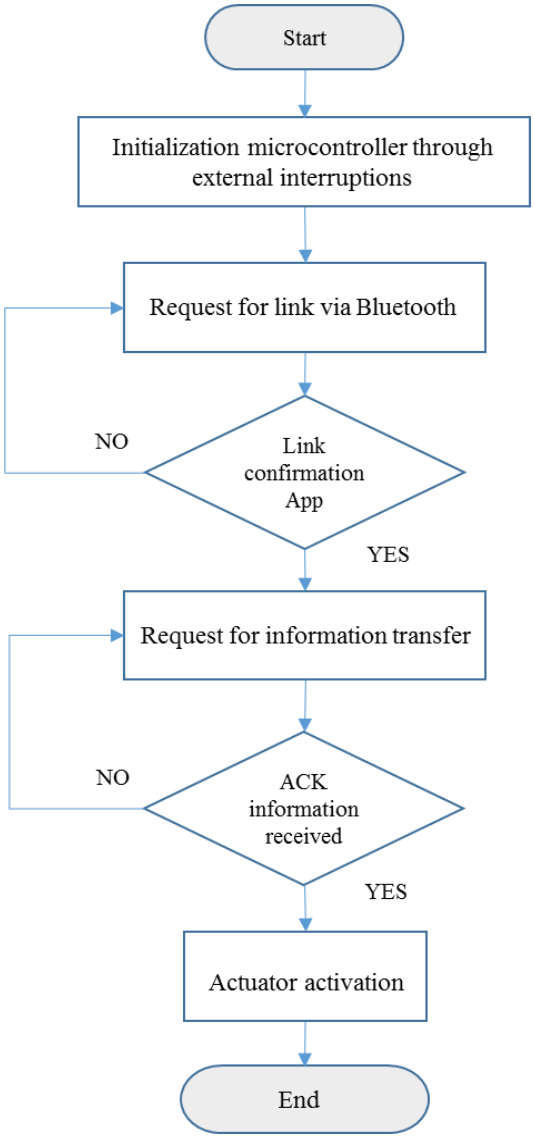


Figure 5: Flow diagram for the communication between microcontroller and APP

Electronic design

The complete architecture proposed for the block of electronic components can be seen in Fig. 6; this step is essential for the control of the proposed system, it depends on the correct operation of the device. Its central core of operation is based on a microcontroller with EEPROM memory within its architecture, since it will contain the basic information associated with the parameters of the product identification and the respective blocking and opening password guaranteeing in this way the correct storage of the information provided by the mobile device application.

In general terms, the proposed architecture for the electronic control unit is based on the implementation of a 32-bit microcontroller embedded system, which is responsible for processing the information received from the application through the BLE; this communication module operates using RS232 protocol configured to 115200.8, N, 1, parameters that define the speed and basic frame size for the byte-by-byte transfer between the operation APP and the microcontroller. Once the whole frame is received, it is stored in the EEPROM memory, in such a way to guarantee the confidentiality, integrity and availability of the same.

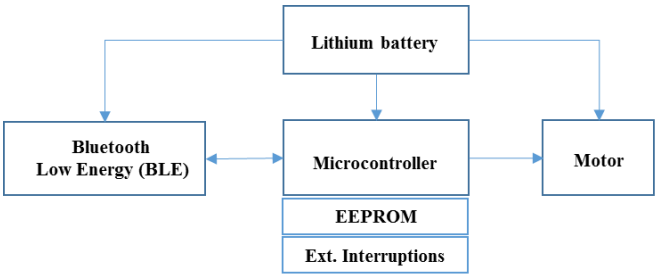


Figure 6: Proposed architecture for the electronic control unit.

The microcontroller will be responsible for using external interrupts enabled for the detection of rising edges, in order to wake up from the "Stand by" state to start operating in "Normal" mode; it will check the battery charge level and control all aspects of the BLE communication module. An important function will be to determine and validate the waiting times associated to the wireless communication link with the mobile device application, since a times protocol defined by the validation of the designed communications frame will be established.

Regarding the communication process between the operation APP and the electronic control unit, a communication frame was designed providing the microcontroller with all the necessary information to reduce the processing times associated with the configuration and remote control of the device; also integrating defined structures where it can be clearly differentiate the protocol bytes from the byte segments associated with the payload.

Table 1: Proposed frame scheme

Frame Fields		Offset	Examp.	Description
Start Delimiter	INITX	0	@	Frame Beginning
Frame Specific Data	ID	1 2	528	ID number
	Info	MBS 3 LSB 8	34 62 89 46 32 90	Password
	Function	9	R	Read / Write
End Delimiter	FINTX	10	#	

All the above in order to reduce to the maximum the execution times associated to the manipulation and processing of the information carried out by the internal algorithm of the microcontroller. The proposed frame can be seen in detail in table 1.

RESULTS

The elaborated design provides a set of elements that make this a new and fully functional device that can be adapted to various vehicle models. The displacement processes measured in the developed test prototype establish zipper closing and opening times not superior to 300 milliseconds, while the transfer rate associated with the communication frame handles a bit time of 8.68 microseconds, thus establishing a total frame transmission time of 954.86 microseconds.

Figure 7: Assembly prototype

Additionally, measurements were made related to the search and realization of the optimal link between the BLE of the design and various mobile devices (Smartphones and tablets), where connection times of less than 1 minute were obtained, as well as distances of coverage and operation of the command (an average of 6 meters of coverage).

CONCLUSIONS

The elaborated design sought to implement a series of low-consumption technological devices, in order to build a pedal lock system for modern and functional vehicles. Similarly, it should be noted that the objective was achieved, so the design eliminated the use of physical keys, proving this way that constant advances in technological devices, whether in the area of communications or using development hardware with mechanical structures, can be linked to multiple useful systems to the day-to-day needs of our society.

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REFERENCES

[1] Amin, S., Ibne M., Nasir, S. and Sobhan, M.: Low Cost GPS/IMU Integrated Accident Detection and Location System. In: Indian Journal of Science and Technology, 9 (10), pp. 1-9 (2016)

[2] Priyadarshni, V., Krishna P. and Sreenivasa K.: GPS and GSM Enabled Embedded Vehicle Speed Limiting Device. In: Indian Journal of Science and Technology, 9 (17), pp. 1-6 (2016)

[3] Singh, A., Balamurugan, S., Aroul, K. and Marimuthu, R.: Design of Universal Module for Personal Security. In: Indian Journal of Science and Technology, 9 (30), pp. 1-6 (2016)

[4] Siyal, K. and Gugapriya, G.: Anti-Theft Vehicle Locking System using CAN. In: In: Indian Journal of Science and Technology, 9 (45), pp. 1-6 (2016)

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

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

[7] Ilayaraja, A. and Venkatesh, V.: A Multilevel Remote Supervisory and Security Network System for Smart Home. In: Indian Journal of Science and Technology, 9 (48), pp. 1-4 (2016)

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

[9] Ha, Y., Jin, J., Koo, H. and Lee, M.: Automatic Generation of BLE Beacon Applications Using Service Specifications. In: Contemporary Engineering Sciences,9 (19), pp. 925-932 (2016)

[10] Lee, T., Kim, K. and Jeong, G.: Design of an Easy-to-Use Bluetooth Library for Wireless Sensor Network on Android. In: Contemporary Engineering Sciences,7 (16), pp. 801-805 (2014)

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

[12] Marimuthu, R., Singh, A., Balamurugan, S. and Aroul, K.: Home Automation Using Bluetooth - A Review. In: Journal of Engineering and Applied Sciences, 11 (21), pp. 12867-12870 (2016)