REMOTE CONTROL FOR A MICROCONTROLLER BASED GRAPHIC EQUALIZER USED IN LIGHT ORGANS

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Abstract: *This paper presents how a graphic equalizer is implemented with a microcontroller circuit that controls an array of LEDs depending on the frequency components of a computer audio file. The software component consists of the application itself, which is performed in C++ and C# programming languages. The hardware consists of the system hardware circuit: system components, PCB and the physically circuit. For the implementation an Atmel ATmega 328p microcontroller, a Bluetooth HC05 module and a RGB of 8x8 LED matrix have been used. The graphic equalizer has Bluetooth communication that is achieved through an UART interface and the LEDs are controlled by an SPI interface. The system is very useful because it has wireless communication, high speed execution, low power consumption and it is implemented with low costs components.*

Keywords: *Graphic equalizer, light organs, Bluetooth, microcontroller, triac, LED*

1. INTRODUCTION

At the end of World War II, through a series of "happy accidents" the light organs were created, by transforming discovery-lights of planes into a light spectacle.

This discovery is, in fact, the first light organ ever used by people. After that, many entrepreneurs have realized that a good light show increases the comfort of the people and began to build light organs on an industrial scale. The first models that fulfilled these needs were implemented with magnetic amplifiers, because in that period the electronic amplifiers were very expensive and the actuators and control systems were very complex.

The light organs are electronic lights in which a number of colored lights flash in different colors, depending on the frequency components of the music. With the development of technology, especially in the second half of the 1980s, when thyristors and power transistors started to be available for general consumption, magnetic amplifiers were replaced by electronic amplifiers. [1, 2]

Light organs can be of several types: with thyristor, with triac, controlled by transistors, or with fluorescent piping. Another classification of light organs can be depending on the type of filters used: light organs containing analog filters with piping and magnetic amplifier, light organs with analog filters and triacs, light organs with digital filters (CMOS (Complementary metal-oxide-semiconductor), TTL (Transistor Transistor Logic)) and thyristors and triacs, light organs with filters implemented in EEPROM (Electrically Erasable Programmable Read-Only Memory) memory and microprocessor based or light organs having digital FIR (Finite Impulse Response) filters implemented in microcontroller and transistorized control bulbs. [2]

Organ light with QL-98-6A bulbs is another type which has dynamic light in six colors, the bulbs can light up to the music using a microphone to capture the audio signal and it can be adjusted with a button to determine the lighting rhythm [7]. Dynamic organ light DJ319D it reacts to the music, from the base panel the lighting speed and the microphone sensibility can be adjusted.[8]

The majority of light organs have several drawbacks, among them being: using a microphone, the type of the bulbs that are used, the high energy consumption and the fact that they do not have a wireless transmission.

Following the market study it can be seen that our implemented system actually improves the current systems available on the market, because it has wireless communication and it is implemented with a microcontroller circuit which is a solution for reducing the electronics components number and the cost of designing and development of the product. Another advantage is the use of LED bulbs that have low power consumption, long life, color stability and do not emit infrared or ultraviolet rays. They are made without toxic materials that require disposal as hazardous waste.

In this paper our contribution to the extension of the LED display control system with different devices (Smartphone, tablet, PC) for improving the ambient atmosphere is explained. This is creating a system that works with any type of audio file and any program that plays audio files, without depending on a particular song extension or a program. The system can be used easily in public places because it uses Bluetooth communication. This technology provides solutions for wireless data communication using low-power energy and low-cost technologies that can be easily integrated into any device and opens the way for total mobility.

2. SYSTEM IMPLEMENTATION AND EXPERIMENTAL RESULTS

Equalization is the process that increases or decreases the selective frequencies of the audio signal. Our graphic equalizer divides the frequency spectrum into bands, allowing control frequency amplitudes in each band independently. The frequency spectrum of this system is divided into 8 zones between 20Hz - 20KHz: low frequency (bass), between 20Hz and 250Hz, medium frequency, between 250Hz and 4kHz, and high frequency, between 4kHz and 16kHz.

The block diagram of the graphic equalizer consists of the modules shown in the Fig. 1 below.

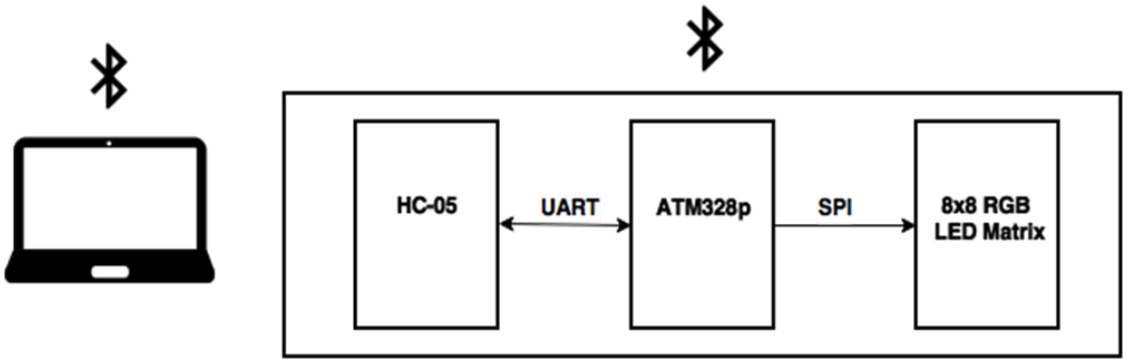

FIG. 1. The system block diagram

2.1 Hardware Implementation. ATMega328p is a chip created by Atmel belonging to mega AVR series. The microcontroller ATMega328p includes as main features 32KB of Flash memory with reading and writing capabilities, 1KB of EEPROM memory, 2KB of SRAM, 23 pins I/O for general use, 32 registers for general use, 3 counters, intern and extern interrupts, USART (Universal Synchronous/Asynchronous Receiver/Transmitter), SPI (Serial Peripheral Interface), I2C (Inter-Integrated Circuit) and a watchdog with internal oscillator. The device has a maximum operating frequency of 20MHz and operates between 1.8V-5.5V [3].

MOD-LED8x8RGB is a 8x8 LED matrix size of 60x60 mm, which allows chaining multiple matrices. The matrix operates at a 5V supply voltage and has an embedded PIC16F1503 microcontroller. This matrix is controlled by the SPI interface [4].

HC-05 module is a Bluetooth SPP (Serial Port Protocol) module easy to use, designed for wireless serial communication. The Bluetooth module is qualified with Bluetooth v2.0+EDR (Enhanced Data Rate), 3Mbps baseband modulation and radio transceiver of 2.4GHZ. The module uses CSR (Cambridge Silicon Radio) 04-Bluecore and it has CMOS technology with AFH (Adaptive Frequency Hopping Feature) [5].

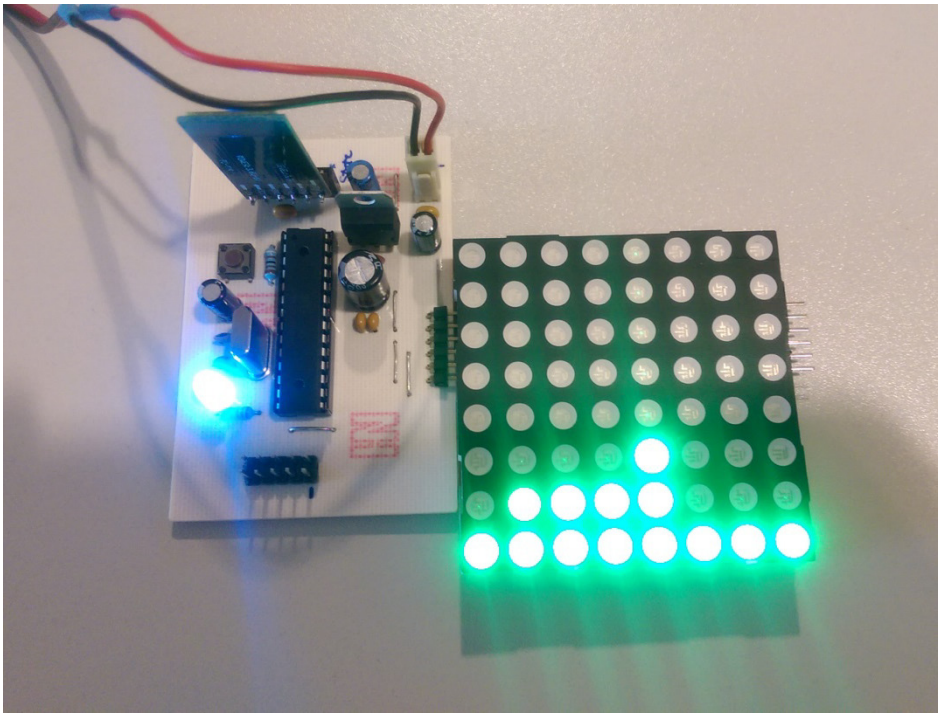

FIG. 2. The hardware component of the system

2.2 Software Implementation. For software implementation the following tools were used: Atmel Studio v.6 for designing the microcontroller application and Visual Studio Express for the user interface. C++ and C# were the programming languages used for this application. The software application establishes the connection between the Bluetooth module and the hardware circuit. After that, the song is played and the FFT (Fast Fourier Transform) filtering is performed. At the same time the application sends the sampled data to the microcontroller and the matrix LEDs will light up depending on the frequency of the song.

As an example, the text below represents the function for send data to the microcontroller via Bluetooth:

```
Stream peerStream; //define the data stream
      int skeep_frame_indx;
      int no_of_frames_to_skeep;
public void write_to_Bluetooth(List<byte> list_buffer)
      {
         {
            skeep_frame_indx ++;
            byte[] buffer = new byte[list_buffer.Count() + 1]; //initialize buffer
            byte[] buffer_tosend = new byte[1]; //initialize buffer that is send to bluetooth
            try
            {
               peerStream = bluetoothClient.GetStream(); //get the data stream
               buffer[0] = (byte)'0';
               Console.WriteLine("Buffer" + " [ " + 0 + "]" + buffer[0]);
               for (int i = 0; i < 8; i++)
               {
                  buffer[i + 1] = (byte)(list_buffer[i] / 32); //because spectrum buffer has
255 number of values, for matrix display I divide the buffer to 32 to obtain 8 values (max
number for 1 column)
                  //if the data is not 0 then the data increase until 8 values
                  if ((list_buffer[i] % 32) != 0)
                  {
                     buffer[i + 1]++;
                  }
                  Console.WriteLine("Buffer" + " [ " + (i + 1) + "]" + buffer[i + 1]);
                  buffer_tosend[0] = buffer[i];
               }

               peerStream.Write(buffer, 0, buffer.Length); //write the data stream to
bluetooth
               Console.WriteLine("Send to placuta:" + buffer.GetEnumerator().ToString());
               Console.WriteLine("Send to placuta:  no_of_data = " + buffer.Length);
            }
            catch (Exception ex)
            {
               Console.WriteLine("ERROR(Mi-s in error catch in Form3.cs): Bluetooth not
connected! error type :" + ex.ToString());
            }
         }

      }
```

The user interface which we designed consists of two main components: the specific window for Bluetooth settings and the window for graphic equalizer settings.

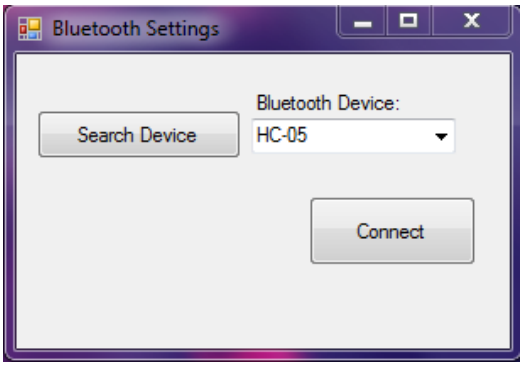

FIG. 3. The window user interface for Bluetooth settings

The window for Bluetooth connectivity (Fig. 3) has four functions: search device, device selection, establishing the connection and sending the data to the Bluetooth hardware circuit (slave).

The user can press the "Search Device" button in order to start searching for available and discoverable Bluetooth devices. Following the search, the devices which were found are displayed in the "Bluetooth Device" box. The user has the ability to select the prefered Bluetooth device by clicking on the right arrow, as this list shows all the found devices. After the preffered device was selected, in order for the connection to be fully established, the user must press the "Connect" button.

The window for setting the graphical equalizer consists of the following functions: spectrum processing, spectrum display, audio device selection and enabling of the entire process.

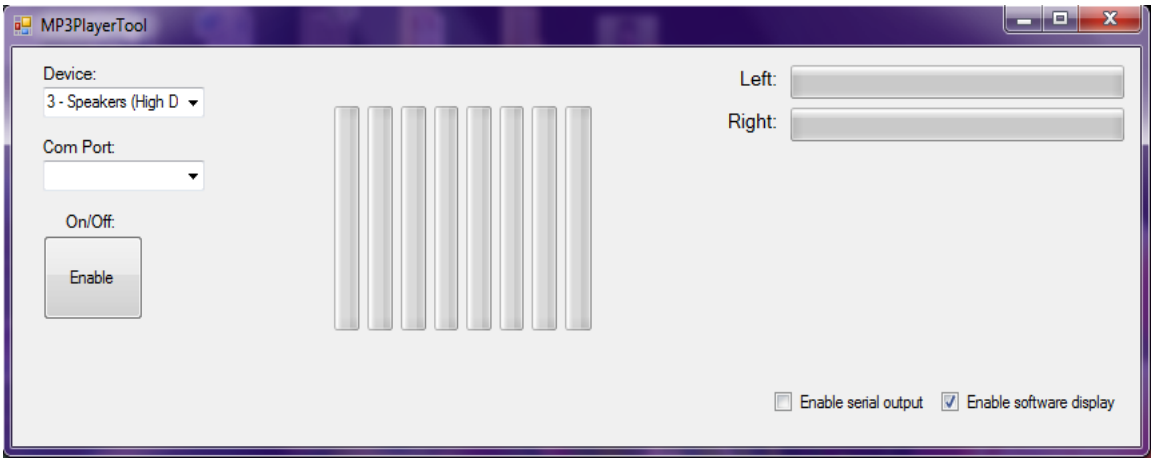

FIG. 4. The window user interface for graphic equalizer settings

The "Enable software display", if checked, enables the spectrum display. The "Device" box is used to select the prefered audio device and has a list of tools that are capable of loopback. These devices should be: laptop speakers, headphones or more. If the user clicks on the right arrow the preffered audio output can be selected. The "Com Port" box is used to select the desired serial port where the Bluetooth connection was established. As in the "Device" box case, it has a list of serial ports available and the user can select the desired port. "Left" and "Right" represents the volume signal from the selected audio device and the middle bars represent the spectrum frequencies of the audio file. To run the application, the user must press the "Enable" button and the application will start running. The last step is to play an audio file (song, video, film and more).

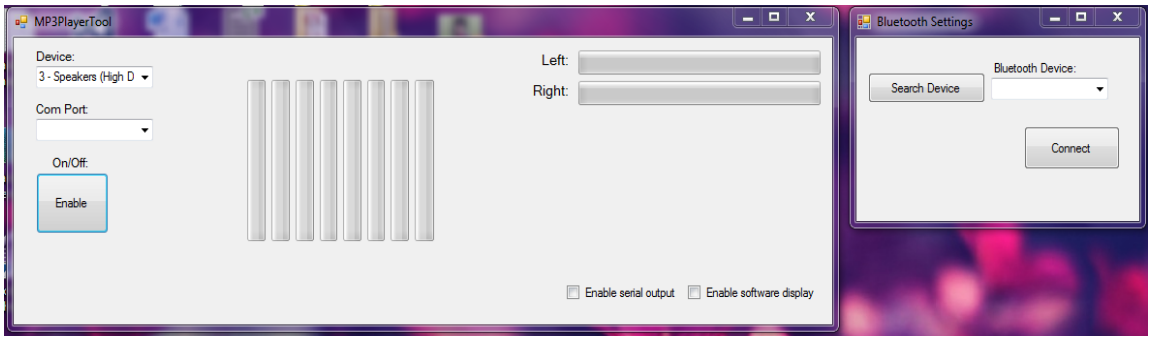

FIG. 5. The user interface

At this point, the application is running, and the LED matrix is lighting providing a simple scenario of a light organ show.

3. CONCLUSIONS AND FUTURE WORK

The main advantage of the designed graphic equalizer is that it is controlled by wireless communication and it can be used easily in public places. Bluetooth technology is an economical solution for wireless communication and the Bluetooth devices can create networks between computers, notebooks, mobile phones and other devices.

Another advantage would be that the devices do not need to be set each time to communicate between them. Also, security is a very important aspect in wireless communication. Thus, Bluetooth specifications define a security model based on three components: authentication, encryption and authorization. Encryption is performed on 128 bits and uses a PIN authentication. Once the authentication is set, the connection is secure and safe for the transmission period.

Furthermore the graphic equalizer offers another benefit from the fact that it is not dependent on a specific type of audio file format or audio program and it has graphical user interface that is easy to use for any user. The product, also can be extended to any audio-video equipment.

For future development, the software can be extended for devices such as tablets, Smartphones and other gadgets. To do this, the software will require implementation of Android or iOS operating systems. Also, the hardware circuit can be developed by extending the capacity of different types of LEDs.

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