Academic Journal of Computing & Information Science
ISSN 2616-5775 Vol. 6, Issue 4: 63-67, DOI: 10.25236/AJCIS.2023.060408

Multi-interface intelligent socket system design

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Abstract: *In order to measure the energy consumption of electrical appliances in multiple applications and to achieve remote control, a smart socket system with multiple interfaces is designed. The hardware part of the system mainly consists of the main control chip, STM32F103C8T6, power module, CAN bus, WiFi module, RS485 module, relay module, power module, etc. The APP side and the socket side are based on the MQTT protocol, and the data interaction is carried out through the OneNet cloud platform to achieve data monitoring and remote control of the microcontroller side from the APP side.*

Keywords: *Multi-interface; MQTT protocol; smart socket*

1. Introduction

With the rapid development of China's economy, science and technology continue to make progress; more and more electrical appliances appear, improving people's lives, so the use of sockets is also increasing year by year. The current smart socket interface on the market has a single function and can only meet a few applications, so there are limitations to its use. Therefore, it is important to design a multi-interface smart socket system to address multiple real-life applications and meet people's needs to a certain extent.

The main control chip of the proposed smart socket system is a high-performance[1], low-cost stm32 chip that integrates multiple interfaces, such as Wifi, CAN, RS485 etc. It is connected to the OneNet[2] IoT platform and communicates with the APP through the MQTT protocol in the application layer. Based on the release subscription mechanism[3], the voltage, current, and power data of electrical appliances can be displayed remotely in real time, and the switch of the socket can be controlled by the user on the APP side[4]. The RS485 module and CAN bus are reserved for the system to have certain networking capabilities and can be applied in industrial manufacturing to detect the voltage and current situation of key nodes and monitor the node equipment in time to prevent the occurrence of a fire. The development of multi-interface intelligent sockets has some practical significance for industrial safety.

2. System hardware design

2.1. PCB design

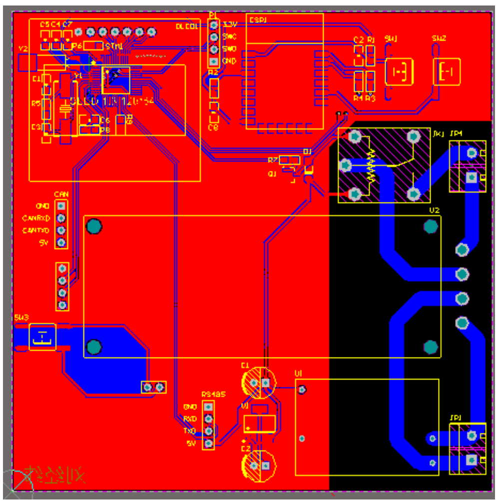

Figure 1: System pcb diagram

ISSN 2616-5775 Vol. 6, Issue 4: 63-67, DOI: 10.25236/AJCIS.2023.060408

The microcontroller is composed of a PCB board in order to make the system small and the signal transmission speedy[5]. The drawing was done using Altium Designer. The system is designed with a double-layer board, which makes the system structure simpler and more intuitive. And the double-layer board allows better control of differential and single-ended impedances as well as the output of some signal frequencies. The PCB process was chosen to lay copper, with the main components, power, and signal lines on the top layer. The overall PCB diagram is shown in Figure 1.The guidelines for constructing the topology model in this paper are as follows.

2.2. Circuit design for each module

2.2.1. Master control module

This system uses the STM32F103C8T6 chip as the main controller of the microcontroller[6]. The STM32F103C8T6 chip is feature-rich, with a built-in CAN controller, serial port, and other communication controllers that can meet the needs of the system design. The main control module schematic is shown in Figure 2.

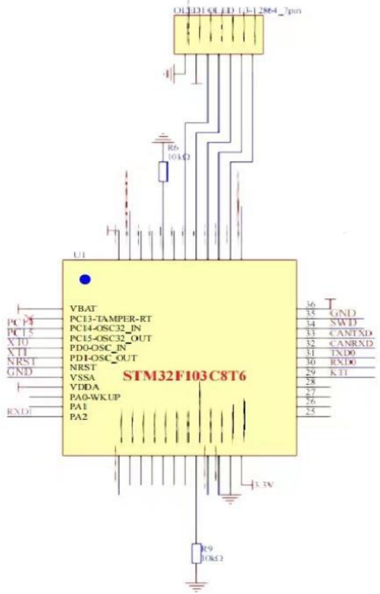

Figure 2: Schematic diagram of the main control module

2.2.2. Power supply module

The module uses the AMS1117-3.3 (a positive low dropout voltage regulator with an output voltage of 3.3V) to convert 220V AC to 3.3V DC and give a stable power supply to the microcontroller and other modules. The schematic diagram of the power supply module is shown in Figure 3.

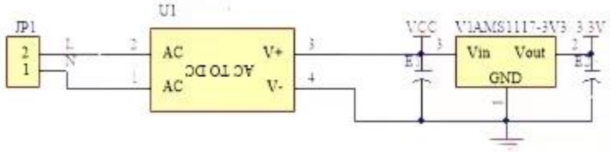

Figure 3: Power supply module schematic

2.2.3. Power display module

The system uses the SUI-101A module, which is capable of collecting DC voltage and operating current through a voltage transformer and a current transformer. The system can measure a maximum voltage of 400 volts and a maximum current of 5 amps. The schematic diagram of the power module is shown in Figure 4.

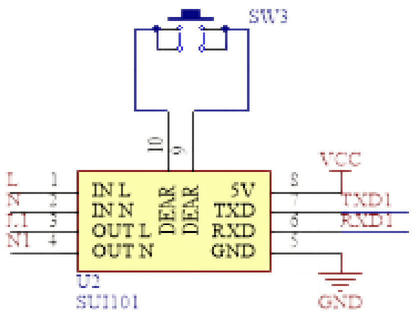

Figure 4: Schematic diagram of the power display module

2.2.4. Relay module

The module uses a relay model SRD-05VDC-SL-C to control the on/off of the entire smart socket. The relay module schematic is shown in Figure 5.

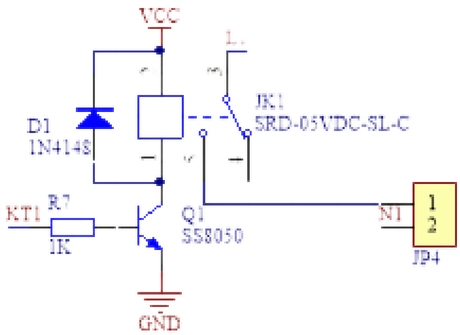

Figure 5: Relay module schematic

3. Hardware interface details and system software design

3.1. Wifi interface, RS485 interface, CAN bus interface

The WiFi interface is responsible for handling the digital communication between the end-user device and the wireless medium and is the core of the intelligence of this system. Through Wifi, a TCP connection is established with the IoT platform so that the smart socket can be operated remotely from the cloud or the APP. The interface uses an ESP8266 module, which is low-cost and small enough to facilitate embedding in the system.

RS485 is a half-duplex physical interface using differential transmission, which, due to its differential transmission characteristics, transmits over longer distances than traditional interfaces and has become one of the most popular interfaces in industry due to its multipoint topology. In this system, a TTL to 485 module is selected, and the ModBUS communication protocol is written to enable data communication between devices from different manufacturers in the industry.

The CAN bus consists of CAN_H and CAN_L twisted pairs and transmits signals via differential voltage. Therefore, CAN bus can improve the anti-interference ability of transmission and ensure the reliability of data transmission. This system uses the STM32F103C8T6 chip with a built-in CAN controller. Using the CAN bus interface, abnormalities in mechanical devices can be detected in industry. This ensures industrial system safety.

3.2. APP and microcontroller related design

The system is developed using the E4A programming tool, a Google Easy Language-based programming tool with Chinese language programming, with fully visualised pages and Chinese code[7], as well as interfaces and support tools for many APIs, COM, DLL, and OCX components, various mainstream databases, various utilities, and other resources. In the development process, just drag and drop the corresponding components to start programming and use E4A's own MQTT class library to establish a TCP connection with the OneNet cloud platform, greatly simplifying the development of the APP side and improving developer efficiency.

The system uses KEIL software development for microcontrollers[8]. KEIL is a software development system compatible with the C language for microcontrollers. It provides developers with a complete development solution, including a C compiler, macro assembly, linker, library management, and emulation debugger. Its easy-to-use integrated environment and powerful software debugging tools facilitate the development of this system. The system is developed using the STM32 standard library. The microcontroller side of the development[9], mainly the WiFi module, serial module, power module, CAN interface, etc.

3.2.1. Serial port module

Using the standard library function library, first configure the IO ports, setting PA2 as the serial TXD push-pull multiplexed output and PA3 as the serial RXD pull-up input, which is used to communicate with the power module. Similarly, set IO port PA10 to TXD push-pull multiplexed output and PA11 to RXD pull-up input for communication with the TTL to 485 module. Afterwards, the four elements of the serial port are initialized: the baud rate of the serial port is set to 9600, the 1-bit stop bit is set, the 8-bit data bit is set, and no parity bit is configured. Finally, the serial port is programmed with a receive interrupt, which is generated when the serial port receives a frame of data, thus ensuring that a complete frame of data can be received.

3.2.2. Power display module

The SUI-101A processes the high voltage and current collected through a voltage transformer and a current transformer to obtain a voltage and current that can be processed by a microcontroller. The microcontroller receives the voltage and current through the Serial port and PA2 port, converts them into the actual voltage or current value, and multiplies them to calculate the power used by the appliance. Once the calculation is complete, the power is displayed on the OLED screen and, based on the MQTT publish-and-subscribe mechanism, passed to the OneNet cloud platform for publishing to the APP.

3.2.3. Wifi module

The Wifi module is mainly used to establish Wifi and TCP connections. Burn the firmware into the ESP8266, send the command AT+CWMODE=1 through the serial port to set the mode to STA+AP mode, and if you receive OK, then the mode setting is successful. Send the command AT+CWDHCP=1,1 to enable the DHCP of STA+AP mode, and send the command AT+CWJAP=\"STM32\",\"123456789\, If you receive a GOT IP, then the WiFi connection is successfully established. Send the command AT+CIPSTART=\"TCP\",\"183.230.40.39\",6002 to establish a connection to the OneNet cloud platform[10]. Finally, the AT+CIPMODE=1 and AT+CIPSEND commands are sent to enter the pass-through mode so that the OneNet cloud platform can receive the data from the microcontroller.

Finally, the system uses the OneNet cloud platform, which is a Paas IoT open platform built by China Mobile. It helps developers easily access and connect their devices and quickly complete product development and deployment[11]. Compared to the Ali Cloud platform, OneNet is free to use, much simpler, and more developer friendly.

To develop the cloud platform, first create a product, get the product ID, then create the APP device or STM microcontroller device that needs MQTT communication in the product, set up the data flow, and add other attributes. Cloud communication is mainly the MQTT protocol; the protocol is based on the subscription and publishing mechanisms: the software side defines the key topic, the microcontroller side subscribes to the key topic through the corresponding MQTT message, the same APP side publishes the key topic, then the APP and the microcontroller side successfully establish a connection. At this time, when the APP side closes the switch, the cloud platform will push this message to the microcontroller side that subscribes to the key topic, and the microcontroller closes the socket switch[12].

4. Conclusion

This paper presents a multi-interface smart socket design that can be used in a variety of applications, enabling the detection of voltage, current, and power consumption of electrical appliances. The system can be used in a variety of applications and is capable of detecting the voltage, current, and power consumption of electrical appliances. It also enables the user to monitor the use of electrical appliances remotely via an APP and to control their switching in a timely manner. The design, modularly integrated

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in the PCB, has been designed in such a way that the modules are isolated from each other and do not affect each other. The socket design is reasonable and compact, and the APP side is clear and user-friendly. It is able to meet people's application of sockets on multiple occasions.

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