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Design of Small Intelligent Poultry Feeding System

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Abstract: *Although many intelligent and information-based intelligent feeding systems exist in traditional poultry breeding, most are oriented to large-scale farms. Applicable intelligent poultry breeding and monitoring systems are scarce for small-scale individual farmers based on family units. In response to this problem, this design is committed to creating a small, intelligent poultry feeding system for individual farmers. The sensor module collects key data such as environmental temperature and humidity, feed tray amount, and water tank level. It transmits the data to the microcomputer for real-time processing. The processed information is visually displayed through the TFT-LCD screen, and the data is uploaded to the Aliyun platform through the Wi-Fi module. After receiving the data, the platform will send the relevant information to the mobile phone app, and the user can operate through the app. The operation instructions are returned to the microcomputer through the cloud server to realize the system's remote control.*

Keywords: *STM32F4, Aliyun, Intelligent feeding, Poultry breeding*

1. Introduction

The poultry breeding industry is essential to China's economic development. Therefore, it is necessary to use intelligent technology reasonably to effectively improve the overall development of the poultry breeding industry [1-5]. With the rapid development of IoT science and technology, a new round of scientific and technological revolution and industrial transformation is surging, and the digital revolution belonging to the poultry industry has entered a new era [6-10]. Since the reform and opening up, the poultry breeding industry has rapidly developed, and the modern poultry breeding industry is undergoing a strategic transformation from quantitative to qualitative. Sustainable development and intelligent breeding will be the main development direction in the future [11-14].

For a long time, as an important part of China's agriculture, the development of the poultry breeding industry has been dependent on the traditional way of artificial feeding. The poultry industry's digital revolution has begun in the new era of rapid informatization and intelligence development. The continuous breakthrough of modern information technology in China provides a broad stage for developing and applying intelligent equipment. In rural areas, poultry farming is often carried out in families. Mainly raising chickens, ducks, and geese, the scale is relatively small. Although the number of breeding is not much, the daily feeding work such as feeding, watering, and inspection still requires a lot of staffing and time. Using IoT, sensors, and intelligent control technology, a small intelligent poultry feeding system is designed to achieve accurate, timing, and quantitative feeding. It can improve breeding efficiency, reduce labor costs, and provide a new and efficient breeding mode for family farming in rural areas.

2. System working principle

The system core is STM32-F407VET6 microcomputer. It acts as the central control MCU and can accurately coordinate the cooperation of the modules in the system. The system integrates multiple fatal circuits, including a crystal oscillator circuit that provides a stable clock signal, a reset start circuit that ensures the stable start of the system, a module expansion circuit for connecting each module, a buzzer circuit for alarm prompts, and a USB to serial port circuit for data communication.

Various sensors are used: The DHT11 temperature and humidity sensor collects the temperature and humidity data of the environment, which provides important information for monitoring the aquaculture environment. The HX711 weighing sensor measures the remaining feed amount of the tray in real time.

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The resistive water level sensor detects the remaining amount in the water tank. In addition, the steering gear control module controls the feeding and the fence's opening/closing, and the human pyroelectric infrared sensor module monitors whether the poultry leaves the fence. The ESP-01S Wi-Fi module uploads the sensor data to the Aliyun server for remote monitoring.

The workflow is as follows: (1) DHT11, HX711, and water level sensor transmit the collected data to STM32. (2) The microcomputer analyzes and processes the data and uploads the data to the Aliyun server through the EPS-01S Wi-Fi module to realize the remote monitoring and synchronization of the data. (3) The TFT-LCD displays the environmental temperature and humidity, residual feed and water, and other information in real time. (4) The touch function of the display screen enables users to interact with the system directly. The touch chip feeds users' operation back to the microcomputer for processing. Users can control the feeding and the fence's opening/closing and set timing feeding or automatic feeding through the touch screen.

3. Hardware circuit design

3.1. Microcomputer system

The microcomputer of this design is STM32-F407VET6, and its pin distribution is shown in Figure 1. For the set circuit of the microcomputer, it is only necessary to connect a 10k pull-up resistor to the NRST reset pin of the microcomputer and connect an ordinary key to the ground so that the microcomputer can be reset by the key. For the download circuit of the microcomputer, the SWDIO and SWCLK pins are extracted, and the standard ST-Link downloader can be used for download and debugging. The microcontroller requires a 3.3V DC power supply for stable operation. In order to prevent some voltage-sensitive peripherals, such as ADCs, from being interfered with by external signals, multiple capacitors for voltage stabilization and filtering are generally connected in parallel to the microcomputer's power supply cable. The microcomputer's analog ground is connected in series with a magnetic bead, and several filter capacitors are connected in parallel for filtering. The interference caused by the instability of the external power supply or external signals can be significantly prevented.

The STM32-F407VET6 minimum system is shown in Figure 2.

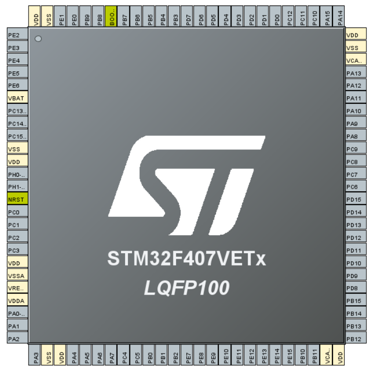

Figure 1: STM32F407VET6 pin distribution

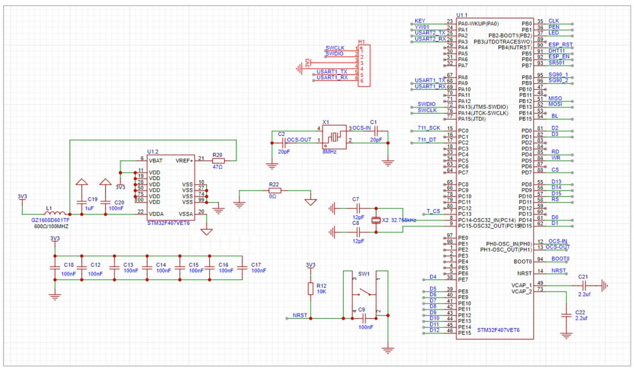

Figure 2: STM32F407VET6 minimum system

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This design requires two voltages: a 5V DC voltage for the display screen and some modules that require a 5V power supply, such as the water level sensor and the human pyroelectric sensor. The other requires a stable 3.3V DC voltage for the central control MCU, the Wi-Fi module, and the buzzer. The Type-C interface is directly connected to the 5V DC voltage, and the LDO linear regulator is used to stabilize the voltage and reduce the voltage to obtain the 3.3V voltage. The advantage of the external 5V DC voltage without using lithium batteries is that the external 5V power supply can usually provide a 5V voltage that has been stabilized. Processing the inputting 5V voltage is unnecessary to obtain a stable enough current for multiple modules and the steering gear. Suppose the lithium battery is used for power supply. In that case, it is also necessary to design a boost voltage regulator circuit, and when the power of the lithium battery decreases, the voltage and current will decrease accordingly. The step-down circuit uses an LDO linear regulator to reduce the voltage. After the 5V DC voltage is reduced by the LDO linear regulator, a stable 3.3V voltage can be obtained. The filter capacitor of the LDO linear voltage regulator needs a tantalum capacitor, a self-recovery fuse, and an ESD electrostatic protection chip to be added to the power supply line to prevent the power supply short circuit and the chip's electrostatic breakdown.

3.2. DHT11 temperature and humidity sensor

The DHT11 sensor integrates the NTC temperature measurement elements and the data conversion chip. When programming, it only needs to read the data sent by the sensor's data pin and perform data conversion. The DHT11 sensor is used to detect the temperature and humidity data of the environment in real time and upload it to the mobile phone app for display. Suppose the user opens the temperature and humidity alarm function in the background of the Aliyun server when the temperature and humidity exceed the set threshold. In that case, the mobile phone app will remind the user that the temperature and humidity are too high, and the user can make the corresponding processing in time.

The DHT11 sensor is a module that integrates the basic drive circuit. When the sensor is connected to the working voltage of 5V, the red light is always on, and the sensor starts to work. The data pin of the sensor outputs the digital signal of temperature and humidity. The microcomputer receives and reads the data through the I/O port and converts the data to obtain temperature and humidity information about the current environment.

3.3. TFT-LCD display

Equipped with a 34Pin interface and a high-performance ILI9341 driver chip, the 2.4-inch TFT-LCD display with a 16-bit true-color RGB display is used to obtain a clear picture. The display is also equipped with the XPT2046 touch chip, which provides a touch function and increases the user experience. The front of the TFT-LCD is shown in Figure 3, the back is shown in Figure 4, and the pin distribution is shown in Figure 5.

Figure 3: The front of TFT-LCD

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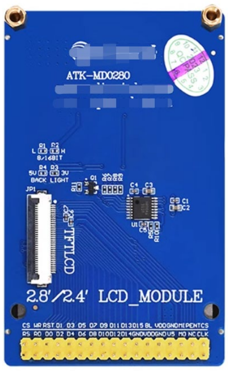

Figure 4: The back of TFT-LCD

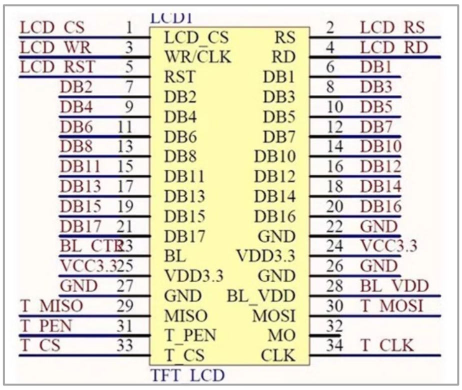

Figure 5: TFT-LCD pin definition

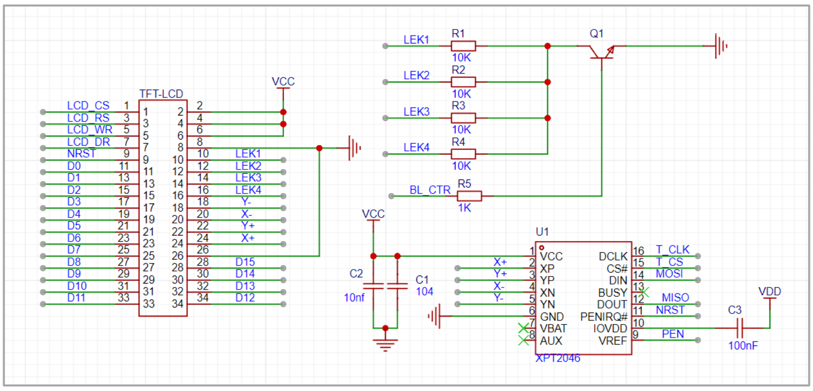

Figure 6: Display's internal circuit

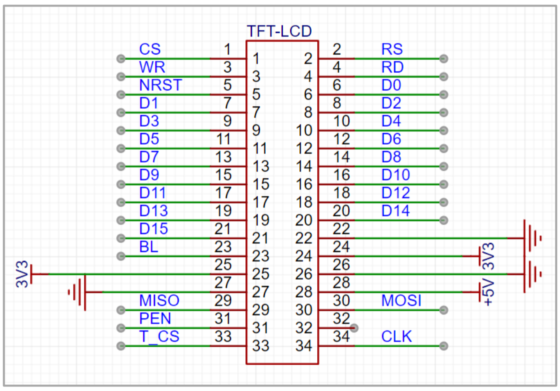

Figure 7: TFT-LCD pin definition

As shown in Figure 6, the internal circuit of the display module has been highly integrated, and the user needs to pay attention to the configuration of the power supply pin. Some of the display's power

ISSN 2706-655X Vol. 7, Issue 1: 49-55, DOI: 10.25236/IJFET.2025.070108

supply pins need to be connected to a 5V power supply, while the others need to be powered by a 3.3V power supply. As shown in Figure 7, The D0-D15 pins are parallel data pins for transmission. The MISO, MOSI, T_CS, and CLK pins correspond to the data receiving, sending, chip selection signal, and clock signal pins of the touch chip using the SPI communication protocol. The PEN pin is used as the indicating pin of the touch signal. The pin will trigger a level change when the user touches the screen. The BL pin controls the backlight brightness of the touch screen. The remaining pins are the display control and power pins, and the 32 pin can be suspended or grounded.

3.4. Buzzer circuit

The active buzzer is used with the HC-SR501 human pyroelectric sensor module. The sensor emits a voltage signal of 3.3V when the human pyroelectric sensor detects the poultry's passage. After the voltage signal passes through the base pole of the NPN-type triode in the buzzer circuit, the buzzer circuit is turned on, and the buzzer sounds. As shown in Figure 8, the positive electrode of the buzzer is connected to a 3.3V voltage, and the negative electrode is connected to the collector of the NPN-type triode. The emitter of the triode is grounded, and its base is connected to the output pin of the human pyroelectric sensor after a 4.7k drop-down resistor.

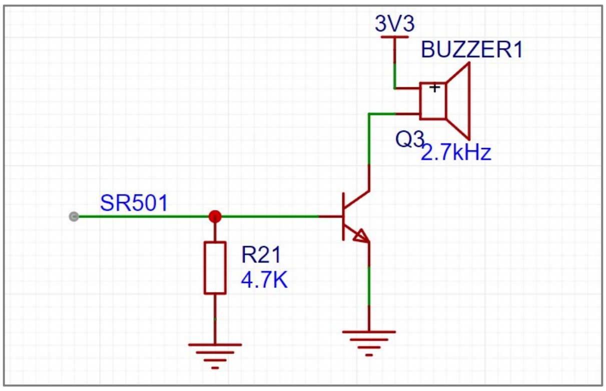

Figure 8: Buzzer circuit

3.5. USB to serial debugging circuit

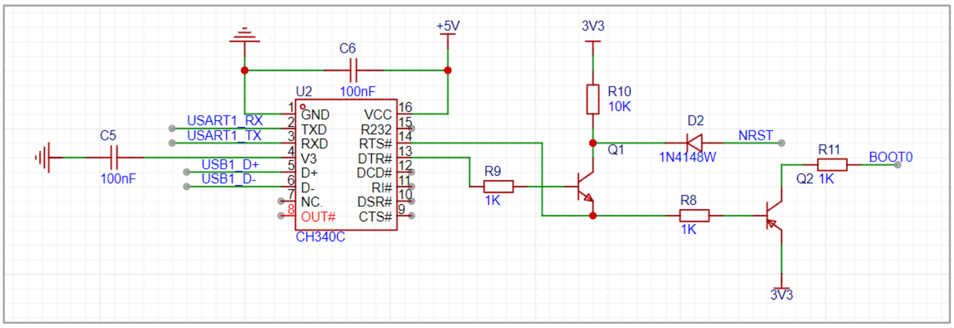

Figure 9: USB to serial circuit

As shown in Figure 9, the TXD and RXD pins of the CH340 chip are connected to the RX and TX pins of the MCU. The CH340's D+ and D- differential signal pins are connected to the USB input port's DP and DN differential signal pins. The differential signal pins of the USB are connected to the input pins of the ESD electrostatic protection chip, so the differential signal pins of the CH340 chip are directly connected to the output pins of the ESD electrostatic protection chip.

In order to download the program to the microcomputer using the serial port, it is necessary to connect the DTR pin of the CH340 chip to the NRST reset pin of the microcomputer through an NPN transistor and a diode, and the RTS pin of the CH340 chip is connected to the BOOT0 boot pin of the microcomputer through a PNP transistor. The CH340 chip is connected with the corresponding current limiting resistors to form an automatic USB download circuit to the serial port.

ISSN 2706-655X Vol. 7, Issue 1: 49-55, DOI: 10.25236/IJFET.2025.070108

4. System software design

The LVGL graphics library designs the interaction interface between the touch screen and the user. As the general embedded graphics library, the LVGL needs to transplant the corresponding screen driver and the touch driver before transplanting to the microcomputer, and it needs the dotting or filling function for the transplanted screen. The touch drive needs the function to obtain the touch coordinates for LVGL to obtain the coordinates of the user's operations. The flash of the microcomputer is adequate to open up 20-40 double buffer arrays, and the double buffer is chosen as the buffering screen brushing.

After the buffering selection, the LVGL's screen brushing function needs to be rebuilt. The color filling function needs to be written according to the screen driver, the disp_flush brushing function needs to be rewritten, and the original dotting function needs to be replaced with regional color filling. The LCD_Color_Fill regional color filling function reconstructs the disp_flush brushing function.

After reconstructing the screen brushing function, the touch driver's coordinate readback data needs to be written to the LVGL. As shown in Figure 10, the LVGL graphics library has the corresponding coordinate processing function, so it only needs to write the coordinates read by the touch chip into the LVGL's touchpad_get_xy function.

Embedded with multiple LVGL versions, the GUI-Guider software simulates the LVGL. Building a development environment, it can run the LVGL directly on the Windows platform without downloading it to the microcomputer, significantly improving development efficiency.

5. Physical operation

The ESP-01S Wi-Fi module is used to connect the Aliyun server. It is connected to the serial port of the microcomputer, and it can be controlled by sending the AT instructions through the serial port of the microcomputer. Before using the AT instructions to control the Wi-Fi module to connect to the Aliyun server, it is necessary to configure the Aliyun server. The initialization processes of the Wi-Fi module are as follows: (1) The microcomputer sends an AT command to the Wi-Fi module through the serial port to connect to the Wi-Fi. If the connection fails, the error message is printed, and it is reconnected. (2) After connecting the Wi-Fi, a connection instruction is sent to the Aliyun server. The server will return OK to the Wi-Fi module if it is connected. If the server returns fail, it indicates that the server is not responding, and the MCU will re-send the connection instruction. (3) After the successful connection of the server, the microcomputer will obtain and save the data by subscribing to the server message. If the sensor data needs to be uploaded to the server when the system is powered on and initialized, a message can be directly issued to the server. Otherwise, the data received by the serial port needs to be cleared to prepare for the subsequent data transmission.

As shown in Figure 10, when the system is powered on, the Wi-Fi module automatically connects to the Wi-Fi network and the Aliyun server and enters the system's primary interface after the connection is successful. When the mobile phone app's small program is opened, the data displayed is consistent with that on the TFT-LCD, indicating regular end-to-end data synchronization.

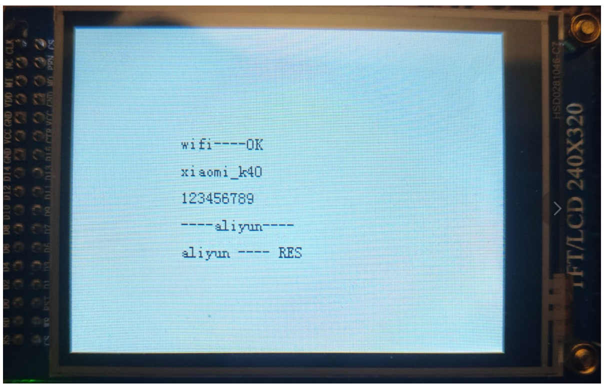

Figure 10: Wi-Fi module connection

ISSN 2706-655X Vol. 7, Issue 1: 49-55, DOI: 10.25236/IJFET.2025.070108

6. Conclusions

The DHT11 temperature and humidity sensor, HX711 weighing sensor, and resistive water level sensor are used to collect environmental temperature and humidity data and important information, such as the tray's residual feed and the tank's remaining water. The microcomputer accurately controls the opening/closing of the steering gear to realize the intelligent feeding function. The system is connected to the Aliyun server through the ESP-01S Wi-Fi module, which is connected to the microcomputer through the serial port and sends the data to the Aliyun platform based on the MQTT protocol. MQTT is a lightweight publishing/subscribing message transmission protocol based on proxy. Its message subscription and sending function are used to upload the data to the mobile app in real time, realizing the remote monitoring of the data and the remote control of the devices. The remote control of the mobile phone app is supported, and users can set timing tasks or perform real-time operations.

Users can remotely monitor the relevant information and feed through the mobile phone app. The high-definition TFT-LCD is equipped to display the relevant information. Users can operate through the touch screen, and the operations are fed back to the microcomputer and processed in real time through the touch chip. It realizes the convenient touch control function and further improves the user experience.

Acknowledgments

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