REMOTE CONTROL LED DIMMER USING NRF24L01+ RADIO AND MICROCONTROLLERS

A Design Project Report

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Submitted by

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Abstract

Master of Engineering Program

School of Electrical and Computer Engineering

Cornell University

Design Project Report

Project Title: Remote Control Led Dimmer Using NRF24L01 radio and PIC32 Microcontroller

Author: Xiaobin Li

Abstract:

The object of this project is to implement a remote control led dimmer using nrf24L01 radios and microcontrollers. There are four button as inputs: on, off, brighter and dimmer which make the led behave accordingly. The design involves button detection, RF remote communication and led circuit design. There are two radios communicating with each other through 2.5GHz frequency signal with data, address and pipe. The microcontroller are used for detecting incoming button press and generating PWM signal to control the light intensity of the led. The remote control dimmer will not only be a convenient product for people's daily life but also an energy-efficient product that could save energy for users.

Keyword: microcontroller, remote control, led

Executive Summary

Lamps are necessary products for everyone’s home. Billions of lamps consumes mass of energy every day. Sometimes, the lamp is kind of far away from where we are and it is not convenient to walk towards the lamp and then come back. Therefore, it is useful to have a remote control led dimmer which can help save energy and make human’s daily life more convenient as well.

Based on the requirements above, a remote control led dimmer is built in this project using nrf24L01+ radio modules and microcontrollers. The control panel includes four buttons for people to choose to turn on, off the led or make it brighter or dimmer. There are two parts for the design: transmitter part and receiver part. Transmitter part includes button detection and message transmitting. Receiver part includes message receiving, pulse width modulation and led circuit. Button signal will go through the whole chain from transmitter part to receiver part to finally control five led light intensities.

Various tests are designed to test the function and performance of the project. There are five light intensities to clearly tell the difference when pressing the buttons. The range of radio communication is over 20 meters after testing it on two sides of the lab. The remote control can also work on different channels such as 2.4GHz and 2.5GHz.

1. Introduction

1.1 Motivation

Remote control is handy and convenience. With the development of embedded system and remote control, lots of electronic equipment becomes wireless and remote control. Imaging you sitting in the sofa, remote-controller in your hand, you can easily switch TV channel or volume from a certain distance. Also think about mouse for personal computer or laptop, more and more people are using wireless mouse without the bother of mouse cable. Now think about a lamp, if we have a remote controller to control a lamp, we can turn it on easily from a distance. A scenario could be coming back home late at night and we turn the lamp on before we entered the house. Also, we can easily turn it off when we want to sleep without getting up to the lamp.

Energy saving is also an important part to mention nowadays. The appearance of mass of electronic devices consumes more and more energy. I am thinking that it would be better if we can dim the light of the remote-control lamp to save energy. With a remote-control dimmer, we can change the light of the bulb according to different conditions.

1.2 Background

There are many ways to do wireless and remote control, such as infrared radiation (IR), radio frequency (RF). Infrared radiation is invisible light with a wavelength between 700nm to 1mm. Remote control for television sets are mainly realized by infrared radiation. However, infrared radiation cannot go through walls or other obstacles. Therefore it is not suitable for our projects since there might be some obstacle between our controller and the lamp. Radio frequency is electromagnetic waves with a frequency range from 3 kHz to 300 GHz. RF is widely used for wireless communication in our daily life, such as WIFI, wireless mouse and wireless keyboard. The waves can go through walls to travel a certain distance with low power which is good enough for our home application.

There are many choices of the light bulb also. Incandescent bulb is classic choice and can be used with a dimmer switch. However, it cost too much energy and all standard incandescent bulbs are out of the market and will no longer be produced. Compact fluorescent (CFL) bulbs is a better option with lower energy cost and reliable quality. CFL bulbs is lighted up by the contact of UV light generated by each end of the tube and phosphor coating on the inside of the bulb. However, it is kind of difficult to make it work with a dimmer. Light emitting diode (LED) are energy-efficient and commonly used in our daily life nowadays. LED bulbs are illuminated by an electrical current pass through semiconductor material. There are 3W or 5W LED which are good enough for our project. The only problem might be the heat. Led will produce mass of heat when it is on, which requires a heat sink to absorb heat and keep the bulb away from damage. In 2017, new US regulation makes it difficult for CFLs to qualify for an ENERGY STAR® rating and many companies decide to drop CFLs and only produce LED bulbs. The bulb for this project should be bright enough to see different level of light and energy-efficient, therefore, a 5W LED bulb will be our final choice.

2. Circuit Design

2.1 Main issues

Based on the discussion above and the requirements, the following figure 1 shows the overview diagram for this project. There are two parts: transmitter part and receiver part. For transmitter part, four buttons are original input source triggered by users. Input signal is received by PIC32 pins and then PIC32 sends message to the transmitter. For receiver part, the radio receives the message and sends it to PIC32. PIC32 will send out corresponding control signal to led circuit. There are three main issues to be solved: button detection, radio communication and LED control circuit.

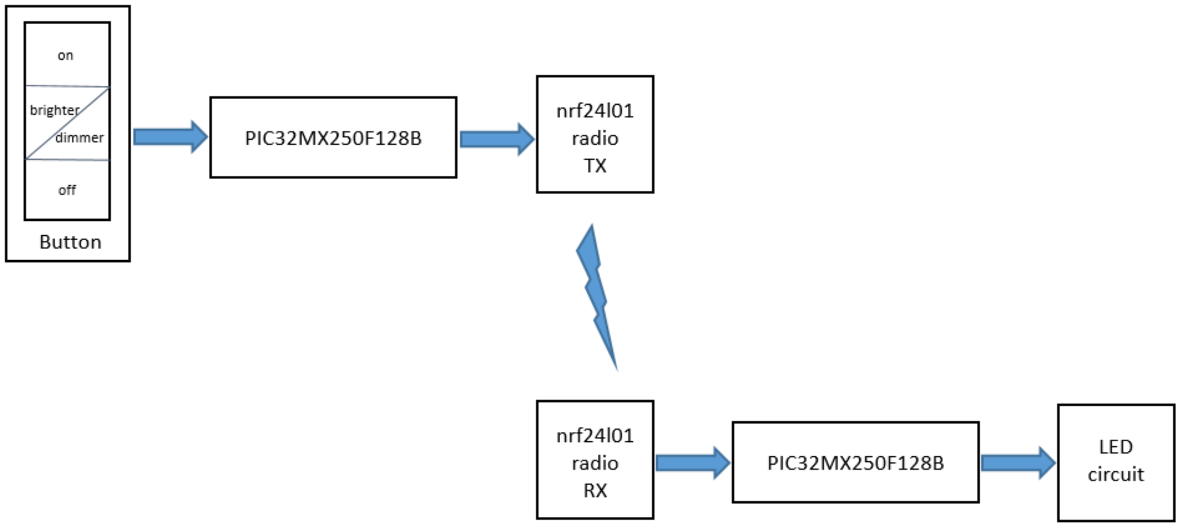
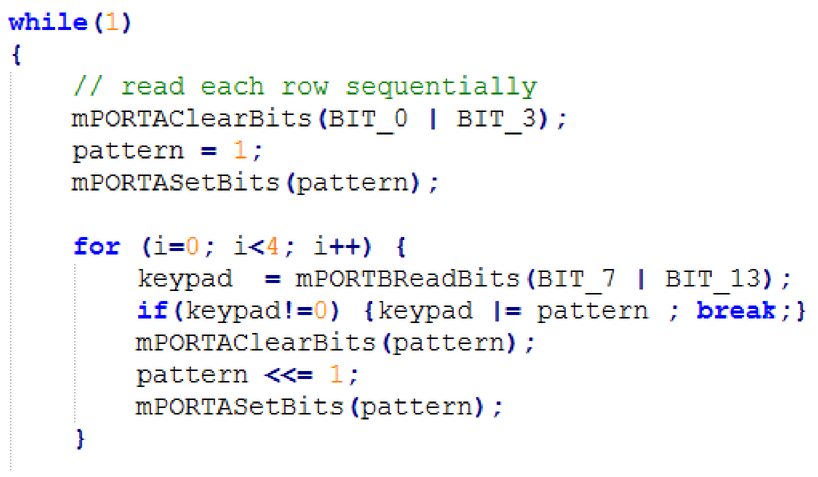


Figure1 Overview Design Diagram

2.2 Button Detection

The button detection scheme is shown in Appendix. A0 and A3 are digital output pins from PIC32 while B7 and B13 are digital in pins from PIC32. There are two kinds of resistors: 300 ohms and 10k ohms. 300 ohms resistors are to avoid short circuit when two buttons are pushed together. 10k ohms resistors are to avoid open circuit input when no button pushed.



```
while(1)
{
    // read each row sequentially
    mPORTAClearBits(BIT_0 | BIT_3);
    pattern = 1;
    mPORTASetBits(pattern);

    for (i=0; i<4; i++) {
        keypad  = mPORTBReadBits(BIT_7 | BIT_13);
        if(keypad!=0) {keypad |= pattern ; break;}
        mPORTAClearBits(pattern);
        pattern <<= 1;
        mPORTASetBits(pattern);
    }
```

Figure2 Snippet of Button Detection

Figure2 is a snippet of button detection that explains how the button detection works: first, set an array called keytable to store all possible button-press cases. Then constant pattern scan each row and detect if there is an input to each column. If the answer is yes, concatenate keypad with pattern which should be a keycode in the keytable.

2.3 NRF24L01 Radio Module

2.3.1 Hardware Connection

The radio module for this project is nrf24L01+. It is a single chip 2.4GHz transceiver to work with microcontroller. There are 8 pins on it which is shown in figure and table below.

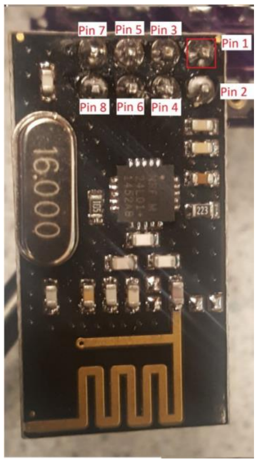


Figure3 Nrf24L01 Radio Pinout

Credit: Nrf24L01 Radio Library by Douglas and Fred

Radio Pin Number	Name	PIC Connection
1	GND	GND
2	Vcc	Vcc
3	CE	Pin 17 (RB8 I/O)
4	CSN	Pin 18 (RB9 I/O)
5	SCK	Pin 26 (SPI SCK 2)
6	MOSI	Pin 9 (RPA2 SPI2 Data In)
7	MISO	Pin 12 (RPA4 SPI2 Data Out)
8	IRQ	Pin 21 (RPB10 External Interrupt 1)

Table1 One Possible Pin Connection for Radio and MCU

Credit: Nrf24L01 Radio Library by Douglas and Fred

The radio requires an SPI connection, an interrupt pin, and a connection to Vdd and ground. A list of pins and their connection is shown in table above. Pin 1 and 2 connects to GND and Vcc correspondingly to PIC32. Pin3 is chip enable and pin4 is chip select which are both control signals. They are connected to I/O pins of PIC32. The radio communicate with PIC32 through SPI and we are using SPI2 and SCK2 of PIC32. Pin8 is interrupt request port which is connected to external interrupt1 of PIC32.

2.3.2 Software Setup

nrf_setup function initializes SPI for communicating with the radio, setup the radio interrupt setup I/O pins, and reset all register values on the radio. It must be called before calling any other radio functions.

2.3.3 Frequency

The nrf24l01+ radio can work with 126 channels, ranging from 2.4 GHz to 2.525 GHz. According to nrf library, the frequency can be set with nrf_set_rf_ch function. There is an equation to calculate the frequency, frequency = 2400 + ch (MHz), where ch is the input to the nrf_set_rf_ch function. Note that the frequency of the transmitter and receiver must be the same to communicate well. The following line of code show an example to set the frequency to 2.5 GHz, which is the frequency we are using for this project.

```
nrf_set_rf_ch(0x64);   // freq = 2400 + 6*16+4 MHz = 2.5GHz
```

2.3.4 Addresses and Pipes

The nrf24l01+ uses addresses on the receiver and transmitter to identify where should each packet go. In order to communicate well, the address on transmitter side and receiver side should be set to the same address. On receiver side, there are six pipes numbered 0-5 for data to be caught. Each of these pipes has a 3-5 byte address field that determines which packets are received on that pipe. The length of the address can be set to be 3-5 bytes using the nrf_set_address_width function. Each pipe can have a different address, allowing them each to receive data from a different module. The address of a pipe can be set using the nrf_set_rx_addr. On transmitter side, there is also an address called TX address. This sets the address which this radio transmits with. In order to send to a pipe on a receiver that has its address set to 0xFFF, the TX address of the transmitter must be set to 0xFFF as well. The address of the transmitter be set using the nrf_set_tx_addr function according to nrf library.

2.3.5 Transmitting and Receiving

The nrf24l01+ can send up to 32 bytes of data in a packet. To send a packet, the desired number of bytes to send must be specified in the nrf_send_payload function. This function will automatically handle transmitting. After calling this function the radio will no longer be in receive mode, so it must be set back to receive mode using the nrf_state_rx_mode function in order to receive more packets. Once in this mode the radio will wait to receive packets. If a packet is received, then nrf_payload_available function will return 1. If no packet is available, nrf_payload_available will return a 0.

When a payload is available, the nrf_get_pipe function will return what pipe the data came in on and the nrf_get_payload_width function will return the length of the received payload. The payload can be read into a buffer using the nrf_get_payload function.

It is necessary to check nrf_payload_available before calling the nrf_get_payload function because we do not want trash data. Also after a payload is received, that payload must be read using nrf_get_payload prior to the next payload being received. If a new payload arrives without the first payload being read, the first payload will be lost.

2.4 LED Control

2.4.1 Pulse Width Modulation

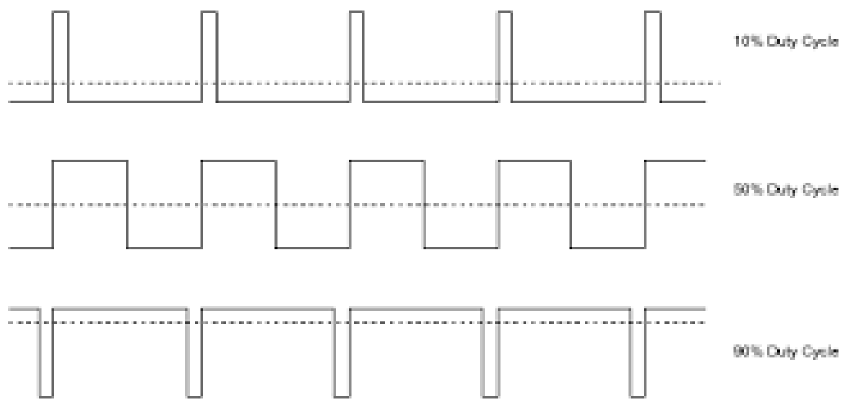


Figure4 Pulse Width Modulation

Pulse width modulation is an easy way to control the light of LED. An example is shown in the figure above. Duty cycle means the percentage of voltage high in a single period. The more duty is, the higher average voltage will be. Therefore, changing the duty cycle will allow us to change the output voltage to the led circuit and therefore change the light of led. In order to tell the difference, there are five levels of output voltage including 0v and 3.3v.

2.4.2 LED circuit

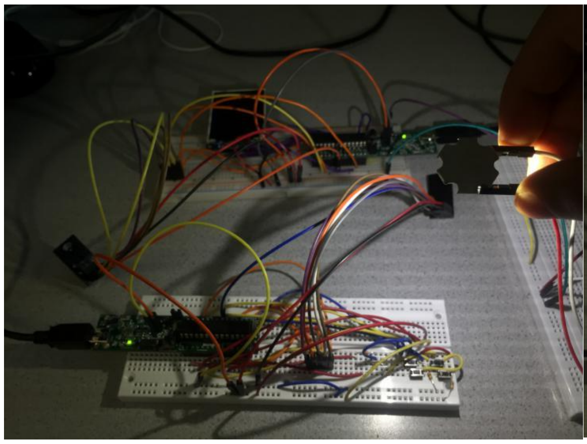
The led we are using for this project is 5w, 700mA white led. Due to the current limit of PIC32, it is not safe to connect led directly to PIC32. Therefore, a led circuit with transistor is designed to separate the working current of led and PIC32 as shown in the Appendix. In order to keep led working under safe condition, we also need a power resistor to keep the current of led circuit below 700mA. Since the power supply is 9V, led is working at 5V. Therefore the power resistor will have 4V at most with 700mA current.

$$I=V/R$$

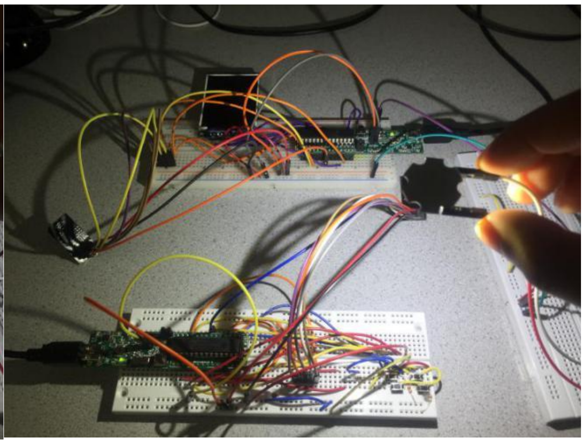
We got power resistor should be around 6 ohms.

3. Result

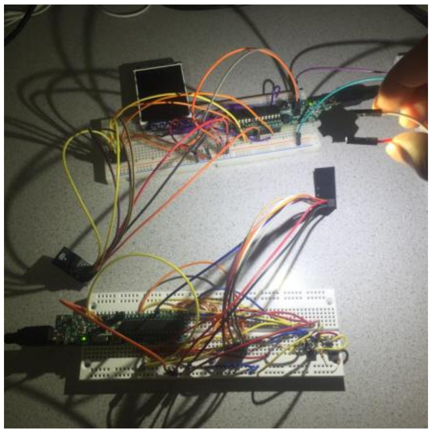
First, I tested the whole design by pressing the button to see if it got corresponding response. There are five light intensities set in PWM. Some of the results are shown in the figure below. The first one on the left top shows the darkest level, the second one on the right top shows a medium level while the third one on the bottom shows the brightest level. Pressing button dimmer, the light intensity will become darker and darker until the darkest level while pressing the brighter button, the light intensity will become brighter and brighter until the brightest level. Pressing off button will turn off the light and on button will turn on the light. Note that the button dimmer and brighter is not available when the light is off.



Dark



Medium



Bright

Then I test the design with different channels and pipes and it works similar to how it worked before. An interesting result is that when I change the frequency to around 2.4GHz, it got garbage messages more easily. That because 2.4GHz frequency overlap with WIFI or other wireless communication like wireless mouse or keyboard.

At last I tested the range of radio communication to see how far it can work. The receiver part was placed at one of the end of the lab while the transmitter part was placed at the other end. The distance should be around 15 meters and the remote control works out fine even with some obstacles such as electronic equipment and desks between transmitter and receiver.

Overall, the design functions well in an environment like home with a communication range more than 15 meters.

4. Conclusion and Future Work

The basic function of remote control LED dimmer has completed and functioned well. To make it more handy and convenient, we may want to add voice control instead of pressing buttons. In that case, we can just say easy commands such as on, off, up, down and do not bother to press buttons to control the light.

5. Acknowledgement

I would like to express my greatest appreciation to Dr. Bruce Land for accepting me as one of his M.Eng project students and his guidance all through the semester. He is always there in the lab, willing to help. His patience and experience helped me solve problems quickly and efficiently. He also provided various devices for testing and what I need for this project. I also want to thank Fred for his valuable advice on setting up the radio.

6. Reference

[1] nrf24l01 Library for PIC32MX250F128B, Douglas Katz and Fred Kummer, May 2016, ece4999 Independent Study, Cornell University

[2] nRF24L01+ Single Chip 2.4GHz Transceiver Product Specification v1.0, Nordic Semiconductor, September 2008

7. Appendix

7.1 Code

Transmitter side

```
// graphics libraries

#include "config.h"

// serial stuff

#include <stdio.h>

#include <stdlib.h>

// threading library

#define SYS_FREQ 40000000 // 40 MHz change the frequency of the clock

// radio library

#include "nrf24l01.h"

#include "pt_cornell_TFT.h"


/*

 * This code is for transmitter side. PIC32 detected button press and send signal to the radio.

 * After radio receive the siganl, it will then send corresponding message to the receiver side.

*/


// set up the radio

void radioSetup() {

   nrf_setup(); // initializing function

   nrf_set_rf_ch(0x64); // freq = 2.5 GHz  2400+ch(MHz)

            nrf_set_arc(0x07);   // 7 restransmits (0-15 times)

            nrf_set_ard(0x00);   // 250 us between retransmission 250+x*250 us

            nrf_en_aa(0);        // enable autoack on pipe0

            nrf_set_pw(1,0);     // set the payload width to be 1 byte (1-32 bytes, 0-5 pipe)
```

```
        nrf_set_address_width(3);   // set the address width 5 bytes(3-5)

        // tx address and the pipe 0 rx address must be the same for autoack mode
        nrf_set_rx_addr(0, 0xAABBCC, 3);  // set pipe 0, receiver address to be 3 bytes
        nrf_set_tx_addr(0xAABBCC);        // set tx address
}

void main(void) {
  INTEnableSystemMultiVectoredInt();
  radioSetup(); // setup the radio for this program
  mINT1ClearIntFlag();

  // === Keypad Thread =============================================
  // connections:
  // A0 -- row 1 -- thru 300 ohm resistor -- avoid short when two buttons pushed
  // A3 -- row 2 -- thru 300 ohm resistor

  // B7  -- col 1 -- 10k pulldown resistor -- avoid open circuit input when no button pushed
  // B13 -- col 2 -- 10k pulldown resistor
  // 0x01 for row 1 ; 0x08 for row 2;
  // 0x80 for col 1 ; 0x2000 for col 2
  // left-top    row1col1 0x81;   right-top    row2col1 0x88;
  // left-bottom row1col2 0x2001; right-bottom row2col2 0x2008;
  int keypad, i, pattern;
  int keytable[4]={0x81, 0x88, 0x2008, 0x2001};
  // init the keypad pins A0,A3 and B7,B13
  // PortA ports as digital outputs
  mPORTASetPinsDigitalOut(BIT_0 | BIT_3);    //Set port as output
  // PortB as inputs
```

```
mPORTBSetPinsDigitalIn(BIT_7 | BIT_13);


char message[4] = {0,1,2,3}; // Byte to be transmitted


while(1)
{
   // read each row sequentially
   mPORTAClearBits(BIT_0 | BIT_3);
   pattern = 1;
   mPORTASetBits(pattern);


   for (i=0; i<4; i++) {
      keypad  = mPORTBReadBits(BIT_7 | BIT_13);
      if(keypad!=0) {keypad |= pattern ; break;}
      mPORTAClearBits(pattern);
      pattern <<= 1;
      mPORTASetBits(pattern);
   }


   // search for keycode
   if (keypad > 0){ // then button is pushed
         if (keypad == 0x81) {        // 0
            while(!nrf_send_payload(&message[0],1));


         }
         else if( keypad == 0x88 ){    // 1
            while(!nrf_send_payload(&message[1],1));


         }
```

```
            else if( keypad == 0x2008 ){  // 2
               while(!nrf_send_payload(&message[2],1));


            }
            else if( keypad == 0x2001 ){  // 3
               while(!nrf_send_payload(&message[3],1));


            }
        }
        else i = -1; // no button pushed


        nrf_delay_ms(300); // button debounce time buffer


    }


} // main
```

Receiver side

```
#include "config.h"
#include "tft_gfx.h"
#include "tft_master.h"
#include <stdio.h>
#define SYS_FREQ 40000000
#include "nrf24l01.h"
// These two defines are for the tft
#define spi_channel       1
#define spi_divider 10
```

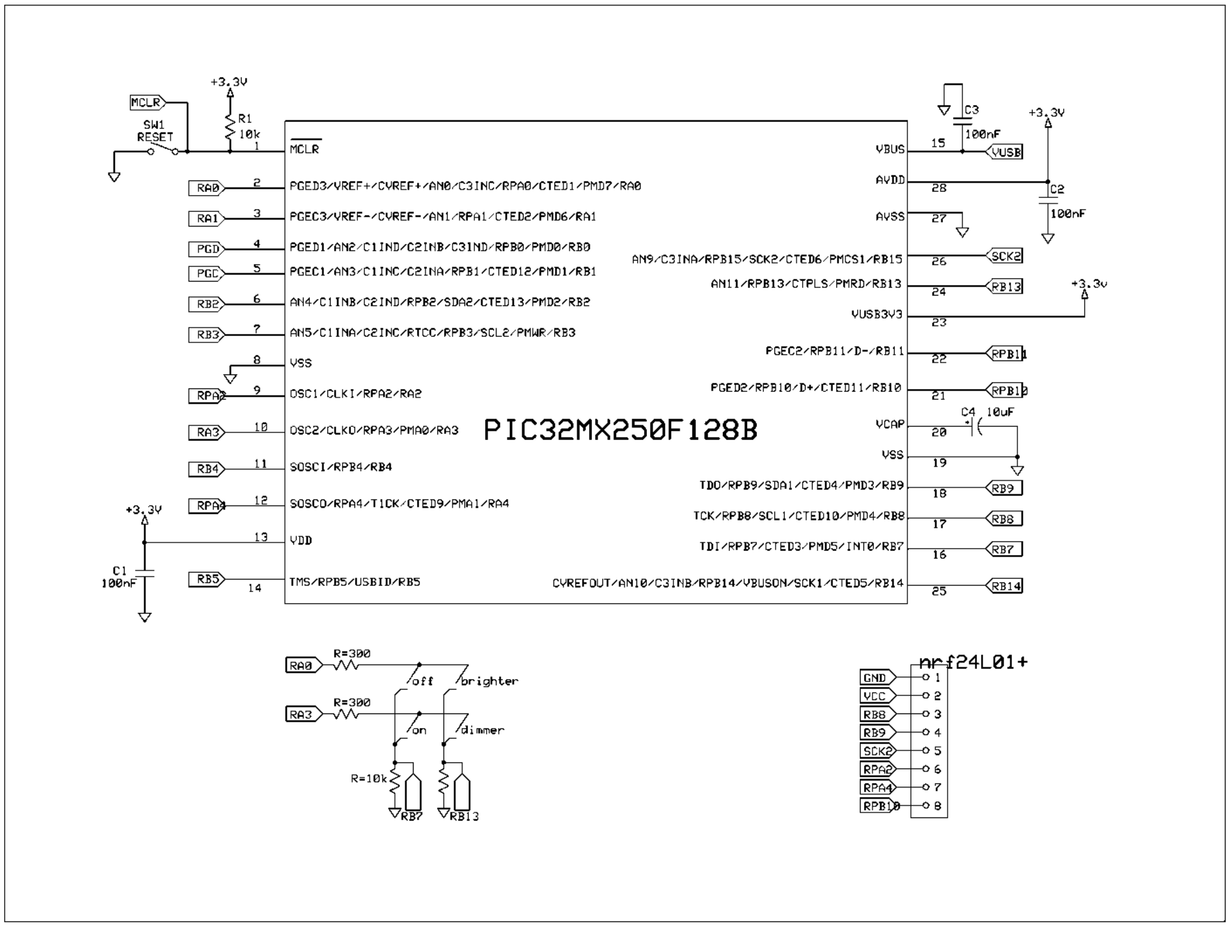
```
/* This code control the receiver and led circuit.
 * The radio catch the message from transmitter and send it to PIC32.
 * PIC32 analyzes the data and generates PWM control siganl for led circuit.
 */

// set up the radio
void radioSetup() {
   nrf_setup(); // initializing function
   nrf_set_rf_ch(0x64); // freq = 2.410 GHz  2400+ch(MHz)

            nrf_en_aa(0);       // enable autoack on pipe0
            nrf_set_pw(1,0);     // set the payload width to be 1 byte (1-32 bytes, 0-5 pipe)

            nrf_set_address_width(3);   // set the address width 5 bytes(3-5)

            // tx address and the pipe 0 rx address must be the same for autoack mode
            nrf_set_rx_addr(0, 0xAABBCC, 3);  // set pipe 0, receiver address to be 5 bytes

}
void main(void) {
   INTEnableSystemMultiVectoredInt();
   radioSetup(); // setup the radio for this program
   OpenTimer3(T3_ON | T3_PS_1_1, 40000);
   mINT1ClearIntFlag();

   // light level: 0-off(ct=0); 2-dim(ct=1500); 3-mid(ct=3000); 4-on(ct=40001))
   // OpenOC1(OC_ON | OC_TIMER3_SRC | OC_PWM_FAULT_PIN_DISABLE , light_level, 20000 ); //
   // OC1 is PPS group 4, map to RPA0 (pin 2)
   PPSOutput(1, RPA0, OC1);
```

```
tft_init_hw(); // setup for tft

tft_begin(); // setup for tft

tft_fillScreen(ILI9340_BLACK);

//240x320 vertical display

tft_setRotation(0); // Use tft_setRotation(1) for 320x240

char buffer[120]; // a buffer for writing to the tft

// arrays to read payloads into

char rx_message;

int width=1; // the width of the received payload

tft_setTextColor(ILI9340_GREEN);

tft_setTextSize(2);

tft_setCursor(0, 0);

sprintf(buffer, "%s", "Waiting for data...");

tft_writeString(buffer);


int led_level=0;

int i=0;  // # of the received messages for TFT

while (1) {


  // enter receive mode to search for packets

  nrf_state_rx_mode();

  if(nrf_payload_available()){ // wait for a payload to be received


    //nrf_delay_ms(10);


    nrf_get_payload(&rx_message, 1); // read the payload into the array


    if(rx_message == 0){
```

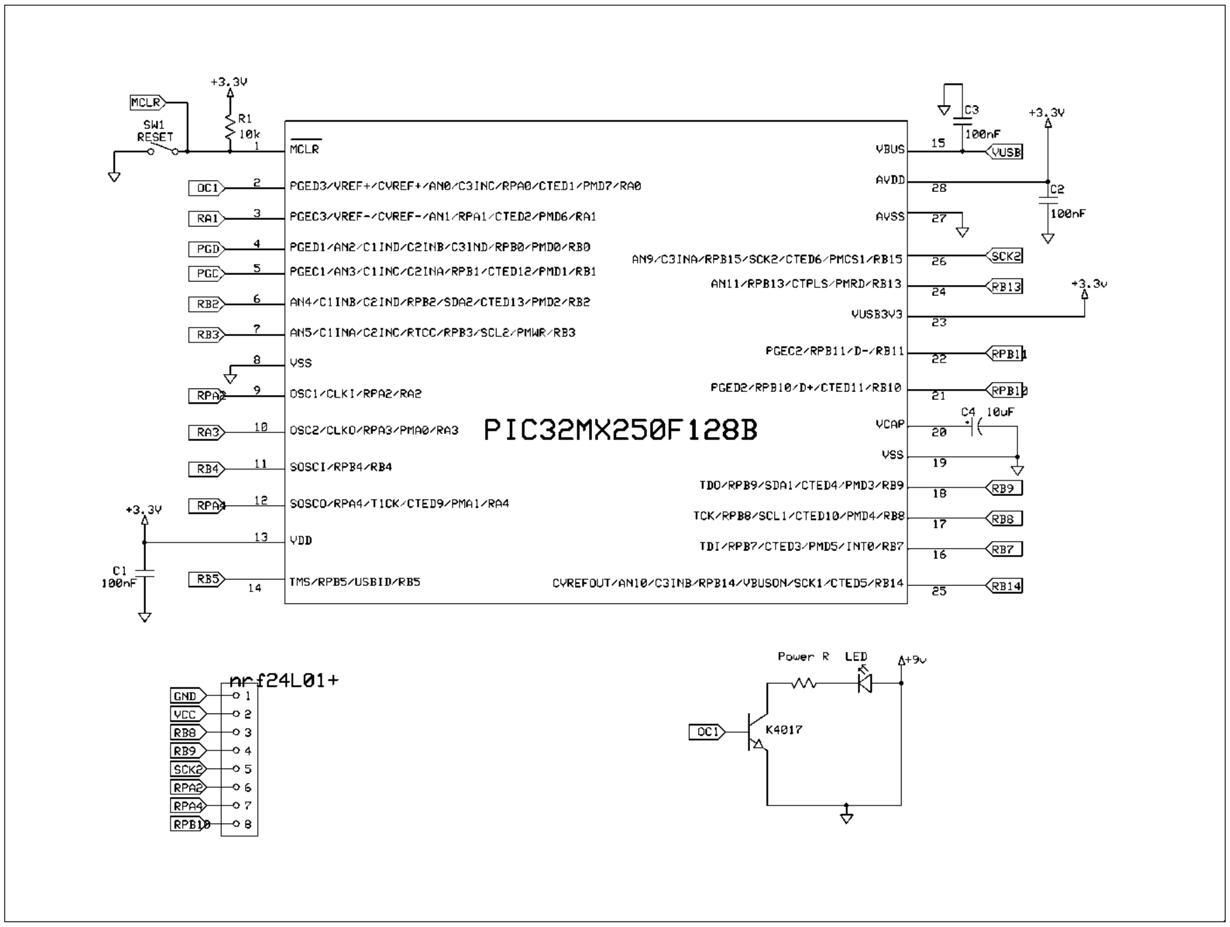
```
    OpenOC1(OC_ON | OC_TIMER3_SRC | OC_PWM_FAULT_PIN_DISABLE , 0, 20000 );
    led_level = 0;
  }
  else if(rx_message == 3){

    OpenOC1(OC_ON | OC_TIMER3_SRC | OC_PWM_FAULT_PIN_DISABLE , 40001, 20000 );
    led_level = 40001;
  }

 if( (led_level>0) & (led_level<=40001) ){

  if(rx_message == 1){

    led_level = led_level + 8000;
    if(led_level>40001)
    {
      led_level = 40000;
    }
    OpenOC1(OC_ON | OC_TIMER3_SRC | OC_PWM_FAULT_PIN_DISABLE , led_level, 20000 );
  }

  else if(rx_message == 2){

    led_level = led_level - 8000;
    if(led_level<8000)
    {
      led_level = 8000;
    }
```

```
              OpenOC1(OC_ON | OC_TIMER3_SRC | OC_PWM_FAULT_PIN_DISABLE , led_level, 20000 );
            }
          }

            // display the received data on the tft
            tft_setTextColor(ILI9340_BLUE);
            tft_setTextSize(2);
            tft_setCursor(0, 20);
            sprintf(buffer, "%s", "Received data:");
            tft_writeString(buffer);

            tft_setCursor(40, 60);
            tft_setTextColor(ILI9340_RED);
            sprintf(buffer, "%s", "Width:");
            tft_writeString(buffer);

            tft_setCursor(110, 60);
            sprintf(buffer, "%d", width);
            tft_writeString(buffer);

            tft_setTextColor(ILI9340_BLUE);
            tft_setCursor(0, 40+20*i);
            sprintf(buffer,"%d", rx_message);
            tft_writeString(buffer);
            i=i+1;
            nrf_delay_ms(500);
         }
      }
   } // main
```

7.2 Schematic


PIC32MX250F128B
+3.3V
MCLR
SW1 RESET
R1 10k
MCLR
PGED3/VREF+/CVREF+/AN0/C3INC/RPA0/CTED1/PMD7/RA0
PGEC3/VREF-/CVREF-/AN1/RPA1/CTED2/PMD6/RA1
PGED1/AN2/C1IND/C2INB/C3IND/RPB0/PMD0/RB0
PGEC1/AN3/C1INC/C2INA/RPB1/CTED12/PMD1/RB1
AN4/C1INB/C2IND/RPB2/SDA2/CTED13/PMD2/RB2
AN5/C1INA/C2INC/RTCC/RPB3/SCL2/PMWR/RB3
VSS
OSC1/CLKI/RPA2/RA2
OSC2/CLKO/RPA3/PMA0/RA3
SOSCI/RPB4/RB4
SOSCO/RPA4/T1CK/CTED9/PMA1/RA4
VDD
TMS/RPB5/USBID/RB5
C1 100nF
VBUS
AVDD
AVSS
AN9/C3INA/RPB15/SCK2/CTED6/PMCS1/RB15
AN11/RPB13/CTPLS/PMRD/RB13
VUSB3V3
PGEC2/RPB11/D-/RB11
PGED2/RPB10/D+/CTED11/RB10
VCAP
VSS
TDO/RPB9/SDA1/CTED4/PMD3/RB9
TCK/RPB8/SCL1/CTED10/PMD4/RB8
TDI/RPB7/CTED3/PMD5/INT0/RB7
CVREFOUT/AN10/C3INB/RPB14/VBUSON/SCK1/CTED5/RB14
C3 100nF
C2 100nF
C4 10uF
VUSB
SCK2
RB13
RPB11
RPB10
RB9
RB8
RB7
RB14
RA0
RA1
PGD
PGC
RB2
RB3
RPA2
RA3
RB4
RPA4
RB5
R=300
off
brighter
on
dimmer
R=10k
RB7
RB13
nrf24L01+
GND
VCC
RB8
RB9
SCK2
RPA2
RPA4
RPB10

Schematic for Transmitter Part


PIC32MX250F128B
MCLR
SW1 RESET
R1 10k
+3.3V
PGED3/VREF+/CVREF+/AN0/C3INC/RPA0/CTED1/PMD7/RA0
PGEC3/VREF-/CVREF-/AN1/RPA1/CTED2/PMD6/RA1
PGED1/AN2/C1IND/C2INB/C3IND/RPB0/PMD0/RB0
PGEC1/AN3/C1INC/C2INA/RPB1/CTED12/PMD1/RB1
AN4/C1INB/C2IND/RPB2/SDA2/CTED13/PMD2/RB2
AN5/C1INA/C2INC/RTCC/RPB3/SCL2/PMWR/RB3
VSS
OSC1/CLKI/RPA2/RA2
OSC2/CLKO/RPA3/PMA0/RA3
SOSCI/RPB4/RB4
SOSCO/RPA4/T1CK/CTED9/PMA1/RA4
VDD
TMS/RPB5/USBID/RB5
C1 100nF
VBUS
AVDD
AVSS
AN9/C3INA/RPB15/SCK2/CTED6/PMCS1/RB15
AN11/RPB13/CTPLS/PMRD/RB13
VUSB3V3
PGEC2/RPB11/D-/RB11
PGED2/RPB10/D+/CTED11/RB10
VCAP
VSS
TDO/RPB9/SDA1/CTED4/PMD3/RB9
TCK/RPB8/SCL1/CTED10/PMD4/RB8
TDI/RPB7/CTED3/PMD5/INT0/RB7
CVREFOUT/AN10/C3INB/RPB14/VBUSON/SCK1/CTED5/RB14
C3 100nF
C2 100nF
C4 10uF
VUSB
SCK2
RB13
RPB11
RPB10
RB9
RB8
RB7
RB14
OC1
RA1
PGD
PGC
RB2
RB3
RPA2
RA3
RB4
RPA4
RB5
nrf24L01+
GND
VCC
RB8
RB9
SCK2
RPA2
RPA4
RPB10
Power R
LED
+9v
K4017
OC1

Schematic for Receiver Part