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MICROCONTROLLERS PROGRAMMING OF MICROCHIP FACTORY WIRELESSLY

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ABSTRACT

This paper presents the transfer of hexadecimal files from the computer to the PIC microcontroller wirelessly, usingHC-06 Bluetooth module with a communication speed of 115200 baud. To meet this goal, it is necessary to install the Bootloader in the lower part of the Flash program memory of the PIC. So that, when it is necessary to update the programs in the microcontroller, reset it by the master clear to enter to Bootloader mode and transfer the hexadecimal file in serial form. For the tests, the microcontrollers PIC16F877A and PIC18F4550 were used.

Keywords: boot loader, PIC16F877A, PIC18F4550, blue tooth.

1. INTRODUCTION

The microcontrollers [1] are confirmed by the central processing unit, memory, input and output peripherals. Currently, there are categories of microcontrollers [2] depending on the size of memory, internal architecture, number of bits and set of instructions, and it can be used for different applications such as: room temperature control system based on microcontroller [3], I-V curves generation of electronic devices based on microcontrollers [4], intelligent traffic control using microcontrollers [5], electrocardiogram signal measurement system [6], among others.

In order to program a microcontroller, a source program is performed, using Assembler or Basic as programming languages. Then, the compiler generates a hexadecimal file [7, 8], the same one that must be recorded in the microcontroller. This process is done by a programmer that can be picKit 2 or picKit 3, which have the ISCP (In Circuit Serial Program) communication protocol.

Applying the active and participatory methodology of teaching-learning on PIC microcontrollers programming, corresponding to Microcontrollers classes of the Electronic and Mechatronic careers in University of the Armed Forces ESPE, students achieved greater autonomy in the accomplishment of laboratory practices and can acquire meaningful knowledge based on case study methods or learning by projects[9].

The laboratory practices of Microcontrollers class are developed in the Laboratory of Digital Electronics of the university, which has only 3 Universal Programmers to transfer the hexadecimal file from the computer to the PIC microcontroller, causing an increase of time to develop the practices. In addition, each student must implement the corresponding hardware using the training modules for PIC microcontrollers [10], which causes more delay in checking the implemented algorithms.

Currently, there are wireless technologies offering solutions to send and receive information with no physical means [11], such as Bluetooth technology [12]. It has leaded in developing applications in embedded systems, due to it works in the band 2.4 GHz, has a short range, and is ideal for establishing communication between mobile equipment and other devices.

The present work is focused on PIC microcontrollers programming wirelessly, using HC-06Bluetooth module, which will be used to carry out the laboratory practices of the Microcontrollers classes. The students can connect to the HC-06 module to establish the wireless communication using their own laptops. Also, the teacher will allow the transfer of the hexadecimal file from the computer to the PIC microcontroller, which is in the trainer module, and check the operation of the implemented algorithm, as shown in Figure-1.

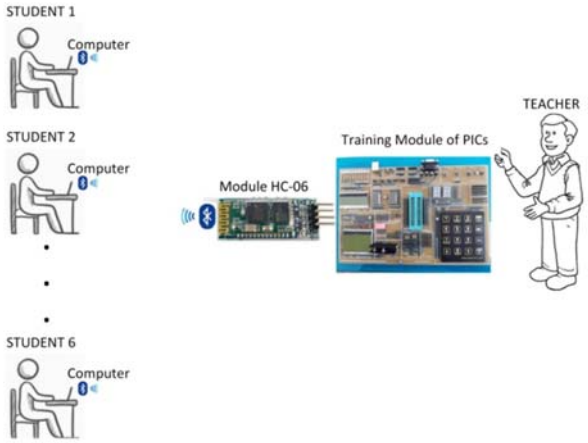

Figure-1. Microcontrollers programming wirelessly.

The work is organized into five sections, including the introduction in section I, materials and methodology are in section II, the design of the procedure is detailed in section III, results are shown in section IV and finally, conclusions are presented in section V.

2. MATERIALS AND METHODOLOGY

HARDWARE

For the development of the present work, a trainer module for PIC microcontrollers was used, which has the following blocks: leds, pushbuttons, LCD, GLCD,

keyboard, displays, servomotor, DC motor, RS 232 interface, LM35 temperature sensor, 40 pins socket, and 2 leds matrices. For operation, it needs to be powered with a 5V source or connected to a PC via USB cable. It is presented in Figure-2.

Figure-2. Trainer for PIC microcontrollers.

The microcontrollers used were PIC16F877A and PIC18F4550, which are connected by cables to the different blocks of the trainer module. A HC-06 Bluetooth module was used to perform wirelessly communication between the PC and the microcontroller, which is factory-configured to work as a slave at a communication speed of 9600 baud. To modify some configuration parameters, AT commands are used.

SOFTWARE

Bootloader is a program that allows downloading the hexadecimal files to the PIC microcontroller using the serial port, without any additional hardware. The Bootloader is loaded at the end of Flash program memory of the PIC. For operation, the microcontroller must be polarized, and then must be reset with a button connected to the master clear terminal. If it is not reset, the PIC continues with the normal execution of the program. But, when it is reset, the Boot loader is started, and the program is transferred to the serial port, which is recorded in the program memory. The memory map of the PIC microcontrollers is shown in Figure-3.

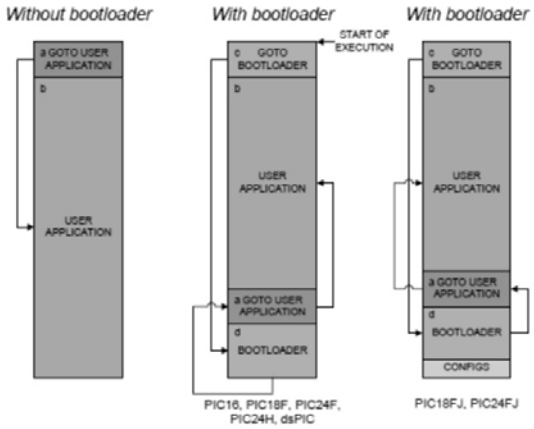

Figure-3. Memory map of PIC microcontrollers.

Several microcontrollers cannot use the Bootloader to update their firmware, for example, the PIC16F84 or the PIC16F628A, because they do not support writing flash memory under the control of the software.

TINY BOOTLOADER: It is software that presents a graphical interface with the following characteristics:

- It allows loading programs to the flash memory of PIC microcontroller.
- It works with some PIC16F, PIC18F and dsPIC.
- It automatically detects the contents of a HEX file and the PIC model.
- It remembers the last configuration used.
- In case of errors, it performs retransmissions or tries to re-synchronize to the PIC.
- The configuration of the communications is editable, and you can choose any number of COM port or baud-rate.
- If a file name is specified as a command line parameter, it will try to write it automatically.

3. DESIGN OF THE PROCEDURE

To perform the laboratory practices of Microcontrollers class, the teacher implements the necessary hardware in the PIC microcontroller trainer. The aim is that the students download through Bluetooth the hexadecimal files to the microcontroller quickly from his computer, and verify the operation of the developed algorithm. This procedure is shown in Figure-4.

Figure-4. Download of HEX file from PC to PIC trainer.

In the stage prior to the transmission of the program, the student develops his algorithm, for example, using the software PIC C Compiler, checks that there is no syntax error, and generates the Hexadecimal file. Then, the factory configuration of the HC-06 Bluetooth module is modified. In this point, an Arduino UNO card, with the corresponding code, was used to send and receive the respective AT commands. In this case, the name and the communication speed was changed from 9600 to 115200 baud, as shown in Figure-5.

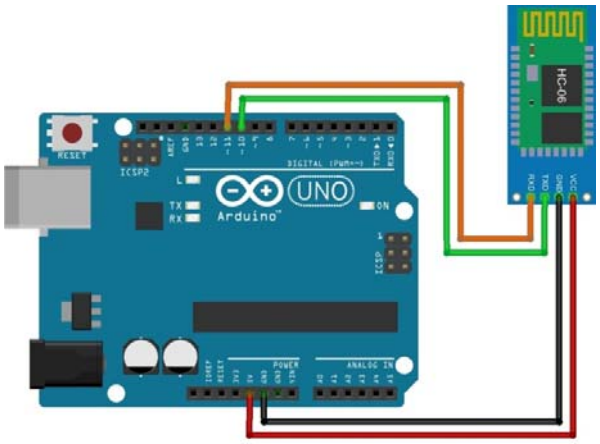

Figure-5. Hardware to configure the HC-06.

The most commonly used AT commands are:

- AT+NAME<Name> (Change name)
- AT+PIN<Pin>(Change binding code)
- AT+BAUD<Number> Change communication speed)

Once the configurations are completed in the HC-06, it is linked to the PC to create the serial communication ports, which were used in the TINY BOOTLOADER to send the hexadecimal file to the microcontroller PIC16F877A and PIC18F4550, as presented in Figure-6.

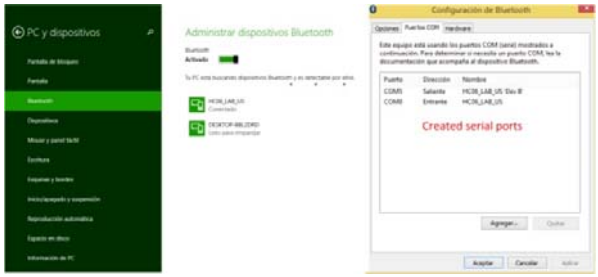

Figure-6. Linking of the HC-06 module and the PC.

The procedure for sending the hexadecimal file to the microcontroller is presented in Figure-7 and Figure-8.

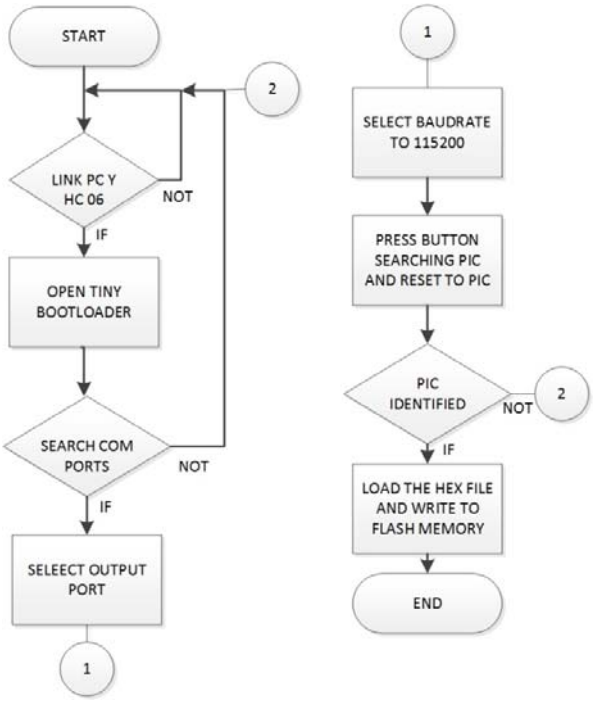

Figure-7. Flow diagram for transferring the HEX file from the PC to the microcontroller.

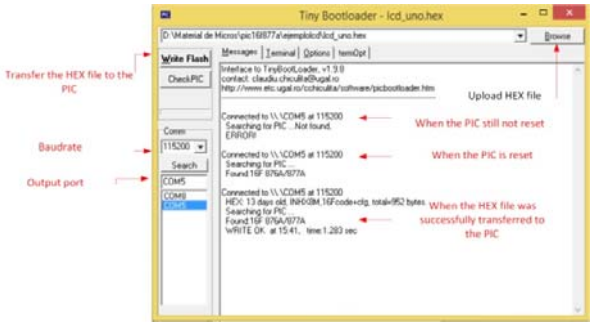

Figure-8. Transfer of the HEX file from the PC to the PIC microcontroller using tiny Bootloader.

Before the stage of program reception, the teacher must load the Bootloader on the PIC microcontroller with help of an external programmer. This process is done only once and, from that, only need to send the hexadecimal file through the serial port.

4. RESULTS

At this point, the results of the hexadecimal files transfer to the microcontrollers PIC16F877A and PIC18F4550are presented. To validate this work developed, a survey was applied to the students of Electronic and Mechatronic careers.

PIC16F877A: In this case, the following laboratory practices were performed: (a) Down counter from 99 to 0, time between data of 1 second, the visualization is in displays applying the technique of

multiplexing. (B) Up counter from 0 to 99 using the 8x1-character EA DOG081x-A LCD, 8 pins of data and 4 pins of configuration are required to communicate with the controller of this LCD to send commands and characters to be displayed inside it. (C) Temperature measurement, using the LM35 sensor, the temperature is detected and its value is displayed on the LCD. The results can be seen in Figure-9.

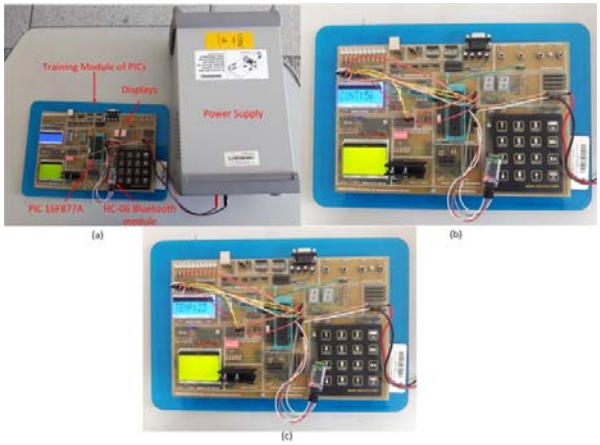

Figure-9. (a) Display multiplexing, (b) LCD up counter, and (c) Temperature measurement.

PIC18F4550: The GLCD EA DOGM128X-6 module was used, which has a resolution of 128x64 pixels in black color with green background. It allows students to implement graphical interfaces and to develop SPI communication, because commands and data must be sent serial way to communicate with the GLCD controller. The main advantage of this device is the reduced number of pins (5 pins) that are used. The practices that were developed were: a) The derivative of the sinusoidal function, and b) The integral of the sinusoidal function, as shown in Figure-10.

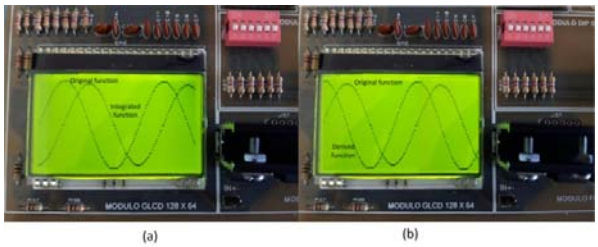

Figure-10. (a) Integral of the sinusoidal signal, (b) Derivative of the sinusoidal signal.

SURVEY TO USERS: The survey was applied to 48 students of Microcontrollers classes of the Mechatronic and Electronic careers, 30 and 18, respectively, to validate if the programming of PIC microcontrollers wirelessly, in relation to traditional programming, improves the teaching-learning process.

Table-1 shows the results of the survey applied.

Table-1. Results of the survey.

QUESTIONS	A	B	C	D	E
Is it easy to download hexadecimal files to PIC microcontrollers using Bluetooth communication?	83,33	16,67	0		
Does Tiny Bootloader present a friendly graphical interface and with necessary configuration parameters?	45,83	54,17	0		
Does hexadecimal files downloading using Bluetooth communication reduce the time spent by the student to test their algorithms?	89,58	8,33	2,08		
Does PIC microcontrollers programming wirelessly improve the teaching-learning process?	85,42	12,50	2,08		
Do I recommend to other students to program PIC microcontrollers wirelessly?	68,75	31,25	0		

A= strongly agree, B=Agree, C=Neutral, D=Disagreement, and E= Strongly Disagree

Most of the student's surveyed strongly agreed that PIC microcontrollers programming wirelessly enhances the teaching - learning process.

5. CONCLUSIONS

PIC microcontrollers programming wirelessly allows the students of the Microcontrollers classes of Electronic and Mechatronic careers to quickly verify the operation of the algorithms implemented, because the teacher will implement the necessary hardware, and the

students will send only the corresponding hexadecimal file to the microcontroller through Bluetooth communication.

The PIC microcontroller trainer module and wireless programming provide a modern learning environment; because the students no longer use protoboards, cables, programmers and electronic devices, which delay the practical verification of each application.

With the survey made to the students, it was determined that the wireless programming of PIC microcontrollers is easy to use. In this way, itis optimized the necessary times for the tests of the developed algorithms in laboratory practices.

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