Research and Design of Integrated System of Headphone Amplifier Based on Bluetooth Technology

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Abstract. Traditional earphones and speakers need to use audio cables to connect mobile devices and sounding units when using audio files of mobile devices such as mobile phones as audio input sources. This paper proposes a solution to this problem. This paper studies and designs a power headphone amplifier integrated system based on Bluetooth technology with STM32F407 as the main control core. The system uses CSR8670 Bluetooth audio SoC chip to realize Bluetooth audio transmission, uses TPA6112 headphone audio amplifier to realize amp function, uses HT8696 class D power amplifier to realize speaker power amplifier function, uses 3.2 inch resistive touch screen to realize human-computer interaction function, and the system introduces STemWin graphics library Implement human-machine UI interface. The system is more practical in the independent output of the amp and the speaker power amplifier circuit, the control method is more humanized, and the human-machine experience is better, which plays a driving role for the popularization of the smart home.

1. Introduction

Audio equipment is one of the important carriers for spreading music. There are many problems in the use of traditional audio equipment, for example, the wiring of equipment such as headphones and speakers is cumbersome, the degree of intelligence is low, the sound source is difficult to switch easily, and the sound source needs to be connected through the wire, and the distance is limited by the length of the connection line. Now, phone has a TRS terminal design, but the audio output is more cumbersome and not friendly to users with high sound quality requirements.[1-2]In order to solve the problems existing in traditional audio equipment and improve the intelligent portability of audio equipment, using Bluetooth headphone amplifier as an audio device can bring intelligence and portability to users.

2. Research and Design Analysis

The completion of the design is inseparable from the hardware module design and overall system design.

2.1. Hardware Module Design

2.1.1.Master chip. The master chip is the main control core of the Bluetooth Headphone Amplifier, which realizes the control of the touch screen. For the later expansion of the system, so the selected master chip is STM32F407VET6.[3-5]

2.1.2.Touch screen. The system adopts 8080 interface, the resolution is 320×240, and the resistive touch TFT LCD screen. The FSMC interface of the MCU uses the LCD screen as an external RAM to drive the LCD screen by writing data.

2.1.3.Bluetooth Audio Transmission. The Bluetooth audio transmission chip is the main function implementation chip of the Bluetooth Headphone Amplifier, and the CSR8670 is selected as the firmware for outputting the analog signal. This chip is a Bluetooth audio SoC with its own powerful DSP processor. The system performs secondary function development according to the IDE development environment provided by CSR, or burns different firmware provided by the official to realize different outputs such as I2S, SPDIF and analog signals.CSR8670 directly outputs two differential analog audio signals for left and right channels after decoding. Differential analog signal has strong anti-interference ability and simple signal processing, but the output signal is weak, and the load capacity is poor. It is difficult to directly drive the earphone. Therefore, the TPA6112 is connected as the headphone driver, and then the classifier amplifiers such as HT8696 and TPA3116D2 are used to realize the power amplifier function.[6-8]

2.2. Overall System Design

The system adopts STM32F407VET6 as the main control core, adopts 3.2-inch TFT touch LCD screen to realize human-computer interaction, adopts CSR8670 Bluetooth audio transmission module to realize Bluetooth audio transmission and decoding, and adopts NXP NTAG216 NFC tag to realize Bluetooth shortcut matching with front-end playback device. The system uses the TPA6112 headphone audio amplifier to convert the analog differential audio signal output by the CSR8670 into a balanced signal and power amplification to drive the headphones, uses the HT8696 Class D power amplifier to implement the power amplifier function to directly drive the speaker. The overall design of the Bluetooth amp amplifier(refer with figure 1).

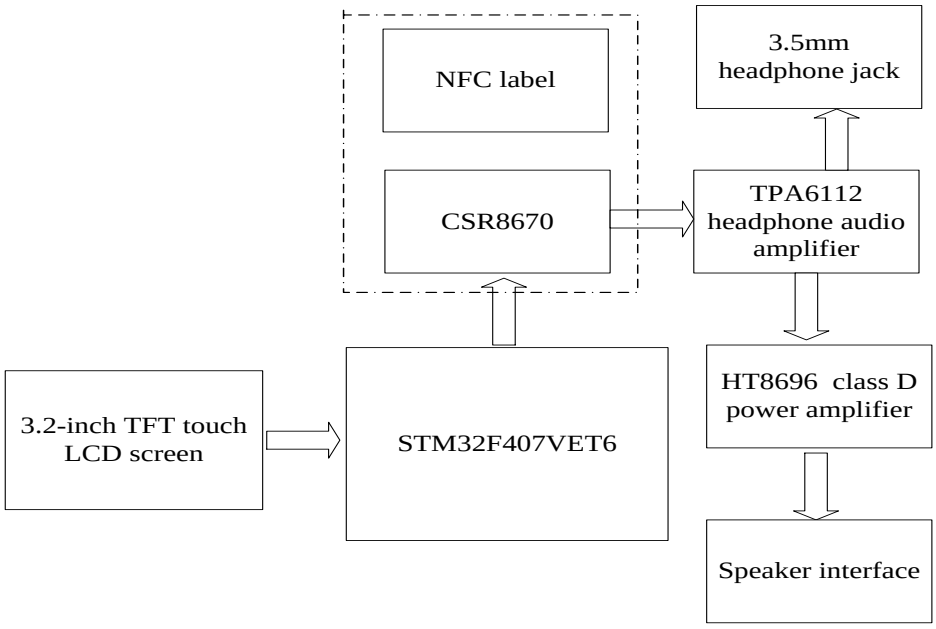

Figure 1. System overall design.

3. System Software Design

3.1. Graphical Interface Design

The system uses the SemWin graphics library of version 5.40 and uses emWin GUIBuilder V5.40a to build the framework of the display interface. The content displayed in the window is the content displayed

on the LCD screen, and the control of different functions is realized by multiple button controls. After the layout is set, save it and you can generate a C language file for the corresponding interface. Controls can call various events, such as song switching, sound adjustment. CSR8670 detects the change of the IO port level caused by the click event of the Button, thus switching the working mode.

STemWin Graphics Library Porting

Graphic display interface adopts the porting function of STemWin graphics library. The code to be written is GUI_X_UCOSII.c, GUI_X_Touch_Analog.c and LCDConf_FlexColor_Template.c. The specific implementation of GUI_X_InitOS, GUI_X_Lock, GUI_X_Unlock, GUI_X_GetTaskId, GUI_X_WaitEvent, GUI_X_SignalEvent, CheckInit, GUI_X_Init, GUI_X_GetKey, GUI_X_WaitKey, GUI_X_StoreKey functions is required in GUI_X_UCOSII.c.

GUI_X_Lock is the lock function and GUI_X_Unlock is the unlock function. They all call the lock and unlock function of the uCOS III operating system. The specific implementation code is as follows:

```
void GUI_X_Lock(void){
    INT8U err;
    OSSemPend(DispSem,0,&err);        // Request Semaphore }
void GUI_X_Unlock(void){
    OSSemPost(DispSem);            // Send Semaphore }
```

GUI_X_GetTaskId is to get the task priority function, the function returns the OSTCBCur->OSTCBPrio task priority, the specific code is as follows:

```
U32 GUI_X_GetTaskId(void){
    return ((U32)(OSTCBCur->OSTCBPrio)); // Get the task priority, which is the task ID
}
// The GUI_X_WaitEvent function is used to wait for an event to occur, using the request message mailbox
void GUI_X_WaitEvent(void){
    INT8U err;
    (void)OSMboxPend(EventMbox,0,&err); //Request message mailbox
}
// GUI_X_SignalEvent is implemented for signal events by sending a message mailbox
void GUI_X_SignalEvent(void){
    (void)OSMboxPost(EventMbox,(void*)1);   //Send a message mailbox
}
```

Touch screen driver function framework included in GUI_X_Touch_Analog.c file. The coordinate information of the X and Y axes of the touch position is read by implementing the GUI_TOUCH_X_MeasureX, GUI_TOUCH_X_MeasureY function and calling the OTT2001A_RD_Reg interface function in the emWin function.

The LCDConf_FlexColor_Template.c file includes the LCD display driver functions LCD_X_Config and LCD_X_DisplayDriver. The LCD display driver function is used to write graphic data to the LCD screen. LCD_X_Config is used to create display driver devices, set color conversion programs and display sizes. LCD_X_DisplayDriver mainly implements LCD initialization.

3.2. MCU Main Block Diagram

The main program design is realized by the uCOS III operating system and STemWin graphics library. The main program block diagram of the system(refer with figure 2).

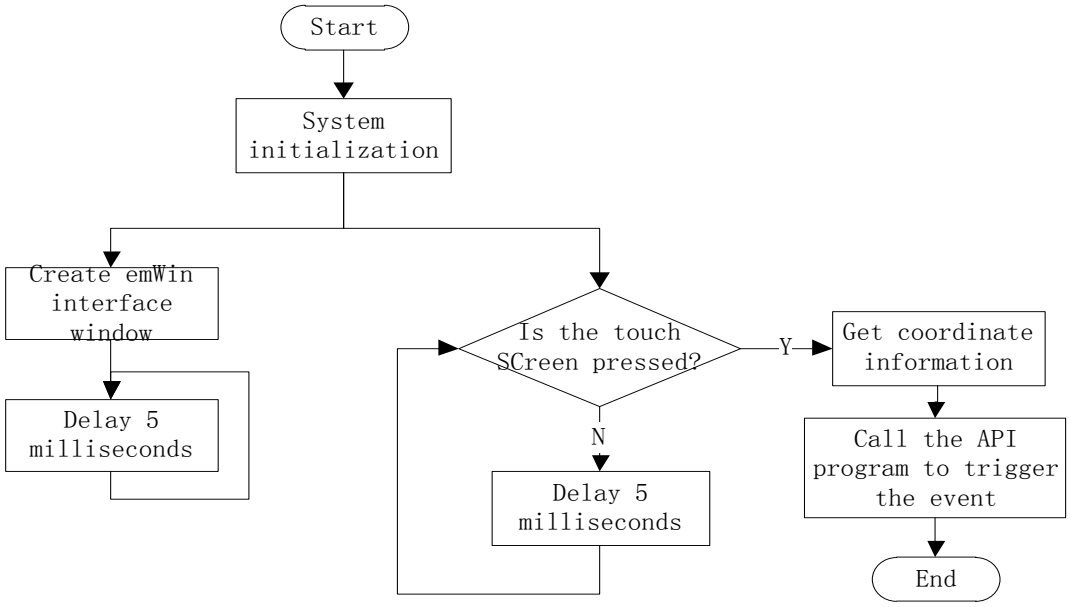

Figure 2. System main program flow chart.

3.3. NFC Fast Pairing Implementation of Bluetooth Headphone Amplifier

Enable fast pairing of Bluetooth headphone amplifier devices by NFC tag, which is implemented by installing TagWritter software on NFC-enabled mobile phones.

Creating a Bluetooth tag and writing the MAC address and device name of the Bluetooth headphone amplifier device to the tag, and selecting the category as a Bluetooth headset. NFC tags are placed close to the phone to implement NFC information write tags. Scaning this tag to pair with a Bluetooth headphone amplifier device to speed up pairing.[9-10] In view of the advantages of long life, strong anti-interference ability, and large storage capacity, NFC tags of NTAG216 are used for pairing.

After a series of debugging, the system can run normally. The physical operation effect(refer with Fig 3).

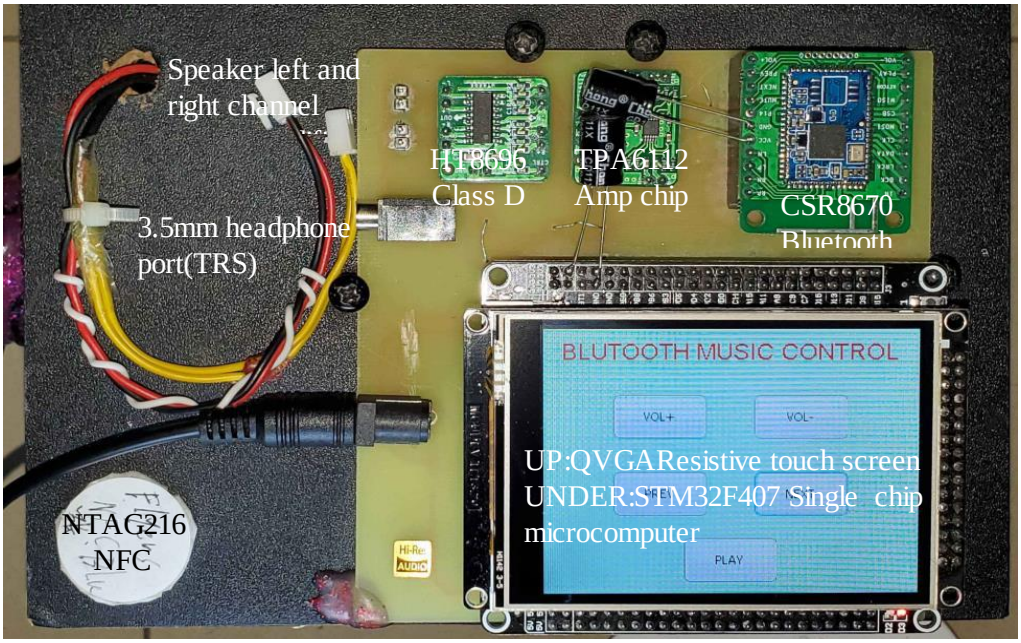

Figure 3. Physical operation diagram

4. Summary

The main research content of this paper is the display of touch interface on uCOS III RTOS system, the design of Bluetooth 5.0 audio module based on CSR8670, and how to call STemWin graphics library to realize the research of human-computer interaction.Research has enabled mobile devices to tap NFC tags for fast Bluetooth binding to connect to audio devices to play music. The touch screen controls the volume, switches songs, and amplifies the output power. But there are also shortcomings，For example: selection of filter power supply, research on audio signal transmission of single crystal copper or mixed wire, adoption of LDAC Bluetooth audio protocol, etc.

5. Acknowledgement

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