Research and Development of Embedded Experiment Box Based on PSOC Technology

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Abstract. With the continuous development of science and technology in recent years, chip technology is also developing rapidly. Embedded technology is a new development of computer application technology with a wide range of application fields and development prospects. With the successful development of PSOC chip technology, it can be effective. The improvement of analog-to-digital conversion, digital-to-analog conversion, display, key operation, pin input and output, etc. for overall design and hardware implementation and software implementation, so research and development of a new type of experimental box is also very helpful, the experimental box can effectively improve The function and rate of code decoding and waveform transformation have a significant effect on the teaching of universities.

1. Introduction
Advances in microelectronics have led to the continued development of integrated circuit designs toward ultra-large scale, very low power consumption and ultra-high speed. At the same time, digital circuits are the future development trend, but the analog circuits will never be eliminated. The conditioning and conversion of analog signals must be completed by analog circuits or analog-digital hybrid circuits. The success of analog circuits during the design of experimental boxes. Design is also a very critical and complex part. With the development of PSoC technology, it has been significantly improved. PSoC refers to Cypress's programmable mixed-signal array chip series based on on-chip microcontrollers, and is also the most powerful series of analog processing capabilities, including CY8C27143 (8-lead Pin), CY8C27243 (20-pin), CY8C27443 (28-pin), CY8C27543 (44-pin), and CY8C27643 (48-pin) [1]. PSoC integrates the traditional analog system with the microcontroller system and digital peripheral interface circuit on the same chip. The analog array and digital array can be freely configured and programmed online to realize the embedded experiment box design process to meet the needs of different users.

2. Embedded system PSoC implementation method
The on-chip system PSoC is realized by integrating the microcontroller system, digital interface circuit, programmable digital logic circuit and analog circuit on the same silicon chip. The key technology realized by PSoC technology is to realize the high integration of switching capacitor SC technology on single silicon and improve the switching frequency [2].

Embedded systems are generally designed with a microcontroller (microprocessor) as the core, plus a data memory and program memory to form a microcontroller system. Depending on the application,
embedded systems typically include peripheral digital device (device) interface circuits and analog Interface Circuit. The peripheral digital device interface includes a keyboard interface, a display interface, a communication interface, a pulse width modulator (PWM), a general digital interface (DI/DO), and the like. The analog interface includes an analog signal input processing circuit such as an instrument amplifier, a low pass/band pass filter, an A/D converter, and an analog output circuit such as a D/A converter. It consists of an embedded system with an analog input channel and an analog output channel [3].

2.1. The meaning of embedded system design using PSoC technology

The PSoC technology is used to simplify the design and development of embedded systems. All the functions in the dashed line can be realized on one chip by PSoC technology. This is attributed to the switch-capacitor circuit technology that integrates the analog circuit with the microcontroller system and the digital interface circuit in a single On the silicon chip [4].

Early switched capacitor circuits are mainly used to realize the function of large resistors in integrated circuits. With the improvement of high frequency analog switch integration technology, the use of switched capacitor circuits is more and more extensive. Switched capacitor circuits can be used to implement AD conversion separately, compare-by-comparison AD converters, integral AD converters, and capacitive DA converters, filters, analog dialers, etc. Switched-capacitor circuits are used in conjunction with continuous-time circuits to achieve high-precision instrumentation amplifiers. More importantly, The switched capacitor circuit realizes the interface between the analog circuit and the microcontroller, so that the analog circuit and the microcontroller no longer rely on the dedicated interface chip, which reduces the system development cost and simplifies the system design and implementation. The system on chip not only The analog circuit and the microcontroller system are integrated on the same chip, and the processing capability of the microcontroller and the function of the digital interface circuit are greatly enhanced. The PSoC is generally designed with the microcontroller as the core, and the interface circuit adopts the functional module design method. The functional modules are divided into digital modules and analog modules. The digital modules mainly realize digital connection with external devices. Function, usually divided into multiple programmable function modules, can be flexibly programmed according to specific applications. The same digital function module can realize counter function, timer function, pulse width modulator function and CRC checker, master/slave Communication functions such as SPI and UART [5]. The analog module mainly implements the analog signal interface function with external devices. It is usually divided into multiple programmable function modules, and can also be flexibly configured and programmed according to the specific application. Continuous time module realizes the simulation of external devices. Signal direct interface, such as the realization of ordinary operational amplifiers, variable gain amplifier functions, and front-end interface circuits of instrumentation amplifiers [6].
3. Experimental box design related wireless network technology
The embedded system is a dedicated computer system with application-centric, computer-based, software and hardware tailoring, adapting to application systems, and strict requirements for function, reliability, cost, size, and power consumption. The embedded system is mainly composed of embedded microprocessor, peripheral hardware device, embedded operating system and user application program. It is a combination of software and hardware that can work independently. The embedded mobile learning teaching experiment box needs the support of embedded system development, mobile communication, wireless network and other technologies [7].

3.1. Application of wireless network technology
Wireless networks include infrared technology, spread spectrum technology, narrowband RF and HomeRF, and Bluetooth technology. The WLAN based on the IEEE 802.11 standard allows wireless connection using an unlicensed 2.4 GHz or 5.3 GHz radio frequency band in a LAN, and has a wide range of applications. The wireless network includes a wireless network card and a wireless access point (AP), and the wireless local area network uses a conventional local area network and interconnected devices to form a backbone network.

3.2. Application of Bluetooth technology
Bluetooth technology is actually a short-range radio technology that uses a decentralized network structure and fast frequency hopping and short packet technology to support point-to-point and point-to-multipoint communication, working in the global 2.4 GHz ISM band. The Bluetooth data rate is 1 Mbit/s, and full-duplex transmission is realized by a time division duplex transmission scheme. The use of Bluetooth technology can effectively simplify the communication between mobile terminals such as computers, smart phones, PDAs, and the Internet, thereby making data transmission between the Internet and the Internet more efficient, and broadening the road for wireless communication.

3.3. WiFi technology application
WiFi is a short-range wireless transmission technology that improves interoperability between wireless network products based on the IEEE 802.11 standard. With the development of technology
and the emergence of standards such as IEEE802.11a and IEEE802.11g, the IEEE802.11 standard has been collectively referred to as WiFi.

WIFI router adopts MT7621 and MT7612E chip design. MT7621 integrates a dual-core MIPS1004K (880MHz), HNAT/HQoS/Samba/VPN accelerator, 5pGbE switch, 2xGMII, usb2.0, usb2.0, 3xPCIe, SD-XC. A powerful CPU with a rich portfolio is suitable for 802.11ac, LTE 4/5, Edge, Hotspot, VPN, AC (Access Control). It can also be connected to touchpanel, zigbeez/zwaves for Internet service routers and home security. Several dedicated hardware is provided for the next-generation router MT7621. The MT7612E is a highly integrated single chip with dual-band 2x2 WLAN. Supports PHY rates up to 867Mbps, optimized RF architecture and baseband algorithms for optimal performance and low power design, MT7612E with built-in PA/LNA, minimal peripherals, MT7612E support for 802.11i security standards, and hardware implementation Accelerate TKIP, CCMP and WAPI. The device also supports 802.11e QoS for video, voice and multimedia applications.

4. The design of the embedded experiment box

Embedded technology features provide clock signal input and display experimental results for PSoC technology. The middle part is the download circuit, which is the heart of the whole circuit. It is connected to the computer and PSoC technology chip, and download programming can be completed by downloading the excuse and latch CD74HC244. The bottom part is the logic level input circuit and the power supply circuit. The function of the logic level input circuit is to provide high and low level input. 16 LEDs are used to form high and low levels under the control of 16 switches. When the switch light is on, it means the input is high level, and if the light is not on, it is not bright. The input is low. The power circuit supplies +5V DC to the entire test chamber.

4.1. Pin diagram of the experiment box

The circuit requires that the compiled program be downloaded from the computer and loaded into the PSoC technology to complete the software experiment. The download and configuration method used here is JTAG. The PSoC technology pin access mode is 3-pin, 1-pin, 5-pin, and 9-pin respectively corresponding to PSoC, 77-pin, 57-pin, and 15-pin of PSoC technology. In addition, the 13-pin, 76-pin, 34-pin, 55-pin, and 12-pin of PSoC technology are connected to the 2.2K pull-up resistor to be connected to the high-level input. As the high-level input, the 31-pin and 32-pin grounding and 75-pin nCE grounding are provided. The power pins are 40, 33, 20, 4, 63, and 45. The ground pins are 82, 68, 46, 41, and 26. The clock circuit requires a designed clock frequency of 1000 Hz, 100 Hz, 10 Hz, and 1 Hz. For a clock with a very low frequency, a multi-vibrator consisting of 555 devices is used to generate a 1000 Hz clock signal, and then a three-chip counter 74LS160 is cascaded to form a frequency divider of 1000 to obtain a 1 Hz clock signal. A 100 Hz and 10 Hz clock is obtained at the outputs of the first and second slices.
4.2. Component diagram of the experiment box
The power circuit consists of a power transformer, a rectifier bridge, an integrated voltage regulator 7805, and a filter circuit. The logic level input circuit has 16-key input and 16 LED input indications. Each switch is connected to +5V power supply, and the other end is connected to the LED, and then grounded. At the same time, the positive pole of the LED is connected to the I/O pin of PSoC technology. When the switch light is on, it means that the input is high. Do not press the switch, the light does not light, it means that it is low level at this time.

4.3. Overall design of the experimental box
The experimental box developed in the whole adopts a modular scheme. In practice, the module is fixed on the motherboard (backplane) through the screw copper column, which is convenient to carry, the module is not easy to be lost, and communicates with each other on the circuit through the pin header and the slot. Modules can be combined with each other to complete a comprehensive experiment. When the interfaces are consistent, the modules can be interchanged, and they can be upgraded on their own to achieve innovative experiments.

The experimental box core module includes: an MPU module and a PSoC technology module, and the two communicate through a parallel bus. The peripheral modules include: DC power module, button display module, audio amplification filter module, audio power amplifier module, serial interface module, high-speed D/A module, high-speed A/D module and communication interface module. The peripheral module communicates with the core module via a parallel bus or a serial bus. The electronic system is built by an optional module. The experiment box can complete the integrated electronic system design experiments such as digital voice storage playback, DDS signal generator, high-speed data acquisition, distributed temperature detection based on CAN bus. The debug interface, the connector and the burnt-out chip and related peripheral circuits are all designed on another large base plate. Finally, the core board and the backplane are connected together by connectors, and other expansion modules required for the experiment box are also tried. It is connected to the backplane by means of a connector.
4.4. **Experiment Box CAN Design**

The main features of the CAN bus are: multi-master station bus access based on priority, non-destructive limited-weight arbitration, multi-address frame transmission with receive filtering, remote data request, configuration flexibility, system-wide data compatibility, error detection and error signaling. According to the design requirements, the master node and the byte point select the MPU module and the communication module to complete the system construction. Because the distance between the master node and the child nodes is relatively close, similar to the various control units distributed in the car, the nodes communicate through the CAN bus. Each node has an exact address, which is convenient for the number of nodes in the future. The common communication methods of PC and lower computer are serial port, USB and network. Among them, the serial communication distance is relatively close and the transmission rate is low. It is usually used for short-distance communication and some functional debugging of the lower computer; USB is difficult to network, and Need to write the corresponding communication protocol on the PC, which is more complicated. Comprehensive comparison, the system uses the LWIP protocol to realize the network communication between the PC and the experiment box, and uploads the temperature information of the child node to the PC through the network in real time.

4.5. **PCB layout of the experiment box**

Considering the heat, the current determines the width of the trace; the beautiful trace is also based on and is conducive to safety considerations; the corners should not have an acute angle; the use of the vias should be avoided, the minimum line width and the minimum spacing should be in the settings. Set it and use a pattern that blocks the passage of obstacles. Wiring is also constantly being modified in the process, constantly adapting, to find the final solution to complete all wiring, we are not limited to what is first clothed, but how to adjust in the process, to maintain aesthetics and adapt. For the signal line, the main digital signal line is preferably parallel, the length difference is not large, the use of via holes is reduced, and the cross-holes must be avoided at the intersection. The problems that often occur in wiring are: too many line holes, and the copper plate-making process will be buried with a little carelessness; the line density in the same direction is too large, it is easy to connect into one piece when welding; The area is not set to apply copper and it is easy to cause uneven corrosion.
4.6. System debugging of the experiment box

(1) CAN bus test

The temperature sensor DS18B20 on the sub-node is replaced by a potentiometer. The main node uses the modular integrated experimental box of PSoC technology to introduce the modular concept to complete the design. The experimental box covers the analog circuit, the digital circuit and the single self-contained debugging tool. Whether the message data received by the master node is correct and will change as the resistance of the potentiometer changes.

(2) Network communication test

Connect the experiment box to the PC with a crossover or direct connection network cable. When the experiment box is powered on, you should observe that the PC network setting panel will have a local connection, and set the PC’s network IP address to the same gateway as the experiment box.

Conclusion

The modular comprehensive experimental box based on PSoC technology developed in this thesis introduces the concept of modularization to complete the design. The experimental box covers various aspects such as analog circuit, digital circuit, single-chip technology, EDA technology and integrated electronic system design. With the help of scientific and technological institutions to improve the extensiveness and accuracy of the experiment, with the help of PSoC technology, the performance of the experimental box has been qualitatively improved, which is of great significance for future experiments and can improve the comprehensive innovation ability.

References

[1] Zhu Chaoyu, et al.Hardware design and implementation of IoT experiment box based on DM365, Vol. 8 (2015) No. 25, p.65-69.
[2] Chen Zhixiong, Kong Yinghui, Zhao Jianli, Xiang Hongyin, et al.An Internet of Things multiple experiment box, Vol. 9 (2016) No. 26, p.315-318.
[3] Collaborative interconnection system design method, Vol. 10 (2016) No. 13, p.271-276.
[4] Ni Zhiping, et al.Discussion on the construction of professional laboratory of Internet of Things engineering, Vol. 05 (2017) No. 26, p.169-173.
[5] Ji Juan, Huang Kaixin, et al.Research and design of university bio-network science innovation teaching platform, Vol. 12 (2017) No. 29, p.165-168.
[6] Luo Jiabing, et al.Design of experimental equipment management system based on Internet of Things technology, Vol.08 (2016) No. 16, p.32-36.
[7] Zhao Chenguang, et al.Internet of Things Experiment TeachingResearch on the development of instrument and equipment industry, Vol. 03 (2016) No. 42, p.85-92.