Design of ZYNQ-based Teaching Platform for Embedded System Education

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Abstract. This paper introduces the design of a teaching platform for embedded system learning. As the latest hybrid architecture embedded processor, ZYNQ are different from traditional FPGA or ARM-based embedded systems in the device architecture, resources, development environment, or applications. Therefore the design of teaching platform demands higher requirement. The hardware of platform and function of platform are introduced respectively. The platform can effectively cover the FPGA and ARM part of ZYNQ architecture during teaching and experiments. Through this platform, students can fully master the development skill of hybrid SOC.

Introduction

Embedded system technology has been widely applied in more and more electronic systems. At present, colleges and universities generally opened embedded design and experimental courses, therefore the teaching platform of embedded technology is also developed. The relevant information and experimental content in course of embedded system teaching has become increasingly standardized. As a new kind of technology with strong practicability and fast technology updating, the embedded system has been updated and changed from its birth. The latest embedded system has already surpassed the past in computing ability and integrated resources. Besides, the development method of embedded technology is also innovated. Along with the change in device architecture, resources, development environment or application, the teaching platform in embedded teaching needs to be updated to meet higher requirements.

Introduction of ZYNQ Series Processors

With the rapid development of chip design technology, applications of ARM + FPGA architecture are growing. This structure can combine their intrinsic strengths: high-speed logic, configurable peripheral interface, parallel programming flexibility of FPGA, integration, easy programming, algorithm processors of ARM. The combination of them can meet the flexibility requirements of the custom system and meet the requirements of the simplicity in the general system, and has wide application prospect.

Xilinx introduced the ZYNQ series hybrid SOC(system on chip) which combines the advantages of FPGA and ARM. Two Cortex-A9 processor and 28nm programmable FPGA are integrated in a chip, breaking the traditional FPGA + ARM / DSP core architecture. The processor system (PS) of ZYNQ consists of two ARM Cortex-A9 processors that communicate
with on-chip memory, SDRAM and Flash memory, and peripheral modules via an AXI (Advanced eXtensible Interface) interconnect mechanism. The PS section is connected to the ZYNQ device's on-chip programmable logic (PL) via multiple AXI ports, and the PL section can be programmed as custom FPGA. This ZYNQ chip in the ARM and FPGA formed between the extremely efficient coupling, which can provide any user-defined functions to extend the performance and functionality of the processor system.

With the birth of ZYNQ chip, the traditional embedded system architecture has gradually changed, the boundaries between FPGA and ARM gradually blurred, the embedded system design process has been gradually changed from "architecture-oriented" to "function-oriented." In view of this characteristic, the teaching curriculum of embedded system also need to keep pace with the times urgently. As a hybrid architecture development platform, ZYNQ is very suitable for learning embedded system. As a teaching platform, students can learn two aspects of the embedded system course (FPGA and ARM) in this platform. Through the design of appropriate teaching experiments, students in the classroom can be more in-depth understanding and master the latest hybrid embedded system design methods, which improve the practical skills at work.

**Hardware Architecture of Teaching Platform**

ZYNQ teaching platform uses Xilinx latest Zynq-7000 series XC7Z010-1CLG400C core chip, which uses 28nm process technology, with high performance, low power consumption. Its main feature is the dual-core ARM Cortex-A9 (processor system, PS) and Xilinx programmable logic (programmable logic, PL) integrated into a single chip. The platform features 512MB of DDR3 memory and 4Gb NAND FLASH for data storage; a USB2.0 ULPI PHY and a USB_UART PHY for data transmission; a CMOS connector and a HDMI interface for display application and Gigabit Ethernet PHY for communication over internet.

![Hardware architecture of teaching platform.](image)
Experiment Function of Teaching Platform

In order to cover the knowledge of FPGA and ARM technology, several experiment can be operated on this platform. Specifically, experiments are listed as follows:

GPIO Experiment

The experiment of GPIO is mainly used to train the understanding of simple digital logic circuit and the basic process of FPGA development. The main content of the experiment is to realize the water lights using GPIO through PL programming.

DDR Controller Experiment

DDR controller is mainly used to train students to call the memory management processor IP core provided by Xilinx in ZYNQ development, and to master the basic principles of IP core, to understand the concept of design reuse, to master the interaction principle custom logic and IP core.

Linux TCP/IP Data Transmission

The main purpose of this experiment is training the C programming skill in LINUX, getting the use of Ethernet interface in ZYNQ, master the design skill of a TCP / IP-based file transferring system. This experiment can improve development capabilities of students in Linux application. Students also learn the ARM kernel in the network interface control process and TCP / IP protocol stack to process data packets.

AXI Bus Communication

AXI (Advanced eXtensible Interface) is a bus protocol that is the most important part of AMBA (Advanced Microcontroller Bus Architecture) 3.0 protocol proposed by ARM. It is also the most commonly used communication bus in ZYNQ. It is responsible for communication between PS and PL. Between the transmission of information and data. The purpose of this experiment is to master the data transmission technique between PS and PL part of ZYNQ.

Conclusions

As a new type of technology, the development technology of embedded system is changing day by day. The corresponding teaching work will inevitably need to closely follow the development of technology. As the latest hybrid architecture embedded processor, ZYNQ are different from traditional FPGA or ARM-based embedded systems in the device architecture, resources, development environment, or applications. Therefore the design of teaching platform demands higher requirement. This paper introduces the design of embedded teaching platform based on ZYNQ and follows the learning rule of experiment course of traditional FPGA / ARM system. In order to adapt to ZYNQ, the platform can effectively cover the FPGA and ARM part of ZYNQ architecture during teaching. Through this platform, students can fully master the development skill of hybrid SOC.
References


