Research on Development of Digital Switching Power Supply Based on FPGA

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Keywords: Switching Power Supply, Digital Control, FPGA

Abstract: With the development of science and technology, the demand for high quality power supply electrical equipment increasing application of analog circuit Control Research and Application Development of power for many years already, but it still has many shortcomings. FPGA as a highly integrated, economical, high speed, low power consumption, it is easy to develop and maintain a significant advantage (upgrades) and the like. And faster, more integrated, more versatile, and other advantages, stand out from the MCU and DSP integrated circuits, etc., become the research and application in the field of power electronics control hot spots. Briefly introduces the basic theory of digital systems, we analyze the structure model of digital systems. There is an overview of the design method of digital control system, the completion of the selected device selection and related development environment and tools. This paper proposes all-digital power control scheme of special surface treatment, and the completion of the controller hardware and software design and implementation.

Introduction of Switching Power Supply

Switching power supply known as energy efficient, it represents the development direction of the power supply, has become the main product of the power supply. Efficient energy-saving and environmental protection has become common in today's world, the world has been gradually on the home appliance and consumer electronic products standby power consumption and efficiency of power began to implement more stringent requirements. The key energy-saving switching power supply work is to further reduce power consumption, so that most of the power supplied to the load, the loss itself should be as small as possible, improve the efficiency of the power supply in the energy transmission system.

With the development of digital chip and power technology, there is now for the power control and developed a control processor, which mainly consists of high-speed AD converter, a digital PID compensator and digital PWM output of three parts, the feedback loop is controlled by the it is to complete, as the central processor used in the power management module. The introduction of new technology significantly reduces the time required for A-D conversion, can reach the megahertz sampling frequency. Although digital control has obvious advantages, but it can't fully meet the requirements of switching power supply, and can meet the requirements are too expensive, so the application is not yet widespread. But with the proposed control processor technology, digital control technology in switching power supplies will be widely applied [1].

With the rapid development of power electronics technology, switching power supply toward green products, high frequency, high power density, high power factor, high efficiency, high reliability, high precision and intelligent digital direction. Intelligent power requirements can only load changes, automatically adjust the output voltage, current, so as to meet the needs of users, it should also include remote monitoring and remote control. Traditional analog control technology to implement more and more difficult to control with digital technology replaces analog control technology has become an inevitable trend.

Technology Advantage of FPGA Digital System

FPGA basic characteristics are: the use of FPGA ASIC circuit design, users do not need to cast film production, and they can get the combination of chips. FPGA can do other full-custom or semi-custom ASIC circuit specimen. FPGA internal triggers and rich I / O pins. FPGA circuit ASIC design cycle is the shortest, lowest development costs, one of the least risky devices. FPGA programmable logic devices has been rapid development, the high integration, high speed and low cost direction constantly moving, expanding its application areas, application in the field of signal processing is also active, mainly has the following characteristics [2]. Fig.1 shows the technology advantage of FPGA digital system.

Fig. 1 The technology advantage of FPGA digital system

Currently on the market, FPGA system gates density from a few thousand to several million system gates. Motor speed control system design, you can use a programmable logic chip instead of the conventional majority circuit functions implemented to reduce PCB area and increase system reliability. Although different companies, FPGA series of different speeds vary, but the running clock can be up to several tens MHz or even more than one hundred MHz, it has been much larger than the DSP and various microcontrollers. In-system programmable technology, making the FPGA development cycle is short, easy design changes, risk-free investment and so on. Since FPGA programming can only repeat I / O ports can also be reconfigured. Thus, when the current system was found flawed, or need to upgrade the system, it might need to change the PCB, but only to reprogram the FPGA to reduce costs and shorten the development cycle.

Simple design and development, improve work efficiency. Electronic Design Automation EDA tools make design entry, synthesis, simulation, very convenient. FPGA development software integrates different development methods, can be adapted to the different needs of a variety of electronic engineers, such as languages and hardware description language ABEL, and schematic design. In FPGA embedded within a certain amount of memory, memory types are dual-port SRAM, ROM, FIFO, signal processing can be used to store coefficients, intermediate results, and so on. CHMOS FPGA using high-speed technology, low power consumption, compatible with CMOS, TTL level. Compared with digital devices, it has a simple, economic, high speed and low power consumption advantages, users can configure the site to change its programming and internal connections and component parameters [3].

Hardware Implementation of FPGA

Traditional high-frequency switching power supply control circuit consists of many discrete components to build up, these discrete devices over time a rather aging, inevitably there is a temperature drift, thus reducing the accuracy and reliability of power supply. In this paper, FPGA-based digital power, the control data operations, logic output section, and PC communication is completed by the FPGA, reducing the control section discrete components used to improve the stability of power supply and technical confidentiality. The control circuit is the brain of the entire power system, and FPGA control circuit includes FPGA board minimum system hardware, voltage and current sampling ADC and its peripheral circuits, circuit and RS232 PC communication and

some external keyboard, LED display interface. Fig. 2 shows the hardware implementation of FPGA.

Fig. 2 The hardware implementation of FPGA

The control circuit is the core of FPGA, FPGA provide ADC clock work at the same time to come into the ADC data mining process, after a certain logic operation output control signal, complete closed-loop control of the power supply. This design uses FPGA is the high cost EP2C8Q208C8, its internal power supply of 1.2V, embedded multipliers and their owners can significantly reduce FPGA LE valuable resources in the implementation of multiplication. PLL module can easily clock frequency, frequency, phase shift function, the clock signal and the output is relatively stable, PLL frequency multiplier to generate high-precision digital PWM function has important applications.

In order to respond to emergency situations (such as short circuit, etc.) as well as over-current voltage at the output lead is too large, the power needed to deal with a corresponding method, the system provides a double protection. If it is determined bus voltage or current is greater than the set maximum value detected immediately blocked drive output full-bridge inverter to stop working, while providing fault status display. Fast switching power switches electromagnetic interference is caused by problems of modern switching power supply design must face, signal integrity is a high-speed circuit board design must pay attention to the problem. Reasonable PCB layout not only reduce the cost-effective means of electromagnetic interference, but also can improve the signal integrity of high-speed circuit the most effective way [4].

Software Implementation of FPGA

All work is done by the power control logic FPGA, several units based on FPGA digital switching power supply controller including: data acquisition and filtering, digital compensator to achieve, generate ZVZCS digital PWM driven waves, with the host computer communication module, protection and status display control module. Although Verilog syntax of C language and in many places there are similarities, but writing Verilog program and C language completely different way of thinking: Verilog program embodied in the FPGA are executed in parallel, completely different from the C language serial execution rules; Verilog description of the hardware circuit, it is necessary to ensure that the syntax used can be integrated into the actual circuit, and C is directed to a software programming language process, does not correspond to the actual application circuit, generally consistent syntax statements can be identified C compiler to produce assembler or machine code for the CPU to execute.

Each module requires an external clock signal clk and reset signals rst n connection. The digital power control system FPGA program uses a modular design, by calling the top of each module framework conducive to reading and maintenance programmer, power control system of top-level program module is as follows: the left pin is an input port, on the right pins output port sub-module FIG follow the same rules [5]. Fig.3 shows the top-level module system of power switch.
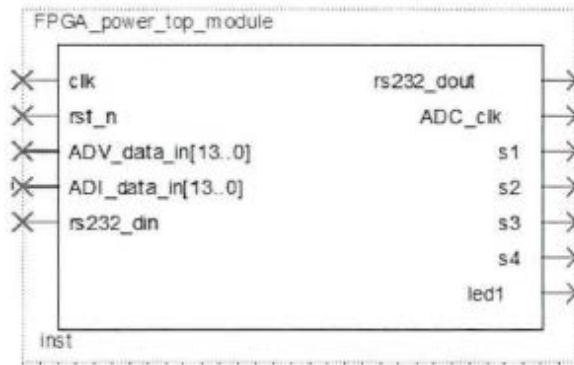
Fig. 3 The top-level module system of power switch

Power control system program FPGA top module FPGA-power top module, instantiating top module requires completion of each sub-module power control system, you need to instantiate the basic modules are: After power up the drive output modules Output delay: delay rst, power soft start module: solft start, ADC clock multiplier control module: clken-gen, voltage, current, digital filtering module: aver filter Uaver filter, digital PID algorithm module: pid, digital PWM signal generation module moving horse C: DPWM, upper and lower computer communication module: rs232 top module.

Conclusions

With the development of power electronics industry, electrical equipment for power supply a higher performance requirements. FPGA digital control can lower device aging, temperature drift on accuracy, digital communications with the outside world to facilitate intelligent control to monitor, improve system stability. This paper presents the design method of main device parameters switching power supply of the main circuit, including an input rectifier filter circuit design, inverter selection, and so the main switch. Power control, the use of FPGA as the main controller of the program, completed the full digital control power. In communications, the provisions of the FPGA and the host computer's RS232 communication protocol frame processing method enables the PC to control the FPGA in a given register value to complete the output is automatically adjusted, while the PC interface display voltage machine gathering lower position, the current information.

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