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Design of Music Spectrometer Based on Stm32l053

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ABSTRACT. *This paper introduces a design of multi-functional music spectrum based on single chip microcomputer, including external heating and humidity detection, infrared detection, digital clock, backlight detection and so on. The system is mainly to sample and filter the voice signal, carry out fast Fourier transform (FFT), and then display the spectrum distribution through LED screen, at the same time, change the screen display of its extended function, and support infrared remote control operation.*

KEYWORDS: *Design, Music spectrometer, Stm32l053*

1. Introduction

Stm32l053 is a popular single-chip microcomputer in the market. It has low power consumption and low price. It is suitable for electronic product design and teaching research. This paper studies a kind of music playing and spectrum display based on stm32l053, which can be applied to toys, simple music display devices, music fountains, etc. This design uses several timing counters to use at the same time, interrupt, key scan, music realization, spectrum display, digital tube use, etc. it is a very comprehensive practical project, which is conducive to the cultivation of students' comprehensive design and debugging ability, and lays a good technical foundation for students majoring in electronic technology application to enter the society.

2. System Overall Design Diagram

In this paper, the stm32l053 single-chip microcomputer with low power consumption is used to design a simple music device which can control music playing, display music spectrum, display tracks and playing time with keys. If there are many tracks or the device needs to realize power-off memory function, at24c16 memory chip with I2C communication mode can be added. The core of this design is stm32l053 single-chip microcomputer, and there are five peripheral parts, which are key scanning, music playing, digital tube display track and playing time, dot matrix display music spectrum and memory chip.

3. The Principle of Music Spectrum

3.1 Production of Music

We can feel wonderful music, mainly based on the human ear can distinguish signals of different frequencies, how to make the single chip computer can send out beautiful music? The principle is mainly to divide the music score into PWM waves with different frequencies and delays. In the single chip computer, PWM waves can be realized by using the timer [1]. The system is based on the HD algorithm, STM32 as the core of drawing and data processing, combined with the necessary external circuit, to realize the analysis of the frequency components of 20hz-10khz audio signal with the accuracy of 20Hz. The system consists of three modules: control and operation center, program-controlled amplifier and DC bias circuit. The dynamic range of the system measurable voltage (peak value) is extended to 10mv-10v by adjusting the gain of the programmable amplifier, and the analysis of the signal distortion is realized. In addition, the frequency and magnitude of the fundamental component and each harmonic component are displayed on the TT LCD. The audio signal analyzer designed in this paper realizes signal acquisition, spectrum analysis, distortion analysis and display. After testing, the system has the advantages of high resolution, good performance, low cost, strong practicability and portability.

3.2 Spectrum

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Human beings can sense the rhythm of music. In electronic products, we can usually watch the beating melody through vision, which is more intuitive. In this paper, the circuit design of the music spectrometer based on stm32l053 is arranged into different spectral shapes with the same notes. With the music playing, these spectral lines are displayed in the lattice [2]. This system is an instrument which can analyze the frequency components of audio signal and measure the distortion of sine wave signal. The design can be divided into three parts: control and operation core, program-controlled amplifier, DC bias circuit. We will focus on the measurement of the power of each frequency component of the input signal, and the difficulty of this design is to ensure the accuracy amplification of the signal to be measured in a large dynamic range. In this design, the audio signal analyzer is a scheme of audio signal analysis based on fast Fourier transform (FFT) algorithm. Its working principle is: use STM32 to collect the measured signal AD, use FFT method to analyze the measured signal, realize the analysis of the frequency component of the audio signal and the measurement of the sine wave distortion. The system designed in this paper has low cost and strong practicability. Power spectrum measurement is mainly through the discrete processing of audio signal, through FFT operation, the power value of each discrete frequency point of the signal is calculated, and then the discrete power spectrum is obtained in order to make the frequency division force reach 20Hz, which means that before ft operation, the frequency resolution f must be 20Hz by adjusting the sampling frequency (k) and the number of sampling points (n). STM32 is the core of control and operation in the system. Two 100 ohm resistors are connected in parallel at the input end to realize the input impedance of 500. The signal to be tested is amplified to the range suitable for a / ① D sampling by the first stage program-controlled amplifier controlled by the analog fast closing CD4051, and then through the DC bias circuit, the input signal is sampled by the 12 bit AD acquisition module built in STM32. The result of sampling is transformed into the frequency domain representation of the signal by FFT, and converted into the power value of the corresponding frequency by STM32, and sorted by power from large to small. Frequency measurement and distortion analysis are also completed by STM32. The corresponding measurement results are displayed by TFT LCD, and the results of a certain moment are intercepted by keyboard.

4. Circuit Design

The whole software design consists of five parts: hardware initialization, ADC audio signal acquisition, ADC sampling results reading and conversion (data sampling processing), frequency division processing of the collected data (using DSP library number, fast Fourier transform 64 point ft or 255 point FFT), conversion of the processed data into the number of points displayed on the LCD screen for display. In order to ensure the validity of audio signal sampling, the sampling frequency must be more than twice of the signal frequency. In this design, the circuit design and PCB production are carried out by the relatively mainstream Altium designer 16 software. Because there are only 40 stm32l0 pins selected and fewer I / O ports, the 74HC595 with 8-bit serial input / 8-bit serial or parallel output is used to connect with the nixie tube for timing and display of tracks. At the same time, the 74LS138 and 74HC595 are used as the row and column selection ends of 8 * 8 lattice, which greatly saves the I / O resources Source, 8 * 8 dot matrix is mainly used for music spectrum display; four buttons are connected with 10K resistor in series directly with stm32l0, and SCM detects user's behavior by interrupting scanning, such as the previous song, the next song, pause and play; in addition, headphone holes are left in the circuit, if the circuit board of this design is connected with playing devices such as mobile phones, the sound emitted by these devices will be played directly, only when The music stored in stm32l0 can only be played when there is no device connected to the headphone hole. That is to say, this design can be used as a normal power amplifier or play music independently.

5. Software Implementation

The program flow of music spectrum analyzer based on STM32L053 is to train students to form good software professionalism. The program is composed of several sub modules. The main program main () function is very concise. In while (1), each sub module is called to function, and the sub module is portable. The difficulty of software implementation is the realization of music with short spectrum code -- the effect of music with stm32l0 is mainly to use the principle of PWM wave + delay to make the human ear receive signals of different frequencies, and then receive music in the mind; secondly, the clock system of STM32 is very complex, and the setting of system clock will affect all modules, and his (internal high-speed) clock is used in the system to produce The 32mhz high-speed signal is used by each sub module; finally, for the compilation of frequency spectrum, we make notes correspond to PWM waves of different frequencies, and make each note into frequency spectrum. When the notes of music change, the frequency spectrum will also jump. The program-controlled amplifier design of this system is to use analog switch to select different resistance value as the feedback

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resistance of the amplifier, so as to realize the amplification of different range. This scheme is simple to control. The gain of each stage is constant as long as the gain bandwidth product and noise suppression ability of the op amp are large enough. In order to solve the influence of the on resistance of the analog switch on the system, the on resistance of the analog switch and the on resistance of the amplifier can be regarded as the reverse resistance of the amplifier. The input voltage range of this system is from LMV to 5V. If the effective range of a / D acquisition is 400mv-3.3v, the maximum magnification required shall not be less than 40. The system adopts level program-controlled amplification, which is divided into five levels. Use the analog switch CD4051 to realize the shift between gears. Considering the on resistance of the analog switch, this resistance should be taken into account when the potentiometer determines the gain, so the feedback resistance of this circuit is replaced by a potentiometer for flexible adjustment. The DC bias circuit can only collect the positive signal for AD acquisition, and the acquisition accuracy is relatively high in the range of IV to 2V. Therefore, this system designs a DC bias circuit to bias the input audio signal. The DC bias circuit used in this system is actually an adder. By adding the audio signal from the program-controlled amplifier and the DC bias voltage, the audio signal is shot high. The main functions of this system are a / D acquisition and FFT transformation. After the measured signal is amplified and biased by program control and DC, AD acquisition is carried out by STM32, and a total of 1024 points are collected each time. Then Fourier transform is carried out with FT algorithm to obtain the spectrum information of the information, calculate the energy of each frequency, and then sort each frequency according to the energy of each frequency with fast sorting algorithm, so as to obtain each frequency component of the measured signal. Frequency distortion is the square root of the ratio of the energy of each harmonic component to the energy of the fundamental wave.

6. Concluding Remarks

The design runs well after debugging, and can be made into a product with a certain mold. The most important thing is that through the design and debugging of the system, students of electronic technology application major have a strong interest in system design, circuit design, programming, etc., and their comprehensive ability has been greatly improved.

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