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Design of Electronic Calendar Based on MCU

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Design of Electronic Calendar Based on MCU

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Abstract. The electronic calendar is an indispensable electronic product in People's Daily life, it not only carries the bright culture of 5,000 years of China, but also is an important book to guide the cultivation of the Chinese nation. This design takes the IAP15 series MCU as the core, and the peripheral circuit includes the main control core, wireless module, display module, clock module, temperature and humidity module and other modules. The wireless module adopts ESP series chip to realize the function of MCU networking. The display module adopts OLED to display time, temperature and humidity. The clock module adopts PCF series chips to realize accurate control of time. The temperature and humidity sensor module uses DHT11 chip to realize the collection of environmental temperature and humidity, and simulation on Proteus with hardware circuit is also included.

1. Introduction

Making a traditional calendar requires a lot of paper and cutting down trees will deteriorate the natural ecosystem. Electronic calendar design based on microcontroller uses electric energy to avoid using paper, which is conducive to alleviate the above problems. In addition, the design adds a WiFi chip on the basis of the common electronic calendar, and can remotely control the calendar through the mobile phone to realize intelligent management of the calendar. The traditional electronic calendar uses a single-chip microcomputer, whose functions are mostly temperature and humidity monitoring, displaying time calendars, and the like. However, in the era of artificial intelligence, the traditional model needs to be broken. It's necessary to connect the electronic calendar to the Internet. The ESP8266 chip can realize the connection between the MCU and the Internet, and supports direct booting from the external flash memory. The buffer speed embedded in the chip is extremely high, which can improve the system performance and reduce the development cost of the previous period to a certain extent.

2. Electronic Calendar Design Scheme

The overall structure of the system is shown in Figure 2.1, with the MCU as the control core. The clock chip calculates the time and transfers the time to MCU; the temperature and humidity sensor collects the temperature and humidity data and transfers the data to MCU; the keyboard is connected to the pin of MCU to set the working mode; the WiFi chip connects MCU to the Internet to reach the purpose of remote control; MCU control display showing various time data. The communication protocol between MCU and the clock chip, the temperature and humidity sensor, display screen is selected as I²C.

At present, STM32 MCU is popular on the market. However, the market price of STM32 is more than ten times that of IAP15F2K61S2 MCU. IAP15F2K61S2 MCU can fully realize all the functions of this design, so from the perspective of cost analysis, IAP15F2K61S2 MCU is better. The IAP15F2K61S2 MCU supports encryption processing for the program. Its assembly instruction set is



compatible with the traditional 8051 core MCU, but the calculation speed is several times faster than the traditional chip.^[1] This MCU has a special data buffer, which can realize keil5 online debugging, simplifying the development of this design. In addition, it contains a double byte reload timer counter, an external interrupt port, and a high-speed asynchronous communication serial port, which is fully qualified for I²C interface communication.

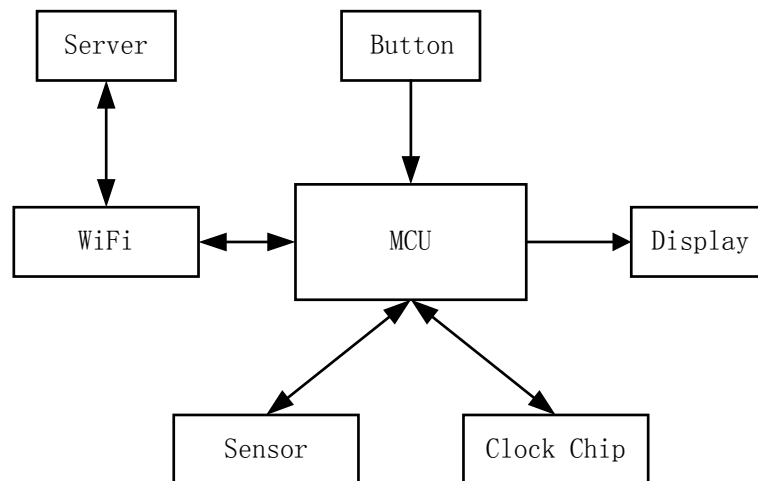


Figure. 2.1 overall structure of the system

IAP15F2K61S2 MCU's internal timer is only suitable for short timing, and there is a certain error in the calculation of time. Therefore, the internal timer cannot meet the requirements. However, the clock chip PCF8563 can better solve the above problems. The time and date registers inside PCF8563 can greatly reduce the complexity of programming and provide high-precision time data. Time can be set by writing data to the internal registers.

Digital tube and LCD occupy more than ten I/O ports of MCU. The great waste of I/O port resources may cause the MCU to have insufficient I/O ports to connect with other chips. After the above analysis, OLED is selected, which includes a pair of power pins and a pair of data pins. Its data pins are compatible with the I²C communication protocol, and can be time-multiplexed with other I²C interface chips. The I²C bus greatly saves the I/O port resources of the microcontroller.

On the one hand, the DS18B20 sensor can only measure temperature, which means another humidity measurement chip is required to achieve the temperature and humidity measurement function of this design. On the other hand, the price of the DS18B20 is much more expensive than the price of DHT11. After the above analysis, the DHT11 chip was finally selected. The chip contains three pins, two power pins and one data pin. It has an average current range of 0.3 to 1 mA, a standby current range of 110 to 145 microamps, and the sampling period is approximately one second. When the sensor is started, a delay should be added to ignore unstable data. The WiFi module selects the ESP8266 chip, which includes FLASH, static RAM, transparent transmission and transmission module, and phase-locked loop.

3. Design Part

3.1 Hardware Design

The main control circuit coordinates the overall hardware work, controls the WiFi chip networking, the clock chip autonomous operation, OLED screen display, sensor data acquisition and I²C communication protocol operation. The wireless circuit is dedicated to the transmission of data between MCU and ESP8266. The clock and display module circuits contain I²C communication protocol circuit.

IAP15F2K61S2 MCU is the core of the main control circuit, which supports 12 frequency division and the working voltage is 5 volts. Pin 7 of MCU is used for AD conversion to monitor whether the

power supply voltage is sufficient. If the voltage is too low, an alarm will be issued; pin 10 is used to connect the buzzer, that is, an external response is made according to the judgment of MCU; pin 20, 25 and 26 are used to connect alarm LEDs, etc. The three pins are respectively connected to three LED lights of different colors to distinguish different alarm information. Pins 23 and 24 are used to simulate the I²C protocol.

The function of reset is to restore the internal register of MCU to the initial state. The contents of all P port registers are uniformly set to "1" (except for the lowest position "0" of the P2 port). The high-level state of sufficient time maintained on the RST pin of MCU can initialize MCU^[8]. The reset circuit is shown in Figure 3.1. The capacitors in the figure are used for filtering. The resistor is used for current limiting. The RST pin connected to the resistor generates two different voltage states, which can realize the button control.

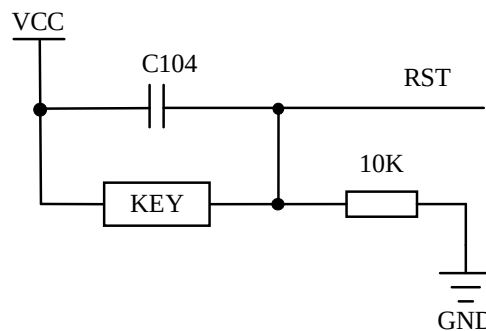


Figure. 3.1 The reset circuit

The power supply circuit is shown in Figure 3.2, and the AMS1117 voltage stabilizing chip is the core. Capacitors applied to both sides of the chip are used for filtering processing, and the ADC interface is used for monitoring whether the power is sufficient, and issue an alarm when the power is insufficient. The left port of the circuit is the input port. The right port of the circuit is the output port, and two capacitors are also added for filtering.

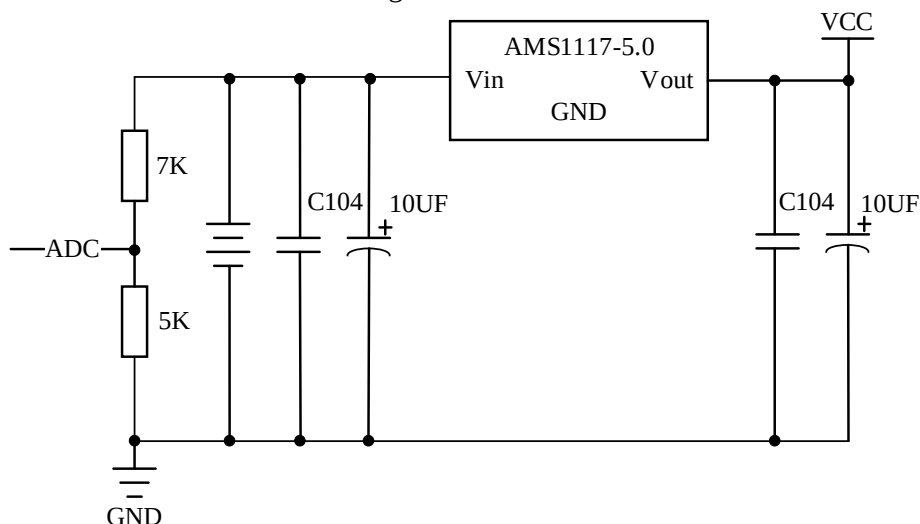


Figure. 3.2 The power supply circuit

The wireless circuit is shown in Figure 3.3, which supports ESP8266 with 3.3V voltage stabilizing circuit. The VCC pin and CF-PU pin are connected to the voltage output port of the 3.3V stabilizing circuit. ESP8266's TXD pin is connected to MCU's RXD pin, and EXP8266's RXD pin is connected to MCU's TXD pin. When data is transmitted, byte data will be converted into bit data.

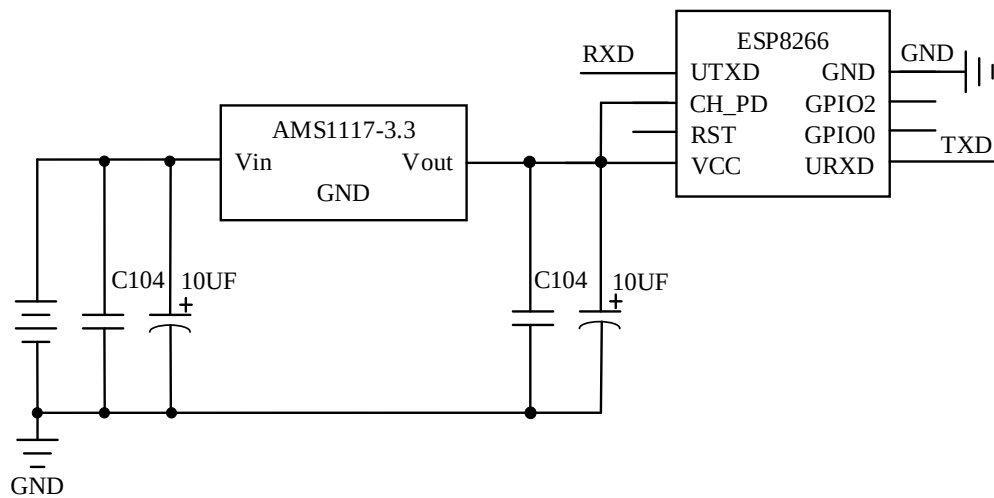


Figure. 3.3 The wireless circuit

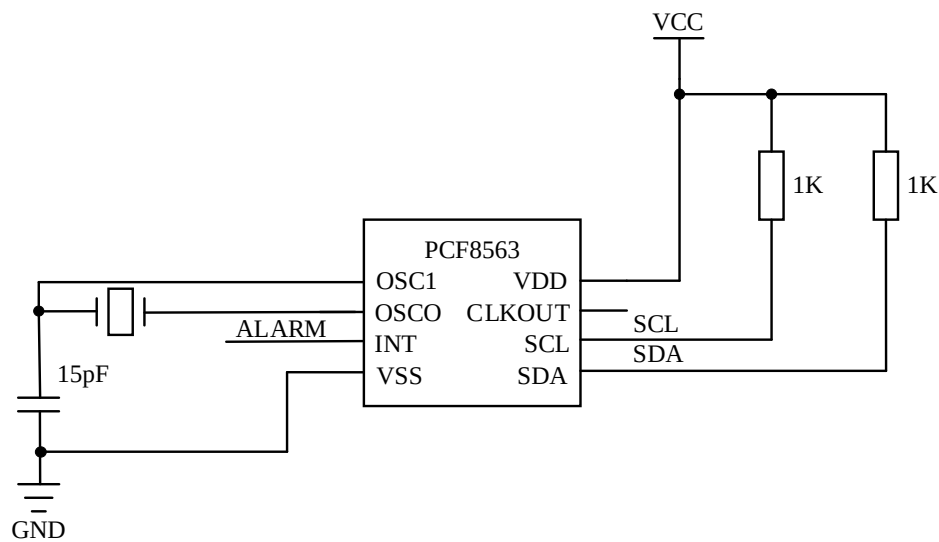


Figure. 3.4 The clock circuit

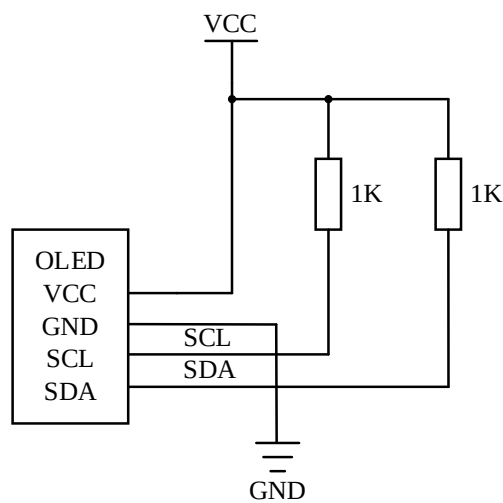


Figure. 3.5 The display circuit

The clock circuit is shown in Figure 3.4. Both the clock line and the data line are connected to the 5V stabilizing circuit output. MCU controls two I/O ports or gives control to the I²C chip. The allocation of the protocol address is as follows: the communication address of the clock chip is A2H and A3H. A total of two chips are mounted on the I²C protocol line, and the capacitance added to the communication line is within the allowable range.

The display circuit is shown in Figure 3.5. The VCC pin is connected to the 5V stabilizing circuit and the GND pin is grounded. The OLED display receives data from MCU through SCL pin and SDA pin. The biggest advantage of this circuit design is that it saves the I/O port resources of MCU. The clock line and data line are connected to a 5V voltage regulator circuit through a pull-up resistor. The communication address of the OLED is 78H.

3.2 Software Design

The main program flow is as follows. First, configure the working mode of I/O port, then initialize the serial port and interrupt port. Secondary, clean the OLED screen for initialization. Then, set the working mode of ESP8266 which includes the rate of communication. Next, initialize PCF8563 and DHT11. After the above initialization, the program starts to loop. In the loop, reads the clock, temperature and humidity data first, then MCU catches the data and controls displaying. In MCU's initialization, all I/O ports are configured to work in weak pull-up mode by writing data to its corresponding registers. After that, open the external interrupt switch, external sub-interrupt switch, and configure it as falling edge trigger. Then, open timer and configure it as baud rate generator for serial port.

The I²C communication protocol subroutine includes a delay subroutine and an I²C data transmission response subroutine. I²C delay is dedicated to the time required to maintain an I²C waveform. When the bus is not busy, both signal lines are high voltage. Under the premise that the clock line is at high voltage, a drop edge signal occurs on the data line, which is a data transmission start signal. Data can be transmitted only when the clock line is high. The I²C data transmission response subroutine transfers data in units of bytes, and the ninth bit of the data is the response. When all the data is transmitted, the slave doesn't response and the host reclaim the I²C usage rights. The I²C protocol program flow is that the host generates a start signal and then issues a communication address. The slave mounted on the bus determines whether the address is its own address, and if so, handshaking with MCU. If the connection is successful, data will be transmitted between the host and the slave.

This design includes 4 buttons, two of which work as the input of interrupt. The other two buttons adopt the query method. After the execution of the main program, the query of these two keys will be carried out. If the key has any action, the relevant code will be executed. Wi-Fi subroutine flow is as follows. First the following commands are written to ESP8266 successively: baud rate modification; reset ESP8266 by sending data "AT + RST"; set multiplexing mode by sending data "AT + CIPMUX = 1"; set working mode as the client by sending data "AT + CIPCLIENT=1, 8080"; connect to the router by sending data "AT+CWJAP = '604', '12345678'". In MCU, the working mode of serial port and timer is configured. PCF8563 sub-routine includes initialization subroutine and time subroutine. The initialization subroutine starts the data transmission by calling the I²C protocol sub-routine. Firstly, it sends address A2H to PCF8563, and waits for PCF8563's response. The data is transmitted in sequence as follows: 0x02 is the first register's address, followed by the time information registers, and finally the alarm setting information registers. OLED sub-routine displays Chinese in a fixed position to save time. Because it's not necessary to change Chinese displayed on OLED, so the unchanged Chinese and the changed numbers are displayed separately, which can reduce the time occupied by the OLED display subroutine. Since the time information is encoded in BCD format, the format conversion of the data is required before the display. OLED's initialization subroutine sequentially writes the following commands: turns off the display, sets the high column address, sets the low column address, sets the starting row address, sets the page address, sets the segment remapping, sets the scanning direction, and sets the display offset, set the area color mode, set the pre-charge time, and finally turn on the OLED display.

As shown in Figure 3.6, the simulation diagram of Proteus uses the I²C DEBUG module to

simulate I²C protocol. The debugging method is as follows: first write data "HELLO WORLD!" to the memory chip 24C02, then read the data and display it. Since the 8.6 version of Proteus does not have OLED library components, LCD1602 is selected instead.

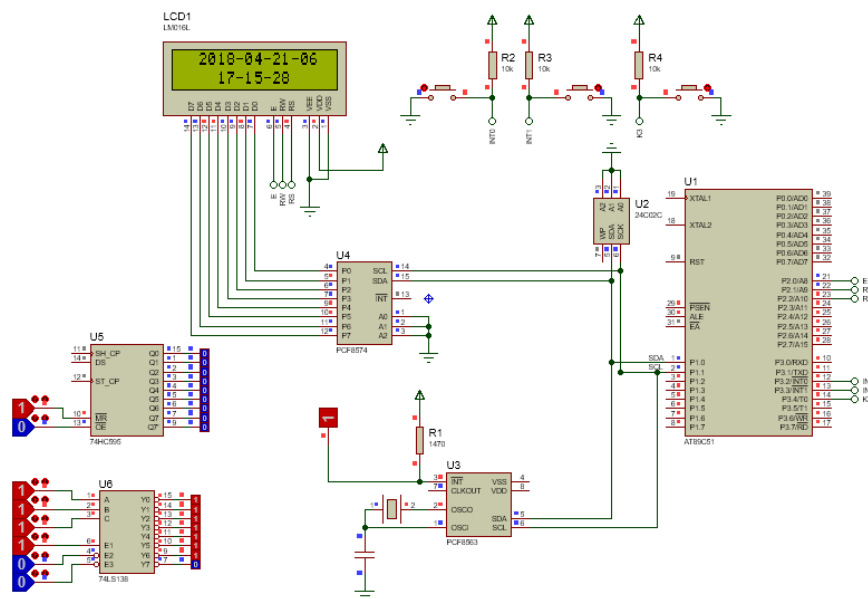


Figure.3.6 The simulation diagram of Proteus

4. Conclusion

This paper introduces the design process of a wifi-based electronic calendar from the aspects of the overall status, design scheme, hardware design and software design. In the development process of this design, some problems have been encountered. For example, the data format of PCF8563 is different from the data format of MCU, thus BCD code and decimal code conversion are required. In the design of PCB schematic, the power line width should be set at about 55mil. The width of other lines is generally set at about 25 mils according to actual needs. There should be as few holes through the double-layer plate as possible. And the lines at the same layer should avoid to be too close. Because of capacitance effect, parallelism should be avoided, which can also enhance signal transmission rate.

5. References

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