University of Moaratuwa
Faculty of Engineering
Department of Electronic and Telecommunication

BM1190 : Engineering Design Project
Group BM-3
SITZU(Migraine theraputic device)

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1 Introduction

1.1 Problem Description

Migraine is a global health issue without a solution. According to the results of the surveys done, one out of ten people in the world are suffering from migraine. This is a complex neurological disease mainly that results in,

- Intense headache on one side of the head.
- Moderate or sever throbbing sensation getting worse when move.

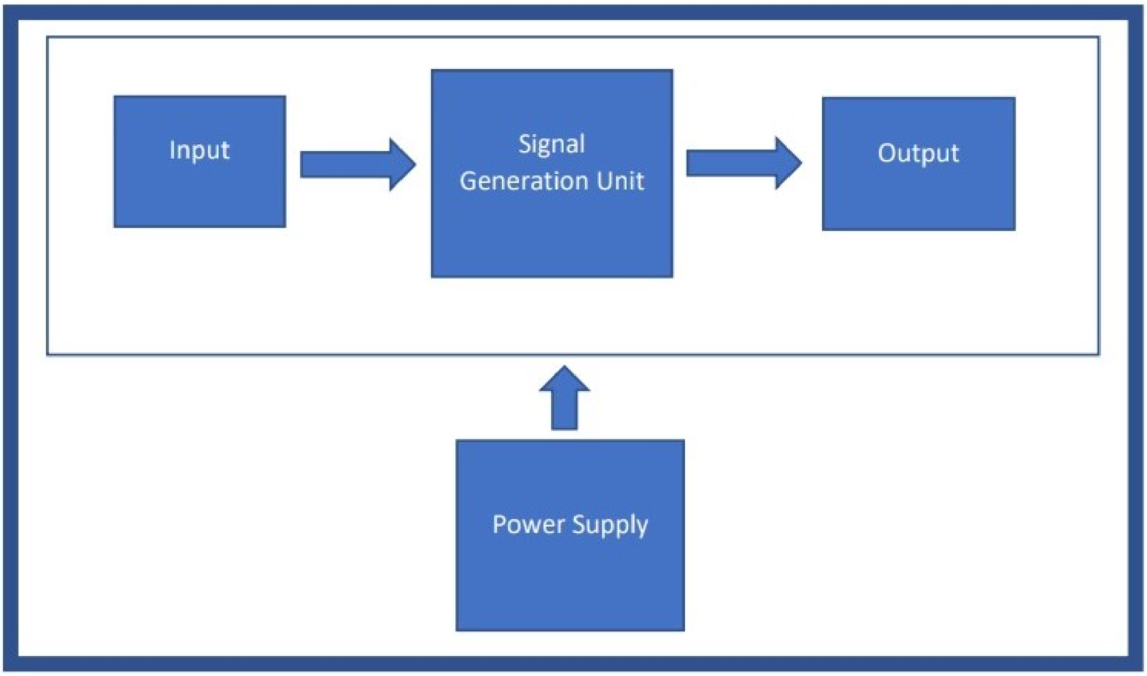
Although there is no permanent medical treatment for migraine, there are some ways to minimize the pain. Most people who are usually suffering from migraine use to massage their forehead as an external treatment and to take pain killers as a medical treatment. But when the pain occurs, patients have to stop their all-other works to do massaging. It is time consuming and cause big issues to students and busy people. On the other hand, taking pain killers very often can cause side effects such as gastritis, ulcers and kidney or liver damages etc. Therefore, there is a huge need of an effective solution for migraines.

1.2 Solution

Transcutaneous electrical nerve stimulation (TENS) is a popular non-invasive self-administered technique to relieve pain. In this method tiny electrical current is delivered through the skin using electrode pads attached to the skin surface. Most importantly this is a technique with few side effects.

The gate control theory of pain is the underlying mechanism behind the TENS. This method reduces the transmission of pain sensation messages to the brain by deactivating the relevant sensory fibers. In our method we placed electrodes on the forehead with intension to minimize the migraine pain. Here we are stimulating the afferent paths of the Supratrochlear and Supraorbital nerves of the ophthalmic branch of the Trigeminal nerve. In our method we are using high frequency low intensity electrical signals. At the beginning low intensity is used and gradually intensity increases. The intension of this is to stimulate selectively large diameter low threshold fibers (A-beta) at first and after that stimulate high threshold (A-delta) fibers. This reduces the transmission of migraine pain sensation messages to the brain and give relief to the patient when migraine is occurred.

2 Product Architecture



Input : power on device(button press), power for recharging

Output : current to electrode, feedback sounds and lights

Signal generation : generate desired signal

Power Supply : supply power to each unit ,recharging battery

Figure 1: Product architecture

2.1 Main modules

1. Inputs
   Push button switch is used as the main input of device.We have used a 6Pin Two Row Through Hole Mount DPDT Self-Locking Mounting Tact Tactile Power Micro Push Button as our switch.

2. Signal Generation Unit
   This module has divided into several sub-modules.

   - Micro-controller Unit - Generate a PWM signal with varying duty cycle.We have programmed Micro-controller such that it deliver PWM signal with increasing duty cycle for about 16 minutes and then decrease duty cycle for next 4 minutes.

- Digital-Analog Converter - This sub-module convert above PWM signal to Analog stair case signal.We have selected cut-off frequency of filter such that filter circuit would filter out all the harmonics except DC component of signal.We have used a second order filter circuit in order to obtain a more accurate output signal.
- Sampling Signal Generator - This signal is used to sample staircase signal obtained in above sub-module.And this unit mainly comprise of 555 timer IC.We could not use a PWM signal obtain from micro-controller for achieve our purpose because we needed sampling signal around 100Hz but micro-controller could not provide such low frequency PWM signal.
- Sampling Unit - Main function of this sub-module is to sample the stair-case signal.For that we used a very primary but efficient method.We used a BJT transistor in switching mode.Base and collector resistor values were calculated to make sure that transistor operates in switching region.
- Voltage-Current Converter In the final stage of our circuit we have to convert generated voltage signal into a current signal.Key feature of this sub-module is it should be able to deliver a current signal independent of output load.So we have used a Op-Amp circuit which functions as a voltage-current converter whose out put current is independent of output load.

3. Outputs
   Our main output is the generated current.And it is delivered using 3 electrode terminals.Besides our product has feed-back outputs to make our product user friendly.Two LEDs and a buzzer is used to output feed-backs.A red LED is used to indicate that device is in Power ON mode.A green LED is used to indicate that device is in Operating mode.And buzzers is making beep sound at the beginning and the end of the Operating mode.

4. Power Supply Unit
   Four coin-cells are used as main power source of the device.And 7805 IC is used to regulate the supply voltage.

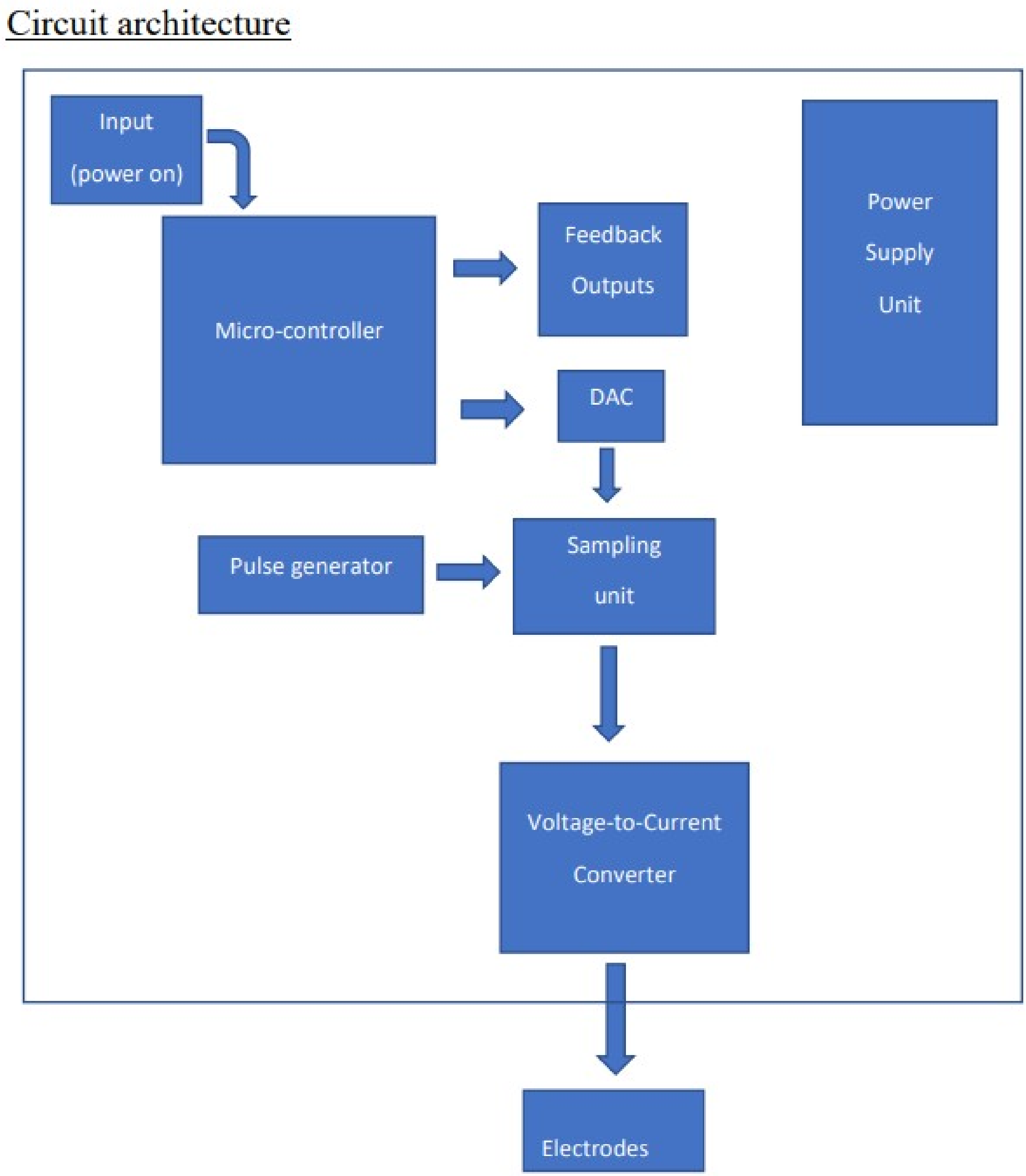


Figure 2: Circuit architecture

2.2 Technical Specification

- Standards
  - Pulse frequency :100 Hz
  - Pulse duration :500 μs
  - Pulse width :250 μs
  - Step-up intensity :30 μs
  - Intensity : 5 mA

- Output Current Waveform - Begins when user switches ON the device and delivers a square pulse current signal with an increasing amplitude for about 16 minutes and decreasing current within about 4 minutes.
- Weight - about 50g
- Dimensions - 7cm x 4.8cm x 3cm (without headband)

2.3 Component Specification

- Input Unit
  1. 6Pin Two Row Through Hole Mount DPDT Self-Locking Mounting Tact Tactile Power Micro Push Button
- Signal Generation Unit
  - Micro-controller Unit
    1. Atmega328p
    2. 16 MHz oscillator
    3. capacitors (22pF x 2)
  - DAC Unit
    1. LM358 Dual Op-Amp IC
    2. Resistors ($1k\Omega$, $33k\Omega$)
    3. capacitors ($1\mu F$ x 2)
  - Sampling Signal Generator
    1. NE555 IC
    2. resistors ($1k\Omega$, $750k\Omega$)
    3. 10nF capcitor
  - Sampling Unit
    1. 2N222 transistor
    2. resistors (100Ω, $1k\Omega$)
  - Voltage-Current Converter
    1. LM358 Dual Op-Amp IC
    2. Resistors ($1k\Omega$ x 4)
- Output Unit
  1. Electrodes
  2. 2 LED bulbs
  3. 2 resistors
  4. 5V buzzer
- Power Supply Unit

1. LM7805
2. coin cells
3. Capacitors (100nF x 4)

3 Design

3.1 Designing circuit

We have designed and simulated our circuit using Proteus software.Initially we started with an analog circuit which can generate square pulse signal with varying amplitude.But as we move on it was converting our design to digital domain was essential.Because we needed to program our device such that it would operate within a fixed time period and vary the amplitude of signal in a manner we specified.

The main modules in our circuit were discussed above.During simulations we have checked out put signal of each stage and verified that signal is generated according to our standards.

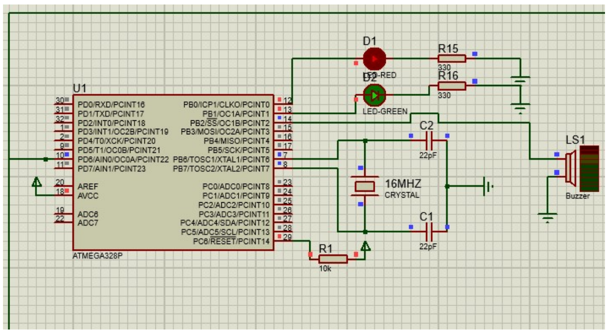


Figure 3: Micro-controller Unit

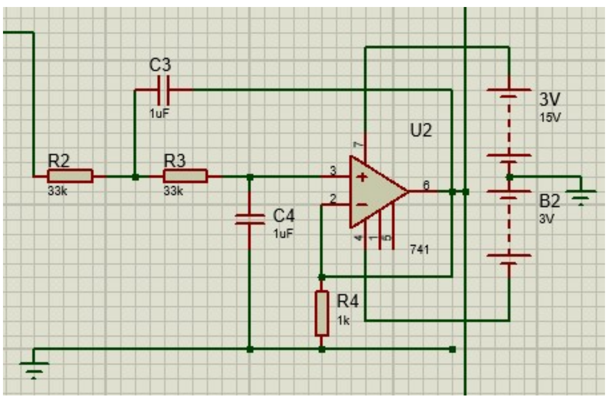


Figure 4: DAC unit

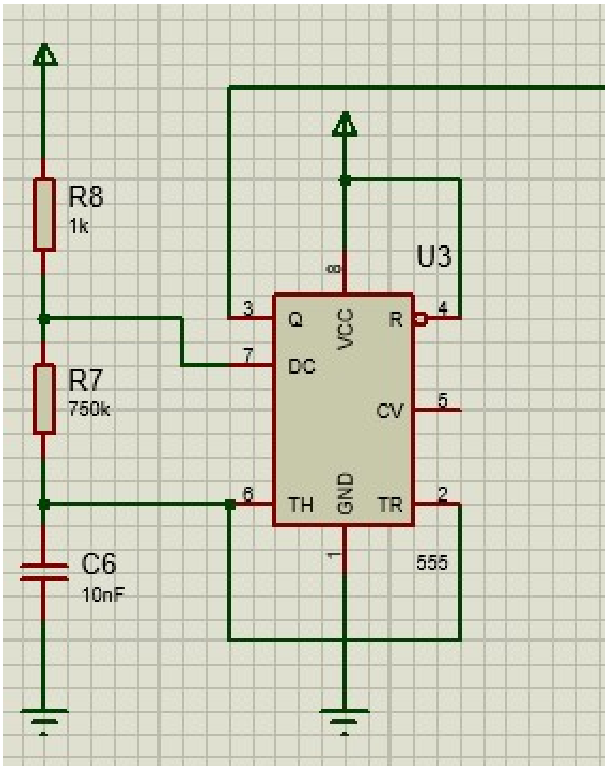


Figure 5: Sampling Signal Generator Unit

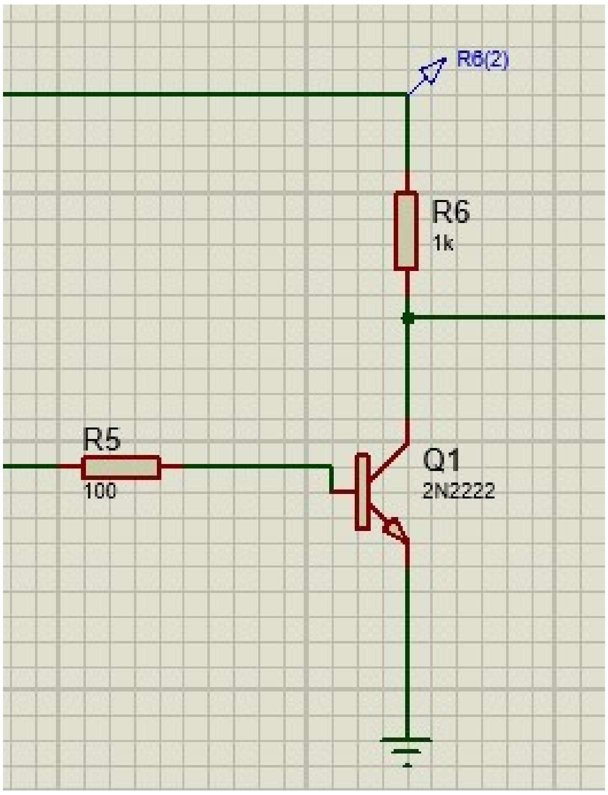


Figure 6: Sampling Unit

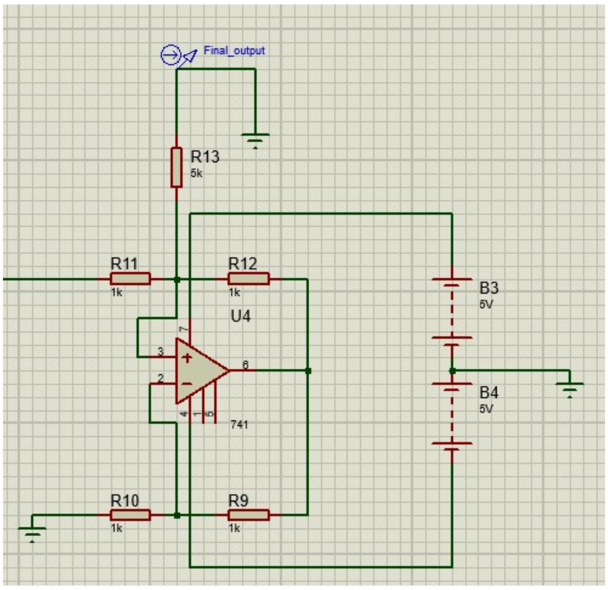


Figure 7: Voltage-Current Converter

3.2 Designing and fabricating PCB

Our product required a Printed Circuit Board with several connectors, buttons, micro controller and ICs. So in order to mount these components on the PCB we used the software Altium to design the PCB schematic and PCB layout.We used two layer PCB layout and after printing PCB, we manually soldiered components.

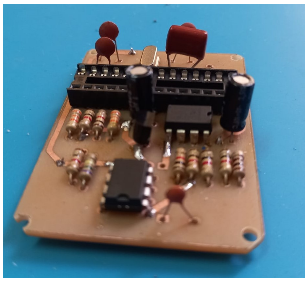


Figure 8: fabricated PCB

3.3 Enclosure Design

The enclosure design is done using the SolidWorks software.We separated our enclosure into three parts and designed them.

- Top Lid

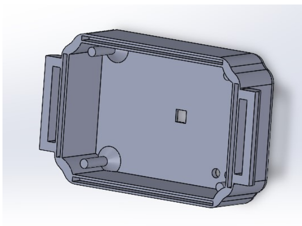


Figure 9: Top Lid

- Bottom Lid with battery case

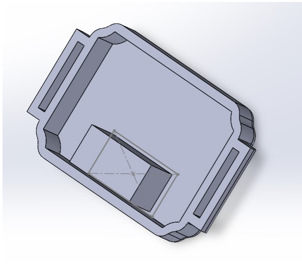


Figure 10: Bottom Lid

- Battery case cover

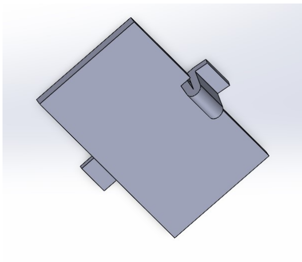


Figure 11: Battery case cover

After designing parts separately, we assembled them in Solidworks and checked whether they fit together.

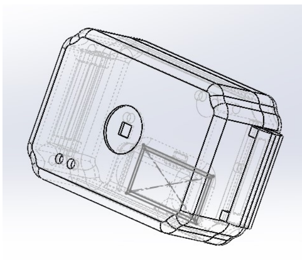
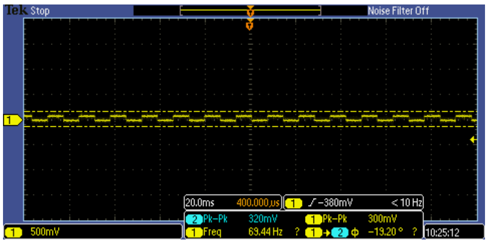


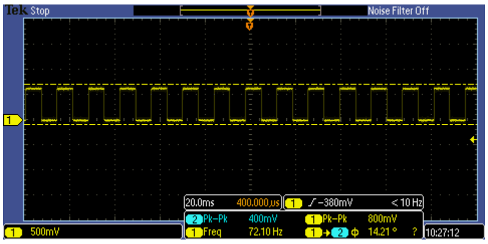
Figure 12: Assembled Enclosure

4 Testing

We tested the operation of the circuit at the laboratory to ensure that it works correctly and generates the required wave form. We observed the wave forms at each sub module using the oscilloscope and we were able to get the required wave forms at each step.So the observed final output waveform is as follows.



(a)



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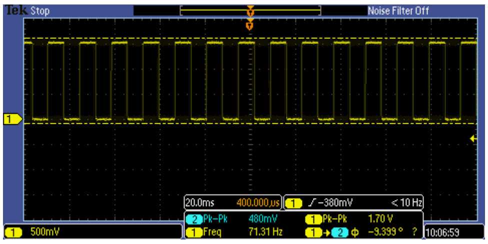
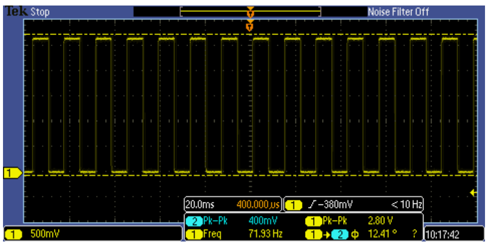
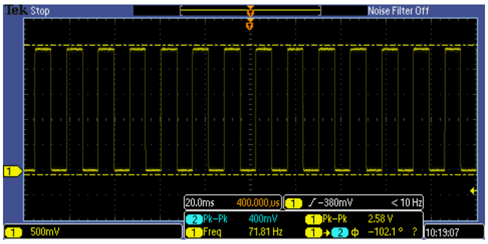


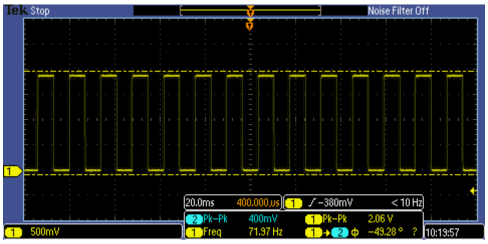
(c)



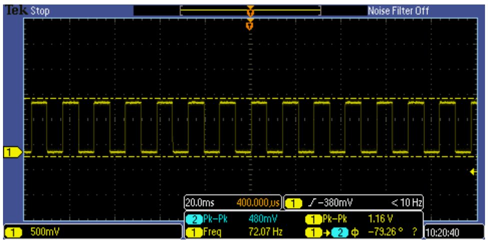
(d)



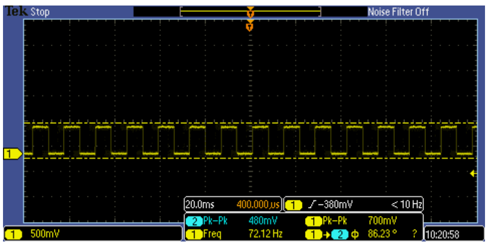
(e)



(f)



(g)



(h)

5 Bill of materials

Equipment	Quantity	Net Price (LKR)
Atmega328p	1	1200.00
LM358(dual Op-Amp IC)	1	40.00
555 timer	1	40.00
Resistors	13	26.00
2N2222 transistor	1	5.00
Capacitors	7	50.00
7805 voltage regulator	1	40.00
Battery	4	200.00
LED	2	10.00
Button switch	1	20.00
Buzzer	1	80.00
Electrodes	3	300
Other Equipment		999.00
PCB		500.00
Enclosure		1190.00
Cost		4400.00
Sales Price		10000.00

6 Appendices

Appendix I - Circuit Schematic

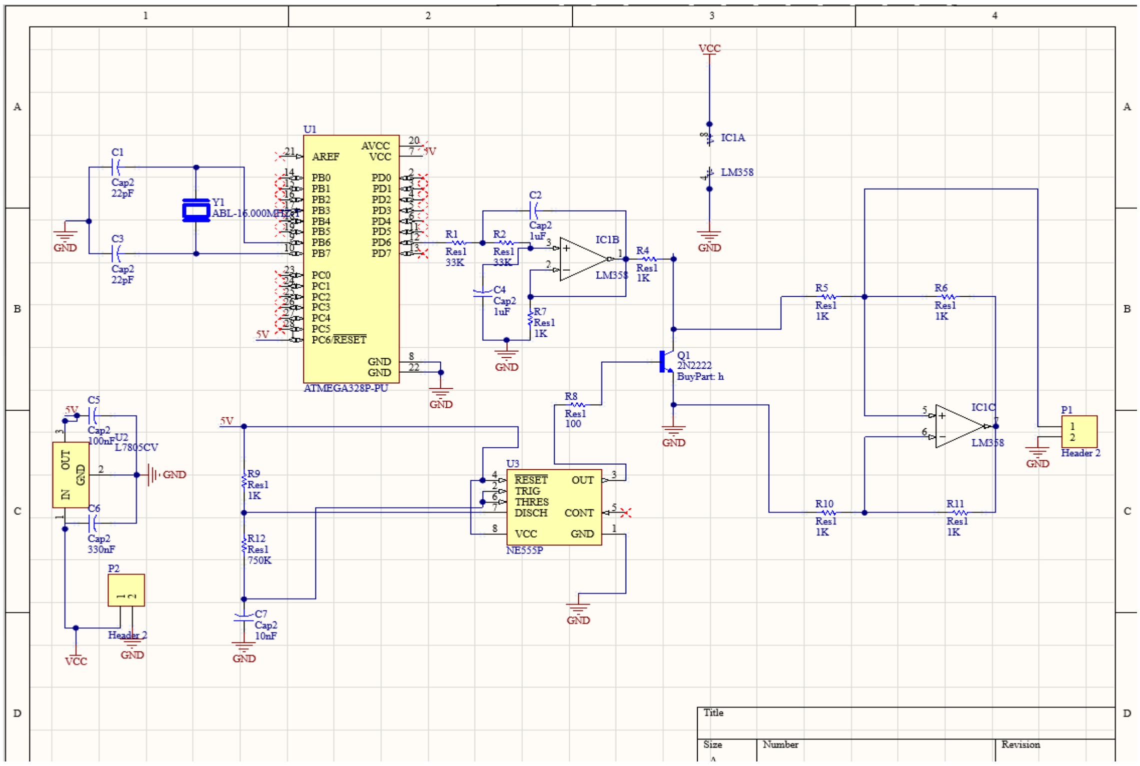


Figure 13: PCB schematics diagram(drawn using Altium)

Appendix II - PCB design

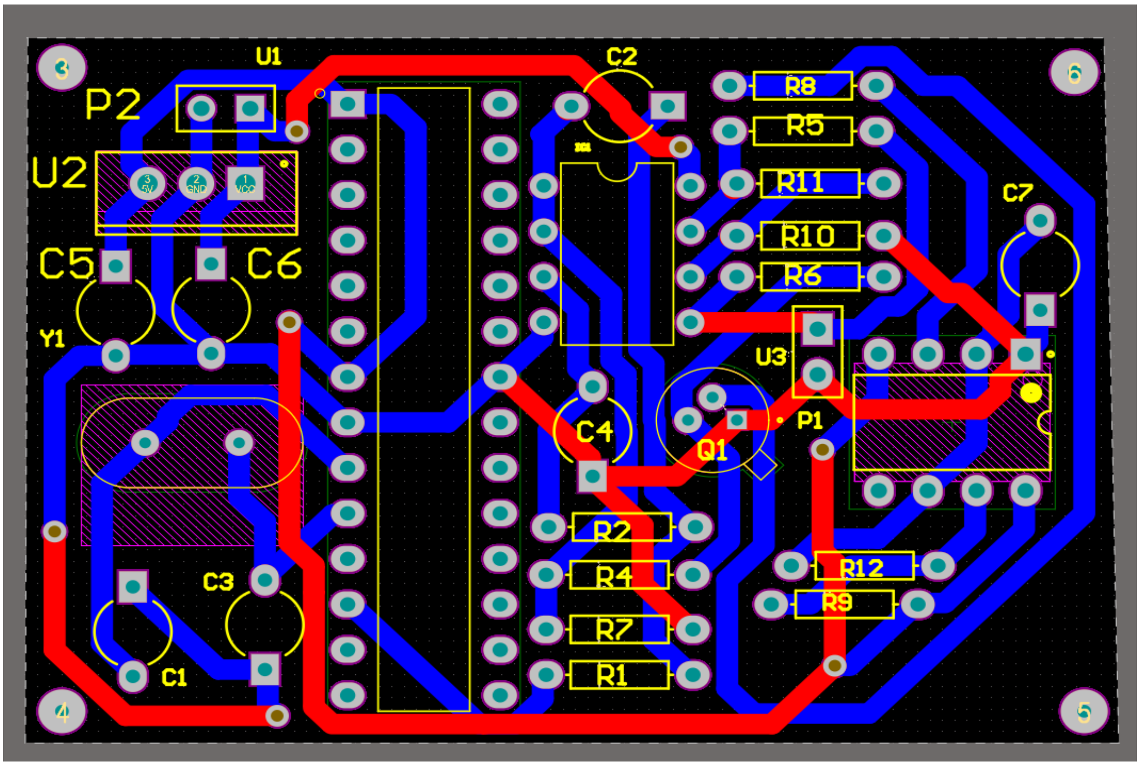


Figure 14: PCB layout(designed using Altium)

Appendix III - Source Code

```
#ifndef F_CPU
#define F_CPU 16000000UL
#endif

#include <avr/io.h>
#include <util/delay.h>

int main()
 {

   DDRD |= (1<<PD6);    //Fast PWM output at OC0A pin

   //Setting up feedback output pins
   DDRB |= 0x07;
   PORTB |= 0x5;
   _delay_ms(25); // period of beep sound
   PORTB &= 0xFB;



  int i = 255;
  while(1){
     PORTB |= (1<<1);
     int j = 0;
       while(j < 50){
         int k = 0;
         while(k < 20){
           OCR0A = i;  // Duty cycle of 75%
           TCCR0A |= (1<<COM0A1) | (1<<COM0A0) | (1<<WGM01) | (1<<WGM00);  //Inverting Fast PWM mode 3
           TCCR0B |= (0<<CS02)|(1<<CS01)|(1<<CS00);  //No-Prescalar
           _delay_ms(1000);
           k = k +1;
         }

         i = (i-5)%256;
         if ( i < 0 ){
           i = i + 255;
         }

         j = j + 1;
       };
```

```
i = 0;
int l = 0;
while(l < 10){
    int k = 0;
    while(k < 20){
      OCR0A = i;  // Duty cycle of 75%
      TCCR0A |= (1<<COM0A1) | (1<<COM0A0) | (1<<WGM01) | (1<<WGM00);  //Inverting Fast PWM mode 3
      TCCR0B |= (0<<CS02)|(1<<CS01)|(1<<CS00);  //No-Prescalar
      _delay_ms(1000);
      k = k +1;
    }

    i = (i+25)%256;
    if ( i < 0 ){
      break;
    }

    l = l + 1;
  };


//switching off PWM signal
DDRD &= (0<<PD6);    //Fast PWM output at OC0A pin

//switching off greed LED
DDRB &= 0x01;
PORTB &= (0<<1);




  // feedback beeps
  PORTB |= 0x5;
  _delay_ms(25);
  PORTB &= 0xF9;
  _delay_ms(75);
  PORTB |= 0x5;
  _delay_ms(25);
  PORTB &= 0xF9;



  break;

};



  return 0;
}
```