A Design for an MCU based Self-service Laboratory Education System

Buxin Zhou [a], Chengwei Cai [b], Lei Cheng [c], Shupo Bu [d]

Department of Electronics and Communication Engineering, Suzhou Institute of Industrial Technology, Suzhou 215104, China.

[a]00080@siit.edu.cn, [b]00332@siit.edu, [c]00310@siit.edu.cn, [d]00658@siit.edu.cn

Abstract

This system introduces how to use MCU RA8806 as the controller's LCD module and use MCU AU6850B as the core's MP3 module to design a self-help education system for laboratory use. This system can be installed on every bench, and the students can find the corresponding lab equipment audio and text tutorials by touching the buttons on the touchscreens, facilitating one-on-one teaching, improving the classroom efficiency and reducing education cost.

Keywords

MCU, RA8806, touchscreen, education system, circuit.

1. Introduction

The purpose of experiments in labs is to let the students understand the procedures of the different experiments and the final result analysis, and whether the students are skilled with the equipment is directly related to the procedures of the experiments. Classical education of electronical devices usage is carried out by placing multiple devices on one bench such as one oscilloscope, one power supply, one millivolt meter, one function signal generator, and letting the teacher give lectures and demonstrate in front of several dozens of students. Because of the large number of operating buttons on the equipment, the complicated operating procedure and the limited time in classroom, the education outcome must be quite low. This article introduces the design of an education-facilitating, self-service audio laboratory education system, which allows the students to teach themselves in off-class hours. The self-learning of device operation during off-class hours can motivate themselves very well in learning the operation skills. The most important benefits include the low cost, its good performance and the potential market value.

2. Overall Design

The system must be installed on every bench, with all the devices in the lab organized. The detailed audio tutorials were recorded by professional teachers and saved in the system's mp3 module. The accompanied text files and picture files were saved in the SD card of the MCU, which allows the students, via the buttons on the touchscreen, to identify the corresponding audio, text and picture tutorial files about the experiment devices, and makes one-on-one teaching possible and improved education efficiency. The system design includes the power supply, the MCU, the touchscreen circular, and the mp3 audio circular. The specific design is provided in Figure 1.

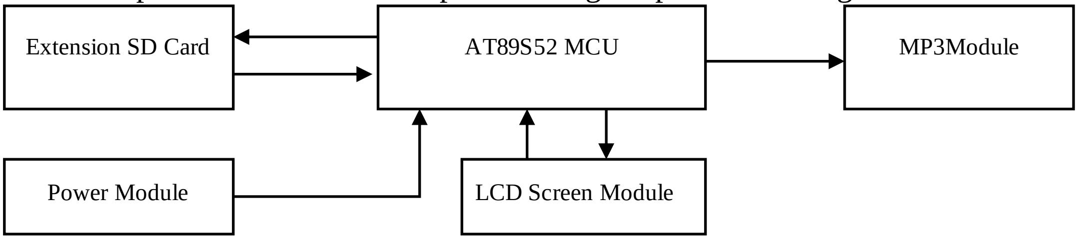

Figure 1. System diagram

3. Introduction to Related Modules

3.1 LCD Touchscreen Module

For the LCD touchscreen module, we use the ZLG240128F-BTSSWE-YAA-TP touchscreen from Shenzhen ZuoLiEn Technology Co., Ltd, whose Chinese LCD display is a Chinese-English text and drawing dot-matrix LCD display module with 512KB ROM font code, which displays Chinese characters, numbers, and English/Japanese/European characters, and a built-in two-page display memory [2]. In text mode, it is capable of displaying Chinese characters by receiving standard Chinese inner code, instead of using graphic mode to describe the character, and therefore it improves the processing efficiency to display Chinese character on LCD, by saving CPU time. It supports text and drawing hybrid display mode and supports 2-page display mode, with two build-in 4.8K/9.6KB (15x20D) display RAM, a total of 9.6 KB/19.2 KB RAM, which allows 4-rank display. It includes a 512 KB ROM, in which the standard Chinese BIG5 code consists of 13094 frequent and less-frequent fonts, 408 special characters and two set of ASCII CODE, and the simple characters include 7602 standard GB code for simple Chinese characters. This module uses power with VDD= +5.0V ±5%, and 14V for driving of LCD. The backlight voltage is 5.0V with a display size of 240*128. It is driven by 1/128DUTY or 1/12BIAS and controlled by RA8806 chip. It has built-in smart controller for touch-sensing display and supports 4-wire resistive touch screen. 8*8 keyboard scan interface is included. Programmable pulse width modulation is used to adjust the contrast or backlight of the LCD display. The hardware diagram is demonstrated in Figure 2.

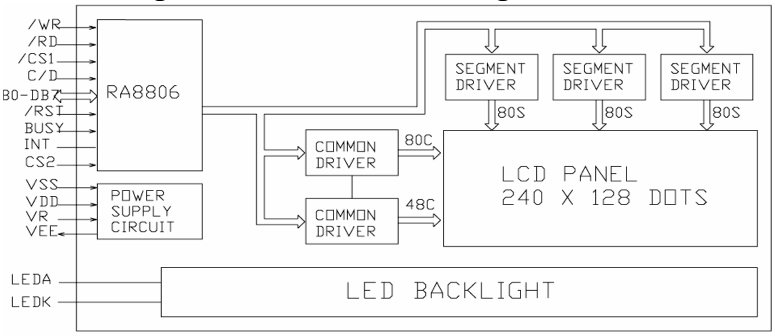

Figure 2. Hardware diagram in LCD display module

3.2 BA Series MP3 Module

BA Series MP3 Module includes AU6850B as the core chip, which is made by Shanghai ShanJing, and consists of USB Host interface, SD interface, MP3 decoding circuit and 8051-compatible MCU, which can directly read audio files in flash disks and SD cards. The design diagram of this module is provided in Figure 3.

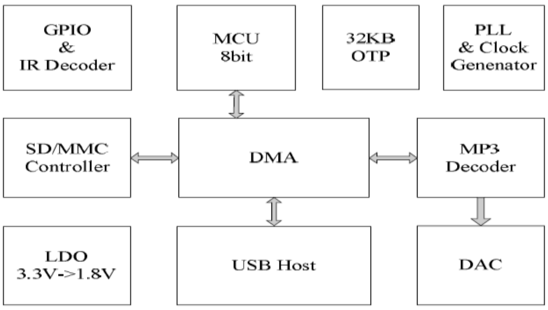

Figure 3. Diagram of inner BA series MP3 module

4. Design of Hardware Circuits

4.1 BA Series MP3 Module and 51 MCU Interface Circuit

We connect the MP3 module with MCU in parallel. Namely, P1 is connected with 1-8. Binary-coded decimal (BCD) is used for the setting agent for music encoding. For example, P1 pin are 00H and it selects all the audio files numbered as 0; while 01H selects audio files labeled as 1. In such manner, all files from 0 to 255 can be selected in theory. However, in the actual tests, the number of audio files in the SD card could not exceed 200; otherwise, the excessive files would not be processed. P2.7 is connected to the PL pin of the module, which is used to control the playback. When the PL pin detects falling edge of clear terminal, it immediately reads the data from the data terminal and plays the corresponding audio files. P3.3 connects to the 13 pin of the module, which is used for the determination of busy signal. If the pin is low level, it means the module is currently working. The interface circuit is shown as Figure 4.

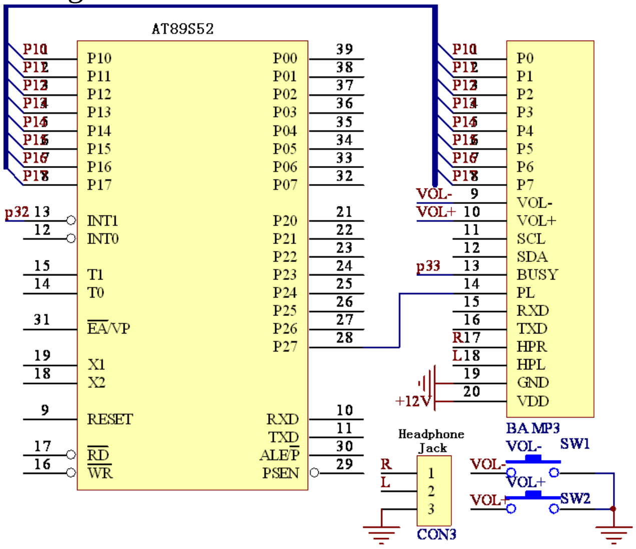

Figure 4. The interface circuit between mp3 module and 51 MCU

4.2 Interface circuit between LCD touchscreen module and 51 MCU

LCD touchscreen supports 4 bit or 8 bit data bus of the MCU interface for 8080/6800. In this design, we adapt the MCU interface of 8 bit data bus for 8080 series. P0 is connected to the DB0-DB7 data terminal of the touchscreen module; P2.3 is connected to enable terminal CS1, in which case that CS2 is linked to high level and the low level of CS1 is enabled. P2.0 is connected to instruction/data RS terminal. The instruction terminal is high level and the data terminal is low level. P2.1 links to WR terminal, which controls the writing of the data and enables low level. P2.2 links to data read terminal, RD terminal, which enables low level as well. P2.4 connects to determination terminal for busy signal. P2.5 is for system reset and P3.2 is for the issue ends of the interrupt signal. The interface circuit is shown as Figure 5.

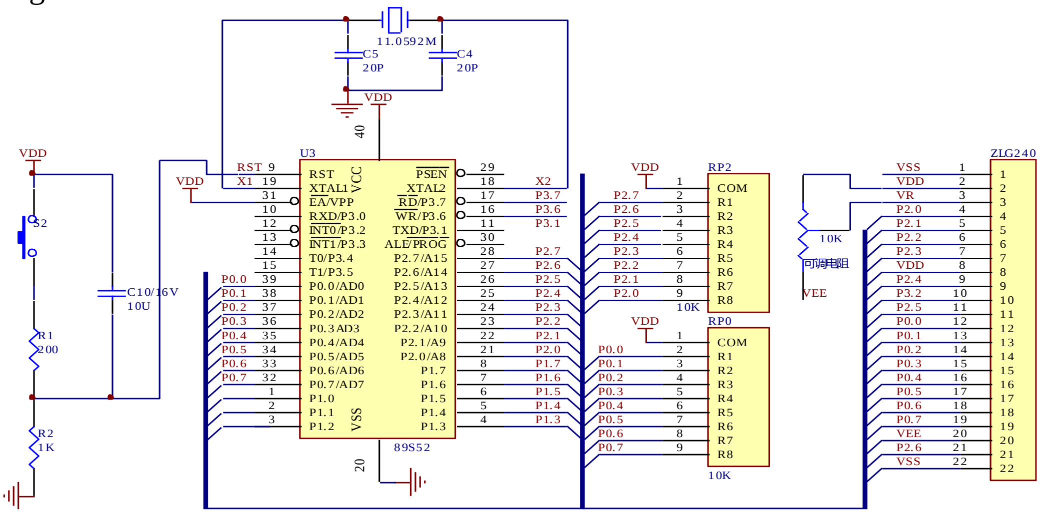

Figure 5. Interface circuit between the LCD touch screen and 51 MCU

4.3 Interface circuit for extensible SD card and MCU

Due to the high demand for graphic files used in teaching, the system requires external storage, such as SD card, which is a cheap memory card with large capacity, small size and interface for convenient read/write; otherwise, it would use up storage space of MCU when generating the code. According to the different protocols, SD card provides two modes for usage: SD mode and SPI mode. [5] The first mode is not used here since the normal MCU does not have SD bus. Although it can be simulated with general line by software, however, there are limitations in speed and the consumption in CPU time. On the other hand, MCU contains SPI bus. In this design, SPI bus is used to visit SD card. For 8051 based SPI system, firstly, I/O port function is set and select switch control registry XBR0, XBR1, XBR2，I/O port P3.4, P3.5, P3.6 and P3.7 is configured as SPI functional pin SCK, MISO, MOSI and NSS, respectively. Now the I/O ports P3.4, P3.5, P3.6 and P3.7 are assembled as SPI interface. The interface circuit is shown in Figure 6.

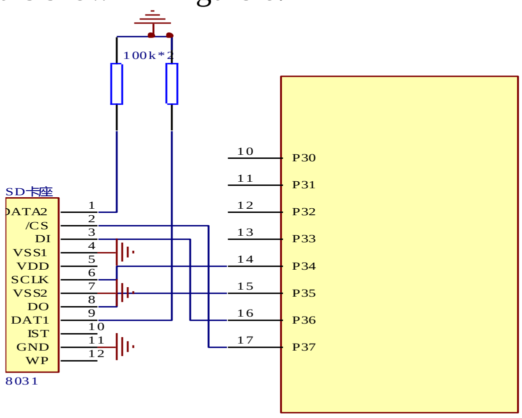

Figure 6. Simplified circuit for the interface of MCU and its external SD card

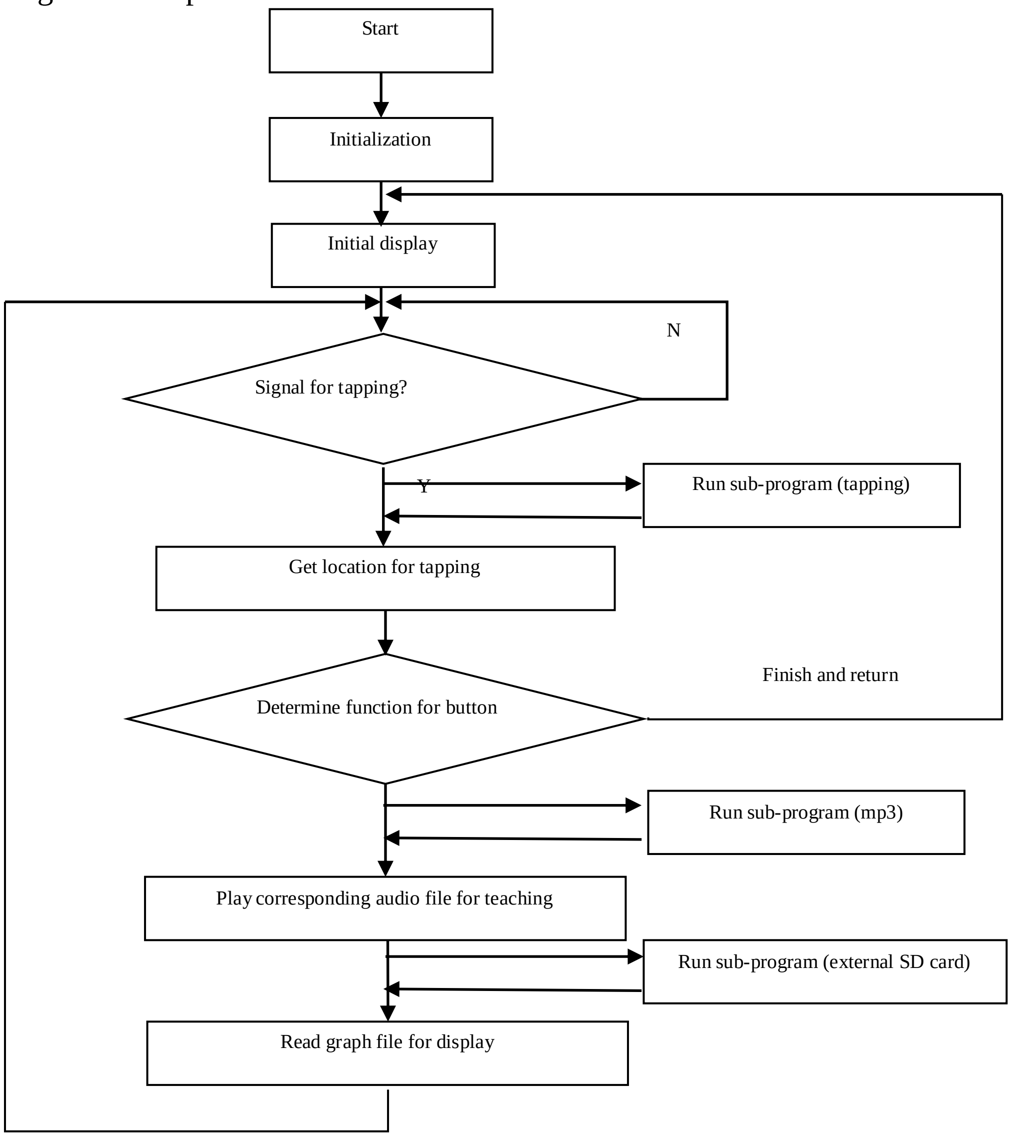

Figure 7. System Diagram

5. System Software

5.1 Workflow for software design

The software design involves the design for touchscreen display and software design for sensing, mp3 module, and external SD card. The design starts with the initializations for each interface and register, and displays the name of the instrument on LCD, with touch button. The next step relates to the determination of press button event. If the button is pressed, the LCD displays the sub-program and the corresponding graph from the external SD card, as well as the audio file for teaching. The detailed workflow is shown in Figure 7.

5.2 Programming example

Among the designed sub-programs, the most challenging one is the use of touchscreen. The reason is the transformation of x- and y- axis for locating the tapping event. Some common positioning approaches include max-and-minimum positioning, four-point positioning, and calibration with full matrix. Although the last approach has the best accuracy, it is not very common for its complexity. This program uses the max-and minimum positioning, and the formulas are as follows [3],

$$X_{LCD} = \frac{X - X_{\min}}{X_{\max} - X_{\min}} \times W \qquad Y_{LCD} = \frac{Y - Y_{\min}}{Y_{\max} - Y_{\min}} \times H$$

By measuring the diagonal of the touchscreen in the LCD display area, Xmin=92, Xmax=936, Ymin=108 and Ymax=896. In the program, it is set that x_tps=Xmin-Xmax=-844, y_tps=Ymin-Ymax, thus, it needs to use negative value after transformation since the actual position and the order for writing the position is exactly 180 degrees' difference. trans_tpx(y) is the function for transforming and positioning in LCD, which is coded by the following program.

```
unint trans_tpx(unint x)
{
  long tp_x;
  long temp;
  temp=(((long)x)-x_tps0)*240;
  tp_x=temp/x_tps;
  return tp_x;
}
unint trans_tpy(unint y)
{
  long tp_y;
  long temp;
  temp=(((long)y)-y_tps0)*128;
  tp_y=temp/y_tps;
  return tp_y;
}
```

6. Conclusion

This design integrates MCU and modules such as voice, touchscreen and other ones, for developing a laboratory teaching system and improving the learning experience for students. The highlights include novelty of the idea, the cheap cost and easy maintenance. However, due to the limitation in selecting modules, there are defects in functionality. They may be improved in the future.

Acknowledgements

The study was supported by Suzhou Science and Technology Project Grant No. SYN201402, SYG201534.

References

[1] S. Liu．LCD and interface technique of 51 MCU based on RA8806 controller, International Electronic Elements, 2009, 17(8) ,125-126.
[2] Instruction of ZLG240128F-BTSSWE-YAA-TP touch screen, 2011, Shenzhen Zolen Technology Co. Ltd.
[3] Y.Q. Zhang, The ADS7846 Controller Used in the Resistive Touch Screen, Electronic Science and Technology, 2006, 9, 49-53.
[4] Instruction of BA-series high fidelity audio module, 2009, Hangzhou BaiMeng Electrical Technology Co. Ltd.
[5] C.Y. Li, X.D. Wu, B.S. Sun, et al. Design of SD Card Host Controller Based on C8051F020, Microcomputer Information, 2007, 23(9-2), 120-122.
[6] Y.G. Zhang: *Fundamentals and application of MCU*. (Higher Education Press,Beijing 2010).