Indoor Ambient Temperature and Light Automatic Detection System

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Abstract. This paper designs an automatic detection system for indoor temperature and light temperature based on STC12C5A60S2 single-chip microcomputer. The whole system is composed of a host control module, a photoelectric detection module, an analog-to-digital conversion module, a temperature detection module, a voice broadcast module and a liquid crystal display module. The ambient temperature and light conditions are detected by the temperature sensor DS18B20 and the photosensitive resistor, and the ISD1730 voice chip is used to realize the voice broadcast of the temperature value and the light condition. At the same time, the liquid crystal LCD 12864 is used to display the current temperature value and the illuminance value. The system has been tested to be stable, with low power consumption, small size and economical advantages.

Keywords: STC12C5A60S2, DS18B20, Temperature Detection, Light Detection

1. Introduction
At present, temperature and light are important parameters in environmental detection. For example, in agriculture, differences in temperature and light directly affect the growth and cultivation of crops. In the home life, comfortable living temperature and reasonable light affect the quality of people's lives. Therefore, temperature and light detection are very important in our lives. This paper is based on STC12C5A60S2 single-chip microcomputer to realize the design of automatic temperature and light detection system. The system has stable performance, low power consumption, small size and economical and practical. It can be used in agriculture or smart home [1].

2. Circuit Design Principle
The indoor ambient temperature and light automatic detection system designed in this paper is divided into two modules, namely temperature detection module and light detection module. The temperature detection detects the temperature through the temperature test part composed of the DS18B20 temperature sensor. The light temperature detection module collects the light through the illumination collection system composed of the photodiode, and the converted voltage signal is amplified by the AD623, and then converted by an AD. The device performs analog-to-digital conversion, and inputs the converted digital signal into the single-chip microcomputer [2]. After the signal processing, the
ISD1700 performs voice broadcast on the measured temperature and light, and displays the temperature and light with the LCD12864 liquid crystal.

3. Overall Design
The system specifically includes a photoelectric detecting portion, a signal amplifying portion, an AD converting portion, a temperature measuring portion, a button portion, a voice broadcast portion, a liquid crystal display portion, and a power source [3]. The functions realized by the system are mainly: the system detects the temperature and light of the surrounding environment; the single chip controls the voice chip and the liquid crystal module, and broadcasts and displays the detected temperature and light. The overall system block diagram is shown in Figure 1.

![Figure 1. Overall system block diagram](image)

The photosensor selects the photodiode, and its spectral characteristics and temperature characteristics are relatively good and stable. The temperature sensor selects the DS18B20, which requires only one port line to connect to the microprocessor to realize the two-way communication of the microprocessor, and the measurement result directly outputs the digital temperature signal. The voice chip selects the ISD1700 series, which includes a full range of integrated system functions such as automatic gain control, microphone preamplifier, speaker driver circuit, oscillator and memory [4].

4. Hardware Design
The hardware circuit of this system consists of the following five parts:
1. STC12C5A60 controls the DS18B20 for temperature detection;
2. The data collected by the STC12C5A60 on the photodiode is amplified by the AD623 and then serially converted by the result of analog-to-digital conversion;
3. STC12C5A60 controls the ISD1700 voice chip;
4. STC12C5A60 controls LCD12864;
5. Power supply section.

4.1 STC12C5A60S2 Microcontroller Minimum System Design
The clock circuit design of the system is an internal mode, as shown in Figure 2, that is, the internal oscillation circuit of the chip is utilized. The STC12C5A60 microcontroller has a high-gain inverting amplifier for the oscillator. Pins XTAL1 and XTAL2 are the input and output of this amplifier, respectively. This amplifier forms a self-excited oscillator together with an off-chip crystal resonator as a feedback element. The external crystal resonator and the capacitors C1 and C2 form a parallel resonant circuit connected to the feedback loop of the amplifier [5]. Therefore, the crystal oscillator value of this system circuit is 12MHz, and the capacitor should be selected as much as possible, and the capacitance value is about 20PF. When soldering the circuit board, the crystal oscillator and capacitor should be
mounted as close as possible to the microcontroller chip to reduce parasitic capacitance and better ensure stable and reliable operation of the oscillator [6].

![Figure 2. STC12C5A60S2 microcontroller minimum system schematic](image)

The reset is implemented by an external reset circuit. The reset circuit usually adopts two methods of power-on automatic reset and button reset. This circuit system uses power-on and button reset circuit. In this design, when the clock frequency is 12MHz, C takes 10μF, Rs is about 300Ω, and R32 is about 3K [7].

### 4.2 Temperature Detection Circuit Design

As shown in Figure 3. When the DS18B20 is connected to the microprocessor, only one port is required. This is connected to the DQ line by P2.3 to realize the two-way communication between the DS18B20 and the STC12C5A60S2. The basic timing of the one-wire bus. When operating the DS18B20, there are only the following basic timings on the one-wire bus. All control operations and data/command transmissions are combined with these basic timings. A separate DQ line on the bus is embodied. The basic timing is:

1. Read Time Slots, including read 1 and read 0.
2. Bus reset signal (Reset Plus);
3. Write Time Slots, including write 1 and write 0;
4. The slave device has a response signal (Presence Plus).

![Figure 3. Schematic diagram of the DS18B20 circuit](image)

### 4.3 Voice Alarm Circuit

The voice chip ISD1700 is connected to an external oscillating resistor R5, which determines the sampling frequency and recording and playback time. R5 is 80K, the corresponding sampling frequency is 8KHZ, and the recording and playback time is 30S. Table 1 is a parameter table of the time length and sampling frequency of the ISD1700.

| Model | ISD1730 | ISD1740 | ISD1750 |
|-------|---------|---------|---------|
| 12kHz | 20s     | 26s     | 33s     |
| 8kHz  | 30s     | 40s     | 50s     |
| 6.4kHz| 37s     | 50s     | 62s     |

Table 1. ISD1700 sampling frequency and storage time parameter table
5. Software Design
The software program part of this system uses the P0, P1, and P2 ports of STC12C5A60 to control the data. Ports P0, P2.6, and P2.7 are used to control the liquid crystal module to display the measured temperature and light values of the current environment [8]. The P1.0–P1.3 port is used to control the ISD1700 voice chip. According to the light intensity, if the light is too weak, the system broadcasts: “The light is too weak, please pay attention to protect the eyes”. If the light is too strong, the system broadcasts that "the light is too strong, please pay attention to protect the eyes." P1.4–P1.6 is used to scan the buttons and judge whether to perform voice broadcast and other functions. P2.0–P2.2 is used for synchronous serial communication after converting photovoltaic signals into digital signals in the light collecting part. The block diagram of the program processing flow is shown in Figure 4.

![Figure 4. Program processing block diagram](image)

6. System Test
6.1 Design Results
After debugging the system hardware and software, when pressing the record button, according to the prompt on the LCD, for example, when the LCD display is “rec dark!”, the voice input “light is too dark, please pay attention to protect the eyes!”, when the LCD The display shows “rec softness !”, and the
voice is recorded as “light soft!” [10]. The recording of these voices is performed according to the specified address. When the voice needs to be played, the system will play the voice segment of the specified address. Finally, according to the temperature value and illuminance value of the current environment, the temperature value and the light level are broadcasted and a specific value can be displayed on the liquid crystal. When the broadcast light button is pressed, it is divided into three levels according to the degree acceptable to the human eye: the light is too weak, the light is soft, and the light is too bright. Since these voices have been entered into the system, if the light is below the minimum standard illumination set by the system, the system will report “The light is too weak, please pay attention to protect the eyes!”; if the light exceeds the maximum standard illumination set by the system, the system will broadcast “Light is too bright, please pay attention to protect your eyes!”; when the broadcast temperature button is pressed, the system will broadcast the real-time temperature value.

6.2 Data Analysis

(1) Analysis of temperature detection data.
When detecting the temperature value, in order to obtain a wide range of data, the test method is to put a popsicle in the container, and then put the DS18B20 temperature sensor and the thermometer into the container at the same time, and measure the temperature value and the thermometer at different time periods. The displayed temperature values are compared to obtain measurement errors and calculate relative errors. Because the accuracy requirement of the temperature in the design task is 1°C, if the error of the measurement data can reach 1°C, it is in compliance with the requirements. The measured data is as follows:

| Frequency | Parameter          | 1   | 2   | 3   | 4   | 5   | 6   |
|-----------|--------------------|-----|-----|-----|-----|-----|-----|
| Measure temperature | 12 | 13.5 | 15.5 | 17.1 | 18.3 | 19.3 |
| Actual temperature    | 11.9 | 13.3 | 15.6 | 17.2 | 18.5 | 19.4 |
| Absolute error         | 0.1 | 0.2  | -0.1| -0.1 | -0.2 | -0.1 |
| Relative error (%)     | 0.84 | 0.15 | -0.06| -0.05| -0.01| -0.05|

Error analysis: According to Table 2, the relative error is based on the formula:

\[ Ea = x - T \] (1)

The relative error is based on the formula:

\[ Er = \frac{Ea}{T} \times 100\% \] (2)

It can be found from the calculation that when the temperature value is initially measured, the thermometer and the DS18B20 need to be as close as possible, because in the same room, the temperature values of different distances will have a large deviation. Moreover, the measurement process avoids the heat source as much as possible, otherwise the measured temperature value will always move up, so that the measured temperature value is not accurate. When the measurement conditions are good, the measured data is still deviated from the data measured by the standard thermometer, but they are all within the range of -0.5 °C to 0.5 °C. The main reason for the deviation is the spontaneous heat dissipation of the chip.

(2) Analysis of light detection data
By consulting the data, there is no specific measure of light intensity. When measuring data, the theoretically measured illuminance range should be [0, 1023], and the measured data is as follows:
Table 3. Illuminance measurement data sheet (unit: Lux lx)

| Frequency | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Illuminance (lx) | 0   | 43  | 104 | 187 | 408 | 685 | 867 | 950 | 986 | 1023 |

Data analysis: According to the photoelectric detection and signal amplification part, the theoretical value of the signal analog-to-digital conversion of TLC1549 is calculated according to the formula, the minimum value is 0lx, and the maximum value is 1023lx. The illuminance level defined here is: (0lx, 100lx) is too dark, (100lx, 800lx) is soft, (800lx, 1023lx) is too bright. Illuminance measurement is also measured according to different time periods of the day, where 0lx is measured without illumination at night, and the maximum value of 1023lx is measured when the daytime is very bright, and other data can be used. The light from the desk knob is controlled. After the test, the light measurement completely meets the requirements. Among them, the system will alarm when the illuminance is less than 100lx, "The light is too weak, please pay attention to protect the eyes!", when the illuminance is between 100lx and 800lx, the system will broadcast "light softness", when the illuminance value is greater than 800lx, the system will broadcast "The light is too bright, please pay attention to protect your eyes!".

7. Conclusions
This design adopts STC12C5A60 single-chip microcomputer, DS18B20 temperature sensor, ISD1700 voice chip, photoelectric detection circuit and liquid crystal display to form an automatic temperature and light detection system, which displays when temperature and illuminance are detected, and performs voice with contrast level and temperature value. Call the police.

The environment test system can complete the following functions: 1. According to the intensity of the light, a warm reminder: if the light is weak, the voice broadcasts "The light is too weak, please pay attention to protect the eyes"; if the light is strong, the voice broadcasts according to the detected result, the accuracy of the temperature display is 0.1 °C, and the illuminance value can also be divided into three levels according to the light intensity: the light is too weak, the light is soft, and the light is too bright. This test system can be used in the field of environmental testing.

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