

## Remote Control of Lighting Using Programming Language Matlab, ZigBee Technology and PIC18F452 Microcontroller

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### Abstract

*Microcontrollers are used in automated products and devices, such as automobile engine control systems, remote controls, office machines, power tools, toys and other systems that are embedded. Also, the ZigBee networks are very suitable for network applications. ZigBee is a low-cost, low-power, wireless mesh network standard targeted at the wide development of long battery life devices in wireless control and monitoring applications. Bearing in mind the numerous advantages and ease of linking these two technologies, the remote control of lighting is practically implemented. Lighting assembly is made from more types of light sources. The PIC18F452 microcontroller and transistor amplifiers are used to control lighting. XBee modules are used for serial communication to PIC18F452 microcontroller and computer. The graphical user interface, designed in the programming language MATLAB, is used for remote control of lighting. In this way, the user has a complete overview of the state of lighting at any time.*

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**Keywords:** PIC18F452 microcontroller, XBee modules, XCTU, lighting, graphical user interface

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### 1. INTRODUCTION

The occurrence of microcontrollers and microprocessors are regarded as one of the greatest technical achievements that characterized twentieth century. Main difference between microcontrollers and microprocessors is that they are the first optimized for speed and performance with computer programs, while microcontrollers are optimized towards integration of a large number of circuits real-time control, mass production, low cost and low power consumption [1]. Microcontrollers are also more resistant on variation of voltage, temperature, humidity, vibration, etc. Huge advantage is reflected in the fact that can be programmed, beside Assembler, and in high-level programming languages: C, Pascal, Basic, etc. [2]. This increases number of users who can write programs and thus also apply [1],[3]. They are used in a wide variety of modern devices such as: robots, telecommunication devices, satellites, cars, measuring instruments, mobile phones, cameras, etc. Also they are widely used in many home devices such as washing machines, microwave ovens, breadmakers, etc. [3]. Today on market there are few major manufacturers microcontroller which in its production program have different microcontroller families. The most popular of them are Intel, Motorola, Amtel and Microchip. In this paper is used PIC18F452 microcontroller [4]- [10].

XBee radio module is a brand company Digi International which fully implement the Zigbee protocol [11]. XBee is tiny RF (radio frequency) module that has been developed and specifically designed to provide a simple and cost-effective performance of ZigBee wireless technology. It requires minimal energy to operate and provides reliable data transmission between devices [12]-[15]. Available are different protocols and characteristics of RF modules, which allow the user great flexibility to choose the best option for their needs. Family Xbee module is composed (March 2016) from 18 different modules of different qualities [16]. Remote control of lighting is achieved using XBee modules, where a module is connected to the computer, and the other is attached to the model. Communication is achieved by using wireless networks established between them using ZigBee network.

In programming language MATLAB is created a graphical user interface for lighting control. The user interface sends data using the serial port. On the serial port the XBee module is connected. XBee module is programmed using a programming language X-CTU. Received data from the MATLAB programming language, using XBee wireless communication module is sent to the second XBee module which is connected to the PIC18F452 microcontroller. The PIC18F452 microcontroller is controlling lighting system.

## 2. PIC18F452 MICROCONTROLLER

The PIC18F452 microcontroller is a modern microcontroller with a large storage space and a large number of I/O lines, implemented in CMOS technology. In CMOS technology, consumption is noticeable only in the transition from the state of logic zero in the state of logical units, or vice versa. Consequently, the PIC18F452 microcontroller has a low power consumption. Also, microcontroller made in this technology is resistant to impulse noise at the I/O lines and the power supply. In figure 1 (a) shown the appearance PIC18F452 microcontroller in 40-pin DIP package and in figure 1 (b) shown the appearance PIC18F452 microcontroller in 44-pin TQFP package.

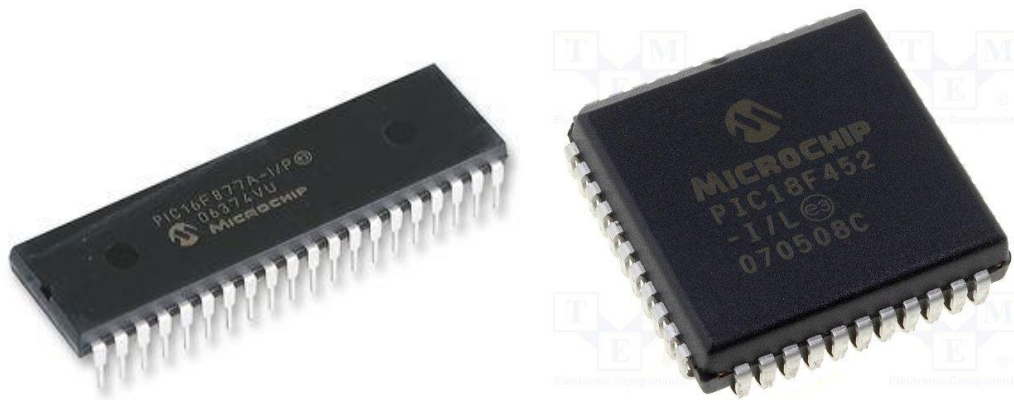


Figure 1. (a) The PIC18F452 microcontroller 40-pin DIP package (b) The PIC18F452 microcontroller 44-pin TQFP package

In this paper, PIC18F452 microcontroller in 40-pin DIP package is used. In Figure 2 shown the pin diagram of PIC18F452 microcontroller and pins description.

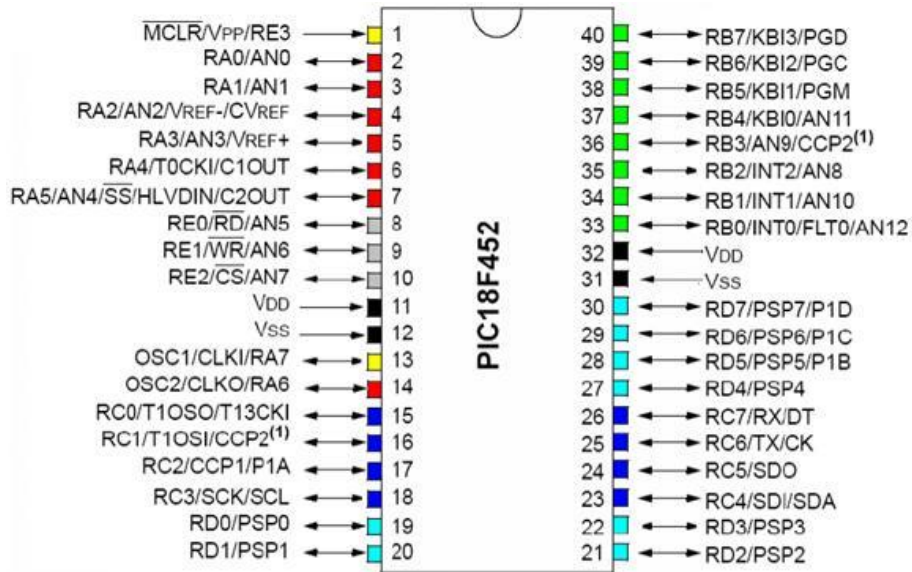


Figure 2. Pin diagram of PIC18F452 microcontroller and pins description [8]

From Figure 2 we see that the PIC18F452 microcontroller has, in addition to the basic pins for power supply, connect the oscillator and reset, 34 digital I/O pins, 8 analog inputs and two ten-bits inputs and two PWM modules.

Written program should be placed in the microcontroller memory. Programming microcontrollers is done by entering the instruction in the EPROM according to the instructions of the microcontroller used, and according to a set of instructions that are supported by the central unit. In this paper, the code written in assembly language, using MPLab integrated development environment. Hexadecimal file, using programmer MPLAB ICD2, is transferred to PIC18F452 microcontroller. The code is not listed in this paper because of its size.

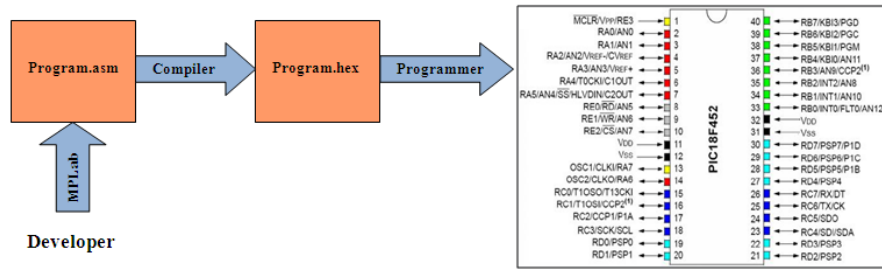


Figure 3. A method of programming PIC18F452 microcontroller

On Figure 3 the steps to programme the microcontroller PIC18F452 are shown.

### 3. XBEE MODULES

XBee radio module is a brand of company Digi International to fully implement the Zigbee protocol [11]-[13]. XBee is a tiny RF (radio frequency) module that has been developed and specifically designed to provide a simple and cost-effective performance of ZigBee wireless technology. Requires minimal energy to operate and provide reliable data transfer between devices [14]. Different protocols and features of RF modules are available, which allow the users great flexibility to choose the best option for their needs.

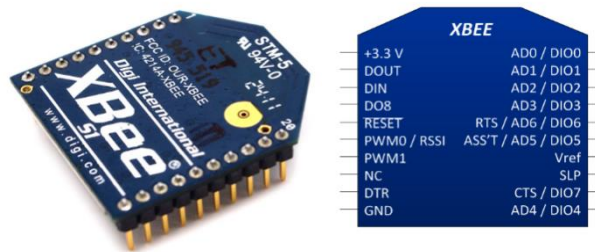


Figure 4. XBee Module 24

XBee/XBee PRO modules have 20 pins (see Figure 4). For work of XBee module four basic pin connections are sufficient - power supply Vcc (3.3 V), ground GND, Data input DIN and Data output DOUT. Other pins are used as input-output pins for the analog and/or digital data as well as control pins (sleep, status, reset, etc.).

Characteristics of XBee module 24 are [12]:

- Supply Voltage 2.8 – 3.4 V
- Indoor/Urban Range Up to 30 m
- Outdoor RF line-of-sight Range Up to 90 m
- Transmit Power Output (software selectable) 1mW (0 dBm)
- Operating Frequency ISM 2.4 GHz
- Seven 10-bit ADC input pins
- 8 digital I/O pins

- 128-bit encryption
- AT or API command set
- ...

To program XBee module programming tool X-CTUis used. X-CTU set program is shown in Figure 5.



Figure 5. Appearance of XCTU program

Table 1 shows how to configure the XBee modules to communicate with each other.

Table 1. Configure the XBee modules to communicate with each other

	Xbee 1	Xbee 2
<b>PAN ID</b>	3010 (or any number in the range of 0-FFFF)	3010 (or any number in the range of 0-FFFF)
<b>CH</b>	C	C
<b>MY Address</b>	1	2
<b>DH</b>	0	0
<b>DL</b>	2	1

Besides basic configuration it is necessary to set a large number of parameters for proper and safe operation of the ZigBee network. After programming the XBee modules they are ready to communicate with each other. In our project XBee modules are used to send data from the computer to the PIC18F452 microcontroller.

#### 4. REMOTE CONTROL OF LIGHTING USING PROGRAMMING LANGUAGE MATLAB, ZIGBEE TECHNOLOGY AND PIC18F452MICROCONTROLLER

In programming language MATLAB is created a graphical user interface for lighting control. The graphical user interface sends data using the serial port. On the serial port the XBee module is connected. XBee module is programmed using a programming tool X-CTU. Received data from the MATLAB programming language, using XBee wireless communication module is sent to the second XBee module which is connected to PIC18F452 microcontroller. The PIC18F452 microcontroller is controlling lighting system. This is shown in Figure 6.

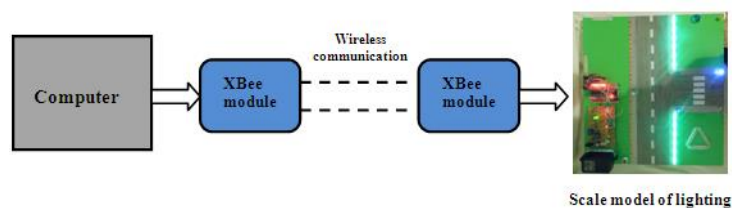


Figure 6. Block diagram of model of lighting

In order to use the PIC18F452 microcontroller for lighting control, amplification of its output signal must be made. We used MOSFET transistors IRFZ 44 and relays to do so. After designing in the programming language Circuit Wizard, development and soldering necessary parts receive the energy part of the system as shown in Figure 7.

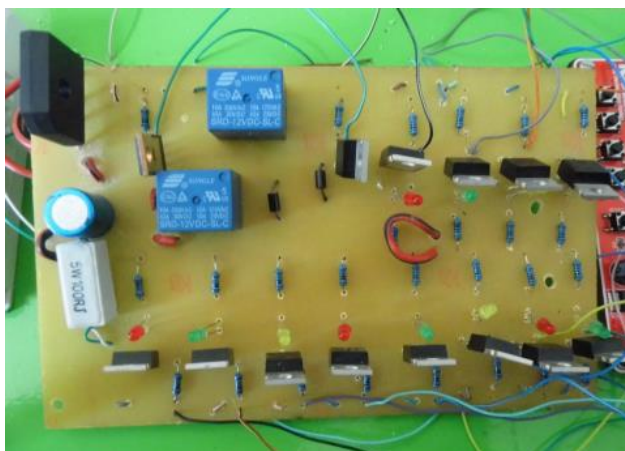


Figure 7. The appearance of the energy part of lighting control system

For the PIC18F452 microcontroller is used a development board for 40-pin PIC microcontrollers shown in Figure 8



Figure 8. Development board for 40-pin microcontrollers with the PIC18F452 microcontroller

After connecting and testing we're getting circuit for remote control of lighting shown in Figure 9.



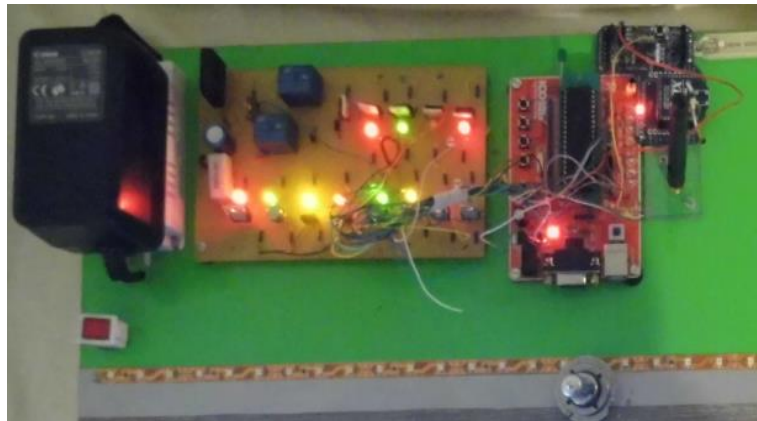


Figure 9. The appearance of the finished circuit for remote control of lighting

From Figure 9 we see that XBee module wirelessly receives signals from XBee module connected to the serial port. The received control signals are sending to the PIC18F452 microcontroller where these signals are being processed and sent to the individual outputs from the PIC18F452 microcontroller. The processed signals are then amplified and sent to individual consumers on the board that is used to verify the work designed system for remote control of lighting. Consumers are at the lighting: incandescent bulbs, LEDs, LED modules and LED strips.

## 5. EXPERIMENTAL RESULTS

In this part of the paper experimental verification of work created system was carried out. User is using the graphical interface created in programming language Matlab, controls the work of the remote system lighting. Pressing the green buttons (see figure 10) turn on light bulbs, LED strips or LED modules and pressing the red buttons turn off the specified lighting. Panel (white or yellow color) at the end of each pair of on-off changes color depending on whether it is on or off lighting. The yellow color of the panel means that turn on bulbs (LED strip, LED module) which spatially corresponds included on-off pair.

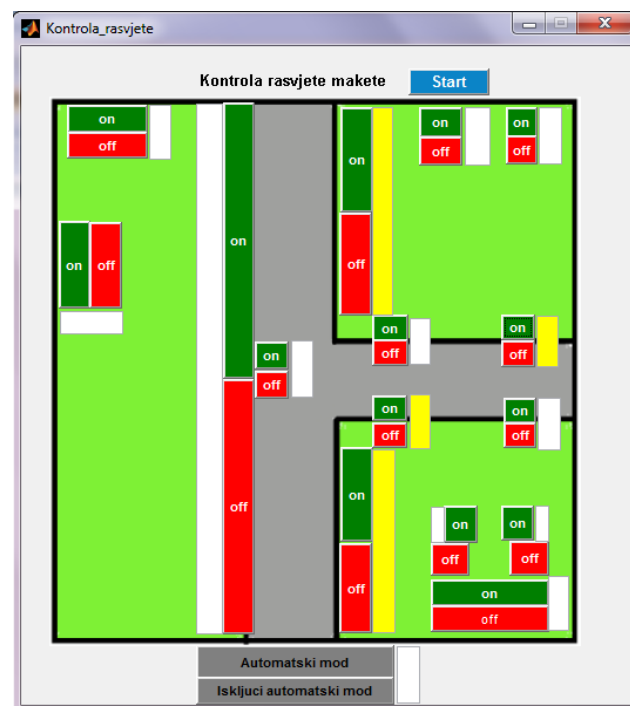


Figure 10. The graphical user interface with the turn on four bulbs (LED strips, LED bulbs)

Figure 11 shows the appearance of the model lighting for this case. We see that they include two LED strips along the street, and two LED bulbs equivalent to yellow panels on the graphical interface shown in Figure 10. From this we can conclude that the project to a remote control model of lighting works well. At any time, the user knows which the bulb (LED strip, LED Module) is turned on and which one is not.



Figure 11. The appearance of created system for remote control of lighting

We can also select the mode "Automatski mod" (see figure 10) in which the light bulbs (LED strips, LED modules) turn on/turn off the pre-programmed order. Pressing the button titled "Iskljuci automatski mod" again switches to manual operation system for remote control of lighting.

## 6. CONCLUSION

Based on the experimental analysis, we can conclude that the system designed for remote control of lighting works well. With minimal changes (suited real system) designed system can be used to control lighting of smart house.

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