Wireless Music Player Design Based on White LED
Visible Light Communication

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Abstract. We design a music player system based on white light emitting diode (LED) in visible light communication (VLC) system, using infrared remote to control. The transmitter loads music data from the storage device, decodes it and sends it to modulate LED arrays. The receiver transforms the optical signals to electrical signals, through the PIN circuits. After the amplifying circuits manage them, they are sent to a speaker to play. At the same time, a LCD will display the information of the music playing. The test shows that the music player can play fluently a variety of formats of music files and be easily controlled by the infrared remote control.

Introduction

With frequency spectrum becoming more and more congestible, communication with higher frequency is the hotspot today. LED’s short response time and high-speed modulation make it an ideal option for Visible Light Communication, which combines lighting and high speed communication [1]. It has also attracted more and more attention due to its high accuracy, security and low power cost [2]. White LEDs based on indoor VLC system can provide people the energy-saving lighting and complete information transfer.

In this paper, we propose a music player based on a white-LED-wireless-communication-system. The system includes two main parts: sending end and receiving end. STM32F103RCT6 is the main controller; SD card stores music files; VS1053 chip is an audio decoder. Figure 1 shows the flow diagram of the player system. In the down link, after decoding the music files, through the LED drive circuit, LED array will be controlled by the analog modulation signals. Receiving end gets the signals and plays the song through a speaker. In the uplink, infrared signals will select songs and adjust the volume. STM32 micro-controller is also connected to a LCD to display real-time information. Using light instead of electromagnetic waves, it is not only an improvement for modern digital players, but also a practical application of VLC system.

Figure 1. Flow diagram of the system.

System Overview

Master Device

We use STM32F103 as the main control chip, realizing the functions we need can be managed. SPI communication mode is used and microcontroller reads music information from SD card sector, communicating through four signal lines and 3 pins (PA5, PA6, PA7).
Infrared receiver module is installed, including keyboard matrix, driver, remote control ASIC and infrared LED. The circuit of receiver module are shown in Figure 2. The PAM (pulse amplitude modulation) signals drive the infrared LED, using a 38kHz carrier wave. After the probe HS0038 receives pulse-code modulated signals, the amplification circuit will amplify and send them into the STM32, where the infrared signal will be decoded to the certain key code.

![Figure 2. Circuit of receiver module.](image)

Here we define Remote_Scan to accomplish this function and the main program is as follows:

```c
if (RmtSta&(1<<6))                 // Get a button
{
    t1=RmtRec>>24;                  // Get the address code
    t2=(RmtRec>>16)&0xff;           // Get the anti-code of address code
    ...
    if(t1==(u8)-t2) sta=t1;            // Key is correct
    ...
    if((sta==0)||((RmtSta&0X80)==0))   // Key data error / no key pressed
        RmtSta&=(1<<6);       // Clear the received valid key
    ...
```

**Program Design**

Figure 3 shows the flow diagram of the program of the whole system.

`mp3_play_song` is for music playing. Some of the key code is as follows:

```c
if((VS_Send_MusicData(databuf+i)==0)&&(pause==0))
// Send audio data to the VS1053
    { i+=32; }                                  // Send 32 bytes
else    {
    key=Remote_Scan();                            // Scan infrared key
    ...
    switch(key) {
        case2:str_1="PLAY";pause=!pause;break;     // Pause and play
        case194:str_1="RIGHT";rval=KEY0_PRES;break;  // Next song
        mp3_msg_show(fmp3->fsize);}                  // Show information on LCD
```
Music Decoding

The system uses VS1053 chip to decode, communicating with microcontroller through SPI.

STM32 sends data to the VS1053 audio decoder module, after which the internal register will resolve it. For example, DECODE_TIME is used for storing decoding time; HDAT0 and HDTA1 get the code rate and calculate the total length of the media; The VOL controls the output of the left and right channels, separately.

Playing music through VS1053 requires a configuration for registers and a reset before each song is played, ensuring the device is ready to decode the next song. VS_WR_Cmd() is to configure the register:

- VS_WR_Cmd(SPI_CLOCKF, 0X9800);  //Set clock for VS1053
- VS_WR_Cmd(SPI_MODE, temp);        //Set the module
- VS_WR_Cmd(SPI_VOL, volt);          //Set the volume
- VS_WR_Cmd(SPI_BASS, bass_set);     //Set BASS

The audio data stream is transmitted in an orderly manner under the control of the DREQ signal. When DREQ goes high, it sends 32 bytes to the VS1053. After DREQ goes high again, it continues to transmit until the audio data is transmitted.

If (VS_DQ != 0)              //Send data to VS1053
...                         //Send 32 bytes

Four I/O ports and SCK, MOSI, MISO are needed for SPI communication with allocating pins of PA4, PA5, PA6, PA7, PA8, PA11 and PA12.

Circuit at Transmitter

The transmitter circuit receives the analog signals decoded by VS1053 for further processing. TL062 amplifier amplifies them and ICL7660S converts the voltage to provide -5V when there is only a single power supply. Figure 4 shows the schematic diagram.

The signal inputs from the SIGNOL IN. R01, R15 provide the same biased voltage with biased amplifier, and R16 and R17 provide a negative feedback. To ensure that the signal does not distort, the voltage for LEDs’ work ranges from 2.5 to 3V. The amplified current drives LEDs, controlling their luminous intensity change with the input signals [3], and converses music information into the visible light.
To solve the problem on transmission distance and transmission power with only one LED, LED arrays [4] are preferred. Considering the fact that the specific driving voltage can only drive a certain number of LED lights, combined with the actual needs for lighting [5], after calculation and several experiments, we confirm the appropriate layout: one drive circuit with 6 LED lights, two series with each other, and three groups of these are in parallel. The overall system uses 6 drive circuits to drive 6 arrays, 36 lights.

**Circuit at Receiver**

The optical signals carrying the music information need to be changed into playable electric signals again. Analyzing two widely used photodetectors—APD avalanche photodiode and PIN photodiode, the BPX65 PIN tube with higher cost-efficient [6] is selected for system design. However, the PIN tube brings more noise. In this device, we design a pre-stage circuit to improve Signal to Noise Ratio (SNR). LM833 is used as an amplifier. The trans-impedance structure meets the circuit system requirements with the low input and output resistance, high sensitivity and SNR, strong anti-interference and large bandwidth. The circuit is shown in Figure 5.

After pre-stage circuit, UA741CN amplifier builds an active low-pass amplifier circuit, which can control the filter and amplification by adjusting the resistance values as well as the cut-off frequency. Finally, through further power amplification, the signals drive the speaker and we can hear the music.
**Experiment**

In the test, the system can play a variety of formats of music files in SD card, and at the same time, the song’s name, volume can also be displayed correctly to the LCD. Infrared remote sets the volume and selects music in 8 meters away, satisfying the requirement to walk freely in a room. The transmission distance of music information in VLC achieves 6 meters and LED arrays have no significant flicker. Figure 6 shows the practical circuits and system.

![Figure 6](image)

(1) Transmitter  (2) Receiver  (3) LCD

**Conclusion**

In this paper, we proposed a music player based on white LEDs in VLC. The system can smoothly play music files from SD card and correctly display the song’s name, volume and other information to the LCD screen. The transmission distance met the requirement to use freely indoor. In the experiment, we showed that this was an effective method for playing music and lighting at the same time. This is the first attempt to design a real application based on VLC. We will seek to generalize our results. Future work includes conducting other applicable devices in VLC.

**Reference**


