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ASSEMBLY LANGUAGE & INTERFACING TECHNOLOGY

汇编语言与接口技术

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Assembly Language & Interfacing Technology

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PREFACE

Today's digital technology, computer technology have penetrated into various fields. The ability to master and apply computer technology has become one of the criteria to measure the quality of a professional technicians. Assembly Language & Interfacing Technology is an important computer technology course in science and engineering of higher education.

Although the rapid development of computer technology, microprocessors have been from 32 to 64-bit transition, for a variety of control systems, we commonly use 8-bit, 16-bit interface technology to meet the application requirements, so 32 or even 64 microprocessor to explain the working principle of microcomputers is not suitable. This book is a 16-bit microprocessor model, about the basic principles of computer and interface technology, easy to learn and understand, its basic concepts, basic ideas and basic methods and 32-bit processor are the same.

This book is mainly for the general colleges and universities of computer science, electromechanical contror and non-electronics majors students. The preparation of this book focuses on theory with practice and engineering applications. In the preparation of teaching materials in the introduction of life ,a lot of examples witch are easy to understand are used to help readers understand the basic concepts of computer. After talking about the working principle of various interface chips, the book gives a number of examples which can be directly applied, and give some different solutions to achieve the function.

The book is divided into 7 chapters. Chapter 1 introduces the basics of comicrocomprter systems; Chapter 2 introduces assembly

language in graphical form; Chapter 3 introduces the assembly language programming method; Chapter 4 introduces the 16-bit processor Pins, read and write timing; Chapter 5 describes the I/O interface, the basic composition, read and write technology and data transfer; Chapter 6 introduces the concept of interrupts and functions of programming 8259A chip. Chapter 7 introduces the internal structure and programming of the programmable parallel interface chip 8255A, the serial interface chip 8251A, and the timer/counter interface chip 8253/8254.

This book is comprehensive, and self-contained, the assembly language programming part and the computer principle and interface technology are orgamied together, through appropriate choice, and is suitable both computer professional and non-computer professional students.

This book is writen by Zeng Lanling, Han Xiaoru, and Li chang; Adjardiah Winfred Kudjo Patrick as deputy editors.

The authors of this book in the process of writing referred to a lot of excellent reference materials, thanks to the author of these materials, in particular, thanks especially to Ma Weihua, Qian Xiajie and Yang Wenxian. In addition, the writing of this book has been the national teaching quality engineering network of professional comprehensive reform project and Jiangsu University teaching reform project support.

Due to the limitation of editors, there are some errors and omission, please critilize. If you encounter problems with the use of the textbook, contact the author. E-Mail: lanling@ujs. edu. cn.

Editor

August 2018

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CHAPTER 1
SUMMARY OF MICROCOMPUTER SYSTEM

[Abstract] This chapter is the basis for learning other chapters. First, this chapter introduces the development and application of microcomputer , and then focus on basic concept ,composition and main performance indicators of microcomputer system. The computer data representation and coding and basic content of logic circuit are for non-professional computer students, computer professional students can skip this part.

[Learning Goal]

- Learn the development and application of microcomputer.
- Grasp basic concept of microprocessor, microcomputer and microcomputer system.
- Learn the composition and performance indicators.
- Grasp methods of conversion from any number from base 2, base 10, or base 16 to either of the other two bases.
- Learn logic gates to diagram simple circuits.

1.1 Development and application

1.1.1 Development of electronic computer

As usually referred as computer by people, it refers to electronic digital computer. It is made of electronic devices, with abilities of computing , peforming logical judgment , processing equipments for automatic control and memory function. The world's first digital computer was inboduced in february 1946, it is an electronic numerical integrator and calculator (referred to as ENIAC). It was co-developed by physicist Mo Keli (J. Mauchly) and engineer Eckert (JPEckert) at the University of Pennsylvania.

ENIAC is the first official computer to run, but it does not have the capability of "stored programs". In June 1946, Dr. Von Neumann proposed the computer design of the "storage program" with the following:

(1) The computer hardware system is composed of five basic components , including calculator, memory, controller ,input devices and output devices.

(2) The computer uses binary representation of data and instructions.

(3) Its cores principles are "stored programs" and "program control".

The program is stored in the main memory in advance, in the case that the computer at work without the need for operator intervention , automatically remove the instructions one by

one and implement.

Computer designed by this principle called Von Neumann type computer, the structure shown in Figure 1-1. The architecture proposed by Von Neumann laid the foundation of modern computer architecture theory and a milestone in the history of computer development. ① The computer architecture given by Von Neuman is minimum subset. ② The lack of any one can not become a system, a memory, a controller, an operator, an input device, and an output device. At present, the common computer in addition to Von Neumann type computer, there are Harvard structure of the computer. Harvard structure is essentially different from the Von Neumann structure, but the data and the program separately stored, with two memories, speed up the system at the same time also increased the CPU peripheral interface.

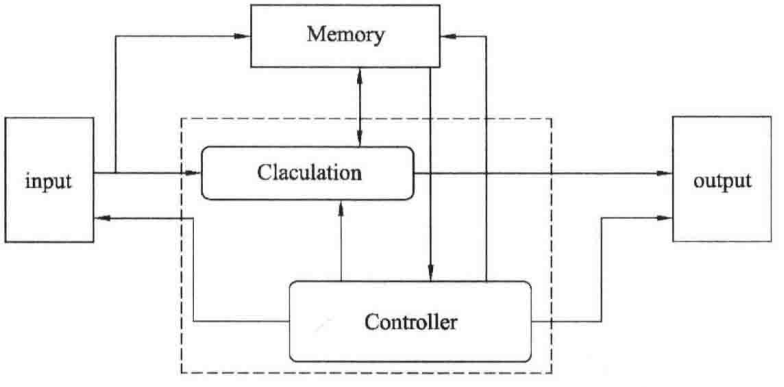

Figure 1-1 The architecture of von Neumann

From the birth of the first electronic computer to the present, computer has gone through more than half a century of development. During this period, the computer system structure is constantly changed, the application field continues to widen. Generally based on the computer used by the main physical devices, the computer development is divided into several stages, a stage called generation (Table 1-1).

Table 1-1 History of computer development

Age	First Generation 1946—1957	Second Generation 1958—1964	Third Generation 1965—1970	Forth Generation 1971—Now
Electronic Device	(electron) Tube	Transistor	Integrated circuits	Large scale integrated circuits
Memory	Delay line Magnetic core Drum tape Tape	Core Drum Tape Disk	Semiconductor memory Core Drum Tape Disk	Semiconutor memory Tape Disk CD
Processing Method	Machine language Assembly language	Monitoring program High language	Real-time processing Operating System	Real-time/time-sharing network Operating System

continued

Age	First Generation 1946—1957	Second Generation 1958—1964	Third Generation 1965—1970	Forth Generation 1971—Now
Application Field	Scientific computing	Scientific computing Dataprocessing Process control	Scientific computing System design and so on Science and technology field	All walks of life
Calculation Speed	5000 to 30000 times per second	Hundreds of thousands to million times per second	Million to several million times per second	A few million to 100 billion times per second
Typical models	ENIAC EDVAC IBM705	UNIVAC Ⅱ IBM7094 CDC6600	IBM360 PDP 11 NOVA1200	ILLIAC-Ⅳ VAX 11 IBM PC

1.1.2 Development of microcomputer

The most significant event in computer development in the 1970s was the birth and rapid spread of microcomputers. A microcomputer is an organic whole that connects the microprocessor, memory, and input/output interfaces together via a bus. The microprocessor is von Neumann machine operator and controller in a chip in the organic combination, its appearance has greatly promoted the popularity of the computer.

M-E-Hoff, a young engineer at Intel Corporation in the United States, in 1969 he accepted the commission of a Japanese company to design a complete circuit for a desktop computer system. He boldly put forward a vision to put all the computers on the four chips, namely the central processor chip, the random access memory chip, the read-only memory chip and the register circuit chip. This is a 4-bit microprocessor Intel 4004, a 320-bit (40 bytes) of random access memory, a 256-byte read-only memory and a 10-bit register, they are connected through the bus, so the 4-bit microcomputer——MSC-4,1971 was born in the United States of America. Since then, just 40 years time, the development of micro-computer has gone through seven or eight stages. People generally use the word length and the typical microprocessor chip as a sign of each stage.

The first stage (1971—1973) is the 4-bit and 8-bit low-end microprocessor era. Often referred to as the first generation, the typical products are Intel's 4004 and 8008 microprocessors and MCS-4 and MCS-8 microcomputers respectively. Basic features are mainly machine language or simple assembly language, less of instructions (more than 20 instructions), for home appliances and simple control occasions.

The second stage (1973—1978) is the 8-bit high-end microprocessor era. Commonly known as the second generation, the typical products are Intel's 8080/8085, Rockwell's 6502, Motorola's MC6800, Zilog's Z80, and a variety of 8-bit microcontroller. They are characterized by a relatively complete command system, with a typical computer architecture and interrupt, DMA and other control functions. Software in addition to assembly language, there are BASIC, FORTRAN and other high-level language and the corresponding interpreter and compiler, also appeared in the latter part of the operating system, such as CM/P

is a popular operating system. This period of the more well-known computer products have 8 micro-computer TRS-80 (using Z80 microprocessor) and Apple Ⅰ/Ⅱ (commonly known as "Mac", using 6502 microprocessor). In addition, 8085 is more used in embedded control, 6052 and MC6800 are more used in computer game system.

The third stage (1978—1985) was the 16-bit microprocessor era. Commonly known as the third generation, its typical products are Intel's 8086/8088 and 80286, Motorola's M68000, Zilog's Z8000, and other microprocessors. It is characterized by a richer, perfect, multi-level interrupt, multiple addressing modes, segment storage mechanism, hardware multiplication and division components, and configuration of the software system.

Well-known computer products are IBM's PC (Personal Computer) in this period. The IBM PC was introduced in 1981 with 8088 CPUs. Then in 1982, the expansion of the personal computer IBM PC/XT, it has expanded the memory, and added a hard disk drive. In 1984, IBM introduced the IBM PC/AT, a 16-bit enhanced personal computer with a 80286 processor core. As IBM in the development of PC uses a technology open strategy, so that the PC swept the world.

The fourth stage (1985—1992) is the 32-bit microprocessor era. Also known as the fourth generation, its typical products are Intel's 80386/80486, Motorola's M68030/68040 and so on. It features 32-bit address lines and 32-bit data buses. 6 million instructions per second (MIPS, Million Instructions Per Second). Microcomputer function has reached or even more than super small computer, fully capable of multi-tasking, multi-user operations. At the same time, some other microprocessor manufacturers (such as AMD, TEXAS, etc.) also introduced the 80386/80486 series of chips.

The fifth stage (1993—1995) is the Pentium (Pentium) series of microprocessor era. Commonly known as the fifth generation. Typical products are Intel's Pentium family of chips and compatible with AMD's K6 series of microprocessor chips. The internal use of superscalar instruction pipeline structure, and has been independent of the instructions and data cache. With the emergence of MMX (Multi Media eXtended) microprocessors, the development of microcomputer in the network, multimedia and intelligent and so on, go to a high leve 1.

The sixth stage (1995—1999) is the use of P6 architecture family of processors and microcomputer era. Typical products are Intel's Pentium Pro, Pentium Ⅱ, Pentium Ⅲ and so on, the internal use of three superscalar instruction pipeline structure, the operating frequency is getting higher and higher, the bus frequency is also greatly improved. Supports multimedia extended instruction set (SIMD) MMX, SSE.

The seventh stage (2000—2007) is the NetBurst architecture Pentium 4 (Pentium 4, referred to as P4 or Pentium 4) system processor and Pentium 4 microcomputer era. As the system product performance differences, with the processor number that Pentium 4 products, typical Pentium 4 such as 5XX, 6XX, 7XX and so on. Supports SSE2, SSE3 and SIMD instructions. From 80386 to Pentium 4 early are IA-32 architecture, usually 8086/8088 and 80286 as IA-32 compatible form, no division of IA-16.

The eighth phase (2007 so far) is the use of Core architecture Core (Core) and Core Duo (Core 2) series of microprocessors. The main representatives of the product are

Core 2 Dou, Core 2 Qaurd and Core 2 Extreme and so on. The dual-core Core 2 family of microprocessors is an epoch-making new microprocessor, both 32-bit and EM64T (Extended Memory 64 Technology) technology, is a typical 32/64-bit processor. Known as the IA-32E (Incremental IA-32) architecture, which is called Intel64 because it supports 64-bit access technology.

Parallel to the fifth phase of the parallel development of pure 64-bit processors, such as Intel's Itanium, Itanium II and other processors, they use IA-64 structure. In 2008, Intel Corporation introduced the 64-bit four-core microprocessor Core i7.

1.1.3 Application of microcomputer

As the microcomputer has the advantages of small size, low price, low power consumption and high reliability, its application field is very broad. Summed up, it can be divided into two main directions. There are several application areas as follows:

1. Scientific calculation and information processing

Scientific computing refers to the use of computers to complete the scientific research and engineering technology proposed in the calculation of mathematical problems. Currently a lot of micro-machines have strong computing power, especially a number of processors constitute the system, its function can often match the mainframe, or even more than the mainframe, and the cost is low enough to make the mainframe tends to phase out. In recent years, due to the development of parallel computing technology, the parallel computing system composed of multiprocessors is very powerful in scientific computing power, and can realize various scientific computing problems which can not be solved manually.

Information processing refers to the computer on the information recording, collation, statistics, processing, use, communication and a series of activities in general. Information processing is one of the most widely used fields in computer applications. For example, the candidates in the college entrance examination work and the statistical work, railways, aircraft ticket booking system, internal cost accounting management, personnel management, salary management, financial management, contract management and banking system business management, etc., are data processing range.

2. Computer aided design, auxiliary manufacturing, auxiliary education and computer aided testing

Computer-aided design (CAD-Computer Aided Design) is the use of computer computing, logic and other functions to help people to product design and engineering technology design. Computer-aided design and auxiliary manufacturing (CAM) can be combined directly with the CAD design of the product processing out. In recent years, the industrialized countries have further developed the computerized integrated manufacturing system (CIMS-Computer Integrated Manufacturing System) at the forefront and direction of automation technology. CIMS is a large-scale computerized, automated and intelligent modern production system integrating engineering design, production process control, production and operation management. It is the future of manufacturing.

Computer-aided Education (CBE-Computer Based Education) is a computer in the field of educational applications, including computer-aided teaching (CAI), computer-aided management teaching (CMI).

Computer-aided testing (CAT) refers to the use of computers to carry out complex and extensive testing work.

3. Multimedia applications and network applications

Multimedia technology began in the 1980s. The sound, image, word processing into one, so that the computer has a computer, television, game consoles, fax machines, telephones and VCD machine integrated functions, to a machine. Computer communication is an important field of computer application developed rapidly in recent years. Through the network to achieve information sharing and remote control.

4. Process control

Process control is one of the most widely used applications for microcomputers. Currently, the manufacturing industry and daily lives, manufacturers use the computer to control automated production line, micro-machine applications in these sectors for the production capacity and the rapid improvement of product quality.

5. Embedded application direction

Embedding the microprocessor into the host application system (ie, embedded applications) to play a role is an important aspect of microcomputer applications. Microcontrollers and digital signal processors are two typical chips for this type of application. Microcontroller is known as a controller (Microcontroller), which is mainly oriented to control, in the host system as a control center; and digital signal processor is mainly for large flow of digital signal real-time processing, in the host system as a data processing center. The field of embedded applications is very extensive, from industrial production to our daily lives. For example, in the field of instrumentation, they use microprocessors to replace the traditional mechanical parts, so that it is intelligent. Again in the medical field, there are used as the core components of the microprocessor CT scanner and ultrasonic scanner, the network remote consultation. It is possible in the field of transportation, the bus train has a microprocessor everywhere, and its can achieve precise control; in life, the microprocessor-Controls, washing machine, microwave oven, refrigerator which are very popular household appliances, and microcontrollers Control of the temperature control system, automatic timekeeping, alarm have also entered the family, the phone almost become a necessity for everyone.

The current microcomputer technology is moving in two directions: one is high-performance, multi-functional direction, from this continuous achievement is the micro-machine gradually replace the expensive, superior function, the minicomputer; the other is low prices , direction of functional specificity, this development is the micro-machine in the production areas, service departments and daily life has been more and more widely used.

1.2 Composition of microcomputer

Microcomputer system consists of hardware and software, the hardware composition of the computer is called "bare metal." Bare machine is not able to run independently and handle transactions. Therefore, the hardware system must be equipped with the appropriate software system to work properly.

1.2.1 Hardware system of microcomputer

Microcomputer hardware system refers to the composition of the computer induding a variety of physical devices, that is, they are the tangible physical equipment. Its basic structure and basic functions are roughly the same as large computers and small computers. However, due to the use of large-scale and ultra-large-scale integrated circuit technology and bus structure, making the micro-computer system structure has a simple, standardized and easy to expand the characteristics. The microcomputer consists of a central processor, a memory, an input/output interface and a system bus. The structure is shown in Figure 1-2. Where the central processor and memory constitute the smallest information processing unit, known as the host.

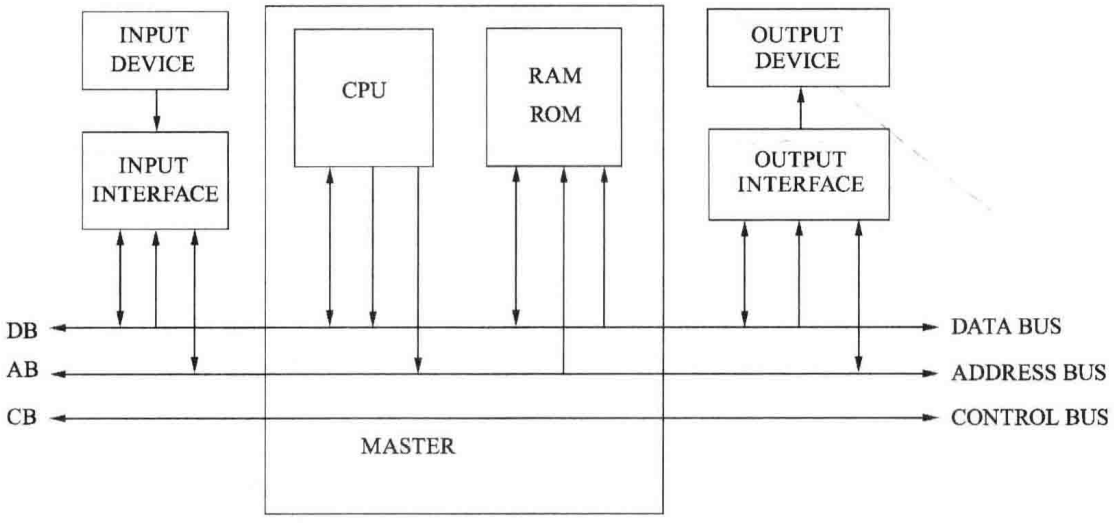

Figure 1-2 The structure of microcomputer

1. Central processing unit

The central Processing Unit (Central Processing Unit) , also known as microprocessors, is the core of microcomputers, integrating the computer operator, controller and related circuits. It is mainly responsible for the implementations of instructions to achieve arithmetic and logic operations, control micro-computer components to coordinate the work.

CPU is a very large scale integrated circuit, which integrates tens of thousands of logic gate array circuit. Although the performance of various CPUs is different, is made up of the arithmetic logic components, controllers and register groups and other basic components. All the microprocessors are based on the development of these. New microprocessors are backward compatible with the characteristics of the three core components on the basis of the new design through the new components to make the CPU with storage management, multimedia and other functions.

2. Internal memory

The main task of the memory is to temporarily or permanently save the program or data resources. The memory is divided into internal memory and external memory, in which the internal memory is used to store temporary or active programs and data, and the external memory is used to permanently save the program and data.

Internal memory, also known as memory or main memory, by which the CPU can

directly address the storage space, made by the semiconductor device. The memory is characterized by fast access speed. We usually use the program, such as windows operating system, typing software, game software, are generally installed in the hard disk and other external memory, but this is not its core function, they must be transferred to memory to run. We usually enter a text, or listen to a song, in fact, they are carried out in memory.

The semiconductor memory constitutes the memory and is divided into a read only memory (ROM) and a random access memory (RAM). ROM information can only be read, generally can not write, even if the machine power failure, the data will not be lost. ROM is usually used to store the computer's basic programs and data, such as BIOS ROM (Basic Input Output System). Its physical form factor is generally a double in-line (DIP) manifold. RAM information can be written and can be read. When the machine is turned off, the data stored in it is lost.

3. Input/Output interface

Input/Output interface circuit (I/O interface circuit) is a bridge between the microcomputers and external devices, and is responsible for data buffering and format conversion, coordination between the host and external equipment. The speed of data transmission differences, complete the data transfer. Different external devices through different I/O interface circuit connected with the host, such as the keyboard through the keyboard interface connected with the host, hard drive through a dedicated hard disk controller and host connection.

4. System bus

The system bus is a general between the various functional components of the public communication trunk, which is composed of wire transmission wiring harness. It is Connected to the microprocessor and memory, input and output interfaces, and it forms a complete microcomputer bus called the system bus. The system bus Retoms three different functions, such as data bus DB (Data Bus), address bus AB (Address Bus) and control bus CB (Control), system bus contains three different functions of the bus.

The data bus DB is used to transfer data information to implement data exchange between the microprocessor, the memory, and the I/O interface. The data bus is a bidirectional tri-state, which can transfer data from the CPU to other components such as memory or I/O interfaces, or to transfer data from other components to the CPU. The number of bits in the data bus is an important indicator of the microcomputer, which is usually consistent with the word length of the microprocessor.

Address bus AB is dedicated to transfer the address, because the address can only be transferred from the CPU to the external memory or I/O port, so the address bus is always one-way three-way, which is different from the data bus. The number of bits of the address bus determines the size of the memory space that the CPU can address directly. For example, the address bus of the 8-bit microcomputer is 16 bits, the maximum addressable space is 2^{16} = 64KB, and the address bus of the 16-bit microcomputer is 20 bits , Its addressable space is 2^{20} = 1MB. In general, if the address bus is n bits, the addressable space is 2^n address space (storage unit).

The control bus CB is used to transmit control signals and timing signals. Some of the