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Desktop 737NG Simulator Simulation Platform Design

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Abstract

This paper is based on STM32F1 series processor and RS485 Bus to realize the hardware simulation of 737NG aircraft autopilot, communication and navigation, instrument display and other functional logic, and design and complete the desktop type 737NG simulator simulation platform. After experimental testing, the platform can be used for teaching demonstration of aircraft communication and navigation, instrument display, automatic flight and other courses, which greatly reduces the cost of flight simulators and improves the efficiency of practical teaching.

Keywords

Desktop; 737NG; Simulator; STM32F1; RS485.

1. Overview

For many airlines and civil aviation industry colleges and universities, the time and economic cost spent on training pilots and aircraft maintenance personnel is huge [1], and how to let students know more about flight operations in a shorter learning time is a topic that needs to be studied. The low-cost and high-efficiency desktop trainer reduces numerous redundant devices, is easy to operate, and facilitates demonstrations during classes, and is also suitable for students to carry out various learning tasks on this device, which has a high development value.

At present, simulators used for domestic training generally rely on imports, which are expensive and occupy a large area [2-3] and cannot meet the needs of a large number of students using them at the same time. For student training and classroom use, a certain number of equipment sets are required, and it is of great importance to develop a desktop-type aircraft simulator trainer with a small footprint, low price, flexible configuration, and easy maintenance. This paper designs a desktop 737NG simulator simulation platform based on the 737NG simulator software platform of the Aircraft Maintenance Virtual Simulation Center. The device relies on a common computer to run the simulator software platform, while the PFD and ND monitor contents on the captain's side are displayed through a monitor, and the hardware simulation platform transmits data interactively through serial communication to achieve simultaneous hardware and software updates.

2. System Components

The desktop 737NG simulator simulation platform mainly consists of the 737NG simulator software platform, simulation panels of each functional module, and display modules. The simulation panel includes MCP flight control panel, communication panel, navigation panel, radar control panel, ATC/TCAS panel and EFIS panel. Each panel is based on STM32F1 series processor, with unified standard power supply and communication interface, anti-plugging design, easy for fast troubleshooting and maintenance, and RS485 Bus for data transmission in order to facilitate later upgrades, the desktop type 737NG cockpit can form different configurations and is very flexible to use. The display module consists of a main display and a secondary display that can be expanded on both sides. The display can be quickly removed to display dynamic schematics and other information or to provide a view outside the cabin.

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3. Hardware Design of the System

As shown in Figure 1, the core controller used in the hardware emulation panel is the STM32F103RCT6 chip from STMicroelectronics (ST), with an ARM 32-bit Cortex-M3 CPU core, up to 72MHz operating frequency, 256K bytes of flash program memory, up to 64K bytes of SRAM and four chip-selected static memory controller, embedded factory-tuned 8MHz RC oscillator, 40kHz RC oscillator with calibration and 32kHz RTC oscillator with calibration, up to 12-channel DMA controller, 112 fast I/O ports, 11 timers, 13 communication interfaces (2 I2C interfaces (SMBus/PMBus support), 5 USART interface (supporting ISO7816, LIN, IrDA interface and modem control), 3 SPI interfaces (18M bits/sec), 2 multiplexable I2S interfaces, CAN interface (2.0B active), USB 2.0 full speed interface, SDIO interface), as well as 3 12-bit analog-to-digital converters with 1μs conversion time (up to 21 input channels) and 2 channels of 12-bit D/A converters. 12-bit D/A converters. The LQFP-64 package is enough to meet the design requirements of each individual panel module.

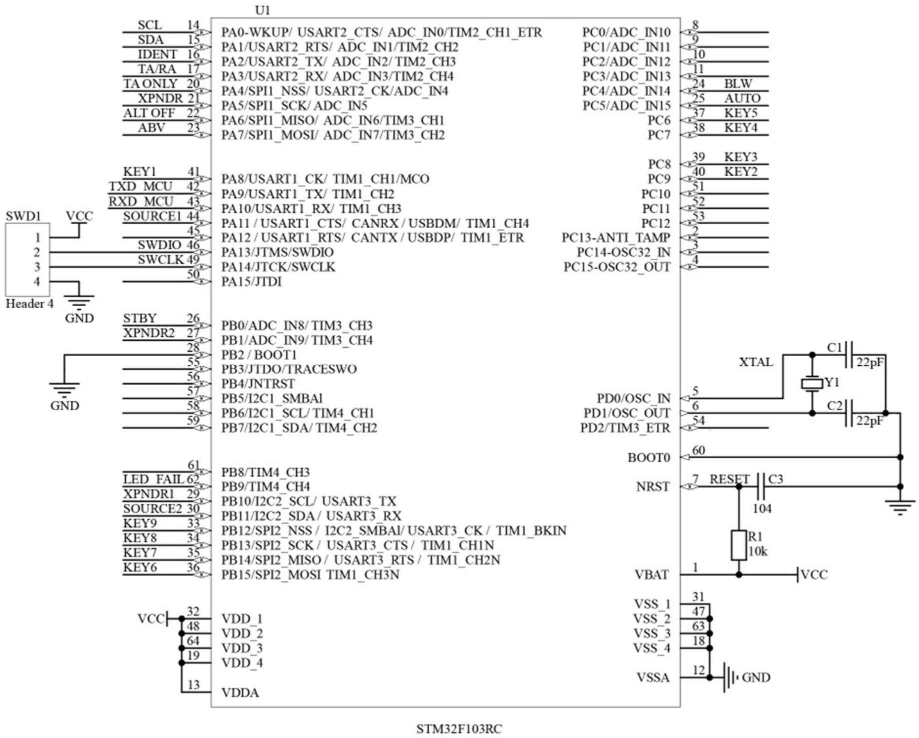

Figure 1. Processor core board schematic

In order to achieve flexible configuration of panels, each panel is designed to be an independent module and a 485 Bus is used for data transmission between the panels. The interface circuit is shown in Figure 2. The RS485 circuit uses the MAX13487E chip, which is a +5V, half-duplex, ±15kV ESD-protected RS-485 transceiver that contains a driver and a receiver with hot-swappable functionality, while the chip has a transmission direction automatic control function that automatically enables the driver during transmission, reducing the work on software design. In addition, the MAX13487E input impedance is 1/4 unit load, so it allows up to 128 transceivers to be hooked up to the bus. One side of the chip is connected to the microcontroller PA9 and PA10 pins, which are connected to the serial communication pins of the microcontroller, and one side is connected to the 485 Bus, which forms the interface circuit between the microcontroller and the 485 Bus communication. All emulation panels communicate via bus, and the hardware and software platform PC communicate via USB. The system converts the TTL signal into USB signal through FT232 chip to interact with the upper computer software platform for data interaction, and the circuit interface is shown in Figure 3.

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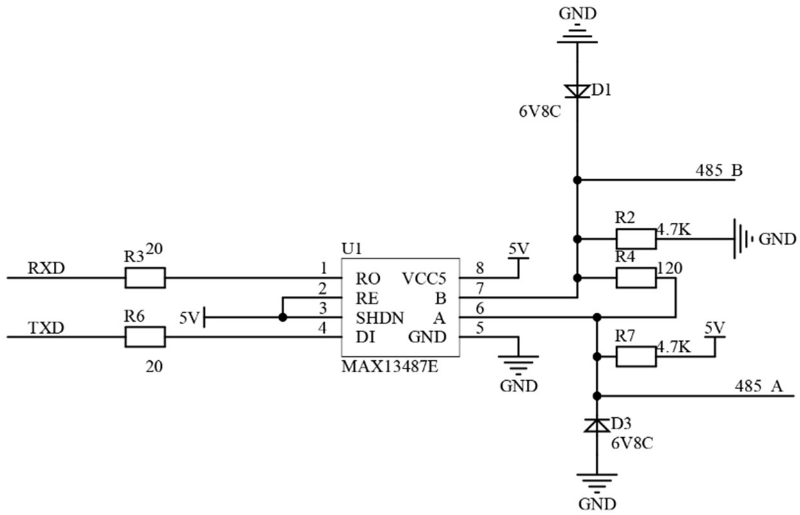

Figure 2. RS485 to TTL interface circuit

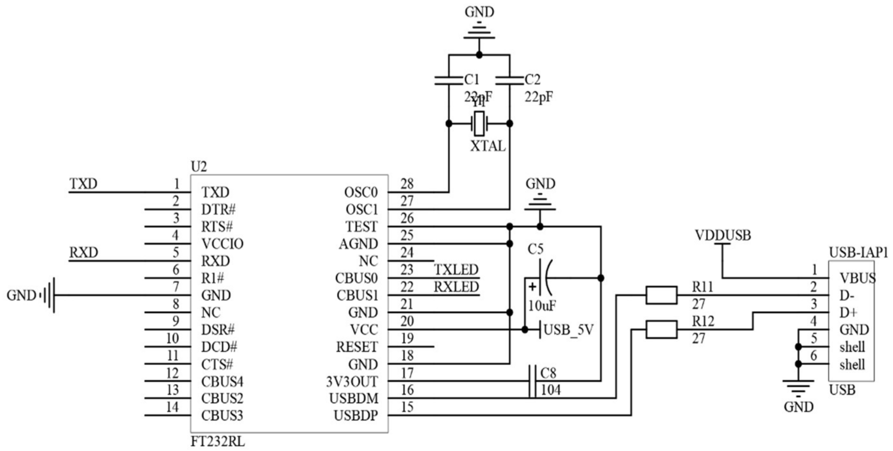

Figure 3. TTL to USB circuit

4. Design of System Software

The software design is mainly to carry out the transmission of data from the upper and lower computer. The following is an example of the software design process using the EFIS control box panel. The internal structure design is shown in the following figure, MINS and BARO use double-layer encoder knob, VOR/ADG selector switch uses knob switch, working mode switch, range selector switch uses gear switch, and the rest of the keys are designed with light touch switch, through the microcontroller to respond to the operation of these keys, send the relevant communication commands to the upper computer, which recognizes the corresponding communication commands, and then drives the PFD, ND meter and the related chapter dynamic schematic to update.

5. Application of Desktop Simulator in Teaching and Learning

By using the desktop 737NG simulator in the classroom, most of the operations on the captain's side can be done. The mouse keyboard can be used to set the takeoff and landing airports and weather, and the hardware simulation panel can be operated to set the autopilot parameters, and the CDU can be used to set the flight plan and flight parameters and a series of other operations. The three-dimensional physical simulation environment stimulates students' desire to learn about flight knowledge and greatly improves learning efficiency. At the same time, the data of each interface of this platform is open to students, and students can develop innovative practice projects. Students can select their own suitable solutions and build their own simulator hardware simulation panels, which are fully compatible as long as they meet the electrical standards and communication protocols of this simulation platform, so this platform plays an important role in aircraft system knowledge learning and innovation training.

6. Conclusion

This paper introduces the software and hardware design of the desktop 737NG simulator platform, which realizes the modularization of flight simulator panels, miniaturization of structure, and flexible configuration setting. Through testing, the hardware and software communication is stable and can respond in time, which is suitable for practical teaching. Students can learn flight knowledge and conduct innovative project training through this platform, and will continue to develop more simulation panels based on this platform to realize more aircraft system knowledge training. Through the test, the hardware and software communication is stable and can respond in time, which is suitable for practical teaching. Students can learn flight knowledge and conduct innovative project training through this platform, and will continue to develop more simulation panels on top of this platform to realize more aircraft system knowledge training.

Acknowledgments

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